

LABORATORY TEST REPORT

RADIO PERFORMANCE MEASUREMENTS

for the

TBCK4E Base Station Transceiver

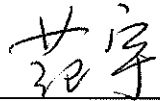
Tested in accordance with:

FCC 47 CFR Part 2, Part 27

Report Revision: 1

Issue Date: 23-August-2016

PREPARED BY: Aaron. Fan


Test Technician

CHECKED & APPROVED BY: M. C. James


Laboratory Technical Manager



IANZ
ACCREDITED LABORATORY

OATS FCC LISTING REGISTRATION: 837095

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REVISION

Date	Revision	Comments
23-August-2016	1	Initial test report

INTRODUCTION

Type approval testing of the BASE STATION, 100 Watt, TBCK4E transceiver. This is a class 2 permissive change to expand the radio's operation into the 757-758MHz/787-788MHz band in accordance with:

FCC 47 CFR Part 2, Part 27

The original test report for this product is TARF 3764

REPORT PREPARED FOR

Tait Ltd
245 Wooldridge Road
Harewood
Christchurch 8051
New Zealand

DESCRIPTION OF SAMPLE

Manufacturer: Tait Limited
Equipment: BASE STATION Transceiver
Type: TBCK4E

TBCK4E Base Station Transceiver consisting of:

FUNCTIONAL DESCRIPTION	PRODUCT DESIGNATION CODE	SERIAL NUMBER (S)
Reciter	T01-01105-TAAA	18222413
Power Amplifier	T01-01136-NBAA	18241506
Power Management Unit	TBA30A0-0100	18169039
Front Panel	T01-01110-CCAA	18169805

Quantity: 1 of each

HARDWARE & SOFTWARE Details:

FUNCTIONAL DESCRIPTION	FIRMWARE VERSION	HARDWARE VERSION
Reciter	dmr-2.20.00.0002	1
Power Amplifier	314	1
Power Management Unit	316	0.03
Front Panel	1.08.00.0002	0.04

TEST CONDITIONS

All testing was performed between 04 August → 23 August-2016, and under the following conditions:

Ambient temperature: 15°C → 30°C
Relative Humidity: 20% → 75%
Standard Test Voltage 120 V_{AC}

STATEMENT OF COMPLIANCE

We, TELTEST LABORATORIES of 558 Wairakei Road, Christchurch, New Zealand, declare under our sole responsibility that the product:

Equipment: BASE STATION Transceiver
Type: TBCK4E
Quantity: 1

to which this declaration relates, is in conformity with the following standards:

FCC 47 CFR Part 2, Part 27

Signature: 

Mike James
Technical Manager

Date: 31 August 2016

MODULATION TYPES, NECESSARY BANDWIDTH & EMISSION DESIGNATORS

MODULATION TYPES:

F3E	FM Analogue Voice	-	-
F2D	Fast Frequency Shift Keying	1200 symbols/sec	1200 bps
FXW	Digital Voice / Data	4800 symbols/sec	9600 bps

CHANNEL SPACINGS: 12.5 kHz

EMISSION DESIGNATORS:

Analogue Voice	11k0F3E
FFSK	7K60F2D
DMR Digital Voice / Data	7K60FXW
DMR Digital Data	7K60FXD

Equation: $B_n = 2M + 2Dk$

(M is highest modulating frequency; D is peak allowable deviation; k is a constant of 1 for FM)

Analogue Voice 12.5 kHz Channel Spacing

Necessary bandwidth

M = 3.0 kHz

D = 2.5 kHz

$$B_n = (2 \times 3.0) + (2 \times 2.5) \times 1$$

$$= 11.0 \text{ kHz}$$

Emission Designator

11K0F3E

F3E represents an FM voice transmission

Fast Frequency Shift Keying (FFSK – 1200 bps) 12.5 kHz Channel Spacing

Necessary bandwidth

M = 1.8 kHz

D = 2.0 kHz

$$B_n = (2 \times 1.8) + (2 \times 2.0) \times 1$$

$$= 7.6 \text{ kHz}$$

Emission Designator

7K60F2D

F2D represents a FM data transmission with the use of a modulating sub carrier

Digital Mobile Radio (DMR)

4 level FSK (as per ETSI TS 102 361-1)

4800 symbols/sec 9600 bps

Digital Data 12.5 kHz Channel Spacing – 7K60FXW

99% bandwidth = 7.6 kHz

Emission Designator

7K60FXW

FXW represents FM combination of data and telephony.

Digital Data 12.5 kHz Channel Spacing – 7K60FXD

99% bandwidth = 7.6 kHz

Emission Designator

7K60FXD

FXD represents FM of data only transmission.

TEST RESULTS

TRANSMITTER OUTPUT POWER (CONDUCTED)

SPECIFICATION: FCC 47 CFR 2.1046
FCC 47 CFR 27.50

GUIDE: TIA-102.CAAA-C 2.2.1

MEASUREMENT PROCEDURE:

1. Refer Annex A for Equipment set up.
2. The coaxial attenuator has an impedance of 50 Ohms.
3. The unmodulated output power was measured with an RF Power meter.

MEASUREMENT RESULTS:

Manufacturer's Rated Output Power:

Switchable: 100 W and 10 W

Tx 757.5MHz	Nominal 100W	Nominal 10W
Measured	91.7	9.0
Variation (%)	-8.31	-10.21
Variation (dB)	-0.4	-0.5
Measurement Uncertainty: ± 0.6 dB		

LIMIT CLAUSES:

Subpart C Section 27.50(b)(1): fixed and base station transmitters in the 757-758MHz band must not exceed 1000 watts ERP.

Therefore the gain of any antenna system attached to this transmitter shall not exceed 10dBd.

TRANSMITTER AUDIO FREQUENCY RESPONSE - PRE-EMPHASIS

SPECIFICATION: FCC 47 CFR 2.1047 (a)

GUIDE: TIA/EIA-603E 2.2.6

MEASUREMENT PROCEDURE:

1. Refer Annex A for Equipment set up.
2. An audio input tone of 1000 Hz was applied with the level set to obtain 20% of maximum deviation. This was used as the 0 dB reference point.
3. The AF was varied while the audio level was held constant.
4. The response in dB relative to 1000 Hz was measured.

MEASUREMENT RESULTS:

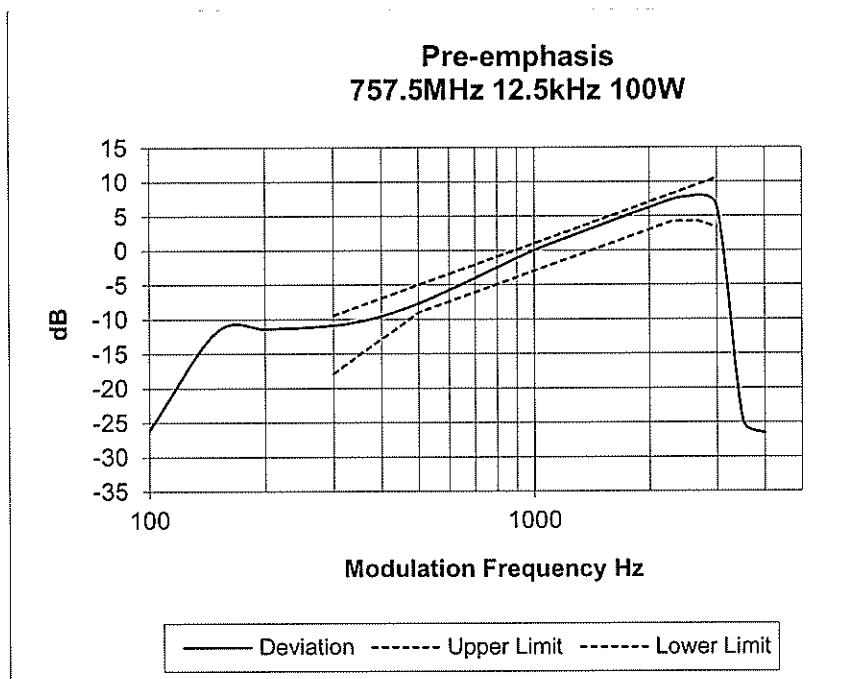
See the plots below for 12.5 kHz channel spacing tested at 100 W transmit power.

LIMIT CLAUSE: TIA/EIA-603E 3.2.6

SPECIFICATION: FCC CFR 2.1047 (a)

Tx FREQUENCY: 757.5 MHz

12.5 kHz Channel Spacing



TRANSMITTER MODULATION LIMITING

SPECIFICATION: FCC 47 CFR 2.1047 (b)

GUIDE: TIA/EIA-603E 2.2.3

MEASUREMENT PROCEDURE:

1. Refer Annex A for Equipment set up.
2. The modulation response was measured at three audio frequencies while varying the input level.
3. Measurements were made for both Positive and Negative Deviation.

MEASUREMENT RESULTS:

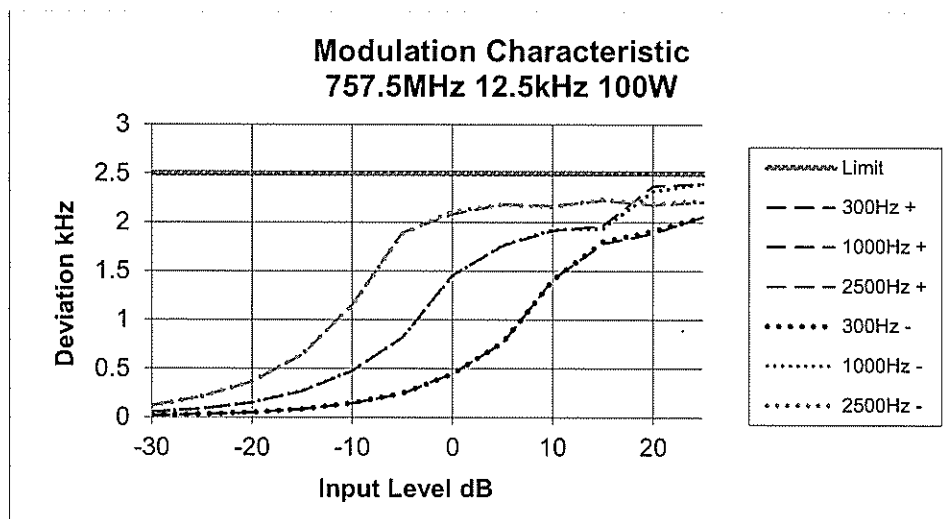
See the plots below for 12.5 kHz channel spacing tested at 100 W transmit power.

LIMIT CLAUSE: TIA/EIA-603E 1.3.4.4

SPECIFICATION: FCC CFR 2.1047 (b)

Tx FREQUENCY: 757.5 MHz

12.5 kHz Channel Spacing



TRANSMITTER OCCUPIED BANDWIDTH

SPECIFICATION: FCC 47 CFR 2.1049 (c)

GUIDE: TIA/EIA-603E 2.2.11 (Analog)
TIA-102.CAAA-C 2.2.5 (Digital)

MEASUREMENT PROCEDURE:

1. Refer Annex A for Equipment Set up.
The EUT was modulated with an internally generated pseudo random bit sequence at the appropriate Baud rates.
2. The Occupied Bandwidth was measured on the Spectrum Analyzer, with bandwidth settings as follows.
Resolution Bandwidth = 300 Hz, Video Bandwidth = 910 Hz

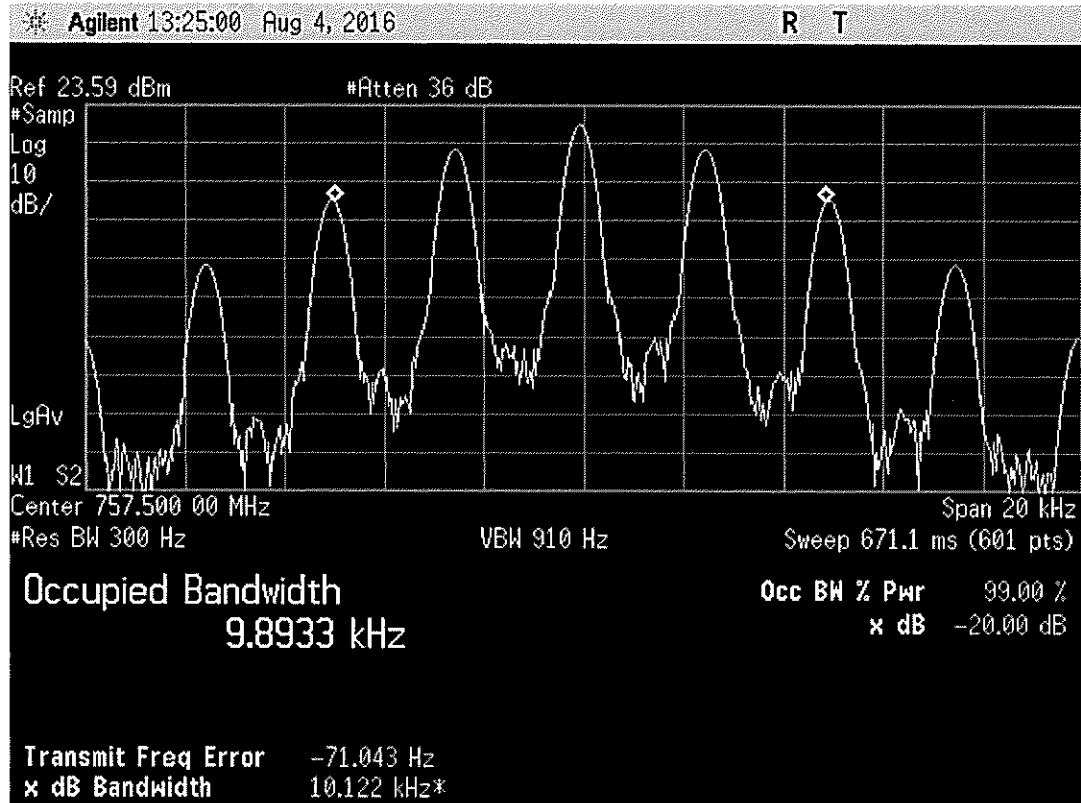
MEASUREMENT RESULTS:

See the plots on the following pages

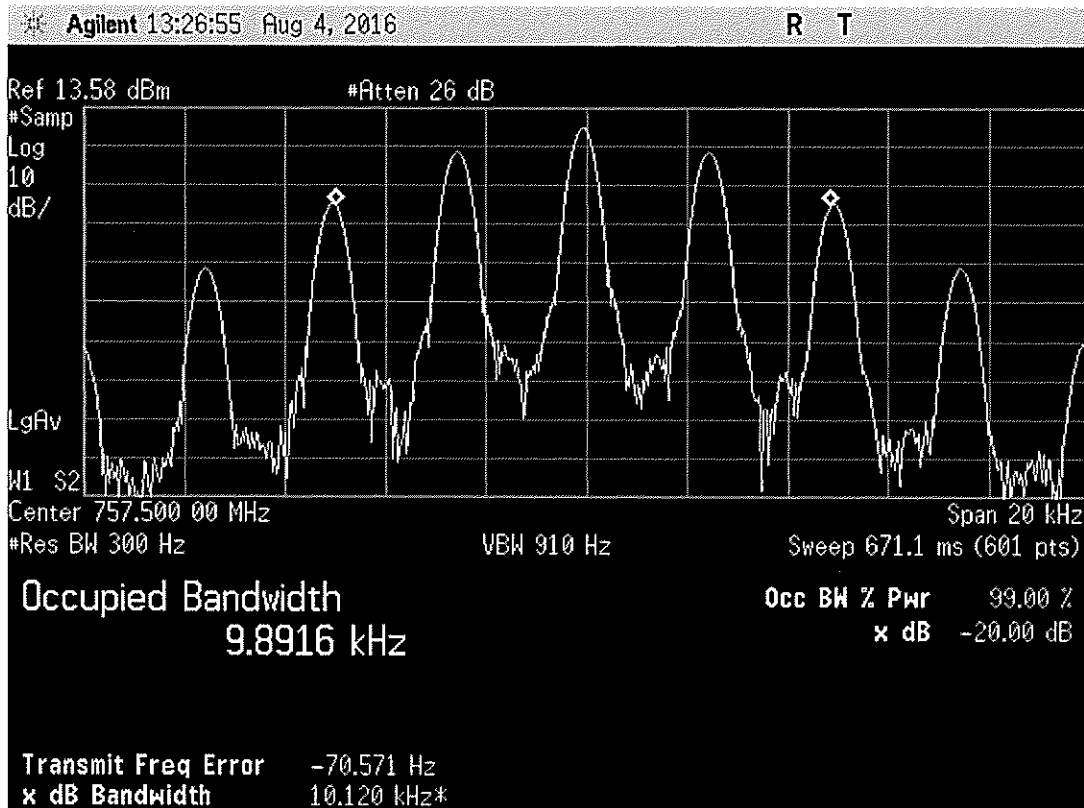
Modulation	Power (W)	Occupied Bandwidth (KHz)
Analogue FM	100	9.89
	10	9.89
FFSK	100	5.88
	10	5.89
DMR	100	7.57
	10	7.48

Occupied Bandwidth

Tx FREQUENCY: 757.5 MHz 100 W Analogue FM

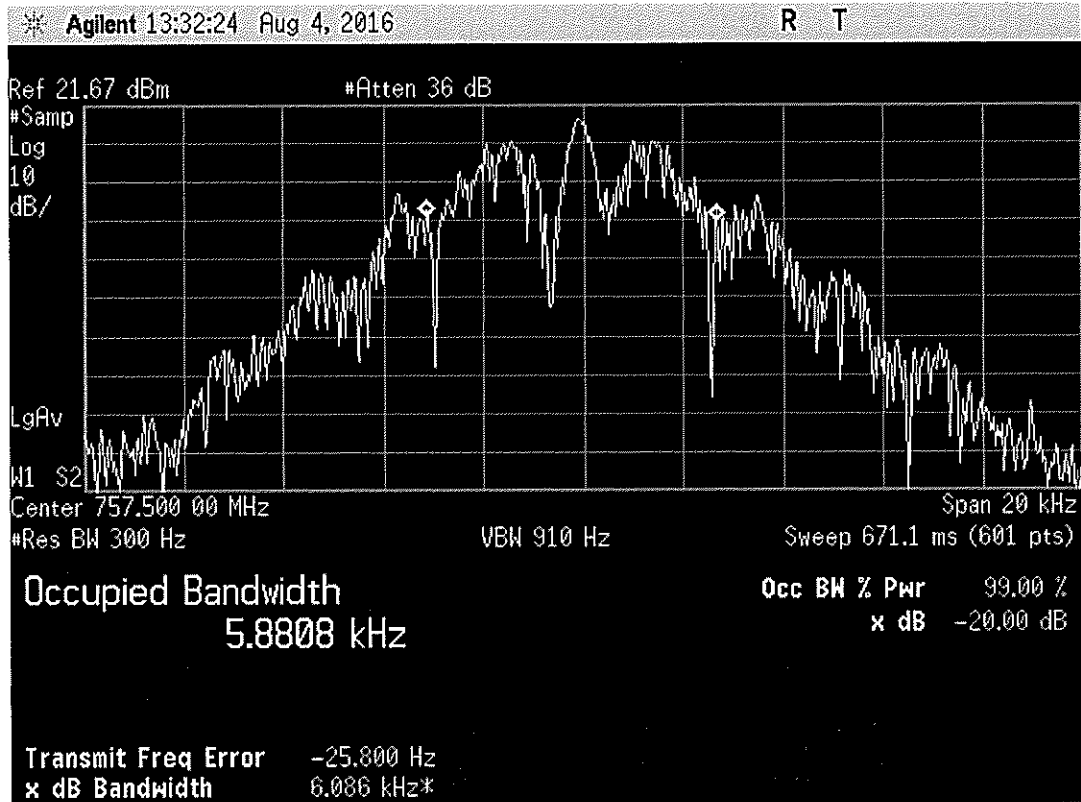


Tx FREQUENCY: 757.5 MHz 10 W Analogue FM

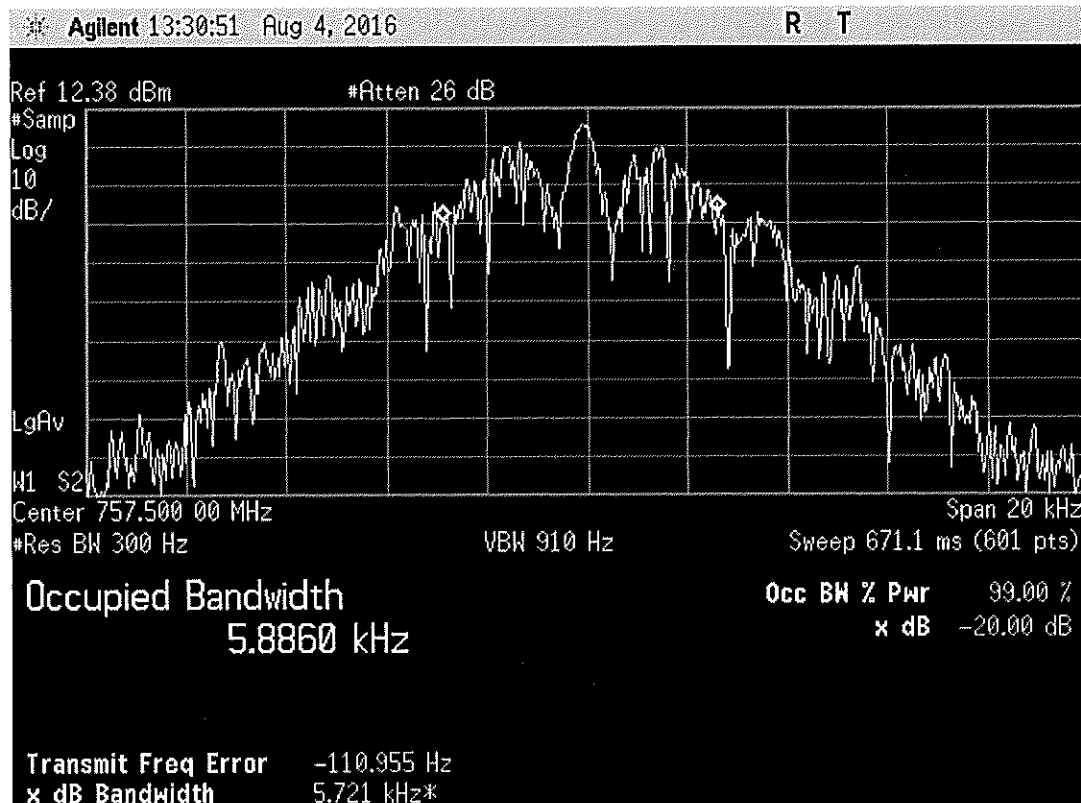


Occupied Bandwidth

Tx FREQUENCY: 757.5 MHz 100 W FFSK

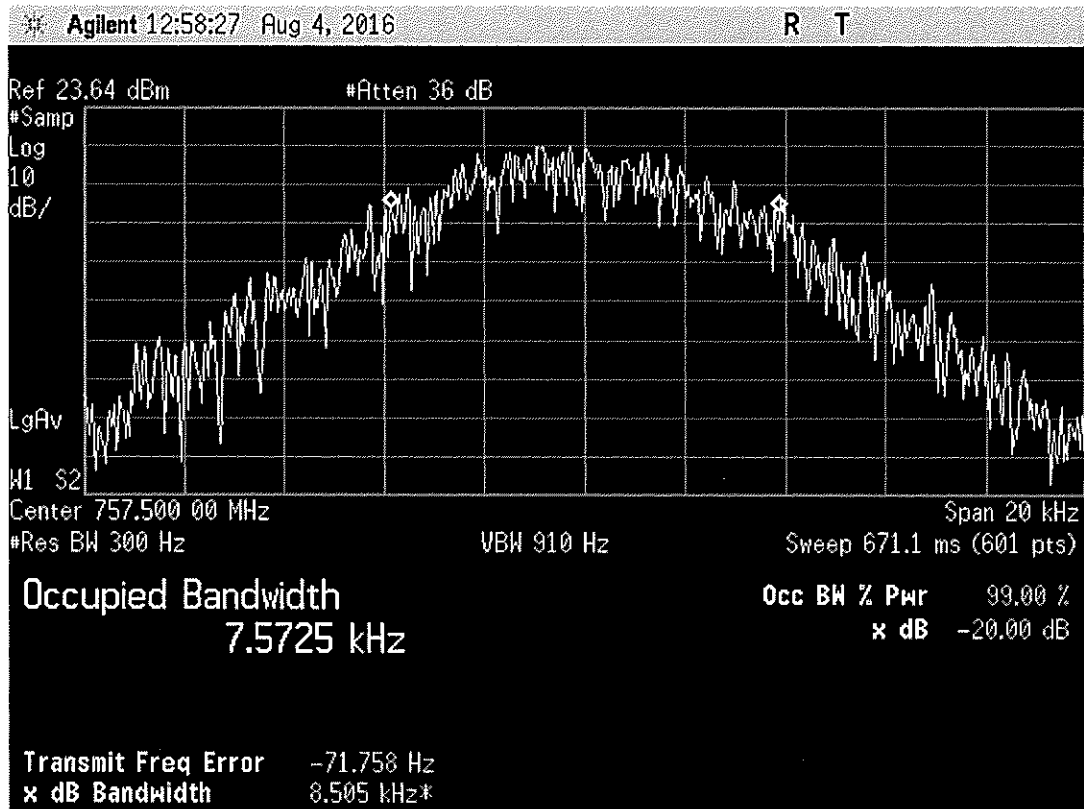


Tx FREQUENCY: 757.5 MHz 10 W FFSK

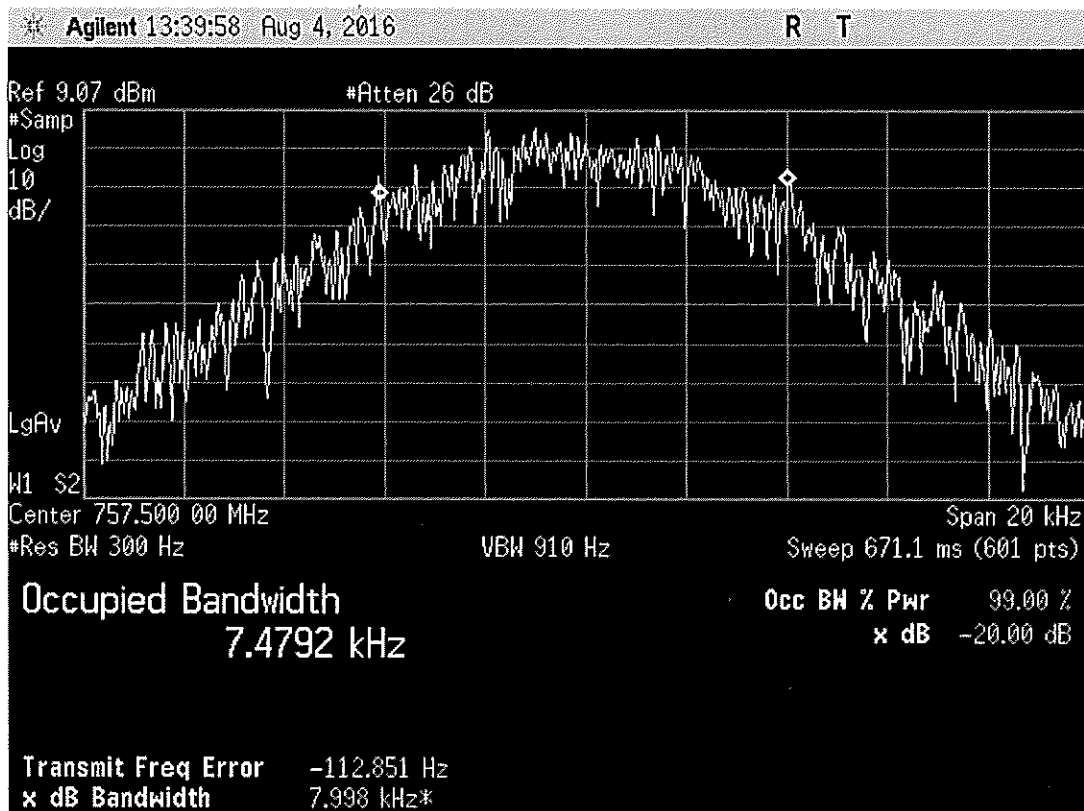


Occupied Bandwidth

Tx FREQUENCY: 757.5 MHz 100 W DMR



Tx FREQUENCY: 757.5 MHz 10 W DMR



TRANSMITTER SPURIOUS EMISSIONS (CONDUCTED) Part 1

SPECIFICATIONS: FCC 47 CFR 2.1051
GUIDE: TIA-102.CAAA-C 2.2.7

MEASUREMENT PROCEDURE:

1. Refer Annex A for equipment set up.
2. The frequency range examined was from the lowest frequency generated within the EUT, to a frequency higher than the 10th Harmonic: 100 kHz to Fc-BW
Fc+ BW to 10Fc GHz
3. A Pre-scan is performed with a resolution bandwidth of 1 kHz, and a video bandwidth of 3 kHz. If any emissions are found to be within 20 dB of the limit a second measurement is made with the carrier modulated, and a resolution bandwidth of 10 kHz, and a video bandwidth of 30 kHz.

Spurious emissions which were attenuated by more than 20 dB below the limit were not recorded.

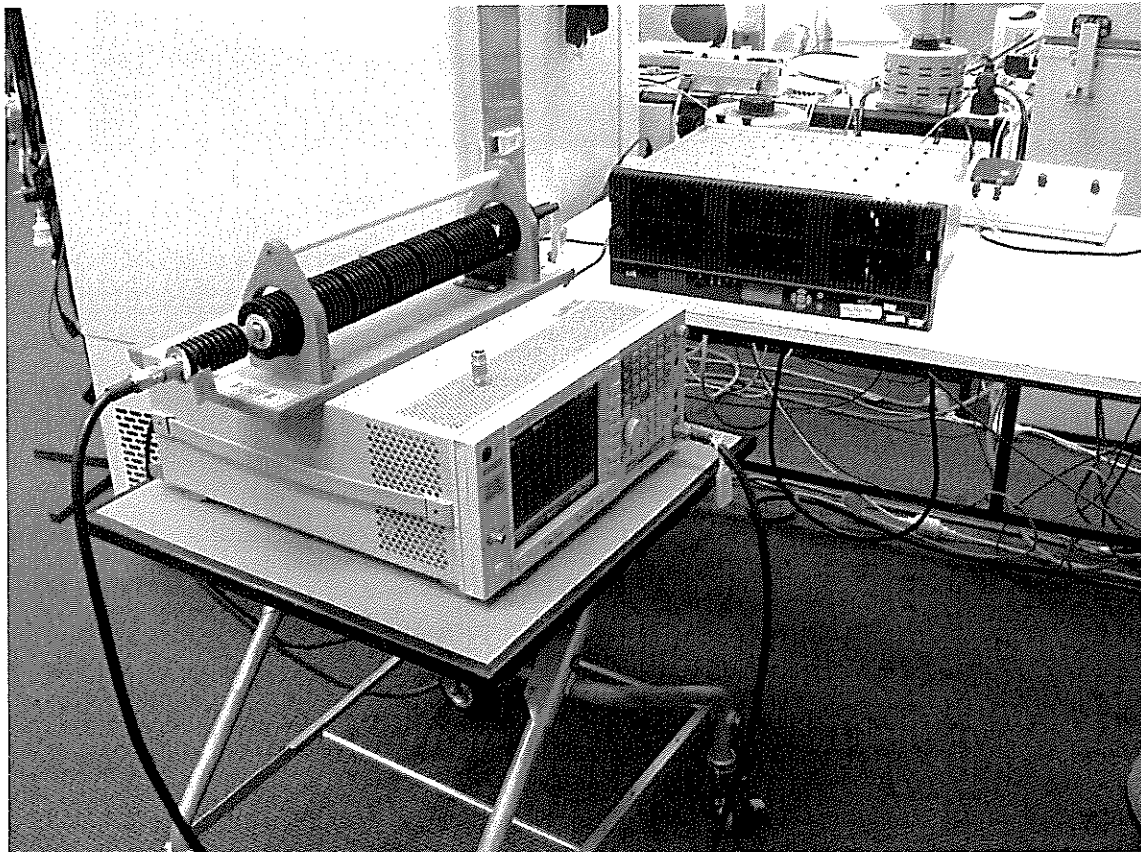
A photograph of the test set-up is included below.

MEASUREMENT RESULTS:

See the tables on the following pages.

LIMIT CLAUSES: FCC 47 CFR 27.53 c(1)

Photo: Conducted Emissions Test Setup



Spurious Emissions (Tx Conducted)

SPECIFICATION: FCC 47 CFR 27.53 c(1)

Tx FREQUENCY: 757.5 MHz

12.5 kHz Channel Spacing 757.5 MHz @ 100 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
1514.99	-36.3	-86.3
No other emissions were detected at a level greater than -40 dBm.		

12.5 kHz Channel Spacing 757.5 MHz @ 10 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No other emissions were detected at a level greater than -40 dBm.		

LIMITS: FCC 47 CFR 27.53 c(1)

Carrier Output Power	Emission Mask D 12.5 kHz Channel Spacing $43 + 10 \log_{10} (P_{\text{watts}})$	
100 W	-13 dBm	-70 dBc
10 W	-13 dBm	-60 dBc

TRANSMITTER SPURIOUS EMISSIONS (CONDUCTED) Part 2

SPECIFICATIONS: FCC 47 CFR 27.53(3)(6)
GUIDE: TIA-102.CAAA-C 2.2.7

MEASUREMENT PROCEDURE:

1. Refer Annex A for equipment set up.
2. The frequency range examined was from 763-775MHz and 793-805MHz.
3. A Scan is performed with a resolution bandwidth of 6.25 kHz, and a video bandwidth of 6.25kHz.

MEASUREMENT RESULTS:

See the tables and plots on the following pages.

LIMIT CLAUSES: FCC 47 CFR 27.53(3)(6)

Tx FREQUENCY: 757.5 MHz

12.5 kHz Channel Spacing 757.5 MHz @ 100 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No emissions were detected exceeding the limit.		

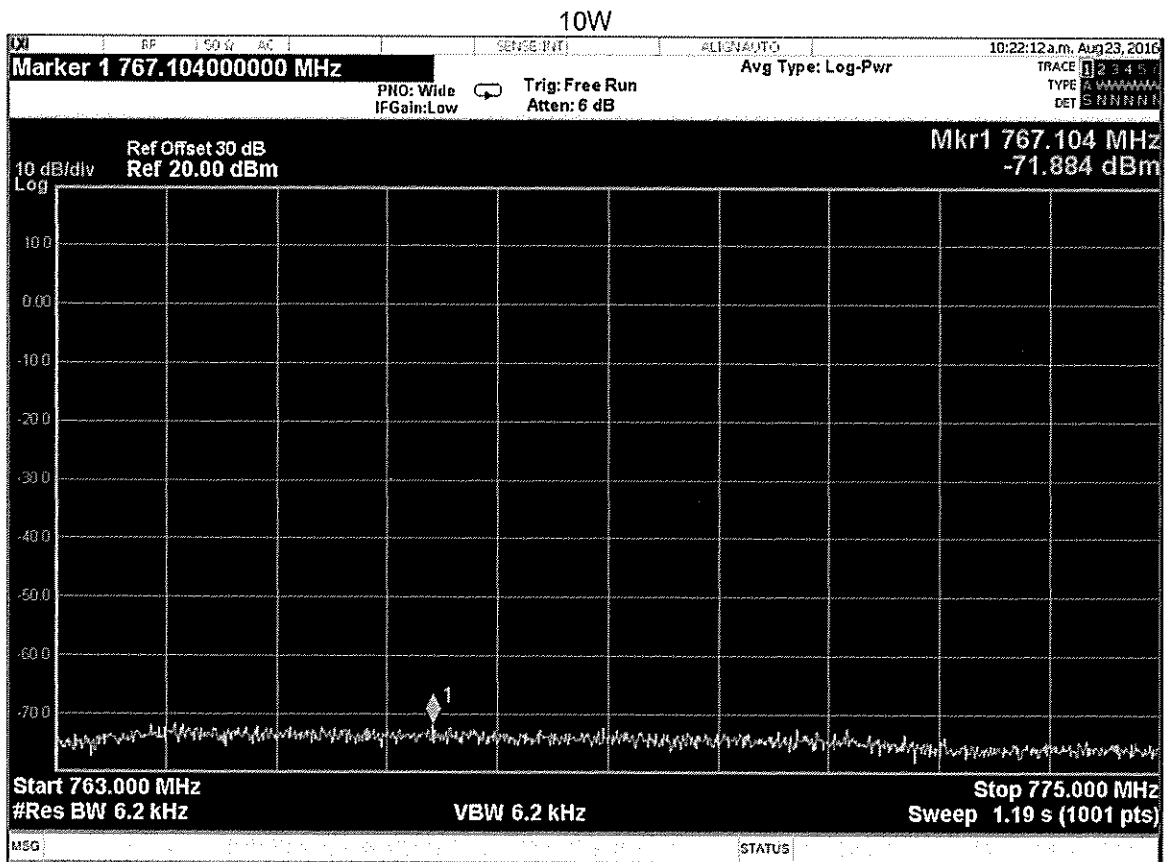
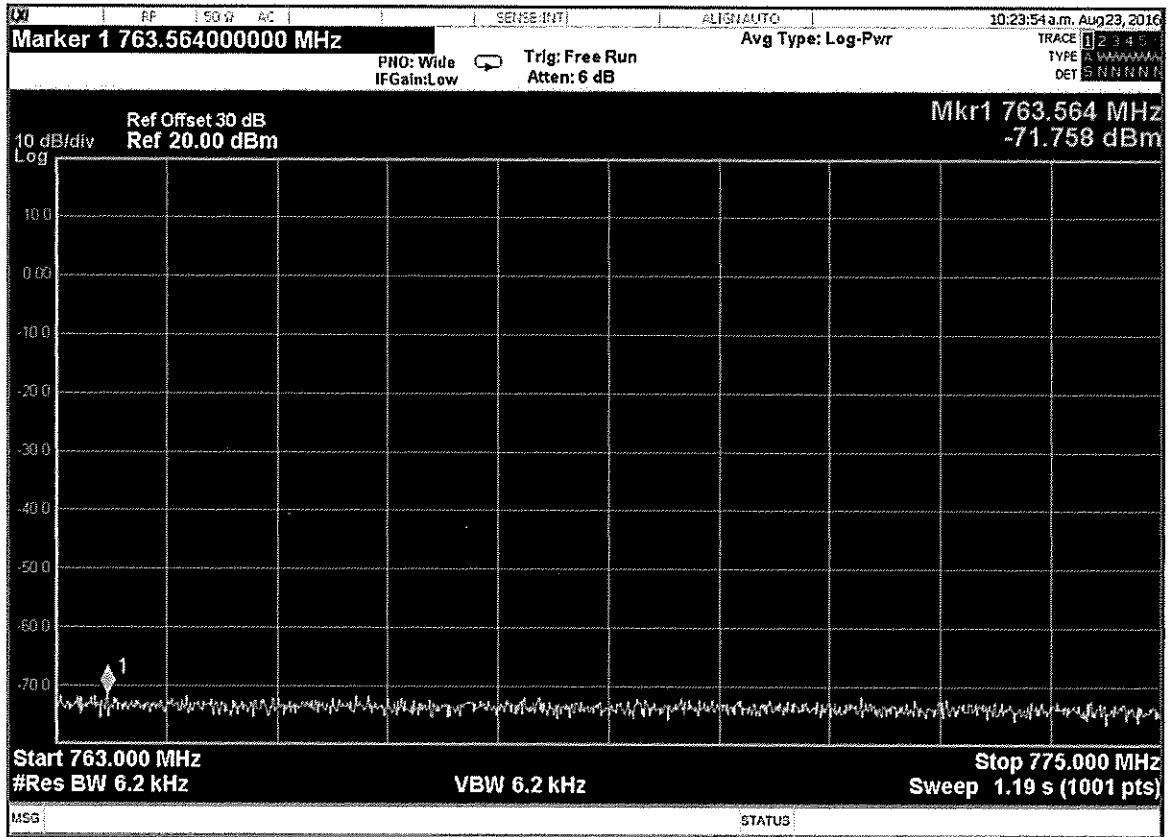
12.5 kHz Channel Spacing 757.5 MHz @ 10 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No emissions were detected exceeding the limit.		

LIMITS: FCC 47 CFR 27.53(3)(6)

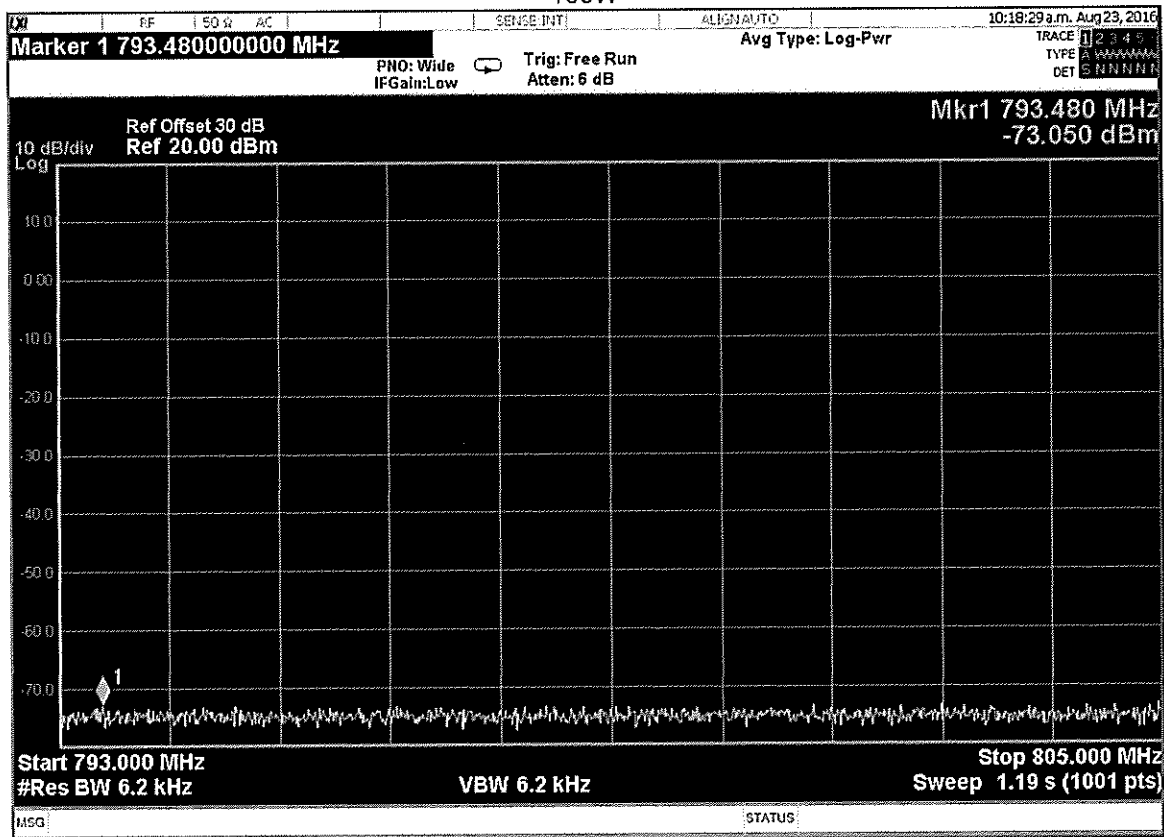
Carrier Output Power	12.5 kHz Channel Spacing $76 + 10 \log_{10} (P_{\text{Watts}})$	
100 W	-46 dBm	-96 dBc
10 W	-46 dBm	-86 dBc

763-775MHz
100W

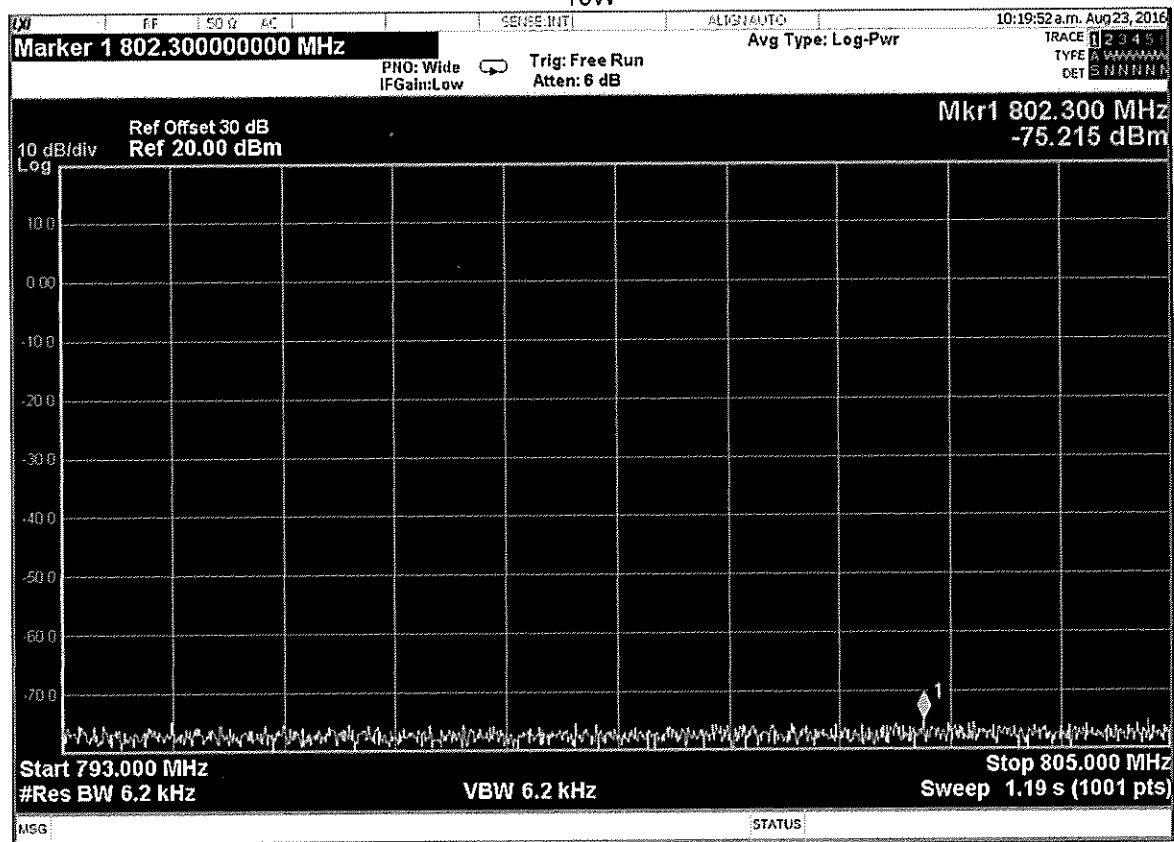


TELTEST Laboratories
Tait Ltd
Report Number 3773B

793-805MHz
100W



793-805MHz
10W



TRANSMITTER SPURIOUS EMISSIONS (RADIATED) Part 1

SPECIFICATION: FCC 47 CFR 2.1053

GUIDE: TIA-102.CAAA-C 2.2.6

MEASUREMENT PROCEDURE:

Initial Scan:

1. The EUT is placed in the S-Line TEM cell and emissions are measured from 30 MHz to 800 MHz. Any emission within 20 dB of the limit is then re-tested on the OATS.
2. The EUT is placed in the reverberation chamber and emissions are measured from 800 MHz to the upper frequency required. Any emission within 20 dB of the limit is then re-tested on the OATS.
3. The harmonics emissions up to the 6th harmonic of the fundamental frequency are measured on the OATS

OATS Measurement:

1. The EUT is placed on a wooden turntable at a distance of three metres from the test antenna. The output terminal is connected to an RF dummy load.
2. The test antenna is raised from 1 m to 4 m to obtain a maximum reading; the turntable is then rotated through 360° to obtain the maximum response of each spurious emission. Valid emissions are determined by switching the EUT on and off.
3. The EUT is then replaced by a signal generator and substitution antenna to make measurements by the substitution method.

MEASUREMENT RESULTS:

See the tables on the following pages

LIMIT CLAUSE: FCC 47 CFR 27.53 c(1)

Spurious Emissions (Tx Radiated)

SPECIFICATION: FCC CFR 2.1053

12.5 kHz Channel Spacing 757.5 MHz @ 100 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No emissions were detected at a level greater than -40dBm		

12.5 kHz Channel Spacing 757.5 MHz @ 10 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No emissions were detected at a level greater than -40dBm		

LIMITS: FCC 47 CFR 27.53 c(1)

Carrier Output Power	Emission Mask D 12.5 kHz Channel Spacing $43 + 10 \log_{10}(P_{\text{Watts}})$	
100 W	-13 dBm	-70 dBc
10 W	-13 dBm	-60 dBc

Tx Radiated Emissions - Continued

Open Area Test Site Results for first six harmonics:

12.5 kHz Channel Spacing

757.5 MHz @ 100 W

Harmonics Emission Frequency (MHz)	Level (dBm)	Level (dBc)
1515	-61.60	-111.60
2272.5	-45.33	-95.33
3030	-47.45	-97.45
3787.5	-59.00	-109.00
4545	-45.75	-95.75
5302.5	-50.25	-100.25

Photo: OATS Setup



TRANSMITTER SPURIOUS EMISSIONS (RADIATED) Part 2

SPECIFICATIONS: FCC 47 CFR 27.53(3)(6)
GUIDE: TIA-102.CAAA-C 2.2.7

MEASUREMENT PROCEDURE:

1. Refer Annex A for equipment set up.
2. The frequency range examined was from 763-775MHz and 793-805MHz.
3. A Scan is performed with a resolution bandwidth of 6.25 kHz, and a video bandwidth of 6.25kHz.

MEASUREMENT RESULTS:

See the tables below.

LIMIT CLAUSES: FCC 47 CFR 27.53(3)(6)

Tx FREQUENCY: 757.5 MHz

12.5 kHz Channel Spacing 757.5 MHz @ 100 W

Emission Frequency (MHz)	Level (dBm)	Level (dBc)
~	~	~
No emissions were detected exceeding the limit.		

LIMITS: FCC 47 CFR 27.53(3)(6)

Carrier Output Power	12.5 kHz Channel Spacing $76 + 10 \log_{10} (P_{\text{Watts}})$	
100 W	-46 dBm	-96 dBc
10 W	-46 dBm	-86 dBc

TRANSMITTER SPURIOUS EMISSIONS (RADIATED) Part 3

SPECIFICATIONS: FCC 47 CFR 27.53 (f)
GUIDE: TIA-102.CAAA-C 2.2.7

MEASUREMENT PROCEDURE:

1. Refer Annex A for equipment set up.
2. The frequency range examined was from 1559-1610 MHz.
3. A Scan is performed with a resolution bandwidth of 1MHz and 1kHz respectively.

MEASUREMENT RESULTS:

Sweep Band (MHz)	Maximum Observed Level (dBuV/m)	Limit (dBuV/m)	Polarity	RBW (Hz)
1559.0-1610.0	45.8	55.2	Horizontal	1M
1559.0-1610.0	45.9	55.2	Vertical	1M
1559.0-1610.0	17.9	45.2	Horizontal	1k
1559.0-1610.0	17.9	45.2	Vertical	1k

LIMIT CLAUSES: FCC 47 CFR 27.53 (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.

Measurements were attempted at a distance of 3 metres which gave the following limits using the formula:

Field strength (V/m) = (square root (30 * power (watts)))/ distance (metres)

This gave limits of 55.2 dBuV/m for wideband emissions and 45.2 dBuV/m for discrete emissions.

TRANSMITTER FREQUENCY STABILITY - TEMPERATURE

SPECIFICATION: FCC 47 CFR 2.1055 (a) (1)

GUIDE: TIA-102.CAAA-C 2.2.2

MEASUREMENT PROCEDURE:

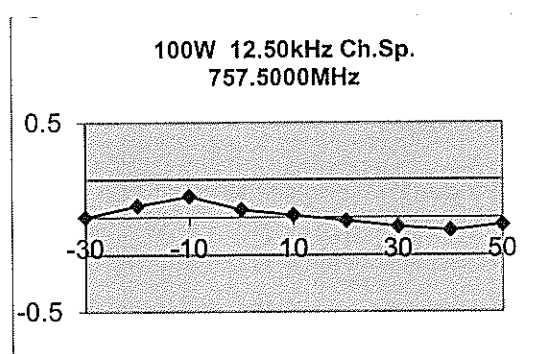
1. Refer Annex A for equipment set up.
2. The EUT was tested for frequency error from -30°C to $+50^{\circ}\text{C}$ in 10°C increments
3. The frequency error was recorded in parts per million (ppm).

MEASUREMENT RESULTS:

See the plots below.

Tx Frequency: 757.5 MHz

Temperature ($^{\circ}\text{C}$)	Frequency (Hz)	Error (ppm)
-30	-3	0
-20	49	0.06
-10	81	0.11
0	31	0.04
10	6	0.01
20	-12	-0.02
30	-37	-0.05
40	-50	-0.07
50	-33	-0.04



LIMIT: FCC 47 CFR 27.54

The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

Taking the calculated necessary bandwidth to be the authorized bandwidth, and the measured 99% bandwidth to be the width of the fundamental emissions, the worst case scenario is for the DMR modulation where the authorized bandwidth = 7.6kHz, and the 99% bandwidth = 7.57kHz. This gives a frequency tolerance of $\pm 150\text{Hz}$ or 0.2 ppm.

TRANSMITTER FREQUENCY STABILITY - VOLTAGE

SPECIFICATION: FCC 47 CFR 2.1055 (d) (1)

GUIDE: TIA-102.CAAA-C 2.2.2

MEASUREMENT PROCEDURE:

1. Refer Annex A for equipment set up.
2. The EUT was tested for frequency error at an input voltage to the radio of 85% to 115%.
3. The frequency error was recorded in parts per million (ppm).

MEASUREMENT RESULTS:

Tx Frequency: 757.5 MHz

Voltage	FREQUENCY ERROR (ppm)	FREQUENCY ERROR (ppm)
	100W	10W
120 V _{AC}	-0.02	-0.07
102 V _{AC}	-0.02	-0.06
138 V _{AC}	-0.02	-0.06

LIMIT: FCC 47 CFR 27.54

The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

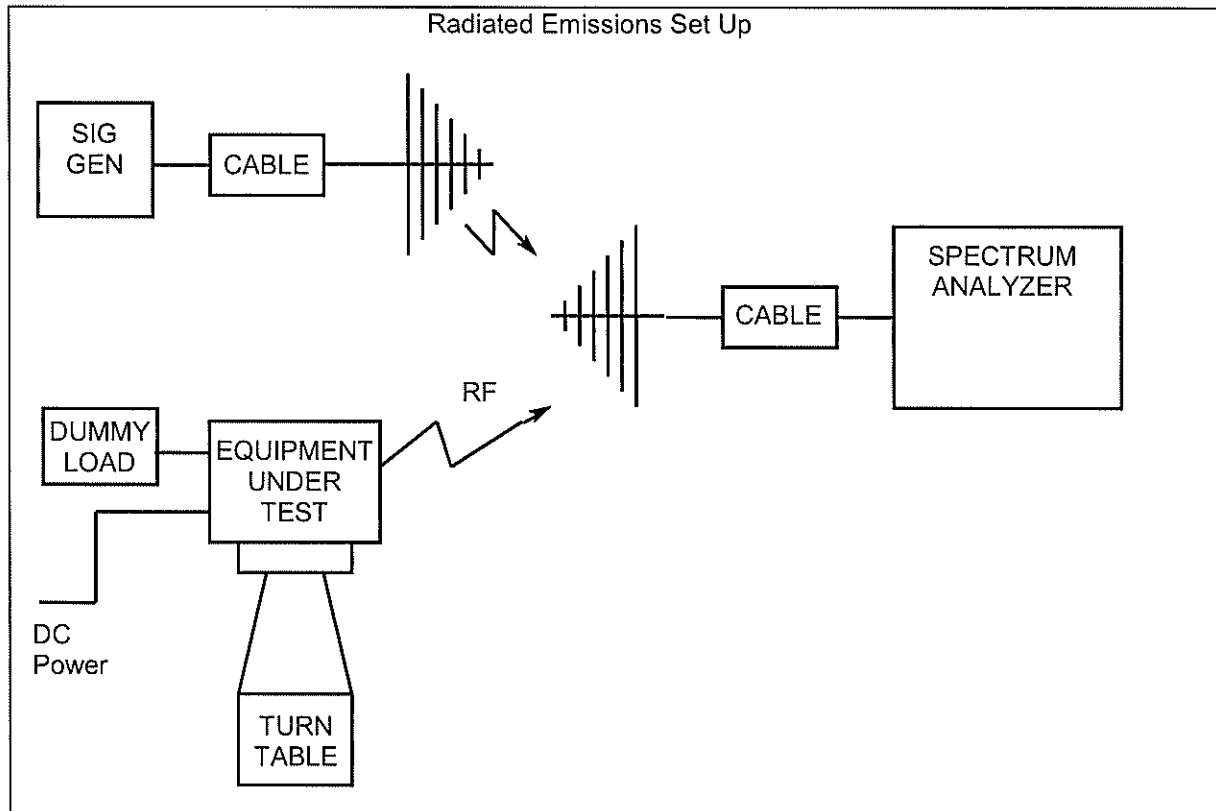
Taking the calculated necessary bandwidth to be the authorized bandwidth, and the measured 99% bandwidth to be the width of the fundamental emissions, the worst case scenario is for the DMR modulation where the authorized bandwidth = 7.6kHz, and the 99% bandwidth = 7.57kHz. This gives a frequency tolerance of $\pm 150\text{Hz}$ or 0.2 ppm.

TEST EQUIPMENT LIST

Equipment Type	Information	Manufacturer	Model No	Serial No#	Tait ID	Cal Due
Modulation Analyser	TREVA1	Hewlett Packard	HP8901B (Opt 002)	2441A00393	E3073	21-Oct-16
Audio Analyser	TREVA1	Hewlett Packard	HP8903A	2437A04625	E4986	21-Oct-16
Power Supply	TREVA1	Hewlett Packard	HP6032A	2441A00412	E3075	13-Oct-17
Antenna	Biconical	Emco	3110B	9307-1680	E3033	
Antenna	18GHz DRG	Emco	DRG3115	9512-4638	E3560	29-Apr-19
Antenna	18GHz DRG	Emco	DRG3115	2084	E3076	29-Apr-19
RF Chamber	S-LINE TEM CELL	Rohde & Schwarz	1089.9296.02	338232/003	E3636	29-Sep-16
RF Attenuator	30dB 250W	Weinschel	45-30-34	JW663	E3386	18-Oct-16
RF Load	150W	Bird	8166	524	E3625	
Coax Cable	2m Black	Suhner	RG214HF/Nm/Nm/2000	TeltestBlack2	E4623	18-Oct-16
Coax Cable	2m Black	Suhner	RG214HF/Nm/Nm/2000	TeltestBlack3	E4624	18-Oct-16
Spectrum Analyser	13.2GHz	Hewlett Packard	HP8562E	3821A00779	E3715	15-Oct-16
Environ. Chamber	Upright	Contherm	5400 RSLT.M	1416	E4051	1-Aug-17
RF Combiner	TREVA1	Minicircuits	ZFSC-4-1	-	E4083	
Spectrum Analyser	13.2GHz	Agilent	E4445A	MY42510072	E4139	22-Oct-16
Coax Cable	OATS Turntable Cable 1	Intelcom	RG214	OATS1	E4621	20-Oct-16
Coax Cable	OATS Tower Cable	Intelcom	RG214	OATS2	E4622	20-Oct-16
OATS	Antenna Tower	Electrometrics	EM-4720-2	112	E4447	
OATS	Controller	Electrometrics	EM-4700	119	E4445	
OATS	Turntable	Electrometrics	EM-4704A	105	E4446	
Antenna	Log Periodic	Schwarzbeck	VUSLP	9111-219	E4617	
TREVA 1		Teltest	-	1	-	14-Nov-16
Coax Cable	Reverb - 4.5m Multiflex 141	TeltestBlue6	MF 141	TeltestBlue6	E4843	20-Oct-16
Coax Cable	Reverb - 2m Multiflex 141	TeltestBlue5	MF 141	TeltestBlue5	E4844	20-Oct-16
Coax Cable	Reverb - 2m Multiflex 141	TeltestBlue4	MF 141	TeltestBlue4	E4845	20-Oct-16
Coax Cable	Reverb - 1m Multiflex 141	TeltestBlue3	MF 141	TeltestBlue3	E4846	20-Oct-16
Coax Cable	Reverb - 1m Multiflex 141	TeltestBlue2	MF 141	TeltestBlue2	E4847	20-Oct-16
Coax Cable	Reverb - 1m Multiflex 141	TeltestBlue1	MF 141	TeltestBlue1	E4848	20-Oct-16
RF Chamber	Reverb - Stirrer controller for reverb chamber	Teseq	Stirrer Controller	29765.1	E4854	
RF Chamber	Reverb - 0.5 - 18GHz Reverberation Chamber	Teseq	RVC XS	29765	E4855	
Antenna	Reverb - 1-18GHz DRG	Schwarzbeck	BBHA 9120 D	9120D-885	E4857	
Antenna	Reverb - 1-18GHz DRG	Schwarzbeck	BBHA 9120 D	9120D-884	E4858	
RF Amplifier	Pre-amplifier	Agilent	87405C	MY47010688	E4941	20-Oct-16
OATS	FCC Listing Registration			837095		8-May-19
Coax Cable	OATS Turntable Cable 2	Intelcom	RG215	OATS3	E4995	20-Oct-16
Signal Generator	Digital 4GHz	Agilent	E4437B	US39260389	E4764	19-Aug-17

NOTE: Items without calibration dates are calibrated immediately before use, or set using calibrated instruments.

ANNEX A – TEST SETUP DETAILS



All other testing is performed using the Teltest Radio **E**VALuation system (TREVA), which is configured as shown below. The Spectrum Analyser is connected to the EUT via the attenuator network for Conducted Emissions testing, and Occupied Bandwidth.

