



Measurement of RF Interference from an PM920 Personnel Module Transceiver

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|----------------|--|
| For | Metrom Rail 1125 Mitchell Court Crystal Lake, IL 60014 |
| P.O. Number | 2056 |
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| Test Personnel | Mark Longinotti |
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REVISION HISTORY

| Revision | Date | Description |
|----------|--------------|-----------------|
| — | 23 June 2016 | Initial release |
| | | |

Measurement of RF Emissions from a Personnel Module, Part No. PM920 Transceiver

1. INTRODUCTION

1.1 Scope of Tests

This document represents the results of the series of radio interference measurements performed on a Metrom Rail Personnel Module, Part No. PM920, Serial No. None Assigned, transceiver (hereinafter referred to as the EUT). The EUT is a digital modulation transceiver. The transceiver was designed to transmit and receive in the 2400-2483.5 MHz band using a PC Tel dipole antenna, model number: 100857CMPAntenna, with 3 dBi gain. The EUT was manufactured and submitted for testing by Metrom Rail located in Crystal Lake, IL.

1.2 Purpose

The test series was performed to determine if the EUT meets the conducted RF emission requirements, radiated RF emissions requirements, and additional provisions of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and 15.109, for receivers and Subpart C, Sections 15.207 and 15.249 for Intentional Radiators Operating within the 2400-2483.5 MHz band.

The test series was also performed to determine if the EUT meets the conducted RF emission requirements, radiated RF emissions requirements, and additional provisions of the Industry Canada Radio Standards Specification RSS-Gen Section 8.8 and Section 7.1.2 for receivers and Industry Canada Radio Standards Specification RSS-Gen Section 8.8 and Industry Canada Radio Standards Specification RSS-247 for Transmitters.

Testing was performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

1.3 Deviations, Additions and Exclusions

There were no deviations, additions to, or exclusions from the test specification during this test series

1.4 EMC Laboratory Identification

This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by the American Association for Laboratory Accreditation (A2LA), A2LA Lab Code: 1786-01.

1.5 Laboratory Conditions

The temperature at the time of the test was 22C and the relative humidity was 31%.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subparts B and C, dated 1 October 2015
- ANSI C63.4-2014, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
- ANSI C63.10-2013, "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"
- Federal Communications Commission Office of Engineering and Technology Laboratory Division, Guidance For Performing Compliance Measurements On Digital Transmissions Systems (DTS) Operating Under §15.247
April 8, 2016

- Industry Canada RSS-247, Issue 1, May 2015, "Spectrum Management and Telecommunications Radio Standards Specification, Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs), and License-Exempt Local Area Network (LE-LAN) Devices"
- Industry Canada RSS-GEN, Issue 4, November 2014, "Spectrum Management and Telecommunications Radio Standards Specification, General Requirements for Compliance of Radio Apparatus"

3. EUT SETUP AND OPERATION

3.1 General Description

The EUT is a Personnel Module, Part No. PM920. A block diagram of the EUT setup is shown as Figure 1 and Figure 2.

3.1.1 Power Input

The EUT was powered by 3.65VDC from an internal Boston Power 5300 Lithium-ion battery.

3.1.2 Peripheral Equipment

No peripheral equipment was submitted with the EUT.

3.1.3 Interconnect Cables

No interconnect cables were submitted with the EUT.

3.1.4 Grounding

The EUT was ungrounded during the tests.

3.2 Software

For all tests the EUT had Firmware Version 1.0.0 loaded onto the device to provide correct load characteristics.

3.3 Operational Mode

The EUT was energized and programmed to transmit continuously at 2441MHz.

3.4 EUT Modifications

No modifications were required for compliance.

4. TEST FACILITY AND TEST INSTRUMENTATION

4.1 Shielded Enclosure

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. With the exception of the floor, the reflective surfaces of the shielded chamber are lined with ferrite tiles on the walls and ceiling. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2014 for site attenuation.

4.2 Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1.

Conducted and radiated emission tests were performed with an EMI receiver utilizes the bandwidths and detectors specified by the FCC.

4.3 Calibration Traceability

Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

4.4 Measurement Uncertainty

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

The measurement uncertainty for these tests is presented below:

| Conducted Emissions Measurements | | |
|---------------------------------------|------|-------|
| Combined Standard Uncertainty | 1.06 | -1.06 |
| Expanded Uncertainty (95% confidence) | 2.12 | -2.12 |

| Radiated Emissions Measurements | | |
|---------------------------------------|------|-------|
| Combined Standard Uncertainty | 2.09 | -2.09 |
| Expanded Uncertainty (95% confidence) | 4.19 | -4.19 |

5. TEST PROCEDURES

5.1 Receiver

Per the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Section 15.101(b), receivers operating above 960MHz are exempt from complying with the technical provisions of part 15.

Per Industry Canada RSS-Gen, Section 5.5, only radio communication receivers operating in stand-alone mode within the band 30-960 MHz, as well as scanner receivers, are subject to Industry Canada requirements. All other receivers are exempted from any Industry Canada certification, testing, labeling and reporting requirements.

5.2 Transmitter

5.2.1 Powerline Conducted Emissions

5.2.1.1 Requirements

Since the EUT was powered by internal batteries and has no connections for AC power, no conducted emissions tests are required.

5.2.2 6dB Bandwidth

5.2.2.1 Requirements

Per 15.247(a)(2), the minimum 6dB bandwidth shall be at least 500kHz for all systems using digital modulation techniques.

5.2.2.2 Procedures

The antenna port of the EUT was connected to the spectrum analyzer through 30dB of attenuation.

The EUT was allowed to transmit continuously at 2441MHz. The resolution bandwidth (RBW) was set to 100kHz,

the video bandwidth (VBW) was set to the same as or 3 times greater than the RBW, and the span was wider than the 6dB bandwidth.

The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

5.2.2.3 Results

The plot on page 20 shows that the minimum 6 dB bandwidth was 54.51MHz which is greater than minimum allowable 6dB bandwidth requirement of 500kHz for systems using digital modulation techniques. The 99% bandwidth was measured to be 58.83MHz.

5.2.3 Peak Output Power and EIRP

5.2.3.1 Requirements

Per section 15.247(b)(3), for systems using digital modulation the maximum peak output conducted power shall not be greater than 1.0W (30dBm). Per section 15.247(b)(4), this limit is based on the use of antennas with directional gains that do not exceed 6dBi. Since the limit allows for a 6dBi antenna gain, the maximum EIRP can be increased by 6dB to 4 Watt (36dBm).

5.2.3.2 Procedures

The antenna port of the EUT was connected to a wideband power sensor, Keysight M/N: N1923A, through 30dB of attenuation. The output of the power sensor was connected to a peak power analyzer, Keysight M/N: 8990B. The EUT was programmed to transmit at 2441MHz. The peak power reading was measured and recorded (correcting for the external attenuation). The gain of the antenna was added to the conducted peak power reading to determine the peak EIRP.

5.2.3.3 Results

The results are presented on pages 21 and 22. The maximum peak output power was 15.38dBm which is below the 30.0dBm limit. The EIRP from the transmitter was 18.38dBm which is below the 36.0dBm limit.

5.2.4 Duty Cycle Factor Measurements

5.2.4.1 Procedures

The duty cycle factor is used to convert peak detected readings to average readings. This factor is computed from the time domain trace of the pulse modulation signal.

With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 0.5msec/div. The amplitude settings are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at the beginning and end of the "on-time" for each pulse. The trace is recorded.

Next the spectrum analyzer center frequency is set to the transmitter frequency with a zero span width and 10msec/div. This shows if the word is longer than 100msec or shorter than 100msec. If the word period is less than 100msec, the display is set to show at least one word. The on-time and off-time are then measured. The on-time is total time signal level exceeds the 4th division. Off-time is time under for the word period. The duty cycle is then computed as the (On-time/ word period) where the word period = (On-time + Off-time).

5.2.4.2 Results

The plots of the duty cycle are shown on data pages 23 through 27. As can be seen from the data, the EUT transmits 4 pulses every 100msec. The total on time of the pulses is 2.084msec. The duty cycle correction factor was calculated to be -33.6dB (-33.6dB = 20*log(2.084msec/100msec)).

5.2.5 Radiated Spurious Emissions Measurements

5.2.5.1 Requirements

Per section 15.247(d), in any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated emissions measurement. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must comply with the radiated emission limits specified in §15.209(a).

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must comply with the radiated emission limits specified in §15.209(a).

Paragraph 15.209(a) has the following radiated emission limits:

| Frequency MHz | Field Strength (microvolts/meter) | Measurement distance (meters) |
|------------------|--------------------------------------|----------------------------------|
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 3 |
| 30.0-88.0 | 100 | 3 |
| 88.0-216.0 | 150 | 3 |
| 216.0-960.0 | 200 | 3 |
| Above 960 | 500 | 3 |

5.2.5.2 Procedures

Radiated measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads.

Preliminary radiated emissions tests were performed to determine the emission characteristics of the EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 30MHz to 25GHz was investigated using a peak detector function.

The final open field emission tests were then manually performed over the frequency range of 30MHz to 25GHz.

- 1) For all harmonics not in the restricted bands, the following procedure was used:
 - a) The field strength of the fundamental was measured using a double ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. The EUT was placed on a 1.5 meter high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.
 - b) The field strengths of all of the harmonics not in the restricted band were then measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. The EUT was placed on a 1.5 meter high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.
 - c) To ensure that maximum or worst case emission levels at the fundamental and harmonics were measured, the following steps were taken when measuring the fundamental emissions and the spurious emissions:
 - i) The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were

measured.

- iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.
- iv) In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer. The measuring antenna was not raised or lowered to ensure maximized readings, instead the EUT was rotated through all axis to ensure the maximum readings were recorded for the EUT.
- d) All harmonics not in the restricted bands must be at least 20 dB below levels measured at the fundamental. However, attenuation below the general limits specified in §15.209(a) is not required.

2) For all emissions in the restricted bands, the following procedure was used:

- a) The field strengths of all emissions below 1 GHz were measured using a bi-log antenna. The bi-log antenna was positioned at a 3 meter distance from the EUT. The EUT was placed on an 80cm high non-conductive stand. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.
- b) The field strengths of all emissions above 1 GHz were measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. The EUT was placed on a 1.5 meter high non-conductive stand. A peak detector with a resolution bandwidth of 1 MHz was used on the spectrum analyzer.
- c) To ensure that maximum or worst case emission levels were measured, the following steps were taken when taking all measurements:
 - i) The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.
 - iv) In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer. The measuring antenna was not raised or lowered to ensure maximized readings, instead the EUT was rotated through all axis to ensure the maximum readings were recorded for the EUT.
- d) For all radiated emissions measurements below 1 GHz, if the peak reading is below the limits listed in 15.209(a), no further measurements are required. If however, the peak readings exceed the limits listed in 15.209(a), then the emissions are remeasured using a quasi-peak detector.
- e) For all radiated emissions measurements above 1 GHz, the peak readings must comply with the 15.35(b) limits. 15.35(b) states that when average radiated emissions measurements are specified, there also is a limit on the peak level of the radiated emissions. The limit on the peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. Therefore, all peak readings above 1 GHz must be no greater than 20 dB above the limits specified in 15.209(a).
- f) Next, for all radiated emissions measurements above 1GHz, the resolution bandwidth was set to 1MHz. The analyzer was set to linear mode with a 10Hz video bandwidth in order to simulate an average detector. An average reading was taken. The reading obtained with the 10 Hz video bandwidth may be further adjusted by a “duty cycle correction factor”, derived from $20 * \log(dwell\ time/100\ msec)$. These readings must be no greater than the limits specified in 15.209(a).

5.2.5.3 Results

Preliminary radiated emissions plots with the EUT transmitting at 2441MHz are shown on pages 28 through 35. Final radiated emissions data are presented on data pages 36 through 38. As can be seen from the data, all emissions measured from the EUT were within the specification limits. The emissions level closest to the limit (worst case) occurred at 7323MHz. The emissions level at this frequency was 16.5dB within the limit.

Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figures 4 through 6.

5.2.6 Band Edge Compliance

5.2.6.1 Requirements

Per section 15.247(d), the emissions at the band-edges must be at least 20dB below the highest level measured within the band but attenuation below the general limits listed in 15.209(a) is not required. In addition, the radiated emissions which fall in the restricted band beginning at 2483.5 MHz must meet the general limits of 15.209(a).

5.2.6.2 Procedures

5.2.6.2.1 Low Band Edge

- 1) The EUT was setup inside the test chamber on a non-conductive stand.
- 2) A broadband measuring antenna was placed at a test distance of 3 meters from the EUT.
- 3) The EUT was set to transmit continuously at the channel closest to the low band-edge.
- 4) The EUT was maximized for worst case emissions at the measuring antenna. The maximum meter reading was recorded.
- 5) To determine the band edge compliance, the following spectrum analyzer settings were used:
 - a. Center frequency = low band-edge frequency.
 - b. Span = Wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, as well as any modulation products which fall outside of the authorized band of operation.
 - c. Resolution bandwidth (RBW) = 100kHz.
 - d. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined.
 - e. The marker was set on the peak of the in-band emissions. A display line was placed 20dB down from the peak of the in-band emissions. All emissions which fall outside of the authorized band of operation must be below the 20dB down display line. (All emissions to the left of the center frequency (band-edge) must be below the display line.)
 - f. The analyzer's display was plotted using a 'screen dump' utility.

5.2.6.2.2 High Band Edge

- 1) The EUT was set to transmit continuously at the channel closest to the high band-edge.
- 2) A double ridged waveguide was placed 3 meters away from the EUT. The antenna was connected to the input of a spectrum analyzer.
- 3) The center frequency of the analyzer was set to the high band edge (2483.5MHz)
- 4) The resolution bandwidth was set to 1MHz.
- 5) To ensure that the maximum or worst case emission level was measured, the following steps were taken:
 - a. The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - b. Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - c. The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
- 6) The highest measured peak reading was recorded.
- 7) The highest measured average reading was recorded.

5.2.6.3 Results

Pages 39 through 41 show the radiated band-edge compliance results. As can be seen from these plots, the radiated emissions at the low end band edge are within the 20 dB down limits. The radiated emissions at the high end band edge are within the general limits.

5.2.7 Power Spectral Density

5.2.7.1 Requirement

Per section 15.247(e), the peak power spectral density from the intentional radiator shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.2.7.2 Procedures

- 1) The antenna port of the EUT was connected to the spectrum analyzer through a 30dB pad.
- 2) The EUT was set to transmit at 2441MHz.
- 3) To determine the power spectral density, the following spectrum analyzer settings were used:
 - a. Center frequency = transmit frequency
 - b. Span = 1.5 times the DTS (6 dB) bandwidth
 - c. Resolution bandwidth (RBW): $3\text{kHz} \leq \text{RBW} \leq 100\text{kHz}$
 - d. Sweep time = auto
 - e. The peak detector and 'Max-Hold' function was engaged.
 - f. The display line represents the 8 dBm limit
 - g. The analyzer's display was plotted using a 'screen dump' utility.
- 4) If measured value exceeds limit, reduce RBW (no less than 3kHz) and repeat.

5.2.7.3 Results

Page 42 shows the power spectral density results. As can be seen from this plot, the peak power density is less than 8dBm in a 3kHz band during any time interval of continuous transmission.

6. CONCLUSIONS

It was determined that the Metrom Rail Personnel Module, Part No. PM920 digital modulation transceiver, Serial No. None Assigned, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and 15.109 for receivers and Subpart C, Sections 15.207 and 15.247 for Intentional Radiators Operating within the 2400-2483.5 MHz band, when tested per ANSI C63.4-2014 and ANSI C63.10-2013.

It was also determined that the Metrom Rail Personnel Module, Part No. PM920 digital modulation transceiver, Serial No. None Assigned, did fully meet the conducted and radiated RF emission requirements of the Industry Canada Radio Standards Specification, RSS-Gen, Section 8.8 and Section 7.1.2 for receivers and the Industry Canada Radio Standards Specification RSS-Gen Section 8.8 and Radio Standards Specification RSS-247 for transmitters, when tested per ANSI C63.4-2014.

7. CERTIFICATION

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the EUT at the test date. Any electrical or mechanical modification made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

8. ENDORSEMENT DISCLAIMER

This report must not be used to claim product certification, approval, or endorsement by A2LA, NIST or any agency of the Federal Government.

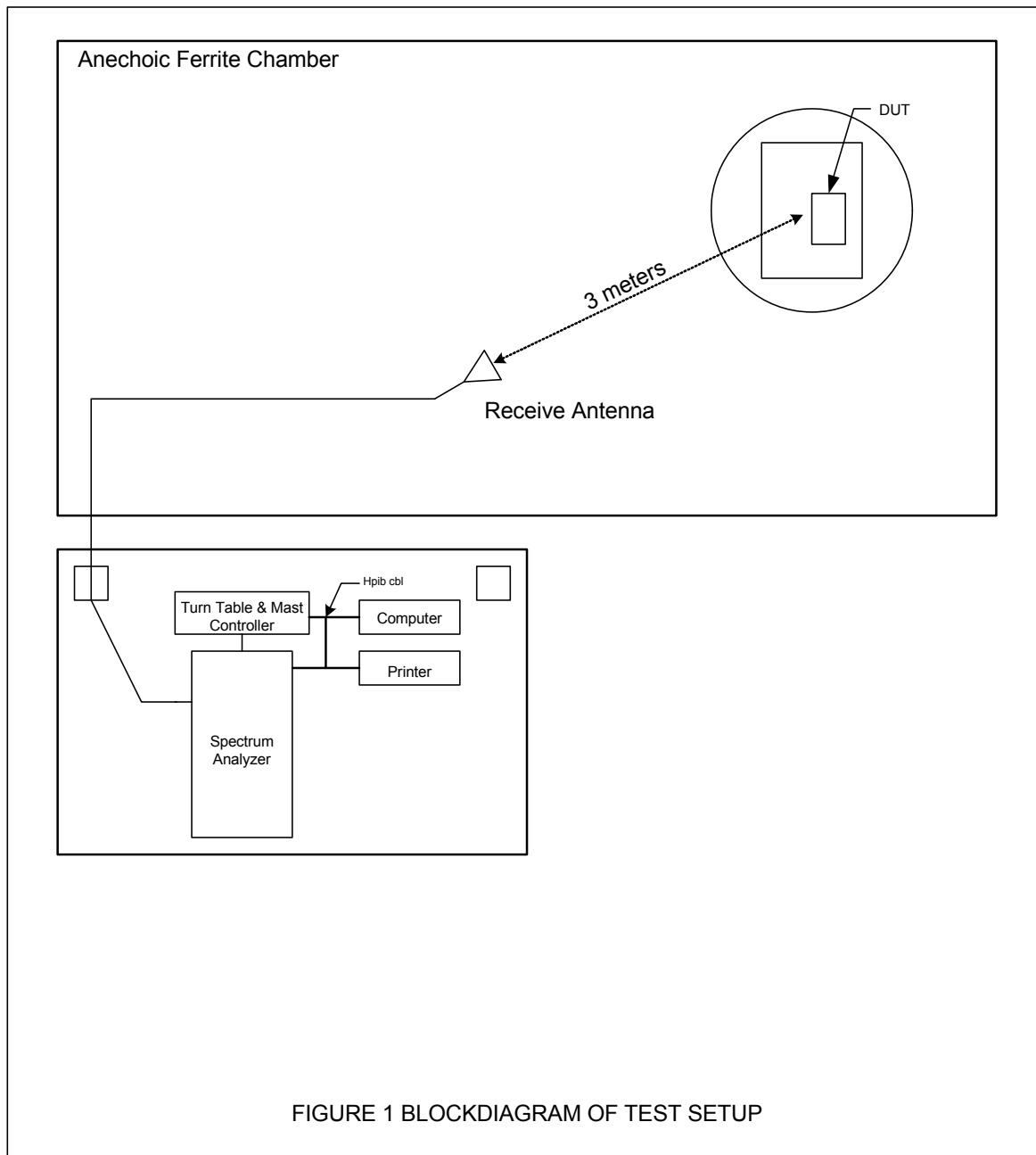
9. EQUIPMENT LIST

Table 9-1 Equipment List

| Eq ID | Equipment Description | Manufacturer | Model No. | Serial No. | Frequency Range | Cal Date | Due Date |
|-------|---------------------------------|--------------------|-----------------|-------------|-----------------|-----------|-----------|
| APW0 | PREAMPLIFIER | PLANAR ELECTRONICS | PE2-30-20G20R6G | PL2926/0646 | 20GHZ-26.5GHZ | 3/2/2016 | 3/2/2017 |
| CDU2 | LAPTOP COMPUTER | DELL | PRECISION | --- | --- | N/A | |
| CDX8 | COMPUTER | ELITE | WORKSTATION | | | N/A | |
| MPW0 | POWER METER | KEYSIGHT | 8990B | MY51000388 | | 2/5/2016 | 2/5/2017 |
| MWPA | WIDEBAND POWER SENSOR | KEYSIGHT | N1923A | MY56080002 | 50MHZ-18GHZ | 2/17/2016 | 2/17/2017 |
| NHG0 | STANDARD GAIN HORN ANTENNA | NARDA | 638 | --- | 18-26.5GHZ | NOTE 1 | |
| NTA3 | BILOG ANTENNA | TESEQ | 6112D | 32853 | 25-1000MHz | 3/23/2016 | 3/23/2017 |
| NWQ1 | DOUBLE RIDGED WAVEGUIDE ANTENNA | ETS-LINDGREN | 3117 | 66655 | 1GHZ-18GHZ | 4/4/2016 | 4/4/2018 |
| RAKG | RF SECTION | HEWLETT PACKARD | 85462A | 3549A00284 | 0.009-6500MHZ | 2/22/2016 | 2/22/2017 |
| RAKH | RF FILTER SECTION | HEWLETT PACKARD | 85460A | 3448A00324 | --- | 2/22/2016 | 2/22/2017 |
| RBA1 | EMI TEST RECEIVER | ROHDE & SCHWARZ | ESIB26 | 100146 | 20HZ-26.5GHZ | 2/12/2016 | 2/12/2017 |
| SES0 | 24VDC POWER SUPPLY | P-TRANS | FS-32024-1M | 001 | 18-27VDC | NOTE 1 | |
| T1E0 | 10DB 25W ATTENUATOR | WEINSCHEL | 46-10-43 | AU1882 | DC-18GHZ | 5/2/2016 | 5/2/2017 |
| T1P0 | 10dB ATTENUATOR (40GHz) | WEINSCHEL | 89-10-12 | 254 | DC-40GHz | 3/3/2016 | 3/3/2018 |
| T2DS | 20DB, 25W ATTENUATOR | WEINSCHEL | 46-20-34 | BS0916 | DC-18GHZ | 6/9/2016 | 6/9/2018 |
| T2Q0 | 20DB, 20W ATTENUATOR | AEROFLEX/WEINSCHEL | 89-20-21 | 337 | DC-40GHZ | 8/20/2015 | 8/20/2017 |
| XOB2 | ADAPTER | HEWLETT PACKARD | K281C,012 | 09407 | 18-26.5GHZ | NOTE 1 | |

I/O: Initial Only N/A: Not Applicable

Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.



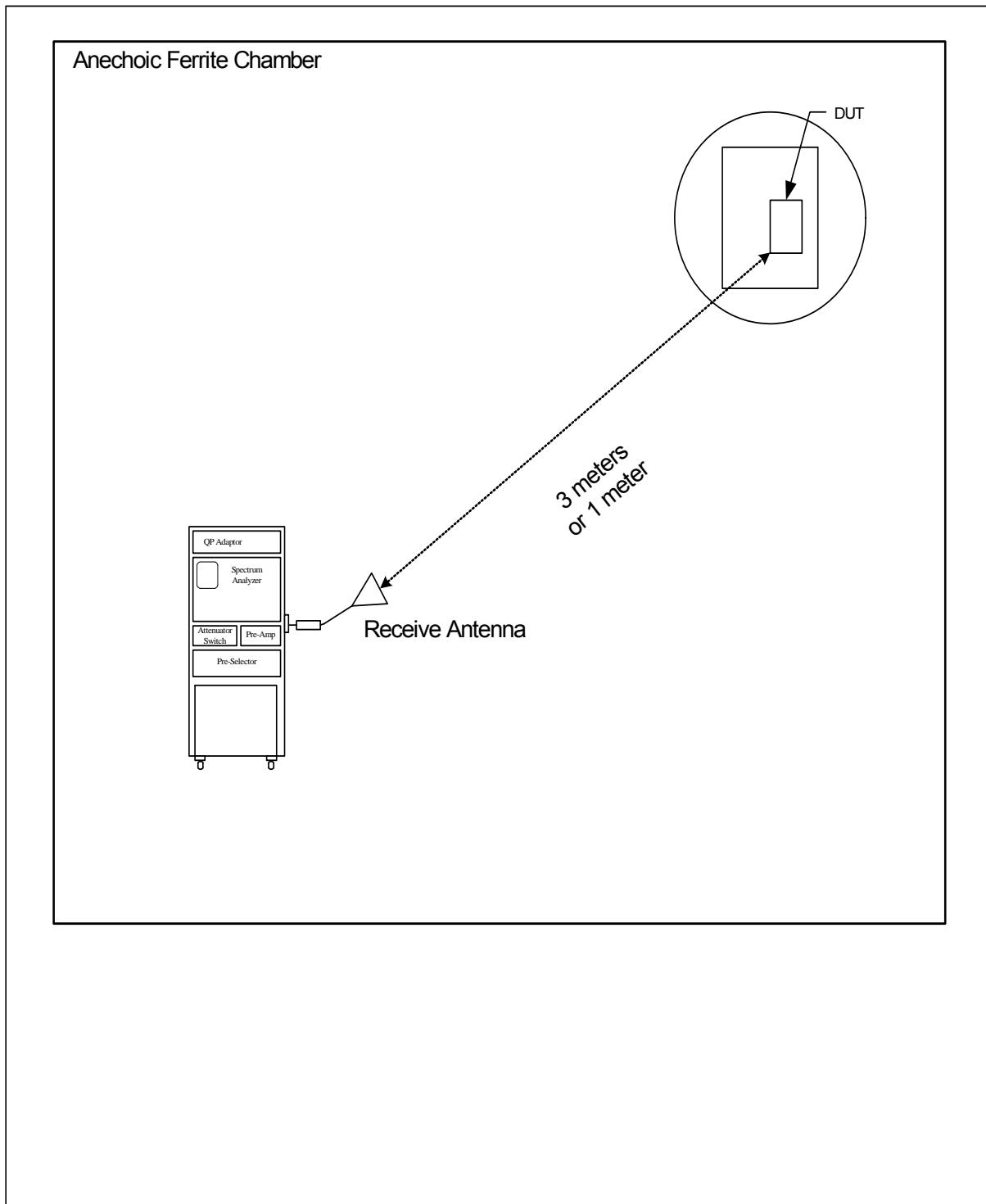


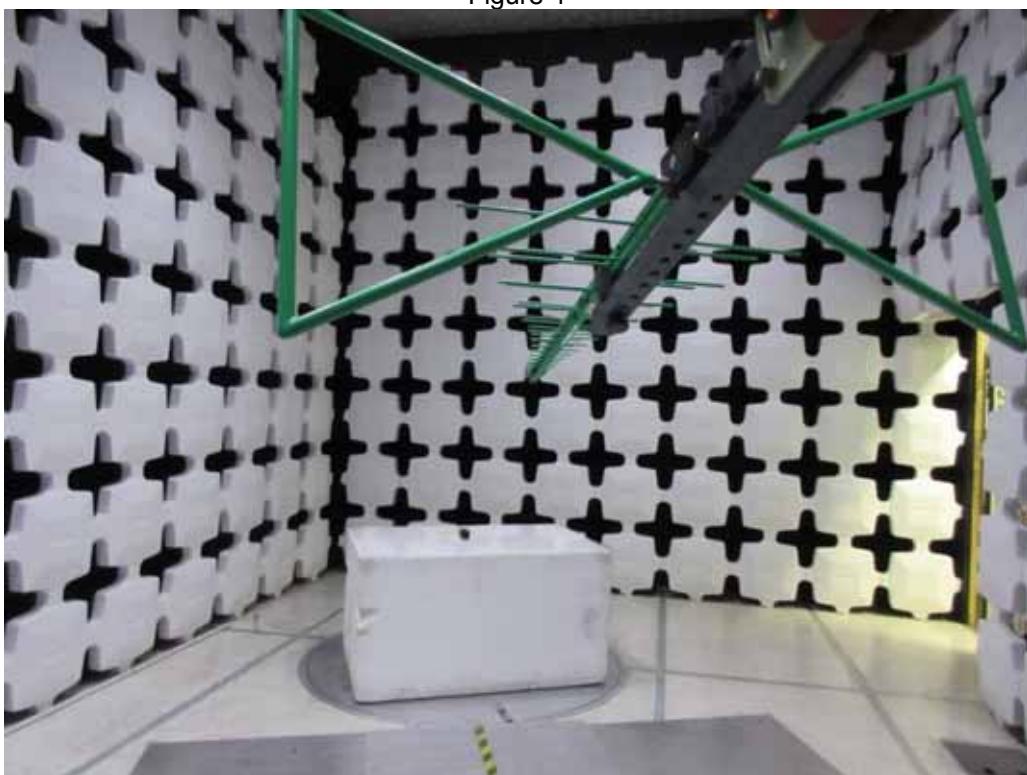
Figure 2: BLOCK DIAGRAM OF TEST SETUP FOR RADIATED EMISSIONS ABOVE 18GHZ

Figure 3



Photograph of the EUT

Figure 4



Test Setup for Radiated Emissions – 30MHz to 1GHz, Horizontal Polarization

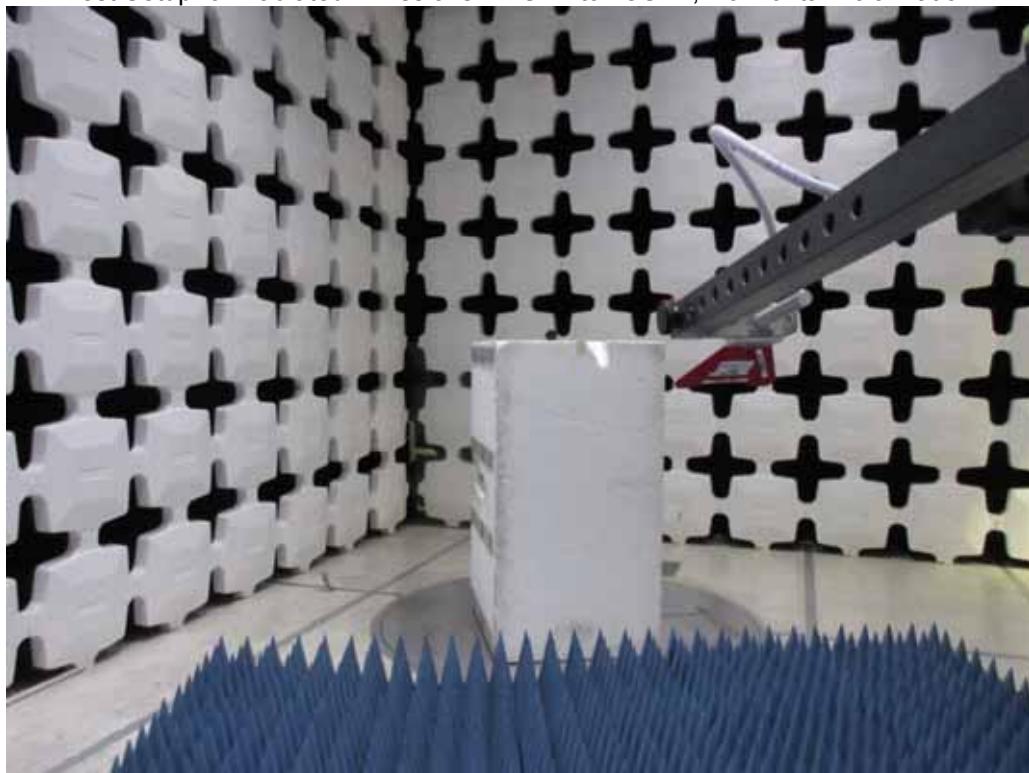


Test Setup for Radiated Emissions – 30MHz to 1GHz, Vertical Polarization

Figure 5



Test Setup for Radiated Emissions – 1GHz to 18GHz, Horizontal Polarization



Test Setup for Radiated Emissions – 1GHz to 18GHz, Vertical Polarization

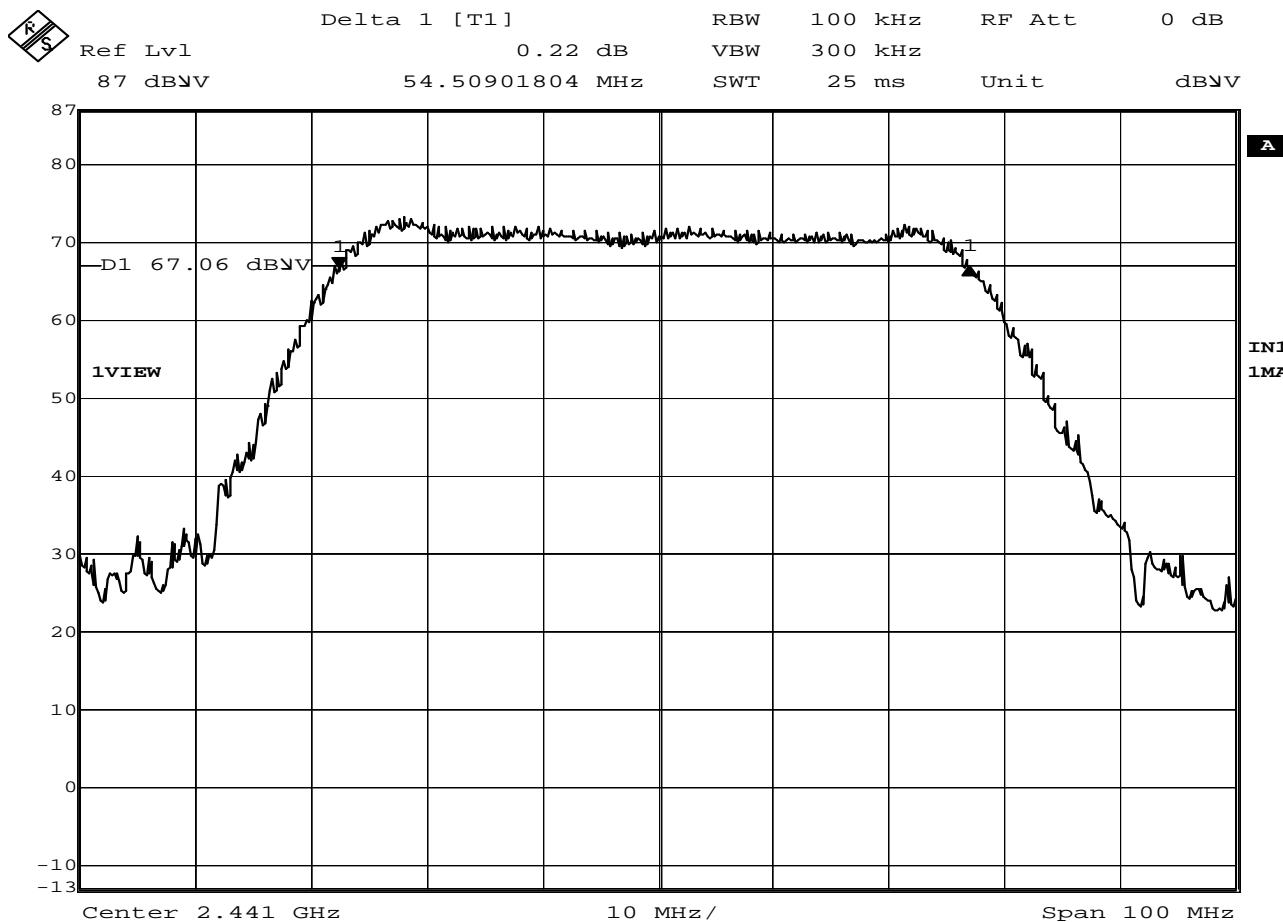
Figure 6



Test Setup for Radiated Emissions – 18GHz to 25GHz, Horizontal Polarization



Test Setup for Radiated Emissions – 18GHz to 25GHz, Vertical Polarization



FCC 15.247 6dB (DTS Bandwidth)

MANUFACTURER : Metrom Rail
 MODEL NUMBER : Personnel Module
 TEST MODE : Transmit at 2441MHz
 NOTES : 6dB (DTS) bandwidth = 54.51MHz
 EQUIPMENT USED : RBA1, T2DS, T1E0

Manufacturer : Metrom Rail
Test Item : Personnel Module
Model No. : PM920
Serial No. : None Assigned
Mode : Transmit at 2441MHz
Test Specification : FCC-15.247, Peak Output Power
Date : June 6, 2016
Equipment Used : MPW0, MWPA, T2DS, T1E0
Notes : Antenna Port Conducted Emissions Tests
Notes : Peak Power Readings with a Peak Power Meter

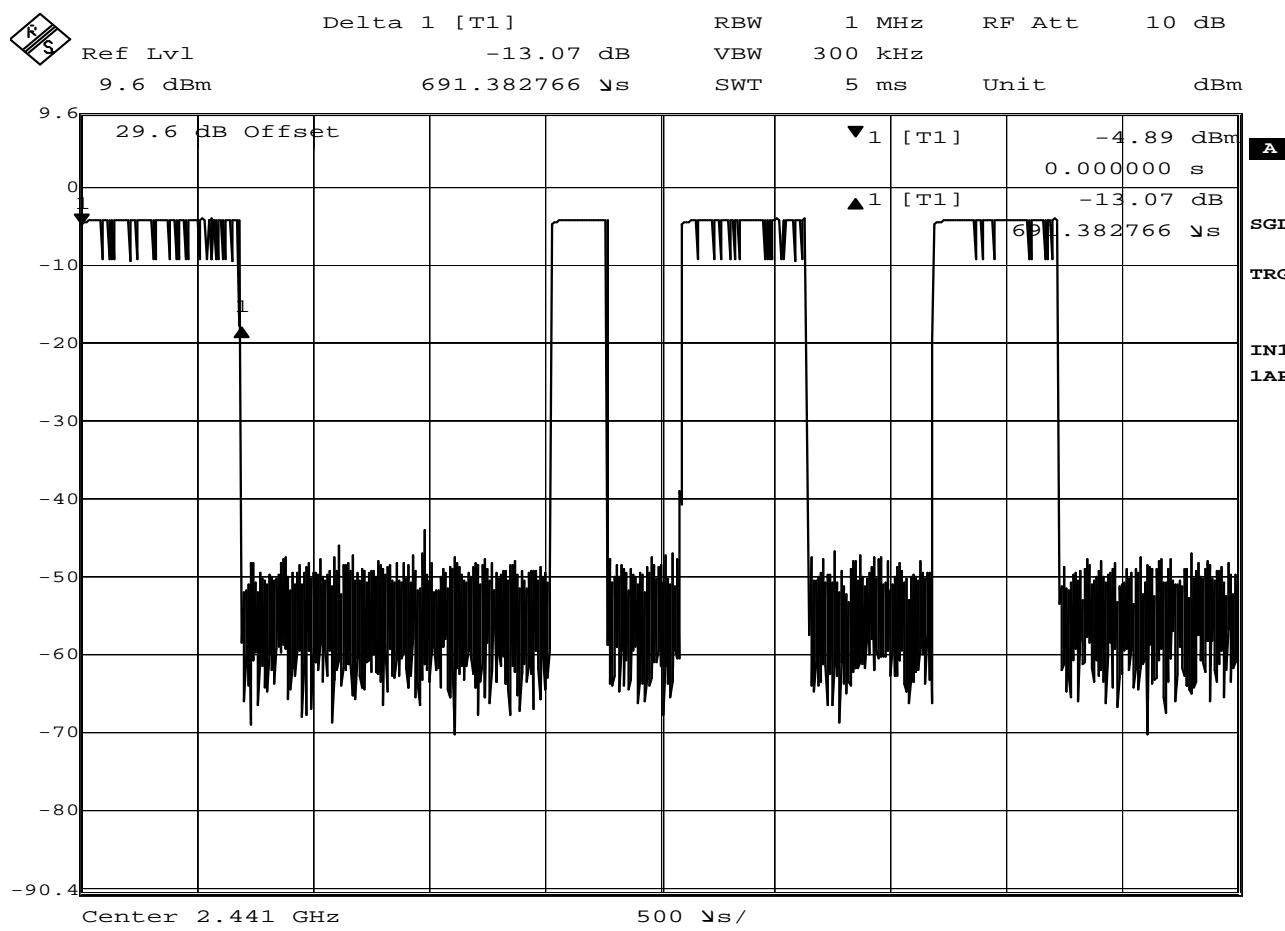
| Frequency MHz | Peak Power Reading dBm | Attenuator dB | Peak Output Power dBm | Peak Output Power Limit dBm |
|------------------|------------------------------|------------------|-----------------------------|-----------------------------------|
| 2441 | -14.38 | 29.76 | 15.38 | 30.0 |

Peak Output Power (dBm) = Peak Power Reading (dBm) + Attenuator (dB)

Manufacturer : Metrom Rail
Test Item : Personnel Module
Model No. : PM920
Serial No. : None Assigned
Mode : Transmit at 2441MHz
Test Specification : FCC-15.247, EIRP
Date : June 6, 2016
Equipment Used : MPW0, MWPA, T2DS, T1E0
Notes : Antenna Port Conducted Emissions Tests
Notes : Peak Power Readings with a Peak Power Meter

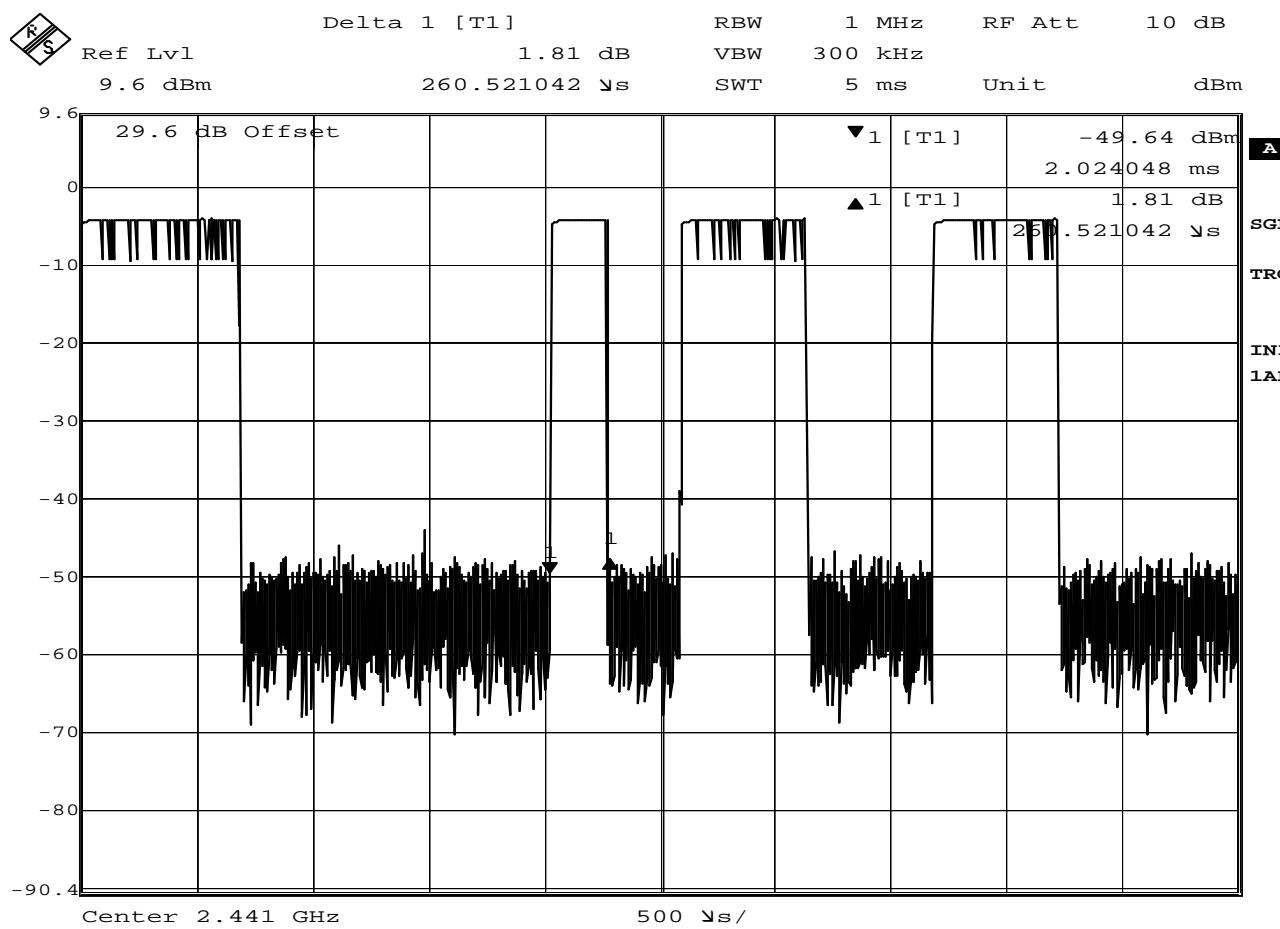
| Frequency MHz | Peak Power Reading dBm | Attenuator dB | Peak Output Power dBm | Antenna Gain dBi | Peak EIRP dBm | EIRP Limit dBm |
|------------------|------------------------------|------------------|-----------------------------|------------------------|---------------------|----------------------|
| 2441 | -15.68 | 29.76 | 15.38 | 3.0 | 18.38 | 36.0 |

Peak EIRP (dBm) = Peak Power Reading (dBm) + Attenuation (dB) + Antenna Gain (dB)



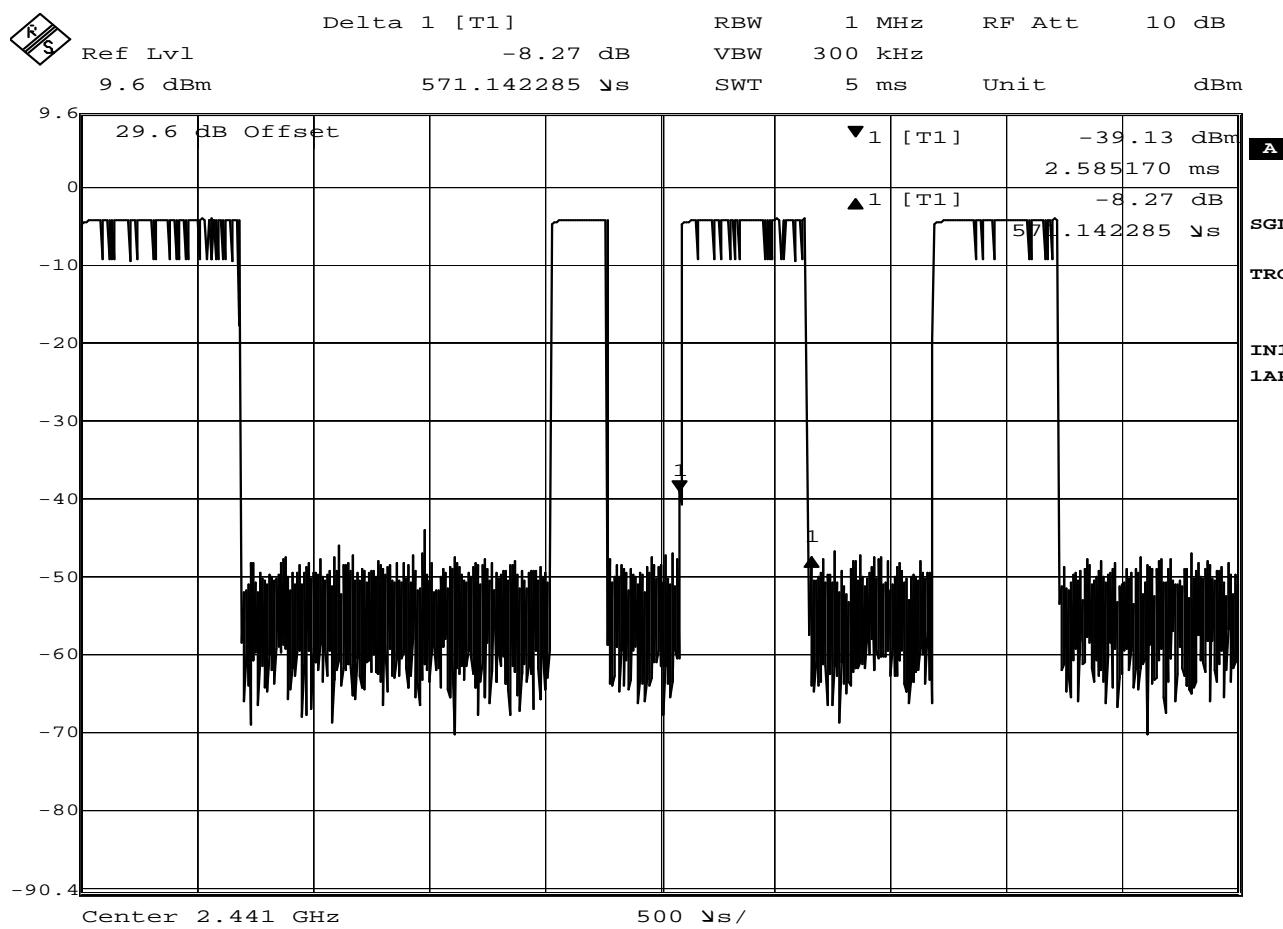
FCC 15.247 Duty Cycle Factor

MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : Pulse 1 is 691.4usec
EQUIPMENT USED : RBA1, T2DS, T1E0



FCC 15.247 Duty Cycle Factor

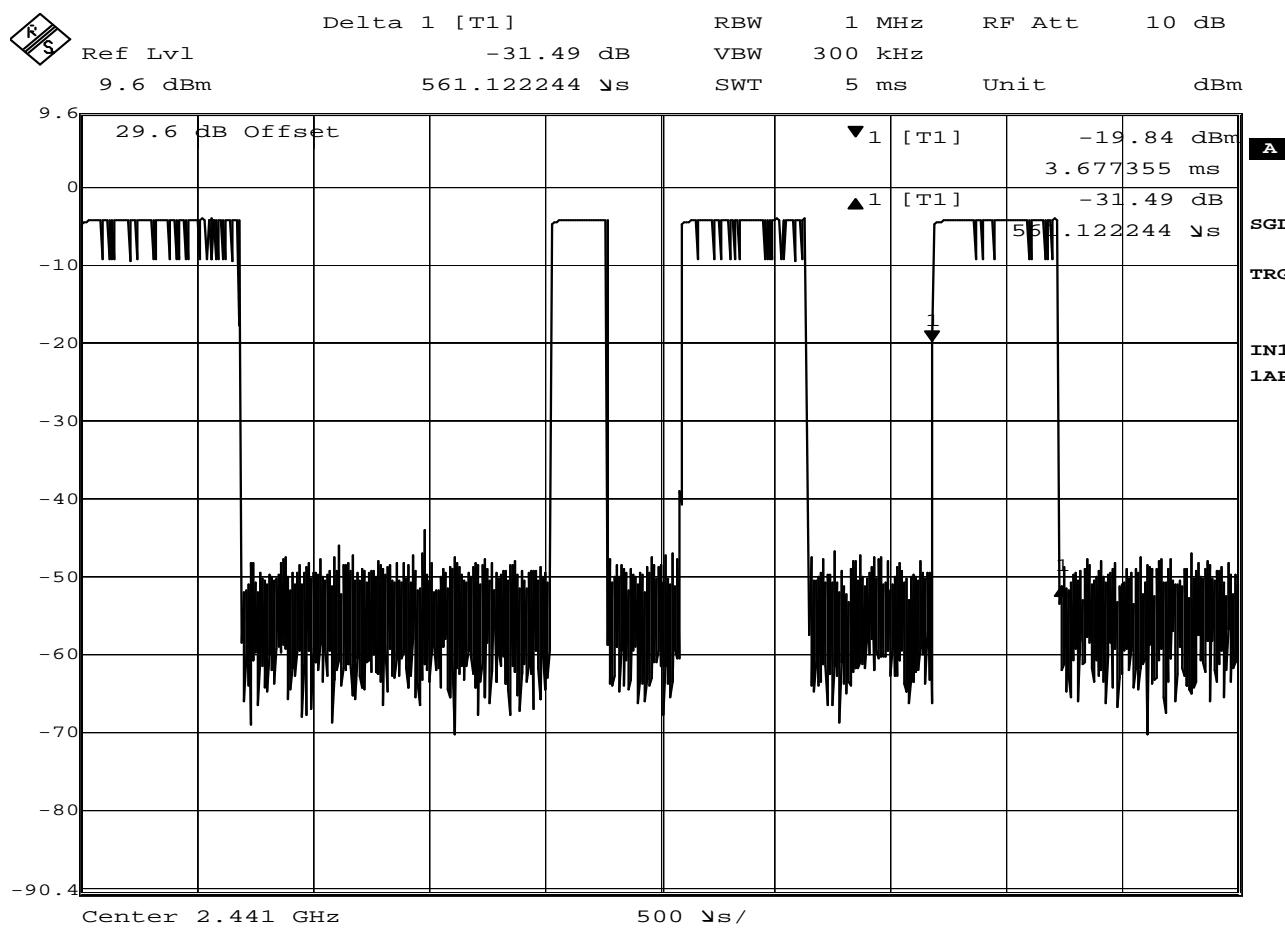
MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : Pulse 2 is 260.5usec
EQUIPMENT USED : RBA1, T2DS, T1E0



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FCC 15.247 Duty Cycle Factor

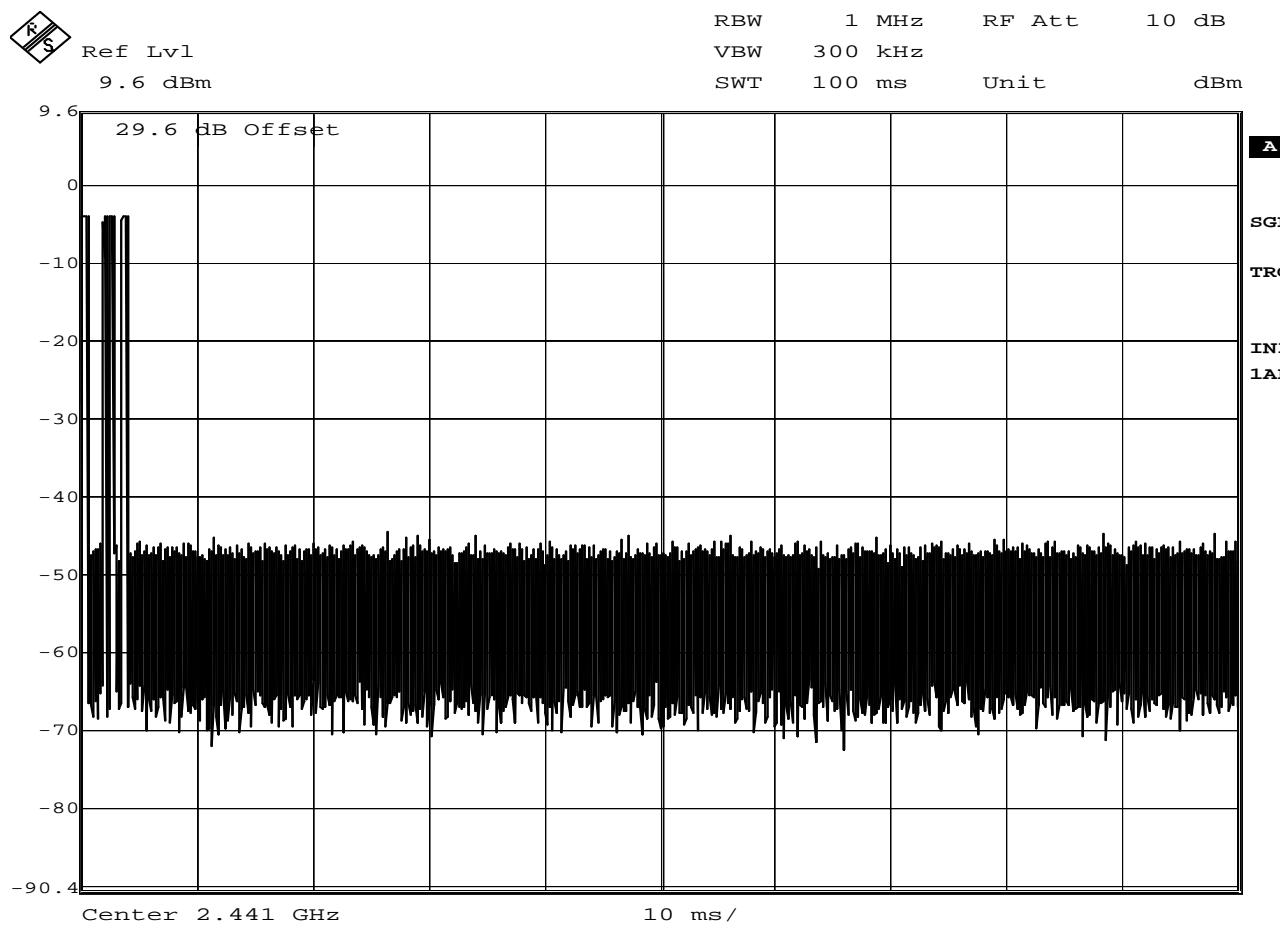
MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : Pulse 3 is 571.1usec
EQUIPMENT USED : RBA1, T2DS, T1E0



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FCC 15.247 Duty Cycle Factor

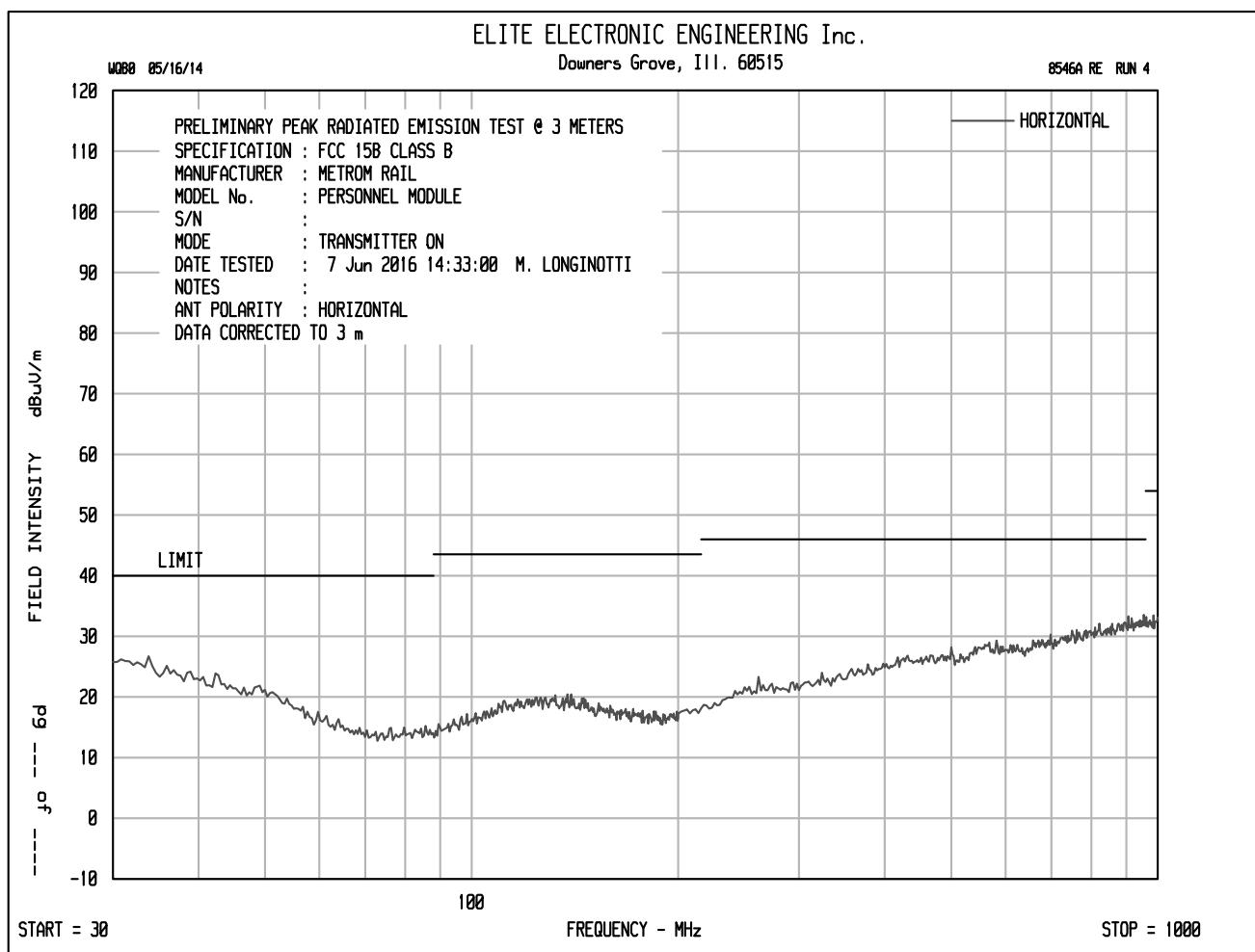
MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : Pulse 4 is 561.1usec
EQUIPMENT USED : RBA1, T2DS, T1E0

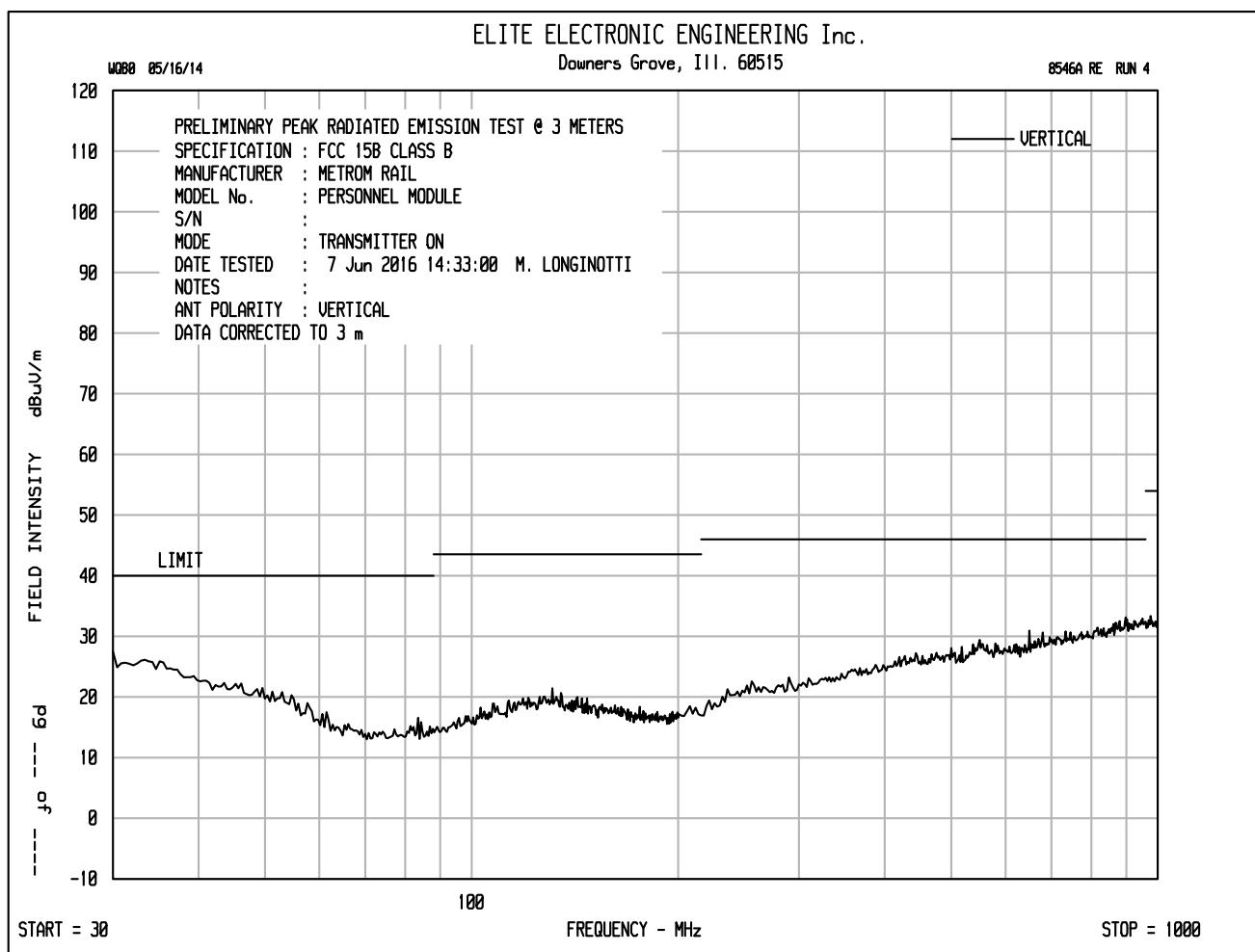


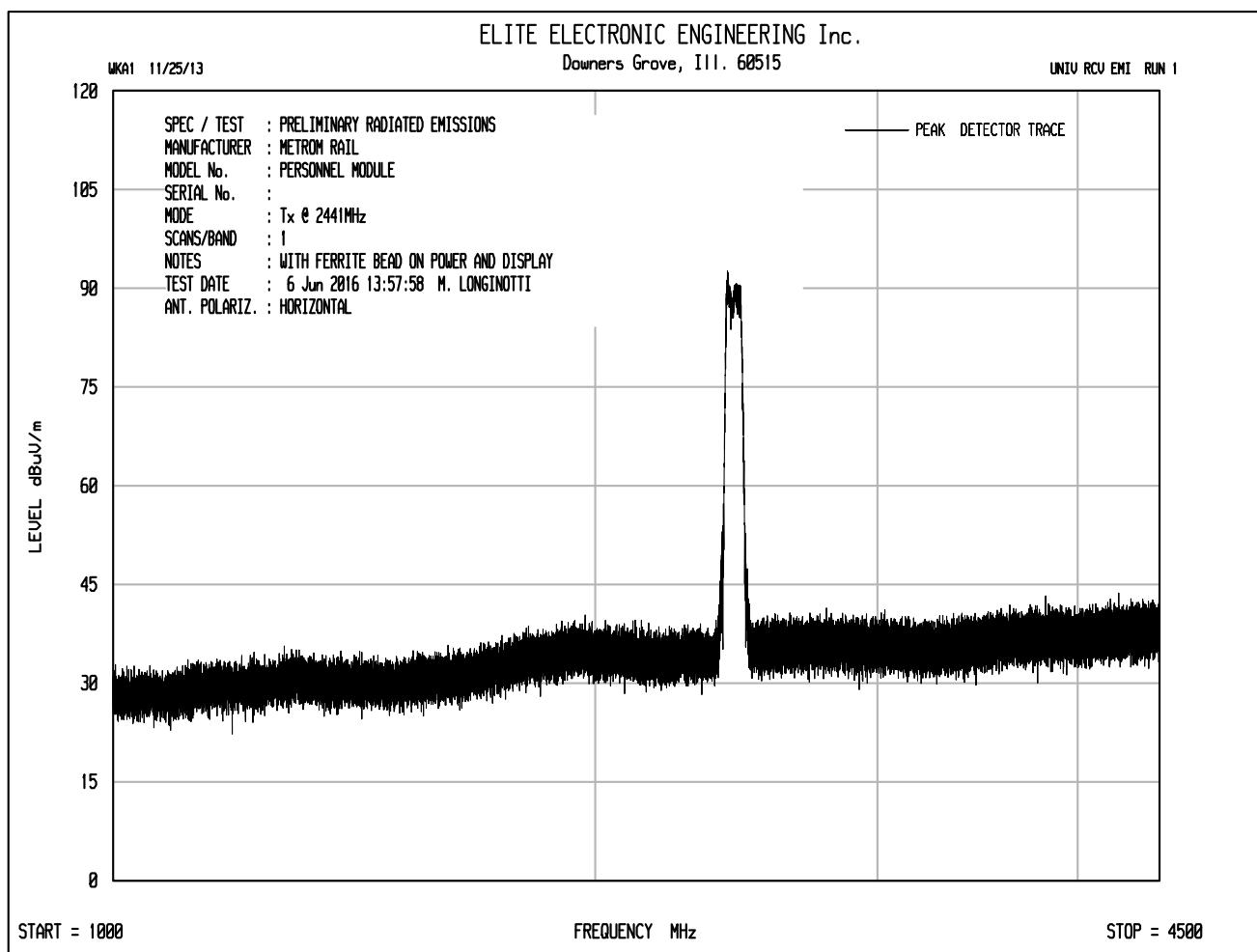
Date: 7.JUN.2016 13:10:52

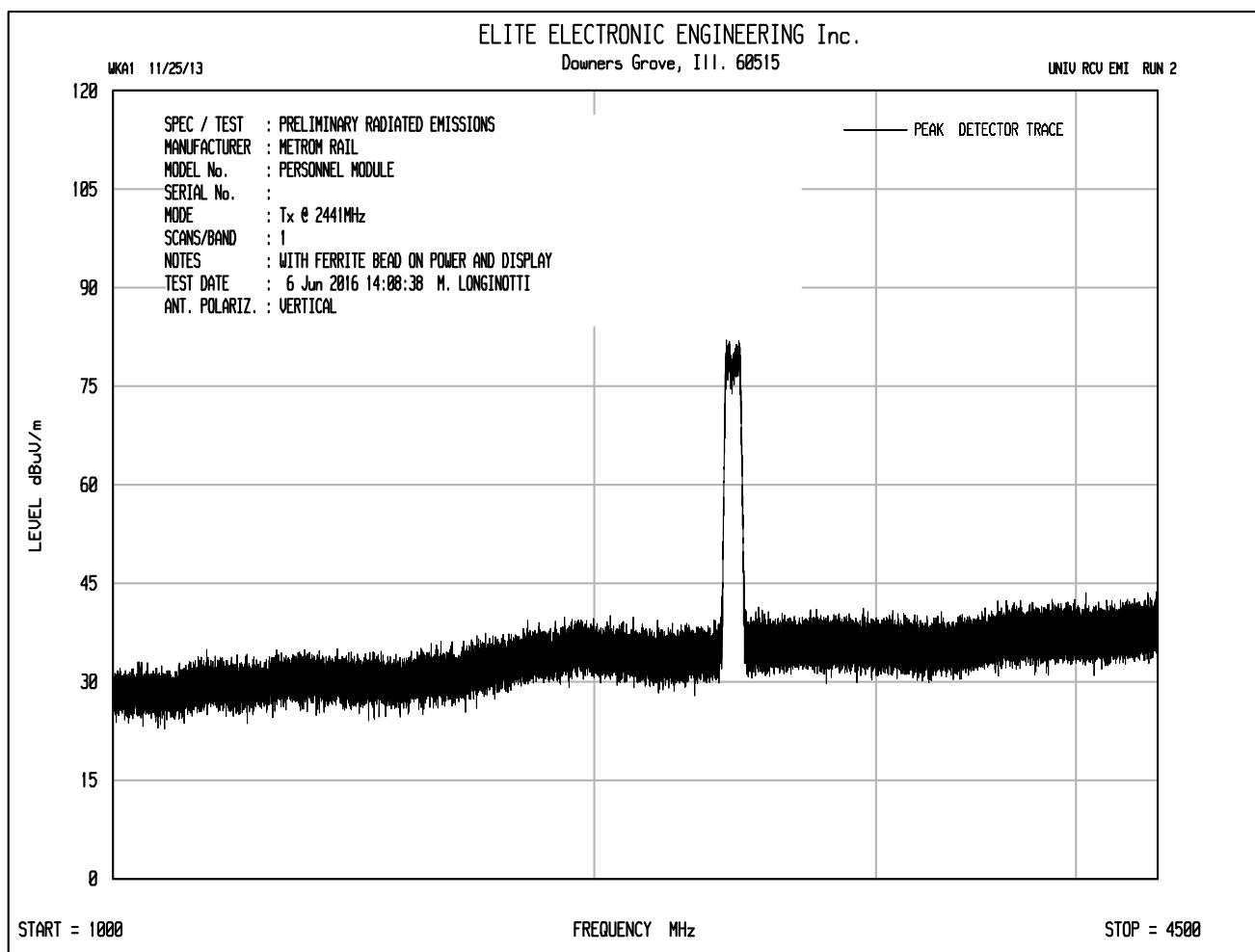
FCC 15.247 Duty Cycle Factor

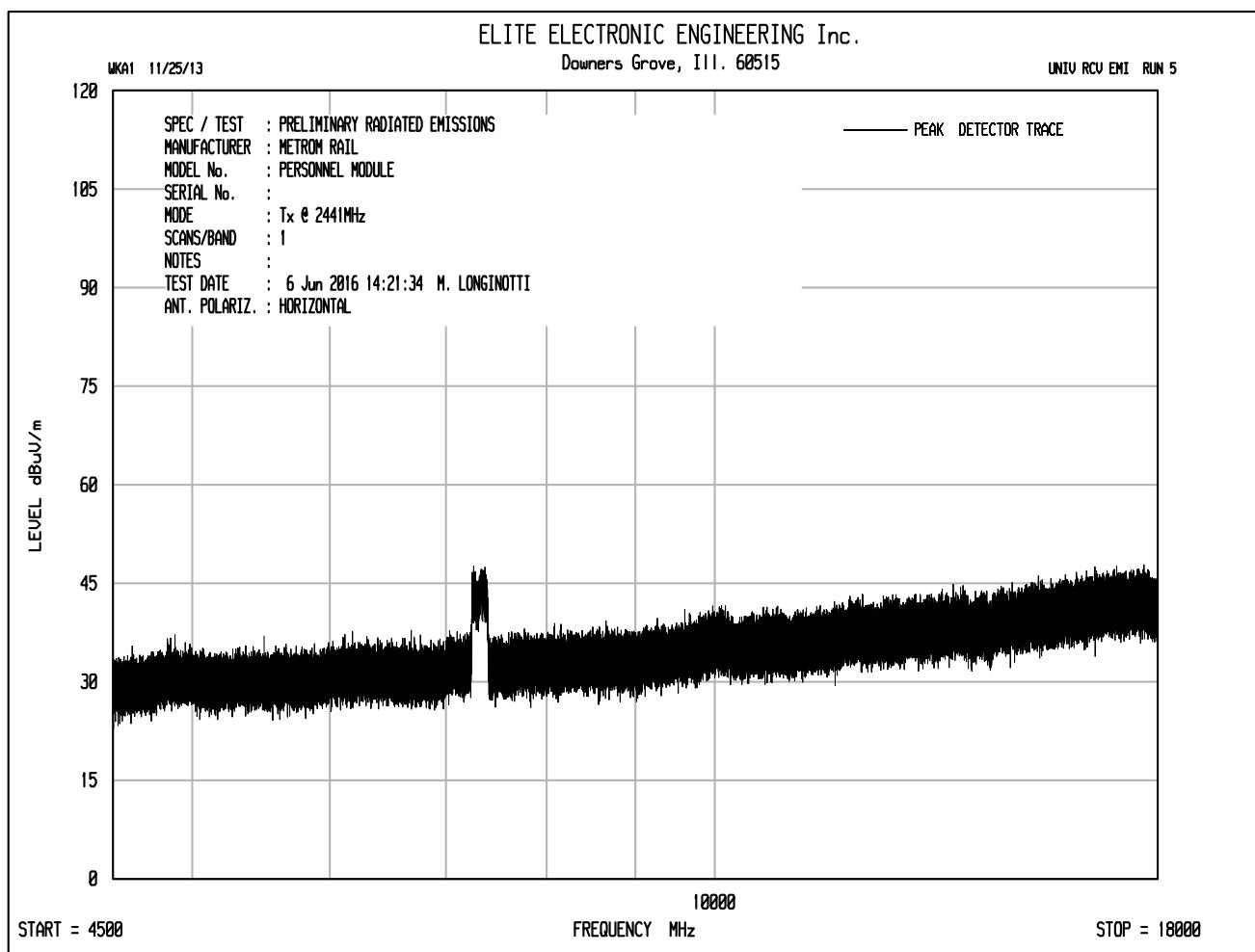
MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : 1 transmission in 100msec
: Duty Cycle Correction Factor = $20\log(pulse\ 1 + pulse\ 2 + pulse\ 3 + pulse\ 4) \times$
: (number transmissions in 100msec/100msec)
: Duty Cycle Correction Factor = $20\log(691.4\text{usec} + 260.5\text{usec} + 571.1\text{ usec} +$
: $561.1\text{usec}) \times 1 \text{ transmission /100msec}$
: Duty Cycle Correction Factor = -33.6dB
EQUIPMENT USED : RBA1, T2DS, T1E0

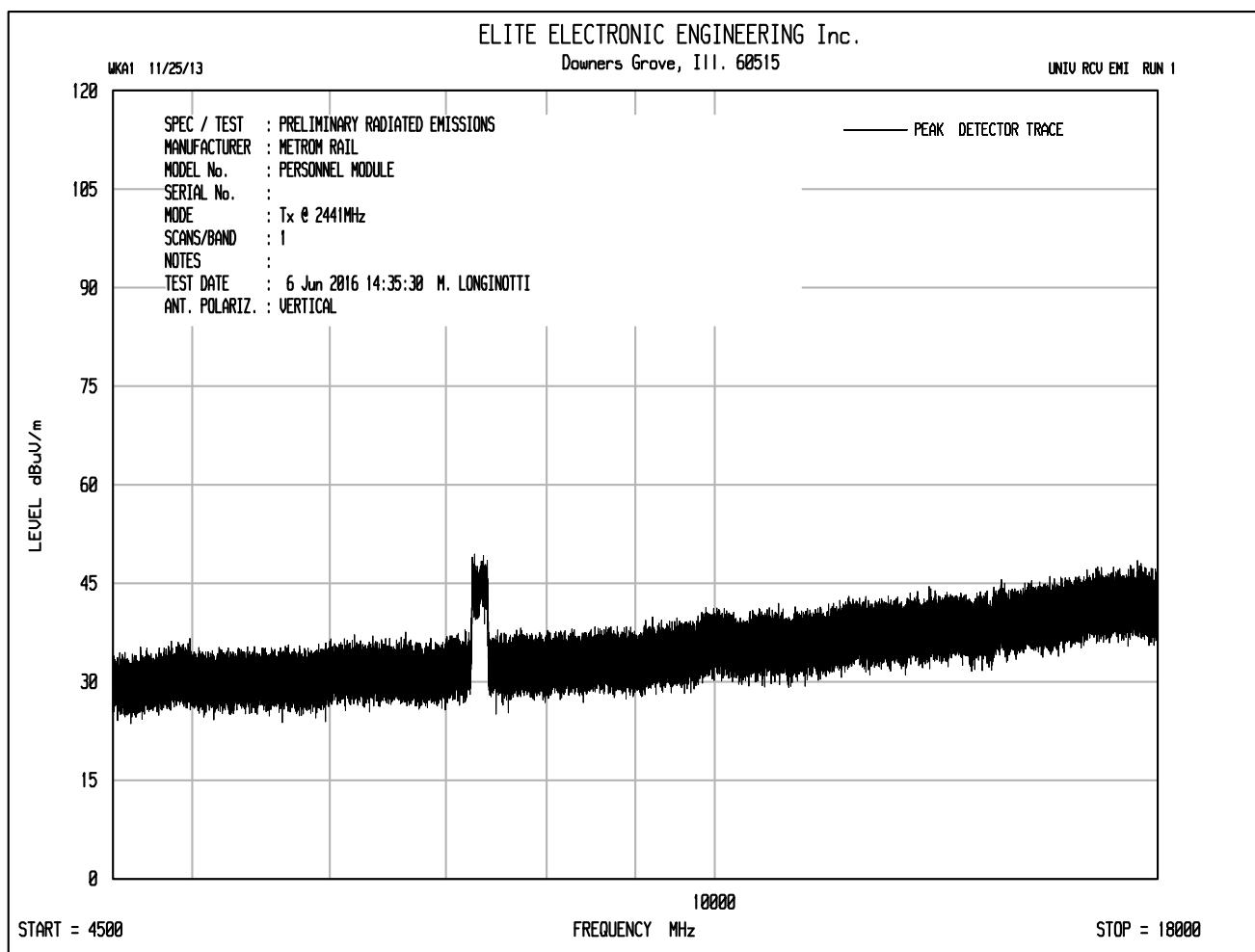


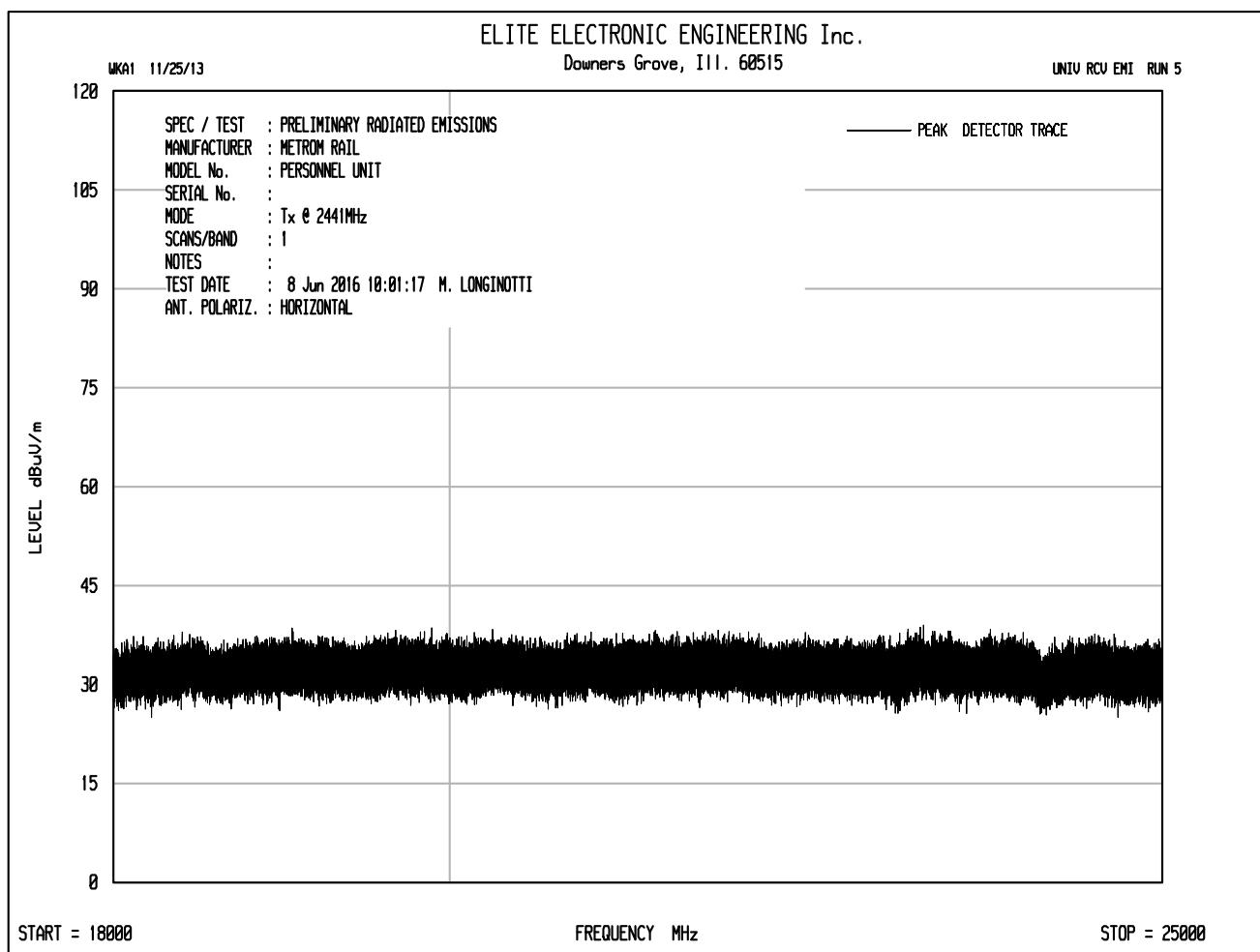


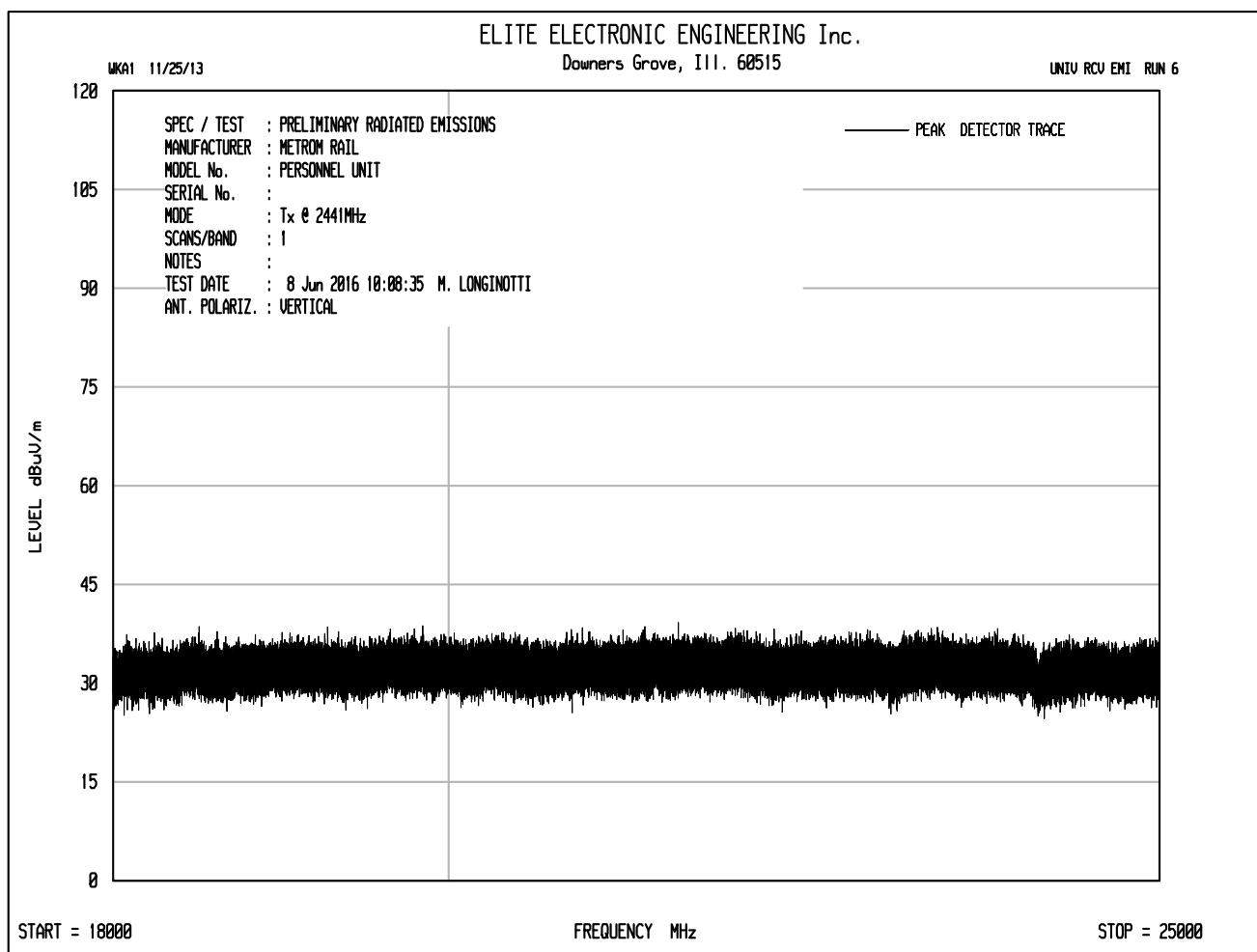












Manufacturer : Metrom Rail
 Test Item : Personnel Module
 Model No. : PM920
 Serial No. : None Assigned
 Mode : Transmit at 2441MHz
 Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions in Restricted Bands
 Date : June 6, 2016 through June 8, 2016
 Test Distance : 3 meters
 Notes : Peak Detector with 1MHz Resolution Bandwidth

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | CBL Fac (dB) | Ant Fac (dB) | Pre Amp (dB) | Peak Total dBuV/m at 3m | Peak Total uV/m at 3 m | Peak Limit uV/m at 3 m | Margin (dB) |
|--------------|------------|----------------------------|---------|--------------------|--------------------|--------------------|----------------------------------|---------------------------------|---------------------------------|----------------|
| 4882.00 | H | 50.1 | Ambient | 3.7 | 34.8 | -39.3 | 49.2 | 290.0 | 5000.0 | -24.7 |
| 4882.00 | V | 49.0 | Ambient | 3.7 | 34.8 | -39.3 | 48.1 | 255.5 | 5000.0 | -25.8 |
| 7323.00 | H | 56.2 | | 4.7 | 35.6 | -39.4 | 57.0 | 711.6 | 5000.0 | -16.9 |
| 7323.00 | V | 56.6 | | 4.7 | 35.6 | -39.4 | 57.4 | 745.1 | 5000.0 | -16.5 |
| 12205.00 | H | 48.4 | Ambient | 6.1 | 39.0 | -39.1 | 54.4 | 523.8 | 5000.0 | -19.6 |
| 12205.00 | V | 47.9 | Ambient | 6.1 | 39.0 | -39.1 | 53.9 | 494.5 | 5000.0 | -20.1 |
| 19528.00 | H | 33.4 | Ambient | 2.2 | 40.4 | -28.5 | 47.5 | 238.0 | 5000.0 | -26.4 |
| 19528.00 | V | 33.4 | Ambient | 2.2 | 40.4 | -28.5 | 47.5 | 238.0 | 5000.0 | -26.4 |

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

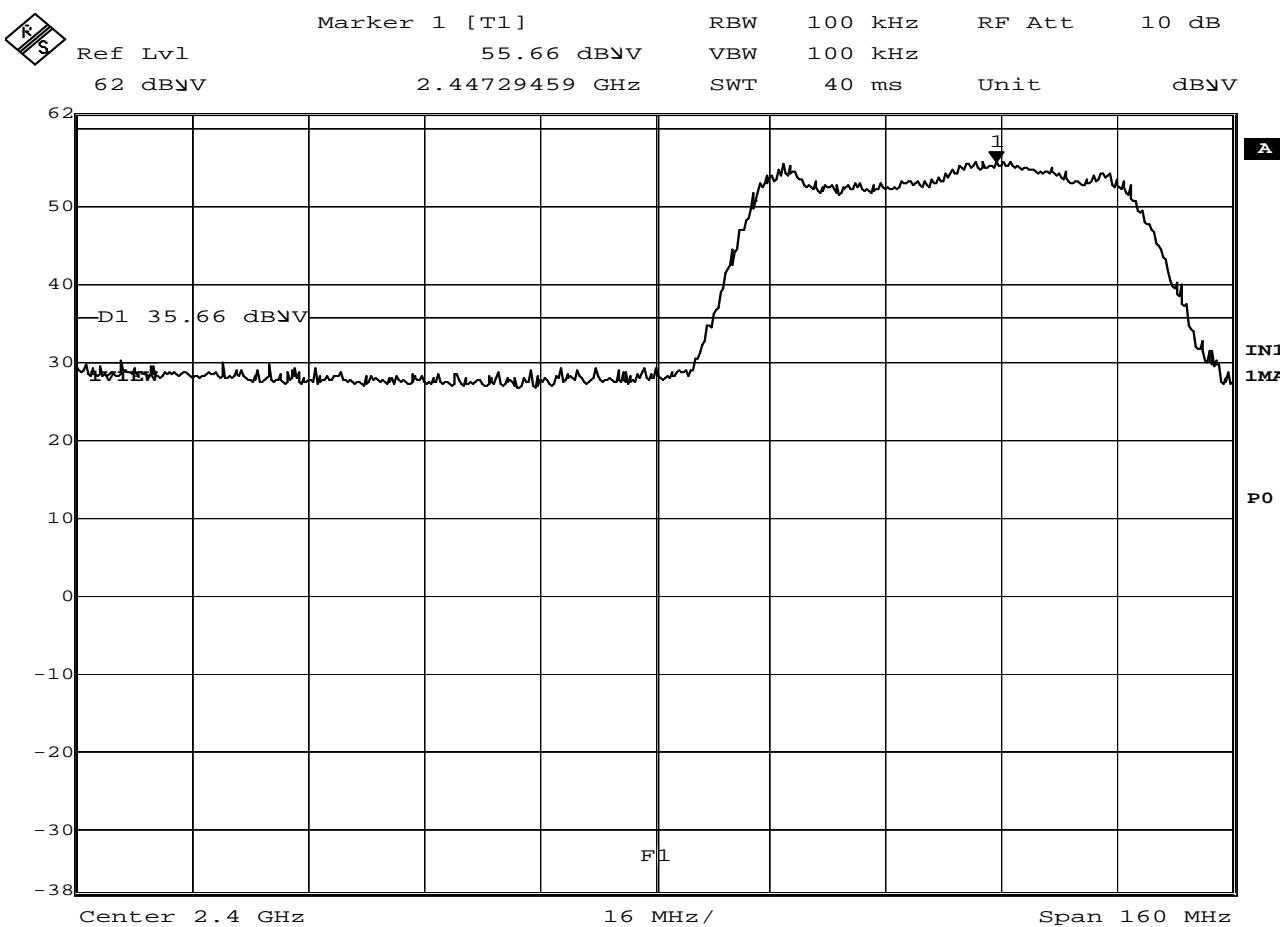
Manufacturer : Metrom Rail
 Test Item : Personnel Module
 Model No. : PM920
 Serial No. : None Assigned
 Mode : Transmit at 2441MHz
 Test Specification : FCC-15.247, RSS-247 Average Radiated Emissions in Restricted Bands
 Date : June 6, 2016 through June 8, 2016
 Test Distance : 3 meters
 Notes : Average Detector with 1MHz Resolution Bandwidth

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | CBL Fac (dB) | Ant Fac (dB) | Pre Amp (dB) | Duty Cycle (dB) | Average Total dBuV/m at 3m | Average Total uV/m at 3 m | Average Limit uV/m at 3 m | Margin (dB) |
|--------------|------------|----------------------------|---------|--------------------|--------------------|--------------------|-----------------------|-------------------------------------|------------------------------------|------------------------------------|----------------|
| 4882.00 | H | 36.3 | Ambient | 3.7 | 34.8 | -39.3 | -33.6 | 1.8 | 1.2 | 500.0 | -52.1 |
| 4882.00 | V | 36.3 | Ambient | 3.7 | 34.8 | -39.3 | -33.6 | 1.8 | 1.2 | 500.0 | -52.1 |
| 7323.00 | H | 49.10 | Ambient | 4.7 | 35.6 | -39.4 | -33.6 | 16.3 | 6.6 | 500.0 | -37.6 |
| 7323.00 | V | 50.5 | Ambient | 4.7 | 35.6 | -39.4 | -33.6 | 17.7 | 7.7 | 500.0 | -36.2 |
| 12205.00 | H | 36.1 | Ambient | 6.1 | 39.0 | -39.1 | -33.6 | 8.5 | 2.7 | 500.0 | -45.5 |
| 12205.00 | V | 36.1 | Ambient | 6.1 | 39.0 | -39.1 | -33.6 | 8.5 | 2.7 | 500.0 | -45.5 |
| 19528.00 | H | 22.2 | Ambient | 2.2 | 40.4 | -28.5 | -33.6 | 2.7 | 1.4 | 500.0 | -51.2 |
| 19528.00 | V | 22.0 | Ambient | 2.2 | 40.4 | -28.5 | -33.6 | 2.5 | 1.3 | 500.0 | -51.4 |

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp + Duty Cycle

Manufacturer : Metrom Rail
 Test Item : Personnel Module
 Model No. : PM920
 Serial No. : None Assigned
 Mode : Transmit at 2441MHz
 Test Specification : FCC-15.247, RSS-247 Peak Radiated Emissions not in Restricted Bands
 Date : June 6, 2016 through June 8, 2016
 Test Distance : 3 meters
 Notes : Peak Detector with 100kHz Resolution Bandwidth

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | CBL Fac (dB) | Ant Fac (dB) | Pre Amp (dB) | Peak Total dBuV/m at 3m | Peak Total uV/m at 3 m | Peak Limit uV/m at 3 m | Margin (dB) |
|--------------|------------|----------------------------|---------|--------------------|--------------------|--------------------|----------------------------------|---------------------------------|---------------------------------|----------------|
| 2441.00 | H | 58.3 | | 2.6 | 32.2 | 0.0 | 93.1 | 45155.0 | | |
| 2441.00 | V | 48.4 | | 2.6 | 32.2 | 0.0 | 83.2 | 14444.6 | | |
| 9764.00 | H | 35.5 | Ambient | 5.2 | 36.9 | -39.3 | 38.4 | 83.2 | 4515.5 | -34.7 |
| 9764.00 | V | 39.6 | Ambient | 5.2 | 36.9 | -39.3 | 42.5 | 133.4 | 4515.5 | -30.6 |
| 14646.00 | H | 39.7 | Ambient | 6.7 | 39.9 | -38.2 | 48.0 | 252.6 | 4515.5 | -25.0 |
| 14646.00 | V | 38.3 | Ambient | 6.7 | 39.9 | -38.2 | 46.6 | 215.0 | 4515.5 | -26.4 |
| 17087.00 | H | 38.1 | Ambient | 7.3 | 41.5 | -37.6 | 49.3 | 291.9 | 4515.5 | -23.8 |
| 17087.00 | V | 37.8 | Ambient | 7.3 | 41.5 | -37.6 | 49.0 | 282.0 | 4515.5 | -24.1 |
| 21969.00 | H | 24.8 | Ambient | 2.2 | 40.6 | -29.2 | 38.4 | 83.3 | 4515.5 | -34.7 |
| 21969.00 | V | 24.9 | Ambient | 2.2 | 40.6 | -29.2 | 38.5 | 84.2 | 4515.5 | -34.6 |
| 24410.00 | H | 25.3 | Ambient | 2.2 | 40.6 | -30.2 | 37.9 | 78.9 | 4515.5 | -35.2 |
| 24410.00 | V | 25.6 | Ambient | 2.2 | 40.6 | -30.2 | 38.2 | 81.7 | 4515.5 | -34.9 |



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FCC 15.247 Band Edge

MANUFACTURER : Metrom Rail
 MODEL NUMBER : Personnel Module
 TEST MODE : Transmit at 2441MHz
 NOTES : Display Line (D1) represents the level 20 dB below that in the 100 kHz bandwidth
 : within the band that contains the highest level of the desired power. Display Line
 : (F1) represents the band edge (2400MHz).

Manufacturer : Metrom Rail
 Test Item : Personnel Module
 Model No. : PM920
 Serial No. : None Assigned
 Mode : Transmit at 2441MHz
 Test Specification : FCC-15.247, RSS-247 Band Edge
 Date : June 6, 2016 through June 8, 2016
 Test Distance : 3 meters
 Notes : Peak Detector with 1MHz Resolution Bandwidth

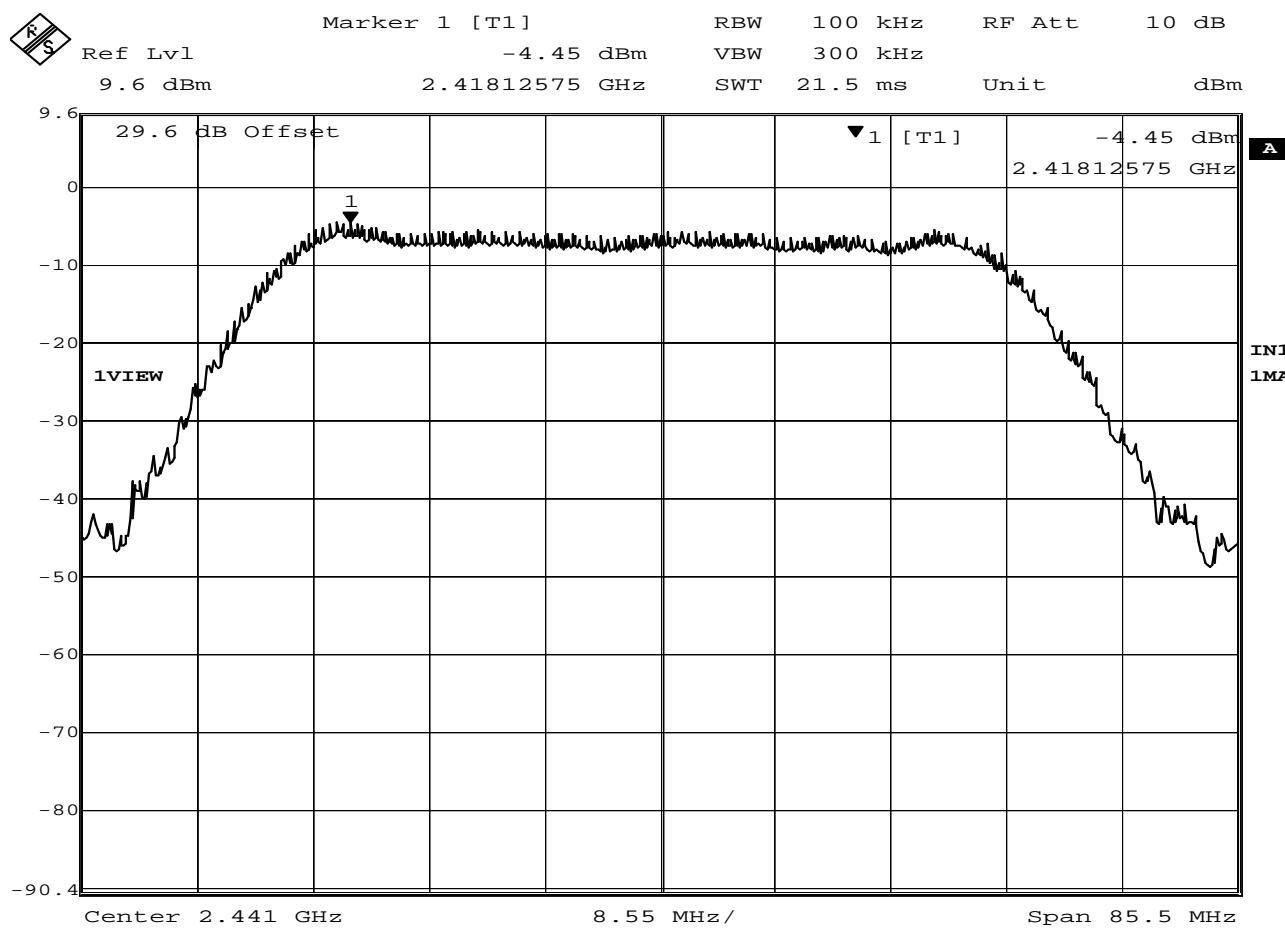
| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | CBL Fac (dB) | Ant Fac (dB) | Pre Amp (dB) | Peak Total dBuV/m at 3m | Peak Total uV/m at 3 m | Peak Limit uV/m at 3 m | Margin (dB) |
|--------------|------------|----------------------------|---------|--------------------|--------------------|--------------------|----------------------------------|---------------------------------|---------------------------------|----------------|
| 2483.80 | H | 22.8 | | 2.7 | 32.4 | 0.0 | 57.8 | 779.6 | 5000.0 | -16.1 |
| 2483.90 | V | 18.9 | | 2.7 | 32.4 | 0.0 | 53.9 | 497.6 | 5000.0 | -20.0 |

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp

Manufacturer : Metrom Rail
 Test Item : Personnel Module
 Model No. : PM920
 Serial No. : None Assigned
 Mode : Transmit at 2441MHz
 Test Specification : FCC-15.247, RSS-247 Average Radiated Emissions in Restricted Bands
 Date : June 6, 2016 through June 8, 2016
 Test Distance : 3 meters
 Notes : Average Detector with 1MHz Resolution Bandwidth

| Freq. MHz | Ant Pol | Meter Reading (dBuV) | Ambient | CBL Fac (dB) | Ant Fac (dB) | Pre Amp (dB) | Duty Cycle (dB) | Average Total dBuV/m at 3m | Average Total uV/m at 3 m | Average Limit uV/m at 3 m | Margin (dB) |
|--------------|------------|----------------------------|---------|--------------------|--------------------|--------------------|-----------------------|-------------------------------------|------------------------------------|------------------------------------|----------------|
| 2483.80 | H | 14.7 | | 2.7 | 32.4 | 0.0 | -33.6 | 16.1 | 6.4 | 500.0 | -37.8 |
| 2483.90 | V | 7.3 | | 2.7 | 32.4 | 0.0 | -33.6 | 8.7 | 2.7 | 500.0 | -45.2 |

Total (dBuV/m) = Meter Reading + CBL FAC + Ant Fac + Pre Amp + Duty Cycle



FCC 15.247 Power Spectral Density

MANUFACTURER : Metrom Rail
MODEL NUMBER : Personnel Module
TEST MODE : Transmit at 2441MHz
NOTES : Power Spectral Density = -4.45dB in a 100kHz bandwidth
EQUIPMENT USED : RBA1, T2DS, T1E0