ERA TECHNOLOGY

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ERA Business Unit: ANTENNA SYSTEMS

Report Title: **Test Report for the Sea Tel 1 metre Ku Band Reflector Antenna**

Frequency: Tx 13.75 – 14.5 GHz
Model No: 4006

Author: M M Drew

Client: Sea Tel

Client Reference: PO No: 42799

ERA Document No:: 14096/TR001
Issue 1

ERA Project Number: 51-ST-14096

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1. Introduction

This document describes the laboratory and range measurements undertaken at ERA Technology on the 1.0 metre linearly polarised Ku band reflector antenna required to demonstrate the performance of the system. The reflector system consists of a circularly symmetric main reflector and a feed chain/subreflector combination supported at the apex of the main reflector. The subreflector is a 'splash plate' configuration and it is supported at the feed aperture by a dielectric cone. The feed chain includes a rotating joint for polarisation alignment and a two port Orthomode Transducer (OMT) providing orthogonally polarised transmit and receive functions simultaneously. The back port of the OMT is the transmit port and the side port of the OMT is the receive port. The mounting of the feed chain/subreflector combination at the apex of the main reflector supports the feed chain and subreflector and the design of this fixture ensures that the configuration can be precisely integrated with the main reflector in the correct manner.

The Test Plan and procedures undertaken at ERA are consistent with *IEEE Standard Test Procedures for Antennas ANSI/IEEE Std 149-1979*.

2. Objective

The objective of the Tests is to measure the radiation patterns and gain of the 1.0 metre reflector antenna at Ku band operating in linear polarisation.

3. Testing Site

All testing has been undertaken at the ERA laboratories and outdoor far field range located as follows:

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4. Identification of Item for Testing

The item tested consists of a 1.0 metre circularly symmetric reflector and a Ku band feed chain/subreflector combination supported at the apex of the main reflector. A photograph of the configuration on the ERA far field range is shown in Figure 1, whilst Figure 2 shows detail of the feed/subreflector combination. The unit is identified by Model No: 4006.

Figure 1: 1.0 metre Ku band reflector on ERA far field range

Figure 2: Detail of feed/subreflector combination of 1.0 metre Ku band reflector

5. Electrical Specification

The electrical specification for the antenna is given in Table 1.

Table 1: Specification and Measurement Matrix

Parameter	Specification	Measurement
Frequency	Rx: 10.95 – 12.75 GHz Tx: 13.75 – 14.50 GHz	Rx: 10.95 – 12.75 GHz Tx: 13.75 – 14.50 GHz
Polarisation	Orthogonal Linear	Orthogonal Linear
Gain	41.8 dBi nominal Tx Band 40.1 dBi nominal Rx Band Measured value not more than 1 dB above the nominal	Table 5
Off-axis Co-polar Gain Tx Band	29-25log(θ) dBi for $(100\lambda/D)^o<\theta<20^o$ -3.5 dBi for $20^o<\theta<26.3^o$ 32-25log(θ) dBi for $26.3^o<\theta<48^o$ -10 dBi for $48^o<\theta<180^o$	Section 7; Pattern plots
Cross-polar Gain, Tx Band	-30 dB within pointing error -22 dB within 1dB beamwidth (relative to co-polar peak)	Section 7; Pattern plots
Off-axis Cross-polar Gain, Tx Band	19-25log(θ) dBi for $(100\lambda/D)^o<\theta<7^o$ -0.1-2.4log(θ) dBi for $7^o<\theta<26.3^o$ 32-25log(θ) dBi for $26.3^o<\theta<48^o$ -10 dBi for $48^o<\theta<180^o$	Section 7; Pattern plots
Return Loss	≤ -17.5 dB	Table 4, Figures 3 & 4
Isolation (feed only without transmit reject filter)	> 35 dB for 13.75-14.5 GHz > 35 dB for 10.95-12.75 GHz	Table 4, Figures 5 & 6
Waveguide port	WR75	WR75

6. Quality Control Procedures

ERA Technology Ltd operates a Quality Management System that is registered, by BSI, as complying with BS EN ISO 9001:2000 including the TickIt requirements (Registration number FM1303). The Company maintains other Quality Management System Accreditations and Certifications that are linked either to a specific market, technology or Client.

Our Quality Management System is defined in general terms by a Quality Manual and in detail by a series of Quality Procedures. These documents, and other relevant material, are provided to all ERA staff via our Intranet. This Quality Management System is implemented so as to meet the specific contractual and technical requirements of each individual project.

The Quality Assurance Manager is responsible to the Managing Director for defining the Quality Management System, maintaining it and, when needed, for continually improving the processes and standards. The Quality Assurance Manager is also responsible for identifying quality problems and initiating effective solutions. Individual Project Quality is devolved down from the Heads of Business Units to the Department Managers and, for day-to-day activities, to Project Managers. Quality Assurance Representatives are appointed from the engineering staff to give local support quality and provide a link between their departments and the Quality Assurance Manager.

Copies of our Quality Manual, ISO 9001 Certification and UKAS Accreditation are available either on request or from our web site http://www.era.co.uk/corporate/qualityassurance.asp. Copies of our other approvals are available on request.

7. Measurements

7.1 Introduction

Measurements of antenna radiation patterns and gain were undertaken using ERA's 220 metre far field test range. The range comprises a remotely controlled primary transmitter unit and a receive facility located in a purpose-built test tower 15 metres in height. The receive facility is equipped with programmable *Scientific Atlanta* positioners, receivers and automatic data logging equipment. The transmitter site is furnished with a series of transmit points to cover the various bands. For Ku band the transmitter is a reflector about 900 mm diameter and it utilises a linearly polarised feed chain. The transmitter can be rotated around its axis to align the polarisation as required.

Detailed surveys of this test range have been carried out in the most commonly used microwave bands that indicate co-polar reflectivity better than -50 dB and cross-polar isolations better than 55 dB.

7.2 Test Equipment

The test equipment used in the laboratory and test range measurements are listed in Tables 2 and 3 respectively.

Table 2: Laboratory Equipment Check List

Project No:	**51-ST-14096**	**Phase:**	**1**	**Engineer:**	MMD
Project Title	**1 metre Ku Band Antenna Testing - Model 4006**				
Measurement:	Tune and Test			**Date:**	10 July 2007

Equipment Used	**Serial No.**	**Calibration Date**	**Tick Box**
Amplitude analyser 8757A	2706A2326	14 Sept 2006	
Sweep oscillator mainframe 8350B	2649U02154	14 Sept 2006	
RF plug-in 83550A 8-20 GHz	2741A00528	14 Sept 2006	
RF plug-in 86260B 10-15.5 GHz	2417A00655	Indication only	
Frequency counter EIP578	374	Indication only	
HP5342A	1916A01711	14 Dec 2006	
Plotter 7550A	2520A12676	Indication only	
Detector 11664E	02229	14 Sept 2006	
Detector 11664E	02172	14 Sept 2006	
Detector 11664E	04878	14 Sept 2006	
Detector 11664D	00626	14 Feb 2005	
Detector 11664D	00627	14 Feb 2005	
Detector 11664D	00632	14 Feb 2005	
Waveguide coupler WG17132-10	582	Indication only	
Waveguide coupler WG17132-20	220	Indication only	
Waveguide coupler WG17132-20	183	Indication only	
Waveguide to coax transitions WG17094-NF10	53	Indication only	
Waveguide to coax transitions WG17093-NF10	1384	Indication only	
Waveguide to coax transitions WG17093-NF10	1927	Indication only	

Equipment Used	Serial No.	Calibration Date	Tick Box
Test cables used:			
Rosenberger 18 GHz	924201	Indication only	✓
Rosenberger 18 GHz	924202	Indication only	✓
Rosenberger 40 GHz	924701	Indication only	
Rosenberger 40 GHz	924702	Indication only	
Wiltron semi-rigid 3670 K50-2	101003	Indication only	
Wiltron semi-rigid 3670 K50-2	301010	Indication only	
Other: 5061-5359	847015	Indication only	
Anritsu Network Analyser 37397c	R1056	13 Feb 2007	✓
Calibration Kits:			
WG6 Flann 06708	21	Indication only	
WG15 Flann 15708	23	Indication only	
WG16 Maury X7005	Individually marked	Indication only	
WG17 Flann 17708	21	Indication only	✓
WG18 Flann 18708	21	Indication only	
WG20 Flann 20708	23	Indication only	
WG22 Flann 22708	24	Indication only	
Wiltron Coaxial Kit 3652-1	80024	13 Dec 2005	
HP 7mm Cal Kit 85031B	2541A00868	13 Dec 2005	
Other Equipment:			
HP "N" type Fixed 6B Attenuator Type 8419B	23557	Indication only	
Flann Waveguide to coax transitions Type 17091	25 and 26	Indication only	

Table 3: Antenna Systems Range Equipment List

Equipment Used	Serial No.	Calibration Date	Tick Box
For range testing of antenna assembly:			
Scientific Atlanta Positioner Az/El/Az 55150A-1	72AG	Indication Only	✓
Scientific Atlanta Positioner Polarisation 56060-18	489	Indication Only	✓
Flann Standard Gain Horn Model No. 17240		Indication Only	✓
Dell Computer with Midas Software	DTOHZOJ	Indication Only	✓
Agilent 20 GHz Lo Source 83623B	3844A01682	29 Jan 2007	✓
Agilent 50 GHz RF Source 83650B	3844A01529	29 Jan 2007	✓
Agilent Receiver 8530A	3901A00722	29 Jan 2007	✓
Agilent Test Mixer Module 85320A-H50	2944A00942	29 Jan 2007	✓
Agilent Ref Mixer Module 85320B	2944A00156	29 Jan 2007	✓
Agilent Lo/IF distribution Unit 85309A	3224A00707	29 Jan 2007	✓
Orbit Pos. Controller AL-4806-3A	91	Indication Only	✓
Orbit Pos. Controller AL-4906-3A	292	Indication Only	✓

7.3 Laboratory Tests

The assembled reflector with the feed/subreflector combination was measured in the laboratory. The return loss measurements were swept frequency over 10.95 – 12.75 GHz and 13.75 – 14.5 GHz, whilst isolation was measured over 10.95 – 14.5 GHz. The following were measured:

i) Return loss at Rx and Tx ports.

ii) Port-to-port isolation.

When measuring the return loss, the unused port was terminated in waveguide load and for all measurements the reflector was radiating into free-space or suitable anechoic shield.

Typical measurement accuracy after 12-term vector error correction can be read directly from graphs provided by the analyser manufacturer for reflection coefficient and transmission loss. The errors are Root-Sum-Squares (RSS) calculations of the contributions of residual directivity, load and source match, frequency response, isolation, network analyser dynamic accuracy and connector repeatability. This gives:

i) Return loss of 20 dB : Uncertainty (Reflection coefficient) =0.017 dB (RSS)

ii) Return loss of 15 dB : Uncertainty (Reflection coefficient) =0.019 dB (RSS)

Table 4: Laboratory Measurements

	Frequency	Figure	Measurement
Return loss Rx Band	10.95 – 12.75 GHz	Figure 3	≤ -17.6 dB
Return loss Tx Band	13.75 - 14.50 GHz	Figure 4	≤ -18.6 dB
Isolation Tx - Rx	10.95 - 12.75 GHz 13.75 - 14.50 GHz	Figure 5 Figure 6	> 35 dB > 37 dB

7.4 Antenna Range Measurements

7.4.1 Introduction

The procedures undertaken at ERA are consistent with *IEEE Standard Test Procedures for Antennas ANSI/IEEE Std 149-1979*. The measurements were undertaken using a linearly polarised Ku band transmit source.

The antenna under test (AUT) was installed on the positioner and the mixer connected to the relative antenna port.

7.4.2 Pattern measurements procedure

For antenna pattern measurements:

i) Select the frequencies; co-polarise the transmitter with the AUT and steer the AUT to receive maximum signal. Set azimuth and elevation indications to zero.

ii) Rotate the required axis and record the co-polar pattern.

iii) Rotate transmitter polarisation by 90° and record the cross-polar pattern.

iv) Repeat for other frequency bands.

All the measurements were taken by rotating in azimuth. For the elevation cut measurements, the AUT was rotated by 90° and the measurements taken with the AUT rotated in azimuth. Patterns were taken ±180° or a narrower limited range with the angular increment 0.5° or less, as described in the Range Measurements Plan, Section 7.4.5.

7.4.3 Gain measurements procedure and results

The antenna gain measurements were performed by comparing with a commercially available linearly polarised Standard Gain Horn (SGH):

i) Locate Standard Gain Horn (SGH) on antenna mount.

ii) Select frequencies; co-polarise the transmitter with the AUT and steer the AUT to receive maximum signal. Set azimuth and elevation indications to zero.

iii) Record the co-polar signal from the AUT.

iv) Record the signal from the SGH.

v) Repeat iii) and iv).

The AUT gain will be determined by the average of the two measurements taken. Table 4 gives the gain computations.

Table 5: Measured Gain

Frequency GHz	**14.0**	**14.25**	**14.50**
AUT dB	-13.7	-14.1	-12.2
SGH dB	-29.0	-29.1	-27.3
Diff dB	15.3	15.0	15.1
SGH Gain dBi	26.6	26.75	26.9
AUT Gain dBi	**41.9**	**41.75**	**42.0**

7.4.4 Far field range measurement uncertainties

Typical far field range measurements uncertainties are given in Table 5.

Table 6: Far field Range measurement uncertainties

Parameter	Value
Mutual Coupling	0.0 dB
Tx Amplitude Taper (0.25 dB)	0.1 dB
Reflections (Elevated Range)	0.01 dB
Frequency Stability	0.01%
Power Level	< ± 0.05 dB
Standard Gain Horn	± 0.25 dB
Spacing Tx to AUT	0.01 dB
Tx isolation	0.01 dB
Total RSS (Root-Sum-Square)	**0.27 dB**

The overall accuracy of the gain measurements undertaken using a commercial Standard Gain Horn is estimated to be ±0.27 dB.

7.4.5 Range measurements plan

The Test Plan for the range measurements is given in Table 7. All the measurements were recorded by rotating in azimuth. The elevation cut measurements were recorded by rotating in azimuth after turning the AUT by 90°. Since the AUT is linearly polarised, the cuts in Table 7 are identified as E-plane or H plane cuts. For example, for a vertically polarised antenna, E-plane is the elevation cut and H-plane is the azimuth cut. Co-polar and cross-polar component patterns were be taken for ±180° in θ, the angular increment 0.5°. Co-polar and cross-polar measurements were taken for ±22.5° in θ with the angular increment 0.05°.

All the measurements were recorded as ASCII text files in amplitude (dB). The data were then processed in Excel spreadsheets in the format required by Anatel and were supplied with the Test Report.

The recorded patterns are included in this Test Report and identified by the Pattern Number as given in Table 7.

Table 7: Range measurements Test Plan

			Pattern Number		
Angular scale degrees	**Cut**	**Component**	**Frequency GHz**		
			14.0	**14.25**	**14.50**
±22.5	E-Plane	Co & Cross	1	2	3
±22.5	H-Plane	Co & Cross	4	5	6
±22.5	45°-Plane	Co & Cross	7	8	9
±180	E-Plane	Co & Cross	10	11	12
±180	H-Plane	Co & Cross	13	14	15
±180	45°-Plane	Co & Cross	16	17	18
Gain		Co	✓	✓	✓

7.4.6 Antenna range Test Log sheet

ANTENNA RANGE TEST LOG SHEET			
TITLE:	Sea Tel 1.m Reflector	OPERATOR:	MMD
PROJECT NO:	14096	DATE:	9 July 2007
DESCRIPTION:	1 m Reflector Model 4006	FREQUENCIES:	14, 14.25, 14.50 GHz
TEST PLAN:	As test Plan 14096/TP001	DATAFILE DIRECTORY:	Data/SeaTel_14096

DATA FILE NAME				
PATTERN			CO-POLAR	CROSS-POLAR
±22.5º	Co & X	E-Plane	Sea	Sea 1
±22.5º	Co & X	H-Plane	Sea 4	Sea 5
±22.5º	Co & X	45º-Plane	Sea 8	Sea 9
±180º	Co & X	E-Plane	Sea 3	Sea 2
±180º	Co & X	H-Plane	Sea 7	Sea 6
±180º	Co & X	45º -Plane	Sea 11	Sea 10

SET-UP FILE NAMES:		DIRECTORY:	
PROCESSED DATA FILE NAMES:		AZ/EL ALIGNMENT:	Yes
TX EQUIPMENT USED:			
COMMENTS: .			

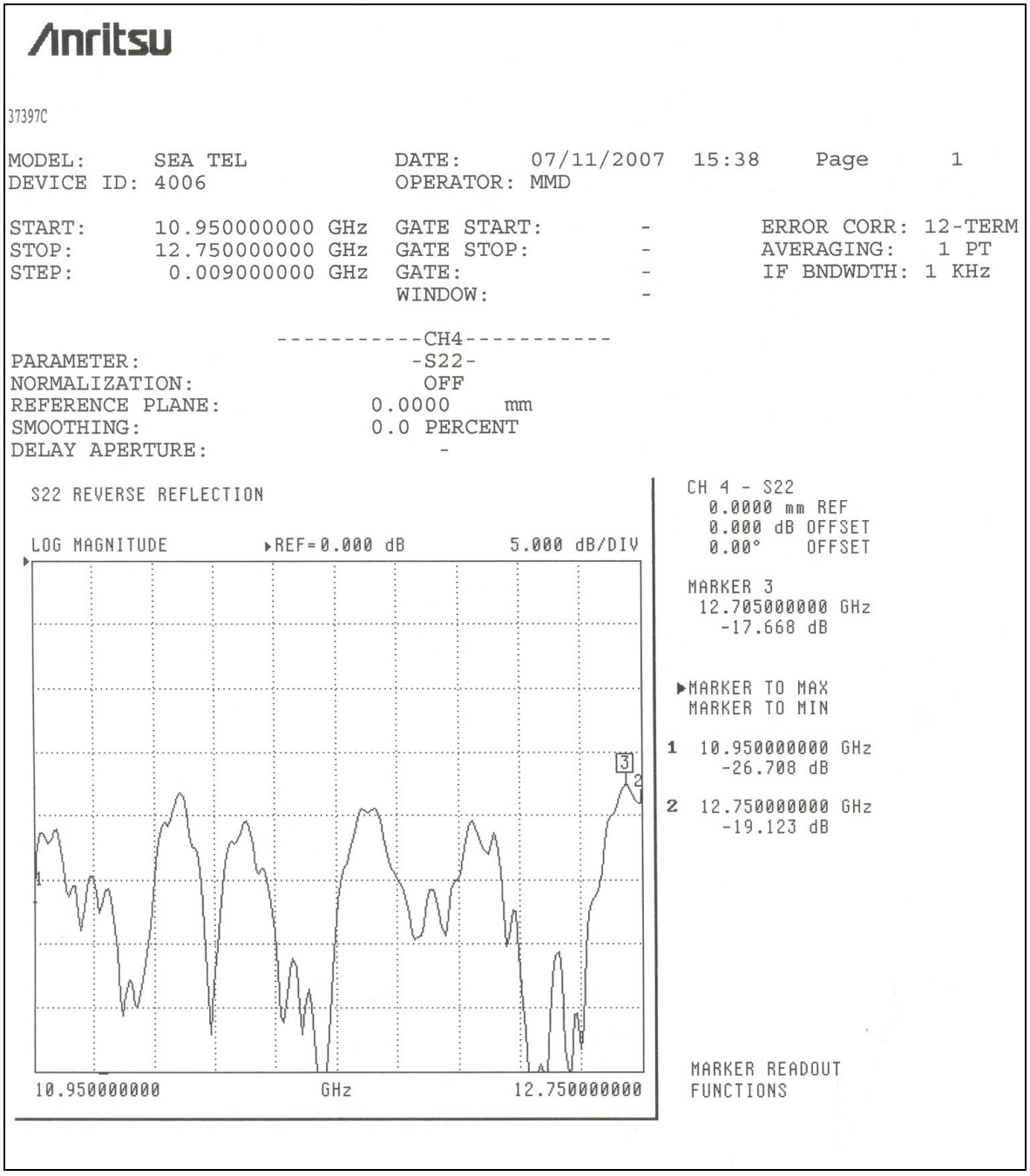


Figure 3: Measured return Loss – Rx Band

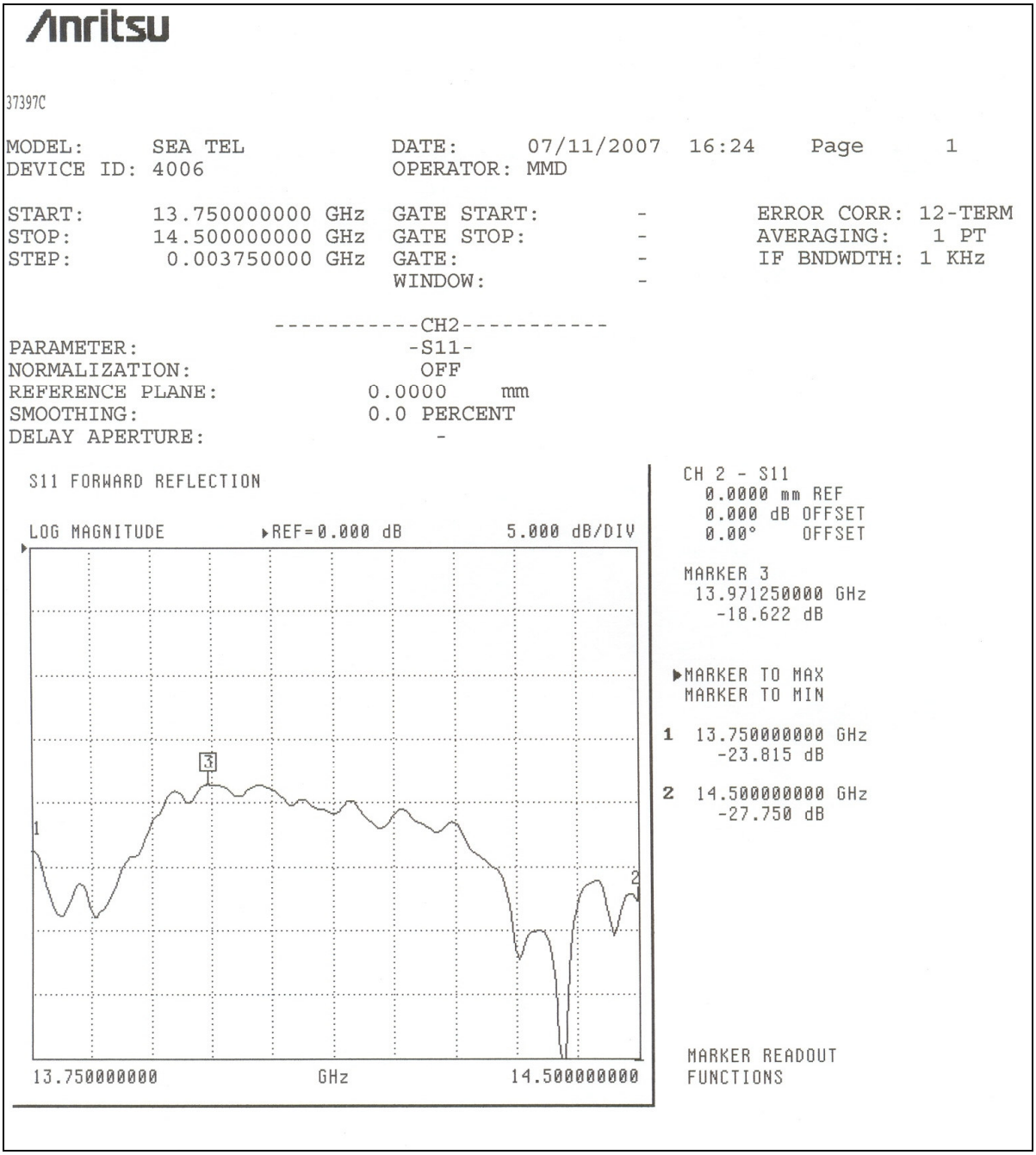


Figure 4: Measured return Loss – Tx Band

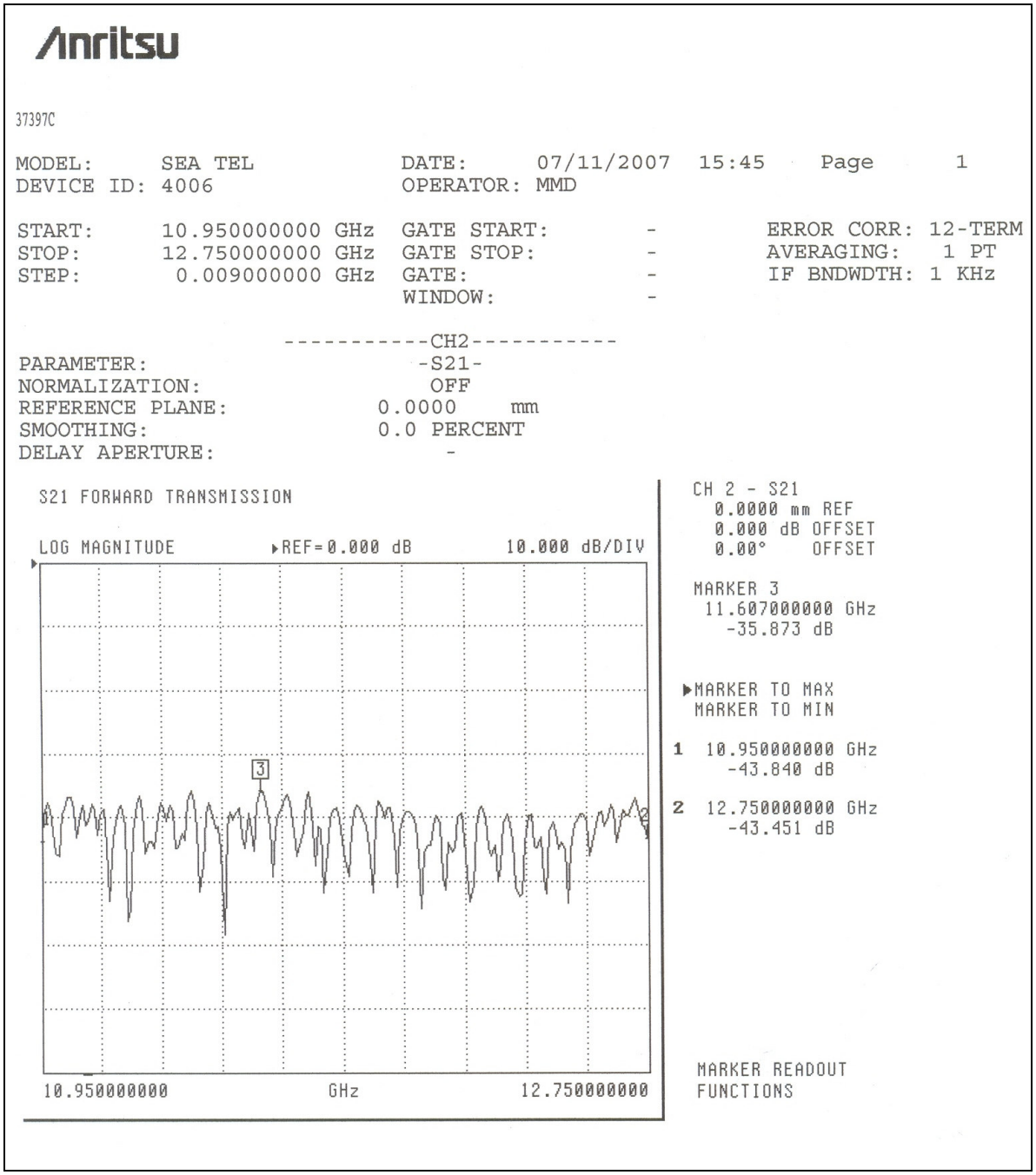


Figure 5: Measured Port to Port isolation – Rx Band

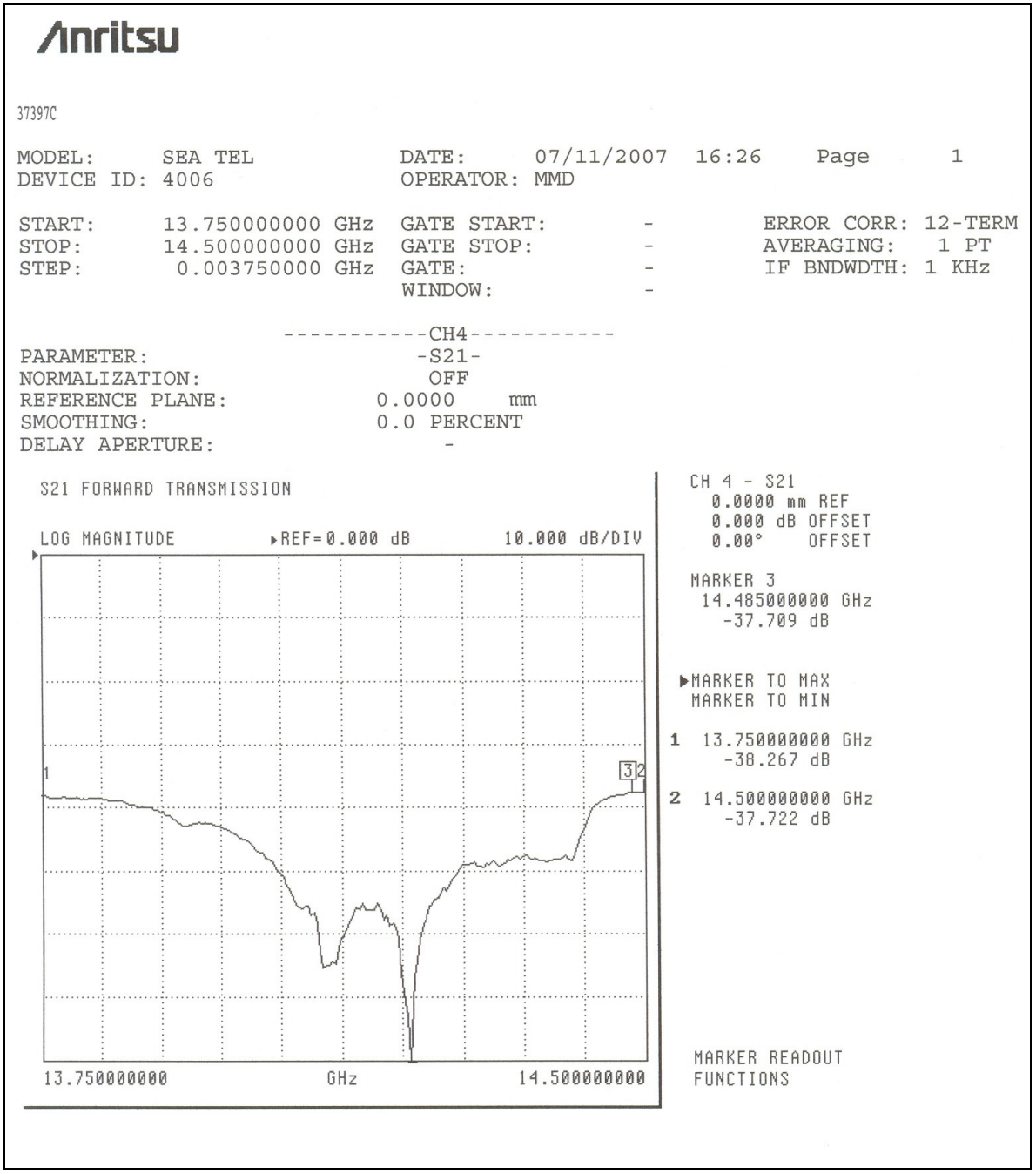
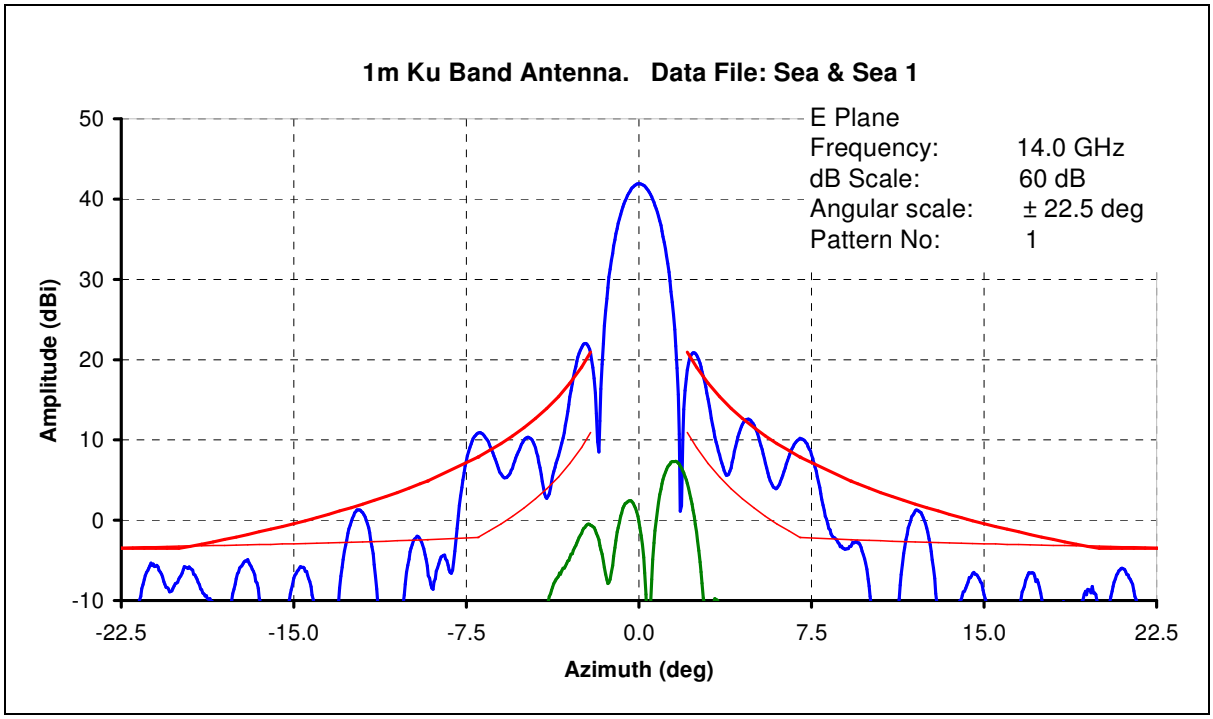
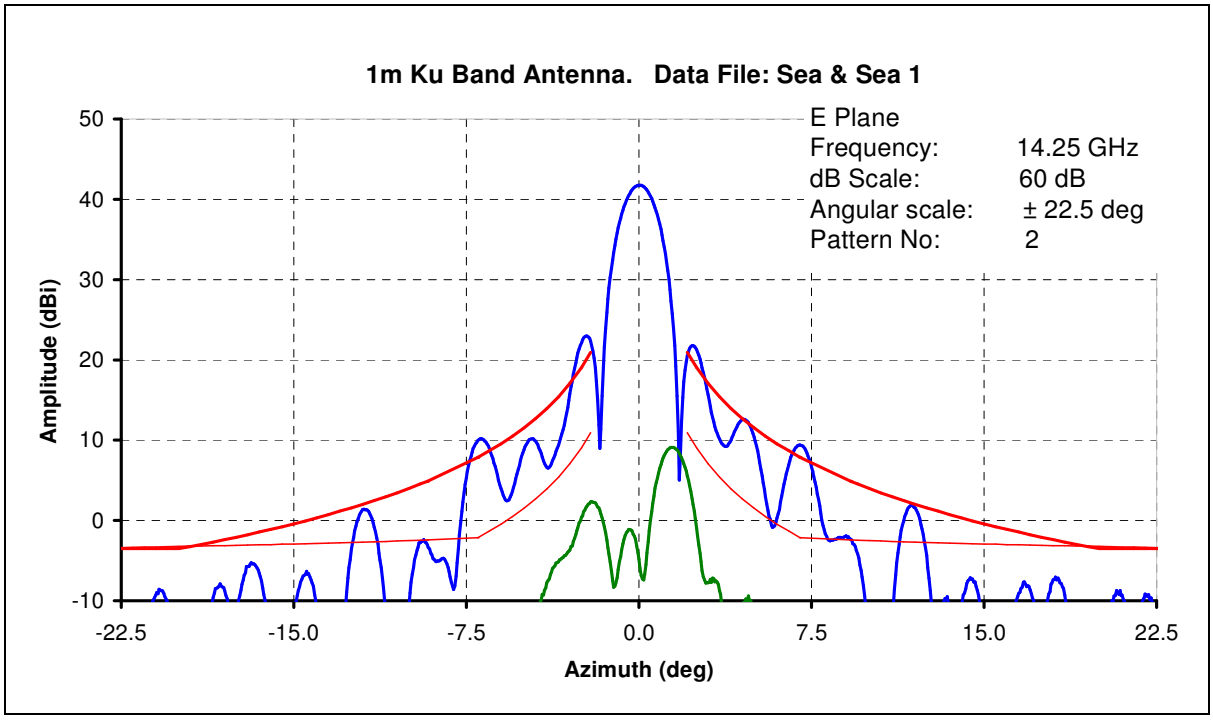
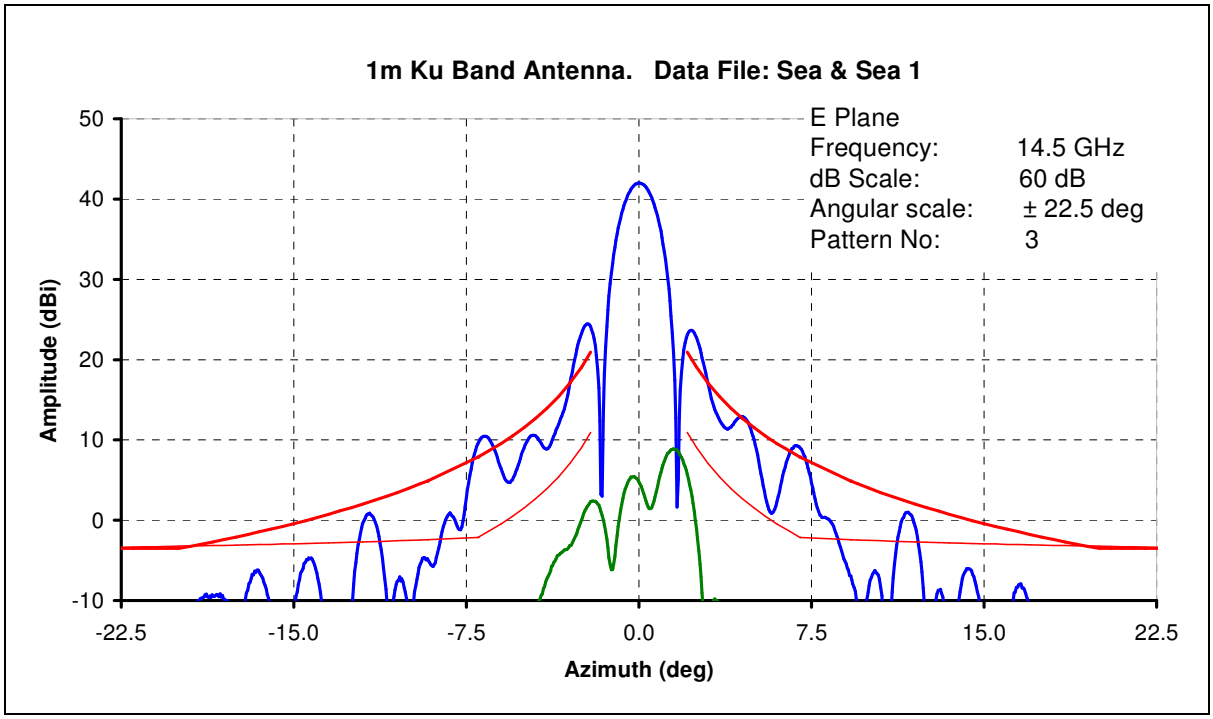
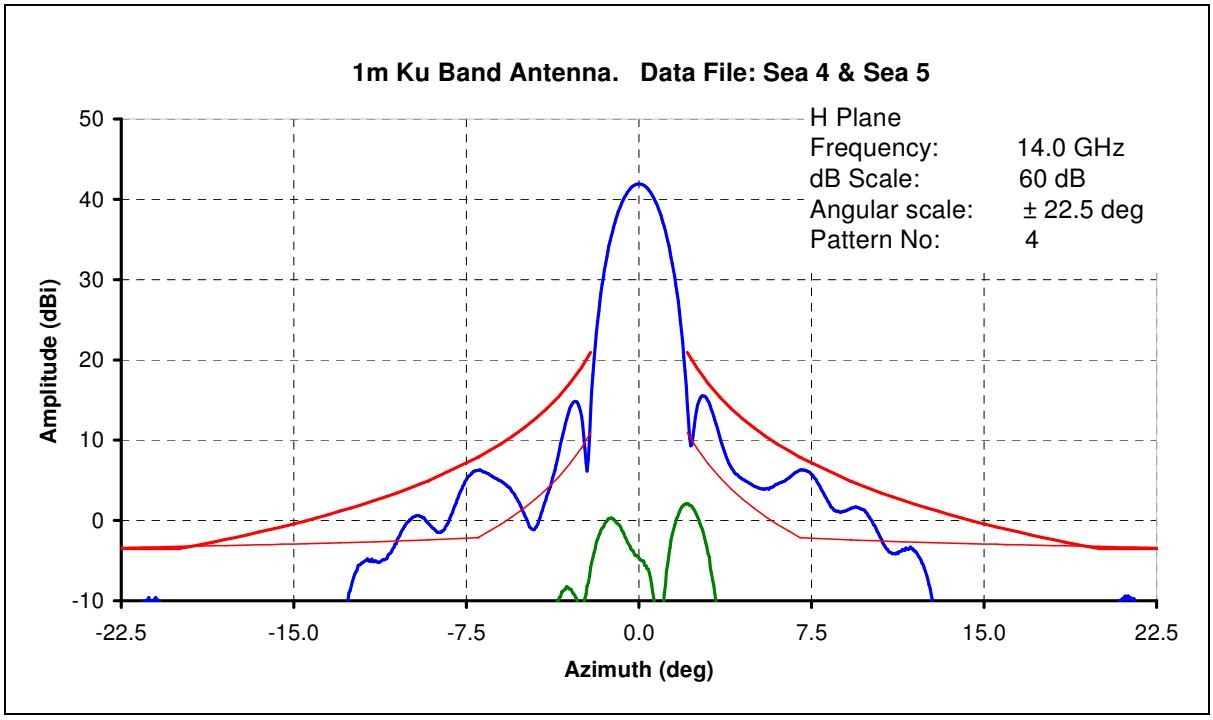


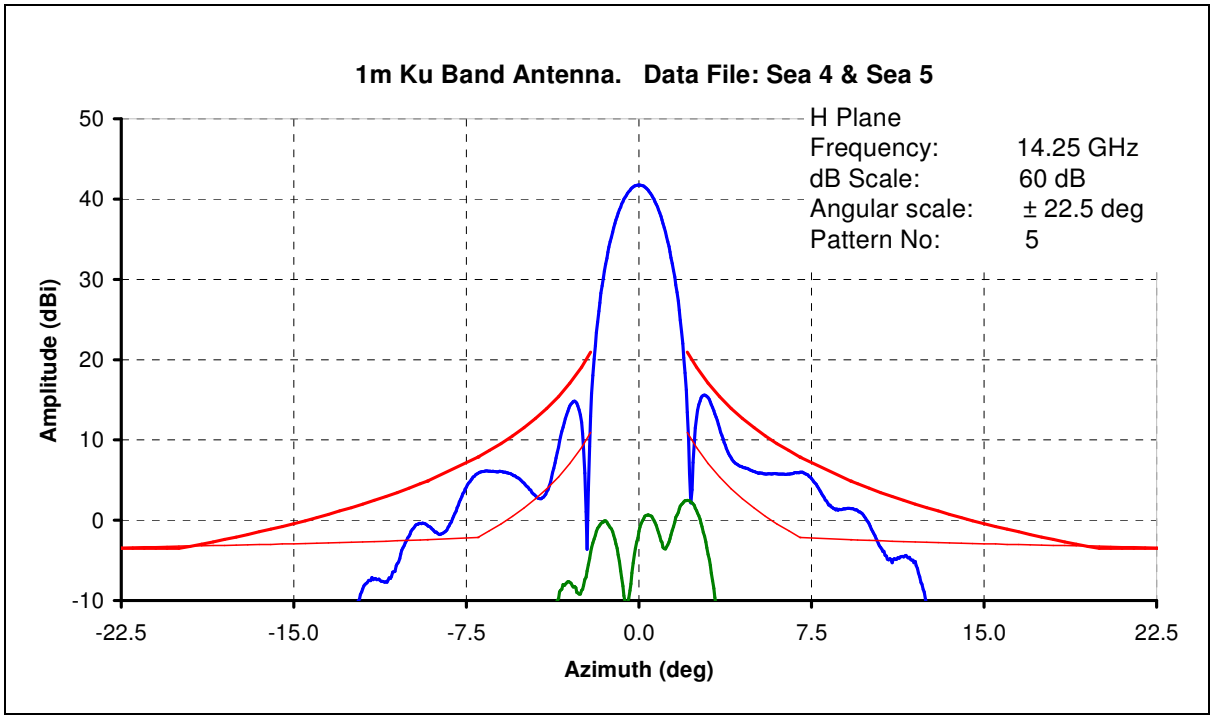
Figure 6: Measured Port to Port isolation – Tx Band

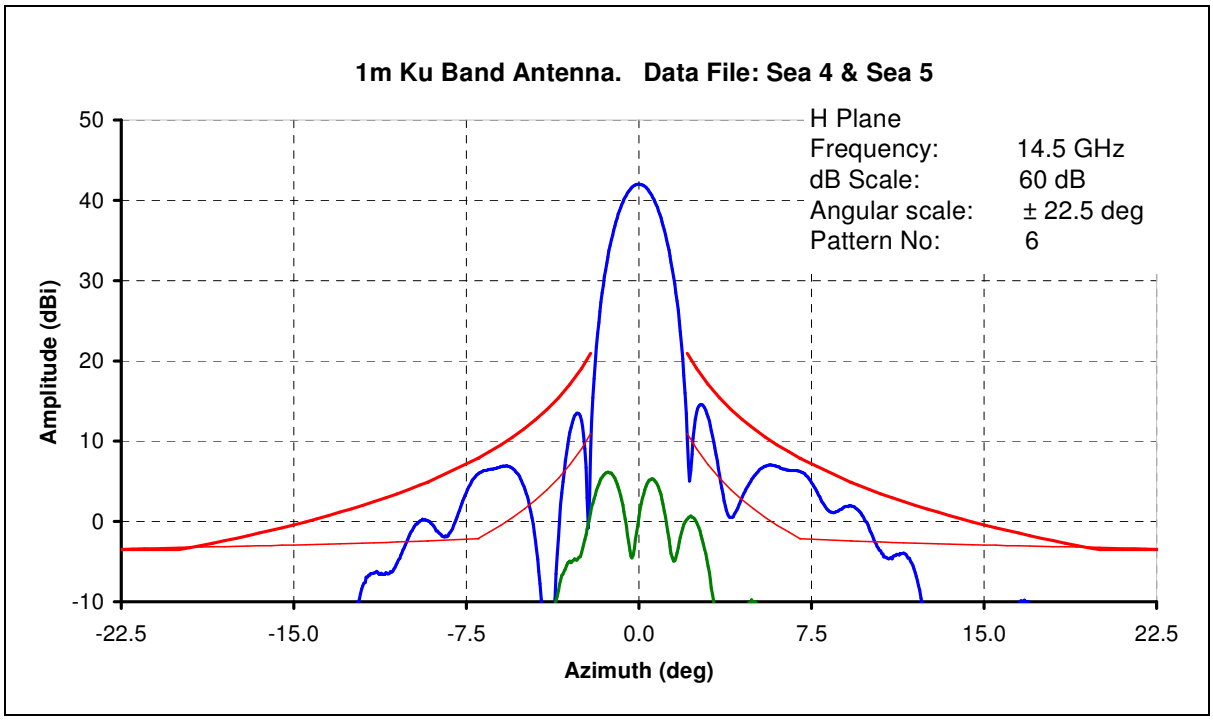


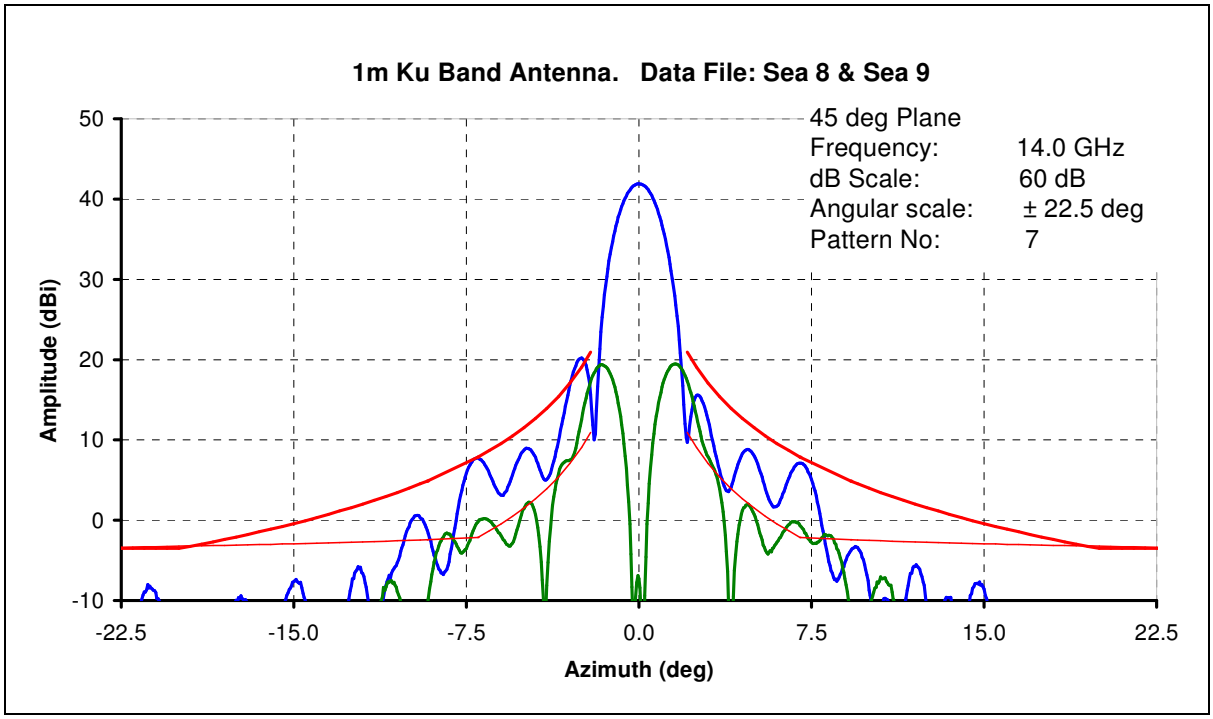


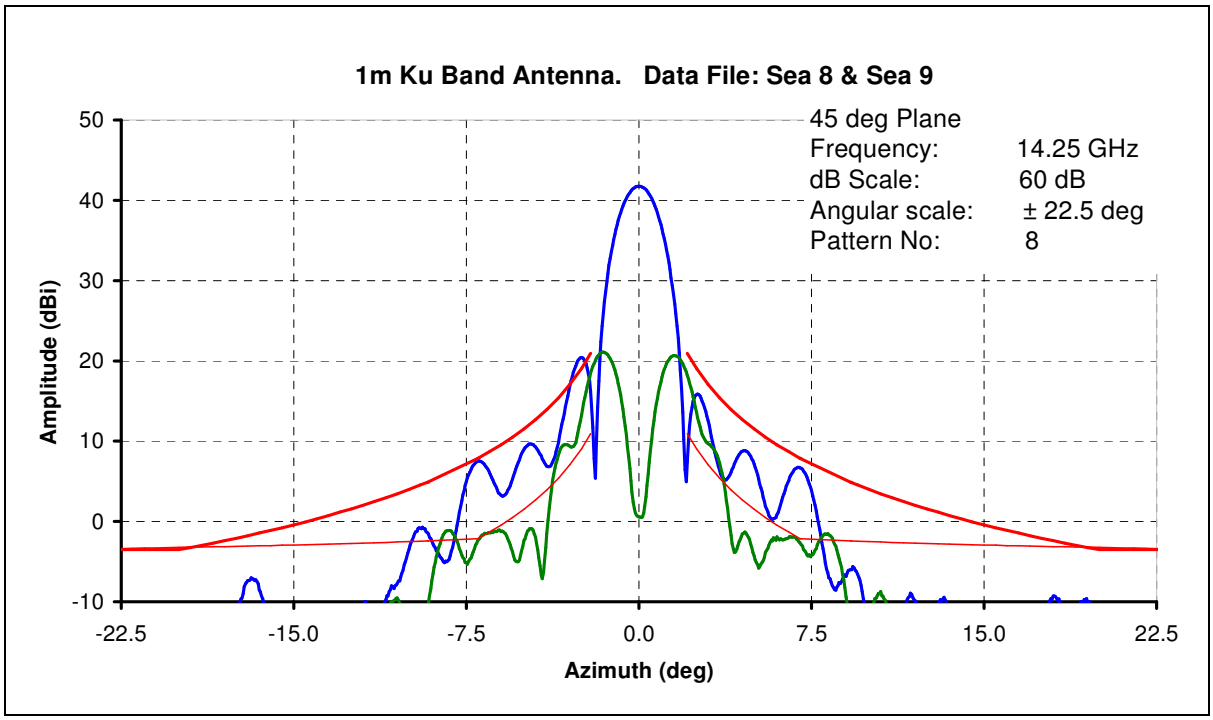


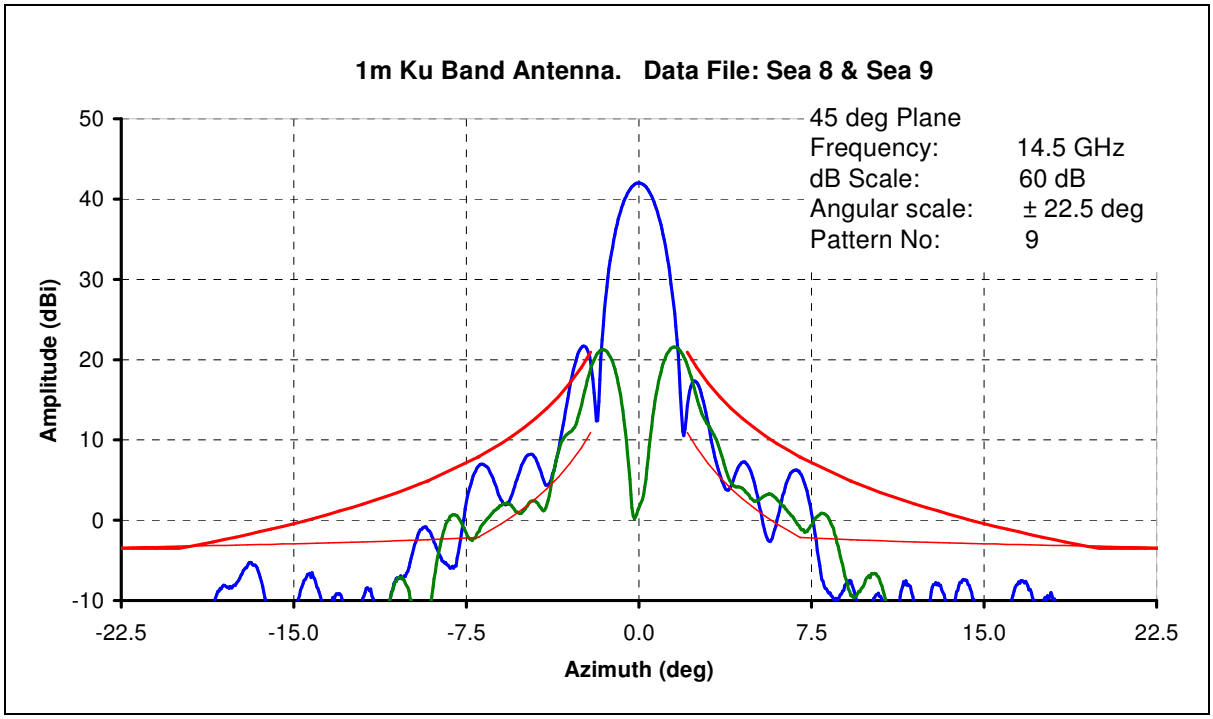


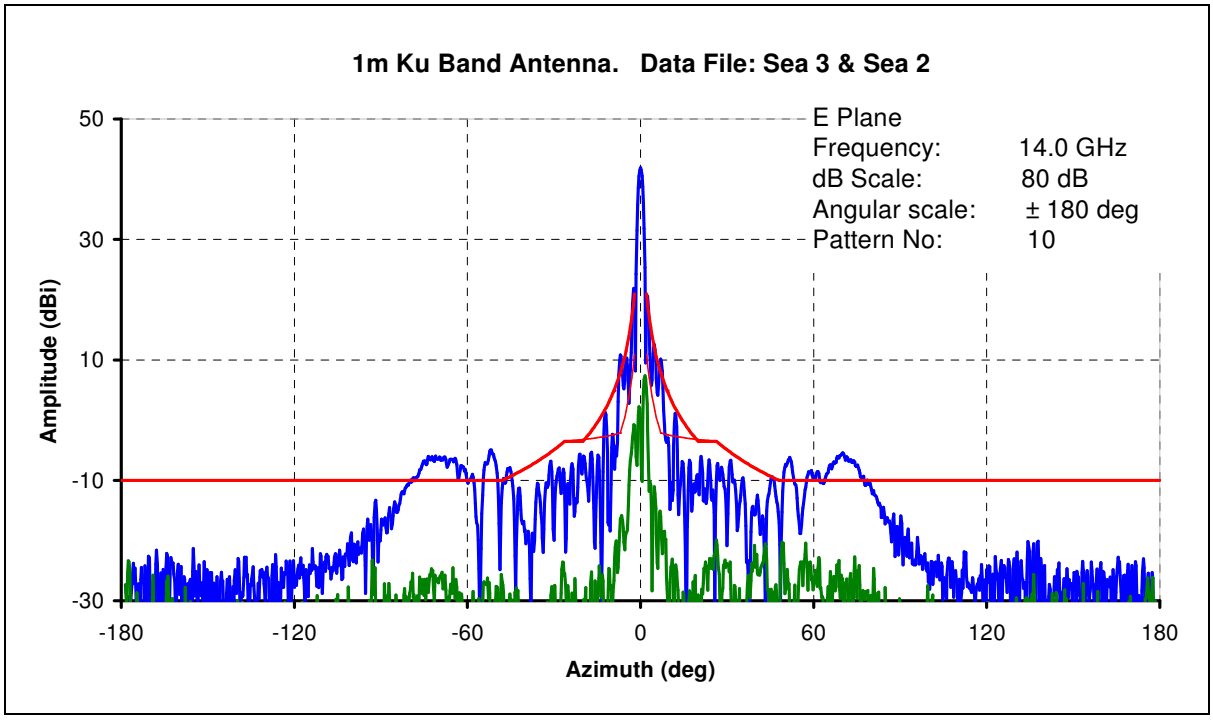


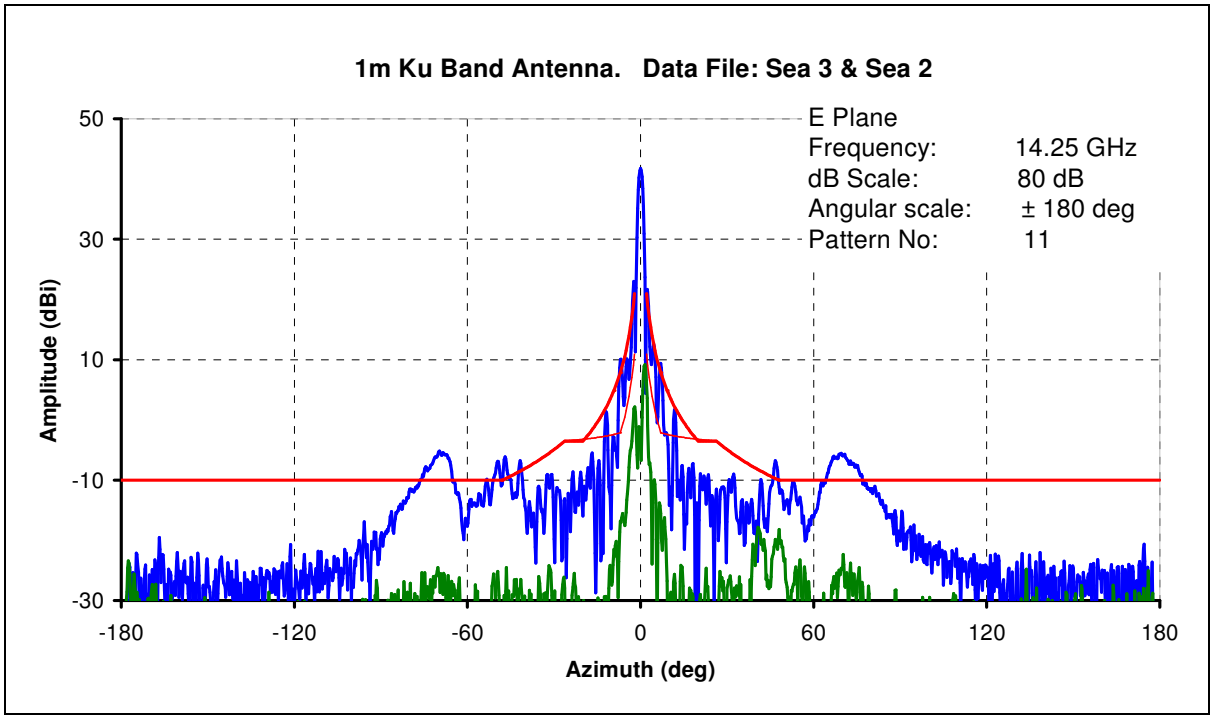


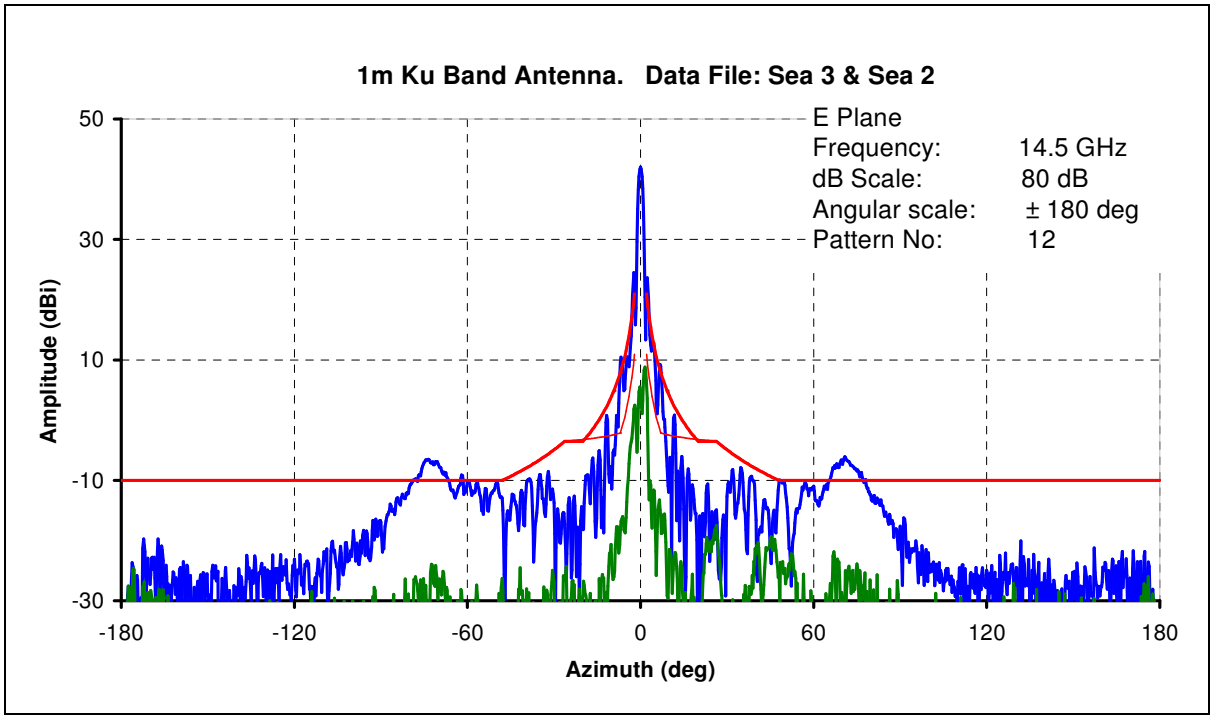


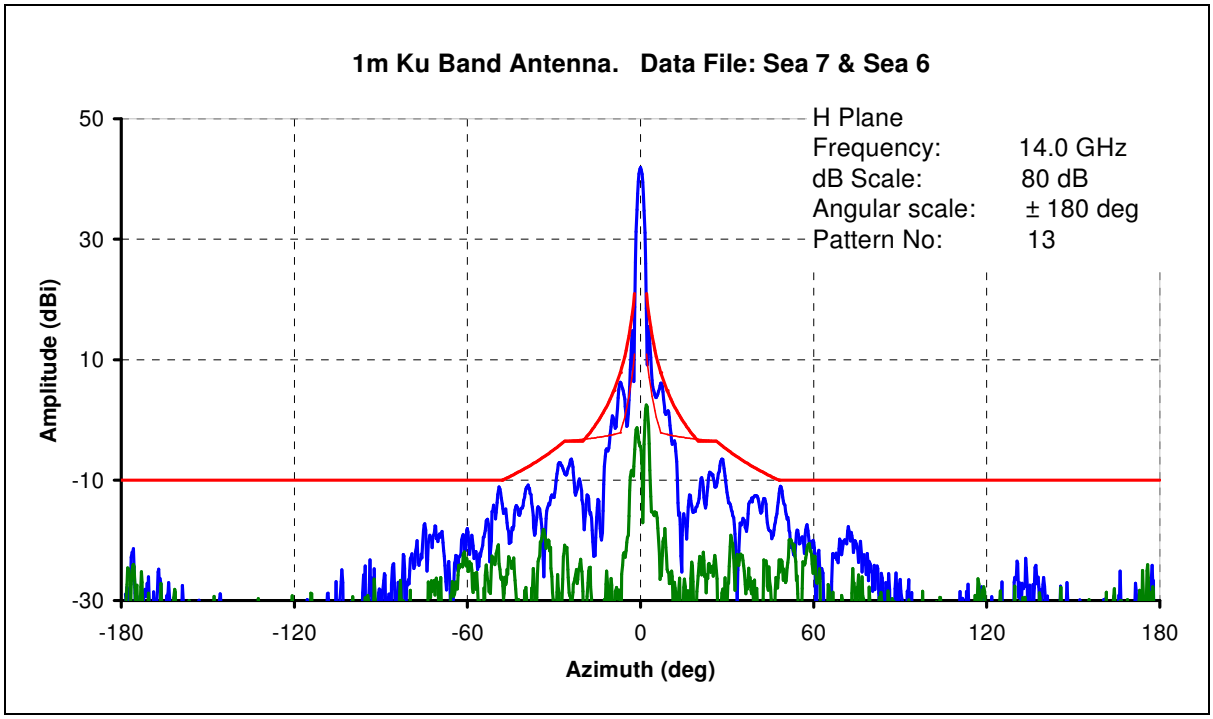


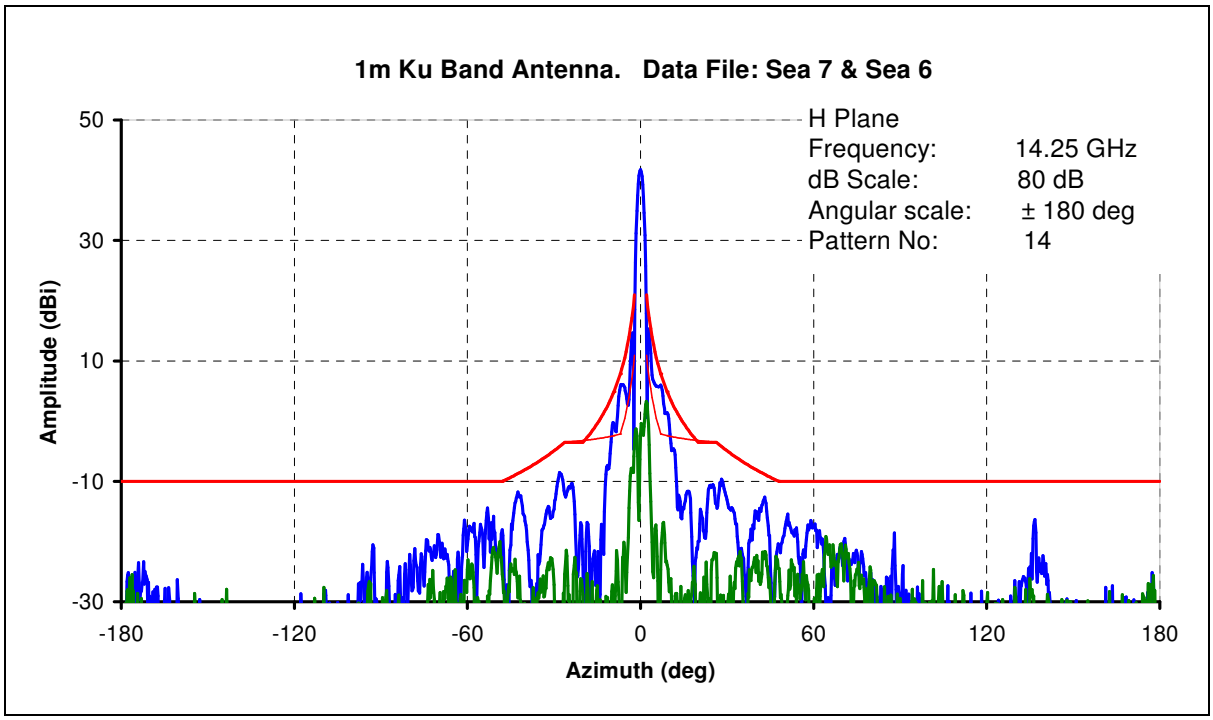


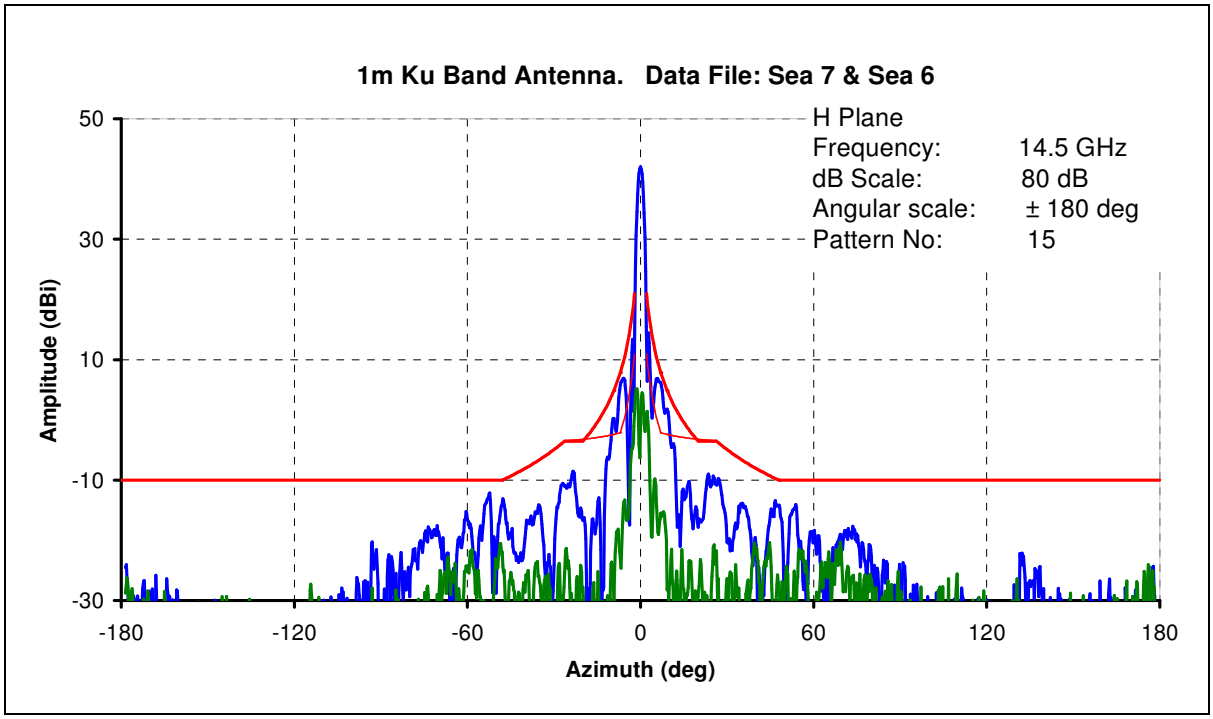


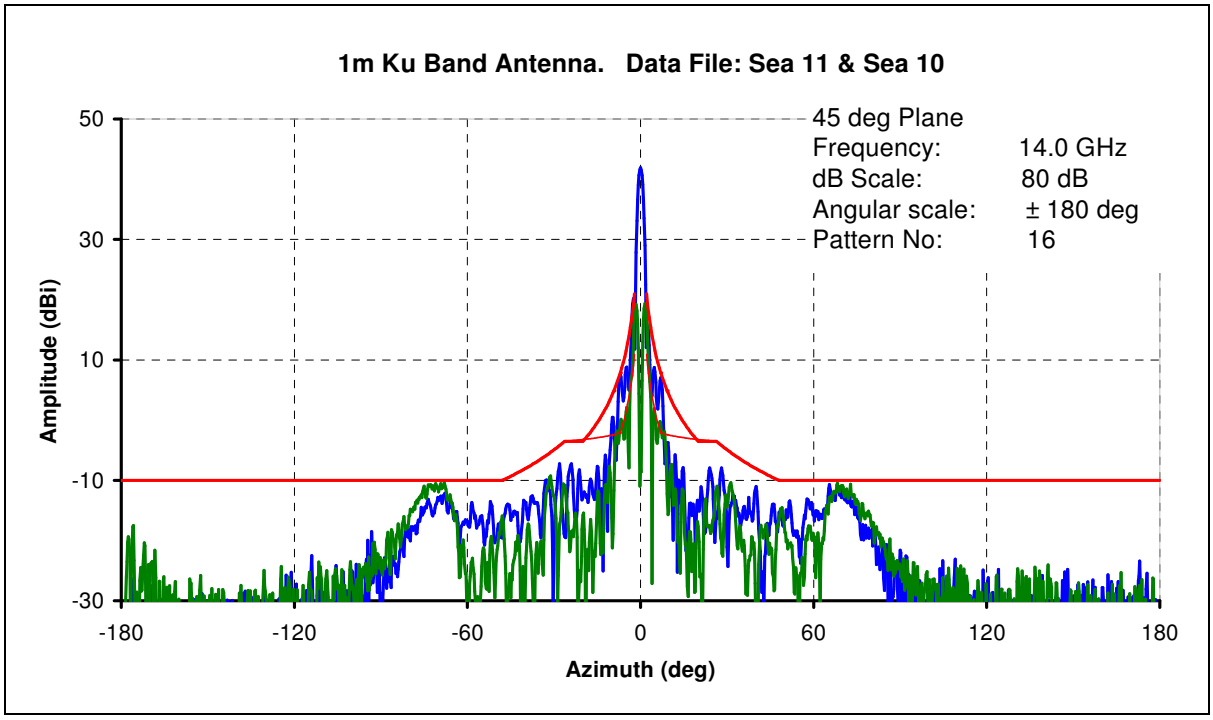


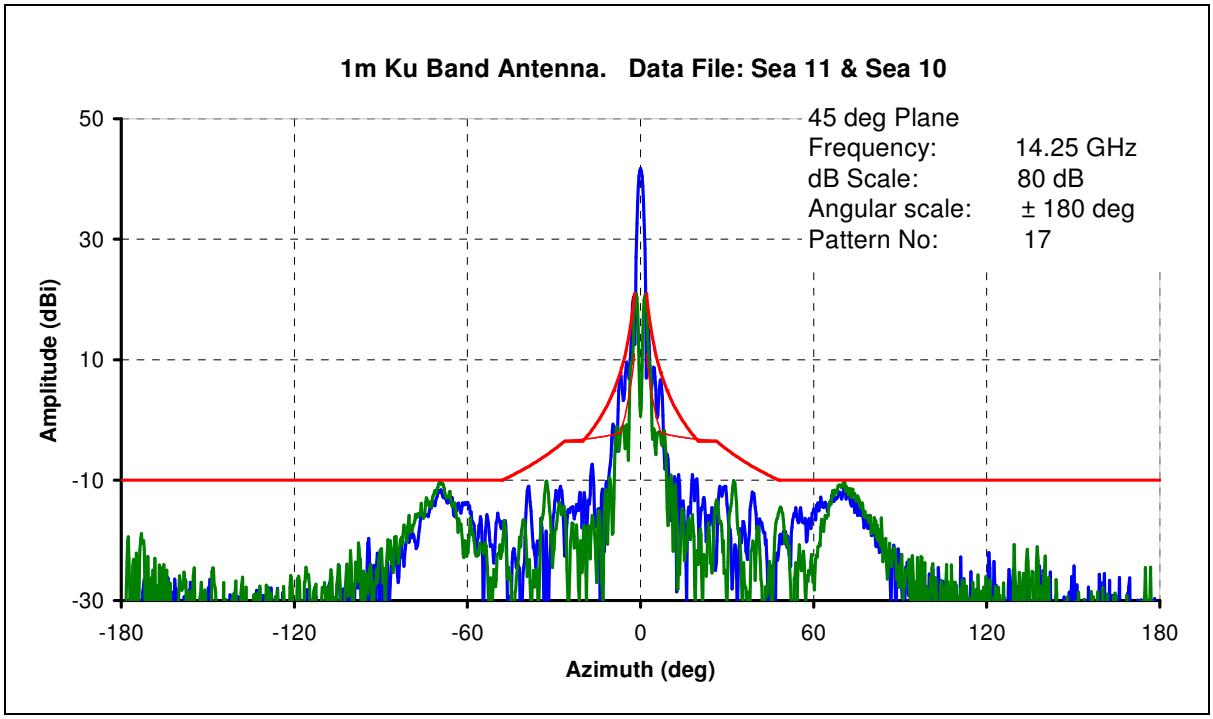


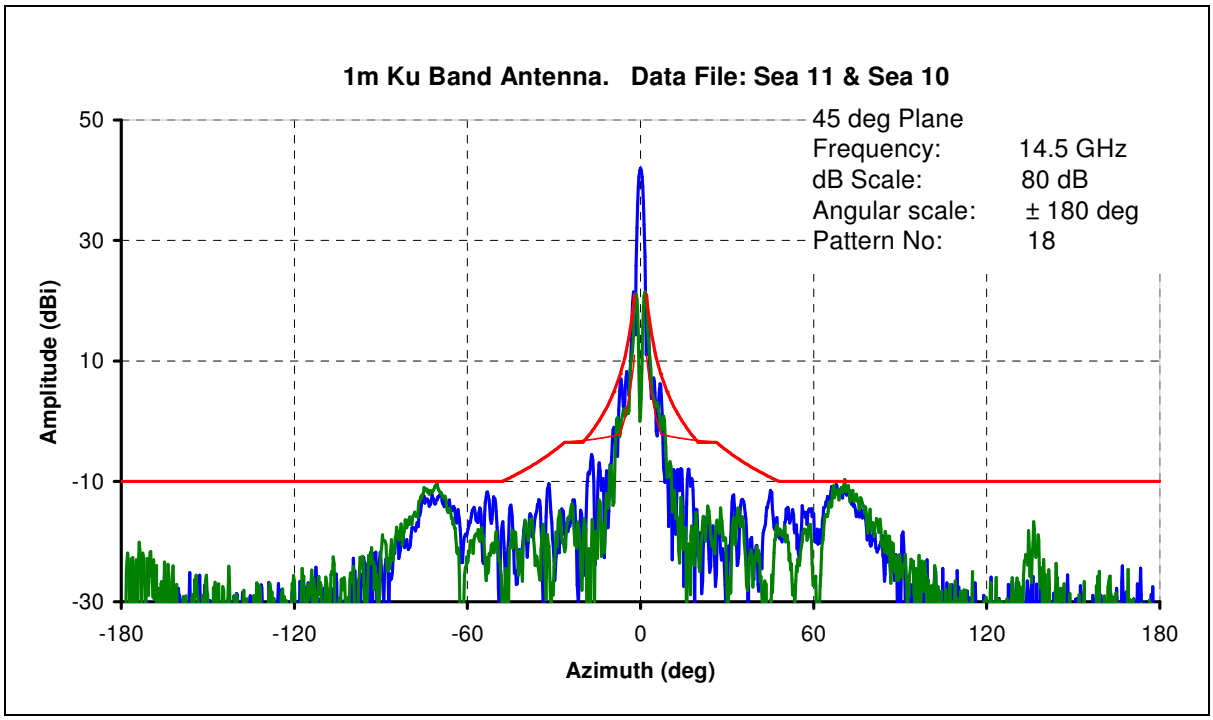












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