SEE Test Plan V2.0
Heavy ion SEE test of SMFLHP2815S from Interpoint

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Test Date(s): March 2-6, 2010

I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the SMFLHP2815S, Single DC/DC Converters, for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Radiation Effects Facility at The Cyclotron Institute located on the campus of Texas A&M University. This test was performed for the investigation of radiation susceptibility of transient events and destructive events for Crane Interpoint. This work was in conjunction with the NASA Electronics Parts and Packaging (NEPP) Program. NEPP is a HQ sponsored program that seeks to find new developments that will benefit NASA.

II. Devices Tested

The sample size of Device Under Test (DUT) for testing was two. Each device was exposed to the radiation beam and the results will be compared for verification. For the SMFLHP2815S, the test samples code markings for DUT1 is SN-0161 & DUT2 SN-0141 with DC-0623 on both. The device is packaged in a 12-pin lead metal can package. The device was prepped for test by delidding. The SMFLHP series 28 volt DC/DC converters are rated up to 100 watts output power over a temperature range -55C to +125C with a 28V DC nominal input. Dual input models, up to 70% of the rated output power can be drawn from either the positive or negative outputs. Current sharing allows the units to be paralleled for total power of up to 228 watts. The welded, hermetically sealed package is only 3.005 x 1.505 x 0.400 inches, giving the series an overall power density of up to 67 watts per cubic inch.

The SMFLHP series are switching regulators that use a quasi-square wave, single ended forward converter design with a constant switching frequency of 600 kHz. Isolation between input and output circuits is provided with a transformer in the forward path and wide bandwidth magnetic coupling in the feedback control loop. These devices use a unique dual loop feedback technique that controls output current with an inner feedback loop and output voltage with a cascaded voltage mode feedback loop. An additional secondary current mode feedback loop improves transient response in a manner similar to primary current mode control and allows for ease of paralleling.

III. Test Facility

Facility: Texas A&M Cyclotron Radiation Effects Facility, 15 MeV/u beams
Flux: 5.49×10^2 to 1.45×10^5 particles/cm^2/s.

Fluence: For destructive events, all tests were ran to 1 x 10^6 p/cm^2 or until destructive events occurred
For non destructive events, all tests were ran to 1 x 10^6 p/cm^2 or until a sufficient (>100) number of transient events occurred.

The ions and LET values used for these tests are Xe & Ta.

IV. Test Conditions and Error Modes

Test Temperature: Room Temperature
Bias conditions V_{in} = 28V, V_{out} = +/-15V
See Figure 2 for detailed conditions

	Vsupply (V)	Isupply (A)	Vin (V)	Loading %
DUT 1	+15/-15	.057	28V	0
DUT 1	+15/-15	1.34	28V	30
DUT 1	+15/-15	2.17	28V	50
DUT 1	+15/-15	1.76	21V	30
DUT 1	+15/-15	1.10	35V	30
DUT 2	+15/-15	.056	28V	0
DUT 2	+15/-15	1.33	28V	30
DUT 2	+15/-15	2.15	28V	50
DUT 2	+15/-15	1.74	21V	30
DUT 2	+15/-15	1.10	35V	30

Table 1: Test conditions

PARAMETERS OF INTEREST: Power supply currents, output voltage

SEE Conditions: SEL, SEGR, SET

V. Test Methods

The block diagram, as shown in Figure 1, for the DC-DC Converters contains a power supply for +/- input voltages, an electronic load, a DUT board for the test circuitry and devices, a computer for GPIB control of measurement equipment, and a digital scope to capture any output anomalies, and after the desired voltage input is applied, each of the two device outputs will display on the digital scope, which is set to trigger on voltages that are above or below a predetermined threshold (set to 250 mV). Each device output was tested one after each other.

Table 1, shows the test conditions where tests were conducted for an input nominal voltage of 28V with and without loading and also with worse case conditions of 21V and 35V with 30% loading. Figure 2, shows the test schematic circuit of the SMFLHP2815S and Figure 3, shows the device and test board mounted at the beam at TAMU.

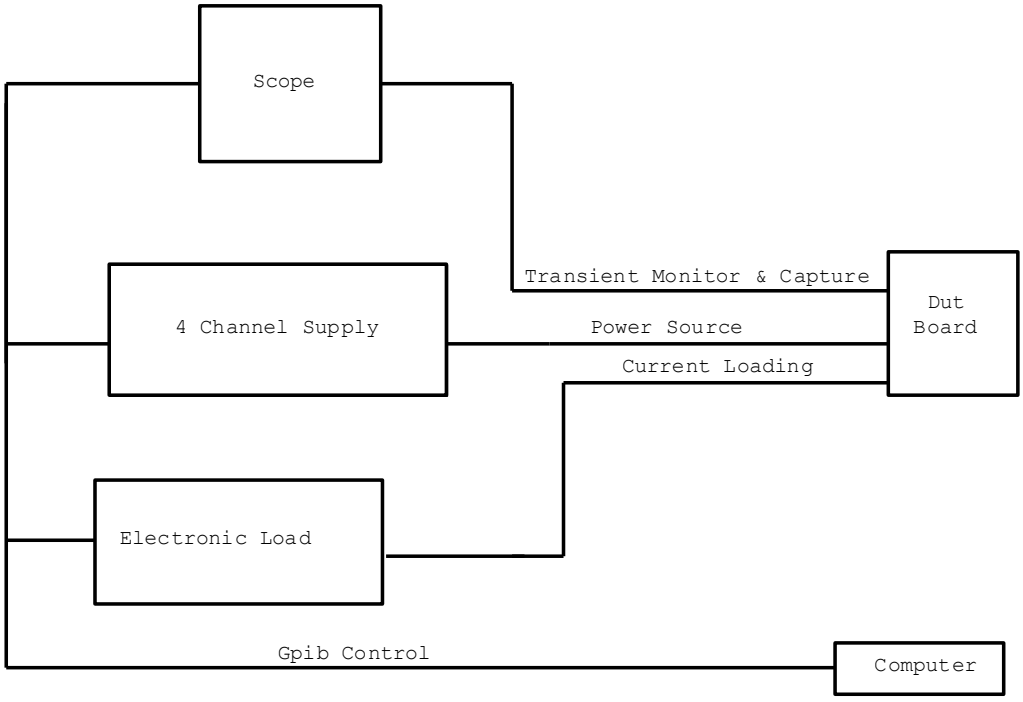


Figure 1. Overall Block Diagram for the testing of the SMFLHP2815S

VI. Test Performance

- Destructive test at high LET (>79 MeVcm^2/mg) on 2 parts up to a fluence of 10^6 #/cm^2.
- SET test on 2 parts for at least 2 LET values (starting from lowest LET) for each device output and each condition described in Table 1.

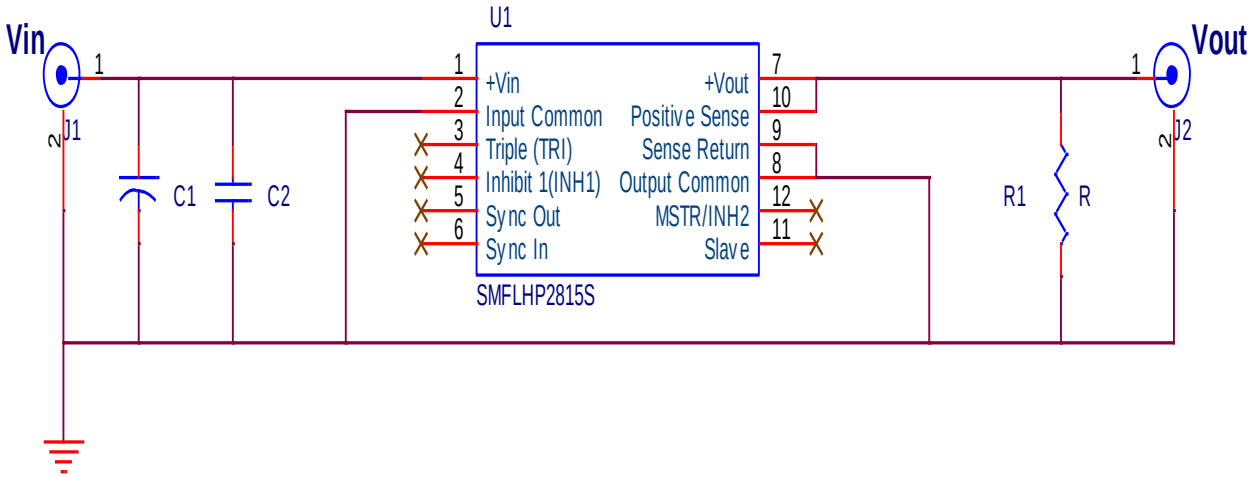


Figure 2. Overall Block Diagram for the testing of the SMFLHP2815S

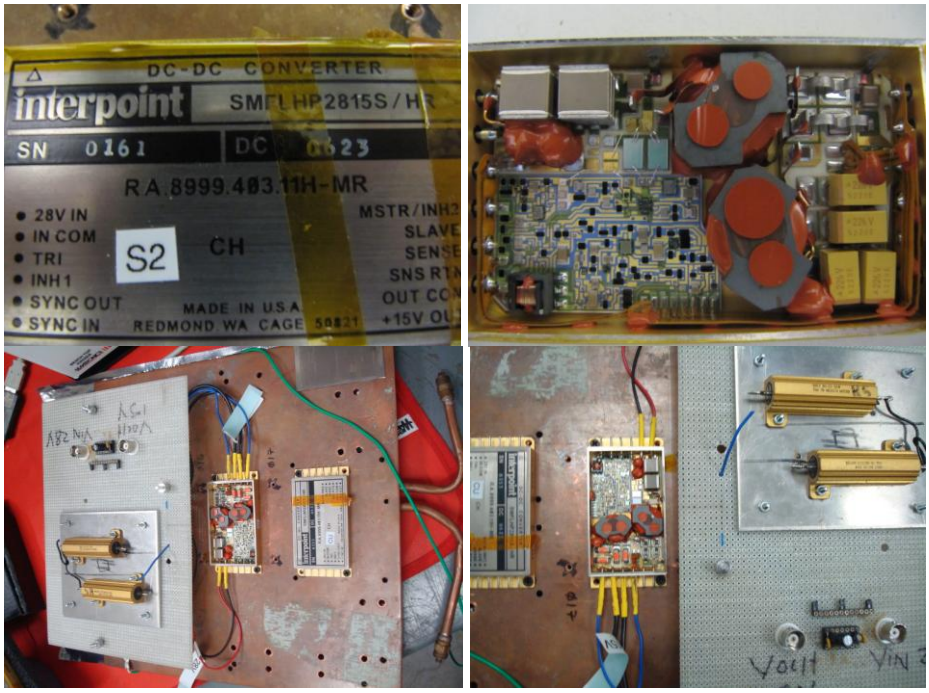
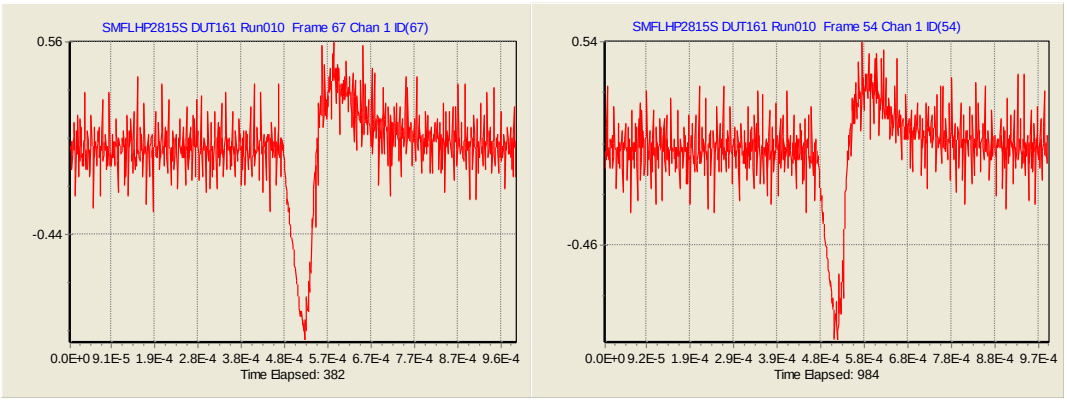


Figure 3. SMFLHP2815S mounted to metal plate to dissipate heat during test at TAMU

VII. Test Results

Detailed test results are shown in Table 2 below. The devices were exposed from a fluence of 8.49 x 10^3 to 3.03 x 10^6 particles/cm^2 of the Xenon and Tantalum ion beams. Observations for destructive and non-destructive events were for energies up to the maximum LET of 79 MeV-cm^2/mg at normal angle of incidence. There were no destructive events observed for the SMFLH2815S, but the device was sensitive to SETs

and did experience transient events that can be mitigated with using the appropriate LC filtering circuitry in conjunction with this DC-DC converter, with the worse case occurring around -1V of peak and 200us for worse case width duration. Charts 1 & 2 show the worse case transients and Chart 3 shows the SET cross sections observed. The tests were run with an input of 28V with no loading and with 30% loading and additional runs were with worse case, 21V, & 35V at 30% & 50% loading conditions. In general most SETs were small; therefore this device is suitable for space applications.



Charts 1&2. Typical Worse Case Transients of approx -1V peak and 200us

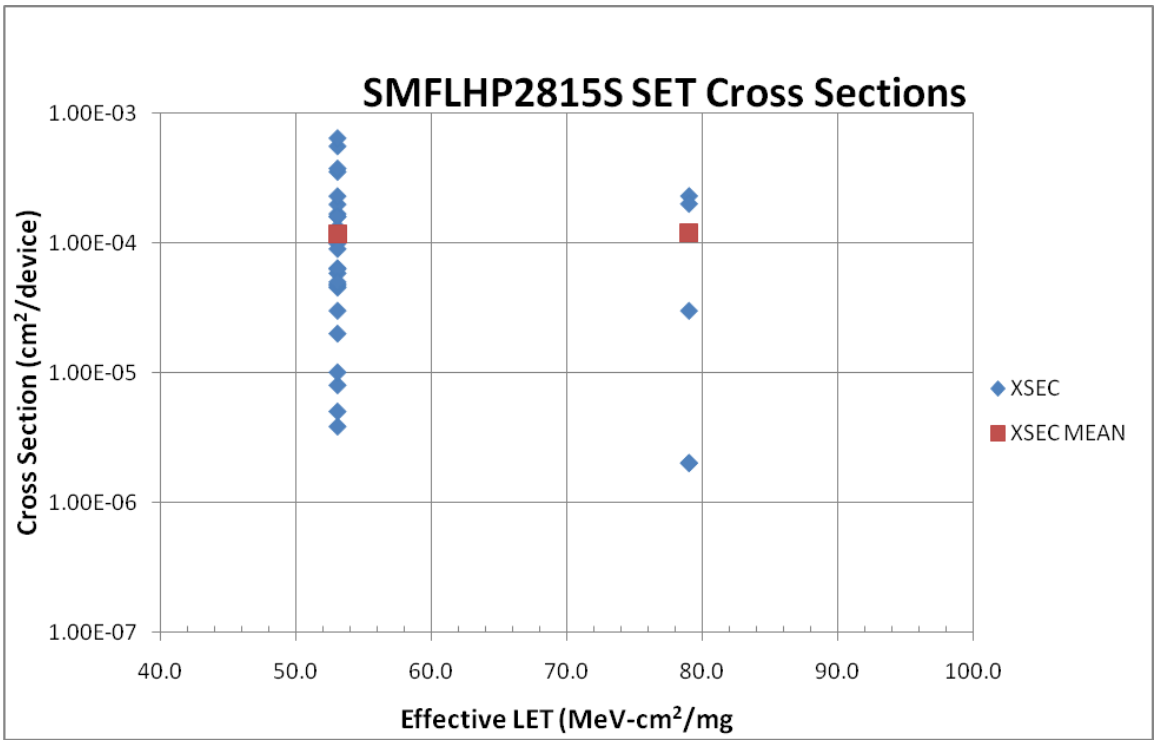


Chart 3. SMFLHP2815S SET Cross Sections

Run#	Part #	Serial	DC	Sect	Voltage	Trig	Current(A)	Load(A)	Ion	Energy	LET	LET(eff)	angle	Flux	$Fluence_{eff}$	SET	SEL	σ_{seu}
1	SMFLHP2815S	0161	0623	3	28	14	0.057	0	Xe-15	1366	53.1	53.1	0	8.93E+03	3.03E+06	0	0	0.00E+00
2	SMFLHP2815S	0161	0623	3	28	14.5	0.057	0	Xe-15	1366	53.1	53.1	0	1.44E+05	8.49E+03	0	0	0.00E+00
3	SMFLHP2815S	0161	0623	3	28	14.75	0.057	0	Xe-15	1366	53.1	53.1	0	1.45E+05	2.43E+06	110	0	4.53E-05
4	SMFLHP2815S	0161	0623	3	28	14.75	1.34	2	Xe-15	1366	53.1	53.1	0	1.11E+04	1.01E+06	59	0	5.84E-05
5	SMFLHP2815S	0161	0623	3	28	14.5	1.34	2	Xe-15	1366	53.1	53.1	0	1.19E+04	1.30E+06	5	0	3.84E-06
6	SMFLHP2815S	0161	0623	3	28	14.5	1.34	2	Xe-15	1366	53.1	53.1	0	1.21E+04	1.00E+06	8	0	8.00E-06
7	SMFLHP2815S	0161	0623	3	35	14.5	1.1	2	Xe-15	1366	53.1	53.1	0	1.29E+04	1.62E+06	76	0	4.69E-05
8	SMFLHP2815S	0161	0623	3	21	14.5	1.76	2	Xe-15	1366	53.1	53.1	0	1.27E+04	9.99E+05	0	0	0.00E+00
9	SMFLHP2815S	0161	0623	3	21	14.5	1.76	2	Xe-15	1366	53.1	53.1	0	1.25E+04	8.10E+05	136	0	1.68E-04
10	SMFLHP2815S	0161	0623	2	21	14.5	1.76	2	Xe-15	1366	53.1	53.1	0	1.25E+04	4.35E+05	154	0	3.54E-04
11	SMFLHP2815S	0161	0623	2	28	14.5	1.34	2	Xe-15	1366	53.1	53.1	0	1.25E+04	9.07E+05	119	0	1.31E-04
12	SMFLHP2815S	0161	0623	2	35	14.5	1.1	2	Xe-15	1366	53.1	53.1	0	1.28E+04	1.00E+06	64	0	6.40E-05
13	SMFLHP2815S	0161	0623	1	35	14.5	1.1	2	Xe-15	1366	53.1	53.1	0	1.32E+04	9.98E+05	30	0	3.01E-05
14	SMFLHP2815S	0161	0623	1	28	14.5	1.34	2	Xe-15	1366	53.1	53.1	0	1.21E+04	9.97E+05	5	0	5.02E-06
15	SMFLHP2815S	0161	0623	1	28	14.5	0.057	0	Xe-15	1366	53.1	53.1	0	1.29E+04	1.00E+06	0	0	0.00E+00
16	SMFLHP2815S	0161	0623	1	21	14.75	1.76	2	Xe-15	1366	53.1	53.1	0	1.30E+04	7.33E+05	117	0	1.60E-04
17	SMFLHP2815S	0161	0623	2	28	14.5	0.064	0	Xe-15	1366	53.1	53.1	0	1.34E+04	7.17E+05	0	0	0.00E+00
18	SMFLHP2815S	0161	0623	2	28	14.5	0.057	0	Xe-15	1366	53.1	53.1	0	1.37E+04	1.00E+06	48	0	4.80E-05
19	SMFLHP2815S	0161	0623	2	28	14.5	1.76	2	Xe-15	1366	53.1	53.1	0	1.37E+04	9.99E+05	117	0	1.17E-04
20	SMFLHP2815S	0161	0623	2	28	14.5	2.17	3.3	Xe-15	1366	53.1	53.1	0	1.34E+04	4.36E+05	243	0	5.57E-04
21	SMFLHP2815S	0141	0623	2	28	14.75	0.056	0	Xe-15	1366	53.1	53.1	0	1.30E+04	1.00E+06	63	0	6.30E-05
22	SMFLHP2815S	0141	0623	1	28	14.5	1.33	2	Xe-15	1366	53.1	53.1	0	1.30E+04	5.89E+05	117	0	1.99E-04
23	SMFLHP2815S	0141	0623	1	35	14.5	1.1	2	Xe-15	1366	53.1	53.1	0	1.24E+04	7.53E+05	173	0	2.30E-04
24	SMFLHP2815S	0141	0623	2	21	14.5	1.74	2	Xe-15	1366	53.1	53.1	0	1.28E+04	5.86E+05	220	0	3.75E-04
25	SMFLHP2815S	0141	0623	2	28	14.5	2.15	3.3	Xe-15	1366	53.1	53.1	0	1.65E+03	1.17E+05	75	0	6.44E-04
26	SMFLHP2815S	0141	0623	3	28	14.75	0.057	0	Xe-15	1366	53.1	53.1	0	1.58E+03	1.01E+05	10	0	9.90E-05
27	SMFLHP2815S	0141	0623	3	28	14.5	1.33	2	Xe-15	1366	53.1	53.1	0	1.62E+03	1.00E+05	0	0	0.00E+00
28	SMFLHP2815S	0141	0623	3	28	14.5	1.33	2	Xe-15	1366	53.1	53.1	0	1.52E+03	9.93E+04	1	0	1.01E-05
29	SMFLHP2815S	0141	0623	3	21	14.5	1.74	2	Xe-15	1366	53.1	53.1	0	1.50E+03	1.00E+05	16	0	1.60E-04
30	SMFLHP2815S	0141	0623	3	35	14.5	1.1	2	Xe-15	1366	53.1	53.1	0	1.52E+03	1.00E+05	9	0	9.00E-05
31	SMFLHP2815S	0141	0623	1	28	14.75	0.057	0	Xe-15	1366	53.1	53.1	0	1.47E+03	1.00E+05	5	0	5.00E-05
32	SMFLHP2815S	0141	0623	1	28	14.5	1.33	2	Xe-15	1366	53.1	53.1	0	1.46E+03	1.00E+05	2	0	2.00E-05
33	SMFLHP2815S	0141	0623	1	28	14.75	0.057	0	Ta-15	1858	79	79.0	0	5.49E+02	8.86E+04	0	0	0.00E+00
34	SMFLHP2815S	0141	0623	1	28	14.75	1.3	2	Ta-15	1858	79	79.0	0	1.08E+04	9.98E+05	0	0	0.00E+00
35	SMFLHP2815S	0141	0623	1	28	14	1.3	2	Ta-15	1858	79	79.0	0	1.20E+04	7.24E+05	0	0	0.00E+00
36	SMFLHP2815S	0141	0623	1	28	14.5	1.3	2	Ta-15	1858	79	79.0	0	1.26E+03	9.96E+05	0	0	0.00E+00
37	SMFLHP2815S	0141	0623	1	28	14.5	1.3	2	Ta-15	1858	79	79.0	0	1.47E+04	1.00E+04	0	0	0.00E+00
38	SMFLHP2815S	0141	0623	1	28	14.5	1.67	2	Ta-15	1858	79	79.0	0	1.59E+04	9.98E+05	2	0	2.00E-06
39	SMFLHP2815S	0141	0623	1	21	14.5	1.3	2	Ta-15	1858	79	79.0	0	1.79E+04	9.93E+05	2	0	2.01E-06
40	SMFLHP2815S	0141	0623	1	35	14.5	1	2	Ta-15	1858	79	79.0	0	1.97E+04	1.00E+06	0	0	0.00E+00
41	SMFLHP2815S	0141	0623	1	40	14.5	0.955	2	Ta-15	1858	79	79.0	0	1.11E+03	4.99E+04	66	0	1.32E-03
42	SMFLHP2815S	0141	0623	1	35	14.5	1	2	Ta-15	1858	79	79.0	0	1.12E+03	9.99E+04	23	0	2.30E-04
43	SMFLHP2815S	0141	0623	1	28	14.5	1.3	2	Ta-15	1858	79	79.0	0	1.14E+03	1.00E+05	3	0	3.00E-05
44	SMFLHP2815S	0141	0623	1	21	14.5	1.67	2	Ta-15	1858	79	79.0	0	1.17E+03	9.97E+04	20	0	2.01E-04
45	SMFLHP2815S	0141	0623	1	21	14.5	0.057	0	Ta-15	1858	79	79.0	0	1.22E+03	1.00E+05	0	0	0.00E+00
46	SMFLHP2815S	0141	0623	1	28	14.5	0.057	0	Ta-15	1858	79	79.0	0	1.24E+03	4.81E+04	0	0	0.00E+00
47	SMFLHP2815S	0141	0623	1	28	14.5	1.3	2	Ta-15	1858	79	79.0	0	1.24E+03	1.00E+05	0	0	0.00E+00

Table 2: SMFLHP2815S Data Collected at TAMU