NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

October 26, 2015

Multiple Electronic Devices

Specialist's Factual Report
by Bill Tuccio, Ph.D.

1. EVENT

Location: West Columbia, South Carolina
Date: May 23, 2015
Aircraft: BR Legend LLC Turbine Legend
Registration: N42BR
Operator: Private
NTSB Number: ERA15FA221

On May 23, 2015, about 0921 eastern daylight time, an experimental amateur built BR Legend LLC Turbine Legend, N42BR, registered to BR Legend LLC, operated by a private individual, collided with trees and a pond approximately 1.2 nautical miles west of the Columbia Metropolitan Airport (CAE), West Columbia, South Carolina. Visual meteorological conditions prevailed at the time and a visual flight rules (VFR) flight plan was filed for the 14 *Code of Federal Regulations* Part 91 personal flight from CAE to Asheville Regional Airport (AVL), Asheville, North Carolina. The airplane was destroyed and the commercial pilot and a dog were fatally injured. The flight originated from CAE about 0914.

2. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following Electronics International (EI) cockpit instruments:

Device 1:   EI Oil Temperature and Pressure Instrument (OPT-1)
Device 1 Serial Number: 33441

Device 2:   EI Torque Instrument (M-1-T-300)
Device 2 Serial Number: 36447

Device 3:   EI N1 Instrument (R-1-N1)
Device 3 Serial Number: 33445

Device 4:   EI N2 Instrument (R-1-N2)
Device 4 Serial Number: 33447

Device 5:   EI ITT Instrument (M-1-ITT)
Device 5 Serial Number: ending in "45"[1]

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[1] Due to damage, the serial number was illegible.

Device 6:   EI Fuel Level Instrument (FL-1CA)
Device 6 Serial Number: Unknown[1]

2.1. EI Instruments Device Description

EI instruments are electronic instruments capable of displaying information for specific engine related parameters needed by the pilot including: oil pressure, oil temperature, compressor speed (N1), propeller speed (N2)[2], inter-turbine temperature (ITT), torque, and fuel levels. A limited history of parametric data and instrument settings may be recovered from non-volatile memory[3] (NVM) on the devices; this data may only be recovered by a direct read of the NVM and is intended for manufacturer purposes. The sampling rate of the history is generally greater than once every 2 minutes.

The fuel level instrument (FL-1CA) uses resistive or capacitive probes to measure fuel tank level.

2.1.1. EI Instruments Data Recovery

Upon arrival at the Vehicle Recorder Division, an exterior examination revealed the EI instruments had sustained various degrees of structural damage. Figures 1 through 6 show the instrument and the NVM located on the respective device's printed circuit board (PCB); the NVM chip is annotated in red. The NVM chip was removed from each PCB and a raw-data binary readout was obtained using a Xeltek SP3000u EEPROM programmer. The raw-binary readout was decoded with assistance from the manufacturer, EI.

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[2] This report assumes N1 was measuring compressor speed and N2 was measuring propeller RPM based on values retrieved.
[3] Non-volatile memory is semiconductor memory that does not require external power for data retention.

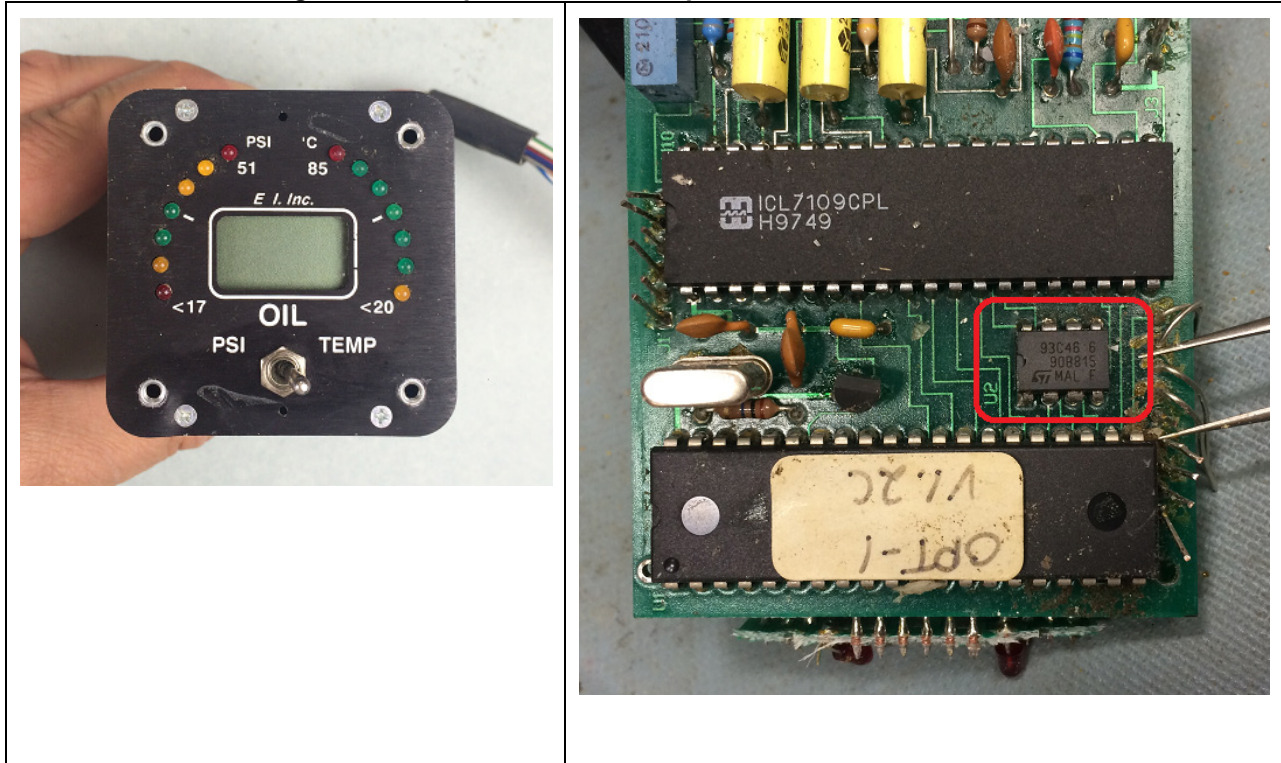**Figure 1. EI Oil pressure and temperature instrument and NVM.**
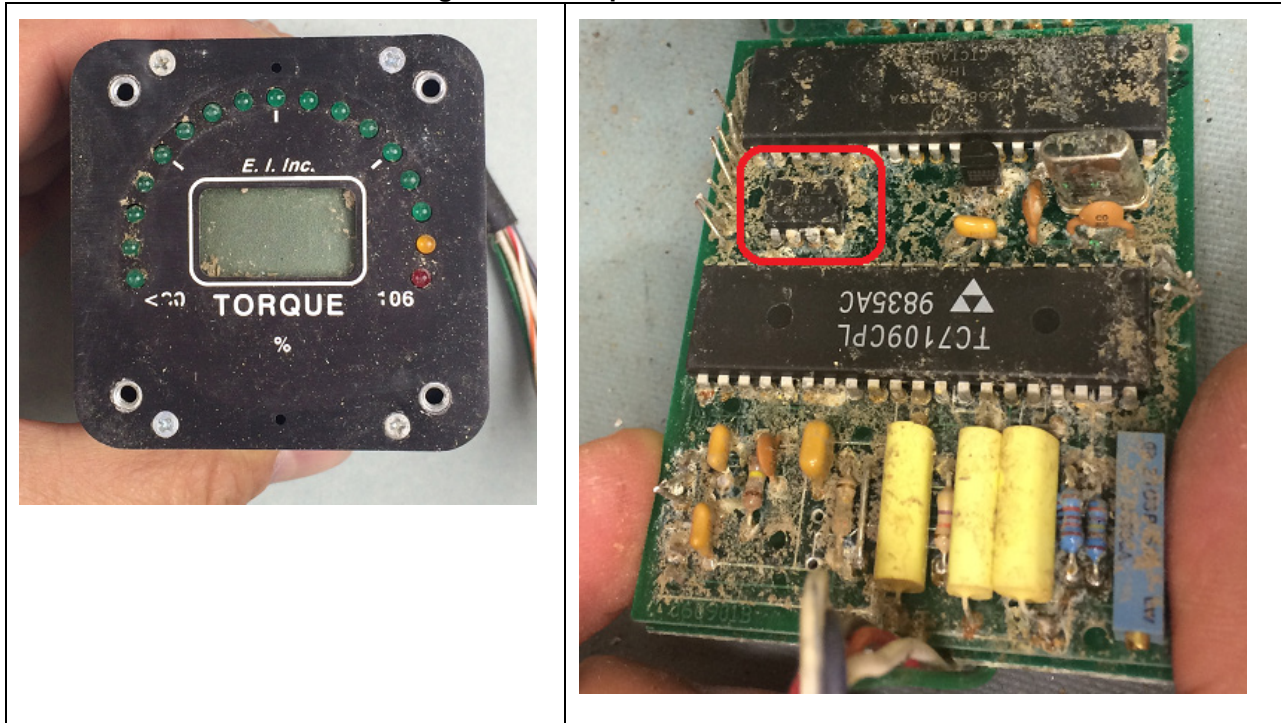

Figure 2. EI torque instrument and NVM.
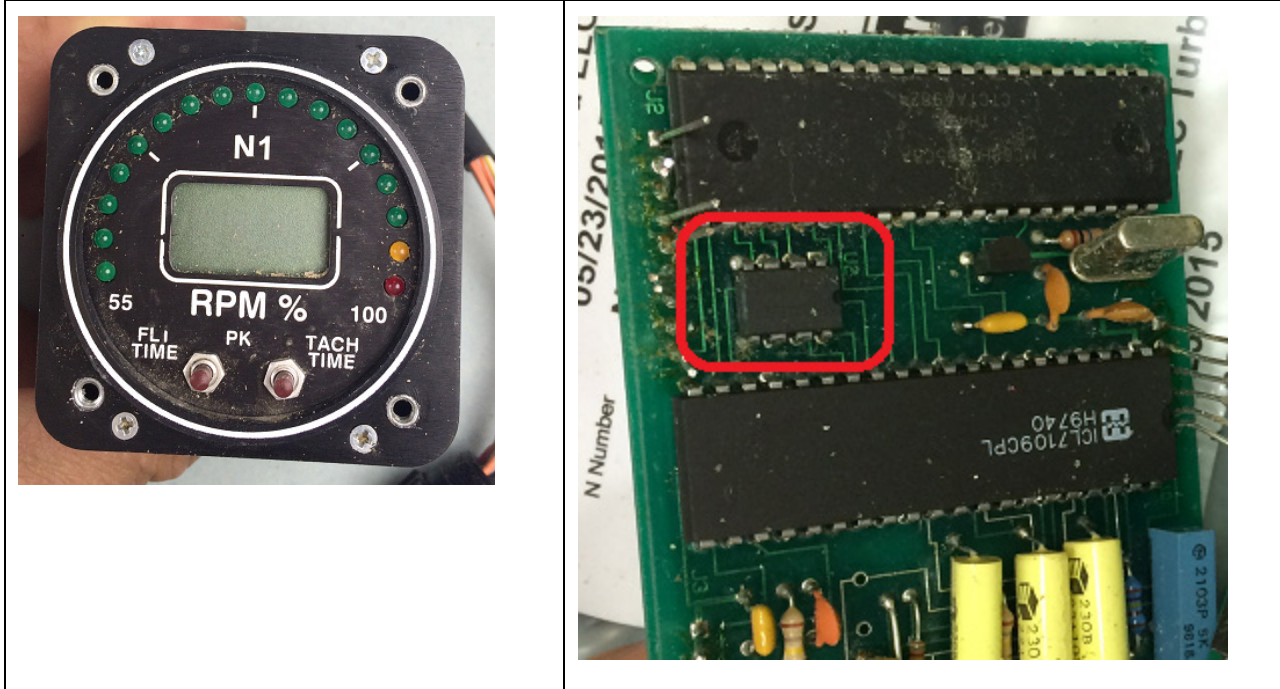
Figure 3. EI N1 instrument and NVM.

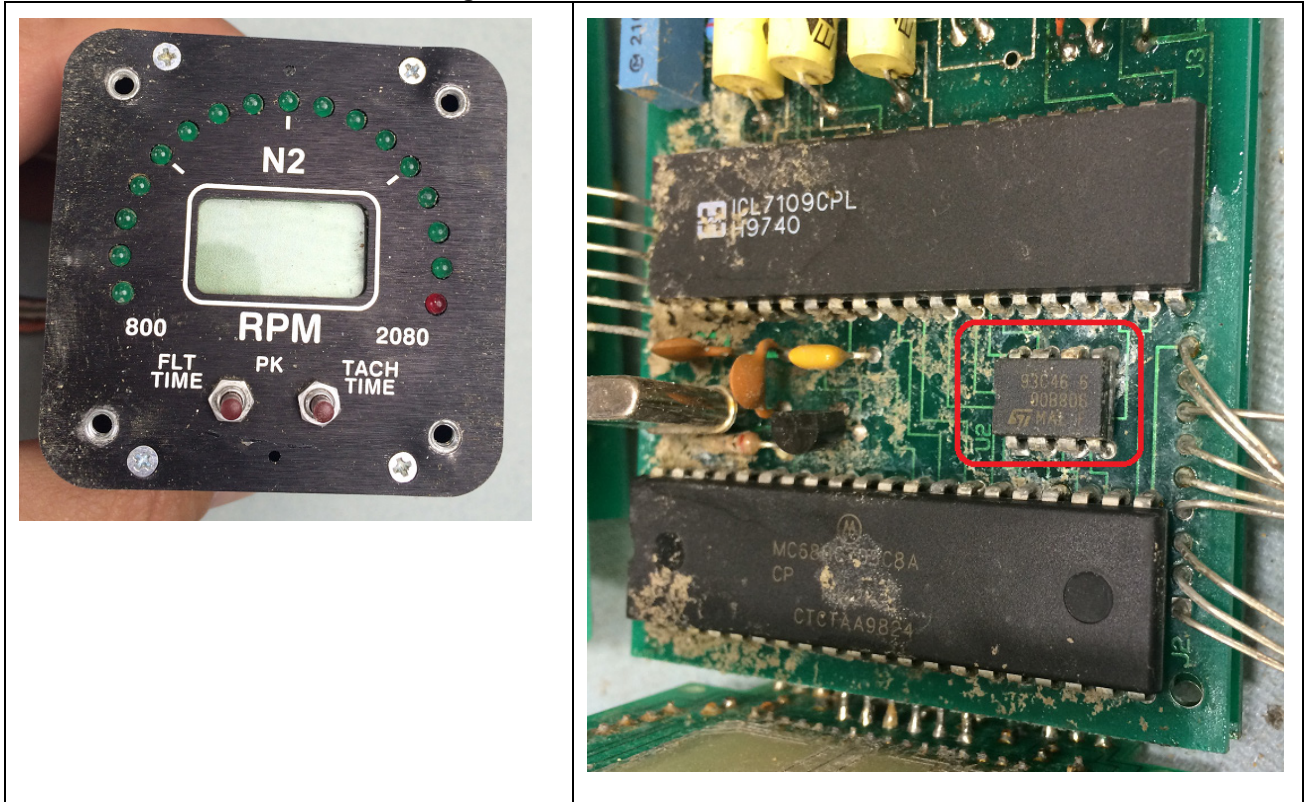**Figure 4. EI N2 instrument and NVM.**

Figure 5. EI ITT instrument and NVM.

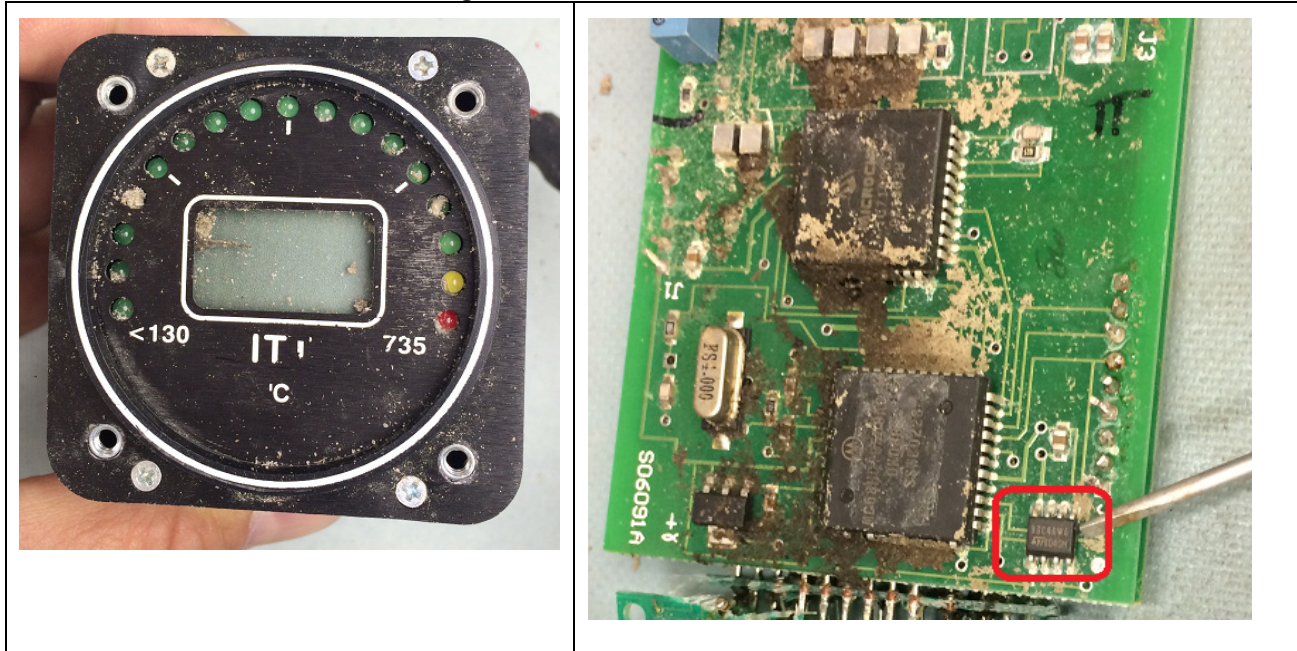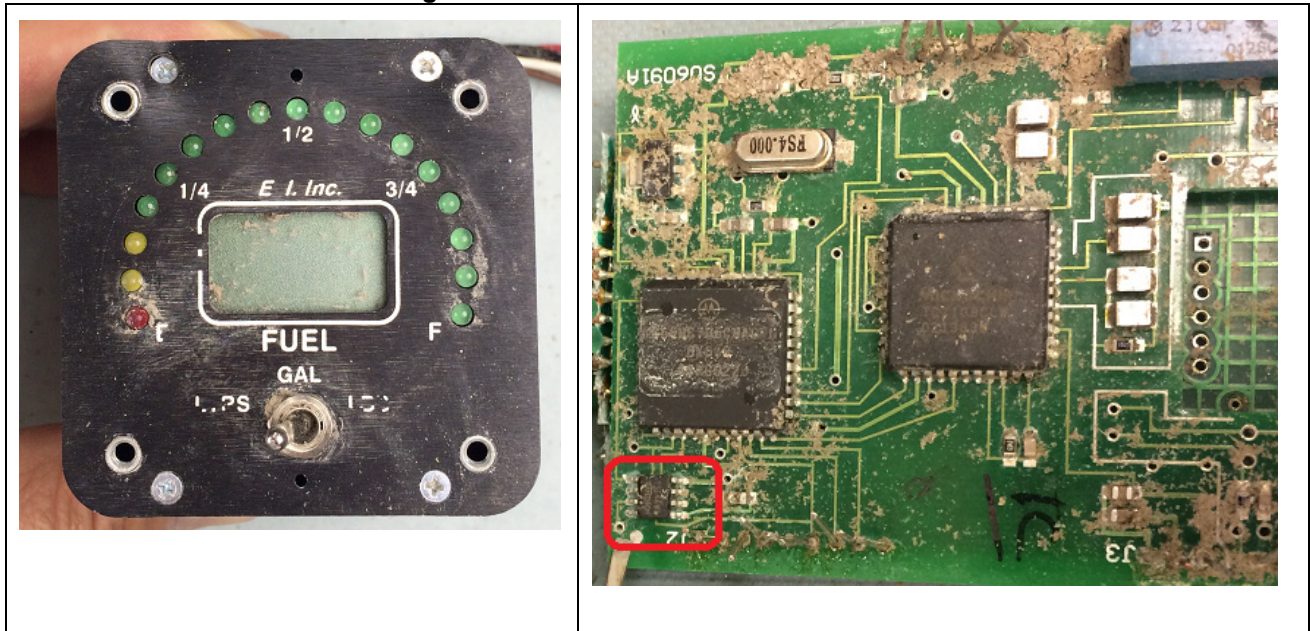**Figure 6. EI fuel level instrument and NVM.**

2.1.2. EI Instruments Data Description

Raw data was recovered from all devices' NVM and the raw data was converted to engineering units using documentation provided by the manufacturer.

Only recorded data related to the last power cycle are shown for each instrument. The time scale is time elapsed since power was applied to the instrument. Based on

documentation from the manufacturer, the accuracy of the time interval is expected to be within +/-30 seconds.

2.1.2.1. EI Oil Temperature and Pressure Instrument Data Description

Table 1 provides recorded oil pressure and temperature. Oil pressure is reported in pounds per square inch (psi) and oil temperature in degrees Fahrenheit (degC).

Table 1. Oil temperature and pressure last recorded values.

Elapsed Seconds	Pressure (psi)	Temperature (degC)
236	17	15º
472	34	49º
708	31	57º

2.1.2.2. EI Torque Instrument Data Description

Table 2 provides recorded torque. Torque is reported in percent (%) of maximum.

Table 2. Torque last recorded values.

Elapsed Seconds	%
218	14
436	78
654	17

2.1.2.3. EI N1 Instrument Data Description

Table 3 provides recorded N1. N1 is reported in percent (%) of maximum. Only one value was present in the last recording.

Table 3. N1 last recorded values.

Elapsed Seconds	%
163	58.4

2.1.2.4. EI N2 Instrument Data Description

Table 4 provides recorded N2. N2 is reported as revolutions per minute (RPM). Only one value was present in the last recording.

Table 4. N2 last recorded values.

Elapsed Seconds	RPM
163	1950

2.1.2.5. EI ITT Instrument Data Description

Table 5 provides recorded ITT. ITT is reported as degC.

Table 5. N2 last recorded values.

Elapsed Seconds	degC
217	485º

| 434 | 620º |
| 651 | 410º |

2.1.2.6. EI Fuel Level Instrument Data Description

Table 6 provides recorded fuel level in gallons. The instrument was calibrated such that the maximum fuel level was 91 gallons.

Table 6. Fuel level last recorded values.

Elapsed Seconds	Gallons
480	91

All other EI gauges in this report used binary coded decimal conversions (BCD); whereby, the hexadecimal values were interpreted as decimal numbers. The fuel level instrument recorded fuel level history as unsigned integers. Due to the difference in conversions for the fuel level gauge (relative to other gauges in this report), table 7 provides the raw, binary data from the fuel level gauge. Four column-sets of information are presented representing all NVM data (a total of 128 bytes): decimal byte position followed by the raw-binary data expressed as the hexadecimal value (hex). Last recorded values are in byte positions 75 and 76 and are highlighted in yellow.[4]

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[4] Using byte positions 75 and 76 as an example, the conversion from hexadecimal to gallons is: $((05B0\&H)_{10})/16$.

Table 7. Fuel level raw-binary data.

Byte Position	Hex Value	Byte Position	Hex Value	Byte Position	Hex Value	Byte Position	Hex Value
1	00	33	FF	65	FF	97	50
2	E0	34	0F	66	FF	98	04
3	20	35	FF	67	FF	99	03
4	D0	36	0F	68	FF	100	04
5	40	37	FF	69	FF	101	79
6	D0	38	FF	70	FF	102	03
7	60	39	FF	71	FF	103	73
8	D0	40	FF	72	FF	104	03
9	80	41	FF	73	F9	105	F9
10	D0	42	FF	74	20	106	02
11	91	43	FF	75	**B0**	107	60
12	F0	44	FF	76	**05**	108	03
13	00	45	FF	77	FF	109	FF
14	D0	46	FF	78	FF	110	FF
15	00	47	FF	79	17	111	FF
16	D0	48	FF	80	05	112	FF
17	00	49	FF	81	70	113	6F
18	D0	50	FF	82	03	114	04
19	34	51	FF	83	67	115	6F
20	06	52	FF	84	03	116	04
21	D4	53	FF	85	51	117	FF
22	07	54	FF	86	03	118	FF
23	4F	55	FF	87	D7	119	68
24	08	56	FF	88	03	120	04
25	B6	57	FF	89	FF	121	FF
26	08	58	FF	90	FF	122	FF
27	15	59	FF	91	FF	123	FF
28	09	60	FF	92	FF	124	FF
29	3B	61	FF	93	FF	125	FF
30	09	62	FF	94	FF	126	FF
31	FF	63	FF	95	FF	127	FF
32	0F	64	FF	96	FF	128	FF