

8. Conducted Spurious Emissions

8.1 *Specification*

FCC Part 15, Subpart H, Section 15.709(c)

8.2 *Test Procedure*

The E.U.T. antenna terminal was connected to the spectrum analyzer through an external attenuator (30 dB) and an appropriate coaxial cable (cable loss = 0.3 dB). The spectrum analyzer was set to 100 kHz resolution BW. Three operational frequencies were tested: 473 MHz, 587 MHz and 695 MHz.

8.3 *Test Results*

JUDGEMENT: Passed

The EUT met the requirements of the F.C.C. Part 15, Subpart H, Section 15.709(c) specification.

For additional information see *Figure 238* to *Figure 249*.

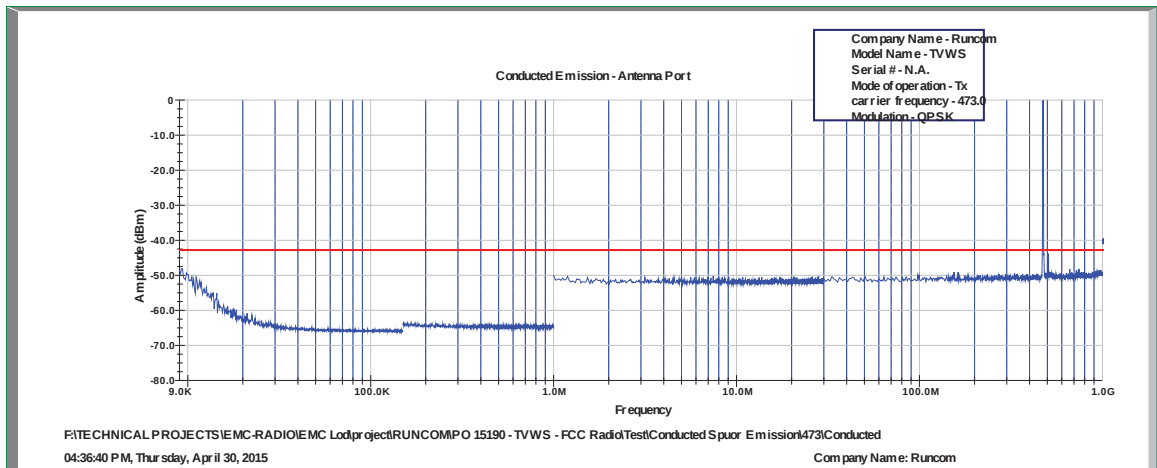


Figure 238 Conducted Emission 473.0 MHz – Port 1

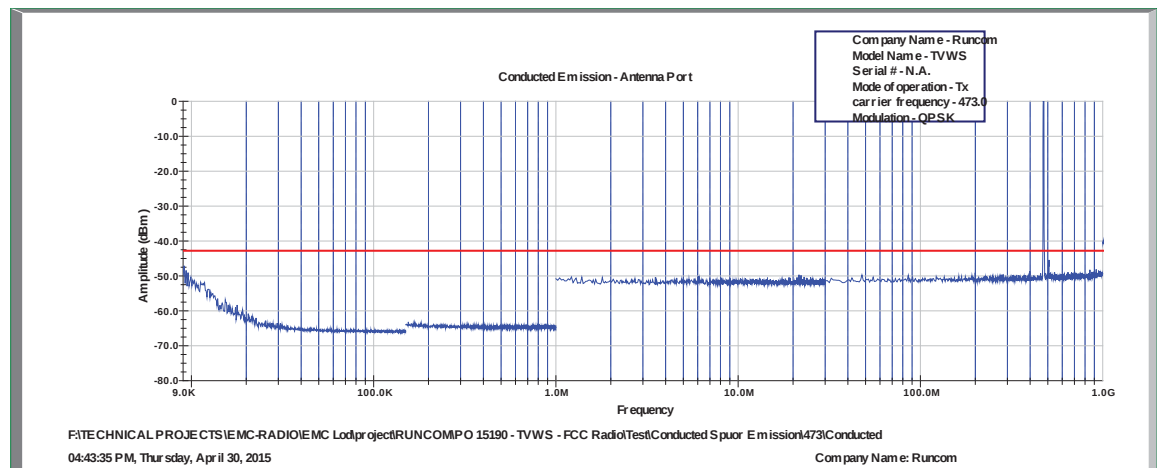


Figure 239 Conducted Emission 473.0 MHz – Port 2

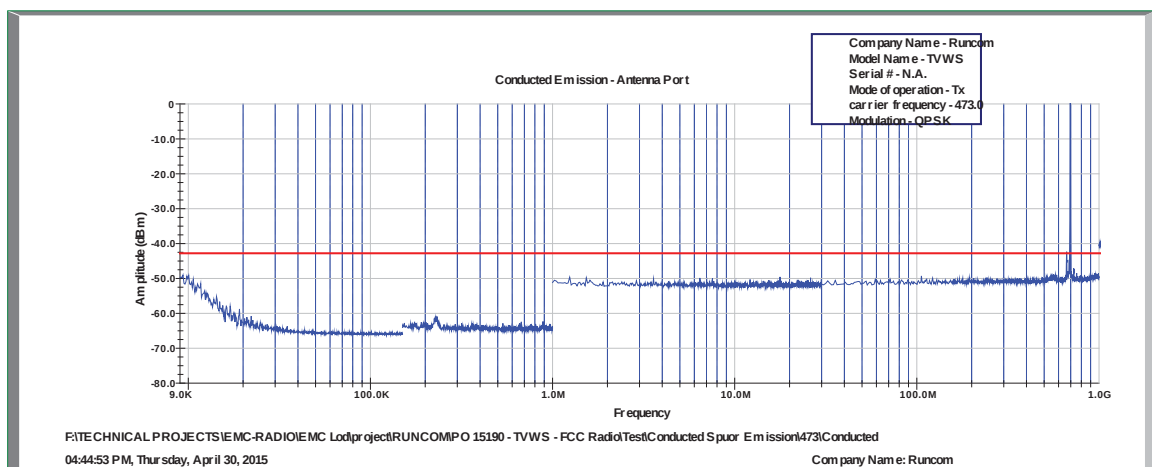


Figure 240 Conducted Emission 473.0 MHz – Port 3

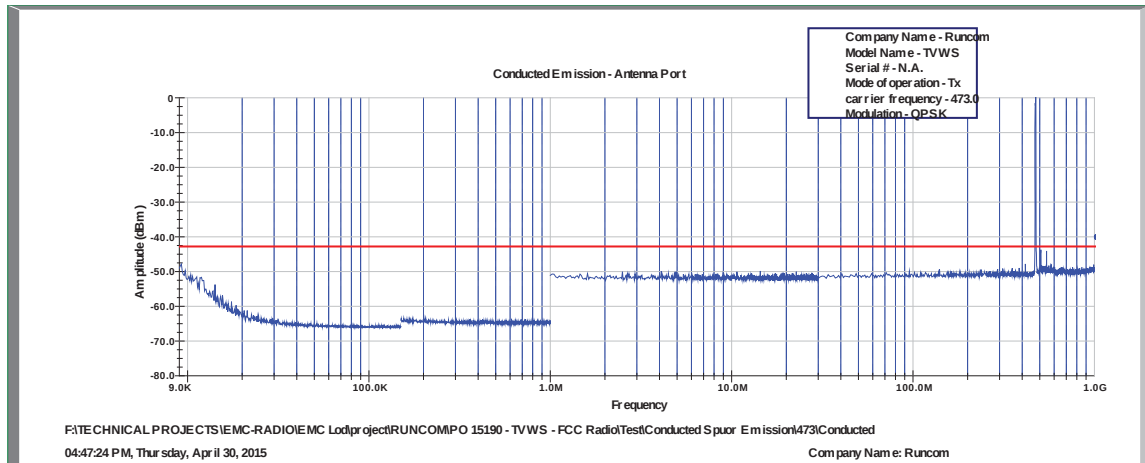


Figure 241 Conducted Emission 473.0 MHz – Port 4

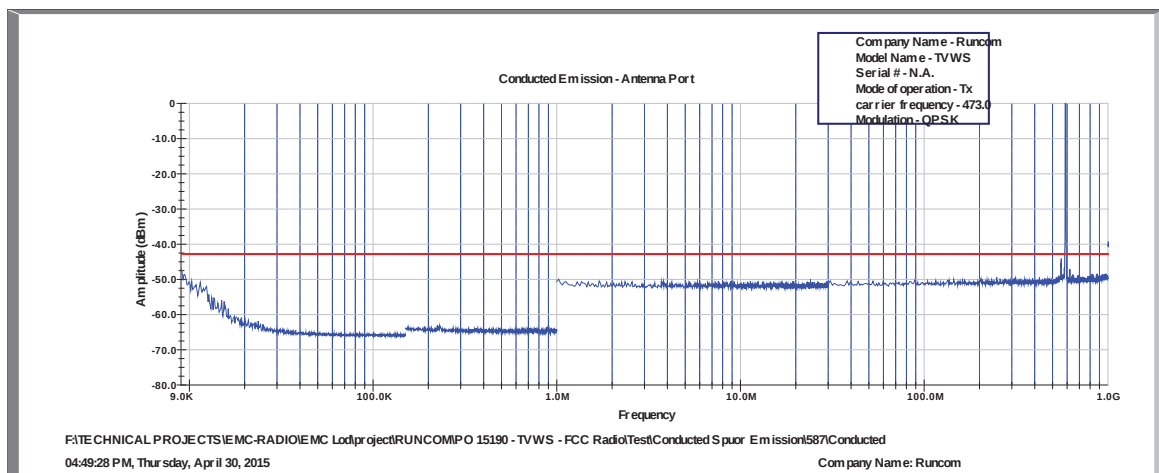


Figure 242 Conducted Emission 587.0 MHz – Port 1

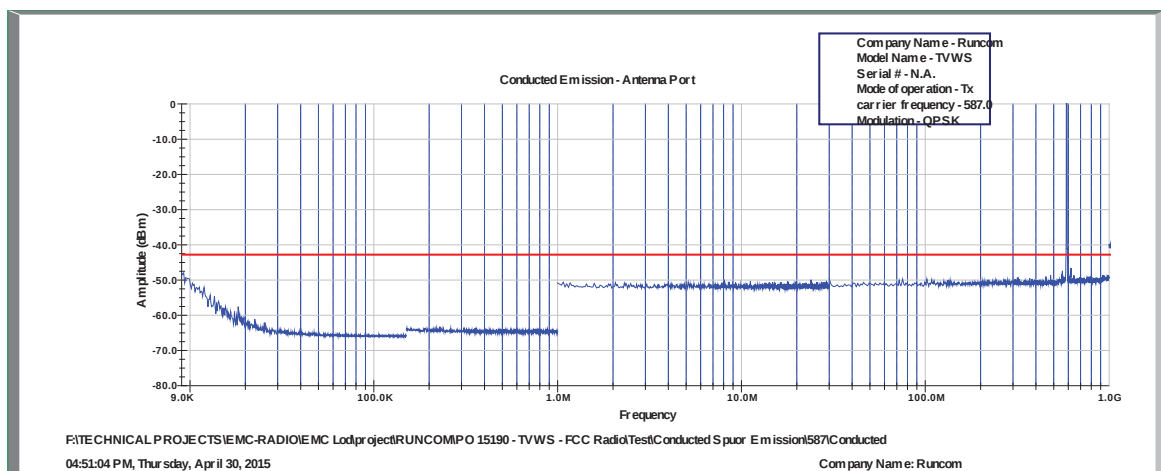


Figure 243 Conducted Emission 587.0 MHz – Port 2

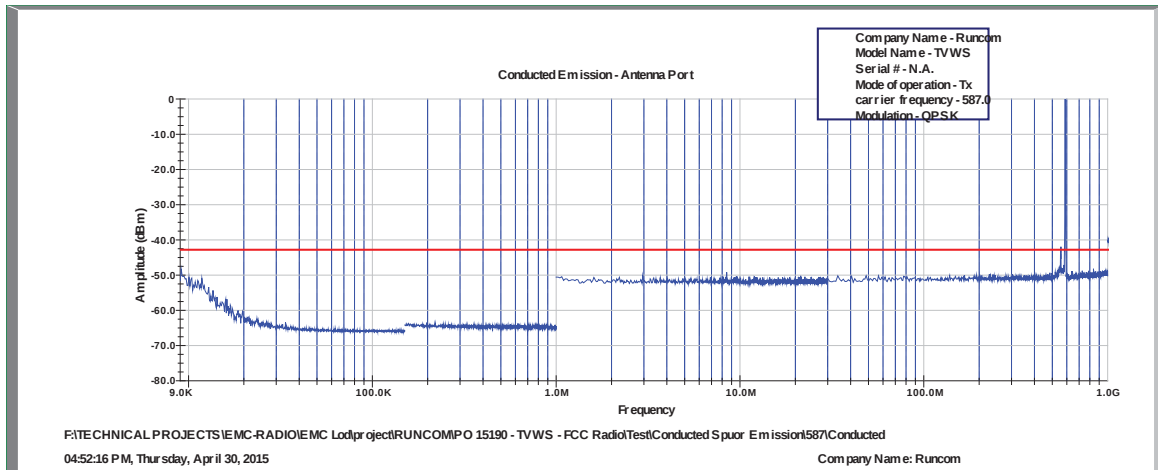


Figure 244 Conducted Emission 587.0 MHz – Port 3

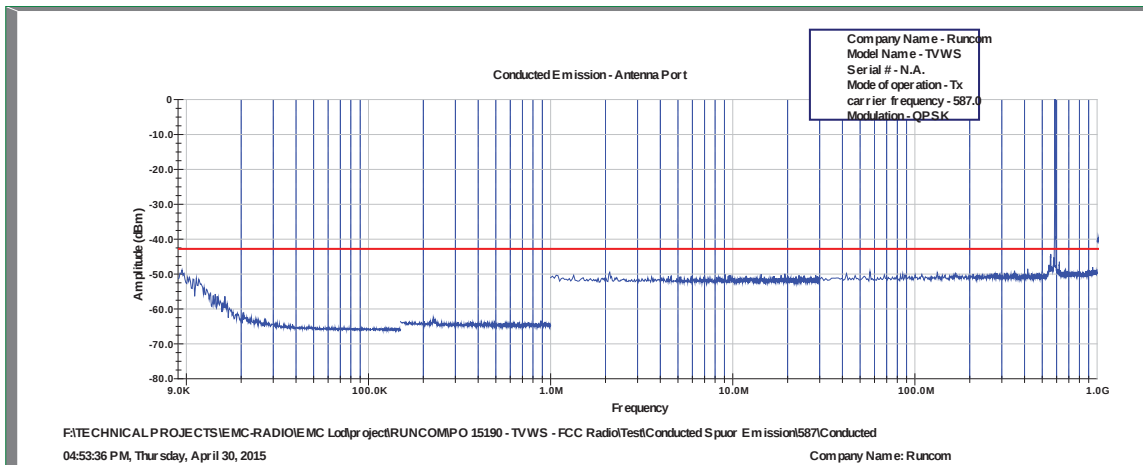


Figure 245 Conducted Emission 587.0 MHz – Port 4

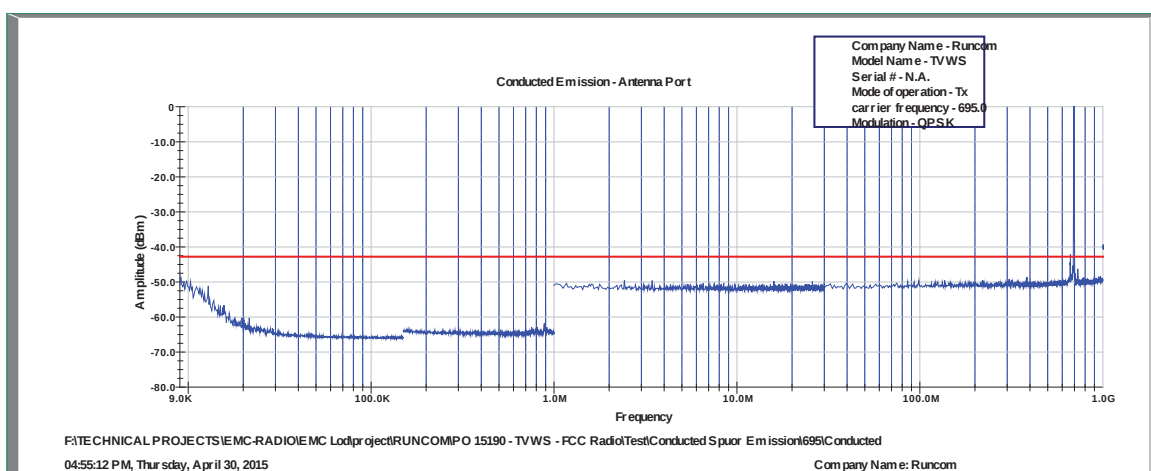


Figure 246 Conducted Emission 695.0 MHz – Port 1

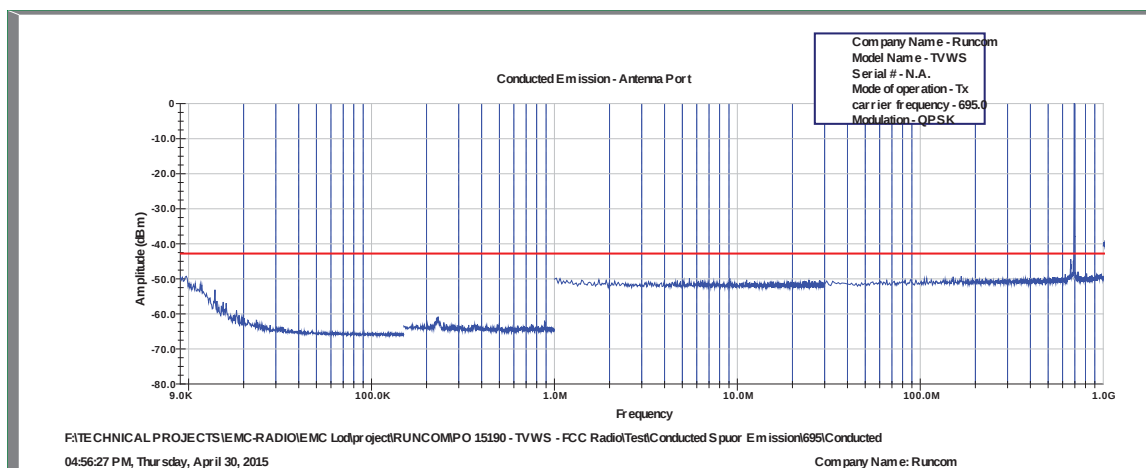


Figure 247 Conducted Emission 695.0 MHz – Port 2

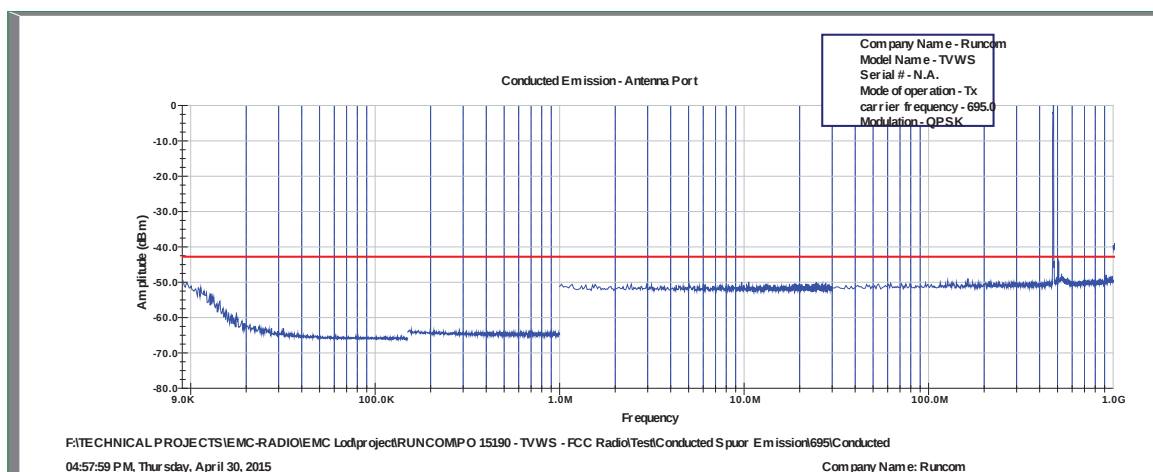


Figure 248 Conducted Emission 695.0 MHz – Port 3

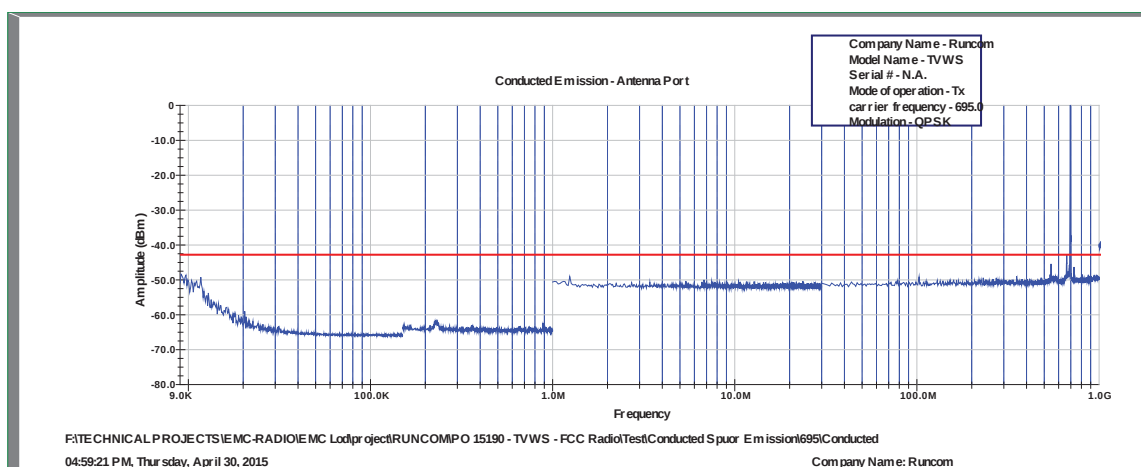


Figure 249 Conducted Emission 695.0 MHz – Port 4



8.4 *Test Equipment Used; Conducted Emission*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
Spectrum Analyzer	HP	8592L	3826A01204	March 4, 2015	1 year
30 dB attenuator	Weinschel Engineering	49-30-34	PD426	January 14, 2015	1 year

Figure 250 Test Equipment Used

9. Radiated Emission, 9 kHz – 30 MHz

9.1 Test Specification

9 kHz-30 MHz, F.C.C. Part 15, Subpart H, Section 15.709(c)(3)

9.2 Test Procedure

The E.U.T. operation mode and test set-up are as described in Section 2.

A preliminary measurement to characterize the E.U.T was performed inside the shielded room at a distance of 3 meters, using peak detection mode and broadband antennas. The preliminary measurements produced a list of the highest emissions. The E.U.T was then transferred to the open site, and placed on a remote-controlled turntable. The E.U.T was placed on a non-metallic table, 0.8 meters above the ground. The configuration tested is shown in Figure 1.

The frequency range 9 kHz-30 MHz was scanned.

The emissions were measured using a computerized EMI receiver complying with CISPR 16 requirements. The specification limits and applicable correction factors are pre-loaded to the receiver.

In the frequency range 9 kHz-30MHz, the loop antenna was rotated on its vertical axis. The antenna height (center of loop) was 1 meter at a distance of 3 meters.

The E.U.T. was operated at the low, mid and high channels using a peak detector.

9.3 Test Results

No signals were detected in the frequency range of 9kHz-30MHz.

JUDGEMENT: Passed

The EUT met the requirements of the F.C.C. Part 15, Subpart H, Section 15.709(d) specification.



9.4 *Test Instrumentation Used, Radiated Measurements*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	R&S	ESIB7	100120	January 1, 2015	1 year
Active Loop Antenna	EMCO	6502	9506-2950	November 4, 2014	1 year
Antenna Mast	ETS	2070-2	9608-1497	N/A	N/A
Turntable	ETS	2087	-	N/A	N/A
Mast & Table Controller	ETS/EMCO	2090	9608-1456	N/A	N/A

Figure 251 Test Equipment Used

9.5 **Field Strength Calculation**

The field strength is calculated directly by the EMI Receiver software, and a "Correction Factors", using the following equation:

$$FS = RA + AF + CF$$

FS:	Field Strength [dB μ V/m]
RA:	Receiver Amplitude [dB μ V]
AF:	Receiving Antenna Correction Factor [dB/m]
CF:	Cable Attenuation Factor [dB]

Example: $FS = 30.7 \text{ dB}\mu\text{V (RA)} + 14.0 \text{ dB (AF)} + 0.9 \text{ dB (CF)} = 45.6 \text{ dB}\mu\text{V}$

No external pre-amplifiers are used.

10. Spurious Radiated Emission, 30 – 7000 MHz

10.1 Specification

FCC Part 15, Subpart H, Section 15.709(c)(3)

10.2 Radiated Emission 30-7000 MHz

The E.U.T operation mode and test set-up are as described in Section 2.

See Section 2.1 Justification of the System Test Configuration concerning the E.U.T. orientation for this test.

A preliminary measurement to characterize the E.U.T was performed inside the shielded room, using peak detection mode and broadband antennas. The preliminary measurements produced a list of the highest emissions. The E.U.T was then transferred to the open site, and placed on a remote-controlled turntable. The E.U.T was placed on a non-metallic table, 0.8 meters above the ground. The configuration tested is shown in *Figure 1*.

The levels of the emissions within the frequency ranges of the restricted bands (Section 15.205 of FCC Part 15) were compared to the limits of the table in Section 15.209 (a), General Requirements.

In the frequency range 30-7000 MHz, a computerized EMI receiver complying with CISPR 16 requirements was used.

The test distance was 3 meters.

The readings were maximized by adjusting the antenna height between 1-4 meters, the turntable azimuth between 0-360°, and the antenna polarization.

Verification of the E.U.T emissions was based on the following methods: turning the E.U.T on and off; using a frequency span less than 10 MHz; observation of the signal level during turntable rotation. (Background noise is not affected by the rotation of the E.U.T.)

The E.U.T. was operated at the low, mid and high channels using a peak detector.

10.3 Test Results

JUDGEMENT: Passed by 6.2 dB

For the operation frequency of 473.0 MHz, the margin between the emission level and the specification limit is in the worst case 6.2 dB at the frequency of 946.00MHz, vertical polarization.

For the operation frequency of 587.0 MHz, the margin between the emission level and the specification limit is in the worst case 9.4 dB at the frequency of 1761.0 MHz, vertical and horizontal polarization.

For the operation frequency of 695.0 MHz, the margin between the emission level and the specification limit is in the worst case 7.2 dB at the frequency of 2085.0 MHz, vertical and horizontal polarization.

The EUT met the requirements of the F.C.C. Part 15, Subpart H specification.

The details of the highest emissions are given in *Figure 252* to *Figure 255*.

Radiated Emission

E.U.T Description Base Station
Type RNU4000-TVWS
Serial Number: Not designated

Specification: FCC Sub Part H (15.209)

Antenna Polarization: Horizontal, Vertical Frequency range: 30 MHz to 1000MHz
Antenna: 3 meters distance Detectors: Peak, Quasi-peak
Operating frequency: 473.0 MHz

Frequency	Antenna Polarization		Peak Amp	QP Amp	Limit	Margin
(MHz)	Hor.	Ver.	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB)
946.0	X		45.4	39.6	46.0	-6.4
946.0		X	47.0	39.8	46.0	-6.2

Figure 252 Radiated Emission – 473.0 MHz – 30 - 1000MHz - Peak, Quasi Peak

Specification: FCC Sub Part H (15.209)

Antenna Polarization: Horizontal, Vertical Frequency range: 1 GHz to 7 GHz
Antenna: 3 meters distance Detectors: Peak, AVG
Operating frequency: 473.0 MHz

Frequency	Antenna Polarization		Peak Amp	AVG Amp	Limit Peak	Limit AVG	Margin
(MHz)	Hor.	Ver.	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB)
1419.0	X		58.5	-	74.0		-15.5
1419.0	X		-	42.9		54.0	-11.1
1419.0		X	55.9	-	74.0		-18.1
1419.0		X	-	42.5		54.0	-11.5

Figure 253 Radiated Emission – 473.0 MHz – 1 – 7GHz - Peak, AVG

Radiated Emission

E.U.T Description Base Station
Type RNU4000-TVWS
Serial Number: Not designated

Specification: FCC Sub Part H (15.209)

Antenna Polarization: Horizontal, Vertical Frequency range: 1 GHz to 7 GHz
Antenna: 3 meters distance Detectors: Peak, AVG
Operating Frequency 587.0 MHz

Frequency	Antenna Polarization		Peak Amp	AVG Amp	Limit Peak	Limit AVG	Margin
(MHz)	Hor.	Ver.	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB)
1174.0	X		53.8	-	74.0		-20.2
1174.0	X		-	40.8		54.0	-13.2
1761.0	X		58.5	-	74.0		-15.5
1761.0	X		-	44.6		54.0	-9.4
1174.0		X	55.5	-	74.0		-18.5
1174.0		X	-	41.6		54.0	-12.4
1761.0		X	58.8	-	74.0		-15.2
1761.0		X	-	44.6		54.0	-9.4

Figure 254 Radiated Emission – 587.0 MHz – 1 – 7GHz - Peak, AVG

Radiated Emission

E.U.T Description Base Station
Type RNU4000-TVWS
Serial Number: Not designated

Specification: FCC Sub Part H (15.209)

Antenna Polarization: Horizontal, Vertical Frequency range: 1 GHz to 7 GHz
Antenna: 3 meters distance Detectors: Peak, AVG
Operating Frequency 695.0 MHz

Frequency	Antenna Polarization		Peak Amp	AVG Amp	Limit Peak	Limit AVG	Margin
(MHz)	Hor.	Ver.	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB μ V/m)	(dB)
1390.0	X		55.7	-	74.0		-18.3
1390.0	X		-	43.1		54.0	-10.9
2085.0	X		61.1	-	74.0		-12.9
2085.0	X		-	46.8		54.0	-7.2
1390.0		X	57.9	-	74.0		-16.1
1390.0		X	-	42.4		54.0	-11.6
2085.0		X	61.1	-	74.0		-12.9
2085.0		X	-	46.8		54.0	-7.2

Figure 255 Radiated Emission – 695.0 MHz – 1 – 7GHz - Peak, AVG

10.4 Test Instrumentation Used, Radiated Measurements Above 1 GHz

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	R&S	ESIB7	100120	January 1, 2015	1 year
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
Active Loop Antenna	EMCO	6502	9506-2950	November 4, 2014	1 year
Biconilog Antenna	EMCO	3142B	1250	May 22, 2014	2 years
Horn Antenna	ETS	3115	6142	March 14, 2012	3 years*
Horn Antenna	ARA	SWH-28	1007	March 30, 2014	3 years
Spectrum Analyzer	HP	8592L	3826A01204	March 4, 2015	1 year
Spectrum Analyzer	HP	8564E	3442A00275	March 11, 2015	1 year
Low Noise Amplifier	DBS MICROWAVE	LNA-DBS-0411N313	013	August 22, 2014	1 year
Low Noise Amplifier	Sophia Wireless	LNA 28-B	232	August 29, 2014	1 year
Antenna Mast	ETS	2070-2	9608-1497	N/A	N/A
Turntable	ETS	2087	-	N/A	N/A
Mast & Table Controller	ETS/EMCO	2090	9608-1456	N/A	N/A

*Note – Extended to May 19, 2015

Figure 256 Test Equipment Used

11. Radiated Emission in the band 602 – 620 MHz

11.1 Specification

FCC Part 15, Subpart H, Section 15.709 (c)(4)

11.2 Radiated Emission 602-620 MHz

The E.U.T operation mode and test set-up are as described in Section 2.

See Figure 2 of Justification of the System Test Configuration concerning the E.U.T. orientation for this test.

A preliminary measurement to characterize the E.U.T was performed inside the shielded room, using peak detection mode and broadband antennas. The preliminary measurements produced a list of the highest emissions. The E.U.T was then transferred to the open site, and placed on a remote-controlled turntable. The E.U.T was placed on a non-metallic table, 0.8 meters above the ground. The configuration tested is shown in Figure 2.

The test distance was 1 meters.

The readings were maximized by adjusting the antenna height between 1-4 meters, the turntable azimuth between 0-360°, and the antenna polarization.

Verification of the E.U.T emissions was based on the following methods: turning the E.U.T on and off; using a frequency span less than 10 MHz; observation of the signal level during turntable rotation. (Background noise is not affected by the rotation of the E.U.T.)

A B.P.F (band pass filter) was used to prevent overload and enable required sensitivity. The B.P.F was tuned so that the tested band was in the pass band and the transmission carrier was out of the pass band. The insertion loss in the 602M-620MHz was in the worst case 1 dB. This loss was taken care in the final correction factor.

The E.U.T. was operated at channels 35 and 39 (599 MHz and 623 MHz respectively) using a PEAK\Q.PEAK detector, 120kHz RBW and 300kHz VBW.

FREQ SUB BAND (MHz)	Limit (dBμV/m)	Worst Case (dBμV/m)
602-607	$120-5*\{F(\text{MHz})-602\}$	95(F=607MHz)
607-608	95.0	95.0
608-614	30.0	30.0
614-615	95.0	95.0
615-620	$120-5*\{620-F(\text{MHz})\}$	95(F=615MHz)

Figure 257 Limit Table

Antenna Polarization: Horizontal, Vertical **Frequency range: 602MHz to 620 MHz**
Antenna: 1 meters distance **Detectors: Peak, Quasi-peak**
Operating Frequency 599.0 MHz

Frequency	Antenna Polarization		Peak Amp	Q.PEAK Amp	Worst Case Limit (Q.Peak)	Margin
(MHz)	Hor.	Ver.	(dBμV/m)	(dBμV/m)	(dBμV/m)	(dB)
604.8	X		36.5	-	95.0	-58.5
608.0	X		-	29.3	30.0	-0.7
610.7	X		-	29.1	30.0	-0.9
612.8	X		-	29.8	30.0	-0.2
618.7	X		45.9	-	95.0	-49.1
602.5		X	38.5	-	95.0	-56.5
604.4		X	38.2	-	95.0	-56.8
608.1		X	-	29.8	30.0	-0.2
612.6		X	-	28.2	30.0	-1.8
618.7		X	42.8	-	95.0	-52.2

Figure 258 Radiated Emission, Channel 35

Antenna Polarization: Horizontal, Vertical **Frequency range: 602MHz to 620 MHz**
Antenna: 1 meters distance **Detectors: Peak, Quasi-peak**
Operating Frequency 623.0 MHz

Frequency	Antenna Polarization		Peak Amp	Q.PEAK Amp	Worst case Limit (Q.Peak)	Margin
(MHz)	Hor.	Ver.	(dBμV/m)	(dBμV/m)	(dBμV/m)	(dB)
604.8	X		40.0	-	95.0	-55.0
608.0	X		-	27.4	30.0	-2.6
609.4	X		-	28.5	30.0	-1.5
611.0	X		-	27.6	30.0	-2.4
614.9	X		26.0	-	95.0	-69.0
618.7	X		36.9	-	95.0	-58.1
620.0	X		29.8	-	95.0	-65.2
602.1		X	29.5	-	95.0	-65.5
604.8		X	40.1	-	95.0	-54.9
608.0		X	-	29.8	30.0	-0.2
610.5		X	-	26.9	30.0	-3.1
613.9		X	-	25.7	30.0	-4.3
617.7		X	36.1	-	95.0	-58.9
620.0		X	52.9	-	95.0	-42.1

Figure 259 Radiated Emission, Channel 39



11.1 Test Instrumentation Used, Radiated Measurements Above 1 GHz

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	HP	85422E	3906A00276	March 19, 2015	1 year
RF Section	HP	85420E	3705A00248	March 19, 2015	1 year
Biconilog Antenna	EMCO	3142B	1250	May 22, 2014	2 years
Band Pass Filter	K&L	5BT-500/1000-5-N/N	237	November 17, 2014	1 year
Antenna Mast	ETS	2070-2	9608-1497	N/A	N/A
Turntable	ETS	2087	-	N/A	N/A
Mast & Table Controller	ETS/EMCO	2090	9608-1456	N/A	N/A

Figure 260 Test Equipment Used



12. Antenna Gain/Information

The antenna gain is 8.0 dBi.

13. R.F Exposure/Safety

Typical use of the E.U.T. is as a base station.

The typical placement of the E.U.T. is on a pole. The customer has stated that the typical distance between the E.U.T. and the user, is at least 200 cm.

Calculation of Maximum Permissible Exposure (MPE) Based on Section 1.1310 Requirements

Using table 1 of Section 1.1310 limit for general population/uncontrolled exposures, the above level is an average over 30 minutes.

$$\text{FCC limits at 473.0 MHz is: } \frac{f}{1500} = 0.32 \frac{\text{mW}}{\text{cm}^2}$$

$$\text{FCC limits at 587.0 MHz is: } \frac{f}{1500} = 0.39 \frac{\text{mW}}{\text{cm}^2}$$

$$\text{FCC limits at 695.0 MHz is: } \frac{f}{1500} = 0.46 \frac{\text{mW}}{\text{cm}^2}$$

The highest peak power for all chains was in the 587.0 operating frequency.

Modulation	Oper. Freq (MHz)	Chain 1 Peak Power		Chain 2 Peak Power		Chain 3 Peak Power		Chain 4 Peak Power		Sum Peak Power (mW)
		(dBm)	(mW)	(dBm)	(mW)	(dBm)	(mW)	(dBm)	(mW)	
16QAM	587.0	25.0	316	24.4	275	24.8	302	24.6	288	1181
64QAM	587.0	24.7	295	24.0	251	24.3	269	24.2	263	1078
QPSK	587.0	24.4	275	23.7	234	24.1	257	24.2	263	1029

(a) The power density produced by the E.U.T. is

$$S = \frac{P_t G_t}{4\pi R^2}$$

P_t - Transmitted Power (Peak) = 1181 mW

G_t - Antenna Gain, 8.0 dBi = 6.31 numeric

R - Distance from Transmitter using 200cm

(b) The peak power density is:

$$S_p = \frac{1181 \times 6.31}{4\pi(200)^2} = 0.015 \frac{\text{mW}}{\text{cm}^2}$$

(c) This is below the FCC limit.

14. APPENDIX A - CORRECTION FACTORS

14.1 Correction factors for CABLE

from EMI receiver
to test antenna
at 3 meter range.

Frequency (MHz)	Cable Loss (dB)	Frequency (MHz)	Cable Loss (dB)
0.010	0.4	50.00	1.2
0.015	0.2	100.00	0.7
0.020	0.2	150.00	20.1
0.030	0.3	200.00	2.3
0.050	0.3	300.00	2.9
0.075	0.3	500.00	3.8
0.100	0.2	750.00	4.8
0.150	0.2	1000.00	5.4
0.200	0.3	1500.00	6.7
0.500	0.4	2000.00	9.0
1.00	0.4	2500.00	9.4
1.50	0.5	3000.00	9.9
2.00	0.5	3500.00	10.2
5.00	0.6	4000.00	11.2
10.00	0.8	4500.00	12.1
15.00	0.9	5000.00	13.1
20.00	0.8	5500.00	13.5
		6000.00	14.5

NOTES:

1. The cable type is SPUMA400 RF-11N(X2) and 39m long
2. The cable is manufactured by Huber + Suhner

14.2 Correction factors for CABLE
from EMI receiver
to test antenna
at 3 meter range.

FREQUENCY (GHz)	CORRECTION FACTOR (dB)
1.0	1.2
2.0	1.6
3.0	2.0
4.0	2.4
5.0	3.0
6.0	3.4
7.0	3.8
8.0	4.2
9.0	4.6
10.0	5.0
12.0	5.8

NOTES:

- 1. The cable type is RG-8.*
- 2. The overall length of the cable is 10 meters.*

14.3 Correction factors for CABLE
from spectrum analyzer
to test antenna above 2.9 GHz

FREQUENCY (GHz)	CORRECTION FACTOR (dB)	FREQUENCY (GHz)	CORRECTION FACTOR (dB)
1.0	1.9	14.0	9.1
2.0	2.7	15.0	9.5
3.0	3.5	16.0	9.9
4.0	4.2	17.0	10.2
5.0	4.9	18.0	10.4
6.0	5.5	19.0	10.7
7.0	6.0	20.0	10.9
8.0	6.5	21.0	11.2
9.0	7.0	22.0	11.6
10.0	7.5	23.0	11.9
11.0	7.9	24.0	12.3
12.0	8.3	25.0	12.6
13.0	8.7	26.0	13.0

NOTES:

1. The cable type is SUCOFLEX 104 E manufactured by SUHNER.
2. The cable is used for measurements above 2.9 GHz.
3. The overall length of the cable is 10 meters.

14.4 Correction factors for

Bilog ANTENNA

Model: 3142

Antenna serial number: 1250

3 meter range

FREQUENCY	AFE	FREQUENCY	AFE
(MHz)	(dB/m)	(MHz)	(dB/m)
30	18.4	1100	25
40	13.7	1200	24.9
50	9.9	1300	26
60	8.1	1400	26.1
70	7.4	1500	27.1
80	7.2	1600	27.2
90	7.5	1700	28.3
100	8.5	1800	28.1
120	7.8	1900	28.5
140	8.5	2000	28.9
160	10.8		
180	10.4		
200	10.5		
250	12.7		
300	14.3		
400	17		
600	19.6		
700	21.1		
800	21.4		
900	23.5		
1000	24.3		

14.5 Correction factors for Horn ANTENNA.

Model: 3115

Antenna serial number: 6142
3 meter range

FREQUENCY	Antenna Factor	FREQUENCY	Antenna Factor
(MHz)	(dB/m)	(MHz)	(dB/m)
1000	23.9	10500	38.4
1500	25.4	11000	38.5
2000	27.3	11500	39.4
2500	28.5	12000	39.2
3000	30.4	12500	39.4
3500	31.6	13000	40.7
4000	33	14000	42.1
4500	32.7	15000	40.1
5000	34.1	16000	38.2
5500	34.5	17000	41.7
6000	34.9	17500	45.7
6500	35.1	18000	47.7
7000	35.9		
7500	37.5		
8000	37.6		
8500	38.3		
9000	38.5		
9500	38.1		
10000	38.6		

14.6 Correction factors for ACTIVE LOOP ANTENNA

Model 6502

S/N 9506-2950

FREQUENCY	Magnetic Antenna Factor	Electric Antenna Factor
(MHz)	(dB)	(dB)
.009	-35.1	16.4
.010	-35.7	15.8
.020	-38.5	13.0
.050	-39.6	11.9
.075	-39.8	11.8
.100	-40.0	11.6
.150	-40.0	11.5
.250	-40.0	11.6
.500	-40.0	11.5
.750	-40.1	11.5
1.000	-39.9	11.7
2.000	-39.5	12.0
3.000	-39.4	12.1
4.000	-39.7	11.9
5.000	-39.7	11.8
10.000	40.2	11.3
15.000	-40.7	10.8
20.000	-40.5	11.0
25.000	-41.3	10.2
30.000	42.3	9.2