Closed Caption Monitoring

WFM6120/7020/7120 & WVR6020/7020/7120 Version 5.0.2 Software

What Is Closed Captioning?

There are a variety of methods to add captioning to the program material depending upon the video format. CEA 608 standardizes the process of adding caption data to standard definition (SD) signal. This can be added as an analog signal to line 21 of the active NTSC signal as shown in Figure 1. The signal contains a clock and two data bytes which are transmitted on each field of the video signal (120 Bytes per second or 960 bits per second (bps)). Alternatively in SD-SDI (Serial Digital Interface) this analog signal ma y be digitized as part of the active video or alternatively carried as an ancillary data packet within the video signal. For high definition (HD) a new standard was created for the addition of captions to the video signal which is standardized in CEA708. This captioning standard provides a wider range of captioning service, while still maintaining backwards compatibility with CEA 608, and is carried an ancillary data packet within the HD-SDI signal. The DTVCC (Digital Television Closed Captioning) provides a maximum data rate of 9600bps. This increased capacity allows for the possibility of simultaneously providing captions in multiple languages and multiple reading levels.
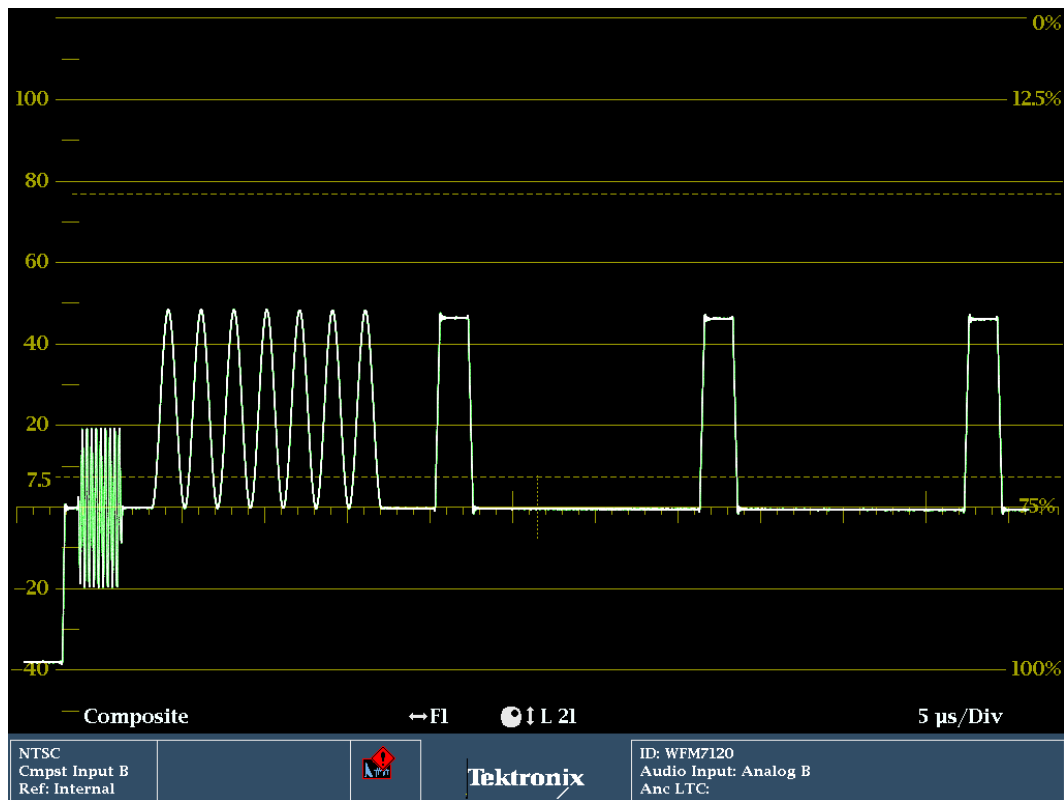

Figure 1. NTSC Line 21 Closed Caption Signal.

The latest version of the WFM and WVR series firmware version 5.0.2 now supports the simultaneous decode of CEA 708 and 608 closed captioning, allowing the operator to monitor both data streams for compatibility.

How to Configure Simultaneous Closed Caption Decoding

1. Select one of the tiles (1,2,3 or 4) and press the **PICTURE** button.
2. Push and Hold the **PICTURE** button to enable the menu.
3. Using the up and down arrows navigate to **CC/Teletext Format** and press right arrow to select sub menu.
4. Select **CEA708** to allow decoding of the DTVCC closed caption data within the picture display.
5. Select a different tile and press the PICTURE buttons to display another picture display.
6. Push and Hold the **PICTURE** button to enable the menu.
7. Using the up and down arrows navigate to **CC/Teletext Format** and press right arrow to select sub menu. Select **CEA608** to allow decoding of the closed caption data within the picture display.
8. Press the **PICTURE** button to dismiss the menu

Note: Auto mode will automatically select the closed caption present in the signal.

Figure 2. Picture Display showing menu for Closed Caption decoding.

Now the instrument will simultaneously decode CEA 708 DTVCC caption in one tile and the other tile will be decoding caption from CEA 608. There are a variety of different formats for CEA 608 and these can be configured automatically or user selected from the CONFIG menu.

1. Press the **CONFIG** menu button.
2. Use the up and down arrows to navigate to the **Aux Data Settings** menu.
3. Press **SEL** button to enter the sub menu and use the up and down arrow keys to navigate to the **CEA 608 Settings**.
4. Press **SEL** button again to enter sub menu and navigate to the **CEA 608 Transport** selection.

5. You can select **Auto, Line 21, S334(RAW) or S334(CDP)** that perform the following functions.
    - **Auto:** The instrument automatically searches for CEA 608 streams and sets the transport based on the first stream detected.
    - For Composite: Searches only for CEA 608 (VBI).
    - For SD: Searches for CEA 608 (VBI), then 608-ANC.
    - For HD: Searches for 608-ANC, then CEA 608.
    - **Line 21:** Extracts the closed caption data from the analog NTSC signal on line 21.
    - **S334 (RAW):** Extracts the closed caption data from the Ancillary data packet SMPTE 334M (Data Identifier DID0x61 Secondary Data Identifier SDID 0x02).
    - **S334 (CDP)** : Extract the 608 closed captions that are embedded in the CEA 708 Ancillary data stream of SMPTE 334M (DID 0x61 SDID 0x01).
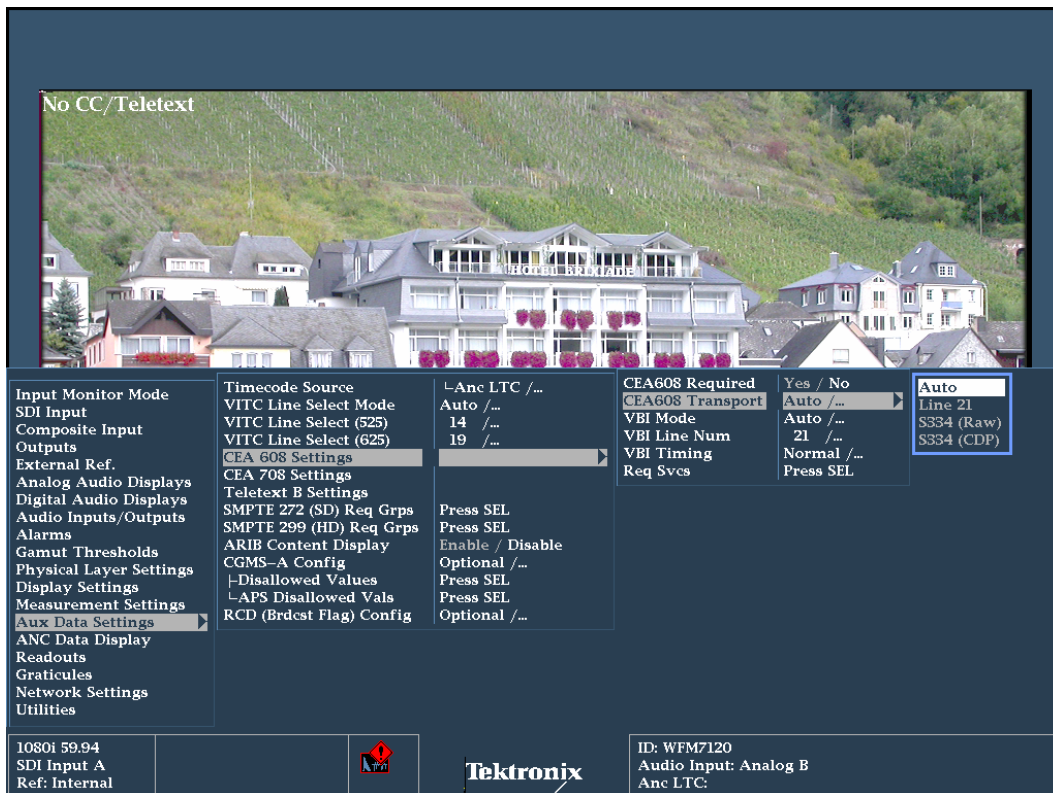

Figure 3. Aux Data Settings configuration menu

By pressing the Help button the user can find detailed information about the various functions within the instrument. For instance you may wish to find out more information about the **CEA608 Required** function, simply navigate to that function and press the **HELP** button. The following information will be displayed.

You can set the instrument to generate an alarm if CEA608 is missing. To access this setting, perform the following steps:

1. Press the **CONFIG** button.
2. Use the General knob to highlight **Aux Data Settings**.
3. Press the right arrow button to navigate to the submenu.
4. Use the General knob to highlight **CEA 608 Settings**.

5. Press the right arrow button to navigate to the submenu.
6. Press the **SEL** button to select **Yes** or **No**.

The CEA 608 can carry four closed caption streams denoted as CC1, CC2, CC3, CC4 and four Text services TXT1, TXT2, TXT3, TXT4. Information regarding the presence of the services can be found in the Aux Data Status display. The user can also select which of the **CEA 608 CC Services** they wish to decode from the Picture display menu. The user can define the required services within the configuration menu. An alarm can be generated when these required services are not present within the SDI signal. In the case of CEA 708 the user can select any one of the 6 services which maybe present within the data stream from the Picture display menu **CEA 708 CC Services.** Within the configuration menu the user can defined the required services for CEA 708 that should be present within the signal. Note multiple picture displays can be used to decode different closed caption services as well as decoding of CEA608 and CEA708 simultaneously for verification that different languages are present within the signal and are being decoded correctly.

Understanding the Auxiliary Data Status Display
The Aux Data Status display provides a summary of the closed caption services present within the signal.
1. Select one of the tiles (1,2,3 or 4) and press the **STATUS** button.
2. Push and Hold the **STATUS** button to enable the menu.
3. Using the up and down arrows and navigate to **Display Type** and press **SEL** button to select the sub menu.
4. Navigate to the **Aux Data Status** display.
5. Press the **STATUS** button to dismiss the menu.

The Auxiliary Data Status display provides the following information on the closed caption data service.

Presence of CEA 608 and CEA 708 and the type of the data stream.

*   Possible values are CEA-608 (VBI Vertical Blanking Interval), CEA-608 (ANC as Ancillary Data), CEA-608 (708), CEA-708

Presence of the various services within the closed caption data stream. If a service has no activity for 30 seconds, it is considered missing.

*   CEA608 CC1234 TXT1234 XDS (Extended Data Service)
*   CEA708 CC123456
*   RP207 indicates the presences of Program Description Data (DID0x61 SDID 0x02)
*   CDP indicates presences of Caption Distribution Packets
*   Frame Rate indicates the frame rate of the closed caption data stream
*   Data Count 608 typically has four data words present

- Data Count 708 can vary depending on the frame rate and can have up to 46 data words as defined by SMPTE 334M
- V-Chip Rating detects ratings from these four systems: MPAA (US), TV (US), Canadian, English and Canadian French

Figure 4. FlexVu™ showing simultaneous picture decodes of 608 and 708 closed captions

Figure 4 shows the FlexVu™ display of a 4-tile configuration. Tile 1 shows the ANC Data Inspector which can be used to identify the presence of various ANC data packets within the SDI signal. Tile 2 shows the Auxiliary Data Status display providing a summary of the presence of the closed caption data. Tile 3 is a picture display configured to decode the CEA 708 closed caption data within the picture. Tile 4 is a picture display configured to decode the CEA 608 data present within the CEA 708 data stream per SMPTE 334M, typically referred to as 608 in 708.

Troubleshooting Closed Caption Problems

The tools available within the waveform monitor and rasterizer products from Tektronix can aid in troubleshooting closed caption problems within the video signal.

Decoding of Closed Captions Within Picture Display

By displaying the closed captioning within the picture display the user can verify that the closed caption service is being decoded correctly. If a problem exists within the decoding of the closed caption then the engineer should initially look at the Aux Data Status to verify the presence of the type of closed caption data within the video signal.

Aux Data Status Display

The Aux Data Status indicates the types of closed caption present CEA708, CEA608 in CEA708, CEA 608 and CEA 608 (VBI). Ensure that the correct type is selected within the picture display. Secondly a variety of service can be carried within the closed caption data stream, within the Aux Data Status the engineer can verify the presence of the different services indicate by the number if present. Ensure that this service is selected within the picture display to allow the closed caption data stream to be decoded. The alarm status or error log may report syntax errors which have been detected by the instrument and can be viewed on the instrument or logged for analysis of when the errors occurred. Additional the engineer can confirm the instrument to alarm when required services on not present within the video signal.

Note: The V-Chip Rating can be used by consumer television sets to allow only certain rated programs to be viewed certain members of the household. It is therefore important that this information is carried correctly within the program material.

If the configurations of the closed caption decoder are verified to be setup correctly, however the services are not being decoded correctly. It will be necessary to delve into the problem a little further.

Caption Distribution Packet Syntax

The Aux Data Status provides simple verification of the presence of the Caption Distribution Packet (CDP) that consists of the CEA-708B DTVCC data, the CEA 608 caption data, caption service information and timecode if present. These CDP packets should be present in the broadcast closed caption delivery chain in order to deliver the closed caption information to the transport stream for broadcast to the end customer. In the ATSC (Advanced Television Systems Committee) / MPEG encoding process the frame rate of the video signal should match the frame rate of the closed caption data stream otherwise this can potential cause problems in the encoding process and may prevent captions from being transmitted. The Aux Data Status display provides information on the Frame Rate of the caption data and the engineer should compare this information with the current video format to ensure they are identical. In some cases the original material may have been caption at a video frame rate of 23.98p. However, if the program is being broadcast at 59.94 the MPEG encoder may not be able to embed the closed caption data correctly within the transport stream.

The Aux Data Status provides information on the number of data words present for the closed caption packet. In CEA 608 there are typically four words present (two bytes on each field of a NTSC signal). In the case of CEA 708 the number of data words present will depend on the frame rate of the signal. The following table 1 indicates the maximum possible data words as defined by SMPTE 334M.

Table 1. CDP Frame Rate

Frame Rate (Hz)	CC_Count	CEA-608 Data Bytes	CEA-708 Data Bytes
23.98	25	4/6	46/44
24	25	4/6	46/44
25	24	4	44
29.97	20	4	36
30	20	4	36
50	12	2	22
59.94	10	2	18
60	10	2	18

Within the WFM7120 DAT option Ancillary Data Inspector can be used to investigate the data structure of the Closed Caption packet that is defined in SMPTE334M.

How to use ANC Data Inspector to explore the Closed Caption Data

1. Select one of the tiles (1,2,3 or 4) and press the **MEASURE** button.
2. Push and Hold the **MEASURE** button to enable the menu.
3. Using the up and down arrows navigate to **Display Type** and press **SEL** button to select the sub menu.
4. Navigate to the **ANC Data Display** menu item.
5. Press the **MEASURE** button to dismiss the menu.
6. Press the **FULL** button to display the ANC Data Inspector in full screen mode, if not already selected.
7. Using the up and down arrows navigate to the S334 ancillary data types.
8. Press the **MAG** button to expand the ancillary data window.

The closed caption data conforms to SMPTE 291 and depending on the type of data has a specific set of DIDs and SDID which are defined in SMPTE RP291 and SMPTE334

- CEA 608 DID 161h (0x61h) SDID 102h (0x02h) Data mapping into HDTV VBI, VANC space Line 9 of Field 1 or 2.
- CEA 708 DID 161h (0x61h) SDID 101h (0x01h) Data mapping into HDTV VBI, VANC space Line 9 of Field 1 or 2.

The Ancillary data payload of a CEA 608 packet is relatively simple and contains the two used data words for the bytes of data present represented on Line 21 of the VBI. The data structure is defined as follows Ancillary Data Flag 000h, 3FFh, 3FFh, DID-161h, SDID-102, Data Count (DC)-203, User Data Word (UDW1), (UDW2), CS Checksum. The preferred method of carrying the CEA 608 in a DTV system is to encapsulate the CEA 608 data within the data structure of the CEA 708 packet. The structure of the CEA708 ancillary data packet is a little more complex than CEA 608.

Figure 5 shows the Ancillary Data Inspector display of a SMPTE 334 CDP 708 data stream. The data stream structure may consist of the follow data types.

- Timecode
- CEA-708 caption data
- CEA-608 data
- Caption service information
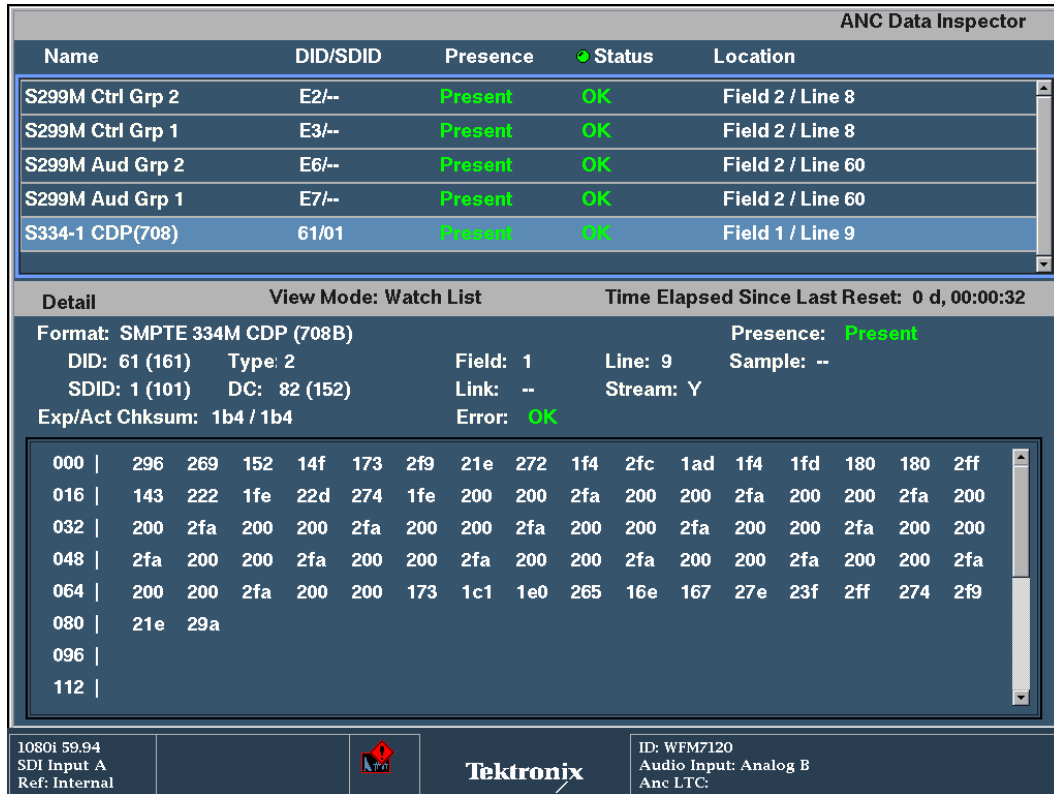- Sequence counts to detect discontinuities in the caption data packets

Figure 5. ANC Data Inspector display showing CEA 708 closed captions.

To understand further the data structure of the closed caption data it is necessary to describe the contents of the packets. This information can vary depending on the types of data present within the data stream.

CDP Caption Distribution Packet contains

- CDP_Header - Required
- Timecode - Optional
- CC Data Section(s) – Optional
- CCSVCInfo Section(s) - Optional
- CDP_Footer – Required

To aid in understanding the syntax of the SMPTE 334 syntax, review the example of the data stream shown in Figure 4 of the Ancillary Data Inspector. Note the packet structure can vary depending on the closed caption optional data information present within the signal. Appendix 1 provides the syntax information for the various data types present within the data stream.

Data Identifier   DID 0x61h (161h)   SMPTE 334M (CDP 708B)
Secondary Data Identifier SDID 0x01h (101h)
Data Count   DC 82 (152h)
Data Present on Field 1 Line 9
Checksum Expected/Actual 1B4h/1B4h   OK No data error

Data Value	Interpretation	Evaluation
296 269	CDP Identifier	296, 269 (0x9669) CDP Identifier always begins with this value
152	CDP Length (8 bits)	0x52 = 82
14F	Frame Rate (4 bits) Reserved (4 bits)	0x4F Frame Rate = 4 = 29.97 Reserved = F = (1111)
173	If value = '1' then present Timecode Present (1 bit) CC Data Present (1 bit) Service Information Present(1 bit) Service Information Start (1 bit) Service Information Change (1 bit) Service Information Complete (1 bit) Caption Service Active (1 bit) Reserved (1 bit)	0x73 = (0111 0011) Not Present Present Present Present Not Present Not Present Present '1'
2F9 21E	CDP Header Sequence Counter	2F9, 21E = (0XF91E) Current Value = 63774
272	CC Data Section Id	272 (0x72h)
1F4	Marker bits (3 bits) CC Count (5 bits)	1F4 (0xF4h) =(1111 0100) '111' 10100 = 20
2FC	Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FC (0xFCh) =(1111 1100) '11111' 1 = CC Valid 00 =NTSC line 21 Field 1 CC
1AD	CC Data 1	(0xAD)
1F4	CC Data 2	(0xF4)
1FD	Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FD (0xFDh) =(1111 1101) '11111' 1 = CC Valid 01 =NTSC line 21 Field 2 CC
180	CC Data 1	Value of 180 indicates no active data present
180	CC Data 2	Value of 180 indicates no active data present
2FF	Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FA (0xFFh) =(1111 1111) '11111' 1 = CC Valid 11 = DTVCC Channel Packet Start
143	CC Data 1	(0x43)
222	CC Data 2	(0x22)
1FE	Marker bits (5 bits)	2FA (0xFAh) =(1111 1010) '11111'

		CC Valid (1 bit) CC Type (2 bits)	0 = CC Invalid 10 =DTVCC Channel Packet Data
22D		CC Data 1	(0x2D)
274		CC Data 2	(0x74)
1FE		Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FA (0xFAh) =(1111 1010) '11111' 0 = CC Invalid 10 =DTVCC Channel Packet Data
200		CC Data 1	(0x00)
200		CC Data 2	(0x00)
2FA		Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FA (0xFAh) =(1111 1010) '11111' 0 = CC Invalid 10 =DTVCC Channel Packet Data
200		CC Data 1	Null Data
200		CC Data 2	Null Data
………			Total of 20 data packets = CC Count
2FA		Marker bits (5 bits) CC Valid (1 bit) CC Type (2 bits)	2FA (0xFAh) =(1111 1010) '11111' 0 = CC Invalid 10 =DTVCC Channel Packet Data
200		CC Data 1	Null Data
200		CC Data 2	Null Data
173		CC Service Info Section	273 (0x73h)
1C1		Reserved (1 bit) Service Info Start (1 bit) Service Info Change (1 bit) Service Info Complete (1 bit) Service Count (1 bit)	1C1 (0xC1h) =(1100 0001) 1 Present Not Present Not Present Count = 1
1E0		Reserved (1 bit) CSN Size (1 bit) Reserved (1 bit) Caption Service Number (5 bits)	1E0 (0xE0h) =(1110 0000) 1 1 1 00000 = 0
265		Service Data Byte 1 (8 bits)	265 (0x65h)
16E		Service Data Byte 2 (8 bits)	16E (0x6Eh)
167		Service Data Byte 3 (8 bits)	167 (0x67h)
27E		Service Data Byte 4 (8 bits)	27E (0x7Eh)
23F		Service Data Byte 5 (8 bits)	23F (0x3Fh)
2FF		Service Data Byte 6 (8 bits)	2FF (0xFFh)
274		CDP Footer Id	274 (0x74)
2F9		CDP Header Sequence Counter	2F9, 21E = (0XF91E)
21E			Current Value = 63774
2ED		Checksum	

The ANC Data Inspector allows the user to quickly verify that the closed caption data is on the correct line of the SDI signal (typically Line 9 of Field 1 for 1080i 59.94 format). The Data Count (DC) provides information on the total number of data words present in the ANC data packet. The following table shows the length of the CDP for various HD formats, assuming the CDP does not contain time code information, according to SMPTE334-2.

Video Format	Contains Service Information	CDP Length
720p	Yes	52
720p	No	43
1080i	Yes	82
1080i	No	73

Normally the ANC data packet will contain the information for only one service and the information for the entire set of services will be distributed over a sequence of CDPs. However in some cases the CDP many contain all services and the length of the CDP will depend on the number of services present.

Video Format	Number of Services	CDP Length
720p	1	52
720p	2	59
720p	3	66
720p	4	73
1080i	1	82
1080i	2	89
1080i	3	96
1080i	4	103

Confirming there are no checksum errors present in the ancillary data packet as shown within the ANC Data Inspector.

From this example in Figure 6, you can see how to further interpret the various data types that may be present within the closed caption data stream of SMPTE 334. Using Appendix 1 as a guide, the user can ensure compliance to standards through the various syntax values for the closed caption data stream.

To aid in the analysis of data, use the CaptureVu™ feature to store a complete frame of the SDI data. You can review the captured data within the instrument, or save to USB and download to a PC for conversion to a spreadsheet using the CaptureVu utility available from the Tektronix website (www.tektronix.com).
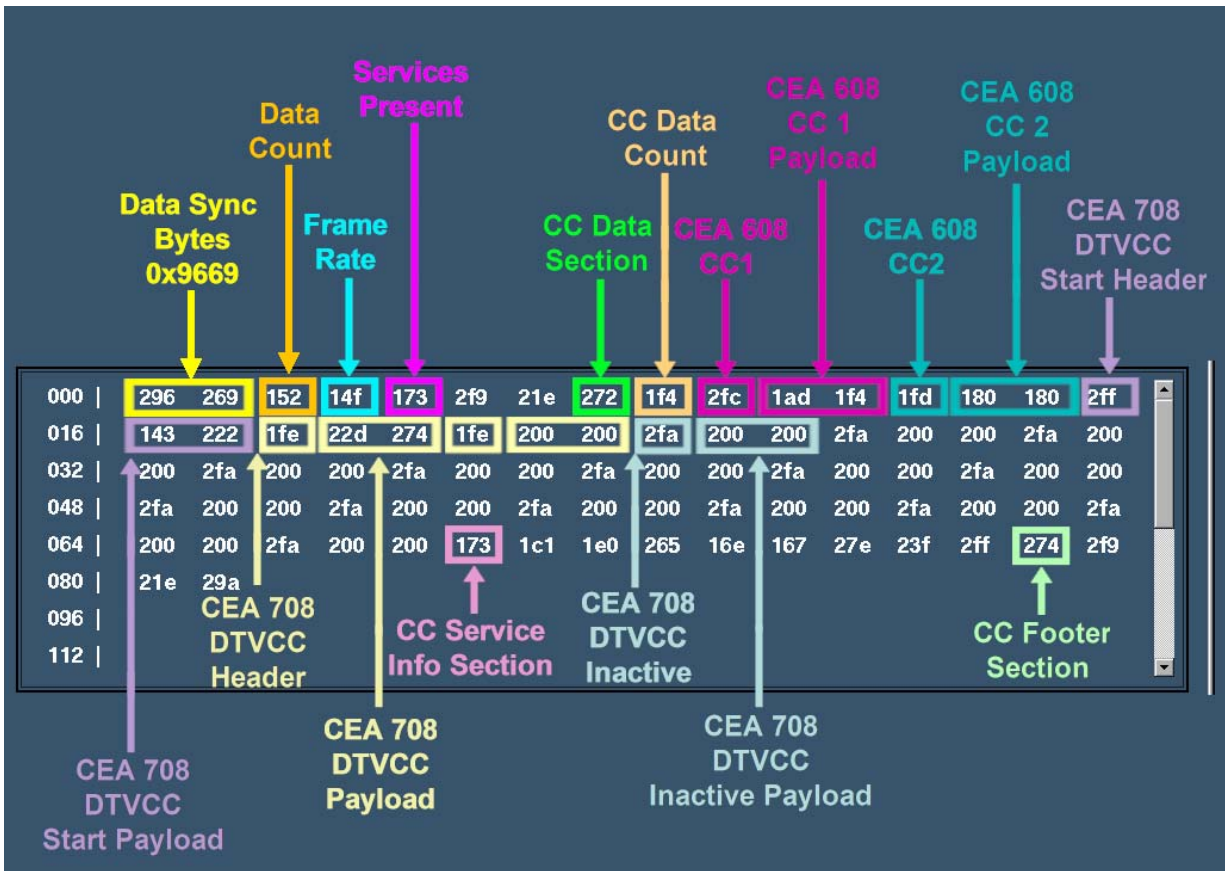
Figure 6. Example of the various data types within SMPTE 334.

Appendix 1 SMPTE 334M syntax.
CDP Header Syntax (Required)

CDP Header	Bits	Format
CDP Identifier	16	0x9669 CDP always begins with this value
CDP Length	8	No. bytes in entire CDP
CDP Frame Rate	4	Frame Rate
Reserved	4	Reserved all 1s
Timecode Present	1	Timecode present = 1
CC Data Present	1	CC Data Present = 1
Service Information Present	1	Service Info Present = 1
Service Information Start	1	Service Info Start = 1
Service Information Change	1	Service Info Change = 1
Service Information Complete	1	Service Info Complete = 1
Caption Service Active	1	Caption Service Active
Reserved	1	Reserved = 1
CDP Header Sequence Counter	16	Incremental counter that adds one to the previous CDP header sequence counter. Value ranges = 0 -65535 (0x0000-0xFFFF)

CDP Frame Rate Syntax

CDP Frame Rate	Frame Rate	CC Count	CEA608 Data Bytes	CEA708 Data Bytes
(0000) 0x0h	Forbidden			
(0001) 0x1h	23.98	25	4/6	46/44
(0010) 0x2h	24	25	4/6	46/44
(0011) 0x3h	25	24	4	44
(0100) 0x4h	29.97	20	4	36
(0101) 0x5h	30	20	4	36
(0110) 0x6h	50	12	2	22
(0111) 0x7h	59.94	10	2	18
(1000) 0x8h	60	10	2	18
--------	Reserved			
(1111) 0xFh	Reserved			

CDP Timecode Syntax (if present)

CDP Header	Bits	Format
Time Code Section Id	8	0x71 Indicates Time code Packet
Reserved	2	'1'
TC 10Hrs	2	Tens of hours
TC 1Hrs	4	Units of hours
Reserved	1	'1'
TC 10min	3	Tens of minutes
TC 1min	4	Units of minutes
TC Field Flag	1	Field Flag
TC 10sec	3	Tes of seconds
TC 1 sec	4	Units of seconds
Drop Frame Flag	1	Drop Frame Flag
Zero	1	'0"
TC 10Frames	2	Tens of frames
TC1Frames	4	Units of frames

CDP CC Data Section (if present)

CDP Header	Bits	Format
CC Data Section Id	8	0x72 (272h) Indicates CC Data Section
Marker bits	3	'111'
CC Count	5	CC Count value based on frame rate
Marker bits	5	'11111'
For (1 to CC Count)		
CC Valid	1	1
CC Type	2	00
CC Data 1	8	Closed Caption Data Word 1
CC Data 2	8	Closed Caption Data Word 2

CC Type	Format
00	NTSC line 21 field 1 Closed Captions
01	NTSC line 21 field 2 Closed Captions
10	DTVCC Channel Packet Data
11	DTVCC Channel Packet Start

Valid Values for CDP Closed Caption Data

CC Data Byte Marker Bits 11111 CC Valid (1 bit) CC Type (2 bits)	CC_Valid	CC_Type
2FC (0xFCh) 1111 1 100	CC Valid 1	00 NTSC line 21 field 1 Closed Captions
1FD (0xFDh) 1111 1 101	CC Valid 1	01 NTSC line 21 field 2 Closed Captions
1FE (0xFEh) 1111 1 110	CC Valid 1	10 DTVCC Channel Packet Data
2FF (0xFFh) 1111 1 111	CC Valid 1	11 DTVCC Channel Packet Start
2FA (0xFAh) 1111 1 010	CC Invalid 0	10 DTVCC Channel Packet Data

CDP CC Service Information Syntax (if present)

CDP Header	Bits	Format
CC Service Info section	8	0x73 (273h) Indicates CC Service Info Section
Reserved	1	'111'
Service Info Start	1	CC Count value based on frame rate
Service Info Change	1	
Service Info Complete	1	
Service Count	4	Number of Service contructs
For (1 to service count		
Reserved	1	
CSN Size	1	
If CSN Size = 1 then		
Reserved	1	
Caption Service Number	5	
Else		
Caption Service Number	6	
Service Data Byte 1	8	
Service Data Byte 2	8	
Service Data Byte 3	8	
Service Data Byte 4	8	
Service Data Byte 5	8	
Service Data Byte 6	8	
End		

CDP CC Footer Section Syntax (Required)

CDP Footer	Bits	Format
CDP Footer Id	8	0x74 (274h) Indicates CDP Footer Section
CDP Footer Sequence Counter	16	
Packet Checksum	8	

References

- WFM6000/7000 Series Waveform Monitors
- WVR6000/7000 Series Waveform Monitors

Data Sheets, Fact Sheets and additional product materials can be found at www.tektronix.com/video_test/signal_monitors.html

For Further Information
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