INVESTIGATING UNKNOWN IRIG CHAPTER 4, CLASS I OR II FORMATS

Wayne Rettig
Principle Field Support Engineer
Lumistar, Inc.
2270 Camino Vida Roble Suite L Carlsbad, CA 92011
wrettig@lumistar.net

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.

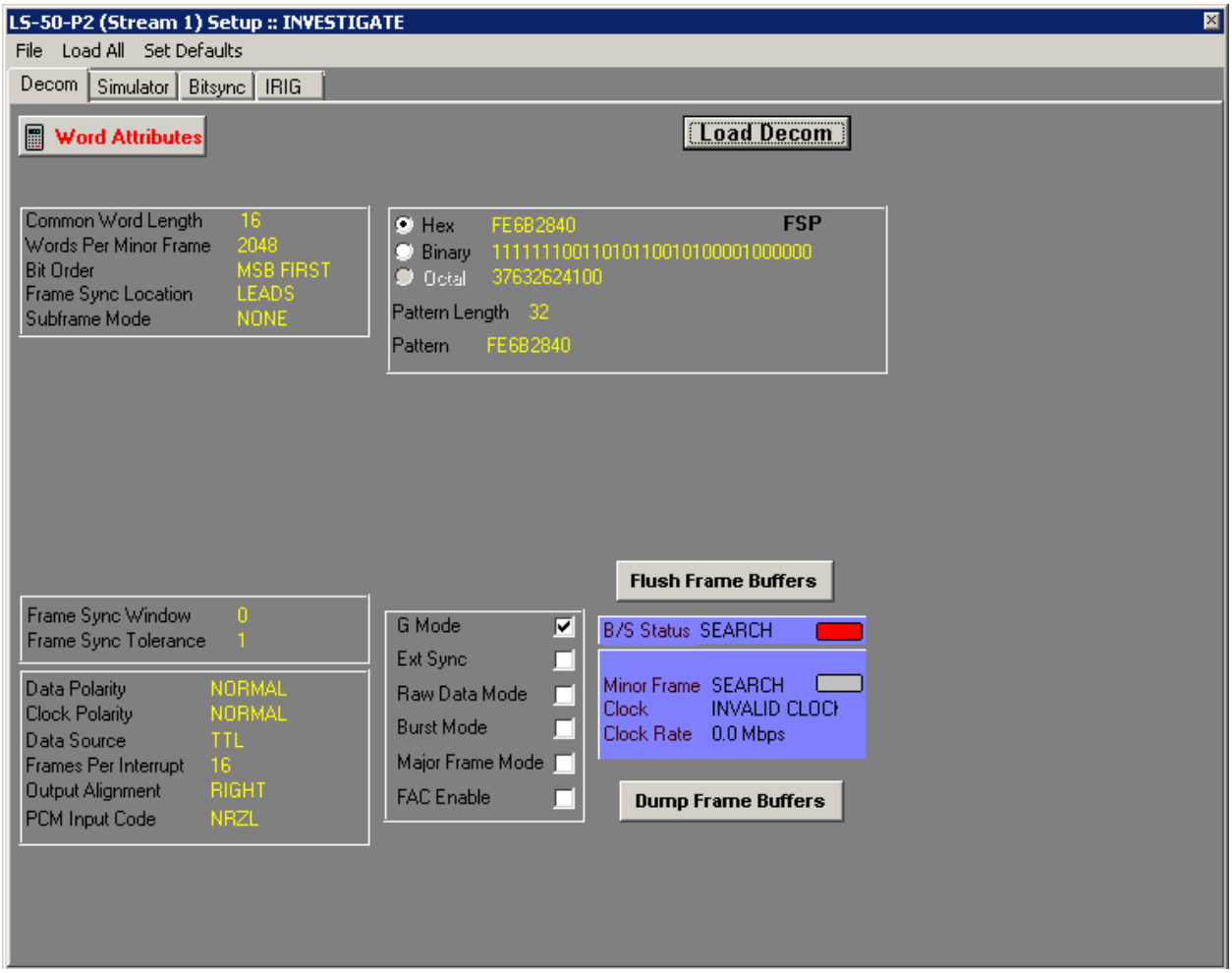


Figure 1: Initial Decom Setup

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 tying 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.

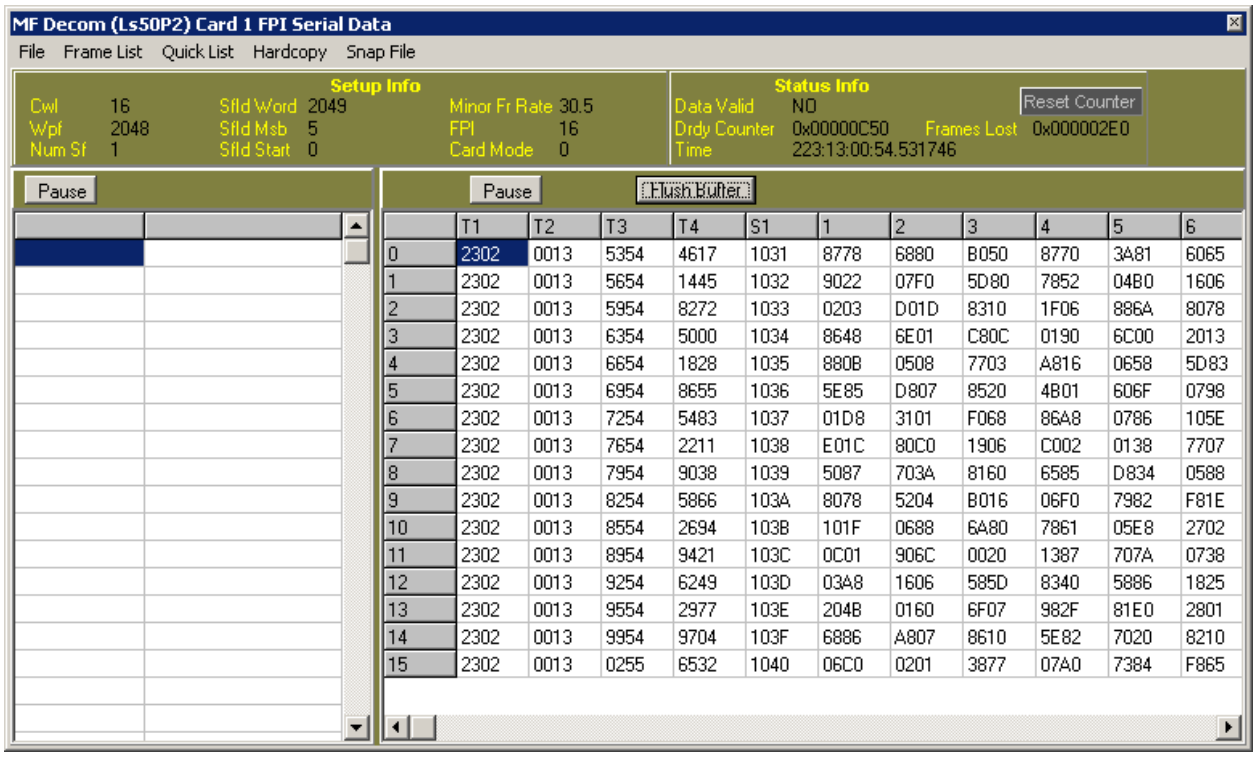


Figure 2: Raw Data Buffer, no 0xFE6B2840 pattern found

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

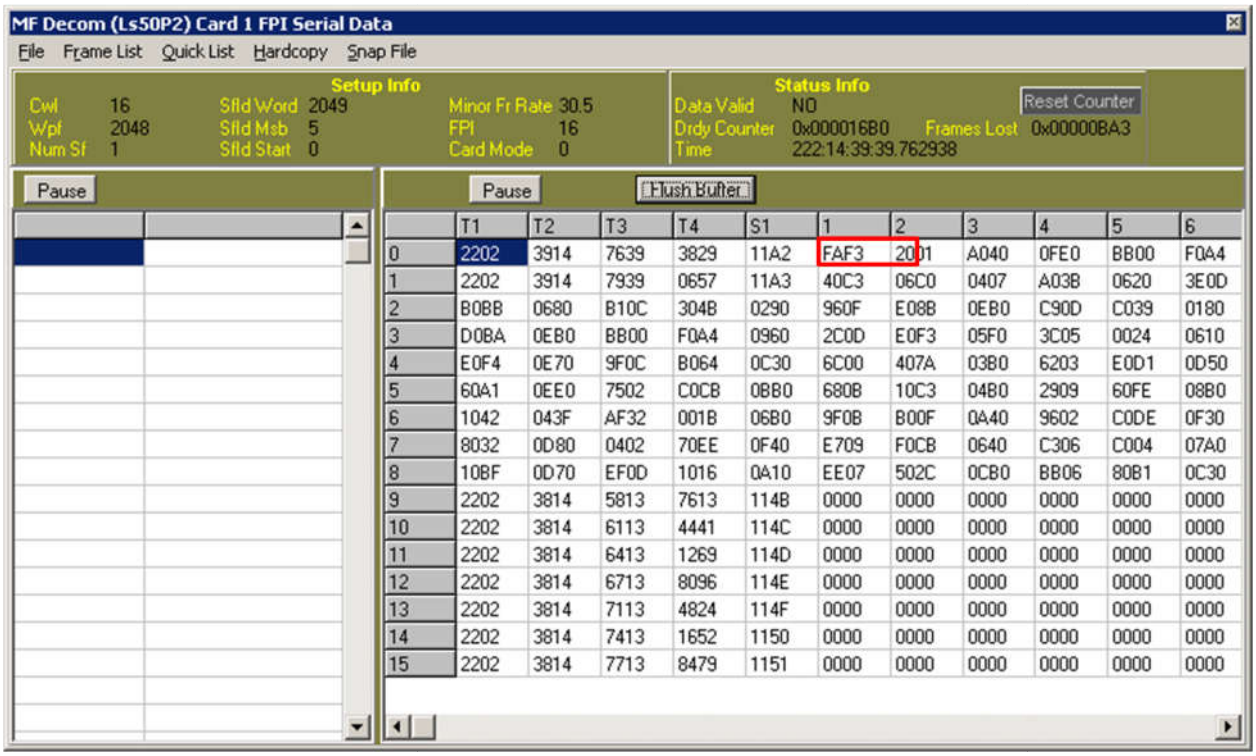


Figure 2: Raw Data Buffer, 0xFAF320 pattern found

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.

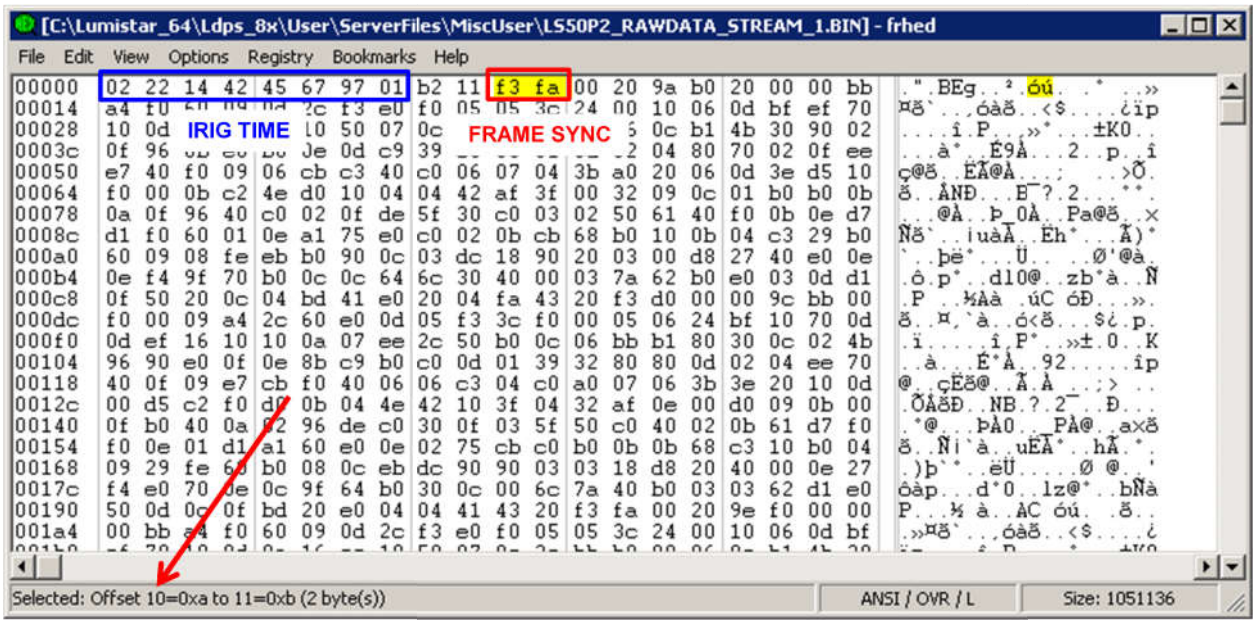


Figure 3: First Frame Sync location using a Hex Viewer

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.

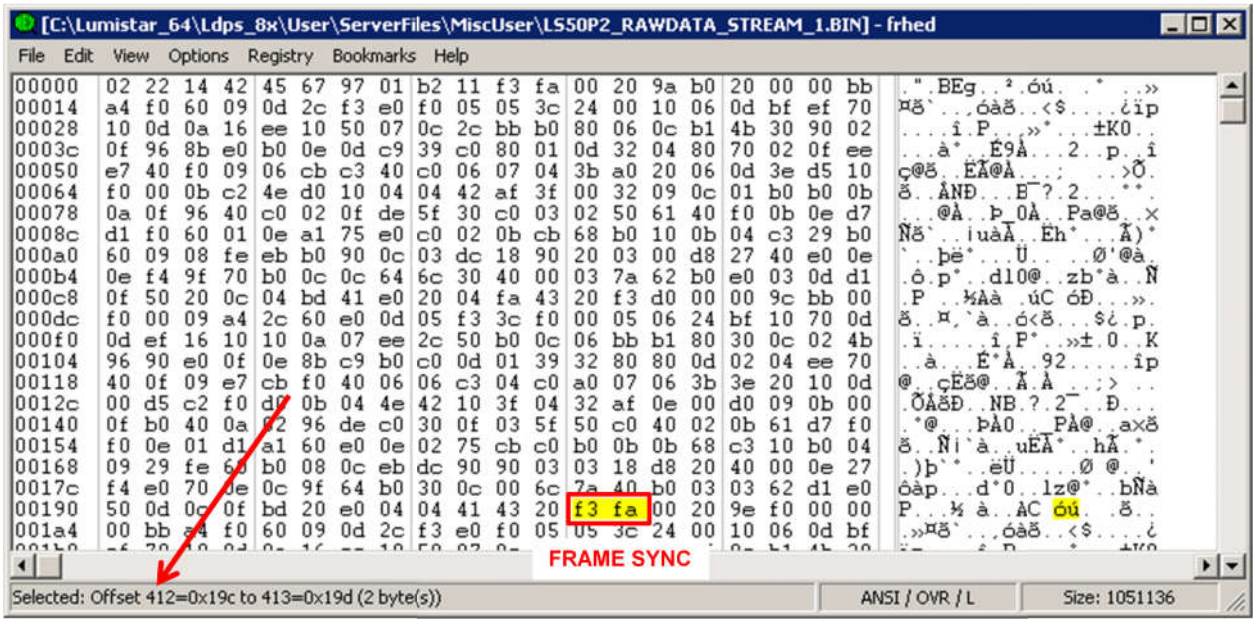


Figure 4: 2nd Frame Sync location

This Frame Sync has a 412 byte offset value.

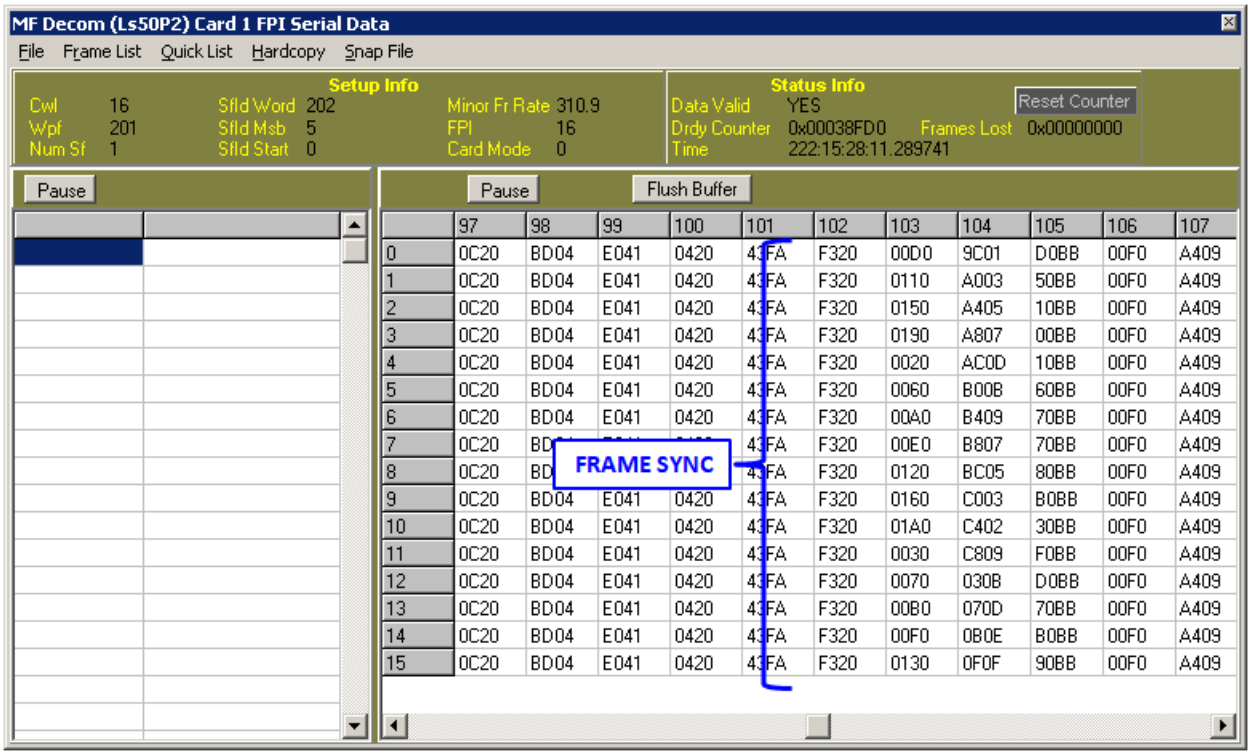
Looking 10 bytes to the left of the Frame Sync, shows there is no IRIG timestamp and Status bytes..Therefore Minor Frame length (the number of bytes between Frame Syncs) can be calculated.

(**412** bytes - **10** bytes) = **402** bytes or **201** 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.



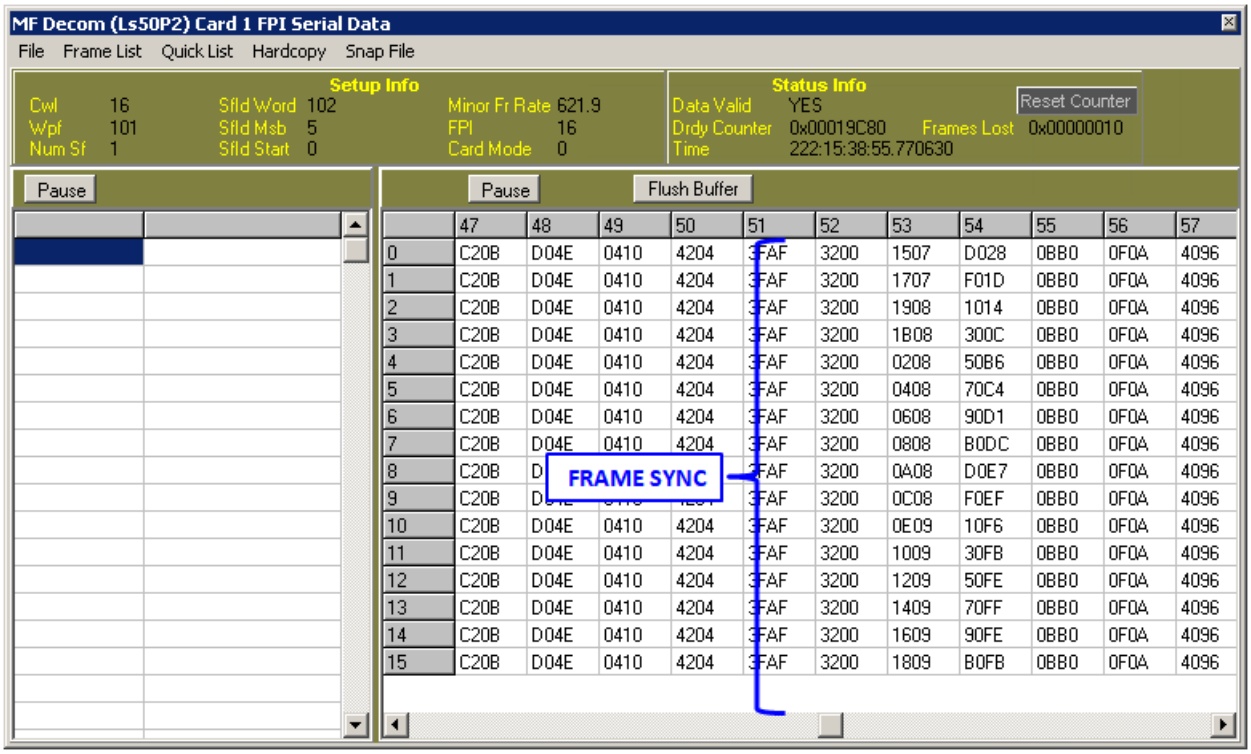
	97	98	99	100	101	102	103	104	105	106	107
0	0C20	BD04	E041	0420	43FA	F320	00D0	9C01	D0BB	00F0	A409
1	0C20	BD04	E041	0420	43FA	F320	0110	A003	50BB	00F0	A409
2	0C20	BD04	E041	0420	43FA	F320	0150	A405	10BB	00F0	A409
3	0C20	BD04	E041	0420	43FA	F320	0190	A807	00BB	00F0	A409
4	0C20	BD04	E041	0420	43FA	F320	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	BD			43FA	F320	00E0	B807	70BB	00F0	A409
8	0C20	BD			43FA	F320	0120	BC05	80BB	00F0	A409
9	0C20	BD04	E041	0420	43FA	F320	0160	C003	B0BB	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	B0BB	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** 16-bit words / **2**) = **100.5** 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.



	47	48	49	50	51	52	53	54	55	56	57
0	C20B	D04E	0410	4204	3FAF	3200	1507	D028	0BB0	0F0A	4096
1	C20B	D04E	0410	4204	3FAF	3200	1707	F01D	0BB0	0F0A	4096
2	C20B	D04E	0410	4204	3FAF	3200	1908	1014	0BB0	0F0A	4096
3	C20B	D04E	0410	4204	3FAF	3200	1B08	300C	0BB0	0F0A	4096
4	C20B	D04E	0410	4204	3FAF	3200	0208	50B6	0BB0	0F0A	4096
5	C20B	D04E	0410	4204	3FAF	3200	0408	70C4	0BB0	0F0A	4096
6	C20B	D04E	0410	4204	3FAF	3200	0608	90D1	0BB0	0F0A	4096
7	C20B	D04E	0410	4204	3FAF	3200	0808	B0DC	0BB0	0F0A	4096
8	C20B	D			3FAF	3200	0A08	D0E7	0BB0	0F0A	4096
9	C20B	D			3FAF	3200	0C08	F0EF	0BB0	0F0A	4096
10	C20B	D04E	0410	4204	3FAF	3200	0E09	10F6	0BB0	0F0A	4096
11	C20B	D04E	0410	4204	3FAF	3200	1009	30FB	0BB0	0F0A	4096
12	C20B	D04E	0410	4204	3FAF	3200	1209	50FE	0BB0	0F0A	4096
13	C20B	D04E	0410	4204	3FAF	3200	1409	70FF	0BB0	0F0A	4096
14	C20B	D04E	0410	4204	3FAF	3200	1609	90FE	0BB0	0F0A	4096
15	C20B	D04E	0410	4204	3FAF	3200	1809	B0FB	0BB0	0F0A	4096

Figure 7: Raw Data Buffer, 2ndrMid Frame Inspection

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

(**100.5** 16-bit words / **2**) = **50.25** 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** Word * **16** bits/Word) / **12** bits/Word = **67** 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.

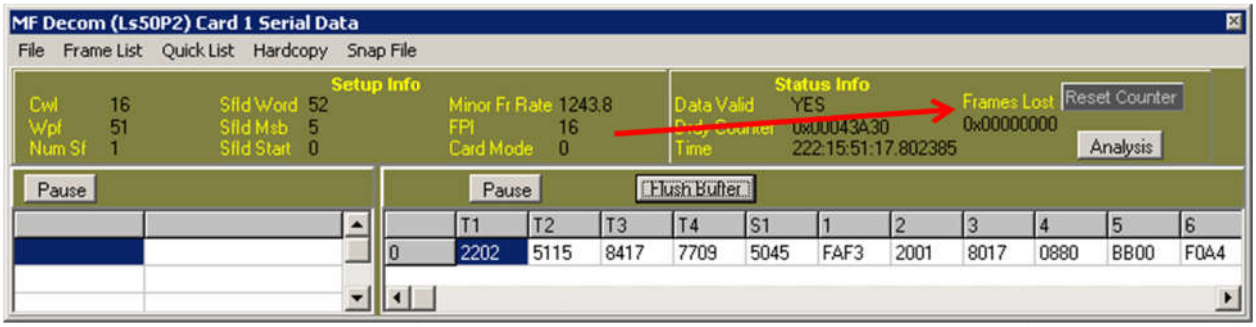


Figure 8: Frame Buffer Showing No Lost Frames

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.

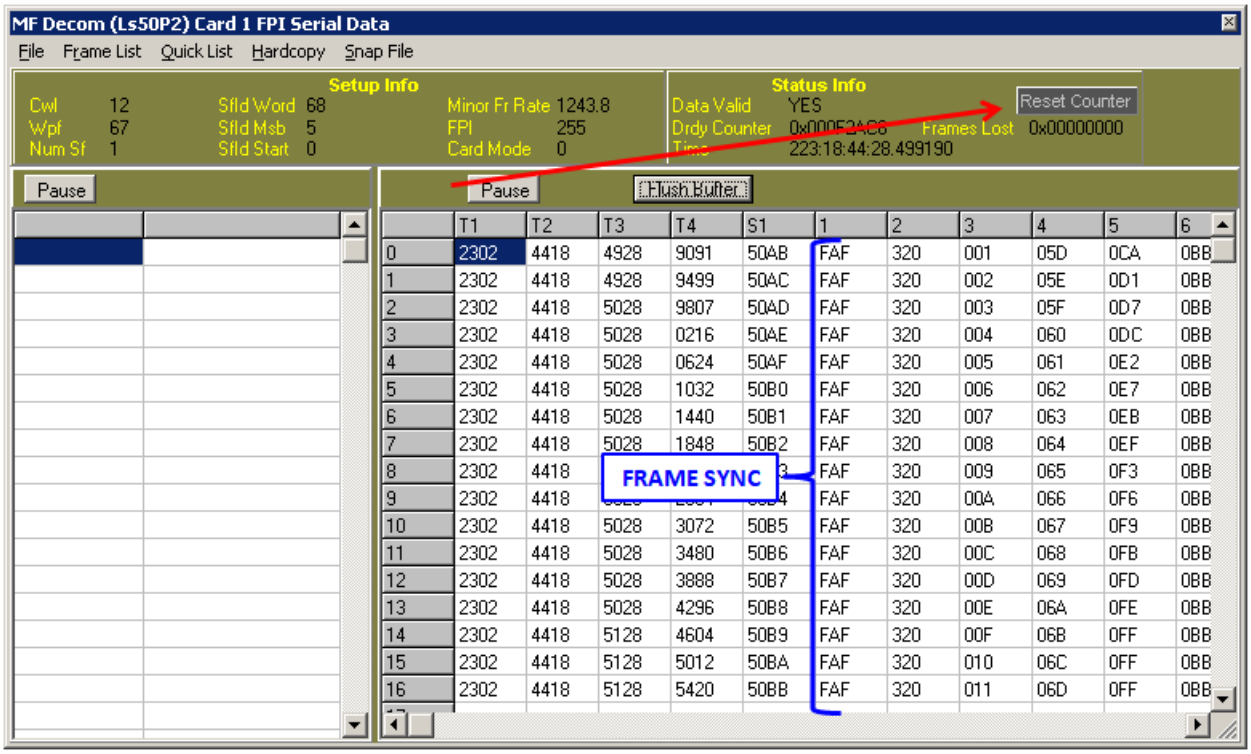


Figure 9: Raw Data Buffer Shows No Lost Frames

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.

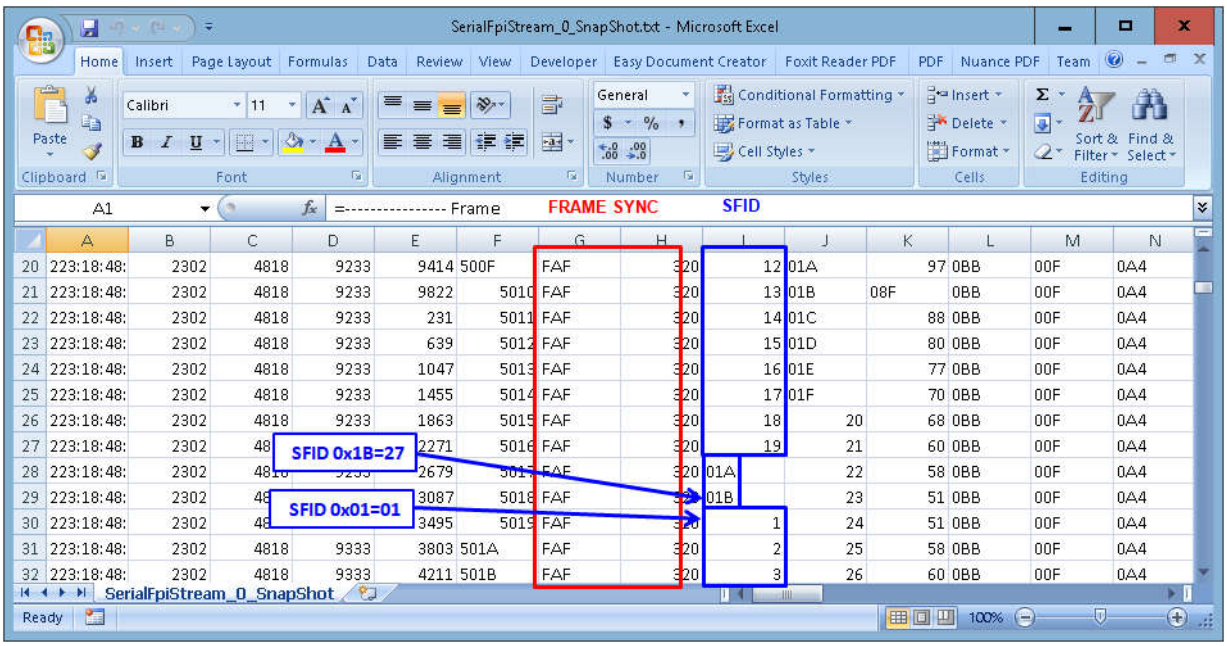


Figure 10: Reviewing Raw Data Snapshot for SFID Data

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.

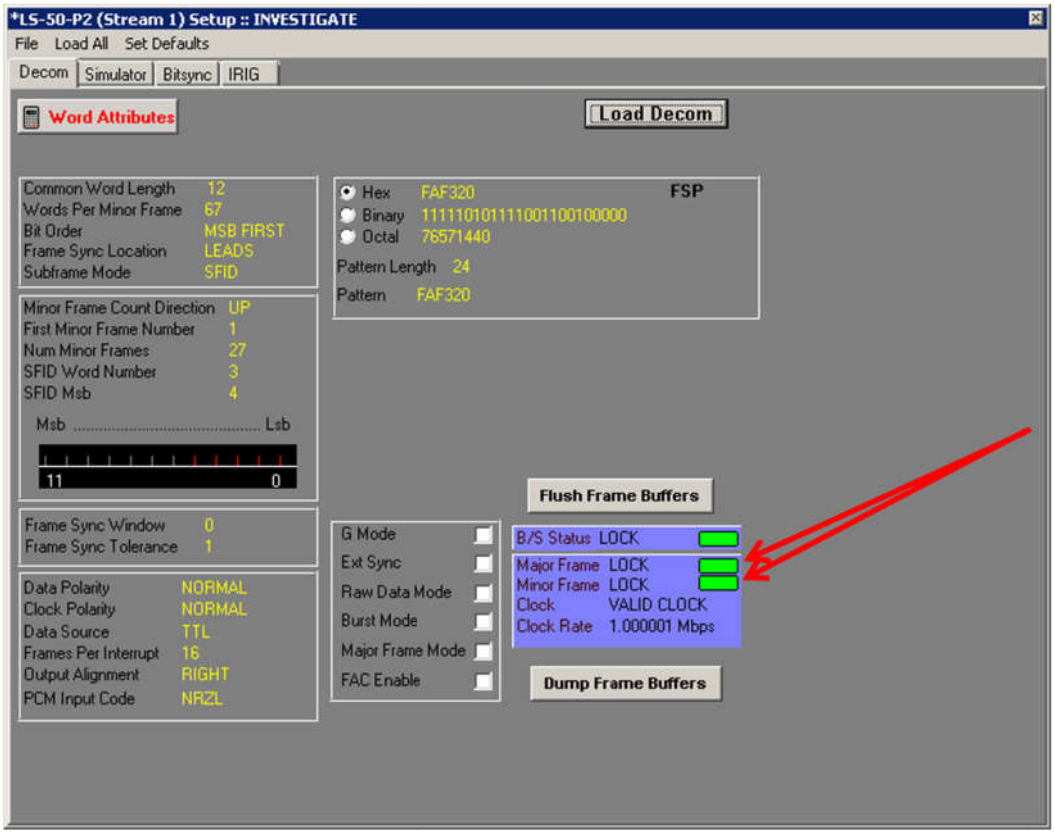
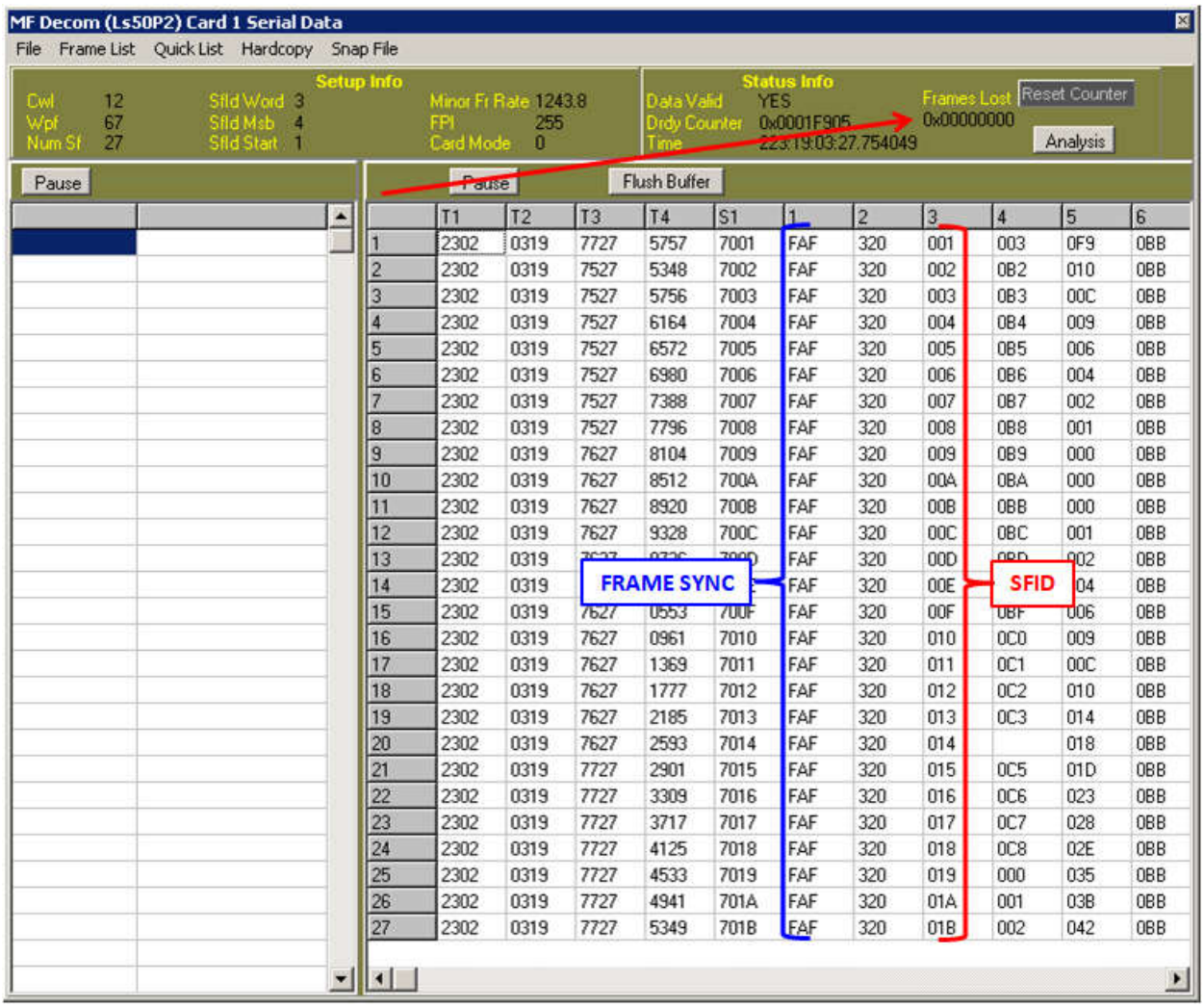


Figure 11: Final Decom Configuration with Solid Locks

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



	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				FAF	320	00D		002	0BB
14	2302	0319				FAF	320	00E		04	0BB
15	2302	0319	7627	0553	700F	FAF	320	00F	0BF	006	0BB
16	2302	0319	7627	0961	7010	FAF	320	010	0C0	009	0BB
17	2302	0319	7627	1369	7011	FAF	320	011	0C1	00C	0BB
18	2302	0319	7627	1777	7012	FAF	320	012	0C2	010	0BB
19	2302	0319	7627	2185	7013	FAF	320	013	0C3	014	0BB
20	2302	0319	7627	2593	7014	FAF	320	014		018	0BB
21	2302	0319	7727	2901	7015	FAF	320	015	0C5	01D	0BB
22	2302	0319	7727	3309	7016	FAF	320	016	0C6	023	0BB
23	2302	0319	7727	3717	7017	FAF	320	017	0C7	028	0BB
24	2302	0319	7727	4125	7018	FAF	320	018	0C8	02E	0BB
25	2302	0319	7727	4533	7019	FAF	320	019	000	035	0BB
26	2302	0319	7727	4941	701A	FAF	320	01A	001	03B	0BB
27	2302	0319	7727	5349	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