Table of Contents

Change Log

Date	Issue	Change
18 November 2006	0.1	Initial drafting of document
27 November 2006	0.11	Circulate for comment
12 Jan 2007	0.2	Some changes
16 March 2007	0.3	More updates for PFM DRB summary

1. Scope

This document reports and documents the RS susceptibility tests carried out at ESTEC on the SPIRE CQM instrument in the PFM Cryostat within the scope of the satellite STM2 test campaign during the period 16-Oct-2006 to 21-Oct-2006.

2. Reference Documents

RD1: ''PLM EQM EMC Test Procedure, HP-2-ASED-PR-0033, dated 21.09.05
RD2: "SPIRE EQM EMC Test Procedure" SPIRE-RAL-PRC-002545, Issue: 2.0 pre-release

3. Channels monitored during testing

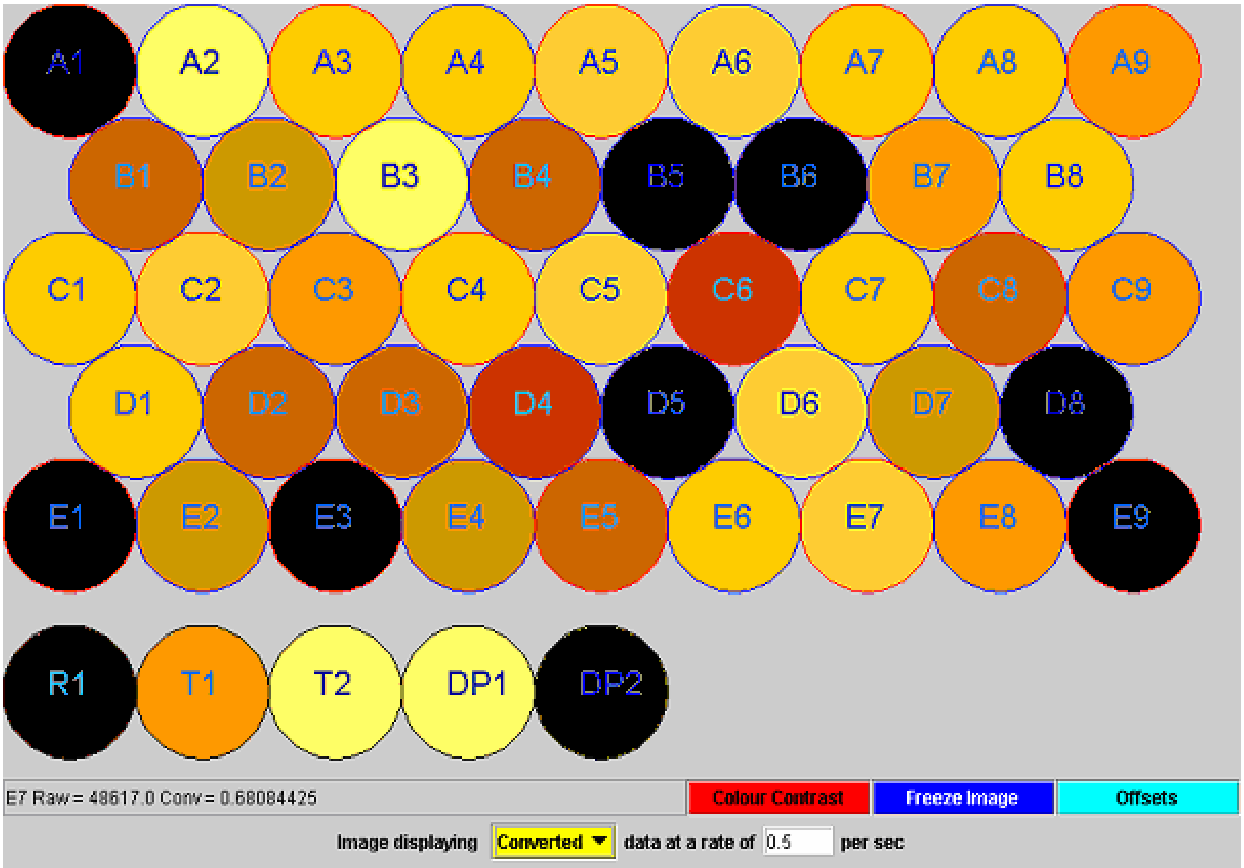


Figure 1 - PLW Array pixel map – bad channels are identified by black colouring.

Figure 1 shows the physical mapping of the various detector channels onto the array. The channels prefixed by the letters A-E are normal optical pixels. Channel R1 is designated as a resistor channel which is intended to have a similar impedance to a normal working pixel, but with a static impedance independent of the bias current or temperature. Channels T1 and T2 are mounted on the 300-mK bath and are intended to monitor the base temperature of the bolometers.

They have a strong thermal coupling to the 300-mK bath and should therefore show a weak correlation between thermal loading and temperature rise. Channels DP1 and DP2 are physically similar to the normal optical pixels except that they are enclosed inside a dark cavity and should show no optical response.

The channel yield for the CQM array is 38/48 (79.2%) and the following channels are listed as being out of specification and are therefore excluded from the EMC analysis.

R1
B5
B6
A1
E1
E3
D5
D8
DP2
E9

Table 1 – Bad channels in the SPIRE CQM array

It was noted that the response (ΔV) of pixel C5 to P-Cal flashes was approximately 5 times higher than comparable neighbouring pixels.

4. Injection calibration

The E-Field generated by the combination of the antenna, RF amplifier and signal synthesizer was calibrated in the ESTEC Maxwell anechoic facility. The E-Field was measured with a calibrated probe, 1 m from the radiating antenna. A calibration file was generated which was stored in the signal synthesizer to achieve the correct field strength in the clean room.

5. Test results

5.1 8-20MHz Band

5.1.1 Test conditions

Test type	Frequency Sweep
Signal	Sinusoidal
Amplitude Modulation	100% Amplitude 1 Hz 80% duty cycle (800ms on: 200ms off)
ObsID	0xB000003E
Injection Amplitude	1.2V/m + 6dB = 2.4V/m
Start Frequency	8MHz
End Frequency	20MHz
Frequency Step	1% (Log-linear)
Step Dwell	5 sec
EMI Countermeasures	None
Antenna	Monopole, ~ 1m from cryostat
Time and date	17-Oct-2006 12:03 to 12:37
Counter measures	None

5.1.2 Channel susceptibilities

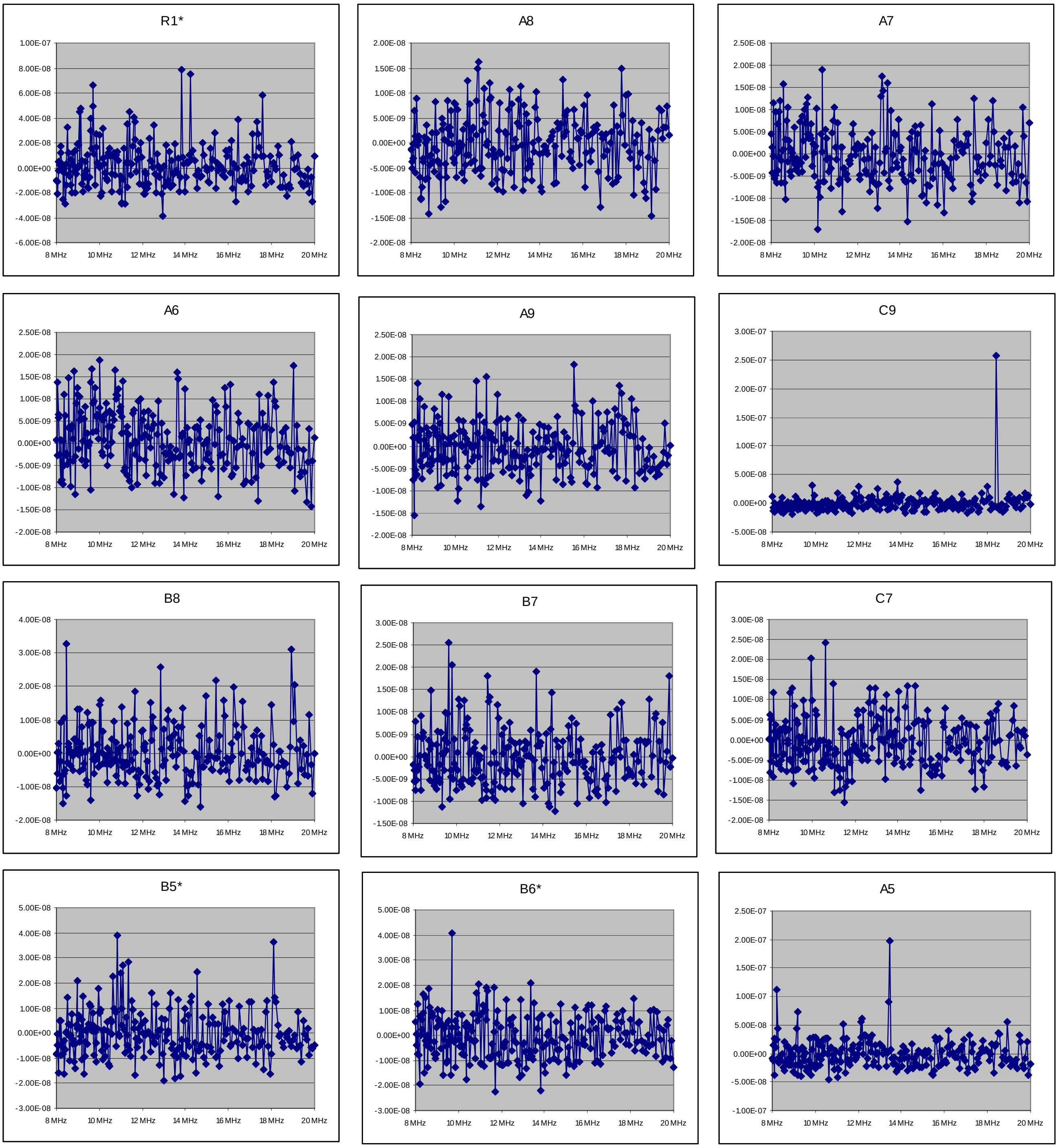


Figure 2 - 8-20MHz sweep channel 1-12 response

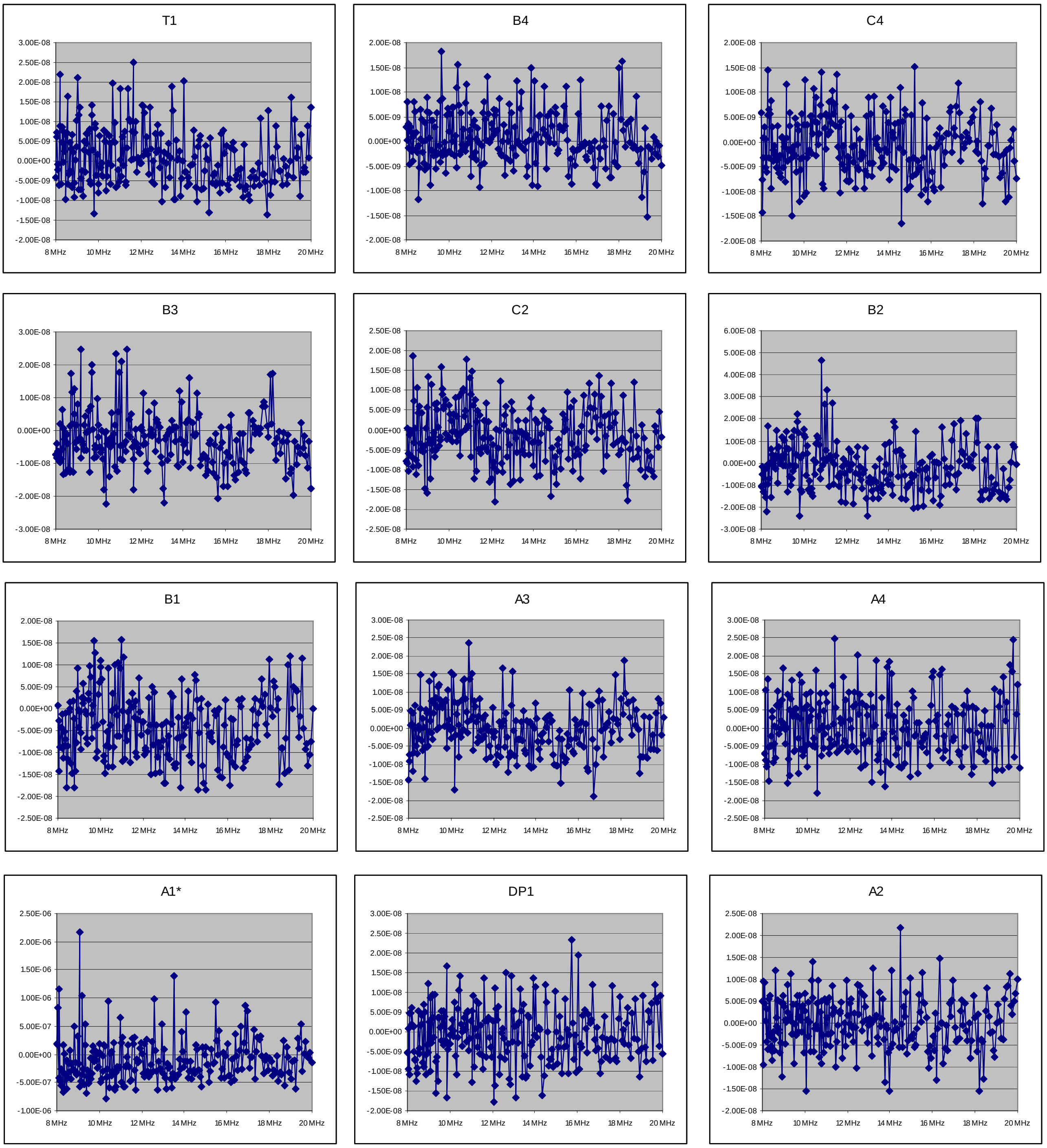


Figure 3 - 8-20MHz sweep channel 13-24 response

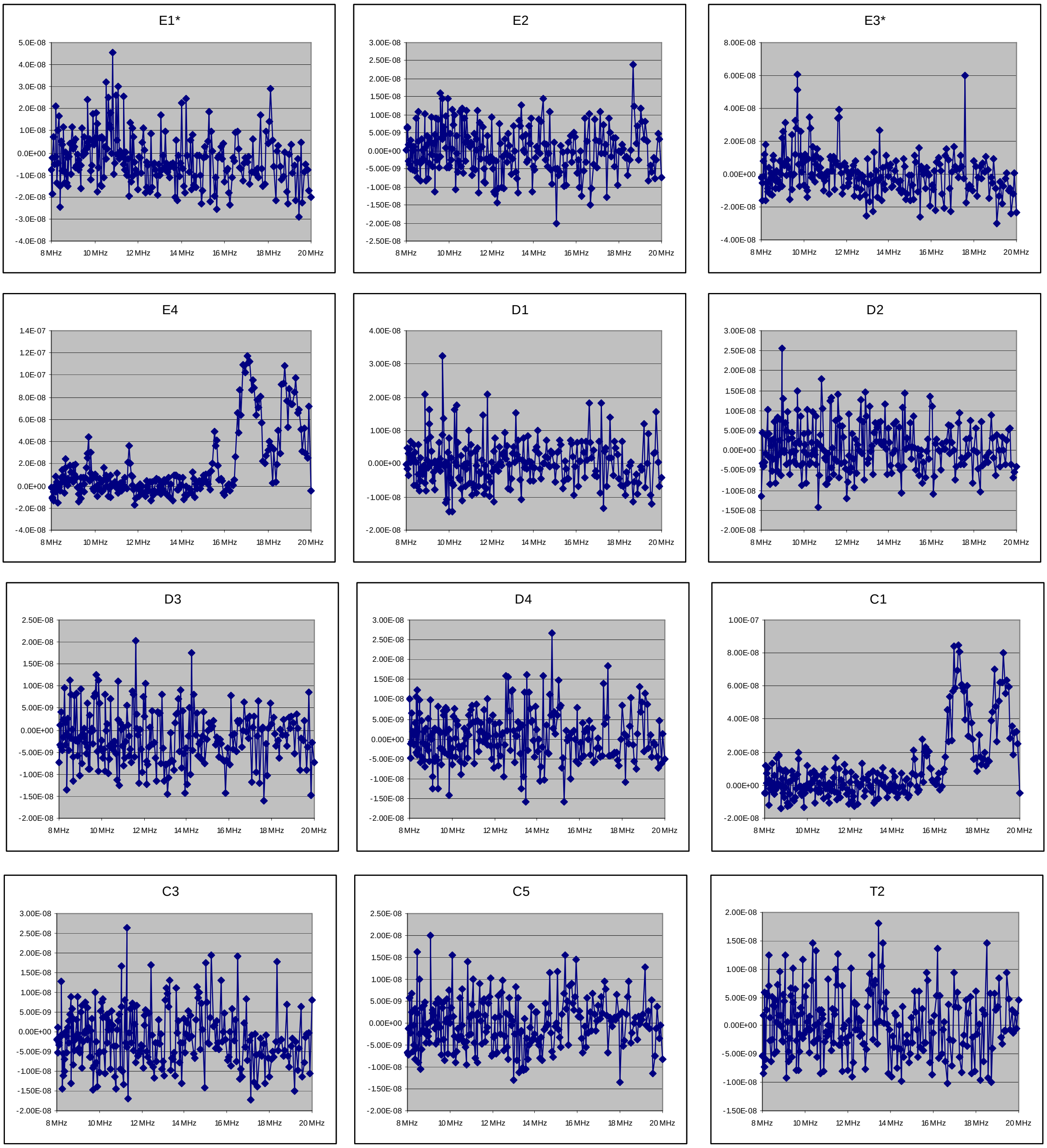


Figure 4 - 8-20MHz sweep channel 25-36 response

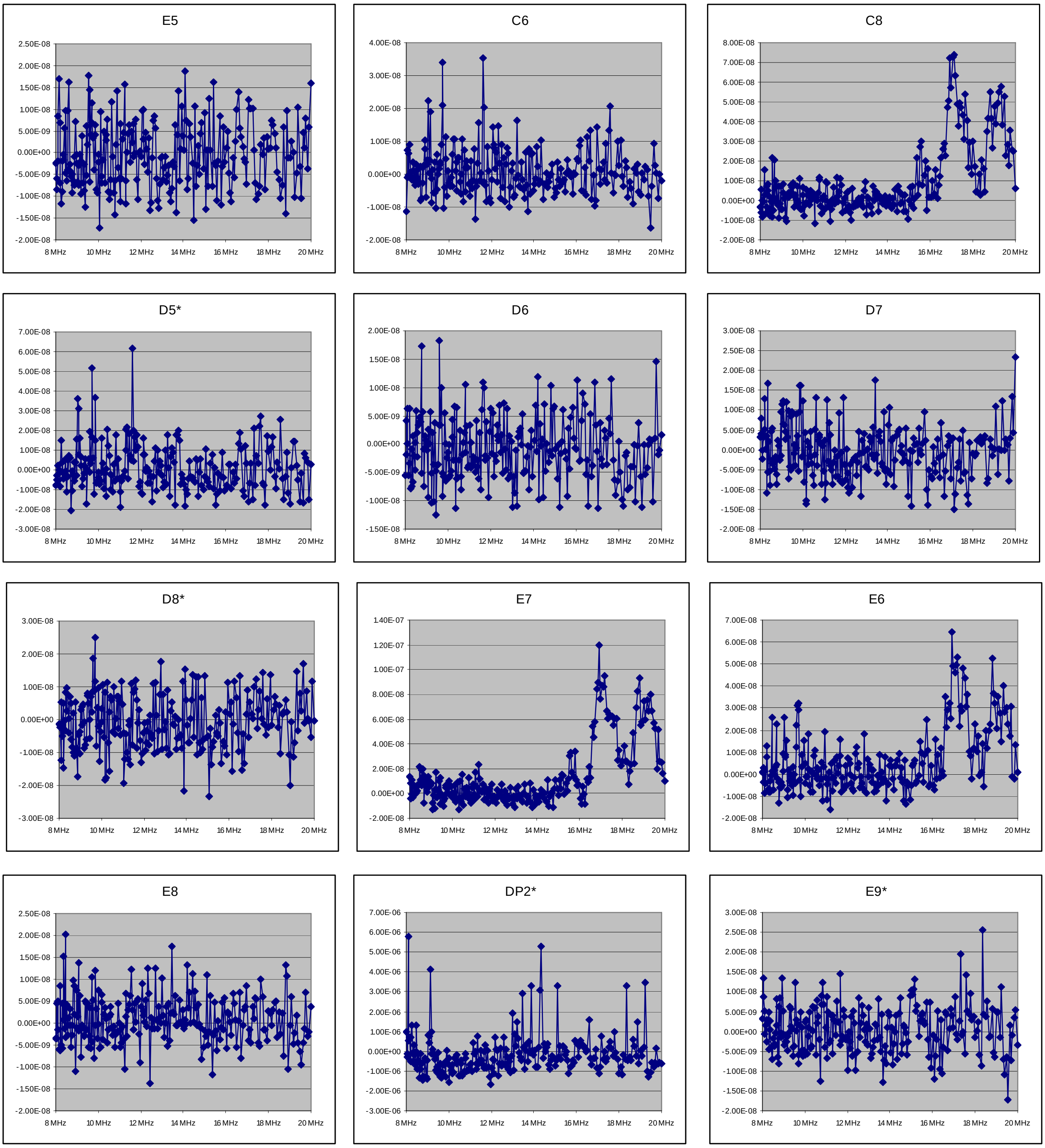


Figure 5 - 8-20MHz sweep channel 25-36 response

5.2 20-120MHz Band: 1.2V/m + 6dB

5.2.1 Test conditions

Test type	Frequency Sweep
Signal	Sinusoidal
Amplitude Modulation	100% Amplitude 1 Hz 80% duty cycle (800ms on: 200ms off)
ObsID	0xB0000040
Injection Amplitude	1.2V/m + 6dB = 2.4V/m
Start Frequency	20MHz
End Frequency	120MHz
Frequency Step	1% (Log-linear)
Step Dwell	5 sec
EMI Countermeasures	None
Antenna	Biconic, ~ 1m from cryostat
Time	17-10-2006 12:38

Susceptibilities were on QLA during this test, so it was decided to repeat this portion of the spectrum at 1.2V/m.

5.3 20-120MHz Band: 1.2V/m + 0dB

5.3.1 Test conditions

Test type	Frequency Sweep
Signal	Sinusoidal
Amplitude Modulation	100% Amplitude 1 Hz 80% duty cycle (800ms on: 200ms off)
ObsID	0xB0000042
Injection Amplitude	1.2V/m + 6dB = 2.4V/m
Start Frequency	20MHz
End Frequency	120MHz
Frequency Step	1% (Log-linear)
Step Dwell	5 sec
EMI Countermeasures	None
Antenna	Biconic, ~ 1m from cryostat

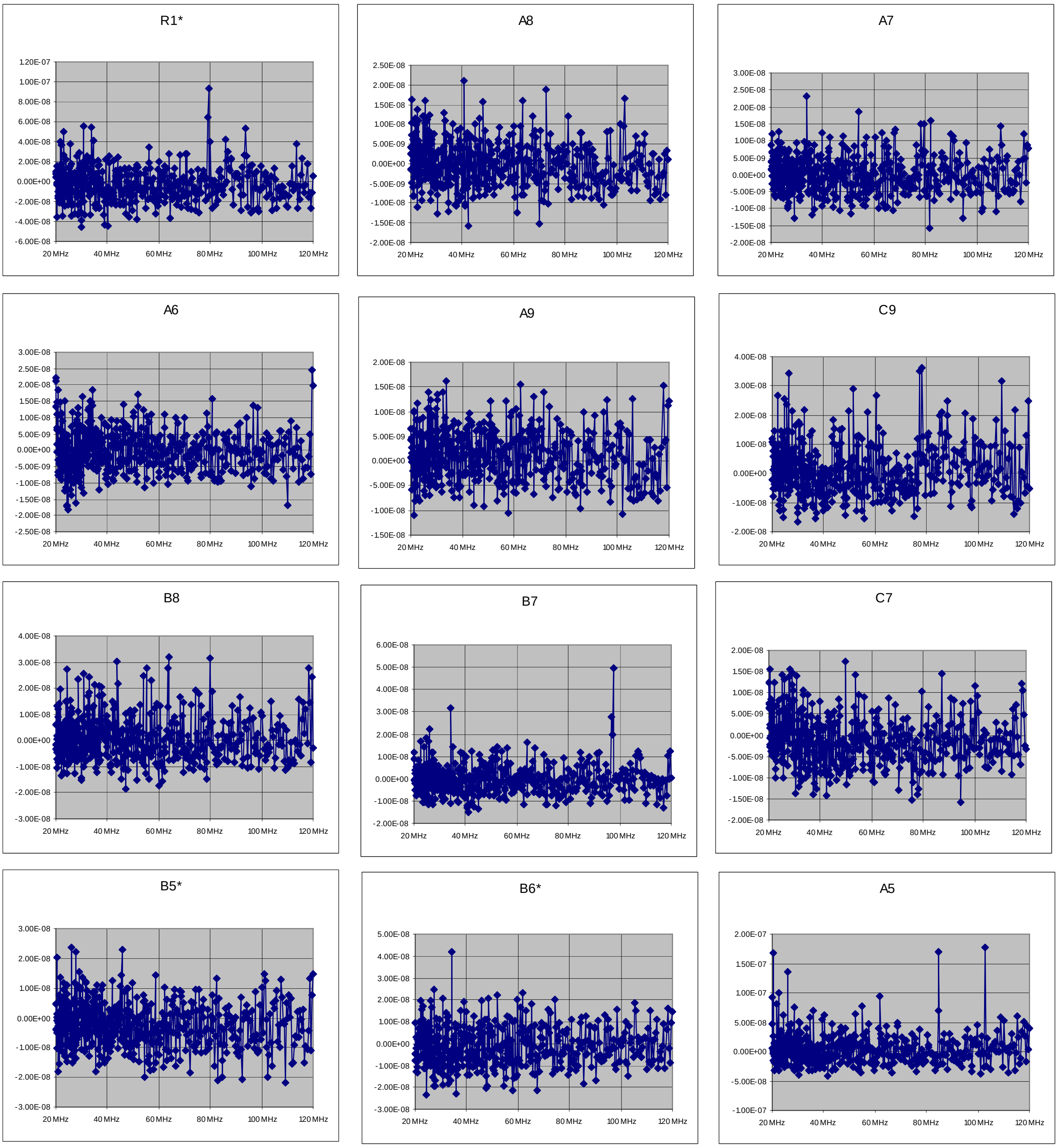

R1*
A8
A7
A6
A9
C9
B8
B7
C7
B5*
B6*
A5
20 MHz
40 MHz
60 MHz
80 MHz
100 MHz
120 MHz

Figure 6

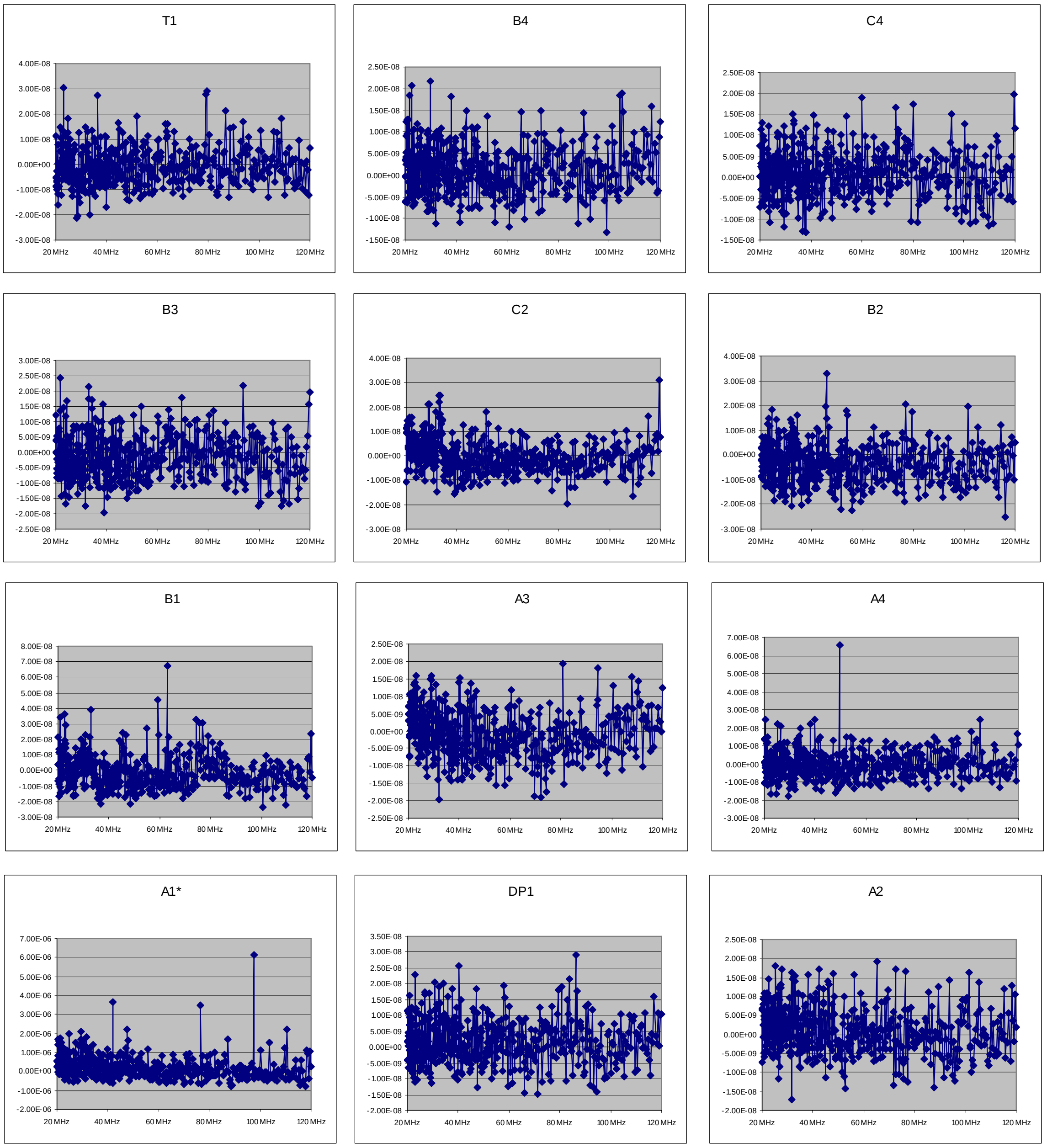
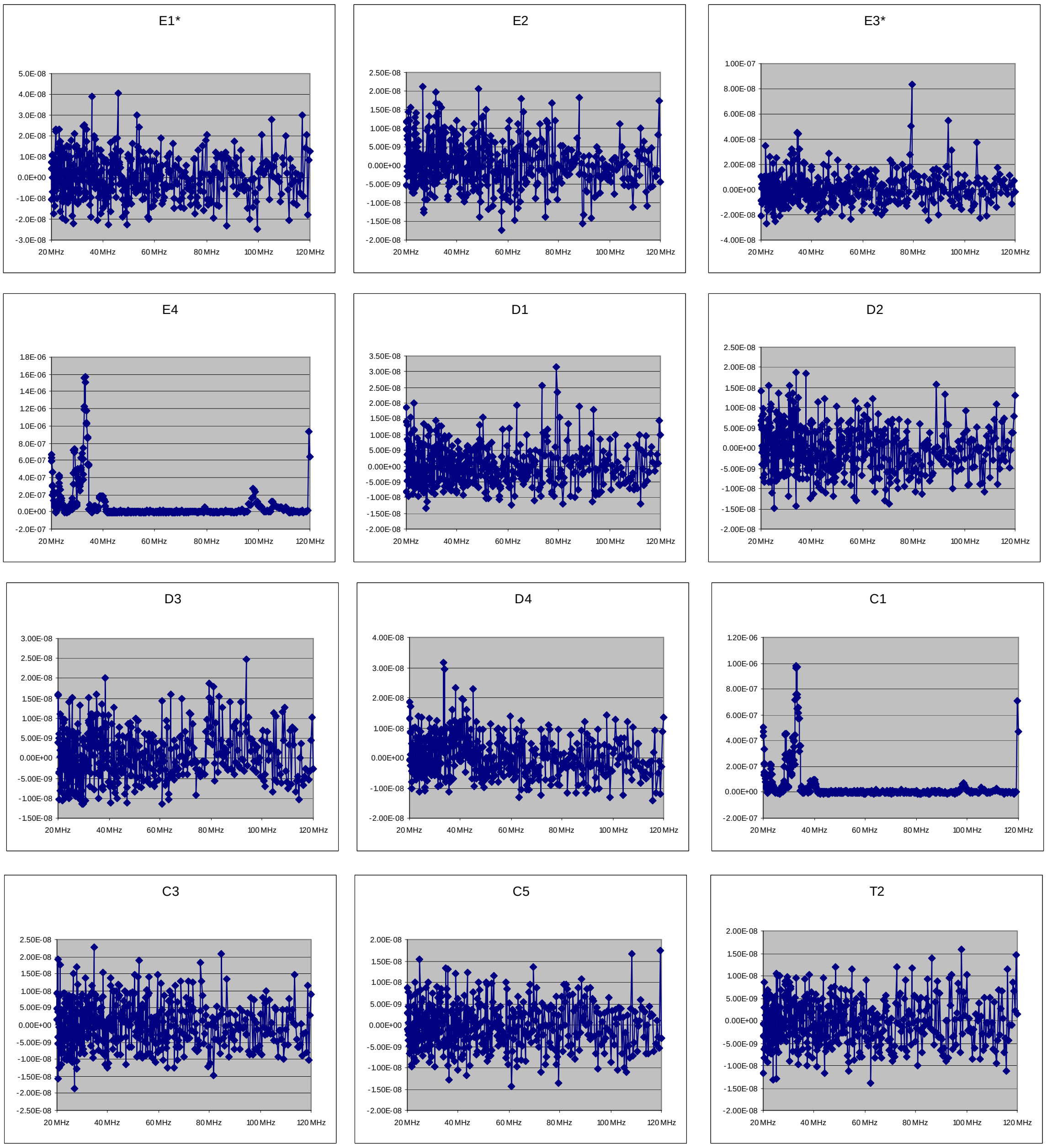

T1
B4
C4
B3
C2
B2
B1
A3
A4
A1*
DP1
A2
20 MHz
40 MHz
60 MHz
80 MHz
100 MHz
120 MHz

Figure 7



E1*
E2
E3*
E4
D1
D2
D3
D4
C1
C3
C5
T2
20 MHz
40 MHz
60 MHz
80 MHz
100 MHz
120 MHz

Figure 8

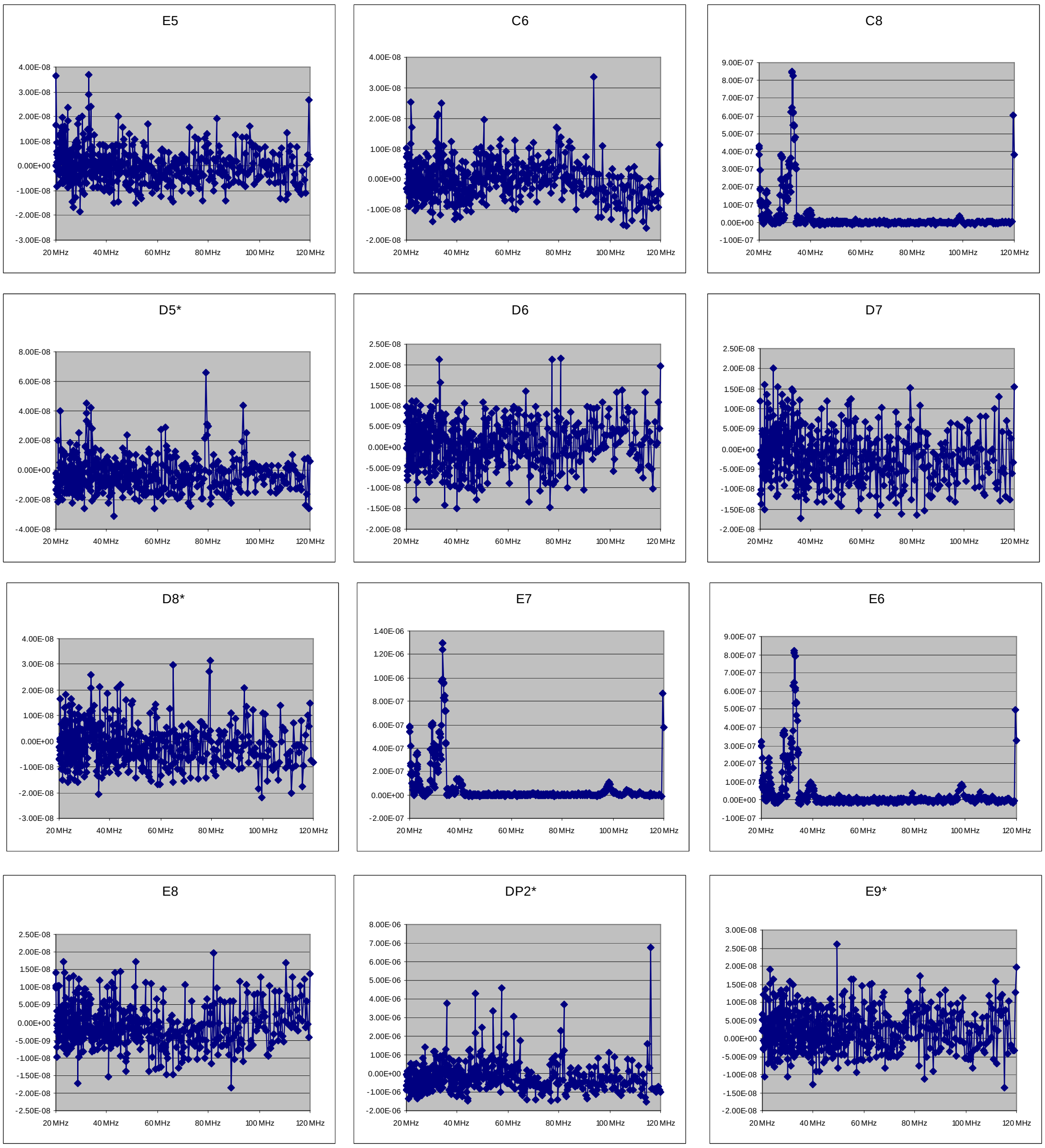


Figure 9

5.3.2 Manual search for Peak Susceptibilities

Test carried out by setting the function generator to an initial frequency known to be lower than the peak susceptibility and manually stepping the frequency up in small increments. At each step, the magnitude of the EMI is recoded as being better or worse. The assumption is that there is only one global peak susceptibility in the range of frequencies selected.

32.56697	
32.89264	Worse
33.22156	**Worst**
33.55378	Better

22.5365	
22.76187	Worse
22.98948	**Worst**
23.21938	Better
23.45157	Better

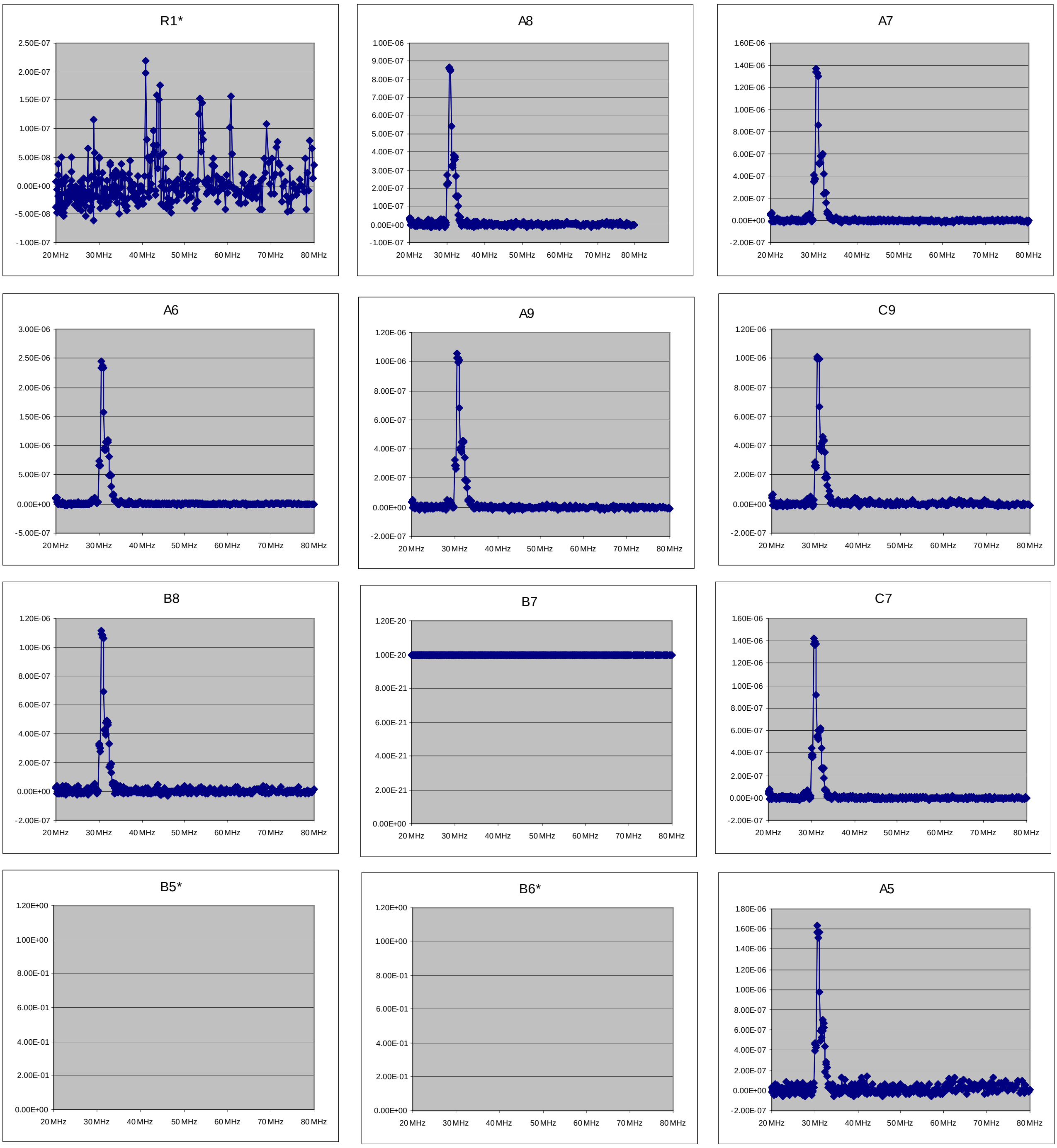

R1*
A8
A7
A6
A9
C9
B8
B7
C7
B5*
B6*
A5
20 MHz
30 MHz
40 MHz
50 MHz
60 MHz
70 MHz
80 MHz

Figure 10

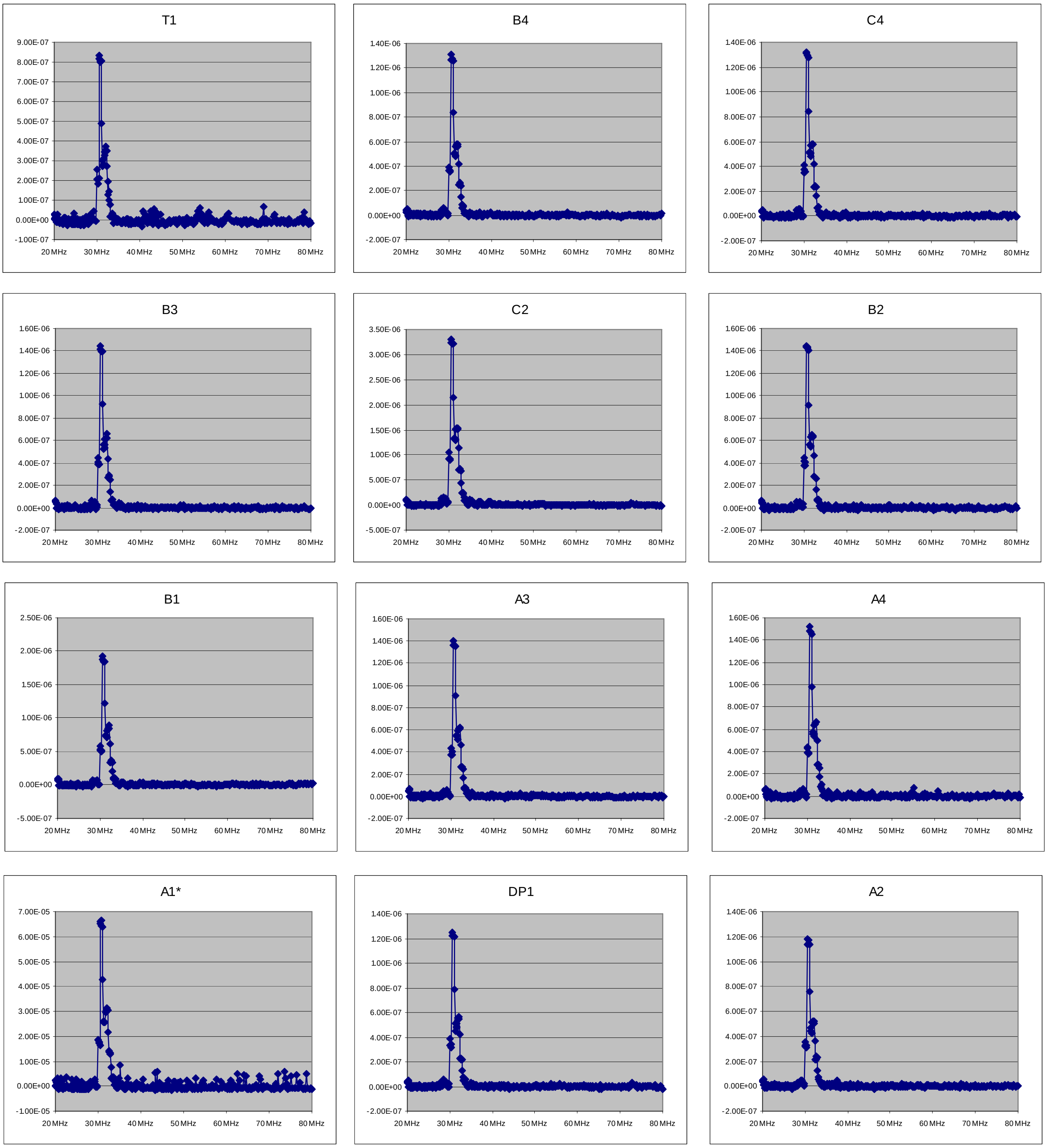


Figure 11

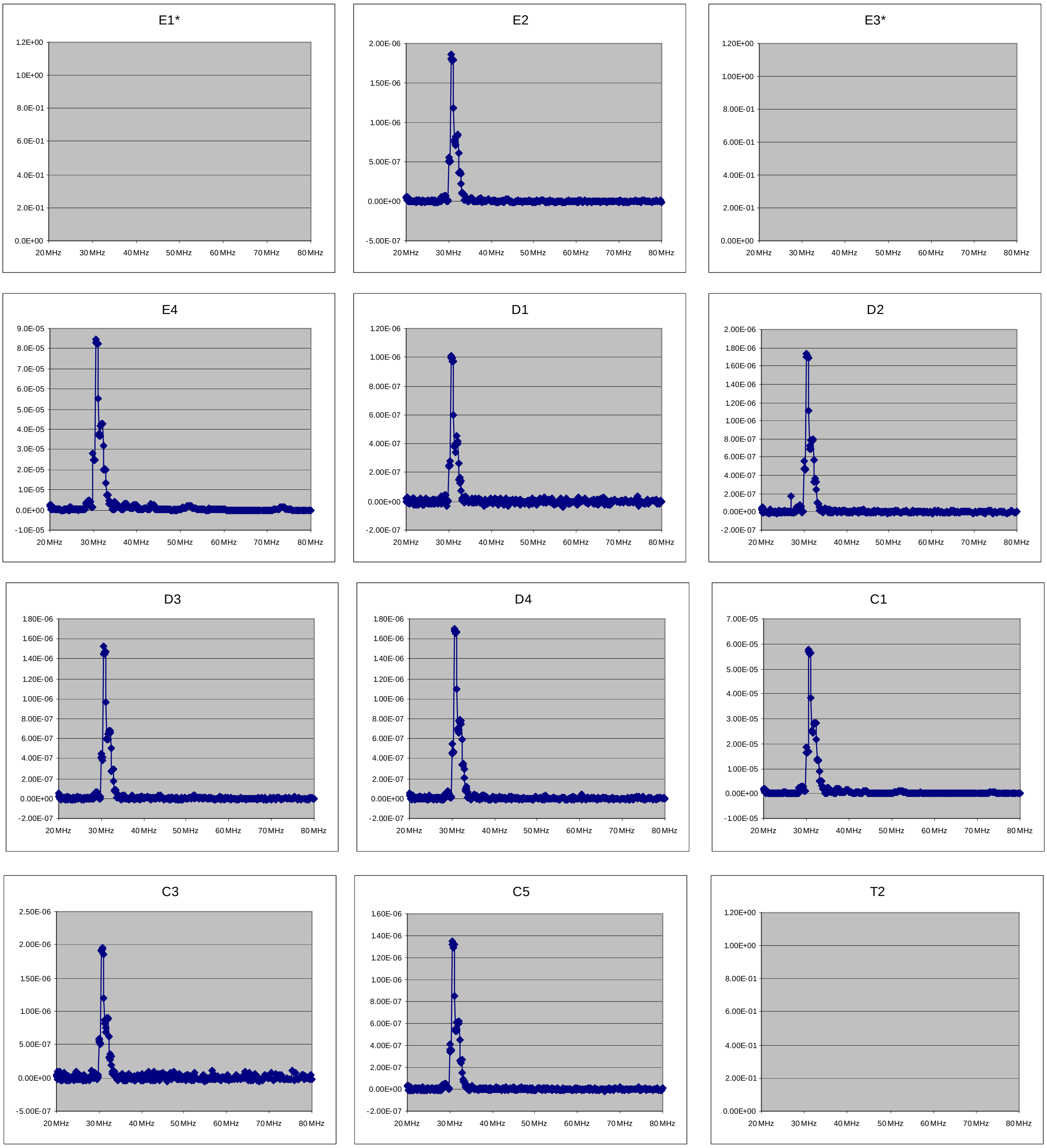
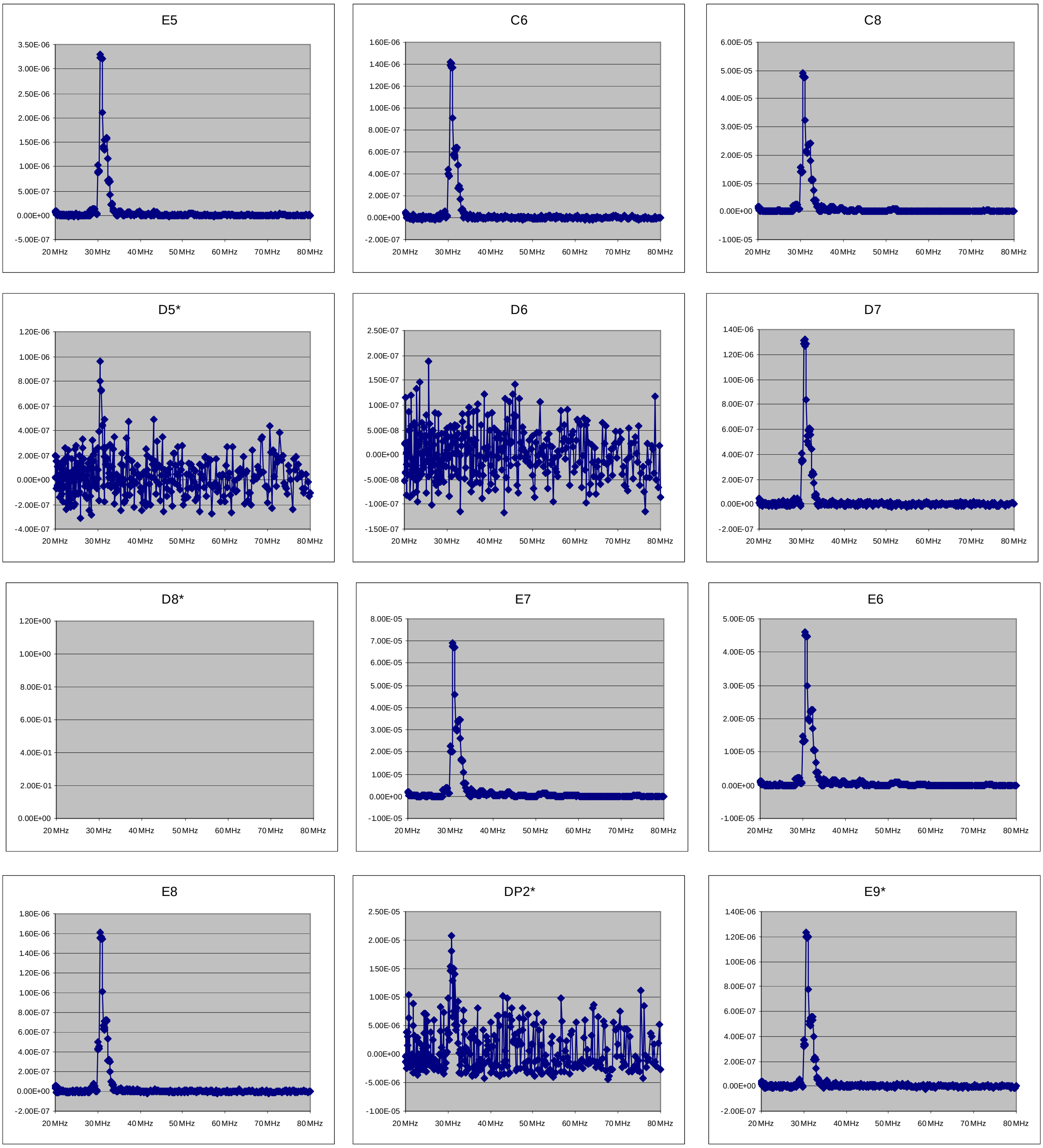

E1*
E2
E3*
E4
D1
D2
D3
D4
C1
C3
C5
T2
20 MHz
30 MHz
40 MHz
50 MHz
60 MHz
70 MHz
80 MHz

Figure 12



E5
3.50E-06
3.00E-06
2.50E-06
2.00E-06
1.50E-06
1.00E-06
5.00E-07
0.00E+00
-5.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
C6
1.60E-06
1.40E-06
1.20E-06
1.00E-06
8.00E-07
6.00E-07
4.00E-07
2.00E-07
0.00E+00
-2.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
C8
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
-1.00E-05
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
D5*
1.20E-06
1.00E-06
8.00E-07
6.00E-07
4.00E-07
2.00E-07
0.00E+00
-2.00E-07
-4.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
D6
2.50E-07
2.00E-07
1.50E-07
1.00E-07
5.00E-08
0.00E+00
-5.00E-08
-1.00E-07
-1.50E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
D7
1.40E-06
1.20E-06
1.00E-06
8.00E-07
6.00E-07
4.00E-07
2.00E-07
0.00E+00
-2.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
D8*
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
E7
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
-1.00E-05
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
E6
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
-1.00E-05
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
E8
1.80E-06
1.60E-06
1.40E-06
1.20E-06
1.00E-06
8.00E-07
6.00E-07
4.00E-07
2.00E-07
0.00E+00
-2.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
DP2*
2.50E-05
2.00E-05
1.50E-05
1.00E-05
5.00E-06
0.00E+00
-5.00E-06
-1.00E-05
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz
E9*
1.40E-06
1.20E-06
1.00E-06
8.00E-07
6.00E-07
4.00E-07
2.00E-07
0.00E+00
-2.00E-07
20 MHz 30 MHz 40 MHz 50 MHz 60 MHz 70 MHz 80 MHz

Figure 13

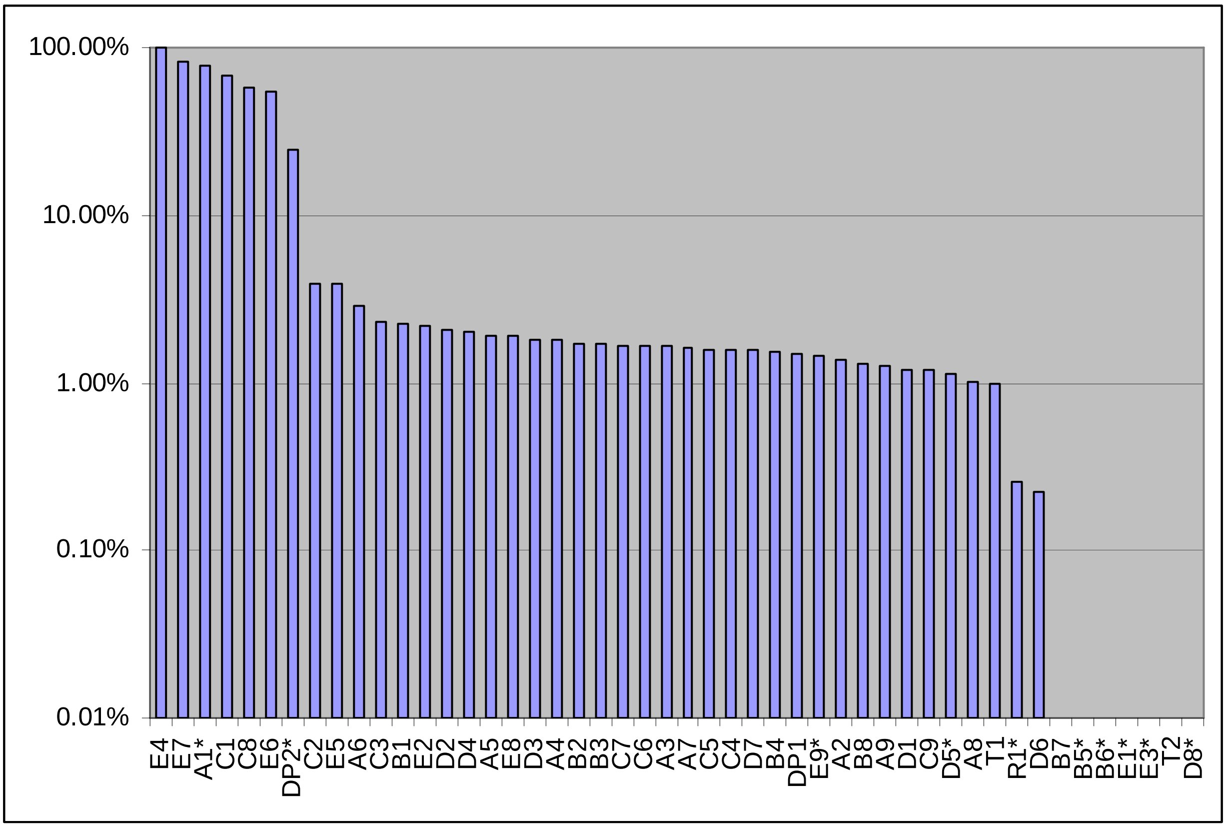


Figure 14 – Normalised susceptibilities (wrt E4 which showed highest susceptibility in this sweep)

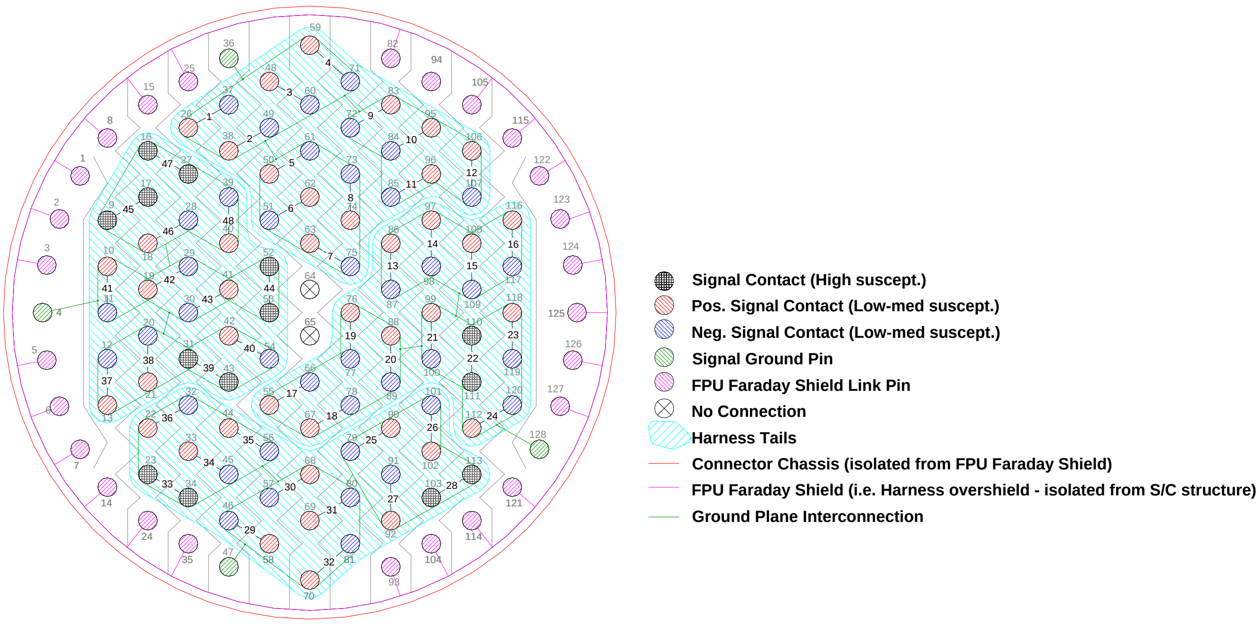


Figure 15 - Schematic view of contact arrangement/allocation on PLW vacuum feedthru. The seven most susceptible channels are cross hatched in black ink.

Channel	BDA Connector	Cable ident	JFET Conn.	JFET Module	Output Conn.	Cable Ident	Pos	CVV C6 Neg	GND	Cryostat Wall	DCU Conn.	DCU LIA	DCU ADC
R1	J05	F6-12ax-A1	J35	JFP_P7	J13	C6-12ax-A1	26	37	36 (A1)	CVV_6	J14	CH17/LIA_P5	ADC_4
A8	J05	F6-12ax-A2	J35	JFP_P7	J13	C6-12ax-A2	38	49	36 (A1)	CVV_6	J14	CH18/LIA_P5	ADC_4
A7	J05	F6-12ax-A3	J35	JFP_P7	J13	C6-12ax-A3	48	60	36 (A1)	CVV_6	J14	CH19/LIA_P5	ADC_4
A6	J05	F6-12ax-A4	J35	JFP_P7	J13	C6-12ax-A4	59	71	36 (A1)	CVV_6	J14	CH20/LIA_P5	ADC_4
A9	J05	F6-12ax-B1	J35	JFP_P7	J13	C6-12ax-B1	50	61	36 (A1)	CVV_6	J14	CH21/LIA_P5	ADC_4
C9	J05	F6-12ax-B2	J35	JFP_P7	J13	C6-12ax-B2	62	51	36 (A1)	CVV_6	J14	CH22/LIA_P5	ADC_4
B8	J05	F6-12ax-B3	J35	JFP_P7	J13	C6-12ax-B3	63	75	36 (A1)	CVV_6	J14	CH23/LIA_P5	ADC_4
B7	J05	F6-12ax-B4	J35	JFP_P7	J13	C6-12ax-B4	74	73	36 (A1)	CVV_6	J14	CH24/LIA_P5	ADC_4
C7	J05	F6-12ax-C1	J35	JFP_P7	J13	C6-12ax-C1	83	72	36 (A1)	CVV_6	J14	CH25/LIA_P5	ADC_4
B5	J05	F6-12ax-C2	J35	JFP_P7	J13	C6-12ax-C2	95	84	36 (A1)	CVV_6	J14	CH26/LIA_P5	ADC_4
B6	J05	F6-12ax-C3	J35	JFP_P7	J13	C6-12ax-C3	96	85	36 (A1)	CVV_6	J14	CH27/LIA_P5	ADC_4
A5	J05	F6-12ax-C4	J35	JFP_P7	J13	C6-12ax-C4	106	107	36 (A1)	CVV_6	J14	CH28/LIA_P5	ADC_4
T1	J05	F6-12ax-D1	J35	JFP_P7	J14	C6-12ax-D1	86	87	128 (A2)	CVV_6	J14	CH29/LIA_P5	ADC_4
B4	J05	F6-12ax-D2	J35	JFP_P7	J14	C6-12ax-D2	97	98	128 (A2)	CVV_6	J14	CH30/LIA_P5	ADC_4
C4	J05	F6-12ax-D3	J35	JFP_P7	J14	C6-12ax-D3	108	109	128 (A2)	CVV_6	J14	CH31/LIA_P5	ADC_4
B3	J05	F6-12ax-D4	J35	JFP_P7	J14	C6-12ax-D4	116	117	128 (A2)	CVV_6	J14	CH32/LIA_P5	ADC_4
C2	J05	F6-12ax-E1	J35	JFP_P7	J14	C6-12ax-E1	55	66	128 (A2)	CVV_6	J15	CH01/LIA_P6	ADC_4
B2	J05	F6-12ax-E2	J35	JFP_P7	J14	C6-12ax-E2	67	78	128 (A2)	CVV_6	J15	CH02/LIA_P6	ADC_4
B1	J05	F6-12ax-E3	J35	JFP_P7	J14	C6-12ax-E3	76	77	128 (A2)	CVV_6	J15	CH03/LIA_P6	ADC_4
A3	J05	F6-12ax-E4	J35	JFP_P7	J14	C6-12ax-E4	88	89	128 (A2)	CVV_6	J15	CH04/LIA_P6	ADC_4
A4	J05	F6-12ax-F1	J35	JFP_P7	J14	C6-12ax-F1	99	100	128 (A2)	CVV_6	J15	CH05/LIA_P6	ADC_4
A1	J05	F6-12ax-F2	J35	JFP_P7	J14	C6-12ax-F2	110	111	128 (A2)	CVV_6	J15	CH06/LIA_P6	ADC_4
DP1	J05	F6-12ax-F3	J35	JFP_P7	J14	C6-12ax-F3	118	119	128 (A2)	CVV_6	J15	CH07/LIA_P6	ADC_4
A2	J05	F6-12ax-F4	J35	JFP_P7	J14	C6-12ax-F4	112	120	128 (A2)	CVV_6	J15	CH08/LIA_P6	ADC_4
E1	J06	F6-12ax-A1	J36	JFP_P8	J15	C6-12ax-G1	90	79	47 (A3)	CVV_6	J15	CH09/LIA_P6	ADC_4
E2	J06	F6-12ax-A2	J36	JFP_P8	J15	C6-12ax-G2	102	101	47 (A3)	CVV_6	J15	CH10/LIA_P6	ADC_4
E3	J06	F6-12ax-A3	J36	JFP_P8	J15	C6-12ax-G3	92	91	47 (A3)	CVV_6	J15	CH11/LIA_P6	ADC_4
E4	J06	F6-12ax-A4	J36	JFP_P8	J15	C6-12ax-G4	103	113	47 (A3)	CVV_6	J15	CH12/LIA_P6	ADC_4
D1	J06	F6-12ax-B1	J36	JFP_P8	J15	C6-12ax-H1	58	46	47 (A3)	CVV_6	J15	CH13/LIA_P6	ADC_4
D2	J06	F6-12ax-B2	J36	JFP_P8	J15	C6-12ax-H2	68	57	47 (A3)	CVV_6	J15	CH14/LIA_P6	ADC_4
D3	J06	F6-12ax-B3	J36	JFP_P8	J15	C6-12ax-H3	69	80	47 (A3)	CVV_6	J15	CH15/LIA_P6	ADC_4
D4	J06	F6-12ax-B4	J36	JFP_P8	J15	C6-12ax-H4	70	81	47 (A3)	CVV_6	J15	CH16/LIA_P6	ADC_4
C1	J06	F6-12ax-C1	J36	JFP_P8	J15	C6-12ax-I1	23	34	47 (A3)	CVV_6	J16	CH17/LIA_P6	ADC_4
C3	J06	F6-12ax-C2	J36	JFP_P8	J15	C6-12ax-I2	33	45	47 (A3)	CVV_6	J16	CH18/LIA_P6	ADC_4
C5	J06	F6-12ax-C3	J36	JFP_P8	J15	C6-12ax-I3	44	56	47 (A3)	CVV_6	J16	CH19/LIA_P6	ADC_4
T2	J06	F6-12ax-C4	J36	JFP_P8	J15	C6-12ax-I4	22	32	47 (A3)	CVV_6	J16	CH20/LIA_P6	ADC_4
E5	J06	F6-12ax-D1	J36	JFP_P8	J16	C6-12ax-J1	13	12	4 (A3)	CVV_6	J16	CH21/LIA_P6	ADC_4
C6	J06	F6-12ax-D2	J36	JFP_P8	J16	C6-12ax-J2	21	20	4 (A3)	CVV_6	J16	CH22/LIA_P6	ADC_4
C8	J06	F6-12ax-D3	J36	JFP_P8	J16	C6-12ax-J3	31	43	4 (A3)	CVV_6	J16	CH23/LIA_P6	ADC_4
D5	J06	F6-12ax-D4	J36	JFP_P8	J16	C6-12ax-J4	42	54	4 (A3)	CVV_6	J16	CH24/LIA_P6	ADC_4
D6	J06	F6-12ax-E1	J36	JFP_P8	J16	C6-12ax-K1	10	11	4 (A3)	CVV_6	J16	CH25/LIA_P6	ADC_4
D7	J06	F6-12ax-E2	J36	JFP_P8	J16	C6-12ax-K2	19	29	4 (A3)	CVV_6	J16	CH26/LIA_P6	ADC_4
D8	J06	F6-12ax-E3	J36	JFP_P8	J16	C6-12ax-K3	41	30	4 (A3)	CVV_6	J16	CH27/LIA_P6	ADC_4
E7	J06	F6-12ax-E4	J36	JFP_P8	J16	C6-12ax-K4	53	52	4 (A3)	CVV_6	J16	CH28/LIA_P6	ADC_4
E6	J06	F6-12ax-F1	J36	JFP_P8	J16	C6-12ax-L1	9	17	4 (A3)	CVV_6	J16	CH29/LIA_P6	ADC_4
E8	J06	F6-12ax-F2	J36	JFP_P8	J16	C6-12ax-L2	18	28	4 (A3)	CVV_6	J16	CH30/LIA_P6	ADC_4
DP2	J06	F6-12ax-F3	J36	JFP_P8	J16	C6-12ax-L3	16	27	4 (A3)	CVV_6	J16	CH31/LIA_P6	ADC_4
E9	J06	F6-12ax-F4	J36	JFP_P8	J16	C6-12ax-L4	40	39	4 (A3)	CVV_6	J16	CH32/LIA_P6	ADC_4

Figure 16 - Detector channel system table. Yellow highlighted rows correspond to nominally functional channels with large susceptibility

5.4 Test conditions

Test type	Frequency Sweep
Signal	Sinusoidal
Amplitude Modulation	100% Amplitude 1 Hz 80% duty cycle (800ms on: 200ms off)
ObsID	0xB000007E
Injection Amplitude	1.2V/m + 6dB = 2.4V/m
Start Frequency	20MHz
End Frequency	80MHz
Frequency Step	2% (Log-linear)
Step Dwell	10 sec
EMI Countermeasures	6 Ferrites on each harness
Antenna	Biconic, ~ 3m from cryostat

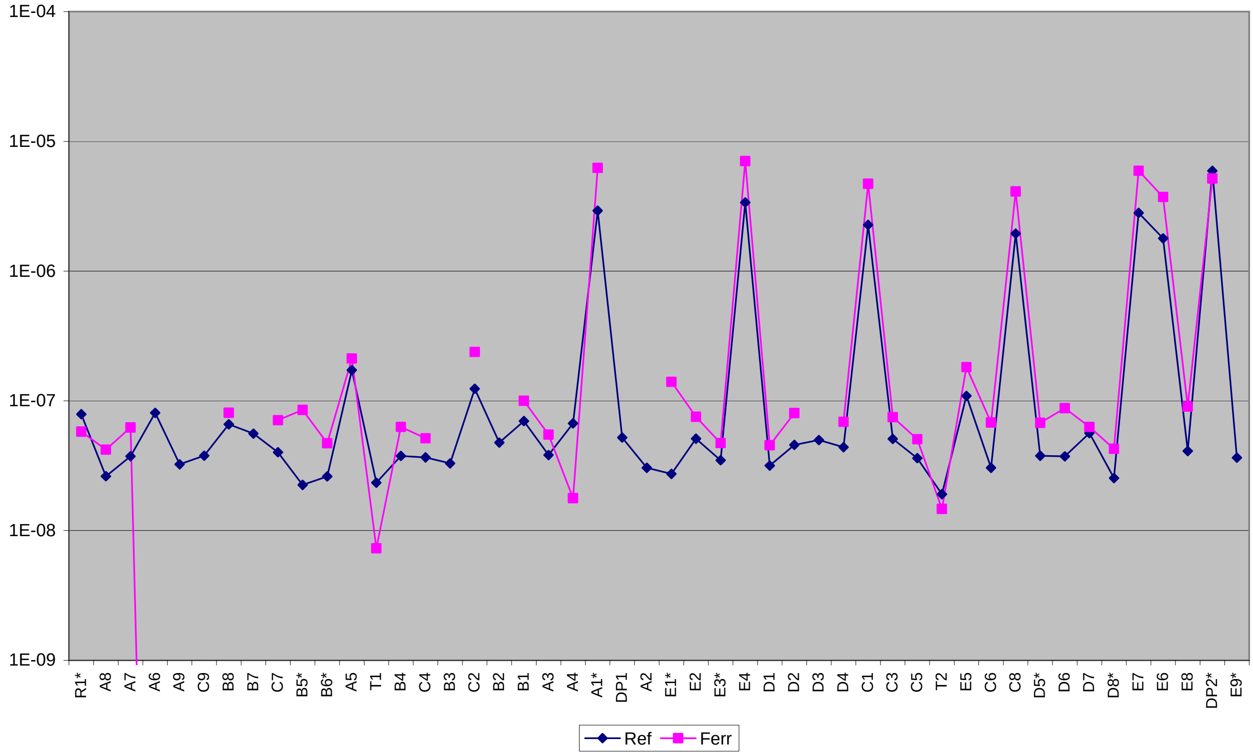


Figure 17 - Comparison between peak susceptibility in the 20-80MHz range with Ferrite to the peak without a Ferrite

Figure 18

5.5 Susceptibility Threshold at 30.9 MHz

5.5.1 Channels 1-12

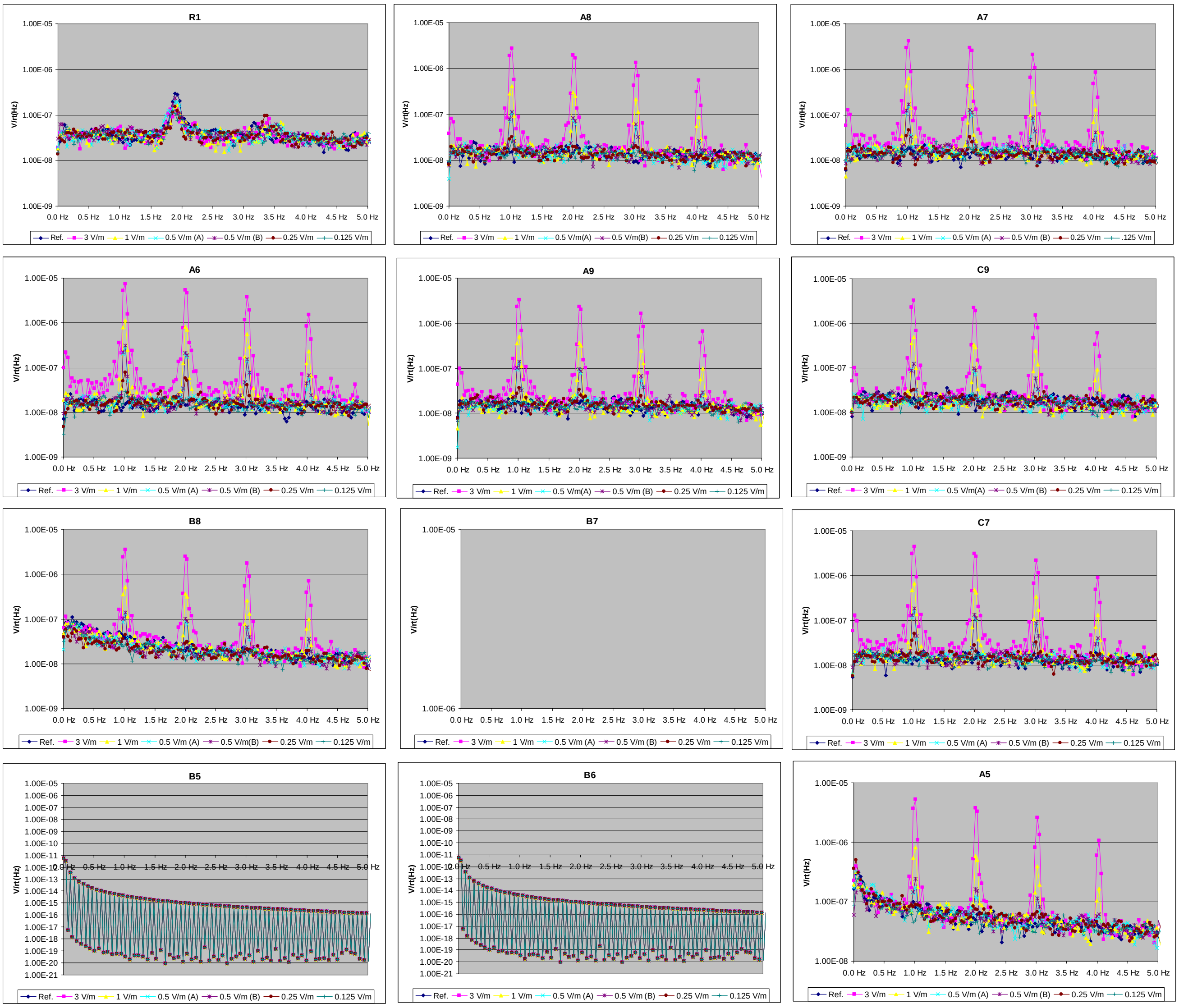


Figure 19

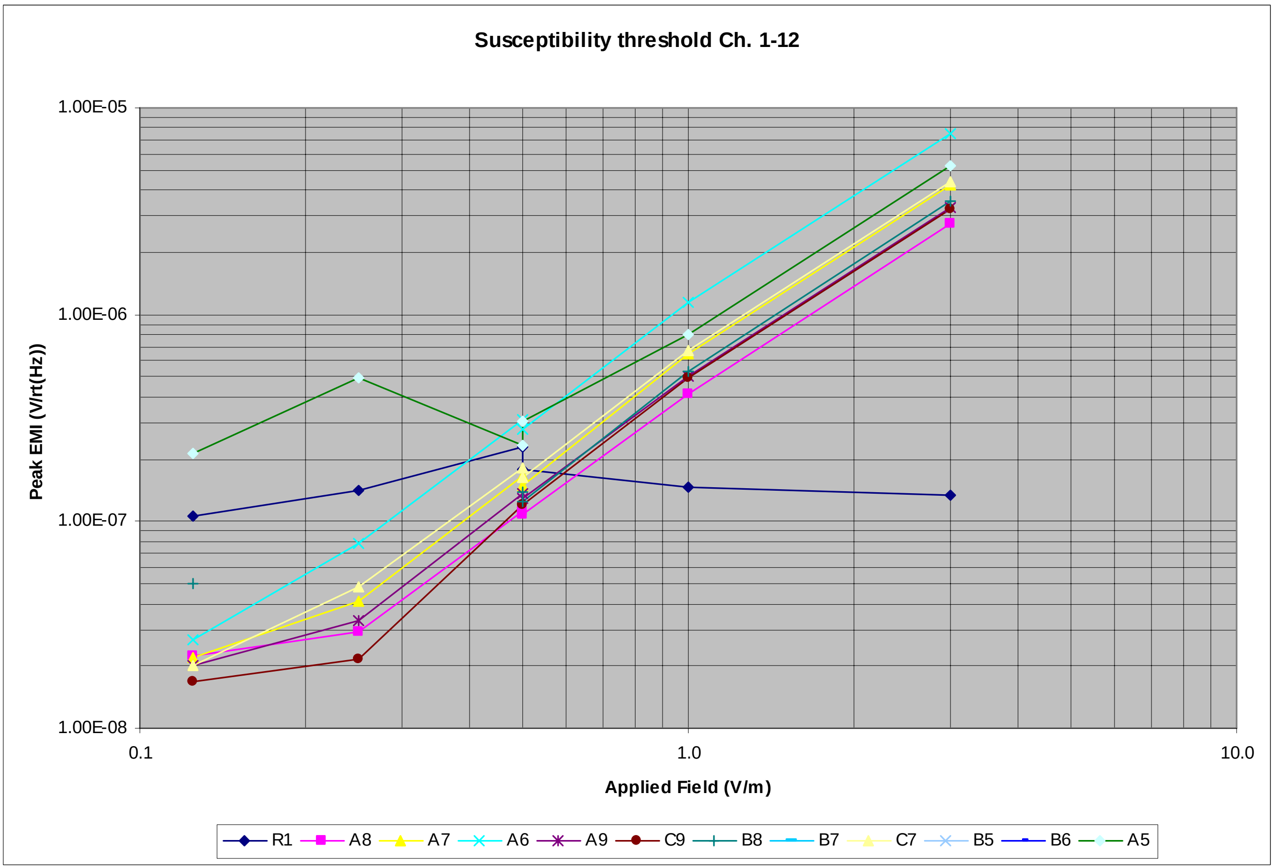

Susceptibility threshold Ch. 1-12
Peak EMI (V/rt(Hz))
1.00E-05
1.00E-06
1.00E-07
1.00E-08
0.1
1.0
10.0
Applied Field (V/m)
R1
A8
A7
A6
A9
C9
B8
B7
C7
B5
B6
A5

Figure 20

5.5.2 Channels 13-24

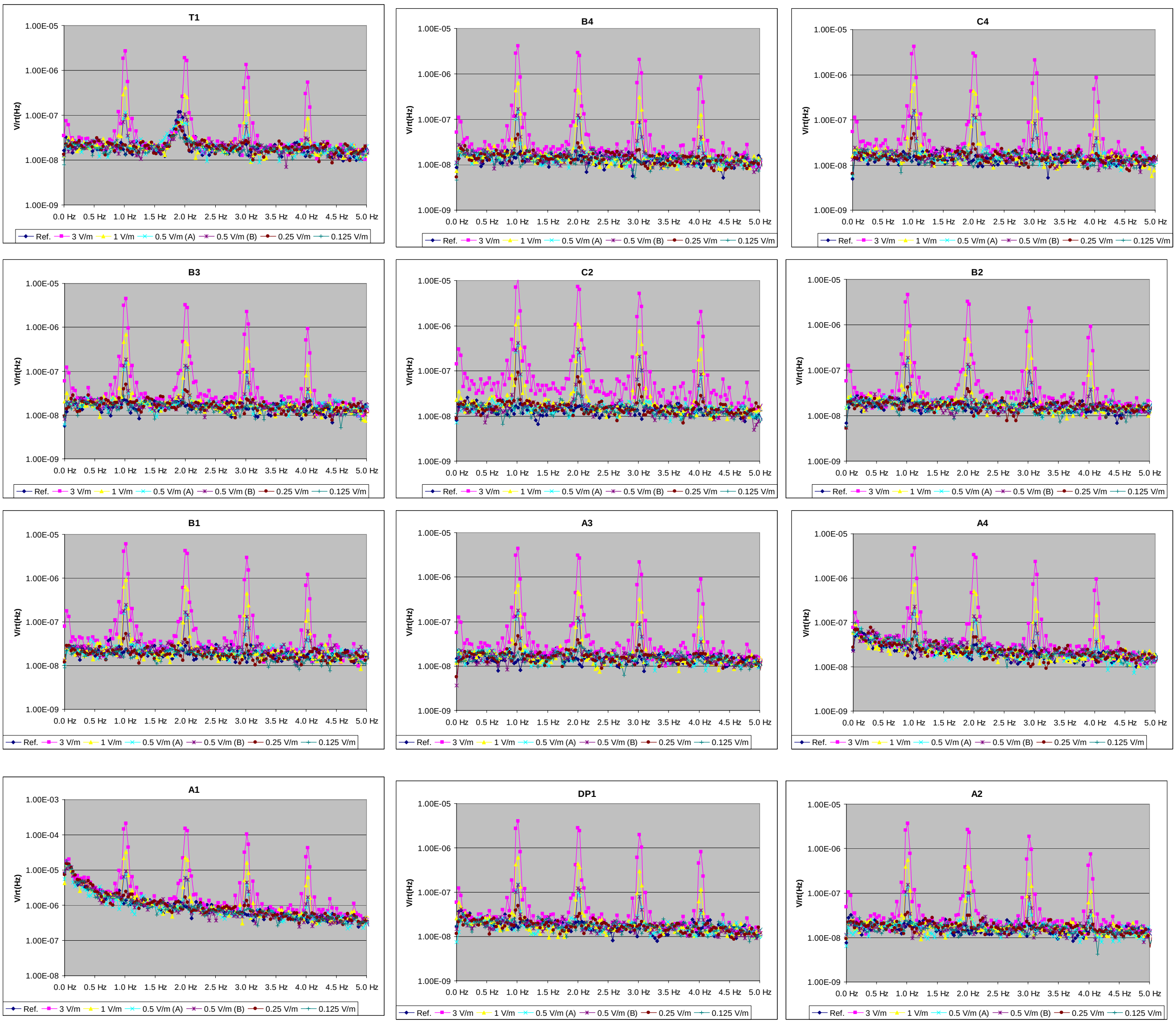


Figure 21

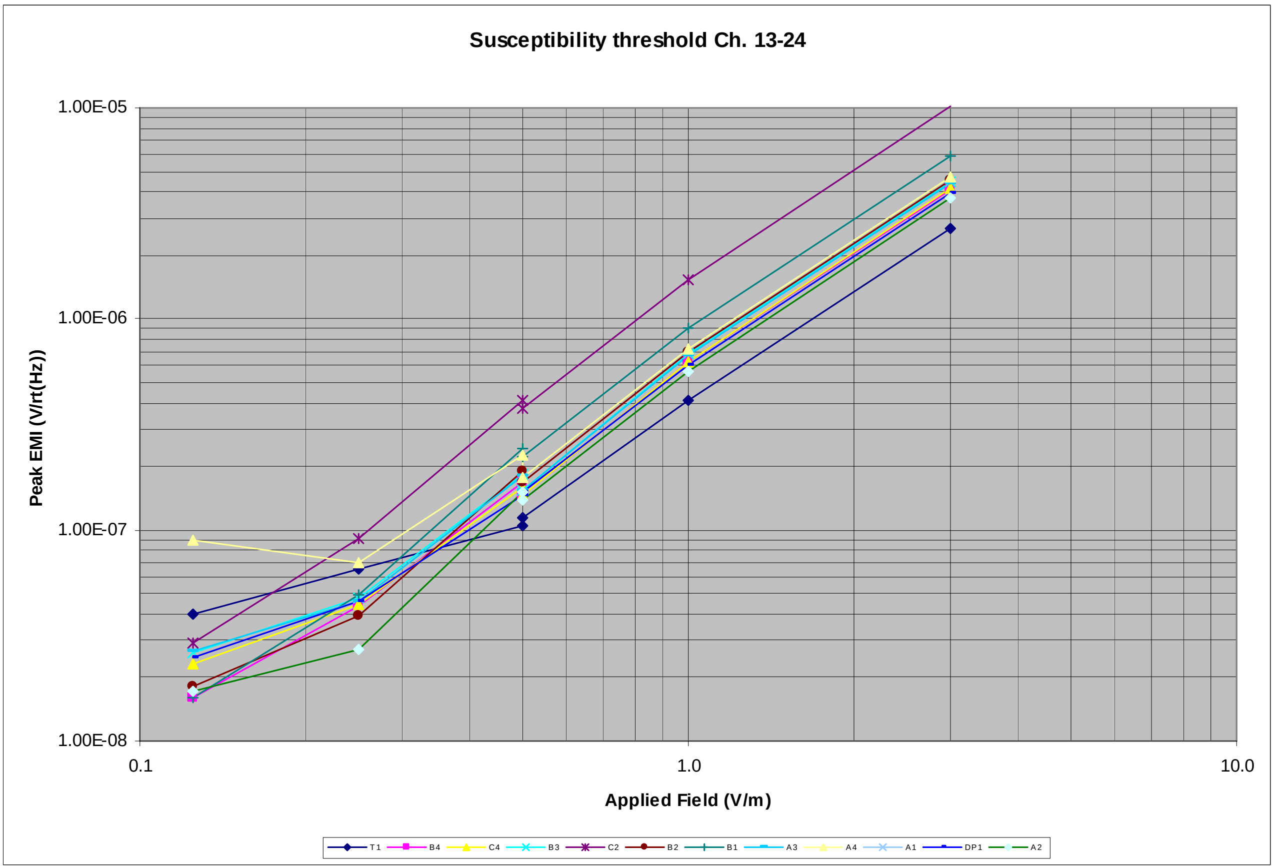

Susceptibility threshold Ch. 13-24
1.00E-05
1.00E-06
1.00E-07
1.00E-08
Peak EMI (V/rt(Hz))
0.1
1.0
10.0
Applied Field (V/m)
T1
B4
C4
B3
C2
B2
B1
A3
A4
A1
DP1
A2

Figure 22

5.5.3 Channels 25-36

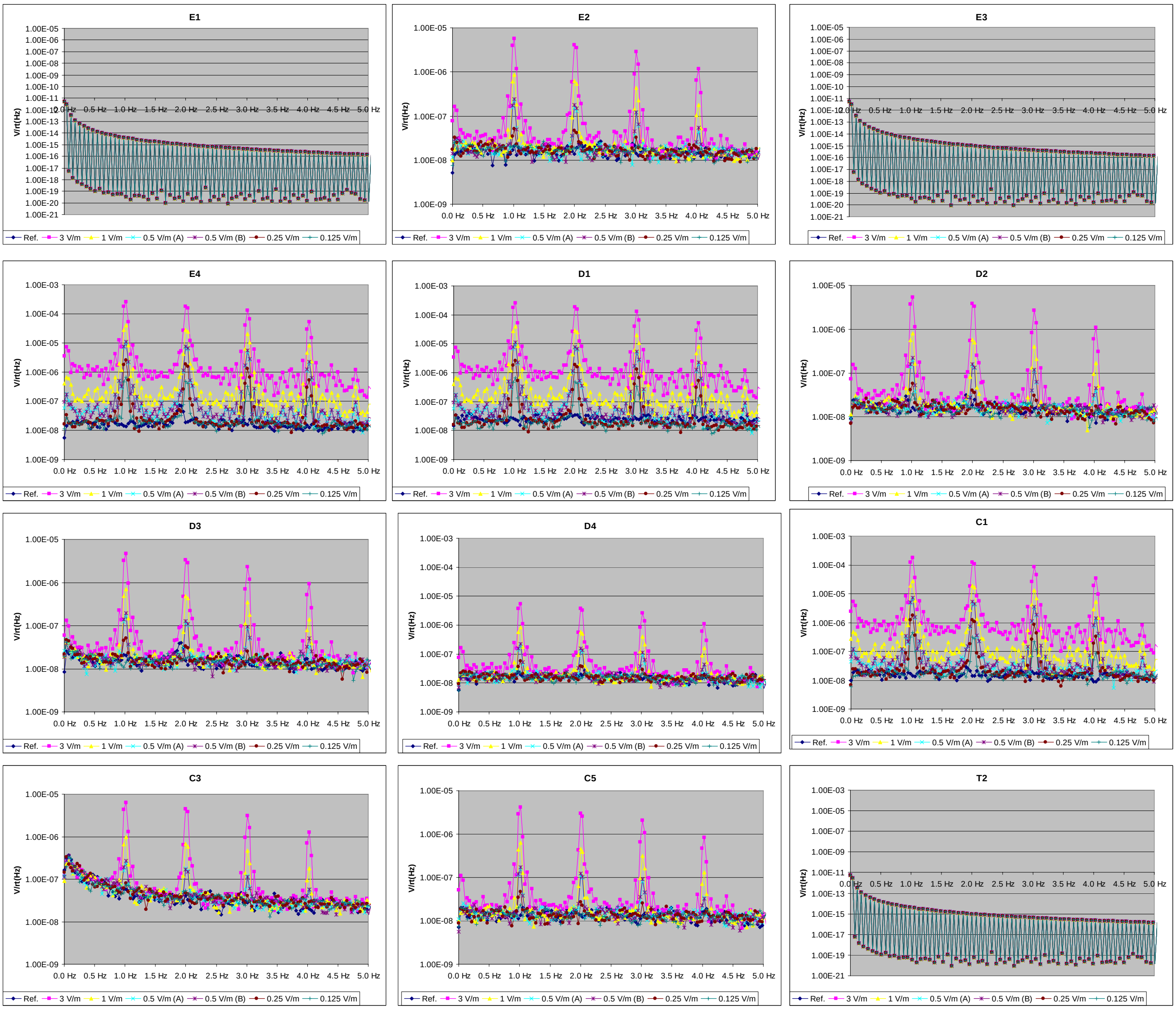


Figure 23 – Channels E1

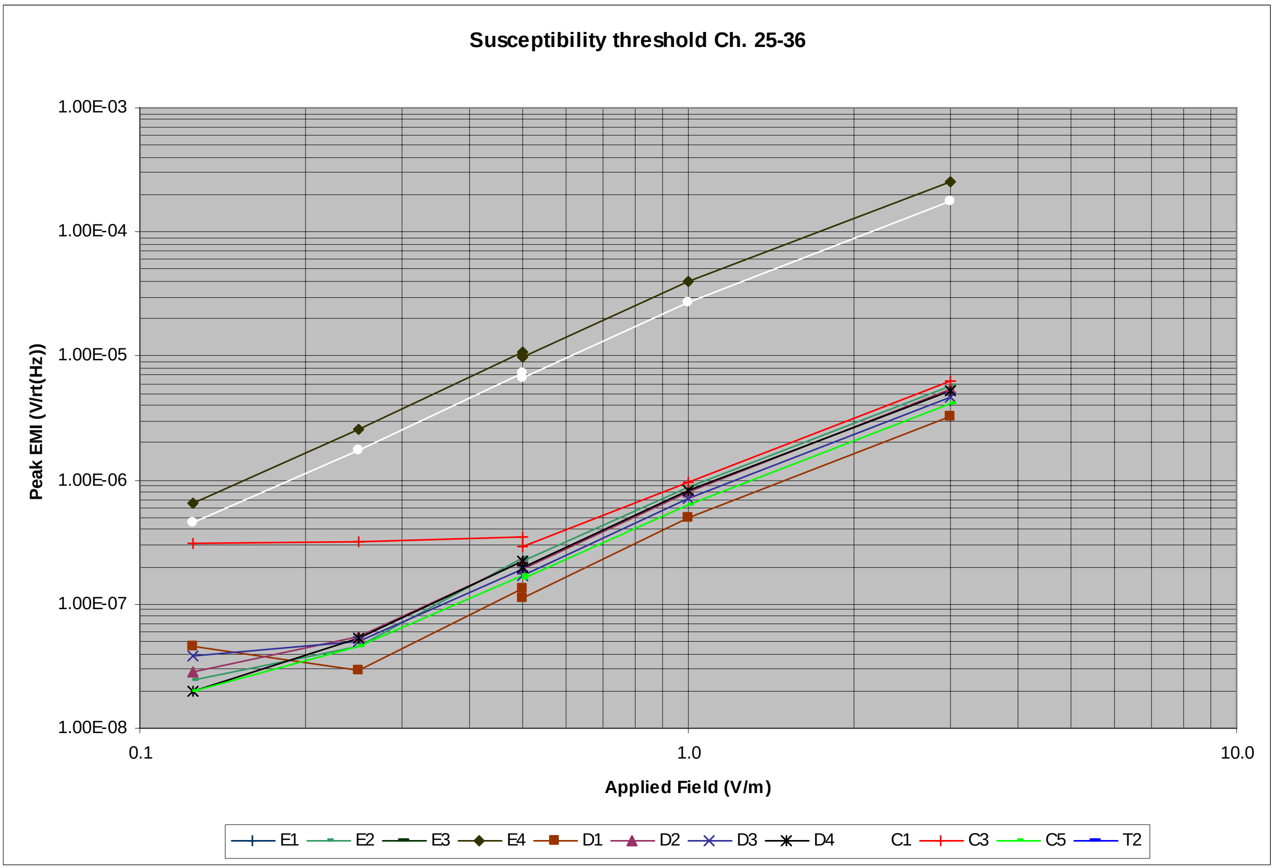

Susceptibility threshold Ch. 25-36
Peak EMI (V/rt(Hz))
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
0.1
1.0
10.0
Applied Field (V/m)
E1
E2
E3
E4
D1
D2
D3
D4
C1
C3
C5
T2

Figure 24

5.5.4 Channels 37-48

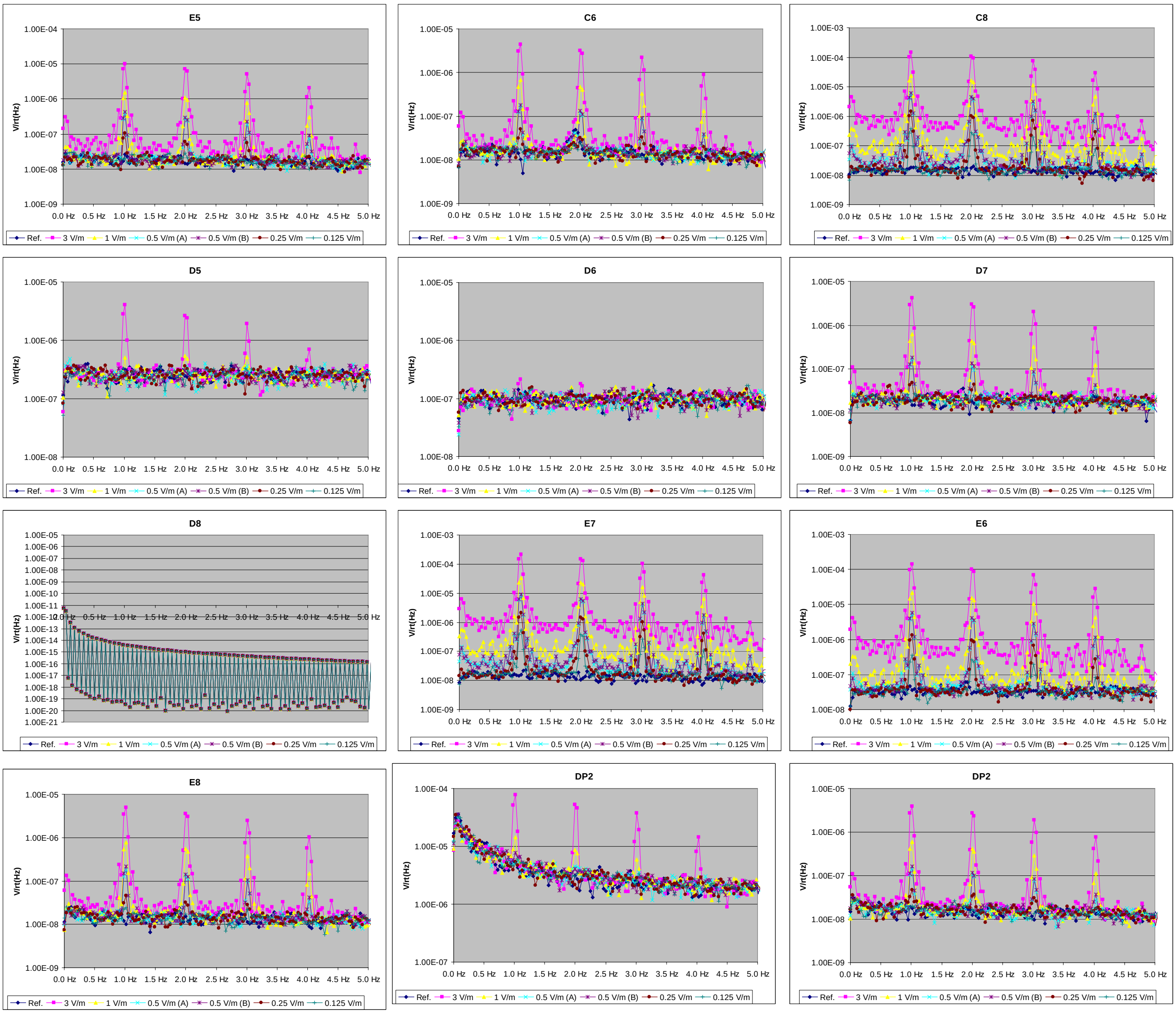


Figure 25

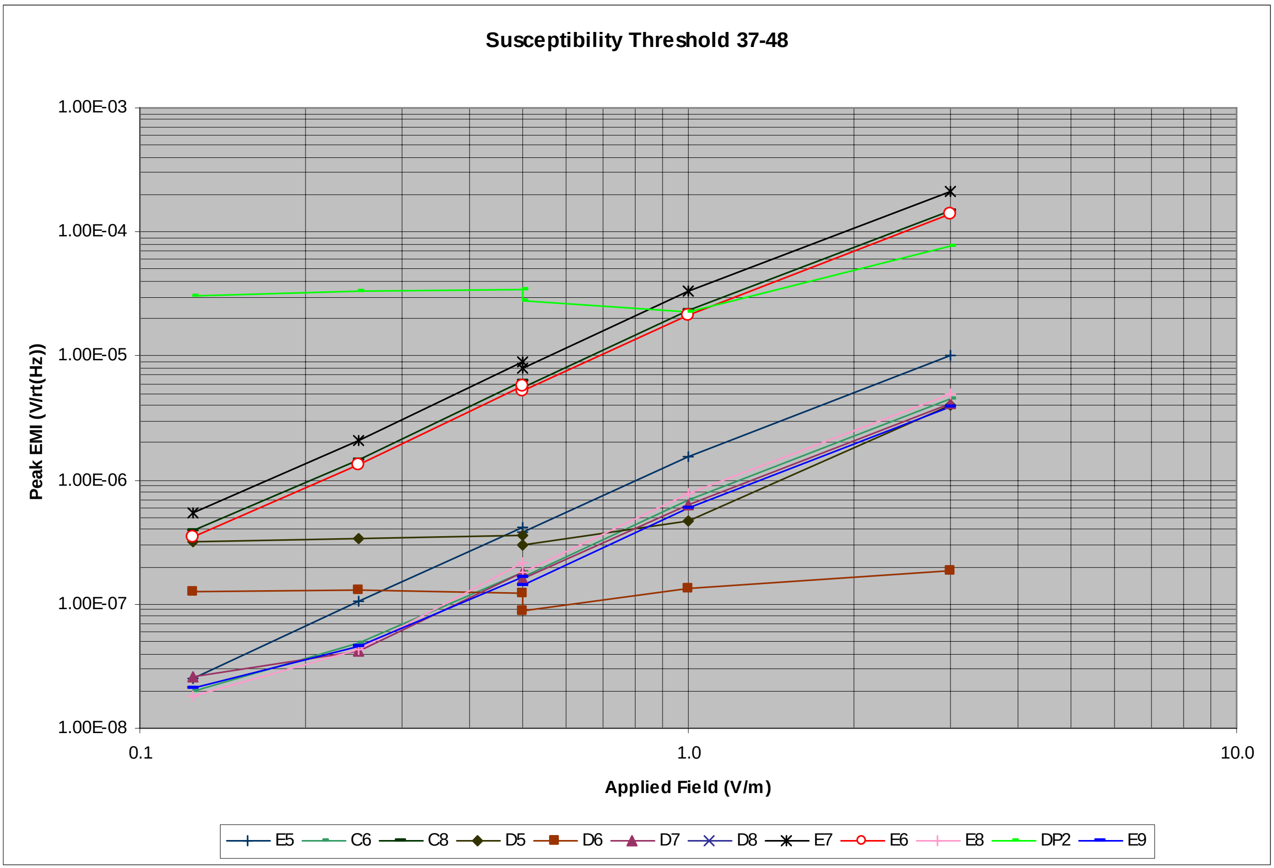

Susceptibility Threshold 37-48
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
Peak EMI (V/rt(Hz))
0.1
1.0
10.0
Applied Field (V/m)
E5
C6
C8
D5
D6
D7
D8
E7
E6
E8
DP2
E9

Figure 26

6. Comparison STM2 and EQM susceptibility thresholds

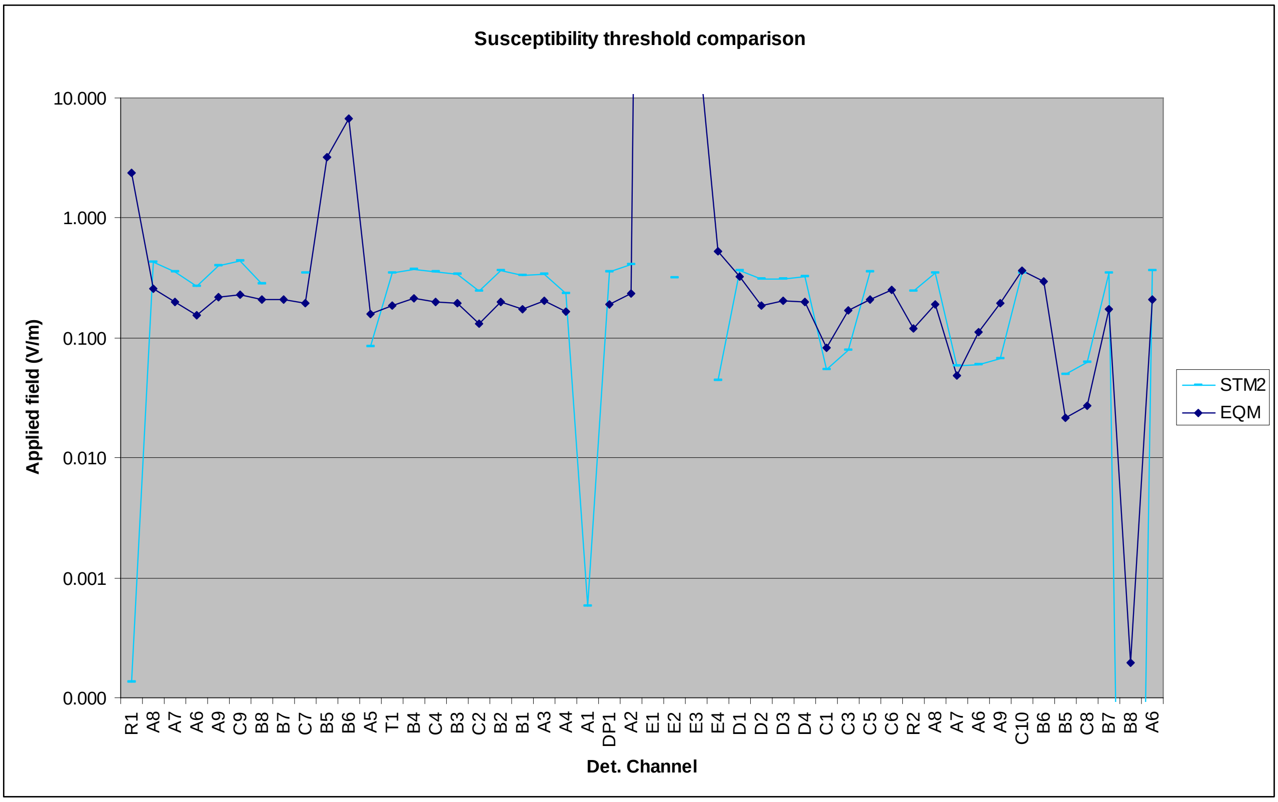


Figure 27 - Comparison between susceptibility threshold found during EQM and STM2 tests. Plots indicate the field which induces a peak noise PSD of 100nV/rt(Hz)

7. Load curve analysis

Estimated power and noise for 30 MHz EMC test during STM2 testing.

Upper plot is estimated absorbed power measured two different ways – comparison to dark loadcurve (red) and comparison to internal thermistor (purple)

Lower plot is estimated voltage noise for dark loadcurve (black) and during EMC irradiation (purple)

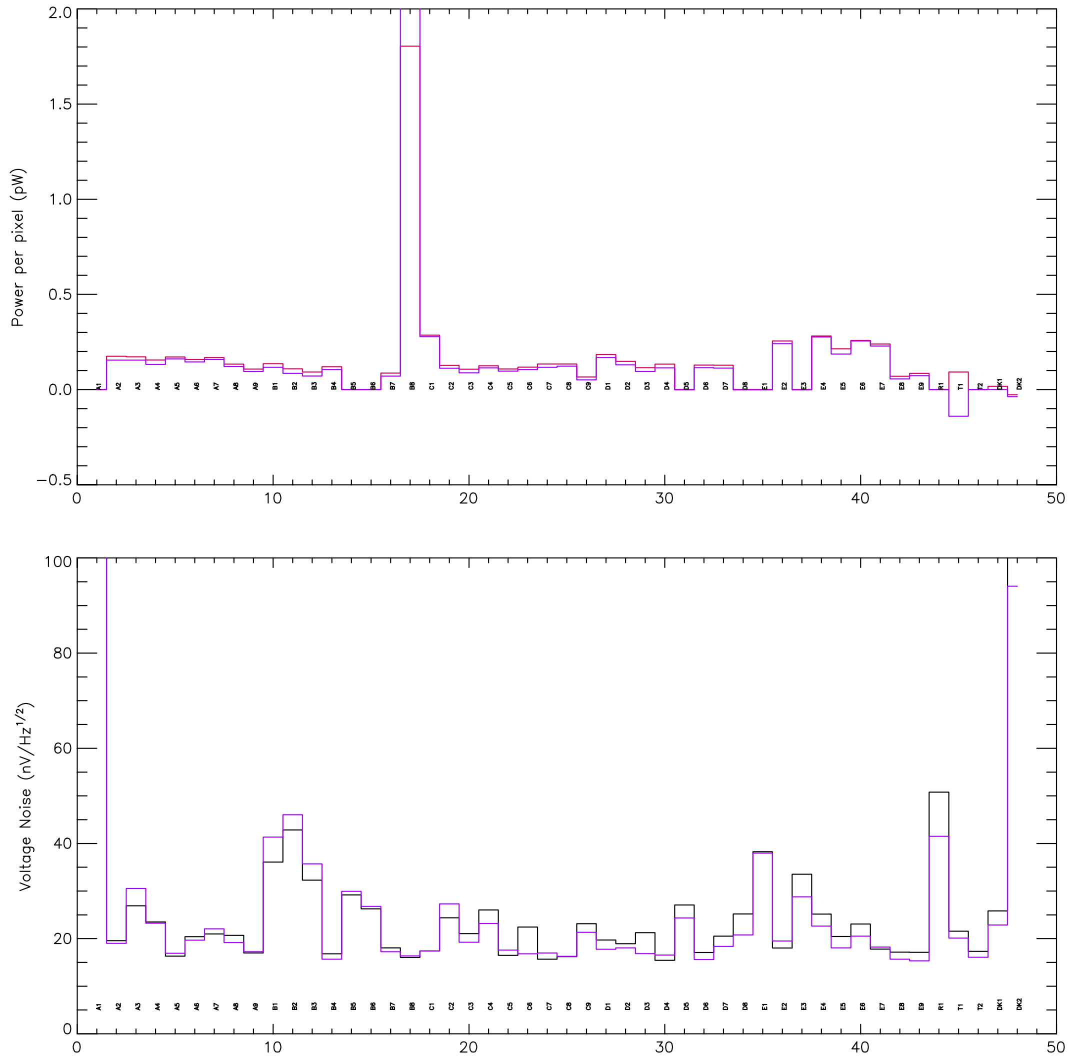


Figure 28 - Load curve analysis

8. Appendix 1 – Susceptibility threshold during EQM Test Campaign

9. Appendix 2: Length of cryoharness and λ/2 resonance

Function	Harness	CS	IS	SS	Total	Half wave resonant frequency
Spect Bias	SIH-01	1350 mm	2455 mm	1245 mm	5.05 m	29.7 MHz
SSW	SIH-02	1315 mm	2816 mm	1206 mm	5.34 m	28.1 MHz
Phot Bias	SIH-03	1270 mm	2136 mm	1547 mm	4.95 m	30.3 MHz
PMW	SIH-04	1280 mm	2816 mm	1556 mm	5.65 m	26.5 MHz
PMW	SIH-05	1200 mm	2816 mm	1728 mm	5.74 m	26.1 MHz
PLW	SIH-06	1165 mm	2816 mm	1265 mm	5.25 m	28.6 MHz
PSW	SIH-07	1035 mm	2365 mm	1242 mm	4.64 m	32.3 MHz
PSW	SIH-08	1245 mm	1905 mm	1279 mm	4.43 m	33.8 MHz
PSW	SIH-09	1295 mm	2816 mm	1252 mm	5.36 m	28.0 MHz
S/S Prime	SIH-10	1790 mm	2024 mm	1784 mm	5.60 m	26.8 MHz
S/S Prime	SIH-11	1710 mm	1843 mm	1858 mm	5.41 m	27.7 MHz
S/S Red.	SIH-12	1630 mm	1896 mm	1717 mm	5.24 m	28.6 MHz
S/S Red.	SIH-13	1790 mm	1748 mm	2015 mm	5.55 m	27.0 MHz

Table 2

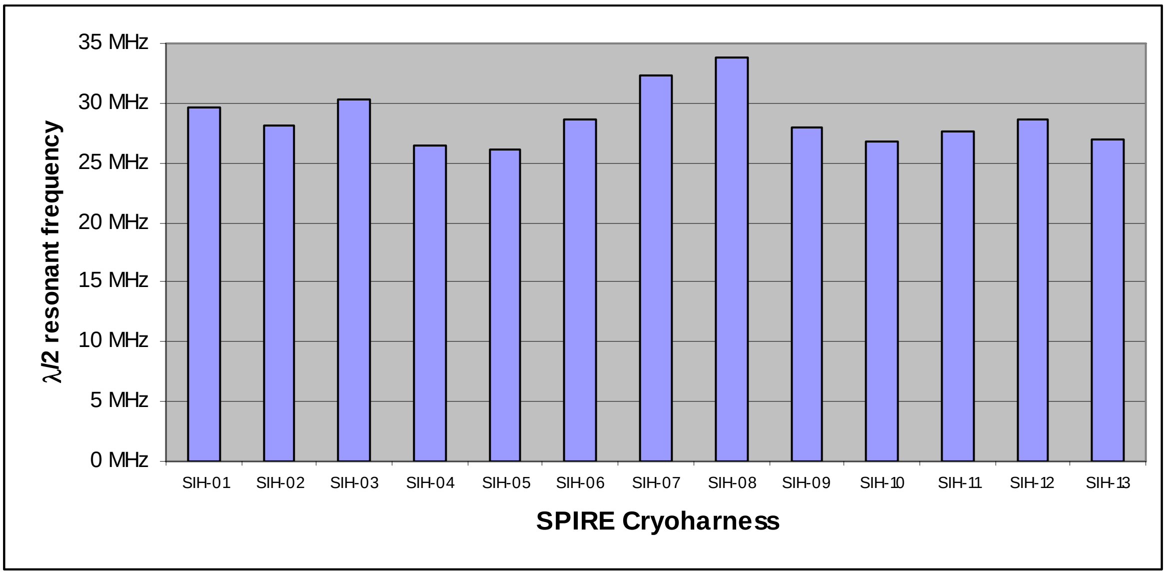


Figure 29