# 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

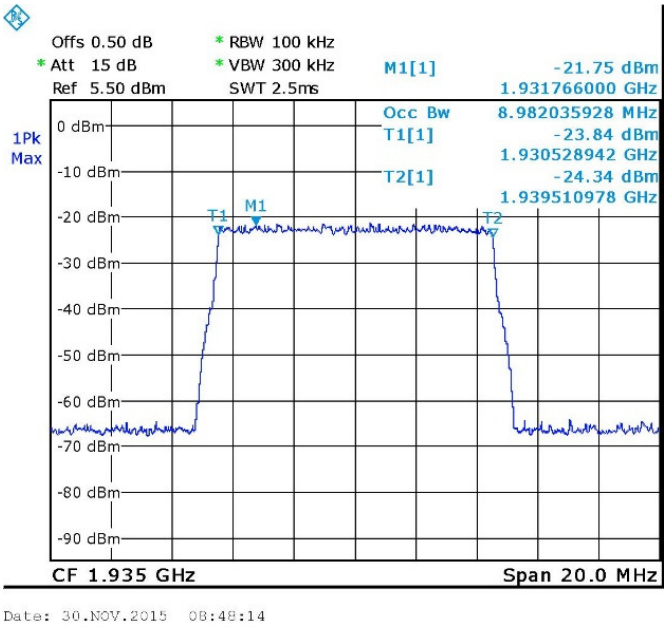


**Figure 110. LTE 64QAM - 1935.0 MHz Input**

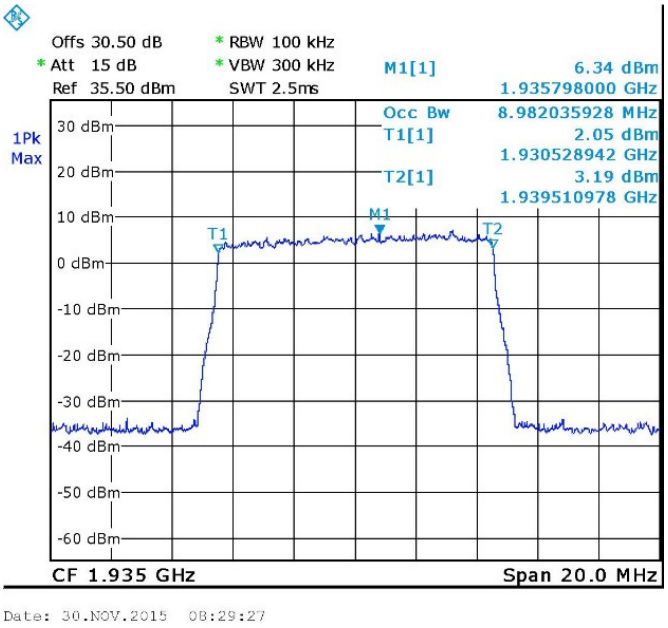


**Figure 111. LTE 64QAM - 1935.0 MHz Output**

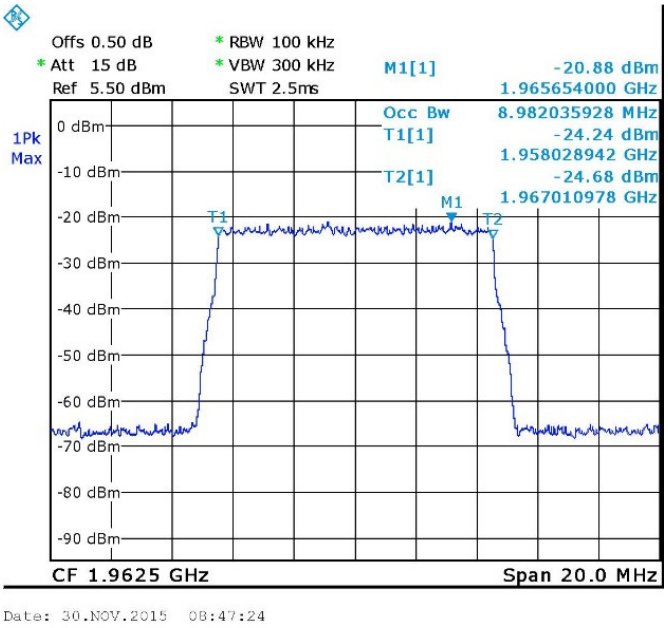


**Figure 112.LTE 64QAM - 1962.5 MHz Input**

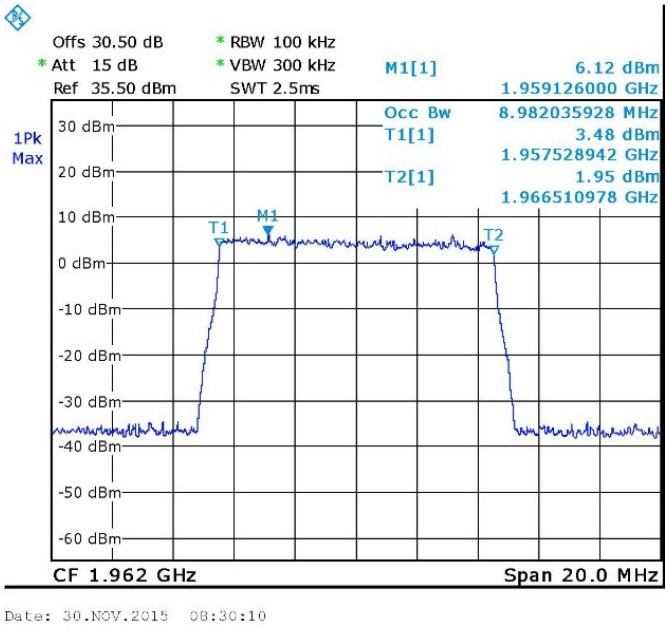


**Figure 113. LTE 64QAM - 1962.5 MHz Output**

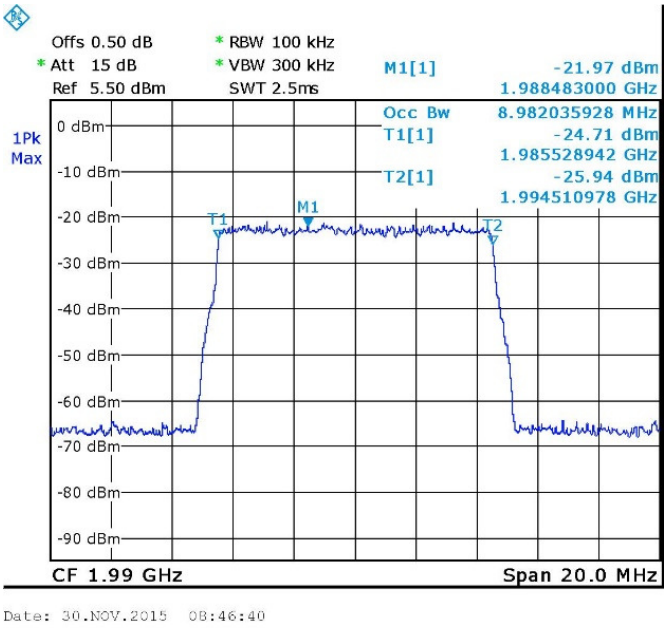


**Figure 114. LTE 64QAM - 1990.0 MHz Input**

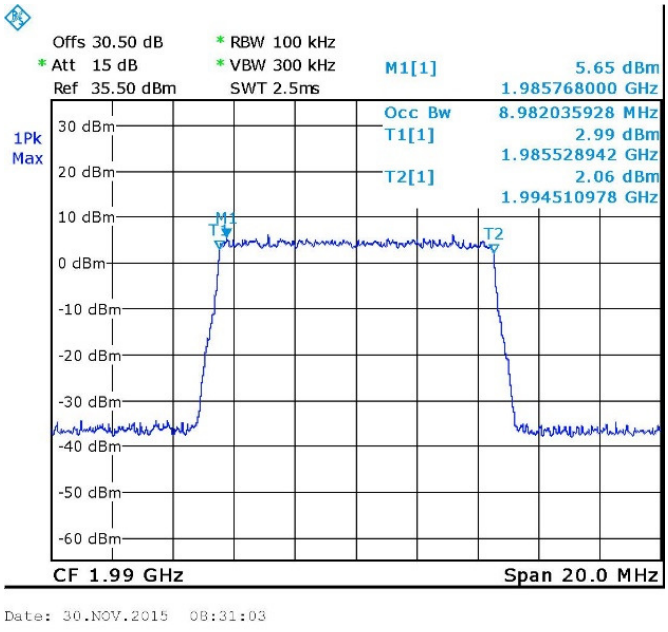


**Figure 115. LTE 64QAM - 1990.0 MHz Output**

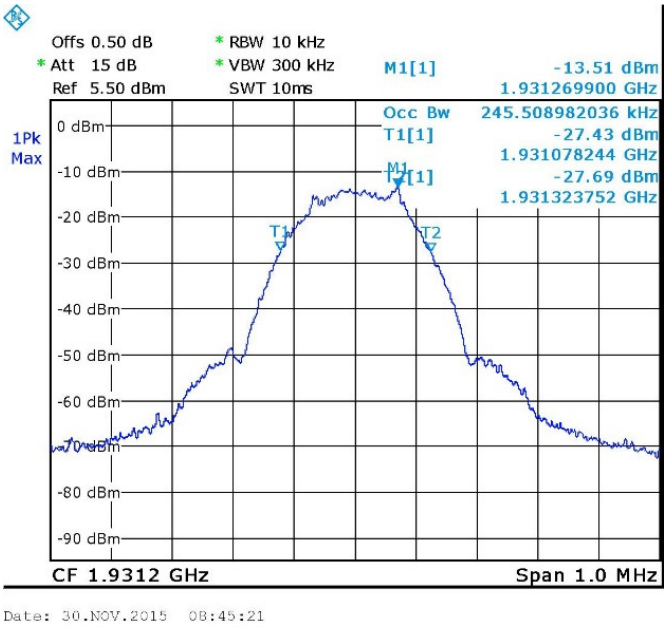


**Figure 116. GSM - 1931.2 MHz Input**

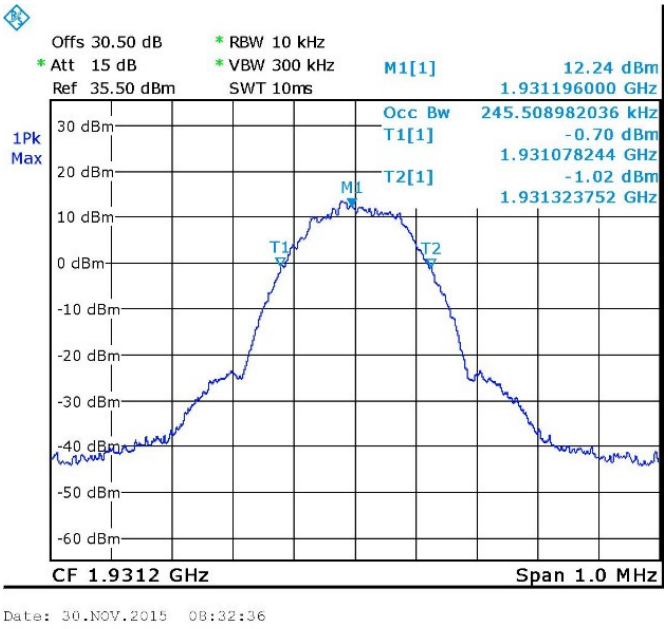


**Figure 117.GSM - 1931.2 MHz Output**

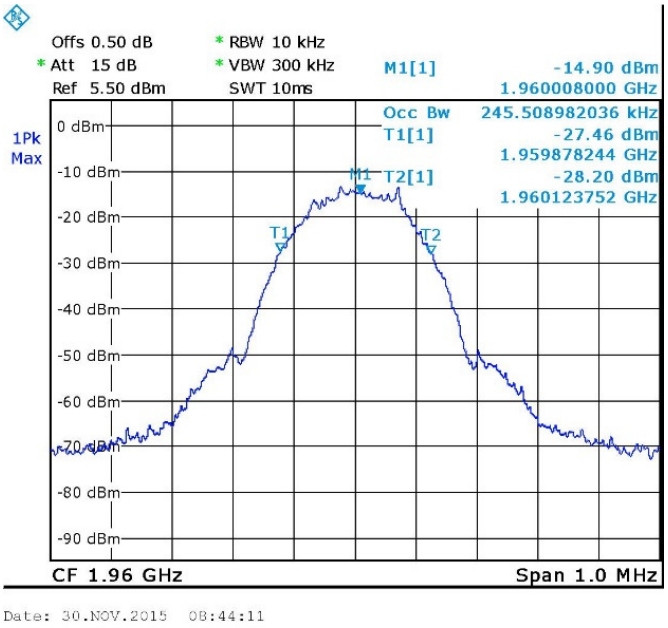


**Figure 118. GSM - 1960.00 MHz Input**

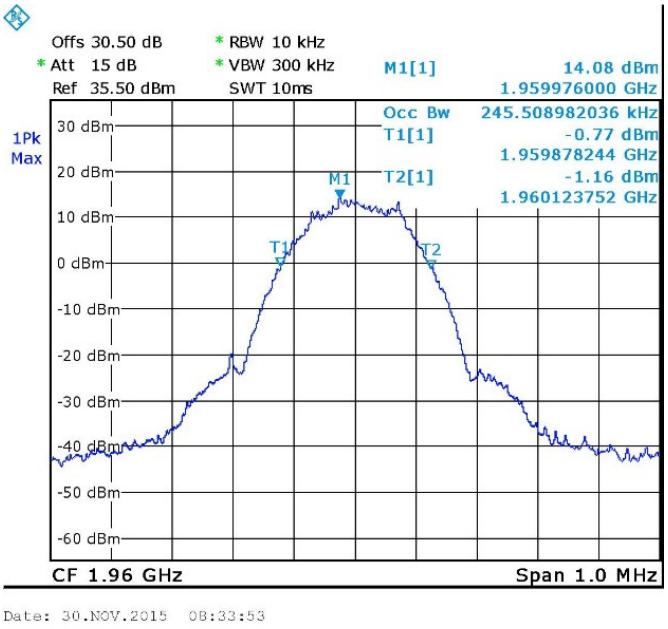


**Figure 119. GSM - 1960.00 MHz Output**

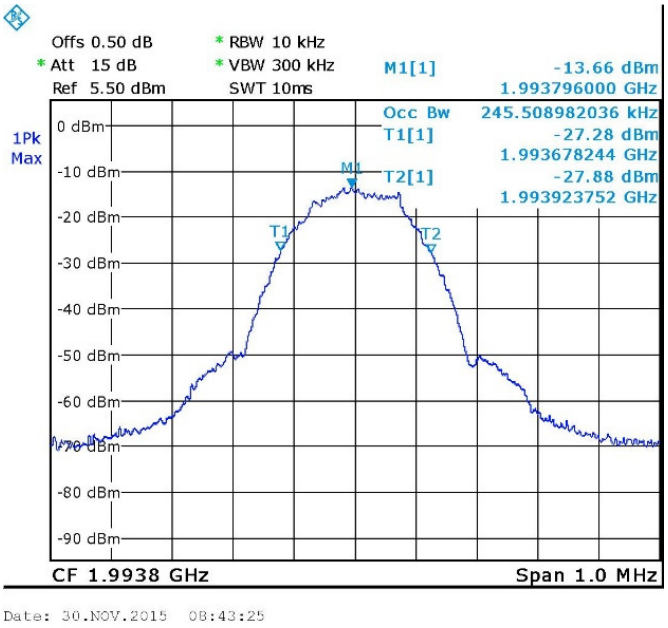


**Figure 120. GSM - 1993.8 MHz Input**

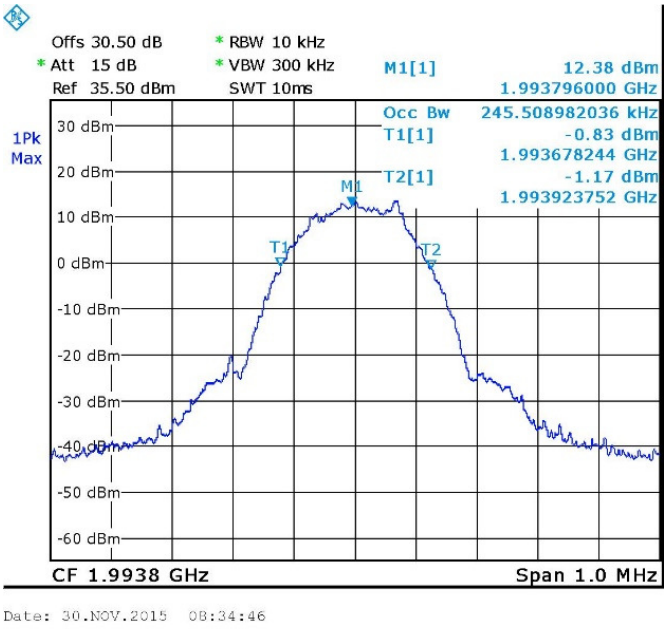


**Figure 121.GSM - 1993.8 MHz Output**

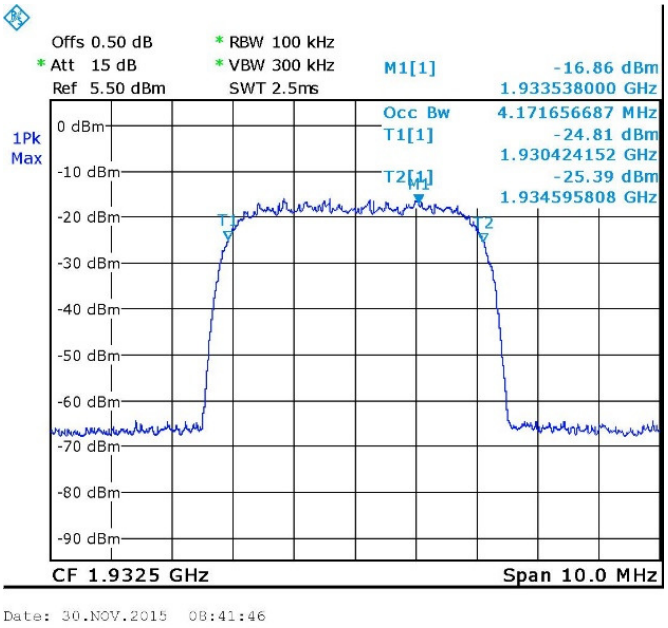


**Figure 122.WCDMA - 1932.5 MHz Input**

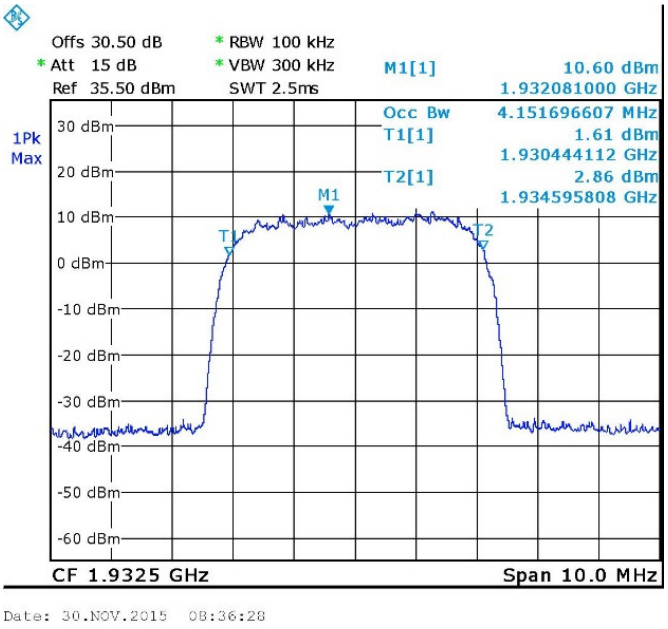


**Figure 123. WCDMA - 1932.5 MHz Output**

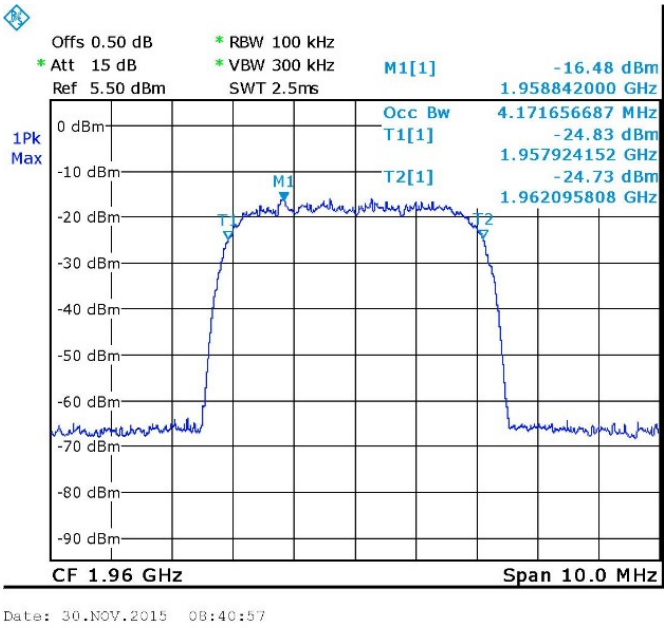


**Figure 124. WCDMA- 1960.0 MHz Input**

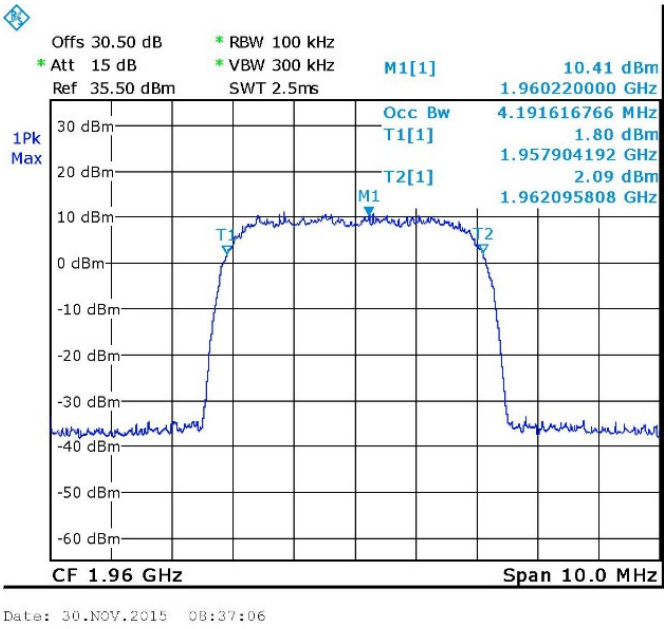


**Figure 125. WCDMA - 1960.0 MHz Output**

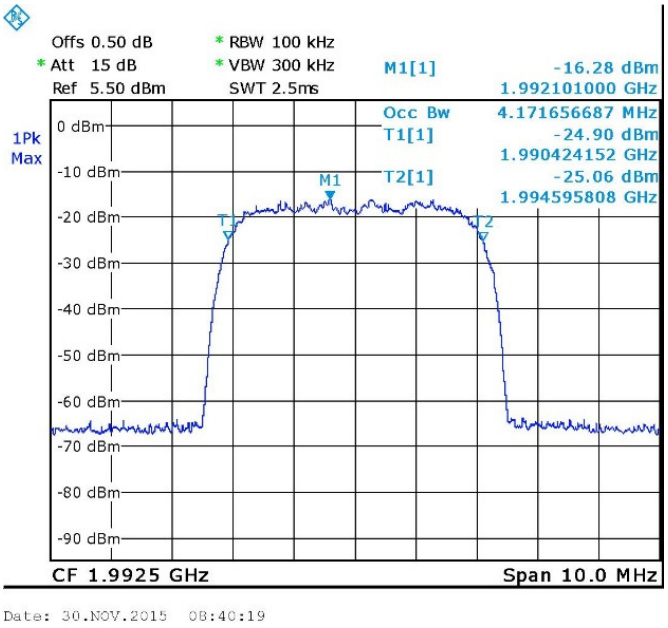


**Figure 126. WCDMA - 1992.5 MHz Input**

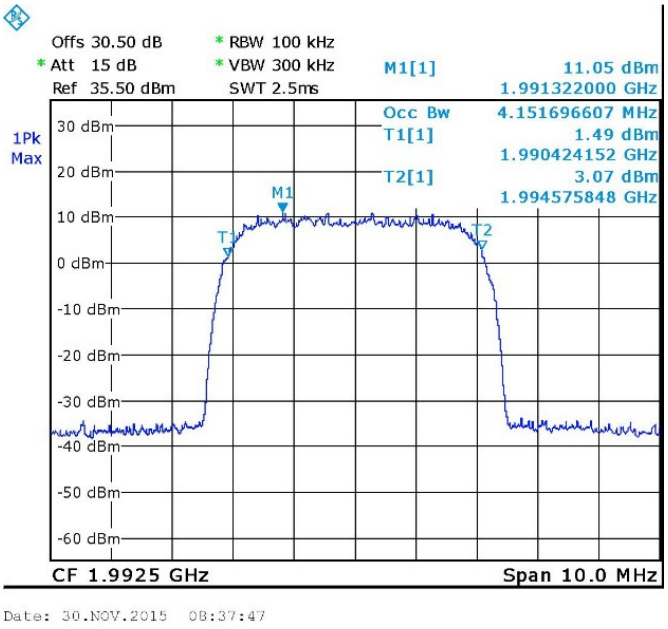


**Figure 127. WCDMA - 1992.5 MHz Output**

## 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

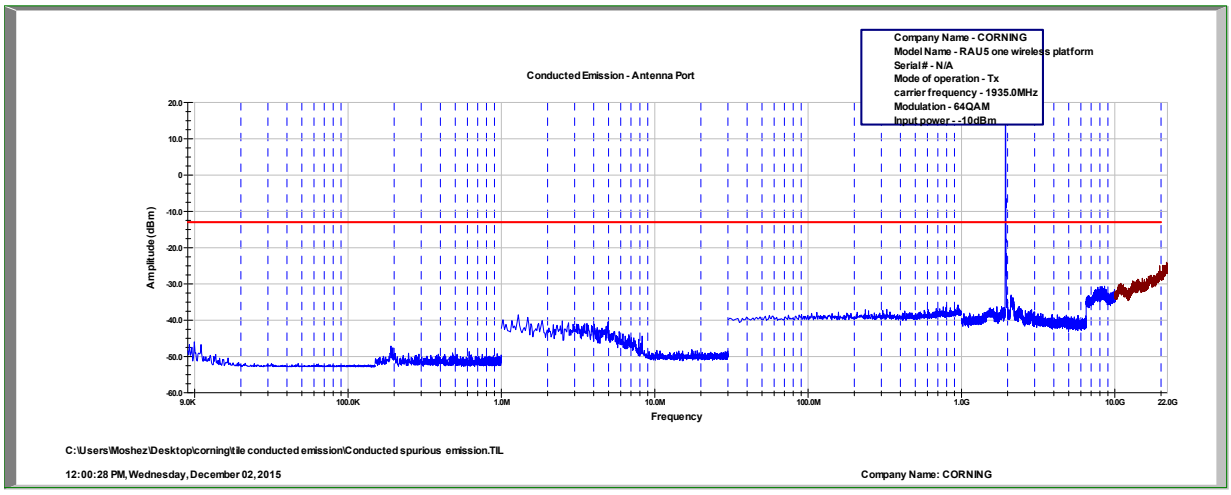


**Figure 129 64QAM - 1935.0 MHz**

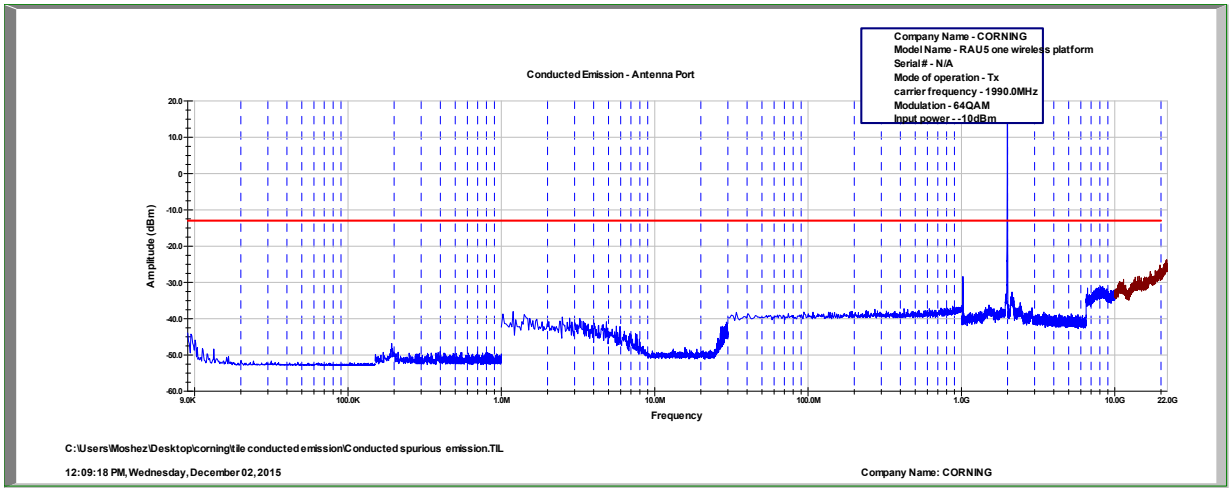


**Figure 130 64QAM - 1962.5 MHz**

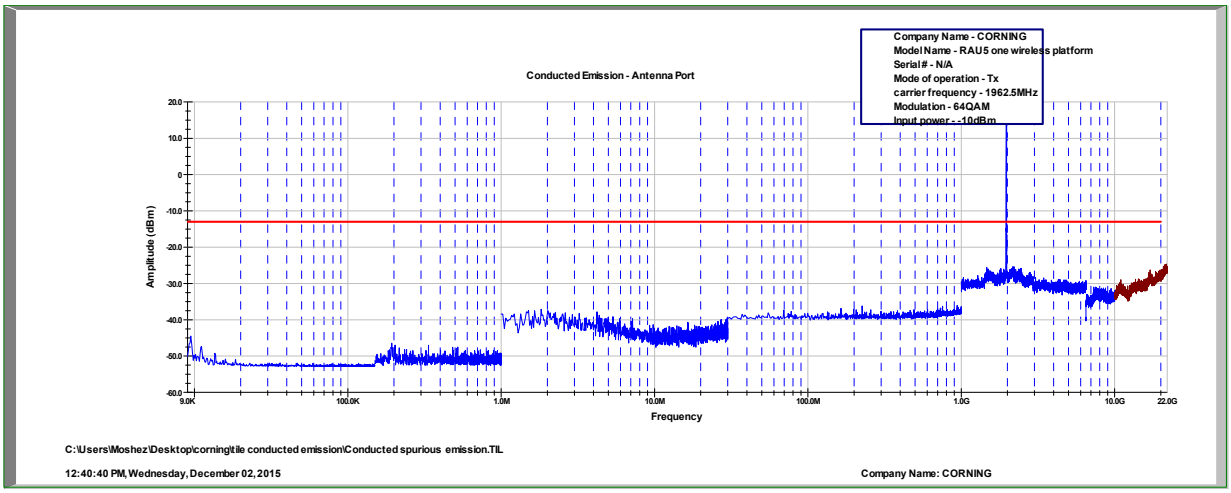


**Figure 131 64QAM - 1990.0 MHz**

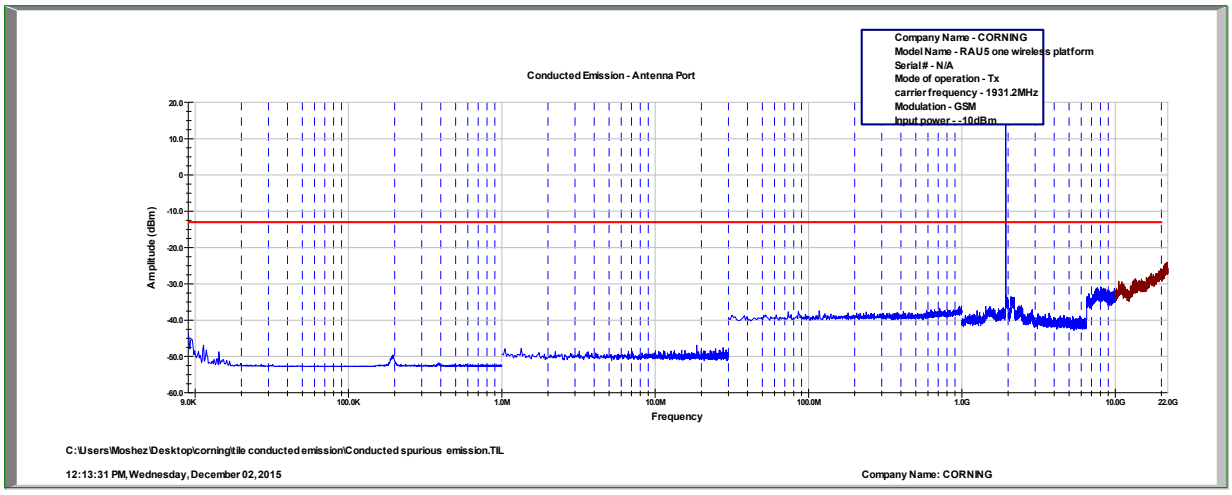


**Figure 132 GSM - 1931.2 MHz**

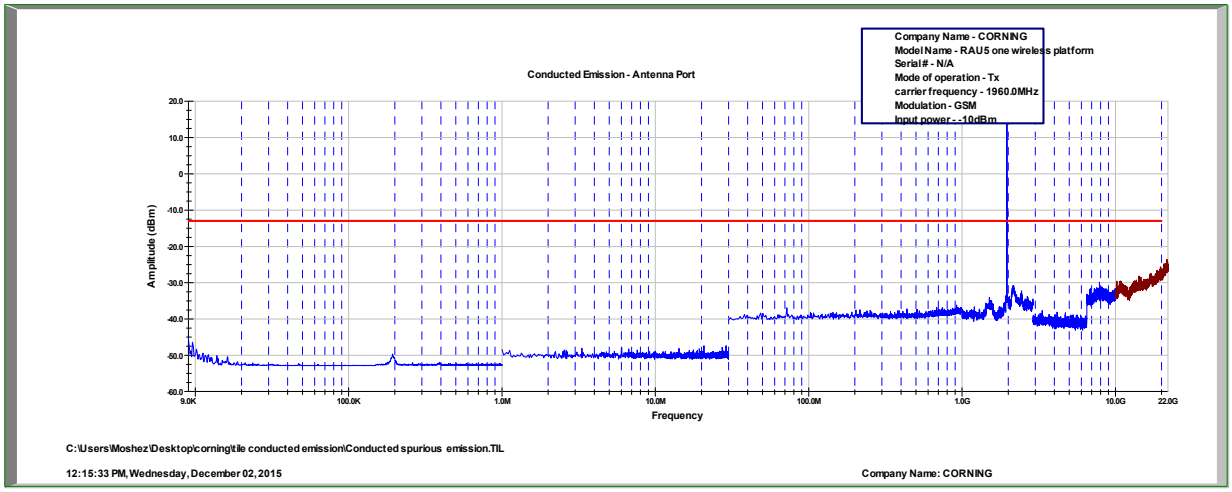


**Figure 133GSM - 1960.0 MHz**

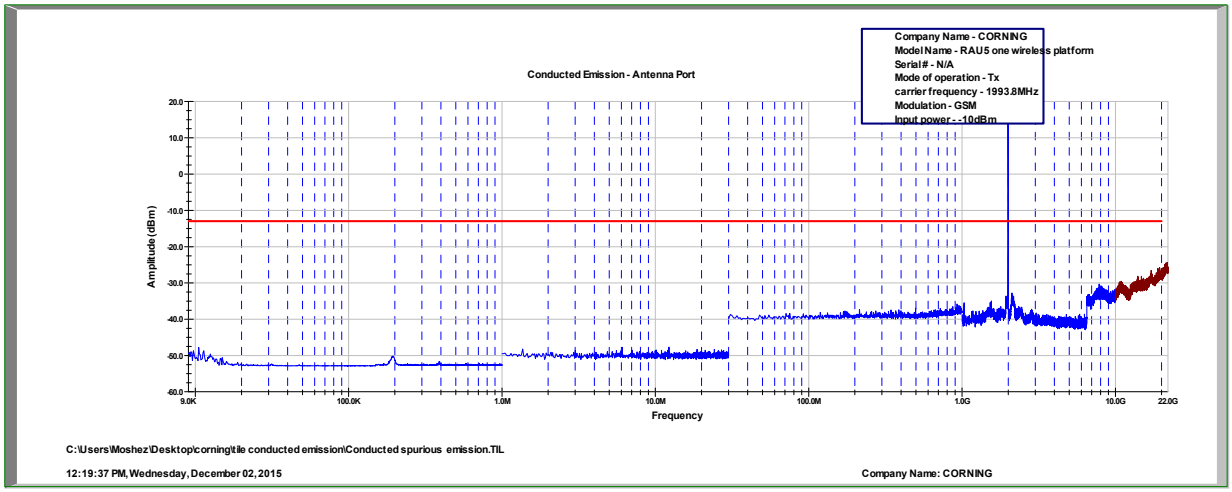


**Figure 134 GSM - 1993.8 MHz**

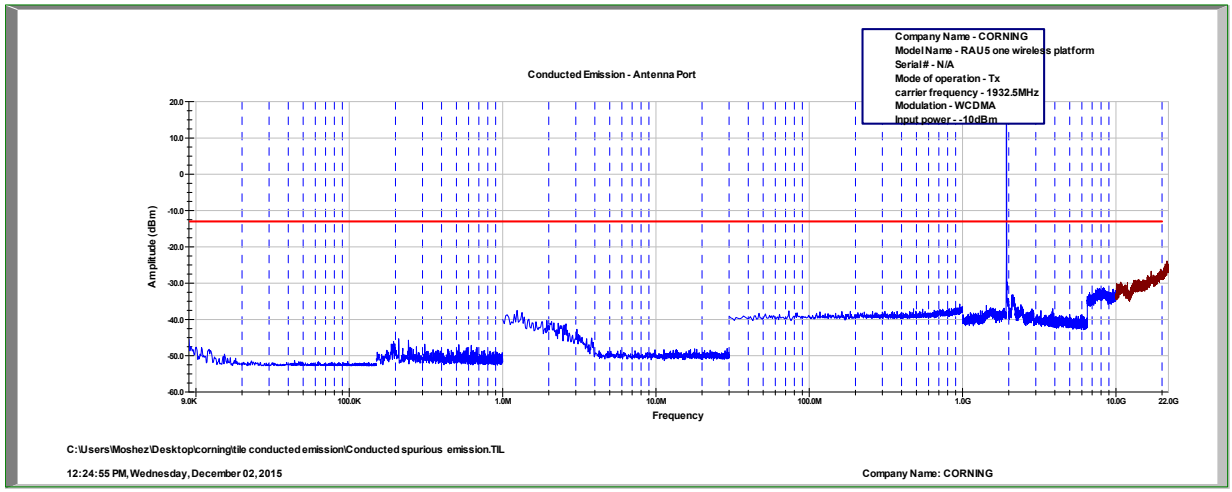


**Figure 135 WCDMA - 1932.5 MHz**

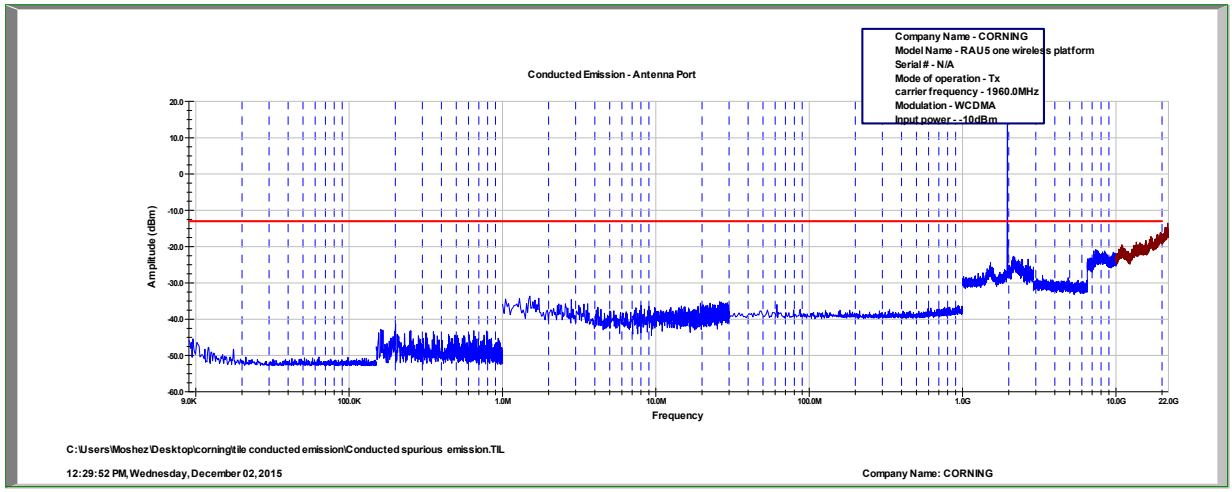


**Figure 136 WCDMA - 1960.0 MHz**

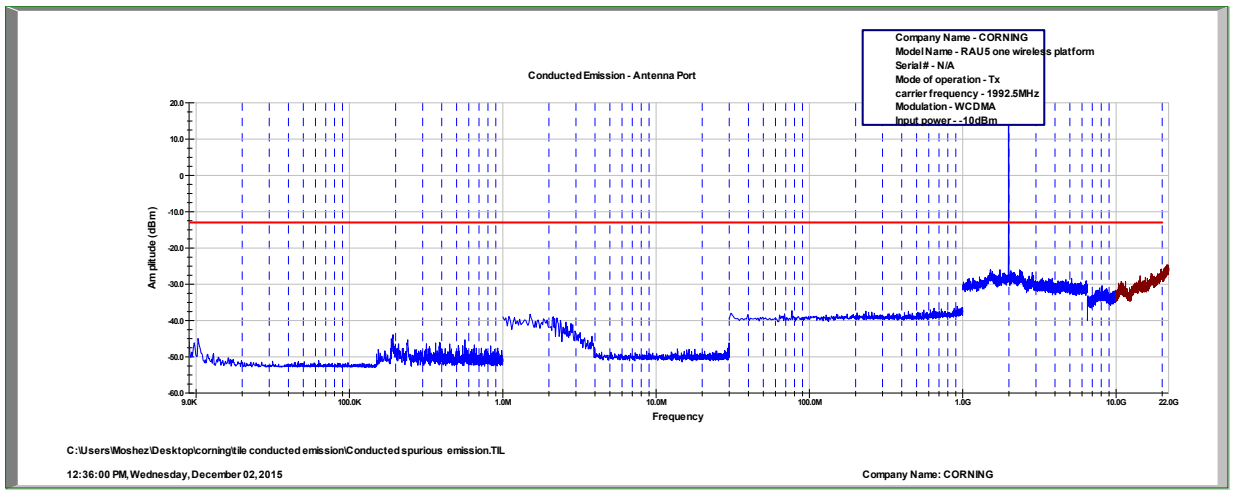


**Figure 137 WCDMA - 1992.5 MHz**

## 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

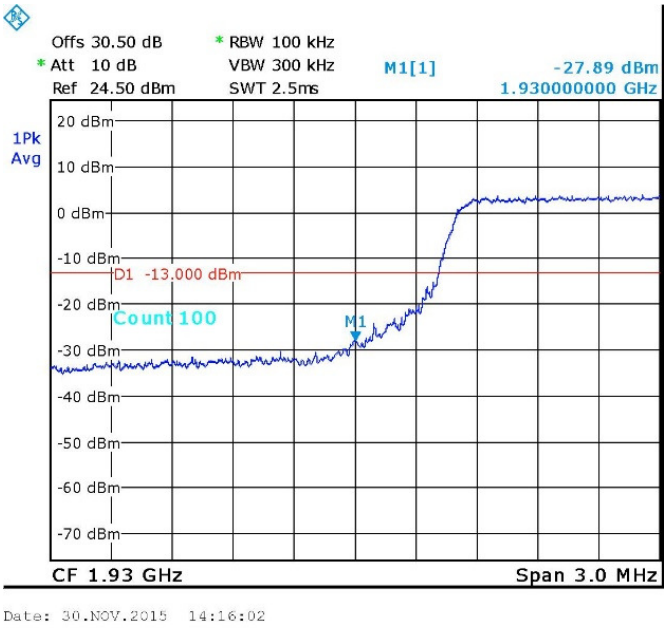


**Figure 140— LTE 64QAM - 1935.0 MHz**

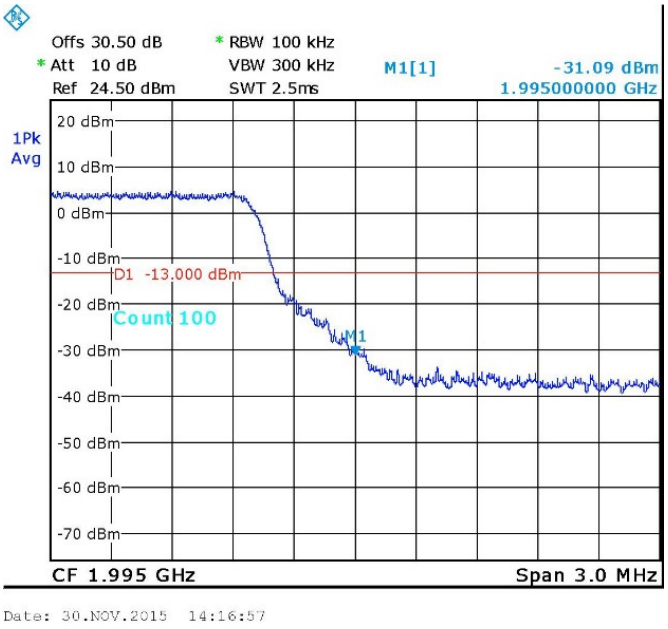


**Figure 141— LTE 64QAM - 1990.0 MHz**

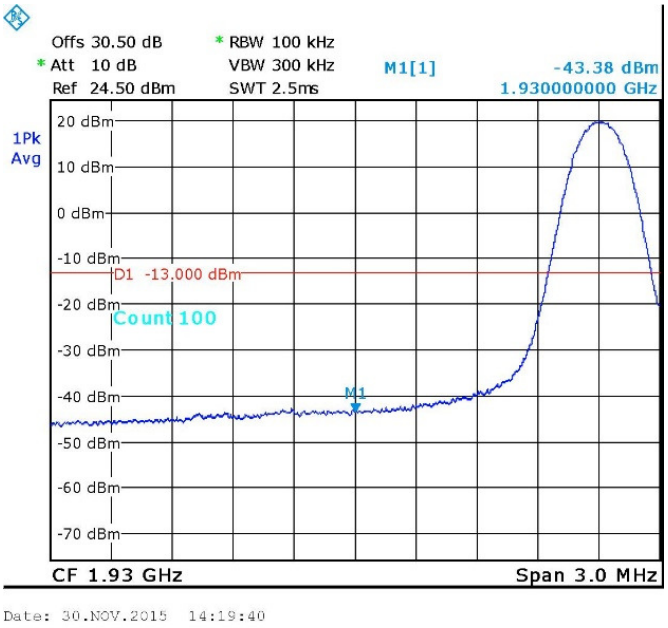


**Figure 142—GSM - 1931.2 MHz**

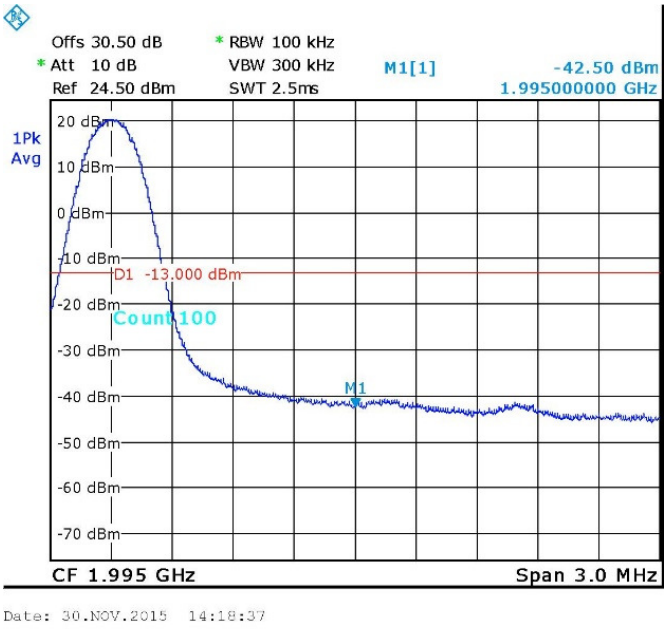


**Figure 143— GSM - 1993.8 MHz**

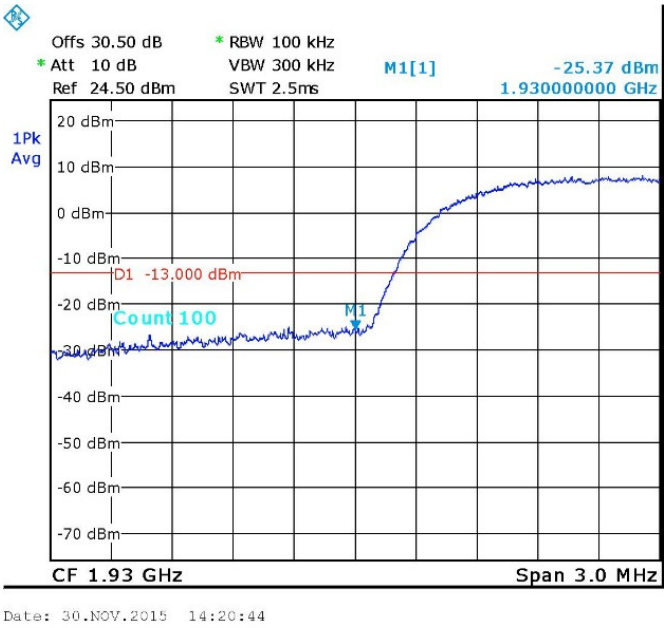


**Figure 144— WCDMA - 1932.5 MHz**

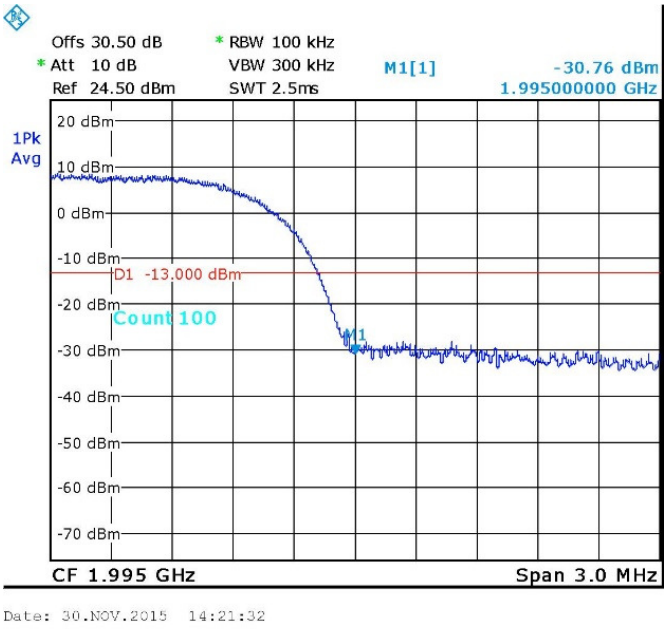


**Figure 145—WCDMA - 1992.5 MHz**

### *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:

$P_d$(dBm) = $P_g$(dBm) – Cable Loss (dB) + Substitution Antenna Gain (dB)

$P_d$ = Dipole equivalent power (result).
$P_g$ = Signal generator output level.

### 18.3 Results Table

| Carrier Channel (MHz) | Freq. (MHz) | Antenna Pol. (V/H) | Maximum Peak Level (dBµV/m) | Signal Generator RF Output (dBm) | Cable Loss (dB) | Antenna Gain (dBi) | EIRP (dBm) | Spec. (dBm) | Margin (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 Double Ridged Waveguide 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 |

### *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 dBμV to obtain field strength in dBμV/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 dBμV to obtain field strength in dBμV/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 |