7. Maximum Transmitted Peak Power Output

7.1 *Test Specification*

FCC Part 15, Subpart H, Section 15.709 (a)(1)

7.2 *Test Procedure*

The E.U.T operation mode and test set-up are as described in Section 2 of this report. 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. Peak power level was measured by power channel with 6 MHz bandwidth with a RMS detector.
A sweep time of 500msec was used for 1msec per trace point.

7.3 *Test Results*

JUDGEMENT: Passed

For additional information see *Figure 67* to *Figure 79.*

Chain #	Modulation	Operation Frequency (MHz)	Reading (dBm)	Limit (dBm)	Margin (dB)
Chain 1	16QAM	473.00	20.0	30.0	-10.0
		587.00	19.0	30.0	-11.0
		695.00	20.9	30.0	-9.1
	QPSK	473.00	22.5	30.0	-7.5
		587.00	19.6	30.0	-10.4
		695.00	21.6	30.0	-8.4
Chain 2	16QAM	473.00	20.8	30.0	-9.2
		587.00	20.2	30.0	-9.8
		695.00	21.6	30.0	-8.4
	QPSK	473.00	19.5	30.0	-10.5
		587.00	19.3	30.0	-10.7
		695.00	20.4	30.0	-9.6

Figure 67 Peak Power – Chain 1 & 2

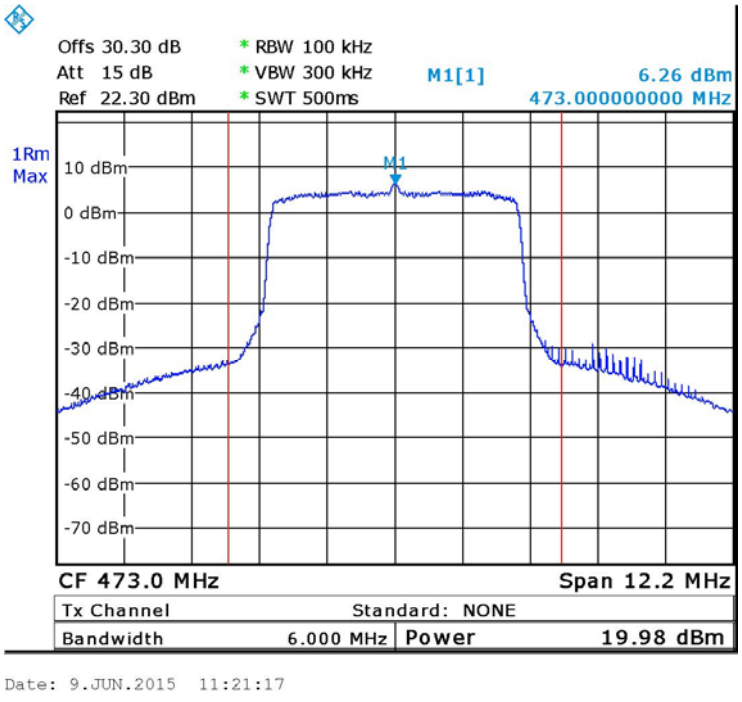


Figure 68. Chain 1 – 16QAM – 473MHz

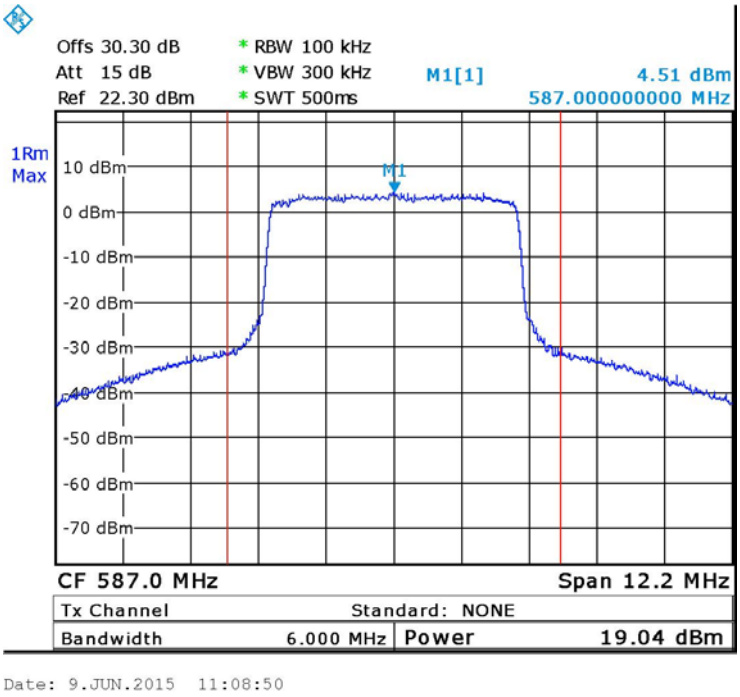


Figure 69. . Chain 1 - 16QAM – 587MHz

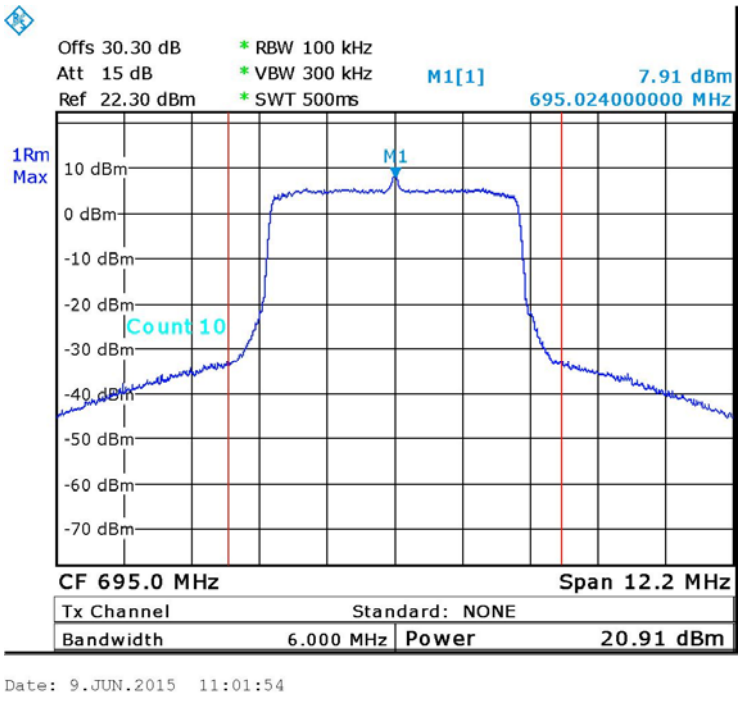


Figure 70. Chain 1 - 16QAM – 695MHz

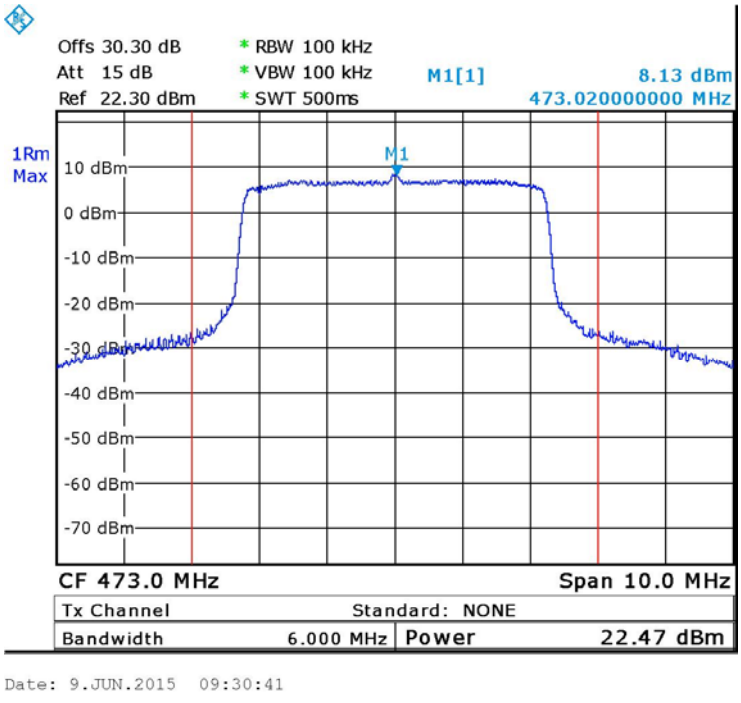


Figure 71. Chain 1 - QPSK – 473MHz

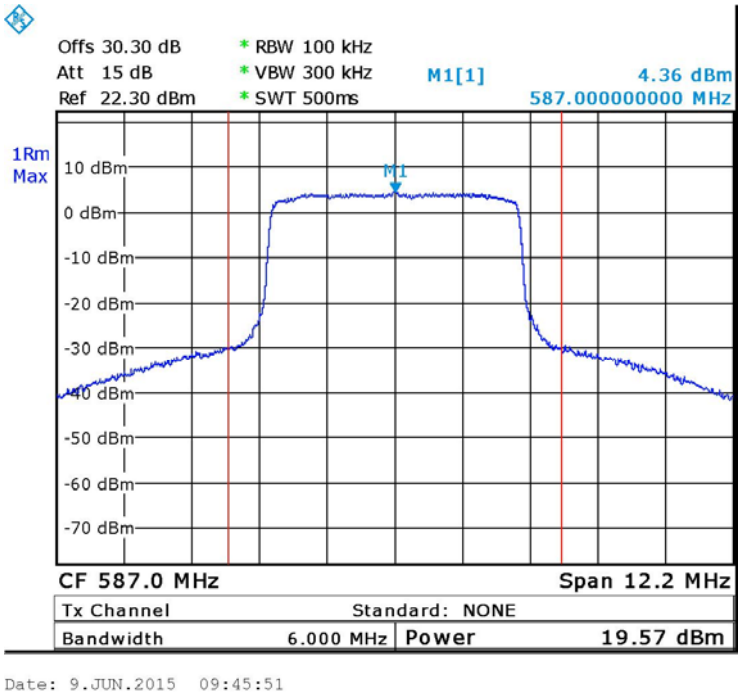


Figure 72. . Chain 1 –- QPSK – 587MHz

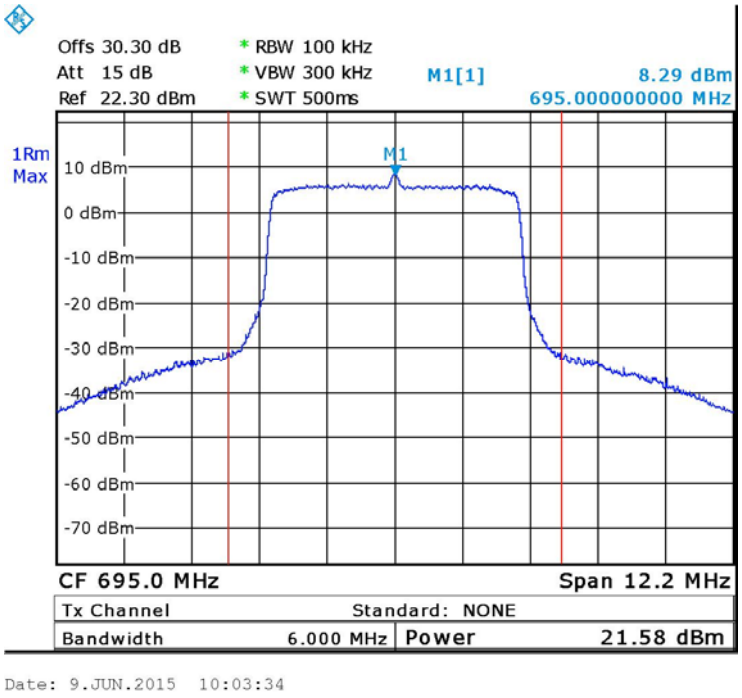


Figure 73. Chain 1 –- QPSK – 695MHz

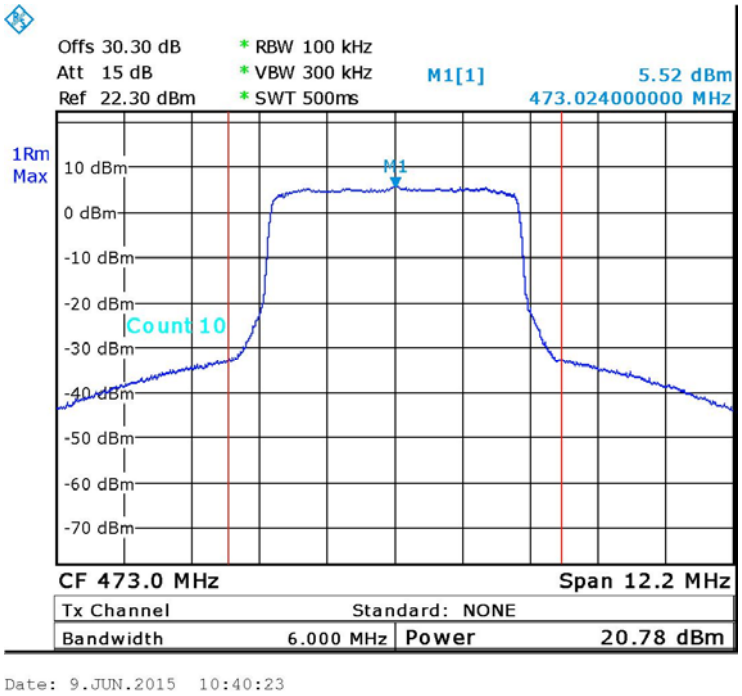


Figure 74. Chain 2 –16QAM – 473MHz

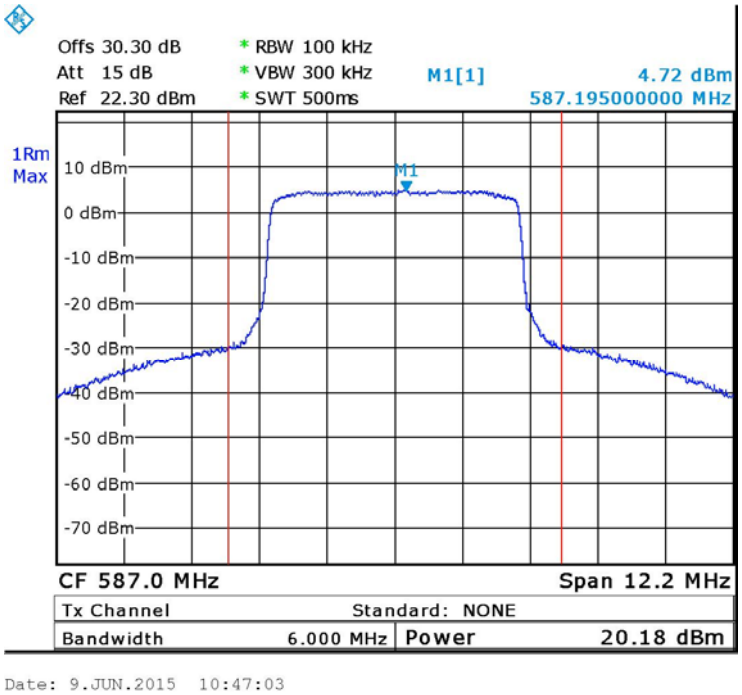


Figure 75. . Chain 2 – 16QAM – 587MHz

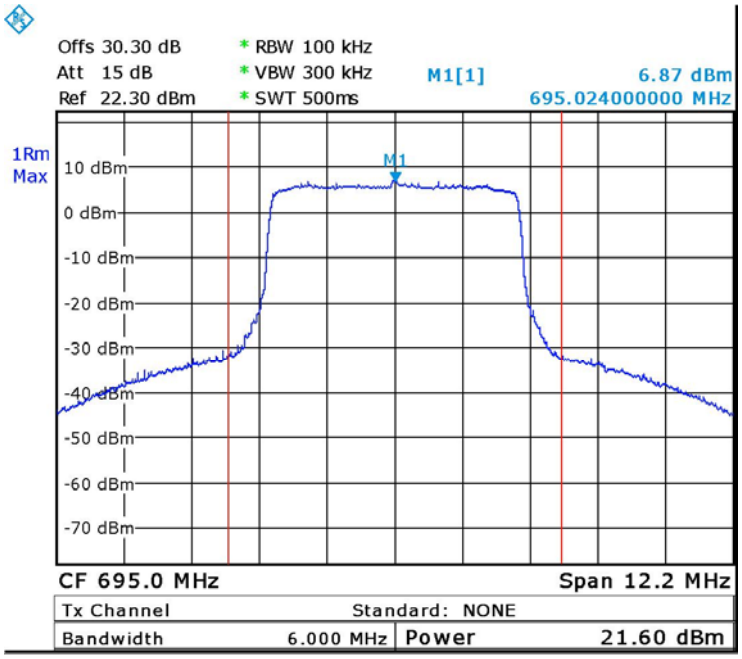


Figure 76. Chain 2 –- 16QAM – 695MHz

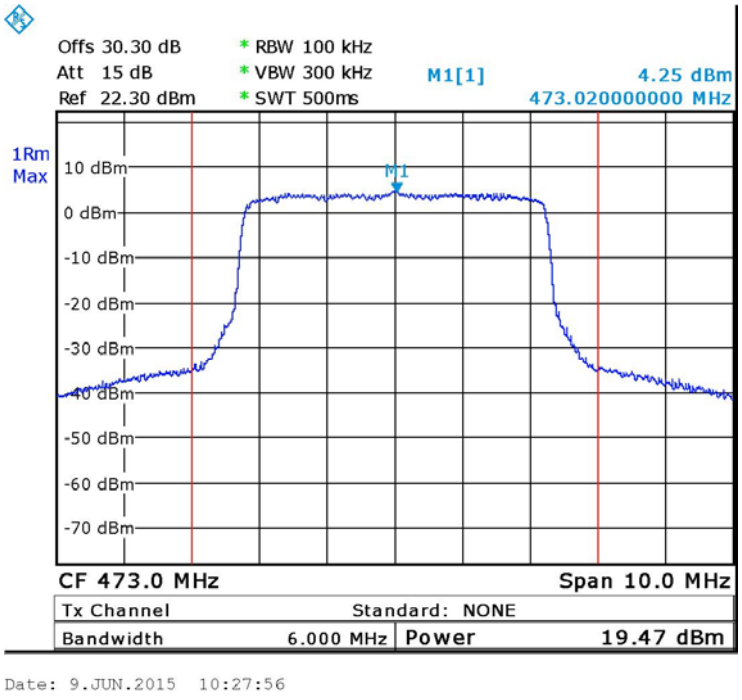


Figure 77. Chain 2 - QPSK – 473MHz

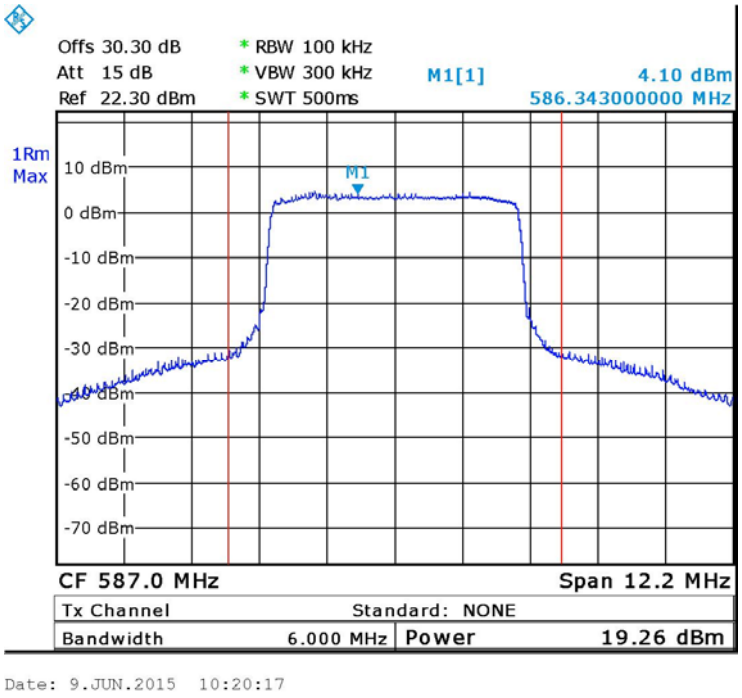


Figure 78. . Chain 2 - QPSK – 587MHz

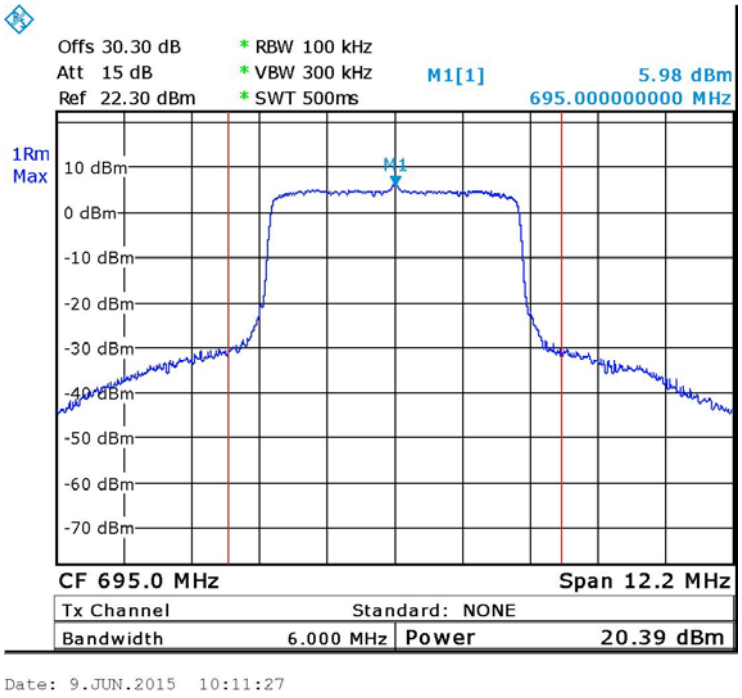


Figure 79. Chain 2 - QPSK – 695MHz

7.4 *Test Equipment Used; Maximum Transmitted Peak Power Output*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
30 dB attenuator	BIRD	8304-N30DB	-	June 2, 2015	1 year
Coupler	Macom	96341	2025-6006-10	-	-

Figure 80 Test Equipment Used

8. Power Spectral Density

8.1 *Specification*

FCC Part 15, Subpart H, Section 15.709(a)(5)(i)

8.2 *Test Procedure*

The E.U.T operation mode and test set-up are as described in Section 2 of this report. 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. Peak power level was measured in any 100 kHz bandwidth and with an RMS detector.
A sweep time of 500msec was used for 1msec per trace point.

8.3 *Test Results*

JUDGEMENT: Passed

For additional information see *Figure 81* to *Figure 93.*

Note: This product has a maximum PSD of 8.3 dBm (100kHz). Since the Database will allocate to the products TVWS Channels according to the 30dBm conducted power limit the PSD limit that shall apply is 12.6dBm which is met by this product.

Chain #	Modulation	Operation Frequency (MHz)	Reading (dBm)	Specification (dBm)	Margin (dB)
Chain 1	16QAM	473.00	6.3	12.6	-6.3
		587.00	4.5	12.6	-8.1
		695.00	7.9	12.6	-4.7
	QPSK	473.00	8.1	12.6	-4.5
		587.00	4.4	12.6	-8.2
		695.00	8.3	12.6	-4.3
Chain 2	16QAM	473.00	5.5	12.6	-7.1
		587.00	4.7	12.6	-7.9
		695.00	7.9	12.6	-4.7
	QPSK	473.00	4.3	12.6	-8.3
		587.00	4.1	12.6	-8.5
		695.00	6.0	12.6	-6.6

Figure 81 Peak Power – Chain 1 & 2

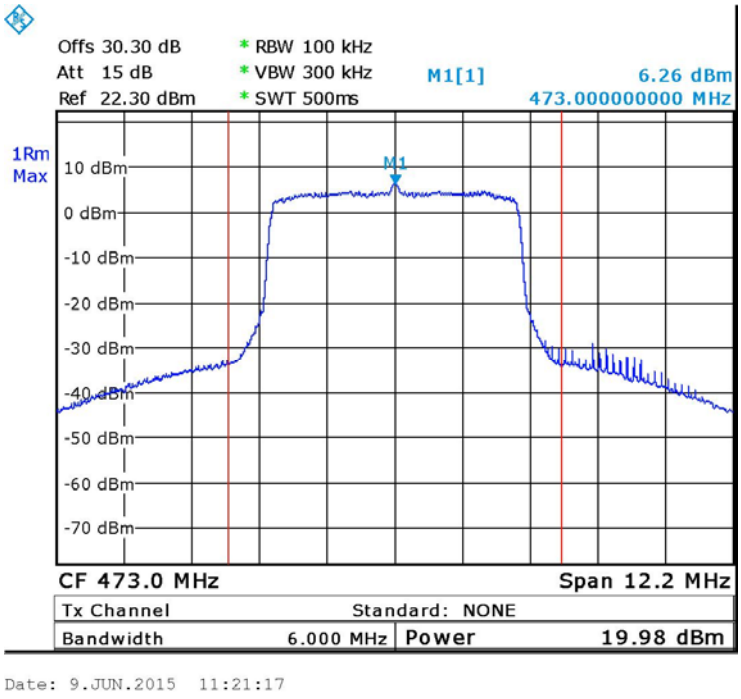


Figure 82. Chain 1 – 16QAM – 473MHz

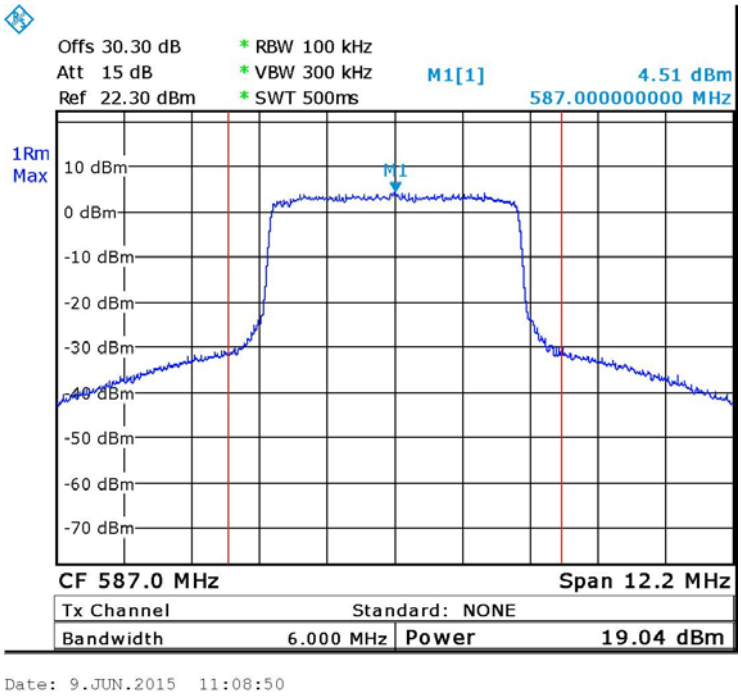


Figure 83. . Chain 1 - 16QAM – 587MHz

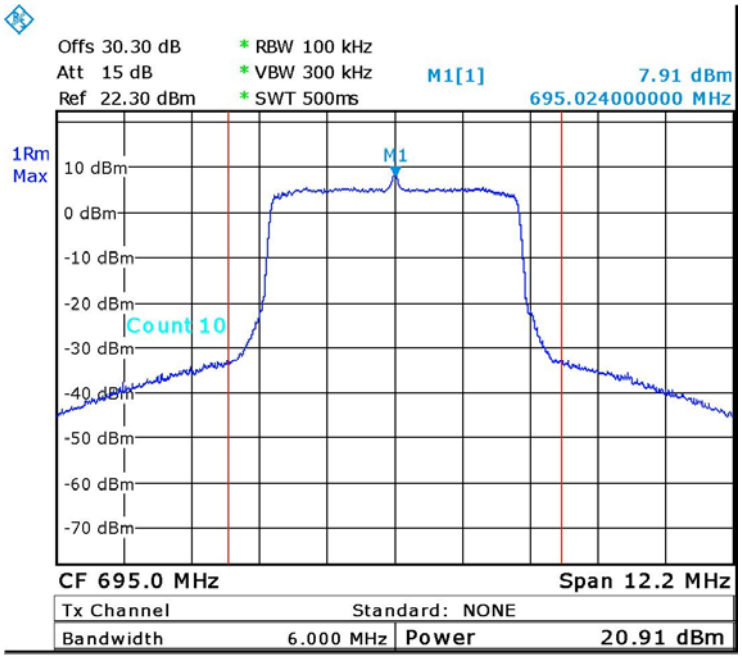


Figure 84. Chain 1 - 16QAM – 695MHz

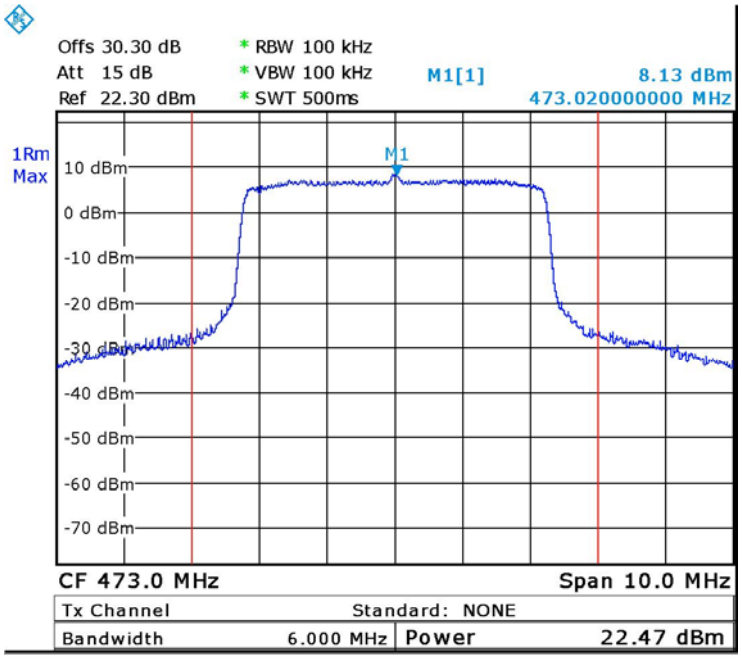


Figure 85. Chain 1 - QPSK – 473MHz

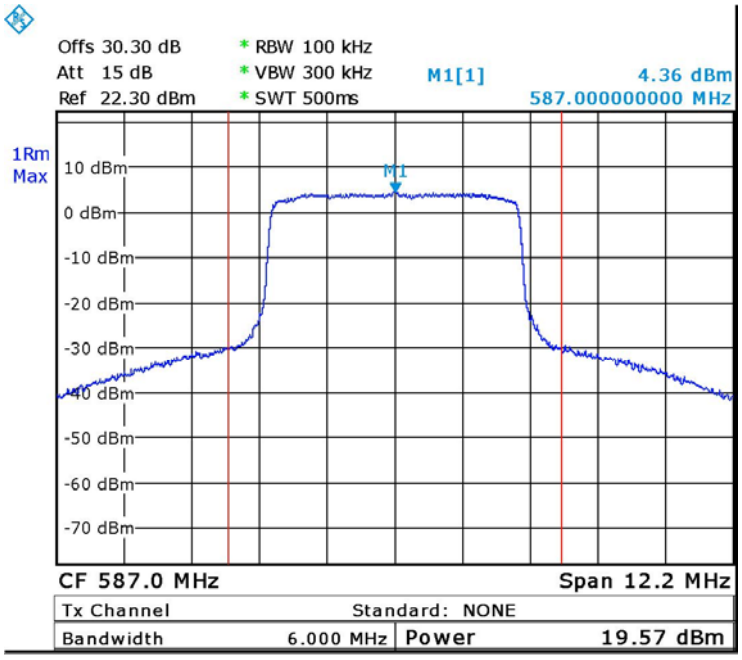


Figure 86. . Chain 1 –- QPSK – 587MHz

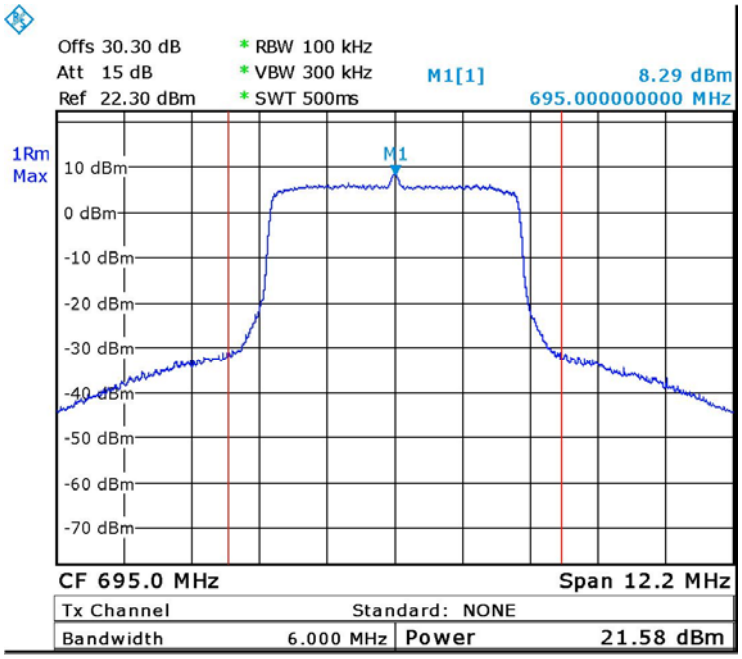


Figure 87. Chain 1 –- QPSK – 695MHz

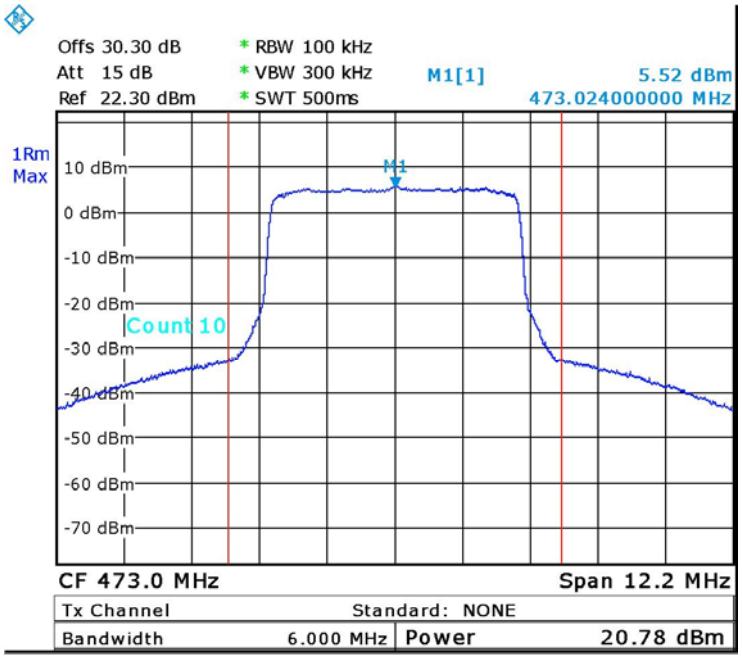


Figure 88. Chain 2 –16QAM – 473MHz

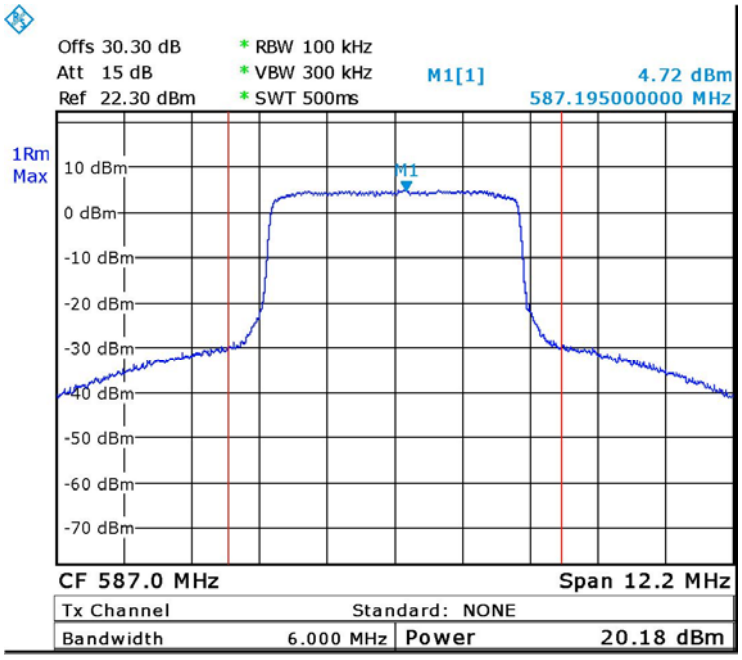


Figure 89. . Chain 2 – 16QAM – 587MHz

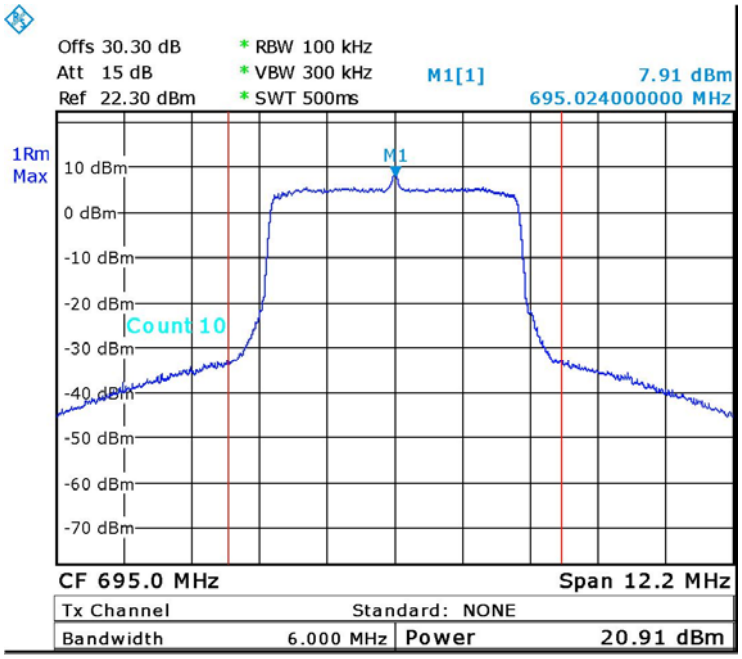


Figure 90. Chain 2 –- 16QAM – 695MHz

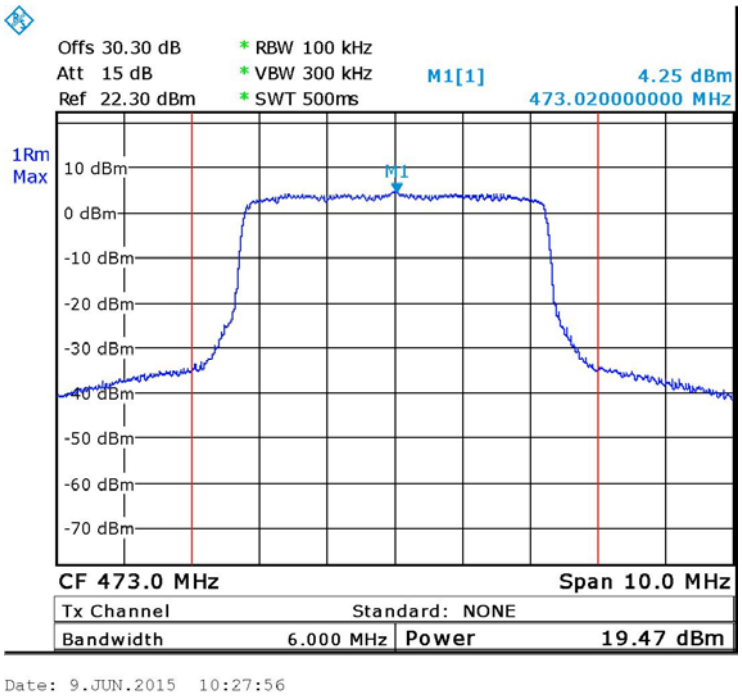


Figure 91. Chain 2 - QPSK – 473MHz

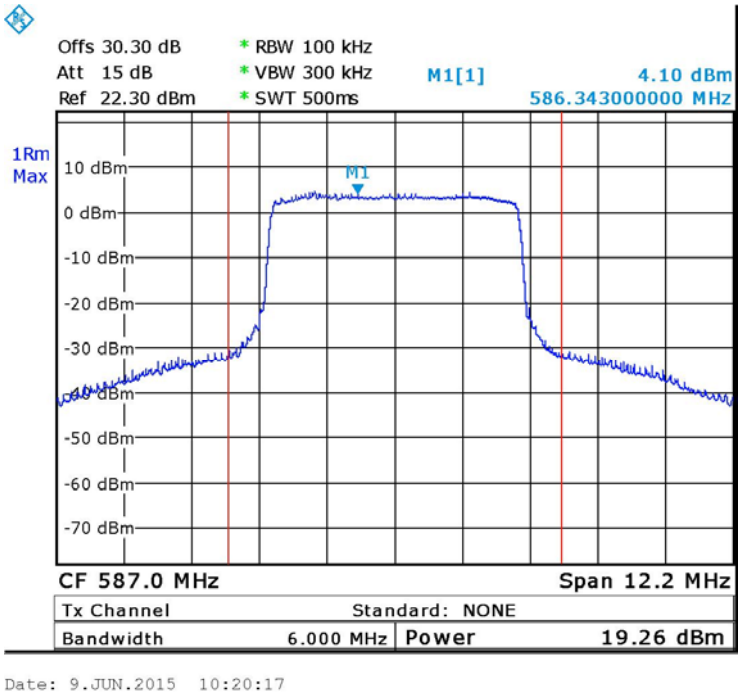


Figure 92. . Chain 2 - QPSK – 587MHz

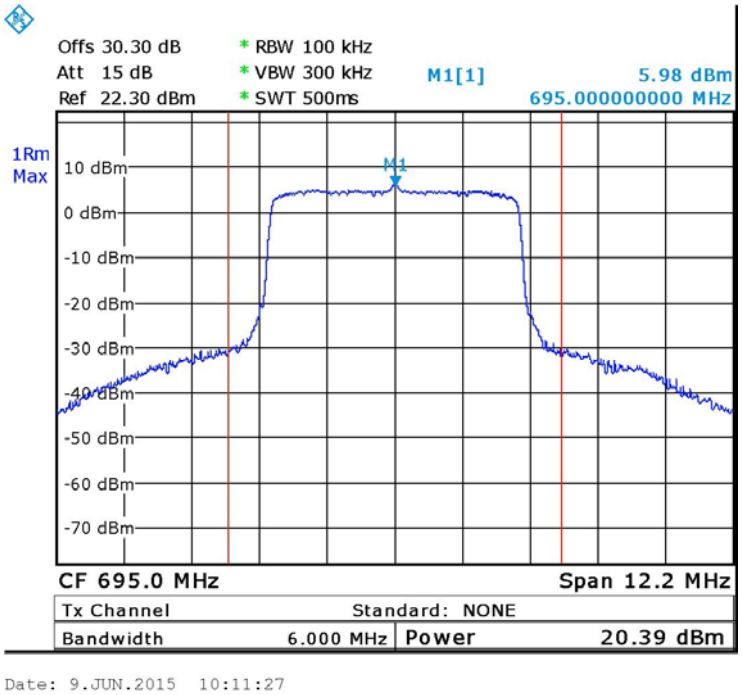


Figure 93. Chain 2 - QPSK – 695MHz

8.4 *Test Equipment Used; Power Spectral Density*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
30 dB attenuator	BIRD	8304-N30DB	-	June 2, 2015	1 year
Coupler	Macom	96341	2025-6006-10	-	-

Figure 94 Test Equipment Used

9. Conducted Spurious Emissions

9.1 *Specification*

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

9.2 *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: 473.00 MHz, 587.00 MHz and 695.00 MHz.

9.3 *Test Results*

JUDGEMENT: Passed

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

For additional information see *Figure 95* to *Figure 100*.

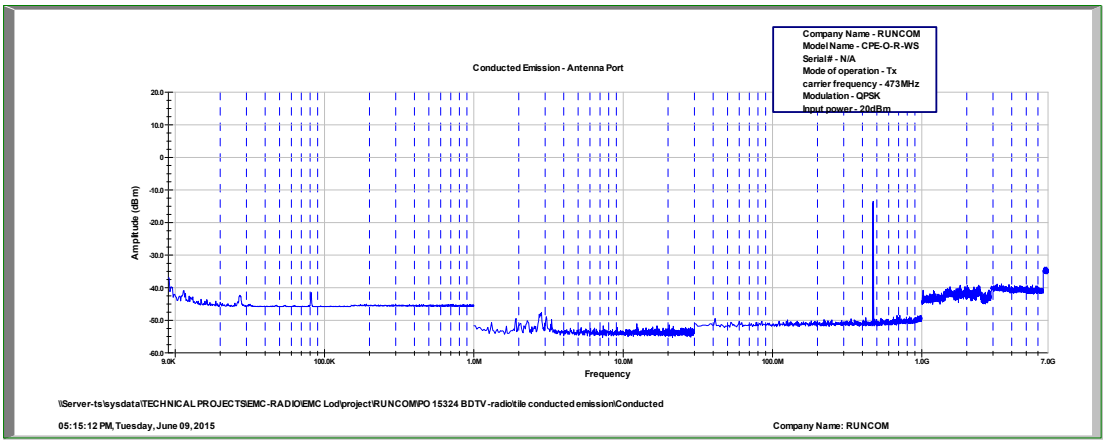


Figure 95 Conducted Emission 473.0 MHz – Port 1

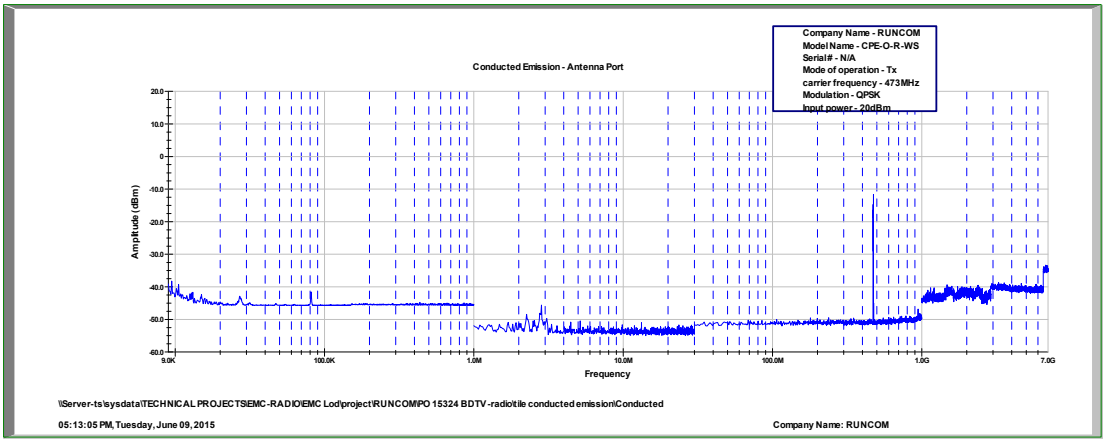


Figure 96 Conducted Emission 473.0 MHz – Port 2

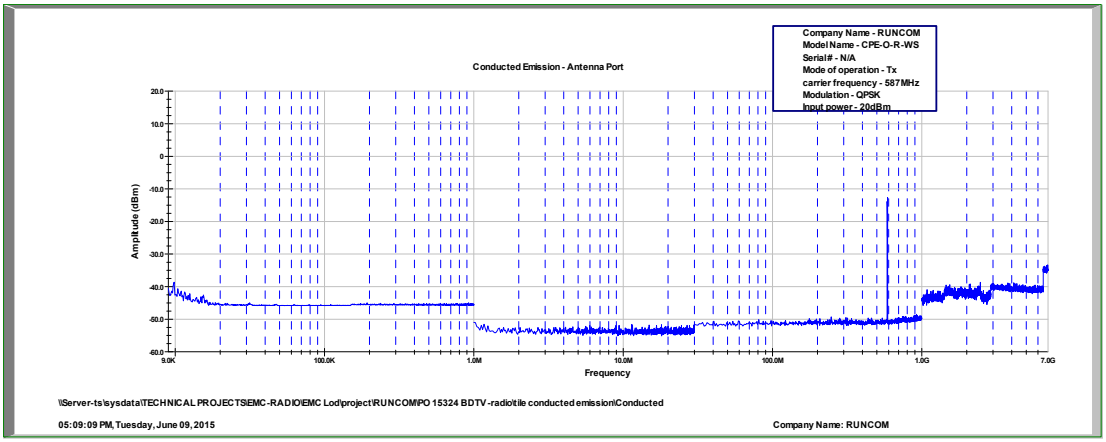


Figure 97 Conducted Emission 587.0 MHz – Port 1

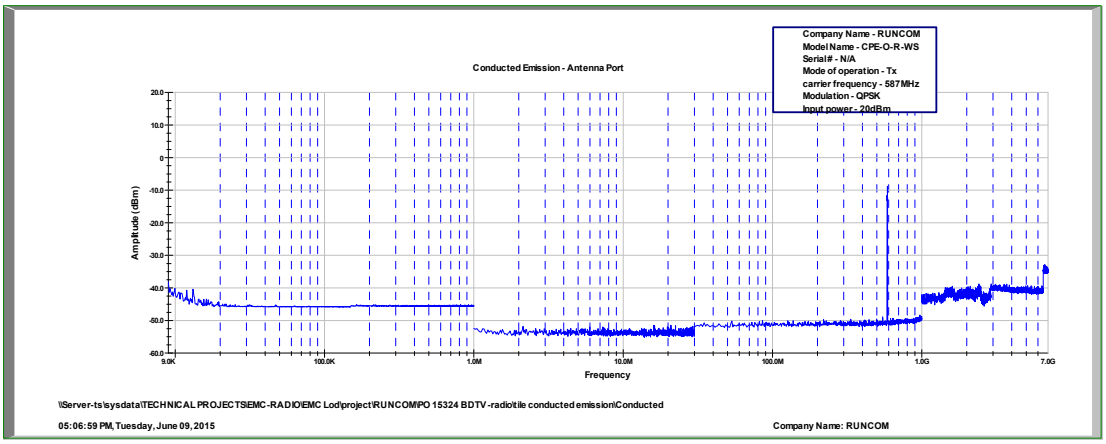


Figure 98 Conducted Emission 587.0 MHz – Port 2

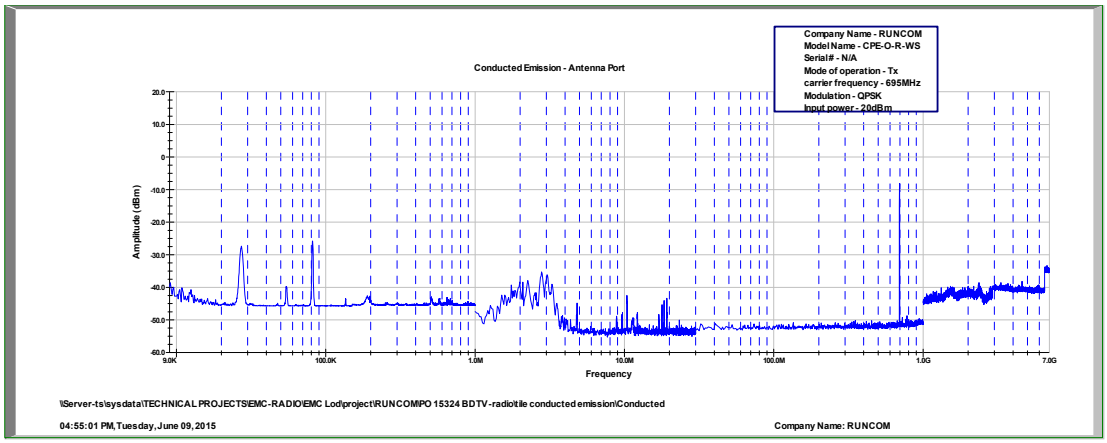


Figure 99 Conducted Emission 695.0 MHz – Port 1

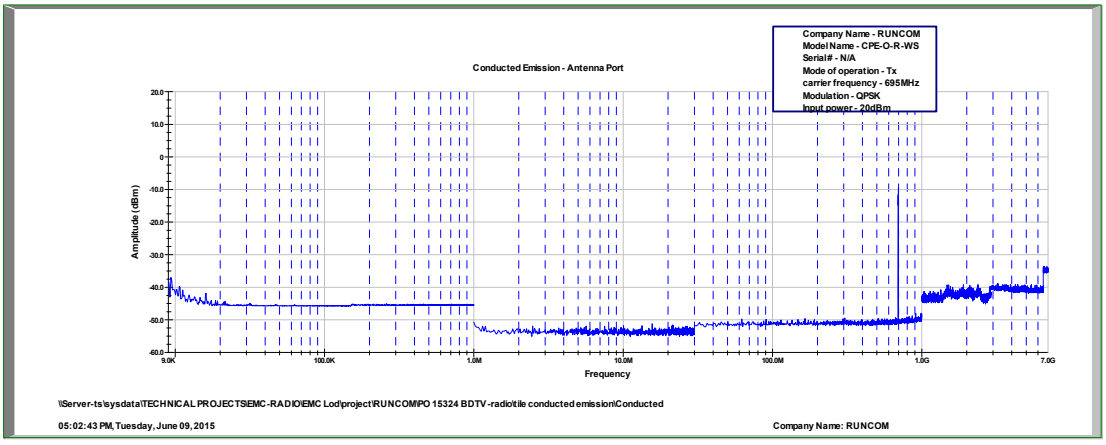


Figure 100 Conducted Emission 695.0 MHz – Port 2

9.4 *Test Equipment Used; Conducted Emission*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
30 dB attenuator	BIRD	8304-N30DB	-	June 2, 2015	1 year
Coupler	Macom	96341	2025-6006-10	-	-

Figure 101 Test Equipment Used

10. Radiated Emission, 9 kHz – 30 MHz

10.1 *Test Specification*

F.C.C. Part 15, Subpart H, Section 15.709(c)(3)

10.2 *Test Procedure*

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

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 2.

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.
Measurements were performed using a peak detector.

10.3 *Test Results*

All signals were below the receiver background noise level which is more than 6 dB below the specification limit.

JUDGEMENT: Passed

The EUT met the requirements of the F.C.C. Part 15, Subpart H, Section 15.709(c)(3) specification.

10.4 *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 [dBµv/m]
RA: Receiver Amplitude [dBµv]
AF: Receiving Antenna Correction Factor [dB/m]
CF: Cable Attenuation Factor [dB]

Example: FS = 30.7 dBµV (RA) + 14.0 dB (AF) + 0.9 dB (CF) = 45.6 dBµV

No external pre-amplifiers are used.

10.5 *Test Instrumentation Used, Radiated Measurements*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	R&S	ESIB7	100120	January 4, 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 102 Test Equipment Used

11. Spurious Radiated Emission, 30 – 7000 MHz

11.1 *Specification*

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

11.2 *Radiated Emission 30-7000 MHz*

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, 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 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 30-7000.0 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 (473.0 MHz, 587.0 MHz, 695.0 MHz).

11.3 *Test Results*

JUDGEMENT: Passed by 1.5dB

For the operation frequency of 473.00 MHz, the margin between the emission level and the specification limit is in the worst case 5.8 dB at the frequency of 1419.0 MHz, vertical polarization.

For the operation frequency of 587.00 MHz, the margin between the emission level and the specification limit is in the worst case 1.5 dB at the frequency of 1761.0 MHz, vertical polarization.

For the operation frequency of 695.00 MHz, the margin between the emission level and the specification limit is in the worst case 2.4 dB at the frequency of 1390.0MHz, vertical polarization.

The EUT met the requirements of the F.C.C. Part 15, Subpart H, Section 15.709(c)(3) specification.

The details of the highest emissions are given in *Figure 103.*

Radiated Emission

E.U.T Description CPE (Customer Premises Equipment)
Type CPE-O-R-WS
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, Average
Operating frequency: 473.0 MHz, 587.0 MHz, 695.0 MHz

Freqency operation	Frequency	Antenna Polarization		Peak Amp	AVG Amp	Limit Peak	Limit AVG	Margin
(MHz)	(MHz)	Hor.	Ver.	(dBµV/m)	(dBµV/m)	(dBµV/m)	(dBµV/m)	(dB)
473.0	1419.0	X		65.3	-	74.0		-8.7
	1419.0	X		-	43.7		54.0	-10.3
	1419.0		X	67.1	-	74.0		-6.9
	1419.0		X	-	48.2		54.0	-5.8
587.0	1761.0	X		67.8	-	74.0		-6.2
	1761.0	X		-	50.5		54.0	-3.5
	1761.0		X	61.0	-	74.0		-13.0
	1761.0		X	-	52.5		54.0	-1.5
695.0	1390.0	X		65.3	-	74.0		-8.7
	1390.0	X		-	51.0		54.0	-3.0
	1390.0		X	66.8	-	74.0		-7.2
	1390.0		X	-	51.6		54.0	-2.4

Figure 103 Radiated Emission

11.4 *Test Instrumentation Used, Radiated Measurements*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	R&S	ESIB7	100120	January 4, 2015	1 year
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
Biconilog Antenna	EMCO	3142B	1250	May 22, 2014	2 years
Horn Antenna	ETS	3115	29845	May 19, 2015	3 years
Spectrum Analyzer	HP	8592L	3826A01204	March 4, 2015	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 104 Test Equipment Used

12. Radiated Emission in the Band 602 – 620 MHz

12.1 *Specification*

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

12.2 *Test Procedure*

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

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.

The E.U.T. was operated at 35, 39 channels.

Measurements were performed using a PEAK\Q.PEAK detector and 120 kHz RBW and 300 kHz VBW.

FREQ SUB BAND (MHz)	Limit (dBµV/m)	Worst case (dBµV/m)
602-607	120-5*{F(MHz)-602}	95(F=607MHz)
607-608	95	95
608-614	30	30
614-615	95	95
615-620	120-5*{620-F(MHz) }	95(F=615MHz)

Figure 105 Limit Table

12.3 Test Results

JUDGEMENT: Passed by 5.7 dB

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 106* to *Figure 107.*

Radiated Emission

E.U.T Description	CPE (Customer Premises Equipment)
Type	CPE-O-R-WS
Serial Number:	Not designated

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)
604.4		X	54.2	-	95.0	-40.8
607.5		X	32.5	-	95.0	-62.5
611.2		X	-	24.1	30.0	-5.9
614.7		X	32.5	-	95.0	-62.5
618.8		X	38.4	-	95.0	-56.6
602.1	X		51.6	-	95.0	-43.4
607.7	X		30.7	-	95.0	-64.3
610.0	X		-	23.8	30.0	-6.2
614.3	X		32.5	-	95.0	-62.5
618.8	X		35.4	-	95.0	-59.6

Figure 106 602M-620MHz Band, Channel 35 Test Results

Radiated Emission

E.U.T Description	CPE (Customer Premises Equipment)
Type	CPE-O-R-WS
Serial Number:	Not designated

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)
602.3		X	33.9	-	95.0	-61.1
607.5		X	31.7	-	95.0	-63.3
609.6		X	-	24.3	30.0	-5.7
614.9		X	32.8	-	95.0	-62.2
619.8		X	51.3	-	95.0	-43.7
603.5	X		30.5	-	95.0	-64.5
607.9	X		30.3	-	95.0	-64.7
610.0	X		-	23.8	30.0	-6.2
614.3	X		31.5	-	95.0	-63.5
619.3	X		34.7	-	95.0	-60.3

Figure 107 602M-620MHz Band, Channel 39 Test Results

12.1 *Test Equipment Used; Radiated Emission 602-620 MHz*

Instrument	Manufacturer	Model	Serial No.	Last Calibration Date	Period
EMI Receiver	HP	8542E	3906A00276	March 11, 2015	1 year
RF Filter	HP	85420E	3705A00248	March 19, 2015	1 year
Antenna Log Periodic	EMCO	3146	9505-4081	December 28, 2014	1 year
Coupler	Macom	96341	2025-6006-10	-	-

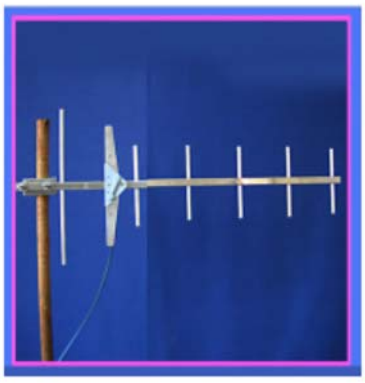
13. Antenna Gain/Information

The antenna gain is 6.0 dBi.

Runcom Technologies Ltd.

TVWS Antenna for CPE

Runcom Part Number	ANT-TVWS-CPE-6
Frequency range	470-700 MHz
Bandwidth	Broadband
Polarization	Vertical
Connector	F-type
Maximum Power Handling Capability	10 W
Gain (at mid band, ref. to λ/2 dipole)	6.0 dbi
VSWR (in the whole band)	< 1.8:1
Impedance	50 ohm
Front to back ratio	> 20 dB
Cross Polarization Isolation	> 14 dB
Lightning Protection	DC Grounded Elements
Horizontal Beam width (at -3 dB, depends on frequency)	90°
Vertical Beam width (at -3 dB, depends on frequency)	35° - 21°



14. R.F Exposure/Safety

Typical use of the E.U.T. is as a CPU.

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.

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

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

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

Modulation	Oper. Freq	Chain 1 Peak Power		Oper. Freq	Chain 2 Peak Power		Sum Peak Power
	(MHz)	(dBm)	(mW)	(MHz)	(dBm)	(mW)	(mW)
16QAM	695.0	20.9	*123*	695.0	21.6	*145*	268
QPSK	473.0	22.5	*178*	695.0	20.4	*110*	288

(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) = 288 mW
G_T- Antenna Gain, 6.0 dBi = 4.0 numeric
R- Distance from Transmitter using 200cm

(b) The peak power density is:

$$S_p = \frac{288 \times 4}{4\pi (200)^2} = 0.002 \frac{mW}{cm^2}$$

(c) This is below the FCC limit.

15. APPENDIX A - CORRECTION FACTORS

15.1 *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

15.2 *Correction factors for* *Bilog ANTENNA*

Model: 3142
Antenna serial number: 1250
3 meter range

FREQUENCY (MHz)	AFE (dB/m)	FREQUENCY (MHz)	AFE (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		

15.3 *Correction factors for Horn ANTENNA.*

Model: 3115
Antenna serial number: 29845
10 meter range

FREQUENCY (MHz)	AFE (dB/m)	FREQUENCY (MHz)	AFE (dB/m)
1000	22.4	10000	36.1
2000	25.2	11000	37.0
3000	31.1	12000	41.3
4000	30.2	13000	38.1
5000	34.2	14000	41.7
6000	31.6	15000	39.0
7000	34.7	16000	38.8
8000	34.8	17000	43.2
9000	36.2	18000	43.7

15.4 *Correction factors forACTIVE LOOP ANTENNA*

Model 6502
S/N 9506-2950

FREQUENCY (MHz)	Magnetic Antenna Factor (dB)	Electric Antenna Factor (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

15.5 *Correction factors for Log Periodic Antenna*

Model 3146
S/N 9505-4081

CALIBRATION DATA

Frequency, MHz	Antenna factor, dB/m [1]
200	11.55
250	11.60
300	14.43
400	15.38
500	17.98
600	18.78
700	21.17
800	21.16
900	22.67
1000	24.09

[1] The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.