FCC Part 15 Subpart C

Direct Sequence
Spread Spectrum Transmitter

Certification Test Report

Manufacturer: SchlumbergerSema, Inc.

Model: ENIGMA RF MODULE
WITH SENTINEL METER

FCC ID: F9CSMFMM-1

Rules Section: 15.247(Modular Approval)

Test Begin Date: July 25, 2002

Test End Date: September 16, 2002

Report Issue Date: October 14, 2002

ACS Report Number: 02-0118-15C

Test Result: PASS

Prepared by: R. Sam Wismer Engineering Manager

Table of Contents

1.0 GENERAL

1.1 Introduction
The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description

1.2.1 General
The Equipment Under Test (EUT), is the Model Enigma RF Module with the Sentinel Meter manufactured by SchlumbergerSema, Inc. Located at the following address:

SchlumbergerSema, Inc.
313-B North Highway 11
West Union, South Carolina 29696

Detailed photographs of the EUT are filed separately with this filing.

1.2.2 Intended Use
The EUT is intended to transmit power usage to a data collection point via a Direct Sequence Spread Spectrum RF link. The power meters are fixed devices typically installed outdoors on the sides of buildings, or otherwise greater than 2 meters from nearby persons.

1.2.3 Technical Specifications

Table 1.2.3-1: Specifications

Frequency Band	902-928
Number of Channels	1
Channel Bandwidth	1.0 MHz Nominal
Channel Spacing	N/A
Output power	23.66dBm nominal
Antenna Type	Dipole
Antenna Gain	2dBi
Antenna Connector Type	Permanently Attached to PCB

1.2.4 Antennas
The antenna is a tuned dipole on a printed circuit board that is located on the faceplate of the SENTINEL meter.

Table 1.2.4-1 below gives the antennas that will be employed with the Enigma RF Module with the Sentinel Meter. Photographs are submitted separately as appendix B with this filing.

Table 1.2.4-1: Antennas

Mfg.	Mfg. Model No.	Antenna Type	Gain (dBi)	Connector Type	System EIRP (dBm)
Schlumberger	Proprietary	Dipole	2	Soldered to Board	26

2.0 LOCATION OF TEST FACILTY

All testing was performed by qualified ACS personnel located at the following address:

ACS, Inc.
5015 B.U. Bowman Drive
Buford, GA 30518

2.1 DESCRIPTION OF TEST FACILITY

Radiated and conducted emissions were conducted at an ACS facility specifically prepared for this testing. Both sites have been fully described and submitted to, and accepted by the FCC and Industry Canada. FCC registration number 89450 and Industry Canada Lab Code IC 4175 have been assigned in recognition of the sites. Both sites are also in conformance with publication CISPR16.

2.1.1 Open Area Test Site

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.
The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane, however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 3.2-1 below:

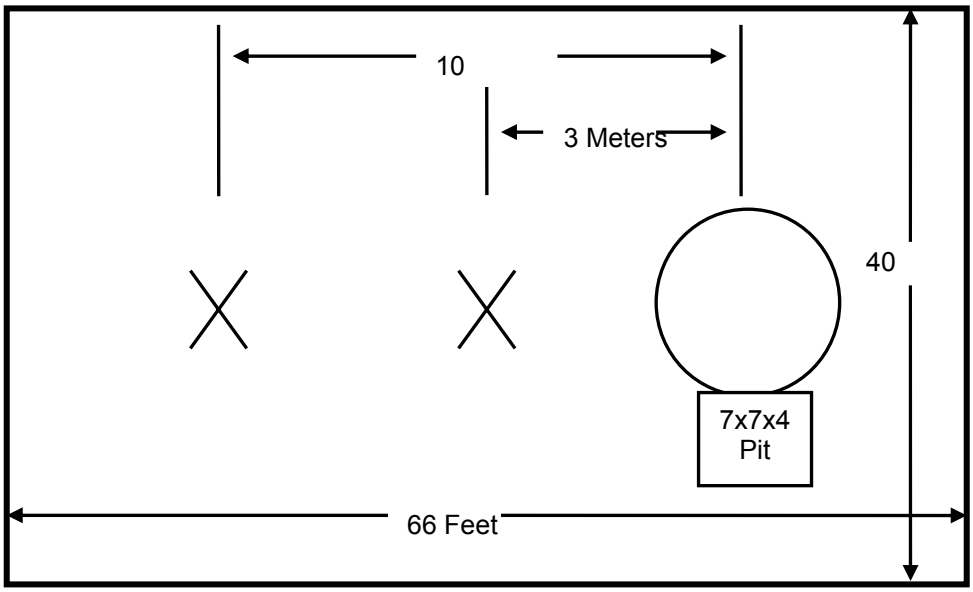


Figure 3.2-1: Open Area Test Site

2.1.2 Conducted Emissions Test Site Description
The AC mains conducted EMI site is a shielded room with the following dimensions:

- Height: 3.0 Meters
- Width: 3.6 Meters
- Length: 4.9 Meters

The room is manufactured by Rayproof Corporation and installed by Panashield, Inc. Earth ground is provided to the room via an 8' copper ground rod. Each panel of the room is connected electrically at intervals of 4".

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 1B42-60P manufactured by Rayproof Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 2.1.2-1:

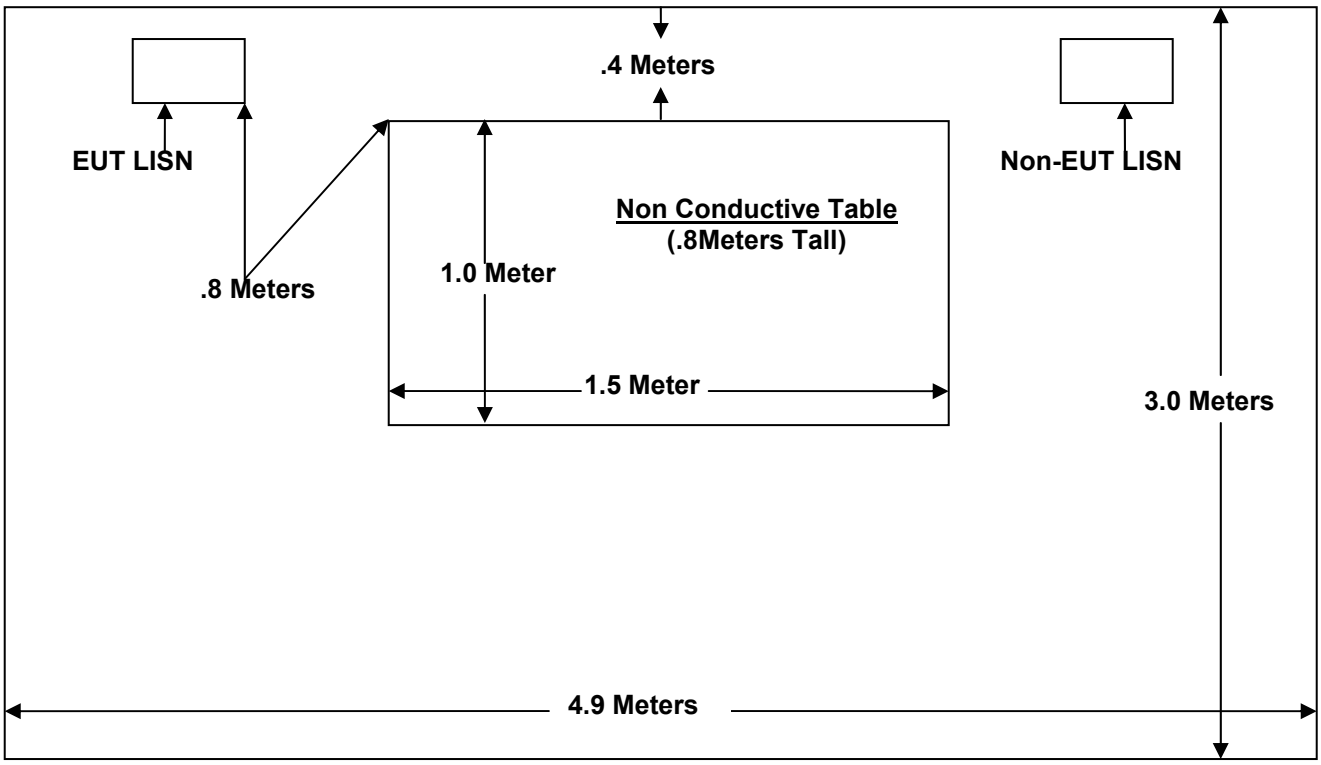


Figure 3.3-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

1 - ANSI C63.4-1992: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz

2 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2000)

3 - FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Table 4-1: Test Equipment

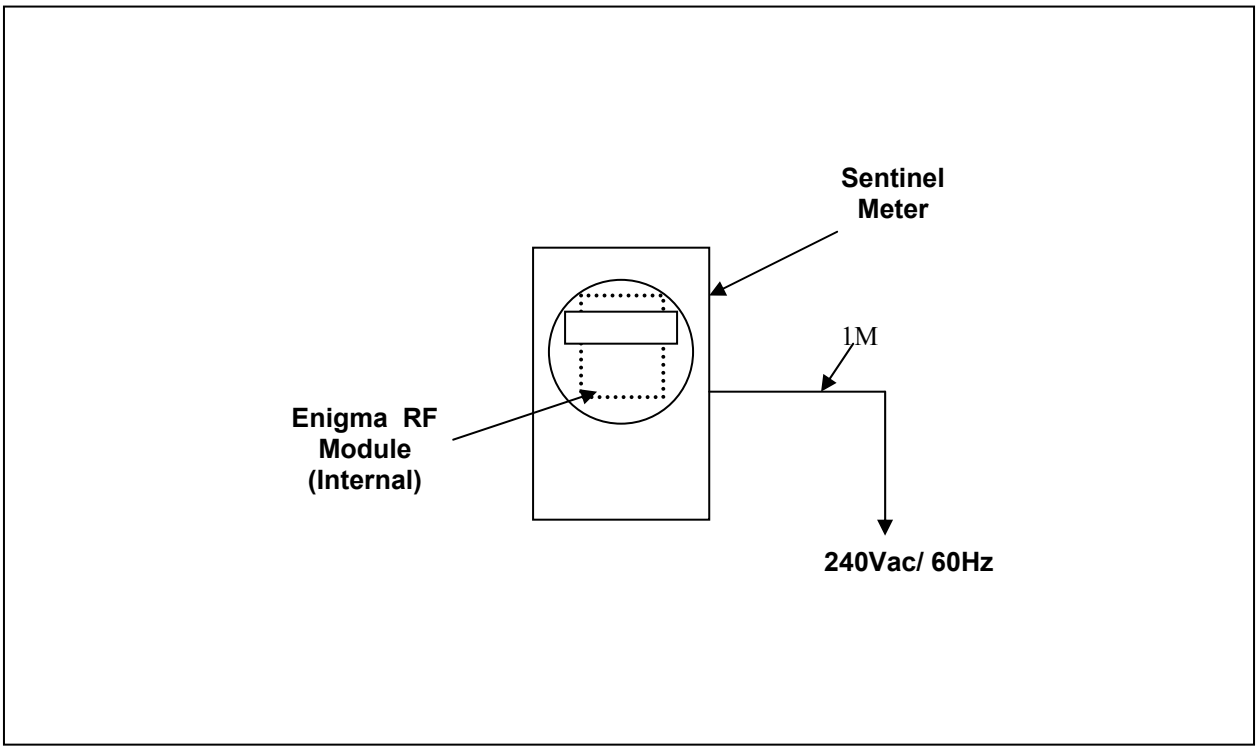
Equipment Calibration Information					
Mfg.	**Eq. type**	**Model**	**S/N**	**ACS #**	**Cal. Due**
Rohde & Schwarz	Spectrum Analyzer	1032.5640.53	833827/003	4	8/16/03
Rohde & Schwarz	Display Unit	804.8932.52	839379/011	3	8/16/03
Rohde & Schwarz	Spectrum Analyzer	1032.5640.53	839587/003	2	12/26/02
Rohde & Schwarz	Display Unit	804.8932.52	839379/011	1	12/26/02
Chase	Bi-Log	CBL6111	1044	26	8/26/03
Microwave Circuits	Hi-Pass Filter	H1G810G1	2123-01 DC0225	105	6/20/03
ACS	Cable	RG8	16	16	3/1/03
ACS	Cable	RG8	23	23	12/13/02
ACS	Cable	Heliax	24	24	12/13/02
ACS	Cable	LL-335	None	5	7/31/03
ACS	Cable	LL-335	None	6	7/31/03
Agilent	Pre-Amplifier	8449B	3008A00526	22	9/21/03
EMCO	Horn Antenna	RGA-60	6166	N/A	05/02/03

5.0 SUPPORT EQUIPMENT

Table 5-3: Support Equipment

Manufacturer	Equipment Type	Model Number	Serial Number	FCC ID
	EUT Was Self Supporting			

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM



M = Meters **S = Shielded** **U = Unshielded**

Figure 6-1: EUT Test Setup

7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement - FCC Section 15.203

The antenna used with the RF Module is soldered to the board and would require electrical modification to change. The antenna is specifically tuned for optimum performance and unauthorized modification would result in poor performance.

7.2 Power Line Conducted Emissions - FCC Section 15.207

Conducted emissions were performed from 450kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. Results of the test are shown below in figure 1 and tables 7.2-1 and 7.2-2.

Figure 7.2-1: Conducted Emissions Graph

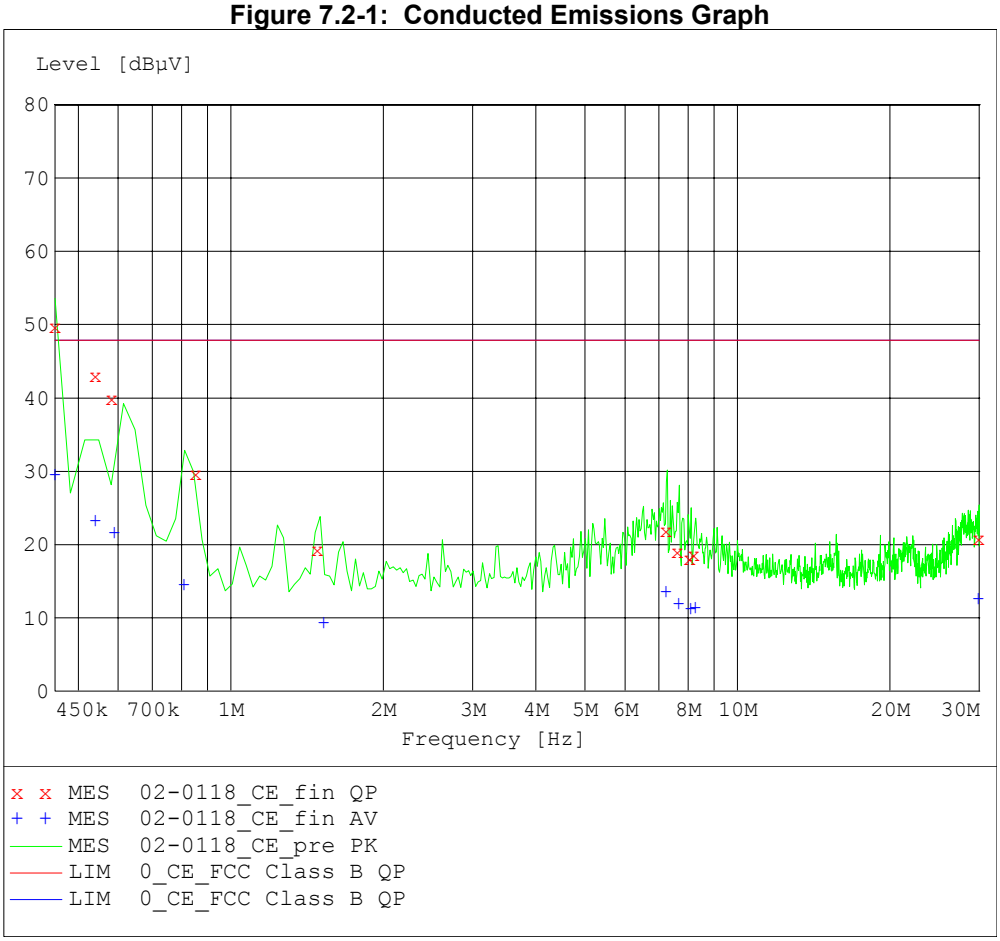


Table 7.2-1: Line 1 Conducted EMI Results (Quasi-Peak)

Frequency MHz	Level	Transducer dBµV	Limit dB	Margin dBµV	Line dB	PE
0.45*	36.80*	10.50	47.90	11.1	N	GND
0.54	43.10	10.50	47.90	4.70	N	GND
0.58	40.00	10.50	47.90	7.80	L1	GND
0.85	29.80	10.60	47.90	18.00	N	GND
1.48	19.30	10.60	47.90	28.50	N	GND
7.23	21.90	11.00	47.90	25.90	L1	GND
7.61	19.10	11.00	47.90	28.70	L1	GND
8.06	18.20	11.00	47.90	29.70	N	GND
8.20	18.70	11.00	47.90	29.10	L1	GND
29.93	20.80	12.10	47.90	27.00	N	GND

Table 7.2-2: Line 2 Conducted EMI Results(Average)

Frequency MHz	Level	Transducer dBµV	Limit dB	Margin dBµV	Line dB	PE
0.45	29.60	10.50	47.90	18.20	N	GND
0.54	23.30	10.50	47.90	24.50	L1	GND
0.59	21.70	10.50	47.90	26.10	N	GND
0.81	14.60	10.60	47.90	33.20	L1	GND
1.52	9.30	10.60	47.90	38.50	N	GND
7.23	13.60	11.00	47.90	34.20	L1	GND
7.66	12.00	11.00	47.90	35.80	L1	GND
8.09	11.30	11.00	47.90	36.50	L1	GND
8.24	11.50	11.00	47.90	36.30	L1	GND
29.86	12.70	12.10	47.90	35.10	N	GND

* Signal determined to be broadband since the average level was greater than 6dB below the Quasi-Peak measurement. QP measurement reduced by 13 dB and compared with the limit in accordance with section 15.207(b). Receiver used employed an average detector with a linear IF amplifier. Dynamic range of the receiver was not exceeded to make the measurement.

Test setup photographs are shown below in figure 7.2-2:

Figure 7.2-2: Conducted Emissions Test Setup

7.3 Radiated Emissions - FCC Section 15.209

Radiated emissions tests were performed over the frequency range of 30MHz to 10GHz, 10 times the highest fundamental frequency. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120KHz for measurements above 30MHz.

The EUT was caused to go into a "Receive Only" mode of operation for this test. Results of the test are given in Table 7.3-1 below:

Table 7.3-1: Radiated Emissions Tabulated Data

Frequency (MHz)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Uncorrected Reading (dBµV)	Cable Loss + Antenna Factor - Amplifier Gain (dB)	Corrected Reading (dBµV)	Limit (dBµV)	Margin (dB)	Results
32.16	V	100	225	0	20.26	20.26	40	19.7	**Pass**
58.02	v	125	20	19.7	8.49	28.19	40	11.8	**Pass**
82.81	h	125	304	16.2	9.85	26.05	40	14.0	**Pass**
86.04	H	125	332	12.3	10.39	22.69	40	17.3	**Pass**
169.03	H	100	164	15.5	13.44	28.94	43.5	14.6	**Pass**
174.42	H	100	315	14.9	12.96	27.86	43.5	15.6	**Pass**
308.07	H	100	202	12.5	17.42	29.92	46	16.1	**Pass**
485.9	v	125	359	15.8	22.38	38.18	46	7.8	**Pass**
696.06	h	100	0	10	28.60	38.60	46	7.4	**Pass**
952.57	h	100	0	8.2	32.93	41.13	46	4.9	**Pass**

Radiated emissions test setup photographs are shown below in figure 7.3-1:

Figure 7.3-1: Radiated Emission Test Setup

7.4 Peak Output Power Requirement - FCC Section 15.247(b)

The peak output power of the EUT was made at the antenna connector using an 8560E Spectrum Analyzer. The 6dB bandwidth of the device was measured to be 1.2MHz, therefore a spectrum analyzer with the RBW set to 2MHz was used to measure the output power of the device. For the measurement, the EUT was caused to generate a constant carrier. Results are shown below in Table 7.4-1 and Figure 7.4-1.

Table 7.4-1: Peak Output Power

Frequency (MHz)	Output Power (dBm)
917.53	23.66

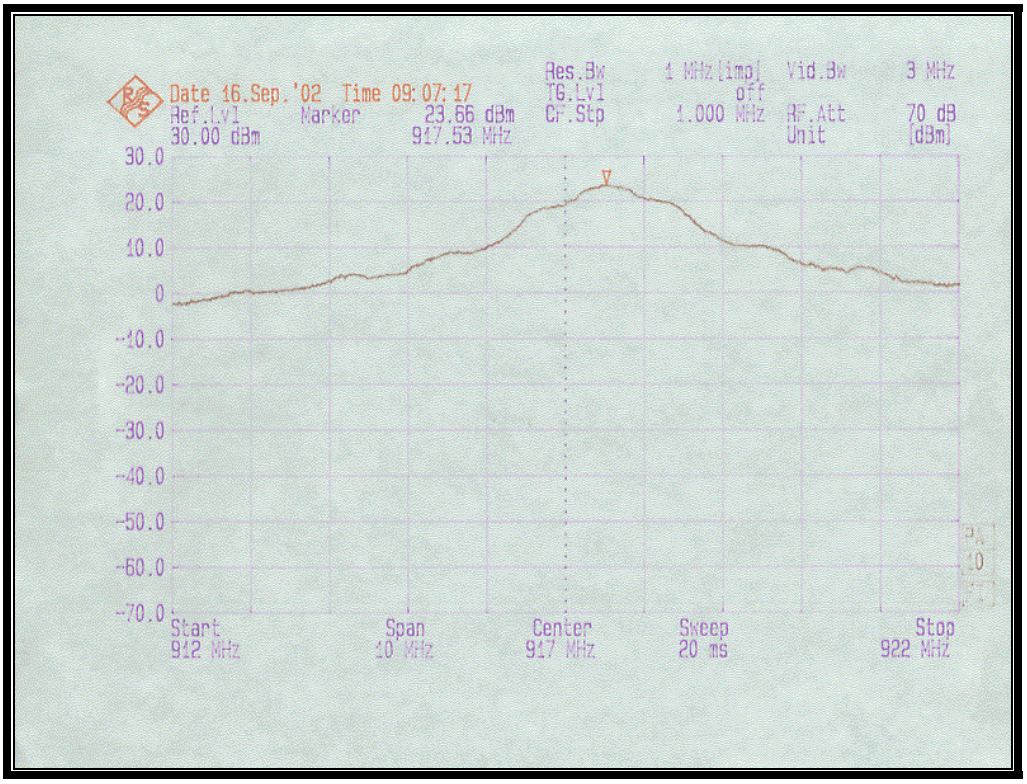


Figure 7.4-1: Output power

7.5 6dB Bandwidth

For the 6dB bandwidth test, the EUT was caused to generate a continuous carrier on the fundamental frequency. The result is shown below in table 7.5-1:

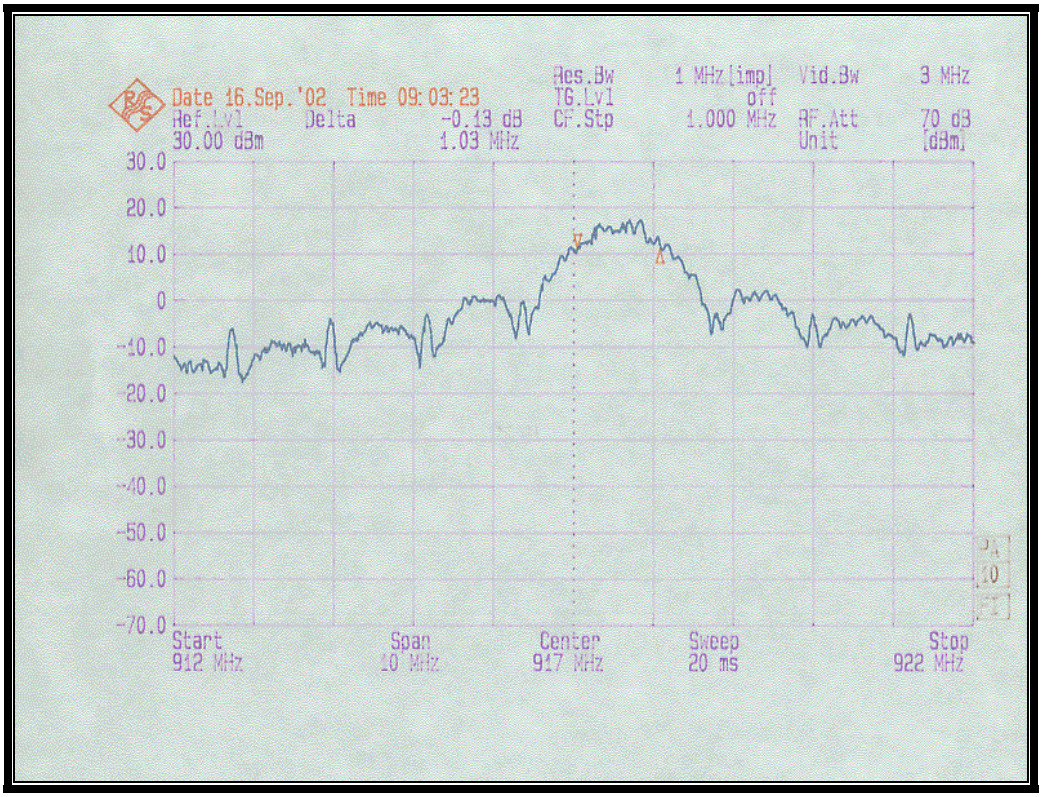
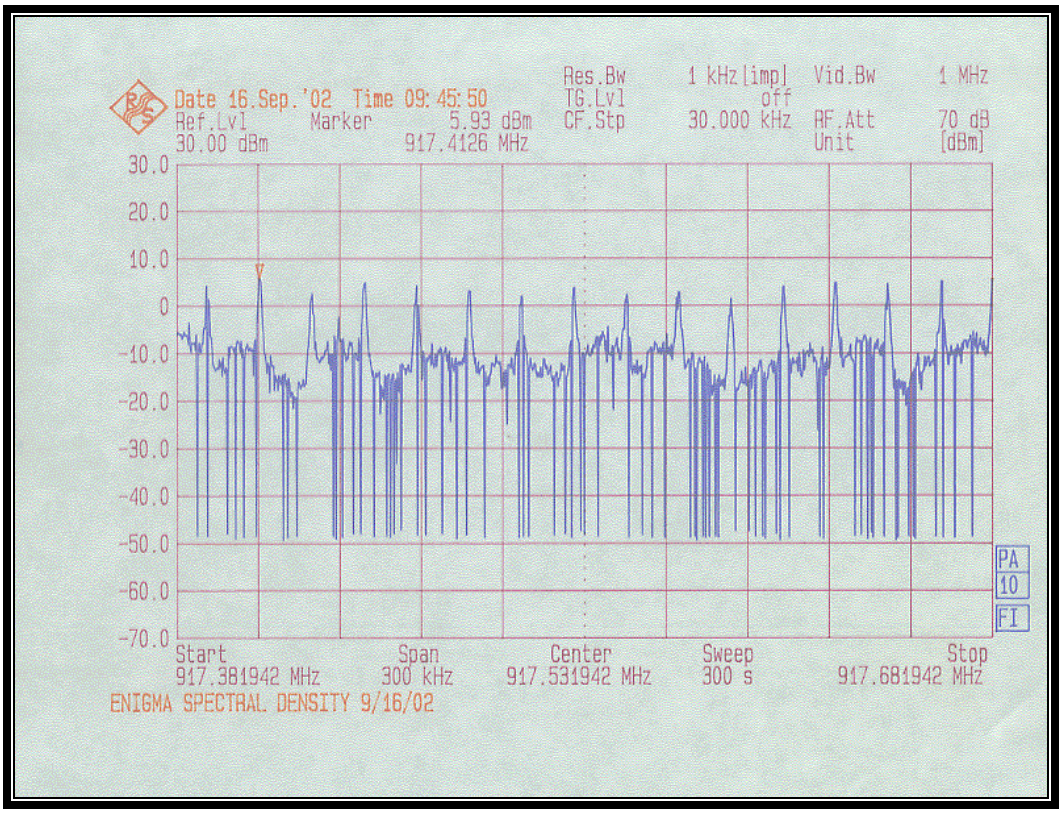


Figure 7.5-1: 6dB Bandwidth

7.6 Power Spectral Density

The power spectral density was measured in accordance with OET bulletin 97-114, appendix C. The EUT was caused to generate a constant carrier on the fundamental frequency. The results are recorded in figure 7.6-1 below.



7.7 Spurious Emissions - FCC Section 15.247(c)

7.7.1 RF Conducted Spurious Emissions

The EUT was investigated for conducted spurious emissions from 30MHz to 10GHz, 10 times the highest fundamental frequency. For each measurement, the spectrum analyzer's VBW was set to 100kHz and the RBW was set to 1MHz.

7.7.1.2 Test Results

The RF conducted spurious emissions found in the band of 30MHz to 10GHz are reported in Figures 7.7.1.2-1 through 7.7.1.2-3 below. Each emission was compared to the fundamental reference level to determine if they were at least 20dB below the reference level.

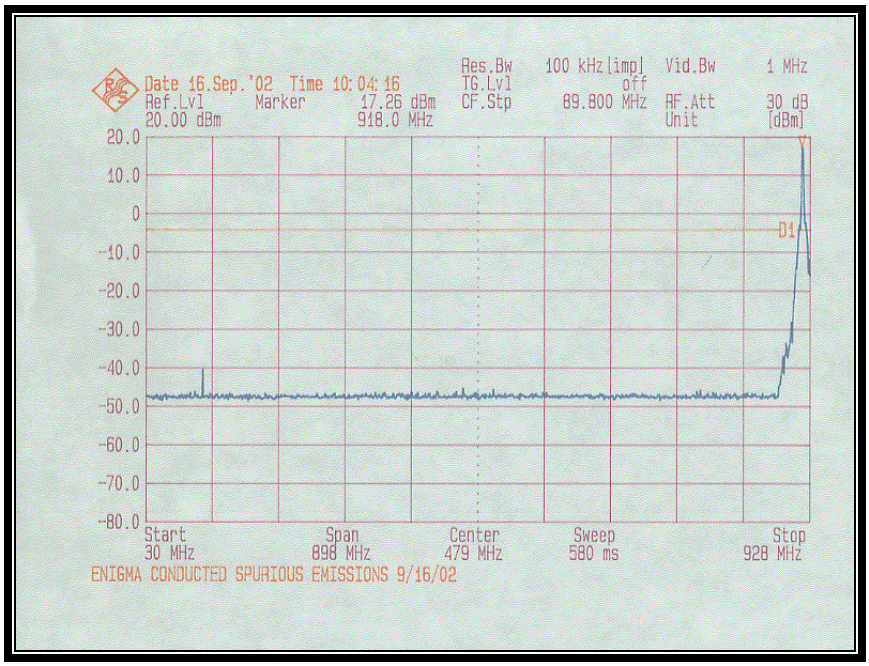


Figure 7.7.1.2-1: Conducted spurious from 30MHz to 1000MHz

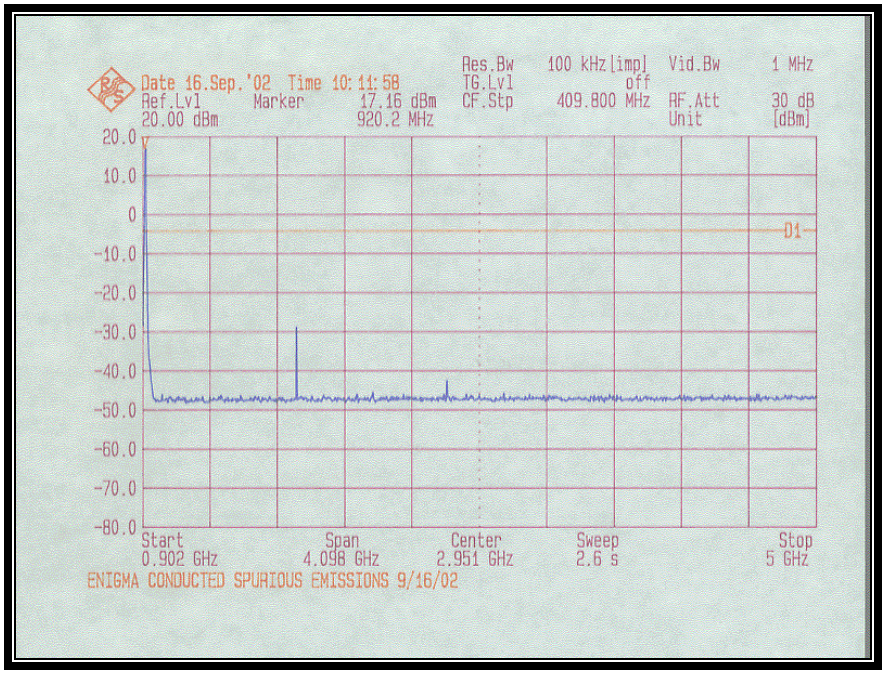


Figure 7.7.1.2-2: Conducted spurious emissions from 902MHz to 5.0GHz

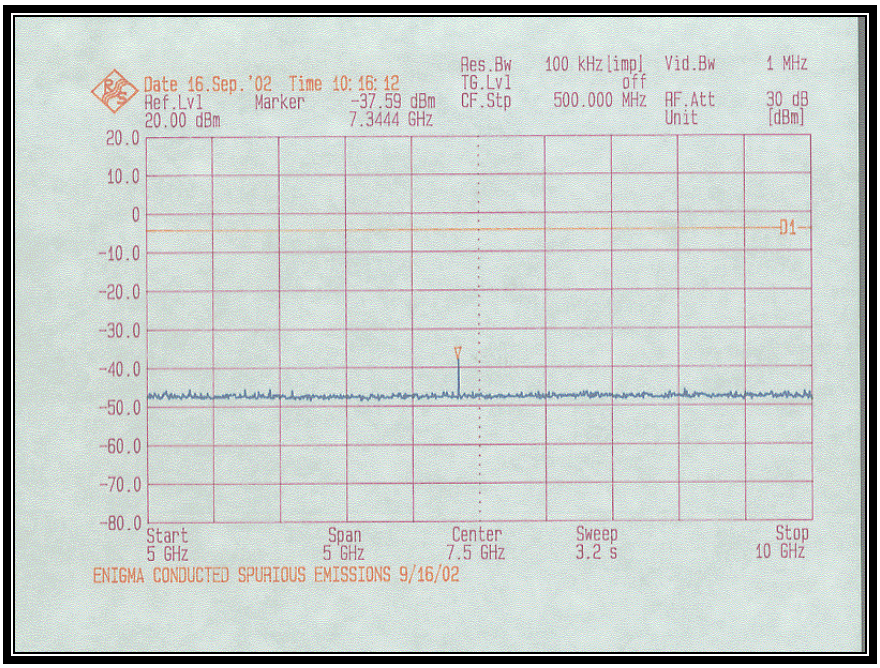


Figure 7.7.1.2-3: Conducted spurious from 5.0GHz to 10GHz

7.7.2 Radiated Spurious Emissions(Restricted Bands) - FCC Section 15.205

Radiated emissions tests were made over the frequency range of 30MHz to 10GHz, 10 times the highest fundamental frequency on each antenna given in section 1.2.3.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth(RBW) of 120kHz and a video bandwidth(VBW) of 300kHz. For frequencies above 1000MHz, average measurements were made using an RBW of 1MHz and a VBW of 10Hz and peak measurements were made with RBW of 1MHz and a VBW of 1MHz.

The EUT was caused to generate a carrier signal on the high, mid and low channels of operation.

7.7.2.1 Duty Cycle Correction

For average measurements, the measured level was reduced by a factor 14dB to account for the duty cycle of the EUT. The EUT transmits no more than 20mS in any 100mS. The duty cycle correction factor is determined using the formula: 20log(.2). The 14dB factor is included in the

7.7.2.2 Test Results

Radiated spurious emissions found in the band of 30MHz to 10GHz are reported in Table 7.7.2.2-1. Plots of these emissions are also presented separately in Appendix A of this filing. Each emission found to be in a restricted band as defined by section 15.205, was compared to the radiated emission limits for a class B device defined in section 15.209.

Table 7.7.2.2-1: Radiated Spurious Emissions

Frequency (MHz)	Level(R_U) (dBuV)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors(CF_T) (dB)	Corrected Level(R_C) (dBuV)	Limit (dBuV)	Margin (dB)	Final Result (Pass/Fail)
AVERAGE MEASUREMENTS								
2753.03	37.95	H	135.00	-12.00	25.95	54.00	28.05	**PASS**
3670.12	34.95	H	89	-9.51	25.44	54.00	28.56	**PASS**
4587.97	33.73	H	1	-8.08	25.65	54.00	28.35	**PASS**
7340.66	32.57	V	81	-3.47	29.10	54.00	24.90	**PASS**
8258.25	30.31	V	0	-2.82	27.49	54.00	26.51	**PASS**
9175.66	28.58	V	0	-2.12	26.46	54.00	27.54	**PASS**
PEAK MEASUREMENTS								
2752.67	67.46	V	135	2.00	69.46	74.00	4.54	**PASS**
3670.3	57.96	H	89	4.49	62.45	74.00	11.55	**PASS**
4587.89	60.14	H	1	5.92	66.06	74.00	7.94	**PASS**
7340.75	53.5	V	81	10.53	64.03	74.00	9.97	**PASS**
8258.63	46.84	V	0	11.18	58.02	74.00	15.98	**PASS**
9175.93	44.05	V	0	11.88	55.93	74.00	18.07	**PASS**

Sample Calculation:
$R_C = R_U + CF_T$

Where:
CF_T = Total Correction Factor (AF+CA+AG)-DC(Average Measurements Only)
R_U = Uncorrected Reading
R_C = Corrected Level
AF = Antenna Factor
CA = Cable Attenuation
AG = Amplifier Gain
DC = Duty Cycle Correction Factor

Example Calculation:

Corrected Level: 37.95 – 12 = 25.95dBuV

Margin: 54dBuV – 25.95dBuV = 28.05dB

8.0 RF EXPOSURE SECTION 15.247(b)(4)
Although Table 1 of OET Bulletin 65, Supplement C, does not cover 915MHz devices operating at less than 2.5 Watts where nearby persons are normally ***greater*** than 20cm from the device, the EUT satisfies the "Applicable Methods to Ensure Compliance" for devices operating at 915MHz at less than 2.5 Watts where nearby persons are normally ***less*** than 20cm from the device. Routine environmental evaluation is not required and special instructions and/or warnings are not warranted.

9.0 CONCLUSION

In the opinion of ACS, Inc. the Enigma RF Module with the Sentinel Meter Direct Sequence spread spectrum module, manufactured by SchlumbergerSema, Inc., meets the requirements of FCC Part 15 subpart C.