Sulis Consultants
CE Marking and Product Approvals

# RF Test Report:

# Altiostar Networks

# AWS Band iRM4451 RRH

FCC ID: NXP-44510400

# SC_TR_181A

Prepared for:

Altiostar Inc.
100 Ames Pond Drive
Tewksbury
MA 01876
USA

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# 1 Revision History

| Revision | Originator | Date | Comment |
|---|---|---|---|
| A | C Blackham | 16 Dec 2015 | 1st release |

# 2 Purpose

This document details the FCC RF testing performed on the Altiostar AWS Band iRM4451 RRH (Remote Radio Head), model number iRM44510400, designed to transmit in the 2110-2155 MHz band.

# 3 Reference Documents

| | | |
|---|---|---|
| [Ref 1] | 47CFR2 | Title 47 Code of Federal Regulations Part 2: frequency allocations and radio treaty matters; general rules and regulations |
| [Ref 2] | 47 CRF27 | Title 47 Code of Federal Regulations Part 27: Miscellaneous Communications Services |
| [Ref 3] | TIA-603-D | Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards |
| [Ref 4] | KDB 662911 D01 v02r01 | Federal Communications Commission Office of Engineering and Technology Laboratory Division; Emissions Testing of Transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc) |
| [Ref 5] | KDB971168 DO1 v02r02 | Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement guidance for certification of licensed digital transmitters. |

# 4 Test Information

## 4.1 Client

Altiostar Inc.

100 Ames Pond Drive

Tewksbury

MA 01876

USA

## 4.2 Test personnel

**Antenna port tests**

Testing was performed by Charlie Blackham of Sulis Consultants Ltd at Altiostar UK offices on 15th December 2015 and at Hursley EMC on 16th December 2015.

**Radiated Spurious Emissions (section 12)**

Testing was performed by Richard Pennell of Hursley EMC services Ltd, at their FCC Registered test facility, UK designation number UK0006, on 16th December 2015 under job 15J551.

## 4.3 Test sample

The results herein only refer to sample detailed in section 6

# 5 Product Description

The basestation supports operation with 5, 10, 15 and 20 MHz bandwidths, with OFDMA modulation at the following modulation rates:

- QPSK, 3GPP test model E-TM1.1
- 16 QAM, 3GPP test model E-TM3.2
- 64 QAM, 3GPP test model E-TM3.1

The unit is fitted with four RF transceiver RF ports, Ant1, ANT2, ANT3 and Ant4. These are designed to support MIMO operation and are connected to external antennas. Typically these would be two cross polarised 2T2R antennas or a single xx-polarised 4T4R. These are provided by the licensee and gain dealt with at time of licensing.

Transmit power was set to maximum permitted of 30 W (44.7 dBm) per port.

Measurements were performed on the following channels within the band of operation:

5 MHz channel : 2112.5 MHz

10 MHz channel: 2115.0 MHz

15 MHz channel : 2117.5 MHz

20 MHz channel: 2120.0 MHz

The test waveform has a 100% duty cycle so no gating or allowance for duty cycle was required when taking measurements

# 6 Test Configuration

## 6.1 Test sample and Operating mode

The equipment under test (EUT) was:

| Manufacturer | Model Number | Serial Number |
|---|---|---|
| Altiostar | iRM44510400 | PLW47150005 |

**Table 1: Equipment under test**

## 6.2 Equipment set-up

Equipment was configured as per figure 1:

- The iRM4451system was configured using a web browser application that allowed the unit to be placed into a test mode and the required frequency, bandwidth and power to be set
- All 4 ports were set to transmit on maximum power with the same modulation and channel bandwidth
- For conducted measurements, the insertion loss of the Attenuator and Co-ax cables were measured before testing and their combined path-loss was programmed into the analyser as a negative external gain[1].

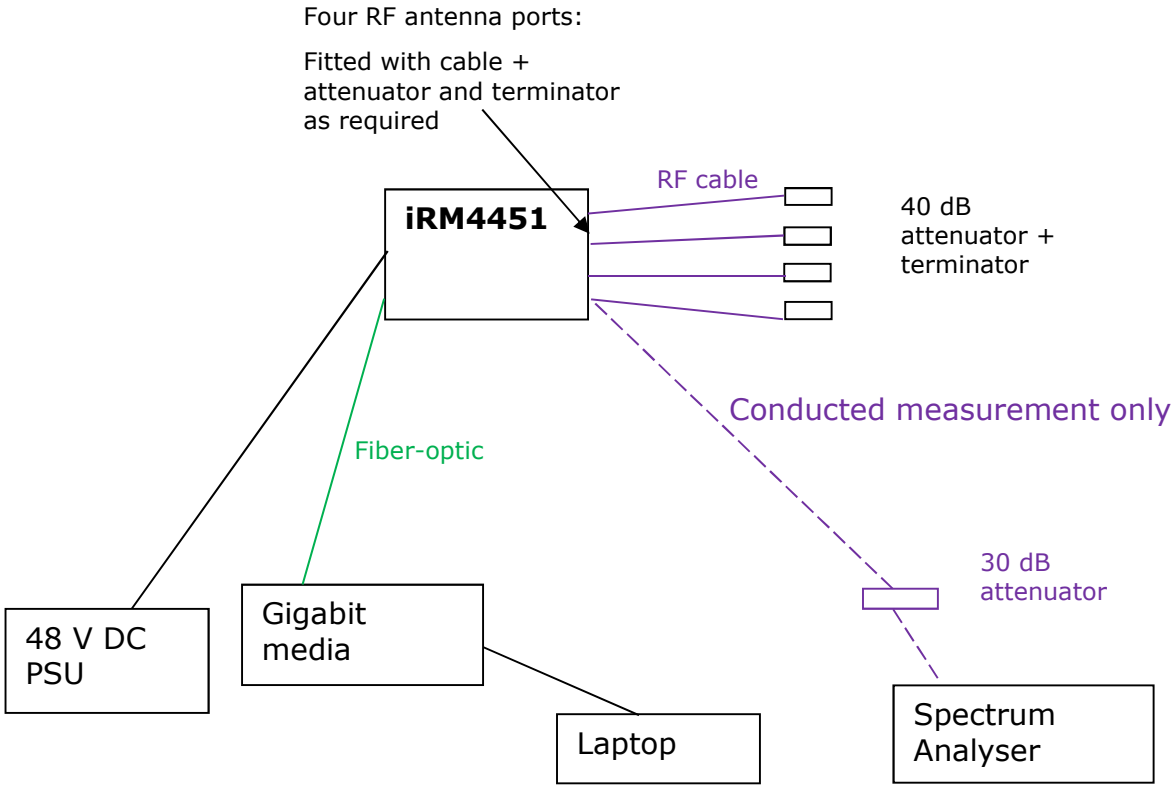



**Figure 1: Configuration for test**

[1] Except for the 13-22 GHz Conducted Spurious Emission measurement where insertion loss was loaded into analyser as a Transducer Factor.

## 6.3 Support equipment

The support equipment was:

| Description | Manufacturer | Model | Serial Number |
|---|---|---|---|
| Laptop | HP | 250 | Dvt-mobile altiostar |
| USB/Ethernet adapter | Startech | | 13320402522 |
| Gigabit media converter (on laptop) | TP-Link | MC220L | 2158186001559 |
| 48 V DC PSU | Agilent | N8737A | US14C3870M |
| 40dB attenuator (Quantity 4) | Fairview microwave | SA3N1007-40 | various |

**Table 2: Support Equipment**

# 7 Summary of Tests performed

| Test | 47 CFR Part | Result | Section |
|---|---|---|---|
| Transmit Power | 27.50(d)(2) / 2.1046 | Pass | 8 |
| Spectral Power Density | 27.50(d)(2) / 2.1046 | Pass | 9 |
| Occupied Bandwidth | 2.1049 | Pass | 10 |
| Conducted Spurious Emissions (out of band) | 27.53(h) / 2.1051 | Pass | 11 |
| Radiated Spurious Emissions | 27.53(h) / 2.1053 | Pass | 12 |
| Frequency Stability | 27.54 / 2.10 | See report SC_TR_182 | |

**Table 3: Summary of tests performed**

# 8 Transmit Power 47CFR90.1321

## *8.1 Requirement and test method*

**27.50 Power limits and duty cycle.**

(d) (2) The power of each fixed or base station transmitting in the 1995-2000 MHz, the 2110-2155 MHz 2155-2180 MHz band, or 2180-2200 MHz band and situated in any geographic location other than that described in paragraph (d)(1) of this section is limited to:

(i) An equivalent isotropically radiated power (EIRP) of 1640 watts when transmitting with an emission bandwidth of 1 MHz or less;

(ii) An EIRP of 1640 watts/MHz when transmitting with an emission bandwidth greater than 1 MHz.

(d)(5) Equipment employed must be authorized in accordance with the provisions of §24.51. Power measurements for transmissions by stations authorized under this section may be made either in accordance with a Commission-approved average power technique or in compliance with paragraph (d)(6) of this section. In measuring transmissions in this band using an average power technique, the peak-to-average ratio (PAR) of the transmission may not exceed 13 dB.

Measurement made using KDB971168 DO1, section 5.2

The total power was summed in accordance with KDB662911D01 and the result compared against the limit. Specifically, the power was measured at Antenna port 1 and then 10log4 dB, or 6 dB, was added to show total power from all four ports.

## 8.2 Test results: Transmit Power

The table below shows results obtained.

| Channel Bandwidth | Modulation | TX power (dBm) | Summed TX power (dBm) | TX power (W) | Limit EIRP (W) | Result |
|---|---|---|---|---|---|---|
| 5 | QPSK | 44.72 | 50.72 | 118.03 | None | Pass |
| | 16 QAM | 44.60 | 50.60 | 114.82 | None | Pass |
| | 64 QAM | 44.90 | 50.90 | 123.03 | None | Pass |
| 10 | QPSK | 44.79 | 50.79 | 119.95 | None | Pass |
| | 16 QAM | 44.82 | 50.82 | 120.78 | None | Pass |
| | 64 QAM | 44.84 | 50.84 | 121.34 | None | Pass |
| 15 | QPSK | 44.93 | 50.93 | 123.88 | None | Pass |
| | 16 QAM | 44.86 | 50.86 | 121.90 | None | Pass |
| | 64 QAM | 44.67 | 50.67 | 116.68 | None | Pass |
| 20 | QPSK | 44.88 | 50.88 | 122.46 | None | Pass |
| | 16 QAM | 44.88 | 50.88 | 122.46 | None | Pass |
| | 64 QAM | 44.77 | 50.77 | 119.40 | None | Pass |

**Table 4: Transmit power**

Plots are provided in SC_TR_181-plots.

Notes:

1. All emission bandwidths are > 1 MHz so limit is EIRP/MHz as discussed in section 9.
2. Two plots are shown for each measurement to capture lower and upper bandedge marker measurements for section 11.

## 8.3 Test results: Peak-to-average ratio

The Peak to average waveform is related to modulation and not to frequency of operation of bandwidth. Results are presented for 5 and 20 MHz channels.

Peak to Average (PAR) ratio is controlled using crest factor reduction techniques and worst case is 7.36dBm.

| Channel Bandwidth | Modulation | 0.1% PAR | Limit | Result |
|---|---|---|---|---|
| 5 | QPSK | 7.07 | 13.00 | Pass |
| | 16 QAM | 6.99 | 13.00 | Pass |
| | 64 QAM | 7.00 | 13.00 | Pass |
| 20 | QPSK | 7.36 | 13.00 | Pass |
| | 16 QAM | 7.17 | 13.00 | Pass |
| | 64 QAM | 7.33 | 13.00 | Pass |

**Table 5: Peak-to-average measurements**

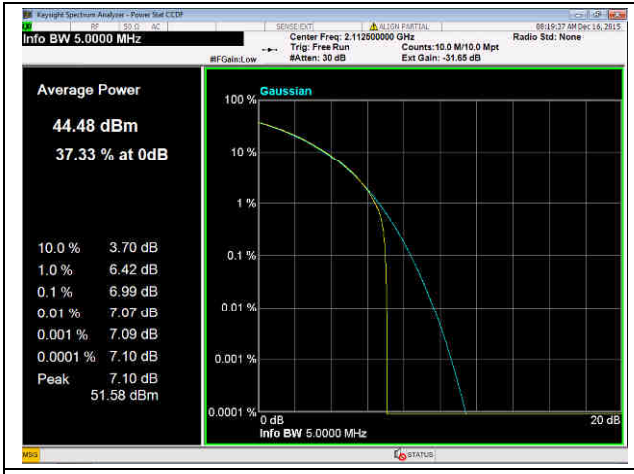
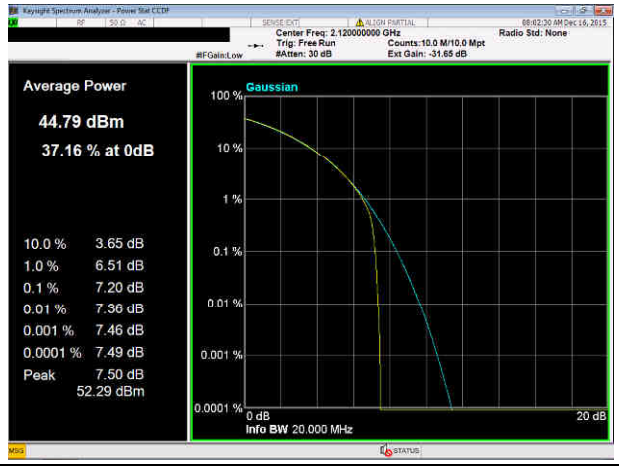
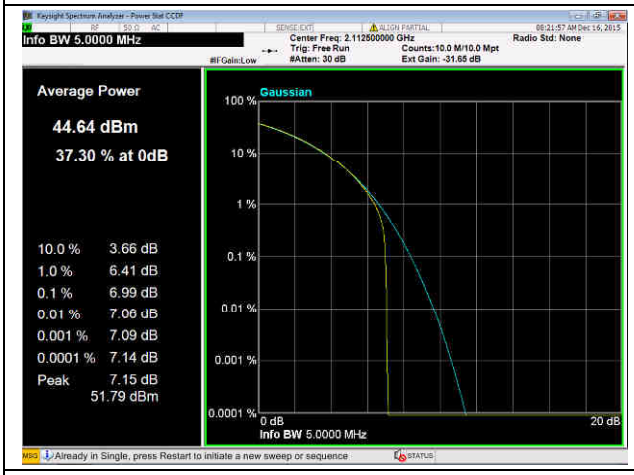
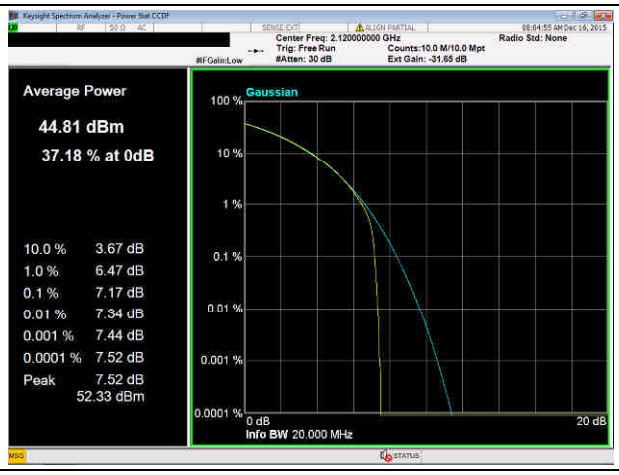
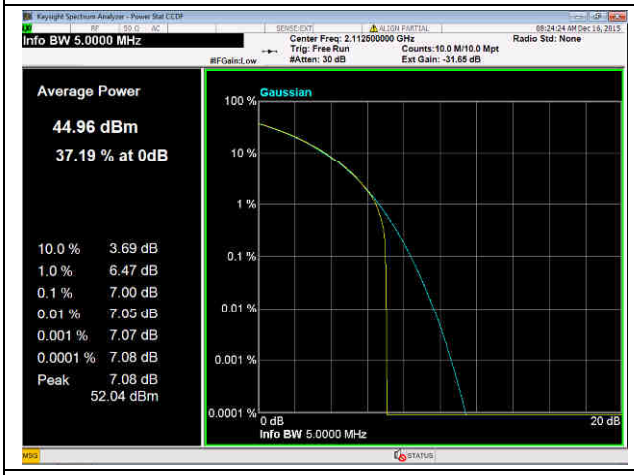
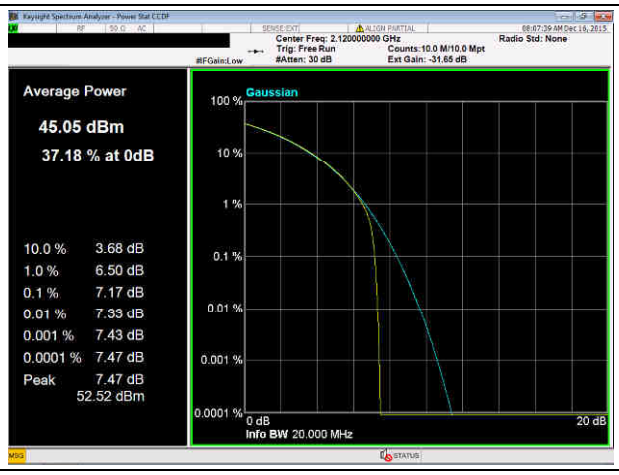
| | |
|---|---|
|  |  |
| 5 MHz Channel, QPSK | 20 MHz Channel, QPSK |
|  |  |
| 5 MHz Channel, 16 QAM | 20 MHz Channel, 16 QAM |
|  |  |
| 5 MHz Channel, 64 QAM | 20 MHz Channel, 64 QAM |

**Figure 2: Peak-to-Average plots**

# 9 Spectral Power Density

## *9.1 Requirement and test method*

As per section 8.1

Measured using 1 MHz RBW and peak search

## *9.2 Test results*

The table below shows results for plots in figure 3.

| **Channel B'width (MHz)** | **TX power (dBm/MHz)** | **Summed TX power (dBm/MHz)** | **TX power EIRP (W/MHz)** | **Limit EIRP (W/MHz) See note** | **Result** | **Modulation** |
|---|---|---|---|---|---|---|
| 5 | 38.53 | 44.53 | 28.38 | 1640.0 | Pass | QPSK |
| | 38.85 | 44.85 | 30.55 | 1640.0 | Pass | 16 QAM |
| | 39.03 | 45.03 | 31.84 | 1640.0 | Pass | 64 QAM |
| 10 | 36.20 | 42.20 | 16.60 | 1640.0 | Pass | 64 QAM |
| 15 | 33.67 | 39.67 | 9.27 | 1640.0 | Pass | 64 QAM |
| 20 | 32.98 | 38.98 | 7.91 | 1640.0 | Pass | 64 QAM |

**Table 6: Transmit power spectral density**

Notes:

1. Maximum antenna gain for compliance with the limit is dealt with at time of licensing.

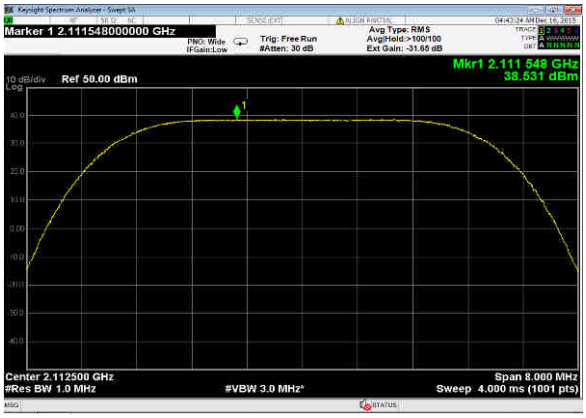
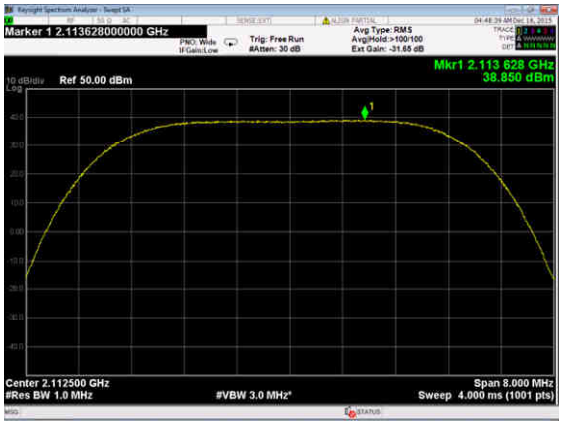
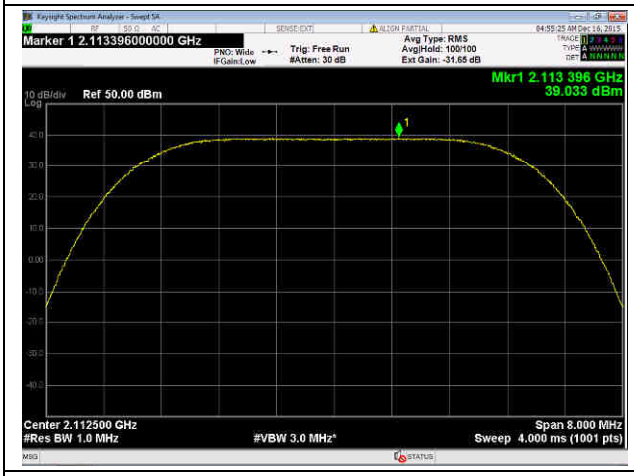
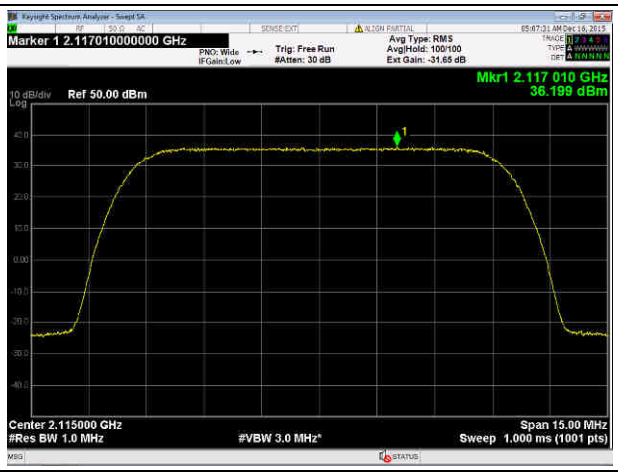
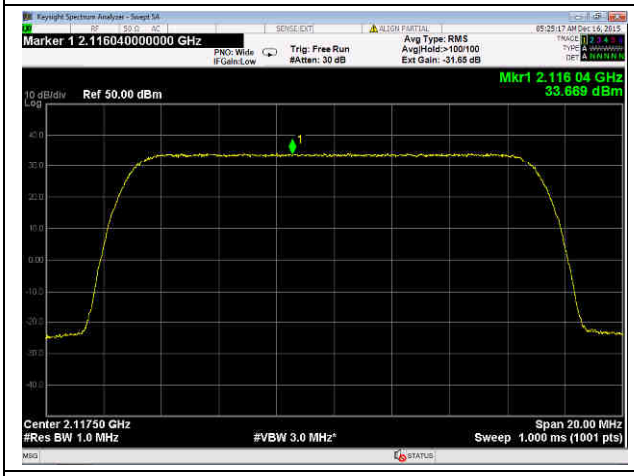
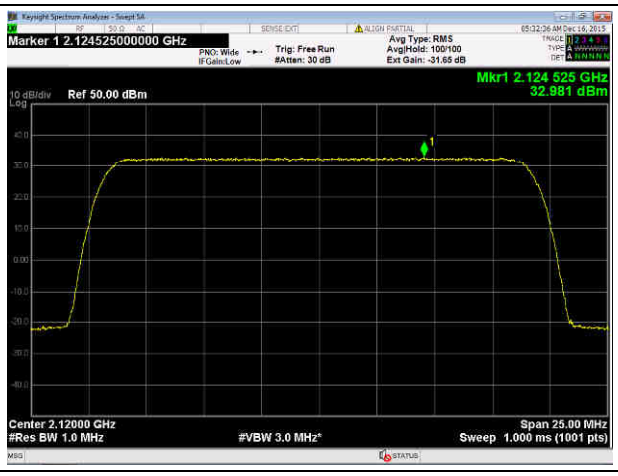
| | |
|---|---|
|  |  |
| 5 MHz QPSK | 5 MHz 16 QAM |
|  |  |
| 5 MHz 64 QAM | 10 MHz worst case |
|  |  |
| 15 MHz worst case | 20 MHz worst case |

**Figure 3: Transmit Power Spectral Density plots**

# 10 Occupied Bandwidth

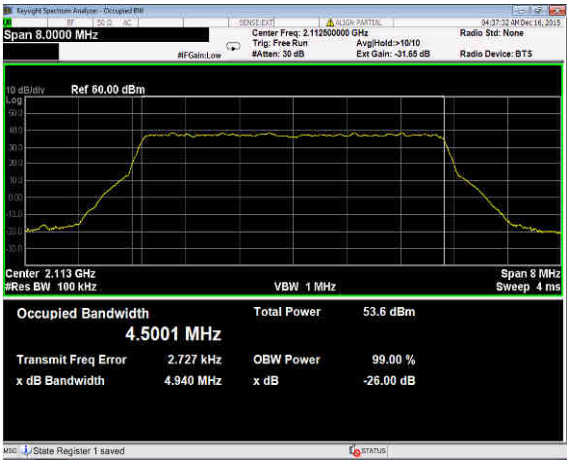
The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the -26 dB emission bandwidth. Measurement was made using a peak detector.

There is no pass/fail criterion so measurement results are reported without reference to a limit for measurements on antenna port 1.

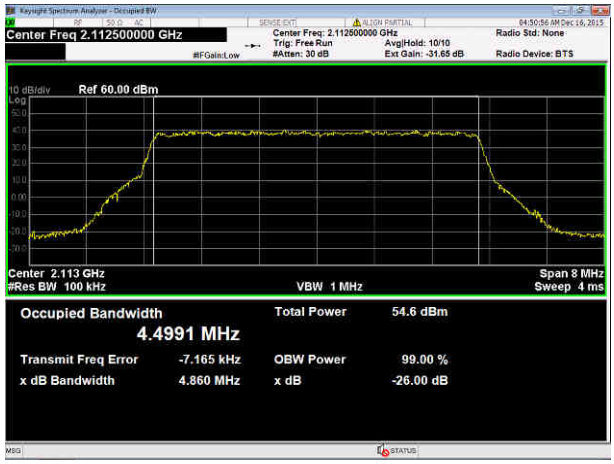
The table below shows worst case results for plots in figure 4.

| Channel Bandwidth | TX Freq (MHz) | -26dB Occupied Bandwidth (MHz) | Modulation |
|---|---|---|---|
| 5 | 2112.5 | 4.94 | QPSK |
| | | 4.86 | 16 QAM |
| | | 4.88 | 64 QAM |
| 10 | 2115.0 | 9.61 | QPSK |
| 15 | 2117.5 | 14.49 | QPSK |
| 20 | 2120.0 | 19.26 | QPSK |

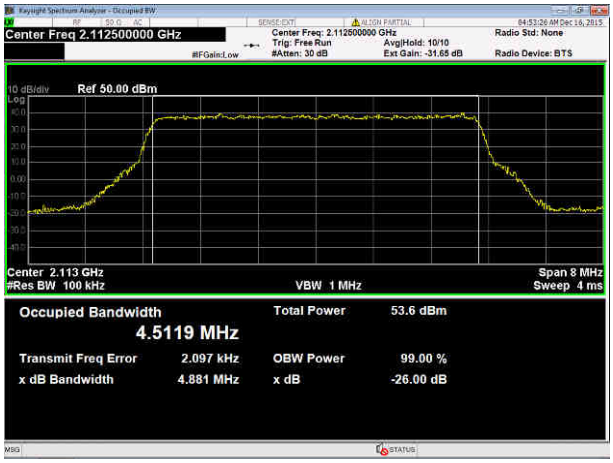
**Table 7: Occupied Bandwidth test results**



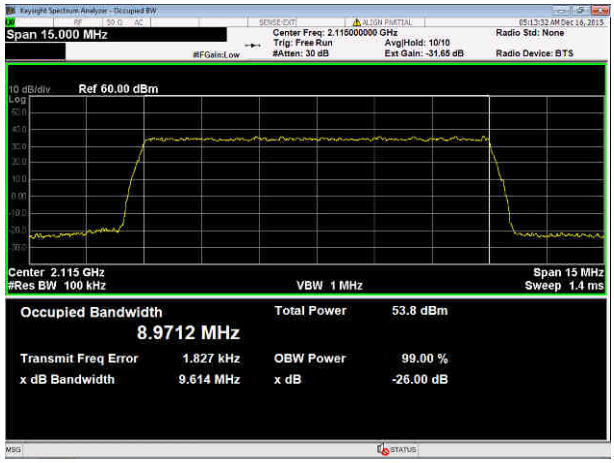

5 MHz QPSK



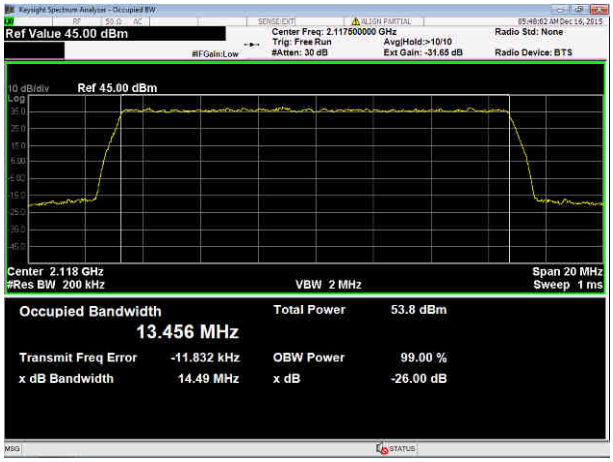

5 MHz 16 QAM



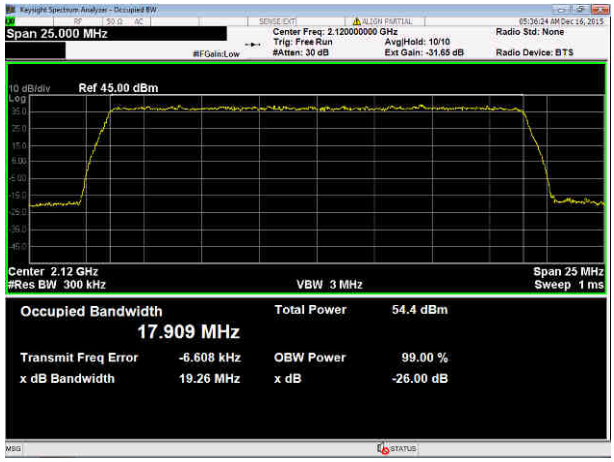

5 MHz 64 QAM




10 MHz worst case




15 MHz worst case




20 MHz worst case

**Figure 4: Occupied Bandwidth plots**

# 11 Conducted Spurious Emissions inc. Band Edge

## *11.1 Requirement and test method*

27.53(h) AWS emission limits—

(1) General protection levels. Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB.

(3) *Measurement procedure.*

(i) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

The licensed band of operation was considered to be a single 5 MHz channel for 5 MHz operation, a single 10 MHz channel for 10 MHz operation and so on.

Emissions within 1 MHz of the bandedge were measured using a narrow resolution bandwidth as per 27.53(h).

Transmit power was measured using an RMS detector so spurious emissions have also been measured using an RMS detector.

Emissions between 1 and 3 MHz from the band edge were measured using adjacent channel power measurement capability of the spectrum analyser..

Determination of total spurious emission was done by adding 10 log (4), or 6.0 dB to the emission level measured on port Ant1 and this was compares with limit of -13dBm as per KDB 662911 section 3(a)(iii)

## 11.2 Band edge results

Plots for band-edge compliance are shown in SC_TR_181-plots.

Worst case emission is the highest emission within 3 MHz of bandedge:

- Narrow RBW peak search within 0-1 MHz of band edge
- **Or** Integrated power measurement for the next two 1 MHz blocks

| Channel Bandwidth | Modulation | Worst case emission | Summed TX power (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|---|
| 5 | QPSK | -19.95 | -13.95 | -13.0 | Pass |
| | 16 QAM | -23.28 | -17.28 | -13.0 | Pass |
| | 64 QAM | -21.23 | -15.23 | -13.0 | Pass |
| 10 | QPSK | -23.78 | -17.78 | -13.0 | Pass |
| | 16 QAM | -24.92 | -18.92 | -13.0 | Pass |
| | 64 QAM | -21.71 | -15.71 | -13.0 | Pass |
| 15 | QPSK | -22.78 | -16.78 | -13.0 | Pass |
| | 16 QAM | -23.14 | -17.14 | -13.0 | Pass |
| | 64 QAM | -24.89 | -18.89 | -13.0 | Pass |
| 20 | QPSK | -24.61 | -18.61 | -13.0 | Pass |
| | 16 QAM | -24.35 | -18.35 | -13.0 | Pass |
| | 64 QAM | -23.90 | -17.90 | -13.0 | Pass |

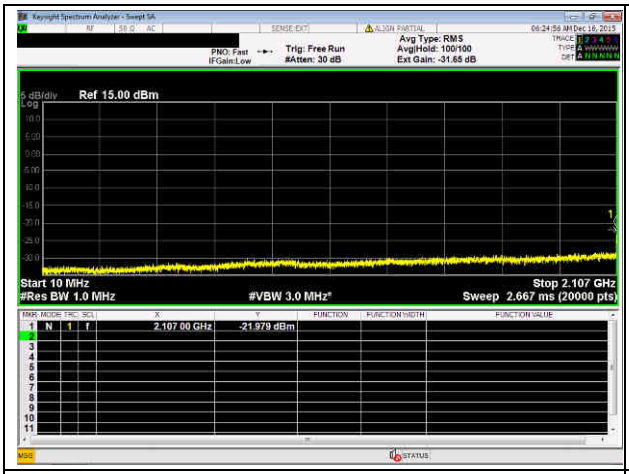
**Table 8: CSE Band edge results**

## 11.3 Conducted spurious emissions

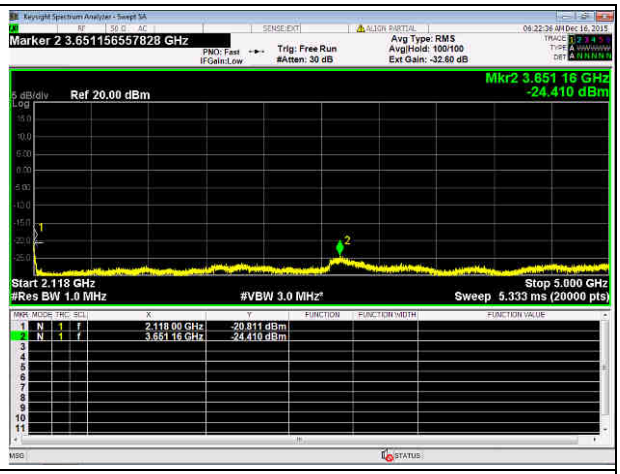
Conducted Spurious emissions were investigated from 10 MHz to 22 GHz at frequencies ≥3 MHz from the bandedge, the worst case results are shown in table 10 and accompanying plots in figure 5.

| Channel Bandwidth | Worst case emission | Summed TX power (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|
| 5 | -20.81 | -14.81 | -13.0 | Pass |
| 10 | -23.92 | -17.92 | -13.0 | Pass |
| 15 | -23.76 | -17.76 | -13.0 | Pass |
| 20 | -24.05 | -18.05 | -13.0 | Pass |

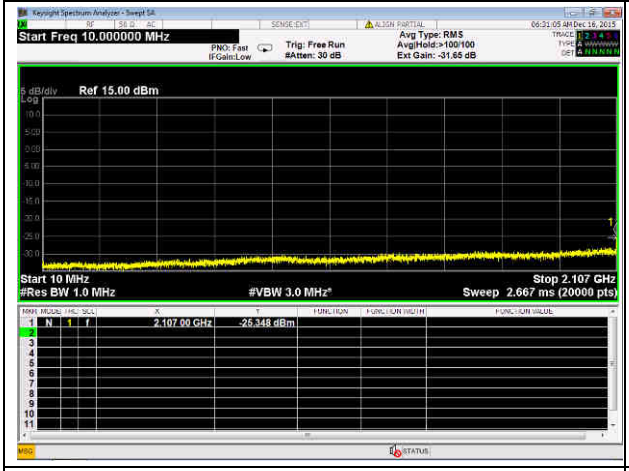
**Table 9: CSE results except bandedge**



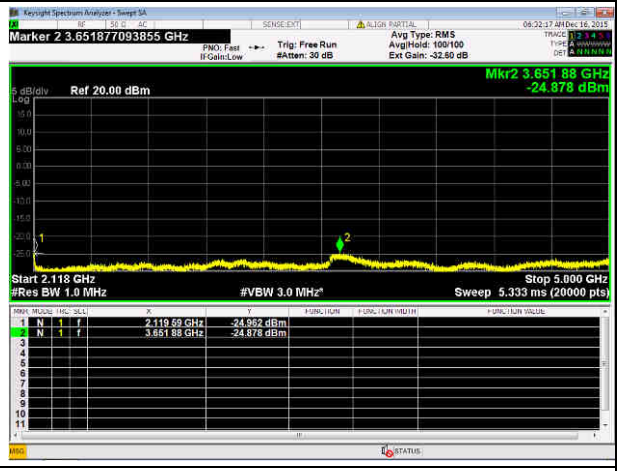

5 MHz QPSK



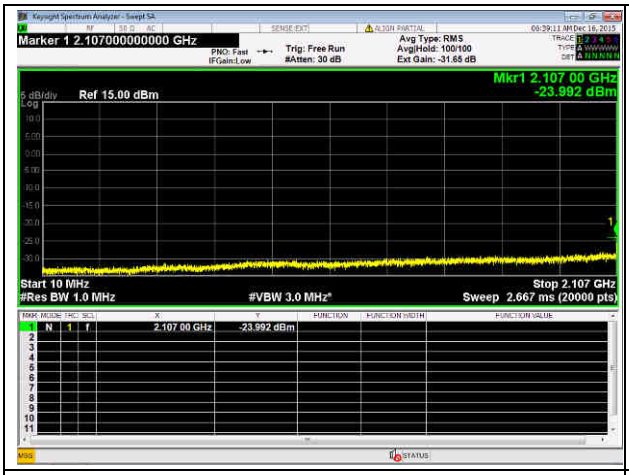

5 MHz QPSK



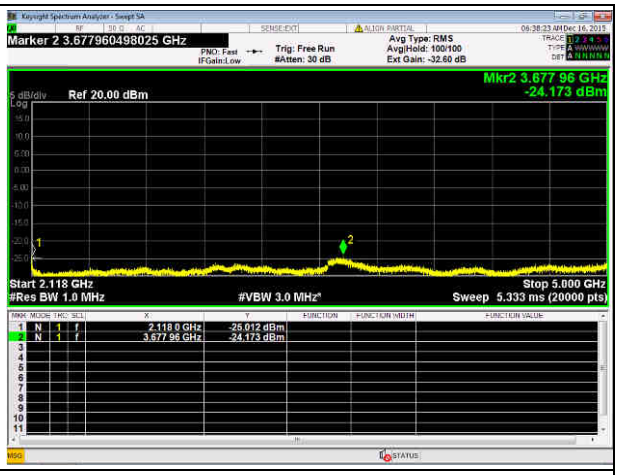

5 MHz 16QAM



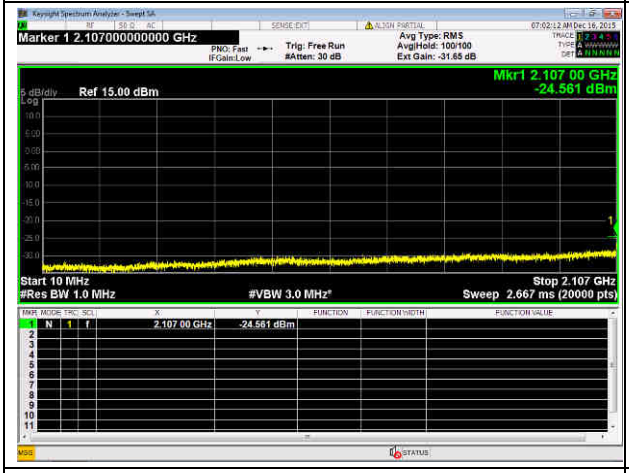

5 MHz 16QAM



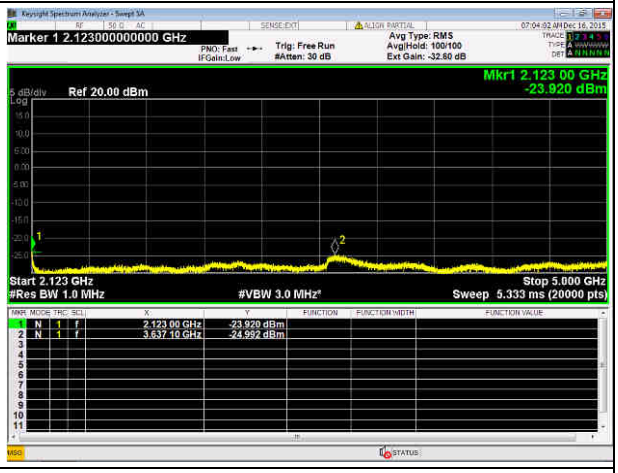

5 MHz 64QAM



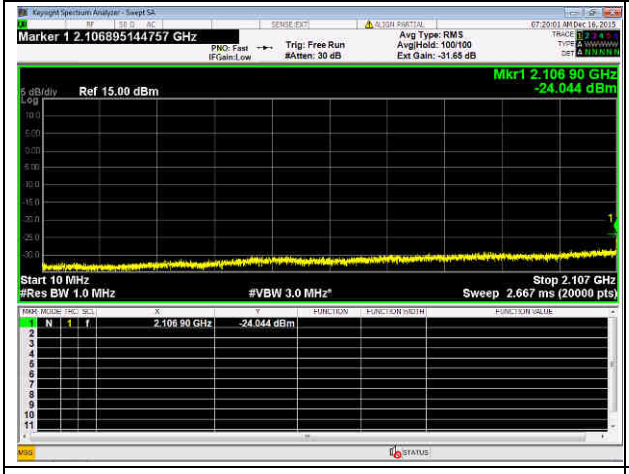

5 MHz 64QAM



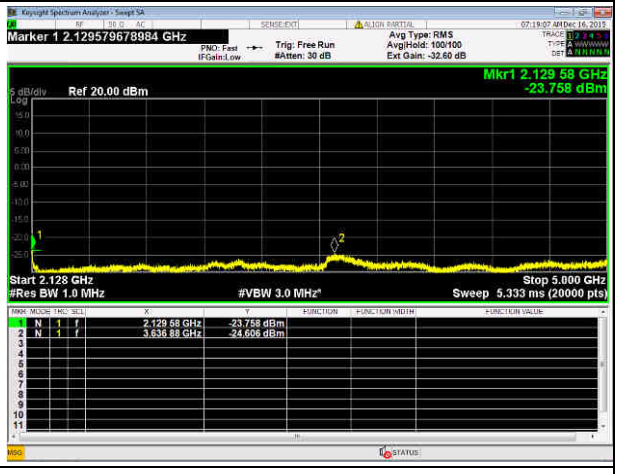

10 MHz QPSK




10 MHz QPSK




15MHz QPSK




15 MHz QPSK

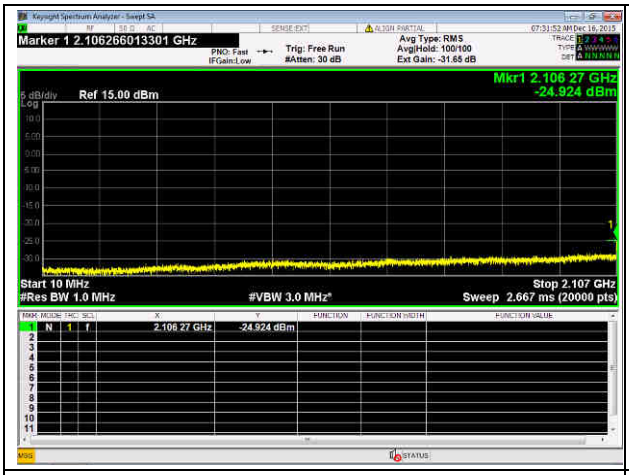
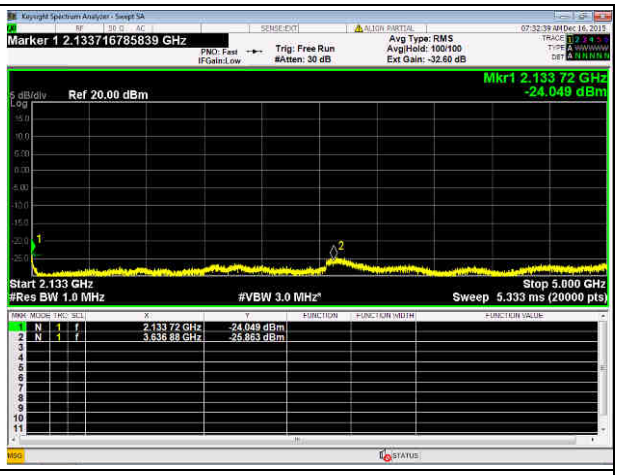
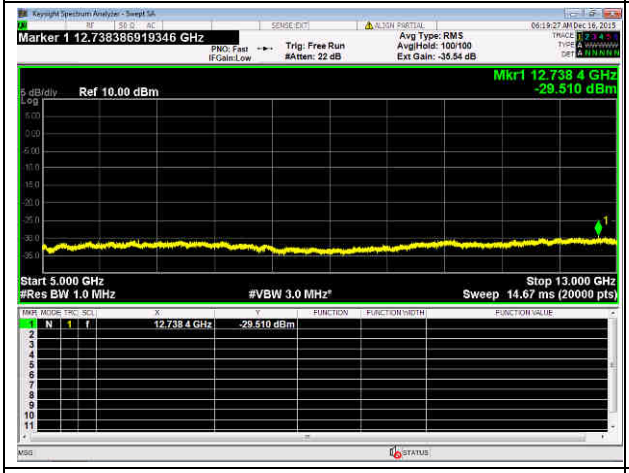
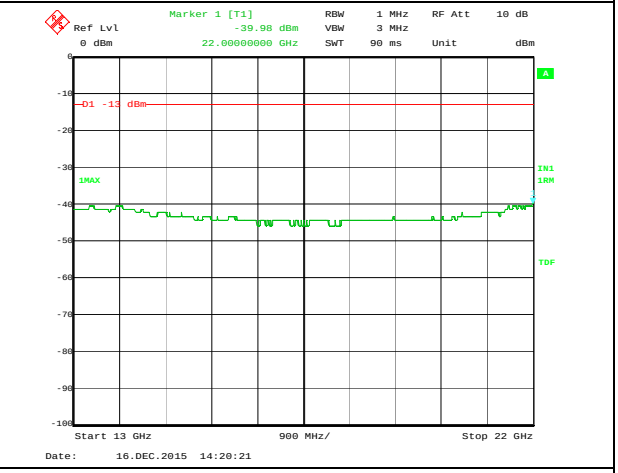
| | |
|---|---|
|  |  |
| 20 MHz QPSK | 20 MHz QPSK |
|  |  |
| 13 to 26 GHz: worst case mode; 5 MHz QPSK | 13 to 26 GHz: worst case mode; 5 MHz channel, QPSK |

**Figure 5: CSE plots**

# 12 Radiated Spurious Emissions

## *12.1 Requirement and test method*

27.53(h) AWS emission limits—

(1) General protection levels. Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB.

(3) *Measurement procedure.*

(i) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

The licensed band of operation was considered to be a single 5 MHz channel for 5 MHz operation, a single 10 MHz channel for 10 MHz operation and so on.

Emissions within 1 MHz of the bandedge were measured using a narrow resolution bandwidth as per 27.53(h).

Attenuation of 43+10log(P) dBm equates to an absolute limit of -13dBm.

All measurements below 18 GHz were performed at 3m distance

Emissions above 18 GHz were measured at 1m.

Pre-scan measurements were performed with a spectrum analyser, using a peak detector with 100 kHz RBW for frequencies below 1 GHz and 1 MHz for frequencies above 1 GHz.

The cabinet radiation was performed while antenna ports were terminated with attenuators and 50Ω loads. Since all ports were transmitting, no summation of spurious emissions is required for radiated tests.

Initial pre-scan measurements were performed with limit determined by

$E = EIRP - 20\log D + 104.8$

Where pre-scans showed emissions within 20dB of the limit, final measurement was made using substitution method, with results presented in section 12.2.

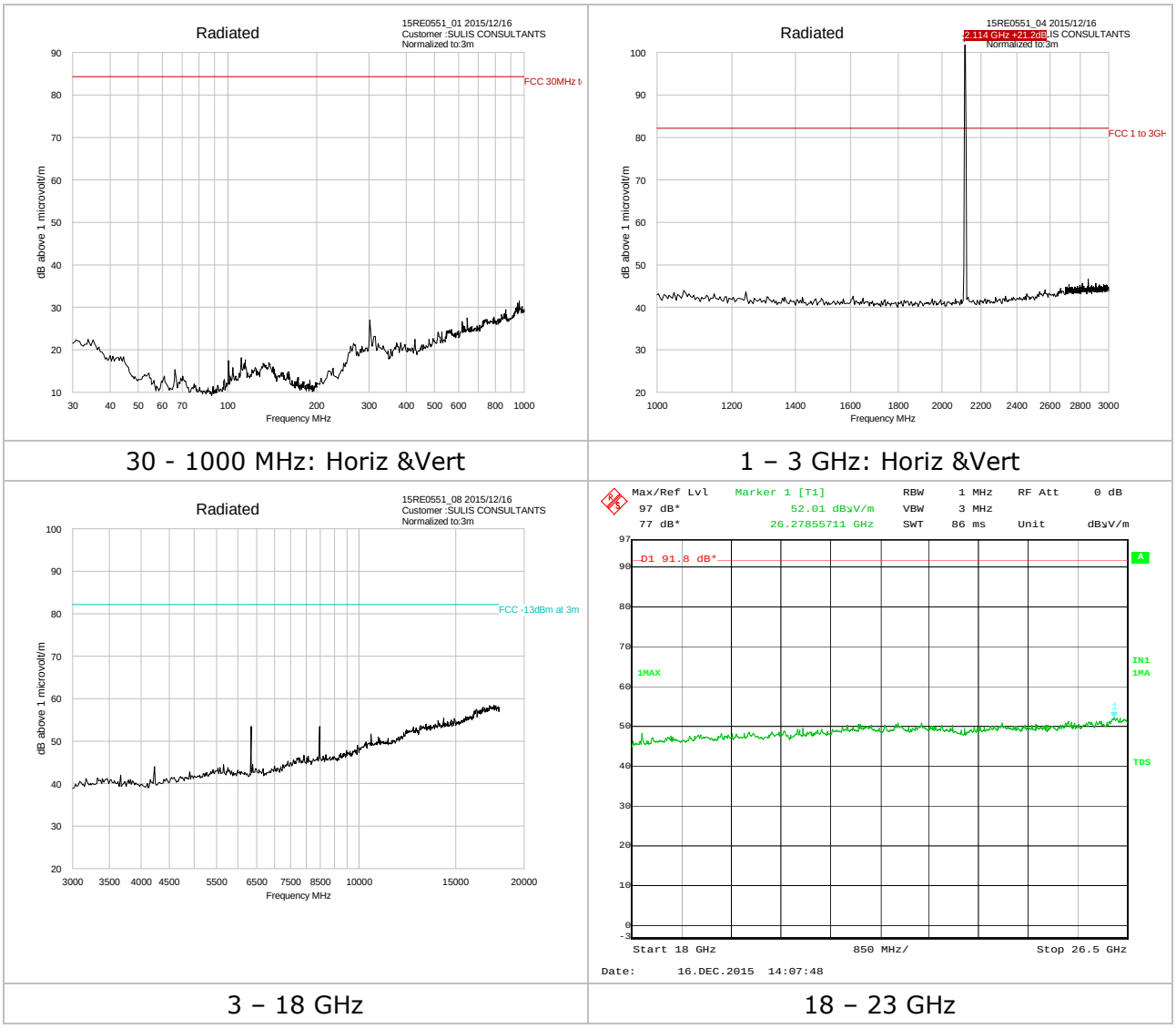



**Figure 6: RSE pre-scans, 5 MHz channel**

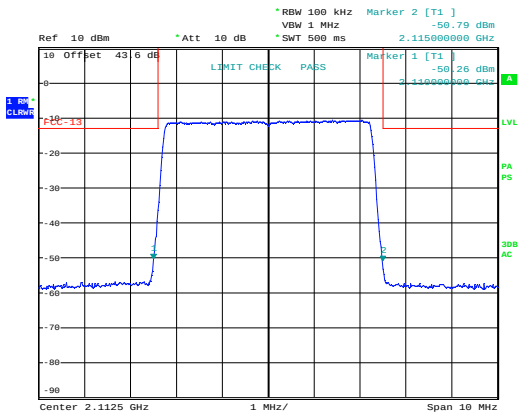
## 12.2 Results

Final pre-scans were performed and emissions maximised for any emissions within 20dB of the limit, a substitution test was performed which was only required for band edge and was performed for all channel bandwidths and modulations:

| Channel Bandwidth | Modulation | Frequency (MHz) | Measurement bandwidth | Emission level (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|---|---|
| 5 | QPSK | 2110.0 | 100 kHz | -50.26 | -13.0 | Pass |
| | QPSK | 2115.0 | 100 kHz | -50.79 | -13.0 | Pass |
| | QPSK | 2110.0 | 300 kHz | -18.52 | -13.0 | Pass |
| | QPSK | 2115.0 | 300 kHz | -18.09 | -13.0 | Pass |
| | 64 QAM | 2110.0 | 300 kHz | -18.03 | -13.0 | Pass |
| | 64 QAM | 2115.0 | 300 kHz | -17.52 | -13.0 | Pass |
| 10 | QPSK | 2110.0 | 300 kHz | -33.37 | -13.0 | Pass |
| | QPSK | 2120.0 | 300 kHz | -32.67 | -13.0 | Pass |
| | 64 QAM | 2110.0 | 300 kHz | -33.38 | -13.0 | Pass |
| | 64 QAM | 2120.0 | 300 kHz | -32.62 | -13.0 | Pass |
| 15 | QPSK | 2110.0 | 300 kHz | -45.48 | -13.0 | Pass |
| | QPSK | 2125.0 | 300 kHz | -44.77 | -13.0 | Pass |
| | QPSK | 2110.0 | 1 MHz | -17.72 | -13.0 | Pass |
| | QPSK | 2125.0 | 1 MHz | -16.81 | -13.0 | Pass |
| | 64 QAM | 2110.0 | 1 MHz | -17.45 | -13.0 | Pass |
| | 64 QAM | 2125.0 | 1 MHz | -16.44 | -13.0 | Pass |
| 20 | QPSK | 2110.0 | 1 MHz | -23.35 | -13.0 | Pass |
| | QPSK | 2130.0 | 1 MHz | -22.90 | -13.0 | Pass |
| | 16 QAM | 2110.0 | 1 MHz | -22.87 | -13.0 | Pass |
| | 64 QAM | 2130.0 | 1 MHz | -22.08 | -13.0 | Pass |

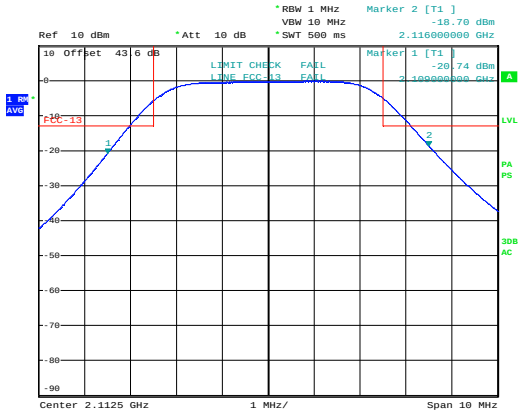
**Table 10: Radiated Spurious Emissions Substitution results**

Note: some results are presented with more than one permitted measurement bandwidth.



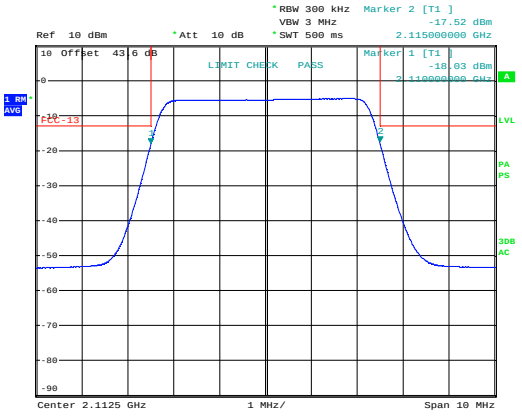

Date: 16.DEC.2015 18:12:30

15J551_5MHZ_QPSK_RSE_100KHZ_RBW



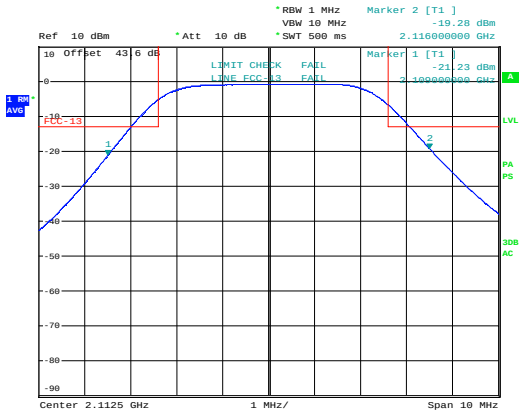

Date: 16.DEC.2015 19:01:23

15J551_5MHZ_64QAM_RSE_1MHZ_RBW



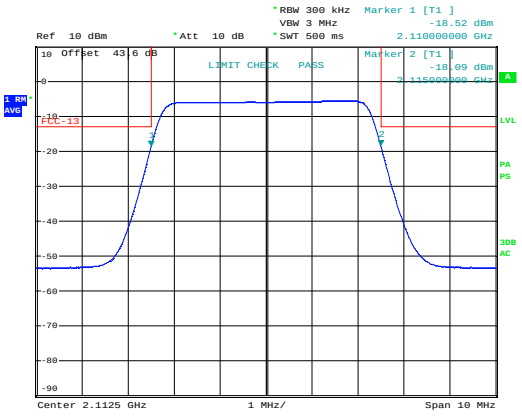

Date: 16.DEC.2015 18:58:32

15J551_5MHZ_64QAM_RSE_300kHZ_RBW



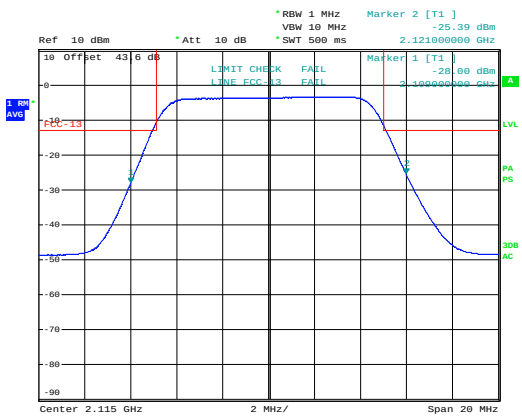

Date: 16.DEC.2015 17:31:37

15J551_5MHZ_QPSK_RSE_1MHZ_RBW

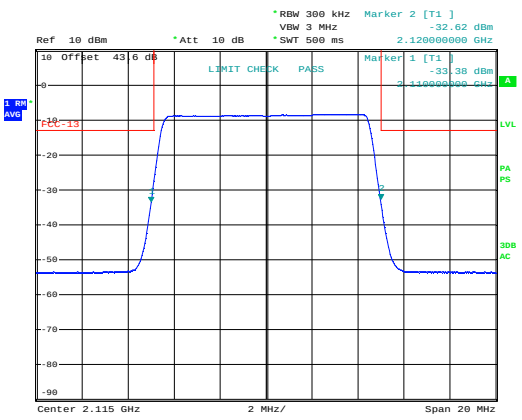



Date: 16.DEC.2015 18:15:25

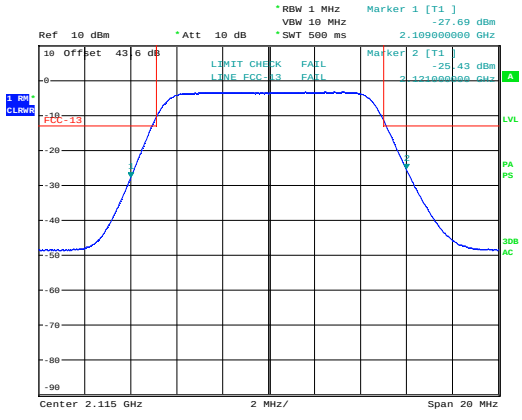
15J551_5MHZ_QPSK_RSE_300KHZ_RBW



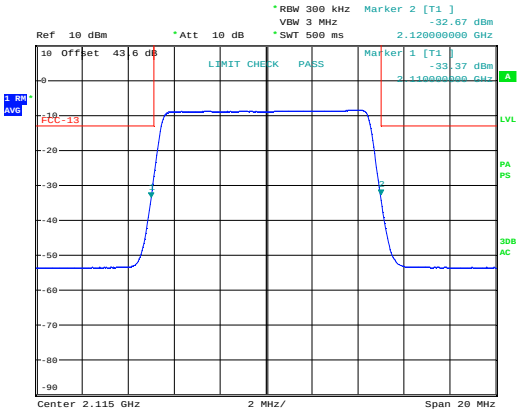

15J551_10MHZ_64QAM_1MHZ_RBW



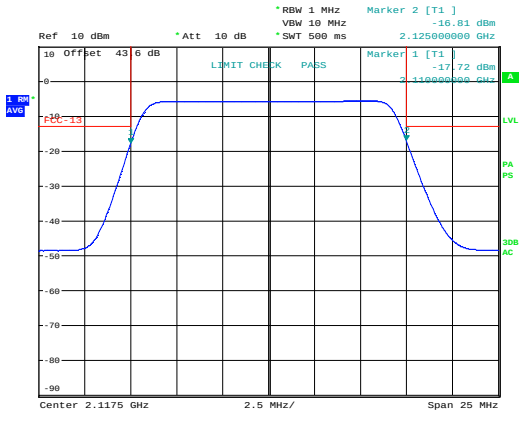

15J551_10MHZ_64QAM_300KHZ_RBW



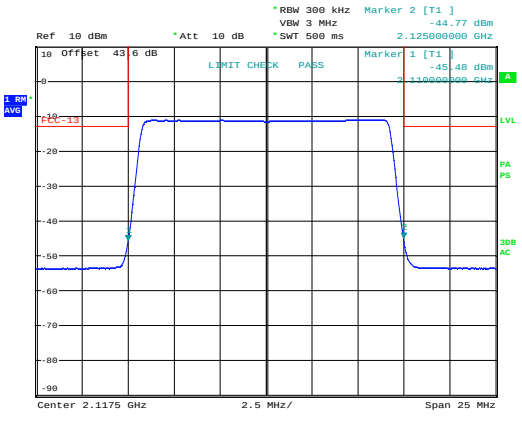

15J551_10MHZ_QPSK_RSE_1MHZ_RBW



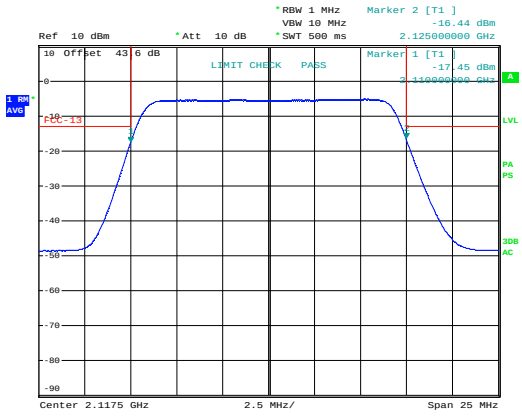

15J551_10MHZ_QPSK_RSE_300KHZ_RBW




15J551_15MHZ_QPSK_RSE_1MHZ_RBW

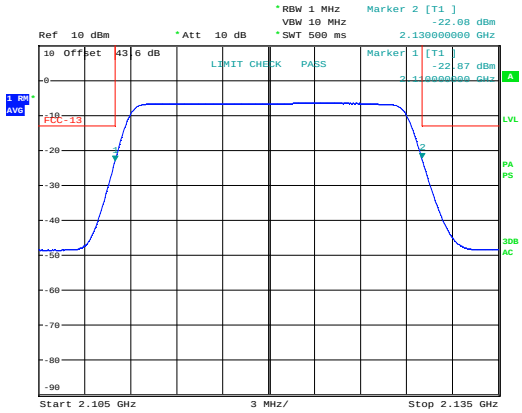


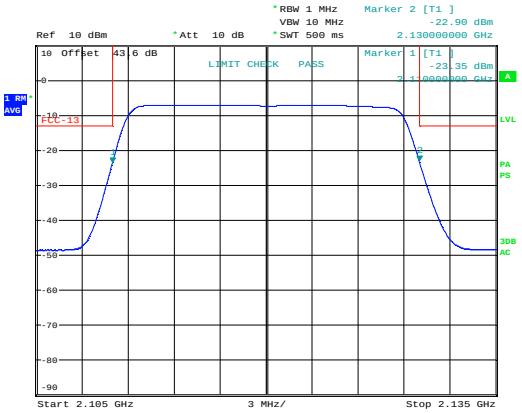

15J551_15MHZ_QPSK_RSE_300KHZ_




No measurement required
(QPSK above for additional margin only)

15J551_15MHZ_64QAM_RSE_1MHZ_




15J551_20MHZ_64QAM_RSE_1MHZ_RBW | 15J551_20MHZ_QPSK_RSE_1MHZ_RBW

**Figure 7: RSE final measurements**

# 13 Test equipment

| Description | Manufacturer | Name | Serial Number | Calibration certificate |
|---|---|---|---|---|
| **Testing at Altiostar** | | | | |
| PXA Signal Analyser | Agilent | N9030A | MY541702228 | 4105006-4886110-1 Due 05/06/16 |
| Network Analyser | HP | 8719D | US38110410 | Electroservices T469471R Due 15/10/16 |
| Attenuator | Fairview Microwave | SA18N100-30 | None | Calibrated before test using Network Analyser |
| RF cable | Times Microwave | SLU18-SMNM-01.50m | 3155 | |
| | | | 3950 | |
| **Testing at Hursley**[2] | | | | |
| Pink 30M-2G Antenna | CHASE | CBL 6141 | HEMC #ID 452 | Cal due 01/10/2018 |
| 1-10GHz Horn | Schwarzbeck | BBHA 9120 571 | HEMC #ID 466 | Cal due 29/01/2016 |
| 2-18GHz Horn | Schwarzbeck | BBHA 9120 C | HEMC #ID 676 | Cal due 28/07/2018 |
| 40GHz receiver | Rohde & Schwarz | ESIB 40 no.2 | HEMC #ID 651 | Cal due 19/02/2016 |
| CISPR 7GHz Receiver | Rohde & Schwarz | ESCI 7 | HEMC #ID 289 | Cal due 12/06/2016 |
| Spectrum analyser | HP | 8593EM | HEMC #ID 033 | Cal due 22/09/2016 |
| RF cable | Intelliconnect | yellow H duty | HEMC #ID 644 | Cal due 05/02/2016 |
| Horn antenna (1-10GHz) | Schwarzbeck | BBHA9120B | HEMC #ID 073 | Cal due 03/07/2016 |

**Table 11: Test Equipment**

[2] Calibration data held by Hursley EMC Services Ltd under their UKAS accreditation, no. 1871