

The use of Time Code within a Broadcast Facility

Application Note

Introduction

Time Code is a critical reference signal within a facility that is used to provide timing and control code information for a variety of equipment with the facility and is used by such equipment as servers and automation systems for

playout of material. Time Code described time in terms of Hours, Minutes, Seconds and Frames (HH:MM:SS;FF) with frame rates of 60, 59.94, 50, 30, 29.97, 25, 24 and 23.98 supported. There are several ways in which this Time Code information can be carried within the system.

When using the Tektronix SPG8000 with the GPS option as the external timing reference signal the Universal Time Code (UTC) information can be used to derive time code information and act as a Network Time Protocol (NTP) server. The user should select the Time of Day reference as the source of the time and date information from the Global Positioning System (GPS) signal. If the SPG does not have the GPS option installed or the user has configured the SPG to be in internal mode. Then the Time Setup will be in internal mode and the user can configure a user defined master time. When a video reference signal (NTSC/PAL) is applied that has Vertical Interval Time Code (VITC) present then the user can configure to use this time code signal to derive the timecode reference outputs. Alternatively the SPG8000 LTC 1 can be configured as an input and the time code information can be obtained from this signal for the various timecode outputs. When an external timecode signal from LTC or VITC input is used for the timing reference the phase reference for the video output will not be derived from these timing signals.

Leap Second Information

A leap second is a one second adjustment that is made to compensate for the difference between UTC and the mean solar time. Typically these occasional adjustments are made on 30th June or December 31st at 23:59:60 UTC and occur worldwide at the same time with compensation made for each local time zone. In some cases this maybe an inconvenient time to make a local clock adjustment and the user can defer making the leap second adjustment on these dates for up to 24 hours. The GPS signal provides signaling information of the number of leap seconds between GPS time and UTC. There have been a total of 35 leap seconds between SMPTE Epoch (TAI) and UTC as of December 31, 2012. The GPS option is required in order to obtain the Leap Second information from the GPS signal and is updated every 20 to 30 minutes. This leap second information is then stored within the instrument and used when the instrument is rebooted or the GPS signal is missing.

Timing Adjustments

The SPG8000 provides a number of ways to make local time adjustments to the various time code outputs. For instance a network may have different facilities located in various time zones and local facilities may wish to use their local time zone. Then within the configuration menu of the SPG a time zone offset can be applied in hours:minutes:seconds. This allows a great deal of flexibility in setting the offset time for not only the typical hour offset but parts thereof. In certain geographical regions Daylight Saving Time (DST) is used and when this is the case the time will be changed twice a year. Within the SPG8000 the user can program the adjustment of DST by adding or subtracting the specified amount from the current time and can schedule the date and time the change should be made. In addition to the Time of Day the user can use a Program Time this can be configured as a specific time and then used as a timecode source for any output. For example this could be used during the creation or mastering of content to place a specific timecode start at the beginning of the program material. Each of the timecode sources available within the SPG8000 is independently timeable and the user can add a specific timing offset to each output. This could be used by a network to produce timing offsets for the various time zones that the broadcaster operates and provide feeds with each specific time zone offset applied.

The Timecode signals have evolved over the years originally Longitudinal Time Code (LTC) was used as a method for sending timing information as a separate discrete analog signal. Further evolution of timecode embedded information within the vertical interval of a standard definition signal known as Vertical Interval Time Code (VITC). When the transition to digital occurred the time code information was embedded as ancillary data and both LTC and VITC can be carried within this data stream. The following sections describe each of the various timecode formats.

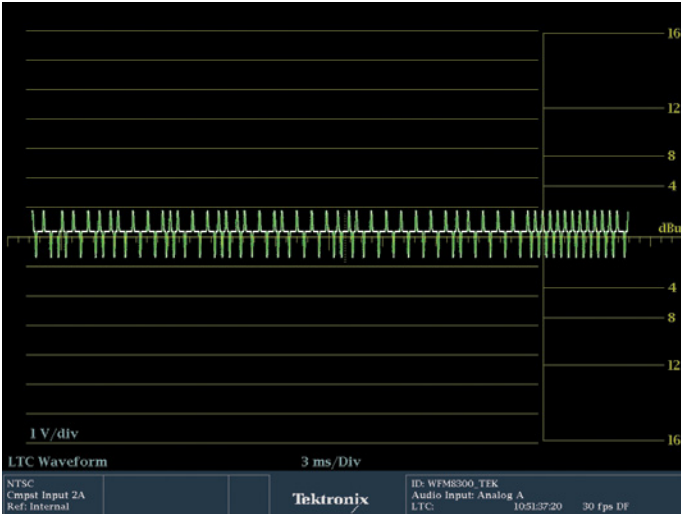


Figure 1. Linear Time Code waveform display with decode of data in status bar.

Linear Time Code (LTC)

This is an analog low frequency signal that was originally recorded on tape or transported as a separate serial signal over a separate interface. The LTC signal can be carried on a balanced XLR audio interface or on a single ended unbalanced output of a BNC connector. One of the LTC signals produced by the SPG8000 can be connected to the rear of the waveform monitor via the 15 pin remote connector. The waveform display of the LTC signal can then be viewed on the waveform monitor to check presence and level of the signal Figure 1. The preferred amplitude is between 1-2 Volts but can have an allowable range between 0.5V to 4.5V. The waveform monitor can also be configured to decode the LTC value. Within the configuration menu of Aux/ANC Data Settings->Time Code Source menu select LTC and the time code information will be decoded and shown in the status bar if present Figure 1.

The LTC codeword consists of 80 bits as shown in Table 1 for various frame rates.

There are three Binary Group Flags (BFG0,BFG1,BFG2) that depending on their bit values define what the Binary Group information can be used for. In some cases the binary groups are used for date and time zone information or page/line multiplex with clock information. The bit values for this additional information can be found in the Aux Data Status display of the waveform monitor showing Time Code Flags, BG Flags and BG Data.

Bit Value	30 Frame Bit	25 Frame Bit	24 Frame Bit
0	Frame 1	Frame 1	Frame 1
1	Frame 2	Frame 2	Frame 2
2	Frame 4	Frame 4	Frame 4
3	Frame 8	Frame 8	Frame 8
4	Binary Group 1 LSB	Binary Group 1 LSB	Binary Group 1 LSB
5	Binary Group 1	Binary Group 1	Binary Group 1
6	Binary Group 1	Binary Group 1	Binary Group 1
7	Binary Group 1 MSB	Binary Group 1 MSB	Binary Group 1 MSB
8	Frame 10	Frame 10	Frame 10
9	Frame 20	Frame 20	Frame 20
10	Drop Frame	- "0"	- "0"
11	Color Frame	Color Frame	- "0"
12	Binary Group 2 LSB	Binary Group 2 LSB	Binary Group 2 LSB
13	Binary Group 2	Binary Group 2	Binary Group 2
14	Binary Group 2	Binary Group 2	Binary Group 2
15	Binary Group 2 MSB	Binary Group 2 MSB	Binary Group 2 MSB
16	Unit Second 1	Unit Second 1	Unit Second 1
17	Unit Second 2	Unit Second 2	Unit Second 2
18	Unit Second 4	Unit Second 4	Unit Second 4
19	Unit Second 8	Unit Second 8	Unit Second 8
20	Binary Group 3 LSB	Binary Group 3 LSB	Binary Group 3 LSB
21	Binary Group 3	Binary Group 3	Binary Group 3
22	Binary Group 3	Binary Group 3	Binary Group 3
23	Binary Group 3 MSB	Binary Group 3 MSB	Binary Group 3 MSB
24	Unit Second 10	Unit Second 10	Unit Second 10
25	Unit Second 20	Unit Second 20	Unit Second 20
26	Unit Second 40	Unit Second 40	Unit Second 40
27	Polarity Correction	Binary Group Flag BGFO	Polarity Correction
28	Binary Group 4 LSB	Binary Group 4 LSB	Binary Group 4 LSB
29	Binary Group 4	Binary Group 4	Binary Group 4
30	Binary Group 4	Binary Group 4	Binary Group 4
31	Binary Group 4 MSB	Binary Group 4 MSB	Binary Group 4 MSB
32	Unit Minute 1	Unit Minute 1	Unit Minute 1
33	Unit Minute 2	Unit Minute 2	Unit Minute 2
34	Unit Minute 4	Unit Minute 4	Unit Minute 4
35	Unit Minute 8	Unit Minute 8	Unit Minute 8
36	Binary Group 5 LSB	Binary Group 5 LSB	Binary Group 5 LSB
37	Binary Group 5	Binary Group 5	Binary Group 5
38	Binary Group 5	Binary Group 5	Binary Group 5
39	Binary Group 5 MSB	Binary Group 5 MSB	Binary Group 5 MSB
40	Unit Minute 10	Unit Minute 10	Unit Minute 10

Table 1. LTC Bit Values.

Bit Value	30 Frame Bit	25 Frame Bit	24 Frame Bit
41	Unit Minute 20	Unit Minute 20	Unit Minute 20
42	Unit Minute 40	Unit Minute 40	Unit Minute 40
43	Binary Group Flag BGF0	Binary Group Flag BGF2	Binary Group Flag BGF0
44	Binary Group 6 LSB	Binary Group 6 LSB	Binary Group 6 LSB
45	Binary Group 6	Binary Group 6	Binary Group 6
46	Binary Group 6	Binary Group 6	Binary Group 6
47	Binary Group 6 MSB	Binary Group 6 MSB	Binary Group 6 MSB
48	Hour 1	Hour 1	Hour 1
49	Hour 2	Hour 2	Hour 2
50	Hour 4	Hour 4	Hour 4
51	Hour 8	Hour 8	Hour 8
52	Binary Group 7 LSB	Binary Group 7 LSB	Binary Group 7 LSB
53	Binary Group 7	Binary Group 7	Binary Group 7
54	Binary Group 7	Binary Group 7	Binary Group 7
55	Binary Group 7 MSB	Binary Group 7 MSB	Binary Group 7 MSB
56	Hour 10	Hour 10	Hour 10
57	Hour 20	Hour 20	Hour 20
58	Binary Group Flag BGF1	Binary Group Flag BGF1	Binary Group Flag BGF1
59	Binary Group Flag BGF2	Polarity Correction	Binary Group Flag BGF2
60	Binary Group 8 LSB	Binary Group 8 LSB	Binary Group 8 LSB
61	Binary Group 8	Binary Group 8	Binary Group 8
62	Binary Group 8	Binary Group 8	Binary Group 8
63	Binary Group 8 MSB	Binary Group 8 MSB	Binary Group 8 MSB
64	Sync Word "0"	Sync Word "0"	Sync Word "0"
65	Sync Word "0"	Sync Word "0"	Sync Word "0"
66	Sync Word "1"	Sync Word "1"	Sync Word "1"
67	Sync Word "1"	Sync Word "1"	Sync Word "1"
68	Sync Word "1"	Sync Word "1"	Sync Word "1"
69	Sync Word "1"	Sync Word "1"	Sync Word "1"
70	Sync Word "1"	Sync Word "1"	Sync Word "1"
71	Sync Word "1"	Sync Word "1"	Sync Word "1"
72	Sync Word "1"	Sync Word "1"	Sync Word "1"
73	Sync Word "1"	Sync Word "1"	Sync Word "1"
74	Sync Word "1"	Sync Word "1"	Sync Word "1"
75	Sync Word "1"	Sync Word "1"	Sync Word "1"
76	Sync Word "1"	Sync Word "1"	Sync Word "1"
77	Sync Word "1"	Sync Word "1"	Sync Word "1"
78	Sync Word "0"	Sync Word "0"	Sync Word "0"
79	Sync Word "1"	Sync Word "1"	Sync Word "1"

Table 1. LTC Bit Values.

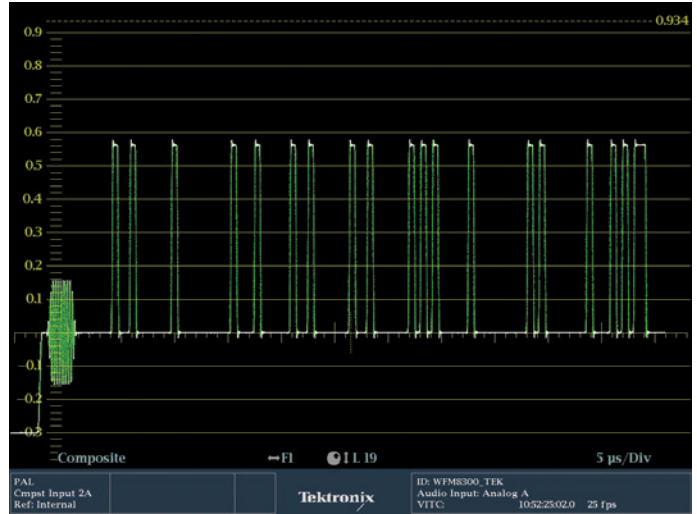
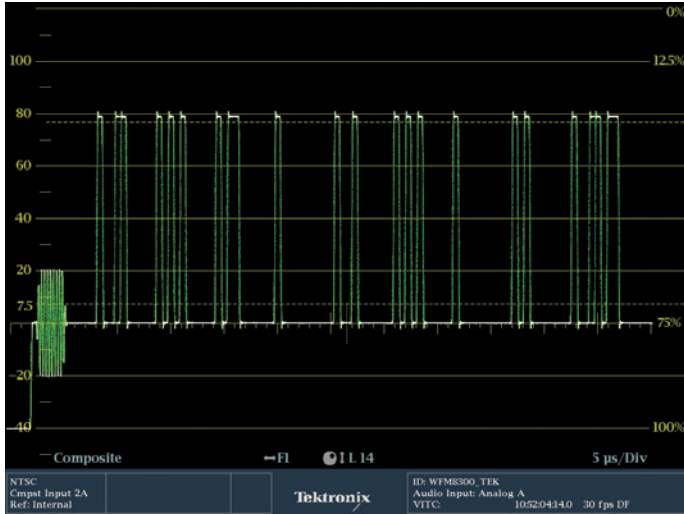


Figure 2. Vertical Interval Timecode waveform display for NTSC and PAL.

Vertical Interval Time Code (VITC)

The Tektronix SPG8000 can configure the time code information to be added to the analog blanking interval of a 525 or 625 signal and is referred to a Vertical Interval Time Code (VITC). Additionally this analog signal may be digitized within the SD-SDI signal and it is typically referred to as D-VITC. The number of bits used to carry the time code information in VITC code words is slightly longer than that used for LTC with a total of 90 bits used. An additional two bits are used for synchronization code words (“1,0”) followed by the eight data bits. This VITC signal produces eight 10 bit groups that contain the time code information plus an additional ninth group that provides a Cyclic Redundancy Code (CRC) word. Figure 2 shows a line select waveform view of one of the VITC signals. Using the waveform display you can measure the amplitude and timing of the VITC signal. Typically the amplitude of the signal should be 70-90IRE for 525 and 500-600mv for 625 with timing starting at 10μS for 525 and 11.2μS for 625 from negative sync. Typically the VITC lines are inserted between line 10-20 of a 525 system with

preferred location of line 14 (277) or optionally on line 16 (279). For legacy equipment it is necessary to provide the VITC on two consecutive lines (14 & 16). In the case of 625 systems the VITC can be placed between line 6 (319) and line 22(335). The preferred lines are 19(332) and 21 (334). The waveform monitor allows the user to select the lines they wish the VITC information to be decoded from and the status bar will show the decoded time code value Figure 2. The preferred lines for each standard are used as the default values for VITC decoding.

Within the SPG8000 analog black burst reference (NTSC/PAL) outputs a VITC signal can be added onto the preferred lines numbers (default) or the user can select specific line numbers. The timecode time of day information can be derived from the GPS signal (Option GPS) and a timing offset can be applied if necessary to account for different time zones. Alternatively the user can set up their own Program Time from which to start the timecode value. This can be used to insert a specific timecode value onto program material that needs to have a specific timecode start such as 01:00:00:00.

Bit Value	30 Frame Bit	25 Frame Bit	24 Frame Bit
0	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
1	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
2	Frame 1	Frame 1	Frame 1
3	Frame 2	Frame 2	Frame 2
4	Frame 4	Frame 4	Frame 4
5	Frame 8	Frame 8	Frame 8
6	Binary Group 1 LSB	Binary Group 1 LSB	Binary Group 1 LSB
7	Binary Group 1	Binary Group 1	Binary Group 1
8	Binary Group 1	Binary Group 1	Binary Group 1
9	Binary Group 1 MSB	Binary Group 1 MSB	Binary Group 1 MSB
10	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
11	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
12	Frame 10	Frame 10	Frame 10
13	Frame 20	Frame 20	Frame 20
14	Drop Frame	- "0"	- "0"
15	Color Frame	Color Frame	- "0"
16	Binary Group 2 LSB	Binary Group 2 LSB	Binary Group 2 LSB
17	Binary Group 2	Binary Group 2	Binary Group 2
18	Binary Group 2	Binary Group 2	Binary Group 2
19	Binary Group 2 MSB	Binary Group 2 MSB	Binary Group 2 MSB
20	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
21	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
22	Unit Second 1	Unit Second 1	Unit Second 1
23	Unit Second 2	Unit Second 2	Unit Second 2
24	Unit Second 4	Unit Second 4	Unit Second 4
25	Unit Second 8	Unit Second 8	Unit Second 8
26	Binary Group 3 LSB	Binary Group 3 LSB	Binary Group 3 LSB
27	Binary Group 3	Binary Group 3	Binary Group 3
28	Binary Group 3	Binary Group 3	Binary Group 3
29	Binary Group 3 MSB	Binary Group 3 MSB	Binary Group 3 MSB
30	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
31	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
32	Unit Second 10	Unit Second 10	Unit Second 10
33	Unit Second 20	Unit Second 20	Unit Second 20
34	Unit Second 40	Unit Second 40	Unit Second 40
35	Field Identification Flag	Binary Group Flag BGFO	Field Identification Flag
36	Binary Group 4 LSB	Binary Group 4 LSB	Binary Group 4 LSB
37	Binary Group 4	Binary Group 4	Binary Group 4
38	Binary Group 4	Binary Group 4	Binary Group 4
39	Binary Group 4 MSB	Binary Group 4 MSB	Binary Group 4 MSB
40	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
41	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
42	Unit Minute 1	Unit Minute 1	Unit Minute 1
43	Unit Minute 2	Unit Minute 2	Unit Minute 2
44	Unit Minute 4	Unit Minute 4	Unit Minute 4
45	Unit Minute 8	Unit Minute 8	Unit Minute 8
46	Binary Group 5 LSB	Binary Group 5 LSB	Binary Group 5 LSB

Table 2. VITC Bit Values.

Bit Value	30 Frame Bit	25 Frame Bit	24 Frame Bit
47	Binary Group 5	Binary Group 5	Binary Group 5
48	Binary Group 5	Binary Group 5	Binary Group 5
49	Binary Group 5 MSB	Binary Group 5 MSB	Binary Group 5 MSB
50	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
51	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
52	Unit Minute 10	Unit Minute 10	Unit Minute 10
53	Unit Minute 20	Unit Minute 20	Unit Minute 20
54	Unit Minute 40	Unit Minute 40	Unit Minute 40
55	Binary Group Flag BGF0	Binary Group Flag BGF2	Binary Group Flag BGF0
56	Binary Group 6 LSB	Binary Group 6 LSB	Binary Group 6 LSB
57	Binary Group 6	Binary Group 6	Binary Group 6
58	Binary Group 6	Binary Group 6	Binary Group 6
59	Binary Group 6 MSB	Binary Group 6 MSB	Binary Group 6 MSB
60	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
61	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
62	Hour 1	Hour 1	Hour 1
63	Hour 2	Hour 2	Hour 2
64	Hour 4	Hour 4	Hour 4
65	Hour 8	Hour 8	Hour 8
66	Binary Group 7 LSB	Binary Group 7 LSB	Binary Group 7 LSB
67	Binary Group 7	Binary Group 7	Binary Group 7
68	Binary Group 7	Binary Group 7	Binary Group 7
69	Binary Group 7 MSB	Binary Group 7 MSB	Binary Group 7 MSB
70	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
71	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
72	Hour 10	Hour 10	Hour 10
73	Hour 20	Hour 20	Hour 20
74	Binary Group Flag BGF1	Binary Group Flag BGF1	Binary Group Flag BGF1
75	Binary Group Flag BGF2	Field Identification Flag	Binary Group Flag BGF2
76	Binary Group 8 LSB	Binary Group 8 LSB	Binary Group 8 LSB
77	Binary Group 8	Binary Group 8	Binary Group 8
78	Binary Group 8	Binary Group 8	Binary Group 8
79	Binary Group 8 MSB	Binary Group 8 MSB	Binary Group 8 MSB
80	"1" Sync Bit	"1" Sync Bit	"1" Sync Bit
81	"0" Sync Bit	"0" Sync Bit	"0" Sync Bit
82	CRC X ⁸	CRC X ⁸	CRC X ⁸
83	CRC X ⁷	CRC X ⁷	CRC X ⁷
84	CRC X ⁶	CRC X ⁶	CRC X ⁶
85	CRC X ⁵	CRC X ⁵	CRC X ⁵
86	CRC X ⁴	CRC X ⁴	CRC X ⁴
87	CRC X ³	CRC X ³	CRC X ³
88	CRC X ²	CRC X ²	CRC X ²
89	CRC X ¹	CRC X ¹	CRC X ¹

Table 2. VITC Bit Values.

DID	SDID	DC	User Data Words (UDW)																B		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
260h	260h	110h	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B8	B9	
			Parity Bit																B8		
			Time Code Data See Table 4																B7		
																			B6		
																			B5		
																			B4		
			Bit 3 = DBB 1								Bit 3 + DBB 2								B3		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B2
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B1
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	B0

Table 3. Time Code Ancillary packet format.

Ancillary Time Code

For SDI formats both the LTC and VITC time code information can be embedded as ancillary data packet as defined in SMPTE 12-2 (Transmission of Time Code in the Ancillary Data Space). The data conforms to SMPTE 291 (Ancillary Data Packet and Space Formatting) with ancillary data flag (ADF) 000h, 3FFh, ,3FFh followed by a Data Identification Data (DID)

of 60h and a Secondary Data Identification Data (SDID) of 60h. The Data Count 10h indicates that there are 16 User Data Words (UDW) used for time code and the final packet of the ancillary data is a checksum value. The data structure of the ANC time code is shown in Table 3 and the time code data is shown in Table 4.

ANC Time Code		
UDW	BIT	Time Code Value
1	4	Frame 1
	5	Frame 2
	6	Frame 4
	7	Frame 8
2	4	Binary Group 1 LSB
	5	Binary Group 1
	6	Binary Group 1
	7	Binary Group 1 MSB
3	4	Frame 10
	5	Frame 20
	6	Flag
	7	Flag
4	4	Binary Group 2 LSB
	5	Binary Group 2
	6	Binary Group 2
	7	Binary Group 2 MSB
5	4	Unit Second 1
	5	Unit Second 2
	6	Unit Second 4
	7	Unit Second 8
6	4	Binary Group 3 LSB
	5	Binary Group 3
	6	Binary Group 3
	7	Binary Group 3 MSB
7	4	Unit Second 10
	5	Unit Second 20
	6	Unit Second 40
	7	Flag
8	4	Binary Group 4 LSB
	5	Binary Group 4
	6	Binary Group 4
	7	Binary Group 4 MSB

ANC Time Code		
UDW	BIT	Time Code Value
9	4	Unit Minute 1
	5	Unit Minute 2
	6	Unit Minute 4
	7	Unit Minute 8
10	4	Binary Group 5 LSB
	5	Binary Group 5
	6	Binary Group 5
	7	Binary Group 5 MSB
11	4	Unit Minute 10
	5	Unit Minute 20
	6	Unit Minute 40
	7	Flag
12	4	Binary Group 6 LSB
	5	Binary Group 6
	6	Binary Group 6
	7	Binary Group 6 MSB
13	4	Hour 1
	5	Hour 2
	6	Hour 4
	7	Hour 8
14	4	Binary Group 7 LSB
	5	Binary Group 7
	6	Binary Group 7
	7	Binary Group 7 MSB
15	4	Hour 10
	5	Hour 20
	6	Flag
	7	Flag
16	4	Binary Group 8 LSB
	5	Binary Group 8
	6	Binary Group 8
	7	Binary Group 8 MSB

Table 4. Time Code Data Mapped into ANC Data space.

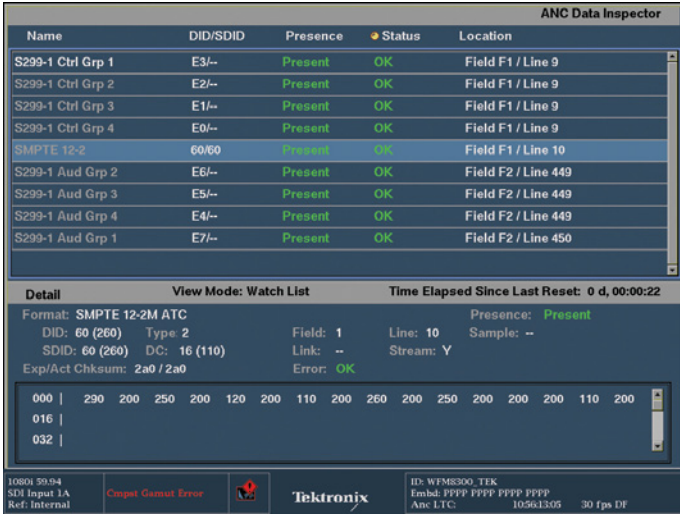


Figure 3. ANC Data Display with SMPTE 12-2 Time Code present.

The Tektronix WFM8300 waveform monitor can display the ancillary data of SMPTE 12-2 timecode information if present within the signal. Figure 3 shows the ANC Data Inspector display of the extracted timecode user data words and the decoded timecode information is show in the status bar of the display.

Drop Frame

The timecode value is represented in Hours, Minutes, Seconds and Frames (HH:MM:SS:FF) each of the values is a whole integer number and in even rate video system such as 60, 50, 30, 25, 24 there are a whole number of frames within each time interval. In the case of NTSC the frame rate is 30/1.001 (29.97) and this slight difference between the integer time

code value and the non-integer NTSC frame rate will cause a divergence from “real time”. In one hour there are 108,000 frames and for NTSC at 29.97 there are about 107,892.11 frames. Therefore there is a difference of approximately 108 frames between 29.97 and 30 frames. The Drop Frame (DF) algorithm is designed to minimize this difference by skipping frames. The first two frames (00 & 01) shall be skipped from the start of each minute except at 00, 10, 20, 30, 40 and 50 minutes. Therefore using this algorithm a total of 110 frames shall be skipped using drop frame compensation and reducing the difference in time to approximately 3.6ms. In a 24-hour period the divergence in time will be minimized to 86ms instead of 86 seconds in no drop frame compensation was applied. To further minimize this difference jam sync can be applied that will skip an additional two frames. Other non-even frame such as 59.94, 29.97, 23.98 can also use Drop Frame to compensate for the timing difference between the integer values and the 1/1.001 frame rate. The waveform monitor and sync generator will show “DF” when the drop frame algorithm is applied to the timecode values.

Conclusion

The various formats of timecode are used within a wide variety of equipment within a broadcast or post production facility. Therefore it is important to understand the data structures of the various formats to ensure data integrity throughout the facility. The GPS signal provides an accurate method of obtaining timing information and the GPS option of the Tektronix SPG8000 provides a variety of different timecode formats and timecode offsets to suit the demanding needs of today’s facility.

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