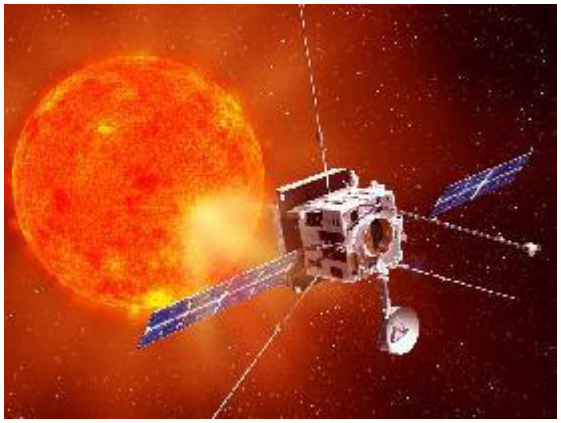

SOLAR ORBITER ENERGETIC PARTICLE DETECTOR

EPT-HET PQM EMC Test Report

Document ID: SO-EPD-KIE-TR-0014

Issue: 1

Revision: 1

Date: 12/02/2016

Note:

The original test report provided by the test facility is attached as Annex A. This cover page is for the EPD configuration control.

Signature not needed if electronically approved by route					
Written	**Checked**	**Approved Configuration Control**	**Approved QA**	**Approved Experiment Manager**	**Approved Principal Investigator**
Original test report author: Jamie Mills (ADS, test facility) Date and Signature	**Ali Ravanbakhsh Date and Signature**	**César Martín Date and Signature**	**Michael Richards Date and Signature**	**Date and Signature**	**Date and Signature**

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CHANGES RECORD

Issue	Revision	Date	Modified by	Section / Paragraph modified	Change implemented
1	0	15/09/2015		All	Initial external release after internal revisions between CAU and Test facility.
1	1	12/01/2016	Jamie Mills(test facility) and Ali Ravanbakhsh Based on the RIDs and guidelines from EPD PO, Ref: "RID_EPT-HET_QM_DRB_SEN_Kiel_disposition_afterDRB.xlsx" After DRB with PO on 25.09.2015	Sec.2 of Annex A	DC Magnetic moment added.
				Sec.3.3 of Annex A	H-field characterization inadvertently missed data 5kHz-10kHz deviation.
				Sec.4.10.5 Sec.4.10.6 of Annex A	Some of the H-filed plots were revised for better data presentation.

ANNEX A (128 PAGES): THE TEST REPORT BY THE FACILITY (RP14899_ISS 3.PDF)

EPT-HET
Solar Orbiter Energetic Particle Detector
PQM Model
EMC DRAFT TEST REPORT
14899

Author: Jamie Mills

Test Dates: 17th April to 8th May 2015

Reviewed by

Responsible Engineer: Ali Ravanbakhsh

Quality Assurance: Michael Lee Richards

Project Manager: Cesar Martin

Airbus Defence and Space Ltd

Anchorage Road, Portsmouth, Hampshire, PO3 5PU, England

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CONTENTS

1. SCOPE:

This report describes and analyses the EMC test results for the Solar Orbiter EPT-HET PQM EMC tests. The tests were carried out according to the requirements of specific sections of EMC test procedure SO-EPD-KIE-TP-0020 Iss 1 Rev 1.

1.1 Purpose:

The purpose of the testing was to demonstrate that the Solar Orbiter EPT-HET PQM when operated with maximum signal levels complies with the EMC requirements specified in EMC test procedure SO-EPD-KIE-TP-0020 Iss 1 Rev 1.

1.2 Applicable Documents:

AD1	SO-EPD-KIE-TP-0020 Iss 1 Rev 1	EPT-HET EMC Test Plan and Procedure
AD2	SOL.S.ASTR.TN.00252	Solar orbiter E-Field and H-Field characterization test procedure guidelines
AD3	ECSS-E-ST-20-07C Rev 1.	Space Engineering Electromagnetic compatibility

1.3 Reference Documents

RD1	MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
RD2	MIL-STD-1541A	Electromagnetic Compatibility Requirements for Space Systems

2. COMPLIANCE STATUS:

Test Description	Result
Grounding and Bonding	Complied
Conducted Emissions - Inrush	Complied
Conducted Emissions - Primary Power Lines (Frequency Domain)	Complied
Conducted Emissions - Primary Power Lines (Time Domain)	Complied
Conducted Susceptibility – Primary Power Lines – Sinewave Injection	Complied
Conducted Susceptibility - Primary Power Lines - Transients	Complied
Conducted Susceptibility – Common Mode	Complied
Radiated Emissions - Wide Band Sweep and Notches	Complied*
Radiated Susceptibility – Wide Band Sweep and Notches	Complied
H-Field Characterisation	Complied*
E-Field Characterisation	N/A
Electrostatic Discharge (ESD)	Complied
DC Magnetic Moment	Did not comply**

*Note: Non-compliance was a noise floor issue.

**Note: Non-compliance is being followed by CAU team in the scope of SO-EPD-KIE-NC-0014.

3. TEST DESCRIPTION:

3.1 EUT Details:

The equipment under test (EUT) consisted of the Solar Orbiter Energetic Particle Detector EPT-HET PQM.

3.2 Test Documentation:

The test requirements for the EUT were specified in the EMC test procedure SO-EPD-KIE-TP-0020 Iss 1 Rev 1. The test procedure closely follows the requirements of the ECSS-E-ST-20-07C Rev 1.

For the E-Field and H-Field characterisation the test procedure SOL.S.ASTR.TN.00252 was adhered to.

All test steps were recorded in the Test Log, which is held by EMC Test Engineering, together with all the test plots, and filed under Job Number 14899.

3.3 Test Deviations:

Some of the test sequence was changed to improve the efficiency of the test campaign at the discretion of the test lab but in agreement with the customer.

Radiated Susceptibility: For the high field strength notches, not all the levels could be fully achieved. The levels achieved are noted in the Radiated susceptibility section of this report.

Radiated Emissions: The 7162 to 7182 MHz limit was not achievable with the test equipment available.

E-Field Characterisation: The antenna required to perform the low levels was not available at the time of test so the best possible noise floor measurement was made using the equipment available.

ESD: The minimum amplitude for the radiated test was 40A. as a result the test distance was increased to limit the risk of overstressing the EUT.

H-Field Characterisation: Due to the test being performed in time domain, 5kHz to 10kHz was inadvertently missed. This will be repeated at flight level using a FFT test receiver.

3.4 Equipment Configuration:

The EUT was tested in the following configuration as specified within the test procedure.

3.4.1 Configuration and Set-Up:

The following tests were carried out in Building 23A, EMC Chamber 2 at Airbus Defence and Space, Portsmouth.

The EUT was configured by the customer prior to the test.

A photograph is shown for reference:

Figure.1 General EMC Test Setup.

3.5 Operation Modes:

During the tests the EUT was operated in the following operating modes:

- Ambient: EUT Off, EGSE On, 28V On.
- Active Mode: EUT On in EMI mode, EGSE On, 28V On.

4. TEST RESULTS:

4.1 Grounding, Bonding and Isolation:

4.1.1 Test Details:

Test Engineer(s):	J.Mills			
Test Plan Reference:	6.1			
Test Dates:	**Start:**	20th April 2015	**End:**	20th April 2015
Ambient Conditions:	**Temp:**	23ºC	**Humidity:**	34%

4.1.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Milliohmeter	Keithley	580	002127	19-Dec-15

4.1.3 Test Procedure:

Grounding and bonding was performed using a four point measurement method as shown below, with the measurement points detailed.

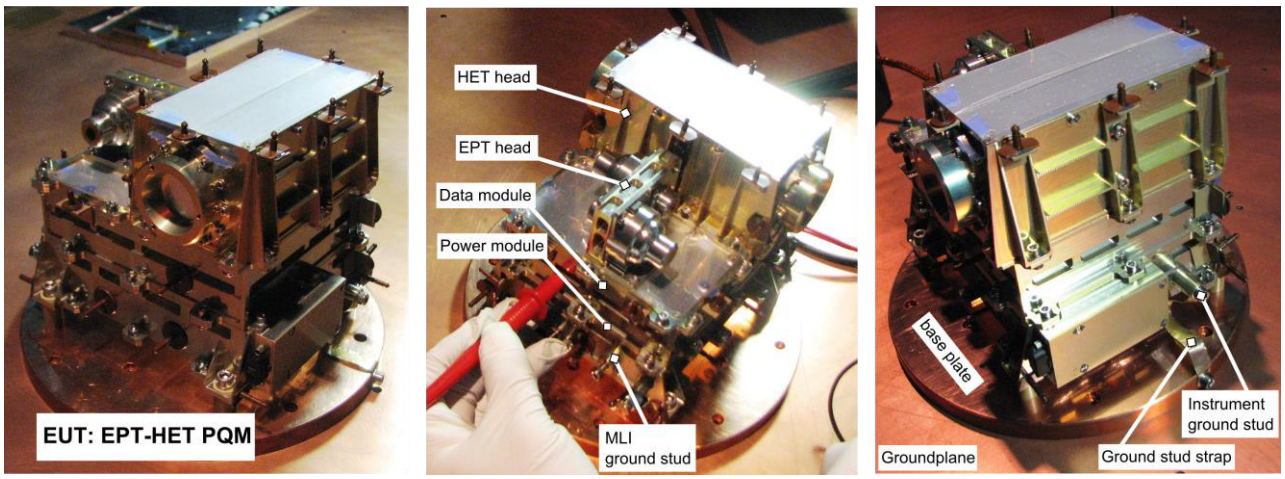


Figure.2

4.1.4 Results Summary:

Measurement	Result (mΩ)
Baseplate to Groundplane	0.1
Instrument to Ground stud strap	2.06
Instrument to Ground stud screw	3.8
Screw head to screw head either end of copper strap	4.2
HET Head to Ground stud strap	3.46
EPT Head to Ground stud strap	3.75
EPT Baseplate to Ground stud strap	3.75
Data Module to Ground stud strap	3.26
Power module to Ground stud strap	3.25
MLI Ground to Ground stud strap	4.6
Baseplate to Ground stud strap	3.3

4.2 Conducted Emissions: Inrush Current:

4.2.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.2			
Test Dates:	**Start:**	20th April 2015	**End:**	20th April 2015
Ambient Conditions:	**Temp:**	23.3ºC	**Humidity:**	34%

4.2.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029769	09-May-15
Current Amp	Tektronix	TCPA300	040925	28-Jan-16
Current Probe	Tektronix	TCP312A	040926	28-Jan-16
Spike Generator	Solar	7054-1	034047	Verified in use
PSU	Farnell	-	005702	Verified in use
Resistor	Solar	7144-5.0	031509	19-Nov-15

4.2.3 Test Procedure:

Prior to testing, a system measurement check was performed in accordance with section 5.4.4 of the ECSS-E-ST-20-07C Rev 1.

The inrush current was performed at three Bus voltages of 26, 28 and 29V. The current probe was attached around the relevant power line at the LCL of the LISN as shown in Figure.1.

An oscilloscope was used to capture the resultant inrush when the Bus voltage was applied. 3 different time bases were used to capture the inrush current. The voltage transient was also captured for information only.

Figure.3

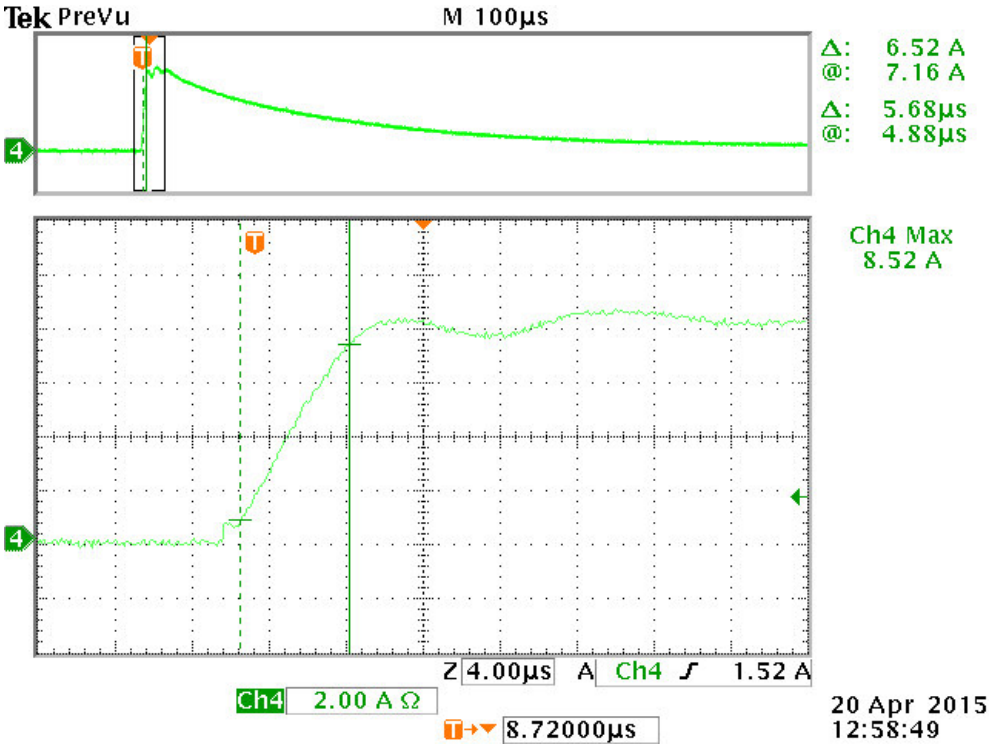
4.2.4 Results Summary:

+VE at LISN LCL

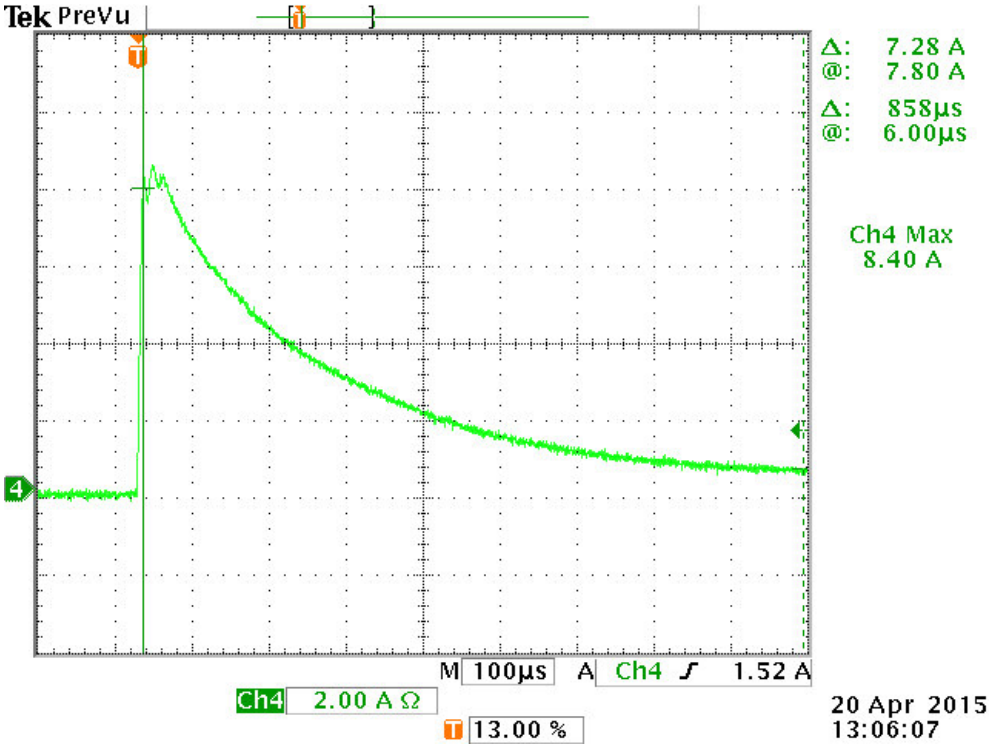
Test Mode	Parameter	Level	Limit	Plot No	Result
Initial power application at 26V	Max Current (A)	7.84	10	008, 009, 010, 011, 012	Complied
	Transient 1 Amplitude (A)	5.32	N/A		N/A
	Transient 1 Rise Time (µs)	5.28	N/A		N/A
	di/dt (A/µs)	1.00758	N/A		N/A
	Time to Nominal (ms)	1.81	6.7		Complied
	Charge (mC)	2.18	3.7		Complied
Initial power application at 29V	Max Current (A)	8.8	10	005, 006, 007, 015	Complied
	Transient 1 Amplitude (A)	6.2	N/A		N/A
	Transient 1 Rise Time (µs)	4.8	N/A		N/A
	di/dt (A/µs)	1.29167	N/A		N/A
	Time to Nominal (ms)	1.92	6.7		Complied
	Charge (mC)	2.37	3.7		Complied
Initial power application at 28V	Max Current (A)	8.5	10	002, 004, 013, 014	Complied
	Transient 1 Amplitude (A)	6.52	N/A		N/A
	Transient 1 Rise Time (µs)	5.68	N/A		N/A
	di/dt (A/µs)	1.14789	N/A		N/A
	Time to Nominal (ms)	2.0	6.7		Complied
	Charge (mC)	2.27	3.7		Complied

4.2.5 Plots:

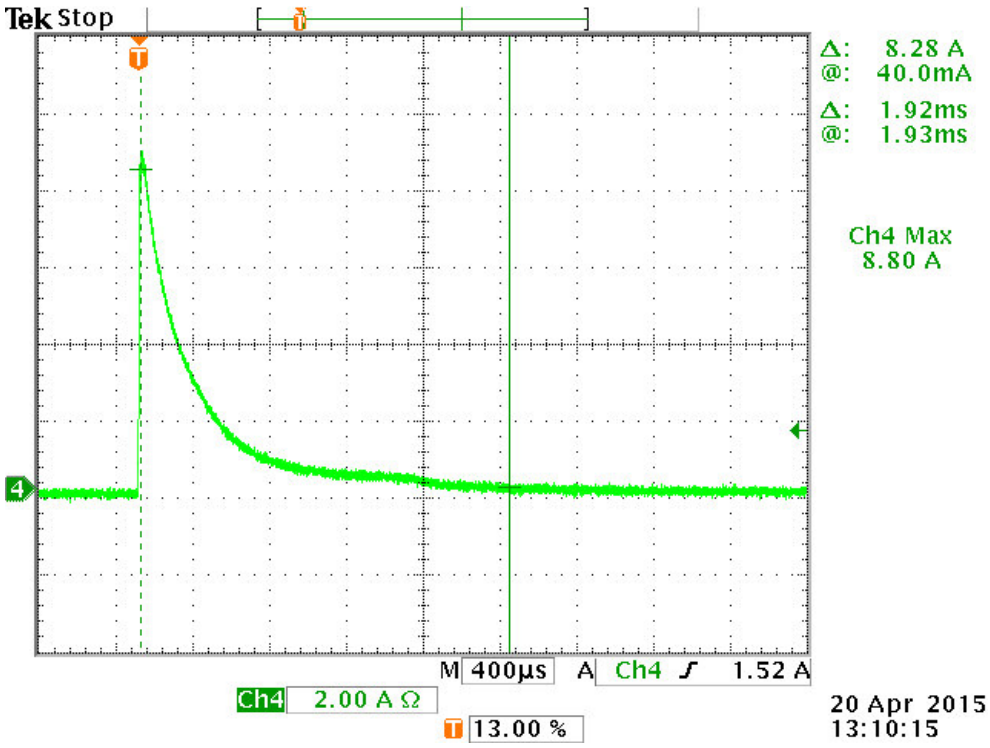
Plot 002



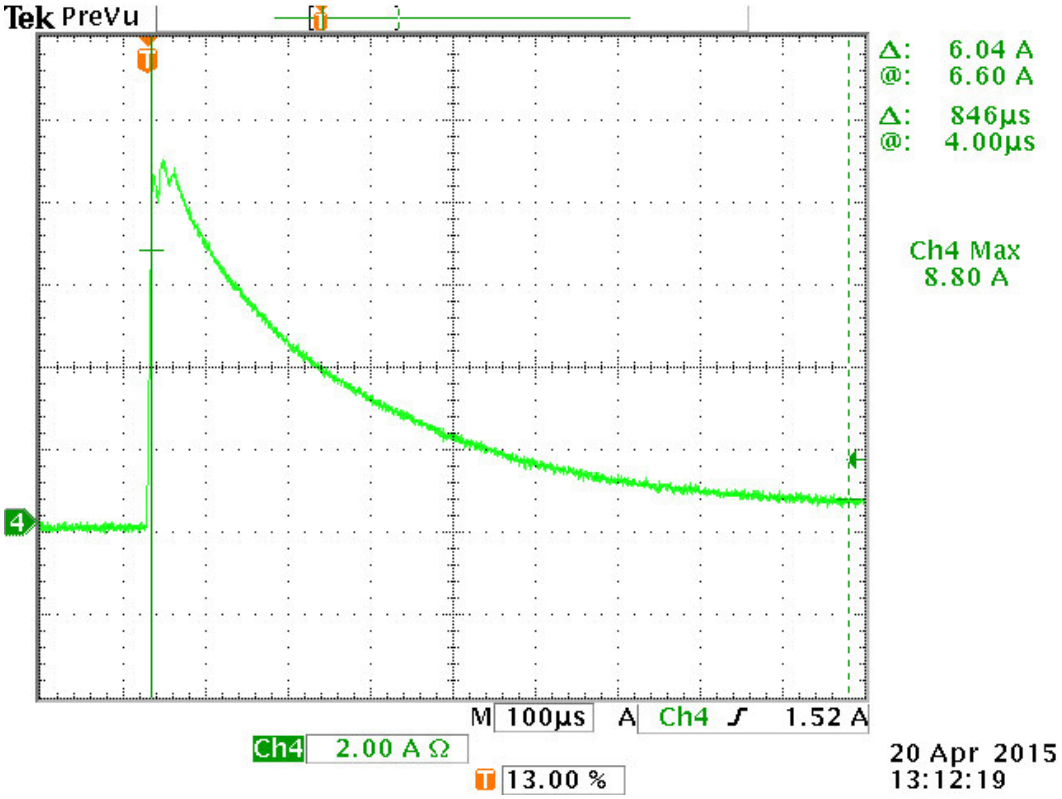
Plot 004



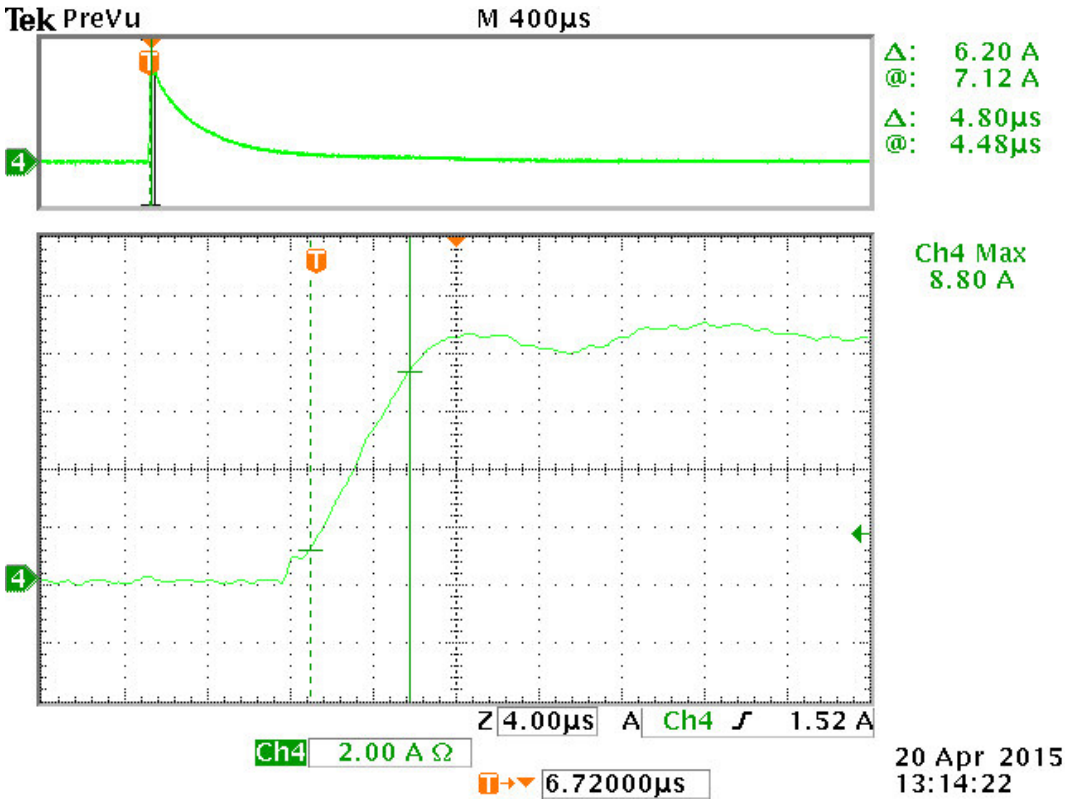
Plot 005



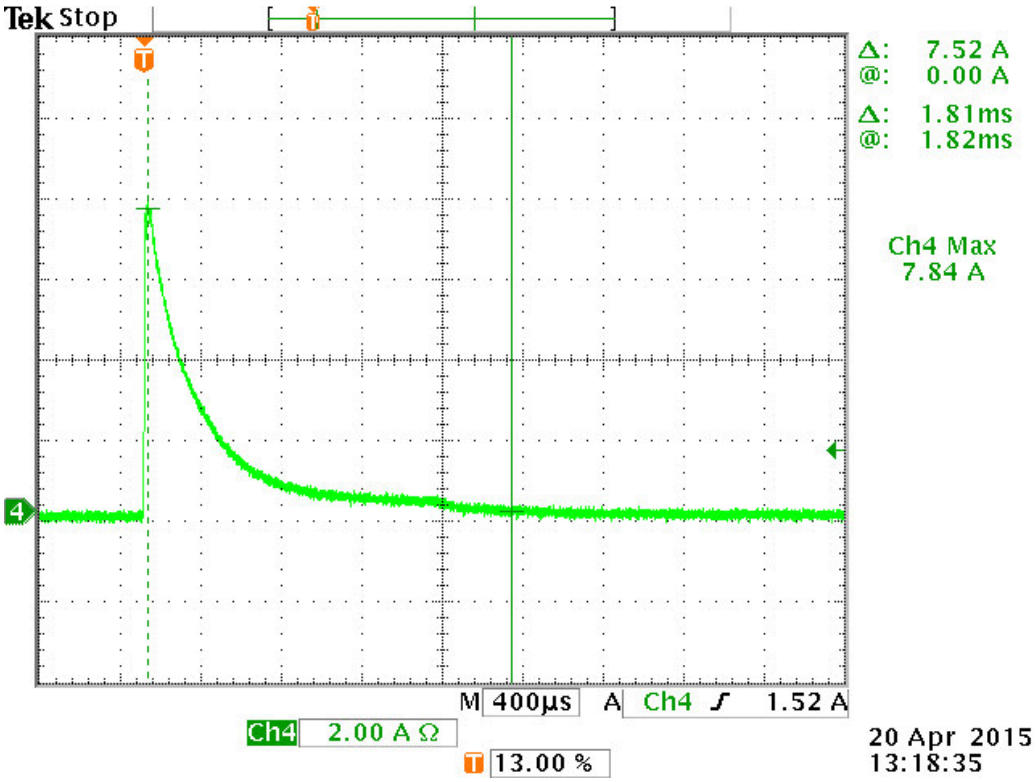
Plot 006



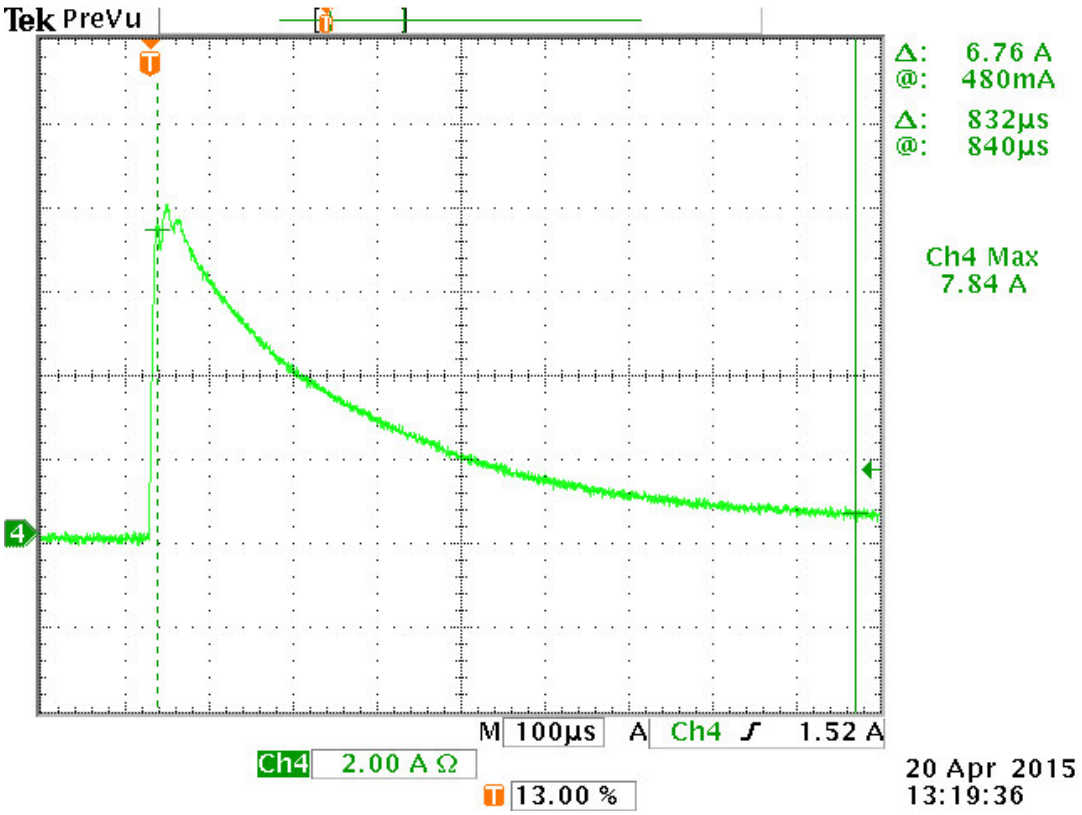
Plot 007



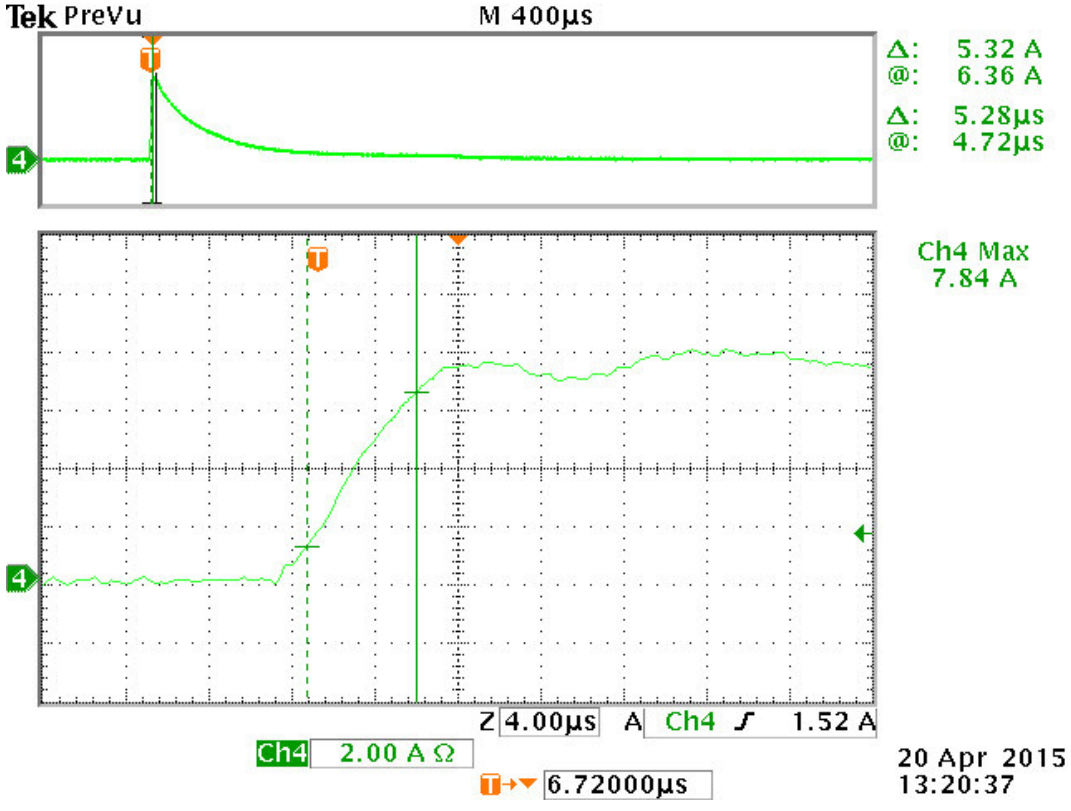
Plot 008



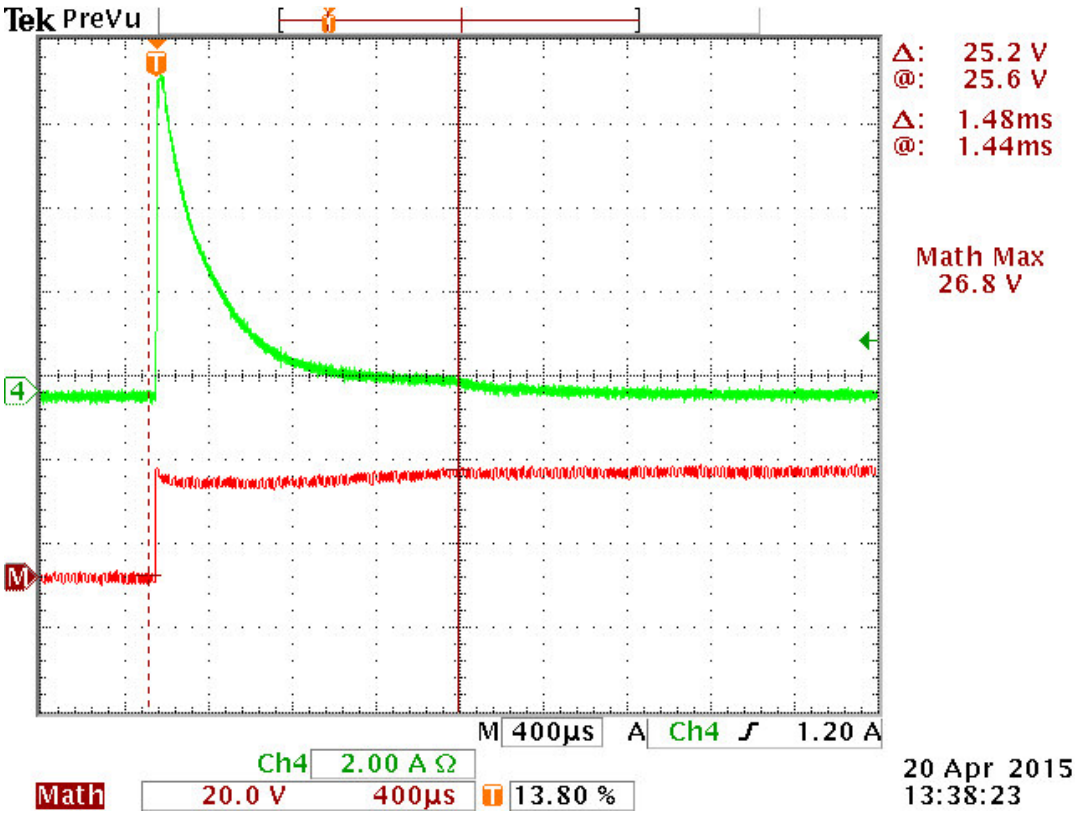
Plot 009



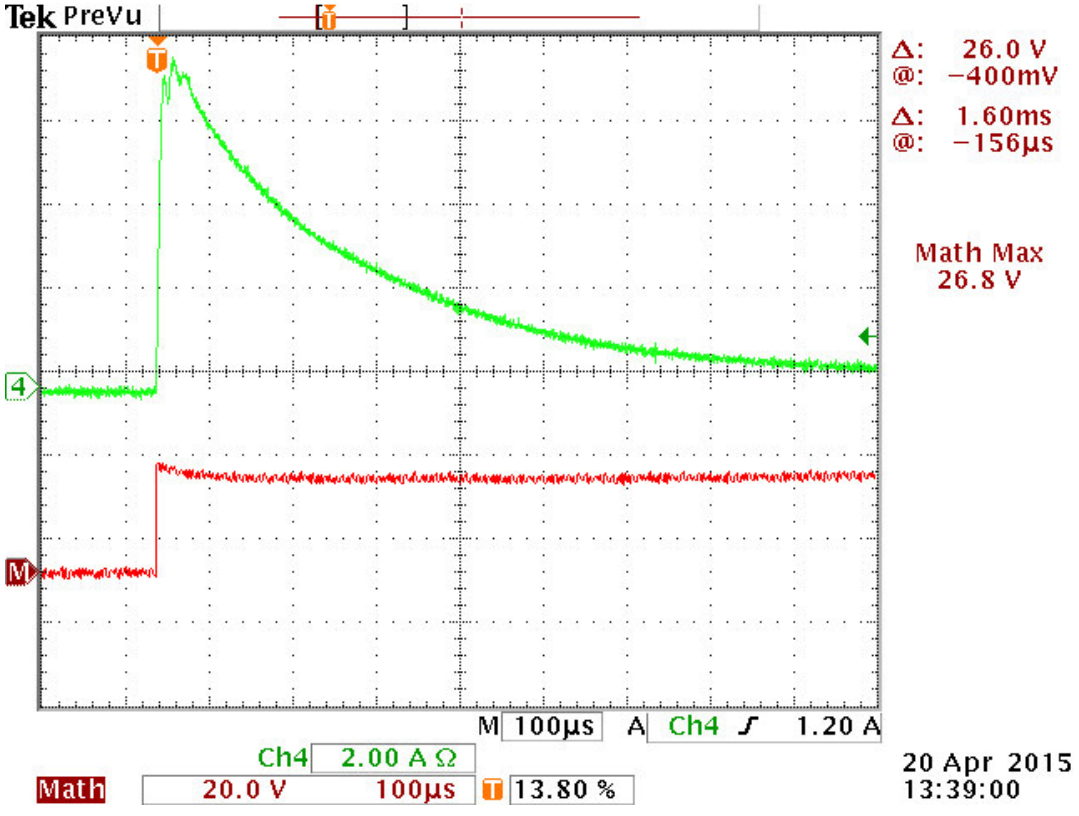
Plot 010



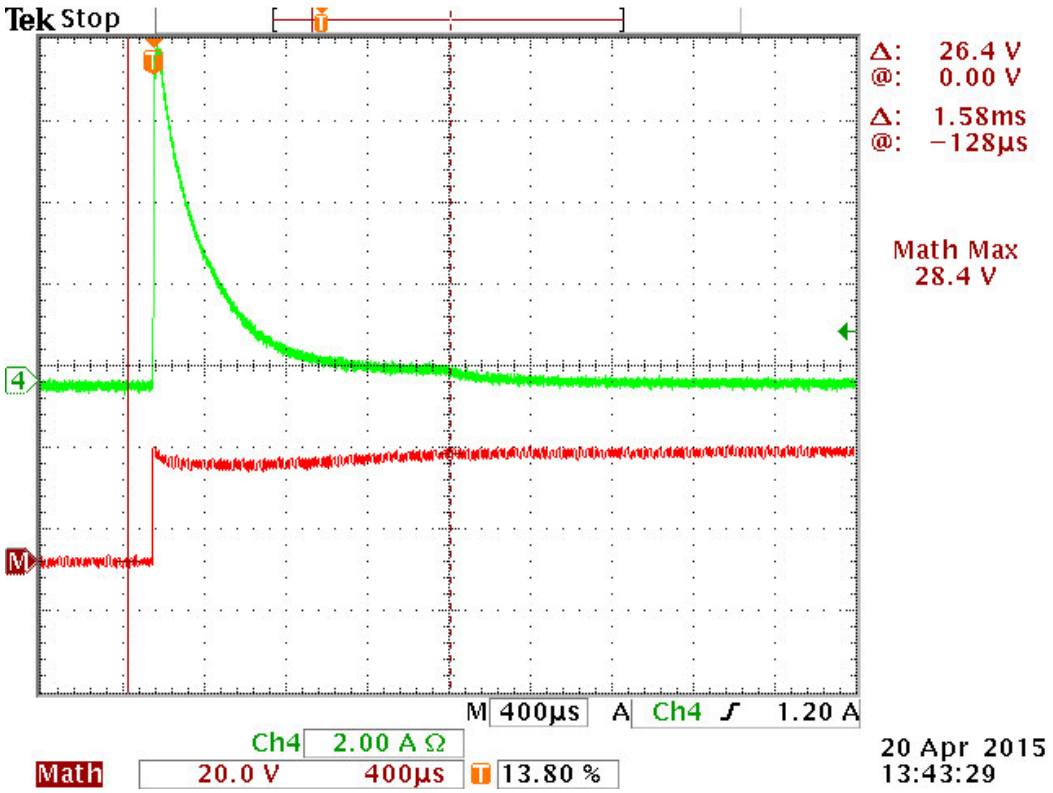
Plot 011



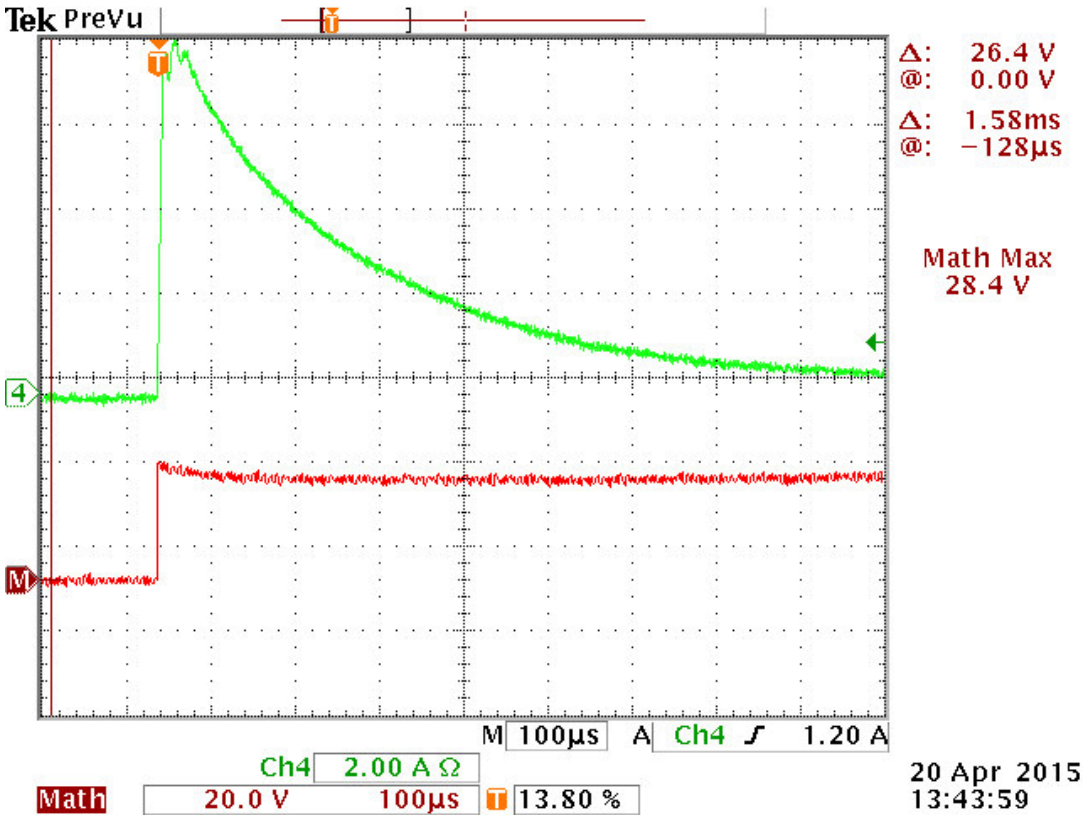
Plot 012



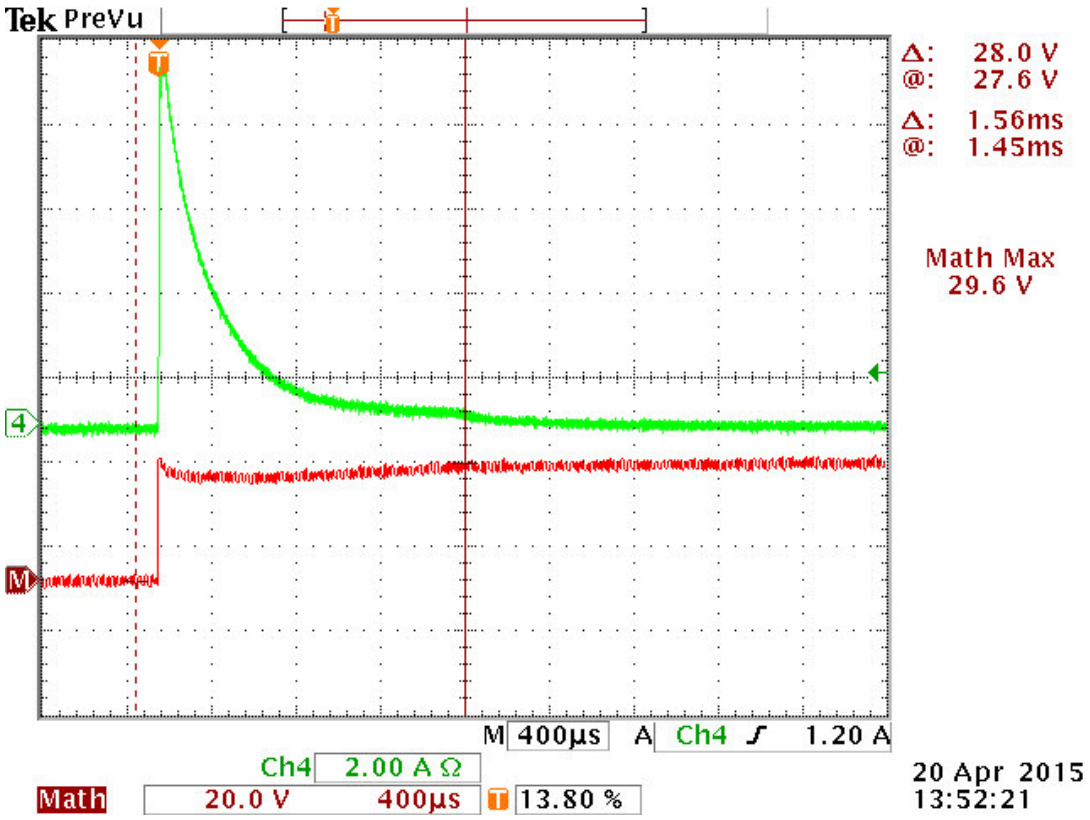
Plot 013



Plot 014



Plot 015


Tek PreVu
Δ: 28.0 V
@: 27.6 V
Δ: 1.56ms
@: 1.45ms
Math Max
29.6 V
M 400µs A Ch4 1.20 A
Ch4 2.00 A Ω
Math 20.0 V 400µs 13.80 %
20 Apr 2015
13:52:21

4.3 Conducted Emissions (Frequency Domain):

4.3.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.3, 6.5			
Test Dates:	**Start:**	20th April 2015	**End:**	21st April 2015
Ambient Conditions:	**Temp:**	24.0ºC	**Humidity:**	33%

4.3.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
RF Current Probe	Ailtech	91550-2B	004328	04-Jun-15
Cable 3m	Rosenberger Micro Coax	FB311A1030005050	029718	19-May-15
Test Receiver	Rhode & Schwarz	ESIB40	028970	17-Dec-15
RF Current Probe	HP	0960-0847	014340	20-Feb-16

4.3.3 Test Procedure:

All test cables were verified using a network analyser prior to use.

The current probe was placed around the powerlines at the breakout part of the LISN. First in common mode then the +VE and –VE lines separately. 2 current probes were used to cover the frequency ranges as shown in Figures 3 and 4.

A background measurement was only performed for the common mode as the frequency domain demonstrated sufficient margin.

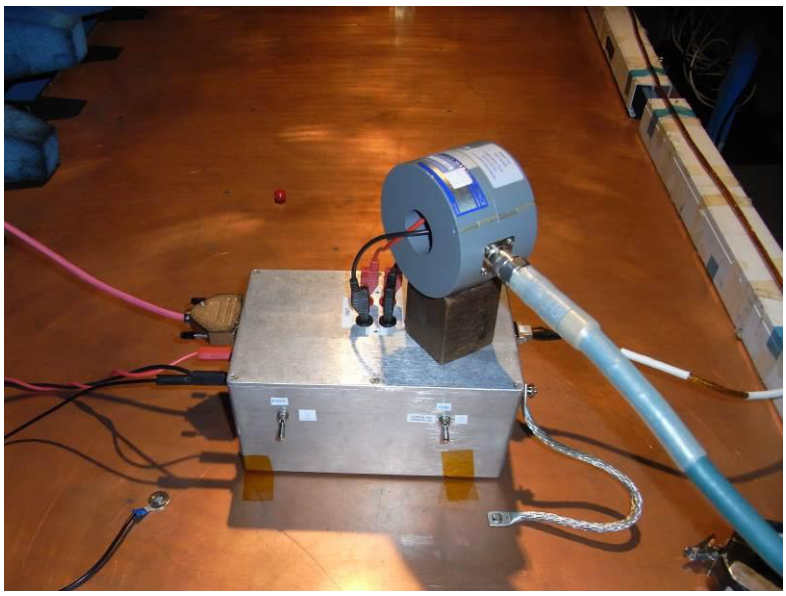


Figure.4 Low Frequency Probe Common mode

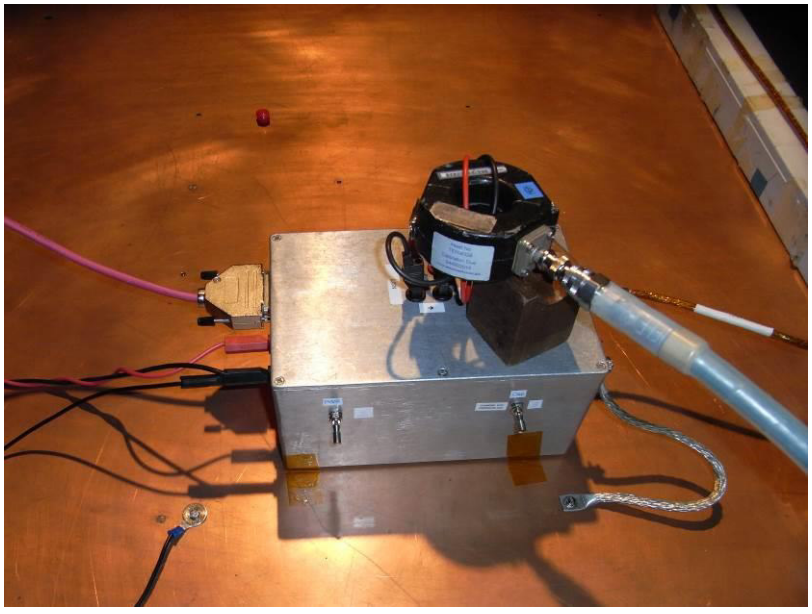


Figure.5 High Frequency Probe Common mode

Results Summary:

Probe Position	Frequency Range (kHz)	Bandwidth	Measured Frequency (kHz)	Measured Level (dBµA)	Limit (dBµA)	Result	Plot	
Common	0.03 to 1	10Hz	0.055	34.6	60.0	Complied	027	308
	1 to 10	100Hz	1.159	-5.1	60.0	Complied	026	
	10 to 150	1kHz	126.087	34.9	58.5	Complied	025	
	150 to 1000	10kHz	628.873	33.0	48.0	Complied	024	
	1000 to 30000	10kHz	19660.346	5.7	30.0	Complied	023	
	30000 to 50000	100kHz	48043.111	5.8	30.0	Complied	022	
	50000 to 100000	100kHz	64000	34.5	Info only	N/A	048	
Common Background	0.03 to 1	10Hz	0.054	33.0	60.0	Complied	016	
	1 to 10	100Hz	1.132	-4.3	60.0	Complied	017	
	10 to 150	1kHz	31.770	-5.3	46.8	Complied	018	
	150 to 1000	10kHz	775.13	1.2	26.0	Complied	019	
	1000 to 30000	10kHz	11953.615	12.0	20.0	Complied	020	
	30000 to 100000	100kHz	48023.369	12.6	20.0	Complied	021	

Probe Position	Frequency Range (kHz)	Bandwidth	Measured Frequency (kHz)	Measured Level (dBµA)	Limit (dBµA)	Result	Plot	
+VE	0.03 to 1	10Hz	0.066	31.6	60.0	Complied	033	309
	1 to 10	100Hz	1.28	17.0	60.0	Complied	034	
	10 to 150	1kHz	125.200	25.2	58.1	Complied	035	
	150 to 1000	10kHz	626	26.3	44.0	Complied	036	
	1000 to 30000	10kHz	1000	4.9	20.0	Complied	032	
	30000 to 50000	100kHz	48520	11.0	20.0	Complied	031	
	50000 to 100000	100kHz	64000	30.3	Info only	N/A	038	
-VE	0.03 to 1	10Hz	0.066	31.3	60.0	Complied	043	310
	1 to 10	100Hz	1.2	19.7	60.0	Complied	044	
	10 to 150	1kHz	124.800	30.7	58.2	Complied	045	
	150 to 1000	10kHz	750	19.9	44.1	Complied	046	
	1000 to 30000	10kHz	24696	0.7	20.0	Complied	041	
	30000 to 50000	100kHz	44400	11.0	20.0	Complied	040	
	50000 to 100000	100kHz	63960	27.8	Info only	N/A	039	

4.3.4 Plots:

Plot 308

Common Mode

Plot 309

Differential Positive Line

Plot 310

Differential Negative Line

4.4 Conducted Emissions: Power Lines (Time Domain):

4.4.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.4, 6.6			
Test Dates:	**Start:**	21st April 2015	**End:**	22nd April 2015
Ambient Conditions:	**Temp:**	24.5ºC	**Humidity:**	30%

4.4.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029769	09-Jun-15
Current Amp	Tektronix	TCPA300	040925	28-Jan-16
Current Probe	Tektronix	TCP312A	040926	28-Jan-16

4.4.3 Test Procedure:

For common mode a current probe was used to monitor the current ripple and spikes on the primary powerlines at the breakout of the LISN.

For differential mode the current probe was positioned around the +VE line of the Bus and then repeated on the -VE line. The voltage was measured differentially across the primary powerlines.

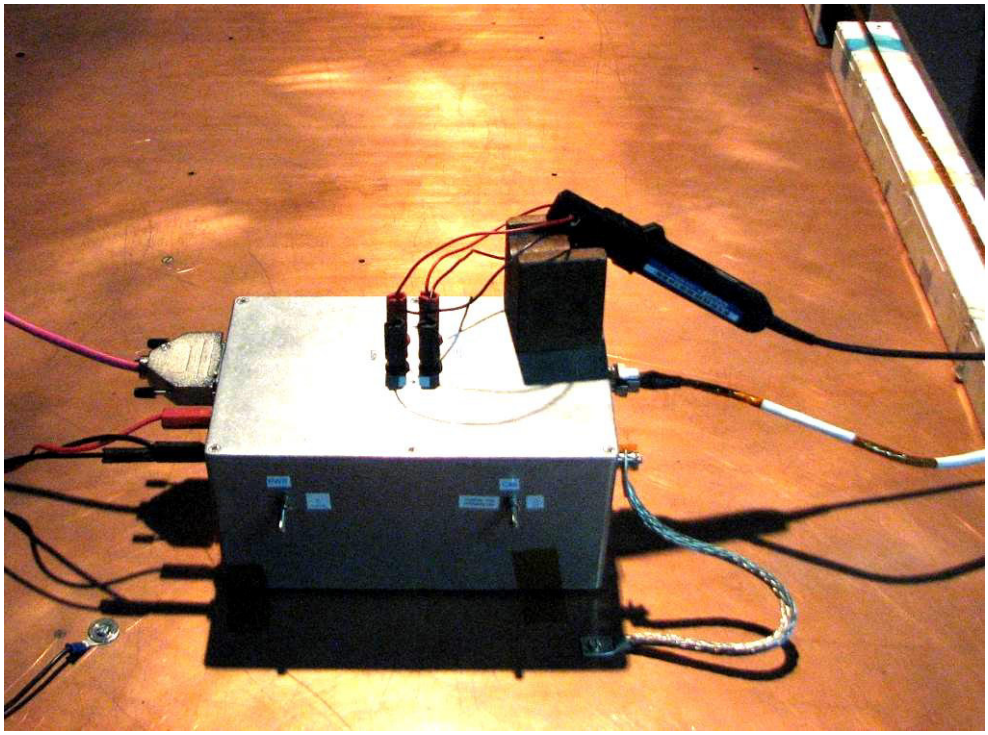


Figure 6. Common mode

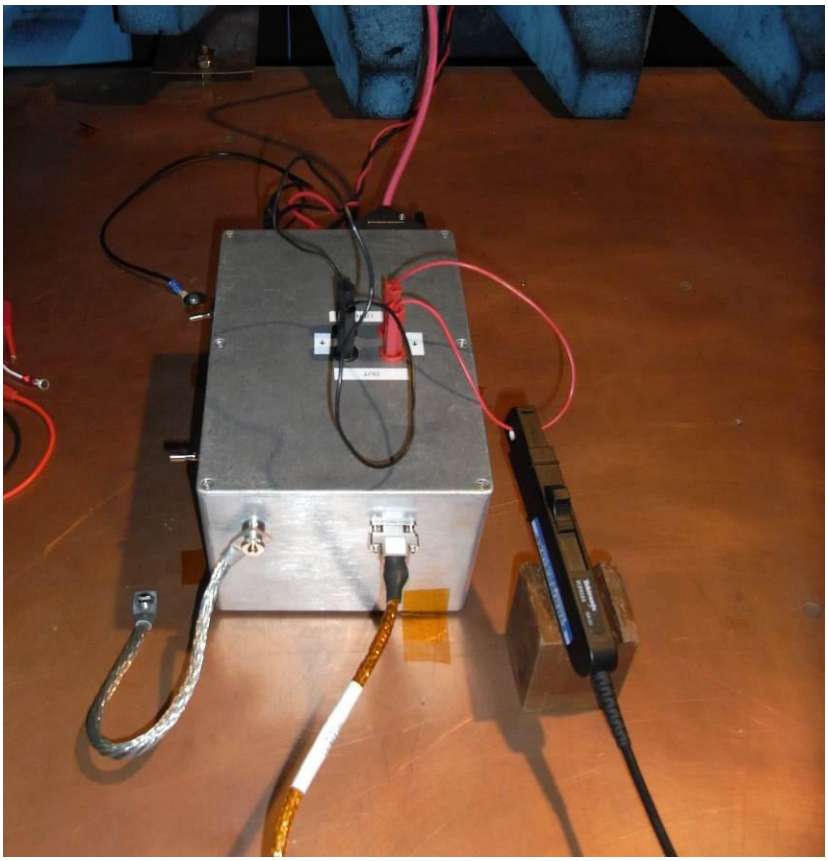


Figure 7. Differential mode: +VE Line

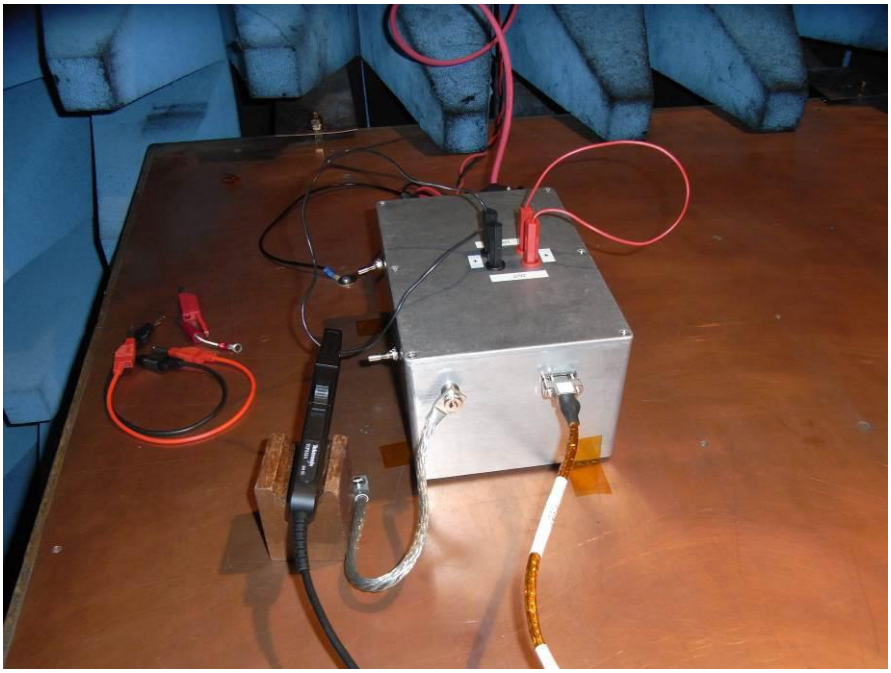


Figure 8. Differential mode: -VE Line

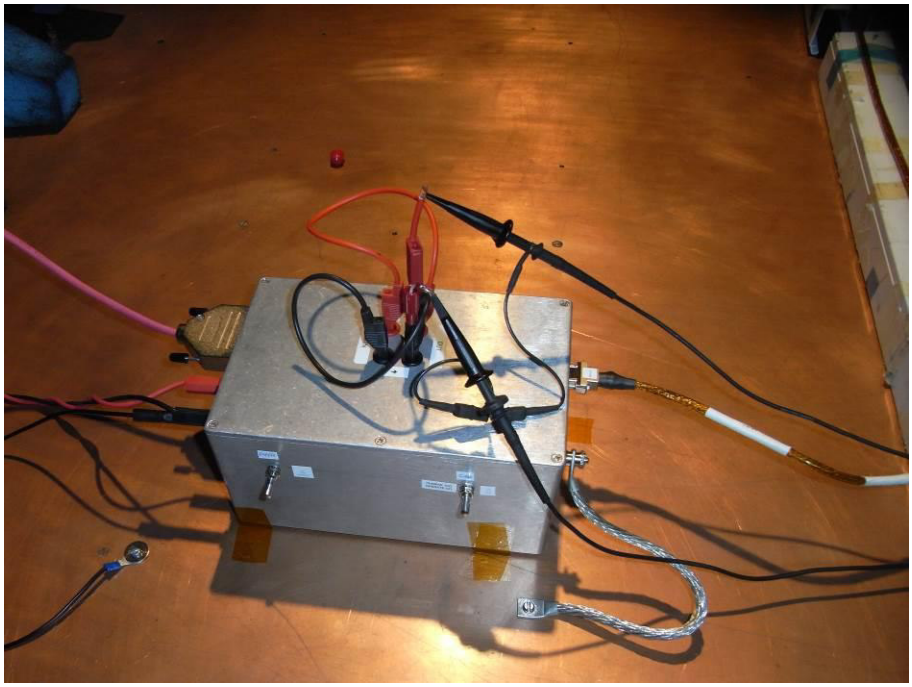


Figure 9. Differential Voltage ripple and spike

4.4.4 Results Summary:

Current:

Probe Position	Measurement Type	Bandwidth	Measured Level (mA pk-pk)	Limit (mA pk-pk)	Result	Plot
Common	Ripple	150M	0.8	1.0	Complied	54,55,56,57
	Spike	150M	1.8	1.0	Did not comply**	
Common*	Ripple (average)	150M	0.6	1.0	Complied	68,70,71,72,73
	Spike (average)	150M	1.5	1.0	Did not comply**	
+VE	Ripple	150M	0.9	3.0	Complied	58,59,60,61
	Spike	150M	1.5	3.0	Complied	
-VE	Ripple	150M	0.7	3.0	Complied	62,63,64,65
	Spike	150M	1.3	3.0	Complied	

*Note: Measurement was repeated with averaging on to produce a more stable measurement.

**Note: Did not comply according EIDA-DFU but does comply according to the EIDA R-317.

Background: (EGSE and Power supply On, EUT Off)

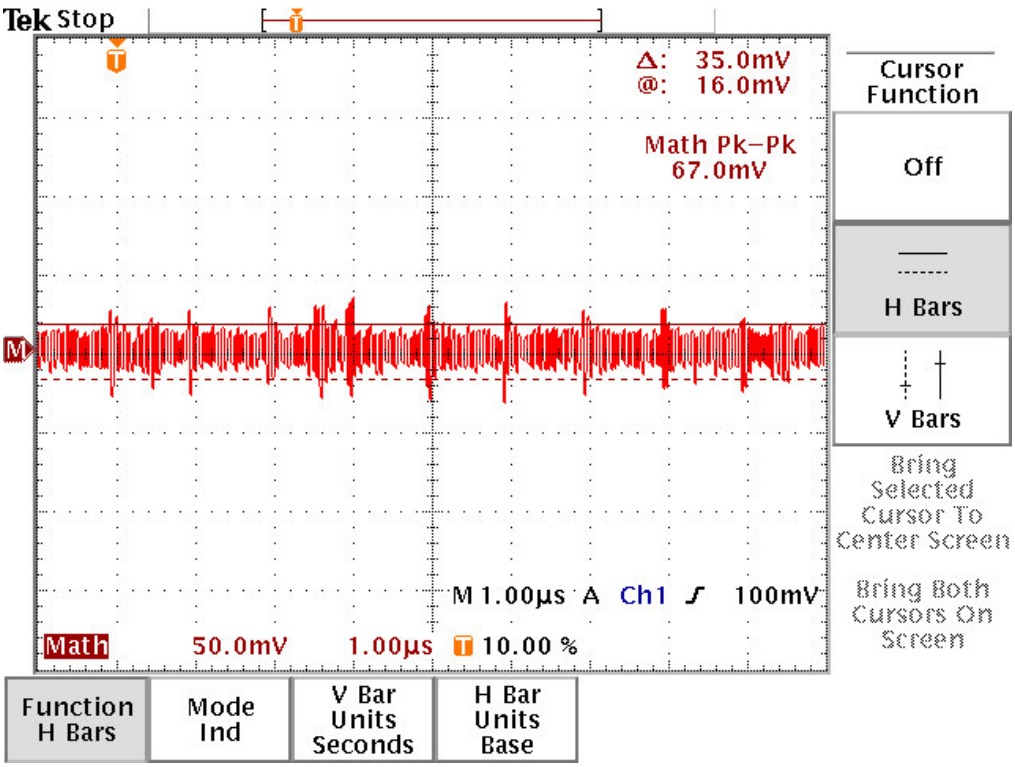
Probe Position	Measurement Type	Bandwidth	Measured Level (mA Pk-Pk)	Limit (mA pk-pk)	Result	Plot
Common	Ripple	150M	0.6	1.0	Complied	67
	Spike	150M	1.0	1.0	Complied	
Common*	Ripple (average)	150M	0.1	1.0	Complied	74,75,76
	Spike (average)	150M		1.0	Complied	

Voltage:

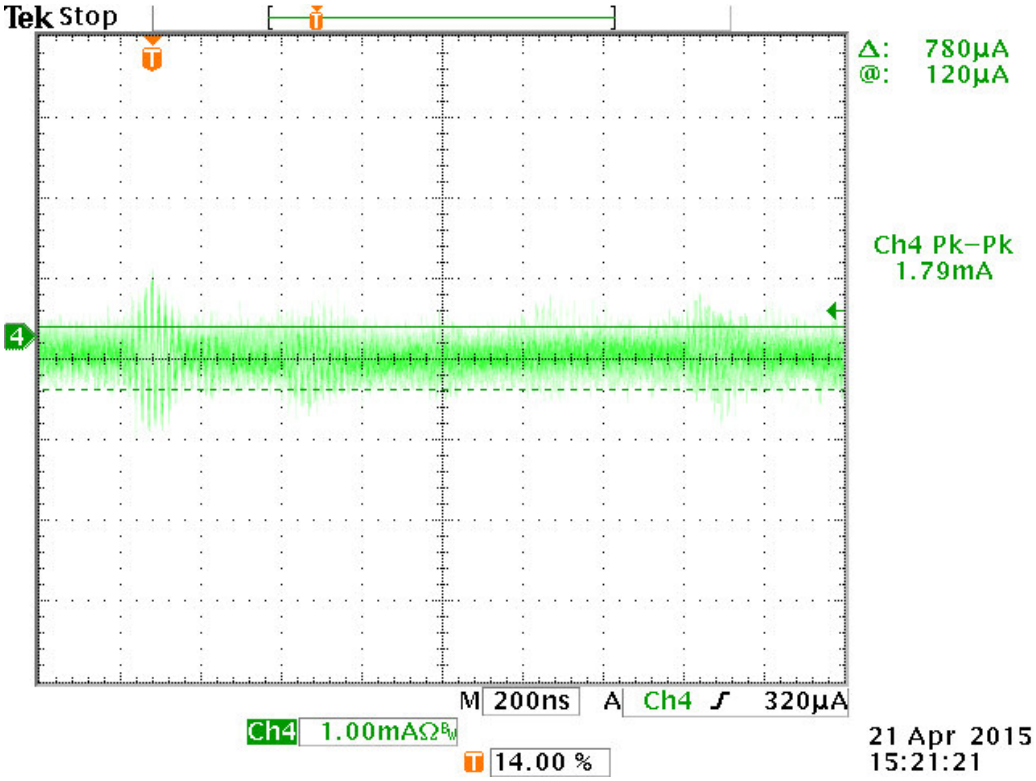
Probe Position	Measurement Type	Bandwidth	Measured Level (mV Pk-Pk)	Limit (mV pk-pk)	Result	Plot
Differential	Ripple	150M	35.0	150.0	Complied	53
	Spike	150M	67.0	280.0	Complied	

4.4.5 Plots:

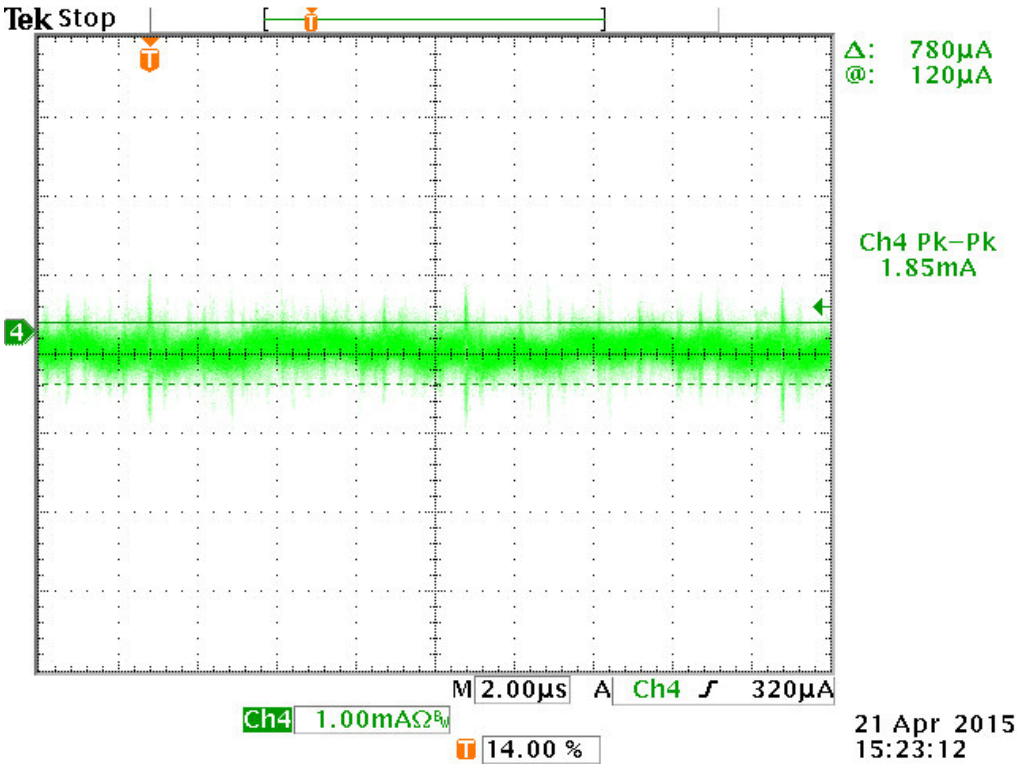
Plot 053



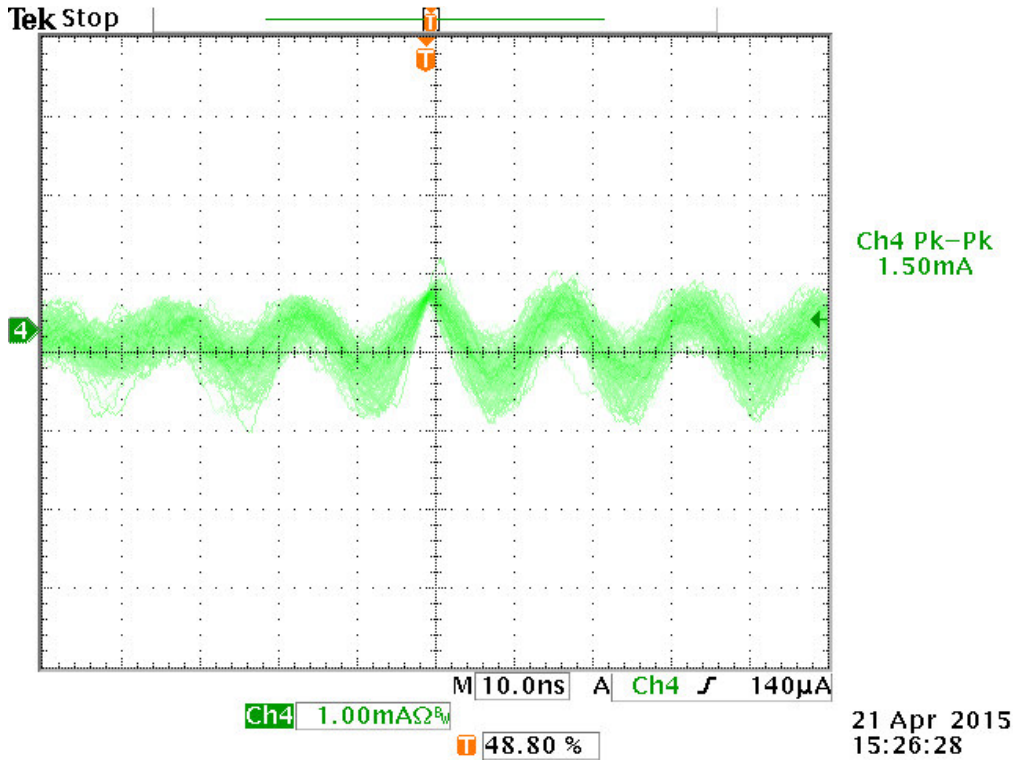
Plot 054



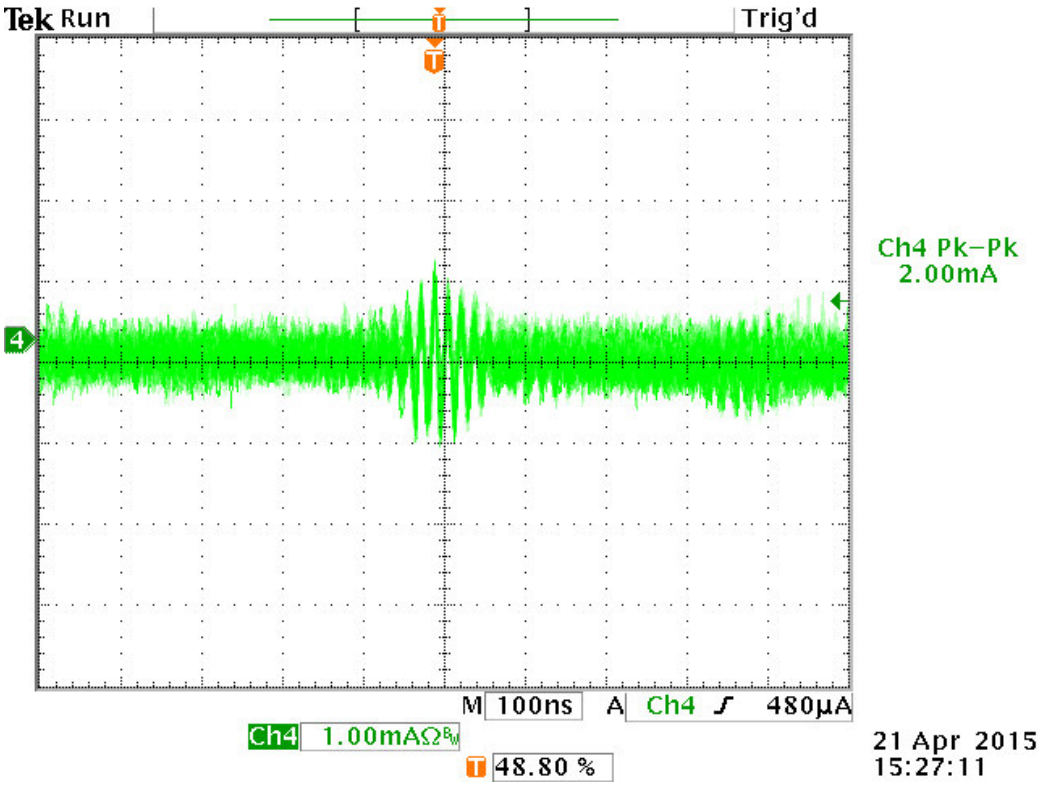
Plot 055



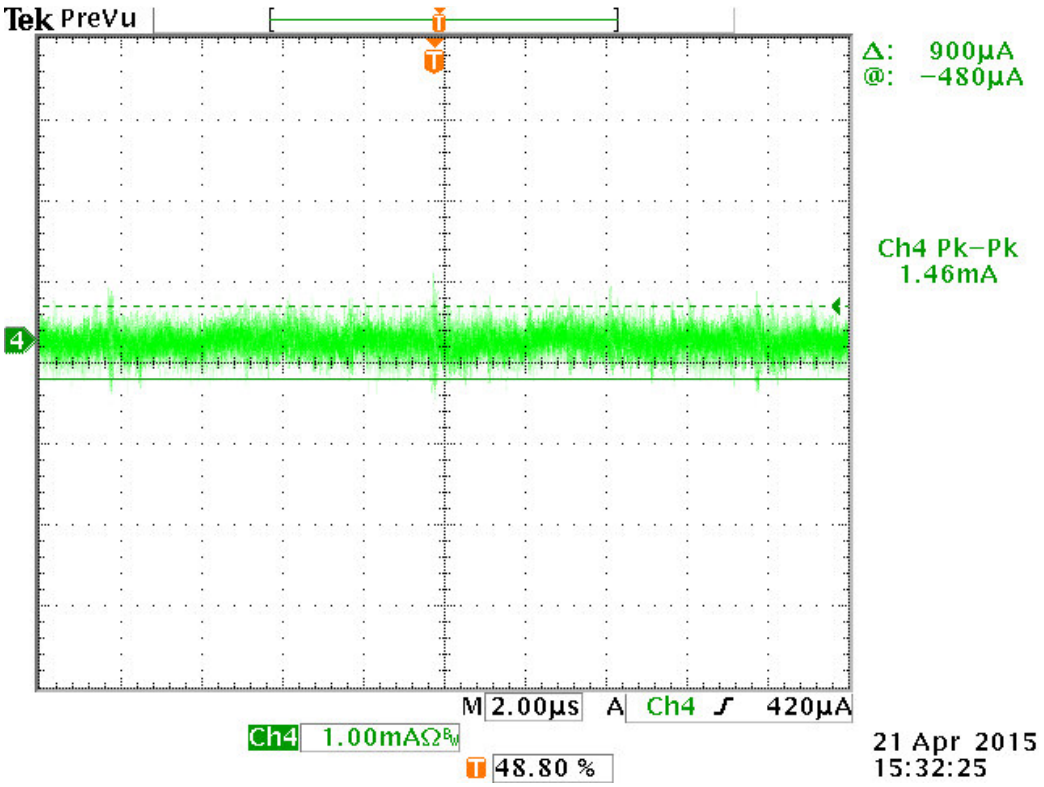
Plot 056



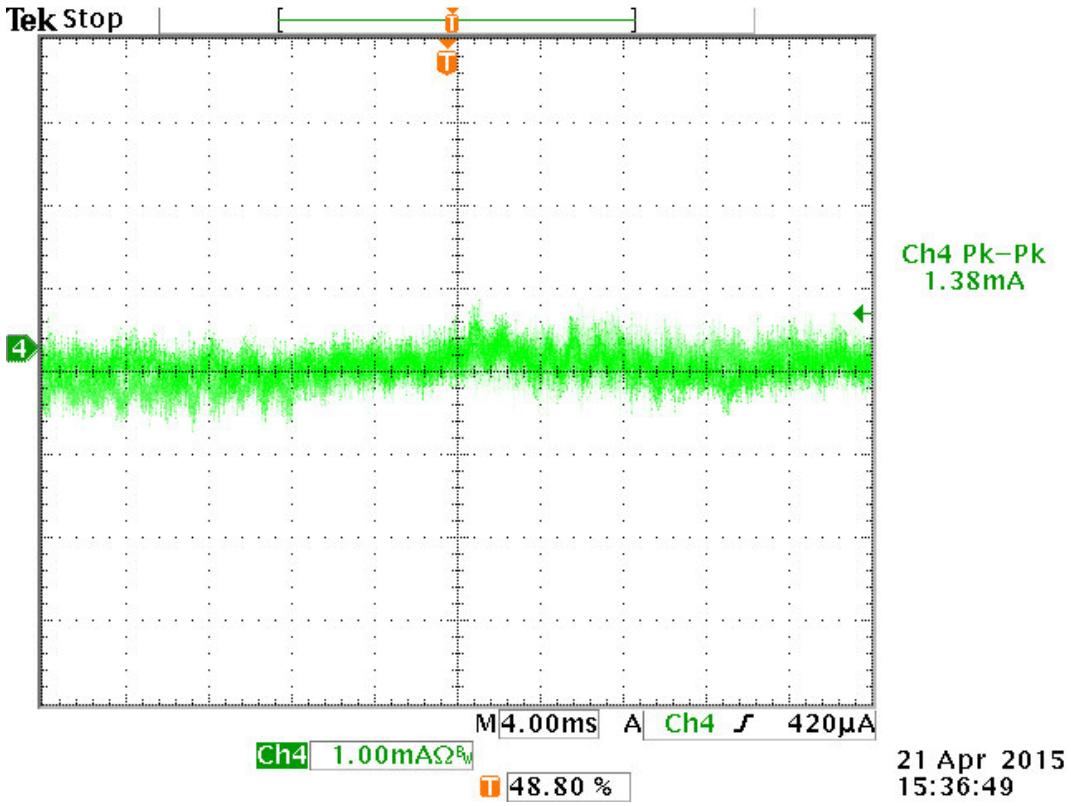
Plot 057



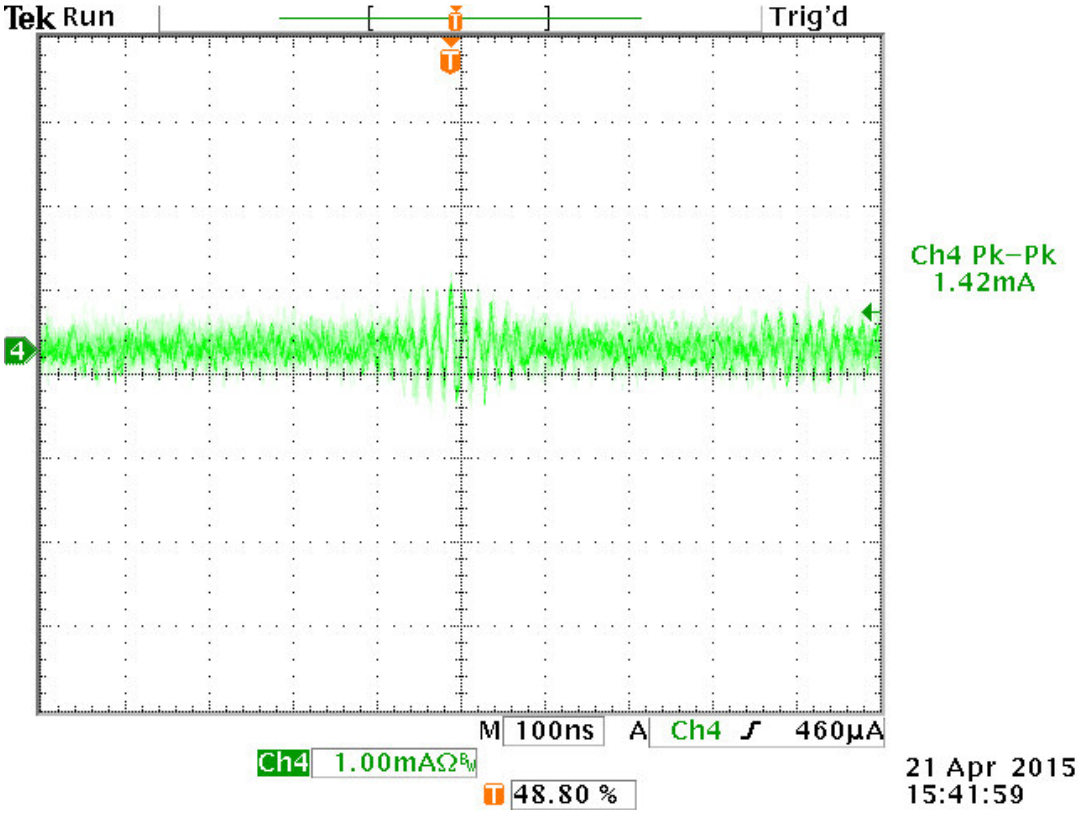
Plot 058



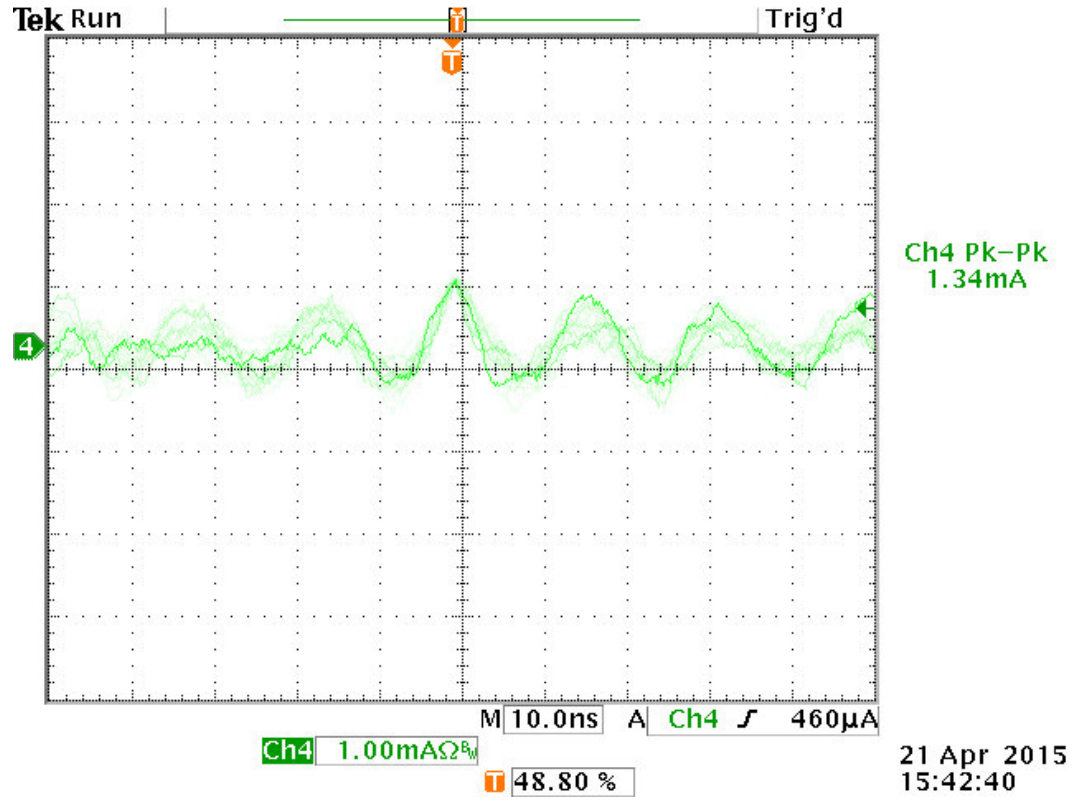
Plot 059



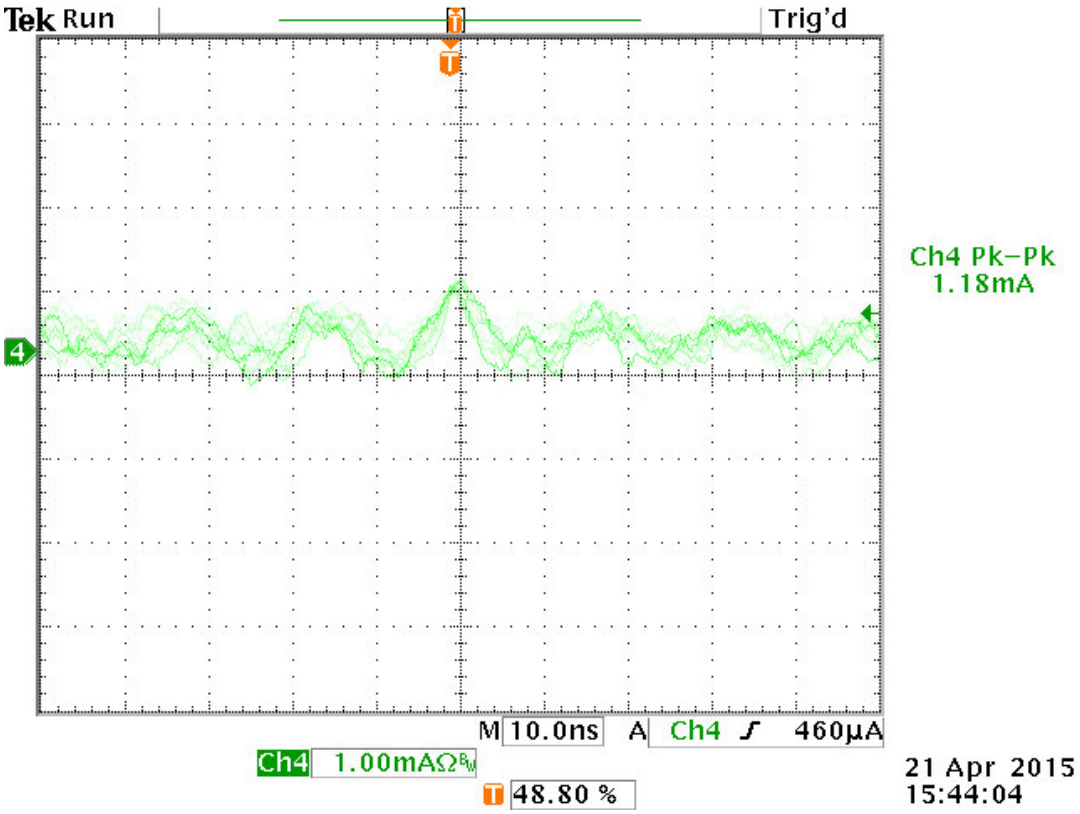
Plot 060



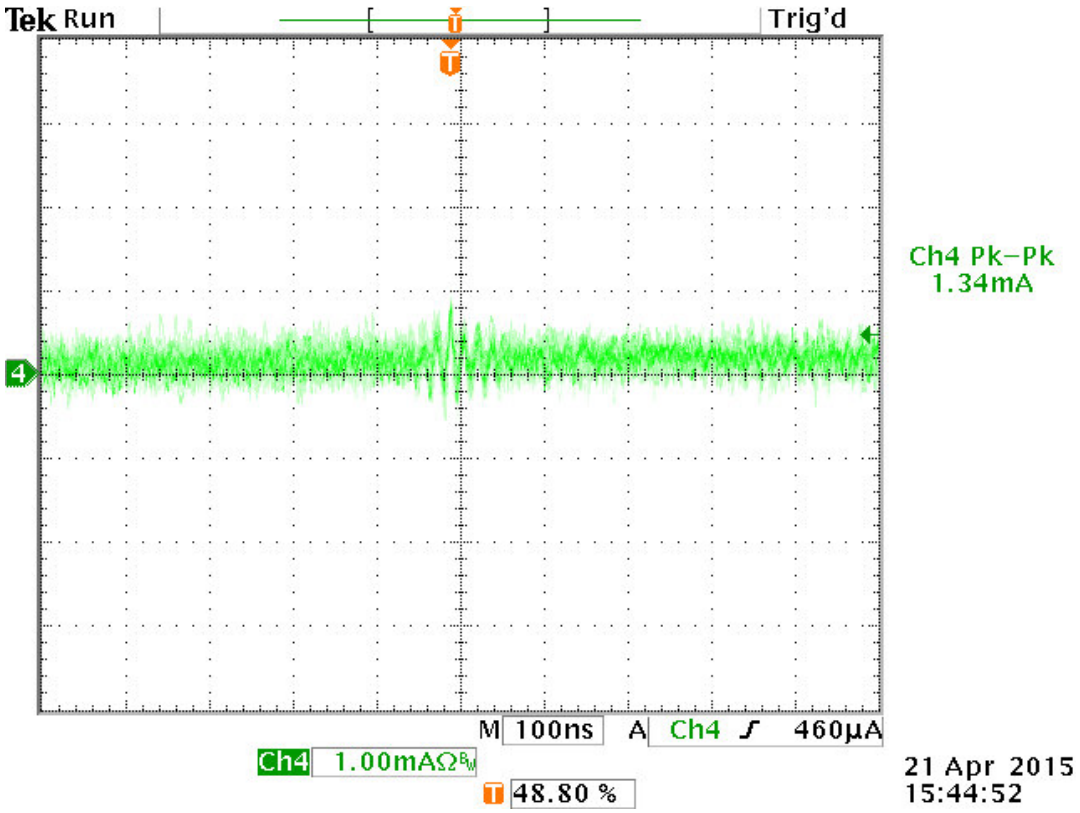
Plot 061



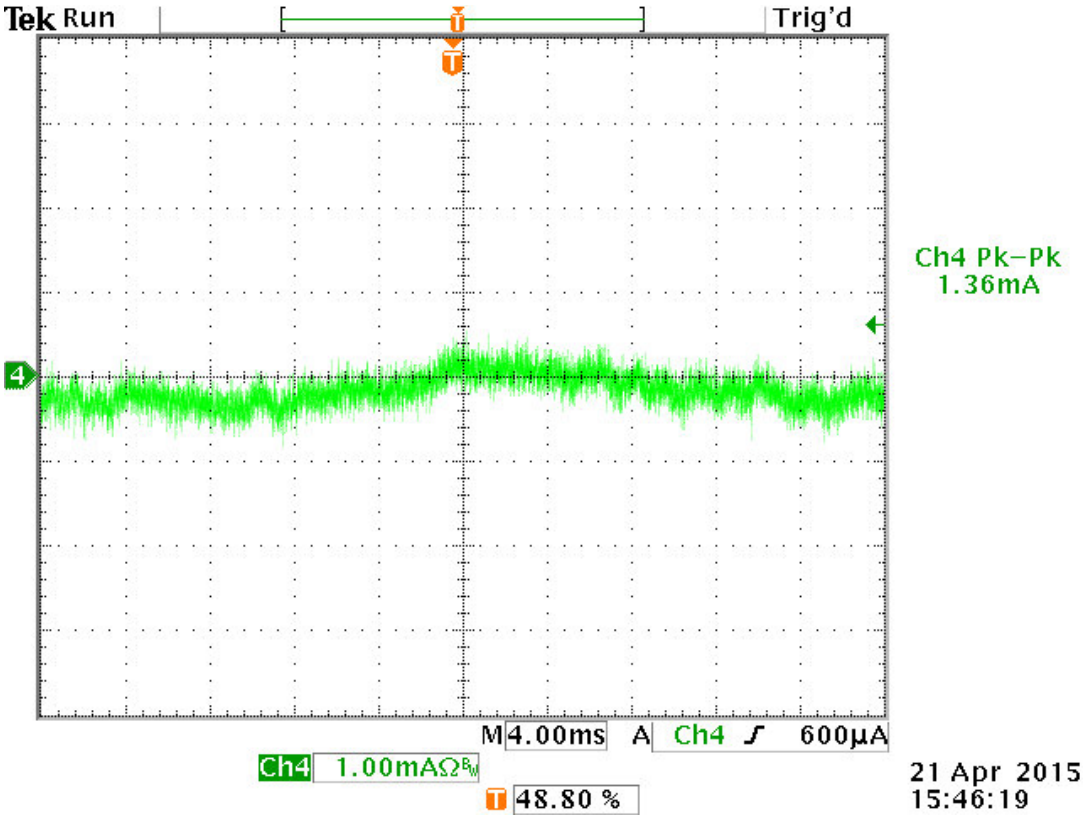
Plot 062



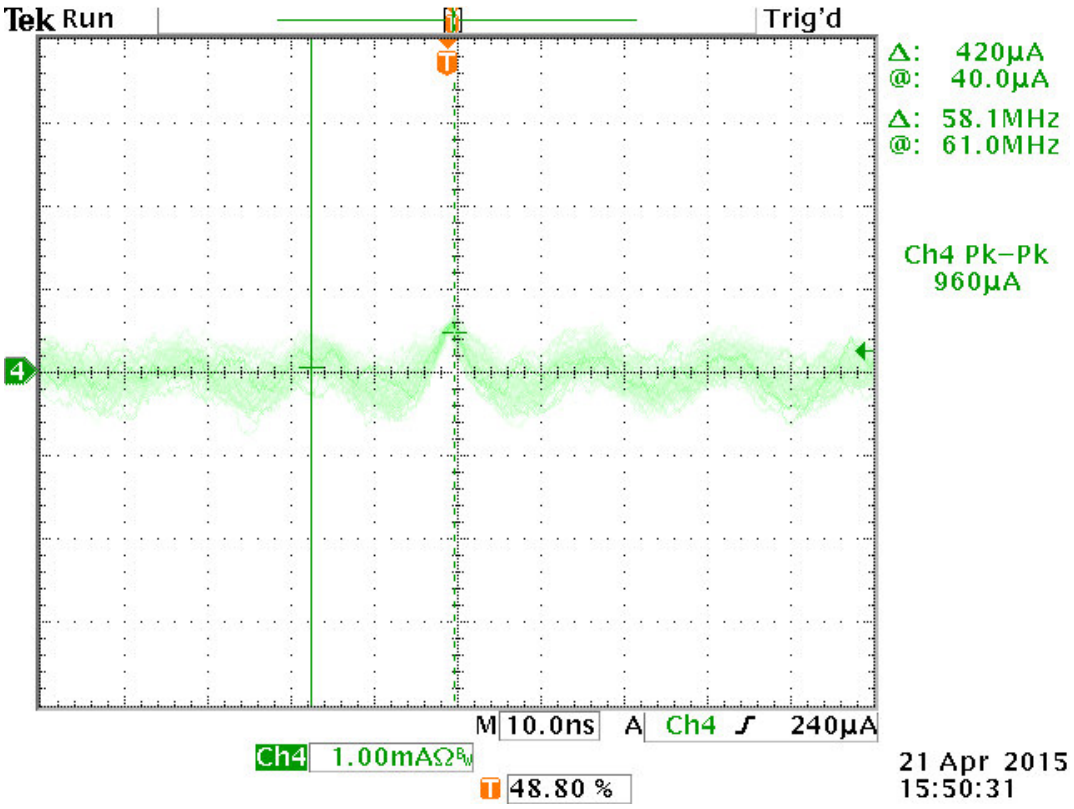
Plot 063



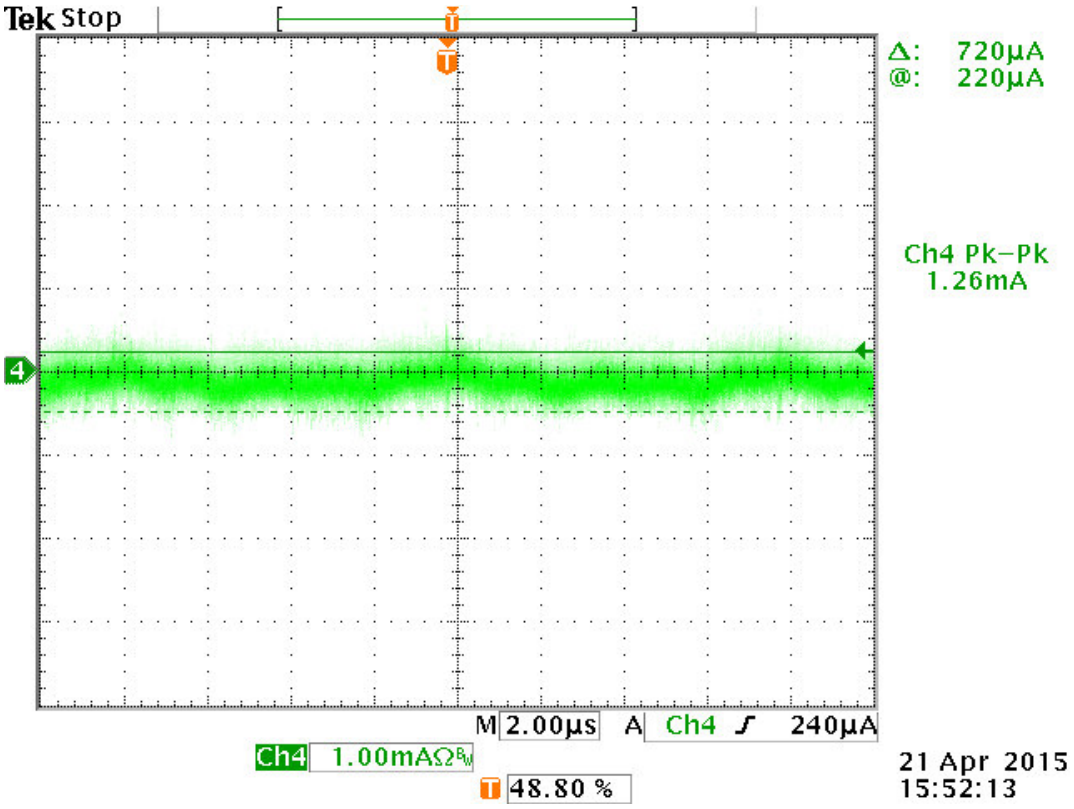
Plot 064



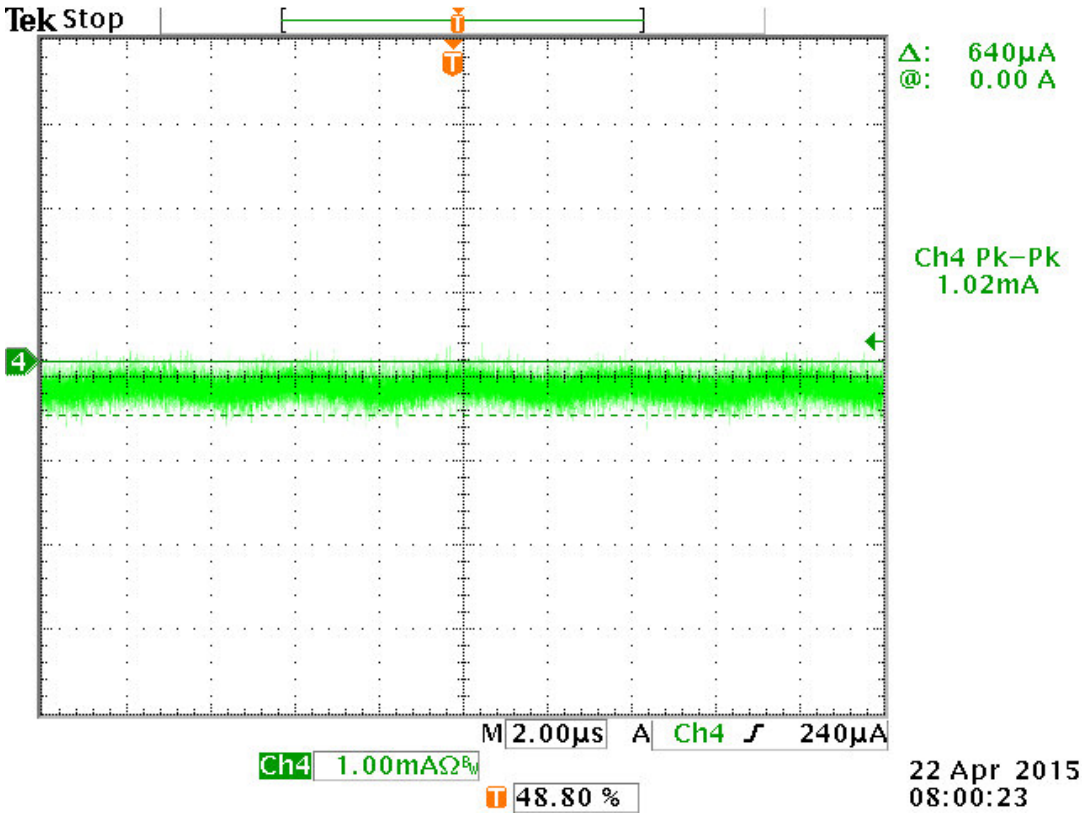
Plot 065



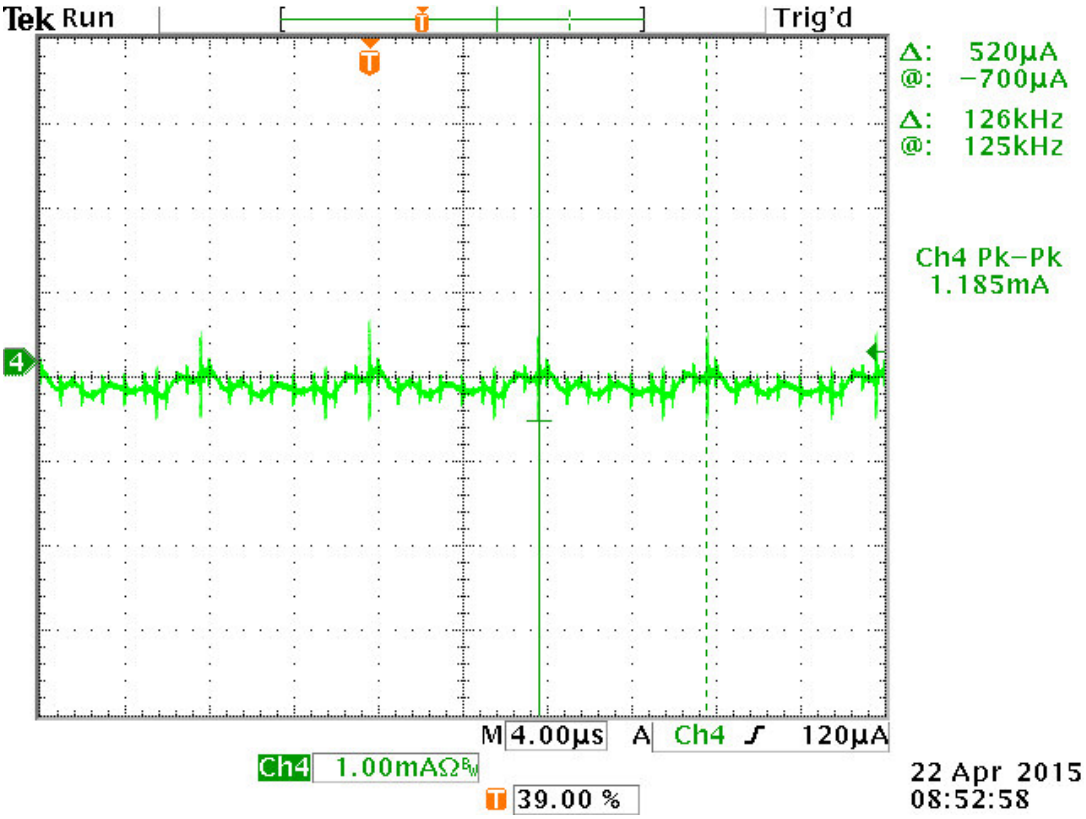
Plot 066



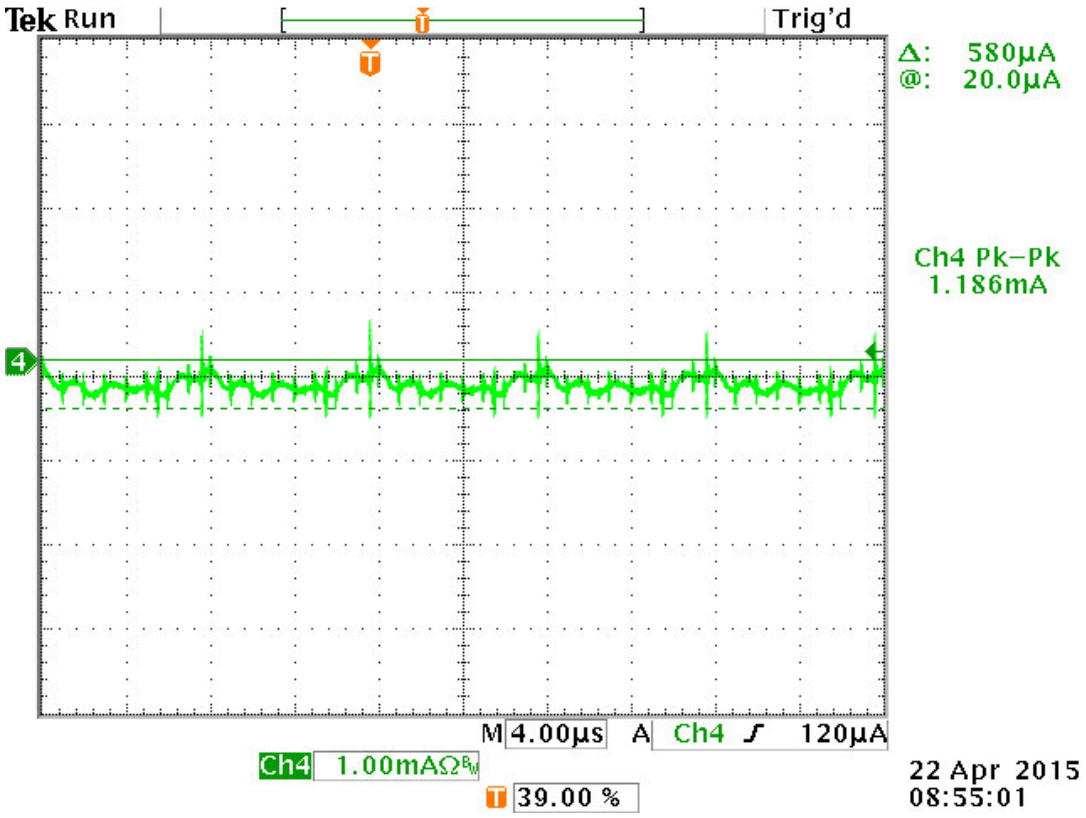
Plot 067



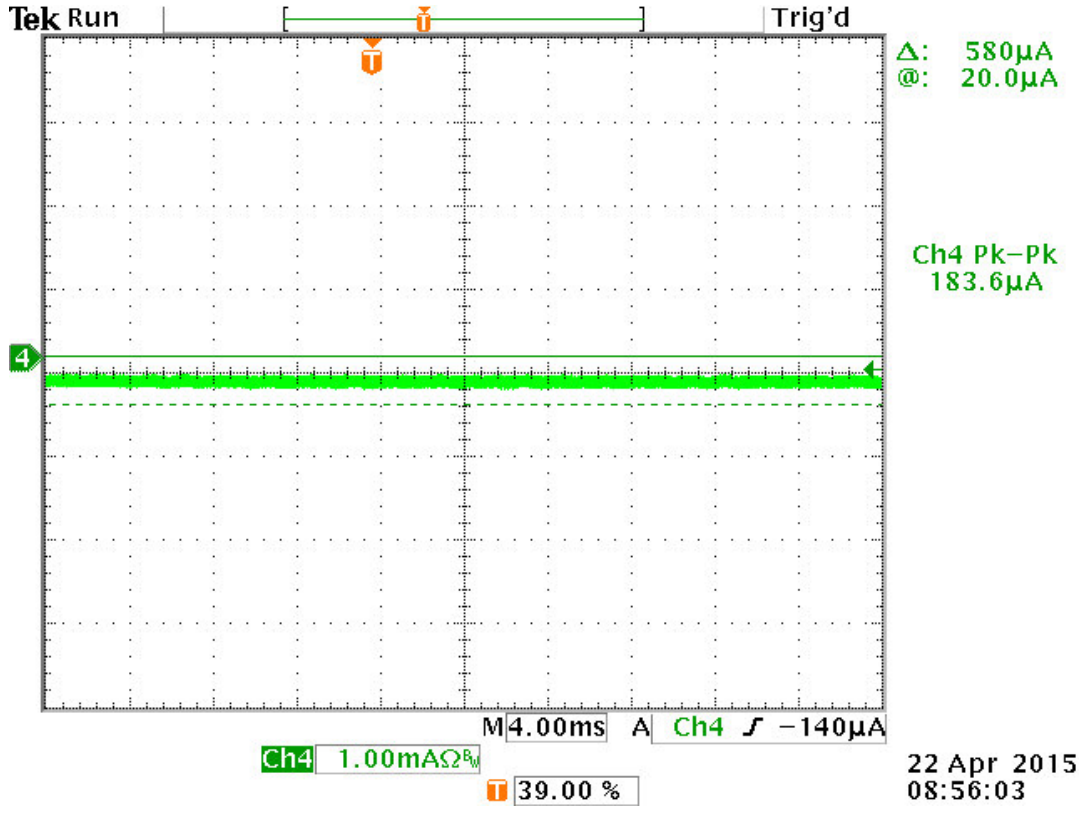
Plot 068



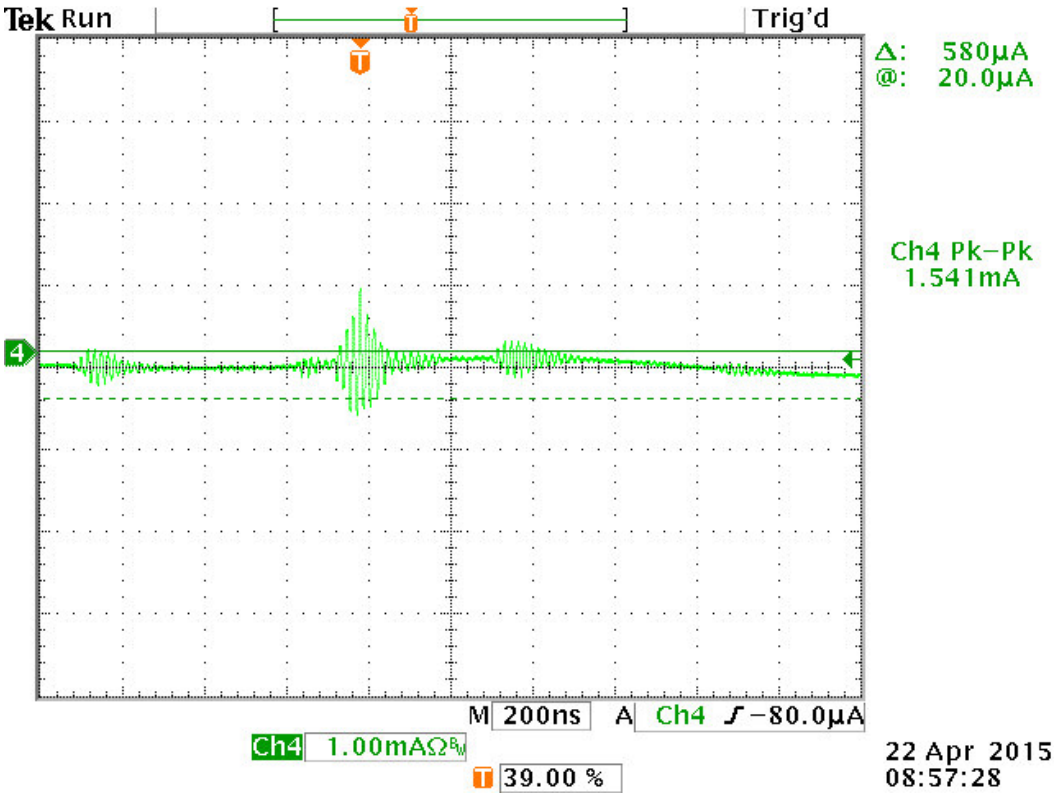
Plot 069



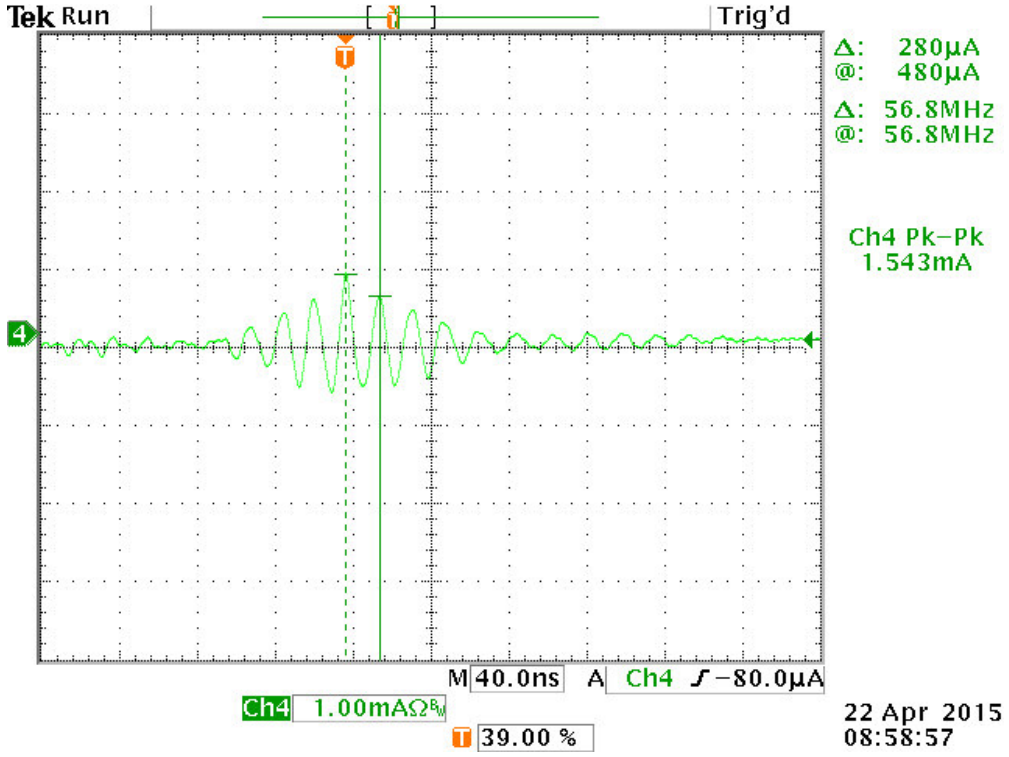
Plot 070



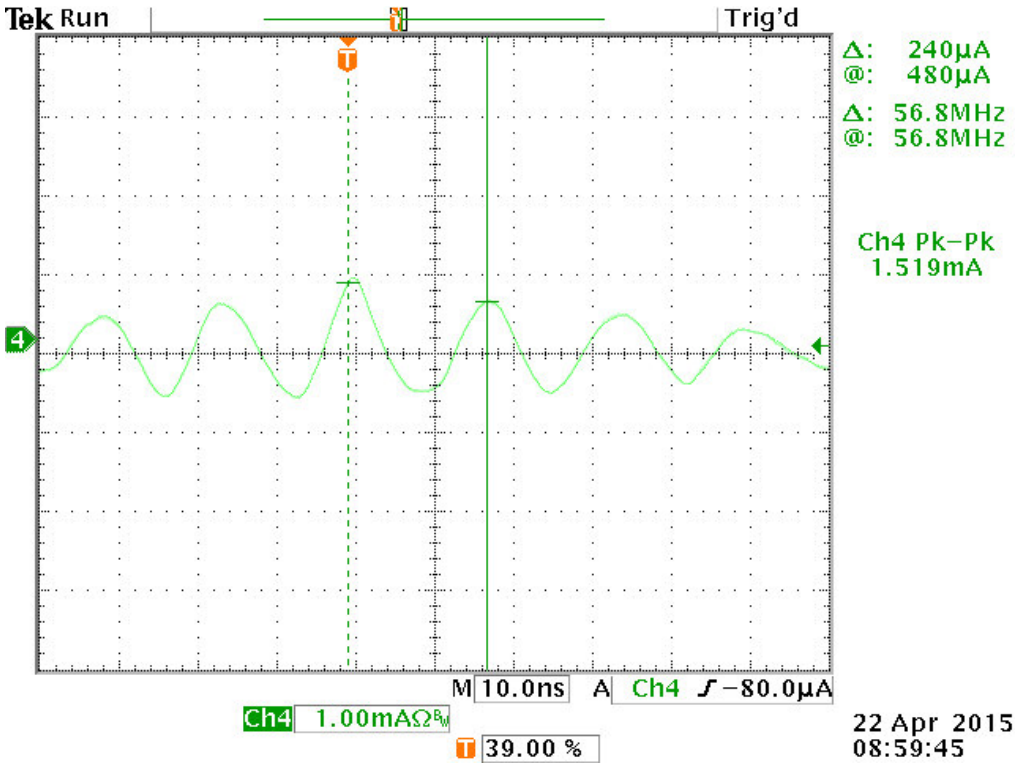
Plot 071



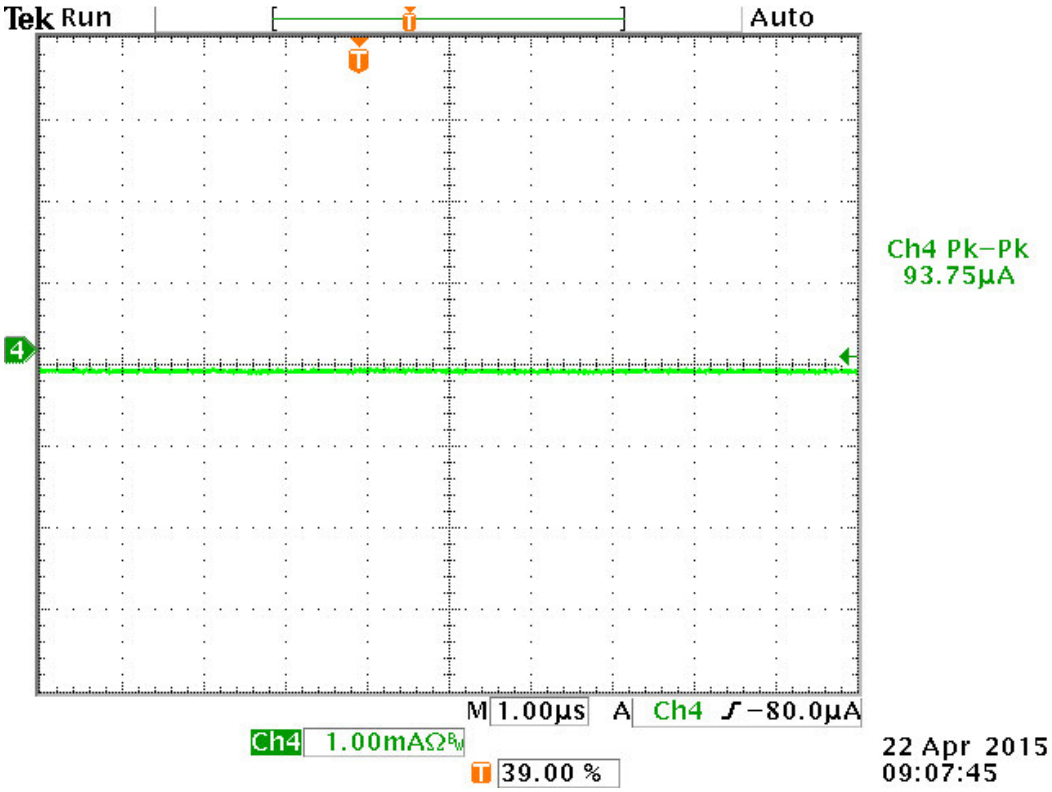
Plot 072



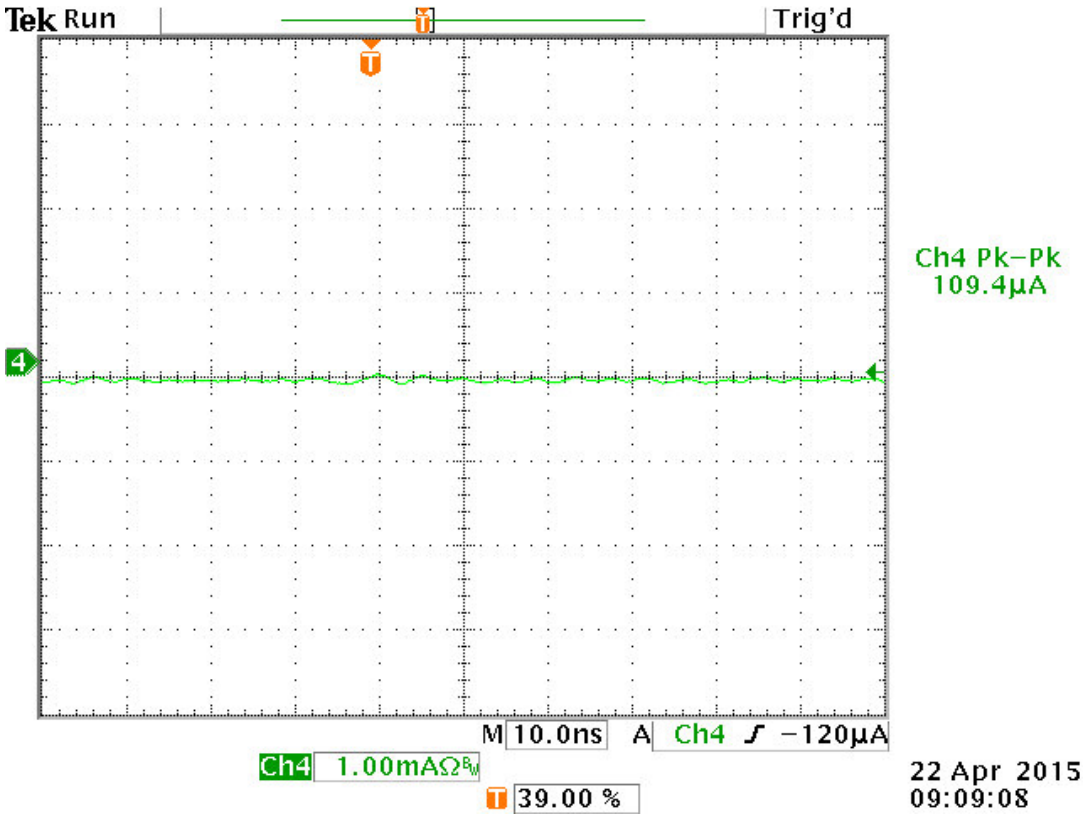
Plot 073



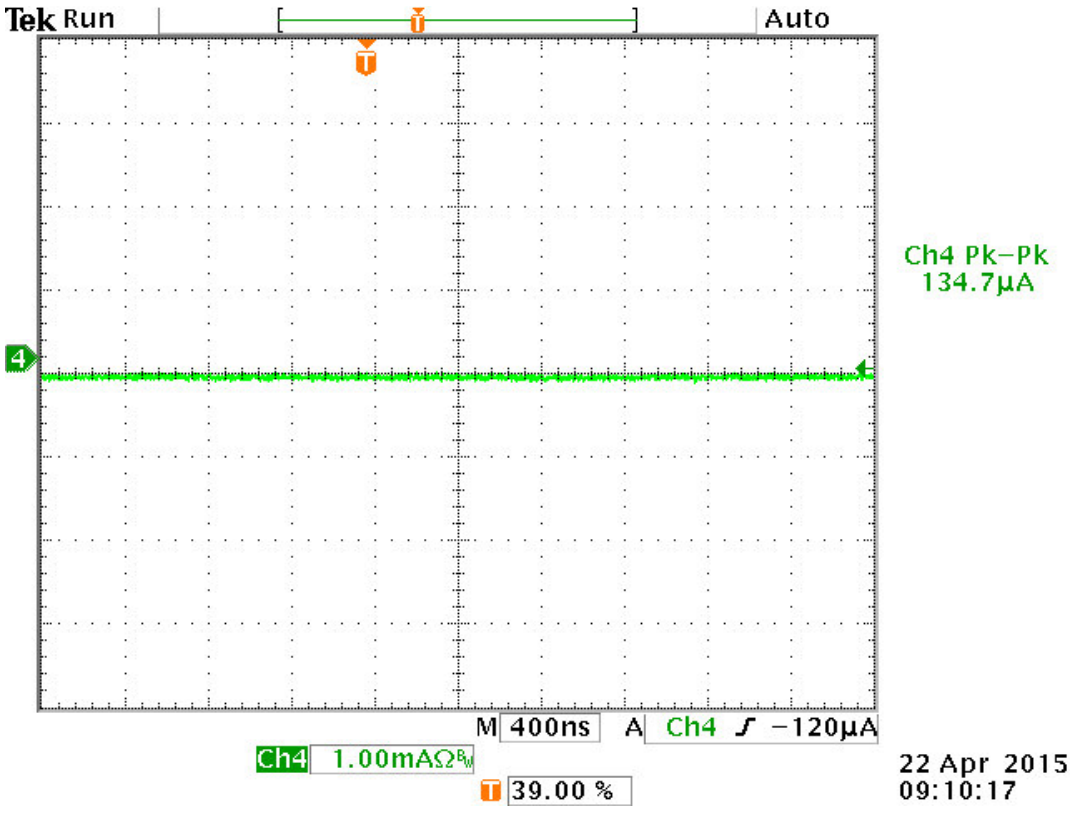
Plot 074



Plot 075



Plot 076



4.5 Conducted Susceptibility: Power Lines: Sinewave injection:

4.5.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.7			
Test Dates:	**Start:**	22nd April 2015	**End:**	22nd April 2015
Ambient Conditions:	**Temp:**	24.4ºC	**Humidity:**	30%

4.5.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029769	09-Jun-15
Current Amplifier	Tektronix	TCPA300	040925	28-Jan-16
Current probe	Tektronix	TCP312A	040926	28-Jan-16
Function Generator	HP	8116A	001571	20-May-15
Audio Isolation Transformer	Solar	6220-1A	013146	Verified in use
Resistor	Solar	7144-1.0	003431	21-Oct-15
Amplifier (Audio)	Solar	6552-1A	013077	Verified in use
Software Automation	Dare	-	-	N/A

4.5.3 Test Procedure:

A precalibration was performed by applying a constant 1Vrms and 1Arms sinewave into a 1 Ohm resistor between the frequencies 30Hz and 100kHz. A function generator fed the signal via an audio amplifier and then to an isolation transformer. The levels were monitored using an oscilloscope. The function generator drive level was recorded for the required injection level at each frequency.

When applying the sinewave injection to the EUT the isolation transformer was connected inline to the +VE line at the breakout of the LISN and then repeated on the –VE line. The voltage was monitored differentially across the primary powerlines and the current probe attached to the line under test.

Software automation was used to control the sweep rate at 5% with a 10 second dwell and to keep the injection level at 1Vrms without exceeding the safety requirement of 1Arms or the precalibration level.

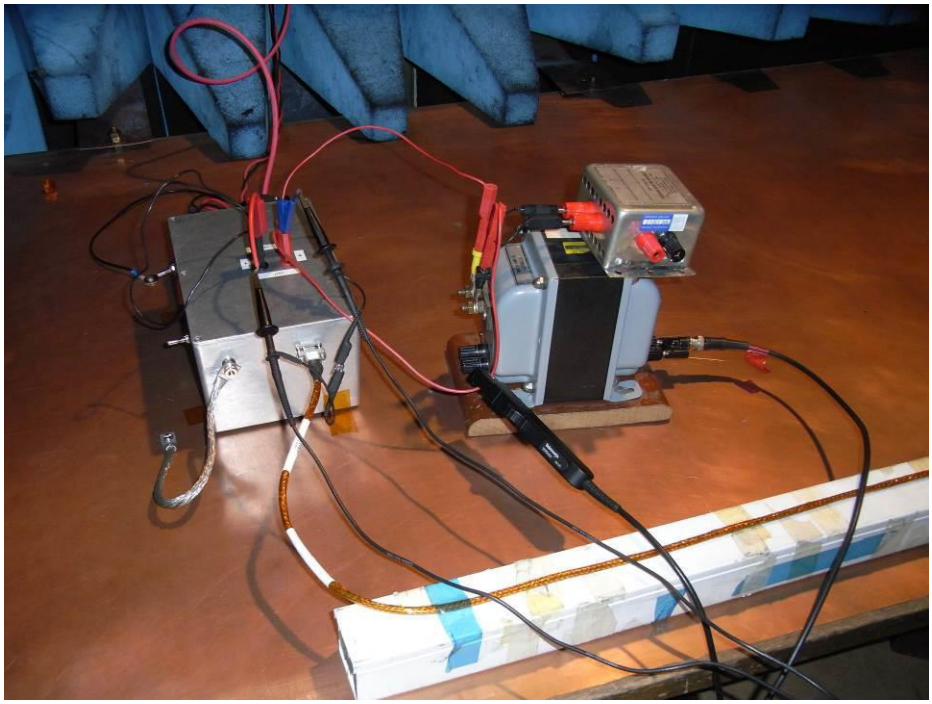


Figure 10. +VE Line

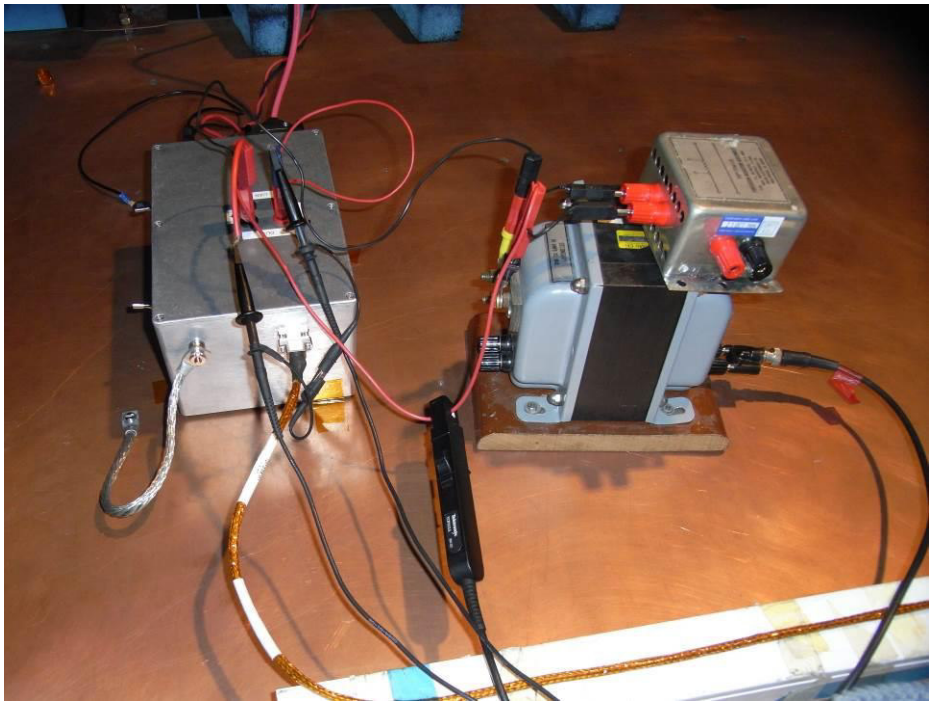


Figure 11. -VE Line

4.5.4 Results Summary:

+VE Line:

Frequency	Level (Vrms)	Level (mArms)	Result
30Hz to 100kHz	1	<150	Complied

-VE Line:

Frequency	Level (Vrms)	Level (mArms)	Result
30Hz to 100kHz	1	<150	Complied

4.6 Conducted Susceptibility: Transients:

4.6.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.8			
Test Dates:	**Start:**	23rd April 2015	**End:**	23rd April 2015
Ambient Conditions :	**Temp:**	24.4ºC	**Humidity:**	31%

4.6.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029769	09-Jun-15
Transient Pulse Generator	Solar	8282-1	025834	Verified in use
Resistor	Solar	7144-5.0	031509	19-Nov-15
Spike Generator	Solar	7054-1	034047	Verified in use
Current Amp	Tektronix	TCPA300	040925	28-Jan-16
Current Probe	Tektronix	TCP312A	040926	28-Jan-16

4.6.3 Test Procedure:

Two pre-calibrated transients of amplitude equivalent to +100% and -100% of the Bus voltage, one with a duration of 150ns and the second at 10µs. A 5 Ω resistor was used for the calibration.

When applying the transients to the powerlines the transient generator was connected in series firstly on the positive line and then on the negative line. The voltage and current were monitored and recorded using an oscilloscope.

Fig 12. 150ns Transient set-up (-VE Line)

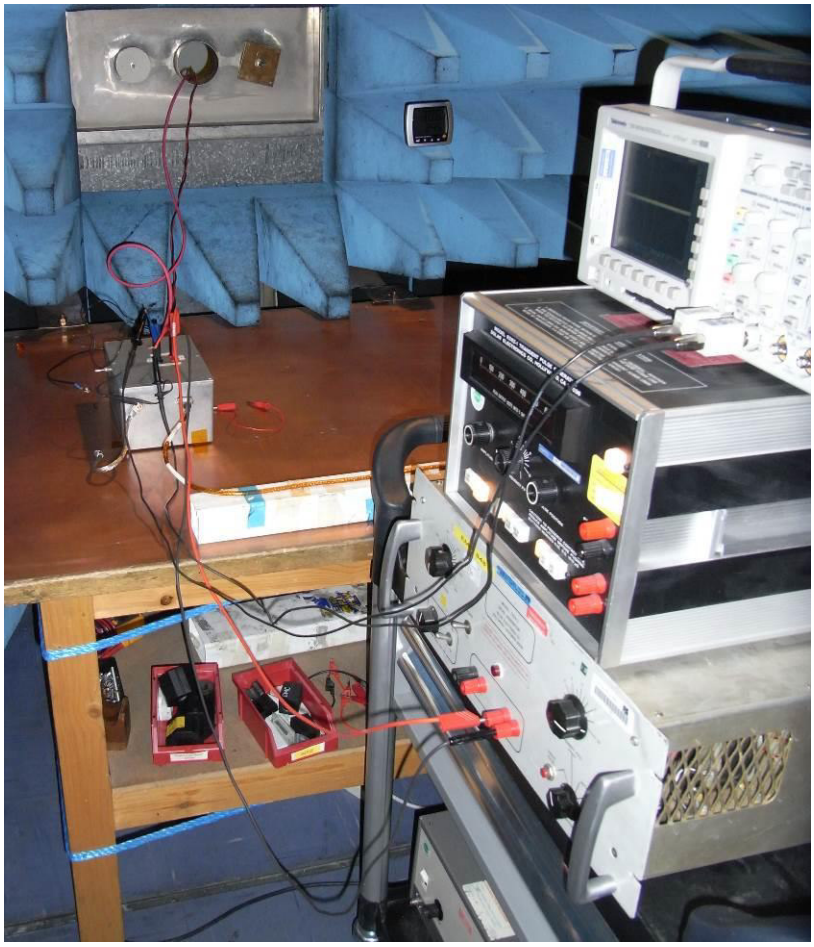


Fig 13. 10µs Transient set-up (+VE Line)

4.6.4 Results Summary:

+VE Line

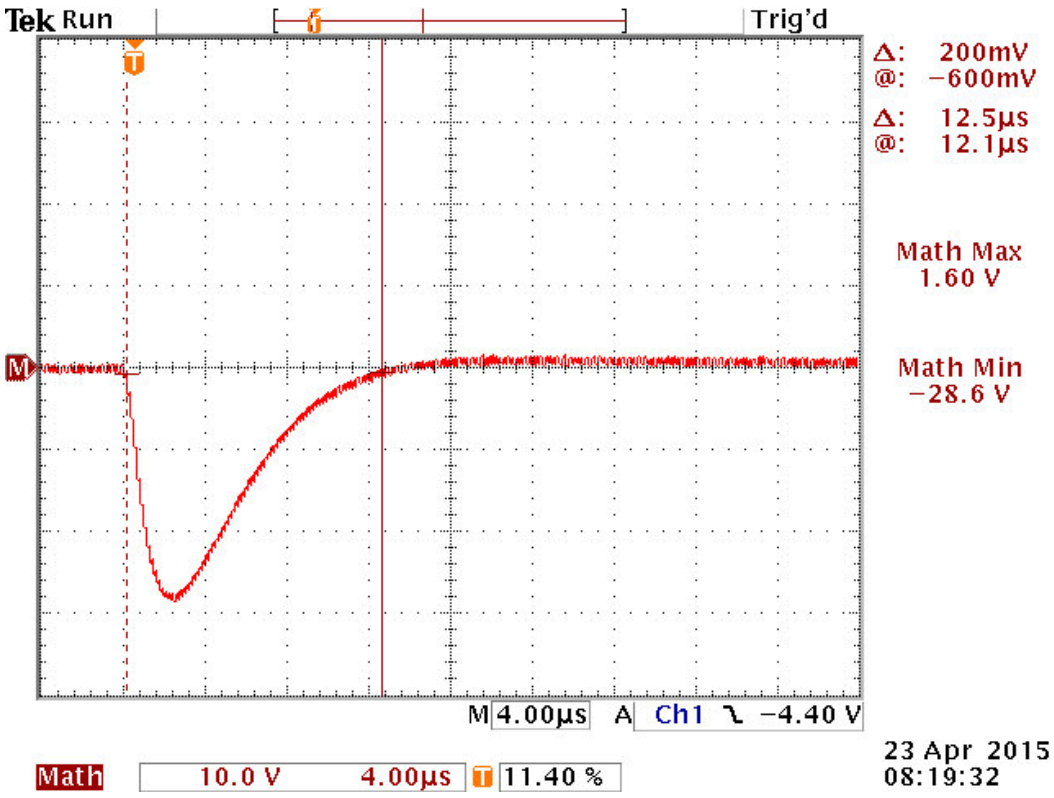
Pulse Polarity	Duration	Repetition Rate	Application Time	Cal plot	Test Plot	Result
+28V	10µs	10pps	2mins	082, 083	085	Complied
-28V	10µs	10pps	2mins	081	088	Complied
+28V	150ns	10pps	2mins	094	096	Complied
-28V	150ns	10pps	2mins	095	098	Complied

-VE Line

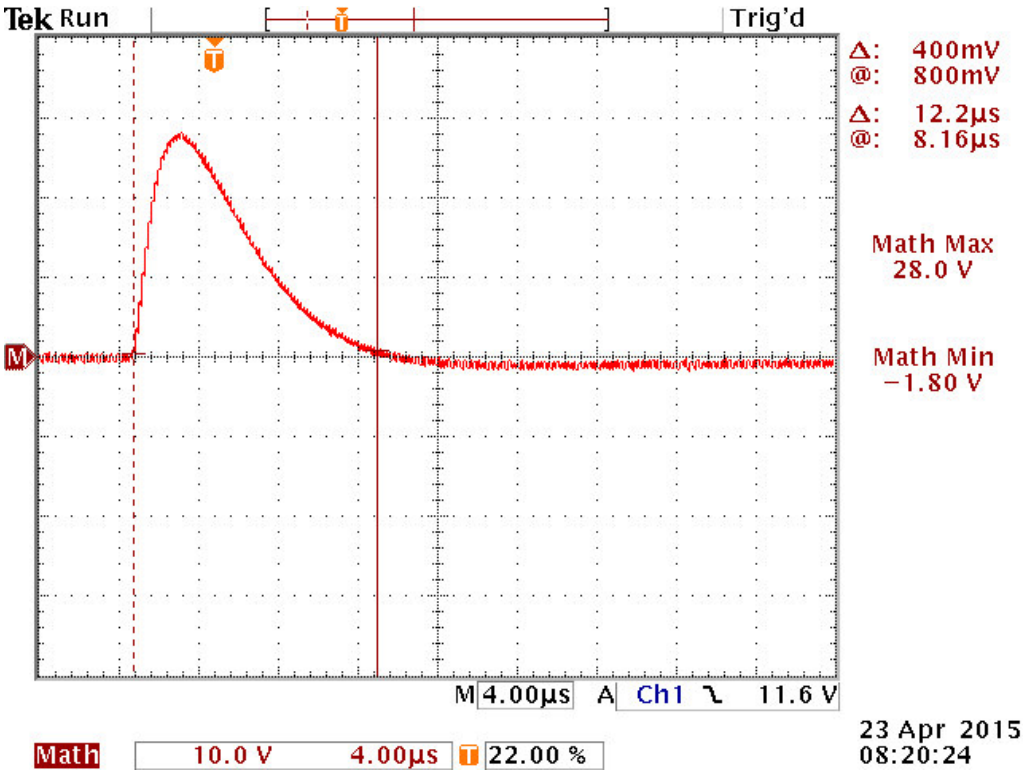
Pulse Polarity	Duration	Repetition Rate	Application Time	Cal plot	Test Plot	Result
+28V	10µs	10pps	2mins	082, 083	093	Complied
-28V	10µs	10pps	2mins	081	091	Complied
+28V	150ns	10pps	2mins	094	102,103	Complied
-28V	150ns	10pps	2mins	095	100	Complied

4.6.5 Plots:

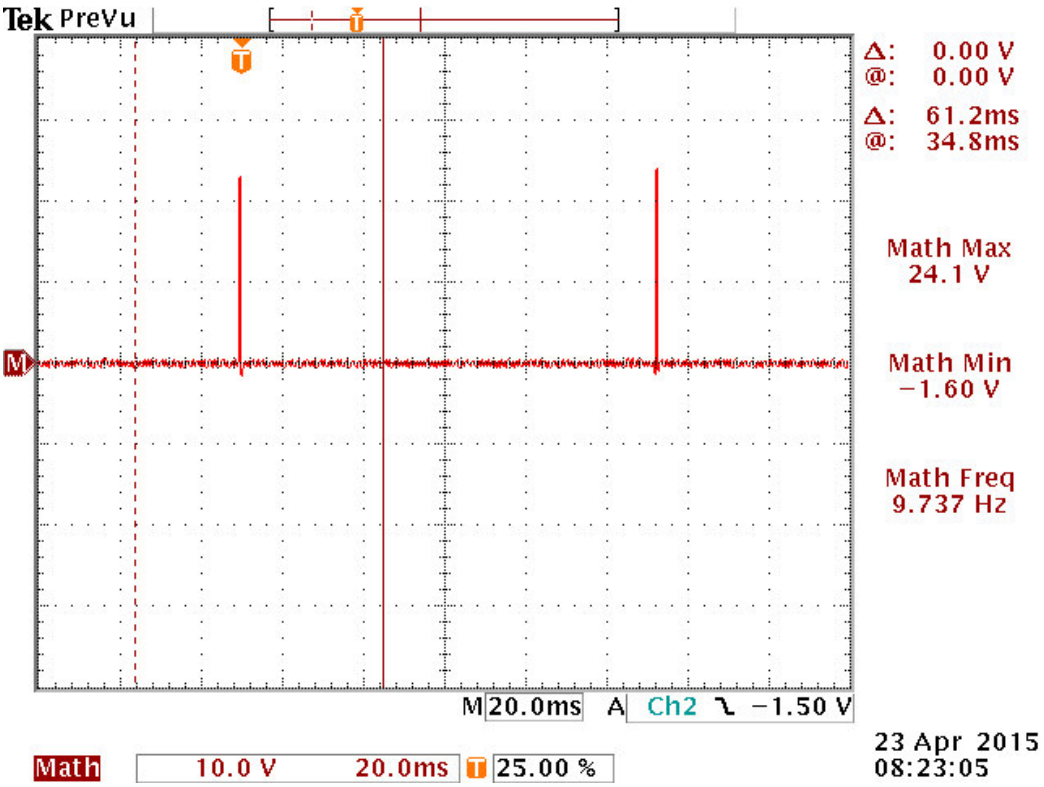
Plot 081



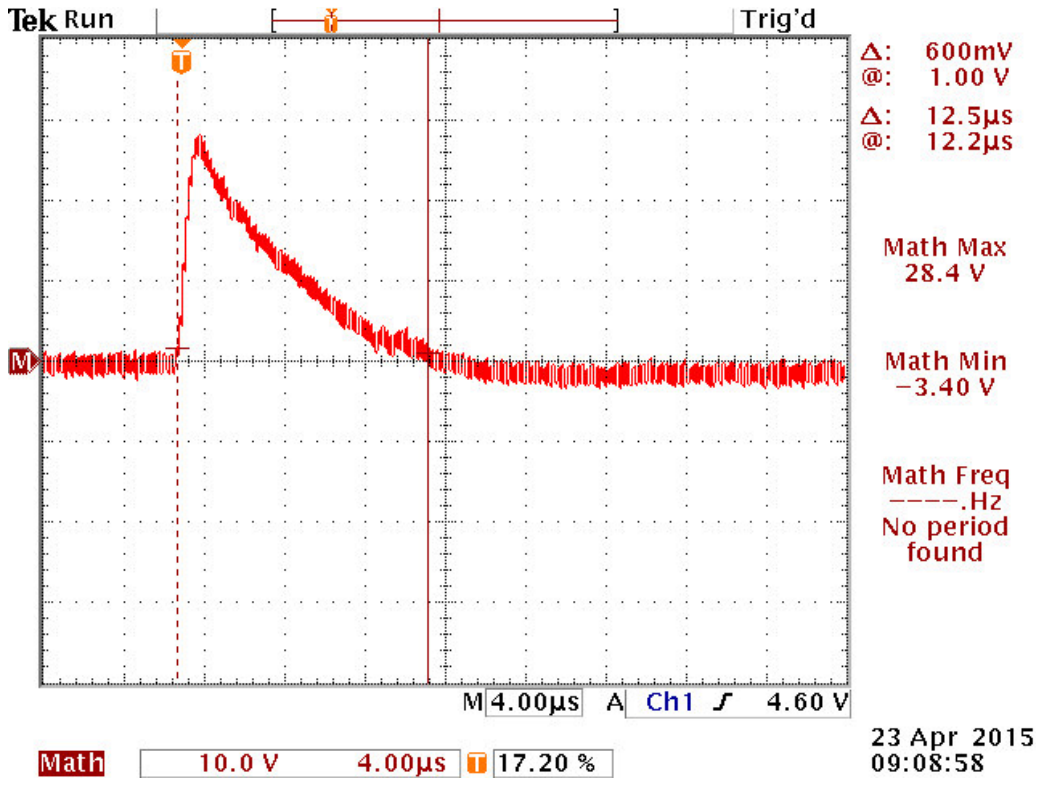
Plot 082



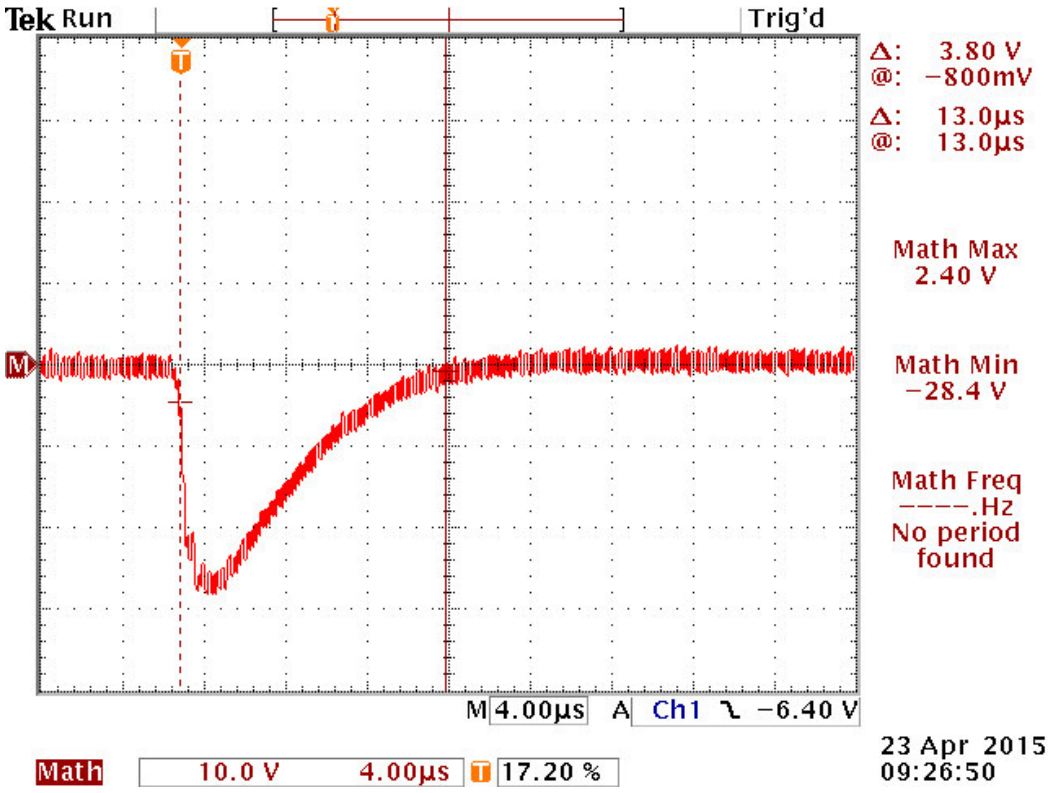
Plot 083



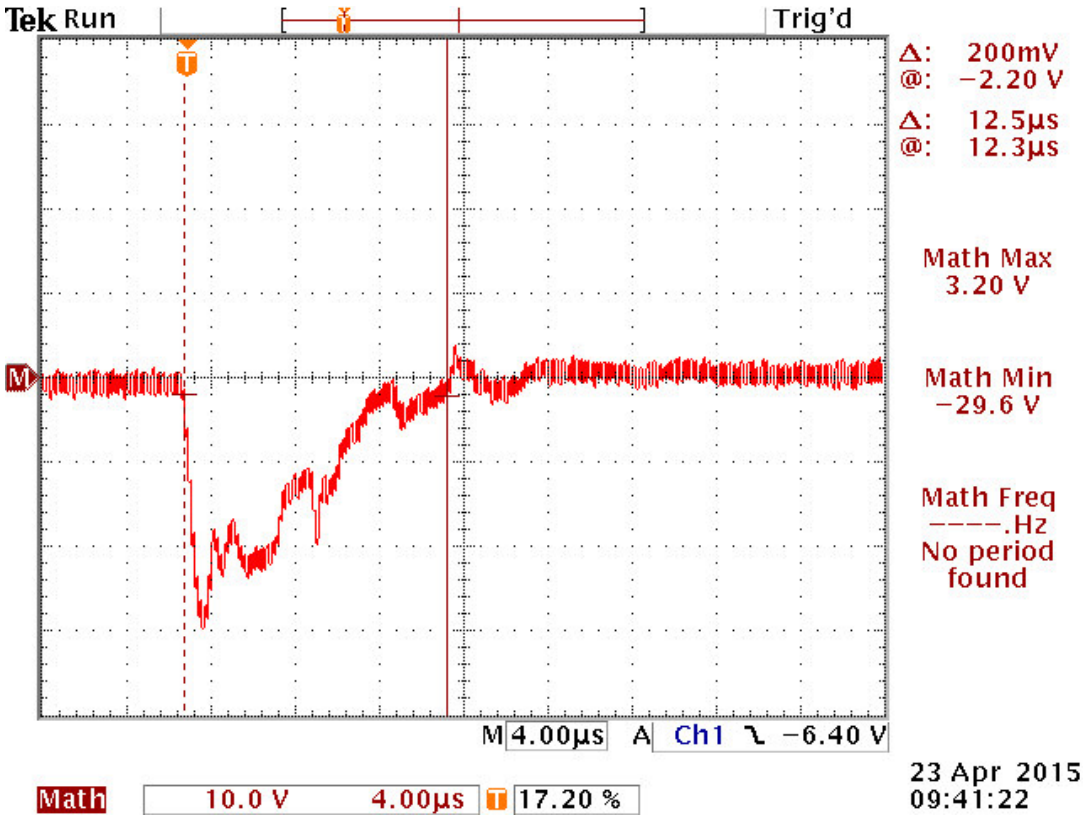
Plot 085



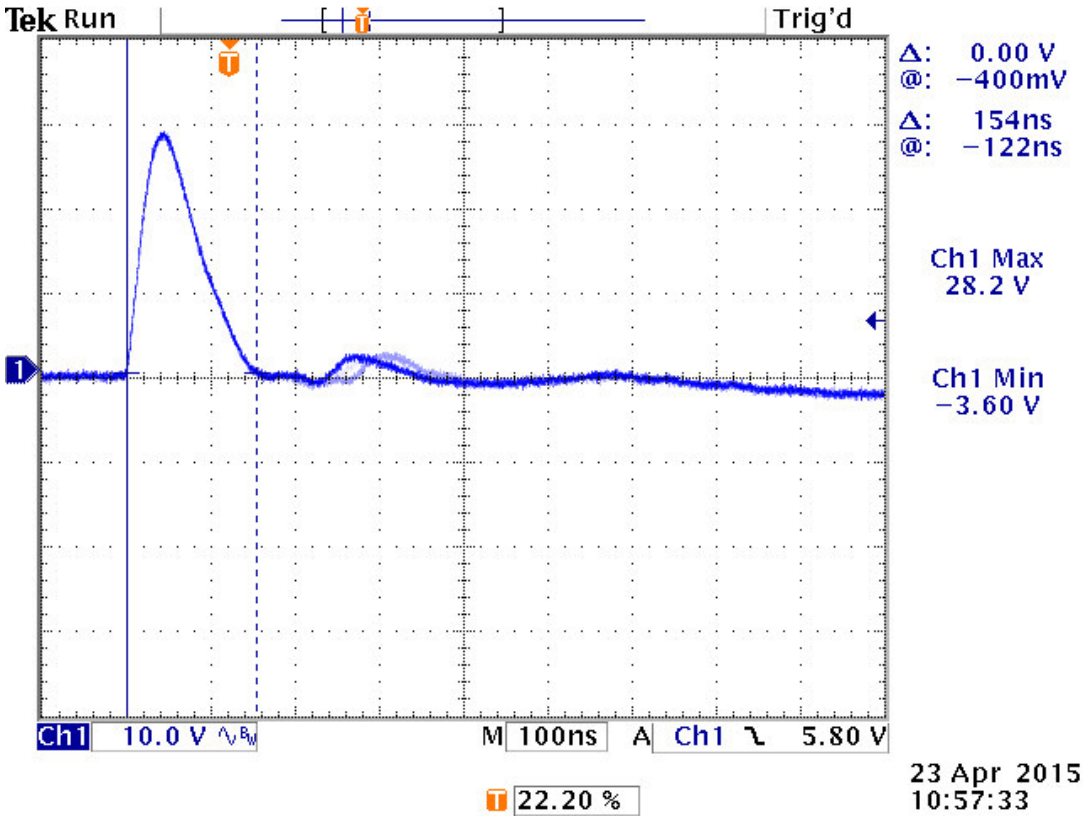
Plot 088



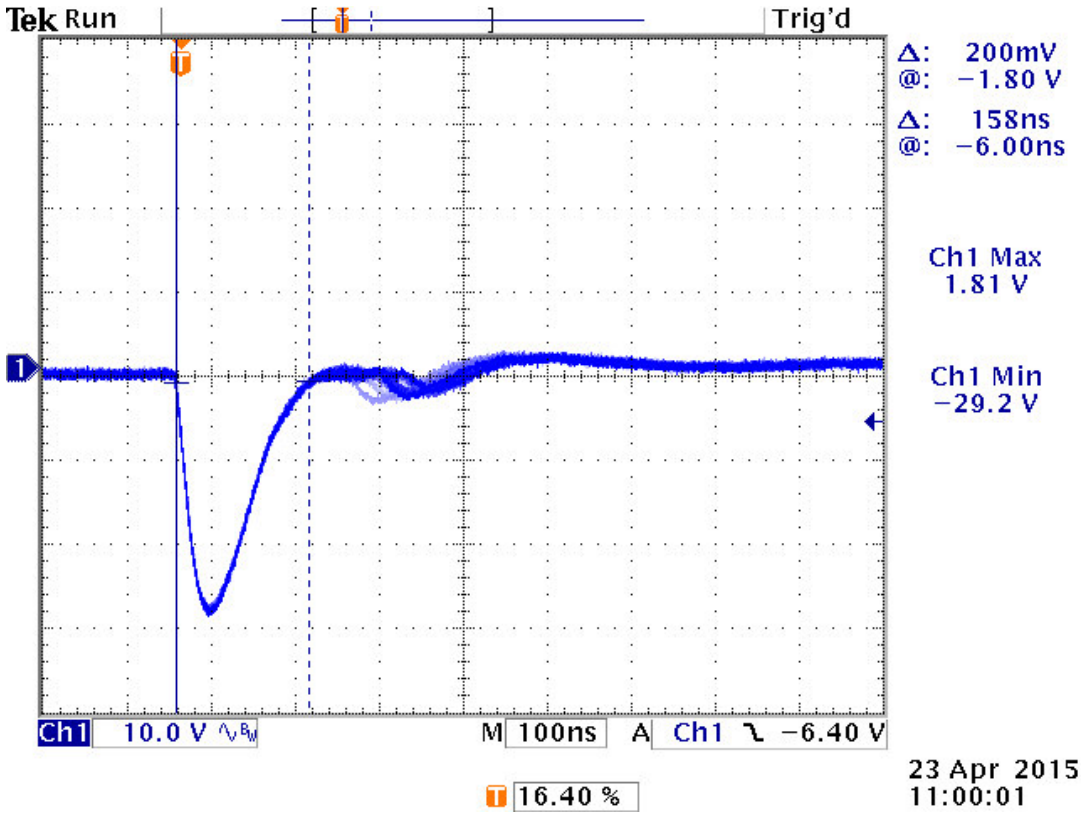
Plot 091



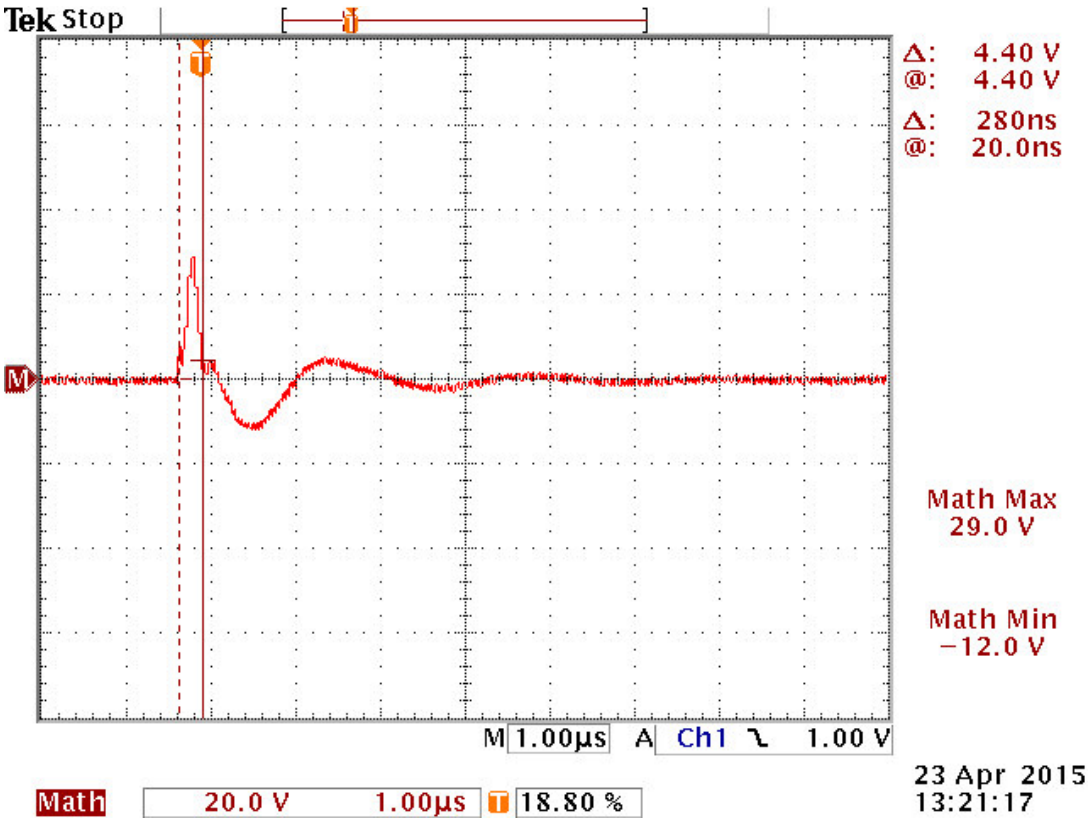
Plot 094



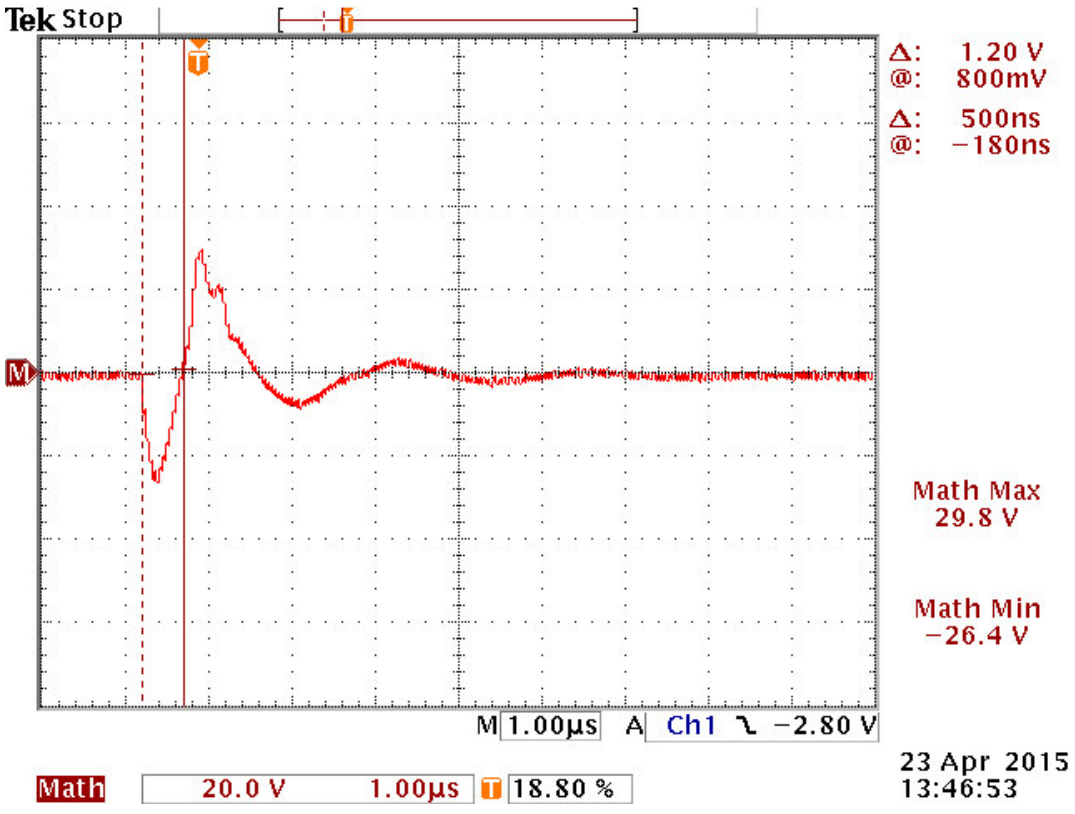
Plot 095



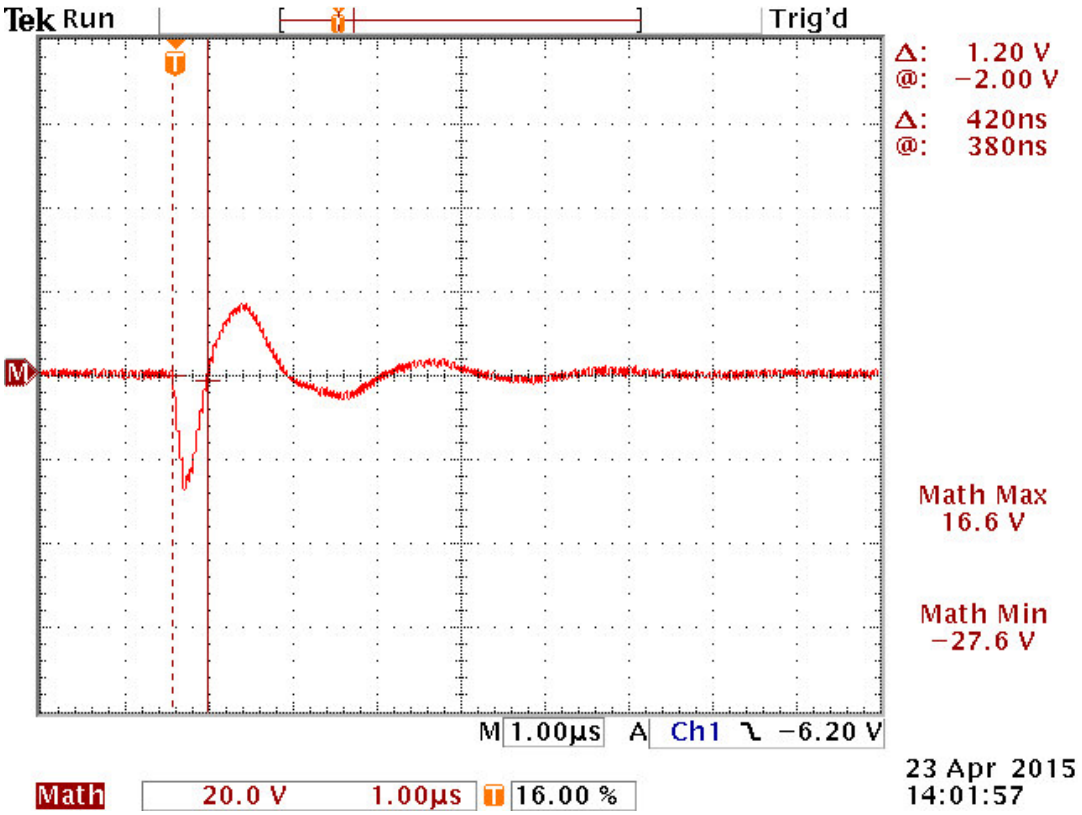
Plot 096



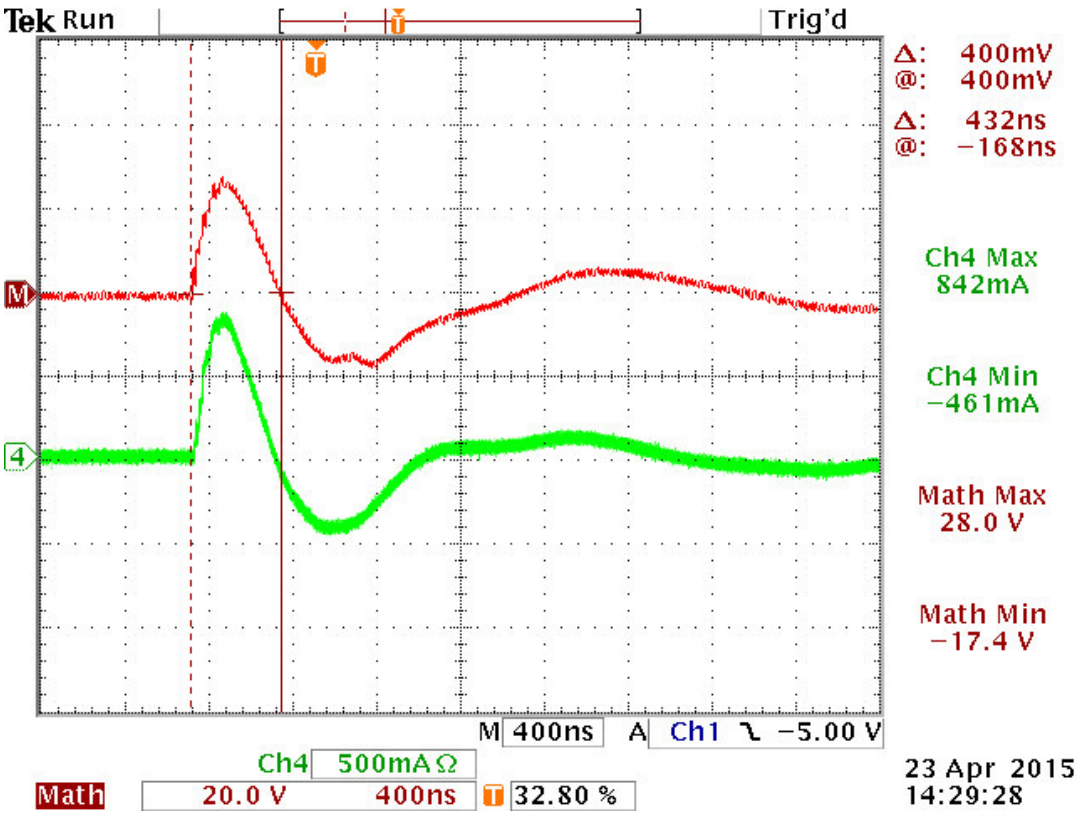
Plot 098



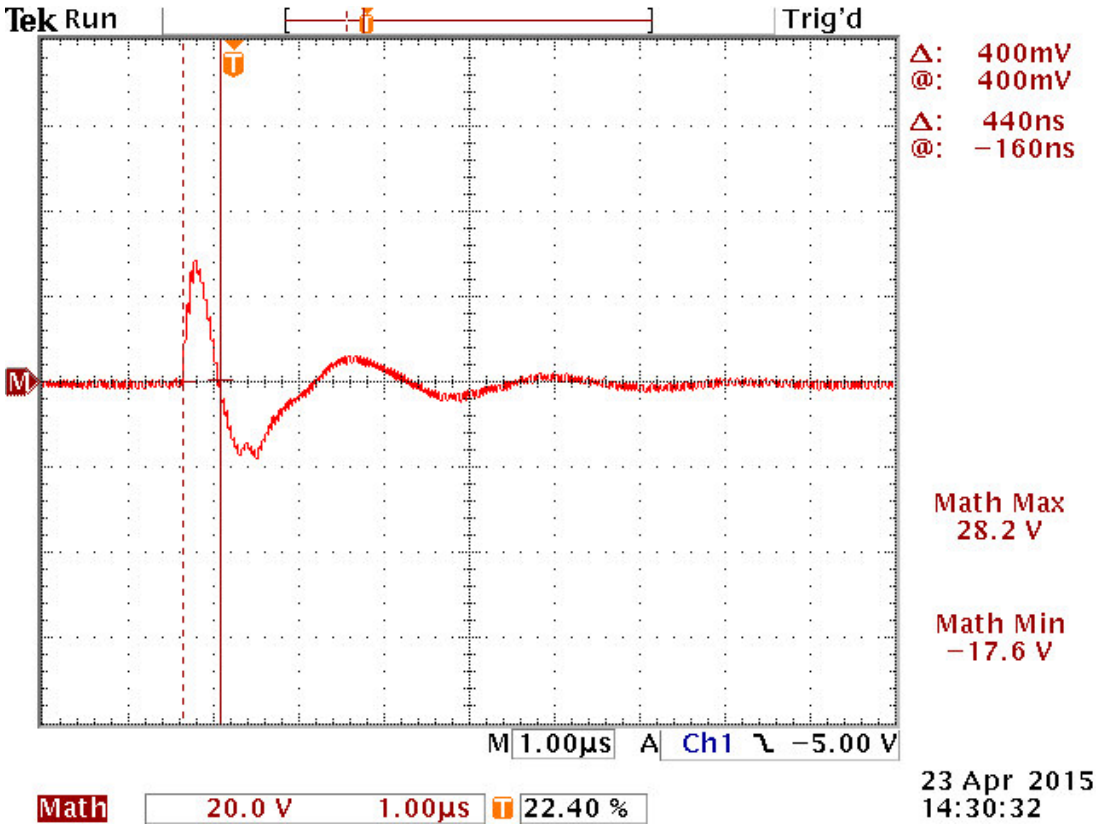
Plot 100



Plot 102



Plot 103


Tek Run
Trig'd
Δ: 400mV
@: 400mV
Δ: 440ns
@: −160ns
Math Max
28.2 V
Math Min
−17.6 V
M 1.00µs A Ch1 ∖ −5.00 V
23 Apr 2015
14:30:32
Math 20.0 V 1.00µs T 22.40 %

4.7 Conducted Susceptibility: Common mode:

4.7.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.9			
Test Dates:	**Start:**	24th April 2015	**End:**	24th April 2015
Ambient Conditions:	**Temp:**	24.3ºC	**Humidity:**	32%

4.7.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029769	09-Jun-15
Current amp	Tektronix	TCPA300	040925	28-Jan-16
Current probe	Tektronix	TCP312A	040926	28-Jan-16
Test Receiver	Rhode & Schwarz	ESIB40	028970	17-Dec-15
CABLE 5m	Rhophase	NPS-1551AT-5000-NPS	001125	19-May-15
RF Current Probe	Ailtech	91550-1L	004699	30-Jul-15
Signal Generator	Marconi	2042	001280	06-Feb-17
Function Generator	Rhode & Schwarz	AM300	035819	Verified during use
Amplifier (Power)	AR	15A250	013174	Verified during use
RF Inj Current Probe	AH Systems	ICP-200/524	013138	Verified during use
Software Automation	Dare	-	-	N/A

4.7.3 Test Procedure:

A precalibrated drive level equivalent to 3 volts peak to peak was established by injecting via a current clamp into a 50 Ohm load. The output was monitored using a test receiver. The drive level was recorded and programmed in to the software to allow the sweep to be automated at a sweep rate in accordance with the Mil-Std 461. Modulation was also applied. Plots were recorded of the precalibration modulation.

For the test the current clamp was placed around the cable bundle 20cm from the EUT and a monitoring current clamp was placed between the EUT and the injection clamp at 10cm from both. The level was increased until either 3V pk-pk, 3A pk-pk or the pre-cal drive level was reached. These levels were not exceeded at any time.

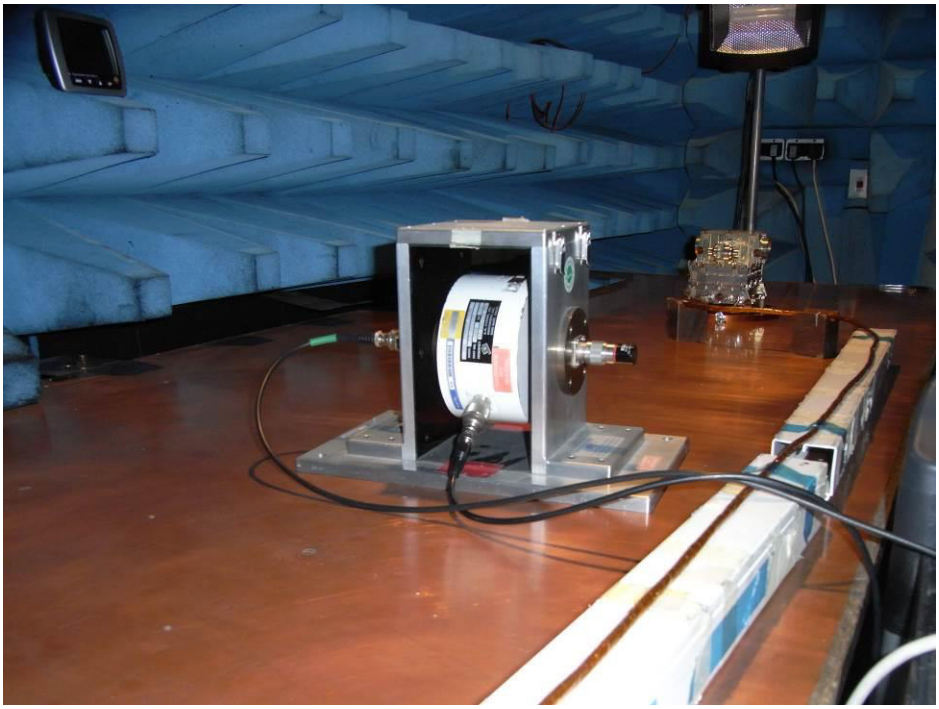


Figure 14. Calibration

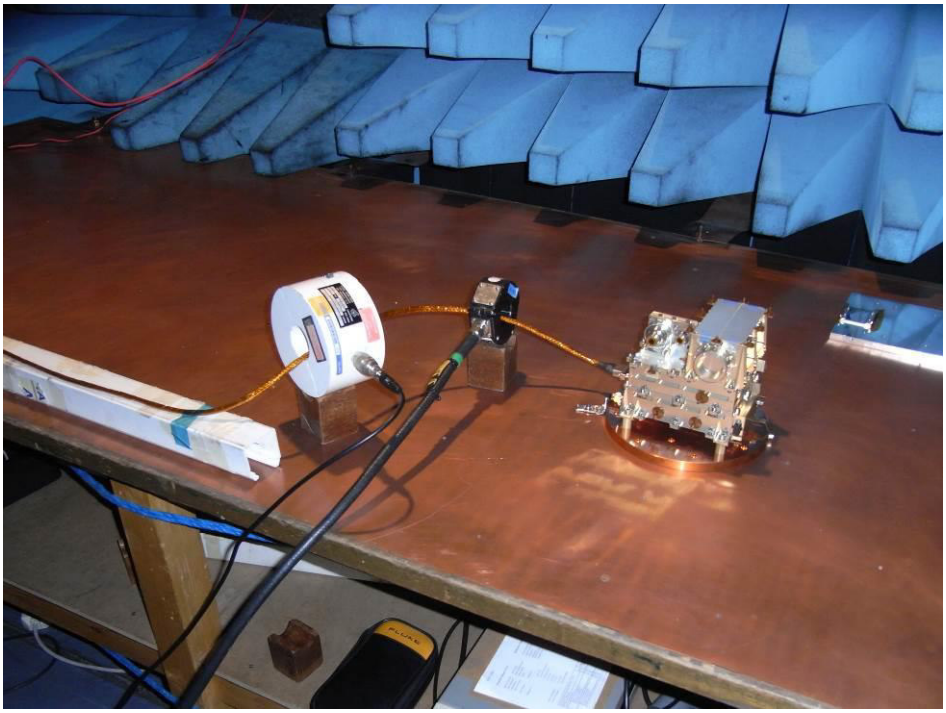


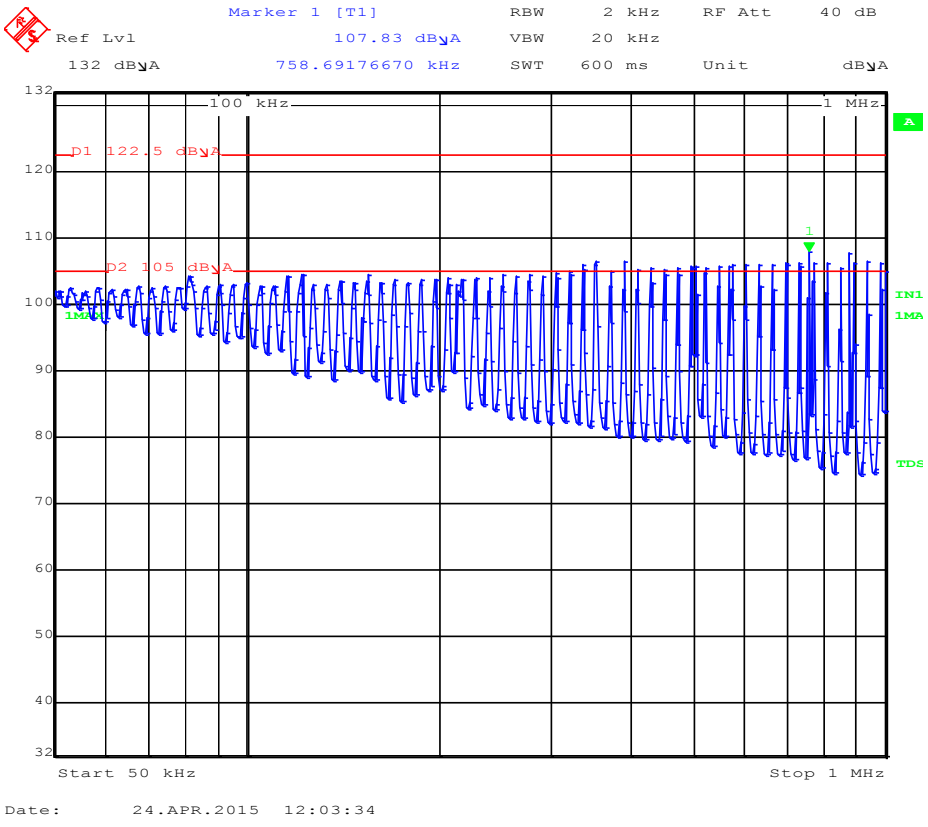
Figure 15. Common mode injection

4.7.4 Results Summary:

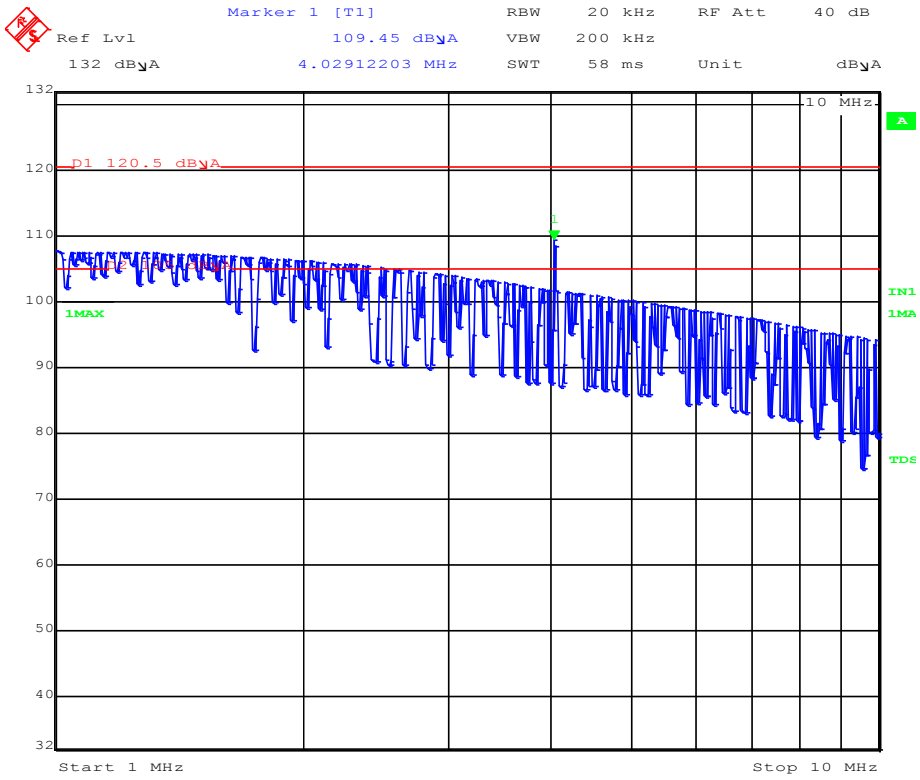
Frequency Range (MHz)	Injection level reached	Modulation	Sweep Rate	Dwell Time (Seconds)	Current level Plot	Result
0.05 to 1	3V	1kHz, 50%	5%	3	110	Complied
1 to 10	3V	1kHz, 20%	1%	3	111	Complied
10 to 100	3V	1kHz, 5%	0.5%	3	113	Complied

4.7.5 Plots:

Plot 110

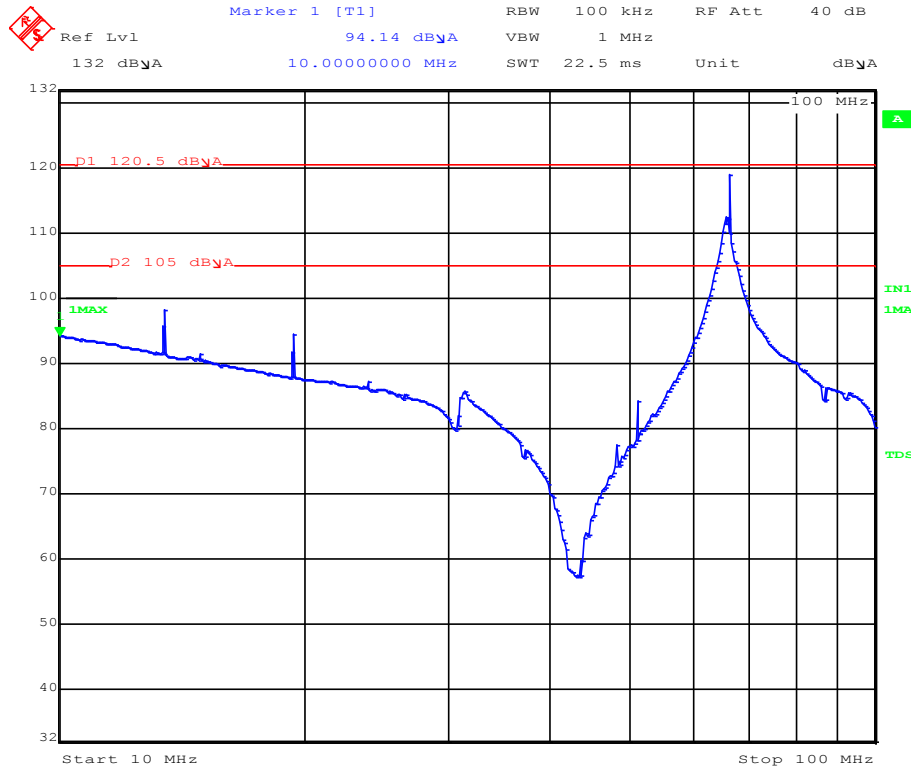


Plot 111



Date: 24.APR.2015 12:39:08

Plot 113



Date: 24.APR.2015 14:39:35

4.8 Radiated Emissions: Wide Band Sweep and Notch Frequencies:

4.8.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.10			
Test Dates:	**Start:**	27th April 2015	**End:**	29th April 2015
Ambient Conditions:	**Temp:**	22.2ºC	**Humidity:**	35%

4.8.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Cable 3m	Rosenberger Micro Coax	FB311A1030005050	029718	19-May-15
Test Receiver	Rhode & Schwarz	ESIB40	028970	17-Dec-15
CABLE 5m	Rhophase	NPS-1551AT-5000-NPS	001125	19-May-15
Antenna Rod Pre-Amp	ETS Lindgren	3301B	029034	29-Jul-15
Antenna Bi-Con	Chase	VBA6106A	004901	19-Jun-15
Antenna DRG	Ailtech	3115	003851	29-Jan-16
Antenna DRG	Schwarzbeck	BBHA 9120 F	029479	03-Mar-16
LNA	AML	AML012L3601	029584	07-Jan-16
LNA	Avantek	AMT4024M	002589	03-Aug-15
LNA	AML	AML48L4001	034155	06-Jan-16
LNA	Miteq	AFS6-08001800-35-TC6	004430	03-Aug-15
Antenna DRG	Schwarzbeck	BBHA 9120 F	029479	03-Mar-16

4.8.3 Test Procedure:

All tests were performed at a distance of 1m with the exception of the notch frequencies where the distance was reduced in order to apply an offset to reduce the noise floor. The cable from the EGSE to the LISN was shielded using metal foil. Photos of the different antenna types are shown on the following pages.

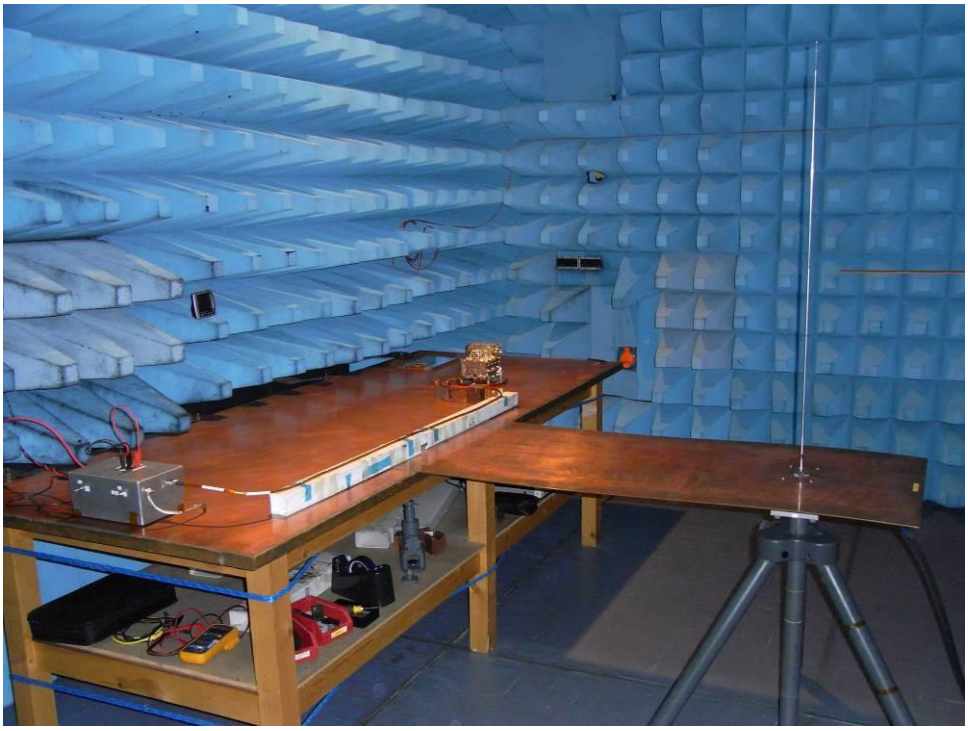


Figure 16. 14kHz to 30MHz

Figure 17. 30MHz to 200MHz

Figure 18. 200MHz to 1000MHz

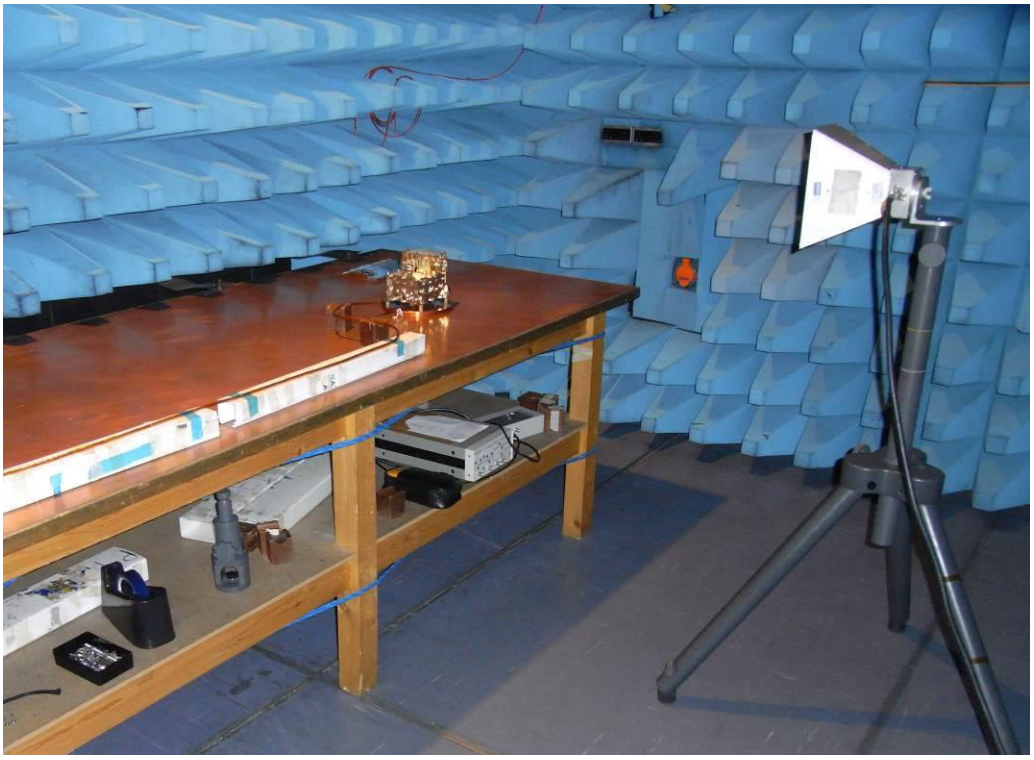


Figure 19. 1000MHz to 18000MHz

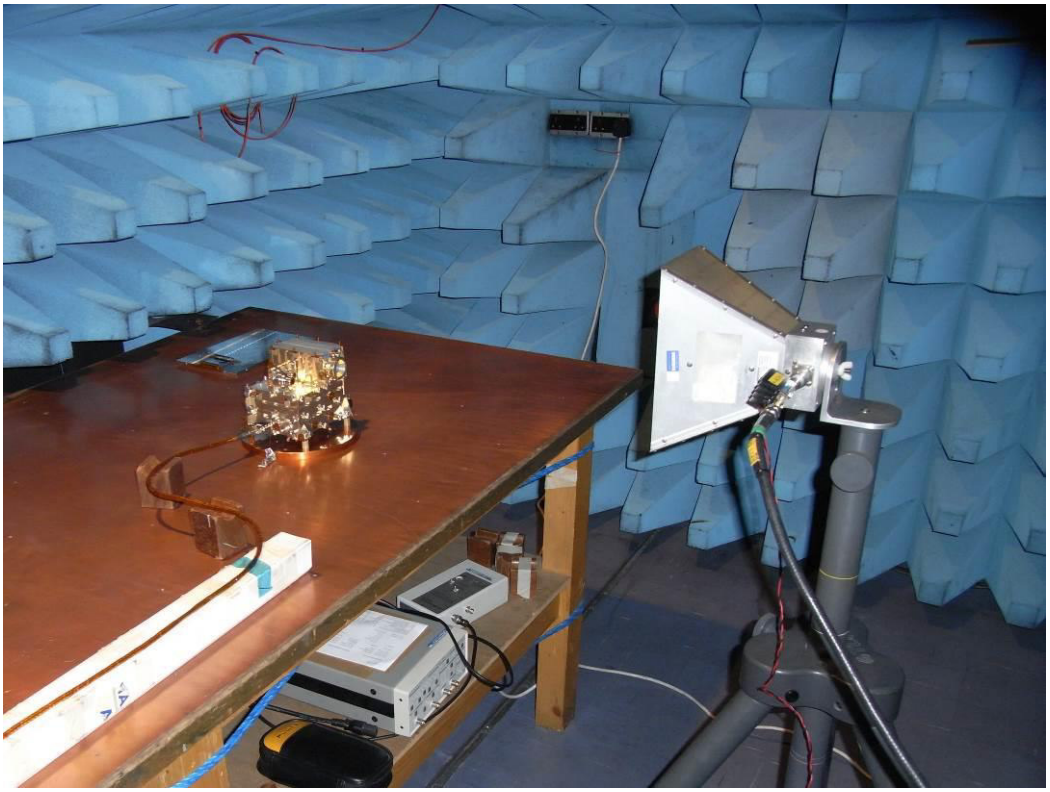


Figure 20. Notch Frequency at 50cm using a Low noise amplifier

4.8.4 Results Summary:

Wideband Sweep: EUT On

Frequency (MHz)	RBW (kHz)	Antenna Polarity	Measured Frequency (MHz)	Measured Level (dBµV/m)	Limit (dBµV/m)	Plot	Result
0.014 to 0.15	1	V	0.014	35.0	40.0	132	Complied
	0.2	V	0.018	28.5	40.0	133	info only
0.15 to 30	10	V	0.158	24.9	40.0	131	Complied
30 to 200	100	H	180.120	31.8	45.0	135	Complied
		V	182.960	32.5	45.0	136	Complied
200 to 1000	100	H	912.000	41.9	59.2	176	Complied
		V	960.000	43.3	59.4	175	Complied
1000 to 2000	1000	H	1104.000	38.8	60.0	139	Complied
		V	1104.000	50.7	60.0	140	Complied
2000 to 4000	1000	V	3758.000	49.4	60.0	141	Complied
		H	3901.600	49.1	60.0	167	Complied
4000 to 8000	1000	H	69908.000	46.0	60.0	143	Complied
		V	6983.200	46.0	60.0	160	Complied
8000 to 18000	1000	H	17883.371	55.1	60.0	175	Complied
		V	17941.590	56.1	60.0	174	Complied

Background:

Frequency (MHz)	RBW (kHz)	Antenna Polarity	Measured Frequency (MHz)	Measured Level (dBµV/m)	Limit (dBµV/m)	Plot	Result
0.014 to 0.15	1	V	0.152	36.2	40.0	125	Complied
0.15 to 30	10	V	13.558	19.3	40.0	130	Complied
30 to 200	100	H	172.440	32.2	45.0	138	Complied
		V	198.920	31.9	46.2	137	Complied
200 to 1000	100	H	204.280	12.3	46.0	308	Complied
		V	200.000	12.9	46.0	309	Complied
1000 to 2000	1000	H	1996.800	34.4	60.0	171	Complied
		V	1969.200	34.5	60.0	170	Complied
2000 to 4000	1000	H	3924.000	48.9	60.0	168	Complied
		V	3818.800	48.7	60.0	169	Complied
4000 to 8000	1000	H	7497.600	45.6	60.0	159	Complied
		V	6949.200	45.7	60.0	158	Complied
8000 to 18000	1000	H	17854.332	55.5	60.0	172	Complied
		V	17854.332	55.6	60.0	173	Complied

Notch Frequencies: EUT On

Frequency (MHz)	RBW (kHz)	Antenna Polarity	Measured Frequency (MHz)	Measured Level (dBµV/m)	Limit (dBµV/m)	Plot	Result
7072 to 7122	2	H	7073.102	14.6	23.0	144	Complied
		V	7110.677	14.7	23.0	161	Complied
7122 to 7162	0.5	H	7153.983	3.1	8.0	145	Complied
		V	7122.232	3.0	8.0	166	Complied
7162 to 7182*	0.5	V	7163.482	-16.2	-22.0	147	N/A**
		H	7163.923	-16.6	-22.0	146	N/A**
7182 to 7222	0.5	H	7213.342	4.0	8.0	164	Complied
		V	7213.022	4.0	8.0	165	Complied
7222 to 7272	2	H	7229.414	14.6	23.0	163	Complied
		V	7227.310	15.4	23.0	162	Complied

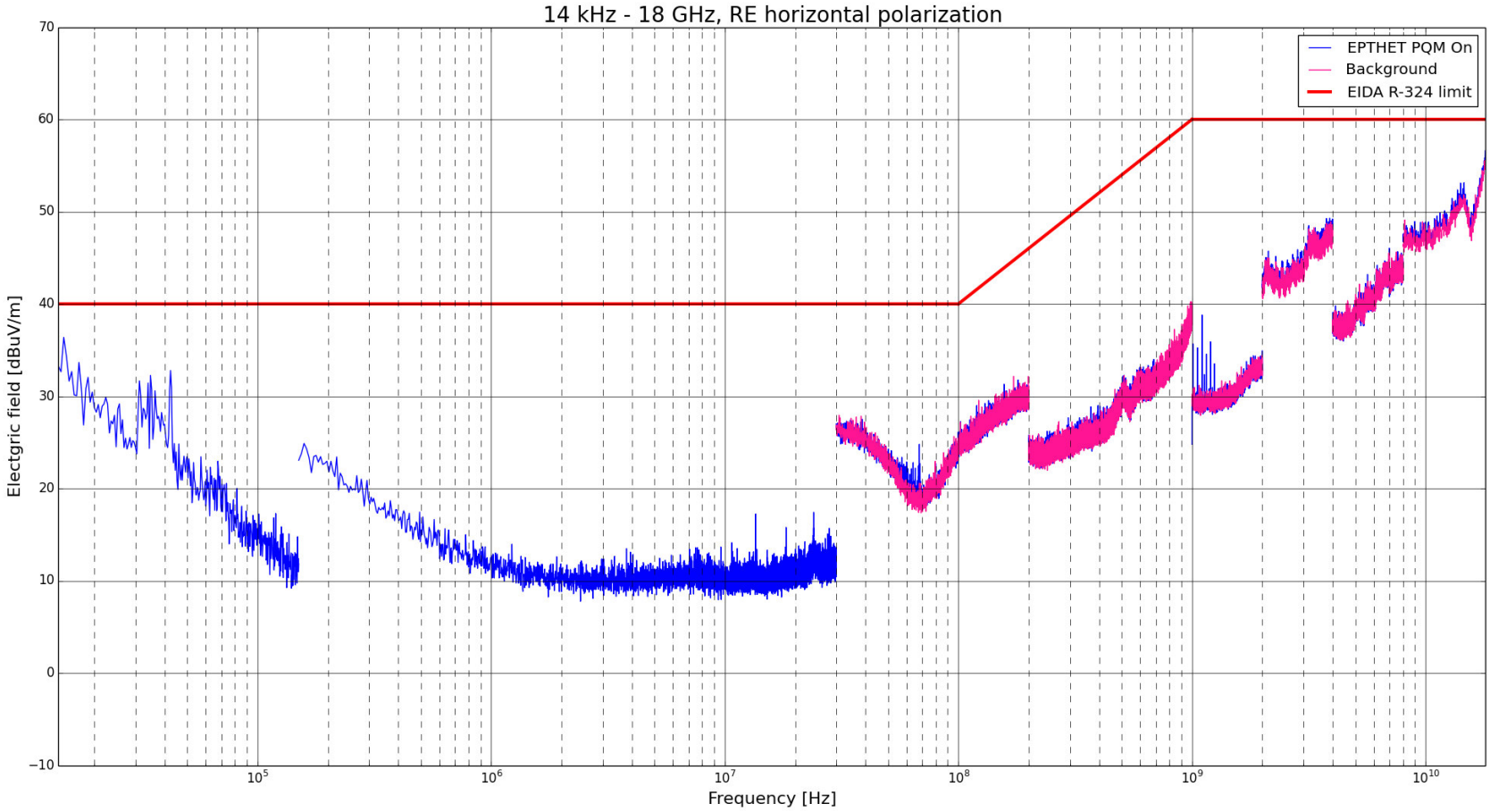
Background:

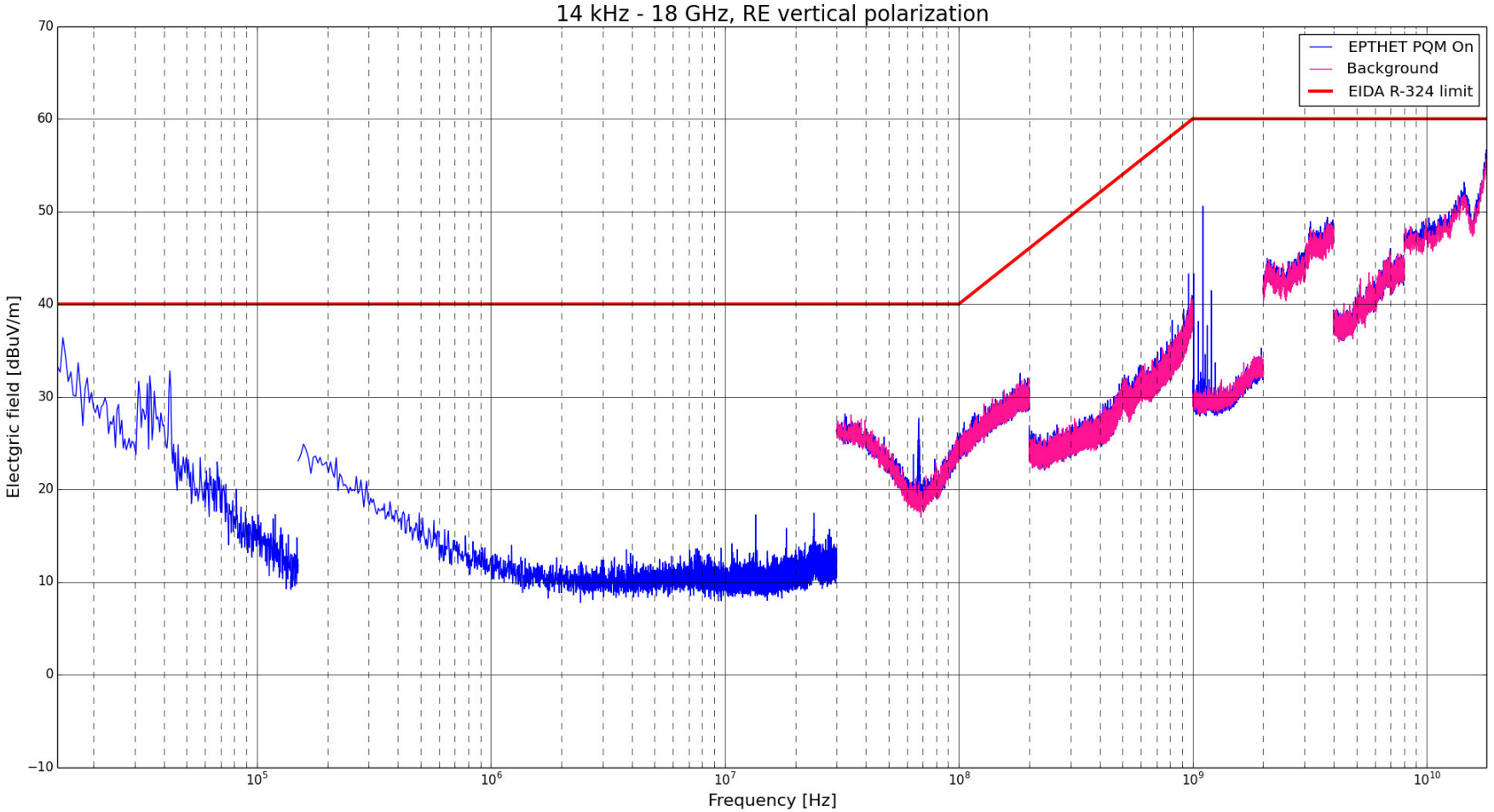
Frequency (MHz)	RBW (kHz)	Antenna Polarity	Measured Frequency (MHz)	Measured Level (dBµV/m)	Limit (dBµV/m)	Plot	Result
7072 to 7122	2	H	7116.488	14.7	23.0	155	Complied
		V	7072.801	14.4	23.0	156	Complied
7122 to 7162	0.5	H	7143.643	3.4	8.0	150	Complied
		V	7162.000	4.1	8.0	151	Complied
7162 to 7182*	0.5	V	7167.891	-15.9	-22.0	148	N/A**
		H	7168.533	-16.4	-22.0	149	N/A**
7182 to 7222	0.5	H	7193.703	3.5	8.0	153	Complied
		V	7190.577	3.2	8.0	152	Complied
7222 to 7272	2	H	7226.609	14.9	23.0	154	Complied
		V	7236.328	14.9	23.0	157	Complied

*Note: Measurement performed at 25cm and a -12dB offset applied in order to reduce the noise floor.

**Note: Non-compliance was a result of not being able to achieve a low enough noise floor. Reducing the bandwidth to reduce the noise floor was not possible due to the very slow sweep rate and time constraints.

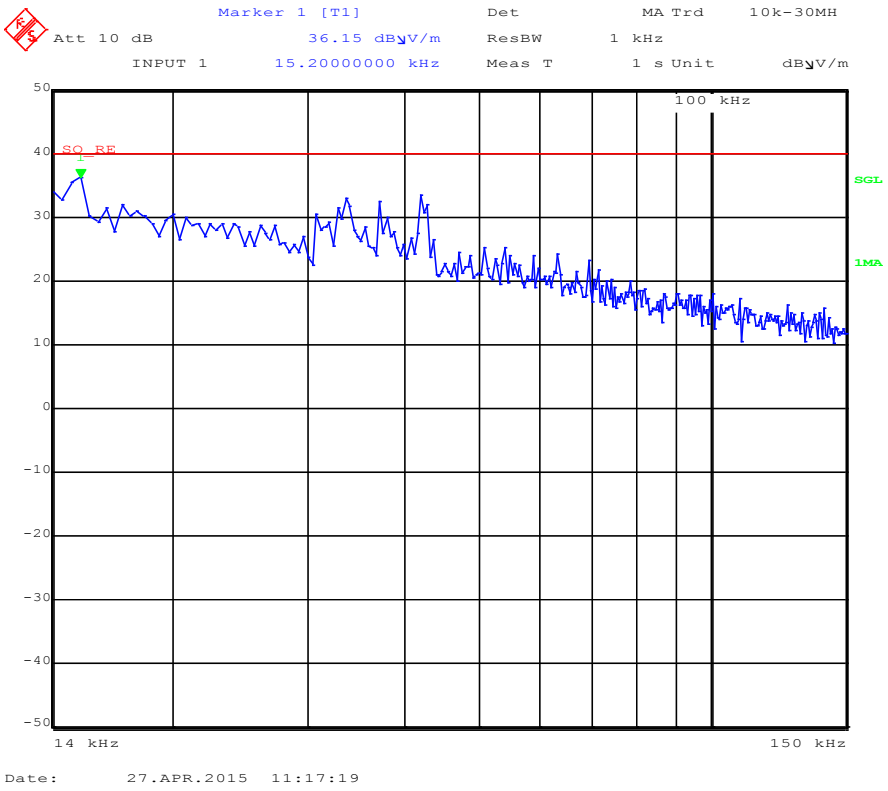
4.8.5 Plots:


14 kHz - 18 GHz, RE horizontal polarization
EPTHET PQM On
Background
EIDA R-324 limit
Electgric field [dBuV/m]
Frequency [Hz]
70
60
50
40
30
20
10
0
−10
10^5
10^6
10^7
10^8
10^9
10^{10}

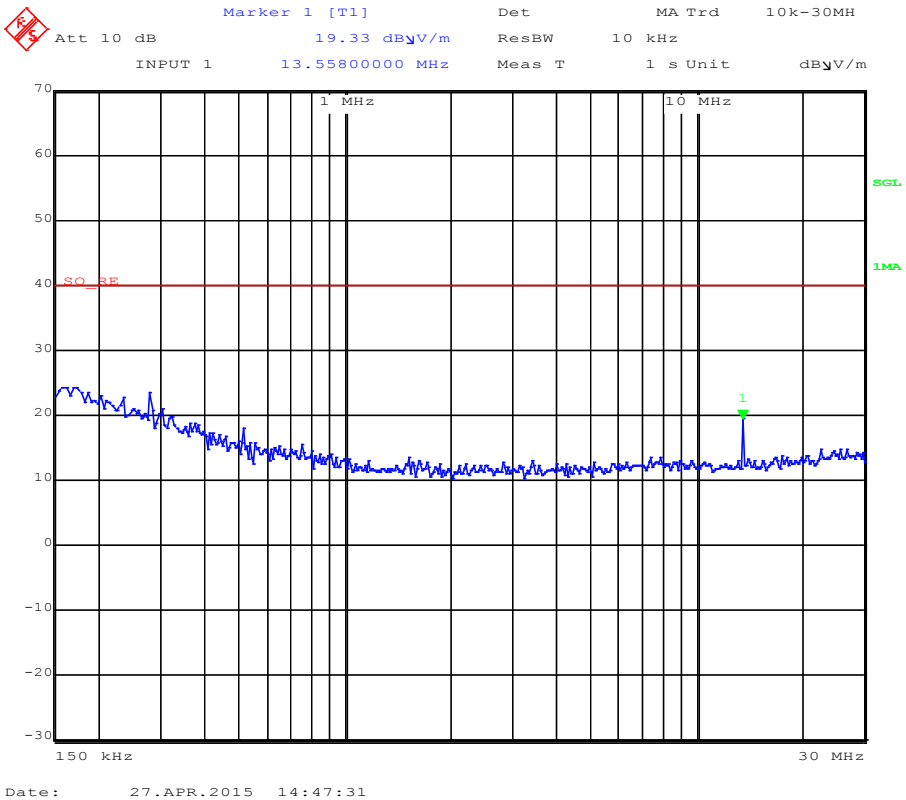


14kHz to 30MHz Background Plots:

Plot 125

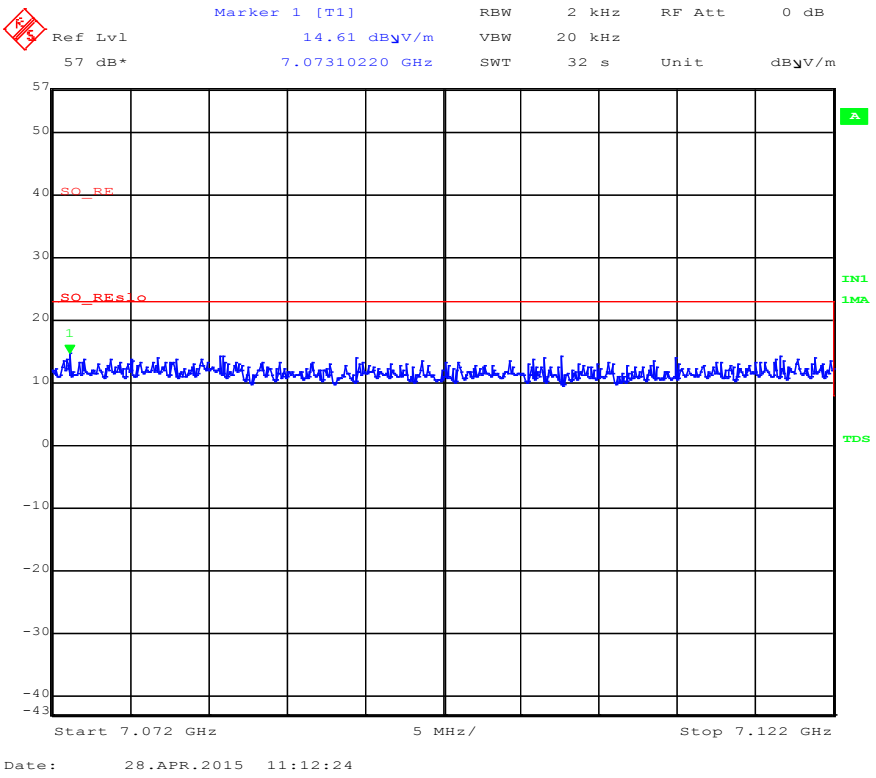


Plot 130

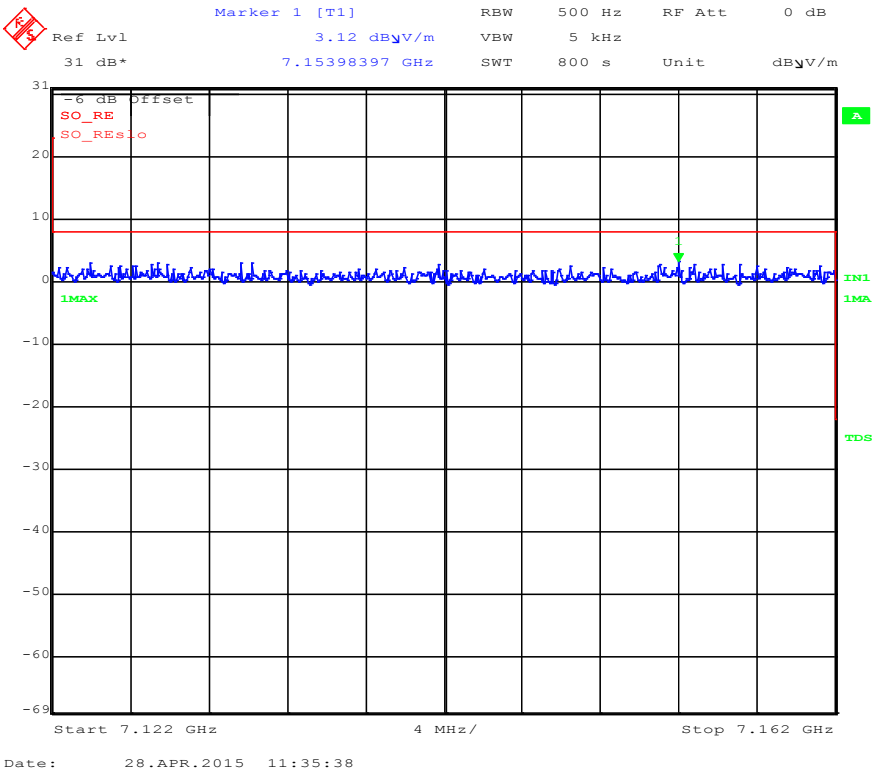


Notch Frequency Plots:

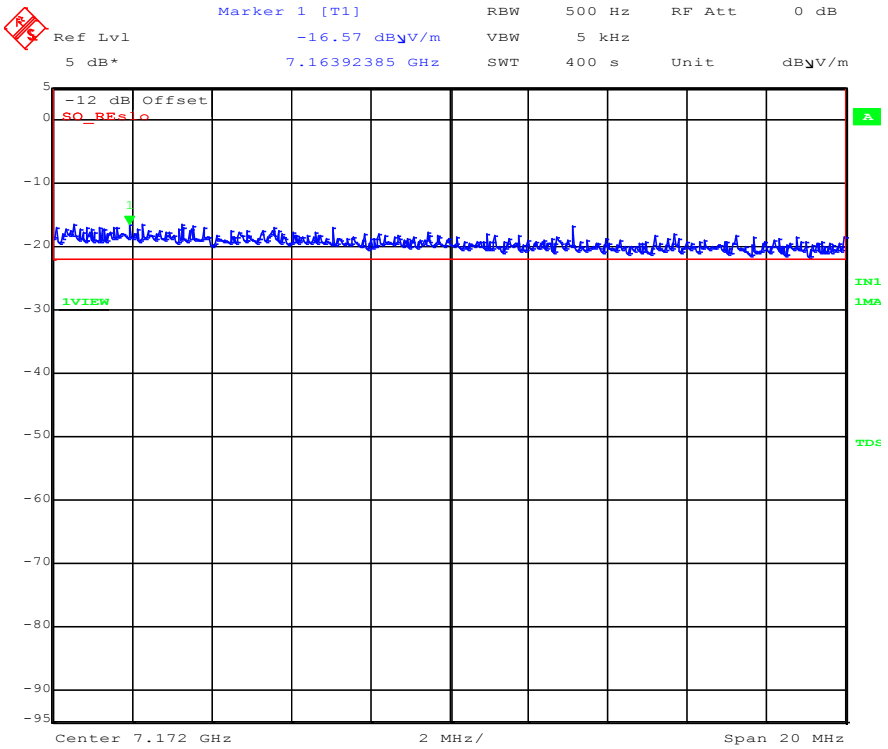
Plots 144



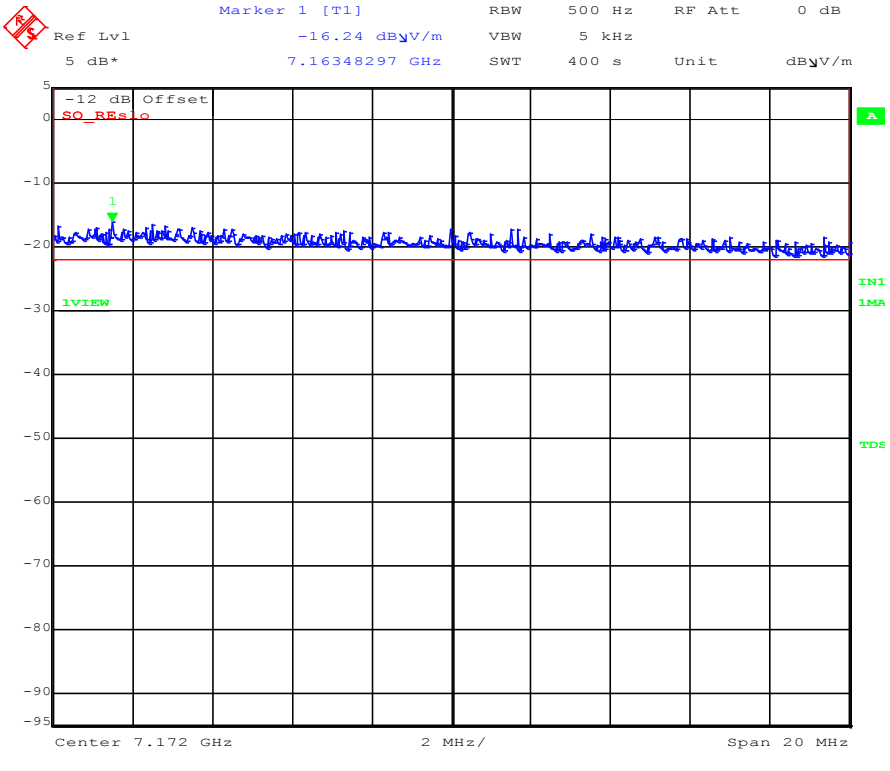
Plots 145



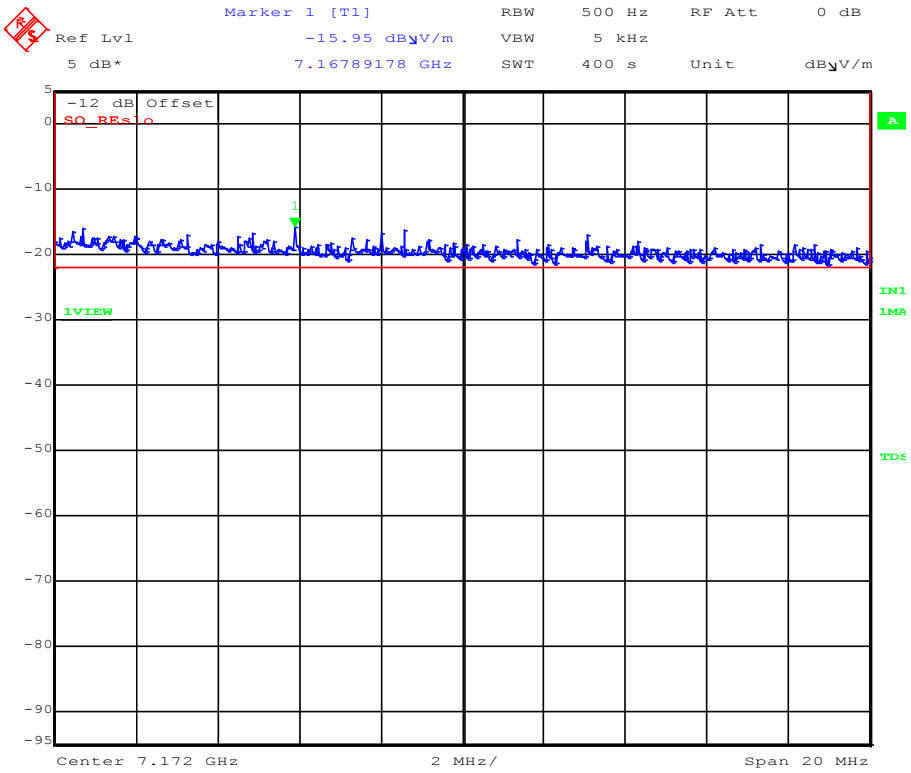
Plots 146



Plot 147

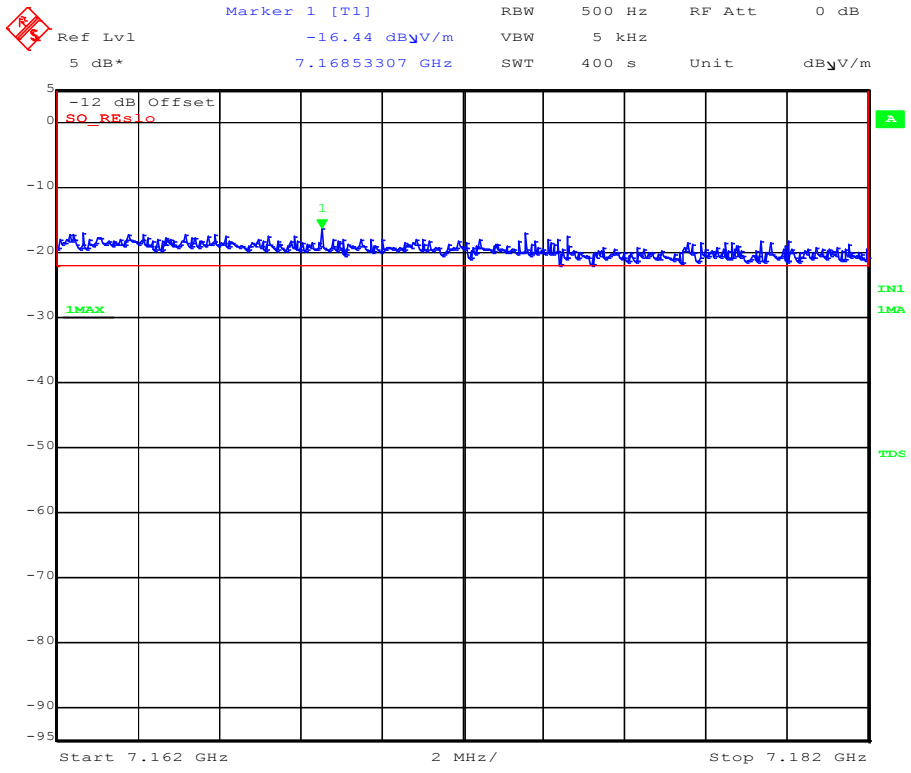


Plot 148



Date: 28.APR.2015 14:18:25

Plot 149



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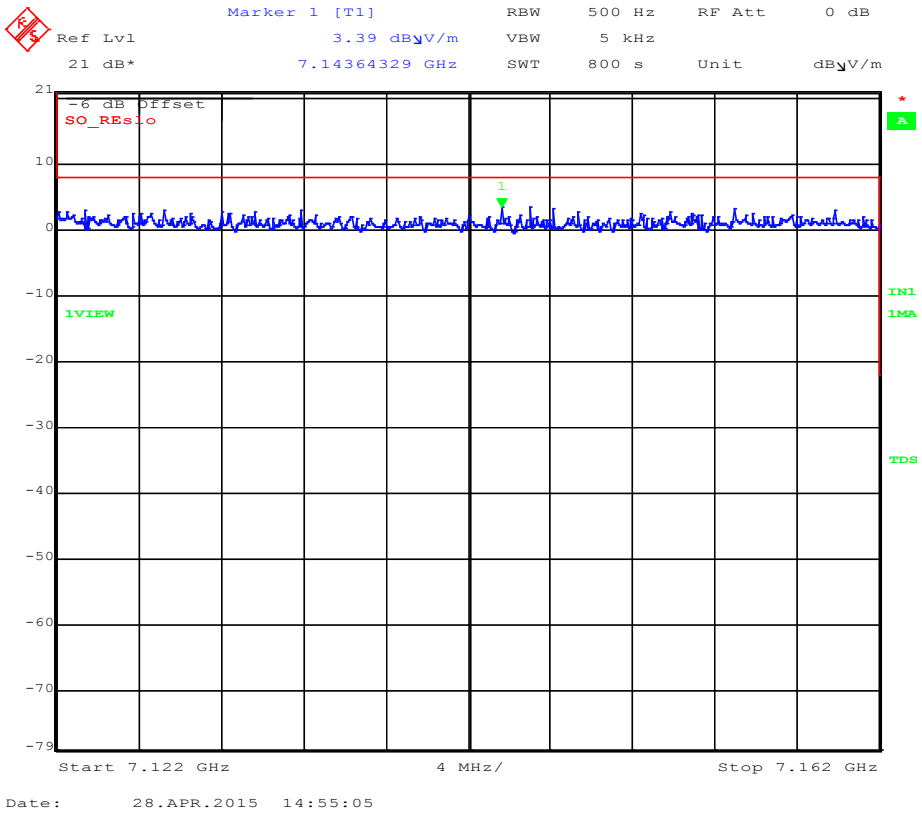
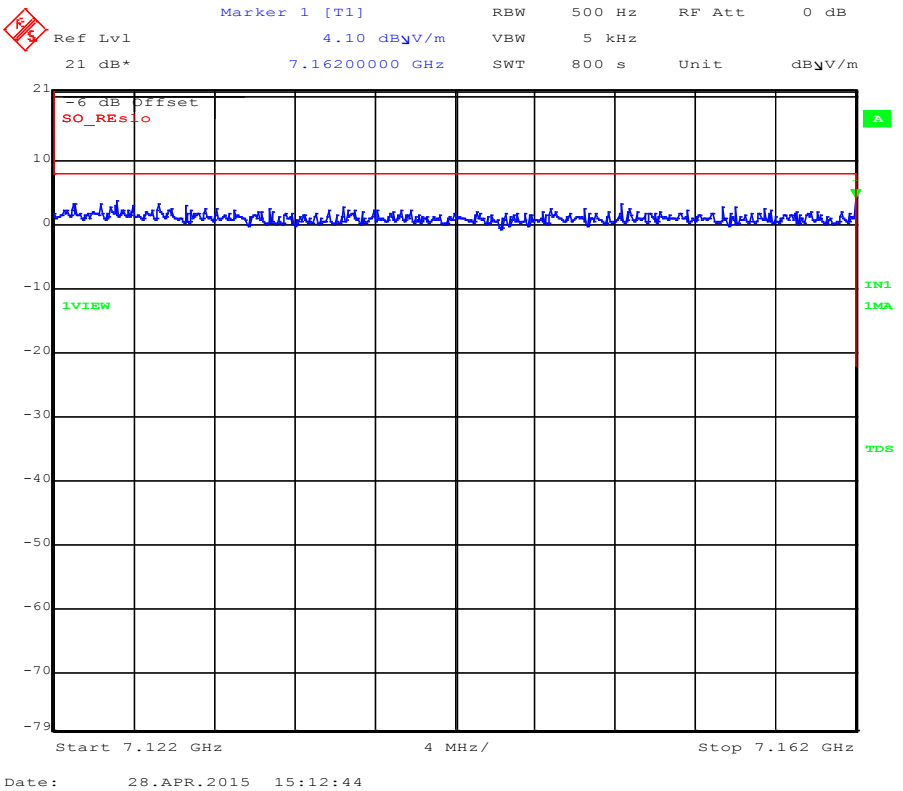
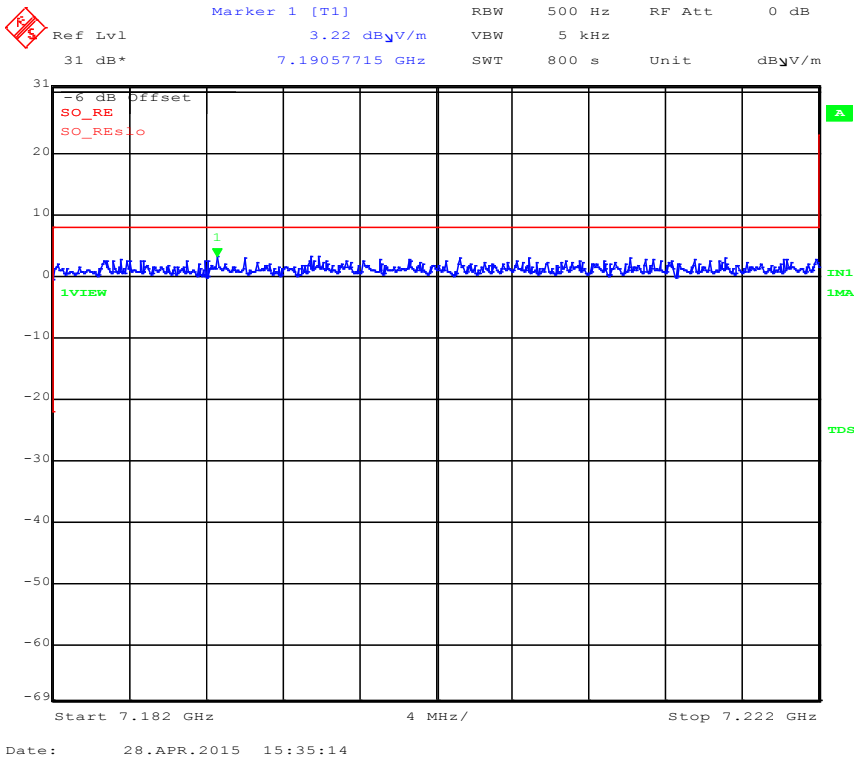


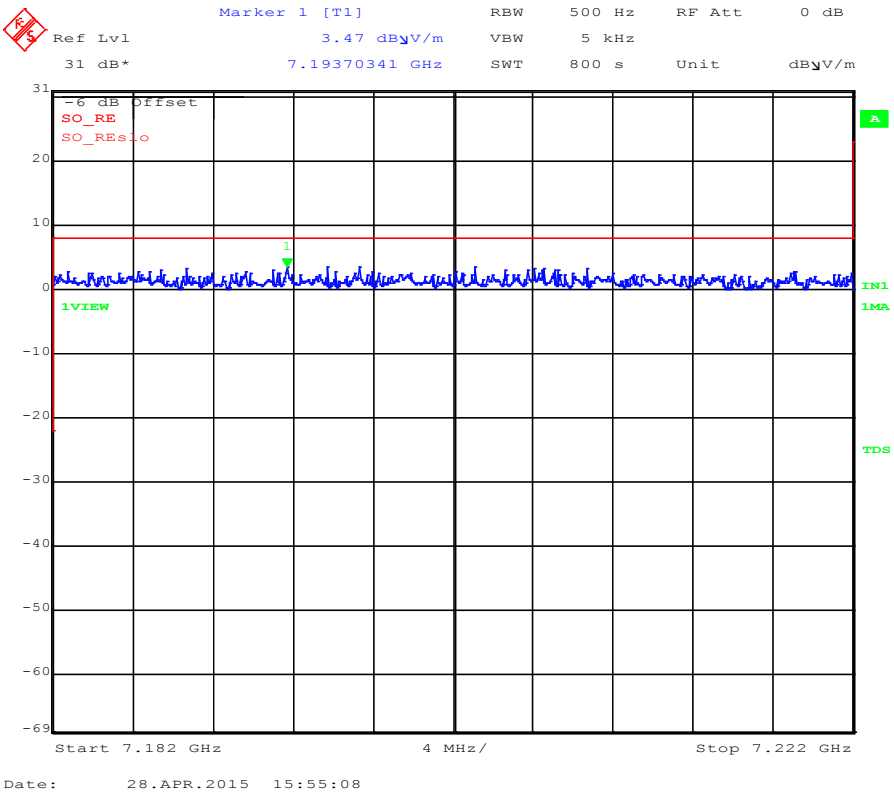
Plot 151



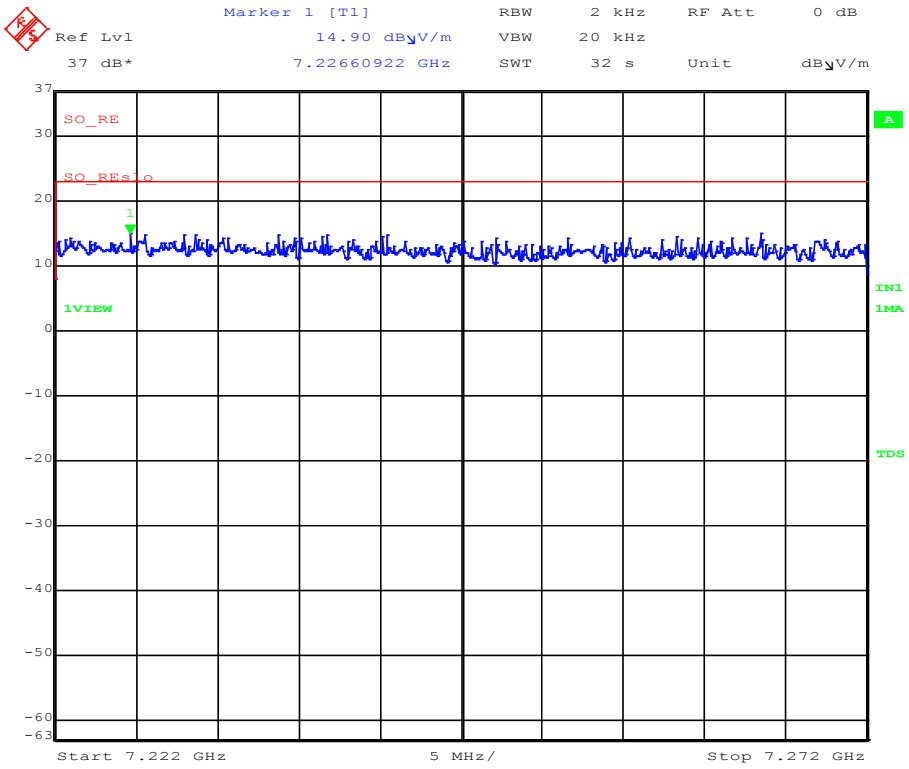
Plot 152



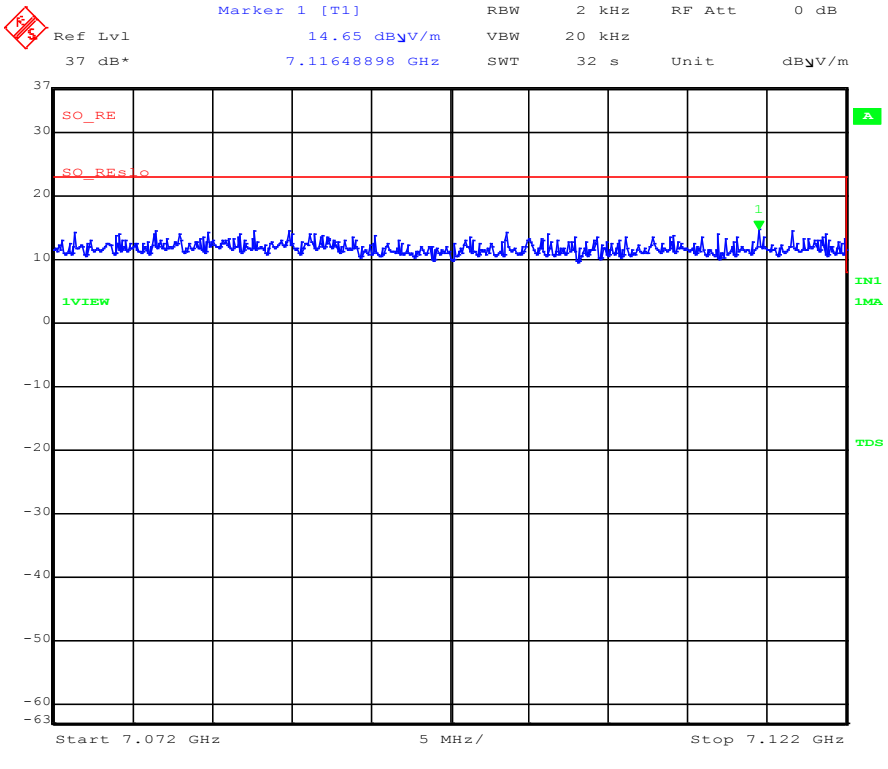
Plot 153



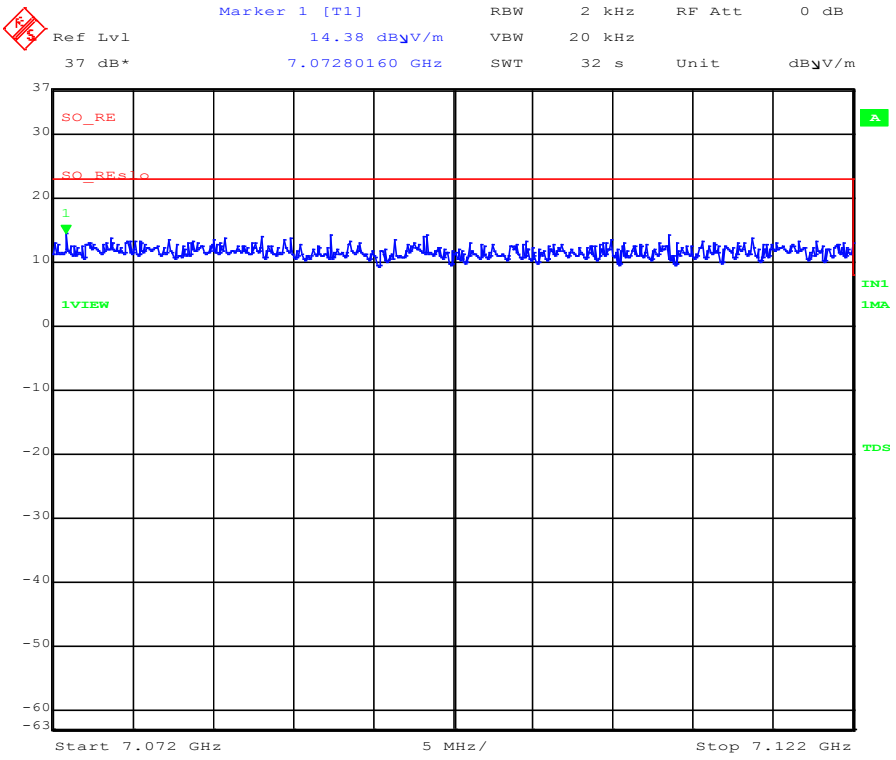
Plot 154



Plot 155



Plot 156



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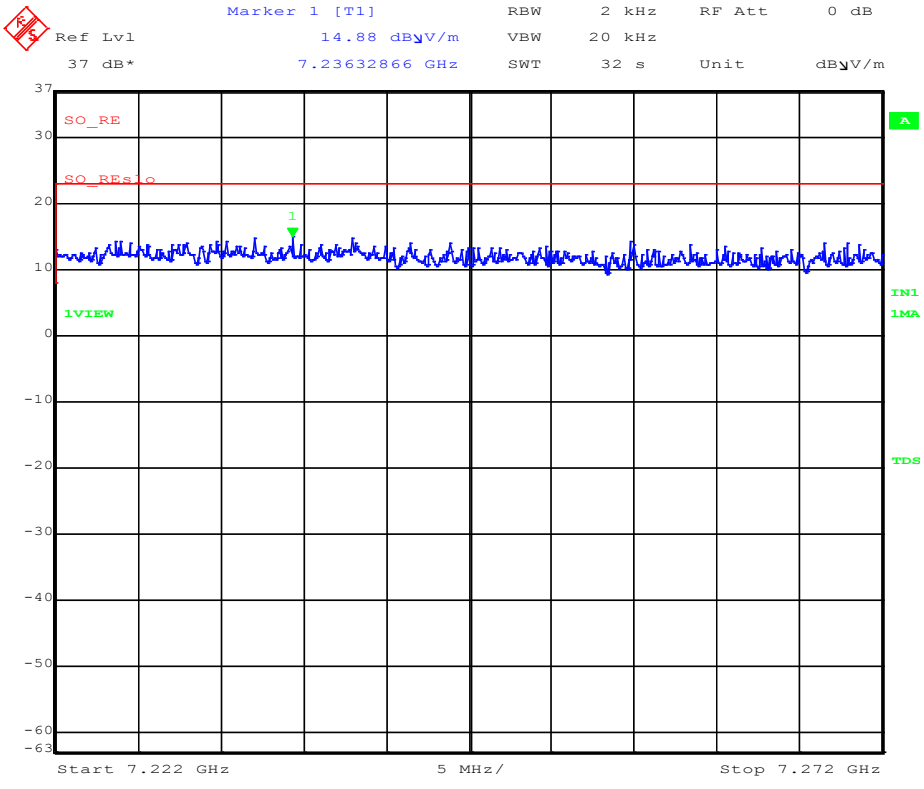
Plot 157



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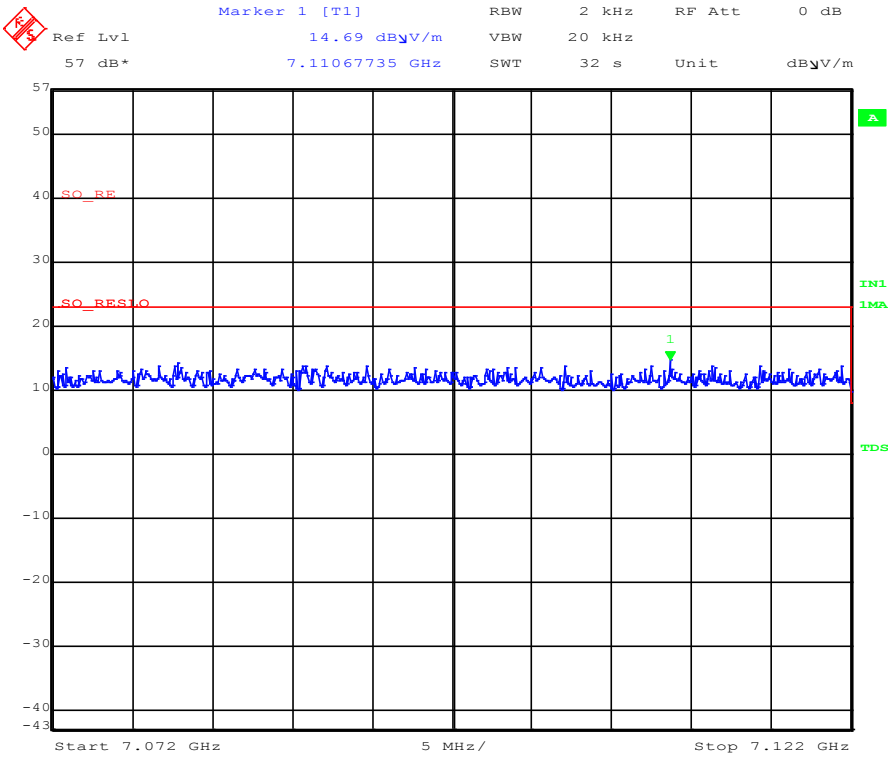
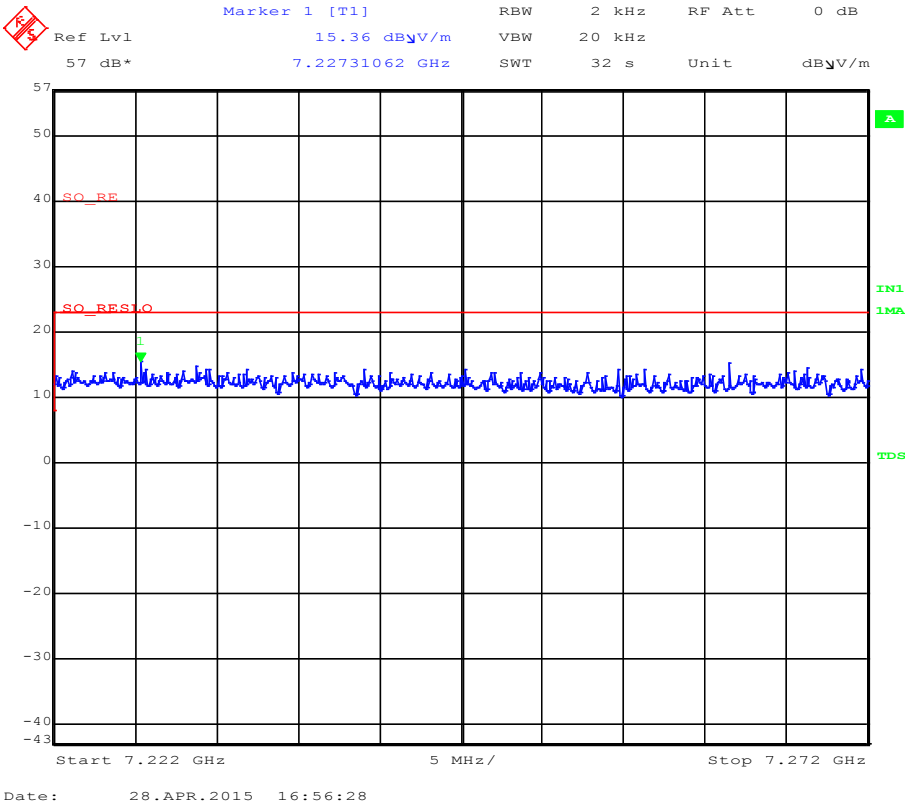
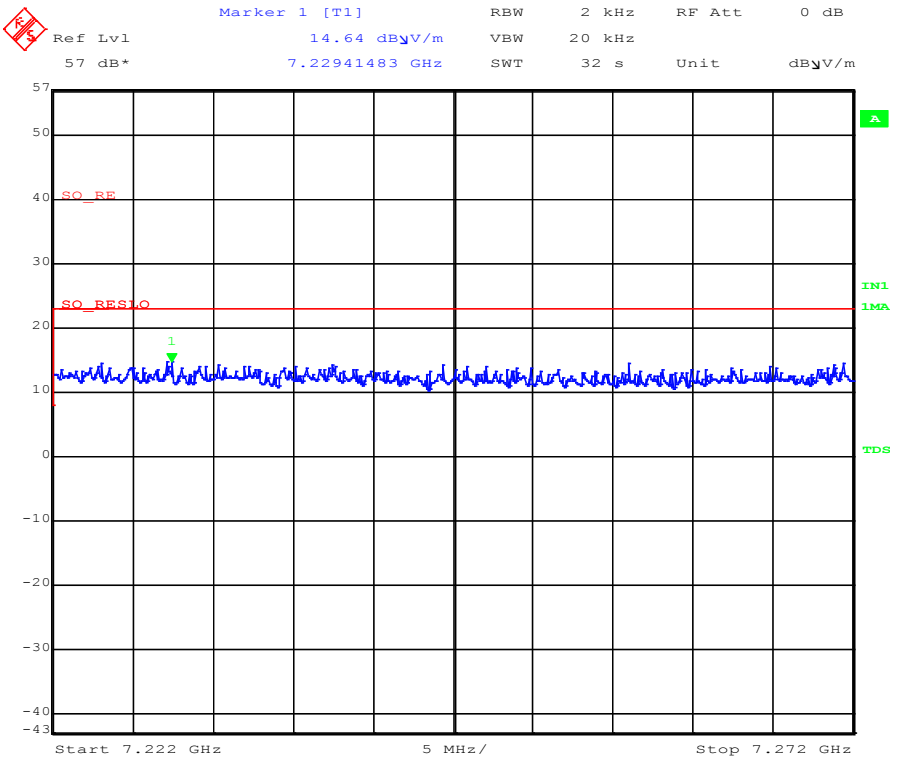


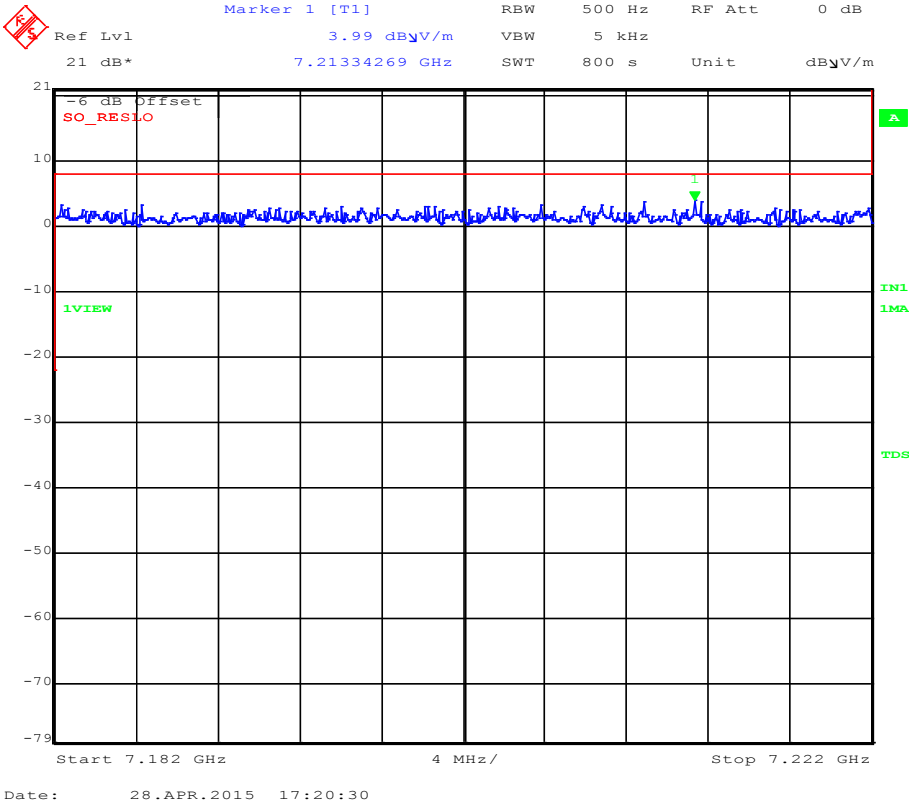
Plot 162



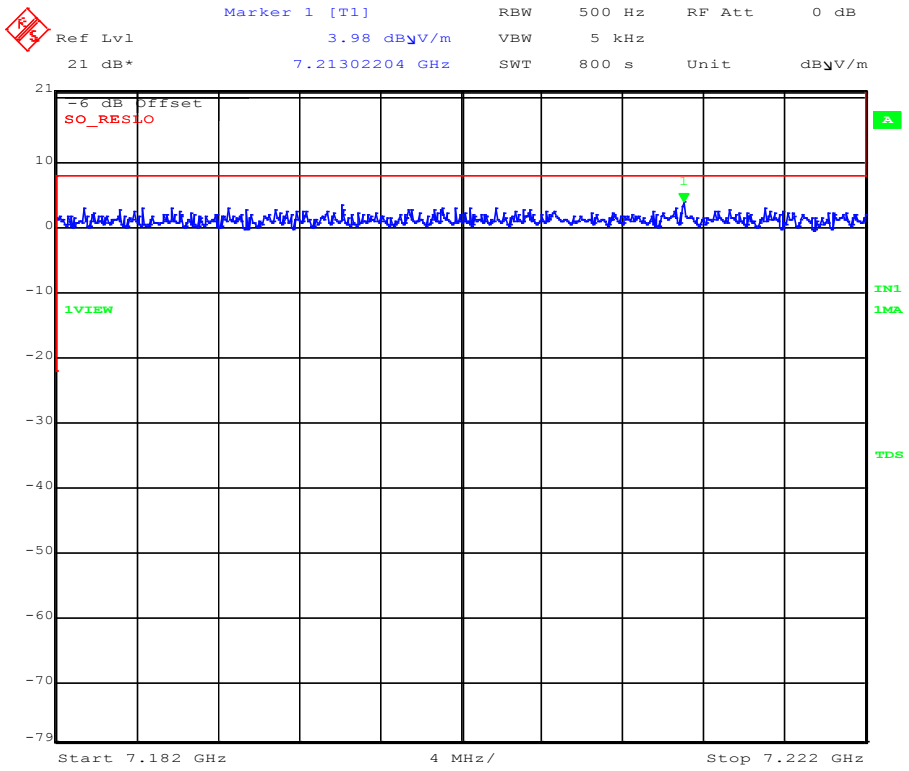
Plot 163



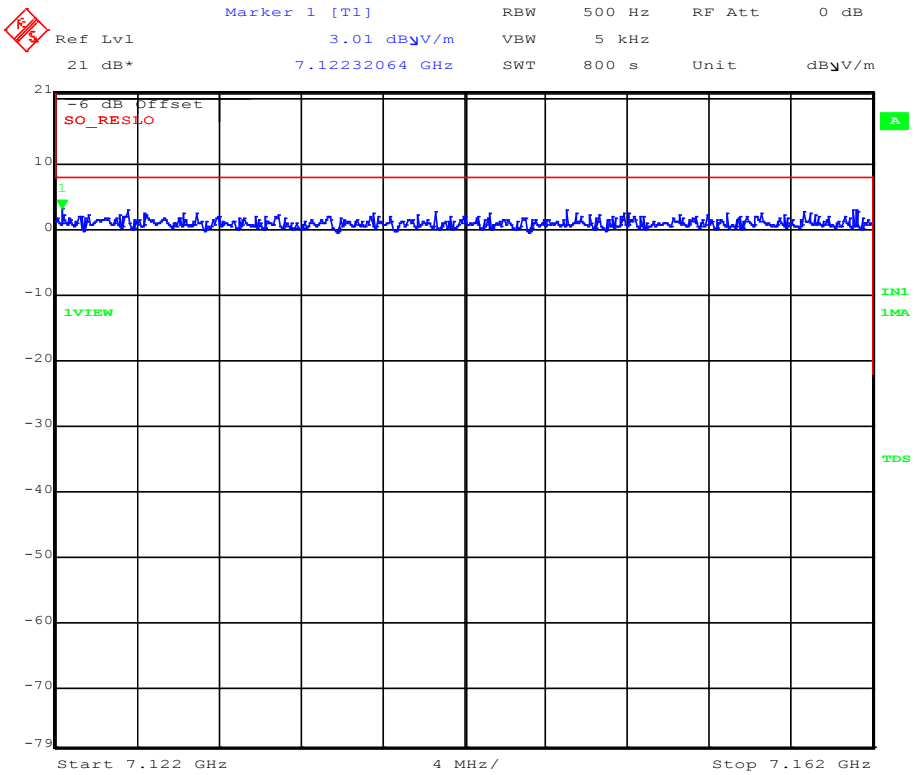
Plot 164



Plot 165



Plot 166



4.9 Radiated Susceptibility: Wide Band Sweep and Notch Frequencies:

4.9.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.11			
Test Dates:	**Start:**	29th April 2015	**End:**	30th April 2015
Ambient Conditions:	**Temp:**	23.0ºC	**Humidity:**	35%

4.9.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Signal Generator	HP	83640B	009115	11-Feb-16
Amplifier	AR	150W1000	029851	Verified in use
E-Field Probe	AR	FP4000	028971	14-Aug-15
E Field Probe	AR	FP4080	029035	15-Aug-15
Antenna Tx Bi con	AH Systems	SAS-200/543	013289	Verified in use
Antenna Tx DRG	AH Systems	SAS-200/571	013117	Verified in use
Antenna Rod Pre-Amp	ETS Lindgren	3301B	028035	15-Aug-15
Antenna Tx Log Periodic	AR	AT1000	013116	Verified in use
Amplifier TWTA	TMD	PTC 6348	013123	Verified in use
Amplifier	AR	25S1G4A	025807	Verified in use
Amplifier	HP	874222A	041203	Verified in use
Antenna Tx Horn	Mid-Centry Microwave	20/31B	031454	Verified in use
Software Automation	Dare	-	-	N/A

4.9.3 Test Procedure:

All tests were performed at a distance of 1m. Below 1GHz the antenna was positioned central to the entire set-up, from the LISN to the EUT. Above 1GHz the antenna was positioned opposite the EUT. A field probe was placed opposite the antenna to monitor the field strength. Software was used to automate the sweep rates and control the field strength. Modulation was applied once the field had been established. For the higher field strengths the antenna was moved closer to the field probe in order to achieve a higher field strength. The test was performed in accordance to MIL-STD 462.

Photos of the different antenna types and test positions are shown on the following pages.

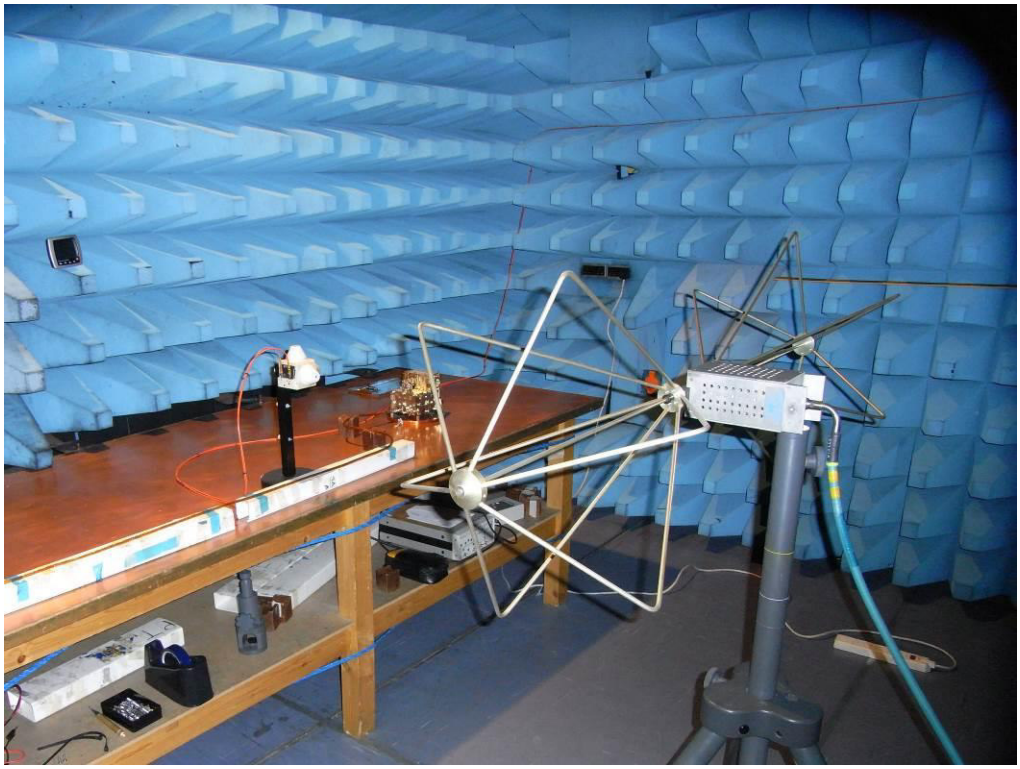


Figure 21. 100 to 200MHz, Horizontal

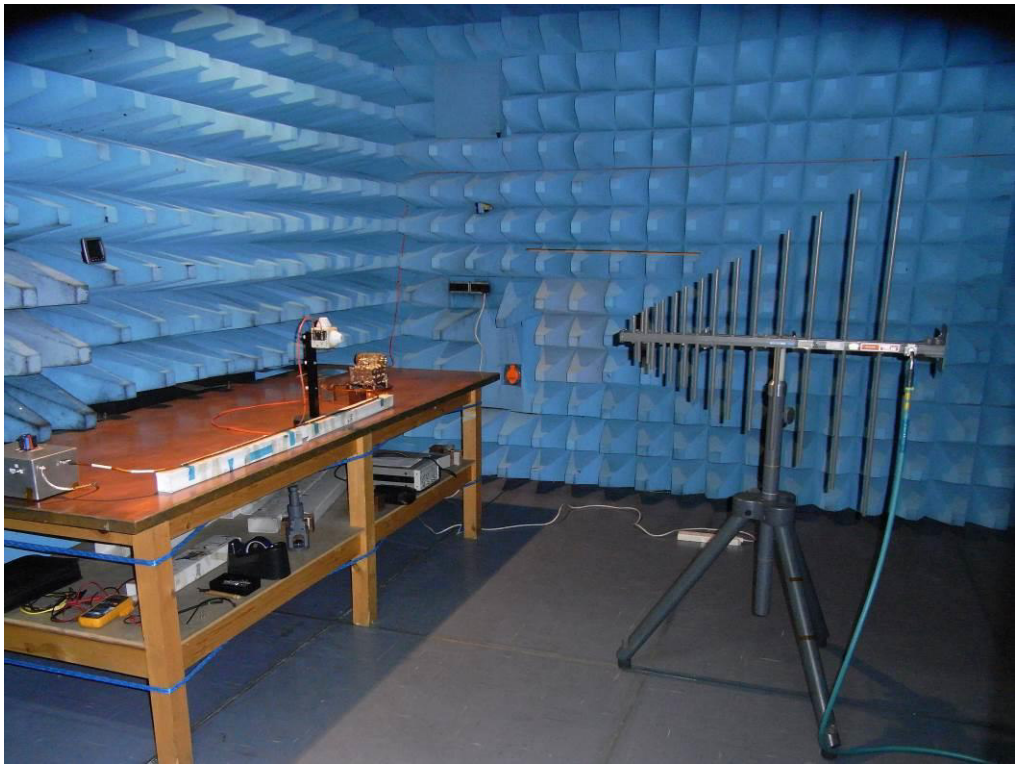


Figure 22. 200 to 1000MHz, Vertical

Figure 23. 1000 to 18000MHz, Horizontal

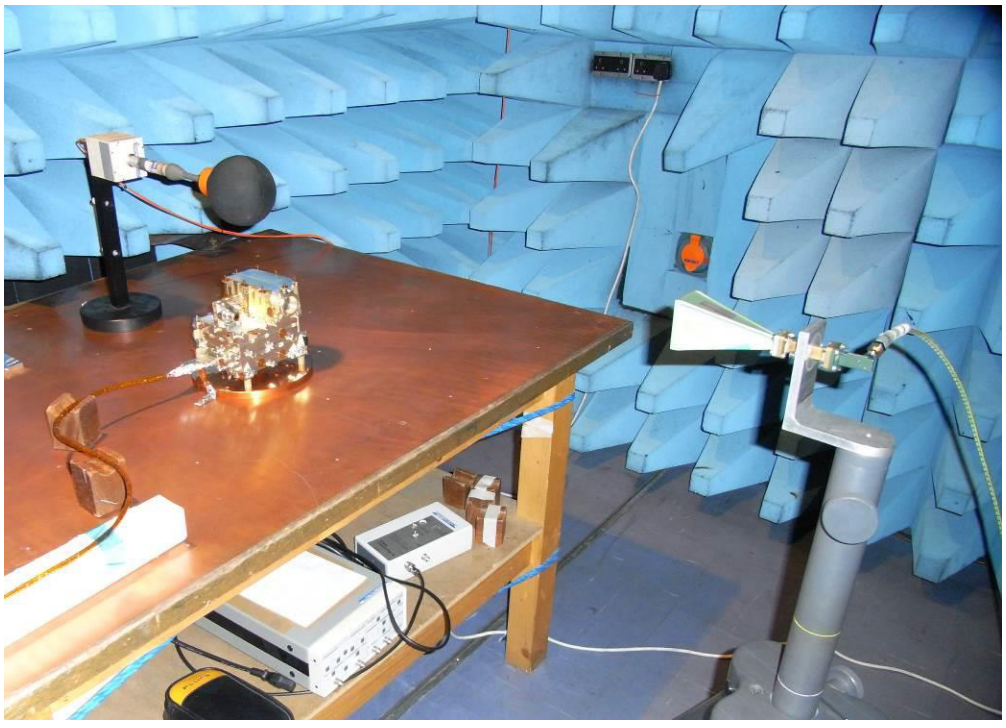


Figure 24. 18000 to 20000MHz, Horizontal

4.9.4 Result summary:

Wideband:

Frequency (MHz)	Field (V/m)	Modulation	Polarity	Result
100 to 200	20	1 kHz pulse, 50% duty cycle	H	Complied
			V	Complied
200 to 1000			V	Complied
			H	Complied
1000 to 2000			H	Complied
			V	Complied
2000 to 4000			V	Complied
			H	Complied
4000 to 6000			H	Complied
			V	Complied
6000 to 18000			V	Complied
			H	Complied
18000 to 20000			H	Complied
			V	Complied

Notch frequencies:

Frequency (MHz)	Field (dBµV/m)	Field Achieved (dBµV/m)	Modulation	Polarity	Result
2210 to 2212	157	157	1 kHz pulse, 50% duty cycle	V	Complied
				H	Complied
2254 to 2256	150	150		V	Complied
				H	Complied
2864 to 2866	150	150		V	Complied
				H	Complied
5300 to 5900	154	154		V	Complied
				H	Complied
5524 to 5526	171	168		V	Complied
				H	Complied
5525 to 5800	169	168		V	Complied
				H	Complied
9409 to 9411	152	152		H	Complied
				V	Complied

4.10 H-Field Characterisation:

4.10.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.13			
Test Dates:	**Start:**	30th April 2015	**End:**	8th May 2015
Ambient Conditions:	**Temp:**	23.0ºC	**Humidity:**	35%

4.10.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Antenna Loop (60cm)	Ailtech	94608-1	013191	27-Jan-16
Test Receiver	Rhode & Schwarz	ESIB40	028970	17-Dec-15
Cable 3m	Rosenberger Micro Coax	FB311A103000 5050	029718	19-May-15
AC magnetometer	Trawid	scm06	032185	N/A
LNA	Stanford research systems	SR560	039334	04-July-15
Oscilloscope	Tektronix	TDS3054B	029691	17-Apr-16

4.10.3 Test Procedure:

The H-field tests were tested in accordance with the test procedure SOL.S.ASTR.TN.00252 Iss 3. This document was prepared by Max Pudney who was consulted through the whole test.

The test was performed using a magnetometer probe over the frequency range 10Hz to 10kHz and a 60cm Loop antenna over 10kHz to 1MHz. the tests were performed with the antenna rotated about 3 axis, X, Y and Z (as shown in the photos on the following page). 3 axis of the EUT, -X, +Y and +Z were also tested. The EUT was positioned at the front edge of the ground plane and the bonding checked between each move. The EUT was rotated 90 degrees to test the +Y face. For the +Z the antenna was positioned above the EUT.

The test was performed at a distance of 0.5m on all faces and the worst case determined where the 1m test would be performed. In this case both X and Y was performed at 1m. Only Y (worst case) was performed at 2.9m between 100kHz and 1MHz (in order to see the 125kHz spike). Distance was measured from the centre of the EUT to the centre of the antenna. The limit is adjusted according to the distance. For the frequency ranges above 10kHz the worst case limit was used as there was sufficient margin. Below 1kHz the formula below was used and is reflected in the relevant plots.

At 0.5m:

EPT-HET: distance to search coil = 2.75m, assume a $1/r^n$ where n=2 scaling law, so:

$$Scaling = n \times 20 \times \log_{10}\left(\frac{measurement\ distance}{distance\ to\ search\ coil}\right)$$

$$Scaling = 2 \times 20 \times \log_{10}\left(\frac{0.5}{2.75}\right) = 29.6dB$$

A low noise amplifier was used for all frequency ranges.

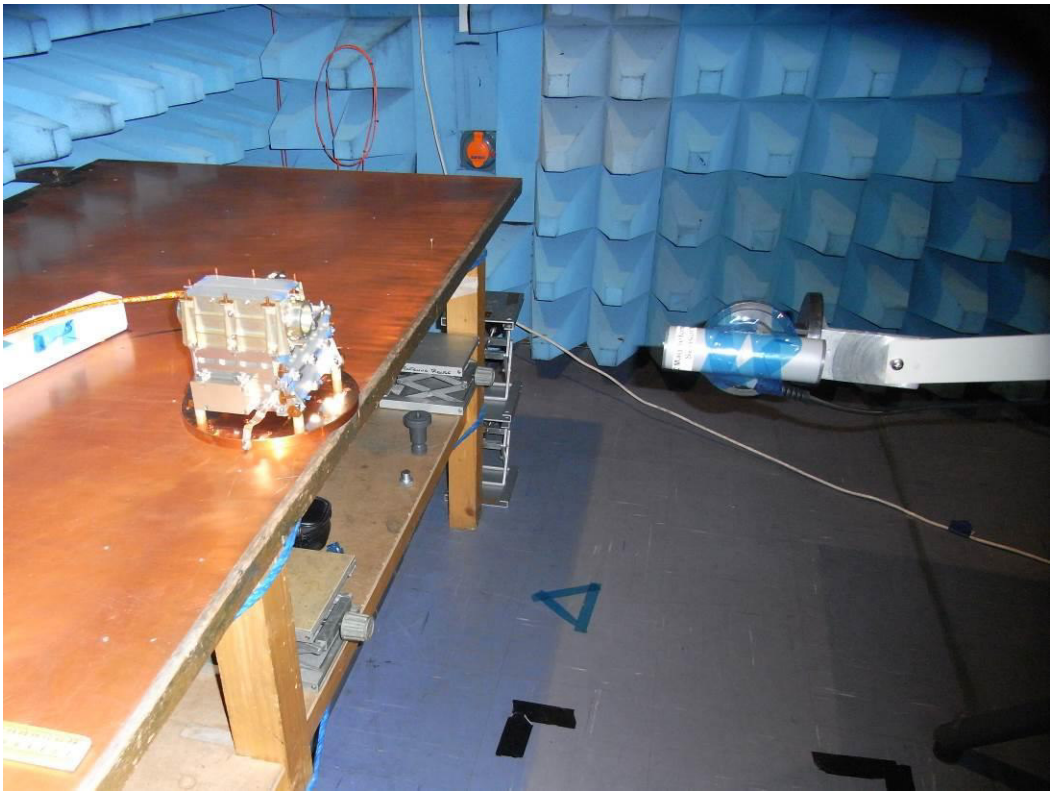


Figure 25. Magnetometer X orientation, -X Face

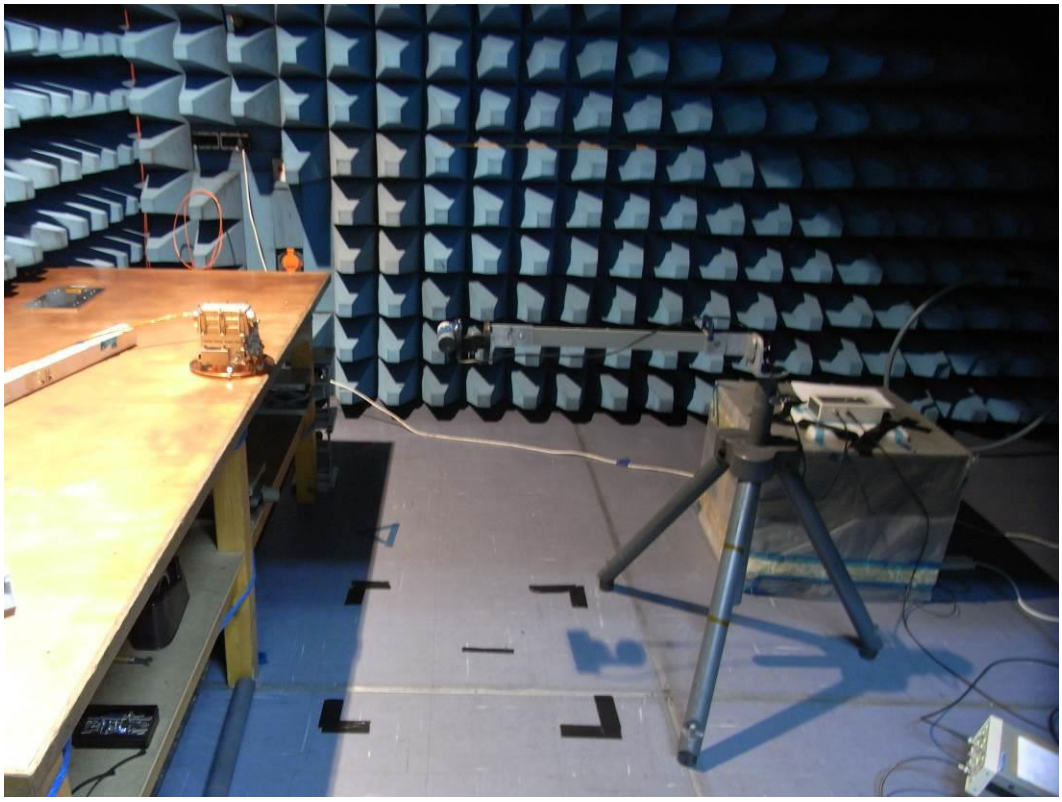


Figure 26. Magnetometer Y orientation, -X Face

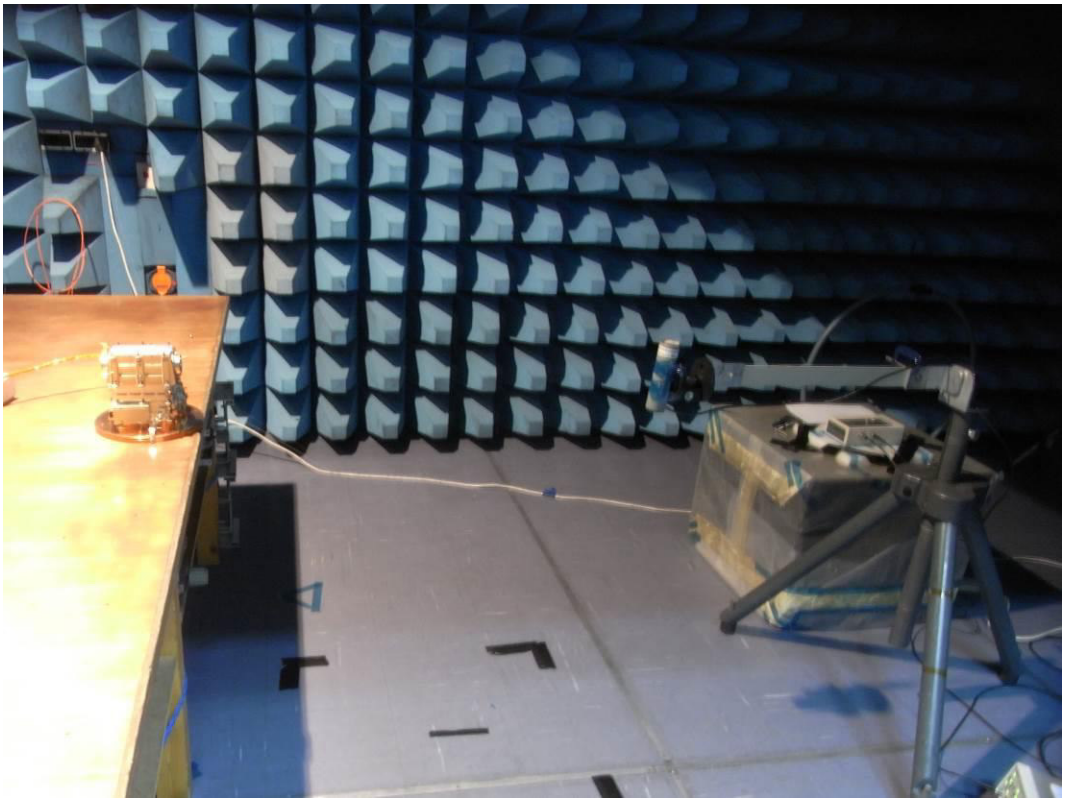


Figure 27. Magnetometer Z orientation, -X Face

Figure 28. Magnetometer X orientation, +Z Face

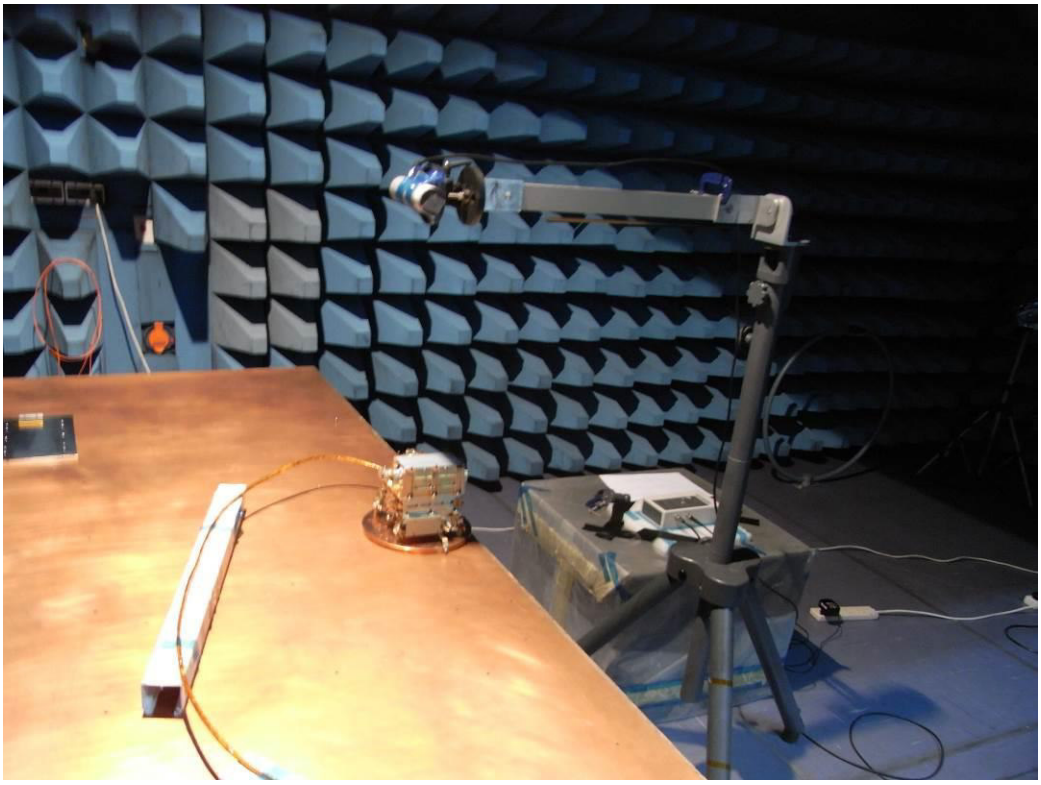


Figure 29. Magnetometer Y orientation, +Z Face

Figure 30. Magnetometer Z orientation, +Z Face

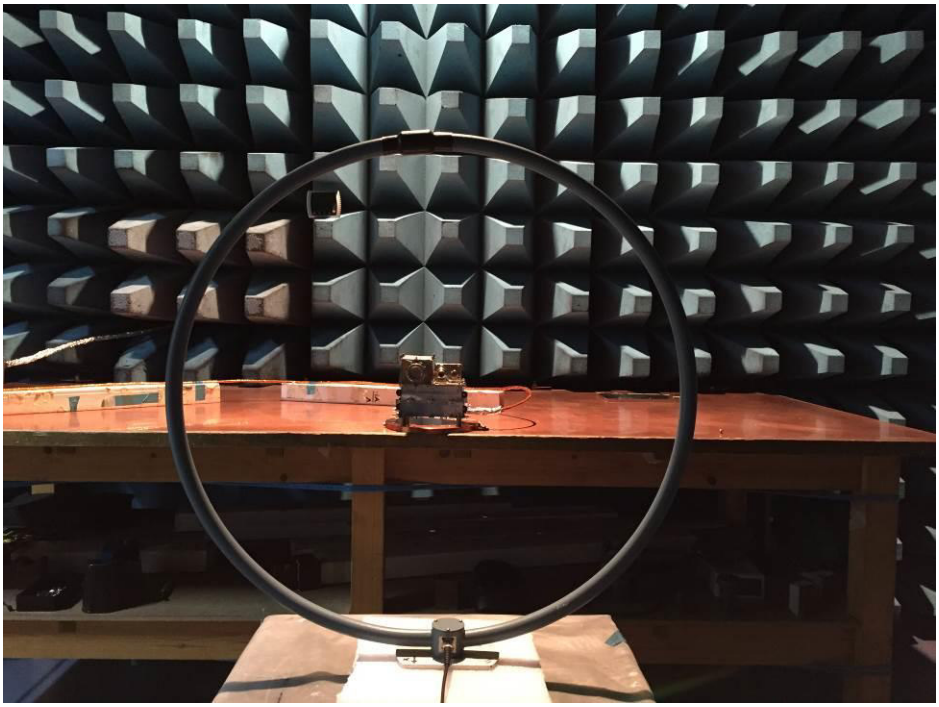


Figure 31. Loop Antenna X orientation, -X Face

Figure 32. Loop Antenna Y orientation, -X Face

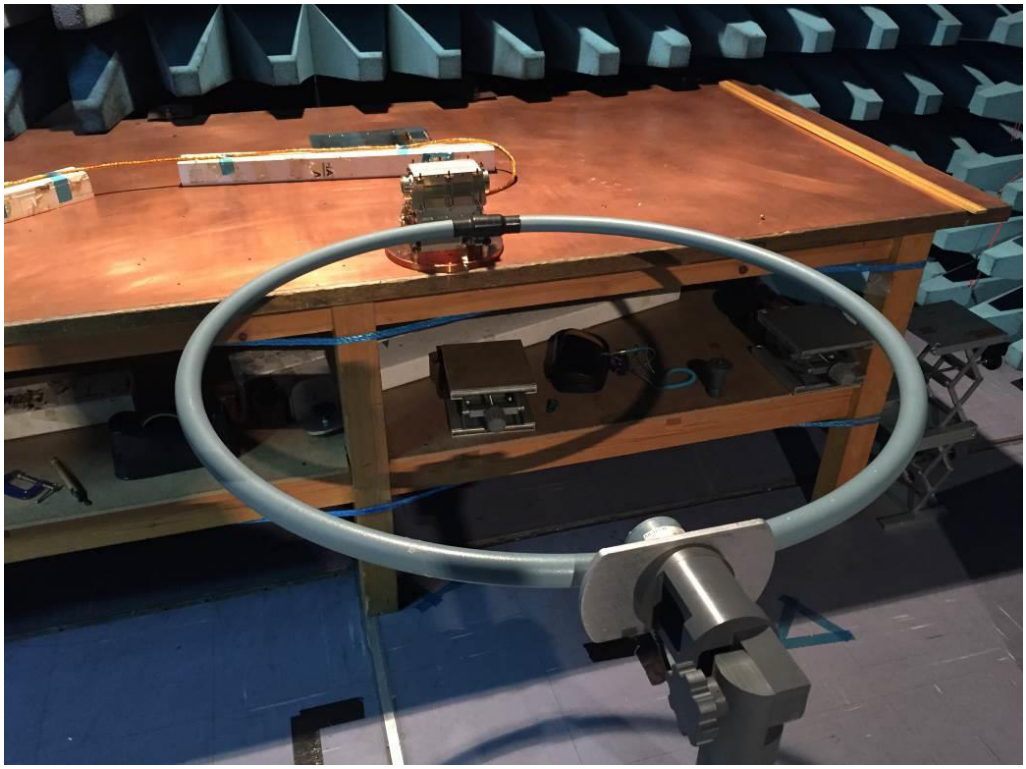


Figure 33. Loop Antenna Z orientation, +Y Face

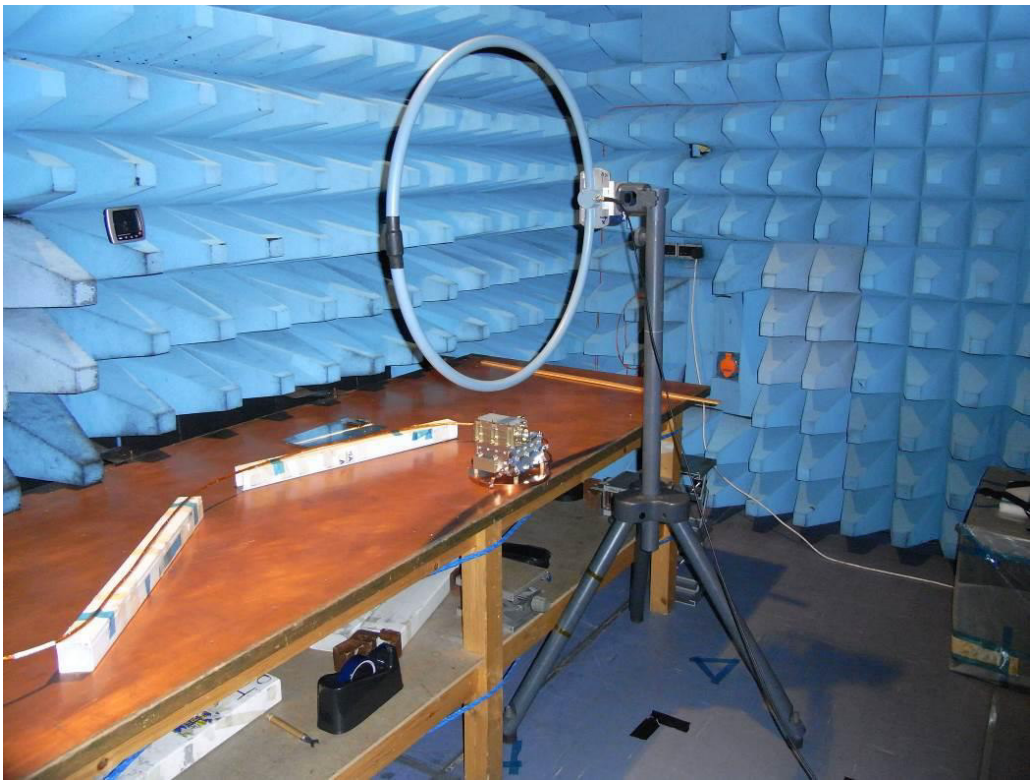


Figure 34. Loop Antenna Z orientation, +Z Face

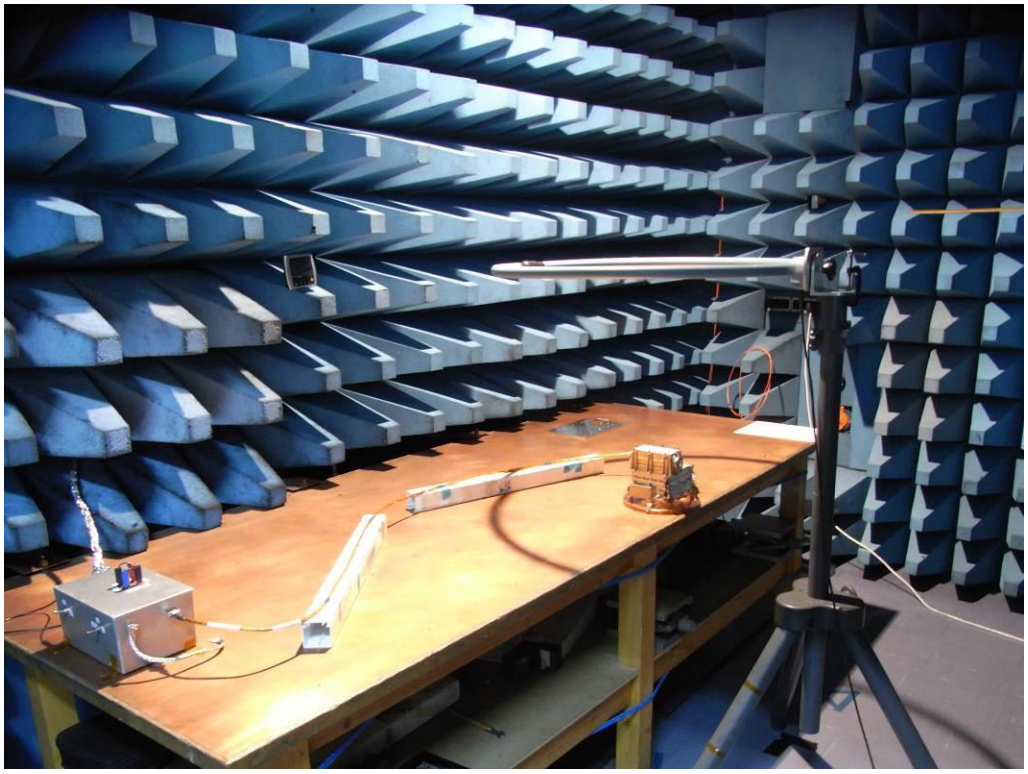


Figure 35. Loop Antenna X orientation, +Z Face

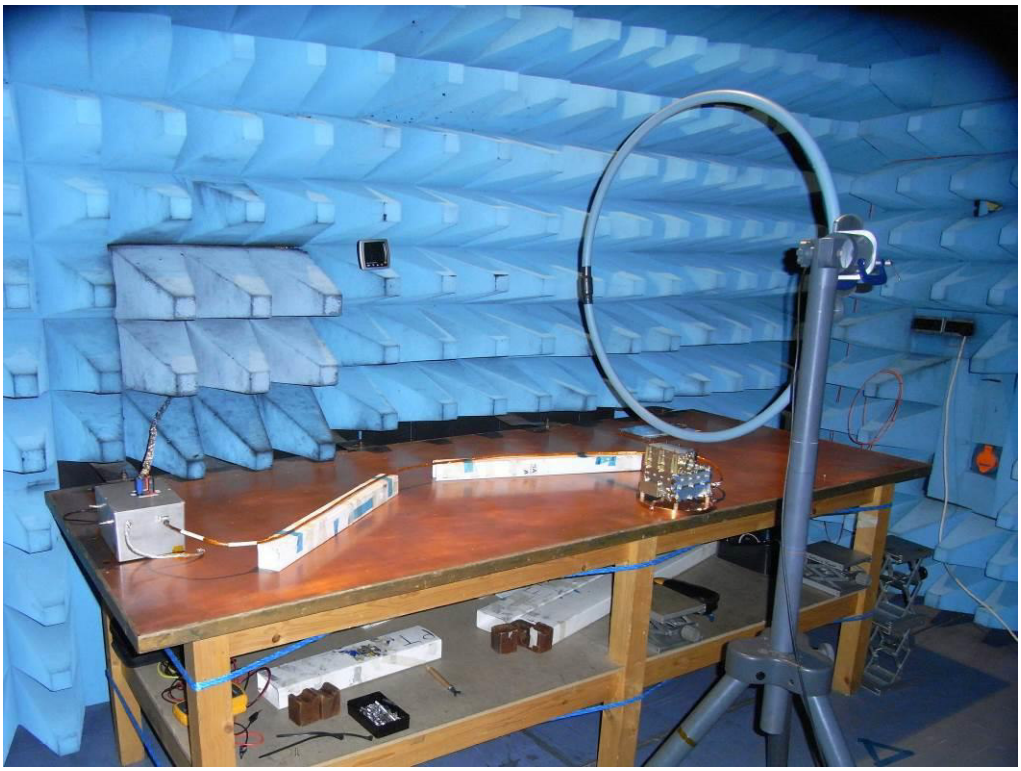


Figure 36. Loop Antenna Y orientation, +Z Face

4.10.4 Results Summary:

Ambient:

EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
+Z	X	10 Hz	5 kHz	-	0.5m	49.6	48.5	232	Did Not Comply
		10 kHz	100 kHz	50Hz	0.5m	-8.1	20.0	226	Complied
		100 kHz	1 MHz	200 Hz	0.5m	22.7	38.4	227	Complied
	Y	10 Hz	5 kHz	-	0.5m	51.3	48.5	234	Did Not Comply
		10 kHz	100 kHz	50Hz	0.5m	-7.0	21.0	229	Complied
		100 kHz	1 MHz	200 Hz	0.5m	21.2	39.2	228	Complied
	Z	10 Hz	5 kHz	-	0.5m	48.0	48.5	233	Complied
		10 kHz	100 kHz	50Hz	0.5m	-10.1	20.0	230	Complied
		100 kHz	1 MHz	200 Hz	0.5m	14.6	38.7	231	Complied
-X	X	10 Hz	5 kHz	-	0.5m	48.7	48.5	236	Did Not Comply
		10 kHz	100 kHz	50Hz	0.5m	-13.9	21.0	249	Complied
		100 kHz	1 MHz	200 Hz	0.5m	17.6	39.1	250	Complied
	Y	10 Hz	5 kHz	-	0.5m	46.5	42.4	239	Did Not Comply
		10 kHz	100 kHz	50Hz	0.5m	-13.5	21.0	248	Complied
		100 kHz	1 MHz	200 Hz	0.5m	16.3	39.1	247	Complied
	Z	10 Hz	5 kHz		0.5m	55.9	48.5	238	Did Not Comply
		10 kHz	100 kHz	50Hz	0.5m	-7.3	22.8	251	Complied
		100 kHz	1 MHz	200 Hz	0.5m	21	38.4	252	Complied
	X	10 Hz	5 kHz	-	1m	50.7	36.5	242	Did Not Comply
		10 kHz	100 kHz	50Hz	1m	-10.8	21.0	244	Complied
		100 kHz	1 MHz	200 Hz	1m	18.2	38.7	243	Complied
	Y	10 Hz	5 kHz	-	1m	51.3	36.5	240	Did Not Comply
		10 kHz	100 kHz	50Hz	1m	-14.9	20.0	245	Complied
		100 kHz	1 MHz	200 Hz	1m	15.0	39.1	246	Complied
	Z	10 Hz	5 kHz	-	1m	52.7	36.5	241	Did Not Comply
		10 kHz	100 kHz	50Hz	1m	-12.0	21.0	254	Complied
		100 kHz	1 MHz	200 Hz	1m	16.7	38.4	253	Complied

EUT On:

EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
-X	X	10 Hz	5 kHz	-	0.5m	36.8	42.4	216	Complied
		10 kHz	100 kHz	50Hz	0.5m	-8.5	21.0	204	Complied
		100 kHz	1 MHz	200 Hz	0.5m	7.0	22.0	203	Complied
	Y	10 Hz	5 kHz	-	0.5m	42.6	42.4	215	N/A*
		10 kHz	100 kHz	50Hz	0.5m	-5.3	21.0	201	Complied
		100 kHz	1 MHz	200 Hz	0.5m	7.4	22.0	202	Complied
	Z	10 Hz	5 kHz	-	0.5m	50.4	48.5	214	N/A*
		10 kHz	100 kHz	50Hz	0.5m	-4.0	21.0	197	Complied
		100 kHz	1 MHz	200 Hz	0.5m	20.4	36.2	198	Complied
	X	10 Hz	5 kHz	-	1m	44.0	28.0	217	N/A*
		10 kHz	100 kHz	50Hz	1m	-11.5	21.0	221	Complied
		100 kHz	1 MHz	200 Hz	1m	16.0	39.0	220	Complied
	Y	10 Hz	5 kHz	-	1m	45.5	28.0	218	N/A*
		10 kHz	100 kHz	50Hz	1m	-15.1	20.0	222	Complied
		100 kHz	1 MHz	200 Hz	1m	13.4	38.7	223	Complied
	Z	10 Hz	5 kHz	-	1m	22.1	36.5	219	Complied
		10 kHz	100 kHz	50Hz	1m	-9.6	20.0	225	Complied
		100 kHz	1 MHz	200 Hz	1m	23.8	38.7	224	Complied

*Note: The non-compliance was an ambient issue and not as a result of the EUT.

EUT On:

EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
+Y	X	10 Hz	5 kHz	-	0.5m	41.6	48.5	272	Complied
		10 kHz	100 kHz	50Hz	0.5m	-11.2	23.0	261	Complied
		100 kHz	1 MHz	200 Hz	0.5m	1.82	21.5	260	Complied
	Y	10 Hz	5 kHz	-	0.5m	50.5	48.5	274	N/A*
		10 kHz	100 kHz	50Hz	0.5m	2.8	27.5	262	Complied
		100 kHz	1 MHz	200 Hz	0.5m	15.9	22.0	263	Complied
	Z	10 Hz	5 kHz	-	0.5m	54.3	48.5	273	N/A*
		10 kHz	100 kHz	50Hz	0.5m	-8.2	20.5	270	Complied
		100 kHz	1 MHz	200 Hz	0.5m	15.5	22.0	271	Complied
	X	10 Hz	5 kHz	-	1m	48.2	36.5	277	N/A*
		10 kHz	100 kHz	50Hz	1m	-11.0	21.0	266	Complied
		100 kHz	1 MHz	200 Hz	1m	15.9	38.7	267	Complied
	Y	10 Hz	5 kHz	-	1m	50.4	36.5	276	N/A*
		10 kHz	100 kHz	50Hz	1m	-12.0	22.0	265	Complied
		100 kHz	1 MHz	200 Hz	1m	15.5	38.9	264	Complied
	Z	10 Hz	5 kHz	-	1m	54.1	36.5	275	N/A*
		10 kHz	100 kHz	50Hz	1m	-12.2	19.7	269	Complied
		100 kHz	1 MHz	200 Hz	1m	17.0	38.7	268	Complied

*Note: The non-compliance was an ambient issue and not as a result of the EUT.

EUT On:

EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
+Z	X	10 Hz	5 kHz	-	0.5m	40.3	48.5	213	Complied
		10 kHz	100 kHz	50Hz	0.5m	-6.8	33.8	209	Complied
		100 kHz	1 MHz	200 Hz	0.5m	-0.6	22.6	210	Complied
	Y	10 Hz	5 kHz	-	0.5m	50.2	48.5	212	N/A*
		10 kHz	100 kHz	50Hz	0.5m	-7.5	34.5	208	Complied
		100 kHz	1 MHz	200 Hz	0.5m	10.2	11.8	207	Complied
	Z	10 Hz	5 kHz	-	0.5m	48.2	48.5	211	Complied
		10 kHz	100 kHz	50Hz	0.5m	7.8	19.2	205	Complied
		100 kHz	1 MHz	200 Hz	0.5m	9.4	12.6	206	Complied

*Note: The non-compliance was an ambient issue and not as a result of the EUT.

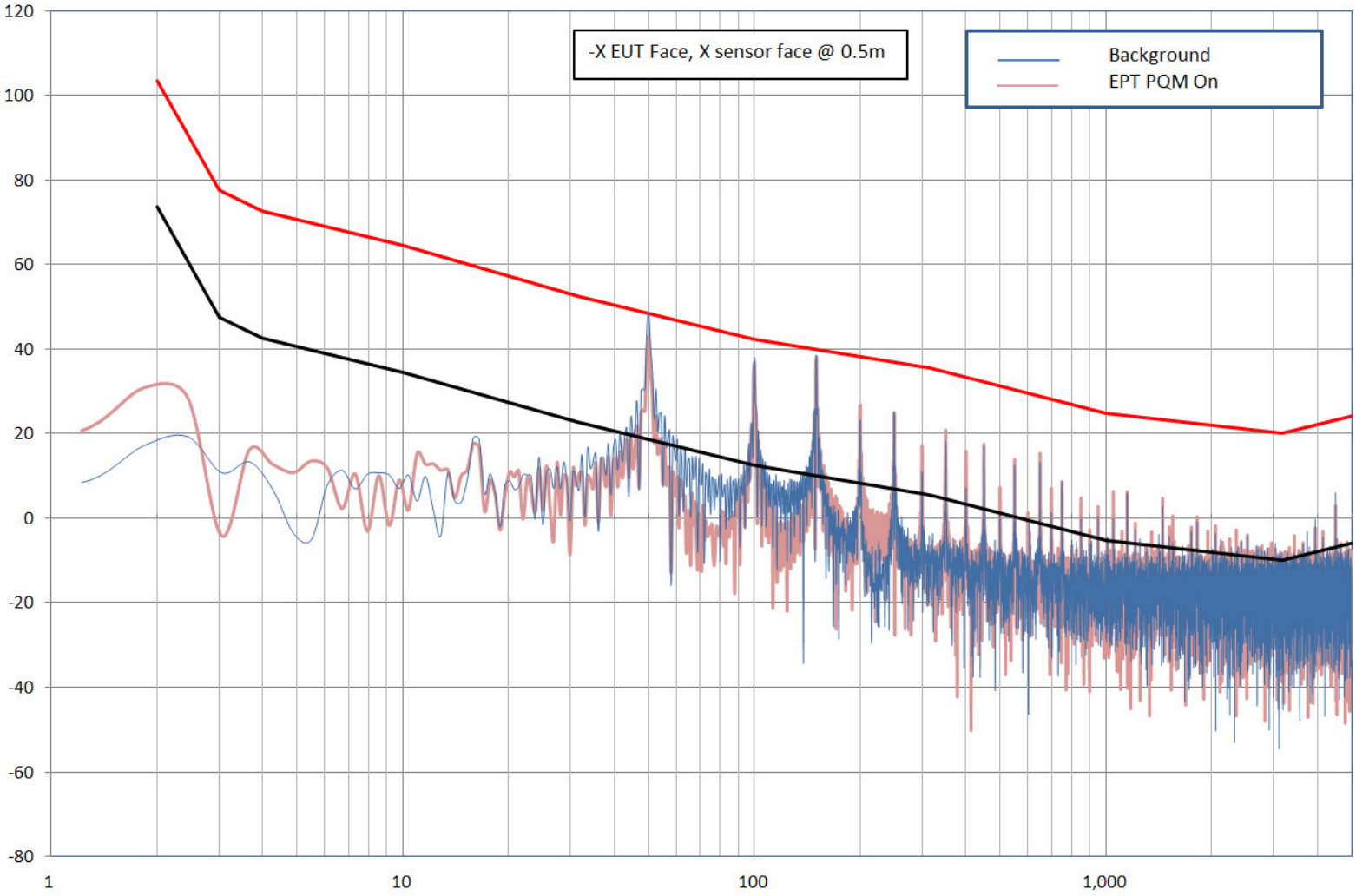
EUT On:

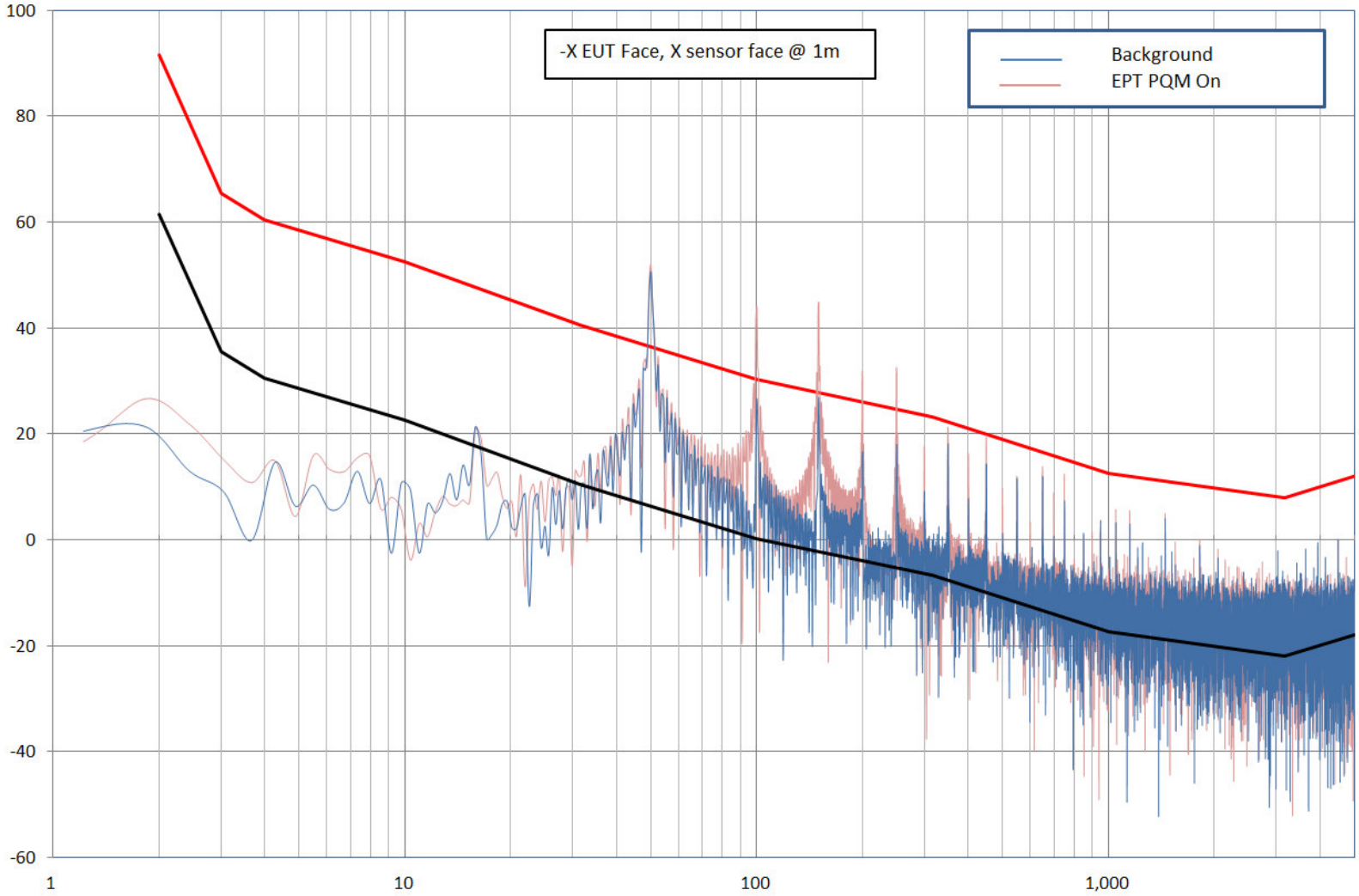
EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
+Y	Y	100 kHz	1 MHz	200 Hz	2.9m	-16.4	22	296	Complied
+Y	Z	100 kHz	1 MHz	200 Hz	2.9m	-18.9	22	295	Complied

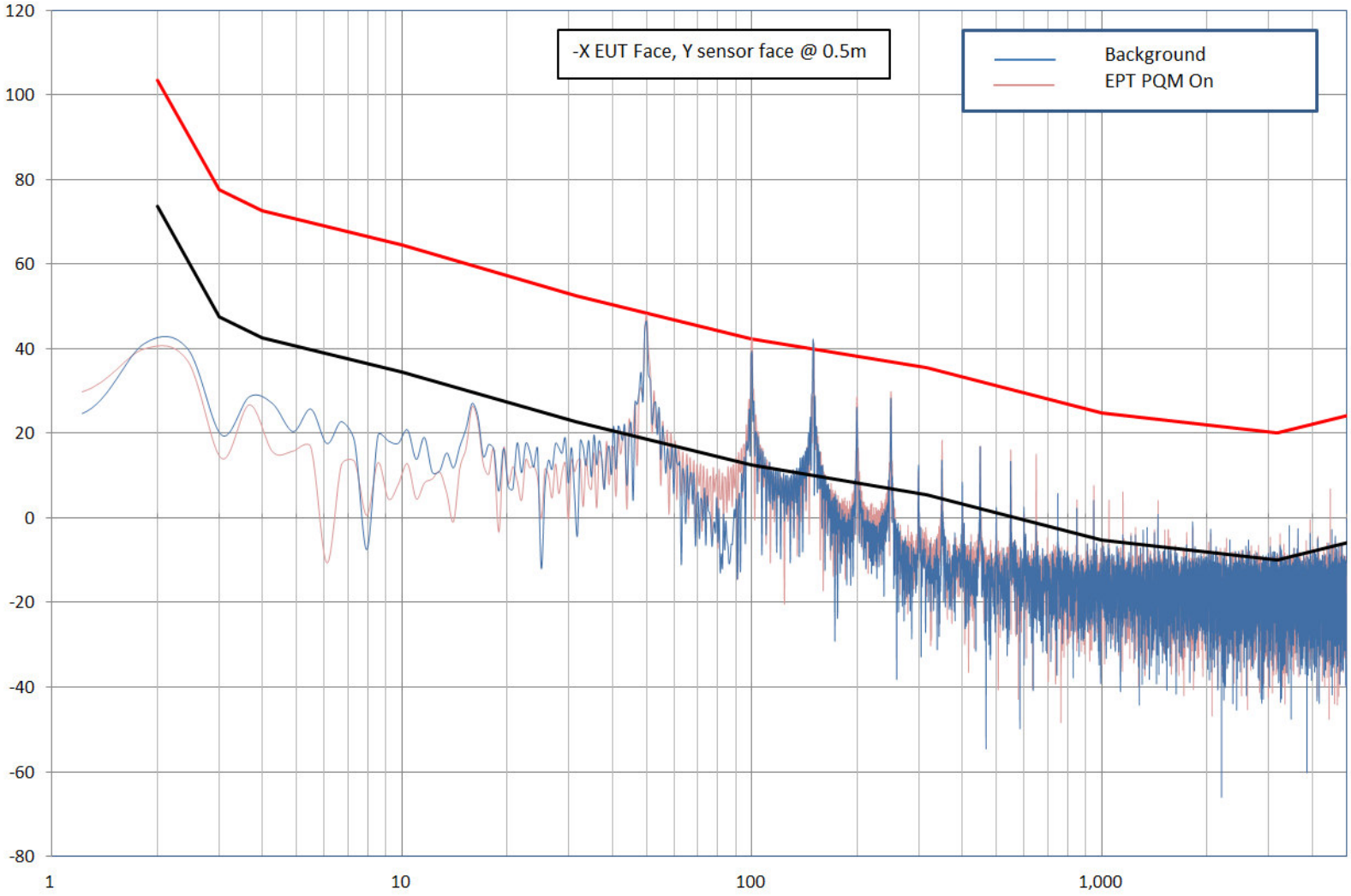
Ambient:

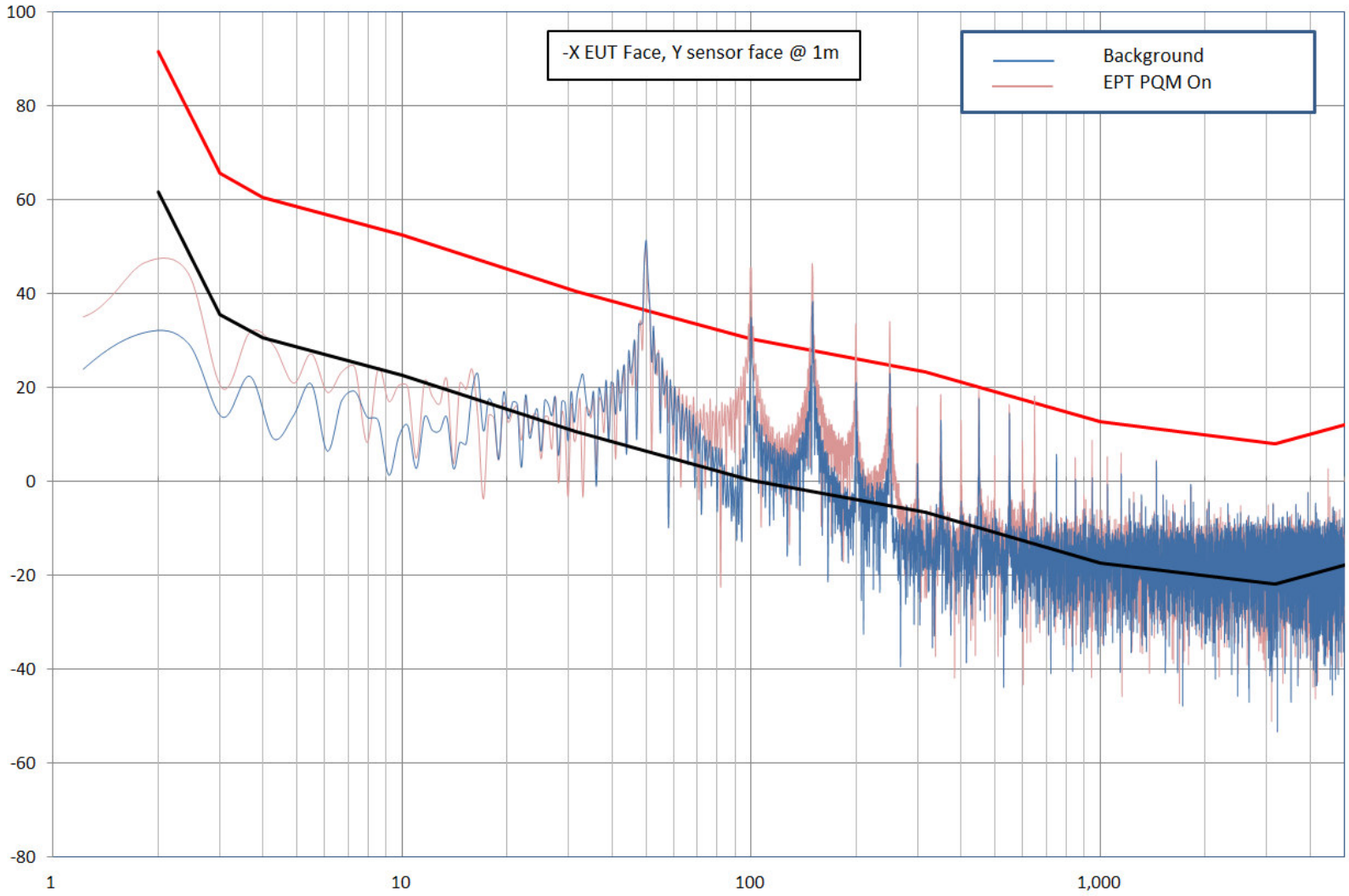
EUT Face	Sensor Orientation	Start	Stop	Bandwidth	Distance	Level (dBpT)	Limit (dBpT)	Plot	Result
+Y	Y	100 kHz	1 MHz	200 Hz	2.9m	-23.6	22	297	Complied
+Y	Z	100 kHz	1 MHz	200 Hz	2.9m	-20.8	22	298	Complied

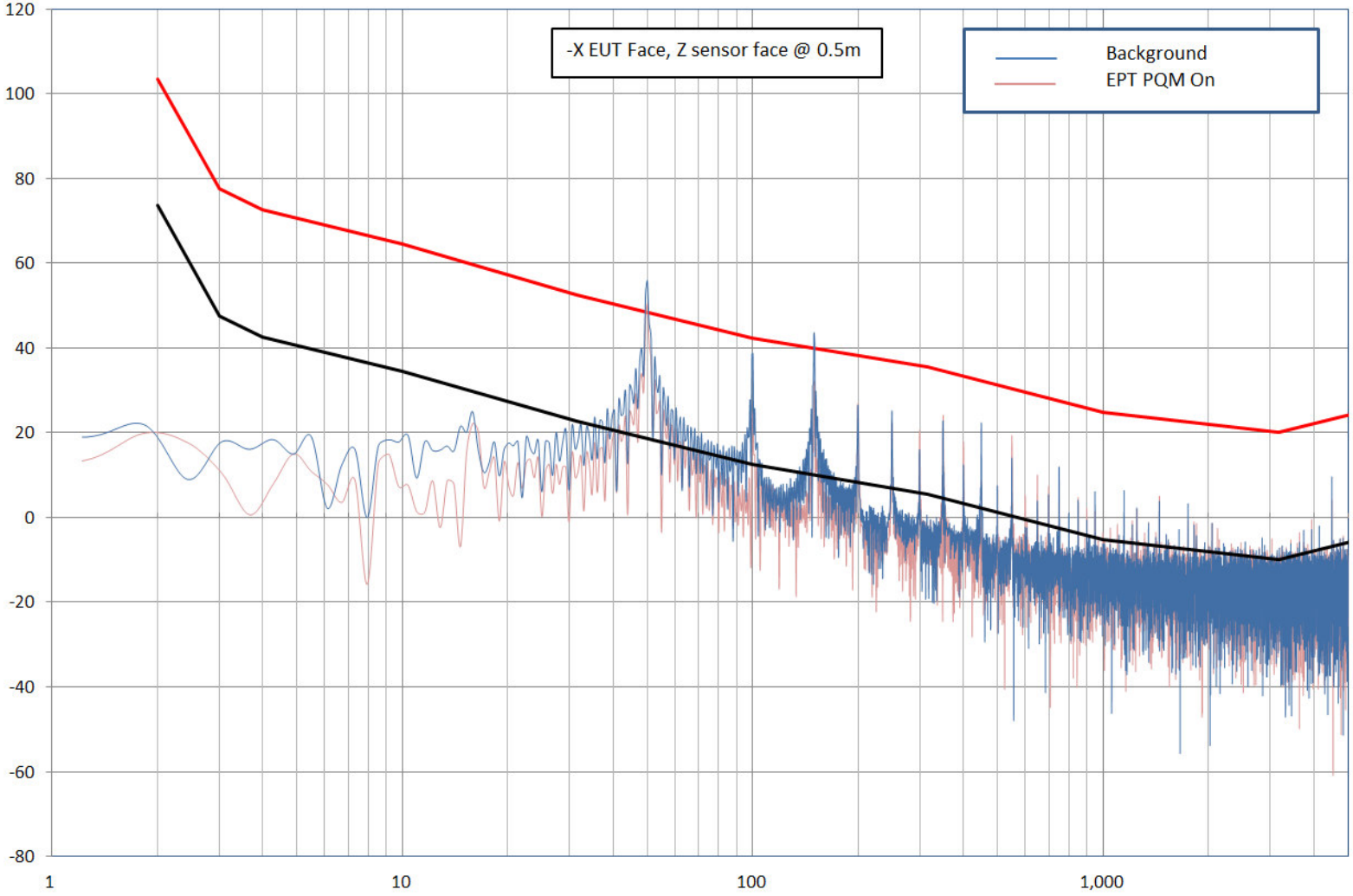
4.10.5 Plots: 10Hz to 5kHz:

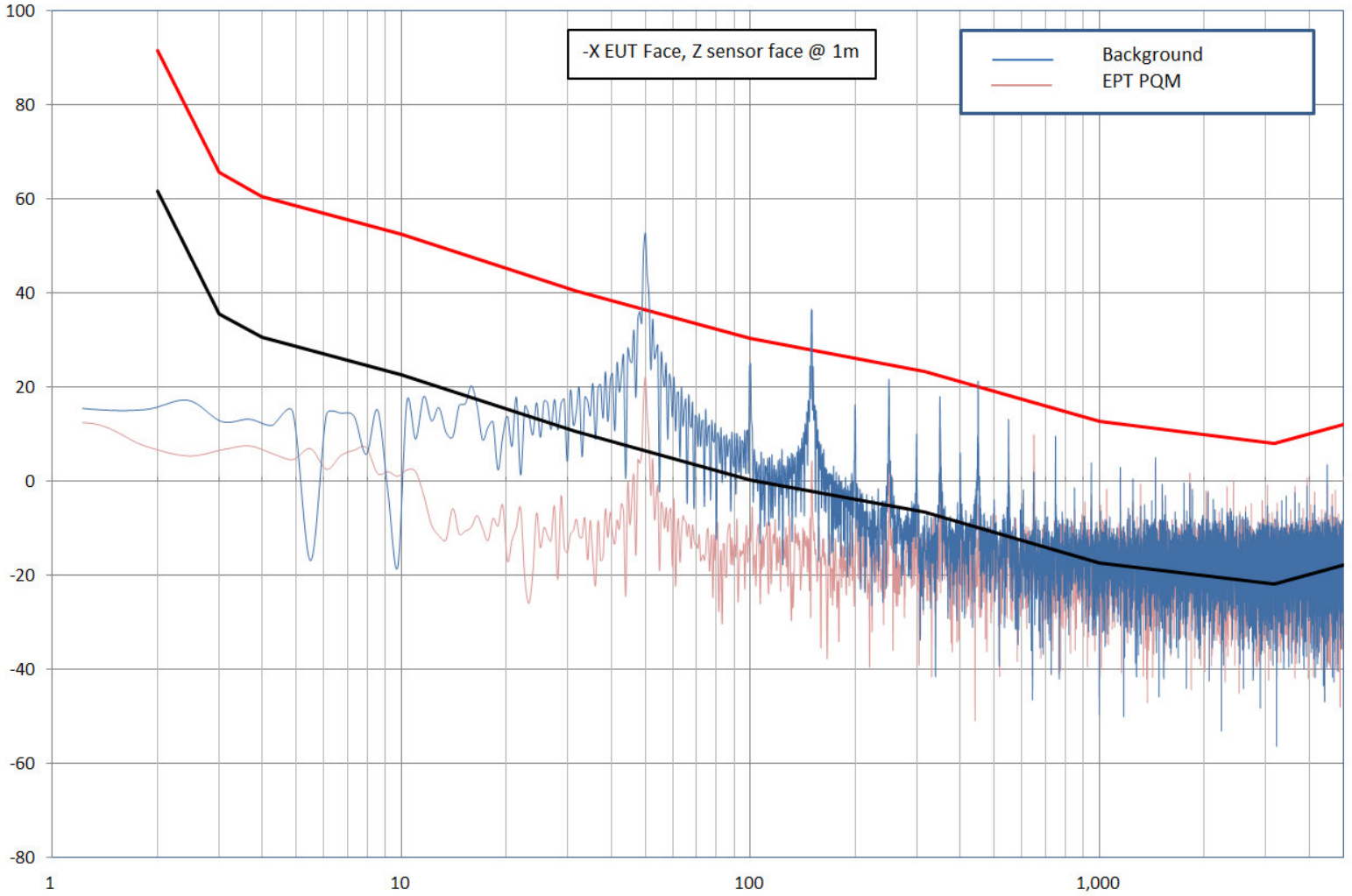


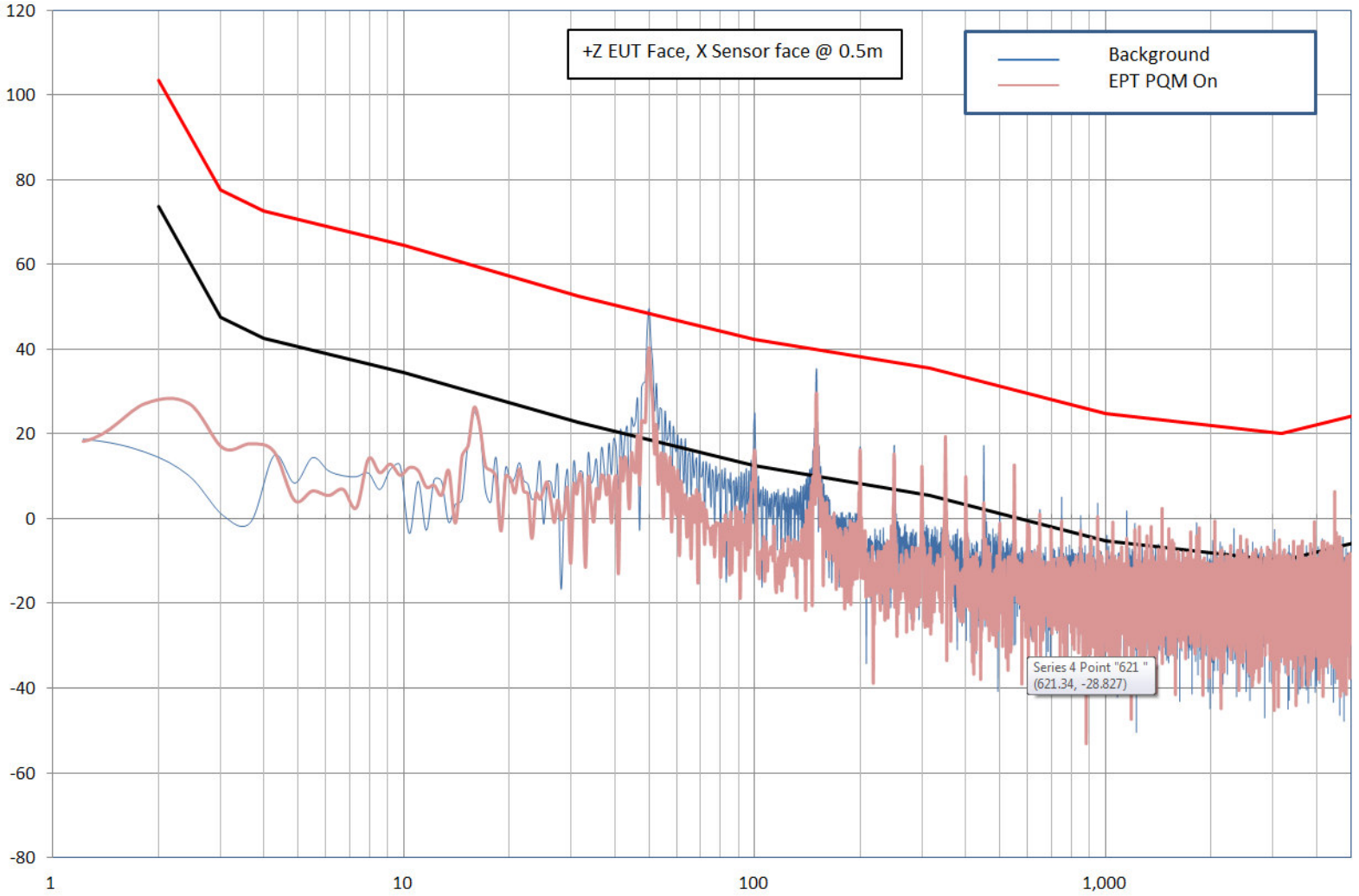

-X EUT Face, X sensor face @ 1m
Background
EPT PQM On
100
80
60
40
20
0
-20
-40
-60
1
10
100
1,000

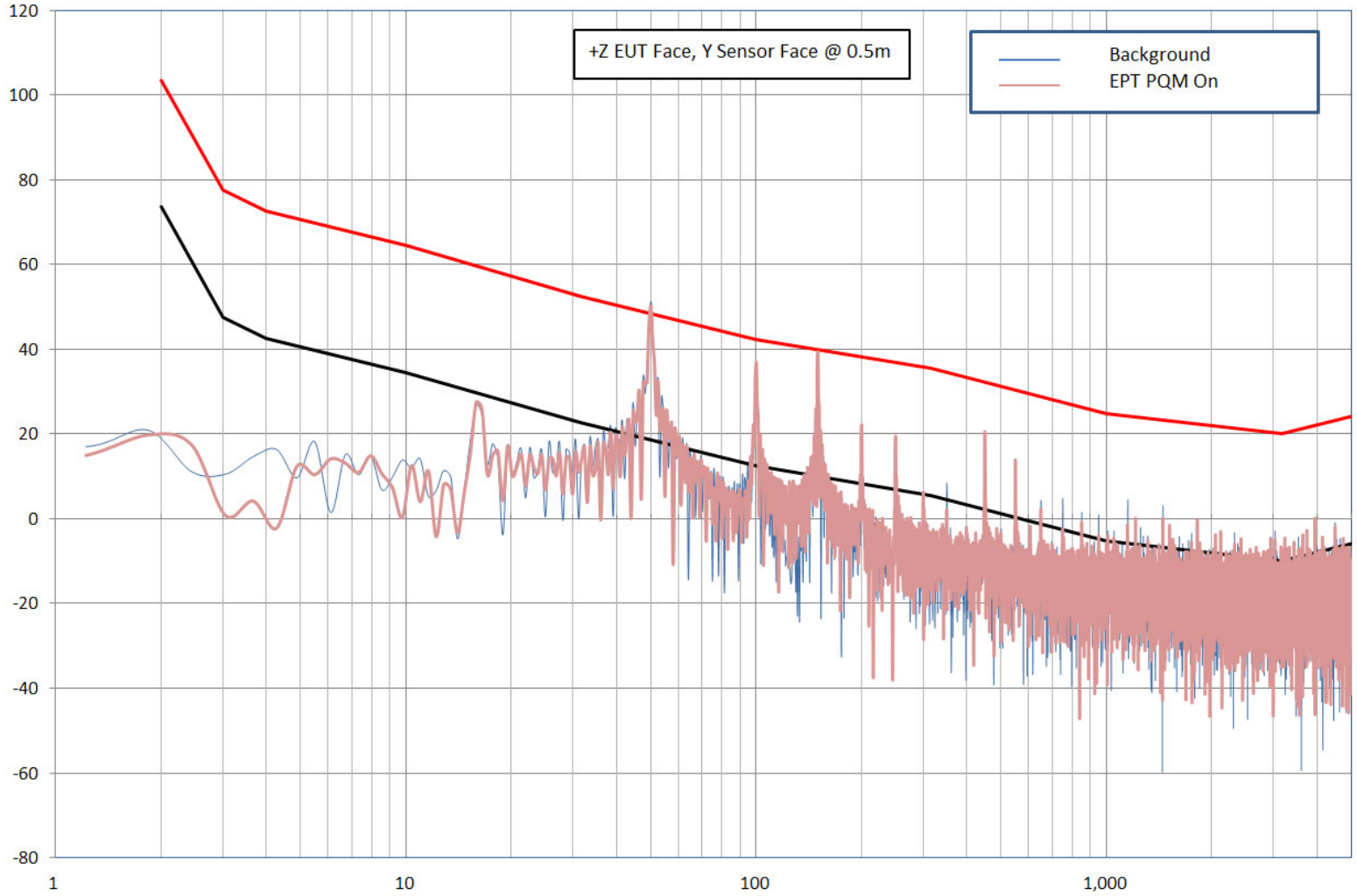

-X EUT Face, Y sensor face @ 0.5m
Background
EPT PQM On
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

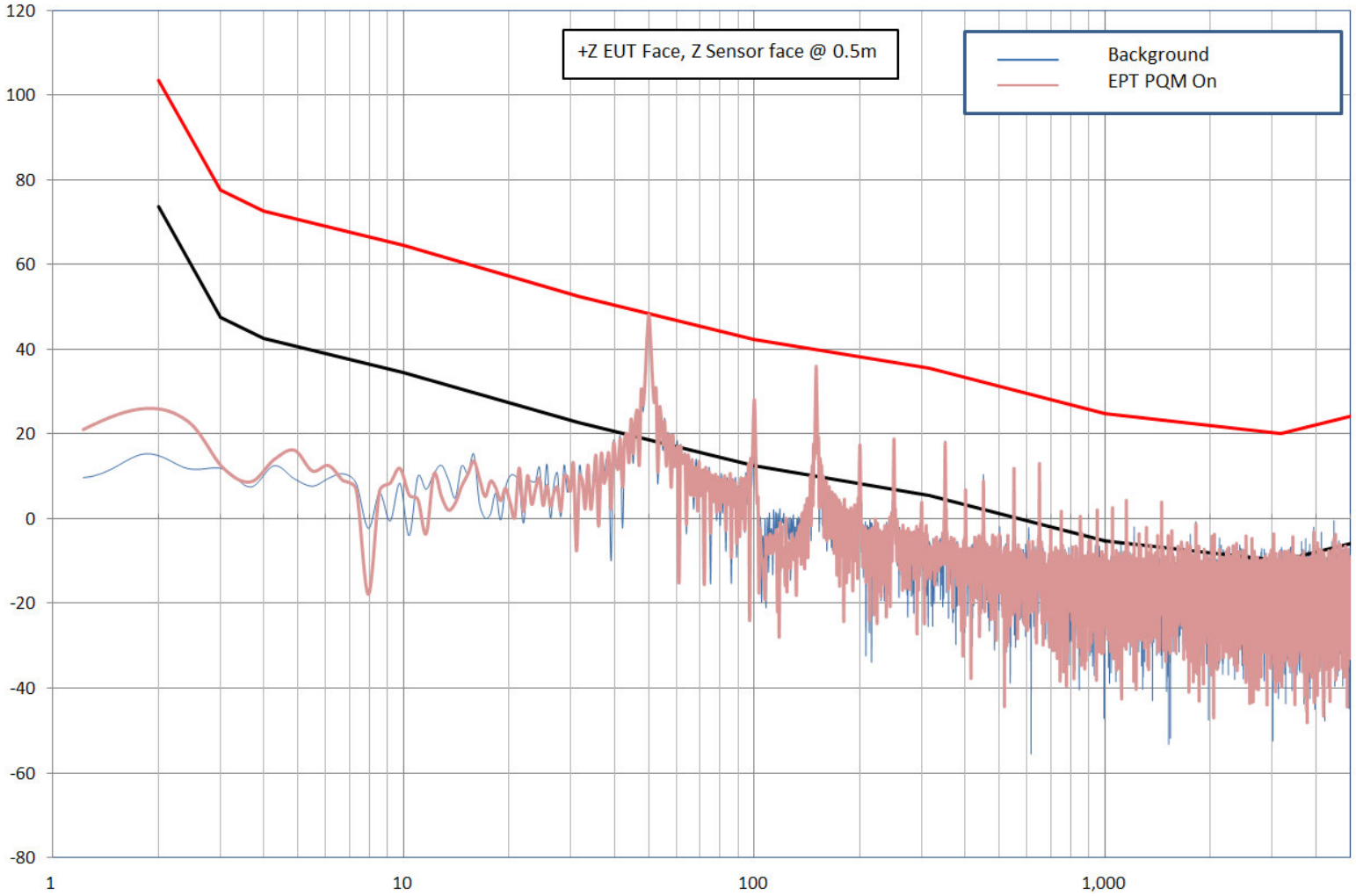

-X EUT Face, Y sensor face @ 1m
Background
EPT PQM On
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

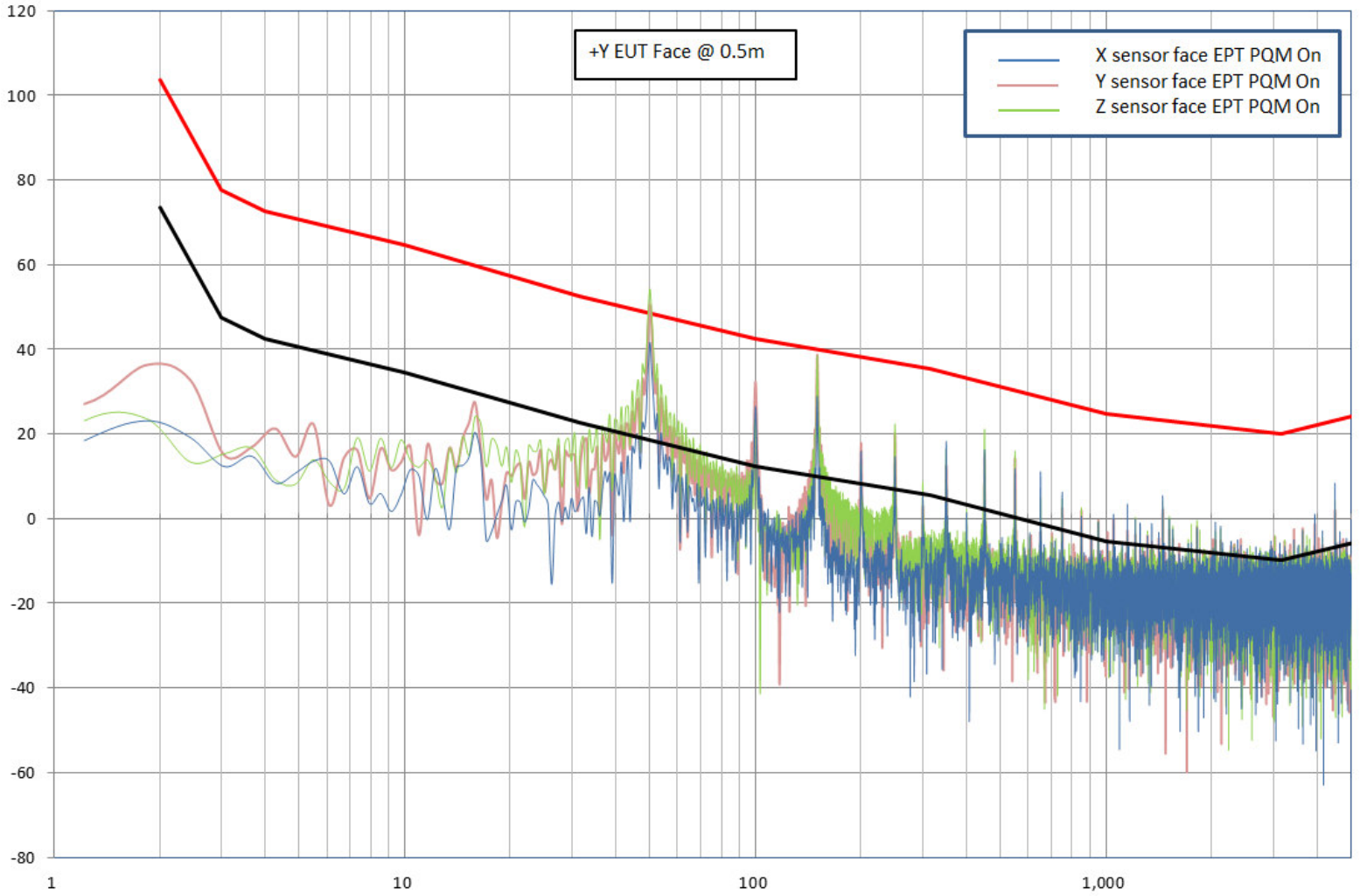

-X EUT Face, Z sensor face @ 0.5m
Background
EPT PQM On
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

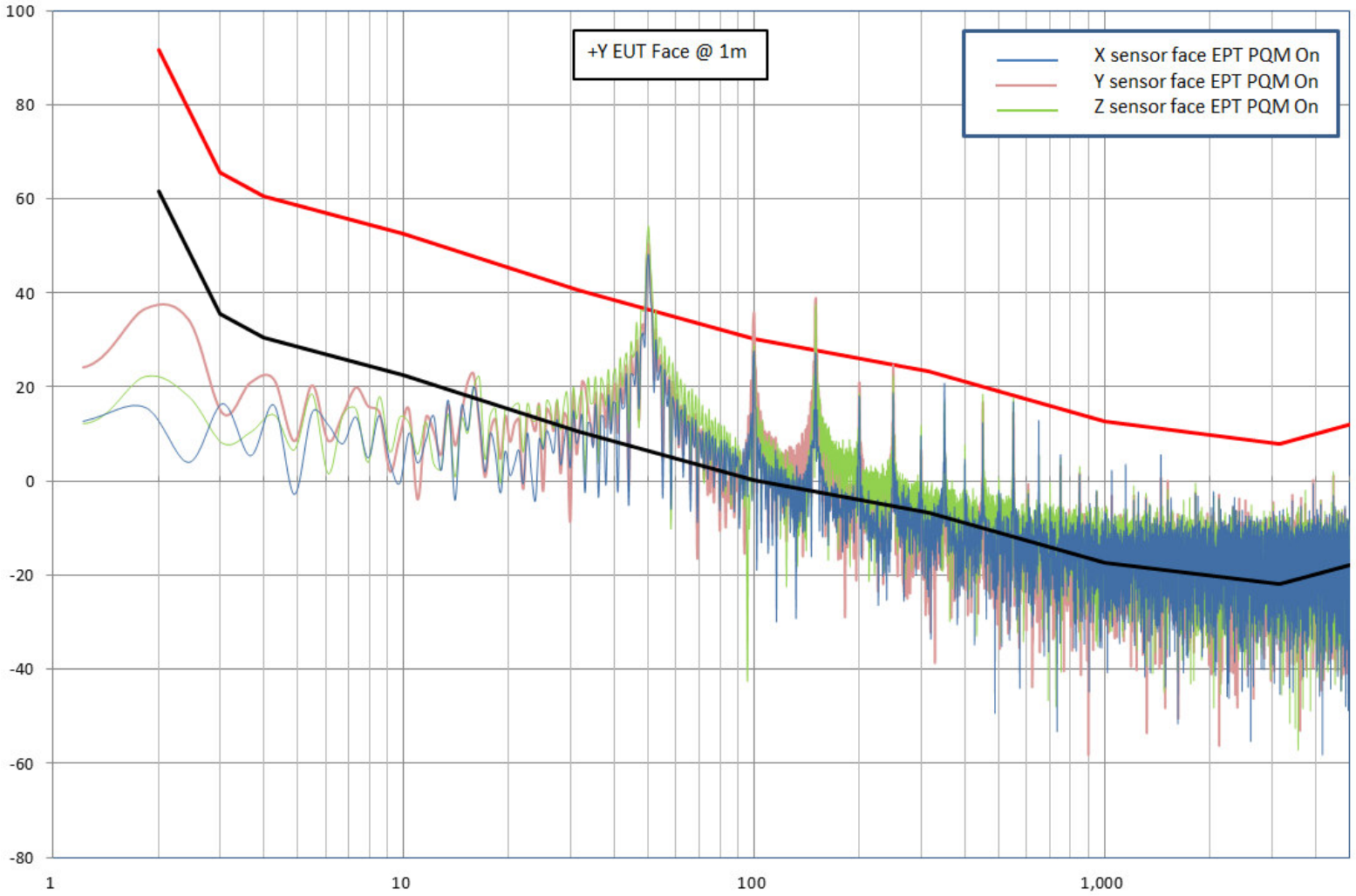

-X EUT Face, Z sensor face @ 1m
Background
EPT PQM
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000


+Z EUT Face, X Sensor face @ 0.5m
Background
EPT PQM On
Series 4 Point "621 "
(621.34, -28.827)
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

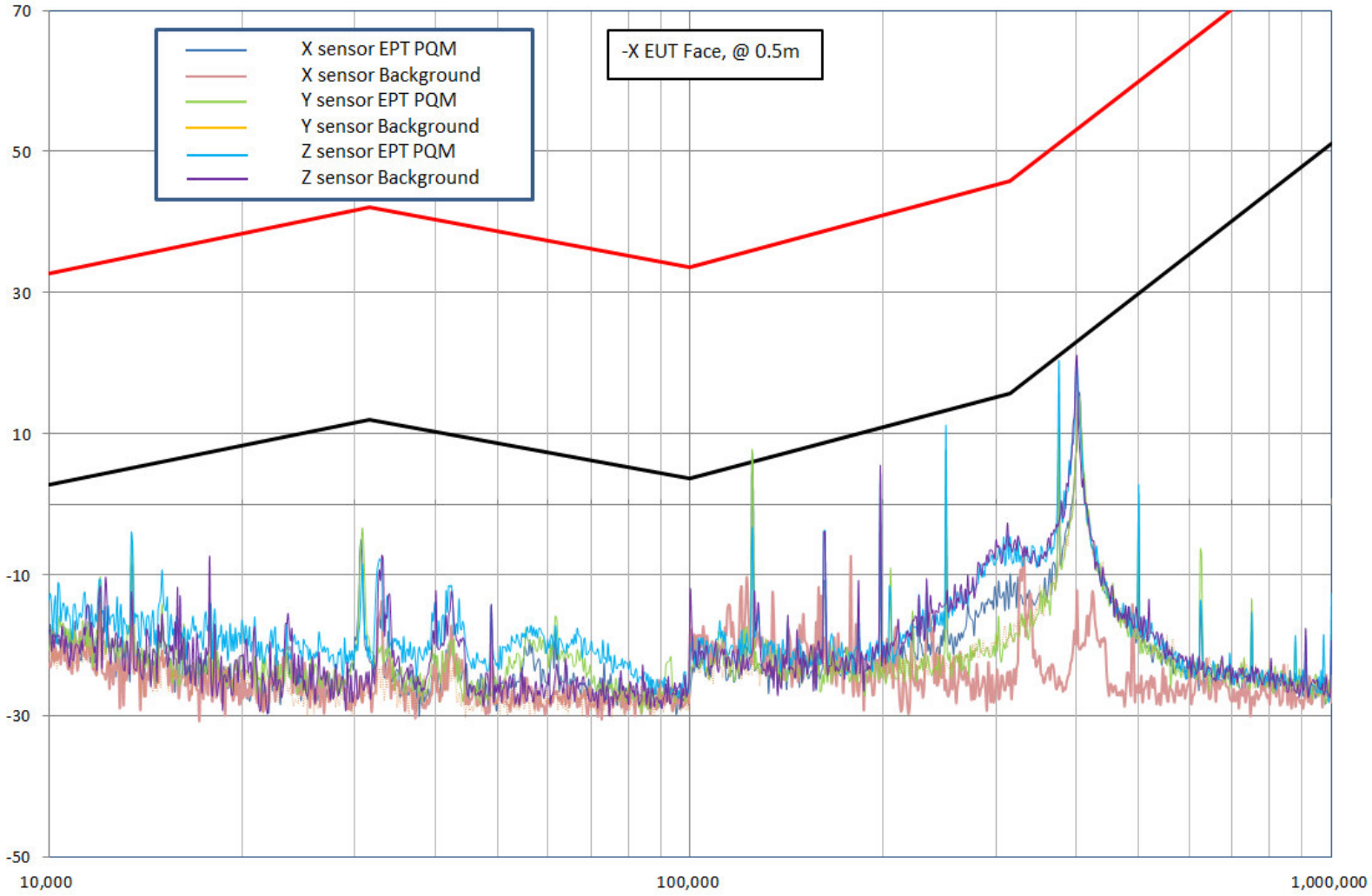

+Z EUT Face, Y Sensor Face @ 0.5m
Background
EPT PQM On
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

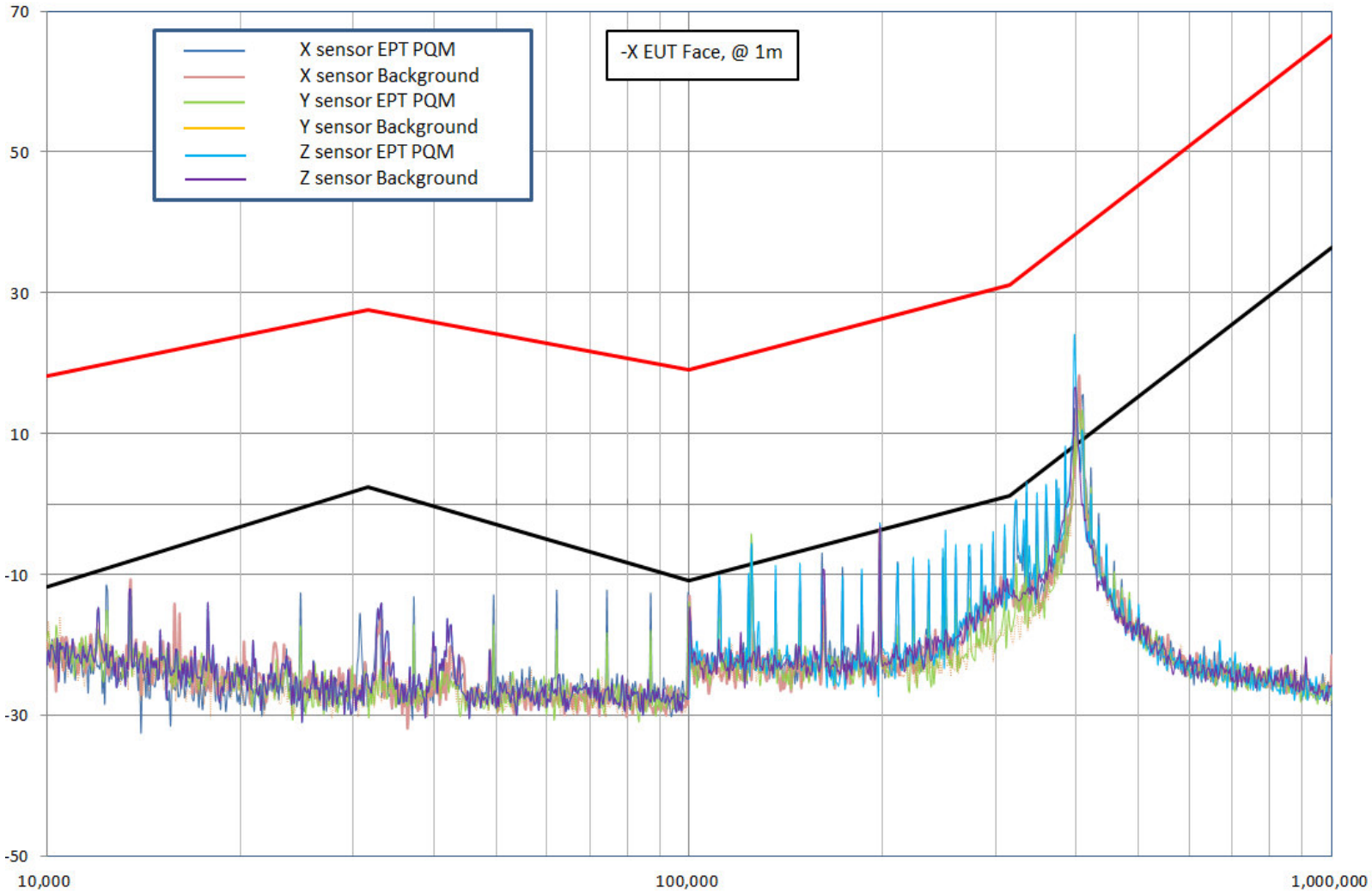

+Z EUT Face, Z Sensor face @ 0.5m
Background
EPT PQM On
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

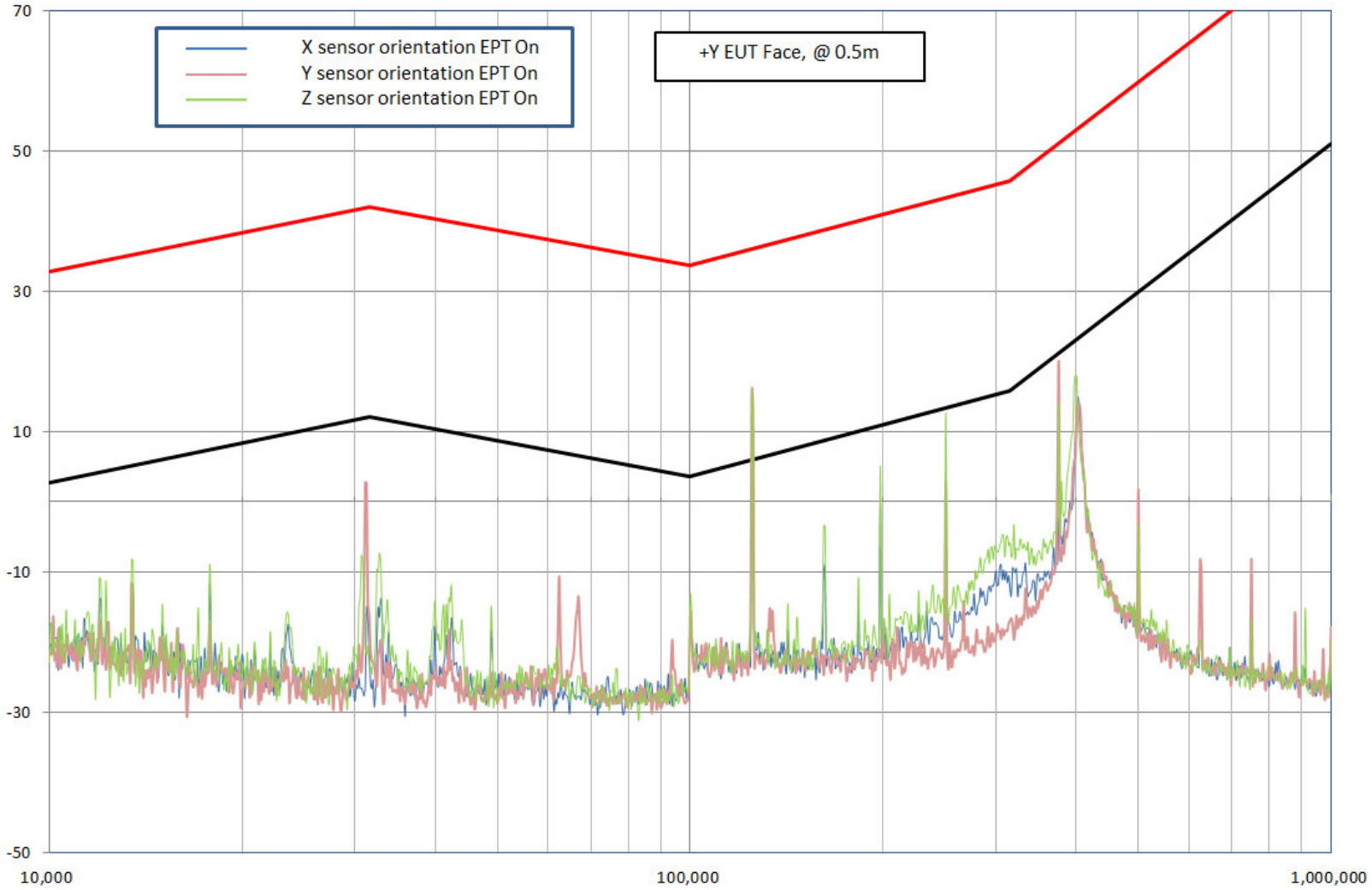

+Y EUT Face @ 0.5m
X sensor face EPT PQM On
Y sensor face EPT PQM On
Z sensor face EPT PQM On
120
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

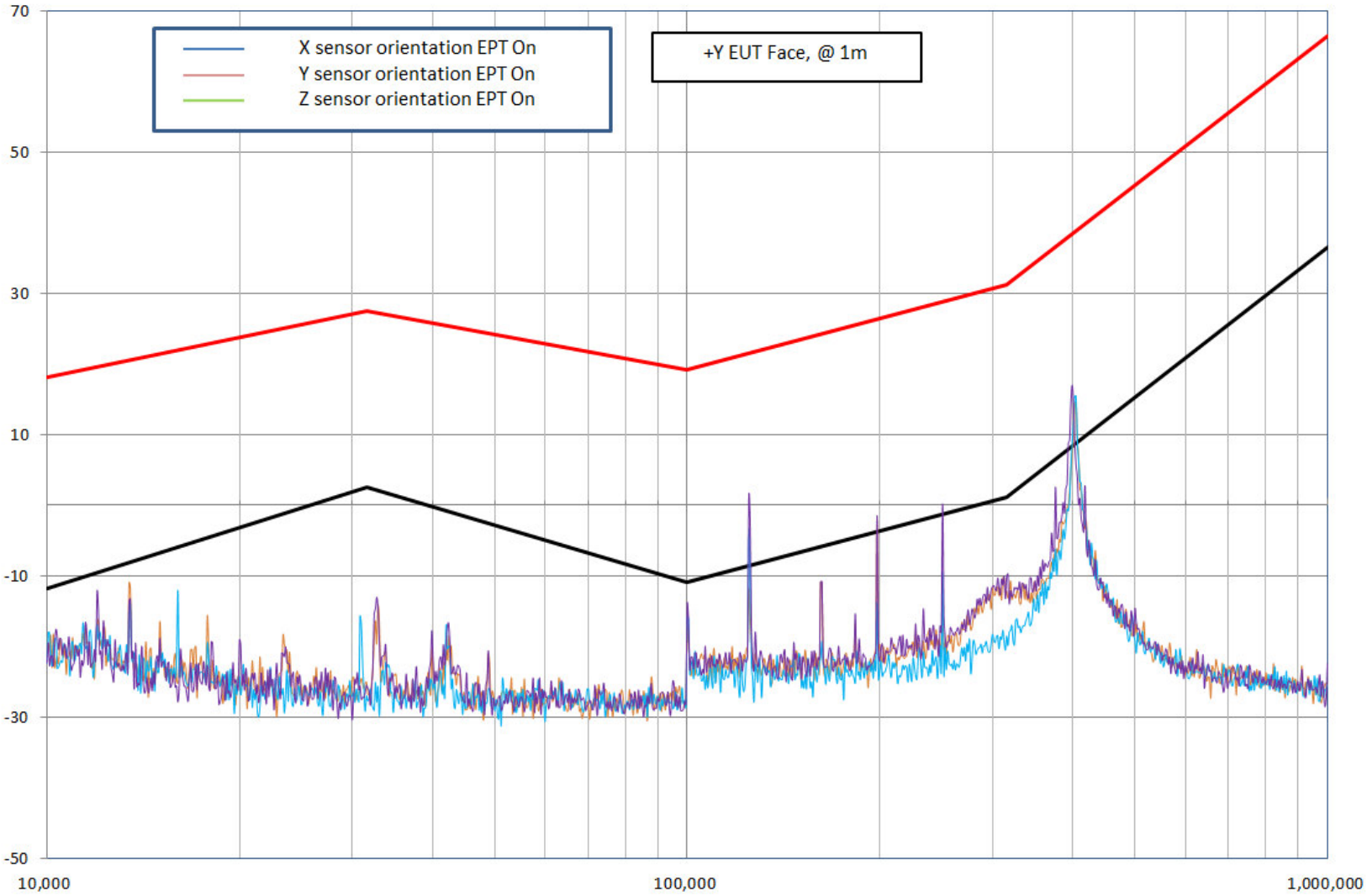

+Y EUT Face @ 1m
X sensor face EPT PQM On
Y sensor face EPT PQM On
Z sensor face EPT PQM On
100
80
60
40
20
0
-20
-40
-60
-80
1
10
100
1,000

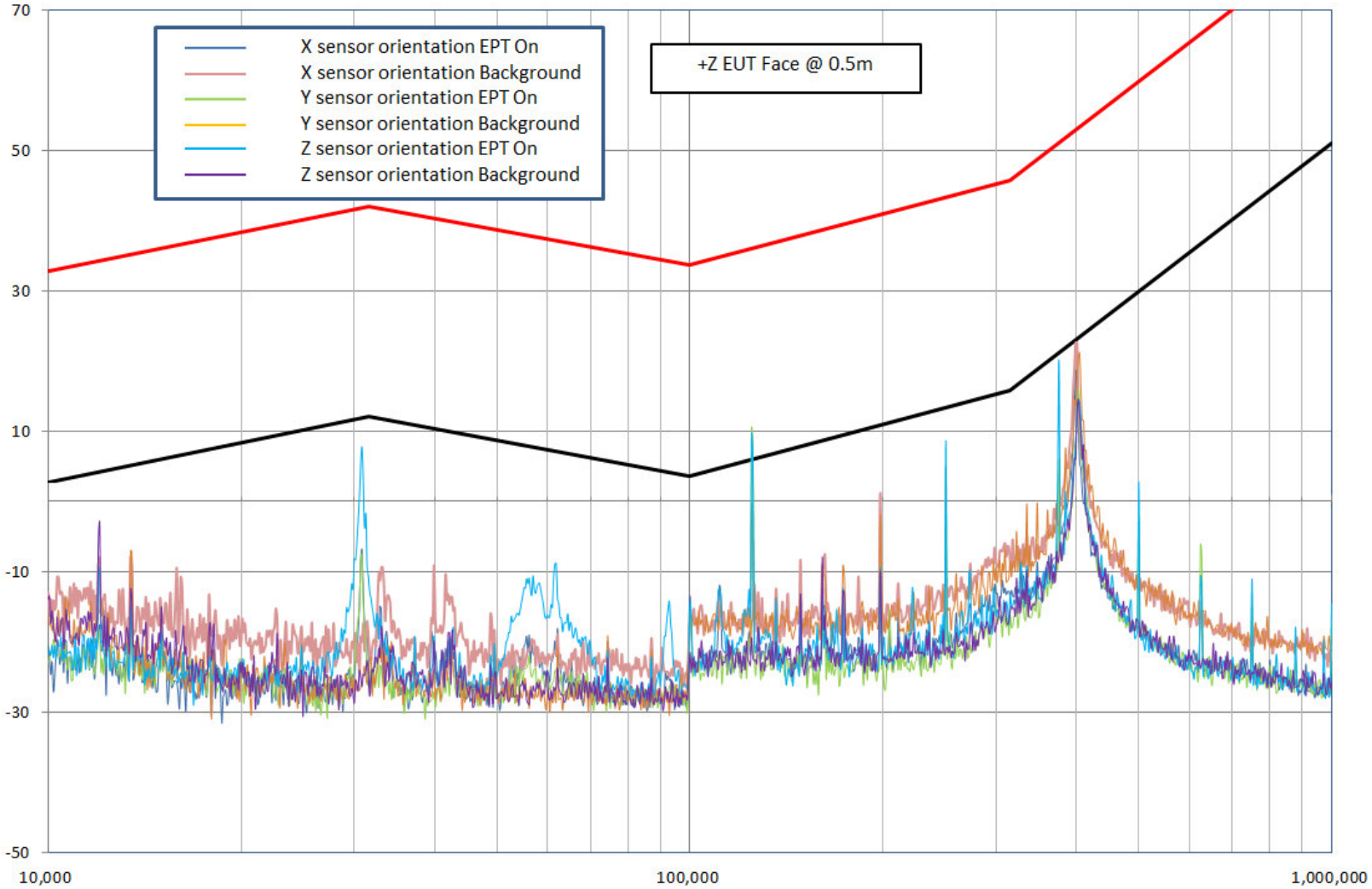
4.10.6 Plots: 10kHz to 1MHz:

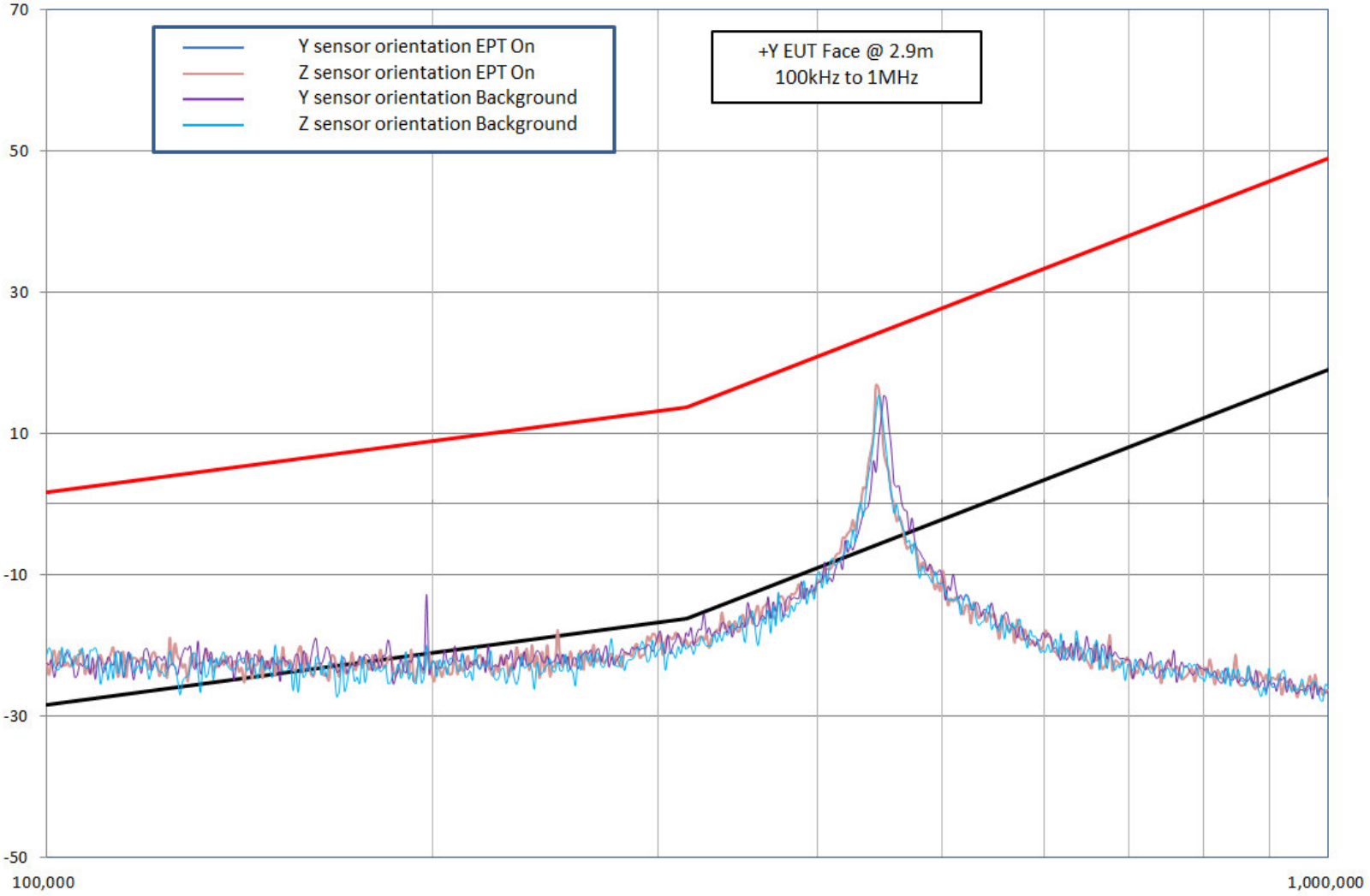





X sensor orientation EPT On
Y sensor orientation EPT On
Z sensor orientation EPT On
+Y EUT Face, @ 0.5m
70
50
30
10
-10
-30
-50
10,000
100,000
1,000,000


X sensor orientation EPT On
Y sensor orientation EPT On
Z sensor orientation EPT On
+Y EUT Face, @ 1m
70
50
30
10
-10
-30
-50
10,000
100,000
1,000,000


X sensor orientation EPT On
X sensor orientation Background
Y sensor orientation EPT On
Y sensor orientation Background
Z sensor orientation EPT On
Z sensor orientation Background
+Z EUT Face @ 0.5m
70
50
30
10
-10
-30
-50
10,000
100,000
1,000,000


Y sensor orientation EPT On
Z sensor orientation EPT On
Y sensor orientation Background
Z sensor orientation Background
+Y EUT Face @ 2.9m
100kHz to 1MHz
70
50
30
10
-10
-30
-50
100,000
1,000,000

4.11 E-Field Characterisation:

4.11.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.12			
Test Dates:	**Start:**	7th May 2015	**End:**	7th May 2015
Ambient Conditions:	**Temp:**	23ºC	**Humidity:**	35%

4.11.2 Test Equipment:

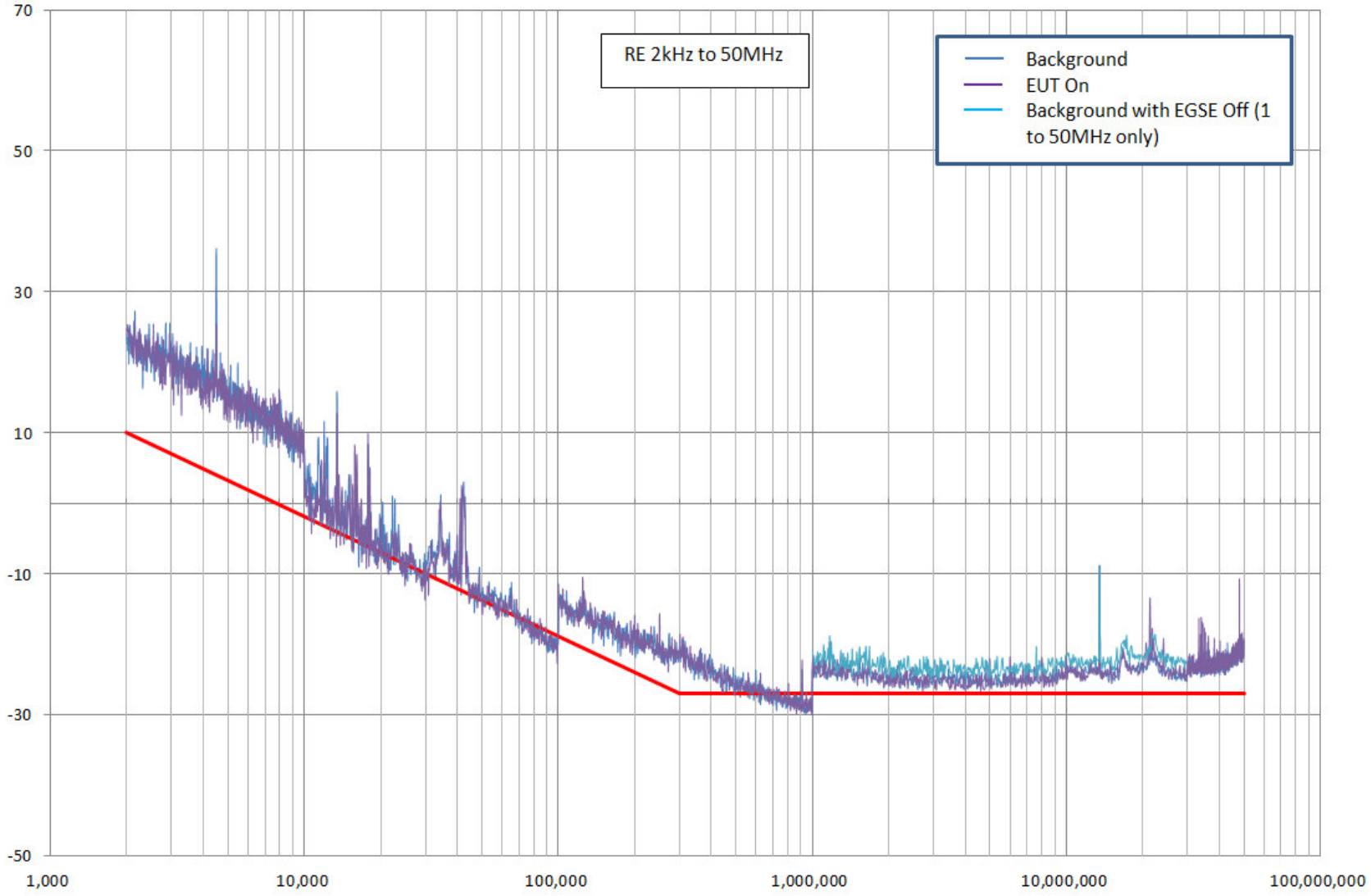
Description	Manufacturer	Type No	TE No	Cal Due Date
LNA	Miteq	AU-1027	013120	02-Jun-16
LNA	Stanford Research Systems	SR560	039334	04-July-15
CABLE 5m	Rhophase	NPS-1551AT-5000-NPS	001125	19-May-15
Cable 3m	Rosenberger Micro Coax	FB311A1030005050	029718	19-May-15
Antenna Rod Pre-Amp	ETS Lindgren	3301B	028035	30-Jun-15

4.11.3 Test Procedure:

A rod antenna with built in pre-amplifier was used to measure the E-Field across the frequency range 2kHz to 50MHz. Additional low noise amplifiers were also used as well as the build in pre-amp of the test receiver in some cases. Some attenuation was applied where the test receiver was overloaded by the low level sensitivity of the equipment. The test was performed as close to the limit as possible with the equipment available but a compromise had to be made with the time constraints so the resolution bandwidth could not be reduced so much that the sweep rate was too slow.

4.11.4 Results Summary:

Test Type	Frequency band	Polarisation	Bandwidth	Level (dBµV/m)	Limit (dBµV/m)	Plot
Ambient	2 kHz to 10 kHz	Vertical	10Hz	27.1	4.1	289
	10kHz to 100kHz	Vertical	20Hz	15.6	-3.9	286
	100kHz to 1MHz	Vertical	100Hz	-11.0	-18.8	285
	1 MHz to 30 MHz	Vertical	300Hz	-8.0	-27.0	282
	30 MHz to 50 MHz	Vertical	500Hz	-19.2	-27.0	292
Characterisation	2 kHz to 10 kHz	Vertical	10Hz	25.4	4.1	288
	10kHz to 100kHz	Vertical	20Hz	12.3	-3.9	290
	100kHz to 1MHz	Vertical	100Hz	-10.4	-20.3	284
	1 MHz to 30 MHz	Vertical	300Hz	-8.8	-27.0	283
	30 MHz to 50 MHz	Vertical	500Hz	-10.6	-27.0	291
Ambient with EGSE Off	1 MHz to 30 MHz	Vertical	500Hz	-8.8	-27.0	281


RE 2kHz to 50MHz
Background
EUT On
Background with EGSE Off (1 to 50MHz only)
70
50
30
10
-10
-30
-50
1,000
10,000
100,000
1,000,000
10,000,000
100,000,000

4.12 Electrostatic Discharge (ESD):

4.12.1 Test Details:

Test Engineer:	J.Mills			
Test Plan Reference:	6.15 and 6.16			
Test Dates:	**Start:**	8th May 2015	**End:**	8th May 2015
Ambient Conditions:	**Temp:**	23.6ºC	**Humidity:**	36%

4.12.2 Test Equipment:

Description	Manufacturer	Type No	TE No	Cal Due Date
Oscilloscope	Tektronix	TDS3054B	029691	17-Apr-16
Current probe	Tektronix	TCPA300	040925	28-Jan-15
Current amp	Tektronix	TCP312A	040926	28-Jan-15
ESD Gun	Schaffner	NSG438	029480	27-Nov-15
Spike Generator	Solar	7054-1	034047	Verified in use

4.12.3 Test Procedure:

Prior to the test, the ESD test equipment was connected to a suitable groundplane to enable a calibration to be performed. The set-up was then transferred to the test ground plane. A plot of the calibration was recorded.

Conducted

The ESD transient was applied to a point of the EUT deemed to be the most susceptible by the customer. A 10kV transient was applied for a maximum of 30 pulses over 3 minutes. The test transient was recorded. The Mil-Std-1541A method was adhered to.

Radiated

A minimum of 40A positive and negative transient could only be achieved with the test equipment. In order to prevent over stressing the EUT the test coupling distance was increased to 2cm. 15 pulses were applied, one per second.

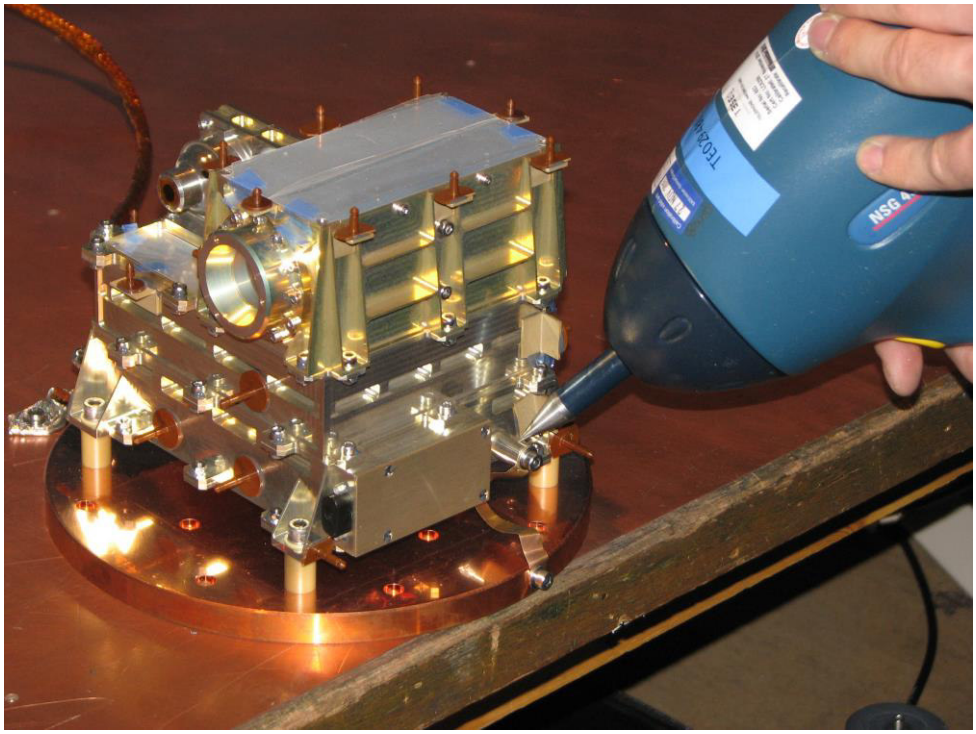


Figure 37. Conducted ESD

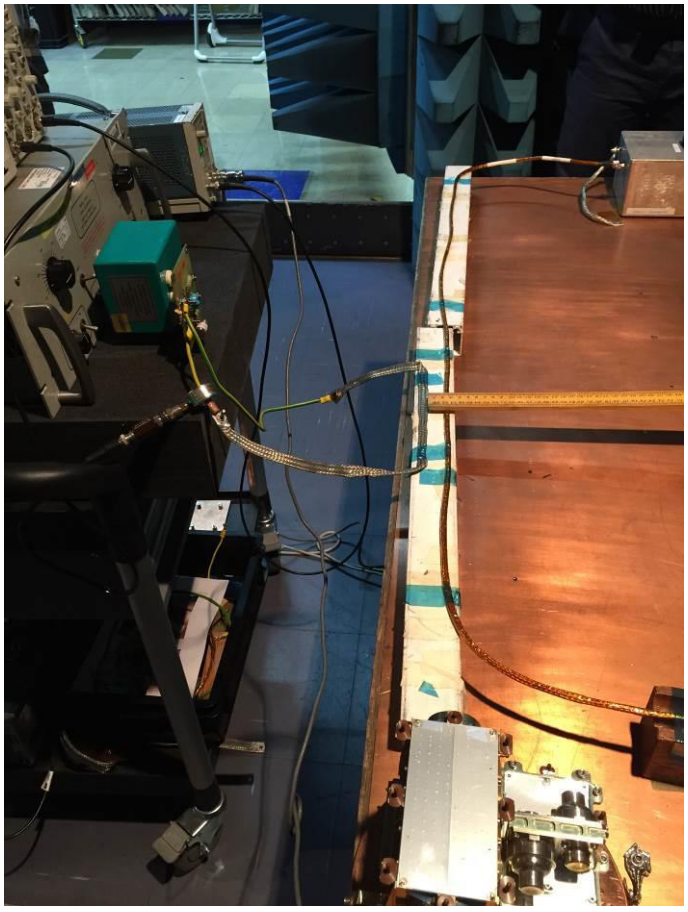


Figure 38. Radiated ESD

4.12.4 Results Summary:

Conducted

Voltage	No of pulses	Cal Plot	Test Plot	Result
10kV	30 over 3mins	299, 300	301	Complied

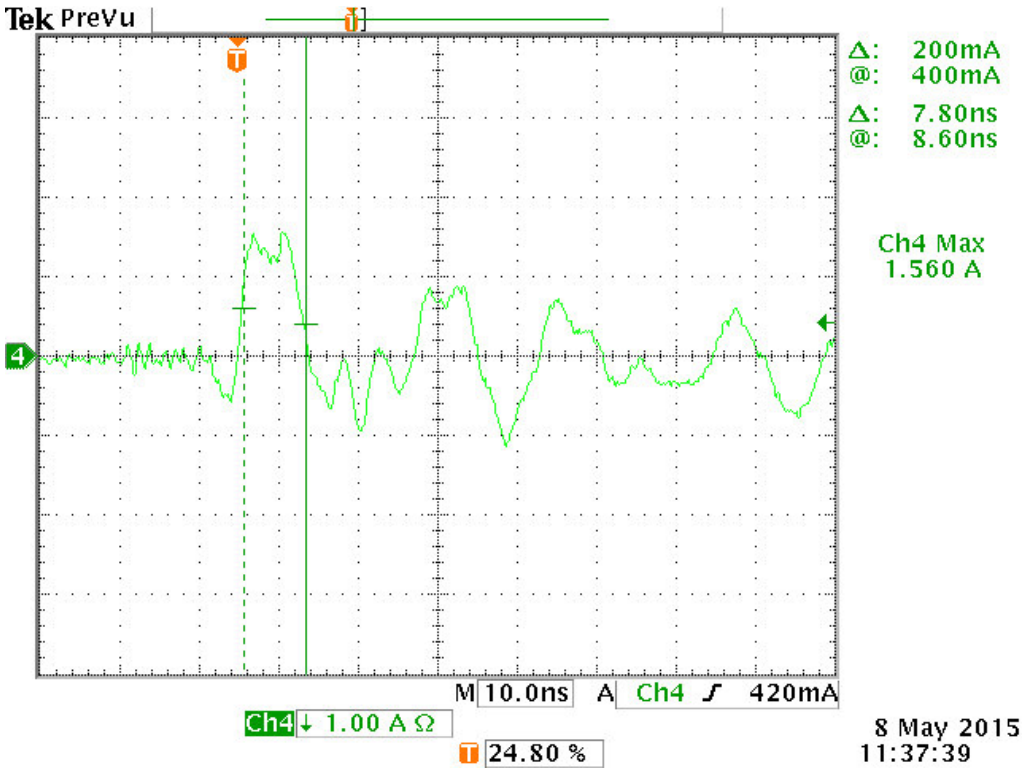
Radiated

Current	No of pulses	Cal Plot	Test Plot	Result
+30A	15 in 15 seconds	302*, 303	304	Complied
-30A	15 in 15 seconds	302*, 303	305	Complied

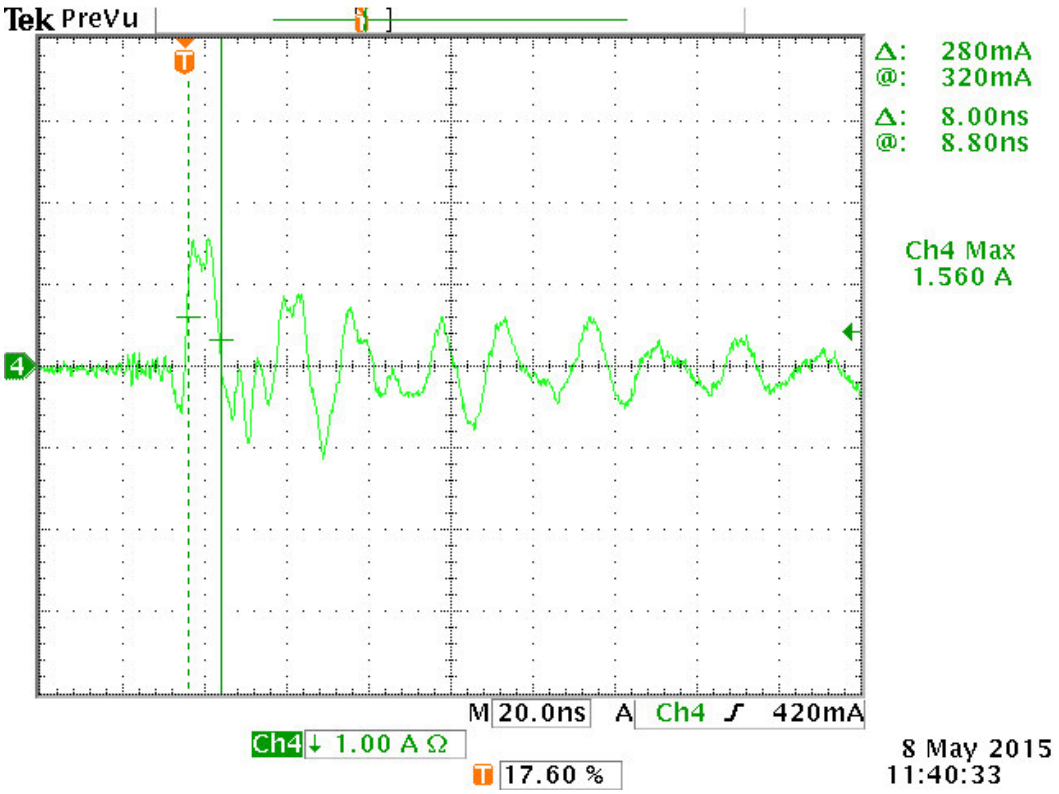
*Note: Two current probes used to verify the current.

4.12.5 Plots:

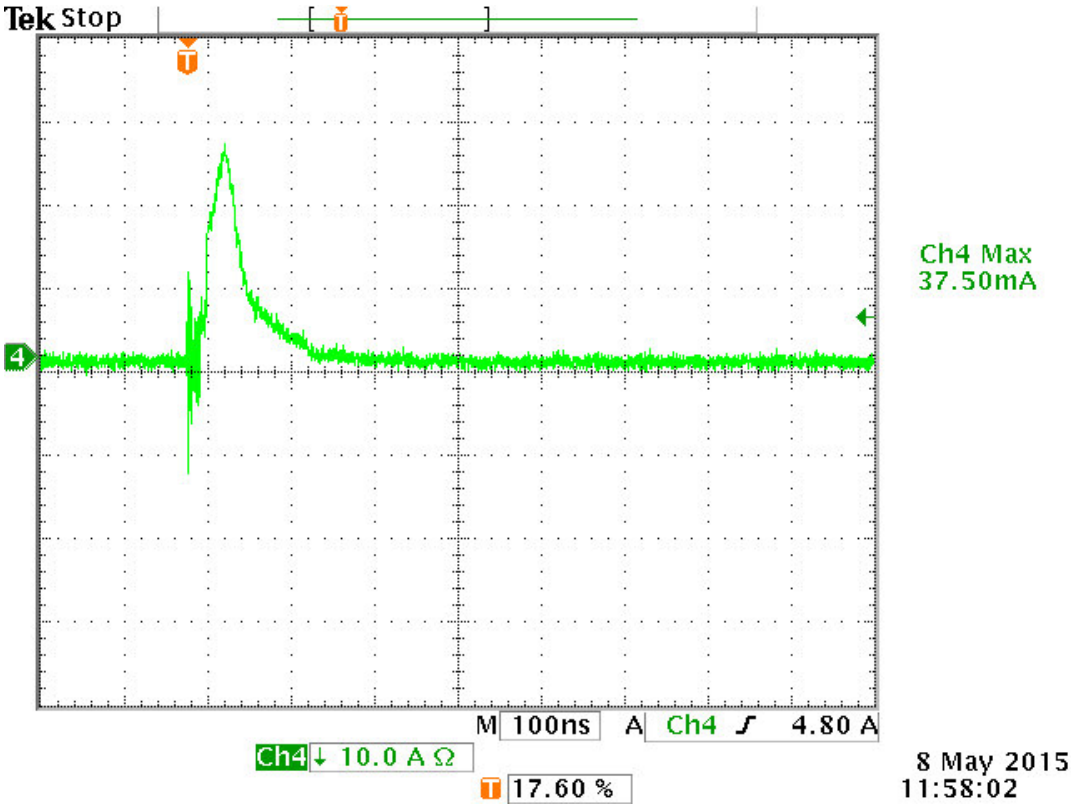
Plot 299



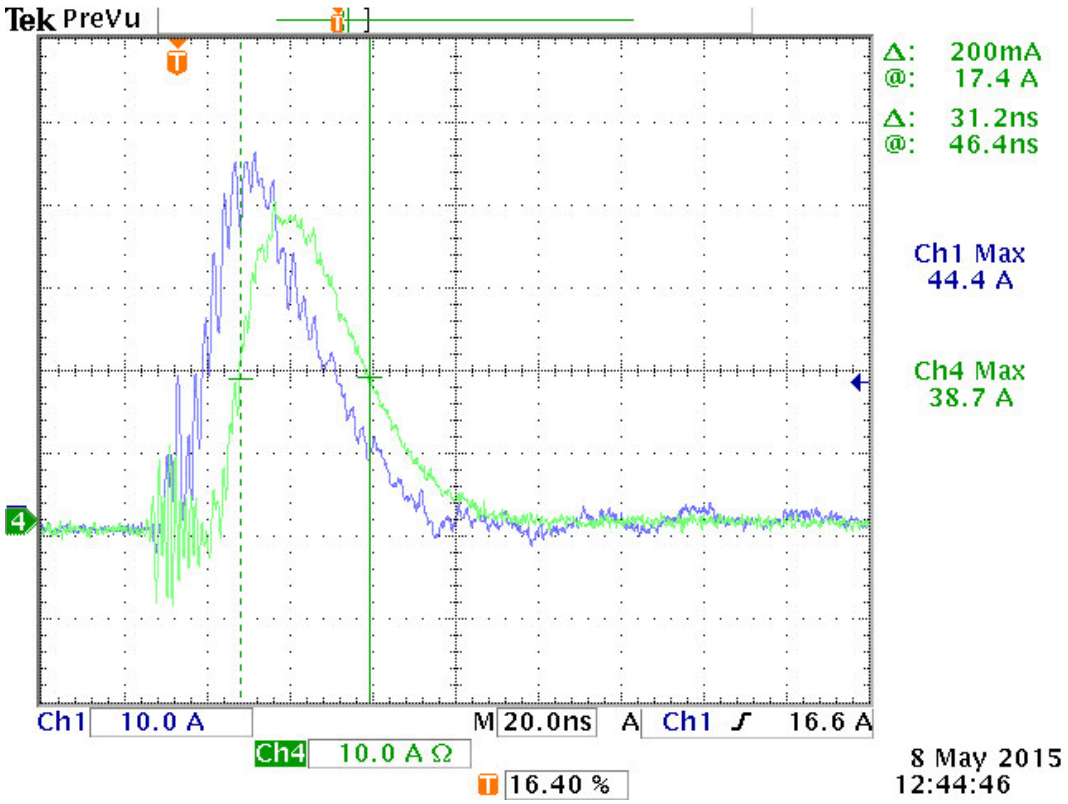
Plot 300



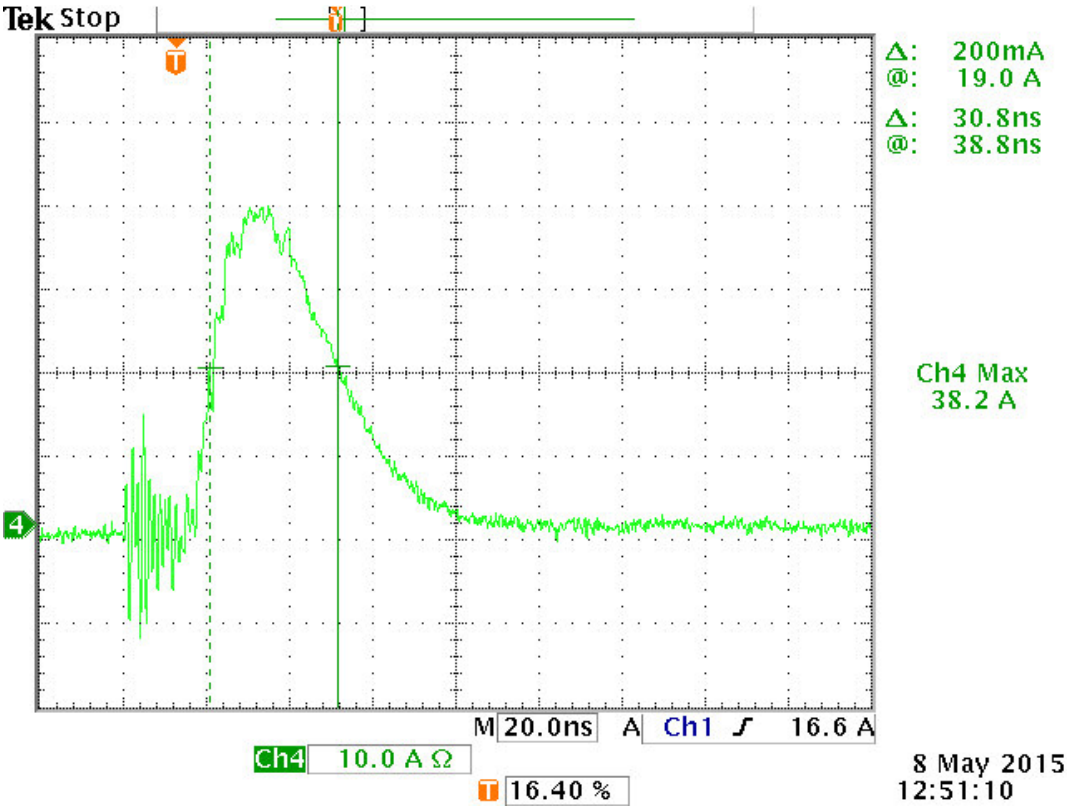
Plot 301



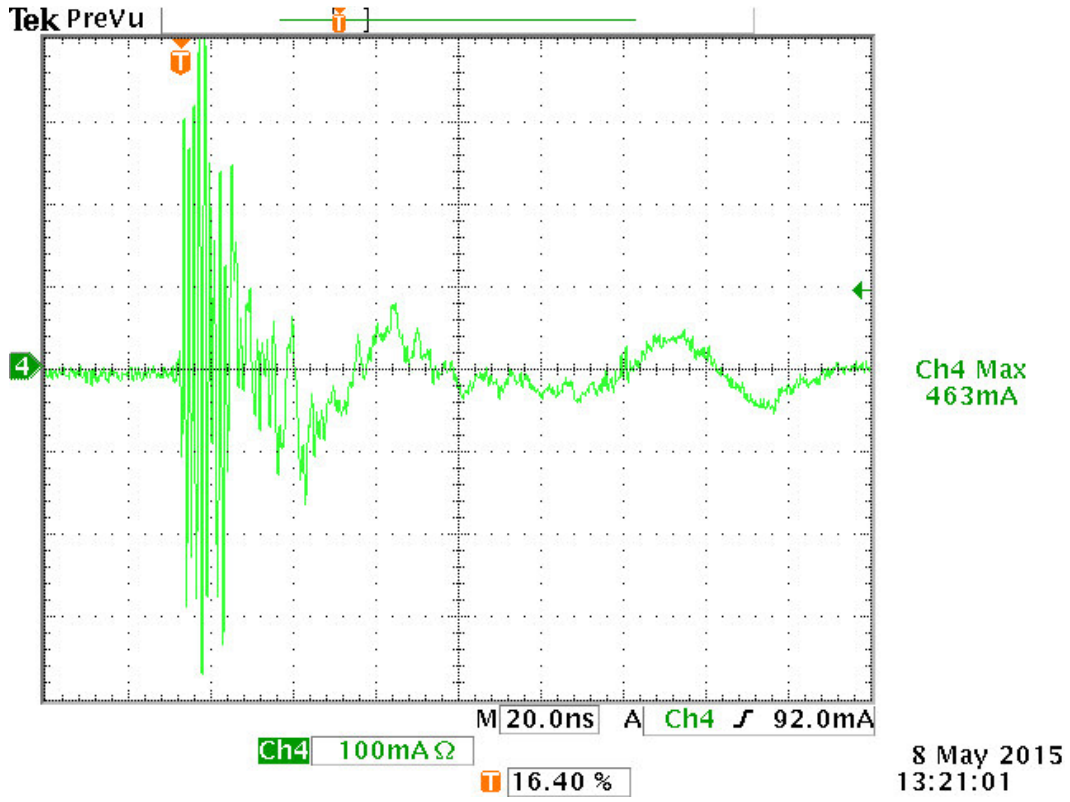
Plot 302



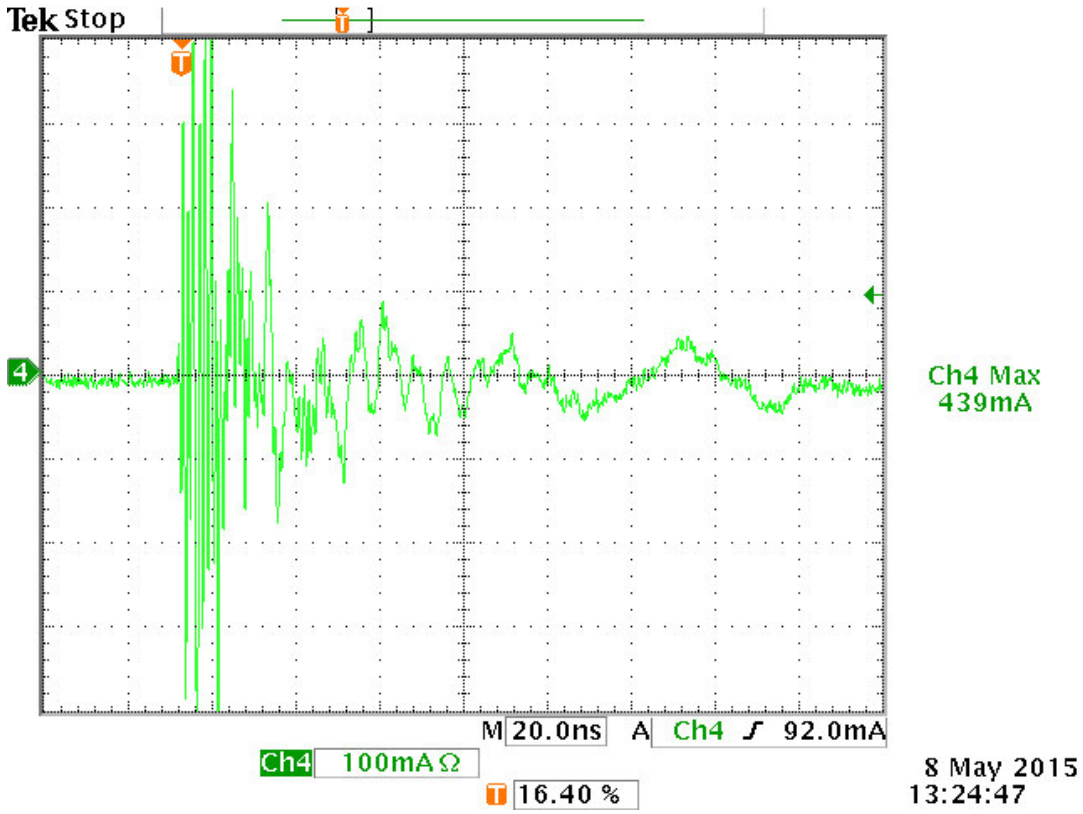
Plot 303



Plot 304



Plot 305



4.13 DC Magnetic Moment:

4.13.1 Test Details:

Test Engineer: G.Kapfunde, M.Pudney

Test Plan Reference: 6.14

Test Dates: **Start:** 15th April 2015 **End:** 16th April 2015

Test Location: Air Bus Defence and Space, Stevenage

4.13.2 Test Equipment

Description	Manufacturer	Type No	TE No	Cal Due Date
Fluxgate magnetometer	Bartington	Mag03-MSL100	N/A	12-Sept-15

4.13.3 Test Procedure:

The following information was provided by Max Pudney of Air Bus Defence and Space, Stevenage for inclusion in this report;

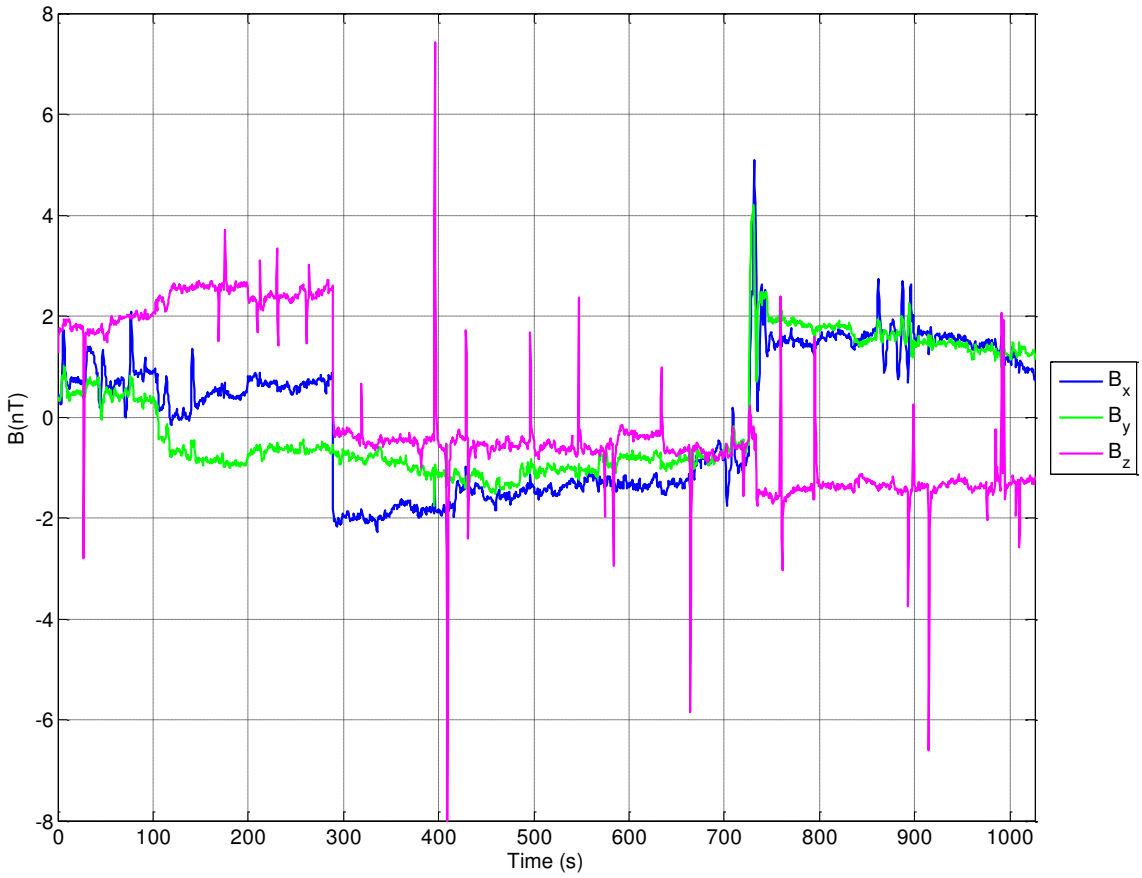
Measurements taken with a 0.5Hz sample rate, using a Bartington fluxgate magnetometer with 100µT range.

The requirements for transients and variations are written for a 1m distance. However, measurements needed to be taken closer to the instrument in order to resolve small variations to meet the requirement. Therefore the requirements for EPT-HET need to be scaled. The scaling is performed assuming a dipolar field fall-off ($B \propto r^{-3}$). The requirements for EPT-HET 1 are the most stringent; therefore the requirements are re-calculated based on EPT-HET 1.

4.13.4 Results Summary: Periodic Transients

Distance measured [m]	Transient requirement [nT]	Periodic variations requirement [pT]
1.00	18	110
0.55	110	660
0.32	550	3400 (=3.4nT)

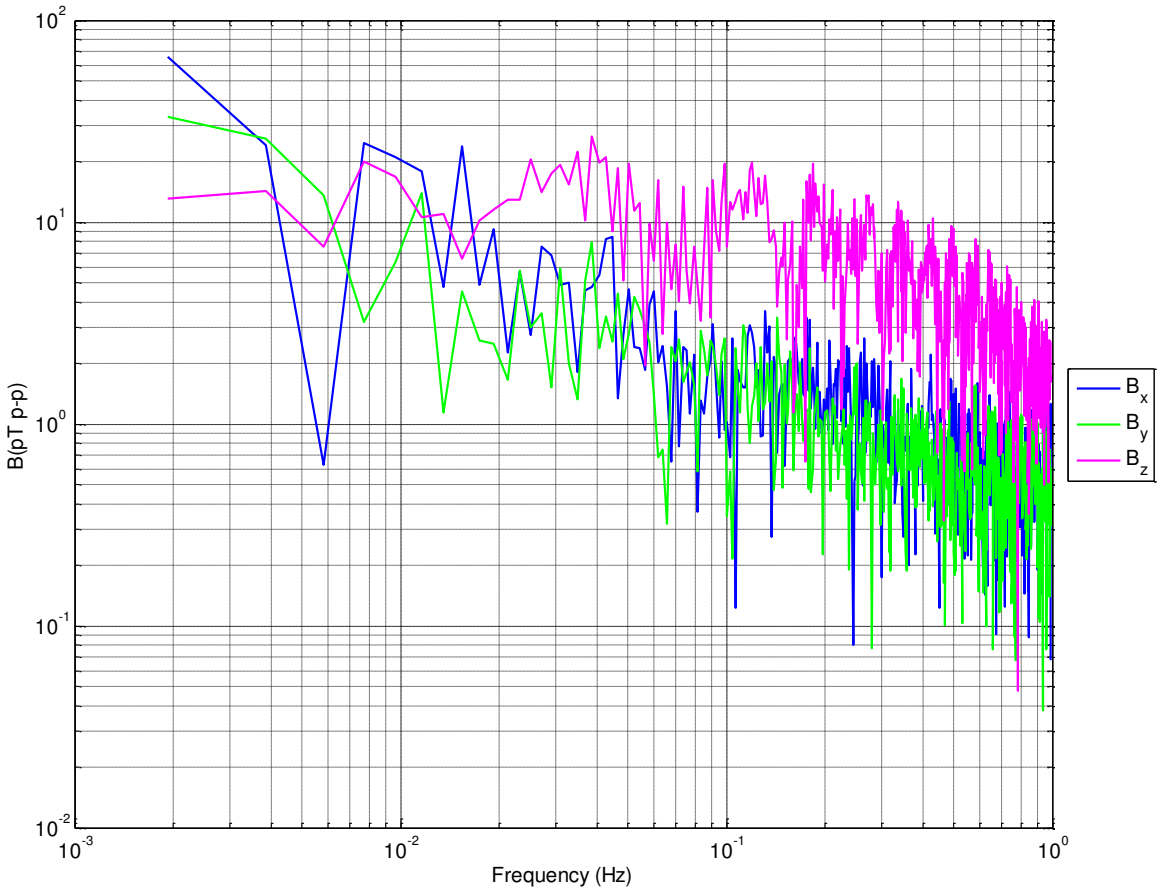
Measurements were also taken at 55cm, which yielded the following results:



Event time-tagging:

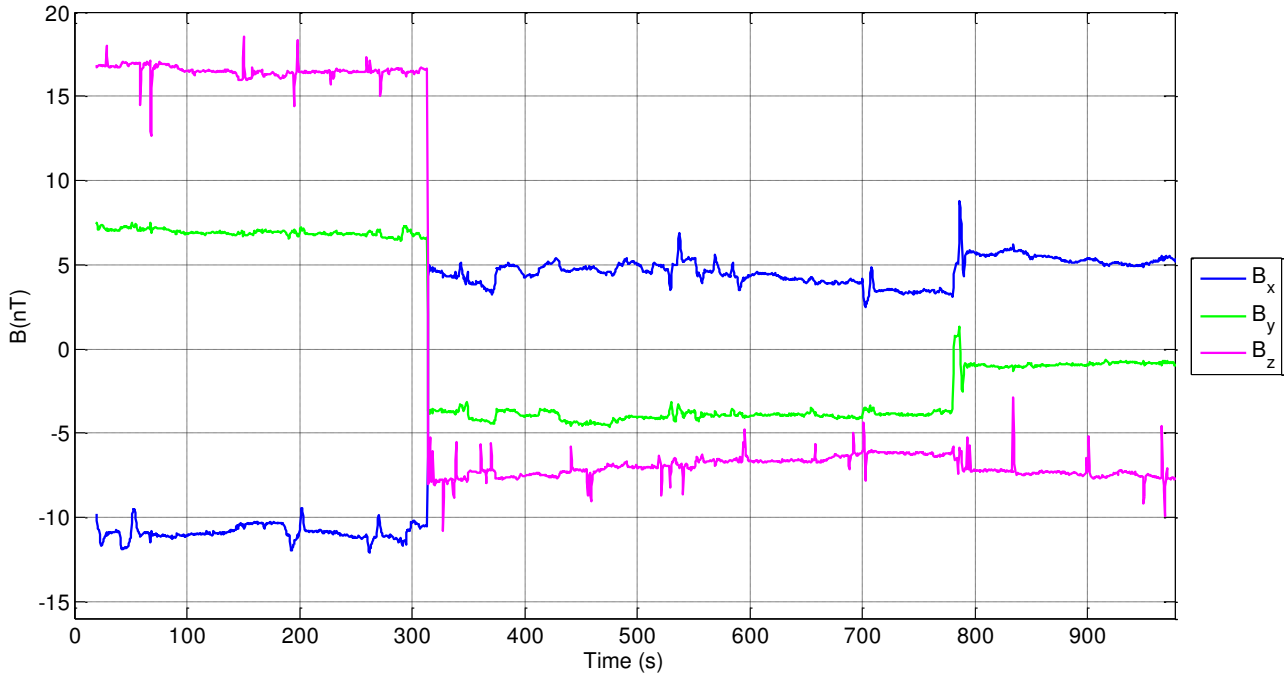
1. 0 – 300 seconds – ambient background, closed chamber, laptop and GSE on
2. 300 – 380 seconds – power on sequence
3. 380 – 700 seconds – confirmed stable operational mode
4. 700 – 760 seconds – switch down sequence, all switched off, laptop removed from EGSE area
5. 760 – 1060 seconds – ambient background

Measurements made at 55cm – frequency spectrum during the stable operational mode



For the transient and variations observed in the 5cm time series and frequency domain, the unit is compliant to the transient requirements R-842, but it is not clear whether or not compliance is achieved for R-681, which is the reason for the measurements taken at 32cm.

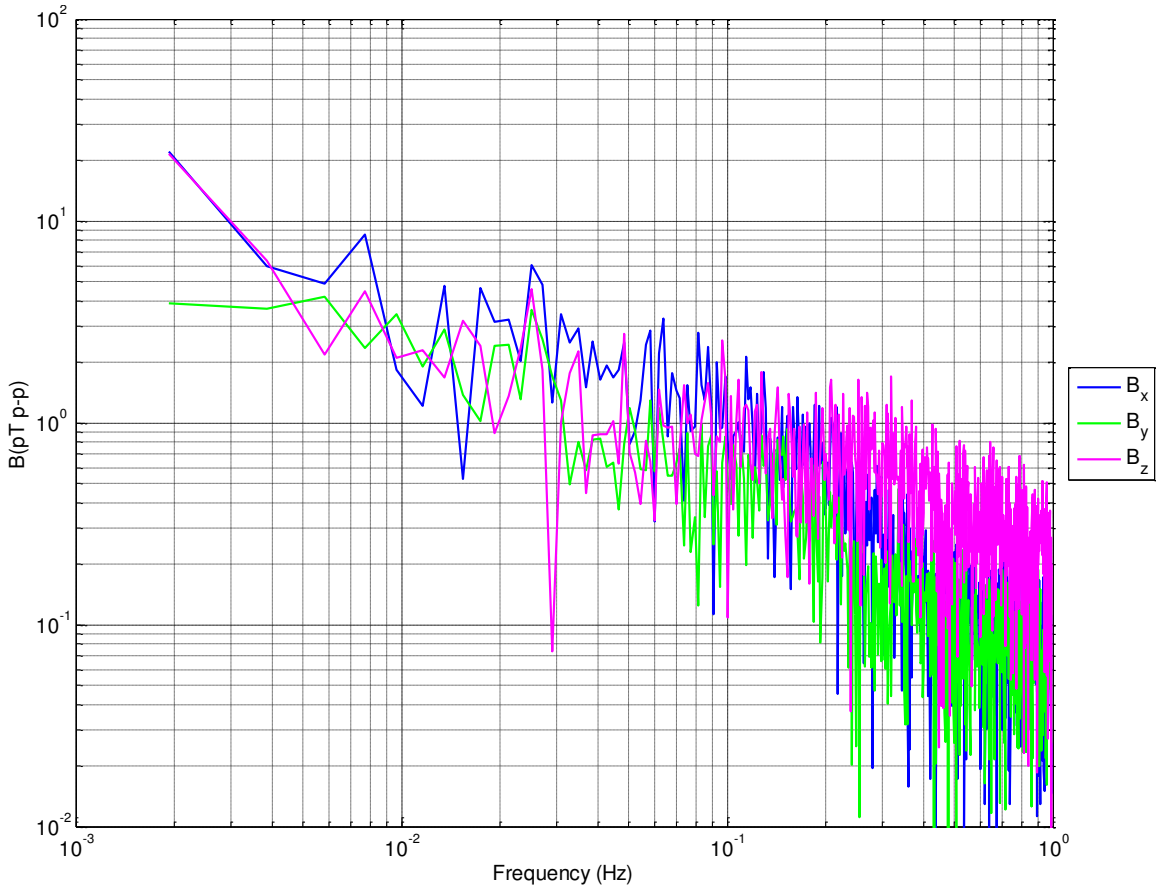
Measurements made at 32cm – time series



Event time-tagging:

1. 0 – 300 seconds – ambient background, closed chamber, laptop and GSE on
2. 300 – 375 seconds – power on sequence
3. 375 – 700 seconds – confirmed stable operational mode
4. 700 – 790 seconds – switch down sequence, all switched off, laptop removed from EGSE area
5. 790 – 980 seconds – ambient background

Measurements made at 32cm – frequency spectrum during the stable operational mode



For the transient and variations observed in the 32cm time series and frequency domain, the unit is compliant to the requirements R-842 and R-681.

4.13.5 Results Summary: DC Magnetic Moment

Distance (cm)	Status	Summarized (RSS) Dipole Moment, |m| (mAm^2)	Max No Dipoles Used	Total RMS Residuals %
20	Initial	46	5	23.1
20	Initial	31.5	2	16.4
30	Initial	28.6	2	23.1
50	Initial	31.8	2	54.9
50	Deperm	19	5	17.6
50	Perm	17.6	5	15.9

DOCUMENT CHANGE DETAILS AND DISTRIBUTION LIST:

Document Change Details:

ISSUE	CHANGE AUTHORITY	CLASS	RELEVANT INFORMATION/INSTRUCTIONS
1	Upissued	-	First Issue
2	Upissued	-	1. Page 66: Notch frequencies, 7162 to 7182MHz changed from Did not comply to N/A with a footnote. 2. Section 4.10.4; H-Field low frequency, EUT On; Did not comply changed to N/A and footnote added. 3. ESD: 4.12.3; test procedure for Radiated amended. 4. Page 92: H-Field plot 278 changed to 250.
3	-	-	1. Page 6: DC mag moments line added with non-compliant and note. 2. Page 7: 3.3; Deviations for H-field added. 3. Page 96: Section 4.10.5; 10Hz to 5kHz-field plots replaced. 4. Page 105: Section 4.10.6; 10kHz to 10MHz plots updated/replaced

Distribution List:

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