ENGINEERING TEST REPORT

Water Sentinel
MODEL NO.: WS500A

FCC ID: PLC500A

FCC PART 15, SUBPART C, PARA. 15.249
LOW POWER TRANSMITTERS
OPERATING IN THE FREQUENCY BAND FROM 902 - 928 MHz

UltraTech's File No.: QPS28_F249

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: ……	
Report Prepared by: Mike Tom	Tested by: Hung Trinh
Issued Date: March 26, 2001	Test Dates: February 26, 2001

The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.

UltraTech

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EXHIBIT 1. SUBMITTAL CHECK LIST

Exhibit No.	Exhibit Type	Description of Contents	Quality Check (OK)
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9	Test Setup Photos	Test Setup at the OATS	Ok
10	External Photos of EUT	Transmitter Unit Only	Ok
11	Internal Photos of EUT	Transmitter Unit Only	Ok
12	Cover Letters	• Letter from UltraTech for Certification Request • Letter from the Applicant to appoint UltraTech to act as an agent • Letter from the Applicant to request for Confidentiality Filing	Ok Ok Ok
13	Application Forms	• Form 731 • Form 159 • Confirmation of Exhibits sent to FCC • Status of Exhibits sent to FCC	Ok Ok Ok Ok
14	ID Label/Location Info	• Labeling requirements and placement on EUT	Ok
15	Block Diagram	Water Sentinel Transmitter	Ok
16	Schematic Diagrams	Water Sentinel Transmitter	Ok
17	Parts List/Tune Up Info	Parts List of Transmitter	Ok
18	Operational Description	Theory of Operation	Ok
19	RF Exposure Info	Not Required	Ok
20	Users Manual	Operating Instructions	Ok

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247:1998
Title	Telecommunication - Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	To gain FCC Certification Authorization for Intentional Transmitters operating in the Frequency Band 902 – 928 MHz.
Test Procedures	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 - 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.
Environmental Classification:	• Residential • Commercial, Industry and Light Industry

2.2. RELATED SUBMITAL(S)/GRANT(S)

None

2.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19	1999	Code of Federal Regulations – Telecommunication
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
CISPR 22 & EN 55022	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1		Specification for Radio Disturbance and Immunity measuring apparatus and methods

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT:	
Name:	Custom Assemblies Ltd.
Address:	541 Ferdinand Boul. Dieppe, New Brunswick Canada, E1A 7G1
Contact Person:	Mr. Francois Boudreau Phone #: 506-877-0735 Fax #: 506-858-8142

MANUFACTURER:	
Name:	Custom Assemblies Ltd.
Address:	541 Ferdinand Boul. Dieppe, New Brunswick Canada, E1A 7G1
Contact Person:	Mr. Francois Boudreau Phone #: 506-877-0735 Fax #: 506-858-8142

3.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

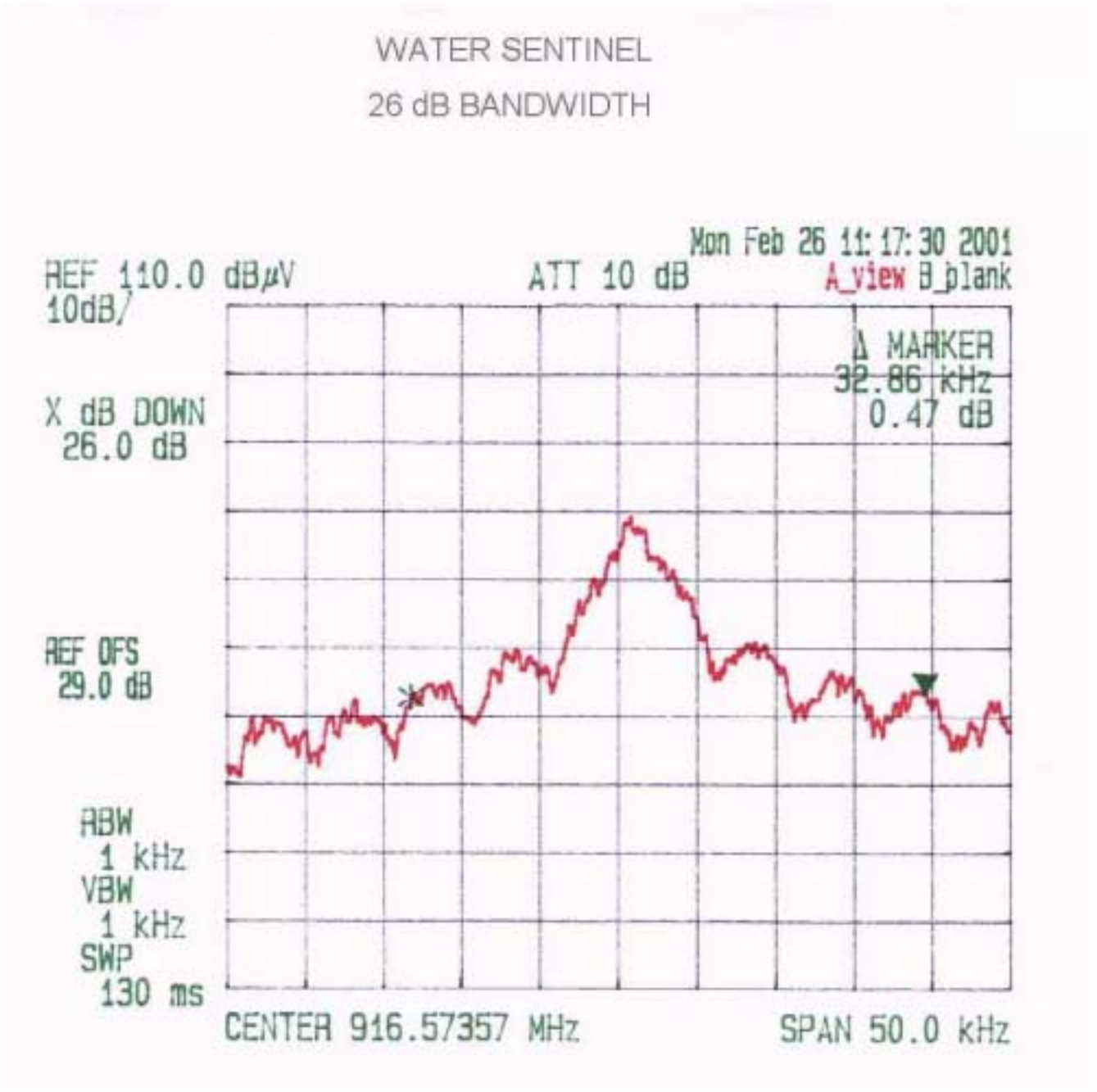
Brand Name	Custom Assemblies Ltd.
Product Name	Water Sentinel
Model Name or Number	WS500A
Serial Number	CNTL500A
Type of Equipment	Low-Power Transmitter
Input Power Supply Type	Transmitter: Internal Battery Receiver: 120V 60 Hz AC
Primary User Functions of EUT:	Provide signaling communication link through air

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	Base station (fixed use)
Intended Operating Environment:	▪ Residential ▪ Commercial, Industry and Light Industry
Power Supply Requirement:	3.5V, 25 mA
RF Output Power Rating:	78.4 dBµV/m @ 3 meters (Average)
Operating Frequency Range:	902 – 928 MHz
RF Output Impedance:	50 Ohms
Duty Cycle:	0.34 %
Modulation Type:	4800 BAUD On-Off-Keyed (OOK)
***Emission Designation:**	32K9N1D
Oscillator Frequencies:	916.5 MHz
Antenna Connector Type:	Integral, permanently attached, Printed Circuit, Open stub
Antenna Description:	Manufacturer: PC Board Trace Type: Printed Circuit Whip, Open Stub Model: N/A Frequency Range: 902 – 928 MHz In/Out Impedance: 50 Ohms Gain: -8 to –12 dBd

** Refer to the attached measurement plot below for details.*

-26 dBc Bandwidth Plot



3.4. LIST OF EUT'S PORTS

NONE.

3.5. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

NONE.

3.6. GENERAL TEST SETUP

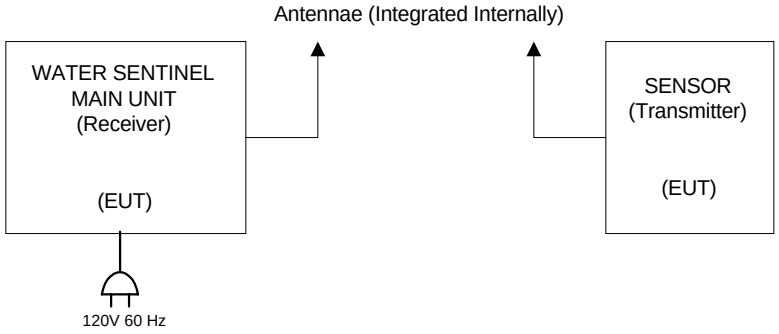


EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	Transmitter: Battery Operated Receiver: 120V 60Hz AC

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	Momentary transmission at 916.5 MHz
Special Test Software:	None Required
Special Hardware Used:	None Required
Transmitter Test Antenna:	Integral

Transmitter Test Signals:	
Frequencies: ▪ 902 – 928 MHz	916.5 MHz
Transmitter Wanted Output Test Signals: ▪ RF Power Output (measured maximum output power): ▪ Normal Test Modulation ▪ Modulating signal source:	 ▪ 87.56 dBµV/m at 3 meters ▪ N1D ▪ Internal

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. LOCATION OF TESTS

All of the measurements described in this report were performed at UltraTech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- Radiated Emissions were performed at the Ultratech's 3 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: Sep.20, 1999.

5.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
15.249(a), 15.209,	Transmitter Radiated Emissions, Harmonic/Spurious Emissions	Yes

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

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS AND TEST DATA FOR EMC EMISSIONS

6.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 8 of this report

6.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 7 for Measurement Uncertainties.

6.3. MEASUREMENT EQUIPMENT USED:

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C64-3:1992, FCC 15.231 and CISPR 16-1.

6.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUACTURER:

The essential function of the EUT is to provide signaling between the transmitter and receiver through the air.

6.5. TRANSMITTER HARMONICS/SPURIOUS EMISSIONS @ FCC 15.249

6.5.1. Limits

The equipment shall meet the limits of the following table:

Section 15.249

Frequency Range (MHz)	Fundamental Limit @ 3m (dBμV/m)	Spurious/Harmonic Limit @ 3m (dBμV/m)	EMI Detector Used	Measuring Bandwidth (kHz)
902-928	94	54	Peak	RBW = 100 kHz, VBW ≥ 100 kHz

For Spurious/Harmonic emissions which fall into the restricted bands of section 15.205, the measured level shall meet the limits of the following table:

Section 15.209(a)

Frequency Range (MHz)	Spurious/Harmonic Limit @ 3m (dBμV/m)	EMI Detector Used	Measuring Bandwidth (kHz)
216-960	46	Quasi-Peak	RBW = 120 kHz, VBW ≥ 120 kHz
Above 960	54	Average	RBW = 100 kHz, VBW ≥ 100 kHz

6.5.2. Method of Measurements

Please refer to the Exhibit 8 of this test report and ANSI C63-4:1992 for radiated emissions test method.

The EUT shall be scanned from 30 MHz to the 5th harmonic of the highest oscillator frequency in the digital devices or 1 GHz whichever is higher.

6.5.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz to 32 GHz with external mixer for frequency above 32 GHz
EMI Receiver System/Spectrum Analyzer	Hewlett Packard	HP 8546A	3520A00248	9KHz-5.6GHz, 50 Ohms
Microwave Amplifier	Hewlett Packard	HP 83017A	311600661	1 GHz to 26.5 GHz
Biconilog Antenna	EMCO	3143	1029	20 MHz to 2 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz

6.5.4. Test data

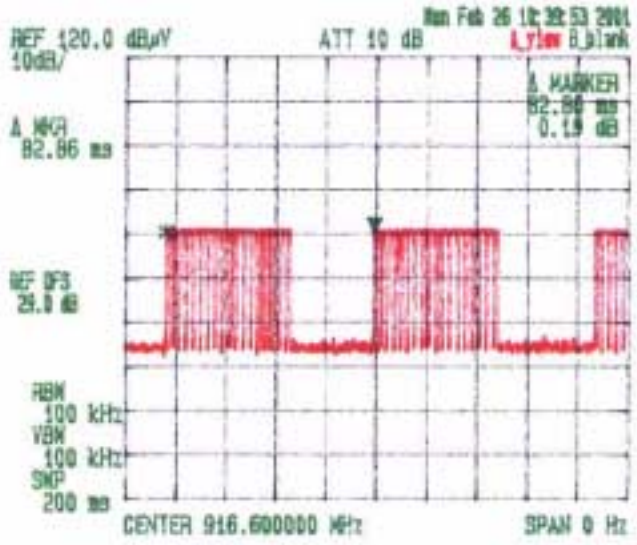
Duty Cycle Measurements: 0.34 % or Peak to Average Conversion factor = 20*log(0.34) = -9.2 dB
Please refer to the following plot for measurement details of the duty cycle.

The emissions were scanned from 30 MHz to 4.523 GHz at 3 Meters distance and all emissions less than 20 dB below the limits were recorded.

Frequency (MHz)	Peak RF Level (dBµV/m)	Average (1) RF Level (dBµV/m)	Antenna Plane (H/V)	Average Limit (dBµV/m)	Restricted (2) Band Limits @ 3m (dBµV/m)	Margin (dB)	Pass/ Fail
916.6	87.6	78.4	V	94.0	54.0	-15.6	PASS
916.6	84.5	75.3	H	94.0	54.0	-18.7	PASS
1833.2	46.2	37.0	V	54.0	54.0	-21.4	PASS
1833.2	46.3	37.1	H	54.0	54.0	-21.8	PASS
2749.8	49.3	40.1	V	54.0	54.0	-19.3	PASS (2)
2749.8	44.5	35.3	H	54.0	54.0	-22.7	PASS (2)
3666.4	48.9	39.7	V	54.0	54.0	-20.3	PASS (2)
3666.4	48.8	39.6	H	54.0	54.0	-20.2	PASS (2)

(1) Average RF calculated by adding the duty cycle correction to the peak RF reading.
(2) Emissions within Restricted Bands of Section 15.205.

6.5.5. Duty Cycle Measurement Plot



Ton = 18 x 1.6 ms = 28.8 ms

$$\text{DUTY CYCLE} = \frac{\text{Ton}}{\text{Ton + Toff}} = \frac{28.8\ \text{ms}}{82.86\ \text{ms}} = 0.34 = -9.2\ \text{dB}$$

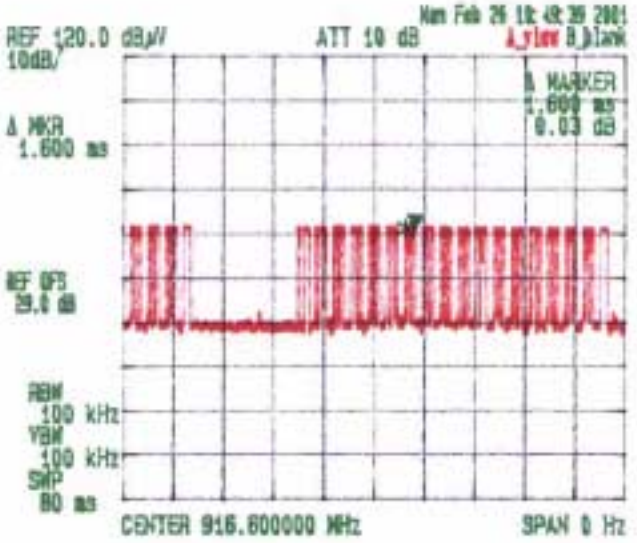


EXHIBIT 7. MEASUREMENT UNCERTAINTY

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

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 M	3 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 Directivity	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center 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 Γ_1 = 0.2 Antenna VRC Γ_R = 0.67(Bi) 0.3 (Lp) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	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 3 M biconical antenna including a factor of k=2 is used:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB

EXHIBIT 8. GENERAL TEST PROCEDURES

8.1. GENERAL TEST CONDITIONS

The following test conditions shall be applied throughout the tests covered in this report.

8.1.1. Normal temperature and humidity

- Normal temperature: +15°C to +35°C
- Relative Humidity: +20% to 75%

The actual values during tests shall be recorded in the test report.

8.1.2. Normal power source

8.1.2.1. Mains Voltage

The nominal test voltage of the equipment to be connected to mains shall be the nominal mains voltage which is the declared voltage or any of the declared voltages for which the equipment was designed.

The frequency of test power source corresponding to the AC mains shall be between 59 Hz and 61 Hz.

8.1.2.2. Battery Power Source.

For operation from battery power sources, the nominal test voltage shall be as declared by the equipment manufacturer. This shall be recorded in the test report.

8.1.3. Operating Condition of Equipment under Test

- All tests were carried out while the equipment operated at its rated fundamental frequency.
- Modulation were applied using the Test Data sequence
- The transmitter was operated at the highest output power, or in the case the equipment able to operate at more than one power level, at the lowest and highest output powers

8.2. METHOD OF MEASUREMENTS - SPURIOUS EMISSIONS (CONDUCTED & RADIATED)

For both conducted and radiated measurements, the spurious emissions were scanned from the lowest frequency generated by the EUT or 10 MHz whichever is lower to 10^{th} harmonic of the highest frequency generated by the EUT.

8.2.1. Spurious Emissions (Conducted)

- The radio was connected to the measuring equipment via a suitable attenuator.
- The spectrum analyzer were used and set as follows:

  - Resolution BW: 100 kHz
  - Video BW: same or greater
  - Detector Mode: Positive Peak
  - Averaging: Off
  - Span: 100 MHz
  - Amplitude: Adjust for middle of the instrument's range
  - Sweep Time: Auto

8.2.2. Spurious Emissions (Radiated)

- 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, Industry Canada, ACA/Austel, NVLap and ITI.
- Radiated emissions measurements were made using the following test instruments:

  1. Calibrated EMCO Biconilog antenna in the frequency range from 30 MHz to 2000 MHz.
  2. Calibrated Emco Horn antennas in the frequency range above 1000 MHz (1GHz - 40 GHz).
  3. Calibrated Advantest spectrum analyzer and pre-selector were used. The spectrum analyzer would be used as follows:

     For frequencies below 1 GHz:
     - Resolution BW: 100 kHz
     - Video BW: same or greater
     - Detector Mode: Positive Peak
     - Averaging: Off
     - Span: 100 MHz
     - Amplitude: Adjust for middle of the instrument's range
     - Sweep Time: Auto

     For frequencies above 1 GHz:
     - Resolution BW: 1 MHz
     - Video BW: same or greater
     - Detector Mode: Positive Peak
     - Averaging: Off
     - Span: 500 MHz
     - Amplitude: Adjust for middle of the instrument's range
     - Sweep Time: Auto

- 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 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 steps:

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

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 allowable 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 dBuV 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 = 60 + 7.0 + 1.0 - 30 = 38.0 dBuV/m., and Field Level = $10^{(38/20)}$ = 79.43 uV/m..

EXHIBIT 9. PHOTOGRAPHS OF TEST SETUP