

# **INVESTIGATING UNKNOWN IRIG CHAPTER 4, CLASS I OR II FORMATS**

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## **ABSTRACT**

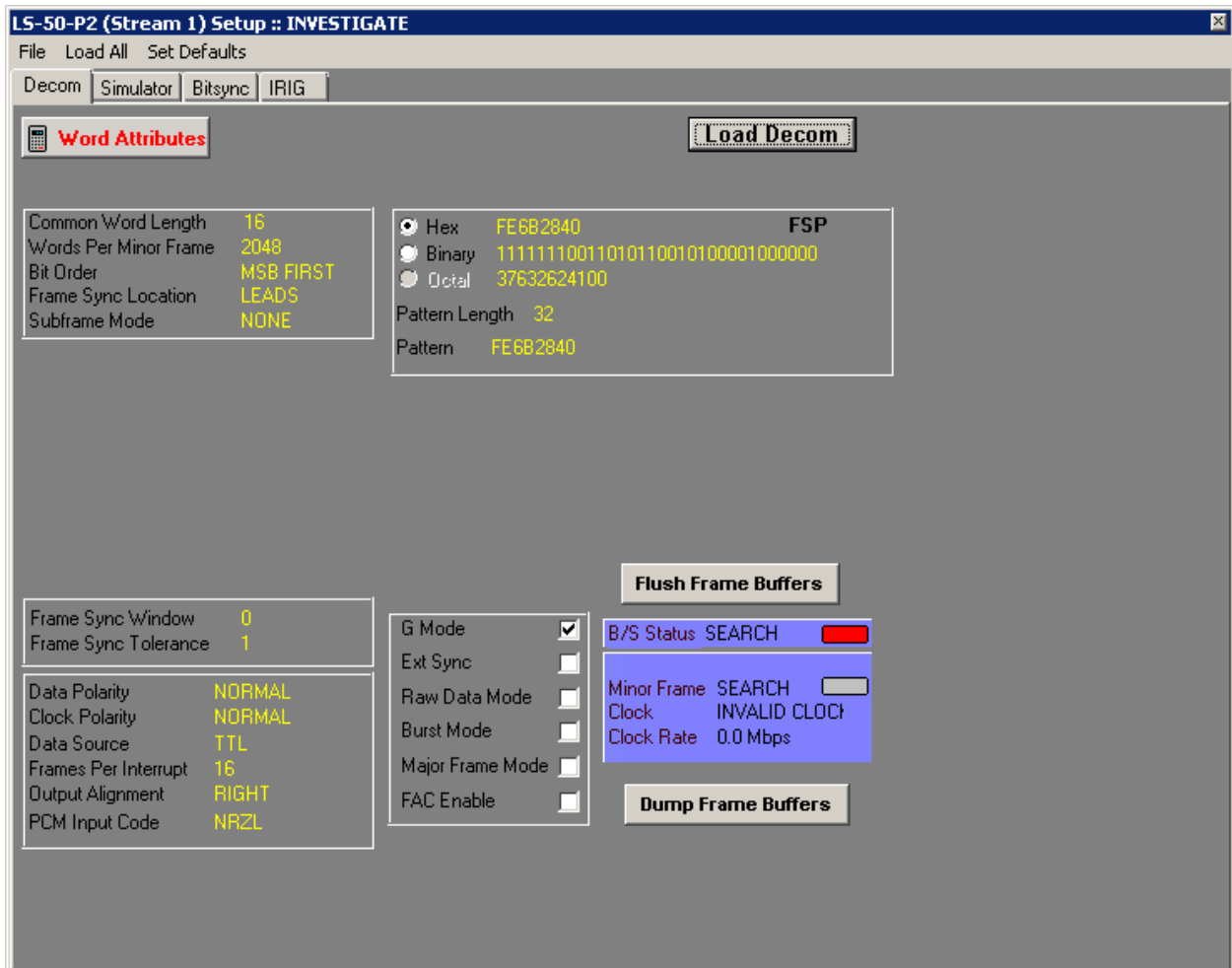
This describes one approach to investigating an unknown IRIG 106, Chapter, 4 Class I or Class II Pulse Code Modulation (PCM) format. The assumption is that you are supplied with decrypted data and clock signals for the unknown PCM stream. This technique is optimized for 16, 12, or 8-bit Word Minor Frames. Standard IRIG 106, Appendix C, Table C-1, Frame Synchronization (Frame Sync) values of 32, 24, 16-bit patterns are simpler to investigate. Other IRIG Frame Sync patterns can also be investigated, but are not dealt with in this document. This document will utilize a sample 24-bit Frame Sync pattern, because it will produce Endian issues in the recorded data.

## **INTRODUCTION**

The system used to investigate the unknown PCM Frame is Windows based. The Decommutator utilizes a mode that records the raw data from the Decom Current Value Table memory onto the Hard Drive as 16-bit Words that are Little Endian swapped. The 16-bit Word 0x1234 in CVT memory is stored onto the HD as 0x3412. Using a combination of real-time Raw Data Buffer, Frame Buffer and recorded data inspected with a Hexadecimal Viewer will give insight into the unknown Frame. Using this information to update the Decom settings and repeating this inspection process, eventually a successfully lock on the unknown PCM Frame format will be achieved.

## PROCEDURE

Setup the Decommutator (Decom) for PCM Frame investigation as shown in Figure 1.



**Figure 1: Initial Decom Setup**

This configuration is optimal for 16, 12, 8, bit Words. **Note:** the G Mode selected above allows locking onto the Frame Synchronization (Frame Sync) pattern if found. However, even if no Frame Sync pattern is found, the Decom will collect buffers of data and then record them to the hard drive when placed in the archiving mode.

Since the format is unknown, we will try 32, 24 and 16-bit Frame Sync patterns until the pattern is found. This is accomplished by trying each Frame Sync pattern and observing the Raw Data Buffer (indicated by the term **FPI** in the banner). Starting with the 32-bit Frame Sync pattern 0xFE6B2840, the Raw Data Buffer is inspected for this Frame Sync pattern in Figure 2.

MF Decom (Ls50P2) Card 1 FPI Serial Data											
File Frame List Quick List Hardcopy Snap File											
Setup Info						Status Info					
Cwl	16	Sfld Word	2049	Minor Fr Rate	30.5	Data Valid	NO	Reset Counter			
Wpf	2048	Sfld Msb	5	FPI	16	Drdy Counter	0x00000C50	Frames Lost	0x000002E0		
Num Sf	1	Sfld Start	0	Card Mode	0	Time	223:13:00:54.531746				
Pause						Pause Flush Buffer					
	T1	T2	T3	T4	S1	1	2	3	4	5	6
0	2302	0013	5354	4617	1031	8778	6880	B050	8770	3A81	6065
1	2302	0013	5654	1445	1032	9022	07F0	5D80	7852	04B0	1606
2	2302	0013	5954	8272	1033	0203	D01D	8310	1F06	886A	8078
3	2302	0013	6354	5000	1034	8648	6E01	C80C	0190	6C00	2013
4	2302	0013	6654	1828	1035	880B	0508	7703	A816	0658	5D83
5	2302	0013	6954	8655	1036	5E85	D807	8520	4B01	606F	0798
6	2302	0013	7254	5483	1037	01D8	3101	F068	86A8	0786	105E
7	2302	0013	7654	2211	1038	E01C	80C0	1906	C002	0138	7707
8	2302	0013	7954	9038	1039	5087	703A	8160	6585	D834	0588
9	2302	0013	8254	5866	103A	8078	5204	B016	06F0	7982	F81E
10	2302	0013	8554	2694	103B	101F	0688	6A80	7861	05E8	2702
11	2302	0013	8954	9421	103C	0C01	906C	0020	1387	707A	0738
12	2302	0013	9254	6249	103D	03A8	1606	585D	8340	5886	1825
13	2302	0013	9554	2977	103E	204B	0160	6F07	982F	81E0	2801
14	2302	0013	9954	9704	103F	6886	A807	8610	5E82	7020	8210
15	2302	0013	0255	6532	1040	06C0	0201	3877	07A0	7384	F865

Figure 2: Raw Data Buffer, no 0xFE6B2840 pattern found

Reconfigure the Decom to look for 24-bit Frame Sync pattern 0xFAF320 then inspect the Raw Data Buffer as in Figure 3.

MF Decom (Ls50P2) Card 1 FPI Serial Data											
File Frame List Quick List Hardcopy Snap File											
Setup Info						Status Info					
Cwl	16	Sfld Word	2049	Minor Fr Rate	30.5	Data Valid	NO	Reset Counter			
Wpf	2048	Sfld Msb	5	FPI	16	Drdy Counter	0x00001680	Frames Lost	0x000008A3		
Num Sf	1	Sfld Start	0	Card Mode	0	Time	222:14:39:39.762938				
Pause						Pause Flush Buffer					
	T1	T2	T3	T4	S1	1	2	3	4	5	6
0	2202	3914	7639	3829	11A2	FAF3	2001	A040	0FE0	BB00	F0A4
1	2202	3914	7939	0657	11A3	40C3	06C0	0407	A038	0620	3E0D
2	B0BB	0680	B10C	304B	0290	960F	E088	0E80	C90D	C039	0180
3	D0BA	0EB0	BB00	F0A4	0960	2C0D	E0F3	05F0	3C05	0024	0610
4	E0F4	0E70	9F0C	B064	0C30	6C00	407A	03B0	6203	E0D1	0D50
5	60A1	0EE0	7502	C0CB	08B0	680B	10C3	04B0	2909	60FE	08B0
6	1042	043F	AF32	001B	06B0	9F0B	B00F	0A40	9602	CODE	0F30
7	8032	0D80	0402	70EE	0F40	E709	F0CB	0640	C306	C004	07A0
8	10BF	0D70	EF0D	1016	0A10	EE07	502C	0CB0	8B06	80B1	0C30
9	2202	3814	5813	7613	11A8	0000	0000	0000	0000	0000	0000
10	2202	3814	6113	4441	11A4	0000	0000	0000	0000	0000	0000
11	2202	3814	6413	1269	11A0	0000	0000	0000	0000	0000	0000
12	2202	3814	6713	8096	11A6	0000	0000	0000	0000	0000	0000
13	2202	3814	7113	4824	11AF	0000	0000	0000	0000	0000	0000
14	2202	3814	7413	1652	1150	0000	0000	0000	0000	0000	0000
15	2202	3814	7713	8479	1151	0000	0000	0000	0000	0000	0000

Figure 2: Raw Data Buffer, 0xFAF320 pattern found

The unknown PCM Frame uses a 24-bit Frame Sync. Record Raw Data and review this recording using a Hex Viewer looking for the Frame Sync. Since the recorded data is Little Endian swapped, look for the pattern 0xF3FA as in Figure 3.

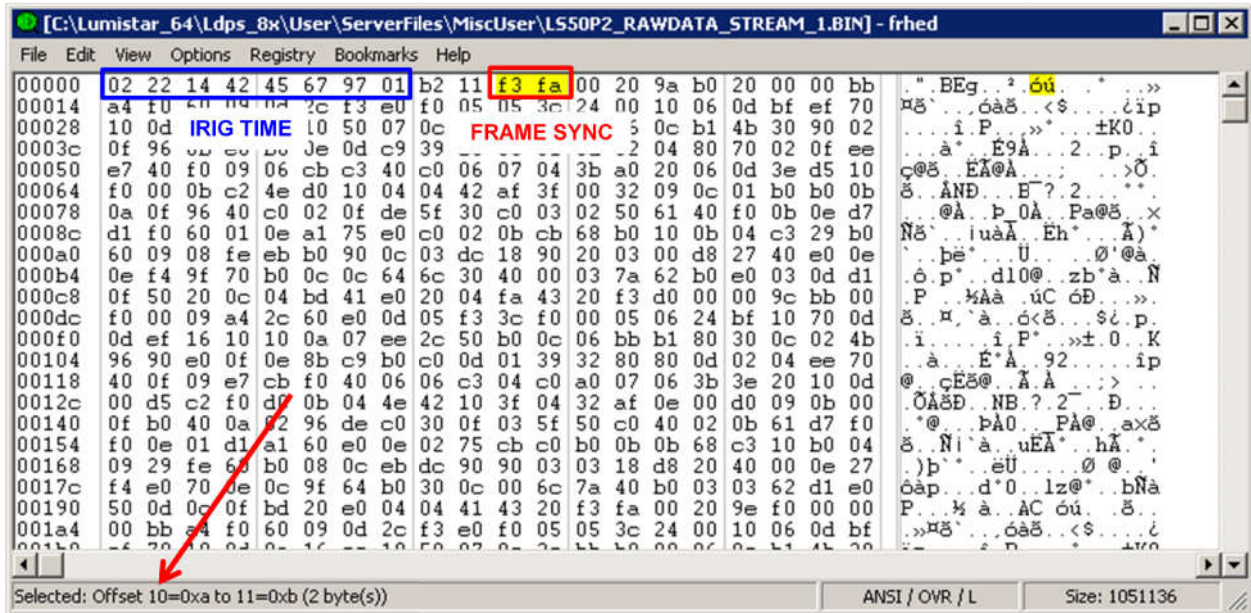


Figure 3: First Frame Sync location using a Hex Viewer

The first Frame Sync found has a 10 byte offset value. **Note:** this Decom will prepend 10 bytes of data in front of the Frame Sync. This is comprised of an IRIG Time Stamp and various status flags. The next Frame Sync occurrence is shown in Figure 4.

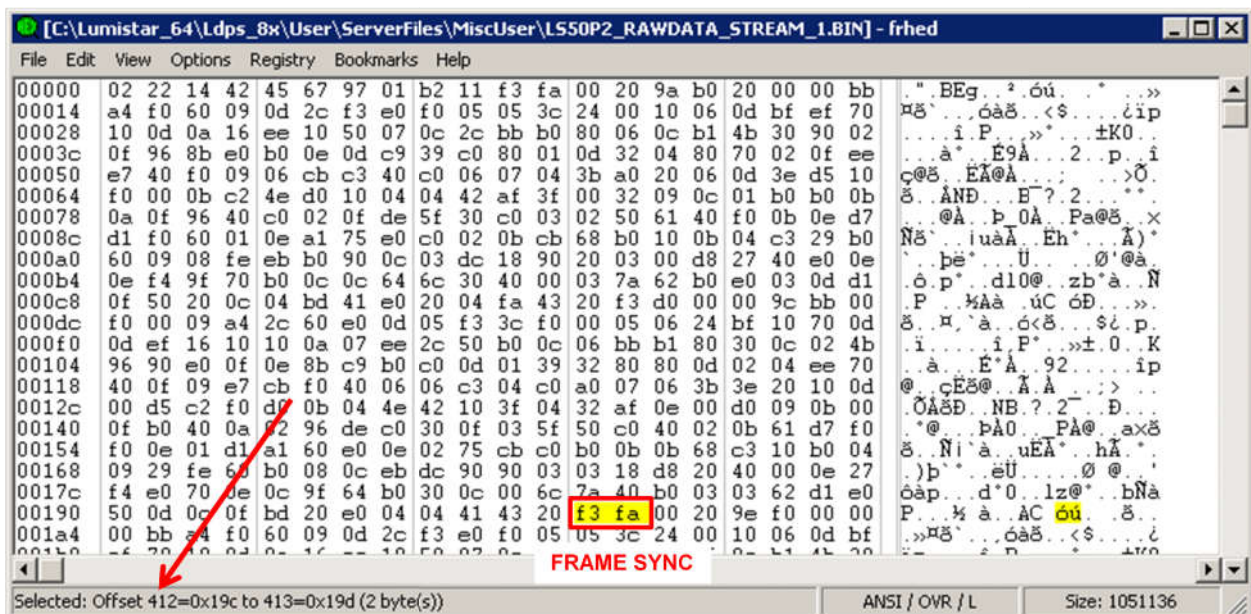


Figure 4: 2nd Frame Sync location

This Frame Sync has a 412 byte offset value.

Looking 10 bytes to the left of the Frame Sync, shows there is no IRIG timestamp and Status bytes..Therefore Minor Frame length (the number of bytes between Frame Syncs) can be calculated.

$$(412 \text{ bytes} - 10 \text{ bytes}) = 402 \text{ bytes or } 201 \text{ 16-bit Words}$$

Since the Decom is set for 16 bit Words, reconfigure the Decom to look for **201** 16-bit word Minor Frames. The incoming data now indicates a Frame Lock in Figure 5.



**Figure 5: Frame Lock Indicator**

The Frame Lock affirms the Minor Frame length or it is a multiple of the Minor Frame length. To determine which is the case, look in the middle of the Raw Data Buffer in Figure 6.

The screenshot shows the 'MF Decom (Ls50P2) Card 1 FPI Serial Data' window. The 'Setup Info' section includes:

- Cwl: 16, Sfld Word: 202, Minor Fr Rate: 310.9
- Wpf: 201, Sfld Msb: 5, FPI: 16
- Num Sf: 1, Sfld Start: 0, Card Mode: 0

The 'Status Info' section includes:

- Data Valid: YES
- Dirty Counter: 0x00038FD0
- Frames Lost: 0x00000000
- Time: 222:15:28:11.289741

The 'Raw Data Buffer' table shows the following data:

	97	98	99	100	101	102	103	104	105	106	107
0	0C20	BD04	E041	0420	43FA	F320	00D0	9C01	D0BB	00F0	A409
1	0C20	BD04	E041	0420	43FA	F320	0110	A003	50BB	00F0	A409
2	0C20	BD04	E041	0420	43FA	F320	0150	A405	10BB	00F0	A409
3	0C20	BD04	E041	0420	43FA	F320	0190	A807	00BB	00F0	A409
4	0C20	BD04	E041	0420	43FA	F320	0020	AC0D	10BB	00F0	A409
5	0C20	BD04	E041	0420	43FA	F320	0060	B00B	60BB	00F0	A409
6	0C20	BD04	E041	0420	43FA	F320	00A0	B409	70BB	00F0	A409
7	0C20	BD04	E041	0420	43FA	F320	00E0	B807	70BB	00F0	A409
8	0C20	BD04	E041	0420	43FA	F320	0120	BC05	80BB	00F0	A409
9	0C20	BD04	E041	0420	43FA	F320	0160	C003	80BB	00F0	A409
10	0C20	BD04	E041	0420	43FA	F320	01A0	C402	30BB	00F0	A409
11	0C20	BD04	E041	0420	43FA	F320	0030	C809	F0BB	00F0	A409
12	0C20	BD04	E041	0420	43FA	F320	0070	030B	D0BB	00F0	A409
13	0C20	BD04	E041	0420	43FA	F320	00B0	070D	70BB	00F0	A409
14	0C20	BD04	E041	0420	43FA	F320	00F0	0B0E	80BB	00F0	A409
15	0C20	BD04	E041	0420	43FA	F320	0130	0F0F	90BB	00F0	A409

**Figure 6: Raw Data Buffer Mid Frame Inspection**

This Frame Sync is offset by one byte midway down the current Minor Frame. Recalculating to reduce the Minor Frame length.

$$(201 \text{ 16-bit words} / 2) = 100.5 \text{ 16-bit Words}$$

Set the new Decom settings to **101** 16-bit Words with Word **101** set to **8** bits in length. Again look for a Frame Sync mid Minor Frame in the Raw Data Buffer, Figure 7.

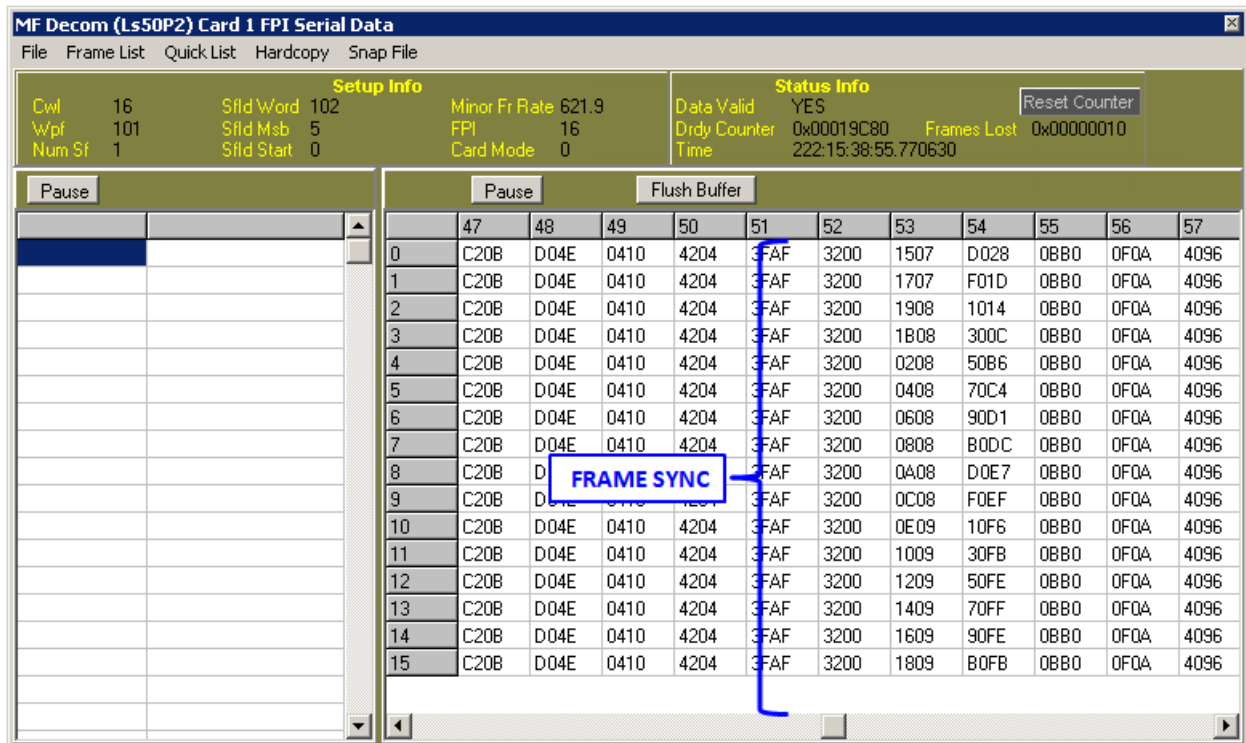


Figure 7: Raw Data Buffer, 2ndrMid Frame Inspection

This indicates the Minor Frame length is still twice the required size, recalculating.

$$(100.5 \text{ 16-bit words} / 2) = 50.25 \text{ 16-bit Words}$$

Change the Decom settings to **51** 16-bit Words with Word **51** set to **4** bits in length and look at the Raw Data Buffer for a Frame Sync mid Minor Frame - none was found. The Minor Frame length has been determined. Take the Decom out of the Raw Data mode to allow it to lock appropriately on the Minor Frame with no SFID.

Since the 16-bit Minor Frame Word count requires a variable word, calculate the Minor Frame length in 12 bit words.

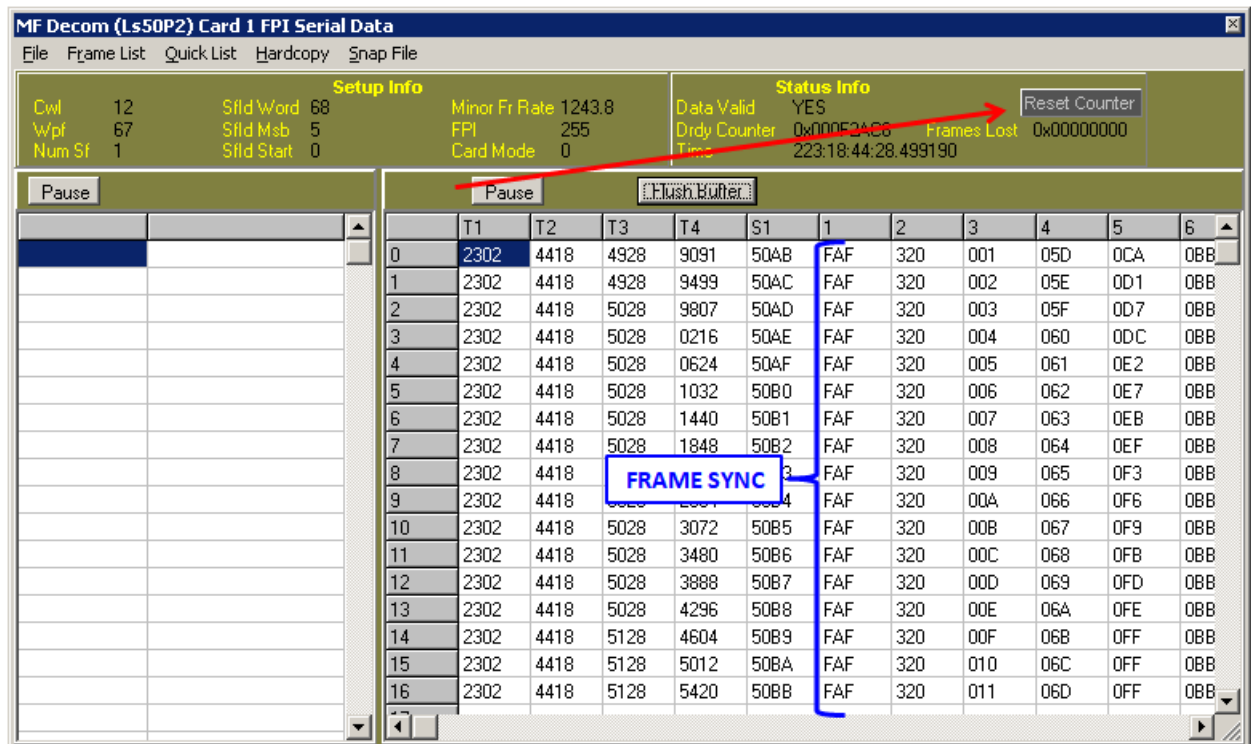
$$(50.25 \text{ Word} * 16 \text{ bits/Word}) / 12 \text{ bits/Word} = 67 \text{ 12-bit Words}$$

After setting these new values into the Decom, look at the Frame Buffer (indicated by NO FPI term in the banner), there are no dropped Frames seen in Figure 8.



**Figure 8: Frame Buffer Showing No Lost Frames**

Change the raw data buffer size to maximum (255 with this hardware). This buffer will be frame aligned for easier inspection as seen in Figure 9.



**Figure 9: Raw Data Buffer Shows No Lost Frames**

Now use the Decom's Snap File feature which records a snapshot of the entire Raw Data Buffer into a text file. Using Excel to import this text file and organize the data into columns. Look for possible Subframe ID (SFID) data in Figure 10.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N		
20	223:18:48:	2302	4818	9233	9414	500F	FAF		320	12	01A		97	0BB	00F	0A4
21	223:18:48:	2302	4818	9233	9822	5010	FAF		320	13	01B	08F		0BB	00F	0A4
22	223:18:48:	2302	4818	9233	231	5011	FAF		320	14	01C		88	0BB	00F	0A4
23	223:18:48:	2302	4818	9233	639	5012	FAF		320	15	01D		80	0BB	00F	0A4
24	223:18:48:	2302	4818	9233	1047	5013	FAF		320	16	01E		77	0BB	00F	0A4
25	223:18:48:	2302	4818	9233	1455	5014	FAF		320	17	01F		70	0BB	00F	0A4
26	223:18:48:	2302	4818	9233	1863	5015	FAF		320	18		20	68	0BB	00F	0A4
27	223:18:48:	2302	4818	9233	2271	5016	FAF		320	19	21		60	0BB	00F	0A4
28	223:18:48:	2302	4818	9233	2679	5017	FAF		320	01A		22	58	0BB	00F	0A4
29	223:18:48:	2302	4818	9233	3087	5018	FAF		320	01B		23	51	0BB	00F	0A4
30	223:18:48:	2302	4818	9233	3495	5019	FAF		320	1		24	51	0BB	00F	0A4
31	223:18:48:	2302	4818	9333	3803	501A	FAF		320	2		25	58	0BB	00F	0A4
32	223:18:48:	2302	4818	9333	4211	501B	FAF		320	3		26	60	0BB	00F	0A4

**Figure 10: Reviewing Raw Data Snapshot for SFID Data**

The SFID is seen to rollover at 27 and starts with 1, indicating a total of 27 Minor Frames. Using this new information and making note of the SFID bit alignment, make final Decom settings for this Frame as shown in Figure 11.

**Figure 11: Final Decom Configuration with Solid Locks**



Finally, Looking at the Frame Buffer, no lost Frames are seen in Figure 12.

**MF Decom (Ls50P2) Card 1 Serial Data**

File Frame List Quick List Hardcopy Snap File

Setup Info				Status Info	
Cwl	12	Sfld Word	3	Data Valid	YES
Wpf	67	Sfld Msb	4	Drdy Counter	0x0001F305
Num Sf	27	Sfld Start	1	Time	22:19:03:27.754049
Minor Fr Rate	1243.8	Frames Lost	0x00000000	Reset Counter	
FPI	255			Analysis	
Card Mode	0				

	T1	T2	T3	T4	S1	1	2	3	4	5	6
1	2302	0319	7727	5757	7001	FAF	320	001	003	0F9	0BB
2	2302	0319	7527	5348	7002	FAF	320	002	0B2	010	0BB
3	2302	0319	7527	5756	7003	FAF	320	003	0B3	00C	0BB
4	2302	0319	7527	6164	7004	FAF	320	004	0B4	009	0BB
5	2302	0319	7527	6572	7005	FAF	320	005	0B5	006	0BB
6	2302	0319	7527	6980	7006	FAF	320	006	0B6	004	0BB
7	2302	0319	7527	7388	7007	FAF	320	007	0B7	002	0BB
8	2302	0319	7527	7796	7008	FAF	320	008	0B8	001	0BB
9	2302	0319	7627	8104	7009	FAF	320	009	0B9	000	0BB
10	2302	0319	7627	8512	700A	FAF	320	00A	0BA	000	0BB
11	2302	0319	7627	8920	700B	FAF	320	00B	0BB	000	0BB
12	2302	0319	7627	9328	700C	FAF	320	00C	0BC	001	0BB
13	2302	0319	7627	9736	700D	FAF	320	00D	0BD	002	0BB
14	2302	0319	7627	0553	700E	FAF	320	00E	0BE	004	0BB
15	2302	0319	7627	0961	700F	FAF	320	00F	0BF	006	0BB
16	2302	0319	7627	1369	7010	FAF	320	010	0C0	009	0BB
17	2302	0319	7627	1777	7011	FAF	320	011	0C1	00C	0BB
18	2302	0319	7627	2185	7012	FAF	320	012	0C2	010	0BB
19	2302	0319	7627	2593	7013	FAF	320	013	0C3	014	0BB
20	2302	0319	7627	2901	7014	FAF	320	014		018	0BB
21	2302	0319	7727	3309	7015	FAF	320	015	0C5	01D	0BB
22	2302	0319	7727	3717	7016	FAF	320	016	0C6	023	0BB
23	2302	0319	7727	4125	7017	FAF	320	017	0C7	028	0BB
24	2302	0319	7727	4533	7018	FAF	320	018	0C8	02E	0BB
25	2302	0319	7727	4941	7019	FAF	320	019	000	035	0BB
26	2302	0319	7727	5349	701A	FAF	320	01A	001	03B	0BB
27	2302	0319	7727	5757	701B	FAF	320	01B	002	042	0BB

The IRIG Chapter 4 Frame Format has been determined and can be recorded for later data reduction by Analysts.

## CONCLUSIONS

This example was based on a 12-bit word, 24 bit Frame Sync Encoder. If this had been based on an encoder using 8-bit words the SFID would be bit shifted. This shift would still be identified with this technique. To further investigate the SFID alignment, there is a binary Data Radix display mode for the Raw Data and Frame Buffers. The data can be paused and the displayed data can be reviewed to more easily identify the SFID rollover pattern in this binary form.

This investigative approach has been successfully used for 32 and 16-bit Frames Syncs also. Other word length data and Frame Syncs will require changing the bits per word after finding the proper Frame Sync pattern to align bit boundaries. Resulting fill data will need to be taken into account when determining the final Decom configuration.

## REFERENCES

- [1] Range Commanders Council Telemetry Group, Range Commanders Council, White Sands Missile Range, New Mexico, *IRIG Standard 106-15: Telemetry Standards*, 2015
- [2] Lumistar Inc., "P2" Platform PCM Decommutator LS-50-P2 (R5) Technical Manual, Document U500501, August 2008