

RF Test Report:

Zinwave ORU

FCC part 27 cellular

FCC ID: UPO302-1107

SC_TR_175_D

Contents

| | | |
|--------|---|----|
| 1 | Revision History | 4 |
| 2 | Purpose..... | 4 |
| 3 | Reference Documents | 4 |
| 4 | Test Information | 5 |
| 4.1 | Client and manufacturer..... | 5 |
| 4.2 | Test Locations..... | 5 |
| 4.3 | Test sample..... | 5 |
| 5 | Test Configuration | 6 |
| 5.1 | Test sample and Operating mode | 6 |
| 5.2 | Support equipment..... | 6 |
| 5.3 | Equipment arrangement..... | 7 |
| 6 | Summary of Tests performed..... | 8 |
| 6.1 | Comments on requirements in KDB 935210 D05 V01: | 8 |
| 7 | Determination of f_0 | 9 |
| 8 | Transmit Power: 698 – 758 MHz..... | 10 |
| 8.1 | Test method | 10 |
| 8.2 | Test results | 10 |
| 8.2.1 | AWGN signal..... | 10 |
| 9 | Occupied bandwidth: 698 – 758 MHz | 11 |
| 9.1 | Test method | 11 |
| 9.2 | Test results | 11 |
| 10 | FCC CSE inc. Band Edge: 698 – 758 MHz | 12 |
| 10.1 | Requirement and test method 698-746 MHz band | 12 |
| 10.2 | Test results for 698-746 MHz band | 12 |
| 10.2.1 | Single frequency, inc. band edge..... | 13 |
| 10.2.2 | Dual Channel: AWGN..... | 14 |
| 10.3 | Requirement and test method 746-758 MHz band | 15 |
| 10.4 | Test results for 746-758 MHz band | 15 |
| 10.4.1 | Single frequency, inc. band edge..... | 16 |
| 10.4.2 | Emissions between 763-775 MHz and 793-805 MHz | 17 |
| 10.4.3 | Emissions in the band 1559-1610 MHz..... | 18 |
| 10.4.4 | Dual Channel: AWGN..... | 19 |
| 11 | Transmit Power: 2110-2155 MHz | 20 |
| 11.1 | Test method | 20 |
| 11.2 | Test results | 20 |
| 12 | Occupied Bandwidth: 2110-2155 MHz | 21 |
| 12.1 | Test method | 21 |
| 12.2 | Test results | 21 |
| 13 | CSE inc. Band Edge: 2110-2155 MHz | 22 |

| | | |
|--------|----------------------------------|----|
| 13.1 | Requirement and test method..... | 22 |
| 13.2 | Test results | 22 |
| 13.2.1 | Wideband single frequency | 23 |
| 13.2.2 | Dual Channel: AWGN..... | 25 |
| 14 | Test equipment | 26 |

Tables

| | | |
|----------|----------------------------------|----|
| Table 1: | Equipment under test | 6 |
| Table 2: | Support Equipment | 6 |
| Table 3: | Summary of tests performed | 8 |
| Table 4: | Transmit power | 10 |
| Table 5: | Transmit power | 20 |
| Table 6: | Test Equipment..... | 26 |

Figures

| | | |
|------------|---|----|
| Figure 1: | Test configuration – single channel | 7 |
| Figure 2: | Test configuration – dual channel..... | 7 |
| Figure 3: | Determination of f_0 for bands of operation..... | 9 |
| Figure 4: | Power and Peak to Average (PAR) plots | 10 |
| Figure 5: | Input vs output plot | 11 |
| Figure 6: | Example 3-8 GHz CSE (720.5 MHz) showing noise floor emissions | 12 |
| Figure 7: | CSE except band edge for 698 – 746 MHz band | 13 |
| Figure 8: | CSE band edge for 698 – 746 MHz band – dual channel..... | 14 |
| Figure 9: | CSE inc band edge for 746 – 756 MHz band | 16 |
| Figure 10: | Emissions between 763-775 MHz and 793-805 MHz | 17 |
| Figure 11: | Emissions in the band 1559-1610 MHz..... | 18 |
| Figure 12: | CSE band edge for 746-758 MHz band – dual channel | 19 |
| Figure 13: | Peak to Average (PAR) plots for two supported modulations | 20 |
| Figure 14: | Input vs output plot | 21 |
| Figure 15: | CSE except band edge 2110-2155 MHz Band..... | 23 |
| Figure 16: | CSE and band edge 2110-2155 MHz Band | 24 |
| Figure 17: | CSE and band edge 2110-2155 MHz Band dual channel | 25 |

1 Revision History

| Revision | Originator | Date | Comment | Signature |
|-----------------|--|----------------|-------------------------|---|
| A | C Blackham Director, Sulis Consultants Ltd | 08 Dec 2015 | Customer copy | |
| B | C Blackham Director, Sulis Consultants Ltd | 09 Jan 2016 | 1 st release | |
| C | C Blackham Director, Sulis Consultants Ltd | 09 Feb 2016 | Minor update | |
| D | C Blackham Director, Sulis Consultants Ltd | 04 May 2016 | Minor update |  |

2 Purpose

This document details the Zinwave Optical Remote Unit, ORU, model number 302-1107, whilst operating in the Part 27 698 – 758 MHz and 2110 – 2180 MHz cellular bands.

3 Reference Documents

- [1] 47CFR2 Title 47 Code of Federal Regulations Part 2: frequency allocations and radio treaty matters; general rules and regulations
- [2] 47 CFR27 Title 47 Code of Federal Regulations Part 27: Miscellaneous Communications Services
- [3] TIA-603-D Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards
- [4] KDB 935210 D05 V01 Federal Communications Commission Office of Engineering and Technology Laboratory Division; Measurement guidance for Industrial and Non-consumer signal booster, repeater and amplifier devices
- [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 and manufacturer

Zinwave Ltd

Harston Mill

Harston

Cambridge

CB22 7GG

UK

4.2 Test Locations

Testing was performed by Charlie Blackham of Sulis Consultants Ltd between 13th and 29th October 2015, and on the 6th January 2016 and the 2nd May 2016 at Zinwave's offices detailed in section 4.1.

4.3 Test sample

The results herein only refer to sample detailed in section 5

5 Test Configuration

5.1 Test sample and Operating mode

The equipment under test (EUT) was:

| Manufacturer | Name | Model Number | Serial Number |
|--------------|------|--------------|---------------|
| Zinwave | ORU | 302-1107 | 310400000022 |

Table 1: Equipment under test

Modifications during test: None

Procedure:

- Set the system to maximum gain using the network management software
- Connect the signal generator to the RF service module of the Primary Hub
- Raise the signal level until the maximum output power is reached
- Perform the required test.

Test modulations:

- The system supports operation with a number of wideband services, so testing was performed with AWGN signal as per KDB 935210 D05.

5.2 Support equipment

The following equipment shall be used, configured as shown in Figure 1:

| Name | Part Number | Label | Serial Number |
|---------------------------------------|-------------|----------|-------------------|
| Zinwave UNIhub (Primary Hub) | | | |
| Chassis | | 302-1001 | 00-17-68-00-09-B7 |
| RF Service module | | SM 1/6 | 030370002050 |
| Optical module | | OM 1/6 | 050750002036 |
| Zinwave UNIhub (Secondary Hub) | | | |
| Chassis | | 302-1001 | 00-17-68-00-09-67 |
| Input Optical module | | OM 5/6 | 050750002039 |
| Optical module | | OM 3/6 | 050750002010 |

Table 2: Support Equipment

5.3 Equipment arrangement

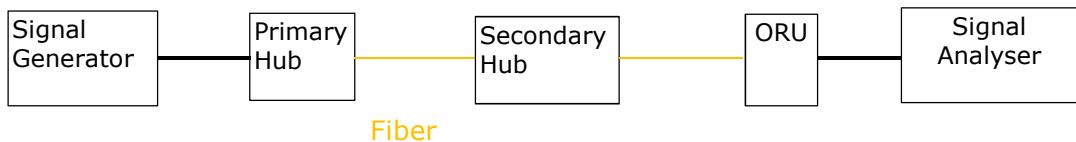


Figure 1: Test configuration – single channel

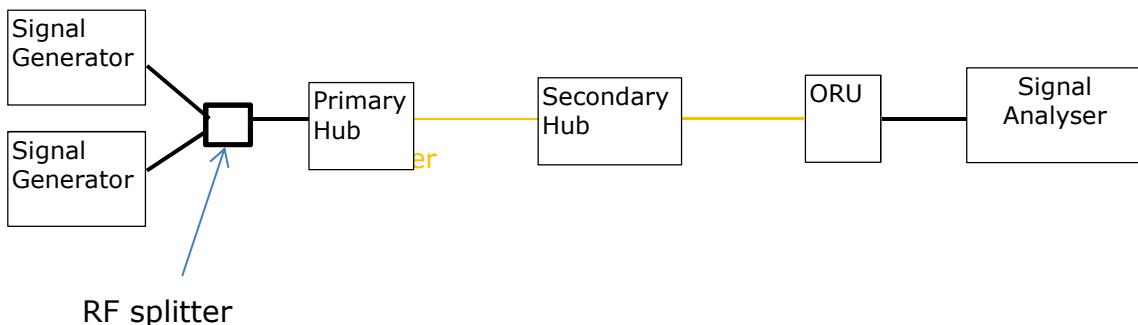


Figure 2: Test configuration – dual channel

Notes – additional connections not shown:

1. IQ output from SMBV100A Vector Signal Generator connected to IQ input of SMJ100A signal generator
2. 10 MHz Ref Clock output of FSV40 Signal Analyser connected to Ref Clock inputs of the two signal generators

6 Summary of Tests performed

| Test | Band (MHz) | 47 CFR Part | FCC limit | Section | Result |
|---|-------------|---|-----------------------|---------|--------|
| Determination of f_0 | 698 – 758 | KDB 935210 D05 Section 3.3 | None | 7 | N/A |
| | 2110 - 2180 | | | 7 | N/A |
| Transmit Power | 698 - 758 | 27.50(c) | 65 W ERP ¹ | 8 | Pass |
| | 2110 - 2180 | 27.50(d) | 1640 W EIRP | 11 | Pass |
| Occupied Bandwidth | 698 – 758 | 2.1049 KDB 935210 D05 Section 3.4 | None | 9 | Pass |
| | 2110 - 2180 | | | 12 | Pass |
| Conducted Spurious Emissions inc. band edge | 698 – 746 | 27.53(g) | -13dBm | 10 | Pass |
| | 746 - 758 | 27.52(c) | Various | | Pass |
| | 2110 - 2180 | 27.53(h) | - 13dBm | 13 | Pass |

Table 3: Summary of tests performed

6.1 Comments on requirements in KDB 935210 D05 V01:

| Section | Comment |
|--|---|
| 3.1 General | Two signal sources shall be used: <ul style="list-style-type: none"> “narrowband” 200kHz MSK “wideband” 4.2 MHz 16QAM |
| 3.2 Measuring the EUT AGC threshold | Not applicable to ORU and 3000 DAS “Devices intended to be directly connected to an RF source only need to be evaluated for any over-the-air transmit paths.” There are no such over-the-air paths |
| pre-TCB KDB FCC response | Increased input level test not required due to 3.2 |
| 3.7 EUT frequency stability measurements | Not required as DAS does not contain oscillator and therefore has no ability to change frequency. |

¹ Limit is actually W / MHz, but since bandwidth of signal is not known and the actual TX power is < 1W EIRP, the 65 W limit from table 3 covers all options for bandwidth and antenna height across the whole band

7 Determination of f_0

As per kDB 935210 D05 section 3.3, but measurement was performed over the service band frequency range only.

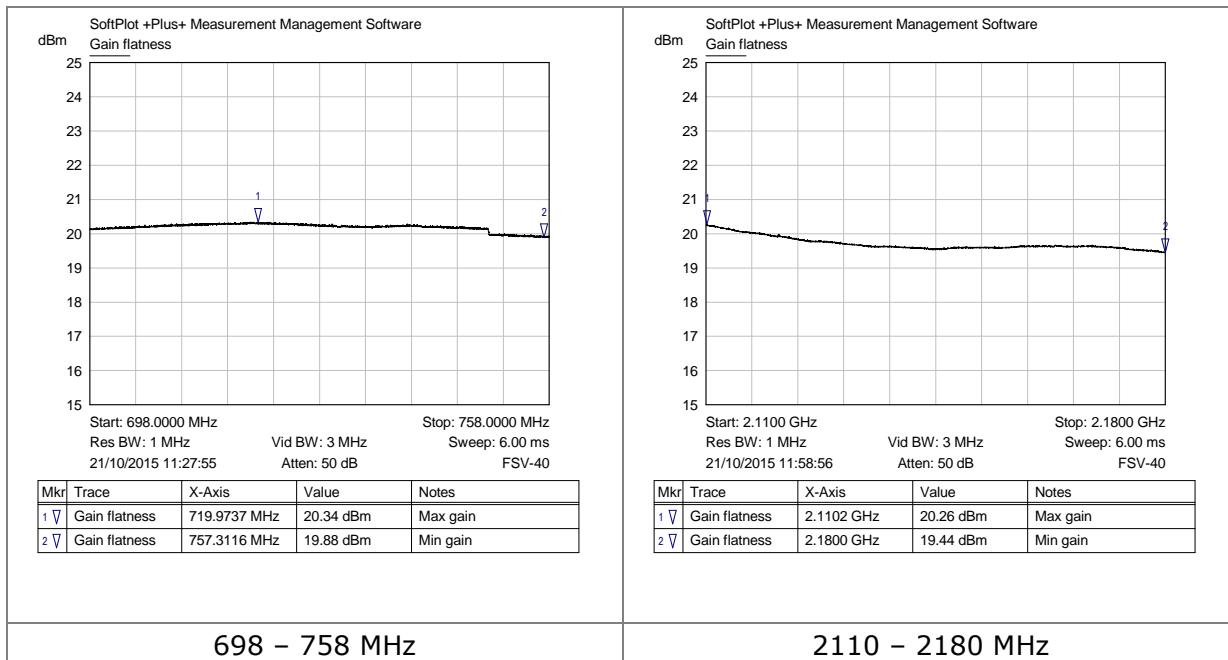


Figure 3: Determination of f_0 for bands of operation

8 Transmit Power: 698 – 758 MHz

8.1 Test method

The equipment was configured with maximum gain of 25dB and connected as per figure 1.

The signal generator was set to provide -5dBm to the input of the hub and the frequency set to an appropriate channel to include f_0 as determined in section 7.

Measurements were made in accordance with KDB 971168 D01 using an RMS detector and the Peak to Average ratio was measured using the CCDF function of the analyser.

8.2 Test results

8.2.1 AWGN signal

The table below shows the results for

| Frequency | TX power (dBm) | TX power EIRP (dBm) | TX power EIRP (W) | Limit EIRP (W) | 0.1% PAR | Result |
|-----------|----------------|---------------------|-------------------|----------------|----------|--------|
| 720.0 | 19.15 | 27.15 | 0.52 | 1640.0 | 8.72 dB | Pass |

Table 4: Transmit power

Plots may be seen in figures 7 and 13.

Peak to Average (PAR) ratio is related to the modulation waveform, and not the frequency of operation, so results presented for channel 1587 cover all frequencies in this band of operation

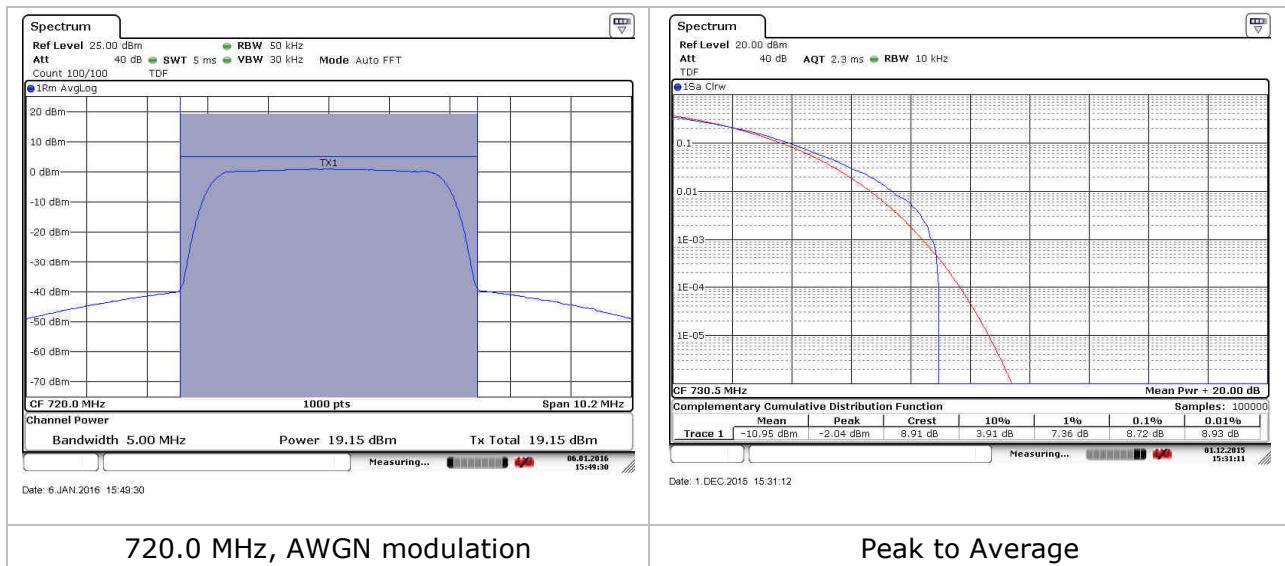


Figure 4: Power and Peak to Average (PAR) plots

9 Occupied bandwidth: 698 – 758 MHz

9.1 Test method

KDB 935210 D05 section 3.4

The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the 99% emission bandwidth. Measurement was made using peak detector.

The results were captured using Softplot and the output signal was overlaid over the input signal.

9.2 Test results

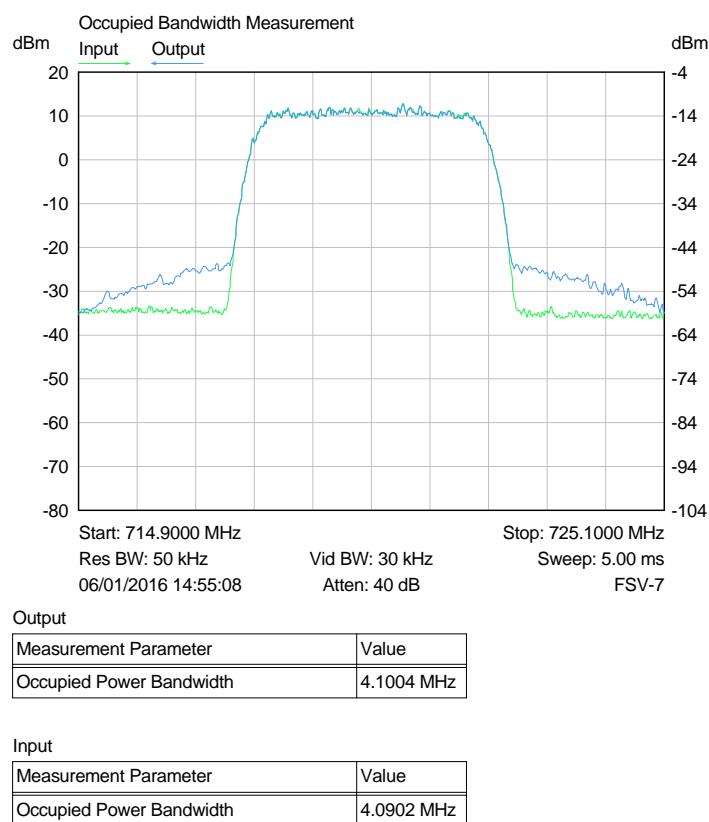


Figure 5: Input vs output plot

10 FCC CSE inc. Band Edge: 698 – 758 MHz

10.1 Requirement and test method 698-746 MHz band

27.53

(g) For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P)$ dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

Some emissions > 1 MHz from bandedge were measured using the spectrum analyser adjacent channel power function that integrated power from a lower resolution bandwidth into the 1 MHz required by the rule part.

10.2 Test results for 698-746 MHz band

Plots are included for all modes up to 3GHz.

No emissions above noise floor above 3 GHz for any frequency of operation

Single channel measurements were > 20 dB below the limit

Dual channel measurements were > 15 dB below the limit

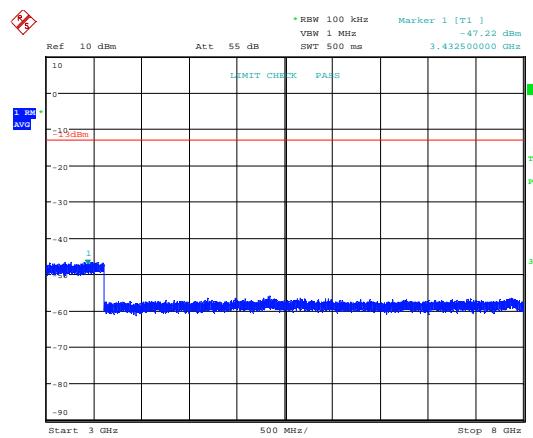


Figure 6: Example 3-8 GHz CSE (720.5 MHz) showing noise floor emissions

10.2.1 Single frequency, inc. band edge

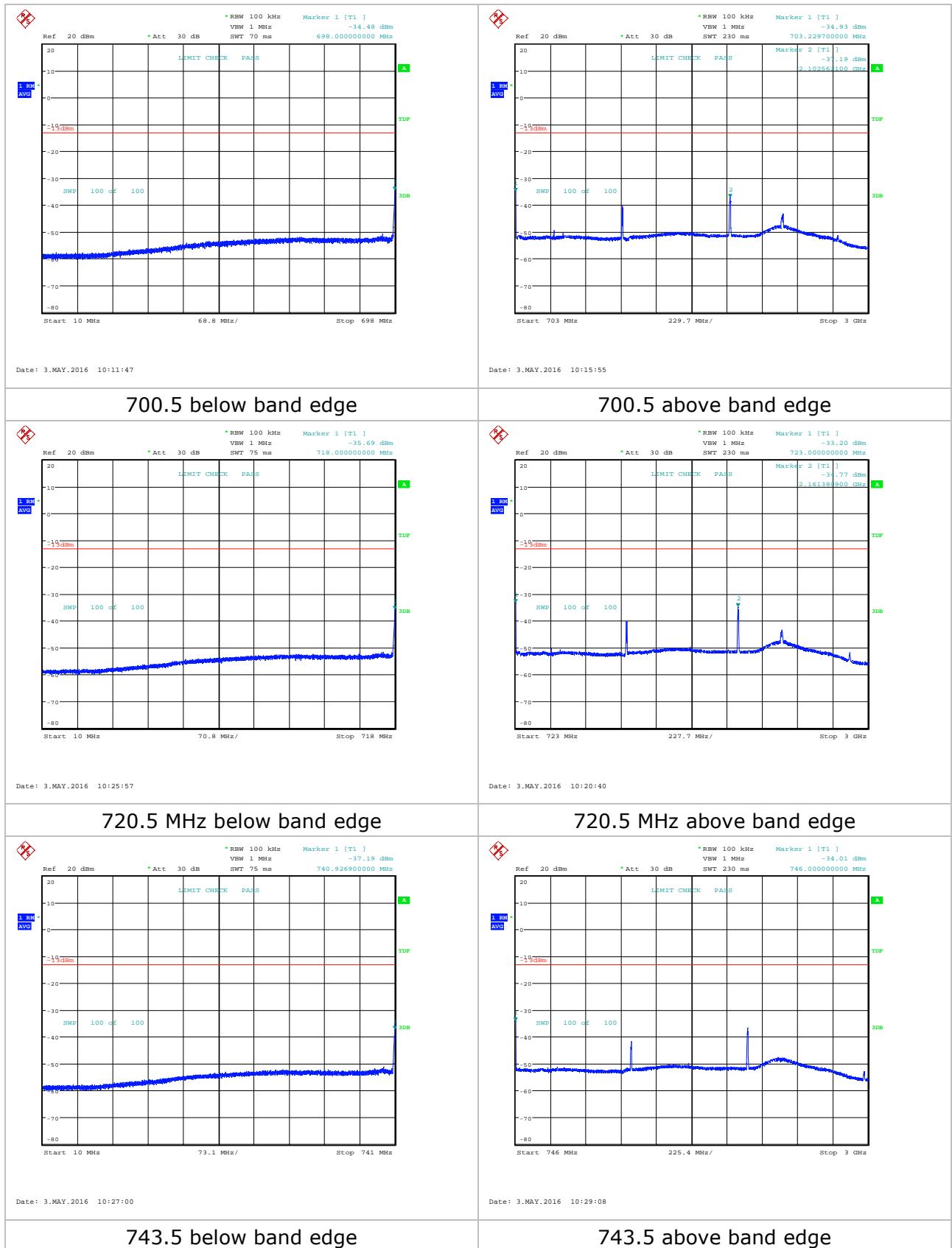


Figure 7: CSE except band edge for 698 – 746 MHz band

10.2.2 Dual Channel: AWGN

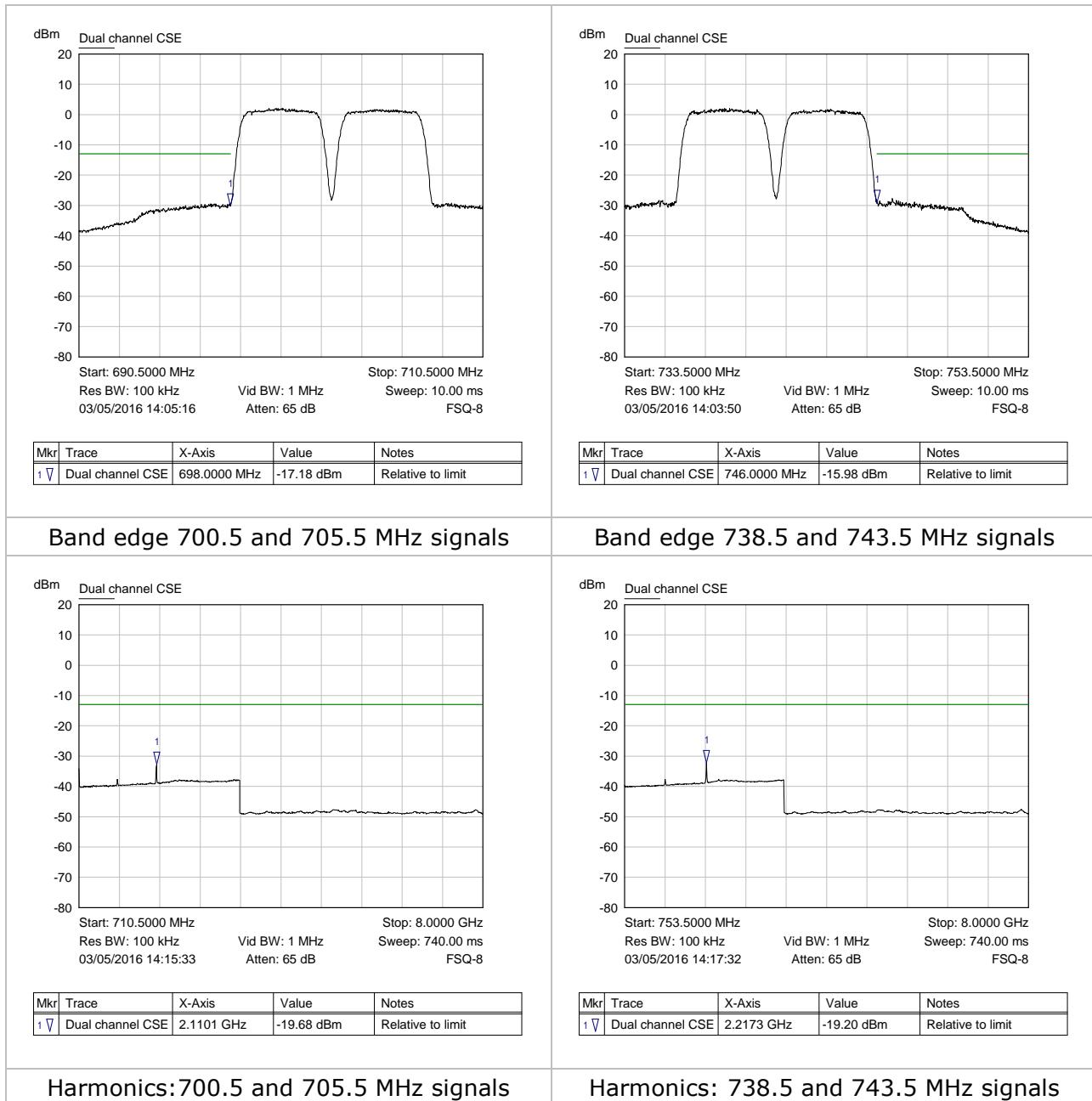


Figure 8: CSE band edge for 698 – 746 MHz band – dual channel

10.3 Requirement and test method 746-758 MHz band

27.53

(c) For operations in the 746-758 MHz band and the 776-788 MHz band, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

- (1) On any frequency outside the 746-758 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least $43 + 10 \log (P)$ dB;
- (3) On all frequencies between 763-775 MHz and 793-805 MHz, by a factor not less than $76 + 10 \log (P)$ dB in a 6.25 kHz band segment, for base and fixed stations;
- (5) Compliance with the provisions of paragraphs (c)(1) and (c)(2) of this section is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. However, in the 100 kHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of at least 30 kHz may be employed;
- (6) Compliance with the provisions of paragraphs (c)(3) and (c)(4) of this section is based on the use of measurement instrumentation such that the reading taken with any resolution bandwidth setting should be adjusted to indicate spectral energy in a 6.25 kHz segment.

(f) For operations in the 746-758 MHz, 775-788 MHz, and 805-806 MHz bands, emissions in the band 1559-1610 MHz shall be limited to -70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation

(note: -70 dBW EIRP equates to a limit of -78 dBW conducted for 8dBi antenna, which is -48 dBm and -80 dBW EIRP equates to a limit of -88 dBW conducted for 8dBi antenna, which is -58 dBm for narrowband)

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

10.4 Test results for 746-758 MHz band

Plots are included for all modes up to 3GHz.

No emissions above noise floor above 3 GHz for any frequency of operation

10.4.1 Single frequency, inc. band edge

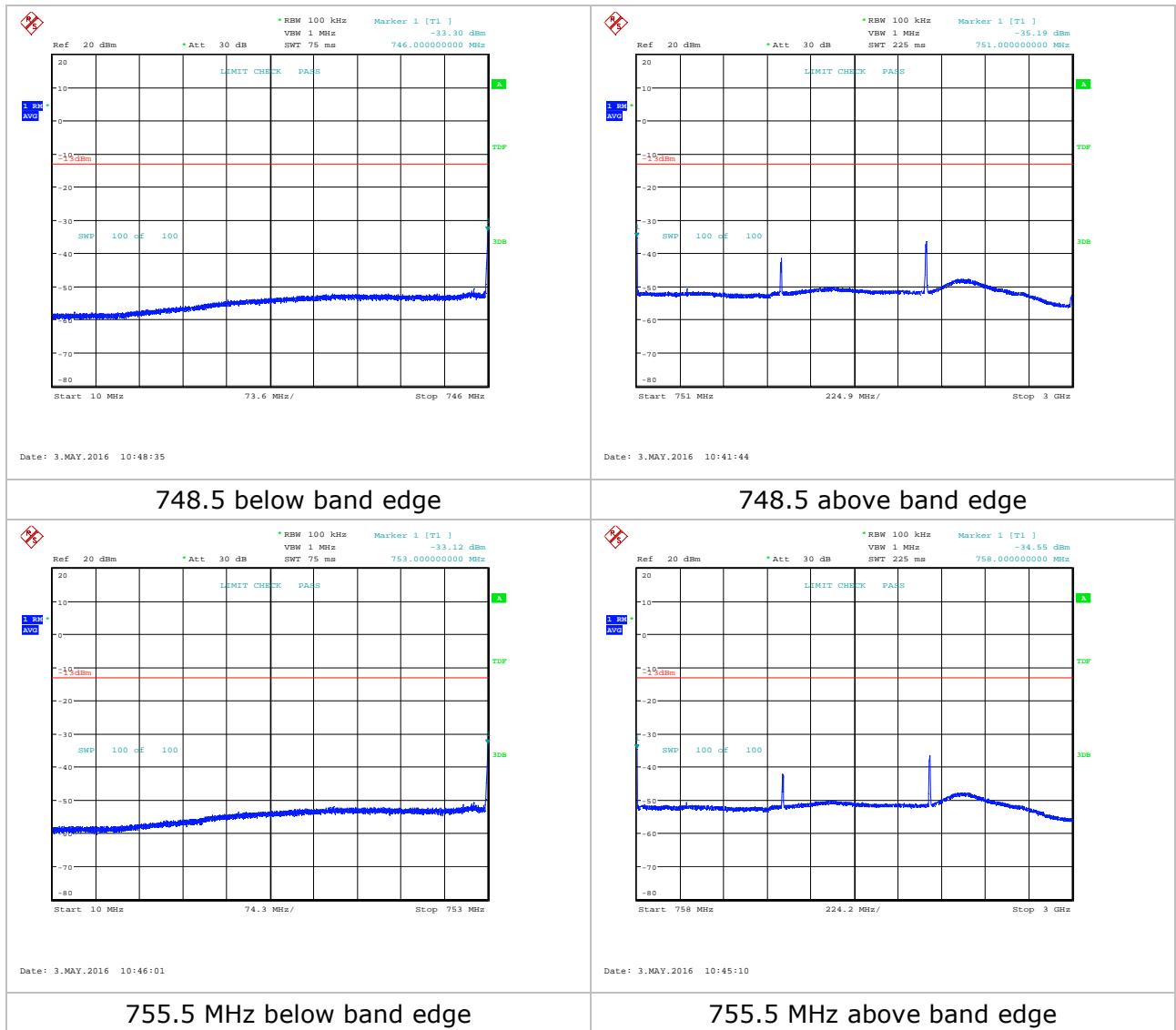


Figure 9: CSE inc band edge for 746 – 756 MHz band

10.4.2 Emissions between 763-775 MHz and 793-805 MHz

On all frequencies between 763-775 MHz and 793-805 MHz, by a factor not less than $76 + 10 \log (P)$ dB in a 6.25 kHz band segment, for base and fixed stations;

This equates to a limit of -46dBm

Note: 6.25kHz Narrowband emissions measured with a 10kHz RBW which was sufficient for showing compliance.

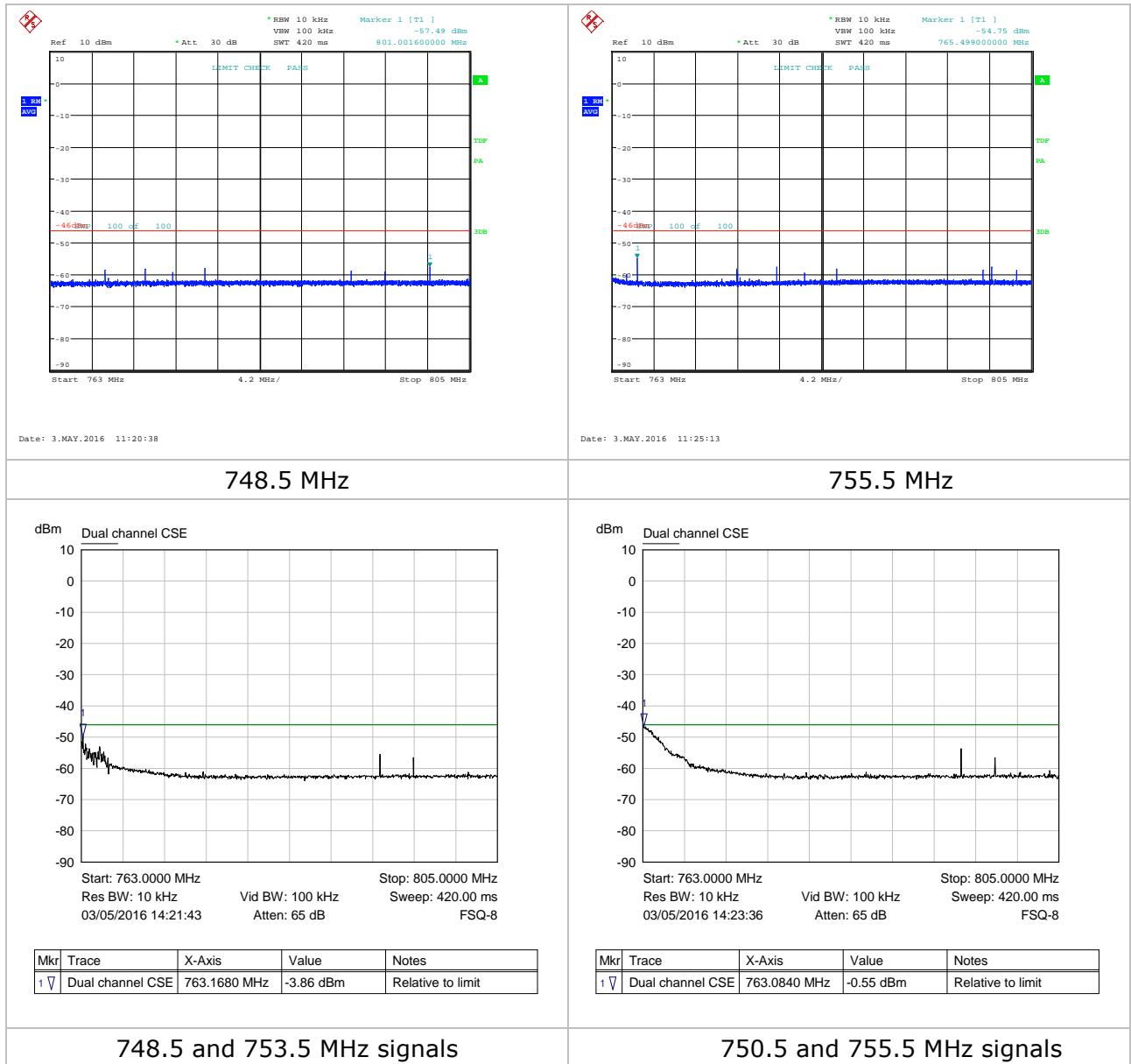


Figure 10: Emissions between 763-775 MHz and 793-805 MHz

10.4.3 Emissions in the band 1559-1610 MHz

(f) For operations in the 746-758 MHz, 775-788 MHz, and 805-806 MHz bands, emissions in the band 1559-1610 MHz shall be limited to -70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation

Note: -70 dBW EIRP equates to a limit of -78 dBW conducted for 8dBi antenna, which is -48 dBm and -80 dBW EIRP equates to a limit of -88 dBW conducted for 8dBi antenna, which is -58 dBm for narrowband

Wideband emissions measured with a 1 MHz RBW, and narrowband emissions measured with a 10kHz RBW which was sufficient for showing compliance.

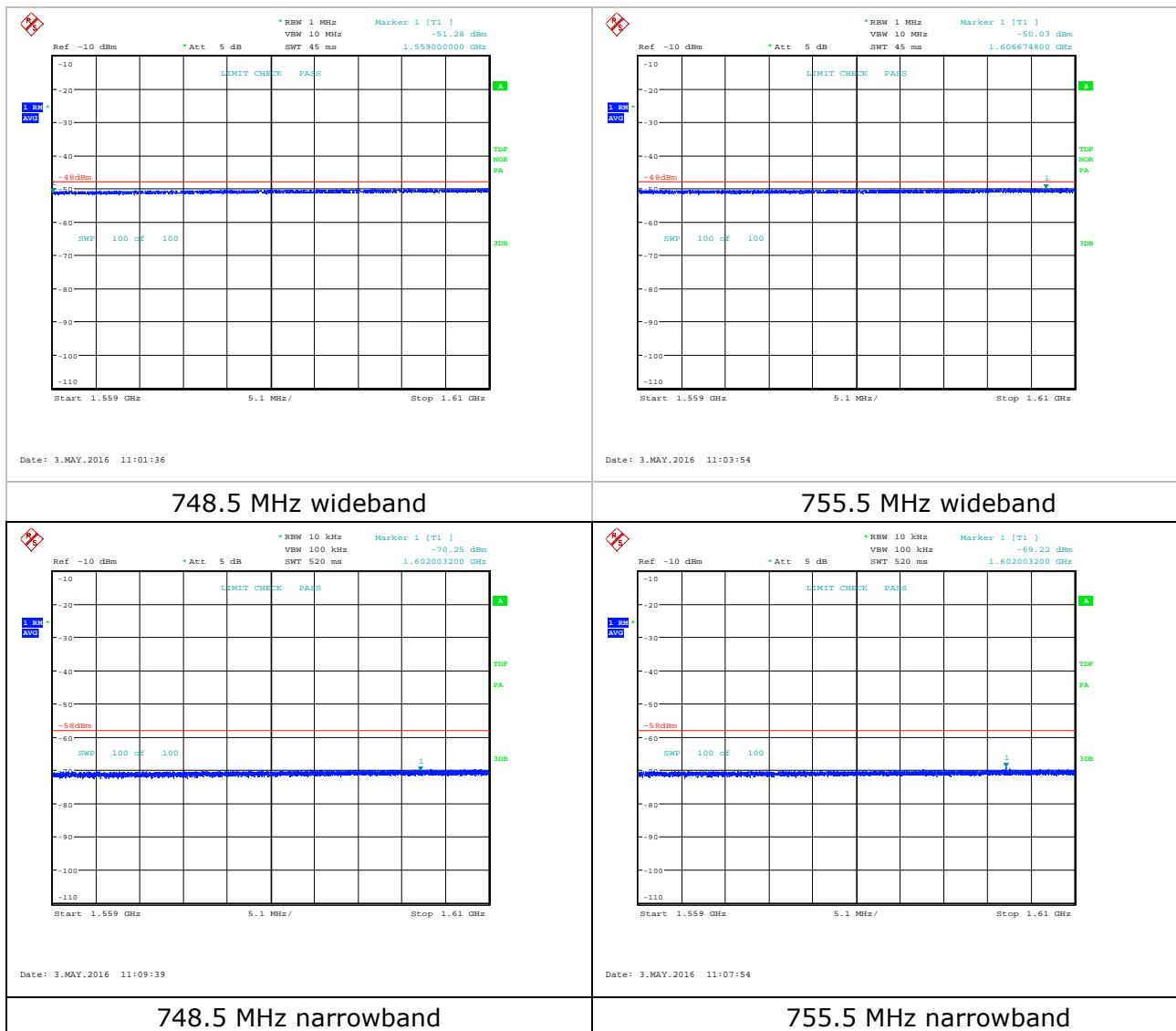


Figure 11: Emissions in the band 1559-1610 MHz

10.4.4 Dual Channel: AWGN

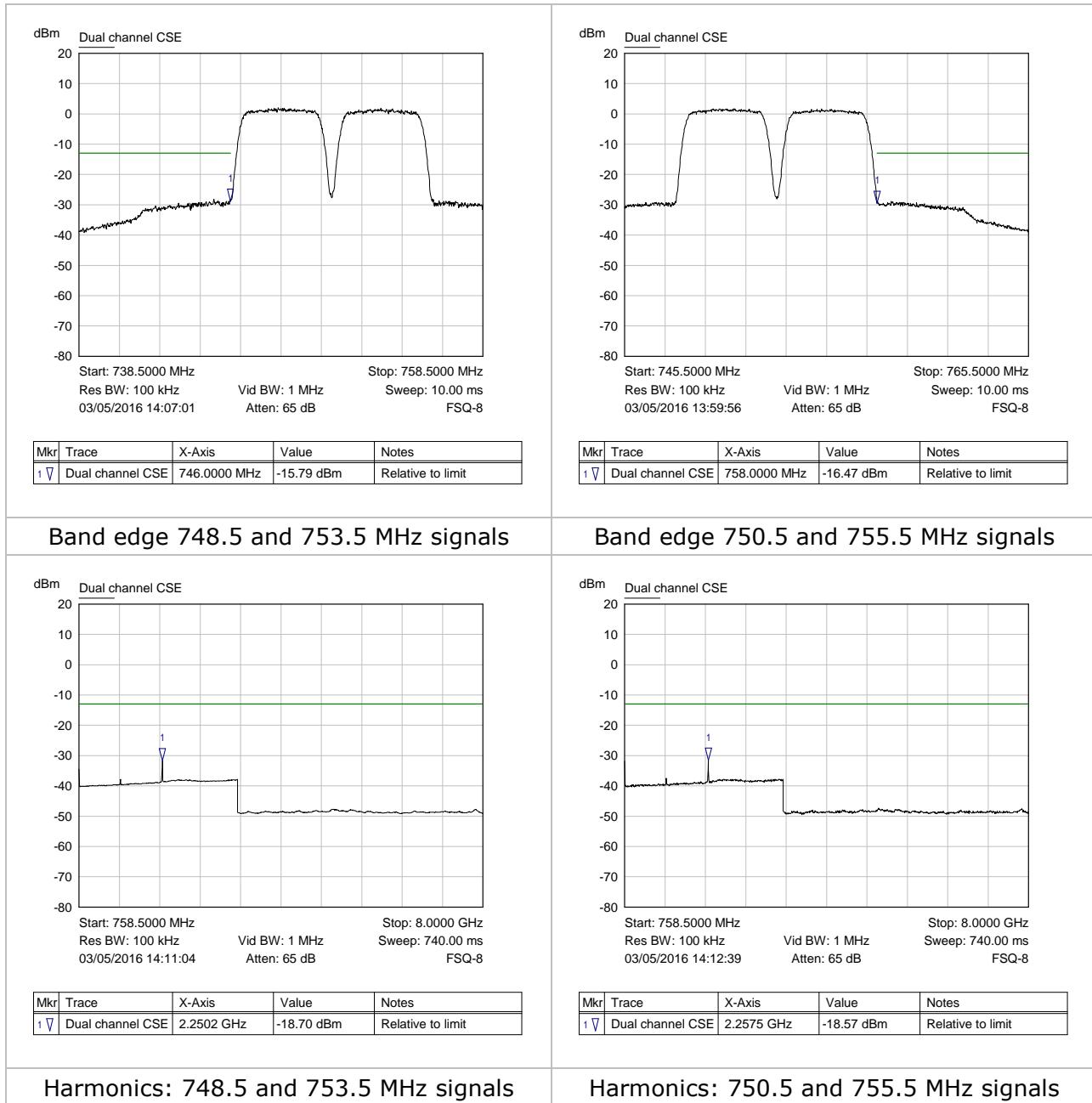


Figure 12: CSE band edge for 746-758 MHz band – dual channel

11 Transmit Power: 2110-2155 MHz

11.1 Test method

The equipment was configured as per figure 1 and the measurements were made in accordance with KDB 971168 D01 using an RMS detector and the Peak to Average ratio was measured using the CCDF function of the analyser.

11.2 Test results

| Frequency | TX power (dBm) | TX power EIRP (dBm) | TX power EIRP (W) | Limit EIRP (W) | 0.1% PAR | Result |
|-----------|----------------|---------------------|-------------------|----------------|----------|--------|
| 2112.5 | 21.45 | 29.45 | 0.88 | 1640.0 | 8.29 dB | Pass |

Table 5: Transmit power

Peak to Average (PAR) ratio is related to the modulation waveform, and not the frequency of operation, so results presented for channel 1587 cover all frequencies in this band of operation

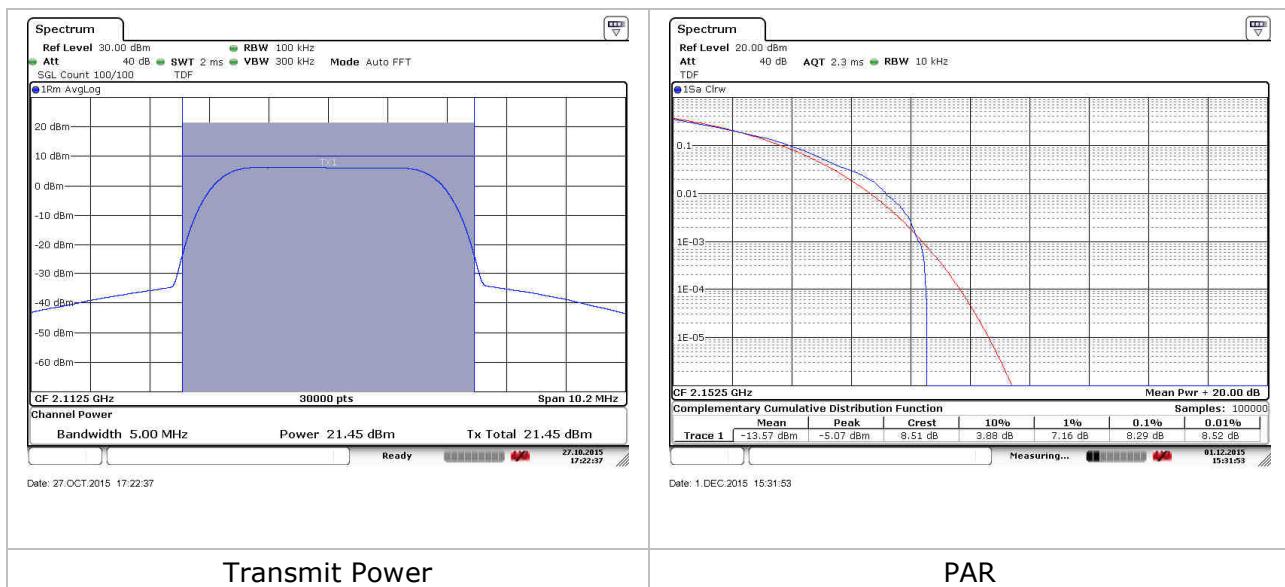


Figure 13: Peak to Average (PAR) plots for two supported modulations

12 Occupied Bandwidth: 2110-2155 MHz

12.1 Test method

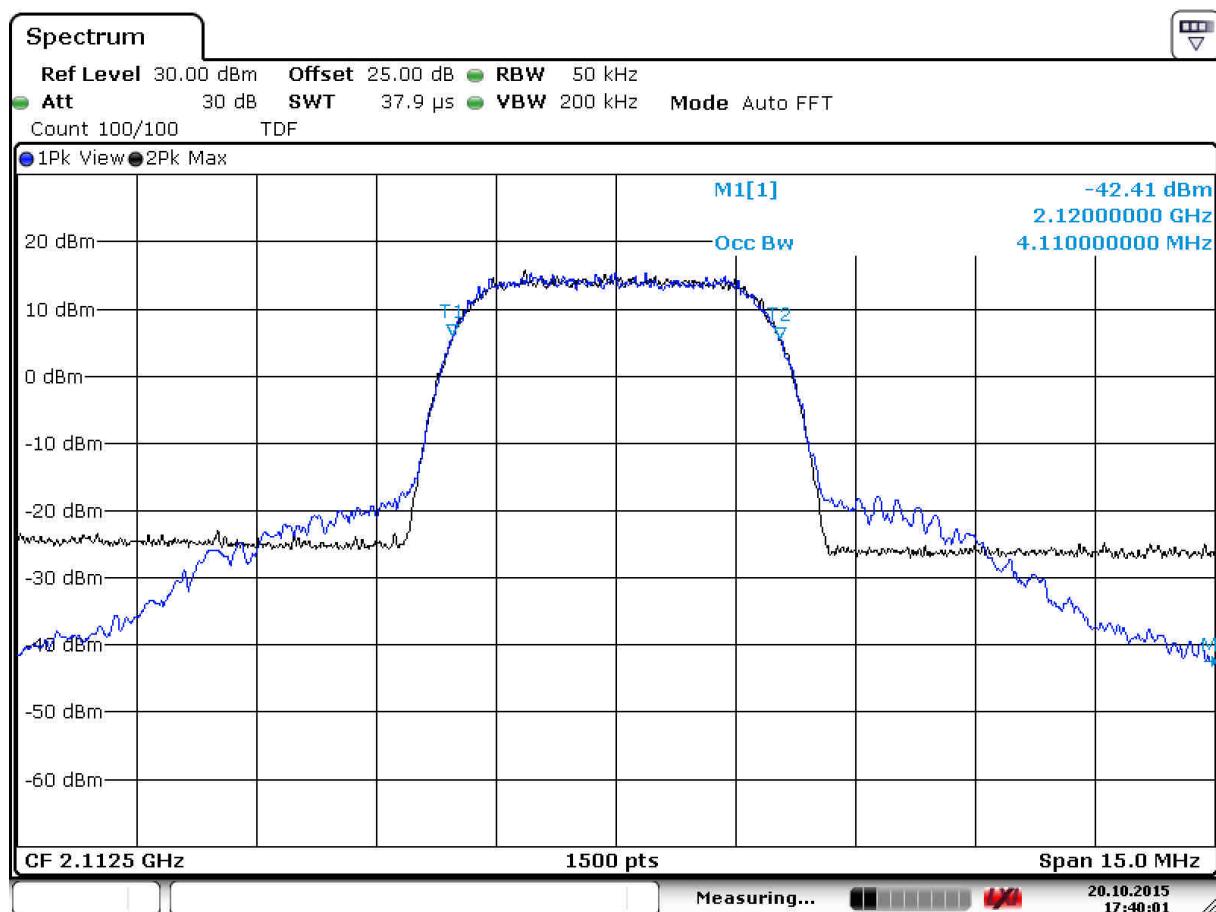
KDB 935210 D05 section 3.4.

The occupied bandwidth was measured using the inbuilt function on the Signal Analyser set to measure the 99% emission bandwidth. Measurement was made using peak detector.

Black trace is the output of the EUT with occupied bandwidth value reported

Blue trace is input to the EUT with Ref Level Offset adjusted by 25dB to overlap the plot

12.2 Test results



Date: 20.OCT.2015 17:40:00

Figure 14: Input vs output plot

13 CSE inc. Band Edge: 2110-2155 MHz

13.1 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 $43 + 10 \log_{10} (P)$ 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 emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.
- (ii) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges, both upper and lower, as the design permits.
- (iii) The measurements of emission power can be expressed in peak or average values, provided they are expressed in the same parameters as the transmitter power.

The licensed band of operation was considered to be a single 5 MHz channel for the 5 MHz operation.

Some emissions > 1 MHz from bandedge were measured using the spectrum analyser adjacent channel power function that integrated power from a lower resolution bandwidth into the 1 MHz required by the rule part.

13.2 Test results

Single channel measurements were > 10 dB below the limit

Dual channel measurements were > 6 dB below the limit

13.2.1 Wideband single frequency

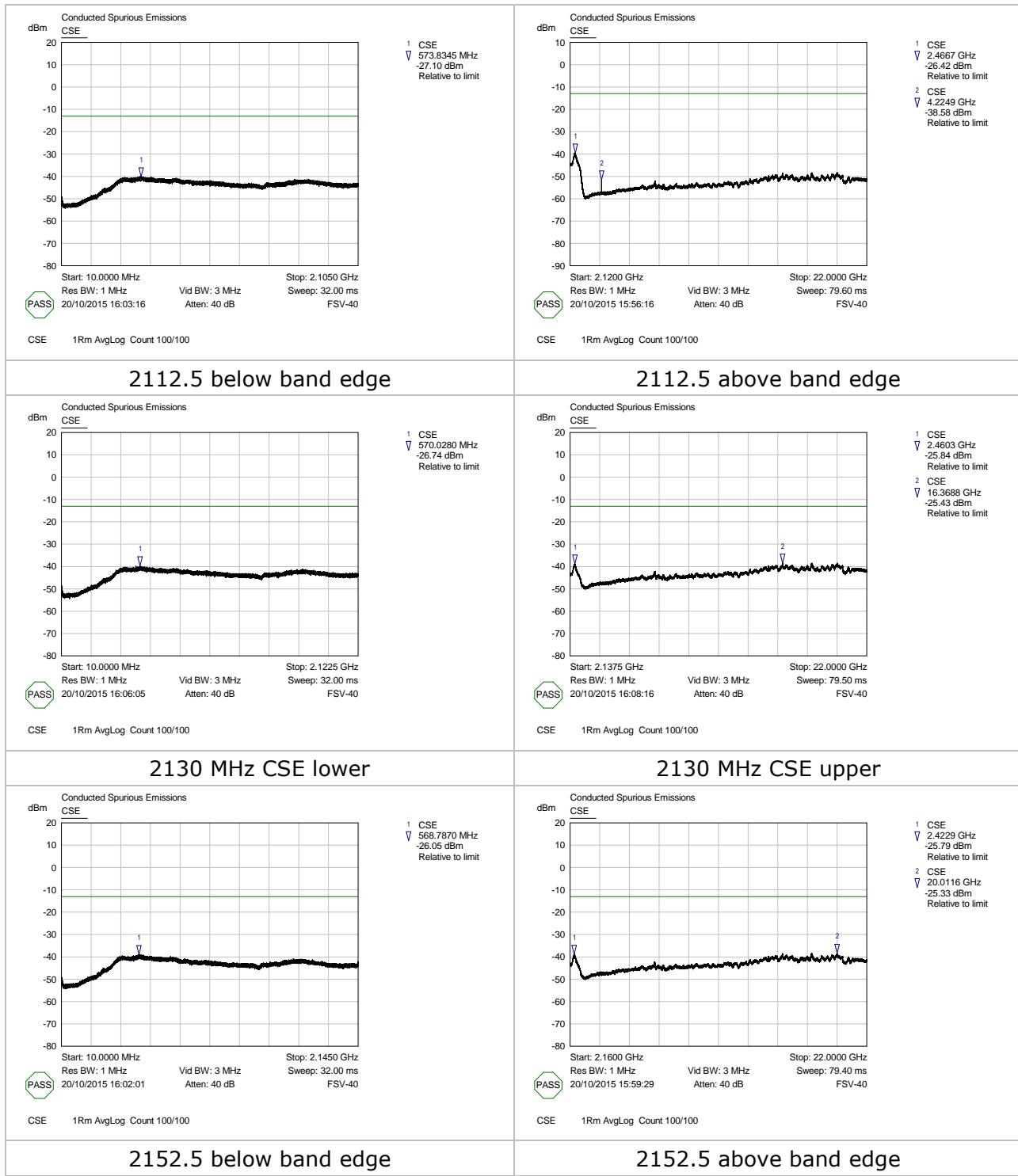


Figure 15: CSE except band edge 2110-2155 MHz Band

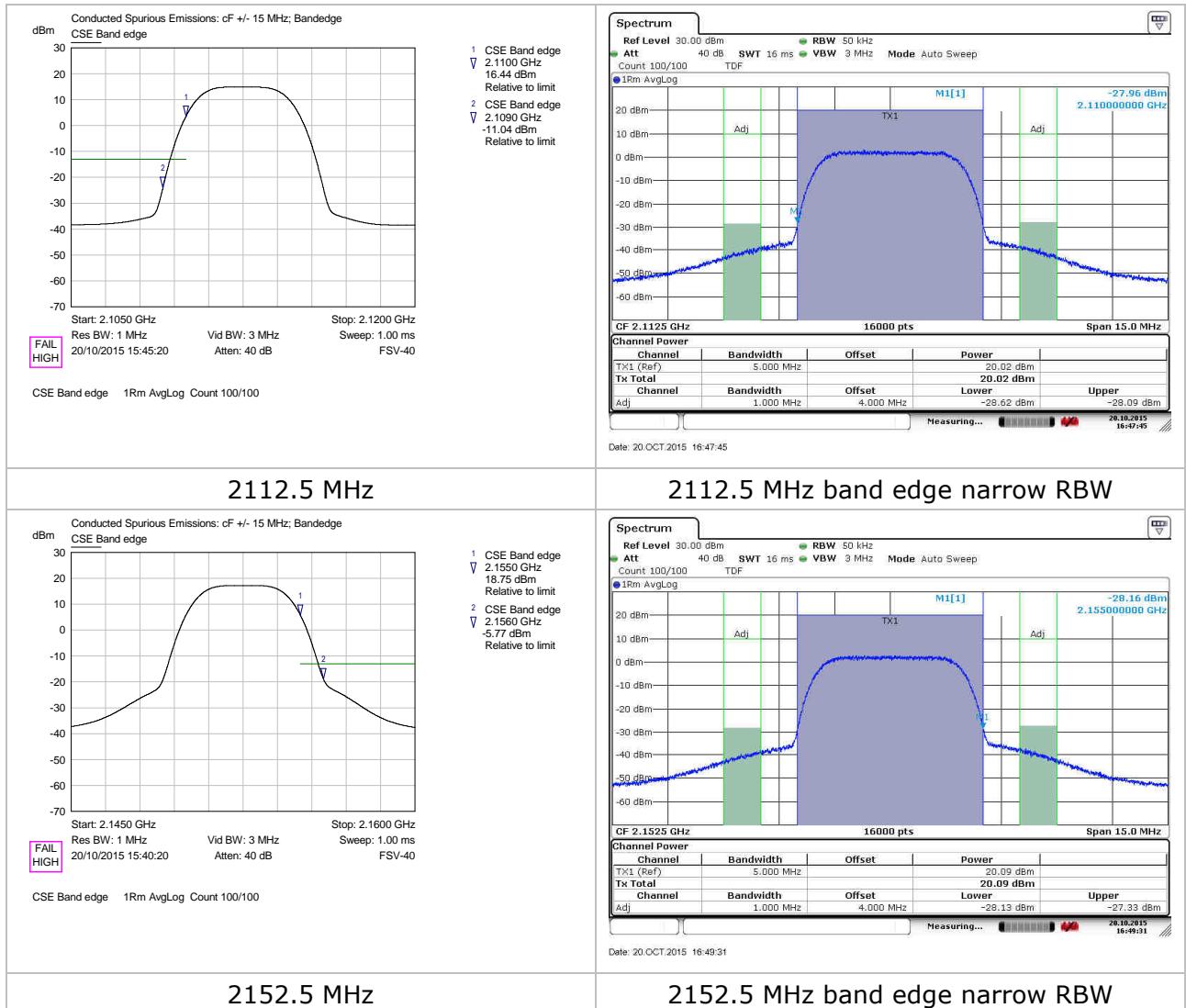


Figure 16: CSE and band edge 2110-2155 MHz Band

13.2.2 Dual Channel: AWGN

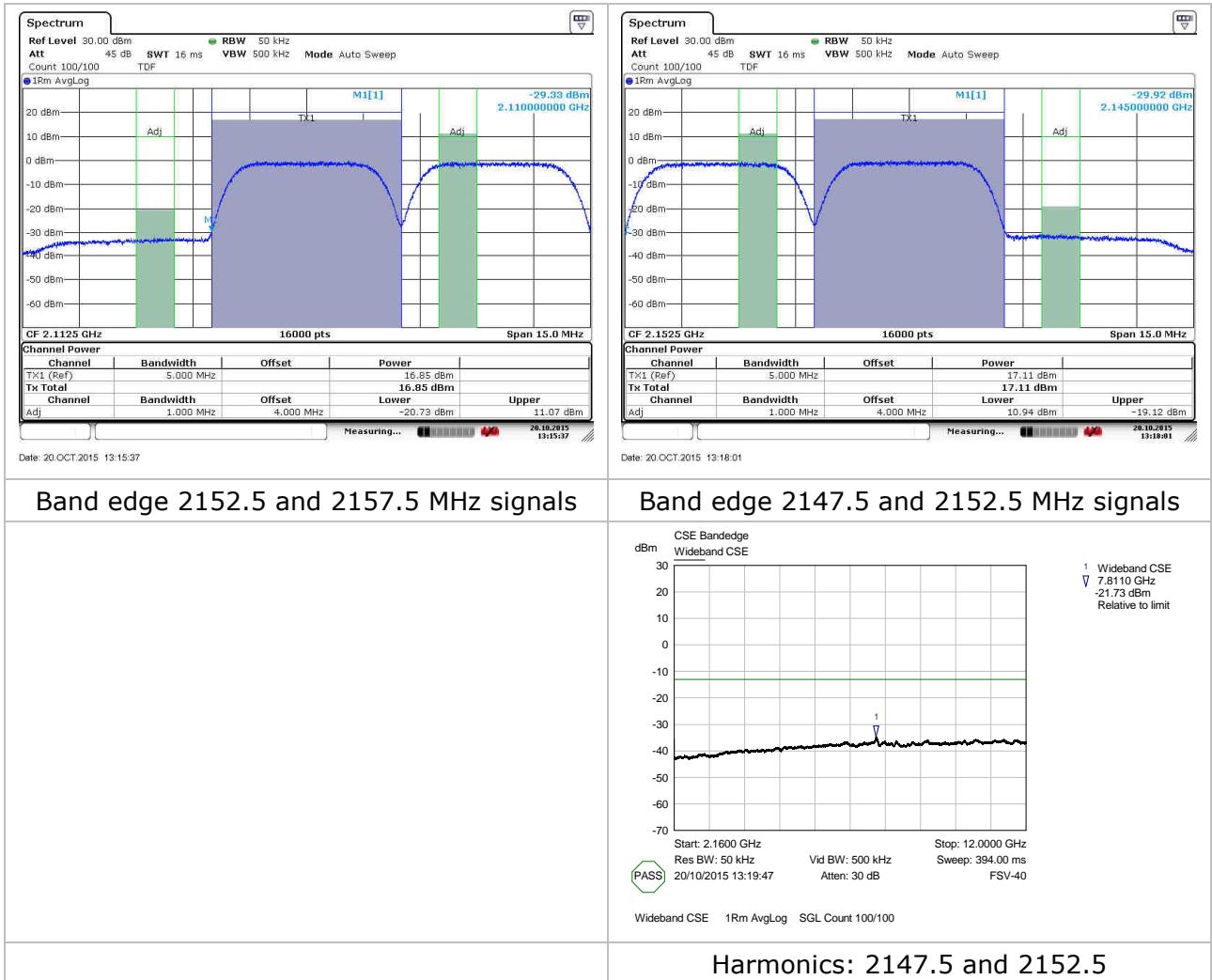


Figure 17: CSE and band edge 2110-2155 MHz Band dual channel

14 Test equipment

| Description | Manufacturer | Model | Serial Number | Calibration |
|------------------------|-----------------|--------------|-------------------------------|---|
| Signal Analyser | Rohde & Schwarz | FSV 40 | Livingston Hire asset X479651 | Code: 161467 Due 19 May 16 |
| Signal Analyser | Rohde & Schwarz | FSQ8 | 100152 | Ref: 1-7510563598-1 Due 23 Dec 16 |
| Signal Generator | Rohde & Schwarz | SMBV100A | Microlease asset 45440 | Ref: 45440 Due 19 Nov 15 |
| Cable | Utiflex | BUA01G | FA210A0009M30309 | ABEX UK. Ref: green bua01g Due 08 Oct 17 |
| Signal Generator | Rohde & Schwarz | SMJ100A | 100156 | Verified as part of system test |
| Signal Generator | Agilent | E4437B | US39260377 | |
| Attenuator | Mini-circuits | VAT 10 | 3 0433 | |
| Cable (input) | Mini-circuits | CBL-1M-SMNM+ | 120274 | |
| Cable (input) | Mini-circuits | CBL-1M-SMNM+ | 120295 | |
| 2-way splitter (input) | Mini-circuits | ZN2PD2-63-S+ | UU21401232 | |

Table 6: Test Equipment

Measurement uncertainty for test equipment

Analyser ±0.5 dB