Dual Link

Introduction

Film still continues to dominate within high-end production as the main acquisition medium, despite all the advances in digital signal processing. Although the transition to digital is making advances with various applications such as digital cinema and high-end post production such as film to data transfers, visual effects and color correction. The quest is therefore higher and higher image resolutions such as 2K or 4K image formats that more emulate the "film look" of the material. By having a high resolution digital distribution master of the material, we now have ready access to the wide range of duplication formats for the program - from Digital Cinema to HD or SD formats.

Tektronix
Enabling Innovation

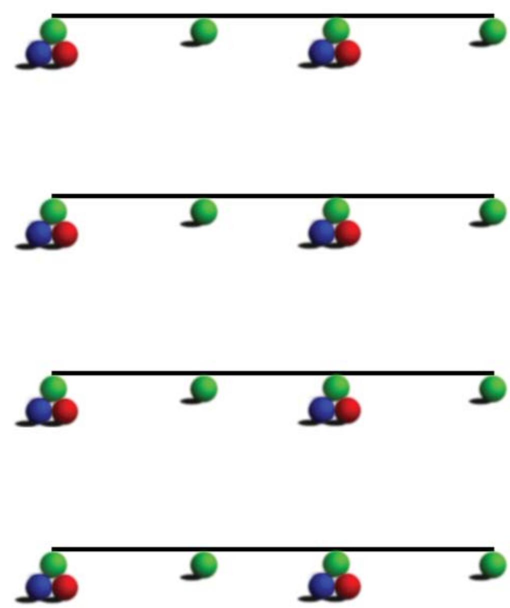
Signal Format sampling structure / pixel depth	Frames / field rates
4:2:2 Y'C'bC'r 10-bit	60 59.94 and 50 Progressive
4:4:4 R'G'B' 10-bit 4:4:4 R'G'B' + (A) 10-bit	30, 29.97, 25, 24, 23.98 Progressive pSF 60 59.94 and 50 Interlaced
4:4:4 Y'C'bC'r 10-bit 4:4:4 Y'C'bC'r + (A) 10-bit	
4:4:4 R'G'B' 12-bit	
4:4:4 Y'C'bC'r 12-bit	
4:2:2 Y'C'bC'r(A) 12-bit	

► **Table 1.** *Dual Link Supported formats defined in SMPTE 372M.*

To achieve distribution of these high resolution formats, various methods of transmitting the signal between various pieces of equipment is necessary. One method to do this is by using multiple High Definition (HD) Serial Digital Interfaces (SDI) such as defined for the Dual Link formats in SMPTE (Society of Motion Picture & Television Engineers) 372M (See Table 1.)

These various formats are mapped into an HD-SDI signal which is standardized in SMPTE 292M. Typically, SMPTE 292M transports a Y'C'bC'r signal using a 4:2:2 sampling structure with 10-bit words for each sample. The 4:2:2 sampling structure is illustrated in Figure 1 and consists of sampling the luma signal (Y') at twice the frequency of each color difference signal (C'b & C'r). By performing this format conversion from the original R'G'B' signal, a simple bandwidth compression of the signal is achieved. (E.g. Each R'G'B' channel in HD requires 30 MHz, giving a total combined bandwidth of 90 MHz, whereas in Y'C'bC'r, there is one full bandwidth channel (Y') of 30 MHz and two color difference signals of 15 MHz, giving a combined bandwidth of 60 MHz.)

In the case of an HD signal, a sampling frequency of 74.25 MHz is used for Y' and half that rate (37.125 MHz) is used for the color difference signals. To calculate the bit rate of the interface, let us consider the progressive format of 1920x1080 at 30 frames per second.



► **Figure 1.** *4:2:2 Sampling Structure.*

Data Rate Calculation

30 progressive frames/ second

x 2200 words per line (1920 active image data)

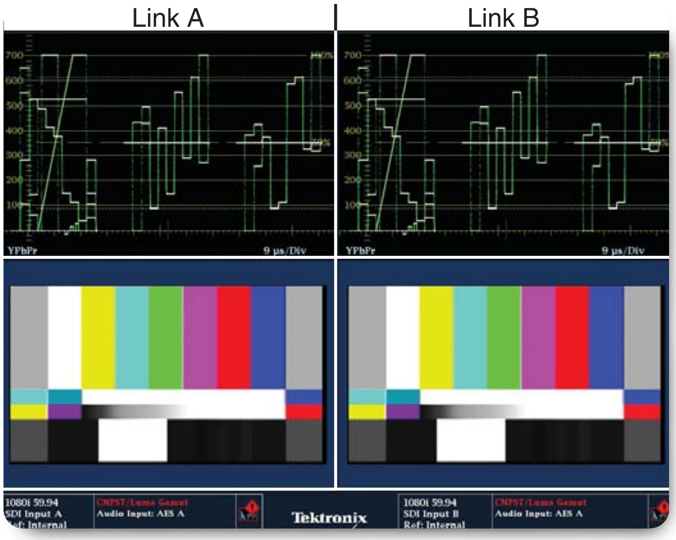
x 1125 lines (1080 active image data)

x 10 bits per word

x 2 words per sample (1Y' and 1 C'b or C'r)

= 1.485 Gb/s

For other frame rates, the number of words per line is adjusted to maintain the same data rate. (E.g. 2640 words for 25p or 2750 words for 24p). In the case of odd frame rates such as 59.94 Hz, 29.97 Hz or 23.98 Hz, the frame rate is divided by 1.001 and therefore the sampling rates are also divided by the same number. The overall data rate of these formats is 1.4835 Gb/s. For the Dual Link formats we have two HD-SDI signals making a total data rate of 2.97 Gb/s or 2.97/1.001 Gb/s. Then, the color components of the various formats are mapped between the two links. The primary link is defined as “Link A” and the secondary link is defined as “Link B”.



▶ **Figure 2.** *Link A and Link B of a 4:2:2 10-bit 1920x1080 60p SMPTE219 color bar signal.*

Link A	$C'b_0$: 0-9	Y'_0: 0-9	$C'r_0$: 0-9	Y'_1: 0-9	$C'b_2$: 0-9	Y'_2: 0-9	$C'r_2$: 0-9
Link B	$C'b_0$: 0-9	Y'_0: 0-9	$C'r_0$: 0-9	Y'_1: 0-9	$C'b_2$: 0-9	Y'_2: 0-9	$C'r_2$: 0-9

▶ **Table 2.** *Data Structure of Link A and B for fast progressive formats.*

Digital Interface	1	...	20	...	560	561	562	563	564	...	1123	1124	1125	1
Link A	2	...	40	...	1120	1122	1124	1	3	...	1121	1123	1125	2
Link B	3	...	41	...	1121	1123	1125	2	4	...	1122	1124	1	3

▶ **Table 3.** *Progressive image format divided between Link A and Link B.*

Dual Link Fast Progressive Formats. (Y'C'bC'r 4:2:2 10-bit @ 60p, 59.94p, 50p)

The mapping of fast progressive formats maintains the same structure of 4:2:2 10 bits format for the HD-SDI signal. Therefore, the data stream is divided equally between Link A and Link B. On an HD waveform monitor, the various trace displays of each link look no different than a similar 1920x1080 interlaced signal as shown in Figure 2.

Table 2 shows how the samples are mapped between the two links A and B; in this case the fast progressive formats conform within the HD-SDI sample structure. Within this format it is important to understand that the original image was scanned as a full frame progressive image and has been divided between the two links for easy transport across an existing HD-SDI infrastructure. Therefore the mapping of the lines between the two links is characterized within the standard. Notice the difference between how the image is divided up between the two digital fields of the HD-SDI interface as shown in Table 3.

▶ **Figure 3.** *Waveform displays of Dual Link A and B signal for R'G'B' (A) 4:4:4:4 format.*

In order to maintain a constant data rate for these three fast progressive frame rates of 60/59.94p and 50p the blanking interval is changed. For 60/59.94p a total of 2200 words are used per line, whereas in 50p format a total of 2640 words per line are used.

R'G'B' 4:4:4 & R'G'B' (A) 4:4:4:4 10-bit (30, 29.97, 25, 24, 23.98 Progressive PSF, 60 59.94 and 50 Interlaced)

The predominant use of the Dual Link format is to carry film originated R'G'B' material at 23.98p/24p in order to maintain the quality of the original material. In this way there is no loss of resolution in format conversion to Y'C'bC'r color space. However, the R'G'B' signal has a sampling structure of 4:4:4 and this structure has to be constrained to fit within the two 4:2:2 HD-SDI data streams. To achieve this Link A [Y'] data space is filled with the G' channel and the [C'b/C'r] data space is filled with the even-numbered B' and R' channels respectively. In Link B the [Y'] channel data space can be optionally filled with Alpha channel data and the [C'b/C'r] data space is filled with the odd-numbered B' and R' channel samples as shown in Table 4. The Alpha channel can be used to carry a data stream or, alternatively, can be used to carry a key channel which can be used within the post production process for digital compositing. If the Alpha channel is not present then its value should be set to blanking level of 64_H.

When each of these Dual Link signals is viewed on a waveform monitor, the resulting waveform displays are formed as shown in Figure 3 using the SIM option of the WFM7120 allowing both links to be viewed simultaneously. Notice the Y' channel values are of the correct levels but the C'b/C'r values are not representative of the true level of the signal and require that the two Dual Links signals are combined into a single display.

Link A	B'_0: 0-9	G'_0: 0-9	R'_0: 0-9	G'_1: 0-9	B'_2: 0-9	G'_2: 0-9	R'_2: 0-9
Link B	B'_1: 0-9	A_0: 0-9	R'_1: 0-9	A_1: 0-9	B'_3: 0-9	A_2: 0-9	R'_3: 0-9

▶ **Table 4.** *Data Structure for R'G'B' (A) 4:4:4:4 10-bit Dual Link format.*

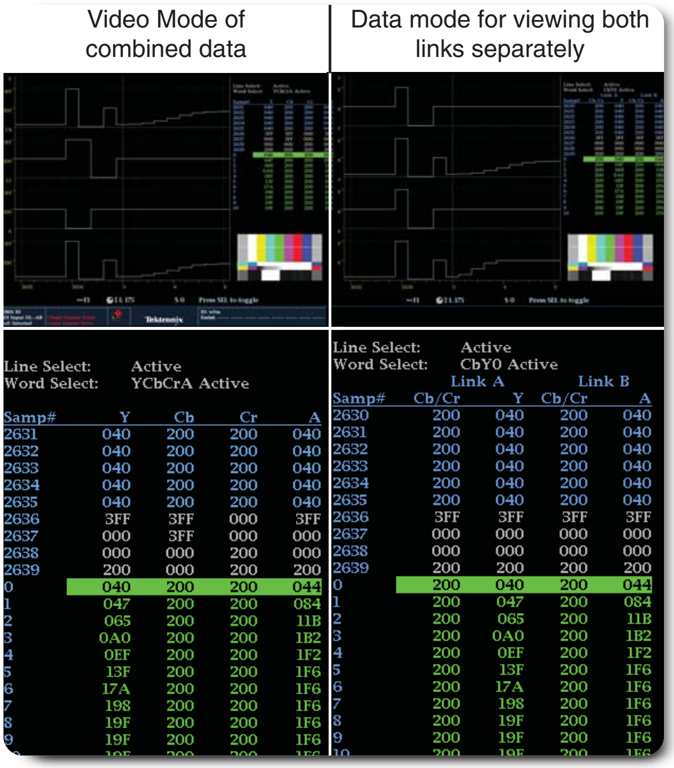
▶ **Figure 4.** *Waveform displays of Dual Link A and B signals for Y'C'bC'r(A) 4:4:4:4 10-bit format.*

Link A	$C'b_0$: 0-9	Y'_0: 0-9	$C'r_0$: 0-9	Y'_1: 0-9	$C'b_2$: 0-9	Y'_2: 0-9	$C'r_2$: 0-9
Link B	$C'b_1$: 0-9	A_0: 0-9	$C'r_1$: 0-9	A_1: 0-9	$C'b_3$: 0-9	A_2: 0-9	$C'r_3$: 0-9

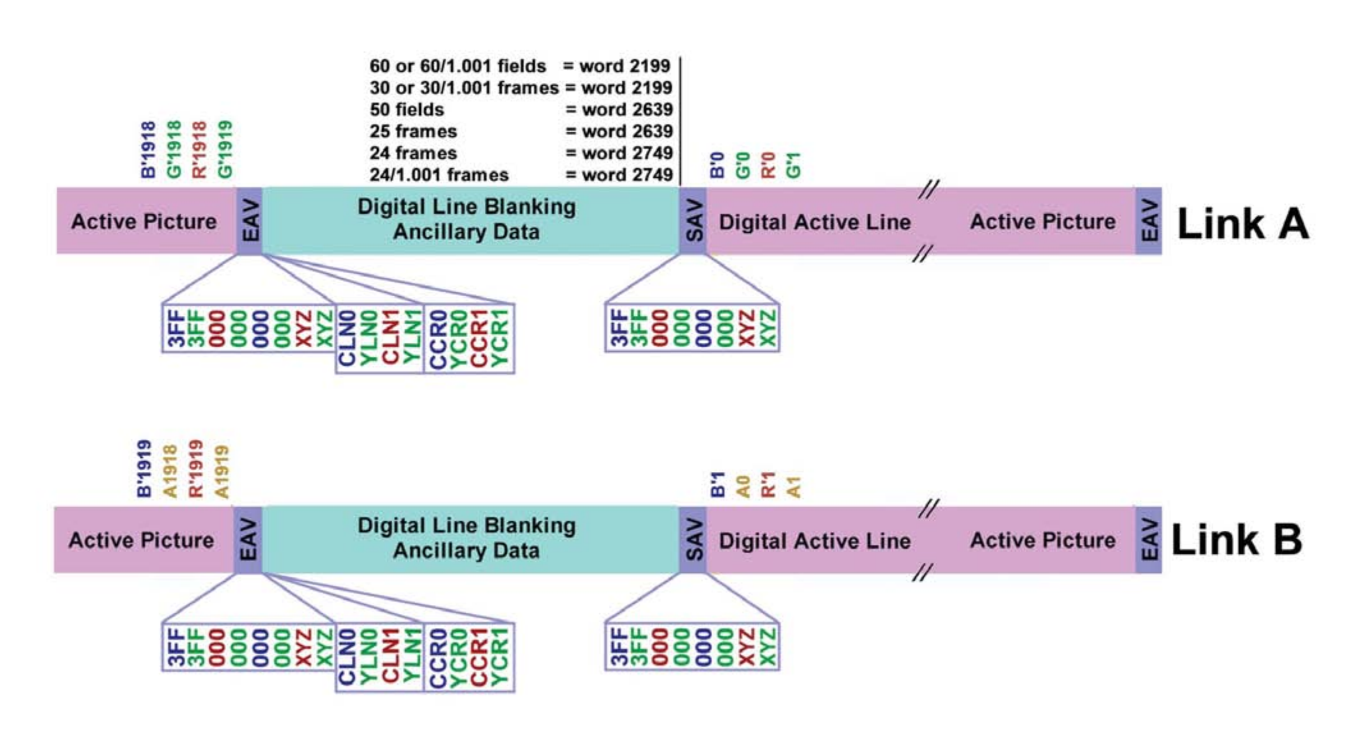
▶ **Table 5.** *Data Structure for Y'C'bC'r(A) 4:4:4:4 Dual Link format.*

Y'C'bC'r 4:4:4 & Y'C'bC'r(A) 4:4:4:4 10-bit (30, 29.97, 25, 24, 23.98 Progressive pSF, 60 59.94 and 50 Interlaced)

The structure of this format is similar to R'G'B' (A) 4:4:4:4 as shown in Table 5. Link A [Y'] data space is filled with the Y' channel and the [C'b/C'r] data space is filled with the even-numbered C'b and C'r channels respectively. In Link B the [Y'] channel data space can be optionally filled with Alpha channel data and the [C'b/C'r] data space is filled with the odd-numbered C'b and C'r channel samples. However since this format conforms to the Y'C'bC'r format of the HD-SDI data stream, Link A is representative of the signal and can be viewed on a HD waveform monitor. The trace of the Link B signal is dependent on the value present in the Alpha channel, as shown in the picture tile in Figure 4. With the waveform monitor, it is possible to view the Alpha channel waveform traces by selecting the Alpha channel view in the picture menu of the instrument. In the WFM7120/7020, the signals can also be down-converted from the Dual Link signal into a single HD-SDI signal. This signal can be output from the waveform monitor for use in simple monitoring, without the additional need for a Dual Link picture monitor.



▶ **Figure 5.** *Data mode views for combined and separate links.*



▶ **Figure 6.** *Data Structure of R'G'B'(A) 4:4:4:4 format for both Link A and Link B.*

Frame/Field Rate	Total words per line	Total active words per line
60 or 60/1.001 fields 30 or 30/1.001 frames	2200	1920
50 fields 25 frames	2640	1920
24 or 24/1.001 frames	2750	1920

► **Table 6.** *Total number of words per line for various frame rates.*

Data Structure

Within the WFM7020 or WFM7120, with the DAT option installed, the user can view the data list under the measure menu and can see the structure of each link in data mode or the resulting combined data in the video mode as shown in Figure 5. This allows the user to see the combination of the data values between the two links and to verify the sample length and structure of the stream. Table 6 shows the total number of words that are present within the various frame rates and Figure 6 shows how the data is split across the two links for an R'G'B'(A) 4:4:4:4 formats. These same views can be applied to the other formats.

Link A	B'_0: 2-11	G'_0: 2-11	R'_0: 2-11	G'_1: 2-11	B'_2: 0-9	G'_2: 2-11	R'_2: 2-11
Link B	B'_1: 2-11	$R'G'B'_0$: 0-1	R'_1: 2-11	$R'G'B'_1$: 0-1	B'_3: 0-9	$R'G'B'_2$: 0-1	Rv_3: 2-11

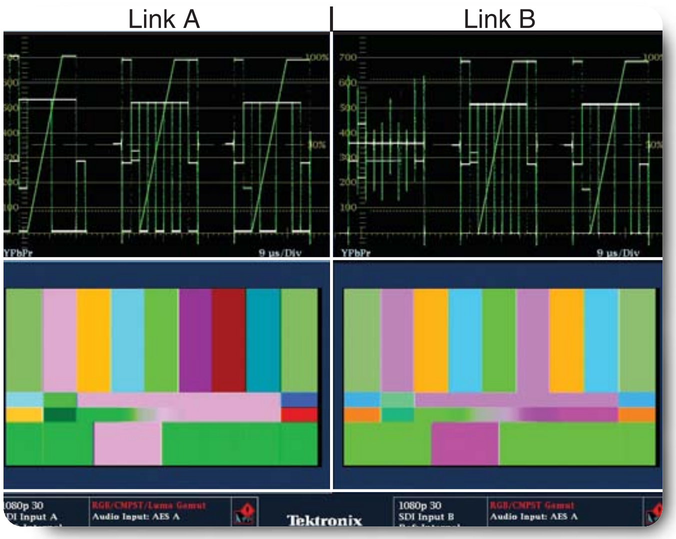
▶ **Table 7.** *Channel representation for RGB 12-bit.*

	Bit Number									
Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
	Not B8	EP	G'n:1	G'n:0	B'n:1	B'n:0	R'n:1	R'n:0	Reserved	Reserved

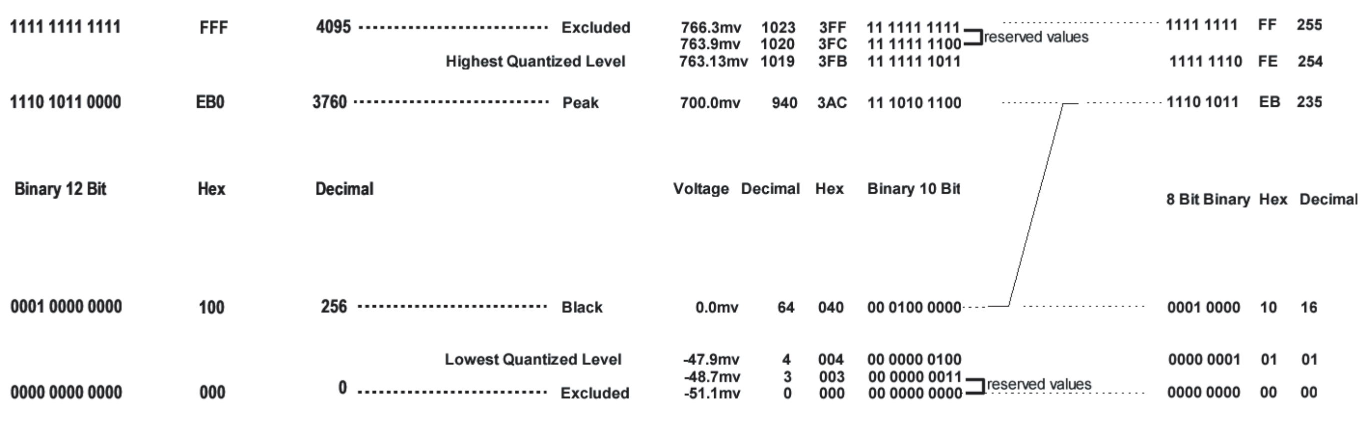
▶ **Table 8.** *Mapping structure for R'G'B' 0-1.*

R'G'B' 4:4:4 12-bit (30, 29.97, 25, 24, 23.98 Progressive pSF, 60 59.94 and 50 Interlaced)

To achieve a greater dynamic range for the signal, a 12-bit data format can be accommodated within the Dual Link standard. The problem here is that the data structure of each link conforms to 10-bit words. Therefore, a method has been defined to carry the 12-bit data across multiple 10-bit words. In the case of R'G'B' 4:4:4 12-bits, the most significant bits (MSBs) 2-11 are carried with the 10-bit words. The additional two bits for each of the R'G'B' channels are combined into the Y' channel of Link B as shown in Table 7. Link A carries the G' channel bits 2-11 and even sample values of B' and R' bits 2-11. In Link B the alpha channel is replaced by the combined bits 0-1 of the R'G'B' samples. The odd samples of the B' and R' bits 2-11 are carried within the [C'b/C'r] words. The combined R'G'B' 0-1 data is mapped into the 10-bit word as defined in Table 8, where EP represent even parity for bits 7-0, the reserved values are set to zero and bit 9 is not bit 8.

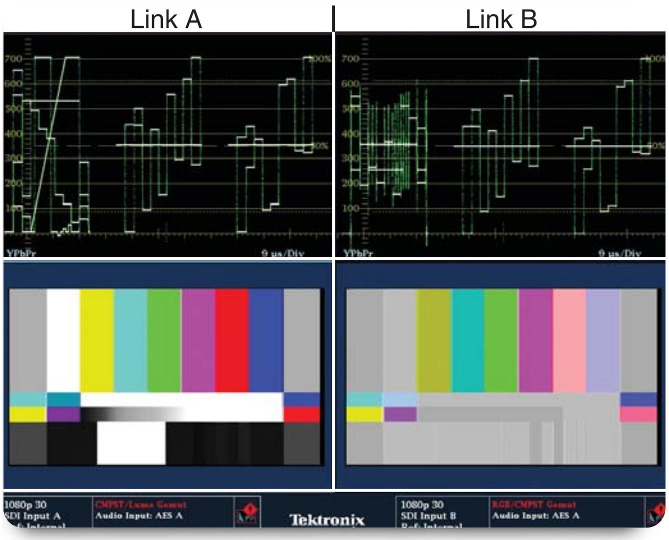


▶ **Figure 7.** *Waveform displays of Dual Link A and B signals for R'G'B' 4:4:4 12-bit format.*



▶ **Figure 8.** *10 and 12 bit luma quantization values.*

Many people will already be familiar with 10-bit values used within the SDI format, since this is in common use today. However many users will not be use to dealing with the video signal in 12 bit values. Therefore, the following diagram (Figure 8) provides some useful information regarding the level value differences between 10-bit and 12-bit values.



▶ **Figure 9** *Waveform displays of Dual Link A and B signals for Y'C'bC'r 4:4:4 12-bit format.*

Link A	C'b $_0$: 2-11	Y'$_0$: 2-11	C'r$_0$: 2-11	Y'$_1$: 2-11	C'b $_2$: 0-9	Y'$_2$: 2-11	R'$_2$: 2-11
Link B	C'b $_1$: 2-11	Y'C'bC'r $_0$: 0-1	C'r$_1$: 2-11	Y'C'bC'r $_1$: 0-1	C'b $_3$: 0-9	Y'C'bC'r $_2$: 0-1	R'$_3$: 2-11

▶ **Table 9.** *Channel representation for YCbCr 12-bit.*

	Bit Number									
Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
	Not B8	EP	Y'n:1	Y'n:0	C'b'n:1	C'b n:0	C'r n:1	C'r n:0	Reserved	Reserved

▶ **Table 10.** *Mapping structure for Y'C'bC'r 0-1.*

Y'C'bC'r 4:4:4 12-bit (30, 29.97, 25, 24, 23.98 Progressive pSF, 60 59.94 and 50 Interlaced)

The structure of the Y'C'bC'r 12-bit data is similar to the G'B'R' 12-bit structure where G' is equivalent to Y', B' is equivalent to C'b and R' is equivalent to C'r. Table 9 shows the channel mapping for the Y'C'bC'r samples and Table 10 shows the bit 0-1 mapping structure within the 10-bit data word. Figure 9 shows the waveforms of both links using the SIM option on the WFM7120.

Link A	C'b $_0$: 2-11	Y' $_0$: 2-11	C'r$_0$: 2-11	Y' $_1$: 2-11	C'b $_2$: 0-9	Y' $_2$: 2-11	R'$_2$: 2-11
Link B	A_0	Y'C'bC'r $_0$: 0-1	A_1	Y' $_1$: 0-1	A $_2$	Y'C'bC'r $_2$:0-1	A_3

▶ **Table 11.** *Channel representation for Y'C'bC'r(A) 4:2:2:4 12-bit.*

	Bit Number									
Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
	Not B8	EP	Y'n:1	Y'n:0	C'b n:1	C'b n:0	C'r n:1	C'r n:0	Reserved	Reserved

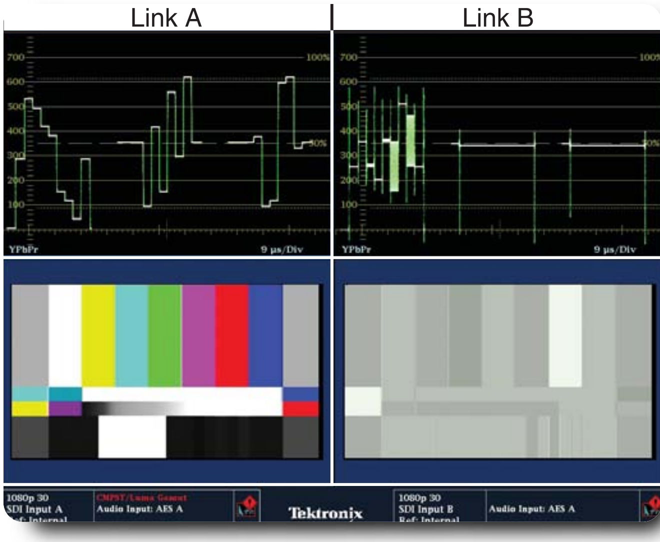
▶ **Table 12.** *Mapping structure for Y'C'bC'r 0-1.*

	Bit Number									
Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
	Not B8	EP	Y'n:1	Y'n:0	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

▶ **Table 13.** *Mapping structure for Y' 0-1.*

Y'C'bC'r(A) 4:2:2:4 12-bits (30, 29.97, 25, 24, 23.98 Progressive pSF, 60 59.94 and 50 Interlaced)

For those applications that need to transport the Alpha channel and YCbCr 12-bit data, the following data stream is defined for 12-bit within the constraints of the 10-bit SDI structure. The MSBs for Y'C'bC'r bits 2-11 are carried in Link A and conform to the C'bY'C'rY'* multiplex of the SDI signal. The 10-bit Alpha channel and the LSBs of the Y'nC'bnC'rn and Yn+1 are carried in Link B and mapped according to the Table 11. The 0-1 bits of the Y'C'bC'r samples are carried in the 10-bit word as defined in Table 12 and the additional Y'* samples are mapped as shown in Table 13.



▶ **Figure 10.** *Waveform displays of Dual Link A and B signals for Y'C'bC'r(A) 4:2:2:4 12-bit format.*

▶ **Figure 11.** *Video Session displays of WFM7120 showing that the error messages for Links A and B.*

With the wide array of formats used within the Dual Link standard, it can be difficult to identify the format being transmitted by the two links. If the users become familiar with the structure of the two links, they maybe able to recognize the waveform displays of a color bar signal. The above figures (2, 3, 4, 7, 9 & 10) can be used as examples to identify the type of format being transported between the two links. However, the color bar signal is more easily identifiable than "live" material. Within the Video Session display of the WFM and WVR series instruments, automatic detection algorithms can help identify the payload of the signal and provide the user with a visual interpretation of the applied format - provided that the video payload identification is present within the signal. Within video facilities, it can sometimes be difficult to ensure that the correct Dual Link A and B signal are transported by the routing switcher to the correct destination. Operator error may lead to the links being swapped or a link (A or B) may not be transmitted correctly. The video session display can alert the user to these types of problems. (See Figure 11 Video Sessions displays of WFM7120 showing that the error messages for Links A and B.) The assumption within the instrument is that Link A is the dominant signal and must be present in order for the Dual Link signal to be correctly combined. If Link B has the incorrect format or the wrong video payload identification, the video session display will indicate a Link Error. When Link B is missing the error message "partial Dual Link" is displayed.

The standard tells us that the SMPTE 352M video payload identification should be present within the transport. However, some video equipment may not carry this ancillary data. In this case the user has to force the format to the appropriate sampling structure. This can be done

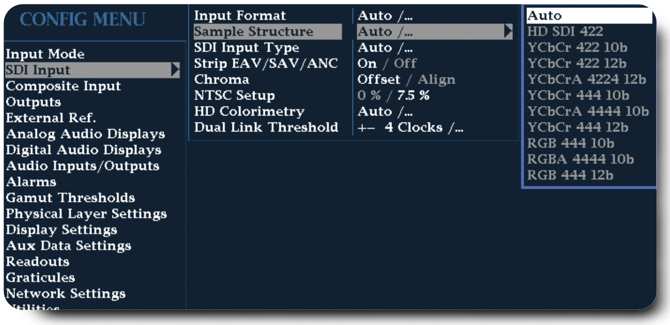


Figure 12. *Sampling structure menu.*

Bits	Byte 1	Byte 2	Byte3	Byte 4
Bit 7	1	Interlaced (0) or progressive (1) transport	Reserved	Reserved
Bit 6	0	Interlaced (0) or progressive (1) picture	Reserved	Channel Assignment Link A (0) Link B (1)
Bit 5	0	Reserved	Reserved	Reserved
Bit 4	0	Reserved	Reserved	Dynamic Range 100% (0_h), 200% (1_h) 400% (2_h), Reserved (3_h) .
Bit 3	0	Picture Rate	Sampling Structure	
Bit 2	1			Reserved
Bit 1	1			Bit Depth
Bit 0	1			8-bit (0_h), 10-bit (1_h) 12-bit (2_h), Reserved (3_h)

Table 14. *Video Payload Identification.*

within the configuration menu of the instrument - as shown in Figure 12. If the user knows the format, they can directly select it from the menu. Or, the correct format can be verified by selecting each of the sampling structures and viewing the picture or waveform displays until a suitable trace display or picture is shown.

Video Payload Identification SMPTE 352M

To simplify the automatic format detection of Dual Link formats, the WVR and WFM will display the data values of the SMPTE 352M data packet and will display the interpretation of this payload identification as shown in Figure 11. The SMPTE 352M ancillary data packet has four bytes of information which are used to interpret the picture rate, sampling structure, dynamic range, bit depth and channel assignment. The ancillary data packet conforms to SMPTE 291M and is identify by a data identification (DID) of 41_h and a secondary data identification (SDID) of 01_h. By using the data option of the waveform monitor, the user can view the ANC data packet and find the location of both the line and field where the ancillary data is present. For a 1080 format, the packet is located on line 10 of field one and line 572 of field 2. The Ancillary Data Display will selectively scroll through all appropriate available data packets.

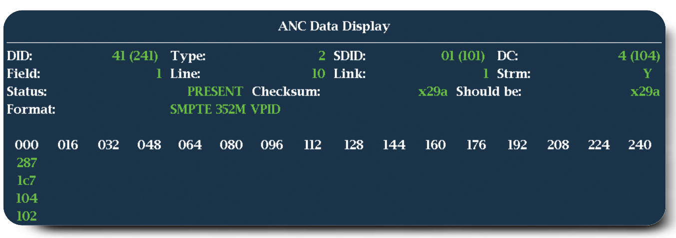
For a 1920x1080 video format Byte 1 is set to 87_h and the structure of Byte 2-4 is shown in Table 14.

Value	Picture Rate
0_h	No defined value
1_h	Reserved
2_h	24/1.001
3_h	24
4_h	Reserved
5_h	25
6_h	30/1.001
7_h	30
8_h	Reserved
9_h	50
A_h	60/1.001
B_h	60
C_h	Reserved
D_h	Reserved
E_h	Reserved
F_h	Reserved

▶ **Table 15.** *Picture Rate.*

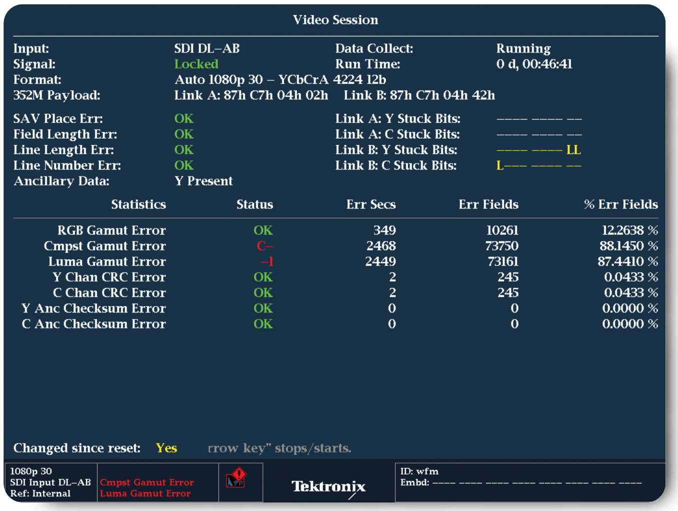
Value	Sampling Rate
0_h	4:2:2 [default] (YCbCr)
1_h	4:4:4 (YCbCr)
2_h	4:4:4 (GBR)
3_h	4:2:0
4_h	4:2:2:4 (YCbCrA)
5_h	4:4:4:4 YCbCrA
6_h	4:4:4:4 (GBRA)
7_h	Reserved
8_h	4:2:2:4 (YCbCrD)
9_h	4:4:4:4 (YCbCrD)
A_h	4:4:4:4 (GBRD)
B_h	Reserved
C_h	Reserved
D_h	Reserved
E_h	4:4:4:4 (GBRA) 2048x1080
F_h	Reserved

▶ **Table 16.** *Sampling structure.*

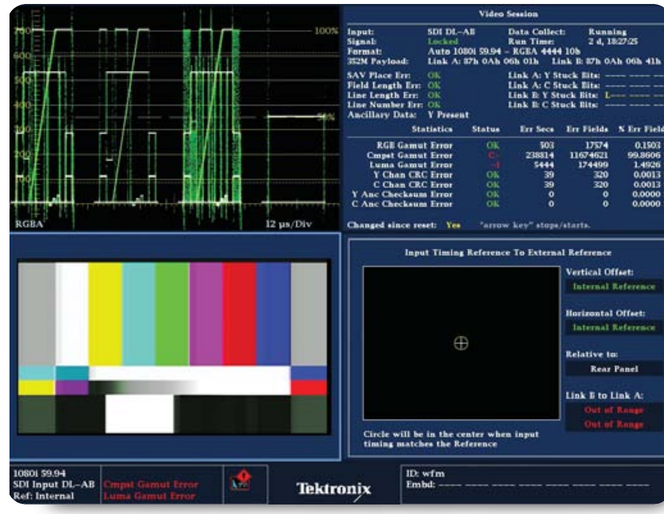


▶ **Figure 13.** *Ancillary Data Display of SMPTE 352M payload.*

The picture rate value is defined by Table 15 and the sampling structure by Table 16. With the information from these tables, we can then interpret the SMPTE 352M payload. For example, using the information in Figure 13 from the ancillary data display, we can interpret the format of the signal. The four bytes of the packet are 287_h, $1C7_h$, 104_h, 102_h. The first byte of the packet 287_h indicates that this is a 1080 format. The second byte, $1C7_h$. from Table 14 is separated into two parts. First, the C_h value (1100 in binary) defines a progressive transport (1) and progressive picture (1). Second, the picture rate is 7_h, indicating a rate of 30 from Table 15. The third byte is 104_h. From Table 14, the upper bit values are reserved. The lower bit value of 4_h corresponds to a 4:4:4:4 Y'C'bC'rA format as shown in Table 16. Finally the fourth byte is 102_h. From Table 14, the upper value 0 represents Link A and the value of 2_h represent a 100% dynamic range with a bit depth of 12-bit. Therefore we can interpret the video payload shown in Figure 14 (Video Session Display as 1080p30 - Y'C'bC'rA 12b).



▶ **Figure 14.** *Video Session Display showing SMPTE352M payload.*



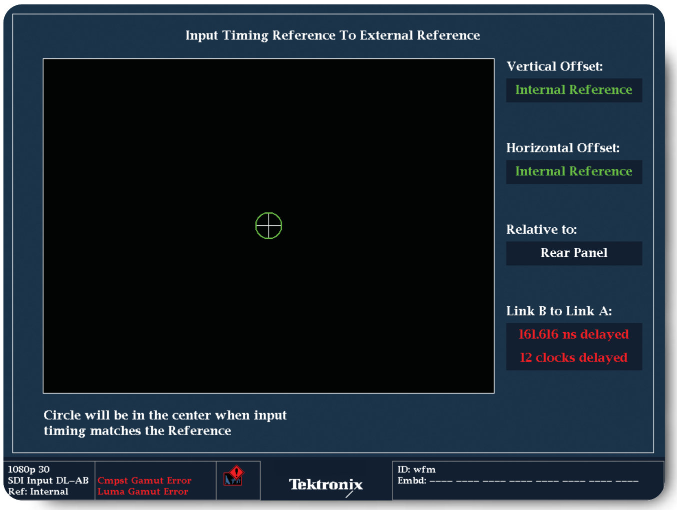
▶ **Figure 15.** *Inter-channel Timing between Links A and B.*

A variety of ancillary data can be sent on the two links. For example, embedded audio can be added to the horizontal ancillary data of both links and up to 32 channels can be supported. Link A has priority over Link B which means that the first sixteen channels should be placed within Link A, and that the audio should not be split between the links. In the case of 24 channels the first 16 channels should be embedded into Link A and the other remaining eight channels embedded into Link B.

The Tektronix TG700 multi-format signal generator has the capability to generate a range of Dual Link test signals formats using the HDLG7 module. The module can up-convert a high definition signal such as an HD test signal from the HDVG7 module to an appropriate Dual Link format. The embedded audio from the HD input can also be output to the Dual Link format in this mode to provide up to 32 channels of embedded audio.

Dual Link Inter-Channel Timing

Within a video facility the two links can be routed along different paths. This can potentially introduce timing errors between the two links. The SMPTE 372M standard defines an allowable timing difference of 40 ns between the two links at the source of the output from the device, but does not define an allowable maximum difference for the timing between the two links. Therefore it is important to check the specifications of equipment to see the allowable range of timing difference at the inputs to the device and to ensure that the electrical lengths of the paths carrying the two Dual Link signals are identical. For instance, the TG700 HDLG7 module allows the user to adjust the timing difference between the two links up to +/- 200ns. In some cases the internal buffer within the piece of equipment maybe able to account for any inter-channel timing difference applied to its input. However, care should be taken not to exceed the specification of the device, or the Dual Link signal may not be combined correctly. For instance the WFM7120 has a buffer of 30 clocks. If this timing difference is exceed, a shift will occur between the channels and the data will not be combined correctly as shown in Figure 15. In this example a significant amount of cable was added to link B to cause this error. Notice the Y-C shift in the picture display and the noise within the channels on the waveform display.

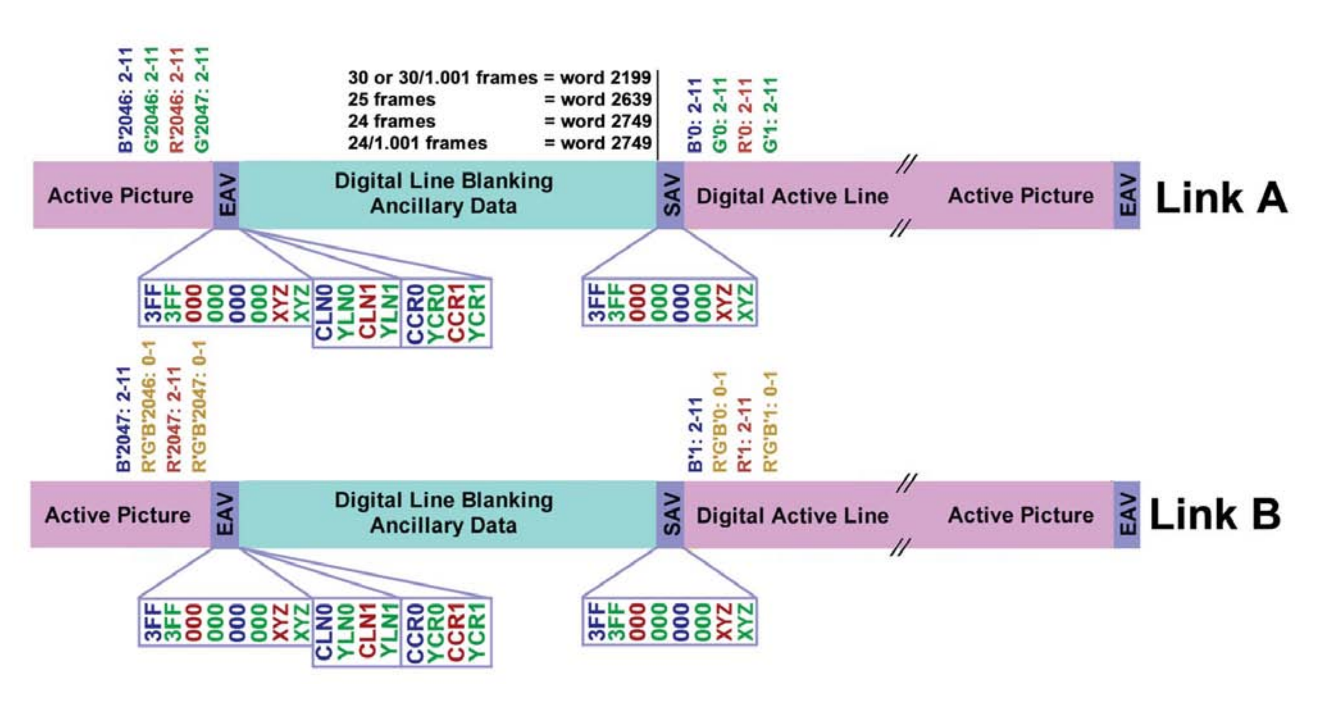


▶ **Figure 16.** *Inter-channel Timing measurement of a Dual Link signal.*

Frame/Field Rate	Total Words per line	Total Active words per line	H Blanking
60 or 60/1.001 fields 30 or 30/1.001 frames	2200	2048	152
50 fields 25 frames	2640	2048	592
24 or 24/1.001 frames	2750	2048	702

▶ **Table 17.** *Total number of words per line and blanking interval for 2048x1080 formats at various frame rates.*

Within the WFM and WVR series, the timing display shows the inter-channel timing difference between Link B with respect to Link A when a Dual Link signal is applied to the input as shown in Figure 16. In this case a total of 161ns (12 clocks) was measured as the inter-channel timing difference between Link B and Link A. Note that the inter-channel timing measurement measures the timing between the two links themselves and does not directly affect the timing measurement between the reference and input signal. Within the instrument it is also possible to set-up an alarm threshold for when the timing between the two channels exceeds a number of clock samples.



▶ **Figure 17.** *2048x1080 R'G'B' 12-bit Dual Link data structure format.*

Additional formats

Additions formats have be added to the original SMPTE 372M standards to further extend the capabilities of the Dual Link transport interface. For instance, 2048x1080 formats can be fitted within the structure of the two links for various frame rates (24/1.001, 24, 25, 30/1.001, 30). In this case, the blanking is shortened in order to fit 2048 samples per line, but the total number of words in the frame remains the same between 2048x1080 and 1920x1080. In Figure 17, the data structure is shown for a 2048x1080 signal with a 12-bit R'G'B' format. In this case, the digital line blanking is smaller to take account of the larger number of active line samples. Therefore, in some cases, the way in which the embedded audio is fitted within the horizontal ancillary data space may be more limited than in a 1920x1080 format.

▶ **Figure 18.** *EAV Data mode view of 2048x1080 R'G'B' 12-bit Dual Link format.*

Figure 18 shows the End of Active Video (EAV) samples for the 2048x1080 R'G'B 12-bit format. Both the data mode and video mode are shown to illustrate each link's structure plus the combined data of the Dual Link format. These figures illustrate the ability to look at the combined data stream into a 12-bit signal or to view the two links separately as 10 bit data streams.

Conclusion

The Dual Link format allows video facilities to use their existing HD-SDI infrastructure to carry these extended higher resolution formats. In order to carry these Dual Link formats, it is important to ensure that inter-channel timing errors are not introduced within the transmission path which could cause problems for equipment to combine the two signals. Additional care has to be take to ensure that correct signals are applied to the device for Link A and Link B. The WFM7x20 and WVR7x20 series are useful tools to identify errors within the transmission of Dual Link signals, and for monitoring the separate or combined data streams.

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