A GUIDE TO THE PANASONIC AG-CX350 CAMCORDER

BY BARRY GREEN

Contents

Acknowledgements

This book has drawn heavily from my prior works, but much of it has been completely rewritten or added because of the new features and capabilities of the AG-CX350, especially in regards to its live streaming and networking capabilities. I am so lucky to have benefited from the many talented, dedicated, and knowledgeable people who lent me their expertise. I'd like to take a moment to acknowledge and thank them.

First, there's Panasonic USA's **Steve Cooperman**. Steve has championed having these books published, in the interest of making sure that his customers have the best support materials so they can use the products to their best capability.

From Panasonic Japan, I'd like to acknowledge and thank **Ayuta Onishi**, who has supported these book projects from the beginning, and **Ota Yusuke**, who has been extremely helpful and instrumental in providing support and information to make sure that the information in these pages is as accurate as it can be.

Many thanks to **Victoria Hart** of Pink Kitty Creative in Las Vegas for the graphic design work.

And, of course, huge thanks to **Jarred Land** and the **membership of www.DVXUser.com**. Jarred created a one-of-a-kind community where filmmakers and shooters share information, knowledge, questions, techniques, answers, and footage. I've met some incredible people through that site, and interacting with tens of thousands of shooters around the globe is what led to the creation of the original DVX Book. Thanks to every one of you!

Frequently Asked Questions

If you're a new shooter, or new to professional cameras, you may find some of the topics in this section relevant. Even some shooters with years of experience behind them, might be new to the Panasonic line of professional camcorders. There are many differences in the way a professional camcorder works, as compared to a consumer camera or DSLR. I've collected a series of frequently-asked questions here, so be sure to check these out before getting frustrated with your new camera.

Why Doesn't The Touchscreen Work?

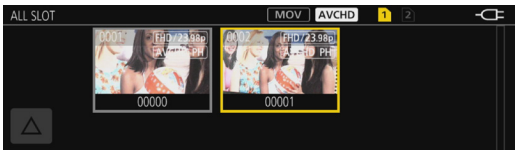
A source of frustration for new owners is when they try to touch the LCD screen, and nothing happens. Isn't this supposed to be a touchscreen camera? Yes, yes it is, and it will work, but you have to change your approach. To bring up the menus, you have to touch AND HOLD the screen for a couple of seconds. You can't just touch and release like on your cell phone; the camera ignores momentary touches and only brings up the menus if you hold down your finger on the screen for a couple of seconds. After that initial delay, the touchscreen functions just like any other, with instantaneous response.

Why Can't I Play My Clips Back?

After shooting some clips and experimenting with the various recording modes, new shooters frequently bring up the thumbnail screen and then worry when they see a red "CANNOT PLAY" symbol on their footage. What happened? Is the camera faulty? Is the SD card bad? And why have some of the clips disappeared entirely? Is the footage lost?

No, none of the above, and there's no reason to panic. There are two issues here, and I'll tackle them separately. The first is: why do some of the thumbnails disappear? Well, what's happening is a byproduct of the

camera having two different recording modes available: AVCHD, and MOV. In playback mode, the camera will only display clips that were shot in the same mode as it's currently set in. What this means is, if you shoot some clips in MOV format, and another couple of clips in AVCHD, and then you go to the thumbnail screen to play them back, the only clips you'll be able to play back will be the AVCHD clips you just shot! The MOV clips won't even show up. Now, there's nothing wrong with the MOV clips, they're all still there, but the camera was last set in AVCHD mode, so that's the only mode of clip that's available for playback. You'll know that there are also MOV clips on your card because the camera will display "MOV" on a black background, and "AVCHD" on a white background, signifying that AVCHD is the current setting and that there are MOV clips available too, if you switch to MOV mode. Note that if there were no MOV clips available, the camera would only show "AVCHD" on a white background, and wouldn't say MOV at all.



Resolving this is really very simple; just change the playback format to match the clips you want to play. Go to the menus and choose SYSTEM>FILE FORMAT, and choose MOV to view the thumbnails of all the clips that were recorded using the MOV recording modes; or choose AVCHD to view the thumbnails of all the clips that were recorded using AVCHD.

That will get all the thumbnails displayed, but that brings us to the second issue: there may still be cases of some clips that allow playback and some that won't. If a clip is showing that it won't play, then generally you will have to configure the camera to match the frequency and possibly the resolution that that clip was shot in. If you shot some clips in 25.00P and some others in 29.97P, you can't view them all together, you have to pick which ones you want to play and change the SYSTEM>REC FORMAT and possibly the SYSTEM>FREQUENCY to match. The camera displays the frequency and frame size right in the thumbnail, so you just have to go to the menus and match them to enable playback of those clips.

Sounds like a hassle, but in reality it's not usually a big deal. Usually you only change recording modes when you're experimenting, but once you settle down to shoot a particular project, you'll usually pick one recording

mode for the entire project, so the mode-changing issue becomes largely irrelevant in actual practice. Just remember that if you can't see a clip's thumbnail (or you can and it's saying it can't play back), that just means you need to match the camera's settings to how that clip was recorded before being able to play the clip back.

How can I view the footage on my computer?

Generally, a multi-purpose file playing program should be able to handle playing back the footage; for .MOV files you may want to use Apple's Quicktime Player or VLC Player; for AVCHD files you may want to use something like VLC Player.

Do be aware, however, that playing 4K or UHD footage can be extremely processor-intensive, and may benefit greatly from a modern graphics card. Which means — it's possible that your computer just may not be powerful enough to properly play 4K or UHD footage. Furthermore, unless you have a very modern monitor that's capable of 4K (or UHD) resolution, you may not be able to see the full detail and quality of the footage on your computer. There's no solution for that other than to try to play the footage back on a system that's fast enough to properly display it, and on a monitor that's large-enough and high-enough resolution to properly display the footage. On smaller or lower-resolution monitors, your video playback software can be configured to "full-screen" mode, in which it will automatically re-size (or "scale") the footage to fit the resolution of your screen. That will enable you to watch the footage, but not at 100% quality.

Also, you should test the recorded footage on your computer to see which performs best. Frequently, modern computers will have a graphics card that provides accelerated processing under some circumstances. You may find, for example, that your computer has hardware acceleration for the HEVC codec, and that HEVC footage plays back spectacularly well on your computer, whereas the h.264 footage may not. Or, for your particular computer, it may be the other way around. Or they may play equally well, or they may equally struggle. Knowing what your computer is capable of can make a tremendous difference in editing the footage, which means a little testing beforehand (and configuring the camera appropriately to the results of your testing) might make editing a much simpler process.

What is the red light on the front of the camera, and why is it on? Or, why is it not on?

That's the Rec Lamp or "Tally Lamp" which lets you know if the camera is currently recording. You can turn it on or off, whichever you prefer. See OTHERS>LED>TALLY LED for more information.

Why Does My SD Card Show Up In The Camera As "Format Error Card" or "Not SDXC Card" or "Incompatible Card"?

Well, assuming that there's nothing wrong with your memory card(!), there's likely no need to panic. The CX350 is a "world" camera; each camera has the ability to shoot 50Hz or 59.94Hz footage. However, the AVCHD recording system specifies that only one type (50Hz or 59.94Hz) can be recorded on each card. A memory card formatted by a camera set to 59.94Hz (or 23.98 or 29.97), cannot be used to record AVCHD clips (or play back AVCHD clips) in a camera set to 25Hz/50Hz mode (and vice versa). If you're encountering a card where it's telling you "Format Error Card", check your SYSTEM>FREQUENCY menu setting, and make sure that you're operating in the mode you should be in, for that card.

This restriction doesn't apply to .MOV clips; you can freely mix MOV clips recorded in any frequency on a memory card regardless of how that memory card was formatted. The 50Hz-only or 59.94Hz-only restrictions apply only to AVCHD clips.

The "Not SDXC Card" message is telling you that, well, the memory card you have inserted is indeed not an SDXC card. There are several types of memory cards, including the original SD card, the "high capacity" SDHC card, and the modern ultra capacity SDXC card. For AVCHD footage, any of these types of cards can be used (Class 6 or faster), but for recording MOV footage, an SDXC card is required. The warning is letting you know that that memory card cannot be used to record MOV footage on.

As far as "Incompatible Card" goes, the CX350 has certain minimum requirements for recording MOV footage. First, the memory card must be an SDXC card, and second, it must meet at least the minimum speed classification for the recording format you want to use. 50mbps footage generally needs a card that is certified to at least V10 or Class 10 or UHS-I; most other modes require at least a card rated at V30 speed classification. Note that if you are using a high-bitrate codec (like 400mbps), and you

insert a card that doesn't support the necessary minimum speed rating (in this case V60), the camera will tell you that your card is incompatible. If you had inserted a V30 card, for example, in this case you can change your recording mode to a lighter bitrate (such as LongGOP 150mbps) so that the recording will be compatible. Or, you can change your memory card to one that is appropriately speed-rated for the bitrate you want to use. In some cases the camera will tell you the card is incompatible, but won't prevent you from recording on it anyway. It sometimes works because sometimes memory cards are faster than the speed rating that they report back to the camera. But even if it works sometimes, this is certainly not a recommended practice; it's something you may be able to get away with, but there's no telling when the card might fail to record. It's well worth it to buy high-quality, properly-rated cards when recording valuable video footage. When in doubt, buy a V60 or V90 card; those cards are rated to handle any and all recording modes that the CX350 is capable of.

One last cause of "Incompatible Card" may be that the memory card was formatted by some device other than the AG-CX350 camera. For example, if you format a memory card on your computer, or in a different type of camera or on a tablet or any other device, it may not be formatted properly for the camera to use. You should only ever format memory cards in the camcorder, if you want to be able to record footage on them.

Why did the camera split my footage up into multiple clips?

If you record one long continuous clip, you may find that on the memory card there are actually multiple clips. Generally this happens most often when using AVCHD, since AVCHD files are split approximately every 4 gigabytes. 4 gigabytes can accommodate about 20 minutes of AVCHD PH footage. So if you're recording AVCHD for 30 continuous minutes, what happens? Well, the camera knows to automatically split the recording into two files, close off the first file at the 4 gigabyte file limit and continue recording into the second file. The camera will also create "pointers" for the two clips, so that each section of the clip "knows" that it is only part of a larger master clip and it will know what clip follows it, and what clip precedes it.

For AVCHD, all of this is done automatically and seamlessly behind the scenes. When you view the AVCHD clip in-camera there will be only one

thumbnail, making it look as if there's only one clip on the card, because, essentially, there is only one clip (it just happens to be made up of several pieces, but inherently it's all intended to be treated as one continuous clip). If you use a nonlinear editing (NLE) program that is properly AVCHD-aware, it will know how to properly reassemble all the pieces into one contiguous clip, seamlessly and effortlessly. If your software doesn't recognize the attached nature of the clips, then you'll have to manually copy over all the pieces, and string them together end-to-end on your timeline. Note that some earlier versions of NLE software didn't know how to do this seamlessly, and would introduce small gaps between the pieces of a clip. That is a software error, not a footage problem! The camera records all the footage seamlessly. If your NLE software can't display it seamlessly, look into upgrades or fixes for your software; as of the time of this writing most if not all major NLEs can now seamlessly handle spanned AVCHD clips.

If you're recording in the MOV file formats onto an SDXC card, you can expect that the camera may also split the clip into individual files at the limit of its maximum file size. It takes a LOT of recording to reach this point though, usually in excess of three hours, so this should be a generally rare situation unless you're recording multiple-hour events. Unlike AVCHD recordings, the camera will display each and every one of those MOV clips with individual thumbnails, and they will import into your NLE as individual clips; you'll have to manually align them end-to-end on your NLE timeline.

Why won't my HDMI monitor display UHD?

The CX350's HDMI output is an HDMI 2.0 connection, which is capable of sending out UHD video footage at 3840 x 2160 resolution, in 10-bit 4:2:2 color, at up to 50.00 or 59.94Hz. In other words, the camera's output is capable of outputting anything that the camera can create.

However, not all monitors are capable of receiving such a signal, and even if your monitor says it's capable of HDMI 2.0, that doesn't necessarily mean it's capable of everything HDMI 2.0 can deliver. There are two signal standards for HDMI 2.0; either a 10.2 Gbps signal, or an 18 Gbps signal. In the CX350, it's capable of outputting both, but some monitors may only be capable of receiving the 10.2 Gbps signal (and, worse, some cables may not be capable of transmitting the 18 Gbps signal!) For this reason, the CX350 has the ability to configure the output for either 10-bit 4:2:2 (which takes 18 Gbps) or for 8-bit 4:2:0 (which only requires 10.2 Gbps). If your monitor

won't display the 10-bit 4:2:2 signal, it's possible that it's only capable of receiving and displaying the 8-bit 4:2:0 signal, so try switching the output in the VIDEO OUT/LCD/VF>HDMI OUT>OUT FORMAT menu option.

Second, note that some monitors don't support HDMI 2.0, some support only HDMI 1.4. HDMI 1.4 is an earlier standard that supports up to UHD 2160p at 29.97 frames per second, but does not support 2160/59.94p or 2160/50.00p. If your monitor is an HDMI 1.4 monitor, but you're shooting in 2160/50.00 or 59.94, you may have to change your HDMI output down to 1080p in order to get an image on your monitor.

If you verify that your monitor is indeed capable of receiving the 18 Gbps 10-bit 4:2:2 signal, but it still isn't working, then you may be using an inappropriately-rated HDMI cable. Look for a cable that is specifically rated for 18 Gbps, or perhaps is labeled "Ultra High Speed".

Why can't I choose a faster variable frame rate?

The choice of variable frame rates will be limited by the recording codec you choose. For example, the 2160-29.97p/422 ALL-I 400M codec can handle a maximum of 30 frames per second. If you enable variable frame rates and try to select a speed faster than 30, you'll find that it just can't; it supports from 1 to 30 frames per second. You'd have to choose a codec that supports up to 60 frames per second in order to unlock variable frame rates higher than 30 (up to 60); an example in this case would be the 2160-59.94p/HEVC LongGOP 200M codec.

Why can't I choose a UHD Rec Format, or configure for streaming?

Sometimes menu items are disabled because other menu items have been activated. In this case, if you chose a menu option that requires the camera to be operating in 1080, then you won't have any UHD options available. Two examples would be if you set the FILE FORMAT to AVCHD, or if you have enabled streaming video using the NETWORK FUNC options of STREAMING or NDI|HX. In order to support streaming, the camera must be in HD recording, and will disable UHD options. You'd have to disable the network function for it to unlock the UHD choices again. The relationship between menu items can be complex; for example, enabling SUPER SLOW recording will disable the option of choosing a NETWORK FUNC. Streaming can't happen at 100 or 120 frames per second, so you'd have to disable SUPER SLOW in order to enable the network features.

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Articles

Some of the articles in this section are going to be really basic, and some will be more advanced. It's impossible to know the experience level of the reader, so I've taken the tactic of explaining things from the beginning. Even if you're an experienced shooter, you may find some nuggets of knowledge in these pages.

How To Set Up Live YouTube Streaming

One of the exciting new capabilities in the CX350 is support for live video streaming, using either a hardwired Ethernet connection, or using the optional AJ-WM50 wi-fi adapter which lets you connect the camera to a wi-fi network for streaming.

To configure the camera for live streaming, you first have to connect to a network. That network can be an in-house Local Area Network (LAN), it can be a peer-to-peer network (connecting the camera directly to a computer), or it can be a wi-fi or Ethernet cable connection to a router that gives you access to the Internet for worldwide streaming capability. There are many streaming service providers, such as YouTube or FaceBook Live, that let users connect to their service and stream live video. In this article I am going to show you the easiest way to use the CX350 to stream to YouTube Live; if you're using a different streaming service, the principles should be the same, you'll just have to check with your streaming service (such as FaceBook Live) on how to log in and get the appropriate video URL and Streaming Key.

For purposes of this article, we're going to assume that you have a YouTube account, that your YouTube account is approved for streaming, and that you have internet service at your home or business where you want to stream video from.

The first thing you need to do is set the camera to a suitable format for streaming. The CX350 doesn't support streaming UHD, so let's choose an HD format:

1. go to SYSTEM>FILE FORMAT and choose MOV
2. go to SYSTEM>REC FORMAT and choose a 1080p format; for this example we'll choose 1080-29.97p/422LongGop50M.

The next thing you need to do is connect the camera to the internet. Perhaps the easiest way to do that is to plug in an Ethernet cable from the camera to your wi-fi router. Then, configure the camera to connect to the network; go into the camera menus and:

1. set NETWORK>DEVICE SEL to LAN
2. set NETWORK>NETWORK FUNC to STREAMING
3. set IP REMOTE to DISABLE
4. set LAN PROPERTY>IPV4 SETTING>DHCP to CLIENT

Or, alternately, you can connect wirelessly via wi-fi if you have the optional AJ-WM50 wireless adapter installed in your camera. If you do, the steps you'd take to configure your camera are:

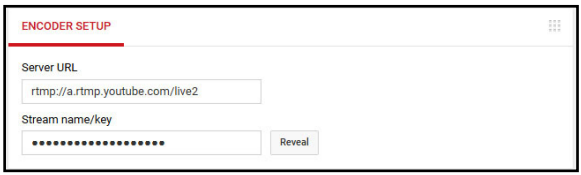
1. set NETWORK>DEVICE SEL to WLAN
2. set NETWORK>NETWORK FUNC to STREAMING
3. set IP REMOTE to DISABLE
4. set WLAN PROPERTY>TYPE to INFRA(SELECT)
5. use WLAN PROPERTY>SSID to select your wi-fi router network
6. use WLAN PROPERTY>ENCRYPT KEY to enter the wi-fi password
7. set WLAN PROPERTY>IPV4 SETTING>DHCP to CLIENT

At this point the camera should negotiate with the router and establish an internet connection. If you're using the Ethernet cable, you'll see the "network connection" icon in the upper right of the LCD turn WHITE when the connection is established. If you're using the wi-fi adapter, you'll see the "broadcast" icon in the upper right of the LCD turn WHITE when the connection is established.

You should use the STREAMING>STREAMING FORMAT menu to choose the video quality and bandwidth you want to transmit. The more detail you choose to send, the more bandwidth it will take up. If you have a very high speed, rock solid internet connection, you should feel free to choose a 1080p frame size, and the higher the Megabits you choose, the higher quality your video will be (in our 1080/29.97p example, the highest streaming video quality we can choose is 1920x1080-30fps 14M). But if your internet connection isn't so robust (maybe you're connecting via wi-fi to a coffee shop or a budget motel's substandard wi-fi), you might need to choose a smaller frame size and smaller Megabit bandwidth in order to get a good consistent video stream.

Next, let's establish that you want the camera to control streaming. Set STREAMING>START TRIGGER to CAMERA.

The last step is to tell the camera what internet address to stream the video to. Here you have to go to your streaming platform provider (such as YouTube) and look for the streaming setup options. You should find a URL, or perhaps a Server URL and Stream Key. In YouTube, it will look something like this:

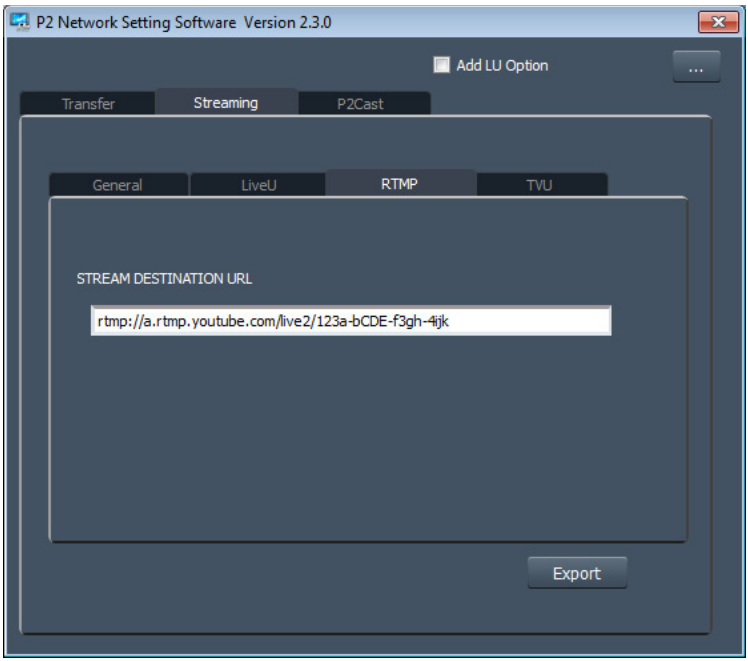


When you press the REVEAL button to reveal the Stream name/key, you'll see that it's a long sequence of numbers and letters, something like "123a-bCDE-f3gh-4ijk". So what you have to do is combine the Server URL and the Stream name/key together, resulting in something like this from our example:

rtmp://a.rtmp.youtube.com/live2/123a-bCDE-f3gh-4ijk

When combined together, that becomes the URL that you need to enter into the camera at STREAMING>RECEIVER URL. Be extremely careful to enter the URL exactly, and uppercase/lowercase is very important too. Even one tiny mistake will mean you won't be able to connect. Also, note that there needs to be a "/" between the Server URL and the stream key; some providers (such as Facebook) automatically include the trailing "/", and some (like YouTube) don't.

Typing in the URL/Stream Key combination can be difficult; fortunately there's an easier way. You can copy and paste your URL and Stream Key on a Windows computer using the P2 NETWORK SETTING SOFTWARE, available as a free download on Panasonic's website. Go to the STREAMING tab, and choose RTMP. Then copy the URL from YouTube and paste it into the STREAM DESTINATION URL in the P2 Network Setting Software (and manually add a "/" if the URL doesn't already end with a slash). Then copy the Stream key URL from YouTube and paste it at the end of the URL/ in the STREAM DESTINATION URL. The result should look something like the following image.



Once you've got the URL and Stream Key ready, go to the camera and format an SD card, and then put the SD card in your computer and choose the P2 Network Setting Software's "EXPORT" button. The camera will write a file (named something like "P2STREAM.CNF") onto the SD card into the PRIVATE/MEIGROUP/PAVCN/SBG/P2SD directory. Put that SD card into slot 1 in the camera, and then choose NETWORK>STREAMING>LOAD (SD CARD). The camera will automatically load the proper URL from the card.

Once you've entered the URL, it's time to start streaming! Just go to STREAMING>START and set it to ON, and the camera will connect to your streaming server and start streaming video to it!

Understanding Exposure

Perhaps the primary ingredient in getting good-looking video is to get a proper exposure. In this section we're going to cover the ins and outs of the exposure system and talk about all the various ways that you can control the exposure in the camera, as well as attempt to define what qualifies as a "good exposure" and how you know when you've got it!

To understand exposure, we have to really narrow it down to a couple of very key concepts – we're talking about how much light falls onto the

camera's sensor, and for how long. Both elements (the amount of light, and the duration) when taken together, result in the total quantity of light hitting the camera's chip. The art of getting a proper exposure is to control that amount of light so that you don't get too much, and you don't starve the camera either, you need to get the amount of light "just right" and, when you do, the camera can work magic.

If you starve the camera of light, the results will be unpleasant. You'll get a noisy, grainy, muddy, flat, ugly mess of a picture. How do you avoid that and get beautiful results? Feed the camera enough light.

If you give it too much light, the results will also be unpleasant. You'll have harsh, blown-out, ugly images. How do you avoid that and get beautiful results? Again, the key is to control the light and make sure that the right amount gets through – not too much, and certainly not too little.

There are three primary ways we as shooters control the amount of light entering the camera. The first, and most important, is the lens aperture (or "iris"). The aperture is a variable-sized hole in the lens, which the light flows through. The bigger the hole, the more light gets let in. The smaller the hole, the less light gets through. The size of the aperture is known as its f-stop; the smaller the number (such as f/2.8) the bigger the hole and the more light comes through it; the larger the number (such as f/11) the smaller the hole and the more light it stops from coming through.

The second way we control the amount of light is through the shutter speed. The shutter speed controls the amount of time that light is allowed to enter the lens; the longer the time, the more light gets through, and the shorter the time, the less light gets through. However, while the shutter is capable of helping us control the flow of light, it's not really something you want to be using for that purpose, because the shutter speed also affects the way motion is captured. Typically a video shooter will use the iris/aperture to control the amount of light, and they'll leave the shutter speed alone (unless the shooter has a very specific need and a thorough understanding of what the side effects of changing the shutter speed will be!)

The third way of controlling the amount of light is through Neutral Density (ND) filters. ND filters are like "sunglasses" for your camera. They darken the incoming light, with no side effects (no color shifts, no polarization, etc). ND filters are used in bright conditions (sunny day exteriors) and are usually not necessary in darker or indoor conditions. The CX350 has

three built-in ND filters, allowing the user to select from various levels of light-cutting capability. You can also get additional external ND filters that attach to the front of the lens (by screwing into the lens threads) or in an external filter holder (such as a matte box).

Automatic or Manual Exposure?

Now that you know the basics of how to control the amount of light entering the camera, the next major question is: how much is enough? What's the right amount, and how do you know?

There are primarily two ways to judge, either automatically or manually. The camera has the ability to automatically control the iris, and it will judge how much light is necessary and open up or close down the iris to the appropriate size. Additionally, the camera can optionally automatically control the shutter speed or the electronic gain; more on those later.

Automatic exposure can work well in some circumstances, and it's certainly handy to be able to turn over the task of exposure to the camera so that it frees you up to concentrate on other things, but rarely does the best video come from automatic exposure. Professionals frequently (if not exclusively) rely on manual exposure control, for many reasons. Manual exposure control lets you decide what's the most important element in the scene to expose for, and it keeps the exposure from changing in the middle of a shot (something that can happen during auto-exposure).

Manual exposure is the professional way to control the camera's exposure system. The camera gives you complete control over shutter speed, iris setting, gain/ISO, and ND filtration.

How do you know how much exposure you're getting?

The key to getting proper manual exposure is to know how much light the sensor is receiving, and to know if it's too little, too much, or just right. And the way you know this is by using a wide variety of monitoring tools, including:

1. the viewfinder or LCD monitor
2. the Zebras
3. the Y Get function
4. the Waveform monitor
5. an external monitor
7. relying on the auto-exposure system to tell you

Learning how these monitoring tools work will greatly improve the overall look and quality of the video your camera generates. Let's start with the LCD monitor.

Using the LCD Monitor to Judge Exposure

This is probably far and away the most common way that shooters, especially new shooters, use to judge exposure. It is also a terrible way to judge exposure! Seriously, it's a bad, bad idea to just look at the LCD and say "yep, hey, that looks good, let's shoot it." There are many reasons why, and I'll go into some of them, but please trust me when I say that you simply must not rely on just looking at the LCD, you have to learn how the other tools work and USE THEM.

Okay, so why is just looking at the LCD a bad idea? I mean, if it looks good there, it looks good, right? Well, no. Not necessarily. Because the LCD monitor isn't an absolute reference point, it's subjective, and it can be influenced by a lot of things, including the lighting conditions you're in (a dark room? or broad daylight?) And the LCD is quite reflective; if you're in a bright environment the reflections can make it look washed-out, which might adversely affect your opinion of what the exposure actually is.

A second reason judging exposure off the LCD is a terrible idea is, the backlight setting on the LCD can change the brightness in the LCD by a huge amount – yet it's not changing the brightness of the video at all! So if your LCD is representing the video as brighter than it really is, you could end up underexposing your video without even realizing it. And if the LCD is representing the video too dark, you might be tempted to overexpose the video just to get it to look brighter on the LCD — when in reality, you're destroying the recorded footage!

So, the moral of the story is: don't rely on how the image looks in the LCD to be the deciding factor on whether you've exposed the image properly. The LCD is a relative display, and how it looks is relative to how high you have the backlight set, it's relative to what angle you're viewing the LCD at, and it's relative to the prevailing lighting conditions (meaning, if you're in a very bright environment, the LCD is going to look too dark, and if you're in a dark environment, the LCD might end up looking too bright). So, for the sake of your footage, don't rely on just looking at the LCD, and instead learn how to use the more accurate professional monitoring tools built into your camera. And if you insist on using the LCD, at least set the LCD Backlight according to the color bars, to have a prayer of it being at least in the ballpark of accurate. See VIDEO OUT/LCD/VF>LCD for more info.

The LCD is handy, if not a precise gauge of exposure. But there are many highly accurate professional measuring tools included for exposure too.

The IRE Scale - How to Know How Bright "Bright" Is

When we talk about professional monitoring tools, we're going to be talking about devices and meters that tell us definitively, objectively, how bright the video signal is. And the scale that we use is the IRE scale (IRE being the Institute of Radio Engineers), and on that scale, video brightness is measured from 0 (pure black) to 109 (clipped white). So as we talk about video levels, just keep in mind that we're basically talking about percentages, with about 50 to 55 IRE representing a medium gray, and 0 to 5 being pretty much pitch black, and anything over about 100 being pure white. *(Note: these IRE numbers are very different for different gamma curves; we're using the general HD gamma as our point of reference here.)*

Zebras

The first monitoring tool we're going to talk about are the zebras. Zebras are an overlay on the video monitor that show up any time an element in your image is brighter than a predetermined level (and who determines that level? You do, using the VIDEO OUT/LCD/VF>EI ASSIST>ZEBRA DETECT menu settings). Zebras are great because they let you know instantly, at a glance, what areas of your video might be too bright. If you set your zebras on 105, then you'd only ever see zebras on areas that are dangerously near overexposure (with 109 IRE representing a totally overexposed signal, zebras at 105 would show any portions of the screen that were at 105, 106, 107, 108, or 109 IRE). If you set your zebras to 80, then a zebra pattern would show up on the screen for any areas that were brighter than about 80% of maximum (again, on the 0-109 scale). The great thing about zebras is that they remove the subjective guesswork entirely from the equation, and they plainly and clearly tell you when something is brighter than your predetermined threshold. As a general guideline, you never want to see 105+ zebras anywhere on your screen if you can avoid it (some things, like the sun or a light bulb in the shot, might be unavoidable, but you definitely want to avoid it in the sky or on white buildings, etc). Also, when shooting a fair Caucasian face, you don't really want to see any higher than about 70 IRE showing up on the face, so if you set your zebras at 70 IRE and you set exposure on a light-skinned face, you don't want to see zebras anywhere other than maybe a little bit on the very brightest areas (typically the forehead or nose). For darker skin colors you'll need to adjust, there is no hard and fast rule for other specific skin colors because they vary in shade so widely. And, again, remember that these IRE levels are general

guidelines for the HD gamma setting; the levels will be different for the FILM-REC or FILMLIKE or other gamma settings.

Y Get Spot Meter

The Y Get User Button enables a central Spot Meter, and this Spot Meter goes hand-in-hand with the zebras. Where the zebras will tell you what areas of the screen are exceeding a certain brightness threshold, the Spot Meter will tell you exactly what brightness is occurring at the center of your screen. Turn on the Spot Meter and a little box will show up in the center of the screen, and a numeric readout shows up at the bottom left of the screen, which will tell you basically the IRE value of what's being displayed in that central box. By using the Spot Meter and panning the camera around your scene, you can tell exactly how bright the brightest patch of skin is, or how dark the shadowed areas are, etc. The reason it's called a "Y Get" is because in video terms, brightness is usually called "Y" for shorthand (it's the 'Y' in YUV), so the Y Get spotmeter "gets" the Y value (brightness) of what's in the central box.

Waveform Monitor

The ultimate exposure guide for video is the WaveForm Monitor (WFM). This is like a million zebras and spot meters all combined, it's almost like a three-dimensional zebra. The waveform monitor tells you the brightness of your image not just in a 2-D scale like the zebras, but in the third dimension by showing relative brightness across the screen, and how many pixels in each column are at what brightness. Learn to read the waveform monitor and you'll be able to tell at a glance whether your image is properly exposed, underexposed, overexposed, clipping, and where any trouble spots are in the frame. CLICK HERE for a detailed introduction to the WFM.

Using an External Monitor

Whenever possible, using a proper external production monitor is a great idea to see what your actual video will look like. Unlike the on-camera LCD, a properly-calibrated external production-quality monitor is a great way to judge what your image will look like. However, you do have to factor in that camera technology is changing quickly, and the CX350 is capable of outputting a signal that your monitor may not be able to display properly (for example, you can configure the CX350 to output High Dynamic Range footage or Standard Dynamic Range; you'd want to ensure that your monitor is capable of receiving the proper signal to properly display the video that's being sent). If you're shooting HDR footage, but your monitor isn't capable of displaying HDR, then -- it may not be as much help to

you as you were hoping. But modern monitors frequently include a wide array of their own exposure tools, including False Color, zebras, waveform monitors, and other tools that may make it easier to get accurate spot-on exposure.

Asking Autoexposure for Help

Lastly, a way to monitor the exposure might be to ask the autoexposure system what it thinks the exposure should be. You can quickly pop into autoexposure mode by pressing the IRIS button on the handgrip or the one on the left side of the camera; when you do so the system will judge the exposure and set the iris, and then when you're satisfied with how the image looks you can press the IRIS button again to switch back to manual iris control. Autoexposure may not get it exactly right, but it's frequently pretty close. For example: a situation when you can use autoexposure to help you determine proper exposure could include a case of when you're shooting a wide shot of people, but you want the faces to be accurately exposed. In that scenario you might zoom all the way in on someone's face, press the IRIS button, and let it expose for the face. Then press the IRIS button again to lock the exposure, and you can zoom out, and compose your shot. Just be careful when you do so; you have to check to make sure that the rest of the shot is reasonably exposed (for example, you don't want the sky to be terribly blown out, so pop on the waveform monitor or the zebras to check the sky). If the sky is too bright, you have three choices at that point – either frame out the sky as much as you can, or stop down the iris (knowing that you'll be losing some exposure brightness off the faces too), or re-compose the shot by putting the sun at your back. With the sun at your back, the sky will be its darkest, and should be the easiest opportunity to control overexposure. Or, of course, you could always shine more light onto the faces, but that's not always an option. Another option might be to switch to a high dynamic range gamma such as HLG or maybe FILMLIKE3 or FILM-REC @ 600%; those gammas have extended highlight range that will help preserve more detail in the brighter portions of the image.

Learning how to control the exposure, and framing shots so that you've included only the portions you want (at the proper exposure levels) will cause the quality of your video to skyrocket. Automatic exposure is of course the easiest way to go, but it usually results in the worst quality video, because constantly-changing exposure looks pretty bad to a viewer. If you want great quality you have to do the work yourself, but you'll be rewarded with more professional-looking, more artistic, and better overall video. In

this article I've given you the basics, but now let's go into more detail on each of the exposure systems so you have a thorough understanding of how exposure works and what your camera can do.

Aperture or Iris

As said before, the aperture is the size of the hole that light flows through, and by controlling the size of that hole, you control the amount of light that gets through. The size of the aperture is measured in "f-stops."

F-stops are basically a way to describe the amount of light the iris STOPS from getting into the lens. In simple terms, f/1 would be admitting as much light as the lens is possibly capable of (think of it as "f/1" = "f divided by one"... "f" = the maximum amount of light, so "f" divided by 1 would still be "f"). F-stops are numbered according to the following sequence: f/1, f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, and f/11. Each additional f-stop cuts in half the amount of light admitted by the previous f-stop; f/1.4 admits half as much light as f/1 does, f/2 admits half as much light as f/1.4, and so on. F-stop numbers are based off of two base numbers, f/1.0 and f/1.4. Each new f/stop number is a double of the previous number:

1.0⇢ 1.4
2.0⇢ 2.8
4.0⇢ 5.6
8.0⇢ 11 (rounded down from 11.2)

So if you remember 1.0 and 1.4, you can calculate the rest of the sequence easily.

You can think of the f/stop notation as a diameter formula for the lens iris. Whatever "f" stands for, when expressed in the term of "f/2.0," would mean an iris size of "f" divided by 2, which would let in 1/4 as much light as an "f" divided by 1. Remember, if you want half the light, you'd use f/1.4, so f/2 actually lets in half of half, or a total of ¼. Think in terms of a square: if you cut the length of the sides of a square in half, the new square isn't half the area, it's actually 1/4 the size of the original: a 4" x 4" square has an area of 16 sq inches, but cut those sides in half and you get a 2" x 2" square, with an area of 4 square inches, which is 1/4 the area of the 16 square inches of the 4x4 square. So to get half as much area, you don't divide by two, you need to divide by 1.4 (the square root of 2). If you take the 4" side of the square and divide that by 1.4, you'd get a square of 2.83" x 2.83", which has an area of 8 square inches (2.83 x 2.83 = 8.0). And 8 sq. in. is 1/2 as much area as the original 4x4 square's 16 square inches. So to get half as much

light coming in, you need to divide by 1.4 (which is why the first f-stop after f/1 is f/1.4.)

Therefore, the numbers you divide "f" by are: 1, 1.4, 2, 2.8, 4, 5.6, 8, 11. Each successive number lets in half as much light as the previous number. So if you want to cut in half the amount of light coming into the lens, you'd "stop down" by one f/stop. (Note, the maximum opening on the CX350's lens is f/2.8 when the lens is zoomed all the way out to wide angle).

Shutter Speed

The shutter speed is another way to increase or decrease the amount of light entering the camera. Whereas the aperture is a hole that lets in a certain amount of light (and the bigger the hole, the more light that comes in), the shutter is more like a gate – the longer it's open, the more light gets in, and when the gate is "shut" the light stops coming in.

Because the shutter speed affects the amount of light coming in, you could use it to help control exposure. If you cut the shutter duration in half (i.e., use 1/120 instead of 1/60) then only half as much light will reach the sensor. To compensate, you will need to add twice as much light to get the same level of exposure (or, open up the aperture by one f-stop). If you double the shutter duration (i.e., 1/24 instead of 1/48) then twice as much light will get through to the camera's chip, and your image will be twice as bright. You'd need only half as much light at 1/24 for the same exposure as you would need at 1/48.

However, video shooters generally don't use the shutter speed to control exposure except in rare circumstances, because there's a noticeable side effect to changing the shutter speed: it affects the motion blur of your shot. Photographers use the shutter speed all the time to control exposure, but in video it's not used nearly as frequently, because changing the shutter speed will affect the motion blur of anything moving in your shot (and, because you're shooting video and not stills, that means it'll pretty much affect everything!)

Generally, when shooting video-style footage, you will turn the electronic shutter off, which results in the most light hitting the sensor and results in a shutter speed that's basically the same as the system frequency (i.e., about 1/50 shutter in 50.00i or 50.00p, and 1/60 in 59.94i or 59.94p). When shooting film-style footage, you can use the SYNCHRO SCAN function to choose a 180.0 degree setting, which results in a shutter speed that's half the duration of your frame rate (so, about 1/48 for 23.98p, 1/50 for 25.00p, and 1/60 for 29.97p). Small variations in shutter speed won't affect the look of your video much (i.e., 1/60 will pretty much look the same as 1/50 or 1/48). Film cameras use anywhere from 1/43 to 1/60 as a standard,

and it all pretty much looks like film motion, so small variations won't normally matter. However, there is one place where it matters very much: when you're shooting under fluorescent or HMI or stadium lights or other ballasted light sources! I'll explain why, but before I do, let me just say this loudly and clearly: if you're shooting under fluorescent lights or HMI lights (with a magnetic ballast) or sodium-vapor or mercury vapor lights (such as streetlights or stadium lights), or LED lights on a dimmer, you have to be extremely careful with the shutter speed. In territories that use 60Hz power, put the shutter speed on 1/60th and do not change it without a very, very good reason. (and yes, that does include when shooting 24p!) In territories that use 50Hz power, put the shutter speed on 1/50th and do not change it without a very good reason. Changing the shutter speed when shooting under magnetic/ballasted light sources may cause a noticeable and annoying artifact in your video footage, where you see orange or black bands or scrolling waves cycling through your image.

You can usually totally avoid this artifact by simply leaving the shutter speed at 1/60th (in 59.94Hz territories) or 1/50th (in 50Hz territories). If you're using high-frequency electronic ballasts (such as Kino Flo™ fluorescent lights or electronic flicker-free HMI lights) then you'll probably have more flexibility with the shutter speed, but even so, you'd only ever want to change the shutter speed for specific looks.

Here are examples of the type of circumstances where you'd want to use alternate shutter speeds:

1. For a stuttery/choppy action sequence (such as the "Saving Private Ryan" or "Gladiator" effect): try a fast shutter speed such as 1/250 or 1/500 (of course, be cautious when trying this under fluorescent lights as mentioned above).

2. Overcranking for slow motion: if you're shooting variable frame rates for slow motion, you should probably change the shutter speed. Try 1/120 for 60 fps or 1/100 for 50p. A film camera running at 60 frames per second would have a shutter speed of about 1/120, so if you're shooting 60fps for slow motion, you would normally want to match the shutter speed for film-style motion blur. This camera makes this easy when shooting different frame rates; you can set the shutter to the SYNCHRO SCAN setting of 180.0 degrees and it will automatically compensate the shutter speed to correspond to 1/2 the duration of the frame rate.

3. Sync'ing with monitors: you may have to modify the precise shutter speed (or use 1/60 in NTSC countries or 1/50 in PAL countries), to match the camera's refresh rate with computer monitors or televisions in the shot to stop the "rolling dark band" syndrome.

4. Special blur effects: the opposite of the "Saving Private Ryan" effect. Use a slower shutter speed (like 1/24 or slower) to add smear and blur to the motion in your shot. Shutters as slow as 1 second (1 fps with 357-degree shutter) can make for excellent smearing of taillights in a long-exposure freeway shot, for example.

5. Minimize strobing: If you think there's too much strobing in your 24P/25P footage, you can try a slower shutter speed to introduce a little blur into your footage. 1/43 or 1/36 are popular choices, but again, watch out for fluorescent or HMI or vapor lights.

6. Extreme low light situations: when in 24P mode, using 1/36 instead of 1/50 will gain you half a stop of low-light performance, and still look reasonably like film. Using 1/24 will gain you a whole stop of light performance, but with smearier motion. The camera is capable of going all the way down to 1 full second for exposure, which gives incredible sensitivity, but it also results in an effective frame rate of only one frame per second.

7. If you're shooting in a different territory, such as when shooting 59.94Hz footage under 50hz lights, or 50Hz under 60hz lights, you may have to adjust the shutter speed to avoid flicker or pulsing. Set it to match the frequency of the power system where you're at, to have the best chance at minimizing any conflict with the lighting; you might have to choose 1/100 for a 59.94Hz camera in PAL territories, for example.

8. Freezing water droplets or rain: for specific instances like shooting a food commercial where someone pours champagne or squeezes a lemon and you want to show the individual droplets clearly, you might try using a very short shutter speed (like 1/2000). Typically these shots are done using strobe lights, but strobe lights generally won't work with the CX350 (see the Partial Exposure section of the article on ROLLING SHUTTER MOS SENSORS to see why). Although you probably can't use strobes with an MOS rolling-shutter camera, you may be able to get a satisfactory facsimile of the effect by using a super-fast shutter speed, as long as you aren't trying to do so under magnetic fluo/HMI lighting; you'll need high-frequency electronic ballasts to pull that off.

Be aware that when using a shutter speed slower than your frame rate, the net result will be dropping frames. You cannot have a shutter speed slower

than your frame rate; trying to use 1/30th shutter in 59.94p mode will result in duplicated frames, in essence dropping your frame rate to 29.97p.

Also, when using a slower shutter speed, definitely use a tripod!

Gain

Gain is an electronic amplification of the video signal. In other words, it artificially makes the picture brighter. While brightness sounds good, you have to understand that the penalty for making it brighter is that the picture gets "noisier." Electronic noise is a byproduct of electronic gain, and the more gain you apply, the brighter your picture will get, and the noisier your picture will get. The camera can employ sophisticated noise reduction that can help compensate, but the tradeoff is that it may result in losing some of the fine detail in the picture and the colors may become flatter, softer, and more "washed out". Generally the best images come when using as little gain as possible.

Gain is measured in decibels, or dB. Zero dB means that no gain is applied, the picture is unmodified and no brightness or noise is added. Every 6 dB of gain amounts to doubling the brightness of the picture, so 6 dB of gain would make the picture twice as bright, or the equivalent of 1 f-stop brighter. 12 dB of gain would be twice as bright again (or four times as bright as zero gain), and 18db is twice as bright as that (for an image that appears to be eight times as bright as zero gain).

Another thing to understand about Gain is that it can only amplify the signal that the camera is currently seeing; it cannot add detail that can't be currently seen. If you're shooting under low light conditions and need to employ gain to get the picture bright enough, you should understand that your video is in all likelihood underexposed, and using gain will artificially brighten up the picture, but it will not restore detail that wasn't properly captured due to the underexposure. Gain is usually used as a "last resort" – when shooting under dim conditions you should take other measures to increase the brightness of the scene first, including removing all neutral density filters, opening up the iris to its maximum opening, perhaps using a slower shutter speed, and adding light whenever possible.

The camera has two shooting modes, NORMAL and HIGH SENS. When using HIGH SENS, the video becomes twice as bright as NORMAL (the same as it would if you employed 6dB of gain), but the HIGH SENS mode employs some noise reduction to reduce the impact of the gain.

Understanding White Balance

Yet another element to understand in videography is the concept of White Balance. In the simplest explanation, light is not all the same color. Even though it may look the same to the human eye, the camera sees a particular light for what it is: reddish, greenish, blueish, etc. Daylight does not give off the same color as an incandescent light bulb, for example. Our eyes may automatically compensate, but the camera doesn't, and it needs to be told what "white" should be – which is why we have the White Balance function. Executing a proper White Balance will help the camera to record colors more accurately.

Light color is measured in degrees Kelvin, in accordance with what color a hunk of platinum will glow when heated to certain temperatures. When heated to about 3200 degrees Kelvin (or 3200K), the platinum will glow an orangish-red color (which is pretty much how traditional household lamps work: they're small filaments of metal that are heated until they glow that orangish-red color). If the metal is heated more, the color will shift towards the blues, and at 5600K the metal will glow blue-white. These temperatures, and their corresponding colors, are referred to as "color temperature." In general there are two color temperatures you need to be aware of: 3200K and 5600K. Daylight is typically said to be around 5600K, and tungsten (or most artificial) lights burn at around 2900K to 3200K.

Proper white balance is vital to accurately record the colors in a scene. To white-balance the camera, first decide if you want to use one of the existing presets or if you want to use a manual white balance. The presets are selected by setting the WHITE BAL switch to PRST, and then you can press the AWB button repeatedly to cycle through the three presets. These presets generally correspond to indoor lighting (3200 Kelvin) and outdoors/daylight (5600 Kelvin); the third preset is a variable number that you can modify. While the presets are perhaps an okay starting point, there are many circumstances where a preset will not deliver the most accurate color rendition. For example, many incandescent and halogen lamps burn at color temperatures different from 3200 Kelvin; some may burn as low as 2700 K. If you're using 2700 K lamps to light your scene, and you have the white balance set to 3200K, your white walls will not look white, they'll look orange-ish. Also, daylight varies tremendously in color temperature, from around 3000 K during sunrise/sunset to over 10,000 K on an overcast, cloudy day. So the presets may be useful for on-the-run shooting, but if you have the time to take a manual white balance you can get more accurate color rendition and it is usually well worth the effort.

To set a manual white balance, first set the white balance switch to either A or B. Next, you'll need a white card (or other white object – a sheet of paper, a T-shirt, whatever you have, although the purer the white the more accurate results you'll get; I highly recommend getting a DSC Labs CamWhite card.) Place that white card/object into the light where you intend to be shooting. Don't just hold it up in front of the camera! You have to move the white card into the light that's hitting your desired subject. Ideally you'd have your subject hold a white card up in front of their face; you need to make sure that the light that your subject is lit by, is the same light that's lighting up the white card. Frame up that white card until it fills the screen (or as close as you can get). Set the exposure so that the white card is hitting about 70% on your zebras, Waveform monitor or Y Get spotmeter. Now you're ready to take a white balance. Press the AWB button; the camera will let you know when the white balance has been properly set. Any time your lighting conditions change, you'll need to re-white balance if you want your colors to continue to be rendered accurately.

Another white balance option is to use Automatic Tracking White (ATW). In this mode, the camera will automatically attempt to continually monitor and change the white balance to what it thinks is correct. To enter ATW mode, you can assign ATW to one of the positions on the White Balance Switch using the CAMERA>SW MODE>ATW menu option, and then move the White Balance Switch to that same position, and the camera will then automatically start tracking white balance by itself, updating as lighting conditions change. Or, you can assign ATW to one of the User Buttons and press that User Button to start the camera automatically tracking the white balance.

ATW is an automatic function, along the same lines as autofocus and auto-exposure. For professional shooting situations you may not want to use ATW very often, but for run 'n' gun type situations it may come in handy.

Black Balance

The camera also offers the ability to perform a Black Balance. It's really simple, and I recommend you get in the habit of doing it frequently. The black balance procedure is simpler than the white balance, because black (unlike white) isn't relative. Black is the absence of all light, so it doesn't really matter what the prevailing lighting conditions are. The camera will automatically shut its iris to prevent any light from hitting the sensor during a black balance procedure. All you have to do to black balance the camera is hold the AWB button in for a few seconds, and then the camera will shut its iris and then analyze the signal coming off its sensor, and it

then compensates for any noise issues or other situations which cause the sensor to be delivering anything other than a pure black signal. I recommend black balancing frequently.

Focusing

Getting precise focus is not so easy in Ultra-High Definition (2160p); certainly not as easy as it was in standard-def! In this section we'll explore focusing and explain the techniques you need to use to get razor-sharp focus.

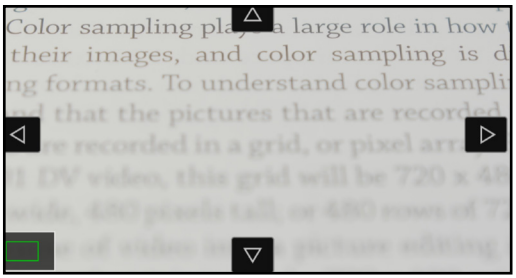
First, understand that proper focus is absolutely critical in UHD. UHD video means a frame that has four times as many pixels as a high-def video frame, and as much as 24x as many pixels as a standard-def frame. Standard-def's low resolution could mask small focus errors; ultra high-def's sharpness will point out focus errors blatantly, each and every time. You have to get your focus right.

Second, it's important to acknowledge another fact: it's impossible to judge focus properly using only the on-camera LCD. The very best you can do is get in the ballpark; it's mathematically impossible to judge focus of an 8-million-pixel UHD image on a 1.4-million-pixel display device like the CX350's LCD. No small display is going to be adequate, by itself, to show you true proper focus; it's just not possible. You simply must rely on some focusing aids.

Setting focus involves finding the exact spot where the focus is pinpoint-sharp on your subject. Usually you do this by adjusting the focus ring until the subject looks as sharp as possible, and then adjusting the ring too far until it actually starts to go out of focus; then you pull back until it comes back into focus and keep adjusting until it goes out of focus again, and keep refining this process and splitting the difference until you get the absolute sharpest image. Obviously this technique relies on being able to actually see the image sharply! And with the LCD not having nearly enough pixels to render the image sharply, you can't truly count on this technique alone.

Fortunately, there are several focus assist methods available to assure you're getting the best focus possible. Use them all: you're going to find they all are helpful.

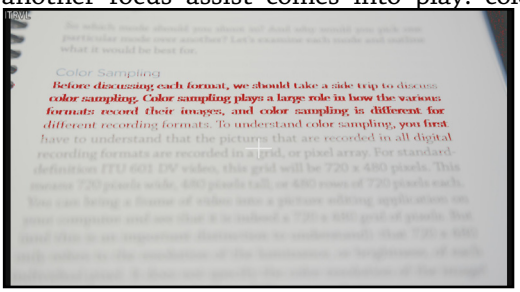
First, there's the EXPANDed focus assist, which magnifies the center extraction from the frame. This magnified focus assist is a wonderful option and indispensable for achieving sharp critical focus. It shows



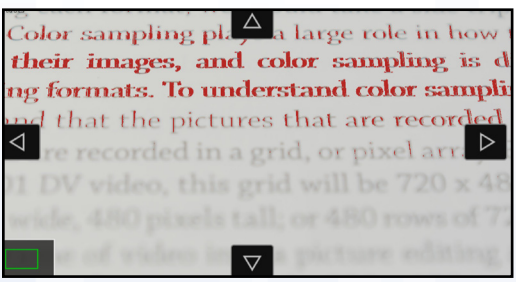
EXPAND focus assist at 2x magnification

you much more detail than the full frame view does, and shows you exact precise focus on an HD image (although even at its maximum magnification of 4x it's not sharp enough by itself to show you pinpoint focus on a UHD image).

The EXPAND focus assist is useful for setting focus on your subject, but won't show you the full frame when actually recording. That's where another focus assist comes into play: colored PEAKING. This option draws an outline around objects that are in sharp focus, in the color of your choosing (in this example, it's using red peaking). The colored peaking is a great option that works even while recording. Generally I highly recommend using both the EXPAND and the PEAKING together. It gives you the most detailed, easily-focusable focusing aid when lining up your shot, and on the CX350 both focus assist tools work even during recording. And if you want the best UHD focus possible, it's vital to combine PEAKING with EXPAND; the PEAKING will highlight areas when they come into sharp focus even if the details are too fine for even the EXPANDed focus assist to render sharply. You'll get the best focus on the CX350 when combing EXPAND with PEAKING.



PEAKING focus assist, in red



EXPAND and PEAKING focus assists simultaneously

When using the EXPAND FOCUS ASSIST, you can set the level of magnification in the menus, and you can move the magnified box around the frame to check or set focus on different sections of the video frame. You can move it by either using the arrow buttons on the touchscreen, or by using the PLAY/STOP/FF/RW buttons under the LCD, or rotating the multidial.

The caveat with the PEAKING focus system is that it only functions when it sees suitable contrast in the scene, and doesn't work on low-contrast scenes. In bright light it's usually very easy to see, but in darker scenes on flatter subjects, it may be a struggle to see the colored PEAKING at all. You can make it bolder and more visible by adjusting the VIDEO OUT/LCD/VF>FOCUS ASSIST>PEAKING LEVEL menu option, but that may just make the system more generous in assessing what it believes is actually in focus; taken too far, it might report that items are in focus when in fact they might be slightly out. So the colored PEAKING focus assist is a great tool, and I highly recommend its use; just be aware that there are some limitations with the system.

A very common technique on conventional video cameras is to zoom all the way in to your subject before setting focus. Not only does this magnify the image so you can more clearly see what's in sharp focus and what isn't, but it also narrows the depth of field, meaning that the area that is in focus is smaller. And narrowing the depth of field is a vital technique for getting proper focus -- the narrower the depth of field, the more critical the focus is, and the more precisely you can nail the focus. Zoom as far in as possible, and open the iris as wide as possible, and that will result in the absolute narrowest depth of field. Use the EXPAND and PEAKING focus assists to set perfect focus. Then, as you zoom back out, and as you stop the iris back down to proper exposure levels, you can be assured that the depth of field is widening, and your subject is getting more and more in focus.

Finally, another focus assist tool you may want to consider is auto focus; you can invoke a quick autofocus operation by pressing the PUSH AUTO button on the left side of the camera, under the focus switch. When you press that button, the camera will attempt to quickly lock into focus; as soon as it does, the camera automatically returns to manual focus. If you have no other way of double-checking your focus, temporary auto focus is better than nothing, but it certainly shouldn't be your primary focus assist tool.

SDHC and SDXC Card Best Practices

Recording video on an SD card will be new to many users, so it seemed like a good idea to put together a "Best Practices" guide to help new users avoid common mistakes.

1. Always format the memory card in the camera.

This is a vital first step. Even though the memory card may come pre-formatted when you buy it, it's still necessary to format it in the camera.

Reports of glitches in the footage seem to be greatly reduced when cards are formatted in the camera instead of by a computer. Never format the card in a computer using your operating system's "format" command.

Note also -- you have to format the cards in THIS camera. Format them in the CX350, not in any other camera or device. Other cameras, especially from other manufacturers, may format the card differently, or they may create different folder or directory structures on the card. The CX350 formats the card in such a way as to be compatible with all the recording modes the CX350 offers. In short, the only way to format memory cards is in the CX350.

2. Never pull the card out when it's being accessed.
This is a big one; if a card is being written to, or read from, and you eject that card, it has the potential to not only ruin the current clip, but perhaps to glitch the entire card! Always make sure a card is not being accessed before you pull it out of any device. This is one reason for the presence of the card door – closing that door will remind you to double-check that recording has stopped. However, do be aware that the camera has hot-swap capability; you can leave the door open and eject a memory card that's not currently being accessed. This gives you the ability to perform an endless RELAY REC, where you can continually swap in new cards and record perpetually. The danger in this scenario is, of course, ejecting the card that's being currently written to. Always double-check yourself and look for the access lights to make sure you only eject that dormant card, and never the card that's currently being written to.

And when removing a card from a computer, be sure to eject the card through your desktop (on Mac, "Eject" or drag its icon to the trash, on Windows, use the green-arrow "Safely Remove Hardware" utility.)

3. Carry the cards in some sort of protective case.
SDXC and SDHC cards should be carried in a protective plastic case, or in a dedicated card holder. You really don't want to have cards roaming around loose in your pockets or at the bottom of your camera bag, where they can be crushed, be subjected to static electricity, be spilled on, or forgotten in your clothes and subsequently washed! Always put a card in a case when you're not using it.

4. Write-protect the cards the instant they come out of the camera.
This has been a backbone of my tapeless workflow for years – the instant the card comes out of the camera, write-protect it. This does several things for you:

A. It prevents your valuable footage from being overwritten.
B. It alerts you that this particular card hasn't been offloaded to a computer yet.
C. It prevents you from getting that card mixed up and formatting it(!)

My standard workflow is to write-protect the card, and leave it write-protected until I've successfully offloaded the footage onto a computer (at least once, and maybe to two separate drives). Once I know the footage is safe, the write-protection tab gets moved to the "unprotect" position. Things can get confusing quickly in a production environment, but with this procedure I always know that my footage is safe from being lost or overwritten. Get in the habit of immediately write-protecting your cards and you'll save yourself from some grief.

5. Use the very best cards you can afford.
This one almost goes without saying, but – I'm going to say it. There are cheap cards out there, and some of them are junk, and some of them are even counterfeit! Not all SDHC/SDXC cards are the same! Some employ technologies for protecting your footage from write errors, from power failures, from wearing out — and the cheaper ones don't. If you're buying no-name cards from third-world countries off internet auction sites, don't be surprised if they don't perform as well as a top-of-the-line card. In fact, don't be surprised if it's a fake/counterfeit/knockoff! There are plenty of examples on the internet of people who received fake cards; unscrupulous sellers have printed their own labels and stuck them over low-quality cards to deceive unwary buyers into thinking they've received a higher-quality, more-expensive card than they actually have.

It's not a matter of footage quality, it's a matter of data integrity. If a card works, it'll record the footage the same as any other card will. But a cheap card might not have as much reliability, it might have "bad sectors" or it might fail unexpectedly. While anything's possible, it's reasonable and practical to expect that a better-quality card will perform more reliably, and in my experience that has held to be the case. They say "you get what you pay for," and going with super-cheap cards may bring nasty surprises when it comes to reliability. Always get the best media you possibly can. And always buy your memory cards from the manufacturer's authorized resellers. You might pay an extra $10 per card, but if it helps you avoid a reshoot, it's extremely cheap insurance!

As to what cards are supported: the minimum requirements are shown in the owner's manual / Operating Instructions. Panasonic produces three cards that are compatible with the CX350: a 64GB V90 SDXC, a 128GB V90 SDXC, and MicroP2 cards. You're not limited to only using Panasonic

cards, but you are guaranteed that these particular cards are going to work properly in the CX350. The V90 cards are actually a grade higher than what the CX350 requires (V60). As for MicroP2 cards, Series A cards can be used just like a V30 card, and Series B cards can record any footage that the CX350 can create.

6. Always use SDXC cards instead of SDHC, whenever possible.
SDHC cards can be used to record AVCHD footage, but that's the only footage they can be used for. In order to record the higher-quality MOV formats, the camera requires an SDXC card. SDXC cards can also be used to record AVCHD, so in general the SDXC card is always the preferred recording medium. Of course you don't need SDXC cards to save setup files or scene files, but they can be used for that purpose too.

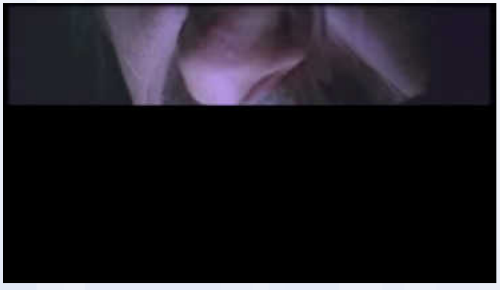
Rolling Shutter MOS Sensors

The CX350 uses an MOS sensor, and like virtually all MOS and CMOS camcorders on the market, it uses what is known as a "rolling shutter." This is a subject you should be aware of, because rolling-shutter chips perform differently in several ways from the CCD chips of older video cameras.

First, what is meant by "rolling shutter"? It's a difference in the way the camera exposes. On a CCD camera (or on a camera with a global shutter), the entire chip is exposed top to bottom, all at once. Across the entire frame, it goes from black to fully exposed, simultaneously. Click the video to the left for an example.

Video simulation of global shutter

A rolling shutter exposes progressively from top to bottom. Simplified, a rolling shutter camera will expose the very top line first, and then the next line, and then the next line, and on and on, until the entire frame has been exposed.



Video simulation of rolling shutter

This differs significantly from the "global" approach of the CCD, and it can result in some image artifacts or differences in the way the camera renders images, that you need to be aware of.

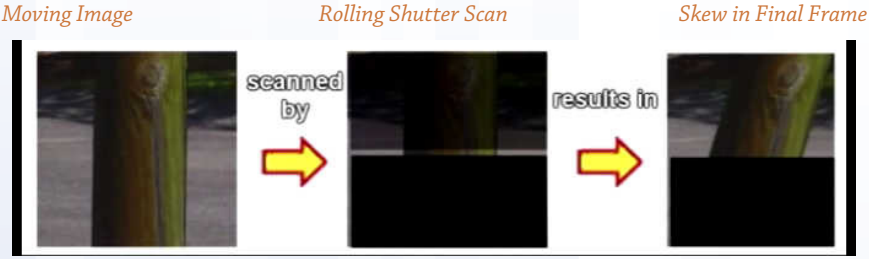
For purposes of this discussion, we're going to talk about three main image artifacts: Skew, Wobble, and Partial Exposure.

Skew

Perhaps the best-known and most-talked-about rolling shutter artifact is known as "skew." This refers to the tendency of objects to lean or tilt (or, well, "skew") when the camera pans past them. Take a rolling shutter camera, with a long telephoto lens, point it at a picket fence, and rapidly pan it back and forth, and you'll see that the vertical lines start leaning depending on which way the camera is panning, and as you reverse direction they actually start to look "rubbery."

It's pretty easy to understand why this happens – again, in the prior section, we talked about how the rolling shutter works, and how it "rolls" through the frame. Well, think about panning past a tree: when you start the pan, and the first line is starting to be exposed, the tree might be on the left side of the frame.

As you continue to pan, the tree is moving across the frame, but the shutter is still rolling down the screen – so as it exposes each new line, the tree has moved some. As the camera frame moves across the tree, the tree may be in a different position as each line is exposed as the shutter rolls down the frame. The resulting frame is a diagonally skewed image.



Click the video above for a simulation of a rolling shutter

Frankly, that's going to happen on any image that you pan quickly past, not just vertical poles or trees or fence posts. It will happen with buildings or flagpoles or cars or signs or... well, anything, really, because that's how a rolling shutter works. And it's not just limited to panning the camera, it

happens with any image motion across the sensor, whether you're moving the camera, or the image is moving relative to the camera (as in, speeding cars going by; you'll notice that the cars may be leaning, especially noticeable on big square vehicles like train cars or moving trucks.)

So how do you control it?

There are some techniques we can use to work with this, but let's get one thing out of the way first – changing the shutter speed will not help. The shutter speed controls how long each row gets exposed for, but it does not cause the scanning to happen any faster. The only difference the shutter speed will make is in how much blur happens in your shot, but the exact same amount of skewing will still exist. There really aren't any camera settings you can change to minimize skew (apart from using Super Slow recording; 100 fps or 120 fps recording does show notably less skew).

The main contributor to skew is the amount of relative motion -- how quickly an object crosses the camera's field of view. The faster you're panning, or the faster the object is moving, the more skewed it will appear. But you can change the amount of relative motion by zooming out, for example. The further you're zoomed out, the longer it will take for an object to cross the frame, and the longer it takes, the less skewed it will be. For this reason, perceived skew is at its strongest when zoomed in, and it's at its mildest when zoomed out to wide angle.

Another way to control relative motion is to try to slow down how quickly an object crosses the camera's field of view through moving the camera. That means either slow down your pans, or slow down the object you're tracking. One way to slow down the relative motion of an object you're tracking is to pan with it as it goes across; the more time the object spends on the screen, the less relative motion it's exhibiting, and the less skew it will display. Remember, it's not about the actual ultimate speed of the object or of the camera, it's about how fast the object moves across the camera's sensor. By moving the camera at the same speed as the object, you've effectively reduced the object's relative motion in the frame to zero, and in that case it would show no skew at all. Using this technique may result in the buildings in the background visibly skewing, but the subject your viewer's eye is following should be significantly less skewed.

Wobble

The second major image artifact to discuss is "wobble." Wobble gives a rubbery, gelatin-ish, bouncy/stretchy texture to the footage. Wobble happens primarily in cases of vibration, where the camera is being

constantly moved up and down or side to side very rapidly. Wobble is really an extension of Skew, and happens for the same reason. If you zoom in really far and wave the camera back and forth, you'll see vertical lines get kind of "wobbly"; the same thing will happen with vibration. Another example would be if you had the camera mounted on a tripod, and somebody bumped into the tripod — during that bump, you're going to see the image get "wobbly."

How can you deal with wobble?

1. Use the camera's Optical Image Stabilization. It's not a fix-all, but the OIS can certainly help minimize some instances of wobble. Of course, there are reasons to avoid using OIS when on a tripod, too, so you'll have to make a judgment call as to when OIS on a tripod is an appropriate choice.

2. The ultimate cure here is to avoid those scenarios! If you're going to be mounting the camera to a highly vibrationary surface (such as an ultralight airplane or a helicopter or dirt bike) you can expect wobbly footage. You have to minimize or eliminate the vibration whenever possible. The lens's optical stabilizer can help to overcome some of the high-frequency vibration, and a vibration-absorbing mounting (such as a CineKinetic CineSaddle™) can help absorb the vibrations and eliminate or at least minimize the rubbery effect. Regardless of how you choose to approach it, recognize that if the camera is put in a vibration-prone environment or is used in a herky-jerky handheld style, you're going to see wobbling, and the only real way to prevent it is to prevent the wobbles from reaching the camera in the first place.

Partial Exposure

This artifact is also known as "flash banding." This is perhaps the most prevalent of the rolling shutter effects. What happens is that when a flash goes off, only part of the flash is recorded, resulting in bright or dark bands in the frame.

Again, think back on how that rolling shutter rolls through the frame; as it rolls from top to bottom, it exposes the frame onto its sensor. If the image is uniformly lit, you'll get a uniform image, such as the one on the left. However, what if a flash was happening in the frame when the rolling shutter starts exposing, and then halfway down the frame the flash stops? It'll record the bottom

half of the frame without the flash, but the top half has already been recorded when the flash was happening! The result is you'll see a frame where only part of the frame is lit up by the flash, and the lower half is darker.

The CX350 has a function specifically designed to minimize or even eliminate the appearance of flash bands. You can assign FBC (Flash Band Compensation) to a User Button; with FBC enabled, the camera can usually compensate for flashes in a frame. It's not perfect, and it has limitations on when it can be used, but it's generally quite good.

Another effect you need to watch out for is scrolling bars in your image, which are mainly caused by using a shutter speed that doesn't match the light frequency when shooting under fluorescent, sodium vapor, mercury vapor, or HMI lighting. If the shutter speed isn't timed to the same frequency that the light is operating at, then the rolling shutter will cause brightening/darkening bands to appear (similar to when you shoot a computer monitor or television at an "off" shutter speed.) The way to minimize this is generally to always use a shutter speed that matches your country's power frequency (in the USA or NTSC territories, that means use 1/60th; in Europe or PAL territories, use 1/50th). There are some other shutter speeds that may prove safe in these scenarios, such as 1/25th in PAL territories, or 1/24, 1/30, or 1/40 in NTSC territories, but those are only available if you're shooting in a slower frame rate anyway. In general it's easiest to remember that in NTSC territories, the way to best avoid any bars/bands in the footage is to stick to 1/60th, and in PAL territories, stick to 1/50th. This won't guarantee that you'll never have the problem, but it should minimize instances where the problem occurs.

Video of "partial exposure" bands

How do you know if your fluorescent/HMI lights are likely going to cause a problem? Sometimes the scrolling bands are not very apparent on slow shutter speeds (such as when shooting 24P at 1/50), but they will become

glaringly apparent if you use a short shutter speed. One easy way to test for the problem is to set the shutter speed to something very fast, such as 1/250 or 1/500. If you don't see black bars or scrolling orange bars at those short shutter speeds, you're very unlikely to see them at more normal shutter speeds. But if the black bars do show up, you know that you're shooting under potentially problematical lighting. The safest course of action is to replace that lighting with your own, but if you can't re-light the scene, keep a close eye on your shutter speed and manipulate it to minimize the prospect of scrolling bars in your footage.

Note that with some LED lights, their dimmers can cause rolling bands too — and you can't eliminate that banding with the shutter speed! Some LED lights dim their lights by actually cycling the light off and on briefly, and the rates at which they do this are not easily trackable by adjusting the shutter speed. You really have to be careful when working with dimmed LED lights, and keep them at full brightness to avoid the rolling band issue.

An Introduction to the Waveform Monitor and Vectorscope

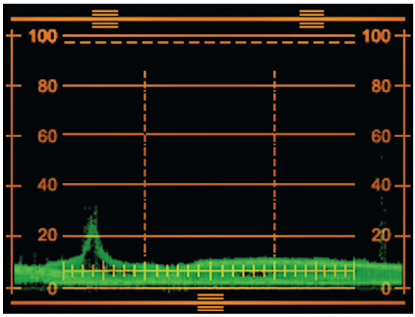
The best tools for calibrating the color accuracy and exposure accuracy of your video signal are the WaveForm Monitor (WFM) and the VectorScope (VS). These tools have been a staple of professional video production for many years, and they provide a way to evaluate the actual video signal. Buying a standalone waveform monitor is an expensive proposition, but the CX350 actually offers a free, built-in waveform monitor and vectorscope!

An exhaustive look at all the possibilities afforded you by a waveform monitor and a vectorscope is far beyond the scope of this article. This section will introduce you to these tools and show you basic fundamental operations, which should allow you to evaluate and monitor your video signal more accurately than you may have experienced before.

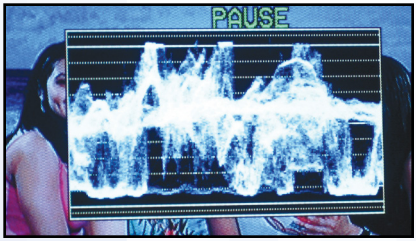
The waveform monitor ("WFM") is the most useful tool for judging your video's exposure levels. The waveform monitor can tell you at a glance whether your footage is overexposed, underexposed, clipped, and – if any of those conditions are true, the waveform monitor will also tell you where your footage is overexposed, underexposed, or clipped. The waveform monitor is like having the ultimate light meter available to you, but it's infinitely more informative and precise than a light meter, because the waveform monitor takes into account all the signal processing the camera does – the gamma curves, the master pedestal, the effect of the knee, all of these effects can be discerned from looking at the waveform monitor,

and none of these things could be known by just using a light meter. Light meters work great for lighting film, but when working with video a waveform monitor is a far more useful tool to have on hand.

In simple terms, a waveform monitor is essentially a graph of your video signal. It draws a mathematical representation of the brightness of the image, from left to right, and it plots its pixels according to the brightness of the image: the brighter the source image, the higher up on the scale it will plot the pixels.

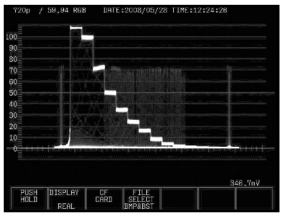


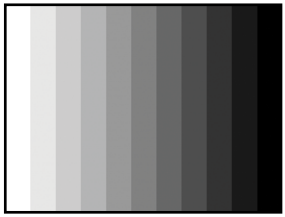
Here's an example of a waveform monitor screen. Vertically you can see that there are certain denominators at predetermined reference points (0, 20, 40, 60, 80, and 100 IRE; on the camera's waveform monitor the solid lines are at zero, 50, and 100, with dotted/dashed lines at the other reference points). You can think of these numbers as basically telling you the overall percentage of brightness; a dark gray object might illuminate around the 10 to 20 IRE mark, and a bright white light might stretch all the way up to or even past the 100 IRE mark (up to as much as 110 IRE). The brighter the signal, the higher up the chart it will mark. In this example you can see an extremely underexposed image; the plot of image brightness is almost entirely down at the 0 to 10 IRE level (but there's a small spike about 15% of the way across the screen, in our video image there was something a bit brighter there.) If your waveform monitor looked like this, you'd get terrible video quality: the image would be underexposed, muddy, and probably very grainy and noisy.



Ideally, for most real world scenes, you want a rich saturated image with brightness distributed across the full scale, which shows that you're taking advantage of the maximum dynamic range the camera affords. Look at this image for an example of a fully saturated, brightly exposed scene. In a moment I'll show you how to read the waveform monitor and fine-tune the image in order to get the best overall exposure; this example is just to show you more of what you should be aiming for in terms of a rich, saturated, full signal.

As said before, the waveform samples the brightness (luminance) of the picture and plots a graph of the image on its screen. Horizontally, the waveform monitor plots out the image just like on your video screen; if a very bright object was located in the center of your monitor, you should see a bright spike in the center of the waveform display. The next pictures show what a waveform monitor looks like when shooting a chart full of gray bars. The brighter bars are represented on the left side, and the darker bars are on the right. The waveform monitor looks at the brightness of the image as it scans horizontally and it plots the relative brightness vertically, so white is the highest point and black is the lowest point, and the shades of gray are distributed in-between.



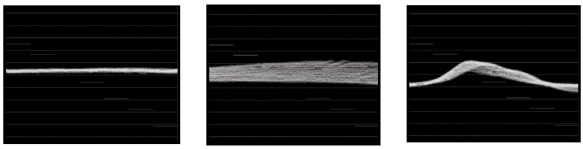


These waveform plots show clean lines where each bar appears on the screen. That's because the waveform will plot the entire vertical height of each vertical line of the display, and it will plot pixels on top of each other – so, the more pixels that appear at a certain brightness level, the brighter that section of the waveform monitor will be plotted. In our example there's only one level of brightness in each gray bar, so the waveform monitor plots a thin clean line. If you looked at a waveform display of a perfectly flat white sheet of paper, you'd see a razor thin line running across the waveform monitor's display. That's because, with no variation in brightness, there's no variation of where the pixels get plotted, so they all get plotted on top of each other, making that section of the waveform display brighter and brighter. If, on the other hand, we were to feed the waveform monitor a signal that had wildly varying brightness in each vertical column, you'd see a large swath of pixels plotted on the waveform display.

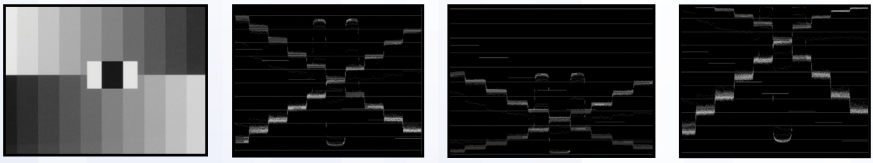
This is a very valuable aspect to a waveform monitor because you can use this to evaluate the relative brightness of your scene, especially when shooting something like a greenscreen. If your greenscreen lighting is perfectly flat and even, you should see a tiny thin line plotted across the waveform monitor's display. The thicker the waveform's plot, the more variation there is in your lighting (which will make it more difficult to pull the best-quality key from your footage). Also, if the line is not perfectly flat, but it dips in the corners or has peaks and valleys across the screen, that is telling you that your lighting is uneven; wherever the waveform monitor dips, that's showing you have a darker spot, and wherever there are peaks

or hills on the display, that's telling you that there are hotspots on your greenscreen. The waveform monitor is the best tool for helping you light a perfectly flat, perfectly even greenscreen.

Here are three examples of lighting a greenscreen using a waveform monitor. In the first example the screen is evenly and flatly lit, so the waveform shows a tight thin horizontal line of brightness. In the second example the screen is unevenly lit, so the line on the waveform is much thicker. In the third example there's a brighter spot on the screen about 1/3 of the way across.

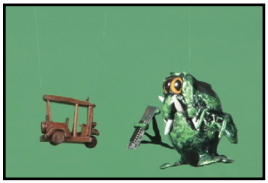


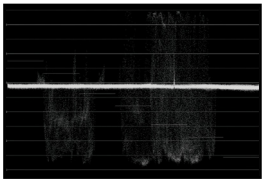
Besides telling you evenness of lighting and overall exposure levels, the waveform monitor tells you what sections of your footage might be overexposed or underexposed. If you see a big clump of bright plots down at the bottom of the waveform, you know that your exposure level is really low in that section. Conversely, if you see a flat line clipping off the top of the waveform, that alerts you that portions of your video signal are "too hot" and are, in fact, clipping (losing all detail and becoming a big blob of overexposed white). Keep an eye on your video signal and watch for those clipping hot spots, and either lower the light level on those hotspots, or stop your iris down some to keep them from blowing out. Blown out highlights on video are ugly, ugly, ugly, and are best avoided. And if you're seeing sections of your video that are grossly underexposed, either iris up or shine some light onto that portion of the scene to prevent you from getting stuck with noisy, muddy, underexposed video.



The above examples are of a gray 10-step chart; notice how the gray bars form an "X" on the waveform. The first example is properly exposed. The second example is quite underexposed, look at all the wasted range at the top end of the waveform. And the third example is very overexposed, look at how the white bars are actually clipping off the top of the waveform.

The great thing about a waveform monitor is that it tells you absolutely what your video signal is doing. You don't have to try to trust your eyes to a perhaps - miscalibrated monitor, or strain to see where the zebras may or may not be hitting, or (worst of all) just guess. Instead, at a glance, you can see whether you're getting a full and proper exposure and whether your image is clipping or crushed.





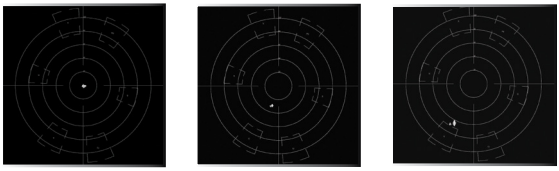
In this example, you can see that the greenscreen is evenly and flatly lit at about 57 IRE (as shown by the thin line running throughout), the wooden car is darker on the left, and the monster is both dark and light on the right (and its white teeth are coming close to clipping off the top of the waveform). Diligent use of the waveform monitor will be your best method for ensuring strong, richly exposed video.

Whereas a Waveform Monitor (and especially the waveform monitor in these cameras) is designed to monitor brightness, the Vectorscope is a tool to help you judge the accuracy of color rendition and the level of color saturation in your image. When used with proper test charts the Vectorscope can give you an overview of your camera's color rendition at a glance, and you can also see exactly what the menu setting changes do to the way the camera manipulates the color of the images.

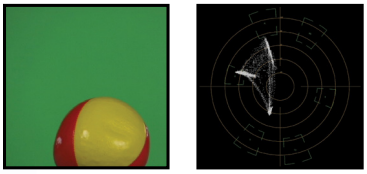
The vectorscope plots colors along certain vectors. The graphical overlay (or "graticule") of a vectorscope will always have some boxes to indicate where the pure color vectors should be lining up, and frequently a vectorscope's graticule will include some circular or gradated marks to show the percentage of saturation (in terms of IRE) of the color signal. The camera's vectorscope only shows the color boxes, so we'll focus on that aspect of the vectorscope.

The vectorscope features six boxes, representing (clockwise from the top, starting at about 11:00) red, magenta, blue, cyan, green, and yellow. The vectorscope analyzes the video frame and plots dots on the display according to how many pixels it finds in each particular group (or, obviously, between groups for mixed shades). When shooting a black and white picture, ideally you should see a tight bunching of pixels at the center of the vectorscope. When shooting an object of a pure color (such as a greenscreen), you should

see all the plotted dots bunched tightly in one place, ideally towards the green box. The plotted dots will be closer to the center or closer to (or even beyond) the color box, depending on how saturated the color is. These next three examples are of: 1) a black and white picture, 2) a very low-saturated greenscreen, and 3) a highly saturated greenscreen.



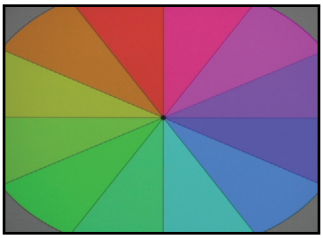
In these examples, the only color involved was green, so you only see pixels plotted on the screen either at the center (the black and white picture, no color present), or slightly towards the green box (a greenscreen picture with low color saturation), or a lot of plotted pixels closer to the green box (a highly saturated greenscreen). It's uncommon to see such simple vectorscope plots; most scenes have a lot of color in them and so the plot will be "busier."

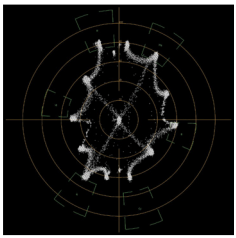


Here's an example of a red and yellow ball against a green screen. There's a good deal of color purity here with intense plots at the red, yellow, and green boxes.

In real-world monitoring, you're not likely to use the vectorscope nearly as much as you will the waveform monitor. The vectorscope is a more useful tool for setting up and evaluating camera performance, whereas a waveform monitor can (and ideally should) be used on every shot to evaluate exposure and lighting. However, a vectorscope can be useful to solve lighting problems because, like the waveform monitor, it reports exactly what's happening in the video signal – rather than trusting your eyes to a perhaps - miscalibrated production monitor. In the following example the white balance is grossly off; we white-balanced for tungsten light but the actual light was daylight, so the image is too blue. The effect of this is clearly observable at a glance in the vectorscope, as the plot is bleeding towards the blue vector instead of being a tightly-controlled pack of pixels as in the second example.

A vectorscope may be most useful with test charts, to see how the color is being rendered by the camera under controlled conditions. Here is an example of a DSC Labs CamBook™ color chart, and the vectorscope display. This is a 12-color chart so you'll see heavy plots in the six main boxes for the six specified colors (red, magenta, blue, cyan, green, and yellow) as well as heavy plots in-between those colors. The goal, for accurate color representation, is to adjust the lighting and the camera settings until the primary six colors align as best as possible with the color boxes on the vectorscope's graticule, and the intermediate colors appear halfway between the primary colors.





Whether you choose to use the vectorscope or not, my advice to all video shooters is to become thoroughly versed with the waveform monitor and use it on every shoot you possibly can. Proper use of the waveform monitor will help you to more accurately expose your video image, keeping you from getting noisy underexposed images or clipped/overexposed video. You'll find that the waveform monitor (especially used in tandem with a properly-calibrated production monitor) will help you in your lighting and exposure far more than any light meter would be able to. These cameras make it extremely easy to spot-check with the waveform monitor. Other options would include getting a dedicated waveform/vectorscope device, or using a production monitor with a built-in waveform monitor, or perhaps an external recorder such as a Ninja Shogun Inferno, which includes its own waveform and vectorscope.

Which Mode to Shoot in?

The CX350 presents a dizzying array of formats, frame rates, frame sizes, and recording modes to choose from. Everything from standard-definition 480i or 576i, high-definition 720p, 1080i, and 1080p, and Ultra High Definition (also called 4K), in base frame rates of 23.98, 24.00, 25.00, 29.97, 50.00, and 59.94 frames per second, in various combinations of bitrates in long-GOP as well as some choices for intraframe recording, and most of that is available to be recorded in your choice of two different file formats (AVCHD, or MOV)! So which mode should you shoot in? And why would you pick one particular mode over another?

I'll try to do my best to simplify this. In general, there are three main choices you'll be making in the menus. They are:

SYSTEM>FREQUENCY. Here you'll choose between 50.00Hz or 59.94Hz. Generally this is something you'll only ever set once, and the camera will already be configured for the right setting from the factory. If you're in the USA, Japan, or any former-NTSC territory, you'll choose 59.94Hz. If you're in Europe or any former-PAL territory, choose 50.00Hz. Generally the only time you'd want to change this setting is if you know that you're creating footage for other territories in the world; an example might be if you live in the USA but get hired by a visiting European production company to shoot footage for a travel show which they will then take back to Europe to edit and broadcast. In that scenario you'd change the SYSTEM>FREQUENCY to 50.00Hz.

The second main decision you have to make is the SYSTEM>FILE FORMAT. Here you'll choose between AVCHD and MOV. In general, most shooters will stick with MOV, as the most features and highest resolution are only available in the MOV format. If you need to shoot in UHD, or you want the highest quality footage, or you want to shoot Super Slow frame rates, you need the MOV format. Generally someone only would use AVCHD if they only need HD or standard-definition footage, or they need extraordinarily long recording times, or if for some other reason the client is requesting AVCHD. AVCHD uses very little bandwidth, and results in very small file sizes. The MOV formats take up much more space, but produce higher quality footage.

The third decision is the big one: SYSTEM>REC FORMAT. In this menu you'll find many options. The choices are vast and confusing, but can be boiled down rather simply once you know what your project priorities are. You mainly need to consider your frame size, project frame rate, and finally you may need to choose your codec bit rate. I'll break it down here simply.

Frame Size

Are you shooting standard definition? High definition? Or Ultra High Definition? The MOV format supports UHD 2160p and HD 1080, whereas AVCHD doesn't support UHD but it does support standard def, 720p, and 1080p/1080i. The general advice here is to choose the largest frame size you can, unless the client has specifically requested a particular frame size. Whenever possible, I recommend shooting MOV and UHD, unless you know for a fact you'll never need the larger UHD frame size; in that case I'd recommend 1080 MOV.

Frame Rate - You need to decide on your project's frame rate; this is the base frame rate at which the footage will be played back. In editing terms, this would be the same as what type of timeline you'd set in your editing program. The choices change depending on what SYSTEM>FREQUENCY you've chosen. For 59.94Hz, the choices are:

23.98P - Technically 23.976 fps, it is frequently rounded off to "23.98" and in common vernacular it is usually referred to as "24P". This is the standard frame rate for shooting film-looking footage for display on 59.94Hz televisions, or for release on Blu-Ray or DVD discs. Generally if you're shooting footage that you want to have the "film look", this is the frame rate that you will normally be choosing.

29.97P - This is also frequently called "30P". This mode offers a faster frame rate than 23.98P, and delivers sort of a hybrid between the "film look" and the "video look".

59.94i - (aka "60i") - This is the "live video" look for recording footage to be broadcast or delivered on Blu-Ray or DVD in 59.94Hz territories in the world ("NTSC" countries); 1080-resolution HDTV broadcasts in the USA are broadcast as 1080/59.94i; in this mode the camera would be producing footage that could be used for broadcast directly. However, it would be a poor choice for video that will be viewed on a computer, and in general 59.94P would be the better choice for any footage that will be displayed on a progressive-scan TV or computer.

59.94P - (aka "60P") - This is a fully progressive version of the "live video" look. Fundamentally it delivers the same general feel as 59.94i video, with the benefit of more resolution because each motion sample is made from a complete frame, rather than a "half frame" field as used in 59.94i. 59.94p footage can be easily converted to 59.94i for broadcast if necessary, and in general is a superior choice to 59.94i except for instances where the footage is going to be broadcast unedited or unconverted.

If you have chosen a SYSTEM>FREQUENCY of 50.00Hz, the choices are:

25.00P - 25.00P is essentially the 50Hz counterpart of 23.98P. It is a "film look" mode that creates footage that is compatible for broadcast or display on 50Hz televisions. If you live in a "PAL" territory (i.e., if your country's standard-definition television was PAL), then 25.00P is the "film-look" frame rate that you'd want to choose to create film-looking footage for television.

50.00i - This is the "live video" look for recording footage to be broadcast or delivered on Blu-Ray or DVD in 50Hz territories in the world ("PAL" countries). 50.00i video is interlaced and would be appropriate for footage that is going to be broadcast in 1080i or standard-def. It would

make for a poor choice for computer video though; 50.00P would be a far better choice.

50.00P - This is a fully progressive version of the "live video" look. 50.00p footage can be easily converted to 50.00i for broadcast if necessary, and in general is a superior choice to 50.00i except for instances where the footage is going to be broadcast unedited or unconverted.

Now that you've identified the frame size and frame rate, it's time to choose the recording codec. If you're using the AVCHD format, the choice of recording codec is already made for you; AVCHD always uses 8-bit 4:2:0 h.264, so there's nothing else to consider other than bitrate. But for the MOV format, there are several choices that come into play; you can choose the recording codec (either h.264 or HEVC/h.265) and whether you want the footage recorded frame-by-frame (ALL-I) or by groups of frames (Long-GOP). Additionally, you may have some choice regarding the color sampling or bit depth. Sound overwhelming? It can be, but in reality the choices are pretty simple once you understand what these things do.

Long-GOP or ALL-I: The compression system of the CX350's MOV recording formats offer two distinct encoding mechanisms: either all intraframes (ALL-I) or groups of pictures (Long-GOP). While this could become a complex subject, you'll see that the choice is actually very easy to make between them.

ALL-I - The ALL-I recordings are made using nothing but so-called "intraframes". In this compression system, each and every frame is compressed individually; nothing that happens in any frame will have any influence on anything that happens in any other frame. Each frame stands alone. This is much easier for a computer to decode, and you may find that working with ALL-I footage is more responsive or "snappier" on your computer, than Long-GOP footage is. But the downside is that ALL-I recordings usually take up much more file space, ALL-I recordings will usually be 2x to 4x as large as comparable-quality Long-GOP recordings.

Long-GOP - This method groups images together into a big Group Of Pictures (GOP) and compresses them all at once. The first picture in the group will be an "intraframe", and then all successive pictures in the group are encoded by only charting the changes between frames. If you think about it, in many if not most video scenes, the amount that changes from frame to frame is generally not very much. In a tripod-based interview, for example, the background may never change from frame to frame, and large portions of the person's face may not change. Long-GOP encoding takes advantages of these similarities and results in much smaller file sizes, at equivalent video quality, when

compared to ALL-I. These groups of pictures are however harder for a computer to decode, taking more processing power, so it's possible that people working with older computers may find that working with Long-GOP footage may be more sluggish on that computer.

In general, Long-GOP footage averages to be about 2x to 3x more efficient in encoding space than ALL-I footage is. In terms of visual quality, Long-GOP 150-megabit is generally comparable to ALL-I 400-megabit. Long-GOP 50-megabit is about on par with ALL-I 100-megabit. When using LongGOP encoding, you'll generally get longer record times on your memory cards, and faster file transfers, with the possible downside of slower editing performance. When using ALL-I encoding you'll have larger file sizes and slower file transfers, with the possible upside of faster editing performance. There is not a substantial quality difference between them so long as you're comparing comparable levels (i.e., the highest-bitrate LongGOP will perform on par with the highest-bitrate ALL-I; the lowest-bitrate LongGOP will generally perform on par with the lowest-bitrate ALL-I.)

Color Sampling and Bit Depth - I've grouped these two very distinct concepts together because the CX350's recording formats group them together. There are recording formats that record 4:2:2 color sampling and 10 bit quantization, and there are other recording formats that record 4:2:0 color sampling and 8-bit quantization, with only one exception (HEVC recordings are 10-bit 4:2:0). So when choosing codec and color sampling, you are inherently also making a choice about bit depth (and vice versa). So we'll discuss both of these unique topics in this section. Note, though, that these choices are only relevant to the LongGOP MOV recording modes. In the other modes (AVCHD and ALL-I), the choice is inherently already made for you; AVCHD is always 8-bit 4:2:0, and ALL-I is always 10-bit 4:2:2. It is only in the LongGOP codecs where you have a choice between them.

Color Sampling: - There are two color sampling systems offered: 4:2:2 and 4:2:0. We could get very complex in the description, but it's also possible to explain this very simply: 4:2:2 color sampling results in recordings that retain literally twice as much color information as 4:2:0 color sampling does. This is extremely important in interlaced recordings (1080i) but is not of much concern in 4K/UHD recording, where all recording is done in progressive-scan mode.

In 4:2:0 color sampling, each 2x2 block of pixels is assigned a single color, equivalent to the average of all 4 pixels. So each 2x2 block

retains individual brightness information for each of the 4 pixels, but all 4 pixels share the same color information. In 4:2:2 color sampling, the color is dealt with for each pair of pixels. Instead of averaging the color among four pixels (as in 4:2:0), the color is averaged among every pair of pixels. This results in higher color fidelity and more accurate color recording, and can result in higher quality footage. Further, 4:2:2 color sampling can make for more accurate greenscreening, since the edges will be rendered with twice as much color information. As a pure question of which is "better", there can be no question: 4:2:2 is "better" than 4:2:0. However, when it comes time to compress the footage for recording or broadcast, 4:2:2 requires a lot more data to encode than 4:2:0 does. 4:2:0 in general looks quite good; all HDTV broadcasts and all Blu-Ray encoded discs are encoded using 4:2:0 color sampling. 4:2:2 is better, but the advantages are usually realized when greenscreening or compositing; visually it's not easy to distinguish 4:2:0 from 4:2:2.

4:2:2 was (and still is) required by many broadcasters, such as the BBC, when recording 1080 or 720 footage. However, for UHD, 4:2:0 is generally the recommended recording system. In UHD, the color information at 4:2:0 is already reaching or exceeding the human eye's ability to discern colors, and using up additional bandwidth to encode 4:2:2 is an inefficient way to maximize image quality within a given data rate. 4:2:2 UHD is still of benefit for footage that will be undergoing extensive compositing or keying; that's one reason why the CX350 supports UHD 4:2:2 at the common film-look frame rates of 23.98 and 25.00 frames per second, even up to 29.97 frames per second. In 50p or 60p, 4:2:0 is the color sampling system used, and it corresponds to the recommendations from the major broadcast organizations for UHD footage. For HEVC, the color sampling is always 4:2:0, in accordance with the HEVC standards for the Main10 profile.

Bit Depth: Hand-in-hand with color sampling, you'll be choosing the bit depth you want to encode your footage at. The choices are 8-bit quantization, or 10-bit. Now, you don't get to make this choice actively; instead it's tied to the color sampling or codec you've chosen: if you've chosen 4:2:2 or HEVC or ALL-I, the bit depth will automatically be set at 10 bits; if you've chosen a recording format that uses 4:2:0, the bit depth will automatically be set at 8 bits. When deciding between them, the simple truth is that "more = better." 10 bits looks better than 8 bits. 10 bits holds more data than 8 bits does. In 10-bit recordings, each pixel has its brightness individually coded to one of 1,024 levels; in 8-bit recordings the brightness is encoded in 1 of 256 levels. 10-bit recordings are literally capable of distinguishing 4x as much brightness information, which means the differences between

pixels can be much finer. There are 1,024 shades of gray (or shades of blue, or green, etc) in a 10-bit recording, whereas there would be only 256 shades in an 8-bit recording. The tangible visible benefit of this usually shows up in gradients (such as a blue sky, or a light shining on a white wall); where there is a subtle variation in shade or tone, the 10-bit recording will capture more detail and will render finer tones without "banding". This is especially true when recording with the Hybrid Log (HLG) gamma for recording HDR, as the higher bit depth of 10-bits will help the recording hold all that dynamic range while reducing visible banding in the footage. I would also heartily recommend 10-bit when using FILM-REC gamma.

Bit Rates - The bit rate is how much data is involved in recording each second of video. And to make this simple -- bigger numbers generally yield better quality footage, all other things being equal.

AVCHD mode uses the very smallest bitrates; even the best quality AVCHD mode (PS recording) uses only about 25 megabits per second, as compared to the lowest-quality MOV recording which uses 50 megabits per second, which means the MOV images are less compressed and will show fewer compression artifacts.

So generally, bigger numbers = better. But, that doesn't necessarily hold true when comparing Long-GOP to the ALL-I modes; ALL-I is not as efficient a compression system as Long-GOP, and it's possible that Long-GOP at 150 megabits will look every bit as good as ALL-I at 400 megabits.

Finally, when selecting MOV, there's the question of h.264 or h.265/HEVC recording. HEVC is more recent technology than h.264, and is generally more efficient than h.264, and should result in better-looking pictures than h.264 at the same bitrate, but there is one area where h.264 has the advantage: it can record 4:2:2 color, whereas the HEVC recording modes in the CX350 only support 4:2:0 color (at 10-bit depth). Even so, HEVC recordings may look as good or better than the 4:2:2 h.264 recordings (especially in UHD) because of the more advanced compression system; you just need to be aware of the differences. If you're shooting a greenscreen project with a lot of keying expected to be done, I'd probably still recommend h.264 4:2:2 as the preferred recording codec. Other than that, I think HEVC will result in better-looking images. But, there is another area where h.265/HEVC has a big advantage: many modern computers have HEVC decoding

built-in, which means that they can play back HEVC-recorded files very easily with no skipping or stuttering. You should test some HEVC files on your computer to see how they play; if your computer has hardware acceleration that results in effortless HEVC playback, that might be reason enough to choose HEVC as your recording format.

Putting It All Together - Deciding On A Format - Now that you know what the choices are, you should feel more empowered to make the right decision on what formats and recording options best suit your projects.

There is no overall "best" choice, there's only "the best choice for the current project." If you're shooting news for a 1080i station and uploading footage from the field, it's possible that AVCHD HA mode might be the best choice for you, for that project, because the file sizes will be so tiny. If you're shooting a film to enter the Sundance Festival, it's far more likely that UHD/23.98P would be the right choice.

Generally when approaching this decision, I rely on a few basic factors to inform the final choice. First — what do I want this project to look like, "live video" or "filmic"? If it's a live event, news, sports, or some other project that generally benefits most from the "live video" look, I would choose 59.94p whenever possible, and 59.94i only if the client specifies and requires 59.94i. On the other hand, if producing a project that would benefit most from a cinematic look, I'll shoot 23.98p every time.

(note: for users in 50Hz countries, just substitute 25.00P for 23.98P or 24.00P, and 50.00P/50.00i for 59.94P/59.94i).

As for ALL-I (intraframe) or LongGOP, I generally hold that with sufficient bandwidth, LongGOP is more efficient and makes for smaller file sizes. The ALL-I codecs are very good, especially the 400Mbps version. It really depends on how you intend to edit the footage (as in, do you get sufficiently responsive performance from LongGOP footage, or does your computer perform much better with ALL-I?)

As for bitrate, I hold to the general rule that more = better. 50Mbps MOV looks better and retains better quality than 25Mbps AVCHD. 100Mbps MOV looks better and retains better quality than 50Mbps, etc. Whenever possible, I would always choose the highest bitrate codec with 10-bit encoding, and in 1080 I would choose the 4:2:2 versions of the codec. The bigger numbers really do help the quality of the footage.

For UHD, I recommend HEVC whenever possible. And if recording in the Hybrid Log (HLG) gamma or FILM-REC, I recommend selecting an HEVC codec. Smart TVs and other playback devices that support HLG generally have better compatibility with HEVC than h.264.

Recording Time on an SDHC/SDXC Card

How much footage can you fit on a card? That's a question that doesn't have a very simple answer, from the perspective that each shooting mode takes up a different amount of space on the card, and, furthermore, the camera can employ variable bitrate recording — which means that for easy-to-encode scenes, it may take less space than you might otherwise think.

The following table should give you ballpark estimates for how much footage will fit on a card, with the understanding that these are probably worst-case estimates and real-world recordings may actually fit more footage than what is listed here.

Bitrate	32GB SDHC	64GB SDXC	128GB SDXC
400M ALL-I		20:00	40:00
200M ALL-I		40:00	80:00
150M LongGOP		55:00	1:50:00
100M ALL-I or LongGOP		1:20:00	2:40:00
50M LongGOP		2:40:00	5:20:00
AVCHD PS 1080P	2:40:00	5:20:00	10:40:00
AVCHD PH 1080i & 1080P	3:00:00	6:00:00	12:00:00
AVCHD HA 1080i	4:10:00	8:30:00	17:00:00
AVCHD PM 720P	8:30:00	17:10:00	34:20:00

Optimizing for Low Video Noise

"Noise" in a video signal is a random variation in the color and intensity of each pixel. This random variation is very small compared to a strong signal (i.e., a bright part of the image), but becomes relatively more apparent as the signal level decreases (i.e., in dark parts of the image). In general, a properly-exposed image will show much less noise than an underexposed image!

Depending on the settings of the camera, noise can be minimal, or quite invasive (just try 36dB of Super Gain for an example). A small amount of noise is usually present in all scenes, but there are steps you can take to

minimize the appearance of the noise. By taking advantage of the various menu settings, as well as employing proper lighting, you can reduce the appearance of some of the image noise.

The most important determining factor for how much noise is in the image is the electronic gain level. In general, the higher the gain, the more noise will be in the image. Now, sometimes it's easier to just crank up the gain to get a shot in challenging lighting — but just understand that doing so can raise the noise level slightly, moderately, or even significantly, depending on how much gain you add. If you need the picture brighter, adding light to the scene will do much more for the quality of your picture than gain ever would, because adding too much gain can cause the image to get very noisy, muddy and soft. Adding light will give you a cleaner picture and adequate light can help to suppress noise that might otherwise have been there. Underexposing video leads to increased noise in the signal; giving the camera proper exposure will clean up the signal nicely. A camera is a light-gathering device, so giving it enough light will help it perform its best. A camera feeds on light – feed it, and it will reward you with gorgeous imagery; starve it and you may not be as pleased by its results.

As for menu settings, there are a few that can help. The first and most obvious is the SCENE FILE>DNR menu. This is a dedicated Digital Noise Reduction menu. You can set the noise reduction off, level 1 (mild), or level 2 (maximum). Noise reduction can be quite effective, but keep in mind that a side effect of noise reduction can be the loss of fine detail in the image; also, more aggressive noise reduction could potentially introduce "ghosting" or "afterimages" in some scenes with very high contrast and a lot of movement. Generally the least amount of noise reduction is better, but if you're seeing more noise than you prefer, you can definitely use the Noise Reduction settings to clean some of it up.

There are some more menu options that can have a significant impact on the visibility of noise in the image. The SCENE FILE>MASTER DTL menu setting is the master detail control. If the DETAIL SETTING>DETAIL menu is switched on, it can contribute to the perception of noise. Lowering the MASTER DTL can mask the visibility of noise. It doesn't really change the presence of noise itself, but the higher detail level settings will actually accentuate the edges of the noise, and can even draw edge-enhancement outlines around the noise, making it much more noticeable. The lower you set your detail level, the less visible the noise will be (but, of course, the softer the image will look, too). Hand in hand with lowering the detail level is the idea of drawing the detail edge enhancement less aggressively. The lower you set the DETAIL SETTING>DTL GAIN(+) & (-) menu settings,

the less visible the edge enhancement effect will be, which will lower the amount of perceived edge enhancement on noise.

If the issue you're having is that you want some detail edge enhancement around your images, but it ends up making your shadows too noisy, you might be able to raise the DETAIL SETTING>LEVEL DEPEND setting to leave your shadows cleaner (less enhanced).

Hand in hand with the detail level control is DTL CORING. Coring is designed to suppress edge enhancement on noise. What this means is, the higher you turn up CORING, the less visible noise you'll see in your picture, but it really depends on your overall MASTER DTL settings. If the MASTER DTL is very low, then there will be little to no visible edge enhancement happening on the noise, so there won't be much of anything for CORING to do. But the higher you set the MASTER DTL, the more effect CORING will have in suppressing the visibility of the noise. Just be aware: CORING can't tell the difference between fine high-frequency image detail and general noise though, so setting CORING up to a high level may reduce the apparent sharpness of high-frequency detail too. You can also rein in the visibility of the overall DETAIL by setting the SCENE FILE> DETAIL SETTING>DTL FREQ to a lower setting. The higher that's set, the more visible the edge enhancement will be, and if the edge enhancement is outlining the noise, the obviously a higher setting will make the noise more visible.

Also, the SKIN TONE DTL functions can help smooth out noise in skin tones. It works just like CORING but only on colors that it perceives to be skin tones (the general idea being to smooth out skin blemishes.) If you're aiming to minimize noise as much as possible, enabling some of the SKIN TONE DTL settings may help.

Finally, the camera's SYSTEM>SHOOTING MODE>HIGH SENS function may be an option you want to consider. HIGH SENS adds gain to the image, and then increases the noise reduction in an effort to vacuum up the additional noise that was just added to the signal. In general it works quite well, giving you a sort of "free" additional 6 dB of gain, but as with all noise reduction implementations, there are side effects; you may notice a loss of fine detail or you may see "ghosting" and "afterimage" effects on high contrast edges when there's a lot of movement in the shot.

Also, remember to Automatic Black Balance frequently. Black Balancing may help the camcorder's sensor to sort out, minimize, and mask noise in the darker regions.

How To Synchronize Timecode among Multiple Cameras

The camera offers the ability to synchronize timecode to another camera, or you can also sync to an external timecode generator, timecode slate, or other device that sends or receives LTC timecode.

The key to synchronizing timecode is to use FREE RUN timecode. For most normal recording situations, it's typical to use REC RUN. However, for synchronizing multiple cameras, FREE RUN is the only way to maintain synchronization if one of the cameras stops recording. With FREE RUN, all of the cameras should maintain sync (or extremely close to sync) no matter how many times a camera operator stops or starts recording. This can make matching up takes in the edit bay easy and effortless.

You'll designate one camera as the "master timecode" camera, and all other cameras will sync to the master camera. Make sure the cameras (or timecode slate or decks or whatever devices you're synchronizing) are set in FREE RUN mode, they all need to be set in the same recording format and frame rate (i.e., all need to be in 1080/50.00p or all need to be in UHD/59.94p or whatever format you're using) and all the cameras need to be set equally to either DROP FRAME or NON DROP FRAME. In short, make sure that the recording modes and timecode settings are identical among all the cameras.

If your camera is the master timecode source, first ensure that it is in camera mode, not playback. Then:

1) Set the timecode generator to FREE RUN. Use RECORDING>TC/UB>FREE/REC RUN and choose FREE RUN.

2) Set the timecode preset to whatever you want it to be (typically you'd set it to match the current time of day, or you might set it to 0:00:00:00 at the start of each shoot day.) Use RECORDING>TC/UB>TC PRESET to program the timecode preset to what you want.

3) Configure your camera's TC IN/OUT port for output. Go to RECORDING>TC/UB>TC IN/OUT SEL and choose TC OUT.

4) You'll also want to make sure that the output timecode is real-time, and not delayed to match the output video. Go to RECORDING>TC/UB>TC OUT REF and choose RECORDING.

At that point, your camera will be able to serve as a master timecode source for any other camera or for things like a timecode slate or external recorders. You'll now want to connect the other cameras so they can receive the timecode. Connect the other cameras or devices to it using a

double-shielded BNC cable (the manual recommends a 5C-FB cable). Then, assuming you're connecting another CX350, you'll want to go into this camera's menus and:

1) As said before, ensure that the recording format and system frequency are the same as the master camera. They must be set identically.

2) Set the timecode generator to FREE RUN. Use RECORDING>TC/UB>FREE/REC RUN and choose FREE RUN.

3) Configure this camera's TC IN/OUT port for INPUT. Go to RECORDING>TC/UB>TC IN/OUT SEL and choose TC IN.

At this point, the camera should be receiving timecode from the master camera and you should see identical timecode on both cameras' displays.

You can leave the cable connected, or you can disconnect it and continue on with your shoot; the cameras should stay basically in sync although, as noted before, you may encounter some timecode drift throughout the day. The receiving camera will conform its timecode to the master camera's timecode so long as the cable is connected, but only when the receiving camera is not currently recording. The timecode will be jammed to the receiving camera during standby, but once the camera goes into record mode it uses its internal timecode generator to advance the clock. There should be little to no drift during the day, but it's possible there will be a small amount of drift if the cameras' clocks are not perfectly synchronized. If you need the timecode to be as consistent as possible, keep the cable connected as much as you can.

Finally, do be aware that the CX350 does not have GENLOCK capability (meaning, it doesn't have the ability to sense the start of a new frame and synchronize that with the other camera's start of frame). Accordingly, it's possible for the timecode to be out of sync by up to one frame. The timecode will always be transmitted, but if the cameras' cycles are slightly mismatched, the synchronized timecode could be off by no more than one frame. As such, absolute frame accuracy is not guaranteed when using the timecode sync method. It should be very very very close throughout the day, but you cannot expect it to maintain perfect frame alignment among multiple devices when all the devices are running on their own internal clocks. If you notice timecode drift happening, you can always re-sync by re-attaching the cable when the receiving cameras are in recording standby.

Variable Frame Rates

The CX350 allows variable-frame-rate shooting in a wide selection of frame rates and frame sizes. The variable frame rates provide you with a variety of creative choices.

To start with understanding why variable frame rates even matter, let's reference back to how movie film gets shot. In film, slow motion is shot by running the camera at a faster frame rate. Film normally runs at 24 frames per second (fps), but for slow motion the camera operator might shoot it at something like 48 fps. When those 48 frames are played back at the 24 fps speed, it'll take twice as long to play back, so everything will be moving at half speed, giving that superb film-style slow-motion look. Shooting at a faster frame rate is called "overcranking," because in the early days cinematographers used a hand-crank to drive the camera, and for slow-mo they would actually crank the film faster. Similarly, shooting at a slower-than-normal frame rate results in a "fast motion" effect – think of the Keystone Kops or an old Charlie Chaplin movie and you'll get the idea. If you only shoot 12 frames in a second, but you play those frames back at the 24fps speed, it'll only take 1/2 second to play back action that took a full second to record – accordingly, the motion will be twice as fast as normal. This is referred to as "undercranking."

Using actual overcranking and undercranking can yield dramatically smoother, superior off-speed effects in your productions. Prior to the introduction of genuine over/undercrank, video shooters had to try to synthesize slow motion effects in their nonlinear editors. This led to frames being blended together, footage being de-interlaced, new frames being interpolated, motion artifacts, and all sorts of other compromises that resulted in lower-quality footage and a less-than-filmlike slow motion experience. With the true overcranking and undercranking potential of this camera you no longer have to settle for those types of compromises; now you can shoot genuine frame-accurate film-style slow motion effects (or fast-motion effects).

I will discuss some examples of what many of the frame rates might be useful for, and ways that you could use them. This is not by any means an exhaustive list, there are likely many, many more uses where each frame rate could be used, but this listing will give you a basic overview. Each of the choices listed below assumes that you're going to be playing back the footage at the film-look rate of 23.98 or 25fps.

2 fps: Extreme fast motion, also for time lapse type photography. If you wanted to record a city street at night, with cars smearing by and leaving trails of taillights, 2fps with the shutter off would be an excellent choice for that.

12 fps: Usable for fast motion, twice as fast as normal motion. Traditionally used for comic effect.

18 fps: This is the frame rate that early silent films were shot at, and the frame rate that most 8mm and Super 8mm home movies were filmed at. Since film has been standardized at 24fps these older films usually are played back with fast-motion effects. If you're looking for the "Keystone Kops" or "Charlie Chaplin" look, 18 fps is where you should start.

20 fps: 20 fps is a fast-motion effect that's not nearly as exaggerated as 12fps is, but it's fast. If you wanted to show someone running extremely quickly, 20 fps might be a good choice for that. It starts to push the bounds of what the audience can believe is "real," but it's very fast motion without being exaggeratedly fast (like 12 fps is).

22 fps: This is a subtle fast-motion effect. 22 fps is a very popular frame rate for karate action movies – shooting at 22 fps and playing back at 24 fps makes motion look very fast but completely believable. Shooting a car chase or a fight scene at 22 fps will lend an added edge of excitement and action to your scenes. The 50Hz mode equivalent would be 23fps.

24 fps: This is the standard movie film speed. Shooting at 24 fps and playing back at 24 fps gives your footage the temporal feel of motion picture film. This is the speed you'd normally shoot all dialogue scenes and "normal action" scenes. If you're producing footage for "PAL" territories or broadcasters who broadcast at 50Hz, the equivalent would be 25fps.

26 fps: This frame rate can add a subtle, subliminal slow motion effect to your footage, but the effect is very mild. Things moving slower than normal can be perceived as being "larger than life" – if you want to add a bit of elegance and grandeur to your scene, but don't want it to be obvious that you've done so, 26 fps can add that additional element of drama. The 50Hz mode equivalent would be 27fps.

30 fps: This is a slow motion speed. It's mild slow motion, but noticeable. 30fps is not too subtle, it's the first of the "real" slow motion speeds.

36 fps: At 36 fps, the scene is obviously slow motion. Action takes 1.5 times as long to play out as it took to shoot it. 36 fps is as slow or slower than many movie cameras can shoot.

48 fps: Full-fledged slow motion. 48 fps makes everything take twice as long to play back as it did to shoot it.

60 fps: Super-slow motion. 60 fps is suitable for shooting explosions or extreme slow motion scenes. This is the fastest frame rate (for the slowest motion) that the CX350 is capable of when shooting UHD.

100 or 120 fps: Ultra slow motion. In 120 fps, motion takes five times as long to play back, as it took to shoot it (if shooting in a base frame rate of 24p). Even if your main project is set to 59.94p, 120 fps footage will still be quite slow motion. These frame rates are only available by enabling "Super Slow" recording, and they're only available in 1080 resolution.

Obviously, having dozens of different frame rates gives the camera operator a great degree of flexibility and creative choices. But remember that there's also an intervalometer feature. You can use that to shoot one single frame at certain specified intervals. While not quite the same thing as having more frame rates, it does give you even more options for creative interpretation in how you want to record motion.

Next, consider that each of the frame rates can deliver a different look, depending on what your playback rate is (i.e., what you set the SYSTEM>FREQUENCY to, and what you set our editing system's timeline to). Since there are five basic playback rates (23.98, 25p, 29.97p, 50p and 59.94p) you actually can get up to five different looks out of each frame rate. Depending on the playback rate you set, each of those frame rates can deliver a different look. Take the example of 28fps. When you set the camera to record 23.98p footage, and you set the variable frame rate to 28fps, it will deliver a very mild slow-motion effect. But if you had instead set the camera to record 29.97p footage at the same VFR of 28fps, it would instead be delivering a mild fast-motion effect! The frame rates and their overall perceived motion are dependent on the playback rate that you've chosen. Obviously 60fps is going to be slow motion when played back at a project frame rate of 29.97p, but it's even slower motion when played back at the 23.98p frame rate. And when played back at the 59.94p frame rate, it's not slow motion at all -- instead, it's "live", "video"-style footage!

The acquisition rate, and the playback rate, are two different things. Under normal circumstances you want them to be the same – i.e., acquire at 24 frames per second, play back at 24 frames per second, and you get real-time action. Acquire at 29.97 fps and play back at 29.97 fps, and you also get real-time action – a bit smoother than the 24fps/24fps sequence, and less film-like, but still real-time. Acquire at 59.94 frames per second and play back at 59.94 frames per second, and you also get real-time motion. 59.94fps/59.94fps looks nothing like film, it looks like "video," and gives the smoothest strobe-free motion possible. In the 50Hz mode, the equivalent would be to shoot 50fps and play back at 50fps for the "video" look.

But what happens if you acquire at 60 fps and play back at 29.97fps? The result is slow motion, a 2-to-1 slowdown factor. And what if you acquire at 60fps and play back at 24fps? It's also slow motion, but it's even slower: it's a 2.5-to-1 slowdown factor. And if you acquire at 30fps and play back at 29.97fps, it'll be real-time, but if you acquire at 30fps and play back at 59.94fps, the result is 2:1 fast motion. The same frame rate, played back at different time bases, delivers different looks to the viewer.

Selecting your time base, and selecting your acquisition frame rate, are therefore interconnected when you decide what type of look you're choosing for your program. With 24P or 25P you'll have film-like footage, and the most wide-ranging slow-motion capabilities. With 30P you'll have hybrid film/video footage – it'll be smoother/less stroby than 24p, but it will still have some strobing and a somewhat film-ish look to it, and it'll still be capable of up to 4:1 Super Slow motion. With 59.94p you'll have video-looking footage, with the capability for 2:1 Super Slow motion but also with tremendous fast-motion capability: imagine 1fps acquisition played back at 59.94fps – it'd be 60-to-1 fast motion.

Something else to consider: sound will not be recorded when you're filming "off-speed" footage. What that means is: when shooting 23.98P, sound will only be recorded if you set the frame rate to 24. If you shoot at slower or faster frame rates, no sound will be recorded. The same holds true for 25.00p, 29.97p, 50.00p, and 59.94p — sound is only recorded when the selected frame rate matches the recording frame rate. Don't worry though, a warning will be displayed in the LCD display to tell you when audio won't be recorded.

You should also know that using variable frame rates may result in a brief pause in very long-form recordings. Generally, you can record up to 10 hours in one continuous recording; any more than 10 hours and the system will have to pause recording for a few frames and re-start with a new recording. When using VFR, that will still need to happen, but it will happen at different times depending on the ratio of frames being imaged vs. frames being recorded. For example, if recording in the 29.97 format but imaging 60 frames per second, the recording will be paused briefly after five hours, rather than 10 hours.

You cannot record high-speed variable frame rates externally on an HDMI or SDI video recorder. The SDI and HDMI outputs are capable of a maximum of 59.94 frames per second; if you set the camera to a VFR of 120 fps, the monitor outputs will show every other frame (thus lowering the actual

output to the max of 59.94p). You won't see the slow motion effect during monitoring, you can only view it properly during footage playback.

Using NDI|HX with the AG-CX350 Camera

NDI|HX is a fascinating network connectivity system that the CX350 camera can become a part of. Developed by NewTek™, it's a way to connect and integrate camera systems, switchers, and computers and other video equipment across a network, which makes connecting and accessing all the different parts of the network simple and easy.

Since the dawn of video, we've connected cameras to video monitors (or switchers) using a direct cable connection; whether that was an RCA red/yellow/white video cable or an SDI or HDMI cable, we've always had to connect one camera to one monitor via a cable, and if we wanted multiple monitors to be able to see the output of that camera, we had to loop cables from the output of one monitor to the input of the next monitor, and on and on. If you wanted to use a switcher to view and swap between multiple camera inputs, then each camera would need to run cables to the switcher too. And there are problems with running cables, specifically with a cable like HDMI where there are very definite maximum cable lengths.

The Internet taught us an entirely different way of looking at things, through the concept of the web page. When a computer hosts a web page, any other computer in the world can view that web page, just by pointing their browser at the web page's IP address. You may not know how many people are looking at the web page, or how far away they are, or whether they're using dial-up or cable or DSL or wi-fi or a direct LAN connection, and none of that matters; the web page presents itself to the network, and any device that wants to look at it can look at it.

NDI (Network Device Interface) applies that approach to video sources and video cameras. An NDI|HX enabled camera like the CX350 can be connected to a computer network via an ethernet cable. And when it's connected, any device (such as a computer or NDI|HX-enabled switcher) can all see that camera's video output. Video is streamed out of the camera and distributed across the network to all devices that are currently monitoring that camera. People involved in the production can monitor the output of each camera by installing the free Studio Monitor software from NewTek, and "browsing" their monitor to the camera they want to see. In fact, anyone anywhere connected to that

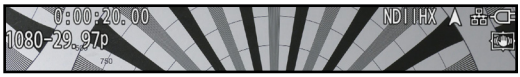
network can monitor that camera, with no additional connections, no additional cabling, without buying dedicated computer monitors, and without having to load up dedicated video conferencing software and without having to connect to a streaming video service like YouTube or Facebook Live.

Monitoring is not the only possibility; you may also have some limited control over the camera through the network. Panasonic provides support for the AW protocol, which runs concurrently alongside NDI|HX. Hardware or software that supports the AW protocol (such as NewTek's TriCaster or Panasonic's HLC100, or even the free Studio Monitor software) can control some features of Panasonic's Pan/Tilt/Zoom cameras; while the CX350 is not a PTZ camera, the PTZ controls of these AW-enabled switchers or programs do give some limited control over the CX350's zoom and focus position. The number pad under the PTZ positioning icon is for stored positions, not for User Buttons; that number pad is not used with the CX350.

NDI|HX is the latest revision to NDI; it's a "high efficiency" version that adds extremely compact video streaming to the NDI architecture. For more information and free software tools for using NDI|HX, visit www.NewTek.com.

In order to use NDI|HX with the AG-CX350 camera, you need to take a number of specific steps.

1. Install the NDI Tools software (version 3.8 or later) from www.NewTek.com.
2. Run the Studio Monitor (Windows) or Video Monitor (Mac) software from NDI Tools.
3. Connect the camera to your router using an Ethernet cable. Your computer and camera must be on the same network, ideally plugged into the same router. You cannot use wireless to connect the camera to the router, it must be done through an Ethernet cable.
4. Set NETWORK>DEVICE SEL to LAN
5. Set NETWORK>NETWORK FUNC to NDI|HX
6. Set NETWORK>IP REMOTE to DISABLE
7. Set LAN PROPERTY>IPV4 SETTING>DHCP to CLIENT
8. Exit all menus.



At this point, you should see a white "CONNECT" icon and an upward-pointing triangular arrow in the upper right corner of the LCD, right after the words NDI|HX. Your camera is now ready to be registered.

On a Windows computer, go to the Studio Monitor software and navigate the mouse cursor towards the upper left corner. A multi-line "menu" item will appear at the top left of the monitor display; click it to bring up a list of NDI|HX sources that are available to monitor. You should see your AG-CX350 there. On a Macintosh computer, use the NewTek NDI Video Monitor software, and look at the FILE menu; it should show your CX350 as an available source.

Once you can access the CX350 as an available video source, select it. If the camera has never been registered at NewTek before, the screen will change to say "This camera is capable of being used as an NDI Device; please go to www.NewTek.com to purchase a license for this camera." You'll see a "REGISTER" icon in the lower right corner of the monitor. If you have an active Internet connection, clicking on that REGISTER icon will bring up the registration window. Go to NewTek's website and buy a license for a Panasonic CX350 camera; they will then give you a code to enter in this registration window. Once you've registered the camera, the NDI|HX function will be activated and the camera will now be monitorable, and controllable, by NDI|HX software and devices on your network (and no Internet connection is required to use NDI|HX).

You can also plug the camera directly into the computer to create a direct peer-to-peer connection, without using a router to connect to an otherwise existing network. When using a peer-to-peer connection, I find it easiest to set the camera to be the DHCP server (by setting NETWORK>LAN PROPERTY>IPV4 SETTING>DHCP to SERVER), and configure the computer to automatically detect and set its network settings. Generally this should work, although you may have to wait a minute or two for the computer to sort out the connection and update itself. If DHCP doesn't result in a working connection, you may have to manually enter the network information into the computer and camera; ask your network administrator how to set the IP Address, Default Gateway, and Subnet Mask fields.

Once you've configured the network, exit all the menus on the camera, and click OK on the computer's Internet Protocol Properties window. Then run the NewTek NDI Monitor software, and your camera should connect and the NDI|HX arrow should switch to the "active" icon on the camera's LCD. Connect the Studio Monitor software to your camera using the menu in the upper left.

With the camera now properly registered and connected, you're ready to use it in an NDI|HX network with other NDI|HX-enabled software and hardware.

Recommended F-Stop Range

When packing more pixels onto a sensor to increase resolution (such as for a UHD camera), it is necessary to make the pixels smaller in order to have them all fit. And an issue that can affect small-pixel cameras is the issue of diffraction: the propensity of light to scatter when forced through a too-small aperture, which makes it appear like the image is out of focus – an issue that especially affects ultra-high-definition cameras with small sensors. However, the CX350 has a relatively large sensor -- so is diffraction an issue?

I tested the lens for diffraction and to find the f-stop range where the lens is sharpest, and can conclude that in Full HD or less (1080p/1080i, 720p, and standard-def), diffraction is really a non-issue. The camera maintains full resolution across the entire f-stop range, from f/2.8 to f/11.

For Ultra HD (2160P), I found that there is some loss of sharpness at the extreme ends of the iris range. From f/4.0 to about f/8.0, it's quite uniform and is outstandingly sharp, rendering a clear 2000 TV lines per picture height. It is incredibly sharp in the range of f/4.0 to f/8.0. The further beyond f/8 you go, the more diffraction can soften the image. At f/9.6 it's mildly softer than f/8, rendering about 1900 TVL. At f/11 it's definitely softer than at f/8, rendering about 1700 TVL. It's still an Ultra HD image and much sharper than 1080p; just notice that it's not quite as sharp as it was at f/8.0. Additionally, the widest-open stop (f/2.8) shows a very slight softening, to about 1850 TVL.

The practical result of this is: when shooting in Ultra HD, try to keep your iris between f/4.0 and f/8.0 for the sharpest images. Use the neutral density filters outdoors, so you can keep the iris more open. The softening is not significant, in fact it's quite mild, so this isn't something you have to pay much attention to, but if you're in pursuit of the very sharpest images, it's a factor you may want to keep in mind.

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CAMERA Menu

The first menu in the camera is for controlling how all the buttons and switches on the camera operate, and for adjusting physical camera operations such as the speed of the autofocus. This menu is further divided into three sub-menus: SW MODE (for the behavior of the general switches and buttons), AUTO SW (for controlling how the camera behaves when the AUTO/MANU switch is set to AUTO), and USER SW (for assigning various functions to the physical and software-based User Buttons).

SW Mode>Gain Switch

Before addressing what the Gain Switch does, you should understand what Gain is. Please see the section on Gain in the Understanding Exposure article.

There is a physical switch for the amount of electronic gain, with three positions: Low, Mid, and High. You can choose how much Gain gets assigned to each position, anywhere from -3 to +18dB, in 1dB increments. The lower you set the gain, the darker the picture becomes, and the cleaner the noise becomes (i.e., less grainy). The higher you set the gain, the brighter the picture becomes, with a corresponding increase in the amount of grain and noise in the image.

There is no provision on the Gain Switch for automatic gain control, but you can put the camera in automatic gain using the CAMERA>AUTO SW menu and setting the AUTO/MANU switch to AUTO.

Note: sometimes you can change the gain and the exposure doesn't seem to change at all. Check to see if the camera is in either auto-iris or auto-shutter mode; if so, it may be adjusting the exposure on its own, which may be cancelling out the changes in gain you're making.

SW Mode>Super Gain

In addition to the gain choices offered by the Gain switch, you can also get up to +24 to +36 dB of Super Gain. Super Gain is only possible through the

use of the User Buttons. This menu item lets you decide how much gain will be applied when you enable Super Gain. Just remember, use of Super Gain should be restricted to times when it's absolutely necessary, since the image will become much noisier and grainier under Super Gain.

SW Mode>O.I.S. (Optical Image Stabilizer)

This menu item engages or disables the optical image stabilization system. The camera has a User Button dedicated to this function (User Button 1); however, if you've reassigned User 1 to a different function, you can still come into the menus and use this selection to enable or disable the O.I.S. Read more about the O.I.S. in the Physical Switches, Buttons, and Jacks section.

SW Mode>Hybrid O.I.S.

The camera's optical image stabilization system can work in two different modes: normal, and "hybrid".

Normal optical image stabilization is done on two axes, pan and tilt. The lens elements detect motion and they are repositioned to effectively cancel out that motion. It's effective and it works well. However, if you engage the Hybrid O.I.S., the camera adds three more axes of stabilization (sliding left/right, sliding up/down, and rotation. It does this using electronic stabilization technology; scanning a further area around the sensor lets the system reposition the image to cancel out horizontal or vertical sliding motion, and rotation. These types of motion are especially likely to happen when walking while carrying the camera, for example, so Hybrid O.I.S. is especially effective for handheld footage. However, if you're doing a shot that specifically uses horizontal or vertical sliding (such as mounting the camera on a sliding dolly), you may want to disable Hybrid O.I.S. for those occasions.

SW Mode>O.I.S. Mode

You can program the optical image stabilizer to optimize it for certain different shooting scenarios. The default settings are an attempt to provide good, all-purpose stabilization for handheld shooting, but sometimes you may want to customize the stabilizer for a particular type of shooting. As a simple example, the optical stabilization needs while running with the camera during a reality-TV shot, are probably quite different from the optical image stabilization needs when you've got the camera mounted to a dolly and are tracking a moving subject.

There are three choices:

NORMAL is a general-purpose setting, most suitable for handheld use or when you expect that you will be moving the camera around.

PAN/TILT is optimized to eliminate tiny motions (like vibration or subtle shaking). It expends most of its efforts in eliminating small motions, allowing larger moves to proceed without any stabilizing effort. This would be a good setting for a tripod shot where you do plan on panning or tilting. When on a tripod, the tripod itself should stabilize the camera adequately, so any small vibrations or little motions would be something the O.I.S. would be optimized to cancel out.

STABLE is suitable for a locked-off tripod shot, where no camera motion is expected at all. Here the camera will actively and aggressively try to combat any shaking or vibration. It assumes that there should be no motion, so any motion is to be stabilized against. This would be a poor choice for handheld footage or for when you expect to move the camera by panning or tilting.

SW Mode>ATW

To understand the ATW (Auto Tracking White) function, one should first understand the concept of color temperatures and white balance; please refer to the article on Understanding White Balance.

The White Balance switch offers three positions: Preset, A, and B. In Preset, pressing the AWB button on the front of the camera will toggle between P 3200K, P 5600K, and Variable settings. In position A and position B, you have the choice of configuring those channels for manual or automatic white balance.

In manual white balance, you point the camera at a white card in the scene, filling the screen with white, and press the AWB button in. The camera will analyze what it's looking at, and figure out how to manipulate the colors so that the object on the screen will actually look white. In automatic-tracking white (or ATW) mode, the camera continuously evaluates the scene and continuously adjusts the colors in a never-ending search for the proper white balance. See the Physical Switches, Buttons, and Jacks section for more info on the White Bal Switch and its settings.

This ATW menu setting lets you choose which position (PREset, A channel, or B channel) to assign the automatic white balance tracking to. The ATW is not assigned to the White Balance switch by default, but this menu item

can be used to assign it to one of the positions on the White Balance switch. Normally you have two separate white balance settings you can keep in-camera (A channel and B channel), but this menu setting lets you assign ATW to "A", "B", or to the PRST (Preset) position.

If you want to use automatic white balance, you either have to assign ATW to one of the positions on the white balance switch, or assign it to a User Button. Either method results in identical operation; the difference is whether you prefer to take up one of the three positions on the White Balance switch, or if you'd instead rather use up one of your User Buttons to get it.

SW Mode>ATW Speed

When using automatic tracking white balance, the camera will adjust its white balance to match the current lighting conditions. This menu item lets you establish how quickly those adjustments happen. The slower the speed, the more gradual the transition.

SW Mode>ATW Target R and ATW Target B

These menu items work very similarly to the SCENE FILE menu's RB GAIN CONTROL SETTING menu options, but are used for adapting the ATW's color balance. Adjusting the ATW TARGET R lets you influence the automatic white balance to bias the color towards more or less red; adjusting ATW TARGET B lets you influence the ATW system to add or remove some blue. Whereas RB GAIN CONTROL SETTING can't be used during ATW operation, these menu controls give you similar power over the image specifically when using ATW. Of course, if you're not using ATW, then this menu item will have no effect on the image.

SW Mode>W.Bal Preset

This lets you set what color temperature you want assigned to the PRST position of the white balance switch (either 3200K, 5600K, or Variable). Regardless of what you set it to here in the menu, you can toggle it by using the AWB button on the front of the camera under the lens. For information on how to set the Variable color temperature, see the next menu item.

SW Mode>WB VAR

You can set the WB Preset value's color temperature to either a preset 3200K, or a preset 5600K, or a variable setting ranging from 2,000K all the

way up to 15,000 Kelvin. This menu item lets you set the value that will be used when the White Balance switch and AWB button are used to select the Variable white balance preset. This menu item is disabled unless you've set the SW MODE>W.BAL PRESET to "VAR".

While setting the white balance manually to a specific color temperature is convenient (and popular), it may not lead to the best quality video. In many circumstances you'll get better color rendition by taking a proper manual white balance off of a white chart (like a DSC Labs CamWhite). When you set the white balance manually using the preset, it can account for variations in color temperature (on the red/blue axis) but it won't adjust for any variations in color fidelity (on the magenta/green axis). If you have low-CRI (Color Rendering Index) lights, they may be putting out a greenish cast, which will not be accounted for when using manual variable white balance; that type of color cast is only properly resolved by taking a proper manual white balance and letting the camera see the actual color the lights are casting on a white object, so the camera can adjust and balance its processing to render proper colors under that light. Note that you can adjust on the magenta/green axis using the SCENE FILE menu items, but those are specific to the scene file selected, not to the prevailing light conditions.

SW Mode>H. Zoom Speed

The zoom lever on the camera's top handle operates at a single fixed speed. This menu item lets you choose what speed you want. On the slowest speed ("1"), it will take almost three minutes to zoom from full wide angle to full telephoto. On the fastest speed ("99"), it takes about two seconds to zoom from full wide to full telephoto. Note that "Fast Zoom" does not affect the handle zoom speed.

SW Mode>i.Zoom

This menu item is functionally identical to assigning "i.ZOOM" to a User Button. It allows you to enable or disable the i.ZOOM function. The i.Zoom is a way to extend the zoom range of the camera, without compromising quality. Whereas the Digital Zoom works by digitally scaling up the existing video frame, the i.Zoom works quite differently — it crops in further and further on the sensor to create its zoom effect. Because the CX350 is an Ultra High Definition camera, it uses massive oversampling when in the HD and SD modes; that means there are more than enough pixels to produce a fully-resolved, full-detail image, even at the maximum

i.Zoom setting of 1.6x magnification. When in UHD mode, the i.Zoom provides up to 1.2x additional magnification without resolution loss.

The i.Zoom is integrated into the normal zoom range. If the lens is set to anything other than 100% telephoto, then all zooming will be done optically, using the optical zoom range. Once you reach 100% telephoto, that's when the i.Zoom kicks in. You'll see on the LCD display next to the zoom setting that in normal/optical zooming, the readout will show a lower-case "i" next to the zoom display when i.Zoom is enabled, but when you exceed the maximum optical zoom, the "i" becomes inverted (black "i" on a white background), indicating that you're in the i.Zoom range.

If you were to combine the camera's 20x optical with i.Zoom when in HD mode, it gives the camera a practical 32x zoom range when i.Zoom is enabled and used. When in UHD mode, it gives the camera a practical 24x zoom range.

SW Mode>MF Assist

When using manual focus in the field, it's not always easy to get pinpoint focus. MF ASSIST is designed to help in these scenarios. MF ASSIST works only when the camera is set in manual focus, and it enables a little bit of autofocus at the end of your focus move. With MF ASSIST engaged, you'd focus as normal, and when you stop moving the focus ring then the camera will kick in autofocus in a very limited range right at the end to try to nail pinpoint focus. It then reverts to manual focus mode, locking in the focus position. For cinema-style shooting you may want to leave this off, but for ENG or run 'n' gun, turning it on can make one-man-band focusing a simpler task. Now, there's no guarantee that focus will be perfect when using MF ASSIST; for one thing, it can only work within very narrow parameters, so if your manual focus is too far off the mark, then MF ASSIST won't be able to overcome that. You have to get your manual focus close enough that MF ASSIST is able to finish off the job within the limited amount of range that it's given. If it can't find proper sharp focus after a few seconds, it will abandon the attempt and return the focus position to where you had left it when you finished your manual focus.

SW Mode>Macro

Generally the lens is capable of focusing to a minimum of 3.11 feet at full telephoto. You can enable the MACRO focus option here, which allows the

lens to focus closer (as close as about two inches when the lens is zoomed out to maximum wide angle). Using this menu item is fundamentally the same as assigning FOCUS MACRO to a User Button; see that discussion for more information. If you're using manual focus, go ahead and enable MACRO; if you're using a lot of autofocus, and are not planning on using the ultra-close range, then the autofocus system can perform quicker and more efficiently with the macro turned off. The autofocus system can be more responsive if it's using the range from 3 feet to infinity, rather than having to hunt all the way down to two inches and back to verify focus.

SW Mode>AF Area Width

You can configure the area on the screen that the autofocus system uses to judge focus. When you enable this feature, a red box appears on the LCD screen and viewfinder; you can use the multidial wheel to make the red box wider or narrower. Constraining the autofocus to only evaluating your subject (and thus ignoring the rest of the screen) can result in better, more responsive autofocus performance. Setting the width of the autofocus area can be done here, or via a User Button; either way the results are the same.

SW Mode>A. Iris Speed

When the camera is set in automatic iris mode, the camera adjusts the iris for proper exposure according to the existing light conditions. This menu item lets you control how quickly the camera can adjust the iris. The slower you set it, the more gradual any changes will be; the faster you set it the more abrupt the changes will be.

SW Mode>A. Iris Window

This menu item lets you instruct the camera as to what area of the frame to evaluate when making automatic iris exposure decisions. The choices are:

NORMAL1: In this mode, the camera acts like just about any other camera on the market, it evaluates a large section of the center of the frame and sets exposure to what it thinks best represents the whole frame.

NORMAL2: In this mode the camera evaluates the lower section of the frame. This would be most useful in outdoor shooting, where a bright sky might otherwise override the exposure and make all the ground-based subjects look too dark; with NORMAL2 the lower section of the frame is evaluated on its own, thus minimizing how much effect the sky at the top of the frame influences the exposure.

CENTER: In this mode, the camera restricts its exposure evaluation to a small central section of the screen. This can be very effective if, for

example, you want to set exposure properly for faces; you could zoom in on a face, let the auto-iris system establish exposure, and then switch to manual exposure and zoom back out to compose and shoot. In this scenario the exposure on the faces should be spot-on, and not adjusted based on additional dark grass, black tuxedoes, or bright skies or white buildings or other objects that re-enter the frame when you zoom back out.

SW Mode>Area Mode: The AREA function can be used to set which area of the screen the autofocus or exposure system prioritizes. This can come in handy if you're trying to direct the viewer's eye to a section of the screen that's not the center of the screen (normally autofocus prioritizes what's in the dead center of the screen). Or, if you're shooting an interview and you've established the framing with the subject on the left side of the screen, and there's a window behind them on the right side, you might want to use the AREA function to tell the camera to prioritize exposure on the subject's face, ignoring the window. The options in this menu include:

INHIBIT: This inhibits the AREA function from working at all, even if you've pressed the User Button assigned to AREA.

Focus: This tells the system that it should direct its autofocus system to work on the area of the screen that you designate (by touching the LCD when the AREA function is active, or using the playback play/ff buttons to move the area box around the frame). If you're operating the camera in manual focus, it will briefly engage autofocus when you touch the LCD, grab a quick focus point, and then return to manual focus.

Iris: Choosing this option lets you direct the camera as to what area of the screen it should prioritize when determining exposure levels, when using automatic exposure. Note that even though the name of this is IRIS, the camera will not be limited to using just the iris; it may also use the automatic shutter (if enabled) and automatic gain (if enabled).

Y Get: The "spot meter" function normally reports the brightness value of whatever's in the center of the screen. With this function you can sample the image anywhere on the screen, and perhaps in a larger area too (if you change the size of the AREA function's sampling rectangle to a larger or smaller size, using the multidial wheel).

Focus/Iris: Tells the system to use the selected region for both autofocus and autoexposure purposes.

Focus/Y Get: Tells the system to use the selected region for both autofocus purposes, and to also have the "marker" system report the brightness level of the selected area.

Note that none of this will happen if you haven't used a User Button to enable the AREA function. This menu is establishing what functions will happen when AREA is enabled, but you must use the User Button to enable the AREA function before this menu item can take effect.

SW Mode>IR Rec

The CX350 has the ability to remove its internal infrared filter, which results in the camera being able to record in the infrared portion of the light spectrum. Since infrared light is invisible to the human eye, this means that if you use an auxiliary infrared light, the CX350 can literally record in the dark. Note that there are exposure limitations when IR REC is engaged; the iris will be set to maximum wide open and will not be adjustable, and the neutral density filters are disabled. This is suitable for shooting in the dark, but can make getting exposure in bright light very difficult. You do have limited exposure control when IR REC is enabled however; you can use the gain switch and you can use the manual shutter speed to control exposure.

Auto SW sub-menu

The camera features a handy switch called "AUTO/MANU." When you slide the switch towards AUTO, the camera can override all sorts of manual settings and go into fully-auto mode: useful if you need to grab the camera and start shooting something, with no time to adjust manual settings. The "AUTO" setting might help you guarantee that you get your shot, even if it's not the absolute best video quality (which can usually only be obtained with proper tuning of manual settings.) But the AUTO/MANU switch doesn't necessarily have to mean that everything goes full-auto: you can control which functions are operated in auto mode and which ones stay in manual control.

Note: these functions have no impact on the camera's operations at all if the AUTO/MANU switch is set to MANU. These only come into play when the switch is slid to AUTO.

Auto SW>A. Iris

If you set this setting to ON, then when the "AUTO/MANU" switch is slid to AUTO the camera will perform auto-iris functions. If this menu setting is OFF then the camera will operate according to what the IRIS button was

previously set to. Even when the AUTO/MANU switch is set to AUTO, you can still toggle back and forth between automatic and manual iris operation using the IRIS button on the side of the lens, and you can still use the AREA function to direct where in the frame the camera uses to evaluate automatic exposure.

Note that when the iris is in automatic mode, you still have the ability to influence the exposure by using the iris ring; you can bias the exposure system to overexpose or underexpose by rotating the ring. The iris will still be controlled automatically, but the system will take your request into account and it will adjust the exposure relative to the number you've set with the iris ring.

Auto SW>AGC

AGC stands for Automatic Gain Control. This is a way for the camera to control exposure through adjusting the gain, rather than through the iris or shutter. This menu item controls whether or not the camera will have permission to automatically control the gain when the AUTO/MANU switch is slid to AUTO.

Auto SW>AGC Limit

This switch lets you control the ceiling of how much gain the Automatic Gain Control is allowed to use. You can choose to limit the AGC system to as little as 3 dB of gain, or give it the ability to use up to 18 dB of gain.

The camera will decide how much gain to use, up to the maximum that you specify, when the AUTO SW>AGC is set to ON and the AUTO/MANU switch is set to AUTO. Note that the gain being discussed is only for the picture; if you want to have the camera automatically adjust the audio levels you have to do that by setting the AUDIO>REC CH SETTINGS/CH1/2 LEVEL menu settings to AUTO.

Auto SW>AGC Point

When the camera is in AUTO mode and the AUTO SW>AGC is set to ON, the camera is able to automatically control the picture gain to adjust exposure; however, in general the camera would prefer to adjust the iris instead of the gain whenever possible. If the AUTO SW>A. IRIS is enabled, the camera will adjust the iris before it adjusts gain; if the lighting conditions dictate that the iris is all the way open, then the gain takes over to continue increasing brightness. In this case, gain is not used unless the iris has already reached its maximum opening. On the other hand, if the AUTO

SW>A. IRIS is disabled, then the camera won't be able to adjust the iris, so if it judges that the picture needs to be brighter then it will use automatic gain regardless of where you've manually set the iris. When the AUTO SW>A. IRIS is enabled, gain is only used once the camera has opened its iris up to a certain threshold; this menu item lets you determine what that maximum opening will be: you can set it so that gain takes over when the iris reaches f/4.0, or when the iris reaches f/5.6. This lets you prioritize using gain instead of iris for that last f-stop of brightness.

If you've configured the camera for manual iris (even when the AUTO/MANU switch is set to AUTO), then the camera will ignore this threshold and will use gain to adjust the exposure at all times.

Auto SW>A.Shutter

This switch controls whether or not the camera can automatically adjust the shutter speed, when the AUTO/MANU switch is set to AUTO. You can prevent the camera from automatically changing the shutter speed by setting this to OFF. Normally the camera will choose to adjust the iris instead of the shutter whenever possible, but if the iris is already as closed as it can get, the camera will then turn to adjusting the shutter speed. The camera can also slow down the shutter to increase brightness in darker scenes, depending on your recording format: for 29.97p it can use a slow shutter down to 1/30, for 25.00p it can use down to 1/25, and for 23.98p it can use down to 1/24.

Auto SW>A.Shutter Limit

When the automatic shutter is enabled, the camera can automatically adjust the shutter speed to a higher shutter speed to lower the exposure in bright conditions. This menu item lets you control how much adjusting the automatic shutter can do. Normally, when the shutter is off, the shutter speed is usually 1/50 or 1/60 second; this menu item lets the automatic shutter go up to 1/100, or 1/120, or as much as 1/250 of a second.

Auto SW>A.Shutter Point

Earlier we described how the automatic gain can take over to allow the image to continue to be made brighter even though the iris has reached its maximum opening limit. This menu item works for the opposite end of the scale; generally the exposure system prefers to close the iris down further and further to cope with too-bright exposure, until the iris has reached its minimum size. After that, the automatic shutter can take over to continue

darkening the scene even further. This menu item lets you choose at what iris setting that transition takes place; either at f/8.0 or at f/9.6. Generally for the very sharpest images you don't want to stop the iris down very far, but for the smoothest motion you generally don't want the shutter speed to be too high either. This menu item lets you prioritize diffraction sharpness or shutter speed motion when the AUTO/MANU switch is set to MANU, and the A.Shutter is enabled.

Auto SW>ATW

Two settings, ON or OFF, determine whether the camera will perform automatic tracking of white balance when in AUTO mode. If it's set to ON, the camera will start automatically tracking white balance when the AUTO/MANU switch is set to AUTO. If it's set to OFF, the camera will be forced to use whatever setting the WHITE BAL switch has currently selected. You can always set the camera to ATW without resorting to the AUTO/MANU switch, of course.

Auto SW>AF

This setting determines whether the camera goes into Autofocus mode when the AUTO/MANU switch is set to AUTO. If set to ON, the camera will go into autofocus mode, regardless of whether the FOCUS switch is set to Auto, Manual, or Push Auto. None of those switches will have any effect, because the camera will ignore them and continue to run in autofocus mode. When set to OFF, the FOCUS switch controls how focus operates: if it's set to Auto, or Push Auto is held down, autofocus will continue to work; if it's set to Manual, then it'll be operating in manual focus.

When used with slow shutter speeds, Autofocus is much slower to respond. Also, when used with a slower frame rate (such as 23.98p), autofocus responds more slowly. Autofocus performs best in 50p/59.94p or interlaced modes, and under bright light conditions, with a 1/60 or faster shutter. Autofocus performs less efficiently in slower frame rates, under lower light conditions, or when using slow shutter speeds. Also, enabling the MACRO function can make autofocus much slower to respond; for the fastest autofocus performance you'd want to leave that set to OFF unless you're shooting at very short distances to your subject.

User SW sub-menu

The camera has 12 available User Buttons that can be customized to perform one of dozens of different functions. There are 7 physical buttons, and five "virtual" buttons which are available when you hold your finger on the LCD screen for a couple of seconds. This menu lets you assign which function you want to each of the 12 User Buttons.

Notice that all of the physical User Buttons have pre-assigned labels next to them. The 1st User Button has an actual printed label on the camera body that says "O.I.S.", and this button is programmed by default to control the Optical Image Stabilizer. Likewise, User Button 5 has a preprinted label of SLOT SEL and is located on the bottom left rear side of the camera near the memory cards. The thing to note here is that while many of the User Buttons are already labeled for convenient functions, they are not restricted to those functions. You can reprogram any of the User Buttons to perform any of the functions contained in this USER SW menu. In fact, you can program a User Button (or even all of the User Buttons) to do nothing at all; if you set a User Button's function to INHIBIT, then pressing that button will have no effect whatsoever. So the layout and programming of the camera's buttons are completely modifiable and configurable to however you'd prefer to work. I would just point out that while you could set the Waveform Monitor to be activated by User Button 7/AWB, and you could program User Button 3/WFM to invoke the White Balance function, you should probably think twice before doing so, as the printed labels could make it confusing to operate the camera, especially if you have a secondary camera operator involved. But, the flexibility exists and the choice is yours as to how you want to program your camera and what functions you prefer to have quick access to.

You can always quickly verify what functions are assigned to which User Buttons by holding down and then repeatedly pressing the DISP/MODE CHK button.

User SW>Inhibit: Assigning this function essentially disables this particular user button. If you find yourself accidentally/unintentionally pushing user buttons, you might want to "inhibit" them with this function.

User SW>AWB: This provides the same functionality as pressing the AWB button on the front of the camera. In fact, it is the same functionality; since the AWB button is actually a reprogrammable User Button in and

of itself, this AWB function is the default function assigned to it. If for some reason you decided you wanted to use the AWB button for some other purpose and programmed it to a different function, you could assign this AWB function to a different User Button so you still had access to the same functionality. Note that this is not the same thing as ATW; the AWB function initiates a manual white balance, whereas the ATW function initiates the process of continual automatic white balance tracking.

User SW>DRS: The SCENE FILE>DRS capability is discussed in the Scene File menu section. Assigning this function to a User Button lets you toggle the Dynamic Range Stretching function on or off. It's the same as if you went into the Scene File menu and manually changed the DRS menu item, but locating it here lets you toggle DRS with the push of a button instead of having to go into the menus. Note: this doesn't allow you to set the intensity of the DRS effect; it only enables or disables DRS processing. You set the intensity of the DRS effect using the SCENE FILE>DRS EFFECT DEPTH menu option.

User SW>FBC: This User Button enables or disables the Flash Band Compensation function. Flash Band Compensation is designed to minimize the bright and dark bands common with rolling-shutter cameras when a flash goes off. The issue is discussed in the PARTIAL EXPOSURE section of the Rolling Shutter article. When the camera detects that part of the frame is very bright and then suddenly very dark, it can try to compensate to make the entire frame continuously bright or continuously dark, thus evening out the transition and removing the artifact known as "flash banding". You should only enable this function when you know you're going to be in an environment where photographic flashes might be going off; otherwise, leave it disabled. Note that it will only work if the shutter speed is set to OFF; if you've set a manual shutter speed then the FBC button will just display "invalid."

User SW>One Push AF: When you're using Manual Focus, you can tell the camera to execute a quick one-touch autofocus procedure by using the One Push AF function. This will temporarily put the camera in autofocus mode until it locks in focus, at which point it will revert to manual focus mode. Alternately, you can hold the button in to keep it in autofocus mode until you want to let go; at that point it will stay in autofocus until it locks in, and then revert to manual. Assigning this function to a User Button is functionally the same as using the PUSH AUTO button on the side of the camera under the Focus Switch.

User SW>S.Gain: Besides the settings you can assign to the Gain button, there's a separate user-settable maximum limit of electronic gain, called SUPER GAIN. You set the limit in the CAMERA>SW MODE>SUPER GAIN menu. Then, assign S.GAIN to a User Button; pressing that User Button will trigger S.GAIN. Consider that 30dB of gain makes the image 32 times brighter than at 0dB, and 36 dB of gain makes the image a full 64 times brighter! That's a whole lot of gain, and it will bring a whole lot of noise with it. Your image quality will be seriously compromised by using such a high level of gain, but if you can't get the shot any other way, you may want to consider it.

User SW>Area: If you've ever wanted to just point to a spot on the LCD screen and tell the camera "focus here" — well, that's what the AREA function can do. You have the capability to specify what section of the frame you want the camera to prioritize when it comes to certain functions. Assigning AREA to a User Button lets you enable this "AREA" mode; you'll see a yellow crosshairs display on the screen and there'll also be an indicator saying "AREA" in the upper right of the display.

The AREA function is not just for focus; you can have the system also prioritize exposure, or even other features, depending on how you've set up the CAMERA>SW MODE>AREA MODE function.

Assigning AREA to a User Button, and pressing that button, activates the AREA mode. It will stay activated until you press that same User Button again to de-activate it. While the AREA mode is active, you can move the frame anywhere you want just by touching the LCD display, or by using the play/fast forward/rewind/stop buttons to move the cursor around. The camera will automatically set the focus or exposure (or whatever function you've specified) in that region of the frame. You can also use the MultiDial to change the size of the AREA frame, so you can have your chosen function take place based on a larger or smaller section of the screen. While the AREA mode is active, you can't use the touchscreen for anything else; you won't be using the touchscreen to access the menus, for example. You'd have to use the physical MENU button to be able to access the menus. This also means that the five "virtual" User Buttons (#'s 8, 9, 10, 11, and 12) won't be available while you're using Area Mode.

Also, keep in mind that the functionality of the Area Mode depends on how you have the camera configured for automatic or manual control. If you've set the camera to manual focus and manual exposure, but you configure the AREA MODE function for "FOCUS/IRIS", then the camera will briefly

go into automatic focus and automatic iris when you move the AREA box on the screen. It'll return to manual focus and manual iris once it's grabbed focus/iris; it won't continually monitor focus and exposure in that case. On the other hand, if you set the camera to automatic focus and automatic iris, then yes, the camera will continually monitor and adjust focus and iris while in AREA mode.

User SW>AF Area: This is another way to control what region the autofocus system uses to determine what to prioritize for focus. Unlike the AREA function, this doesn't let you move the region around the screen, but it does let you define the size of the region that the autofocus system will use to focus on. Press the User Button you've assigned to this function, and the camera will draw a red box on the LCD showing what the current autofocus region is. Then use the multidial wheel to change the size of the box; the camera will then prioritize its autofocus efforts to focus on that section of the frame. This is a temporary modification; it's in effect until you cancel it (by pressing this User Button again). If you want to adjust the size of the box while the AF AREA function is active, you can use the multidial wheel to scroll to "AF AREA", and press the wheel in like a button; it will then bring up the AF AREA box and you can adjust it as before.

This function is only possible if the camera is set in Autofocus mode, of course.

User SW>ATW: Enables or disables Automatic Tracking White balance: for more information see CAMERA>SW MODE>ATW.

User SW>ATW Lock: When using ATW, the system will constantly hunt for what it considers the optimal white balance. You can stop the camera from hunting and tell it to lock in the current white balance setting by using the ATW LOCK function. If you use ATW LOCK to lock in the white balance, and then press ATW LOCK again, it will un-lock and return to hunting in ATW mode. Note that this ATW LOCK function is only available if the current white balance mode is ATW; it won't work if the current white balance is set to a preset or to manual white balance.

User SW>Spotlight: Pressing this button will cause the system to expose about 1 1/3 f-stops darker, as versus what it would normally auto-expose at. If the camera was set in manual iris mode, pressing SPOTLIGHT will force it to go to auto-iris mode. When SPOTLIGHT mode is enabled, you'll see the iris display on the LCD will be prefixed by "SPOT" instead of "STD".

User SW>Backlight: Pressing this button will cause the auto-exposure system to expose about 2/3 of a stop more brightly than it would otherwise have done. If the camera was set to manual iris, pressing BACKLIGHT will force it to go to auto-iris mode. When BACKLIGHT is enabled, you'll see the iris display on the LCD will be prefixed by "BACK" instead of "STD".

User SW>A. Iris Level: This enables (or disables) the ability to instruct the automatic exposure system to bias for brighter or darker images. Assigning this function to a User Button allows you to toggle the feature on or off without having to go into the SCENE FILE>A.IRIS LEVEL menu to change it. This is the default function of User Button 4.

User SW>Iris: This toggles the automatic iris on or off. This is the default function of User Button 6, and a duplication of the IRIS BUTTON on the left side of the camera under the ND Filter switch.

User SW>Y Get: This function enables (or disables) the Y Get spotmeter. When enabled, the camera will sample the brightness in the center of the screen and report that average IRE level in the lower left of the screen. White will generally be represented at >95%, and black will usually be represented with <3% (although those levels can be affected by your scene file settings, especially the black stretch, master pedestal, and white clip functions).

User SW>Focus Macro: The lens generally focuses to a minimum distance of about 3.11 feet. It can, however, focus much closer if you use the Focus Macro User Button. With Focus Macro enabled, the lens can focus closer; the more you zoom out, the closer it can focus, down to as close as about two inches from the front of the lens. The close focus distance depends on the zoom setting; it's about 2 inches from 8.8 mm up to about 55 mm, and then it gradually increases to about 1 foot at about 81mm, up to around 3.11 feet at 149mm to full telephoto.

Why would you ever want to turn Focus Macro off? The main reason would be for when using automatic focus. If Focus Macro is on, it greatly increases the range that autofocus has to search, to find proper focus. Turning Focus Macro OFF reduces the range it has to search, and results in more responsive, quicker autofocus (assuming, of course, that what you're focusing on is further than about 3.11 feet from the front of the lens!)

User SW>O.I.S.: This lets you assign a User Button to toggle the Optical Image Stabilizer on/off. By default, User Button 1 is programmed with this function. See the section on the O.I.S. BUTTON for more information.

User SW>i.Zoom: This user button enables or disables the i.Zoom function. This functions the same as setting the CAMERA>SW MODE>I. ZOOM function to ON or OFF, but lets you do so through a button press rather than having to go into the menus to do it.

User SW>D.Zoom: The camera has the ability to digitally magnify the image ("digital zoom") by a factor of 2x, 5x, or 10x. This magnification operates independently of the optical zoom, so you could (if so desired) have the lens zoomed out to wide angle, but still engage the digital zoom (although there are probably few valid reasons to actually do that.) Using D.ZOOM extracts a central portion of the image and digitally stretches it up to fill the frame, but it also causes a corresponding loss of resolution and contrast. The more magnification, the softer the resolution will be, and the flatter the contrast will be. How useful it is depends to a degree on what mode you're shooting in. A Digital Zoom of 10x is going to look extremely low-resolution, soft, and aliased if it's mixed into in the middle of a UHD production, for example, but a D.ZOOM of 2X might look outstanding when recording in standard-definition mode.

In 1080p HD, a 2X D.ZOOM will be a little softer than a non-zoomed image, but I find that it looks surprisingly good; at 5X the image is definitely softer and flatter but still looks decent and may or may not meet your standards of acceptability. I think 10X is too much and the resulting image is too soft and flat and blocky to successfully integrate alongside normal HD footage.

In UHD, I find that 2X is about the limit for retaining decent sharpness and contrast; 2X may or may not meet your standards. I find that in UHD, any usage of 5X or 10X D.ZOOM results in a notable loss of resolution and a significant loss in contrast.

D.ZOOM might perhaps be most appropriate when shooting in lower light conditions where zooming in optically might result in the lens stopping down the iris, and if you're in a case where brightness is more important than sharpness you might be able to optically zoom back out and use the digital zoom (especially when in HD and using only 2X).

User SW>IR Rec: This User Button enables (or disables) the Infrared Recording Mode. When you enable it, the camera removes its built-in infrared filter, allowing it to record footage solely via infrared light. This literally lets the camera see in the dark (as long as there is some infrared light available). You generally don't use this in daylight; it's designed for low-light use, and will usually require using an accessory infrared light. With an infrared-emitting light installed, you can film in pitch-black conditions, which may be useful for reality TV or wildlife filming, for example. Do be aware that the focus distances reported by the camera may not be accurate when recording in IR REC. When IR REC is enabled, the camera will force the iris to maximum wide open and disable the neutral density filters in order to let in the most light. You retain some ability to set the exposure by using the shutter speed or by changing the gain. If that's not enough, you can consider adding external ND filters in front of the lens to control exposure even further.

User SW>Fast Zoom: This User Button enables or disables the Fast Zoom option. This allows a higher-speed drive mode of the zoom motor, which results in approximately doubling the fastest maximum zoom speed at the trade-off of hearing more zoom motor noise during the zoom. If you want the fastest possible zooming, turn this on. If you need the quietest possible zooming, leave this set off.

User SW>PRE REC: Assigning this to a User Button lets you toggle PRE-REC on or off without having to go into the RECORDING>PRE REC menu to do so. Using this User Button won't actually start recording; instead it will start the PRE REC buffering. You'll still have to press the regular red record button to start actual recording (including the PRE REC buffer).

Note that PRE REC won't work while recording VFR or when set for BACKGROUND RECORDING or time-lapse Interval Recording. PRE REC will also time out after about three hours; if you haven't hit record within three hours of enabling PRE REC, it'll turn itself off. And, obviously, if you start recording immediately after enabling PRE REC, you can't expect to get the full three to ten seconds of pre-record (that would only be possible if at least 11 seconds have passed between enabling PRE REC, and starting recording).

User SW>VFR: This User Button enables Variable Frame Rate (VFR) recording if certain criteria are met (such as that the camera must be in MOV recording, and you can't have set BACKGROUND or SIMULTANEOUS

recording, and all the other usual prohibitions associated with VFR.) Fundamentally, this User Button does the same thing as going into the SCENE FILE menu and choosing VFR. You can toggle the state of VFR on or off with this User Button, exactly as you can do with the SCENE FILE Menu option. See the discussion on SCENE FILE>VFR for more information.

User SW>Super Slow: This button toggles Super Slow Recording on/off. It provides the same functionality as the SYSTEM>SUPER SLOW menu item, but with the convenience of it being on a User Button. Of course, all the same restrictions about Super Slow Recording apply (for example, it won't work in AVCHD or UHD recording or if streaming is enabled, etc.)

User SW>REC Check: This will play back the last few seconds of footage you shot, without having to switch the camera over to thumbnail mode. You can't use this button to actually rewind and watch the whole clip; you'd have to toggle over into playback mode to review the entire clip. Note that there are several circumstances that will make this function not work, such as turning the camera off, or changing the recording format, or ejecting the memory card. It also won't work if you've established 2-slot recording (either Simultaneous or Background), or if you're using PRE-REC or time-lapse interval recording. Using this function is fundamentally identical to using the dedicated REC CHECK button on top of the handgrip.

User SW>Backgr Pause: When using Background Recording, typically card slot 1 is started and stopped frequently, whereas card slot 2 records continuously. But using this User Button function, you can pause the recording on card slot 2; just assign this function to a User Button and hold in that User Button for five seconds or more to pause the background recording. Note that this will only work if you've already paused the first card slot's recording. You can't have card slot 1 recording and card slot 2 paused, background recording doesn't work that way.

User SW>Del Last Clip: This function allows you to immediately delete the last clip you've just shot. Instead of toggling over to the playback mode and manually selecting and deleting a clip, you can instead delete the last clip with the press of a USER button (and, of course, verifying that you actually do intend to delete that clip). It's convenient, but it's not dangerous; it's difficult to accidentally delete a clip because the system asks you to confirm that you really intend to delete it. The DEL LAST CLIP function won't work if you've changed recording formats since shooting your last clip, or if you've powered down the camera, or if you've gone into playback

mode, or if you've ejected a memory card since recording the clip. It also won't work during interval recording, or if you're using the 2-slot recording functions (other than RELAY REC).

User SW>Slot Sel: This lets you change which card slot the camera will record to next. This is the default function of User Button 5.

User SW>Expand: You can assign either EXPANDed focus assist, or colored PEAKING, to the Focus Assist button, and additionally, you can assign the EXPANDed focus assist by itself to a user button. So if you've set the FOCUS ASSIST button to PEAKING, you could assign EXPAND to a User Button, and then be able to use both functions simultaneously.

User SW>Peaking: You can assign either EXPANDed focus assist, or colored PEAKING, to the Focus Assist button, and additionally, you can assign the PEAKING focus assist by itself to a user button. So if you've set the FOCUS ASSIST button to EXPAND, you could assign PEAKING to a User Button, and then be able to use both functions simultaneously.

Note that this is not the same as VIDEO OUT/LCD/VF>FOCUS ASSIST>DETAIL; this PEAKING is the red (or other color you specify) peaking assist. This is a much higher resolution focus assist than the EVF/LCD DETAIL; the PEAKING operates at the pixel level on the image, outlining details that are in focus. The EVF/LCD DETAIL function sharpens the image that's on the monitor, but doesn't work at the pixel level on a UHD frame like PEAKING does.

User SW>WFM: This enables (or disables) the WaveForm Monitor (WFM) or Vectorscope (or both), depending on how you've configured the VIDEO OUT/LCD/VF>EI ASSIST>WFM MODE menu item. Note that User Button 3 is configured for the WFM by default, so assigning WFM to a different button may be redundant. Also, the WFM cannot be used while you're using the EXPAND focus assist.

User SW>Zebra: This User Button allows you to designate one of the physical or virtual User Buttons to enable the Zebra display. By default, User Button 2 is programmed with this function. See the section on ZEBRAS for more information.

User SW>Level Gauge: The camera has a built-in two-axis level gauge that can display both horizontal skew (camera rotated as compared

to the horizon), and vertical tilt (the camera being tilted up or down, and not level). This can be a great way to keep your eye on your horizons to keep them nice and flat. It's also a great way to level the camera when setting up a tripod, especially if your tripod head doesn't have a bubble level.

To read the level gauge, keep in mind that there are two indicators on each side of the frame - there's an orange line that grows longer the more rotated the camera is off of level (and it turns blue when the camera is leveled rotationally), and there's an indicator for tilt up/down which is the short white line. If the camera is flat and level, that short line will be white. If the camera is slightly off level (tilted up or down), the short line will turn blue; the further the camera is off from level, the further the whole indicator will move up or down. Watch how the indicator moves in relation to the center crosshairs; if the indicator is in line with the crosshairs and the line turns white, the camera is level (on the tilt axis); the further it is away from level, the further the indicator will move from the central crosshairs.

User SW>Level Gauge Set: No matter what orientation the camera is currently in, you can tell the Level Gauge that the current setting is the new "normal". Assign LEVEL GAUGE SET to a User Button, and press that User Button, and it tells the camera to treat the current orientation as flat and level. That way you can still use the Level Gauge to see deviations from your preferred aiming, tilting, and rotation point. When you want to reset the level gauge to true level settings, you can use the VIDEO OUT/LCD/VF>LEVEL GAUGE>LEVEL GAUGE RESET menu item.

User SW>LCD/VF HDR: When you've set SCENE FILE>GAMMA MODE SEL to HLG, this function lets you toggle the onboard displays (the LCD panel and the electronic viewfinder) between displaying standard dynamic range, and displaying High Dynamic Range. This is only for when shooting in the HLG gamma. Using this User Button is functionally equivalent to toggling the state of the VIDEO OUT/LCD/VF>LCD/VF HDR menu item. When shooting in HLG and setting the LCD/VF to HDR, you'll see all the tonality in the image, but the image will also look dark, muted, and flat. If you swap into SDR mode the image will look brighter and more saturated, but you won't be able to discern the additional dynamic range in the brighter tones. In some ways, you can think of the SDR display as like a "viewing LUT" for when shooting HDR images; it gives you a preview of what the footage will look like when displayed on a proper HDR display in terms of brightness, color and exposure.

User SW>VF ON/OFF: Generally the viewfinder is always enabled, but it might be turned off if its eye proximity sensor isn't being triggered. With this User Button you can force the LCD to turn on, or turn off; turning the VF off might save a little bit of battery and may result in slightly longer runtime from battery. When set to ON, the viewfinder will always stay on; when set to OFF, the viewfinder will shut off but will turn back on if its proximity sensor detects an eye close enough to the viewfinder.

User SW>LCD/VF Detail: This function lets you enable (or disable) the "detail" feature on the ViewFinder (VF) and LCD touchscreen panel. This can be a useful focusing aid for HD, but is not as accurate as the PEAKING focus assist when shooting UHD. You configure the particular settings for the amount of detail and its sensitivity in the VIDEO OUT/LCD/VF>FOCUS ASSIST menu; this User Button enables or disables the function.

User SW>Menu: This lets you duplicate the function of the physical MENU button on another physical or virtual User Button. There's not much point in duplicating it on another physical button, seeing as the camera already offers two physical MENU buttons, but this option is used by default for the #12 virtual User Button. When you touch the touchscreen and the bottom-left option is "MENU", that's a result of this function being assigned to virtual User Button 12. You can assign this to any other virtual User Button (or, for that matter, any physical User Button) if you so choose.

User SW>Load Setup File: If you've saved a camera setup file onto one of your SD cards, this function can be used to load that setup file. This would be useful anytime you want to reset a camera to a specific known set of settings. Make sure the memory card is in Slot 1; the camera won't load a setup file from Slot 2.

User SW>LCD Backlight: This function can be used to adjust the brightness of the LCD panel. Each press of the button toggles through the available settings (-1, 0, +1, or +2). A brighter setting makes the LCD easier to see in the daylight (I set mine on +2), but may result in quicker battery drain..

User SW>Card Reader Mode: The camera can be used as a USB card reader, by enabling Card Reader Mode. When this is enabled, and you plug the camera's USB-C port into a computer, the camera will be recognized as

two external "hard drives"; each slot's card will be the contents of that hard drive. Generally you want to leave this set OFF unless you're specifically using the camera to read USB cards at that time. This User Button function is functionally identical to using the OTHERS>USB DEVICE>CARD READER MODE menu option.

User SW>Streaming Start: If you've configured the camera for RTMP streaming, and have it connected to a network already, then you can use this User Button function to start or stop streaming to the network. This User Button function is functionally identical to changing the NETWORK>STREAMING>START menu option.

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Scene File Menu

The camera offers the ability to store and recall groups of image-control settings, called "Scene Files." You can have up to six different "looks" pre-programmed into the camera and many more readily accessible on your SD memory card. The settings that make up these Scene Files are contained in this SCENE FILE menu.

The following descriptions of the scene file properties will give you a better understanding of how these settings affect the image. You may need to zoom in to some of the pictures at up to 300% to see the differences clearly.

Please note: the color photos included in this book are for convenience, but should not be taken as absolutely accurate, that would depend on the color accuracy of each computer monitor it is being viewed on. As such, the photos should be considered approximations.

Note: many of these menu items can be adjusted over a wide range (Chroma Level, for example, ranges from -99% up to +99%, that's a range of almost 200 steps). It would be slow and tedious to use the touchscreen to navigate through 200 steps of adjustment. Consider using the multidial wheel instead, it's much easier to move through many steps of adjustment by using the wheel. It's especially efficient if you push the wheel in and hold it in while you move it up or down; it will rapidly scroll through the available settings as long as you hold the wheel in. Alternately, you can use the play/rewind/fast forward/stop buttons; holding those down will scroll through the available settings rapidly.

File Select

The camera has six internal slots for holding individual Scene Files. This menu item lets you select among those six. If the Scene File you want isn't among the six that are currently loaded, you can load in packages of Scene Files from your SD card using the OTHERS>FILE>SCENE FILE(SD CARD) menu option.

When you select a Scene File using this command, its settings are immediately applied to the image. Note, however, that there are some settings that may not be possible in the current recording format; for example, the Scene File lets you store the status of the Variable Frame Rate recording and its actual frame rate, but if you have the camera currently set to AVCHD recording (which, of course, doesn't support VFR mode) then you can't expect those Scene File settings to be applied.

Name Edit

Each Scene File can have an individual name. You select which scene file (F1 through F6) you want to work with by using the FILE SELECT menu option. Then, using this NAME EDIT function, you can type in a distinct name so you can remember what this particular scene file is supposed to accomplish, image-wise (examples might be BRDCAST for a scene file that's meant to create a standard Rec.709 broadcast-style image, or EVA1LIKE for a scene file that's meant to match to an AU-EVA1 camera, etc.)

Load/Save/Initialize

The process of "loading" and "saving" scene files can be confusing, so please take a moment to understand the way the camera's scene file information is stored.

Scene Files can be saved into the camera's internal memory storage, or they can be saved onto an SD/SDHC/SDXC memory card. This menu item has nothing to do with the memory card, this menu item is solely concerned with the camera's internal memory storage. For loading from or saving to a memory card, see the OTHERS>FILE>SCENE FILE(SD CARD)>SAVE AS menu item.

The camera has three separate blocks of memory for Scene Files: the CURRENT settings, the SAVED settings, and the INITIAL settings. Each block of memory holds six complete Scene Files.

When you make changes in the SCENE FILE menu (such as boosting the color saturation or changing the gamma or adjusting the frame rate) those changes are made only to the CURRENT settings. The current settings hold the current copies of all six Scene Files, and any changes made to any of the Scene Files will stay current, even if you turn the camera off.

If you've made changes that you like, you can SAVE those changes to the camera's internal memory, into the SAVED settings block. After saving the

scene file data, you can continue to experiment or make changes, secure in the knowledge that you can always go back to your "good" settings by LOADing in the SAVED settings.

Alternatively, if you want to abandon all your changes and go back to the factory original settings, you can INITIALIZE the Scene Files and the current Scene File settings will be overwritten by the factory original settings.

Note that when you SAVE, LOAD, or INITIALIZE, you're only affecting one Scene File (the one chosen in the FILE SELECT menu.) The process is one of either saving the current settings into the internal camera memory, or copying the saved settings from internal camera memory and overwriting the current settings, or copying the saved settings from the factory original settings and overwriting the current settings. Note that when you INITIALIZE a Scene File, it doesn't affect your saved settings, it only overwrites the current settings. Your saved settings will always be there until you choose to overwrite them by saving new settings over them. Changing the current settings doesn't change the saved data in internal camera memory; only executing a SAVE command will do that. If you want to export or share this Scene File data with another camera, or just keep it permanently, you can use the OTHERS>FILE>SCENE FILE(SD CARD)>SAVE menu option to write out the current Scene File data to the memory card in Slot 1.

VFR

VFR stands for Variable Frame Rates. When shooting in MOV format, you have the option of enabling or disabling variable frame rate operation. This menu item lets you choose whether to enable variable frame rates, or to prevent them. When this is set to ON, no audio will be recorded, unless the frame rate is set to the same as the recording rate, i.e. 24fps in 23.98p, 30fps in 29.97p, 60fps in 59.94p, or 25fps in 25p or 50fps in 50.00p. Be very careful with this setting, because you don't want to get in a scenario where you didn't end up recording any audio. The camera will warn you to this effect by disabling the audio meters.

You can enable VFR here in this menu, or you can instead assign a User Button to the VFR function and enable or disable it by pressing that User Button.

Enabling VFR also enables the ability for the multidial wheel on the side of the camera to select a variable frame rate.

Note that VFR cannot be enabled when recording AVCHD footage, or 1080i footage.

Frame Rate

If VFR Mode is enabled, you can set your desired frame rate here, or you can set it by using the multidial. For a description of the various frame rates, see the article on Variable Frame Rates.

The FRAME RATE cannot be changed during recording, and you can't do "speed ramping" in-camera.

Sync Scan Type

The Synchro Scan is a special customizable shutter speed, named originally after its purpose of allowing you to synchronize the shutter speed to match the scan rate of CRT monitors (thus helping you avoid the rolling or scrolling black bands that would otherwise display on a CRT). Nowadays, the Synchro Scan has evolved to where it is a completely customizable shutter speed.

This menu item lets you control how the Synchro Scan shutter speed is displayed and, by extension, how the shutter itself is set. There are two choices: "deg" (short for "degrees") and "sec" (short for "seconds"). When you choose "sec", the Synchro Scan shutter speed is displayed as a fraction of a second, like a typical video camera shutter speed. Examples would include 1/60.0, 1/250.0, etc. When you choose "sec", you're establishing a fixed exposure time that will remain constant regardless of what frame rate you've chosen, with the caveat that a shutter time can never be shorter than the frame rate itself, so when shooting 23.98p the shortest real speed you can choose is 1/24.0; when in 25p the shortest speed is 1/25.0, when in 29.97p it's 1/30.0, when in 50i or 50p it's 1/50.0, and when in 59.94i or 59.94p it's 1/60.0. Outside of the Sync Scan system the camera does provide the option of selecting even slower shutter speeds, but the net result will be that frames will be duplicated while the camera buffers up the longer shutter speed.

The fun begins when you change this menu item over to "deg". When in "deg", the shutter speed is expressed in terms of angles of degrees of a circle – an entire circle would be 360 degrees, a half-circle would be 180 degrees, etc. The default is "180.0d", meaning that the shutter is emulating a film camera shutter that's half-exposing, half-obscuring – and that means that the exposure time will be exactly 1/2 the frame rate.

When shooting 180.0d at 24p, your exposure time will be 1/48th, when shooting at 29.97p it'll be 1/60th, when shooting 59.94p it'll be 1/120. The important thing to note is: this menu setting will cause the system to use a different shutter speed for every frame rate. The shutter exposure time is calculated based on the frame rate and the angle of degrees, and if you change the frame rate, that will change the exposure time. This is a great feature; it directly emulates the way a movie camera works and it will keep the motion blur in your shot consistent at all frame rates. But you will manually have to use the iris to compensate for the difference in exposure that will result from it using a different shutter speed when you change frame rates.

Also note - you have to be extra careful when using the "deg" option, to avoid the Partial Exposure effect that can happen under certain types of lights. When using the "deg" function, it's easy to end up with a shutter speed that is not an exact multiple of 1/60 or 1/50, so when shooting under fluorescent lights or HMIs you'll want to be extra careful to check for scrolling bands in the footage. See the Rolling Shutter article for more information.

Sync Scan

This is the actual shutter speed setting for the Synchro Scan shutter speed, when using this particular Scene File. The Synchro Scan shutter speed is selected by using the Shutter Button and the Multidial wheel to select the shutter speed that appears between the fastest and slowest shutter speeds; for example, if you use the multidial to choose the very fastest shutter speed (1/10000), and then try to select the very next faster shutter speed after that, it will show up with a decimal point (something like 1/60.0 or 180.0d, depending on how you have the SYNC SCAN TYPE set). If you use the multidial to select the Synchro Scan shutter speed, then the actual value of that shutter speed will be what you set here in the SYNC SCAN menu.

Master DTL

Please see the descriptions of DETAIL SETTING and DTL CORING as these three topics are all interrelated.

The MASTER DTL menu option determines how much sharpening should be applied to the finer details in the image overall. This sharpening is also known as "edge enhancement." Note that no matter what you set it to though, it will not take effect unless DETAIL SETTING>DETAIL is ON. If

DETAIL SETTING>DETAIL is set to OFF, no edge enhancement or sharpening will happen. When it's set to ON, then the amount of edge enhancement is dictated by this MASTER DTL menu option. Note that the default value is "0", but that does not mean there's no edge enhancement happening! "0" is the midpoint; the scale ranges from -31 to +31. At -31, a small amount of edge enhancement will be applied; at +31 a significant amount of edge enhancement/sharpening will occur. -31 is not the same as "off"; there is still a bit of enhancement applied at -31. If you want no edge enhancement at all, set DETAIL SETTING>DETAIL to OFF.

Detail circuit set to OFF

Detail circuit set to ON, Master DTL set to -31

Detail circuit set to ON, Master DTL set to +31

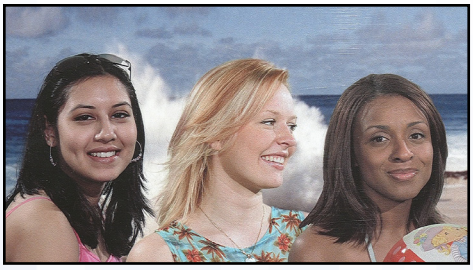
Also consider that the higher the MASTER DTL level is set, the more noticeable overall image noise will be! The noise is a fine fluctuation in brightness levels, which looks a whole lot like "fine detail" to the sharpening circuitry in the camera — and that's why the edge enhancement process may actually sharpen the edges around the noise in the video signal. If you want to minimize the appearance of noise in your footage, lowering the MASTER DTL setting can go a long way towards accomplishing that. See the DTL CORING section for more information on controlling noise from MASTER DTL.

When deciding on what MASTER LEVEL value to use, first consider how large your footage will be displayed. The larger the display, the less artificial detail you normally would want to use. On a small screen a high detail

setting can look nice and sharp, but on a movie theater screen it may look too artificial. Second, consider how much post-processing you might do to the image. If you're planning on extensive color grading or special effects work, you probably want to use as little artificial edge enhancement as possible. You can always add more sharpening in post, but you can never remove it from your footage once you've recorded it that way.

The smaller the MASTER DTL number, the softer and more organic the image will look. The larger the MASTER DTL level, the sharper (but perhaps more electronic) it'll look. For most purposes, this camera delivers enough raw resolution that you don't need to add much in the way of artificial detail; I usually use no more than about 0, and prefer lower levels down to around -15. In UHD, I like to turn detail off entirely. For a film transfer or projection on a movie theater screen you may want to turn the detail entirely off, but for smaller screens and lower resolutions the camera benefits from a little dosage of detail; a small detail setting can sharpen up the image nicely without creating large objectionable "outlining" around high-contrast edges. For greenscreen work, a lower detail level (such as -31 to -10) may be preferred.

If you want to tone down the "grittiness" that the detail circuit can introduce to the picture, consider lowering the DTL GAIN functions, as they have a significant impact in how visible the edge enhancement effect is.



Detail Coring 0 (view at 300% or higher)

Detail Coring 60

DTL Coring

DTL CORING is one of those functions that "appears" to do one thing, while "actually" doing something else. At its most basic level, you can think of Coring as a noise control; the higher you set it, the less noticeable the noise should be in your image. That's not really what it does, but it appears to mask the appearance of noise in the image. To understand the effect of DTL CORING, you have to understand the interaction between MASTER DTL and noise in the image.

The MASTER DTL control tells the system to accentuate contrast between low-contrast elements of the picture, but it doesn't know the difference between fine high-contrast detail, and noise in the signal. As such, a high MASTER DTL may make the noise significantly more visible; a high MASTER DTL actually causes the detail circuit to sharpen the edges of the noise, drawing attention to it. DTL CORING can help bypass that process.

DTL CORING can be thought of as a threshold control; the higher you set it, the wider the range of frequencies that will not be sharpened by MASTER DTL. The lower you set DTL CORING, the more frequency range will fall under the jurisdiction of the MASTER DTL. The higher the DTL CORING setting, the more it will cause the system to ignore sharpening of high-frequency detail. This means that if you set it high enough, the noise won't become sharpened/edge enhanced as much, making it less visible; the tradeoff is that your legitimate high-frequency detail won't receive the contrast-enhancing sharpening effect either, so your image may not look as sharp as it otherwise could. Finding that level where you minimize the sharpening of the noise, but retain the sharpening you want, is the key to successfully using DTL CORING.

The effect of DTL CORING is most noticeable when the MASTER DTL is set to a high value (because the noise will be exaggerated when MASTER DTL is set to a high level; that makes the effect of DTL CORING easier to observe.) When set to 0 (the minimum value), DTL CORING has little effect on the noise or grit. The higher you set it, the more it cleans up the image. At its maximum value of +60 it has its most significant smoothing effect, and can clean up the noise in the video signal some (again, at the expense of legitimate detail). Now, please understand it's not actually removing the noise, it's removing the sharpening that accentuates the noise, which makes the noise much less visible and less objectionable.

The higher the DTL CORING setting, the smoother the image, but too high of a level can lead to your picture looking softer and even "blotchy," because if too much of the contrast-enhancing effect is removed, sections of the image with fine color transitions or detailed edges can look like one big "blob." Removing all or most of the fine detail will affect surface texture and skin appearance. This is especially prone to happen if you're using a lower bitrate recording mode (like any of the AVCHD modes); the lower the bitrate, the more likely the compression engine will be to lump similar-looking sections together into one big blob. The presence of some noise can help the compression engine to avoid such "blobbiness" and can help to eliminate some gradient banding effects caused by low bitrate compression.

Also, the lower the MASTER DTL setting, the less effect DTL CORING will have on the image. For maximum sharpness, detail and resolution on your image you may want to set DTL CORING lower, but doing so may make noise more visible (noise manifests itself in a crawling texture on the surface of the video, sort of like film grain). With MASTER DTL set all the way down to –31 the image may look somewhat soft if there's not adequate contrast in the scene already. With MASTER DTL set up to +31 the image will look much sharper and crisper, but a higher MASTER DTL makes the edge enhancement more visible, resulting in artificial video sharpening that can look unnatural, gritty, or even coarse.

Detail Setting>Detail

This is a hugely important function, hidden away in the DETAIL SETTING sub-menu. This menu item can be set to ON or OFF. This affects whether the camera will do any Detail processing at all. It may seem like this ON/OFF switch only affects the items contained within this DETAIL SETTING sub-menu, but that is not the case; this menu item affects all the DETAIL SETTING sub-menu items, but it also affects the MASTER DTL and DTL CORING settings too. See the pictures under MASTER DTL for examples of how much difference the DETAIL ON/OFF setting can make.

Detail Setting>V.Dtl Level

V.DTL LEVEL affects perceived sharpness similar to the MASTER DTL control, but V.DTL LEVEL enhances the contrast only vertically (i.e., between horizontal lines, or above and below the fine detail.) Depending on how high you set the level, it will sharpen the contrast vertically between horizontal lines in the video image. This enhanced contrast leads to the illusion that the picture is actually sharper.

V.DTL LEVEL as an independent control is probably most suited for when shooting interlaced (480i/576i or 1080i) as it gives you a bit of control over interline detail which may help reduce line twitter on an interlaced monitor or television. As the world replaces interlaced monitors with progressive monitors (such as LCD, LED or OLED) that becomes less and less of a concern. Also, the effect is much subtler for V.DTL LEVEL than it is for the MASTER DTL.

Detail Setting>Dtl Freq.

Once the decision to add detail sharpening/outlining has been made (by the MASTER DTL and as attenuated by the DTL CORING), then the question

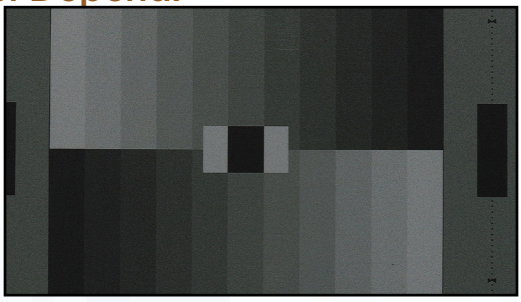
is: how thick should the outlining be? This menu item lets you determine that thickness. Look at the pictures to the right to see examples of just how much change is possible. Again, consider the size of the display your footage will be seen on. The larger the display, the more "electronic" a large outline will appear. Smaller edges may be appropriate for very large displays, but may not show much enhancement on a small screen. Larger edges will show up more prominently on a small screen, but may look unnatural and overly sharpened on a big screen.

Detail Freq -7

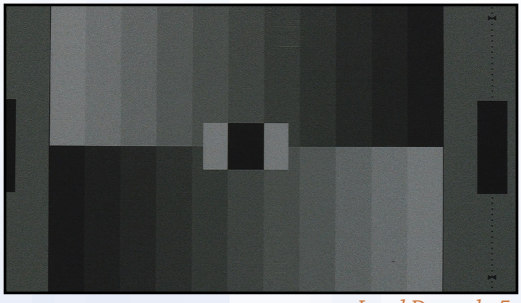
Detail Freq +7

Detail Setting>Level Depend.

Level Depend can be thought of as "use the detail circuitry to sharpen the edges, DEPENDING on the video LEVEL." So what this effectively means is, you can raise or lower the video brightness threshold at which point the detail circuit will start sharpening. In effect it's like coring, except instead of making its decision based on how much contrast there is between edges, the LEVEL DEPEND makes its decision based on how bright the overall video level is in the area that



Level Depend -7



Level Depend +5

it's examining for sharpening. What this really means is that with a low setting for LEVEL DEPEND, pretty much all the brightness range of the video will be sharpened (according to the governing settings of MASTER DTL, DTL CORING, and all the other settings in the DETAIL SETTING MENU). But the higher you raise the LEVEL DEPEND number, the more it will leave dark areas alone -- and that can help keep grain and noise in the shadows from becoming enhanced (and therefore more noticeable). A higher LEVEL DEPEND setting should make the shadows and dark areas of the image cleaner, since they shouldn't be receiving detail enhancement. So the darker areas will be cleaner, but softer detail. The lower you set LEVEL DEPEND, the more the dark areas will receive detail enhancement, which can make them sharper and perhaps make the noise more visible. The response may not be exactly linear, so experiment to set the level that results in the best looking images.

Detail Setting>Knee Ape Lvl

KNEE APE LVL stands for Knee Aperture level. This function works like a limited-range MASTER DTL control. It affects sharpening of the image, but only in a very limited range of brightness levels (approximately 80 IRE and above). This is the range where the KNEE circuit typically affects the image, and using a lot of knee compression can result in eliminating some of the fine detail that the MASTER DTL function might otherwise have sharpened. The result is, the more knee compression you've used, the softer your highlights (80+ IRE) may look. The KNEE APE LVL lets you add detail sharpening back into that 80+ IRE range, in six discrete steps (0 = no additional sharpening, 5 = maximum sharpening).

Note, however, that this function is not dependent on the KNEE level or slope at all. The use of the word "knee" in its name should be thought of as a reminder of what brightness range this function will affect. However, if you turn the KNEE to OFF, this function will not function either.

Detail Setting>DTL Gain(+) and (-)

These settings let you influence how the sharpened edges get rendered; in effect they let you "paint" the detail level. Remember that the detail circuit primarily works by enhancing the contrast between the edges of fine detail; that means (coarsely put) that it will draw a white edge around a darker object, or it could choose to draw a black edge around a brighter object, but either way it's putting edges on objects. What this setting lets you determine is how bright the bright edges it draws are, and how dark the dark edges that it draws are. So there are two menu options here: DTL Gain(+)

is for controlling when the detail circuit is brightening the edges, and basically lets you tell the system just how bright it should make that edge; larger numbers lead to more obvious detail enhancement, and smaller numbers lead to less obvious enhancement. Likewise, the DTL Gain(-) is for when the system is going to darken an edge; this menu item lets it know how much darkening it's allowed to do. Larger numbers mean more noticeable edges, smaller numbers mean less noticeable.

DTL Gain(+) at -31, DTL Gain(-) at -31

DTL Gain(+) at +31, DTL Gain(-) at -31

DTL Gain(+) at -31, DTL Gain(-) at +31

DTL Gain(+) at +31, DTL Gain(-) at +31

Put another way: these menu settings control the intensity of the outlining effect. For DTL GAIN(+), the smallest number (-31) means that only the faintest white edge will be added, and it will likely be hardly discernible. Setting it up to +31 means the edge will be as white as possible, and highly noticeable. This doesn't affect the thickness of the edge (that's done by DTL FREQ) and it doesn't affect the propensity of the system to add an edge at all (that's MASTER DTL), but once the decision has been made to add a white/bright outline, this menu item lets you dictate how bright that edge will be.

Similarly, DTL GAIN(-) controls the visibility of the darker outlines that get drawn. A low number (-31) means only the very slightest amount of darkening will happen on the edge, a higher number means that a darker edge will be drawn. So in both cases the outlines (whether dark or light) will be at their minimal intensity when the relevant DTL GAIN control is set to -31, and at their most intense when the control is set to +31.

These two menu items are very powerful, and make a big difference in how noticeable the overall detail enhancement is in the picture. With these menu settings at minimum levels (0), you may not see much if any effect on the image when enabling the detail function. Push these menu items to the extreme (-31 or +31) and you should see very stark visible differences in the image when enabling or disabling the detail function.

Skin Tone Detail Settings

The CX350 offers an advanced and highly customizable Skin Tone Detail function. Before discussing the individual options, let's first lay out what the Skin Tone Detail function does and how it differs from the DETAIL function. Skin Tone Detail is designed to help smooth the appearance of mild imperfections on people's skin. When set to ON, the overall detail circuit avoids sharpening anything it perceives as "skin tones," without affecting any other aspect of the picture. When set to OFF, it doesn't try to smooth skin tones (meaning, the skin tones will be treated just like any other area of the image, in terms of receiving the sharpening effect of the detail circuitry). For a description of how the SKIN DTL function works, look at the description for DTL CORING. SKIN DTL works like DETAIL CORING, except only on colors and tones that it perceives to be "skin." The higher you have the MASTER DTL set, the more noticeable the SKIN DTL effect will be. Also, note that it doesn't smooth

Skin DTL Effect 0

Skin DTL Effect 31

"skin", it operates on what it thinks are areas that are colored the types of colors it thinks skin colors are; I've seen it smooth out detail on blonde and red hair too, on beach sand, on a wooden desk or, well, anything that falls in the same basic tonal range as skin tones. If you find that your subject's face is looking too flat and smooth, consider turning this function off. If your subject is elderly, has acne or otherwise has "bad skin," you may find this function makes for a more flattering appearance on your subject.

Skin Tone DTL A, B, and C

So how does the system know what "skin tones" are? Well, there are three tables that you can select from, which can be individually programmed to precisely define the area of the color spectrum that you want the system to consider as skin tones. You can enable one of these tables, or more than one of these tables, or even all three tables simultaneously. For a proper understanding of the Skin Tone DTL function, please review the discussion on all the Skin Tone menu controls below, as they are quite interrelated.

Skin Tone Zebra

If you want a visual representation of what tonal area you've enabled, you can turn on the SKIN TONE ZEBRA function, although it won't display these zebras until you enter the SKIN TONE DTL SETTING menu; SKIN TONE ZEBRAs are only ever displayed while the SKIN TONE DTL SETTING menu is active.

The Skin Tone Zebras will show all skin tones from all active tables. If you've enabled only SKIN TONE DTL A, then the zebras will only show the areas covered by table A, regardless of what B and C are set to. If you haven't enabled any of the tables, then SKIN TONE ZEBRA won't show any zebras at all. If you've enabled more than one table, then SKIN TONE ZEBRAS will show all the areas covered by all the enabled tables. The only way to isolate a specific table is to disable the other tables; that way you will see only the zebra area of the enabled table.

Skin Tone Detail Setting

This menu setting lets you modify the parameters of the three SKIN TONE DTL A, B, and C tables, but only one at a time. Also, entering this menu enables the display of the SKIN TONE ZEBRA function, if you've previously enabled it and also enabled at least one of the three tables (A, B, and/or C).

Stick with me though, as this can be confusing. This menu lets you adjust the parameters of one of the tables, but the displayed zebras do not

necessarily reflect the table that you're modifying! Keep in mind that the zebras will show all of the areas that are affected by the skin tone detail function, and that means that it takes into account all of the tables that are currently active. Put simply, if you enable only Table A, and then you enter this menu and start modifying Table C, the zebras will never show any changes -- they'll only show the effect of the currently-enabled Table A, and will ignore any changes you're making to the currently-selected Table C. It can be confusing, but if you always remember to enable the table you're modifying (and only the one table that you're currently modifying!) then the zebras will show the results of any changes that you make in this menu.

Skin Tone Detail Setting>Detect Table

This menu item lets you choose which skin tone table you'll be modifying. As said before, it does not mean that the table you choose will be represented by the Skin Tone Zebras; you'd have to go back to the SKIN TONE DTL A/B/C functions and enable the specific table you're intending on modifying (and only that table) before the zebras will properly reflect your changes.

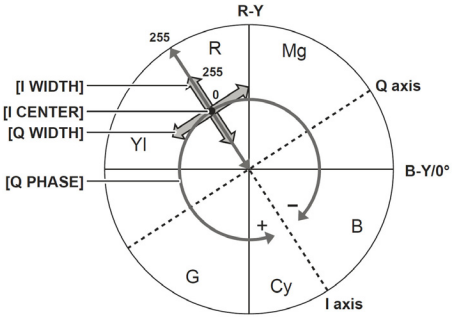
Skin Tone Detail Setting>Skin DTL Effect

This menu lets you select the amount of softening or non-sharpening that will happen when the currently-selected table is enabled. This is not a simple on/off menu item as on previous cameras; on the CX350 it is adjustable among a range of strengths. The higher you set the number, the softer the skin will be. To examine pictures showing the strength of the SKIN DTL EFFECT menu item, look at the section on SKIN TONE DTL SETTINGS.

Skin Tone Detail Setting>I Center, I Width, Q Width, and Q Phase

Here's where you get to establish the exact range of tones that will be covered by the currently-selected Skin Tone DTL table. Referring to the following illustration of a vectorscope display, you'll see that there are two axes drawn on the vectorscope, the I axis (which runs from about 11:00 down to about 5:00), and the Q axis (which runs from about 8:00 up to about 2:00). On the vectorscope, human skin tones generally fall on the I axis in the upper left quadrant. Medium skin tones appear on the vectorscope right at about the spot marked on the illustration, where the I CENTER is set at zero. You can adjust the positioning of the table itself by adjusting the I CENTER; larger numbers will push it outwards toward the

outer ring of the I axis; smaller numbers will bring it inwards toward the center of the vectorscope.



The I WIDTH lets you establish how wide a range of skin tones (in terms of dark to light) you want to have included in this table. Larger numbers include a wider range of variations, smaller numbers tighten up the range that will be included.

The Q WIDTH lets you establish how narrowly skin tones will be interpreted in the range of yellow to red. All human beings have skin tones generally falling along the I axis, but different races may be more or less fair, more or less dark, etc. With this menu item you can keep the skin tones narrowly defined (if that suits your particular subjects) or you can expand the range to include tones beyond the narrowly-defined.

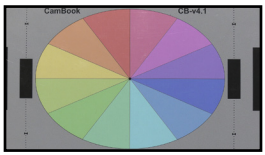
The Q PHASE lets you rotate the skin tone table around the color wheel. If your lighting or art direction is not allowing the skin tones to precisely follow the I axis, you can rotate the color wheel until the skin tone table lines up with where the camera is rendering your subject's skin tones. Larger numbers rotate the colors towards green/cyan, smaller numbers push the colors toward the magenta/blue range.

RB Gain Control Setting

These settings allow you to "paint" the camera's image, by adjusting the level of blue and/or red saturation. You can add some red to the image to "warm it up", or turn it more blue to "cool it off". There's quite a bit of adjustment possible by using these settings, you can really push the color palette around by adjusting these two controls, and you can assign different settings to the different WHITE BAL channels (PRST, Ach or Bch).

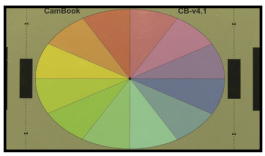
You can add or subtract from either the red channel, or the blue channel, or both, for each position on the WHITE BAL switch. The range is huge, from -200 to +200 for each. At mild settings, this function can help to warm up skin tones for interviews, comparable to using something like an #812 warming filter. On the other hand, aggressive use of positive values for the blue control can perhaps be useful for creating a "Day For Night" scene.

These settings can be combined with the color matrix and saturation levels, and with the various gamma options and the COLOR CORRECTION feature, to give you extensive control over the camera's color palette.

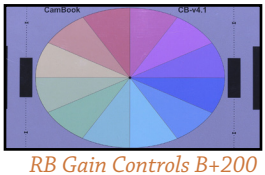


RB Gain Controls at 0,0

This RB GAIN CONTROL SETTING function is only available when using the presets or the manual white balance channels A and B. If you set the camera in ATW (Automatic Tracking White) mode, the RB GAIN CONTROL SETTING will be bypassed - even if you assign ATW to be the designated function for either Ach or Bch.

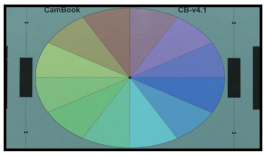


RB Gain Controls B-200

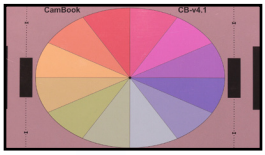


RB Gain Controls B+200

Note that when you're adjusting the levels, the changes will be shown for the channel that is currently selected on the WHITE BAL switch. If you're trying to adjust the R GAIN AWB B, but your WHITE BAL switch is set to channel A, then you won't see any effect of the modifications you're making. You'd have to switch the WHITE BAL switch to B in order to see the changes being applied to your images.



RB Gain Controls R-200



RB Gain Controls R+200

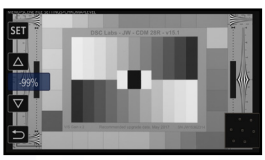
In addition to the red and blue levels, there's another option in this menu, and that's AWB A (and B) GAIN OFFSET (OFF/ON). The name of this function is not intuitive, it's not obvious as to what it does, but the general idea is that this option lets you decide whether or not your adjustments will survive the next time you do a manual white balance. You can have your custom settings applied to the new white balance (by choosing ON), or you can have the parameters reset to zero automatically the next time you manually white balance the camera (by choosing OFF). So when it's OFF, each time you take a manual white balance you get a pure and proper white balance, unadjusted by this menu (because the parameters are re-set to zero). When it's ON, the camera will take a proper white balance and then adjust it based on this menu's parameters. Note that you can choose individually whether each channel's settings survive a manual white balance operation.

Color Temp Ach (and Bch) Setting

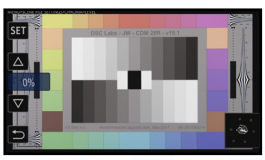
When the camera takes a manual white balance (or when it's automatically tracking the white balance), it makes a number of decisions on how to interpret the color it's seeing: it evaluates the color temperature (COLOR TEMP), and any R GAIN or B GAIN it needs to apply to make the color temperature accurately represent the current lighting conditions, and it may have to adjust the amount of green that's added to or subtracted from the prevailing light (G AXIS) in order to render proper neutral colors. This menu item will display all those parameters, and you can also change each of them to customize the white balance to your taste.

Chroma Level

CHROMA LEVEL refers to the amount of color saturation the overall picture has. The lower the CHROMA LEVEL, the more pale and muted the colors will be. The higher the CHROMA LEVEL, the more saturated the colors become. At OFF the image will be drained of all color and will be a true "black and white" grayscale image. The default setting of 0 delivers a richly saturated color palette. You can crank it up to maximum color saturation at +99%, at which point he colors will be very strong and rich and vibrant.



Chroma Level -99



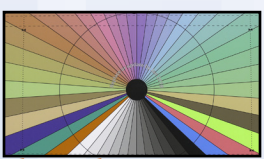
Chroma Level 0

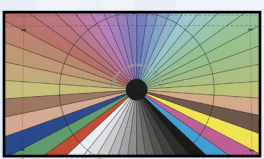
Chroma Level +99

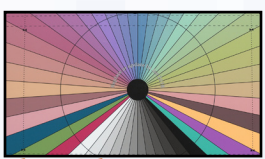
Note: the more saturated the colors are, the more likely that overexposure will cause one or more of the color channels to "clip", resulting in yellowish skin highlights or color shifts in bright objects like clouds. If you're having issues with color shifting in clipped highlights, setting a lower Chroma Level may reduce the amount of color shifting.

Chroma Phase

CHROMA PHASE works as a hue control. It allows you to, effectively, rotate the color wheel on your images. Setting it to negative values


Chroma Phase -31

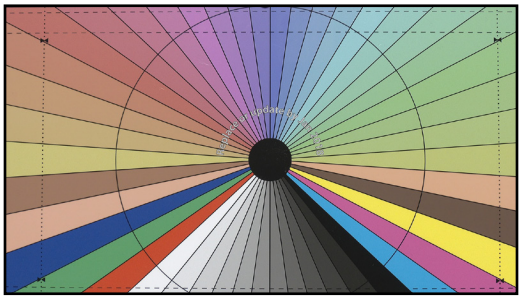

Chroma Phase 0


Chroma Phase +31

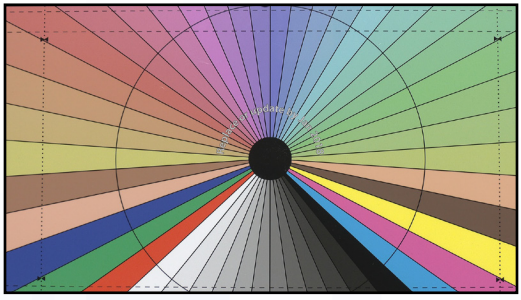
rotates the color plot on the vectorscope display counter-clockwise; setting it to positive values rotates the color plot on the vectorscope display clockwise. The range is +/- 31 steps, and the maximum adjustment results in approximately a 40-degree rotation of the color wheel.

Matrix

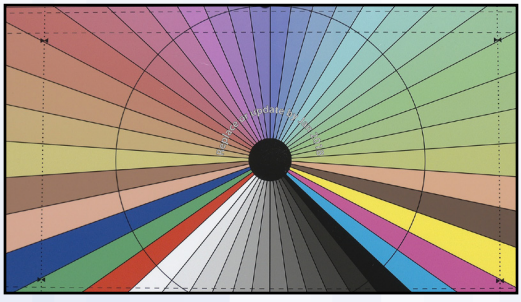
The MATRIX setting lets you choose different palettes of overall color reproduction. Using the MATRIX you have a limited amount of control over how saturated the colors are, and which colors get enhanced and which do not.



NORMAL 1 is a mild, normal color response. In NORMAL 1 the colors are at their most technically accurate of these matrices. This matrix is frequently used for shooting outdoors or under halogen lighting in the studio; it is the most accurate and least "stylized" of the color matrices. Panasonic says that that this color look is preferred in NTSC territories such as the USA and Japan.



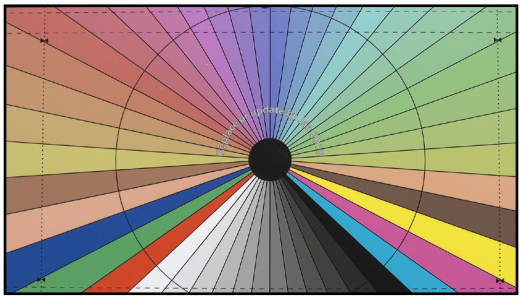
NORMAL 2 matrix brings up the brightness and saturation of the colors. In terms of color accuracy it's largely similar to NORMAL 1, but with brighter reds, blues and purples. It also renders fair Caucasian skin a bit warmer. Panasonic says that this color look is preferred in PAL territories such as Europe.



In FLUO. the colors are largely the same as in NORMAL 2, meaning brighter and more vibrant than in NORMAL 1, but the green, yellow and magenta colors are more saturated in

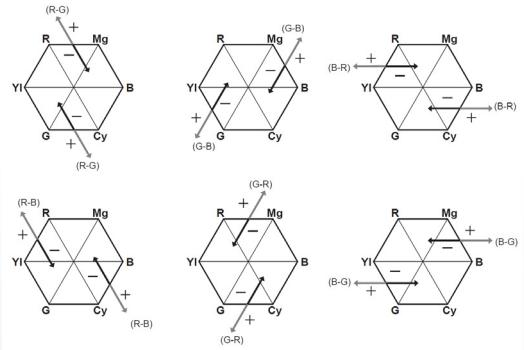
FLUO. Skin tones are slightly warmer than in NORMAL 2, and notably warmer than in NORMAL 1.

In CINELIKE all the colors except blue and cyan are strongly saturated, as compared to NORMAL 1. This matrix is used to produce richer, cinema like color. The skin tones are accurate but slightly warmer than in NORMAL 1.

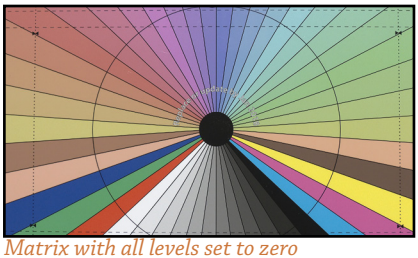


Matrix Setting>R-G, G-B, B-R, R-B, G-R, and B-G

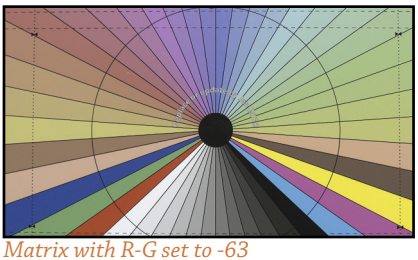
There are six primary colors on the "color wheel" of a video camera (Red, Magenta, Blue, Cyan, Green, and Yellow). If lines are drawn between each of the six anchor points, we end up with six slices of a hexagon-shaped pie. The camera's MATRIX control allows you to adjust the color on each axis in that pie. Make sense? No? Perhaps this image from the Operating Instructions will help it make sense.



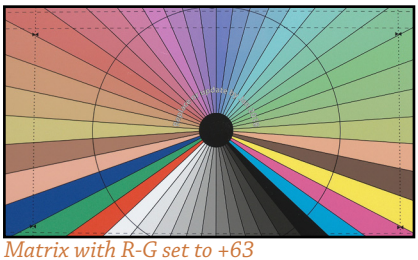
The color wheel is arranged with the six primary colors as the points of the "color hexagon", and connecting the axes results in six slices of color pie. Each of the options in the MATRIX affects two slices of color pie. As shown in the above illustration, adjusting R-G will affect the slice of pie between Red (R) and Magenta (Mg), and it will simultaneously affect the slice of pie between Green (G) and Cyan (Cy). You can stretch or squash the color hexagon along any of these axes, but it will always affect two slices of pie. And, in reality, it's not just those slices that are being affected; the entire color palette is affected, but the changes are centered on the slices as illustrated above.



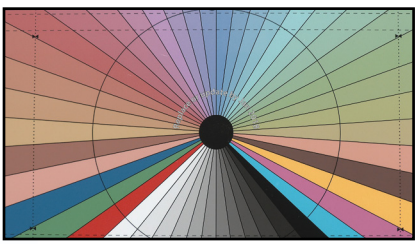
Matrix with all levels set to zero



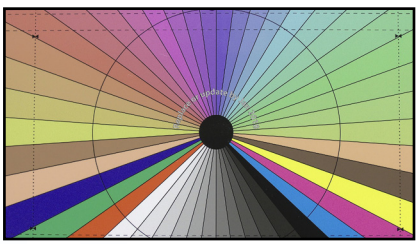
Matrix with R-G set to -63



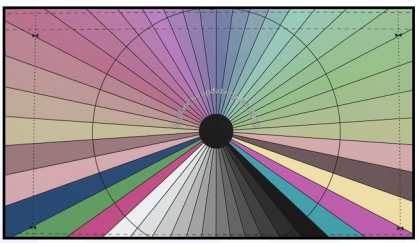
Matrix with R-G set to +63



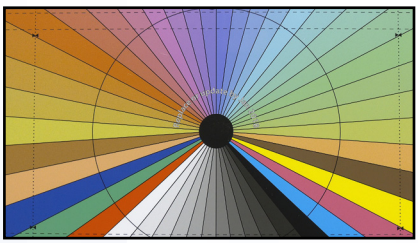
Matrix with G-B set to -63



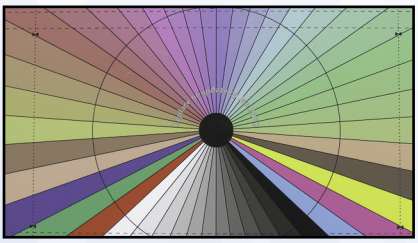
Matrix with G-B set to +63



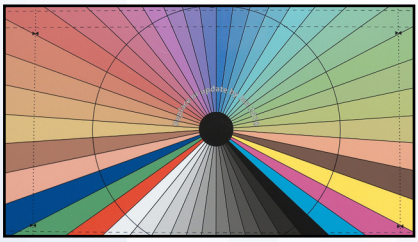
Matrix with B-R set to -63



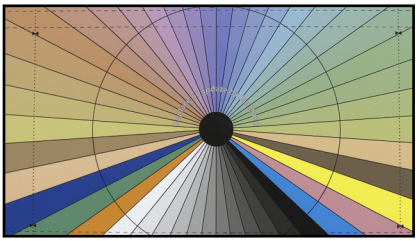
Matrix with B-R set to +63



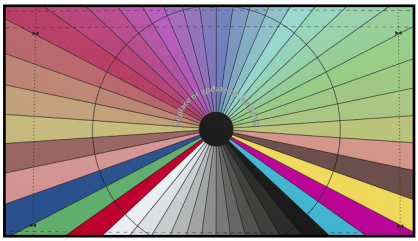
Matrix with R-B set to -63



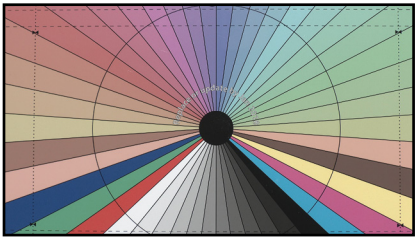
Matrix with R-B set to +63



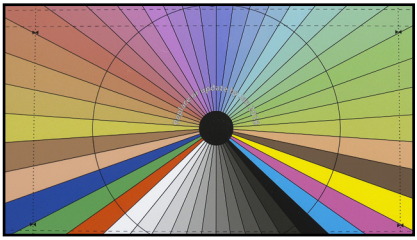
Matrix with G-R set to -63



Matrix with G-R set to +63



Matrix with B-G set to -63



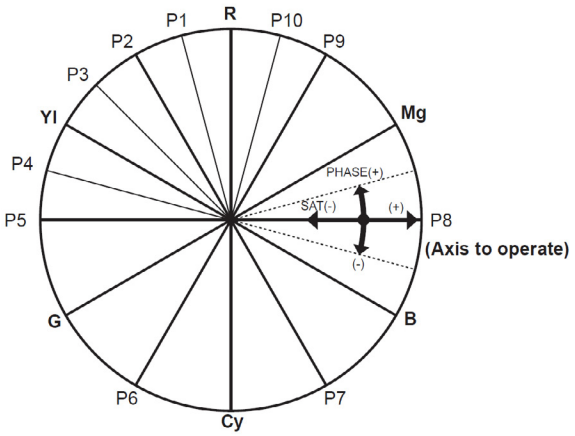
Matrix with B-G set to +63

COLOR CORRECTION

The CX350 offers a 16-pole color correction matrix. You can individually control the saturation and phase of sixteen different points on the color wheel. This gives you a tremendous amount of control over how the images are rendered, as you can individually fine-tune the color axes to get exactly the look you're after.

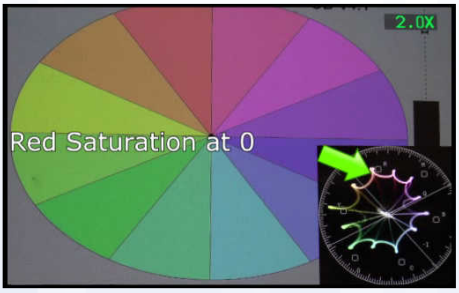
If you're not used to working with an in-camera color correction feature, it can seem intimidating at first, but it's really quite simple. As you'll remember from the discussion on the vectorscope, there are six boxes on the vectorscope and those correspond to six colors: Red, Magenta, Blue, Cyan, Green, and Yellow. This COLOR CORRECTION menu gives you control over those six poles, as well as another 10 that sit in-between. Some of the poles are halfway between two colors (such as P9, which controls colors that are halfway between Red and Magenta). Some of the primary color axes have two colors in between them (such as between Yellow and Green, you'll find P4, which is 1/4 of the way from Yellow to Green, and you'll also find P5, which is 1/2 of the way from Yellow to Green).

Some of the 16 poles are named according to the primary color that they represent; the others are named "Px", where "x" represents which of the 10 intermediate poles it is, in order from Red (P1) counterclockwise around the color wheel. This graphic shows the specific locations of each of the poles, and their conventional names (such as P8's name "Mg-B", since it represents a position halfway between the Magenta and Blue primary color poles.)



R: Red
P1: (Yl-R)-R
P2: (Yl-R)
P3: Yl-(Yl-R)
Yl: Yellow
P4: (G-Yl)-Yl
P5: (G-Yl)
G: Green
P6: (Cy-G)
Cy: Cyan
P7: (B-Cy)
B: Blue
P8: (Mg-B)
Mg: Magenta
P9: (R-Mg)
P10: R-(R-Mg)

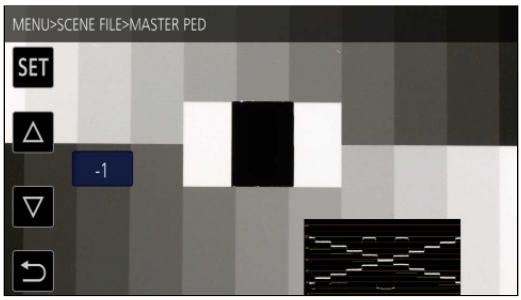
For each of these poles, you can control the SATuration, and also the PHASE. The SAT control governs the color saturation level of each particular pole, allowing you to intensify that color or make it more muted. The PHASE control adjusts the chroma phase for that individual color pole; setting lower values will rotate that pole counterclockwise on the color wheel, and setting positive values will rotate that pole clockwise on the color wheel. The effect is to move the color rendering closer to that of another pole; setting the Red color phase to positive values will move the red color rendition away from pure red and start moving it closer to yellow; the result is that the reds will start turning orange as you do so (red + yellow = orange).



The poles don't operate in complete autonomy from each other; there is some overlap. If you increase the Green saturation substantially, you may see that its neighbors (the P5 and P6 axes) will probably become somewhat more saturated too. You may have to go back and forth between the controls to get exactly the painted image you're looking for.

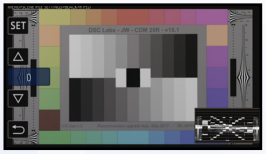
Master Ped

The MASTER PEDESTAL governs the overall brightness level of "black" in the picture. The lower you set the MASTER PED, the lower, deeper, and richer the black level will be, and, correspondingly, the middle and darker tones overall may move lower. The lower you set it, the harder it becomes to distinguish between the darker items in the frame; at some point more dark items will all blend together into black, giving you stronger, harsher contrast and, after a certain point, a loss of detail in the shadow areas. Conversely, the higher you set the MASTER PED, black will be rendered as a lighter and lighter shade of gray. This results in making the overall contrast look softer and flatter, but up until a certain point you may also preserve more detail in the shadows — it's easier to discern between shades of medium gray than it is to discern between shades of deep black. Put another way, a higher MASTER PED value may preserve detail in the darker areas of the picture but make the blacks "milky"; it may also affect the appearance of noise in the image.



Click above for a video demonstration of the Master Ped

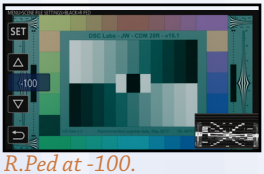
As such, there are very practical limits as to how far you'd want to adjust the MASTER PED. Boosting or lowering the black level is certainly a valid image control to exercise, but exercise it in moderation; boosting or lowering it significantly will cause you to lose image detail due to crushing or clipping.



R.Ped/G.Ped/B.Ped at 0

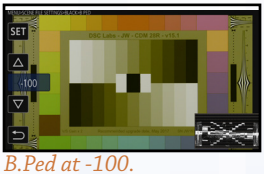
RGB Black Control Setting>R, G, and B Ped

The MASTER PED governs the overall black level for all three color channels. However, you can



R.Ped at -100.

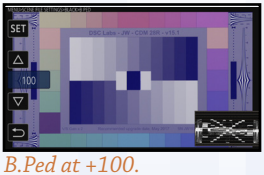
G.Ped at -100.



B.Ped at -100.

R.Ped at +100.

G.Ped at +100.



B.Ped at +100.

adjust each color channel individually to dial in a specific look. You can add or subtract any of the primary colors. The modifications you make here are temporary until the next Automatic Black Balance, but you can retain the offsets even through an ABB if you use the next menu item.

RGB Black Control Setting>Pedestal Offset

Generally, when performing an Automatic Black Balance (ABB), the camera will internally adjust its red, green, and blue channels to the appropriate levels to generate a true black output. However, the camera gives you the ability to adjust those individual channels using the RGB BLACK CONTROL SETTING>R, G, and B PED menu commands. This PEDESTAL OFFSET menu item gives you the choice as to whether you want to retain your manual adjustments to the R PED, G PED, and B PED settings when doing an ABB process, or if you want the ABB process to automatically reset the R PED, G PED, and B PED to zero.

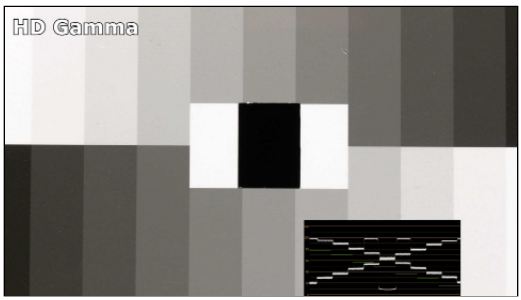
Gamma Mode Sel

The gamma curves control how brightness information is distributed in the picture. Gamma correction can correct for the nonlinear light-output characteristics of a standard TV picture tube. Picture-tube gamma (like on a CRT television) stretches the whites and compresses the blacks. Camera gamma compresses the whites and stretches the blacks. For the technically inclined, camera gamma can be properly set by using logarithmic gray scale charts and a waveform monitor. Camera gamma must be the reciprocal of picture gamma which is 2.2, so the camera gamma is usually 0.45.

Why is this a problem? Well, back when CRT monitors were the standard, their picture tubes created nonlinear response, and the cameras had to compensate in order to make proper-looking pictures. When new monitor technologies were being introduced (such as LCD, LED, and OLED), they didn't necessarily have to be constrained by the CRT tube's restrictions, but in order to work properly with the vast library of footage that had already been created, LCD/LED/OLED monitor manufacturers have continued the trend of using CRT-style gamma reproduction. And so, cameras need gamma functions to create images that will look "correct" when broadcast or displayed on these monitors.

The CX350 offers eight different gamma curves. The gamma curves in the camera affect how the sensor maps its tonality. If you are skilled in photo editing or video editing and post-production, you may be familiar with the

concept of applying "curves" to your photos or video footage, or of manipulating the "levels". Essentially, that's what the gamma function does, in-camera. By choosing among the gamma curves you can select from a variety of choices of how the camera maps the shadows, midtones, and highlights into displayable IRE values.



Click above for a video demonstrations of the gammas

The HD gamma produces standard video-looking pictures according to the international standard Rec 709. It's basically your typical, "video"-looking picture. HD will be the base gamma curve that we compare all the others to. HD is an all-purpose gamma that can be used for many situations, but it is a particularly suitable choice for sports, news, or other footage where the immediate, "live" look is the goal. When using a DSC Labs Chroma DuMonde chart and allowing the camera to automatically set exposure, fair Caucasian skin tones are generally properly exposed around 70 IRE, and the darkest skin tones are generally exposed properly at around 30 IRE.

SD is provided for times when you might want to retain compatibility with the DVX100 series of cameras' "NORM" gamma, or when you need a gamma that complies with the standard-definition recording space of Rec 601. SD handles highlights and dark tones similar to HD, with slightly lifted midtones. If you're shooting standard-def, or you're shooting footage that might be downconverted and mixed into a standard-def program, SD may be the right choice for that. Caucasian skin tones should be exposed at about 71 IRE, and dark skin tones should be about 31 IRE.

FILMLIKE1 is basically a reformulated version of the HD gamma, but designed to better retain highlights. The range from medium gray to black is handled comparably to HD, but FILMLIKE1 adds about a half an f-stop's extended range above medium gray to hold more highlights. This gamma reproduces more dynamic range than HD. Fair Caucasian skin tones are generally properly exposed around 67 IRE, and the darkest skin tones are generally exposed properly at around 30 IRE.

FILMLIKE2 takes the idea of FILMLIKE1 and pushes it even further. From black to medium gray it's quite comparable to FILMLIKE1, but the range from medium gray to white is slightly compressed, providing about 1/3 stop more headroom for holding a bit more highlights. As compared to HD, FILMLIKE2 provides similar tonality from black to middle gray, but compresses the region above middle gray to provide about 2/3 stop more headroom than HD gamma does.

FILMLIKE3 is very different. It doesn't just bring down the highlights, it lowers everything across the board — midtones, grays, highlights, everything is brought down, and the result is notably increased dynamic range. As an example, under proper exposure of a grayscale chart, HD gamma reproduces a certain shade of gray at about 55 IRE; in FILMLIKE3 that same medium gray is rendered at about 40 IRE. The entire curve's tonality range is compressed, which provides notably more dynamic range from deepest black to whitest white. Compared to HD gamma, with whitest whites set to 100%, changing to FILMLIKE3 renders those same whites at just about 79 IRE. When exposing consistently for the dark tones, fair Caucasian skin should be exposed no higher than about 50 IRE, and dark skin at around 20 IRE. If instead you want to hold shadow detail, you can open up the iris almost a full f-stop and still hold the highlights to 100 IRE, while letting more light fall on the shadow areas; that will of course adjust the proper exposure level for skin tones.

FILM-REC is a gamma curve made famous by the original VariCam; it is a gamma curve designed to mimic the characteristics of film that's been transferred to video. It provides a wide and flat range of tones, with the emphasis on capturing very high dynamic range. FILM-REC is not principally designed to be viewed on a monitor; because the curve is so flat and the dynamic range so wide, FILM-REC is more suitable for post production grading than it is for direct viewing. Of course, if you like the flat, wide, soft texture of the FILM-REC gamma, you can use it as-is; but generally it's designed for grading the image in post. You can further modify the FILM-REC gamma curve by using the F-REC DYNAMIC LVL and F-REC BLACK STR LVL menu items. If you're used to working on earlier Panasonic cameras that offered the CINELIKE-D gamma, FILM-REC is the most comparable gamma in the CX350. Because FILM-REC reapportions its range depending on what you set the DYNAMIC LVL to, proper skin tone levels change as well. At 200% DYNAMIC LVL, and exposing on the Chroma DuMonde chart using autoexposure, fair Caucasian skin

comes in at about 68 IRE, and dark skin at 26 IRE. When changing to 600% DYNAMIC LVL, Caucasian skin comes in at about 48 IRE, and dark skin at 20 IRE.

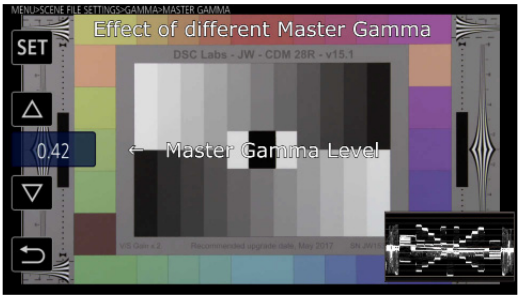
VIDEO REC is, basically, a modified version of FILM-REC, adapted to make its images more suitable for display on a monitor. Whereas FILM-REC retains the flattest images and the widest dynamic range, the resulting images are not really suited for display on a television. VIDEO-REC adapts the video signal specifically for display purposes, adding suitable contrast while still retaining the even tonality throughout the lower range. The VIDEO-REC gamma can also be further modified by using the V-REC KNEE SLOPE and V-REC KNEE POINT menu options. If you're used to working on earlier Panasonic cameras that offered the CINELIKE-V gamma, VIDEO-REC is the most comparable gamma in the CX350. When the V-REC KNEE SLOPE is set to 150%, fair Caucasian skin tones are properly exposed at about 60 IRE, and dark skin at about 30 IRE. When V-REC KNEE SLOPE is set to 500%, that changes; fair Caucasian skin tones are properly exposed then at about 51 IRE, and dark skin at about 28 IRE.

HLG is a hybrid of a regular video gamma in the lower and midtones, and a logarithmic encoding of the upper half of the tones (hence the name, Hybrid Log or HLG). The purpose behind HLG is to support High Dynamic Range (HDR) recording for television, and the HLG gamma curve extends the dynamic range to 1200%. The Hybrid Log gamma also uses BT.2020 colorspace. To put it in perspective, conventional standard-dynamic range display devices can encode and display up to about 10 stops without visible banding. HLG extends that to up to 17.6 stops without visible banding. The CX350 can't resolve 17.6 stops, but HLG is more than enough to handle the entire range of tones the CX350 is capable of creating.

HLG could be used to broadcast High Dynamic Range (HDR) video as-is; it would be a suitable choice for a live production sending broadcast-ready HDR footage. HLG is also encoded to support both standard dynamic range (SDR) displays and high-dynamic range (HDR) displays (although of course the full range of the image can only be fully displayed on an HDR display). For maximum compatibility with existing video devices, I would recommend using the HEVC recording formats when using HLG gamma.

Exposing HLG properly is very different from a regular gamma; HLG gamma looks flat and muted and dark when displayed on the LCD in HDR mode. It's easy to overexpose HLG gamma. According to the autoexposure system when pointed at the Chroma DuMonde chart, fair Caucasian skin tones should be exposed at about 47 IRE, and dark skin at about 22 IRE.

Gamma Setting>Master Gamma

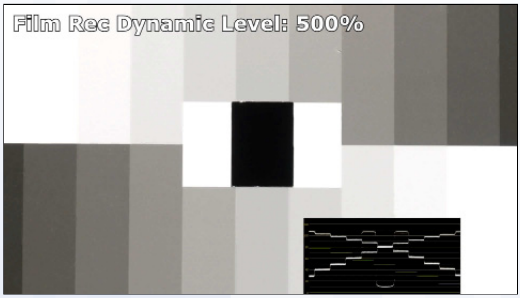


Click the video above for a demonstration of Master Gamma

After you've chosen a gamma curve, you can also modify the shape of the gamma curve. You can take it as low as .30 or as high as .75. The lower you set it, the more the dark tones will stretch out, and the more the lighter tones will compress. And the higher you set it, the more compressed the lower end of the tonal scale, while expanding the higher end of the scale. At 0.50, the central crossover point on a DSC Labs Chroma DuMonde chart is properly rendered at about 55 IRE. Setting the MASTER GAMMA to its lowest setting (0.30) results in that same crossover point being rendered at 65 IRE, effectively grabbing the midtones and dark tones and stretching them up higher. Setting the MASTER GAMMA to its highest setting (0.75) results in the crossover point being rendered at about 43 IRE, effectively grabbing the midtones and pulling them down some. Of course, any adjustment to the MASTER GAMMA will affect where skin tones should be properly exposed at too.

Gamma Setting>F-REC Dynamic Lvl

After selecting the FILM- REC gamma curve, you can modify its overall dynamic range by choosing this menu item. The choices range from 200% to 600%. You might be tempted to think of this menu setting as if it were a "knee", but -- it's not at all a knee. Instead, this menu item instructs the FILM-REC gamma as

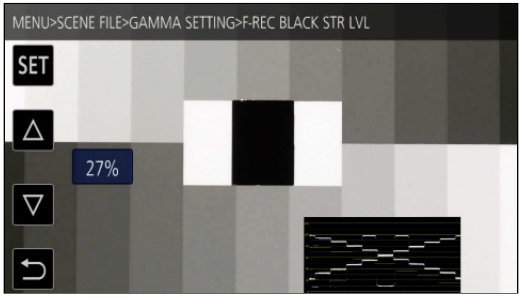


Click the video above for a demonstration of FILM-REC Dynamic Level

to how much dynamic range it should collect and package into the typical video signal's 0-100% range. The choices here correspond to how bright of an image FILM-REC will be able to retain; if "white" is normally rendering at 100% brightness, FILM-REC can retain detail in images that are twice as bright (200%), up to 600% brightness, and then remap it all down to where it fits evenly in the recorded 0-100 range. So effectively, the choice here is in how much dynamic range FILM-REC will capture. However, there are good reasons to select the lower levels! FILM-REC allocates the brightness evenly throughout the curve, so if you try to cram more dynamic range into the same-sized container, you'll find that there are fewer "steps" provided for each stop. For the best image rendering, you'd want to use the lowest number here that is sufficient to capture all the dynamic range your scene exhibits.

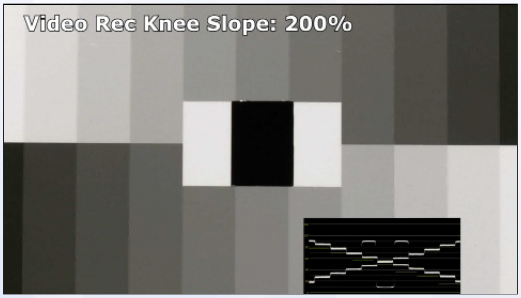
Gamma Setting>F-REC Black Str Lvl

When using FILM-REC gamma, you can adjust how it processes the darkest tones in the image, by stretching them up to be brighter (or not). You can set the stretch level from 0 to 30%. Setting a lower level will "crush the blacks", setting a higher level may bring more detail into the shadow tones, at the expense of making the darkest tones "milkier" and lowering the overall perceived contrast of the scene.



Click the video above for a demonstration of FILM-REC Black Stretch Level

Gamma Setting>V-REC Knee Slope

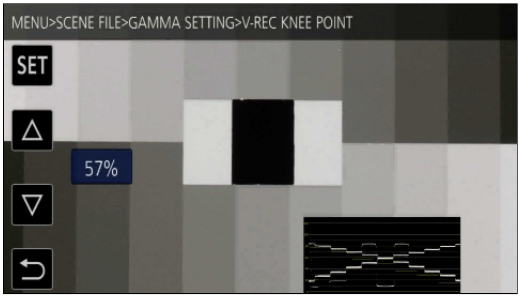


Click the video above for a demonstration of VIDEO-REC Knee Slope

The VIDEO-REC gamma has its own knee point and knee slope commands. VIDEO-REC functions more like FILM-REC than it does a conventional video gamma, and with the V-REC KNEE SLOPE you set how much dynamic range you want the VIDEO-REC gamma curve to retain

(and remap into the 0-109 range of conventional video). The options are from 150% to 500% (viewed in relation to white being at 100%), so 150% would retain about 1/2 stop more highlight information than at 100%.

Gamma Setting>V-REC Knee Point

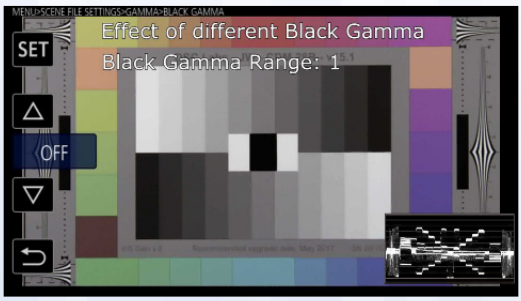


Click the video above for a demonstration of VIDEO-REC Knee Point

Here is where you set the knee point for VIDEO-REC gamma's proprietary knee circuit. The range is tremendous -- you can have the system start compressing tones as low as 30%! Generally a knee point in video doesn't start until around 80% to 90% of brightness, but VIDEO-REC lets you start the attenuation much lower -- which means that you can fit more data into the curve, although the lower you set the knee point, the more tones will be affected. If you were to set the knee point to, say, 50%, then that means that all tones above 50% brightness will be a little darker in VIDEO-REC than they normally might be, depending on just how much additional highlight information VIDEO-REC has to try to compress into the normal video range. If using 150%, then the compression will be quite mild, but at 500% the tonal compression needs to be more aggressive in order to fit it all into the 0-109 range of video encoding.

Gamma Setting>Black Gamma

The BLACK GAMMA function lets you adjust the shape of the gamma curve for the darkest areas of the image. It lets you pull the shadows down darker, or push them lighter. This function determines just how much to pull or push the dark range of the gamma curve. A setting of 0 is standard and leaves the gamma curve unmodified; a negative setting pulls the shadows/dark tones down (and the lower the number, the deeper the shadows are pulled); this can result in sharper and harsher contrast and, if taken too far, can result in losing



Click the video above for a demonstration of Black Gamma and Black Gamma Range

detail in the shadows. With BLACK GAMMA set to positive numbers, that results in pushing the shadows up, brightening up the darkest tones in the image. This will, of course, reduce the overall contrast in the image, but it can also help preserve shadow detail that might otherwise be lost. BLACK GAMMA doesn't result in increased exposure latitude, but it does help you to discern and emphasize what latitude the camera has already captured. Do be aware that pushing the shadows brighter can result in noticeably more noise in the image; noise lives in the darker regions, so magnifying those regions will also magnify the noise that is in them. In some ways you can think of the BLACK GAMMA as sort of a "dark knee"; BLACK GAMMA lets you manipulate the dark tones of the image sort of similarly to how the KNEE lets you manipulate the brightest tones of the image.

Gamma Setting>B. Gamma Range

This menu setting determines just how much of the exposure range is affected by the BLACK GAMMA menu option. In general, setting "1" means that BLACK GAMMA will stretch or crush the range from 0 to about 20 IRE; setting "2" means that BLACK GAMMA will stretch or crush the range from 0 to about 30 IRE, and setting "3" means that BLACK GAMMA will stretch or crush the range from 0 to about 40 IRE.

Knee Setting>Knee Mode

The KNEE helps smooth the transition to overexposure by compressing and rolling off the intensity of the brightest parts of the picture. With the KNEE circuit engaged, the camera will detect when the highlights are getting too bright and will start attenuating the signal to bring them back lower to be within the 109-IRE limit of video brightness. This can help to save detail in clouds in a bright sky, for example.

Why would you want to turn the knee off? It seems like a good thing, doesn't it? It saves highlights? Well, yes, it does, but it does so by artificially compressing the brightest range of tones. The result is that the highlights may not look natural, they may lose color saturation, they may lose detail, they may even shift color somewhat. For the most natural rendering of the scene, you would perhaps want to leave the knee OFF, and control your exposure to not let anything reach into the overexposure/clipping area. This is, of course, not always possible, and it's particularly challenging when shooting in uncontrollable scenarios (such as sports or news or live events); it's more practical to turn the knee off when you're shooting in a studio and/or under controlled lighting. Never ever let your flesh tones be adjusted by the knee! For the best skin tones, keep the knee OFF, or raise the KNEE POINT so high that it cannot possibly affect your skin tones.

Knee Setting>A.Knee Response

If you've set the knee in automatic mode, you can control how quickly the automatic knee makes adjustments. For quick response, set a lower number; for a more gradual response, set a higher number.

Knee Setting>Knee Point

This setting lets you decide at what point on the IRE scale the knee begins working. The range is from 70% to 107%. What this means is, the knee circuit will ignore any area of the image that is less bright than the KNEE POINT. Only sections of the image that are as bright or brighter than the KNEE POINT will be modified. How much they will be modified depends on the KNEE SLOPE setting.

The lower you set the KNEE POINT, the more of the image will be affected by the knee. Generally, you want to keep the knee away from your skin tones; knee compression on skin tones can make them look quite ugly. The proper exposure range for skin tones varies depending on which gamma you are using; for the HD gamma the lightest, fairest Caucasian skin should generally not be exposed over about 80 IRE whenever possible; when using FILM REC, that maximum could be much lower. The KNEE POINT's minimum value is 70%, so when shooting in HD gamma, it's possible that the skin tones might encounter the knee. The solution, of course, is to set the KNEE POINT higher. The default is 93.0 IRE. At that setting, it's unlikely that the knee will interfere with skin, but it's more likely that it will come into play to try to retain detail on something that's superbright, such as clouds in the sky.

Generally, set the KNEE POINT as high as you can to keep it from interfering with image detail that has been exposed properly; you generally only want the knee working with superbright areas that are prone to overexpose. On the other hand, the lower you set the KNEE POINT, the more range the knee has to work with and the more gradual the highlight rolloff can be.

Knee Setting>Knee Slope

With the KNEE POINT you set at what IRE threshold the knee begins compressing the signal. With the KNEE SLOPE, you tell the knee how quickly to compress the signal. The range is between 0 and 99; at a setting of 0 there will be no compression, and at a setting of 99 the knee will extremely aggressively squash any highlights in the range at or above the KNEE POINT. At lower settings the knee slope is more like a vertical line, and at higher settings the knee slope is more like a horizontal line.

For maximum dynamic range retention you'd want to set the KNEE SLOPE as gentle (small) as possible while still holding on to the very brightest sections of the image. If you set the KNEE SLOPE too high, it's entirely possible that it will squash highlights so thoroughly that none of them ever reach the 109 IRE limit; in doing so, you wouldn't be avoiding signal clipping, you'd in fact be causing it. As an example: imagine you had a scene with the knee turned OFF, and highlights as high as 109 IRE. If you set the KNEE POINT to 80, and set the KNEE SLOPE to its most aggressive compression of 99, the result would be that everything in your image at 80 IRE and above would be squashed down to 80 IRE — effectively forcing a hard clip. Generally, that's not the desired outcome of using the knee!

Consider that normally, as the intensity of light increases, so does the signal proportionally until the signal exceeds the ability of the camera to record it; any brighter and it just clips to solid white. The knee extends the dynamic range by compressing high intensity signals, somewhat like an audio limiter compresses audio signals to prevent overmodulation and distortion. But, just like an audio limiter, limited audio doesn't sound all that great, and knee-limited video doesn't look all that great. It looks better than clipped whites, but it's still something to be used sparingly if image fidelity is your principle concern.

Knee Setting>HLG Knee SW, Point, and Slope

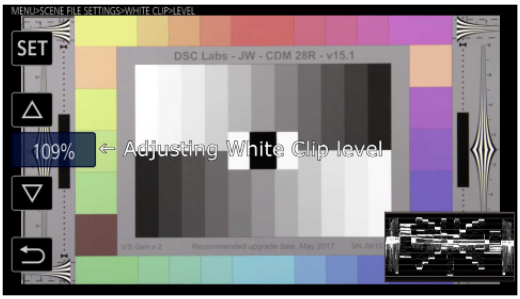
These menu items are only available if you've set the GAMMA MODE SEL to "HLG". They work just like the KNEE settings do, so refer to KNEE POINT and KNEE SLOPE. The settings are different because of the much wider highlight range HLG can accommodate as compared to a video gamma. Generally you'll use a lower HLG KNEE POINT than you would use a regular video KNEE POINT, and a milder HLG KNEE SLOPE than you would use with a video gamma's KNEE SLOPE.

White Clip Setting>White Clip

This menu item lets you enable or disable the white clip circuit. You can establish a hard level above which no data is allowed -- anything that would render above that given level would be rendered as pure white.

White Clip Setting>White Clip Level

If the WHITE CLIP is set to ON, this menu item lets you establish the white clip level (from 90 to 109 IRE). Using the WHITE CLIP LEVEL, you can establish a maximum output IRE signal that the camera will



Click the video above for a demonstration of White Clip Level

generate, and anything brighter than that level will be forced to match the WHITE CLIP LEVEL setting. An example of when you might want to use this is if your broadcaster has specified that they want the white level set to 100 (or some other value). Without the WHITE CLIP enabled, the camera can generate values up to 109 IRE. With the WHITE CLIP enabled, you can specify a maximum level between 90 and 109 IRE.

DRS (Dynamic Range Stretching)

The DRS function is designed to extend the dynamic range of a scene, avoiding blown-out highlights and crushed shadows. To understand it, think about enabling the automatic knee, along with automatic black gamma, across your images. That gives you the general idea of how DRS works (it can compress the highlights like a knee, and it can stretch out the shadows like black gamma), but it's more complex than that, because DRS doesn't get applied globally to the entire frame; instead it gets applied section by section. It's almost like having an individual exposure level for every pixel on the screen!

It sounds great, and it can be very helpful. But, it is an automatic function, and like all automatic functions, it might act when you didn't necessarily want it to. You have to keep a careful eye on DRS, and only use it when the scenes really call for it. DRS changes dynamically, on the fly, adapting to lighting conditions or changing scene conditions, and as such, the amount of intensity it employs can change too. The result can be somewhat akin to when automatic exposure changes the exposure on you when you didn't want it to — it's nice that it can do it, but generally in professional videography you're going to be manually controlling your exposure, and you'd probably generally want to manually control your dynamic range too. That said, there are times when automatic exposure is a lifesaver, and there are times when DRS will be exactly what you need to get the shot. It's not magic, and it's not a cure-all, but there are times when it may be exactly what you need. Do be aware that using DRS effectively cancels out the GAMMA menu settings, since the DRS system overrides tonal exposure all throughout the frame.

DRS Effect Depth

There are three levels of DRS, labeled "1", "2", and "3". They all work similarly, but the bigger the number, the more effect it can have. On level 1, there is mild compression of the highlights and mild stretching of the shadows. On level 3, there's quite a lot of compression of the highlights and quite a bit more stretching of the shadows.

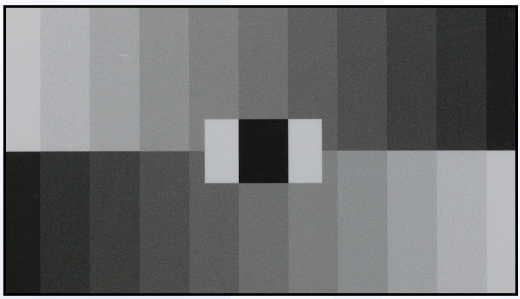
How much DRS to use is a question that gets answered on a scene-to-scene basis. On some scenes there may be no need for DRS at all; in some scenes there may be no way to get the shot without employing the maximum amount of DRS. You have to evaluate the use of it based on the lighting conditions you're facing.

There are three general side effects to using DRS. First, there's the automatic nature of the feature, in that it can change things on you in the middle of a scene. Second, there's compression in the highlights — which can save an overexposed item, but may affect its tonality or color (see the KNEE section for more info). And third, there's the potential to add noise to the shadows. The more the shadows get lifted and stretched, the noisier they will become. On level 1, the stretch is very mild and the commensurate noise increase is very modest, but on level 3 the camera is able to really significantly stretch the shadows, and that may result in quite a bit of noise being added to them.

There's another side effect that may happen under certain conditions; a shadowing effect that happens when something bright meets something dark; because DRS darkens brights and lightens darks, when those two meet it might have to make some compromises. Observable compromises would include a minor ring or faint shadow of darkness around brighter objects.

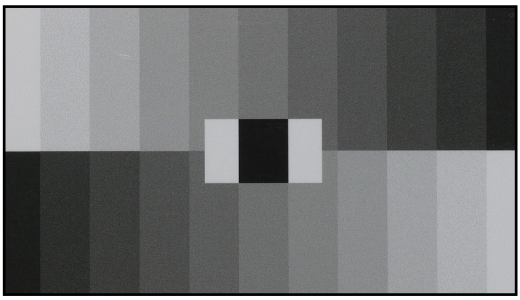
DNR (Digital Noise Reduction)

The CX350 camera has sophisticated noise reduction circuitry that can help minimize the appearance of grain or noise in the picture. Noise reduction works to minimize the amount of visible grain in the image, but a possible side effect may be that the finest

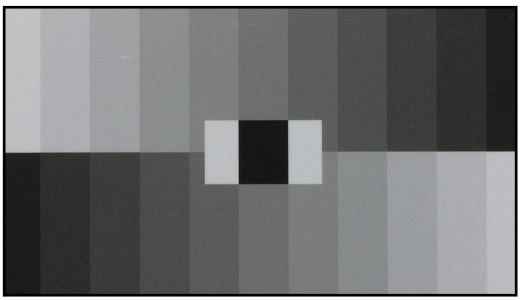


Noisy image, DNR OFF

details in your image are smoothed over. With DNR set to OFF, the image will be the sharpest it can be, and you may or may not notice a little "grittiness" in certain areas of the picture, especially out of focus areas. Setting DNR to 1 will smooth out some of that grit, setting DNR to 2 will aggressively smooth out even more.



Noisy image, DNR 1



Noisy image, DNR 2

The more aggressive Noise Reduction you use, the more side effects you may see in the image. Generally the side effects of noise reduction include a softening of fine detail, perhaps a flattening of colors, and with the most aggressive noise reduction (or using the HIGH SENS mode) you may see a brief after-image or trailing ghosting artifact on high contrast edges.

A.Iris Level and A.Iris Level Effect

The A.IRIS LEVEL setting lets you instruct the automatic exposure system to bias the exposure to be darker or brighter. The A.IRIS LEVEL EFFECT tells the automatic exposure system just how much to adjust the exposure. The range is from -50 to +50. A setting of -50 results in the auto-iris system choosing an exposure about 2 stops underexposed as compared to "normal"; a setting of +50 results in it choosing an exposure about 2.5 stops overexposed as compared to "normal". Use care with the A.IRIS LEVEL setting, especially with + values, as you can easily overexpose your video, leading to ugly "blown out" highlights.

Note also that while this menu item is named A.IRIS LEVEL, it can affect more than just the iris! The actual effect is to raise or lower the overall exposure, not just the iris, and the camera will use whatever tools are available to it to accomplish that. For example, if automatic gain is enabled, the camera may choose to add gain. If the automatic shutter is enabled, the camera may choose to adjust the exposure by using the shutter speed instead of the iris. Or, it may choose a combination of all three.

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Audio Menu

This section of the book describes the CX350's audio settings, including the limiters, automatic level control, test tone volume and other audio-related settings.

Input Settings>Input1 and Input2 MIC Level

Different microphones have different levels of output. If you find that the audio level coming from your microphone is too low and that you're having to crank the audio dials up high just to get a usable level, then you'd probably be better off to try changing the appropriate channel's MIC Level setting to boost the audio levels. –60dB makes the mic input louder than –50dB, and would be appropriate for use with a less-sensitive microphone. -40dB is the lowest-resistance setting and would be used if -50dB isn't enough.

Note that these settings are only relevant if the associated channel's INPUT switch is set to MIC or +48V.

Input Settings>Input1 and Input2 Line Level

For line-level equipment, some signals are sent at a hotter level than others. The camera can compensate, by using this menu item. You can choose 0dB or +4db. Generally professional equipment will be outputting signals at +4dB; if your signals are mismatched and your audio input is higher or lower than what you were expecting, you may be able to adjust this menu item to compensate.

Note that these settings are only relevant if the associated channel's INPUT switch is set to LINE.

Rec CH Settings>CH1/CH2 Level

You can choose automatic or manual level control for each channel. In typical professional productions you'd want both channels to be manually controlled at all times, and especially if you're working with an external

mixer — the sound mixer will control the levels, so you definitely don't want the camera trying to automatically compensate too. However, there are scenarios where one person can't do everything — say, news coverage or events or sports or some other intensive/fast-reaction setting, and if it means the difference between getting the shot or not, you may want to use automatic level control in those scenarios. Or, another technique would be to route the same microphone onto both channels, but set one to manual and the other to automatic control, just in case for some reason the manual audio level isn't accurately handled (i.e., sound suddenly gets very loud, and you can't react quickly enough mid-shot to crank the volume knobs down). You can also assign the limiter to either channel to help control sudden loud bursts; see the REC CH SETTINGS>CH1/CH2 LIMITER for more details.

Rec CH Settings>CH1/CH2 Mic Lowcut

You can assign a low-cut filter to each audio channel individually. Effectively, this will cut out or de-emphasize lower frequencies, while preserving middle and higher frequency sounds. Some examples of when you might want to use this would include if there's a big truck idling outside the location you're recording in, or if you're recording in a windy outdoors environment; when wind hits a microphone, the results are a rumbling muffling mess in your audio track. Sometimes this can ruin your recordings. The rumbling is usually quite low frequency, and establishing the MIC LOWCUT can knock out some of that wind rumbling and result in a less-distracting audio track.

If you need to cut out the rumbling or wind noise, consider setting the MIC LOWCUT feature on. However, if you don't need it, don't use it – the MIC LOWCUT works by chopping out some of the lower bass frequencies in your recorded audio, and that can result in your recorded audio sounding thinner. For maximum audio fidelity, you want this set to OFF. But if you're in a windy environment and relying on the onboard microphones, you might want to turn it on to minimize the rumbling wind noise, or if there's a low-frequency rumble or other unwelcome noise in the low frequency areas of the soundtrack, this feature might give you clearer and better sound without the low-frequency interference.

Rec CH Settings>CH1/CH2 Limiter

The CX350 has individual control over both of its audio channels, as to whether either, neither, or both of them use the automatic limiter capability. The Limiter is optional, and can help you avoid blown-out or

distorted audio that gets too loud. Note that the limiter is only available when setting the audio levels manually.

When the Limiter is engaged, the camera will try to "clamp down" excessive volume to prevent clipping or overdriving the audio channel. It won't modify the overall signal level, it will just try to keep loud levels from distorting (sort of like the KNEE control for protecting against overexposure). It may not catch brief transitory peaks (clapping close to the mic may defeat the limiter and result in overmodulated sound) but in general if the overall sound level is too high for more than the briefest moment, the limiter will lower the volume to keep it below the maximum allowable threshold. When using mics directly hooked to the camera, it's usually a good idea to keep the limiter ON. When using an external mic-level mixer with its own limiter, you should set the camera's limiter OFF.

If you're recording audio film-style where you run one microphone into both audio channels, and you set one channel lower than the other to prevent clipping, then you probably don't want the limiter engaged. On the other hand, if you're recording ENG or news-style, you may not have time to ride the audio levels and in such a scenario the limiter can be very useful indeed. Generally, the purest quality audio will be recorded when the limiter is off (provided, of course, that you keep an eye on the levels and don't let anything get too loud). If you can't do that, then using the limiter can at least provide some insurance from badly clipped audio.

Rec CH Settings>Head Room

Different territories in the world have different standards as to how loud audio signals should be recorded. The audio level meter in the lower left of the display shows the average audio level with indicators in the middle of the graph. This menu item lets you choose whether those indicators will be drawn at -12dB, -18dB, or -20dB. When set to -20dB, the indicators will be drawn one square to the left of where they would have been drawn on -18dB, which thus provides for a little more room (2dB worth) on the right side of the scale.

Output Settings>Audio Out

You can dictate how the two audio channels are output on the headphone jack. The choices are:

CH1: When setting is selected, only Channel 1 will be output in isolation. Channel 2 will be muted.

CH2: When setting is selected, only Channel 2 will be output in isolation. Channel 1 will be muted. Muting one channel can be a great way to isolate clothing rustling noises from a body-worn microphone, for example.

CH1/2 STEREO: When setting is selected, Channel 1 will be output on the left headphone output, and Channel 2 will be output on the right headphone output.

CH1/2 MIX: When setting is selected, both channels will be output on each output. Channels 1 and 2 get mixed together, and the mixed signal is output on both the left and right headphone outputs.

Alarm>Battery End, Media End, and Warning

The camera can issue a warning alarm if certain conditions arise. If the camera is unattended (in a fixed position maybe, or in the case of a reporter doing a stand-up with a camera on a tripod) it might be very beneficial to know if the camera's battery is running out or if the recording media is full; you might very well also want to be notified if some other warning or system error occurs. You can configure the camera to issue an audible warning in any or all of these cases; in these menu items you can also choose the volume of the alarm warning for each case.

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Video Out/LCD/VF Menu

This menu deals with settings related to the HDMI and 3G-SDI video output terminals, the AV Out jack, and the LCD and viewfinder. Basically if anything is displayable on the viewfinder or LCD, or has anything to do with the video output ports, you'll find it in this menu.

3G-SDI is a professional monitor connector, which supports full-bandwidth high-definition and standard-definition signals (when used for standard-def, it's called "SDI", when used for high-def it's called "HD-SDI"; when used for 1080/59.94P or 1080/50.00P it's referred to as 3G-SDI). In all its modes SDI signals can embed audio and timecode along with the video. But the SDI port cannot output UHD/4K video; that can only be output through the HDMI port.

Video Out Sel

The camera has three video output ports: the SDI terminal, the HDMI terminal, and the AV Out jack. The AV Out jack is a standard-definition analog video output; you use a breakout cable that plugs into the AV Out jack and has the familiar yellow, red and white RCA barrel connectors to plug into analog video equipment.

The HDMI is always active. You have a choice of whether the SDI or the AV Out jack will be active. You can't have SDI+AV Out at the same time. This menu item lets you determine whether the HDMI+SDI are active, or the HDMI+AV Out. When you make your choice here, you'll see that one of the following menus will be disabled, depending on which port you've disabled, either the SDI OUT or the AV OUT.

SDI Out>Output SW

The SDI output can be disabled by using this menu item. If for some reason you want the SDI port turned off (like, perhaps it will save a little bit of battery power) you can disable the SDI port here.

SDI Out>Out Format

The SDI terminal can be used to output a variety of formats, up to 1080/59.94p, and can even output a downconverted signal. This menu item lets you choose what output format you want, within certain restrictions. Specifically, the camera generally doesn't do an "up-convert"; you can't record 720p but output 1080p, for example; the camera will also not convert interlaced footage into progressive output. The SDI terminal can generally be set to output the same format as being recorded (with the exception of UHD) or it can output a downconverted version of that signal. The choices are:

1920x1080p: This menu item is available when recording UHD or 1080 at 50.00P or 59.94P. Note that this setting is not compatible with HD-SDI monitors; HD-SDI is limited to 1080/50.00i or 1080/59.94i. You need a monitor that's capable of at least 3G-SDI for this menu option to work. Also, note that if you've chosen this menu item and later change your recording format to 23.98P, 25.00P or 29.97P, the camera will automatically change the Out Format to 1920x1080PsF.

1920x1080i: This setting is mainly for compatibility with older monitors that only support the HD-SDI standard. This choice is generally not available when choosing a recording format of 29.97, 25.00, or 23.98 frames per second; in those cases you'll have the choice of 1920x1080PsF. If you enable this option, the 3G-SDI OUT menu option will be disabled.

1920x1080PsF: The PsF stands for Progressive Segmented Frame. It is an industry standard for embedding progressive footage inside an interlaced video signal. This menu option is available for when you have chosen a recording format of 23.98, 25.00 or 29.97 frames per second, and you want to output a signal that's compatible with an HD-SDI-only monitor.

1280x720p: This menu item is only available when the recording format is set to AVCHD 1280x720.

720x480i and 720x576i: When recording 1080, 720, or standard definition, the SDI can be configured to output a standard-definition signal (either 720x480i or 720x576i; that's dependent on your SYSTEM>FREQUENCY setting). Note that standard-def output is not available when you're recording UHD.

Note: if you choose an OUT FORMAT, and then later change the recording format menu item, the possibility exists that you'll select a format that is incompatible with your chosen OUT FORMAT. If that happens, the camera will automatically select a compatible OUT FORMAT (usually 1920x1080i

or 1920x1080PsF). So if you change the SYSTEM>REC FORMAT, you may want to come back into this menu to confirm what OUT FORMAT is selected.

SDI Out>3G-SDI Out

When the camera is outputting a 3G-SDI signal (1920x1080p at 50.00p or 59.94p), this menu item is enabled. It's disabled if the camera is outputting HD-SDI (1920x1080i or 1920x1080PsF) or standard definition (480i or 576i). There are two choices:

Level-A: This choice outputs uncompressed 1920x1080 video at up to 59.94 frames per second in one continuous stream.

Level-B: This choice uses the single 3G-SDI to carry a dual-link HD-SDI signal, resulting in uncompressed 1920x1080 video at up to 59.94 frames per second. This is known as Level B Dual Stream. This choice is also the factory default.

SDI Out>SD-SDI EDH

Enables or disables the output of SDI Error Detection and Handling on the SDI output jack. The camera can embed and superimpose the optional error detection and error handling protocol in its output video when it's outputting standard def (but only when it's outputting standard def).

SDI Out>SDI Rec Remote

When connected to an external SDI video recorder, the camera can optionally transmit a start/stop recording flag on its SDI video output. This flag is generated each time the REC button is pressed on the camera. If you want to configure an external SDI recorder so that it will start recording whenever you press the camera's red REC button, then set this menu item to ON. Do be aware that this won't work if you've set the camera to record time-lapse footage (RECORDING>REC FUNCTION>REC MODE set to INTERVAL).

SDI Out>SDI Out Char

This menu governs whether or not to output various screen overlay information (such as shutter speed, remaining battery, etc) and the menus, thumbnails, and other information. There are certain items (like the vectorscope or waveform monitor) which cannot be output over the video outputs.

SDI Out>SDI Out Zebra

You can choose whether you want the zebras to be output to an SDI monitor or not. Obviously if using an SDI recorder or feeding an SDI client monitor, you wouldn't want the zebras on, but this feature can be very helpful for a camera operator's monitor.

SDI Out>SDI Out HDR

When the camera is set to use HLG Gamma, you can configure the SDI output to send either a standard dynamic range signal or a high dynamic range signal. Some monitors may not be able to properly interpret an HDR signal, so you may need to set this to SDR when using a non-HDR-compatible monitor. This menu item will be forced to SDR when recording standard definition (AVCHD SA format), or when you've instructed the SDI port to output a standard definition signal; also, if you're using any gamma other than HLG the SDI port will always output an SDR signal.

HDMI Out>Out Format

The HDMI terminal can be used to output a wide variety of formats; it can output any format that the camera can record, and even some that it can't. For example, the HDMI OUT>OUT FORMAT can be set to output a standard-definition 720x480p or 720x576p image. This menu item lets you choose what output format you want, within certain restrictions. Note, the camera doesn't do an "up-convert"; you can't record 1080p but output UHD, for example. The choices are:

3840x2160p: This choice is only available if the camera's REC FORMAT is set to UHD. This menu option outputs a full 10-bit 4:2:2 color signal at the full 3840x2160p resolution, and at the frame rate you specified in the REC FORMAT. Please note: in order to get the full 3840x2160 4:2:2 10-bit 59.94Hz (or 50.00Hz) signal, it requires a monitor and HDMI cable that are capable of supporting the 18 gigabit data rate (generally labeled "Ultra High Speed" HDMI cables.)

3840x2160p(420/8bit): This choice is only available if the camera's REC FORMAT is set to UHD at 50.00p or 59.94p. This menu option outputs a lower-bandwidth version of the camera's processing signal; this version is a full 3840x2160p resolution, but it is output at 8-bit quantization and 4:2:0 color sampling. Some HDMI monitors and cables are not capable of supporting the 18 gigabit Ultra High Speed data rate of UHD 10-bit 4:2:2, and instead only support the 10.2 gigabit "High Speed" standard. If your monitor and/or cable are not capable of supporting the full 18 gigabit signal, choose this option to have the camera output a signal that should be compatible with your equipment.

1920x1080p: This menu item is available with all UHD and HD REC FORMAT settings except 1280x720. Use this choice if your monitor doesn't support UHD.

1920x1080i: This setting is mainly for compatibility with an ATSC-compatible TV that doesn't support 1080p or UHD. This choice is generally for when you've set the REC FORMAT to 1080/50.00i or 59.94i.

1280x720p: This menu item is only available when the REC FORMAT is set to AVCHD PM 1280x720.

720x480p: This choice results in a standard-definition resolution image being output at 59.94p. This choice is only available if you've set the SYSTEM FREQ to 59.94 and set the recording format to AVCHD SA.

720x576p: This choice results in a standard-definition resolution image being output at 50.00p. This choice is only available if you've set the SYSTEM FREQ to 50.00 and set the recording format to AVCHD SA.

Note: if you choose an OUT FORMAT, and then later change the REC FORMAT menu item, the possibility exists that you'll select a REC FORMAT that is incompatible with your chosen OUT FORMAT. If that happens, the camera will automatically select a compatible OUT FORMAT (usually 1920x1080i or 1920x1080p). So if you change the REC FORMAT, you may want to come back into this menu to confirm what OUT FORMAT is selected.

HDMI Out>HDMI TC Out

You can instruct the camera to embed timecode into its HDMI output, or to leave the timecode out. Early standards for HDMI had no provision for timecode; it was added later. If you encounter a monitor that just won't work properly with the CX350's HDMI output, you might try turning off the HDMI TC OUT. Note that the next menu, HDMI REC REMOTE, requires that HDMI TC OUT be enabled.

HDMI Out>HDMI Rec Remote

When connected to an external HDMI video recorder, the camera can optionally transmit a start/stop flag on its HDMI video output. This flag is generated each time the REC button is pressed on the camera. If you want to configure an external HDMI recorder so that it will start recording whenever you press the camera's red REC button, then set this menu item to ON. Note that this menu item is disabled unless you've also enabled HDMI OUT>HDMI TC OUT.

HDMI Out>HDMI Out Char

This menu governs whether or not to output various screen overlay information (such as shutter speed, remaining battery, etc) and the menus, thumbnails, and other information. There are certain items (like the vectorscope or waveform monitor) which cannot be output over the video outputs.

HDMI Out>HDMI Out Zebra

You can choose whether you want the zebras to be output to an HDMI monitor or not. Obviously if using an HDMI recorder or feeding an HDMI client monitor, you wouldn't want the zebras on, but this feature can be very helpful for a camera operator's monitor.

HDMI Out>HDMI Out HDR

When the camera is set to use HLG Gamma, you can configure the HDMI output to send either a standard dynamic range signal or a high dynamic range signal. Some monitors may not be able to properly interpret an HDR signal, so you may need to set this to SDR when using a non-HDR-compatible monitor. This menu item will be forced to SDR when recording standard definition (AVCHD SA format), or when you've instructed the HDMI port to output a standard definition signal; also, if you're using any gamma other than HLG the HDMI port will always output an SDR signal.

AV Out>Output Sw

You can enable or disable the AV OUT jack. This menu is only available if you've chosen AV + HDMI in the VIDEO OUT SEL menu.

AV Out>AV Out Char

This menu governs whether or not to output various screen overlay information (such as shutter speed, remaining battery, etc) and the menus, thumbnails, and other information. There are certain items (like the vectorscope or waveform monitor) which cannot be output over the video outputs.

AV Out>AV Out Zebra

You can choose whether you want the zebras to be output to the AV OUT jack.

SD Downcon Mode

Under certain circumstances you can be recording UHD or high definition (1080 or 720) footage, and the camera will perform a downconversion to

standard def to output over the AV OUT jack (or, in some cases, over the SDI terminal). This menu item lets you control how your 16:9 widescreen high-definition or UHD image gets downconverted to standard definition. The HD or UHD video the camera is generating will always be recorded as 16:9, but when it is downconverted to standard-def for video output you have a choice of how to deal with the widescreen aspect ratio.

There are two aspect ratios that are common in the world of standard definition television: traditional 4:3 televisions, and widescreen 16:9 televisions. These numbers refer to the width of the picture as compared to its height; a 4:3 television is four units wide and three units tall, whereas a 16:9 television is 16 units wide and 9 units tall (for comparison, a 4:3 television could also be expressed as a 12:9 television, which gives a better understanding of how it compares to a 16:9 television.) Displaying 4:3 video on a 16:9 television will result in video that's horizontally stretched out. Displaying 16:9 video on a 4:3 television will result in a picture that's horizontally squeezed together.

The CX350 is optimized to create video suitable for a 16:9 television; all HD is 16:9 (and so are widescreen DVDs, etc). When recording HD or UHD the camera will always record the full 16:9 frame. This menu item lets you decide how to output a downconverted standard-definition signal for monitoring (or external recording). There are three choices:

SIDE CROP: in this setting, the camera will cut off the sides of the image, leaving a full-height central 4:3 extraction out of the widescreen 16:9 frame. This is similar to a "full screen" DVD or a "Pan & Scan" television broadcast; there won't be any black bars at the top or bottom, but the left and right edges of the image will be cut off in order to make an image that will display properly on a 4:3 television.

LETTER BOX gives you video that is suitable for display on a 4:3 television, but has black bars on the top and bottom, giving the video a widescreen look (like a letterboxed movie.) With this setting you'll see the entire 16:9 image you're recording, but it will be formatted to properly display on a 4:3 television.

SQUEEZE will output a 16:9 anamorphic standard-def version of the full frame, and the video signal will be appropriate for viewing on a 16:9 widescreen monitor.

If you're connecting to a 16:9 monitor, always use Squeeze. If you're connecting to a 4:3 monitor, use Letter Box or Side Crop.

LCD>Brightness, Color, and Contrast

These settings let you control the brightness, color, and contrast of the viewfinder and LCD panel. When lighting conditions change significantly your existing settings may no longer be giving you an accurate representation of the recorded image. You should use the color bars to calibrate your LCD and EVF to continue being able to rely on them to give you an accurate picture (with the caveat that you can't really judge exposure properly from the LCD or EVF alone.) Understand that no built-in LCD is going to show you the full range and full resolution of an ultra-high-definition image; only an external ultra-high-definition monitor can do that. But with proper calibration and attention to brightness and contrast, you can at least configure the LCD and EVF such that you can more accurately judge whether the shadows are crushed or the highlights are being blown out.

LCD>Backlight

This menu item lets you adjust the light output of the LCD display. You can slightly increase the running time of your battery by choosing a lower brightness level, but that may only be practical when shooting in a reasonably dark environment; outdoors in broad daylight you're going to want to set this on +2 to get as much brightness as you can. Be very careful not to try to judge your image's exposure by using the LCD panel as a guide; always use the zebras and waveform monitor to judge exposure. As you can see, you can significantly affect the perceived brightness of the picture by changing this LCD Backlight setting, even though it's not really changing the brightness of your recorded image at all! Don't rely on the LCD display to judge exposure; instead use the tools that are given to you for that purpose: the zebras and the waveform monitor.

LCD>Self Shoot

When you're in front of the camera, you can flip the LCD to face forward so you can see yourself and the camera's frame. This menu item lets you determine if you want to mirror the output left to right so that it looks more appropriate when viewed from in front of the camera.

VF>Brightness, Color, and Contrast

Like the LCD, the viewfinder can be adjusted; see LCD>BRIGHTNESS, COLOR, AND CONTRAST for more information.

VF>VF Color

You can set the viewfinder (but not the flip-out LCD panel) to display in black & white or color. Setting this menu item to ON will enable color in the viewfinder; setting it to OFF will turn the viewfinder to black & white. With color disabled, some people find focusing to be a bit easier, and some camera operators just prefer a black and white viewfinder.

VF>Eye Sensor

The eye sensor is used to control whether or not the OLED viewfinder is enabled. Normally the viewfinder is shut off unless the eye sensor detects that your eye is close to the viewfinder; it will then automatically switch on and stay on until it detects that you are no longer looking in the viewfinder. It does this by means of a proximity sensor, and you can change the sensitivity. On HIGH sensitivity, the viewfinder will turn on even if you are a few inches away from the viewfinder; on LOW sensitivity it will only turn on if you are very close to the viewfinder.

LCD/VF HDR

The LCD and viewfinder are capable of displaying either standard dynamic range (SDR) or high dynamic range (HDR) footage. The HDR capability is only used when the GAMMA MODE SEL is set to HLG; in any other case the LCD and VF will output an SDR image regardless of how this menu item is set. Also, when using standard-def footage (REC FORMAT of AVCHD SA), the output will always be SDR.

Indicator

The LCD monitor and viewfinder are capable of displaying a tremendous amount of information about the camera's current state. In this menu you can pick and choose which displays you want enabled, and which ones you want hidden; there are so many potential displays that your LCD or VF might quickly become quite cluttered if you enabled them all. Note that the camera operator can always hide all this information with a quick press of the DISP/MODE CHK button; as such, I generally recommend to enable all the data, and leave it up to the operator to determine when they need a clean clutter-free display. The camera's Operating Instructions give guidance on what each item represents.

Marker Menu

This menu item lets you enable or disable the variety of frame markers and safety zones on the camera's LCD panel and VF. The CENTER

MARKER and SAFETY MARKER options are self-evident. The SAFETY AREA lets you customize the size of a bounding rectangle displayed on the frame so you can keep vital images within the "safe area" that you choose. And the FRAME MARKER is a different kind of SAFETY AREA; it lets you see the entire 16:9 frame but displays a target frame that you can "protect" for. For example, if shooting local news that may be broadcast to 4:3 televisions or 16:9 televisions, you can enable the 4:3 setting and frame your composition such that all the relevant image data is contained within the 4:3 frame marker. To avoid confusion between the FRAME MARKER and the SAFETY AREA, you can change the color of the FRAME MARKER using the FRAME COLOR menu option.

Focus Assist>Focus Assist SW

This menu item lets you choose which Focus Assist tool (EXPAND or PEAKING) is invoked when you press the camera's dedicated FOCUS ASSIST button. Note that while this menu item makes you choose between one or the other, you can in fact combine EXPAND and PEAKING; just assign one function to this menu item, and assign the other function to a USER BUTTON. When you invoke the FOCUS ASSIST button, also push the User Button you assigned the other focus assist tool to, and you'll have both available simultaneously.

Focus Assist>Expand Mode

There are three modes that can be chosen from to govern how long the expanded focus assist appears on the LCD or VF. If you have EXPAND assigned to the FOCUS ASSIST>FOCUS ASSIST SW and you press the FOCUS ASSIST button (or if you've assigned the EXPAND focus assist to a User Button and then press that User Button), the expanded focus assist will appear. It will disappear depending on how you've configured this menu. The choices are:

10SEC: This setting will cause the expanded focus assist to automatically disengage after 10 seconds of display. Note, if you press the FOCUS ASSIST button (or associated User Button) again (before the 10 seconds have expired) it will cause the expanded focus assist to disengage. In this mode, the expanded focus assist is available even when recording.

HOLD: This setting will cause the expanded focus assist to remain active until the user presses the FOCUS ASSIST or EXPAND User Button again to cancel the feature. In this mode, the expanded focus assist is available even when recording.

UNTIL REC: This setting will cause the expanded focus assist to disengage as soon as the user presses the RECord button to initiate recording. Note that when using this mode, you cannot access the expanded focus assist during recording.

Focus Assist>Expand Value

This lets you choose how magnified the EXPAND focus assist is. The higher the number, the smaller the area of the frame will be expanded, and the more highly magnified it will be. Do note though, even at the maximum expand value (x4), the LCD will not be displaying a pixel-for-pixel display of an Ultra High Definition frame! Precision focusing of an UHD frame will require using a finely-tuned PEAKING focus assist, preferably in combination with the EXPAND assist.

Focus Assist>Peaking Level

With this menu item you can control the intensity of the outlining that the Peaking focus assist performs. When set to LOW, the peaking will be very unobtrusive. It won't be as easy to see what areas are being outlined as being in-focus, but then again, the whole screen won't be covered in red peaking either. When set to HIGH, the camera draws much bigger/brighter outlines around in-focus objects. It makes it very easy to see the peaking effect; however, it's possible that so much of the display will be covered in red peaking outlines that it's harder to see the detail in the scene, and the higher the peaking is set, the harder it may be to discern whether an element is truly "in focus" or if it's just generally in focus. I have found that HIGH can give excellent focus, if you ignore the large swaths of red and instead look for the tiny dots that signify the finest details. LOW is the least intrusive, but it may not show up on the very finest details.

Focus Assist>Peaking Color

The color of the PEAKING is adjustable between red, green, or white, which can come in handy if you're trying to grab focus on a primarily green scene (use red in that case) or a primarily red scene (might want to swap to green or white in that case).

Focus Assist>Black & White

You have the choice of turning off the color in the LCD, either at all times or only when using a focus assist. When using the DURING PEAKING option, the colored peaking becomes much easier to discern, especially when set to LOW intensity. In that case, the only color on the entire display is the peaking, which makes it stand out.

Focus Assist>Detail

Another focus assist option you have is the LCD or VF's DETAIL feature. This is essentially the same basic idea as the PEAKING focus assist, but instead of being red in color, it's a subtle white. This is a highly customizable focus assist that works with or without the EXPAND focus assist, although I wouldn't necessarily recommend combining it with the PEAKING focus assist. The PEAKING function works on the frequencies of the underlying UHD image, whereas this DETAIL function works on the LCD display, so you'll get finer focus control by using PEAKING instead of DETAIL.

Focus Assist>Detail Level

When using the FOCUS ASSIST>DETAIL function, this menu lets you determine how vibrant or how subtle the outlining will be on the LCD screen. Higher numbers make for more exaggerated outlining, making the outlines easier to see (but perhaps masking fine detail in the LCD that would otherwise have been displayed); lower numbers make the outlining effect more subtle.

Focus Assist>Detail Freq.

This function instructs the DETAIL focus assist to emphasize outlines solely on either HIGH frequency detail, or to extend that outlining to include LOW frequency detail too. The result is, when set on LOW, you'll see much more of the image outlined; when set on HIGH, you'll see a lot less gets outlined (but, in all likelihood, those objects that are outlined should be the most crisply in focus). It's possible that the wide range of frequencies provided by LOW may result in you thinking that your overall images are sharper than they actually are, whereas when set to HIGH it may be harder to see the detailing effect, but may lead to more precise pinpoint focus.

EI (Exposure Index) Assist>Zebra

This menu lets you enable or disable the Zebras. Using this menu item is functionally equivalent to assigning ZEBRA to a User Button, and then pressing that User Button. Alternately, you can assign the zebras to be MOMENTary; when you choose this option the zebras will appear when you press the ZEBRA user button, but they will disappear by themselves after about five seconds.

EI Assist>Zebra1 Detect

There are two levels of zebra; you can assign a different IRE level for activation of each zebra setting. The zebras will draw a diagonal line pattern

over any element in the image whose brightness exceeds the level you set here. The range is from 0% to 109%; at 0% everything in the image will be covered with diagonal lines at all times. At 50%, anything in the image that's under 50 IRE will appear normal, any elements that are brighter than 50 IRE will have the diagonal line pattern drawn over them. With the Zebras, you can tell at a glance what elements of your image are brighter than your predetermined threshold. A common way to use the two levels of zebras is to establish a skin tone reference level for Zebra 1, and a peak level reference for Zebra 2. As an example, when shooting in the VIDEO gamma, skin tones should generally be kept between about 50 to 70 IRE, with absolutely no element of the fairest/brightest skin tone exceeding about 75 to 80 IRE. So you could establish 75 for Zebra 1, and that way you can set your exposure so that zebras only start appearing on the very brightest hot spots on your subject's skin. However, when shooting in FILMLIKE3, the levels may be very different; you'd probably want to keep your skin tones within a range of about 40 to 55 IRE, so you might establish Zebra 1 at 55, and then monitor it for any signs of hot spots that might be overexposed.

The Zebra 1 pattern draws lines that head uphill (when looking at the LCD in a left-to-right fashion, the Zebra 1 lines start low on the left and are drawn diagonally upward to the right across the LCD). When you turn on the zebras, Zebra1 will always be enabled.

EI Assist>Zebra2 Detect

There are two potential levels of zebra that you can set. If you've set Zebra 1 to detect skin tones, you may want to set Zebra 2 to warn when elements are getting so bright that they're close to blowing out. Generally a Zebra 2 setting of about 90 to 100 is useful for keeping track of white or very bright elements in the scene, you want to keep the amount of Zebra 2 lines to a minimum when possible. Zebra 2 lines are drawn going downhill (meaning, they start high on the left side of the LCD and are drawn diagonally down to the right side of the LCD). Zebra 2 may or may not be displayed, depending on how you have the next menu item configured (EI ASSIST>ZEBRA2).

EI Assist>Zebra2

The CX350 allows you to choose how you want the Zebra2 display to operate. The choices are:

Off: This option disables Zebra2, so they'll never be seen, regardless of what you set the ZEBRA2 DETECT menu item to.

On: When this is set to ON, you'll see both Zebra1 and Zebra2 displayed at the same time. This is different from how some prior Panasonic cameras worked, where they would display solely Zebra1 first, and then use another push of the button to bring up solely Zebra2. In the CX350, it's either all zebras, or no zebras. The difference is in which angle the zebra lines are drawn; Zebra1 is drawn going "uphill" from left to right; Zebra2 is drawn going "downhill" from left to right.

Spot: This option effectively disables the appearance of Zebra2, and instead repurposes Zebra2 to function as a top limit for Zebra1. Normally, if Zebra2 is disabled, then zebra lines will be drawn on any elements in the image that meets or exceeds the value you've set in ZEBRA1 DETECT. That means if you've set ZEBRA1 DETECT to, let's say, 70%, then any element in the image that's 70 IRE or brighter will have zebra lines drawn on it -- anything from 70 to 80 to 90 to 100 to 109 IRE, it'll all be covered in zebra lines. But what if you wanted zebras to appear only in a certain range (a "spot", if you will)? Like, what if you only want zebras to appear between 80 and 90 IRE? In that case, you can use the ZEBRA1 DETECT level as your "lower" limit, and the ZEBRA2 DETECT level as your "upper" limit, and then set this ZEBRA2 menu item to SPOT. In that case, only Zebra1 lines will be drawn, and they will only be drawn between the ZEBRA1 DETECT and ZEBRA2 DETECT IRE levels.

EI Assist>WFM Mode

The CX350 includes two separate video scopes, a Waveform monitor and a Vectorscope. This menu item lets you determine which of those monitors are displayed when you press the WFM button. The choices are to toggle the Waveform Monitor (WFM) on and off, or to toggle the Vectorscope on and off, or to sequentially display first the Waveform monitor, and then the next button press brings up the Vectorscope, and the next button press removes the video scopes.

EI Assist>WFM Transparence

With this menu item you can determine how transparent the waveform monitor (and/or vectorscope) are when they're displayed. At 0%, the waveform monitor and vectorscope will block the image area where they're displayed, and they will be the easiest to see and read. At increasing levels (25%, or 50%) the waveform monitor and vectorscope are more transparent; that makes it easier to see the image behind them, but it may make it more difficult to read the actual video scope.

Level Gauge>Level Gauge

The camera has a built-in two-axis level gauge that can display both horizontal skew (camera rotated as compared to the horizon), and vertical tilt (the camera being tilted up or down, and not level). This can be a great way to keep your eye on your horizons to keep them nice and flat. It's also a great way to level the camera when setting up a tripod, especially if your tripod head doesn't have a bubble level. The level gauge works great from a tripod, but it doesn't necessarily respond instantly, so — for handheld work it's best for when you've steadied yourself up to take a stable handheld shot, but may not be much use if you're running with the camera, for example. See the discussion on the LEVEL GAUGE in the User Buttons section for more information.

Level Gauge>Level Gauge Reset

This menu option resets the internal parameters for the LEVEL GAUGE back to factory defaults. If you've used the LEVEL GAUGE SET User Button to change the definitions of "level", this menu item can restore it back to true level.

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Recording Menu

Format Media

This menu lets you format one of your media cards. Pretty straightforward, but there are two things to consider.

1) Always, always, always format the memory cards in the camera! Don't format the cards on a computer and think that they'll work reliably, they may not. Don't just delete files off the cards using a computer either, as there are all sorts of files and subdirectories that are interlinked and just deleting clips may render the remaining footage potentially inaccessible. Copy the media off to your computer (and copy the ENTIRE CARD CONTENTS, don't just cherry-pick files!) and then reformat the cards IN THE CAMERA.

2) The SYSTEM>FREQUENCY doesn't matter when formatting cards unless you're using AVCHD mode. In that case, it matters quite a bit. AVCHD cannot store both 50Hz and 59.94Hz material on the same memory card, it's one or the other but never both. If you get a message saying "incompatible media", it's probably due to the camera being in one mode (such as 50Hz) and the media having been formatted under the other mode (in this case, 59.94Hz). It is necessary for AVCHD that you format the cards in the same System Frequency as you'll be shooting the footage in.

Clip Name>Cam Index

You can assign an identifying camera letter to each camera you're using, which can be very helpful when editing the footage; the identifying letter will let the editor know which camera each memory card came from. Choose a single alphabetical character from "A" to "Z". Note that the camera letter will be incorporated in the memory card's name when a card is formatted, and it will be embedded in the filename of any recordings done in .MOV format. However, the AVCHD file format does not provide for having a camera index included in its filename. However, you can still make use of the CAM INDEX in AVCHD mode; you would need to set the User Bits

in TC/UB>UB MODE to “CLIP NAME”; that way the CAM INDEX and the CARD COUNT will be embedded in the clip’s User Bits.

Clip Name>Next Card Count

The Card Count is used in naming the memory card when it’s formatted, and it is also used in the filename of any clips recorded in the .MOV format. With this menu item you can choose what the next Card Count number will be. The Card Count is tied to the particular memory card you’re using; when you format a memory card, the Card Count is attached to that memory card, the card’s volume name is changed to include the CAM INDEX and CARD COUNT, and all clips recorded in .MOV format on that memory card will have that memory card’s Card Count embedded in their filenames. Ideally each memory card should have a different Card Count number. It’s technically possible for you to set the Card Count numbers the same on two different memory cards, but it would be an unwise practice to do so, as you’ll then end up with identical filenames on different memory cards. The Card Count will advance one number every time you format a memory card. So, if you set this value to “000” and format a memory card, your memory card will have an embedded Card Count of “000” and the CLIP NAME>NEXT CARD COUNT will now become “001”. If you format your second memory card, it will receive an embedded Card Count of “001”. This can be an easy way to keep track of shoot days, if you offload all footage at the end of the day and reformat your memory cards you’ll always have separate and distinct identifiers in the volume labels and in the recorded clip filenames (except for AVCHD; AVCHD doesn’t use the CARD COUNT or CAM INDEX identifiers in its filenames). You can, however, get the CARD COUNT stored in the User Bits, which would be accessible in AVCHD recordings; see the TC/UB>UB MODE>CLIP NAME function for more information.

2 SLOTS FUNC>OFF, Relay Rec, Simul Rec and Background

The camera has two memory card slots. You can configure it to work with only one at a time, or use this menu to direct the camera as to how to work with both memory cards. The choices are:

Off: This tells the camera to basically ignore the second memory card slot, and to only record footage onto the currently-active memory card (as selected by the SLOT SEL button). When the current memory card is full, the camera will stop recording. When this menu item is set to OFF, the camera acts as if it doesn’t know that it has a second slot when recording

(although you can always manually swap over to the second card slot, using the SLOT SEL button.)

Relay Rec: recordings can overlap from one card to the next (this is known as creating a "spanned" recording). If you need to record long uninterrupted events or long interviews or long takes, RELAY REC may make sense. But for sheer simplicity in editing, and in making sure that the editor always has the complete footage, turning RELAY REC off will likely result in a simpler workflow in post. Spanned clips from one card to another will need to be manually aligned back to back in the editing suite, so it may be easier and cleaner to record each clip completely on its own card. RELAY REC can record continuously from one card slot to the other, and when that first card is full and the camera is actively recording on the second card, you can eject the first card and swap in a fresh card and the relay recording will be able to continue even after the second card is full. You have to be extremely careful to eject the proper card though! Ejecting the card that's being written to will cancel the recording, and may result in loss of some footage.

Be aware that RELAY REC requires two cards, and they both have to be actively recordable (so one can't be write-protected) and, if you're using AVCHD mode, they both have to be in the same format (meaning, you can't have one card for 50Hz mode and one for 59.94Hz mode, they both have to be formatted in the camera in the same mode, in order to be compatible).

Simul Rec: This allows you to record two identical copies of the footage, simultaneously. This can be an excellent option for security (giving you data redundancy), and it's also a great method for being able to deliver footage that the client can take with them at the end of the shoot day, while you get to keep a backup of the footage (especially because it saves so much time in not having to make a manual backup copy.)

Ideally, you'd want to use two cards that were of comparable performance and comparable capacity. It's possible to establish SIMUL REC recording with cards of different capacity, but the whole benefit of recording simultaneously will be lost when one card runs out of space.

Be aware that if you're recording on two different memory cards, one card may fill up before the other one does; if that happens, the camera will ignore the full card and continue recording to the one slot that does have available space — but obviously you wouldn't have a duplicate/backup of that material. And if one of your memory cards encounters a hardware failure, recording will continue uninterrupted on the other card — but

obviously you won't have a backup of that recording (since, of course, the other memory card failed!)

Background: This is an intriguing recording mode, perhaps especially suitable for live events or news shooters. With BACKGROUND recording, both cards are used to record, but they don't always record simultaneously. Instead, once you start recording, both cards start recording simultaneously, but if you stop recording, only the primary card will stop recording. The second card continues recording continuously. You can start and stop the recording on the first card as many times as you want; the second card will record one continuous long recording without stopping. The idea here is that your primary card will be your "selects" reel, containing the highlights, whereas the secondary card will have the entire event recorded. If nothing unexpected or unusual happens, you can give the editor the "selects" reel to pick the highlights from, but if something were to happen while you weren't actively recording on the main card, you can rest assured that that event will have been captured by the "background" card.

To stop recording on the "background" card, register BACKGR PAUSE to a User Button and press and hold that User Button for about five seconds until the recording stops. Or, you can press and hold the EXIT button for about five seconds to stop BACKGROUND recording on slot 2.

BACKGROUND recording only works in 1080 MOV recording formats, it won't work in AVCHD or when recording UHD.

Also, note that none of the 2-SLOT functions are available when recording VFR or SUPER SLOW frame rates.

PRE REC

This menu item lets you enable or disable the pre-record function. When this function is enabled, the camera will continuously be buffering three to ten seconds of footage. Then when you press RECORD, the camera will commit the contents of that buffer to the memory card, and also begin recording everything from that moment onward. So, in effect, PRE REC lets you begin recording up to ten seconds BEFORE you pressed the record button! This can be very handy in news, sports, and nature photography; you may never miss a shot again because the camera will be recording even before you were ready!

When the camera is set to record 1080 footage, the PRE REC buffer holds about ten seconds of footage; if it's set to record 400 megabit recording modes it will buffer about 3 seconds; otherwise, it will hold about five seconds.

PRE REC isn't active when the thumbnails are displayed or when playing back footage; it's only active when in live camera mode. And PRE REC is not available if VFR is enabled; if you want to use PRE REC, you'll have to turn VFR off. Finally, note that PRE REC cannot be left on indefinitely; you only turn it on when you need it. If three hours have passed since you enabled PRE REC, the system will automatically shut it off.

Rec Function>Rec Mode

REC MODE>NORMAL is what you'll use almost exclusively. But, REC MODE>INTERVAL lets you perform time-lapse photography (such as buildings under construction, clouds moving across the sky, or flowers opening up). When in interval recording mode, the camera will periodically capture one individual frame, at intervals that you specify (which can be as short as one frame every second, or as long as one frame every 10 minutes). Once you set up for interval recording, and establish the interval you want to use, just press the record button and the camera will capture and record individual frames at the predetermined intervals.

Rec Function>Rec Mode Hold

Generally when you power down the camera and then turn it back on, the REC FUNCTION>REC MODE will be returned to NORMAL. However, if you want it to retain the setting you've established, you can set REC MODE HOLD to ON.

Rec Function>Interval Time

The playback rate of your Interval Rec footage will be partly determined by the frame rate you're recording in; for any given amount of recording time, an Interval Rec clip that's been recorded in 59.94P will play back twice as fast as one that was recorded in 29.97P. A clip recorded in 50P will play back twice as fast as one recorded in 25P, etc. The following chart will give you an approximate idea of how the available interval options work to translate real-world elapsed time into actual recorded footage time, at various REC FORMAT settings.

30P Interval	Speed	1 Hour Becomes
1 Second	30x	120 sec. (2 minutes)
10 Seconds	300x	12 seconds
30 Seconds	900x	4 seconds
1 Minute	1800x	2 seconds
2 Minutes	3600x	1 second

25P Interval	Speed	1 Hour Becomes
1 Second	25x	144 seconds
10 Seconds	250x	14.4 seconds
30 Seconds	750x	5 seconds
1 Minute	1500x	2.4 seconds
2 Minutes	3000x	1.2 seconds

24P Interval	Speed	1 Hour Becomes
1 Second	24x	150 seconds
10 Seconds	240x	15.5 seconds
30 Seconds	720x	5.2 seconds
1 Minute	1440x	2.6 seconds
2 Minutes	2880x	1.3 seconds

If you wanted to film a 2-hour event in 24P but have it play back in its entirety in around 30 seconds, you'd use 23.98P REC FORMAT and the 10-second interval, because each hour of realtime would result in 15.5 seconds of footage, so two hours of realtime would play back in about 31 seconds. On the other hand, if you were filming a building under construction you might want to use an interval of 2 minutes, so each hour of realtime that passes will be played back in about 1 second.

No audio is recorded during INTERVAL RECording. Note that INTERVAL RECording cannot be done when VFR is enabled, either.

Time Code Options

Before discussing the timecode menu settings, let's discuss timecode itself. Timecode is a system that numbers and counts every frame of video, in the format of HH:MM:SS:FF (hours:minutes:seconds:frames). An internal timecode generator (TCG) stamps an 80-bit code on every recorded frame. The playback system or NLE will use this number for individually identifying every frame. This code is recorded with the video and audio signals and is stored invisibly in the sub code area written to the memory card, and it's output over the SDI (and, optionally, over the HDMI). These 80 bits of time code contain a lot of information, such as drop frame information, frame rate information and user bit information.

In NTSC/59.94Hz video, timecode can be counted in either Drop Frame (DF) or Non-Drop Frame (NDF) mode. In NDF mode, every frame gets counted and numbered sequentially. In DF mode, some timecode entries are skipped in order to make the running time of the video match the timecode display (by way of explanation, NTSC video runs at 29.97 "frames" per second, but timecode counts at 30 frames per second. Drop Frame counting was invented to resolve this .1% discrepancy, so when an hour of footage has gone by, the DF timecode will read 1:00:00:00, whereas in NDF timecode, after one hour the timecode would read 0:59:56:12.) PAL/50Hz users don't need to worry about this, since PAL televisions run at exactly 25.000 frames per second. PAL/50Hz cameras are always in NDF mode. The 23.98P mode uses NDF only.

There are 32 User Bits in each 80-bit code; these user bits can be used to record a specific code that you can set separately for each camera.

TC/UB>TC Preset

This menu option lets you change the value of the current timecode setting. You can manually set it to all zeroes at the beginning of a work day, or perhaps set it to the current time of day, or whatever other setting works for you. You can also configure the camera to import its TC PRESET from another camera through the TC IN/OUT PORT. The TC PRESET is broken down into HH:MM:SS:FF, for hours:minutes:seconds:frames. Note that the setting of the FF frames is dependent on what REC FORMAT you've chosen; for 23.98P the numbers can range from 00 to 23; for 25P/50P/50I the numbers can range from 00 to 24, and for 29.97P/59.94P/59.94I they can range from 00 to 29.

TC/UB>UB Preset

The User Bit preset can be any 8-character combination you want, using the values from 0-9 and A-F for each character. Note that this field is only relevant when you've set the TC/UB>UB Mode to USER.

TC/UB>Free/Rec Run

This menu setting determines how the time code is treated when the camera is not recording. In FREE RUN mode the timecode clock is constantly advancing whether the camera is recording or not. In REC RUN mode, the timecode clock advances only when actual recording is occurring. In FREE RUN, the timecode is derived from a continuously-running clock inside the camera regardless of how many times you start or stop the recording.

Note: if you're using time-lapse INTERVAL recording, or variable frame rate or Super Slow recording, then the system will automatically force this menu into REC RUN mode. On the other hand, if you're using PRE REC or BACKGROUND recording, the system will force this menu item to FREE RUN.

TC/UB>DF/NDF (29.97P/59.94P/59.94i Only)

This menu setting allows you to select Drop Frame (DF) or Non Drop Frame (NDF) timecode. NDF timecode numbers each and every frame sequentially, whereas DF timecode occasionally skips numbers in order to ensure that the elapsed running time matches the timecode count.

When in the 23.98P, 25P, 50P, and 50i modes, NDF timecode is used exclusively; when you select one of these REC FORMATs this menu item will be disabled. DF is only really relevant when shooting 29.97P, 59.94i or 59.94P. In those cases, you may want to consider setting your timecode to DF when you're planning on delivering the raw footage for broadcast; if it's for your own editing, you may prefer the frame-accurate simplicity of NDF. Then again, if you need the timecode to be time-accurate (i.e., one hour of footage shows one hour of elapsed timecode), you'd be better served with setting this menu item to DF.

TC/UB>UB Mode

The User Bit section of the timecode stamp can store a variety of different fields. You can choose from one (and only one) of the following options:

Frame Rate: You can embed the frame rate that the footage was shot at into the User Bits.

User: This allows you to record the custom information that you established in the TC/UB>UB PRESET menu item.

Time: This embeds the camera's current local time (hh, mm, ss) into the User Bits.

Date: This embeds the camera's current date (yy, mm, dd, hh) into the User Bits.

TC: This embeds the current Time Code value into the User Bits.

Clip Name: This embeds the camera's unique camera index (as set in CAM INDEX) and the current Card Count, into the User Bits.

TC/UB>TC In/Out Sel

The camera's TC IN/OUT jack is bidirectional, it can function as either an input jack, or an output jack. You choose which one it will work as in this menu item.

TC/UB>TC Out Ref

The TC OUT jack outputs the timecode for each frame, but you can choose whether that timecode output is immediate, or whether it's delayed to synchronize with the SDI port's video output. There are two choices:

Recording: When using the CX350 as a timecode source for other cameras, you generally want the timecode output immediately, with no additional delay. That's what RECORDING does. This would also be appropriate for synchronizing multiple cameras in a live camera situation.

SDI OUT: When rendering images onto its SDI output, the SDI display may lag the CX350's internal recording by a frame or more. And the SDI output has timecode embedded in it, which is synchronized to the frames of footage as they were shot. You can choose to have the TC OUT jack delay its timecode signal so that it synchronizes with the SDI OUT's delayed output. Choosing SDI OUT ensures that both the timecode in the SDI video signal and the timecode on the TC OUT jack are synchronized. If you choose RECORDING, those two may very well not be exactly in sync. However, be aware that if no video is being output from the SDI, then the system will not delay the timecode, so in that case the TC OUT REF will always be operating in RECORDING mode.

REC Counter

The camera offers a "COUNTER" function to keep track of the total recorded minutes & seconds. You can have the camera re-set that counter for every clip you record, or show a cumulative time count since the last time you manually re-set the counter to zero. Choosing CLIP re-sets the counter to zero every time you start recording, and it also adds the abbreviation "CLIP" in front of the counter display (when you use the playback panel's Counter Button to display the current clip counter, that is.) Choosing TOTAL causes the counter to count up sequentially until you manually set it back to zero; this will keep a running tally of how much footage you've shot since the last time you zeroed out the counter. Note: you access the COUNTER display by cycling through the options for timecode display by pressing the COUNTER button (located under the LCD panel.)

Time Stamp

This menu setting controls whether the camera will "burn in" the time and/or date information into the recorded video. When set to "ON," the camera will actually print the time of day and/or date display right into your video footage, permanently. Once it's added to your footage there's no way to remove it, so be very sure that you want this. An example of when you

would want the time or date burned into your footage would be when using the camera for legal videography, where the court has specified that every frame of footage needs visible permanent time and date information.

Note that not only will the time stamp be burned into the footage, it will also be embedded on the video display outputs, even if you have SDI OUT CHAR and/or HDMI OUT CHAR set to OFF, and even if you have the DISP/MODE CHK switch set to OFF. That's because it's not a display, it's an integral part of your footage at that point.

The TIME STAMP display looks very different from all other overlaid characters, in that it has a thick black background behind it.

Finally, the TIME STAMP function doesn't work when the camera is set to record standard-definition footage (AVCHD SA mode). If you need the time stamp on SD footage, you can set the camera in HD mode and then downconvert the SDI to output standard def; that signal will still have the time stamp embedded in it.

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Network Menu

The camera has the capability to join a wired Ethernet network, or it can also utilize an optional, separate-purchase USB network adapter to create or join a wireless network. There are three main functions you can utilize with a network connection: live streaming (wired or wireless), NDI|HX remote camera control through an Ethernet cable, or wireless remote control using an Apple iPad or an Android device that's running the Panasonic CX ROP app. At the time of this writing, the only wireless adapter that has been certified as being compatible with the CX350 camera is the Panasonic AJ-WM50. You can check on the Panasonic Pro AV website (http://pro-av.panasonic.net) to see if any other adapters have been certified for use.

Note: be careful when downloading the ROP app from the App Store or Play Store. There are many apps out there, one is called the P2 ROP app, another is the AG ROP app. The CX350 requires the CX ROP app. Do NOT download and run the P2 ROP app or the AG ROP or the EVA ROP app; those won't work properly with your CX350.

The network settings menus can be quite complex. For quick easy set-up guides, see the Articles section for step-by-step instructions on how to configure the camera to work with NDI|HX or for live streaming.

Device Sel

This menu item is the master control setting for whether the camera is connected to a network, or not. You can choose between:

LAN: a wired Local Area Network via an Ethernet cable plugged into the camera's LAN port (useful for direct-connection streaming, or for NDI|HX connections). To make the connection, you'll need to go to LAN PROPERTY>IPV4 SETTING to configure the network settings.

WLAN: a wireless wi-fi network. You must have a compatible wireless network module (such as the Panasonic AJ-WM50) plugged into the camera's USB 2.0 HOST port in order to enable this menu. To power-on and enable the network adapter, choose WLAN. WLAN can be used for

streaming or for remote control from an iOs or Android device through the CX ROP app.

OFF: this choice is for when you're not going to connect the camera to external networks.

Network Func

This menu determines what type of network connectivity you want to use. Note that if you have the IP REMOTE>ENABLE option enabled, then these choices will all be disabled (you can either have IP REMOTE control, or the network function, but not both). There are three options:

STREAMING: This will enable the camera's live streaming capability. The camera can stream live video to either a wireless or wired network, depending on how you have the other options in this NETWORK menu set.

NDI|HX: This enables the wired LAN remote control capability from an NDI|HX controller, and streaming to an NDI|HX network. Note that if you enable NDI|HX, that will inherently disable the ability to connect to the CX ROP app through a wireless adapter.

OFF: With this setting the camera will not be expecting to connect to a network. If you're planning on using the CX ROP app to remotely control the camera, you'd need to set this menu to OFF.

IP Remote>Enable/Disable

This menu governs whether the optional wireless adapter will be able to connect to a tablet or phone running the CX ROP app, for remote control. When using STREAMING or NDI|HX control, this menu will be disabled.

IP Remote>User Account

This menu lets you create one or more account names (and passwords) for various users to connect to the CX ROP app. If you want to use remote control via the CX ROP account, you must create (and connect to) at least one User Account in the camera.

In order to use the CX ROP app for remote control, there are two layers of connections that need to be made; you have to connect to the camera's network by using your phone's or tablet's wi-fi settings, and then you also have to connect to the camera's User Account from the CX ROP app. On the CX ROP app, go to the "settings" icon in the top left corner (the "gear wheel"). The connection options on the CX ROP app will appear in a window on the upper left of the screen. The two elements of interest here

are the User ID and Password fields; you have to enter the exact same User Account name and Password that you established in the camera, into the CX ROP app's User Account and Password fields.

Note that when creating a new User Account, the password requires a minimum of eight characters before it will be accepted.

You can have several different User Accounts registered in your camera, but you can still only have one CX ROP app connected to the camera at a time. Accordingly, you have to specify which User Account you want to connect to, and then make sure that you enter that User Account's name and password in the app's settings. Note that these fields are case-sensitive! Make sure you're using the same upper-case or lower-case letters in both the User ID and also the Password field.

If the camera is not currently connected to any app, then you can log on by using any valid User Account name and password that has already been established in the camera. You don't have to select which User Account you want active in the camera; any User Account can be the active account, it really is up to the app user: whichever account the CX ROP app tries to log into, will be the currently-active User Account in the camera.

IP Remote>Account List

This menu item will then bring up a list of the active User Accounts. But the only action you can take in this menu is to attempt to delete a User Account. If you just want to see what accounts are available, then you can just exit this menu. If you try to select one of the accounts, the system will think you're wanting to delete that account, so do be careful. Remember, you don't have to select a User Account in the camera in order to log in; you can specify any User Account name and password in the CX ROP app and if they match any of the User Accounts in this list, the app will connect to the camera.

Streaming>Streaming Format

The STREAMING menu lets you configure parameters that are relevant to live streaming of footage to a network, either wireless (WLAN) or ethernet wired (LAN).

This STREAMING FORMAT command lets you choose the parameters of the video stream that will be created. You can choose from a very small

quarter-VGA size (320 x 180) all the way up to full 1080p HD (1920 x 1080) and at various bandwidths, from as little as 1/2 of 1 megabit all the way up to 24 megabits (which is basically the same video quality as the best AVCHD format). Your choice will depend on a few things, not the least of which is: how's your connection? If you're running over a hardwired gigabit Ethernet connection, you can probably afford to send 1080p at 24M. But if you're out in the woods with a spotty 3G data signal, you might only be able to afford a very small data rate, so maybe something like 1280x720 at 3M would be more appropriate, or even 320x180 at 0.5M.

Note that not all of these options are available all the time. If you've set the REC FORMAT to 1080p, you'll have different options and different bitrates to choose from as vs. if you'd set the REC FORMAT to 1080i. Likewise, the options change if you've set your REC FORMAT to 23.98p, vs. 29.97p, vs. 59.94p, vs. 50.00p or 25.00p.

Note that this menu item will be disabled if you've chosen a FILE FORMAT of AVCHD, or if you've set a REC FORMAT choice of any UHD mode (2160p). It will only be available if you've set the FILE FORMAT to MOV and a REC FORMAT of 1080p or 1080i.

Streaming>Start Trigger

You can establish a network connection for streaming, without actually streaming video over it. Once a network connection has been established, you can assign who has control over starting the streaming video to flow. If you set it to RECEIVER, then the user receiving the streaming video can control when to start and stop it; in other words, the receiving device will send a "start" or "stop" flag to the camera. Supply the receiving software or device with the IP Address of the camera, and then trigger streaming from the software or other device. Note that when the RECEIVER triggers streaming, only RTSP service is available.

The other choice is for the CAMERA to control the start of streaming, or stop the flow of streaming. If you set this menu item to CAMERA, then you may also want to go into the CAMERA>USER SW menu and assign STREAMING to one of your User Buttons. Pressing that User Button will then trigger the streaming video to start or stop streaming. You can also start or stop streaming by setting STREAMING>START to ON. Note that when the CAMERA starts/stops streaming, only RTMP service is available, and that means IPV6 can't be used. In this case, you may have to go to the NETWORK>WLAN PROPERTY>IPV4 SETTING menu to set up your DHCP setting or configure your internet settings to connect properly.

Streaming>Connection Info

When streaming video, you establish a URL of where you want the video to be sent to, and then the camera connects to that URL. In this menu, you determine where the camera looks to for the URL to stream to. The camera can choose from internal memory, or automatically loading the URL off of the SD card in slot 1.

There are two choices: MEMORY, or SD CARD. When choosing MEMORY, the URL will be stored into internal camera memory. The URL can either be entered by manually typing it into the camera's memory using the STREAMING>RECEIVER URL menu option, or the camera can load in the URL off of an SD card and store it into its internal memory. By loading it from an SD card (using the STREAMING>LOAD (SD CARD) option, the camera will look to the SD card and transfer the stored URL address into internal camera memory, meaning that the SD card with the URL on it can be removed (or formatted or whatever).

If you choose SD CARD instead, the camera bypasses the input process and instead looks directly to the SD card for the URL. The card needs to have a saved URL already stored on it (either from using rthe STREAMING>SAVE (SD CARD) menu option, or by using the P2 Network Setting Software, and the card needs to be in slot 1. Using the SD CARD option, the camera will not overwrite its internal memory URL; whatever you have saved in internal memory will still be there even when choosing the SD CARD option.

Note: this menu item may be disabled unless you set STREAMING>START TRIGGER to CAMERA.

Streaming>Receiver URL

When using STREAMING>CONNECTION INFO>MEMORY, this is where you can enter the URL where you want the streaming video to be sent. The camera supports RTMP streaming protocol, and you can use RTMP streaming directly to services such as YouTube Live or Facebook Live. Whatever streaming receiver you're planning on using, should supply you with the URL to stream to. For example, YouTube Live supplies the URL and a separate "Stream Key"; you would need to enter both in this field to connect to the YouTube live streaming server. As an example: a sample YouTube Live URL might look like "rtmp://a.rtmp.youtube.com/live2" and a sample YouTube Live Stream Key might look like "abcd-qrst-0123-41zu". When you enter the RECEIVER URL, you'd need to enter

both as one continuous URL (and make sure there's a "/" following the YouTube Live URL), so the STREAMING>RECEIVER URL in this case would be "rtmp://a.rtmp.youtube.com/live2/abcd-qrst-0123-41zu".

That's quite a handful to type in manually, and you have to get it exactly right; any tiny mistake would mean your streaming won't work at all. Pay special attention to uppercase and lowercase, especially in the Stream Key portion.

It is certainly less error-prone to copy the streaming URL and stream key together on a computer and save it onto an SD card, so you can then just load the file up from the SD card. See STREAMING>LOAD (SD CARD) for more information.

Once you've gotten the URL working, be sure to save it on an SD card so you can just load it back in in the future.

Note, you have to enter the streaming address as specified by the device or service you're streaming to. The camera expects to see the streaming URL in the format of "rtmp://ip address/(port number)/path".

Streaming>Load (SD Card)

If you have previously saved the URL onto an SD memory card, this menu option lets you load that URL back off the memory card. Note: the SD card must have been formatted in the camera, it must be in slot 1, and it must have a valid streaming URL file on the memory card. The URL files are stored using names such as "P2STREAM.CNF", and will be stored on the memory card in the PRIVATE/MEIGROUP/PAVCN/SBG/P2SD directory.

If you want to make the process of entering a URL much simpler, you can copy and paste your URL and Stream Key on the computer, and then save the URL onto an SD Card, if you use the P2 NETWORK SETTING SOFTWARE, available as a free download on Panasonic's website. The P2 Network Setting Software runs on Windows, and while it is generally designed to work with the AJ-PX270 camera, the RTMP tab can be used to generate a P2STREAM.CNF file on an SD card that can be loaded into the CX350 directly.

Streaming>Save (SD Card)

Once you have the URL entered into the STREAMING>RECEIVER URL field, you can save that URL onto an SD memory card. The camera will

encrypt the URL (thus protecting your Stream Key information) and save the information into a streaming configuration file. In order for this menu item to be active, you must have an SD card in Slot 1, and that SD card must have been formatted in the camera. You can save the URL you have the STREAMING>CONNECTION INFO set to MEMORY. When you save the URL onto the SD card, it will create a new file on the memory card named something like "P2STREAM.CNF", and will be stored on the memory card in the PRIVATE/MEIGROUP/PAVCN/SBG/P2SD directory.

Streaming>Start

Once all the streaming settings are correct and the camera has connected to the network, you'll see a triangular "up arrow" icon on the LCD display when exiting out of the menus. This indicates that the camera is ready to stream, and is currently standing by. Setting this menu item to ON will commence streaming, and the icon on the LCD will change to show that streaming is actively occurring. This menu item can also be accessed from a User Button by assigning STREAMING START to one of your User Buttons and then pressing that button.

NDI|HX Menu

NDI|HX is an optional protocol that can be used for streaming video and enabling remote control of the camera. In order to use NDI|HX, you'll have to buy an "NDI|HX UPGRADE FOR PANASONIC" activation license from www.NewTek.com. Follow the instructions from NewTek and use the NDI|HX>ACTIVATION menu option to activate NDI|HX functionality in your CX350 camera.

Once the camera's activated, it will be seen across your ethernet network as an available NDI source. You can select the streaming format for NDI|HX streaming using the NDI|HX>STREAMING FORMAT menu (see STREAMING>STREAMING FORMAT for a discussion on potential streaming formats, although note that the NDI|HX formats are somewhat different).

For more information on configuring the camera for use with NDI|HX, see the article on NDI|HX in the Articles section of the book.

If you want to discontinue the license you bought for NDI|HX connection for this camera, you can use the CLEAR ACTIVATION menu option.

LAN Property Menu and WLAN Property Menu

Since there are two entirely different ways that the camera can be connected (wireless WLAN and Ethernet-wired LAN) there are two separate menus for network configuration. It's easy to get lost in the depth of all these menus, but remember that it's actually pretty simple, so long as you only pay attention to the particular network menus that apply to the type of network you're connecting to. For connecting to an Ethernet network, it may be as simple as going to LAN PROPERTY>IPV4 SETTING>DHCP and setting it to CLIENT. For a wireless network it may be more complex. Note that the NETWORK>DEVICE SEL must be set to LAN in order to access the LAN PROPERTY menu, and it must be set to WLAN in order to access the WLAN PROPERTY menu.

LAN Property>MAC Address

This isn't really a menu item, in that you can't select it. Rather, this line just displays the camera's MAC address when connected to an Ethernet Local Area Network (LAN). It is not something you can change, but advanced network users may need to know it when establishing connections from other devices.

LAN Property>IPv4 Setting and IPv6 Setting

When connecting to a local area wired network, you can choose to use either IPv4 or IPv6 to connect. However, when using the camera to start or stop streaming, IPv6 can't be used, so you'll need to connect using IPv4 in that case. IPv6 is the newer Internet Protocol, and is backwards compatible with IPv4. But, you would have to make sure that all the elements in your network chain (routers, switches, etc) are all upgraded to be IPv6-compatible. If you don't know, you can try just using IPv4, as it's the existing standard and will work even if your other hardware is also capable of supporting IPv6.

LAN Property>IPv4 Setting>DHCP

This menu item may be used to tell the camera to automatically configure its various network settings. When connecting to an existing network, it's generally easiest to use CLIENT, which will automatically fill in the IP address, Subnet Mask, and Default Gateway fields for you.

If you're connecting the camera directly to one other device, such as connecting the camera directly to a laptop or desktop computer, you may have the best luck with setting the camera to SERVER, and configuring your computer to use DHCP (or, put another way, tell the computer to automatically configure its address). If you set DHCP to OFF, you'll have to manually specify the IP address, Subnet Mask, and Default Gateway items.

If you're joining a network that doesn't support DHCP, you'll need to set this menu item to OFF and contact your network administrator for the details as to how to configure the remaining items in this menu.

LAN Property>IPv6 Setting>Enable/Disable

If you've verified that the network you're joining fully supports IPv6, you can enable using IPv6 here. The default setting is DISABLE, which means the camera defaults to using IPv4. If you want to use IPv6 instead, set this menu to ENABLE.

The DHCP command is similar to the IPv4 menu, but it doesn't support SERVER. Instead, in IPv6, the choices are OFF or CLIENT. See LAN PROPERTY>IPV4 SETTING>DHCP for more information.

If you're joining a network that doesn't support DHCP, you'll need to set the LAN PROPERTY>IPV6 SETTING>DHCP menu item to OFF and contact your network administrator for the details as to how to configure the remaining items in this menu.

WLAN Property Menu

This menu is for configuring the wireless network settings. Note that the NETWORK>DEVICE SEL menu item must be set to WLAN in order for this menu to be enabled.

WLAN Property>Type

This menu item determines what kind of network the wireless adapter will create (or connect to). The choices are:

Direct: In this mode the camera will create its own new wireless network, and will broadcast its own network identification (SSID). When using a DIRECT network, configuration is easiest if you go to the WIRELESS LAN SETUP menu and set DHCP to "SERVER". When the camera creates its own network, the default password for other devices to connect to that network is "0123456789012345678 9abcdef".

INFRA (Select): In this mode the camera will be joining an existing wireless network. If you've established your tablet as a hotspot broadcasting its own network, or if you're using your own network router, you can connect to it using INFRA (Select). If you're wanting the easiest possible setup when connecting to an existing wireless network, the first thing you should do is go into the NETWORK>WLAN PROPERTY>IPV4 SETTING>DHCP menu and ensure that DHCP is set to CLIENT. Then, go

back to this WLAN PROPERTY>TYPE menu and press the INFRA (Select) menu option; this will bring up a list of all the wireless networks within range of your network adapter. Look for your desired network, select it, and press ENTER. If your chosen network uses a password, you'll have to enter that password in the WLAN PROPERTY>ENCRYPT KEY menu item.

INFRA (Manual): This is exactly the same as INFRA (Select), except that the camera won't scan for available networks. Instead, it asks you to specifically enter the name of the network you want to join. If your network's SSID is set to "hidden", then INFRA (Manual) is the way to go to be able to join that network. Enter the network name manually, and then follow all the other connection instructions as outlined above for INFRA (SELECT).

WLAN Property>SSID

This menu item lets you change the name that the CX350 camera generates, when it's set to create a DIRECT connection. The default name of the network it creates is "AG-CX350". As you can imagine, that could be quite confusing in a multi-camera scenario, so you have the ability to change the name (perhaps "CX350-A" and "CX350-B", for example). The relevant thing here is that the name that it broadcasts, is the name you have to connect to on your tablet device before you launch the CX ROP app. If you change this SSID name to "George", then in your iPad's wi-fi settings you should see a new network SSID called "George" that you can connect to.

If you're not using a DIRECT connection, this menu item instead reports the name (the SSID) of the network that the camera is joining, as chosen by INFRA(SELECT) or as specified in INFRA(DIRECT). Selecting this menu item brings up the list of available SSIDs you can join.

WLAN Property>Band

Here you can instruct the network adapter in the camera to use either the 2.4GHz band, or the 5GHz band, to use when creating or looking to connect to a wireless network. The factory default is the 2.4GHz band. This option is only available when you've chosen to create a DIRECT network.

WLAN Property>Channel (2.4GHz) and (5GHz)

The network adapter is able to search on a number of different channels on the 2.4GHz band, and a number of channels on the 5GHz band, depending on which band you've chosen using the WLAN PROPERTY>BAND menu item. You can tell it to automatically select a channel, or you can tell it to specifically look to certain channels. Generally leaving this on AUTO is the easiest way to connect, but if you're not having luck connecting or there are

many other devices trying to connect, you may have more luck by specifying the channel to connect on.

WLAN Property>Encryption

There are a number of different password-protection encryption protocols that are used in wireless communications. When you're trying to connect the camera to an existing wireless network, you want to configure the ENCRYPTION parameter to match what the router or other device is using. This parameter is not used in a DIRECT connection type (where the camera is generating the network and you're establishing a 1-to-1 connection between a tablet and the camera), but it is used when you're connecting to an existing wi-fi network (such as through a router). The camera will generally be able to detect the type of encryption a router is using and will automatically set this menu item when you use INFRA (SELECT), but you have the option to override its choice if you know that another protocol is more appropriate.

WLAN Property>Encrypt Key

This is where you enter the password for the network that you want to join when using INFRA (SELECT) or INFRA (MANUAL). It has to be at least eight characters long. You choose the SSID you want to join using INFRA (SELECT) or by manually typing in the name using INFRA (MANUAL), but you enter the password for that network here in this field.

WLAN Property>IPv4 Setting>DHCP

This menu item may be used to tell the camera how to automatically configure its various network settings. If you're using DIRECT, you'll need this DHCP field set to SERVER. If you're connecting to an existing network using INFRA (SELECT) or INFRA (MANUAL), you generally will want this set to CLIENT. And if you're manually configuring your network parameters, you can set DHCP to OFF.

WLAN Property>IPv4 Setting>IP Address

When you're connecting to the ROP app, whether through a direct connection or through existing network, you will need to know the camera's current IP address; you have to enter the camera's specific IP address in the log-in box on the CX ROP app. When the WLAN PROPERTY>IPV4 SETTING>DHCP is set to CLIENT, this menu item is disabled and it will display the current IP Address of the camera on the network that it's connected to.

If you're creating a new network or connecting without using DHCP, you may want to even establish your own specific IP Address. This menu item reports the existing IP Address, or it allows you to change the camera's IP Address.

If you're connecting to a phone or tablet to use the CX ROP app, then you'll need to enter the camera's IP Address in the CX ROP's log-in settings. Go to the app's upper-left corner (the gear icon), and you'll see three fields: IP Address, User ID, and Password. Enter the camera's IP Address as displayed here in this WLAN PROPERTY>IPV4 SETTING>IP ADDRESS field, and enter an appropriate User ID and Password (they must match an existing entry in your User Account list.) The CX ROP app should then be able to successfully connect to and take control of your camcorder.

Network>Utility>Network Initialize

Use this menu item to reset all the network settings to default. If you've been experimenting unsuccessfully with getting the camera to connect, it can certainly be helpful to re-set the settings to a known default state before trying different settings.

Network>Utility>Easy IP Setting

If you need to manually configure the camera's IP Address, Subnet Mask, or Default Gateway, or otherwise delve deep into the network settings in order to make a connection, you may want to use Panasonic's EASY IP software to configure your camera. If so, this menu item lets you determine just how long the camera will wait to receive EASY IP instructions (i.e., when the camera will time out if it hasn't been properly configured). DISABLE prevents EASY IP from configuring the camera; you can also choose to open up a window of availability of 20 minutes, or you can leave it always open to EASY IP adjustments.

The free EASY IP software can be downloaded from Panasonic's website.

To use it, simply plug the camera into the network (or a direct Ethernet connection directly to your computer), and choose NETWORK>DEVICE SEL>LAN. Then, come into this NETWORK>UTILITY>EASY IP SETTING menu and establish either 20 MIN. or UNLIMITED time. Then, run the EASY IP software on your computer, and click the "SEARCH" button. It should locate your camera. Select your camera, and then you can display its network settings, or change those network settings, from within the EASY IP software.

Network>Utility>Easy IP Camera Title

When using the EASY IP software, you'll need to have an individual name for each camera on the network. If your CX350 is the only camera on the network, you can leave this at the default ("AG-CX350"). If you have more than one CX350 in the network, you will need to go into this menu item and assign them individual names.

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System Menu

Frequency

The CX350 is capable of recording projects in nearly all the major frame rates and standards generally used in television worldwide. Generally there are two frequencies used for television signals: 50.00Hz, and 59.94Hz. 50.00Hz is used throughout Europe, much of Asia, Australia, and elsewhere in the world; if your country's television system was "PAL", then 50.00Hz is the right frequency for your country. 59.94Hz is used in America, Japan, and other territories; generally if a country's television system was "NTSC", then the appropriate system frequency is 59.94Hz.

This menu item sets the internal clock that governs what mode the camera operates internally at. This doesn't directly dictate the recording format, but it does set the operational format. If you want to record at 25.00p, 50.00p, or 50.00i, you'll need to set the FREQUENCY to 50.00Hz. Likewise, if you want to record at 23.98p, 29.97p, 59.94p or 59.94i, you'll have to set the FREQUENCY to 59.94Hz.

The obvious benefit to being able to set the system frequency is that you are now prepared to create video in any territory in the world. If you are hired by an overseas company, for example, you can shoot video that is appropriate for editing and broadcast in their home country.

You can freely intermix recordings made at any frequency on the same memory cards if you choose, with one exception: AVCHD. If you want to record in AVCHD, only one type of footage (25/50Hz or 23.98/29.97/59.94Hz) can be put on any particular card. When a memory card is formatted in the camera, whichever frequency the camera is currently set to will dictate the only type of footage that can be recorded on that memory card. If the camera is in 25 or 50Hz mode when you format the memory card, and you later switch it to 23.98, 29.97 or 59.94Hz, you won't be able to record any AVCHD footage on that memory card so long as the camera is in 23.98, 29.97, or 59.94Hz mode.

File Format

The CX350 can record into two different file formats, either AVCHD or MOV.

AVCHD is a low-bandwidth format; files recorded in AVCHD mode will take up very little space, ranging from as low as 8 megabits per second (for PM mode) up to 25 megabits per second (for PS mode). AVCHD can only be used for recording high definition (1080 or 720) or standard-definition footage. AVCHD is suitable for when you want the smallest file sizes, and can be recorded on SD or SDHC memory cards as well as SDXC cards. All AVCHD recordings are h.264 codec in 8-bit quantizing and 4:2:0 color sampling.

The MOV formats are much higher quality recording formats. If you want to record in the best quality the CX350 can deliver, you want to use the MOV file format. MOV can record in 1920x1080 high definition or in 3840x2160 Ultra High Definition, using h.264 or h.265/HEVC codecs.

For more info on selecting the right codec and recording mode, see the WHICH MODE TO SHOOT IN article.

Rec Format

This is where you choose the resolution, bitrate, frame rate, and color sampling and bit depth of your recordings. There are many, many choices in this menu, and the available choices will change depending on how you've set the FILE FORMAT and FREQUENCY menu items.

For more info on selecting the right codec and recording mode, see the WHICH MODE TO SHOOT IN article.

Generally, for the highest quality recordings, use the highest bitrate you can; use MOV instead of AVCHD, and use Long-GoP instead of ALL-I for the highest-quality recordings (or, if you want to use ALL-I, use the 400mbps version). Use AVCHD for the smallest file sizes for HD footage.

Aspect (Standard-Def Only)

There are two aspect ratios that are common in the world of standard-definition television: traditional 4:3 televisions, and widescreen 16:9 televisions. These numbers refer to the width of the picture as compared to

its height; a 4:3 television is four units wide and three units tall, whereas a 16:9 television is 16 units wide and 9 units tall (for comparison, a 4:3 television could also be expressed as a 12:9 television, which gives a better understanding of how it compares to a 16:9 television.) Displaying 4:3 video on a 16:9 television will result in video that's horizontally stretched out. Displaying 16:9 video on a 4:3 television will result in a picture that's horizontally squeezed together.

This menu item is only available if you've chosen a FILE FORMAT of AVCHD, and set the REC FORMAT to AVCHD SA.

If you're shooting SD for widescreen televisions, or widescreen DVD release, you'll want to always use the 16:9 option.

If you're shooting for display on 4:3 televisions, and you want to fill the full screen (i.e., no black/letterbox bars on the top or bottom of the frame), you will want to use the 4:3 option for fullscreen display.

Super Slow

In addition to the variable frame rate capability discussed in the SCENE FILE menu, the CX350 also has an option for super slow frame rate recording. It provides for extreme slow motion at 100 or 120 frames per second.

It is not necessary to enable VFR in order to use SUPER SLOW, but many of the same conditions for VFR apply for SUPER SLOW. You must use a recording mode of MOV 1080p HD; you can't use UHD or AVCHD or 1080i. And no sound will be recorded when using SUPER SLOW.

SUPER SLOW operates at 100 frames per second when the FREQUENCY is 50.00Hz. When the FREQUENCY is 59.94Hz, the SUPER SLOW operates at 120 frames per second (actually 119.88). SUPER SLOW recordings will always be slow motion, but just how slow will be determined by the frame rate in your chosen REC FORMAT.

23.98p: 5x slow motion
25.00p: 4x slow motion
29.97p: 4x slow motion
50.00p: 2x slow motion
59.94p: 2x slow motion

Shooting Mode

The camera has two base sensitivity settings; NORMAL and HIGH SENS.

NORMAL recordings provide good sensitivity and excellent low noise performance.

The HIGH SENS mode effectively makes the camera one f-stop more sensitive. It acts like a combination of adding 6dB of gain, while also increasing the strength and effectiveness of the noise reduction applied to the image. Normally, adding 6dB of gain would result in adding quite a bit of grain to the image. HIGH SENS addresses that by using more aggressive noise reduction; the end result is actually a picture that's generally comparably as clean as NORMAL mode, while being twice as bright. The benefit to HIGH SENS is more visible in lower gain settings; by the time you get to +18dB of gain in HIGH SENS, it looks about comparable (noise-wise) as +24dB in NORMAL would be.

So why wouldn't you just always use HIGH SENS? A couple of reasons:
1) HIGH SENS works its magic through noise reduction, and noise reduction has side effects. Fine image detail may be lost, the overall image might become "smoother", colors may be a little flatter. You may also see some "ghosting" artifacts or afterimages on high contrast edges. It's really a matter of taste; you have to try it to see if you prefer it.

2) Outdoors. It seems obvious, but you would likely not want to use HIGH SENS during daylight; the NORMAL mode is already plenty sensitive enough that you'll likely need to use 1/64 ND just to get a proper exposure; adding HIGH SENS on top of that may just end up requiring you to use a faster shutter speed to get proper exposure. Generally, during daylight, you'd be better off with NORMAL sensitivity.

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Others Menu

This menu deals with miscellaneous camera operations and settings, such as loading and saving Scene File and camera Setup files to the SD card, setting the clock, or configuring how the various LED indicators on the camera behave.

File Menu

The File Menu deals with loading and saving Scene Files to or from the SD memory card, and with the overall camera Setup Files.

The Scene File options are for saving the image control parameters you've set in the SCENE FILE menu, and only those parameters. A complete list of which items are saved, and which aren't, is available in the Panasonic CX350 Operating Instructions, under "Target Items For Scene File/Setup File/Initialization". Scene Files can be saved on a memory card, moved to another camera, and loaded into another camera; they can be saved as an archived element of a project so if you need to revisit that project in the future you can recall the scene file settings; they can be downloaded from the Internet and saved on a memory card for loading into your camera, etc.

The Setup File options are for saving the operational parameters of the camera and all the various customization you've done to it (such as choosing your preferred zebra levels, your User Button assignments, the configuration of which pieces of information you've enabled on the LCD display, etc), except for the SCENE FILE settings. Some items (such as the current clock settings or the timecode preset or the network MAC address) won't be saved, but nearly all of the parameters are saved in the setup file. A complete list of which items are saved, and which aren't, is available in the Panasonic AG-CX350 Operating Instructions, under "Target Items For Scene File/Setup File/Initialization".

File>Scene File(SD Card)>Load

If you have saved scene files onto a memory card, or perhaps downloaded scene files onto a memory card, then this menu item will let you load those scene files into the camera and set them as the currently-operating scene files. Note that this is very different from the SCENE FILE>LOAD/SAVE/INITIALIZE menu item; that menu item is concerned with loading or saving scene file data into internal camera memory, not from or to a memory card. This menu item works with memory cards; it loads an individual scene file, or an entire package of all six Scene Files, from one of your SD memory cards.

This menu item will be disabled if there are no packages of Scene Files on the memory card in Slot 1, or if there's no memory card in Slot 1.

When you execute a Load command, you are shown a list of the available scene file packages on the memory card. Once you choose one of those packages, you are given the choice of loading all six scene files in the package in at once, or loading in just one of the individual scene files. If you chose ALL, then all six scene files in the currently-selected package on the memory card will be loaded in, and will overwrite the scene files in the camera's current settings (but will not overwrite the scene files saved in the camera's internal memory). When loading ALL, all the scene files in the package on the memory card will be transferred to the same positions in the camera's memory -- so, the data for F1 on the memory card will be transferred to the F1 settings in the camera's memory, and F2 to F2, etc. If, however, you choose to load in only one scene file, then you can pick any of the six Scene Files in the package to load, and that particular scene file will be loaded into the camera's current SCENE FILE>FILE SELECT scene file memory. This means that you could set the SCENE FILE>FILE SELECT to be F3, for example, and then when you go to LOAD in a scene file from the memory card, you could select a given scene file package, and then choose (for example) F5. When doing so, the contents of the memory card package's F5 will be transferred into the camera in the F3 position. This lets you mix and match Scene Files however you'd like, and it also provides for an easy way to load identical Scene Files into two different positions in the camera; this can be useful if you want to experiment with changing a camera setting and then swapping back and forth between the two otherwise-identical Scene Files to identify the exact change you're manipulating.

File>Scene File(SD Card)>Save & Save As

There are two choices for saving Scene Files onto your memory card: SAVE, or SAVE AS. The "SAVE" option is used for replacing or overwriting an

existing package of scene files already on the memory card. If there are no packages of scene files on the memory card, then the SAVE option will be disabled (but SAVE AS will still be enabled).

The first time you save scene files onto a memory card, you must use the SAVE AS function, and assign a name. Thereafter, you can either update that saved file (by using the SAVE command), or you can create another new package of scene files on the memory card by using the SAVE AS command.

Both of these menu options will be disabled if there's no memory card in Slot 1, or if the memory card is write-protected.

File>Setup File(SD Card)>Load

If you have saved a camera setup file onto a memory card, or perhaps downloaded a camera setup file onto a memory card, then this menu item will let you load that setup file into the camera.

This menu item will be disabled if there are no setup files on the memory card in Slot 1, or if there is no memory card in Slot 1.

Saving your setup file can be useful if the camera is shared among many users (such as in a school's cinematography department, or when using a camera rented from a rental facility). With a saved setup file you can instantly configure the camera to all your favorite preferences.

File>Setup File(SD Card)>Save & Save As

There are two choices for saving Setup Files onto your memory card: SAVE, or SAVE AS. The "SAVE" option is used for replacing or overwriting an existing Setup File on the memory card. If there are no Setup files on the memory card, then the SAVE option will be disabled (but SAVE AS will still be enabled).

The first time you save a Setup file onto a memory card, you must use the SAVE AS function, and assign a name. Thereafter, you can either update that saved file (by using the SAVE command), or you can create a new Setup file on the memory card by using the SAVE AS command.

Both of these menu options will be disabled if there's no memory card in Slot 1, or if the memory card is write-protected.

File>Setup File(Memory)>Load, Save, and Initialize

These menu items do not involve the use of a memory card. Instead, they let you save your Setup File settings into internal camera memory. This works exactly like the SCENE FILE>LOAD/SAVE/INITIALIZE menu option, but for Setup Files instead of Scene Files. Once you've configured the camera the way you like it, you should save your Setup File at least into internal memory, and preferably onto an SD Card.

Color Bars>Color Bars Type

You can choose what type of color bars the camera displays when the BARS Button is pressed. The choices are normal SMPTE bars with the PLUGE black levels in the lower right, or FULL-screen bars. The SMPTE bars are generally at 75% brightness; the FULL bars are at 100% brightness.

Color Bars>Test Tone

This governs whether or not a 1KHz test tone is generated when the color bars are displayed. This menu item lets you choose ON or OFF. Note that the test tone will be output on all the camera's outputs except for its internal speaker.

LED>Tally LED

The camera has two "tally" lamps, which light up when the camera is recording. You can select the behavior of those lamps in this menu. For example, sometimes interview subjects may get nervous when they see the red light on the camera come on; you could configure your camera so that only the rear tally light comes on, thus avoiding spooking your interview subject. Or, if you're filming into a reflective surface, you may not want the red light to be visibly reflected in the shot. Or, perhaps you don't want anyone to know the camera is even on at all, during stealth recording -- you may want to turn off both tally lamps in that case. Or, if you're a news reporter tasked with also operating the camera, you'd probably certainly want to make sure the front tally lamp is on, so you know for sure it's recording. In any case, this menu lets you control the operation of both lamps.

LED>Access LED

This menu item controls whether the green or amber lights next to the memory card slots will light up. Generally you'd want these on, as you

usually want to know which card is currently being recorded to and you most definitely want to avoid ejecting a card that's currently being accessed! Turning the lamps off would essentially enable a "stealth" mode where someone observing the camera wouldn't even know that it was actively recording. Unless you have a strong need for such stealth, I highly recommend leaving this menu item set to ON.

USB Device>Card Reader Mode

The camera can be plugged in via its USB-C port to a computer, which will allow the computer to see the contents of the camera's SD cards. As the name implies, you can copy data off the camera's memory cards using this mode, but you can also copy data to the cards in the camera.

USB Device>Service Mode

There is a USB-C port located on the back of the camera, labeled "SERVICE". If you enable Service Mode, and then plug the camera into a computer using the USB-C port, the camera will mount to your computer's desktop as an external USB memory card. You can then open that memory card and see the LICENSE.TXT file, which contains various legal licenses for public domain or other software as used in the camera.

Information>Version

The current version of the camera's firmware and other diagnostic information is available in this menu. You should monitor Panasonic's website for new firmware releases; using this menu item you can check what version of firmware your camera is currently running.

Information>Update

This menu item is for executing a firmware update. If Panasonic releases newer firmware than what you currently have installed, you can place that firmware (called UPDATE.HDC) onto the root of a memory card, and install that memory card in the camera. Then, go into the menus and execute this UPDATE command to start the firmware updating process.

Initialize

This menu item will restore the camera to its factory-original default settings. If the camera's behaving in unexpected ways or you don't understand what's changed and you just want to basically hit the "reset" button, this menu item will restore the factory settings.

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Thumbnail Screen

When you press the THUMBNAIL button, the camera switches to playback mode. The thumbnail display appears, and there are also a number of menu commands available if you press the MENU button; those are discussed in the next section.

Working with the Thumbnail Screen

The CX350's touchscreen makes playback effortless; you simply touch the picture of the clip you're interested in to play it. If there are more clips than can be seen on the screen at one time, you can touch the UP or DOWN arrows to scroll to the next batch of thumbnails, or use the PLAY/FF/REW/STOP buttons to navigate around the thumbnail screen. When you've highlighted a clip (so that the thumbnail has a yellow outline around it), you can get detailed information about the clip by going into the menus and choosing THUMBNAIL>CLIP>INFORMATION.

You can control most playback operations with the physical PLAY/FF/REW/STOP buttons, or you can control playback from the touchscreen. When a clip is playing, a control bar appears on the screen that lets you stop, pause, play, rewind, or fast-forward through the clip (if you press fast-forward or rewind twice, it'll fast-forward or rewind twice as fast.) If you've paused a clip, then the fast-forward and rewind buttons on the LCD display instead become frame-advance buttons; pressing the frame-advance button causes the playback to show the very next frame, one at a time; if you hold down the frame-advance button you can get a nice smooth slow-motion playback effect. Note that if you try to do a frame-reverse, the camera doesn't go frame-by-frame in reverse, it'll jump back about 1/2 second of footage on

each press. At the bottom of the screen is the "Direct Playback Bar" which allows you to jump to any portion of the clip, instantly. Finally, while a clip is playing the controls will disappear after a few seconds; you can bring them back by just touching the touchscreen itself (i.e., not on a control or button).

In general, playback of clips is quite straightforward and simple, provided that the clip you want to play is displayed on the thumbnail page and it doesn't display a red "CANNOT PLAY" icon on it. The CX350 has a wide variety of recording formats and frame sizes, and the playback system is limited to only being able to play back clips that represent the current camera mode settings. Furthermore, the camera has two different recording methods (MOV and AVCHD); the camera can only display thumbnails from one of those recording methods at a time. When the camera is set to a FILE FORMAT of AVCHD, then none of your MOV clips will show up in the thumbnails display. It's not that your clips are gone, it's that the camera cannot display the thumbnails of both types of recordings at the same time. So, likewise, when your camera is set to a FILE FORMAT of MOV, then none of your AVCHD clips will show up on the thumbnail display. This means that you may not be able to quickly find the clips on your memory cards, if you've been changing the recording format (MOV or AVCHD).

A helpful hint - on the top of the thumbnail display it will tell you whether it's displaying MOV or AVCHD clips, in black letters on a white background. If you see just one display (either MOV or AVCHD), then that means you only have that type of clip on your memory cards (either you have all MOV clips, or all AVCHD clips). But, if the top line displays both MOV and AVCHD (one in black letters on a white background, the other in white letters on a black background) then that means you have both MOV and AVCHD clips recorded on your memory cards. You'll have to go to the menus and change the FILE FORMAT to be able to see the other format's clips, but at least you'll know that there are more clips than you can currently see.

Once you see the thumbnail of the clip you want, you may or may not be able to play that clip. It all depends on whether the clip's properties match the camera's current settings. Generally the reason you might see a red "NO PLAYBACK" icon displayed on a clip is when the FREQUENCY the clip was recorded in doesn't match the current FREQUENCY the camera is operating at. Take note of the frequency and other file properties in the

upper right of the thumbnail; all thumbnails will tell you the frame size and frequency of the clip. You can then go into the menus to change the camera's frequency and REC FORMAT to match the clip's settings -- and when you exit the menus, you should now be able to play that clip back.

Generally, it's easier to play back clips from a computer, where you can see all the files, all the folders, and the thumbnails for all the clips simultaneously. It also is much easier to play back the clips on a CX350 if you haven't been changing recording format or system frequency very much. While the camera can play back any clip it shot, it can be a little challenging to find those clips and then configure the FILE FORMAT and REC FORMAT in order to play back those clips; it's easier to do so from a computer.

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Thumbnail Screen Menu Options

When the thumbnail screen is displayed, you can still press the MENU button to access many of the camera's menus. However, when MENU is pressed during thumbnail display, you'll see a new menu at the top: THUMBNAIL. This section describes the options found in that THUMBNAIL menu.

Thumbnail>Playback>Clip Sel

In this menu item you can choose whether you want to see the thumbnails from both memory cards (ALL SLOT), or you can limit the display to just one of the memory cards.

Note that when playing back clips, the camera will not span from one memory card to the other. If you used RELAY recording and you've recorded a clip that spans from one memory card to the other, the playback system will treat that as two separate clips. It will only play the portion of the clip that is represented by the thumbnail you selected. For a clip that spans from one card to the next, there will be at least two thumbnails, one for the portion on the first card, and the other for the portion that's on the second card.

Finally, you can choose to have the system only display thumbnails from clips that were shot in the same format and frequency as the camera's currently set in. This has the general effect of hiding all thumbnails that would otherwise have a red "CANNOT PLAY" icon displayed on them.

Thumbnail>Playback>Resume Play

Normally when you go to play back a clip, the system will start the playback from the very beginning of the clip (the first frame). But if you set this menu item to "ON" the system will "remember" the last time this clip was played, and resume playing from that point. So if you're interrupted during

clip playback and had to stop the playback, then the next time you go to play back this clip it'll start where you left off. A new indicator (looks like three arrows pointing right) will show up on the thumbnail icon of this particular clip, to show that it was in process of being played and will play back from where it left off the next time you play it.

Thumbnail>Clip>Protect

You can protect individual clips from being modified or deleted by using the PROTECT function. When you choose this menu item and choose to SELECT clips to protect, the thumbnail screen will be displayed (and the text at the center of the top line will change to say "PROTECT" to let you know you're in clip protection mode.) Just touch the thumbnails of the clips you want to protect and an orange "key" icon will show on those clips to indicate that they are protected. Protected clips cannot be deleted, either accidentally or on purpose, when using the CLIP>DELETE command (see below). However, protected clips are not indestructible: you can still lose them if you choose to format the card that they're on, or if you delete them by using a computer. To unprotect a clip, go back into this PROTECT menu and just touch the clip's thumbnail again to make the key disappear.

Remember that you're in PROTECT mode, and not normal thumbnail view mode; as long as the text at the top of the display says "PROTECT", the only thing you can do is protect or unprotect clips. You'll have to use the "return" arrow in the lower left of the screen (or the EXIT button) to return to the menus.

Thumbnail>Clip>Delete

You can delete an individual clip (or a group of clips, or all clips) off of the memory card. Deleting is immediate, and the space that the deleted scenes used to occupy will be made available for further recording. Deleting is also irreversible.

To delete all the currently-viewable scenes on the memory cards, choose ALL. Be aware that this does not necessarily mean that you will be erasing every clip on the cards – it will depend on whether you have both AVCHD and MOV clips on your memory cards. When you choose to delete ALL, it will delete all the clips that are currently displaying thumbnails. If the camera is showing all the MOV clips, then choosing DELETE>ALL will delete all the MOV clips, but it won't delete all the AVCHD clips. You'd have to change the FILE FORMAT to an AVCHD codec, and then come back into the thumbnails and choose DELETE>ALL again to delete all the

AVCHD clips. Note that even if you took both steps and deleted all clips of both recording types (MOV and AVCHD), the system still won't delete clips that you protected (by using THUMBNAIL>CLIP>PROTECT). Note that it can take a while to delete clips using the ALL command; if you know for certain that you want every clip gone (whether AVCHD or MOV, whether PROTECTed or not) then it's usually faster to just format the memory cards.

Instead of deleting all clips, you can choose to delete individual selected clips, either one by one or in a group. To do so, choose SELECT. The thumbnails will be displayed again, just like in PROTECT mode, except this time the text at the top of the screen will change to say "DELETE". You can then select clips that you want to delete; each time you select a clip, a red trash can icon will show up on the thumbnail. When you've selected all the clips that you want to have deleted, press the DEL button in the upper left corner of the LCD screen, and the camera will commence deleting those clips. There is no way to un-delete a deleted clip, so be sure that you have selected the proper clip(s) to delete!

Thumbnail>Clip>Copy

This menu item lets you copy AVCHD clips between memory cards, but only for AVCHD clips. If the camera is currently configured to record and display MOV clips, then this COPY menu will be disabled. If you've set the camera's FILE FORMAT to AVCHD, then this menu will be enabled and you'll have the option to copy selected clips, or all clips, from one memory card to the other.

If you choose to select individual clips to copy, then the camera will display the thumbnails again, and you can mark clips to copy by touching the thumbnails; a white copy icon will appear at the top of each selected clip's thumbnail. To execute the copy, press the copy icon in the upper left of the LCD display.

Thumbnail>Clip>Information

This menu item brings up more detailed information about a particular clip. When the clip info is displayed, you can touch the arrow icons to move to the next or previous clip, or rotate the multidial wheel to move to the next clip.

Display>Data

The thumbnail screen shows a thumbnail for each clip, and below each thumbnail is a line of text that helps describe that clip. You can choose

what that line of text will be; you can choose to show the clip's starting timecode, or its clip name.

There are many other menu options than described here; however, their functionality is the same as when in camera mode, so please refer back to the camera menu options to learn how those functions work.

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Physical Switches, Buttons and Jacks

This section will describe some of the features of the camera and observations about how those features work and how they can be best employed. Most descriptions will be accompanied by a photo of the button or switch being described.

Audio Controls: On the left of the camera under the transparent audio controls door are some switches and dials for controlling how the input ports work, which channels they get assigned to, and how volume is controlled. Of note: there are two inputs (XLR1 and XLR2) and there are two audio channels (frequently called L and R, but more appropriately called CH1 and CH2). XLR1 does not have to be routed to CH1, and XLR2 does not have to be routed to CH2. They can be, but it is not required.

CH 1 / CH 2 Audio Level Controls: There are two audio level control dials. These potentiometers control the volume assigned to channel 1 and channel 2, regardless of what source is attached. If you have configured the CH1 SELECT and CH2 SELECT to INT(L) and INT(R), these dials will control the volume of audio coming from the internal microphone. If you set the CH1 or CH2 SELECT switches to INPUT 1 or INPUT 2, these dials will instead control the volume being input through the XLR connectors. It should be noted that it's possible to record XLR input 1 onto both CH1 and CH2, or to record XLR input 2 onto both CH1 and CH2; when doing so, you may find it advantageous to set one of these audio control dials to slightly lower volume; this can give you a clean track of audio that's more protected against clipping and distortion in case you need it in post; or, you may choose to have one channel set manually, and let the other channel be automatically controlled.

Line/Mic/+48V Switches: The LINE/MIC/+48V switches control the signal level sensitivity of the XLR connectors, for mating the connector to the type of component attached to it. For example, when you have a mixer attached to the camera, the mixer may be outputting a LINE level signal, so you'd want to flip the LINE/MIC/+48V switch to LINE for that channel. If instead you hooked up a microphone directly, that mic would be outputting a MIC level signal, so you'd need to flip the LINE/MIC/+48V switch to MIC to match levels to the microphone. If the microphone requires phantom power, you'd instead set the LINE/MIC/+48V switch to +48V. In essence, the three switch settings are LINE, MIC (phantom power off), and MIC (+48V phantom power on). Some types of microphones (such as Dynamic or self-powered) should not have phantom power supplied to them. Other types of mics, such as condenser mics, require phantom power in order to function. And some types of mics (such as electret condensers) can operate as either self-powered or from phantom power; frequently those mics will perform better from phantom power. Make sure you check your microphones to verify whether they should or should not have phantom power supplied.

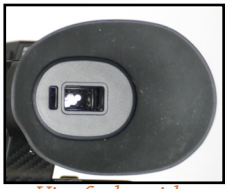
LINE level can be set to +4dBU or +0dBU in the AUDIO>INPUT SETTINGS>INPUT1/2 LINE LEVEL menu. The MIC level can be set to -40 dB, –50 dB or –60 dB, as determined by the AUDIO>INPUT SETTINGS>INPUT1/2 MIC LEVEL menu settings. If you attach a device to the XLR input and you can't get satisfactory audio levels from it (like the audio is way too low, or too loud) then try changing the setting of the LINE/MIC switch for that audio channel to get a better level match.

Audio CH1/CH2 Select: The camera has the ability to record audio from three potential sources: the built-in microphone, XLR connector 1, or XLR connector 2. You can mix and match these inputs to suit your circumstances (i.e., connect a wireless microphone on XLR channel 1, and use the built-in microphone on audio channel 2 for ambience/backup purposes). You can also choose to have one input be recorded on both audio channels. When using the built-in stereo microphone, only the left side can be recorded on channel 1, and only the right side can be recorded on channel 2.

SD Card Access Lamps: Each card slot has a glowing LED lamp near it, and that lamp lets you know the recording or access status of the card. You never want to eject an SD/SDHC/SDXC card when it's being accessed! If the light is flashing next to a card, leave that card alone. These lights will flash when the card is being recorded to, when it's being played from, and when it's being copied from and copied to. Perhaps most importantly, when you're doing a RELAY recording, the amber light will be flashing quickly next to the card that's currently being recorded to, and the other card's light will be green. When you want to swap cards, pay careful attention and only eject the card whose light is currently green.

Viewfinder: The viewfinder is quite versatile, and features a very clear OLED display. You can configure the eyecup for left-eye or right-eye viewing. You can focus the viewfinder sharply using the diopter adjustment dial (very handy when you've forgotten your reading glasses!) The viewfinder is active and available simultaneously with the flip-out LCD panel. The viewfinder can also be configured to be either black and white or color. The viewfinder rotates up to facilitate low-angle shooting.

Warning: Never leave the camera with the viewfinder pointing at the sun! The viewfinder has a magnifying element over it, and when you combine a magnifying glass with the sun, the results will be a burned viewfinder display!



Viewfinder with eye sensor

The camera employs an eye sensor to determine if someone is currently using the viewfinder. The eye sensor detects any objects or obstructions within a certain distance of the viewfinder; you can adjust that distance in the VIDEO OUT/LCD/VF>VF>EYE SENSOR menu. You can also assign VF ON/OFF to a User Button, and use that button to disable the viewfinder and force the LCD to be the only on-camera display.

The primary benefit to the viewfinder over the LCD is that the LCD can be quite reflective which makes it a challenge to use in daylight; the VF is immune to reflection when your eye is pressed up to it so it can be much more useful in daylight shooting situations. Additionally, using the viewfinder can make for more stable footage; when your eye is pressed

against it, it adds a third point of contact (two hands and your skull) that can lead to more stable handheld footage.

Rec Check Button: When the camera is in CAMERA mode, the REC CHECK button will play back the last few seconds of the most-recently shot clip. There are several things you can do that will make this not possible; for example, if you change the FILE FORMAT or REC FORMAT, or eject one of the memory cards, or turn the camera off or switch over to THUMBNAIL mode, it won't work (until you record your next clip, that is). And, if you're using the two-slot SIMULTANEOUS or BACKGROUND recording options, or PRE-REC or INTERVAL recording, it can't work.

Zoom Rocker: The power zoom is controlled by one of the zoom rockers, either the handle zoom or the main zoom rocker. The main zoom rocker is pressure-sensitive, the harder you press it the faster it zooms. At its slowest speed it takes several minutes to travel from wide angle to telephoto; at its fastest speed, it's about 2 seconds (with FAST ZOOM enabled).

The handle zoom rocker is not pressure-sensitive, you tell it what speed you want to zoom at using the CAMERA>SW MODE>H . ZOOM SPEED menu item and it will zoom at only that fixed speed. The settings range from 1 (slowest) to 100 (fastest).

Zoom can also be controlled by using an external CX350-compatible zoom controller connected to the Remote jack on the back of the camera. Finally, you can also control the zoom remotely if you have a compatible wireless network adapter properly configured and are using the Panasonic CX ROP app on a mobile device like a phone or tablet.

Focus Assist Button: Ultra High Definition video is very demanding in terms of focus. Whereas minor focus errors may be tolerable in standard-definition video, ultra high-definition video provides no leeway – shots that are out-of-focus even just a little bit will show. Accordingly, Panasonic has included a very useful magnified Focus Assist, able to be used in concert with or instead of the colored PEAKING focus

assist. When set to EXPAND, the Focus Assist function pops up a window in the center of the viewfinder or LCD panel which shows a high-resolution magnified section of the image. You can configure how the FOCUS ASSIST button functions in the VIDEO OUT/LCD/VF>FOCUS ASSIST>FOCUS ASSIST SW menu. Note that you can also assign either one of the Focus Assist functions (EXPAND or colored PEAKING) to a User Button; that way you can combine both Focus Assist options. See the article on FOCUSING for more information.

Focus Switch: On the side of the lens is a switch named "FOCUS", with three possible settings: "A", "M", and "∞". This switch lets you control the autofocus or manual focus capability of the camera. When the switch is set to "A" the camera operates in full autofocus mode, automatically hunting for the best and sharpest focus; when the switch is set to "M", the camera is set to strictly manual focus (unless the AUTO/MANU switch is set to auto; that can override the "M" setting of this switch). When the switch is pushed to "∞" the camera is instantly set to "infinity" focus, the setting where even the furthest possible objects (such as the moon) should be in sharp focus. Infinity is not really a switch setting, it's just a momentary push – when you push the switch down, the lens gets set to infinity and then the switch automatically returns to manual focus mode.

Some notes on autofocus: autofocus works better at faster frame rates; it works best in 50i/59.94i interlaced mode or 50P/59.94P mode. The autofocus system responds much more slowly when using slower frame rates (such as 23.98P or 29.97P) or when using slow shutter speeds (such as 1/12 or 1/8). The reasoning is simple: in interlaced mode or 50P/59.94P mode, the autofocus system gets fed sixty (or fifty in PAL/50Hz) updates per second. But in slower-frame-rate modes or slower shutter speeds, the updates come far more slowly: in 23.98P mode, the autofocus system only gets 24 updates per second; in 1/12 shutter speed it's only receiving 12 updates per second. With less-frequently-updated information to work from, the autofocus system cannot respond as quickly to changes in the image.

Autofocus works best under brightly lit conditions. Under low light and low contrast conditions autofocus has to work much harder, and will respond much more slowly, and will be more prone to "hunt" for proper focus.

Another factor to consider in autofocus performance is that the autofocus system relies on measuring contrast to determine proper focus points. If the scene you're shooting is very low in contrast the autofocus system will have a harder time determining the proper focus point. Autofocus works quickest when it can easily discern a transition between dark and bright elements, especially vertical elements (i.e., on a black and white picket fence, the autofocus system would perform superbly. Trying to find focus on a solid white wall would be extremely challenging for it.) Autofocus can also perform more quickly when the FOCUS MACRO feature is disabled; enabling Focus Macro requires the autofocus to search a much wider range of potential focus positions.

When the camera is set to Manual focus mode, the focus readout in the LCD display changes from AF to MF to signify the change from Auto Focus to Manual Focus.

When the FOCUS switch is pushed towards the Infinity symbol ("∞"), the lens is set to infinity focus. However, if you've added an accessory lens attachment (such as perhaps a wide-angle or telephoto converter) it's possible infinity focus may not be the same depending on what accessory lenses you may have on the camera. The Push-To-Infinity button is only practical if you have no added lens adapters installed.

When in manual focus mode you can invoke the autofocus system on a temporary basis by pressing the PUSH AUTO button. If you just briefly press the PUSH AUTO button, the camera will attempt to quickly focus and then immediately return to manual focus mode. If you prefer it to go into autofocus mode for a longer period of time, you'll find that the longer you hold the button, the longer autofocus will remain active; when you release the button it reverts to manual focus mode.

Note: the focus ring is still active while the camera is autofocusing. If you encounter a scenario where the camera just can't successfully autofocus, you can kick-start it by moving the manual focus ring. Maybe you are focusing close-up on a wedding signature book, and then you tilt up to an outdoors scene, and the scene is so wildly out of focus that there's just a big blob of blur on the screen, and the camera doesn't know what to do; in that scenario you could manually focus to get the camera "into the ballpark", at which point autofocus can take over and finish the focusing job. The camera also offers a manual focus assist mode, where the primary focusing is done manually and then, when you stop moving the focus ring, the camera engages a little bit of autofocus to "touch up" the manual focus.

Iris Ring and Iris Button: There are three controls for the iris – two push-buttons, and an iris ring (the thinnest ring, the one closest to the camera body).

The iris ring allows you to set the f-stop manually. A common technique is to let the auto-iris set the overall exposure level, then press the Iris Button to switch to manual control and fine-tune the exposure according to taste (or according to the zebras or referencing a production monitor or waveform monitor). The Iris Button lets you toggle between auto-iris and manual mode. In fact there are two Iris Buttons, one on the handgrip next to the zoom rocker, and one on the side of the lens underneath the ND FILTER switch.

To understand how the iris ring/wheel works, you first need to understand what f-stops are. Be sure to read the article on Understanding Exposure for a discussion on what an f-stop is, and how it's numbered.

The iris display shows whole f-stop numbers and decimal numbers in-between. The iris is stepless and smoothly adjustable; it's actually controllable in incredibly tiny increments, I counted 28 different brightness levels between f/5.6 and f/8.0.

The lens is capable of opening as wide as f/2.8, but only at the most wide angle portion of the lens. The maximum wide iris at any point in the zoom range is approximately:
2.8: 8.8 mm
2.9: 10 mm
3.0: 10.8 mm
3.1: 11.6 mm
3.2: 13 mm
3.3: 14.3 mm
3.4: 16.6 mm
3.5: 19.5 mm
3.6: 21.2 mm
3.7: 25.7 mm
3.8: 30.5 mm
3.9: 34 mm
4.0: 41 mm
4.1: 45 mm
4.2: 56 mm
4.3: 64 mm
4.4: 88 mm
4.5: 112 to 176 mm.

Accordingly, be aware that OPEN doesn't always mean f/2.8! Instead, it means the lens is as open as it can possibly be, given the current zoom position. If you're shooting in extreme low light conditions and need the brightest picture you can get, you may want to avoid zooming in very much, as the most telephoto position of the lens is around 1 1/3 f-stops slower than the full wide angle position.

The iris ring can be used even when the camera is in automatic iris control; in this case, the iris ring doesn't directly change the aperture, but it adjusts the amount of general over/under-exposure that you want the camera to make (similar to the Scene File menu's A.IRIS LEVEL EFFECT setting.) The changes you make with the iris ring will show up on the LCD display right after the aperture (i.e., STD F4.5+20; the "+20" part is the effect the iris ring will have on the exposure) but these changes are not stored in the scene file.

Finally, remember to keep your iris from getting too small or you run the risk of losing some sharpness. Read the article on Diffraction for more information.

ND Filter Switch: The camera includes three switchable ND filters. Neutral Density filters are used to control exposure, and ND filters act like "sunglasses" for your camera: they help cut down the amount of light passing through the lens, so in bright conditions you can engage the ND filters to lower the light level and get proper exposure. They're called "neutral" density filters because they add no color shift to the image: they're a neutral shade of gray, so the only image effect should be to lower brightness.

The ND Filter switch has four settings:

CLR: No ND filters (best used in lower light conditions);
1/4: The mildest setting of ND filtration, reducing the amount of light coming into the camera by two stops.
1/16: A medium setting of ND filtration, reducing the amount of light coming into the camera by four stops.
1/64: The strongest amount of ND filtration, reducing the amount of light coming into the camera by 6 f-stops.

ND filters are named according to how many thirds of an f-stop they reduce the incoming light, and typical ND strengths are ND .3 (three thirds, or one full f-stop), ND .6 (six thirds, or two stops) and ND .9 (three stops). An ND .3 reduces light by 3 thirds of an f-stop (or one full f-stop.) Put another way, an ND .3 reduces the amount of light coming into the camera by half. The exposure compensation of an ND .3 is the equivalent of closing down the lens by one f-stop; for example, a camera shooting at f/4 with an ND .3 filter will deliver the same exposure as a camera shooting at f/5.6 with no ND filter.

The CX350 is a highly light-sensitive video camera; in my testing it generally rates at approximately 900 ISO (in NORMAL shooting mode) to 1800 ISO (in HIGH SENS). Because of this sensitivity, you need to use the ND filters to control the amount of light that enters the camera. For indoors shooting you'll usually want the ND filter off, but outdoors will almost always dictate using at least ND 1/4 and frequently ND 1/64. Follow the recommendations of the auto-iris and your zebra display and waveform monitor to determine which ND setting to use, and keep your eye on the f/stop – you don't really want to see the iris stop down into double digits (f/10 or more closed) when shooting UHD, so you may need to use the ND filters to get that iris more open.

User Buttons: The CX350 has seven customizable USER buttons on the camera body (and five more "virtual" buttons that can be displayed on the LCD screen.) Four of these physical User Buttons are grouped together on the side of the camera; there's one at the bottom rear of the camera (pre-programmed for SLOT SEL); User Button 6 is located up by the servo zoom rocker (pre-programmed for IRIS), and User 7 is on the front of the camera below the lens, pre-programmed for AWB. These buttons allow you to instantly switch in certain features, such as turning on super gain, spotlight or backlight compensation, trigger streaming video, etc. Click here for more discussion of what the various USER buttons can do.

Disp/Mode Chk Button: On the left side near the bottom is a button labeled DISP/MODE CHK. This button has two functions — it cycles the display overlays on and off (when pressed and released), or, when pressed and held down it brings up a number of informational displays; each subsequent press of the button brings up a different display. This is a great

button — get to know and love it! When you have all the camera displays turned on, the LCD monitor can become quite cluttered and may actually become a bit of a hindrance to framing your shot. The DISP/MODE CHK button whisks it all away at the press of a button, returning you to a clean, uncluttered viewfinder (or LCD) display. It doesn't actually take away everything, some elements (such as the safety zone, Y Get marker, or the timecode counter) will still be displayed. You can make the timecode display go away by cycling through presses of the COUNTER button (up by the LCD panel).

Instantaneous access to a clean screen is a great compositional aid. But the other nice aspect of the DISP/MODE CHK button is that when you hold it down, it brings up even more info. If you've forgotten which user button you assigned a particular function to, or you want to find out your camera's IP address, you don't have to go digging through the menus, you can just press the DISP/MODE CHK button a few times to see all sorts of status displays.

Gain Switch: The GAIN switch is for controlling picture gain. Gain is an electronic amplification of the video signal, which means that by using gain you can make the picture brighter than it otherwise would look. The downside to using gain is that it introduces more noise into the picture. The more gain you use, the brighter the picture becomes, and the noisier the image gets. The switch has three positions, LOW, MID and HIGH. You can set three different levels of gain in the camera's menus, and swap between them quickly and easily. The factory default for LOW is 0dB, meaning that no gain is applied. The factory defaults for MID and HIGH are 6dB (twice as bright) and 12dB (four times as bright as 0dB). You can change those settings in the CAMERA>SW MODE menu; you can assign any gain value (from -3 to +18dB) to any position on the switch. There is also an option for even higher gain; you can assign a SUPER GAIN setting of up to 36dB, which would give you a picture sixty-four times as bright as with no gain (but the picture will be very noisy). You cannot assign 36dB of gain to the GAIN switch; the only way to get those extreme levels is to assign SUPER GAIN to one of the USER buttons.

White Bal Switch: The camera offers many options for white balance settings, including a fixed PRESET, automatic tracking white balance, and

two positions of manual white balance (A and B). These various choices are selected by use of a WHITE BAL button, and an AWB button on the front of the camera.

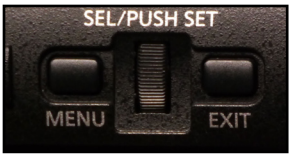
The WHITE BAL switch selects between the fixed PRESET, A channel, and B channel settings. Using this switch in connection with the menus and the AWB button on the front of the camera, you can choose from a wide variety of white balance possibilities: either a 3200k preset, a 5600k preset, a variable color temperature preset, up to two channels of manual white balance, or ATW, an automatically-tracking white balance mode. You choose which channel to affect by using the WHITE BAL switch, and you affect that channel by using the AWB button on the front of the camera, below the lens.

As an example, let's say you wanted to set the white balance to the 5600K preset. You'd set the WHITE BAL switch to PRST; the LCD screen will then show the PRESET white balance option (either P 3200K, P 5600K, or a V followed by a number such as V 4900K). Once you've chosen the white balance channel, you'd then use the AWB button to select among them; it will cycle between the P3200K, P5600K, and Variable choices.

Alternatively, you could choose to execute a manual white balance. You'd use the WHITE BAL switch to choose either A channel or B channel; then you'd point the camera at a white chart or other white object in the scene and zoom in to fill the screen with white, and then you'd press the AWB button to instruct the camera to take a manual white balance reading and assign it to this channel. If you hold the AWB button down for a couple of seconds it will follow up the white balance procedure by doing an automatic black balance (ABB). You should black balance frequently.

Note that the AWB button is actually a User Button; if you've changed the functionality of the AWB button by assigning a different function to User Button 7, then it obviously won't be functioning as the AWB function anymore, so if the camera's not performing as you'd expect, you may want to check and ensure that the AWB function is assigned to User Button 7.

MultiDial Wheel: This multi-purpose control is used to set the shutter speed, the Synchro Scan shutter speed, to navigate the menus, to set a variable white balance temperature, and can also be used to choose a variable frame rate or adjust the gain.



To use this control while in camera mode, rotate the MultiDial Wheel to cycle through the available options, until the one you want appears in the lower left side of the display next to a "gear" icon (examples include SHUTTER, GAIN, ICONS, or WB). When you see the one you want, press the wheel in (like a button) to select it.

When you press the wheel in, the displayed word next to the gear icon goes white, and some other section of the screen will highlight in orange (example: if you'd selected GAIN with the wheel, then the gain display would now be highlighted in orange). Rotate the wheel to change the option you have selected, and press the wheel in again (like a button) to make your selection.

You can also change the variable frame rate with this dial. If you've enabled VFR, then VFR becomes a choice as you scroll the wheel. Choose it, and then you can scroll the dial up or down to change the frame rate.

The wheel can also be used to navigate the menus; just roll the wheel up and down to the menu option you want to change, and press the wheel in to make selections. The wheel is also useful in the menus even when using the LCD, because the wheel can be used to quickly navigate through some of the menu options that are tedious to adjust with the touchscreen. As an example, many of the SCENE FILE menus bring up adjustment choices that can be adjusted across a huge range; the Master Pedestal is adjustable from -200 to +200 — that would take forever to navigate with the touchscreen, one press at a time! You may find that the wheel is much more convenient and quicker to use to adjust those menus. Not only can the wheel adjust those menu items, but in many cases it can do so at an accelerated speed: press and hold in the wheel, and while holding it in, then rotate it either up or down. For example, on the Master Pedestal setting: instead of touching the up and down arrows on the touchscreen, you could rotate the wheel to select more quickly. But to really move along the selection, press and hold the wheel in first, and then rotate it, and you'll see that the system rapidly scrolls through the available settings. Note you can also navigate through the menus using the PLAY/FF/REW/PAUSE buttons under the LCD panel.

Shutter Button: The shutter button lets you choose between default and user-controlled shutter speeds (wherein you can choose a specific shutter

speed using the MultiDial wheel.) If the shutter speed display is blank, that means the default shutter speed is being used (1/60 for 59.94p or 59.94i, or 1/50 for 23.98p/25p/29.97p/50p/50i).

If the shutter speed display shows "A.SHTR", then that means the camera is automatically adjusting the shutter! This is important to know, as shutter speeds can affect how the motion blur looks in your footage, and it can potentially affect whether or not the camera will be susceptible to certain Partial Exposure effects due to the rolling shutter nature of the sensor, when used under certain types of lights. Automatic shutter control happens when you slide the AUTO/MANU switch to AUTO, if you've enabled automatic shutter control in the AUTO SW menu.

If the camera is not set to "Auto Shutter" then it's able to have the shutter speed set by the user. There are stock shutter speeds (such as 1/2, 1/3, 1/6, 1/12, 1/24, 1/30, 1/60, 1/100, 1/120, 1/250, 1/500, etc) and SYNCHRO SCAN. You choose a shutter speed by rotating the MultiDial, and pressing the wheel inwards like a button once it's displaying the shutter speed you want. Note that slow shutter speeds may not be displayed when VFR is set to ON; in VFR, the slowest shutter speed is dependent on the frame rate.

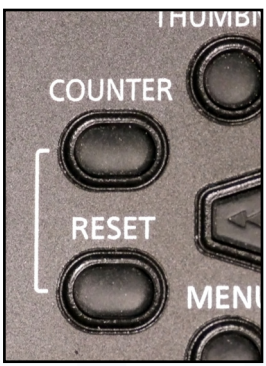
To adjust the Synchro Scan speed, you'll first have to select the Synchro Scan setting as your shutter speed. Press the SHUTTER BUTTON so the word "Shutter" appears next to the gear icon in orange, then press in the MultiDial wheel. Rotate the MultiDial wheel until you've chosen the speed that occurs right after 1/10000; when you choose 1/10000 and then try to choose an even-faster speed, it will wrap around to the Synchro Scan speed, which will have a decimal point (such as 1/60.0 or 180.0d); it's the only shutter speed that has a decimal point. Press the MultiDial wheel in to select that as your current shutter speed. The word next to the gear icon will then change to "SYNCHRO" and you can then use the MultiDial wheel to choose a Synchro Scan speed.

Auto/Manual Switch: These cameras have a wide variety of manual controls and capabilities. But what if you're in a situation where you just have to grab the camera and shoot something (say, a breaking news story?) For circumstances like that, where you simply don't have time to set all the manual settings in time to get the shot, you can slide the AUTO/MANUAL switch to AUTO and the camera will take over many of the

functions automatically. You can configure it to switch into auto-focus, auto-exposure, auto-iris, auto-gain, and auto-white balance... or you can tell it to go into auto-mode for any combination of those settings (see the discussion on the CAMERA>AUTO SW MENU for more information).

Another good use of the AUTO switch might be if you need to hand the camera to someone who's not skilled on it, to get a shot you need. The results will likely not be as good as if you'd manually set up the camera, but the AUTO switch may make the difference between getting a shot, and not getting it at all. Note that the AUTO switch doesn't turn on automatic level control for the audio; automatic control for the audio levels would need to be set in the AUDIO>REC CH SETTINGS>CH1/CH2 LEVEL options.

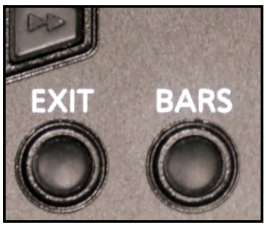
Thumbnail Button: This is one of the buttons you'll be pressing frequently. Press it and the screen will fill with the thumbnails of the recorded clips on the memory card. Press the THUMBNAIL button again to go back to camera mode (or, if you need to start recording immediately, just press one of the RECord buttons; the camera will automatically switch back to camera mode and start recording). Also, be aware there's a whole list of menu options available in playback mode that can only be accessed by pressing the MENU button when the thumbnails are displayed.



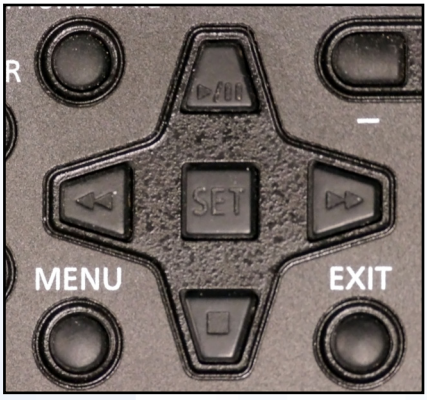
Counter & Reset: These buttons are used to control the display of the timecode (or counter) and to set or reset the timecode preset value. Pressing the COUNTER button will cycle through the timecode/counter displays in the viewfinder/LCD; the possible counter displays include Timecode, User Bits, and Counter. Also, the only way to remove the timecode (or Counter) from the display is to use the COUNTER button; using DISP/MODE CHK won't remove the counter display. If your timecode has disappeared or you're not seeing what you expect, be sure to check this oft-forgotten button to make sure your display is giving you the info you want!

Note: the RESET button here is only for resetting the timecode counter. It isn't a general hardware "reset" button.

When entering a timecode or User Bit preset in the menus, you can zero out the preset by pressing the RESET button. This makes it simple to update the preset every time you change a card, for example – you can zero out the timecode quickly, and then just change the hour setting for each card.



Bars: The camera can display SMPTE (Society of Motion Picture and Television Engineers) color bars, suitable for use in calibrating a professional monitor. When hooking up to a professional monitor, you can calibrate the monitor to know precisely what the recorded image looks like. All too often shooters will try to judge color, contrast, saturation or other picture elements based on how the image looks on a television, or on the camera's viewfinder or LCD. Those are not accurate representations of what the recorded image really looks like. The only way to know exactly what the image looks like is to use a professional monitor, and the color bars help you calibrate that monitor properly. Once calibrated correctly, informed decisions can be made on picture adjustments and settings. You can also record the bars if desired. It can also optionally output a 1KHz (or on 50Hz cameras, 997Hz) reference tone when the bars are displayed. This tone will not be output on the camera's speaker, but it does get recorded and will go out on any audio output jack (such as headphones or HDMI). You can choose the type of bars the camera will output in the OTHERS>COLOR BARS>COLOR BARS TYPE menu.



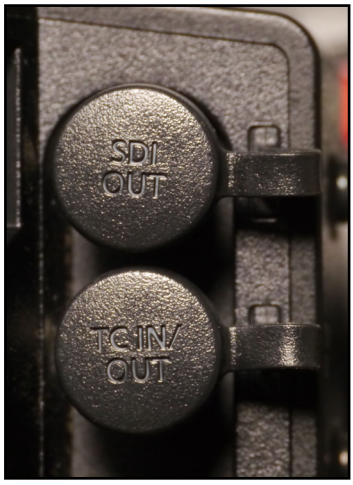
PLAY/FF/RW/STOP/SET Buttons: Under the LCD panel is a set of directional control buttons. These are used when playing back footage from the Thumbnail screen; you can play or pause, rewind or fast forward, or stop playback.

Note that these buttons can also be used to navigate the menus and are extremely helpful in doing so. They work as up/down/left/right buttons, and the center button is used to make menu choices.

These buttons are also used to select icons when choosing clips to delete or copy, etc. Use the up/down/left/right buttons to move the cursor to your desired icon, and press the SET button to make a selection.

Note that when in the menus, you can hold these buttons down to rapidly cycle through long lists of choices.

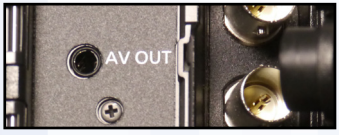
SDI/HD-SDI/3G-SDI Connector: The CX350 includes an industry-standard 3G-SDI output terminal. SDI stands for Serial Digital Interface, and the SDI port lets you monitor (or even record) fully uncompressed digital high-definition video at up to 1080/59.94p. This port is a regular locking BNC connector and is capable of transmitting either high-definition or standard-definition footage. The SDI port is a 3G-SDI port that is fully backward compatible with HD-SDI and standard-definition SDI. The VIDEO OUT/LCD/VF>SDI OUT>OUT FORMAT menu settings govern what type of video signal is sent through the SDI port, whether full-resolution or downconverted video. The camera also sends embedded timecode and audio in its SDI signal, making it suitable for use with computer SDI capture cards or portable recording units.



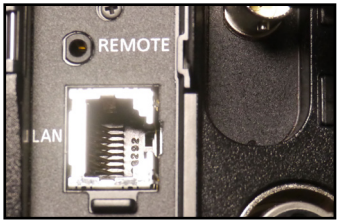
Timecode In/Out: The TIMECODE IN/OUT port is used to synchronize timecode with other cameras or timecode slates or other TC-enabled devices. This is a traditional timecode port that can be continuously sending timecode to any receiving device. It can also be continuously receiving timecode from another device, as long as the camera is in recording standby mode. When actively recording, the camera cannot receive timecode; it will instead rely on its internal timecode generator during recording, but when recording is stopped it can then receive timecode from a connected device.

The camera does not have genlock capability, so absolute frame precision is not possible; it's possible that the timecode could be off by up to one frame. See the article on SYNCHRONIZING TIMECODE for more information.

AV OUT: This port can output composite video in standard definition, along with left and right audio. A 3.5mm 4-pole mini jack cable is available separately that provides standard yellow, red, and white RCA jacks.

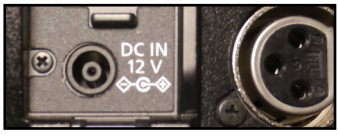


Remote Jack: There is a single remote-control port labeled REMOTE for attaching third-party controllers, and is compatible with controllers for the Panasonic AU-EVA1 camera. Note that older controllers used on different Panasonic camcorders (such as the DVX100 or HPX170) will not work on the CX350. When choosing a remote controller for the CX350, don't use just any third-party controller (even if it partially works); try to choose one that's made specifically for the CX350 because the CX350's remote port provides for iris control.

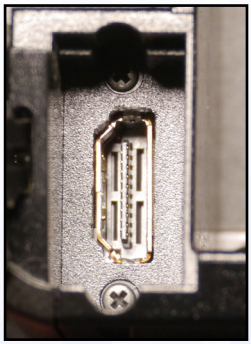


LAN Port: The CX350 includes an Ethernet 10/100/1000 port for connecting the camera to a wired network. The Ethernet port can be used for streaming video, or for connecting the camera to an NDI|HX network. Please see the articles on NDI|HX and on STREAMING VIDEO for more information on how to use the LAN port.

DC In 12V: The same power supply that plugs into the battery charger, can be plugged directly into the camera in this port. Note that that means you can either run the camera off AC power, or you can charge batteries, but you cannot do both at the same time (and no, the battery in the camera won't charge when the AC power supply is plugged in). However, do note that it's a good idea to keep a charged battery in the camera even when operating off AC power. The camera will switch seamlessly between AC and battery power; if you need to move the camera to a new location you can unplug the AC power and the camera will instantly switch to battery power, without missing a beat or dropping a frame. Alternately, if you want to change out the battery in the middle of a recording, you could plug in the AC power, then swap the battery, and then unplug the AC power, all continuously and without interfering with the ongoing recording or live output.



HDMI Connector: The CX350 includes an industry-standard HDMI 2.0b video output terminal. HDMI stands for High Definition Multimedia Interface, and HDMI ports are common on HDTV sets, Blu-Ray players, game systems and other consumer electronics devices. HDMI can also be easily converted to DVI through the use of a simple adapter; using an HDMI->DVI adapter will let you use a computer monitor as a video monitor



(which is not necessarily that good of an idea, but hey, it's an option; also, converting to DVI will mean losing the audio that is carried in the HDMI signal as DVI doesn't support embedded audio).

The HDMI port lets you monitor (or even record) fully uncompressed digital video in standard def, high definition, or UHD. This port is a standard full-size HDMI connector and uses standard HDMI cabling available at electronics stores; but because it is compliant with HDMI 2.0b, you're going to want to use quality ultra-high-speed cables. Cheaper cables might work for high-def, but might fail when using UHD. Ideally your cable should be rated for 18Gbps data, to take advantage of the highest-quality output the camera can deliver.

The camera also sends embedded audio in the HDMI signal, and can optionally send timecode as well. When configured to send timecode, the HDMI can also be used to send a RECord start/stop flag, which can be interpreted by external recorders to start and stop recording, thus enabling one-button recording for both onboard and external recorders.

The HDMI and SDI ports can be used simultaneously.

USB Host Port: The USB Host port is located on the top of the camera, right at the base of the rear handle on the right side. Open the door and you'll see a standard USB port.

The HOST port can supply USB bus power, and is designed to be equipped with the optional AJ-WM50 wi-fi adapter. The WM50 adapter creates a wi-fi network, or joins an existing network; this allows the camera to be remotely controlled by the CX ROP app on an Android phone or tablet, or an iOs phone or iPad tablet. In addition, the WM50 adapter can be used to join a wi-fi network so that the CX350 can output live streaming video to the internet. See the article on LIVE STREAMING for more information.

USB Device Port: There's a USB-C DEVICE port located on the rear of the camera, above the SD card slots. This port can be used to connect the camera to a computer. When connected to a computer, the camera can serve as a USB Card Reader device, allowing the computer to see the contents of the memory cards that are loaded in the camera's SD card

slots. Or, this port can be used as the USB SERVICE port, which allows you to plug the camera into a computer using a standard USB-C cable. The camera will then appear as an external hard disk on your computer's desktop. If you double-click that icon to access the contents of that disk, you'll then see and be able to open the licensing agreements for the various operating system software in the camera. To choose which mode the USB Device port operates as, use the OTHERS>USB DEVICE menu.

LCD Monitor: The LCD monitor is a touchscreen display, useful for monitoring your shots and for controlling the camera's menus (as well as directing the AREA function for specifying what section of the screen you want the camera to focus or expose at). It's a sharp display but it's still not enough resolution to rely on it exclusively for focusing. It can display standard or high dynamic range images (when using HLG gamma).

The VIDEO OUT/LCD/VF>LCD menu gives you some control over the LCD display, including brightness, contrast and color. While it is tempting to think that you could calibrate the LCD to the color bars to match a professional monitor, it's not really practical because a slight change in the ambient light level or changing the backlight level may change how the LCD's display looks. It's much better and safer to rely on a true external production monitor to gauge color, exposure and contrast, or, if one isn't available, use the zebras and waveform and vectorscope.

The touchscreen element of the LCD may take a little getting used to. It doesn't respond immediately to bring up the menus; you have to leave your finger in place for a second or two. Once the menus are displayed, it's highly responsive and easy to use to change settings.

The LCD screen is also quite reflective. That reflectiveness gives it nice rich deep blacks, but it also makes it harder to see under daylight conditions. You may want to invest in an LCD hood (or use the VF) for filming outdoors. If you want to use the LCD outdoors, you'll probably have to set the LCD>BACK LIGHT to its highest level.

XLR Audio Connectors: There are two XLR connectors for attaching microphones, wireless mic receivers, mixers, or other professional audio devices to the camera. Input 1 is located on top of the camera, opposite the LCD panel; Input 2 is on the rear of the camera at the bottom-right. These XLR connectors are

input-only, no audio can be output from them. Also, the XLR connectors only function when in camera mode. The XLR ports can supply phantom power if desired, and can be configured to line or mic level. You can also configure the sensitivity of the XLR inputs in the audio menus.

O.I.S. Button: User Button 1 is pre-programmed for the O.I.S. function. The camera includes an Optical Image Stabilization (OIS) system, which helps smooth out shaky handheld shots. The OIS system consists of a series of moving elements in the lens that actually move and redirect the image coming into the lens, to detect motion and compensate for it. The OIS effect can be most easily seen when at full telephoto: at full telephoto it's harder to hold the camera still without some shake, as the picture is magnified and so any corresponding shake will be similarly magnified. The OIS tracks any movement of the frame and moves the prisms to track the original framing, trying to keep the frame as still as possible. There's a limited amount of compensation it can do.

The OIS can be enhanced by the use of the Hybrid OIS, which adds electronic stabilization to the optical stabilization. The results are really very effective.

Additionally, the OIS system may help to reduce the instances of MOS-sensor "wobble" that may happen in handheld shots or in instances where a tripod-mounted camera might by lightly jostled. The OIS can perform surprisingly well at absorbing those little jolts.

The OIS system is also tunable; you can customize the OIS response to tailor it towards the type of situations you expect to encounter. See the CAMERA>SW MODE>O.I.S. MODE menu for more information.

While the OIS can work quite well, there are times when you will want to turn the OIS off. For example, you will generally want to disable OIS when using the camera on a tripod (or dolly or jib arm or a slider or any other image stabilizing device). When mounted on a tripod, the image should already be adequately stabilized, and any motion that occurs in the frame will be intentional (i.e., if you start panning the camera). But if OIS is enabled, the OIS system may see that motion and try to "compensate," actually canceling out your panning motion. The result is that the OIS will try to "stabilize" your shot, and the further you pan the further it will try to stabilize it, up until the point where it can no longer compensate

(remember that the prism can only move so far before it reaches its limit). The result will then be a noticeably jerky motion in the pan. Or, another side effect may come into play when you stop panning — the OIS might cause the image to slowly drift back to a centered position (where the lens elements are all reset back to their default state). While this might be fine when handheld, it can be noticeably distracting when using a tripod. If you're using a tripod, there aren't many good reasons to have two image stabilization devices trying to do the same job, so turn OIS off and you'll get cleaner, smoother pans and tilts. On the other hand, OIS can be useful even when the camera's on a tripod, to stabilize out minor vibrations or sudden jerks or twitches. You can optimize the OIS to perform well in these scenarios; see the CAMERA>SW MODE>O.I.S. MODE menu for more information.

Zebra Button: The Zebras are discussed in the VIDEO OUT/LCD/VF>EI ASSIST settings section. This button is a general-purpose User Button, and you can redefine it to a different function (or, you can assign Zebra to a different User Button if you want.)

WFM Button: This button enables or disables the WaveForm Monitor (WFM) or VectorScope (VS), according to the menu setting you've assigned to the VIDEO OUT/LCD/VF>EI ASSIST>WFM MODE menu setting. You can display either the waveform monitor or the vectorscope, but not both simultaneously.

The waveform monitor is perhaps the most valuable exposure tool in video. A waveform monitor is an excellent tool for analyzing the video signal and getting proper exposure. For an introduction into how to read the waveform monitor, see this article.

The WFM button is a re-programmable User Button, and you can also access the waveform monitor or vectorscope by assigning the "WFM" function to any other User Button.

A. Iris Level Button: This button enables or disables the A.IRIS LEVEL EFFECT setting from the Scene File menu. The A.Iris Level Effect is the amount of over- or under-exposure you want the camera to

perform whenever it's in automatic iris control (if the A.IRIS LEVEL is engaged, that is). Pressing this button is functionally identical to going into the SCENE FILE>A.IRIS LEVEL menu item and choosing "ON" or "OFF". When this function is active, you'll see a number next to the iris display; at the bottom of the LCD you'll see STD followed by an f-stop number (example: STD 4.8), and when the A.IRIS LEVEL is engaged you'll see another number following the iris (example: STD 4.8 +50). That number is the number you've set in the SCENE FILE>A.IRIS LEVEL EFFECT menu.

You can temporarily override the A.Iris Level Effect by moving the iris ring. That will change the number displayed after the f-stop, and you can move it in the range of -50 to +50. This temporary override does not actually change the value in the scene file; accordingly, when you disable the auto iris level effect by pressing this button, your temporary override will be lost, and the next time you engage this button, the value will be taken from the scene file.

Note that this function is only available when the iris is in automatic control. If you've set the iris to manual control, pressing this button will just result in a message on the screen saying "INVALID". You'll know the iris is in automatic control when it displays the f-stop with a prefix of STD, SPOT, or BACK.

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About the Author

Barry W. Green has been writing camera guides since the original "The DVX Book and DVX DVD" in 2004. He's an Emmy®-award-winning producer with four Emmy nominations for writing and producing television commercials and public service announcements. His technical background includes 13 years as a professional computer programmer and producer for Westwood Studios, creating some of the most popular video games in history. Since leaving the videogame industry in 1999, he now writes and produces award-winning corporate and industrial films, commercials, screenplays and films for Fiercely Independent Films Inc. He's been an instructor in HD training seminars and been an invited guest speaker at video conferences worldwide, is an imaging technician for aerospace cinematography company FlightLine Films, and also serves as partner and moderator for www.DVXUser.com, one of the world's largest online communities for filmmakers, shooters, and content producers of all types, and is the leading source of information for users of the AG-CX350 as well as the AU-EVA1, DVX200, UX cameras, DVX100, HVX200, HPX, and HMC series of cameras. He also produces training videos for filmmakers, including the "Sound for Film and Television" and "Lighting for Film and Television" DVD series, which you can find at www.WrightsvilleBeachStudios.com.

Published by Fiercely Independent Films
3091 College Park Dr Ste 240-6,
The Woodlands, TX USA.