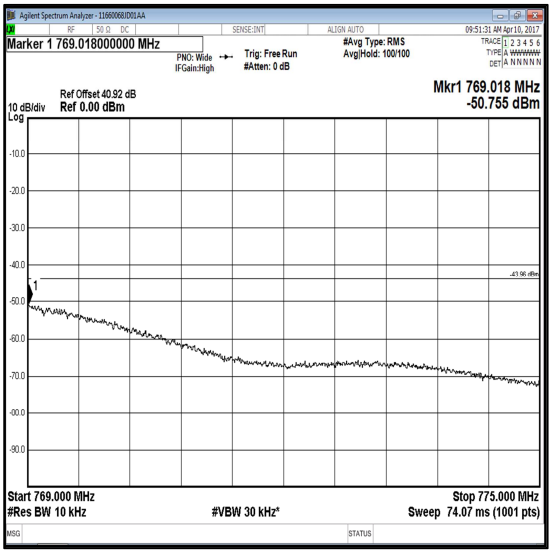
## Transmitter Conducted Emissions Limitations (continued)

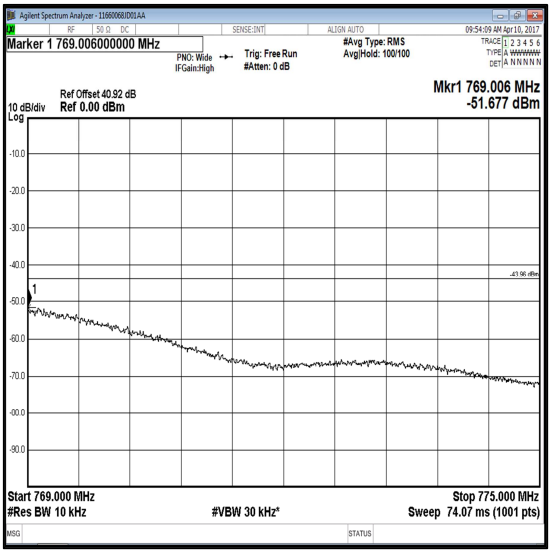
## Results: 10 MHz Channel Bandwidth / Single Channel / 769 MHz to 775 MHz

| Modulation | Peak Emission Level RXTX1 (dBm) | Peak Emission Level RXTX2 (dBm) | Combined Emission Level (dBm) | Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|---|---|
| QPSK | -50.76 | -51.22 | -47.96 | -43.96 | 4.00 | Complied |
| 16QAM | -51.68 | -53.50 | -49.47 | -43.96 | 5.51 | Complied |
| 64QAM | -50.42 | -52.27 | -48.24 | -43.96 | 4.28 | Complied |

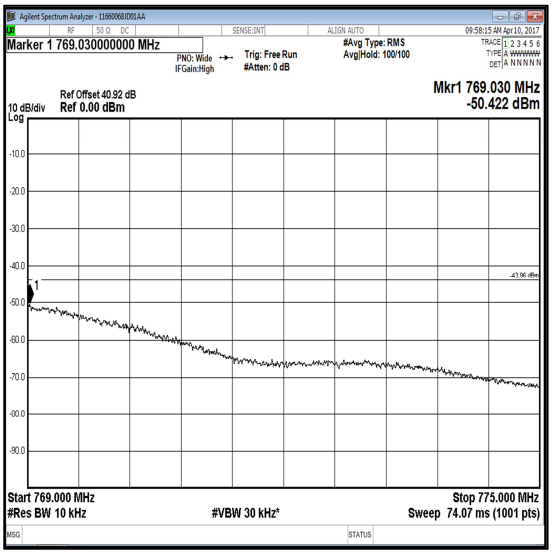
## Results: 10 MHz Channel Bandwidth / Single Channel / 769 MHz to 775 MHz / RxTx1




**QPSK**



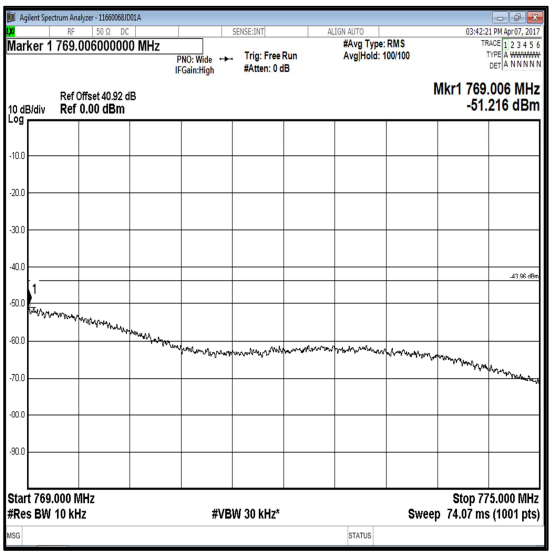

**16QAM**



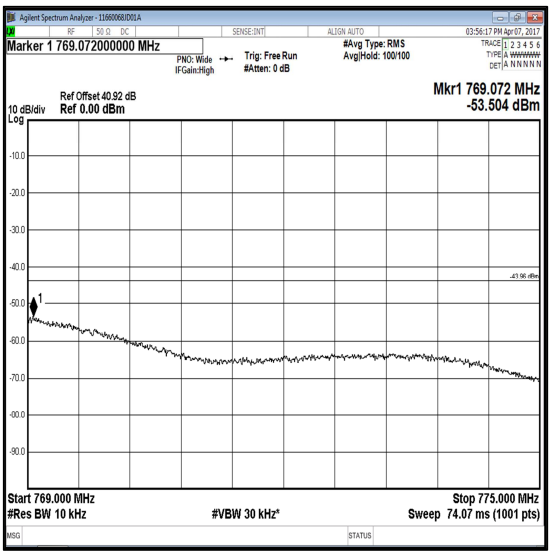

**64QAM**

## Transmitter Conducted Emissions Limitations (continued)

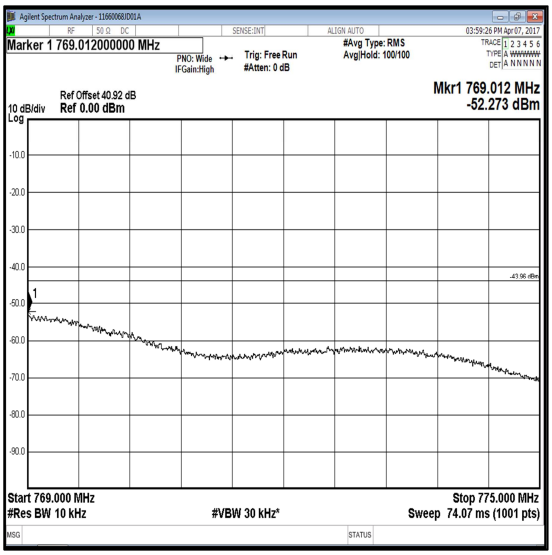
## Results: 10 MHz Channel Bandwidth / Single Channel / 769 MHz to 775 MHz / RxTx2




**QPSK**




**16QAM**



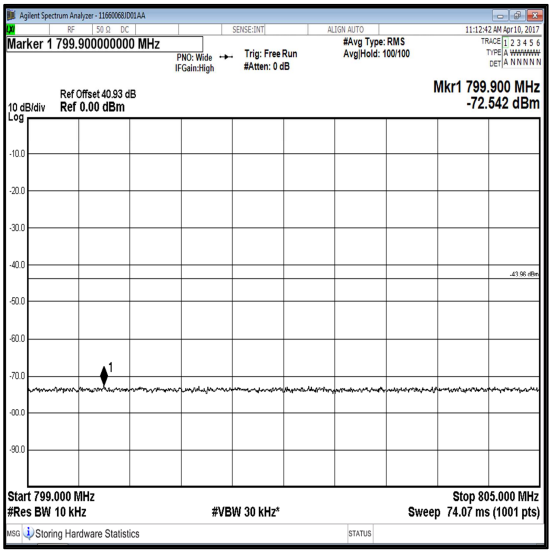

**64QAM**

## Transmitter Conducted Emissions Limitations (continued)

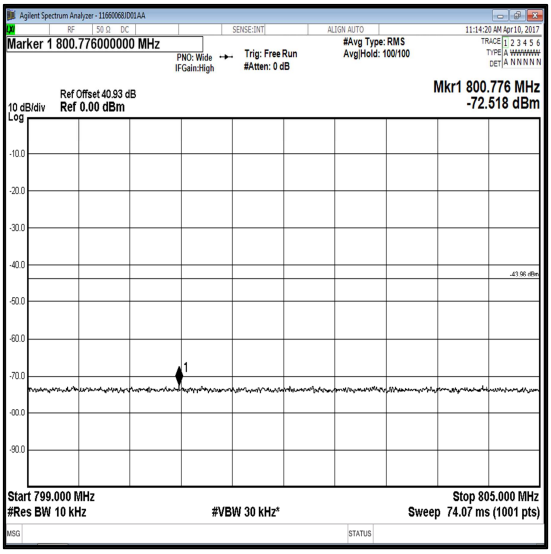
## Results: 10 MHz Channel Bandwidth / Single Channel / 799 MHz to 805 MHz

| Modulation | Peak Emission Level RXTX1 (dBm) | Peak Emission Level RXTX2 (dBm) | Combined Emission Level (dBm) | Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|---|---|
| QPSK | -72.54 | -72.69 | -69.61 | -43.96 | 25.65 | Complied |
| 16QAM | -72.52 | -72.60 | -69.55 | -43.96 | 25.59 | Complied |
| 64QAM | -72.80 | -72.56 | -69.67 | -43.96 | 25.71 | Complied |

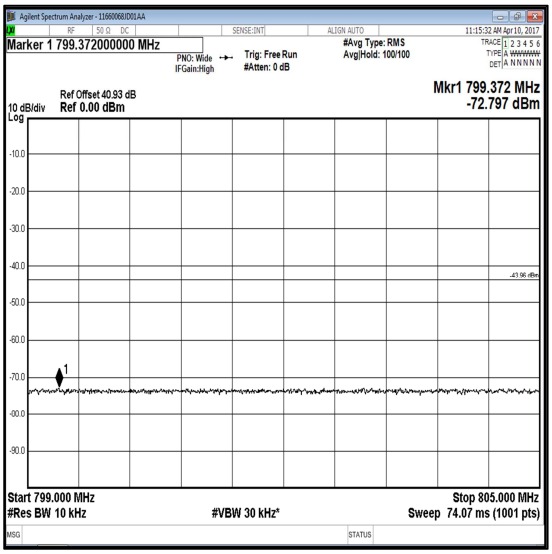
## Results: 10 MHz Channel Bandwidth / Single Channel / 799 MHz to 805 MHz / RxTx1




**QPSK**



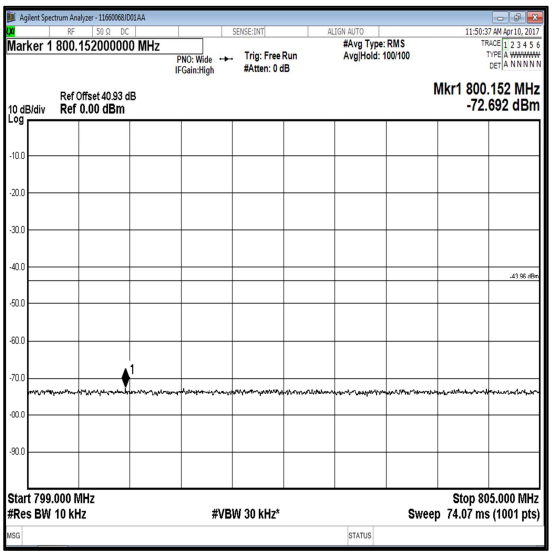

**16QAM**



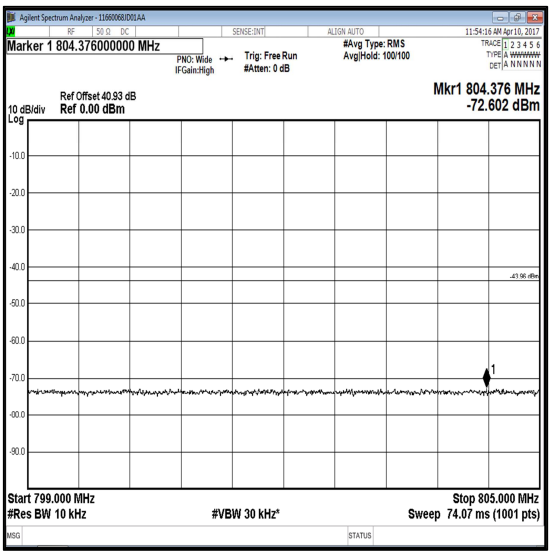

**64QAM**

## Transmitter Conducted Emissions Limitations (continued)

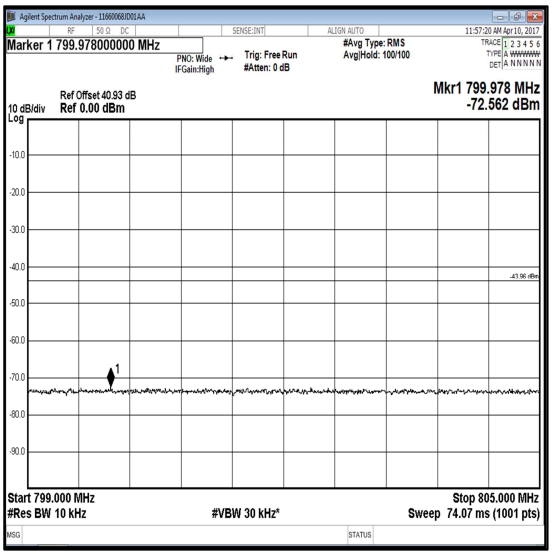
## Results: 10 MHz Channel Bandwidth / Single Channel / 799 MHz to 805 MHz / RxTx2




**QPSK**




**16QAM**




**64QAM**

## Transmitter Conducted Emissions Limitations (continued)

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 22 Feb 2018 | 12 |
| M1832 | Signal Analyser | Agilent | N9010A | MY53470303 | 29 Mar 2018 | 24 |
| A2924 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#7 | Calibrated before use | - |
| A2522 | Attenuator | AtlanTecRF | AN18-20 | 832797#3 | Calibrated before use | - |
| M1252 | Signal Generator | Hewlett Packard | 83640A | 3119A00489 | 26 Oct 2017 | 24 |
| M281 | Power Meter | Hewlett Packard | E4418A | GB37170210-01 | 16 Feb 2018 | 12 |
| M1227 | Power Sensor | Agilent | 8487D | 3318A02122 | 22 Jun 2017 | 12 |

## 5.2.6. Transmitter Radiated Emissions

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Dates:** | 05 May 2017 to 09 May 2017 |
| **Test Sample Serial Number:** | BHMBH01000213 | | |

| | |
|---|---|
| **FCC Reference:** | Parts 90.543(c) and 2.1053 |
| **Test Method Used:** | KDB 971168 D01 Sections 5.8, 6 & 7 |
| **Frequency Range:** | 30 MHz to 32 GHz |

### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 23 to 24 |
| **Relative Humidity (%):** | 35 to 37 |

### Note(s):

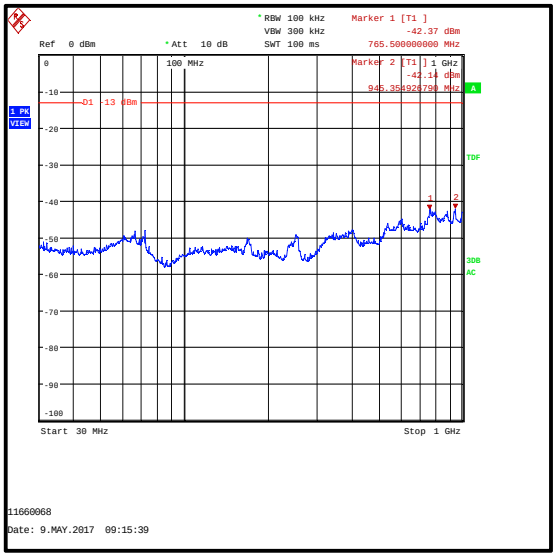
1. The EUT was set to transmit with 16QAM modulation applied, as this was found to have the highest output power and was therefore deemed worst case.
2. The emission seen on the 30 MHz to 1 GHz plot at approximately 765.5 MHz is the EUT carrier.
3. All emissions shown on the pre-scan plots were investigated and found to be ambient, or >20 dB below the applicable limit or below the measurement system noise floor. Therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below.
4. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was vertically oriented and placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0002) at a distance of 3 metres. The EUT was vertically oriented and placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT.
6. Pre-scans were only required to 32 GHz but have been carried out to 40 GHz.

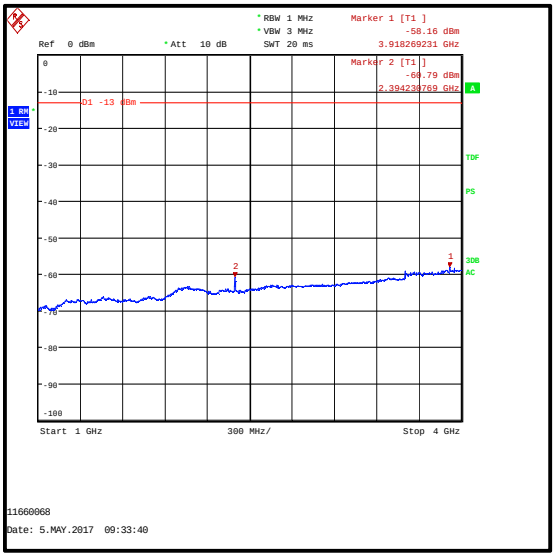
### Results:

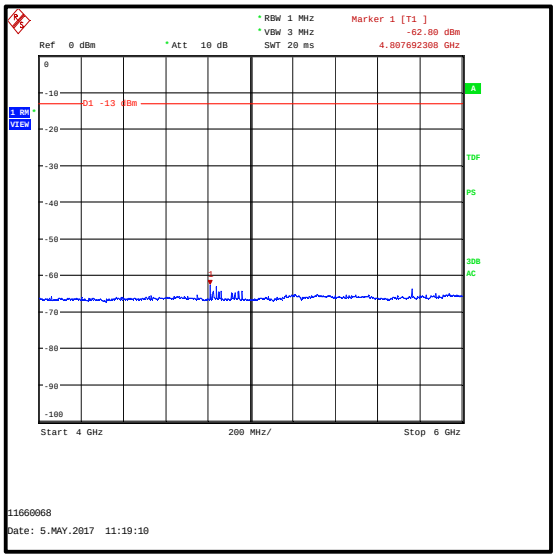
| Frequency (MHz) | Antenna Polarisation | Emission Level (dBm) | Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 945.355 | Vertical | -42.1 | -13.0 | 29.1 | Complied |

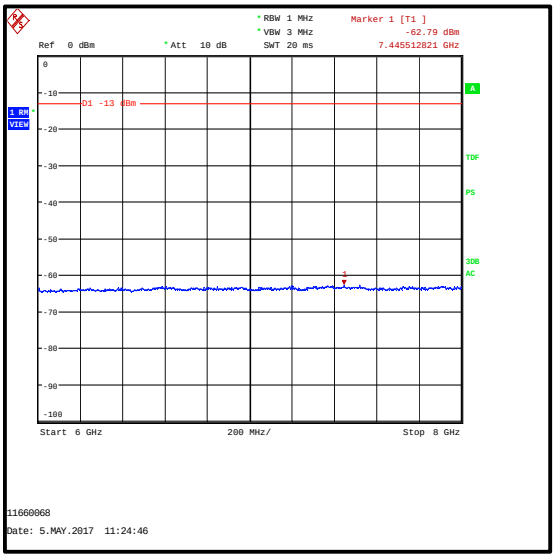
## Transmitter Radiated Emissions (continued)

## Results:



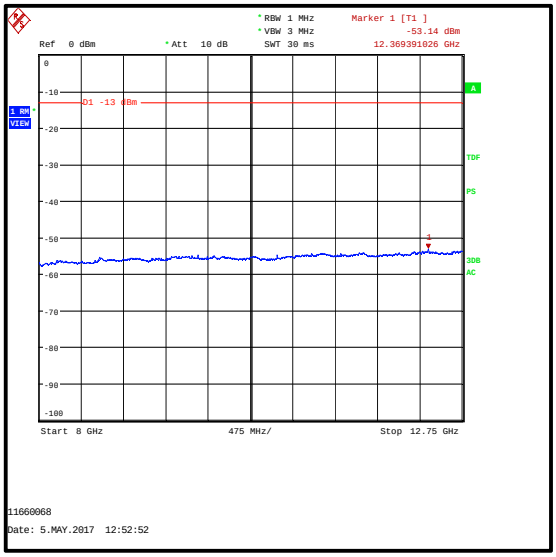



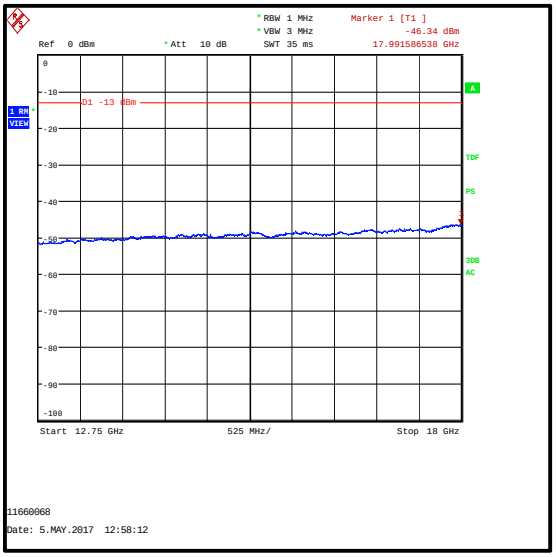



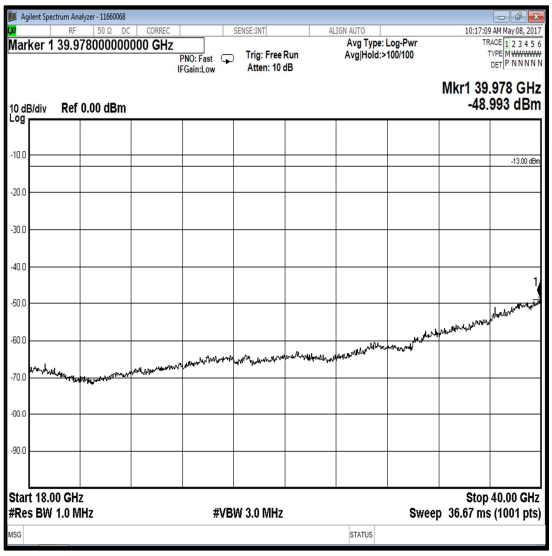



## Transmitter Radiated Emissions (continued)

## Results:



## Transmitter Radiated Emissions (continued)

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M2003 | Thermohygrometer | Testo | 608-H1 | 45046641 | 22 Feb 2018 | 12 |
| K0017 | 3m RSE Chamber | Rainford EMC | N/A | N/A | 14 Apr 2018 | 12 |
| M1995 | Amplifier | Rohde & Schwarz | ESU40 | 100428 | 13 Apr 2018 | 12 |
| A2903 | Antenna | Schwarzbeck | VULB 9163 | 9163-944 | 22 Aug 2017 | 12 |
| K0002 | 3m RSE Chamber | Rainford EMC | N/A | N/A | 16 Nov 2017 | 12 |
| M1874 | Test Receiver | Rohde & Schwarz | ESU26 | 100553 | 28 Oct 2017 | 12 |
| A1534 | Pre Amplifier | Hewlett Packard | 8449B | 3008A00405 | 09 Nov 2017 | 12 |
| A1818 | Antenna | EMCO | 3115 | 00075692 | 08 Nov 2017 | 12 |
| A253 | Antenna | Flann Microwave | 12240-20 | 128 | 08 Nov 2017 | 12 |
| A254 | Antenna | Flann Microwave | 14240-20 | 139 | 08 Nov 2017 | 12 |
| A255 | Antenna | Flann Microwave | 16240-20 | 519 | 08 Nov 2017 | 12 |
| A256 | Antenna | Flann Microwave | 18240-20 | 400 | 08 Nov 2017 | 12 |
| M1656 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 22 Feb 2018 | 12 |
| A1396 | Attenuator | Huber & Suhner | 6810.17.B | 757987 | 28 Feb 2018 | 12 |
| A2895 | Antenna | Schwarzbeck | BBHA 9170 | 9170-728 | 11 Apr 2018 | 12 |
| A2896 | Pre-Amplifier | Schwarzbeck | BBV 9721 | 9721-023 | 09 Nov 2017 | 12 |
| M1832 | Signal Analyser | Agilent | N9010A | MY53470303 | 28 Mar 2018 | 24 |

## 5.2.7. Transmitter Frequency Stability (Temperature Variation)

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | Patrick Jones | **Test Dates:** | 17 May 2017 to 19 May 2017 |
| **Test Sample Serial Number:** | BHMBH01000213 | | |

| | |
|---|---|
| **FCC Reference:** | Part 2.1055 |
| **Test Method Used:** | KDB 971168 Section 9.0 / FCC Part 2.1055 and Notes below |

### Environmental Conditions:

| | |
|---|---|
| **Ambient Temperature (°C):** | 25 to 28 |
| **Ambient Relative Humidity (%):** | 40 to 51 |

### Note(s):

1. A bench power supply was connected to the EUT via a customer supplied power cable at the nominal voltage of 28.0 VDC.
2. Temperature was monitored throughout the test with a calibrated digital thermometer.
3. Frequency stability was measured using a signal analyser marker placed at the lower 99% occupied bandwidth point (bottom channel) or higher 99% occupied bandwidth point (top channel). The delta between the maker frequency and band edge frequency is the margin. The signal analyser's frequency count function was used to give the marker a 1 Hz resolution.
4. During occupied bandwidth testing, the 5 MHz channel bandwidth was shown to use a larger proportion of the channel bandwidth than a 10 MHz channel bandwidth. Therefore, this configuration will result in the emission being closer to the band edge. A 5 MHz channel bandwidth was used for all frequency stability measurements.
5. The fundamental emissions remain within the authorised band of operation during all tests.
6. Frequency error was calculated by finding the difference between the reference frequency measured at +20 °C ($f_{nom}$) and the frequency measured at the required temperature ($f_m$) then converted to PPM. The following equation was used:

$$\textit{Frequency error in PPM} = (((f_m - f_{nom})*1000000)/f_{nom})$$

$$\textit{e.g. } f_m = 758.279034;\ f_{nom} = 758.285048$$
$$(((758.279034 - 758.285048)*1000000)/ 758.285048) = 7.93 \text{ PPM}$$

**Transmitter Frequency Stability (Temperature Variation) (continued)**

**Results: Bottom Channel / RxTx1 (760.5 MHz)**

| Temperature (°C) | Measured Frequency (MHz) | Lower Band Edge Limit (MHz) | Margin (MHz) | Frequency Error (PPM) | Result |
|---|---|---|---|---|---|
| -30 | 758.279034 | 758.0 | 0.279034 | 7.93 | Complied |
| -20 | 758.275518 | 758.0 | 0.275518 | 12.57 | Complied |
| -10 | 758.284962 | 758.0 | 0.284962 | 0.11 | Complied |
| 0 | 758.275358 | 758.0 | 0.275358 | 12.78 | Complied |
| 10 | 758.278451 | 758.0 | 0.278451 | 8.70 | Complied |
| 20 | 758.285048 | 758.0 | 0.285048 | 0.00 | Complied |
| 30 | 758.286123 | 758.0 | 0.286123 | 1.42 | Complied |
| 40 | 758.275661 | 758.0 | 0.275661 | 12.38 | Complied |
| 50 | 758.278733 | 758.0 | 0.278733 | 8.33 | Complied |

**Results: Top Channel / RxTx1 (765.5 MHz)**

| Temperature (°C) | Measured Frequency (MHz) | Upper Band Edge Limit (MHz) | Margin (MHz) | Frequency Error (PPM) | Result |
|---|---|---|---|---|---|
| -30 | 767.731410 | 768.0 | 0.268590 | 9.96 | Complied |
| -20 | 767.731199 | 768.0 | 0.268801 | 9.69 | Complied |
| -10 | 767.730523 | 768.0 | 0.269477 | 8.81 | Complied |
| 0 | 767.729711 | 768.0 | 0.270289 | 7.75 | Complied |
| 10 | 767.722331 | 768.0 | 0.277669 | 1.87 | Complied |
| 20 | 767.723763 | 768.0 | 0.276237 | 0.00 | Complied |
| 30 | 767.727570 | 768.0 | 0.272430 | 4.96 | Complied |
| 40 | 767.730948 | 768.0 | 0.269052 | 9.36 | Complied |
| 50 | 767.714867 | 768.0 | 0.285133 | 11.59 | Complied |

**Transmitter Frequency Stability (Temperature Variation) (continued)**

**Results: Bottom Channel / RxTx2 (760.5 MHz)**

| Temperature (ºC) | Measured Frequency (MHz) | Lower Band Edge Limit (MHz) | Margin (MHz) | Frequency Error (PPM) | Result |
|---|---|---|---|---|---|
| -30 | 758.283522 | 758.0 | 0.283522 | 8.43 | Complied |
| -20 | 758.274950 | 758.0 | 0.274950 | 2.88 | Complied |
| -10 | 758.275417 | 758.0 | 0.275417 | 2.26 | Complied |
| 0 | 758.275625 | 758.0 | 0.275625 | 1.99 | Complied |
| 10 | 758.275321 | 758.0 | 0.275321 | 2.39 | Complied |
| 20 | 758.277131 | 758.0 | 0.277131 | 0.00 | Complied |
| 30 | 758.277957 | 758.0 | 0.277957 | 1.09 | Complied |
| 40 | 758.274871 | 758.0 | 0.274871 | 2.98 | Complied |
| 50 | 758.274601 | 758.0 | 0.274601 | 3.34 | Complied |

**Results: Top Channel / RxTx2 (765.5 MHz)**

| Temperature (ºC) | Measured Frequency (MHz) | Upper Band Edge Limit (MHz) | Margin (MHz) | Frequency Error (PPM) | Result |
|---|---|---|---|---|---|
| -30 | 767.724487 | 768.0 | 0.275513 | 1.95 | Complied |
| -20 | 767.721386 | 768.0 | 0.278614 | 2.09 | Complied |
| -10 | 767.718179 | 768.0 | 0.281821 | 6.27 | Complied |
| 0 | 767.724291 | 768.0 | 0.275709 | 1.69 | Complied |
| 10 | 767.724637 | 768.0 | 0.275363 | 2.14 | Complied |
| 20 | 767.722992 | 768.0 | 0.277008 | 0.00 | Complied |
| 30 | 767.721919 | 768.0 | 0.278081 | 1.40 | Complied |
| 40 | 767.721677 | 768.0 | 0.278323 | 1.71 | Complied |
| 50 | 767.723062 | 768.0 | 0.276938 | 0.09 | Complied |

## Transmitter Frequency Stability (Temperature Variation) (continued)

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 22 Feb 2018 | 12 |
| E0518 | Environmental Chamber | TAS | LTCL 1200 | 24000107 | Calibrated before use | - |
| M1643 | Thermometer | Fluke | 52II | 18890136 | 20 Apr 2018 | 12 |
| M1835 | Signal Analyser | Rohde & Schwarz | FSV30 | 103050 | 06 Mar 2018 | 12 |
| S0577 | DC power Supply | TTI | CPX400S | 436670 | Calibrated before use | - |
| M122 | DVM | Fluke | 77 | 64910017 | 26 Apr 2018 | 12 |
| A2924 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#7 | Calibrated before use | - |
| A2522 | Attenuator | AtlanTecRF | AN18-20 | 832797#3 | Calibrated before use | - |
| M1252 | Signal Generator | Hewlett Packard | 83640A | 3119A00489 | 26 Oct 2017 | 24 |
| M281 | Power Meter | Hewlett Packard | E4418A | GB37170210-01 | 16 Feb 2018 | 12 |
| M1227 | Power Sensor | Agilent | 8487D | 3318A02122 | 22 Jun 2017 | 12 |

## 5.2.8. Transmitter Frequency Stability (Voltage Variation)

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | Patrick Jones | **Test Dates:** | 18 May 2017 to 19 May 2017 |
| **Test Sample Serial Number:** | BHMBH01000213 | | |

| | |
|---|---|
| **FCC Reference:** | Part 2.1055 |
| **Test Method Used:** | KDB 971168 Section 9.0 / FCC Part 2.1055 and Notes below |

### Environmental Conditions:

| | |
|---|---|
| **Ambient Temperature (°C):** | 24 to 28 |
| **Ambient Relative Humidity (%):** | 35 to 51 |

### Note(s):

1. A bench power supply was connected to the EUT via a customer supplied power cable. Voltage was monitored throughout the test with a calibrated digital voltmeter. Minimum, nominal and maximum voltages tested were stated by the customer.
2. Frequency stability was measured using a signal analyser marker placed at the lower 99% occupied bandwidth point (bottom channel) or higher 99% occupied bandwidth point (top channel). The delta between the maker frequency and band edge frequency is the margin. The signal analyser's frequency count function was used to give the marker a 1 Hz resolution.
3. During occupied bandwidth testing, the 5 MHz channel bandwidth was shown to use a larger proportion of the channel bandwidth than a 10 MHz channel bandwidth. Therefore, this configuration will result in the emission being closer to the band edge. A 5 MHz channel bandwidth was used for all frequency stability measurements.
4. The fundamental emissions remain within the authorised band of operation during all tests.
5. Frequency error was calculated by finding the difference between the reference frequency measured at 28 Volts ($f_{nom}$) and the frequency measured at the required voltage ($f_m$) then converted to PPM. The following equation was used:

$$\textit{Frequency error in PPM} = (((f_m - f_{nom})*1000000) / f_{nom})$$

$$\textit{e.g. } f_m = 758.274947;\ f_{nom} = 758.285048$$
$$(((758.274947 - 758.285048)*1000000) / 758.285048) = 13.32 \text{ PPM}$$

## Transmitter Frequency Stability (Voltage Variation) (continued)

### Results: Bottom Channel (760.5 MHz)

| Supply Voltage (V) | Measured Frequency RxTx1 (MHz) | Measured Frequency RxTx2 (MHz) | Lower Band Edge Limit (MHz) | Margin RxTx1 (MHz) | Margin RxTx2 (MHz) | Max Error (PPM) | Result |
|---|---|---|---|---|---|---|---|
| 20.0 | 758.274947 | 758.277305 | 758.0 | 0.274947 | 0.277305 | 13.32 | Complied |
| 28.0 | 758.285048 | 758.277131 | 758.0 | 0.285048 | 0.277131 | 0.00 | Complied |
| 33.0 | 758.279030 | 758.278760 | 758.0 | 0.279030 | 0.278760 | 7.94 | Complied |

### Results: Top Channel (765.5 MHz)

| Supply Voltage (V) | Measured Frequency RxTx1 (MHz) | Measured Frequency RxTx2 (MHz) | Upper Band Edge Limit (MHz) | Margin RxTx1 (MHz) | Margin RxTx2 (MHz) | Max Error (PPM) | Result |
|---|---|---|---|---|---|---|---|
| 20.0 | 767.724269 | 767.729871 | 768.0 | 0.275731 | 0.270129 | 8.96 | Complied |
| 28.0 | 767.723763 | 767.722992 | 768.0 | 0.276237 | 0.277008 | 0.00 | Complied |
| 33.0 | 767.723070 | 767.724137 | 768.0 | 0.276930 | 0.275863 | 1.49 | Complied |

### Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 22 Feb 2018 | 12 |
| E0518 | Environmental Chamber | TAS | LTCL 1200 | 24000107 | Calibrated before use | - |
| M1643 | Thermometer | Fluke | 52II | 18890136 | 20 Apr 2018 | 12 |
| M1835 | Signal Analyser | Rohde & Schwarz | FSV30 | 103050 | 06 Mar 2018 | 12 |
| S0577 | DC power Supply | TTI | CPX400S | 436670 | Calibrated before use | - |
| M122 | DVM | Fluke | 77 | 64910017 | 26 Apr 2018 | 12 |
| A2924 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#7 | Calibrated before use | - |
| A2522 | Attenuator | AtlanTecRF | AN18-20 | 832797#3 | Calibrated before use | - |
| M1252 | Signal Generator | Hewlett Packard | 83640A | 3119A00489 | 26 Oct 2017 | 24 |
| M281 | Power Meter | Hewlett Packard | E4418A | GB37170210-01 | 16 Feb 2018 | 12 |
| M1227 | Power Sensor | Agilent | 8487D | 3318A02122 | 22 Jun 2017 | 12 |

# 6. Measurement Uncertainty

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

| Measurement Type | Range | Confidence Level (%) | Calculated Uncertainty |
|---|---|---|---|
| Conducted Output Power | 758 to 768 MHz | 95% | ±0.76 dB |
| Frequency Stability | 758 to 768 MHz | 95% | ±1.62 ppm |
| Occupied Bandwidth | 758 to 768 MHz | 95% | ±3.92 % |
| Conducted Spurious Emissions | 9 kHz to 32 GHz | 95% | ±2.62 dB |
| Radiated Spurious Emissions | 30 MHz to 1 GHz | 95% | ±5.65 dB |
| Radiated Spurious Emissions | 1 GHz to 32 GHz | 95% | ±2.94 dB |

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

# 7. Report Revision History

| Version Number | Revision Details | | |
|---|---|---|---|
| | Page No(s) | Clause | Details |
| 1.0 | - | - | Initial Version |
| 2.0 | 59 - 64 | - | Added results in PPM and additional notes |

**--- END OF REPORT ---**