Test Report to

CFR47 Part 80
ISO8729-2:2009

Echomax Active-X
Radar Target Enhancer

27th November 2009

1. Introduction

This test report covers the requirements for an active radar target enhancer as required to be carried on vessels below 150 gross tons by SOLAS chapter V, Regulation 19.2.1.7[1].

The unit is compliant with ITU-R M.1176 and has been tested in the X-Band to the specifications listed in the current edition of ISO8729-2:2009. Comments on the relative performance are detailed in the results below.

The equipment was tested at the radar test range of QinetiQ Ltd., (Funtington). Supplementary testing was carried out in the facility of Coverise Limited.

Testing was carried out by Coverise Ltd on behalf of the Active-X manufacturer:-

Aquamate Products Ltd, Champers Farm, Bardfield End Green, Thaxted, Dunmow, Essex CM6 3PX

Testing was carried out between 1st June and 27th July 2009.

1.1. Product Description

The equipment under test (EUT) comprised of the Active-X Radar Target Enhancer (RTE) and its associated terminal connection box. The Active-X consists of a receiving antenna, amplifier and transmitting antenna. The Active-X RTE is designed to enhance the determination of position of small targets by shipborne X-band radars used in the band 9300 – 9500MHz. The use of such devices for radio-determination[2] in this band is allowed under CFR47 part 80.375(d).

The intended operating voltage for the EUT is 10.8V to 15.6V DC. In all

[1] SOLAS chapter V states that a ship shall have 'if less than 150 gross tonnage and if practicable, a radar reflector, or other means, to enable detection by ships navigating by radar…' (regulation 19.2.1.7)

[2] Radio-determination is defined in Federal Standard 1037C as 'The determination of the position, velocity and/or other characteristics of an object,…, by means of propagation properties of radio waves.'

tests the RTE power supply was provided by a 12V DC Laboratory power supply.

Note: in order to stimulate the RTE during CW testing the unit was switched out of standby and into a permanently on mode. This is achieved by reversing the power supplied to the unit positive to negative and negative to positive connections.

1.2. Test Locations

Testing was carried out at the following sites

QinetiQ, Common Road, Funtington, Chichester, PO18 9PD

Tel: +44 (0) 2392 335000

and

Coverise Ltd, Unit 4 Ocivan way, Margate, Kent CT9 4NN

Tel: +44 (0)1843 282930

Note: this test report is based on report number OPP001 submitted to Qinetiq

Report prepared by: .... Date: 27/7/09

Report checked by: .... Date: 27/7/09

2. Test Summary

Clause	Test Description	Result
7.3.2	SPL Measurement	PASS
7.3.3	Time Delay test	PASS
7.3.4	Stability test	PASS
7.3.5	Induced Stability test	PASS
7.3.6	Power Emissions test	PASS
7.3.7	Saturation Power test	PASS
7.3.8	Tolerance to radar in close proximity check	PASS
7.3.9	Pulse length check	PASS
7.6	Electromagnetic Emissions test See EMC report EMC001	PASS
7.7	Electromagnetic immunity tests See EMC report EMC001	PASS
7.8	Spurious Emissions Tests	PASS

Table 1: ISO8729-2 Test Summary

2.1. Test Result

The supplied test sample of the Echomax Active-X Radar Target Enhancer successfully passed the series of tests outlined above. This demonstrates the operational performance of the Active-X Radar Target Enhancer.

2.2. Test Acknowledgment

Testing in the anechoic chamber at QinetiQ Ltd (Funtington) was carried out by Steve Luke of Qinetiq in the presence of Simon Nolan from Coverise.

3. Test Equipment Used

QinetiQ Funtington Calibrated RCS Anechoic Measurement Chamber and associated test equipment.

No.	Test Equipment	Manufacturer	Model No.	Serial No.
NAV1307	Anechoic Chamber	MPE	-	SN: C1162-D1
NAV2043	Spectrum Analyser	Rohde & Schwarz	FSP	SN: 100404
NAV2045	Horn Antenna	Rohde & Schwarz	HF906	SN: 100287
C002	N-Type Cable 10m	Teledyne	-	-
C012	N-Type Cable 3m	Teledyne	-	-
	6200 Scalar Analyser	Marconi	6200	SN
	20dB Attenuator (26GHz)	Hewlett Packard	8493C-20	n/a

Table 2: Pulse length, Power Emissions, Amplifier Gain, Test Equipment

	Excitation Signal Generation / EUT monitoring – All Tests			
No.	**Test Equipment**	**Manufacturer**	**Model No.**	**Serial No.**
	Pulse Generator	Lyons Instruments	PG-2E	SN: 5176
NAV2043	Spectrum Analyser	Rohde & Schwarz	FSP	SN: 100404
-	9.4 GHz Signal Source	Coverise Ltd	-	-
-	6dB Attenuator	HP	8473B	SN: 04917
	Microwave Switch	HP	33144A	SN: 04284
	Switch Driver	HP	33190B	SN: 02187
-	Waveguide to Coax Transition	FMI	-	-
-	Waveguide to Coax Transition	FMI	-	-
	PSU	WEIR	460	SN: 731012
	PSU	Navico	PSU1208	SN: KF0540
	Horn Antenna X-Band	Plessey	3102	SN: 0001
	Horn Antenna X-Band	Plessey	3102	SN: 0002

Table 3: General Equipment Used for Excitation Signal and Monitoring EUT

4. Operation Test Results

Operation test are in accordance with Section 7 – ISO8729-2.

4.1. Stated Performance Level (SPL)

4.1.1. Test Method

Testing was carried out in the Funtington calibrated chamber in accordance with ISO8729-2 Clause 7.3.2.

The EUT was set-up inside the anechoic chamber and connected to a power supply. The RCS (Radar Cross Section) of the EUT was measured at 2º intervals over a full 360º range at 0, +10º and +20º of heel. The EUT was mounted at the same height as the calibration sphere. Corrections were made to the results for the effects of distance offsets at +10º and +20º degrees of heel.

The test layout is shown in Figure 1, page17.

4.1.2. Equipment Used

Refer to section 3.1.

4.1.3. Results

Plot 1**, page 21, s**hows the measurement scans over both azimuth and elevation at the test frequency. The SPL is in excess of the minimum specified in ISO8729-2 (7.5m^2) at both 10º and 20º of heel.

The EUT had an SPL of 94.3m^2 at 10º of heel and 14.8m^2 at 20º of heel.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.3, SPL for X-Band only.

4.2. Time Delay Test

4.2.1. Test Method

Testing was carried out in the Funtington calibrated chamber in accordance with ISO8729-2 Clause 7.3.3.

The EUT was set-up inside the anechoic chamber at 0º of heel and connected to a power supply. The time delay was measured by carrying out a Fourier transform on the Frequency response to give a plot of RCS against time.

The test layout is shown in Figure 1, page 17.

4.2.2. Equipment Used

Refer to section 3.1.

4.2.3. Results

Plot 2 and Plot 3, pages 21 and 22 show the measurement scans with the EUT switched on and off. The delay is within the maximum limit of 10nS.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.3, Time Delay for X-Band only.

4.3. Stability Test

4.3.1. Test Method

Testing was carried out in the Funtington calibrated chamber in accordance with ISO8729-2 Clause 7.3.4.

The EUT was set-up inside the anechoic chamber at 0º of heel and connected to a power supply. The time delay was measured by carrying out a Fourier transform on the Frequency response to give a plot of RCS against time.

The test layout is shown in Figure 1, page 17.

4.3.2. Equipment Used

Refer to section 3.1.

4.3.3. Results

Plot 3, page 22, show the measurement scan with the EUT switched on. The EUT was stable.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.4, Stability for X-Band only.

4.4. Induced Stability Test

4.4.1. Test Method

Testing was carried out in the Funtington calibrated chamber in accordance with ISO8729-2 Clause 7.3.5.

The EUT was set-up inside the anechoic chamber at 0º of heel and connected to a power supply. A 10m2 Corner reflector was placed in the chamber 3m from the EUT pointing directly at the EUT. The time delay was measured by carrying out a Fourier transform on the Frequency response to give a plot of RCS against time.

The test layout is shown in Figure 1, page 17.

4.4.2. Equipment Used

Refer to section 3.1.

4.4.3. Results

Plot 4, page 23, shows the measurement scan with the EUT switched on with the $10m^2$ reflector in place. The EUT was stable.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.5, Induced Stability for X-Band only.

4.5. Power Emission test

4.5.1. Test Method

Testing was carried out in the Funtington calibrated chamber in accordance with ISO8729-2 Clause 7.3.6.

The EUT was set-up inside the anechoic chamber at 0º of heel and connected to a power supply. The RCS was measured with the unit out of saturation at 0º of heel.

The test layout is shown in Figure 1, page 17.

4.5.2. Equipment Used

Refer to section 3.1.

4.5.3. Results

Plot 1, page 21, shows the measurement scan with the EUT switched on. The EUT SPL at 0º of heel was measured at 115.14m2.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.6, Power Emissions for X-Band only.

4.6. Saturated Power Test

4.6.1. Test Method

Testing was carried out at the Coverise R&D Facility in accordance with ISO8729-2 Clause 7.3.7.

The EUT amplifier was connected to a scalar analyser system and powered from a bench power supply. The gain and saturated amplifier output power were measured and recorded over a frequency range 9.3GHz to 9.5GHs.

The test layout is shown in Figure 2, page 18.

4.6.2. Equipment Used

Refer to section 3.1 Tables 2 and 3.

4.6.3. Results

Plot 5, page 24, shows the measurement plot of the EUT amplifier gain and saturated output power. The EUT saturated output power maximum was 26.4dBm when connected to the antenna with maximum gain of 5.8dB, this gives an EIRP of maximum 1.68W.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.7, Saturated Power for X-Band only.

4.7. Tolerance to Radar in Close Proximity

4.7.1. Test Method

With a 2KW/m2 power density (Pd) the maximum input power to the EUT will be as follows:-

Power received at input of EUT amplifier $= \dfrac{\text{Pd x Ant Gain x } \lambda 2}{4.\pi}$

= 0.62 W or 27.9dBm

Where:

Pd = 2KW/m2

Ant Gain = 5.8dB (maximum)

λ = 31.91mm

The EUT was set up without antenna to measure gain as shown in Figure 2, section 8.1, page 17.

The gain was measured and recorded. The EUT CW input power was then increased to 28.9dBm. The gain was then checked to determine any degradation or damage under the high input levels.

4.7.2. Equipment Used

Refer to section 3.1 Tables 2 and 3.

4.7.3. Results

Plot 5, pages 24, shows the measurement plot of the EUT amplifier gain and saturated output power. No degradation was noted after the application of 28.9dbm CW input power.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.8, Tolerance to radar in close proximity.

4.8. Pulse Length Check

4.8.1. Test Method

Testing was carried out at the Coverise R&D Facility in accordance with ISO8729-2 Clause 7.3.9.

The EUT was set-up inside the Coverise anechoic chamber at 0º of heel and connected to a power supply. The test pulses with the EUT powered on an off were received on a Spectrum Analyser. The length of the pulse with the EUT on and off was recorded.

The test layout is shown in Figure 3, page 19.

4.8.2. Equipment Used

Refer to section 3.1 Tables 2 and 3.

4.8.3. Results

Plot 6 and Plot 7, pages 25-26 show the measurement scan with the EUT switched on and off. The Pulse length was the same under both conditions.

The EUT complies with the requirements of ISO8729-2, Clause 7.3.9, Pulse length check.

4.9. Electromagnetic Emissions Test

As required by ISO8729-2, the EUT was tested for Electromagnetic Compatibility to EN60945:2002, clauses 9.2 and 9.3

The test results for Electromagnetic Emissions to EN60945 are covered in the separate EMC report, number EMC001.

4.9.1. Results

The EUT complies with the requirements of ISO8729-2, Clause 7.6 Electromagnetic Emission.

4.10. Immunity to Electromagnetic Environment Test Results

As required by ISO8729-2, the EUT was tested for Electromagnetic Compatibility to EN60945:2002, clauses 10.3, 10.4, 10.5 and 10.9.

The test results for Electromagnetic Immunity are detailed in EMC report EMC001.

4.10.1. Results

The EUT complies with the requirements of ISO8729-2, Clause 7.7 Electromagnetic Immunity.

4.11. Spurious Emissions Test Results

4.11.1. Test Method

The testing for spurious emissions was carried out at Coverise Ltd using a direct connection method.

4.11.2. Measurement set up Port measurement

Since the unit only has X band response and the waveguide antenna cut off frequency is calculated at 6.58GHz, measurement of spurious is only required down to 4.606GHz. This also means that the 3GHz interrogating signal is not required since it is to far below the waveguide cut off to have any effect on performance.

Note: a tracking Yig Filter is not required since the output of the RTE is only 26dBm and a normal spectrum analyser can cope with the dynamic range required.

The RTE Antenna return loss performance at the second harmonic (which is the only place a spurious output signal is likely to be seen) is shown in Plot 8, section 9.8, page 25. Mismatch loss on antenna due to VSWR at 18.6-19GHz is more than 7.6dB (measured) with the gain less than 2dB (estimated).

The performance of product output spurious to meet the required specification of Table 2 from ITU-R SM.329-10 is -43dBc on 1W. This equates to a maximum level of -13dBm EIRP radiated over the frequency range 2GHz to 26GHz, (-7.4dBm at the antenna port taking into account the mismatch and antenna gain losses at 18.6GHz to 19GHz).

The input interrogating signal power level to the RTE was increased until the output power level reached a maximum. The spurious testing was then carried out at this interrogating level.

4.11.3. Equipment Used

Refer to section 3.1 Tables 2 and 3.

4.11.4. Results

The measurement made on the RTE 50 Ohm output port is shown in Plot 9, page 28. The level is less than -15dBm (spectrum analyser noise floor). This demonstrates the RTE passes the spurious emissions test with a significant margin.

A check of the second harmonic level was made by changing the Analyser frequency range to 18-19GHz. The spurious level measured is shown in Plot 11, page 30. This was still the analyser noise floor (-30dBm).

(As a calibration check an 18.8GHz signal at -10dBm was fed into the attenuator/analyser through a cable with loss of 1.8dB and the level noted in Plot 11and Plot 12, pages 30 and 31.)

The EUT complies with the requirements of ISO8729-2, Clause 7.8 Spurious Emissions.

Annex A: Photographs

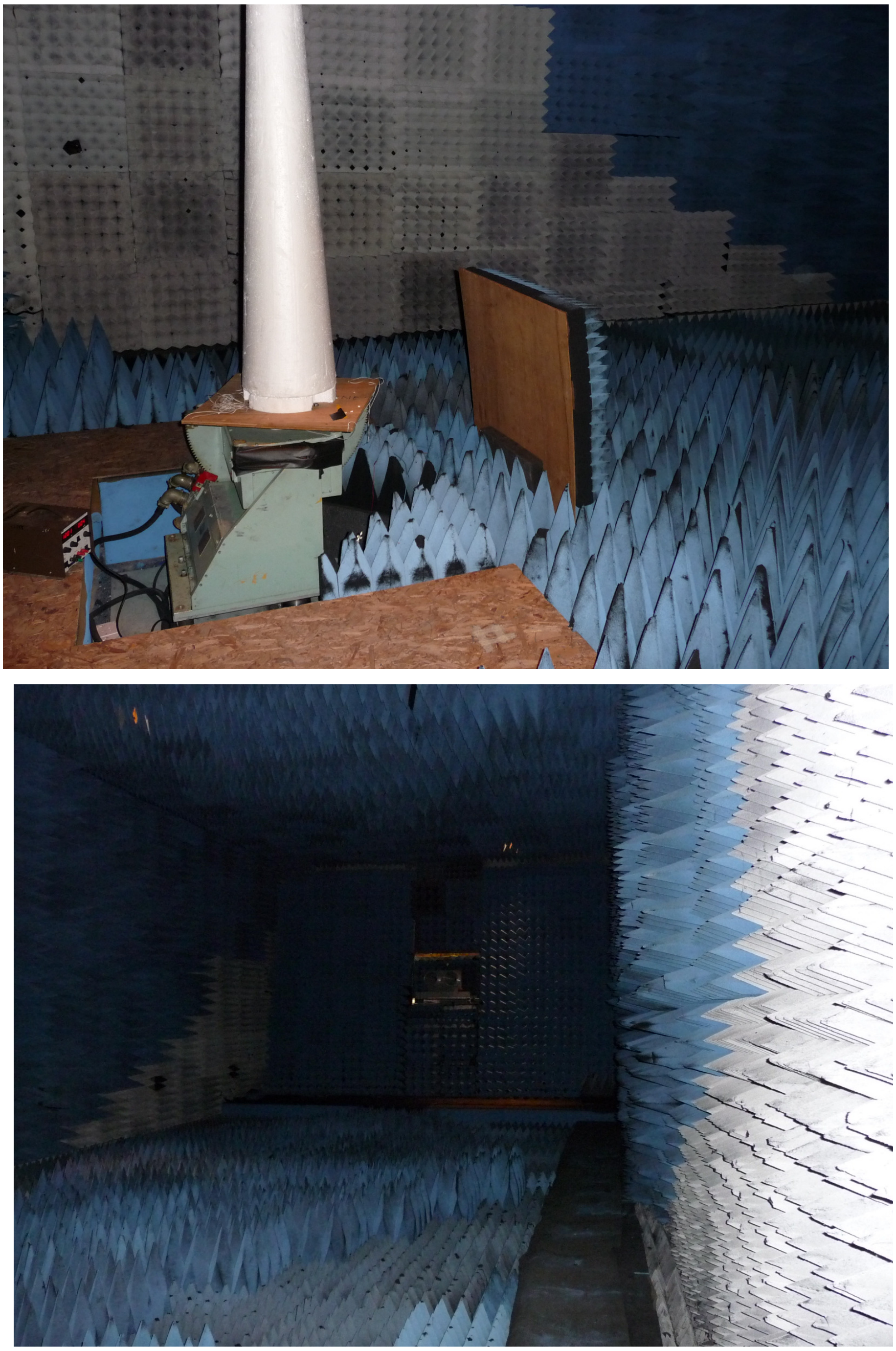


Figure 1: QinetiQ Funtington Calibrated Chamber test set up.

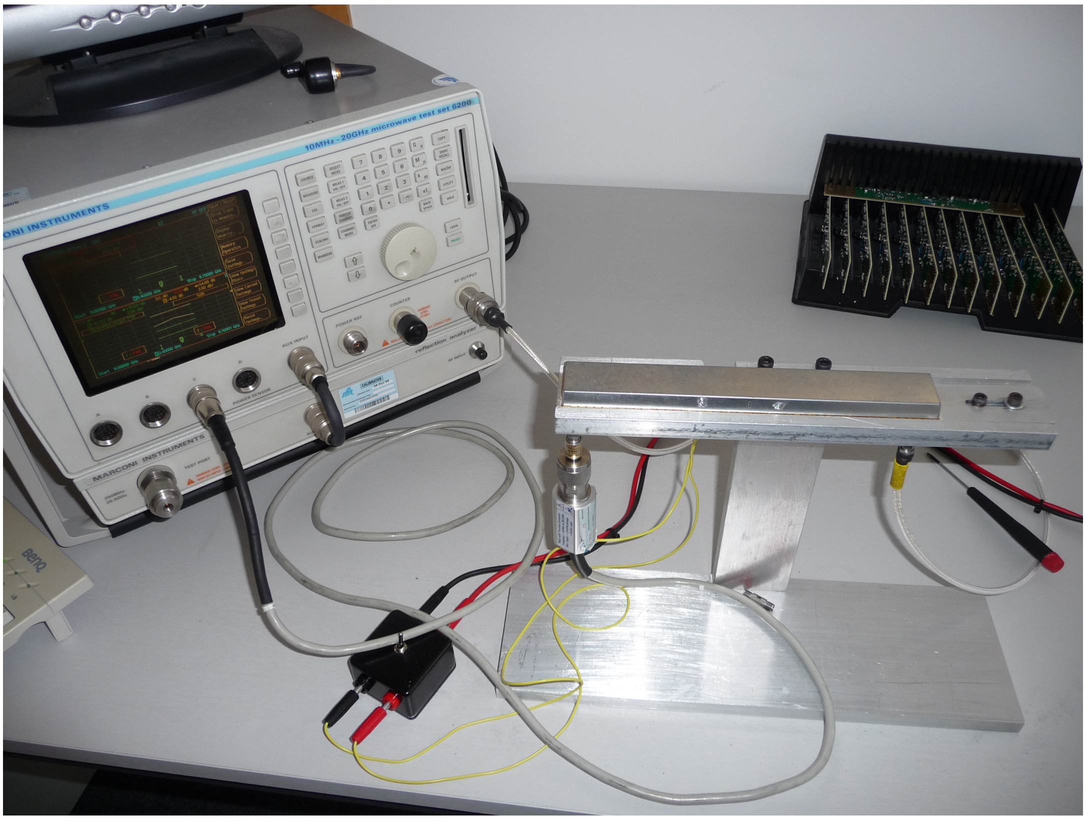


Figure 2: Gain & Saturated Power measurement system

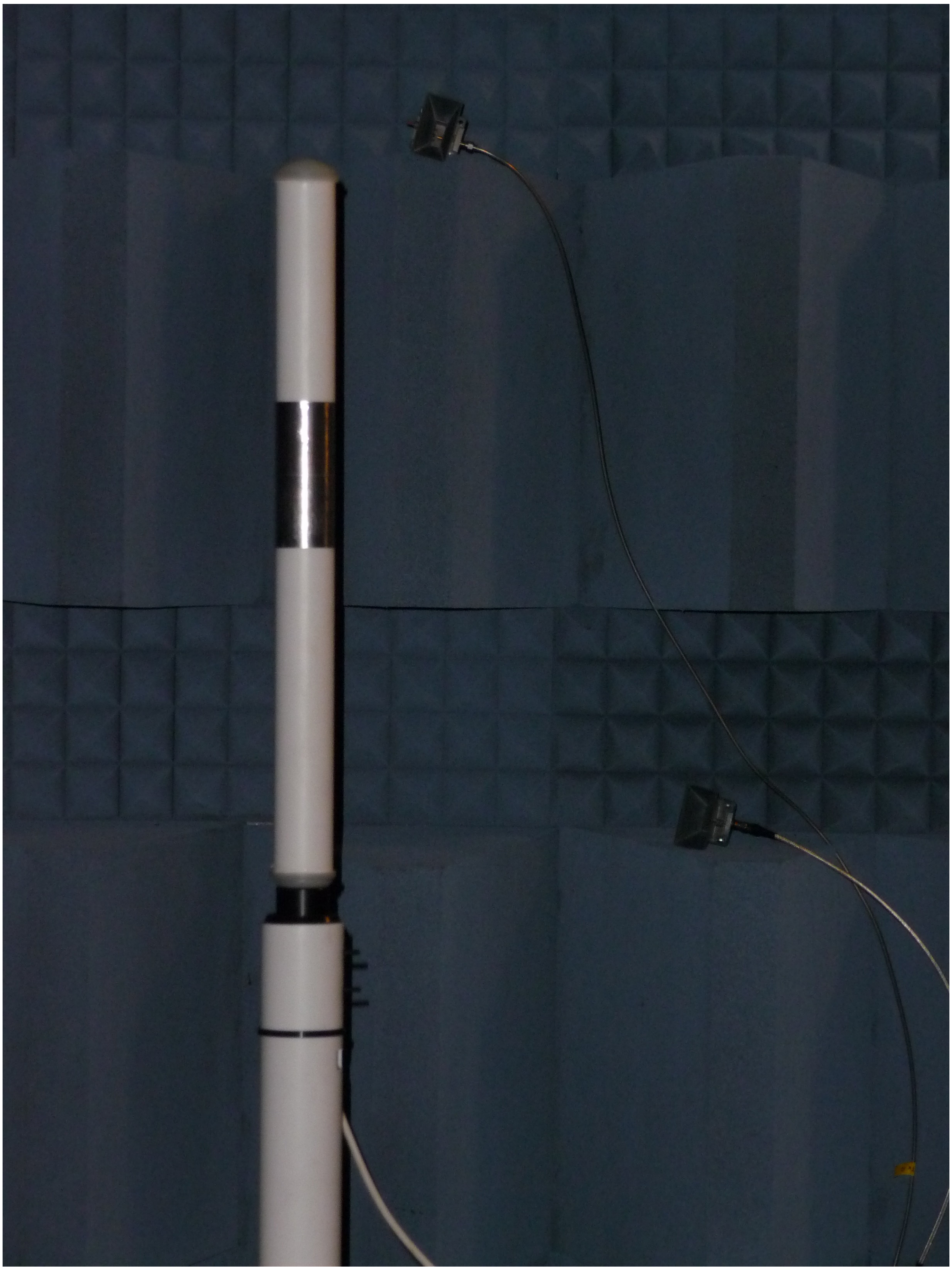


Figure 3: Pulse length test in Anechoic Chamber at Coverise Ltd.

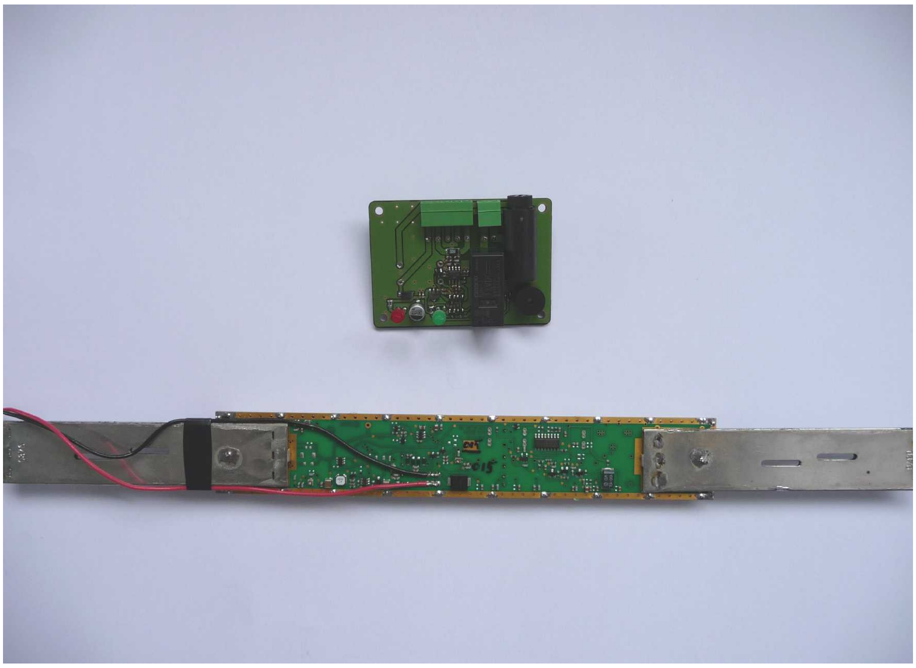
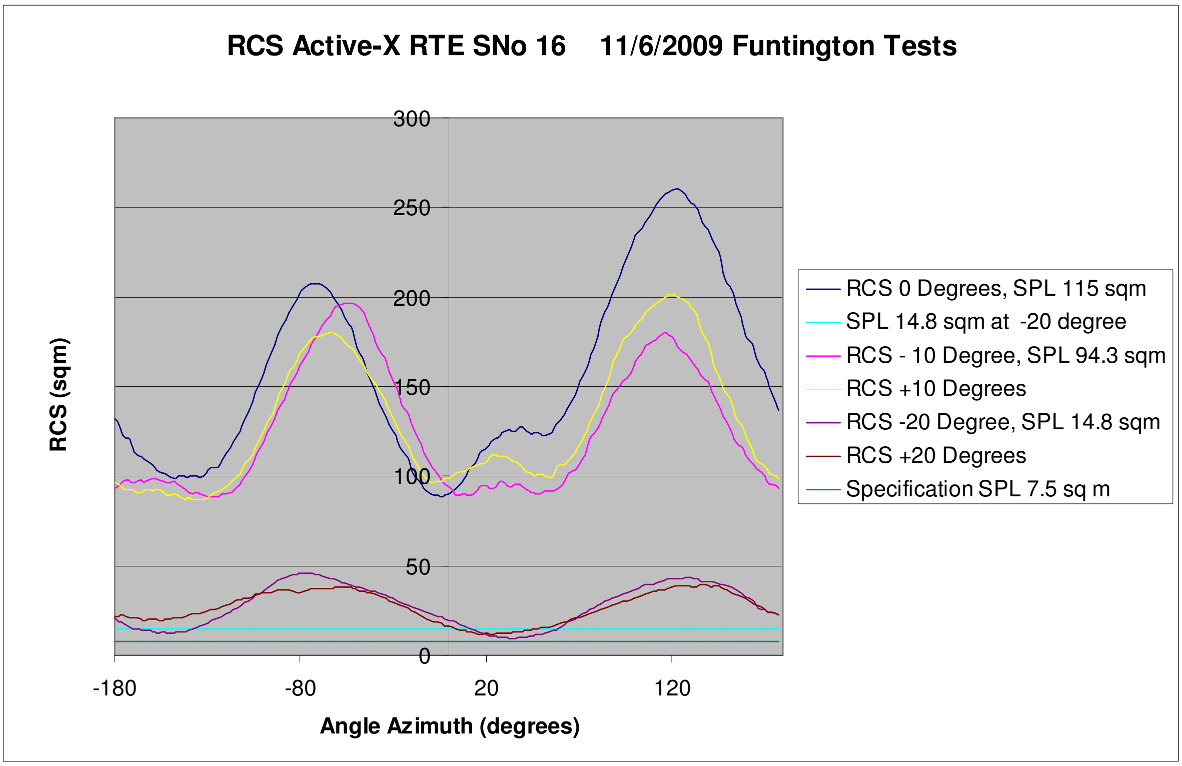
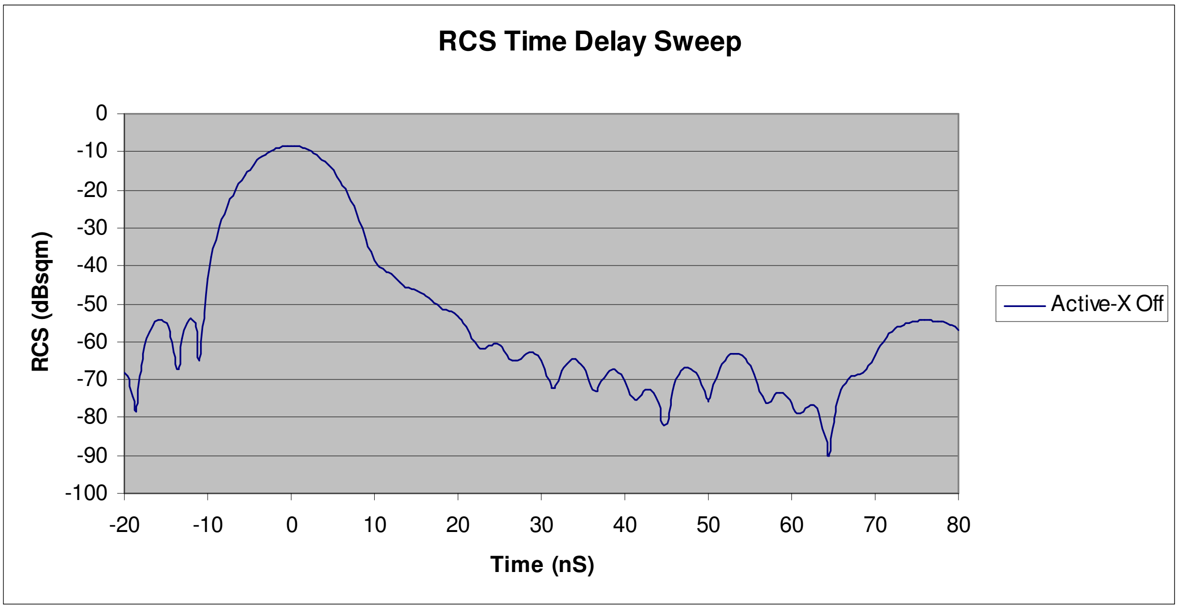


Figure 4: Internal View of EUT (with its control PCB)

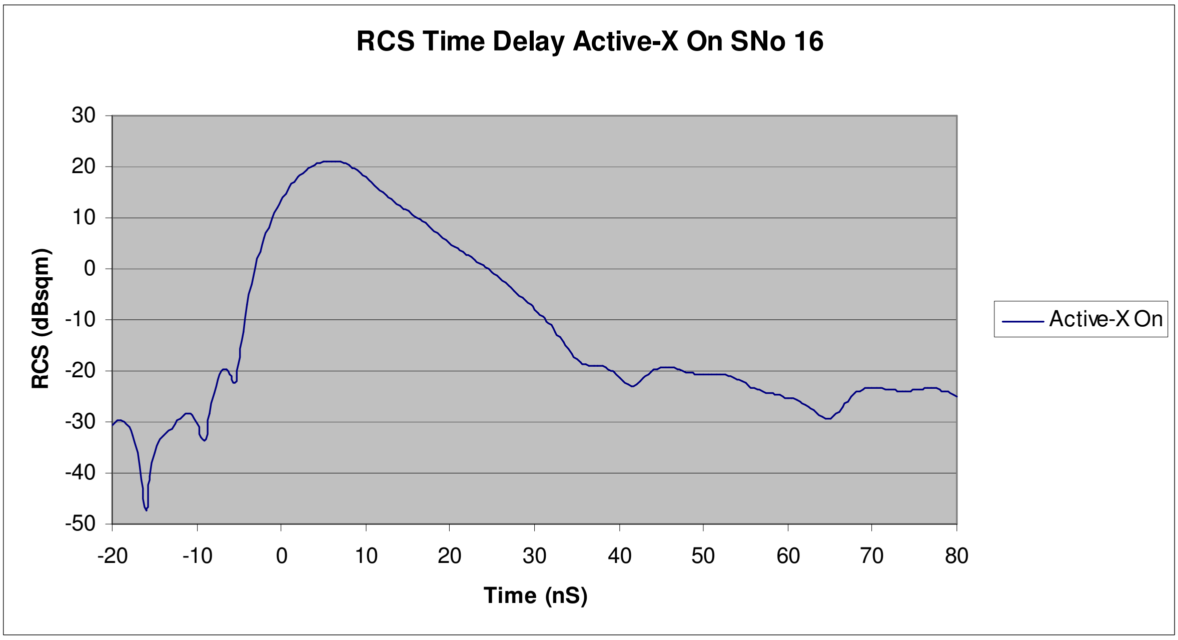
Annex B: Results of Performance Tests



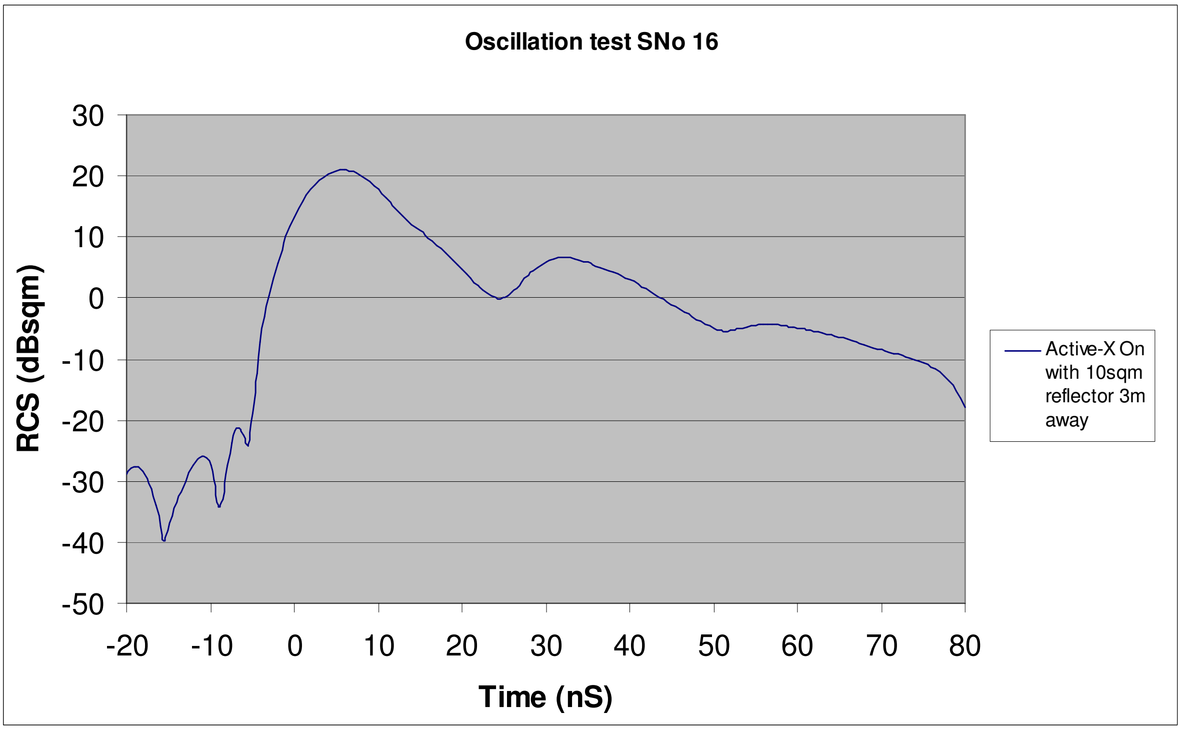
Plot 1: RCS at 0º,+10º,+20º angle of Heel



Plot 2: Time delay Active X Off



Plot 3: Time Delay Active X On



Plot 4: Time Delay Induced Stability

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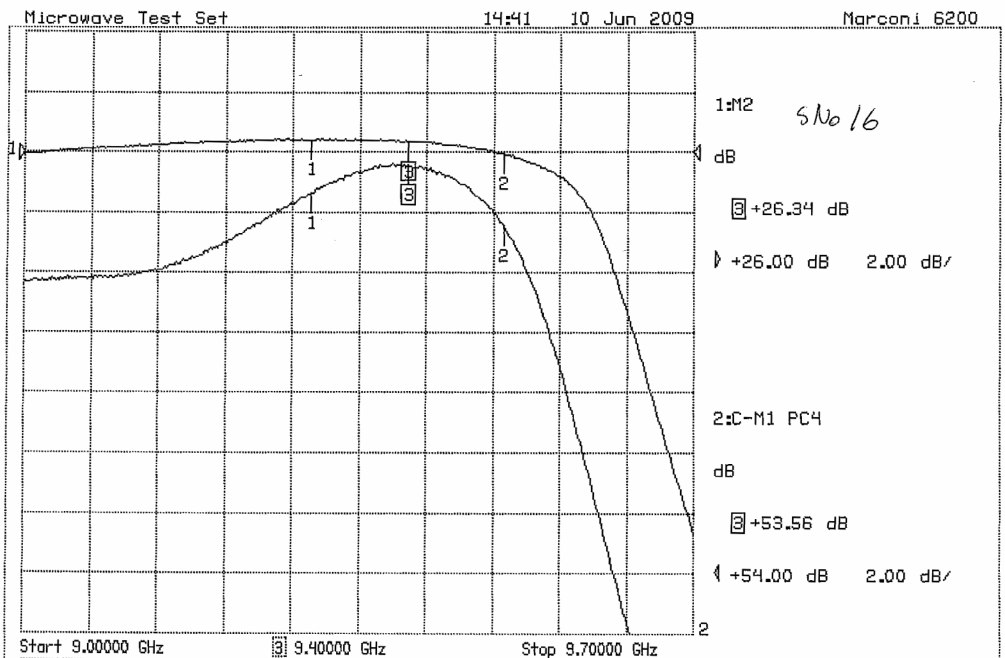
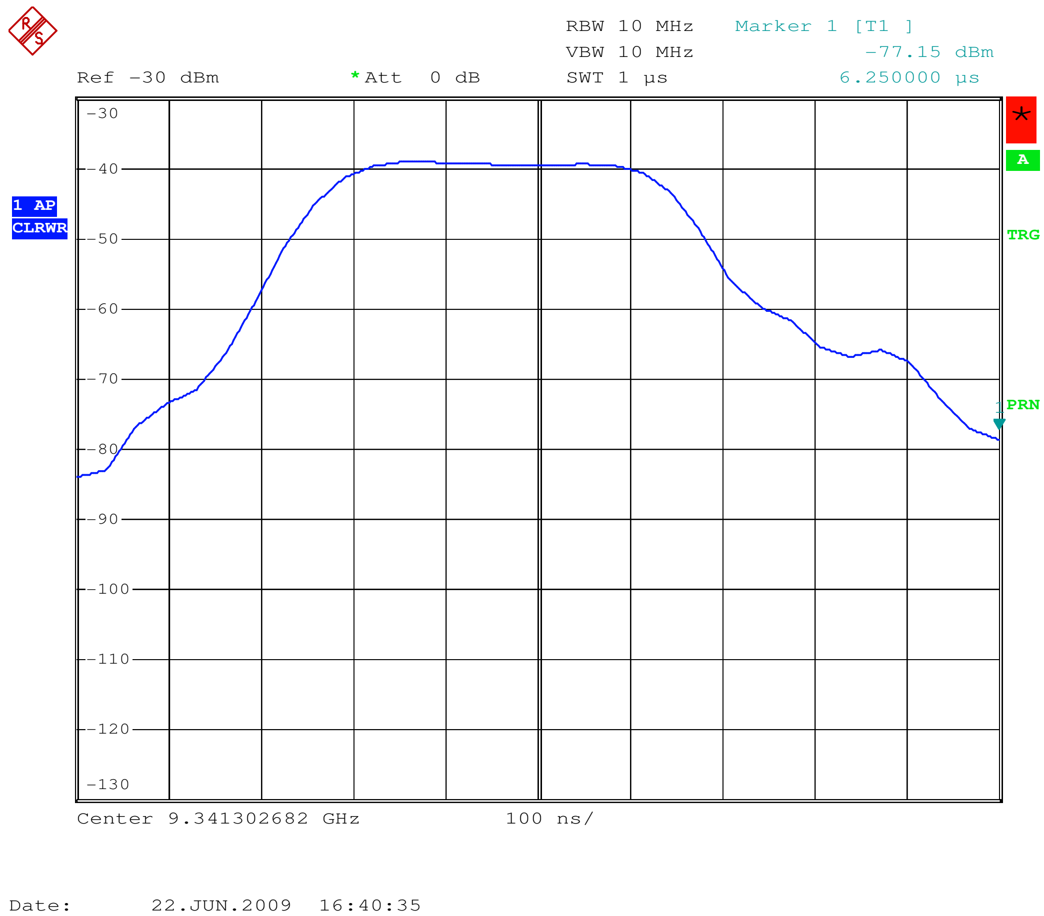


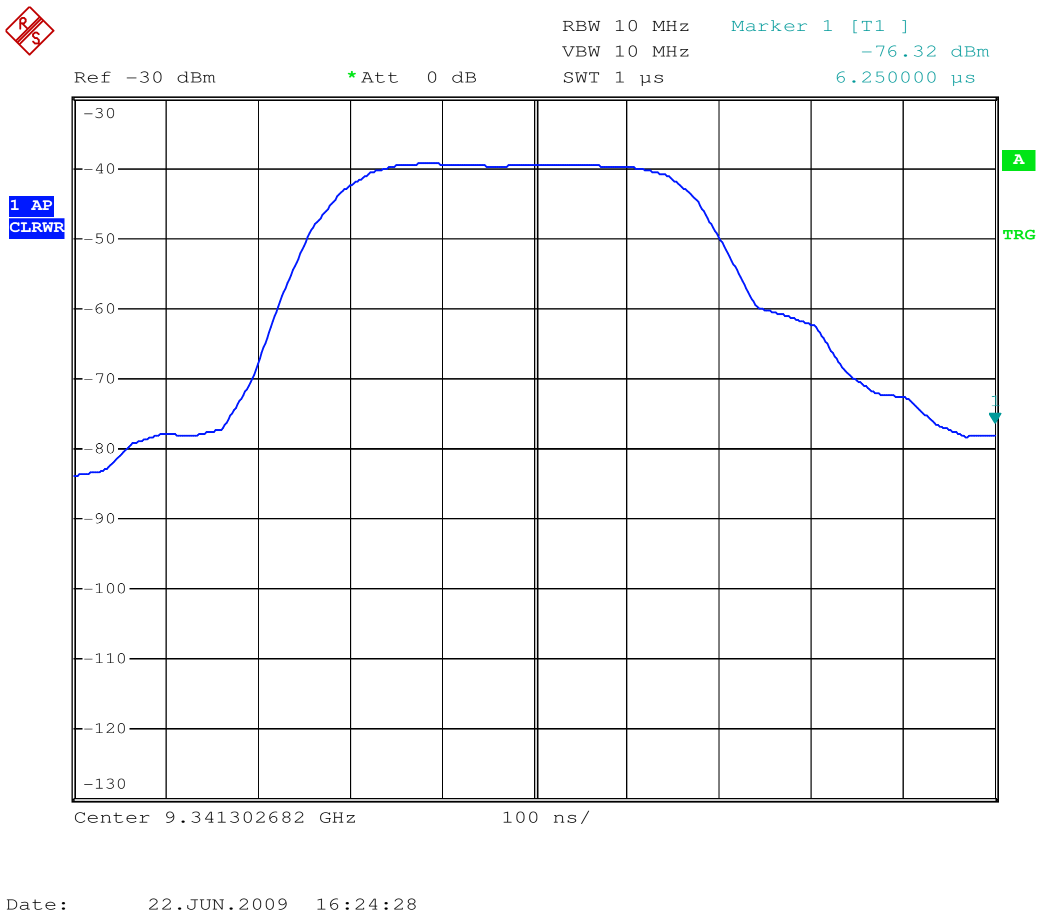
	MARKER POSITION	1: (dB)	2: (dB)		MARKER POSITION	1: (dB)	2: (dB)
1	9.30000 GHz	+26.40	+52.65				
2	9.50000 GHz	+25.94	+51.54				
3	9.40000 GHz	+26.34	+53.56				

Plot 5: Gain and Saturated Output Power

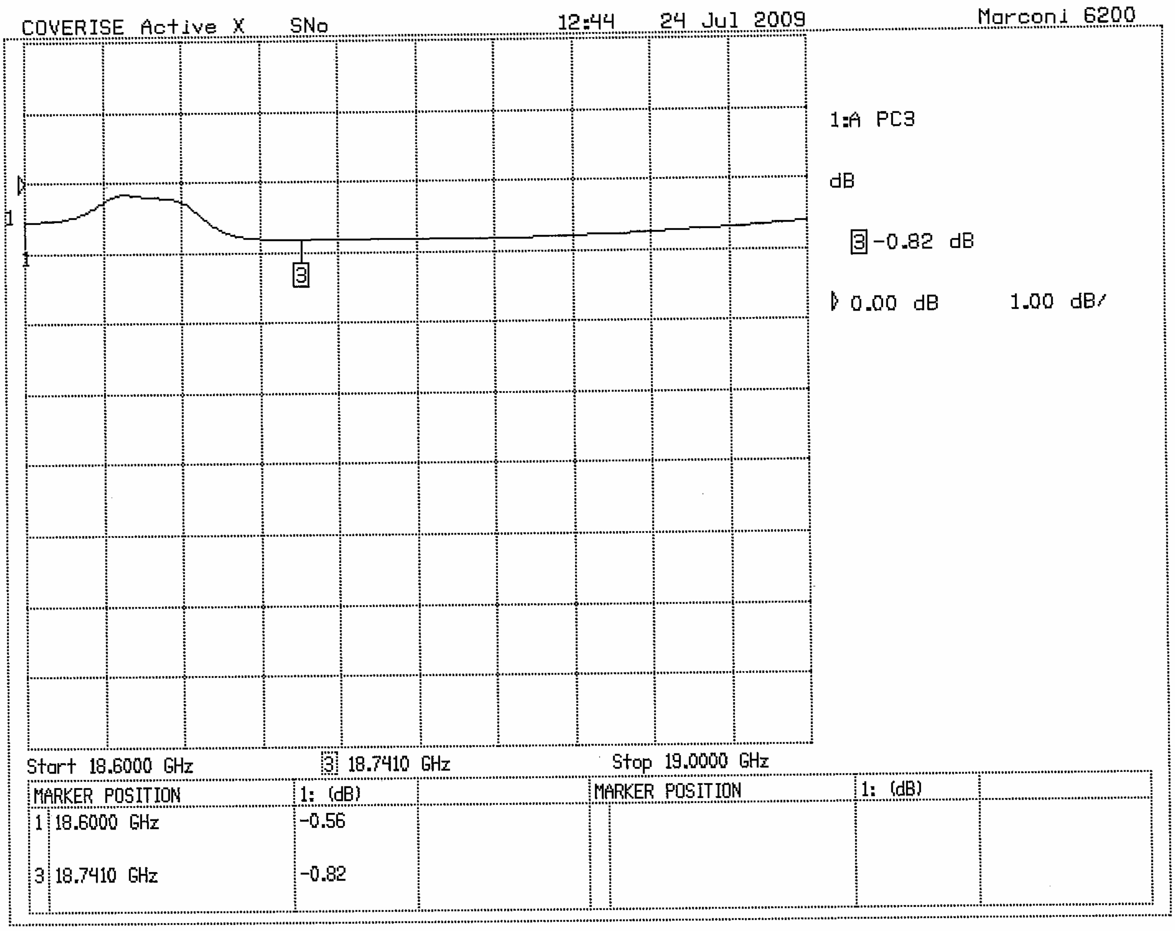


Plot 6: Spectrum Analyser Pulse length Active-X Off

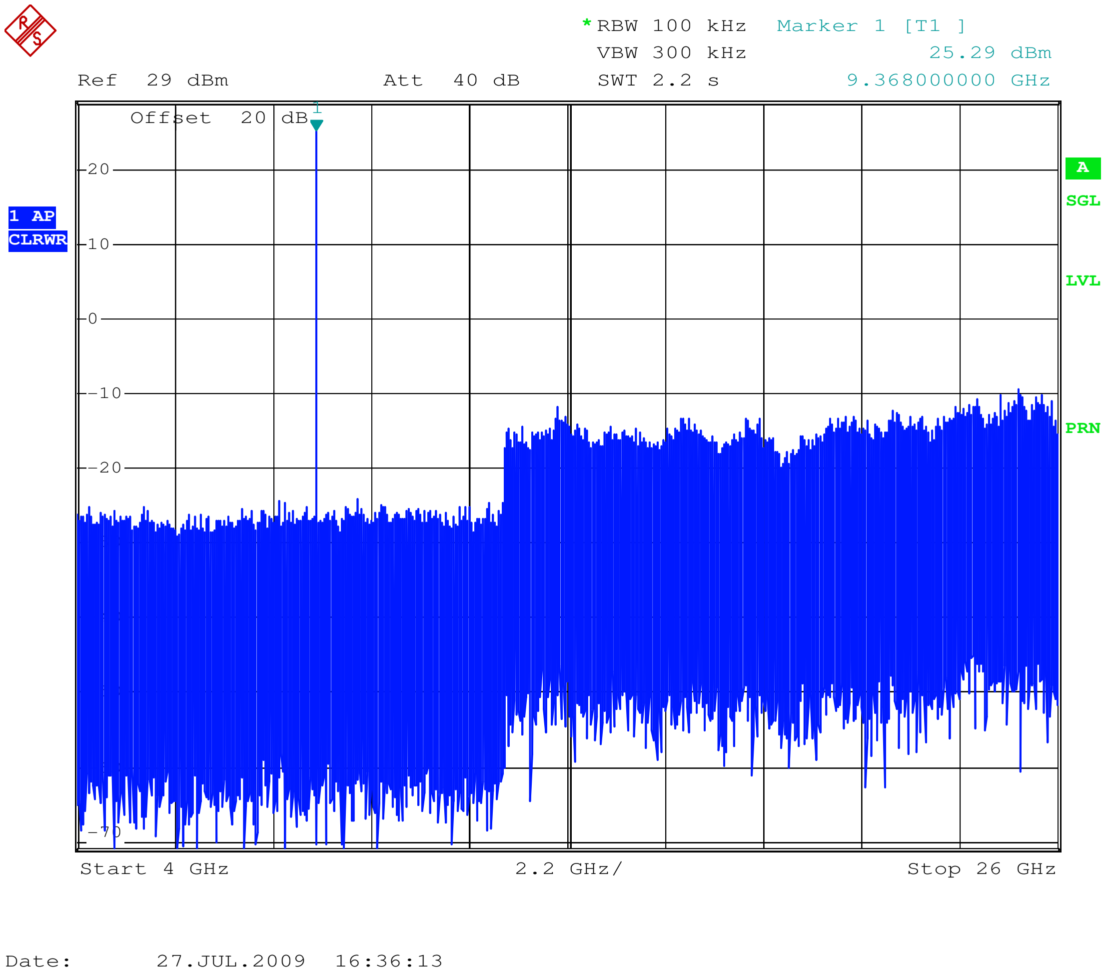
(Antenna's moved to increase signal level for measurement)



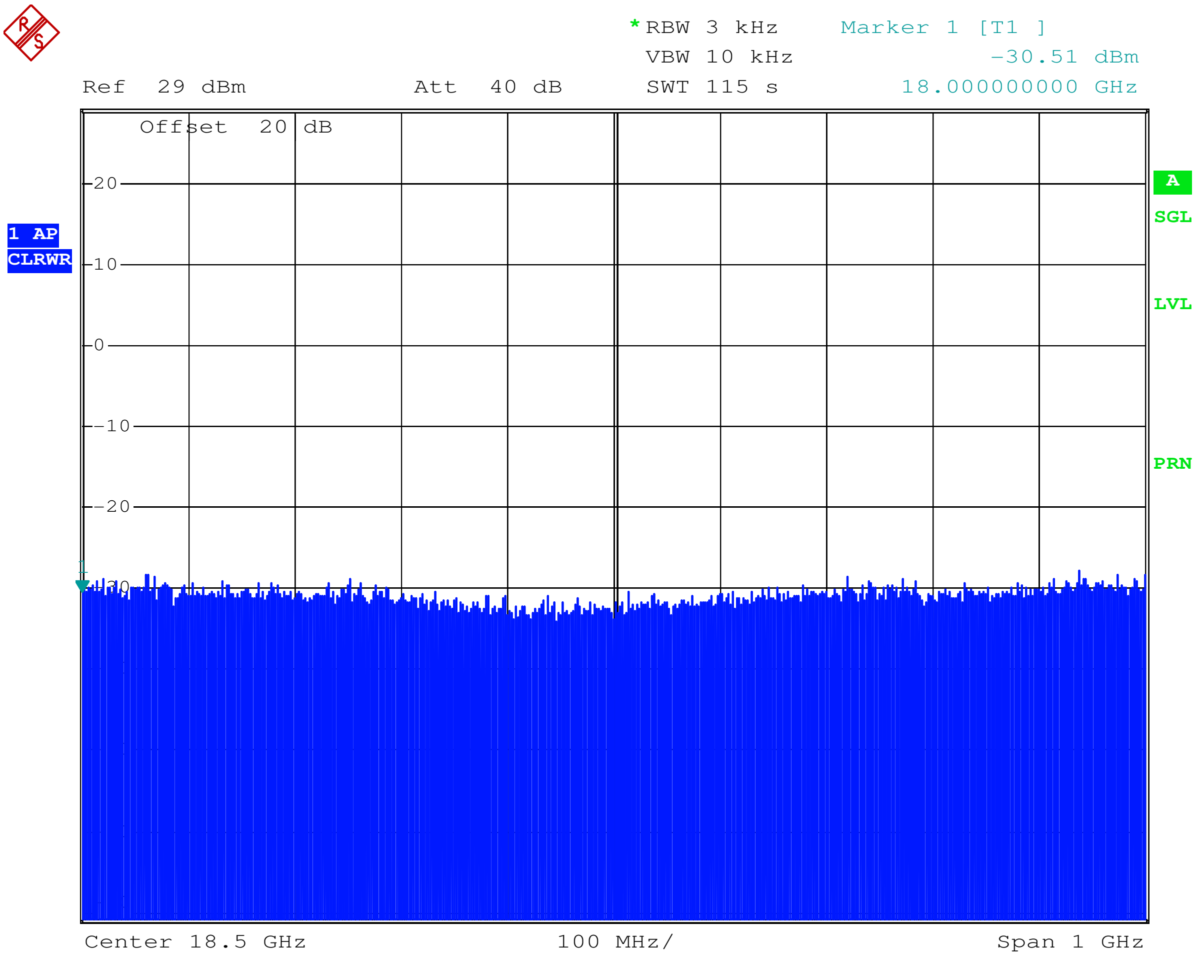
Plot 7: Spectrum Analyser Pulse length Active-X On



Plot 8: RTE Antenna Return loss at 2nd Harmonic



Plot 9: Spurious Emissions Results



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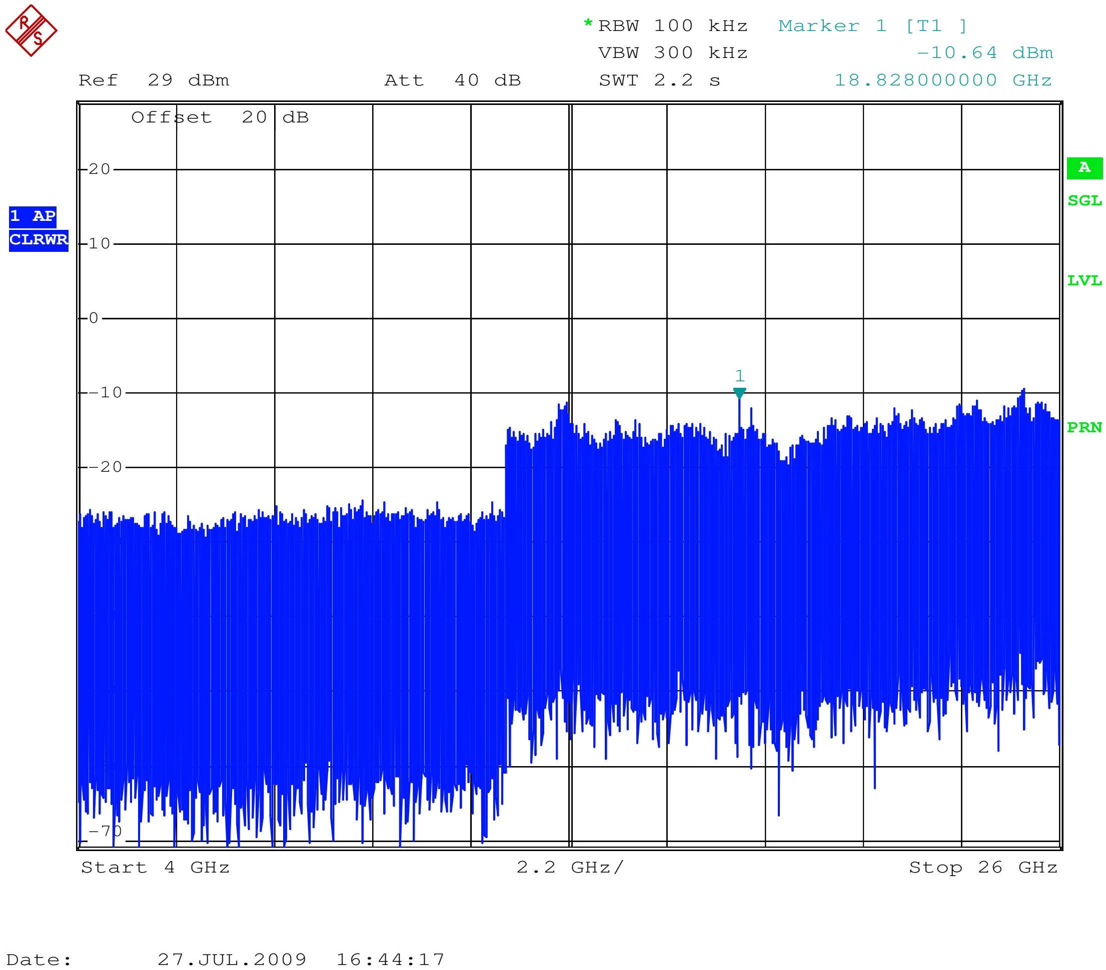
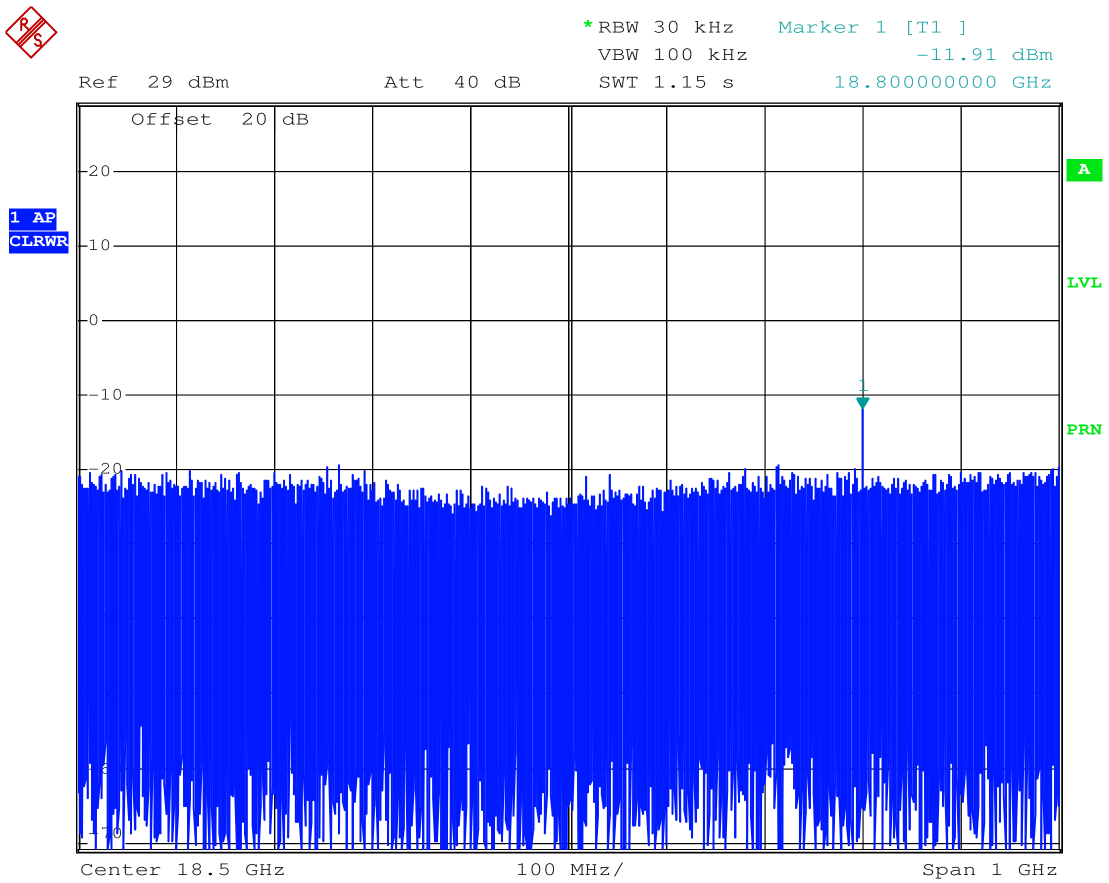
Plot 10: Close up on 18 to 19GHz Spurious Emissions



Plot 11: Analyser showing measurement of signal from generator at 18.8GHz



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Plot 12: Close in plot showing measurement of signal from generator at 18.8GHz