EMC Technologies Pty Ltd
ABN 82 057 105 549
176 Harrick Road
Keilor Park Victoria Australia 3042

Ph: + 613 9365 1000
Fax: + 613 9331 7455
email: melb@emctech.com.au

EMI TEST REPORT
for
CERTIFICATION to
FCC PART 90

FCC ID: S491011SSR03

Test Sample: Work Area Monitor
Model: WAM

Tested for: GroundProbe Pty Ltd

Report Number: M110920R2_Cert_Tx

Issue Date: 16th November 2011

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Report Number:	**Report M110920R2_Cert_Tx**
Test Sample:	Work Area Monitor
Model Number:	WAM
FCC ID:	S491011SSR03
Equipment Type:	Intentional Radiator
Manufacturer/ Tested for:	GroundProbe Pty Ltd
Address:	8 Hockings Street South Brisbane QLD 4101 Australia
Phone:	(617) 3010 8999
Fax:	(617) 3010 8988
Responsible Party:	Benny Chen – benny.chen@groundprobe.com
Test Standards:	FCC Part 90 - Private Land Mobile Services ANSI/TIA-603-C
Test Dates:	20th to 29th September 2011
Test Engineer:	**Chieu Huynh**
Attestation:	*I hereby certify that the device(s) described herein were tested as described in this report and that the data included is that which was obtained during such testing.*

Authorised Signatory:	**Chieu Huynh** **Senior EMC Engineer** **EMC Technologies Pty Ltd**

Issued by EMC Technologies Pty. Ltd., 176 Harrick Road, Keilor Park, VIC, 3042, Australia.
Phone: +61 3 9365 1000 Fax: +61 3 9331 7455 www.emctech.com.au

EMI TEST REPORT FOR CERTIFICATION
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FCC PART 90

1.0 INTRODUCTION

This report details the results of RF tests and measurements performed on the Work Area Monitor, model: WAM.

Test results were obtained using procedures in accordance with the following Federal Communications Commission (FCC) standards/regulations:

The test sample **complied** with the requirements of FCC Part 90 - Private Land Mobile Services.

1.1 Summary of Results

FCC Part 90	Test Performed	Result
2.1046	Power Output	**Noted**
2.1047	Modulation	**Complied**
2.1049	Bandwidth	**Complied**
2.1051	Conducted Spurious	**Complied**
2.1053	Radiated Spurious	**Complied**
2.1055	Frequency Stability	**Complied**
2.1057	Frequency Range	**Noted**

The measurement procedure used was in accordance with ANSI/TIA-603-C.

1.2 EUT – Voltage Power Conditions

Measurements were performed at a voltage of 12 VDC batteries.

1.3 Modifications

A ferrite was installed on the Ethernet cable inside a Camera box.

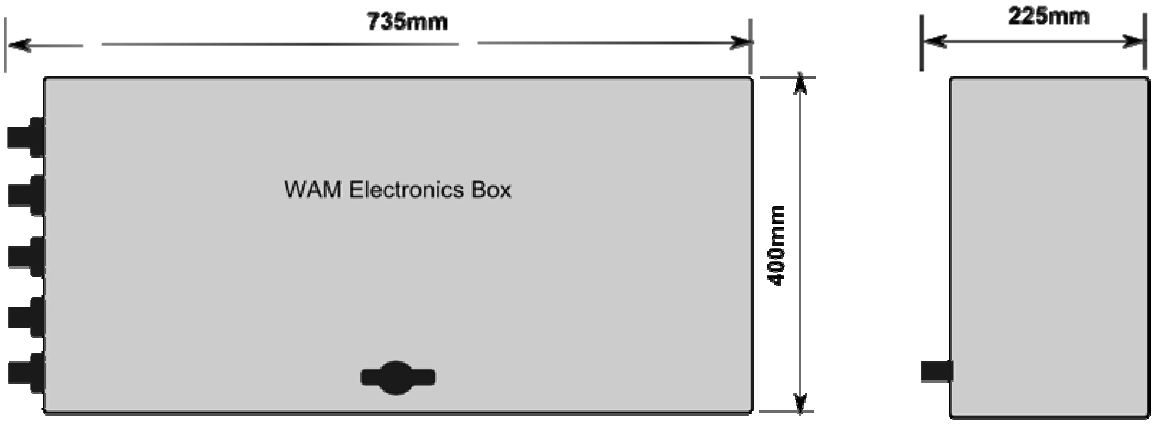
2.0 GENERAL INFORMATION

2.1 Test Sample Description

(Information supplied by the Client)

WAM Radar Electronics Module Specifications:

Emission Designation:	P0N
Centre Frequency:	9552.5 MHz
99% Bandwidth:	105 MHz
Mean Transmitter Power:	30 mW
Peak Transmitter Power:	30 mW
Pulse Width:	4.522 microseconds
Pulse Repetition Frequency:	107.107 kHz
Antenna Gain:	35 dBi
Maximum EIRP:	25.8 dBW
Lowest generated RF:	107.107 kHz
Power Supply:	12V DC batteries charged intermittently by vehicle alternator. Universal AC input battery charger for backup.
Temperature:	-26 degrees to 55 degrees Centigrade



The Work Area Monitor (WAM) is used by open-pit mines as a safety device to monitor the movements of mine walls and provides notification alerts when detected wall movements.

2.2 Test sample configuration

The Work Area Monitor (WAM) system comprises of the following: WAM Electronics Box (WEB), the 2-axis positioner (Gimbal) for position control of the dish antenna, the User Interface Touch Screen, a camera unit and a 12V battery supply. For the FCC tests the WAM Radar was assembled onto a table and set up to carry out a normal continuous raster scanning operation. For the test the scan area was set up with about 20 degrees in Elevation and 100 degrees in Azimuth. For testing purposes the dish antenna was not mounted on the Gimbal so that the Radar beam remains static to allow accurate positioning with the receiver test antenna. For all intensive purposes this is normal operation for the WAM product.

2.3 Test Procedure

Emissions measurements were performed in accordance with the procedures of ANSI/TIA-603-C. Radiated emissions tests were performed at a distance of 1, 3 and 10 metres from the EUT.

2.4 Test Facility

2.4.1 General

EMC Technologies Pty Ltd is listed by the FCC as a test laboratory able to perform compliance testing for the public. EMC Technologies is listed as an FCC part 47CFR2.948 test lab and may perform the testing required under Parts 15 and 18 – **FCC Registration Number 90560**

EMC Technologies Pty Ltd has also been accredited as a Conformity Assessment Body (CAB) by Australian Communications and Media Authority (ACMA) under the APECTEL MRA and is designated to perform compliance testing on equipment subject to Declaration of Conformity (DoC) and Certification under Parts 15 & 18 of the FCC Commission's rules – **Registration Number 494713 & Designation number AU0001.**

EMC Technologies open area test site (OATS) & indoor open are test site (iOATS) have been accepted by Industry Canada for the performance of radiated measurements in accordance with RSS 212, Issue 1 (Provisional) - **Industry Canada OATS number - IC 3569B-1 & Industry Canada iOATS number - IC 3569B-2**

Measurements were performed at EMC Technologies' laboratory in Keilor Park, Victoria Australia.

2.4.2 NATA Accreditation

EMC Technologies is accredited in Australia to test to the following standards by the National Association of Testing Authorities (NATA).

"FCC Part 15 unintentional and intentional emitters in the frequency range 9kHz to 18 GHz excluding TV receivers (15.117 and 15.119), TV interface devices (15.115), cable ready consumer electronic equipment (15.118), cable locating equipment (15.213) and unlicensed national information infrastructure devices (Sub part E)."

The current full scope of accreditation can be found on the NATA website: www.nata.asn.au
It also includes a large number of emissions, immunity, SAR, EMR and Safety standards.

NATA is the Australian national laboratory accreditation body and has accredited EMC Technologies to operate to the IEC/ISO17025 requirements. A major requirement for accreditation is the assessment of the GroundProbe Pty Ltd and its personnel as being technically competent in testing to the standards. This requires fully documented test procedures, continued calibration of all equipment to the National Standard at the National Measurements Institute (NMI) and an internal quality system to ISO 9002. NATA has mutual recognition agreements with the National Voluntary Laboratory Accreditation Program (NVLAP) and the American Association for Laboratory Accreditation (A^2LA).

2.5 Test Equipment Calibration

Measurement instrumentation and transducers were calibrated in accordance with the applicable standards by an independent NATA registered laboratory such as Agilent Technologies (Australia) Pty Ltd or the National Measurement Institute (NMI). All equipment calibration is traceable to Australia national standards at the National Measurements Institute. The reference antenna calibration was performed by NMI and the working antennas (biconical, log-periodic and horn) calibrated by EMC Technologies. The complete list of test equipment used for the measurements, including calibration dates and traceability is contained in Appendix A.

3.0 RF MEASURMENTS

3.1 Power Output, Section 2.1046

The conducted RF power output of the radar module (under normal pulse radar operation) was measured using a spectrum analyser.

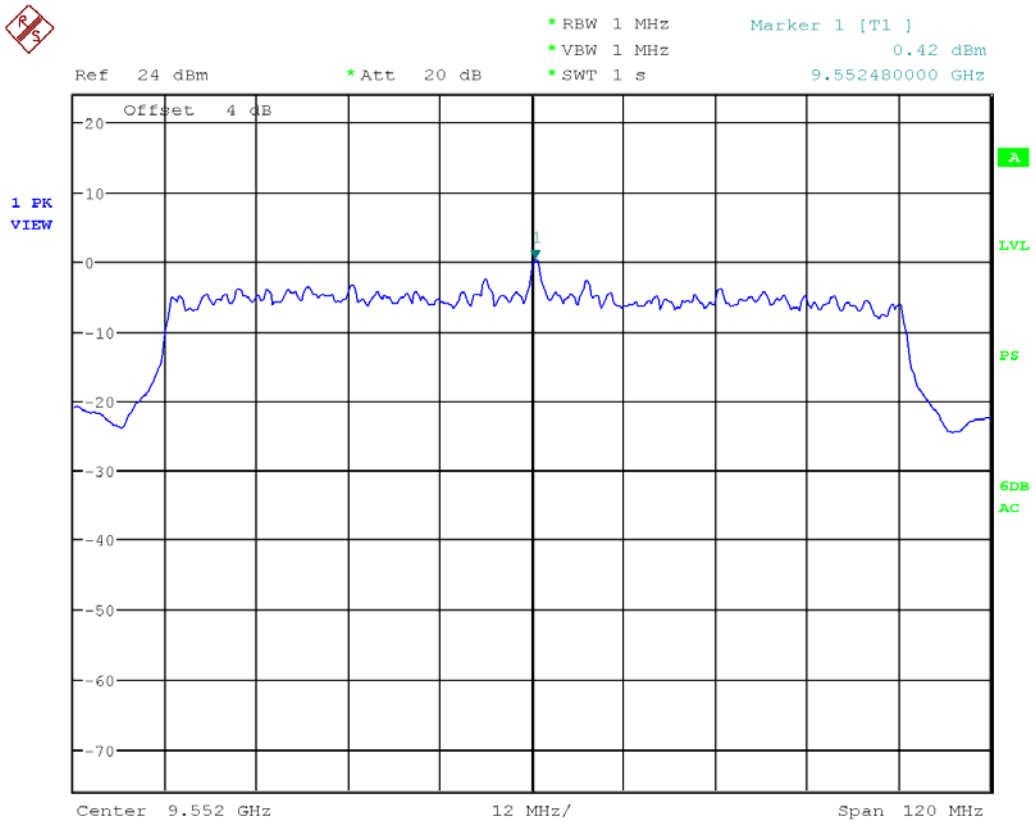
As the signal emission bandwidth (EBW) is greater than the spectrum analyser resolution bandwidth (RBW), the output power measurement was performed using an integration method as per DA 02-2138 with the following settings: RBW = 1 MHz and VBW = 1 MHz. Power was computed by summing power level in each 1 MHz band across the 99% EBW of the signal.

Measurements were made with the input voltage set to 12.9 V DC and when varied by ±15%. Testing was carried out at maximum power output.

Frequency GHz	Battery Voltage V dc	Temperature °C	Measured Power dBm
9.5525	12.9	20	14.13
9.5525	14.8	20	14.19
9.5525	11.0	20	14.19
9.5525	12.9	-26	14.27
9.5525	14.8	-26	14.22
9.5525	11.0	-26	14.19
9.5525	12.9	55	14.11
9.5525	14.8	55	14.06
9.5525	11.0	55	14.07

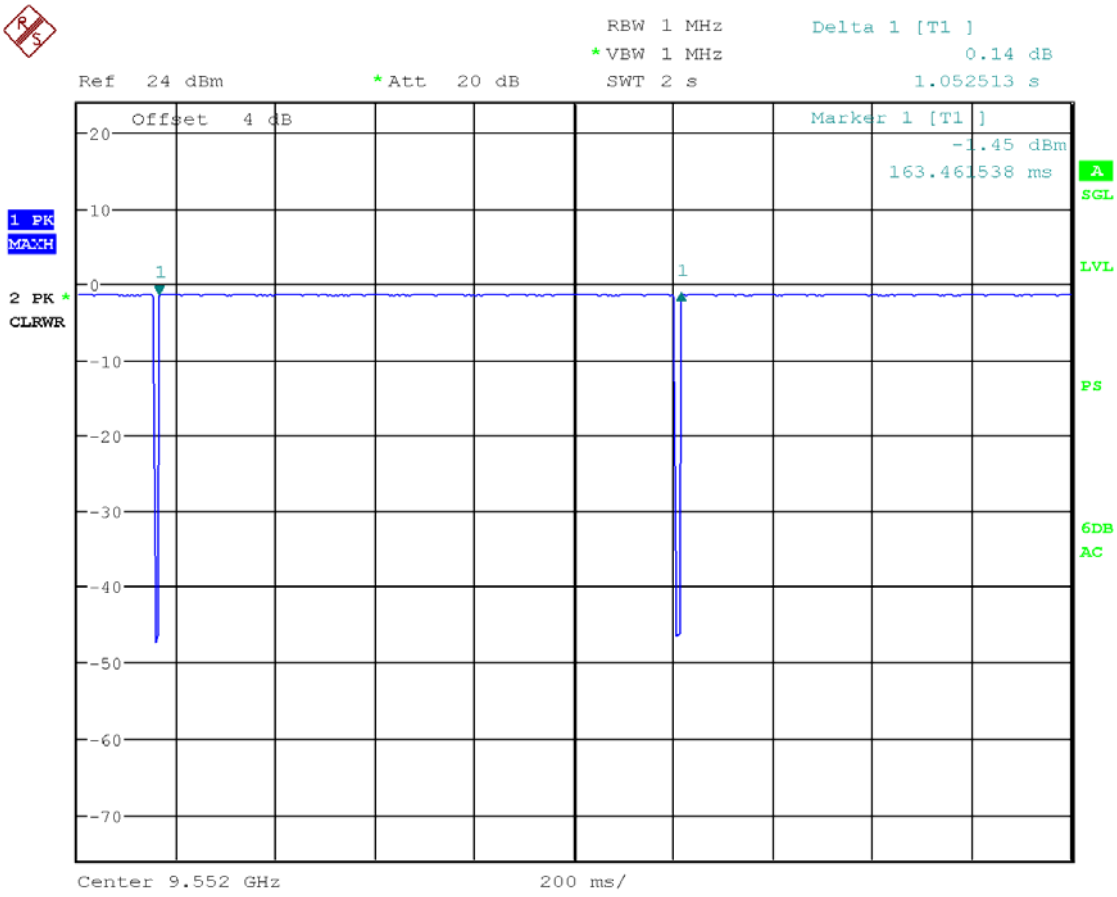
Limits: Clause 90.205(m) of Part 90 specifies that in the maximum allowable effective radiated power will be determined on case by case basis for transmitters not in defined bands.

Result: Noted.



3.2 Modulation Characteristic, Section 2.1047

The duty cycle for the demodulated output is derived from the measured demodulated output of the radar. Measurement was made using a spectrum analyser.



The Pulse Width measured was 1.03648 seconds.

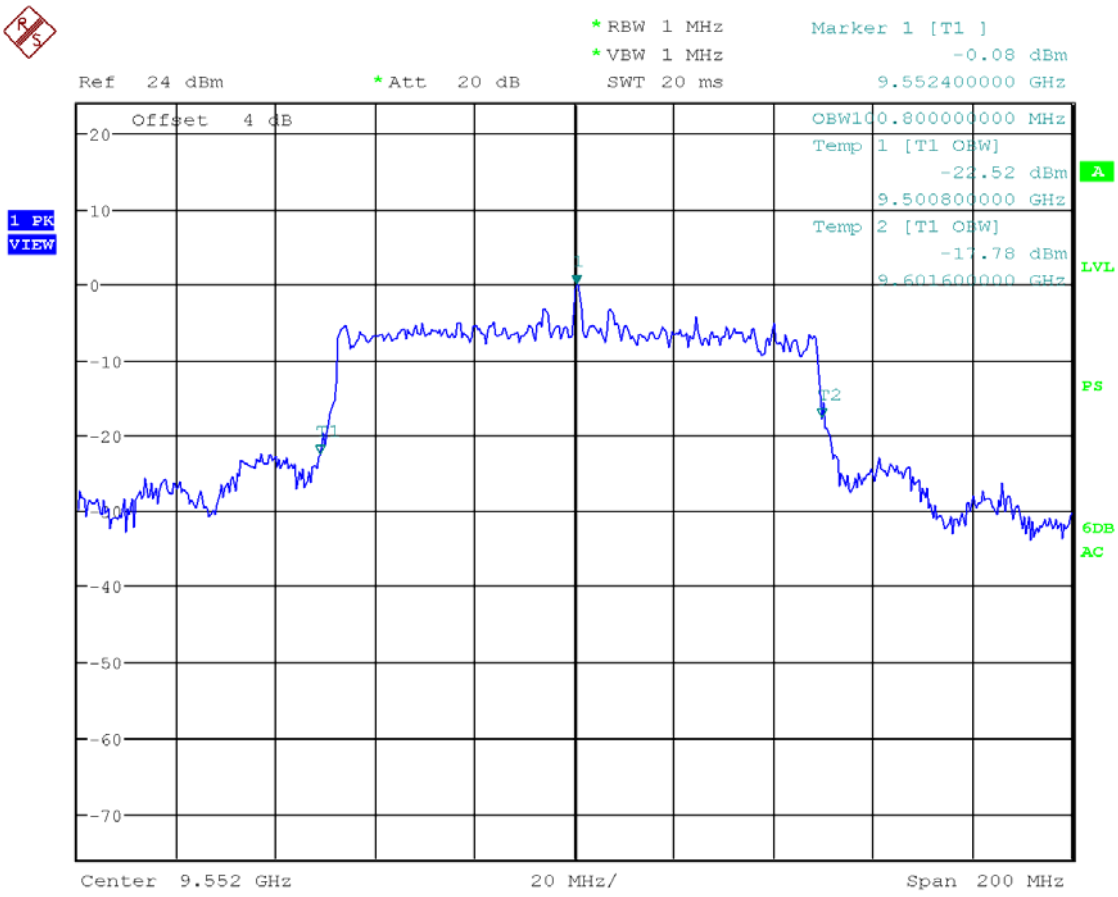
The calculated duty cycle for the demodulated output of the radar was 98.48%

Result: Complied.

3.3 Occupied Bandwidth, Section 2.1049

The occupied bandwidth (OBW) or 99% effective bandwidth (EBW) of the radar module (under normal pulse radar operation) was measured using a spectrum analyser.

The resolution bandwidth of 1 MHz and the video bandwidth of 1 MHz were used.



The occupied bandwidth (OBW) was measured to be 100.8 MHz.

Limit: 105MHz

Result: Complied.

3.4 Conducted Spurious Emissions, Section 2.1051

The conducted spurious emissions were measured using Rohde & Schwarz ESU-40 connected to the antenna port of the radar.

The resolution bandwidth and video bandwidth settings were:

9 kHz - 150 kHz:	1 KHz RBW, 1MHz VBW
150 kHz - 30 MHz:	100 kHz RBW, 1MHz VBW
30 MHz - 1000 MHz:	120 kHz RBW, 1MHz VBW
1GHz - 40 GHz:	1 MHz RBW, 1MHz VBW

The permissible spurious levels are:

Frequency Range (MHz)	Limit (dBm)	Limit (dBuV)
0.09-30	-13	94
30-9500	-13	94
10000-40000	-13	94

Refer to Appendix B for conducted spurious graphs

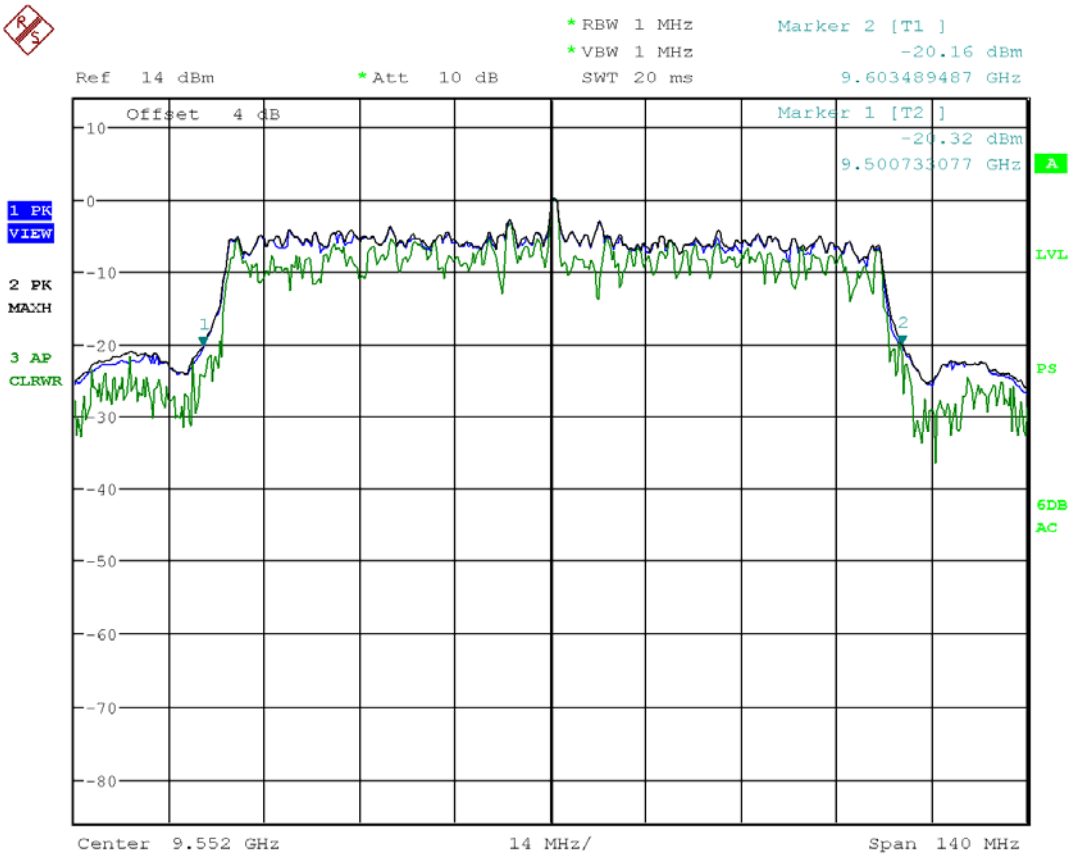
Result: Complied. Spurious emissions were > 20dB lower than the permissible levels.

3.5 Frequency Stability, Section 2.1055

A spectrum analyser (Span and RBW as required to yield adequate marker frequency counter resolution) was used to measure the frequency stability of the carrier frequency, over temperature and supply voltage.

The temperature range was set between –26 deg C to +55 deg C. The primary voltage range was 85 % to 115% of nominal. This correlated to the input DC power supply being varied from 11.0V to 14.8V (12.9VDC nominal).

Note: The frequency stability must be adequate to ensure that emissions remain within the Authorized Band (9,500-10,000 MHz) over the specified temperature and voltage variations.



Temperature ^{0}C	DC Input Voltage (11V)		DC Input Voltage (12.9V)		DC Input Voltage (14.8V)	
	F_L (GHz)	F_H (GHz)	F_L (GHz)	F_H (GHz)	F_L (GHz)	F_H (GHz)
-26	9.500	9.604	9.500	9.604	9.500	9.604
-15	9.500	9.604	9.500	9.604	9.500	9.604
-5	9.500	9.604	9.500	9.604	9.500	9.604
5	9.500	9.604	9.500	9.604	9.500	9.604
15	9.500	9.604	9.500	9.604	9.500	9.604
25	9.500	9.604	9.500	9.604	9.500	9.604
35	9.500	9.604	9.500	9.604	9.500	9.604
45	9.500	9.604	9.500	9.604	9.500	9.604
55	9.500	9.604	9.500	9.604	9.500	9.604

F_L - Frequency low (refer to plot above, marker 1 - band edge low)
F_H - Frequency high (refer to plot above, marker 2 - band edge high)

Result: Complied. Worst case results reported

4.0 RADIATED SPURIOUS EMISSION MEASUREMENTS

4.1 Test Procedure

Testing was performed in accordance with the requirements of FCC Part 90.

The radiated field strength of spurious emissions (under normal pulse radar operation) was measured using a Rohde & Schwarz ESU-40 receiver connected to a calibrated antenna.

The EUT was set up on the table top (placed on turntable) of total height 80 cm above the ground plane, and operated as described in section 2 of this report. The EMI Receiver was operated under software control via the PC Controller through the IEEE.488 Interface Bus Card Adaptor. The test frequency range was sub-divided into smaller bands with sufficient frequency resolution to permit reliable display and identification of possible EMI peaks while also permitting fast frequency scan times. A calibrated Loop antenna was used for measurements between 9 kHz to 30 MHz. A calibrated Biconical antenna was used for measurements between 30 MHz to 200 MHz and a calibrated Logperiodic antenna used for measurements between 200 MHz to 1000 MHz. Calibrated EMCO 3115, EMCO 3116 and ETS standard gain horn antennas were used for measurements between 1 GHz to 40 GHz.

Part 2.1057 states that the spectrum should be investigated up to the 10^{th} harmonic if the transmitter operates below 10 GHz. Testing was performed up to 40GHz.

The resolution bandwidth and video bandwidth settings were:

9 kHz – 150 kHz:	0.3 KHz RBW, 3 kHz VBW
150 kHz – 30 MHz:	10 kHz RBW, 30 kHz VBW
30 MHz – 1000 MHz:	120 kHz RBW, 300 kHz VBW
1 GHz – 40 GHz:	1 MHz RBW, 1MHz VBW

The receiver bandwidth was set to 6 dB.

The EUT was slowly rotated with the Peak Detector set to Max-Hold. This was performed for two antenna heights. When an emission was located, it was positively identified and its maximum level found by rotating the automated turntable, and by varying the antenna height. Each significant peak was investigated. This process was performed for both horizontal and vertical antenna polarisations.

4.2 Field Strength Calculation

The peak field strength was calculated automatically by the software using all the pre-stored calibration data. The method of calculation is shown below:

E = V + AF - G + L Where:

E = Radiated Peak Field Strength in dBμV/m.
V = EMI Receiver Voltage in dBμV. (measured value)
AF = Antenna Factor in dB(m^{-1}). (stored as a data array)
G = Preamplifier Gain in dB. (stored as a data array)
L = Cable loss in dB. (stored as a data array of Insertion Loss versus frequency)

- **Example Peak Field Strength Calculation**

Assuming a receiver reading of 34.0 dBμV is obtained at 90 MHz, the Antenna Factor at that frequency is 9.2 dB. The cable loss is 1.9 dB while the preamplifier gain is 20 dB. The resulting Field Strength is therefore as follows:

34.0 + 9.2 + 1.9 - 20 = 25.1 dBμV/m

4.3 Relation between field-strength and E.I.R.P.

The field strength emission limits are converted to an E.I.R.P. level in dBm using the following equation:

$$E.I.R.P.(dBm) = E_0(dB(uV/m) + 20\ log_{10}\ D(m) - 104.8$$

E.I.R.P. = E.I.R.P. corresponding with the electric field strength E_0 (in dBm)
E_0 = electric field strength (in dB(uV/m))
D = reference measurement distance (in meters).

Note: free-space propagation is assumed.

4.4 Radiated Spurious, Section 2.1053

The limits of any emissions outside the frequency band shall be attenuated by at least 43 + 10log(P) dB, where P is the measured transmitter output power.

Based on an EIRP limit of -13dBm the equivalents E-field are:

E_0(dB(uV/m)) = -13dBm-20 log 3 +104.8 =91.8 dBuV/m (at 1m)
E_0(dB(uV/m)) = -13dBm-20 log 3 +104.8 =82.3 dBuV/m (at 3m)
E_0(dB(uV/m)) = -13dBm-20 log 3 +104.8 =71.8 dBuV/m (at10m)

4.4.1 Frequency Band: 9 kHz - 30 MHz

The measurements were made at a distance of 10 metres.

Refer to Appendix C for radiated spurious graphs

Result: Complied. No spurious emissions were recorded.

4.4.2 Frequency Band: 30 MHz - 1000 MHz

The measurements were made at a distance of 10 metres.

Refer to Appendix C for radiated spurious graphs

Result: Complied. Spurious emissions were > 20 dB lower than the limits.

4.4.3 Frequency Band: 1 GHz - 40 GHz

The measurements were made at a distance of 1 and 3 metres.

Second harmonic was recorded. Therefore, the EUT was replaced with a calibrated horn antenna that was connected to a signal generator. The output level of the signal generator was adjusted until the same level on the spectrum analyser observed. The level of the signal generator output in dBm less any loss due to the connecting cable and added to the antenna.

Frequency MHz	Signal Generator Reading dBm	Antenna Gain dBi	Cable Loss dB	Calculated Level dBm	Limit dBm
19105	-43.0	11.1	3	-34.9	-13

Refer to Appendix C for radiated spurious graphs

Result: Second harmonic emissions complied with the FCC limit by a margin of 21.9dB.

5.0 COMPLIANCE STATEMENT

The Work Area Monitor, model: WAM, tested on behalf of GroundProbe Ltd, complied with the requirements of 47 CFR, FCC Part 90 - Private Land Mobile Services, conditional upon the implementation of the modification of section 1.3.

Results were as follows:

FCC Part 90	Test Performed	Result
2.1046	Power Output	**Noted**
2.1047	Modulation	**Complied**
2.1049	Bandwidth	**Complied**
2.1051	Conducted Spurious	**Complied**
2.1053	Radiated Spurious	**Complied**
2.1055	Stability	**Complied**
2.1057	Frequency Range	**Noted**

6.0 MEASUREMENT UNCERTAINTIES

EMC Technologies has evaluated the equipment and the methods used to perform the emissions testing. The estimated measurement uncertainties for emissions tests shown within this report are as follows:

Power Output:	±0.5 dB
Modulation Characteristic:	±0.5 dB
Occupied Bandwidth:	5%
Conducted Spurious:	±1dB
Frequency Stability:	±2.83MHz

Radiated Spurious:	
0.09 kHz to 30 MHz	±4.1 dB
30 MHz to 300 MHz	±5.1 dB
300 MHz to 1000 MHz	±4.7 dB
1 GHz to 18 GHz	±4.6 dB

The above expanded uncertainties are based on standard uncertainties multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

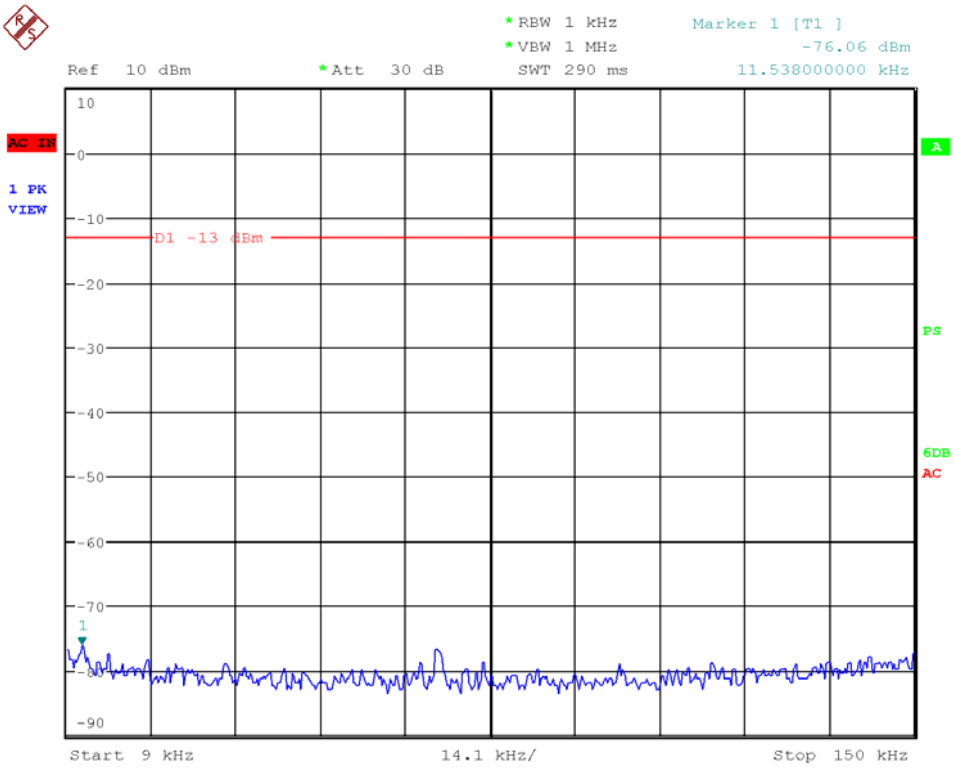
APPENDIX A
MEASUREMENT INSTRUMENT

EQUIPMENT TYPE	MAKE/MODEL SERIAL NUMBER	LAST CAL. DD/MM/YY	DUE DATE DD/MM/YY	CAL. INTERVAL
EMI RECEIVER	HP 8546A Sn: 3549A00290 (R-009)	01/09/11	01/09/12	1 YEAR *2
	Rohde & Schwarz, Model ESU40 SN 1302.6005.40, 20 Hz – 40 GHz	08/12/10	08/12/11	1 YEAR *3
ANTENNAS	EMCO 93146A LOG PERIODIC (A-136) 200 -1000MHz Sn. 98035033	02/05/11	02/05/12	1 YEAR *1
	EMCO 93110B BICONICAL (A-110) 20 - 300 MHz Sn. 96122801	02/05/11	02/05/12	1 YEAR *1
	EMCO 6502 LOOP ANTENNA 9 kHz – 30 MHz Sn: 2021	29/11/08	29/11/11	3 YEAR *1
	EMCO 3115 DOUBLE RIDGED HORN 1 - 18 GHz Sn: 8908-3282	12/01/09	12/01/12	3 YEAR *1
	EMCO 3116 Double Ridged Guide Horn 18 - 40 GHz Sn: 2276	--------	--------	*4
	ETS Standard Gain Horn, M/N: 3160-09	08/02/11	08/02/14	3 YEAR *1
	ETS Standard Gain Horn, M/N: 3160-10	08/02/11	08/02/14	3 YEAR *1
Signal Generator	HP8340B Sn: 2819A00943	Calibration or verify before use		
Thermal Chamber	Haereus Votsch Model HT4033 Temp Range -40^{0}C-180^{0}C	N/A	N/A	N/A

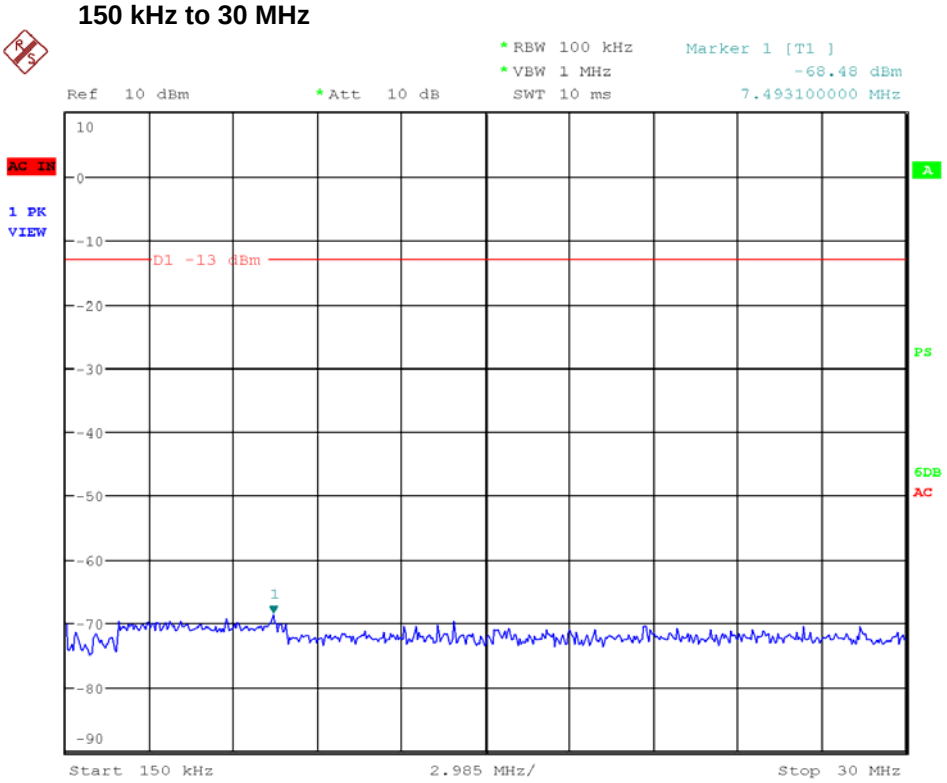
Note *1. In-house calibration. Refer to Quality Manual.
Note *2. NATA calibration by VMS
Note *3. NATA calibration by Rohde & Schwarz
Note *4. Manufacturer's Calibration

APPENDIX B
CONDUCTED SPURIOUS GRAPHS

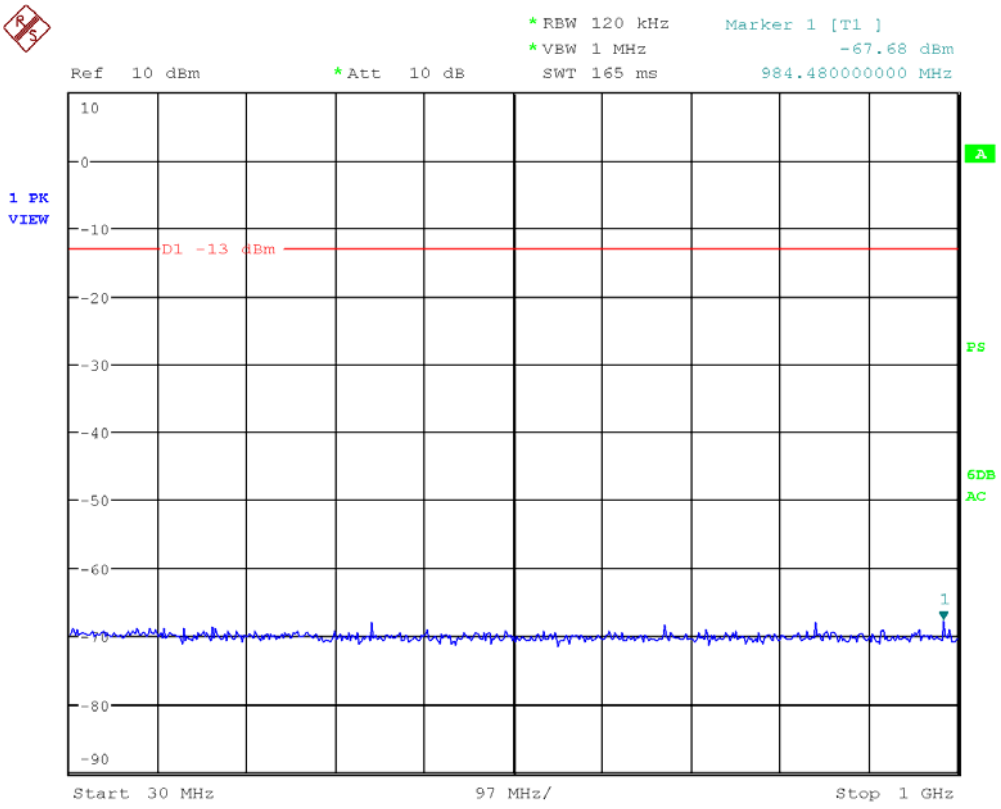
9 kHz to 150 kHz



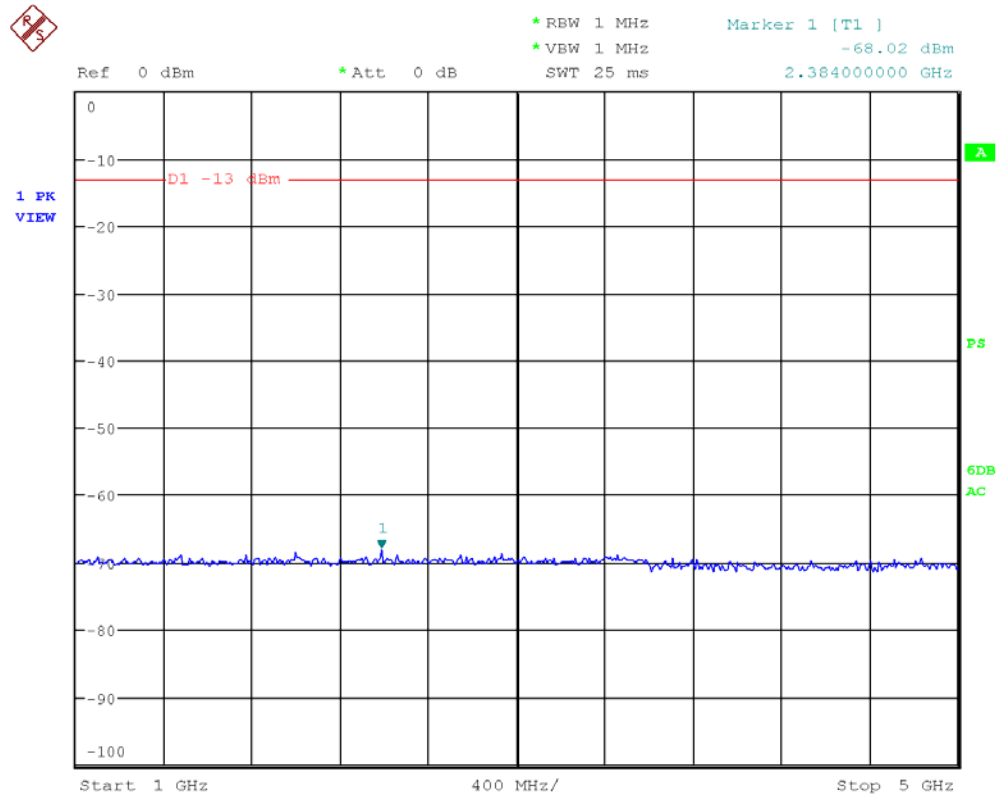
150 kHz to 30 MHz



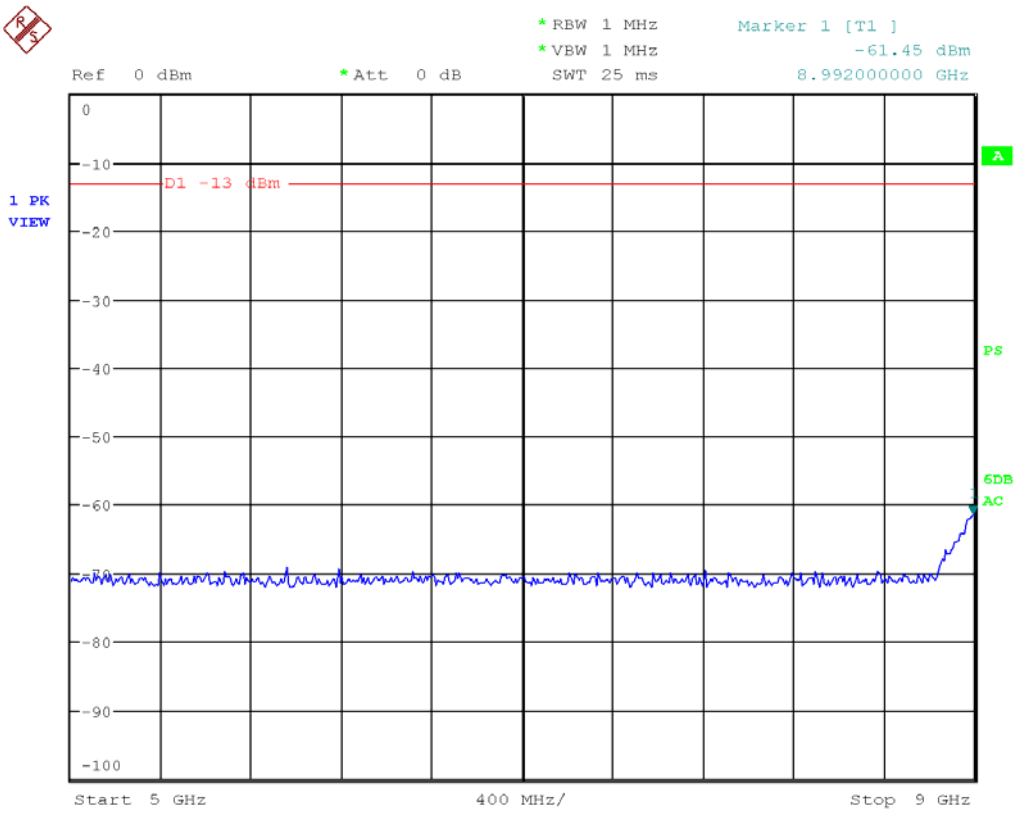
30 MHz to 1000 MHz



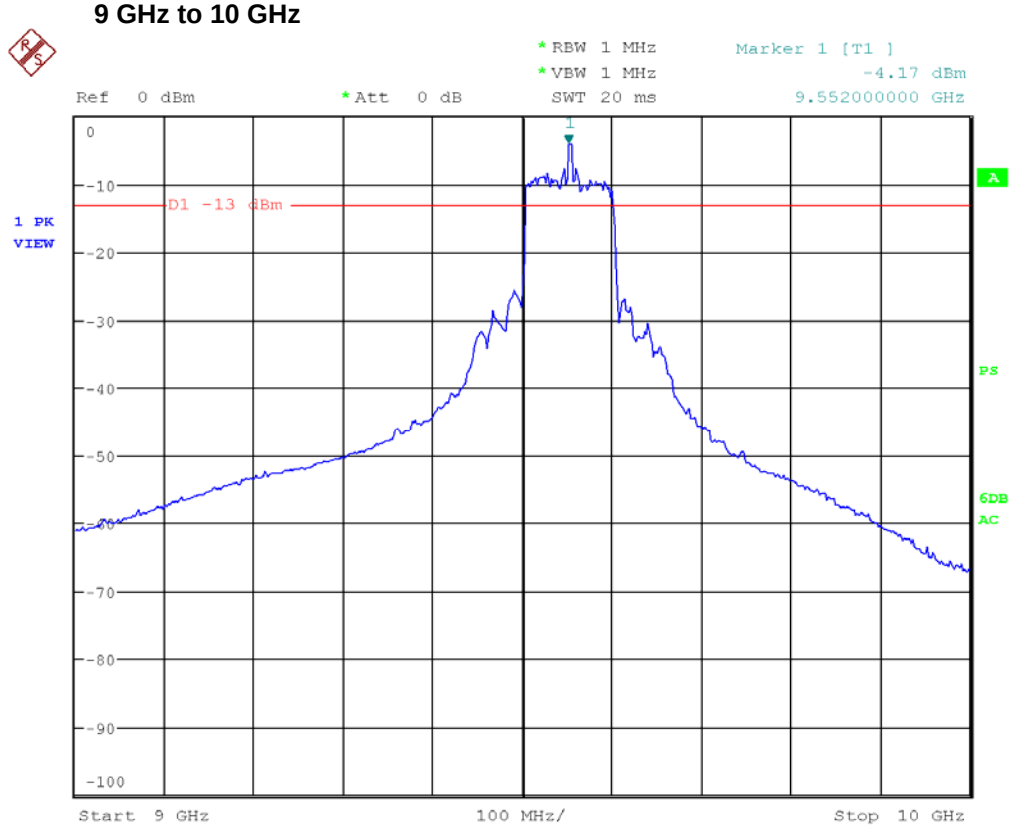
1 GHz to 5 GHz



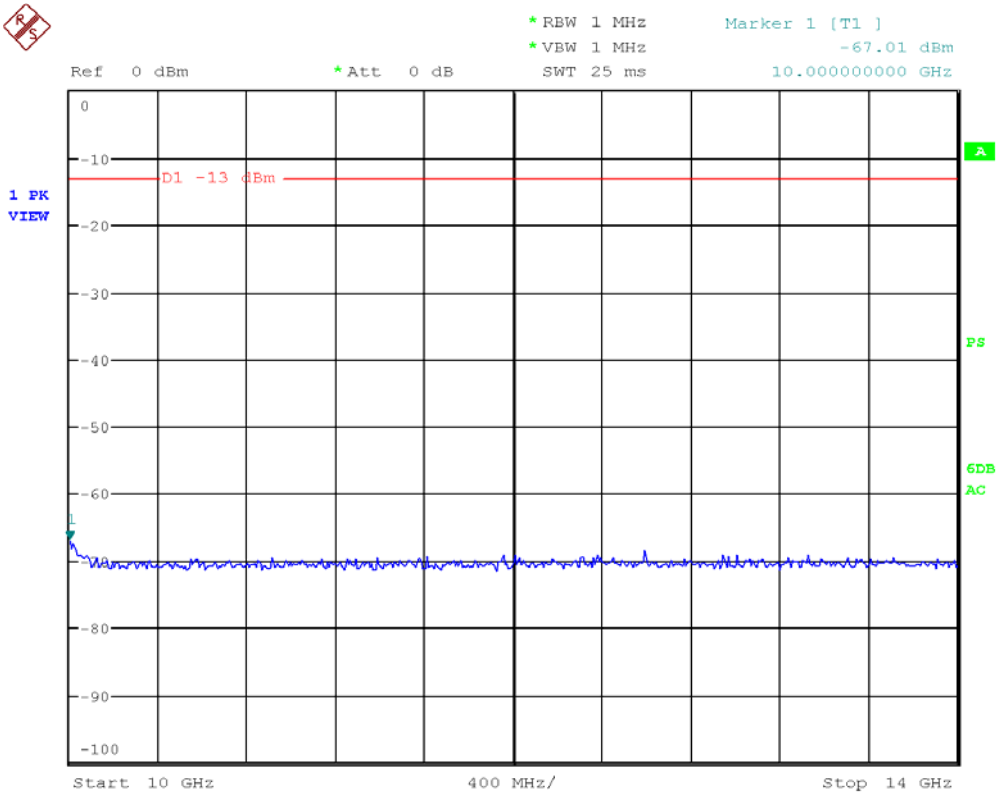
5 GHz to 9 GHz



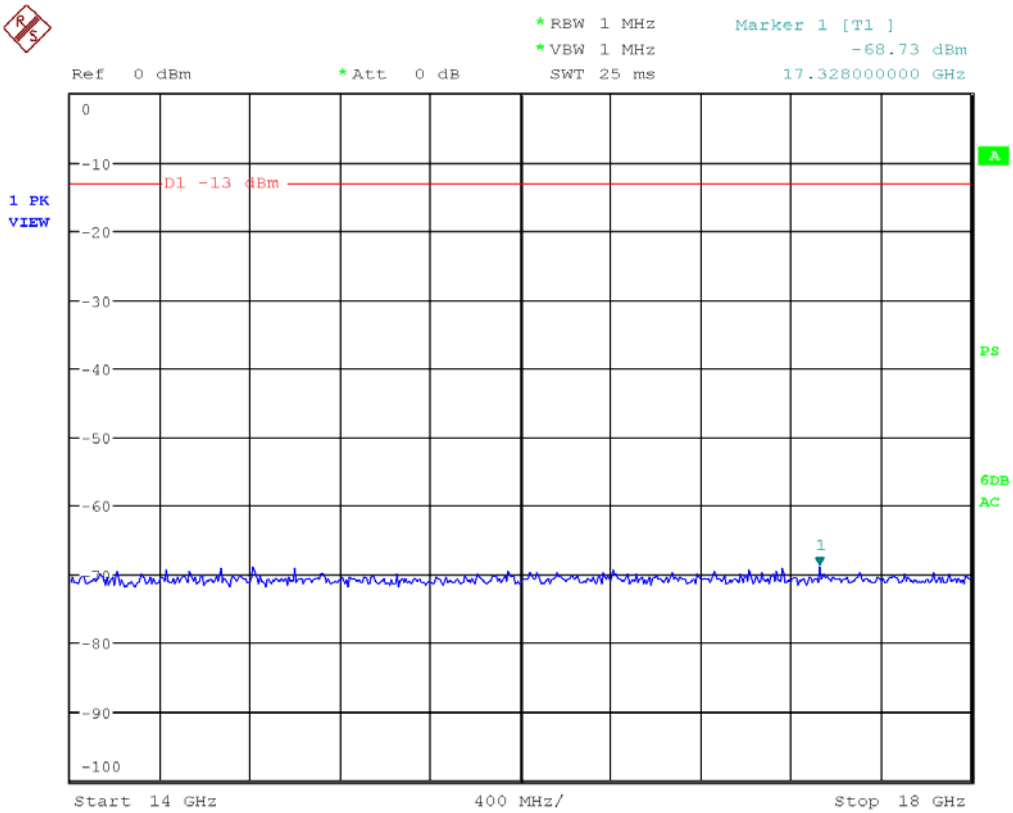
9 GHz to 10 GHz



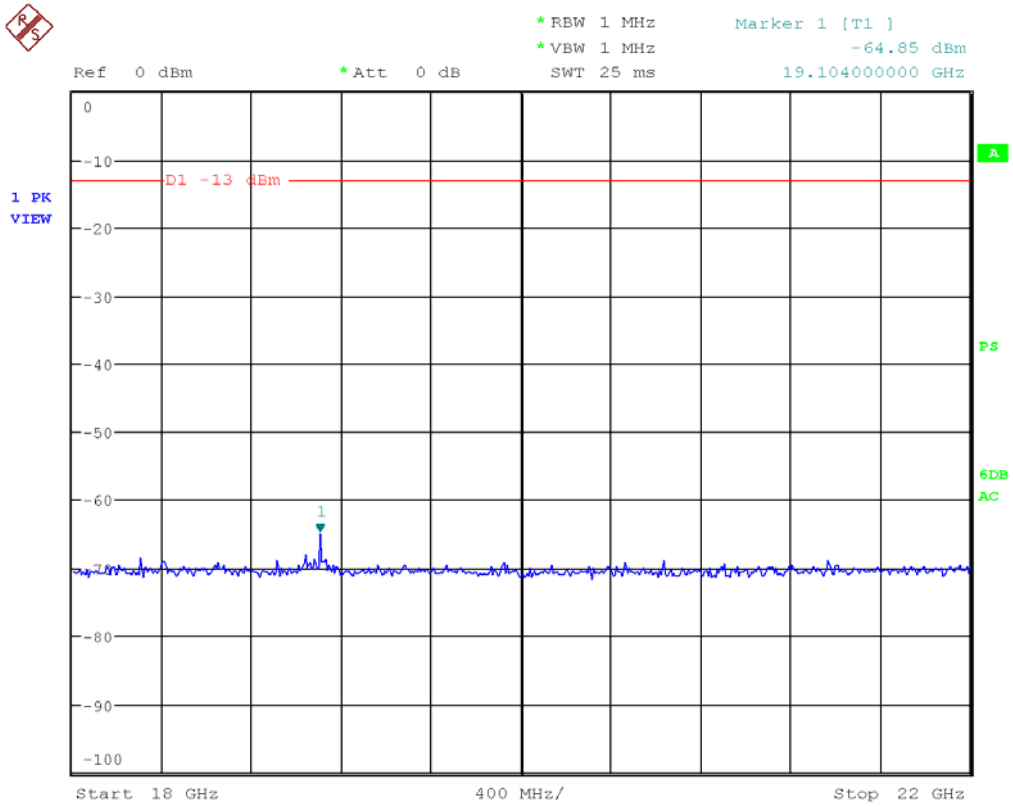
10 GHz to 14 GHz



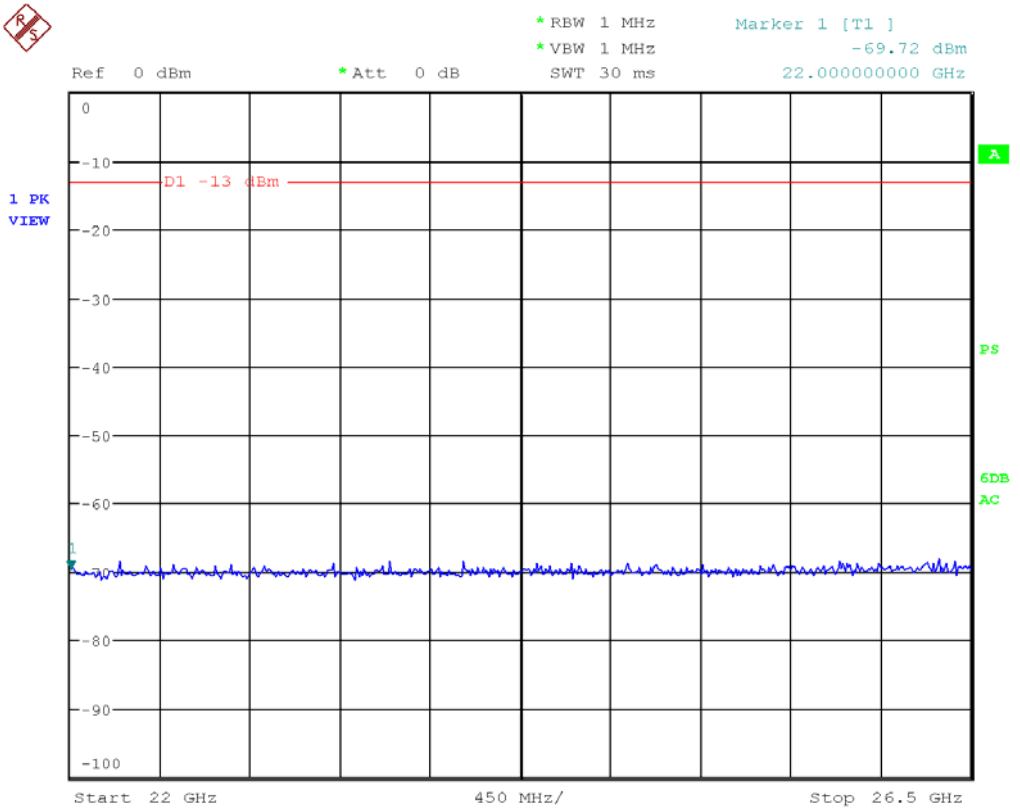
14 GHz to 18 GHz



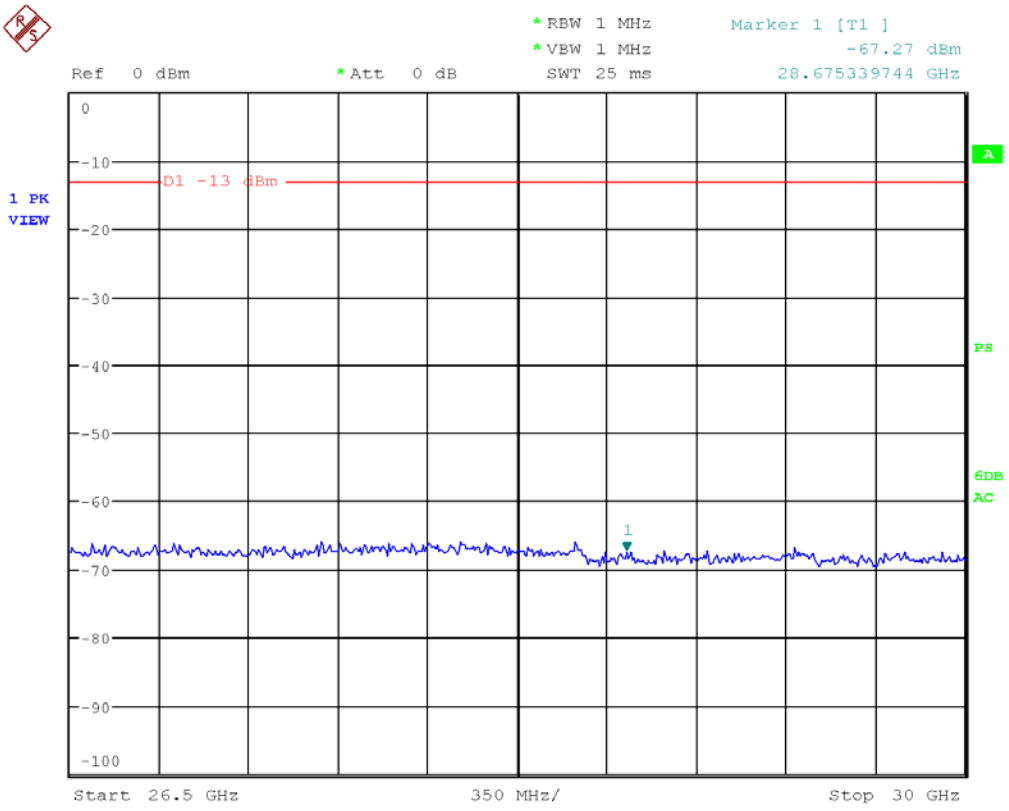
18 GHz to 22 GHz



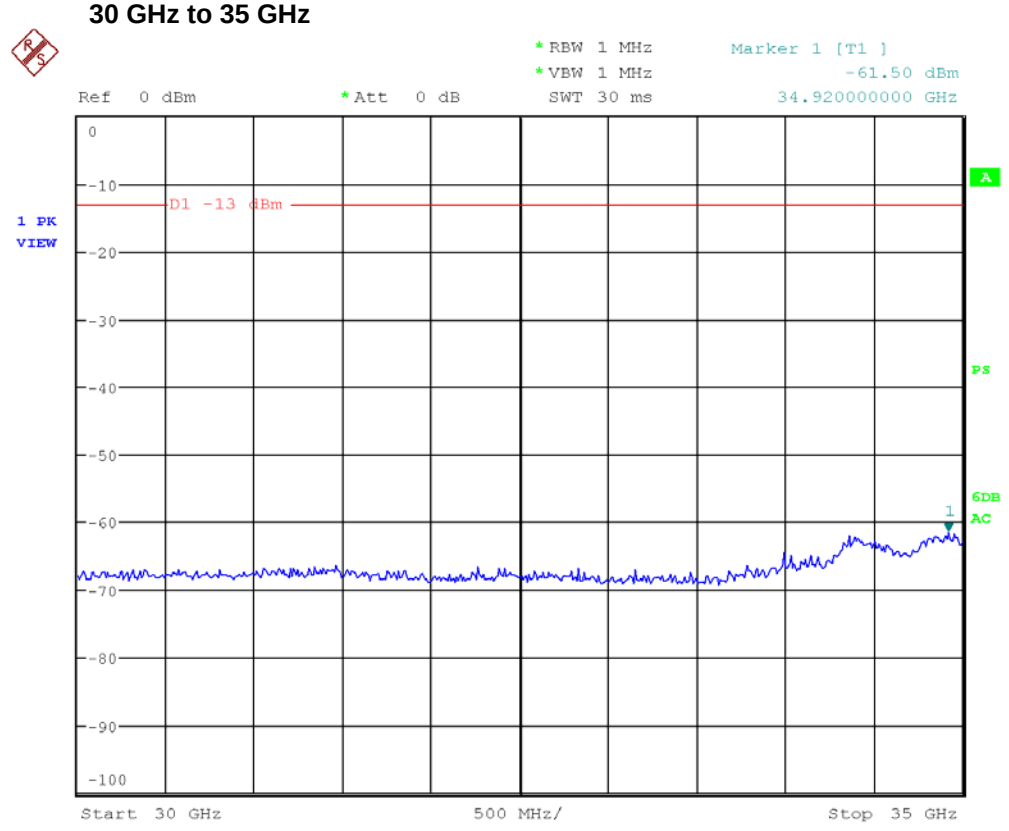
22 GHz to 26.5 GHz



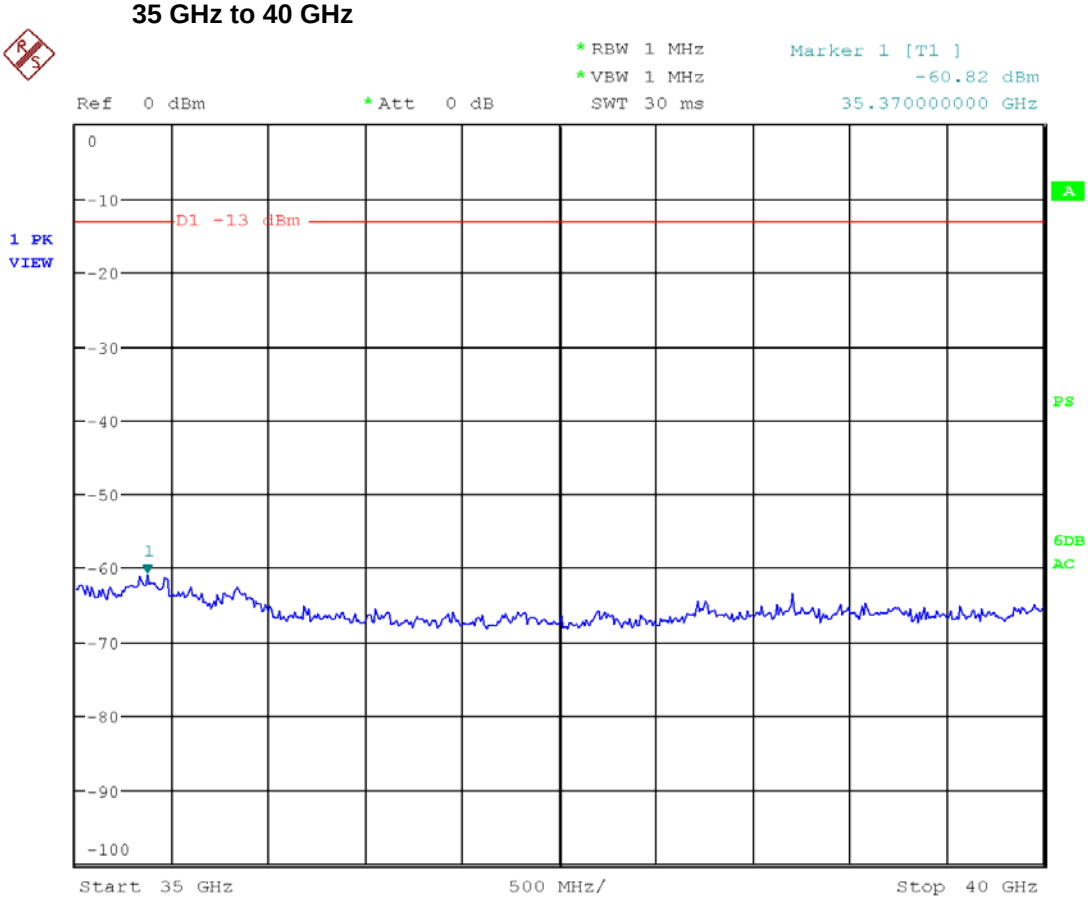
26.5 GHz to 30 GHz



30 GHz to 35 GHz

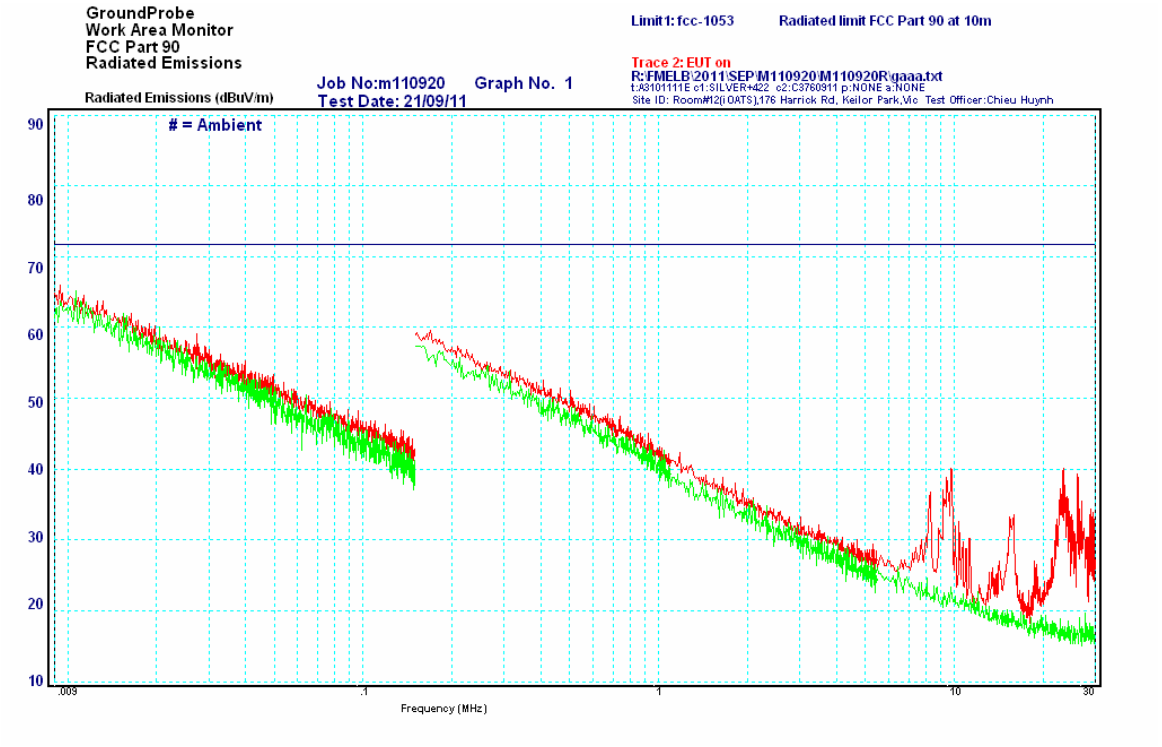


35 GHz to 40 GHz

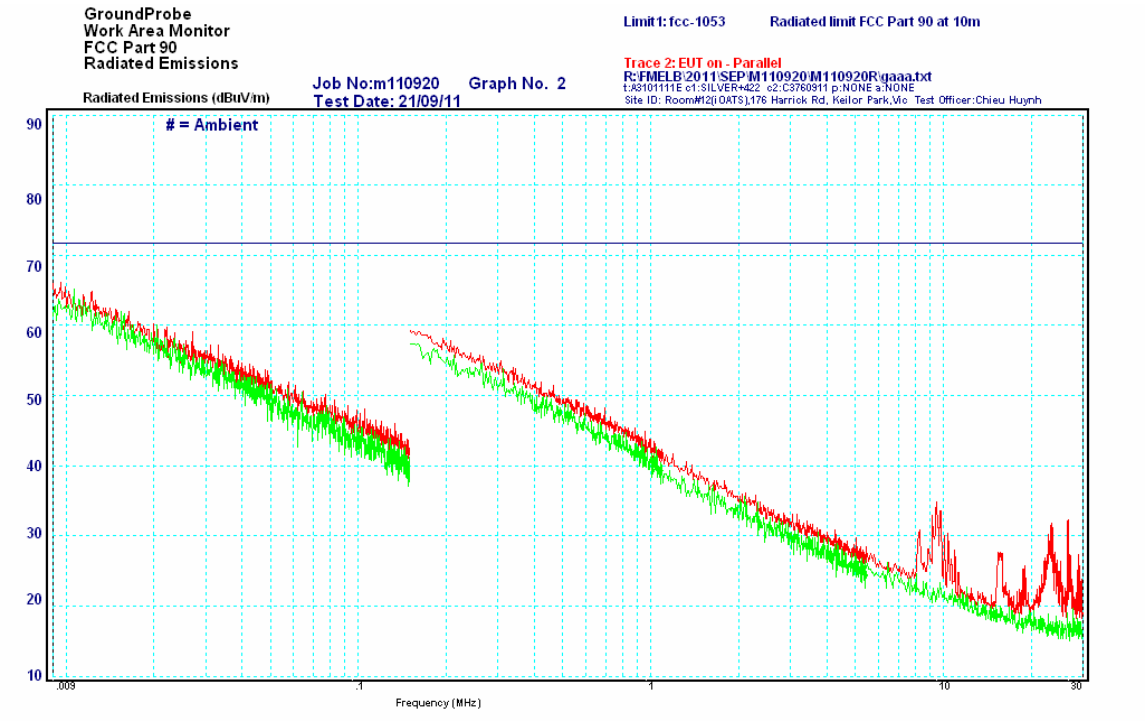


APPENDIX C
RADIATED SPURIOUS GRAPHS

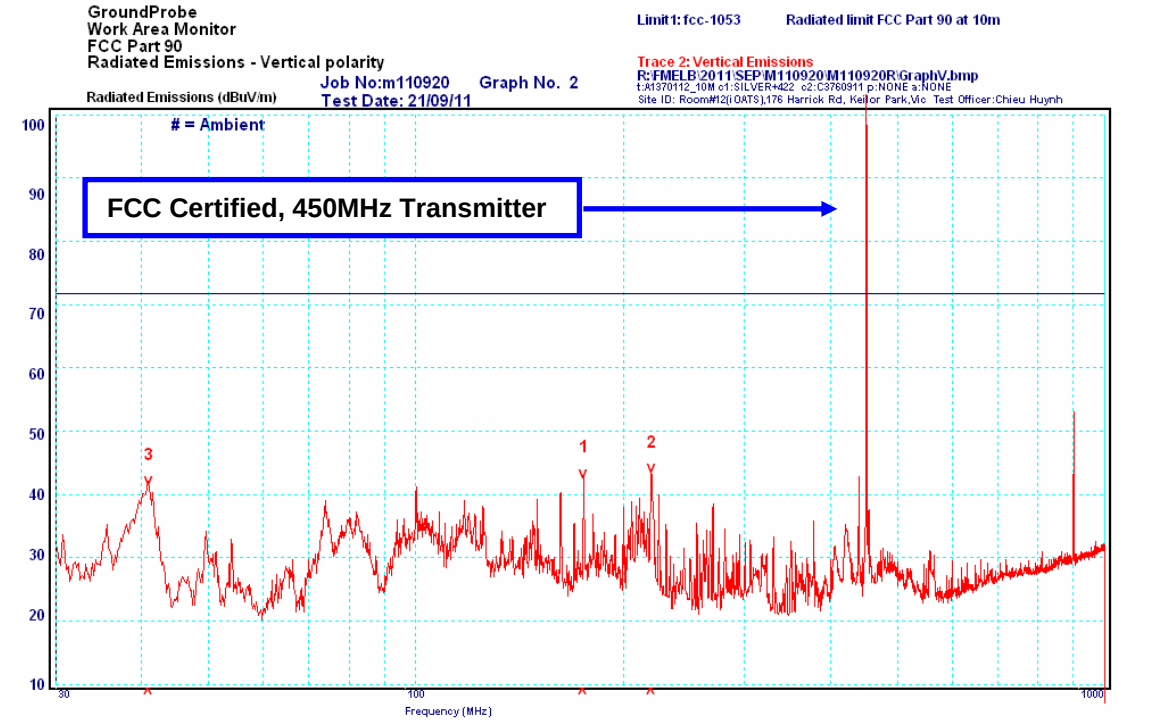
9 kHz to 30 MHz – Perpendicular



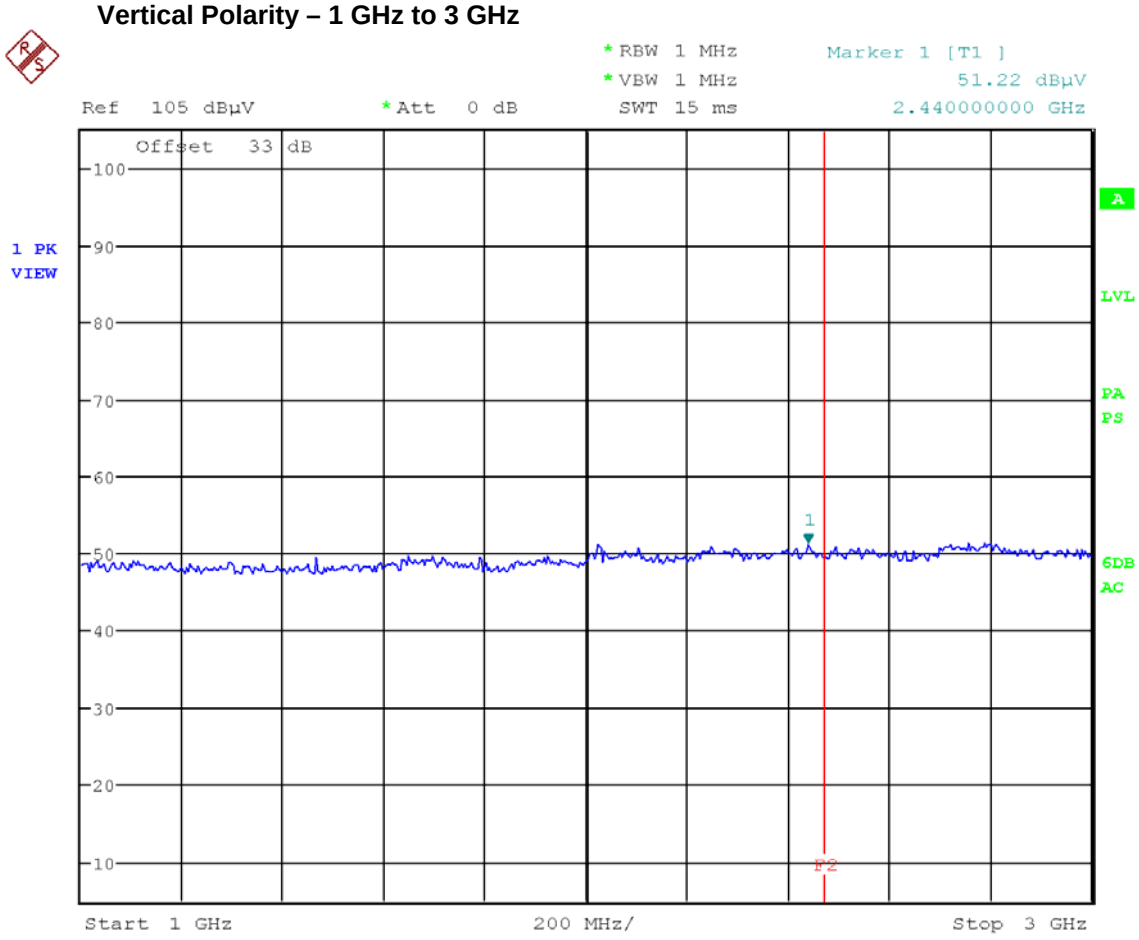
9 kHz to 30 MHz – Parallel



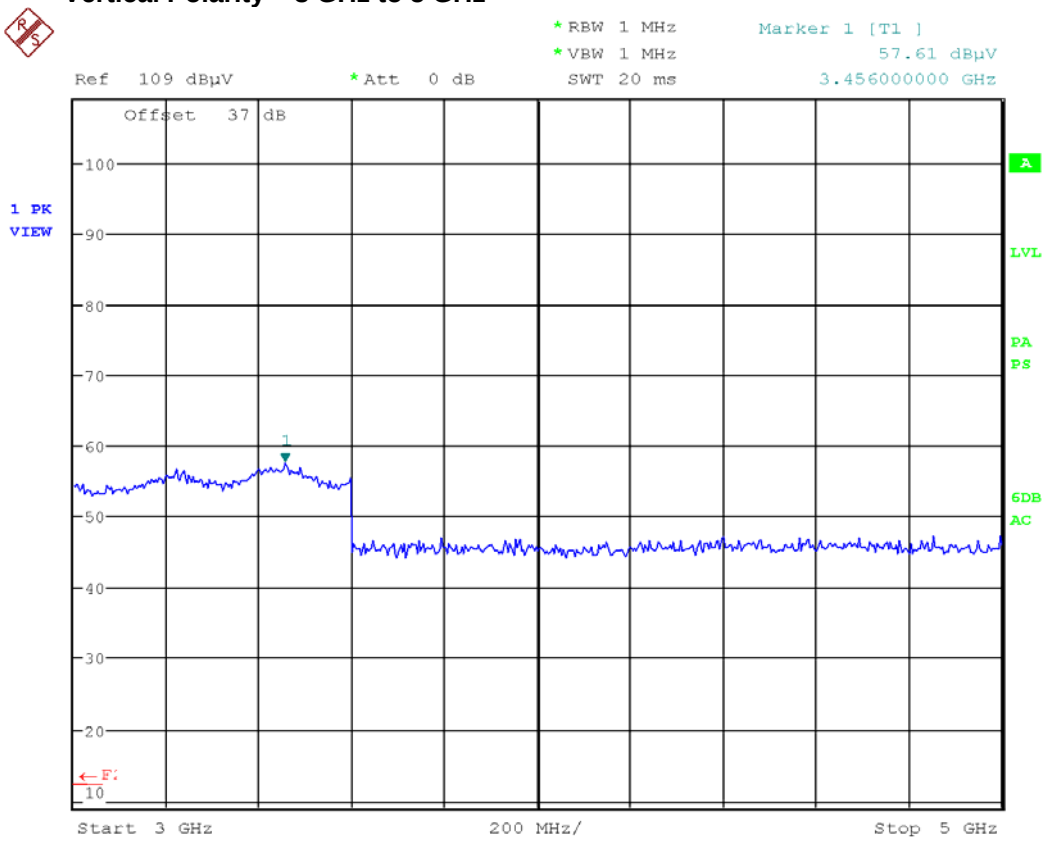
Vertical Polarity – 30 MHz to 1 GHz



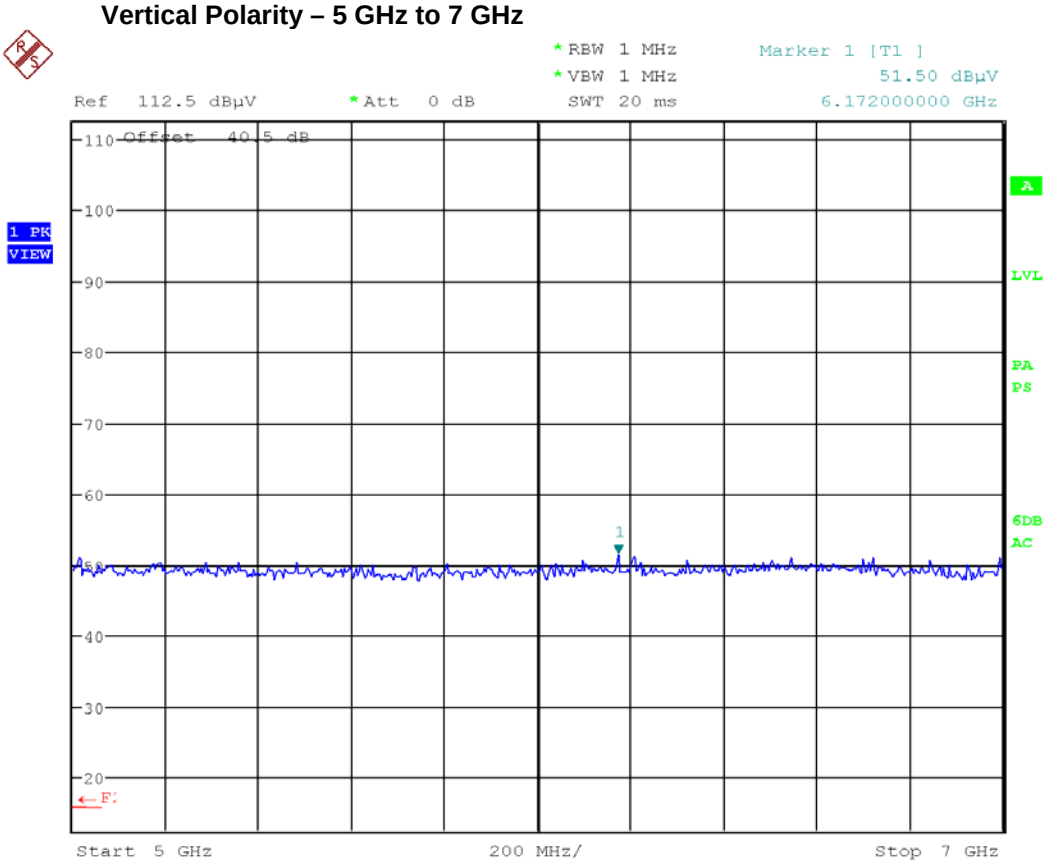
Vertical Polarity – 1 GHz to 3 GHz



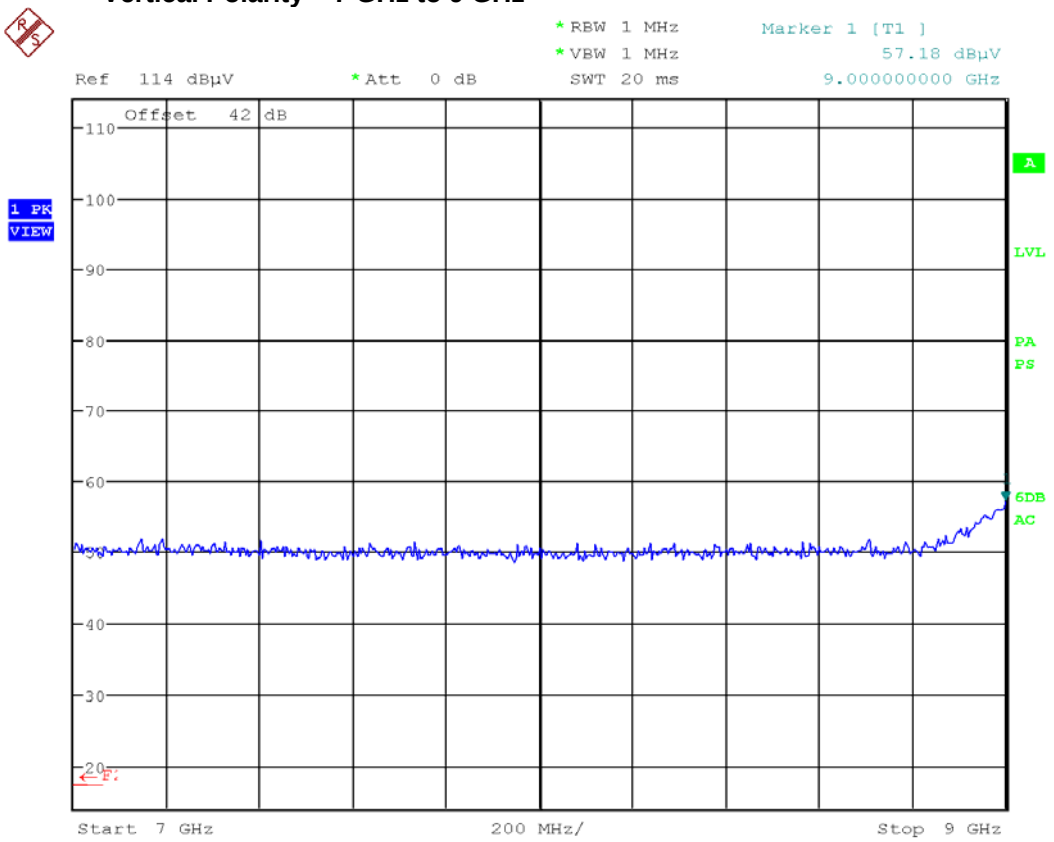
Vertical Polarity – 3 GHz to 5 GHz



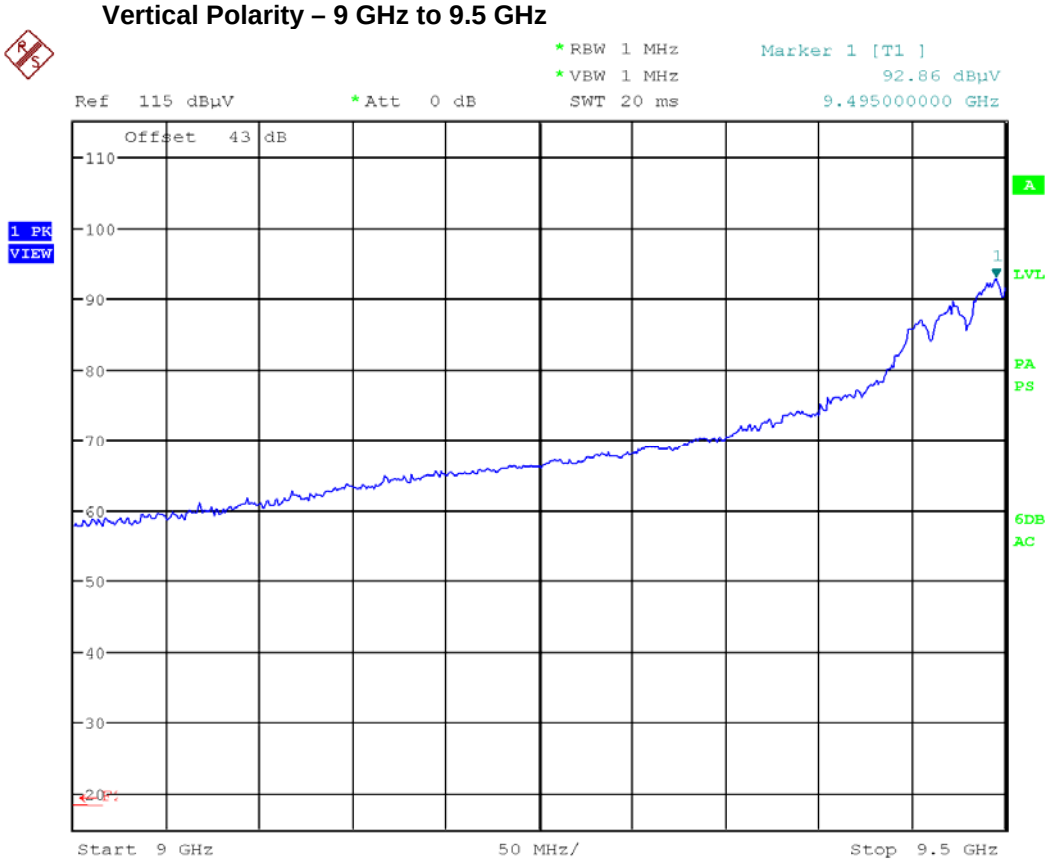
Vertical Polarity – 5 GHz to 7 GHz



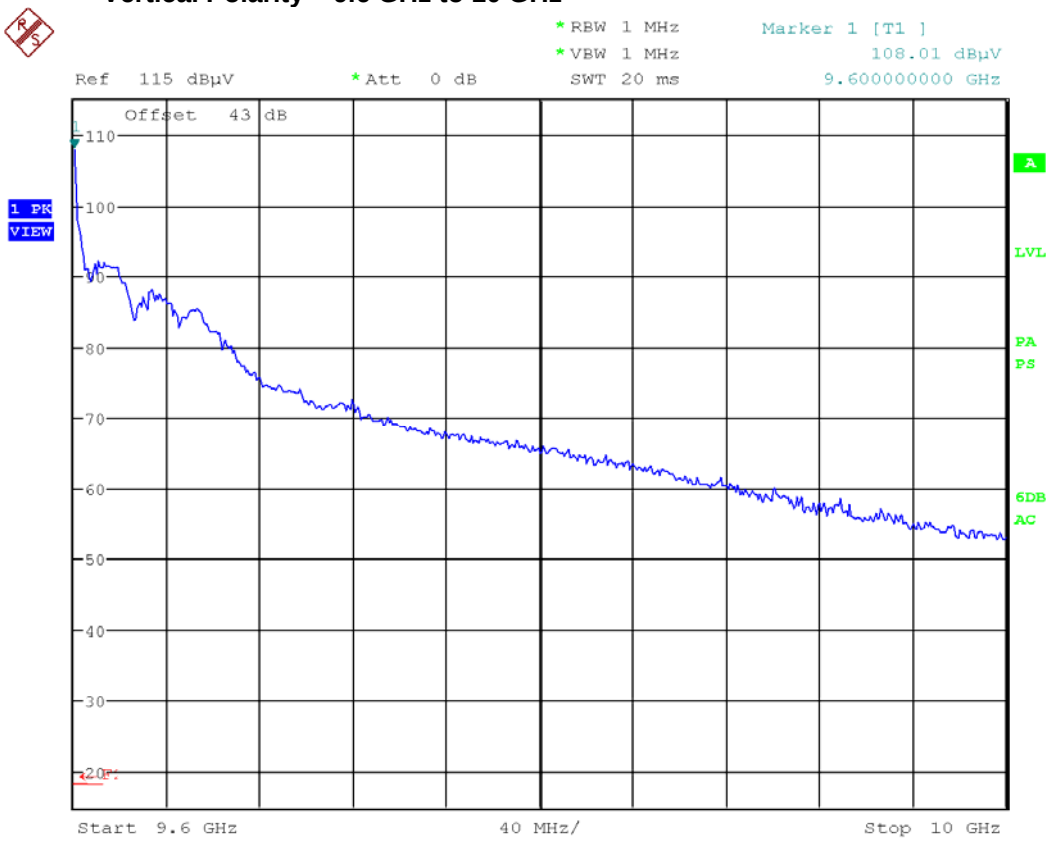
Vertical Polarity – 7 GHz to 9 GHz



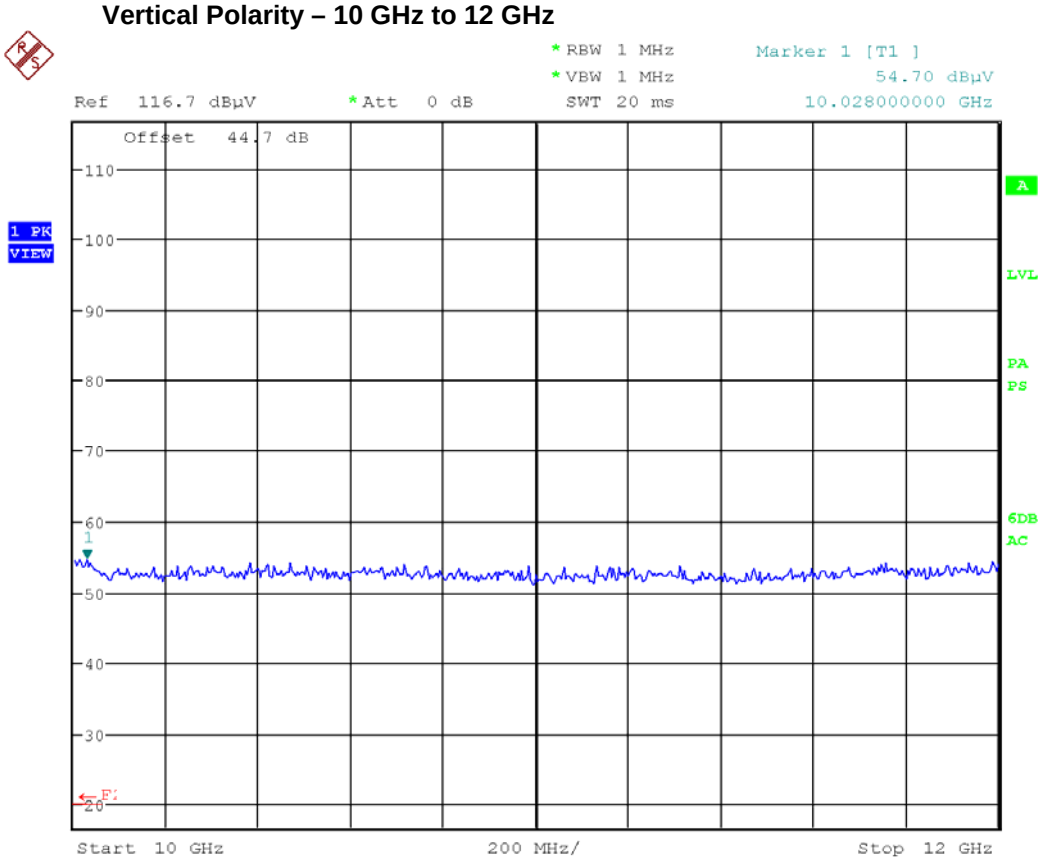
Vertical Polarity – 9 GHz to 9.5 GHz



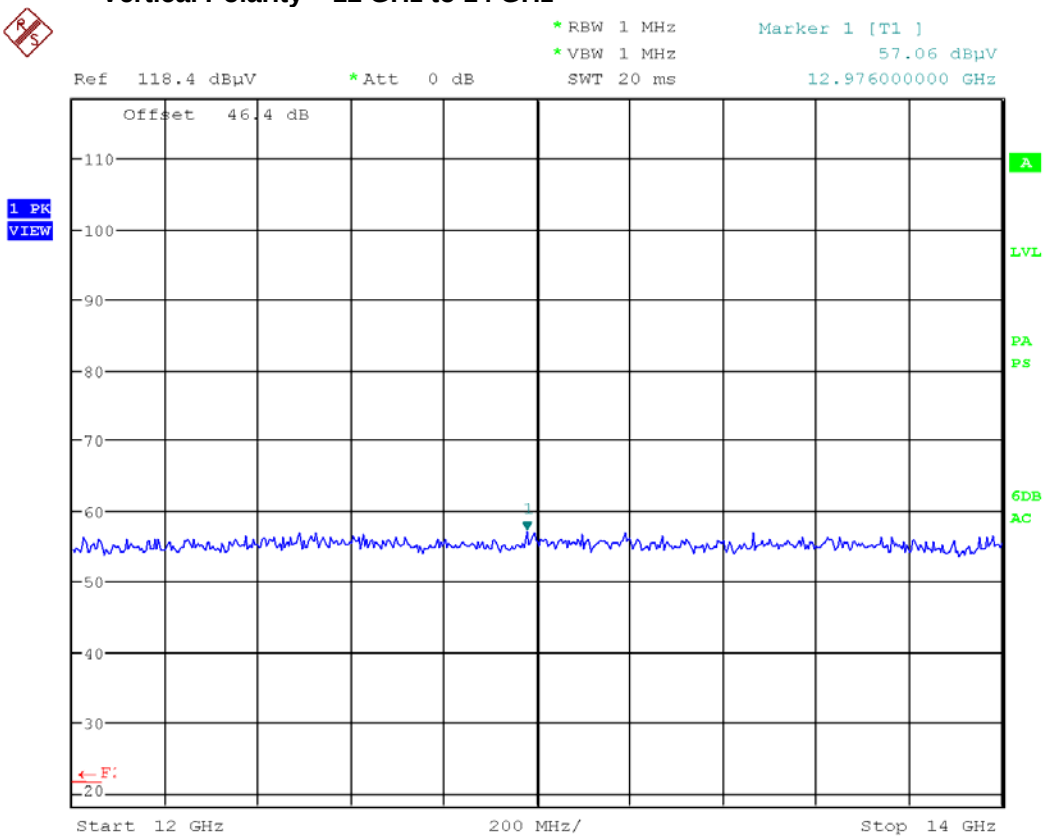
Vertical Polarity – 9.6 GHz to 10 GHz



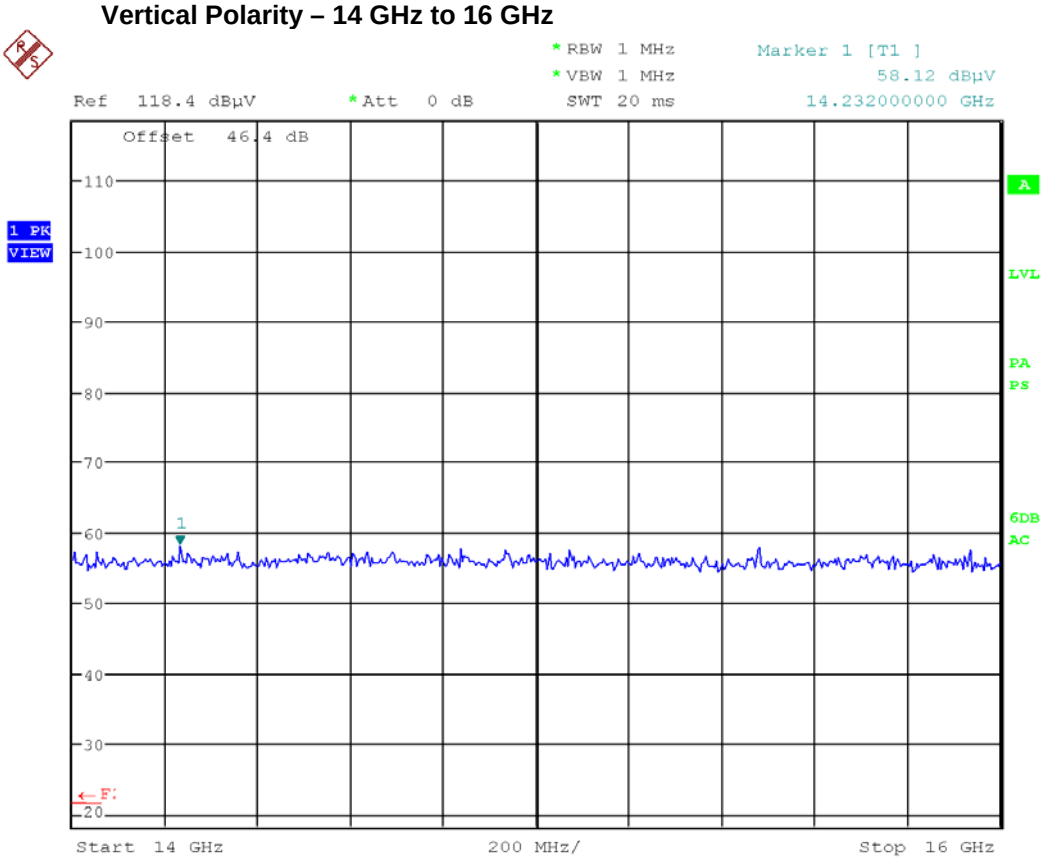
Vertical Polarity – 10 GHz to 12 GHz



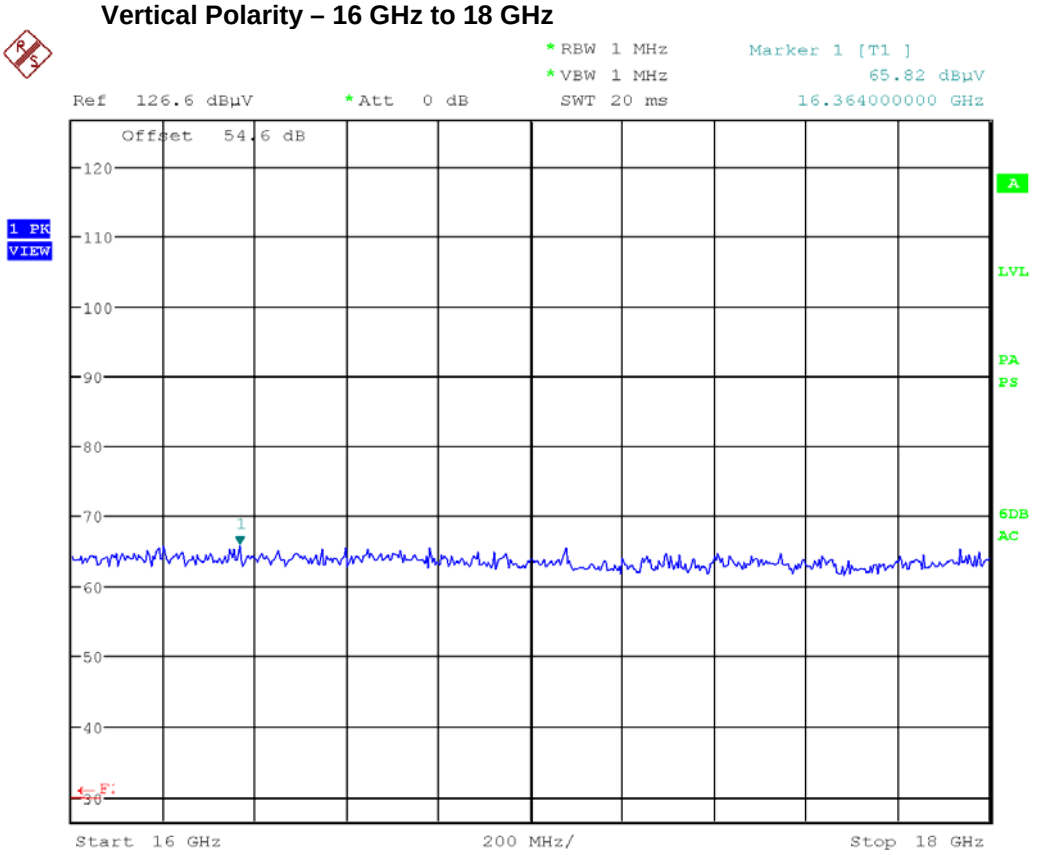
Vertical Polarity – 12 GHz to 14 GHz



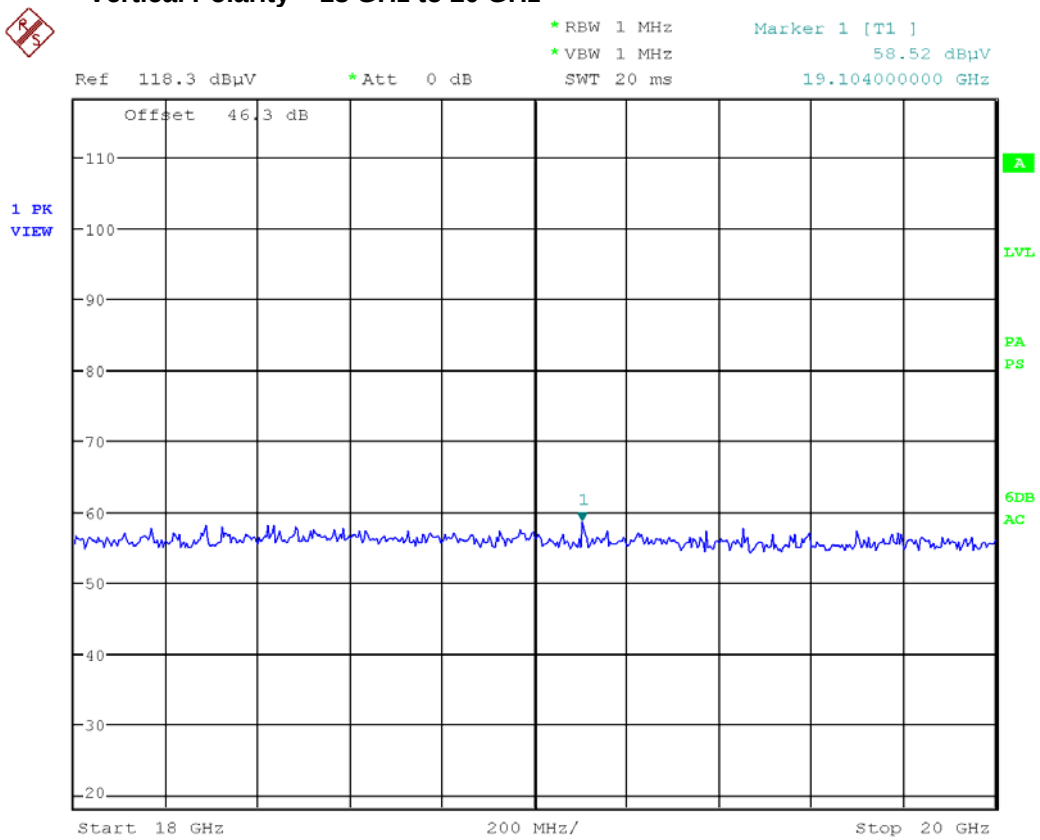
Vertical Polarity – 14 GHz to 16 GHz



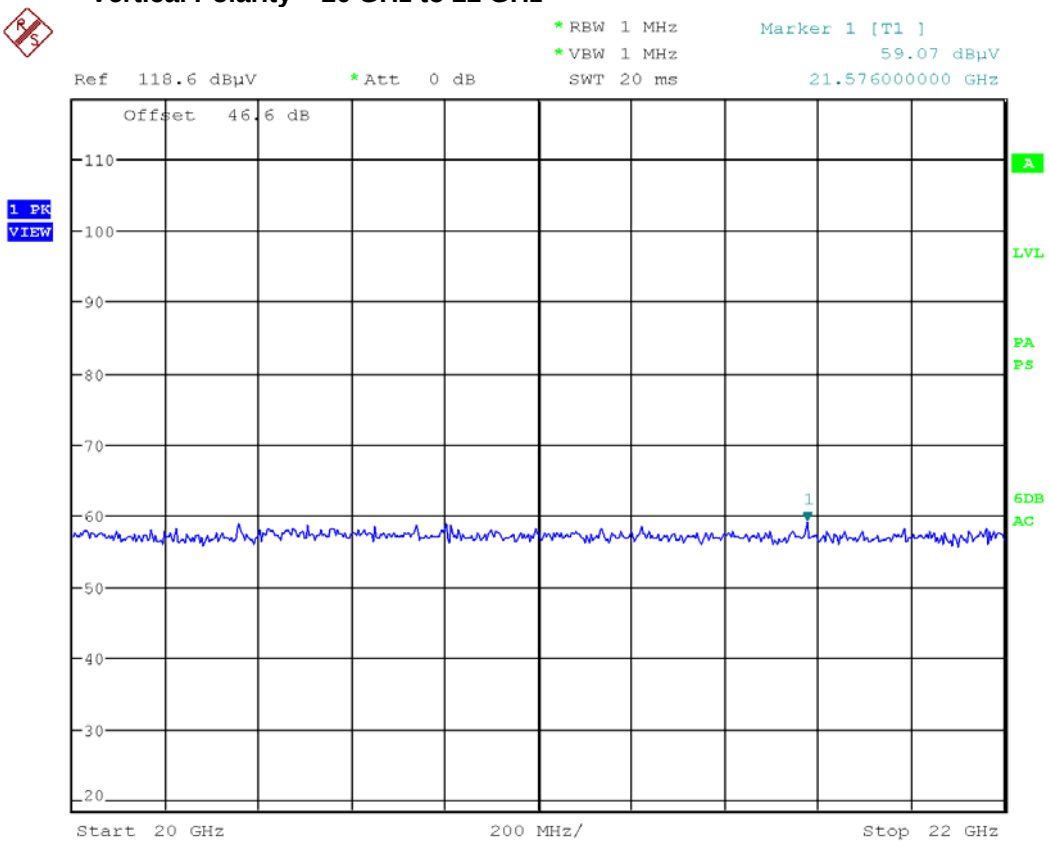
Vertical Polarity – 16 GHz to 18 GHz



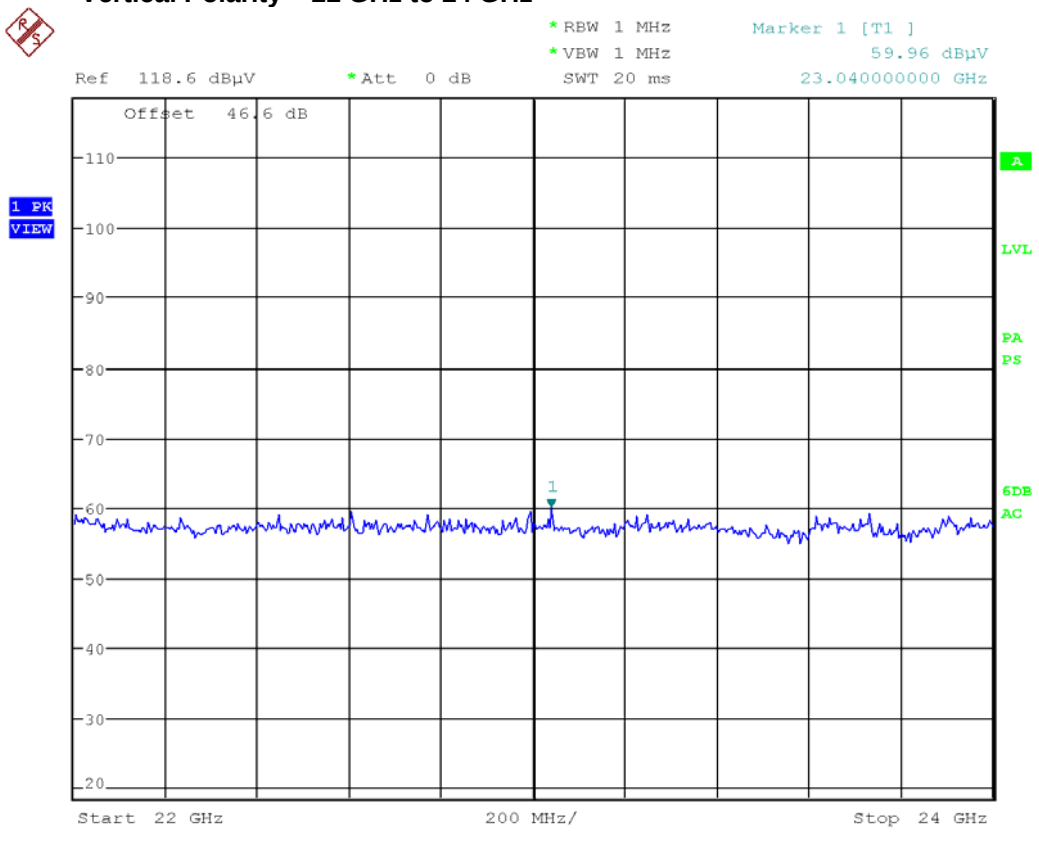
Vertical Polarity – 18 GHz to 20 GHz



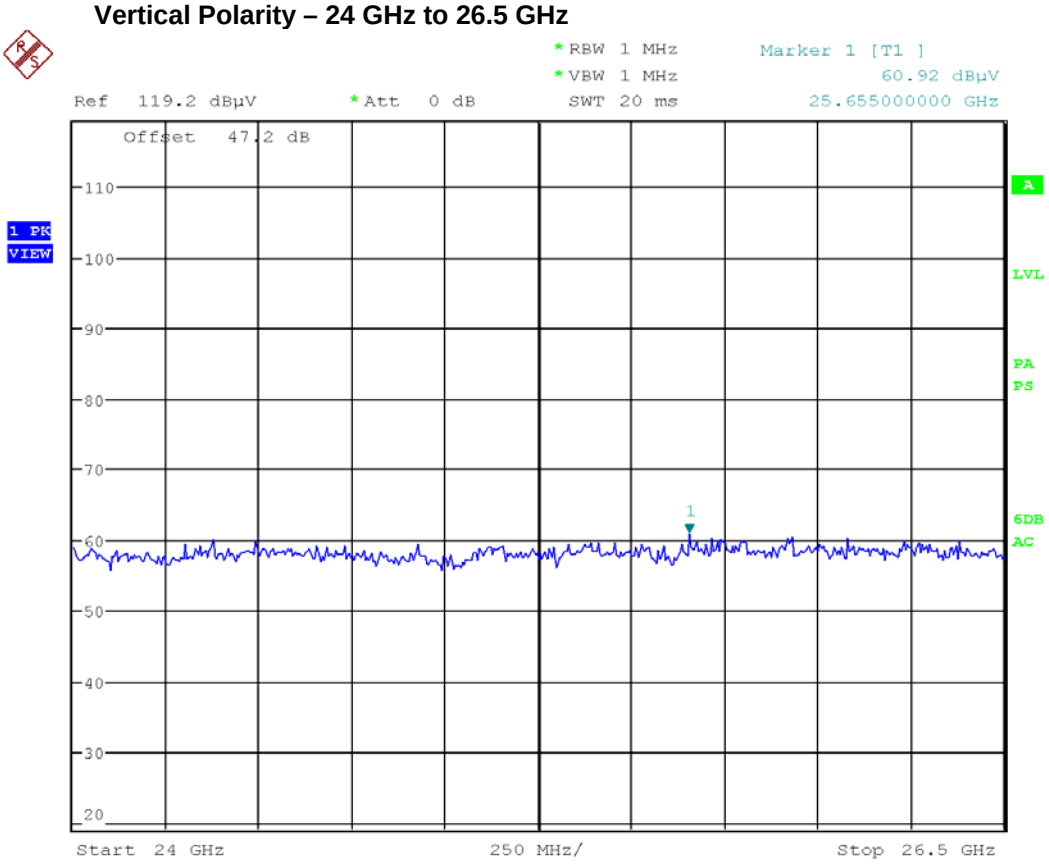
Vertical Polarity – 20 GHz to 22 GHz



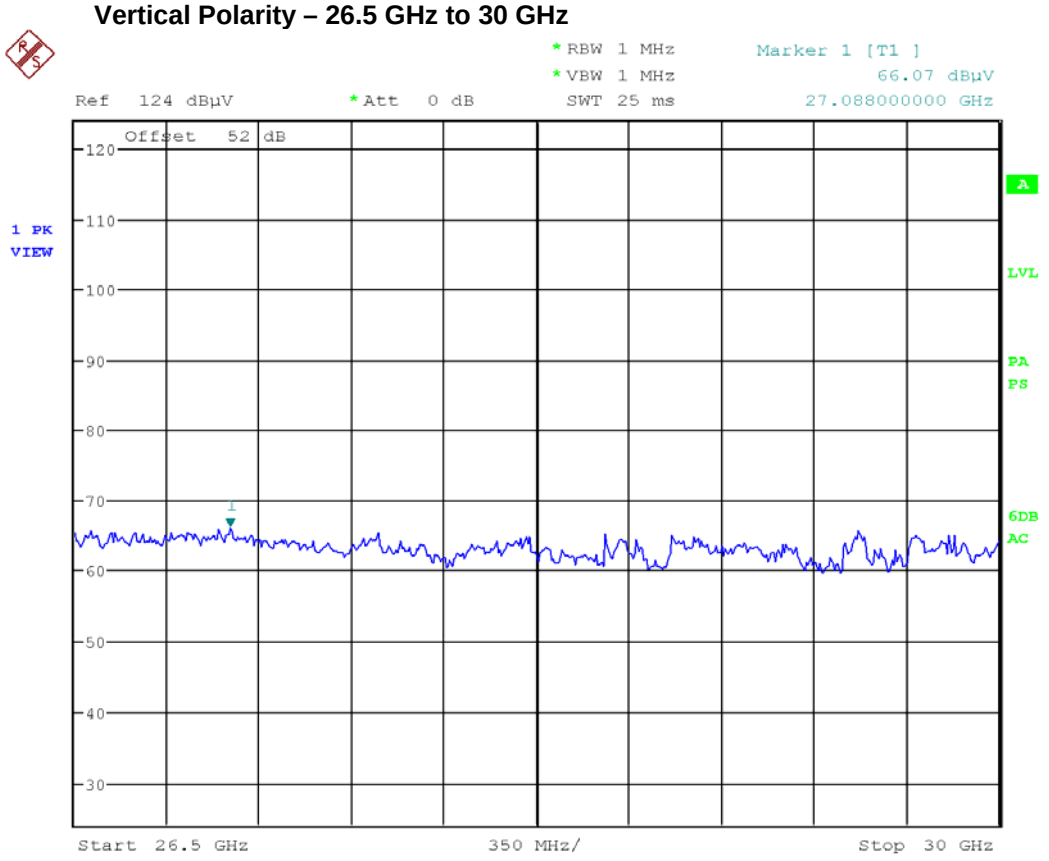
Vertical Polarity – 22 GHz to 24 GHz



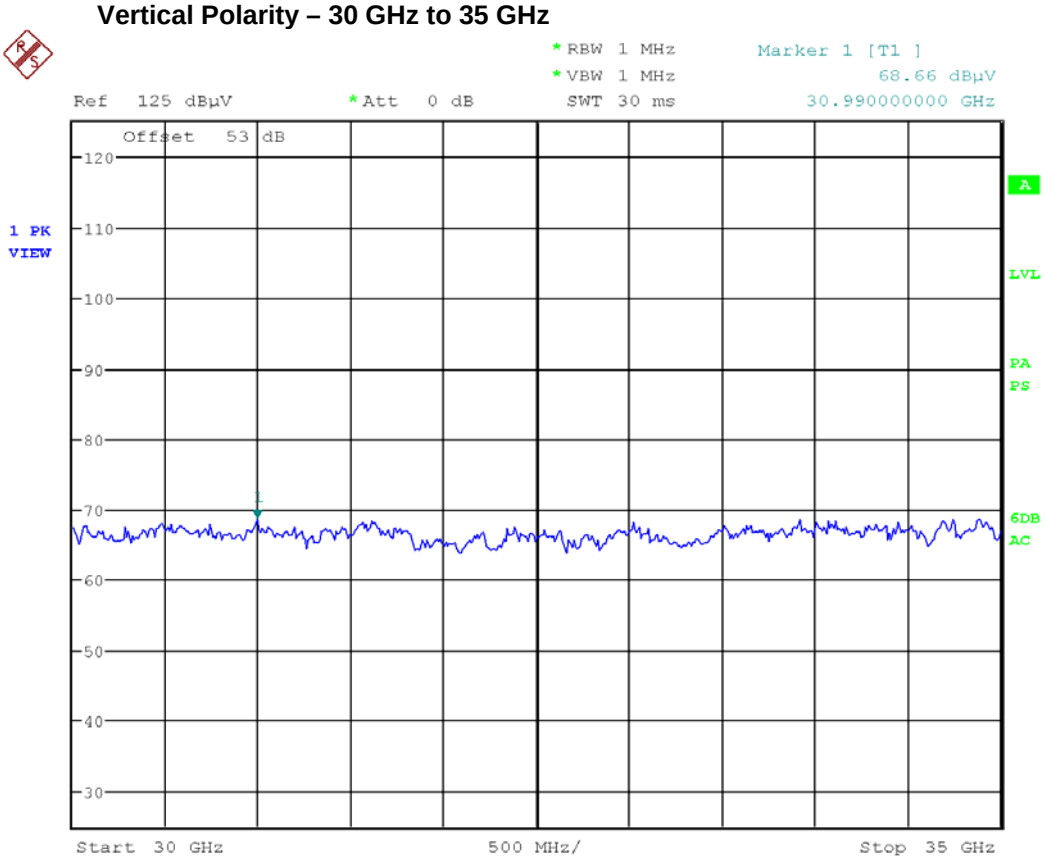
Vertical Polarity – 24 GHz to 26.5 GHz



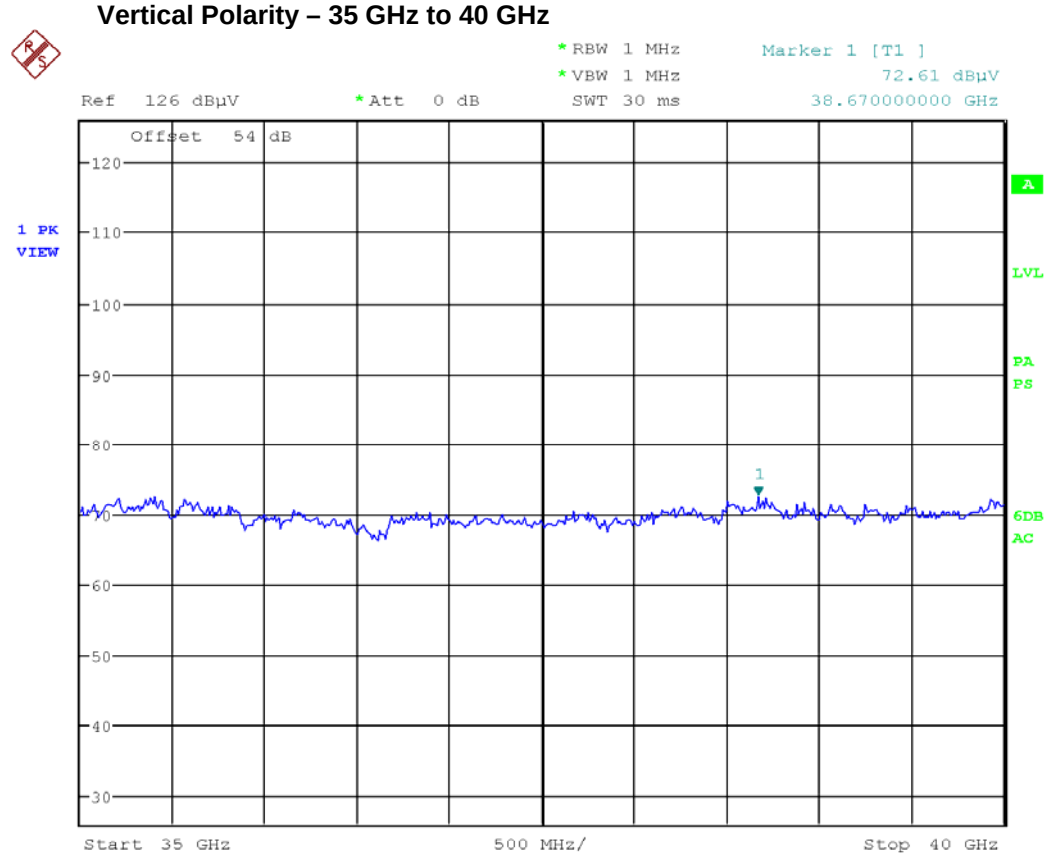
Vertical Polarity – 26.5 GHz to 30 GHz



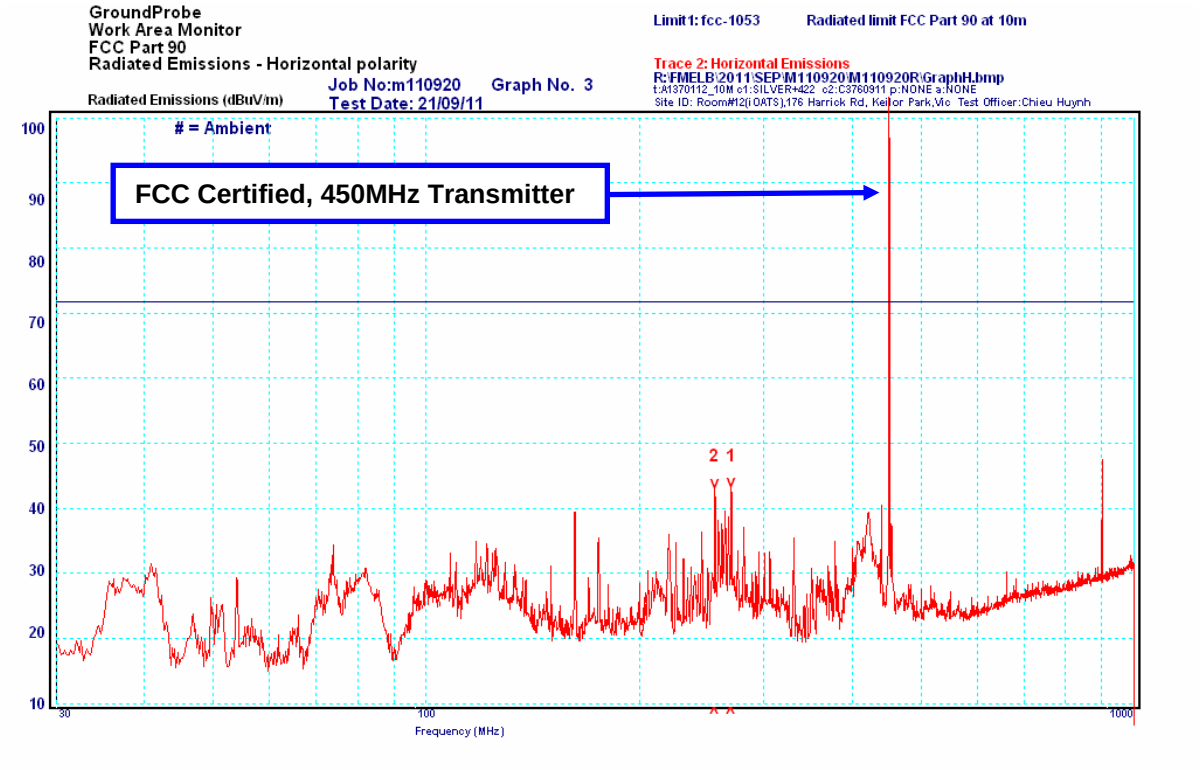
Vertical Polarity – 30 GHz to 35 GHz



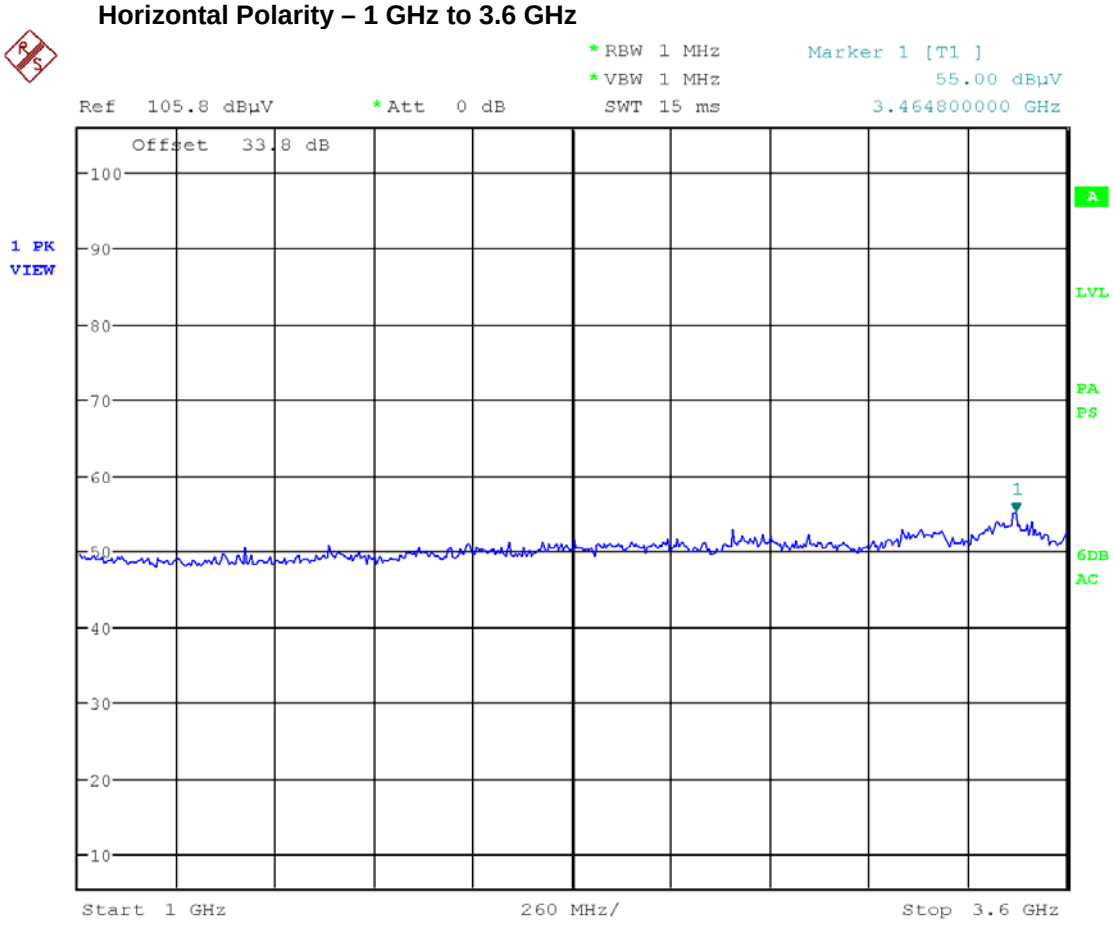
Vertical Polarity – 35 GHz to 40 GHz



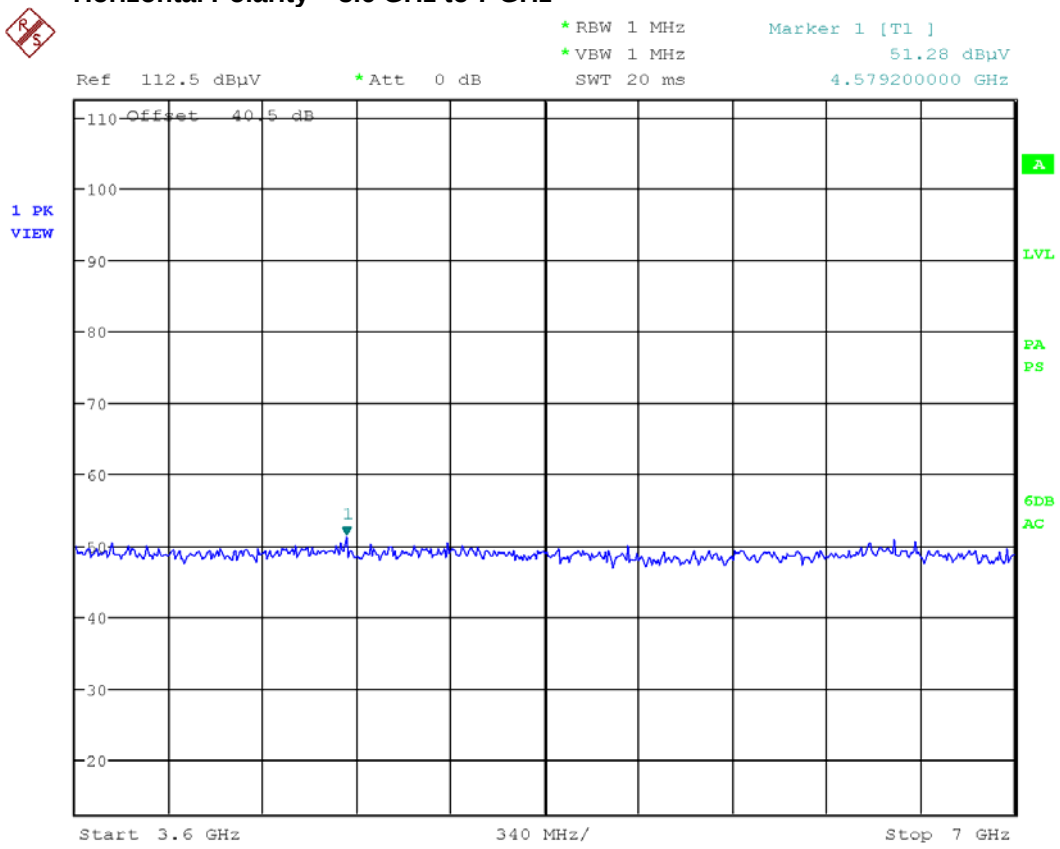
Horizontal Polarity – 30 MHz to 1 GHz



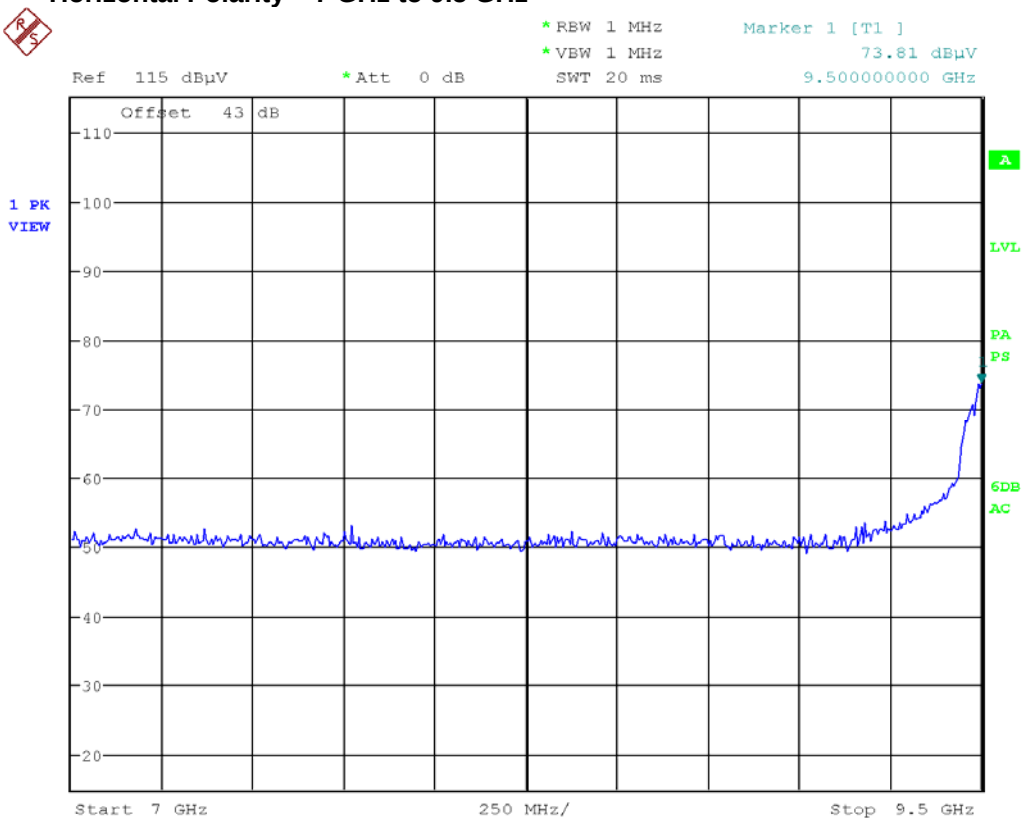
Horizontal Polarity – 1 GHz to 3.6 GHz



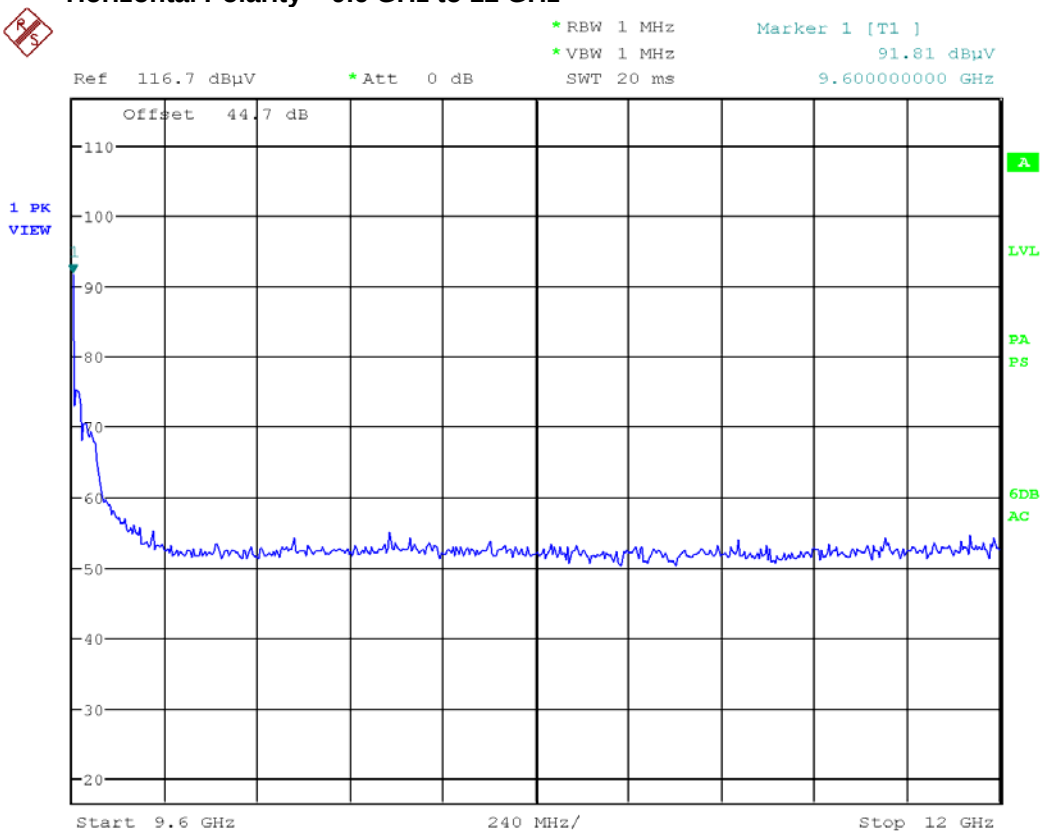
Horizontal Polarity – 3.6 GHz to 7 GHz



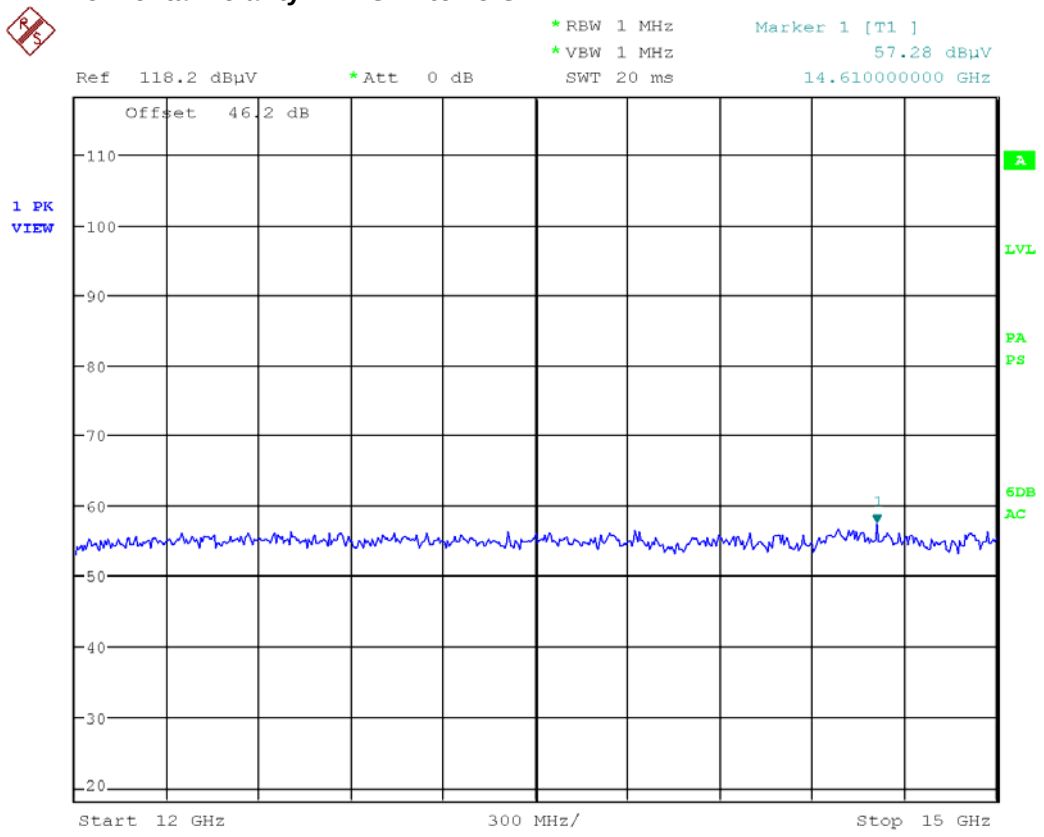
Horizontal Polarity – 7 GHz to 9.5 GHz



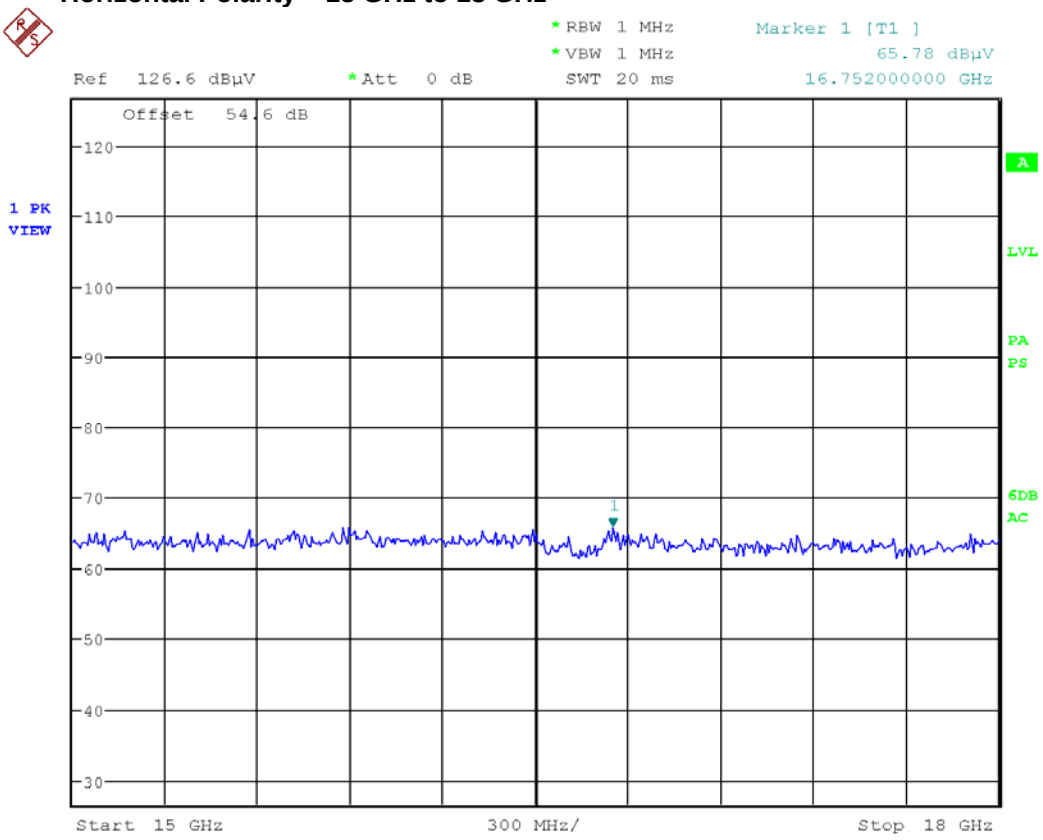
Horizontal Polarity – 9.6 GHz to 12 GHz



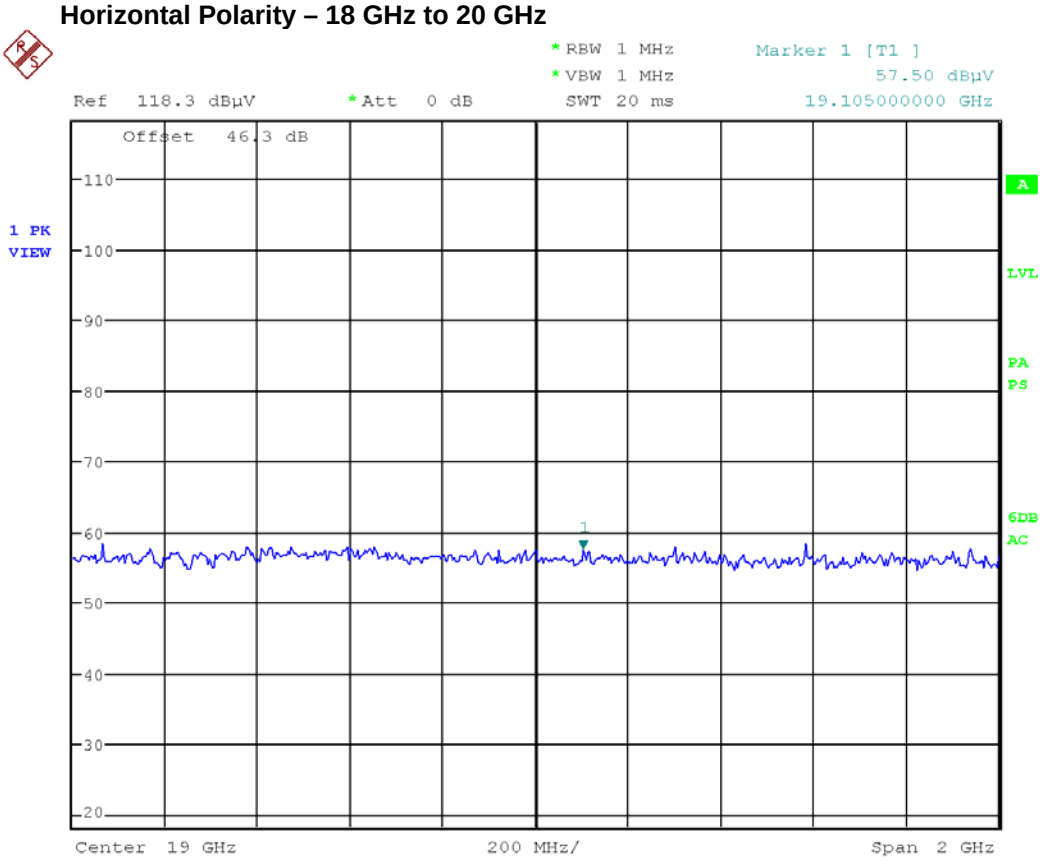
Horizontal Polarity – 12 GHz to 15 GHz



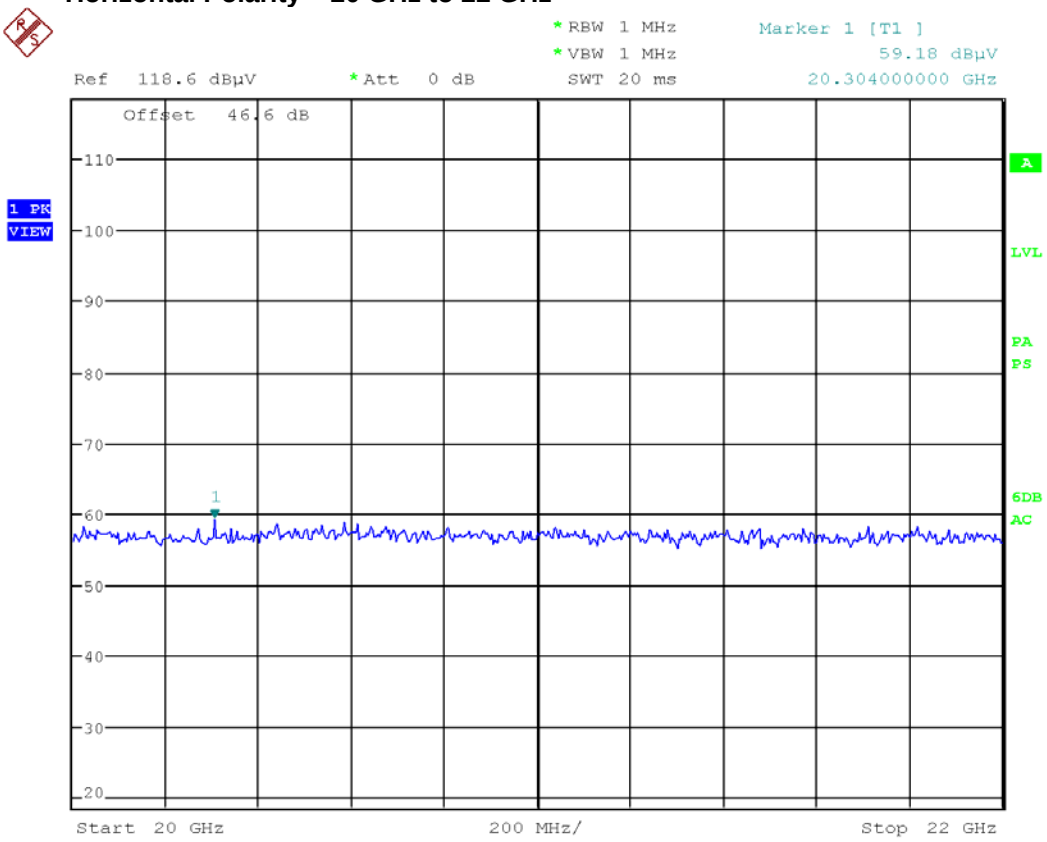
Horizontal Polarity – 15 GHz to 18 GHz



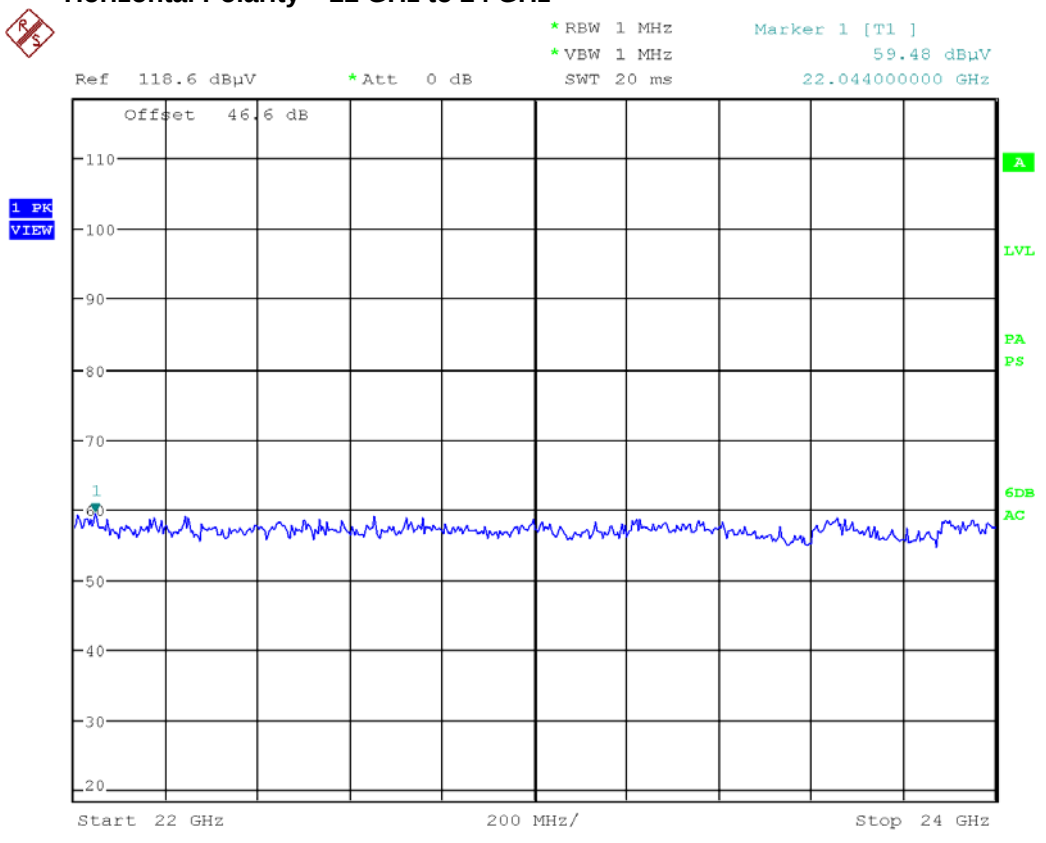
Horizontal Polarity – 18 GHz to 20 GHz



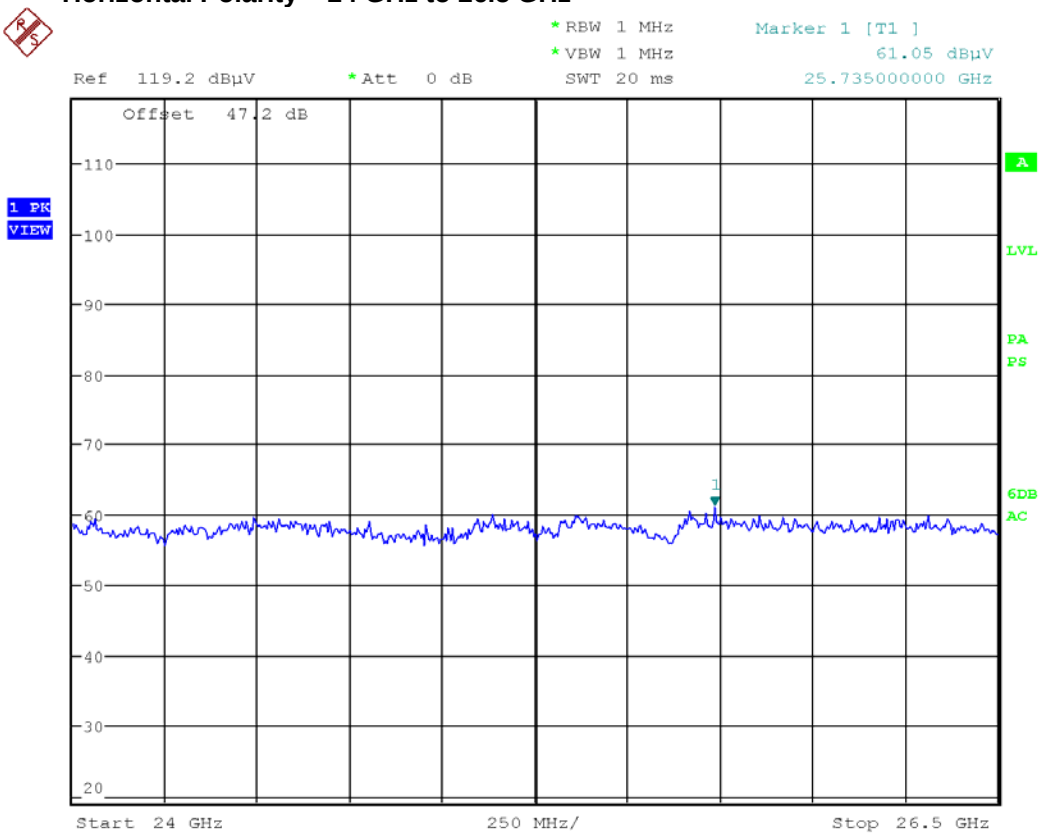
Horizontal Polarity – 20 GHz to 22 GHz



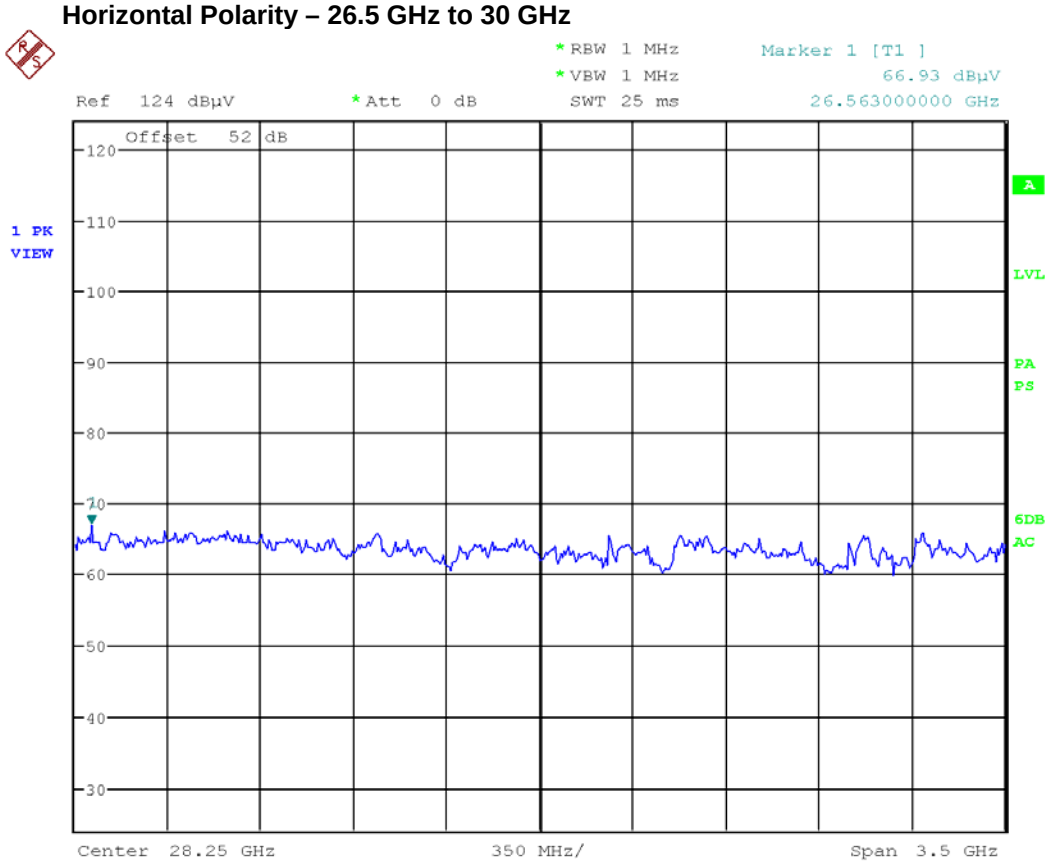
Horizontal Polarity – 22 GHz to 24 GHz



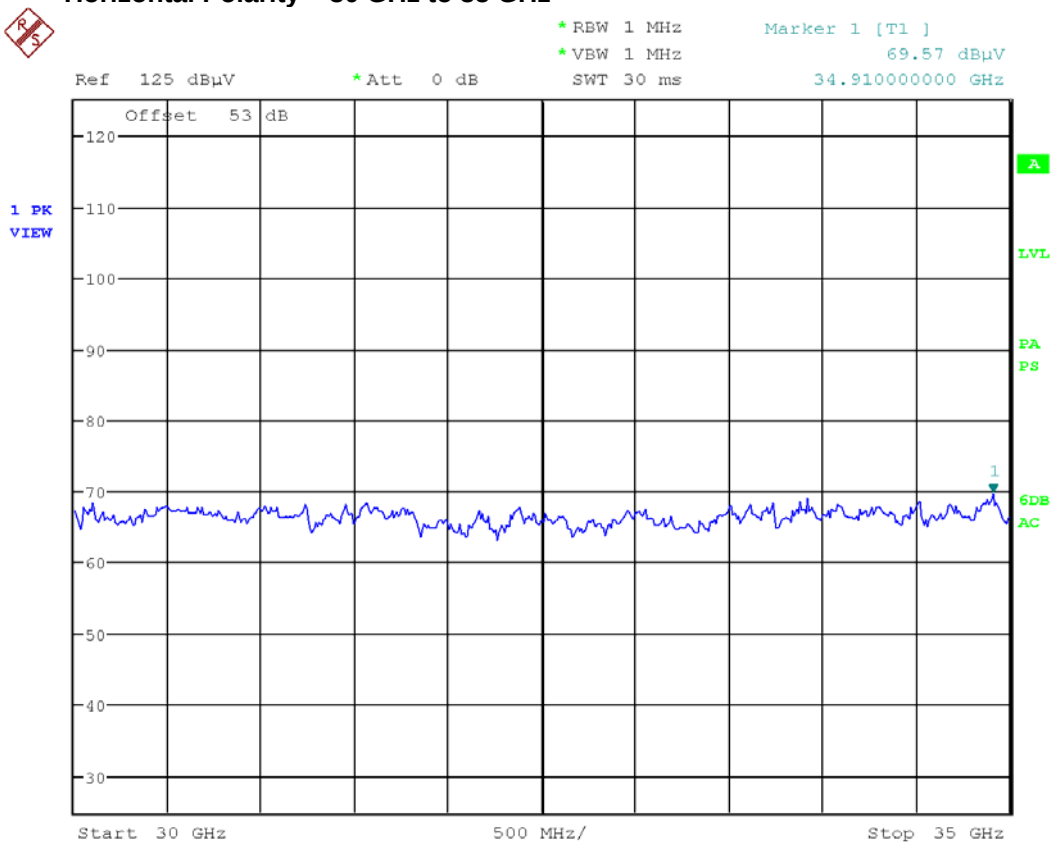
Horizontal Polarity – 24 GHz to 26.5 GHz



Horizontal Polarity – 26.5 GHz to 30 GHz



Horizontal Polarity – 30 GHz to 35 GHz



Horizontal Polarity – 35 GHz to 40 GHz