Report on the Radio Testing

For

Axell Wireless Limited

on

MBF-900

Report no. TRA-039385-47-01B

3 May 2018

Report Number: TRA-039385-47-01B
Issue: A

REPORT ON THE RADIO TESTING OF A
Axell Wireless Limited
MBF-900
WITH RESPECT TO SPECIFICATION
FCC 47CFR Part 90
FCC CFR Part 22
FCC CFR Part 24

TEST DATE: 3rd February - 6th March 2018

Written by:	 Digitally signed by Steven Hodgkinson DN: cn=Steven Hodgkinson, o=Element Materials Technology Ltd, ou, email=steven.hodgkinson@element.com, c=GB Reason: I am the author of this document Date: 2018.05.03 13:48:07 +01'00'	S Hodgkinson Radio Test Engineer
Approved by:	 Digitally signed by John Charters DN: cn=John Charters, o, ou=Element Materials Technology Ltd., email=john.charters@element.com, c=GB Reason: I am approving this document Date: 2018.05.03 13:47:17 +01'00'	J Charters Department Manager - Radio
Date:	2018-05-03	

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	2018-05-03	Original

2 Summary

TEST REPORT NUMBER:	TRA-039385-47-01B
WORKS ORDER NUMBER	TRA-039385-00
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION:	47CFR90, 22, 24
EQUIPMENT UNDER TEST (EUT):	MBF-900
FCC IDENTIFIER:	NEOMBF3709S
EUT SERIAL NUMBER:	L9DH
MANUFACTURER/AGENT:	Axell Wireless Limited
ADDRESS:	Aerial House Asheridge Road Chesham Bucks HP5 2QD United Kingdom
CLIENT CONTACT:	Brian Barton ☎ 01494 777014 ✉ brian.barton@cobham.com
ORDER NUMBER:	126069
TEST DATE:	3rd February - 6th March 2018
TESTED BY:	S Hodgkinson Element

2.1 Test Summary

Test Method and Description	*Requirement Clause*		*Applicable to this equipment*	**Result / Note**
	47CFR90	*KDB935210 D05 v01r02*		
RF power output (mean output power)	90.219(e)(1)	4.5	☒	Note 1
Noise figure	90.219(d)(6)(ii)(iii)	4.6	☒	Note 2
Retransmitted masks	90.219(e)(4)(ii); 90.219(e)(4)(iii) Part 22.359 Part 22.133	4.4	☒	Pass
Occupied bandwidth	2.1049	-	☒	Pass
Out of band rejection	-	4.3	☒	Note 3
Spurious emissions at antenna terminals	90.219(e)(3)	4.7.2	☒	Pass
Intermodulation products	90.219(d)(6)(i)	4.7.2	☒	Note 4
Field strength of spurious radiation	90.219(e)(3)	4.9	☒	Pass
Frequency stability	90.213	4.8	☒	Note 5

Notes:

Note 1: see client declaration found in Annex A
Note 2: see client declaration found in Annex A
Note 3: see client declaration found in Annex A
Note 4: see client declaration found in Annex A
Note 5: see client declaration found in Annex A

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set-up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

3 Contents

4 Introduction

This report TRA-039385-47-01B presents the results of the Radio testing on a Axell Wireless Limited, MBF-900 to specification 47CFR90.219 Use of signal boosters, Part 22 covering Public Mobile Services, Part 24 Personal Communication Services.

The testing was carried out for Axell Wireless Limited by Element, at the address detailed below.

☐ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☒ Element Skelmersdale
Unit 1
Pendle Place
Skelmersdale
West Lancashire
WN8 9PN
UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

FCC Site Listing:
The test laboratory is accredited for the above sites under the US-EU MRA, Designation number UK0009.

ISED Registration Number(s):

Element Skelmersdale	3930B
Element Hull	3483A

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.
The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- Part 90 – Private Land Mobile Radio Services
- FCC KDB Publication 935210 D05 v01r02 October 27, 2017 – Measurements guidance for industrial and non-consumer signal booster, repeater and amplifier devices.
- FCC Part 22 Public Mobile services
- FCC Part 24 Personal Communication Services
- TIA-603-D-2010 – Land Mobile FM or PM - Communications Equipment - Measurement and Performance Standards

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	Denotes a section reference from the standard, not this document
AC	Alternating Current
AM	Amplitude Modulated
AWGN	Additive White Gaussian Noise
BW	Bandwidth
C	Celcius
CW	Continuous Wave
Class A	Class A signal booster is designed to retransmit signals on one or more specific channels where none of its passbands exceed 75kHz.
Class B	Class B signal booster is designed to retransmit any signals within a wide frequency band greater than 75kHz.
dB	Decibels
dBm	dB relative to 1 milliwatt
CDMA	Code Division Multiple Access – a modulation technique used in cellular networks
DC	Direct Current
EIRP	Equivalent Isotropically Radiated Power
emf	electromotive force
erp	Effective Radiated Power
EUT	Equipment Under Test
f	Frequency
FCC	Federal Communications Commission
GSM	Group Special Mobile – a cellular network standard
Hz	Hertz
IC	Industry Canada (now ISED)
IF	Intermediate Frequency
ISED	Innovation, Science and Economic Development Canada
ITU	International Telecommunication Union
KDB	Knowledge Data Base (of the FCC Office of Engineering and Technology).
LO	Local Oscillator
m	metre
max	Maximum
min	Minimum
N/A	Not Applicable
No.	Number
PCB	Printed Circuit Board
PDF	Portable Document Format
PLMR	Private Land Mobile Radio
RE	Radio Equipment
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	Receiver
s	Second
Tx	Transmitter
UKAS	United Kingdom Accreditation Service
V	Volt
W	Watt
Ω	Ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: MBF-900
- Serial Number: L9DH
- Model Number: MBF4126
- Software Revision: SW00087 REV 2.3.0
- Build Level / Revision Number: Rev 1

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Optical Master Unit (OMU)

7.3 EUT Mode of Operation

7.3.1 Transmissions downlink

The mode of operation for transmitter tests was as follows the repeater was operated at maximum Gain and output power

The test signals used were.
16k0F1D
8k10F1E
13k6F3E
16k0F3E

7.4 EUT Radio Frequency Parameters

7.4.1 General

Frequency of operation:	Downlink 929-941 MHz Uplink 896-902 MHz
Passband gain:	31.92dBm
Supported channel bandwidth(s) & class:	Class B > 75 kHz
Rated mean output power (P_{rated}):	37dBm
Nominal Supply Voltage:	110Vdc

7.5 EUT Description

The EUT is a Bi-Directional 900 MHz Fibre fed repeater, the downlink operating in the band 929-941 MHz and the uplink operating 896-902 MHz band.

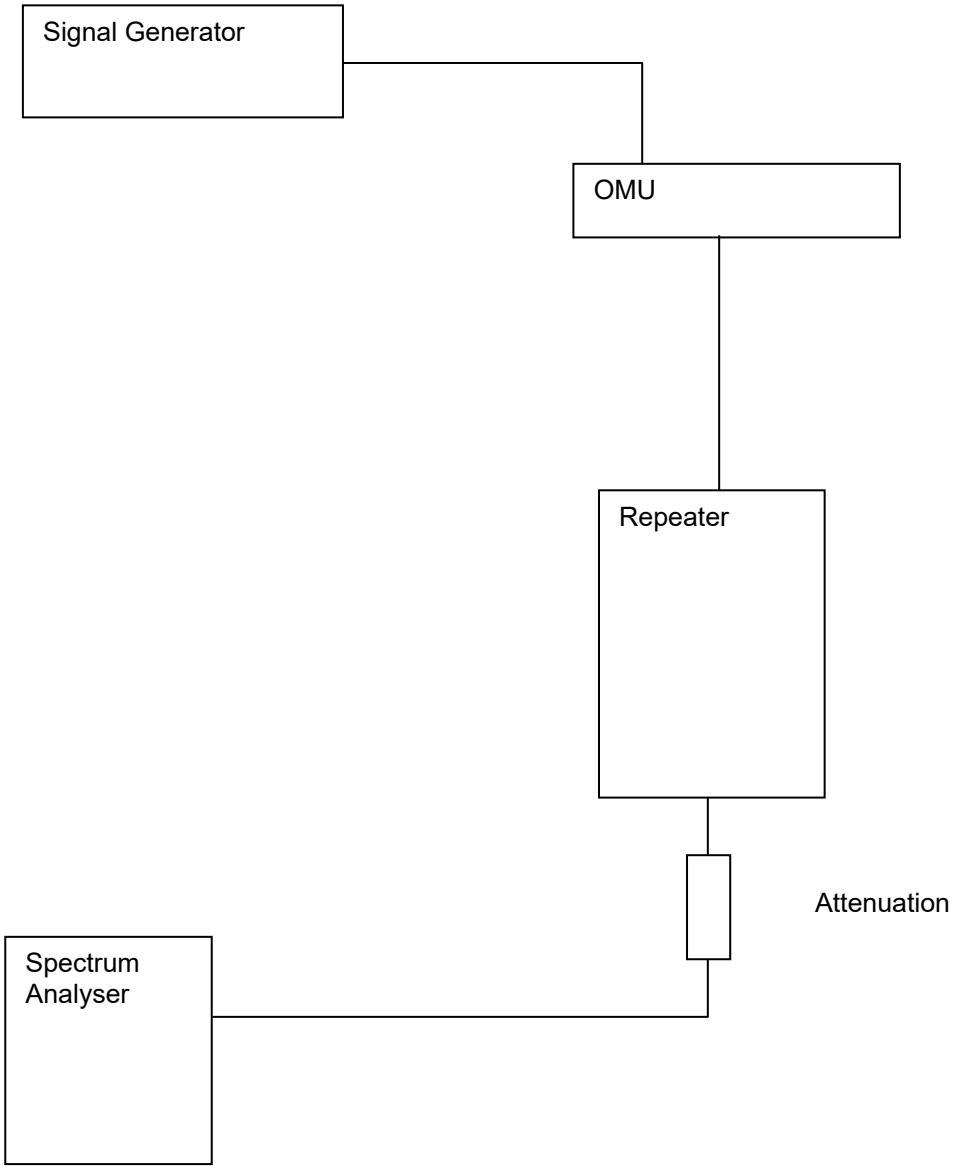
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

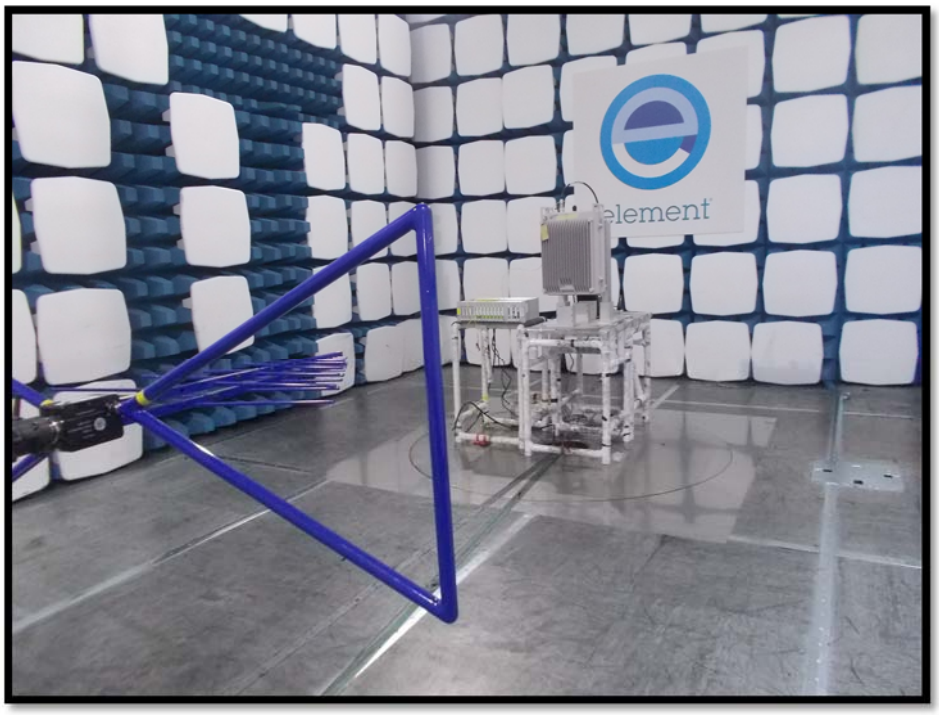
9.1 Block Diagram

The following diagram shows basic EUT interconnections.



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



10 General Technical Parameters

10.1 Normal Conditions

The E U T was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approximately 110 V ac from the mains.

10.2 Varying Test Conditions

Variation of supply voltage is required to ensure stability of the declared output power and frequency. During carrier power and frequency error testing the following variations were made:

	Category	***Nominal***	***Variation***
☒	Mains	110Vac	85% and 115%
☐	Battery	New battery	N/A

10.3 AGC threshold

Testing at and above the AGC threshold was required. The AGC threshold was therefore determined per KDB 935210 D05, clause 3.2.

	Input Signal	***AGC threshold***
Downlink	CW	37.35dBm

11 RF power output (Peak output power)

11.1 Definition

The peak output power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 935210 D05 v01r02, clause 4.5
EUT Operating Frequency Tested:	938.076923 MHz
Source Modulations:	CW
Source Level:	4.72 dBm (maximum input rating)
Deviations From Standard:	None
Bandwidth:	RBW 100 kHz; VBW 3xRBW
Span:	1 MHz
Measurement Detector:	Peak; Max-Hold.

Environmental Conditions (Normal Environment)

Temperature: 23°C	+15 ºC to +35 ºC (as declared)
Humidity: 23%RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	

11.3 Test Limits

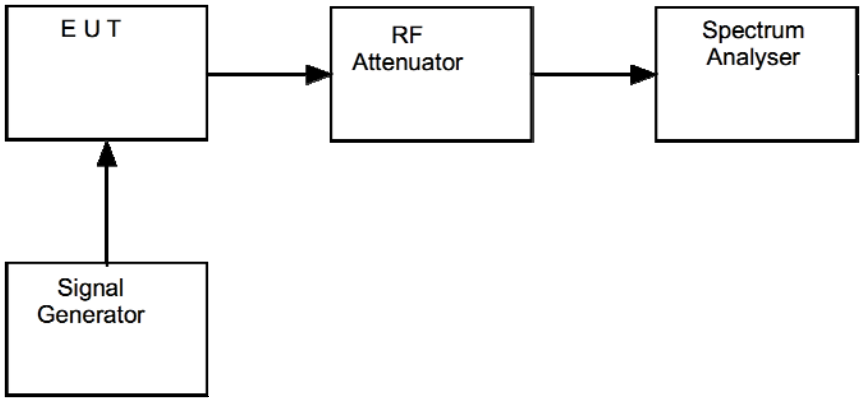
11.3.1 47CFR90

The output power capability of a signal booster must be designed for deployments providing a radiated power not exceeding 5 Watts ERP for each retransmitted channel.

11.4 Test Method

Single Channel:
With the EUT setup as per section 9 of this report and connected as per Figure i, the power of the EUT was calculated by taking into account any cable and attenuator calibration factors. It was confirmed that at the maximum input level there was no compression.
Gain was calculated by removing the EUT from the setup and measuring the signal generator to EUT level.

Figure i Test Setup



11.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09

11.6 Test Results

Single Channel @ AGC Threshold								
Channel Centre Frequency (MHz)	*Modulation*	*Signal Generator Input Level (dBm)*	*Input Cable Loss (dB)*	*Level at Spectrum Analyser (dBm)*	*Output Cable & Attenuator Loss (dB)*	*Gain (dB)*	*Conducted Output Power (dBm)*	*Result*
938.076923	CW	4.72	0.7	0.44	36.9	31.92	37.34	PASS*

Single Channel @ 3dB above AGC Threshold								
Channel Centre Frequency (MHz)	*Modulation*	*Signal Generator Input Level (dBm)*	*Input Cable Loss (dB)*	*Level at Spectrum Analyser (dBm)*	*Output Cable & Attenuator Loss (dB)*	*Gain (dB)*	*Conducted Output Power (dBm)*	*Result*
938.076923	CW	7.72	0.7	0.45	36.9	28.93	37.35	PASS*

Note: Pass* Please see client declaration in Annex A

12 Noise figure

12.1 Definition

A measure of the noise generated within (or degradation in signal/noise ratio as a signal passes through) the device expressed as the ratio of signal/noise power ratio at the input to signal/noise ratio at the output.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	Y-Factor Method (Keysight Technologies Application Note 57-2) KDB 935210 D05 v01, clause 4.6
EUT Operating Frequencies Tested:	929.0 MHz -941.0 MHz
Deviations From Standard:	None
Bandwidth:	RBW 10 kHz

Environmental Conditions (Normal Environment)

Temperature: 25°C	+15 ºC to +35 ºC (as declared)
Humidity: 27%RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	

12.3 Test Limits

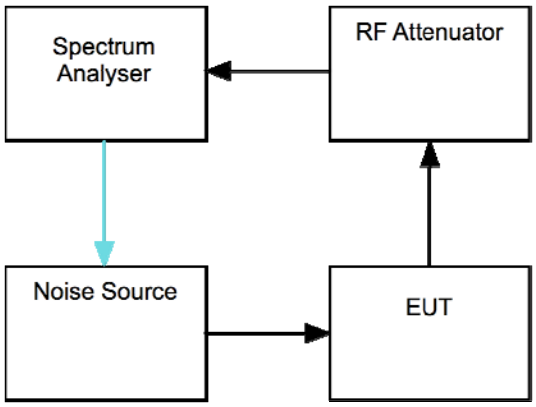
In general the ERP of noise within the passband should not exceed -43dBm in a 10 kHz measurement bandwidth.

In general the ERP of noise on the spectrum more than 1 MHz outside of the passband should not exceed -70 dBm in a 10 kHz measurement bandwidth.

12.4 Test Method

The equipment was setup as shown in Figure iii. A spectrum analyser with a noise figure measurement capability was used. The spectrum analyser provided the on/off control of the noise source as well as measuring the result at its RF input. Prior to measuring the EUT, a calibration of the measurement network was performed with the EUT removed.

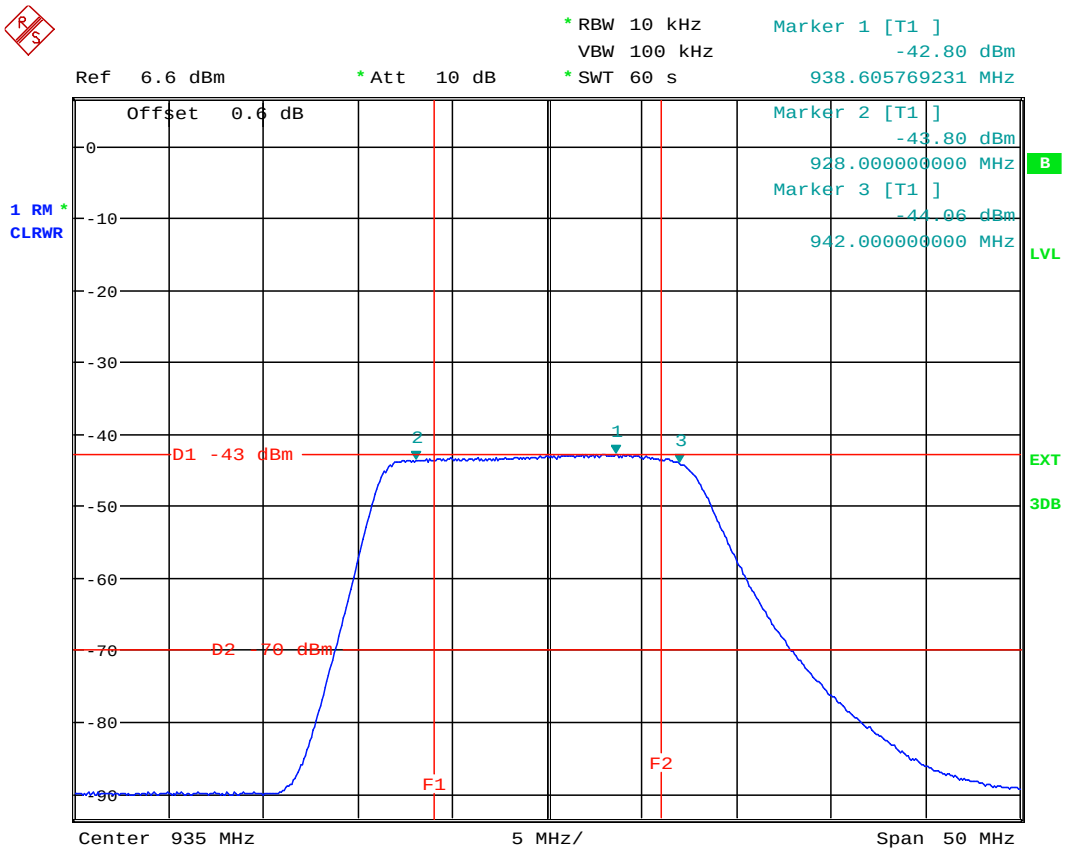
Figure iii Test Setup



12.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09

12.6 Test Results



Date: 20.FEB.2018 14:46:33

Note: Please see client declaration in Annex A

13 Retransmitted masks

13.1 Definition

The emission mask is the required attenuation relative to the channel power up to 250% of the channel bandwidth. For frequencies greater than 250% of the authorized bandwidth, refer to spurious emission measurement.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 935210 D05 v01, clause 4.4
EUT Operating Frequencies Tested:	929.50 MHz 937.50 MHz
Source Modulations:	16k0F1D, 8k10F1E,13k6F3E, 16k0F3E
Source Levels:	4.5, 7.5 dBm (AGC threshold and 3dB above)
Deviations From Standard:	None
Bandwidth, RBW:	Various, see plots. VBW =3xRBW
Span:	Various kHz (2-5 times OBW)
Measurement Detector:	Peak; Max-Hold.

Environmental Conditions (Normal Environment)

Temperature: 23°C	+15 ºC to +35 ºC (as declared)
Humidity: 23%RH	20%RH to 75%RH (as declared)
Supply: 110Vac	

13.3 Test Limits

13.3.1 FCC 47CFR90

(i) There is no change in the occupied bandwidth of the retransmitted signals.
(ii) The retransmitted signals continue to meet the unwanted emissions limits of §90.210 applicable to the corresponding received signals (assuming that these received signals meet the applicable unwanted emissions limits by a reasonable margin).

All emissions in the amplifier's output signal that falls outside a licensed frequency block or allocated bandwidth for the technology under test must be attenuated, relative to P, by at least:

$$43 + 10 \log_{10} P, \text{ or } 70 \text{ dB, whichever is less stringent}$$

where P is the manufacturer's rated output power in watts.

APPLICABLE EMISSION MASKS

Frequency band (MHz)	Mask for equipment with audio low pass filter	Mask for equipment without audio low pass filter
Below 25[1]	A or B	A or C
25–50	B	C
72–76	B	C
150–174[2]	B, D, or E	C, D or E
150 paging only	B	C
220–222	F	F
421–512[2 5]	B, D, or E	C, D, or E
450 paging only	B	G
806–809/851–854	B	H
809–824/854–869[3 5]	B	G
896–901/935–940	I	J
902–928	K	K
929–930	B	G
4940–4990 MHz	L or M	L or M
5850–5925[4].		
All other bands	B	C

[1] Equipment using single sideband J3E emission must meet the requirements of Emission Mask A. Equipment using other emissions must meet the requirements of Emission Mask B or C, as applicable.

Emission Mask G covering 929MHz-930MHz

(g) Emission Mask G. For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but no more than 250 percent of the authorized bandwidth: At least 116 log (fd/6.1) dB, or 50 + 10 log (p) dB, or 70 dB, whichever is the lesser attenuation;
(2) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorised bandwidth: At least 43 + 10 log (P) dB.

Emission Mask J covering 935MHz-940MHz

(j) Emission Mask J. For transmitters that are not equipped with an audio low pass filter, the power of any emission must be attenuated below the unmodulated carrier power of the transmitter (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 2.5 kHz, but no more than 6.25kHz: At least 53 log (fd/2.5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 6.25 kHz, but no more than 9.5kHz: At least 103 log (fd/3.9) dB;

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 9.5 kHz: At least 157 log (fd/5.3) dB, or 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

Part 22.359 Emission limitations.

(a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log (P) dB.

(b) Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 30 kHz or more. In the 60 kHz bands immediately outside and adjacent to the authorized frequency range or channel, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (i.e, 30 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

(c) Alternative out of band emission limit. Licensees in the Public Mobile Services may establish an alternative out of band emission limit to be used at specified frequencies (band edges) in specified geographical areas, in lieu of that set forth in this section, pursuant to a private contractual arrangement of all affected licensees and applicants. In this event, each party to such contract shall maintain a copy of the contract in their station files and disclose it to prospective assignees or transferees and, upon request, to the FCC.

Part 24 .131 Authorized Bandwidth

The Authorized bandwidth of narrowband PCS channels will be 10 kHz for 12.5 kHz channels and 45 kHz for 50 kHz channels. For aggregated adjacent channels, a maximum authorized bandwidth of 5 kHz less than the total aggregated channel width is permitted.

24.133 Emission limits

(a) The power of any emission shall be attenuated below the transmitter power (P), as measured in accordance with 24.132 (f), in accordance with the following schedule:

(1) For transmitters authorized a bandwidth greater than 10 kHz

(i) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (fd in kHz) of upto and including 40 kHz: At least 116 log 10 ((fd + 10)/6.1) decibels or 50 plus 10 log 10 (P) decibels or 70 decibels, whichever is the lesser attenuation.

(2) For transmitters authorized a bandwidth greater of 10 kHz

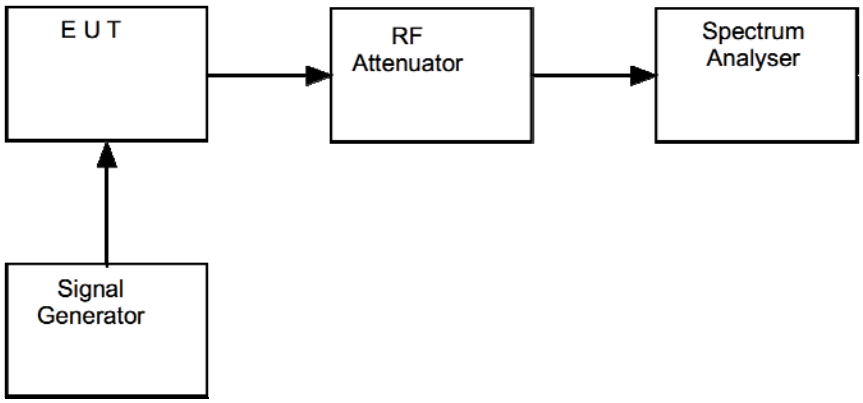
(i) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (fd in kHz) of upto and including 40 kHz: At least 116 log 10 ((fd + 5)/3.05) decibels or 50 plus 10 log 10 (P) decibels or 70 decibels, whichever is the lesser attenuation.

(ii) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 20 kHz: At least 43 + 10 log (P) decibels or 80 decibels, whichever is the lesser attenuation.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the RF spectrum mask was measured on a spectrum analyser and compared to the signal generator output as shown on the plots.
The measurements were performed with EUT set at its nominal / maximum gain.

Figure iv Test Setup



13.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09

13.6 Test Results

Emission Mask G

Emission Masks @ AGC Threshold					
Channel Centre Frequency (MHz)	***Modulation Type***				***Result***
	16k0F1D	***8k10F1E***	***13k6F3E***	***16k0F3E***	
929.5000	Compliant	Compliant	Compliant	Compliant	PASS

Emission Mask G

Emission Masks @ AGC +3dB					
Channel Centre Frequency (MHz)	***Modulation Type***				***Result***
	16k0F1D	***8k10F1E***	***13k6F3E***	***16k0F3E***	
929.5000	Compliant	Compliant	Compliant	Compliant	PASS

Emission Mask J

Emission Masks @ AGC Threshold		
Channel Centre Frequency (MHz)	***Modulation Type***	***Result***
	8k10F1E	
937.5000	Compliant	PASS

Emission Mask J

Emission Masks @ AGC +3dB		
Channel Centre Frequency (MHz)	***Modulation Type***	***Result***
	8k10F1E	
937.5000	Compliant	PASS

Part 22.359

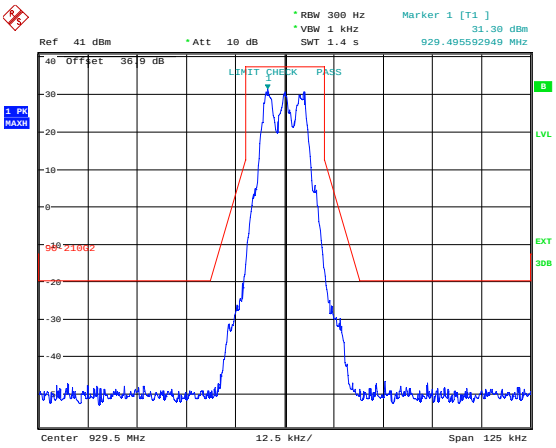
Emission Masks @ AGC Threshold			
Channel Centre Frequency (MHz)	***Modulation Type***		***Result***
	16k0F3E	***13k0F3E***	
931.0125	Compliant	Compliant	PASS
934.9875	Compliant	Compliant	PASS

Part 24.133

Emission Masks @ AGC Threshold		
Channel Centre Frequency (MHz)	***Modulation Type***	***Result***
	16k0F1D	
930.5000	Compliant	PASS
940.5000	Compliant	PASS

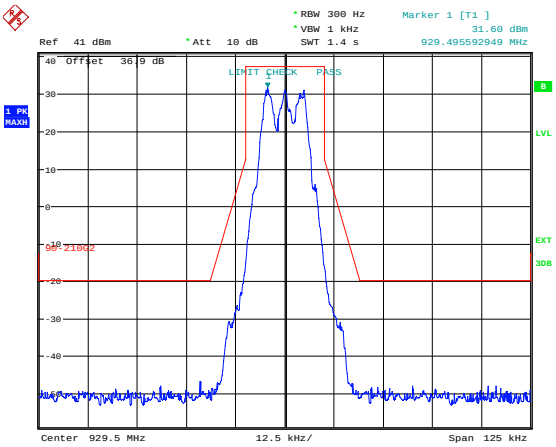
Emission Mask G

16k0F1D @ AGC



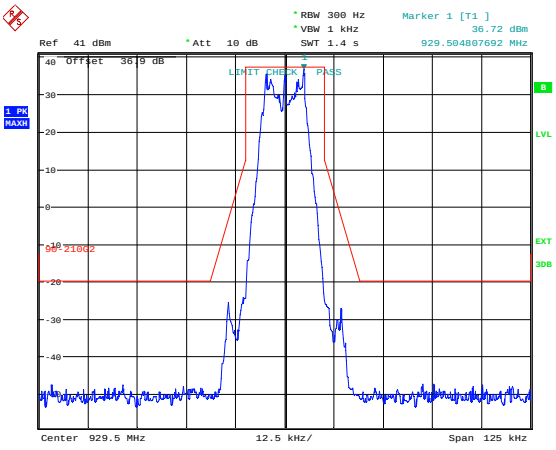
Date: 22.FEB.2018 13:05:28

16k0F1D @ AGC +3dB



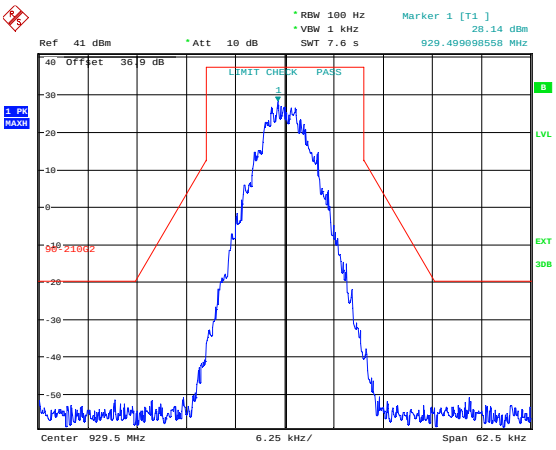
Date: 22.FEB.2018 13:07:12

16k0F1D Signal Generator



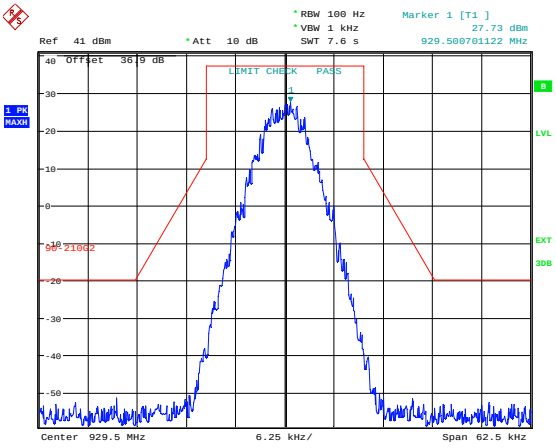
Date: 22.FEB.2018 13:02:27

8k10F1E @ AGC



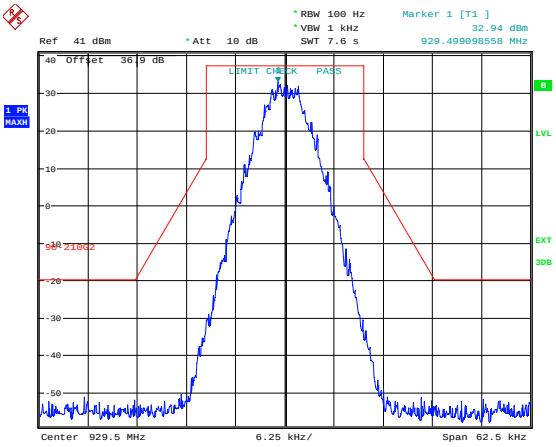
Date: 22.FEB.2018 12:53:23

8k10F1E @ AGC +3dB



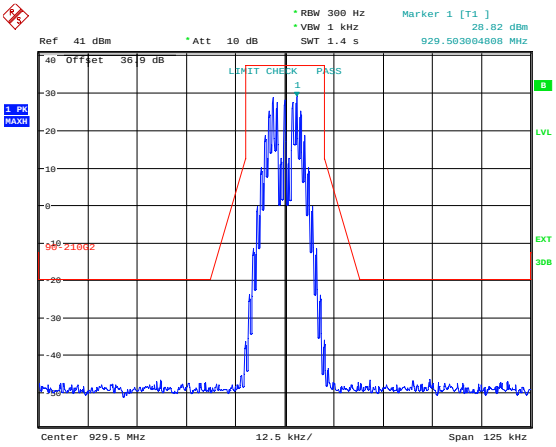
Date: 22.FEB.2018 12:54:14

8k10F1E Signal Generator



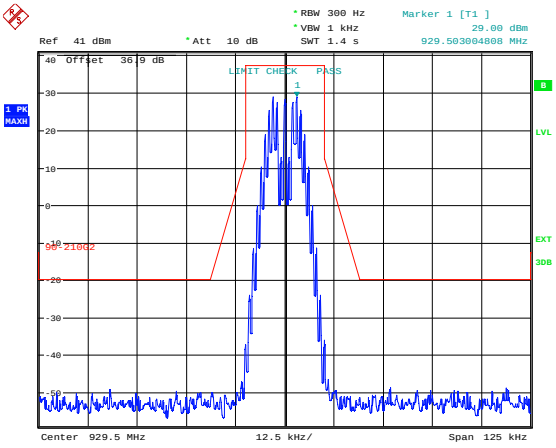
Date: 22.FEB.2018 12:51:00

13k6F3E @ AGC



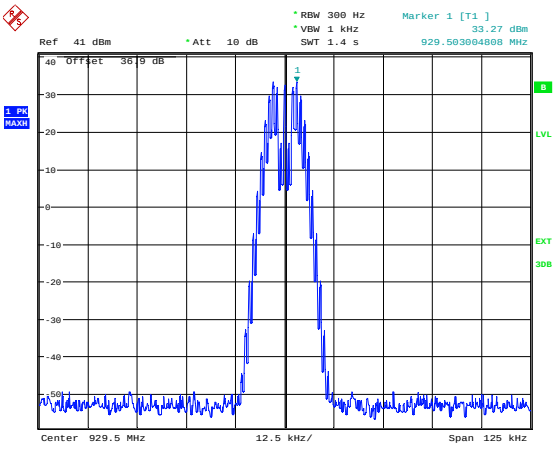
Date: 22.FEB.2018 12:33:22

13k6F3E @ AGC



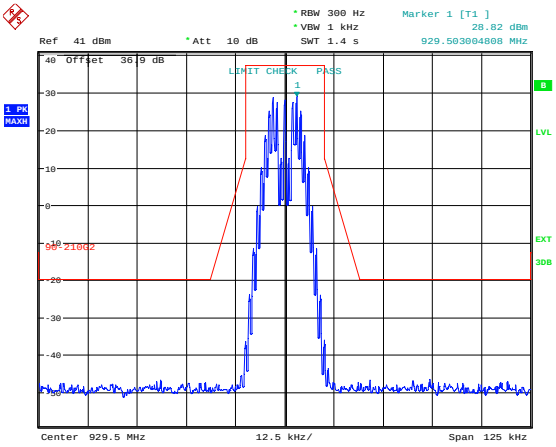
Date: 22.FEB.2018 12:33:46

13k6F3E Signal Generator



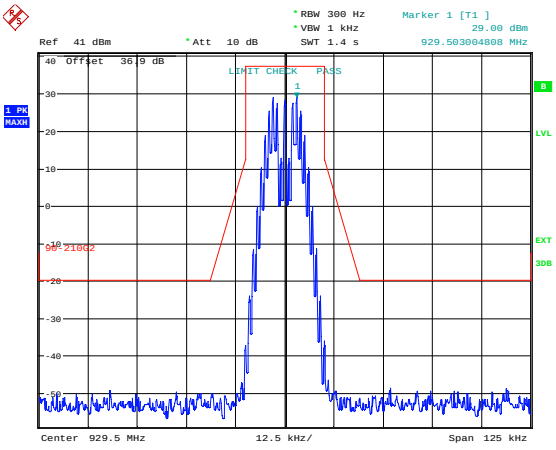
Date: 22.FEB.2018 12:34:55

16k0F3E @ AGC



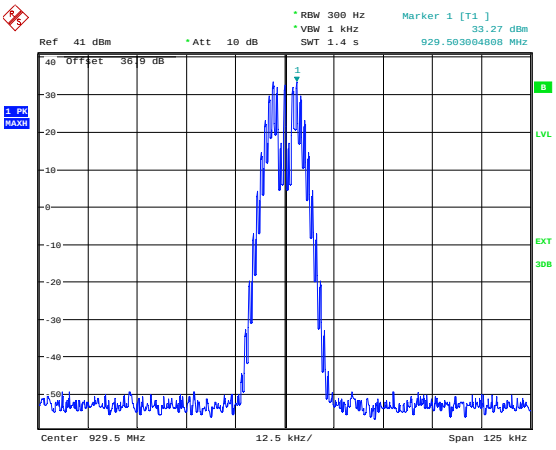
Date: 22.FEB.2018 12:33:22

16k0F3E @ AGC



Date: 22.FEB.2018 12:33:46

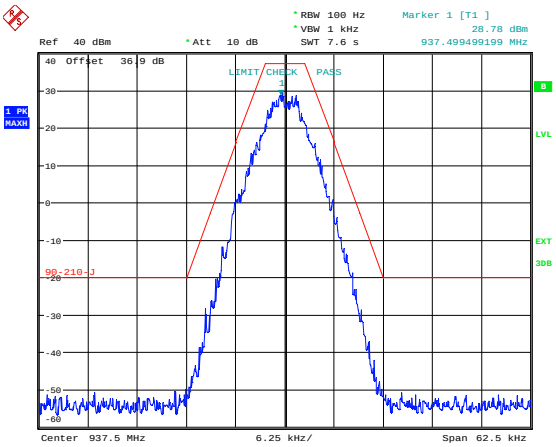
16k0F3E Signal Generator



Date: 22.FEB.2018 12:34:55

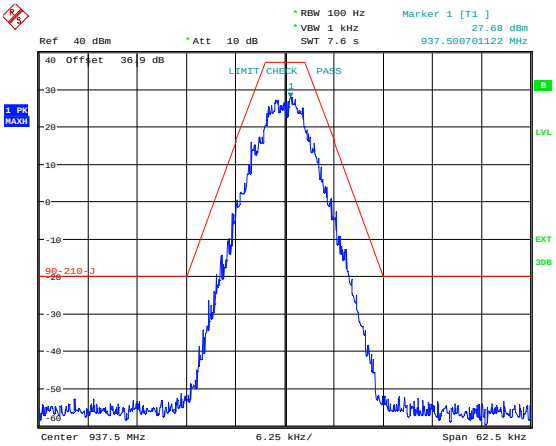
Emission Mask J

8k10F1E @ AGC



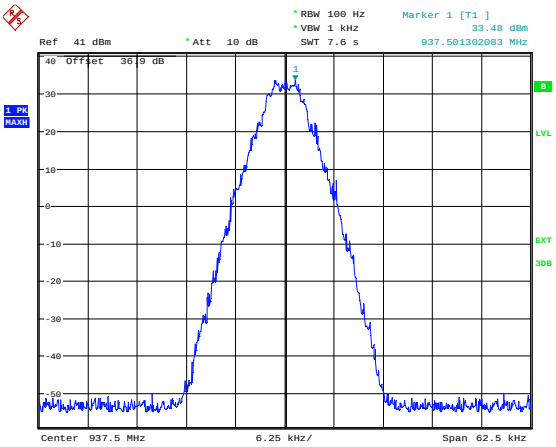
Date: 21.FEB.2018 15:53:16

8k10F1E @ AGC+3dB



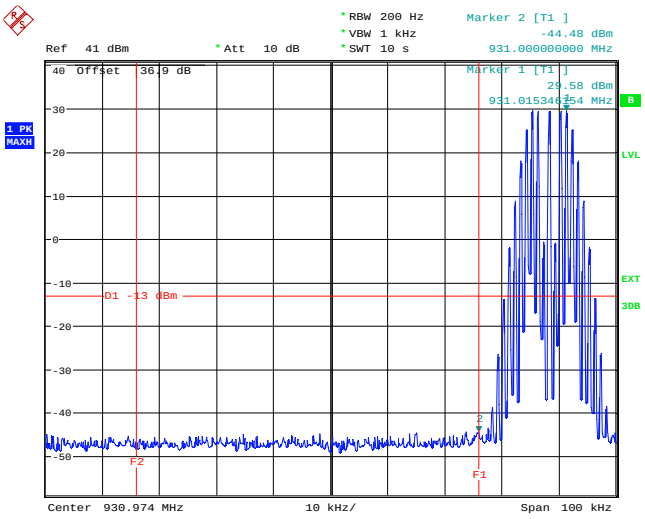
Date: 21.FEB.2018 15:54:39

8k10F1E Signal generator



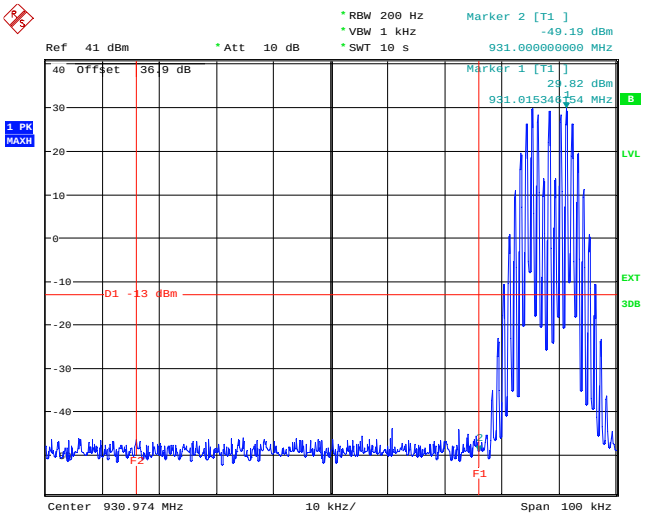
Date: 22.FEB.2018 11:38:54

Part 22.359 13k6F3E Low Channel



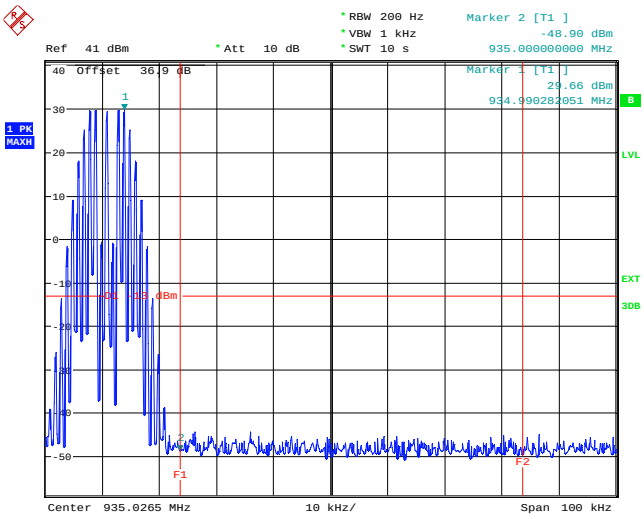
Date: 2.MAR.2018 12:28:08

Part 22.359 16k0F3E Low Channel



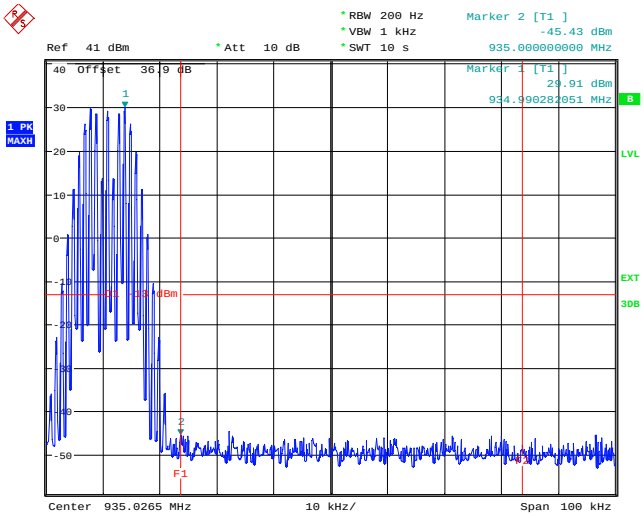
Date: 2.MAR.2018 12:22:52

Part 22.359 13k6F3E High Channel



Date: 2.MAR.2018 11:53:45

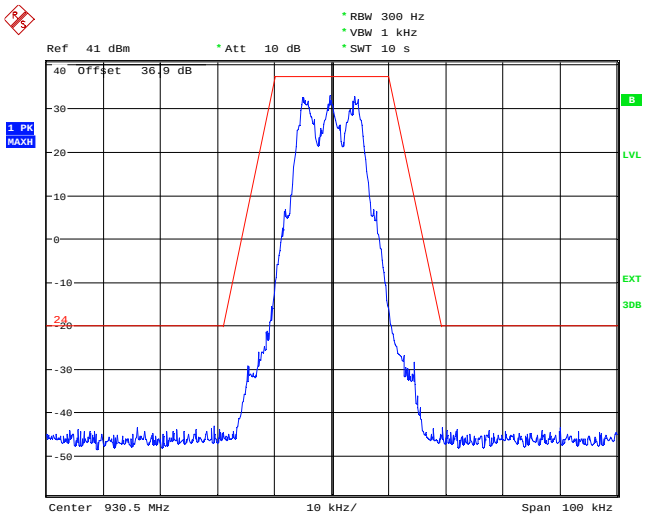
Part 22.359 16k0F3E High Channel



Date: 2.MAR.2018 12:17:22

930 MHz-931 MHz Band

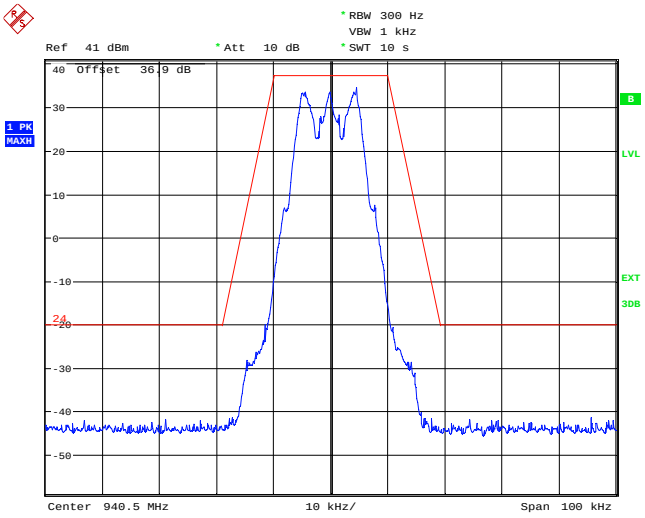
Part 24.133: 930.5 MHz



Date: 6.MAR.2018 10:14:49

940 MHz-941 MHz band

Part 24.133: 940.5 MHz



Date: 5.MAR.2018 11:57:02

.

14 Passband gain and bandwidth

14.1 Definition

The passband is the range of frequencies over which the booster is intended to apply gain. Each booster may include one or more passbands. The bandwidth of each passband is defined by two points either side of the band where the gain has fallen by 20dB from maximum.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 935210 D05 v01r02 , Clause 4.3
Frequency Measured:	935 MHz (+/-250% declared pass band)
Source Modulation:	CW
Source Level:	1.37 dBm (3dB below the AGC threshold)
Sweep Set-Up:	50 kHz steps; 10ms dwell.
Deviations From Standard:	None
Bandwidth:	RBW 200 kHz (1-5% pass band); VBW 1 MHz (3xRBW).
Measurement Detector:	Peak; Max-Hold.

Environmental Conditions (Normal Environment)

Temperature: 24°C	+15 ºC to +35 ºC (as declared)
Humidity: 21%RH	20%RH to 75%RH (as declared)
Supply: 110 V ac	

14.3 Test Limits

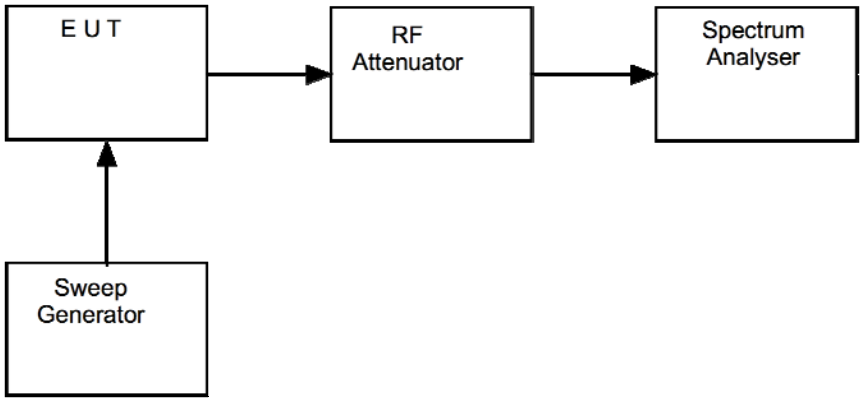
14.3.1 FCC 47CFR90.

Not stated

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the 20dB bandwidth of the EUT was measured on a spectrum analyser.
The measurements were performed with EUT set at its nominal / maximum gain.

Figure v Test Setup

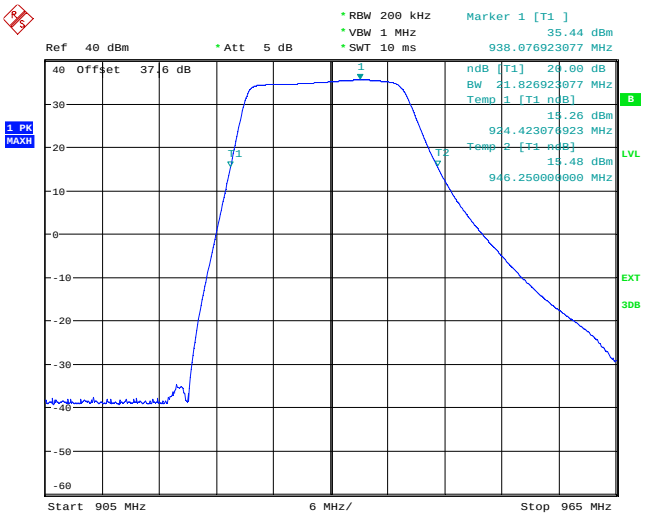


14.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09

14.6 Test Results

Pass Band Nominal Centre (MHz)	Lower Mkr Frequency (MHz)	Upper Mkr Frequency (MHz)	20dB Bandwidth (MHz)	Result
935.00	924.423076	946.250000	21.826	PASS



Date: 19.FEB.2018 13:17:51

15 Spurious emissions at antenna terminals

15.1 Definition

Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 935210 D05 v01r02, clause 4.7.3
EUT Operating Frequency Tested,	935 MHz
Source Modulations:	CW,
Source Level:	4.2 dBm (maximum input rating / AGC threshold)
Deviations From Standard:	None
Bandwidth:	RBW 100 kHz; VBW 3xRBW
Frequency Range Examined:	30 MHz – 10 GHz (10 x highest passband)
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 24°C	+15 ºC to +35 ºC (as declared)
Humidity: 25%RH	20%RH to 75%RH (as declared)
Supply: 110 V ac	

15.3 Test Limits

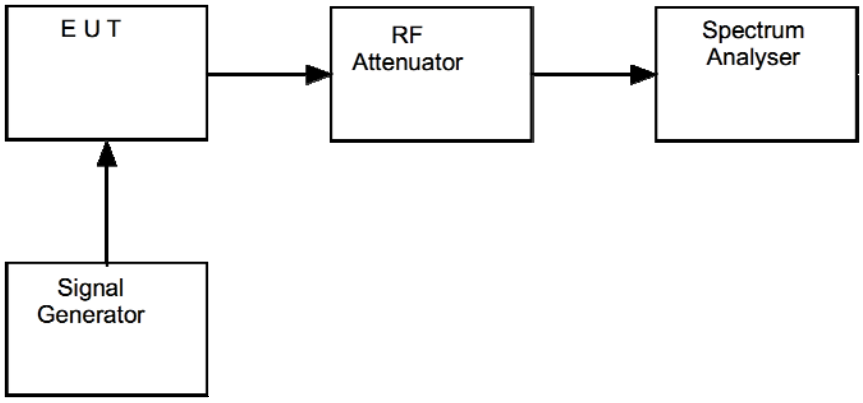
15.3.1 47CFR90

Spurious emissions from a signal booster must not exceed -13 dBm within any 100 kHz measurement bandwidth.

15.4 Test Method

Single Channel:
With the EUT setup as per section 9 of this report and connected as per Figure vi, the emissions of the EUT were calculated by taking into account any cable and attenuator calibration factors. It was confirmed that at the maximum input level there was no compression.

Figure vi Test Setup



15.5 Test Equipment

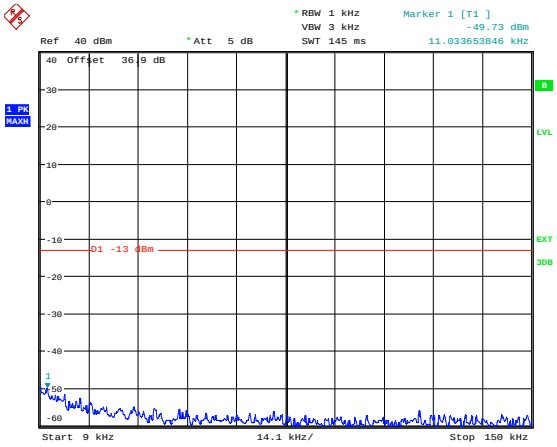
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09

15.6 Test Results

15.6.1 Out-of-band

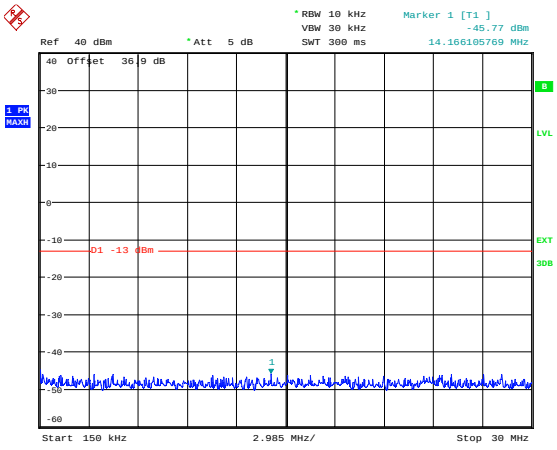
Downlink							
Operating Frequency (MHz)	*Frequency Range*	*Freq. of Emission (MHz)*	*Measured Level (dBm)*	*Attenuator & Cable Losses (dB)*	*Spurious Emission Level (dBm)*	*Limit (dBm)*	*Result*
929.003125	9 kHz-10 GHz	No Significant emissions within 20dB of the limit				-13.0	PASS
935.000000	9 kHz-10 GHz	No Significant emissions within 20dB of the limit				-13.0	PASS
940.996875	9 kHz-10 GHz	No Significant emissions within 20dB of the limit				-13.0	PASS

Bottom Downlink 9 kHz-150 kHz



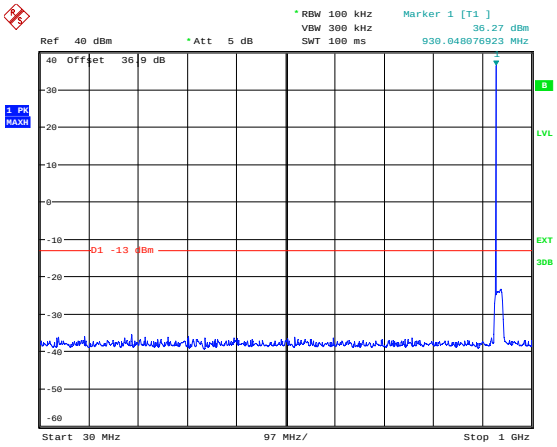
Date: 19.FEB.2018 15:56:03

Bottom Downlink 150 kHz-30 MHz



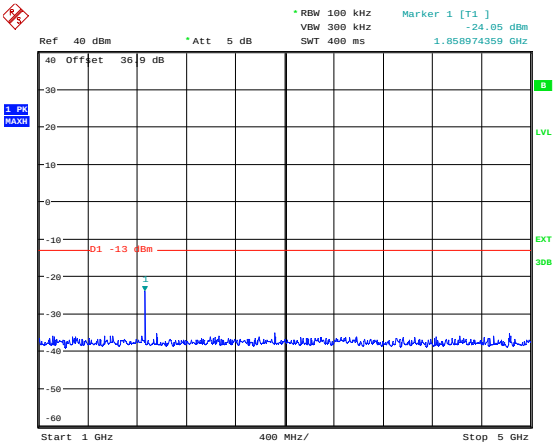
Date: 19.FEB.2018 15:56:28

Bottom Downlink 30 MHz-1 GHz



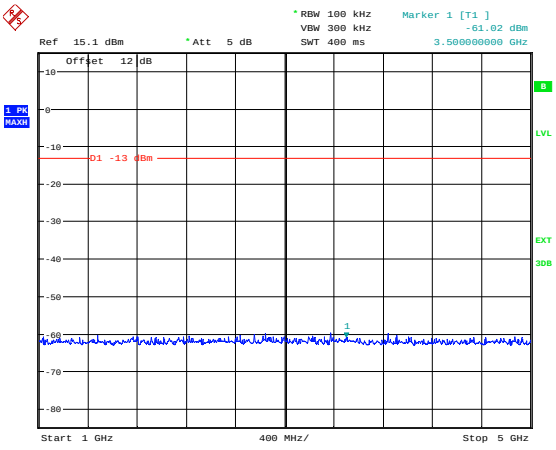
Date: 19.FEB.2018 15:56:50

Bottom Downlink 1 GHz-5 GHz no filter fitted



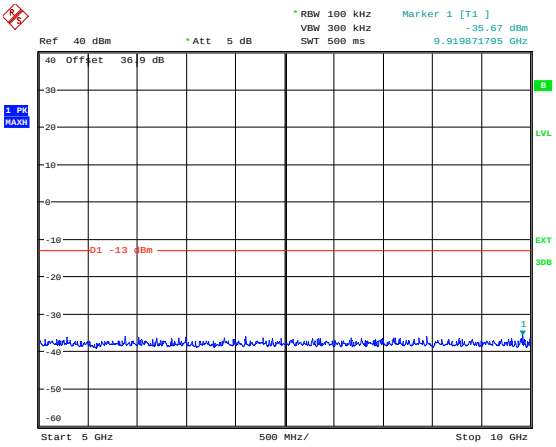
Date: 19.FEB.2018 15:57:18

Bottom Downlink 1.0 GHz-5 GHz Notch filter fitted



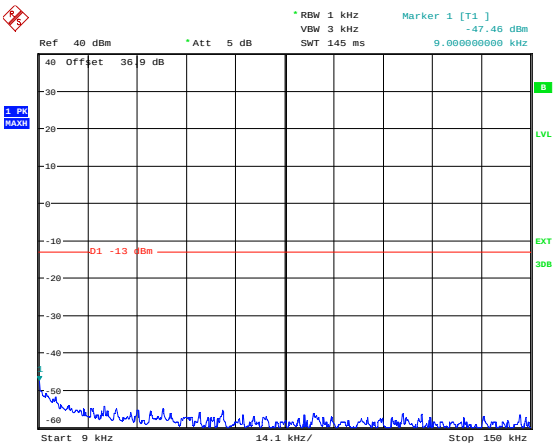
Date: 19.FEB.2018 16:26:37

Bottom Downlink 5 GHz-10 GHz



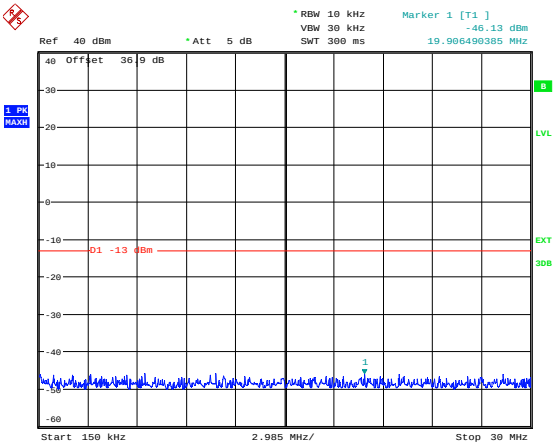
Date: 19.FEB.2018 15:57:43

Middle Downlink 9 kHz-150 kHz



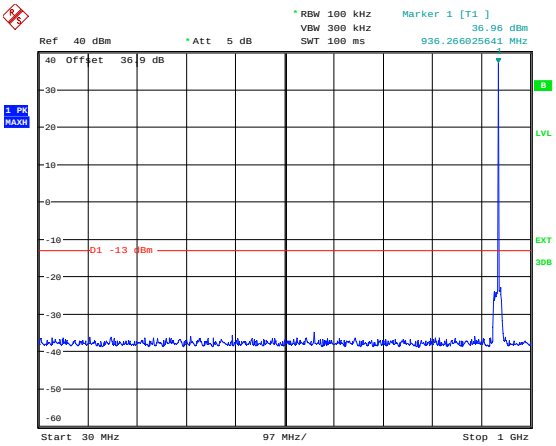
Date: 19.FEB.2018 15:58:52

Middle 150 kHz-30 MHz



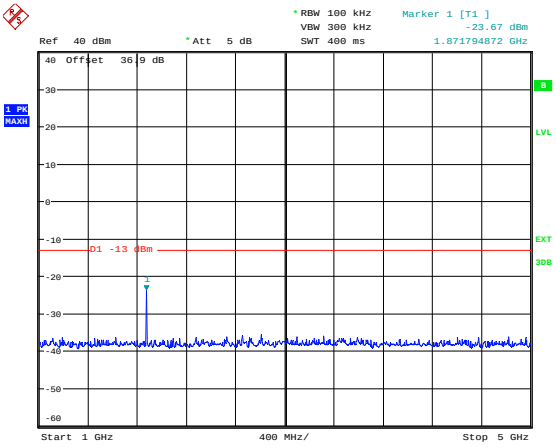
Date: 19.FEB.2018 15:59:21

Middle Downlink 30 MHz-1 GHz



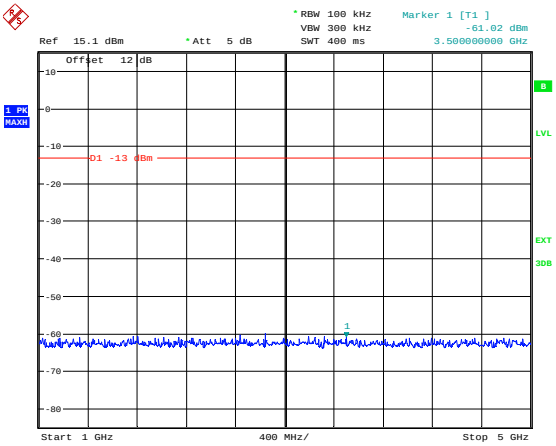
Date: 19.FEB.2018 15:58:22

Middle Downlink 1 GHz-5 GHz no filter fitted



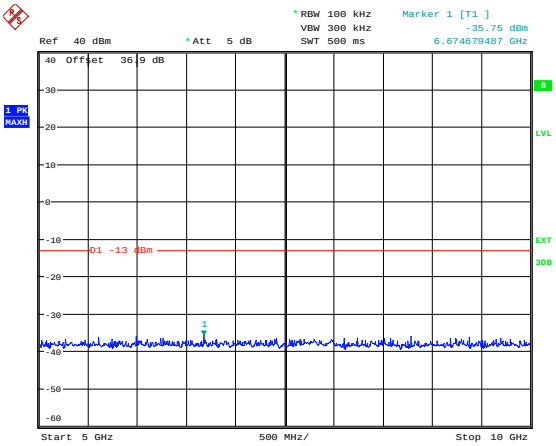
Date: 19.FEB.2018 15:59:42

Middle Downlink 1.5 GHz-5 GHz Notch filter fitted



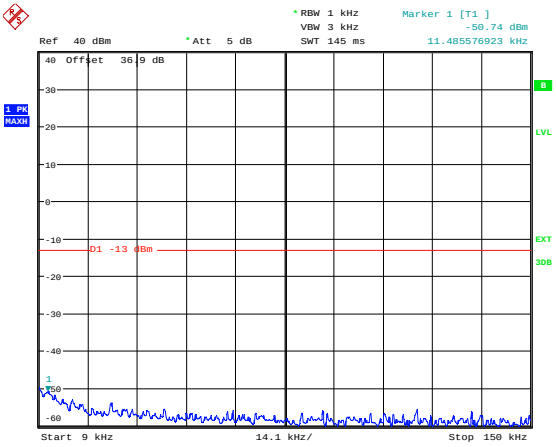
Date: 19.FEB.2018 16:25:49

Middle Downlink 5 GHz-10 GHz



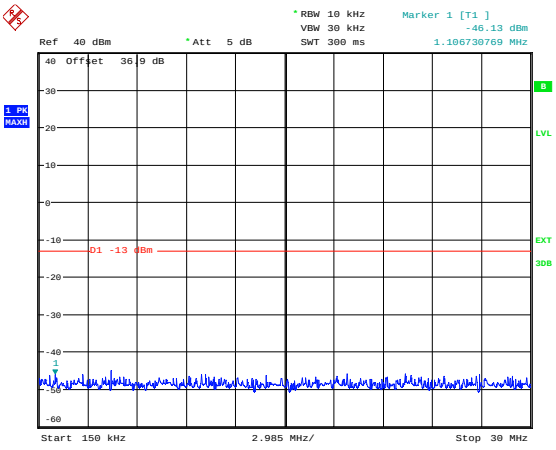
Date: 19.FEB.2018 16:00:10

Top Downlink 9 kHz-150 kHz



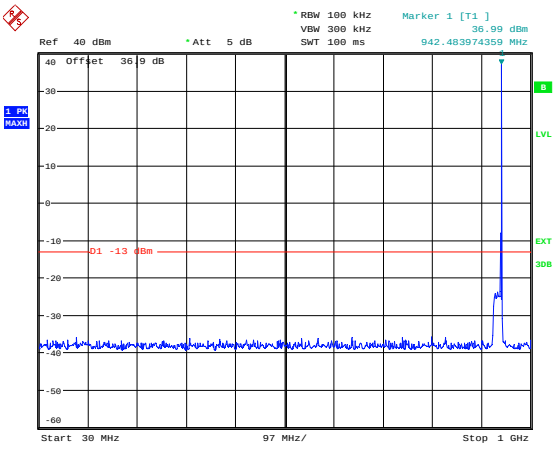
Date: 19.FEB.2018 16:01:57

Top Downlink 150 kHz-30 MHz



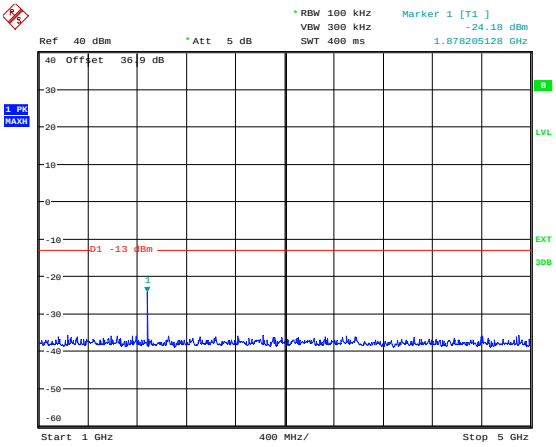
Date: 19.FEB.2018 16:02:39

Top Downlink 30 MHz-1 GHz



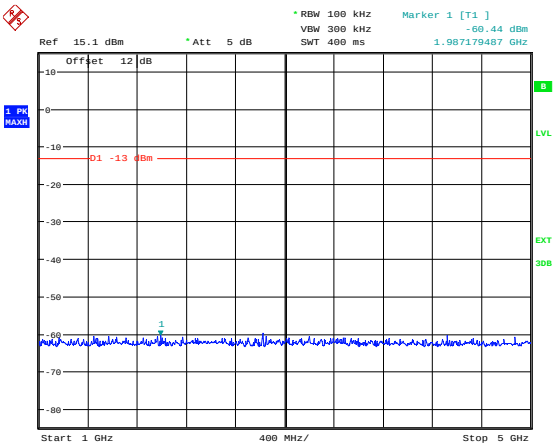
Date: 19.FEB.2018 16:02:58

Top Downlink 1 GHz-5 GHz no filter fitted



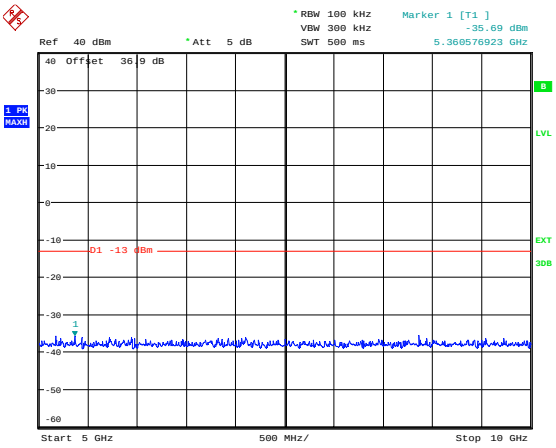
Date: 19.FEB.2018 16:03:24

Top Downlink 1.0 GHz-5 GHz Notch filter fitted



Date: 19.FEB.2018 16:25:21

Top Downlink 5 GHz-10 GHz



Date: 19.FEB.2018 16:03:50

16 Intermodulation products

16.1 Definition

Spurious intermodulation products result from intermodulation between: – the oscillations at the carrier, characteristic, or harmonic frequencies of an emission, or the oscillations resulting from the generation of the carrier or characteristic frequency; and – oscillations of the same nature, of one or several other emissions, originating from the same transmitting system or from other transmitters or transmitting systems.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	KDB 935210 D05 v01, clause 4.5
EUT Operating Frequency Tested, f_0:	938.076923 MHz
Source Tones:	f_0 +/- 12.5 kHz and +/-6.25kHz
Source Level:	4.5 dBm (AGC threshold); 7.5 dBm (3dB above)
Deviations From Standard:	None
Bandwidth:	RBW 300 Hz; VBW 3xRBW
Span:	100 kHz
Measurement Detector:	Average, rms.

Environmental Conditions (Normal Environment)

Temperature:23.5°C	+15 ºC to +35 ºC (as declared)
Humidity: 23%RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	

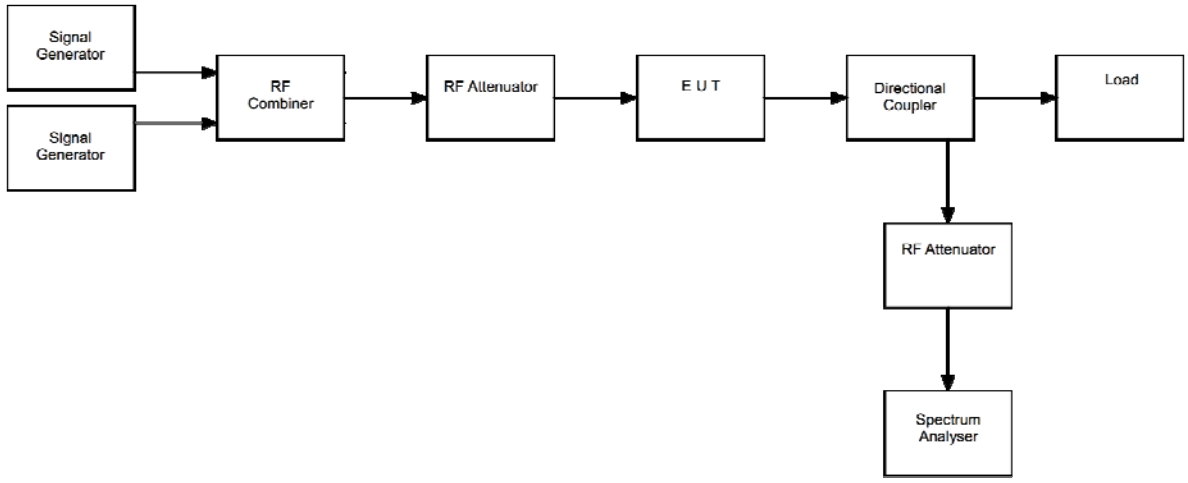
16.3 Test Limits

The retransmitted signals continue to meet the unwanted emissions limits of §90.210 applicable to the corresponding received signals (assuming that these received signals meet the applicable unwanted emissions limits by a reasonable margin).

16.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure viii, two tones were input to the EUT. The combined level at the EUT input was set by the attenuator to just below the EUT AGC threshold level and the intermodulation products were measured on the spectrum analyser.
The measurement was repeated with the input attenuator decreased by 3dB.

Figure viii Test Setup



16.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2017-06-06	12	2018-06-06
Signal Generator	R&S	SMBV100A	REF916	2017-06-09	12	2018-06-09
Signal Generator	Marconi	2023	U105	2017-04-27	12	2018-04-27

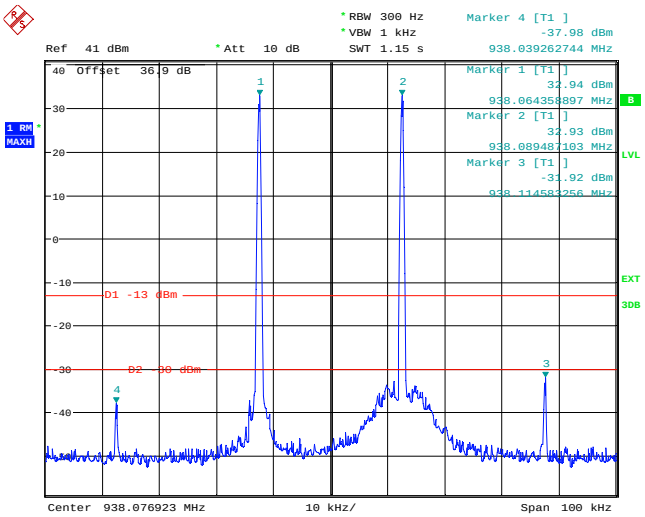
16.6 Test Results

Intermodulation @ AGC threshold						
Centre Frequency (MHz)	*Tone 2 (MHz)*	*Tone 2 (MHz)*	*Frequency of Intermodulation Product (MHz)*	*Highest Intermodulation Product Level (dBm)*	*Limit (dBm)*	*Result*
938.076923	938.064423	938.089423	938.114583	-31.92	-30.00	PASS*
938.076923	938.070673	938.083173	938.095833	-36.19	-30.00	PASS*

Intermodulation @ 3dB above AGC threshold						
Centre Frequency (MHz)	*Tone 2 (MHz)*	*Tone 2 (MHz)*	*Frequency of Intermodulation Product (MHz)*	*Highest Intermodulation Product Level (dBm)*	*Limit (dBm)*	*Result*
938.076923	938.064423	938.089423	938.114583	-24.82	-30.00	PASS*
938.076923	938.070673	938.083173	938.095833	-16.13	-30.00	PASS*

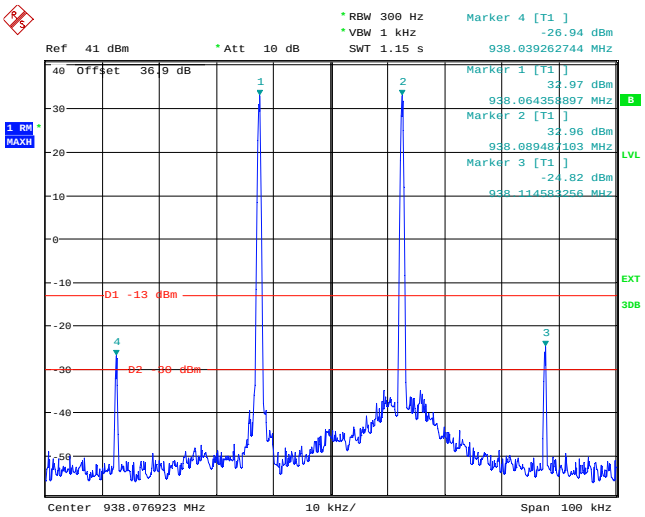
Note: Pass* Please see client declaration in Annex A.

25 kHz @ AGC



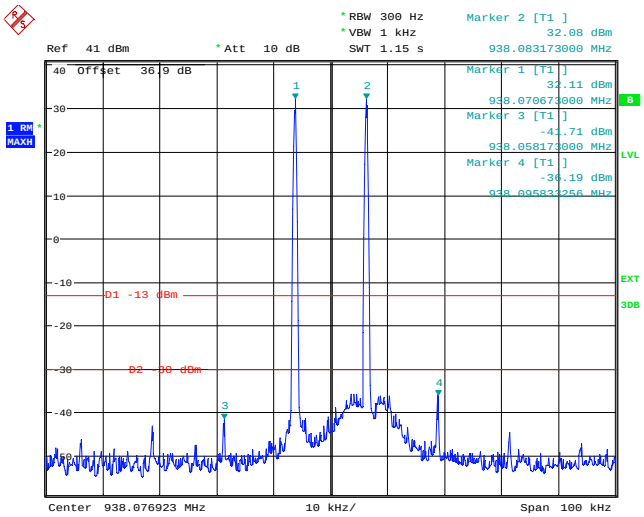
Date: 28.FEB.2018 13:30:52

25 kHz @ AGC +3dB



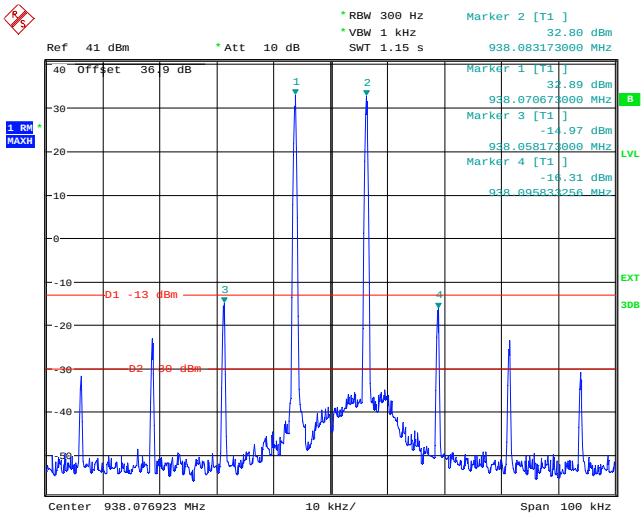
Date: 28.FEB.2018 13:31:37

12.5 kHz @ AGC



Date: 28.FEB.2018 13:41:30

12.5 kHz @ AGC +3dB



Date: 28.FEB.2018 13:42:20

17 Field strength of spurious radiation

17.1 Definitions

Spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio chamber 3
Test Standard and Clause:	TIA 603-D, clause 2.2.12
EUT Operating Channels Tested:	Low / Mid / High
Source Modulations:	CW,
Source Level:	4.7 dBm (maximum input rating / AGC threshold)
Deviations From Standard:	None
Frequency Range Examined:	30 MHz – 10 GHz (10 x highest passband)
Measurement BW:	30 MHz to 1 GHz: 120 kHz Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak Above 1 GHz: Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 ºC to +35 ºC (as declared)
Humidity: 24 %RH	20%RH to 75%RH (as declared)
Supply: 110 Vac	

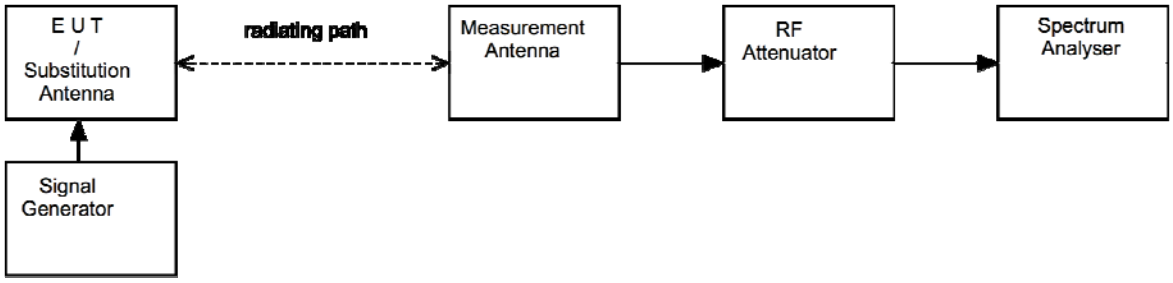
17.3 Test Limits

Spurious emissions from a signal booster must not exceed -13 dBm within any 100 kHz measurement bandwidth.

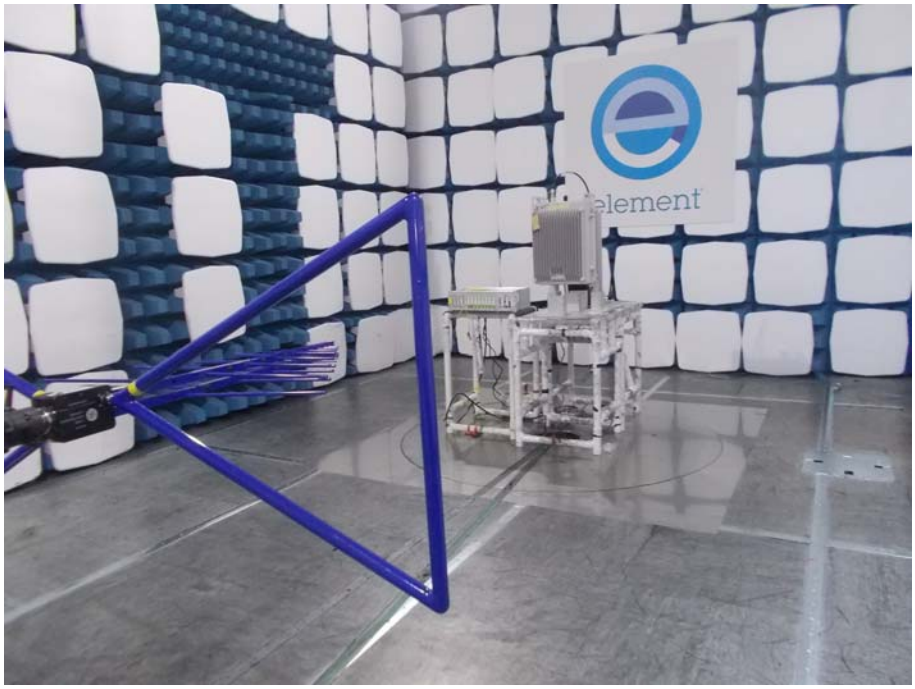
17.4 Test Method

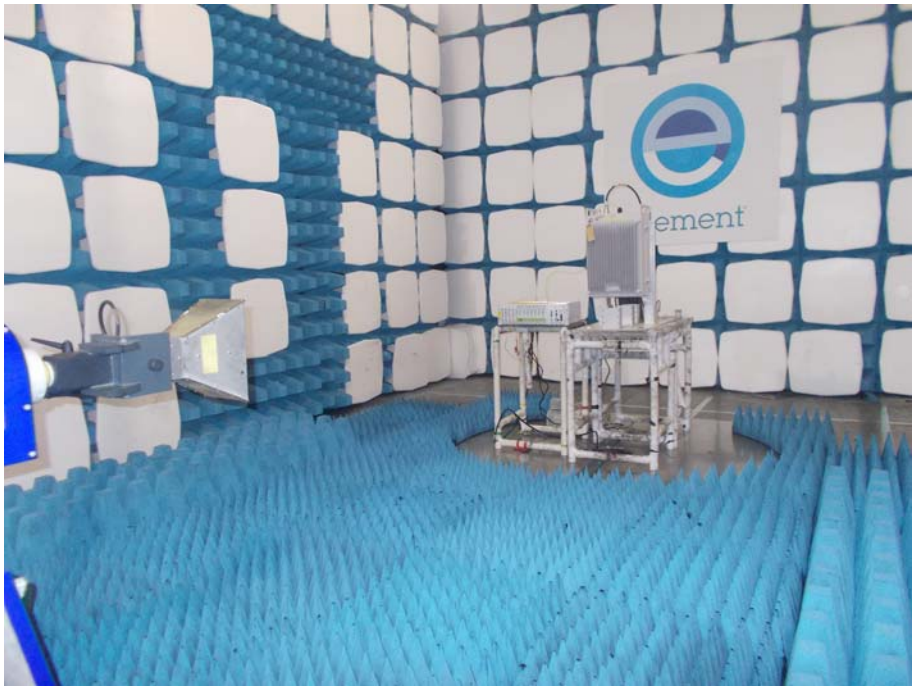
With the EUT setup as per section 9 of this report and connected as per Figure ix and with the EUT's antenna replaced by a non-radiating load, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver. The EUT was rotated in three orthogonal planes and the measurement antenna height scanned (below 1GHz, from 1 to 4 m; above 1GHz as necessary) in order to maximise emissions.
The measurements were performed with EUT set at its maximum gain. All modulation schemes, data rates and power settings were used to observe the worst-case configuration at each frequency.
The EUT was substituted with a known generator and antenna and for the same level achieved at the analyser, the effective radiated power was recorded.
Pre-scan plots are shown with a peak detector and 100kHz RBW.

Figure ix Test Setup



Test Setup Photograph(s)





17.5 Test Equipment

Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Last Cal Calibration*	*Calibration Period*	*Due For Calibration*
Receiver	R&S	ESVS10	L352	2017-07-28	12	2018-07-28
Bilog	Chase	CBL611/A	U573	2017-08-02	24	2019-08-02
1-18GHz Horn	EMCO	3115	L139	2017-09-25	24	2019-09-25
Pre Amp	Agilent	8449B	L572	2017-09-28	12	2018-09-28
Spectrum Analyser	R&S	FSU46	U281	2017-06-19	12	2018-06-19

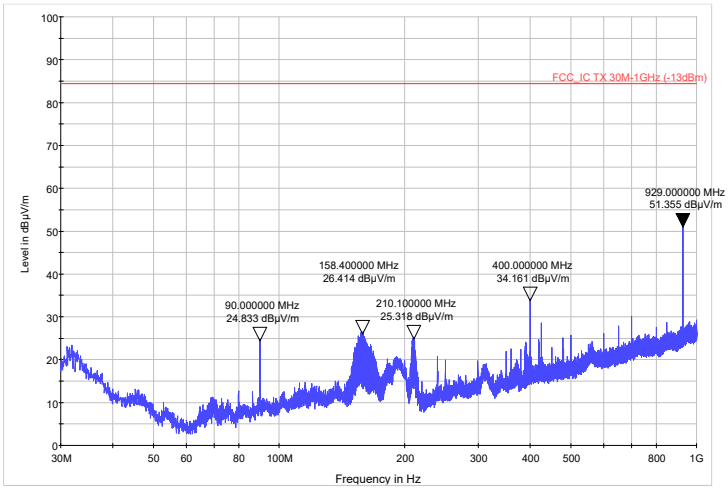
17.6 Test Results

Low Frequency; 929.0125 MHz					
Emission	*Frequency (MHz)*	*Emission level (dBm)*	*Limit (dBm)*	*Margin (dB)*	*Result*
1	No significant emissions within 20dB of the limit				PASS

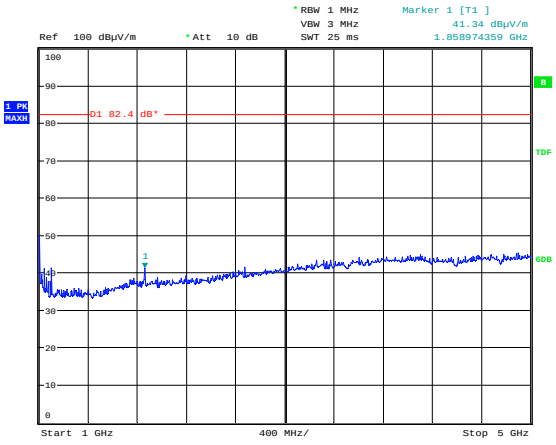
Mid Frequency; 935.0000 MHz					
Emission	*Frequency (MHz)*	*Emission level (dBm)*	*Limit (dBm)*	*Margin (dB)*	*Result*
1	No significant emissions within 20dB of the limit				PASS

High Frequency; 940.9875 MHz					
Emission	*Frequency (MHz)*	*Emission level (dBm)*	*Limit (dBm)*	*Margin (dB)*	*Result*
1	No significant emissions within 20dB of the limit				PASS

Bottom 30 MHz-1 GHz

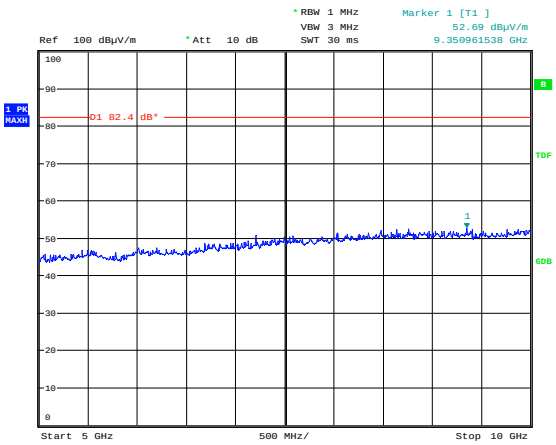


Bottom 1 GHz-5 GHz



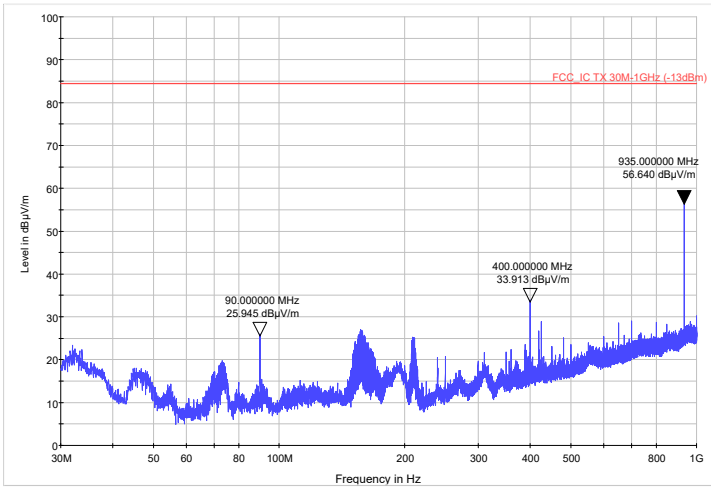
Date: 1.MAR.2018 05:25:17

Bottom 5 GHz-10 GHz

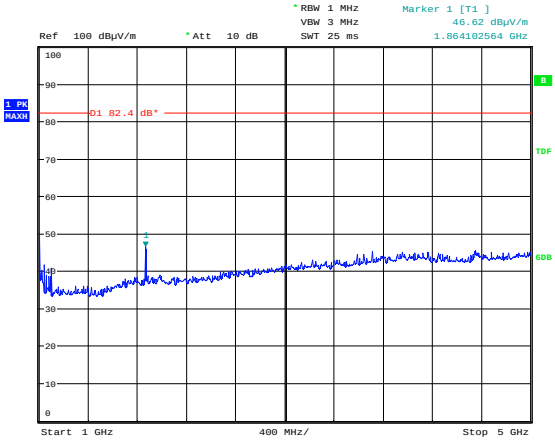


Date: 1.MAR.2018 05:26:50

Middle 30 MHz-1 GHz

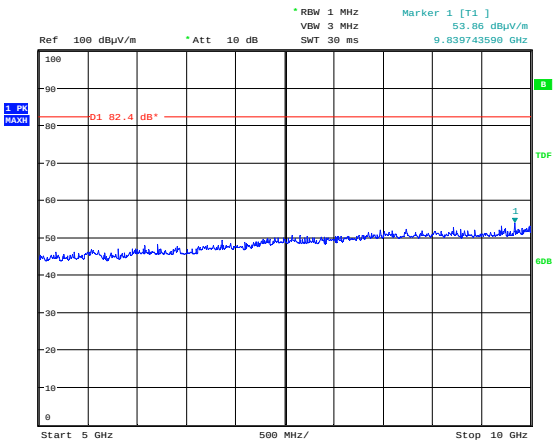


Middle 1 GHz-5 GHz



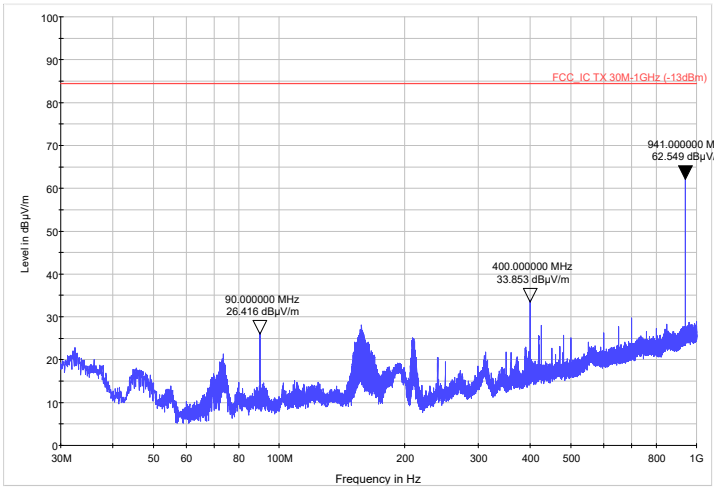
Date: 1.MAR.2018 05:29:58

Middle 5 GHz-10 GHz

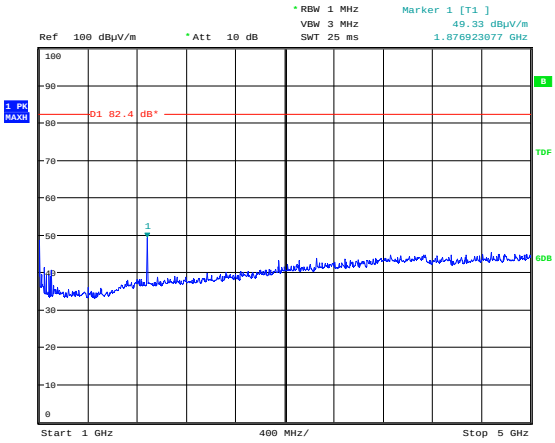


Date: 1.MAR.2018 05:31:03

Top 30 MHz-1 GHz

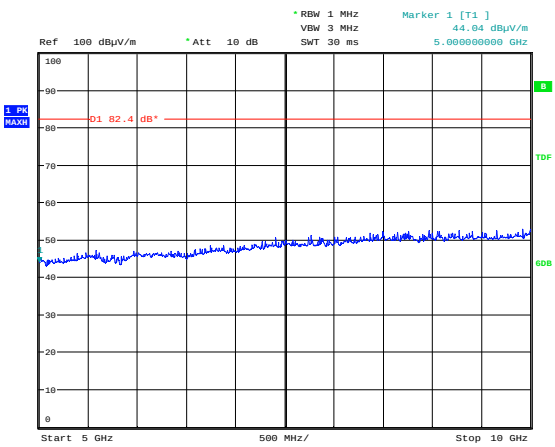


Top 1 GHz-5 GHz



Date: 1.MAR.2018 05:34:10

Top 5 GHz-10 GHz



Date: 1.MAR.2018 05:35:10

18 Measurement Uncertainty

For the test data recorded the following measurement uncertainty was calculated:

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95% confidence where no required test level exists.

[1] Adjacent Channel Power

Uncertainty in test result = **1.86dB**

[2] Carrier Power

Uncertainty in test result (Power Meter) = **1.08dB**
Uncertainty in test result (Spectrum Analyser) = **2.48dB**

[3] Effective Radiated Power

Uncertainty in test result = **4.71dB**

[4] Spurious Emissions

Uncertainty in test result = **4.75dB**

[5] Maximum frequency error

Uncertainty in test result (Frequency Counter) = **0.113ppm**
Uncertainty in test result (Spectrum Analyser) = **0.265ppm**

[6] Radiated Emissions, field strength OATS 14kHz-18GHz Electric Field

Uncertainty in test result (14kHz – 30MHz) = **4.8dB**,
Uncertainty in test result (30MHz – 1GHz) = **4.6dB**,
Uncertainty in test result (1GHz – 18GHz) = **4.7dB**

[7] Frequency deviation

Uncertainty in test result = **3.2%**

[8] Magnetic Field Emissions

Uncertainty in test result = **2.3dB**

[9] Conducted Spurious

Uncertainty in test result – Up to 8.1GHz = **3.31dB**
Uncertainty in test result – 8.1GHz – 15.3GHz = **4.43dB**
Uncertainty in test result – 15.3GHz – 21GHz = **5.34dB**
Uncertainty in test result – Up to 26GHz = **3.14dB**

[10] Channel Bandwidth

Uncertainty in test result = **15.5%**

[11] Amplitude and Time Measurement – Oscilloscope

Uncertainty in overall test level = **2.1dB**,
Uncertainty in time measurement = **0.59%,**
Uncertainty in Amplitude measurement = **0.82%**

[12] Power Line Conduction

Uncertainty in test result = **3.4dB**

[13] Spectrum Mask Measurements

Uncertainty in test result = **2.59% (frequency)**
Uncertainty in test result = **1.32dB (amplitude)**

[14] Adjacent Sub Band Selectivity

Uncertainty in test result = **1.24dB**

[15] Receiver Blocking – Listen Mode, Radiated

Uncertainty in test result = **3.42dB**

[16] Receiver Blocking – Talk Mode, Radiated

Uncertainty in test result = **3.36dB**

[17] Receiver Blocking – Talk Mode, Conducted

Uncertainty in test result = **1.24dB**

[18] Receiver Threshold

Uncertainty in test result = **3.23dB**

[19] Transmission Time Measurement

Uncertainty in test result = **7.98%**

19 APPENDIX A – Client Declarations

DECLARATION

Element Materials Technology
100 Frobisher Business Park
Malvern
Worcestershire
WR14 1BX
UK

Declaration **2018-8**

Ref: NEOMBF3709S

To whom it may concern

Axell Wireless Ltd states in the User Manual for the booster with FCC ID NEOMBF3709S that only suitably qualified, professional people should undertake the installation of the product.

By only using suitably qualified, professional personnel to install the device, installation of the antenna can be maintained, ensuring compliance with FCC RF exposure requirements and FCC rule part §90.219(e)(1) – Ensuring that the Booster does not exceed the 5W EIRP requirement.

Date: 02/03/2018

Brian Barton
Operations Support
Director

Axell Wireless

AXELL WIRELESS UK
Asheridge Road
Chesham, Bucks
HP5 2QD, UK
Tel: + 44 (0) 1494 777000
Fax: + 44 (0) 1494 777002

info@axellwireless.com
www.axellwireless.com

AXELL WIRELESS SWEDEN
Box 7139
174 07 Sundbyberg
Sweden
Tel: + 46 (0) 8 475 4700
Fax: + 46 (0) 8 475 4799

Cobham Wireless
Aerial House, Asheridge Road
Chesham, Buckinghamshire
HP5 2QD, UK

T: +44 1494 777 000
F: +44 1494 777 002

Frequency Stability of Analogue Repeaters

Declaration **2018-7**

Cobham Wireless hereby confirms that the analogue band selective repeaters it designs and manufactures do not incorporate oscillators or similar technology and as such the repeater will not alter the input signal in any way.

Date: 02, 03, 2018

Brian Barton
Operations Support
Director

Cobham Wireless

Cobham Wireless
Aerial House, Asheridge Road
Chesham, Buckinghamshire
HP5 2QD, UK

T: +44 1494 777 000
F: +44 1494 777 002

Out of band rejection - 20dB bandwidth MBF-3709S

Declaration **2018-9**

The MBF-3709S remote fibre fed booster is band select it is in turn fed by either channelized units or base stations via fibre. The channelized units will only pass the required frequencies so no unwanted carriers can be sent to air. In addition the noise squelch in the channelized units means no noise at unwanted frequencies are transmitted to air. So in conclusion although the 20dB bandwidth of the remote booster is significantly wider than that declared, due to the system configuration only wanted carriers will ever be amplified by it.

Date: 07, 03, 2018

Brian Barton
Operations Support
Director

Cobham Wireless

Antenna Installation

Installation of an antenna must comply with the FCC RF exposure requirements. The antenna used for this transmitter must be mounted on permanent structures.

The FCC regulations mandate that the ERP of type B signal boosters should not exceed 5W, this is equivalent to 8.2W EIRP.

Therefore the max antenna gain allowed for this type of signal booster should be limited to the values given by equation 1 (below) for the service antenna.

Equation (1) - Max SERVICE antenna gain
Max SERVICE antenna gain (dBi) = 39.1 – (37dBm - # of antennas in dB – cable losses in dB).

For example:

No. of Antennas	Cable Losses	Max Allowed Antenna Gain
4	3	39.1 - (37-6-3) =11.1dBi
1	3	39.1- (37-0-3) = 5.1dbi
10	3	39.1- (37-10-3) = 15.1dbi

Compliance with FCC deployment rule regarding the radiation of noise and intermodulation product

Good engineering practice must be used in regard to the signal booster's radiation of intermodulation products and noise. Thus, the gain of the signal booster should be set so that the ERP of the output of intermodulation products from the signal booster should not exceed the level of -30 dBm in 10 kHz measurement bandwidth and noise from the signal booster should not exceed the level of -43 dBm in 10 kHz measurement bandwidth.

In the event that the intermodulation or noise level measured exceeds the aforementioned values, the signal booster gain should be decreased accordingly.

In general, the ERP of noise on a spectrum more than 1 MHz outside of the pass band should not exceed -70 dBm in a 10 kHz measurement bandwidth.

The MBF-900 Repeater has a noise level of -43.8 dBm in 10 kHz measurement at 1 MHz spectrum outside the passband of the signal booster, worst case intermodulation products at around -14.9 dBm in a 10 kHz bandwidth and an in-band noise level at around -42.8 dBm in a 10 kHz bandwidth. Therefore, the noise or intermodulation product at the antenna input port should be calculated based on equation (2).

Equation (2) - Input Noise or intermodulation product to service antenna
Input Noise to service antenna:
-XX dBm + Service Antenna gain – Antenna splitter losses in dB – cable loss in dB

Example: Intermodulation product
Signal booster connected to 10 service antennas with a 100m long ½ inch cable.
Losses of such a cable with the connectors = ~ 12dB

Assuming 10 service antennas: antenna splitter losses = 11 dB
Based on equation (2) Input antenna noise (to the antenna) = -14.9-12 -11= -37.9 dBm ERP
The intermodulation product to the antenna should be -14.9 -12-11= -37.9dbm ERP

Example: In band Noise
Signal booster connected to 10 service antennas with a 100m long ½ inch cable.
Losses of such a cable with the connectors = ~ 12dB

Assuming 10 service antennas: antenna splitter losses = 11 dB
Based on equation (2) Input antenna noise (to the antenna) = -42.8-12 -11=-65.8 dBm ERP
The in-band input noise to the antenna should be -42.8 -12-11= -65.8dbm ERP

Example: Out of band noise
Signal booster connected to 10 service antennas with a 100m long ½ inch cable.
Losses of such a cable with the connectors = ~ 12dB

Assuming 10 service antennas: antenna splitter losses = 11 dB
Based on equation (2) Input antenna noise (to the antenna) = -43.8 -12 -11= -66.8dBm ERP
The Out of-band input noise to the antenna should be -43.8 -12-11= -66.8dbm ERP

NOTE: In this example there is a need to add an external band pass filter to attenuate the out of band noise by a further 3.2dB 1MHz away from the band edge. If fewer antennas are deployed then additional filtering will be required.

Conclusion:

Good engineering practice requires that in general when the out of band noise measured at the service antenna input is more than -70 dBm per 10 kHz measurement bandwidth, an external band pass filter should be added to attenuate the out of band noise level.

All Axell Wireless repeaters include high selectivity duplexers and filters to attenuate the out of band noise. Should additional filtering be required, we have a comprehensive range of interference filters which can be supplied upon request.