Tachyon Airborne Satellite Terminal

Exhibit A – Power Spectral Density Analysis Document
For FCC Special Temporary Authorization

Applicant: Tachyon, Inc.
9339 Carroll Park Drive, Suite 150.
San Diego, CA 92121

Table of Contents

TECHNICAL ANALYSIS

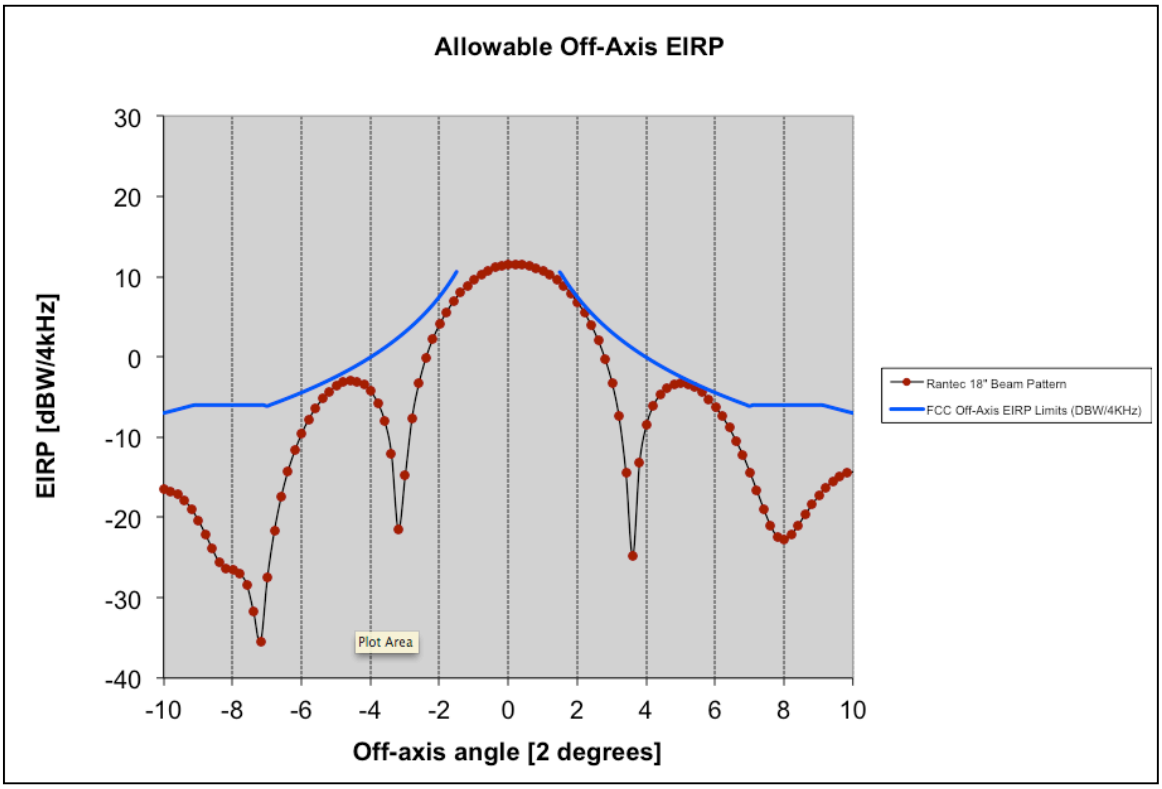
Reference Documents: FCC CFR 47 Part 25
FCC Declaratory Order 3588 4/9/86

1. OVERVIEW OF THE TEST PARAMETERS

Tachyon, Inc. intends to begin conducting tests on a small aperture airborne antenna. The Tachyon small aperture airborne System is a point to multipoint star network consisting of a Hub station and multiple small remote terminals. The proposed tests will demonstrate the performance of the small aperture airborne antenna within a network. The test will be conducted in the 14-14.5GHz and 11.7-12.2GHz range. The hub and antenna will be communicating with Intelsat's Horizons 2 satellite, located at 74.05° W.L.

With regard to FCC compliance there are several conditions for the tests intended to ensure compliance with FCC requirements:

1. The Hub station is licensed separately from this application under call sign E070139. The hub station will be operated in accordance with its licensed parameters.
2. A remote Antenna manufactured by Rantec Microwave Systems will be used for the purpose of testing: their 0.4572 meter airborne antenna model Number 501394. This antenna will be operated in and within 125 nautical miles of a fixed location, with a latitude of 39.521032 North and a longitude of 75.717974 West. This location is the Summit Airport in Middletown, Delaware. Mobile tests will be conducted with the antenna mounted on an aircraft, which will be in motion, either taxiing or in-flight. During the test, the remote earth station will transmit a single 8843 KHz digital carrier with an eirp level of +44 dBW. This corresponds to a transmitted power density level -23.4 dBW/4 KHz. The maximum resulting E-plane eirp density radiation pattern for the above antenna is shown in the Figure immediately below. The corresponding maximum power density level used is -21.4 dBW/4KHz, which is 2 dB higher than the levels transmitted during the test. This shows that the proposed transmission will be compliant with the FCC two-degree spacing requirement as specified in Section 25.218(f) of the FCC Rules, in the range of angles relevant for the purpose of determining harmful interference potential into any lawfully operating co-frequency radio-communication systems. Measured antenna data is also provided in Annex A below.
3. Appropriate measures will be taken to address compliance with FCC radiation hazard requirements, as explained in Exhibit B.



The tests that Tachyon intends to conduct are the following:

1. Inbound Modem performance and BER tests
2. Outbound Modem performance and BER tests
3. Network Management performance
4. Services performance
5. Remote antenna performance

1.1 Test Environment

The hub is located at a commercial teleport facility owned and operated by Intelsat Corporation, and located in Hagerstown, MD. Tests will be operated on Intelsat's H-2 satellite in the Ku-band, and utilizing the East Coast beam.

The number of components tested consists of a field trial quantity of one (1) remote Airborne antenna station and one (1) hub station. The physical location of the remote station will be within 125 nautical miles of GPS coordinates 39.521032 degrees N, 75.717974 degrees W, which is within the continental United States.

All testing will be conducted in a mobile environment.

1.2 VSAT Operation

This document contains a detailed analysis and description of the parameters in the Tachyon, Inc. remote satellite communications terminal using already authorized Ku-Band satellites.

This document will analyze FCC compliance when using a 0.4572 meter airborne antenna with a geostationary satellite in the Ku Band. The remote terminal transmitted signal uses a Multiple Channel Per Carrier (MCPC) waveform. The waveform consists of the following:

Description	Modulation	Data Rates (mbps)	Bandwidth (KHz)
Inbound Waveform	BPSK	1.8	8843
Outbound Waveform	BPSK	1.0	2252

The total system bandwidth for inbound operation is 8843 KHz. The total system bandwidth for outbound operation is 2252 KHz.

The remote antenna produces up to 15.85 Watts of RF power to overcome rainfall availability. The nominal antenna power (clear sky) 10 Watts. The network utilizes spread spectrum techniques to manage power in the inbound path.

The total satellite bandwidth used is 11.095 MHZ.

1. 8.843 MHZ inbound BPSK/SCPC

2. 2.252 MHZ outbound BPSK

The transit frequency requirement is 14.0 GHz to 14.5 GHz Tx, and 11.7 GHz to 12.2 GHz Rx.

The calculations for maximum EIRP are contained in the following sections.

The remote transmitted signal is BPSK digitally modulated waveform plus overhead occupying an RF bandwidth of 8843 KHz within the FCC emissions mask of part 25. The maximum rated RF power into the antenna per terminal is +12 dBW. The maximum controlled power output per terminal is +46 dBW. Under closed loop power control the typical clear sky power is 44 dBW.

Accurate pointing of the antenna is achieved under direction of the Antenna Control Unit (ACU), which is an established product with over 150 units operating on licensed aircraft with 11.5” antennas. The ACU receives aircraft position, heading, orientation and rate of change information from a dedicated Inertial Reference Unit (IRU), which is also an established product with approximately 150 to 175 units in operation on commercial aircraft. The ACU determines the desired antenna azimuth and elevation by executing an open loop pointing algorithm using:

- ephemeris data stored in the modem to determine the satellite location and polarization;
- stored constants to determine the antenna orientation relative to the airframe;
- Latitude, Longitude, and altitude data from the dedicated IRU to determine the aircraft
- location;
- Heading, Yaw, Pitch, and Roll data from the dedicated IRU to determine the aircraft orientation; and
- Speed, Yaw Rate, Pitch Rate, and Roll Rate data from the dedicated IRU to predict changes in aircraft location and orientation.

Once the satellite is acquired, the ACU corrects for aircraft attitude changes based upon the IRU data, without waiting for degradation of the received signal strength. The IRU data is provided every 0.02 seconds, with a data resolution (least significant bit) of 0.05°. The ACU computes the desired antenna azimuth, elevation and polarization 1024 times every second (approximately once every millisecond). The antenna mechanical resolution is 0.09°. The antenna can slew in azimuth and elevation at more than 15° per second, which is sufficient to track aircraft motion within a normal flight envelope. The total root mean square pointing error for the antenna is calculated to be less than 0.1°, which is sufficient to satisfy the requirements for minimizing off-axis emissions, while maintaining the necessary gain for proper system operation.

The link quality measures of E_b/N_o and packet loss rate will be used to determine when the Forward link has degraded to the point where loss of antenna pointing will be declared. The Return link transmission then is terminated within 250 ms typically (820 ms worst case), until the antenna catches up and system lock is restored.

The antenna receive polarization choices are selectable as linear horizontal, linear vertical, right-circular or left-circular. Transmit polarization is linear and aligned to be orthogonal to the selected receive polarization. The antenna dish can be rotated 210°for fine control (0.25°) of the polarization. The ACU executes an open loop algorithm using the same inputs that it uses for antenna pointing to control the polarization.

1.3 Test Objectives

This STA is performed under a US Government program for potential use as part of an existing mobile aeronautical service currently provided outside the United States to a U.S. Government customer. Test this new antenna will allow Tachyon to determine whether it may be incorporated into the existing U.S. Government service offering.

2.0 FCC Compliance

Tachyon, Inc. is providing analysis in this submittal that verifies the system will operate jointly with other primary fixed services on a non-interference basis.

Tachyon, Inc. complies with the requirements of Part 25 in the following ways.

1. The Power Density Requirements (FCC Declaratory Order (fn 35), which is Based in part 25.209(f) "Antenna Performance Standards," is complied with by using 0.4572 meter antenna and additional spread spectrum waveform techniques to meet the Power Density Requirements. Adjacent Satellite interference criteria is met by compliance with this FCC order.

2. Susceptibility to interference from FSS and terrestrial sites are complied with by using 0.4572 meter parabolic center bore feed reflector.

3. The minimum elevation angle part 25.205>5°. This requirement is controlled in installation.

4. Emission Limitations, part 25.202(f) are complied with through appropriate filtering and modulation control.

The analysis, that follows, indicates that the operation of the proposed airborne antenna guarantees that no unacceptable interference into existing KU-Band operations in a 2-degree spacing environment will result.

For guidance on the non-interference issues, the standard references for the power flux density levels are specified in the referenced FCC Declaratory order (see paragraph 10 & 14). This paragraph indicates that the following levels are acceptable within the routine licensing process:

(1) -14 dBW/4kHz Transmit power into the antenna (Inbound Link) (per Earth Terminal Channel)

(2) 512 Kbps maximum gross bit rate (Inbound) (per Earth Terminal)

(5) Antenna conforming to CFR 47 §25.209 or a demonstration that the antenna (and waveform) will not cause unacceptable interference.

The analysis is summarized below using the following parameters (RF Bandwidth=8843 kHz) with a modulation waveform spread spectrum BPSK.

(1) Inbound PD(Into Antenna)-Modulation waveform BPSK.

a.) Maximum Rated Power Density:
= +12 dBW(RF Maximum Power) / 7000 Ksps = -21.4 dBW/4kHz/channel

b.) Clear sky Power Density level:
= +10 dBW(RF Typical Power) / 7000 Ksps = -23.4 dBW/4kHz/channel

To insure that the Inbound terminals do not exceed power density requirements per FCC Declaratory order 3588, the system uses a spread spectrum waveform.

To provide confirmation that the Inbound terminals collectively will not cause interference in a 2 degree spacing environment, the EIRP of the proposed terminals has been compared against the equation referenced in the FCC Declaratory Order, Footnote 35, i.e.[15-25 Log (Lambda)] dBW/4kHz regarding VSAT Power Density requirements.

EIRP is the sum of the Inbound power density calculated above and the gain of the antenna proposed at a given angle off bore axis, with 0 degrees representing maximum gain.

The conclusion is that the terminal proposed is in compliance with FCC Part 25 rulings as well as FCC Declaratory Order 3588 4/9/86.

OEM Vendor Equipment:

1. Remote Antenna – Rantec Microwave Systems 0.4572 meter airborne antenna model Number 501394

3.0 EMISSION DESIGNATOR

The remote terminal will transmit in the 14.0-14.5 GHz (Earth to Space) and receive in the 11.7 to 12.2 GHz (Space to Earth) Fixed Satellite Service (FSS) band. The emission type is standard BPSK. The emission designator is expected to be 8M85G7W. This bandwidth per the FCC definition of occupied 50dB bandwidth, Section 25.202(f1) is presently 8843 KHz or (8843K). The other designator numbers (i.e., G-Phase Modulated, 7-two or more channel per carrier, W- combinations of types of information) are as defined in Section 2.201.

Annex A

Measured Antenna Data

Rantec 18” Ku-band Antenna

Model Number 501394

MI-3000 Analysis Results

Value being computed	*Min*	*Result*	*Max*	*Units*

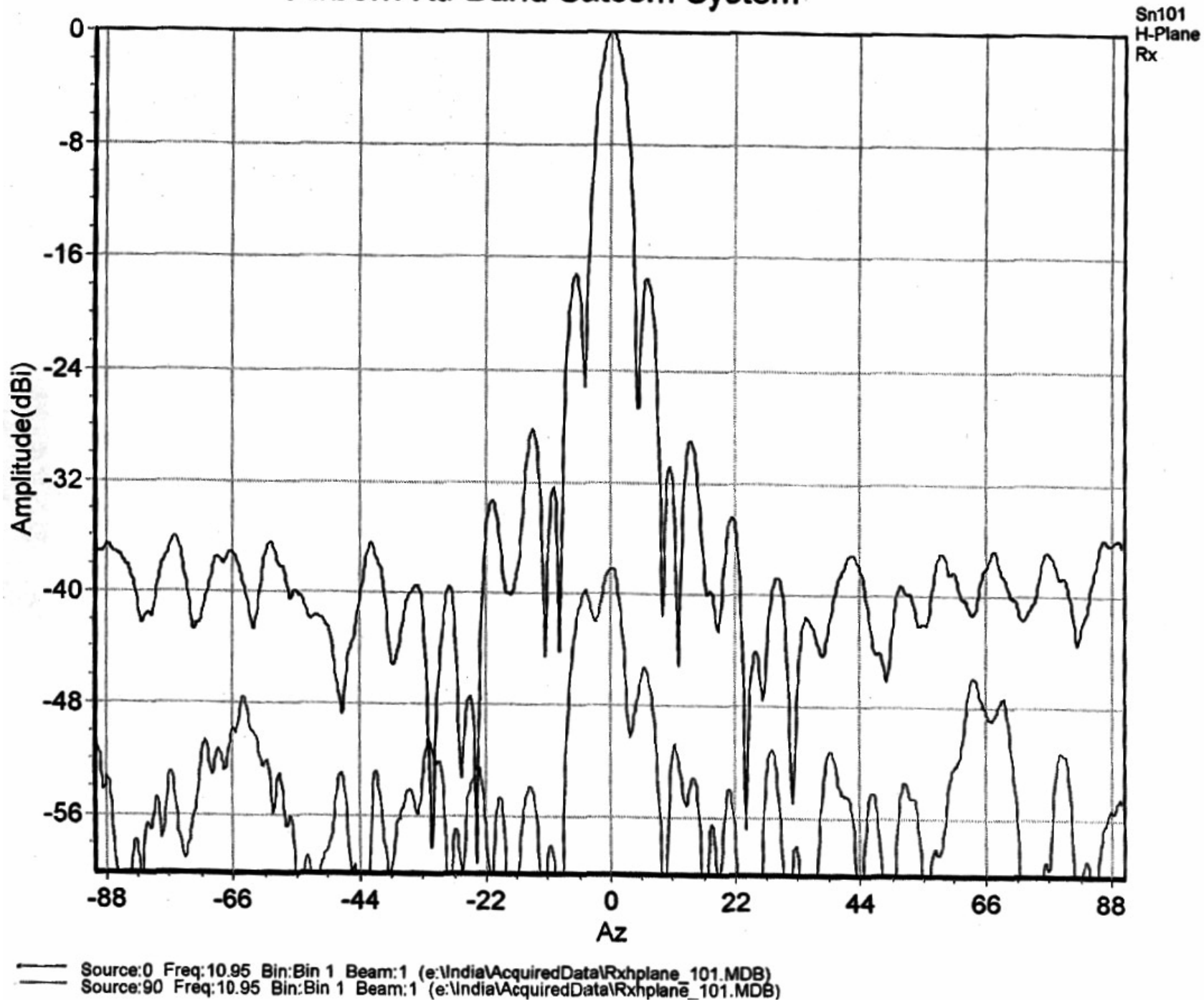
Gain Measurement Analysis

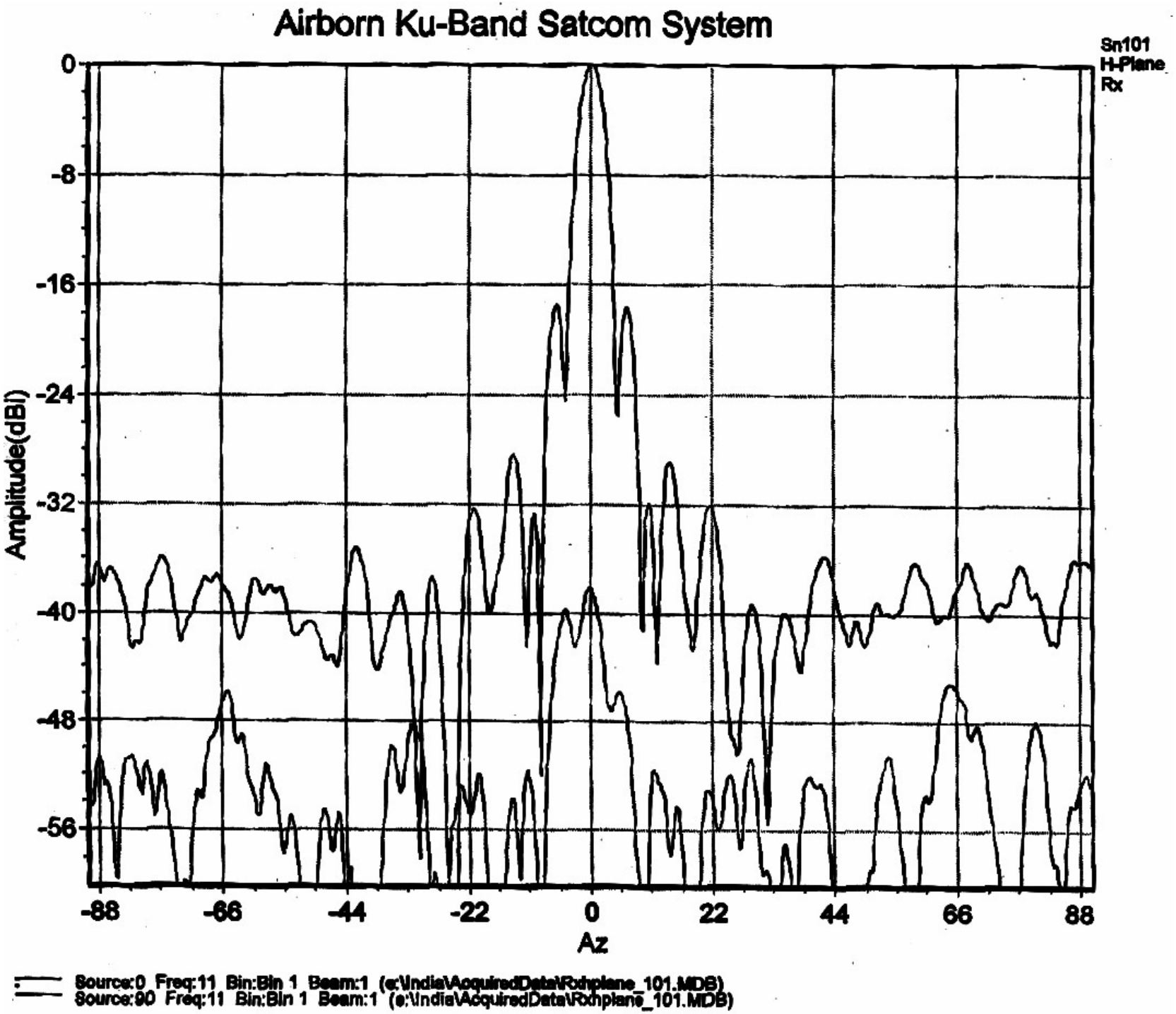
Antenna Gain (dBi) at f =	10.950	**32.08**
Antenna Gain (dBi) at f =	11.000	**32.44**
Antenna Gain (dBi) at f =	11.300	**32.24**
Antenna Gain (dBi) at f =	11.700	**32.77**

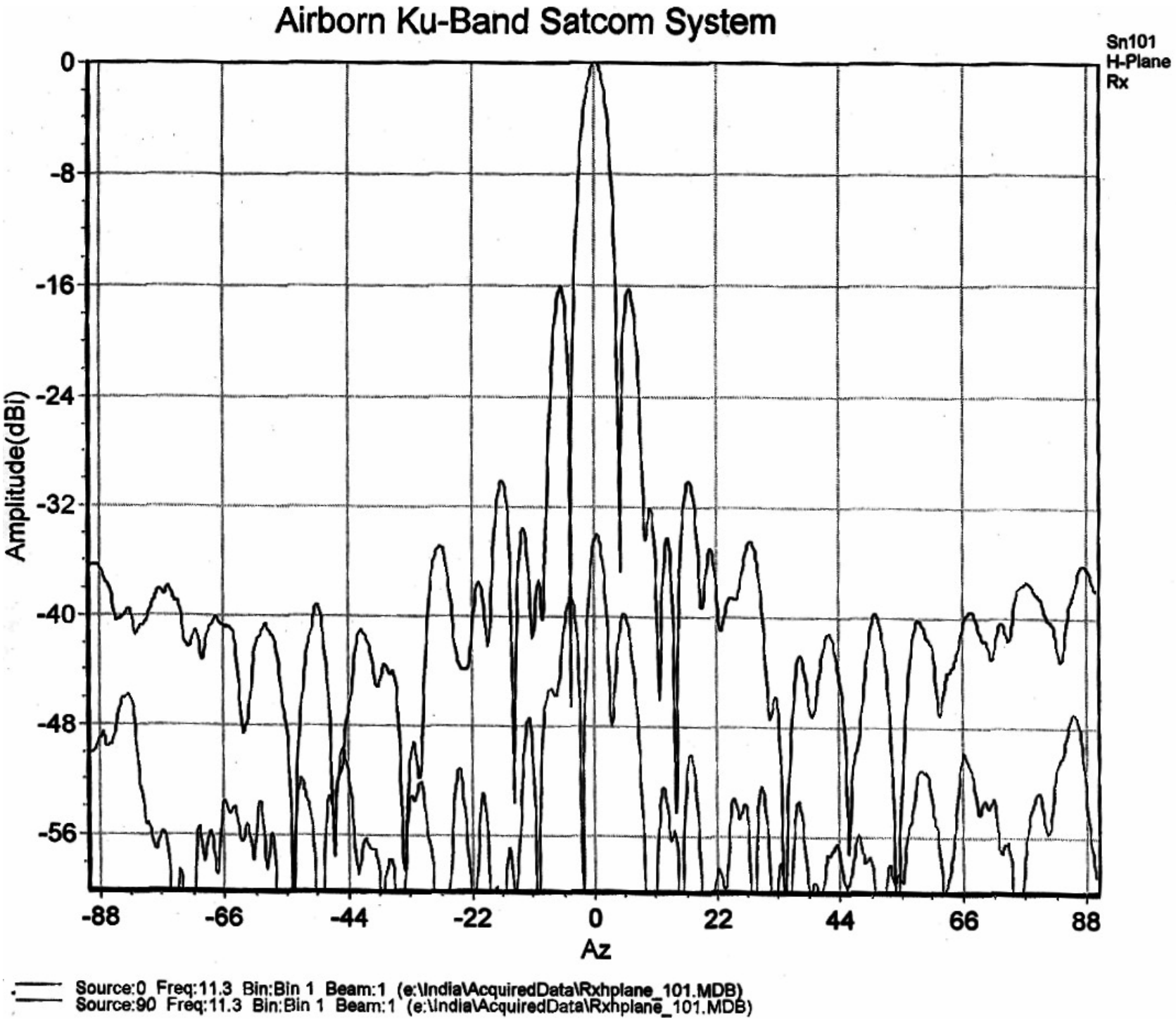
Gain Analysis of file
e:\India\AcquiredData\Rxhplane_101.MDB

Analysis performed on AUT measurements of:
all frequencies
a linearly polarized range and AUT
all channels
and Gain Standard measurements:
from file e:\India\AcquiredData\Rxgst_101.MDB
assuming gain standard '8.2 - 12.4'
on the Bin 1 channel

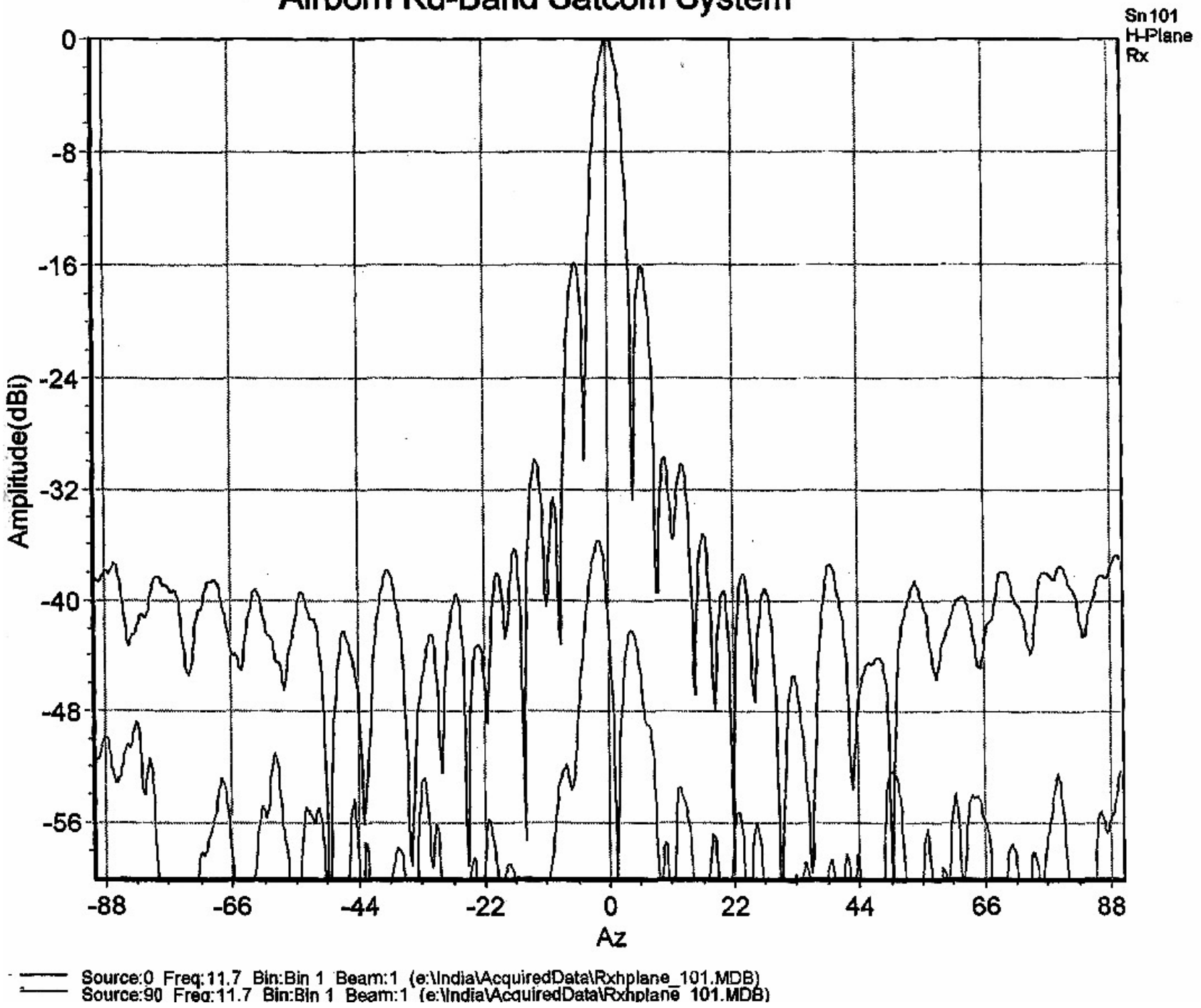
Airborn Ku-Band Satcom System

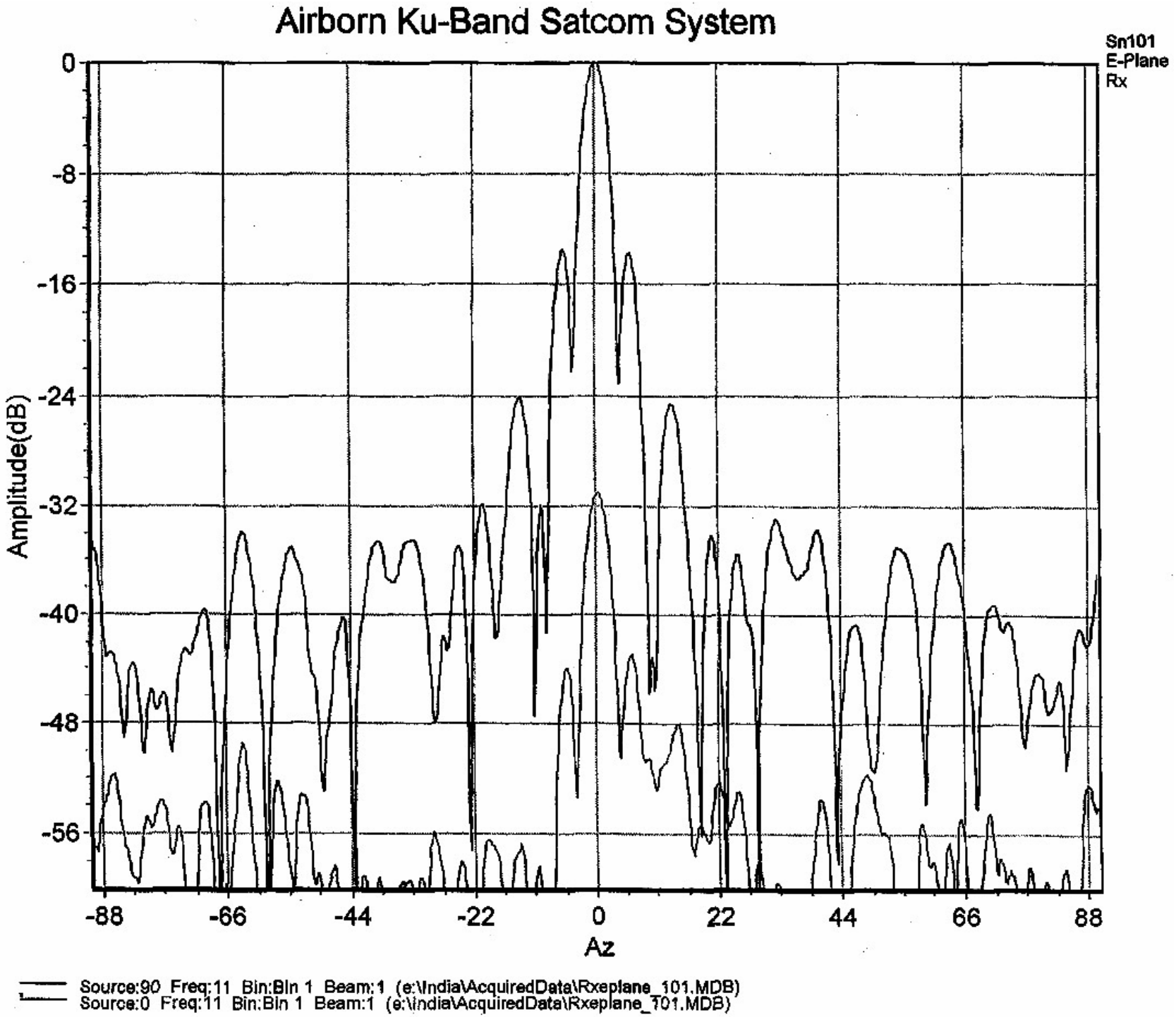


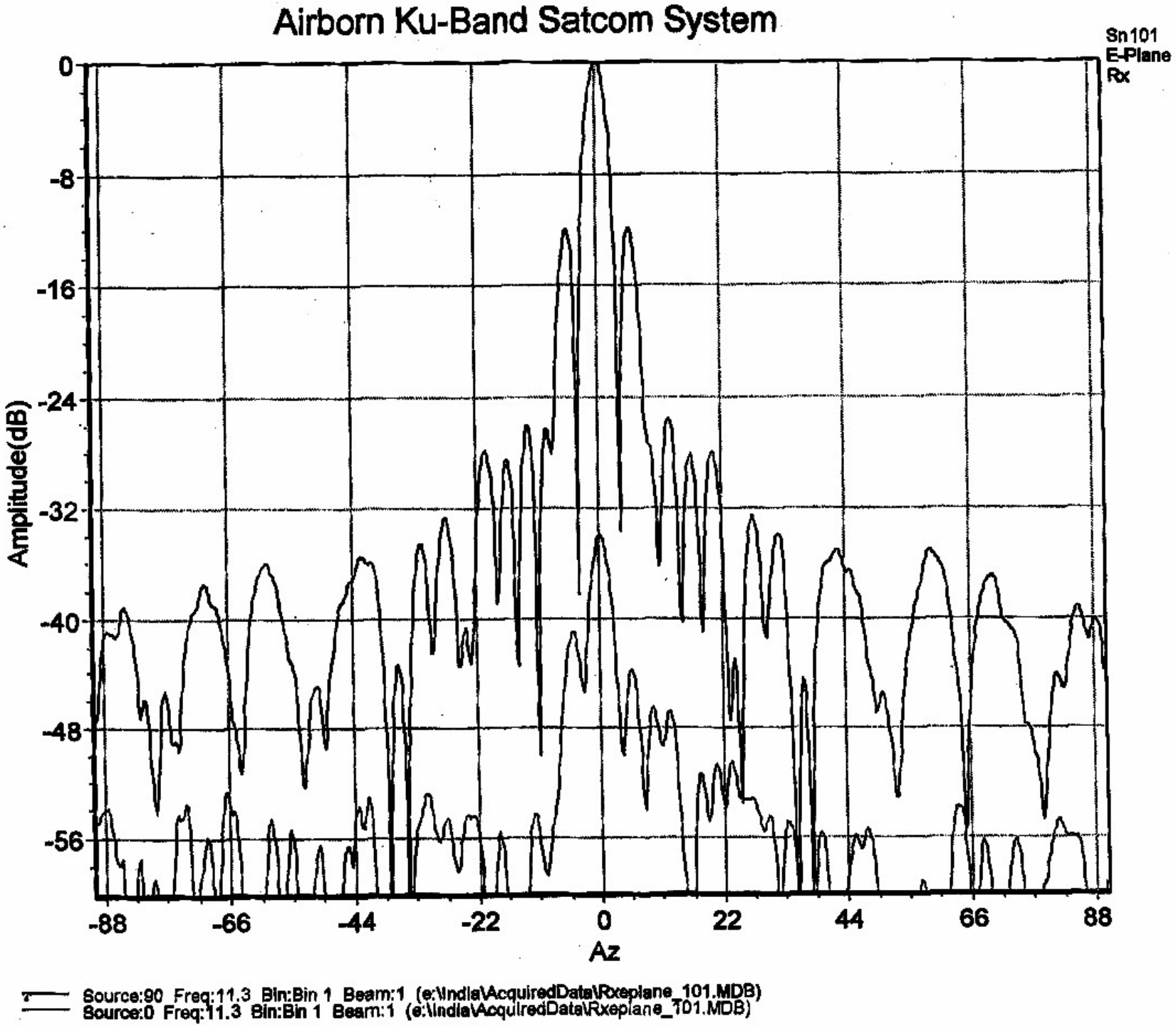

Airborn Ku-Band Satcom System
Sn101
H-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dBi)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rohplane_101.MDB)
Source:90 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rohplane_101.MDB)

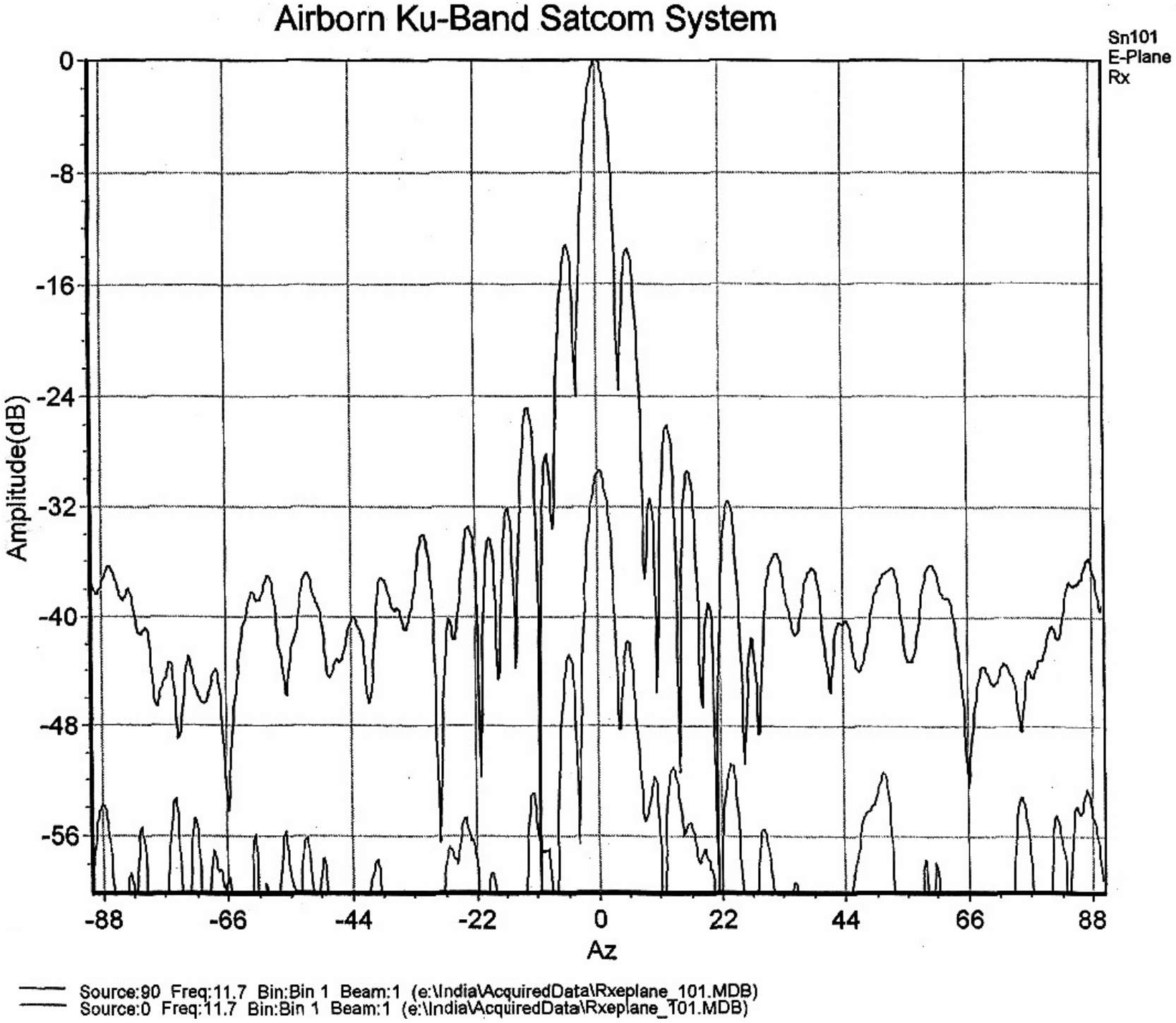

Airborn Ku-Band Satcom System
Sn101
H-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dBi)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxhplane_101.MDB)
Source:90 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxhplane_101.MDB)

Airborn Ku-Band Satcom System




Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
Amplitude(dB)
0
-8
-16
-24
-32
-40
-48
-56
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11.7 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11.7 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)

MI Technologies

MI-3000 Analysis Results

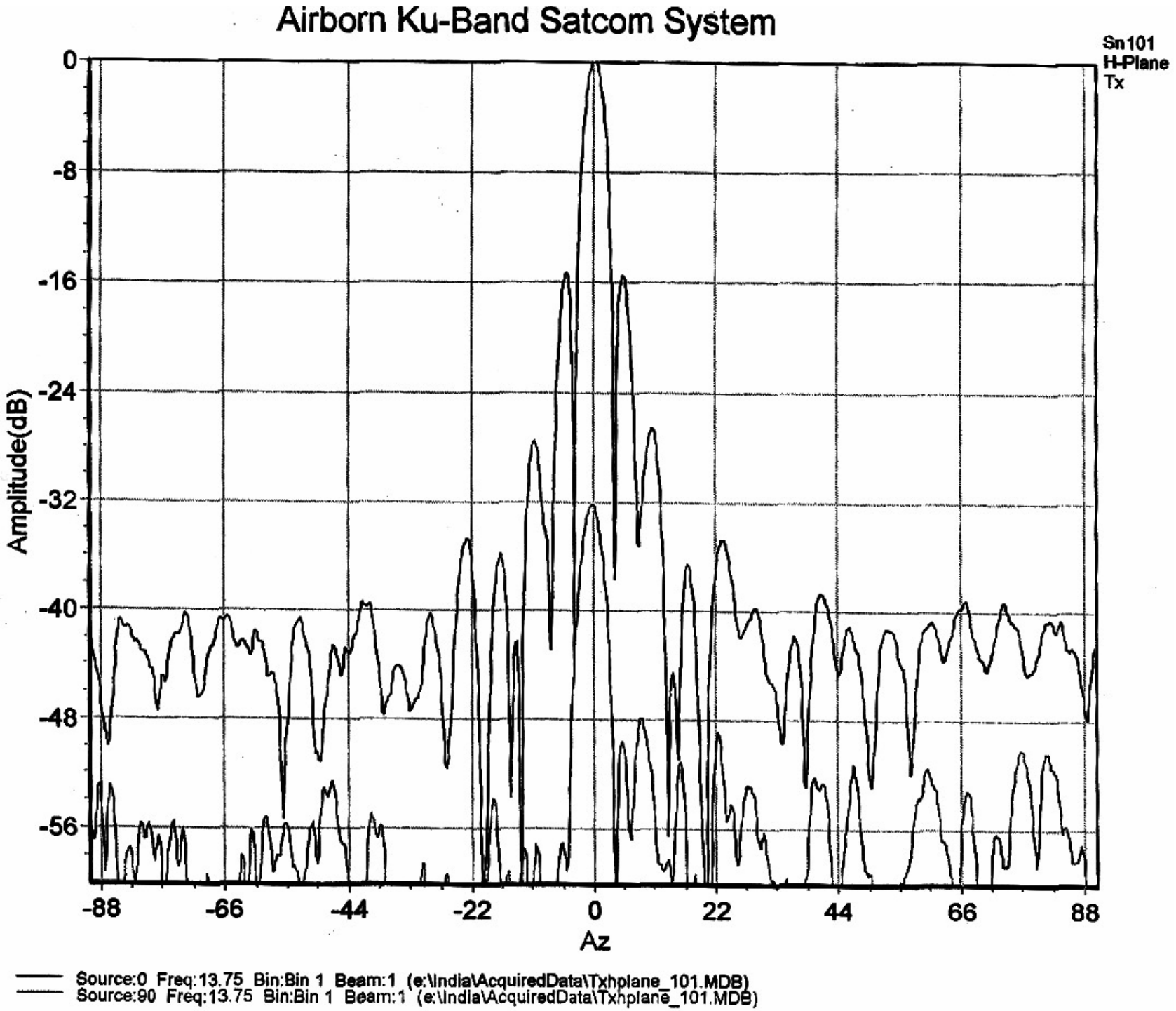
Value being computed	*Min*	*Result*	*Max*	*Units*

Gain Measurement Analysis

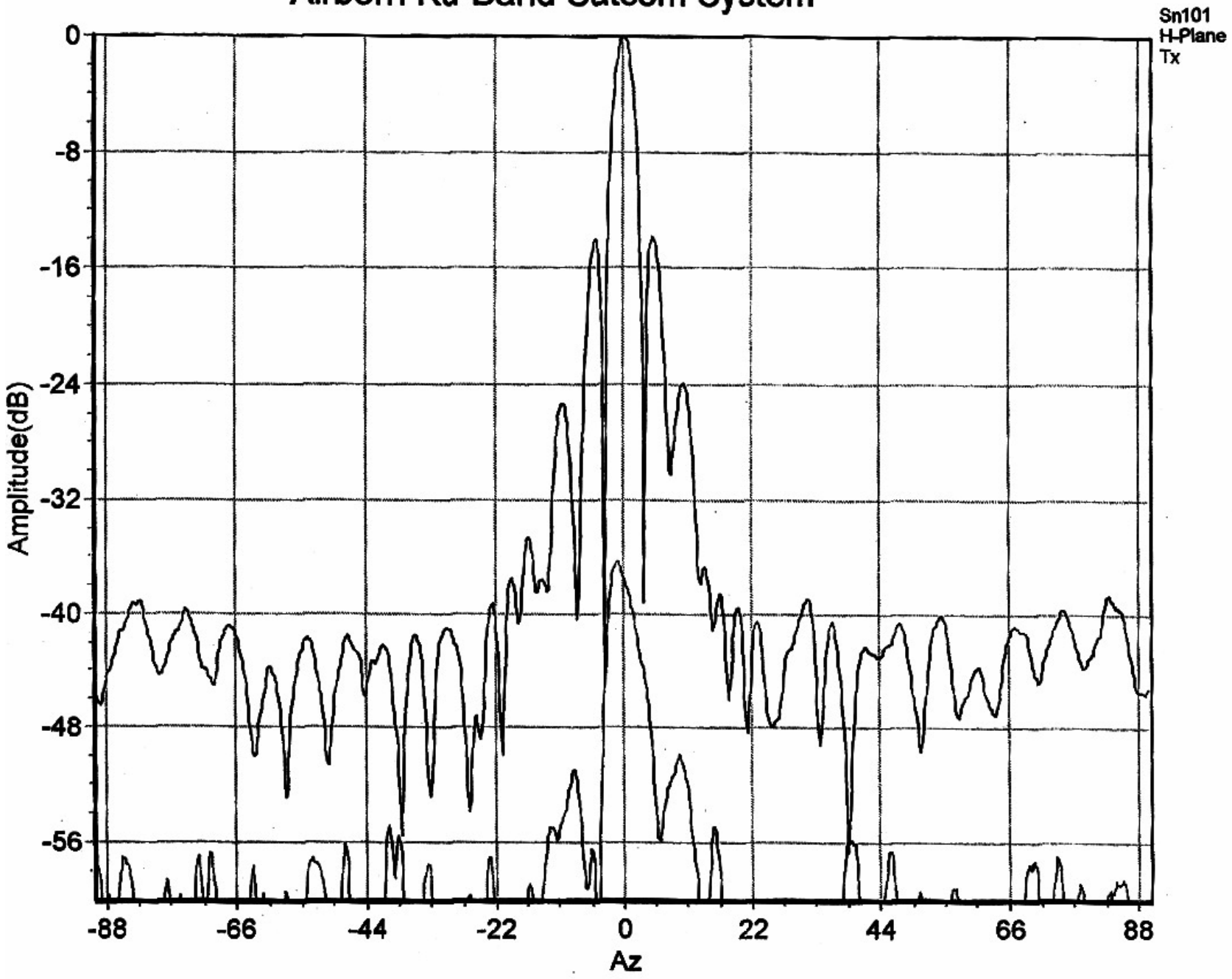
Antenna Gain (dBi) at f =	13.750	**33.69**
Antenna Gain (dBi) at f =	14.000	**34.37**
Antenna Gain (dBi) at f =	14.500	**34.47**

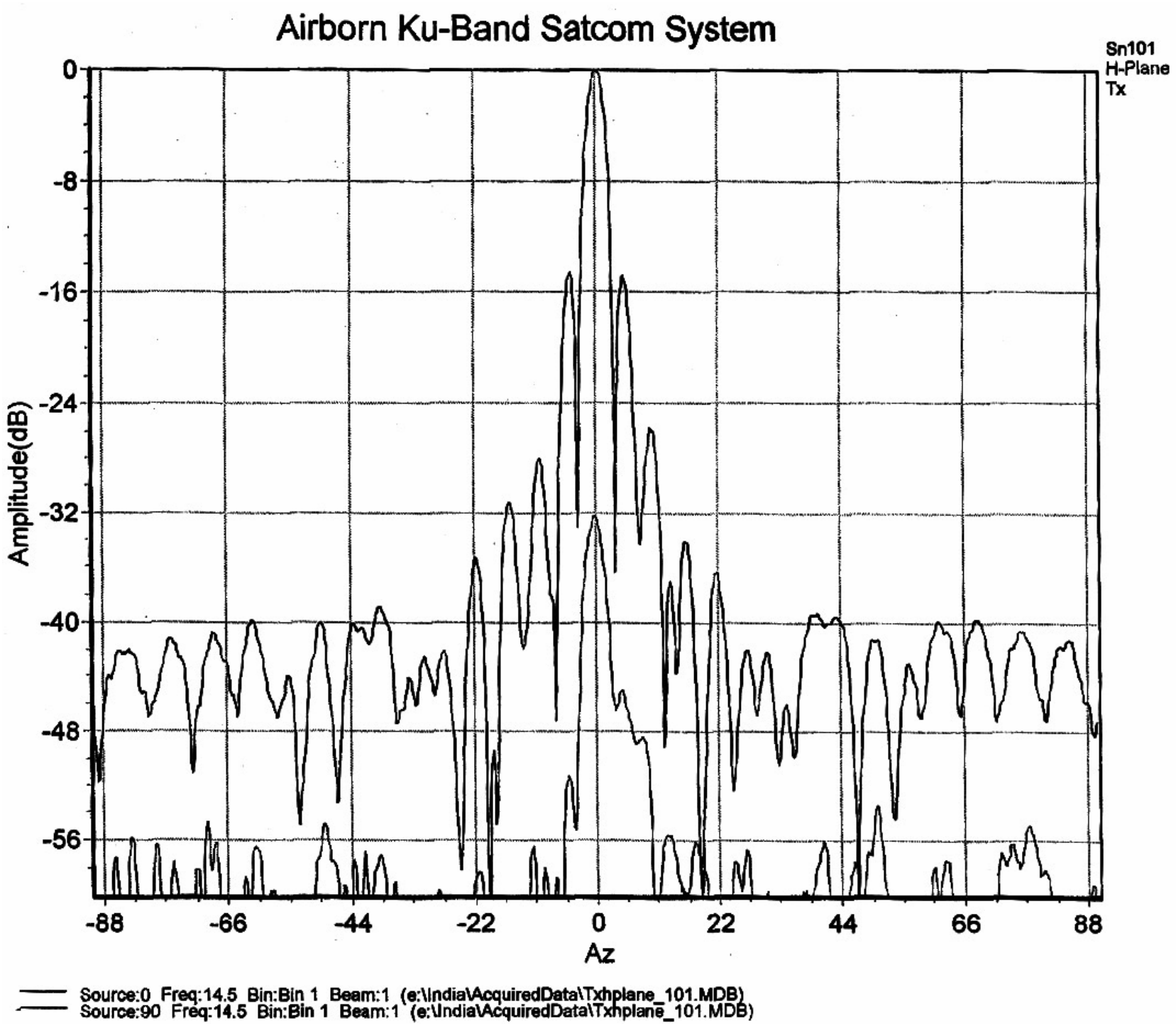
Gain Analysis of file
e:\India\AcquiredData\Txhplane_101.MDB

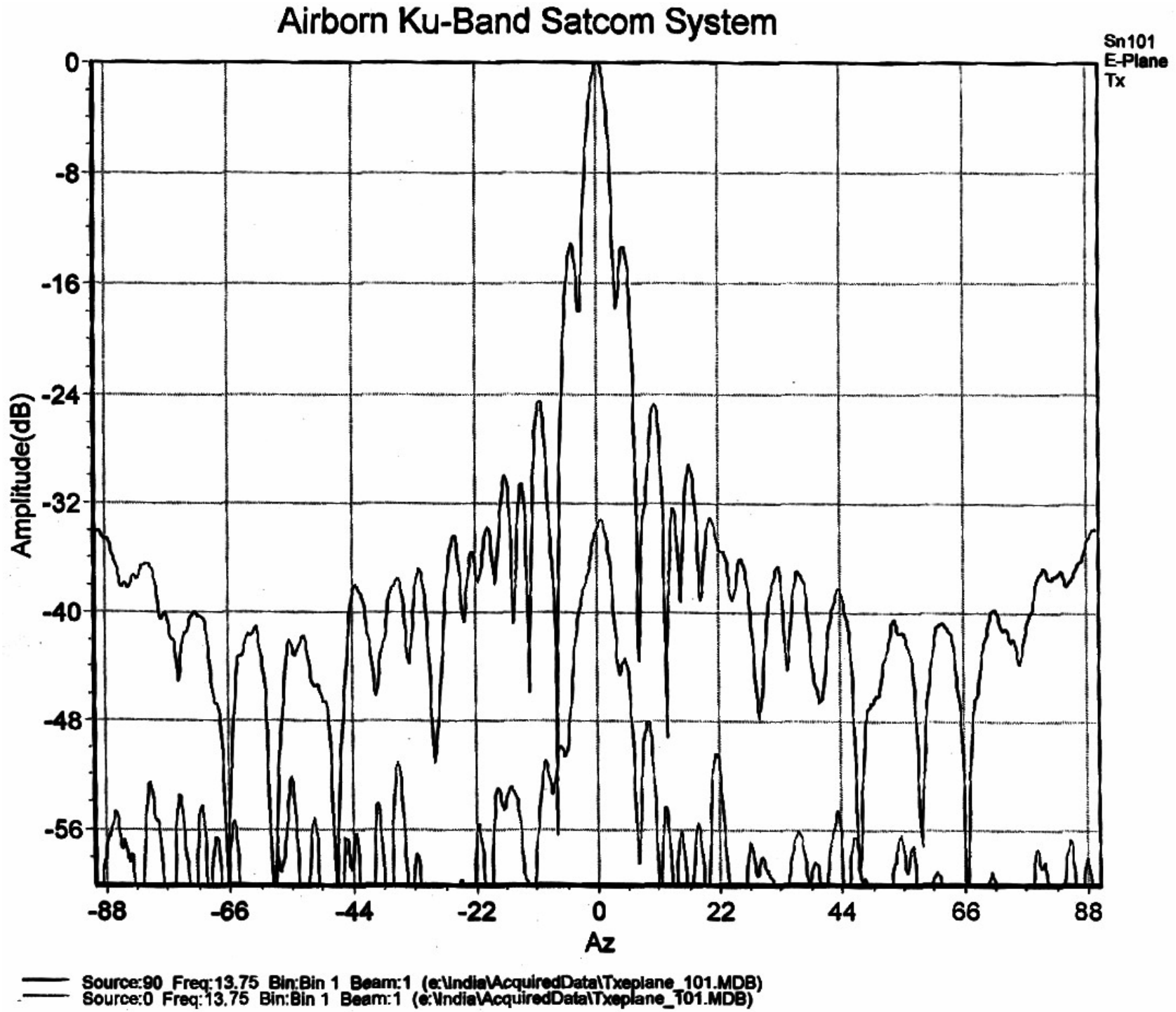
Analysis performed on AUT measurements of:
all frequencies
a linearly polarized range and AUT
all channels
and Gain Standard measurements:
from file e:\India\AcquiredData\Txgst_101.MDB
assuming gain standard '12.4 - 18.0'
on the Bin 1 channel

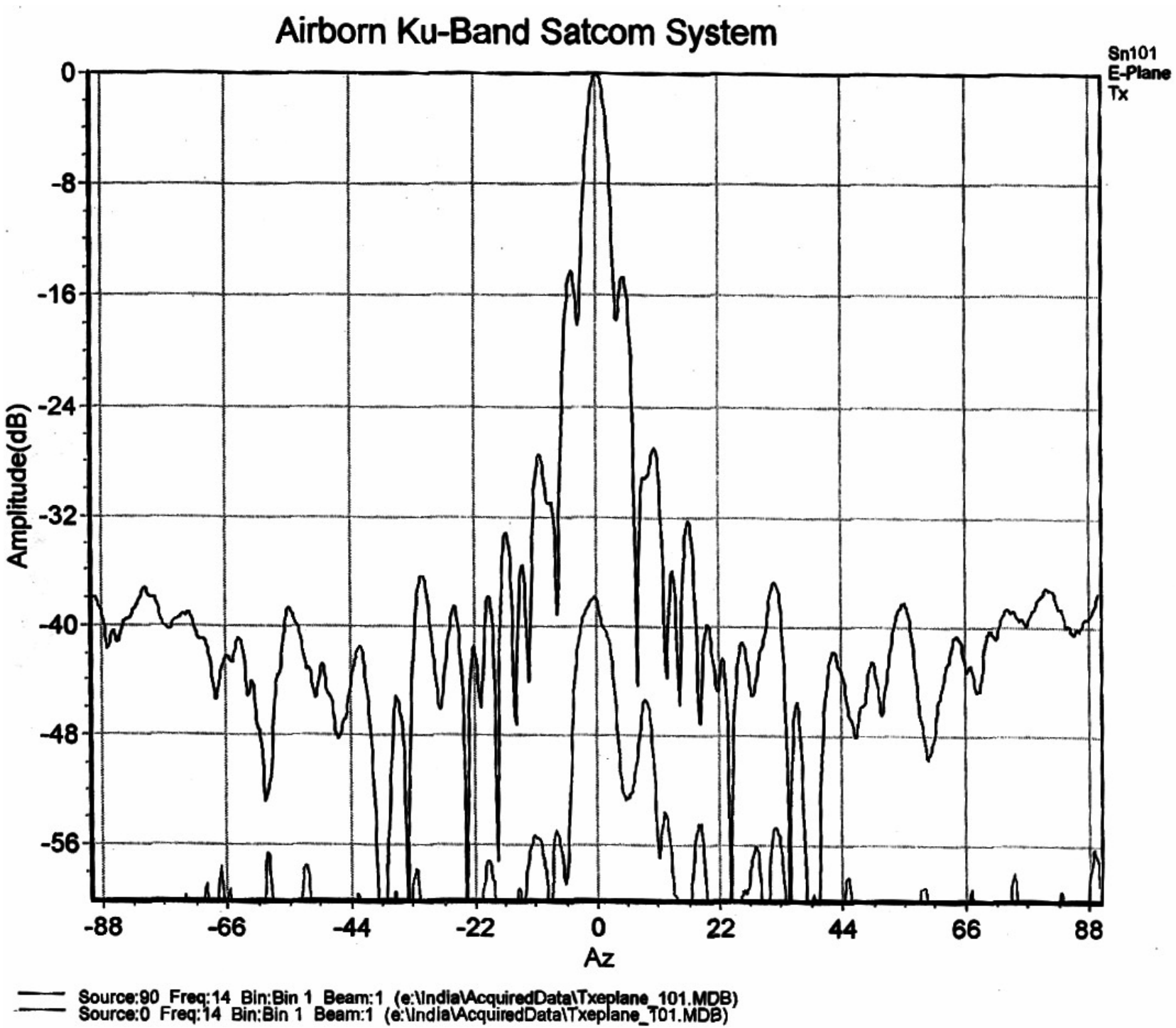

Airborn Ku-Band Satcom System
Sn101
H-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)
Source:90 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)

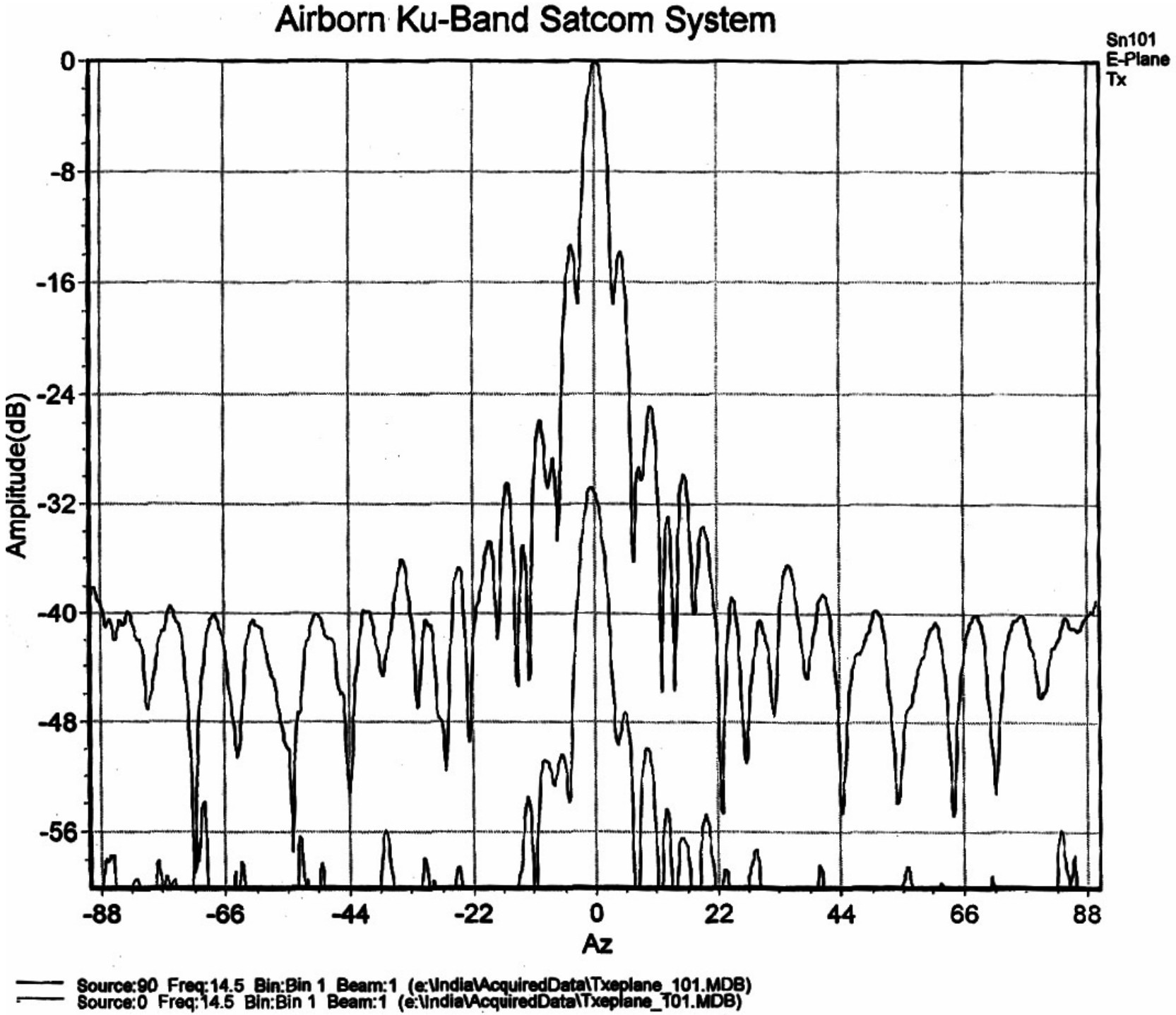
Airborn Ku-Band Satcom System




Airborn Ku-Band Satcom System
Sn101
H-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)
Source:90 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_T01.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:14 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:14 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_T01.MDB)