TEST REPORT

Test Report No. : UL-RPT-RP10407443JD10G V2.0

Manufacturer	:	Apple Inc.
Model No.	:	A1600
FCC ID	:	BCGA1600
Technology	:	LTE Band 13
Test Standard(s)	:	FCC Part 27 Subpart C

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 2.0 supersedes all previous versions.

Date of Issue: 14 September 2014

Checked by:

Sarah Williams
Engineer, Radio Laboratory

Issued by :

pp

John Newell
Quality Manager,
UL VS LTD

This laboratory is accredited by UKAS. The tests reported herein have been performed in accordance with its' terms of accreditation.

UL VS LTD

Pavilion A, Ashwood Park, Ashwood Way, Basingstoke, Hampshire, RG23 8BG, UK
Telephone: +44 (0)1256 312000
Facsimile: +44 (0)1256 312001

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1. Customer Information

Company Name:	Apple Inc.
Address:	1 Infinite Loop Cupertino, CA 95014 U.S.A.

2. Summary of Testing

2.1. General Information

Specification Reference:	47CFR27
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 27 Subpart C (Miscellaneous Wireless Communication Services)
Site Registration:	209735
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	09 July 2014 to 14 September 2014

2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
2.1046 / 27.50(b)(10)	Transmitter Output Power (ERP)	✓
2.1049	Transmitter Occupied Bandwidth	✓
2.1053 / 27.53(c)(2)	Transmitter Radiated Spurious Emissions	✓
2.1053 / 27.53(c)(4) & 27.53(f)	Transmitter Radiated Spurious Emissions Limitations	✓
2.1053 / 27.53(c)(2)	Transmitter Radiated Emissions at Band Edges	✓
2.1055 / 27.54	Transmitter Frequency Stability (Temperature and Voltage Variation)	✓

Key to Results

✓ **= Complied** ✗ **= Did not comply**

2.3. Methods and Procedures

Reference:	ANSI/TIA-603-C-2004
Title:	Land Mobile Communications Equipment, Measurements and performance Standards
Reference:	FCC KDB 971168 D01 v02r01, 7 June 2013
Title:	Measurement Guidance for Certification of Licensed Digital Transmitters

2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number:	A1600
Test Sample IMEI:	352025060238789 *(Radiated Sample)*
Hardware Version Number:	REV1.0
Software Version Number:	iOS 12A314 BB: 3.08.08
FCC ID:	BCGA1600

Brand Name:	Apple
Model Name or Number:	A1600
Test Sample IMEI:	352025060274538 *(Conducted Sample)*
Hardware Version Number:	REV1.0
Software Version Number:	iOS 12A314 BB: 3.08.08
FCC ID:	BCGA1600

3.2. Description of EUT

The Equipment Under Test was a tablet with GSM/GPRS/EGPRS/UMTS/LTE and CDMA technologies. It also supports IEEE 802.11a/b/g/n (MIMO 2x2) and *Bluetooth*®. The rechargeable battery is not user accessible.

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. Additional Information Related to Testing

Tested Technology:	LTE Band 13			
Type of Equipment	Transceiver			
Channel Bandwidth:	5 MHz & 10 MHz			
Modulation Type:	QPSK & 16QAM			
Duty Cycle:	100%			
Antenna Gain:	-5.59 dBd			
Power Supply Requirement:	Nominal	3.8 V		
	Minimum	3.4 V		
	Maximum	4.2 V		
Transmit Frequency Range:	777 MHz to 787 MHz			
Channels Tested:	**Channel Bandwidth**		**N_{ul}**	**Frequency of Uplink (MHz)**
Bottom Channel	5		23205	779.5
Middle Channel	5		23230	782.0
	10		23230	782.0
Top Channel	5		23255	784.5

3.5. Support Equipment

The following support equipment was used to exercise the EUT during testing:

Brand Name:	Dell
Description:	Laptop computer
Model Name or Number:	Inspiron
Serial Number:	Asset RFI00788

Brand Name:	Not stated
Description:	USB Diagnostic cable
Model Name or Number:	Not stated
Serial Number:	Not stated

Brand Name:	Apple
Description:	Test Laptop
Model Name or Number:	MacBook Pro
Serial Number:	C2QLQ03XF9F2

Brand Name:	Apple
Description:	USB Cable
Model Name or Number:	A1480
Serial Number:	Not stated

Brand Name:	Apple
Description:	USB Charger
Model Name or Number:	A1399
Serial Number:	Not stated

Brand Name:	Apple
Description:	PHF
Model Name or Number:	Apple Ear Plugs
Serial Number:	Not stated

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating mode(s):

- Transmit Mode - The EUT was set to transmit with maximum output power using the required channel bandwidth. QPSK and 16QAM modulations were both tested, with Resource Block allocation as detailed in section 4.3.

4.2. Configuration and Peripherals

The EUT was tested in the following configuration(s):

- The EUT was connected to a Rohde and Schwarz CMW500 LTE system simulator, operating in a transceiver mode.
- Transmitter radiated spurious emissions tests were performed with the EUT set to transmit with a 5 MHz channel bandwidth with QPSK modulation applied and 1 resource block with 0 offset. This was found to be the worst case modulation scheme with regards to emissions after preliminary investigations and, as this mode emits the highest transmit output power level, it was deemed to be the worst case.
- Transmitter radiated spurious emissions tests were performed with the AC Charger and PHF connected to the EUT as this was found to be the worst case during pre-scans. All the accessories were individually connected and measurements made during the pre-scans to determine the worst case combination.
- Conducted measurements at temperature and voltage extremes were performed using a conducted sample supplied by the customer. Short 4-wire DC flying leads were connected internally to the device in place of the battery, and exited through a hole in the casing. These leads were then extended to a DC power supply for testing purposes.
- For conducted cellular measurements, the RF conducted port was created by removing a micro connector from the pcb antenna and extending it with a short flexible microstrip supplied by the customer. This microstrip exited the device through a hole in the casing and was terminated in a proprietary micro-coax to SMA adaptor.
- The conducted sample with IMEI 352025060274538 was used for frequency stability, occupied bandwidth and power measurements.
- The radiated sample with IMEI 352025060238789 was used for all radiated measurements.

4.3. Resource Block Allocation

Channel Bandwidth (MHz)	Maximum No. of Resource Blocks	Resource Block / Offset Number							
		Sub Test 1		Sub Test 2		Sub Test 3		Sub Test 4	
		RB	Offset	RB	Offset	RB	Offset	RB	Offset
5	25	1	0	1	24	12	6	25	0
10	50	1	0	1	49	25	12	50	0

Transmitter Output Power was carried out using sub tests 1, 2, 3 and 4, with both QPSK and 16QAM modulation schemes.

Transmitter Occupied Bandwidth was carried out using sub tests 3 and 4, for both QPSK and 16QAM modulation schemes.

Transmitter Radiated Emissions testing was carried out using sub test 1, with a 5 MHz channel bandwidth and QPSK modulation scheme, as this was found to be the worst case modulation scheme with regards to emissions after preliminary investigations and, as this mode emits the highest transmit output power level, it was deemed to be the worst case.

Transmitter Radiated Band Edge Emissions was tested with sub test 4 on all supported channel bandwidths, using QPSK and 16QAM modulations with the maximum resource blocks settings.

Transmitter Frequency Stability test was carried out with sub test 4, with a channel bandwidth of 5 MHz only.

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6* for Measurement Uncertainty details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

5.2. Test Results

5.2.1. Transmitter Output Power (ERP)

Test Summary:

Test Engineer:	Keith Tucker	**Test Date:**	30 July 2014
Test Sample IMEI:	352025060274538		

FCC Reference:	Parts 2.1046 & 27.50(b)(10)
Test Method Used:	As detailed in FCC KDB 971168 Section 5.2.3

Environmental Conditions:

Temperature (℃):	25
Relative Humidity (%):	39

Note(s):

1. The customer stated that the EUT has a maximum antenna gain of -3.44 dBi. As the limit is ERP, the gain in dBi has been converted to dBd. The dBd gain figure has been calculated as:

   -3.44 dBi – 2.15 dB = -5.59 dBd

2. Measurements were performed with the EUT transmitting with QPSK and 16QAM modulation schemes, with resource blocks settings as detailed in section 4.3 of this report.

Transmitter Output Power (ERP) (continued)

Results: 5 MHz Channel Bandwidth / Bottom Channel / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
779.5	25	0	22.4	-5.59	16.81	34.8	17.99	Complied
779.5	12	6	22.6	-5.59	17.01	34.8	17.79	Complied
779.5	1	0	23.4	-5.59	17.81	34.8	16.99	Complied
779.5	1	24	23.4	-5.59	17.81	34.8	16.99	Complied

Results: 5 MHz Channel Bandwidth / Bottom Channel / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
779.5	25	0	21.4	-5.59	15.81	34.8	18.99	Complied
779.5	12	6	21.6	-5.59	16.01	34.8	18.79	Complied
779.5	1	0	22.2	-5.59	16.61	34.8	18.19	Complied
779.5	1	24	22.2	-5.59	16.61	34.8	18.19	Complied

Results: 5 MHz Channel Bandwidth / Middle Channel / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
782.0	25	0	22.3	-5.59	16.71	34.8	18.09	Complied
782.0	12	6	22.5	-5.59	16.91	34.8	17.89	Complied
782.0	1	0	23.5	-5.59	17.91	34.8	16.89	Complied
782.0	1	24	23.3	-5.59	17.71	34.8	17.09	Complied

Results: 5 MHz Channel Bandwidth / Middle Channel / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
782.0	25	0	21.3	-5.59	15.71	34.8	19.09	Complied
782.0	12	6	21.4	-5.59	15.81	34.8	18.99	Complied
782.0	1	0	22.3	-5.59	16.71	34.8	18.09	Complied
782.0	1	24	22.2	-5.59	16.61	34.8	18.19	Complied

Transmitter Output Power (ERP) (continued)

Results: 5 MHz Channel Bandwidth / Top Channel / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
784.5	25	0	22.4	-5.59	16.81	34.8	17.99	Complied
784.5	12	6	22.4	-5.59	16.81	34.8	17.99	Complied
784.5	1	0	23.5	-5.59	17.91	34.8	16.89	Complied
784.5	1	24	23.2	-5.59	17.61	34.8	17.19	Complied

Results: 5 MHz Channel Bandwidth / Top Channel / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
784.5	25	0	21.4	-5.59	15.81	34.8	18.99	Complied
784.5	12	6	21.4	-5.59	15.81	34.8	18.99	Complied
784.5	1	0	22.3	-5.59	16.71	34.8	18.09	Complied
784.5	1	24	22.1	-5.59	16.51	34.8	18.29	Complied

Results: 10 MHz Channel Bandwidth / Middle Channel / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
782.0	50	0	22.3	-5.59	16.71	34.8	18.09	Complied
782.0	25	12	22.3	-5.59	16.71	34.8	18.09	Complied
782.0	1	0	23.5	-5.59	17.91	34.8	16.89	Complied
782.0	1	49	23.4	-5.59	17.81	34.8	16.99	Complied

Results: 10 MHz Channel Bandwidth / Middle Channel / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Conducted RF Power (dBm)	Antenna Gain (dBd)	ERP (dBm)	ERP Limit (dBm)	Margin (dB)	Result
782.0	50	0	21.4	-5.59	15.81	34.8	18.99	Complied
782.0	25	12	21.4	-5.59	15.81	34.8	18.99	Complied
782.0	1	0	22.4	-5.59	16.81	34.8	17.99	Complied
782.0	1	49	22.3	-5.59	16.71	34.8	18.09	Complied

Transmitter Output Power (ERP) (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1658	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	14 Mar 2015	12
M1871	Power Meter	Agilent	N1911A	MY45100338	28 May 2015	12
M1872	Wideband Power Sensor	Agilent	N1921A	MY45241950	08 Oct 2014	12
S0537	DC Power Supply	TTi	EL302D	249928	Calibrated before use	-
M1251	Digital Multimeter	Fluke	175	89170179	19 May 2015	12
A2535	Directional Coupler	AtlanTec RF	CDC-003060-20	14041701719	Calibrated before use	-
A2508	Attenuator	AtlanTec RF	AN18-10	821846#3	Calibrated before use	-
A539	Power Splitter	Rohde & Schwarz	RVZ	22441	Calibrated before use	-

5.2.2. Transmitter Occupied Bandwidth

Test Summary:

Test Engineer:	Keith Tucker	**Test Date:**	17 July 2014
Test Sample IMEI:	352025060274538		

FCC Reference:	Part 2.1049
Test Method Used:	As detailed in KDB 971168 Section 4.2

Environmental Conditions:

Temperature (℃):	25
Relative Humidity (%):	45

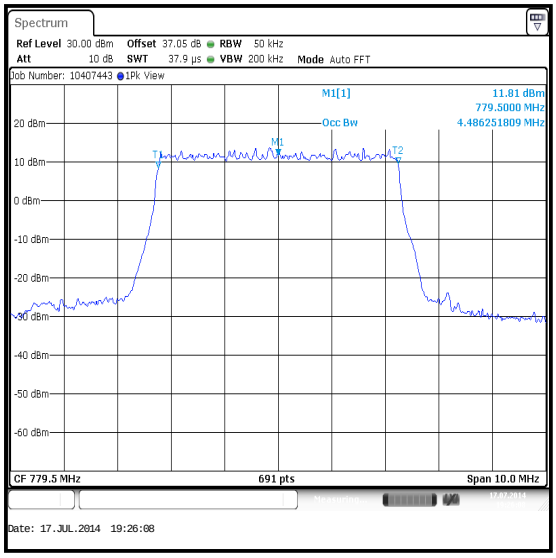
Note(s):

1. Occupied bandwidth (99% bandwidth) was measured using a test receiver occupied bandwidth function.
2. Measurements were performed with the EUT transmitting with QPSK and 16QAM modulation schemes, with resource blocks settings as detailed in section 4.3 of this report.
3. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable.

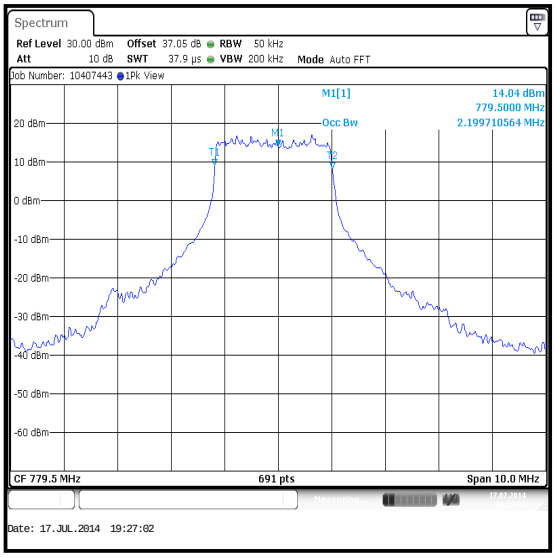
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Bottom Channel / QPSK

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
779.5	25	0	50	200	4.486
779.5	12	6	50	200	2.200



QPSK / 25 Resource Blocks (0 Offset)

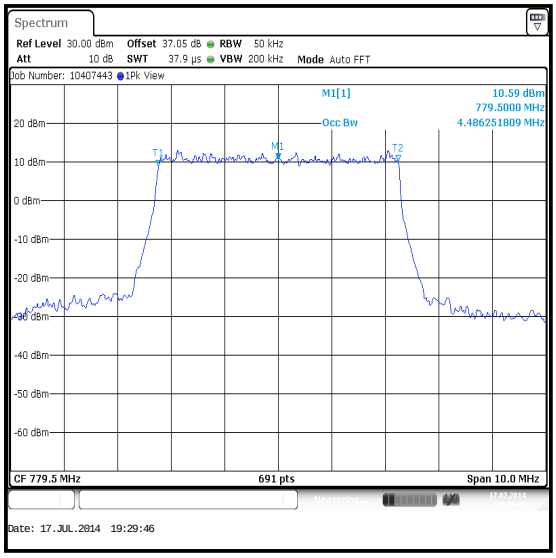


QPSK / 12 Resource Blocks (6 Offset)

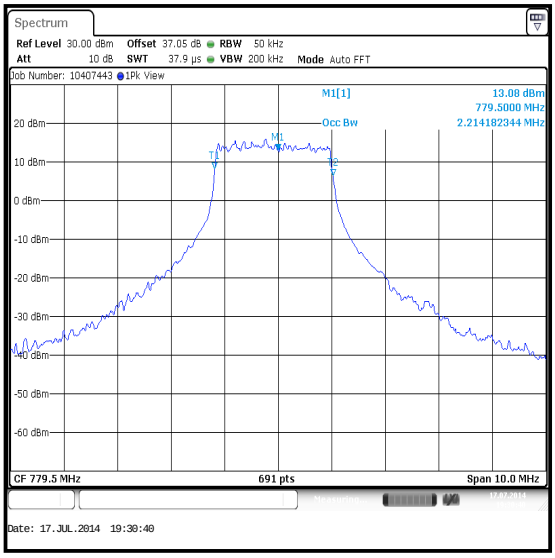
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Bottom Channel / 16QAM

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
779.5	25	0	50	200	4.486
779.5	12	6	50	200	2.214



16QAM / 25 Resource Blocks (0 Offset)

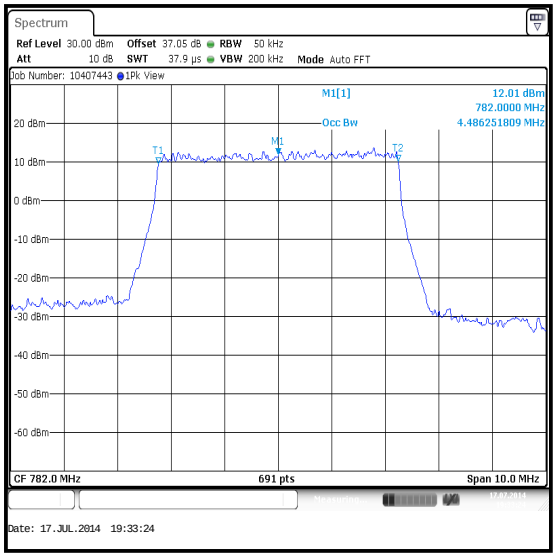


16QAM / 12 Resource Blocks (6 Offset)

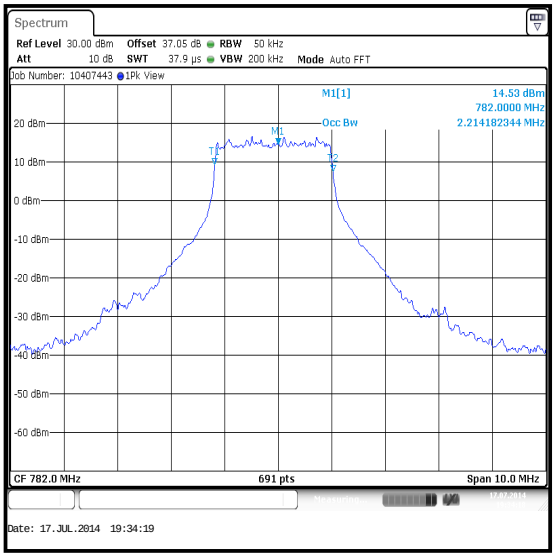
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Middle Channel / QPSK

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
782.0	25	0	50	200	4.486
782.0	12	6	50	200	2.214



QPSK / 25 Resource Blocks (0 Offset)

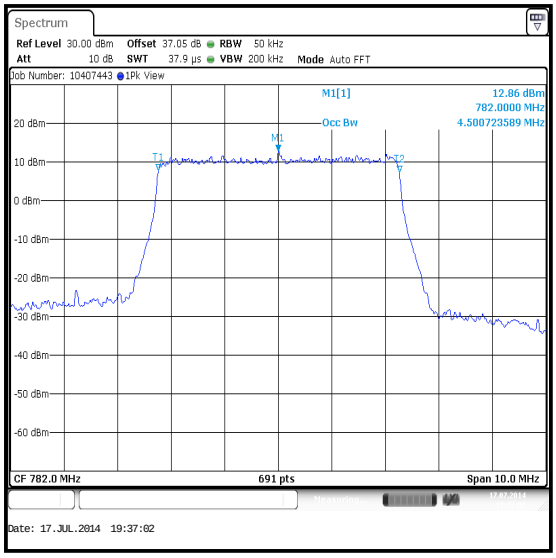


QPSK / 12 Resource Blocks (6 Offset)

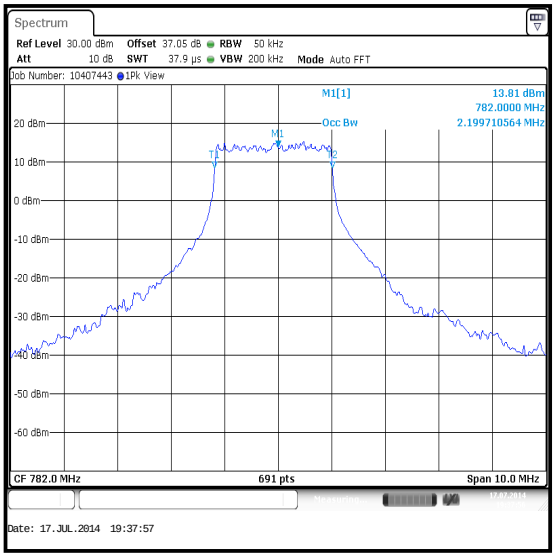
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Middle Channel / 16QAM

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
782.0	25	0	50	200	4.501
782.0	12	6	50	200	2.200



16QAM / 25 Resource Blocks (0 Offset)

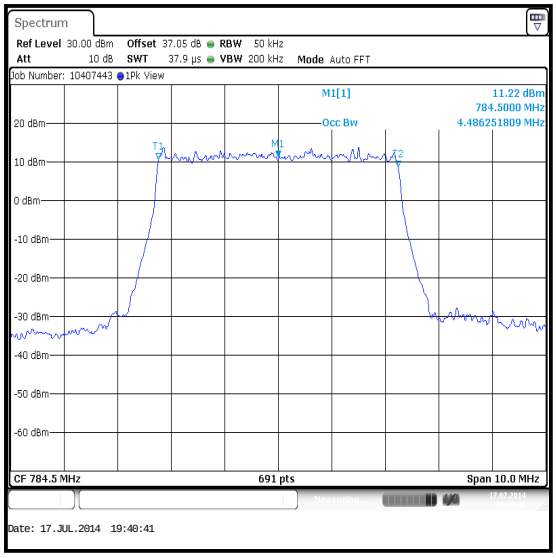


16QAM / 12 Resource Blocks (6 Offset)

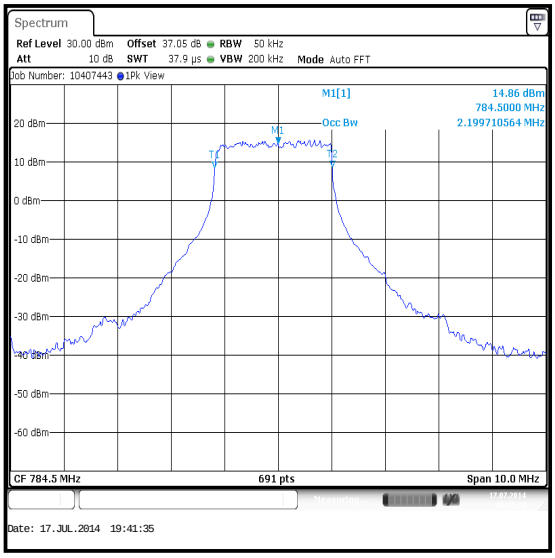
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Top Channel / QPSK

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
784.5	25	0	50	200	4.486
784.5	12	6	50	200	2.200



QPSK / 25 Resource Blocks (0 Offset)

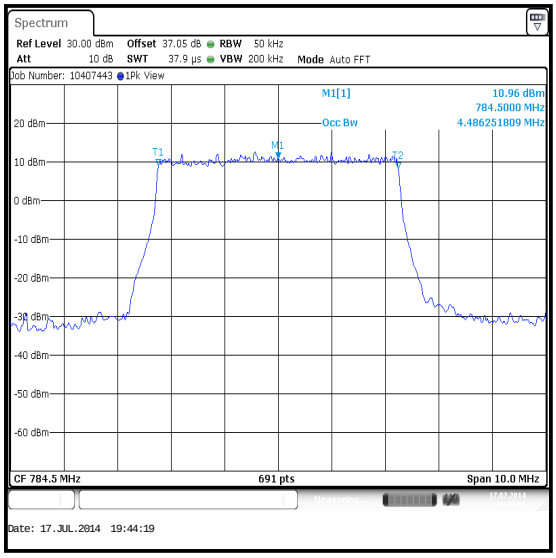


QPSK / 12 Resource Blocks (6 Offset)

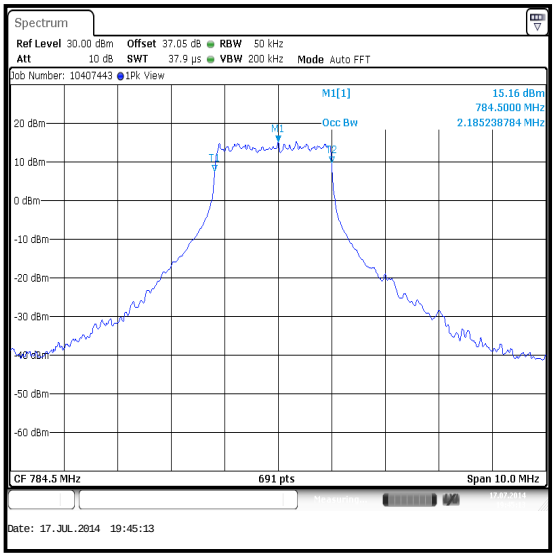
Transmitter Occupied Bandwidth (continued)

Results: 5 MHz Channel Bandwidth / Top Channel / 16QAM

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
784.5	25	0	50	200	4.486
784.5	12	6	50	200	2.185



16QAM / 25 Resource Blocks (0 Offset)

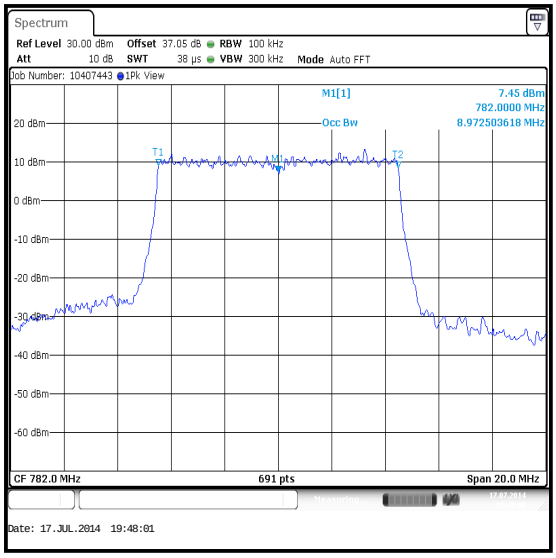


16QAM / 12 Resource Blocks (6 Offset)

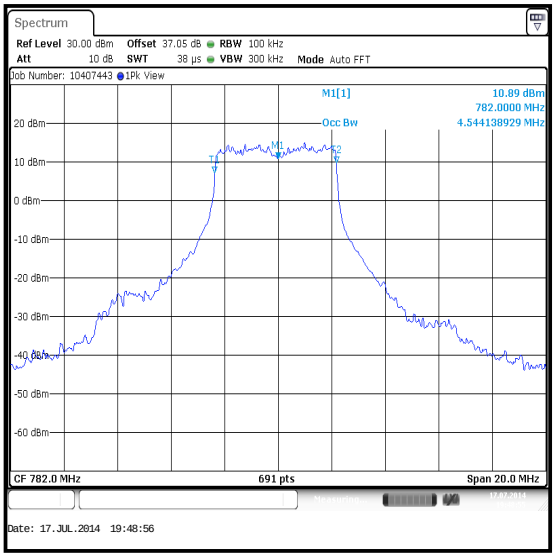
Transmitter Occupied Bandwidth (continued)

Results: 10 MHz Channel Bandwidth / Middle Channel / QPSK

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
782.0	50	0	100	300	8.973
782.0	25	12	100	300	4.544



QPSK / 50 Resource Blocks (0 Offset)

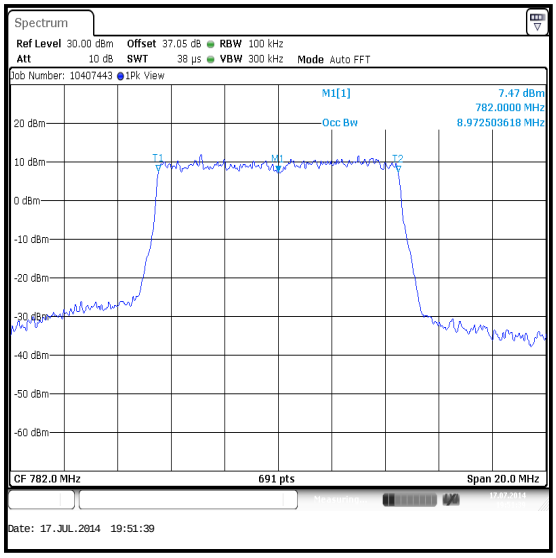


QPSK / 25 Resource Blocks (12 Offset)

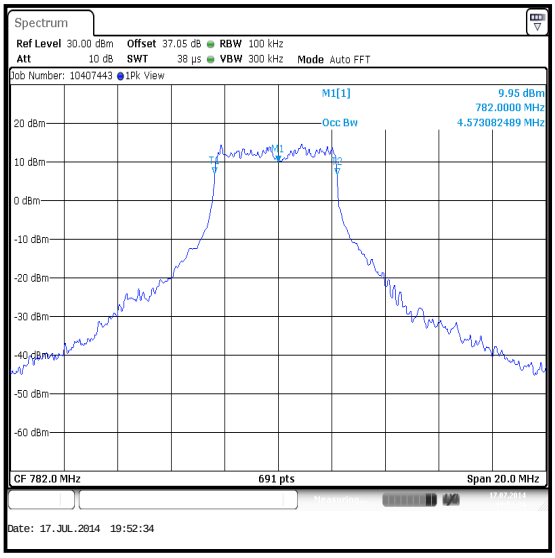
Transmitter Occupied Bandwidth (continued)

Results: 10 MHz Channel Bandwidth / Middle Channel / 16QAM

Frequency (MHz)	Resource Blocks	Resource Block Offset	Resolution Bandwidth (kHz)	Video Bandwidth (kHz)	Occupied Bandwidth (MHz)
782.0	50	0	100	300	8.973
782.0	25	12	100	300	4.573



16QAM / 50 Resource Blocks (0 Offset)



16QAM / 25 Resource Blocks (12 Offset)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1658	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	14 Mar 2015	12
L1127	Signal Analyser	Rohde & Schwarz	FSV13	100863	24 Apr 2015	12
S0537	DC Power Supply	TTi	EL302D	249928	Calibrated before use	-
M1251	Digital Multimeter	Fluke	175	89170179	19 May 2015	12
A2535	Directional Coupler	AtlanTec RF	CDC-003060-20	14041701719	Calibrated before use	-
A2508	Attenuator	AtlanTec RF	AN18-10	821846#3	Calibrated before use	-
A539	Power Splitter	Rohde & Schwarz	RVZ	22441	Calibrated before use	-

5.2.3. Transmitter Radiated Spurious Emissions

Test Summary:

Test Engineers:	Andrew Edwards, Georgios Vrezas & David Doyle	**Test Dates:**	24 July 2014 & 07 August 2014
Test Sample IMEI:	352025060238789		

FCC Reference:	Parts 2.1053 & 27.53(c)(2)
Test Method Used:	As detailed in KDB 971168 Section 6.1 referencing FCC Part 2.1053
Frequency Range:	30 MHz to 8 GHz
Configuration:	5 MHz, QPSK, 1RB, 0 Offset

Environmental Conditions:

Temperature (℃):	21 to 26
Relative Humidity (%):	28 to 42

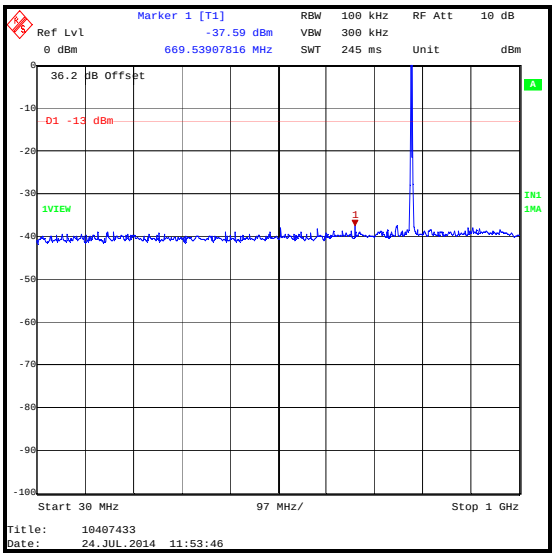
Note(s):

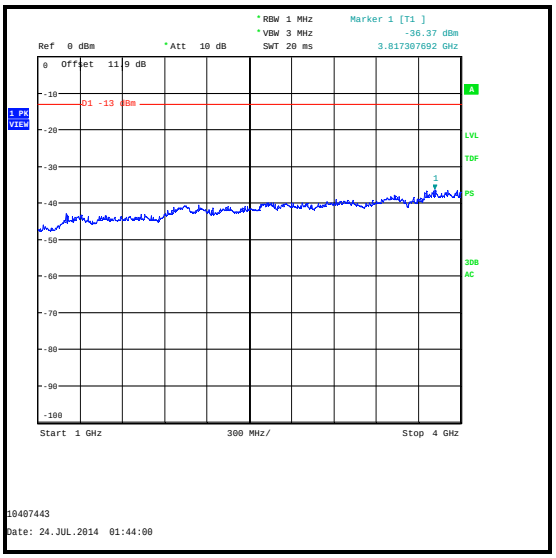
1. The EUT was set to transmit with a 5 MHz channel bandwidth with QPSK modulation applied and 1 resource block with 0 offset, as this was found to be the worst case modulation scheme with regards to emissions after preliminary investigations and, as this mode emits the highest transmit output power level, it was deemed to be the worst case.
2. The emission seen on the 30 MHz to 1 GHz plot at approximately 784.5 MHz is the EUT carrier.
3. No spurious emissions were detected above 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 K0001) at a distance of 3 metres. The EUT was 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 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. Final measurements above 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was 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.

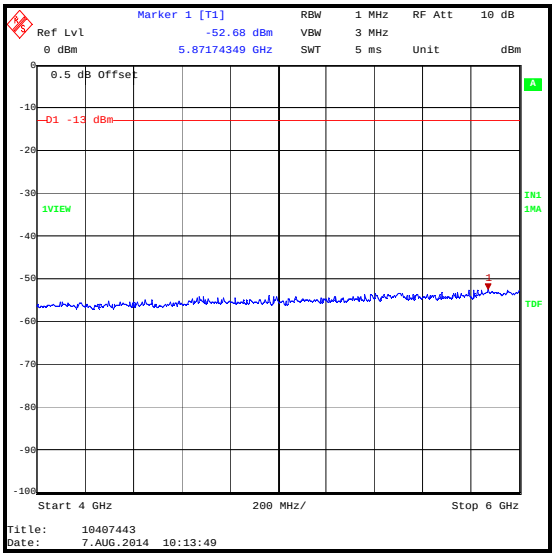
Results: Top Channel

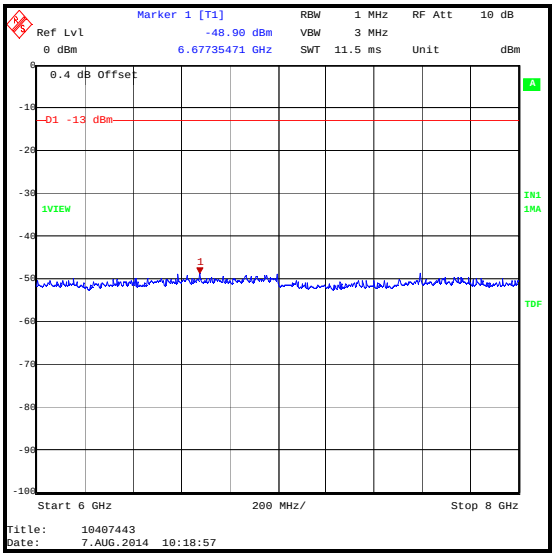
Frequency (MHz)	Peak Level (dBm)	Limit (dBm)	Margin (dB)	Result
3817.308	-36.4	-13.0	23.4	Complied

Transmitter Radiated Spurious Emissions (continued)









Transmitter Radiated Spurious Emissions (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1622	Thermohygrometer	JM Handelspunkt	30.5015.06	None stated	31 Dec 2014	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	26 Nov 2014	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	15 Feb 2015	12
G0543	Amplifier	Sonoma	310N	230801	19 Aug 2014	3
A490	Antenna	Chase	CBL6111A	1590	29 Apr 2015	12
A1834	Attenuator	Hewlett Packard	8491B	10444	15 Nov 2014	12
A2142	Attenuator	AtlanTechRF	AN18-20	081120-23	25 Apr 2015	12
M1656	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	14 Mar 2015	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Nov 2014	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	13 May 2015	12
M1124	Test Receiver	Rohde & Schwarz	ESIB 26	100046K	01 Oct 2014	12
A1534	Pre-Amplifier	Hewlett Packard	8449B	3008A00405	18 May 2015	12
A1818	Antenna	EMCO	3115	00075692	14 Nov 2014	12
A253	Antenna	Flann Microwave	12240-20	128	14 Nov 2014	12
A254	Antenna	Flann Microwave	14240-20	139	14 Nov 2014	12
A1396	Attenuator	Huber & Suhner	6810.17.B	757987	02 May 2015	12
A1974	High Pass Filter	AtlanTecRF	AFH-01000	090000283	12 Apr 2015	12
A1975	High Pass Filter	AtlanTecRF	AFH-03000	090424010	12 Apr 2015	12

5.2.4. Transmitter Radiated Spurious Emissions Limitations

Test Summary:

Test Engineers:	Andrew Edwards & David Doyle	**Test Dates:**	24 July 2014 & 07 August 2014
Test Sample IMEI:	352025060238789		

FCC Reference:	Parts 27.53(c)(4), 27.53(f) and 2.1053
Test Method Used:	As detailed in KDB 971168 Section 6.1 referencing FCC Part 2.1053
Frequency Ranges:	763 to 775 MHz 793 to 805 MHz 1559 to 1610 MHz

Environmental Conditions:

Temperature (°C):	22 to 23
Relative Humidity (%):	41 to 42

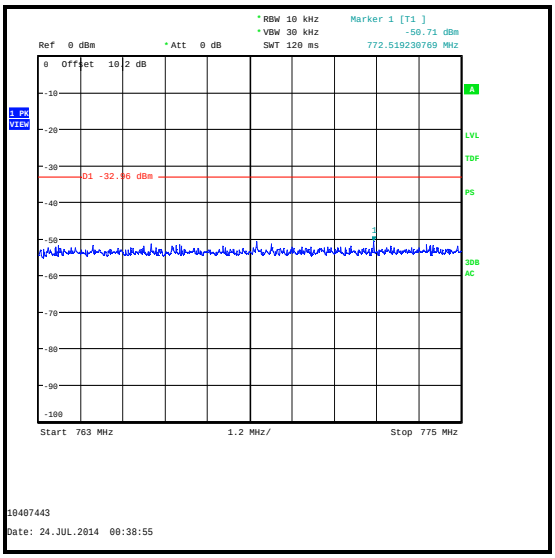
Note(s):

1. Measurements were performed with the EUT transmitting with QPSK and 16QAM modulation schemes, with resource blocks of 1 and 25. For single resource blocks, measurements were performed with the block starting of blocks 1 and 24.
2. Pre-scans were performed on top channel. For the 1559 to 1610 MHz band wideband emissions were observed. Final measurements were also performed on bottom and middle channels. No discrete emissions of less than 700 Hz were observed.
3. All other emissions were >20 dB below the applicable limit or below the level of the noise floor of the measuring receiver.
4. The limit for 27.53(c)(4) is 65 + $10\log_{10}$ (P) = -35 dBm in a 6.25 kHz bandwidth. As it was not possible to set the resolution bandwidth on the test equipment, the bandwidth was set to 10 kHz. The limit was adjusted by 10 $\log_{10}$ (10 kHz / 6.25 kHz) = 2.04 dB. The limit shown in the plots for the 763 MHz to 775 MHz and 793 MHz to 805 MHz bands was set to -35 dBm + 2.04 dB = -32.96 dBm.
5. The limit for 27.53(f) states emissions in the band 1559 MHz to 1610 MHz shall be limited to -70 dBW/MHz (-40 dBm) equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP (-50 dBm) for discrete emissions of less than 700 Hz bandwidth.
6. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was 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.
7. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0002) at a distance of 3 metres. The EUT was 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. Final measurements above 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was 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.

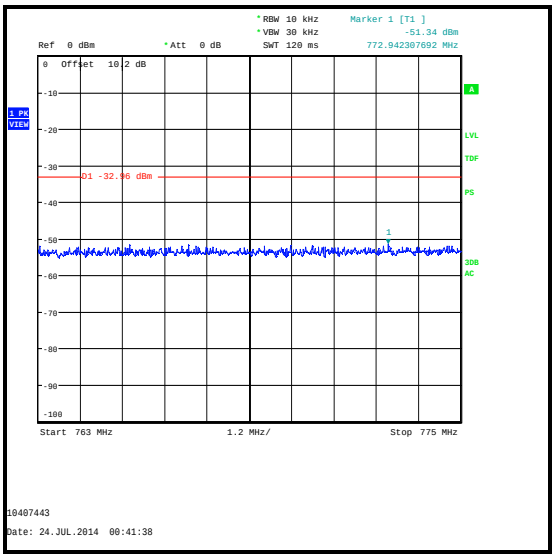
Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 763 MHz to 775 MHz / QPSK / Top Channel

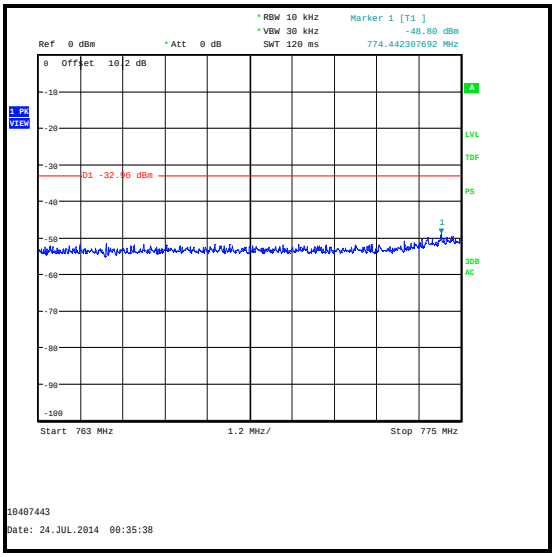
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
772.519	1	0	-50.7	-32.96	17.74	Complied
772.942	1	24	-51.3	-32.96	18.34	Complied
774.442	25	0	-48.8	-32.96	15.84	Complied



QPSK / 1 Resource Block (0 Offset)



QPSK / 1 Resource Block (24 Offset)

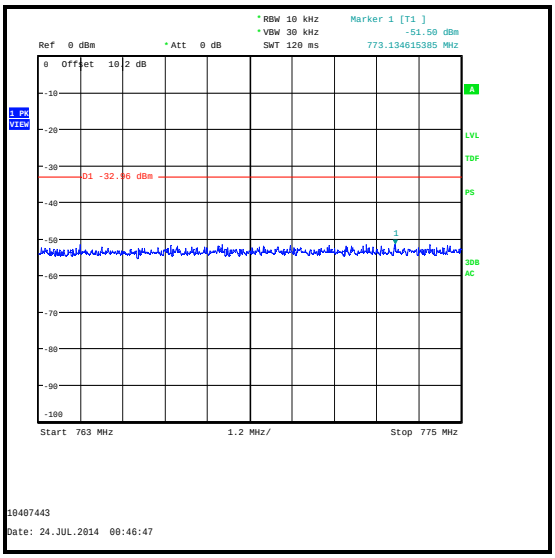


QPSK / 25 Resource Blocks

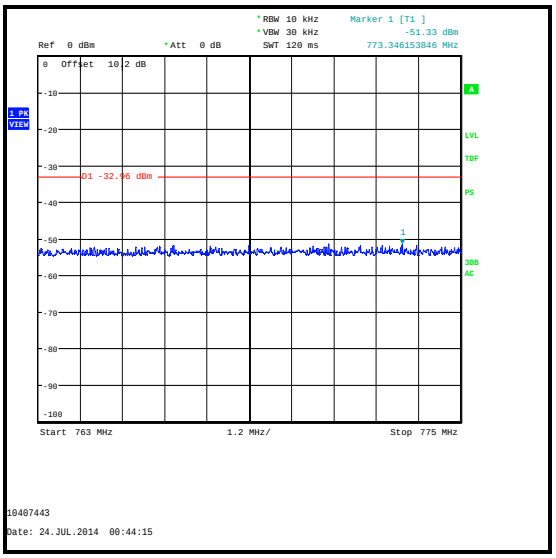
Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 763 MHz to 775 MHz / 16QAM / Top Channel

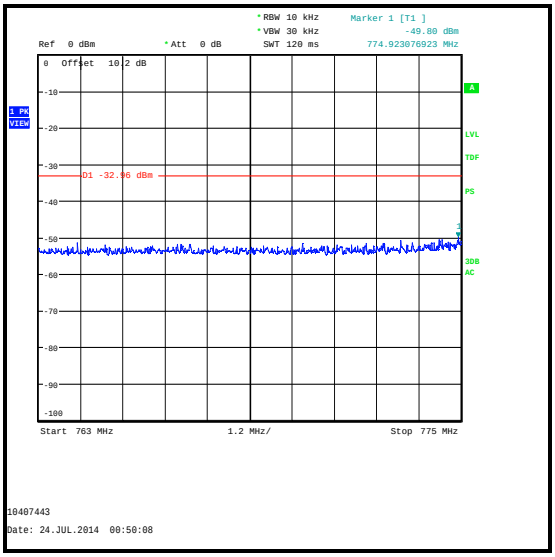
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
773.135	1	0	-51.5	-32.96	18.54	Complied
773.346	1	24	-51.3	-32.96	18.34	Complied
774.923	25	0	-49.8	-32.96	16.84	Complied



16QAM / 1 Resource Block (0 Offset)



16QAM / 1 Resource Block (24 Offset)

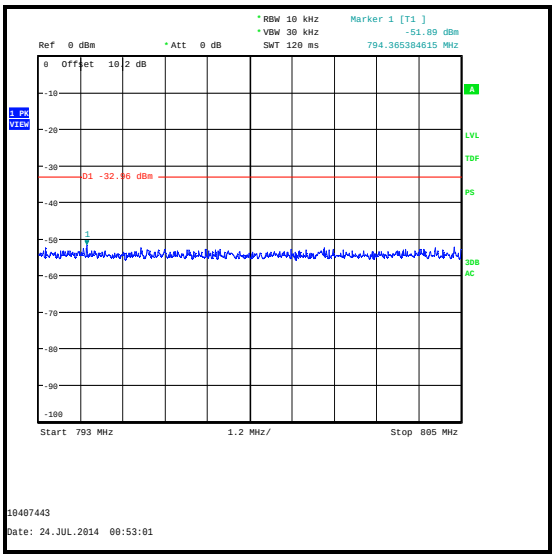


16QAM / 25 Resource Blocks

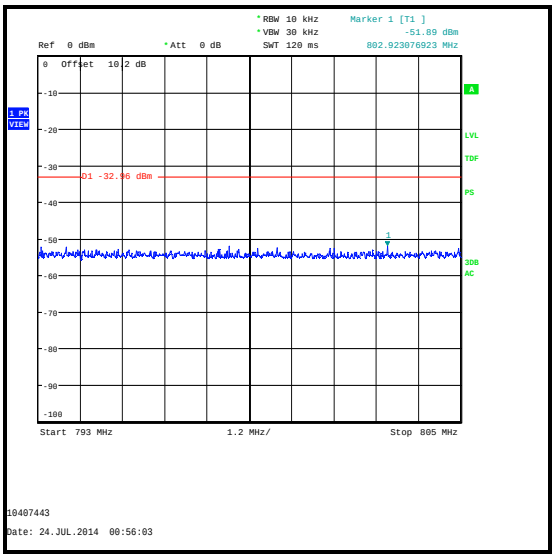
Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 793 MHz to 805 MHz / QPSK / Top Channel

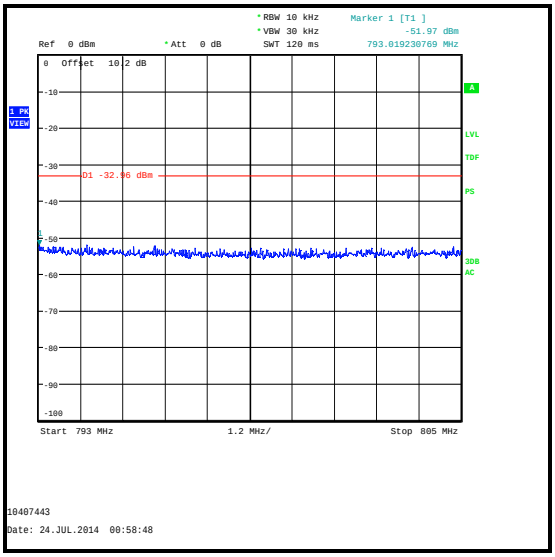
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
794.365	1	0	-51.9	-32.96	18.94	Complied
802.923	1	24	-51.9	-32.96	18.94	Complied
793.019	25	0	-52.0	-32.96	19.04	Complied



QPSK / 1 Resource Block (0 Offset)



QPSK / 1 Resource Block (24 Offset)

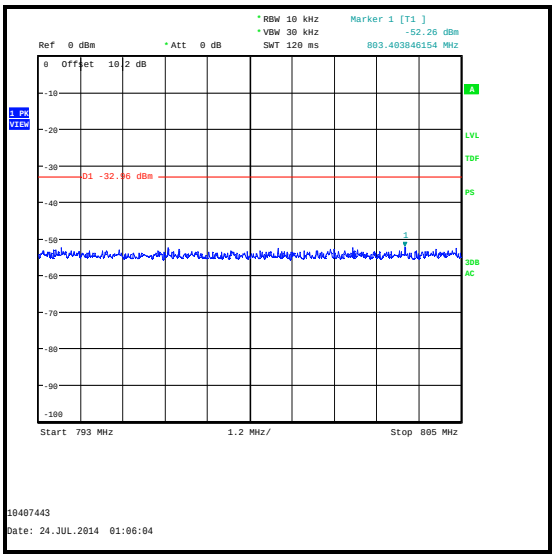


QPSK / 25 Resource Blocks

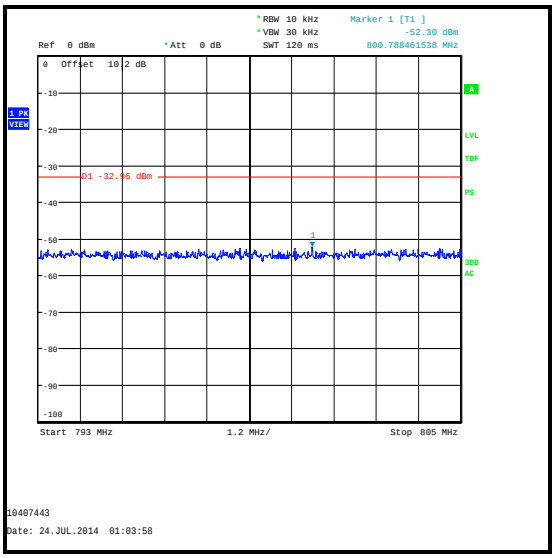
Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 793 MHz to 805 MHz / 16QAM / Top Channel

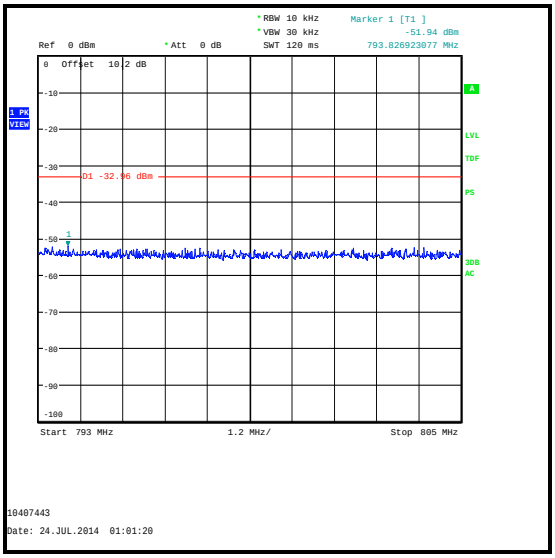
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
803.404	1	0	-52.3	-32.96	19.34	Complied
800.788	1	24	-52.3	-32.96	19.34	Complied
793.827	25	0	-51.9	-32.96	18.94	Complied



16QAM / 1 Resource Block (0 Offset)



16QAM / 1 Resource Block (24 Offset)



16QAM / 25 Resource Blocks

Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 1559 MHz to 1610 MHz / QPSK / Bottom Channel

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1609.755	1	0	-54.0	-40.0	14.0	Complied
1563.577	1	24	-49.9	-40.0	9.9	Complied
1561.861	25	0	-54.5	-40.0	14.5	Complied

Results: 1559 MHz to 1610 MHz / QPSK / Middle Channel

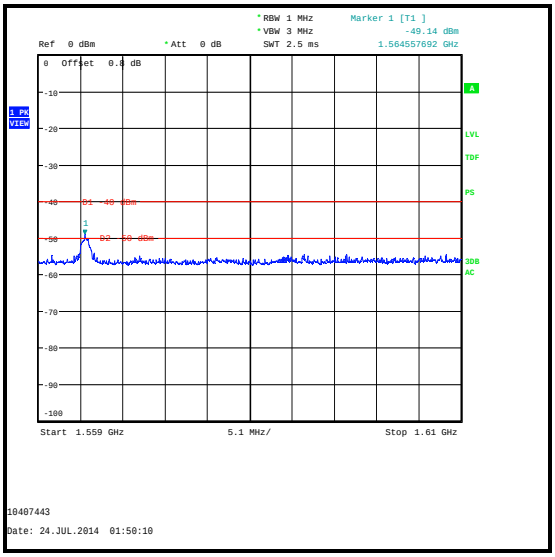
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1559.721	1	0	-50.3	-40.0	10.3	Complied
1568.154	1	24	-48.7	-40.0	8.7	Complied
1563.904	25	0	-53.6	-40.0	13.6	Complied

Results: 1559 MHz to 1610 MHz / QPSK / Top Channel

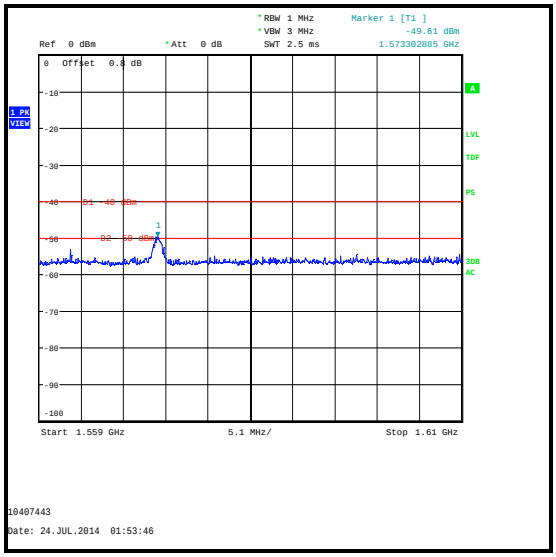
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1564.558	1	0	-49.1	-40.0	9.1	Complied
1573.303	1	24	-49.6	-40.0	9.6	Complied
1568.971	25	0	-53.8	-40.0	13.8	Complied

Transmitter Radiated Spurious Emissions Limitations (continued)

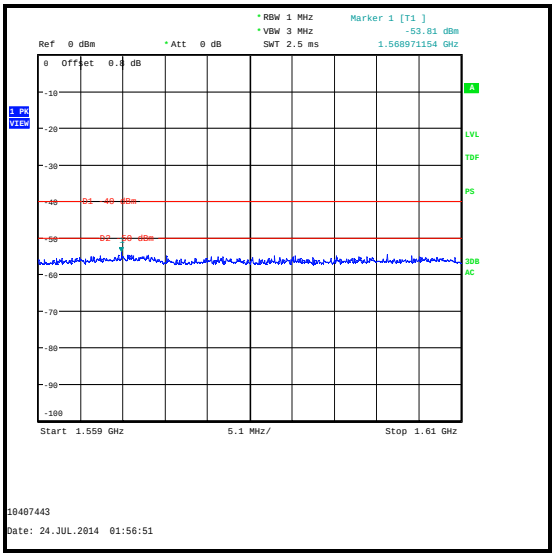
Results: 1559 MHz to 1610 MHz / QPSK / Top Channel



QPSK / 1 Resource Block (0 Offset)



QPSK / 1 Resource Block (24 Offset)



QPSK / 25 Resource Blocks

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter Radiated Spurious Emissions Limitations (continued)

Results: 1559 MHz to 1610 MHz / 16QAM / Bottom Channel

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1606.525	1	0	-62.8	-40.0	22.8	Complied
1563.088	1	24	-51.9	-40.0	11.9	Complied
1559.102	25	0	-60.5	-40.0	20.5	Complied

Results: 1559 MHz to 1610 MHz / 16QAM / Middle Channel

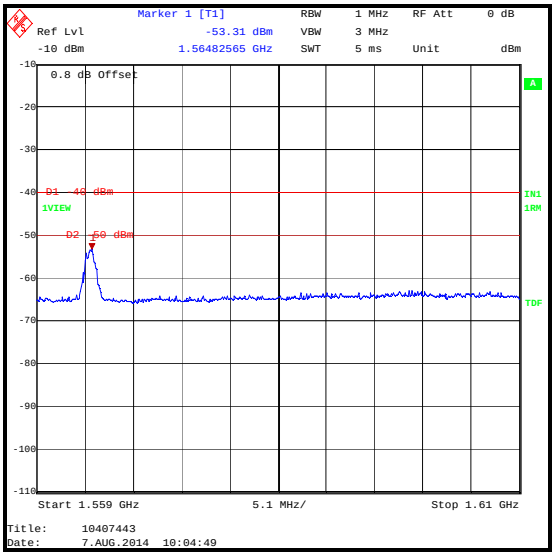
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1559.715	1	0	-52.7	-40.0	12.7	Complied
1568.198	1	24	-54.3	-40.0	14.3	Complied
1562.782	25	0	-61.4	-40.0	21.4	Complied

Results: 1559 MHz to 1610 MHz / 16QAM / Top Channel

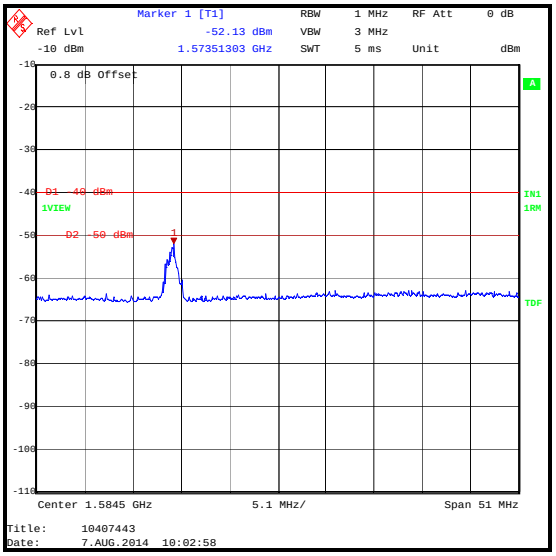
Frequency (MHz)	Resource Block(s)	Resource Block Offset	Peak Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
1564.826	1	0	-53.3	-40.0	13.3	Complied
1573.513	1	24	-52.1	-40.0	12.1	Complied
1567.994	25	0	-62.6	-40.0	22.6	Complied

Transmitter Radiated Spurious Emissions Limitations (continued)

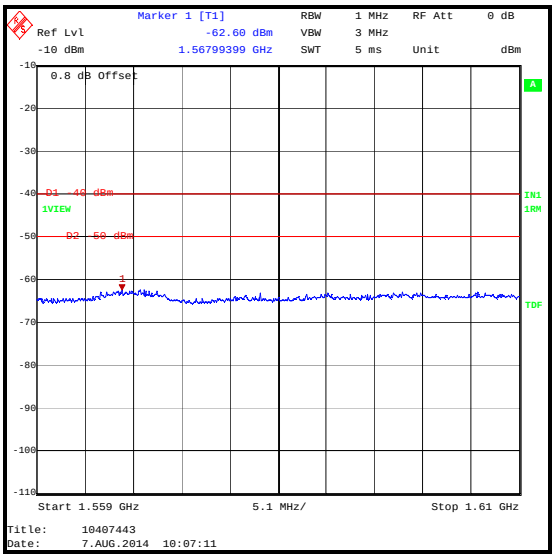
Results: 1559 MHz to 1610 MHz / 16QAM / Top Channel



16QAM / 1 Resource Block (0 Offset)



16QAM / 1 Resource Block (24 Offset)



16QAM / 25 Resource Blocks

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter Radiated Spurious Emissions Limitations (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
A1534	Pre-Amplifier	Hewlett Packard	8449B	3008A00405	18 May 2015	12
A1818	Antenna	EMCO	3115	00075692	14 Nov 2014	12
A288	Antenna	Chase	CBL6111A	1589	20 Aug 2014	12
A1396	Attenuator	Huber & Suhner	6810.17.B	757987	02 May 2015	12
A1974	High Pass Filter	AtlanTecRF	AFH-01000	090000283	12 Apr 2015	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Nov 2014	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	13 May 2015	12
M1124	Test Receiver	Rohde & Schwarz	ESIB 26	100046K	01 Oct 2014	12
M1656	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	14 Mar 2015	12
A1834	Attenuator	Hewlett Packard	8491B	10444	15 Nov 2014	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	26 Nov 2014	12
G0543	Amplifier	Sonoma	310N	230801	19 Aug 2014	3
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	15 Feb 2015	12
M1622	Thermohygrometer	JM Handelspunkt	30.5015.06	None stated	31 Dec 2014	12

5.2.5. Transmitter Radiated Emissions at Band Edges

Test Summary:

Test Engineers:	Andrew Edwards & Nick Steele	**Test Dates:**	24 July 2014 & 14 September 2014
Test Sample IMEI:	352025060238789		

FCC Reference:	Parts 2.1053 & 27.53(c)(2)
Test Method Used:	As detailed in KDB 971168 Section 6.1 referencing FCC Part 27.53

Environmental Conditions:

Temperature (℃):	21 to 22
Relative Humidity (%):	43 to 50

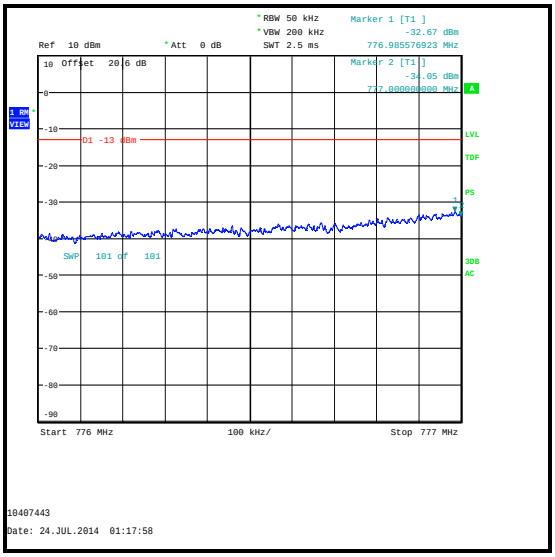
Note(s):

1. Measurements were performed with the EUT transmitting QPSK and 16QAM modulation schemes, with the maximum resource blocks settings.
2. Measurements were performed in a fully anechoic chamber (Asset Number K0002) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. The measurement antenna was placed at a fixed height of 1.5 metres above the test chamber floor in line with the EUT.
3. 5 MHz Channel bandwidth: In the first 1.0 MHz immediately outside and adjacent to the operating band, the test receiver resolution bandwidth was set to 50 kHz (1% of 5 MHz, the widest 26 dB emission bandwidth) and video bandwidth 200 kHz (as close to > three times the resolution bandwidth as the test receiver allowed).
4. 10 MHz Channel bandwidth: In the first 1.0 MHz immediately outside and adjacent to the operating band, the test receiver resolution bandwidth was set to 100 kHz (>1% of 9.9 MHz, the widest 26 dB emission bandwidth) and video bandwidth 300 kHz (three times the resolution bandwidth).

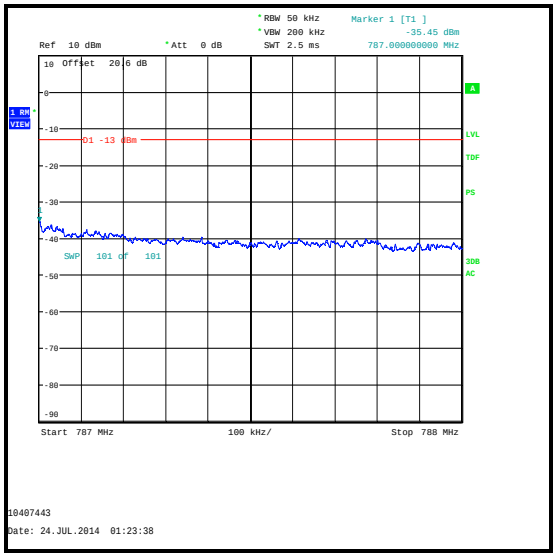
Transmitter Radiated Emissions at Band Edges (continued)

Results: 5 MHz Channel Bandwidth / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
776.986	25	0	-32.7	-13.0	19.7	Complied
777	25	0	-34.1	-13.0	21.1	Complied
787	25	0	-35.5	-13.0	22.5	Complied



QPSK / Lower Band Edge

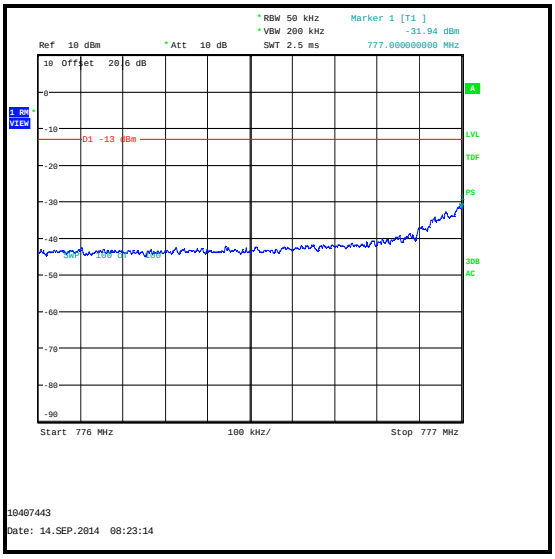


QPSK / Upper Band Edge

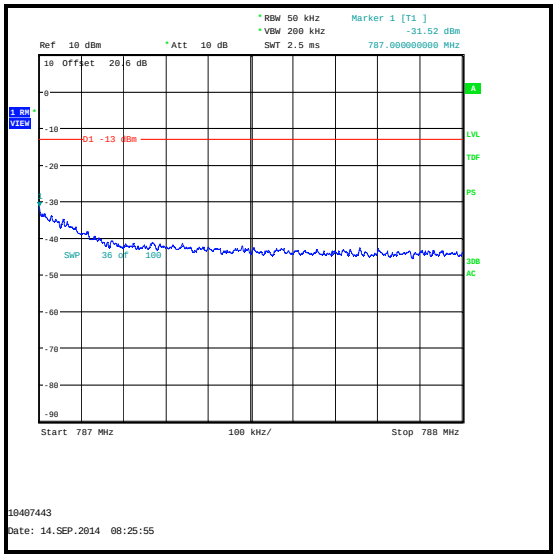
Transmitter Radiated Emissions at Band Edges (continued)

Results: 5 MHz Channel Bandwidth / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
777	1	0	-31.9	-13.0	18.9	Complied
787	1	24	-31.5	-13.0	18.5	Complied



QPSK / Lower Band Edge

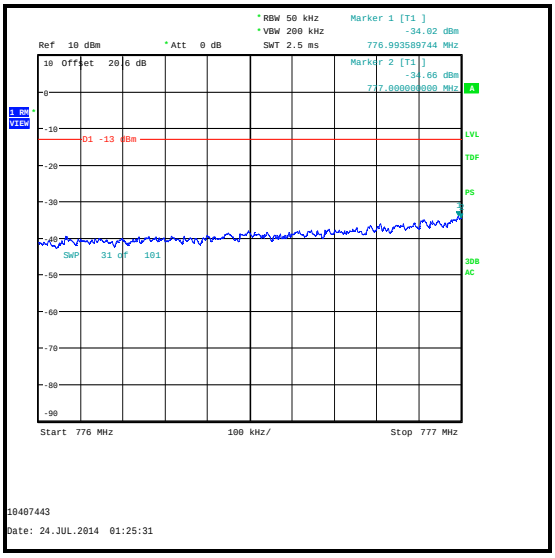


QPSK / Upper Band Edge

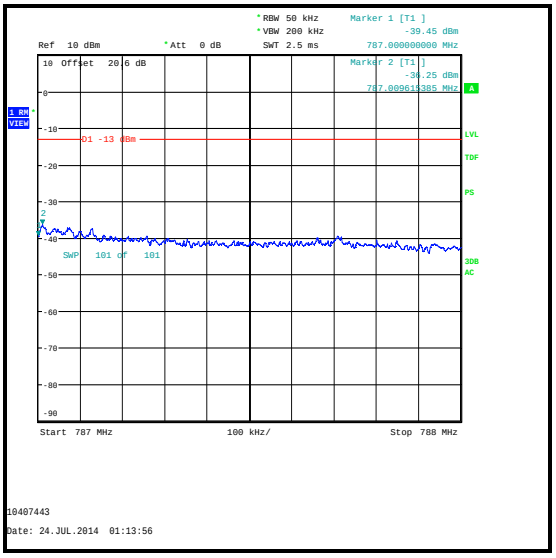
Transmitter Radiated Emissions at Band Edges (continued)

Results: 5 MHz Channel Bandwidth / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
776.994	25	0	-34.0	-13.0	21.0	Complied
777	25	0	-34.7	-13.0	21.7	Complied
787	25	0	-39.5	-13.0	26.5	Complied
787.010	25	0	-36.3	-13.0	23.3	Complied



16QAM / Lower Band Edge

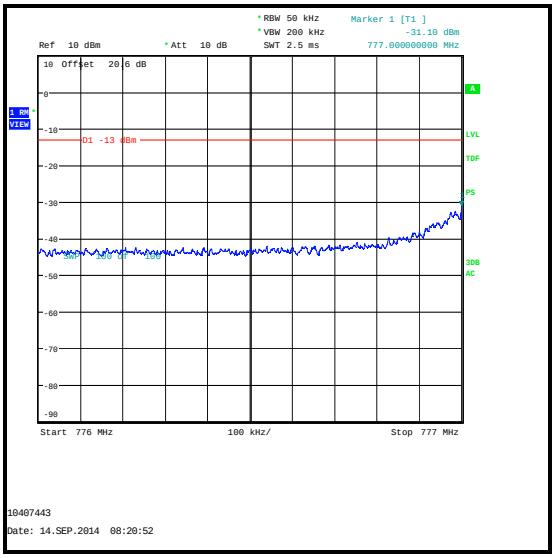


16QAM / Upper Band Edge

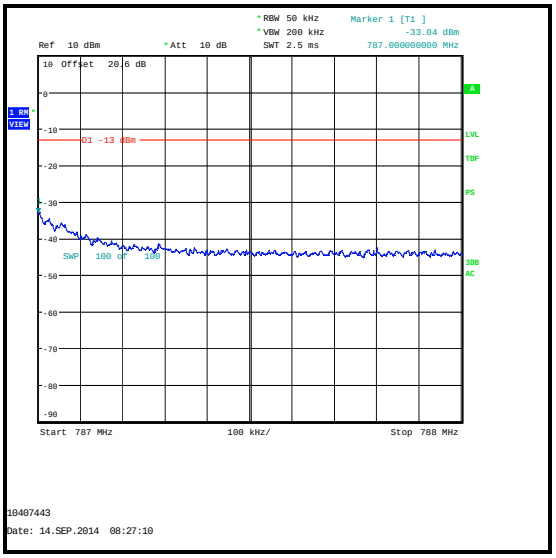
Transmitter Radiated Emissions at Band Edges (continued)

Results: 5 MHz Channel Bandwidth / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
777	1	0	-31.1	-13.0	18.1	Complied
787	1	24	-33.0	-13.0	20.0	Complied



16QAM / Lower Band Edge

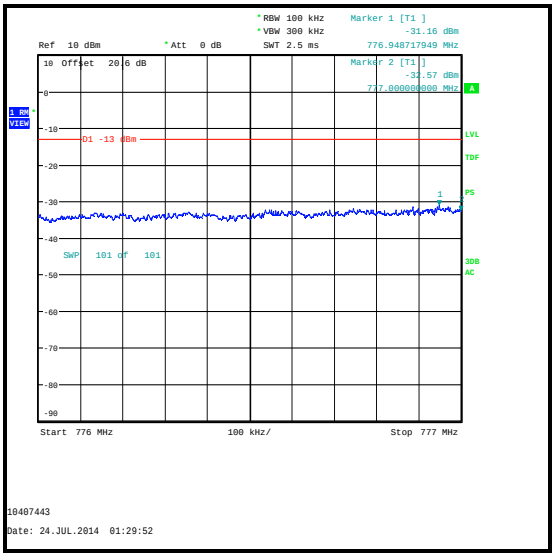


16QAM / Upper Band Edge

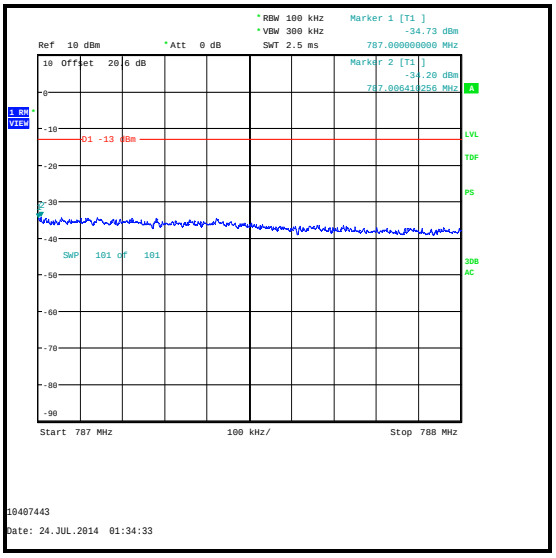
Transmitter Radiated Emissions at Band Edges (continued)

Results: 10 MHz Channel Bandwidth / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
776.949	50	0	-31.2	-13.0	18.2	Complied
777	50	0	-32.6	-13.0	19.6	Complied
787	50	0	-34.7	-13.0	21.7	Complied
787.006	50	0	-34.2	-13.0	21.2	Complied



QPSK / Lower Band Edge

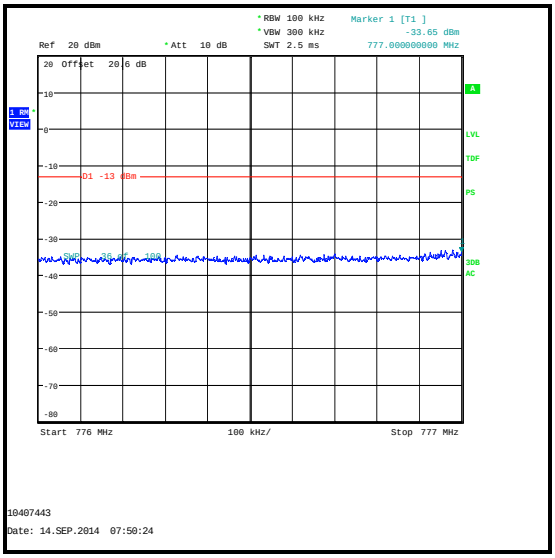


QPSK / Upper Band Edge

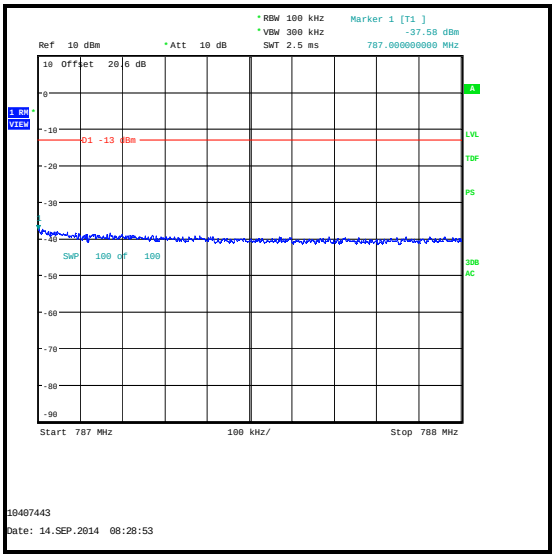
Transmitter Radiated Emissions at Band Edges (continued)

Results: 10 MHz Channel Bandwidth / QPSK

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
777	1	0	-33.7	-13.0	20.7	Complied
787	1	49	-37.6	-13.0	24.6	Complied



QPSK / Lower Band Edge

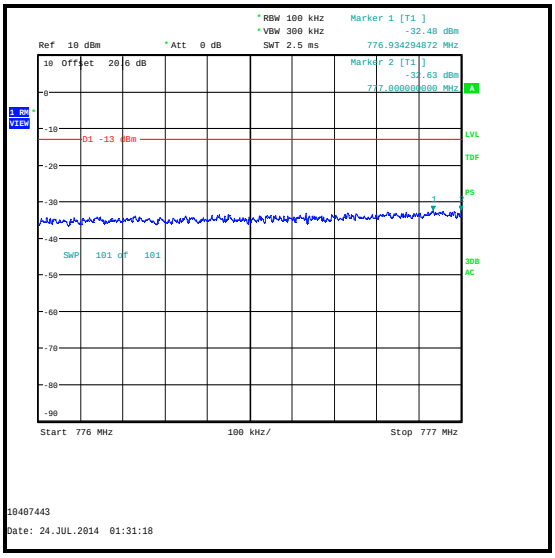


QPSK / Upper Band Edge

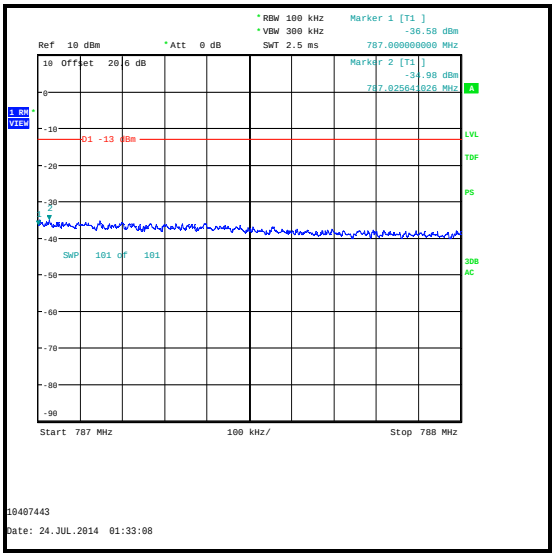
Transmitter Radiated Emissions at Band Edges (continued)

Results: 10 MHz Channel Bandwidth / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
776.934	50	0	-32.5	-13.0	19.5	Complied
777	50	0	-32.6	-13.0	19.6	Complied
787	50	0	-36.6	-13.0	23.6	Complied
787.026	50	0	-35.0	-13.0	22.0	Complied



16QAM / Lower Band Edge

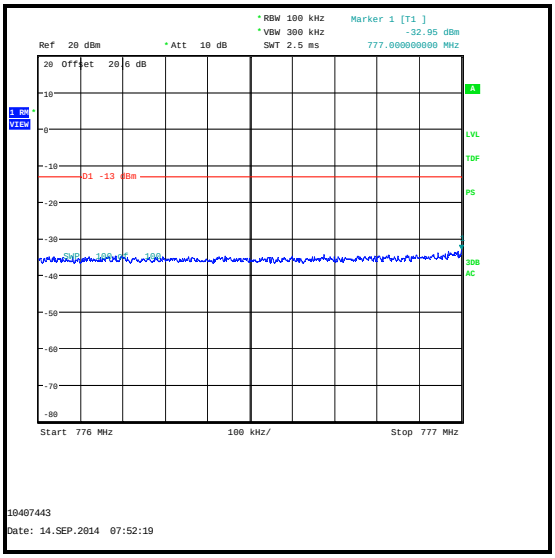


16QAM / Upper Band Edge

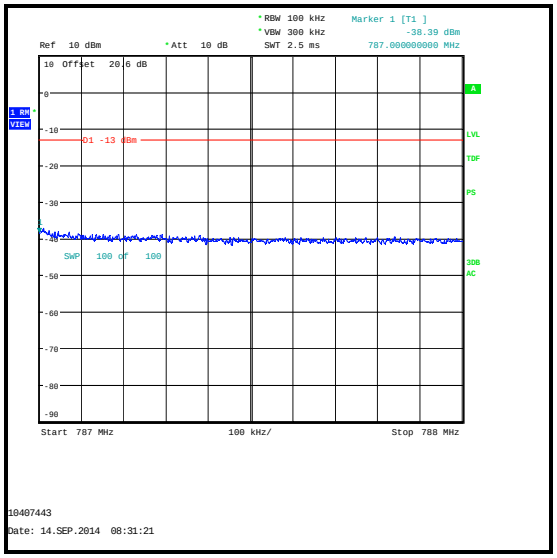
Transmitter Radiated Emissions at Band Edges (continued)

Results: 10 MHz Channel Bandwidth / 16QAM

Frequency (MHz)	Resource Block(s)	Resource Block Offset	Emission Level (dBm)	Limit (dBm)	Margin (dB)	Result
777	1	0	-33.0	-13.0	20.0	Complied
787	1	49	-38.4	-13.0	25.4	Complied



16QAM / Lower Band Edge



16QAM / Upper Band Edge

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1656	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	14 Mar 2015	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Nov 2014	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	13 May 2015	12
A288	Antenna	Chase	CBL6111A	1589	20 Aug 2014	12
A1393	Attenuator	Huber & Suhner	6820.17.B	757456	02 May 2015	12

5.2.6. Transmitter Frequency Stability (Temperature Variation)

Test Summary:

Test Engineer:	Keith Tucker	**Test Dates:**	09 July 2014 & 10 July 2014
Test Sample IMEI:	352025060274538		

FCC Reference:	Parts 2.1055 & 27.54
Test Method Used:	As detailed in KDB 971168 Section 9.0 referencing ANSI TIA-603-C-2004 Section 2.2.2 and FCC Part 2.1055

Environmental Conditions:

Ambient Temperature (℃):	22 to 23
Ambient Relative Humidity (%):	38 to 49

Note(s):

1. Flying leads were connected internally to the EUT in place of the battery. These leads were extended and connected to a bench power supply, set at the EUT nominal voltage.
2. Frequency error was measured using a calibrated Rohde & Schwarz CMW 500 Universal Radio Communications Tester in accordance with current Rohde & Schwarz application notes. The EUT was connected by suitable RF cables to the CMW 500. A bi-directional communications link was established between the EUT and CMW 500. The frequency meter value was recorded.
3. Temperature was monitored throughout the test with a calibrated digital thermometer.

Transmitter Frequency Stability (Temperature Variation) (continued)

Results: Bottom Channel (779.5 MHz)

Temperature (ºC)	Frequency Error (Hz)	Measured Frequency (MHz)	Lower Band Edge Limit (MHz)	Margin (MHz)	Result
-30	6	779.500006	777.0	2.500006	Complied
-20	6	779.500006	777.0	2.500006	Complied
-10	7	779.499993	777.0	2.499993	Complied
0	6	779.500006	777.0	2.500006	Complied
10	7	779.500007	777.0	2.500007	Complied
20	6	779.499994	777.0	2.499994	Complied
30	7	779.500007	777.0	2.500007	Complied
40	7	779.499993	777.0	2.499993	Complied
50	7	779.499993	777.0	2.499993	Complied

Results: Top Channel (784.5 MHz)

Temperature (ºC)	Frequency Error (Hz)	Measured Frequency (MHz)	Upper Band Edge Limit (MHz)	Margin (MHz)	Result
-30	6	784.500006	787.0	2.499994	Complied
-20	6	784.500006	787.0	2.499994	Complied
-10	6	784.499994	787.0	2.500006	Complied
0	5	784.499995	787.0	2.500005	Complied
10	6	784.500006	787.0	2.499994	Complied
20	7	784.499993	787.0	2.500007	Complied
30	7	784.499993	787.0	2.500007	Complied
40	7	784.499993	787.0	2.500007	Complied
50	7	784.499993	787.0	2.500007	Complied

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1658	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	14 Mar 2015	12
M1870	Wideband Radio Comms Tester	Rohde & Schwarz	CMW500	145919	05 May 2015	12
G088	Dual DC power supply	Thurlby Thandar	CPX200	100700	Calibrated before use	-
M1251	Multimeter	Fluke	175	89170179	19 May 2015	12
M1643	Thermometer	Fluke	52II	18890136	07 Apr 2015	12
E013	Environmental Chamber	Sanyo	MTH-4200PR	none	Calibrated before use	-

5.2.7. Transmitter Frequency Stability (Voltage Variation)

Test Summary:

Test Engineer:	Keith Tucker	**Test Dates:**	09 July 2014 & 10 July 2014
Test Sample IMEI:	352025060274538		

FCC Reference:	Parts 2.1055 & 27.54
Test Method Used:	As detailed in KDB 971168 Section 9.0 referencing ANSI TIA-603-C-2004 Section 2.2.2 and FCC Part 2.1055

Environmental Conditions:

Temperature (℃):	22 to 23
Relative Humidity (%):	38 to 49

Note(s):

1. Flying leads were connected internally to the EUT in place of the battery. These leads were extended and connected to a bench power supply.
2. Frequency error was measured using a calibrated Rohde & Schwarz CMW 500 Universal Radio Communications Tester in accordance with current Rohde & Schwarz application notes. The EUT was connected by suitable RF cables to the CMW 500. A bi-directional communications link was established between the EUT and CMW 500. The frequency meter value was recorded.
3. Voltage was monitored throughout the test with a calibrated digital voltmeter.

Results: Bottom Channel (779.5 MHz)

Supply Voltage (V)	Frequency Error (Hz)	Measured Frequency (MHz)	Lower Band Edge Limit (MHz)	Margin (MHz)	Result
3.4	7	779.500007	777.0	2.500007	Complied
4.2	6	779.499994	777.0	2.499994	Complied

Results: Top Channel (784.5 MHz)

Supply Voltage (V)	Frequency Error (Hz)	Measured Frequency (MHz)	Upper Band Edge Limit (MHz)	Margin (MHz)	Result
3.4	6	784.499994	787.0	2.500006	Complied
4.2	7	784.499993	787.0	2.500007	Complied

Transmitter Frequency Stability (Voltage Variation) (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1658	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	14 Mar 2015	12
M1870	Wideband Radio Comms Tester	Rohde & Schwarz	CMW500	145919	05 May 2015	12
G088	Dual DC power supply	Thurlby Thandar	CPX200	100700	Calibrated before use	-
M1251	Multimeter	Fluke	175	89170179	19 May 2015	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	777 MHz to 787 MHz	95%	±0.76 dB
Frequency Stability	777 MHz to 787 MHz	95%	±23 Hz
Occupied Bandwidth	777 MHz to 787 MHz	95%	±3.92 %
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±5.65 dB
Radiated Spurious Emissions	1 GHz to 8 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	-	-	Admin updates Additional Radiated Band Edge measurements

--- END OF REPORT ---