SPIRE EMC Compliance Review
Minutes of Meeting
SPIRE-RAL-MOM-002718
Meeting held: 10 August 2006

Attendance:

Eric Sawyer
John Delderfield
Colin Cunningham
Carsten Scharmberg
Filippo Marliani
Doug Griffin
Guy Dubrovik
Clemens Kalde
Matt Griffin
Siegmund Idler
Ray Carvell

Attachments

A. DKG Overheads
B. Plot of co-added EMI
C. RS Simulation Report
D. CS Report
E. SPIRE Ferrite selection note

1. Review of IID-A requirements and margins philosophy for CS and RS (Filippo)

- Requirements are given in IID-A Section 5
- The heritage of these requirements is based on mil-spec and previous ESA programmes
- Conducted susceptibility
    - Power lines; differential mode: Fig 5.14.3-3
        - 1 V rms up to 100 kHz; 0.5 V rms above 100 kHz
        - Not regarded as a likely problem in practice – waiver can be raised if necessary
        - Below 100kHz the levels in flight could be < 50% of spec and above 100kHz < 30%. The prediction of these levels is very difficult and is based largely in procurement specifications.
        - The noise from the shunt regulators will be small due to the filtering effect of the capacitor on the output of the S/C PCDU
    - Common mode, steady state
        - This spec exists to cover the fact that there is a finite impedance between the PCDU and the units.
        - It is thought that Alcatel will do tests on a flight like SVM to quantify this.
    - 5.14.3.5: can be ignored (agreed with Alcatel)
    - 5.14.3.8.2 (Common mode transient): refers to situation in which a failure has already occurred. Requirement is for unit to survive, but not to have science capability under these conditions. Has been tested at subsystem level on DRCU.
    - Differential mode transient: also refers to switching event but not necessarily a unit failure. Level of 2.5 V for times of a few ms.
        - Not yet tested on SPIRE.
        - Worst case: science data could be corrupted for ~ 10 ms.
        - Questsion: how often will such events occur; and will their occurrence be flagged in the S/C housekeeping? – probably not very often.
        - Test can be done at instrument level. (**Action** DKG to add this to the PFM-4 test plan)
- E-field radiated susceptibility (5.14.3.10)

- 2 V m^{-1} with 30% amplitude modulation at 1 kHz
- Level of 100 mV m^{-1} in flight is not considered unusual
- But it is difficult to predict or model the fields that will occur in flight.
- It is unlikely that there will be any appreciable field > 1GHz

- H-field RS (5.14.3.12)
  - Main source is likely to be solar arrays
    - SPIRE has 20-30 dB attenuation wrt PACS
    - Industry is working to reduce the levels for PACS which will provide further margin for SPIRE.
    - There is no B-Field cancellation as per cluster
    - The switching frequency of the regulator varies between ~560Hz and 1kHZ.
      - first harmonic will be below 1kHz
      - higher order harmonics will be >1kHz
- Conclusions:
  - Differential mode transient susceptibility (due to load switching) should be tested at instrument level in PFM-4 cooldown. Should include a threshold test if susceptibility is seen.

2. Science impact (Matt)

- Bolometer noise typ. 30 nV $Hz^{-1/2}$
  Signal BW: 0 – 5 Hz for photometer; 3 – 25 Hz for FTS
- Bolometer operating temperature: nominally 300 mK with Tb ~ 330 mK.
- Can be increased due to RF heating
- If steady (umnodulated) no direct noise injected in signal BW but bolometer can be heated.
- Results in steady degradation of sensitivity.
- If T_o gets > about 400 mK, sensitivity seriously degraded; > about 600 mK – essentially non-functioning.
- Noise budget:
  - Table from Detector Subsystem Specification Document
- **Action:** Matt to define allowable increase in noise and bolometer temperature based on 15% overall increase in rms noise level or equivalent increase in bolometer operating temperature.

3. SPIRE EMC test results (DKG)

- Summary of campaigns
  - CQM-2:
    - CS tests
    - But incorrect grounding scheme and poor ground plane
    - Tests showed susceptibility but results deemed inconclusive
  - EQM:
    - Radiated susceptibility only
    - E and B field
    - Susceptibilities found
    - Test conditions not fully representative, but results deemed indicative
  - PFM-3 ILT
    - CS: susceptibilities found
    - RS: simulation by bulk current injection on cryoharness
      - Various countermeasures tested

3.1 EQM

- PSW array only with some bad channels
- IID-A levels for E and B
- Test set-up deficiencies
  - WE not fully representative

- Only PLW
    - SPIRE cryoharness not complete
    - Not in anechoic chamber
    - Various EGSE and MGSE items in the set-up
    - Detector sampling rate higher than nominal
- Test signal 100% AM at 1 Hz with 86% duty cycle (off for 240 ms every 1 s)
    - Expected response to heating only would be fundamental at 1 Hz with harmonics
- Analysis carried out to distinguish between increase in bas noise level and features at 1 Hz
- B-field sweep 30 Hz – 50 kHz
    - Large noise increases seen at various frequencies (which depend on the detector bais frequency adopted)
    - Threshold fields calculated (based on Doug's criteria) – typical 80-90 dBpT
        - Worst case 75 dBpT (below 1 kHz)
    - Frequency of B-field generated by solar arrays expected to be stable except during load switching.
    - Below 0.5 kHz, no significant magnetic fields expected.
    - Discussion of possibility of undertest wrt flight system susceptibility
        - Filippo
    - Conclusion:
        - 80 dBpT is about the level for PACS. With additional attenuation at the location of SPIRE (20-30dB) , then there should be margin for SPIRE.
        - CQM-level NCR not closed formally yet for B-field (it probably can be closed out though)
        - PFM-level test could still be done (will be done for PACS anyway)
    - There is some question regarding the differences between EQM and PFM
        - **Action:** DKG to investigate the loop areas of the cryoharness.
- E-field
    - 15khz - 30 MHz and 30 kHz-1GHz sweeps revealed susceptibilities in 16 and 34 +/- 3 MHz region
        - 30 MHz corresponds to quarter wavelength of about 2.5 m
    - No problem from 1 GHz up
    - Noise level degraded by several orders of magnitude
    - Susceptibility thresholds:
        - Typically at the level of a few x 10 mV m^{-1}
        - But varies a lot between detectors, and some detectors go the wrong way
        - The disturbance doesn't drive the detectors out of the offset range
            - Argues against a thermal effect
            - Viktor has speculated that gain variations in the JFETs
        - Highly dependent on the exact test set-up (position and layout of harnesses etc)

3.2 PFM-3 ILT

- All photometer arrays present
- Modulated at 1 Hz (not 100% AM as amplifier does not have this facility)
- CS: Susceptibilities at various frequencies
- Strong sensitivity to where people were sitting or standing during the tests
- 2.48 MHz
    - 0.5 V rms produces 30 dB increase in noise
    - Highly non-linear
    - Extrapolating to no impact: 80 mV ms disturbance for PLW; 70 mV PMW and PSW
- 39 MHz DM susceptibility
    - PSW shows variation in response that correlates with JFET membrane
    - Others don't
- Summary
    - DM: susceptibility level typ. 100 mV
    - CM: 500=700 mV

- RS simulation
  - Disturbance injected on detector lines and bias lines close to DCU and CVV
  - Three different configurations of filtering for various groups of channels
    - CEA filter 170 Ω; 100 pf (10 MHz)
    - Gasket filter (2200pF line to chassis)
    - No filter
  - Injecting on bias near DCU
    - 1–3 MHz: no difference
    - CEA filter provides some improvement at high freques, gasket better at low freqs?
    - Gaskets probably only usable warm (i.e., on SVM only)
  - Ferrite tests
    - About 8 dB per ferrite (based on $20\log_{10}(v1/v2)$)
      - Corresponds to a factor of 2.5
        - So about three would be needed per bundle
    - Ferrites are qualified at least for RT use

4. Review of EMC test plans between now and launch (DKG)

- STM-2 test campaign
  - System will not be as representative as the EQM set-up
  - Main objective of the test will be to evaluate effect of installing ferrites and/or filters
  - Doug and Filippo have formulated a nominal test plan – requires about two days and allows for "playing around" with different configurations.
  - Important to get down to the detector noise thresholds during the test
    - To verify in practice the progressive attenuation achieved by adding more ferrite units
    - There could be additional mechanism(s) for RF coupling into the detectors as well as via the cryoharness.
  - Could be in late Sept. (but depends on other factors such as LSS availability)
  - Various ferrites should be procured ASAP (any varieties that are thought to be potentially useful) to make sure that they are in hand and available for the STM-2 tests
  - Basic plan
    - Survey with no countermeasures
    - Trial ferrites (types, numbers) at 34 MHz (or peak susceptibility)
    - Establish optimum configuration and repeat sweep with gaskets also fitted.
- PFM-4 tests
  - Action: Doug/Eric to baseline a reasonable period in PFM-4 for RS tests – exact nature will depend on the outcome of the STM-2 tests
  - CS:
    - Susceptibility at the level of 70 – 80 mV with ~ 30% modulation depth.
    - But could be of neglible impact if it is not being modulated
    - Req = 300 mV p-p (sawtooth on power line) – corresponds to 110 mV rms
    - Apportioning all this to the instrument signal BW represents a very pessimistic
  - Possible PFM-4 tests:
    - Action: Doug to include test to modulate at 1 kHz – should pass this test easily
    - Action: Filippo will confer with others at ESTEC as to what the verification approach should be. Using 100% modulation @ 1Hz implies that the amplitude of the DM EMI varies by 100% within the signal band of SPIRE. How realistic is this?[1]
- Other countermeasures (discussed at the EMC review at ESTEC):

[1] Clouse of action: The results of the PCDU characterization tests performed by ETCA were discussed with ESTEC power experts. The conclusion from this discussion was that the gain of the regulation loop of the PCDU in the SPIRE band is such that the chance to have a conducted interference on the power leads with magnitude some 10's mVrms in the SPIRE band is practically zero.

- Alcatel and Astrium investigating effectiveness of additional SVM shielding
- At this stage we need to take all possible measures to reduce the potential for serious sensitivity loss.
- Action: Following the investigation of effectiveness of additional SVM shielding, Herschel Project will decide if it should be implemented.

5. Satellite-level testing on the FM

- Doug would like to look at harness routing details in the FM cryostat
- Baseline:
  - Repeat RS E-field test
  - Possible repeat of B-field tests (TBD)
  - Overall compatibility of SPIRE with the complete system

6. System Modelling (JPL)

- Viktor plans to do some PSPICE modelling to explore possible coupling mechanisms but not done yet. He needs information on cryoharness stray impedances.
- Action: Doug to pass information on the harness parasitics to Viktor

A. DKG Overheads

SPIRE EMC Review

10 August 2006

Meeting Aims

Scope:

- EMC compliance of the SPIRE Detector Chain

Aims:

- Review the status of the EMC qualification of the instrument.
- Review the plans for EMC work between now and launch (testing, analysis, reviews)
- To assess the level of risk to Herschel Science operations posed by the apparent EMI susceptibilities

Agenda

- Review of IID-A requirements and margins philosophy
  - CS and RS
- Science impact of EMI
- Overview of test results from EQM RS Tests
- Overview of test results from SPIRE ILT EMC tests
  - CS testing
  - “RS Simulation” testing
- Review of candidate RS counter-measures (DKG)
- Review of EMC Test plans between now and launch (DKG)
- Recommendations / conclusions / planning (DKG)

Summary of Instrument Level SPIRE EMC Testing

- CQM-2
  - Conducted susceptibility tests
  - Carried out under incorrect grounding scheme with poor ground plane
  - Tests showed susceptibility, but results disregarded due to test deficiencies
- CQM/EQM
  - Radiated susceptibility tests
    - E and B Field
  - Susceptibilities found
- PFM-3 ILT
  - Conducted susceptibility tests
    - Susceptibilities found
  - RS “Simulation” via Bulk Current Injection onto the cryoharness.
    - Various counter measures trialed

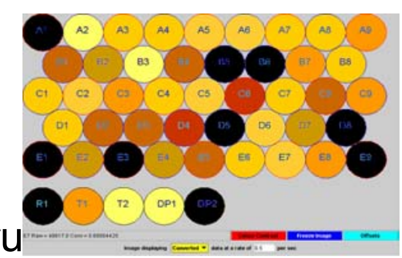
Susceptibility criteria

Table 3-3-3 Nominal Noise* Budget (in nV/√Hz)

	P/LW	P/MW	P/SW	S/LW	S/SW
Photon	21	26	30	24	30
Phonon	9	9	9	9	9
Johnson	7	7	7	7	7
Load resistor	2	2	2	2	2
JFET	7	7	7	7	7
LIA	6	6	6	6	6
A/D	4	4	4	3	3
Quad. Subtotal	26	30	33	28	34
Thermal+	< 6	< 6	< 7	< 11	< 11
EMI/EMC	< 5	< 5	< 5	< 5	< 5
Microphonic	< 5	< 5	< 5	< 5	< 5
Bias lines	< 4	< 4	< 4	< 4	< 4
Quad. Total	< 28	< 32	< 35	< 31	< 37

EQM Testing

- Test IID-A levels
  - E and B Fields
- ISO cryostat with CQM instrument
  - Only PLW implemented
- Survey of entire test spectrum + threshold tests at identified susceptibilities

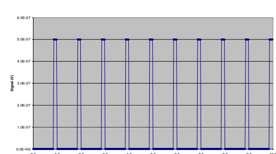


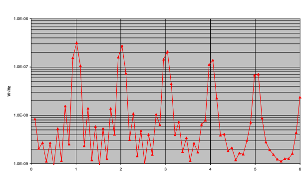
Test deficiencies

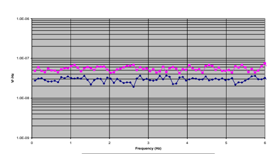
- The Warm Electronics is not flight representative, in particular:
  - The DRCU is not form and fit compliant with flight
  - The PSU is not present and the DRCU is powered by a bench power supply connected to the mains
  - Many boards are missing from the DRCU
  - Extra SPIRE harnesses were present (mechanisms test harness and detector bias isolation harness)
- Only the PLW detector chain is implemented. The PSW, PMW, SSW and SLW detector chains are not implemented
- Only a subset of the SPIRE cryoharness was implemented
- The test was not carried out in an anechoic EMC test facility
- Various items of EGSE (e.g. CCS harnesses) and MGSE (e.g. cryogen pumping ports, cryostat dolly) were present.
- There were several NCRs on the cryoharness manufacture (which were given the disposition use-as-is for the EQM programme)
- There are several (TBD) differences, not covered by the cryoharness NCRs, between the implementation of the EQM cryoharness and the PFM cryoharness
- The detector sampling rate was set to a higher rate than nominal to gain spectral information at higher frequencies
- The susceptibility of the detectors in flight will depend on both the as-delivered performance of the detector and various environmental variables; in particular the “bath” temperature of the detectors, the photon background, the optimum detector bias level etc. Improvement in these factors between the EQM (i.e. CQM) and the PFM will increase the susceptibility of the detector chain.

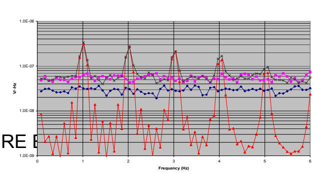
Test Signal

- Test signal 100% AM modulated @ 1 Hz 86% duty cycle
- Data analysis can be used to separate correlated and uncorrelated noise

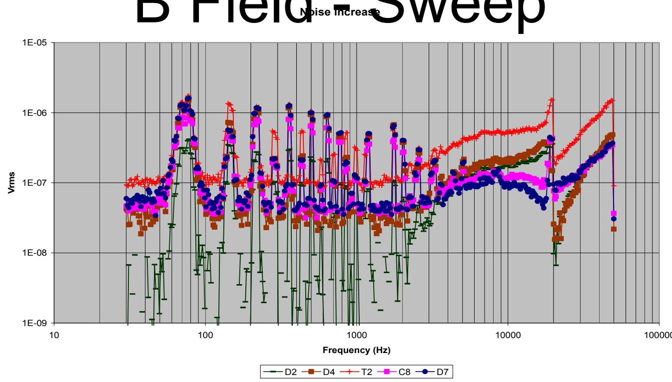








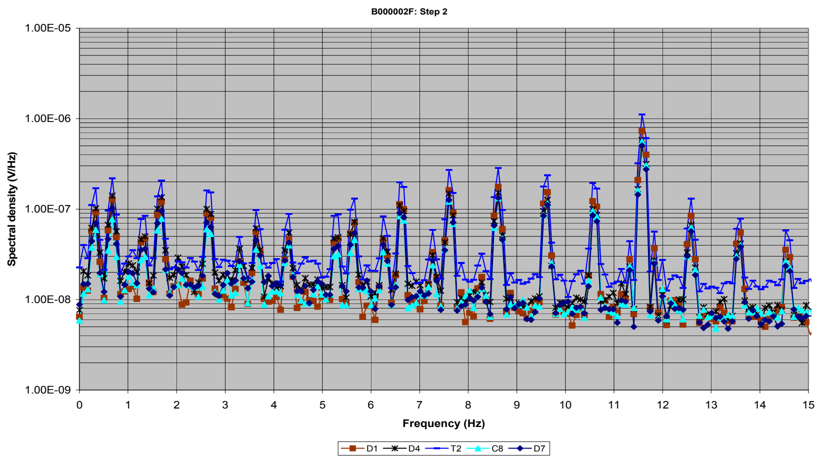
B Field - Sweep



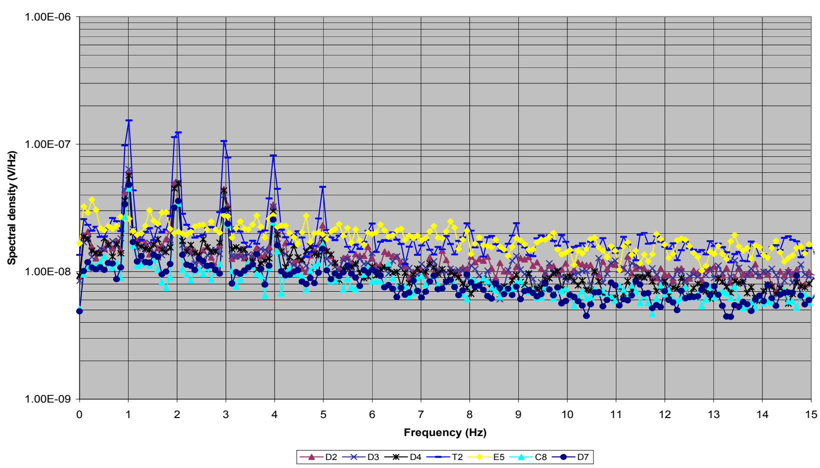
B-Field Susceptibilities

~134Hz
~257Hz
~400Hz
~517Hz
~652Hz
~1.34kHz
~2.41kHz
~2.97kHz
increasing between 4-19kHz
increasing between 20-50kHz

B-Field Susceptibilities
247Hz – 120 dBpT



B-Field Susceptibilities
50kHz – 100 dBpT



260Hz Susceptibility Threshold

Channel (a)	Peak Spectral Intensity @ 120dBpT (b)	Frequency (c)	Peak Spectral Intensity @ 110dBpT (d)	Attenuation (e)	Quiescent Noise intensity (f)	dB Out of Spec @ 120dBpT (g)	Threshold Field dBpT (h)
C8	2215nV/vHz	0.84 Hz	620nV/vHz	-11.1 dB	9.2nV/vHz	43.9 dB	80.3
D1	3571nV/vHz	0.84 Hz	991nV/vHz	-11.1 dB	12.6nV/vHz	46.1 dB	78.6
D2	1950nV/vHz	0.84 Hz	539nV/vHz	-11.2 dB	21.4nV/vHz	37.4 dB	86.5
D4	3750nV/vHz	0.84 Hz	1047nV/vHz	-11.1 dB	12.8nV/vHz	46.5 dB	78.1
D7	2778nV/vHz	0.84 Hz	771nV/vHz	-11.1 dB	10.7nV/vHz	45.0 dB	79.6
T2	6282nV/vHz	0.84 Hz	1746nV/vHz	-11.1 dB	15.3nV/vHz	49.8 dB	75.2

384Hz Susceptibility Threshold

Channel (a)	Peak Spectral Intensity @ 120dBpT (b)	Frequency (c)	Peak Spectral Intensity @ 110dBpT (d)	Attenuation (e)	Quiescent Noise intensity (f)	dB Out of Spec @ 120dBpT (g)	Threshold Field dBpT (h)
C8	2215nV/vHz	0.84 Hz	620nV/vHz	-11.1 dB	9.2nV/vHz	43.9 dB	80.3
D1	3571nV/vHz	0.84 Hz	991nV/vHz	-11.1 dB	12.6nV/vHz	46.1 dB	78.6
D2	1950nV/vHz	0.84 Hz	539nV/vHz	-11.2 dB	21.4nV/vHz	37.4 dB	86.5
D4	3750nV/vHz	0.84 Hz	1047nV/vHz	-11.1 dB	12.8nV/vHz	46.5 dB	78.1
D7	2778nV/vHz	0.84 Hz	771nV/vHz	-11.1 dB	10.7nV/vHz	45.0 dB	79.6
T2	6282nV/vHz	0.84 Hz	1746nV/vHz	-11.1 dB	15.3nV/vHz	49.8 dB	75.2

657Hz Susceptibility Threshold

Channel (a)	Peak Spectral Intensity @ 120dBpT (b)	Frequency (c)	Peak Spectral Intensity @ 110dBpT (d)	Attenuation (e)	Quiescent Noise intensity (f)	dB Out of Spec @ 120dBpT (g)	Threshold Field dBpT (h)
C8	1405nV/vHz	9.04 Hz	395nV/vHz	-11.0 dB	6.0nV/vHz	42.1 dB	81.8
D1	464nV/vHz	9.04 Hz	130nV/vHz	-11.0 dB	6.7nV/vHz	32.0 dB	91.0
D2	457nV/vHz	9.04 Hz	133nV/vHz	-10.7 dB	10.0nV/vHz	29.7 dB	92.3
D4	1460nV/vHz	9.04 Hz	411nV/vHz	-11.0 dB	8.2nV/vHz	40.9 dB	82.8
D7	1698nV/vHz	9.04 Hz	480nV/vHz	-11.0 dB	6.0nV/vHz	43.8 dB	80.1
E5	405nV/vHz	9.04 Hz	112nV/vHz	-11.2 dB	18.6nV/vHz	24.7 dB	97.9
T2	1604nV/vHz	9.04 Hz	451nV/vHz	-11.0 dB	19.9nV/vHz	36.2 dB	87.2

1436Hz Susceptibility Threshold

Channel (a)	Peak Spectral Intensity @ 120dBpT (b)	Frequency (c)	Peak Spectral Intensity @ 110dBpT (d)	Attenuation (e)	Quiescent Noise intensity (f)	dB Out of Spec @ 120dBpT (g)	Threshold Field dBpT (h)
B3	465nV/vHz	8.62 Hz	132nV/vHz	-10.9 dB	11.4nV/vHz	29.0 dB	93.4
C8	1297nV/vHz	8.62 Hz	315nV/vHz	-12.3 dB	6.6nV/vHz	41.0 dB	86.6
D4	1250nV/vHz	8.62 Hz	363nV/vHz	-10.7 dB	8.3nV/vHz	39.5 dB	83.3
D7	1387nV/vHz	8.62 Hz	389nV/vHz	-11.0 dB	7.1nV/vHz	41.2 dB	82.7
E5	524nV/vHz	8.62 Hz	152nV/vHz	-10.7 dB	16.0nV/vHz	27.9 dB	93.9
T2	1222nV/vHz	8.62 Hz	350nV/vHz	-10.9 dB	14.8nV/vHz	35.8 dB	87.0

2986Hz Susceptibility Threshold

Channel (a)	Peak Spectral Intensity @ 120dBpT (b)	Frequency (c)	Peak Spectral Intensity @ 110dBpT (d)	Attenuation (e)	Quiescent Noise intensity (f)	dB Out of Spec @ 120dBpT (g)	Threshold Field dBpT (h)
A6	1069nV/vHz	0.84 Hz	302nV/vHz	-11.0 dB	13.6nV/vHz	35.2 dB	87.9
B3	1067nV/vHz	0.84 Hz	301nV/vHz	-11.0 dB	17.1nV/vHz	33.7 dB	89.4
B8	958nV/vHz	0.84 Hz	276nV/vHz	-10.8 dB	18.5nV/vHz	32.2 dB	90.2
C8	1242nV/vHz	0.84 Hz	347nV/vHz	-11.1 dB	9.2nV/vHz	38.8 dB	85.0
D4	2251nV/vHz	0.84 Hz	635nV/vHz	-11.0 dB	12.8nV/vHz	42.0 dB	81.8
D7	2016nV/vHz	0.84 Hz	572nV/vHz	-10.9 dB	10.7nV/vHz	42.2 dB	81.5
T2	1889nV/vHz	0.84 Hz	528nV/vHz	-11.1 dB	15.3nV/vHz	39.4 dB	84.4

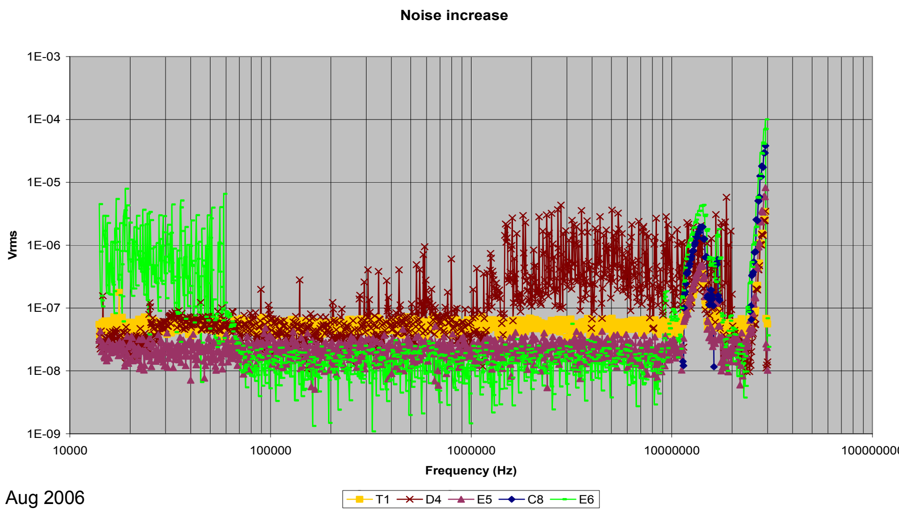
48.176kHz Susceptibility Threshold

Channel (a)	Heating @ 110dBpT (b)	Heating @ 100dBpT (c)	Attenuation (d)	dB OOS @ 110dBpT (e)	Threshold dBpT (f)
C8	601 nV	25 nV	-27.7dB	41.6	95.0
D2	886 nV	30 nV	-29.4dB	45.0	94.7
D3	839 nV	29 nV	-29.4dB	44.5	94.8
D4	823 nV	33 nV	-27.8dB	44.3	94.1
D7	610 nV	25 nV	-27.7dB	41.7	94.9
E5	143 nV	-2 nV	NA	29.1	NA
T2	2243 nV	119 nV	-25.5dB	53.0	89.2

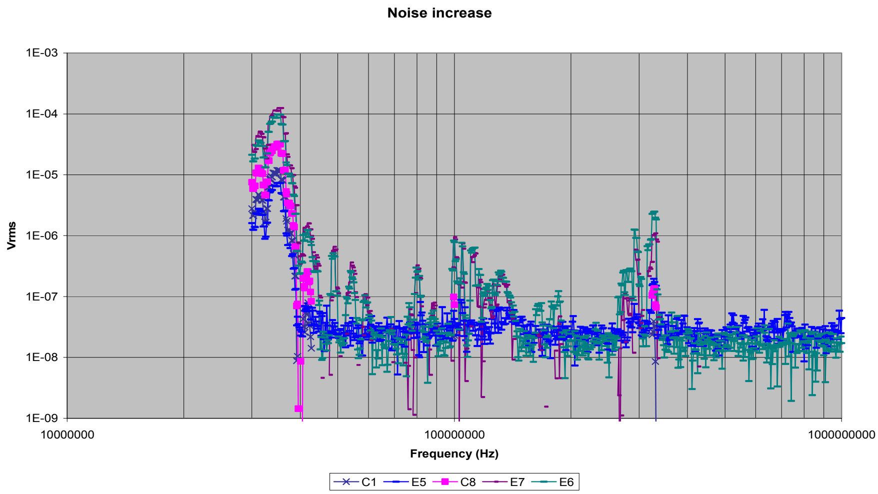
50 kHz Susceptibility Threshold

Channel (a)	Heating @ 110dBpT (b)	Heating @ 100dBpT (c)	Attenuation (d)	dB OOS @ 110dBpT (e)	Threshold dBpT (f)
C8	658 nV	29 nV	-27.2dB	42.4	94.4
D2	996 nV	40 nV	-27.9dB	46.0	93.5
D3	940 nV	34 nV	-28.9dB	45.5	94.2
D4	939 nV	40 nV	-27.4dB	45.5	93.4
D7	670 nV	28 nV	-27.6dB	42.5	94.6
E5	159 nV	1 nV	NA	30.1	NA
T2	2509 nV	129 nV	-25.8dB	54.0	89.0

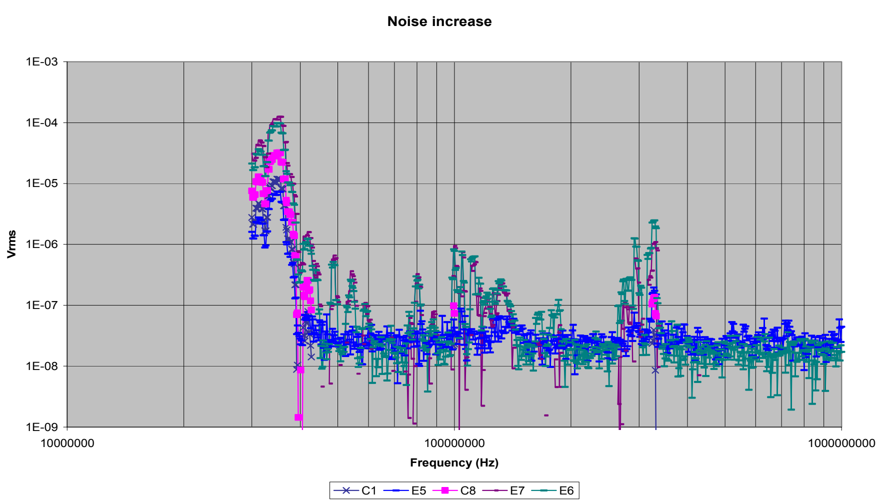
E-Field Tests
15-kHz – 30 MHz Sweep



E-Field
30MHz – 1GHz Sweep



E-Field
30MHz – 1GHz Sweep

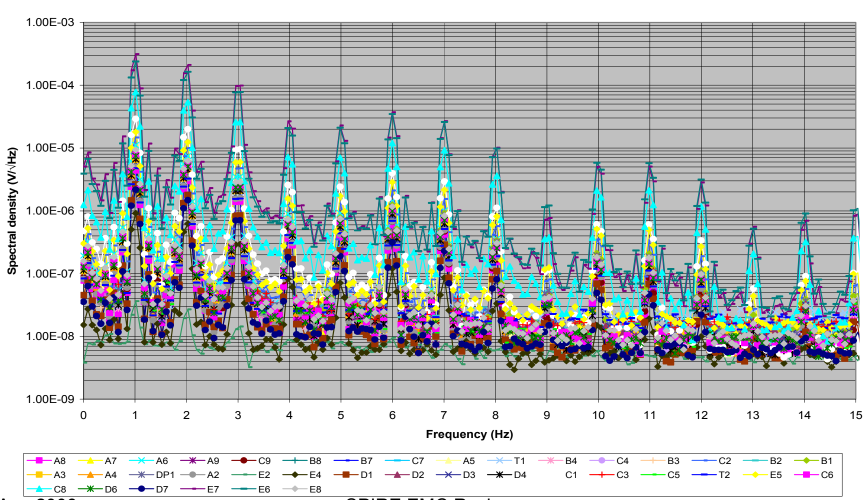


10 Aug 2006
SPIRE EMC Review

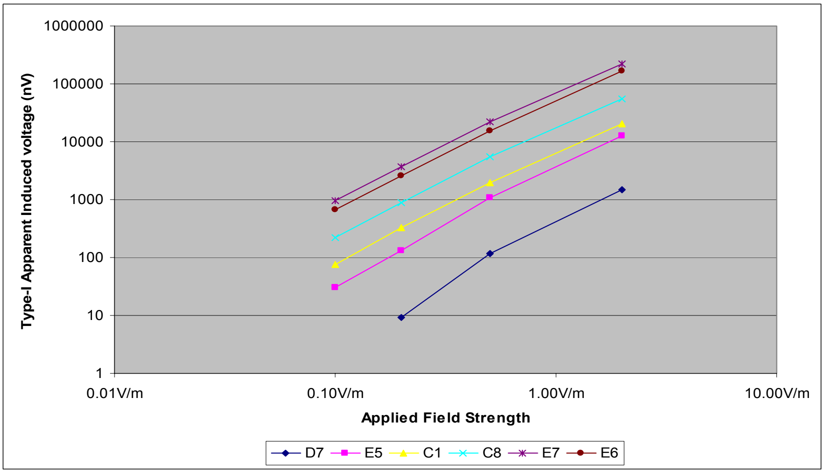
E-Field Susceptibilities

30-40MHz
~41.9MHz
~48.7MHz
~53.9MHz
~58.8MHz
~79.7MHz
~99.6MHz
~104MHz
~113MHz
~116MHz
~132MHz
~168MHz
~186MHz
~270-290MHz
~293MHz
~329MHz

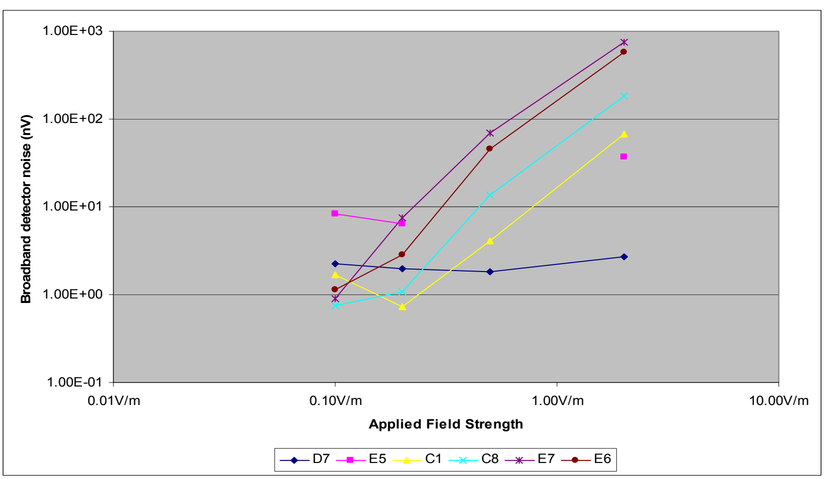
34.204MHz 2V/m



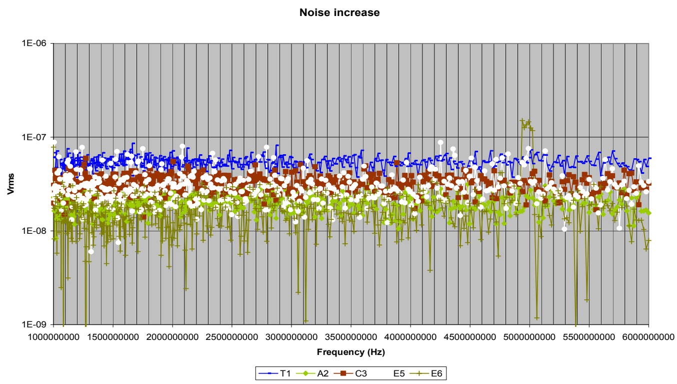
Susceptibility Threshold @ 34.204MHz



Susceptibility Threshold @ 34.204MHz

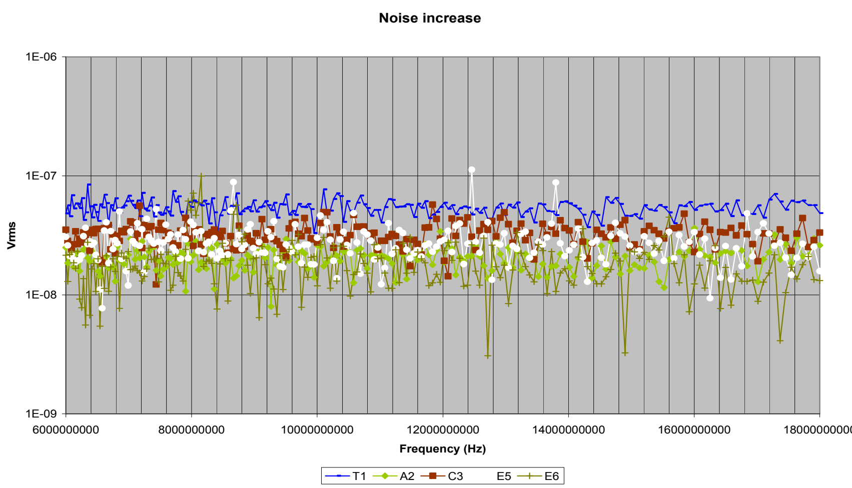


1-6GHz Sweep



10 Aug 2006 SPIRE EMC Review

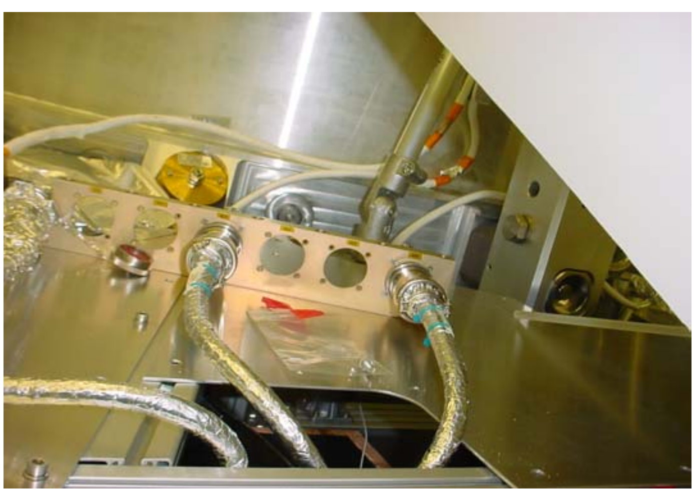
1-6GHz Sweep



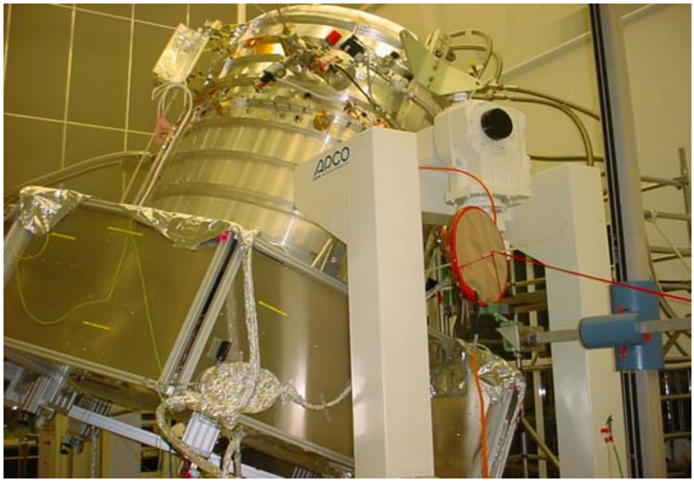
10 Aug 2006 SPIRE EMC Review

Loop Antenna

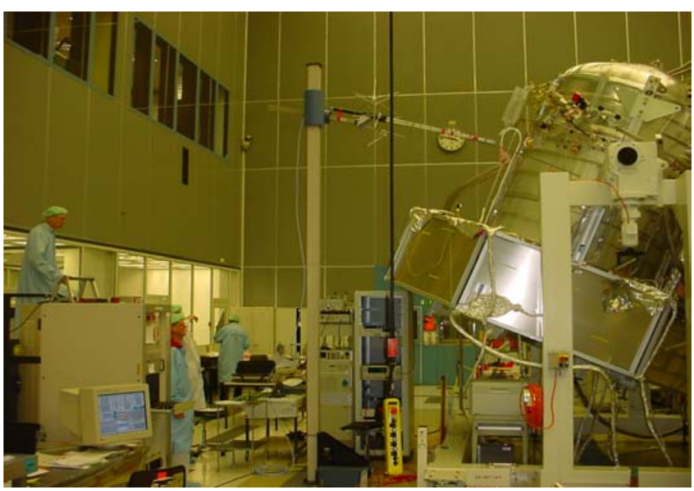
Cryoharness



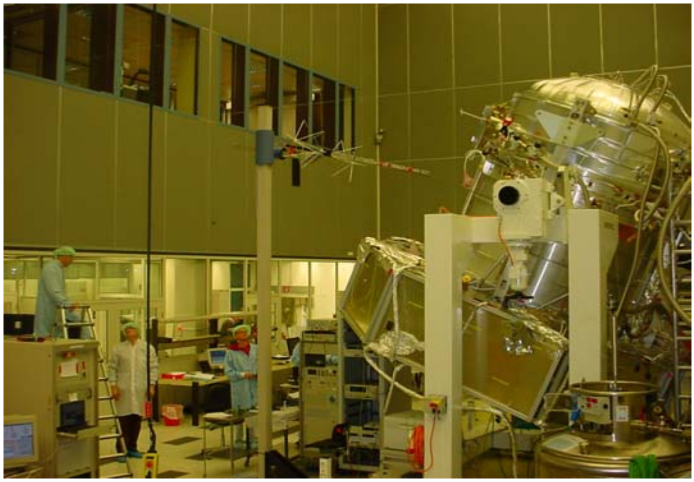
Loop antenna, cryostat and dolly



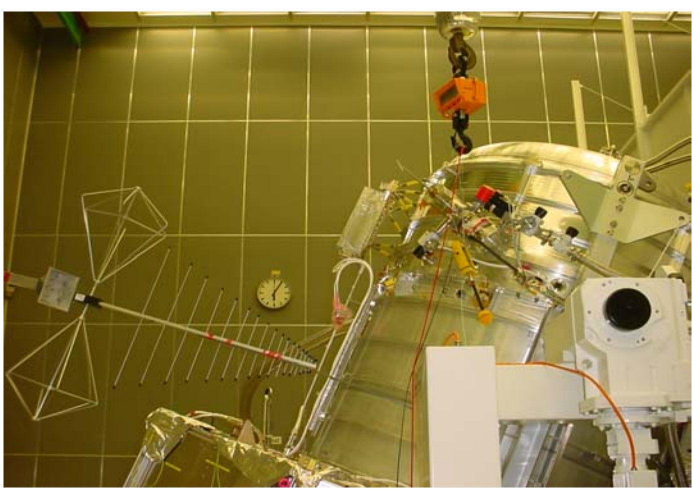
E-Field



E-Field



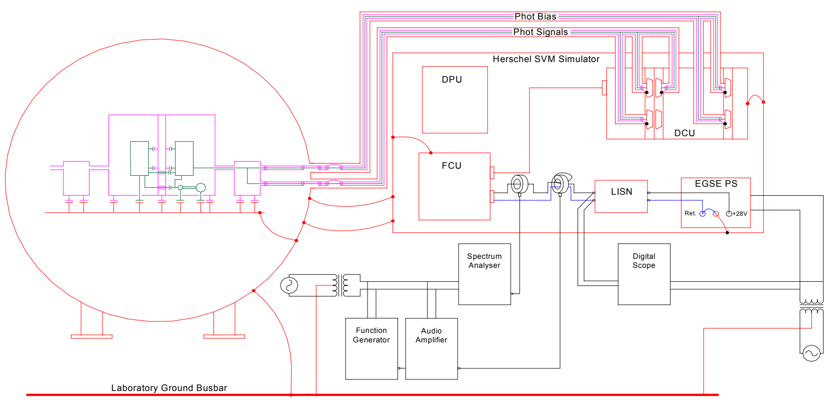
E-Field



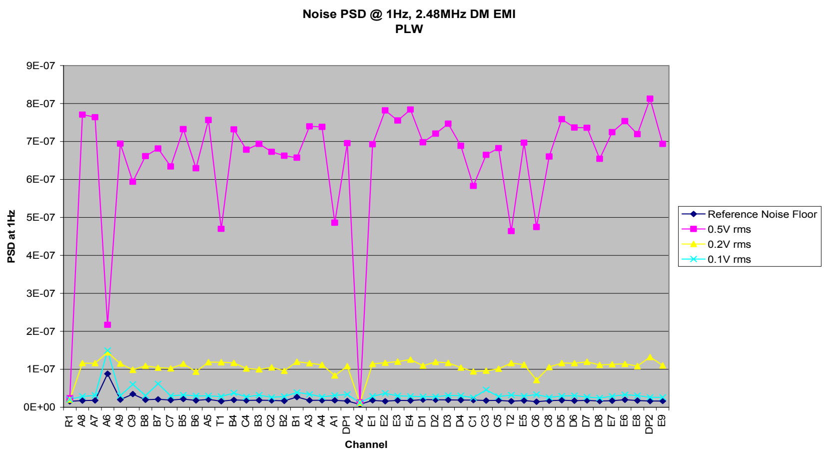
Summary

- Susceptibility thresholds low
  - Probably OK for B-Field
  - Probably not OK for E-Field
- Susceptibility dependence on test set-up

ILT CS Testing
PFM-3 Test

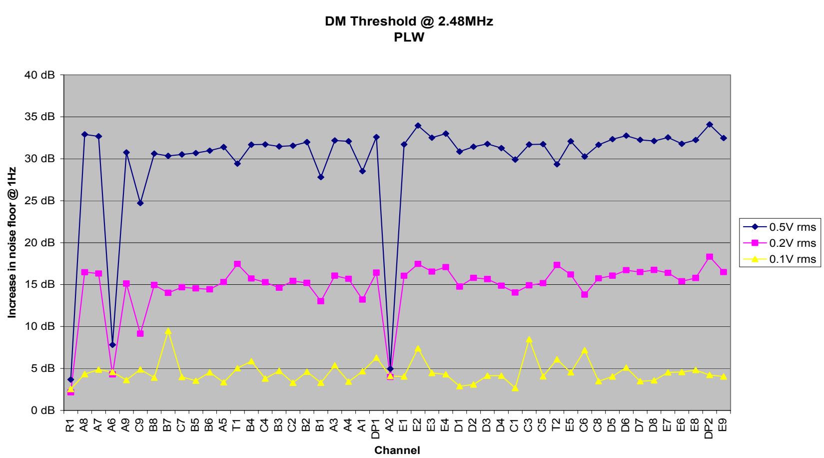


DM Susceptibility @ 2.48MHz



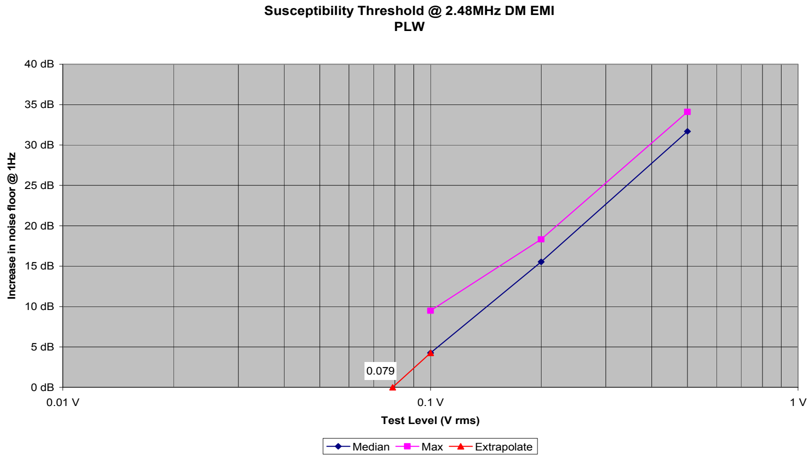
10 Aug 2006 SPIRE EMC Review

DM Susceptibility @ 2.48MHz

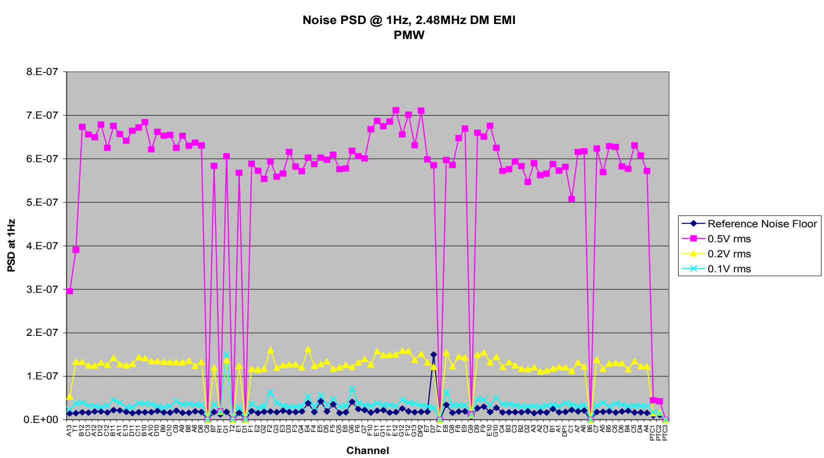


10 Aug 2006 SPIRE EMC Review

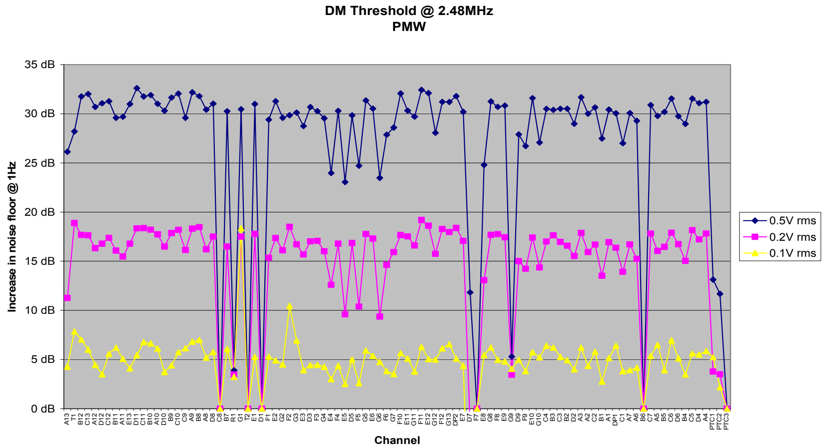
DM Susceptibility @ 2.48MHz



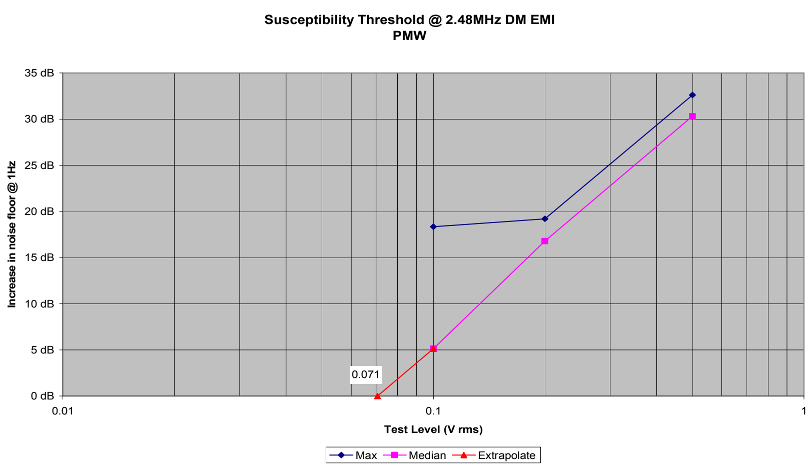
DM Susceptibility @ 2.48MHz



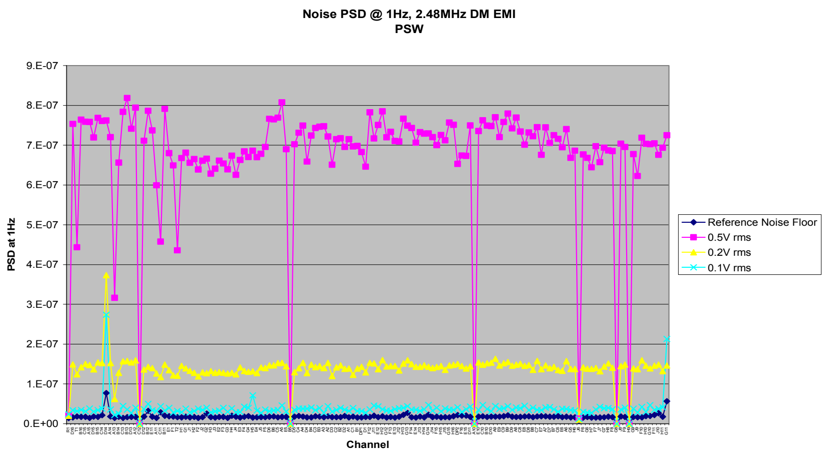
DM Susceptibility @ 2.48MHz



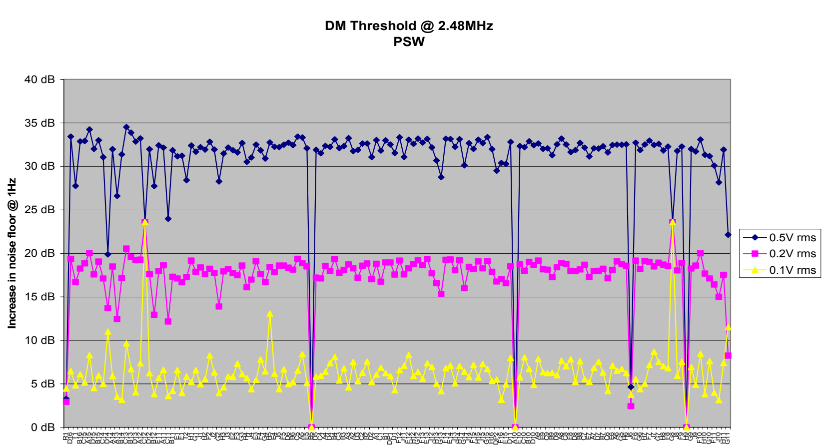
DM Susceptibility @ 2.48MHz



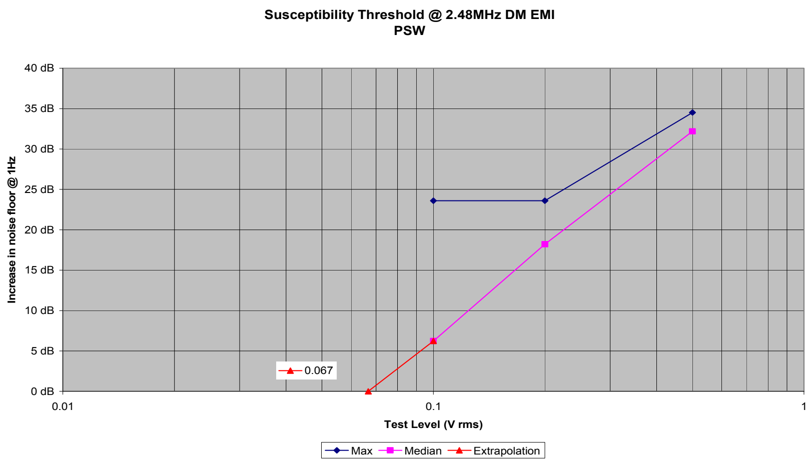
DM Susceptibility @ 2.48MHz



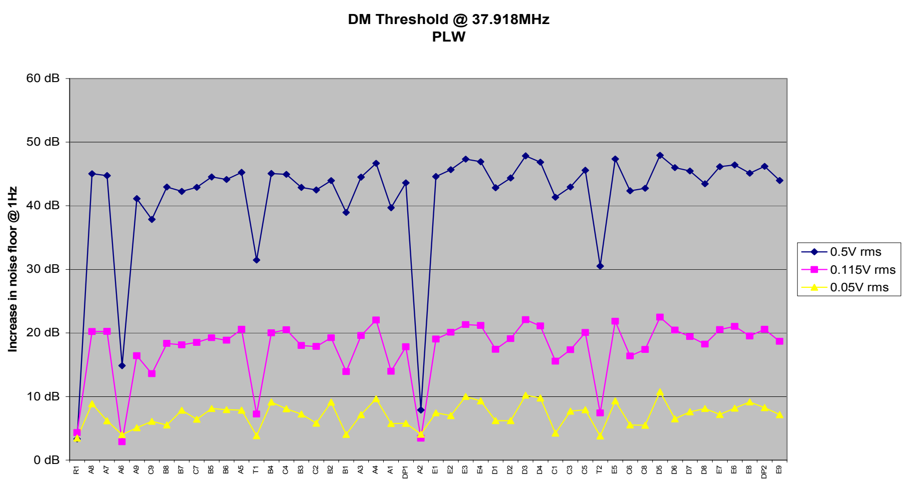
DM Susceptibility @ 2.48MHz



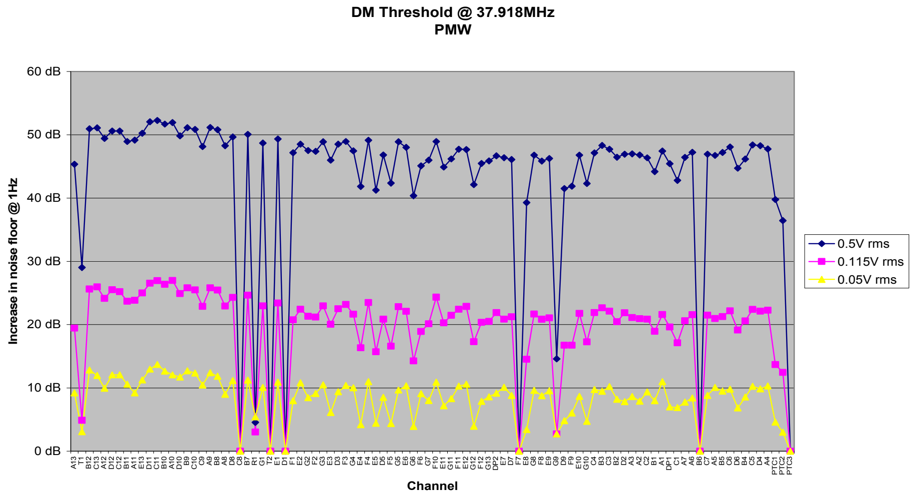
DM Susceptibility @ 2.48MHz



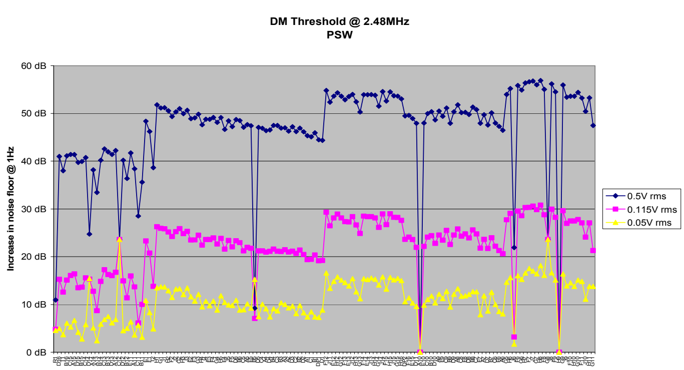
DM Susceptibility @ 37.918MHz



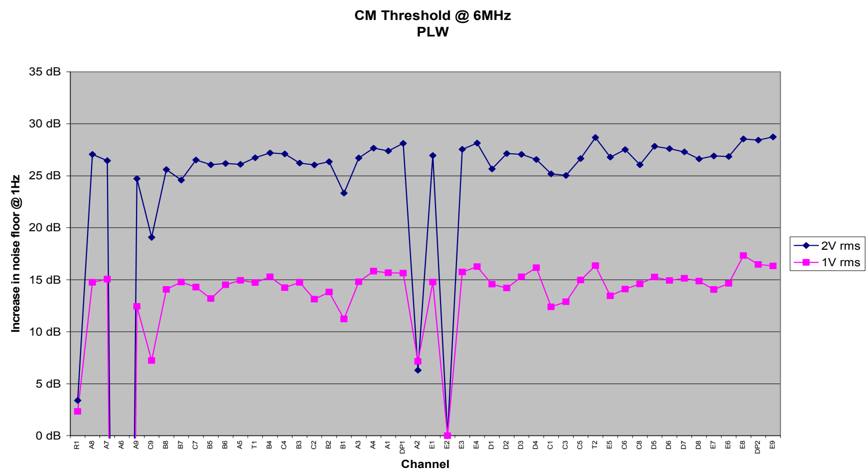
DM Susceptibility @ 37.918MHz



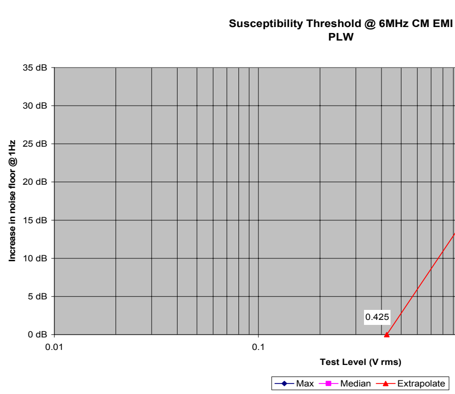
DM Susceptibility @ 37.918MHz



CM Susceptibility 6MHz

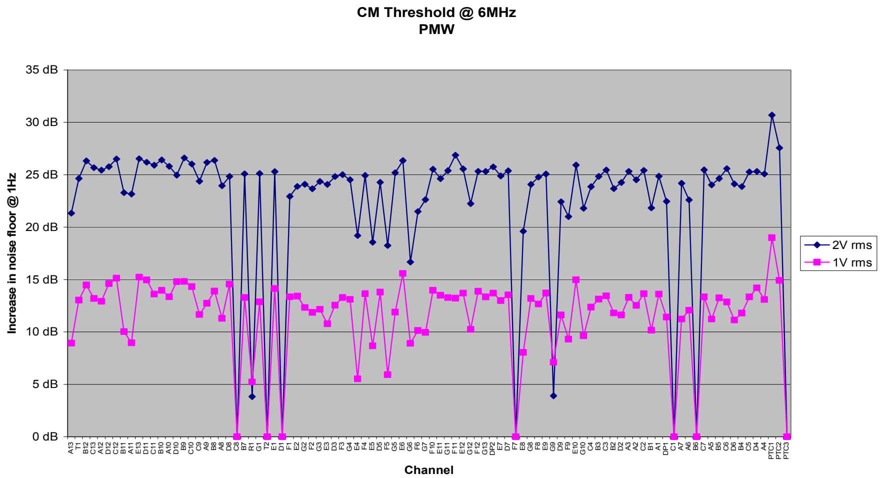


CM Susceptibility 6MHz

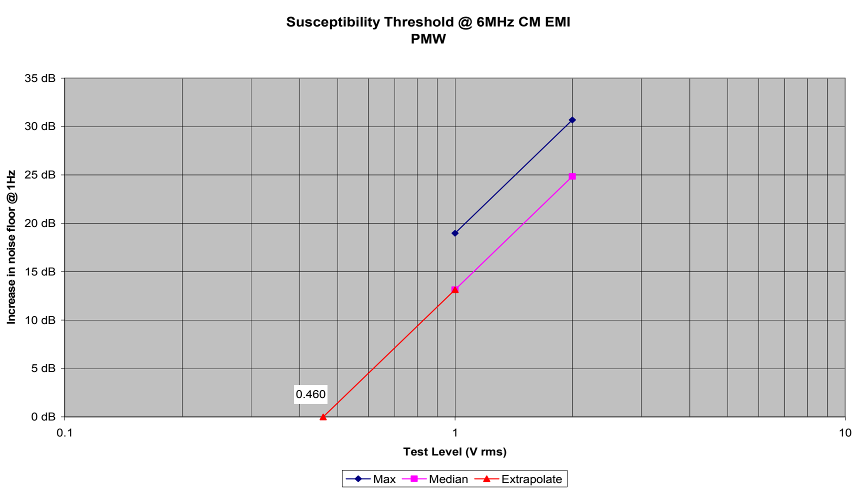


10 Aug 2006 SPIRE EMC Review

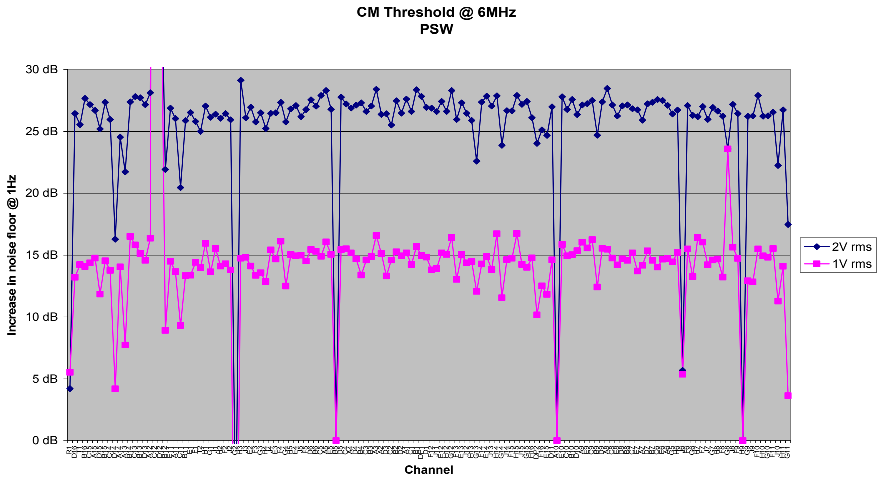
CM Susceptibility 6MHz



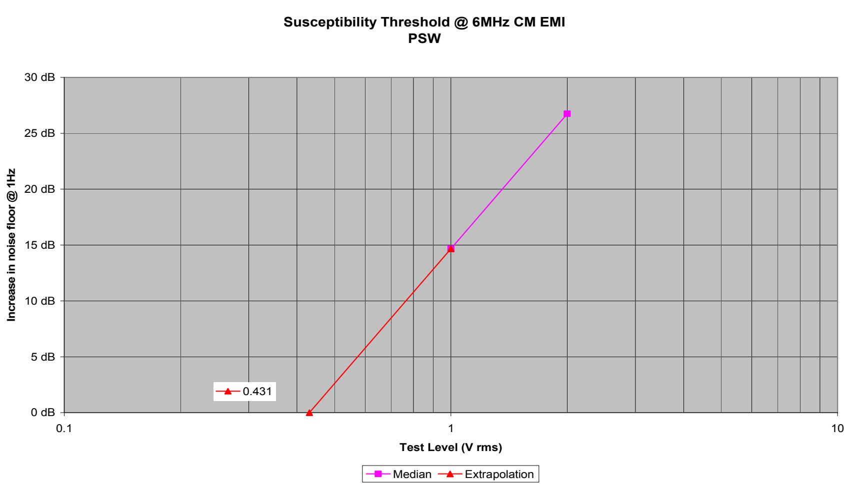
CM Susceptibility 6MHz



CM Susceptibility 6MHz



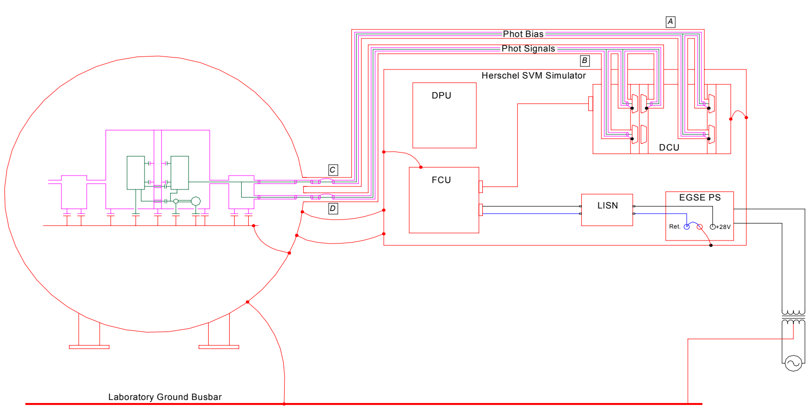
CM Susceptibility 6MHz



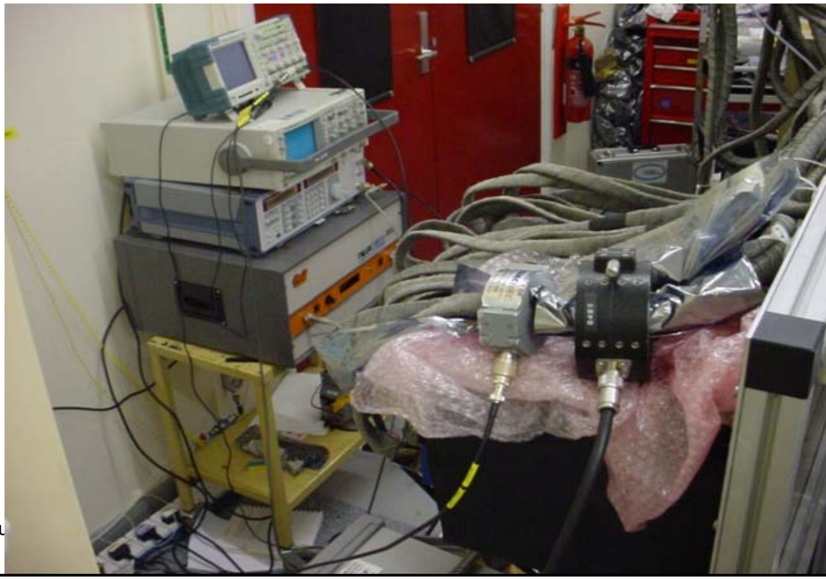
CM Summary

	Frequency	PLW	PMW	PSW
DM	2.48 MHz	79 mV	71 mV	67 mV
	3.67 MHz	92 mV	77 mV	86 mV
	5.40 MHz			
	9.27 MHz			
	11.25 MHz			
	16.17 MHz			
	20.10 MHz			
	28.25 MHz	?	24 mV	31 mV
	36.67 MHz			
	37.92 MHz	33 mV	29 mV	26 mV
CM	6.00 MHz	425 mV	460 mV	431 mV
	8.50 MHz			
	9.50 MHz			
	15.30 MHz	486 mV	603 mV	639 mV
	20.00 MHz			
	34.00 MHz	720 mV	687 mV	732 mV
	39.00 MHz			
	47.60 MHz	749 mV	634 mV	606 mV

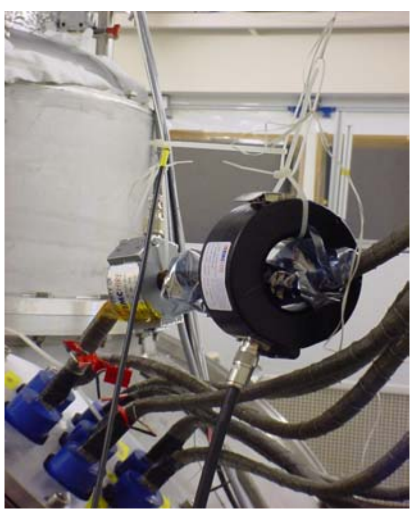
RS Simulation



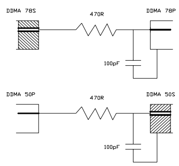
RS Simulation



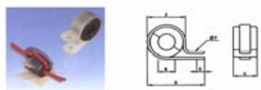
RS Simulation



RS Simulation - Filters



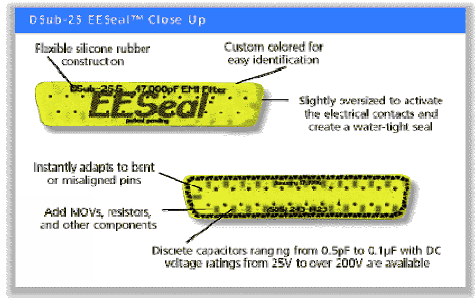
TRCN Split Ferrite Core with Nylon mounting



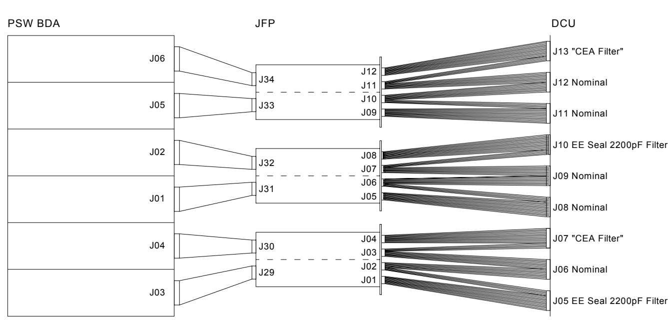
Split construction enables easy installation of cables already wired and installed, or cables with connectors on. The unit comes complete with mounting clamp. Suitable for single or multiple cables.

Specification

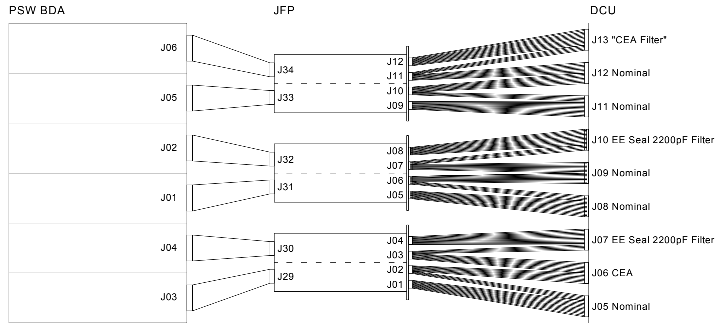
Part No	Dimensions A	B	C	D	E	Impedance Ω 1 turn 25MHz	100MHz	Impedance Ω 2 turn 25MHz	100MHz	Maximum Cable Diameter
TRCN-16-8-13	19.4	8.2	13.0	30.2	4.3	59	93	231	396	8.00
TRCN-16-8-16	19.4	8.2	16.0	30.2	4.3	64	106	291	504	8.00
TRCN-20-10-10	25.7	10.4	10.0	38.2	5.1	53	84	203	360	10.0
TRCN-23-11-14	26.8	11.4	14.0	39.4	5.1	72	112	289	449	11.0
TRCN-28-16-13	32.8	16.4	13.0	45.0	5.1	56	90	325	579	16.0
TRCN-28-16-20	32.8	16.4	20.0	45.0	5.1	79	135	325	579	16.0
TRCN-40-27-15	44.6	27.4	15.0	57.3	5.1	48	84	195	365	27.0



RS Simulation

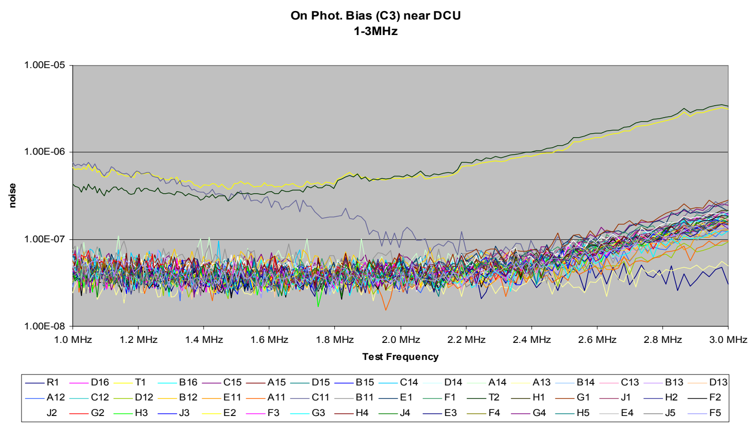


RS Simulation



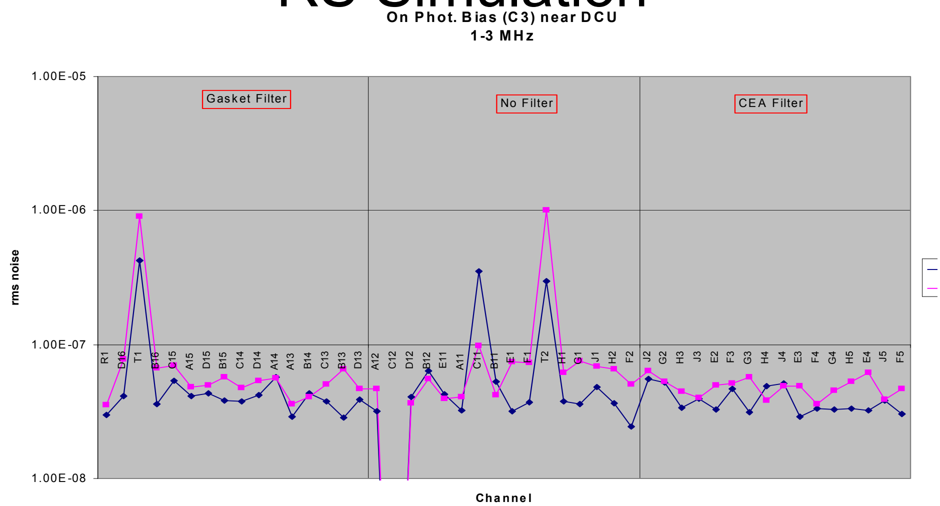
10 Aug 2006 SPIRE EMC Review

RS Simulation



10 Aug 2006 SPIRE EMC Review

RS Simulation



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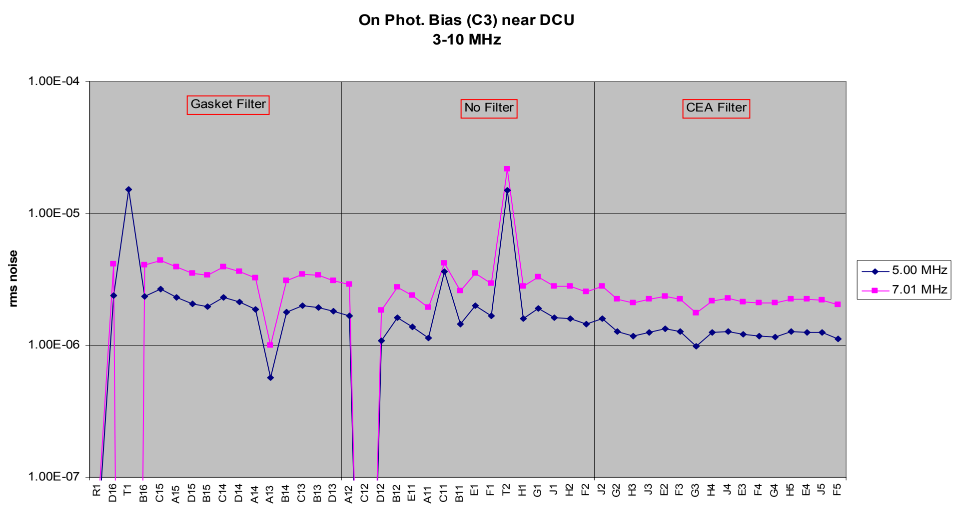
RS Simulation



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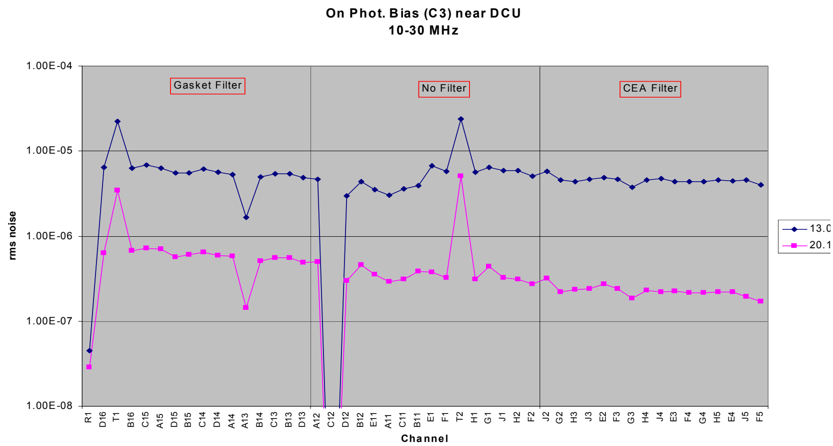
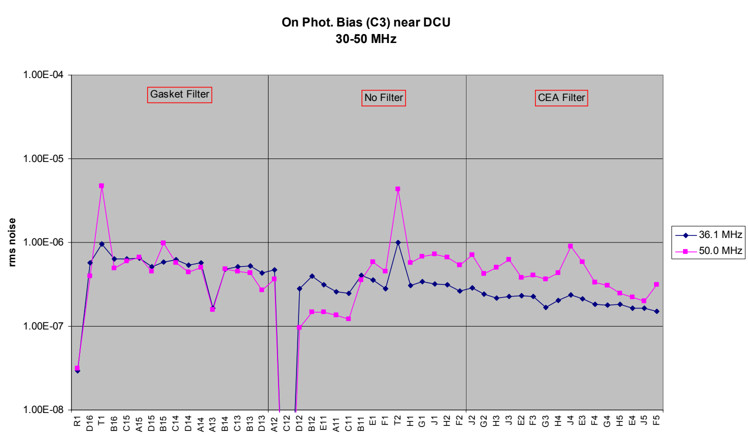
RS Simulation



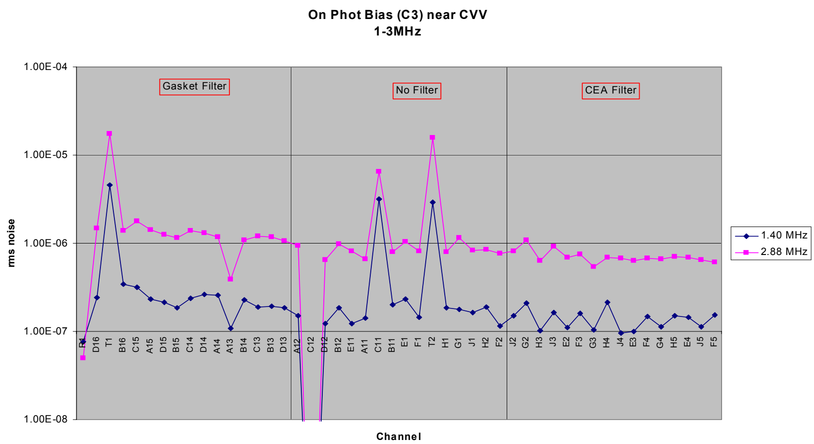
10 Aug 2006 SPIRE EMC Review

RS Simulation



10 Aug 2006 SPIRE EMC Review

RS Simulation



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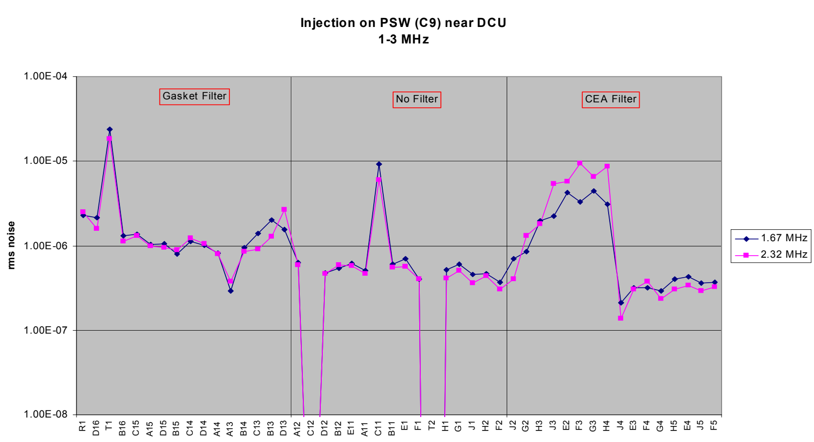
RS Simulation



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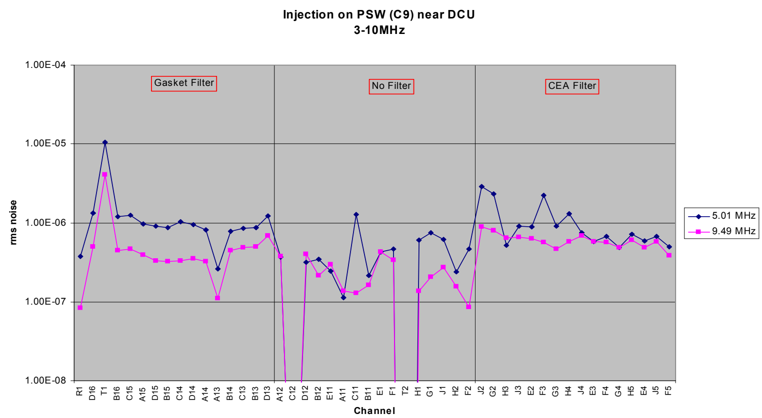
RS Simulation



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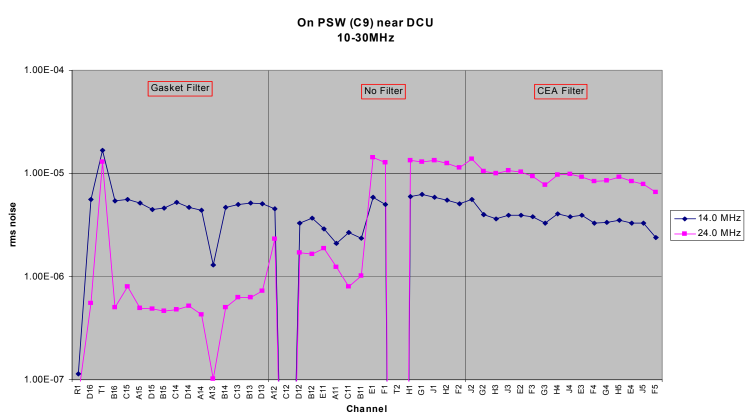
RS Simulation



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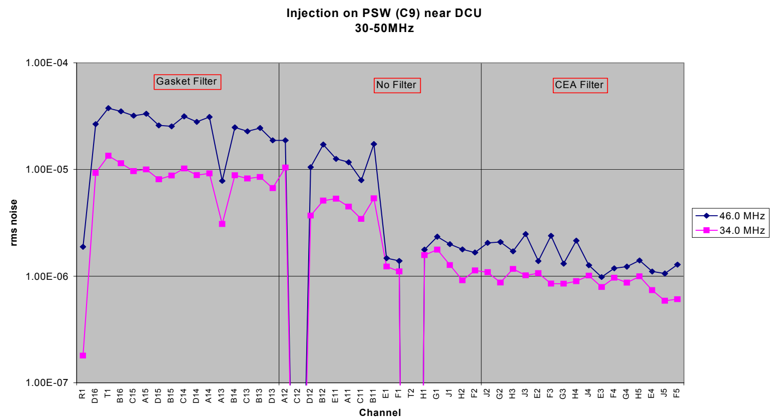
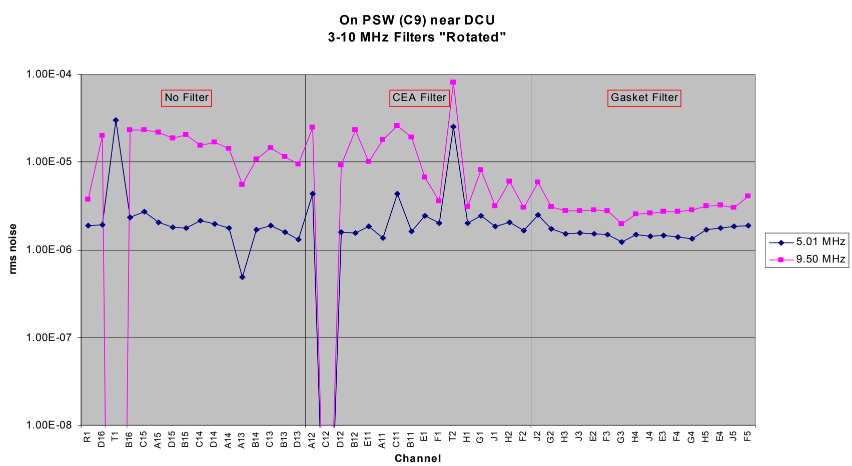
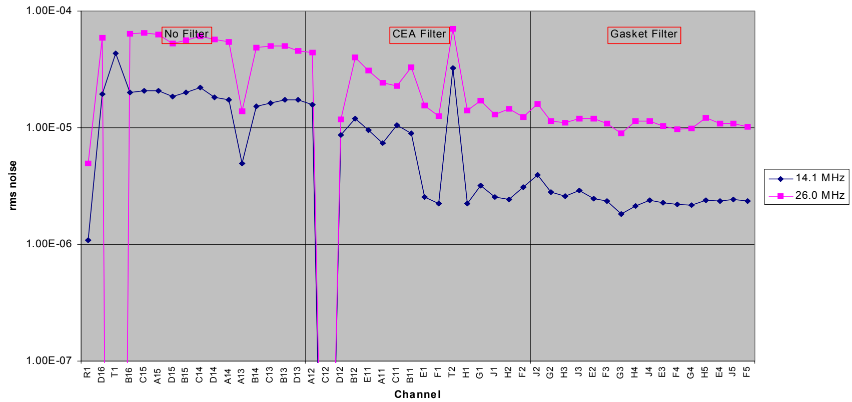


RS Simulation



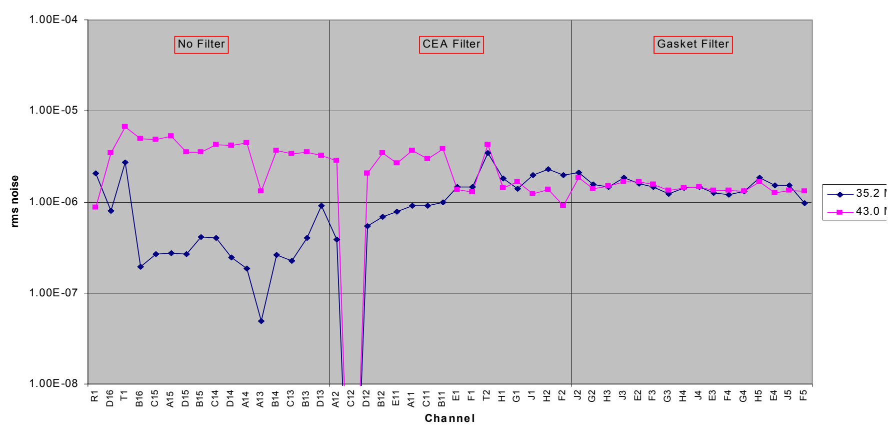
RS Simulation

On PSW (C9) near DCU
10-30 MHz Filters "Rotated"

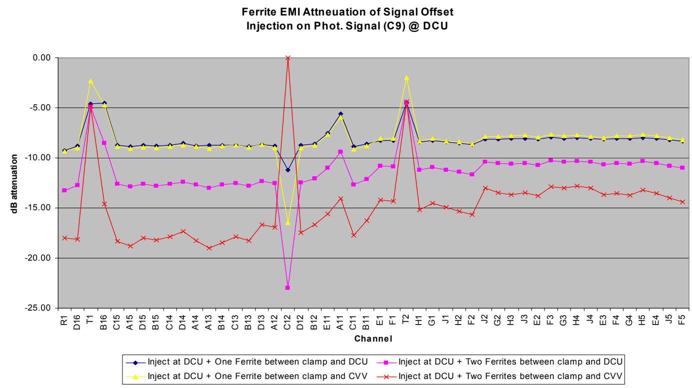


RS Simulation

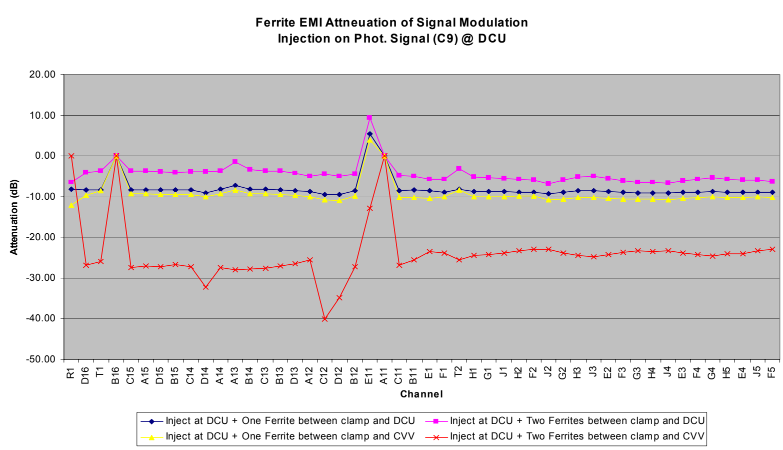
On PSW (C9) near DCU
30-50 MHz Filters "Rotated"



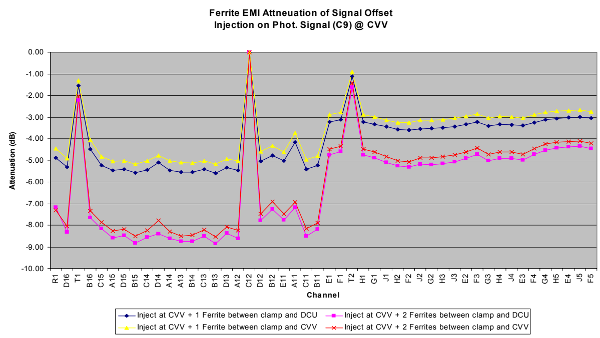
RS Simulation



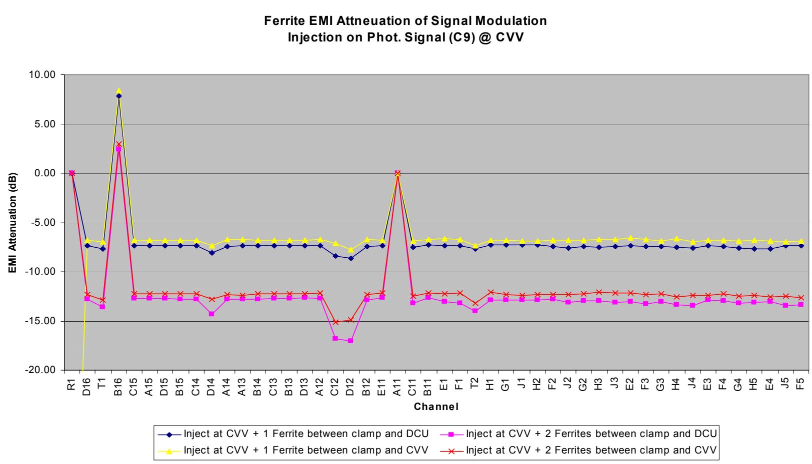
RS Simulation



RS Simulation



RS Simulation



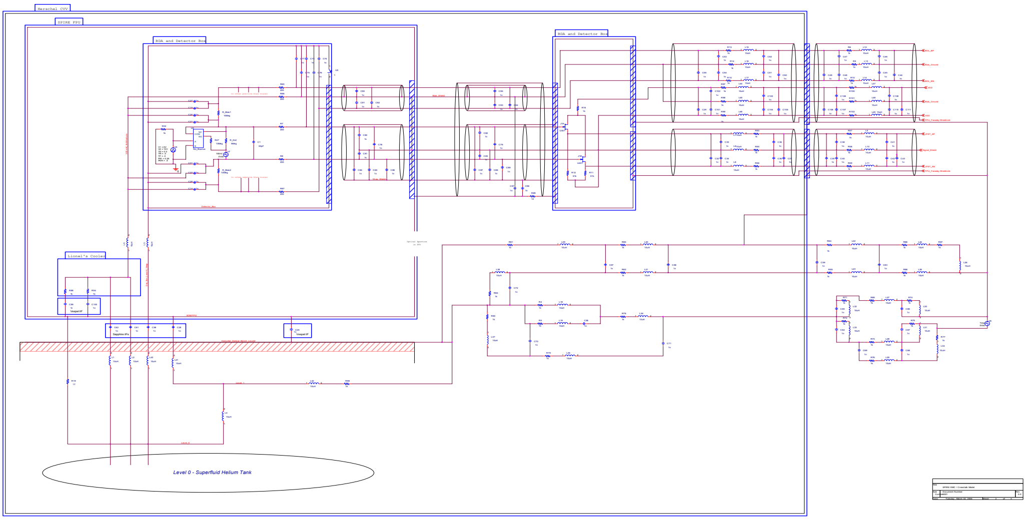
STM-2 EMC Tests

Test	Freq.	Antenna	level	Time	Total time
Sweep 1	8-15MHz	Rod	2V/m	00:30	
Spot 1	Worst in 8-15MHz Band	Rod	2 V/m	00:10	00:40
Spot 2	Ditto	Rod	1 V/m	00:10	00:50
Spot 3	Ditto	Rod	0.5 V/m	00:10	01:00
Spot 4	Ditto	Rod	0.25 V/m	00:10	01:10
Clamp ferrites onto Cryoharness				00:30	01:40
Sweep 2	8-15MHz	Rod	2V/m	00:30	02:10
Spot 5	Worst in 8-15MHz Band	Rod	2 V/m	00:10	02:20
Spot 6	Ditto	Rod	1 V/m	00:10	02:30
Spot 7	Ditto	Rod	0.5 V/m	00:10	02:40
Spot 8	Ditto	Rod	0.25 V/m	00:10	02:50
Remove ferrites				00:10	03:00
Change antenna				00:30	03:30
Sweep 3	15-30MHz	Log-periodic	2 V/m	00:30	04:00
Sweep 4	30-60MHz	Log-periodic	2 V/m	00:30	04:30
Sweep 5	60-120MHz	Log-periodic	2 V/m	00:30	05:00
Spot 9	Worst in 15-120 MHz Band	Log-periodic	2 V/m	00:10	05:10
Spot 10	Worst in 15-120 MHz Band	Log-periodic	1 V/m	00:10	05:20
Spot 11	Worst in 15-120 MHz Band	Log-periodic	0.5 V/m	00:10	05:30
Spot 12	Worst in 15-120 MHz Band	Log-periodic	0.25 V/m	00:10	05:40
Spot 13	2nd worst in 15-120MHz band	Log-periodic	2 V/m	00:10	05:50
Spot 14	2nd worst in 15-120MHz band	Log-periodic	1 V/m	00:10	06:00
Spot 15	2nd worst in 15-120MHz band	Log-periodic	0.5 V/m	00:10	06:10
Spot 16	2nd worst in 15-120MHz band	Log-periodic	0.25 V/m	00:10	06:20
Spot 17	3rd worst in 15-120MHz band	Log-periodic	2 V/m	00:10	06:30
Spot 18	3rd worst in 15-120MHz band	Log-periodic	1 V/m	00:10	06:40
Spot 19	3rd worst in 15-120MHz band	Log-periodic	0.5 V/m	00:10	06:50
Spot 20	3rd worst in 15-120MHz band	Log-periodic	0.25 V/m	00:10	07:00
Clamp ferrites onto Cryoharness				00:10	07:10
Sweep 6	15-30MHz	Log-periodic	2 V/m	00:30	07:40
Sweep 7	30-60MHz	Log-periodic	2 V/m	00:30	08:10
Sweep 8	60-120MHz	Log-periodic	2 V/m	00:30	08:40
Spot 21	Worst in 15-120 MHz Band	Log-periodic	2 V/m	00:10	08:50
Spot 22	Worst in 15-120 MHz Band	Log-periodic	1 V/m	00:10	09:00
Spot 23	Worst in 15-120 MHz Band	Log-periodic	0.5 V/m	00:10	09:10
Spot 24	Worst in 15-120 MHz Band	Log-periodic	0.25 V/m	00:10	09:20
Spot 25	2nd worst in 15-120MHz band	Log-periodic	2 V/m	00:10	09:30
Spot 26	2nd worst in 15-120MHz band	Log-periodic	1 V/m	00:10	09:40
Spot 27	2nd worst in 15-120MHz band	Log-periodic	0.5 V/m	00:10	09:50
Spot 28	2nd worst in 15-120MHz band	Log-periodic	0.25 V/m	00:10	10:00
Spot 29	3rd worst in 15-120MHz band	Log-periodic	2 V/m	00:10	10:10
Spot 30	3rd worst in 15-120MHz band	Log-periodic	1 V/m	00:10	10:20
Spot 31	3rd worst in 15-120MHz band	Log-periodic	0.5 V/m	00:10	10:30
Spot 32	3rd worst in 15-120MHz band	Log-periodic	0.25 V/m	00:10	10:40

PFM EMC Testing

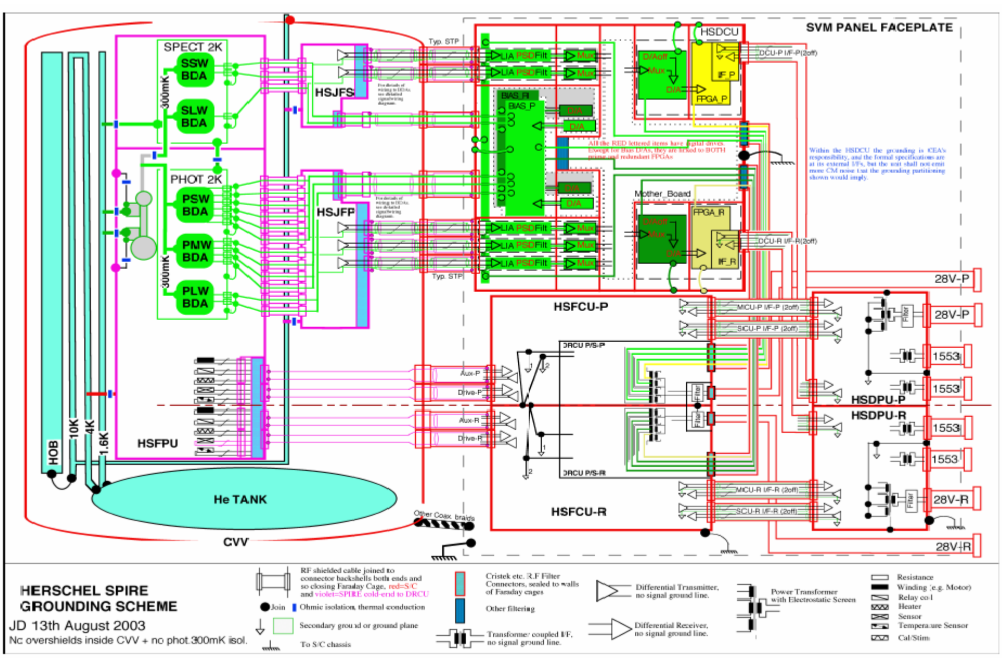
- EMC tests
  - 3 weeks allocated (instrument & satellite)
  - Duration to be refined
  - Refinement of susceptibility identifed during EQM,
- On PFM, during EMC tests
  - Selected representative <u>subsets of IST</u> sequences are run. Sequences are selected wrt EMC

SPIRE Cold Electronics



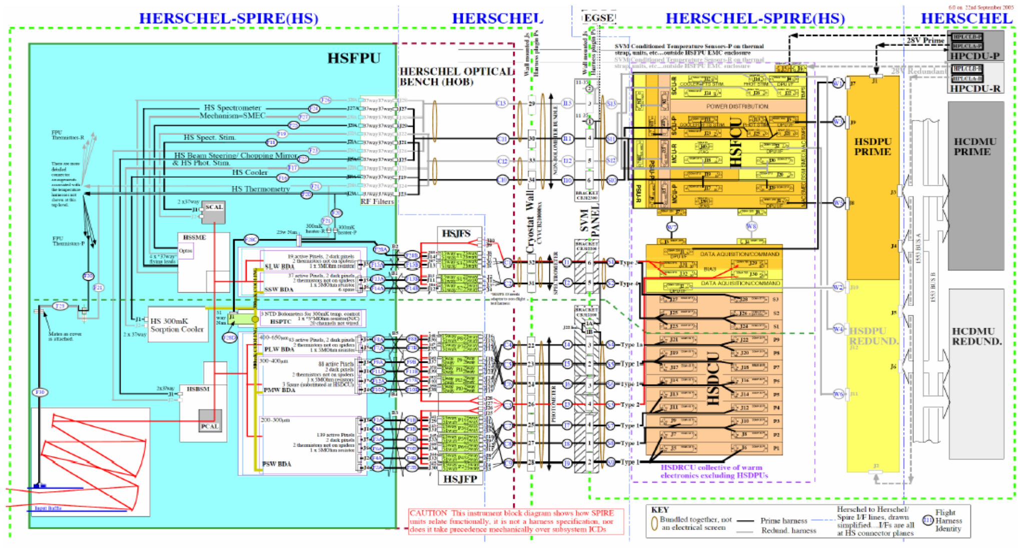
10 Aug 2006 SPIRE EMC Review

SPIRE Grounding Scheme

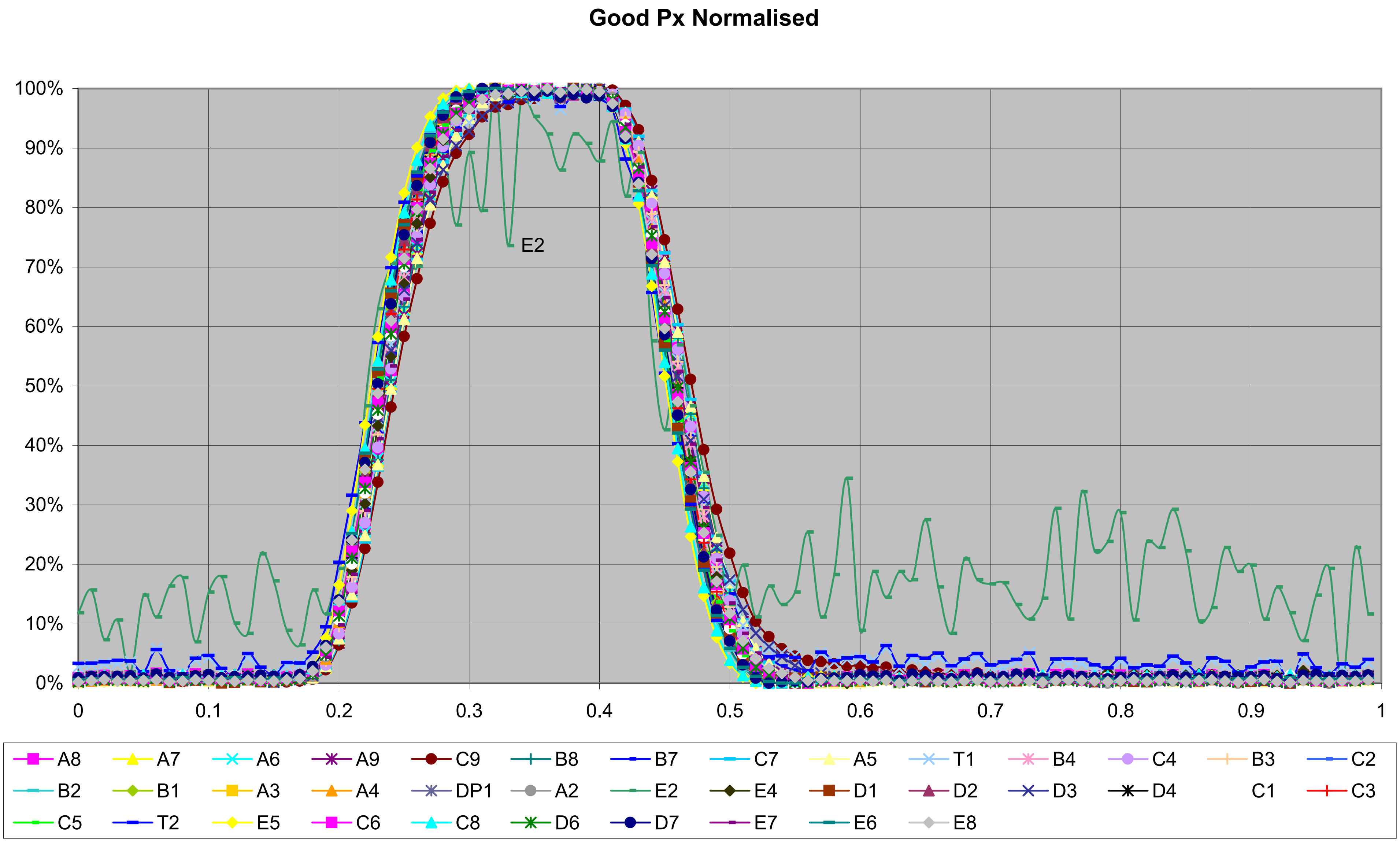


10 Aug 2006 SPIRE EMC Review

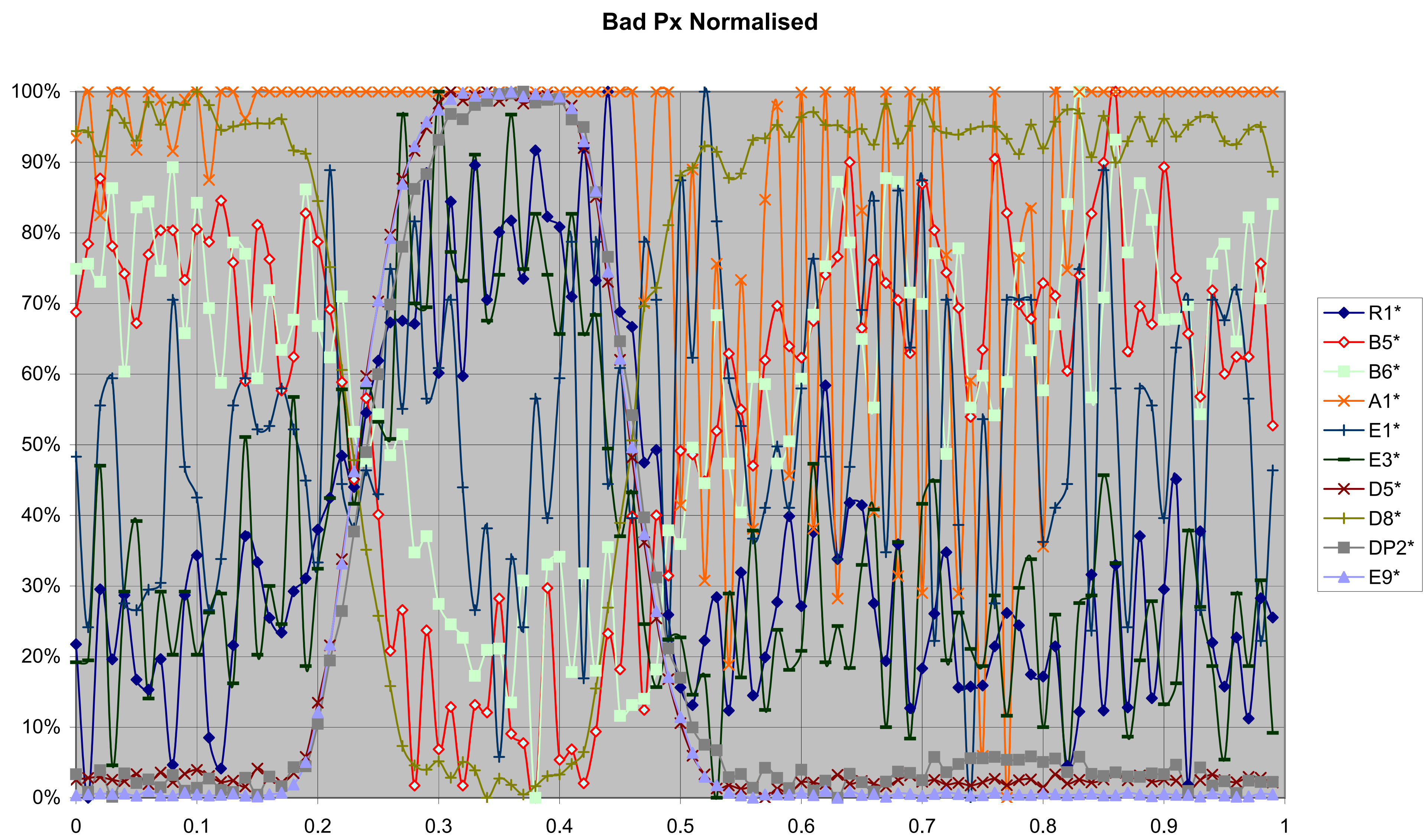
SPIRE Block Diagram



B. Plot of co-added EMI



Good Px Normalised
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
E2
A8
A7
A6
A9
C9
B8
B7
C7
A5
T1
B4
C4
B3
C2
B2
B1
A3
A4
DP1
A2
E2
E4
D1
D2
D3
D4
C1
C3
C5
T2
E5
C6
C8
D6
D7
E7
E6
E8


Bad Px Normalised
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
R1*
B5*
B6*
A1*
E1*
E3*
D5*
D8*
DP2*
E9*

C. RS Simulation Report

1. Introduction

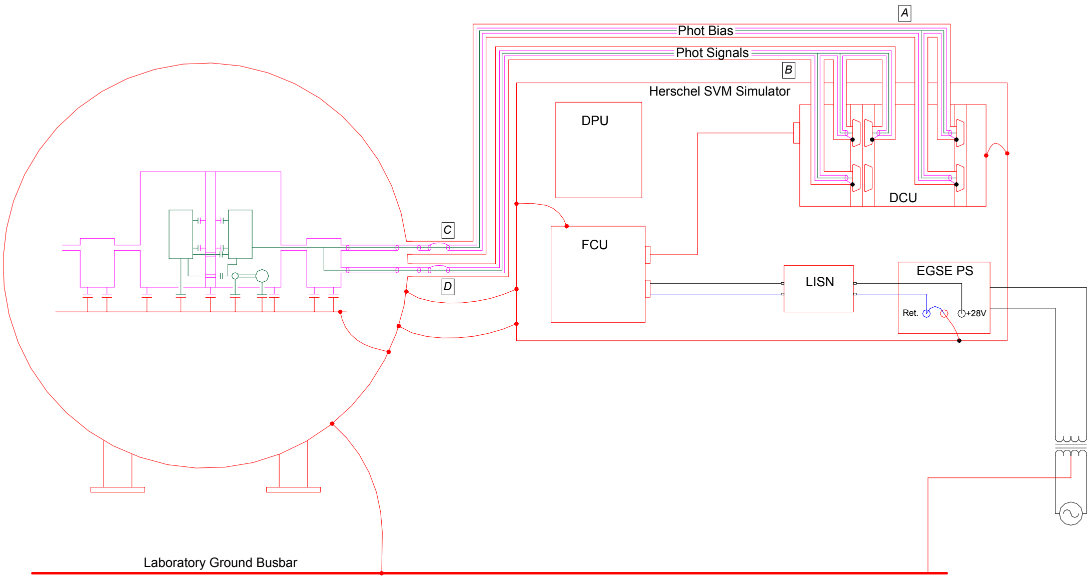


Figure 1 - Test setup

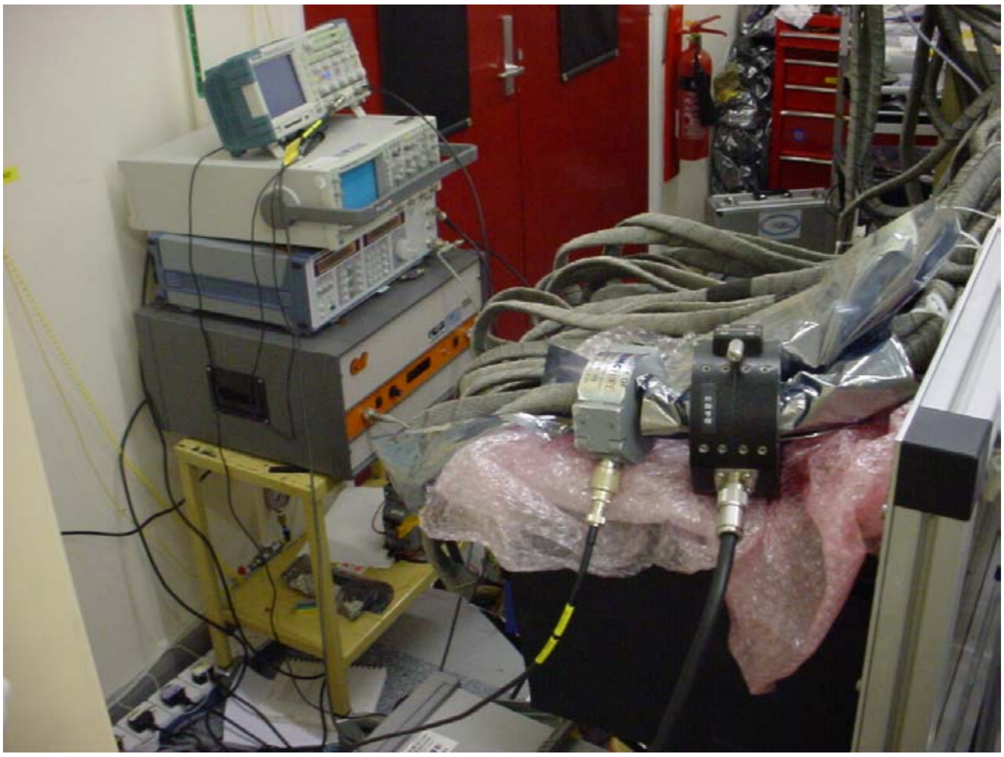


Figure 2 - Injection onto the C3 Phot Bias harness near the DCU

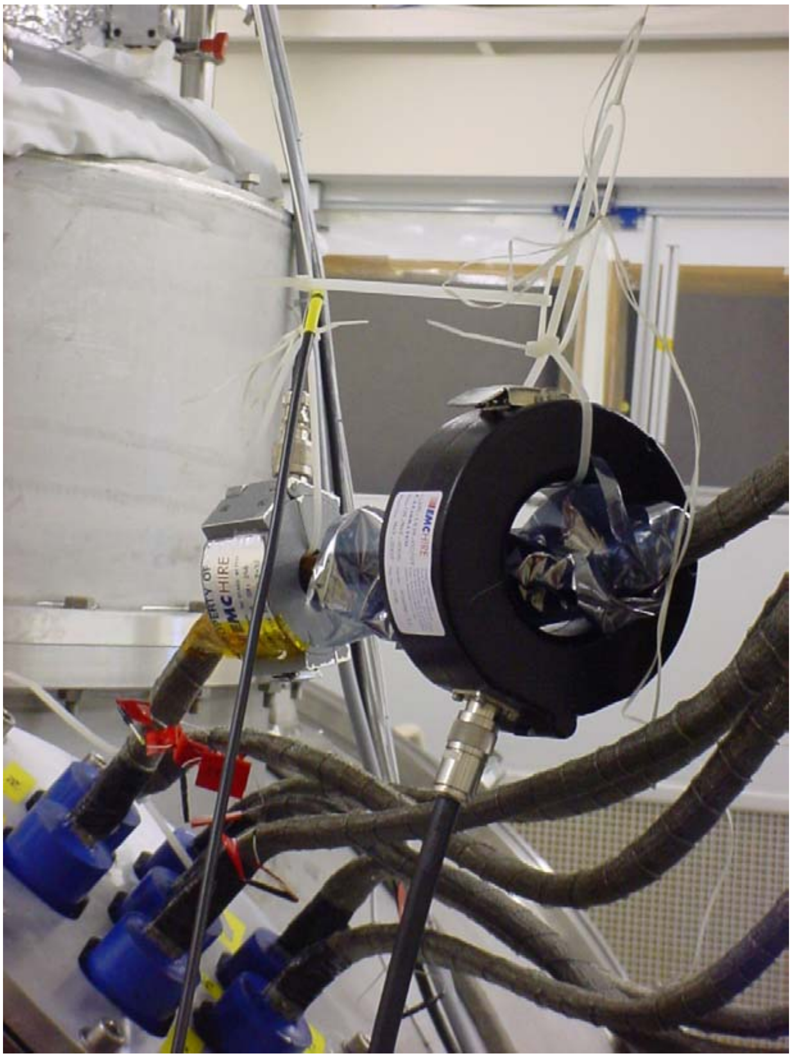


Figure 3 – BCI injection close to CVV

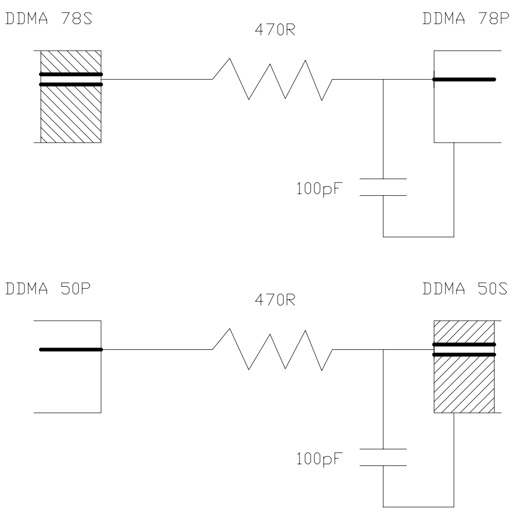
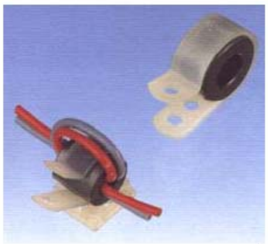
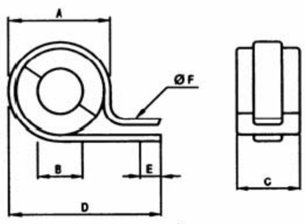


Figure 4 - "CEA Filters" The left hand side of the figure connects with the cryoharness and the right hand side mates with the DRCU.

EE-Seal Filters - 2200pF between each connector contact and backshell.

TRCN Split Ferrite Core with Nylon mounting





Split construction enables easy installation of cables already wired and installed, or cables with connectors on. The unit comes complete with mounting clamp.
Suitable for single or multiple cables.

Specification

Part No	Dimensions A	B	C	D	E	Impedance Ω 1 turn 25MHz	100MHz	Impedance Ω 2 turn 25MHz	100MHz	Maximum Cable Diameter
TRCN-16-8-13	19.4	8.2	13.0	30.2	4.3	59	93	231	396	8.00
TRCN-16-8-16	19.4	8.2	16.0	30.2	4.3	64	106	291	504	8.00
TRCN-20-10-10	25.7	10.4	10.0	38.2	5.1	53	84	203	360	10.0
TRCN-23-11-14	26.8	11.4	14.0	39.4	5.1	72	112	289	449	11.0
TRCN-28-16-13	32.8	16.4	13.0	45.0	5.1	56	90	325	579	16.0
TRCN-28-16-20	32.8	16.4	20.0	45.0	5.1	79	135	325	579	16.0
TRCN-40-27-15	44.6	27.4	15.0	57.3	5.1	48	84	195	365	27.0

Figure 5 - TRCN-40-27-15 used during tests.

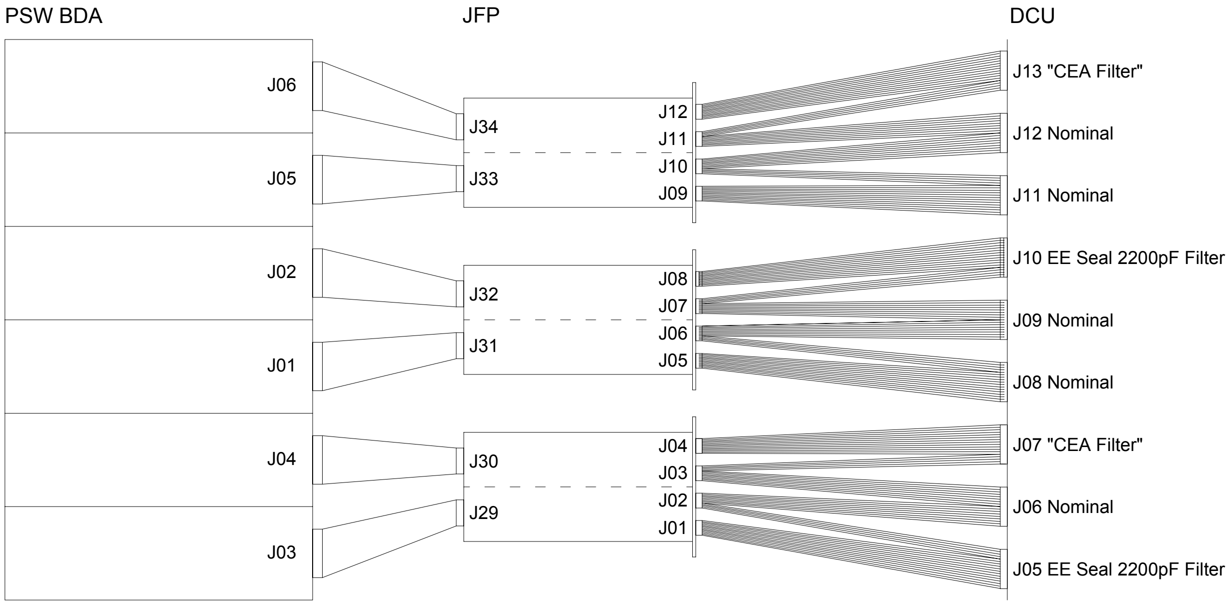


Figure 6 – Filter configuration 1

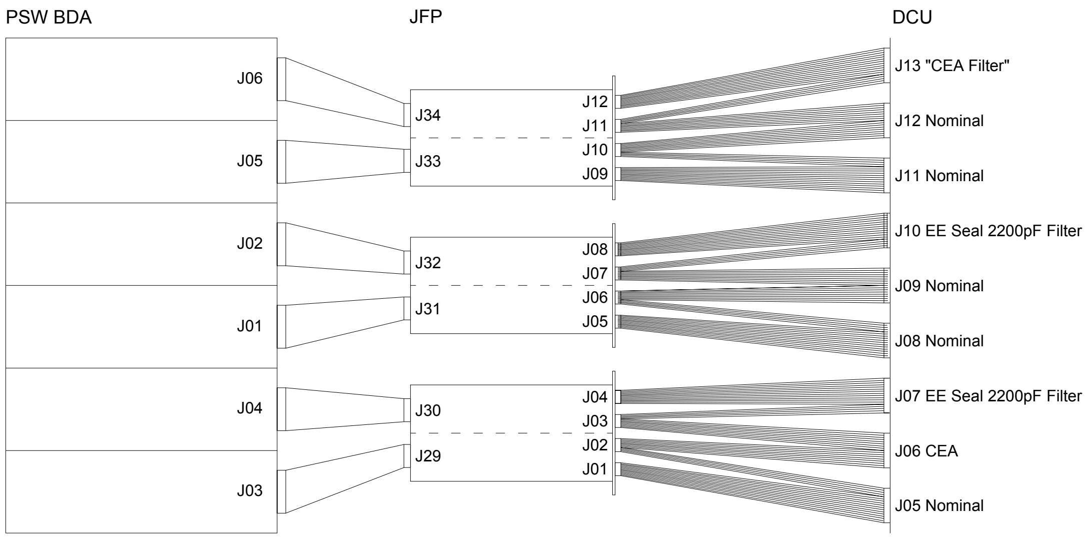


Figure 7 - Test configuration 2

2. Test results

2.1 Injection on Phot. Bias close to DCU (Filter config 1)

2.1.1 1-3 MHz

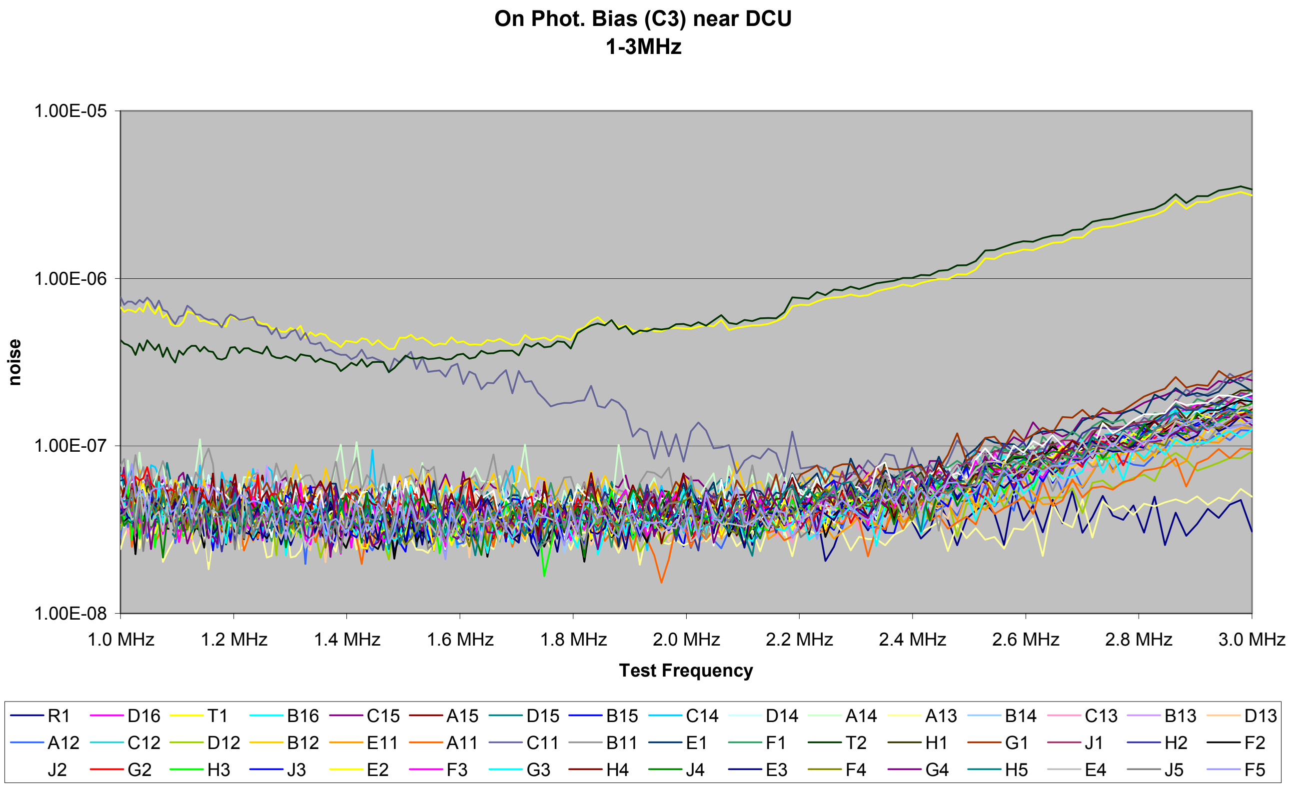


Figure 8

ObsID: 0x3000E360

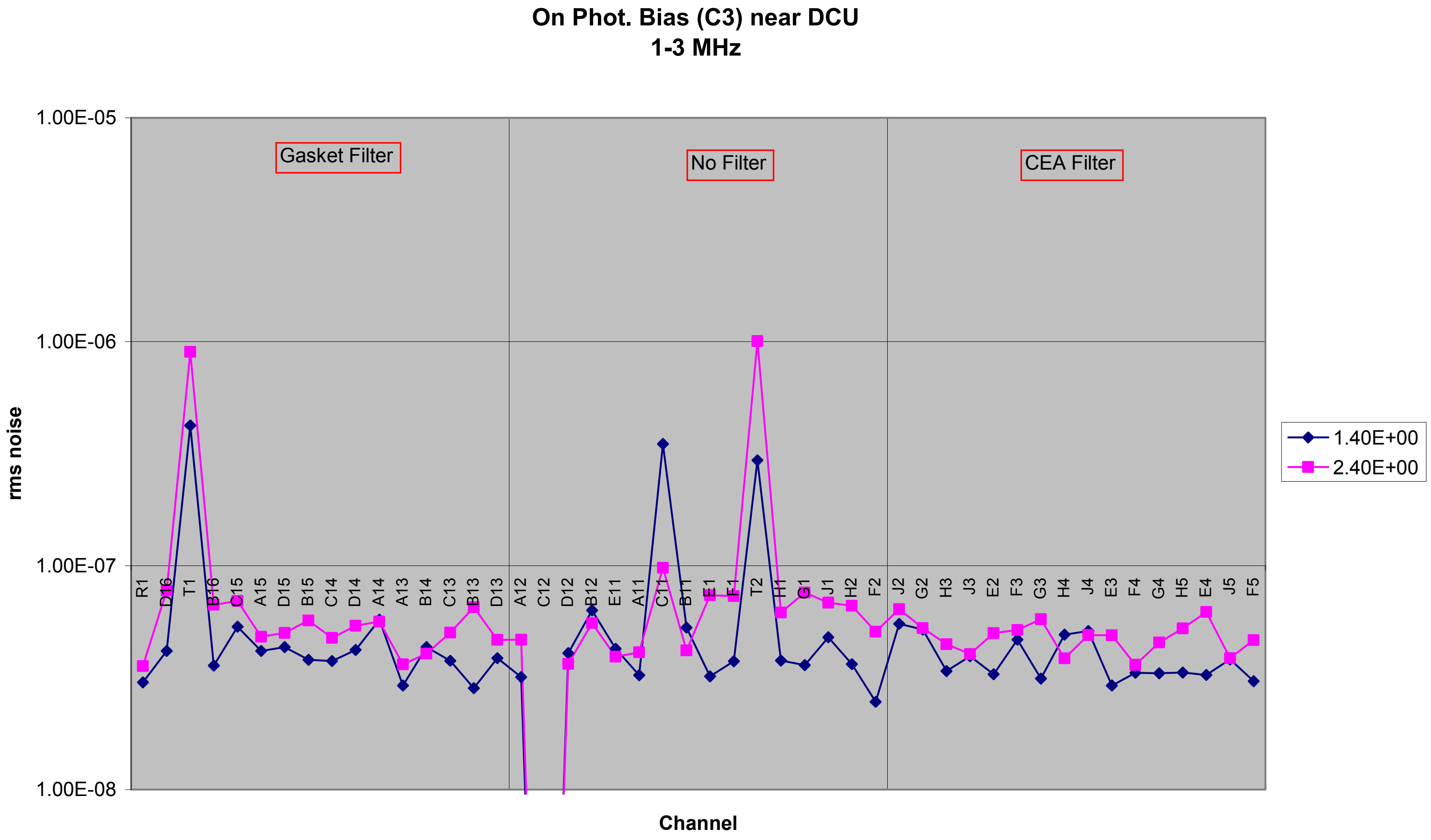


Figure 9

ObsID: 0x3000E360

2.1.2 3-10 MHz

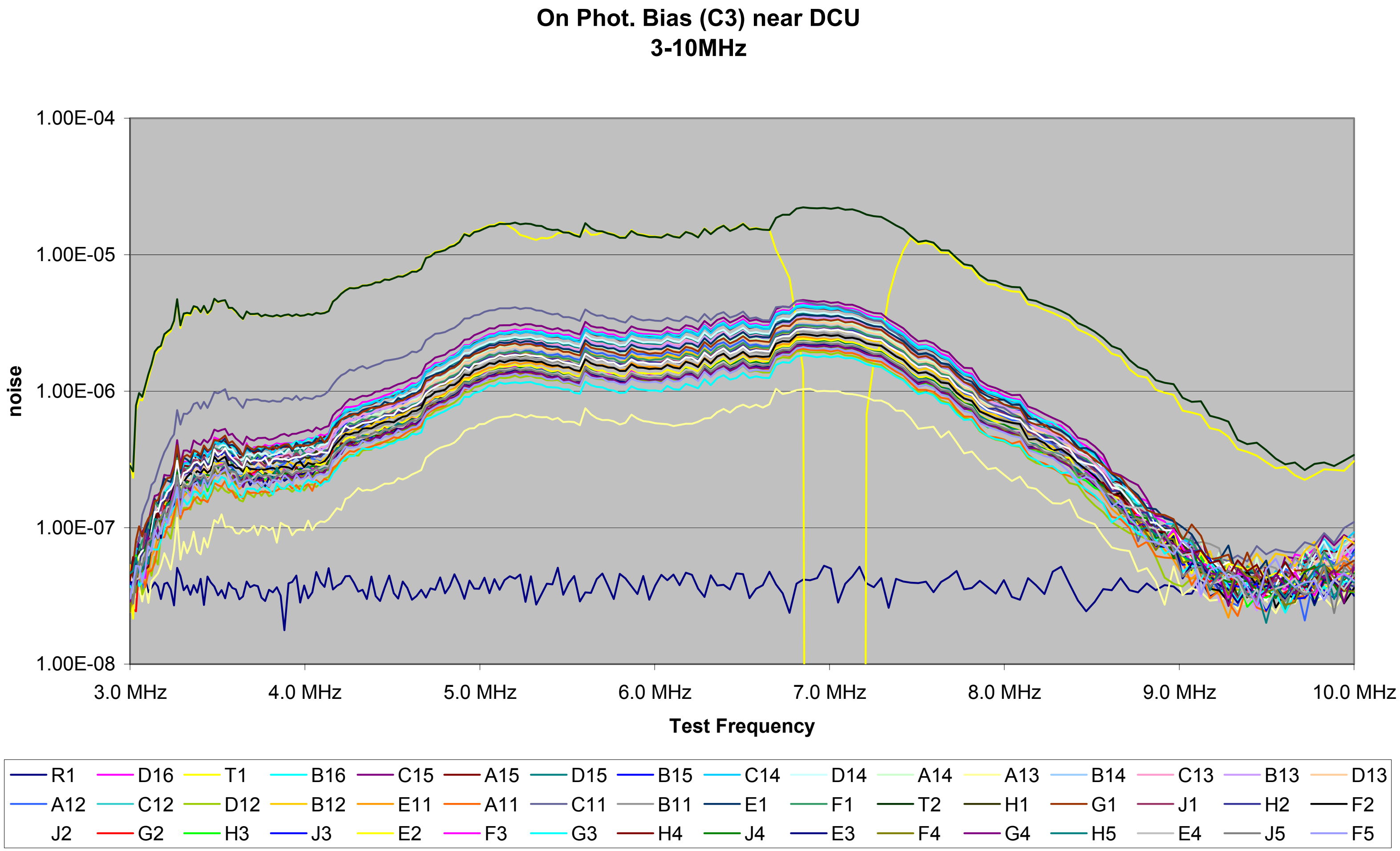


Figure 10

ObsID: 0x3000E360

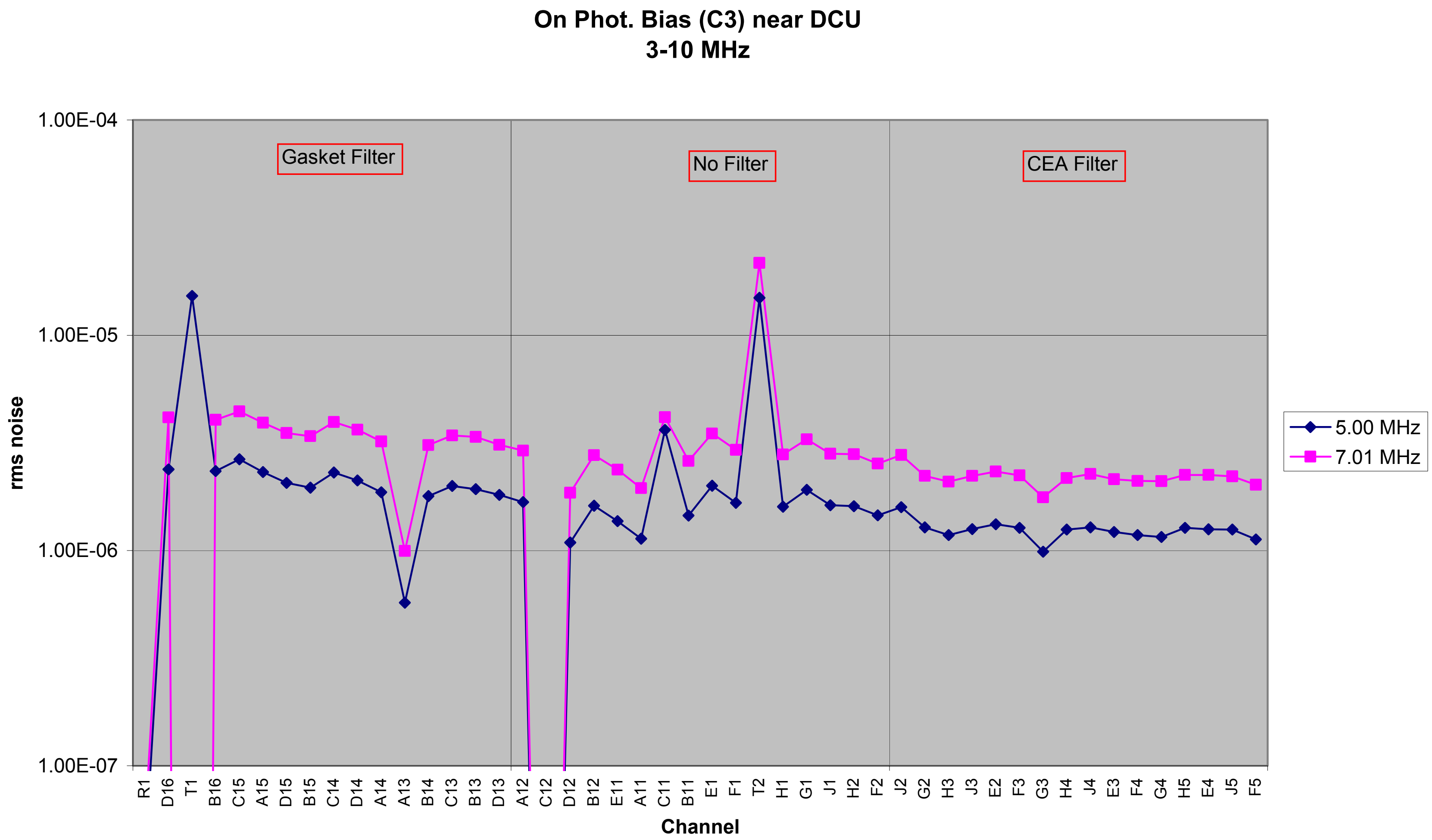


Figure 11

ObsID: 0x3000E360

2.1.3 10-30 MHz

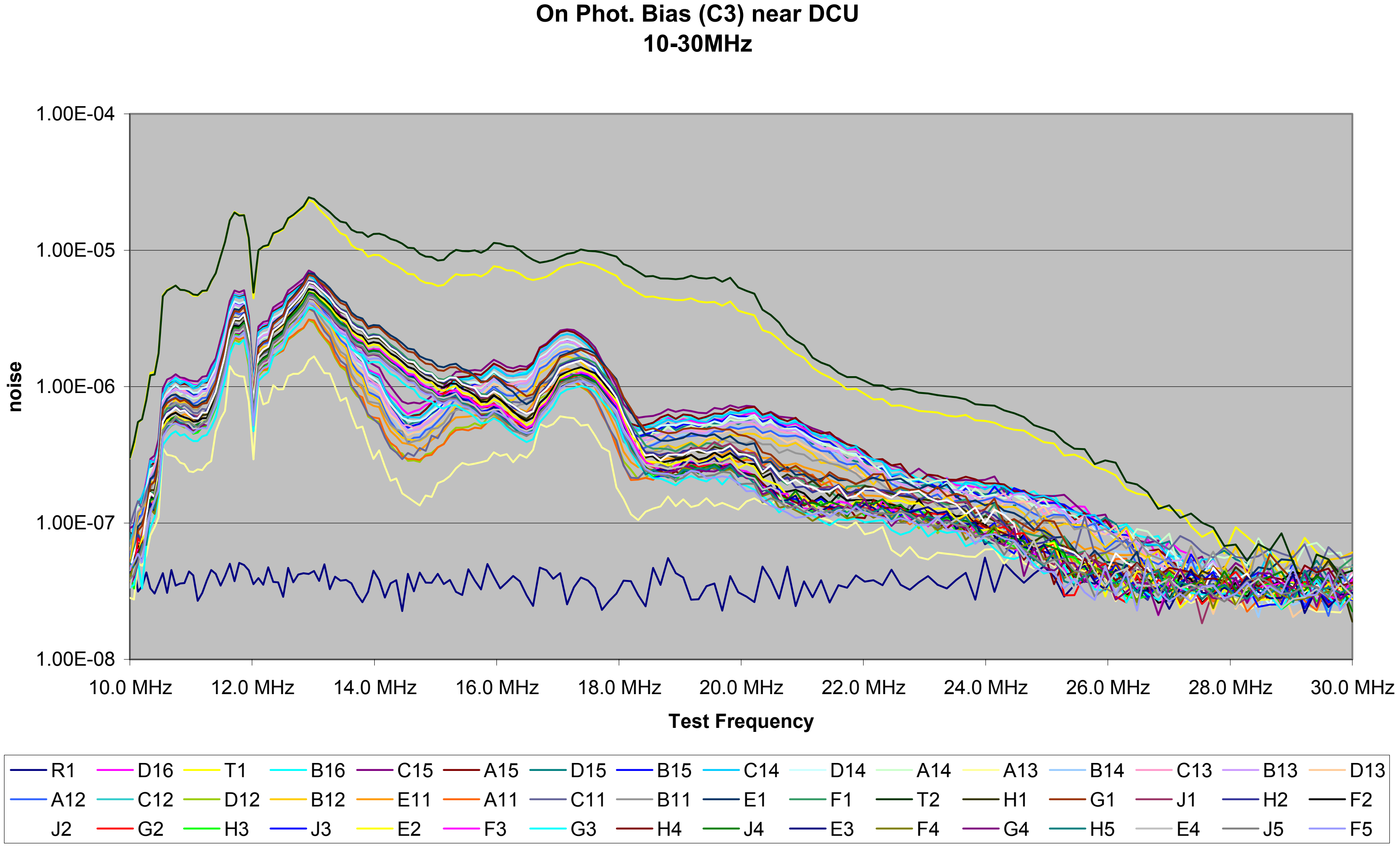


Figure 12

ObsID: 0x3000E360

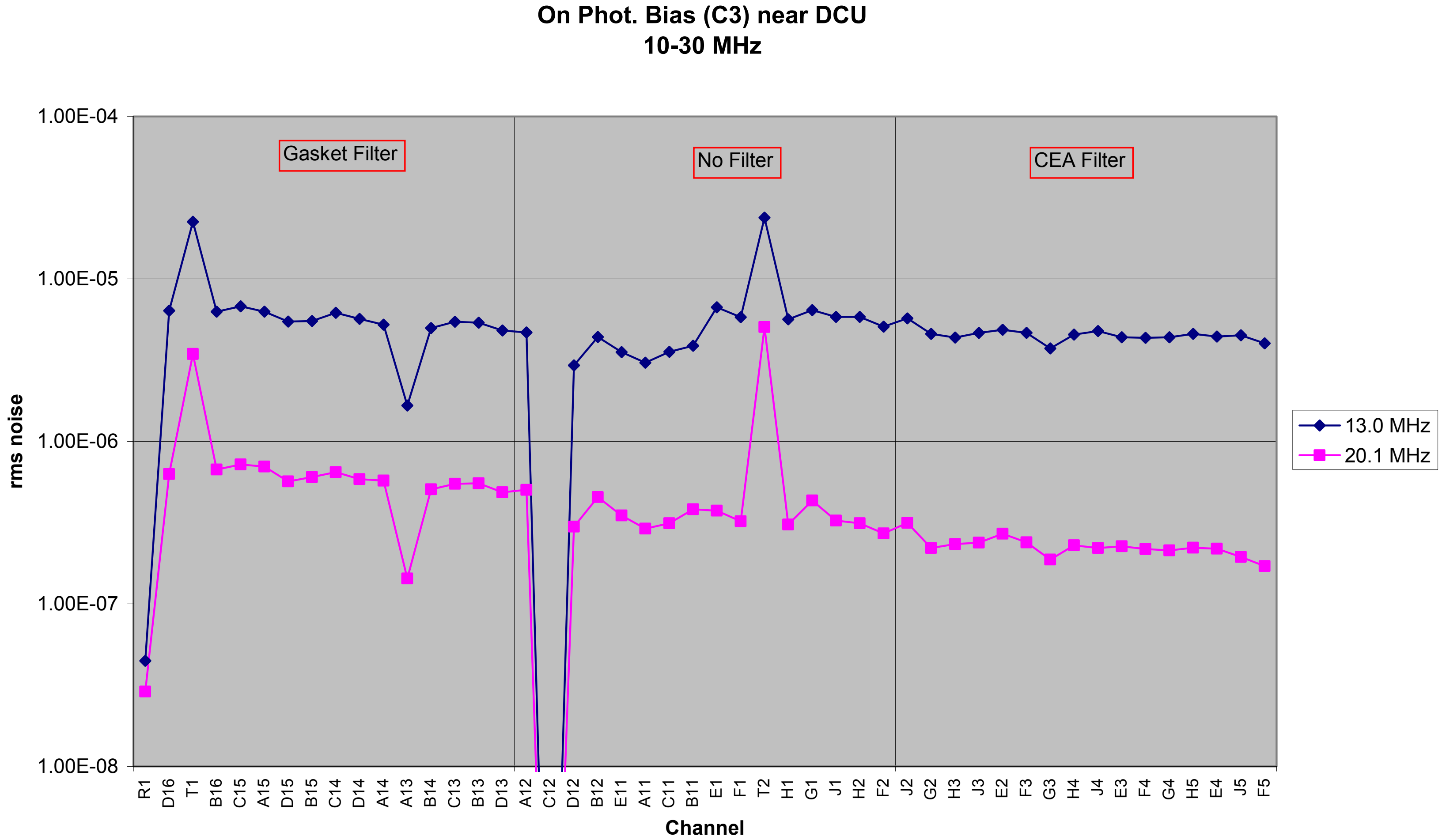


Figure 13

ObsID: 0x3000E360

2.1.4 30-50 MHz

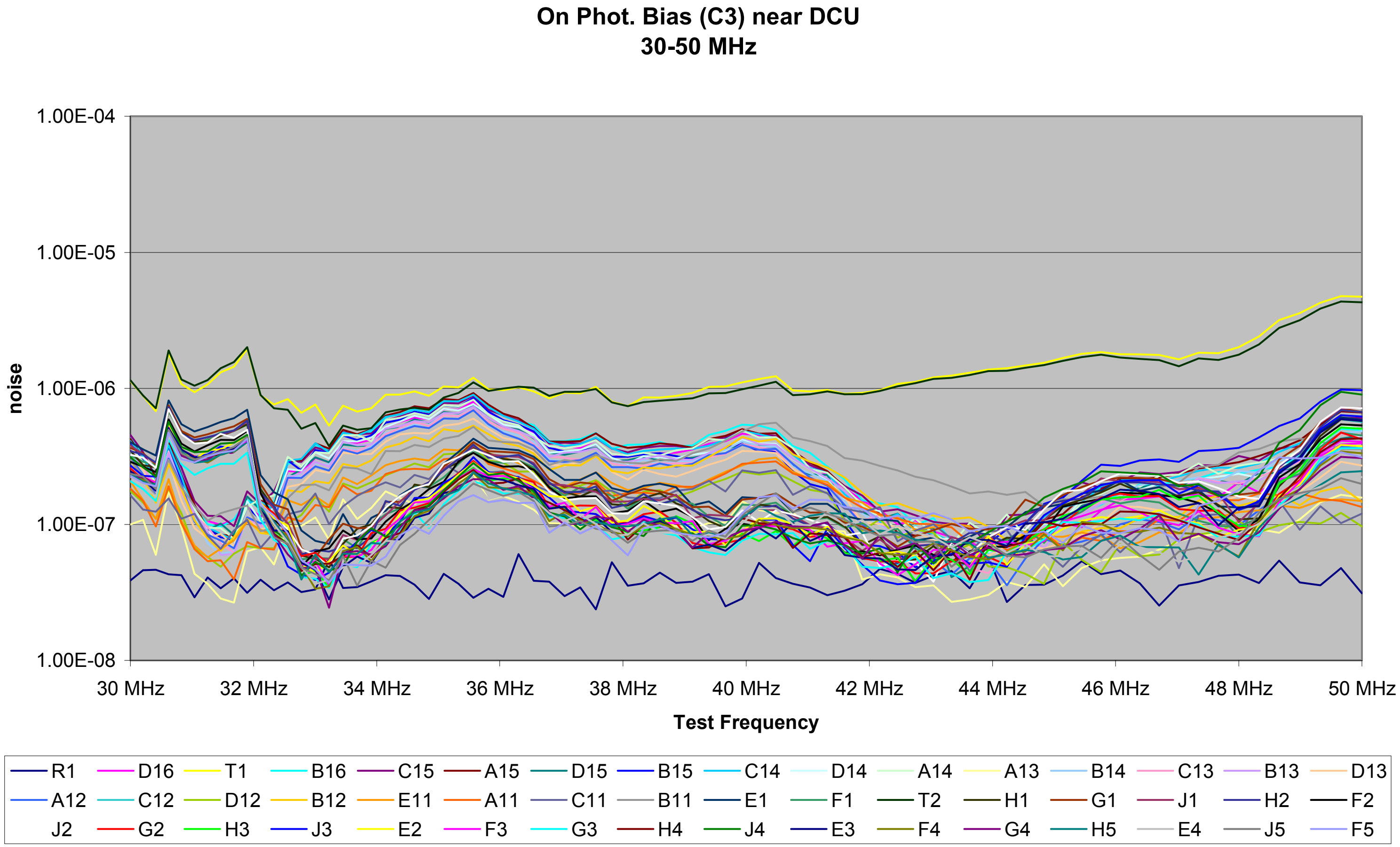


Figure 14

ObsID: 0x3000E360

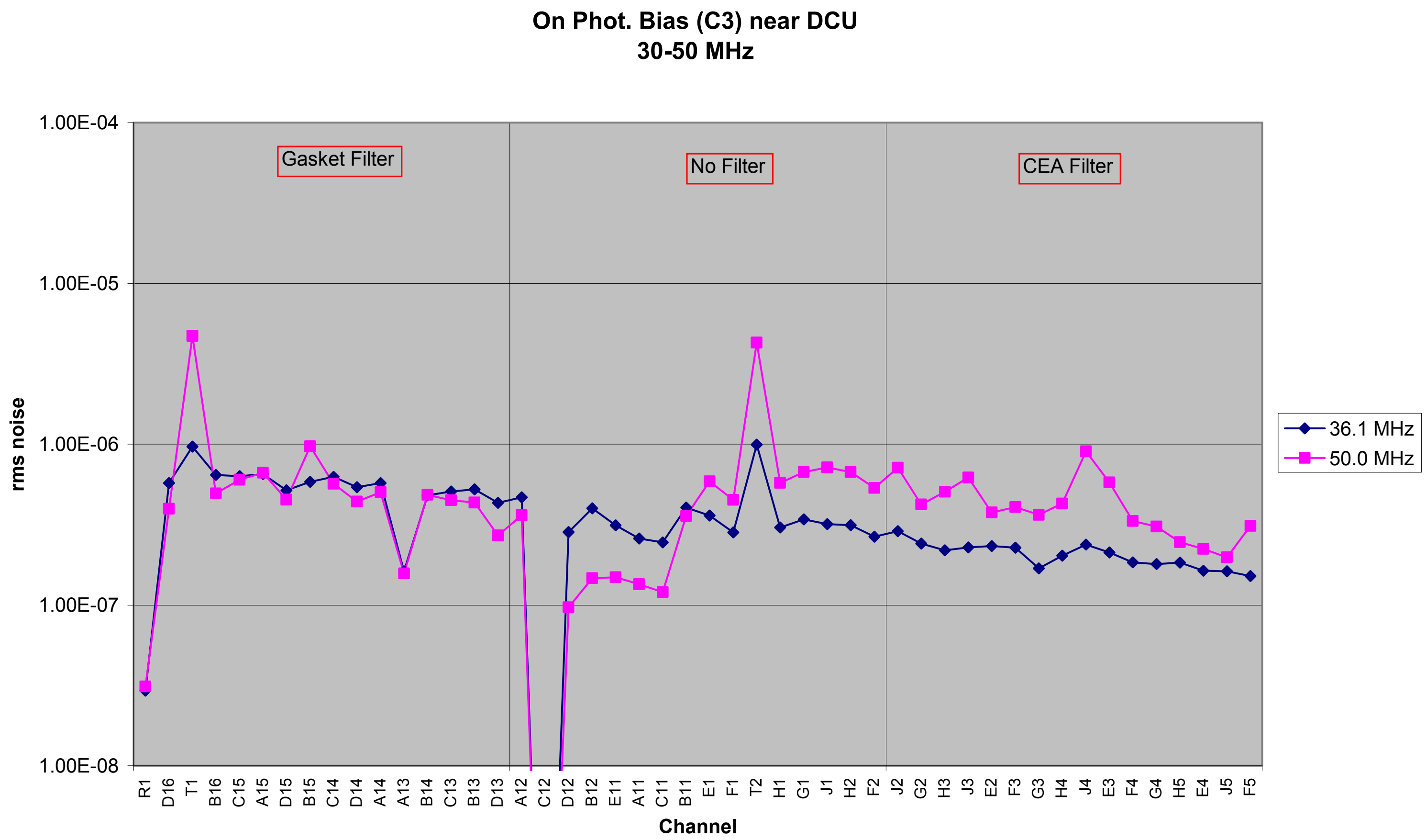


Figure 15

ObsID: 0x3000E360

2.2 *Injection on Phot. Bias close to CVV (Filter config 1)*

2.2.1 1-3 MHz

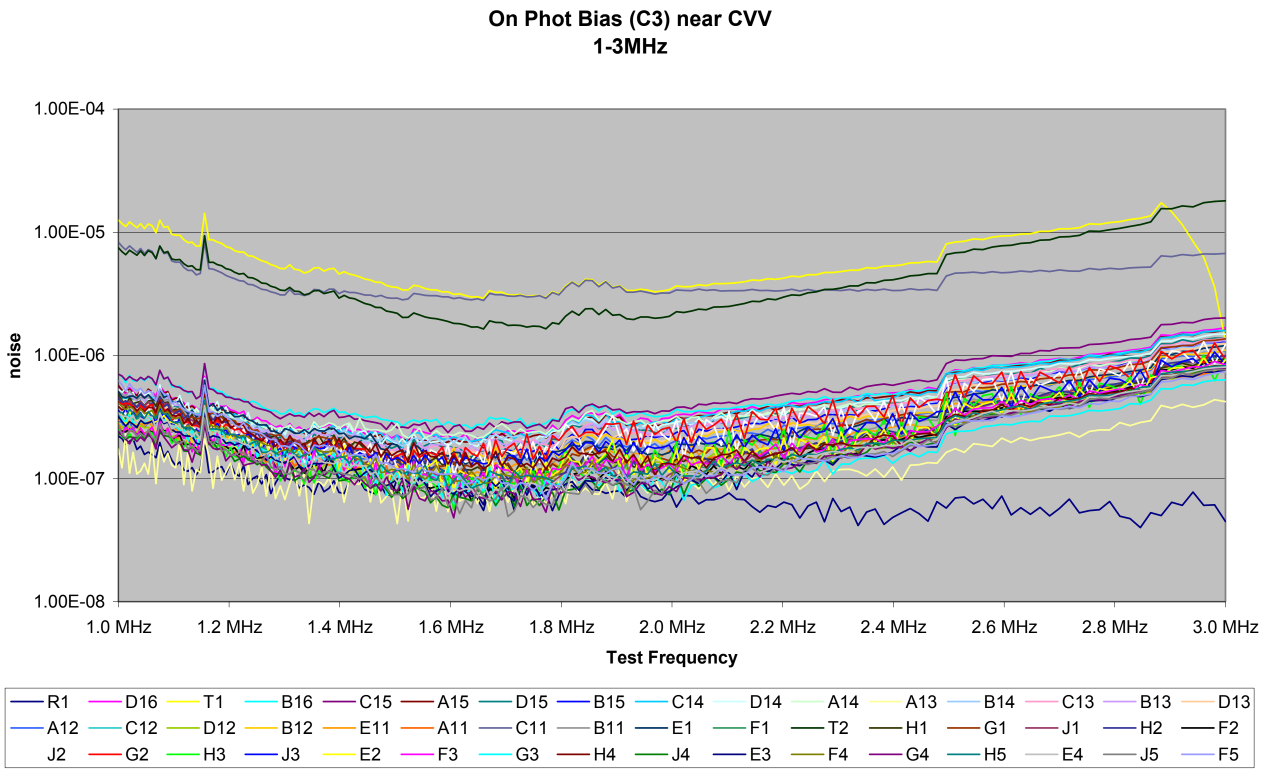


Figure 16

ObsID: 0x3000E362

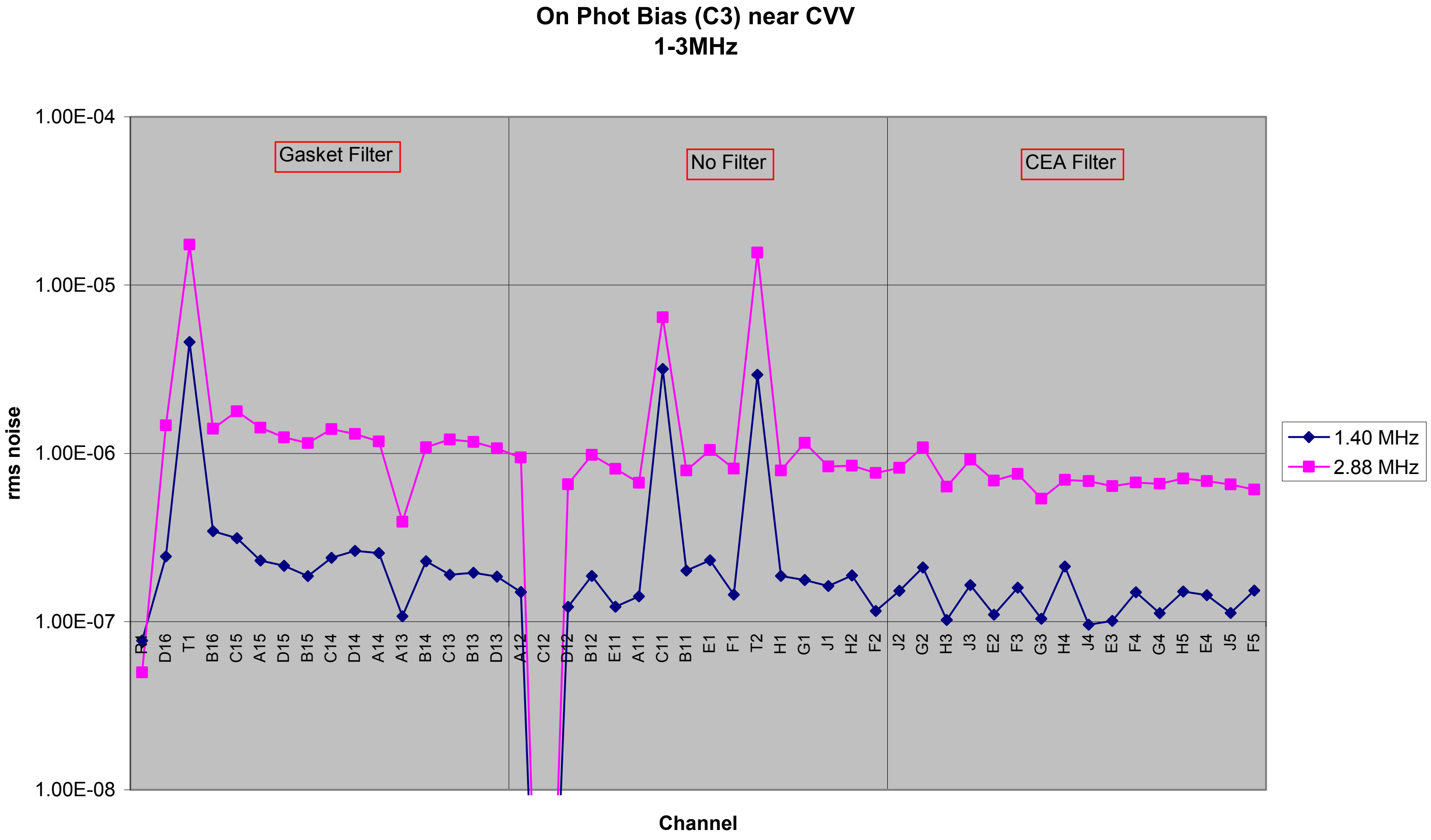


Figure 17

ObsID: 0x3000E362

2.2.2 3-10 MHz

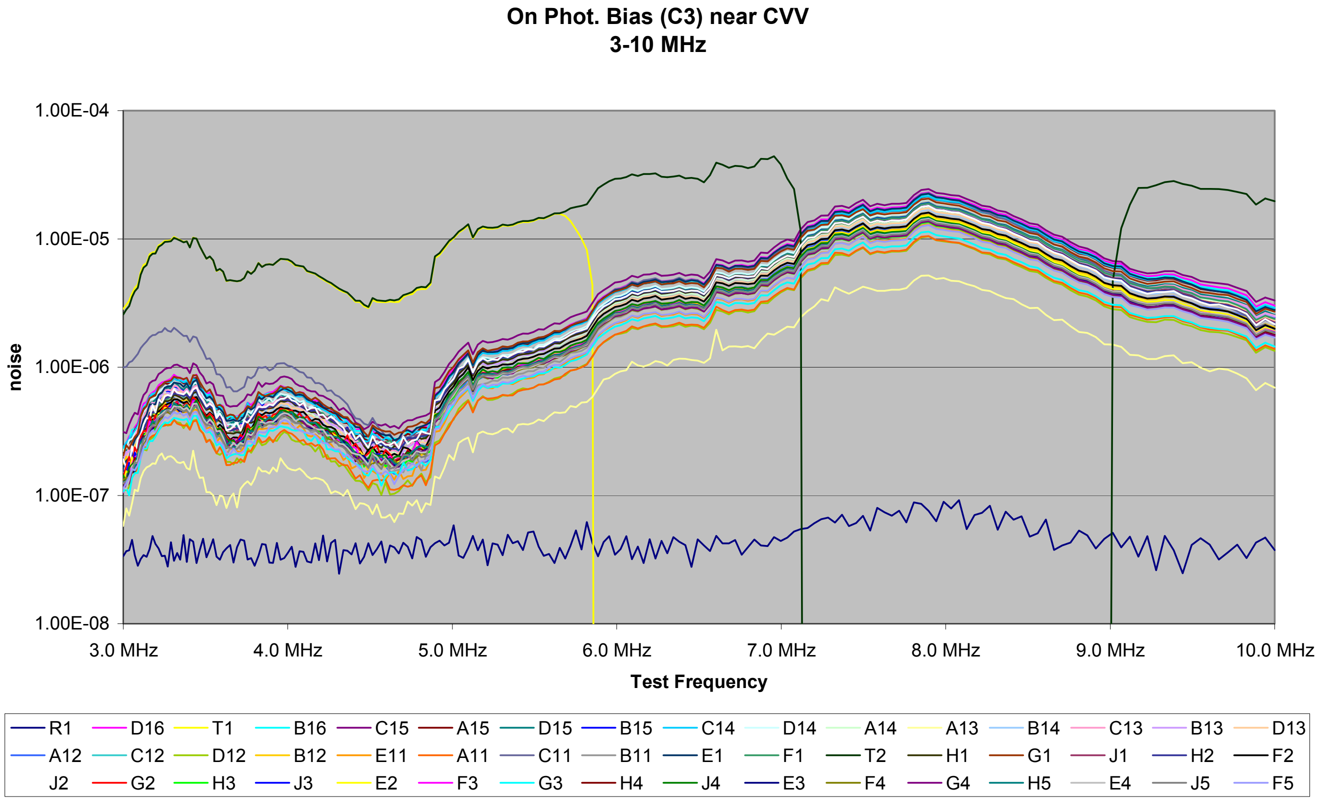


Figure 18

ObsID: 0x3000E362

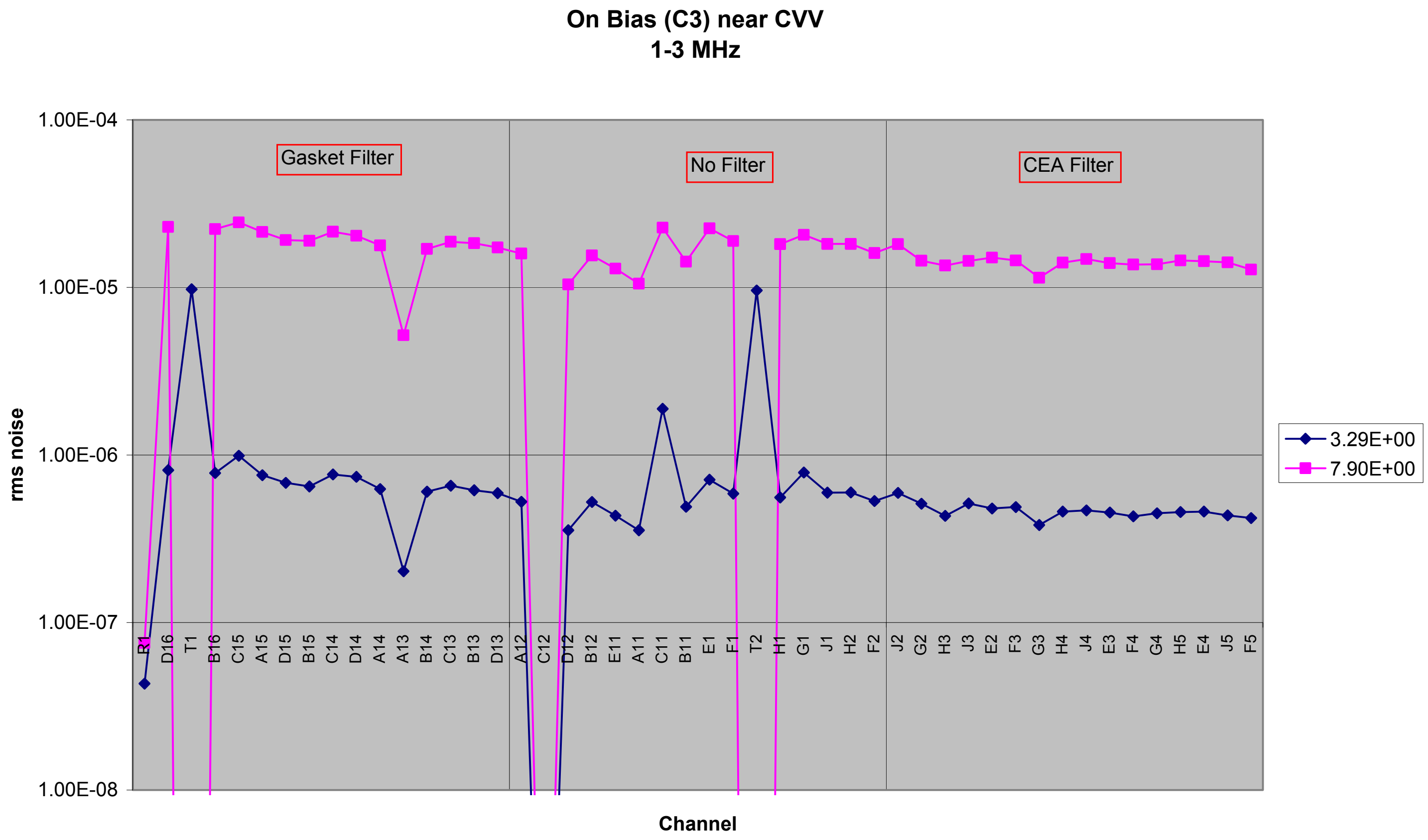


Figure 19

2.2.3 10-30 MHz

ObsID: 0x3000E362

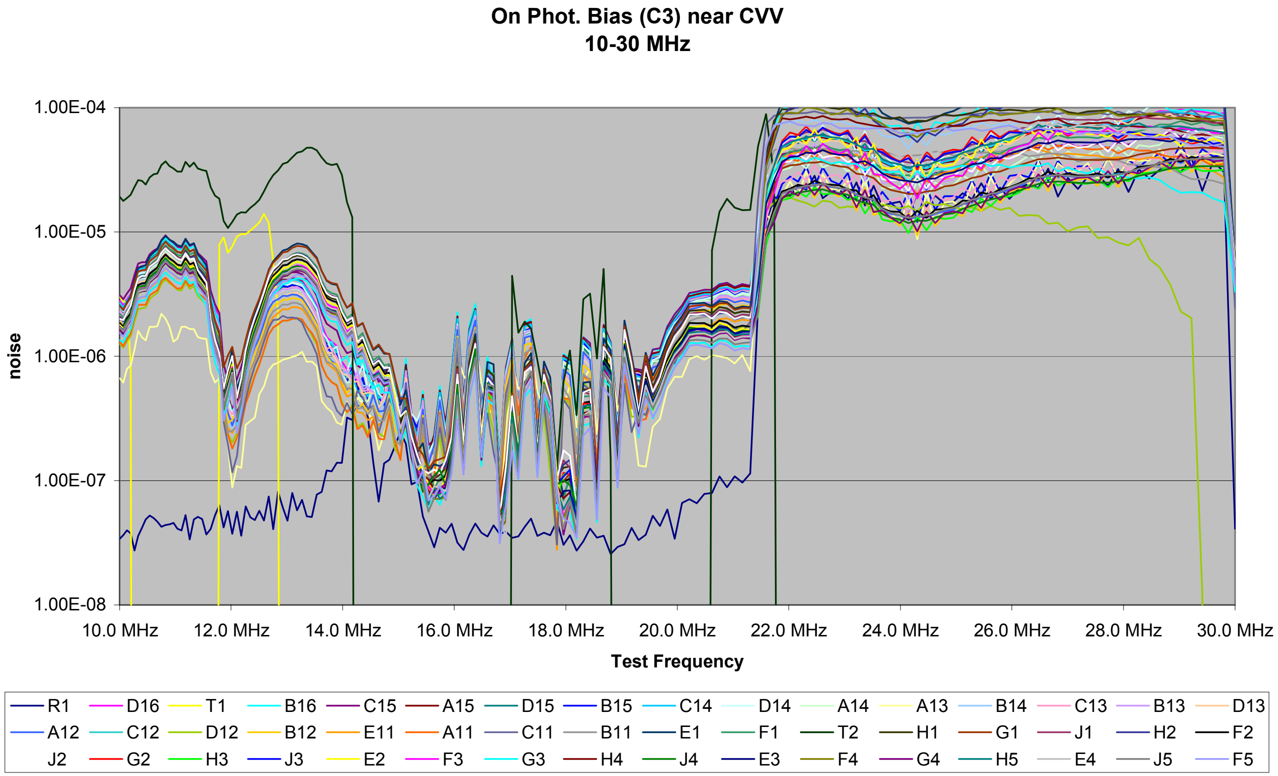


Figure 20

ObsID: 0x3000E362

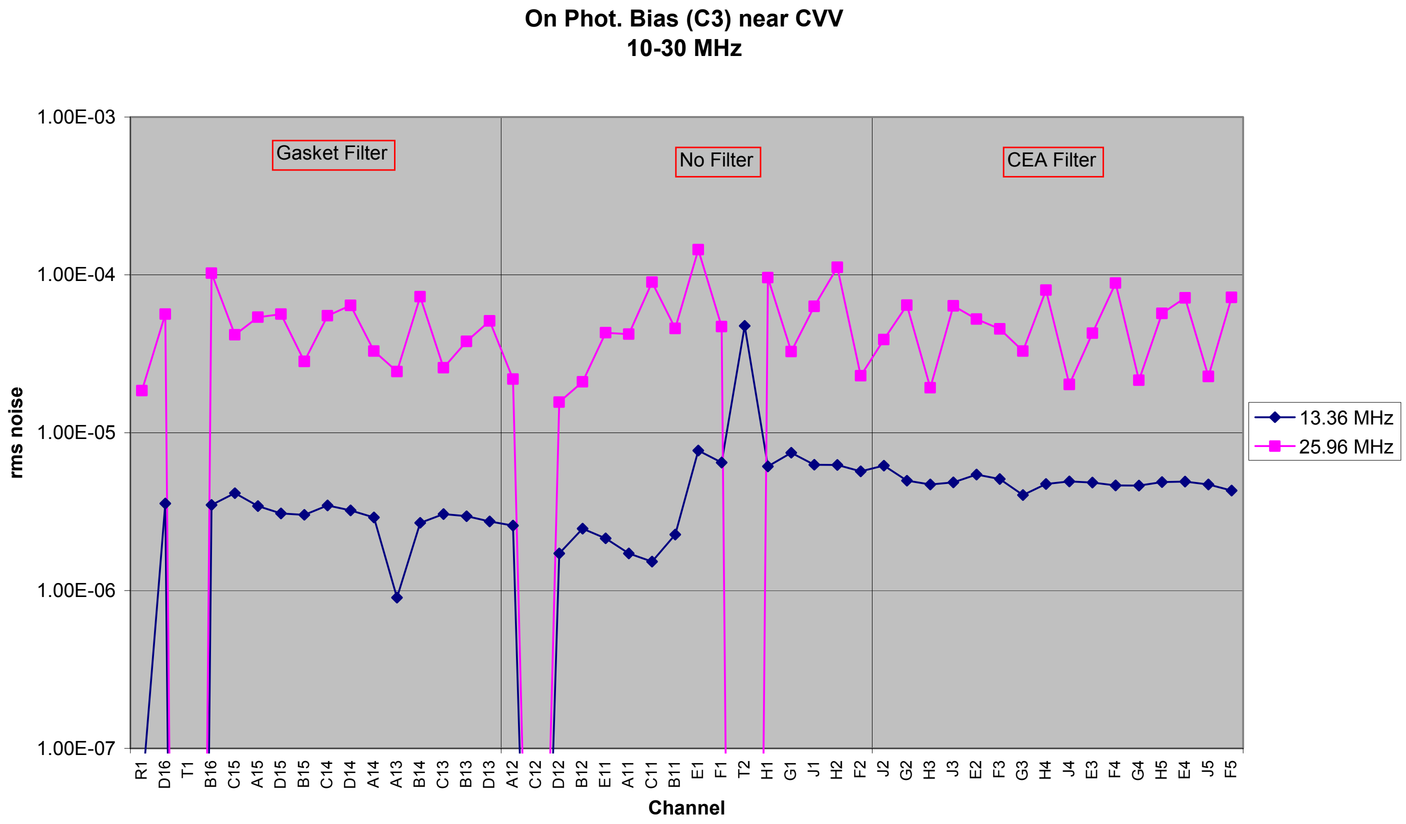


Figure 21

ObsID: 0x3000E362

2.2.4 30-50 MHz

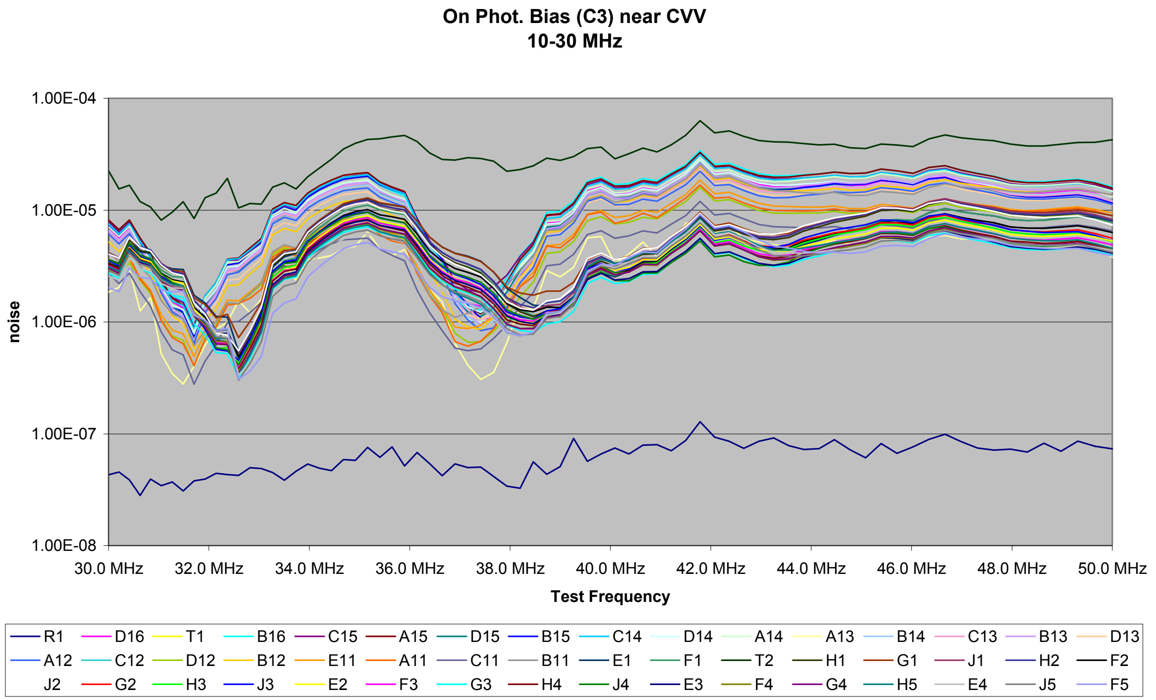


Figure 22

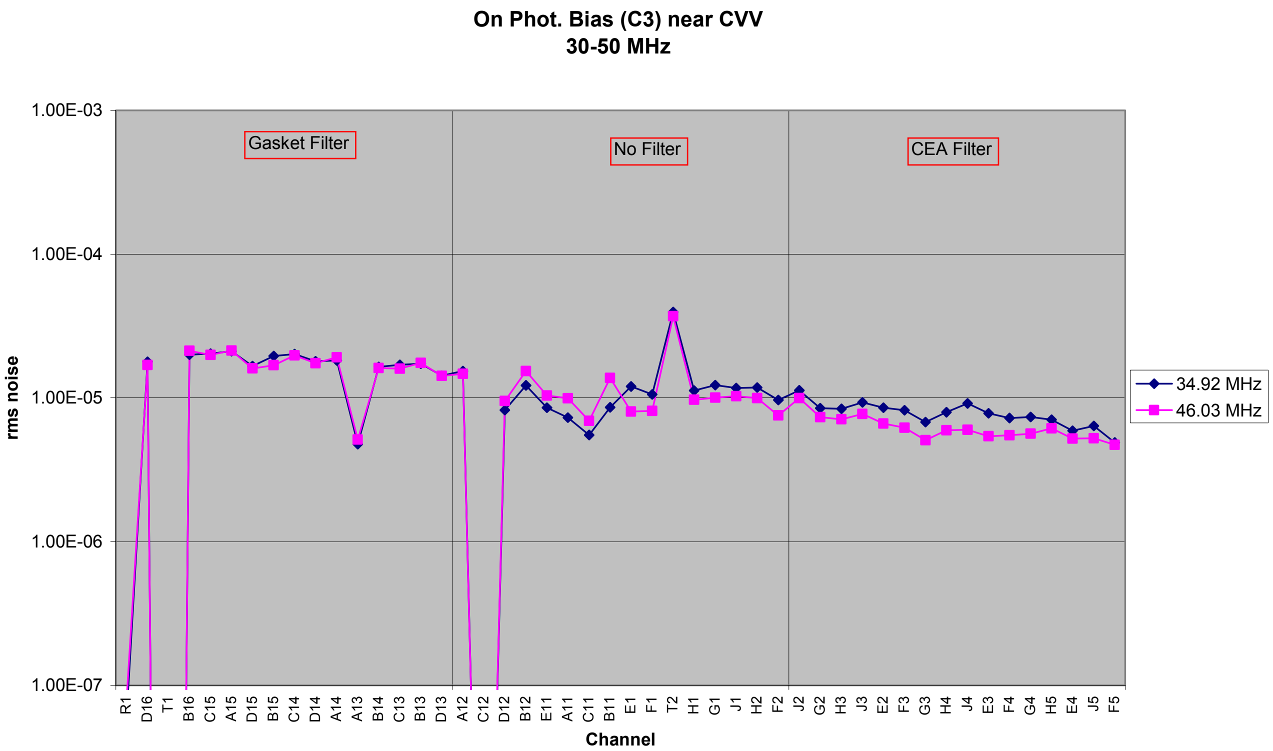


Figure 23

2.3 Injection on detector signals close to DCU (C9) (Filter config 1)

ObsID: 0x3000E362

2.3.1 1-3 MHz

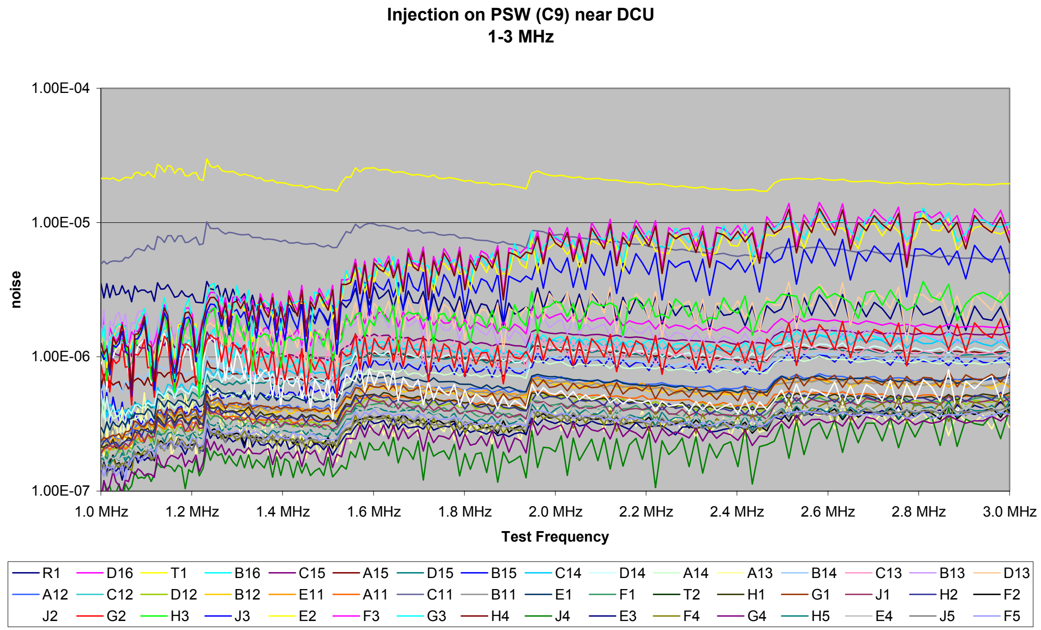


Figure 24

ObsID: 0x3000E35D

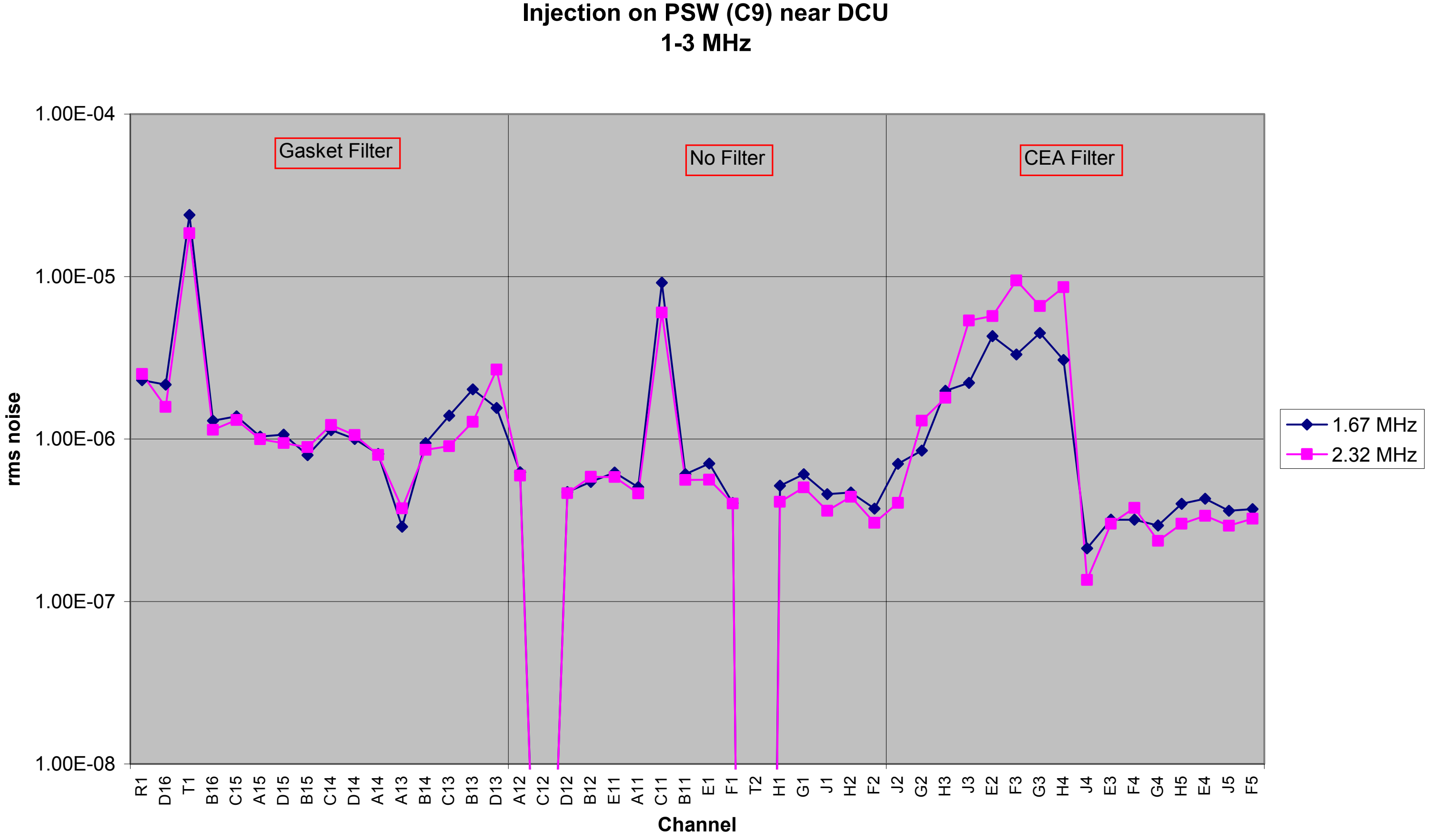


Figure 25

ObsID: 0x3000E35D

2.3.2 3-10 MHz

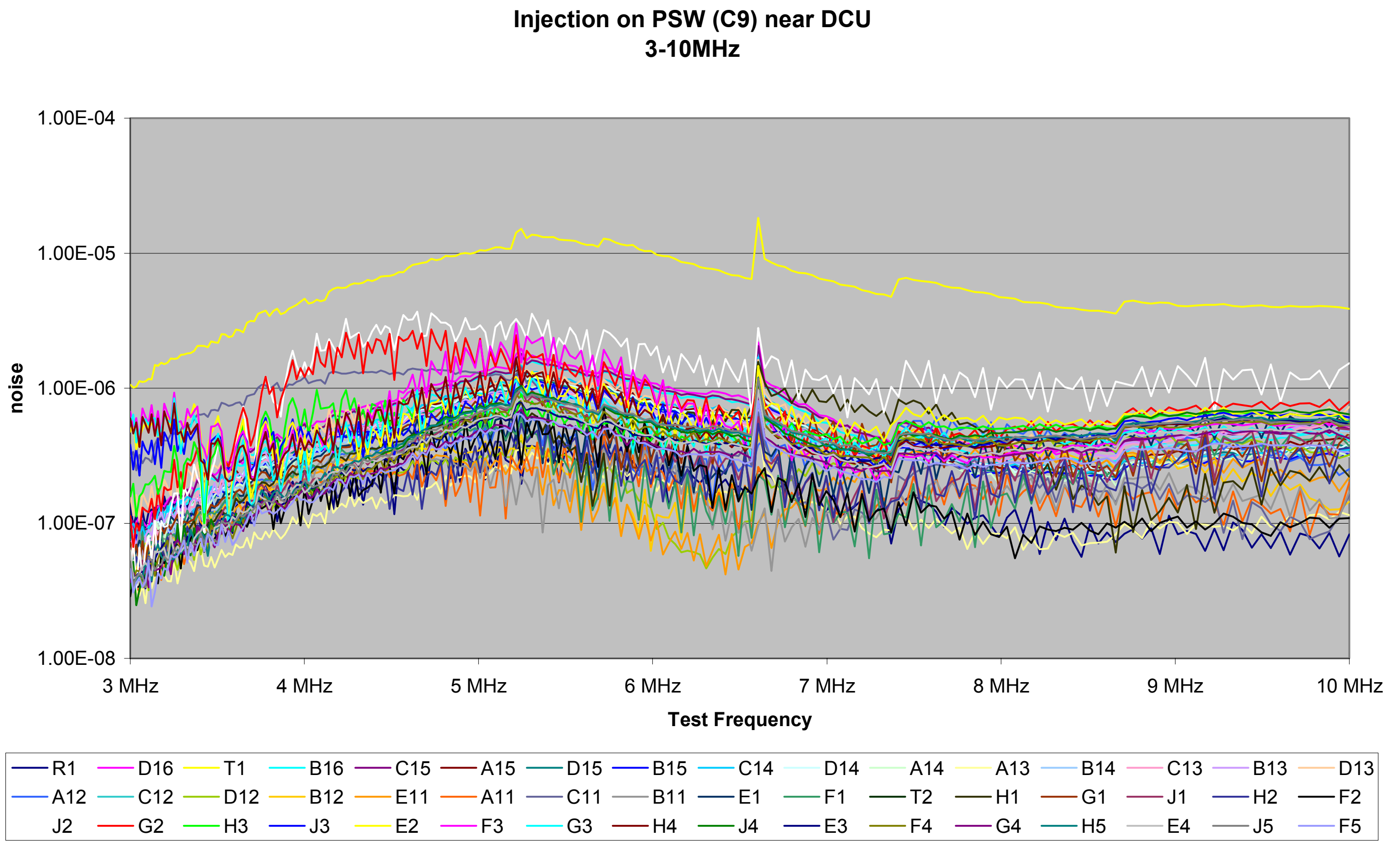


Figure 26

ObsID: 0x3000E35D

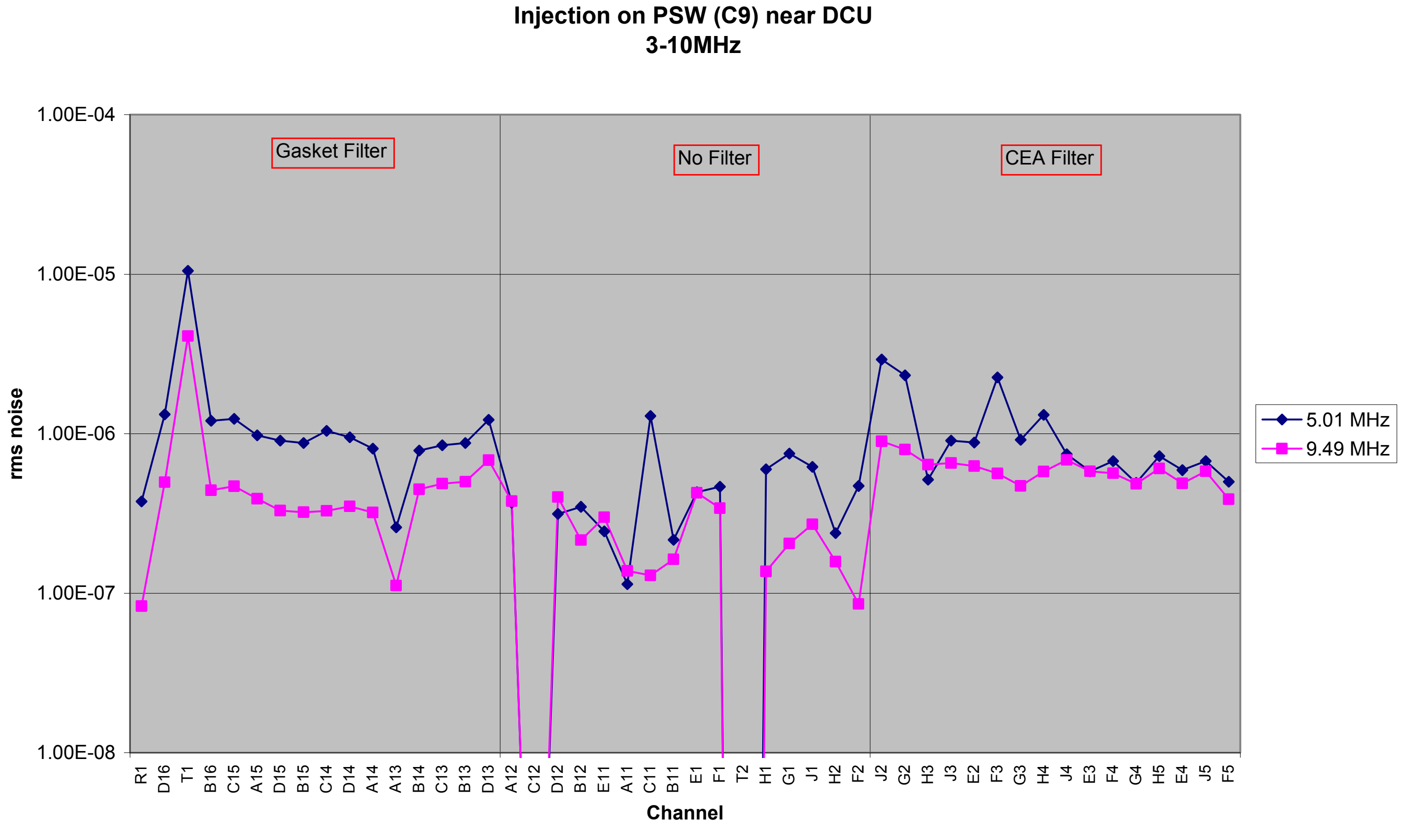


Figure 27

ObsID: 0x3000E35D

2.3.3 10-30 MHz

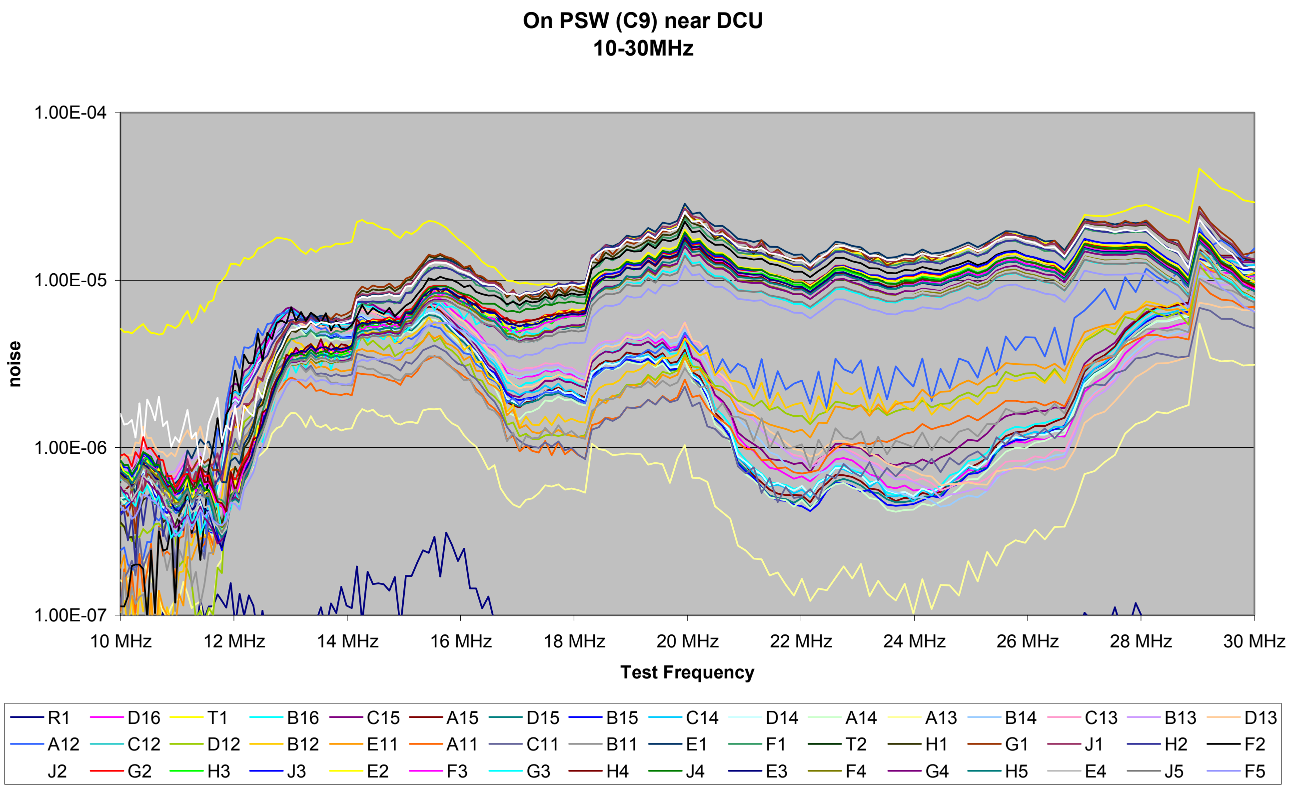


Figure 28

ObsID: 0x3000E35D

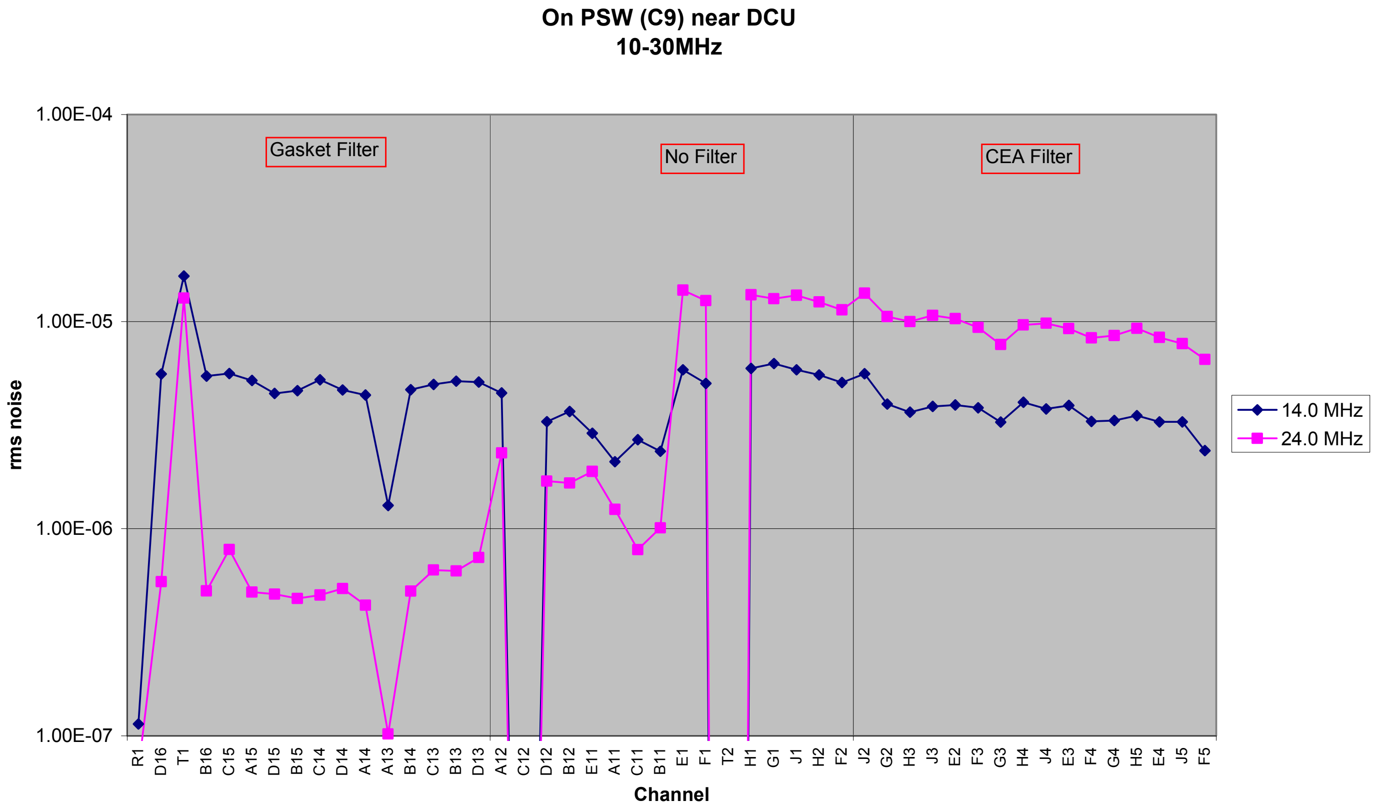


Figure 29

ObsID: 0x3000E35D

2.3.4 30-50 MHz

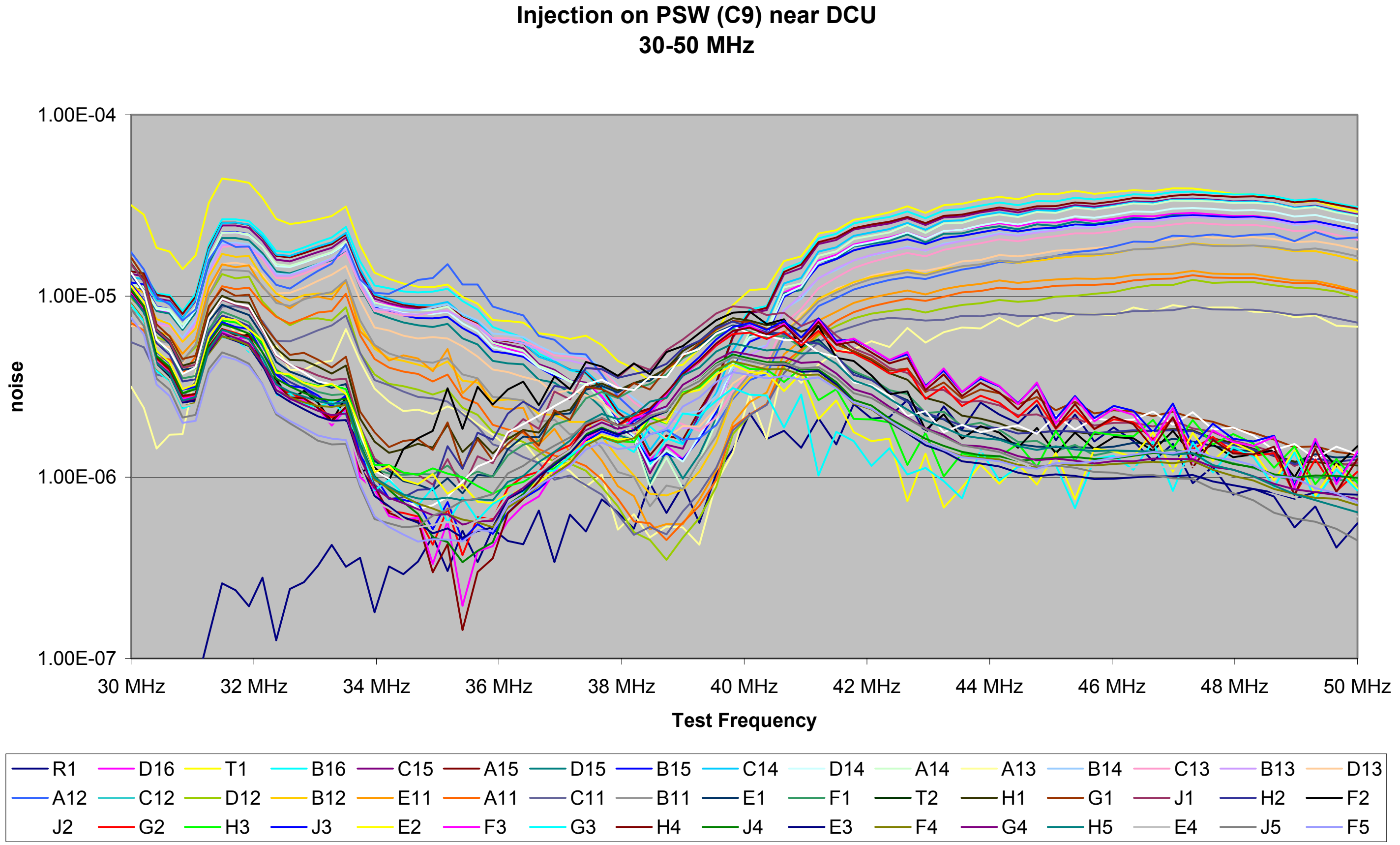


Figure 30

ObsID: 0x3000E35D

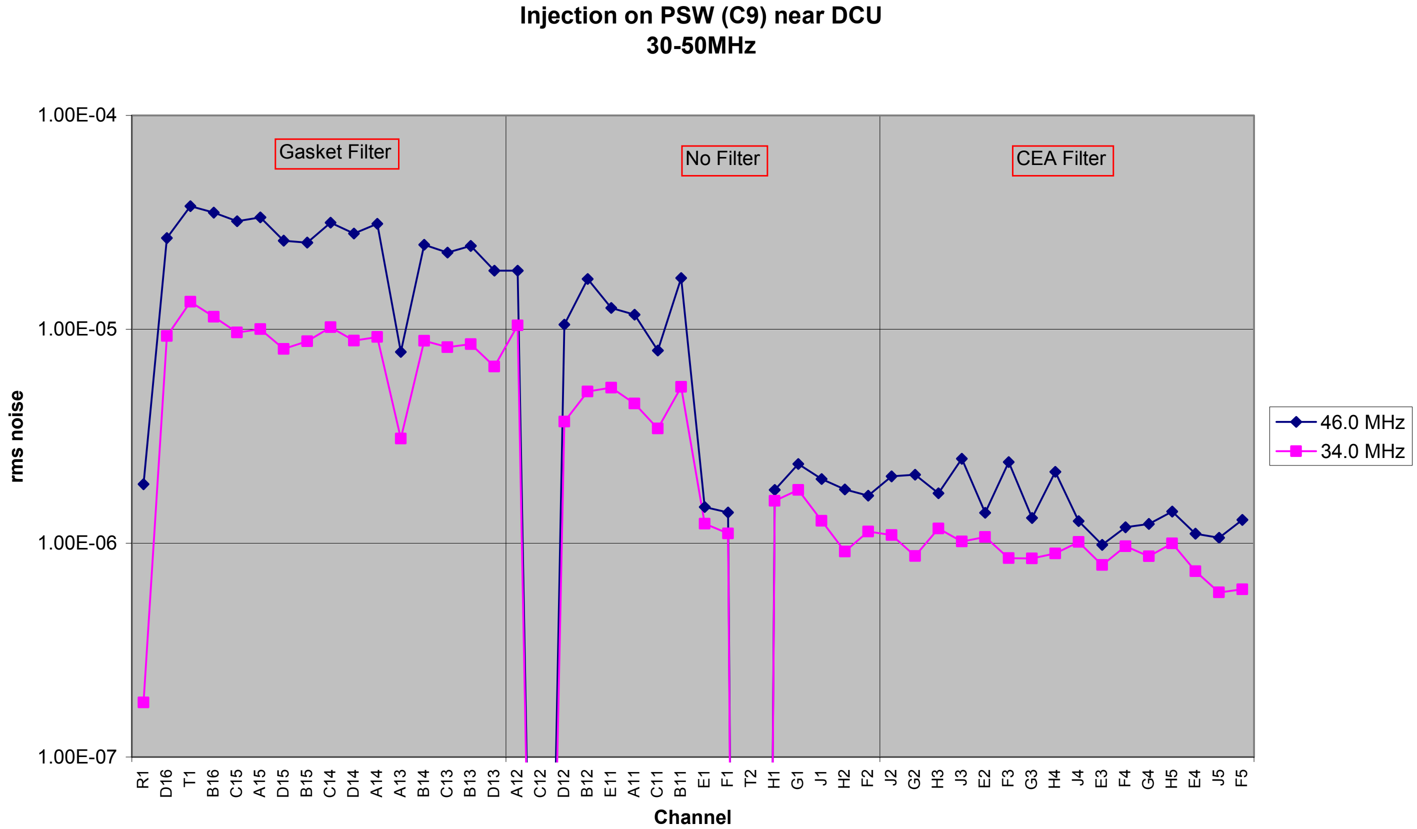


Figure 31

ObsID: 0x3000E35D

2.4 Injection on detector signals close to CVV (C9) (Filter config 1)

2.4.1 1-3 MHz

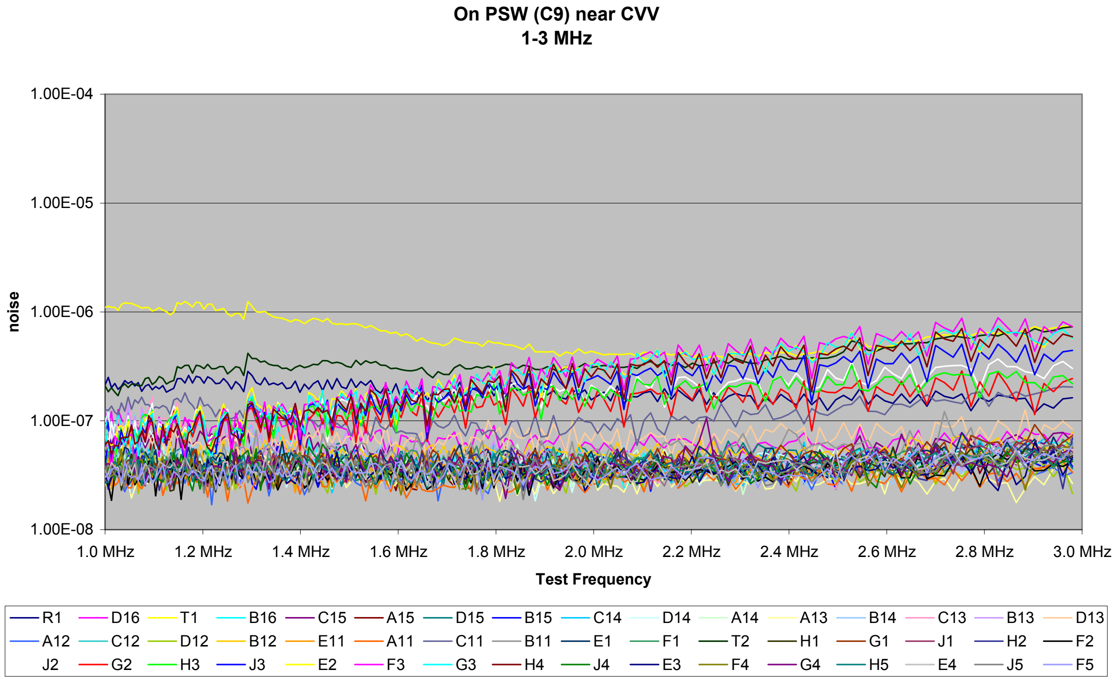


Figure 32

ObsID: 0x3000E364

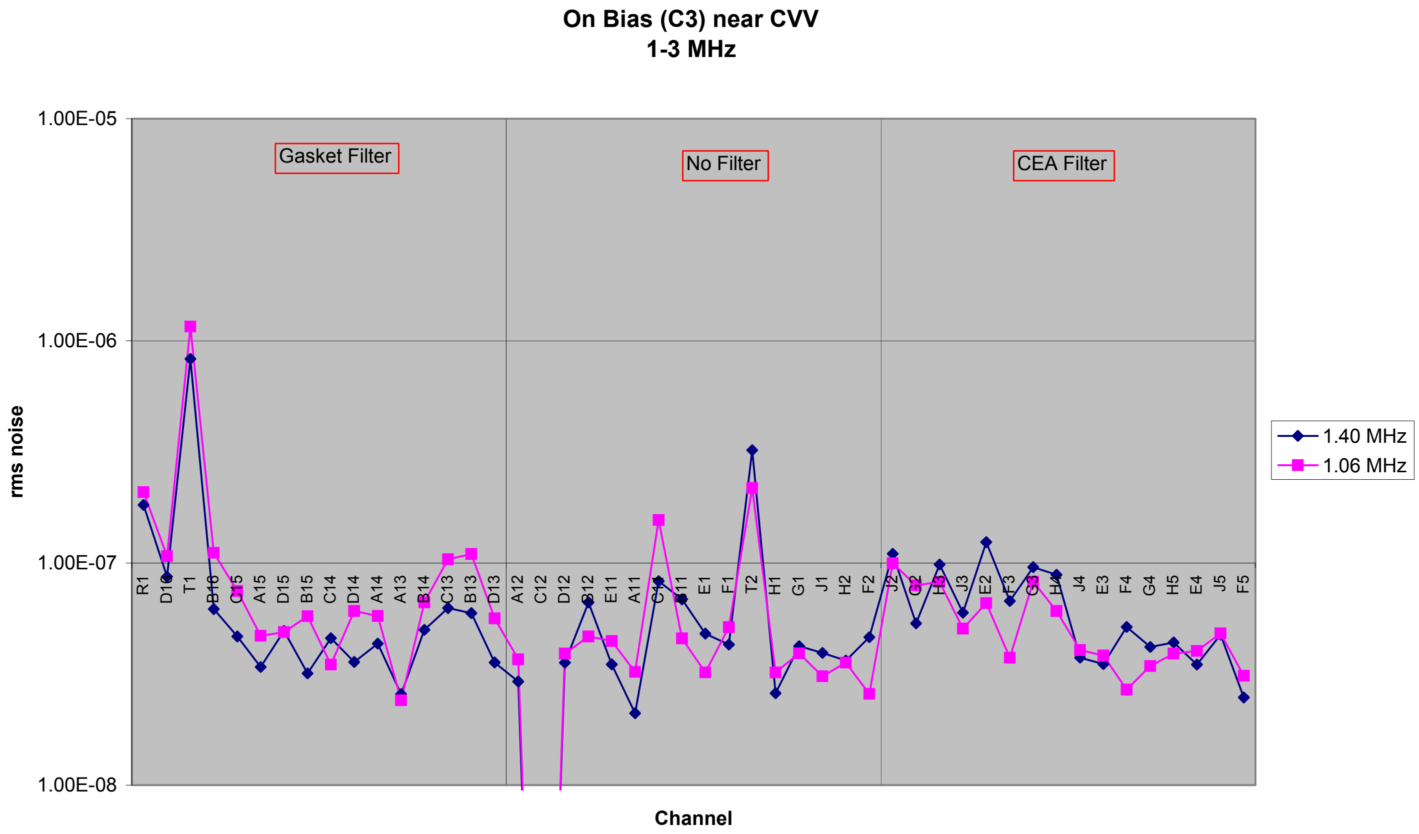


Figure 33

ObsID: 0x3000E364

2.4.2 3-10 MHz

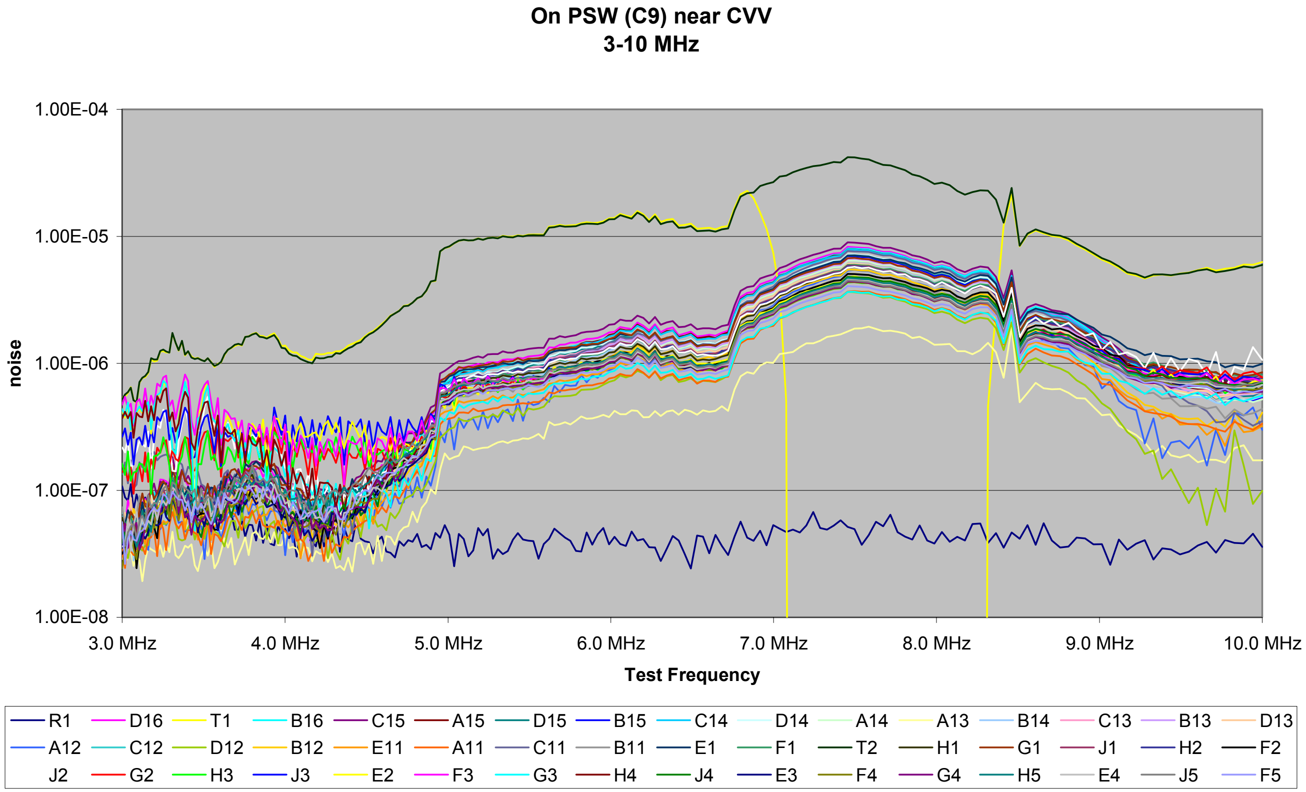
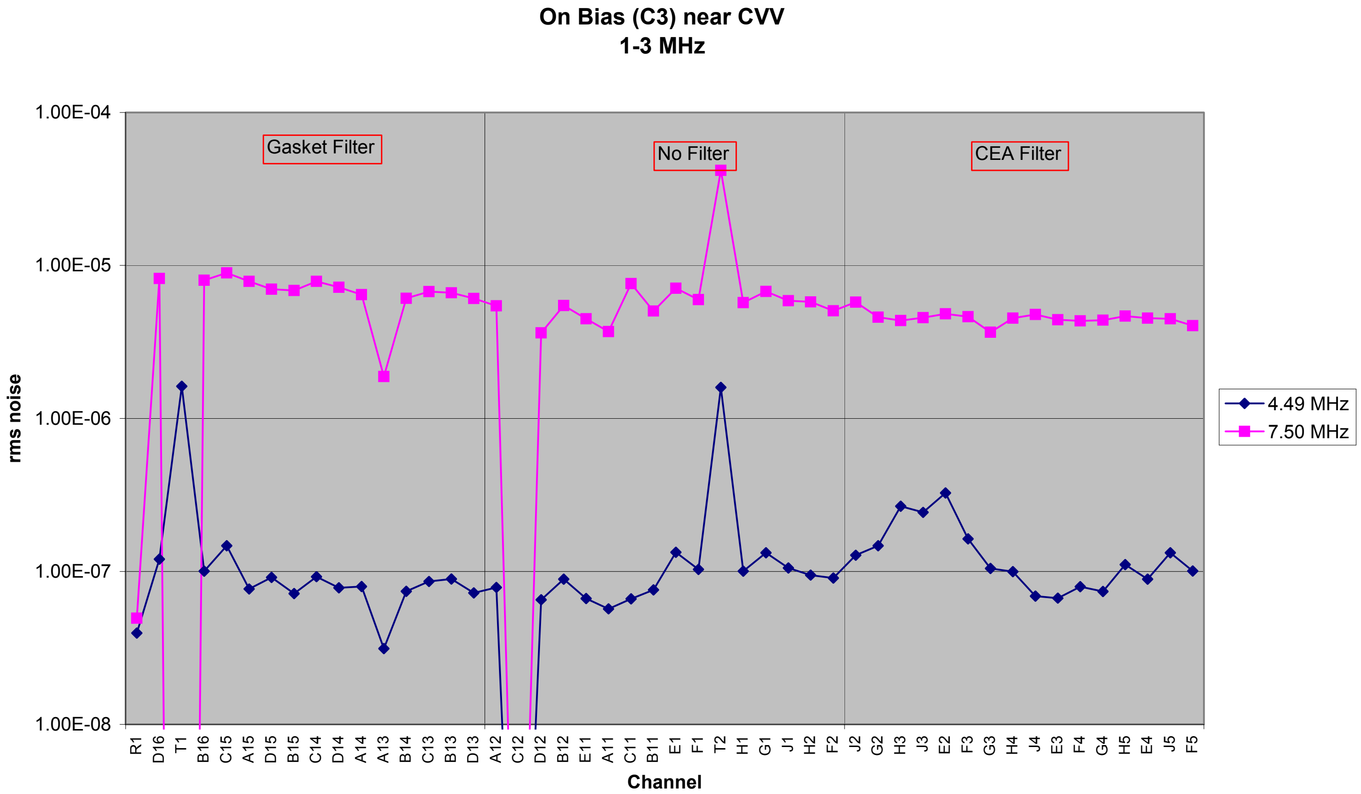


Figure 34

ObsID: 0x3000E364



ObsID: 0x3000E364

2.4.3 10-30 MHz

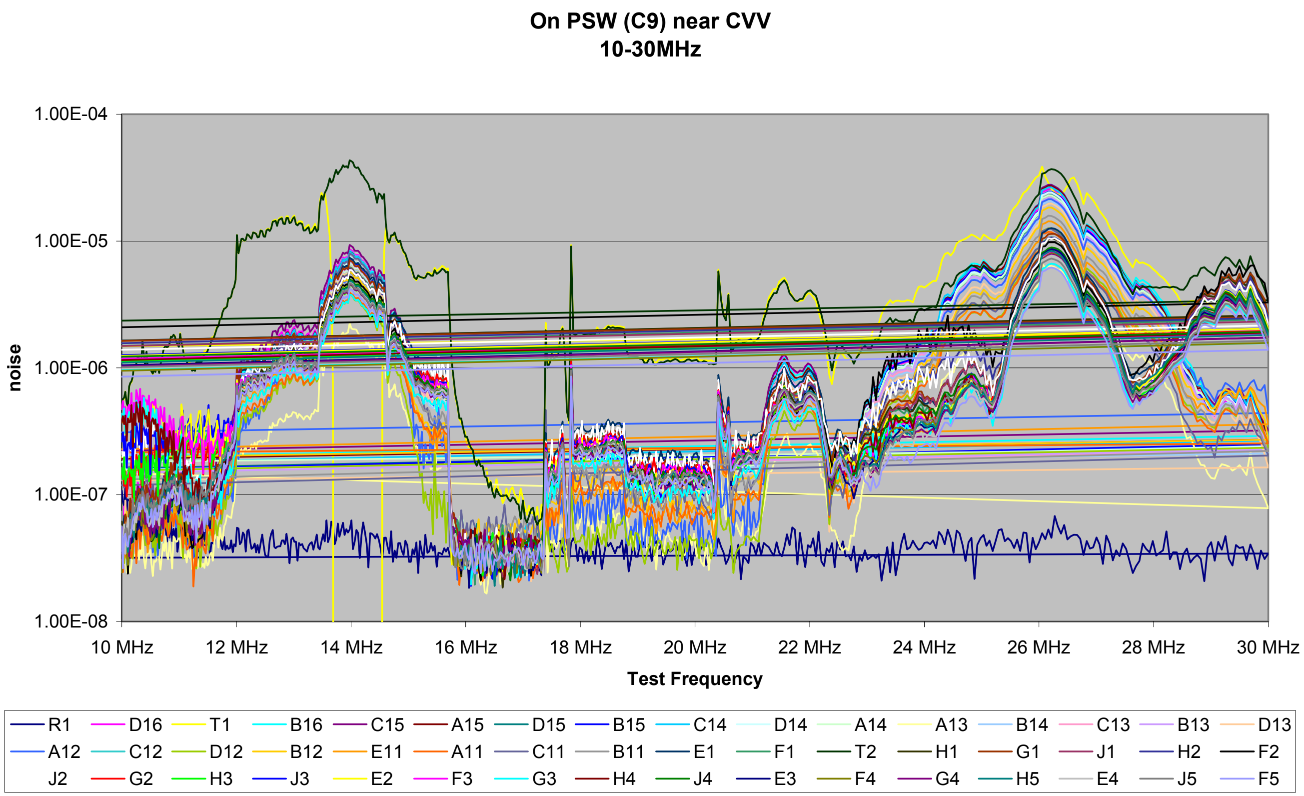


Figure 35

ObsID: 0x3000E364

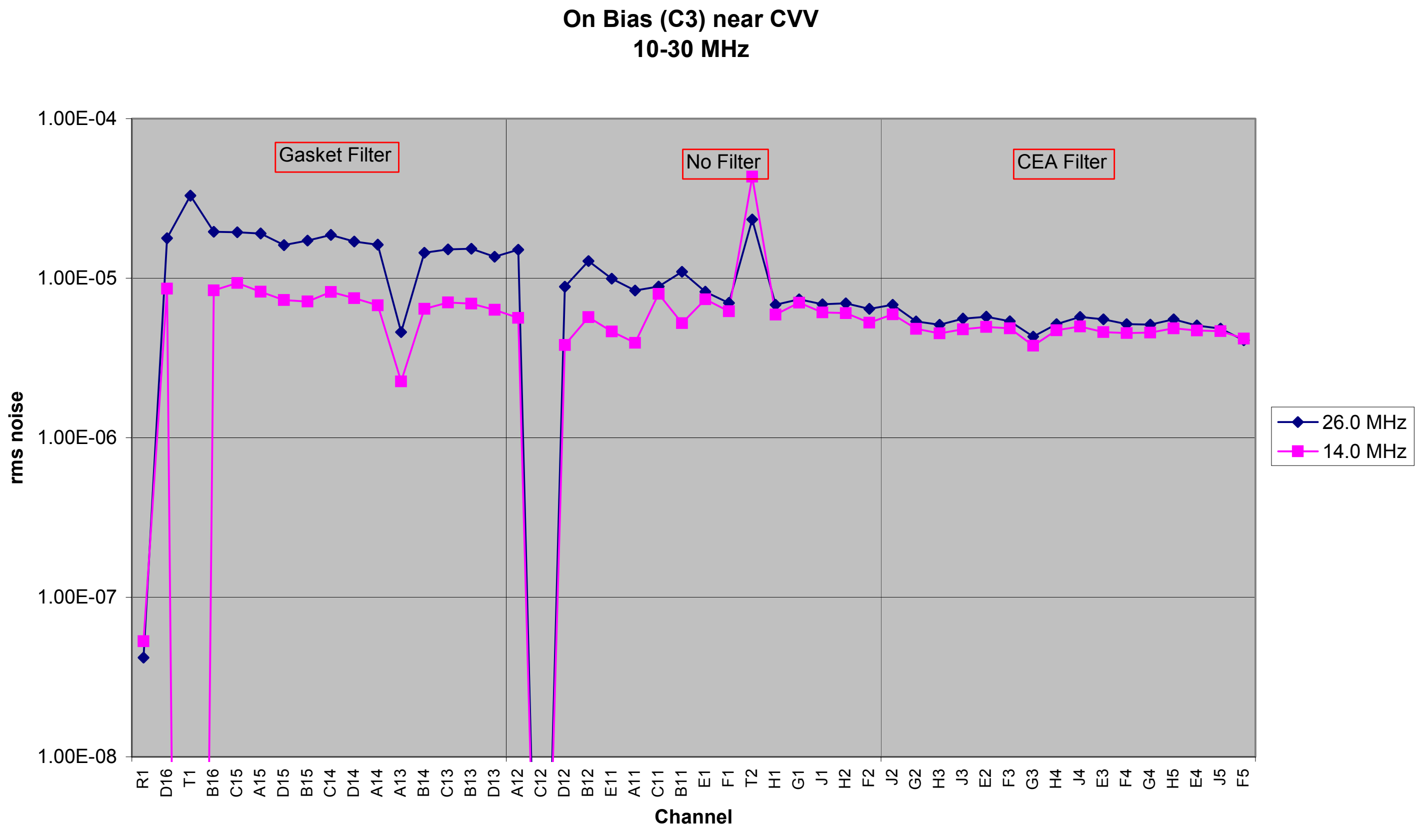


Figure 36

ObsID: 0x3000E364

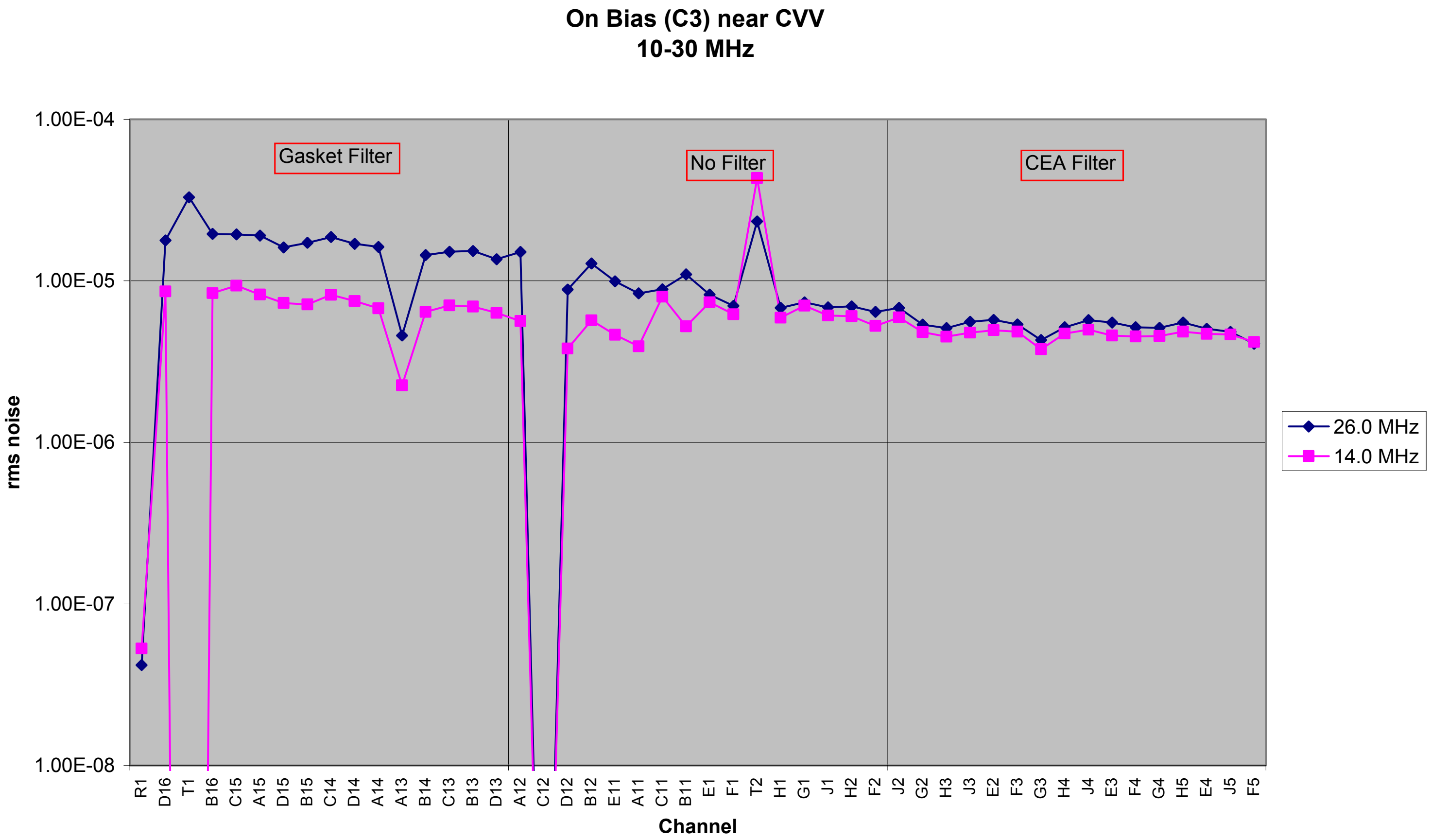


Figure 37

ObsID: 0x3000E364

2.4.4 30-50 MHz

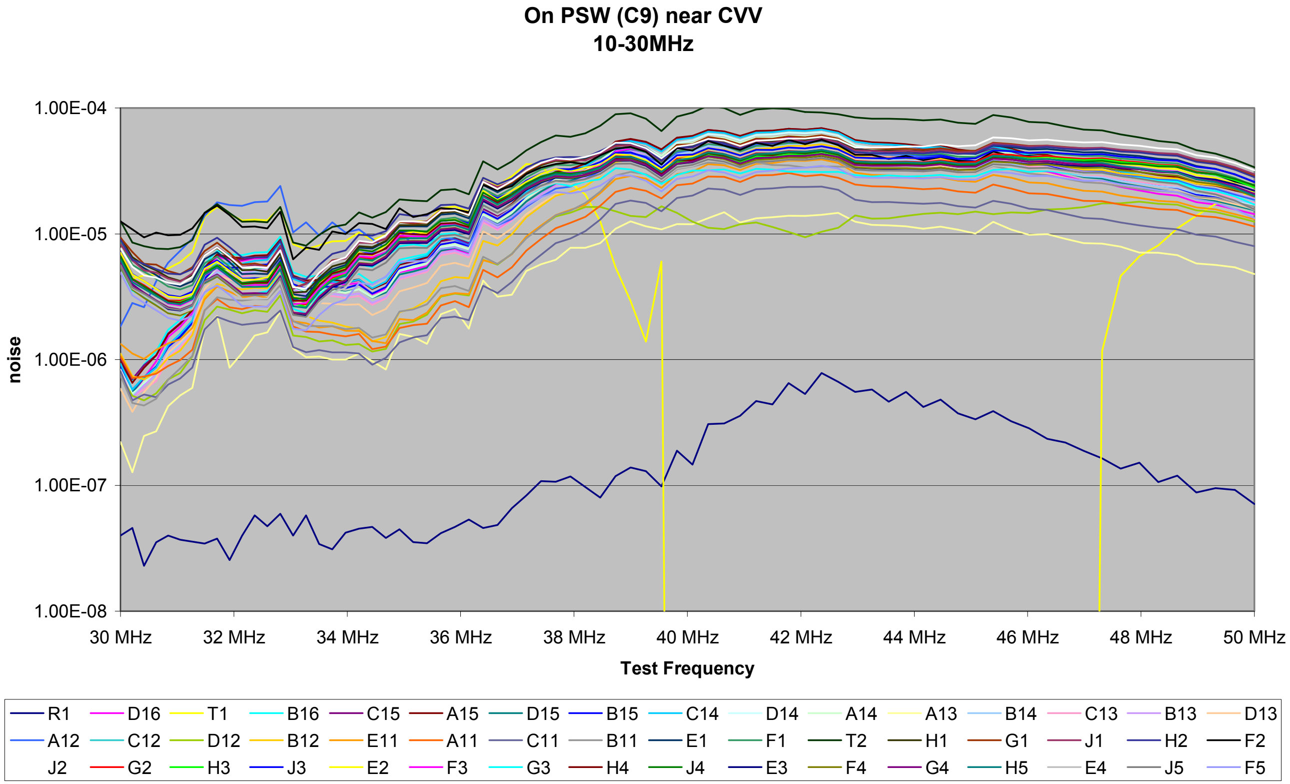


Figure 38

ObsID: 0x3000E364

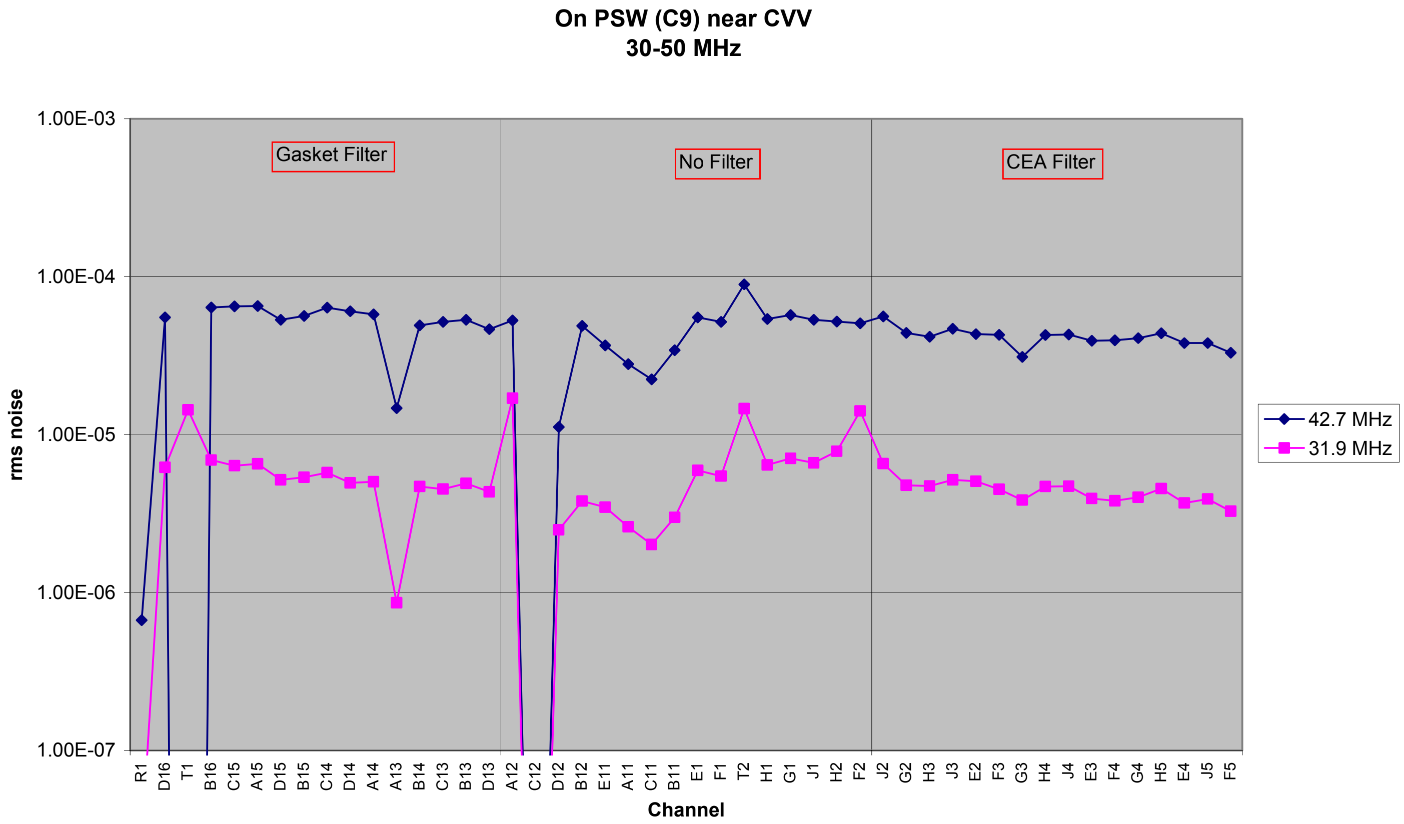


Figure 39

ObsID: 0x3000E364

2.5 *Injection on detector signals close to CVV (C9) filters rotated (Filter config 2)*

2.5.1 1-3 MHz

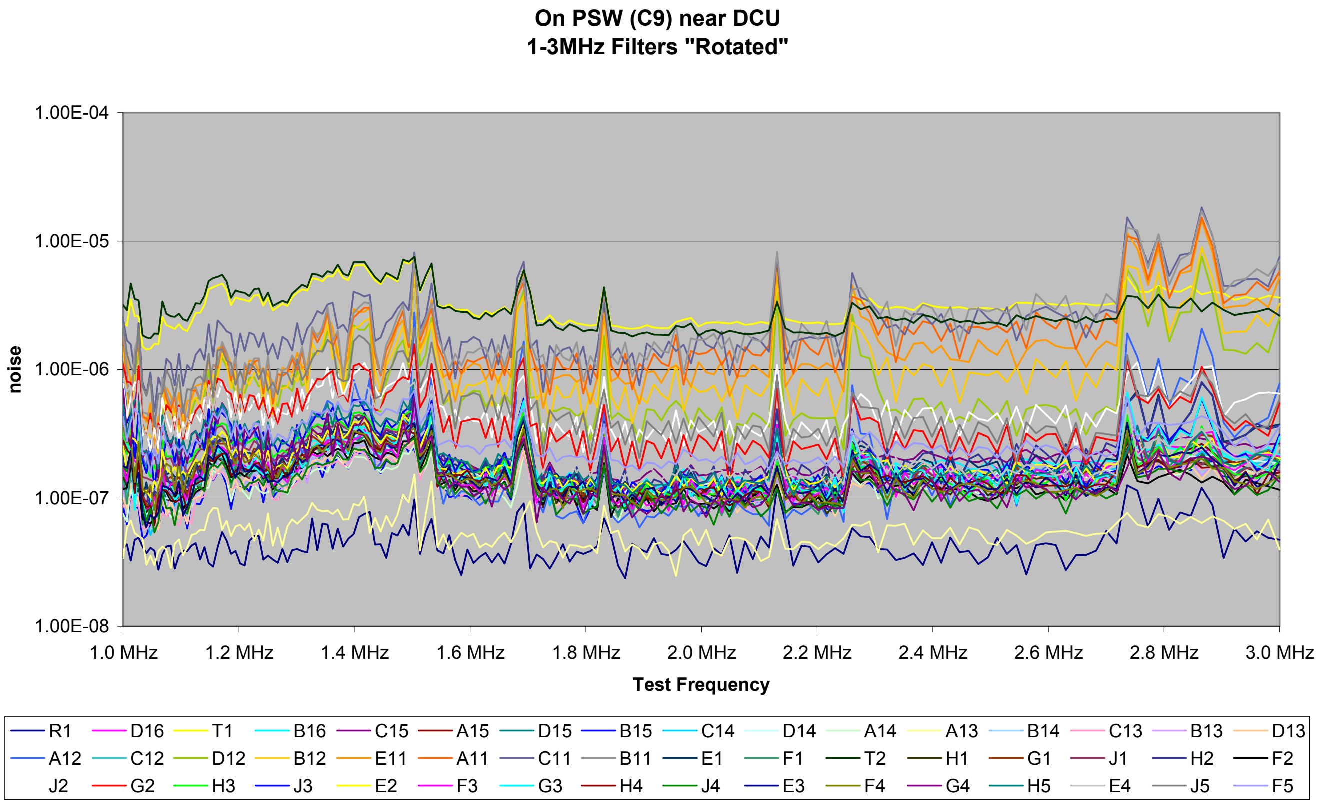


Figure 40

ObsID: 0x3000E370

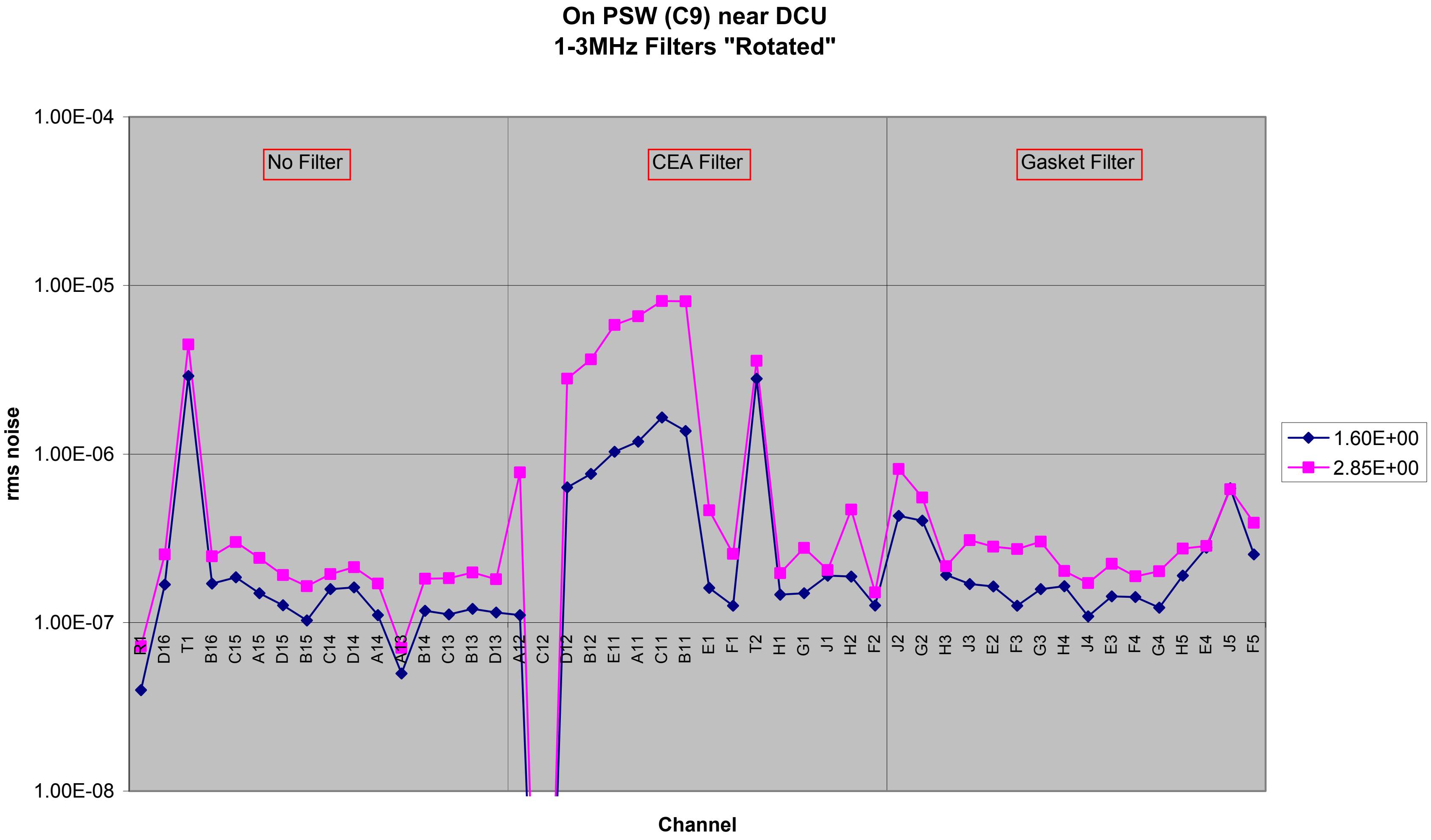


Figure 41

ObsID: 0x3000E370

2.5.2 3-10 MHz

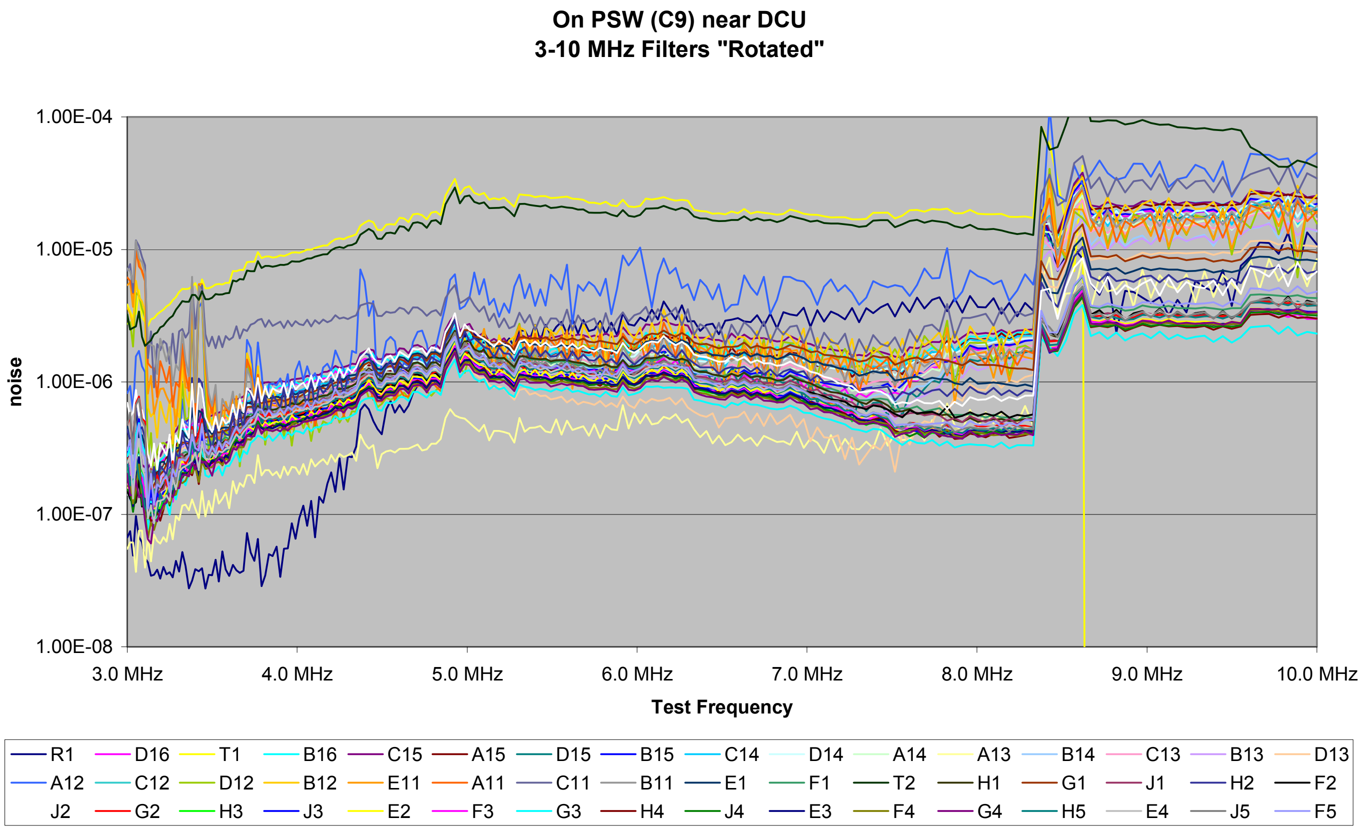


Figure 42

ObsID: 0x3000E370

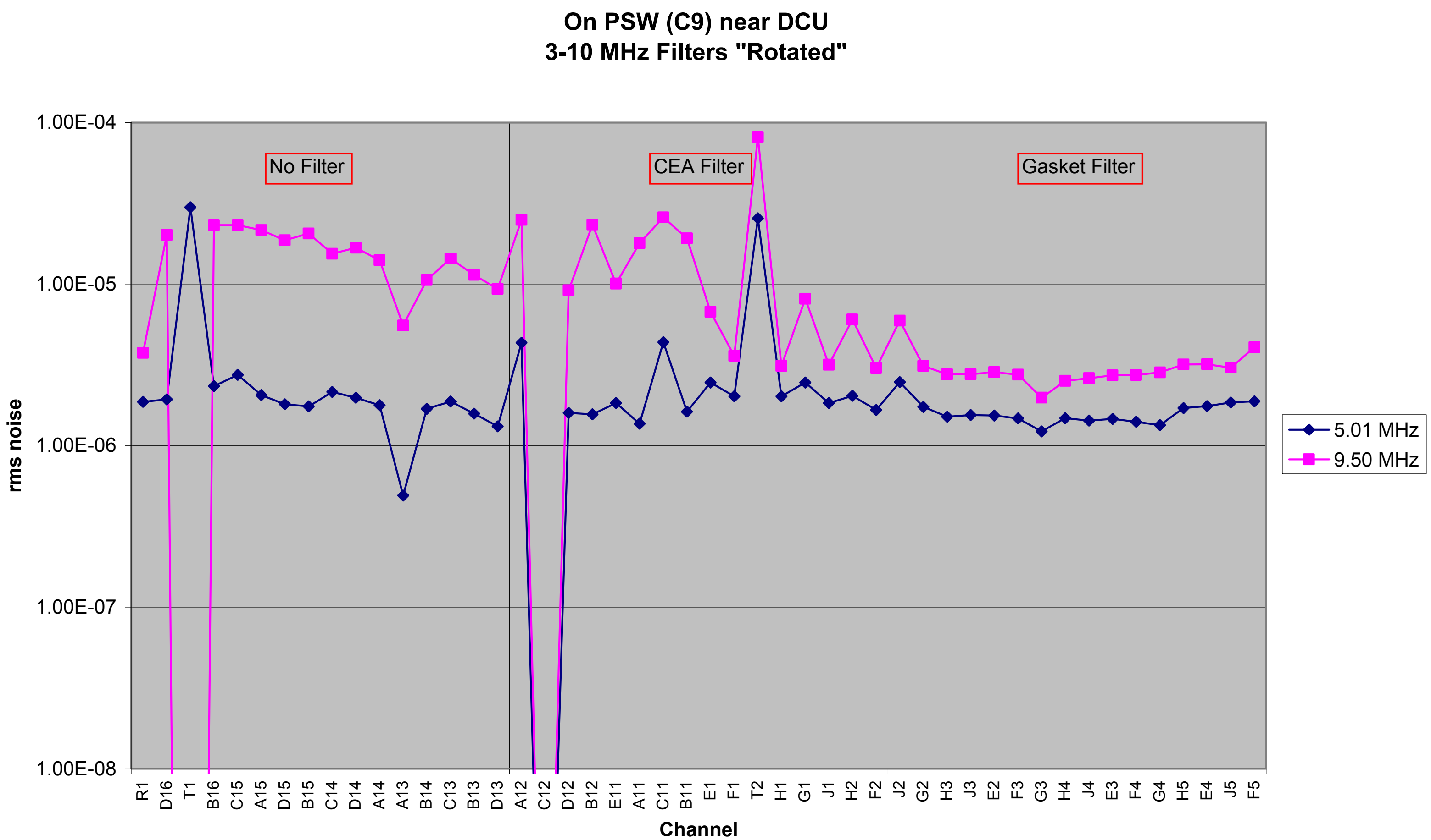


Figure 43

ObsID: 0x3000E370

2.5.3 10-30 MHz

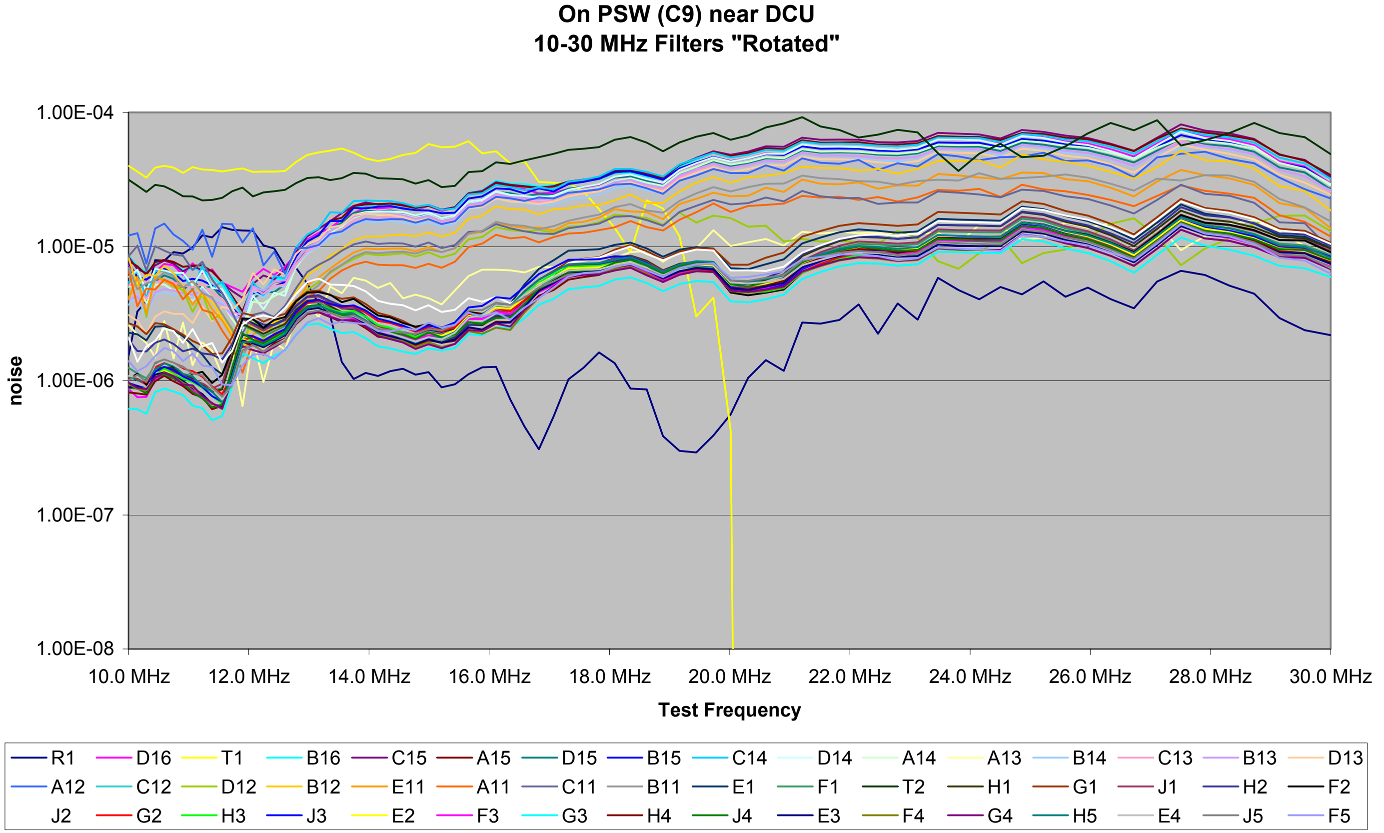


Figure 44

ObsID: 0x3000E370

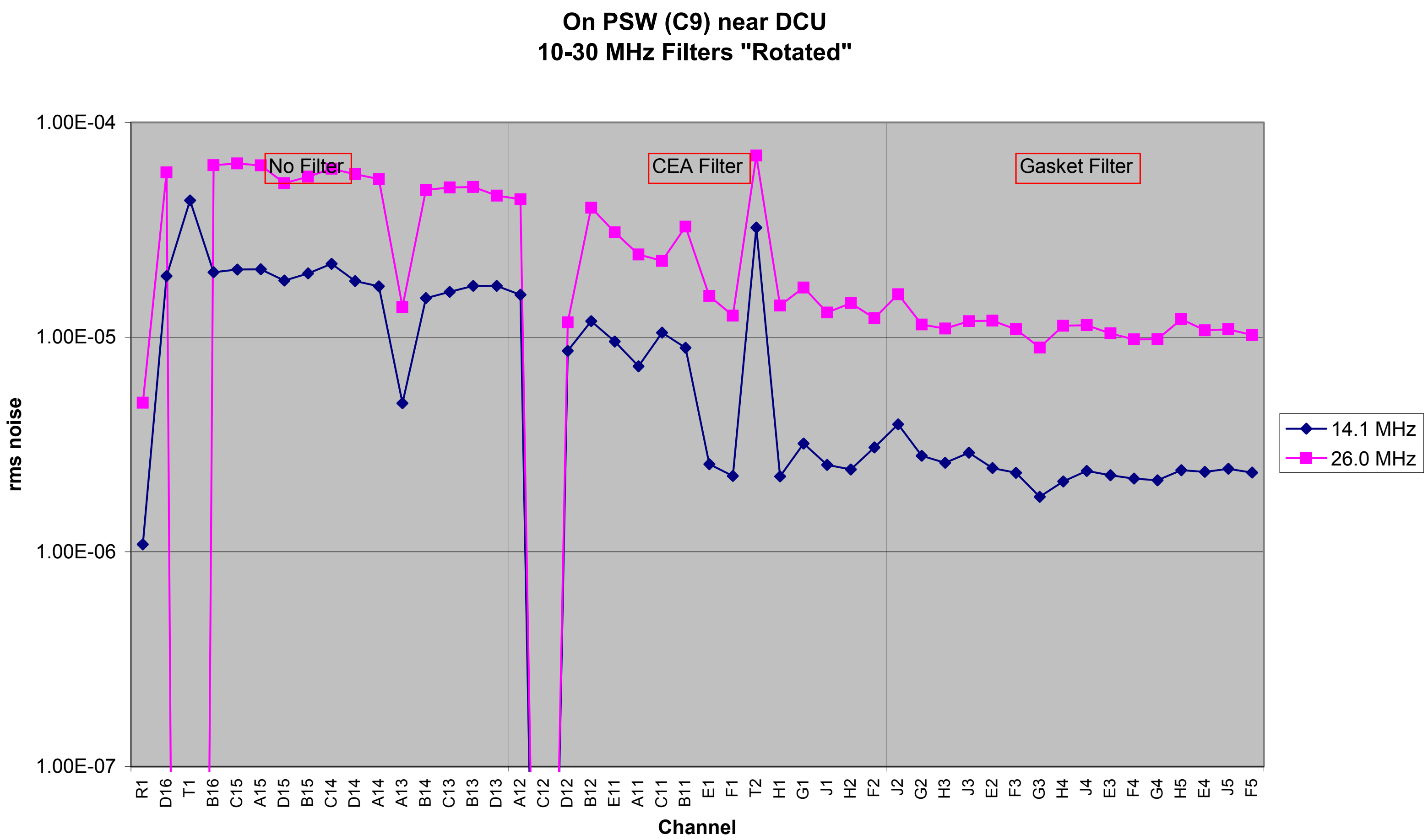


Figure 45

ObsID: 0x3000E370

2.5.4 30-50 MHz

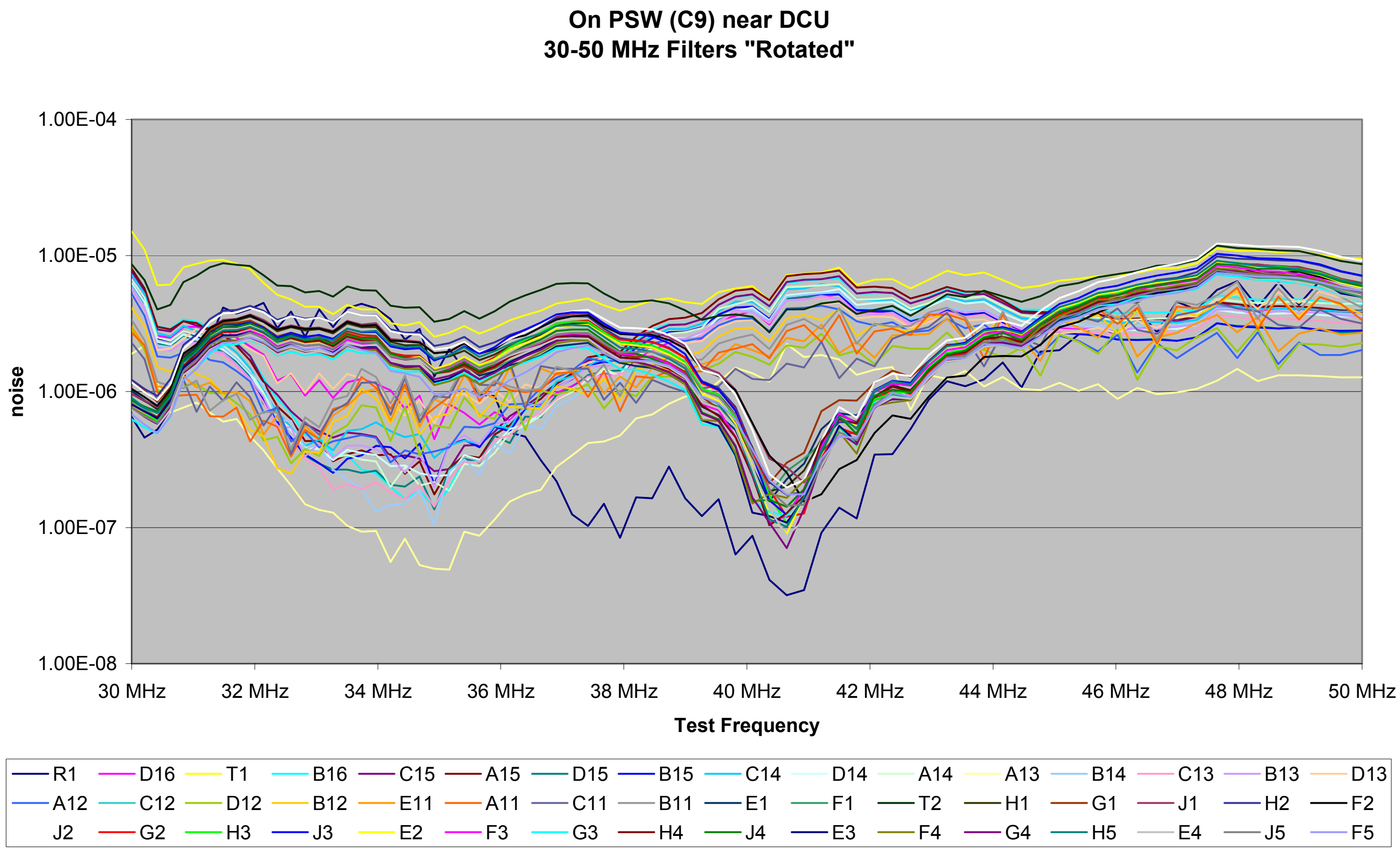


Figure 46

ObsID: 0x3000E370

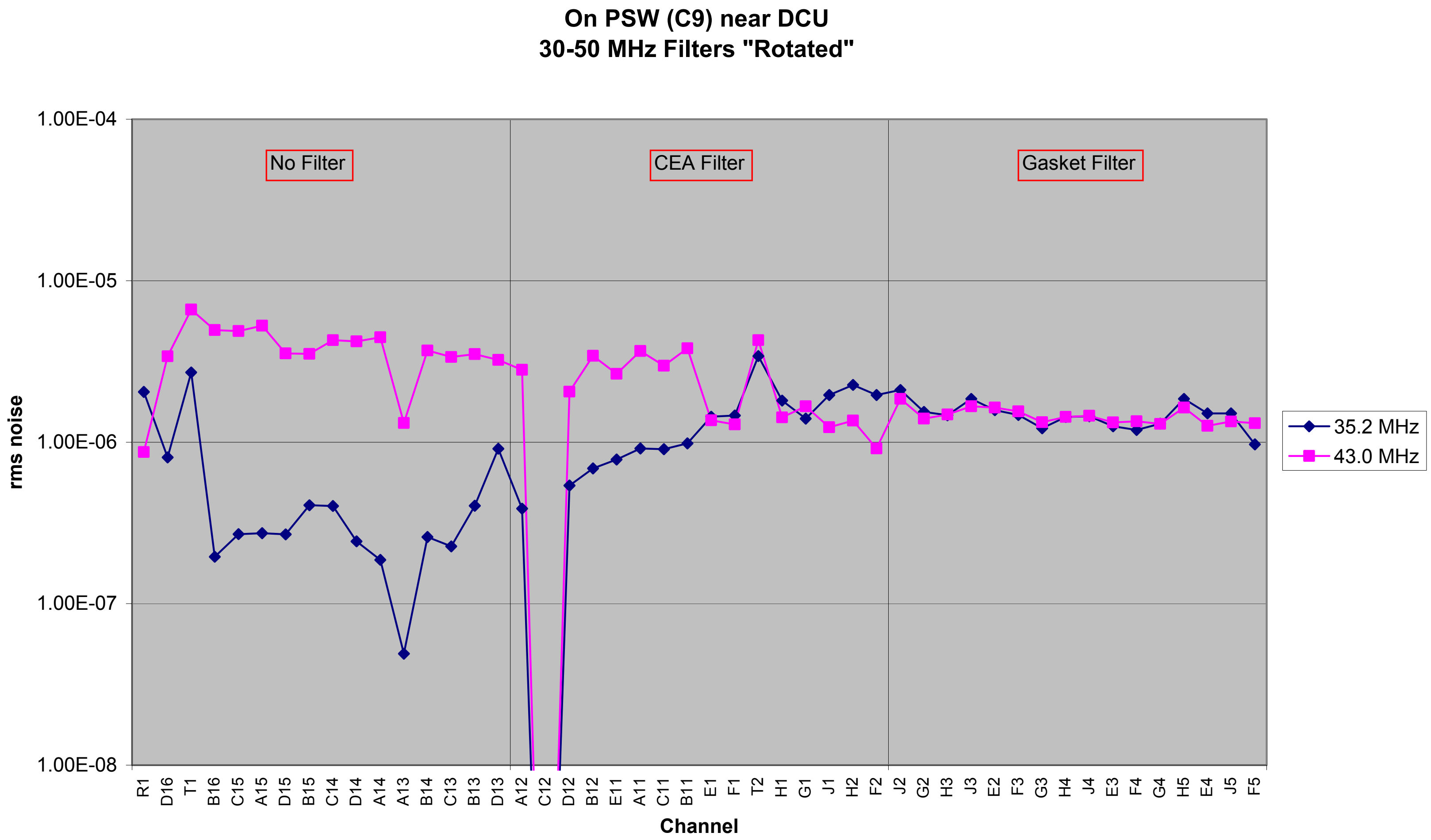


Figure 47

ObsID: 0x3000E370

2.6 Inductive Filter Results

2.6.1 Injection neat DCU

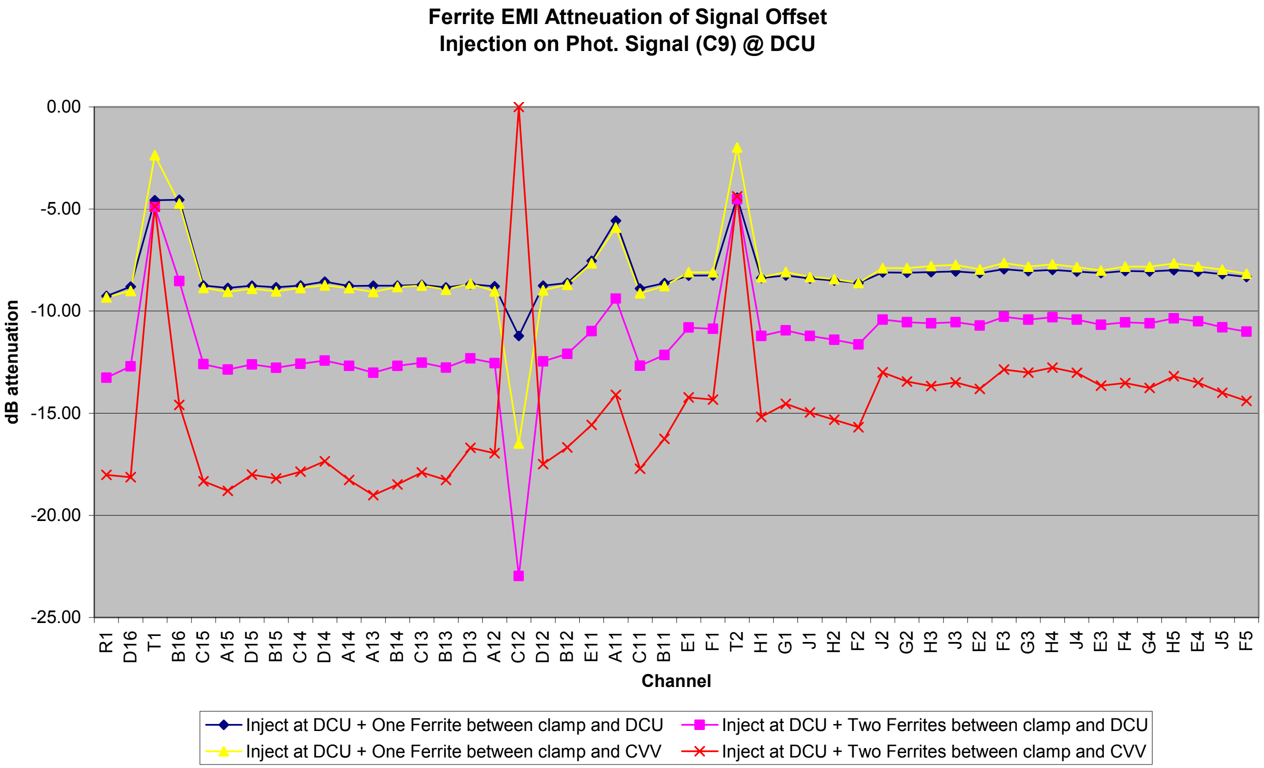


Figure 48

ObsID: 0x3000E370

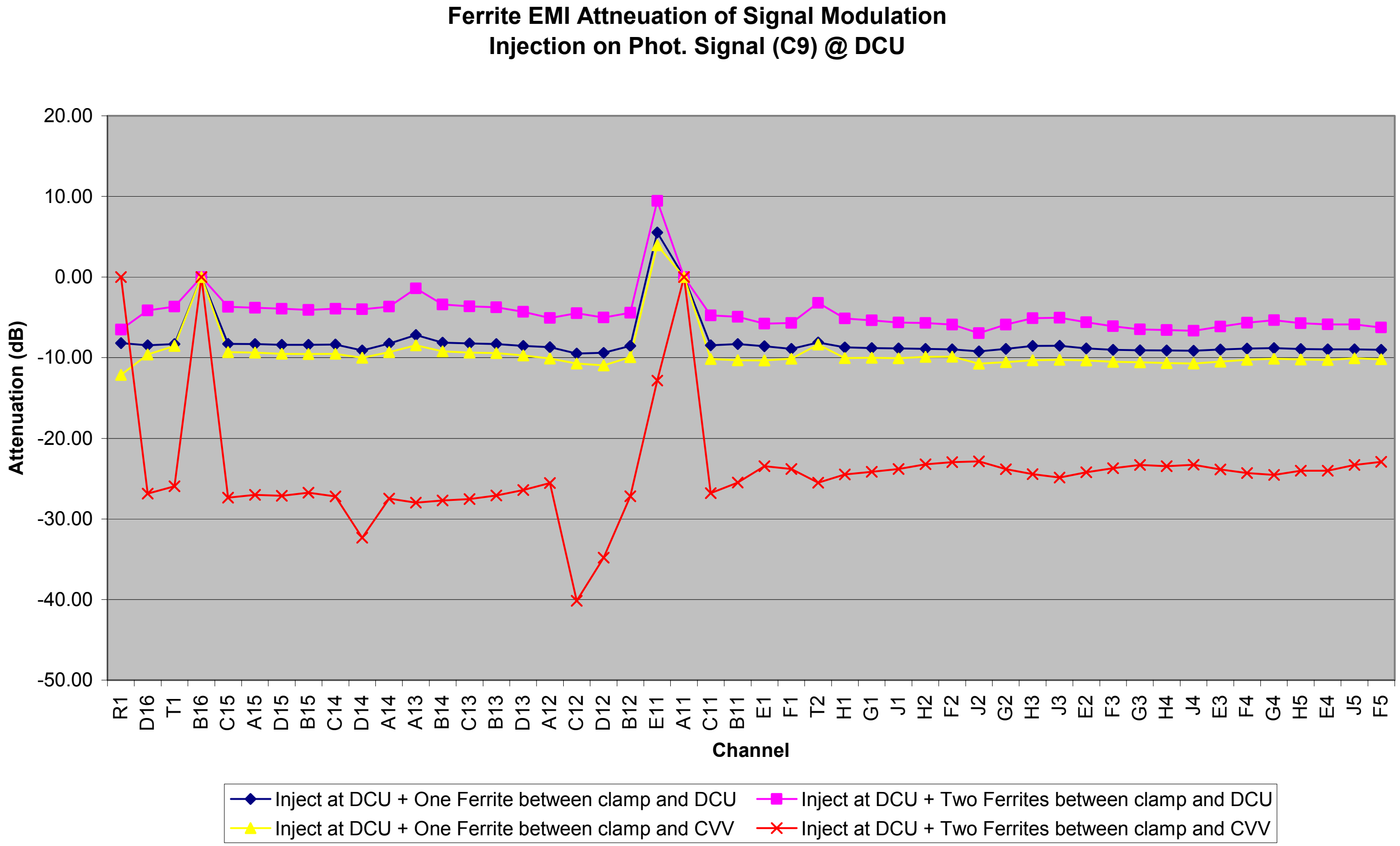


Figure 49

ObsID: 0x3000E370

2.6.2 Injection Close to CVV

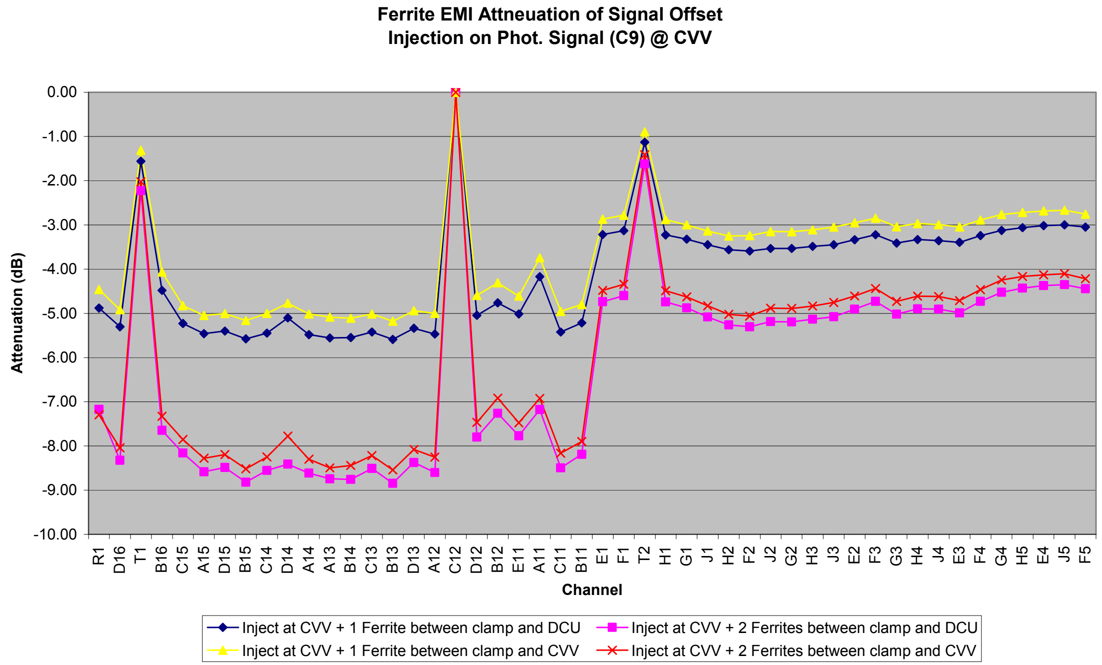


Figure 50

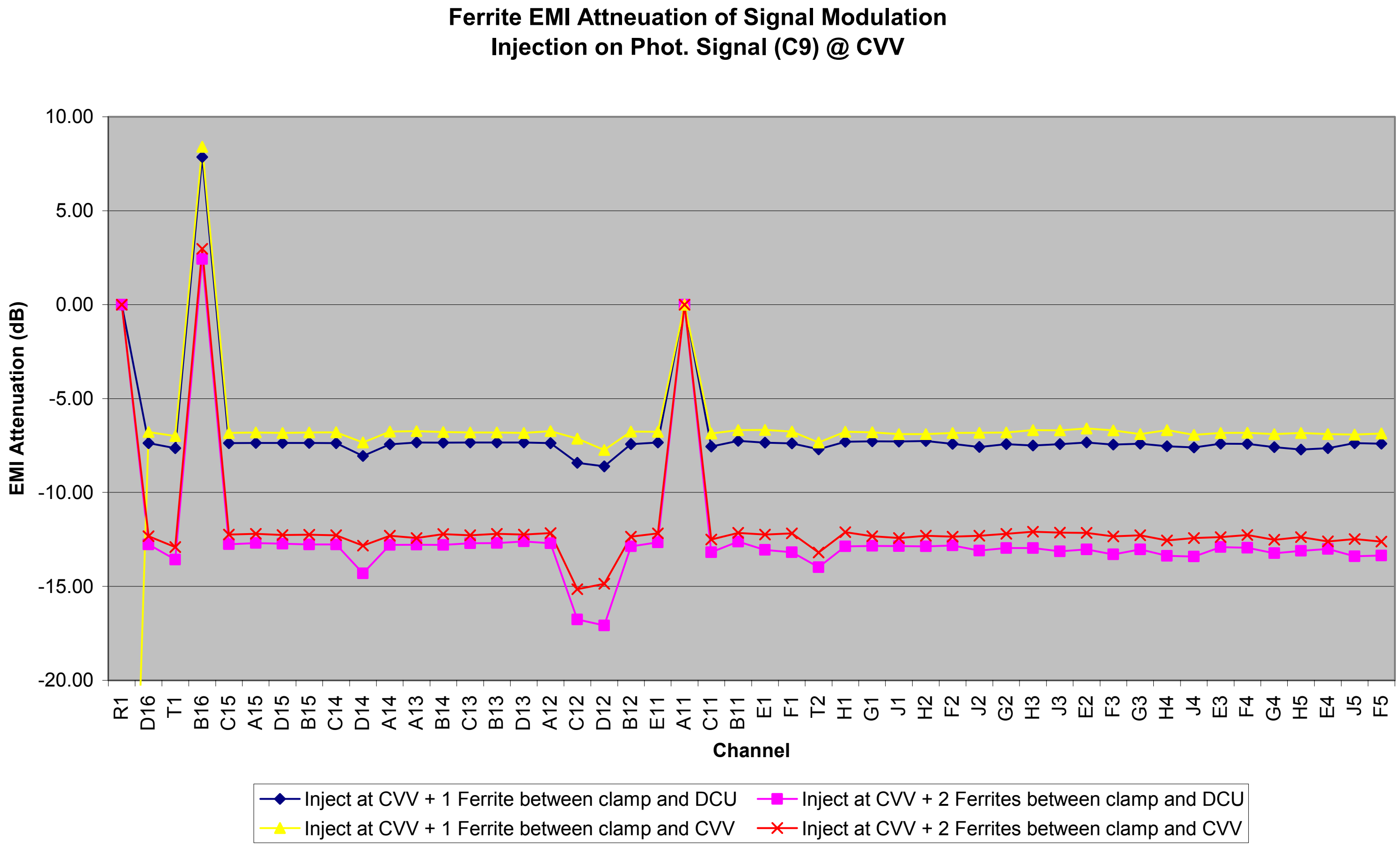


Figure 51

ObsID: 0x3000E370

2.6.3 Injection Close to DCU, Ferrites close to CVV

No attenuation of EMI

ObsID: 0x3000E370

D. CS Report

1. Introduction and Summary

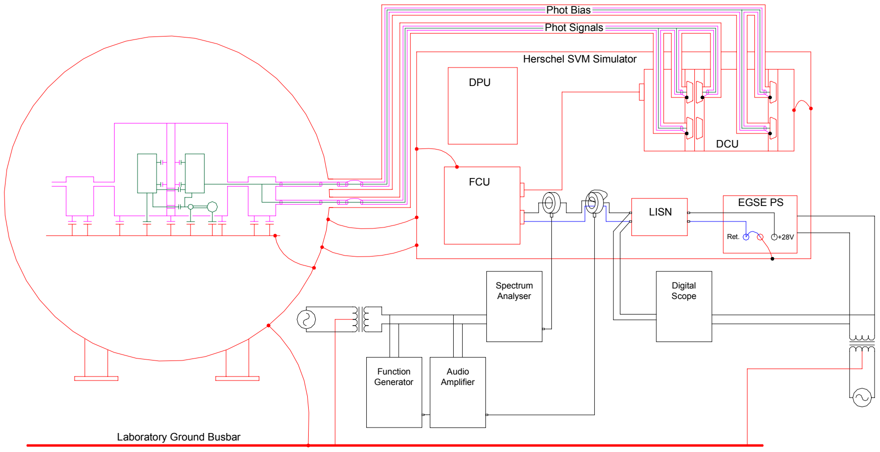


Figure 1 – Test setup for DM test

	Frequency	PLW	PMW	PSW
DM	2.48 MHz	79 mV	71 mV	67 mV
	3.67 MHz	92 mV	77 mV	86 mV
	5.40 MHz			
	9.27 MHz			
	11.25 MHz			
	16.17 MHz			
	20.10 MHz			
	28.25 MHz	?	24 mV	31 mV
	36.67 MHz			
	37.92 MHz	33 mV	29 mV	26 mV
CM	6.00 MHz	425 mV	460 mV	431 mV
	8.50 MHz			
	9.50 MHz			
	15.30 MHz	486 mV	603 mV	639 mV
	20.00 MHz			
	34.00 MHz	720 mV	687 mV	732 mV
	39.00 MHz			
	47.60 MHz	749 mV	634 mV	606 mV

Figure 2 – Susceptibility thresholds

2. Differential Mode

2.1 2.48 MHz

2.1.1 PLW

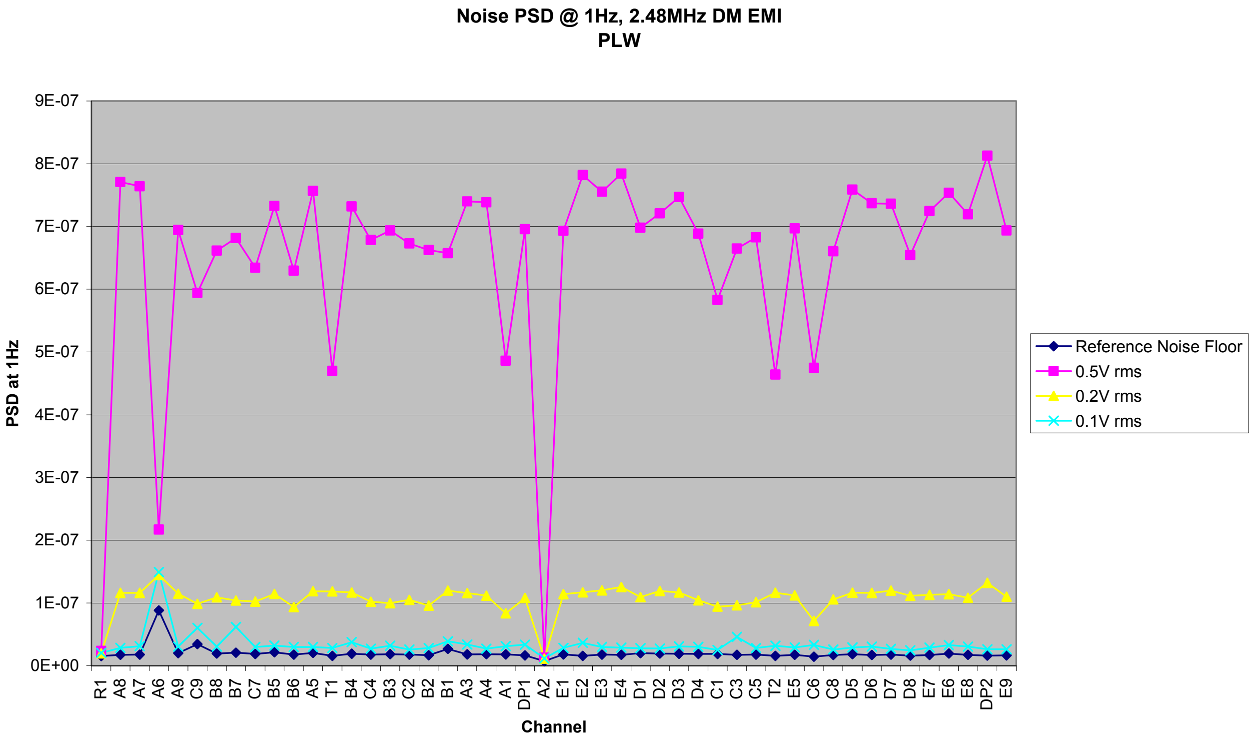


Figure 3

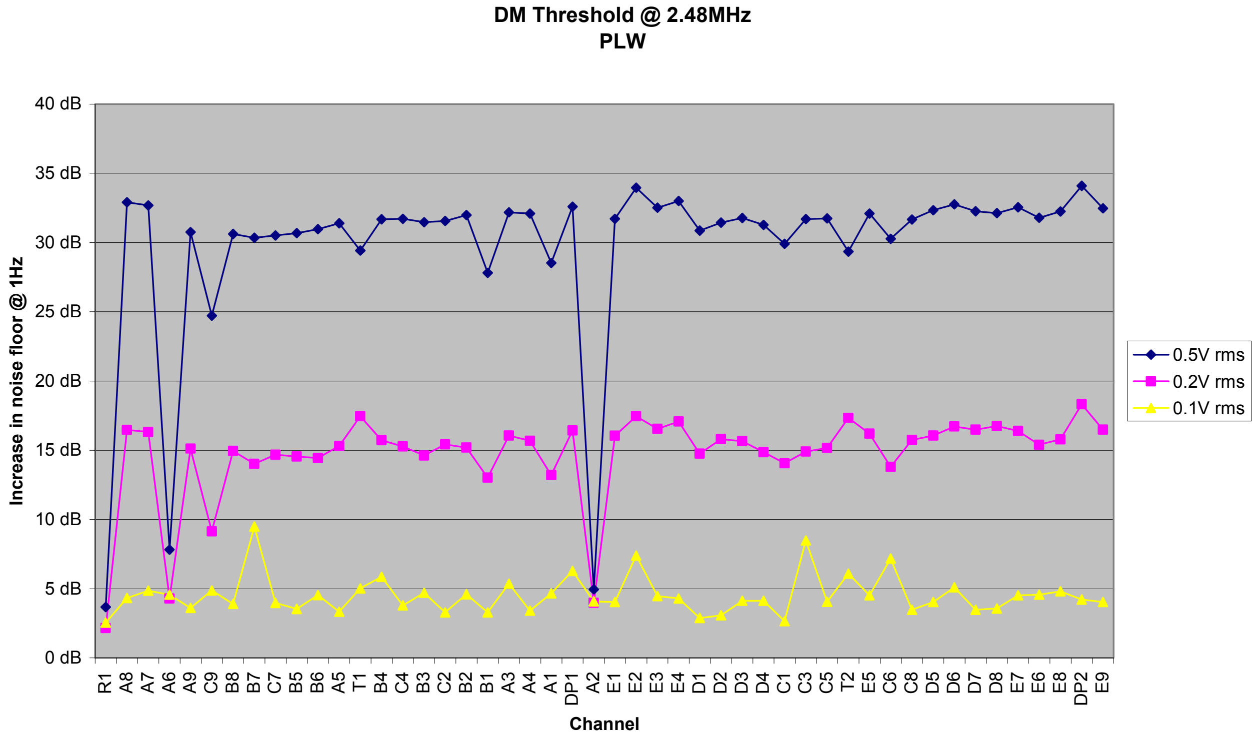


Figure 4

Figure 5

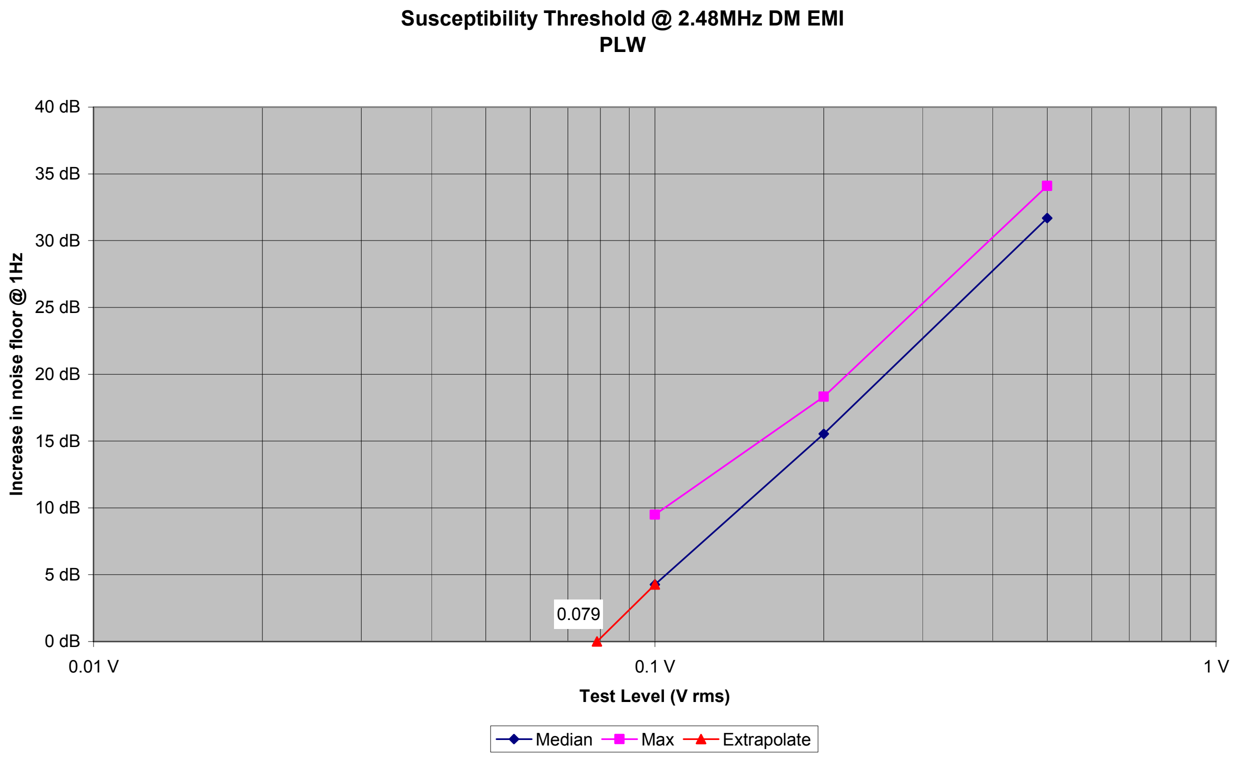


Figure 6

2.1.2 PMW

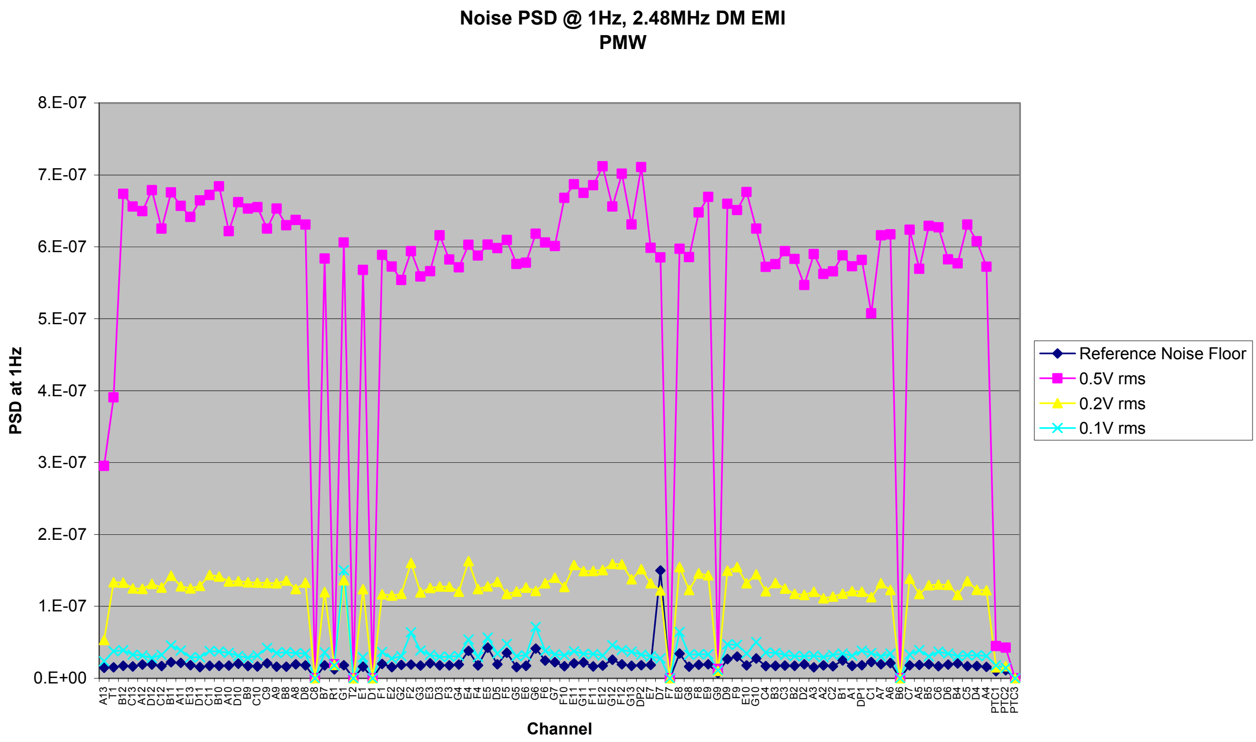


Figure 7

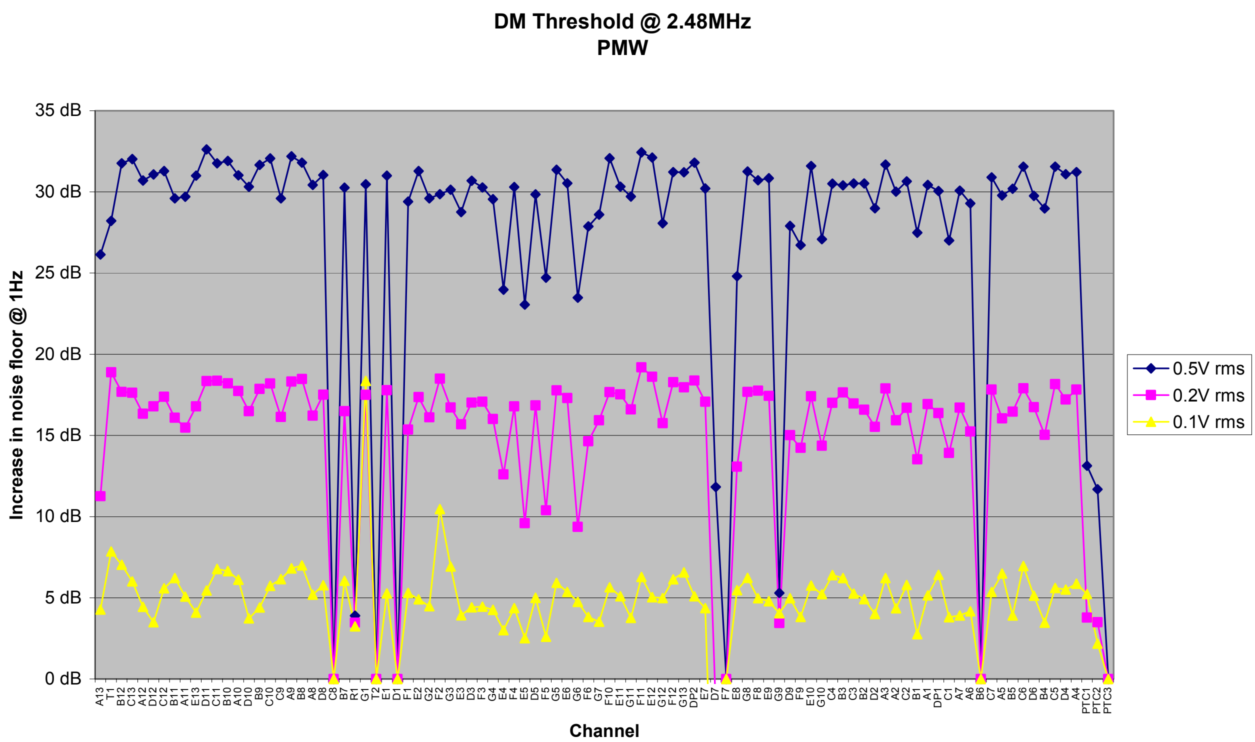


Figure 8

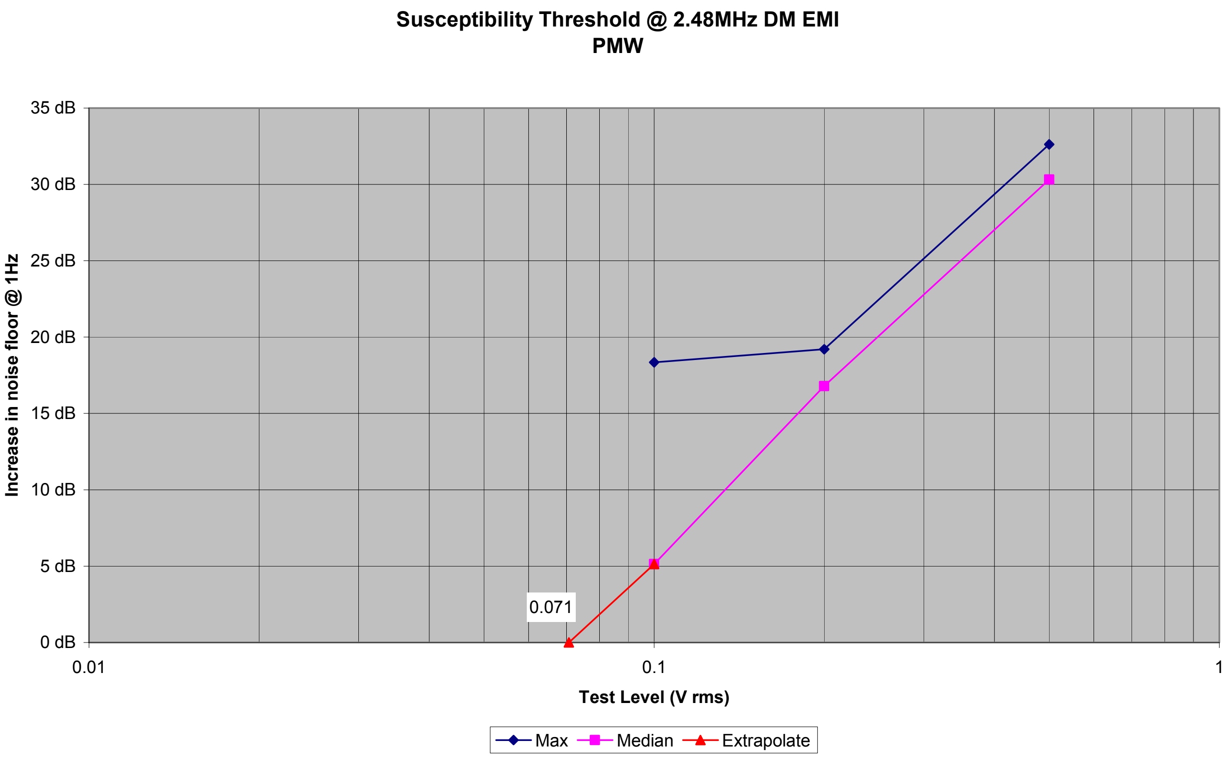

Susceptibility Threshold @ 2.48MHz DM EMI
PMW
35 dB
30 dB
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
Increase in noise floor @ 1Hz
0.071
0.01
0.1
1
Test Level (V rms)
Max
Median
Extrapolate

Figure 9

2.1.3 PSW

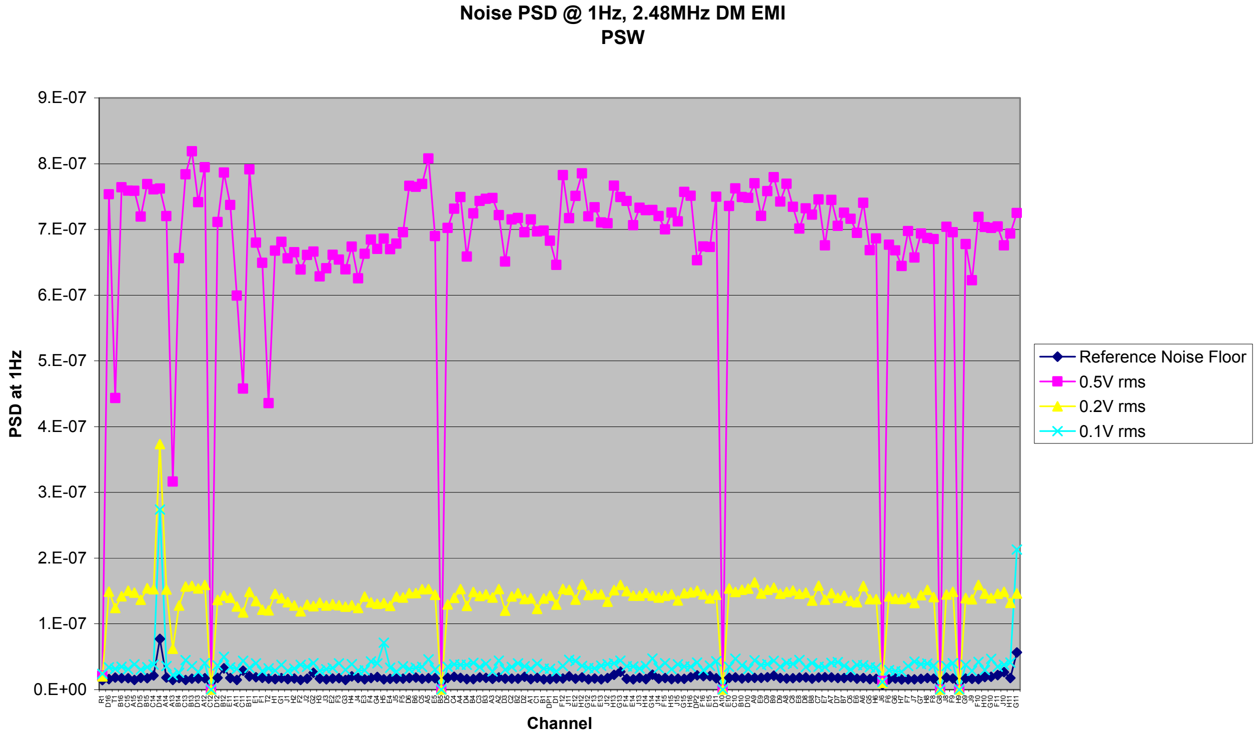


Figure 10

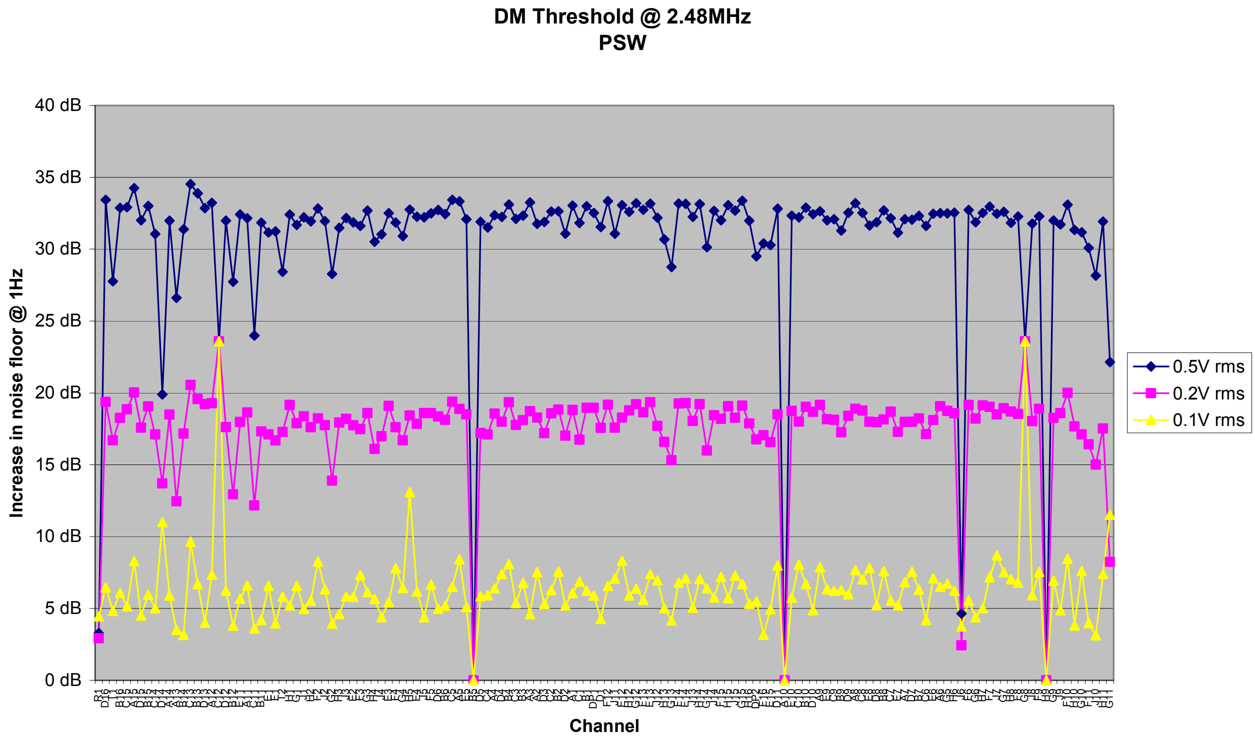


Figure 11

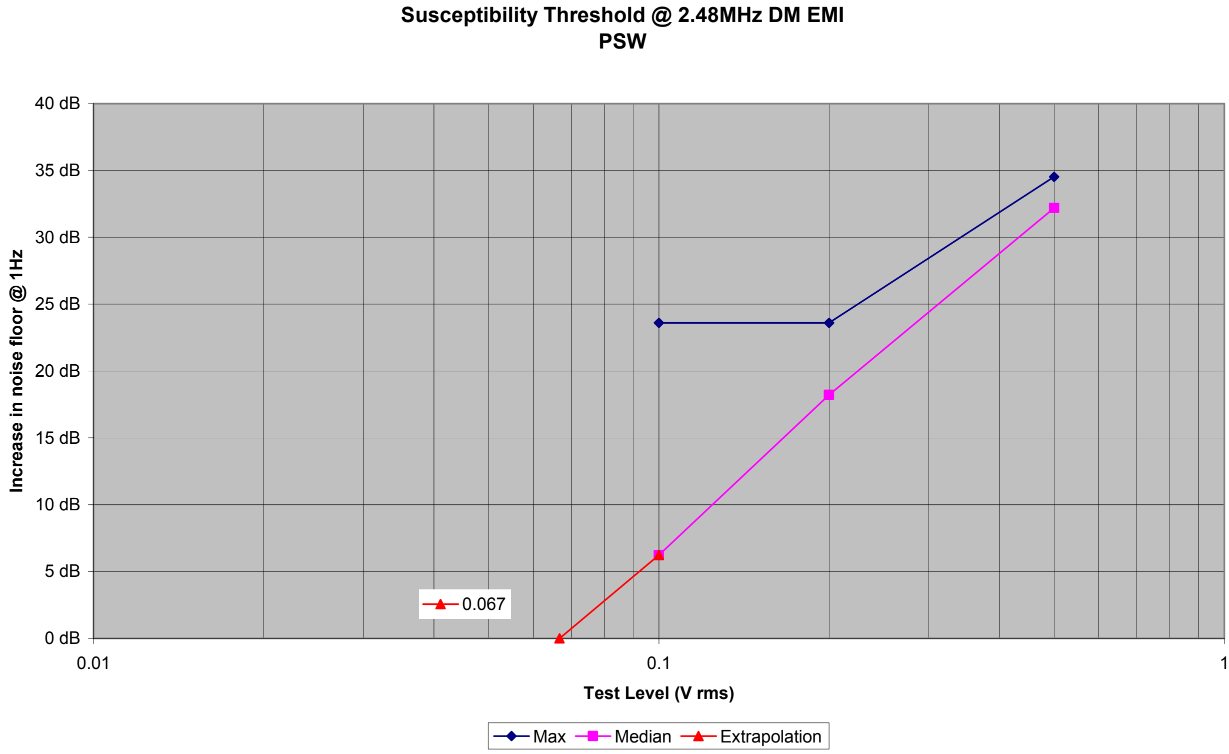

Susceptibility Threshold @ 2.48MHz DM EMI
PSW
40 dB
35 dB
30 dB
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
Increase in noise floor @ 1Hz
0.067
0.01
0.1
1
Test Level (V rms)
Max
Median
Extrapolation

Figure 12

2.2 3.668MHz

2.2.1 PLW

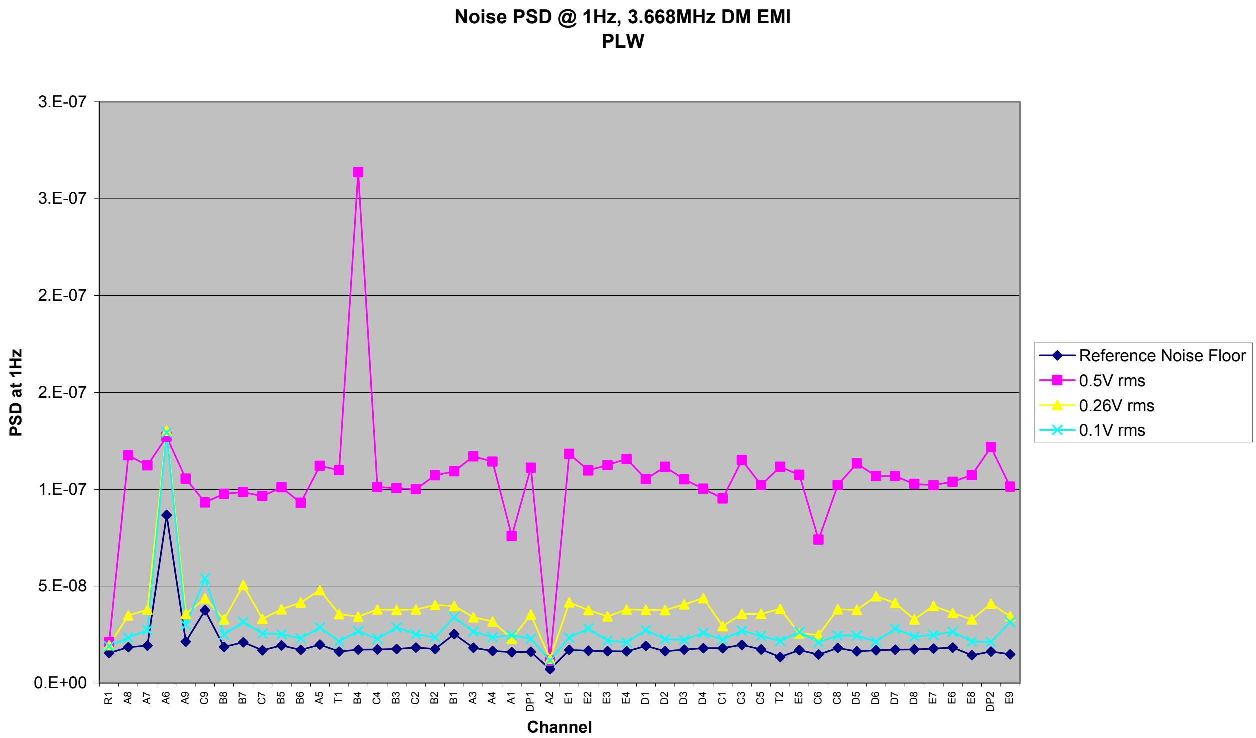


Figure 13

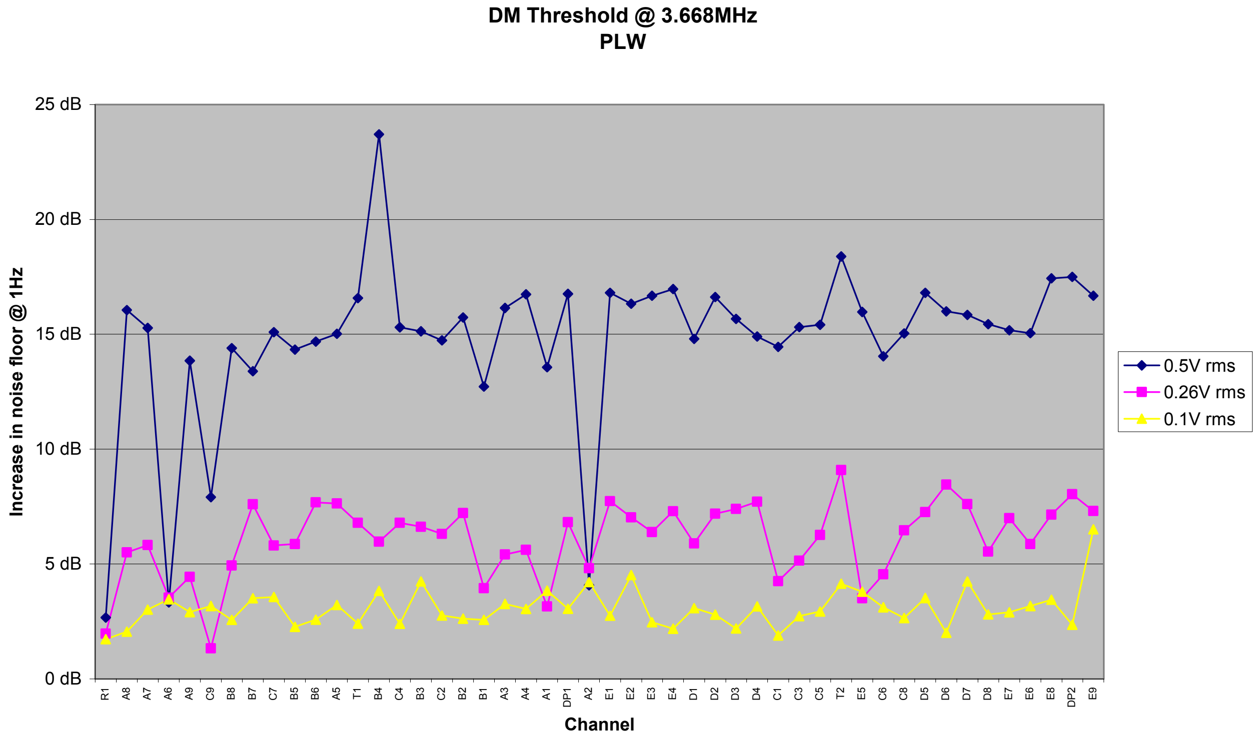


Figure 14

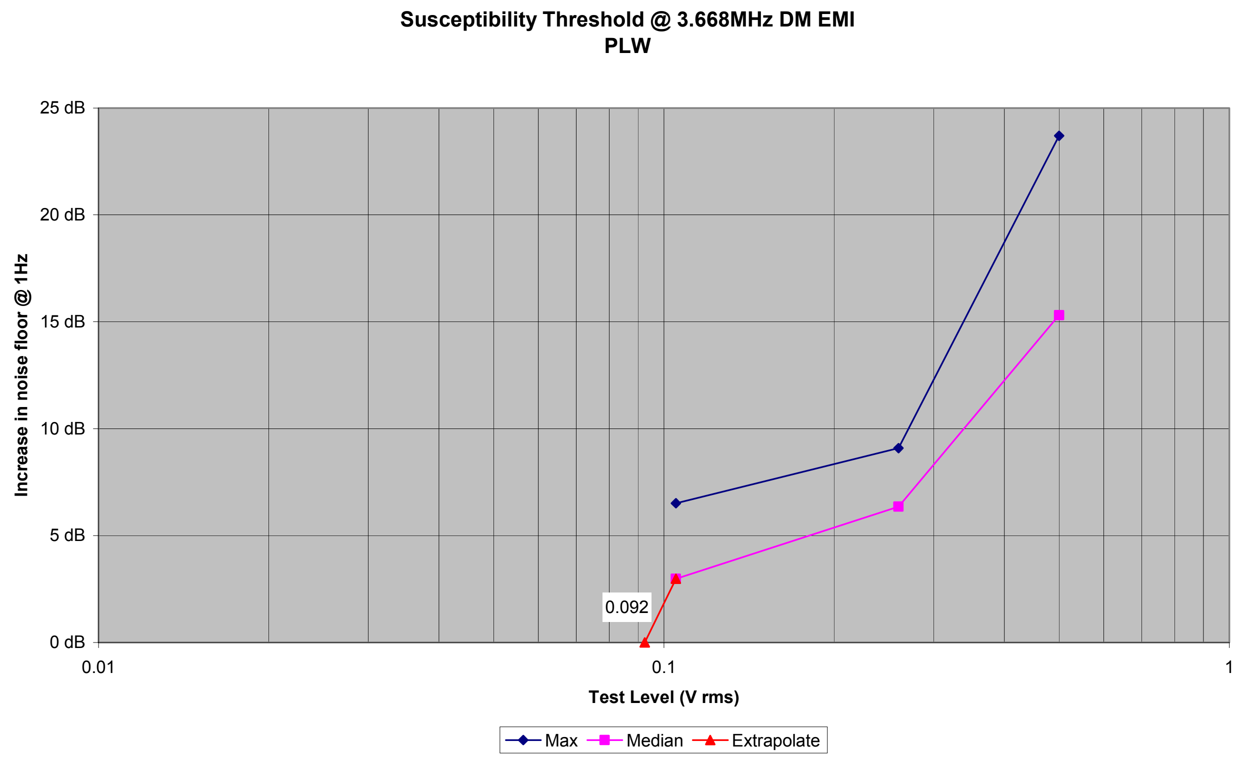


Figure 15

2.2.2 PMW

Figure 16

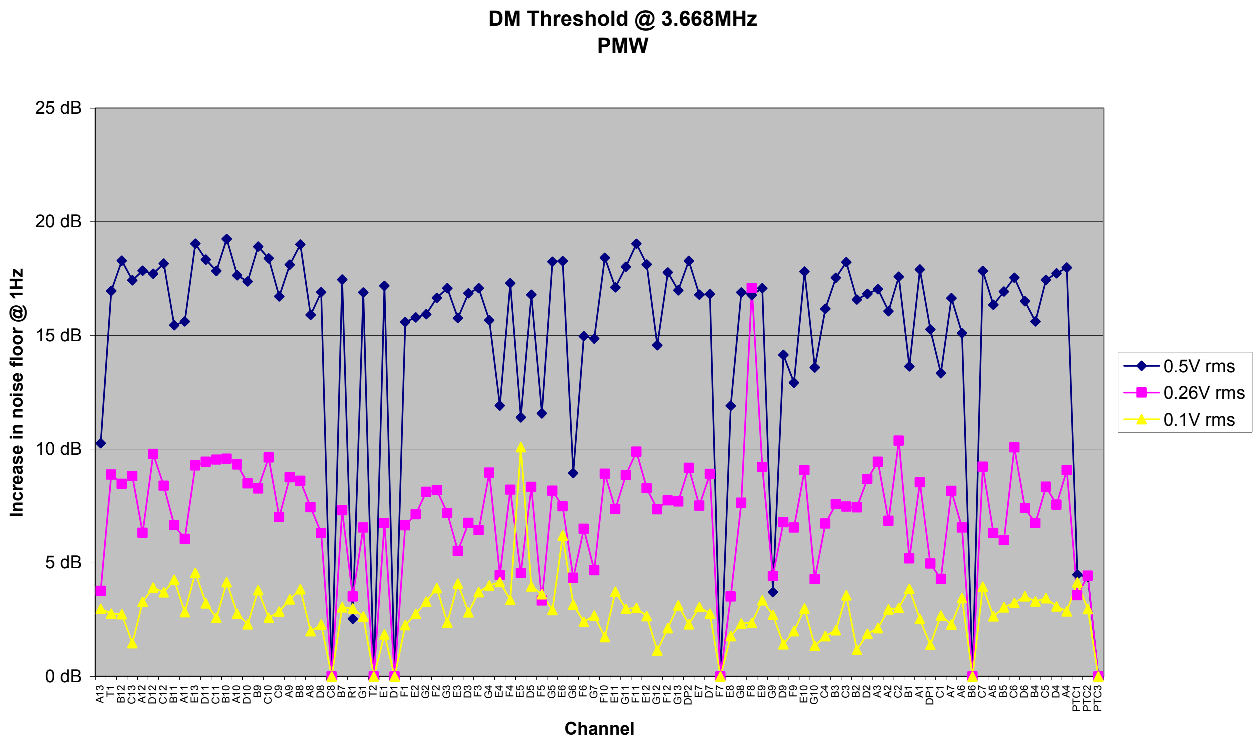


Figure 17

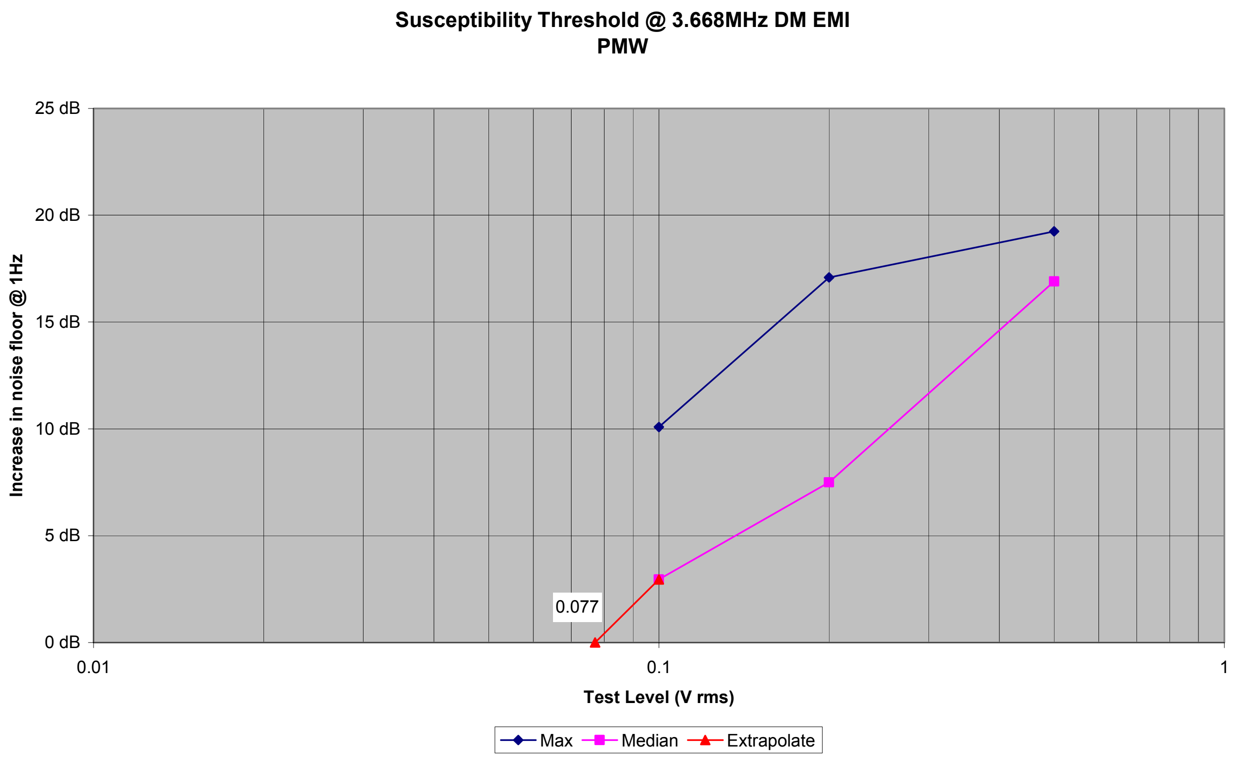


Figure 18

2.2.3 PSW

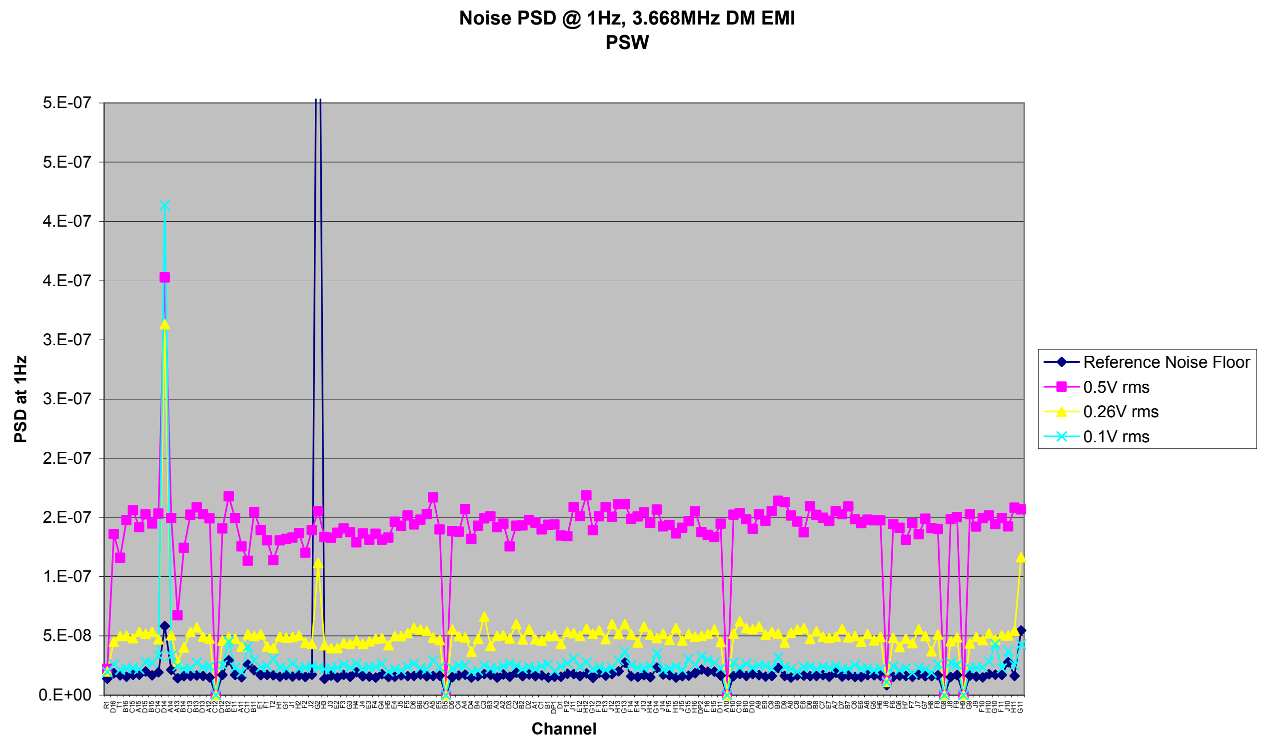


Figure 19

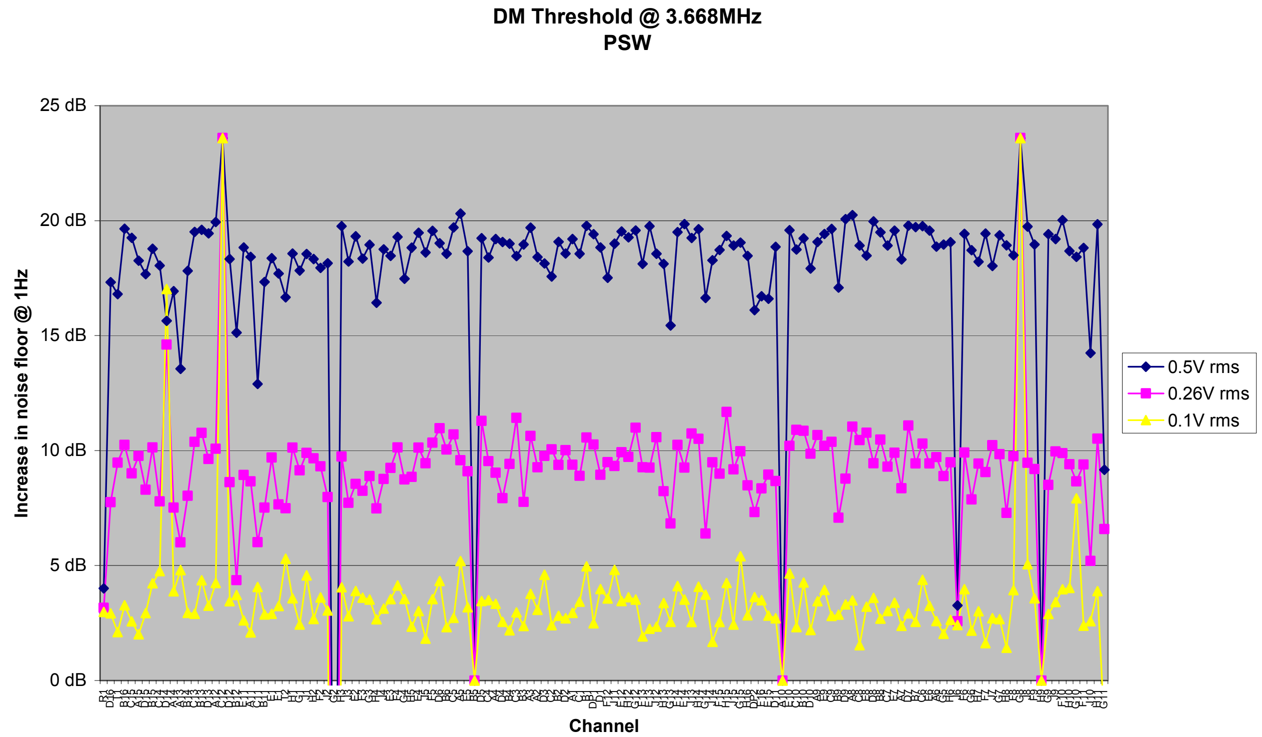


Figure 20

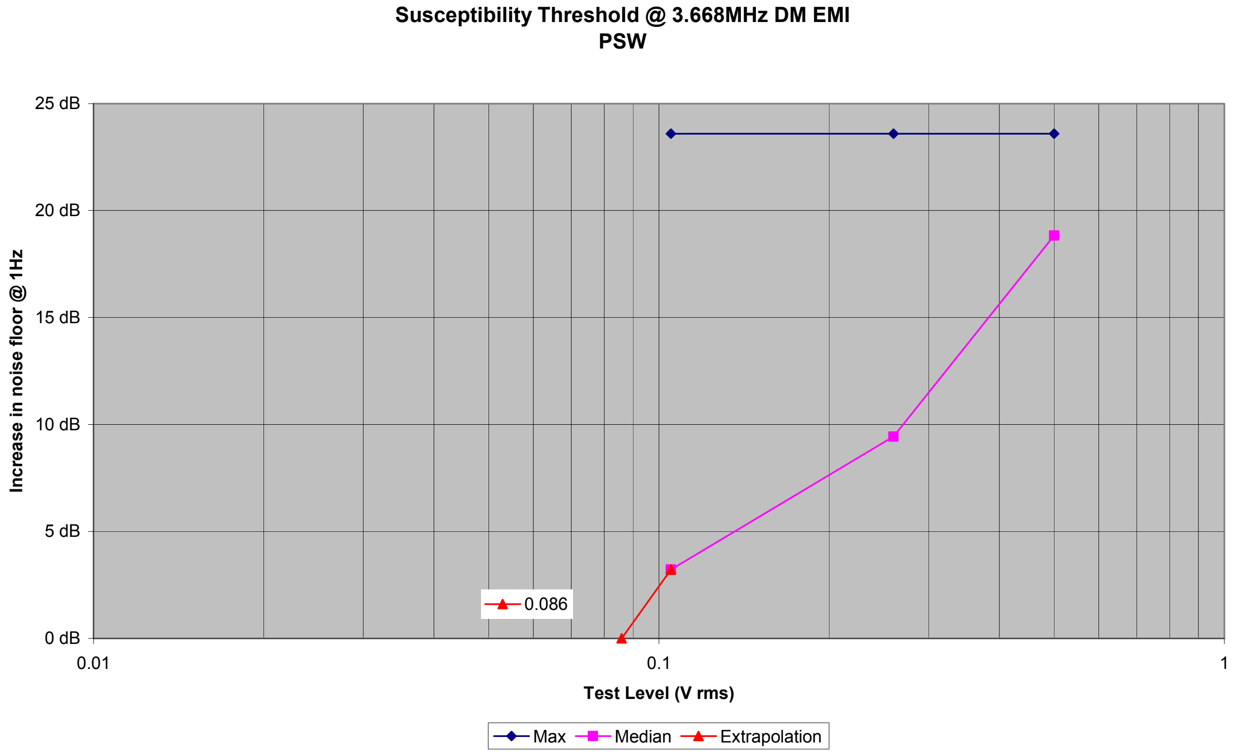

Susceptibility Threshold @ 3.668MHz DM EMI
PSW
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
Increase in noise floor @ 1Hz
0.01
0.1
1
Test Level (V rms)
0.086
Max
Median
Extrapolation

Figure 21

2.3 28.248MHz

2.3.1 PLW

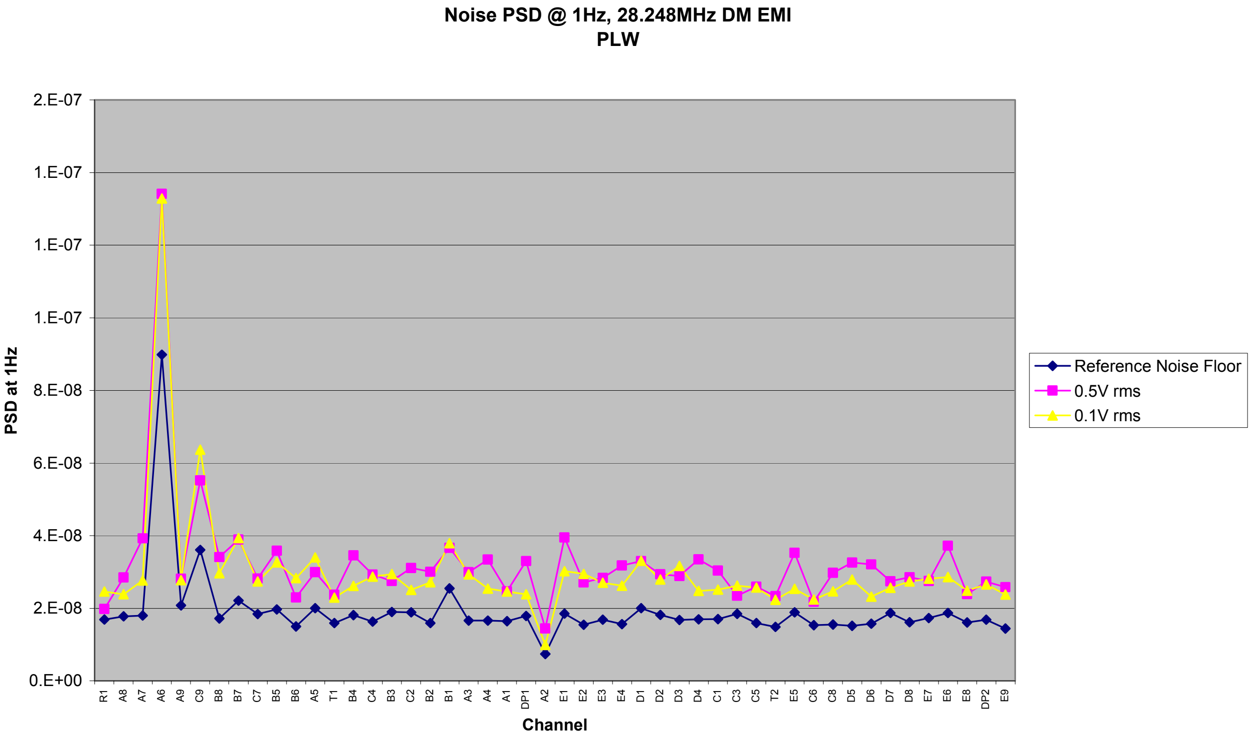


Figure 22

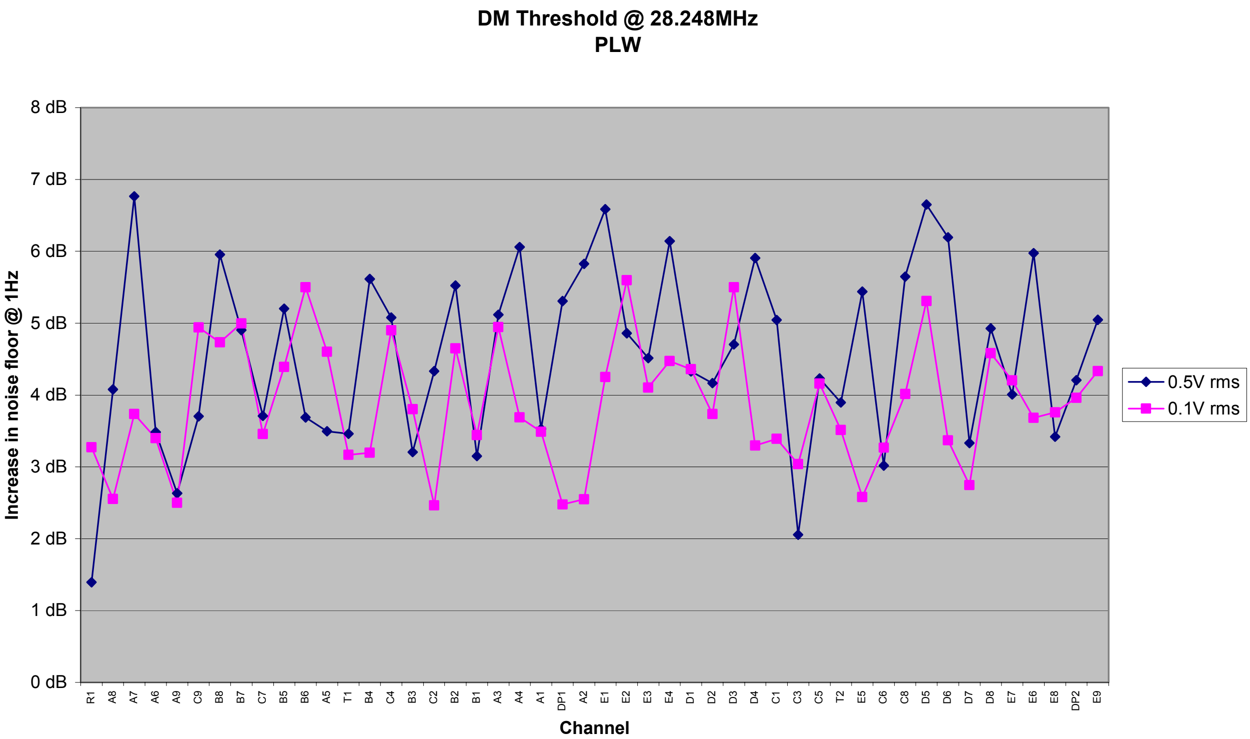


Figure 23

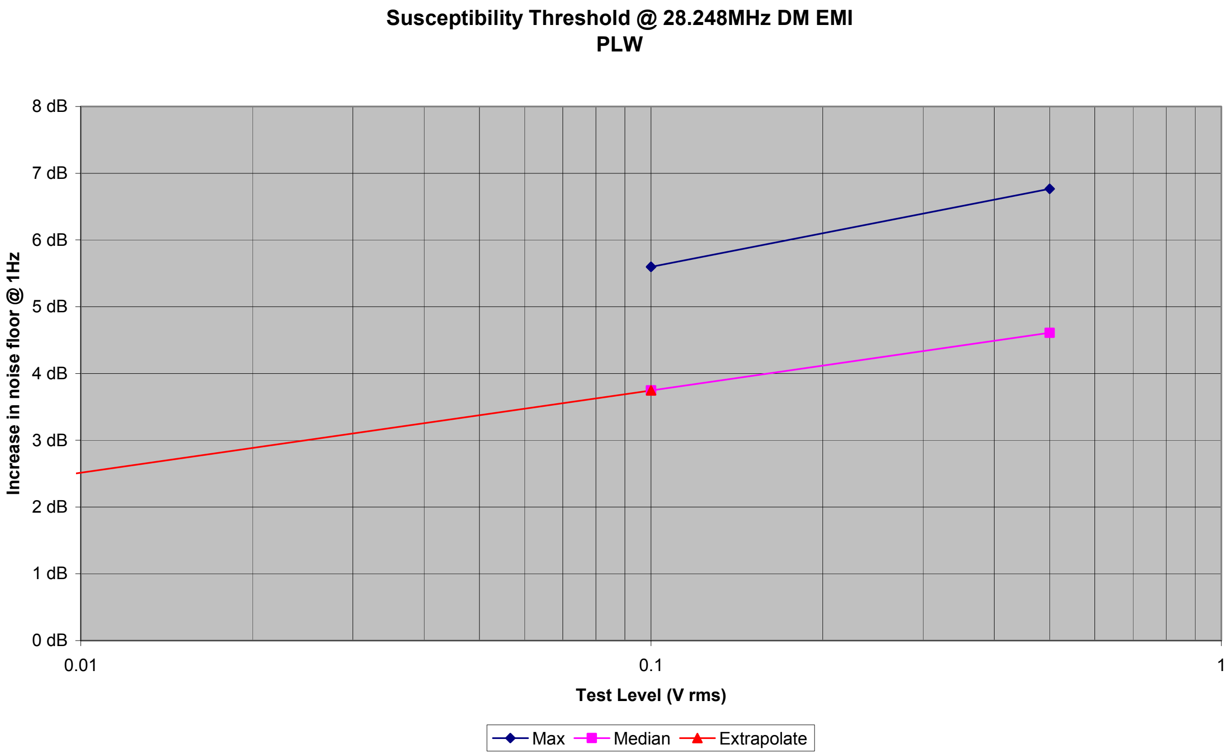


Figure 24

2.3.2 PMW

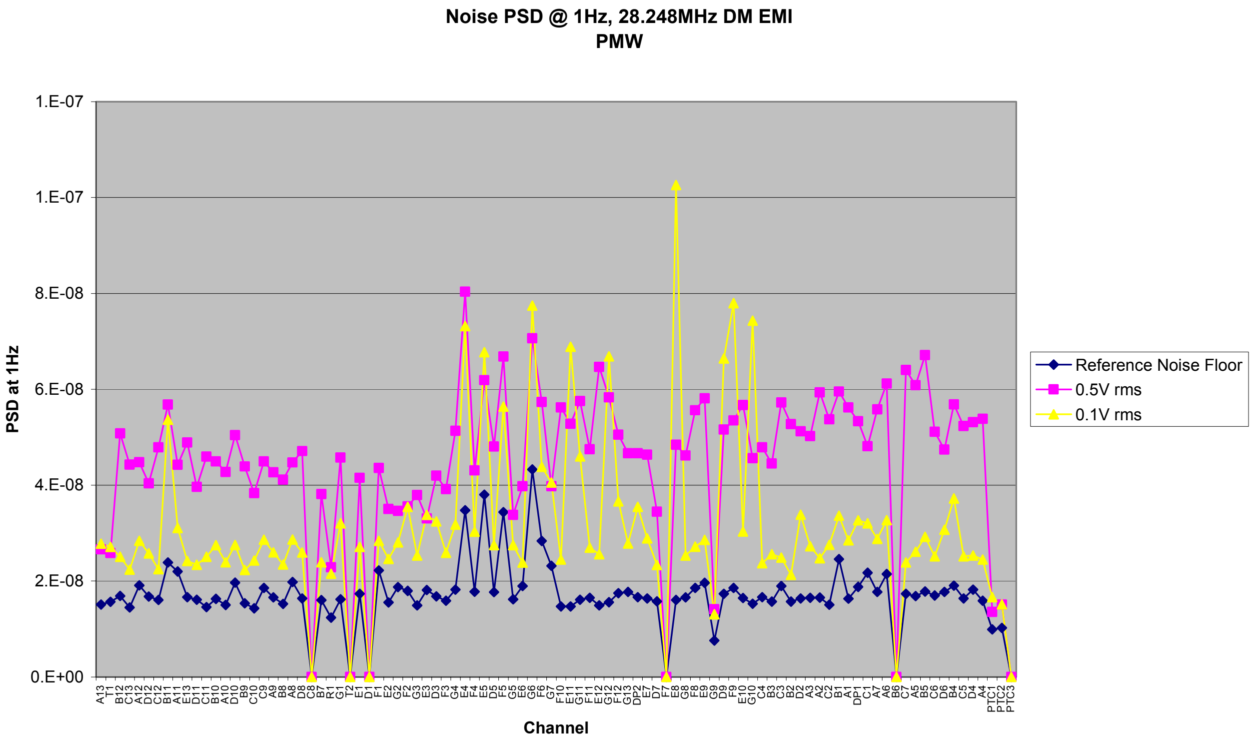


Figure 25

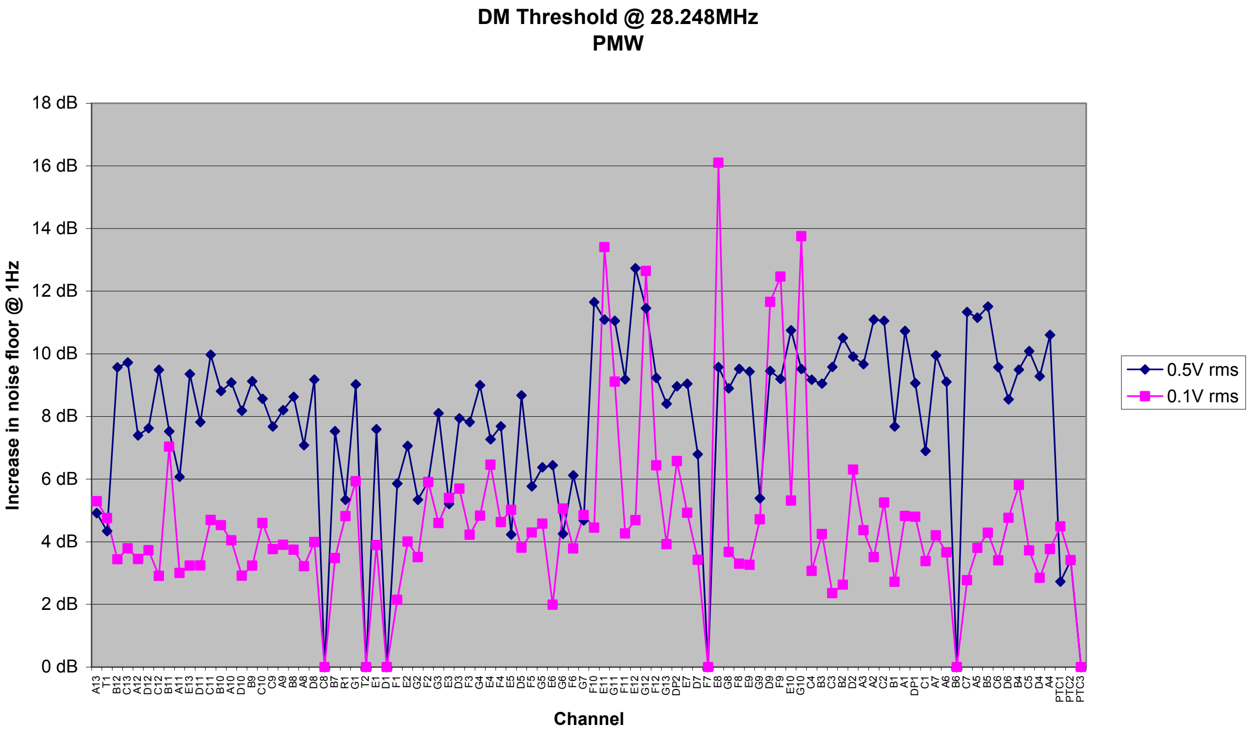


Figure 26

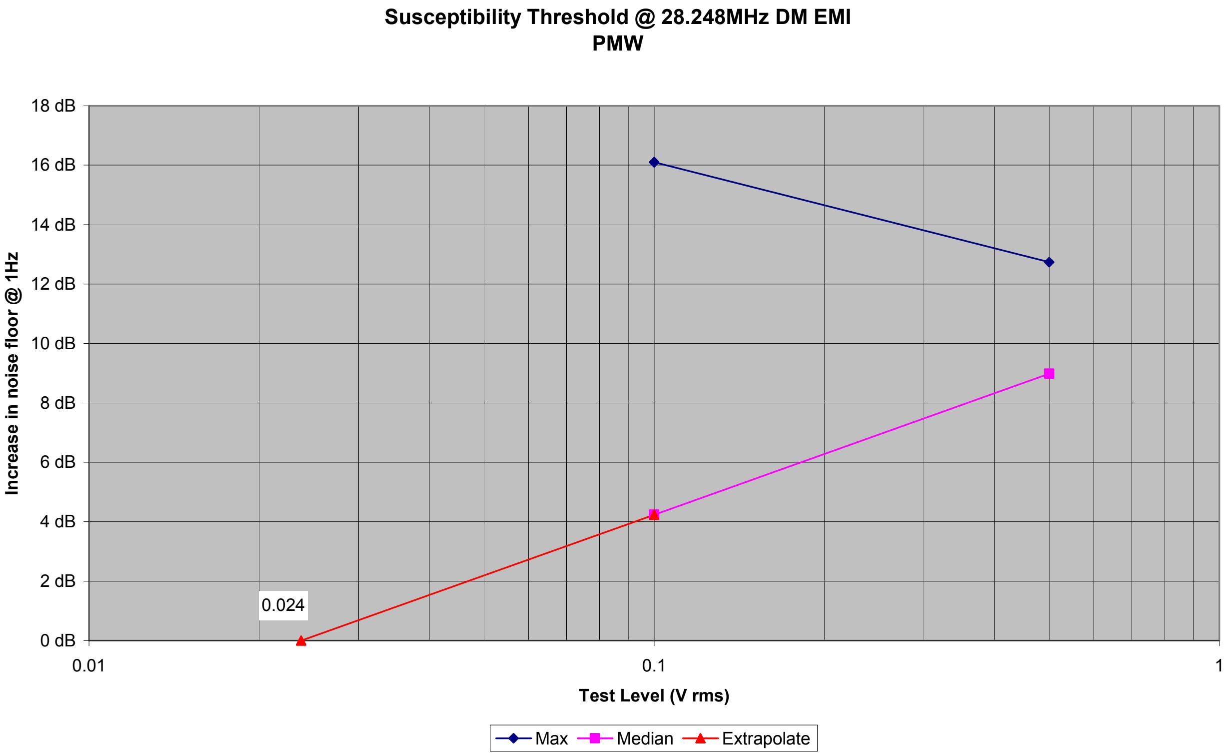


Figure 27

2.3.3 PSW

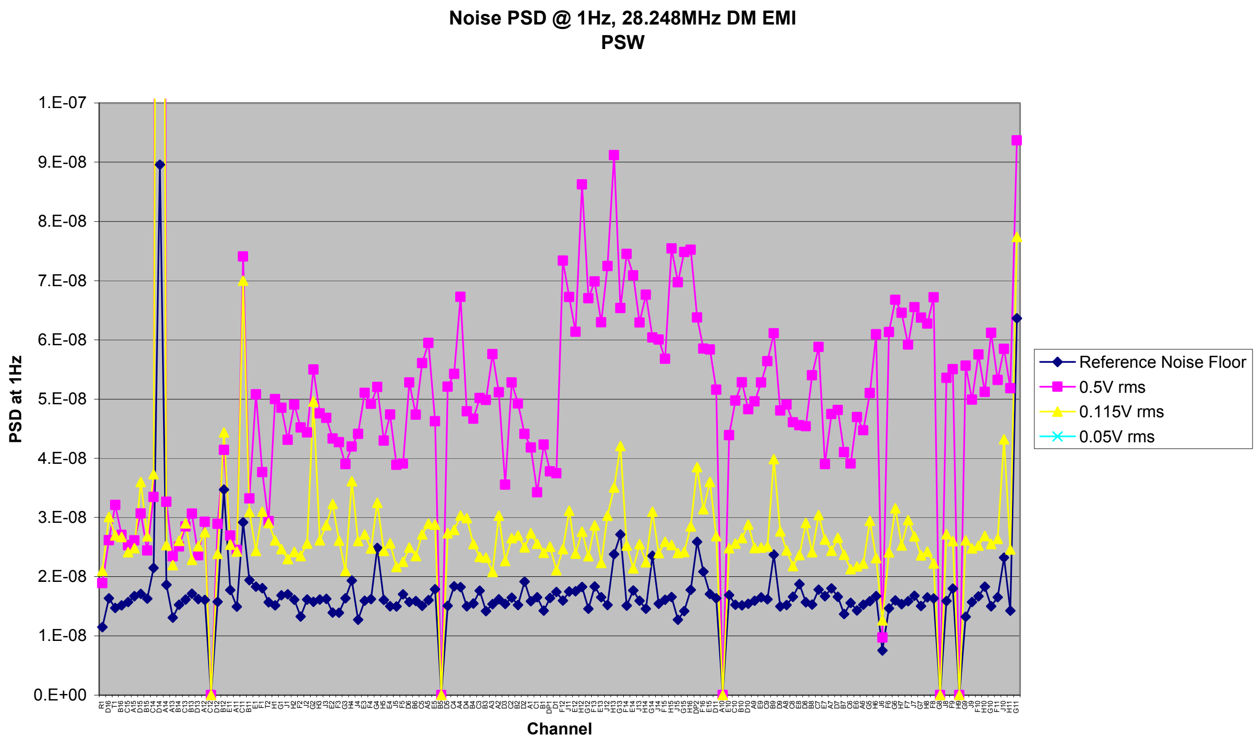


Figure 28

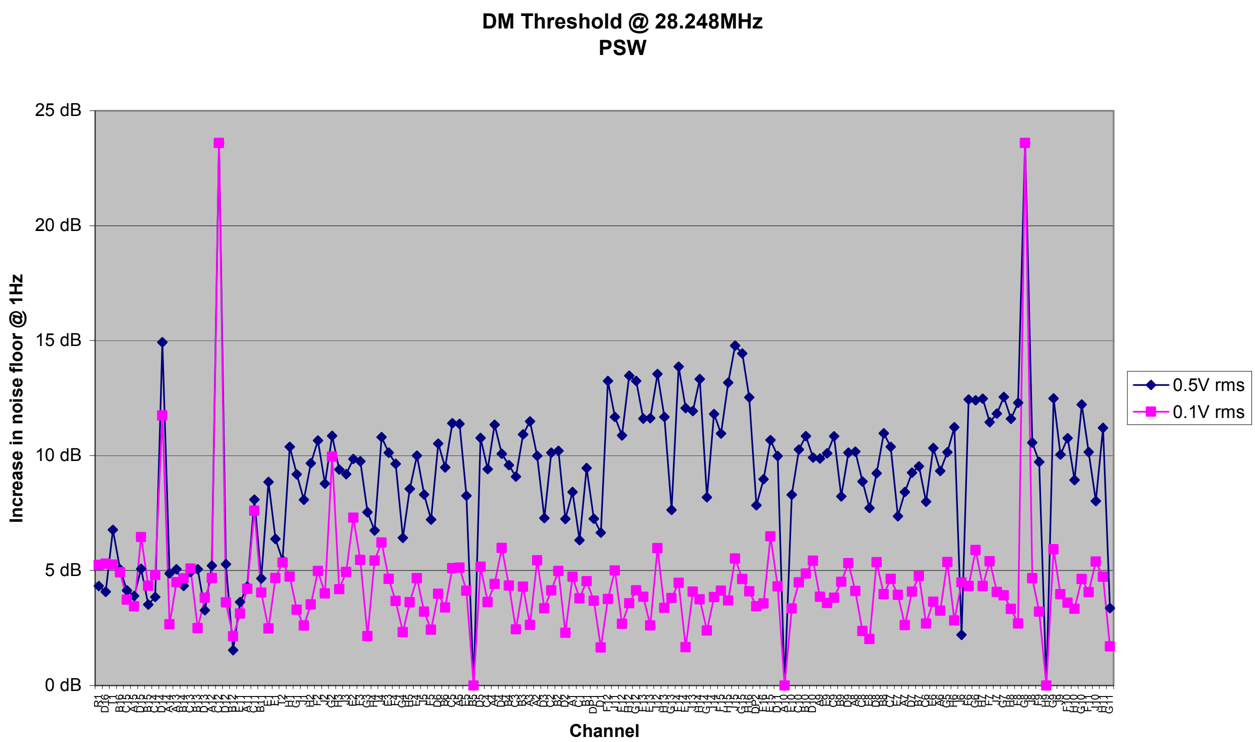


Figure 29

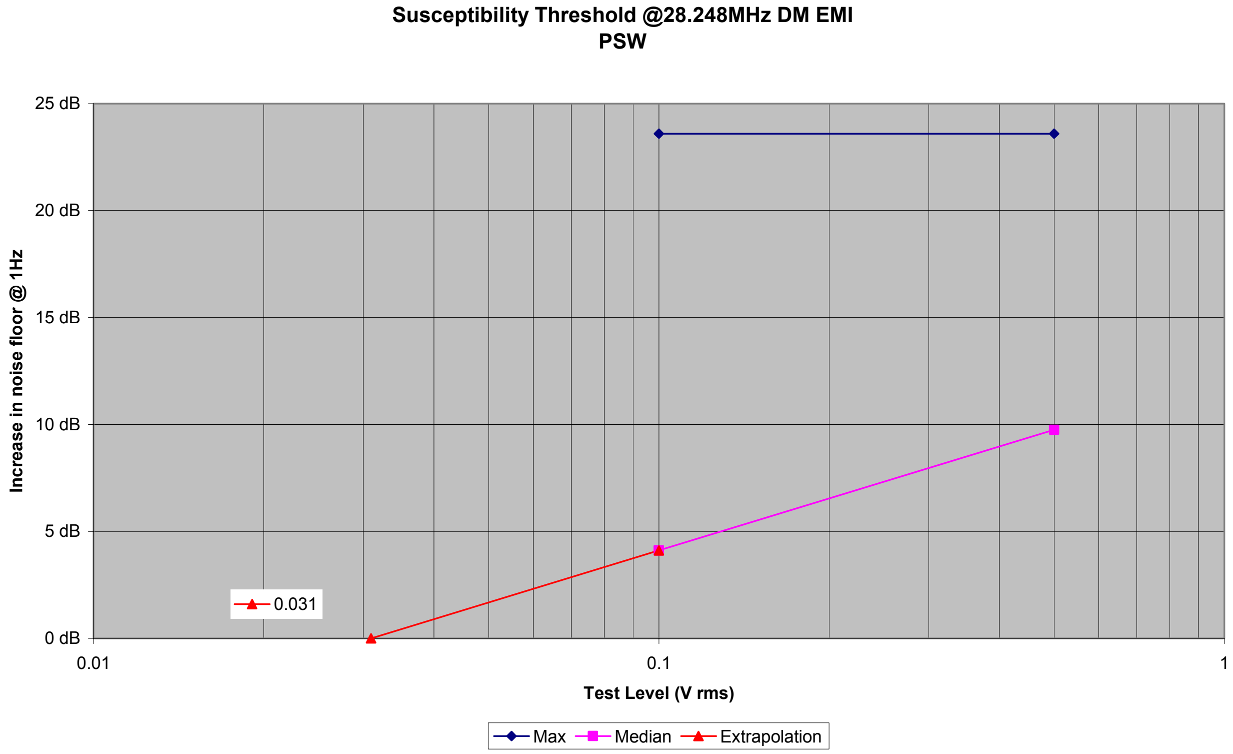

Susceptibility Threshold @28.248MHz DM EMI
PSW
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
Increase in noise floor @ 1Hz
0.031
0.01
0.1
1
Test Level (V rms)
Max
Median
Extrapolation

Figure 30

2.4 37.918MHz

2.4.1 PLW

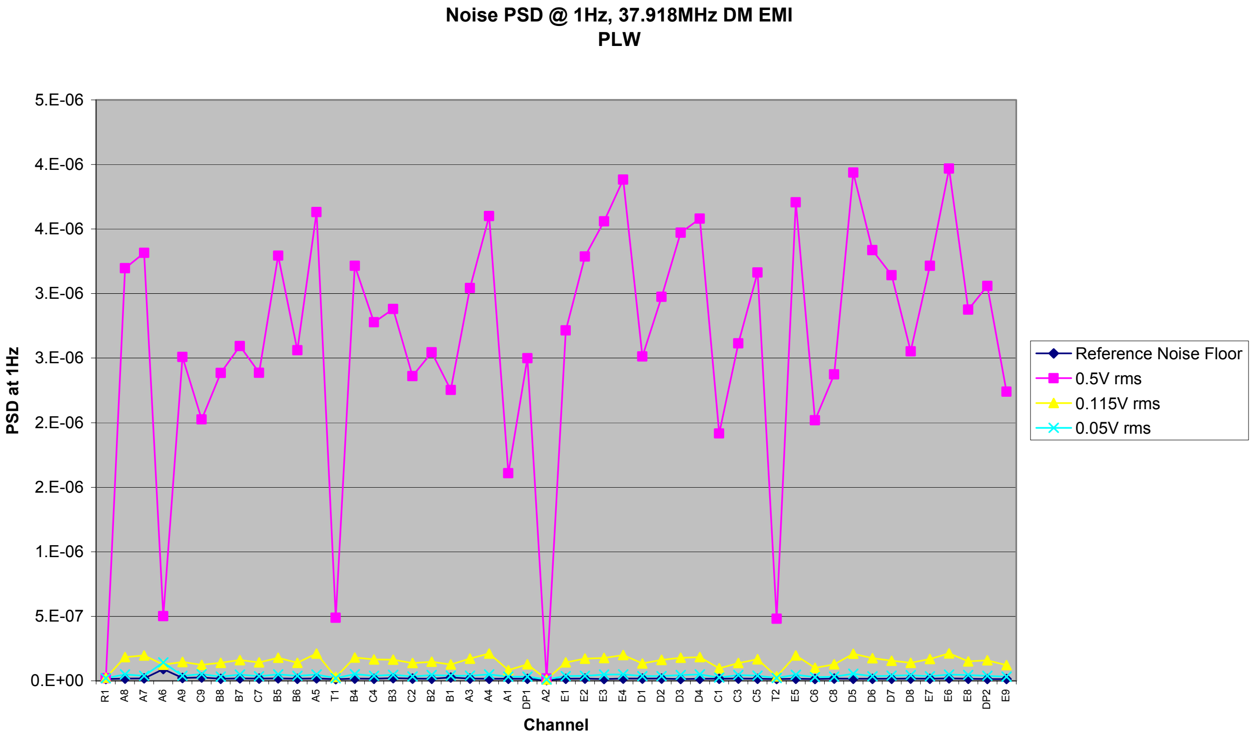


Figure 31

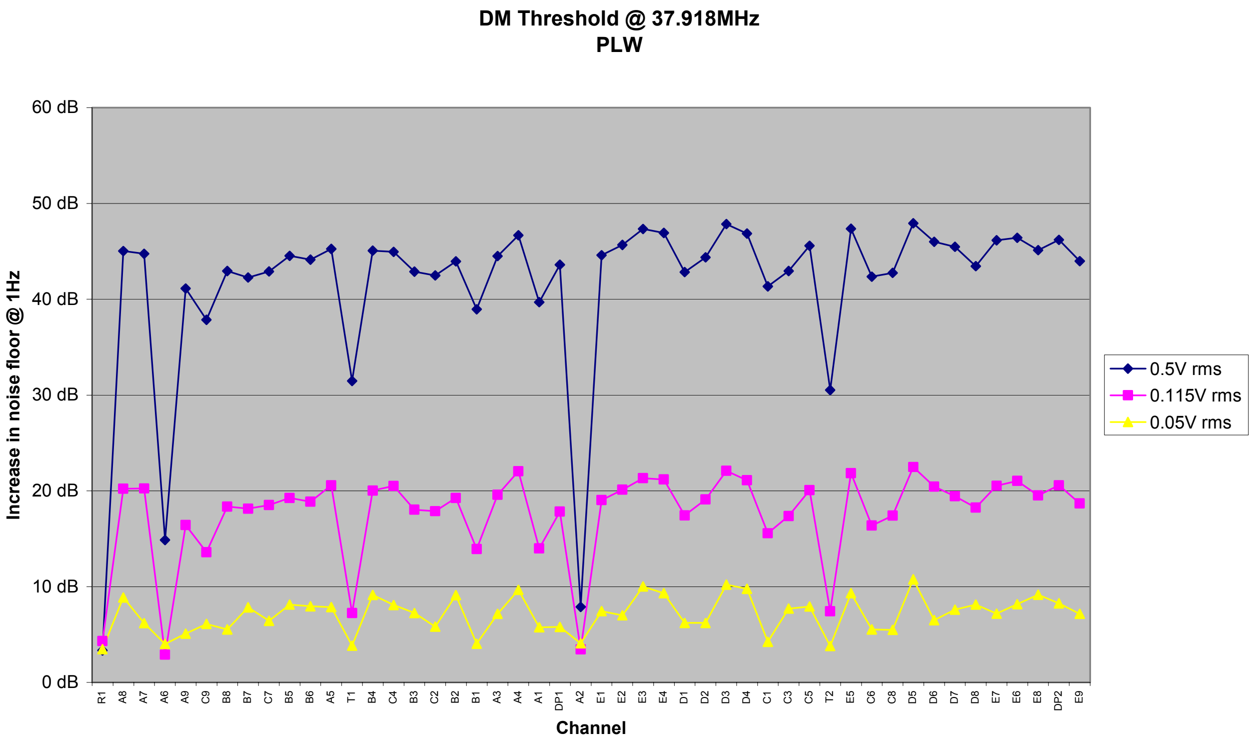


Figure 32

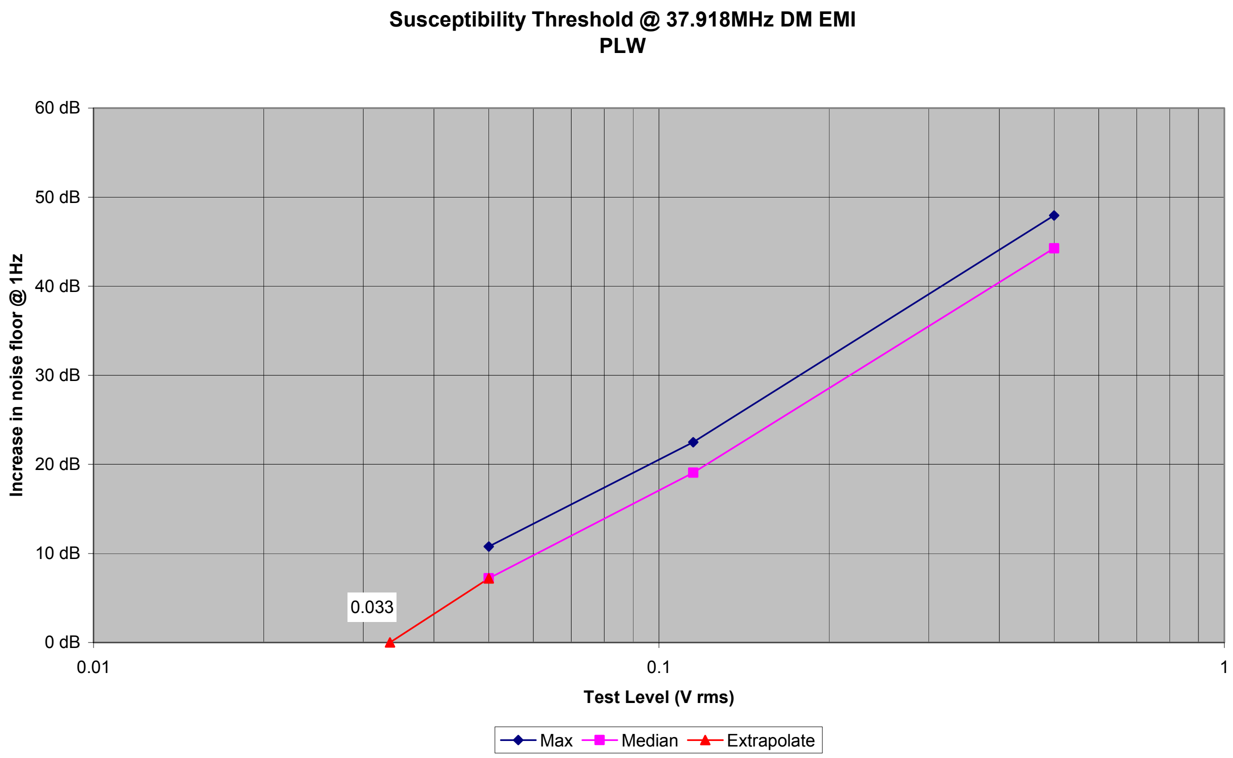


Figure 33

2.4.2 PMW

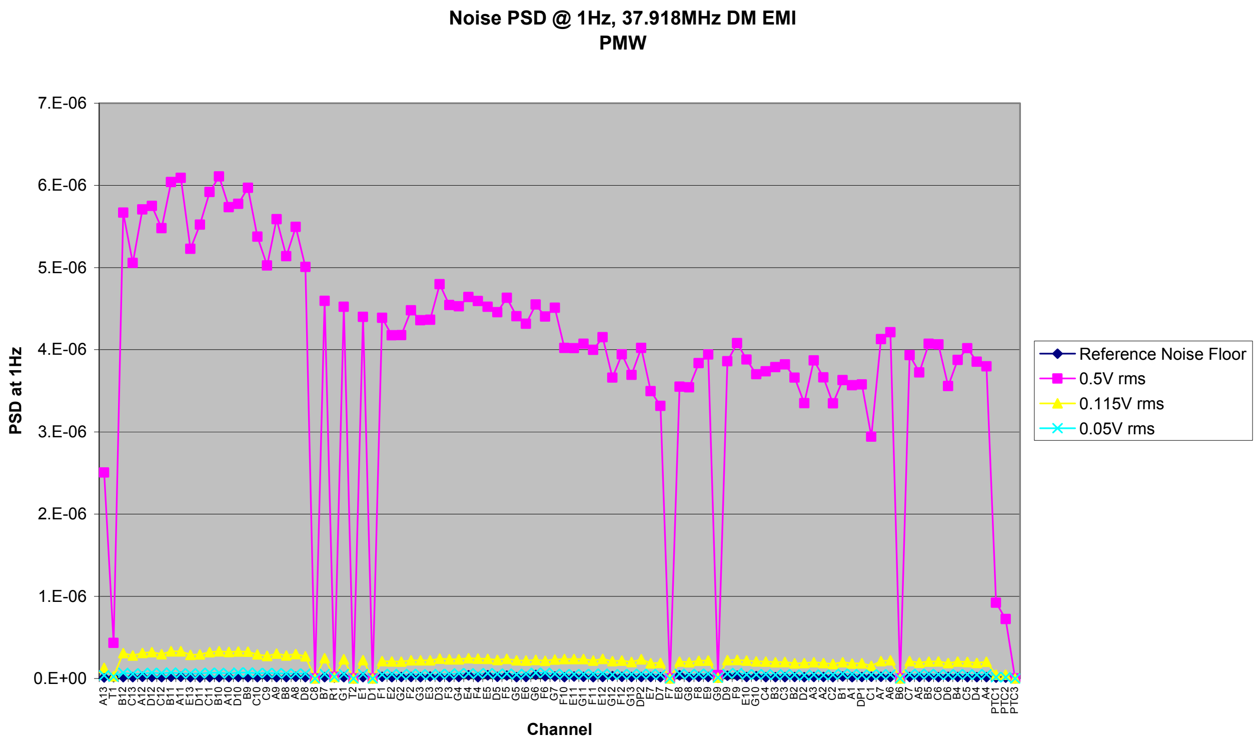


Figure 34

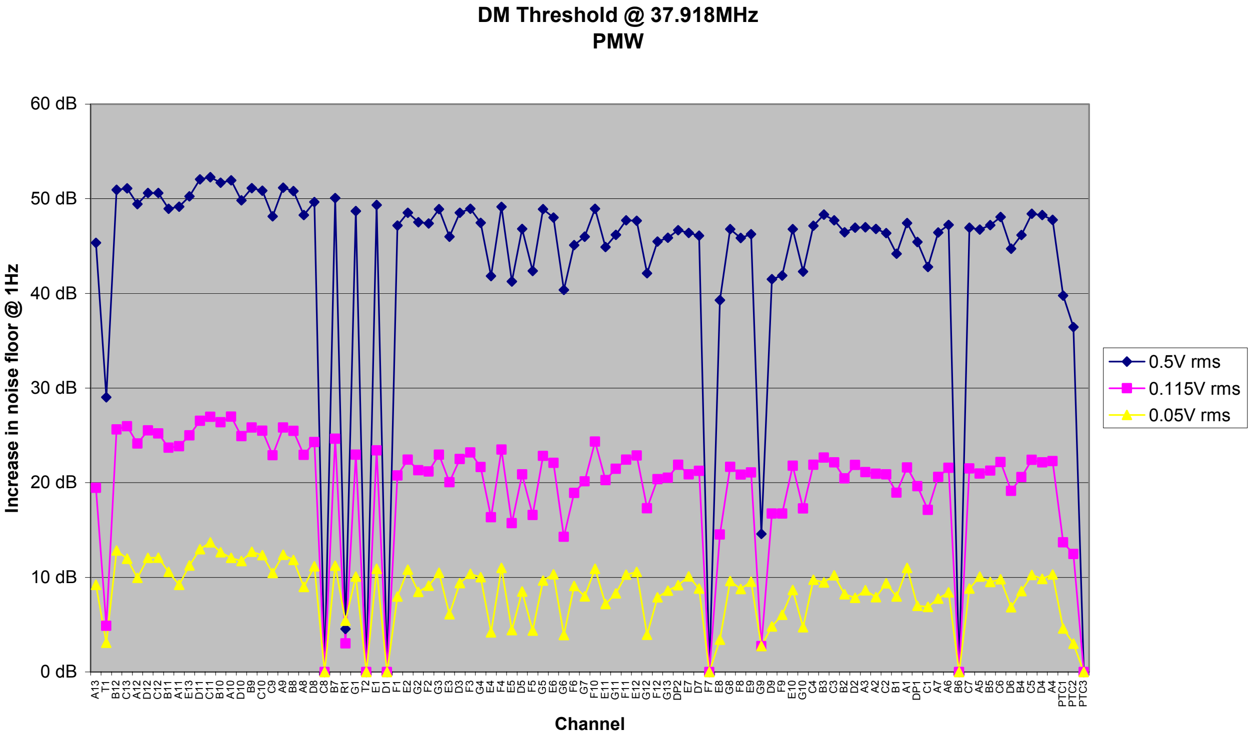


Figure 35

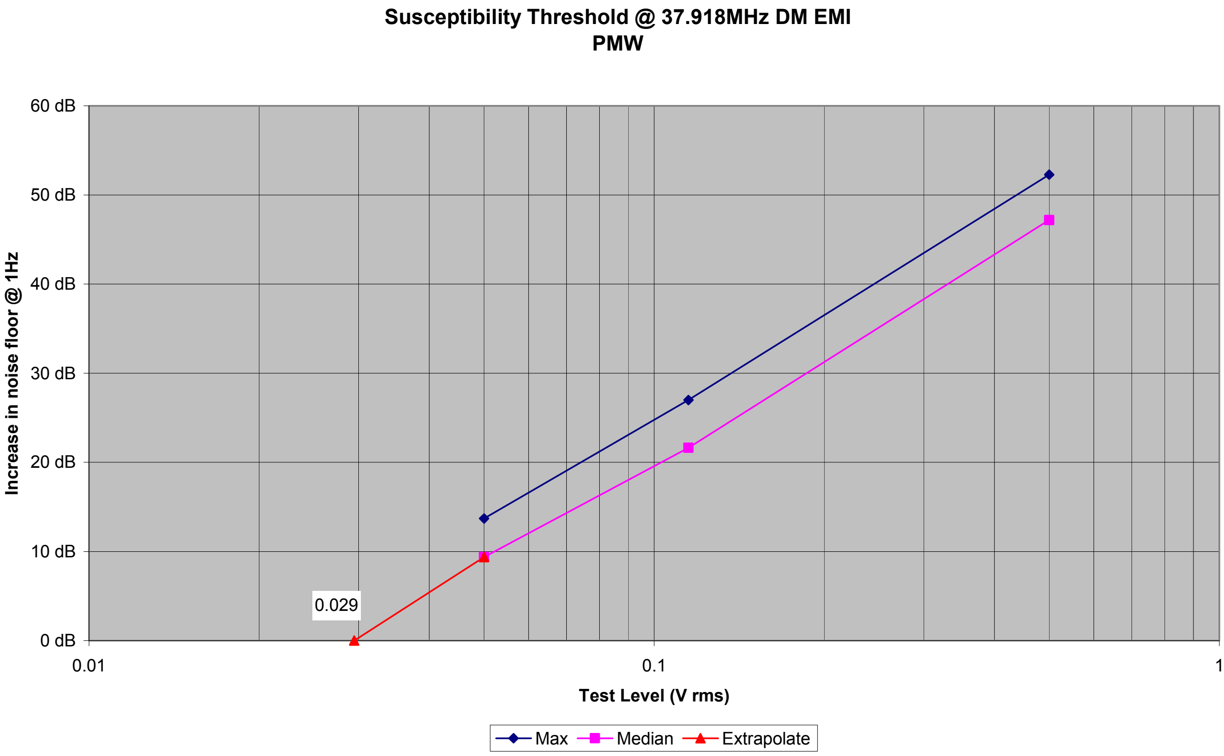


Figure 36

2.4.3 PSW

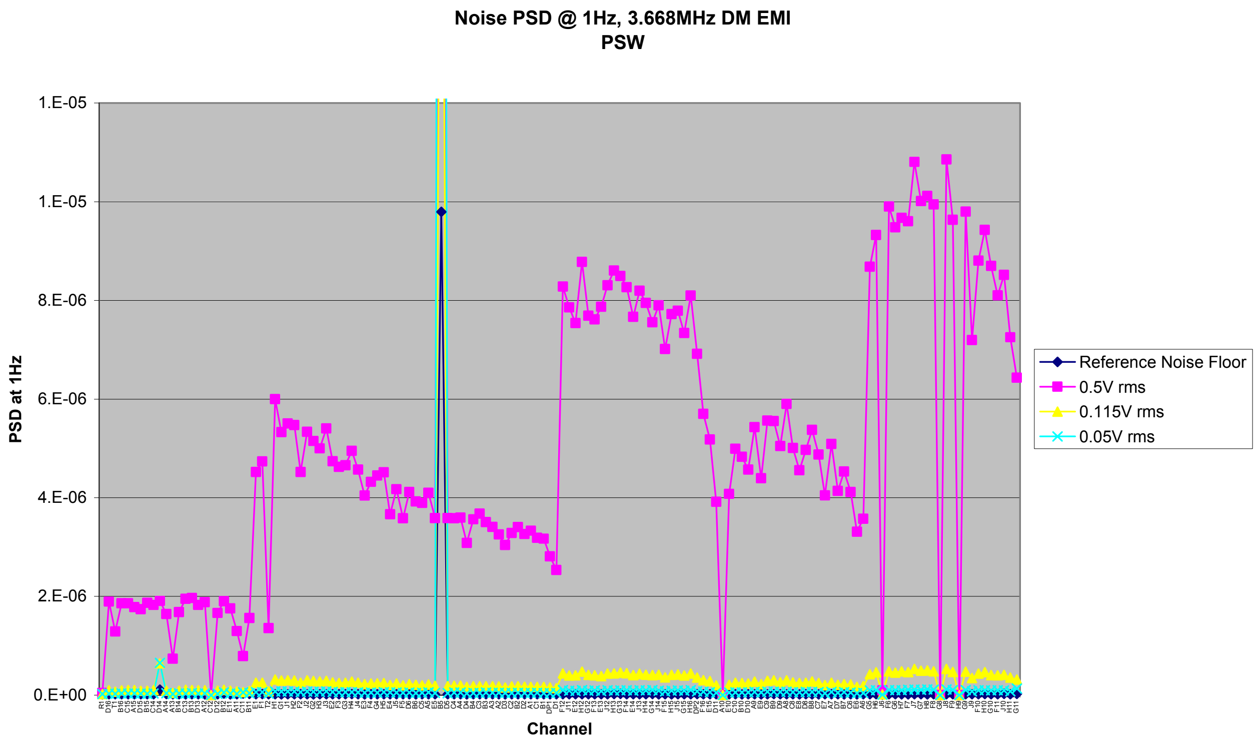


Figure 37

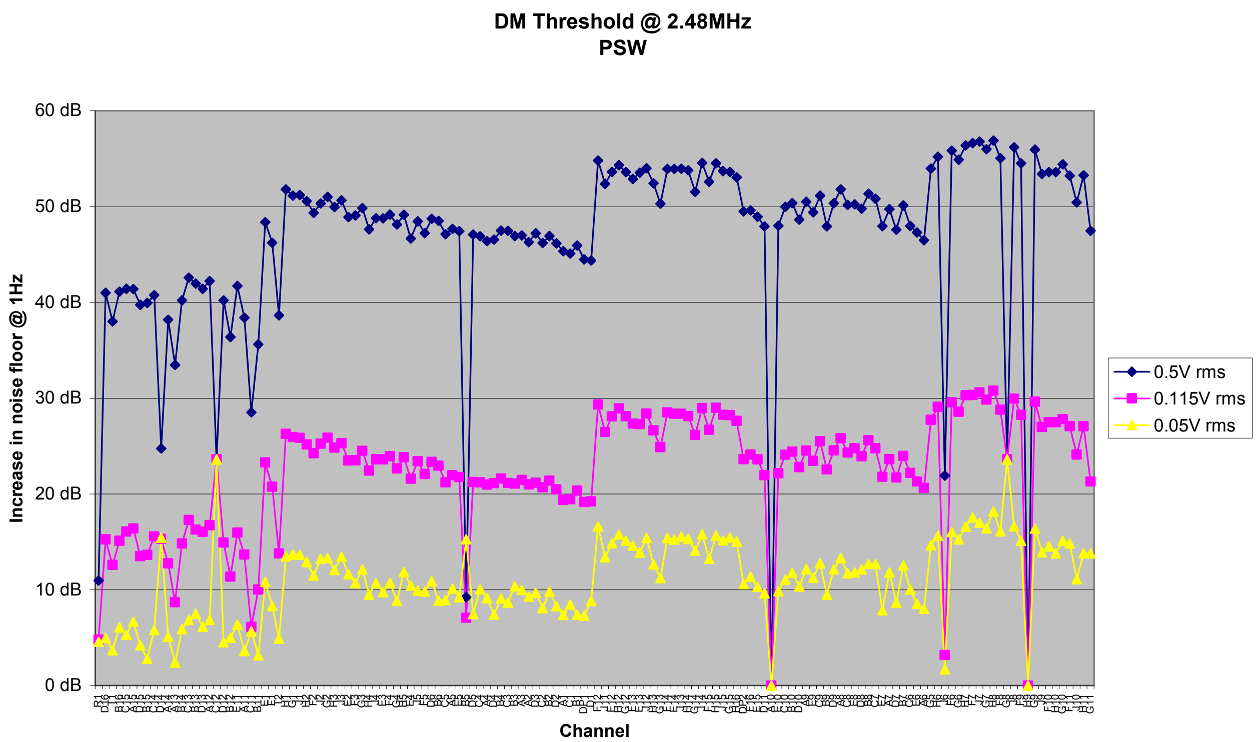


Figure 38

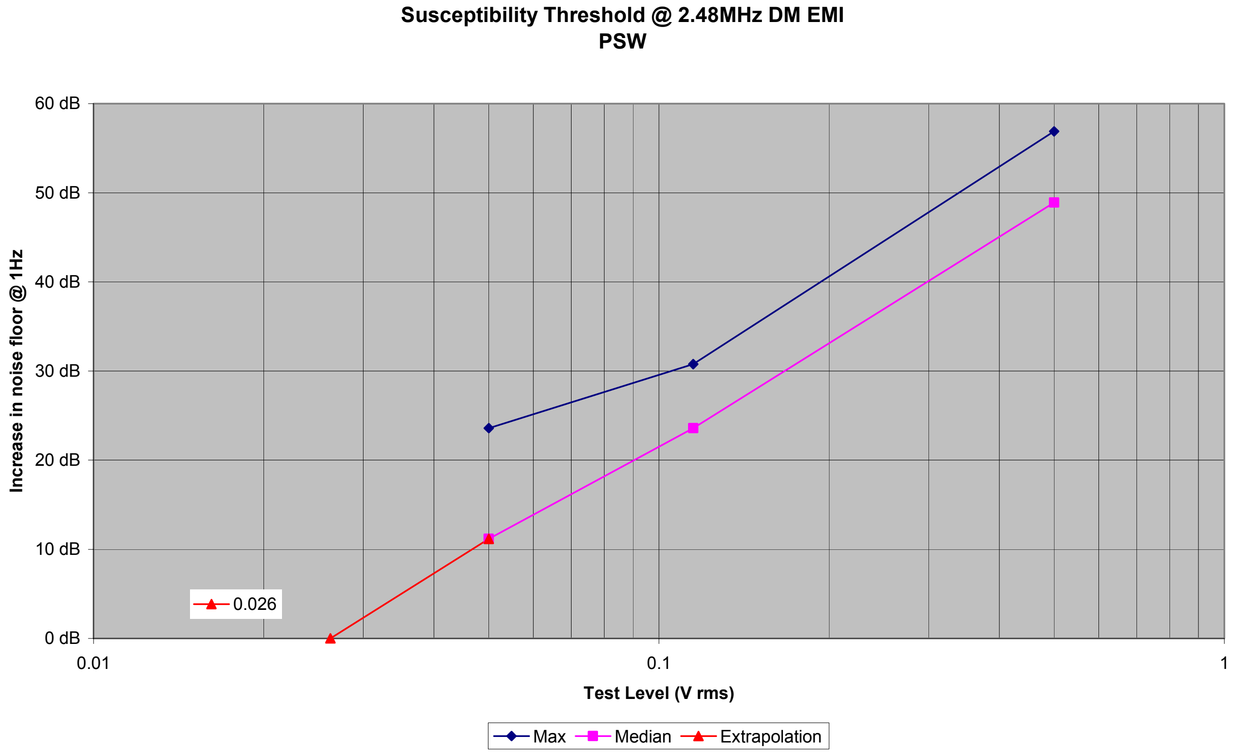

Susceptibility Threshold @ 2.48MHz DM EMI
PSW
60 dB
50 dB
40 dB
30 dB
20 dB
10 dB
0 dB
Increase in noise floor @ 1Hz
0.026
0.01
0.1
1
Test Level (V rms)
Max
Median
Extrapolation

Figure 39

3. Common Mode

3.1 6MHz

3.1.1 PLW

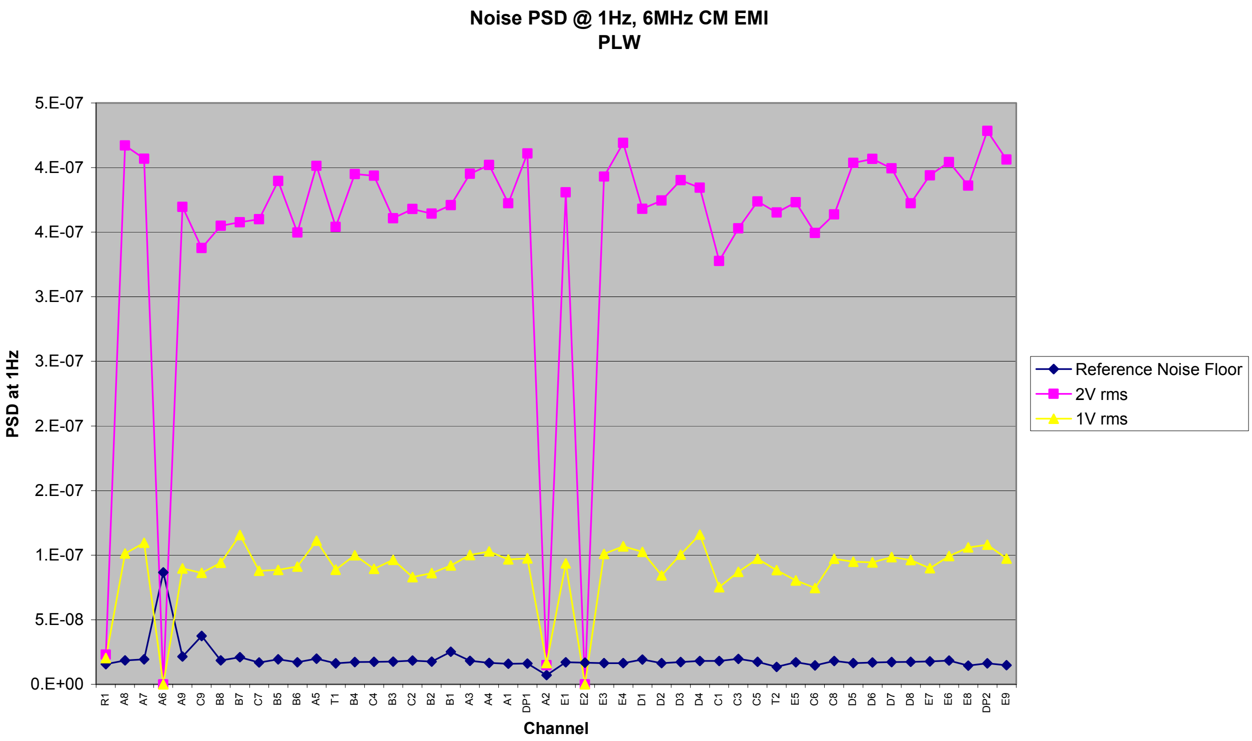


Figure 40

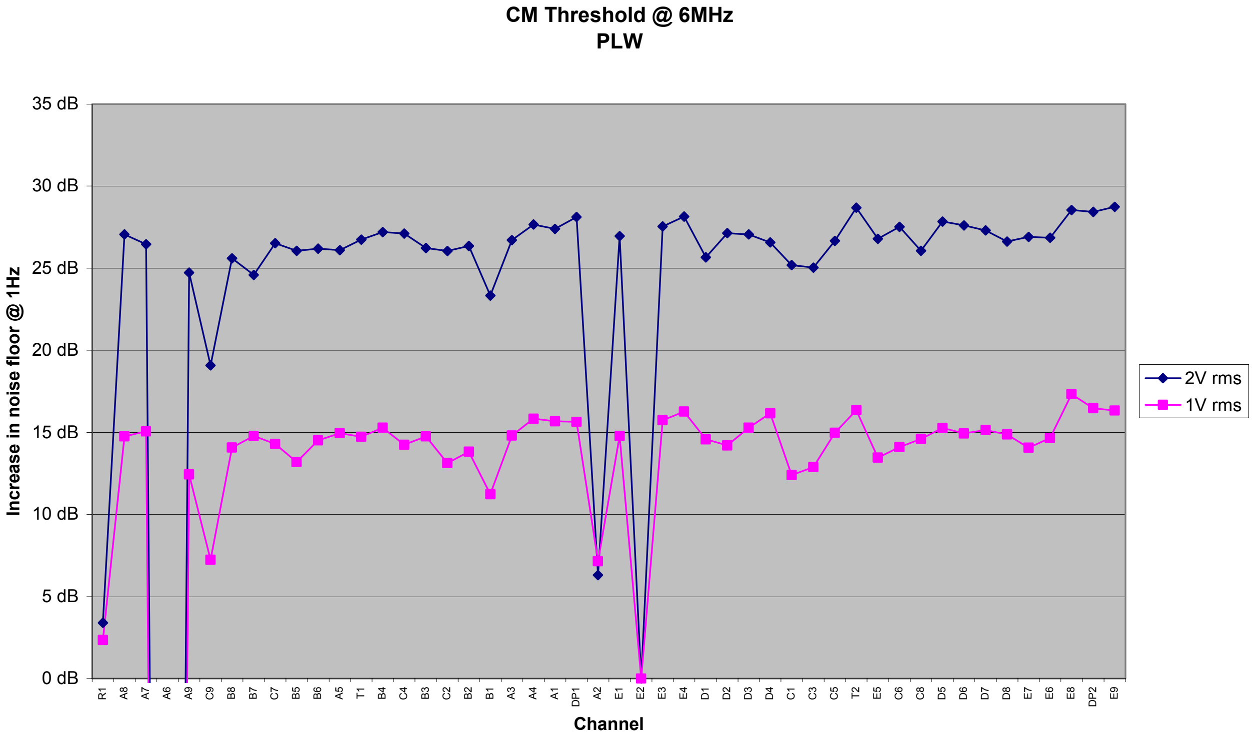


Figure 41

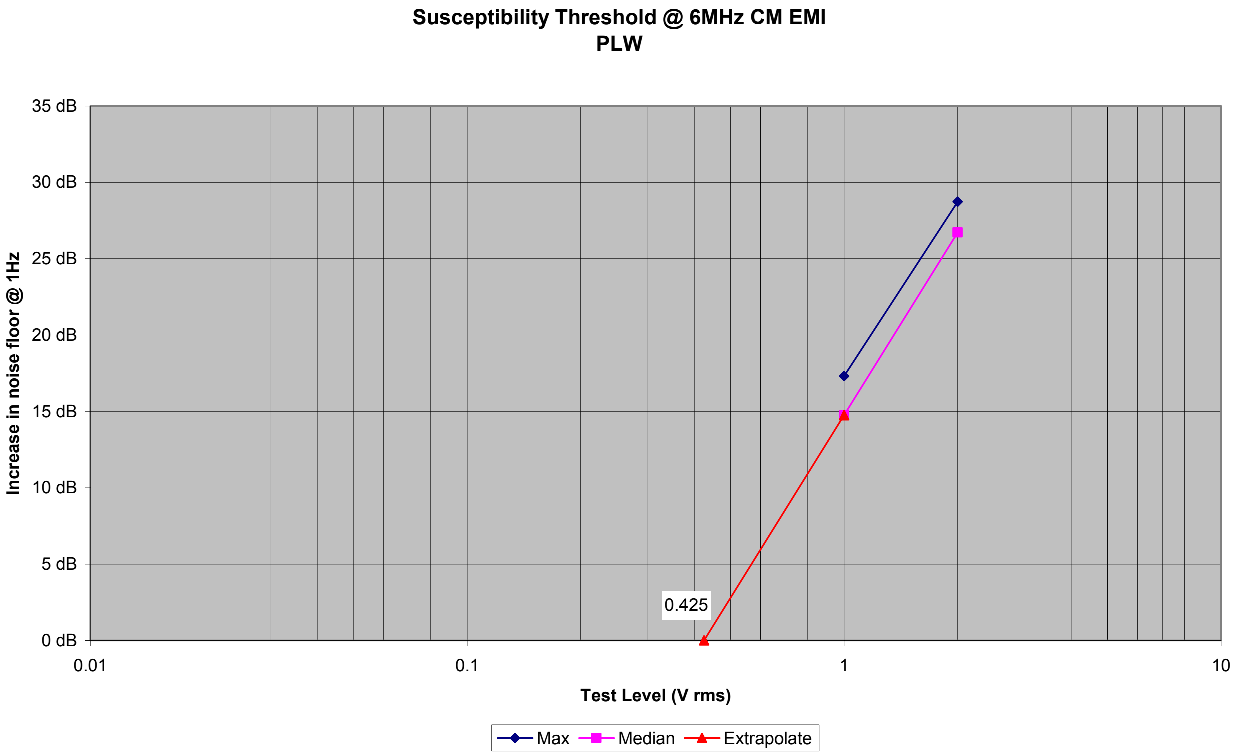


Figure 42

3.1.2 PMW

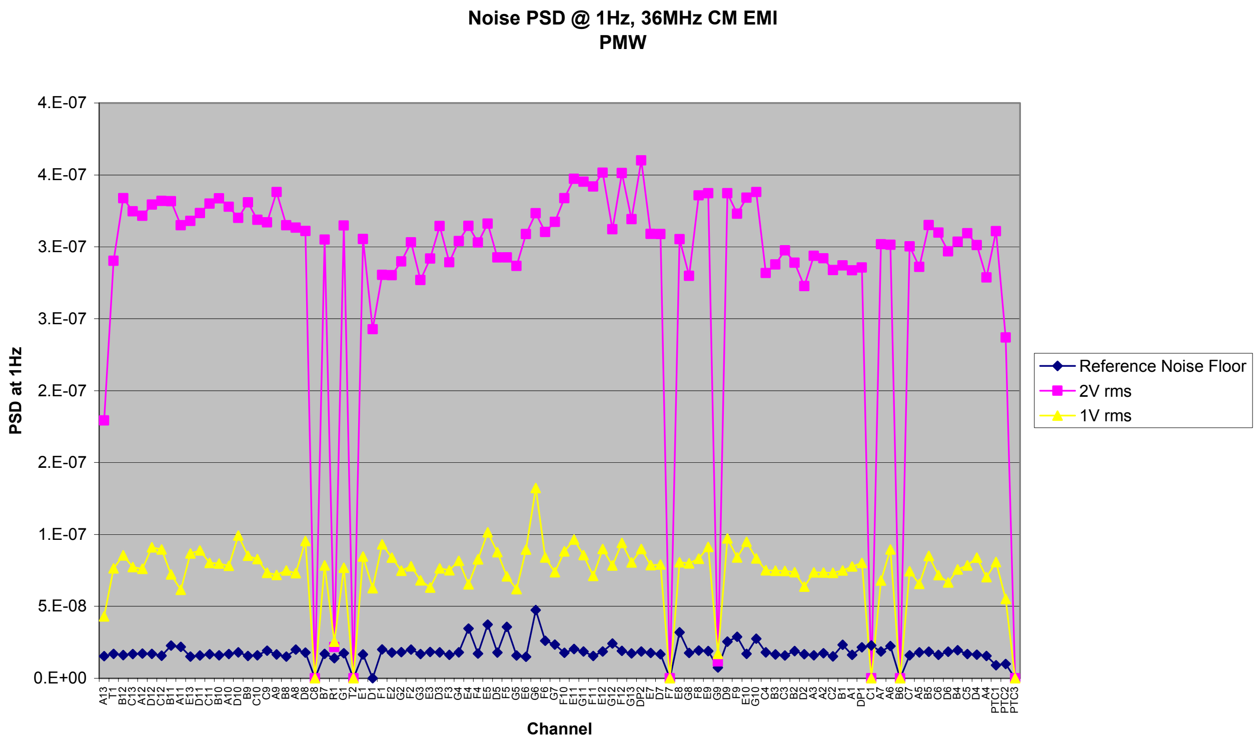


Figure 43

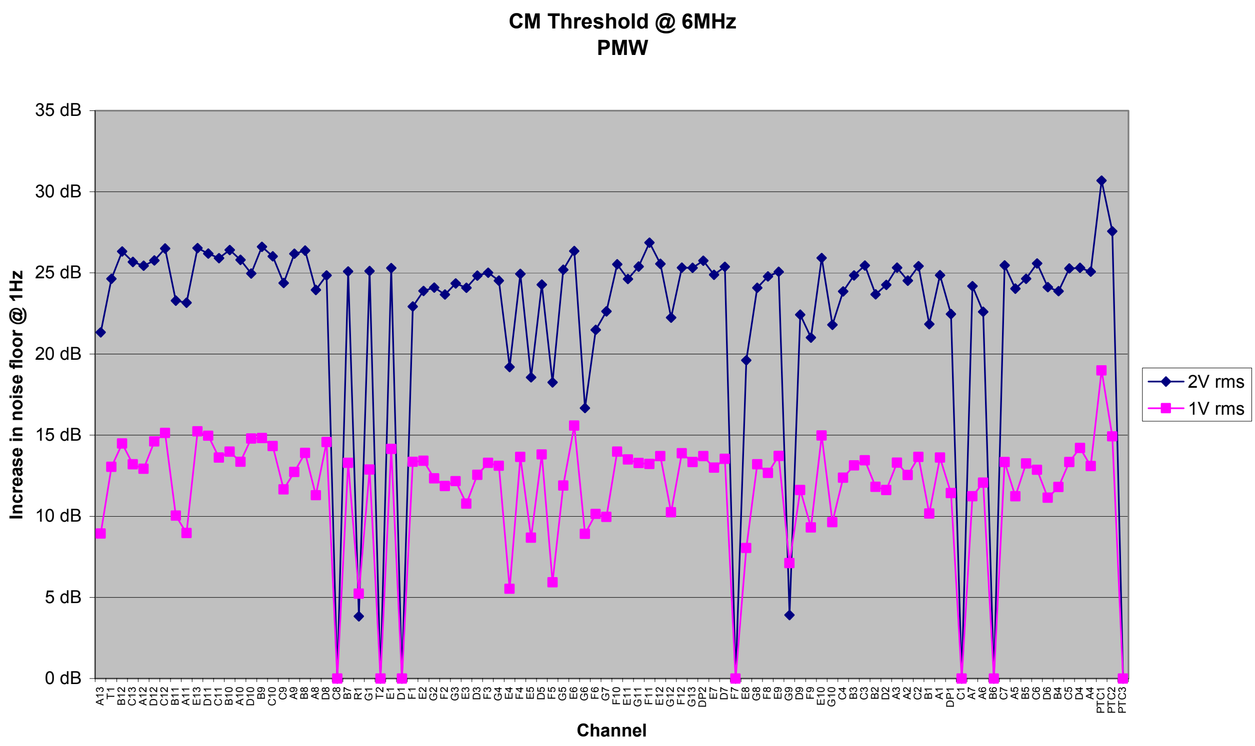


Figure 44

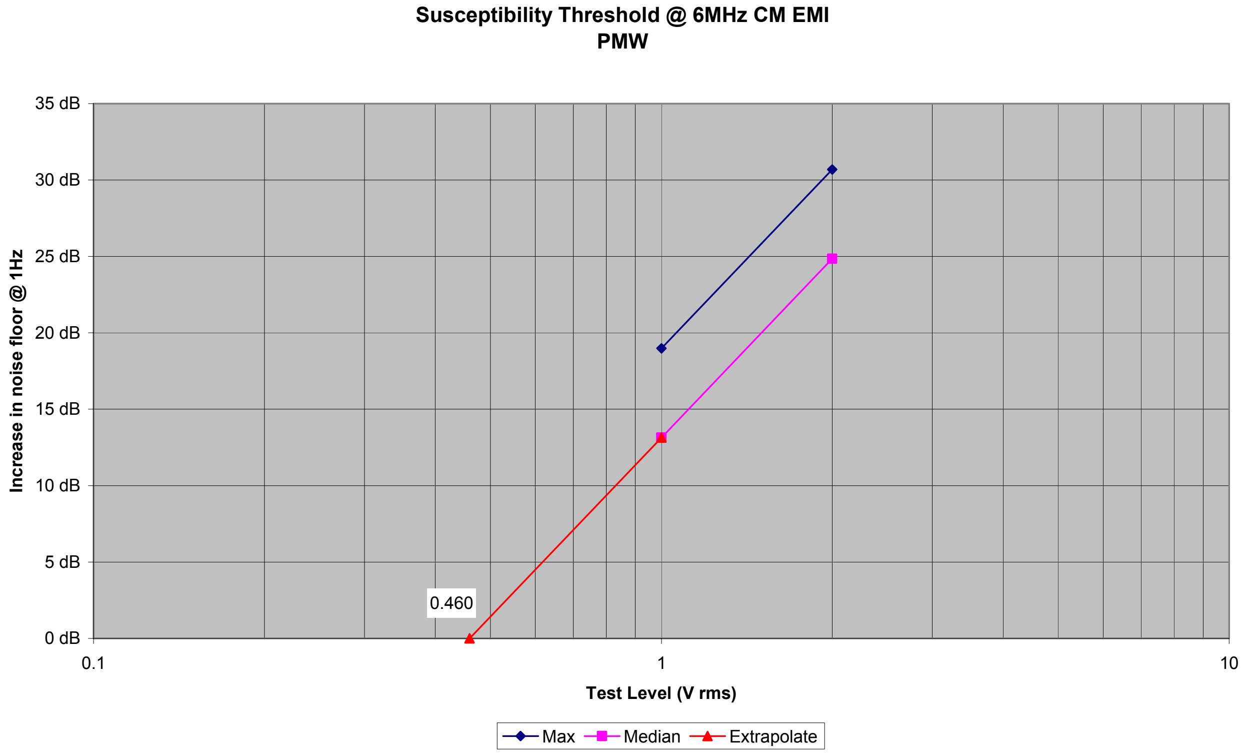


Figure 45

3.1.3 PSW

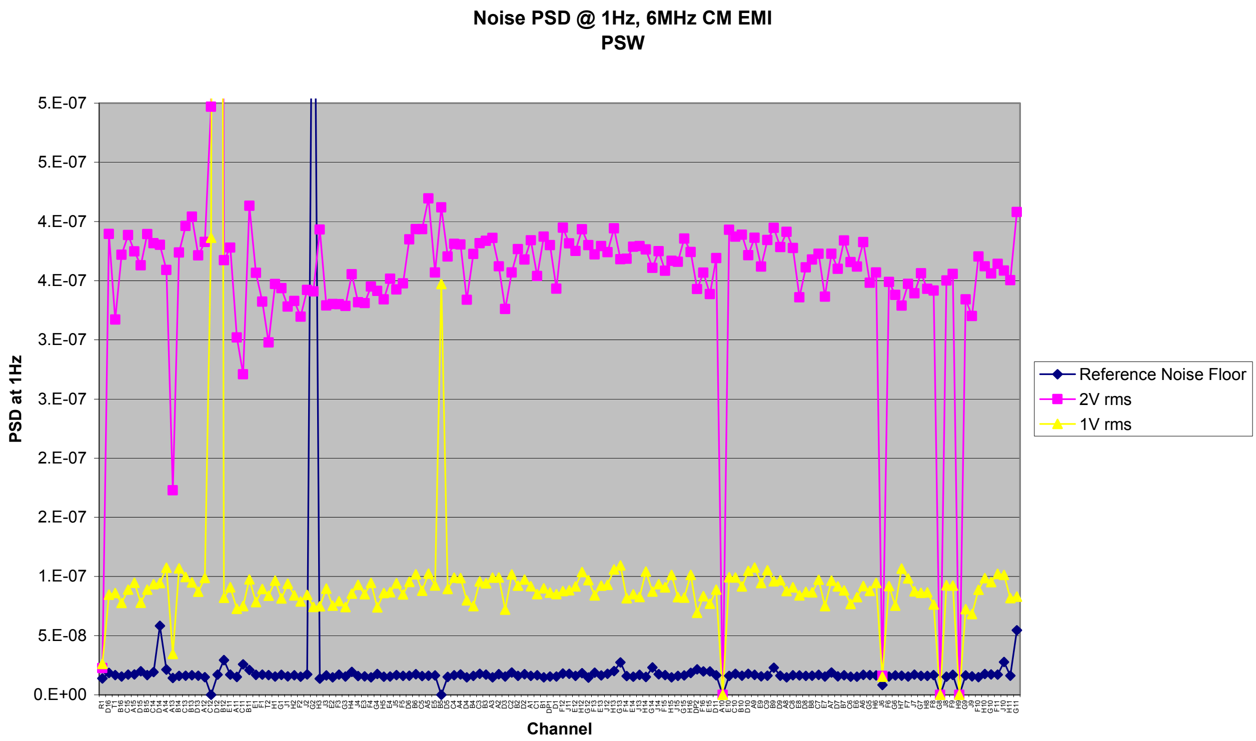


Figure 46

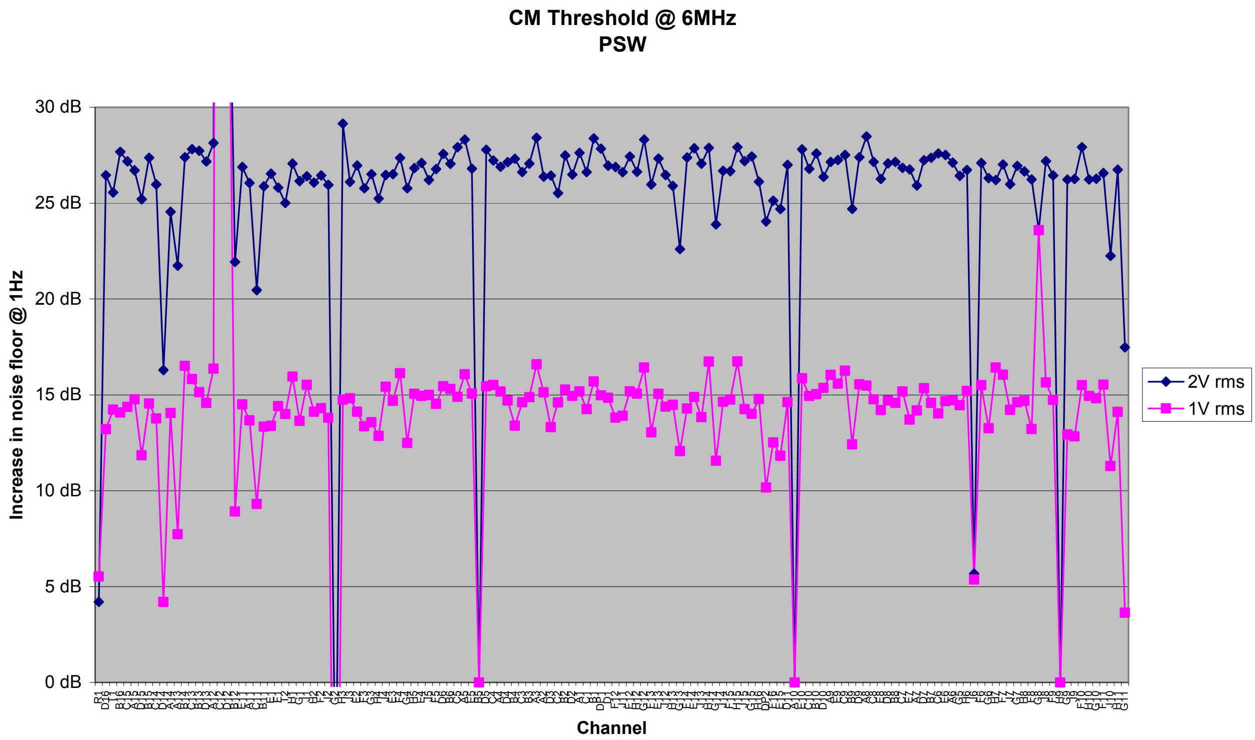


Figure 47

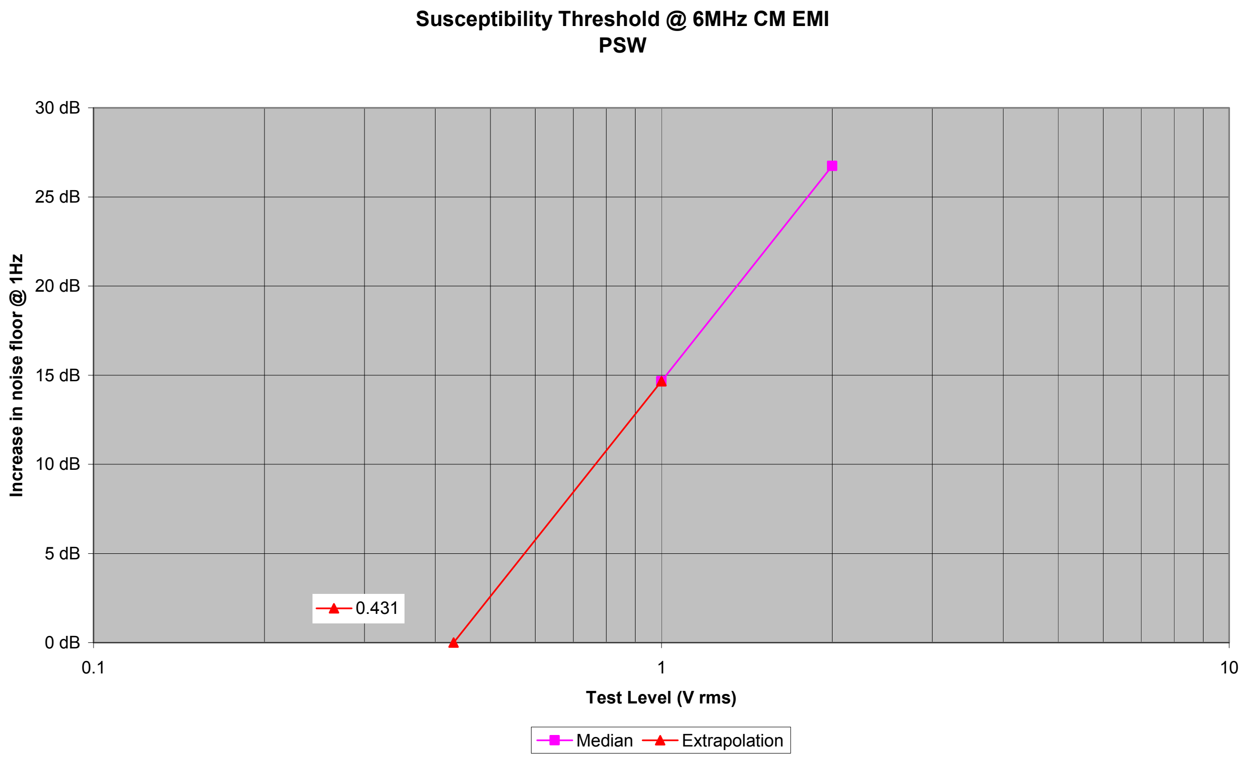


Figure 48

3.2 15.3MHz

3.2.1 PLW

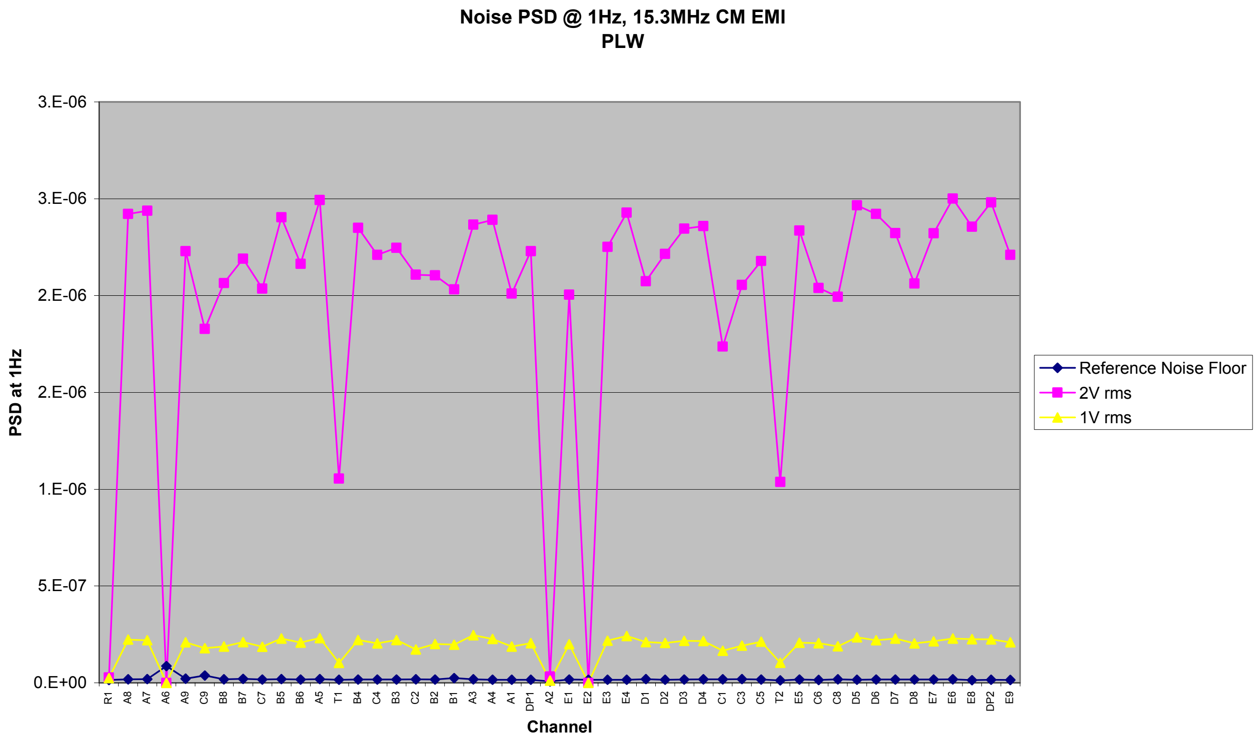


Figure 49

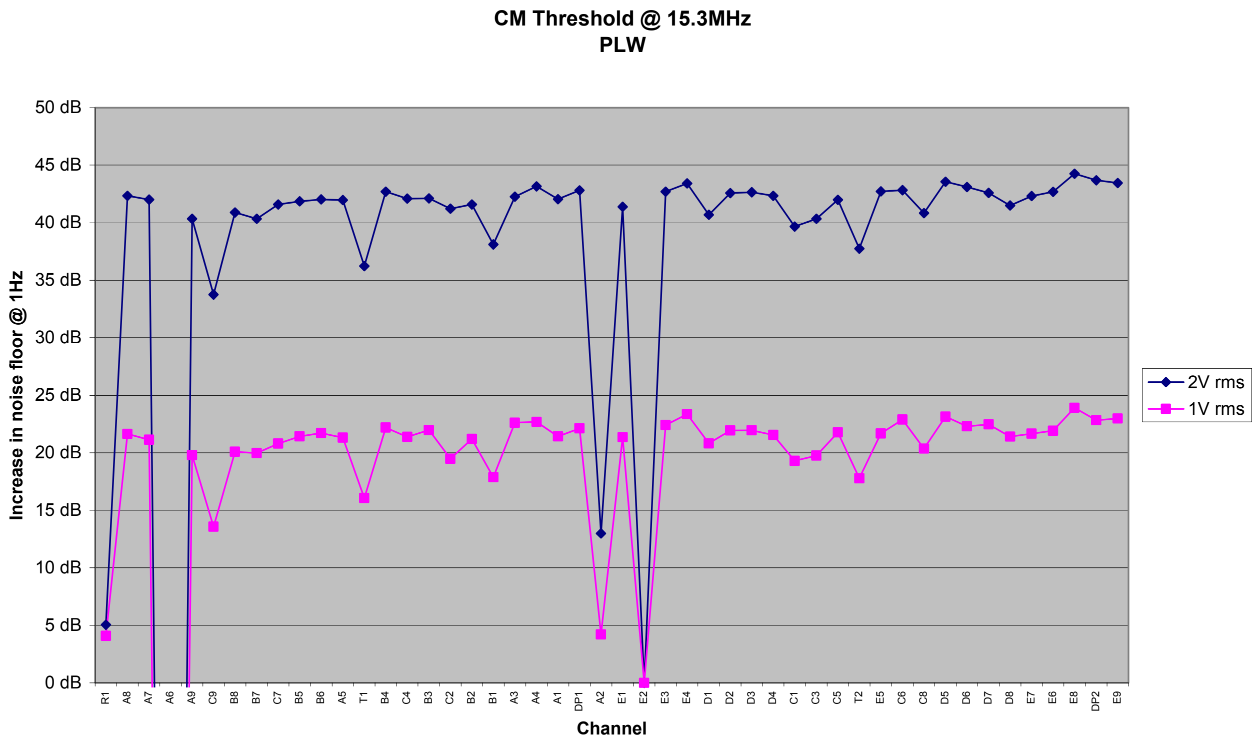


Figure 50

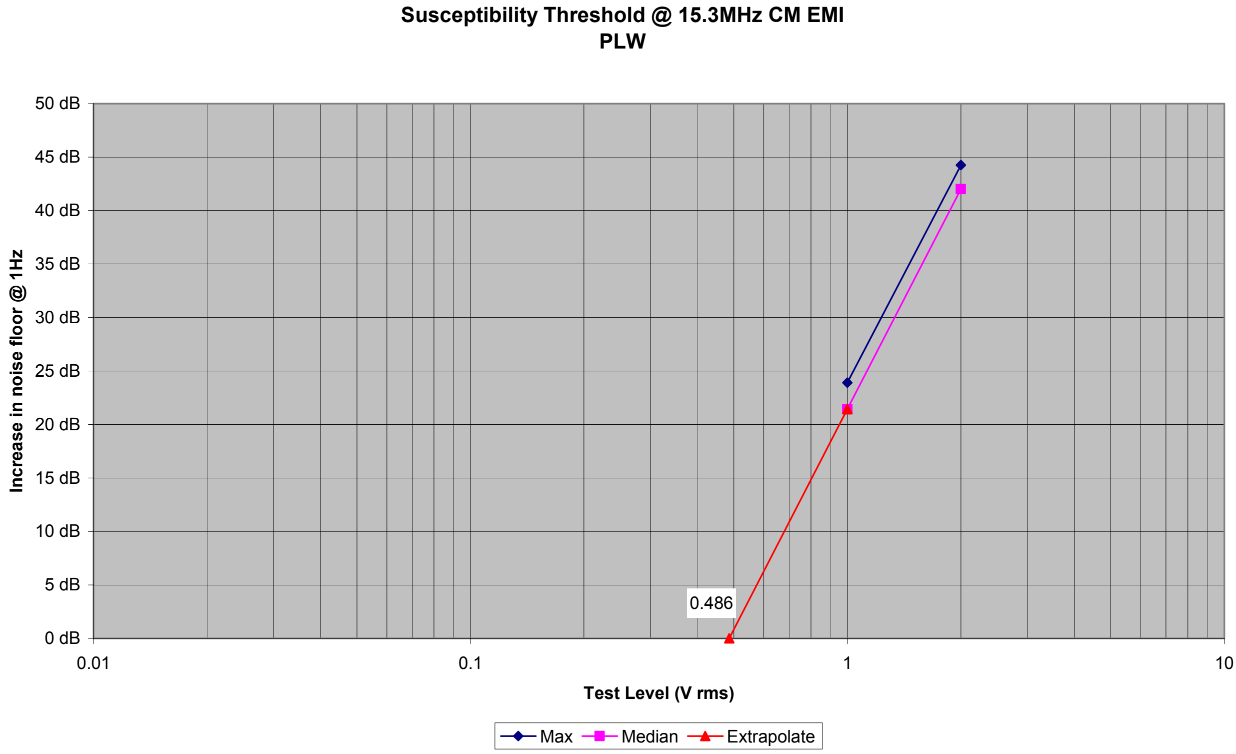


Figure 51

3.2.2 PMW

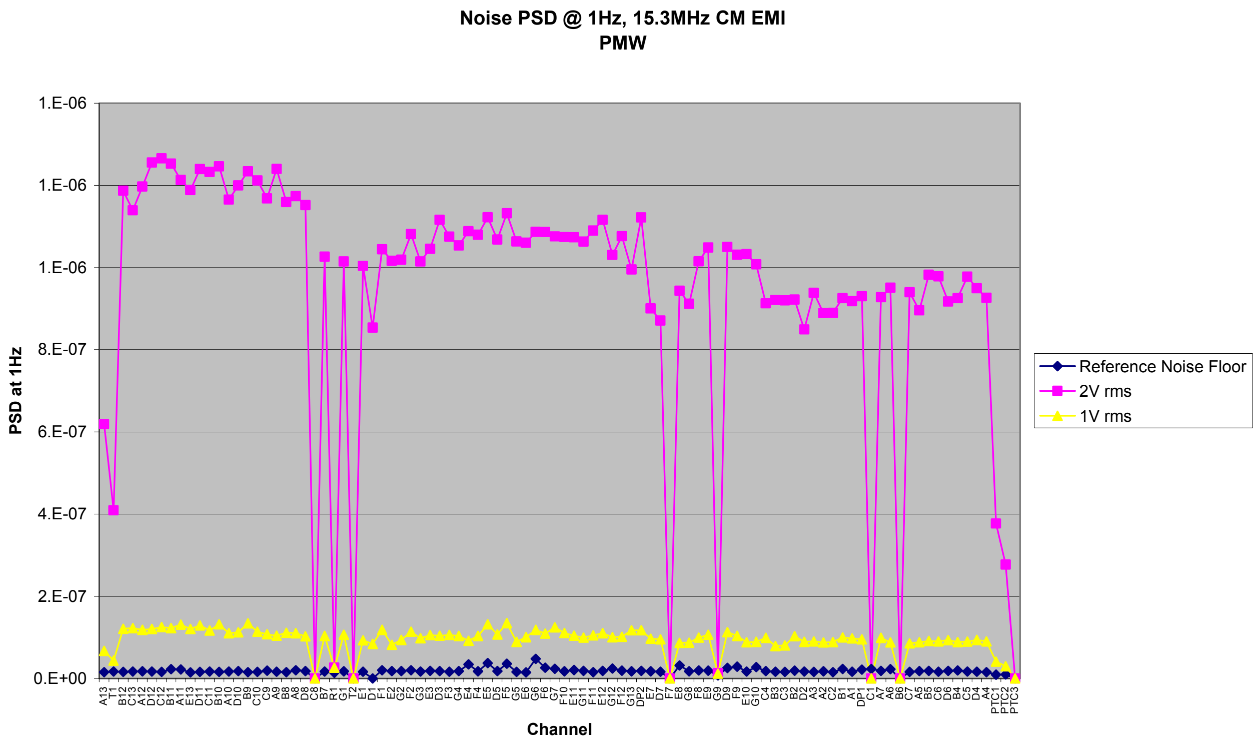


Figure 52

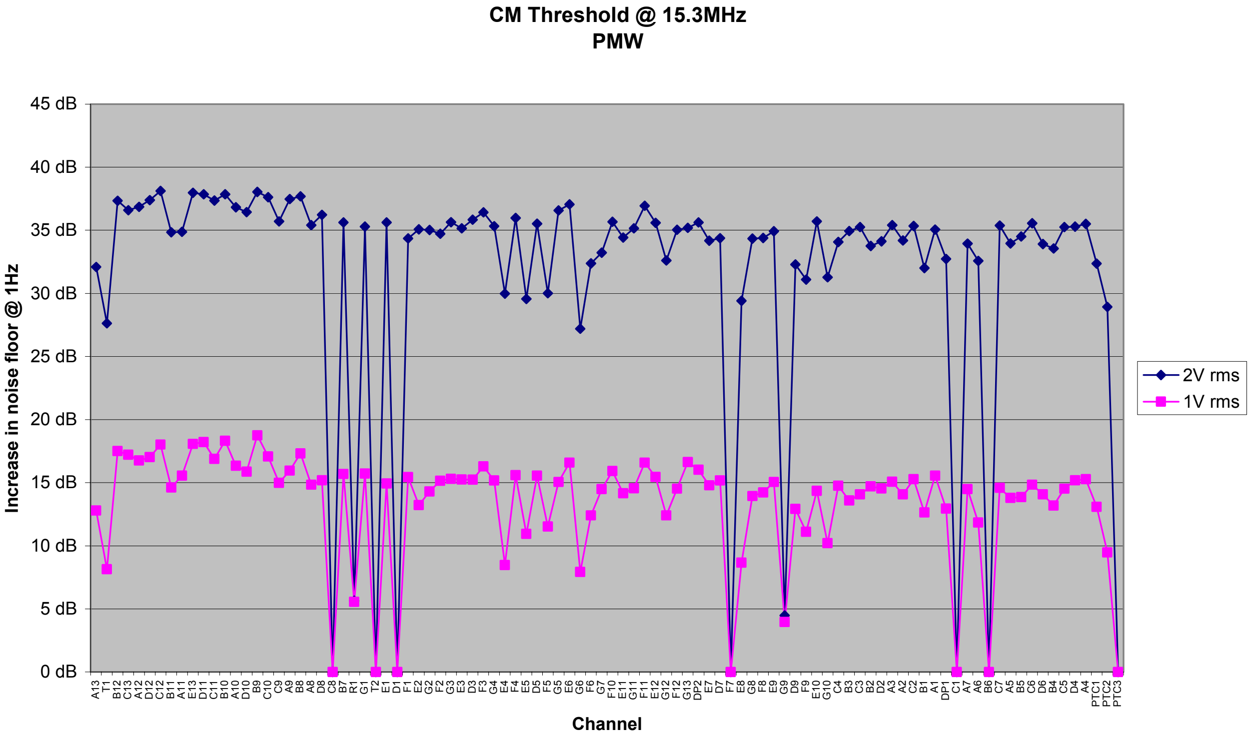


Figure 53

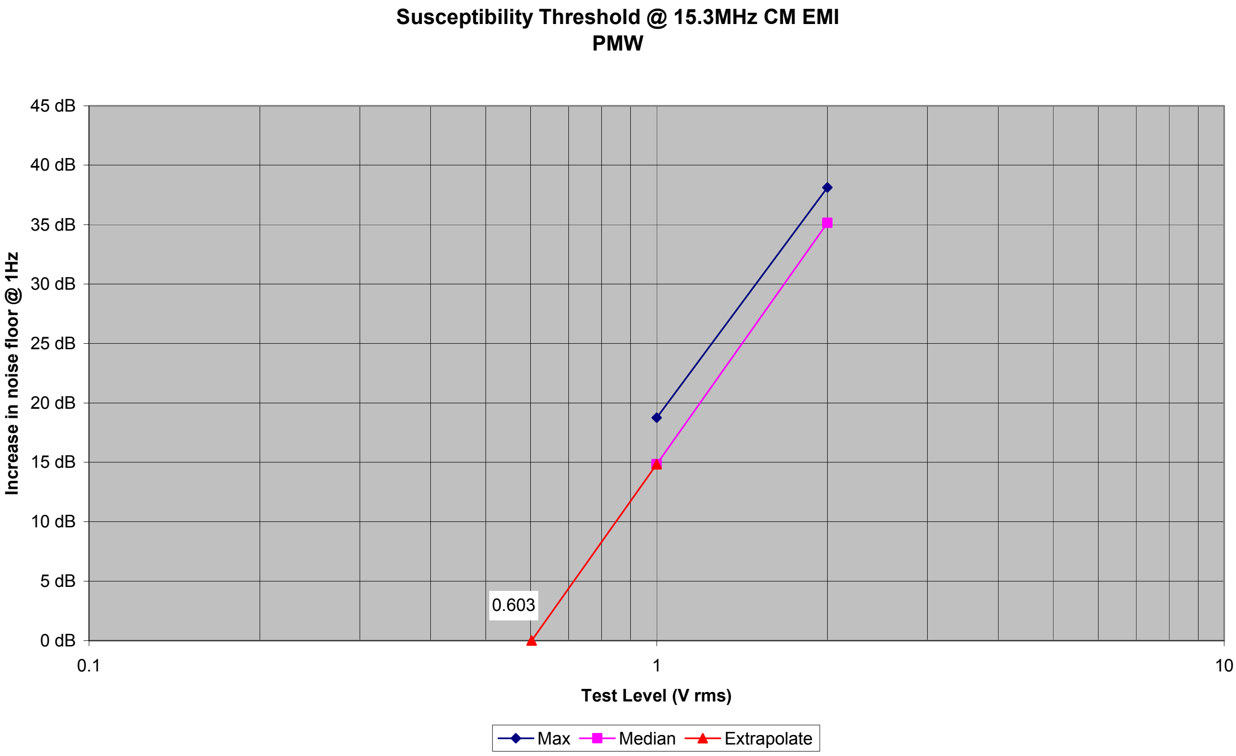


Figure 54

3.2.3 PSW

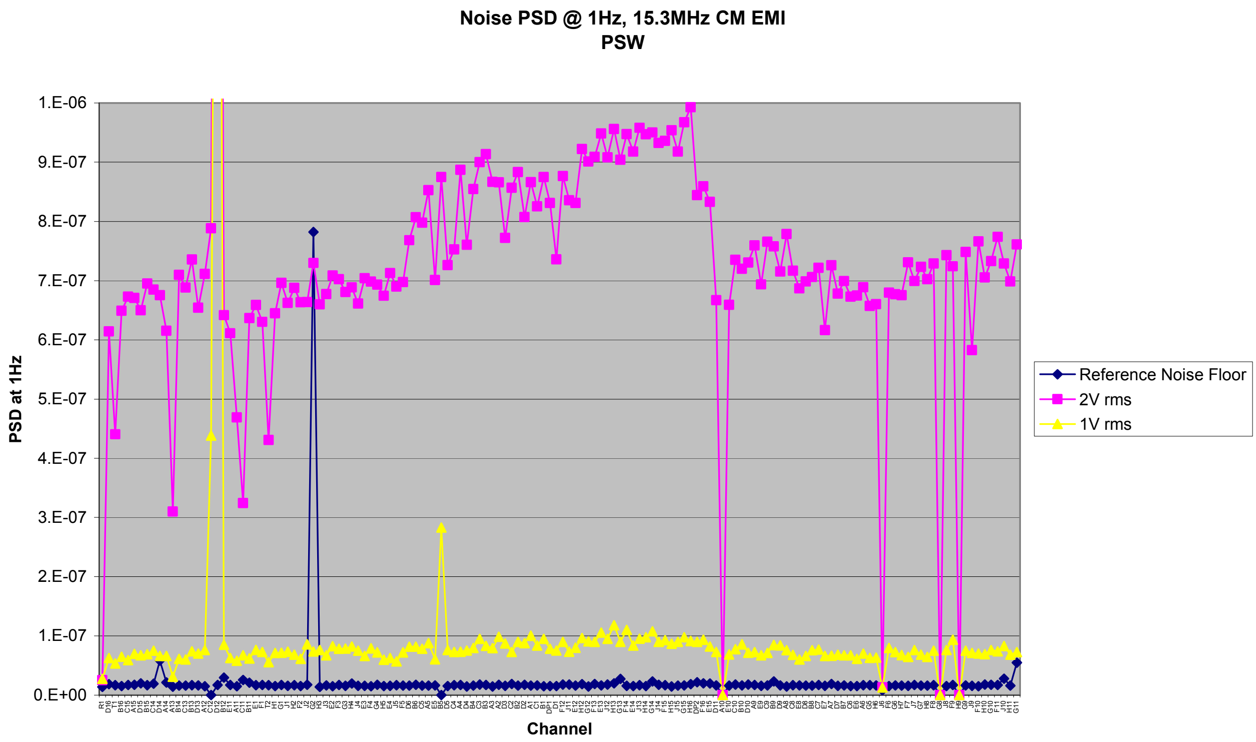


Figure 55

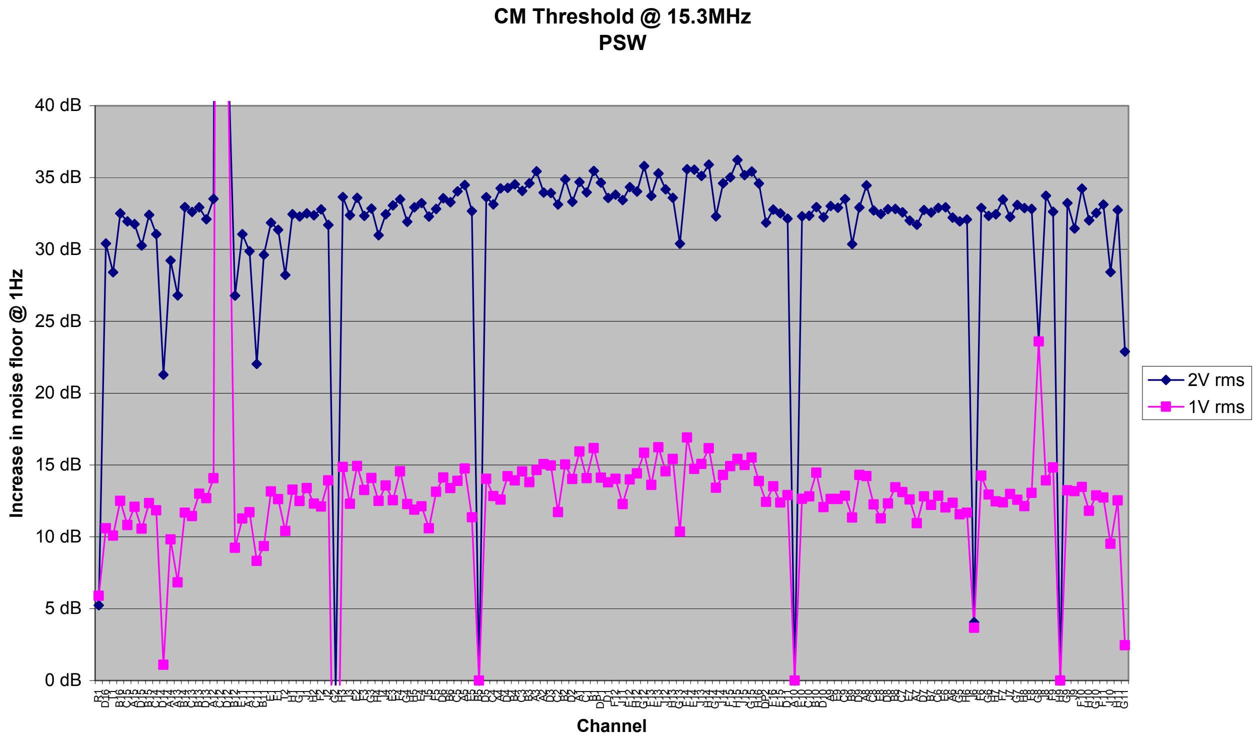


Figure 56

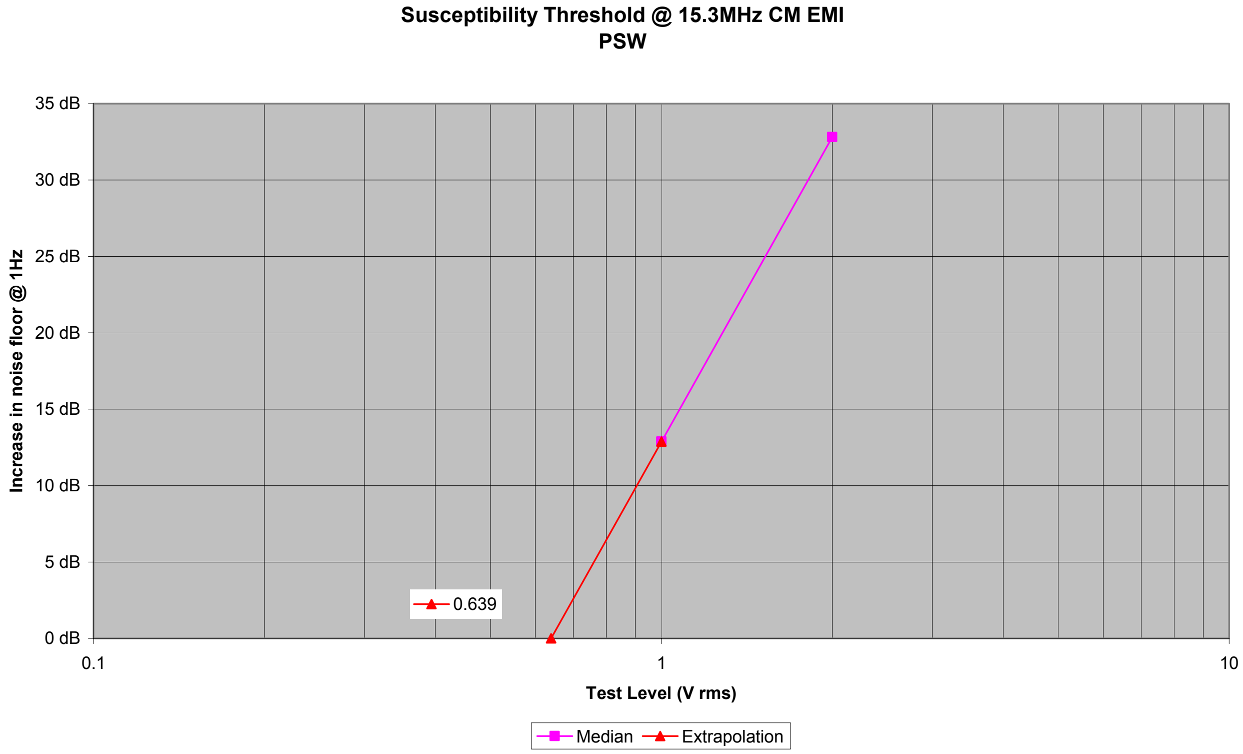

Susceptibility Threshold @ 15.3MHz CM EMI
PSW
35 dB
30 dB
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
Increase in noise floor @ 1Hz
0.639
0.1
1
10
Test Level (V rms)
Median
Extrapolation

Figure 57

3.3 34MHz

3.3.1 PLW

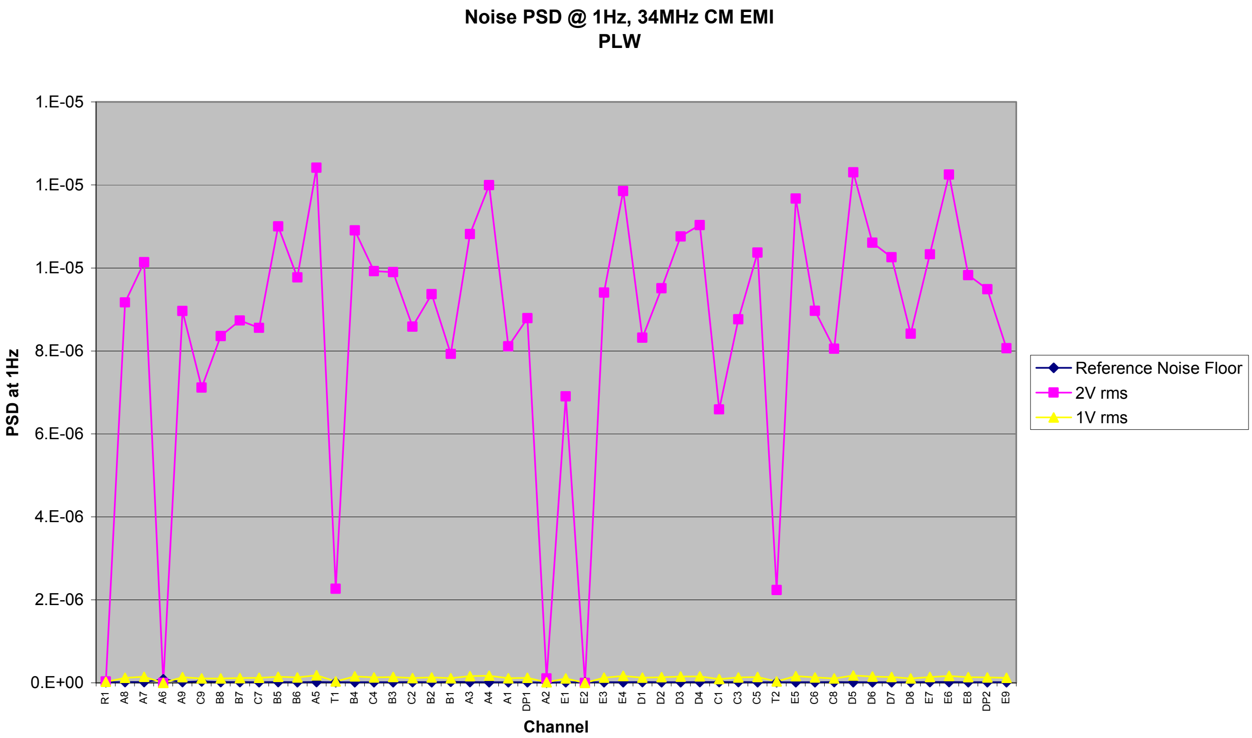


Figure 58

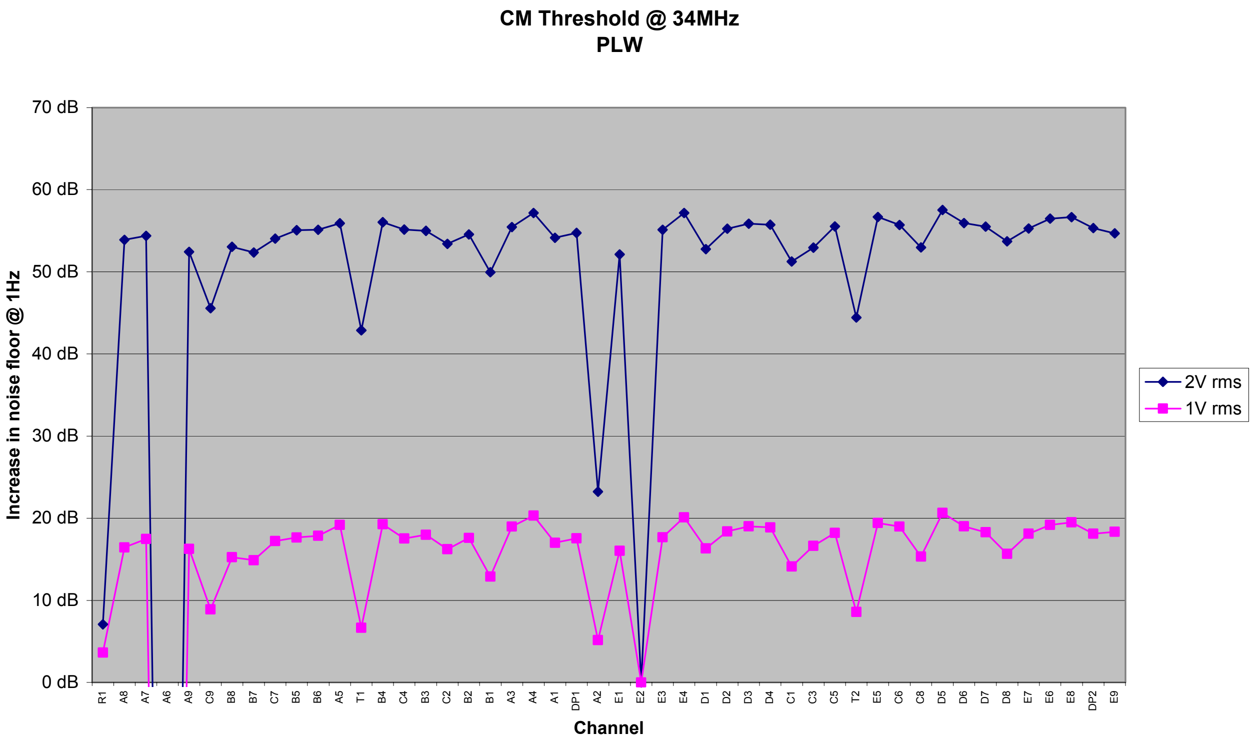


Figure 59

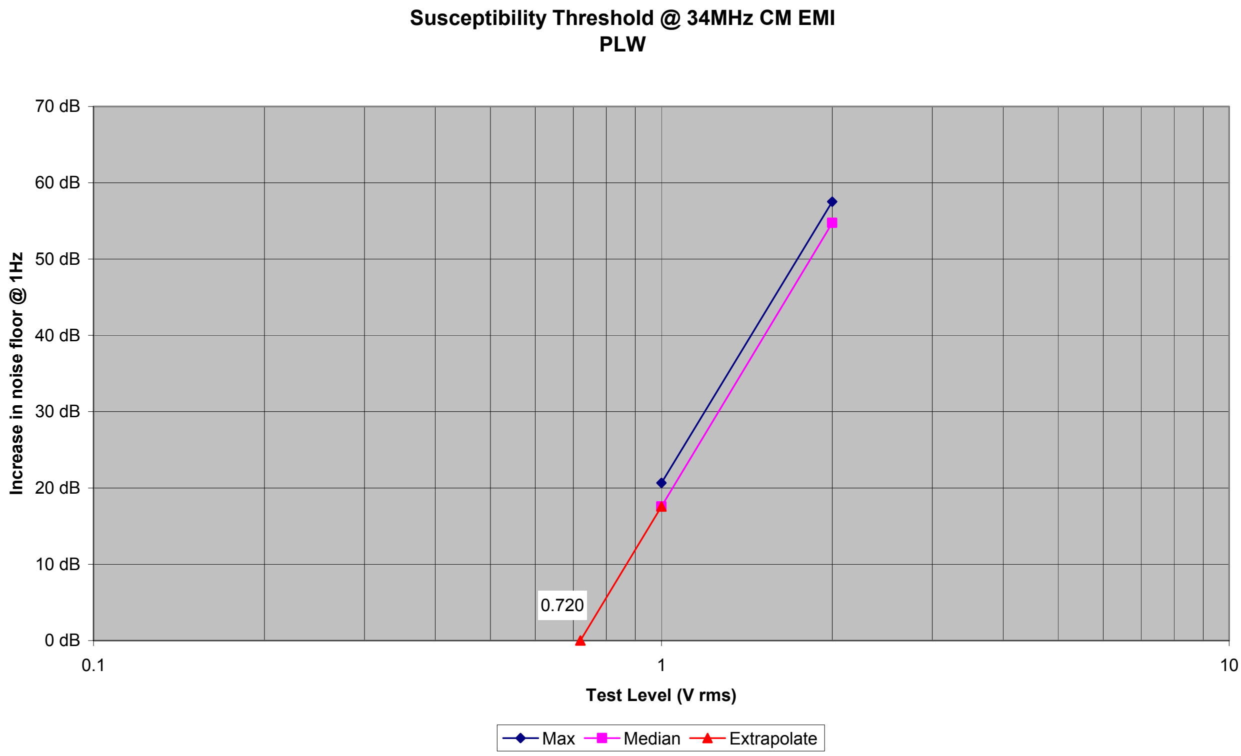


Figure 60

3.3.2 PMW

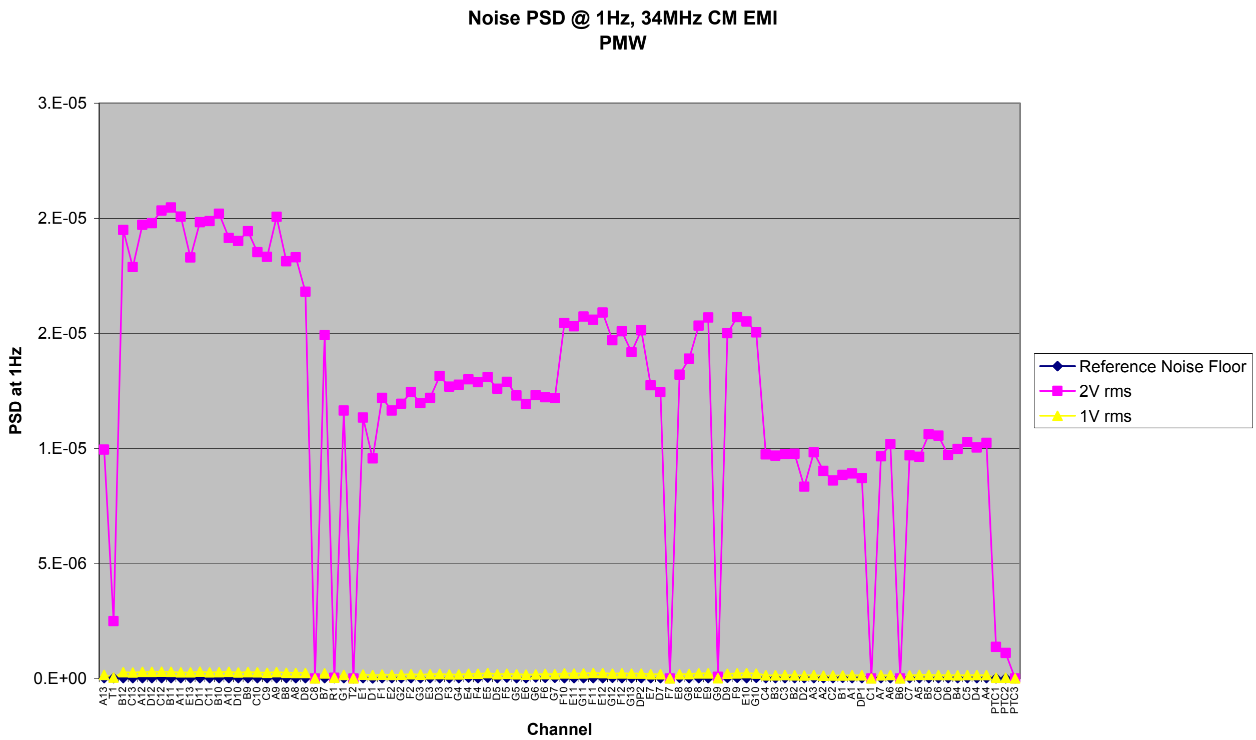


Figure 61

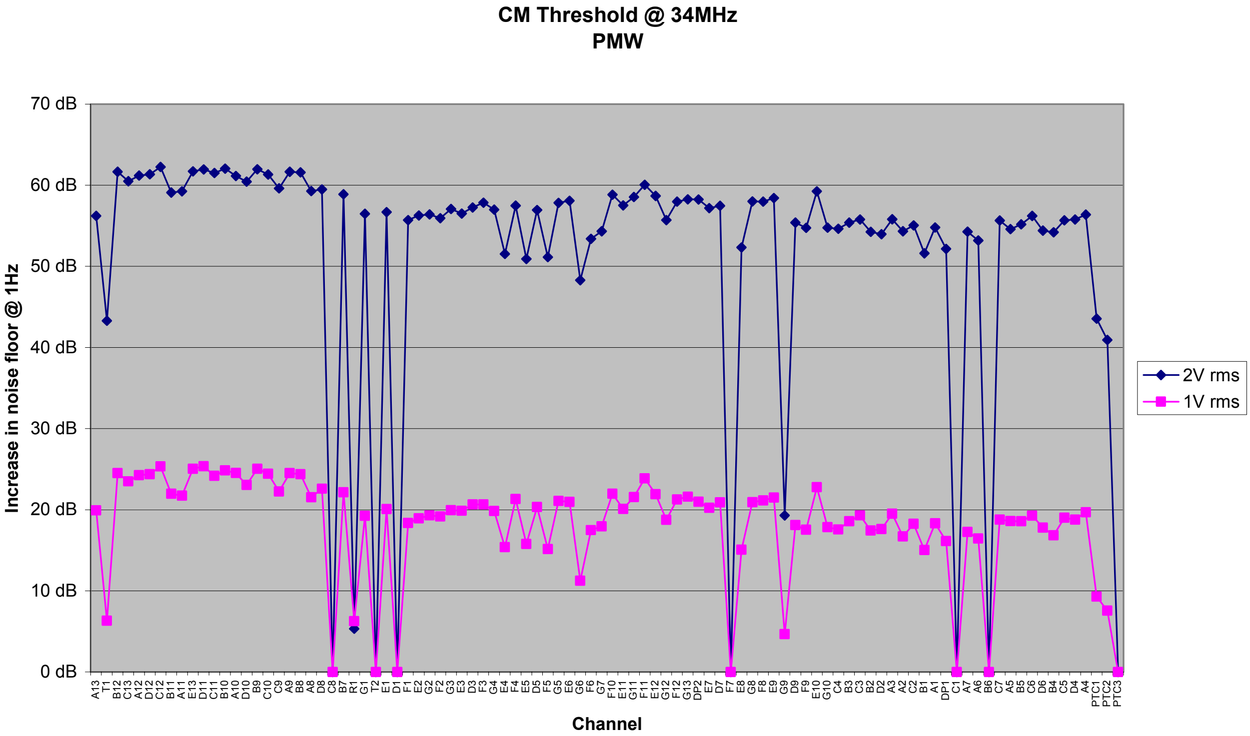


Figure 62

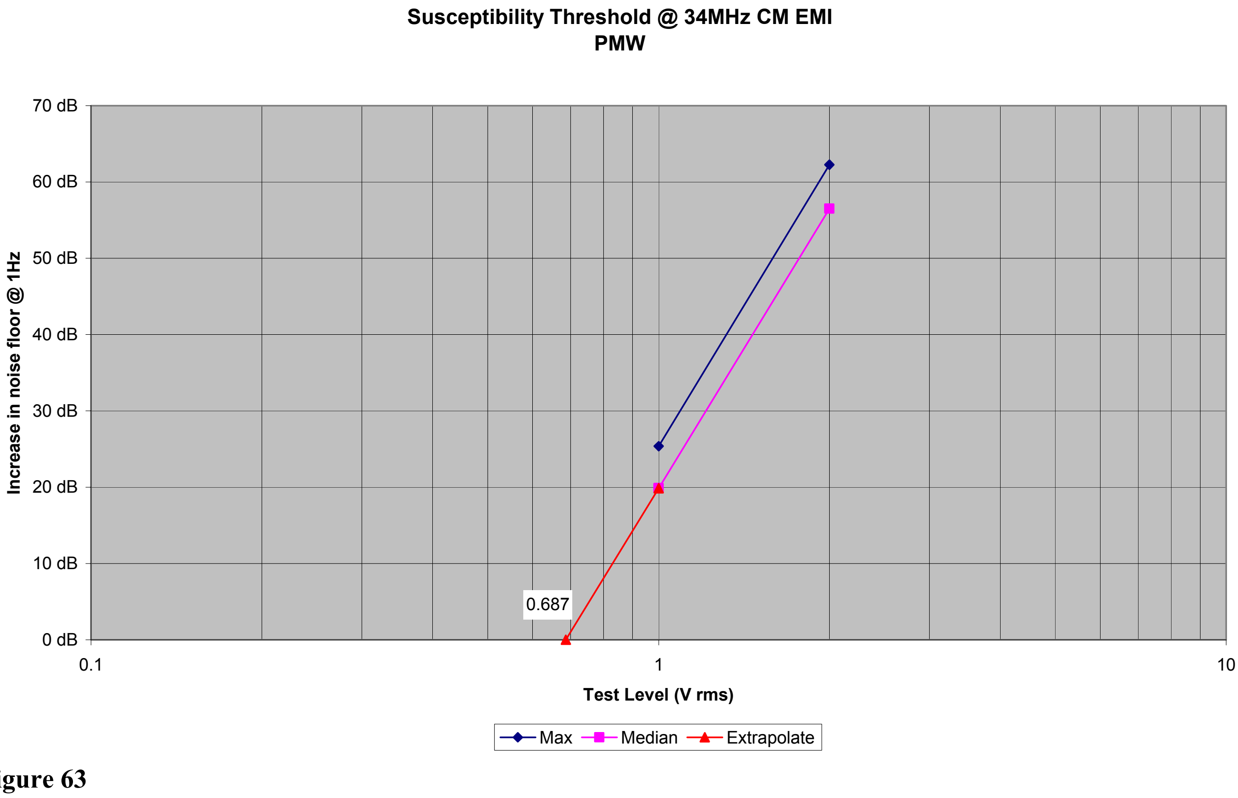


Figure 63

3.3.3 PSW

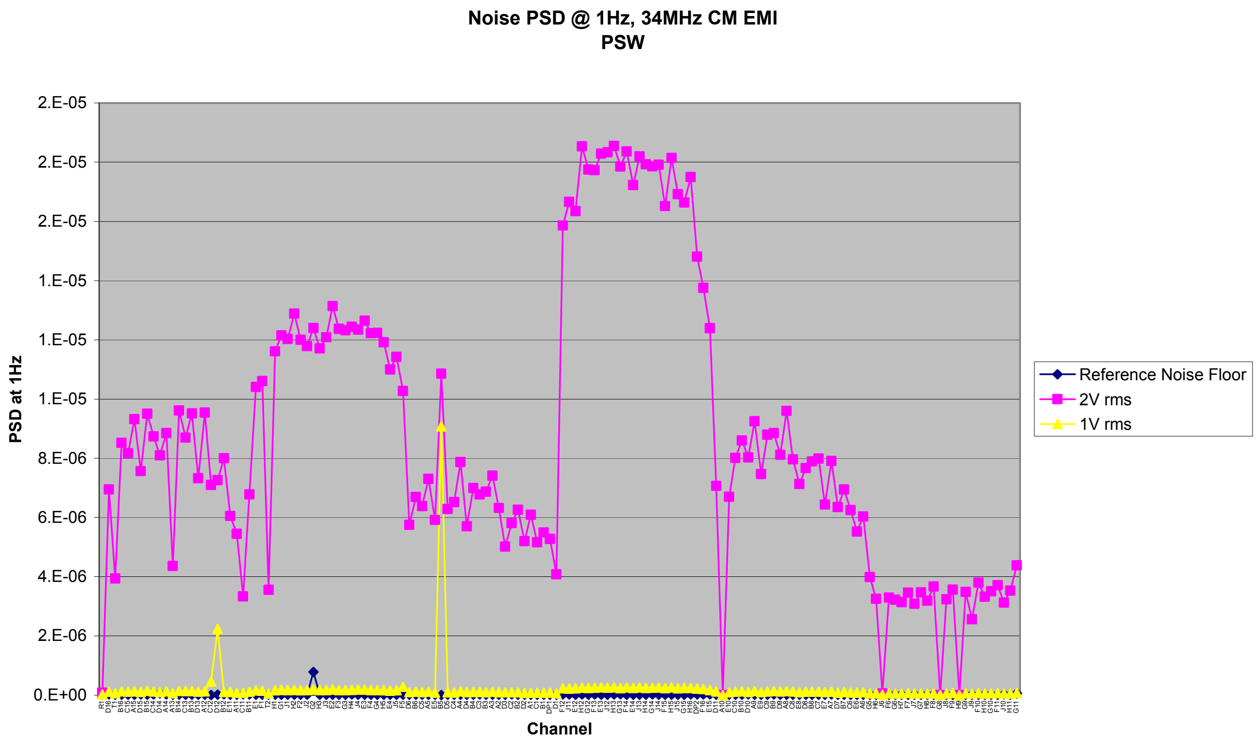


Figure 64

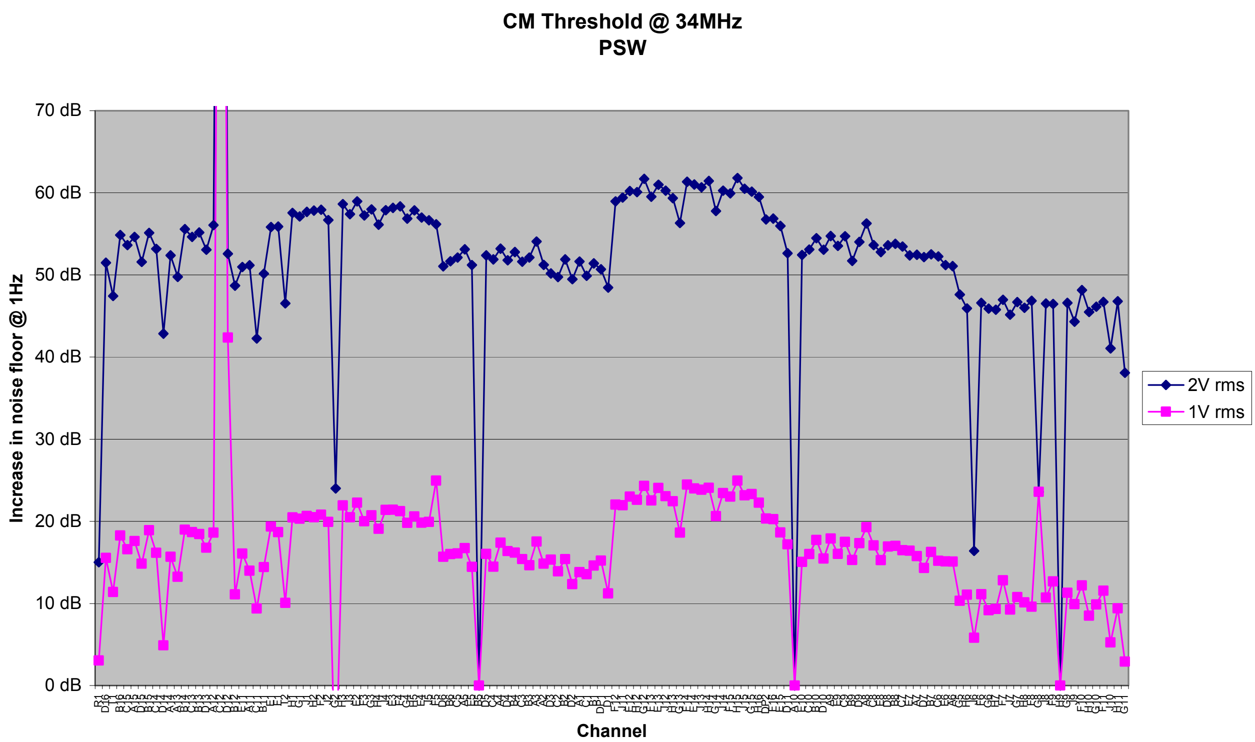
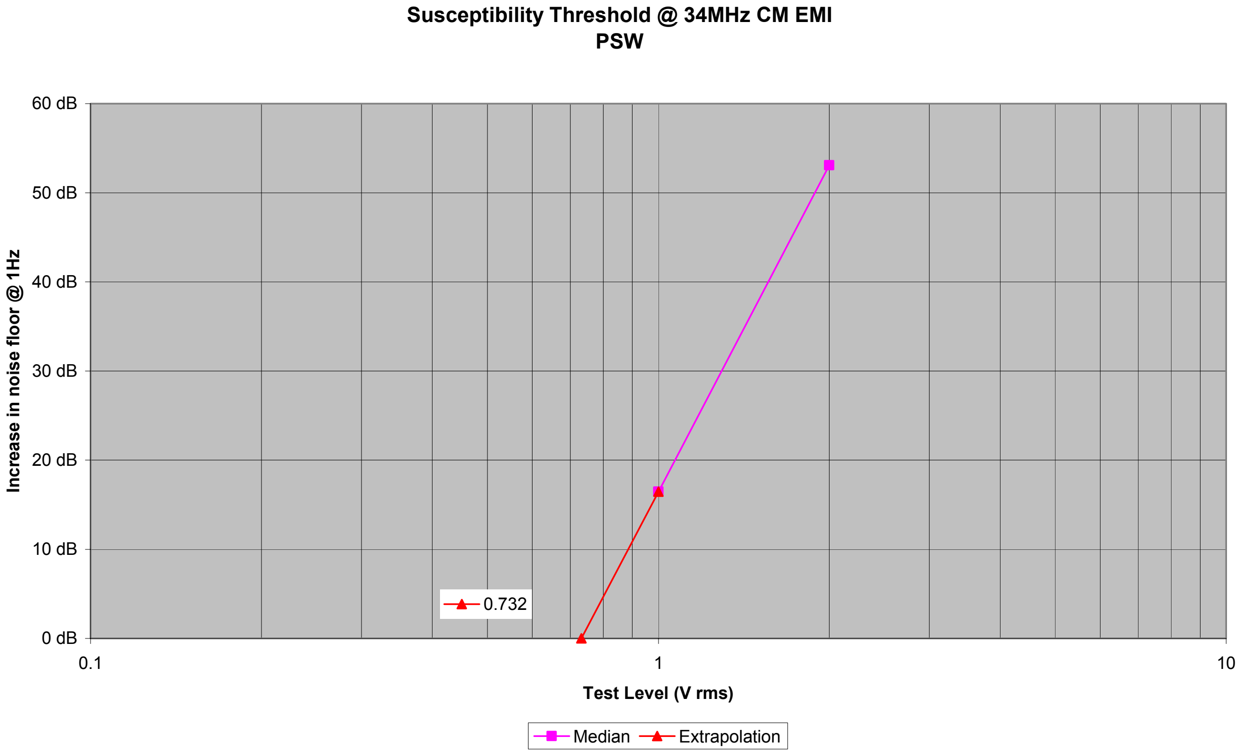


Figure 65



Susceptibility Threshold @ 34MHz CM EMI
PSW
60 dB
50 dB
40 dB
30 dB
20 dB
10 dB
0 dB
Increase in noise floor @ 1Hz
0.732
0.1
1
10
Test Level (V rms)
Median
Extrapolation

Figure 66

3.4 47.6MHz

3.4.1 PLW

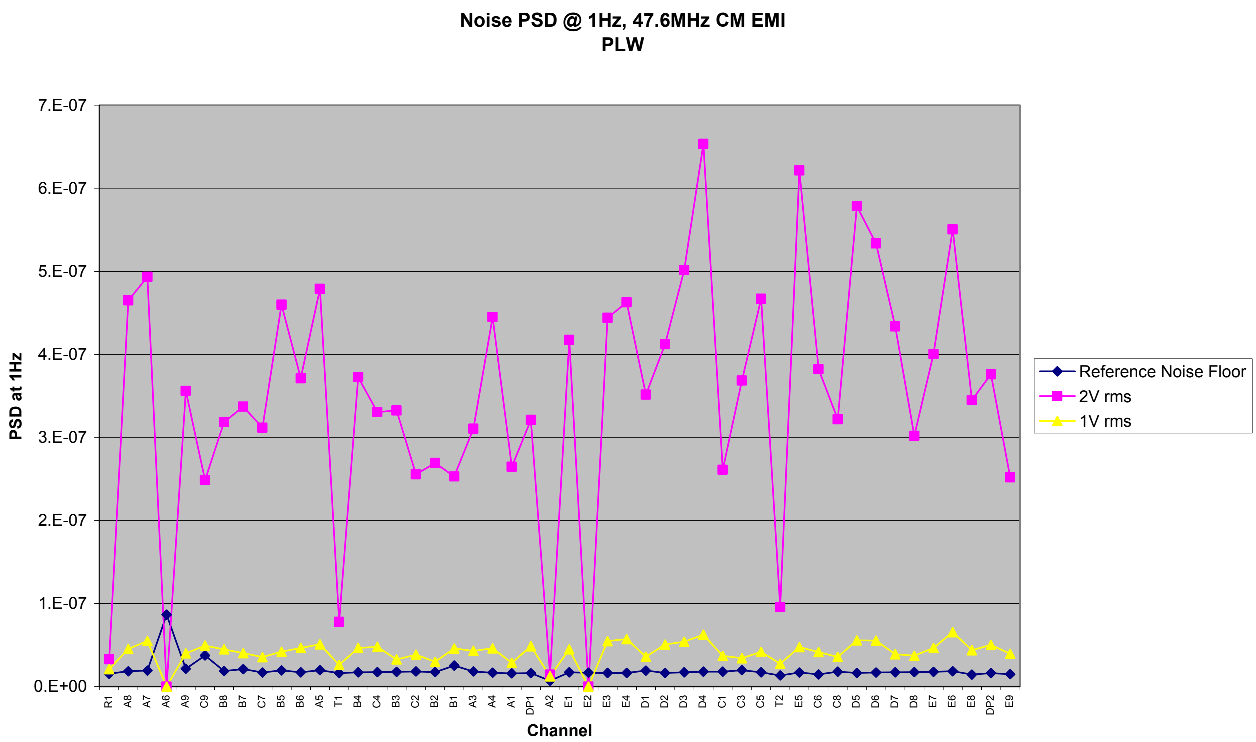


Figure 67

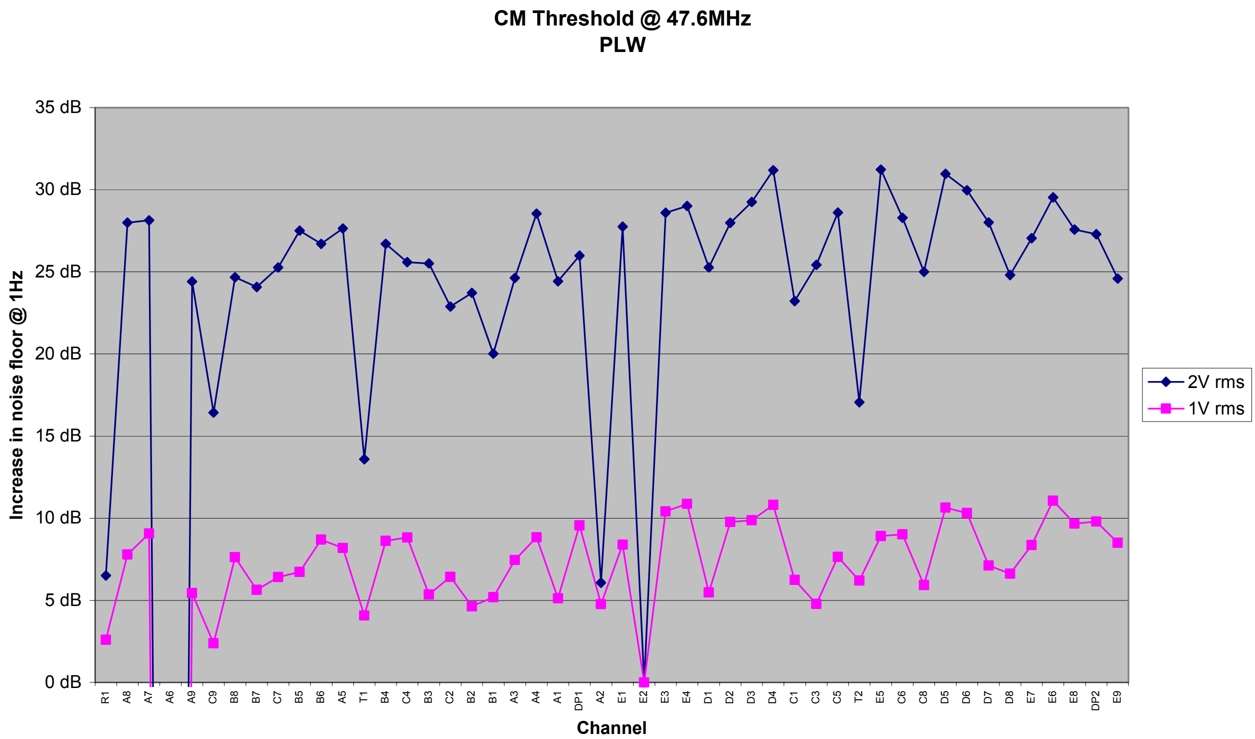


Figure 68

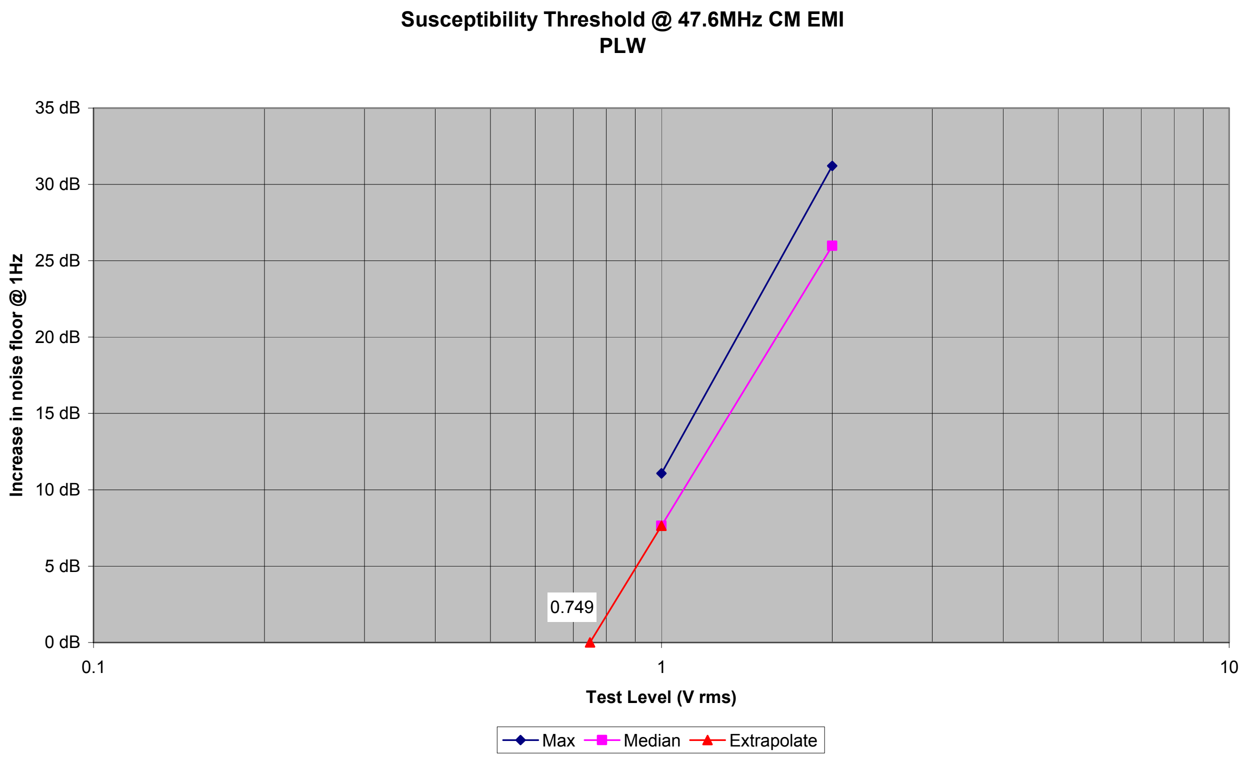


Figure 69

3.4.2 PMW

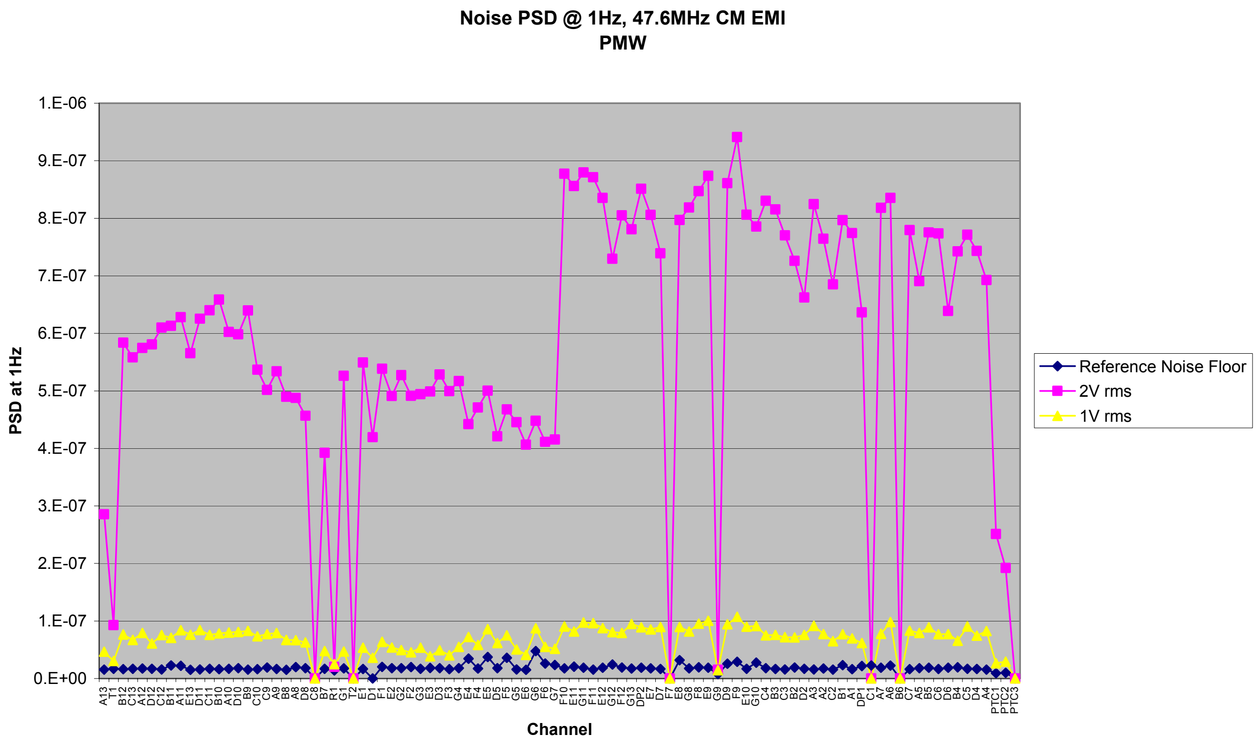


Figure 70

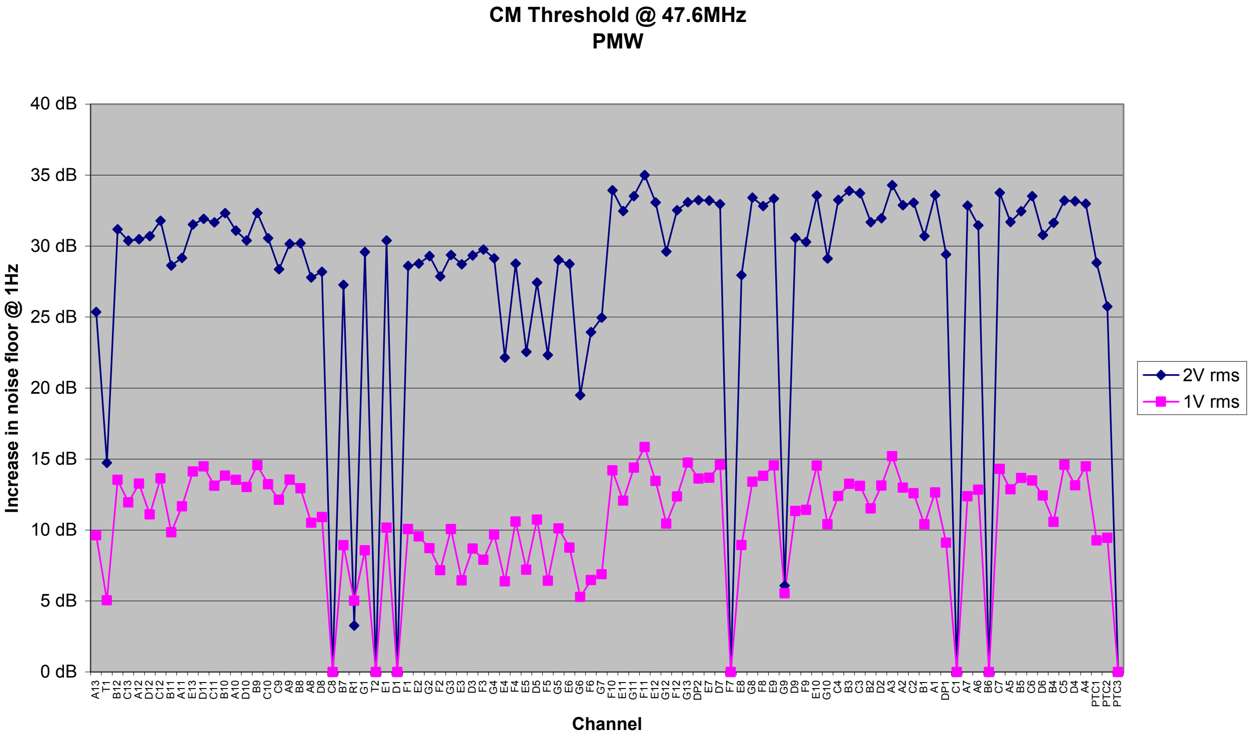


Figure 71

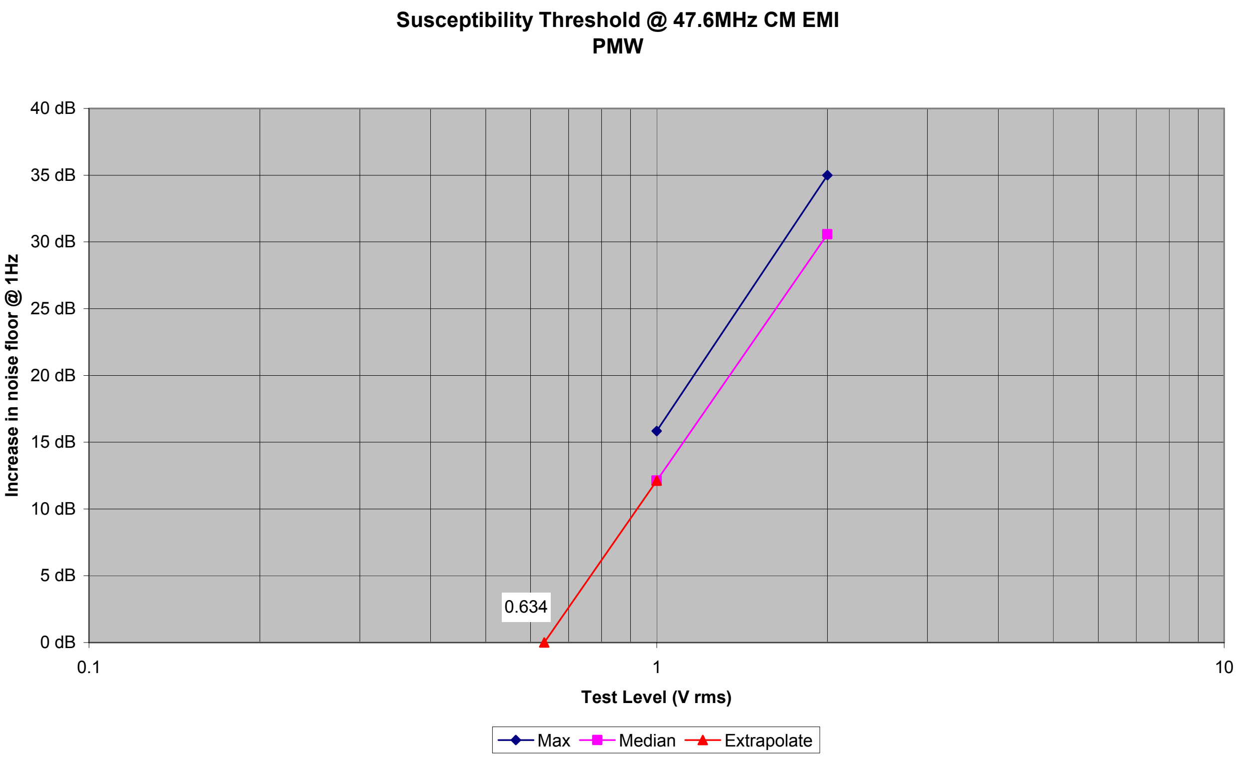


Figure 72

3.4.3 PSW

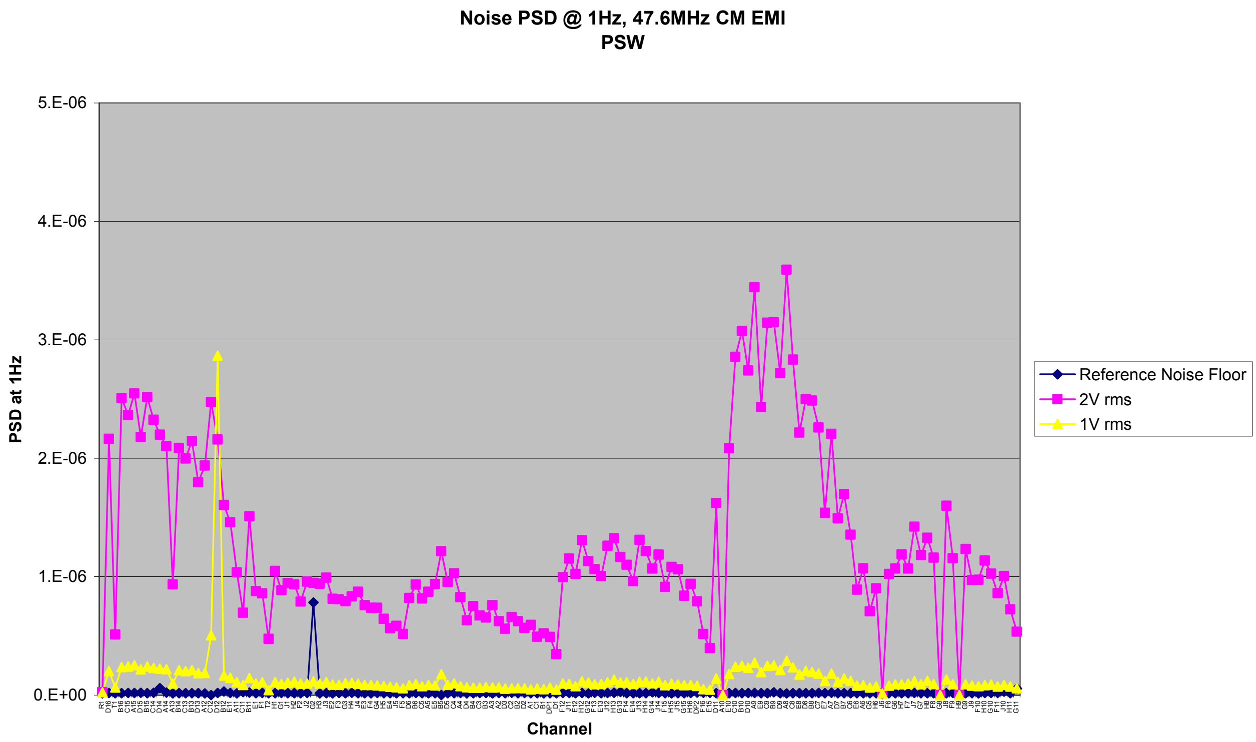


Figure 73

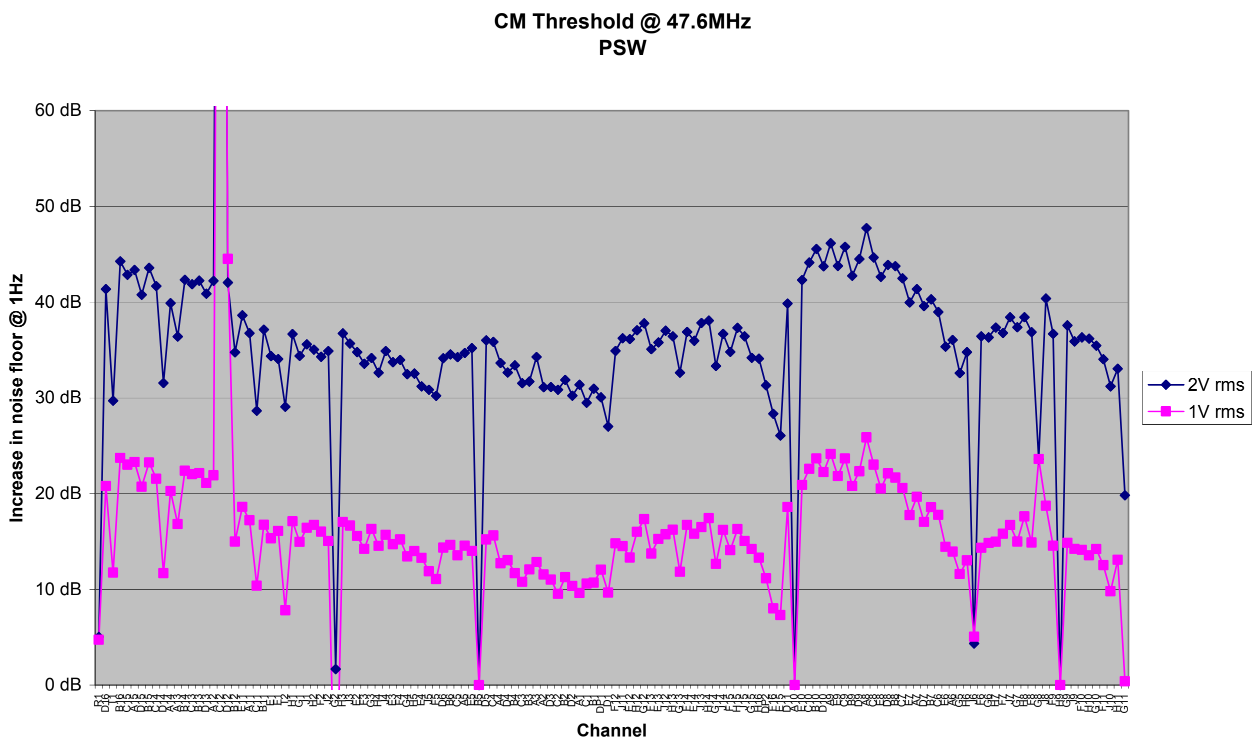


Figure 74

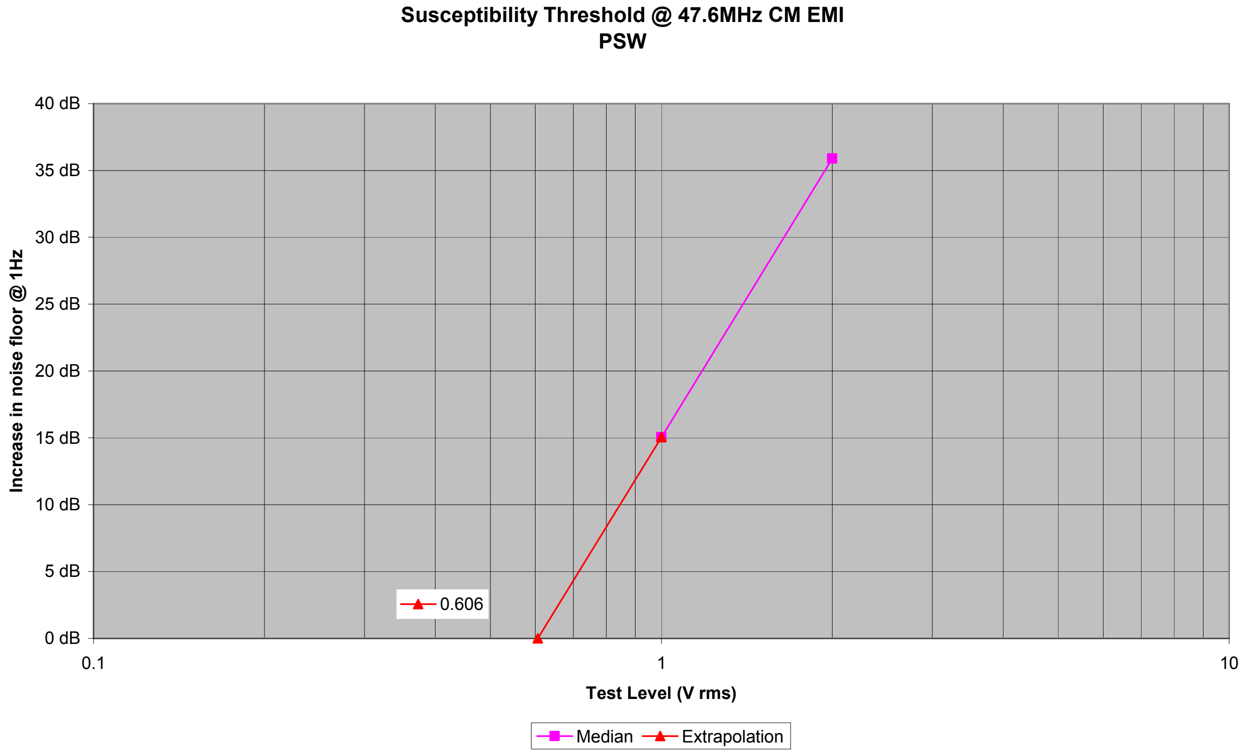

Susceptibility Threshold @ 47.6MHz CM EMI
PSW
Increase in noise floor @ 1Hz
40 dB
35 dB
30 dB
25 dB
20 dB
15 dB
10 dB
5 dB
0 dB
0.606
0.1
1
10
Test Level (V rms)
Median
Extrapolation

Figure 75

E. Ferrite Selection Note

From: Doug Griffin
To: Filippo Marliani
Date: Monday, 05 June 2006

During the meeting (Ref: XXXX) between ESA/Alcatel and Astrium on XXX, it was decided to investigate the possibility of implementing clamped ferrites on the SPIRE cryoharness to reduce the susceptibility to EMI. An action was placed on SPIRE to produce a recommendation for the implementation of these ferrites on the cryoharness.

1. Two ferrites are to be placed on each of the 13 SIH-IS harnesses. These are nominated as the upper and the lower ferrites.
    a. The lower ferrites are to be located ~ 50mm from the connector backshells as indicated schematically in Figure 2.
    b. The upper ferrites are to be located ~50mm from the connector backshells as indicated in Figure 1, Figure 3 and Figure 4.
2. The bundle diameters for these harnesses are shown in Table 1.
3. An impedance of 50 Ohm at 25MHz is to be achieved for each ferrite.
4. An initial review of suitable ferrites is contained in Table 2 . Other considerations regarding the suitability of the ferrites include:
    a. The outgassing performance of the ferrite material and the clamping mechanism
    b. The cryogenic compatibility of the material (structural integrity, filter performance at cryogenic temperature)
    c. Existing flight heritage

sih-is-01	12.00 mm
sih-is-02	11.50 mm
sih-is-03	13.00 mm
sih-is-04	11.50 mm
sih-is-05	12.00 mm
sih-is-06	11.50 mm
sih-is-07	11.50 mm
sih-is-08	11.50 mm
sih-is-09	12.00 mm
sih-is-10	9.50 mm
sih-is-11	12.00 mm
sih-is-12	9.00 mm
sih-is-13	11.00 mm

Table 1 – harness bundle diameters for the SPIRE PFM SIH-IS.

Manufacturer	Part number	
Fair-rite	0431164181	
Ferroxcube	CSA26/13/29-452-EN	
API Delevan	BF 2930	

Table 2 – Possible ferrites

Appendix 1 – Extract from the Fair-rite catalogue

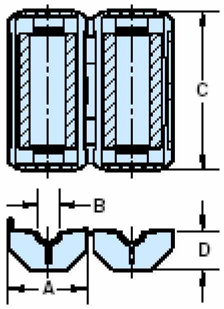


Figure 1

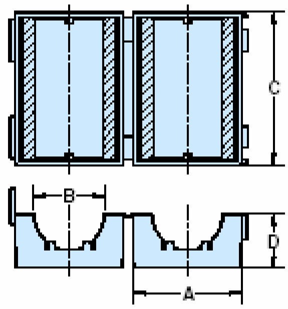


Figure 2

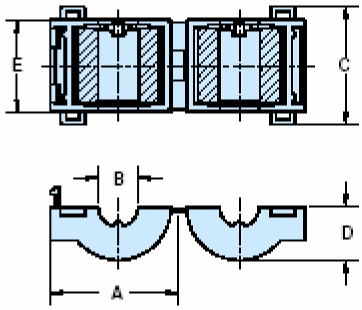


Figure 3

Broadband Frequencies 25-300 MHz (43 & 44 materials)

Dimensions (**Bold numbers are in millimeters**, light numbers are nominal in inches.)

Part Number	Fig.	Max. Cable Diameter	A	B**	C	D	E	Wt. (g)	Typical Impedance(Ω) 10 MHz	25 MHz+	100 MHz+	250 MHz	Solid Equivalent*
0443167251	2	**9.85** .388	**22.1** .870	**10.15** .400	**32.3** 1.272	**11.0** .433		42	79	138	225	285	2643626402
0444167281	1	**9.85** .388	**23.7** .933	**10.15** .400	**39.4** 1.550	**11.7** .460		33	77	125	210	260	2643626402
0443164151	2	**12.7** .500	**29.0** 1.142	**13.05** .514	**32.5** 1.280	**14.8** .583		84	90	156	250	305	2643102002
0444164181	1	**12.7** .500	**31.0** 1.220	**13.05** .514	**39.4** 1.550	**15.25** .600		61	76	138	230	280	2643102002
0443800506	3	**12.8** .504	**29.7** 1.169	**13.2** .520	**20.6** .811	**12.7** .500	**15.6** .614	16	18	35	75	120	2643800502
0443806406	3	**15.0** .591	**34.3** 1.360	**15.5** .610	**21.2** .835	**15.0** .591	**16.2** .638	23	24	43	90	147	2643806402
0444176451	1	**18.0** .709	**38.6** 1.520	**18.35** .722	**47.5** 1.870	**19.15** .755		161	100	175	365	365	2643103002
0444173551	2	**18.5** .728	**29.2** 1.150	**18.8** .740	**42.0** 1.650	**14.7** .579		78	50	95	195	322	2643103102
0444177081	1	**25.4** 1.000	**56.4** 2.220	**25.9** 1.020	**42.95** 1.690	**27.45** 1.080		308	115	194	335	330	2643626202

43 Material

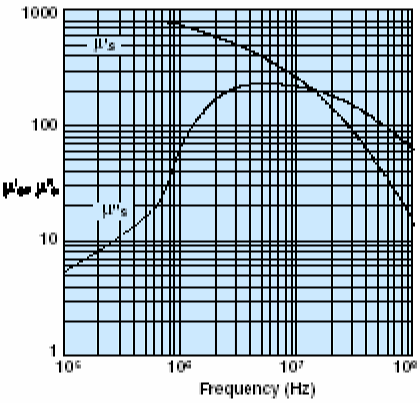
This NiZn is our most popular ferrite for suppression of conducted EMI from 20 MHz to 250 MHz. This material is also used for inductive applications such as high frequency common-mode chokes.

EMI suppression beads, beads on leads, SM beads, multi-aperture cores, round cable EMI suppression cores, split round EMI suppression cores, round cable snap-its, flat cable EMI suppression cores, flat cable snap-its, miscellaneous suppression cores, bobbins, and toroids are all available in 43 material.

43 Material Specifications:

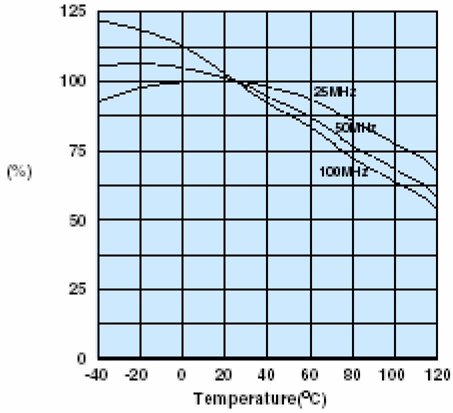
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	800
Flux Density @ Field Strength	gauss oersted	B H	2900 10
Residual Flux Density	gauss	B_r	1300
Coercive Force	oersted	H_c	0.45
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	250 1.0
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		1.25
Curie Temperature	°C	T_c	>130
Resistivity	Ω cm	ρ	1x10[illegible]

Complex Permeability vs. Frequency



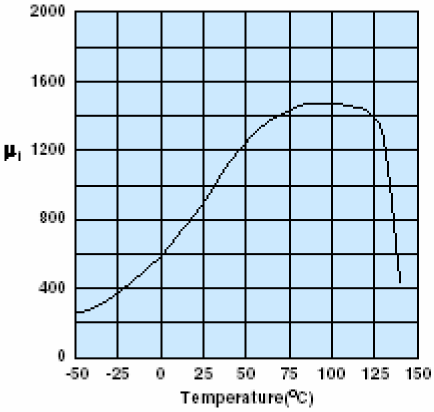
Measured on a 17/10/6mm toroid using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



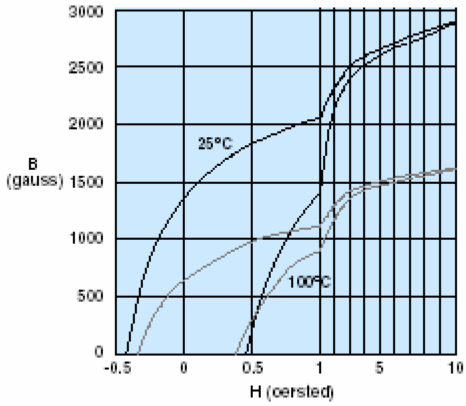
Measured on a 2643000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

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44 Material

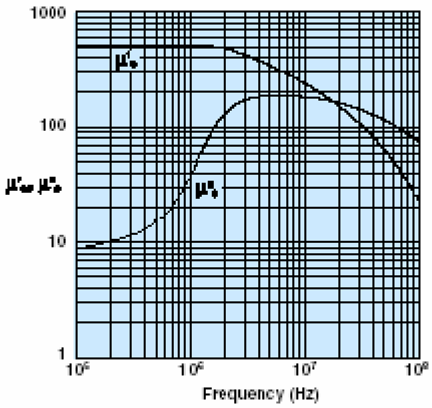
A NiZn ferrite developed to combine a high suppression performance, from 30 MHz to 500 MHz, with a very high dc resistivity.

SM beads, PC beads, wound beads, split round cable EMI suppression cores, round cable snap-its, and connector EMI suppression plates are all available in 44 material.

44 Material Specifications:

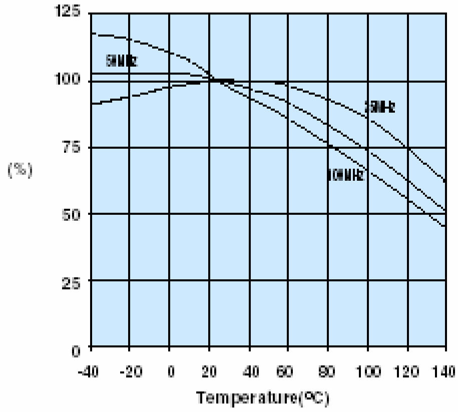
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	500
Flux Density @ Field Strength	gauss oersted	B H	3000 10
Residual Flux Density	gauss	B_r	1100
Coercive Force	oersted	H_c	0.45
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	125 1.0
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.75
Curie Temperature	°C	T_c	>160
Resistivity	Ω cm	ρ	$1\text{x}10^{9}$

Complex Permeability vs. Frequency



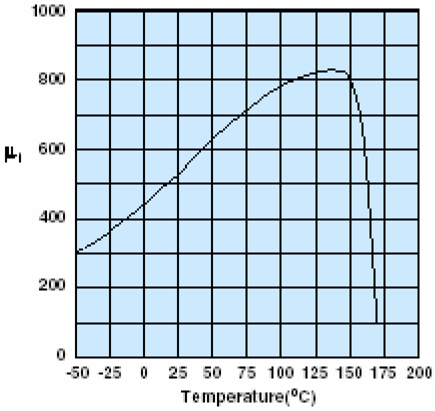
Measured on a 17/10/6mm toroid using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



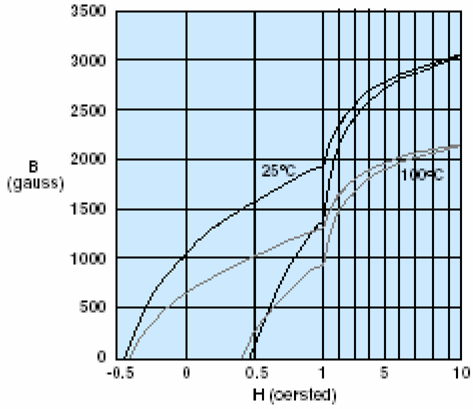
Measured on a 2644000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

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Lower & Broadband Frequencies 1-300 MHz (31 material)

Dimensions (**Bold numbers are in millimeters**, light numbers are nominal in inches.)

Part Number	Fig.	Max. Cable Diameter	A	B**	C	D	Wt. (g)	Typical Impedance(Ω)						Solid Equivalent*
								1 MHz	5 MHz	10 MHz^{+}	25 MHz^{+}	100 MHz^{+}	250 MHz	
0431178181	1	**4.1** .161	**11.8** .465	**4.3** .169	**23.2** .913	**5.6** .221	4.2	12	43	60	90	160	183	
0431173951	1	**4.9** .193	**12.8** .504	**5.1** .201	**25.0** .984	**5.6** .220	6.5	14	44	60	100	180	208	2631023002
0431164951	1	**4.9** .193	**17.3** .680	**5.1** .201	**36.2** 1.420	**8.4** .331	17	25	75	100	169	280	247	2631480002
0431164281	1	**6.3** .250	**20.0** .788	**6.6** .260	**39.4** 1.550	**9.8** .385	26	28	83	105	180	310	240	2631540002
0431178281	1	**8.7** .343	**21.5** .846	**9.0** .354	**39.4** 1.550	**10.55** .415	23	18	63	85	130	250	275	2631665702
0431167281	1	**9.85** .388	**23.7** .933	**10.15** .400	**39.4** 1.550	**11.7** .461	33	18	56	81	144	240	270	2631626402
0431164181	1	**12.7** .500	**31.0** 1.220	**13.05** .514	**39.4** 1.550	**15.25** .600	61	25	71	100	156	260	260	2631102002
0431176451	1	**18.0** .709	**38.6** 1.520	**18.35** .722	**47.5** 1.870	**19.15** .755	161	47	95	130	225	380	370	2631103002
0431173551	2	**18.5** .728	**29.2** 1.150	**18.8** .740	**42.0** 1.65	**14.7** .579	78	16	48	69	125	220	310	2631103102
0431177081	1	**25.4** 1.000	**56.4** 2.220	**25.9** 1.020	**42.95** 1.690	**27.45** 1.080	308	45	90	125	218	375	340	2631626202

31 Material

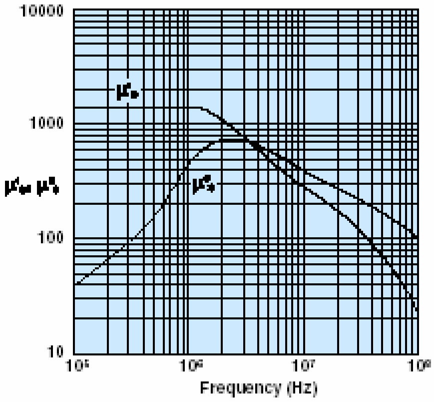
A MnZn ferrite designed specifically for EMI suppression applications from as low as 1 MHz up to 500 MHz. This material does not have the dimensional resonance limitations associated with conventional MnZn ferrite materials.

EMI suppression beads, round cable EMI suppression cores, round cable snap-its, flat cable EMI suppression cores, and flat cable snap-its are all available in 31 material.

31 Material Specifications:

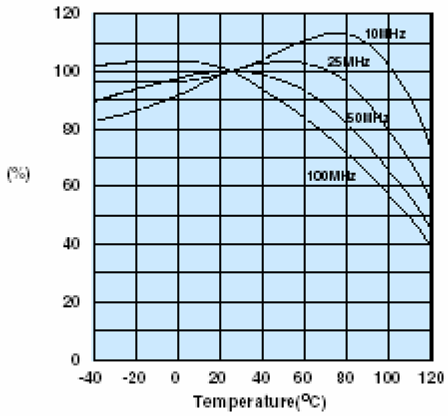
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	1500
Flux Density @ Field Strength	gauss oersted	B H	3400 5
Residual Flux Density	gauss	B_r	2500
Coercive Force	oersted	H_c	0.35
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	20 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		1.6
Curie Temperature	°C	T_c	>130
Resistivity	Ω cm	ρ	$3x10^3$

Complex Permeability vs. Frequency



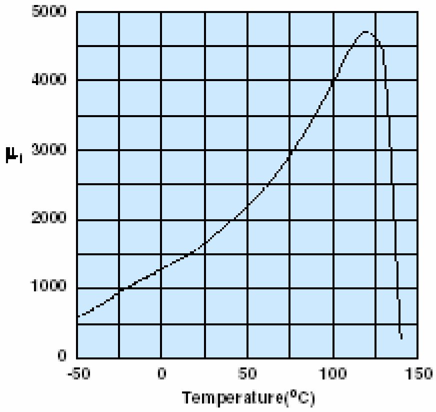
Measured on a 17/10/6mm toroid at 25°C using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



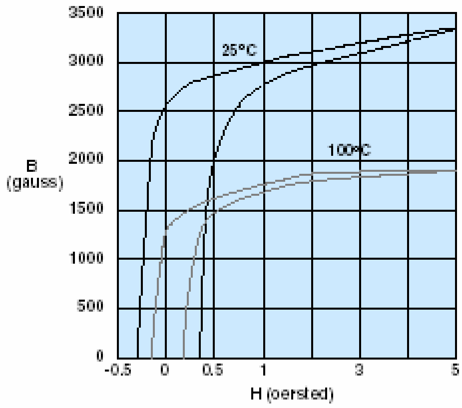
Measured on a 2631000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

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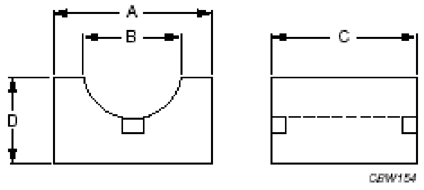
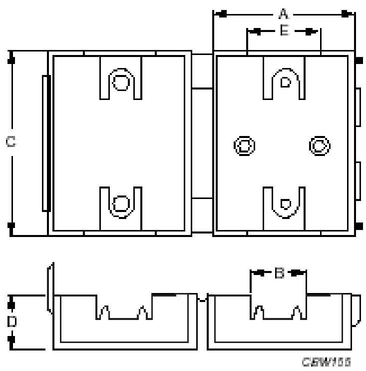
Appendix 2 – Extracts form the Ferroxcube catalogue

Round cable shields (split)



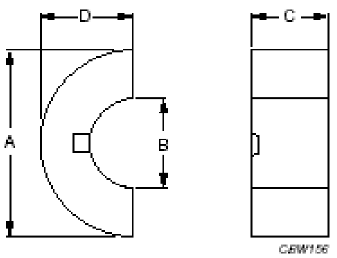
For dimensions see Table 2.

Fig.2 Shield (CSA) outline.



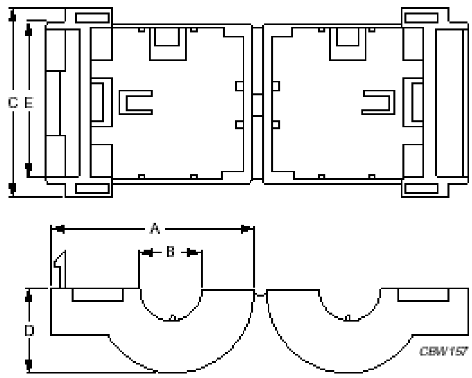
For dimensions see Table 2.

Fig.3 Nylon case.



For dimensions see Table 2.

Fig.4 Shield (CSC) outline.



For dimensions see Table 2.

Fig.5 Nylon case.

General data

ITEM	SPECIFICATION
Case material	polyamide (PA66), glass reinforced, flame retardant in accordance with *"UL94V-0"*, grade A82, colour black

Table 2 Type numbers, dimensions and parameters; see Figs 2 to 5

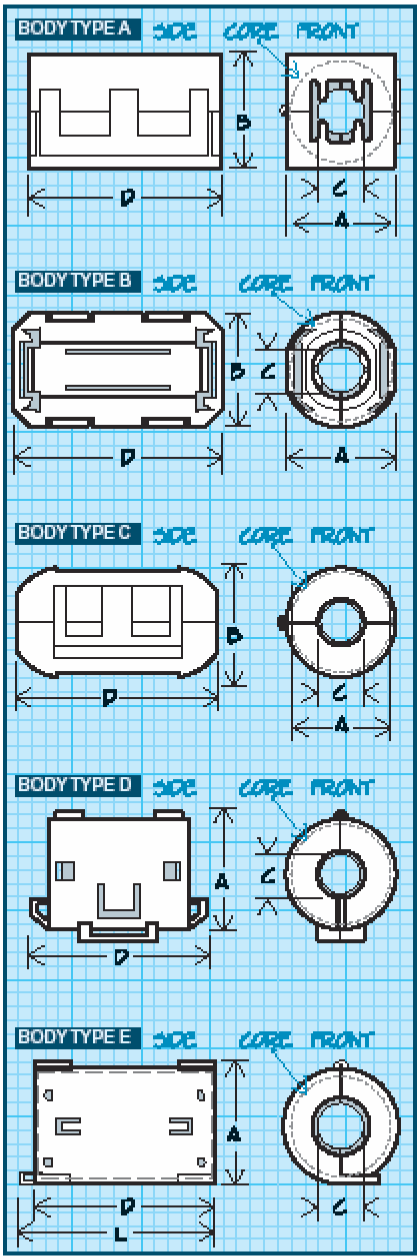
TYPE NUMBER	FIG.	DIMENSIONS					$\|Z_{typ}\|^{(1)}$ (Ω) at	
		A	B	C	D	E	25 MHz	100 MHz
Round cable shields								
CSA15/7.5/29-4S2	2	15 ±0.25	6.6 ±0.3	28.6 ±0.8	7.5 ±0.15	–	165	275
CSA19/9.4/29-4S2	2	18.65 ±0.4	10.15 ±0.3	28.6 ±0.8	9.4 ±0.15	–	140	225
CSA26/13/29-4S2	2	25.9 ±0.5	13.05 ±0.3	28.6 ±0.8	12.8 ±0.25	–	155	250
CSC16/7.9/14-4S2	4	15.9 ±0.4	7.9 ±0.3	14.3 ±0.4	7.95 ±0.2	–	50	113
Round cable shields in matching nylon cases								
CSA15/7.5/29-4S2-EN	2+3	17.9	7.0	32.3	9.2	9.0	165	275
Nylon case	3	17.9	7.0	32.3	9.2	9.0	–	–
CSA19/9.4/29-4S2-EN	2+3	22.1	10.2	32.3	11.7	9.0	140	225
Nylon case	3	22.1	10.2	32.3	11.7	9.0	–	–
CSA26/13/29-4S2-EN	2+3	29	13.4	32.5	14.8	18.0	155	250
Nylon case	3	29	13.4	32.5	14.8	18.0	–	–
CSC16/7.9/14-4S2-EN	4+5	24.7	7.6	22.8	10.2	17.8	50	113
Nylon case	5	24.7	7.6	22.8	10.2	17.8	–	–

Note

1. Minimum guaranteed impedance is $|Z|_{typ}$ − 20%.

Appendix 3 – Extract from the API Delevan catalogue

Series BF Split Ferrite Suppressors for Round Cables



PART NUMBER	UNITS	BODY TYPE	A	B	C	D	L	IMPEDANCE (OHMS) * 25 MHz	IMPEDANCE (OHMS) * 100 MHz
			DIMENSIONS Inches ± 0.04; mm ± 1.0						
SERIES BF - FOR ROUND CABLES									
BF2930	In. mm	A	1.16 29.6	1.20 30.5	0.51 13.0	1.30 33.0	—	155	
BF2223	In. mm	A	0.87 22.3	0.91 23.3	0.39 10.0	1.28 32.6	—	136	
BF1719	In. mm	A	0.70 17.8	0.76 19.5	0.25 6.5	1.28 32.5	—	171	
BF1835	In. mm	B	0.70 18.0	0.77 19.7	0.35 9.0	1.37 35.0	—	112	
BF1125-5	In. mm	B	0.46 11.7	0.51 13.0	0.19 5.0	0.98 25.0	—	96	
BF1125-3	In. mm	B	0.46 11.7	0.51 13.0	0.13 3.5	0.98 25.0	—	139	
BF1429	In. mm	C	0.57 14.5	0.61 15.7	0.22 5.6	1.14 29.0	—	85	
BF1225	In. mm	C	0.50 12.8	0.57 14.7	0.15 4.0	0.98 25.0	—	82	
BF3024	In. mm	D	1.20 30.5	—	0.45 11.4	0.69 17.7	0.94 24.0	51	
BF2125	In. mm	D	0.84 21.5	—	0.32 8.15	0.77 19.7	1.01 25.8	50	
BF2123	In. mm	D	0.84 21.5	—	0.32 8.15	0.66 16.8	0.90 23.0	42	
BF1835-9	In. mm	E	0.73 18.6	—	0.35 9.0	1.22 31.0	1.38 35.2	126	
BF3121	In. mm	D	1.24 31.5	—	0.59 15.0	0.60 15.2	0.84 21.5	41	

Physical Parameters

Material and U.L. Data API-1 Material, see characteristics and information on page 118.

* Note Impedance is typical, based on 1/2 turn (4.0") 18 AWG wire. Impedance measurement using HP4191A.

Color Black; Special colors Available for bases on a non-cancellable, non returnable basis C = Cream; W = White; Gr = Grey

U.L. Recognized

All plastic and adhesive components use U.L. Recognized materials with Flammability Ratings of UL94V-0, UL-510 or UL-746C

SEE Z vs. f GRAPHS ON NEXT PAGE

Appendix 4 – Ferrite locations

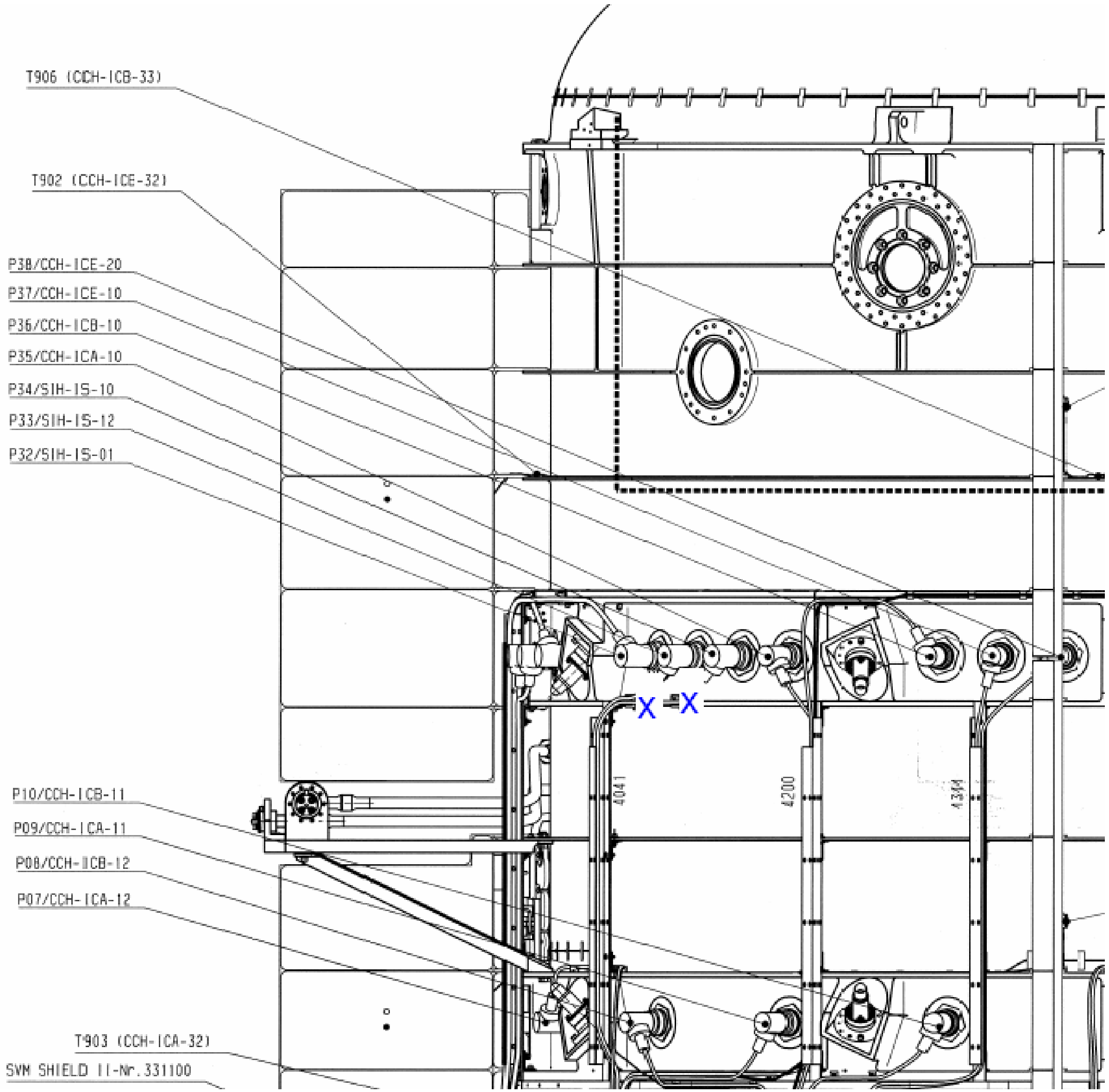


Figure 1 – Location of upper ferrites for SIH-IS-10 and SIH-IS-12. (Taken from 2547-121430-02-B View from +Y)

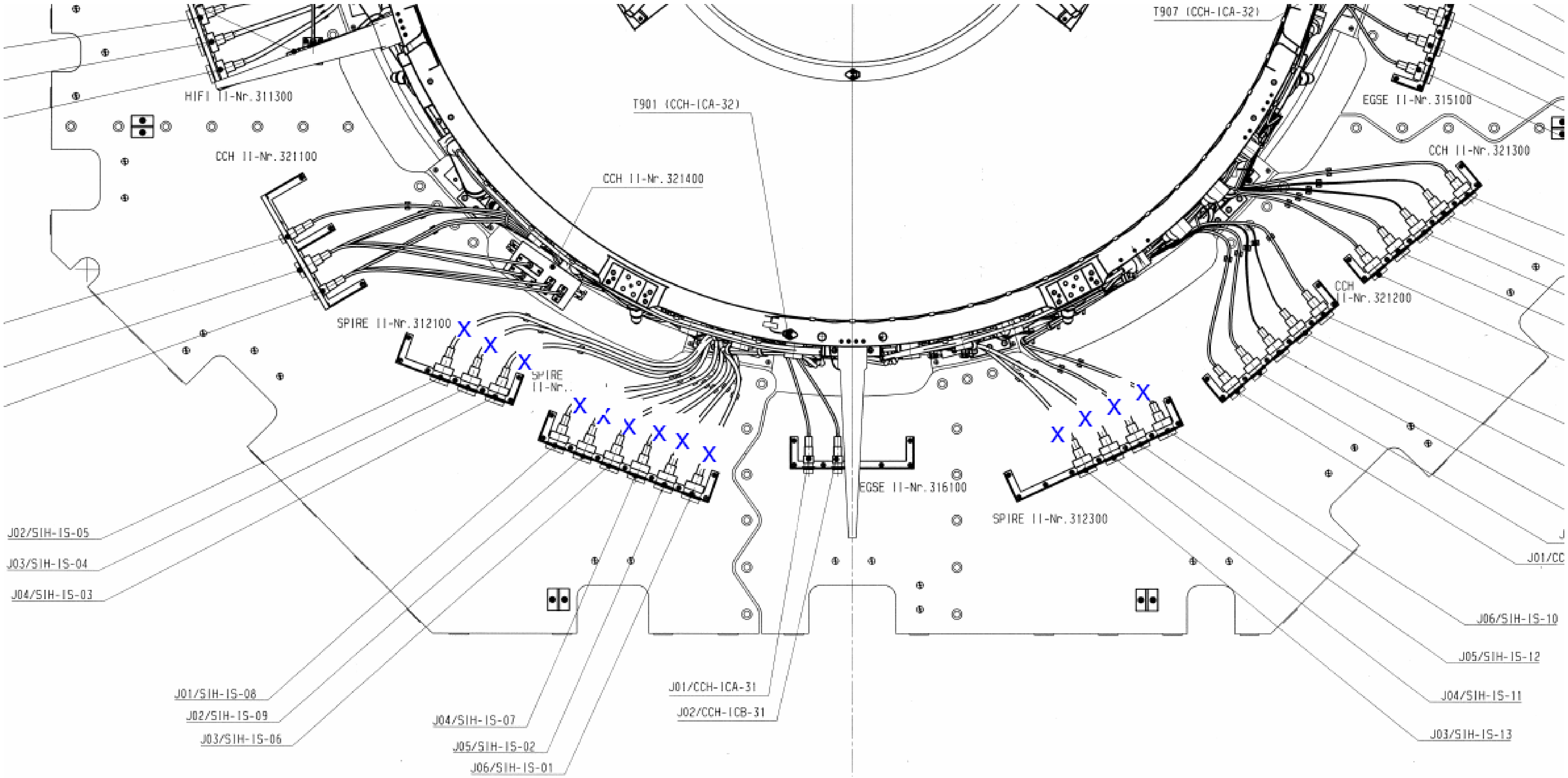


Figure 2 - – Location of lower ferrites for SIH-IS-01 through SIH-IS-13. (Taken from 2547-121430-01-B Top View +Y +Z)

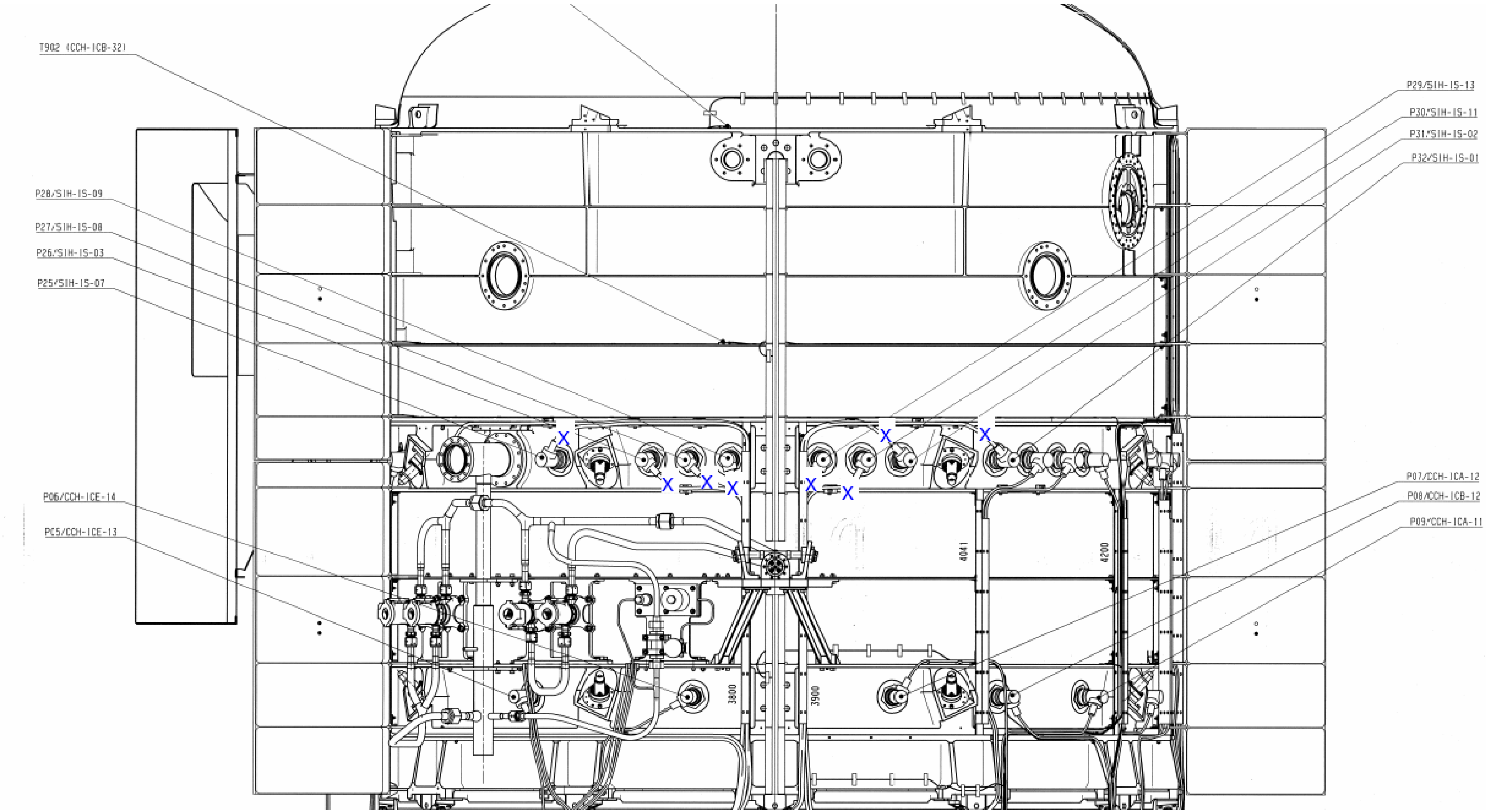


Figure 3 - Location of upper ferrites for SIH-IS-01, SIH-IS-02, SIH-IS-03, SIH-IS-07, SIH-IS-08, SIH-IS-09, SIH-IS-11 and SIH-IS-13. (Taken from 2547-121430-05-B View from -Z)

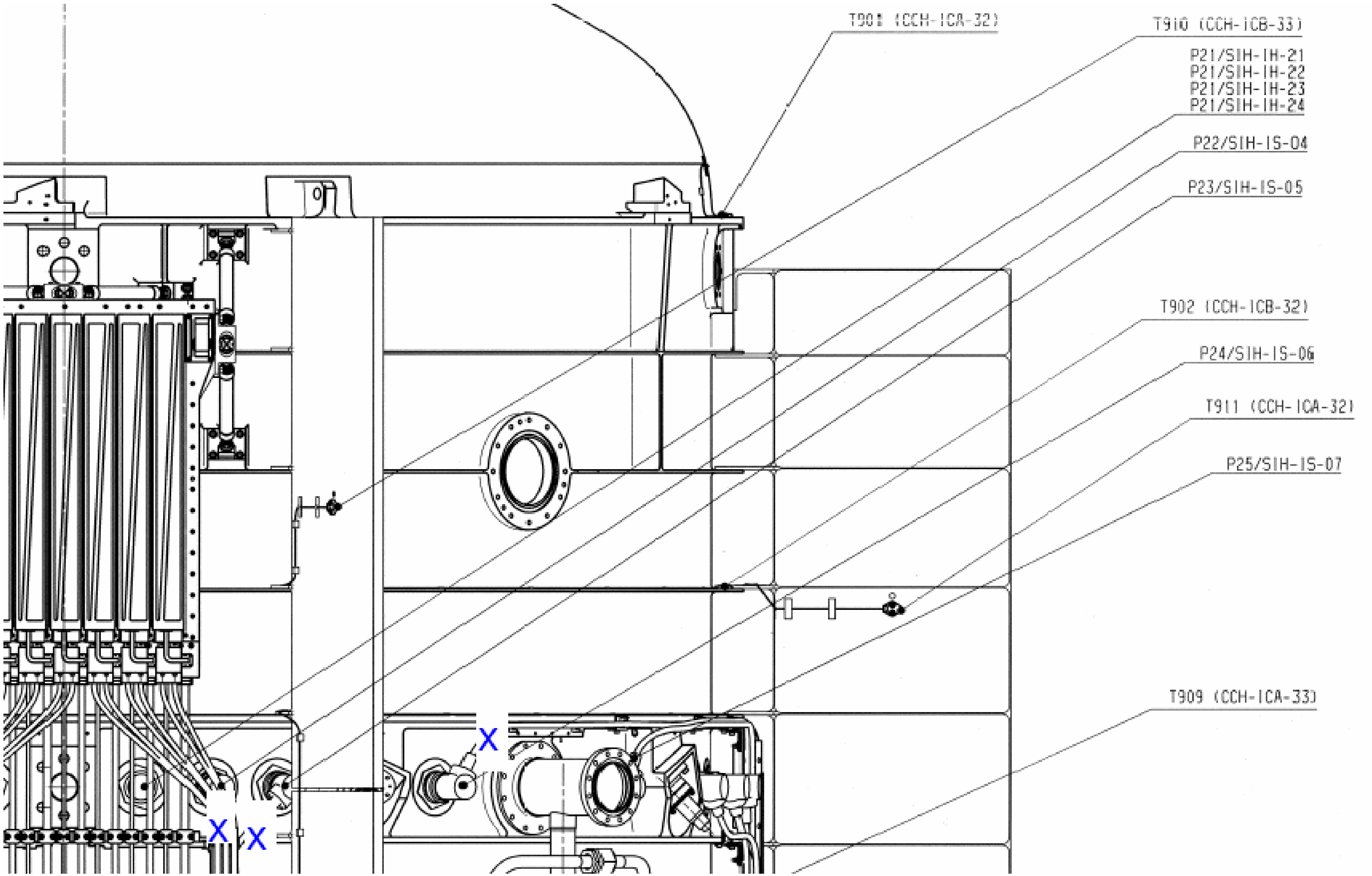


Figure 4 - Location of upper ferrites for SIH-IS-05 and SIH-IS-05. (Taken from 2547-121430-04-B View from -Y)