

ENGINEERING TEST REPORT

**Milltronics Radar Level Gauge (6.3 GHz)
MODEL NO.: IQ RADAR 160**

FCC ID: NJA-IQ160

In Accordance With

**FCC PART 15, SUBPART C, PARA. 15.209
LOW POWER COMMUNICATION DEVICE TRANSMITTER
OPERATING AT 6.3 GHz**

(FCC AUTHORIZATION FOR CLASS II PERMISSIVE CHANGES)

UltraTech FILE NO.: MIL-183FTX

Tested for:

MILLTRONICS

P.O. Box 4225, 1954 Technology Drive
Peterborough, Ontario
Canada, K9J 7B1

Tested by:

ULTRATECH GROUP OF LABS

3000 Bristol Circle
Oakville, Ontario
Canada L6H 6G4

REPORT PREPARED BY: Mr. Tri M. Luu, P.Eng.

DATE: June 25, 1999

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3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4

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

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June 17, 1999

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

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
15.209	Transmitter Radiated Emissions	Yes
15.109	AC Power Conducted Emissions	Not required for this Class II Permissive Change

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

MILLTRONICS
P.O. Box 4225, 1954 Technology Drive
Peterborough, Ontario
Canada, K9J 7B1

Applicant's Representative: Mr. Craig Merchant

2.2. MANUFACTURER

MILLTRONICS
P.O. Box 4225, 1954 Technology Drive
Peterborough, Ontario
Canada, K9J 7B1

2.3. DESCRIPTION OF EQUIPMENT UNDER TEST

OPERATIONAL DESCRIPTIONS:

Milltronics IQ-Radar 160 is intended for use in process industries for the determination of material level in the metal tanks and other process metallic vessels. The metal tanks/vessels can be vented or non-vented and with or without internal stilling wells. The principle used is pulse radar. The device is mounted at the top of the tank or vessel. A short pulse of microwave energy is transmitted towards the surface of the material to be measured. This pulse is reflected from the material surface, and re-transmitted back towards the antenna. The time of flight of the pulse is measured, and hence the distance of the material surface from the antenna is determined (Radar principle). This is then used to calculate the level and/or volume of material in the tank or vessel.

PULSE DESENSITIZATION:

Refer to the attached Exhibit for schematic diagram and Technical description of the Microwave Transmitter operation. This information is submitted with the application under confidentiality filing

Please note that the transmitter circuit is designed with a notch filter at a microstrip transmission line to block any transmission below 5.45 GHz from the rf output to the antenna (which is a restricted band).

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PRODUCT NAME: Milltronics Radar Level Gauge (6.3 GHz)

SERIAL NUMBER: Pre-production

TYPE OF EQUIPMENT: LOW POWER COMMUNICATION DEVICE TRANSMITTER

OPERATING FREQ.: 6.3 GHz

BANDWIDTH: 2.7 GHz
 $BW_n = 4/T = 4/1.5nS = 2.7 \text{ GHz}$

POWER RATING: N/A

EMISSION DESIGNATION: N/A

DUTY CYCLE: 0.075% (Duty Cycle = $T_{on}/T_{on+off} = 1.5 \times 10^{-9} / 2 \times 10^{-6} = 0.00075$)

OSC. FREQUENCY(IES): 500 kHz, 8 MHz and 6.3 GHz

CPU SPEED: 2 MHz

INPUT SUPPLY: 120V 60Hz or 24 Vdc

ASSOCIATED DEVICES: N/A

INTERFACE PORTS: (1) RSS-485 Port
(2) DC Loop Current

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ANTENNA TYPES:

The following antennas will be optionally provided with the Milltronics IQ Radar 160:

Accessory Options							
Antenna Option Number	Antenna/Wave Guide Options	Integral Seal Antenna Base	1.5" Pipe Thread Antenna Base	2" Pipe Thread Antenna Base	3" Sanitary Antenna Base	2" Sanitary Antenna Base	Antenna Emitter
1	Rod Antenna	Yes	Yes	Yes	Yes	Yes	No
2	3" Horn Antenna with option of metallic waveguide extension (4" long minimum)	No	No	No	No	No	Yes
3	4" Horn Antenna with option of metallic waveguide extension (4" long minimum)	No	No	No	No	No	Yes
4	6" Horn Antenna with option of metallic waveguide extension (4" long minimum)	No	No	No	No	No	Yes
5	8" Horn Antenna with option of metallic waveguide extension (4" long minimum)	No	No	No	No	No	Yes
6	Long metallic wave guide without Horn antenna	No	No	No	No	No	Yes
7	Rod antenna extension	Yes	Yes	Yes	No	No	No

Please refer to Exhibit 8 for drawings of antenna options.

Notes: All options of rod antennas, antenna extensions, antenna bases and antenna emitters are available with the different types non-conducting polymer antenna materials (For example: High density polyethylene HDPE, Polypropylene PP and etc....) and Teflon PTFE. These non-conducting antenna materials are used for protection of the EUTs when they are used in measuring different types of chemical liquid. They have no effect on the equipment signals.

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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 6.3 GHz.

Both conducted and 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

AC Powerline Conducted Emissions were performed in UltraTech's shielded room, 16'(L) by 12'(W) by 12'(H).

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 sites 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: Sep. 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 conducted emissions are reported in units of dB referenced to one microvolt [dB(μ V)].

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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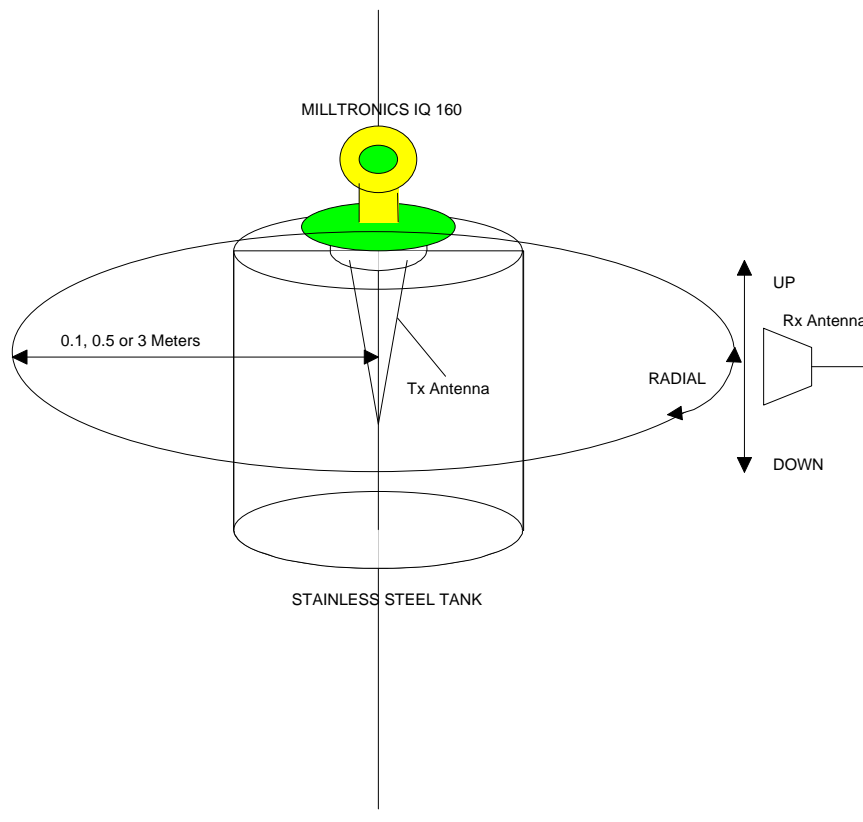
3. EXHIBIT 3 - SYSTEM TEST CONFIGURATION

3.1. TEST SYSTEM DETAILS

The following peripherals, FCC identifiers and types interconnecting cables were used with the EUT for testing:

- (1) **EUT:** MILLTRONICS, Milltronics Radar Level Gauge (6.3 GHz), Model : IQ RADAR 160,, S/N: Pre-production, OSC. FREQ: 500 kHz, 8 MHz and 6.3 GHz.
I/O Cable: All I/O cables were shielded
Power Supply Cable: Non-shielded
- (2) **PERIPHERAL:**
I/O Cable: All I/O Cables were shielded
Power Supply Cable: Non-shielded

3.2. BLOCK DIAGRAMS FOR TEST SETUP OF THE TRANSMITTER MOUNTED ON TOP OF A METAL TANK



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3.3. PHOTOGRAPH OF TEST SETUP FOR THE TRANSMITTER MOUNTED ON TOP OF A METAL TANK

Tested were performed at Milltronics' Facilities.



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3.4. JUSTIFICATION

No deviation, in both configuration and operation manners, different from normal operation were required.

3.5. EUT OPERATING CONDITION

The Milltronics IQ Radar 160 was powered on and transmit the 6.3 GHz microwave signal in a pulse spectrum mode. The measuring resolution bandwidth (RBW) of 3 MHz is used for testing and the corresponding pulse desensitization factor of 43 dB at 1.5 nS pulse width from Figure 28 of HP 150-2 is used for calculation of the peak rf levels.

3.6. SPECIAL ACCESSORIES

No special accessories were required.

3.7. EQUIPMENT MODIFICATIONS

Not required.

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4. EXHIBIT 4 - TEST DATA

4.1. TRANSMITTER RADIATED EMISSIONS @ 3 METERS, FCC CFR 47, PARA. 15.209

PRODUCT NAME: Milltronics Radar Level Gauge (6.3 GHz), Model No.: IQ RADAR 160

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: 120V 60 Hz.

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TEST EQUIPMENT:

- **Spectrum Analyzer**, Advantest, Model R3271, S/N: 15050203, 100 Hz to 32 GHz)
- **Microwave Amplifier**, HP, Model 83017A, Frequency Range 1 to 26.5 GHz, 34-38 dBdB gain nominal.
- **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.
- **Horn Antenna**, Emco, Model 3115, SN 9701-5061, Frequency Range: 1 - 18 GHz, @ 50 Ohms.
- **Horn Antenna**, Emco, Model 3160-09, 18-26.5GHz
- **Horn Antenna**, Emco, Model 3160-09, 18-26.5GHz
- **Horn Antenna**, Emco, Model 3160-10, 26.5-40GHz
- **Mixer**, Tektronix, P/N 118-0098-00, 18-26.5GHz
- **Mixer**, Tektronix, P/N 119-0098-00, 26.5-40GHz

METHOD OF MEASUREMENTS:

Prescans: The EUT will be pre-scanned in the following order to determine its characteristics at different distances before final measurements since its un-corrected emissions are too low to observe at 3 meters distance when it is mounted on top of the metal tank:

1. **Pre-scans** at 3 m distance in the frequency range from 30 MHz to 8 GHz and pre-scans at 1 m distance in the frequency range from 8 GHz to 40 GHz when the IQ-Radar 160 was not mounted on top of the tank. These tests were carried in the Anechoic Room.
2. **Final Measurements** at 3 m distance in the frequency range from 30 MHz to 8 GHz and at 1 m distance in the frequency range from 8 GHz to 40 GHz when the IQ-Radar 160 was mounted on top of the tank. These tests were carried at Milltronics' facility where the metal tank was installed.

Desensitization for Pulse Emissions: Since the Milltronics IQ Radar 160 transmits pulse RF energy with $T_{on} = 1.5$ nS, the desensitization factor (α_p) shall be included in the calculation for the final peak value.

With the measuring resolution bandwidth (RBW) of 3 MHz, the corresponding pulse desensitization factor (α_p) of 43 dB at pulse width $\tau_{eff} = 1.5$ nS can be derived from Figure 28 of HP 150-2.

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

For measurement above 1 GHz, set RBW = 3 MHz, VBW = 3 MHz (Peak)

The average rf level is calculated by the peak reading by subtracting the peak-average correction factor derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

DUTY CYCLE: 0.075% (Duty Cycle = $T_{on}/T_{on+off} = 1.5 \times 10^{-9} / 2 \times 10^{-6} = 0.00075$)

Peak-to-Average Factor = $20 \cdot \log(0.00075) = -62.5$ dB

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There are several conditions which must be satisfied if Eq. (10) is to be valid:

1. The IF bandwidth-pulse width product must be less than two-tenths:

$$B \cdot \tau_{eff} < 0.2 \text{ or } B < \frac{0.2}{\tau_{eff}}$$

2. The normalized scan rate (NSR) of the analyzer must be less than one:

$$NSR = \frac{\text{Scan Width [Hz/Div]}}{\text{Scan Time [s/Div]} \cdot (B[\text{Hz}])^2} < 1$$

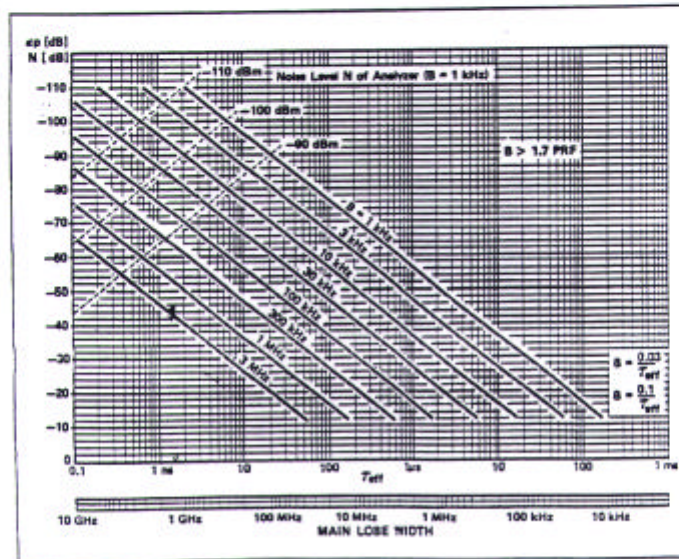
3. The IF bandwidth must be greater than the PRF: $B > \text{PRF}$

The conditions in 1 to 3 are automatically accomplished if the equations (5), (8), and (7) are satisfied.

4. The peak pulse amplitude at the broadband input mixer of the analyzer must stay below the saturation point (1 dB compression). The typical saturation point for HP spectrum analyzers is between -10 dBm and -5 dBm:

$$P_{peak} \leq -10 \text{ dBm} \quad (11)$$

Figure 28 is a diagram showing the pulse desensitization α_p in relation to IF bandwidth B and pulse width τ_{eff} . We see that the PRF does not appear, since it is of no significance for the display amplitude as long as $B > \text{PRF}$. The shaded area between the $B = \frac{0.03}{\tau_{eff}}$ and $B = \frac{0.1}{\tau_{eff}}$ represents the optimum bandwidth range for an analysis of a pulsed signal. There are also three dotted lines which show different noise levels of an analyzer for a fast determination of the dynamic range.



$\alpha_p = 43 \text{ dB}$ for 1.5 nS pulse width pulse desensitization signal, measurement BW = 3 MHz RBW

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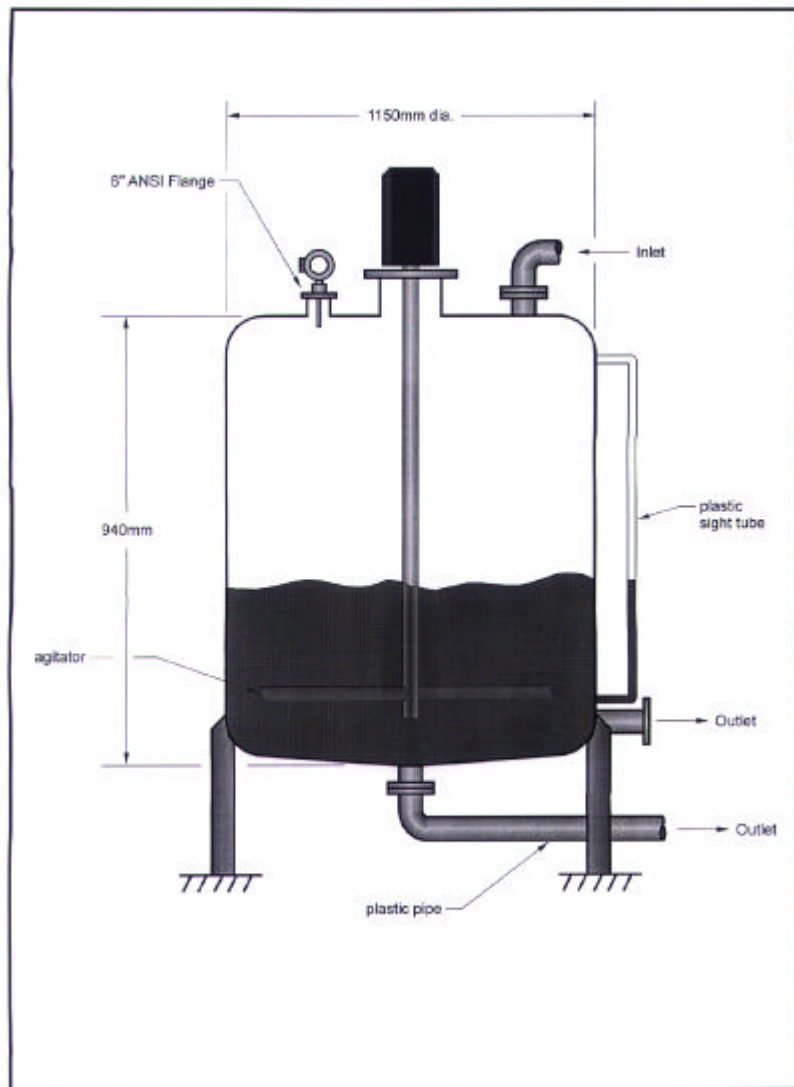
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Description of Metal Tank Used for Testing

The tests were carried out in a typical metal chemical reactor tank. The tank included an agitator and several access flanges.

The IQ Radar 160 was mounted on one of the flanges, with no special gasketing and with the holding screws not tightened. All piping on the inlet and outlet of the tank comprised plastic pipe. A transparent plastic sight tube is located on the side of the tank.

We believe this type of tank represents a typical installation in tanks made mostly of metal but including vents, sight glasses and openings.



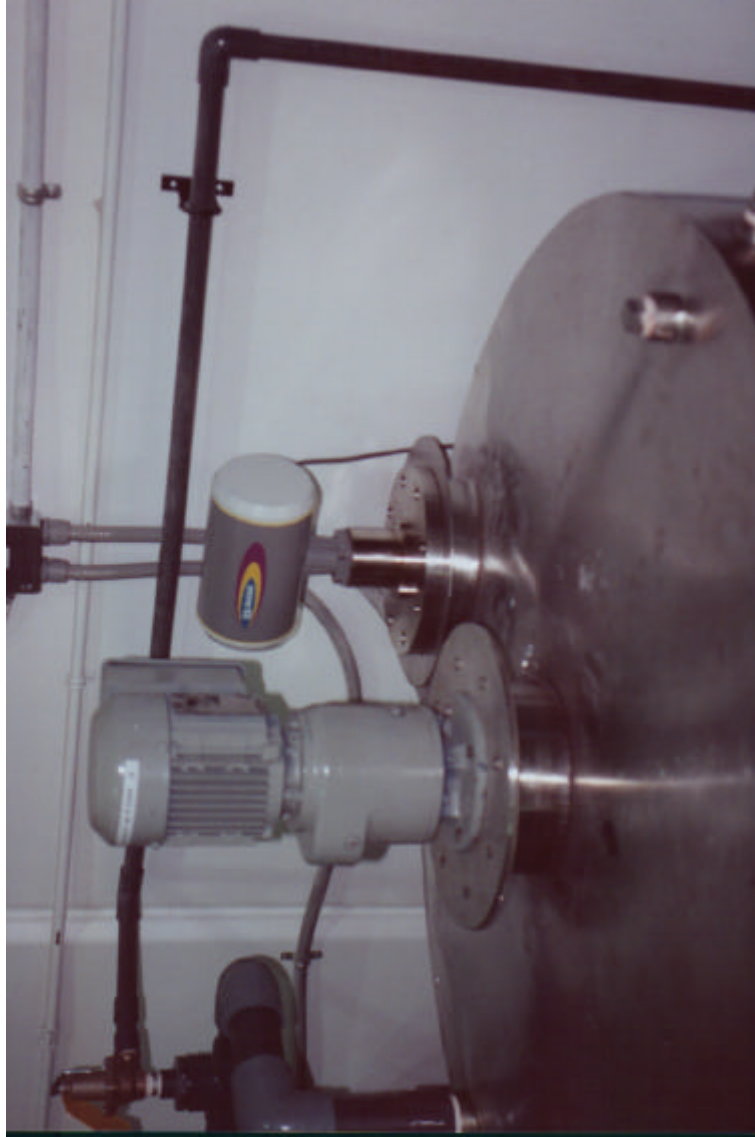
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3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4

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

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TEST RESULTS: Conforms.

TEST PERSONNEL: Mr. Tri Luu, P.Eng.

DATE: June 15, 1999

MEASUREMENT DATA

RADIATED EMISSIONS MEASUREMENTS @ 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 3 MHz RBW, VBW \geq RBW, SWEEP TIME: AUTO, PEAK DETECTOR.
- The receiving antenna is used to probed around, up and down the EUT and the metal tank to search for maximum rf emissions levels.
- **RF Peak Level:** Maximum level readings are added by 43 dB
- **RF Average Level:** the average rf levels were calculated by subtracting the Peak readings added by the duty cycle correction factor. **DUTY CYCLE FACTOR = $20\text{LOG}_{10}(0.00075) = -62.5\text{dB}$**

Remarks:

The following limited number of tests were conducted and represent for all available options (described in page 6 of this report). The limitation of repeating all tests based on the following understandings:

- The options such as antenna base sizes and materials (for rod antenna), antenna emitter (for horn antenna) and extension wave guide shall not change the rf signal characteristics as designed.
- The different size of horn antenna will only change the emission beam-width of the signal which is contained in the metallic tank in one direction toward the metallic tank bottom. Therefore, Tests for all different sizes of antennas are un-necessary.

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4.1.1. Test Configuration #1: Milltronics IQ Radar 160 with Options: Rod Antenna, Integral Seal PTFE Base, No rod antenna extension (Original application)

FREQUENCY (MHz)	RF LEVEL READING @3m (dBuV/m)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT @3m 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
6300	**	**	**	H & V	54.0	**	Pass
No significant spurious/harmonic emissions from the transmitters were found in the frequency from 30 MHz to 40 GHz when the unit was scanned at 3 meters distance (Pre-scans at 1 meter distance was also performed for consistency of measurements).							
Note 1: The Pulse Desensitization Factor (+43 dB) and Duty Cycle Factor (-62.5 dB) of -19.5 dB was used for correction of the final measurements.							

4.1.2. Test Configuration #2: Milltronics IQ Radar 160 with Options: Rod Antenna, 1.5" Pipe Thread Connection PTFE Base, No antenna extension.

FREQUENCY (MHz)	RF LEVEL READING @3m (dBuV/m)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT @3m 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
6300	**	**	**	H & V	54.0	**	Pass
No significant spurious/harmonic emissions from the transmitters were found in the frequency from 30 MHz to 40 GHz when the unit was scanned at 3 meters distance (Pre-scans at 1 meter distance was also performed for consistency of measurements).							
Note 1: The Pulse Desensitization Factor (+43 dB) and Duty Cycle Factor (-62.5 dB) of -19.5 dB was used for correction of the final measurement.							

Remarks: This tests shall cover for uses of rod antenna with different options of rod antenna base type and materials (HDPE, PP or PTFE) since its connection types and materials of antennas', bases' and antenna-extensions' have no effect on RF signal characteristics.

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4.1.3. Test Configuration #3: Milltronics IQ Radar 160 with Options: 3" and 8" Horn Antennas, PTFE Emitter, No waveguide extension.

3" Horn Antenna

FREQUENCY (MHz)	RF LEVEL READING @3m (dBuV/m)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT @3m 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
6300	**	**	**	H & V	54.0	**	Pass

No significant spurious/harmonic emissions from the transmitters were found in the frequency from 30 MHz to 40 GHz when the unit was scanned at 3 meters distance (Pre-scans at 1 meter distance was also performed for consistency of measurements).

Note 1: The Pulse Desensitization Factor (+43 dB) and Duty Cycle Factor (-62.5 dB) of -19.5 dB was used for Correction of the final measurement.

8" Horn Antenna

FREQUENCY (MHz)	RF LEVEL READING @3m (dBuV/m)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT @3m 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
6300	**	**	**	H & V	54.0	**	Pass

No significant spurious/harmonic emissions from the transmitters were found in the frequency from 30 MHz to 40 GHz when the unit was scanned at 3 meters distance (Pre-scans at 1 meter distance was also performed for consistency of measurements).

Note 1: The Pulse Desensitization Factor (+43 dB) and Duty Cycle Factor (-62.5 dB) of -19.5 dB was used for Correction of the final measurement.

Remarks: The above tests with 3" Horn Antenna and 8" Horn Antennas shall cover for uses of Horn Antennas with different size options (4: and 6") in between 3" and 8" sizes of available Horn Antenna. Antenna emitter materials (HDPE, PP or PTFE) shall not have any effect on RF signal characteristics.

4.1.4. Test Configuration #3: Milltronics IQ Radar 160 with Options: 8" Horn Antennas, PTFE Base Emitter, 300mm waveguide extension.

FREQUENCY (MHz)	RF LEVEL READING @3m (dBuV/m)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT @3m 15.209 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
6300	**	**	**	H & V	54.0	**	Pass

No significant spurious/harmonic emissions from the transmitters were found in the frequency from 30 MHz to 40 GHz when the unit was scanned at 3 meters distance (Pre-scans at 1 meter distance was also performed for consistency of measurements).

Note 1: The Pulse Desensitization Factor (+43 dB) and Duty Cycle Factor (-62.5 dB) of -19.5 dB was used for Correction of the final measurement.

Remarks: There is no effect when the antenna is extended using an extension wave guide. Tests of different sizes of horn antennas and for rod antenna with the extension wave guides are un-necessary.

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5. EXHIBIT 5 - 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:

$$FS = RA + AF + CF - AG$$

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:.

$$\text{Field Level in dB}\mu\text{V/m} = 60 + 7.0 + 1.0 - 30 = 38.0 \text{ dB}\mu\text{V/m.}$$

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

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Notes: The frequency and amplitude of at least six highest conducted emissions relative to the limit are recorded unless such emissions are more than 20 dB below the limit. If less than six emissions are within 20dB of the limit, the background or receiver noise level shall be reported at representative frequencies.

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6. EXHIBIT 6 – MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

6.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Line Conducted)	PROBABILITY DISTRIBUTION	UNCERTAINTY (dB)	
		9-150 kHz	0.15-30 MHz
EMI Receiver specification	Rectangular	+1.5	+1.5
LISN coupling specification	Rectangular	+1.5	+1.5
Cable and Input Transient Limiter calibration	Normal (k=2)	+0.3	+0.5
Mismatch: Receiver VRC $\Gamma_1 = 0.03$ LISN VRC $\Gamma_R = 0.8(9 \text{ kHz}) 0.2 (30 \text{ MHz})$ Uncertainty limits $20\text{Log}(1 \pm \Gamma_1 \Gamma_R)$	U-Shaped	+0.2	+0.3
System repeatability	Std. deviation	+0.2	+0.05
Repeatability of EUT	--	--	--
Combined standard uncertainty	Normal	+1.25	+1.30
Expanded uncertainty U	Normal (k=2)	+2.50	+2.60

Sample Calculation for Measurement Accuracy in 150 kHz to 30 MHz Band:

$$u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)} = \pm \sqrt{(1.5^2 + 1.5^2)/3 + (0.5/2)^2 + (0.05/2)^2 + 0.35^2} = \pm 1.30 \text{ dB}$$

$$U = 2u_c(y) = \pm 2.6 \text{ dB}$$

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6.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (\pm dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	+1.0	+1.0
Cable Loss Calibration	Normal (k=2)	+0.3	+0.5
EMI Receiver specification	Rectangular	+1.5	+1.5
Antenna Directivit	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	+2.0	+0.5
Antenna phase centre variation	Rectangular	0.0	+0.2
Antenna factor frequency interpolation	Rectangular	+0.25	+0.25
Measurement distance variation	Rectangular	+0.6	+0.4
Site imperfections	Rectangular	+2.0	+2.0
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67(\text{Bi}) 0.3 (\text{Lp})$ Uncertainty limits $20\text{Log}(1 \pm \Gamma_1 \Gamma_R)$	U-Shaped	+1.1 -1.25	± 0.5
System repeatability	Std. Deviation	+0.5	+0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k=2 is used:

$$U = 2u_c(y) = 2x(+2.19) = +4.38 \text{ dB} \quad \text{And} \quad U = 2u_c(y) = 2x(-2.21) = -4.42 \text{ dB}$$

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7. EXHIBIT 7 - INFORMATION RELATED TO EQUIPMENT UNDER TESTS

7.1. FCC ID LABELING AND SKETCH OF FCC LABEL LOCATION

Refer to the original application

7.2. PHOTOGRAPHS OF EQUIPMENT UNDER TEST

Refer to the attached photographs for antennas options

7.3. SYSTEM BLOCK DIAGRAM(S)

Refer to the original application

7.4. SCHEMATIC DIAGRAMS

Refer to the original application

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

Refer to the original application

8. EXHIBIT 8: Drawings of antenna options

Please refer to the attached Exhibit 8 electronic file for drawings of antenna options

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