FCC TEST REPORT
FOR THE
CONCEPT2, INC.
MODEL PM5
PERFORMANCE MONITOR
FCC ID: J2MPM5

Prepared for:

Concept2, Inc.
105 Industrial Park Drive
Morrisville, VT 05661
USA

Submitted by:

Green Mountain Electromagnetics, Inc.

(802) 388-3390
(802) 388-6279 Fax
gme@gmelectro.com
219 Blake Roy Road • Middlebury, Vermont 05753

Copyright: June 2, 2014

ACCREDITED
Test Lab
Cert 898.01

20 YEARS GREEN MOUNTAIN ELECTROMAGNETICS 1994 – 2014

This report shall not be reproduced, except
in full, without the written approval of GME.

Concept2, Inc.
FCC Testing
At
Green Mountain Electromagnetics, Inc.

Units: Model PM5 Performance Monitor
Received: 5/19/14
Tested: May 21 - 23, 2014

I. Applicable Standards:

The units described in this report were measured for verification of compliance with "47 CFR, Part 15 – Radio Frequency Devices, Subpart C: Intentional Radiators," paragraph 15.209, Radiated Emissions and 15.249, Operation within the 2400 – 2483.5 MHz Band. Measurement procedures were in accordance with ANSI C63.4, "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2009)," and FCC OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields (Jan. 2001)."

Additionally, the units described in this report were measured for certification with the Code of Federal Regulations Chapter 47 – "Telecommunication, Part 2 – Frequency Allocations and Radio Treaty Matters: General Rules and Regulations, Subpart J – Equipment Authorization Procedures." Measurements required were per paragraphs 2.1046 RF Power Output, 2.1047 Modulation Characteristics, 2.1049 Occupied Bandwidth, 2.1053 Field Strength of Spurious Radiation, 2.1055 Frequency Stability and 2.1093 Radiofrequency Radiation Exposure Evaluation: Portable Devices.

II. Measurement Location:

The GME laboratory and Open Area Test Site (OATS) are located at 219 Blake Roy Road, Middlebury, VT. The OATS is a 10/3/1-meter site complete with antenna positioner, ground plane and motorized turntable. The OATS is constructed in accordance with ANSI C63.7-2005 and complies with the requirements for radiated emissions testing in ANSI C63.4-2009 and CISPR standards. GME is internationally accredited by the American Association for Laboratory Accreditation (A2LA) and meets the quality requirements in ISO/IEC 17025 (2005), "General Requirements for the Competence of Testing and Calibration Laboratories."

III. Unit Tested:

The Concept2, Inc. Model PM5 is a performance monitor used in stationary training equipment for data logging/analysis and battery recharging. The PM5 uses DC-battery power and is controlled by a front-panel, LCD-touchpad interface. It consists of the plastic enclosure, signal connectors, the electronics, and the power input circuit. The PM5 has wireless capability using two, 2.4-GHz transceivers (Nordic Semiconductor nRF51422/nRF51822 set for -4 dBm power output and using channels 1-80). The PM5 is intended for use in a residential environment. Model PM5 was connected to electrical loads to represent actual use of the products during testing. The table below describes the units that were subjected to measurements determining compliance with applicable standards:

The following table describes the system physical and electrical properties:

Model	Volts/Amps	H/W/D in cm	Serial #
PM5	3 VDC, two "D" cells	16/12/7	310

The following table describes the support equipment used during testing:

Product	Manufacturer	Model
Laptop PC	Apple	A1005
Performance Monitors (2)	Concept2	PM4
USB Drive	ADATA	4GB
Generator	Concept2	n/a

Power/signal cables were used for testing and are supplied by the manufacturer. The following table describes the unit cable:

Cable	Manufacturer	Description
Signal	Jamer	USB 2.0, UL E219485
Signal (2)	CM	Cat 5e Ethernet , UL E305668
Power/Signal	Concept2	2.5 mm Jack

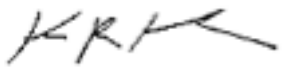
IV. Summary of Results:

The Concept2, Inc. Model PM5 complies with 47 CFR, Parts 2 and 15. Section X contains the results summarized in the table below.

	Test	Mode/Port	CFR 47 Paragraph	Frequency Range/Level	Specified Values	Measured Values
1	Output Power	Transmit	**2.1046 15.249(a)**	2.4 – 2.4835 GHz	94 dBuV/m	92 dBuV/m
2	Modulation Characteristic	Transmit	**2.1047(d)**	All modulation products ANT+ & Bluetooth	Per Manufacturer	Within Tolerance
3	Occupied Bandwidth	Transmit	**2.1049(h) 15.249(d)**	2.4 – 2.4835 GHz	50 dB down outside OBW	>50 dB
4	Frequency Stability	Transmit	**2.1055**	2439.980 MHz	Battery End -30˚C to +50˚C	2439.980 MHz
5	Radiated and Spurious Emissions	Enclosure	**15.209 15.249 2.1053**	30 – 88 MHz 88 – 216 MHz 216 – 960 MHz 960 – 24 GHz	40 dBuV/m 43.5 dBuV/m 46 dBuV/m 54 dBuV/m	Within All Limits
6	Exposure Evaluation	Enclosure	**2.1093**	2.4 – 2.4835 GHz	0.08 W/kg Body 1.6 W/kg 1g Volume	Within All Limits

Exploratory measurements indicate maximum radiation is found when the antenna polarization is aligned with the EUT antenna and when the antenna is pointed directly at the EUT at scan heights >10% of EUT height. Testing was performed by Kyle R. Kowalczyk, president, Green Mountain Electromagnetics and requested by:

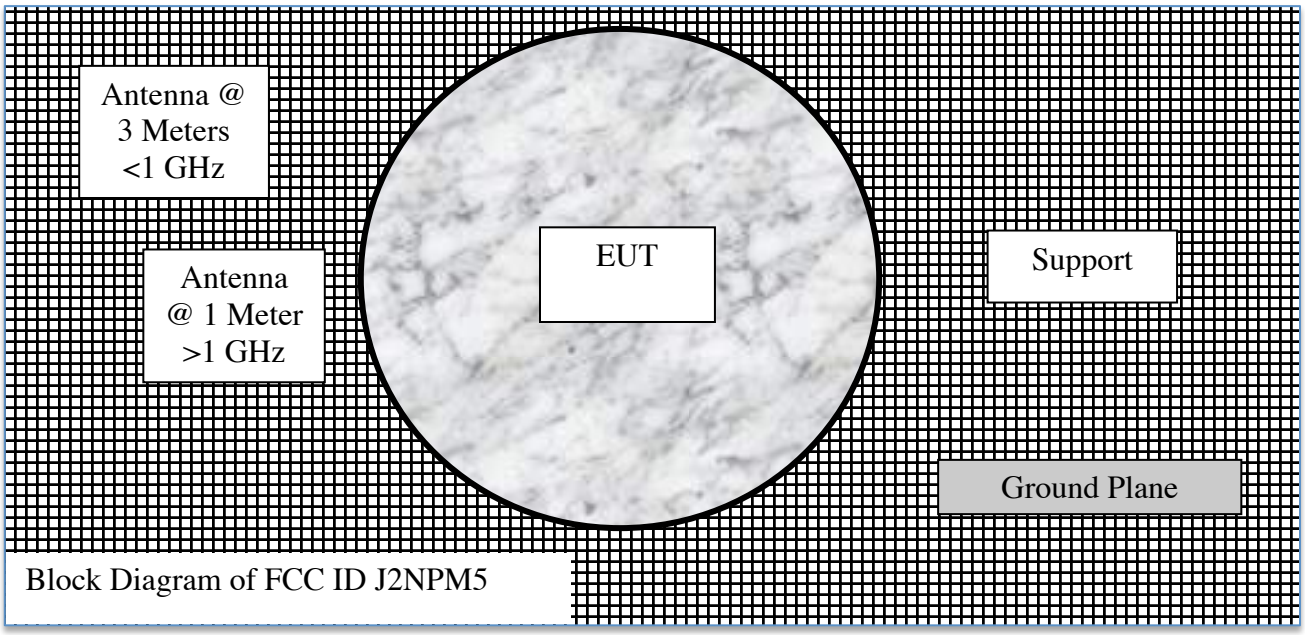
Concept2, Inc.
105 Industrial Park Drive
Morrisville, VT 05661
USA



Kyle R. Kowalczyk
6/2/14

V. Equipment, Software and Cable Configuration:

GME witnessed the unit in satisfactory condition for testing, however the manufacturer is responsible for ensuring that the equipment under test (EUT) represents the product line. The manufacturer is also responsible for the test plan and for assuring that this report is consistent with that plan. The EUT was operating in a continuous mode utilizing and testing its monitoring functions. The EUT was also tested upon power up. The EUT configuration was arranged to produce maximum radiated emissions as shown in the block diagram below. The equipment was subjected to complete emissions tests per the manufacturer's test plan.



Block Diagram of FCC ID J2NPM5

VI. Units of Measurement and Uncertainty:

Measurements of radiated electric fields were made in units of dB referenced to 1 microvolt per meter (dBuV/m). Limits appearing on the spectrum analyzer data were corrected for the appropriate antenna factor, cable loss, amplifier gain (when used) and measurement distances X_{std} and X_{site} in meters.

The following equation was employed:
Corrected Limit (dBuV) = Limit (dBuV/m) + 20 Log(X_{std}/X_{site}) + Amplifier Gain (dB) – Antenna Factor (dB/m) – Cable Loss (dB).
Sample calculation at 30 MHz (Vertical Polarization):
51.8 dBuV corrected limit = 40.0 dBuV/m limit + 20 log(3/3) dB distance + 30 dB amp gain – 17.2dB/m AF – 1 dB cable loss.

Uncertainty

The uncertainty budgets in GME EMC measurements are identified as follows:

1. Field strength between 30 MHz and 26 GHz on a three-meter OATS using broadband antennas:

Contribution	Probability Distribution	Uncertainty (dB)
antenna factor calibration	normal k=2	0.5
cable loss calibration	normal k=2	0.5
analyzer specification	rectangular	1.5
distance variation	rectangular	0.6
height variation	rectangular	0.5
site imperfection	rectangular	2.0
mismatch	u-shaped	1.5
repeatability	standard deviation	0.5
combined uncertainty u(y)	normal	1.946
expanded uncertainty U	normal k=2	3.892

$$u(y) = \sqrt{(\frac{0.5}{2})^2 + (\frac{0.5}{2})^2 + \frac{1.5^2 + 0.6^2 + .5^2 + 2.0^2}{3} + \frac{1.5^2}{2} + 0.5^2}$$

U = k u(y)

Other GME uncertainty values are available upon request. Note: "U" represents an expanded uncertainty expressed at an approximately 95% confidence level using a coverage factor of k=2.

VII. Measuring Equipment:

The table below describes the instrumentation used by Green Mountain Electromagnetics to perform this testing:

Unit	Manufacturer	Model	Serial #	Last Cal.	Next Cal.
Spectrum Analyzer	HP	8592L	3624A00631	12/2/13	12/2/14
Spectrum Analyzer	GW Instek	GSP-830	E1180708	9/11/13	9/11/14
Broadband E-field Antenna	ARA	LPB-2513/A	1224	11/04/13	11/04/14
Horn Antenna	EMCO	3115	2418	10/10/13	10/10/14

Pre-Amplifier	MiniCircuits	ZKL-2R5+	739045986	11/19/13	11/19/14
Power Amplifier	MiniCircuits	ZVE-8G	n/a	1/7/14	1/7/15
Weather Station	Davis Insts.	Perception II	PC30923A07	1/22/14	1/22/15
E-field Meter w/ Probe	Wandel & Goltermann w/NARDA	EMR-30 w/ 2244/90.21	F-0049 F-0038	10/18/13	10/18/14
Temperature-Humidity Probe	PTC	RHTemp101	N00532	8/8/13	8/8/14
Temperature-Humidity Chamber	Thermotron	SM8S	25-2300-04	n/a	n/a

VIII. Measurement Procedures:

1. RF Power Output.

Specification: ≤50,000 uV/m (100% Duty) @ 3m

a. Set up EUT on OATS and test instrumentation in laboratory.
b. Verify spectrum analyzer and EUT operation.
   i. Spectrum analyzer uses internal attenuators.
   ii. Set analyzer to carrier frequency and use span >OBW.
c. Operate EUT at normal power unmodulated.
d. Record level displayed on analyzer.

2. Modulation Characteristic.

Specification: Modulation Products per Bluetooth and ANT+

a. Set up EUT on OATS and test instrumentation in laboratory.
b. Verify analyzer and EUT operation.
   i. Spectrum analyzer uses internal attenuators.
   ii. Set analyzer to carrier frequency and use span necessary to view all modulation products.
c. Operate EUT with standard modulation.
d. Record signal displayed on analyzer.

3. Occupied Bandwidth.

Specification: 50-dB down outside 2.4 – 2.4835 GHz

a. Set up EUT and test instrumentation in laboratory.
b. Verify analyzer and EUT operation.

i. Spectrum analyzer uses internal attenuators.
ii. Set analyzer to carrier frequency and use RBW <10 % of span.

c. Operate EUT with standard modulation.
d. Record signal displayed on analyzer.

4. Frequency Stability.

Frequency Band: 2.4 – 2.4835 GHz
Voltage Specification: Battery End Point Normal Operation

a. Set up EUT in temperature chamber and test instrumentation in laboratory.
b. Verify analyzer and EUT operation.
   i. Spectrum analyzer uses internal attenuators.
   ii. Set analyzer to carrier frequency and use narrowband span.
c. Operate EUT with standard modulation.
d. Record signal displayed on analyzer for high/low temperature and voltage.

5. Radiated Emissions.

Frequency range: 30 MHz to 88 MHz
Limit: 40 dBuV/m @ 3 meters
Frequency range: 88 kHz to 216 MHz
Limit: 43.5 dBuV/m @ 3 meters
Frequency range: 216 MHz to 960 MHz
Limit: 46 dBuV/m @ 3 meters
Frequency range: 960 MHz to 25 GHz & Spurious >960 MHz
Limit: 54 dBuV/m @ 3 meters

a. Set up instrumentation at open area test site.
   i. Mount EUT on ground plane and broadband antenna on antenna positioner.
   ii. Observe temperature, humidity and atmospheric pressure.
   iii. Measurement distance is 3 meters <1 GHz/1 meter >1 GHz and antenna scan height is 1 to 4 meters. Use RF absorber on ground plane >1 GHz.
b. Verify spectrum analyzer and antenna operation.
   i. Spectrum analyzer is connected to antenna. Use broadband horn >1 GHz.
   ii. Preamplifier is inserted between antenna and analyzer to ensure analyzer noise threshold is at least 6 dB below specification limit.
c. Set up, power and operate EUT as in block diagram in Section V.
d. Perform preliminary evaluation of equipment in the near field.
   i. Vary antenna height, antenna polarization, and antenna orientation to EUT.
   ii. Repeat step d.i. while evaluating radiation in the 30-MHz to 25 GHz spectrum.
   iii. Refer to ANSI C63.4-2009: for exploratory measurements >1 GHz.
e. Determine frequencies and equipment orientations that produce maximum radiation.

i. Identify processor, clock and beat frequencies, and harmonics.

f. Perform final evaluation of unit by recording spectrum analyzer data.
   i. Ensure the EUT is producing the maximum radiation found in step e.
   ii. Collect data over the entire frequency range.
   iii. Refer to ANSI C63.4-2009: for final measurements >1 GHz – Manually ensure measurement antenna is in cone of radiation for emission areas determined in steps d.-e. by adjusting in both azimuth and elevation positions. Polarization is oriented for maximum response.

6. Exposure Evaluation.

Frequency: 2.4 GHz

Limit: 0.8 W/kg and 1.6 W/kg

a. Set up instrumentation at open area test site.
   i. Mount EUT on table and isotropic probe or loop on antenna positioner.
   ii. Observe temperature, humidity and atmospheric pressure.
   iii. Measurement distance is 1 meter and antenna scan height is varied over human body dimensions (0.1 to 2 meters).

b. Verify E-field meter operation.

c. Set up, power and operate EUT as described in Section V.

d. Perform preliminary evaluation of equipment in the near field.
   i. Vary probe height, probe polarization, and probe orientation to EUT.
   ii. Repeat step d.i. while evaluating electromagnetic radiation at 2.4 GHz.
   iv. Near field measurements of unit emissions are made at ambient frequencies.

e. Determine equipment orientations that produce maximum radiation.
   i. Set peak hold on meter for 30 minutes while slowly varying probe height.

f. Perform final evaluation of unit by recording spectrum analyzer data.
   i. Ensure the EUT is producing the maximum radiation found in step e.
   ii. Collect data over the entire frequency range.
   iii. Identify all ambient signals.

IX. Photographs of Measurement Setup:

The following pages are photographs of the equipment as it was tested.

Photograph 1 – EUT on OATS <1 GHz

Photograph 2 – EUT on OATS >1 GHz

Photograph 3 – EUT in T/H Chamber

X. Measurement Results:

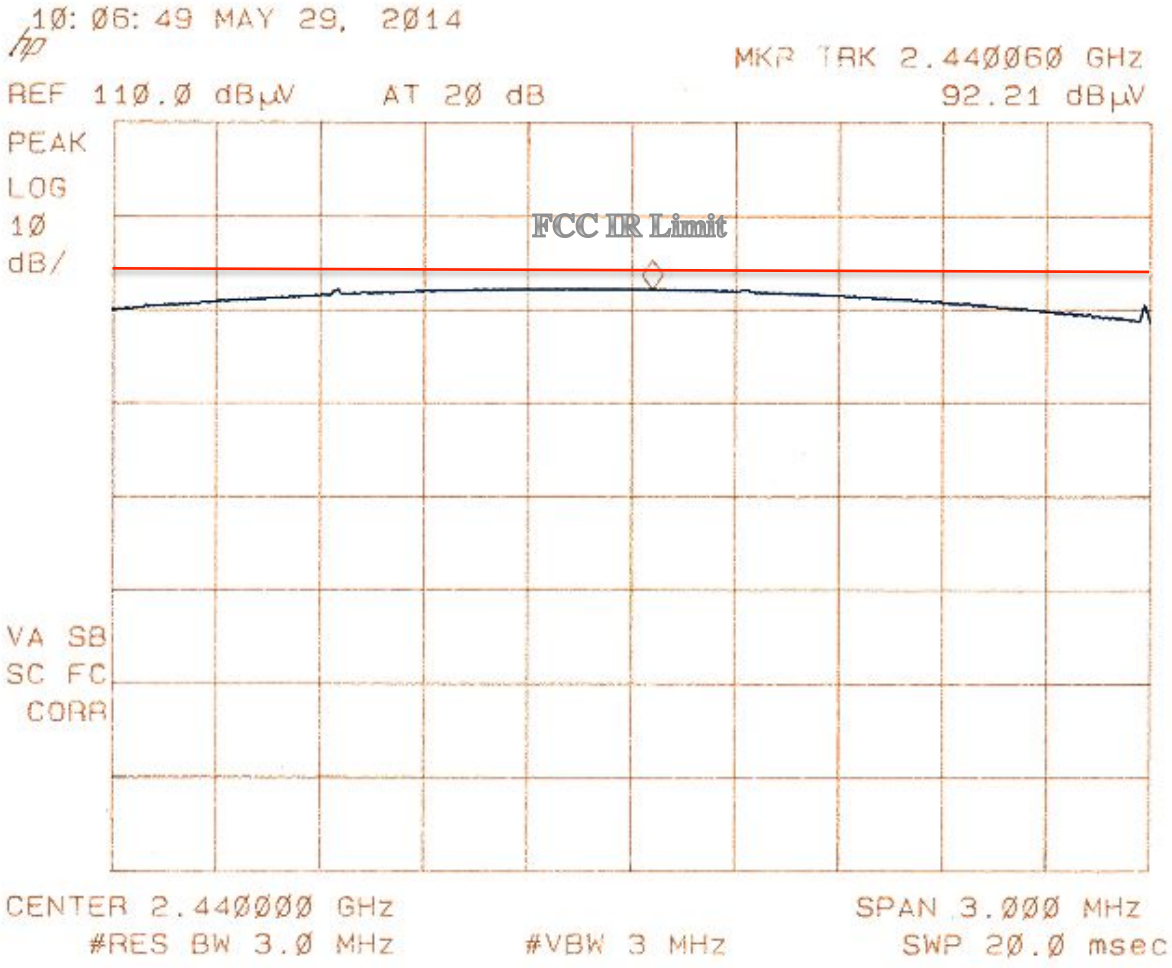
1. RF Power Output.

Specification uV/m	Specification dBuV/m	Amplifier dB	Antenna Factor dB	Cable Loss dB	Corrected Limit dBuV
50,000	94	30.0	29.0	1	94

Table 1 – RF-Power Corrected Limit

Corrected Power (dBm) = Specification (dBuV/m) + Amplifier (dB) – Antenna Factor (dB/m) – Cable Loss (dB).

PM5 nRF51422



X. Measurement Results:

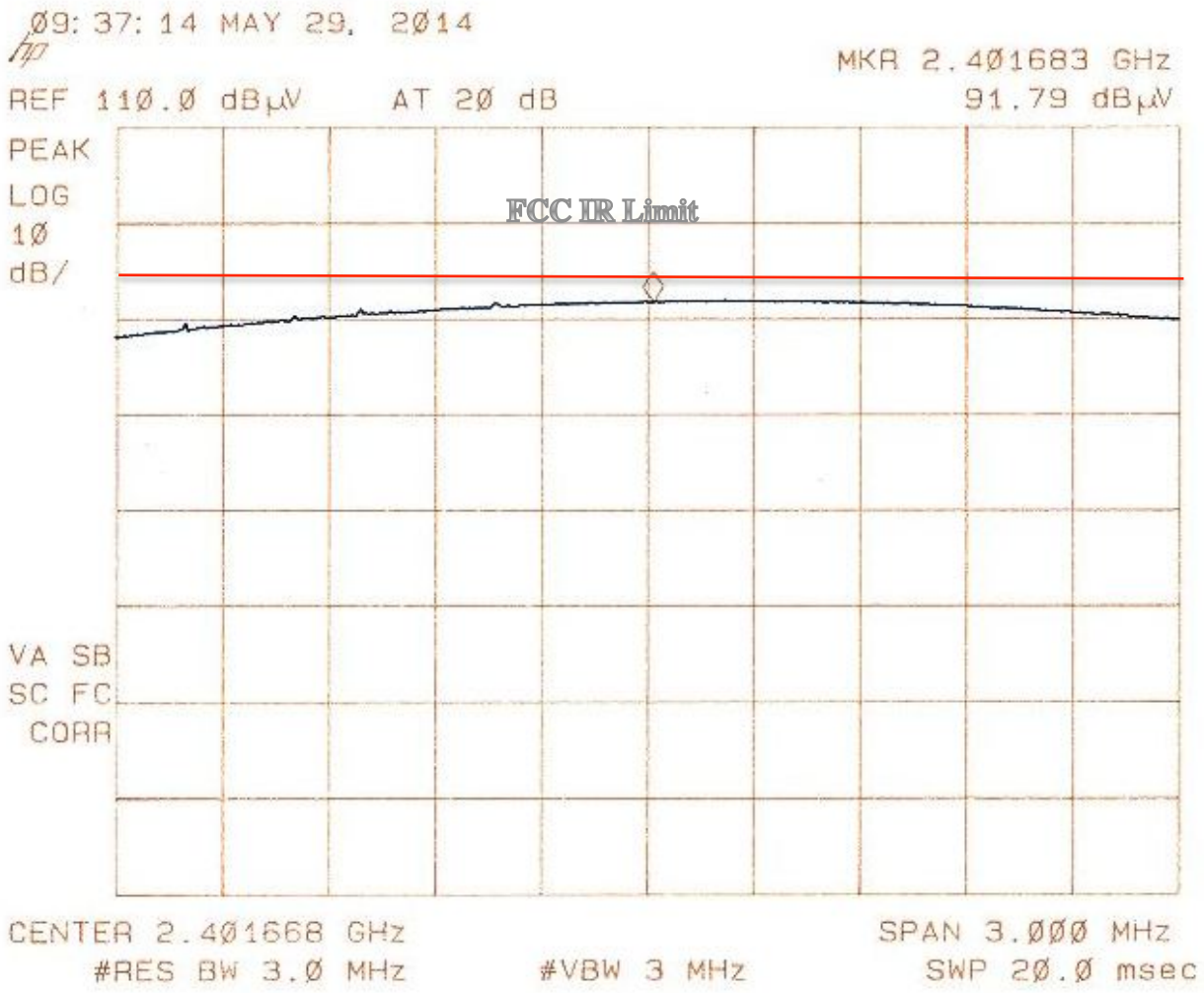
1. RF Power Output.

Specification uV/m	Specification dBuV/m	Amplifier dB	Antenna Factor dB	Cable Loss dB	Corrected Limit dBuV
50,000	94	30.0	29.0	1	94

Table 2 – RF-Power Corrected Limit

Corrected Power (dBm) = Specification (dBuV/m) + Amplifier (dB) – Antenna Factor (dB/m) – Cable Loss (dB).

PM5 nRF51822

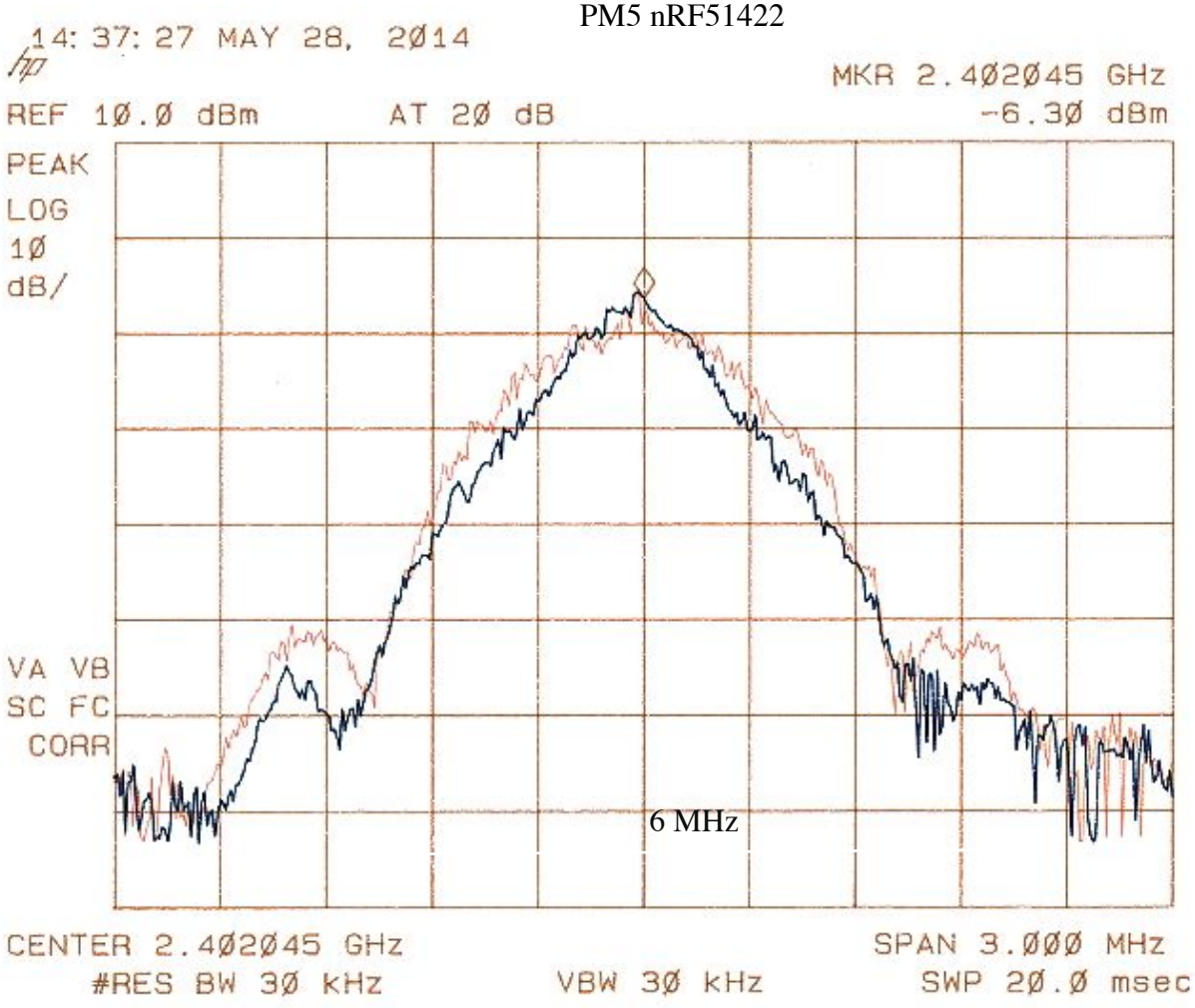


X. Measurement Results Cont'd:

2. Modulation Characteristic.

Black trace is Bluetooth, Brown trace is ANT+.

PM5 nRF51422

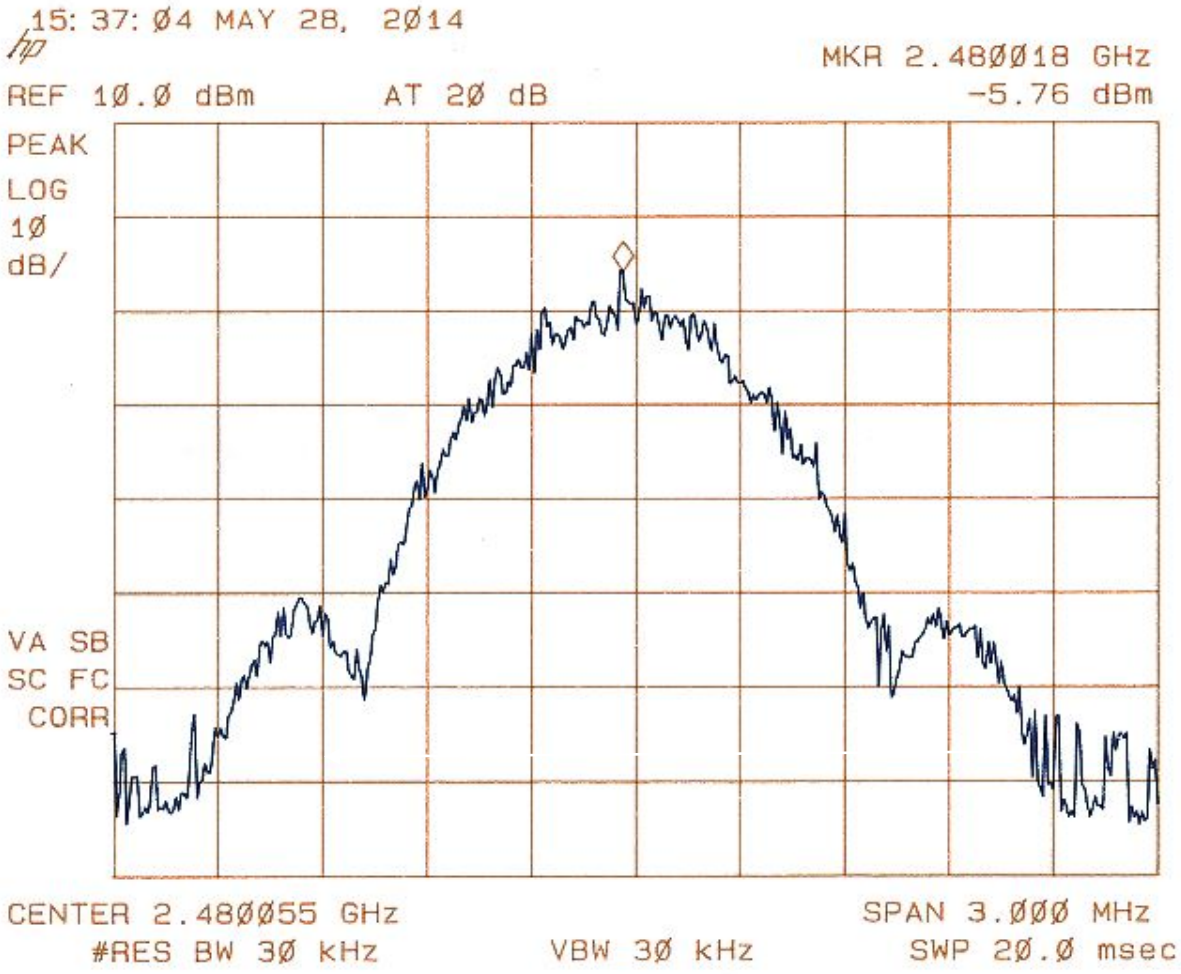


X. Measurement Results Cont'd:

2. Modulation Characteristic.

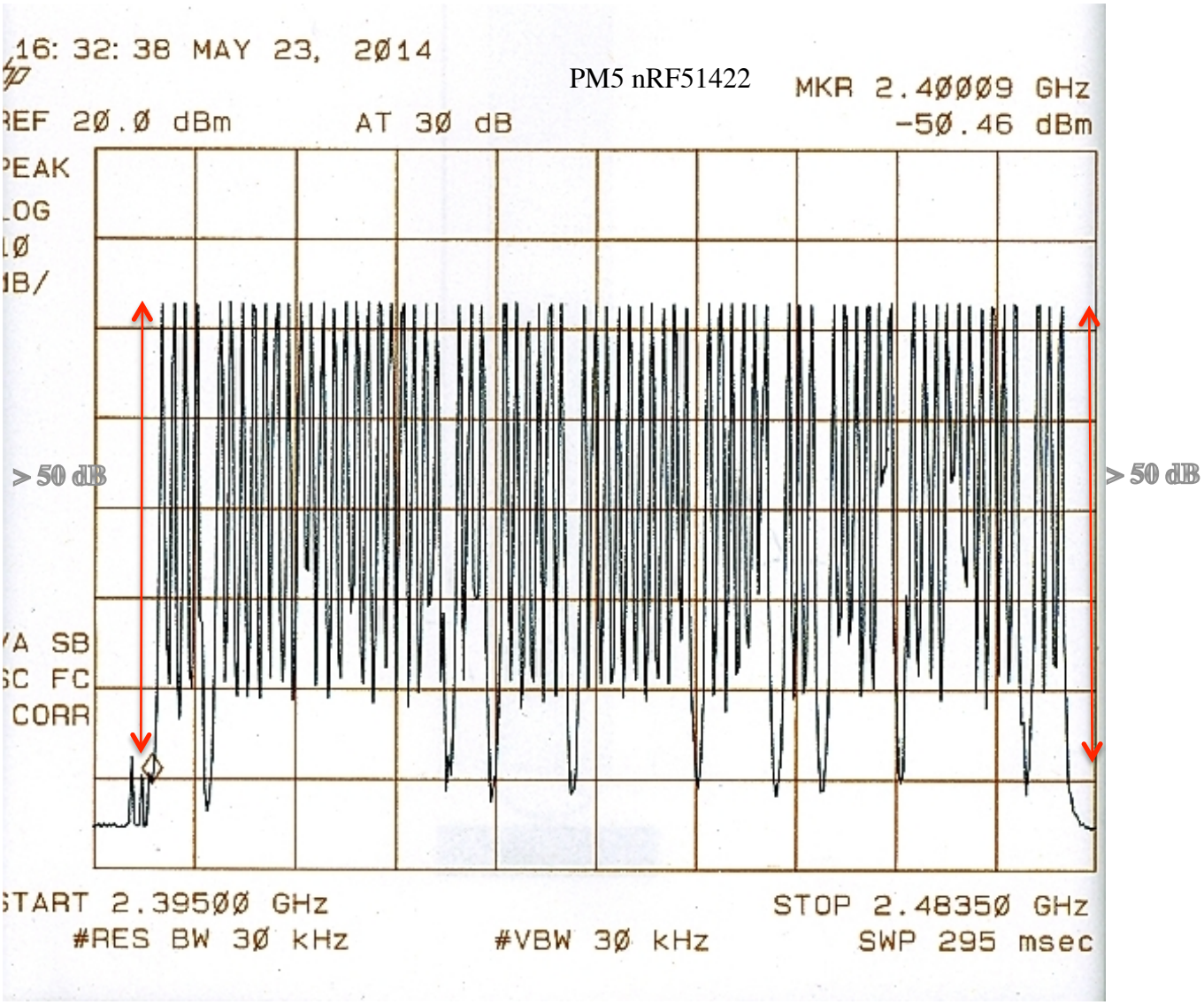
Black trace is Bluetooth.

PM5 nRF51822



X. Measurement Results Cont'd:

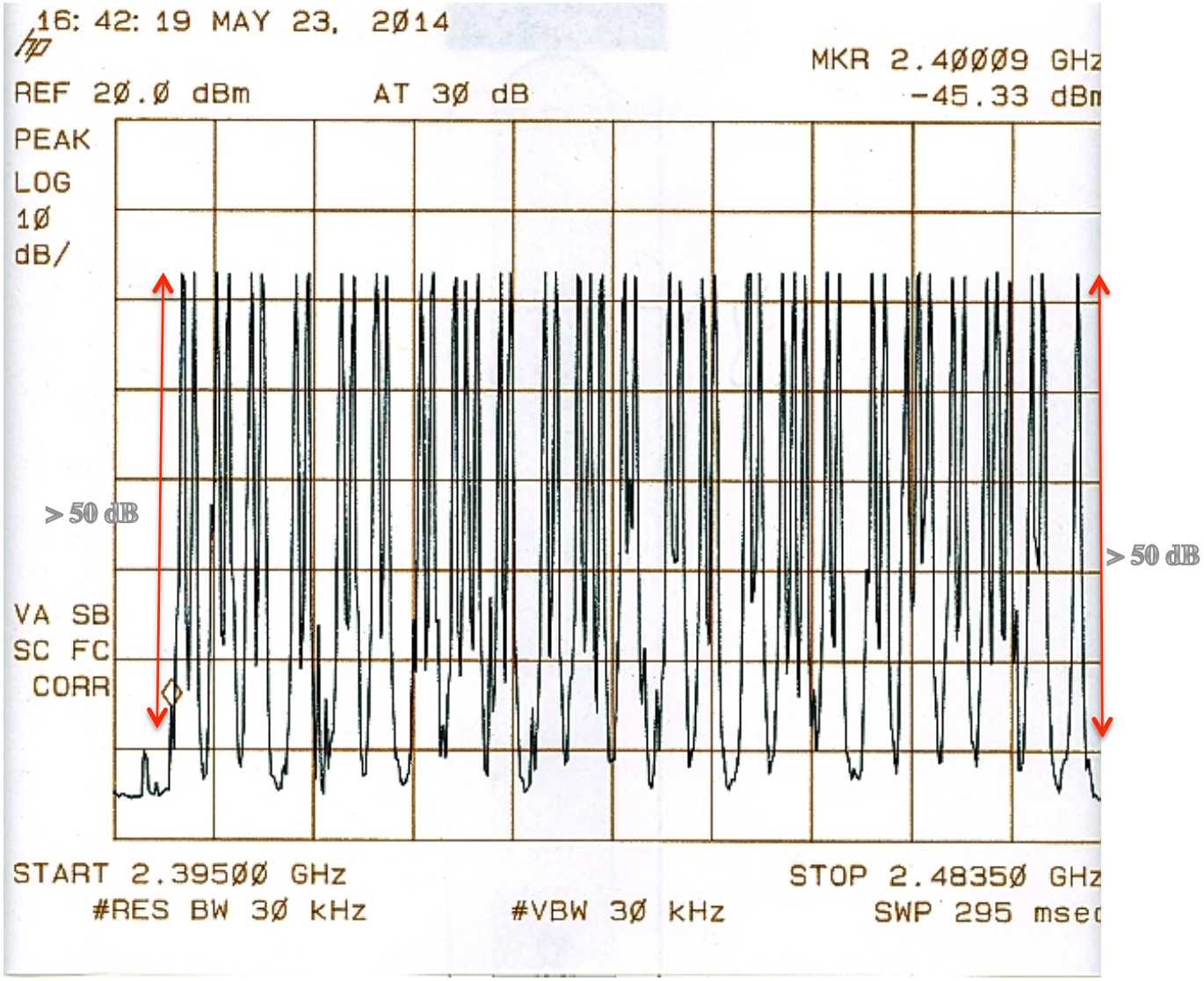
3. Occupied Bandwidth.



X. Measurement Results Cont'd:

3. Occupied Bandwidth.

PM5 nRF51822



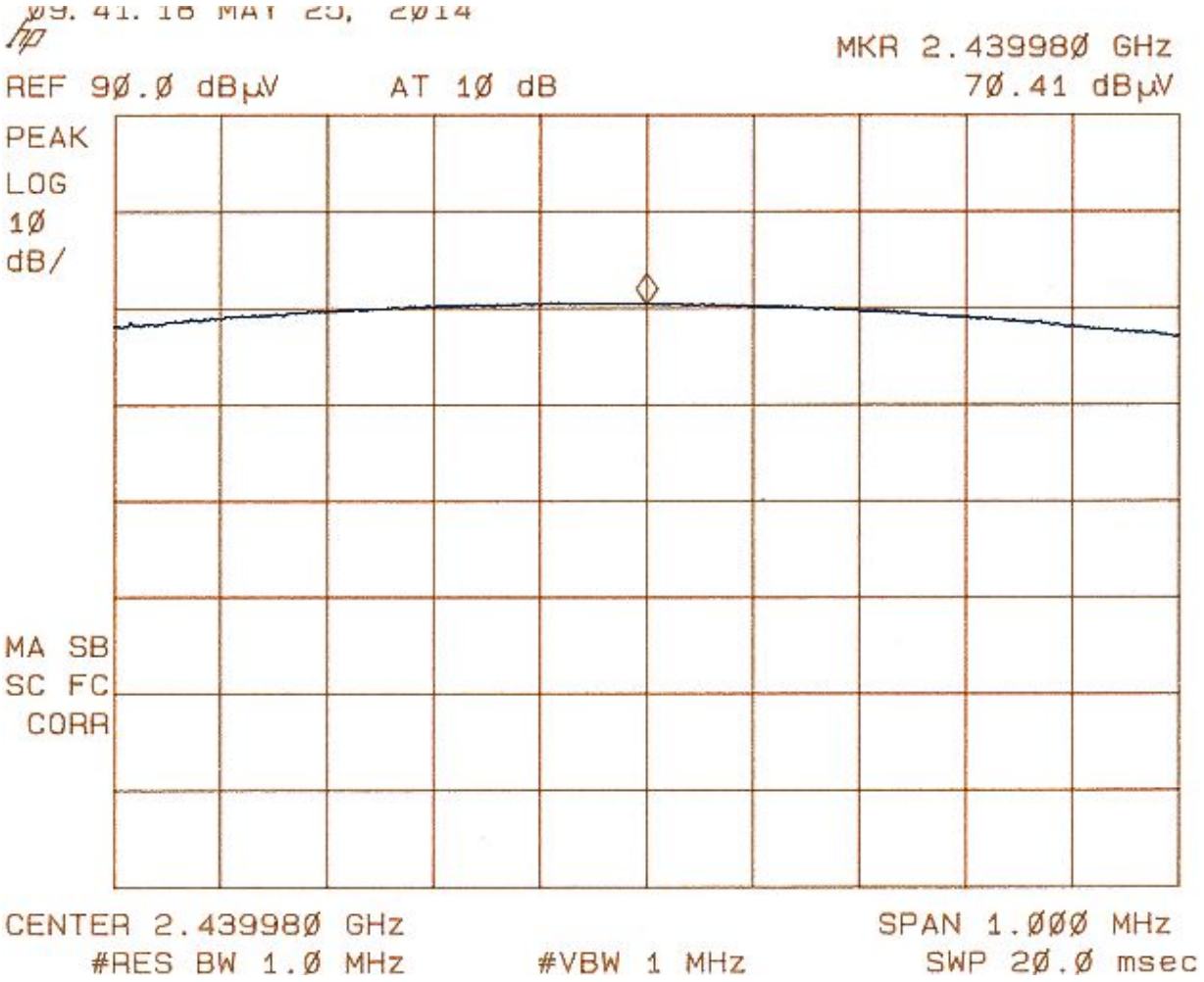
X. Measurement Results Cont'd:

4. Frequency Stability.

Frequency: 2439.980 MHz

Specification: 3 VDC (Normal Operation)

The graph below is the baseline for the measurements.



X. Measurement Results Cont'd:

4. Frequency Stability.

Frequency: 2439.980 MHz
Specification: 3 VDC to Battery End (Normal Operation)

The tables below show that there is not any variation in frequency with selected applied voltage or temperature:

Voltage (VDC)	Frequency (MHz)
3	2439.980
2.8	2439.980
2.6	2439.980

Table 3 – Frequency Vs. Voltage – PM5

Temperature (˚C)	Frequency (MHz)
-30	2439.980
-20	2439.980
-10	2439.980
0	2439.980
10	2439.980
20	2439.980
30	2439.980
40	2439.980
50	2439.980

Table 4 – Frequency Vs. Temperature – PM5

X. Measurement Results Cont'd:

5. Radiated Emissions.

Vertical Polarization

The table below describes the correction factors necessary to apply the limit to the spectrum analyzer output. The following page contains the spectrum analyzer output with the corrected specification limits superimposed. The green trace is the ambient condition, and the orange trace identifies EUT emissions. Maximum amplitudes of vertical polarization are shown in the results below.

Note: Occasional known ambient signals may persist (e.g. local AM/FM/Cell). Unit produced no discernible emissions so data is interpolated through any known ambient signal. Units producing in-band emissions are examined at nearer measurement distances.

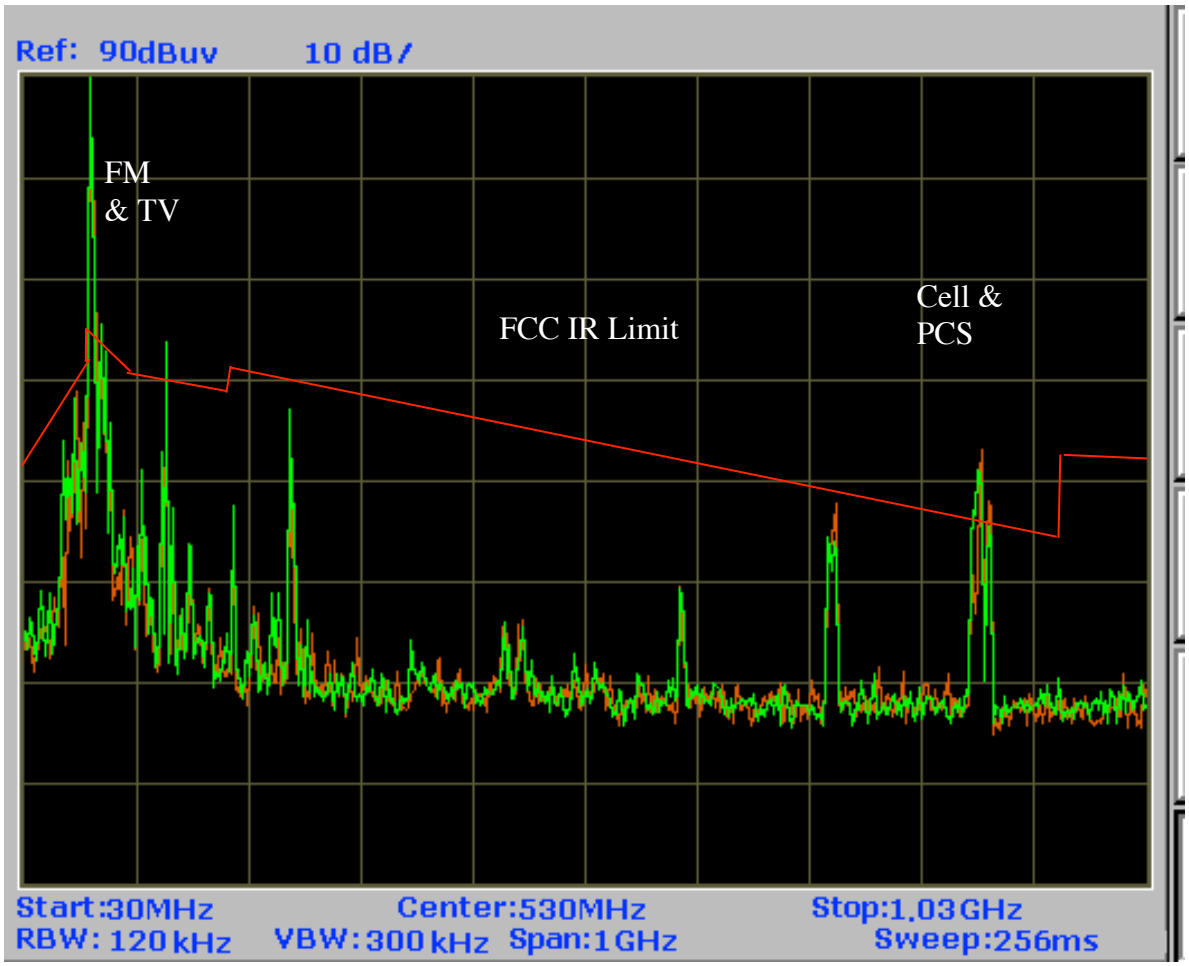
Frequency MHz	IR limit @ 3m dBuV	Amp Gain dB	Antenna Factor dB	Cable Loss dB	Corrected Limit dBuV
30	40	30	17.2	1	51.8
50	40	30	13.6	1	55.4
88	40	30	7.5	1	61.5
89	43.5	30	7.5	1	65.0
125	43.5	30	8.9	2	62.6
150	43.5	30	12.2	3	58.3
216	43.5	30	11.6	3	58.9
217	46	30	11.6	3	61.4
300	46	30	13.9	3	59.1
500	46	30	16.9	6	53.1
960	46	30	23.2	8	44.8
961	54	30	23.2	8	52.8

Table 5 – Corrected Limit - Vertical Polarization

X. Measurement Results Cont'd:

5. Radiated Emissions.

PM5
Maximum of Vertical Polarization
All Ambient – No Discernible Emissions
in Near Field



X. Measurement Results Cont'd:

5. Radiated Emissions.

Horizontal Polarization

The table below describes the correction factors necessary to apply the limit to the spectrum analyzer output. The following page contains the spectrum analyzer output with the corrected specification limits superimposed. The green trace is the ambient condition, and the orange trace identifies EUT emissions. Maximum amplitudes of horizontal polarization are shown in the results below.

Note: Occasional known ambient signals may persist (e.g. local AM/FM/Cell). Unit produced no discernible emissions so data is interpolated through any known ambient signal. Units producing in-band emissions are examined at nearer measurement distances.

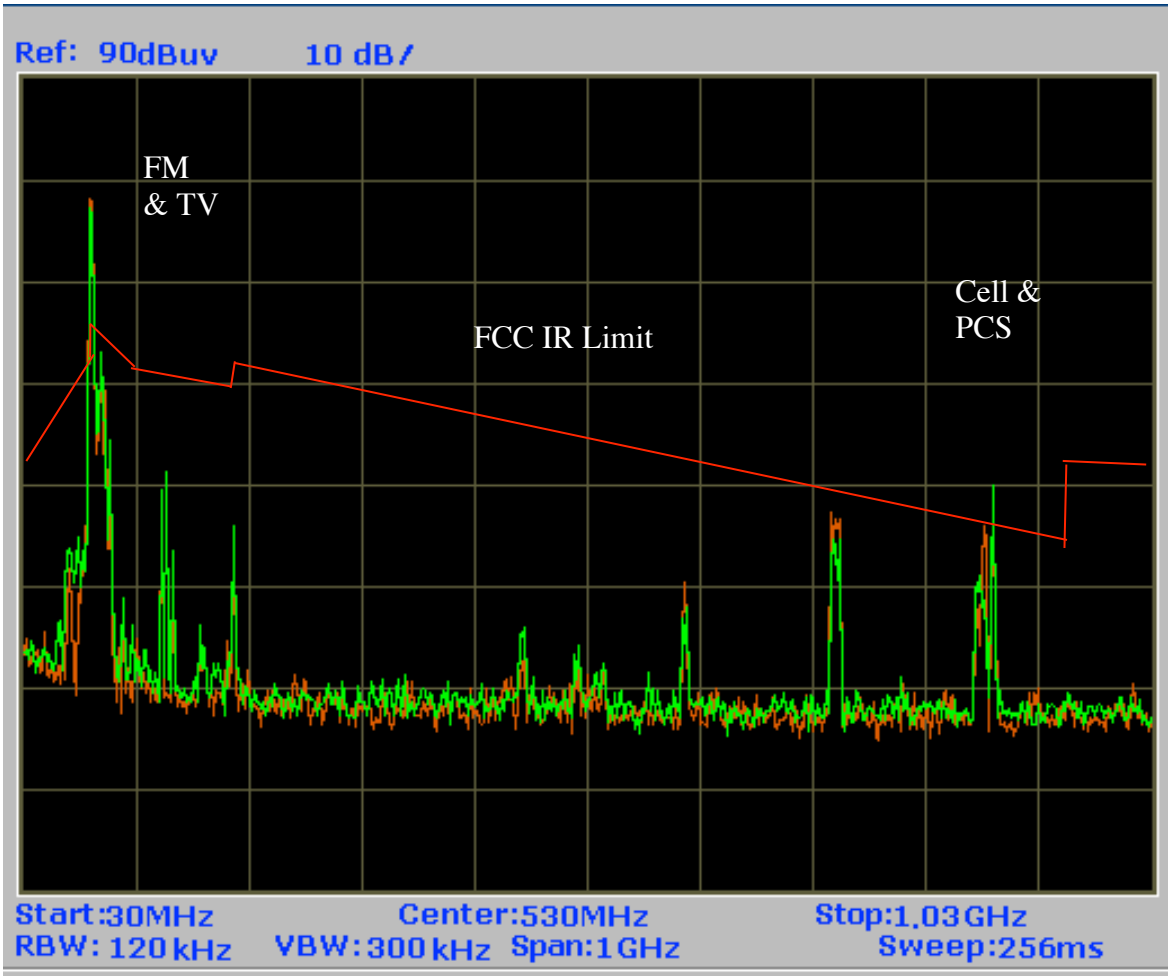
Frequency MHz	IR limit @ 3m dBuV	Amp Gain dB	Antenna Factor dB	Cable Loss dB	Corrected Limit dBuV
30	40	30	16.2	1	52.8
50	40	30	14.8	1	54.2
88	40	30	6.7	1	62.3
89	43.5	30	6.7	1	65.8
125	43.5	30	10.3	2	61.2
150	43.5	30	12.3	3	58.2
216	43.5	30	11.6	3	58.9
217	46	30	11.6	3	61.4
300	46	30	13.3	3	59.7
500	46	30	16.6	6	53.4
960	46	30	22.8	8	45.2
961	54	30	22.8	8	53.2

Table 6 – Corrected Limit - Horizontal Polarization

X. Measurement Results Cont'd:

5. Radiated Emissions.

PM5
Maximum of Horizontal Polarization
All Ambient – No Discernible Emissions
in Near Field



X. Measurement Results Cont'd:

5. Radiated Emissions.

Vertical & Horizontal Polarization >1 GHz.

The table below describes the correction factors necessary to apply the limit to the spectrum analyzer output. The following pages contain the spectrum analyzer output with the corrected specification limits superimposed. The green trace is the ambient condition, and the orange trace identifies EUT emissions. Maximum amplitudes of both polarizations are shown in the results below.

Frequency	IR limit @ 3m	Amp Gain	Antenna Factor	Cable Loss	Corrected Limit
MHz	dBuV	dB	dB	dB	dBuV
1000	54	30	24	3	57
2400	54	30	28	6	50
2750	54	30	31	7	46

Table 7 – Corrected Limit - >1 GHz

X. Measurement Results Cont'd:

5. Radiated Emissions.

PM5
Maximum of Vertical
Polarization

X. Measurement Results Cont'd:

5. Radiated Emissions.

PM5
Maximum of Horizontal
Polarization

X. Measurement Results Cont'd:

5. Radiated Emissions.

Vertical & Horizontal Polarization >3 GHz.

The table below describes the correction factors necessary to apply the limit to the spectrum analyzer output. The following page contains the spectrum analyzer output with the corrected specification limits superimposed. The black trace is the ambient condition, and the green trace identifies EUT emissions. Maximum amplitudes of both polarizations are shown in the results below.

Frequency	IR limit @ 3 m	Distance Correction *Note	Amp Gain	Antenna Factor	Cable Loss	Corrected Limit
GHz	dBuV	dB	dB	dB	dB	dBuV
3	54	20	40	35.0	8	71
25	54	20	40	46.0	12	56

Table 8 – Corrected Limit - >3 GHz

- Unit brought to 30 cm of antenna.
- Near field at ≥3 GHz is ≤10 cm, so antenna is not in reactive field of EUT.

Limits appearing on the spectrum analyzer data were corrected for the appropriate antenna factor, cable loss, amplifier gain (when used) and measurement distances X_{std} and X_{site} in meters.

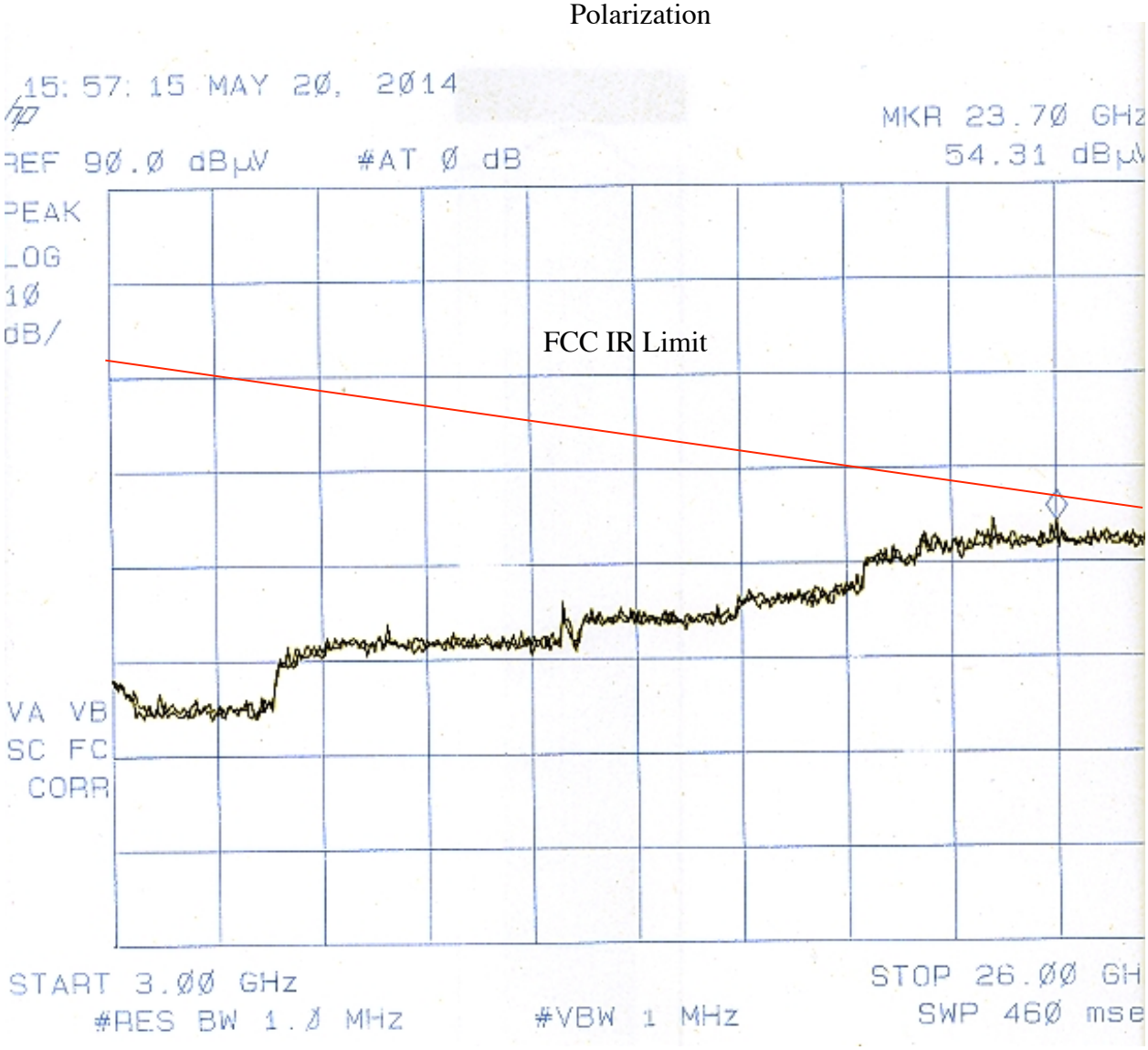
The following equation was employed:

- Corrected Limit (dBuV) = Limit (dBuV/m) + 20 Log(X_{std}/X_{site}) + Amplifier Gain (dB) – Antenna Factor (dB/m) – Cable Loss (dB).
- Sample calculation at 2750 MHz:
- 71 dBuV corrected limit = 54.0 dBuV/m limit + 20 log(3/0.3) dB distance + 40 dB amp gain – 35 dB/m AF – 8 dB cable loss.
- Note that 20 Log(X_{std}/X_{site}) = 20 Log 3/0.3 = 20 dB

X. Measurement Results Cont'd:

5. Radiated Emissions.

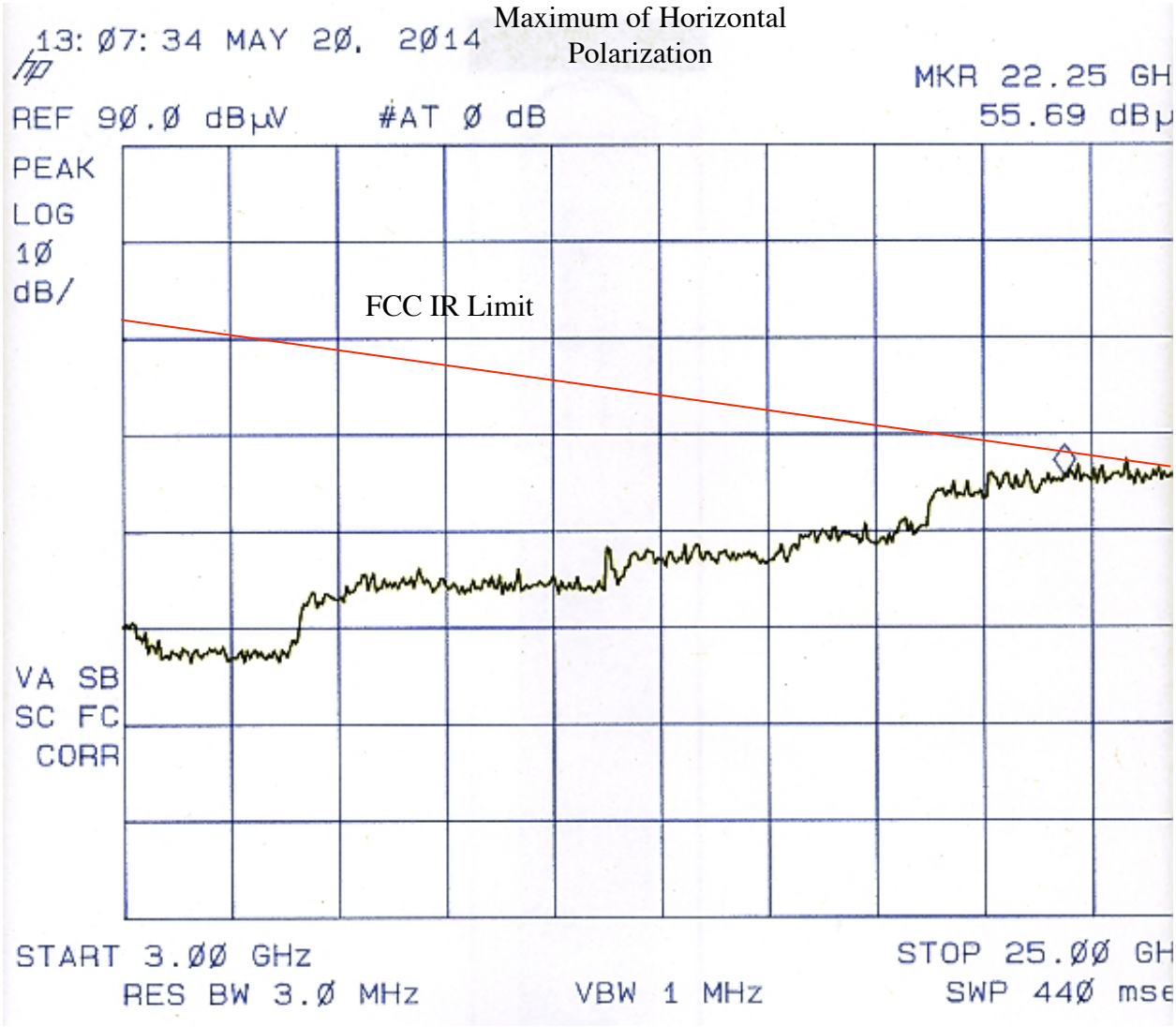
PM5
Maximum of Vertical
Polarization



X. Measurement Results Cont'd:

5. Radiated Emissions.

PM5
Maximum of Horizontal
Polarization



X. Measurement Results Cont'd:

6. Exposure Evaluation.

The analysis below compares the measured power to the maximum permissible exposure limit for general population with uncontrolled access. The PM5 can be used continuously; no special averaging time or limit relaxations are employed. Maximum peak available power is used in calculations.

Unit Frequency: 2.4 GHz
Unit Maximum Average Power .001 Watt available (-4 dBm from design)
Standard User Weight: 100 kg

Specific Absorption Rate (SAR) Limit for whole-body: 0.08 W/kg
Specific Absorption Rate (SAR) Limit for one-gram tissue volume: 1.6 W/kg

SAR Whole body = .001 W/100 kg = 0.00001 W/kg for PM5
SAR 1g tissue = .001 W/.001 kg * = 1 W/kg for PM5

In addition per IEEE C95.1 paragraph 6.10 (2): low power devices are unlikely to expose users in excess of the criteria when power is less than or equal to:
Pmax = 1.4 * (450/f) Watts where f is in MHz.
Pmax is significantly greater than the power available at the PM5:
Pmax = 1.4 * (450/2400) = 0.26 W.