

ENGINEERING TEST REPORT



**Tire Pressure Monitoring Sensor
MODEL NO.: SENS-ASSY**

In Accordance With

**FCC PART 15, SUBPART C, PARA. 15.209
LOW POWER COMMUNICATION DEVICE TRANSMITTER
OPERATING AT 32.768 kHz**

UltraTech FILE NO.: TIR1-FTX

Tested for:

TIREUM INTERNATIONAL INC.
56 Pennsylvania Avenue, Unit #10
Vaughan, Ontario
Canada, L4K 3V9

Tested by:

ULTRATECH GROUP OF LABS
3000 Bristol Circle
Oakville, Ontario
Canada L6H 6G4

REPORT PREPARED BY: Dan Huynh

DATE: August 6, 1999

UltraTech

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1. EXHIBIT 1 - SUMMARY OF TEST RESULTS & GENERAL STATEMENT OF CERTIFICATION

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
**	Spectrum Bandwidth of a Low Power Communication Device Transmitter	Yes
15.209	Transmitter Radiated Emissions	Yes
15.107	AC Power Conducted Emissions	Not applicable for battery operated devices
15.109	Radiated Emissions for Receiver and Digital Circuit Portions	Yes (note 1)

Note 1: The digital portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class A Digital Devices. The engineering test report can be provided upon FCC requests.

TESTIMONIAL AND STATEMENT OF CERTIFICATION

THIS IS TO CERTIFY:

- 1) *THAT the application was prepared either by, or under the direct supervision of the undersigned.*
- 2) *THAT the measurement data supplied with the application was taken under my direction and supervision.*
- 3) *THAT the data was obtained on representative production units.*
- 4) *THAT, to the best of my knowledge and belief, the facts set forth in the application and accompanying technical data are true and correct.*

Certified by:

*Tri Minh Luu, P. Eng.
V.P., Engineering*

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2. EXHIBIT 2 - GENERAL INFORMATION

2.1. APPLICANT

TIREUM INTERNATIONAL INC.
56 Pennsylvania Avenue, Unit #10
Vaughan, Ontario
Canada, L4K 3V9

Applicant's Representative: Mr. David Ellis

2.2. MANUFACTURER

TIREUM INTERNATIONAL INC.
56 Pennsylvania Avenue, Unit #10
Vaughan, Ontario
Canada, L4K 3V9

2.3. DESCRIPTION OF EQUIPMENT UNDER TEST

PRODUCT NAME:	Tire Pressure Monitoring Sensor
SERIAL NUMBER:	Pre-production
TYPE OF EQUIPMENT:	Low Power Communication Device Transmitter
OPERATING FREQ.:	32.768 kHz
EMISSION DESIGNATION:	23K5P0N
OSC. FREQUENCY(IES):	32.768 kHz
INPUT SUPPLY:	Two 3Vdc coin cell lithium batteries on PCB
ASSOCIATED DEVICES:	Tireum International Inc. Tire Pressure Monitor Receiver, Model: RCVR-ASSY
FCC ID:	ON4SENS-ASSY
INTERFACE PORTS:	N/A

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2.4. RELATED SUBMITTAL(S)/GRANT

Not applicable

2.5. TEST METHODOLOGY

These tests were conducted on a sample of the equipment for the purpose of certification compliance with Code of Federal Regulations (CFR47-1991), Part 15, Subpart C, Para. 15.209, Low Power Communication Device Transmitters operating at 32.768 kHz.

Radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4-1992 - 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.

2.6. TEST FACILITY

Radiated Emissions were performed at the UltraTech's 3-10 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario.

The above site have been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville Open Field Test Site has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada File No.: IC2049). Last Date of Site Calibration: September 20, 1998.

The above test site is also filed with Interference Technology International Ltd (ITI - An EC Directive on EMC).

2.7. UNITS OF MEASUREMENTS

Measurements of radiated emissions are reported in units of dB referenced to one microvolt per meter [dB(μ V)/m] at the distance specified in the report, wherever it is applicable.

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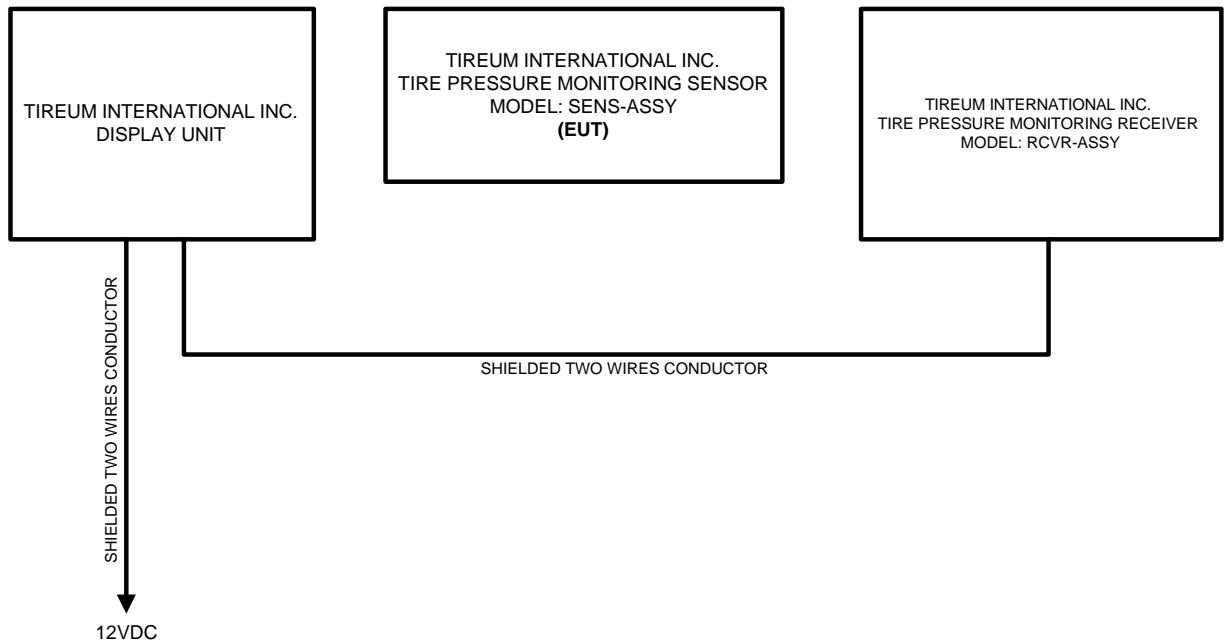
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3. EXHIBIT 3 - SYSTEM TEST CONFIGURATION

3.1. BLOCK DIAGRAMS FOR CONDUCTED & RADIATED EMISSION MEASUREMENTS



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3.2. PHOTOGRAPH FOR RF EMISSION MEASUREMENTS

Please refer to the attached photos.

3.2.1. TEST SETUP FOR RADIATED EMISSIONS MEASUREMENTS

Tests were performed at the Open Field test Site located in Oakville, Ontario, Canada.



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3.3. JUSTIFICATION

The Sensor was set to transmit continuously for the duration of the testing process. This is not normal operating condition.

3.4. EUT OPERATING CONDITION

The Sensor (EUT) was set to transmit continuously during testing.

3.5. SPECIAL ACCESSORIES

No special accessories were required.

3.6. EQUIPMENT MODIFICATIONS

To achieve compliance, the following change(s) were made by UltraTech's test house during compliance testing:

Not required.

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4. EXHIBIT 4 - TEST DATA

4.1. 26 DB BANDWIDTH

PRODUCT NAME: Tire Pressure Monitoring Sensor, Model No.: SENS-ASSY

FCC REQUIREMENTS:

The spectrum of the RF signal shall be entirely in FCC permitted band and shall not spread out in the restricted band.

CLIMATE CONDITION:

Standard Temperature and Humidity:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

Two 3Vdc coin cell lithium batteries on PCB.

TEST EQUIPMENT:

- **EMI Receiver System/Spectrum Analyzer**, Hewlett Packard, Model 8546A, Input +25dBm max., 9KHz-5.6GHz, 50 Ohms, built-in Peak, Quasi-Peak & Average Detectors, Pre-Amplifier and Tracking Signal Generator. This System includes: (1) HP 85460A RF Filter Section, S/N: 3448A00236 and (2) HP 85462A Receiver RF Section/Display, S/N: 3520A00248.
- **Spectrum Analyzer**, Advantest, Model R3271, S/N: 15050203, 100 Hz to 32 GHz
- **Active Loop Antenna**, Emco, Model 6507, SN 8906-1167, Frequency Range 1 KHz - 30 MHz, @ 50 Ohms

TEST RESULTS: Conforms.

TEST PERSONNEL: Mr. Hung Trinh, RFI/EMI Technician

DATE: August 6, 1999

MEASUREMENT DATA:

26 dB BW = 23.50 kHz

See attached plot for detailed OBW measurements. No rf signal was found to be spread out in the adjacent restricted bands,

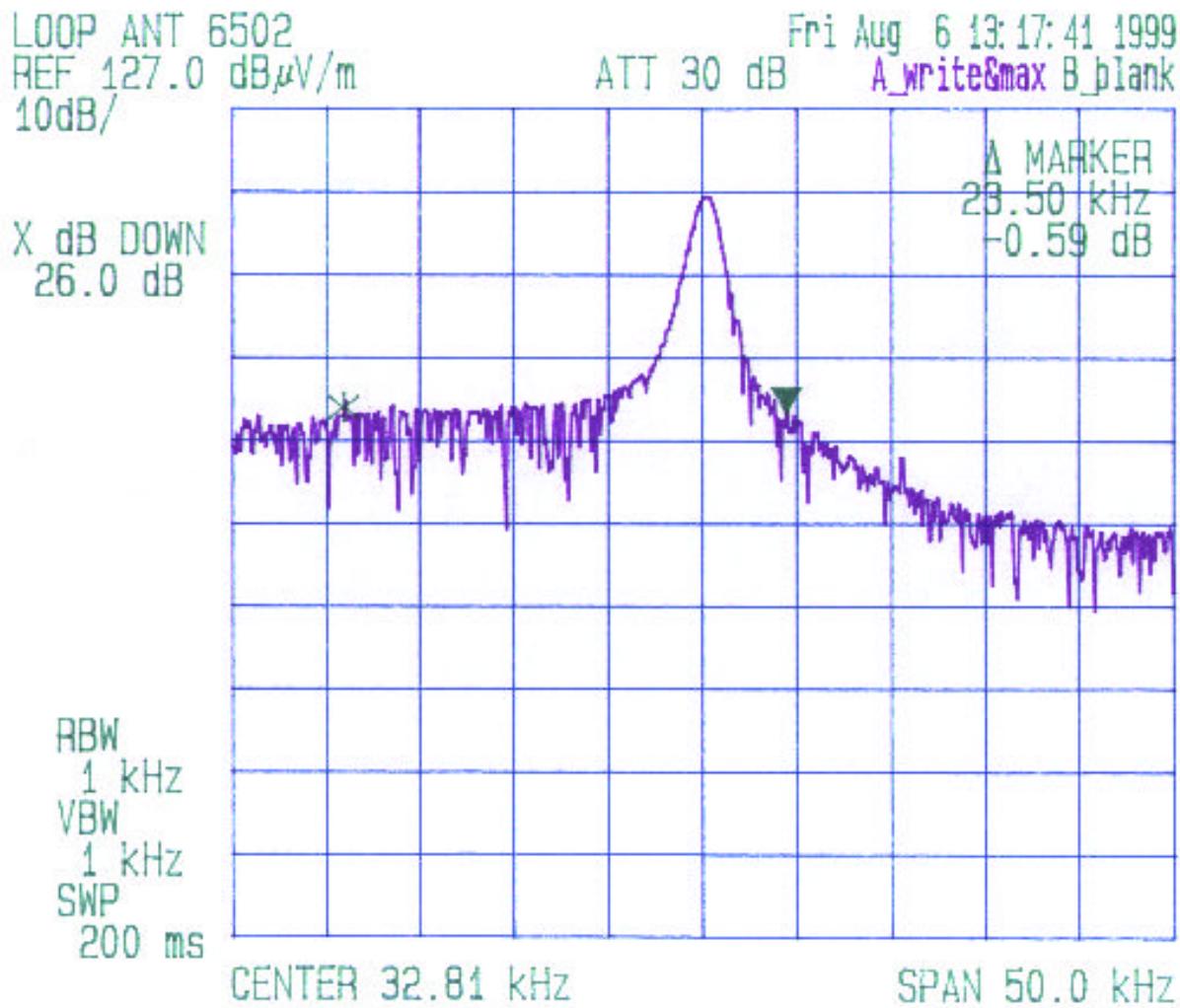
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4.2. TRANSMITTER RADIATED EMISSIONS @ 1 & 3 METERS, FCC CFR 47, PARA. 15.209

PRODUCT NAME: Tire Pressure Monitoring Sensor, Model No.: SENS-ASSY

FCC REQUIREMENTS:

- The rf spectrum carrier shall not fall inside the restricted bands specified in the following table.

FCC CFR 47, Part 15, Subpart C, Para. 15.205(a) - Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	162.0125 - 167.17	2310 - 2390	9.3 - 9.5
0.49 - 0.51	167.72 - 173.2	2483.5 - 2500	10.6 - 12.7
2.1735 - 2.1905	240 - 285	2655 - 2900	13.25 - 13.4
8.362 - 8.366	322 - 335.4	3260 - 3267	14.47 - 14.5
13.36 - 13.41	399.9 - 410	3332 - 3339	14.35 - 16.2
25.5 - 25.67	608 - 614	3345.8 - 3358	17.7 - 21.4
37.5 - 38.25	960 - 1240	3600 - 4400	22.01 - 23.12
73 - 75.4	1300 - 1427	4500 - 5250	23.6 - 24.0
108 - 121.94	1435 - 1626.5	5350 - 5460	31.2 - 31.8
123 - 138	1660 - 1710	7250 - 7750	36.43 - 36.5
149.9 - 150.05	1718.8 - 1722.2	8025 - 8500	Above 38.6
156.7 - 156.9	2200 - 2300	9000 - 9200	

- Fundamental and Spurious/harmonic emissions shall not exceed the limits specified in the following table:

FCC CFR 47, Part 15, Subpart C, Para. 15.209(a)
-- Field Strength Limits within Restricted Frequency Bands --

FREQUENCY (MHz)	FIELD STRENGTH LIMITS (microvolts/m)	DISTANCE (Meters)
0.009 - 0.490	2,400 / F (KHz)	300
0.490 - 1.705	24,000 / F (KHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

CLIMATE CONDITION:

Standard Temperature and Humidity:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

Two 3Vdc coin cell lithium batteries on PCB.

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TEST EQUIPMENT:

- **EMI Receiver System/Spectrum Analyzer**, Hewlett Packard, Model 8546A, Input +25dBm max., 9KHz-5.6GHz, 50 Ohms, built-in Peak, Quasi-Peak & Average Detectors, Pre-Amplifier and Tracking Signal Generator. This System includes: (1) HP 85460A RF Filter Section, S/N: 3448A00236 and (2) HP 85462A Receiver RF Section/Display, S/N: 3520A00248.
- **Spectrum Analyzer**, Advantest, Model R3271, S/N: 15050203, 100 Hz to 32 GHz)
- **Active Loop Antenna**, Emco, Model 6507, SN 8906-1167, Frequency Range 1 KHz - 30 MHz, @ 50 Ohms
- **Log Periodic/Bow-Tie Antenna**, Emco, Model 3143, SN 1029, 20 - 1000 MHz, @ 50 ohms.

METHOD OF MEASUREMENTS:

Refer to **ANSI 63.4-1992, Para. 8** for detailed radiated emissions measurement procedures.

Applies to harmonics/spurious that fall in the restricted bands listed in Section 15.205. the maximum permitted average field strength is listed in Section 15.209. A Pre-Amp and highpass filter are used for this measurement.

For measurement below 1 GHz, set RBW = 100 KHz, VBW \geq 100 KHz, SWEEP=AUTO.

For measurement above 1 GHz, set RBW = 1 MHz, VBW = 1 MHz (Peak)

If the emission is pulsed, modified the unit for continuous operation, then use the settings above for measurements, then correct the reading by subtracting the peak-average correction factor derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

FCC CFR 47, Para. 2.997 - Frequency spectrum to be investigated

The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.993 - Field Strength Spurious Emissions

(a) Measurements was made to detect spurious emissions radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data were supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph 2.989(c) as appropriate. For equipment operating on frequencies below 1 GHz, an Open Field Test is normally required, with the measuring instrument antenna located in the far field at all test frequencies. In event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurement will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with the reference to the

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rated power output of the transmitter, assuming all emissions are radiated from half-wave dipole antennas.

(b) Measurements specified in paragraph (a) of this section shall be made for the following equipment:

- (1) Those in which the spurious emission are required to be 60 dB or more below the mean power of the transmitter.
- (2) All equipment operating on frequencies higher than 25 MHz
- (3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
- (4) Other types of equipment as required, when deemed necessary by the Commission.

TEST RESULTS: Conforms.

TEST PERSONNEL: Mr. Hung Trinh, EMI/RFI Technician

DATE: July 19, 1999

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MEASUREMENT DATA

RADIATED EMISSIONS MEASUREMENTS @ 1 AND 3 METERS

TEST CONFIGURATION

- For measuring radiated emissions at frequencies below 1 GHz, the Spectrum Analyzer was set as 100 KHz RBW, VBW \geq RBW, SWEEP TIME: AUTO, PEAK DETECTOR.
- For measuring radiated emissions at frequencies above 1 GHz, the Spectrum Analyzer was set as 1 MHz RBW, VBW \geq RBW, SWEEP TIME: AUTO, PEAK DETECTOR.
- The following measurements were the worst cases when the radiating antenna was placed in both horizontal and vertical polarization.
- **RF Average Level:** the average rf levels were calculated by subtracting the Peak readings added by the duty cycle correction factor. **DUTY CYCLE FACTOR = $20\log_{10}(0.181) = -14.8 \text{ dB}$**

REMARK:

The EUT was tested at 3 meters distance instead of 300 meters. As the following results indicates that there are no significant RF emissions found in the frequency range from 10 kHz to 1000 MHz at 3 meters. So, the EUT was tested at 1 meter distance and the results are shown below.

RADIATED EMISSIONS MEASUREMENT AT 1 METER

CHANNEL FREQUENCY TESTED: 32.768 kHz						
FREQUENCY (kHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
32.77	101.66	86.86	V	*136.38	-34.72	PASS

No other significant RF emissions found in the frequency range from 10 kHz to 1000 MHz. Refer to attached plots for details

* The converted limit from 300 meters to 1 meter distance using $20\log(300/1)^2$ conversion factor.

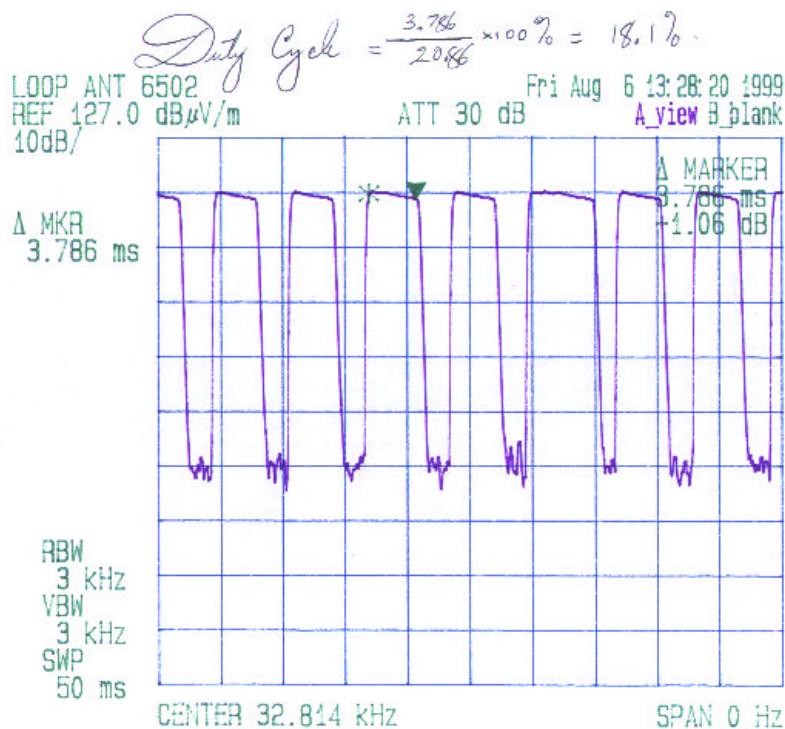
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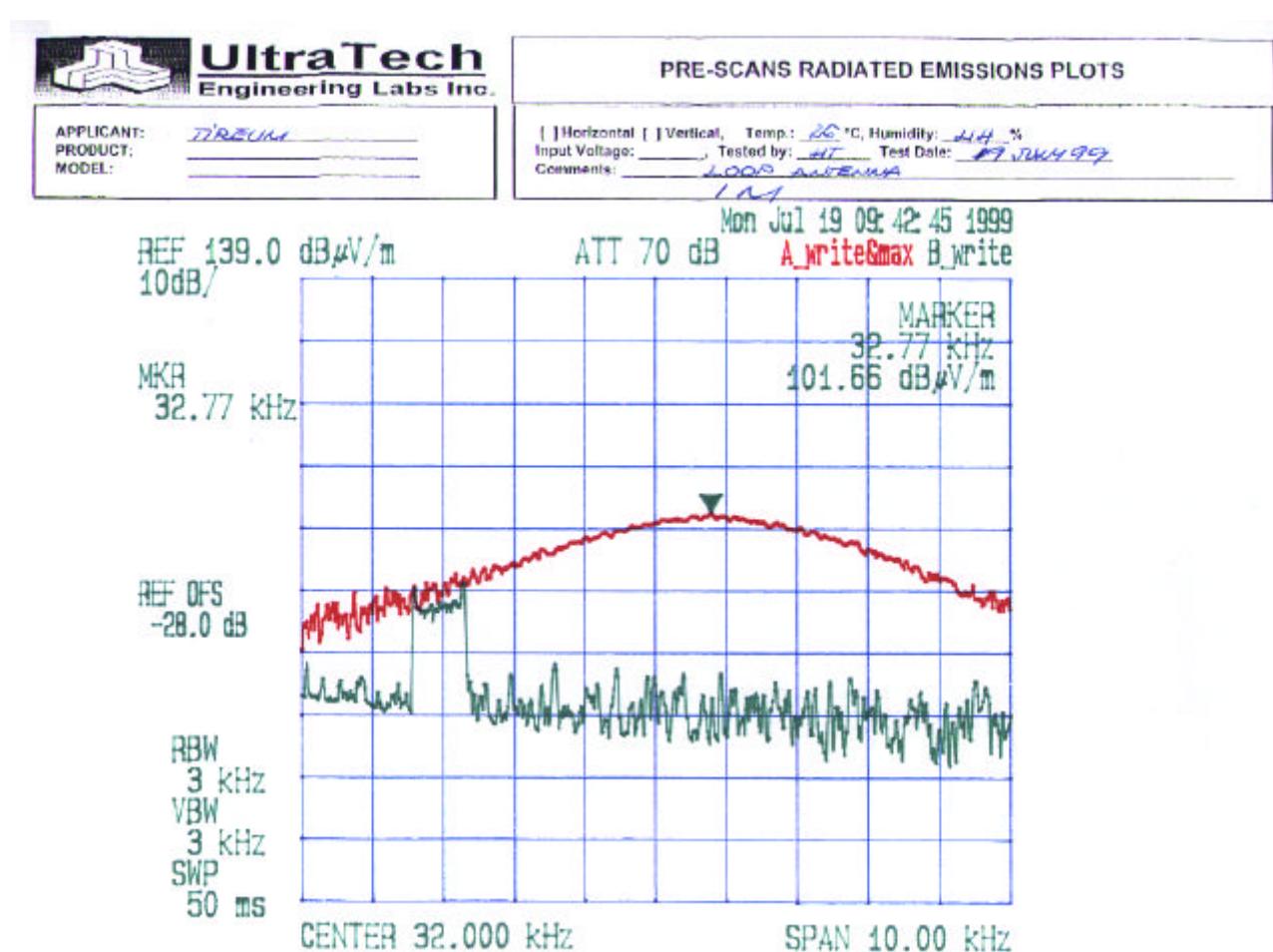
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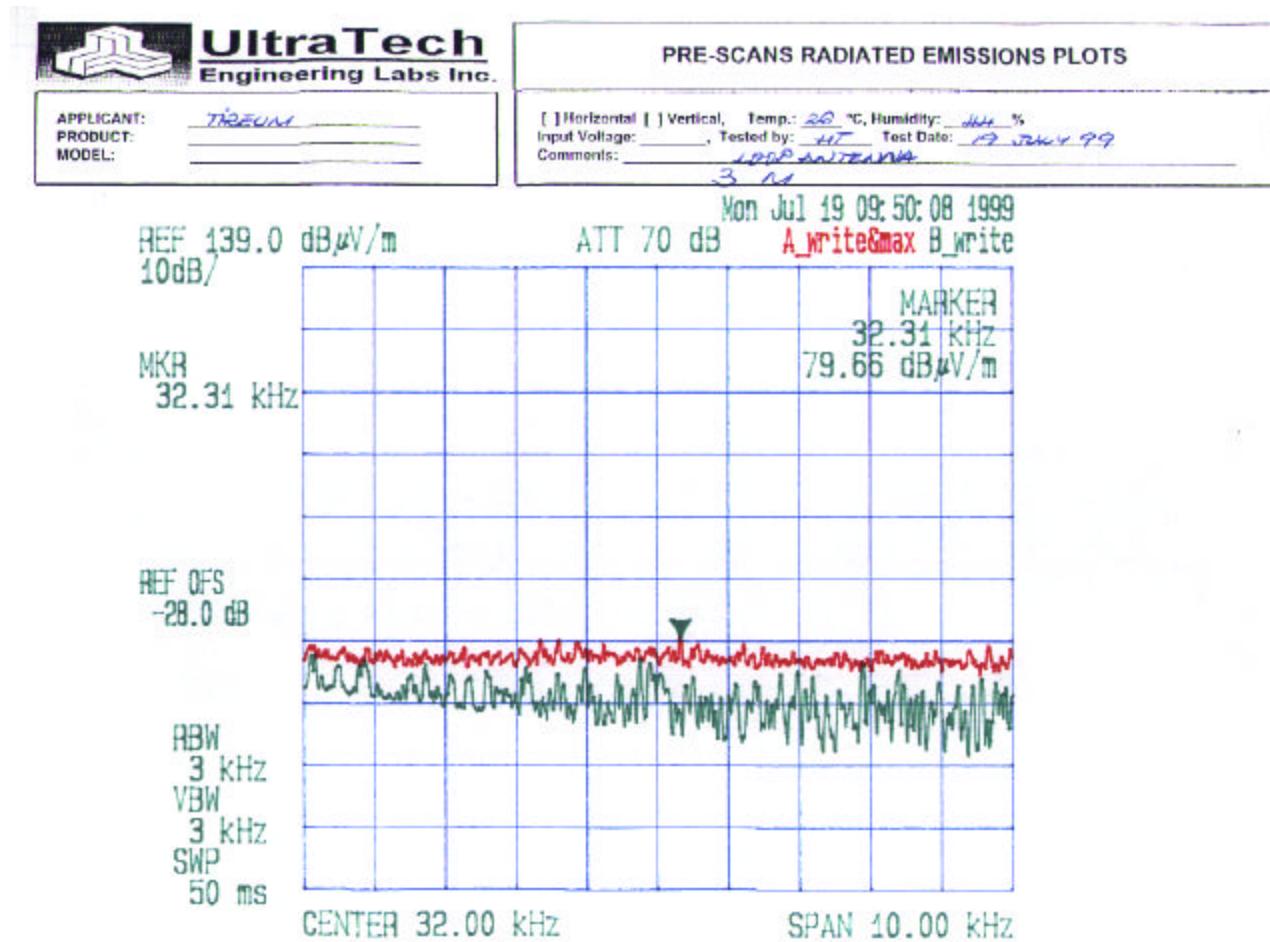
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RADIATED EMISSIONS MEASUREMENT AT 3 METERS

CHANNEL FREQUENCY TESTED: 32.768 kHz

No significant RF emissions found in the frequency range from 10 kHz to 1000 MHz. Refer to attached plots for details



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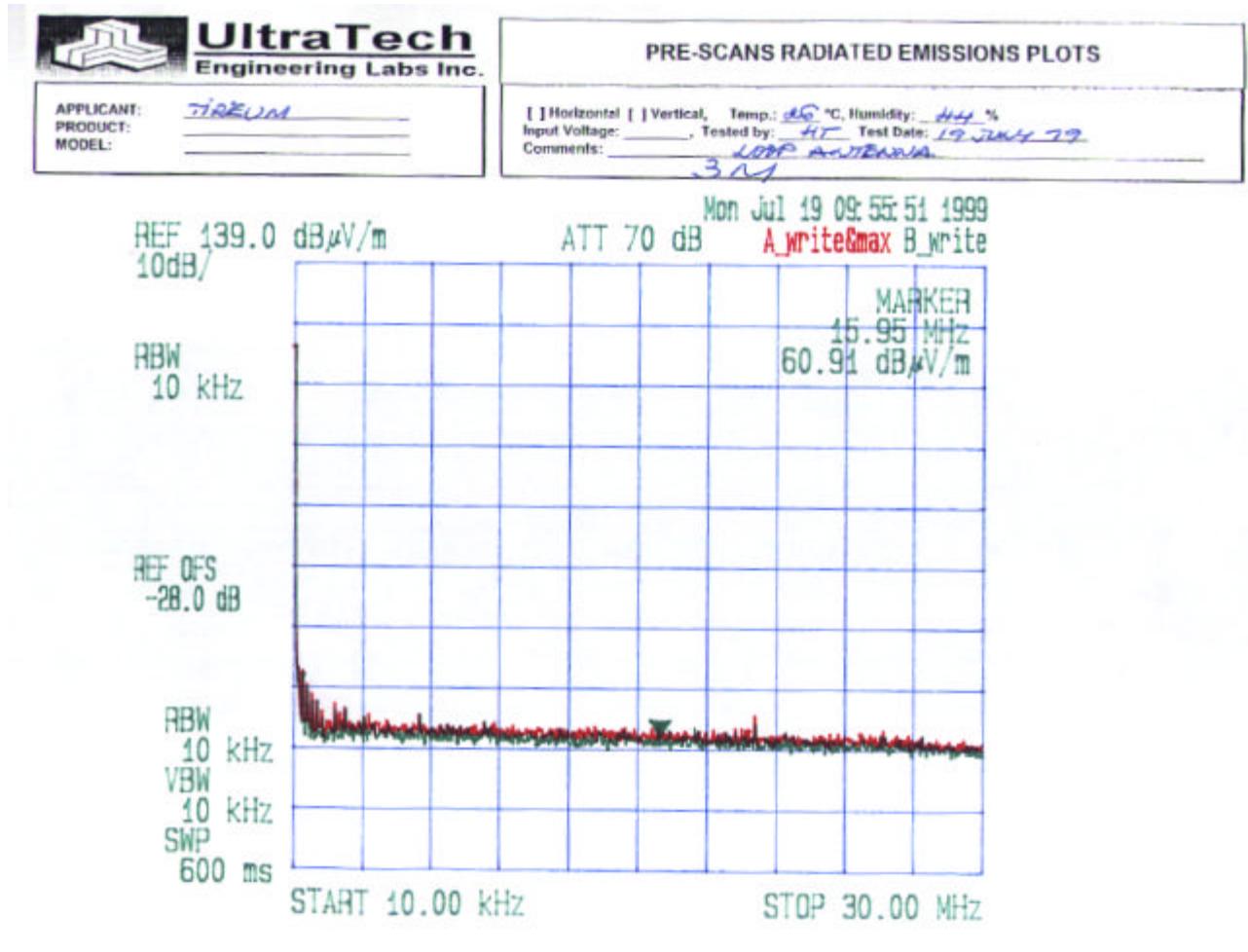
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Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yhk.ultratech@sympatico.ca, Website: <http://www.ultratech-labs.com>

File #: TIR1-FTX
August 6, 1999

- Assessed by ITI (UK) Competent Body, NVLAP (USA) Accreditation Body & ACA/AUSTEL (Australia)
- Recognized/Listed by FCC (USA), Industry Canada (Canada)
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

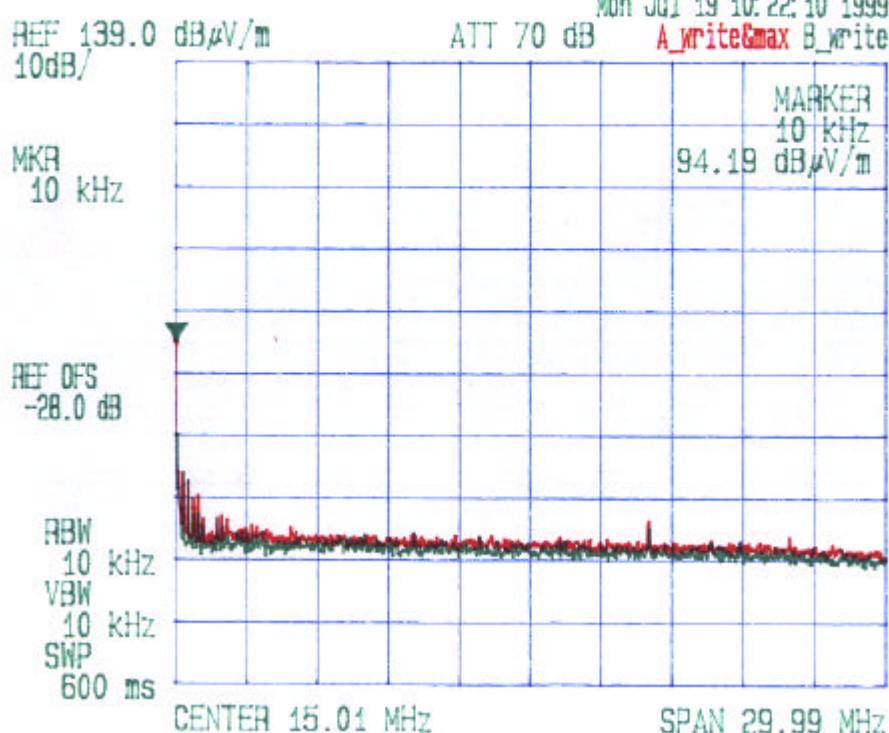


UltraTech
Engineering Labs Inc.

APPLICANT: TIREUM
PRODUCT: _____
MODEL: _____

PRE-SCANS RADIATED EMISSIONS PLOTS

[] Horizontal [] Vertical, Temp.: 25 °C, Humidity: 44 %
Input Voltage: _____, Tested by: AT Test Date: 19 JULY 1999
Comments: LOOP ANTENNA
TRANSMITTER 2 PRE-SCANS 311



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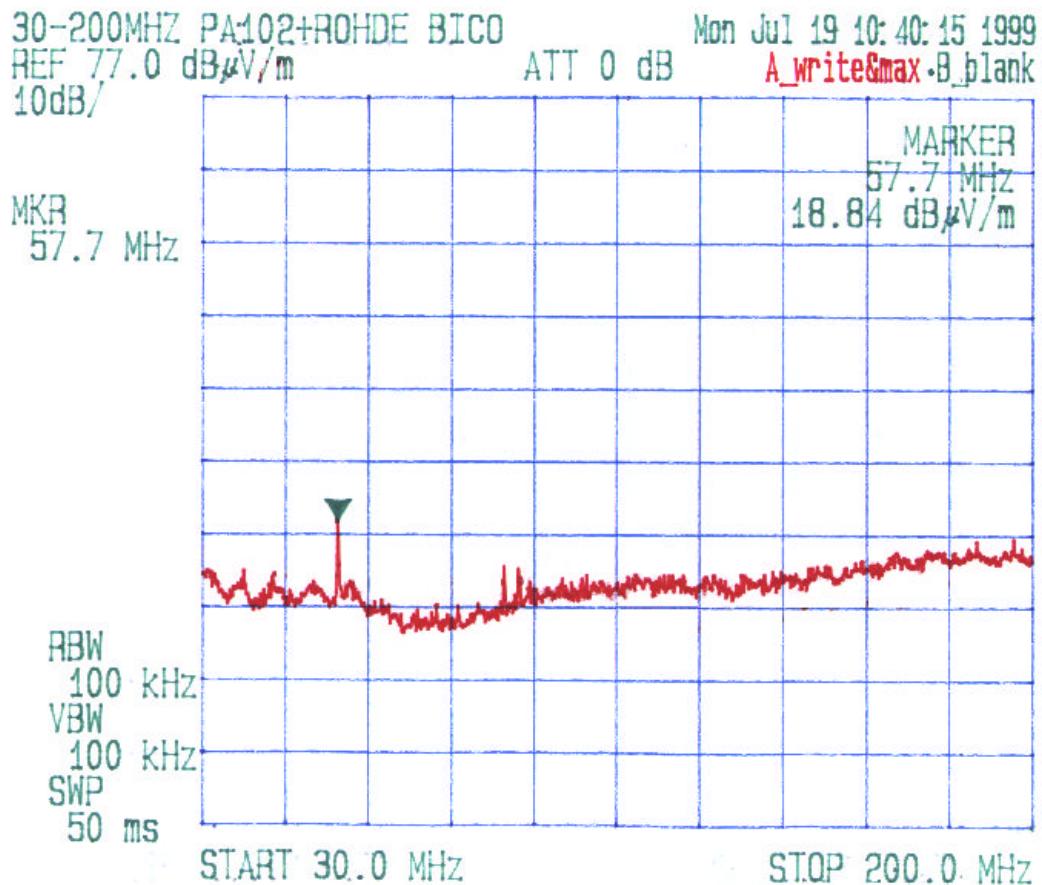
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AMBIENT



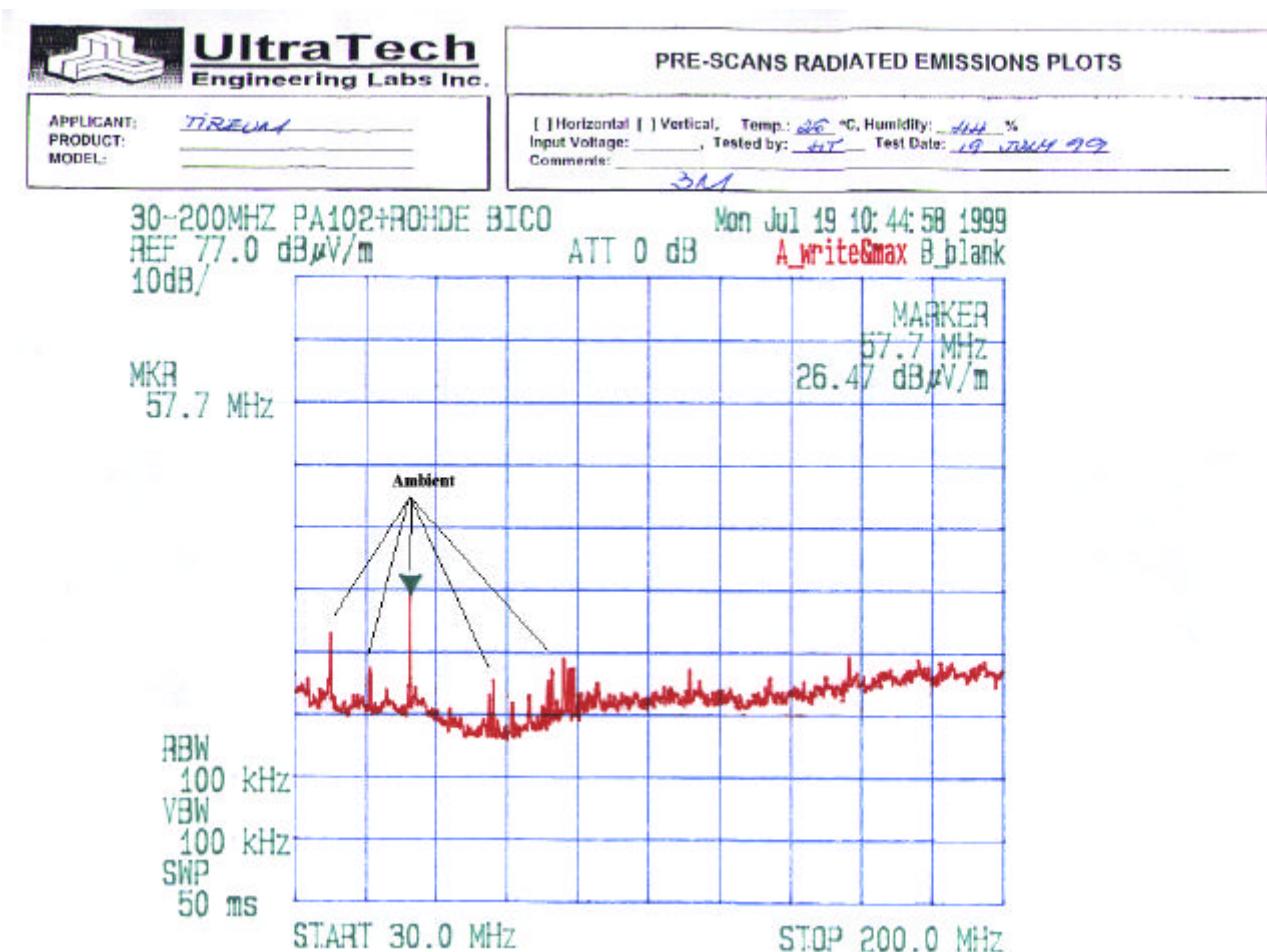
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UltraTech
Engineering Labs Inc.

APPLICANT: TIREUM
PRODUCT: _____
MODEL: _____

PRE-SCANS RADIATED EMISSIONS PLOTS

[] Horizontal Vertical, Temp: 26 °C, Humidity: 50 %
Input Voltage: _____, Tested by: YT Test Date: 19 JULY 99
Comments: 3M

200-1000MHZ PA102+E3146/SN2524 Mon Jul 19 10:56:52 1999
REF 87.0 dB μ V/m ATT 0 dB A_write&max B_write
10dB/

MKR

993.1 MHz

MARKER

993.1 MHz

25.88 dB μ V/m

RBW

100 KHz

VBW

100 KHz

SWP

160 ms

START 200.0 MHz

STOP 1.0000 GHz

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5. EXHIBIT 5 - GENERAL TEST PROCEDURES

5.1. ELECTRICAL FIELD RADIATED EMISSIONS MEASUREMENTS - GENERAL TEST METHOD

- The radiated emission measurements were performed at the UltraTech's 3 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario. The Attenuation Characteristics of OFTS have been filed to FCC.
- Radiated emissions measurements were made using the following test instruments:
 - 1) Calibrated EMCO active loop antenna in the frequency range from 10 KHz to 1 MHz
 - 2) Calibrated EMCO biconilog antenna in the frequency range from 30 MHz to 2000 MHz.
 - 3) Horn Antennas:
 - a) Horn Antenna, Emco, Model 3115, 1 – 18 GHz
 - b) Horn Antenna, Emco, Model 3160-09, 18-26.5GHz
 - c) Horn Antenna, Emco, Model 3160-10, 26.5-40GHz
 - d) Mixer, Tektronix, P/N 118-0098-00, 18-26.5GHz
 - e) Mixer, Tektronix, P/N 119-0098-00, 26.5-40GHz
 - 4) Calibrated Advantest spectrum analyzer and pre-selector/pre-amplifier. In general, the spectrum analyzer would be used as follows:
 - The rf electric field levels were measured with the spectrum analyzer set to PEAK detector (1 KHz RBW and 1 KHz VBW for frequency below 30 MHz, 100 KHz RBW and VBW \geq RBW for Frequency below 1 GHz and 1 MHz RBW and 1 MHz VBW for frequency greater than 1 GHz).
 - If any rf emission was observed to be a broadband noise, the spectrum analyzer's CISPR QUASI-PEAK detector (120 KHz RBW and 1MHz VBW) was then set to measure the signal level.
 - If the signal being measured was narrowband and the ambient field was broadband, the bandwidth of the spectrum analyzer was reduced.
- The EUT was set-up in its typical configuration and operated in its various modes as described in 3.2 of the test report.
- The frequencies of emissions was first detected. Then the amplitude of the emissions was measured at the specified measurement distance using required antenna height, polarization, and detector characteristics.
- During this process, cables and peripheral devices were manipulated within the range of likely configuration.
- For each mode of operation required to be tested, the frequency spectrum was monitored. Variations in antenna heights (from 1 meter to 4 meters above the ground plane), antenna polarization (horizontal plane and vertical plane), cable placement and peripheral placement (each variable within bounds specified elsewhere) were explored to produce the highest amplitude signal relative to the limit.

The maximum radiated emission for a given mode of operation was found by using the following step-by-step procedure:

Step1: Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.

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Step2: Manipulate the system cables to produce highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.

Step3: Rotate the EUT 360 degrees to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat Step 2. Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.

Step4: Move the antenna over its full allowed range of travel (1 to 4 meters) to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to Step 2 with the highest amplitude observation and proceed.

Step5: Change the polarization of the antenna and repeat Step 2 through 4. Compare the resulting suspected highest amplitude signal with that found for the other polarization. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.

Step6: The effects of various modes of operation is examined. This is done by varying the equipment modes as steps 2 through 5 are being performed.

Step7: After completing steps 1 through 6, record the final highest emission level, frequency, antenna polarization and detector mode of the measuring instrument.

Calculation of Field Strength:

The field strength is calculated by adding the calibrated antenna factor and cable factor, and subtracting the Amplifier gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$\boxed{FS = RA + AF + CF - AG}$$

Where FS = Field Strength
 RA = Receiver/Analyzer Reading
 AF = Antenna Factor
 CF = Cable Attenuation Factor
 AG = Amplifier Gain

Example: If a receiver reading of 60.0 dB μ V is obtained, the antenna factor of 7.0 dB/m and cable factor of 1.0 dB are added, and the amplifier gain of 30 dB is subtracted. The actual field strength will be:.

Field Level in dB μ V/m = 60 + 7.0 + 1.0 - 30 = 38.0 dB μ V/m.

Field Level in μ V/m = $10^{(38/20)} = 79.43 \mu$ V/m.

6. EXHIBIT 6 - INFORMATION RELATED TO EQUIPMENT UNDER TESTS

6.1. FCC ID LABELING AND SKETCH OF FCC LABEL LOCATION

Refer to the attached sketch.

6.2. PHOTOGRAPHS OF EQUIPMENT UNDER TEST

Refer to the attached photographs

6.3. SYSTEM BLOCK DIAGRAM(S)

Refer to the attached block diagram

6.4. SCHEMATIC DIAGRAMS

Refer to the attached schematic diagrams

6.5. USER'S MANUAL WITH "FCC INFORMATION TO USER STATEMENTS"

Refer to the attached User's Manual

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