Why MONITOR?

Test, Measurement, Monitoring and Quality Control & How to Calibrate a Monitor

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In an age of digital cinematography, it is increasingly important to make sure that what we are recording on camera meets the broadcast requirements, and that those images withstand the subsequent production chains before they reach the viewers. Monitoring is becoming an essential part of ensuring the quality of video signals at every stage of production. On a snowy Saturday morning at High Wycombe, we gathered to find out what the key factors are in meeting those criteria.

Morning Session: Theory & Technical

The first guest speaker, a video consultant with 26 years' experience, Philip Humphries from Hamlet, kicked off with interesting illustrations and a softly spoken introduction. It was essentially an intense cramming of a 300-page PowerPoint presentation into two and a half hours of in-depth electronic engineering, most of which was certainly beyond my scope, and I am hoping that it wasn't just me feeling that way. Philip stressed that our responsibility doesn't necessarily end when we hand in the rushes or after grading, but ultimately we need to make sure that the images appear the way we intended, and that there are measures that we can take to achieve it.

As background to the subject Philip took us through the history of how video signals have developed into the current digital form and how they are subsequently delivered to the audience.

Originally, the signals that came out of a video camera 'analogue RGB components' were too large to transmit, so they needed to work out a way to reduce the bandwidth. In a video image, Luminance, described as 'Y', is the most important element, as it determines the brightness of the picture - the brightness information has far more impact on picture details to human eyes than colour information does. Therefore they decided to keep the luminance as a full signal and reduced the chrominance, red and blue, by half - which became YUV. This colour sampling concept has contributed to the notion of '4:2:2' that is now widely used. YUV signals were then combined and converted into 'composite', a single manageable signal form for analogue transmission.

There were a lot of discussions at the time as to the formats and standards before they were finally settled. Philip succinctly summarises these acronyms as follows, which hopefully some of the readers might find amusing. PAL: Perfection At Last. NTSC: Never Twice Same Colour. SECAM: System Essentially

Contrary to the American Method.

After that analogue composite, HD/SD SDI (Serial Digital Interface) digital, came along. An uncompressed form of digital signal was achieved by serialising the YUV signal in such a way as UYVY. U and V were placed alternately between every Y, since there was twice as much Luminance (Y) as Chrominance (U) and (V). Various SDI standards were established by SMPTE (Society of Motion Picture and Television Engineers) for several different formats. Amongst them are SMPTE125M and 295M for SD HDI, for which the data rate is 270Mb/s, and SMPTE 240M and 292M for HD SDI, for which the data rate is 1.48Gb/s for even and 148.35Gb/s for odd rates.

Following on from the uncompressed digital signals, we have come to our current form of 'compressed digital signals', which have made it possible for even more channels to be transmitted. The serialised UYVY and SDI signals are encoded using MPEG2 or MPEG4 format. Philip mentioned that the MPEG codec sometimes anticipates movement when encoding, which is clever when it works, but it is not without problems. There was an incident during an outside broadcast, when the Horse Guards went round the fountain at Buckingham Palace - only the upper bodies of the Guards were seen to go round - with the horses' legs getting left behind!

Generally speaking, scenes that contain more details and movements, such as football matches, demand more bandwidth when being transmitted than scenes containing static shots with less movement such as interviews with talking heads. Philip explained that, these days, streaming of this compressed digital data is controlled automatically by a complex system called 'Statistical Multiplexing', in which the allocation of bandwidth is constantly being calculated and switched between programmes and channels, depending on the demand of the scenes. Apparently, despite the high tech system, when things go wrong with, for example, blocky pictures, clients phone the operator to complain. The operator would then adjust the bandwidth accordingly to rectify the problem.

Top: Philip explains the eye diagram and below, the Hamlet equipment display.

Although the advanced technology increased the effective bandwidth of the multiplexing, Philip pointed to a tendency for broadcasters to accept more channels for financial gain rather than retaining the service reliability and the picture and audio quality. Since there is only a fixed amount of bandwidth, there is a trade-off between the number of services they provide and the quality of the signals, even though the efficiency of multiplexing is increased.

This seems to have to been the case with a programme that a GTC member had worked on. He mentioned that as he was watching a programme that he had shot for a satellite channel - which was repeated at different times throughout the day - he noticed that the quality of the picture looked different depending on the time of the day it was shown.

Philip argued that the changes in the formats and hardware in television are driven by the financial gains of the broadcasters and manufacturers. Although one cannot deny the economic benefits and stimulus to the industry, usually consumers are forced to go along with those changes and there is usually no alternative solution.

After the history lesson, Philip showcased his expertise on signal tests, measurement and devices. These tests seemed highly technical and intended for engineers. One thing we should bear in mind is the inherent nature of digital signals. Analogue signals still work even with the presence of noise, whereas digital signals either work or don't work at all - this is called a 'cliff effect'. Moreover, when they stop working, they don't usually give you a warning. Testing and monitoring is perhaps much more essential with digital signals for this reason.

'Eye Diagrams' can be used to analyse serial data signals and diagnose problems such as jitter and noise in a signal. For example, it could be useful to test the cable margin or to detect noise creating false data. A larger opening indicates a greater tolerance for noise and jitter, and better receiver sensitivity. 'Pathological signals' can be used to perform a 'stress test' to check the recovery clock. We should also take care of our cables. Philip highlighted the fact that HD signals will not go round a 90-degree corner, at which point, I thought, perhaps tying BNC cables onto a dolly's handle during a tracking shot is not such a good idea. Furthermore, in order to transfer maximum energy (signal) from a source to destination through a coaxial cable, the cable's characteristic impedance must precisely match that of the source and destination (75 Ohm), appropriate termination is needed, otherwise there will be reflection problems. We also need to make sure that we use connectors that are designed for the cable.

Next discussed were the issues of station requirements, which might be more relevant to us as camera people. Any signals which do not meet broadcasters' standards will result in the whole programme being rejected, and all stages of the video chain needs some form of checking. Checking levels and colour gamut is the absolute minimum, Philip emphasises this because you don't want to get caught by the quality control process employed by some broadcasters, who feed everything through a 'gamut corrector' or a 'legaliser' (which can introduce artefacts). Consequently your signals could end up looking worse than the original problem.

It was explained that any video channel has a specified signal voltage range and the full range of this is called the 'gamut' for the channel. In order to avoid the problems mentioned above, video levels including any line-up should be received within the specified limits so that the programme material can be used without adjustment. Broadcasters refer those 'specified limits' to EBU recommendation R103-200, which can be found on the EBU website.

Gamut limits exist in each signal format, namely RGB, YPbPr and Composite. Unfortunately the limits are not the same for each format and problems can arise when transcoding. Formats can limit colour range, so exceeding gamut may result in clipping. Observing gamut limits also helps ensure repeatable colour reproduction.

Additionally, standards and format conversions and compression cause viewers perceivable artefacts. To make sure the 'look' is preserved to the final viewers, the content creator must be aware of the different formats that the video will transit, and care has to be taken when converting between formats.

There are several instruments that are relevant to monitoring the gamut. PLUGE (Picture Line-Up Generating Equipment) is used to set the brightness of the monitor. SMPTE Colour Bars are used to align colour monitors, and to check colour phase (hue) and amplitude (saturation) using a vector monitor in systems.

Other station requirements include items such as Safe Area, Flashing Video (Photosensitive Epilepsy Guidelines), Audio Level, Sound to Video Sync and Loudness Management.

Hamlet also supplies on-line and off-line file testing software, offering file solutions to items such as Safe Area, Audio Bars, Surround Sound and Loudness. Their on-line measurement tools allow live video and audio, or single audio/video clips to be easily visually checked and monitored for various errors. Hamlet's portable LCD monitor range on display on the day had features such as Focus Peaking, Clip Guides and False Colours. The two latter features in particular help keep the video signals within the range.

Philip concluded by reminding us that the broadcast requirements are there to ensure that the viewers experience our programmes the way we intended. All broadcasters publish technical requirements for programmes that have been commissioned for their delivery, either directly or on tape. In the UK this includes BBC, ITV, Channel 4, Channel 5 and SKY. It is best to fix problems to avoid rejection by broadcasters before submitting your programme.

Afternoon Session: Calibrating a Monitor

The second part of the workshop was a more practical session delivered by ex-Sony consultant engineer, Neil Thompson. It was time to put some of the things we had learnt in the morning session into practice. Neil started by covering the fundamental facts including how our eyes behave and the differences between types of monitors. He covered the ways we can calibrate a monitor correctly, using the test instruments provided by Hamlet, so that we know that the monitor is set correctly and can use it as an invaluable tool in the future when we are shooting.

Obviously it would help to match the monitor with the viewfinder when we are shooting, but, as Neil points out, viewing conditions affect the image to a great extent. We were provided with different monitors with different viewing conditions to demonstrate this. If you view a monitor in a dark tent, it would look more saturated than if you do in ambient light, so it could affect your judgement in determining the exposure.

Neil then explained the different types of monitors. CRT monitors were once the

norm. As an ex-Sony man, Neil admits that Sony gave up the CRT monitor production a little too soon, in order to be one of the first companies to take the initiative to be ecological - CRT monitors have a high lead content in their tubes. Although it was a responsible thing to do as a company, Sony could have profited from making them a little longer: their grade 1 monitors were such high quality that people hung on to them for as long as they could.

Then the LCDs took over from CRTs. There are two types of LCD screens: TN (twisted nematic; Neil loves the sound of this word by the way!) and IPS (In-Plane Switching). IPS is superior to TN in that it has a wider viewing angle and better colour reproduction. One of the Hamlet monitors on display at the workshop – the Precision HDW7 was using an IPS display.

The main shortcoming, which is inherent in all LCDs, is the response time, creating the so called ‘ghosting’ effect. If there is very quick motion happening in the frame, it may leave streaks or blur around the moving object. This is particularly prominent when combined with various processing factors that cause a display lag at the same time. According to Neil, however, despite the claims on the specification sheets, there isn’t much difference between manufacturers with respect to the pixel response time. This is because the “smeary stuff” they put on the surface of LCD screens is all applied in the same factory in Germany.

We are now moving into the new generation of monitors, OLEDs (Organic Light Emitting Diode). They work without a backlight, therefore can display deeper black levels and more contrast ratios with faster response time than LCDs. However they tend to flicker, and apparently the software that they put in to reduce it causes the display to lag. Unfortunately we seem to come back to the same problem again - I suppose we have to decide what the priority in our display needs are and choose the monitor accordingly.

Neil also explained the difference between TV sets and monitors and discussed whether we could use a TV to monitor the picture. He actually brought in his own TV from home, along with other monitors, to demonstrate. Basically, TVs are meant to make the picture look nicer, whereas professional monitors are meant to show the flaws of the picture. TVs also comes with far too many unnecessary functions such as ‘Vivid Colour’, and yet don’t have functions such as ‘Blue Only’, a function needed to set the saturation level on a monitor.

There are several tools that help us calibrate a monitor.

Neil Thompson taking the practical afternoon session

The list that Neil prepared is as follows:

- Colour Bars
- Sawtooth
- Zebra
- Waveform
- Vectorscope
- Charts
- Pixel Zoom
- High Key / Low Key

As Philip pointed out in the morning, the most important element in the video signal is the luminance. The first thing we need to adjust is the brightness. We can do this by using the PLUGE in SMPTE Colour Bars. PLUGE is a small box containing three strips of different black levels towards the bottom right-hand side of the colour bars. You adjust the brightness so that only the right-hand column is just visible.

The left-hand column is called ‘super black’, which is supposed to be blacker than black, therefore it should disappear into the blackness of the surroundings. On the waveform monitor, this should fall below the 0%. The middle one is ‘true black’, where the level should be set to Pedestal, i.e. 0%, and should also be disappearing into the blackness of the surrounding.

Next we need to adjust the contrast. Neil prepared the

Chroma Du Monde chart in front of our camera, we could see all the steps from black to white and vice versa in an opposite direction. Here, you adjust the contrast level so that you can still see the last step on the highlight end but just below the level at which it doesn't get any brighter. At this point Christina Fox, threw in an additional tip she acquired from Alister Chapman. She suggests that we can adjust the contrast by using the 100% White area situated towards the bottom left-hand side of the colour bars in the same way. Make it low to start with and gradually raise the contrast level till it doesn't get brighter anymore and then bring it down by one notch.

Next up is Saturation and this is where 'Blue Only' mode comes in handy. Once you press the 'Blue Only' button on the monitor, the test signal turns into shades of blues and black, but the areas with blue colour in it appear bright and those without appear dark or black. We need to match the colour of blue in the top row of SMPTE Colour Bars, where there used to be White, Cyan, Magenta and Blue with the strips underneath them, which are in identical colours but run in the reverse order to the top row. Adjust the saturation knob so that those areas of blue become seamless. At this point, Christina threw in another tip she acquired, this time from Alan Roberts. If you have to use a TV as a monitor, or the display you are working on happens not to have a 'Blue Only' mode, you can use 'Congo Blue' gel as a substitute. Apparently it works just like 'Blue Only'.

Now that the monitor is properly calibrated, it was time to see the different functions in the camera and compare the effects that they produce in terms of exposure, while looking at the waveform monitor. By introducing the 'Knee' function in the camera, it was demonstrated how the highlight was contained even though the picture was severely over exposed. The grey scales were useful in judging at what degree the details were retained or lost. We could also see the effect with and without the Knee function, by switching it on and off, both on the screen and on the waveform monitor.

Similarly, we experimented with Hypergamma and set the Clip to 107%. Again the highlight details were retained remarkably. We could still see the steps of the Chroma Du Monde chart above 100%. Neil said that, as long as you could see that step, you could bring the details back in post up to 109%, provided that the Clip level is set to 109% and you are using a Hypergamma that goes to 109%. The information in the highlights could be details in clouds and sky.

There are typically four Hypergamma settings in a camera similar to the PDW700 which we were using. For example, Hypergamma 1: HG3250 implies that you have a gamma curve, where 325% input video signal is mapped into 100%. Similarly, Hypergamma 4: HG4609 means 460% of input signals are translated into 109%. The first three digits represent the percentage of input video and the last digit indicates whether it is translated to 100% or 109%. Again we could see the change in the gamma curves and the fall-offs of the highlight respectively in the waveform monitor.

If you are using a S-log gamma curve similar to the one in a Sony F3, you can double check the exposure by setting the Zebra to 38% and displaying a 18% grey card, and by adjusting the stop so that Zebra kicks in at 38%. This is supposed to be the exact exposure and should give you 6.5 stops above and 7.5 stops under the 18% grey.

After plenty of experiments with the luminance level, it was time to have a go at the chrominance using a vector scope. By displaying the SMPTE Colour Bars, we can check if the colours are properly lined up and there are no shifts in colour hue or saturation. In the vector scope, the angle of the axis represents the hue, while the distance from the centre represents the saturation; the further from the centre, the more saturated.

Within the vector scope there are six target areas where each colour is supposed to reside - three primary colours of red, green and blue and three secondary colours of cyan, magenta and yellow. When correctly calibrated, there should be a distinctive and recognisable pattern in the vector scope. This was demonstrated using the Hamlet instrument. You could also check that all the colours are aligned correctly by filling the frame with a white card. As white consists of equal amount of RGB, all the signals should fall into the centre of the vector scope, creating a dot in the middle.

Once you know where everything is with respect to colour you can deviate creatively from that base. In Matrix and the Paint menu setting in the camera, you could either type in individual numbers of your choice or choose one from the Matrix presets. The settings on the preset Matrix are set by various international boards. In the Sony HDW700, they are as follows:
1 = SMPTE240
2 = ITU709
3 = SMPTE-WIDE
4 = NTSC,
5 = EBU (i.e.PAL)
6 = ITU601
Multi Matrix is useful if you are working on multi cameras and you need to match their colours precisely. You can choose a particular colour axis you want to make an adjustment to and move it around until you find a point you want, observing the dot moving around in the vector scope while you do this.

High Key / Low Key is a very useful feature for determining exposure when using a camera capable of capturing a wider dynamic range than your monitor can display. This feature is available in cameras such as Sony F65 which can shift the monitor scale to view each side of the exposure so that you can observe the luminance level more accurately and expose accordingly.

In his summary, Neil posed us with three valid points. First: "If can't trust your monitoring and measurement, then don't bother". He says it is worse than having nothing at all. Second: "Take the time to get familiar with your test equipment". Third: "Before responding to criticism, ask 'How do you know?'. For example, if someone says "Your colour balance is always blue", you know it can't be if the dot in the vector scope is in the middle and you know this is so because you checked it.

I came out of the workshop with the insight that, if you know where you are with brightness and colours and also how to assess them in a monitor that you are familiar with, and if you understand the principals, you can always solve problems. More importantly you know your picture is good.

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The Hamlet HDW 7 and 5 are available to GTC members until the end of March at the special prices that follow:

HDW7 unit list price is £1115.00 special GTC price £995.00
HDW5 unit list price is £ 995.00 special GTC price £857.00
Delivery inside UK is £24.00
All prices include VAT

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