



15. Occupied Bandwidth (PCS)

15.1 Test Specification

FCC Part 2, Section 1049

15.2 Test Procedure

The E.U.T. was set to the applicable test frequency with modulation. The E.U.T. antenna terminal was connected to the spectrum analyzer through an external attenuator (at the output port test) and an appropriate coaxial cable. RBW was set to 1%-5% from OBW.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limit, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission.

The function 99% power bandwidth was used for this evaluation.

Occupied bandwidth measured was repeated in the input terminal of the E.U.T. The E.U.T was evaluated at the low, mid and high channels of the 3 modulations: LTE 64QAM, GSM and WCDMA.

15.3 Test Results

Modulation	port	Operating Frequency (MHz)	Reading (MHz)
LTE 64QAM	Input	1935.0	8.98
	Output	1935.0	8.98
	Input	1962.5	8.98
	Output	1962.5	8.98
	Input	1990.0	8.98
	Output	1990.0	8.98
GSM	Input	1931.2	0.24
	Output	1931.2	0.24
	Input	1960.0	0.24
	Output	1960.0	0.24
	Input	1993.8	0.24
	Output	1993.8	0.24
WCDMA	Input	1932.5	4.17
	Output	1932.5	4.15
	Input	1960.0	4.17
	Output	1960.0	4.19
	Input	1992.5	4.17
	Output	1992.5	4.15

Figure 109 Occupied Bandwidth PCS

See additional information in *Figure 110* to *Figure 127*.

JUDGEMENT: Passed

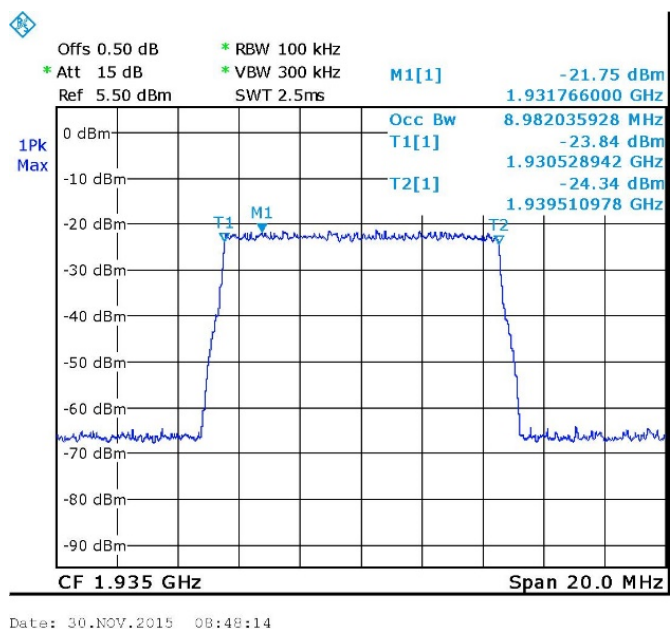


Figure 110. LTE 64QAM - 1935.0 MHz Input

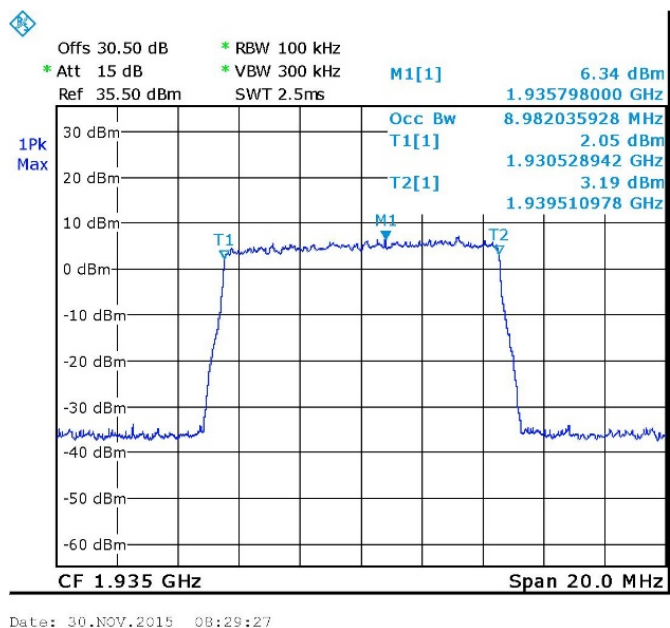


Figure 111. LTE 64QAM - 1935.0 MHz Output

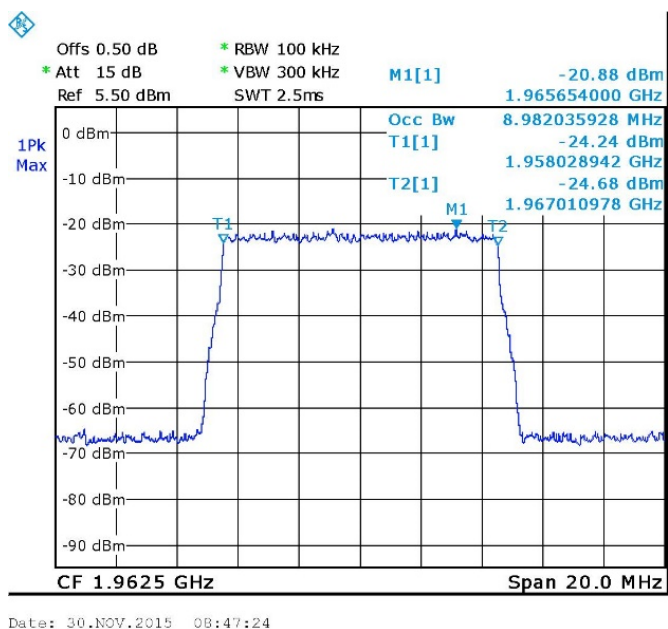


Figure 112.LTE 64QAM - 1962.5 MHz Input

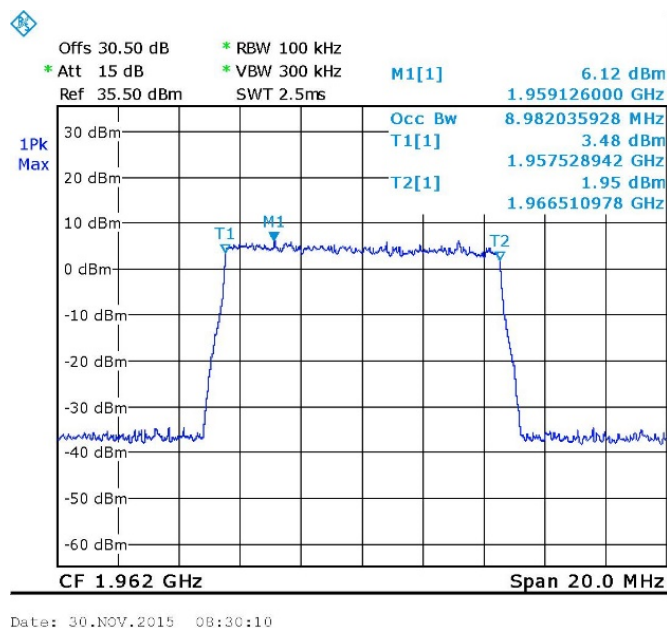


Figure 113. LTE 64QAM - 1962.5 MHz Output

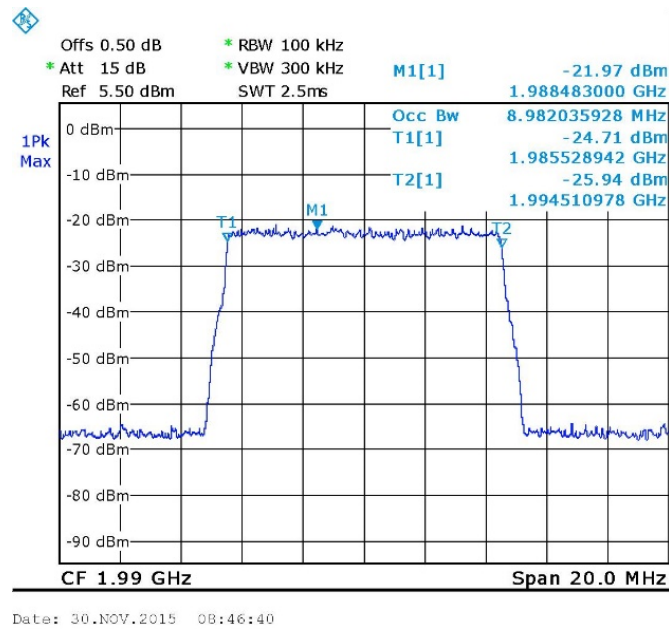


Figure 114. LTE 64QAM - 1990.0 MHz Input

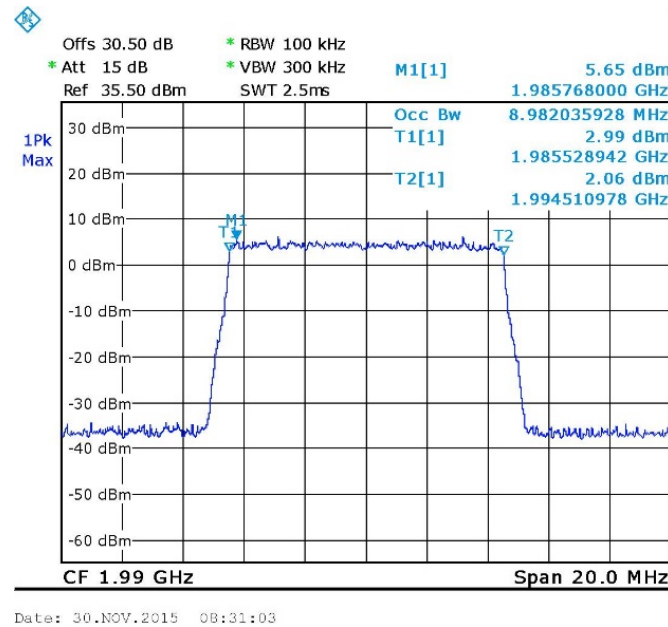


Figure 115. LTE 64QAM - 1990.0 MHz Output

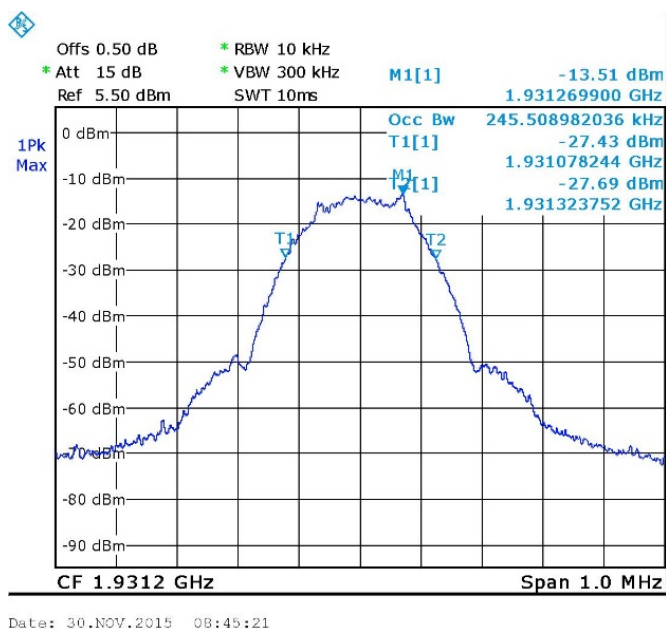


Figure 116. GSM - 1931.2 MHz Input

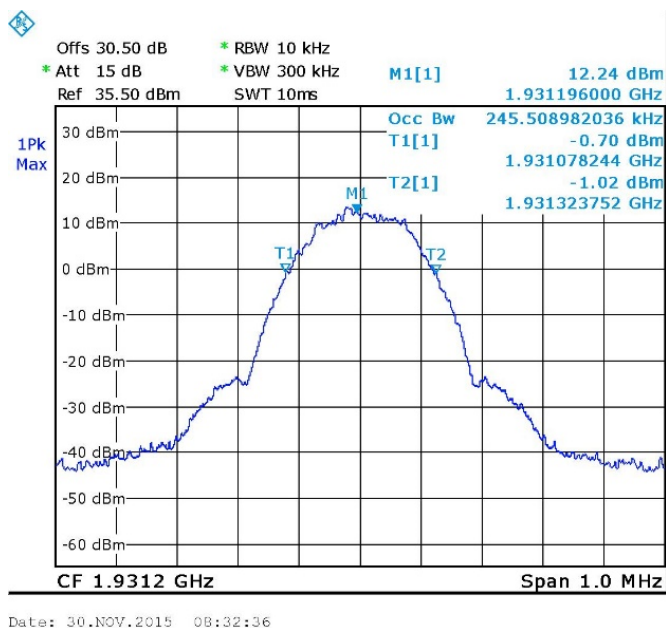


Figure 117. GSM - 1931.2 MHz Output

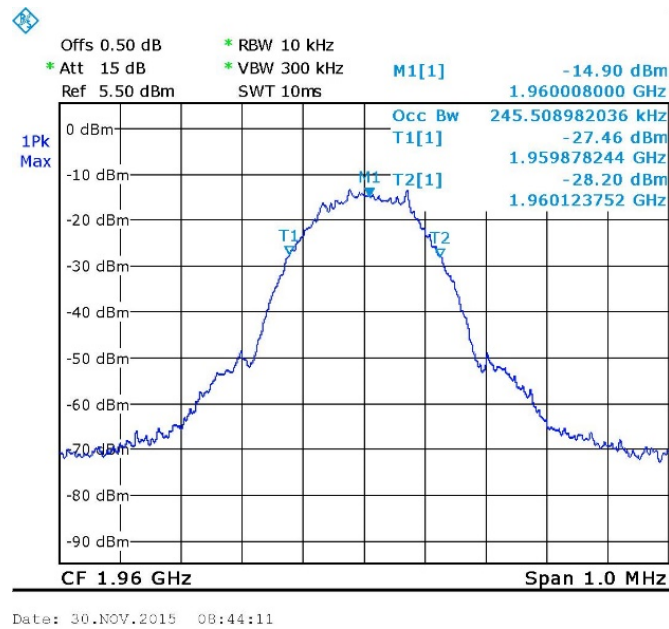


Figure 118. GSM - 1960.00 MHz Input

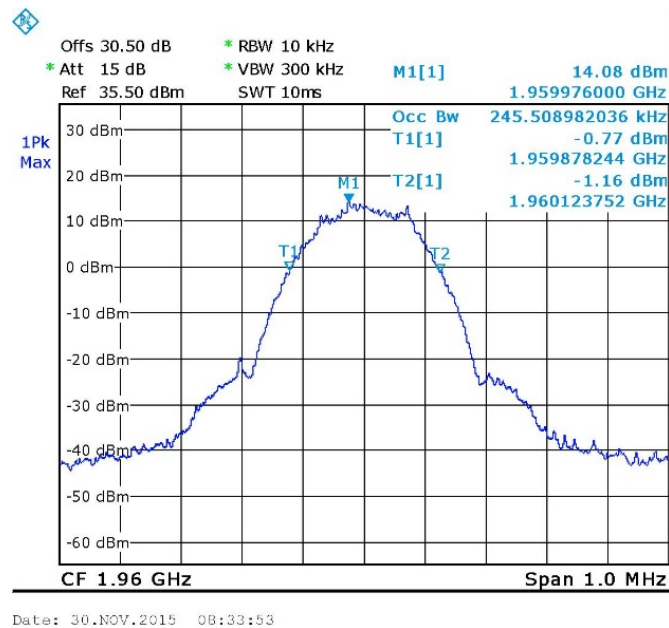


Figure 119. GSM - 1960.00 MHz Output

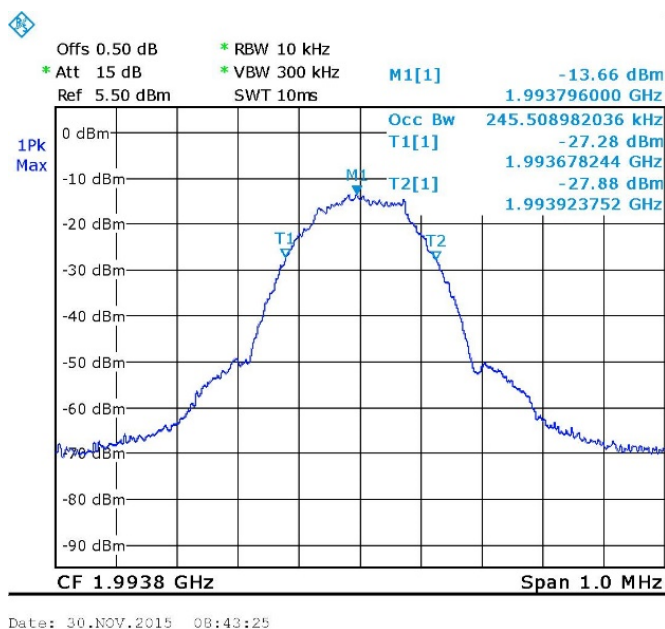


Figure 120. GSM - 1993.8 MHz Input

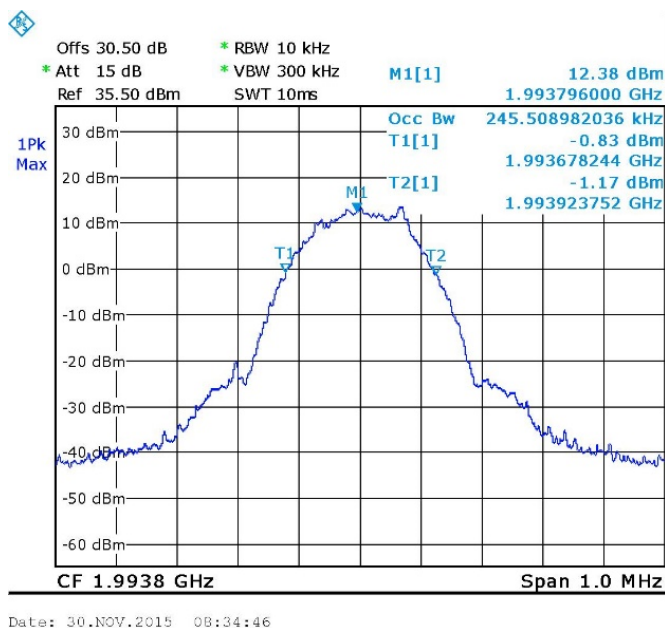


Figure 121. GSM - 1993.8 MHz Output

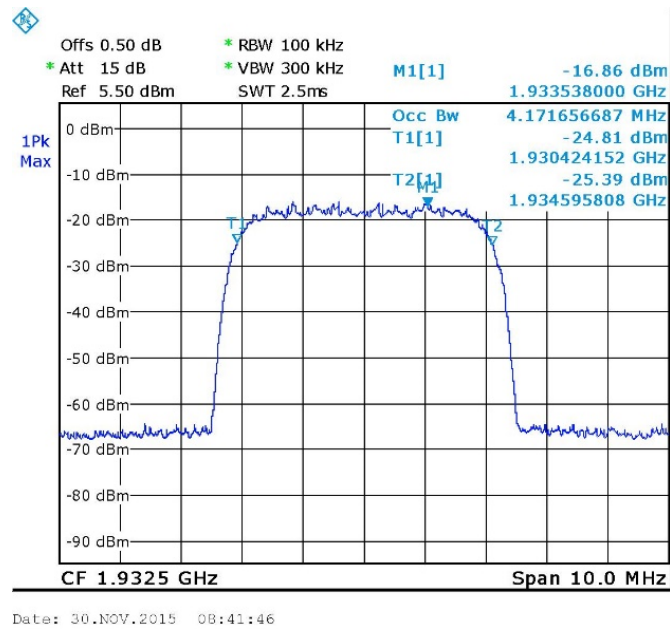


Figure 122.WCDMA - 1932.5 MHz Input

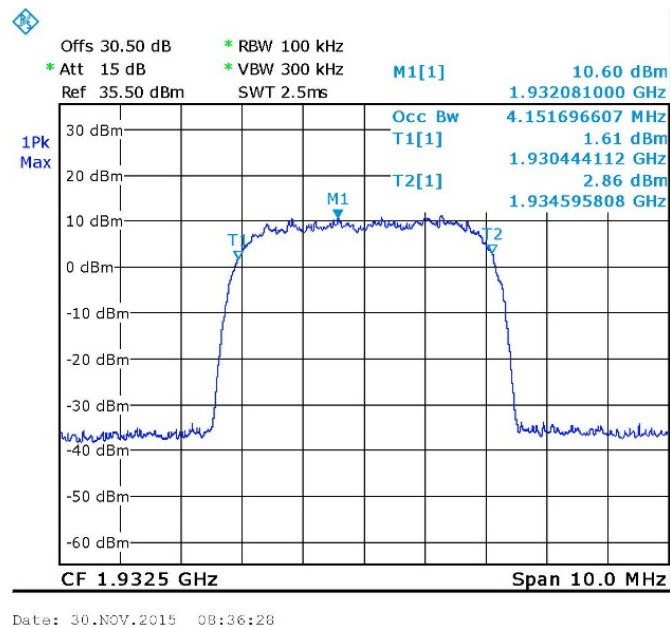


Figure 123. WCDMA - 1932.5 MHz Output

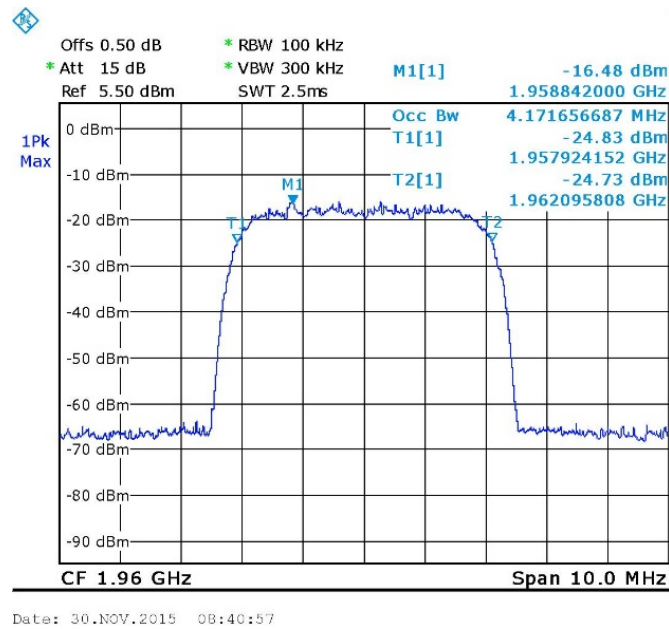


Figure 124. WCDMA- 1960.0 MHz Input

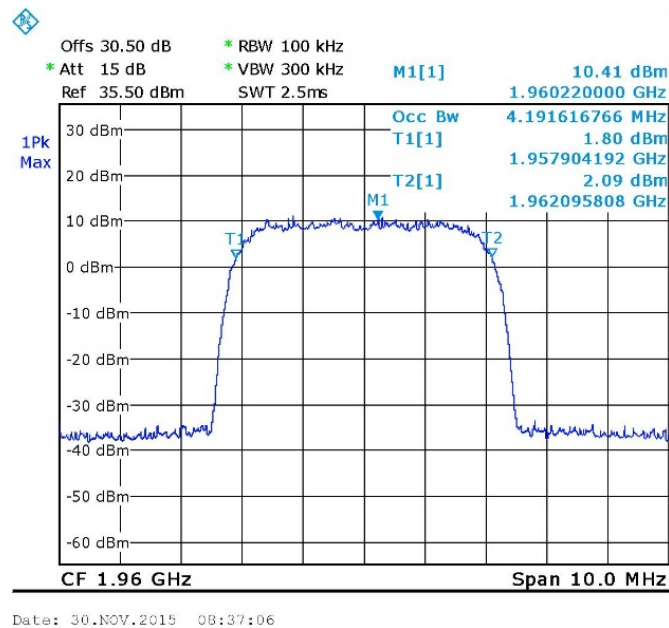


Figure 125. WCDMA - 1960.0 MHz Output

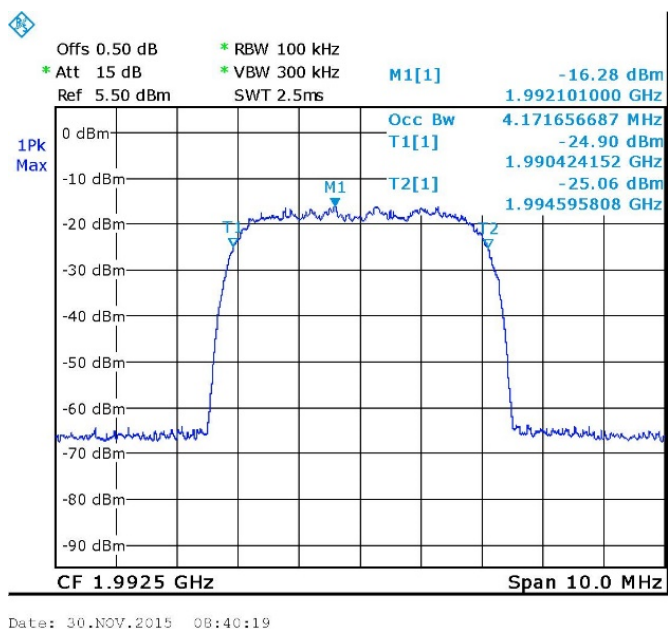


Figure 126. WCDMA - 1992.5 MHz Input

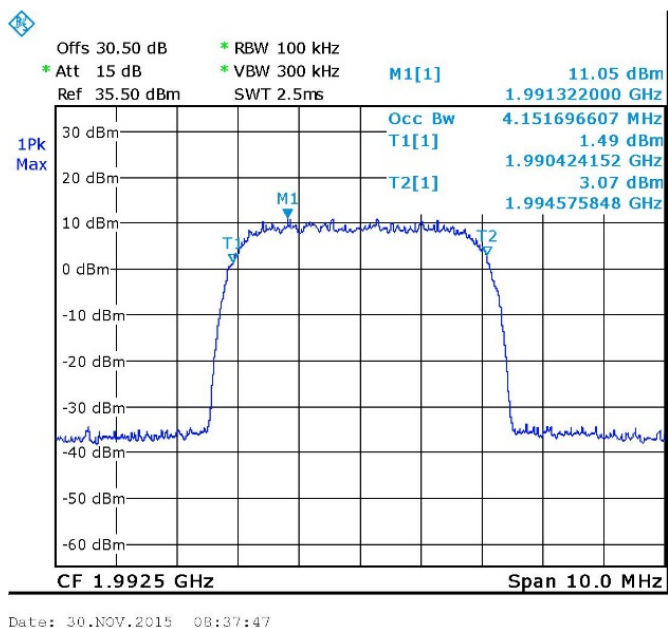


Figure 127. WCDMA - 1992.5 MHz Output



15.4 Test Equipment Used; Occupied Bandwidth PCS

Instrument	Manufacturer	Model	Serial Number	Calibration	
				Last Calibration	Period
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
Vector Signal Generator	Agilent	N5182A	MY48180244	July 16, 2015	1 year
30 dB Attenuator	Weinschel Engineering	49-30-34	PD426	January 14, 2015	1 year

Figure 128 Test Equipment Used

16. Out of Band Emissions at Antenna Terminals (PCS)

16.1 Test Specification

FCC Part 24, Subpart E, Section 238; FCC Part 2.1051

16.2 Test procedure

The power of any emission outside of the authorized bandwidth must be attenuated below the transmitting power (P) by a factor of at least

$43 + \log (P)$ dB, yielding -13dBm .

The E.U.T. antenna terminal was connected to the spectrum analyzer through an external attenuator and an appropriate coaxial cable (max total Loss= 33.0 dB).

The resolution bandwidth was set to 1.0 kHz for the frequency range 9 kHz – 1 MHz, 100 kHz for the frequency range 1 MHz to 1 GHz, and 1 MHz in the frequency range 1 – 22 GHz.

The E.U.T was evaluated at the low, mid and high channels of each of the 3 modulations: LTE 64QAM, GSM, WCDMA.

16.3 Test Results

See additional information in *Figure 129* to *Figure 137*.

JUDGEMENT: Passed

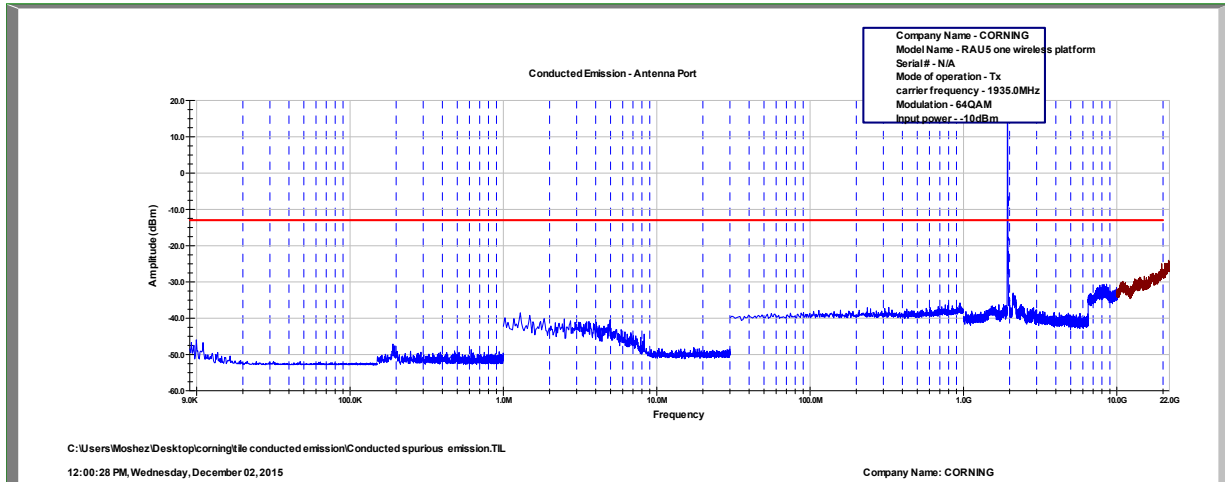


Figure 129 64QAM - 1935.0 MHz

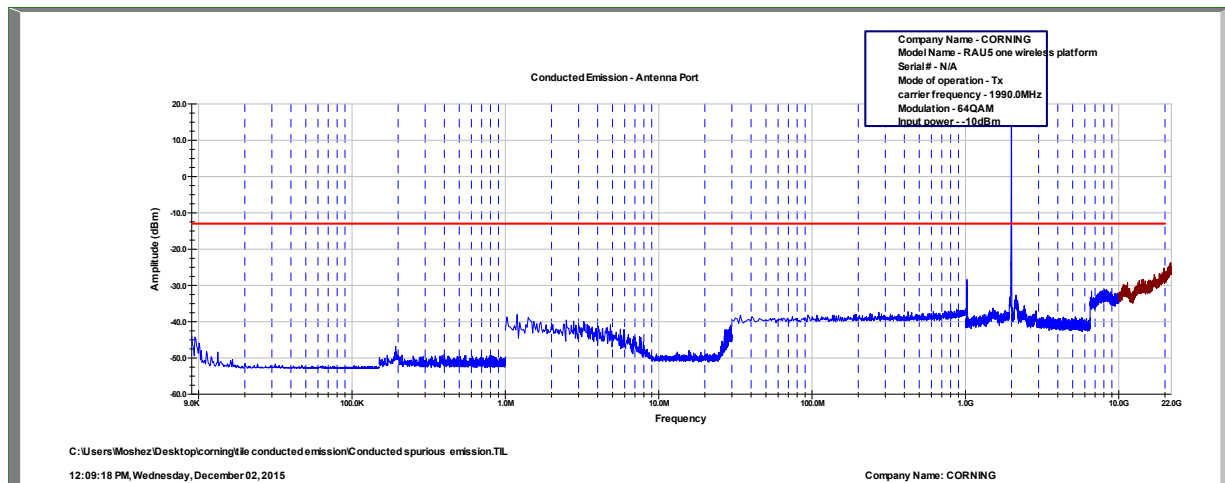


Figure 130 64QAM - 1962.5 MHz

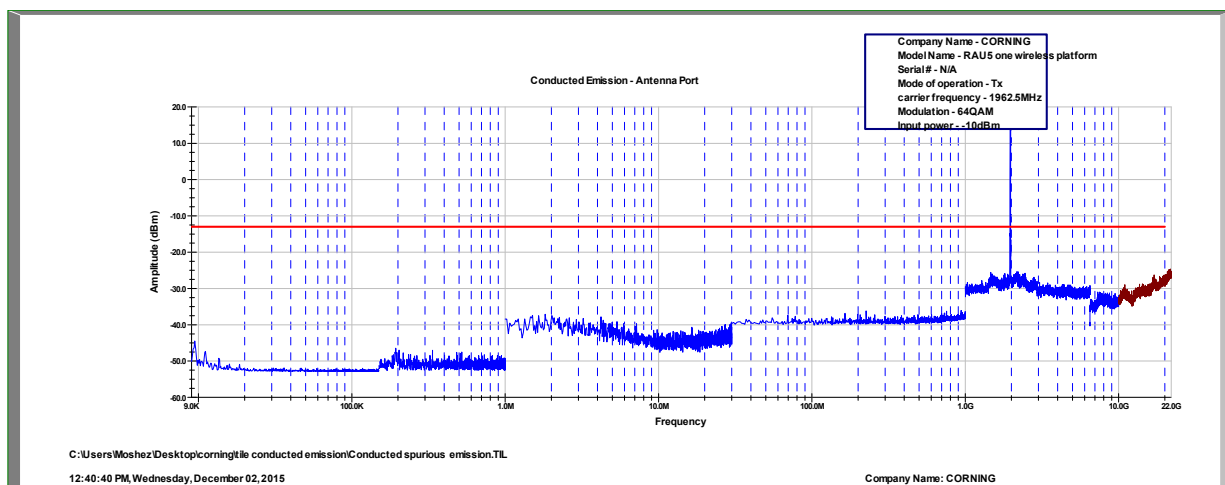


Figure 131 64QAM - 1990.0 MHz

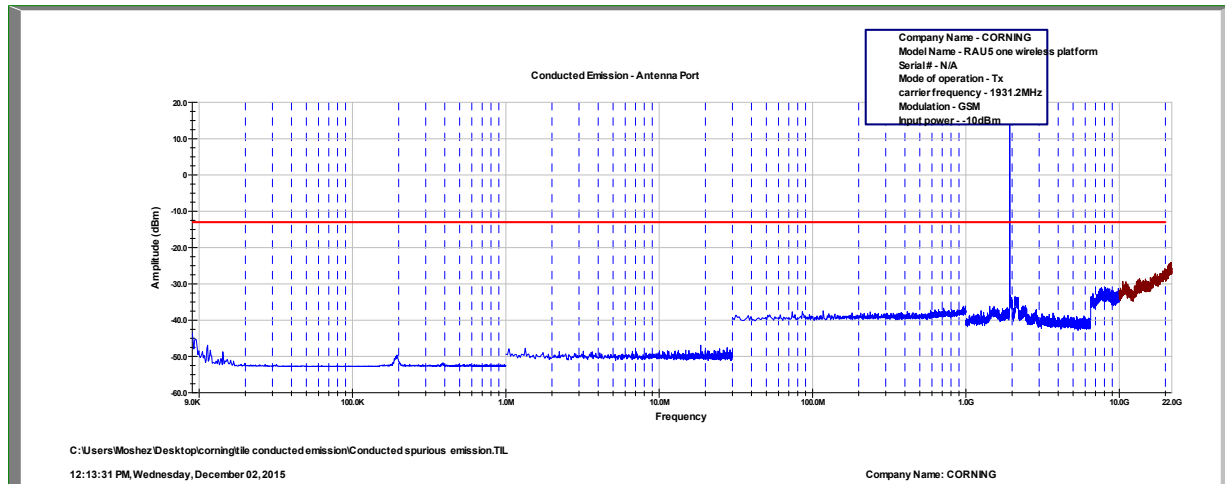


Figure 132 GSM - 1931.2 MHz

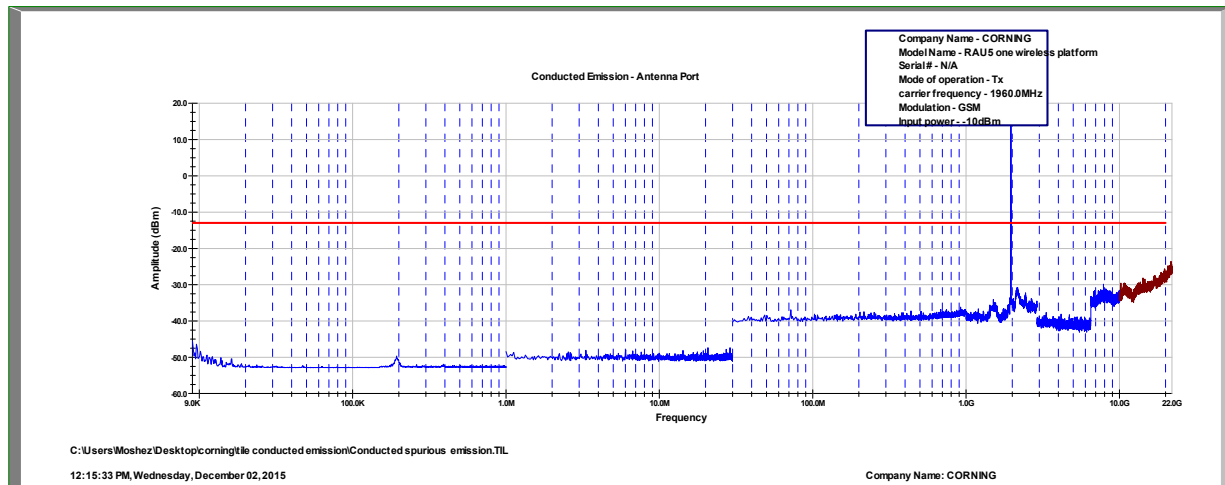


Figure 133GSM - 1960.0 MHz

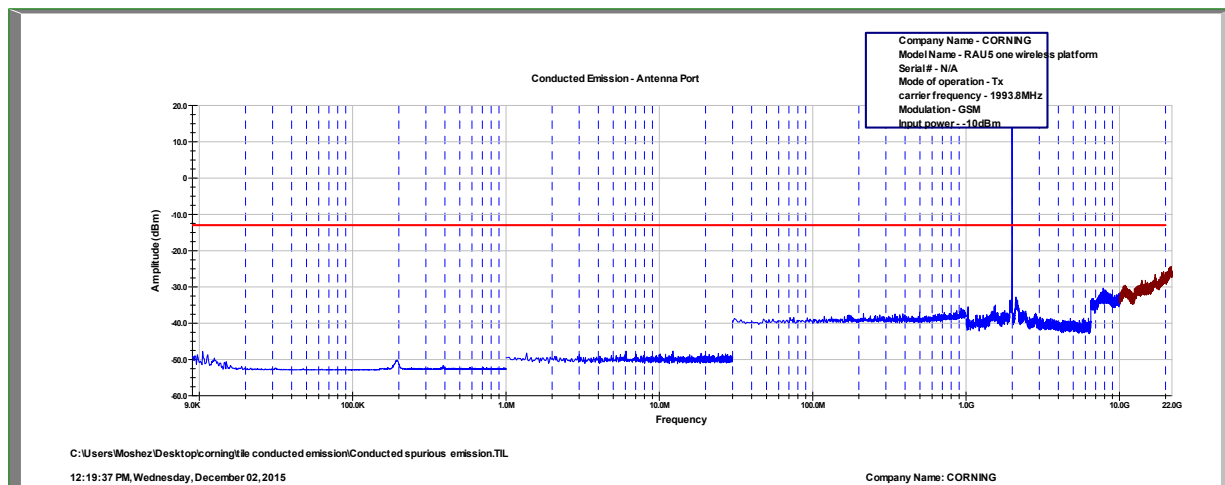


Figure 134 GSM - 1993.8 MHz

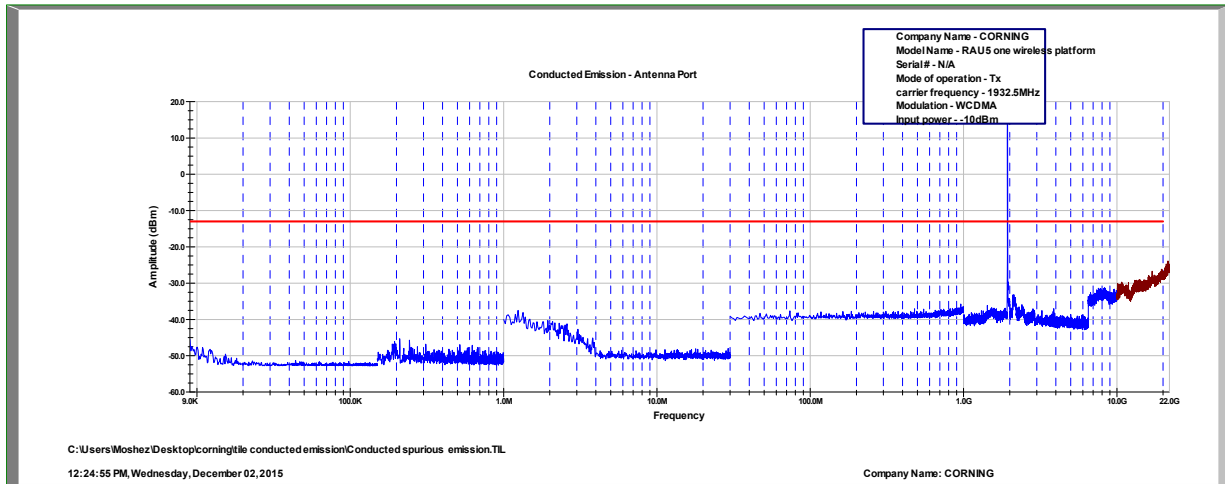


Figure 135 WCDMA - 1932.5 MHz

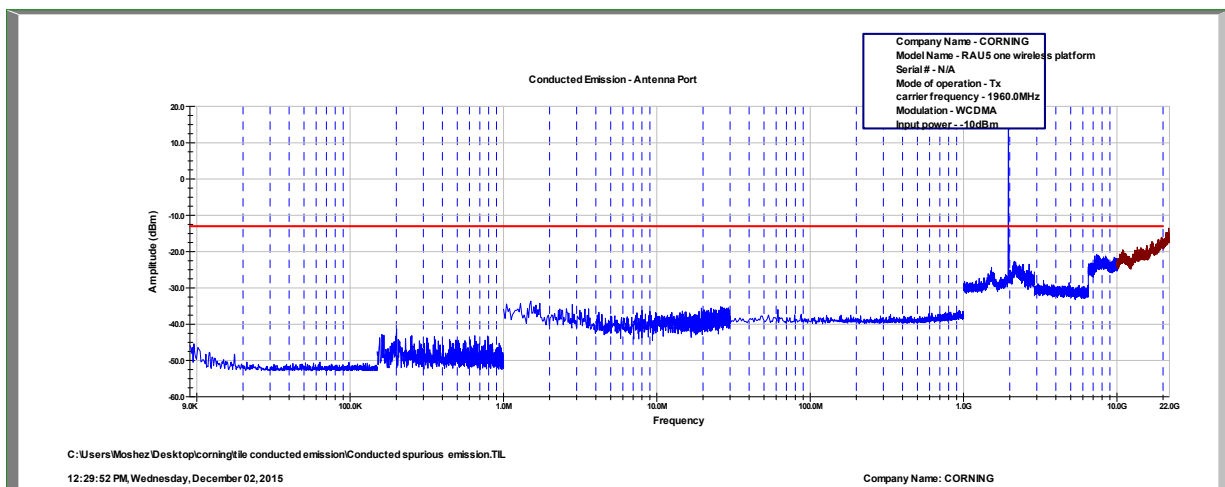


Figure 136 WCDMA - 1960.0 MHz

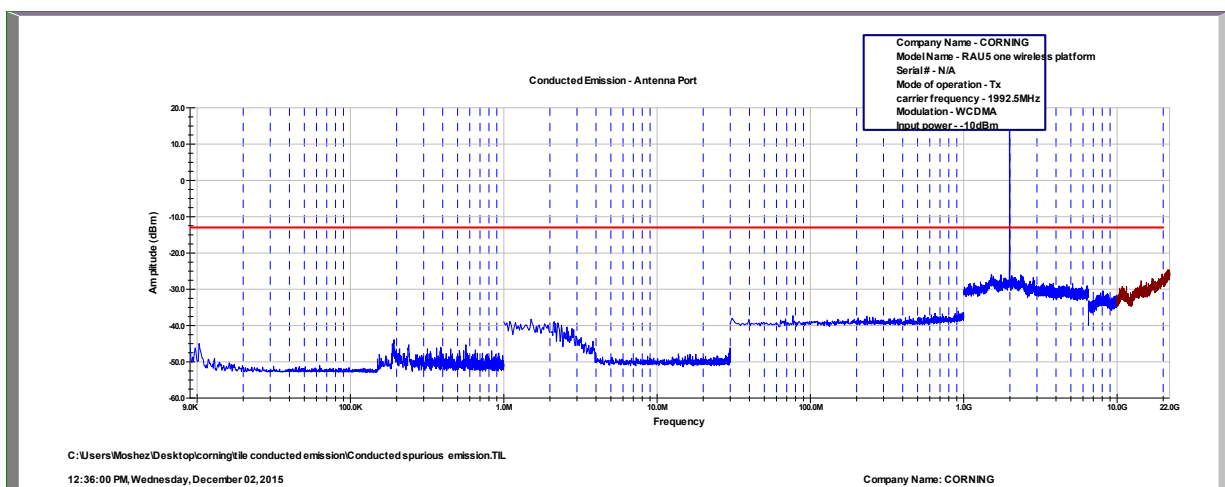


Figure 137 WCDMA - 1992.5 MHz



**16.4 Test Equipment Used; Out of Band Emission at Antenna Terminals
PCS**

Instrument	Manufacturer	Model	Serial Number	Calibration	
				Last Calibration	Period
Spectrum Analyzer	HP	8592L	3826A01204	March 4, 2015	1 year
Vector Signal Generator	Agilent	N5182A	MY48180244	July 16, 2015	1 year
30 dB Attenuator	Weinschel Engineering	49-30-34	PD426	January 14, 2015	1 year

Figure 138 Test Equipment Used

17. Band Edge Spectrum (PCS)

17.1 Test Specification

FCC Part 24, Subpart E, Section 238; FCC Part 2.1051

17.2 Test Procedure

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + \log(P)$ dB, yielding -13dBm.

The E.U.T. antenna terminal was connected to the spectrum analyzer through an external attenuator and an appropriate coaxial cable (30.5 dB).

RBW was set to 100kHz.

The E.U.T was evaluated at the low and high channels of each modulation:
LTE 64QAM, GSM, WCDMA.

17.1 Test Results

Modulation	Operation Frequency (MHz)	Band Edge Frequency (MHz)	Reading (dBm)	Specification (dBm)	Margin (dB)
LTE 64QAM	1935.0	1930.0	-27.9	-13.0	-14.9
	1990.0	1995.0	-31.1	-13.0	-18.1
GSM	1931.2	1930.0	-43.4	-13.0	-30.4
	1993.8	1995.0	-42.5	-13.0	-29.5
WCDMA	1932.5	1930.0	-25.4	-13.0	-12.4
	1992.5	1995.0	-30.8	-13.0	-17.8

Figure 139 Band Edge Spectrum Results PCS

See additional information in *Figure 140* to *Figure 145*.

JUDGEMENT: Passed by 12.4dB

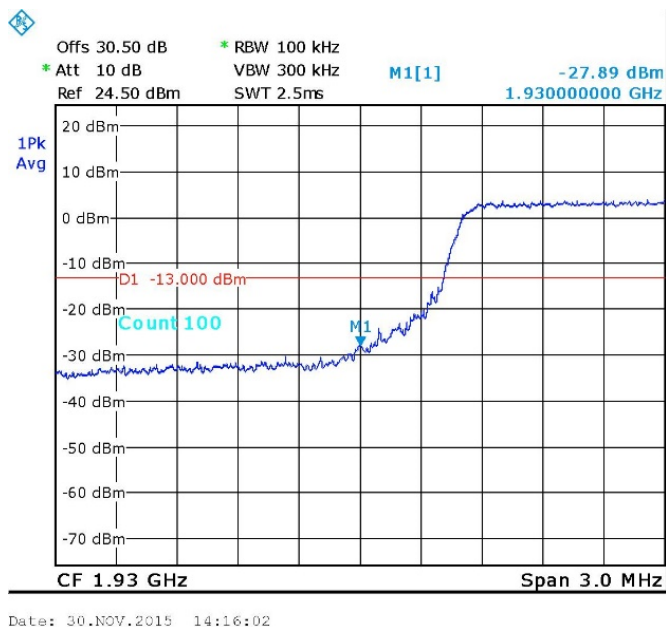


Figure 140— LTE 64QAM - 1935.0 MHz

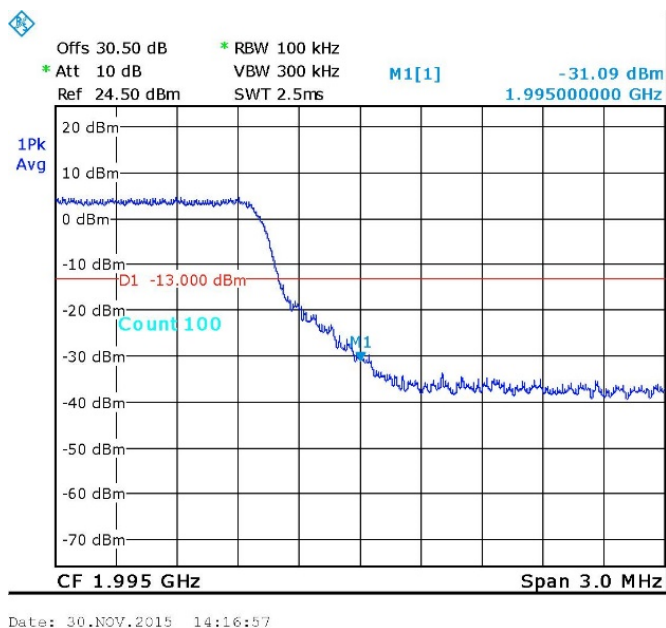


Figure 141— LTE 64QAM - 1990.0 MHz

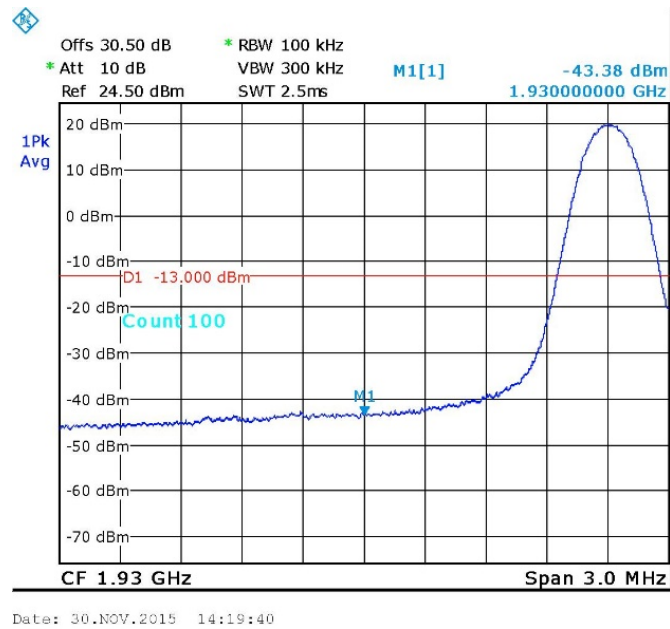


Figure 142—GSM - 1931.2 MHz

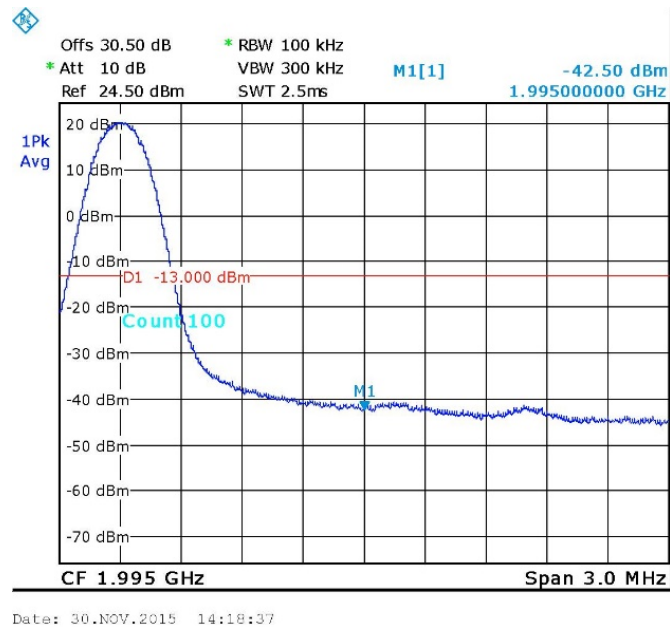


Figure 143— GSM - 1993.8 MHz

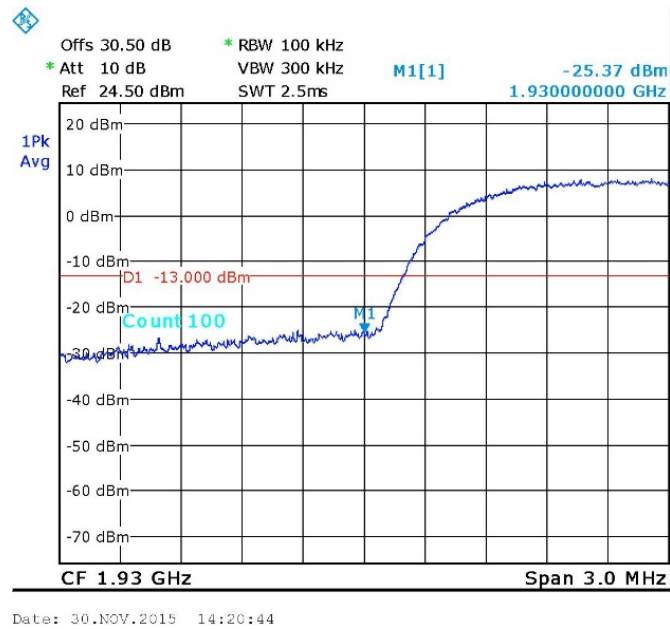


Figure 144— WCDMA - 1932.5 MHz

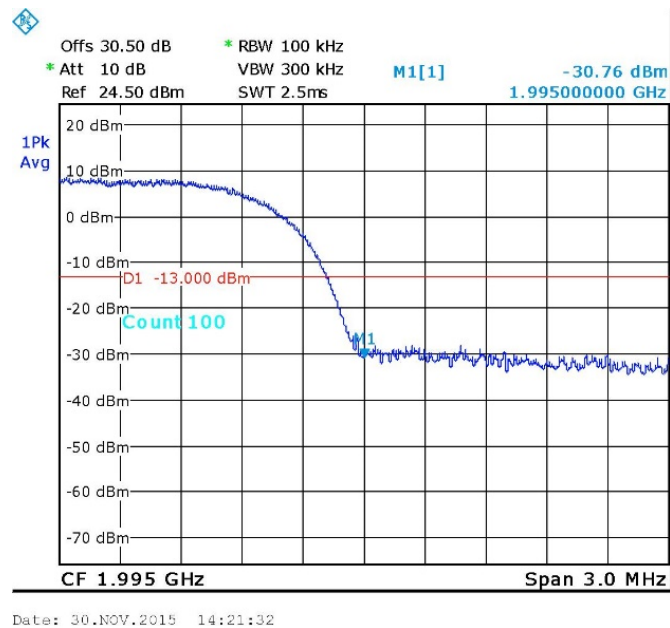


Figure 145—WCDMA - 1992.5 MHz



17.2 Test Equipment Used; Band Edge Spectrum PCS

Instrument	Manufacturer	Model	Serial Number	Calibration	
				Last Calibration	Period
Spectrum Analyzer	R&S	FSL6	100194	January 1, 2015	1 year
Vector Signal Generator	Agilent	N5182A	MY48180244	July 16, 2015	1 year
30 dB Attenuator	Weinschel Engineering	49-30-34	PD426	January 14, 2015	1 year

Figure 146 Test Equipment Used



18. Out of Band Emissions (Radiated) (PCS)

18.1 Test Specification

FCC, Part 24, Subpart E Section 238, FCC Part 2.1053

18.2 Test Procedure

The test method was based on ANSI/TIA-603-C: 2004, Section 2.2.12

Unwanted Emissions: Radiated Spurious.

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB, yielding -13dBm .

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

For measurements between 0.009MHz-30MHz:

The E.U.T was tested inside the shielded room at a distance of 3 meters and the E.U.T was placed on a non-metallic table, 1.5 meters above the ground. The frequency range 0.009MHz-30MHz was scanned. The readings were maximized by the turntable azimuth between 0-360°, and the antenna polarization. The emissions were measured at a distance of 3 meters.

For measurements between 30MHz-1GHz:

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, 1.0 meters above the ground. The frequency range 30MHz -1GHz was scanned and the list of the highest emissions was verified and updated accordingly. The readings were maximized by adjusting the antenna height between 1-4 meters, the turntable azimuth between 0-360°, and the antenna polarization. The emissions were measured at a distance of 3 meters.

For measurements between 1GHz-22GHz:

The E.U.T was tested inside the shielded room at a distance of 3 meters and the E.U.T was placed on a non-metallic table, 1.5 meters above the ground. The frequency range 1GHz -22G was scanned. The readings were maximized by the turntable azimuth between 0-360°, and the antenna polarization. The emissions were measured at a distance of 3 meters.

(b) The E.U.T. was replaced by a substitution antenna driven by a signal generator. The height was readjusted for maximum reading. The signal generator level was adjusted to obtain the same reading on the EMI receiver as in step (a).

The signals observed in step (a) were converted to radiated power using:

$$P_d(\text{dBm}) = P_g(\text{dBm}) - \text{Cable Loss (dB)} + \text{Substitution Antenna Gain (dB)}$$

P_d = Dipole equivalent power (result).

P_g = Signal generator output level.



18.3 Results Table

Carrier Channel	Freq.	Antenna Pol.	Maximum Peak Level	Signal Generator RF Output	Cable Loss	Antenna Gain	EIRP	Spec.	Margin
(MHz)	(MHz)	(V/H)	(dBμV/m)	(dBm)	(dB)	(dBi)	(dBm)	(dBm)	(dB)
1931.2	3862.4	V	41.2	-57.9	0.5	9.5	-48.9	-13.0	-35.9
1931.2	3862.4	H	39.0	-59.5	0.5	9.5	-50.5	-13.0	-37.5
1960.0	3920.0	V	38.2	-60.9	0.5	9.5	-51.9	-13.0	-38.9
1960.0	3920.0	H	39.2	-59.7	0.5	9.5	-50.7	-13.0	-37.7
1993.8	3987.6	V	38.9	-60.2	0.5	9.5	-51.2	-13.0	-38.2
1993.8	3987.6	H	39.2	-59.7	0.5	9.5	-50.7	-13.0	-37.7

Figure 147 Out of Band (Radiated) PCS

The E.U.T met the requirements of the FCC, Part 24, Subpart E, Section 238; FCC Part 2.1053 specifications.

JUDGEMENT: Passed by 35.9 dB



18.4 Test Instrumentation Used, Radiated Measurements (PCS)

Instrument	Manufacturer	Model	Serial Number	Calibration	Period
EMC Analyzer	HP	8593EM	3536A00120ADI	February 24, 2015	1 year
EMI Receiver	HP	8542E	3906A00276	March 11, 2015	1 year
RF Filter Section	HP	85420E	3705A00248	March 19, 2015	1 year
Semi Anechoic Civil Chamber	ETS	S81	SL 11643	N/A	N/A
Active Loop Antenna	EMCO	6502	9506-2950	November 4, 2015	1 year
Biconical Antenna	EMCO	3104	2606	December 28, 2014	1 year
Log Periodic Antenna	EMCO	3146	9505-4081	December 28, 2014	1 year
Horn Antenna	ETS	3115	29845	May 19, 2015	3 years
Horn Antenna	ARA	SWH-28	1007	March 3, 2014	2 years
Vector Signal Generator	Agilent	N5182A	MY48180244	July 16, 2015	1 year
Low Noise Amplifier	Sophia Wireless	LNA 28-B	232	March 1, 2015	1 year
Low Noise Amplifier	DBS MICROWAVE	LNA-DBS-0411N313	013	March 1, 2015	1 year
Antenna Mast	ETS	2070-2	-	N/A	N/A
Turntable	ETS	2087	-	N/A	N/A
Mast & Table Controller	ETS/EMCO	2090	9608-1456	N/A	N/A

Figure 148 Test Equipment Used

19. APPENDIX A - CORRECTION FACTORS

19.1 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	2.1
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



**19.2 Correction factors for
Horn ANTENNA**

Double Ridged Waveguide

Model: 3115

Antenna serial number: 29845

10 meter range

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



19.3 Correction factors for Horn ANTENNA
Model: SWH-28
Antenna serial number: 1007
1 meter range

FREQUENCY (GHz)	AFE (dB /m)	Gain (dB1)
18.0	40.3	16.1
19.0	40.3	16.3
20.0	40.3	16.1
21.0	40.3	16.3
22.0	40.4	16.8
23.0	40.5	16.4
24.0	40.5	16.6
25.0	40.5	16.7
26.0	40.6	16.4



19.4 Correction factors for Biconical Antenna
Model 3104
Serial No 2606

CALIBRATION DATA

Frequency, MHz	Near free space antenna factor, dB/m	Geometry specific correction factor, dB	Free space antenna factor, dB/m ¹⁾
30	12.97	0.13	12.84
35	12.34	0.09	12.25
40	12.03	0.06	11.97
45	11.42	0.02	11.40
50	11.91	0.03	11.88
60	11.92	0.37	11.55
70	9.60	0.25	9.35
80	6.99	-0.45	7.44
90	10.87	-0.34	11.21
100	11.51	-0.06	11.57
120	13.30	0.20	13.10
140	12.56	-0.01	12.57
160	14.49	-0.12	14.61
180	16.53	0.05	16.48
200	15.30	0.15	15.15

¹⁾ The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ V/m.



19.5 Correction factors for Log Periodic
Model 3146
Serial No: 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 dB μ V to obtain field strength in dB μ V/m.



19.6 Correction factors for Active Loop Antenna

Model 6502

Serial No: 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