Elliott Laboratories Inc.
www.elliottlabs.com
684 West Maude Avenue
Sunnyvale, CA 94086-3518
408-245-7800 Phone
408-245-3499 Fax

Electromagnetic Emissions Test Report And Application for Grant of Equipment Authorization Pursuant to FCC Part 15, Subpart C Specifications for an Intentional Radiator on the BadgerMeter, Inc. Model: Ceilink Pit End Point Communications Module

FCC ID:	GIF4545
GRANTEE:	BadgerMeter, Inc. 1585 Industrial Road San Carlos, CA. 94070
TEST SITE:	Elliott Laboratories, Inc. 684 W. Maude Avenue Sunnyvale, CA 94086
REPORT DATE:	December 6, 1999
FINAL TEST DATE:	November 9, 1999
AUTHORIZED SIGNATORY:	Mark R. Briggs Manager, EMC Consulting Services

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SCOPE

An electromagnetic emissions test has been performed on the BadgerMeter, Inc. model Cellink Pit End Point Communications Module pursuant to Subpart C of Part 15 of FCC Rules for intentional radiators. Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in ANSI C63.4-1992 as outlined in Elliott Laboratories test procedures.

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of the BadgerMeter, Inc. model Cellink Pit End Point Communications Module and therefore apply only to the tested sample. The sample was selected and prepared by John Glissman of BadgerMeter, Inc.

OBJECTIVE

The primary objective of the manufacturer is compliance with Subpart C of Part 15 of FCC Rules for the radiated and conducted emissions of intentional radiators. Certification of these devices is required as a prerequisite to marketing as defined in Part 2 the FCC Rules.

Certification is a procedure where the manufacturer or a contracted laboratory makes measurements and submits the test data and technical information to the FCC. The FCC issues a grant of equipment authorization upon successful completion of their review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units which are subsequently manufactured.

STATEMENT OF COMPLIANCE

The tested sample of BadgerMeter, Inc. model Cellink Pit End Point Communications Module complied with the requirements of Subpart C of Part 15 of the FCC Rules for low power intentional radiators.

Maintenance of FCC compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

EMISSION TEST RESULTS

The following emissions tests were performed on the BadgerMeter, Inc. model Cellink Pit End Point Communications Module. The actual test results are contained in an exhibit of this report.

LIMITS OF CONDUCTED INTERFERENCE VOLTAGE

No testing was performed as the device does not connect to the AC power distribution network.

LIMITS OF ANTENNA CONDUCTED POWER

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.247c.

All out-of-band emissions were more than 20dB dB below the highest in-band level when measured in a 100kHz bandwidth. The actual test data and any correction factors are contained an exhibit of this report.

LIMITS OF RADIATED INTERFERENCE FIELD STRENGTH

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.247 and 15.209 in the case of emissions falling within the frequency bands specified in Section 15.205.

The following measurement was extracted from the data recorded during the radiated electric field emissions scan and represents the highest amplitude emission relative to the specification limit. The actual test data and any correction factors are contained in an exhibit of this report.

30 – 10,000 MHz

Frequency MHz	Level dBuV/m	Pol v/h	FCC 15.209 Limit	FCC 15.209 Margin	Detector Pk/QP/Avg	Azimuth degrees	Height meters	Comments
407.840	43.8	h	46.0	-2.2	QP	259	1.7	In restricted band

LIMITS OF POWER AND BANDWIDTH

The EUT tested complied with the limits detailed in FCC Rules Part 15 Section 15.247 (a) (2), 15.247 (b) (1) and 15.247 (d).

The 6 dB bandwidth was 1.360 Megahertz. The maximum power output was 18.7 dBm. The power spectral density was measured to 1.6dBm/3kHz averaged over a 1 second time period.

The actual test data and any correction factors are contained in an exhibit of this report.

MEASUREMENT UNCERTAINTIES

ISO Guide 25 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with NAMAS document NIS 81.

Measurement Type	Frequency Range (MHz)	Calculated Uncertainty (dB)
Conducted Emissions	0.15 to 30	± 2.4
Radiated Emissions	30 to 1000	± 3.2

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The BadgerMeter, Inc. model Cellink Pit End Point Communications Module is a hermetically sealed 917.58 MHz direct sequence spread spectrum transmitter and antenna which is designed to transmit water-metering information from a water meter pit through a ground-level antenna. The sample was received on November 9, 1999 and tested on November 9, 1999. The EUT consisted of the following component(s):

Manufacturer/Model/Description	Serial Number
BadgerMeter Inc / CellinK Pit End Point Communications Module / Spread spectrum data collection unit and transmitter	0-001-199-183

INPUT POWER

The EUT input is rated at 120/240, 50/60 Hz. The EUT contained the following input power components during emissions testing:

Description	Manufacturer	Model
3.3 VDC Dual Lithium Battery	Mallory Duracell	DL2/3A

PRINTED WIRING BOARDS

The EUT contained the following printed wiring boards during emissions testing:

Manufacturer/Description	Assembly #	Rev.	Serial #	Crystals (MHz)
Badger Meter / CPR Xmtr	63704-002			917.580
Badger Meter / Antenna	63720-001			
Badger Meter / Top Disk	63722-001			

ANTENNA

During radiated emissions testing the transmitter was connected to the antenna (refer to subassemblies section) via a SMA connector. Once the product has been installed in a Water pit it the antenna connector is not accessible. Installation of the water meter and EUT into a water pit requires that professional installation personnel be used. Refer to the manufacturer's documentation describing how the EUT is marketed and the installation instructions that are included with the exhibits for the Theory of Operations.

As the product is always professionally installed the requirements of 15.203 are met, even though the antenna connects to the EUT via a SMA connector.

SUBASSEMBLIES

The EUT contained the following subassembly modules during emissions testing:

Manufacturer/Description	Assembly #	Rev.	Serial Number
Badger Meter / Recordall Transmitter Register Model 25	62584-020		
Badger Meter / Pit Transmitter	62752-001		
Badger Meter / Antenna	63726-001		

ENCLOSURE

The EUT's Transmitter enclosure is primarily constructed of Plastic. It measures approximately 16.5 cm wide by 12.5 cm deep by 5 cm high.

The EUT's Antenna circular enclosure is primarily constructed of Plastic. It measures approximately 16.5cm wide by 17cm deep.

EMI SUPPRESSION DEVICES

The EUT did not contain EMI suppression devices during emissions testing.

MODIFICATIONS

The EUT did not require modifications during testing in order to comply with the emission specifications

SUPPORT EQUIPMENT

The following equipment was used as local support equipment for emissions testing:

Manufacturer/Model/Description	Serial Number
Badger / Pit / dirt filled	-

No remote support equipment was used during emissions testing.

EXTERNAL I/O CABLING

The I/O cabling configuration during emissions testing was as follows:

Cable Description	Length (m)	From Unit/Port	To Unit/Port
SMA Male to SMA Male	.25	Transmitter / output	Antenna / input

TEST SOFTWARE

The EUT contained software running during testing which continuously exercised the system by sending data in a one second intervals. The EUT was buried in a cardboard box full of soil such that the top of the meter cover was flush with the top of the soil. The box was located on the table-top during testing.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken on November 9, 1999 at the Elliott Laboratories Open Area Test Site #3 located at 684 West Maude Avenue, Sunnyvale, California. The test site contains separate areas for radiated and conducted emissions testing. Pursuant to section 2.948 of the Rules, construction, calibration, and equipment data has been filed with the Commission.

The FCC recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement with the exception of predictable local TV, radio, and mobile communications traffic. The test site contains separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent FCC requirements.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.4-1992. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

INSTRUMENT CONTROL COMPUTER

The receivers utilize either a Rohde and Schwarz EZM Spectrum Monitor/Controller or contain an internal Spectrum Monitor/Controller to view and convert the receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers.

The Spectrum Monitor provides a visual display of the signal being measured. In addition, the controller or a personal computer run automated data collection programs which control the receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically.

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

POWER METER

A power meter and thermister mount are used for all direct output power measurements from transmitters as they provide a broadband indication of the power output.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A biconical antenna is used to cover the range from 30 MHz to 300 MHz and a log periodic antenna is utilized from 300 MHz to 1000 MHz. Narrowband tuned dipole antennas are used over the entire 30 to 1000 MHz range for precision measurements of field strength. Above 1000 MHz, a horn antenna is used. The antenna calibration factors are included in site factors programmed into the test receivers.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

ANSI C63.4 specifies that the test height above ground for table mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The FCC requires that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.4, and the worst case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

RADIATED EMISSIONS

Radiated emissions measurements are performed in two phases as well. A preliminary scan of emissions is conducted in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed from 30 MHz up to the frequency required by the regulation specified on page 1. One or more of these is with the antenna polarized vertically while the one or more of these is with the antenna polarized horizontally. During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit.

A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth which results in the highest emission is then maintained while varying the antenna height from one to four meters. The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain. Emissions which have values close to the specification limit may also be measured with a tuned dipole antenna to determine compliance.

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements are performed with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS, SECTION 15.207

Frequency Range (MHz)	Limit (uV)	Limit (dBuV)
0.450 to 30.000	250	48

RADIATED EMISSIONS SPECIFICATION LIMITS, SECTION 15.209

The following limits were used for radiated emissions falling within the restricted bands defined in 15.205:

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - B = C$$

and

$$C - S = M$$

where:

R_r = Receiver Reading in dBuV

B = Broadband Correction Factor*

C = Corrected Reading in dBuV

S = Specification Limit in dBuV

M = Margin to Specification in +/- dB

* Broadband Level - Per ANSI C63.4, 13 dB may be subtracted from the quasi-peak level if it is determined that the emission is broadband in nature. If the signal level in the average mode is six dB or more below the signal level in the peak mode, the emission is classified as broadband.

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements. A distance factor, when used for electric field measurements, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBuV/m

L_s = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

EXHIBIT 1:Test Equipment Calibration Data

Test Equipment List - SVOATS#3

November 9, 1999

	Manufacturer/Description		Model	Asset #	Interval	Last Cal	Cal Due
☒	Elliott Laboratories	300-1000 MHz Log Periodic	EL300.1000	55	12	11/3/99	11/3/2000
☒	Elliott Laboratories	Biconical Antenna, 30-300 MHz	EL30.300	773	12	11/3/98	1/3/2000
☐	EMCO	D. Ridge Horn Antenna, 1-18GHz	3115	486	12	3/24/99	3/24/2000
☐	EMCO	D. Ridge Horn Antenna, 1-18GHz	3115	786	12	1/15/99	1/15/2000
☒	EMCO	D. Ridge Horn Antenna, 1-18GHz	3115	868	12	9/25/99	9/25/2000
☐	Filtek	High Pass Filter	HP12/1000-5B	955	12	4/17/99	4/17/2000
☐	Filtek	High Pass Filter	HP12/1000-5B	956	12	4/17/99	4/17/2000
☐	Filtek	High Pass Filter	HP12/1000-5B	957	12	4/17/99	4/17/2000
☐	Fischer	LISN	FCC-LISN-50/2	810	12	2/2/99	2/2/2000
☐	Fluke Mfg Co	Signal Generator.	6062A	852	N/A		
☐	Hewlett Packard	EMC Receiver /Analyzer	8595EM	780	12	1/4/99	1/4/2000
☐	Hewlett Packard	EMC Recever /Analyzer	8595EM	787	12	11/23/98	11/23/99
☒	Hewlett Packard	EMC Spectrum Analyzer	8593EM	1106		10/13/98	11/13/99
☒	Hewlett Packard	Microwave Preamplifier,	8449B	263, (F303)	12	8/3/99	8/3/2000
☐	Hewlett Packard	Microwave Preamplifier,	8449B	785	12	11/25/98	11/25/99
☐	Hewlett Packard	Microwave Preamplifier,	8449B	870	12	11/12/98	11/12/99
☐	Hewlett Packard	Power Meter	432A	259, (F304)	12	2/17/99	2/17/2000
☐	Hewlett Packard	Spectrum Analyzer	8563E	284, (F194)	12	1/18/99	1/18/2000
☐	Hewlett Packard	Thermistor Mount	478A	652	12	2/17/99	2/17/2000
☒	Narda West	EMI Filter 2.4 GHz, High Pass	60583 HPF-161	248	12	4/23/99	4/23/2000
☒	Narda West	EMI Filter 5.6 GHz, High Pass	60583 HXF370	247	12	4/29/99	4/29/2000
☐	Narda West	High Pass Filter	HPF 180	821	12	8/10/99	8/10/2000
☐	Rohde& Schwarz	Pulse Limiter	ESH3 Z2	812	12	12/8/98	12/8/99
☐	Rohde & Schwarz	Test Receiver, 0.009-30 MHz	ESH3	215, (F197)	12	2/17/99	2/17/2000
☒	Rohde & Schwarz	Test Receiver, 20-1300MHz	ESVP	273	12	9/9/99	9/9/2000
☒	Narda	10dB attenuator	774-10	257	12	5/17/99	5/17/2000
☒	Narda	30dB attenuator	757-30	256	12	5/17/99	5/17/2000

File Number: D34559

Date: 11.09.99

Engr: Jerry Hall

All calibration of equipment is traceable to a national standard of measurement such as NIST.

EXHIBIT 2:Test Data Log Sheets

ELECTROMAGNETIC EMISSIONS

TEST LOG SHEETS

AND

MEASUREMENT DATA

T 34559 16 Pages

Client:	BadgerMeter, Inc.	Date:	11.09.99	Test Eng:	Jerry Hill
Product:	CellinK Pit End Point Communication Module	File:	T34559	Proj. Eng:	Jay Dickinson
Objective:	Final Qual	Site:	SVOATS # 3	Contact:	John Glissman
Spec:	FCC Part 15	Page:	1 of 5	Approved:	
Revision	1.1				

Ambient Conditions	
Temperature:	11.1 °C
Humidity:	71.1 % RH

Test Objective

The objective of this test session is to perform final qualification testing the EUT defined below relative to the specification(s) defined above.

Test Summary

Run #1 - Transmitted Power Output Measurement at 917.580 MHz.

PASS Results**:** FCC Part 15.247 (b) (1) was measured to be 18.7 dBm, which is 11.3 dB below the maximum output of 30 dBm (1 W).

Run #1a - Maximized Radiated Emissions, 30–1000 MHz. Restricted Bands.

PASS* Results: FCC B -2.2 dB QP at 407.840 MHz Horizontal

***** The difference between the highest amplitude emission with respect to the specification limit is within the measurement uncertainty.

Run #1b - Maximized Radiated Emissions, 1000–10,000 MHz. Restricted Bands.

PASS Results: FCC B -11.3 dB Pk at 3670.187 MHz Vertical

Run #2 - 6 dB Bandwidth Measurement at 917.58 MHz per FCC Part 15.247 (a) (2)

PASS Results: 6 dB bandwidth was 1.360 MHz, meeting the minimum requirement of 500 kHz.

Run #3 - Maximized Spurious Conducted Emissions-Antenna Port, 30–10,000 MHz

PASS Results: FCC Part 15.247 (c): All Emissions were greater than 20 dB below the Fundamental Frequency.

Run #4- Maximized Radiated Emissions, 30–1000 MHz. Non-Restricted Frequencies

PASS Results: FCC 15.247(c) -11.5 dB Pk at 932.016 MHz Vertical

Run #5 - Transmitted Power Spectral Density @917.58 MHz.

PASS Results**:** FCC Part 15.247 (d) was measured to be 1.6 dBm, which is 7.4 dB below the limit of 8.0 dBm.

Equipment Under Test (EUT) General Description

The EUT is a hermetically sealed 917.58 MHz direct sequence spread spectrum transmitter and antenna. Which is designed to transmit water-metering information from a water meter pit through a ground-level antenna. The electrical rating is 3.3 VDC.

Equipment Under Test (EUT)

Manufacturer/Model/Description	Serial Number	FCC ID Number
BadgerMeter Inc / CellinK Pit End Point Communications Module / Spread spectrum data collection unit and transmitter	0-001-199-183	-

Power Supply and Line Filters

The manufacturer provided the following information:

The EUT used the following external 3.3 V DC Battery.

Description	Manufacturer	Model
3.3 VDC Dual Lithium Battery	Mallory Duracell	DL2/3A

Client:	BadgerMeter, Inc.	Date:	11.09.99	Test Eng:	Jerry Hill
Product:	CellinK Pit End Point Communication Module	File:	T34559	Proj. Eng:	Jay Dickinson
Objective:	Final Qual	Site:	SVOATS # 3	Contact:	John Glissman
Spec:	FCC Part 15	Page:	3 of 5	Approved:	
Revision	1.1				

Printed Wiring Boards in EUT

The manufacturer provided the following information:

Manufacturer/Description	Assembly #	Rev.	Serial Number	Crystals (MHz)
Badger Meter / CPR Xmtr	63704-002			917.580
Badger Meter / Antenna	63720-001			
Badger Meter / Top Disk	63722-001			

Subassemblies in EUT

The manufacturer provided the following information:

Manufacturer/Description	Assembly Number	Rev.	Serial Number
Badger Meter / Recordall Transmitter Register Model 25	62584-020		
Badger Meter / Pit Transmitter	62752-001		
Badger Meter / Antenna	63726-001		

EUT Enclosure(s)

The EUT Meter circular enclosure is primarily constructed of Plastic. It measures approximately 11 cm wide by 15.5cm deep.

The EUT Transmitter enclosure is primarily constructed of Plastic. It measures approximately 16.5 cm wide by 12.5 cm deep by 5 cm high.

The EUT's Antenna circular enclosure is primarily constructed of Plastic. It measures approximately 16.5cm wide by 17cm deep.

EMI Suppression Devices (filters, gaskets, etc.)

Description	Manufacturer	Part Number
None		

Modifications

No modifications were made to the EUT in order to comply with the requirements:

Client:	BadgerMeter, Inc.	Date:	11.09.99	Test Eng:	Jerry Hill
Product:	CellinK Pit End Point Communication Module	File:	T34559	Proj. Eng:	Jay Dickinson
Objective:	Final Qual	Site:	SVOATS # 3	Contact:	John Glissman
Spec:	FCC Part 15	Page:	4 of 5	Approved:	
Revision	1.1				

Local Support Equipment

Manufacturer/Model/Description	Serial Number	FCC ID Number
Badger / Pit / dirt filled	-	-

Remote Support Equipment

Manufacturer/Model/Description	Serial Number	FCC ID Number
None		

Interface Cabling

Cable Description	Length (m)	From Unit/Port	To Unit/Port
SMA Male to SMA Male	.25	Transmitter / output	Antenna / input

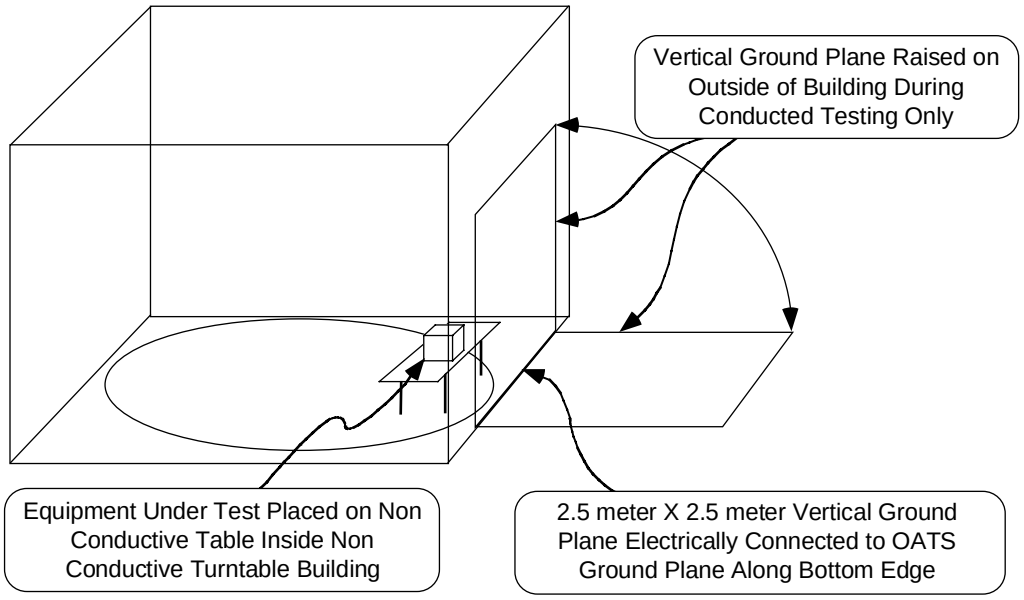
Test Software

The EUT contained software running during testing which continuously exercised the system by sending data in a one second intervals.

Client:	BadgerMeter, Inc.	Date:	11.09.99	Test Eng:	Jerry Hill
Product:	CellinK Pit End Point Communication Module	File:	T34559	Proj. Eng:	Jay Dickinson
Objective:	Final Qual	Site:	SVOATS # 3	Contact:	John Glissman
Spec:	FCC Part 15	Page:	5 of 5	Approved:	
Revision	1.1				

General Test Conditions

During radiated testing, the EUT was powered by 3.3 VDC battery. The EUT was located on the turntable in a In-Ground Pit Enclosure to simulate actual installation for radiated emissions testing.



Test Data Tables

See attached data

Emissions Test Data

Client:	Badger Meter (N. Marshall & Assoc.)	Date:	11.09.99	Test Engr:	Jerry Hill
Product:	Badger Meter s/n 0-001-199-183	File:	T34559	Proj. Engr:	Jay Dickinson
Objective	Final Qual	Site:	SVOATS #3	Contact:	John Glissman
Spec:	FCC Part 15	Distance:	3m	Approved:	

Ambient Conditions
Temperature: 11.1 °C
Humidity: 71.1 % RH

Run #a: Preliminary radiated emissions, 30-1000 MHz
s/n 0-001-199-208

Frequency	Level	Pol	FCC B		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
407.840	44.7	v	46.0	**-1.3**	QP	145	1.4	
407.840	51.7	h	46.0	**5.7**	QP	71	1.0	

Run #b: Fundamental Frequency Measurement
s/n 0-001-199-208

Frequency	Level	Pol	FCC		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
917.580	108.8	v	125.0	-16.2	Pk	143	1.1	
917.580	101.7	h	125.0	-23.3	Pk	15	1.1	

Emissions Test Data

Client:	Badger Meter (N. Marshall & Assoc.)	Date:	11.09.99	Test Engr:	Jerry Hill
Product:	Badger Meter s/n 0-001-199-183	File:	T34559	Proj. Engr:	Jay Dickinson
Objective	Final Qual	Site:	SVOATS #3	Contact:	John Glissman
Spec:	FCC Part 15	Distance:	3m	Approved:	

Run #1: Fundamental Frequency Measurement
s/n 0-001-199-183

Frequency	Level	Pol	FCC		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
917.580	**110.5**	v	125.0	-14.5	Pk	216	1.0	
917.580	103.3	h	125.0	-21.7	Pk	327	2.3	

Run #1a: Maximized radiated emissions, 30-1000 MHz. In restrictive Band.
s/n 0-001-199-183

Frequency	Level	Pol	FCC B		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
407.840	43.8	h	46.0	**-2.2**	QP	259	1.7	
611.720	43.7	h	46.0	**-2.3**	QP	270	1.3	
611.720	43.4	v	46.0	**-2.6**	QP	254	1.2	
407.840	40.2	v	46.0	**-5.8**	QP	116	1.2	
960.812	39.0	v	54.0	-15.0	QP	322	1.3	
964.916	36.9	v	54.0	-17.1	QP	224	1.3	
960.812	35.2	h	54.0	-18.8	QP	359	4.0	noise floor
964.916	35.0	h	54.0	-19.0	QP	200	4.0	noise floor
81.000	19.3	h	40.0	-20.7	QP	0	2.0	ambient
81.000	16.0	v	40.0	-24.0	QP	0	1.0	ambient
216.600	21.7	v	46.0	-24.3	QP	0	1.0	ambient
216.600	21.7	h	46.0	-24.3	QP	0	2.0	ambient
123.000	18.7	v	43.5	-24.8	QP	0	1.0	ambient
123.000	18.5	h	43.5	-25.0	QP	0	2.0	ambient

Run #1b: Maximized radiated emissions, 30-1000 MHz. Not in restrictive Band.
s/n 0-001-199-183

Frequency	Level	Pol	FCC		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
932.016	79.0	v	90.5	-11.5	Pk	282	1.5	
932.016	71.1	h	90.5	-19.4	Pk	325	2.2	
946.116	56.8	v	90.5	-33.7	Pk	289	1.4	
946.116	55.0	h	90.5	-35.5	Pk	58	1.0	
276.757	41.0	h	90.5	-49.5	Pk	200	1.0	
276.757	41.0	v	90.5	-49.5	Pk	15	1.0	
203.894	38.2	h	90.5	-52.3	Pk	20	1.0	
203.894	38.2	v	90.5	-52.3	Pk	175	1.0	

Emissions Test Data

Client:	Badger Meter (N. Marshall & Assoc.)	Date:	11.09.99	Test Engr:	Jerry Hill
Product:	Badger Meter s/n 0-001-199-183	File:	T34559	Proj. Engr:	Jay Dickinson
Objective	Final Qual	Site:	SVOATS #3	Contact:	John Glissman
Spec:	FCC Part 15	Distance:	3m	Approved:	

Run #1c: Maximized radiated emissions, 1000-10000 MHz
s/n 0-001-199-183

-15.9dB was subtracted from Avg Reading for duty cycle correction factor.

Frequency	Level	Pol	FCC B		Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
3670.187	62.7	v	74.0	-11.3	Pk	249	1.0	In restrictive band.
3670.187	60.2	h	74.0	-13.8	Pk	201	1.0	In restrictive band.
2752.600	59.0	v	74.0	-15.0	Pk	343	1.2	In restrictive band.
8258.220	59.0	v	74.0	-15.0	Pk	0	1.0	In restrictive band.
9175.800	58.5	h	74.0	-15.5	Pk	0	1.0	In restrictive band.
9175.800	58.0	v	74.0	-16.0	Pk	0	1.0	In restrictive band.
2752.600	56.5	h	74.0	-17.5	Pk	19	1.6	In restrictive band.
4587.900	55.5	v	74.0	-18.5	Pk	191	1.4	In restrictive band.
6423.060	54.0	h	74.0	-20.0	Pk	0	1.0	not in restrictive band.
4587.900	53.4	h	74.0	-20.6	Pk	252	1.0	In restrictive band.
7340.640	52.3	v	74.0	-21.7	Pk	10	1.0	In restrictive band.
3670.187	31.2	v	54.0	-22.8	Avg	249	1.0	In restrictive band.
8258.220	50.0	h	74.0	-24.0	Pk	0	1.0	In restrictive band.
5505.480	49.5	h	74.0	-24.5	Pk	0	1.0	not in restrictive band.
3670.187	29.4	h	54.0	-24.6	Avg	201	1.0	In restrictive band.
5505.480	49.0	v	74.0	-25.0	Pk	0	1.0	not in restrictive band.
6423.060	48.9	v	74.0	-25.1	Pk	0	1.0	not in restrictive band.
4587.900	25.6	h	54.0	-28.4	Avg	262	1.0	In restrictive band.
4587.900	25.1	v	54.0	-28.9	Avg	262	1.0	In restrictive band.
7340.640	25.1	v	54.0	-28.9	Avg	10	1.0	In restrictive band.
8258.220	25.0	v	54.0	-29.0	Avg	0	1.0	In restrictive band.
2752.600	24.9	v	54.0	-29.1	Avg	345	1.2	In restrictive band.
9175.800	24.6	v	54.0	-29.4	Avg	0	1.0	In restrictive band.
2752.600	24.4	h	54.0	-29.6	Avg	19	1.6	In restrictive band.
8258.220	21.5	h	54.0	-32.5	Avg	0	1.0	In restrictive band.
6423.060	21.4	v	54.0	-32.6	Avg	0	1.0	not in restrictive band.
5505.480	20.8	h	54.0	-33.2	Avg	0	1.0	not in restrictive band.
9175.800	19.1	h	54.0	-34.9	Avg	0	1.0	In restrictive band.
6423.060	18.5	h	54.0	-35.5	Avg	0	1.0	not in restrictive band.
5505.480	18.5	v	54.0	-35.5	Avg	0	1.0	not in restrictive band.

Emissions Test Data

Client:	Badger Meter (N. Marshall & Assoc.)	Date:	11.09.99	Test Engr:	Jerry Hill
Product:	Badger Meter s/n 0-001-199-183	File:	T34559	Proj. Engr:	Jay Dickinson
Objective	Final Qual	Site:	SVOATS #3	Contact:	John Glissman
Spec:	FCC Part 15	Distance:	3m	Approved:	

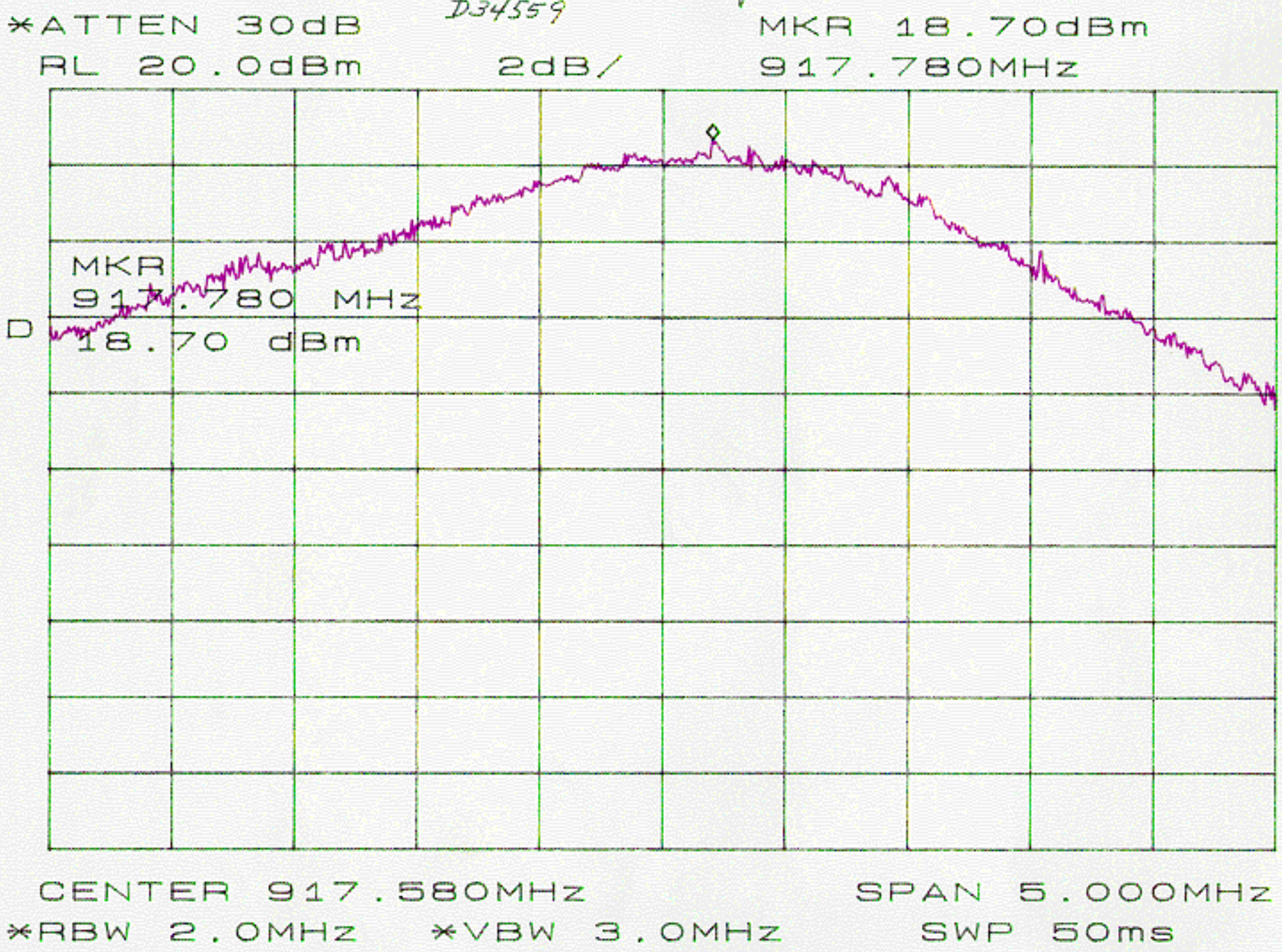
Run #2: 6dB Bandwidth measurement.
Measurement was perform and EUT was found to be 1.360MHz Bandwidth at its 6dB point.

Run #3: Conducted Emissions-Antenna Port.
All detected emissions were found to be greater than 20dBc from the Fundamental Frequency.

Run #4: Transmitted Power Measurement @ 917.58 MHz was measure by the direct port method which was found to be 18.7dBm which is 11.3 dB below the maximum permitted output of 30dBm (1 Watt)

Power Output

Badger Meter
S/N 0-001-199-183
D34559



6dB Bw

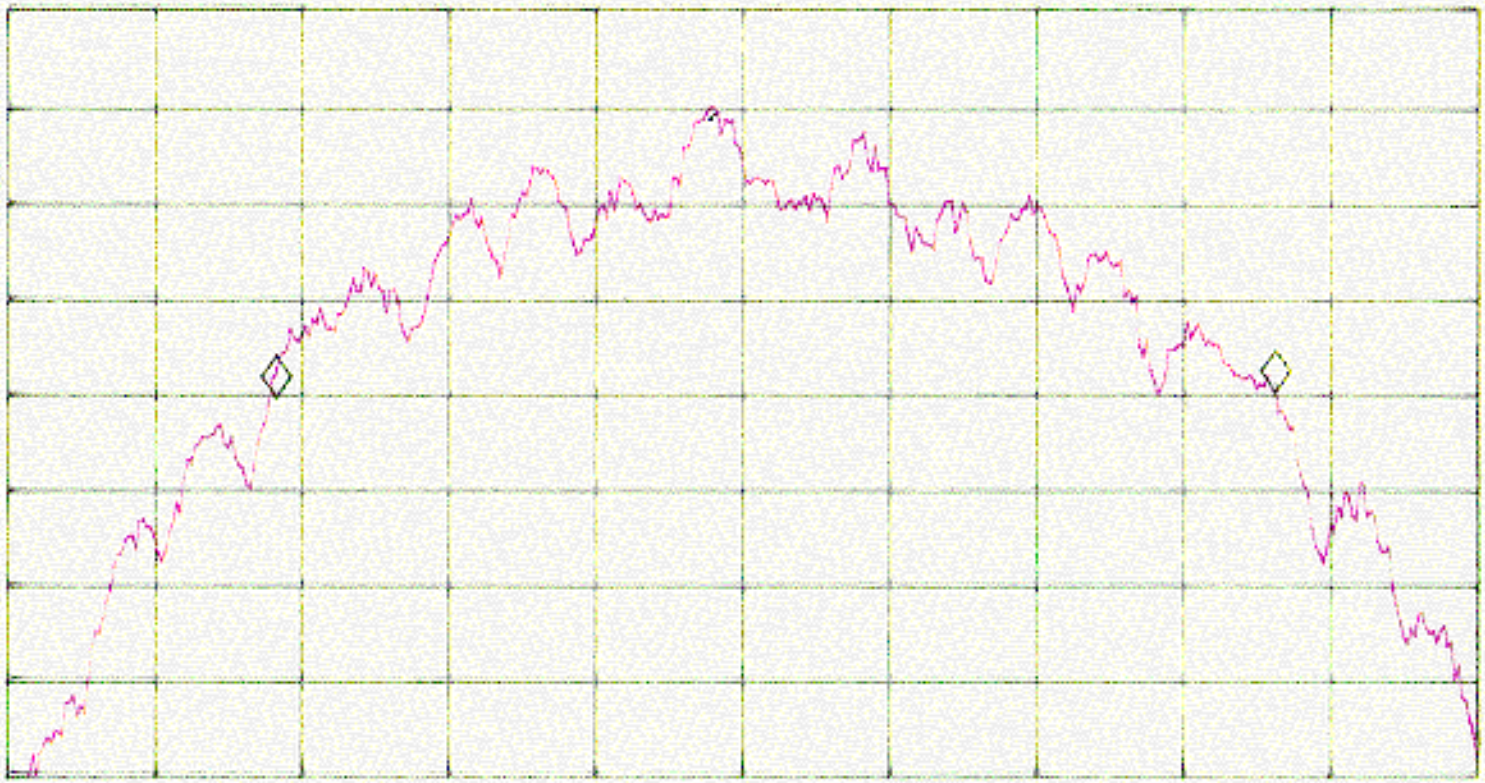
03: 26: 36 NOV 10, 1999

BADGER METER
S/N 0-001-199-183

D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 1.360 MHz
.12 dB

REF OFFST 40.0 dB (External 40dB attenuator)
LOG REF 16.2 dBm
2
dB/
#ATN
20 dB



MA SB
SC FC
CORR

CENTER 917.520 MHz
SPAN 2.000 MHz
#IF BW 100 kHz
#AVG BW 100 kHz
SWP 20.0 msec

03: 45: 34 NOV 10, 1999

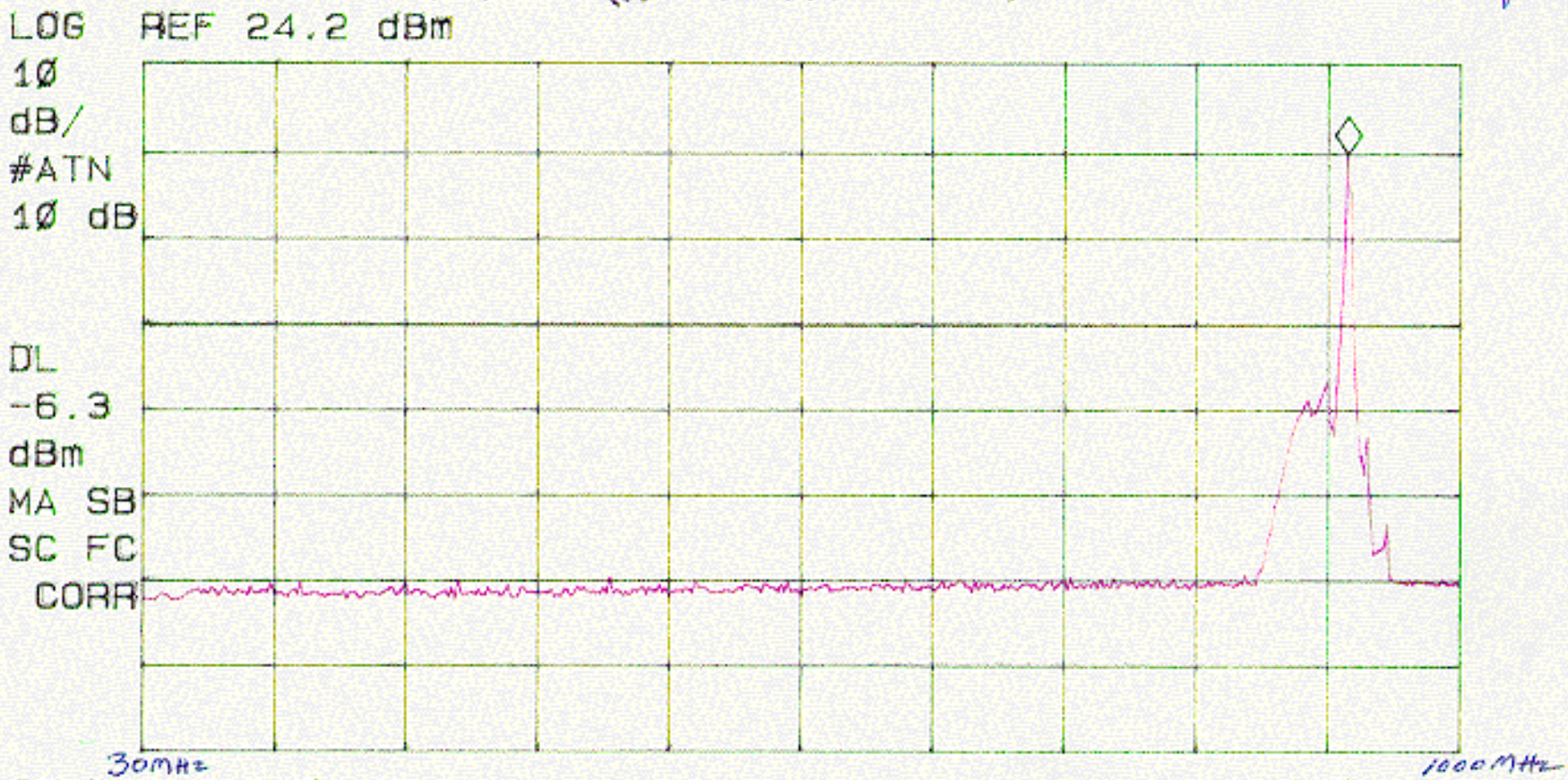
Conducted Emissions, Direct Port Method

BADGER METER
S/N 0-001-199-183

D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 917.6 MHz
13.68 dBm

REF OFFST 40.0 dB (External 40 dB attenuator)



CENTER 515.0 MHz
SPAN 970.0 MHz
#IF BW 100 kHz
#AVG BW 100 kHz
#SWP 500 msec

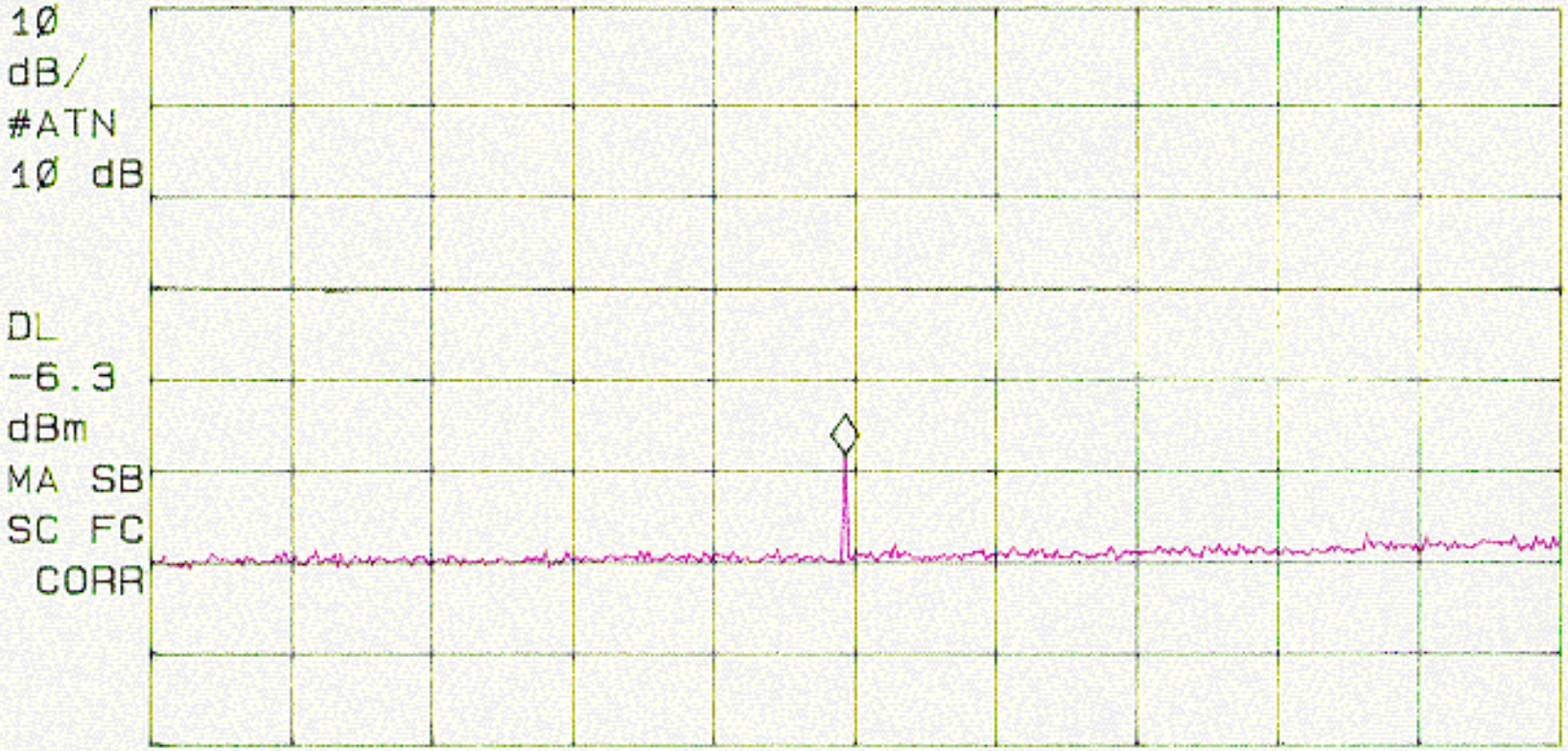
03: 55: 41 NOV 10, 1999

CONDUCTED EMISSIONS, DIRECT PORT METHOD

BADGER METER
S/N 0-001-199-183
D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 1.837 GHz
-24.30 dBm

REF OFFST 40.0 dB (External 40 dB ATTENUATOR)
LOG REF 24.2 dBm



START 1.000 GHz
STOP 2.699 GHz
#IF BW 100 kHz
#AVG BW 100 kHz
#SWP 1.50 sec

04: 03: 18 NOV 10, 1999 Conducted Emissions, Direct Port Method

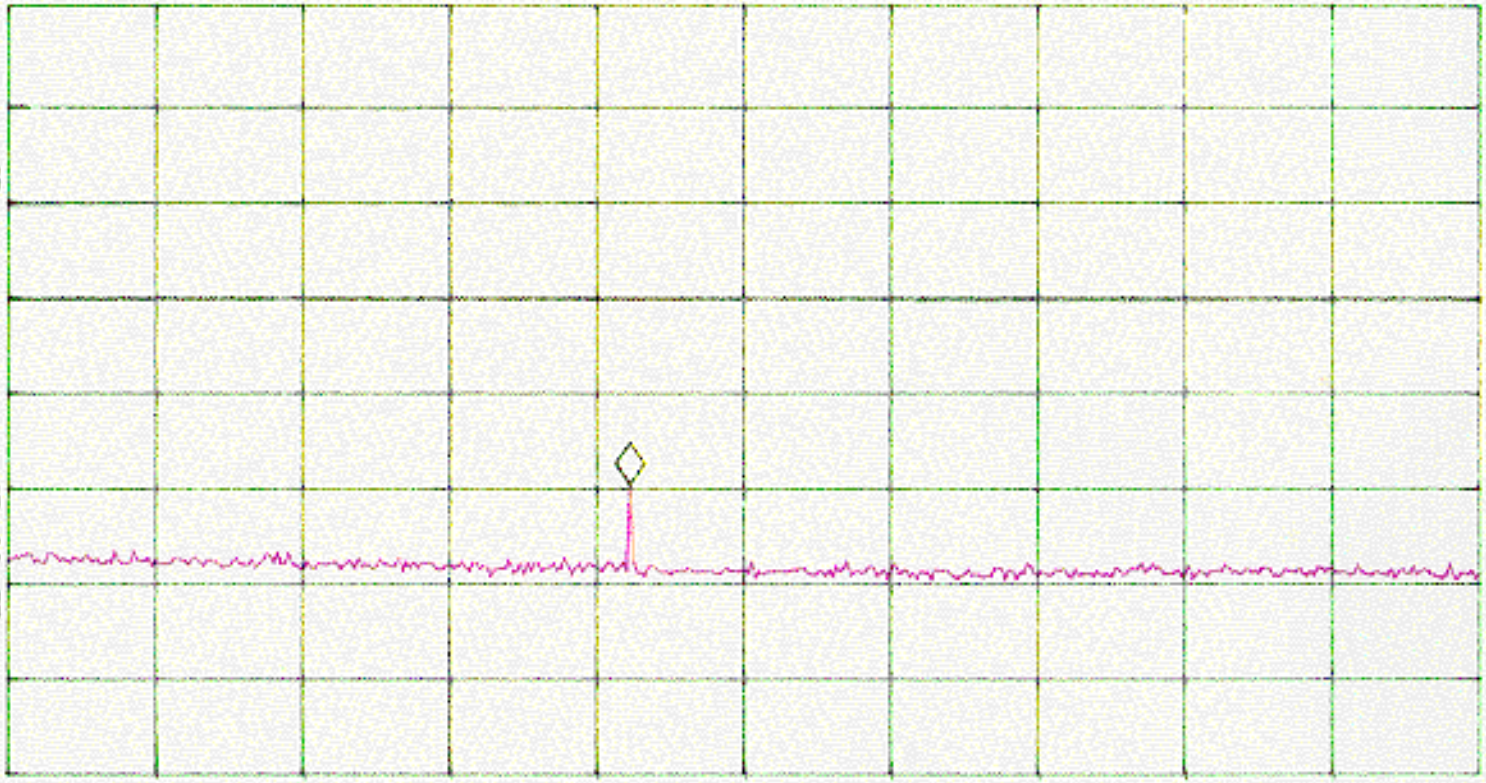
Badger Meter
S/N 0-001-199-183

D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 3.672 GHz
-25.62 dBm

REF OFFST 40.0 dB (External 40dB Attenuator)
LOG REF 24.2 dBm
10
dB/
#ATN
10 dB

DL
-6.3
dBm
MA SB
SC FC
CORR



START 2.700 GHz
STOP 5.000 GHz
#IF BW 100 kHz #AVG BW 100 kHz #SWP 1.50 sec

04: 25: 54 NOV 10, 1999 Conducted Emissions, Direct Port Method

Badger Meter
S/N 0-001-199-183

D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 5.566 GHz
-32.82 dBm

REF OFFST 40.0 dB (External 40 dB Attenuator)
LOG REF 24.2 dBm
10
dB/
#ATN
10 dB

DL
-6.3
dBm
MA SB
SC FC
CORR

START 5.000 GHz
STOP 6.500 GHz
#IF BW 100 kHz #AVG BW 100 kHz #SWP 1.50 sec

04: 20: 44 NOV 10, 1999 CONDUCTED EMISSIONS, DIRECT PORT METHOD

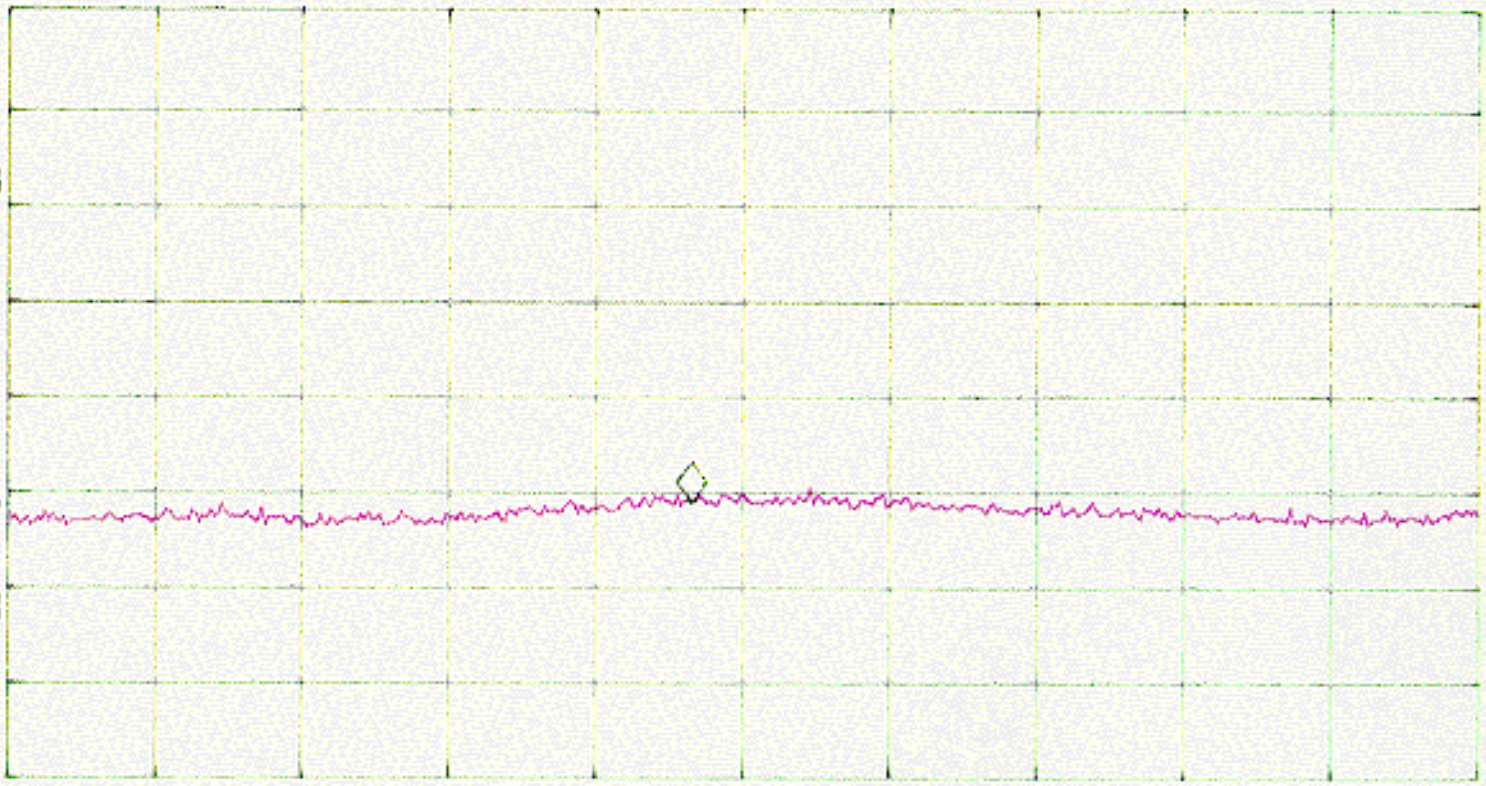
BADGER METER
S/N 0-001-199-183

D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 8.128 GHz
-27.16 dBm

REF OFFST 40.0 dB (External 40 dB Attenuator)
LOG REF 24.2 dBm
10
dB/
#ATN
10 dB

DL
-6.3
dBm
MA SB
SC FC
CORR



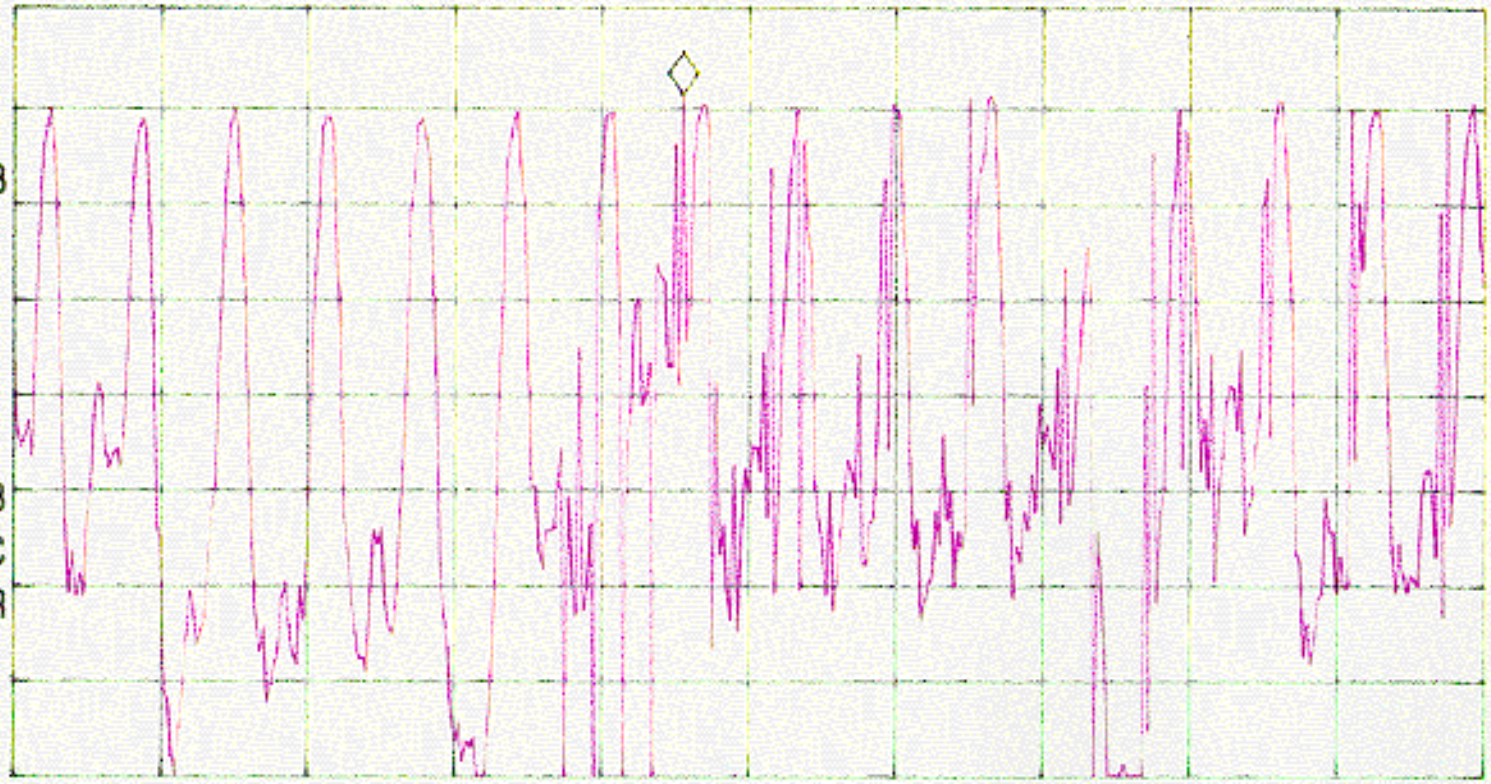
START 6.500 GHz
STOP 10.000 GHz
#IF BW 100 kHz #AVG BW 100 kHz #SWP 1.50 sec

04: 46: 36 NOV 10, 1999

BADGER METER
S/N 0-001-199-183
D34559

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 917.4940 MHz
.60 dBm

REF OFFST 40.0 dB
LOG REF 2.4 dBm
2
dB/
#ATN
10 dB



MA SB
SC FC
CORR

CENTER 917.5075 MHz
SPAN 300.0 kHz
#IF BW 3.0 kHz #AVG BW 3 kHz #SWP 100 sec

PROCESSING GAIN TEST PROCEDURE, BRIEF DESCRIPTION.

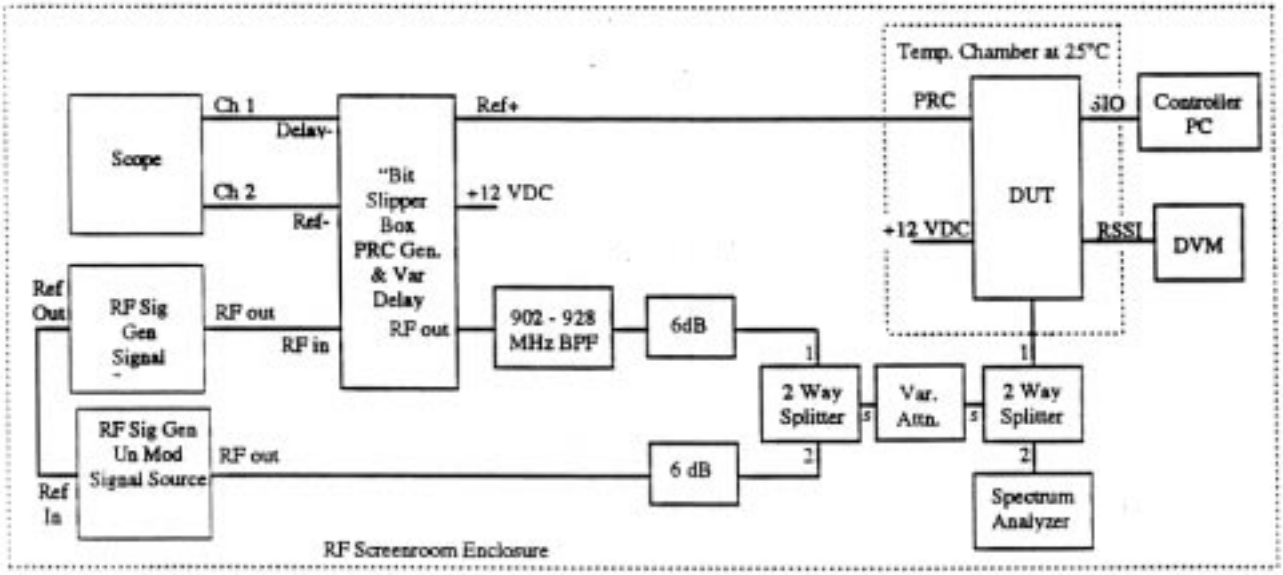
by Gordon Furze

December 22, 1995

The test setup for the PROCESSING GAIN TEST is shown below.

A "Bit Slipper Box" is used to supply a continuous peak correlated spread spectrum source for the DUT. An RSSI voltage is established for a particular input level, starting at -70 dBm. Then, the exact rf power level, but without modulation is supplied instead of the modulated signal. Then, attenuators are decreased to increase the unmodulated signal until the RSSI voltage is the same as it was for the modulated signal. The processing gain is the amount, in dB, that the attenuators have to be decreased to match the modulated RSSI voltage. The test is repeated in 5 dB steps for levels from -75 to -105 dBm.

PROCESSING GAIN TEST CONFIGURATION.



REQUIRED TEST EQUIPMENT.

Qty.	Description	Make, Model Number
2 ea.	Attenuator, 6 dB	Trilithic, FT-50
1 ea.	Bandpass Filter	Toko, 6DFB915E10
1 ea.	Controller Computer	PC 80486 with 16550 UART SIO
2 ea.	DC PWR Supply	Tektronix, PS280
2 ea.	RF Signal Generator	HP 8656B
1 ea.	Screen Room	CellNet
1 ea.	Spectrum Analyzer	HP 8591E
1 ea.	Temp. Chamber	Tenney Jr.
1 ea.	Test Fixture, Bit Slipper	Axonn
1 ea.	Variable Attn.	JFW Industries, Model 50BR-017
2 ea.	2 Way Power Divider	Mini Circuits ZAPD-1
Misc.	Coax Cables and Adapters	

EQUIPMENT SETUP AND TEST.

Set the scope channels one and two to 1 volt per division, and 5 µsec per division. Trigger on NORMAL INTERNAL, trigger source to CHANNEL ONE, DC.

Set both rf signal generators to 917.58 MHz Set the Signal source for the unmodulated signal to 20 dBm and then to RF OFF. Then set the source for Modulated source to 20 dBm. Lock the two sources together with the external reference cable as shown.

Set up the Bit Slipper as shown to a sequence of 1 with an initial delay at 3-8-0 on the slipper switches. Inject the PRC from the Bit Slipper Ref. to U3 pin 6 of the IC while grounding pin 5 of the IC. Power on the Bit Slipper Box with a 12 volt supply other than the one used for the DUT.

Connect the Digital Voltmeter to C27 on the DUT digital board to measure the RSSI output. Setup the voltmeter to read 1.XXX to 5.XXX volts dc (to 3 decimal places).

Place the DUT in a 25°C environment, connect as shown and power ON with 12 volts dc. Control the DUT with a receiver controller program or equivalent to CellNet's GRABBER program. Set the receiver to 917.58 MHz on sequence 1.

Adjust attenuators to 50 dB on the 0 to 100 dB, 10 on the 0 to 10 dB attuntor, and 1 on the 0 to 1dB attenuator.

Peak the indicated RSSI reading by adjusting the three delay switches. Note switch one has a valid range of 0 to 7, switch 2 has a valid range of 0 to 9, switch 3 has a valid range of 0 to 9 only when switch 2 is in position 8. Else, switch 3 is a "don't care."

Set the spectrum analyzer to 917.58 MHz, SPAN to 10 MHz, LEVEL to -30 dBm, BW: RESOLUTION BW 3 MHz, and VIDEO to 100 KHz, SWEEP to 50 ms, trigger to FREE RUN.

Observe the Unmodulated Signal Source on the spectrum analyzer and adjust it to -50 dBm ± <0.1 dB using the generator's LEVEL control. Then, set the generator's LEVEL STEPPING to 5 dB and then to RF OFF.

Set the Signal source for the modulated signal to RF ON and adjust that generator's level control to read -50 dBm on the spectrum analyzer. Then turn the coaxial attenuator 0-100 dB to -20 dB.

Record the RSSI levels for spread spectrum input from -70, -75,-80, -85,. . . . to -100 dBm, using the 0 to 100 and 0 to 10 coaxial attenuators. Then switch the generator (for the modulated signal source) to RF OFF.

Switch the generator source for the unmodulated signal to RF ON. Then for -70 dBm and its resulting RSSI, reduce the attenuation until the RSSI equals the same as it did with the -70 dBm modulated signal. Record this as Processing Gain for -70 dBm. Then repeat the above process for -75 dBm through -100 dBm using the step level switch on the unmodulated signal source generator and recording Processing accordingly.

Then repeat the above for unmodulated signal offset frequencies of ± 50 KHz, ±100 KHz and ± 150 KHz.

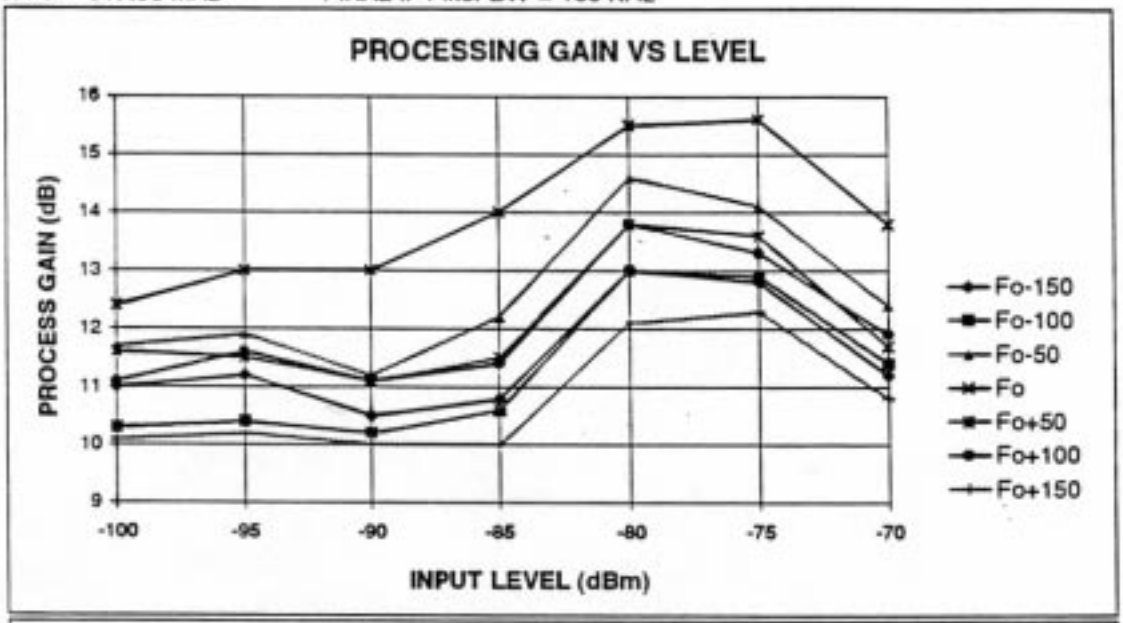
Record the above delta in attenuator settings as processing gains for the various levels respecuvely. Record the bit slipper settings, date and operator on the data sheet.

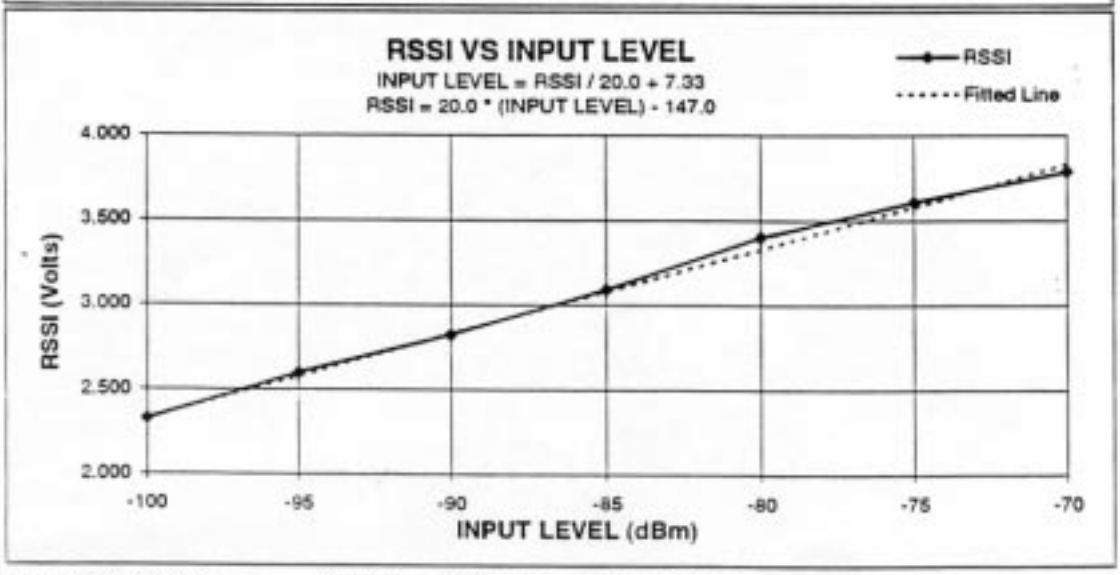
DATA SHEET: 26-1124D LAN RADIO PROCESSING GAIN TEST RESULTS

OPERATOR: *Gordon Furze* **DATE:** *October 10, 1995* **BIT DELAY SETTINGS:** *4 - 8 - 0*

Input Level	RSSI	Fitted Line	Fo-150	Fo-100	Fo-50	Fo	Fo+50	Fo+100	Fo+150
-70	3.788	3.83	11.2	11.4	12.4	13.8	11.7	11.9	10.8
-75	3.610	3.58	12.8	12.9	14.1	15.6	13.6	13.3	12.3
-80	3.404	3.33	13.0	13.0	14.6	15.5	13.8	13.8	12.1
-85	3.092	3.08	10.8	10.6	12.2	14.0	11.5	11.4	10.0
-90	2.825	2.83	10.5	10.2	11.2	13.0	11.1	11.1	10.0
-95	2.600	2.58	11.2	10.4	11.9	13.0	11.5	11.6	10.2
-100	2.328	2.33	11.0	10.3	11.7	12.4	11.6	11.1	10.1

Note: Fo = 917.58 MHz FINAL IF Filter BW = 150 KHz





Fitted Line: RSSI Slope = 0.0499 Volts/dB or 20.0 dB/Volt
RSSI Intercept Pt. = 7.330 Volts

(end of report)

EXHIBIT 3:Radiated Emissions Test Configuration Photographs

EXHIBIT 3: Radiated Emissions Test Configuration Photographs

EXHIBIT 3: Radiated Emissions Test Configuration Photographs
Close-up of meter buried in soil-filled box

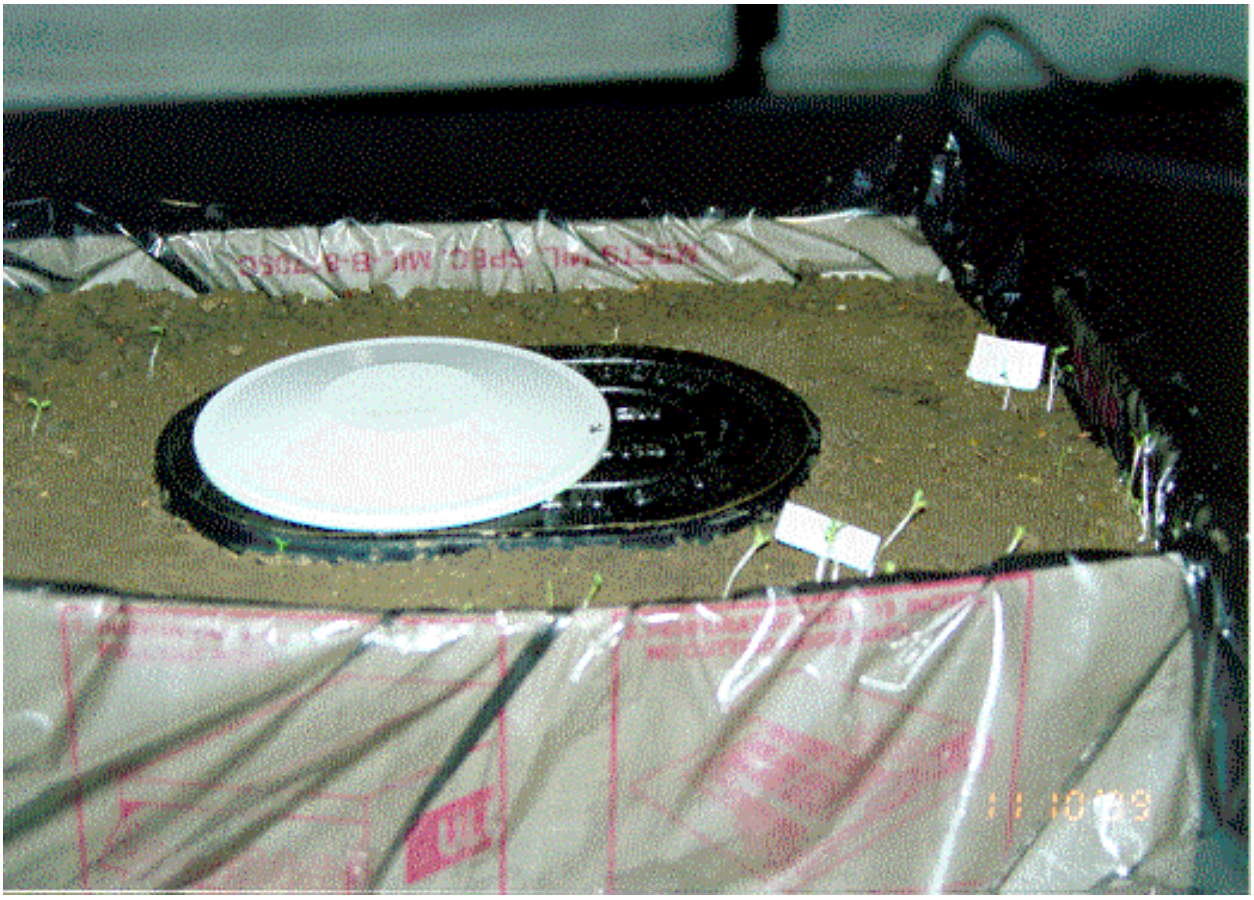


EXHIBIT 4:Proposed FCC ID Label & Label Location

EXHIBIT 5: Detailed Photographs of BadgerMeter, Inc. Model Cellink Pit End Point Communications ModuleConstruction

6 Photographs

EXHIBIT 6:Installation Manual and Marketing Strategy for BadgerMeter, Inc. Model Cellink Pit End Point Communications Module

Installation Procedure 8 Pages
Marketing Strategy 1 Page

Due to the intended use of the Badger Meter Pit End Point Communications Module there is no User Manual as such for the device. The attached documents explain the marketing strategy and installation procedures. The FCC warning statement and compliance information statements are included in the Installation Procedure.

EXHIBIT 7: Block Diagram of BadgerMeter, Inc. Model Cellink Pit End Point Communications Module

1 Page

EXHIBIT 8: Schematic Diagrams for BadgerMeter, Inc. Model Cellink Pit End Point Communications Module

3 Pages

EXHIBIT 9: Theory of Operation for BadgerMeter, Inc. Model Cellink Pit End Point Communications Module

Theory Of Operation 3 Pages