Excellence in Compliance Testing

FCC Part 15.249
Transmitter Certification

Test Report

FCC ID: U9O-RFE

FCC Rule Part: 15.249

ACS Report Number: 07-0157-15C-RFE

Manufacturer: Wireless Control Network Solutions, LLC.; dba Synapse
Brand Name: RF Engine
Model: RFE

Test Begin Date: April 25, 2007
Test End Date: May 1, 2007

Report Issue Date: May 4, 2007

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612-0

This report is not be used to claim certification, approval, or endorsement by NVLAP, NIST or any government agency.

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This report contains 15 pages

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Additional Exhibits Included In Filing

Internal Photographs
Test Setup Photographs
Product Labeling
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Theory of Operation
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Schematics

1.0 GENERAL

1.1 Purpose
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 Synapse RF Engine is an IEEE 802.15.4 compliant RF module. There are 16 total channels of operation in this band. The first channel is centered at 2.405GHz and the last channel is centered at 2.480GHz. These RF modules use a direct sequence spread spectrum transmission with O-QPSK modulation.

Manufacturer Information:
Wireless Control Network Solutions, LLC. ; dba Synapse
132 Export Circle
Huntsville, Alabama 35806

1.2.2 Intended Use
These RF modules are intended to be used by Original Equipment Manufacturers (OEM) and Integrators in order to add RF wireless communication to their products. These RF modules would be plugged in to their host board which would contain the OEM product offering.

1.3 Test Methodology and Considerations
For the purpose of providing a suitable test configuration, the RF Engine module was tested using a support board. The support board was provided by the manufacturer as the host board for powering the RF Engine for FCC certification. With the RF Engine plugged in to the support board, the board provided two functions for the RF Engine. First, it provided the operating power for the RF Engine thru the user accessible pins on the RF Engine which provide power to the module. Secondly, the support board provided a user button function that drives a user input pin on the RF Engine.

There are two versions of the RF Engine, one without an external power amplifier on the transmitter (FCC ID: U9O-RFE) and one with an external power amplifier on the transmitter (FCC ID: U9O-RFET). The information in this report only references the RF Engine model RFE without external amplifier under FCC ID: U9O-RFE. RF Engine model RFET with external amplifier is covered under a separate equipment authorization and report.

1.4 Antenna Information
Integrated F antenna (PCB): 0 dBi

1.5 Test Sample Identification
Synapse 200102.01 Rev C, WO# 98700001
Synapse 200102.01 Rev C, WO# 98700004

2.0 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following address:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications

The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment. In addition, ACS is compliant to ISO 17025 as certified by the National Institute of Standards and Technology under their National Voluntary Laboratory Accreditation Program. The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 89450
Industry Canada Lab Code: IC 4175
VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

NVLAP Lab Code: 200612-0

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 150cm in diameter and is located 160cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' 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.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chases from the turntable to the pit 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.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

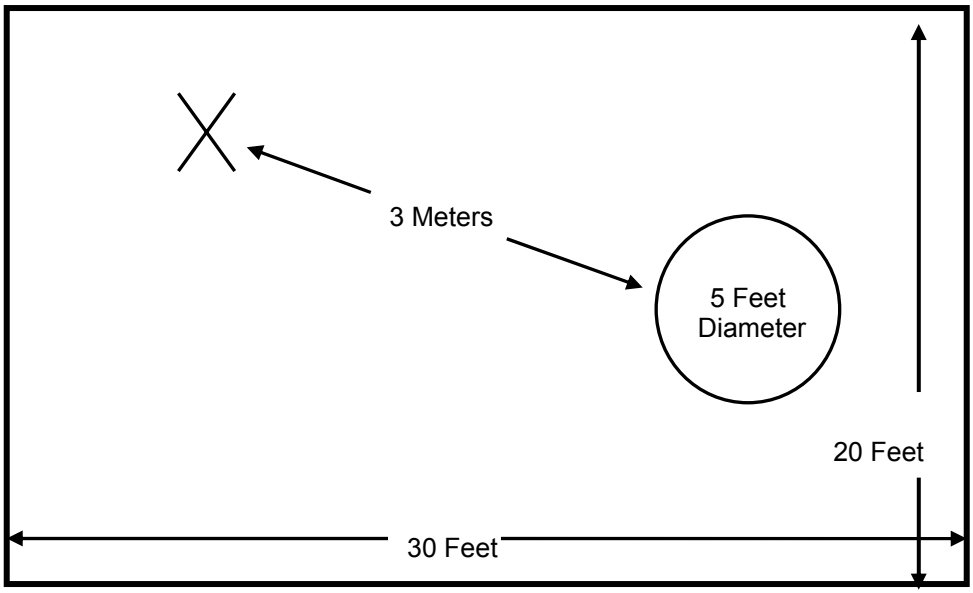

Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

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 2.3-2 below:

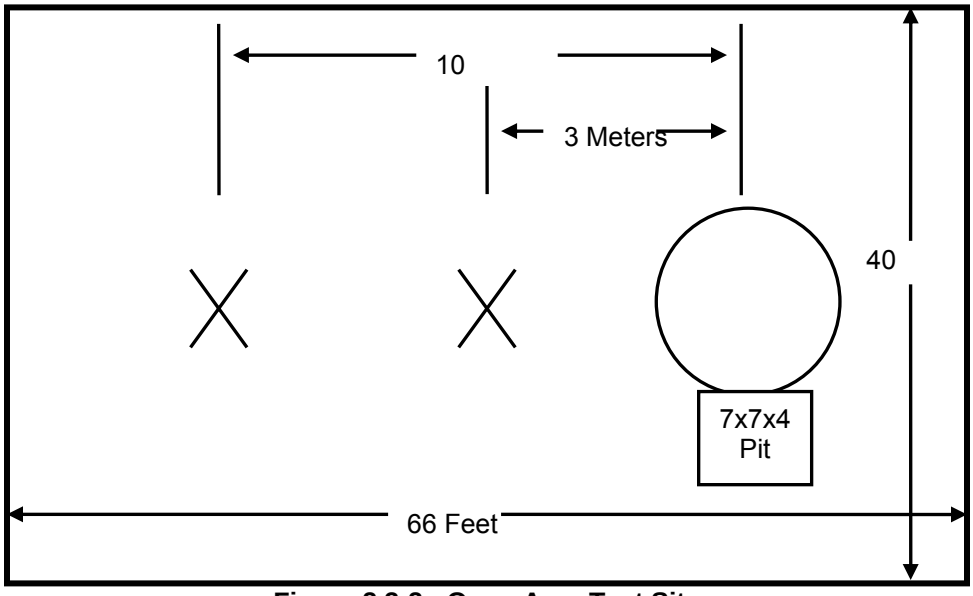

Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8' x 8' solid aluminum horizontal group reference plane (GRP) bonded every 3" to an 8' X 8' vertical ground plane.

The site 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 4.1.3-1:

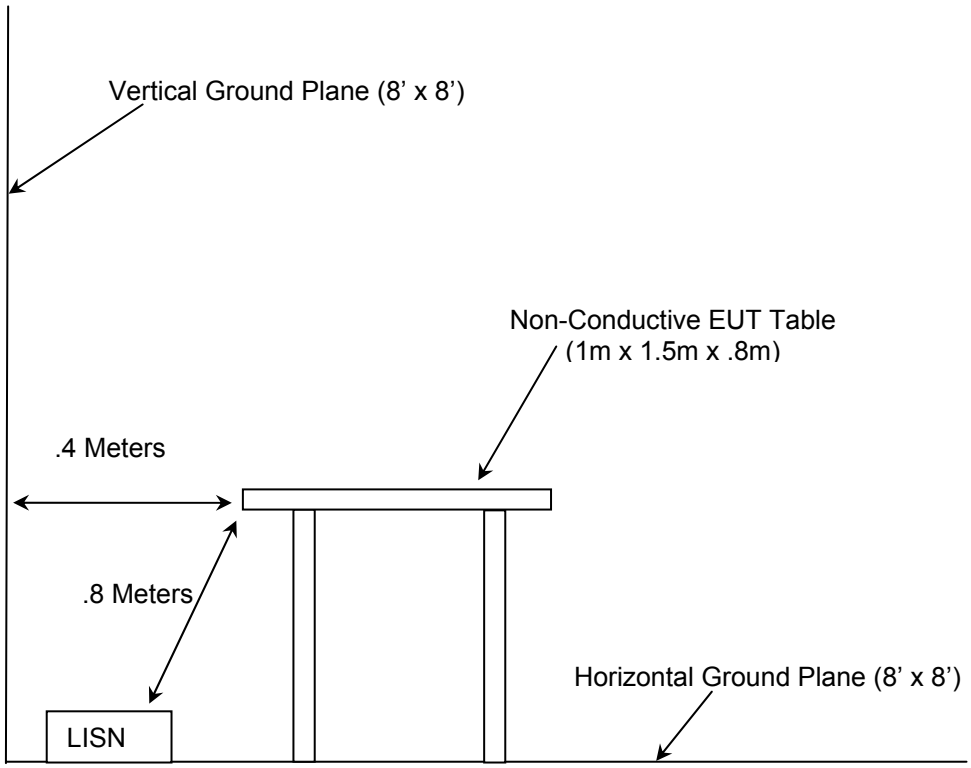

Figure 2.4-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2006
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2006

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

AssetID	Manufacturer	Model Number	Serial Number	Equipment Type	Cal Due
1	Rohde & Schwarz	ESMI - Display	833771/007	Spectrum Analyzers	03/05/08
2	Rohde & Schwarz	ESMI-Receiver	839587/003	Spectrum Analyzers	03/05/08
16	ACS	Cable	16	Cables	05/10/07
25	Chase	CBL6111	1043	Antennas	05/30/07
30	Spectrum Technologies	DRH-0118	970102	Antennas	05/09/07
70	Rohde & Schwarz	ESH-3	879676/050	Spectrum Analyzers	08/09/07
73	Agilent	8447D	2727A05624	Amplifiers	05/10/07
152	EMCO	3825/2	9111-1905	LISN	02/20/08
167	ACS	Chamber EMI Cable Set	167	Cables	01/05/08
168	Hewlett Packard	11947A	44829	Attenuators	03/13/08
253	Florida RF Labs	Lab-Flex 290	253	Cables	08/01/07
282	Microwave Circuits	H2G020G4	74541	Filters	03/12/08
283	Rohde & Schwarz	FSP40	1000033	Spectrum Analyzers	11/09/08
290	Florida RF Cables	SMSE-200-72.0-SMRE	None	Cables	05/03/07
291	Florida RF Cables	SMRE-200W-12.0-SMRE	None	Cables	05/03/07
292	Florida RF Cables	SMR-290AW-480.0-SMR	None	Cables	05/24/07
329	A.H.Systems	SAS-571	721	Antennas	08/24/07
338	Hewlett Packard	8449B	3008A01111	Amplifiers	09/26/07

5.0 SUPPORT EQUIPMENT

Table 5-1: Support Equipment

Item	Manufacturer	Equipment Type	Model Number	Serial Number	FCC ID
1	Synapse	Host PCB	ED111F5-85	NA	NA
2	Triad	Power Supply	WDU6-300	NA	NA

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

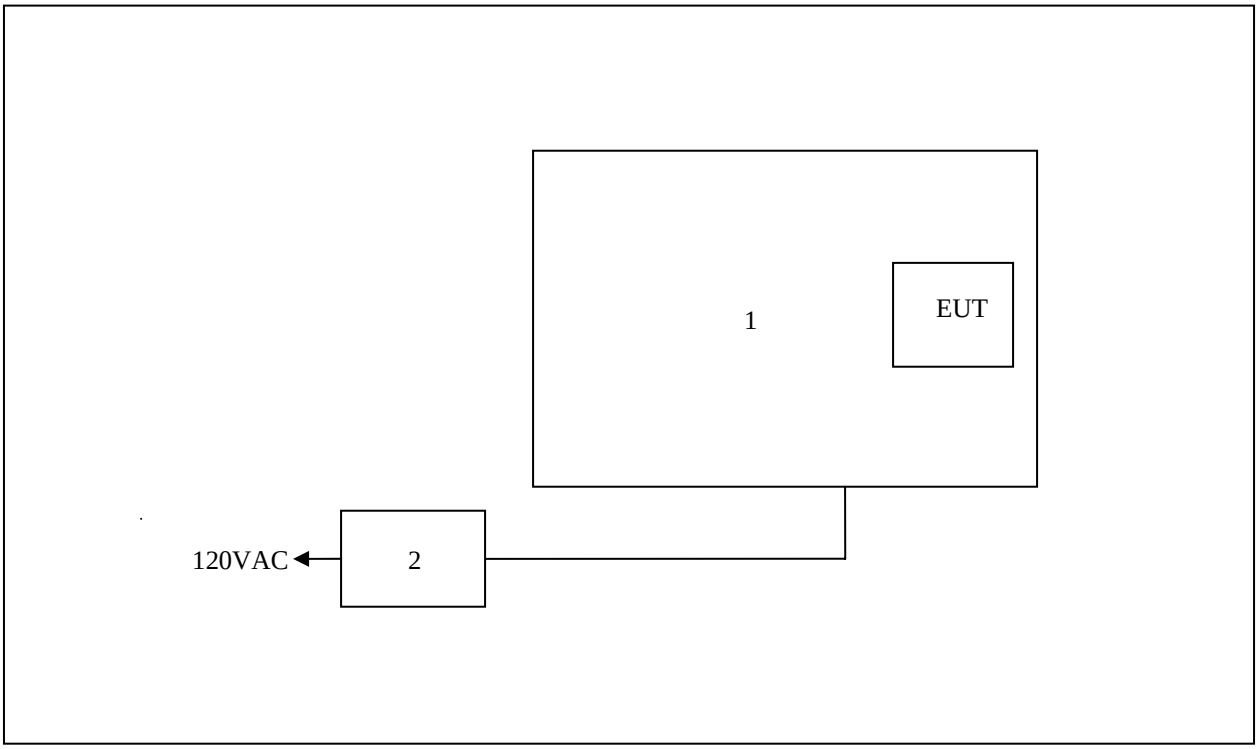

Figure 6-1: EUT Test Setup

*See Test Setup photographs for additional detail.

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 RFE utilizes an integrated PCB F antenna. See section 1.4.

7.2 Power Line Conducted Emissions - FCC Section 15.207

7.2.1 Test Methodology

ANSI C63.4 sections 6 and 7 were the guiding documents for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Applicable Limit - Corrected Reading

7.2.2 Test Results

Results of the test are shown below in and Table 7.2-1.

Table 7.2-1: Conducted EMI Results

Frequency (MHz)	Uncorrected Reading (dBuV)		Total Correction Factor (dB)	Corrected Level (dBuV)		Limit (dBuV)		Margin (dB)	
	Quasi-Peak	Average		Quasi-Peak	Average	Quasi-Peak	Average	Quasi-Peak	Average
Line 1									
0.15	22.4	2.2	9.80	32.20	12.00	66.00	56.00	33.8	44.0
0.21	20.3	1.4	9.80	30.10	11.20	63.21	53.21	33.1	42.0
0.3	19.8	2.9	9.80	29.60	12.70	60.24	50.24	30.6	37.5
0.41	16.9	0.4	9.80	26.70	10.20	57.65	47.65	30.9	37.4
0.57	17.6	0.4	9.80	27.40	10.20	56.00	46.00	28.6	35.8
0.66	16.9	0.2	9.80	26.70	10.00	56.00	46.00	29.3	36.0
Line 2									
0.15	22.3	2.2	9.80	32.10	12.00	66.00	56.00	33.9	44.0
0.18	21.2	8.7	9.80	31.00	18.50	64.49	54.49	33.5	36.0
0.3	17.2	1.9	9.80	27.00	11.70	60.24	50.24	33.2	38.5
0.35	15.8	0.2	9.80	25.60	10.00	58.96	48.96	33.4	39.0
0.57	13	-0.4	9.80	22.80	9.40	56.00	46.00	33.2	36.6
5.54	6	-1.9	9.81	15.81	7.91	60.00	50.00	44.2	42.1

7.3 Radiated Emissions - FCC Section 15.109(Unintentional Radiation)

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 12.5 GHz. 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 120 KHz for measurements above 30MHz. Average measurements are taken with the RBW and VBW were set to 1MHz and 10 Hz respectively for measurements above 1000MHz.

7.3.2 Test Results

Results of the test are given in Table 7.3-1 below:

Table 7.3-1: Radiated Emissions Tabulated Data

Frequency MHz	Level dBµV/m	Transducer dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg
31.55	11.19	-9.40	40.0	28.81	181	286
125.27	7.88	-12.99	43.5	35.62	100	256
345.89	12.25	-9.03	46.0	33.75	141	166
484.82	16.67	-6.11	46.0	29.33	122	12
675.59	20.15	-2.30	46.0	25.85	131	273
929.94	24.17	2.00	46.0	21.83	148	100

* Note: All emissions above 929.94 MHz were attenuated below the permissible limit.

7.4 20dB Bandwidth – FCC Section 15.215

7.4.1 Test Methodology

The spectrum analyzer span was set to 2 to 3 times the estimated 20 dB bandwidth of the emission. The RBW was to ≥ 1% of the estimated 20 dB bandwidth. The trace was set to max hold with a peak detector active. The Delta function of the analyzer was utilized to determine the 20 dB bandwidth of the emission. The span and RBW were examined and re-adjusted if necessary to meet the requirements of 2 to 3 times the 20 bandwidth for the span and ≥ 1% of the 20 dB bandwidth for the RBW.

7.4.2 Test Results

The maximum 20dB bandwidth was found to be approximately 2.66 MHz and is contained in the frequency band designated. Results are shown below in Table 7.4-1 and Figures 7.4-1 through 7.4-3.

Table 7.4-1: 20dB Bandwidth

Frequency [MHz]	Bandwidth [MHz]
2405	2.64
2440	2.66
2480	2.63

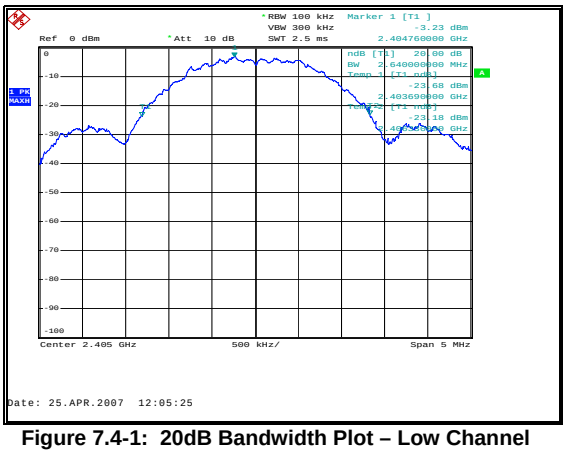

Figure 7.4-1: 20dB Bandwidth Plot – Low Channel

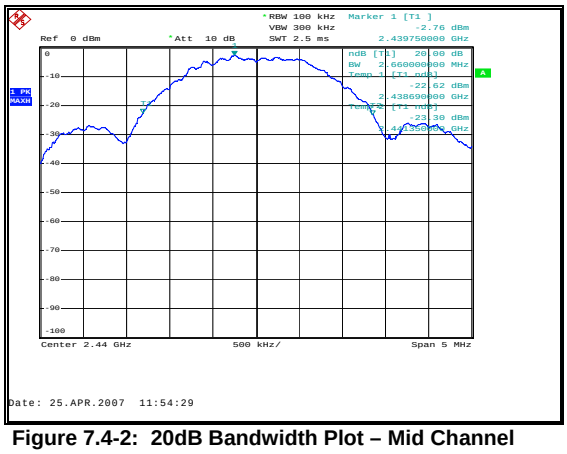

Figure 7.4-2: 20dB Bandwidth Plot – Mid Channel

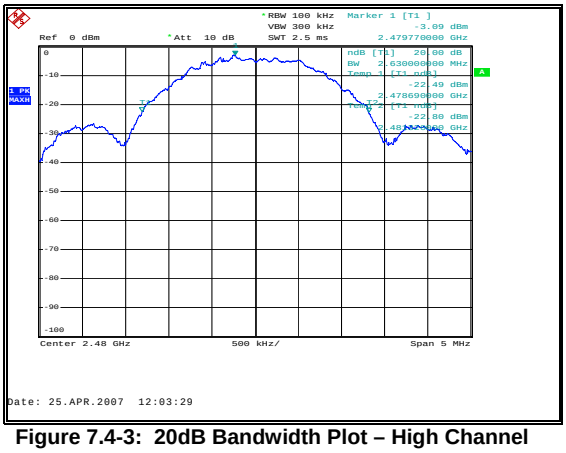

Figure 7.4-3: 20dB Bandwidth Plot – High Channel

7.5 Fundamental Field Strength – FCC Section 15.249(a)

7.5.1 Test Methodology

Radiated emissions tests were made on the 3 channels in the 2400MHz to 2483.5MHz frequency range, the low channel being 2405 MHz, the middle channel being 2440 MHz, and the high channel being 2480 MHz.

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. The limits are specified as average limits however, as shown in 15.35, whenever average limits are specified there is a limit of the peak emission which is 20dB above the maximum permitted average limit. Average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz.

7.5.2 Duty Cycle Correction

For average radiated measurements, the measured peak level was reduced by a factor 26.04dB to account for the duty cycle of the EUT. The transmission duration within a 100ms period is 4.99ms. The duty cycle correction factor is determined using the formula: 20log (4.99/100) = -26.04dB.

A detailed analysis of the duty cycle timing is provided in the Theory of Operation contained in the supporting documentation for this equipment authorization.

7.5.3 Test Results

Results are shown below in Table 7.5-1.

Table 7.5-1: Fundamental Field Strength

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
2405	107.81	107.81	V	-6.54	101.27	75.23	114.0	94.0	12.71	18.75
2440	107.13	107.13	V	-6.42	100.71	74.67	114.0	94.0	13.27	19.30
2480	107.02	107.02	V	-6.28	100.74	74.70	114.0	94.0	13.24	19.28

7.6 Band-Edge Compliance and Spurious Emissions - FCC Section 15.209; 15.249(a), (d) & (e)

7.6.1 Band-Edge Compliance of RF Emissions

7.6.1.1 Test Methodology

The EUT was investigated at the low and high channels of operation to determine band-edge compliance. Band-edge compliance for the lower and upper band-edge was determined using the radiated mark-delta method as outlined in FCC DA 00-705. The radiated field strength of the fundamental emission was first determined and then the mark-delta method was used to determine the field strength of the band-edge emissions as compared to the emission limits of 15.209.

7.6.1.2 Test Results

Band-edge compliance is displayed in Table 7.6.1-1 and 7.6.1-2 as well as Figures 7.6.1-1 – 7.6.1-2.

Table 7.6.1-1: Lower Band-edge Marker Delta Method

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Fundamental Field Strength (dBuV/m)		Delta-Marker (dB)	Band-edge Field Strength (dBuV/m)		Margin to Limit (dBuV/m) 74 / 54	
	pk	avg	(H/V)	(dB)	pk	avg		pk	avg	pk	avg
Fundamental Frequency											
2405	107.81	107.81	V	-6.54	101.27	75.23	41.49	59.78	33.74	14.22	20.26

Table 7.6.1-2: Upper Band-edge Marker Delta Method

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Fundamental Field Strength (dBuV/m)		Delta-Marker (dB)	Band-edge Field Strength (dBuV/m)		Margin to Limit (dBuV/m) 74 / 54	
	pk	avg	(H/V)	(dB)	pk	avg		pk	avg	pk	avg
Fundamental Frequency											
2480	107.02	107.02	V	-6.28	100.74	74.70	36.52	64.22	38.18	9.78	15.82

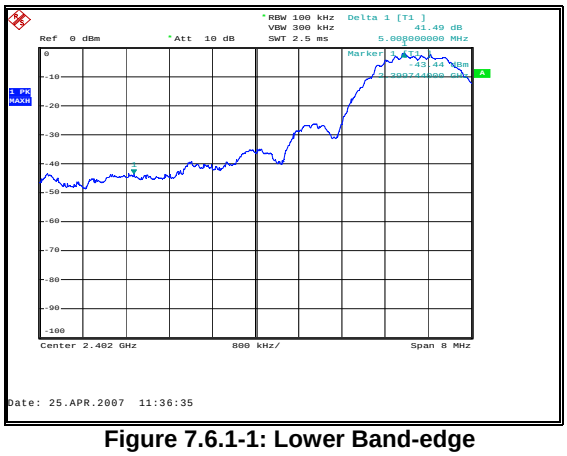

Figure 7.6.1-1: Lower Band-edge

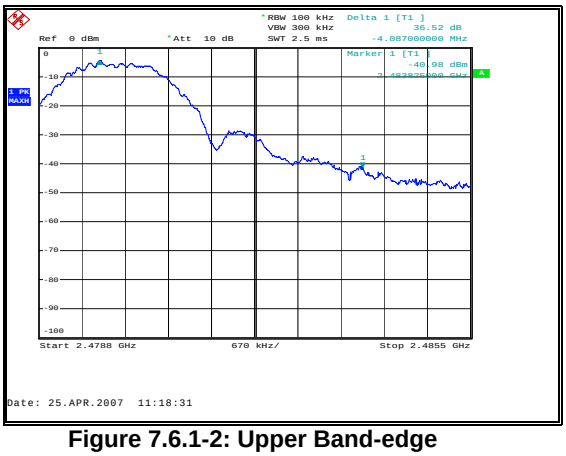

Figure 7.6.1-2: Upper Band-edge

7.6.2 Radiated Spurious Emissions

7.6.2.1 Test Methodology

Radiated emissions tests were made over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency.

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 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000MHz, peak measurements made with RBW and VBW of 1 MHz. Average measurements were made with RBW of 1MHz and a VBW of 10Hz. The average emissions were further corrected by applying the duty cycle correction of the EUT to the average measurements for comparison to the average limit.

7.6.2.2 Duty Cycle Correction

For average radiated measurements, the measured peak level was reduced by a factor 26.04dB to account for the duty cycle of the EUT. The transmission duration within a 100ms period is 4.99ms. The duty cycle correction factor is determined using the formula: 20log (4.99/100) = -26.04dB.

7.6.2.3 Test Results

Radiated spurious emissions found in the band of 30MHz to 25GHz are reported in Table 7.6.2-1.

Table 7.6.2-1: Radiated Spurious Emissions

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Spurious Emissions - 2405MHz										
4810	53.00	53.00	H	1.48	54.48	28.44	74.0	54.0	19.52	25.56
4810	53.45	53.45	V	1.64	55.09	29.05	74.0	54.0	18.91	24.95
7215	53.23	53.23	H	6.92	60.15	34.11	74.0	54.0	13.85	19.89
7215	53.78	53.78	V	6.88	60.66	34.62	74.0	54.0	13.34	19.38
Spurious Emissions - 2440MHz										
4880	52.02	52.02	H	1.71	53.73	27.70	74.0	54.0	20.27	26.30
4880	50.14	50.14	V	1.89	52.03	25.99	74.0	54.0	21.97	28.01
Spurious Emissions - 2480MHz										
4960	53.66	53.66	H	1.98	55.64	29.60	74.0	54.0	18.36	24.40
4960	52.16	52.16	V	2.17	54.33	28.29	74.0	54.0	19.67	25.71

7.6.2.4 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: Peak
Corrected Level: 53.00+ 1.48 = 54.48dBuV/m
Margin: 74dBuV/m – 54.48dBuV/m = 19.52dB

Example Calculation: Average
Corrected Level: 53.00+ 1.48 - 26.04= 28.44dBuV
Margin: 54dBuV – 28.44dBuV = 25.56dB

8.0 CONCLUSION

In the opinion of ACS, Inc. the RFE, manufactured by Wireless Control Network Solutions, LLC.; dba Synapse meets the requirements of FCC Part 15.

END REPORT