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RCS and spurious emissions measurements of a dual band Coverise RTE (Active-XS)

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QINETIQ/TS/SDS/CR1002449
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Administration page

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1 Introduction

A measurement programme was undertaken by QinetiQ Funtington to assess the radar cross section (RCS) and the spurious emissions from a dual band Coverise radar target enhancer (RTE); this RTE is to be marketed as the Echomax ACTIVE-XS dual band RTE.

The task was performed under contract number COM-ICS-10-164-KG for Coverise Ltd.

The equipment under test (EUT) has been tested against sections of active radar reflector RCS specification ISO 8729-2 [1] and R&TTE specification ETSI EN 302 752 [2].

The RCS and spurious emissions measurement results are summarised in a table in the main body of the report with the full results detailed in Annex A for comparison against the specifications.

2 Equipment under test

The EUT consisted of a ACTIVE-XS dual band RTE serial number 001 supplied by Coverise Ltd. Figure 1 shows a photograph of the ACTIVE-XS dual band in the anechoic chamber at Funtington.

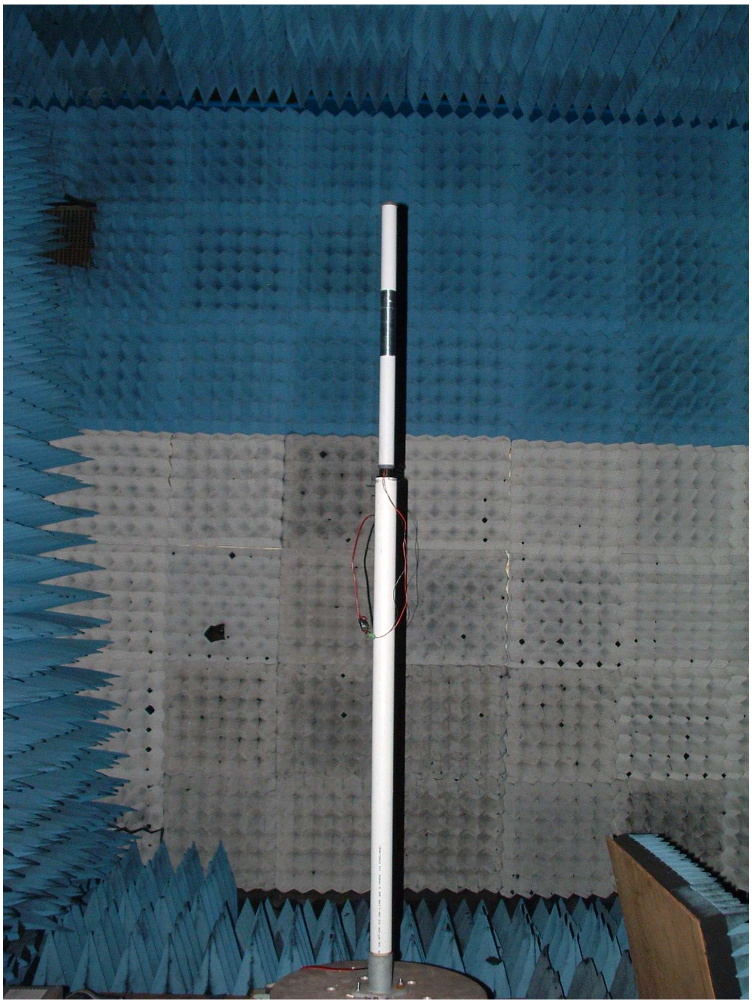

Figure 1 ACTIVE-XS dual band RTE mounted in the anechoic chamber

3 Measurement Techniques

3.1 Radar Cross Section (RCS)

The S and X band RCS measurements were carried out in the anechoic chamber at QinetiQ Funtington, figure 2. The chamber consists of a 15m long, 6m wide and 5m high screened room clad with radar absorbent material (RAM). The radar transmit and receive horns are mounted side by side and are positioned in the middle of the wall at one end of the chamber. At the other end, the target is positioned on a low RCS mount at the same height as the horns and this sits on an azimuth-over-elevation positioner which is screened by a small RAM wall.

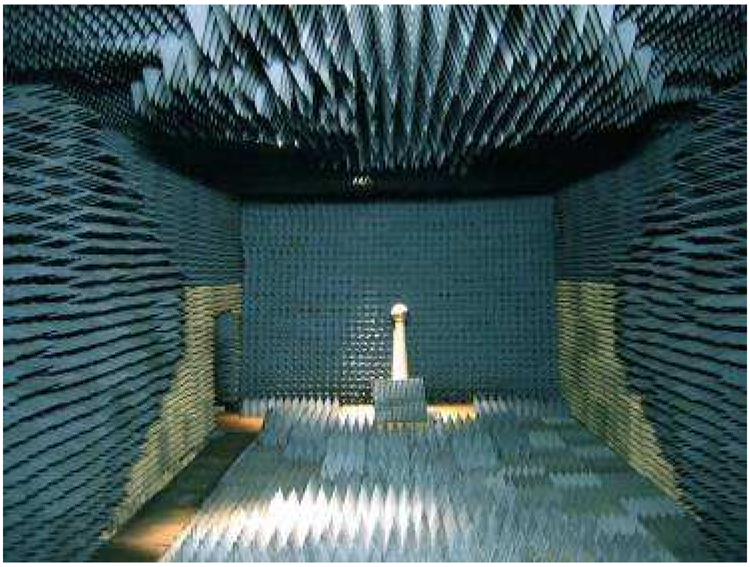

Figure 2 QinetiQ Funtington's anechoic chamber with 300mm sphere being tested

The facility uses a HP8530 vector network analyser with a HP8511A frequency converter unit as the calibrated radar. The system is computer controlled and the positioner data is synchronised with the measured RCS, which is plotted in real time. The RCS system is calibrated using a 300mm-diameter sphere with an RCS of -11.4dBm^2 (0.072m^2). The background clutter from the chamber is suppressed using an automated background subtraction method measured when the chamber is empty.

For the main RCS testing the device was tested below its saturation level. For the saturated power tests at 0° elevation the RCS was tested with a power density of 0.011W/m^2 at S Band and 0.023W/m^2 at X Band were used as specified in the power emission tests of ISO8729-2 section 7.3.6.

The RCS of the RTE was measured in the azimuthal plane over elevation angles of ±20° in 5° steps at a frequency of 3.05GHz (S Band) and 9.41GHz (X Band). From these measurements the stated performance level (SPL) was produced and compared to the specification.

Time delay, stability and induced stability tests were also measured using the calibrated radar. Measurements were made over a swept frequency range of 2.9 – 3.1GHz for S Band and 9.3 to 9.5GHz for X Band. These swept frequency measurements were transformed using a FFT to the time domain to give the time delay, stability and induced stability results.

The time delay test compares the main return from the RTE when power on and off, the difference in time is shown as the delay of the RTE. With the device powered the time domain measurements can show if the RTE is unstable or ringing by showing increasing returns separated by the delay of the device.

To carry out the induced stability test a 0.222m side length triangular trihedral is introduced at a range of 3m from the EUT perpendicular to the direction of the radar. Any instability can be identified using the time domain measurements.

3.2 Pulse Characteristics

The pulse characteristics for the system was measured by triggering the RTE with a 500ns pulsed transmit signal at both 3.05GHz and 9.41GHz separately and measuring the pulse width using a peak power analyser attached to a receive antenna. The pulse width is the width of the pulse measured between the two 50% of peak voltage points, figure 3.

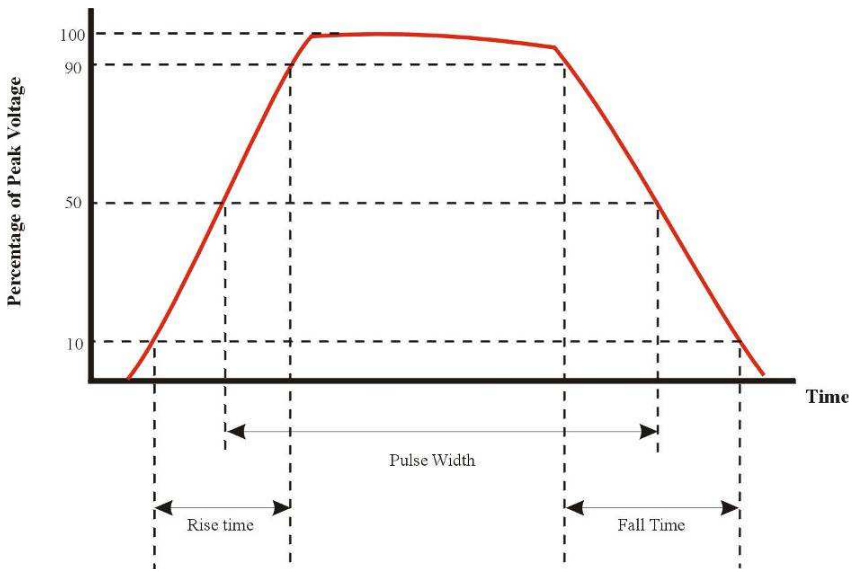

Figure 3 Pulse Characteristics

3.3 Unwanted emissions

The technique employed at QinetiQ Funtington for the measurement of unwanted emissions from maritime navigational radars is based on the direct method described in the latest version of ITU recommendation M.1177 [3]. This method allows the accurate measurement of the spectral emissions from a complete radar system and is applicable to testing RTEs.

The EUT was tested within the anechoic chamber at QinetiQ Funtington. The device was illuminated by two CW tones at a range of 12 metres and the emissions from the EUT were measured using standard gains horns at a range of 3m perpendicular to the direction of illumination. The layout of the test facility is shown in figure 4.

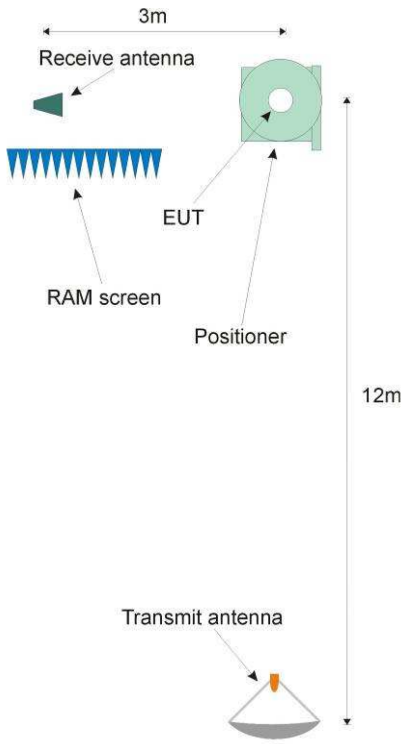

Figure 4 Layout of facility for UE testing of RTE

The test cable from the receive antenna is 4.0 metres long. This connects to a weatherproof box containing the attenuators, YIG filter and pre-amplifier which is mounted directly behind the receive antenna in the anechoic control room. A 3m cable runs from this box to the spectrum analyser.

The measurement system comprises:-

- standard gain antennas
- computer controllable integrated 0-90 dB and 0-11 dB attenuators
- Omni-Yig 2-26.5 GHz computer controllable YIG band-pass filter
- Miteq 100 MHz – 26.5 GHz low noise pre-amplifier
- 26.5 GHz Hewlett Packard Modular Measurement System (MMS) spectrum analyser
- personal computer
- 10 MHz – 26.5 GHz synthesised calibration source
- 18 GHz Hewlett Packard Peak Power Analyser

The measurement equipment schematic is shown in Figure 5.

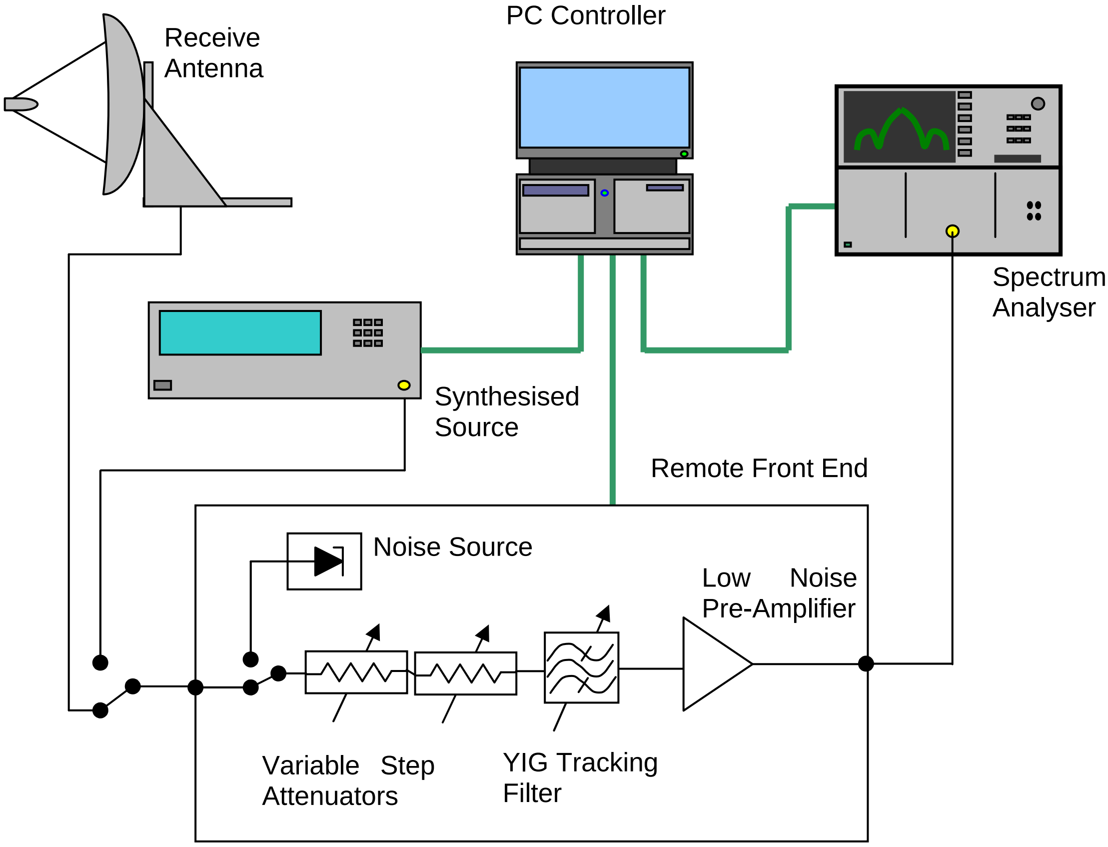

Figure 5 Schematic of the Unwanted Emissions Measurement System

The steps taken in the unwanted emission measurement procedure are outlined below:-

- Switch on receive equipment and warm-up
- Perform spectrum analyser internal calibration
- Perform system calibration with synthesised source or noise source
- Switch on EUT and allow to warm-up
- Measure the peak power spectrum (detailed method shown later)
- Apply the system calibration and antenna gain curve to the data
- Plot calibrated emitted spectrum.

Before commencing a measurement run the receive system is calibrated across the full measurement band using a synthesised source.

When using the synthesised source the frequency is stepped across the band, using a step size equal to Resolution Bandwidth (RBw) which gives a continuous loss figure curve for the system against frequency.

To measure the unwanted emissions of the EUT, the system is required to measure the worst case power spectrum. The analyser is first set to the lowest frequency of the required measurement range with a frequency span of 0 Hz. The measurement bandwidth, known as the impulse bandwidth (BW_I) in this case, is set to an appropriate value for the pulse width of the EUT up to a maximum of 1 MHz. As the EUT was effectively a CW source the RBw was set to 100 kHz to reduce receiver noise effects. The detector mode is set to positive peak and as this is a static system the sweep time was set to 100mS.

During the measurement the analyser measures the received power against time and at the end of the sweep the peak value is recorded and downloaded onto the PC. The PC then adjusts the front end attenuation if the peak value does not fall into an optimum power band (for example -25 to –35 dBm) and the measurement is repeated. If the measured value is satisfactory the frequency is then stepped by the RBw and the procedure repeated. This method provides a continuous measurement of the spectrum. The procedure above continues until the analyser has stepped across the entire measurement range. When carrying out a full SE run of 2 – 26 GHz, the system will generate over 240 thousand data points.

This test was also used to measure the operating frequency of the device at both S and X Band.

The details of the test equipment used are provided in table 1 below. All measurement equipment is calibrated when appropriate in accordance with the QinetiQ Funtington procedures.

Equipment Description	Manufacturer	Model Number	Serial Number
MMS Spectrum Analyser. Display Unit	Hewlett Packard	HP 70004A	3746A05772
MMS Spectrum Analyser IF Section (RBw 10Hz - 300kHz)	“	HP 70902A	3530A05386
MMS Spectrum Analyser IF Section (RBw 100kHz - 3MHz)	“	HP 70903A	3533A03511
MMS Spectrum Analyser Wide Band IF Section (RBw 10 - 100MHz)	“	HP 70911A	3446A00534
MMS Spectrum Analyser Local Oscillator	“	HP 70900B	3647A03148
MMS Spectrum Analyser Precision Frequency Reference	“	HP 70310A	3732A03583
MMS Spectrum Analyser RF Section (100Hz - 26.5GHz)	“	HP 70910A	3822A00628
MMS Spectrum Analyser Mainframe	“	HP 70001A	3801A08870
Synthesised Sweep Generator (10MHz – 26.5GHz)	Wiltron	68159B	981009
90 dB Programmable Step Attenuator	Agilent Technologies	84906K	US42140218
11 dB Programmable Step Attenuator	“	84904K	US42140310
YIG Band Pass Filter	Omniyig	M982D	3109
Low Noise Pre-Amplifier (100MHz - 26.5GHz)	Miteq	AFS42-00102650-42-10P-42	957590
Peak Power Analyser	Hewlett Packard	HP 8991A	3248A00128
Peak Power Sensor	Hewlett Packard	HP 84812A	3130A00283
PC Control Card	National Instruments	PCI-6221	
0.9m Parabolic Reflector	Rhode & Schwartz	AC008	340 158 / 003
Feed (850 MHz - 18 GHz)	“	HL 050	100063
Synthesised Source (10MHz – 20GHz)	Hewlett Packard	HP 8341B	2819A01657
Synthesised Source (10MHz – 20GHz)	“	HP 8341B	2928A03182
½ Watt Amplifier (2 – 20GHz)	“	HP 8349	2513A00210
2 Watt Amplifier (2 – 8GHz)	Aventek	APT – 8266	P5921 9007
Pin Diode Switch (2 – 18GHz)	General Microwave	F192A	9747179
Power combiner (2 – 18GHz)	Macom	20896208	96341
Power meter	Hewlett Packard	437B	3125U14421
Power meter probe	Hewlett Packard	8487A	2742A00306
Standard gain horns	QinetiQ	MGS003-005	
Standard gain horns	Narda	638 & 645	

Table 1 Measurement equipment

4 Measurement results

The measured results and respective specification level is given below in table 2; a full set of measured data is included in Annex A for reference.

	Specification level – S Band	**S Band Result**	**Specification level – X band**	**X Band Result**
Stated Performance Level (SPL) Measurement ISO8729-2 7.3.2	SPL $>0.5m^2$ over $\pm 20^\circ$ elevation	$5.3m^2$ over $\pm 20^\circ$ elevation	SPL $>7.5m^2$ over $\pm 20^\circ$ elevation	$19.35m^2$ over $\pm 20^\circ$ elevation
Time Delay ISO8729-2 7.3.3	<10ns	6ns	<10ns	5.5ns
Stability ISO8729-2 7.3.4	Stable	Stable	Stable	Stable
Induced Instability ISO8729-2 7.3.5	Stable	Stable	Stable	Stable
Power Emission ISO8729-2 7.3.6	SPL $>0.5m^2$ at 0° elevation	$7.66m^2$ at 0° elevation	SPL $>7.5m^2$ at 0° elevation	$29.25m^2$ at 0° elevation
Pulse Length ISO8729-2 7.3.9	500ns ±50ns	499ns	500ns ±50ns	503ns
Operating Frequency ETSI EN 302752 5.3.2	3.05GHz ±1MHz	3.0500GHz	9.41GHz ±1MHz	9.4100GHz
Radiated Output Power ETSI EN 302752 5.3.3	EIRP <10W	0.977W	EIRP <10W	0.525W
Spurious Emissions ISO8729-2 7.8	<-40.2dBc	<-48dBc	<-38.9dBc	<-48dBc

Table 2 Table of results

5 Measurement Uncertainties

A summary of the measurement uncertainties for the tests included in this report are given below:-

RCS measurement	± 1 dB
Power Emission	± 1 dB
Spurious emissions	± 2.54 dB
Pulse width	± 1.5 %
Frequency of operation	± 1kHz

6 Conclusions

The ACTIVE-XS dual band RTE meets all of specifications tested against in sections 7.3.2 – 7.3.6, 7.3.9 & 7.8 of ISO8729-2 [1] and 5.3.2 & 5.3.3 of ETSI EN 302752 [2].

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7 References

[1] ISO8729-2 Marine radar reflectors Part 2 Active Type 2008.
[2] Electromagnetic compatibility and Radio spectrum Matters (ERM); Active radar target enhancers; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive, ETSI EN 302 752 V1.1.1 (2009-02)
[3] Recommendation ITU-R M.1177-3 – Techniques for Measurement of Unwanted Emissions of Radar Systems. (1995 –1997 –2000 –2003)

8 List of abbreviations

Bw_I	-	Impulse Bandwidth
dB	-	decibel
dBc	-	decibels relative to carrier
dBm	-	decibels relative to 1mW
EIRP	-	effective isotropic radiated power
ETSI	-	European Telecommunications Standards Institute
EUT	-	Equipment Under Test.
HP	-	Hewlett Packard
GHz	-	Giga Hertz
Hz	-	Hertz
ISO	-	International Organisation for Standardisation
ITU	-	International Telecommunication Union
kHz	-	kilo Hertz
LNA	-	Low Noise Amplifier
MHz	-	Mega Hertz
MMS	-	Modular Measurement System
PC	-	Personal Computer
PRF	-	Pulse Repetition Frequency
PW	-	Pulse Width
RBw	-	Resolution Bandwidth
RCS	-	Radar Cross Section
RF	-	Radio frequency
R&TTE	-	Radio and Telecommunications Terminal Equipment Directive
Rx	-	Receive
S Band	-	2.6 GHz – 3.95 GHz band (old designations)
SE	-	Spurious Emissions
SPL	-	stated performance level
Tx	-	Transmit
X band	-	8.2 GHz - 12.4 GHz band (old designation)

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A Test Results

A.1 RCS results at S Band

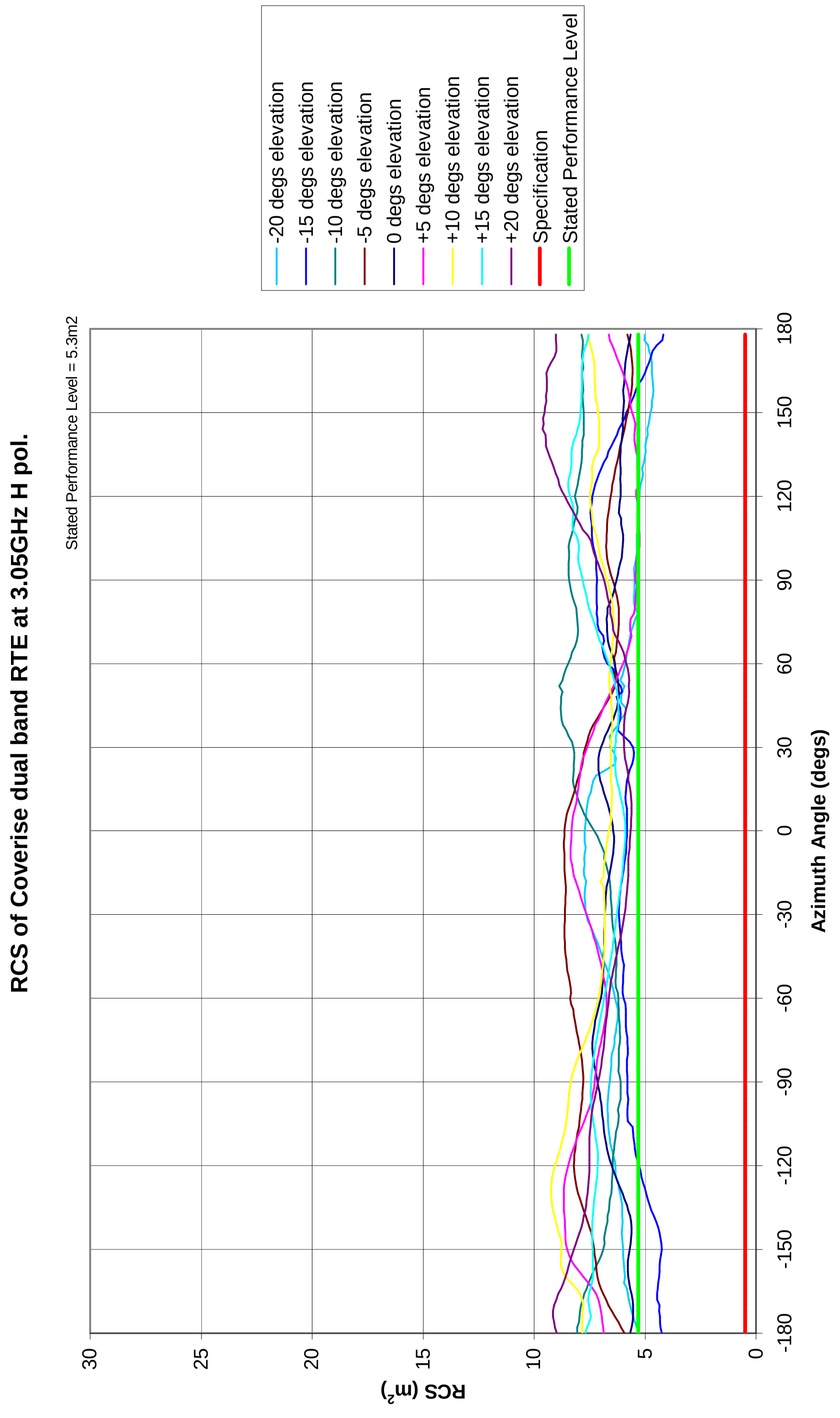

Figure 6 RCS vs azimuth angle of ACTIVE-XS dual band RTE at 3.05GHz

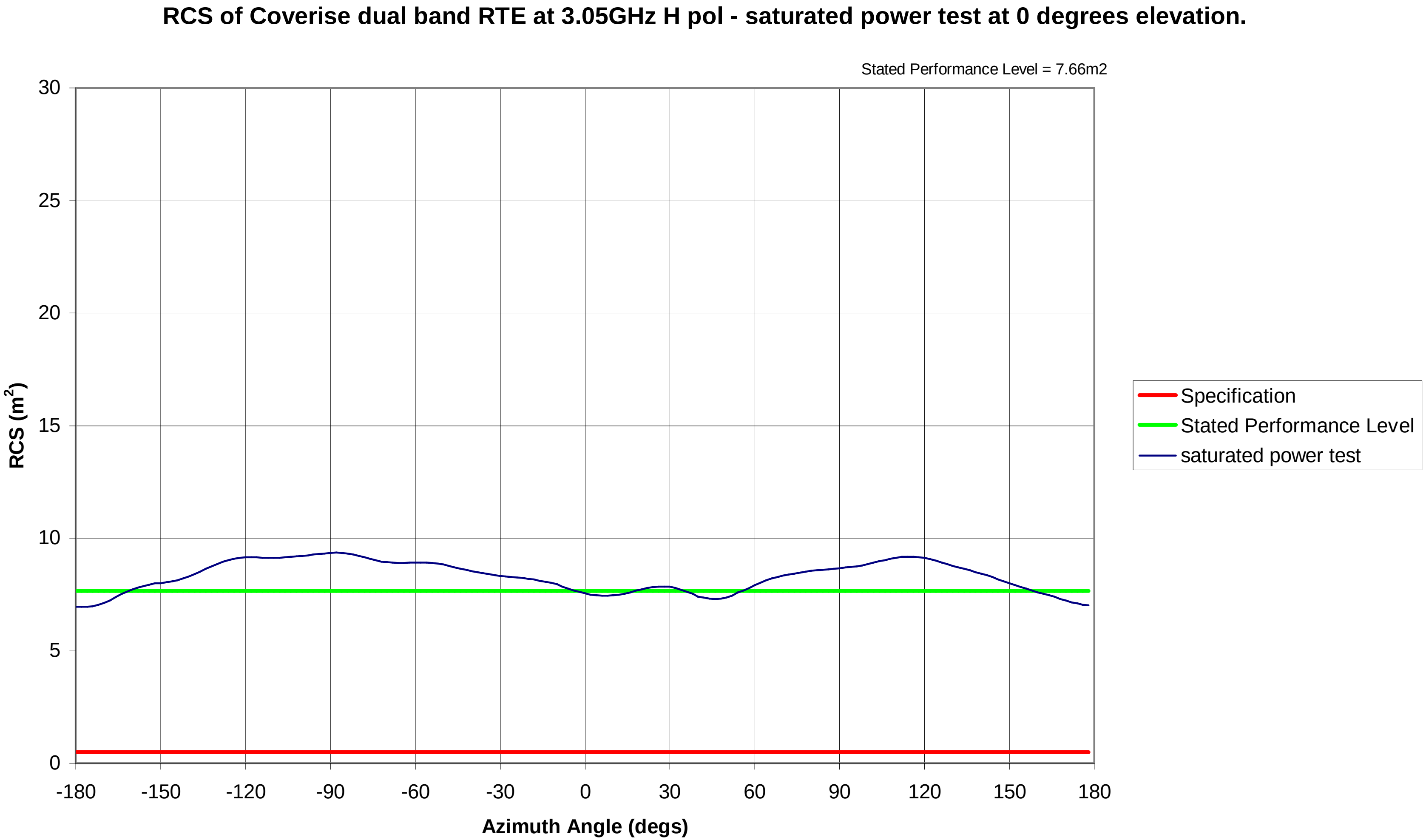

Figure 7 RCS vs azimuth angle of ACTIVE-XS dual band RTE at 3.05GHz 0° elevation – saturated power test

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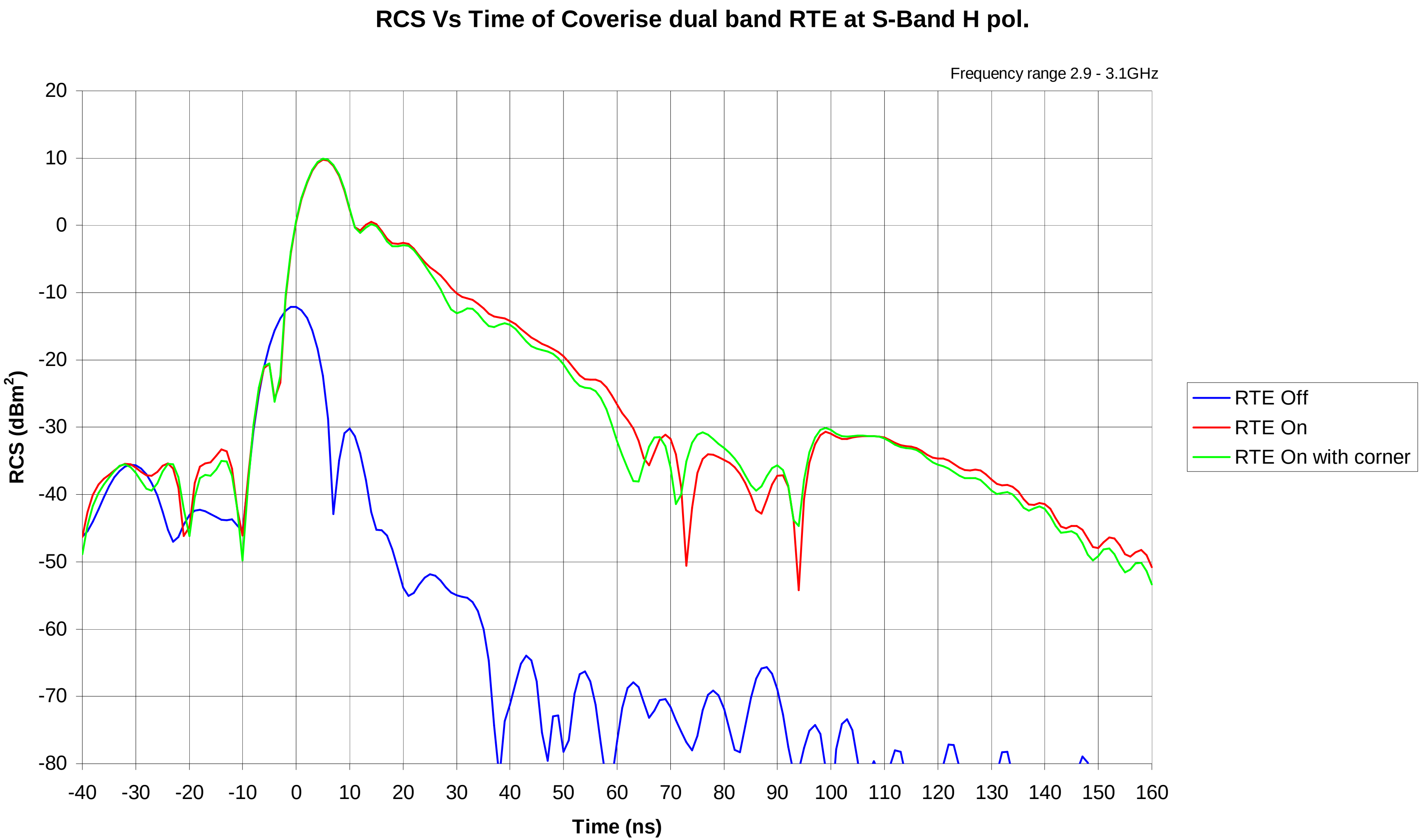

Figure 8 RCS vs time of ACTIVE-XS dual band RTE at S Band (2.9 to 3.1GHz)

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A.2 RCS results at X Band

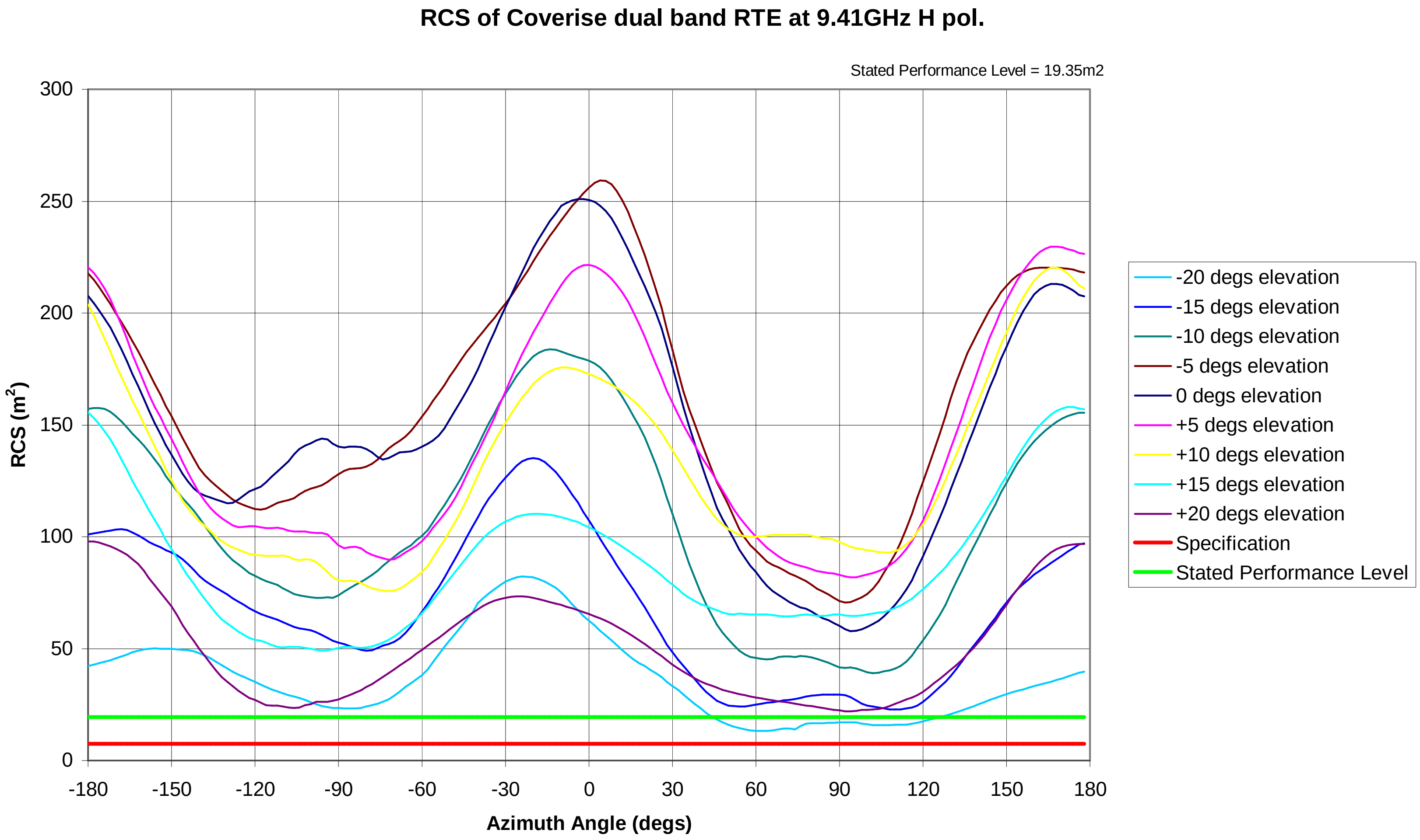

Figure 9 RCS vs azimuth angle of ACTIVE-XS dual band RTE at 9.41GHz

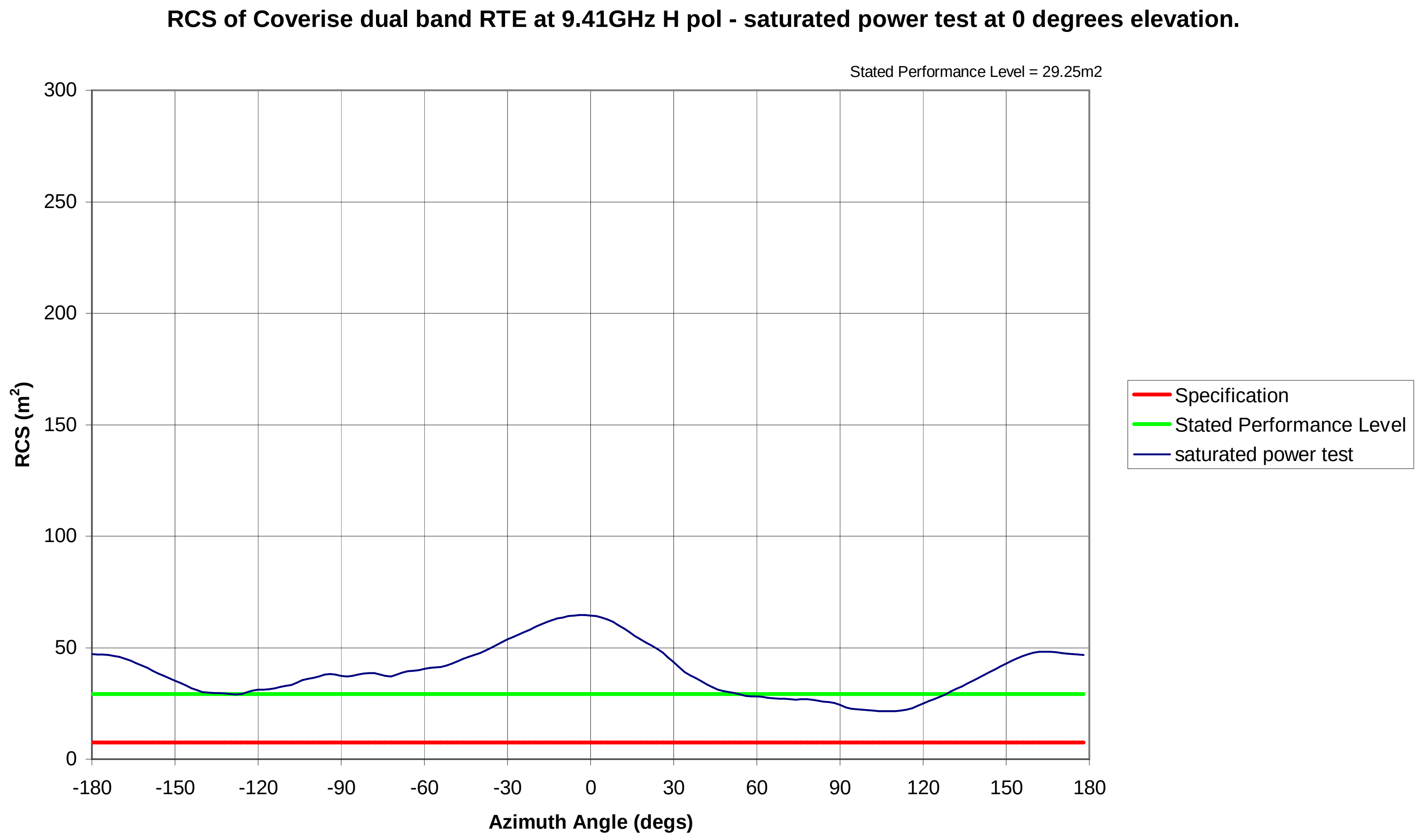

Figure 10 RCS vs azimuth angle of ACTIVE-XS dual band RTE at 9.41GHz 0° elevation – saturated power test

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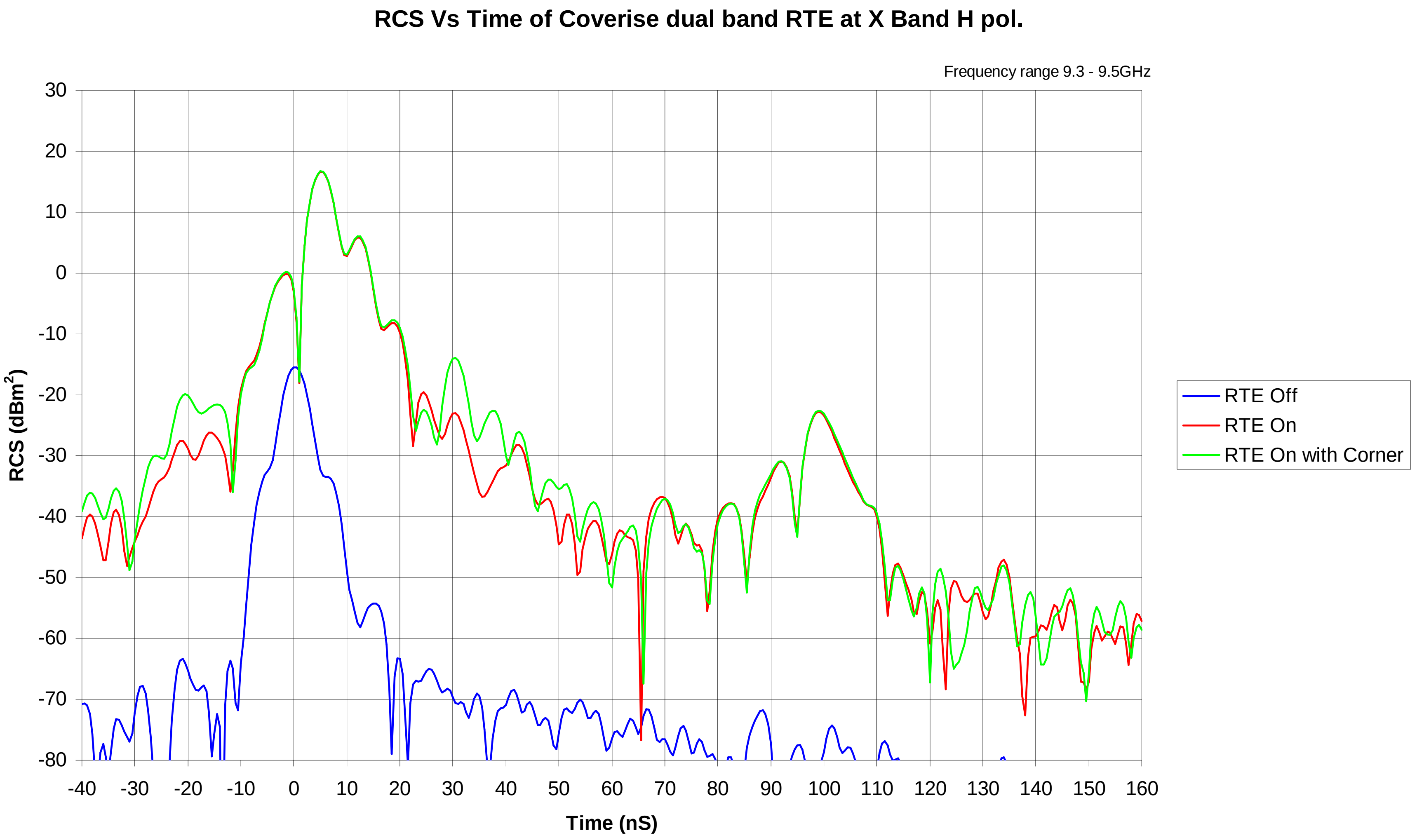

Figure 11 RCS vs time of ACTIVE-XS dual band RTE at X Band (9.3 to 9.5GHz)

A.3 Pulse width results S Band

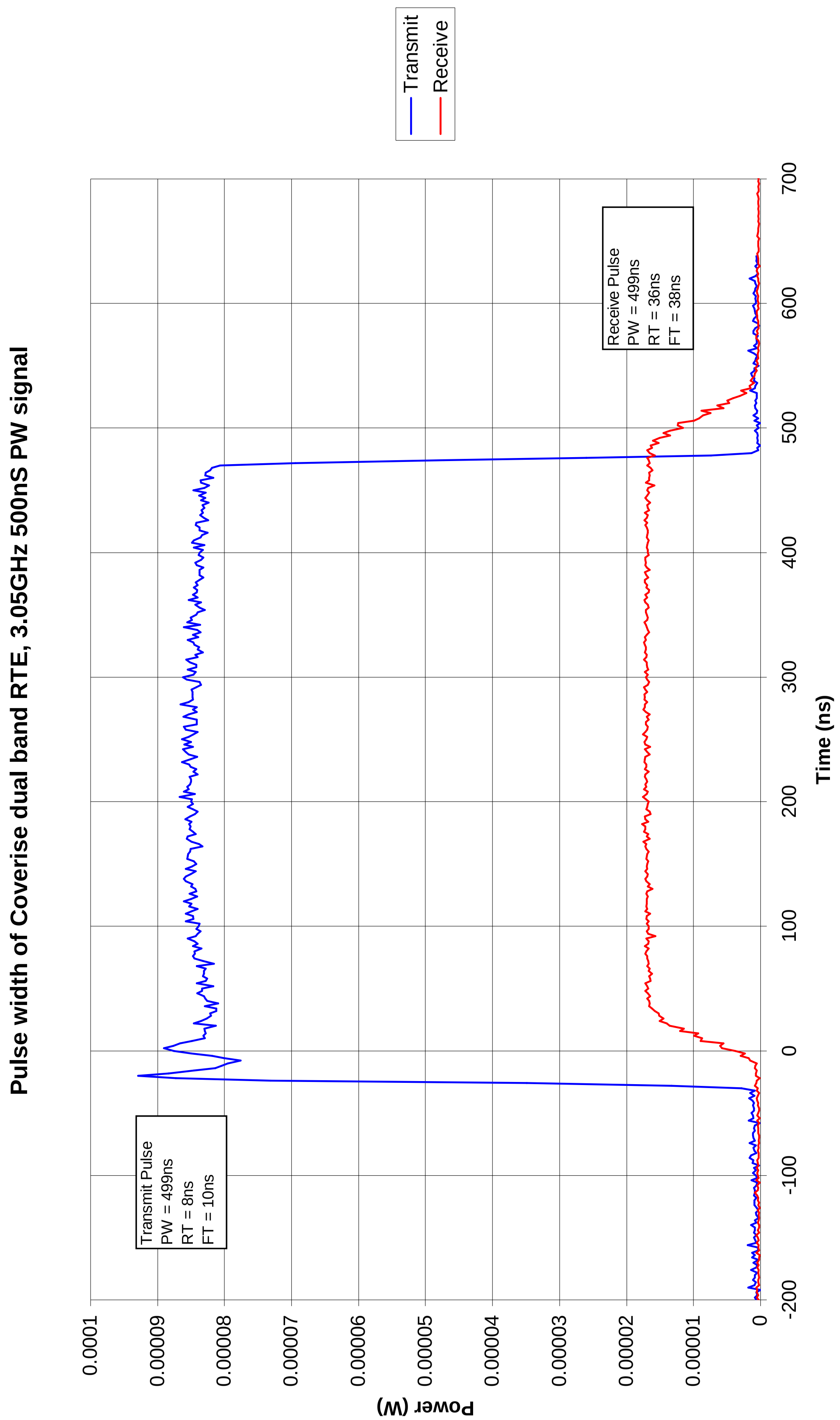

Figure 12 Pulse width measurement of ACTIVE-XS dual band RTE at S Band

A.4 Pulse width results X Band

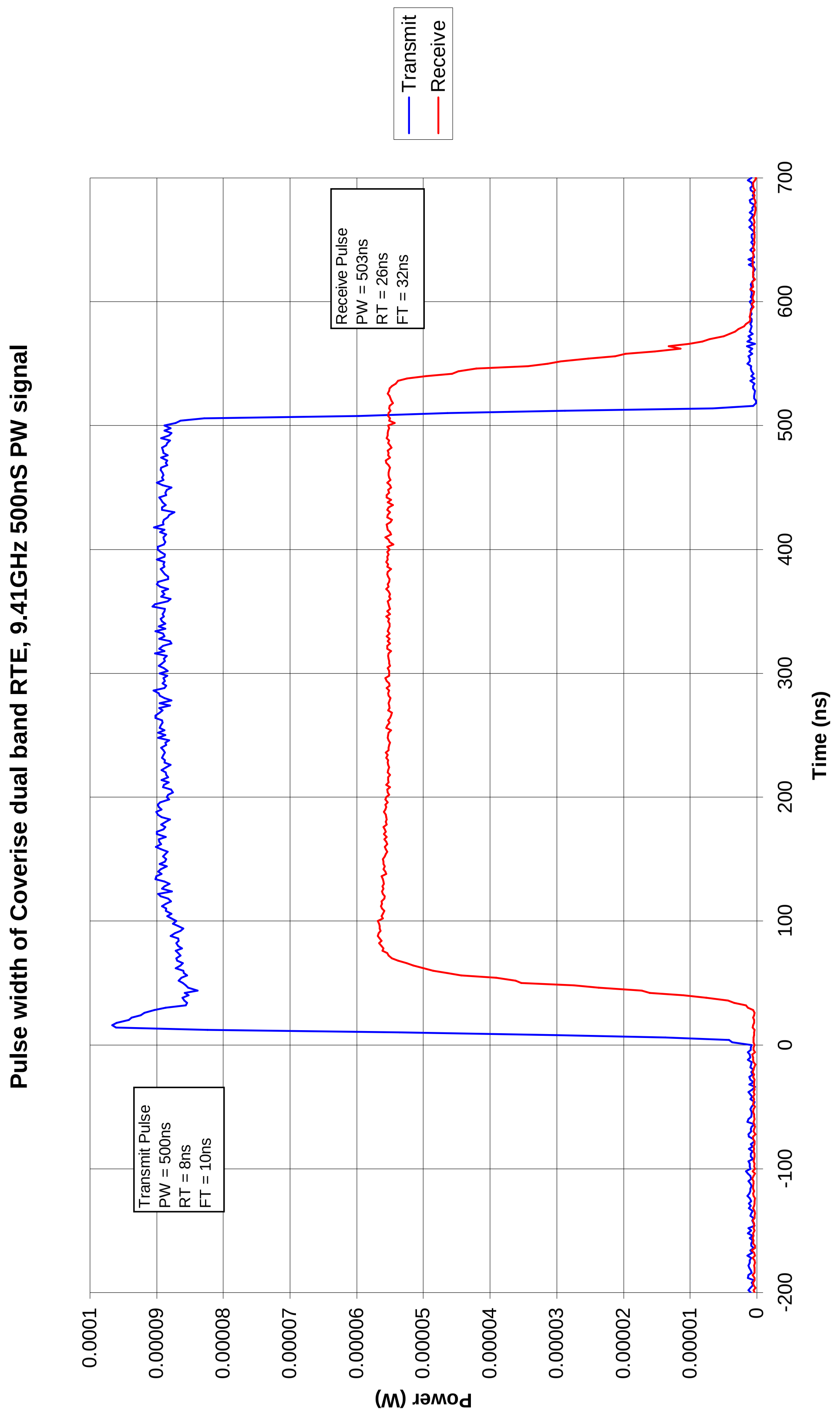

Figure 13 Pulse width measurement of ACTIVE-XS dual band RTE at X Band

A.5 Spurious emissions and frequency of operation results S Band

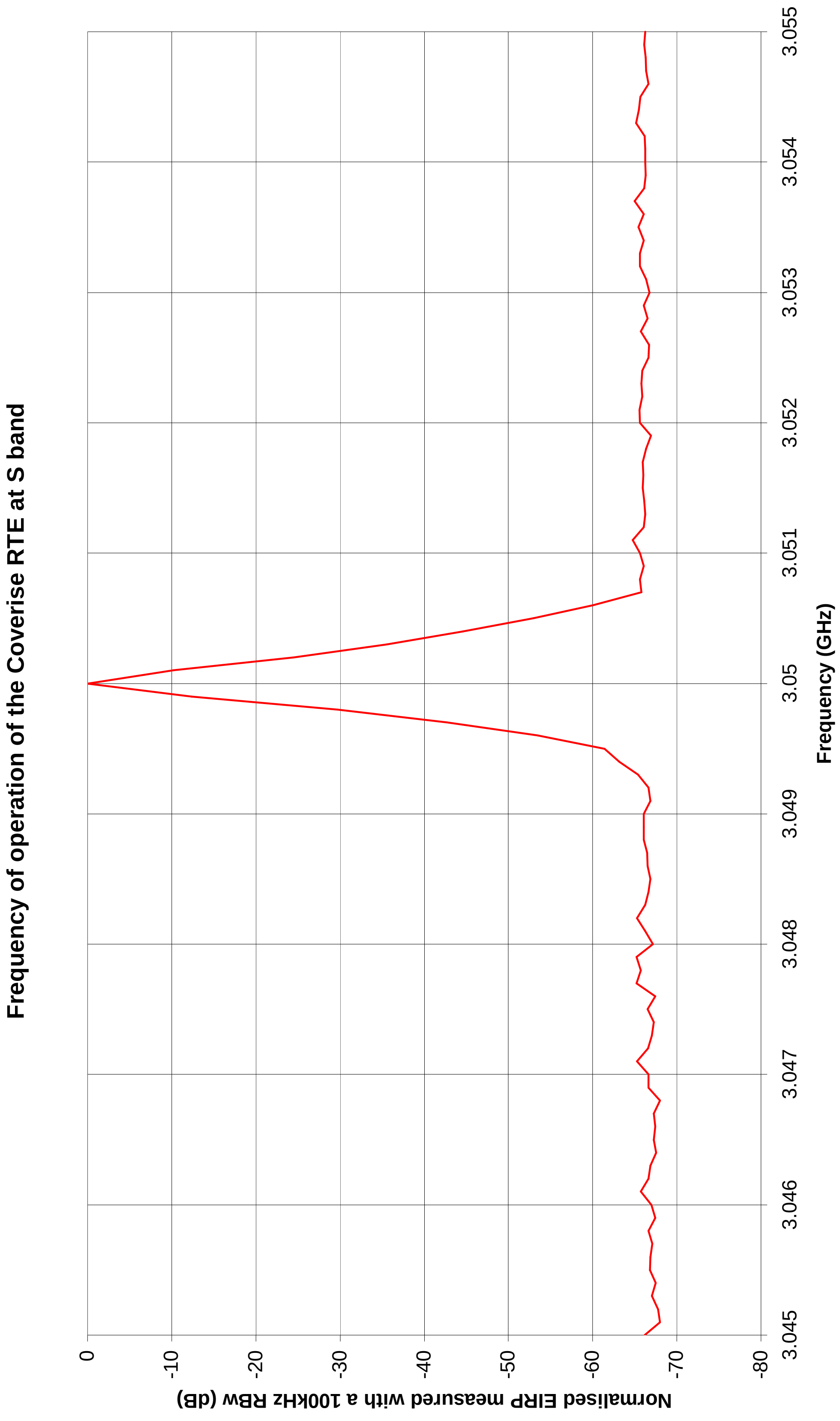

Figure 14 Frequency of operation plot of ACTIVE-XS dual band RTE at S Band

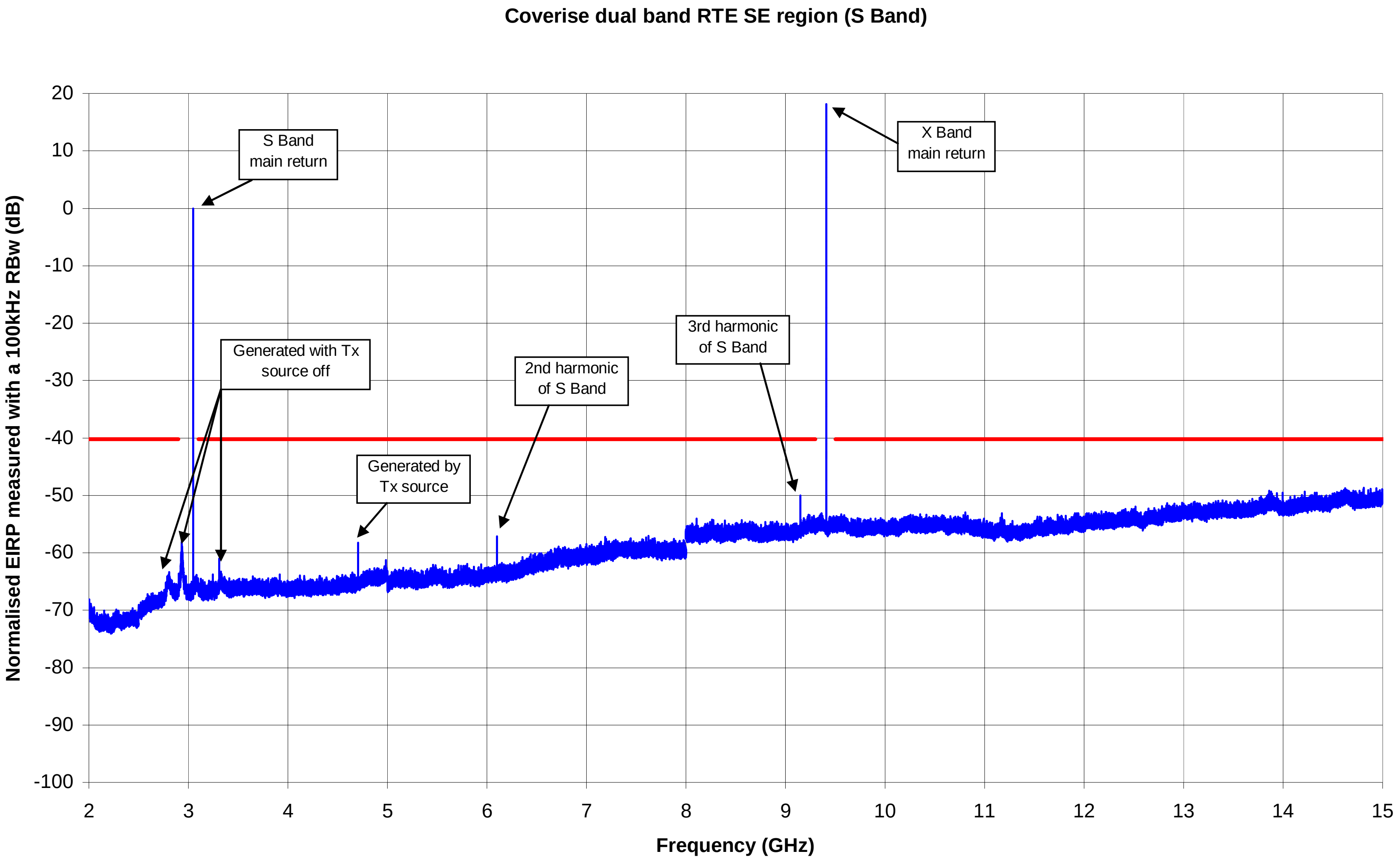

Figure 15 Spurious emissions measurement of ACTIVE-XS dual band RTE at S Band

A.6 Spurious emissions and frequency of operation results X Band

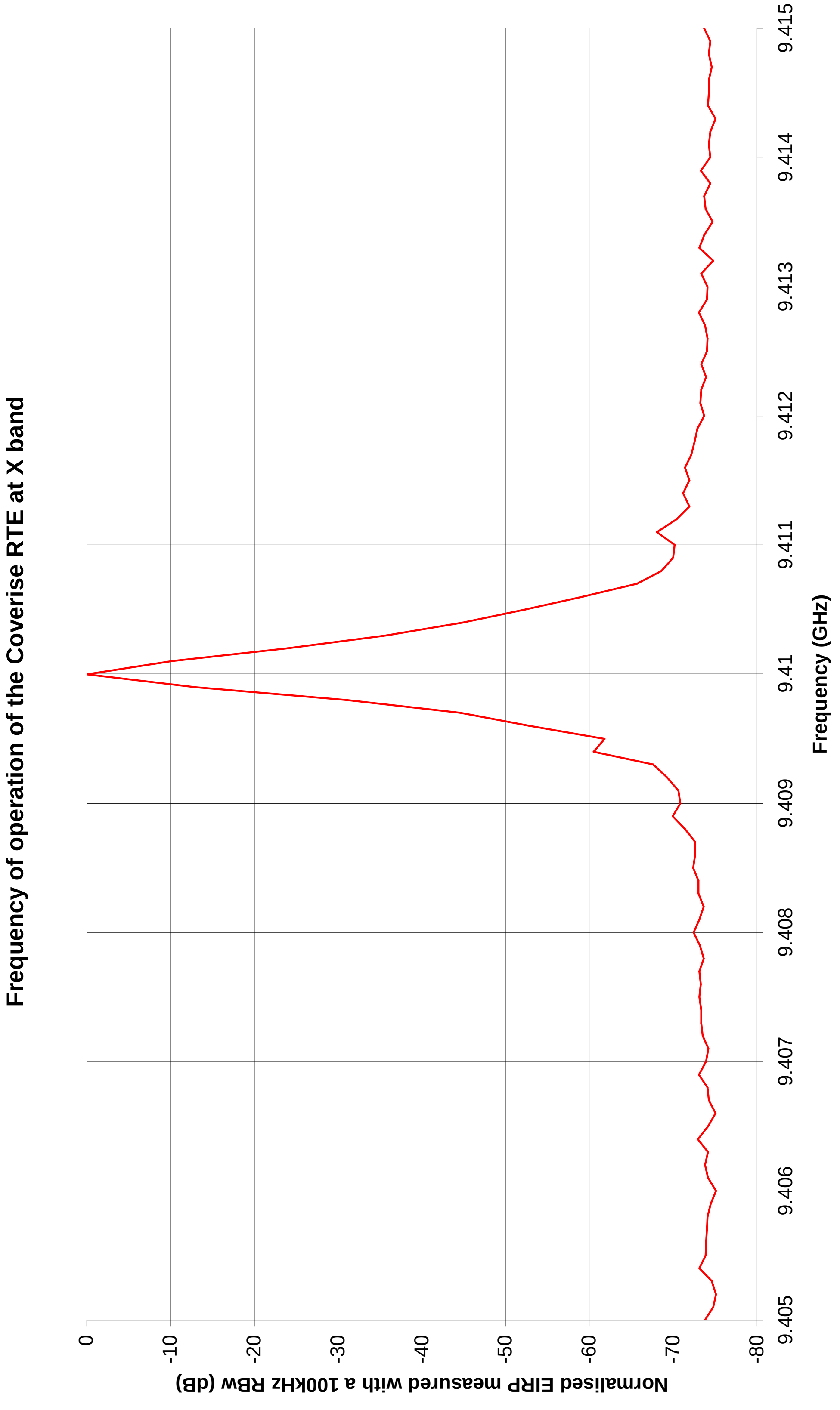

Figure 16 Frequency of operation plot of ACTIVE-XS dual band RTE at X Band

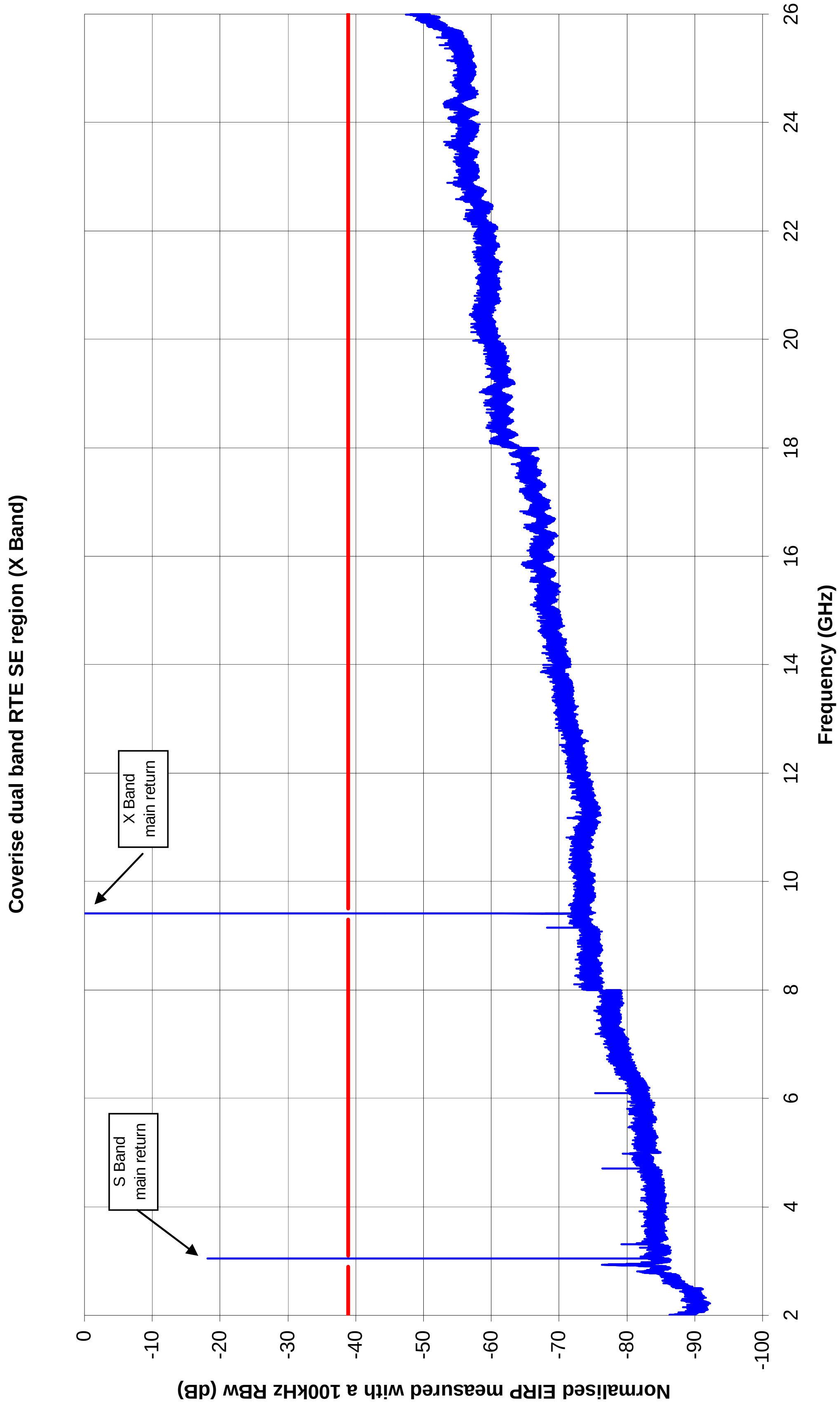

Figure 17 Spurious emissions measurement of ACTIVE-XS dual band RTE at X Band

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Abstract

A measurement programme was undertaken by QinetiQ Funtington to assess the radar cross section (RCS) and the spurious emissions from a dual band Coverise radar target enhancer (RTE); this RTE is to be marketed as the Echomax ACTIVE-XS dual band RTE.

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