TECHNICAL APPENDIX

Panasonic Avionics Corporation

Single Panel Antenna ("SPA")

I. Technical Description

This Technical Appendix describes the operational characteristics of the Panasonic Single-Panel Antenna ("SPA") earth station aboard aircraft ("ESAA") terminal with the licensed eXConnect Ku-band broadband system. The eXConnect System consists of a network of eXConnect ESAA terminals (the "ESAA Segment"), leased satellite capacity on commercial Ku-band FSS satellites (the "Space Segment") and iDirect hub earth stations and network management functionality (the "Ground Segment").

Because this application seeks authority to operate the SPA terminal with a limited number of satellites and no other changes to the eXConnect System are proposed, consistent with the Commission's rules and policies this Technical Appendix only provides new or additional information relating to the proposed SPA operations.

1 ESAA Segment

In addition to the licensed MELCO and Panasonic Phased Array ("PPA") ESAA terminals, the ESAA Segment will include the SPA terminal and a previously described broadband controller. The SPA terminal was specifically designed for the aeronautical environment and compatibility with the eXConnect System.

1.1.1. SPA Antenna Sub-System

The SPA terminal antenna is a mechanically steered phased array antenna using CoMPA™ (Coherent Multi Plate Antenna) technology. It is comprised of a single dual-polarization panel with full receive and transmit bandwidth capability with an elevation range of 0º to 90º. The SPA terminal is shown in Figure 1.

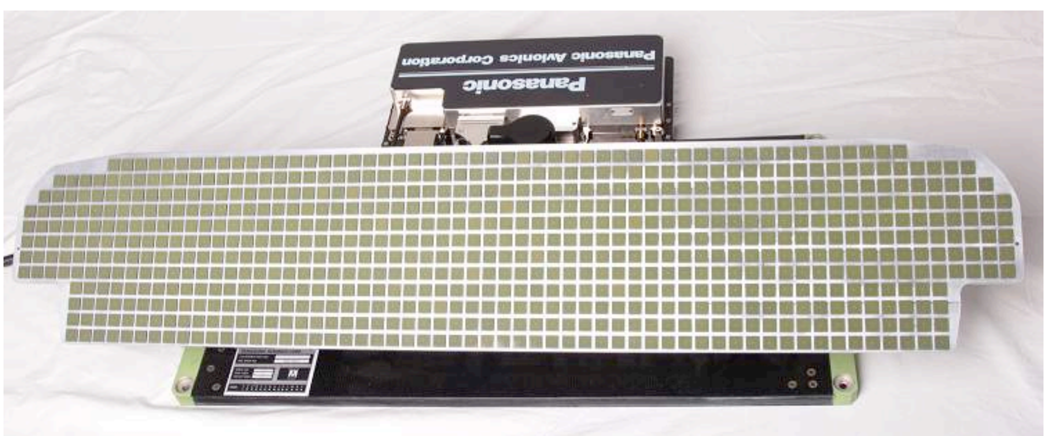

Figure 1. SPA Terminal.

The basic characteristics of the SPA terminal are summarized in Table 1 below.

Table 1. Summary of SPA Terminal Technical Parameters

Antenna diameter	37.4 inches (949mm)
Type of Antenna	Single-panel phased array
Peak Power (SSPA)	10 watts
Transmit Bandwidth	14.0 GHz to 14.5 GHz
Standard Receive Bands	Five Standard Switched Bands of 500 MHz: 10.70 to 11.20 GHz 11.20 to 11.70 GHz 11.70 to 12.20 GHz 12.25 to 12.75 GHz 12.20 to 12.70 GHz
Transmit Gain	35 dBi @14.250 GHz
EIRP	≥ 45 dBW
Transmit Polarization	Horizontal or Vertical
Receive G/T	12.5 dB/k
Transmit Max PSD (dBW/4kHz)	-8.657 dBW/4kHz
Transmit Azimuth Beamwidth	1.25 degrees
Transmit Elevation Beamwidth	7.25 degrees

1.1.2. Antenna Pointing

Pointing for the SPA terminal is accomplished via mechanical steering of the antenna and uses the aircraft attitude data (*i.e.*, yaw, roll, pitch and heading vector), together with location of the aircraft (latitude, longitude and altitude) to calculate the command vectors. This data, available from the ARINC 429 bus, is used in conjunction with the satellite coordinates to yield continuously updated steering commands for the antenna elevation, azimuth, and polarization.

As indicated in the attached Pointing Accuracy Report, which provides a detailed analysis of the SPA terminal's pointing characteristics, the pointing error of the terminal will be less than 0.20 deg 3-sigma. Pointing error is continuously monitored and emissions are automatically inhibited if the azimuth pointing error ever exceeds 0.5 deg.

The basic pointing characteristics of the SPA terminal are summarized in Table 2 below.

Table 2. Summary of Antenna Control Parameters

Azimuth	360 degrees
Elevation	0 to 90 degrees
Position Accuracy	0.2 degrees, 3-sigma
Dynamic Tracking Capability	AZ 40 degrees/sec. velocity EL 20 degrees/sec. velocity

1.1. Waveforms

1.1.1. Description

The eXConnect System uses well established industry standard waveforms: DVB-S2 and iDirect D-TDMA. The iDirect forward link (hub to mobile terminal) will consist of a single DVB-S2 carrier that may occupy up to a full transponder and operate in saturation but in most cases will be operated in a partial transponder. DVB-S2 is a widely adopted standard for digital data and video broadcasting over satellite. Data may be multiplexed on this carrier for multiple terminals. The DVB-S2 standard supports Adaptive Coding and Modulation (ACM) with QPSK, 8PSK, and 16APSK modulations and Low Density Parity Check Coding rates between 0.25 and 0.9.

1.1.2. Out of Band Emissions

The SPA terminal will comply with the emissions limitations in 47 C.F.R. §25.202(f). The SPA terminal antenna ceases transmission in the event of the following fault conditions:

- Loss of ARINC-429 data from the IRS.
- Invalid status message from the IRS.
- Loss of 10 MHz reference.
- Antenna out of position. If azimuth pointing error exceeds 0.5 degrees, the antenna ceases transmission within 100 ms and will not resume transmission until the pointing error is less than 0.2 degrees.
- Any critical fault detected by the antenna.

Furthermore, any event that results in the loss of modem lock to the DVB-S2 downlink will cause the modem to cease all transmission.

2. PROTECTION OF GSO FSS SERVICES

The eXConnect System will protect GSO and NGSO FSS operations, space research, and radio astronomy service operations in the 14.0-14.5 GHz Band. Because coordination agreements and operational restrictions that are already applicable to eXConnect System operations will protect other co-frequency services, the following discussion focuses on SPA terminal operational characteristics in the context of protecting primary GSO FSS operations.

2.1. Off-Axis EIRP Spectral Density Control

The SPA terminal protects GSO FSS uplink (satellite receive) operations by controlling the off-axis EIRP spectral density generated by a SPA terminal so that it is no greater than the levels of interference that have been accepted by the adjacent satellites in coordination or the levels for Ku-band ESAA terminals under FCC Part 25.

The U.S. off-axis limits on EIRP spectral density limits under FCC Part 25 are defined by 25.227, where N = 1 for TDMA, is given by:

15–25log10 (Θ)	dBW/4 kHz	For	1.5° ≤ Θ ≤ 7°
−6	dBW/4 kHz	For	7° < Θ ≤ 9.2°
18–25log10(Θ)	dBW/4 kHz	For	9.2° < Θ ≤ 48°
−24	dBW/4 kHz	For	48° < Θ ≤ 85°
−14	dBW/4 kHz	For	85° < Θ ≤ 180°

Off-axis EIRP spectral density is managed on an individual terminal basis. Only one SPA terminal transmits at a given time and in a given bandwidth. eXConnect does not use contention so management of aggregate emissions is not required. The off-axis EIRP spectral density of an individual eXConnect terminal is a function of its transmit signal bandwidth, input power to the antenna, the projection of the antenna gain pattern of the antenna along the geostationary arc, and antenna pointing error.

Input power to the SPA terminal is controlled by limiting the output power of the modem. A built in power meter in the antenna is used to calibrate the input power to the antenna accurately and remove any gain variation between the modem and the antenna. The input power limitations are specified on a satellite beam-by-satellite beam basis

The contribution of pointing error to off-axis EIRP spectral density is minimized by inhibiting pointing errors greater than 0.5 deg. and not resuming transmission until the pointing error is less than 0.2 deg. The SPA terminal has been proven to operate on an interference-free basis within these pointing parameters in test operations for more than a year. There have been no reported interference cases associated with SPA terminal operations.

Antenna gain and off-axis EIRP of the SPA terminal at various skew angles is shown in the attached Technical Annex. The off-axis EIRP spectral density ("ESD") values are based on the specific link parameters for two-degree compliant operations in the United States. The terminal off-axis ESD remains well below the 25.227 off-axis ESD limit for all off-axis ranges. Even with the pointing error of the terminal is included in the off-axis ESD, it remains below the off-axis ESD limit for a conforming and perfectly pointed terminal.

In addition to the extensive set of antenna gain plots and off-axis EIRP plots included in the Technical Annex to this Technical Appendix, a representative off-axis EIRP table is included for Commission review. Note that SPA terminal antenna performance varies with skew angle and frequency, and power levels may vary with serving satellite (i.e., operations in two-degree versus three-degree spacing environments). As a result, it is not possible to provide plots and tables for all potential variable skew angles and frequencies. In addition, is relying on satellite operator certifications to support the SPA terminal operational characteristics proposed herein.

Nonetheless, Panasonic has provided a range of skew angle data for consideration. Operations at other skew angle generally will have the same off-axis characteristics and vary only by power level to ensure compliance with levels coordinated with adjacent satellite operators within +/- 6 degrees of the serving satellite. Off-axis EIRP will be controlled to permissible two-degree spacing levels or the coordinated limits for the satellite, whichever is greater. Control will be achieved by limiting maximum EIRP spectral density and skew angle.

2 Space Segment

The Space Segment consists of satellite capacity leased on commercial Ku-band satellites from established providers. Uplinks from SPA terminals occur in permissible portions of the 14.0-14.5 GHz band and downlinks will occur in permissible portions of the 10.7-12.75 GHz band.

The eXConnect System may use whole or partial transponders and operated with single saturated carriers (forward link only) in a transponder or with multiple carriers. Forward and return links may be operated in the same or different transponders.

A list of the currently proposed satellite points of communication are shown in Table 3.

Table 3. Satellite Points of Communication for the SPA Terminal

Satellite	Orbital Location	Downlink Frequencies	ITU Region	Service To U.S.
AMC-16	85° W	11.7-12.2 GHz	2	Yes
Galaxy 16	99° W	11.7-12.2 GHz	2	Yes
Galaxy 17	91° W	11.7-12.2 GHz	2	Yes
Eutelsat 172A	172° E	10.95-11.2 GHz; 11.45-11.7 GHz	2	Yes

Panasonic may expand this list to all authorized satellite points of communication in its ESAA license at some point in the future.

Each operator of the proposed satellite points of communications for the SPA terminal has certified that the operations proposed by Panasonic are consistent with the coordination agreements with satellite systems located within +/- 6 degrees of the serving satellites.

3 Ground Segment

The Ground Segment consists of hub earth stations that are leased at commercial teleport facilities, a DVB-S2 modulator and iDirect demodulator installed in the teleport facility, connectivity to the Internet and network management facilities.

The eXConnect gateway earth stations associated with SPA terminal operations are listed in Table 4, below. Installed at the gateway facility will be DVB-S2 modulator cards for the forward link and iDirect demodulators cards for the return link. The eXConnect System will be connected to the Internet and other content providers at the gateway. eXConnect ground stations are separately licensed by the teleport operator and are not a part of this application.

Table 4. Gateway Earth Stations for the SPA Terminal

Satellite/Beam	Location	Gateway Earth Station	
		Location	Operator/Call Sign
AMC-16	85° W	Brewster, WA	USEI, Call Sign E120043
Galaxy 16	99° W	Brewster, WA	USEI, Call Sign E120043
Galaxy 17	91° W	Ellenwood, GA	Intelsat, Call Sign E070139
Eutelsat 172A	172° E	Brewster, WA	USEI, Call Sign E120043

Network control of this earth station and of the eXConnect system will be provided by a Panasonic Mission Control Center ("MCC") in Lake Forest, California.

The eXConnect System is monitored and controlled from the Panasonic MCC in Lake Forest, CA on a 24/7 basis. The MCC makes use of the iDirect's Network Management System (NMS) to provide complete control and visibility to all components the eXConnect network. The NMS system has the capability of shutting down any component in the system that is malfunctioning. The MCC can be reached at:

Primary: Hector Torres (Office) 1-949-672-2578; (Mobile) 1-949-421-7354

Secondary: MCC Supervisors
5am-1pm PST:
Mike Juffer: (Mobile) +1 (949) 300-9615
1pm-9pm PST:
Ray Hashmani: (Mobile) +1 (949) 562-9741
Manny Barela: (Mobile): +1 (949) 466-8583
9pm-5am PST:
Chris Maldonado: (Mobile):+1 (949) 276-1983

MCC direct line: 1-425-415-9800
Email: mcc@panasonic.aero

Address:
Panasonic Avionics Corporation
Attn: Mission Control Center
26200 Enterprise Way
Lake Forest, CA 92630 USA

II. Satellite Operator Certification Letter

ECHOSTAR

October 8, 2015

International Bureau
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

Re: Panasonic Avionics Corporation, Request for Special Temporary Authorization, CallSign E100089 -- Engineering Certification of EchoStar Satellite Operating Corporation

To Whom It May Concern:

This letter certifies that EchoStar Satellite Operating Corporation ("ESOC") is aware that Panasonic Avionics Corporation ("Panasonic") is planning to seek authorization from the Federal Communications Commission ("FCC") to operate Ku-band transmit/receive earth stations aboard aircraft ("ESAA") terminals with the AMC-16 satellite located at 85° W.L. Specifically, in addition to the previously authorized Panasonic Phased Array ("PPA") and Mitsubishi Electric Corporation ("MELCO") Ku-band antenna systems, we understand that Panasonic seeks to operate the new Single Panel Antenna ("SPA") with AMC-16 for commercial purposes consistent with the FCC's ESAA rules, including Section 25.227.[1]

EchoStar confirms and hereby certifies the following with respect to the operation proposed in the above reference application:

a) The proposed Ku-band ESAA operations of Panasonic has the potential to receive interference from satellite networks adjacent to the target satellite that may be unacceptable;
b) The proposed operations of the ESAA transmit/receive terminals at the power density levels defined in the agreement between Panasonic and EchoStar are consistent with existing satellite coordination agreements with operators of satellites within +/-6 degrees of AMC-16.

If the FCC authorizes the operation proposed by Panasonic, EchoStar will include the power density levels specified by Panasonic, defined within the coordination agreement, in all future satellite network coordination with operators of satellites that are adjacent to AMC-16.

Sincerely,

J Londono.

Jaime Londono
VP – Advanced Programs and Spectrum Development
EchoStar Satellite Operating Corporation

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[1] 47 C.F.R. § 25.227.

eutelsat
communications via satellite

October 29th, 2015

Mark DeFazio
Manager, GCS Regulatory and Business Operations
Panasonic Avionics Corporation
26200 Enterprise Way
Lake Forest, CA 92630

Re: Engineering Certification of Eutelsat

Dear Mr. DeFazio,

This letter certify that Eutelsat is aware that Panasonic Avionics Corporation ("Panasonic") is planning to seek a special temporary authorization ("STA") and modification to its blanket authorization from the Federal Communication Commission ("FCC"), Call Sign E100089, to operate a new Ku-band transmit/receive earth stations aboard aircraft ("ESAA") terminal type, the Panasonic Single Panel Antenna ("SPA"). The SPA will operate with the Eutelsat 70B satellite at 70.5°E, the Eutelsat 10A satellite at 10°E and the Eutelsat 172A satellite at 172°E. Eutelsat understands that Panasonic will file the applications pursuant to the FCC rules governing ESAA operations, including Section 25.227.

Eutelsat confirms and hereby certifies the following with respect to the SPA terminal operations proposed by Panasonic:

a) The proposed Ku-band operation of Panasonic's SPA ESAA terminal has the potential to create harmful interference to adjacent satellite networks that may be unacceptable;
b) Panasonic is currently using Eutelsat capacity on the Eutelsat 70B, Eutelsat 10A and Eutelsat 172A satellites for other ESAA operations
c) The proposed operation of the SPA transmit/receive terminals at the power density levels defined in the agreement between Panasonic and Eutelsat is consistent with existing satellite coordination agreements with the adjacent satellites of the Eutelsat 70B, Eutelsat 10A and Eutelsat 172A satellites.

If the FCC authorizes the operation proposed by Panasonic, Eutelsat will include the power density levels specified by Panasonic, defined within the satellite coordination agreements, in all future satellite network coordination with operators of satellite that are adjacent to those satellites addressed by this letter.

Sincerely,

For Eutelsat
Filipe De Oliveira
Head of the Resources Engineering Group

INTELSAT
Envision. Connect. Transform.

November 6, 2015

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

Re: Engineering Certification of Intelsat for G-16, G-17 and IS-29e Satellites

To Whom It May Concern:

This letter certify that Intelsat is aware that Panasonic Avionics Corporation ("Panasonic") is planning to seek a special temporary authorization ("STA") and modification to its blanket authorization from the Federal Communication Commission ("FCC"), Call Sign E100089, to operate a new Ku-band transmit/receive earth stations aboard aircraft ("ESAA") terminal type, the Panasonic Single Panel Antenna ("SPA"). The SPA will operate with the Galaxy 16 satellite at 99°W, the Galaxy 17 satellite at 91°W and the IS-29e satellite to be located at 50°W. Intelsat understands that Panasonic will file the applications pursuant to the FCC rules governing ESAA operations, including Section 25.227.

Intelsat confirms and hereby certifies that the power density levels of the proposed operations are consistent with existing satellite coordination agreements with the satellites with +/-6 degrees of the Galaxy 16, Galaxy 17 IS-29e satellites' orbit locations, and that the proposed operation of Panasonic's SPA ESAA terminal has the potential to create and receive harmful interference from adjacent satellite networks that may be unacceptable.

If the FCC authorizes the operation proposed by Panasonic, Intelsat will include the power density levels specified by Panasonic, defined within the satellite coordination agreements, in all future satellite network coordination with operators of satellite that are adjacent to the satellites addressed by this letter.

Sincerely,

Armand Kadrichu
Senior Technical Advisor, Spectrum Strategy
INTELSAT
7900 Tysons One Place, McLean, VA 22102-5972
T +1 703-559-7525 M +1 202-445-4377
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III. Link Budgets

Forward Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	33.9	deg
Lon	-84.1	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K
Satellite		
Name	G-16	
Longitude	-99.0	deg
Hub Earth Station		
Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.1	dBW
G/T	33.4	dB/K
Signal		
Waveform	DVB-S2	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	1	
Coding Rate	0.89	
Overhead Rate	0.95	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	1.69	bps/Hz
Data Rate	5.06E+07	bps
Information Rate (Data + Overhead)	5.33E+07	bps
Symbol Rate	3.00E+07	Hz
Chip Rate (Noise Bandwidth)	3.00E+07	Hz
Occupied Bandwidth	3.60E+07	Hz
Power Equivelent Bandwidth	3.60E+07	Hz
C/N Threshold	6.6	dB
Uplink		
Frequency	14.420	GHz
Back off	3.2	dB
EIRP Spectral Density	38.1	dBW/4kHz
Slant Range	38509	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	1.5	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	2.9	dB/K
Thermal Noise, C/No	99.5	dBHz
C/(No+Io)	99.0	dBHz
Satellite		
Flux Density	-87.4	dBW/m2
SFD @ Hub	-84.9	dBW/m2
Small Signal Gain (IBO/OBO)	1.5	dB
OBO	1.0	dB
Downlink		
Frequency	12.120	GHz
Transponder Sat. EIRP @ Beam Peak	52.3	dBW
Transponder Sat. EIRP @ Terminal	51.3	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	12.5	dBW/4kHz
Carrier EIRP @ Beam Peak	51.3	dBW
Carrier EIRP @ Terminal	50.3	dBW
Slant Range	37250	km
Space Loss, Ls	205.5	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	84.2	dBHz
C/(No+Io)	83.2	dBHz
End to End		
End to End C/(No+Io)	83.1	dBHz
Implementation Loss	1.0	dB
End to End C/N w/ Imp Loss	7.3	dB
Link Margin	0.7	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	33.9	deg
Lon	-84.1	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K
Satellite		
Name	G-16	
Longitude	-99.0	deg
Hub Earth Station		
Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.1	dBW
G/T	33.4	dB/K
Signal		
Waveform	iDirect	
Modulation	BPSK	
Bits per symbol	1	
Spread Factor	2	
Coding Rate	0.67	
Overhead Rate	0.72	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	0.24	bps/Hz
Data Rate	1.61E+06	bps
Information Rate (Data + Overhead)	2.22E+06	bps
Symbol Rate	3.34E+06	Hz
Chip Rate (Noise Bandwidth)	6.67E+06	Hz
Occupied Bandwidth	8.00E+06	Hz
Power Equivelent Bandwidth	1.98E+05	Hz
C/N Threshold	-1.2	dB
Uplink		
Frequency	14.240	GHz
Back off	0.0	dB
EIRP Spectral Density	12.8	dBW/4kHz
Slant Range	37250	km
Space Loss, Ls	206.9	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
Transponder G/T @ Terminal	4.9	dB/K
Thermal Noise, C/No	71.4	dBHz
C/(No+Io)	70.9	dBHz
Satellite		
Flux Density	-117.6	dBW/m2
SFD @ Terminal	-89.0	dBW/m2
Small Signal Gain (IBO/OBO)	2.5	dB
OBO	26.1	dB
Downlink		
Frequency	11.940	GHz
Transponder Sat. EIRP @ Beam Peak	52.3	dBW
Transponder Sat. EIRP @ Hub	50.3	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	-6.0	dBW/4kHz
Carrier EIRP @ Beam Peak	26.2	dBW
Carrier EIRP @ Hub	24.2	dBW
Slant Range	38509	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	1.8	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	78.8	dBHz
C/(No+Io)	71.8454	dBHz
End to End		
End to End C/(No+Io)	68.3	dBHz
Implementation Loss	0.0	dB
End to End C/N w/ Imp Loss	0.1	dB
Link Margin	1.3	dB

Forward Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	33.9	deg
Lon	-84.2	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K
Satellite		
Name	G-17	
Longitude	-91.0	deg
Hub Earth Station		
Site	Ellenwood, GE	
Lat	33.663	deg
Lon	-84.226	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	DVB-S2	
Modulation	8PSK	
Bits per symbol	3	
Spread Factor	1	
Coding Rate	0.60	
Overhead Rate	0.94	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	1.69	bps/Hz
Data Rate	5.06E+07	bps
Information Rate (Data + Overhead)	5.40E+07	bps
Symbol Rate	3.00E+07	Hz
Chip Rate (Noise Bandwidth)	3.00E+07	Hz
Occupied Bandwidth	3.60E+07	Hz
Power Equivelent Bandwidth	3.60E+07	Hz
C/N Threshold	6.3	dB
Uplink		
Frequency	14.380	GHz
Back off	8.1	dB
EIRP Spectral Density	33.2	dBW/4kHz
Slant Range	37072	km
Space Loss, Ls	207.0	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	3.9	Db
Radome, Lr	0.0	dB
Transponder G/T @ Hub	6.1	dB/K
Thermal Noise, C/No	95.8	dBHz
C/(No+Io)	95.3	dBHz
Satellite		
Flux Density	-94.3	dBW/m2
SFD @ Hub	-92.0	dBW/m2
Small Signal Gain (IBO/OBO)	1.3	dB
OBO	1.0	dB
Downlink		
Frequency	12.080	GHz
Transponder Sat. EIRP @ Beam Peak	51.4	dBW
Transponder Sat. EIRP @ Terminal	50.4	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	11.6	dBW/4kHz
Carrier EIRP @ Beam Peak	50.4	dBW
Carrier EIRP @ Terminal	49.4	dBW
Slant Range	37092	km
Space Loss, Ls	205.5	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	83.4	dBHz
C/(No+Io)	82.3	dBHz
End to End		
End to End C/(No+Io)	82.1	dBHz
Implementation Loss	1.0	dB
End to End C/N w/ Imp Loss	6.3	dB
Link Margin	0.0	dB

Return Link Budget

eXConnect Terminal		
Antenna Type	SPA	
Lat	33.9	deg
Lon	-84.2	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K
Satellite		
Name	G-17	
Longitude	-91.0	deg
Hub Earth Station		
Site	Ellenwood, GE	
Lat	33.663	deg
Lon	-84.226	deg
EIRP max	80.0	dBW
G/T	37.5	dB/K
Signal		
Waveform	iDirect	
Modulation	BPSK	
Bits per symbol	1	
Spread Factor	1	
Coding Rate	0.50	
Overhead Rate	0.78	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	0.39	bps/Hz
Data Rate	2.59E+06	bps
Information Rate (Data + Overhead)	3.34E+06	bps
Symbol Rate	6.67E+06	Hz
Chip Rate (Noise Bandwidth)	6.67E+06	Hz
Occupied Bandwidth	8.00E+06	Hz
Power Equivelent Bandwidth	2.89E+05	Hz
C/N Threshold	1.2	dB
Uplink		
Frequency	14.340	GHz
Back off	0.0	dB
EIRP Spectral Density	12.8	dBW/4kHz
Slant Range	37092	km
Space Loss, Ls	207.0	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
Transponder G/T @ Terminal	6.1	dB/K
Thermal Noise, C/No	72.6	dBHz
C/(No+Io)	72.1	dBHz
Satellite		
Flux Density	-117.6	dBW/m2
SFD @ Terminal	-91.6	dBW/m2
Small Signal Gain (IBO/OBO)	1.3	dB
OBO	24.7	dB
Downlink		
Frequency	12.040	GHz
Transponder Sat. EIRP @ Beam Peak	51.4	dBW
Transponder Sat. EIRP @ Hub	50.4	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	-5.5	dBW/4kHz
Carrier EIRP @ Beam Peak	26.7	dBW
Carrier EIRP @ Hub	25.7	dBW
Slant Range	37072	km
Space Loss, Ls	205.4	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	4.7	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	81.7	dBHz
C/(No+Io)	73.7433	dBHz
End to End		
End to End C/(No+Io)	69.8	dBHz
Implementation Loss	0.0	dB
End to End C/N w/ Imp Loss	1.6	dB
Link Margin	0.4	dB

Forward Link Budget

eXConnect Terminal

Antenna Type	SPA	
Lat	35.0	deg
Lon	-88.5	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K

Satellite

Name	AMC-16	
Longitude	-85.0	deg

Hub Earth Station

Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.0	dBW
G/T	34.4	dB/K

Signal

Waveform	DVB-S2	
Modulation	8PSK	
Bits per symbol	3	
Spread Factor	1	
Coding Rate	0.67	
Overhead Rate	0.94	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	1.88	bps/Hz
Data Rate	5.64E+07	bps
Information Rate (Data + Overhead)	6.00E+07	bps
Symbol Rate	3.00E+07	Hz
Chip Rate (Noise Bandwidth)	3.00E+07	Hz
Occupied Bandwidth	3.60E+07	Hz
Power Equivelent Bandwidth	3.60E+07	Hz
C/N Threshold	7.4	dB

Uplink

Frequency	14.120	GHz
Back off	7.6	dB
EIRP Spectral Density	33.7	dBW/4kHz
Slant Range	39035	km
Space Loss, Ls	207.3	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	1.7	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	2.0	dB/K
Thermal Noise, C/No	94.1	dBHz
C/(No+Io)	93.6	dBHz

Satellite

Flux Density	-92.1	dBW/m2
SFD @ Hub	-89.1	dBW/m2
Small Signal Gain (IBO/OBO)	2.0	dB
OBO	1.0	dB

Downlink

Frequency	11.820	GHz
Transponder Sat. EIRP @ Beam Peak	52.1	dBW
Transponder Sat. EIRP @ Terminal	52.0	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	12.3	dBW/4kHz
Carrier EIRP @ Beam Peak	51.1	dBW
Carrier EIRP @ Terminal	51.0	dBW
Slant Range	37135	km
Space Loss, Ls	205.3	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	85.2	dBHz
C/(No+Io)	83.8	dBHz

End to End

End to End C/(No+Io)	83.4	dBHz
Implementation Loss	1.0	dB
End to End C/N w/ Imp Loss	7.6	dB
Link Margin	0.2	dB

Return Link Budget

eXConnect Terminal

Antenna Type	SPA	
Lat	35.0	deg
Lon	-88.5	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K

Satellite

Name	AMC-16	
Longitude	-85.0	deg

Hub Earth Station

Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.0	dBW
G/T	34.4	dB/K

Signal

Waveform	iDirect	
Modulation	BPSK	
Bits per symbol	1	
Spread Factor	2	
Coding Rate	0.67	
Overhead Rate	0.72	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	0.24	bps/Hz
Data Rate	1.61E+06	bps
Information Rate (Data + Overhead)	2.22E+06	bps
Symbol Rate	3.34E+06	Hz
Chip Rate (Noise Bandwidth)	6.67E+06	Hz
Occupied Bandwidth	8.00E+06	Hz
Power Equivelent Bandwidth	3.71E+05	Hz
C/N Threshold	-1.2	dB

Uplink

Frequency	14.080	GHz
Back off	0.0	dB
EIRP Spectral Density	12.8	dBW/4kHz
Slant Range	37135	km
Space Loss, Ls	206.8	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
Transponder G/T @ Terminal	3.0	dB/K
Thermal Noise, C/No	69.6	dBHz
C/(No+Io)	69.1	dBHz

Satellite

Flux Density	-117.6	dBW/m2
SFD @ Terminal	-90.7	dBW/m2
Small Signal Gain (IBO/OBO)	3.0	dB
OBO	23.9	dB

Downlink

Frequency	11.780	GHz
Transponder Sat. EIRP @ Beam Peak	52.1	dBW
Transponder Sat. EIRP @ Hub	49.0	dBW
DL PSD Limit	13.0	dBW/4kHz
DL PSD @ Beam Peak	-4.0	dBW/4kHz
Carrier EIRP @ Beam Peak	28.2	dBW
Carrier EIRP @ Hub	25.1	dBW
Slant Range	39035	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	2.2	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	80.2	dBHz
C/(No+Io)	74.2412	dBHz

End to End

End to End C/(No+Io)	68.0	dBHz
Implementation Loss	0.0	dB
End to End C/N w/ Imp Loss	-0.3	dB
Link Margin	0.9	dB

Forward Link Budget

eXConnect Terminal

Antenna Type	SPA	
Lat	25.8	deg
Lon	-125.2	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K

Satellite

Name	GE-23	
Longitude	172.0	deg

Hub Earth Station

Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.0	dBW
G/T	37.3	dB/K

Signal

Waveform	DVB-S2	
Modulation	QPSK	
Bits per symbol	2	
Spread Factor	1	
Coding Rate	0.89	
Overhead Rate	0.95	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	1.69	bps/Hz
Data Rate	2.53E+07	bps
Information Rate (Data + Overhead)	2.67E+07	bps
Symbol Rate	1.50E+07	Hz
Chip Rate (Noise Bandwidth)	1.50E+07	Hz
Occupied Bandwidth	1.80E+07	Hz
Power Equivelent Bandwidth	2.70E+07	Hz
C/N Threshold	6.6	dB

Uplink

Frequency	14.303	GHz
Back off	0.8	dB
EIRP Spectral Density	43.4	dBW/4kHz
Slant Range	41051	km
Space Loss, Ls	207.8	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	6.7	dB
Radome, Lr	0.0	dB
Transponder G/T @ Hub	1.0	dB/K
Thermal Noise, C/No	94.2	dBHz
C/(No+Io)	93.7	dBHz

Satellite

Flux Density	-90.8	dBW/m2
SFD @ Hub	-87.9	dBW/m2
Small Signal Gain (IBO/OBO)	1.9	dB
OBO	1.0	dB

Downlink

Frequency	11.503	GHz
Transponder Sat. EIRP @ Beam Peak	47.7	dBW
Transponder Sat. EIRP @ Terminal	47.0	dBW
DL PSD Limit	12.5	dBW/4kHz
DL PSD @ Beam Peak	10.9	dBW/4kHz
Carrier EIRP @ Beam Peak	46.7	dBW
Carrier EIRP @ Terminal	46.0	dBW
Slant Range	39968	km
Space Loss, Ls	205.7	dB
Pointing Loss, Lpnt	0.1	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	79.8	dBHz
C/(No+Io)	79.7	dBHz

End to End

End to End C/(No+Io)	79.6	dBHz
Implementation Loss	1.0	dB
End to End C/N w/ Imp Loss	6.8	dB
Link Margin	0.2	dB

Return Link Budget

eXConnect Terminal

Antenna Type	SPA	
Lat	25.8	deg
Lon	-125.2	deg
EIRP max	45.0	dBW
G/T	11.0	dB/K

Satellite

Name	GE-23	
Longitude	172.0	deg

Hub Earth Station

Site	Brewster	
Lat	48.1	deg
Lon	-119.8	deg
EIRP max	80.0	dBW
G/T	37.3	dB/K

Signal

Waveform	iDirect	
Modulation	BPSK	
Bits per symbol	1	
Spread Factor	4	
Coding Rate	0.50	
Overhead Rate	0.74	
Channel Spacing	1.20	
Spectral Efficiency (Rate/Noise BW)	0.09	bps/Hz
Data Rate	6.13E+05	bps
Information Rate (Data + Overhead)	8.34E+05	bps
Symbol Rate	1.67E+06	Hz
Chip Rate (Noise Bandwidth)	6.67E+06	Hz
Occupied Bandwidth	8.00E+06	Hz
Power Equivelent Bandwidth	9.71E+04	Hz
C/N Threshold	-5.6	dB

Uplink

Frequency	14.039	GHz
Back off	0.0	dB
EIRP Spectral Density	12.8	dBW/4kHz
Slant Range	39968	km
Space Loss, Ls	207.4	dB
Pointing Loss, Lpnt	0.2	dB
Atmosphere / Weather Loss, La	0.0	dB
Radome, Lr	0.0	dB
Transponder G/T @ Terminal	2.0	dB/K
Thermal Noise, C/No	68.0	dBHz
C/(No+Io)	67.5	dBHz

Satellite

Flux Density	-118.2	dBW/m2
SFD @ Terminal	-83.5	dBW/m2
Small Signal Gain (IBO/OBO)	1.9	dB
OBO	32.8	dB

Downlink

Frequency	10.989	GHz
Transponder Sat. EIRP @ Beam Peak	47.7	dBW
Transponder Sat. EIRP @ Hub	45.0	dBW
DL PSD Limit	12.5	dBW/4kHz
DL PSD @ Beam Peak	-17.3	dBW/4kHz
Carrier EIRP @ Beam Peak	14.9	dBW
Carrier EIRP @ Hub	12.2	dBW
Slant Range	41051	km
Space Loss, Ls	205.5	dB
Pointing Loss, Lpnt	0.0	dB
Atmosphere / Weather Loss, La	6.0	dB
Radome, Lr	0.0	dB
PCMA Loss	0.0	dB
Thermal Noise, C/No	66.6	dBHz
C/(No+Io)	64.5460	dBHz

End to End

End to End C/(No+Io)	62.8	dBHz
Implementation Loss	0.0	dB
End to End C/N w/ Imp Loss	-5.5	dB
Link Margin	0.1	dB

IV. Off-Axis EIRP Spectral Density & Gain Data

PANASONIC AVIONICS

Single Panel Antenna ("SPA")

Annex 2
Representative Off-Axis EIRP Spectral Density
(20° and 50° Skew Angles)

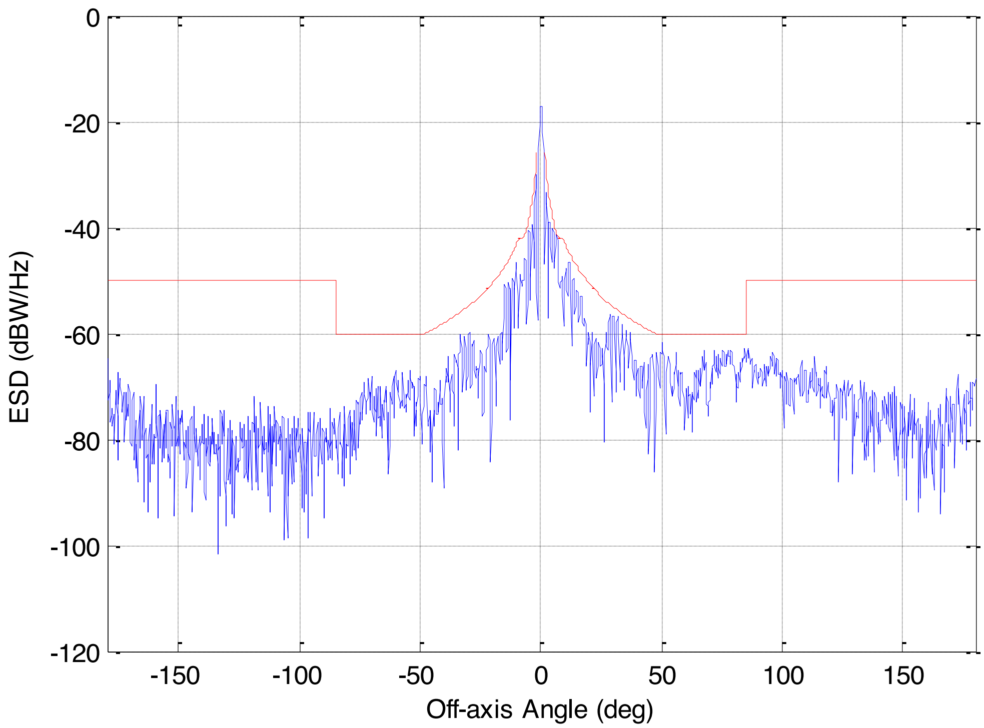

Figure 10. Tx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 8.36e-03 MHz

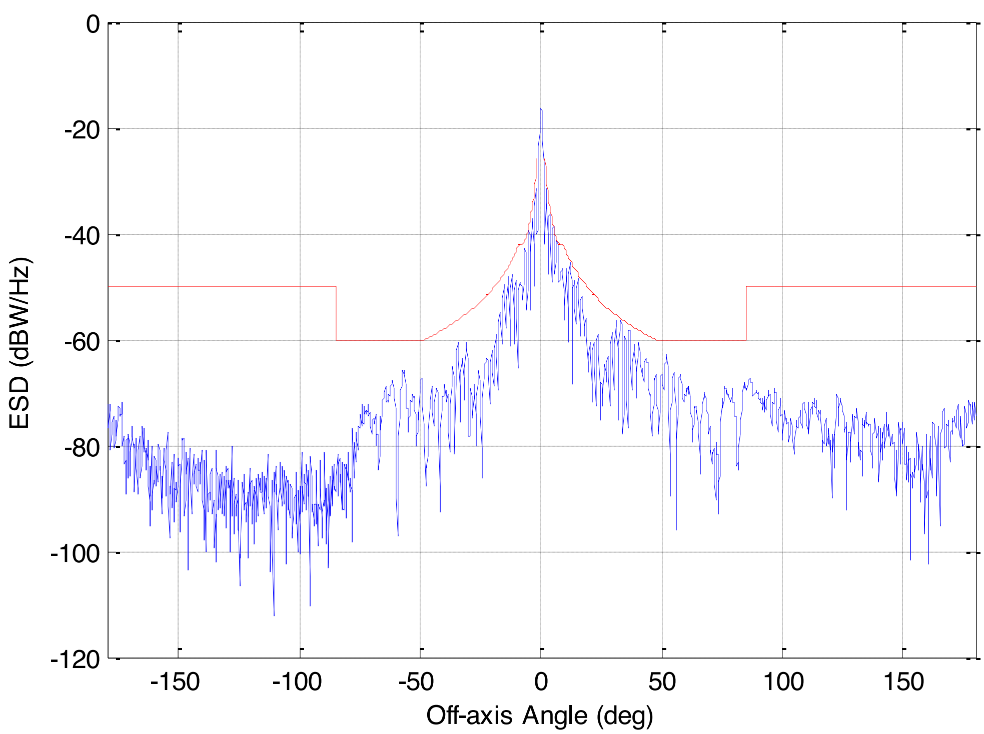

Figure 11. Tx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 1.09e-02 MHz

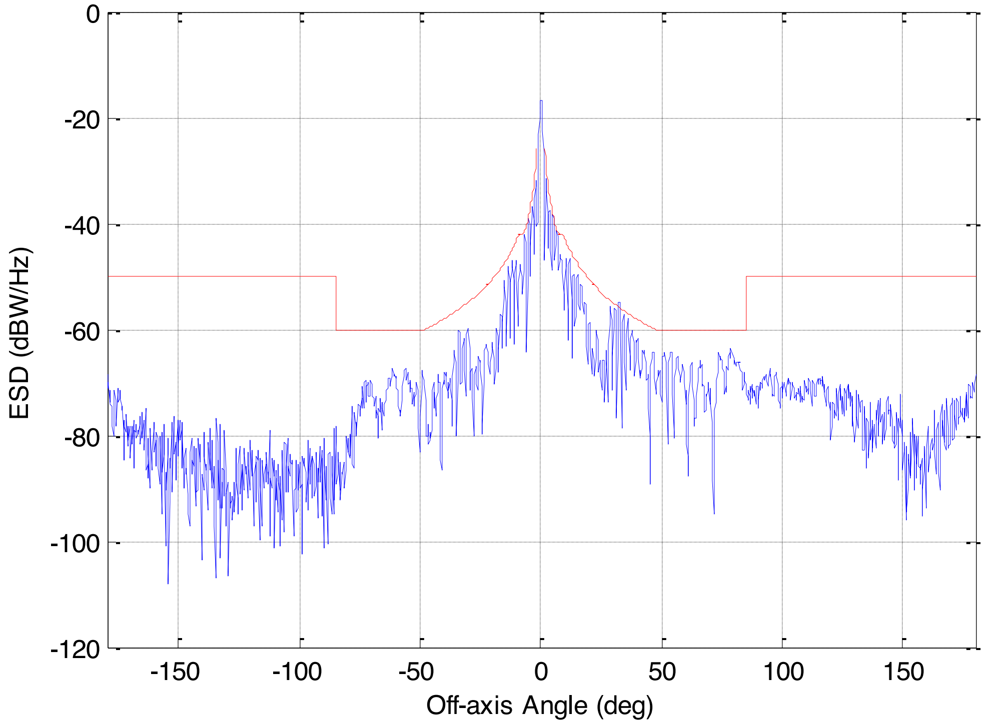

Figure 12. Tx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 6.09e-03 MHz

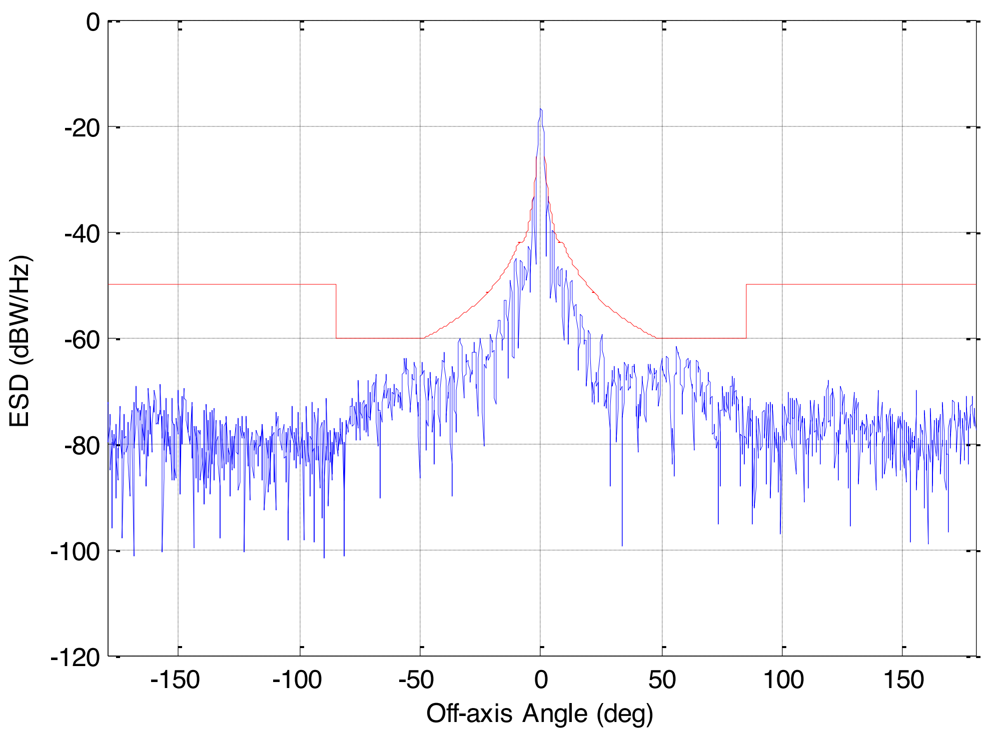

Figure 28. Tx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 4.29e-02 MHz

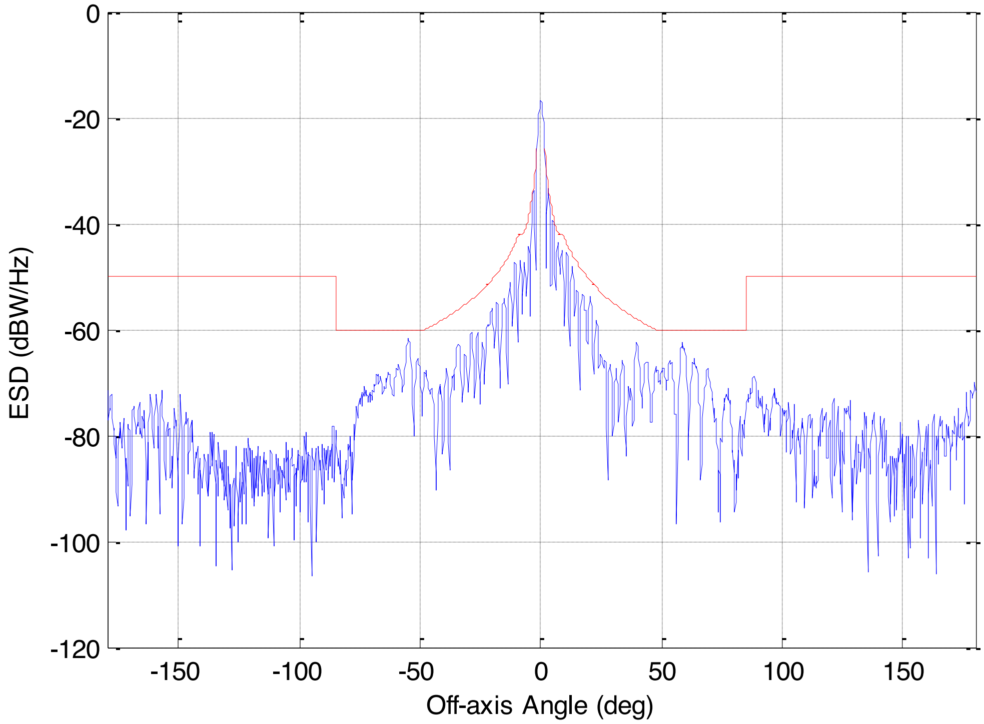

Figure 29. Tx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 4.07e-02 MHz

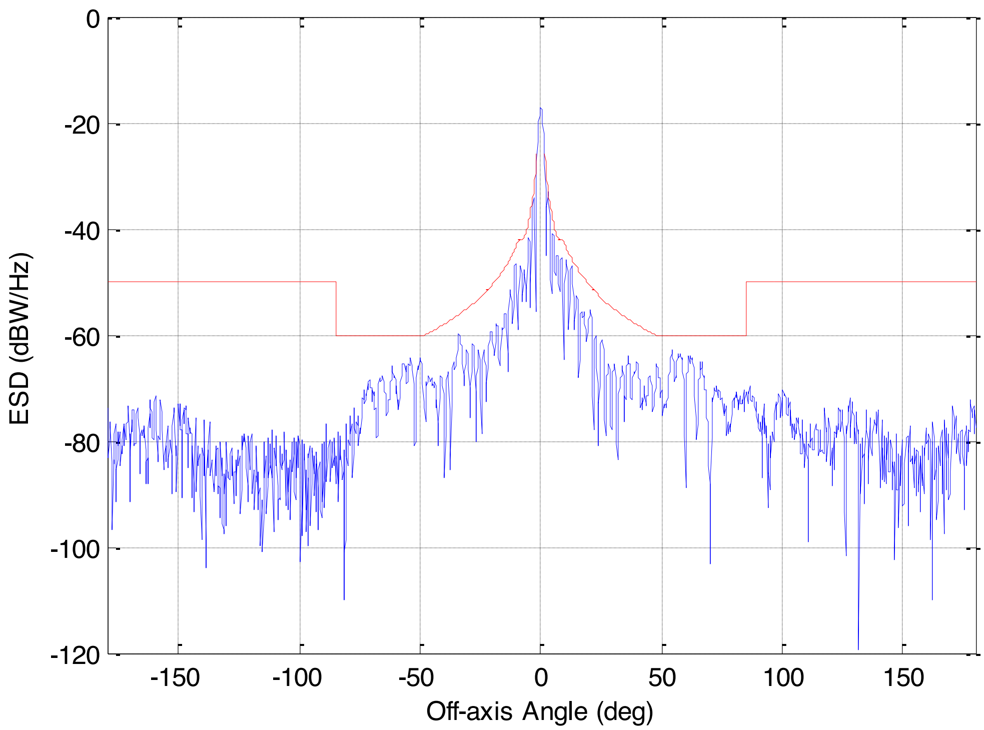

Figure 30. Tx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 5.16e-02 MHz

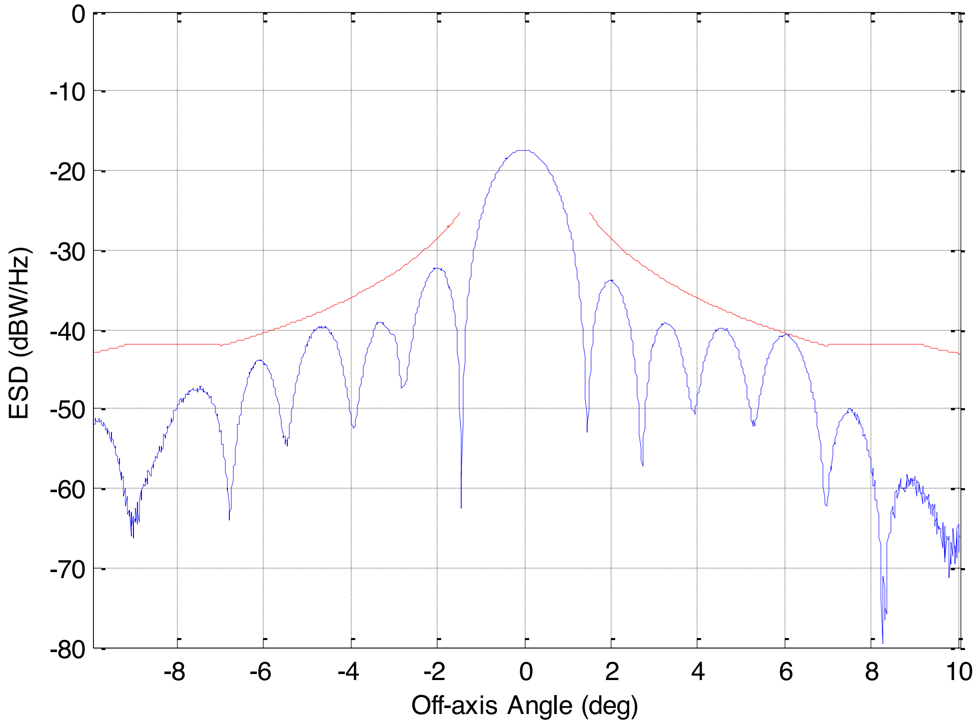

Figure 58. Tx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 0°
Bandwith: 1.13e-02 MHz

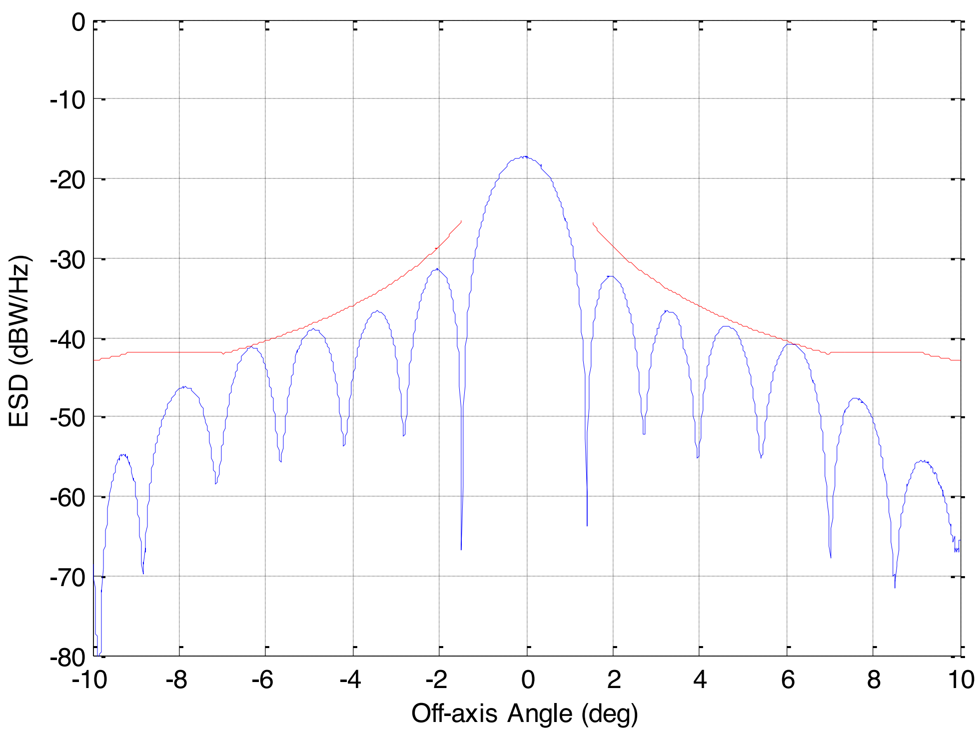

Figure 59. Tx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 0°
Bandwith: 9.85e-03 MHz

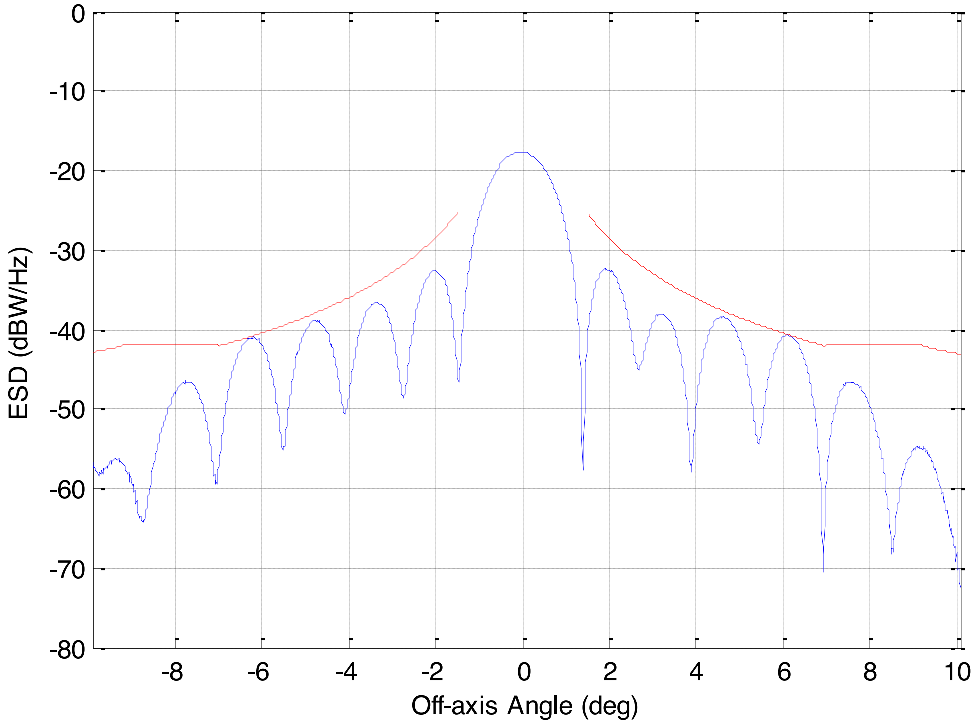

Figure 60. Tx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 0°
Bandwith: 1.11e-02 MHz

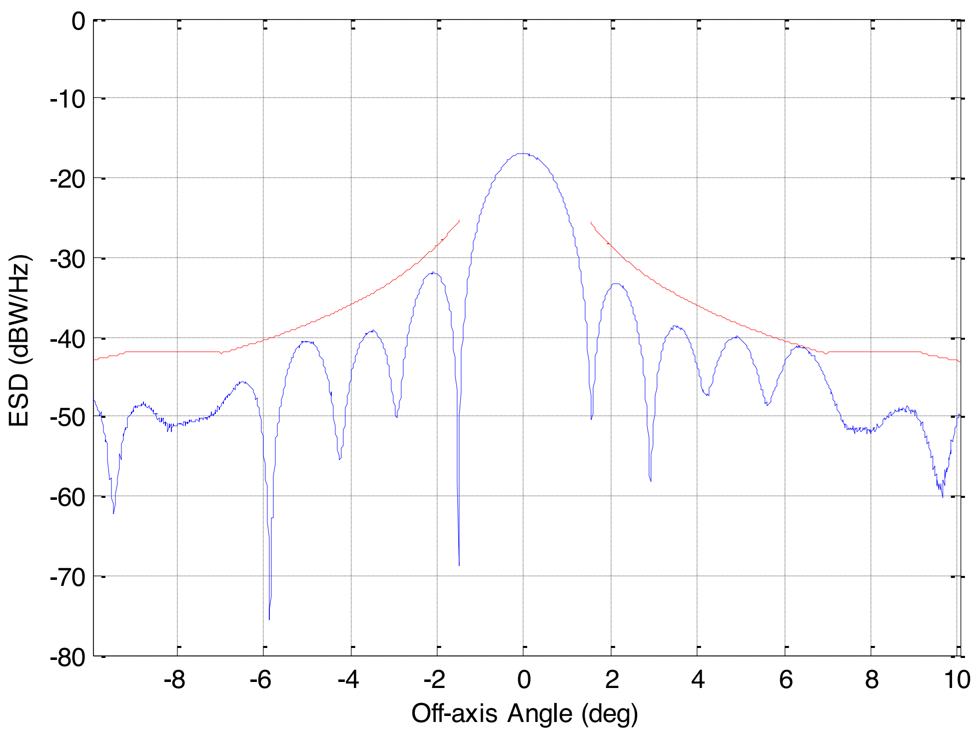

Figure 67. Tx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 7.51e-03 MHz

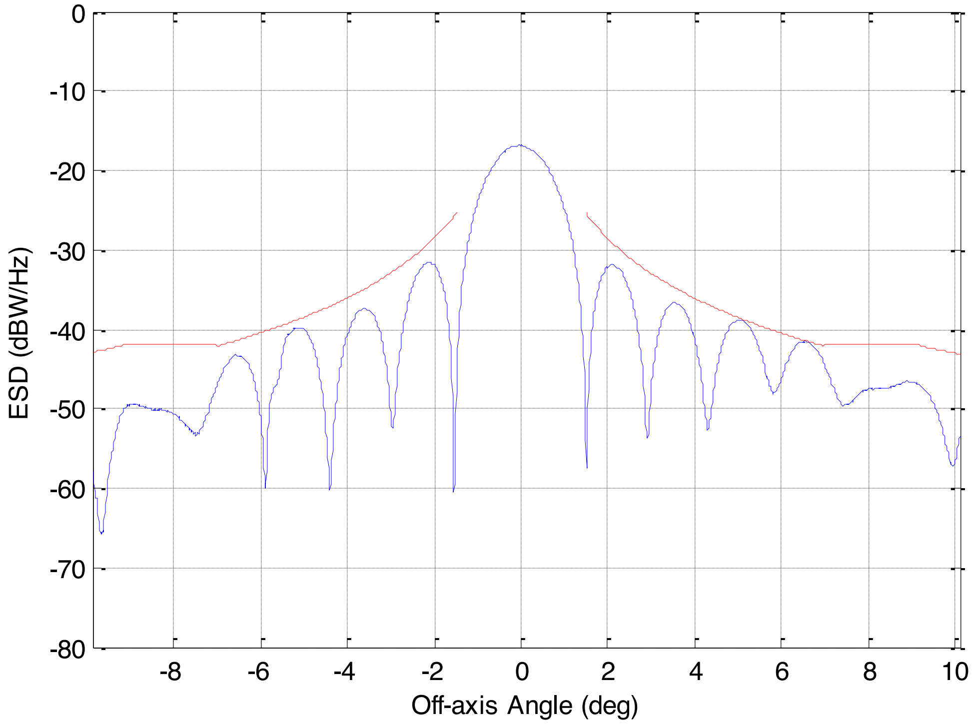

Figure 68. Tx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 6.80e-03 MHz

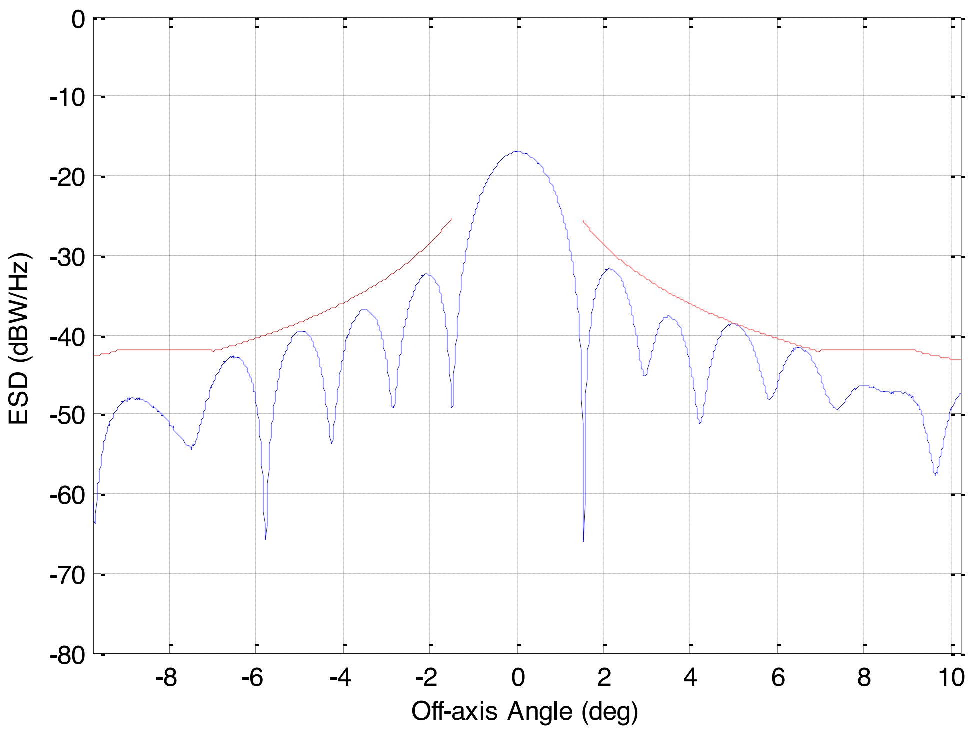

Figure 69. Tx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 20°
Bandwith: 1.37e-02 MHz

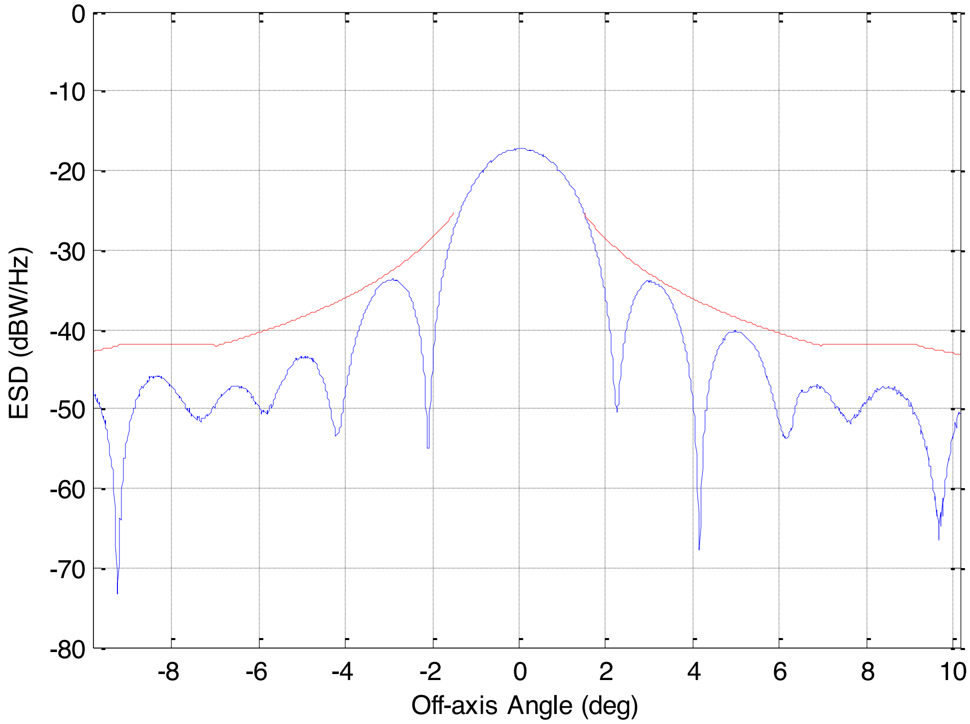

Figure 85. Tx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 3.39e-01 MHz

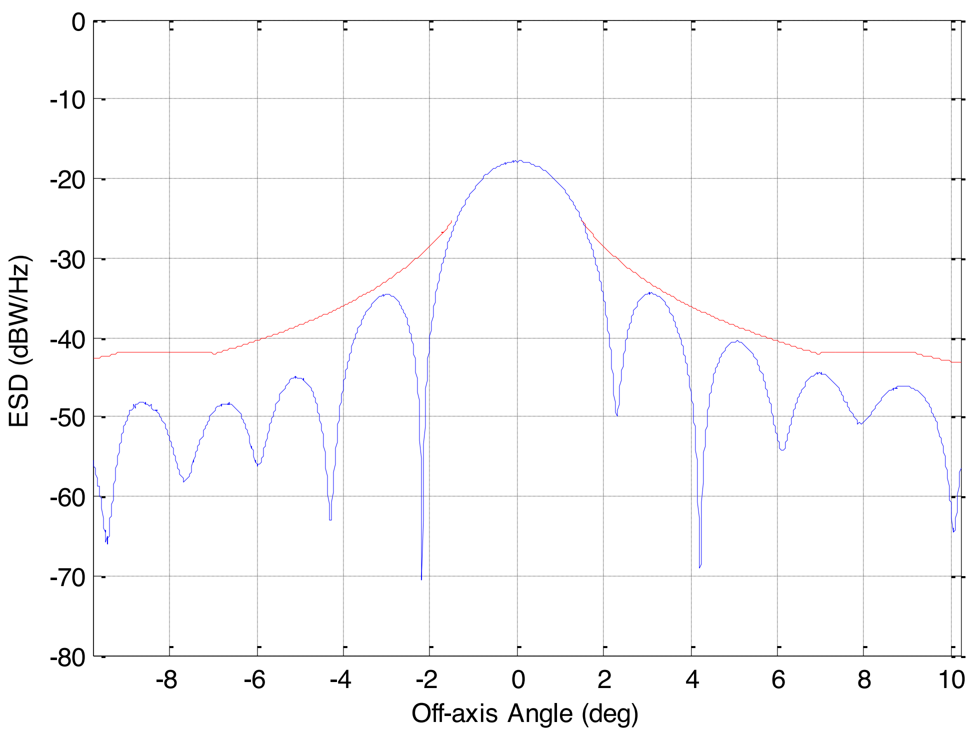

Figure 86. Tx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 4.14e-01 MHz

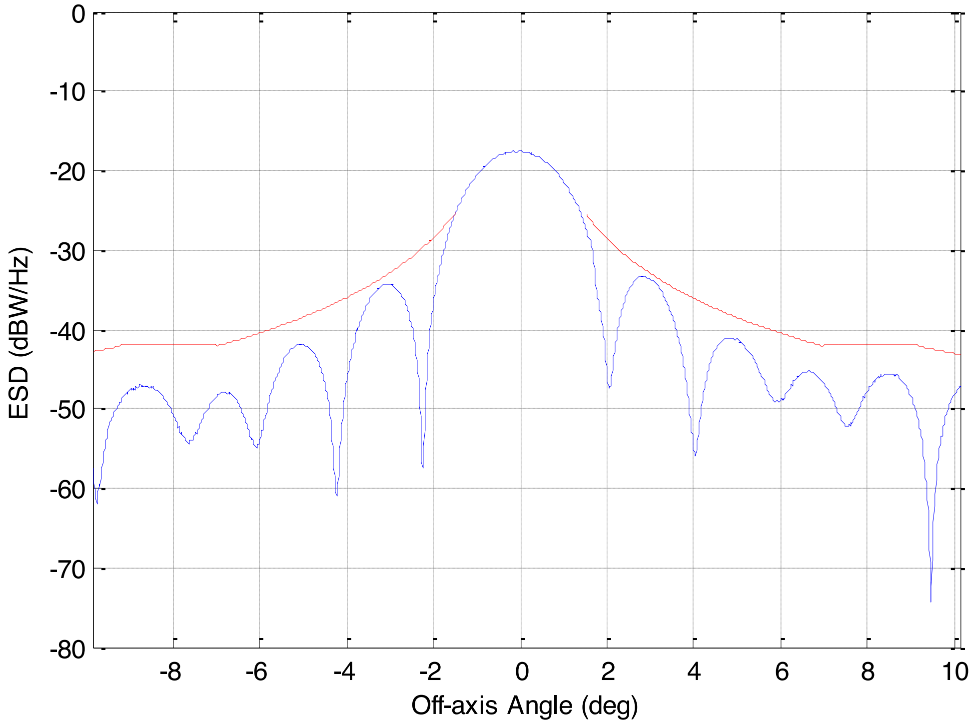

Figure 87. Tx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 50°
Bandwith: 3.68e-01 MHz

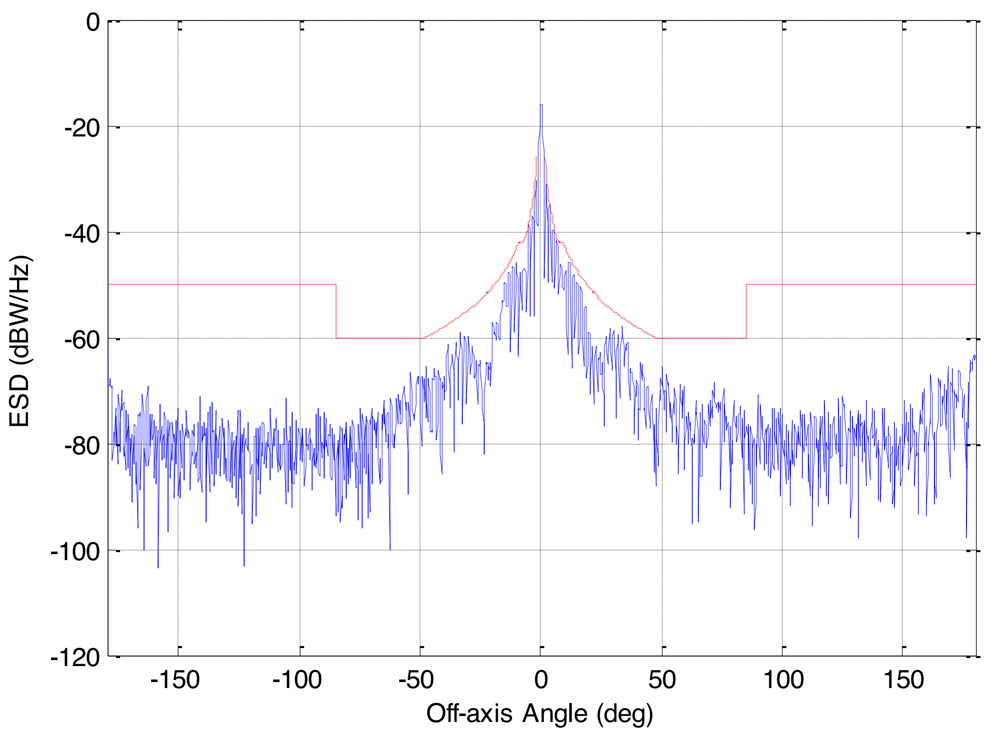

Figure 124. Tx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 2.23e-02 MHz

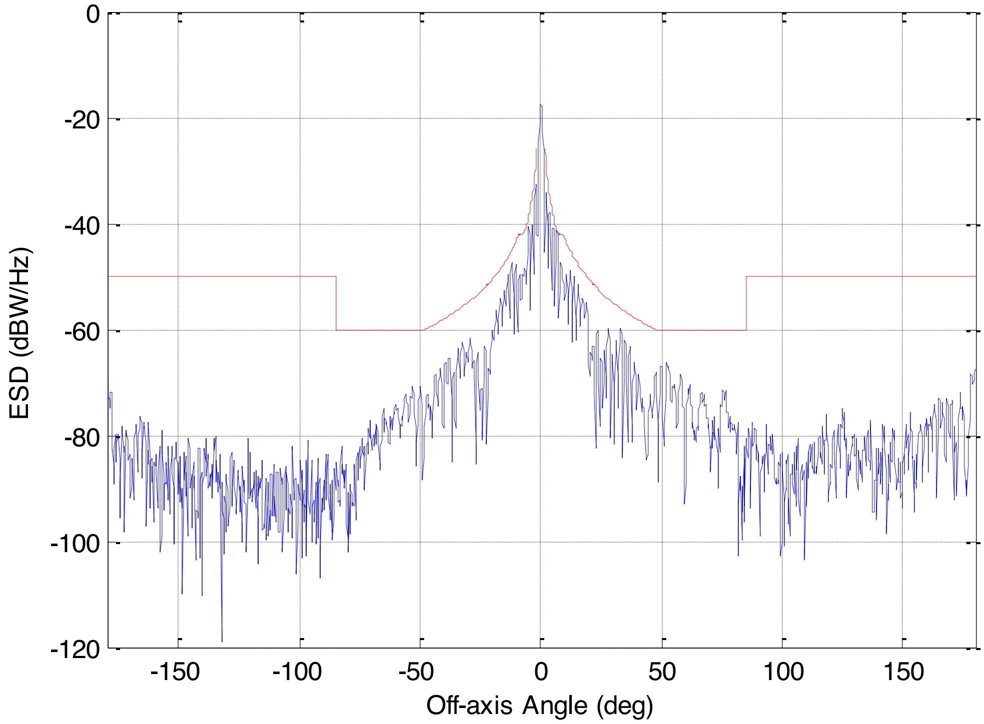

Figure 125. Tx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 1.03e-02 MHz

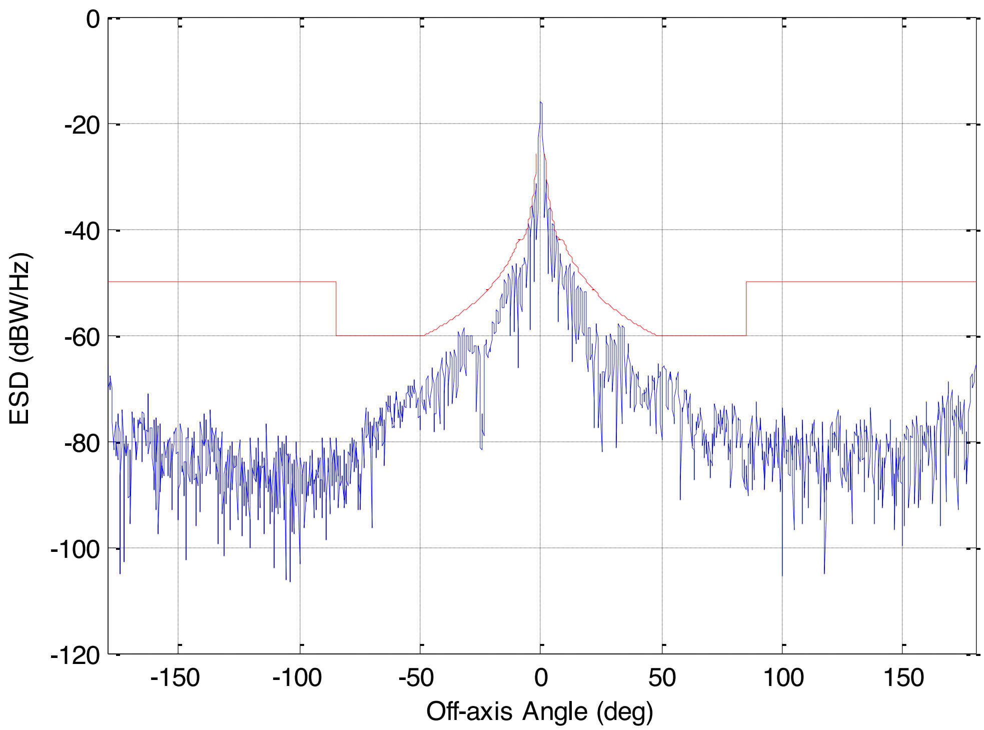

Figure 126. Tx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 5.01e-03 MHz

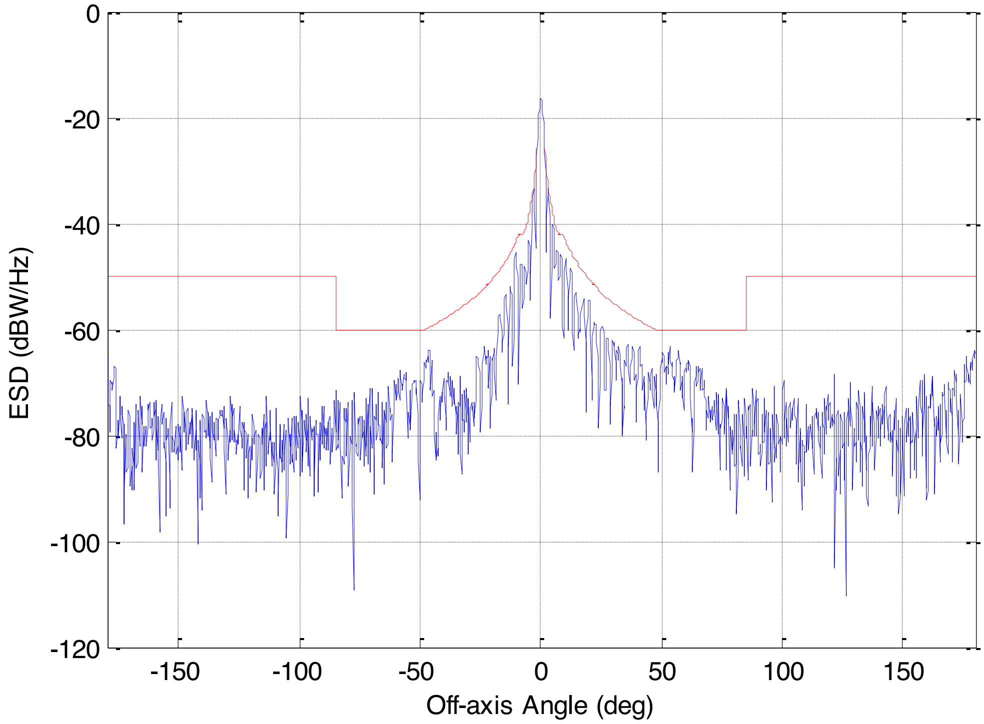

Figure 142. Tx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 3.75e-02 MHz

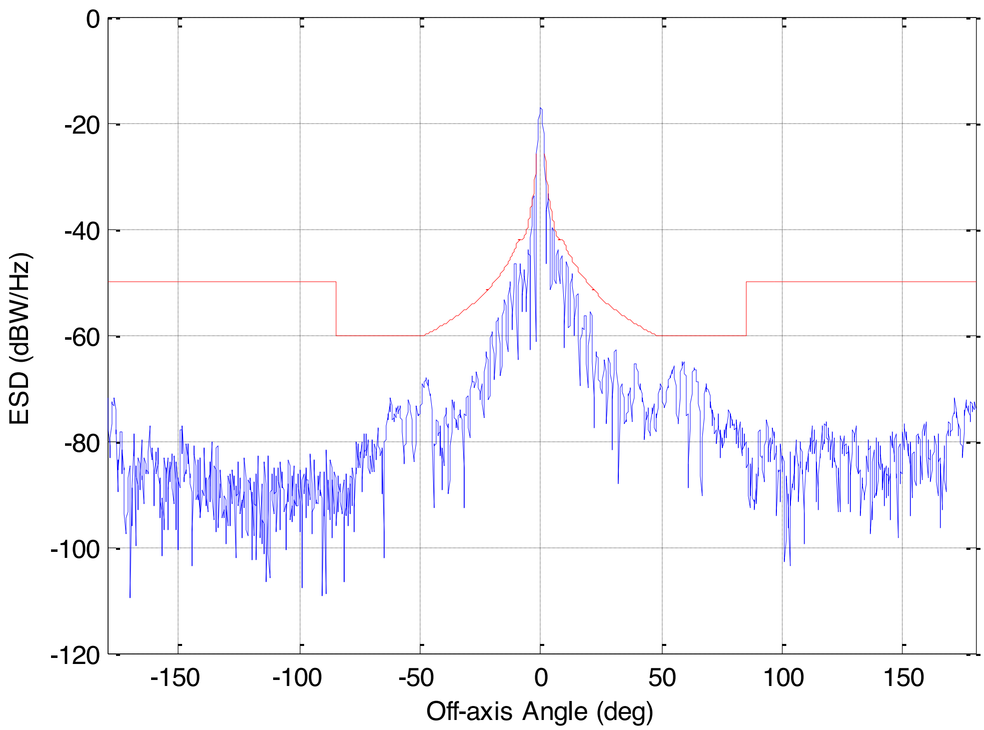

Figure 143. Tx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 2.87e-01 MHz

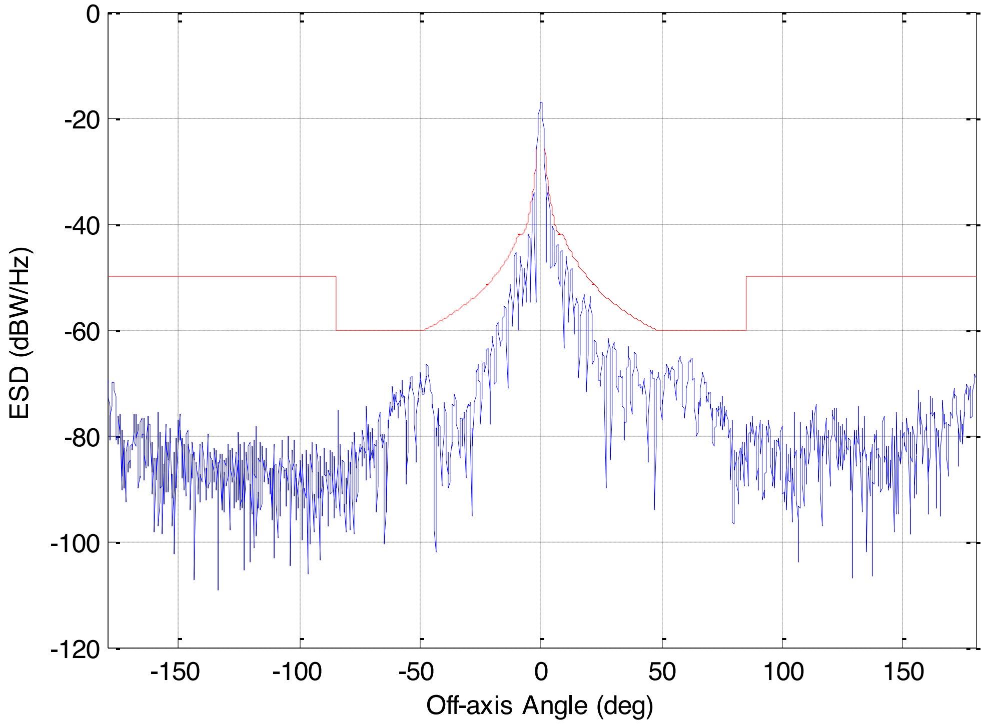

Figure 144. Tx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 4.64e-02 MHz

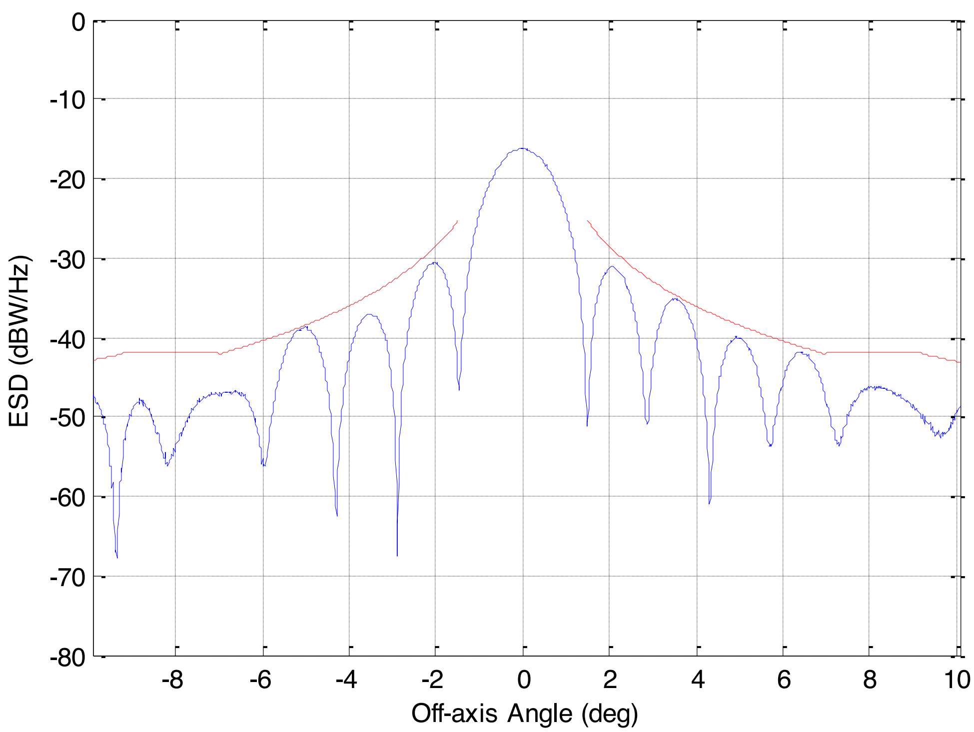

Figure 181. Tx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 1.00e-02 MHz

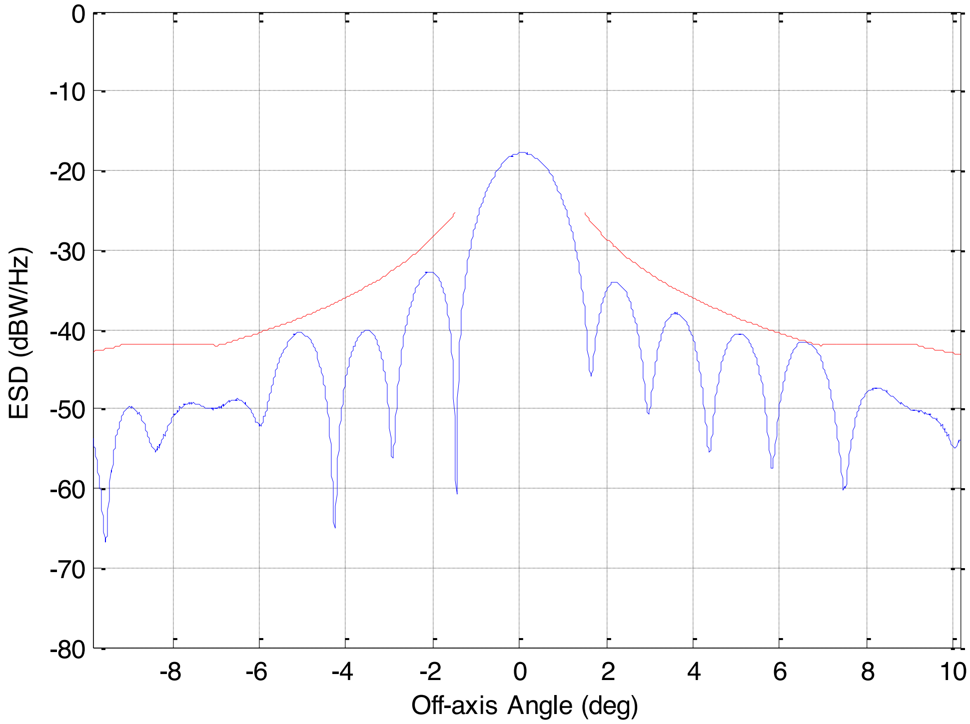

Figure 182. Tx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 1.04e-02 MHz

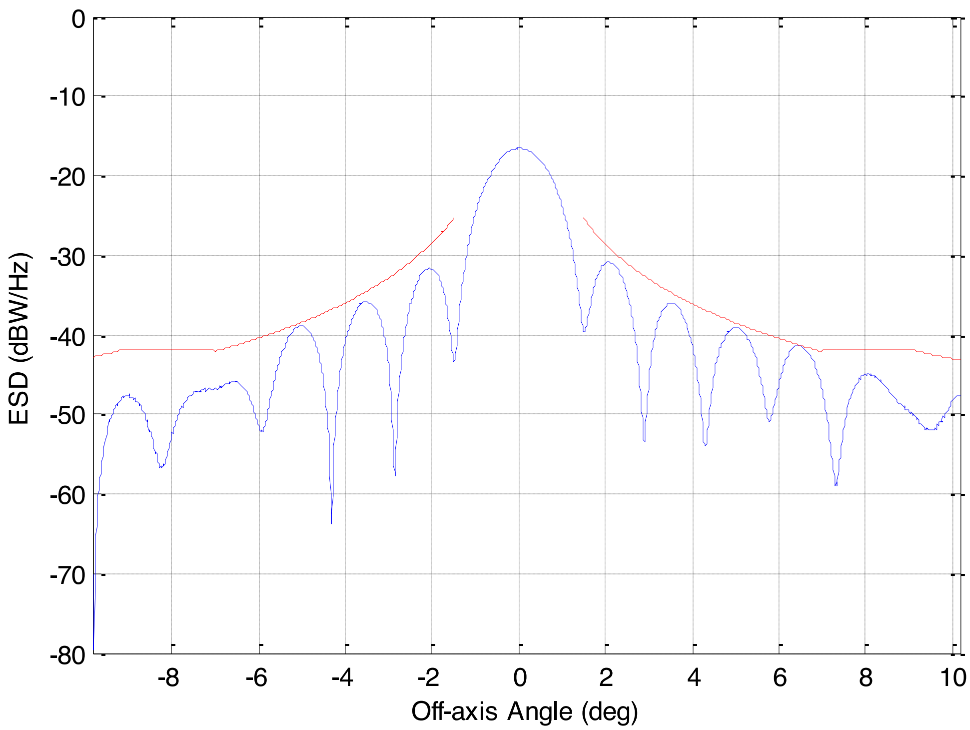

Figure 183. Tx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 20°
Bandwith: 5.80e-03 MHz

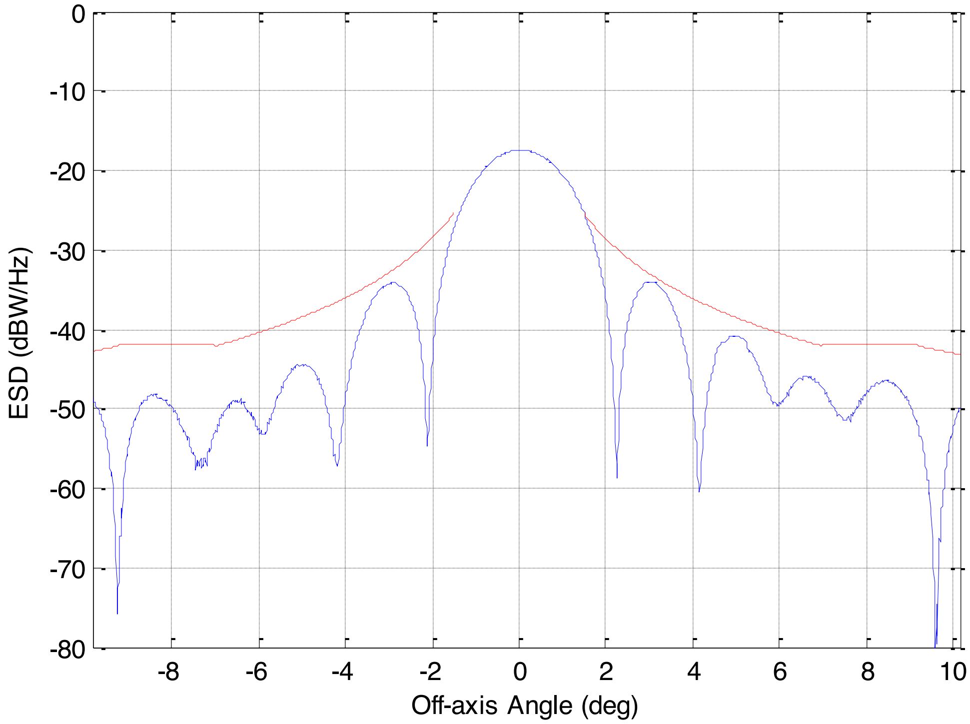

Figure 199. Tx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 3.68e-01 MHz

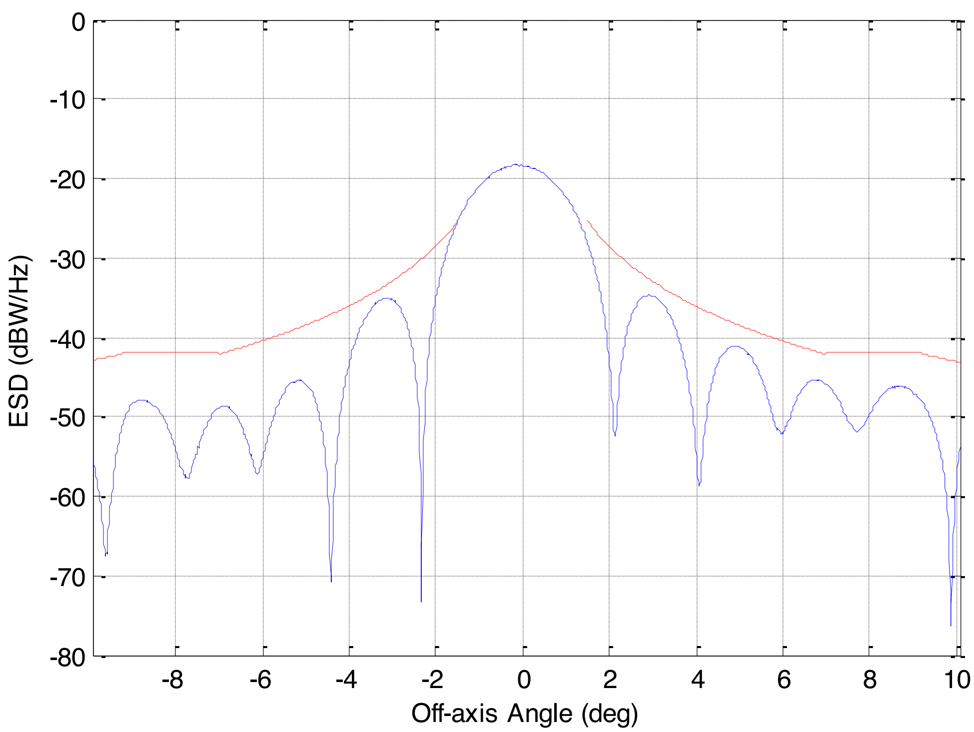

Figure 200. Tx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 5.31e-01 MHz

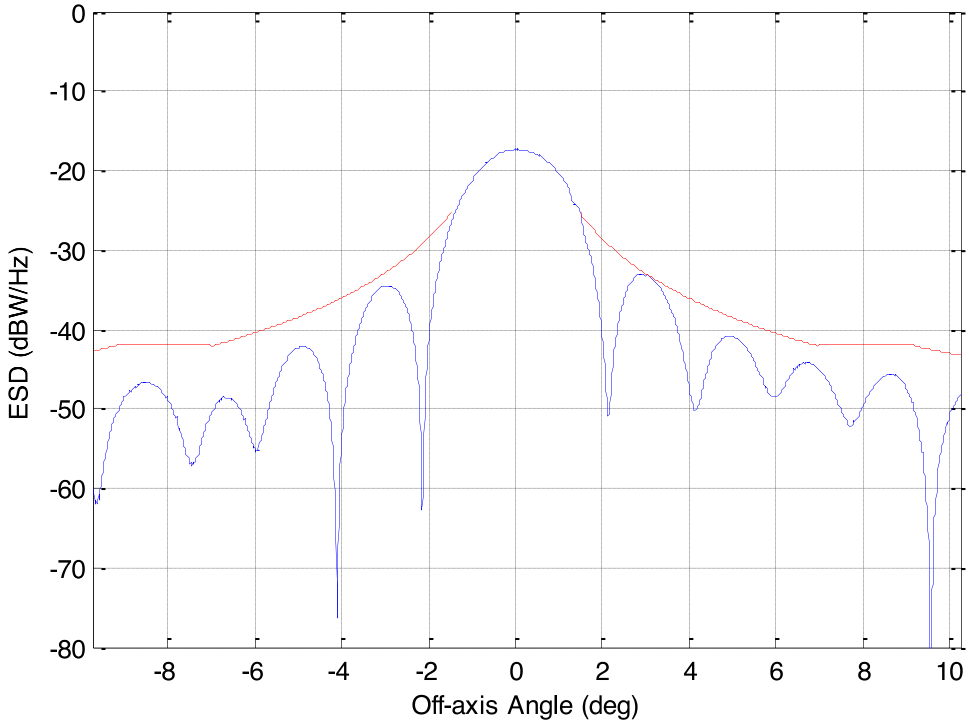

Figure 201. Tx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 50°
Bandwith: 5.39e-02 MHz

PANASONIC AVIONICS

Single Panel Antenna ("SPA")

Annex 3
Representative Antenna Gain
(20° and 50° Skew Angles)

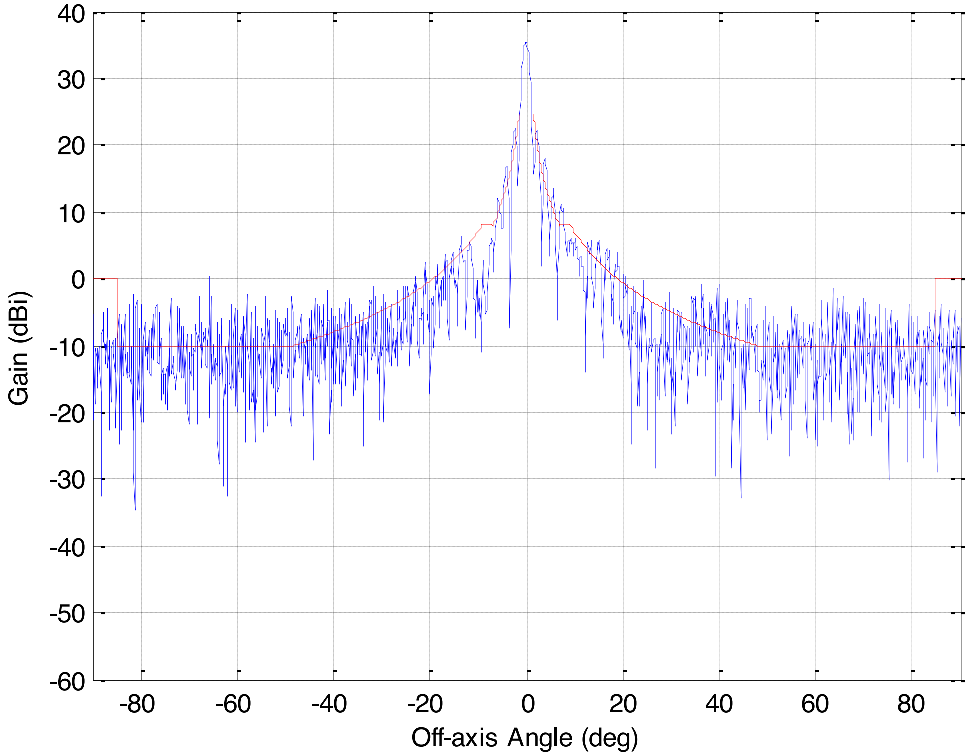

Figure 19. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 20°

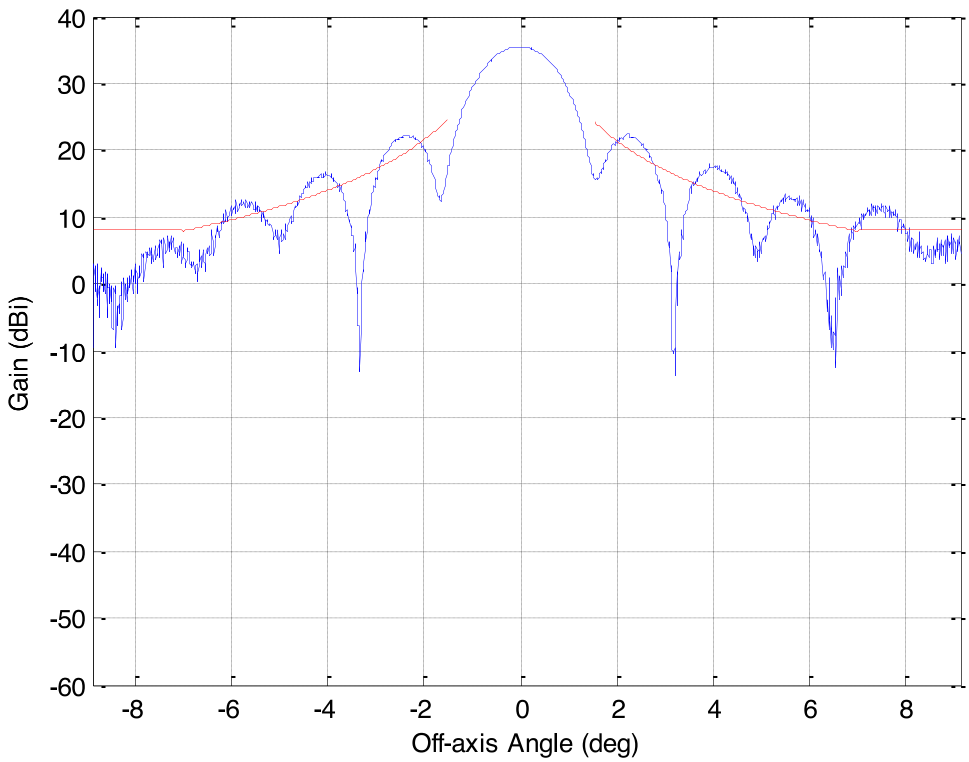

Figure 20. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 20°

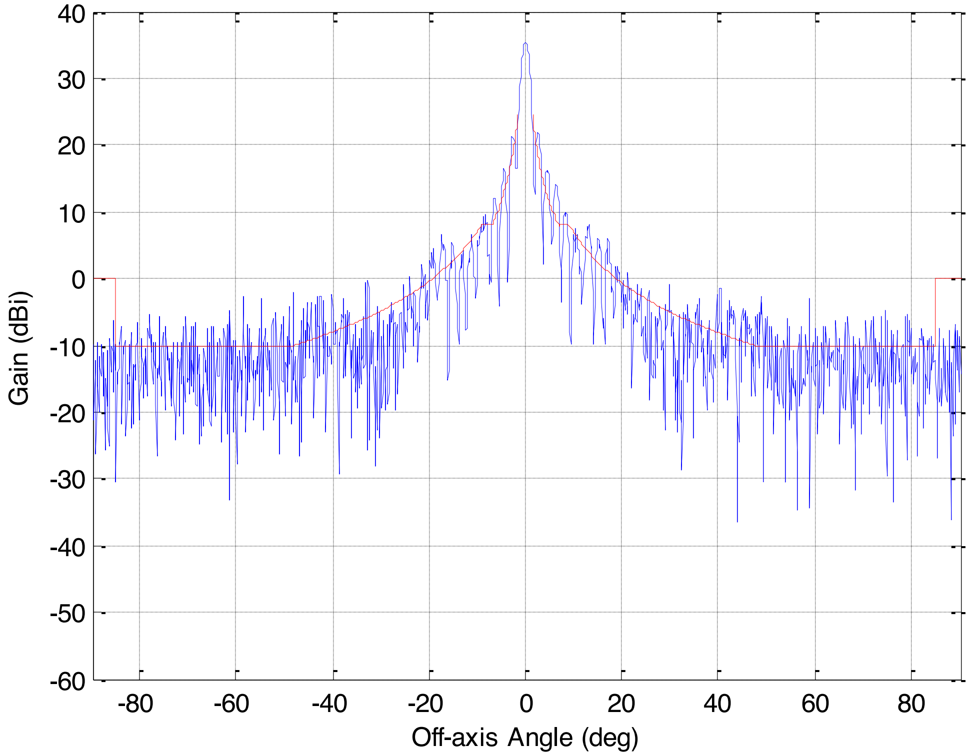

Figure 21. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 20°

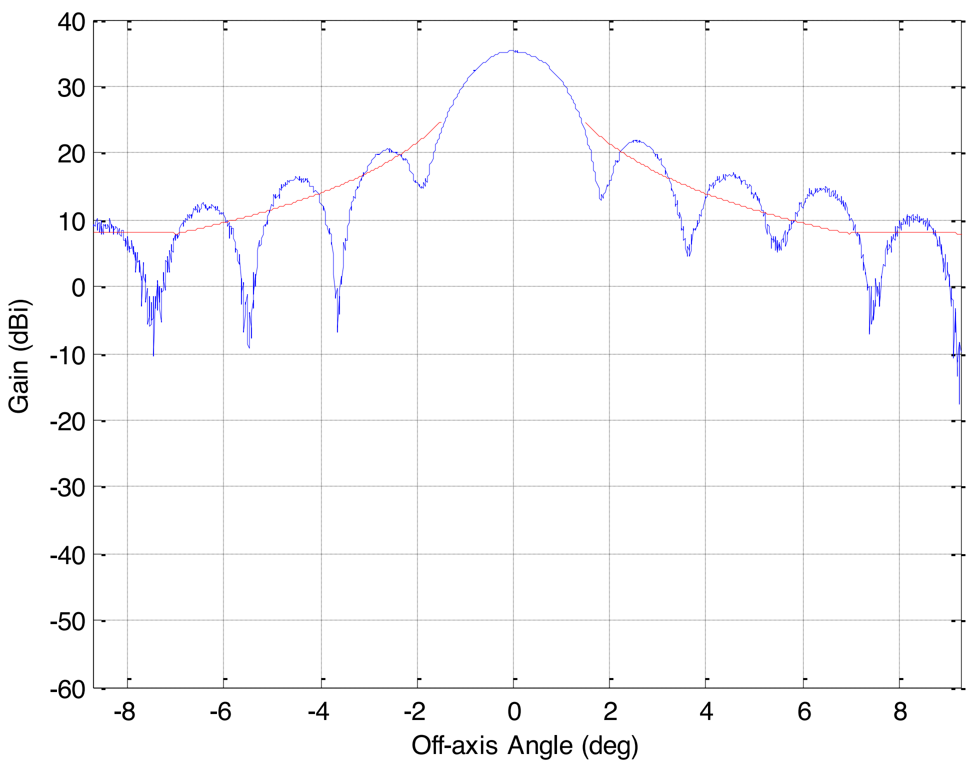

Figure 22. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 20°

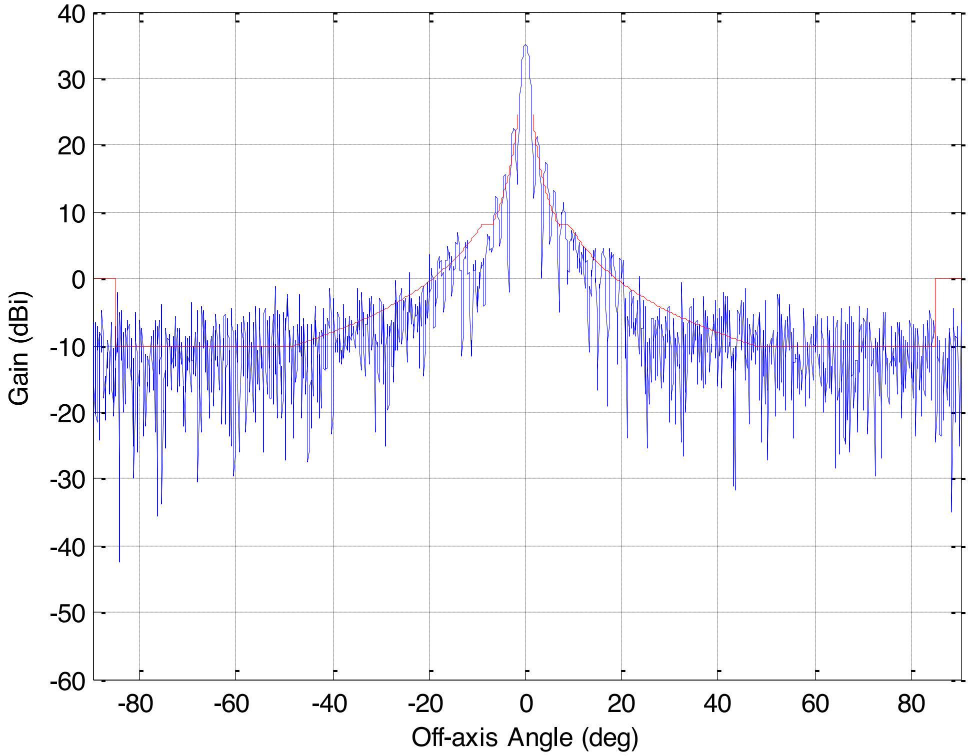

Figure 23. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 20°

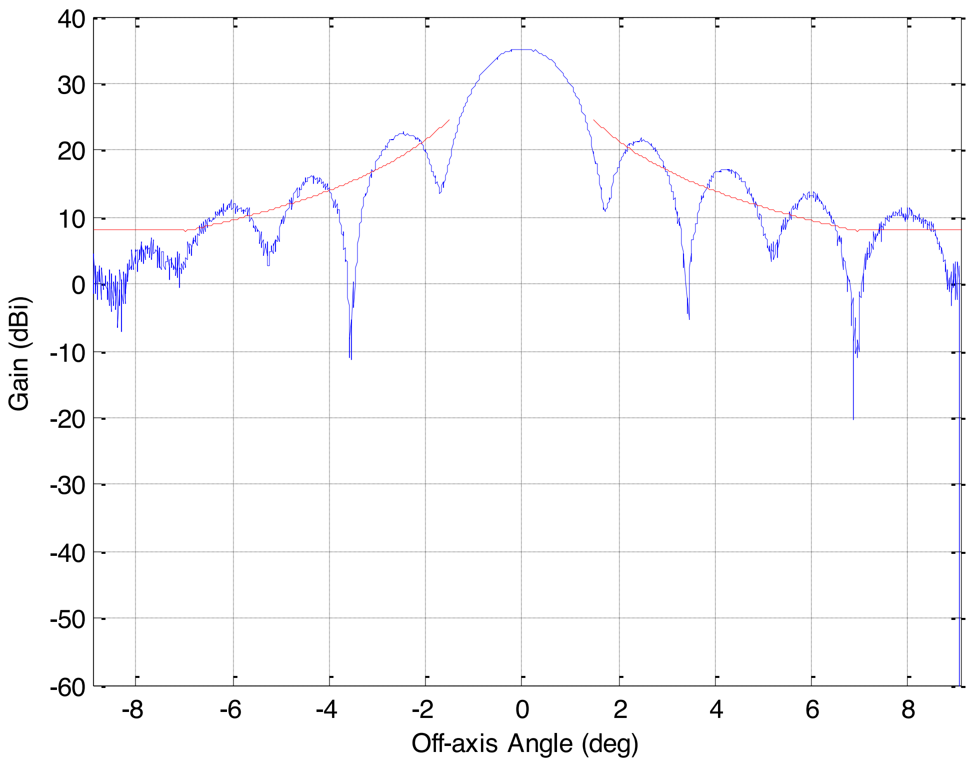

Figure 24. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 20°

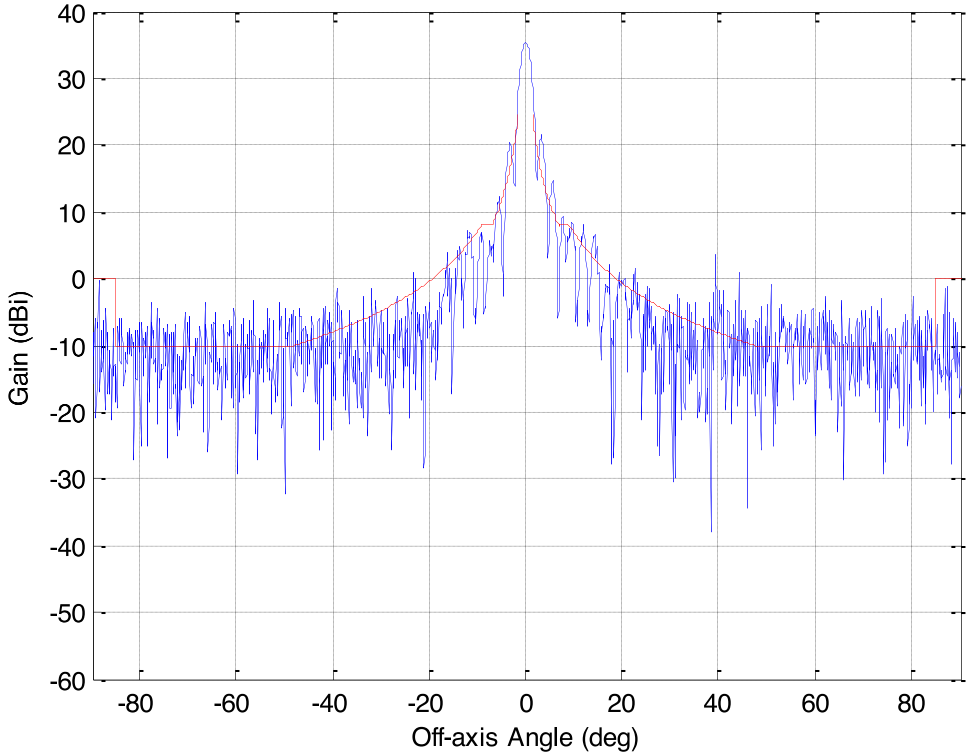

Figure 55. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 50°

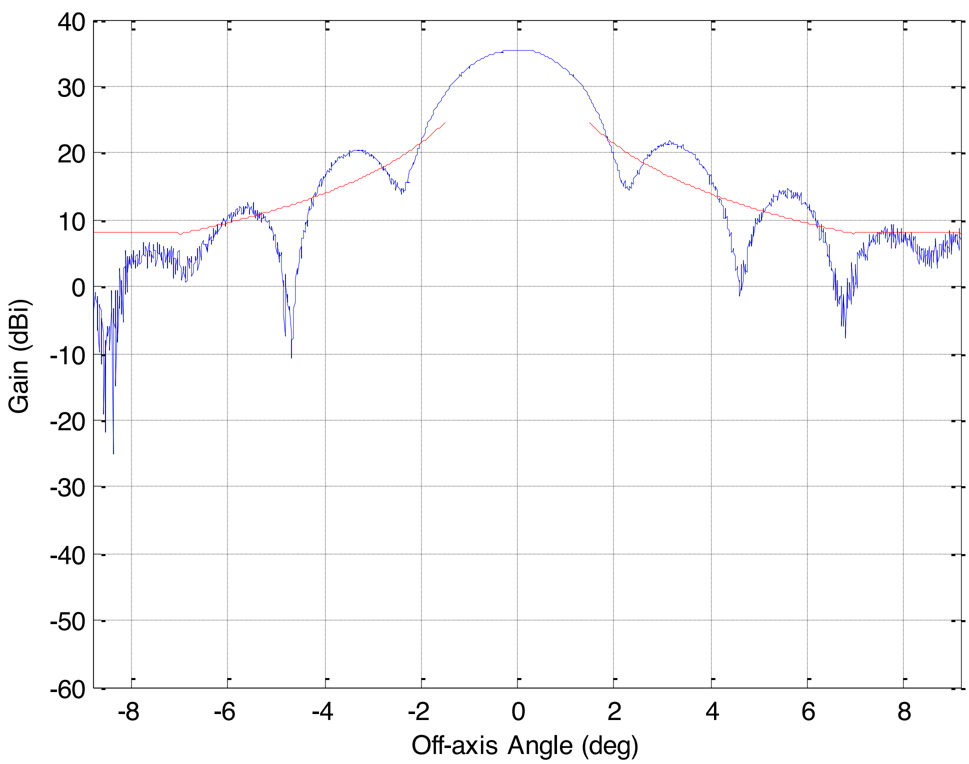

Figure 56. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Co, Skew: 50°

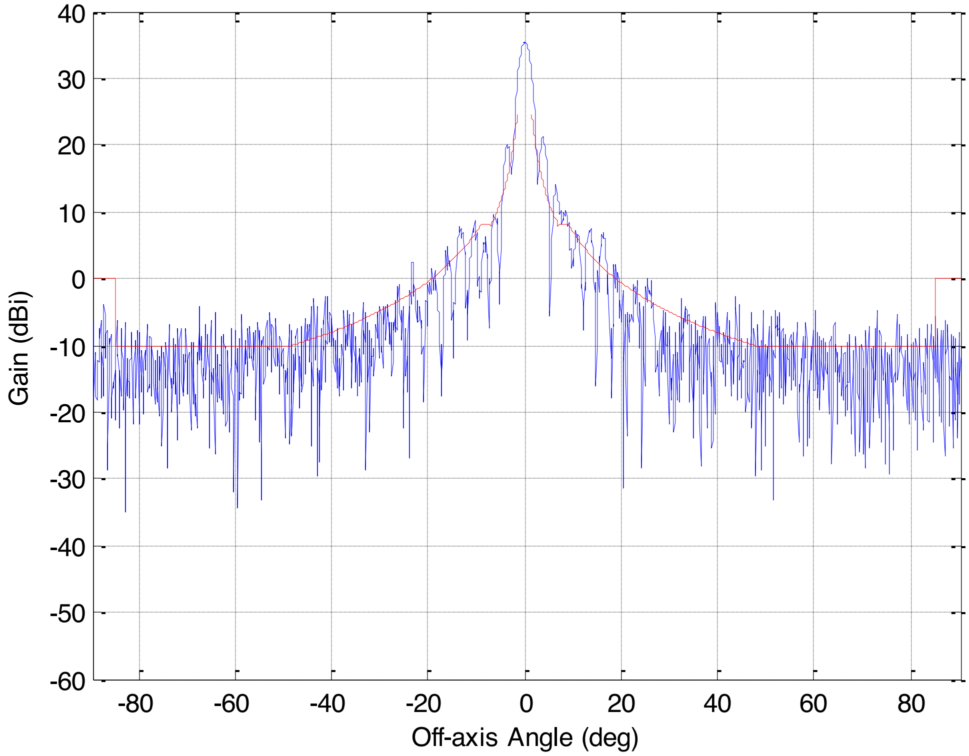

Figure 57. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 50°

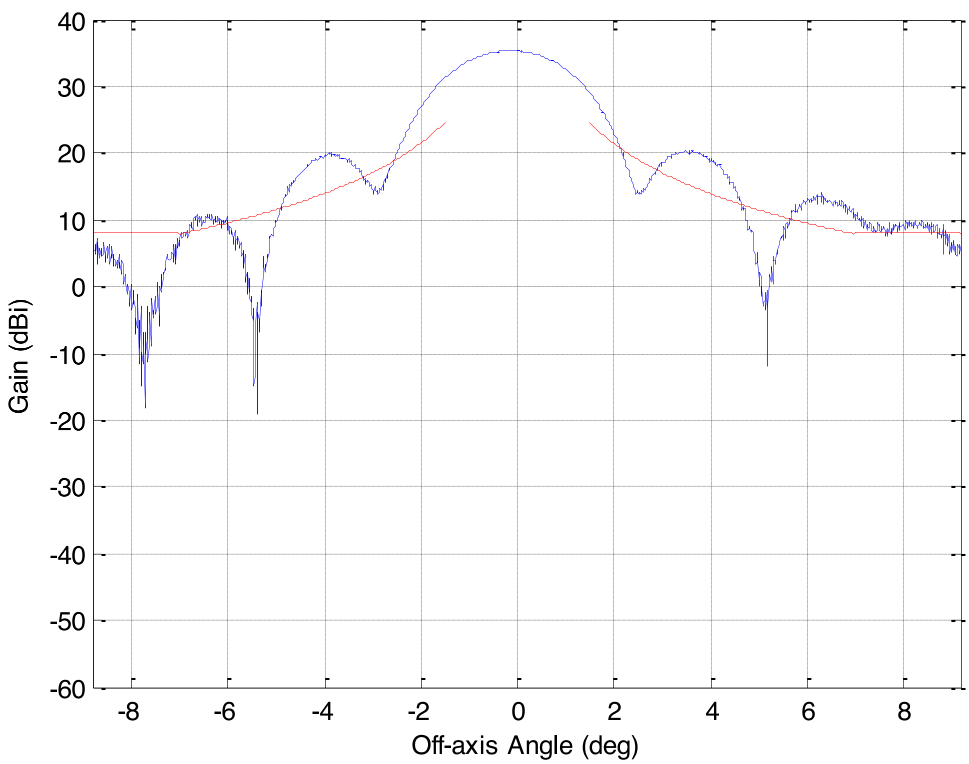

Figure 58. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Co, Skew: 50°

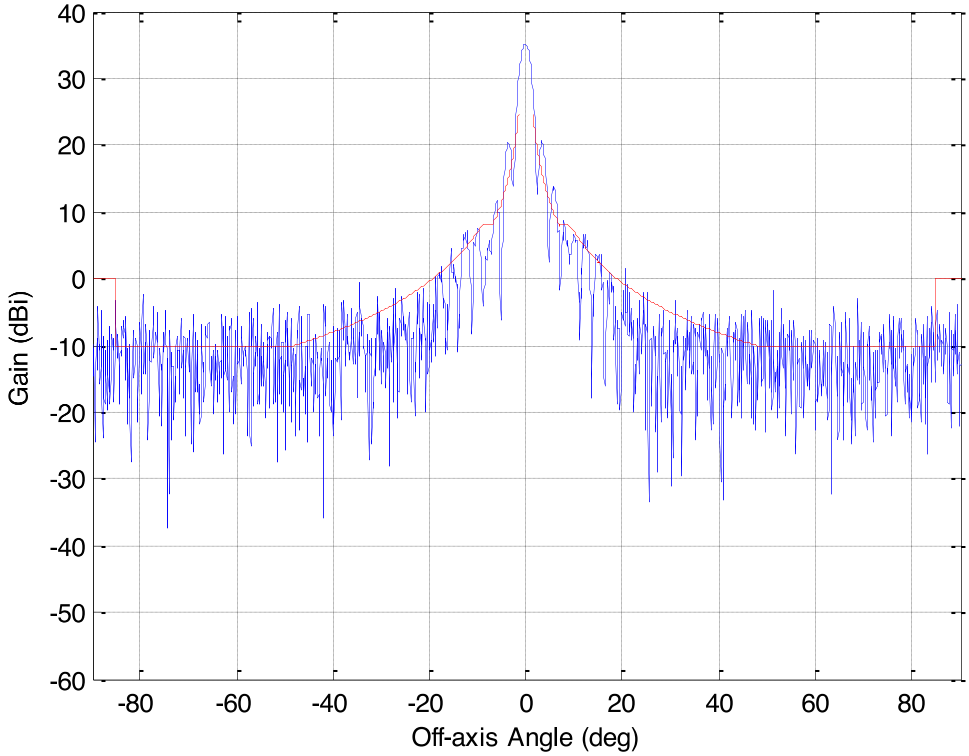

Figure 59. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 50°

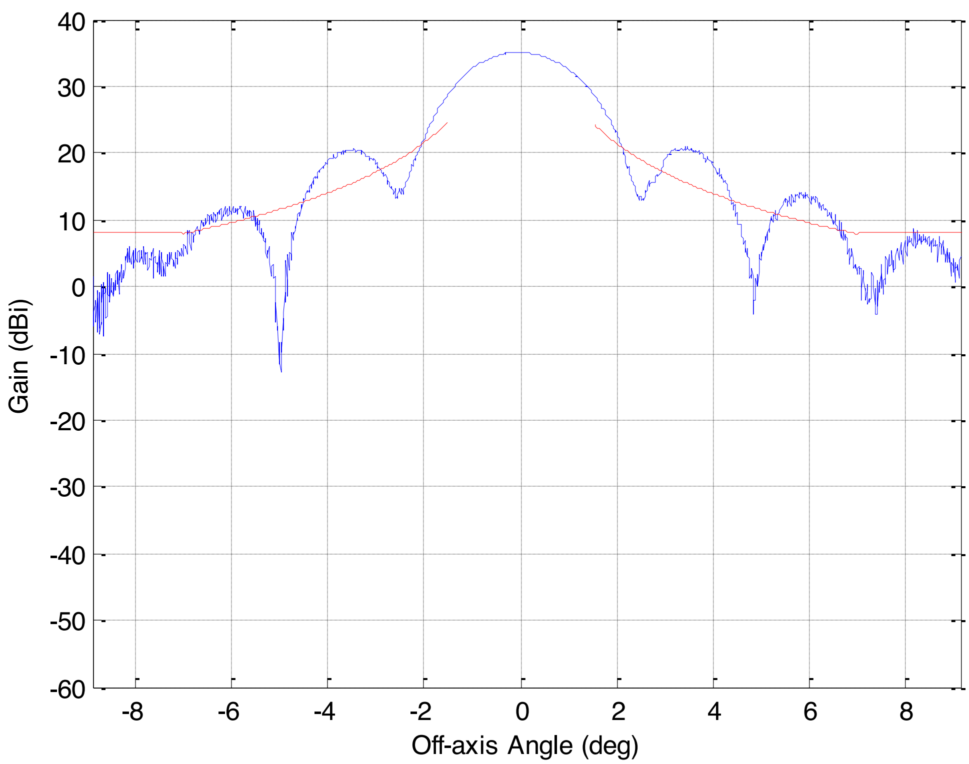

Figure 60. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Co, Skew: 50°

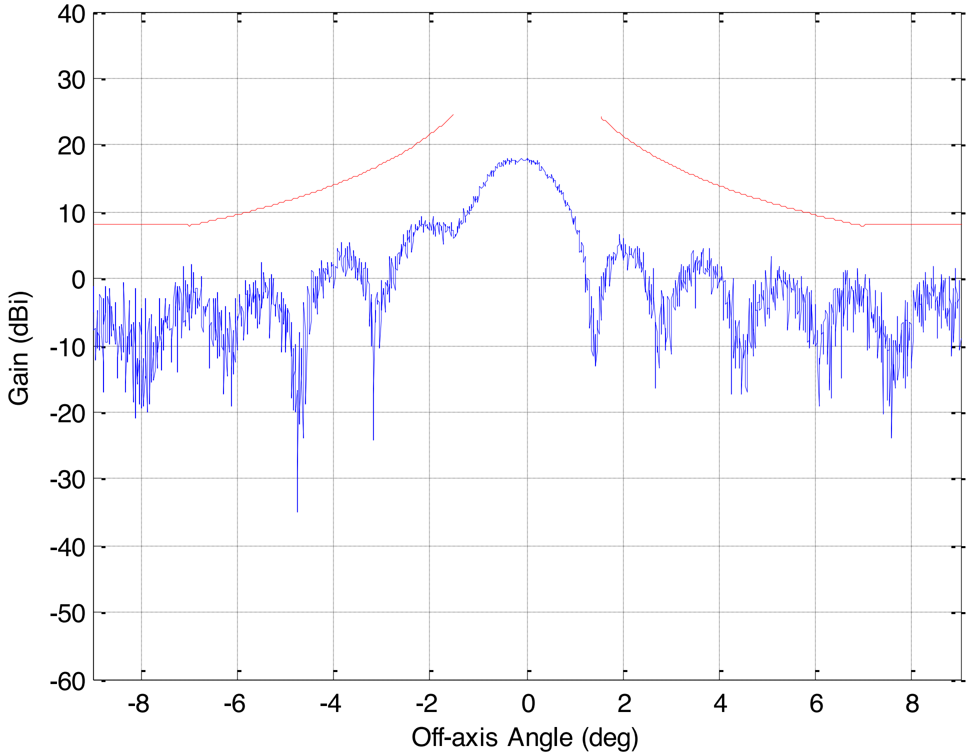

Figure 124. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Cross, Skew: 20°

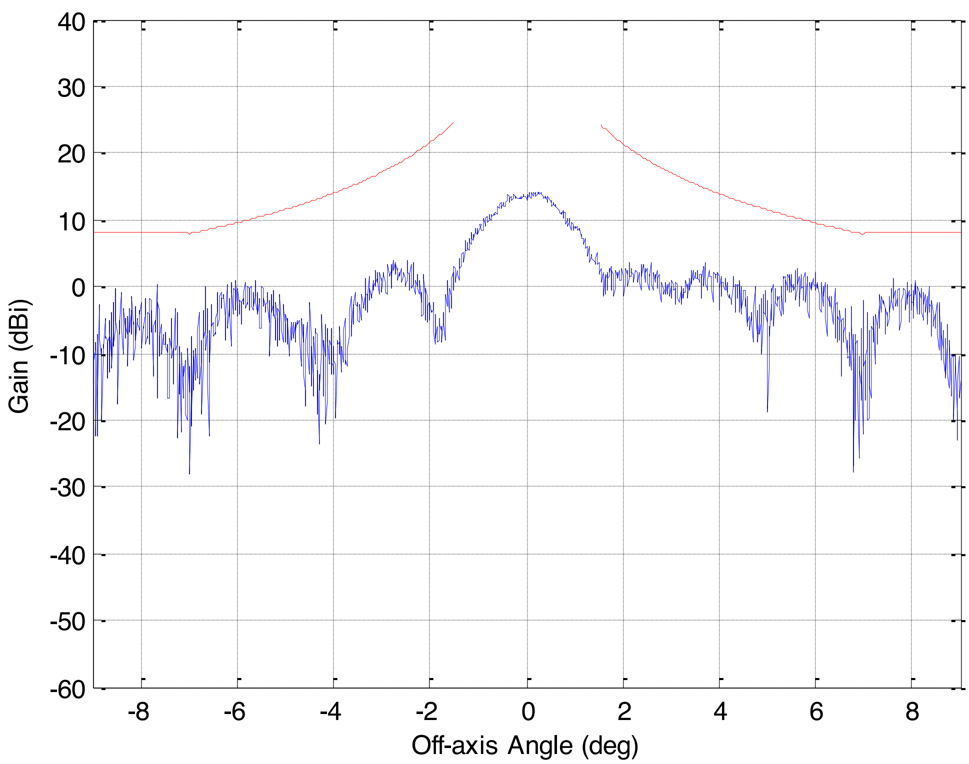

Figure 125. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Cross, Skew: 20°

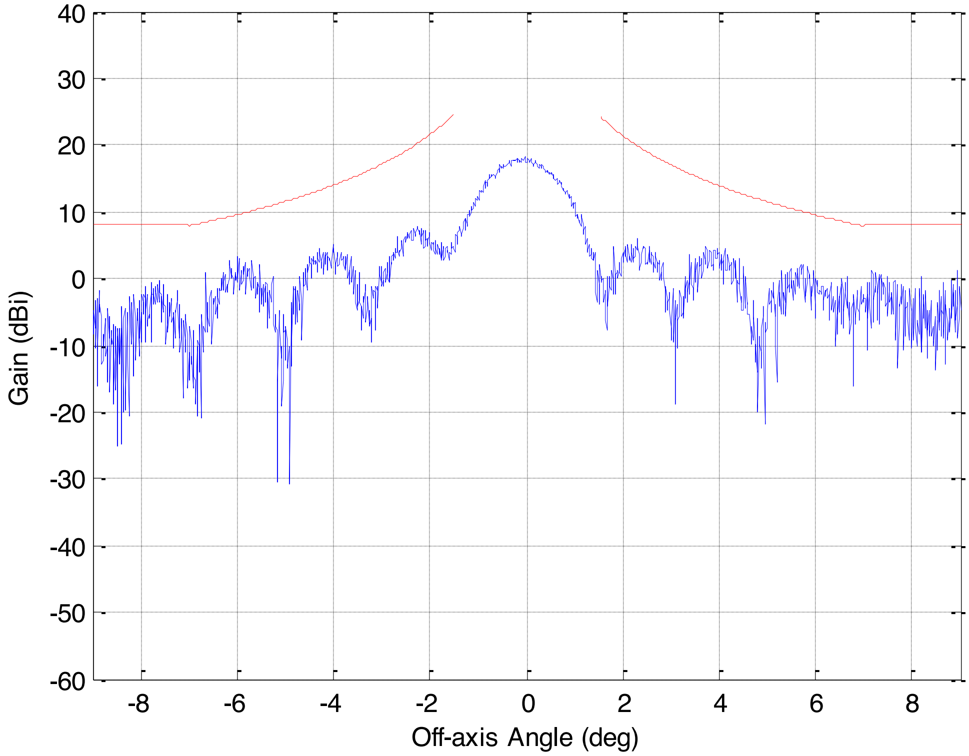

Figure 126. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Cross, Skew: 20°

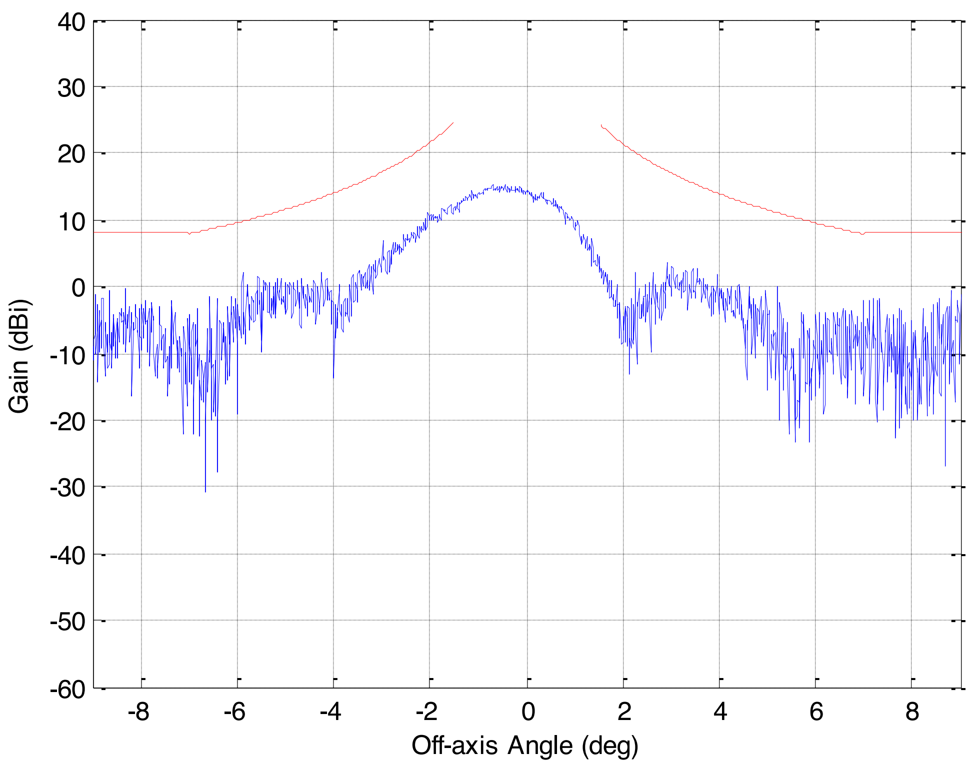

Figure 142. Rx Pattern @ 14.450 GHz, Polarity: H, Plane: Cross, Skew: 50°

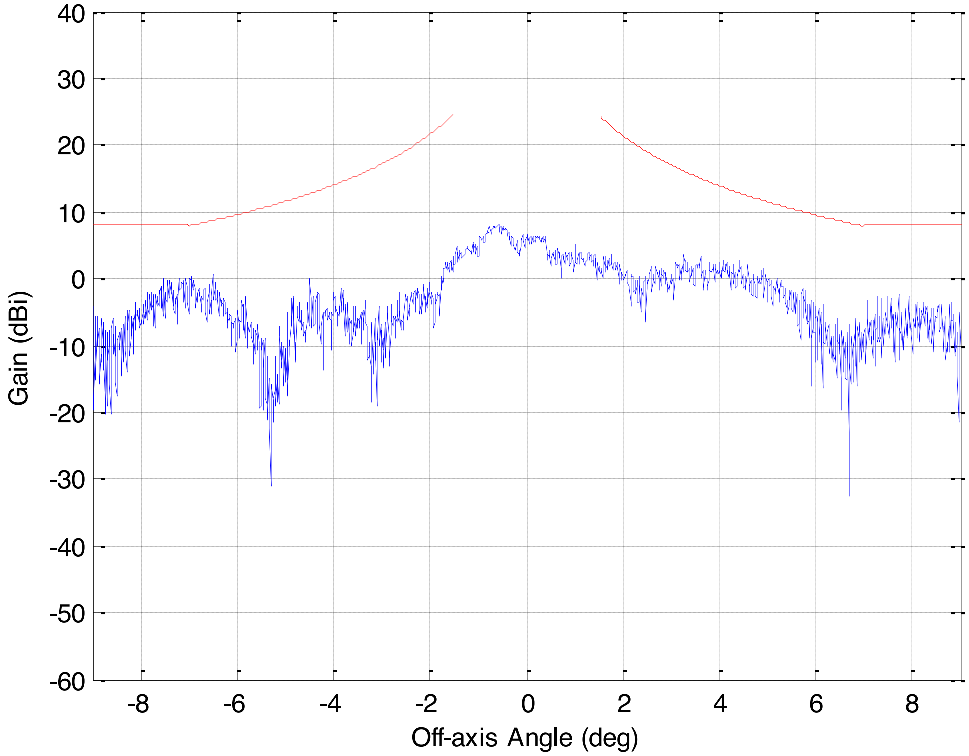

Figure 143. Rx Pattern @ 14.050 GHz, Polarity: H, Plane: Cross, Skew: 50°

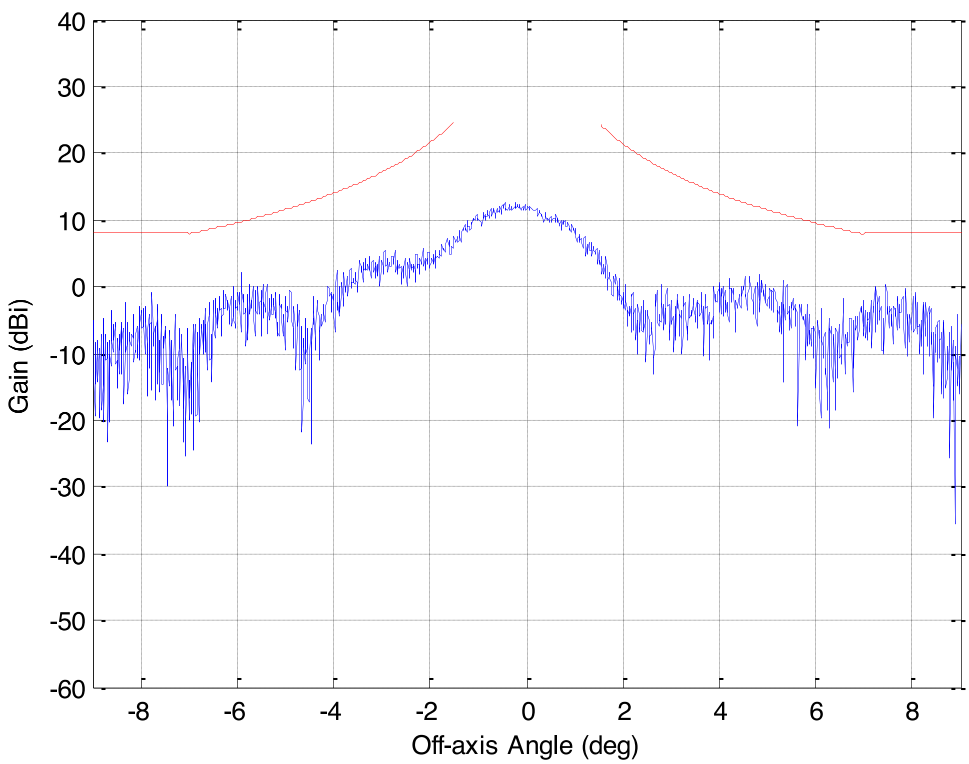

Figure 144. Rx Pattern @ 14.250 GHz, Polarity: H, Plane: Cross, Skew: 50°

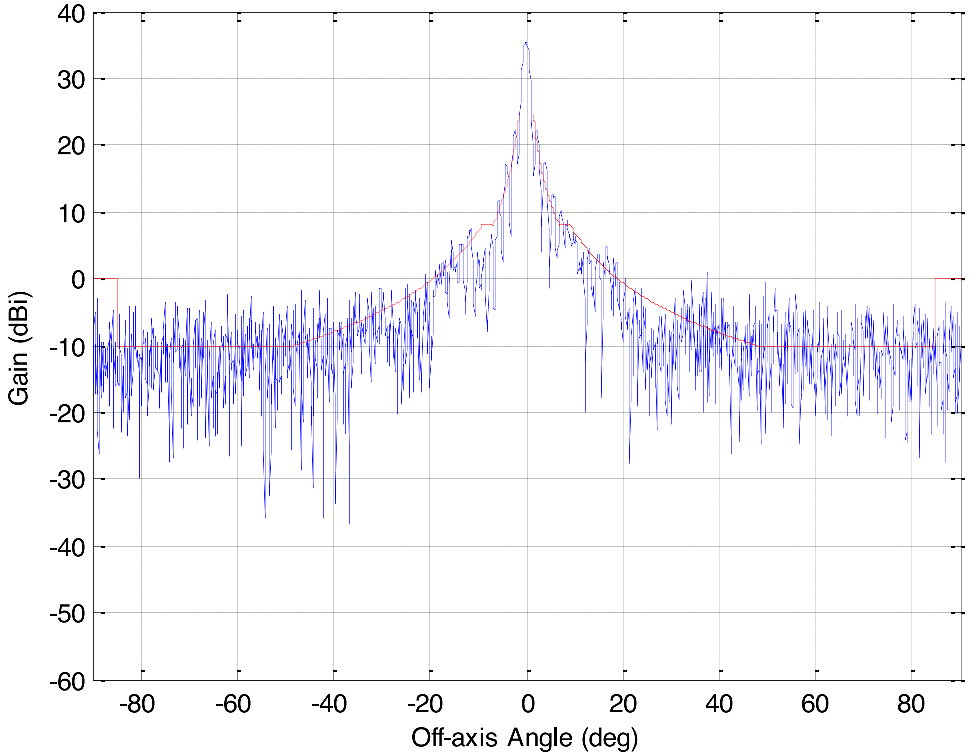

Figure 190. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 20°

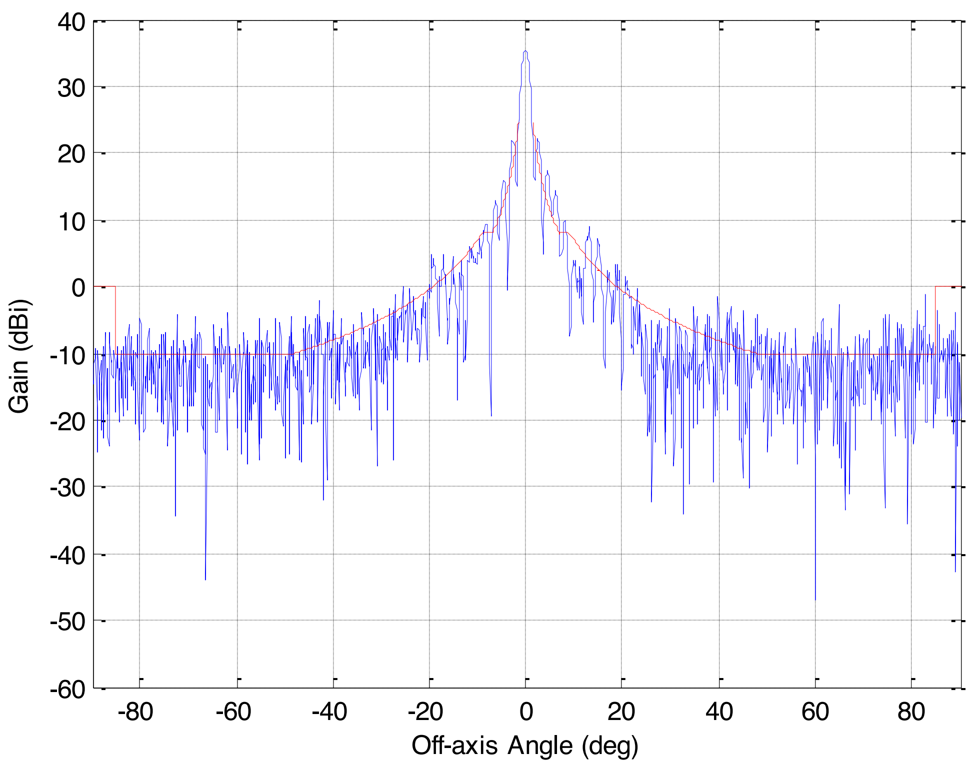

Figure 191. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 20°

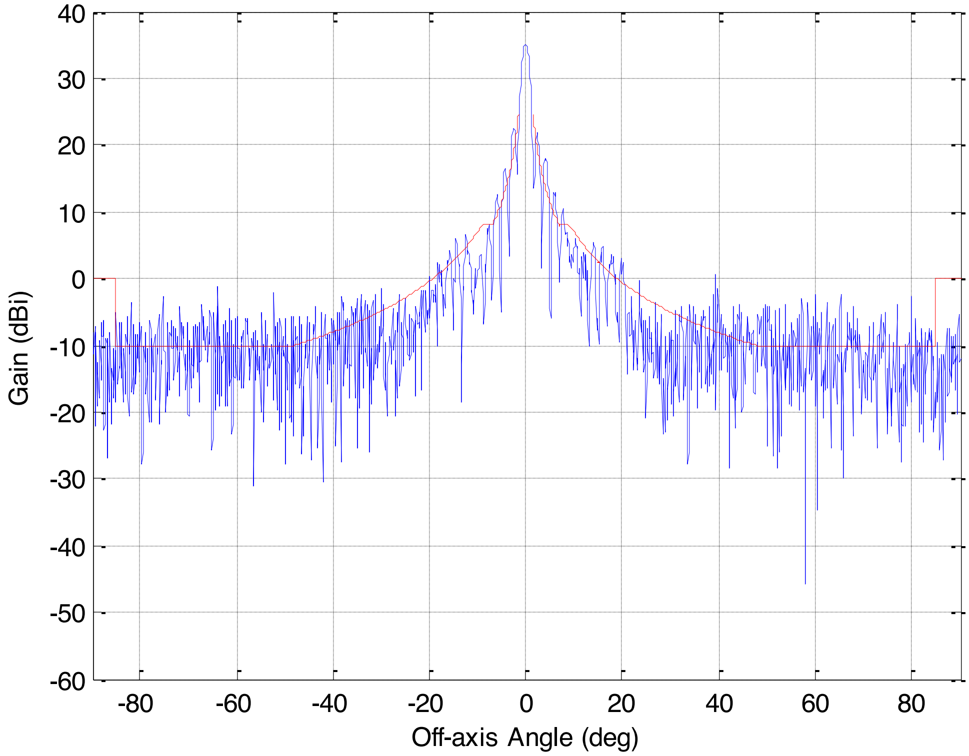

Figure 192. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 20°

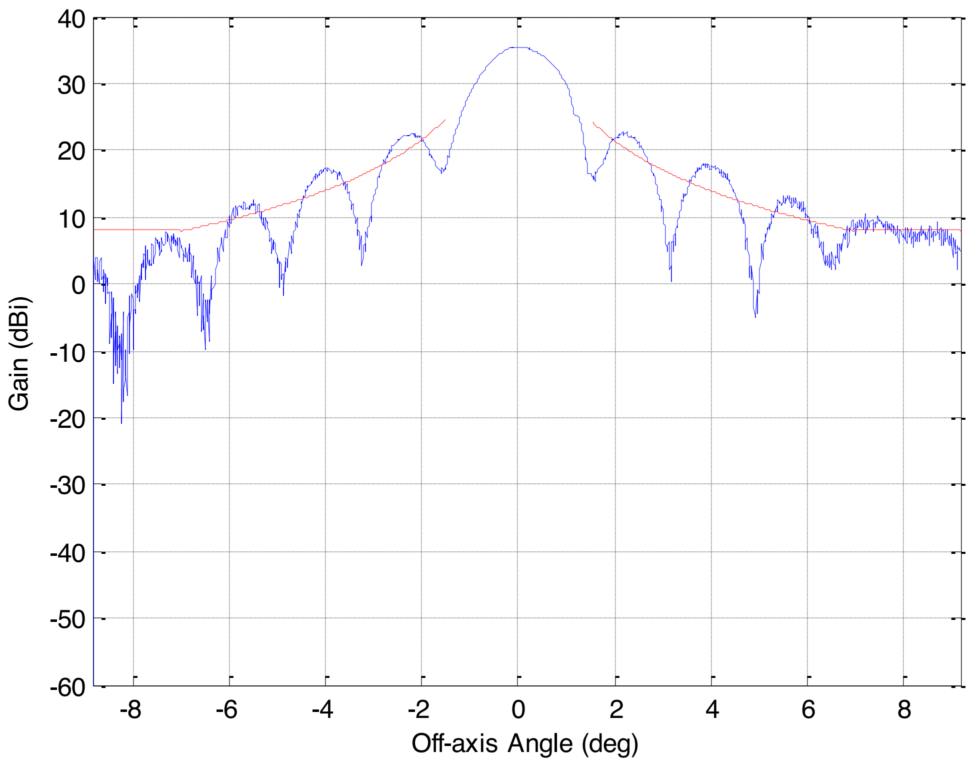

Figure 193. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 20°

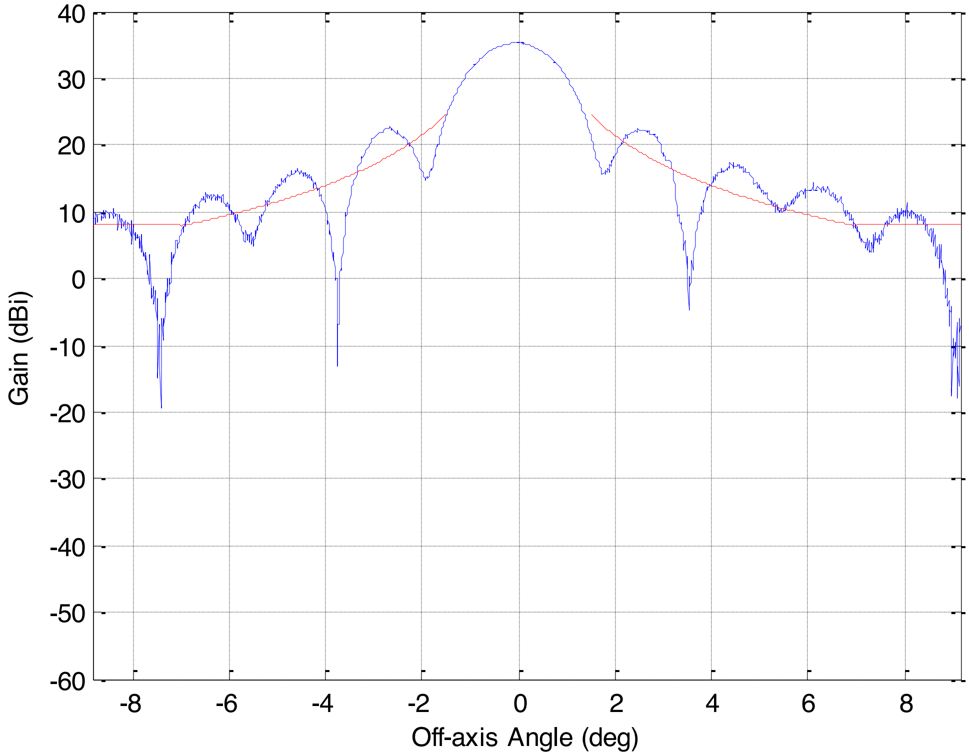

Figure 194. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 20°

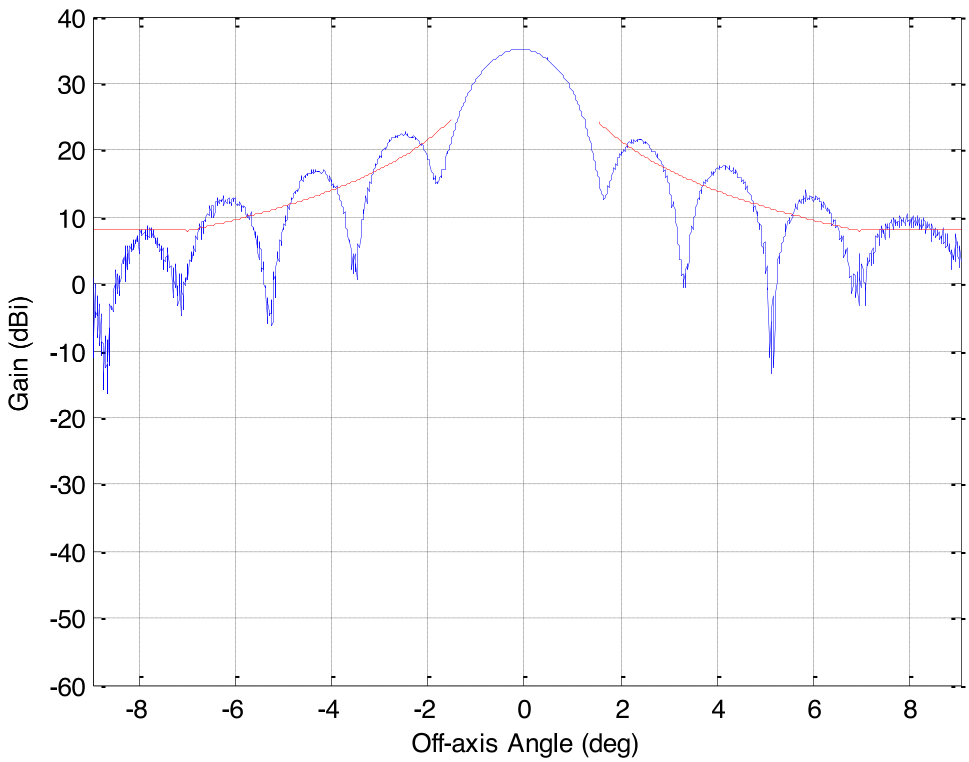

Figure 195. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 20°

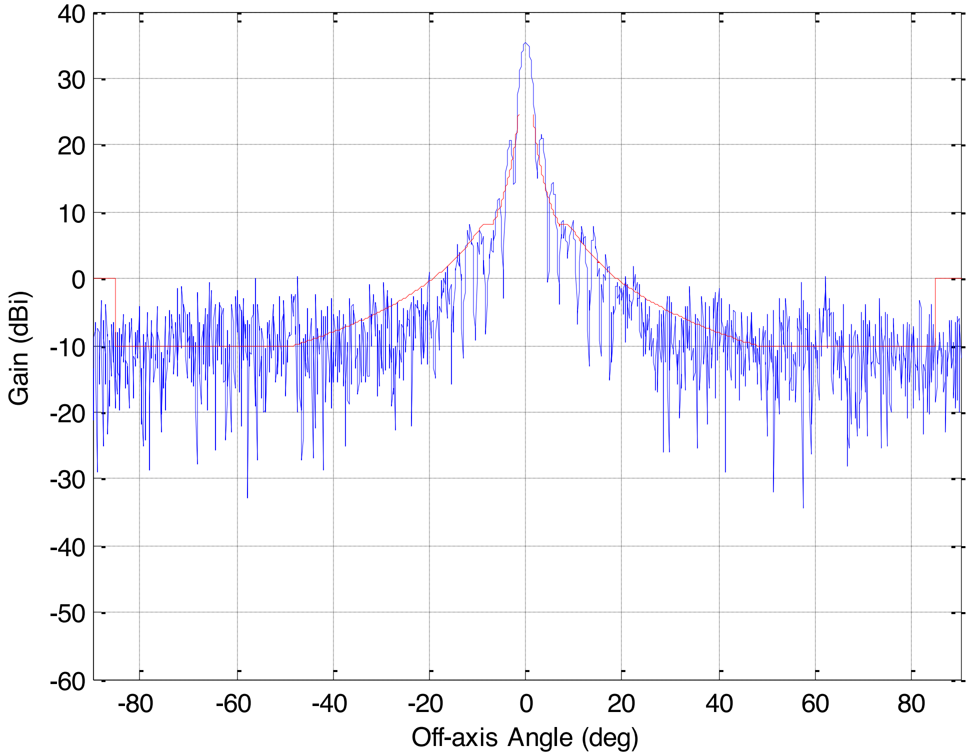

Figure 226. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 50°

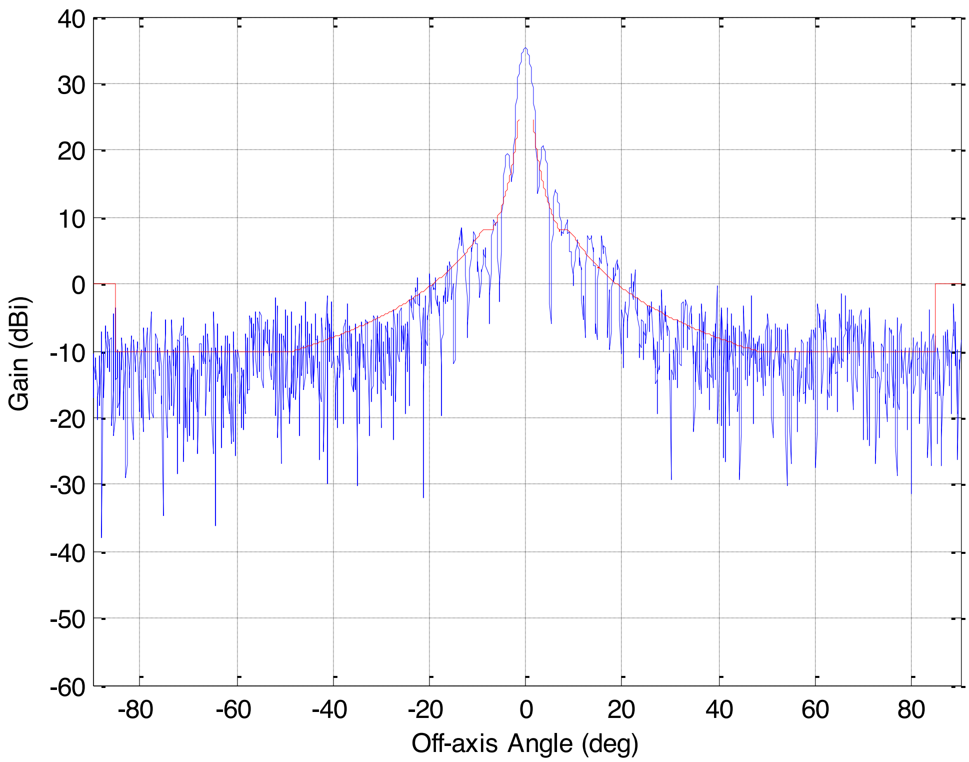

Figure 227. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 50°

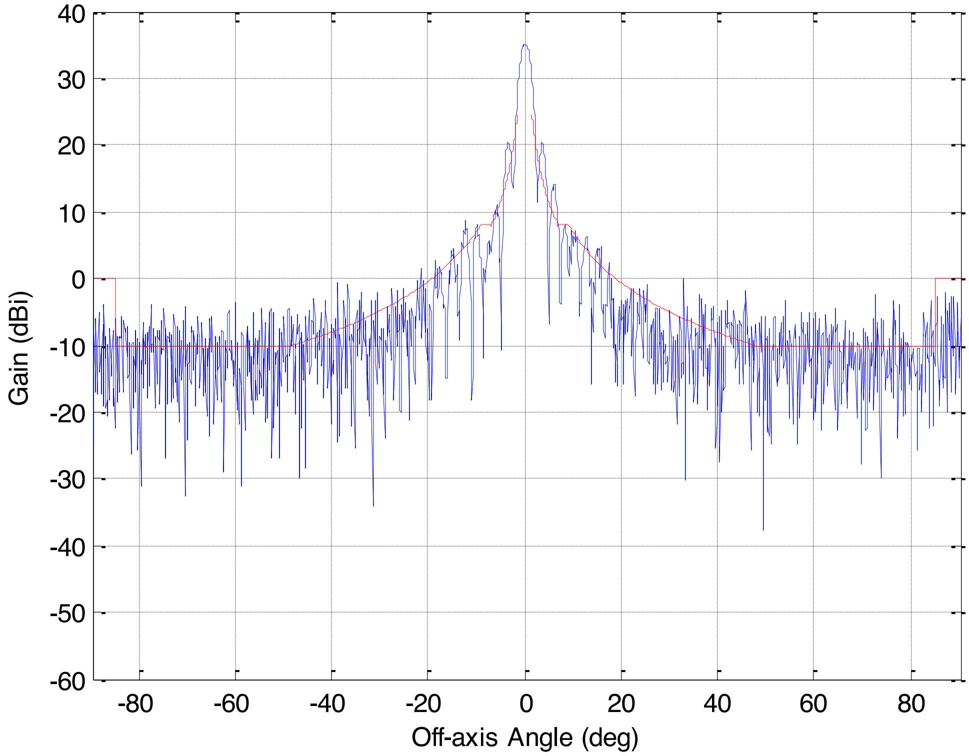

Figure 228. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 50°

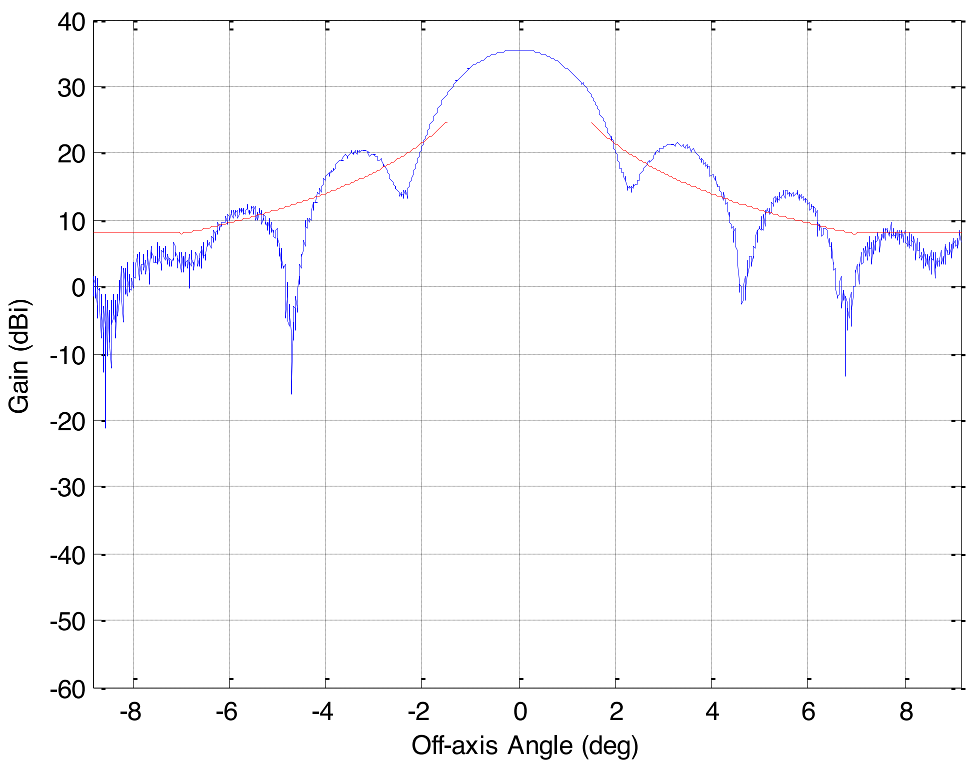

Figure 229. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 50°

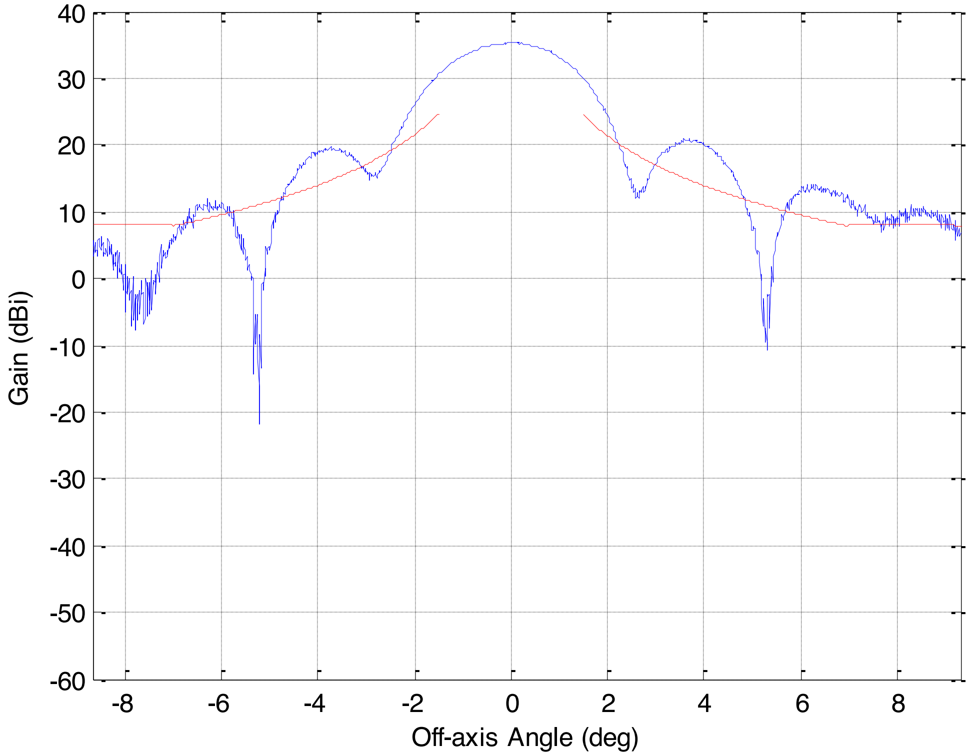

Figure 230. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 50°

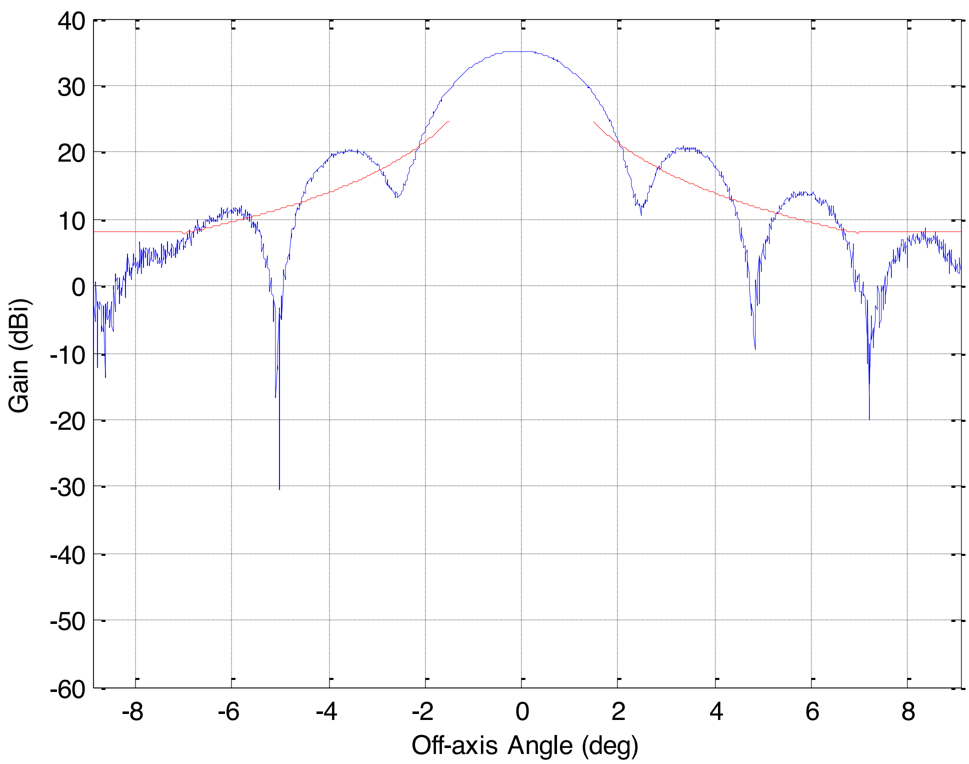

Figure 231. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 50°

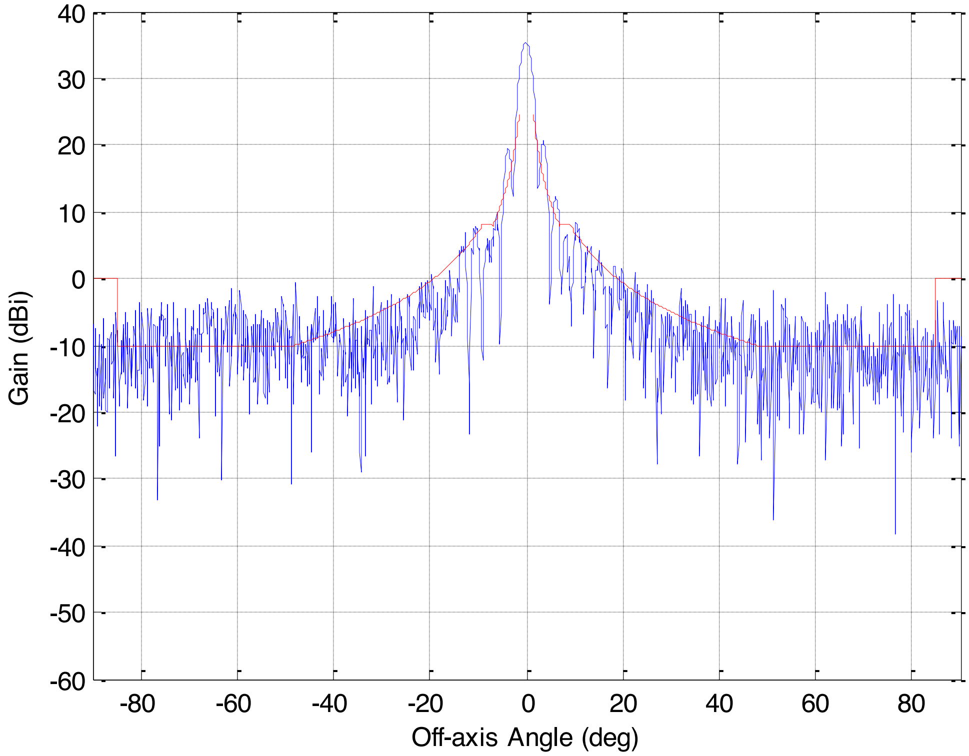

Figure 232. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Co, Skew: 55°

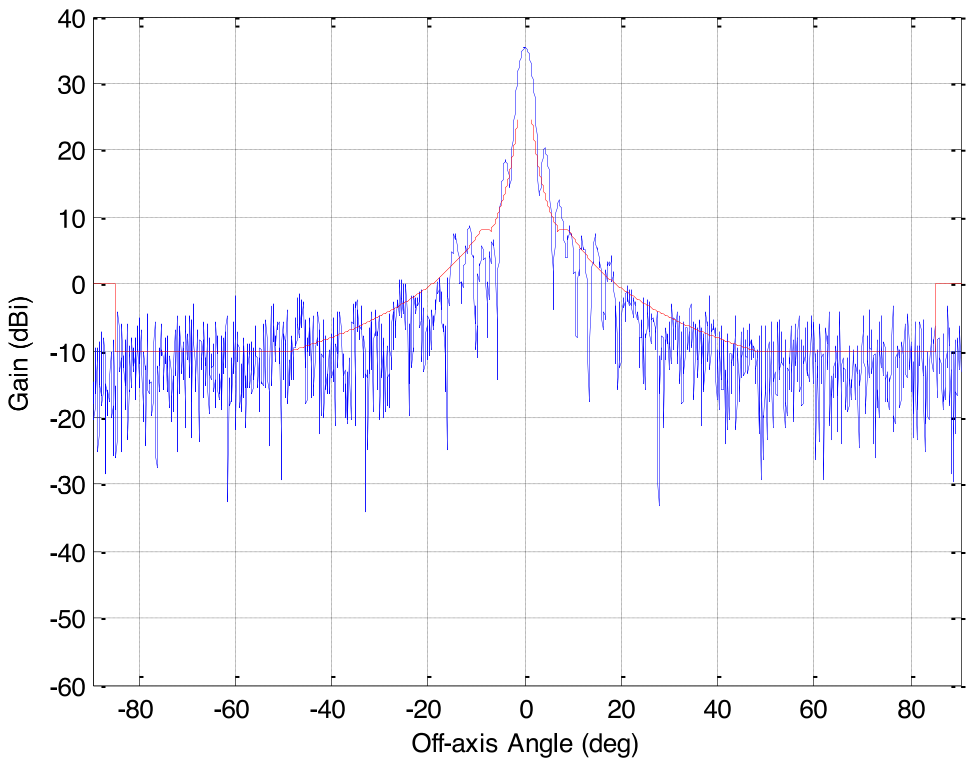

Figure 233. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Co, Skew: 55°

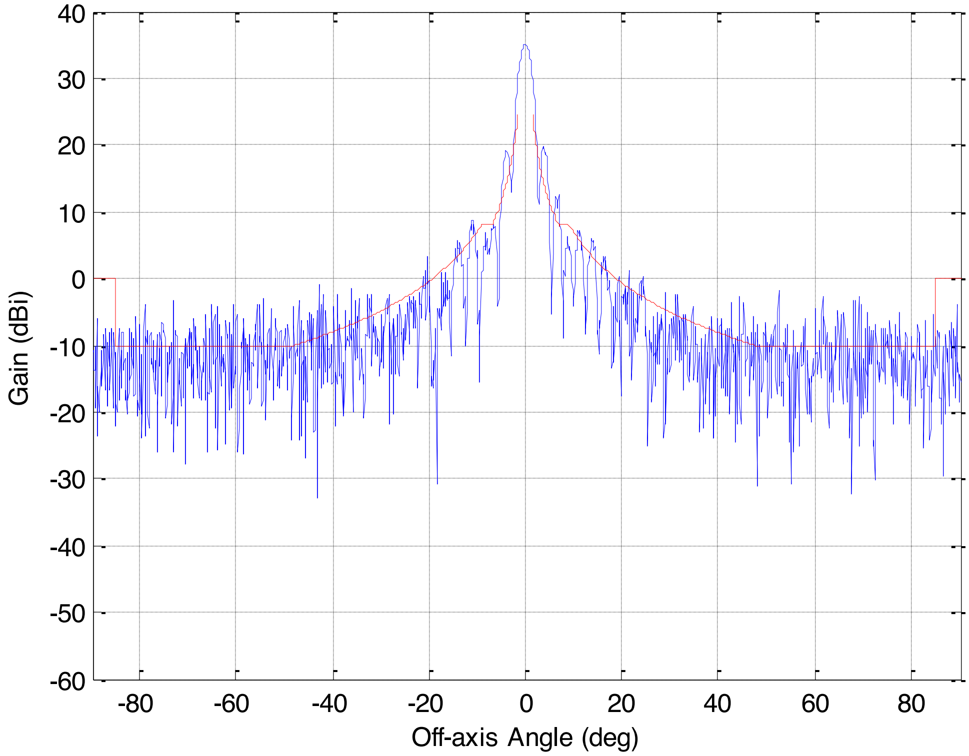

Figure 234. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Co, Skew: 55°

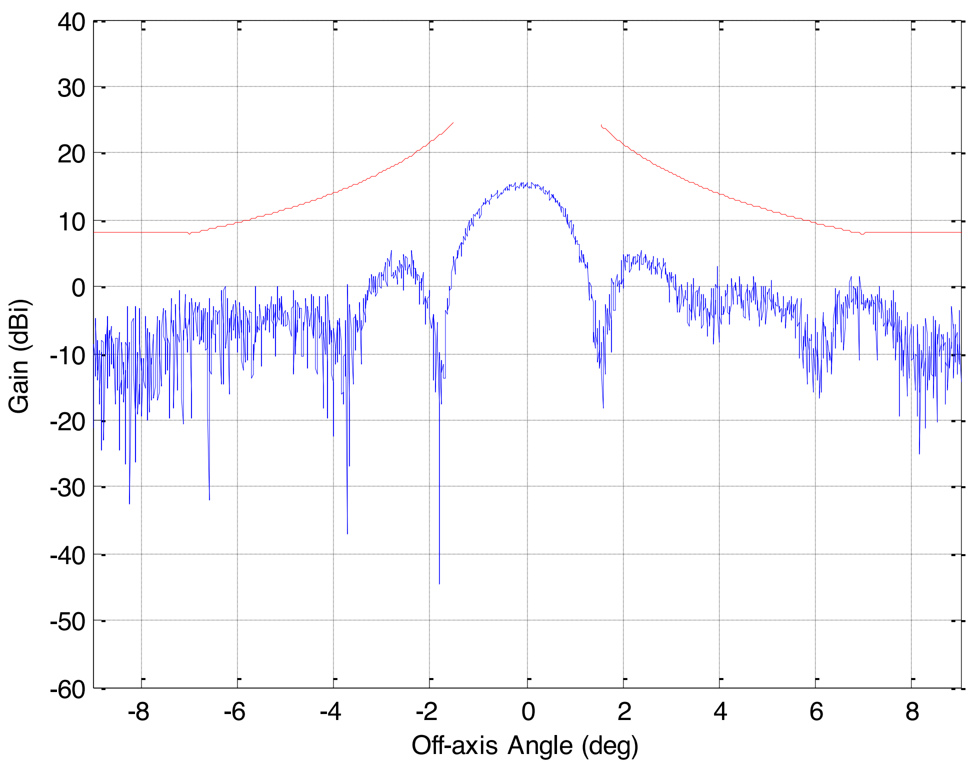

Figure 295. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Cross, Skew: 20°

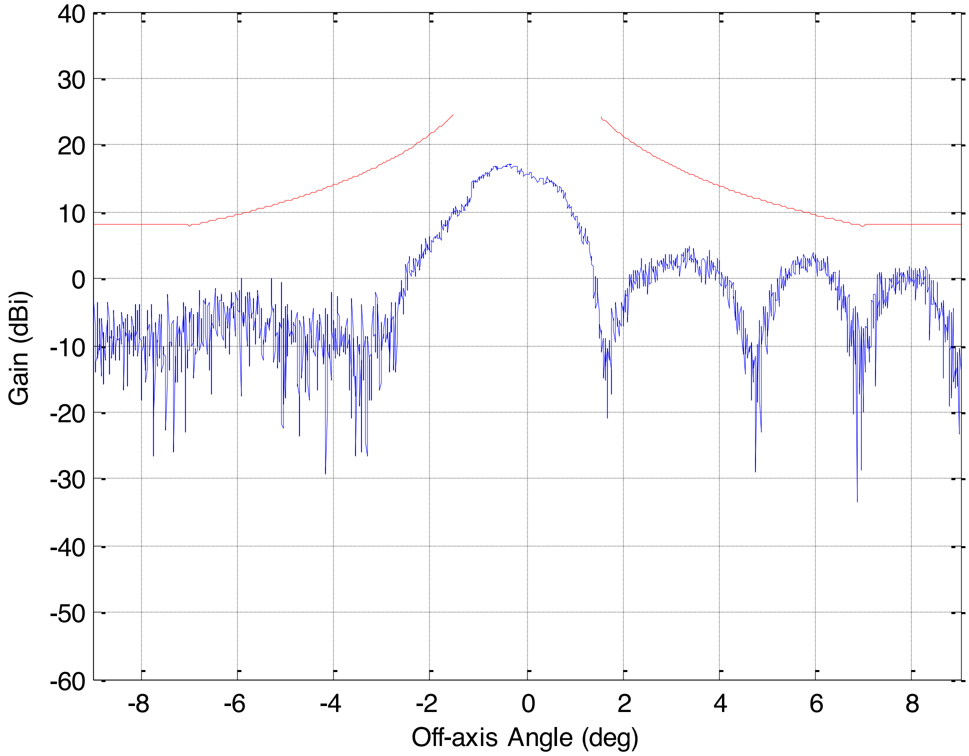

Figure 296. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Cross, Skew: 20°

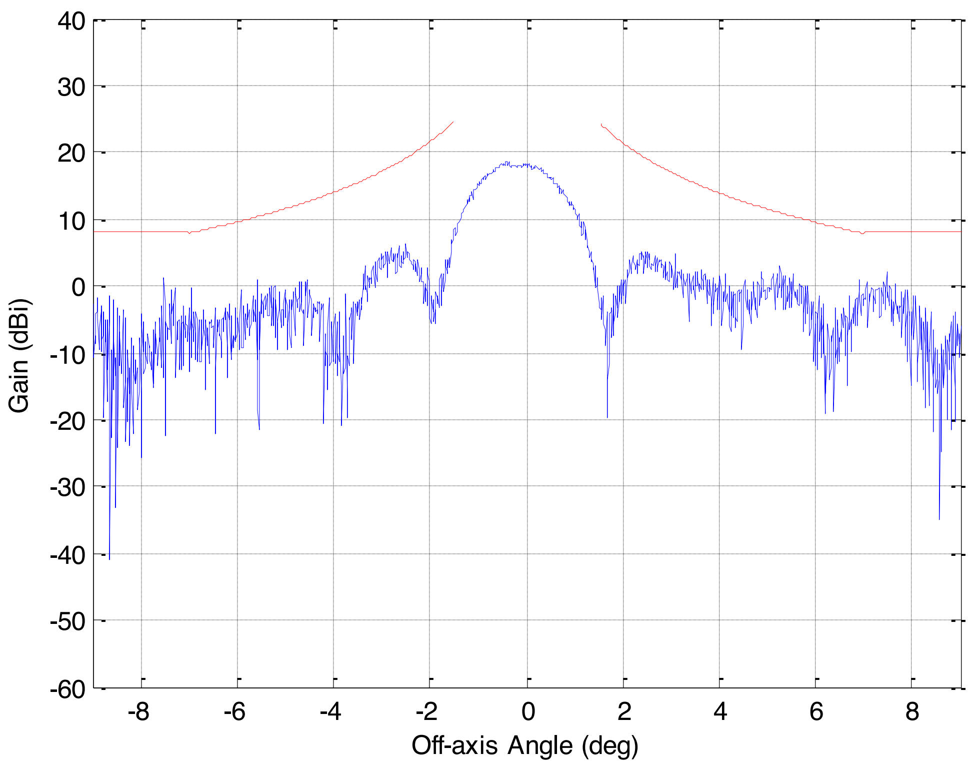

Figure 297. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Cross, Skew: 20°

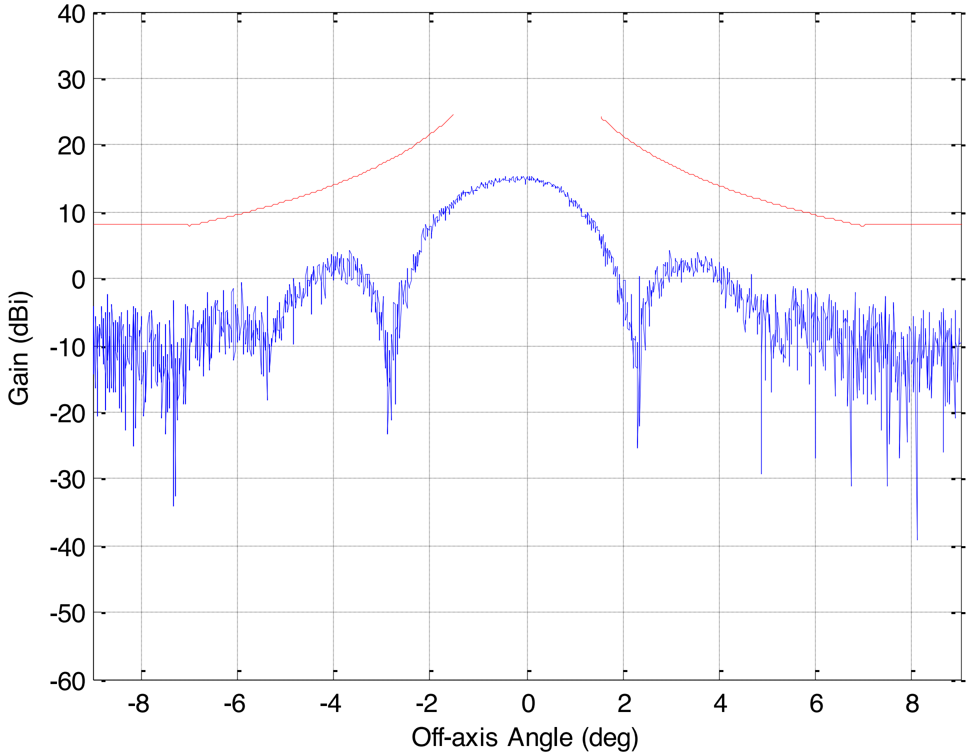

Figure 313. Rx Pattern @ 14.450 GHz, Polarity: V, Plane: Cross, Skew: 50°

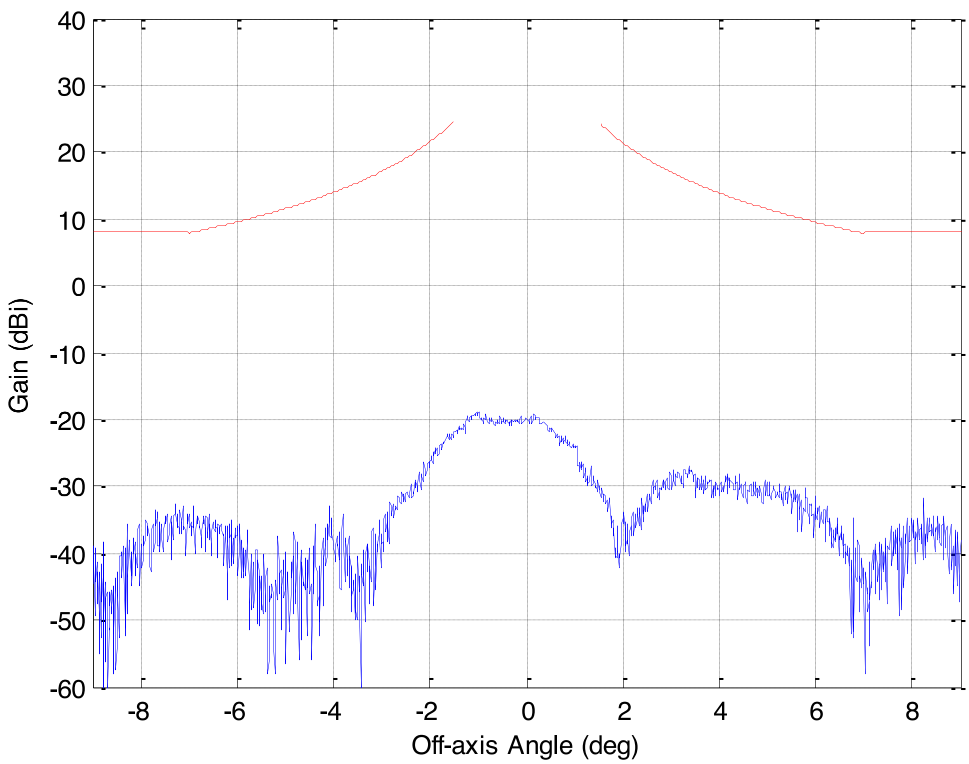

Figure 314. Rx Pattern @ 14.050 GHz, Polarity: V, Plane: Cross, Skew: 50°

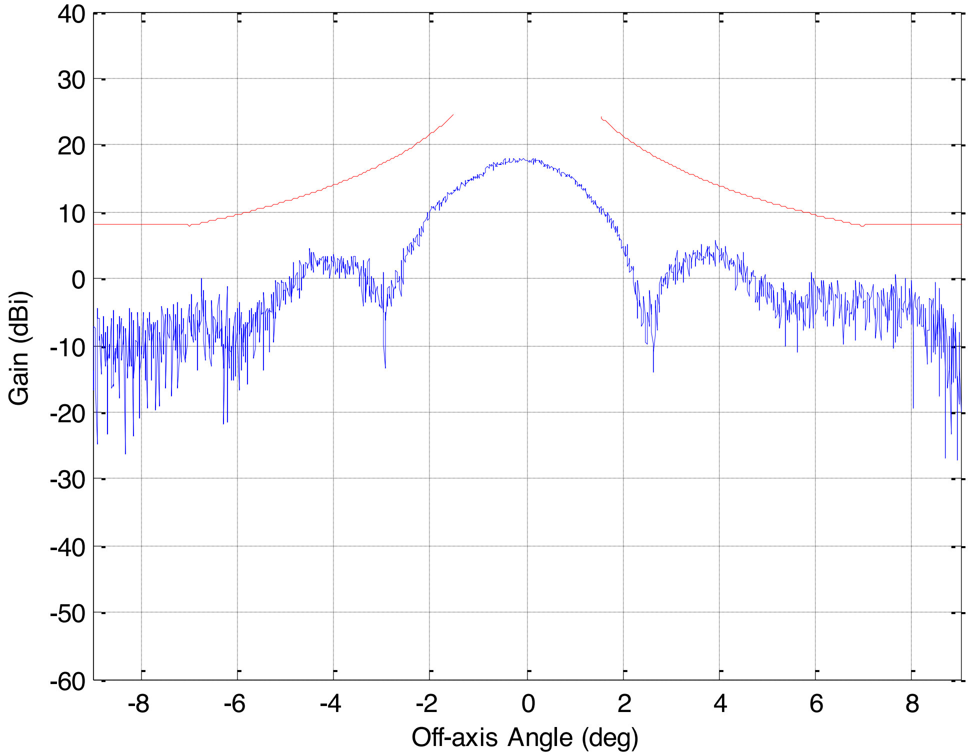

Figure 315. Rx Pattern @ 14.250 GHz, Polarity: V, Plane: Cross, Skew: 50°

V. Radiation Hazard Study

Radiation Hazard Analysis for Panasonic Single-Panel Antenna

This report analyzes the non-ionizing radiation levels for the Panasonic Single-Panel Antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

Bulletin No. 65 specifies that there are two separate tiers of exposure limits that are depending on the area of exposure and/or the status of the individuals who are subject to the exposure -- the General Population/ Uncontrolled Environment and the Controlled Environment, where the general population cannot access.

The maximum level of non-ionizing radiation to which individuals may be exposed is limited to a power density level of 5 milliwatts per square centimeter (5 mW/cm^2) averaged over any 6 minute period in a controlled environment, and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 1 milliwatt per square centimeter (1 mW/cm^2) averaged over any 30 minute period in a uncontrolled environment.

In the normal range of transmit powers for satellite antennas, the power densities at or around the antenna surface are expected to exceed safe levels. Because the antenna is mounted on top of an aircraft fuselage, this area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high exposure area. Procedures will be established to ensure that all transmitters are turned off before this area is accessed by operators, maintenance or other authorized personnel.

Near Field Exposure

The Panasonic Single-Panel Antenna potentially exceeds MPE limits in the near field within the rectangular volume directly in front of the panel (9.0 mW/cm^2). For this calculation, it was assumed that all 16 watts from the SSPA modules are uniformly distributed across the surface area of the panel. This is a reasonable assumption for a flat panel waveguide fed phased array with uniform excitation.

The extent of the near field region is defined by the following

$$R_{nf} = D^2 /(4\lambda)$$

10.7 meters

Where D is the width of the panel (0.95 meters)

The maximum power density in the Near Field can be determined by the following equation:

$$S_{nf} = P_{SSPA} / A$$

5.7 mW/ cm^2

Where A is the surface area of the panel and P is the power available from the SSPA.

In normal operation, this antenna is mounted on the fuselage of an aircraft or rooftop with the main beam pointed toward the sky at a minimum elevation angle of 5 degrees such that human exposure in the near field is not possible. Furthermore, normal TDMA operation uses a duty cycle of 10% or less, reducing maximum near field exposure by an order of magnitude to 0.57 mW/cm^2. Additionally, in normal operation, any blockage in the near field will cause the transmitter to be disabled within seconds as the system does not transmit unless it can receive the downlink carrier from the satellite. Therefore, prolonged exposure in the near field is not possible in normal operation.

Far Field Exposure (in main beam)

$$R_{ff} = 0.60 D^2 / \lambda$$

26 m

$$S_{ff} = P_{EIRP} / (4 \pi R_{ff}^2)$$

0.4 mW/ cm^2

At a distance of 26 meters (far-field boundary), the power density of the antenna is 0.4 mW/cm^2, which is well within the limits of General Population/Uncontrolled Exposure (MPE) even in the direction of the main beam of the antenna. There is no RF hazard to personnel in the far field of the antenna (26 m). The limit of 1 mW/cm^2 for the General Population/Uncontrolled Exposure in the main beam of the antenna occurs in the transition region, which is described below.

Transition Region Exposure (in main beam)

At a distance of 18 m from the antenna, maximum exposure in the main beam is 3.2 mW/cm^2. This assumes that PFD decreases linearly from 5.7 mW/cm^2 to 0.4 mW/cm^2 in this region between the near field and far field (10.7 m to 26 m from the antenna). At a distance of **25 m** from the antenna, maximum exposure in the main beam is **0.8 mW/cm^2**.

Exposure to personnel located below antenna height

The antenna will be mounted at a height above personnel/public locations. In this case, the worst case exposure is due to the first elevation sidelobe at a level of -13 dB. For the Panasonic Single-Panel Antenna, the far field distance in the elevation plane is approximately 1.0 m. The 5 mW/cm^2 threshold is reached at a distance of 1.6 m and the 1 mW/cm^2 threshold is reached at a distance of 3.5 m. Observing the safe radius distance noted above during transmit operations will ensure that the threshold will not be exceeded.

Table 1: Parameters Used for Determining PFD (Panasonic Single-Panel Antenna)

Antenna Width	37.362	in	0.949	m
Antenna Height	7.276	in	0.185	m
Antenna Surface Area			0.175	m^2
Frequency			14250	MHz
Wavelength			0.021	m
Transmit Power			10	W
Antenna Gain			35	dBi
Antenna Gain			3162	
EIRP			45	dBW
Far Field Boundary (Azimuth)			26.0	m
Power Density at far field boundary (Azimuth)			0.4	mW/cm^2
Near Field Distance (Azimuth)			10.7	m
Near Field Power Density (Azimuth)			5.7	mW/cm^2
Elevation sidelobe level			-13.0	dB
Far Field Boundary (Elevation)			1.0	m
Power Density at far field boundary (Elevation)			13.3	mW/cm^2
Safe Far Field Distance (Elevation)			1.6	m
Power Density			4.9	mW/cm^2
Safe Far Field Distance (Elevation)			3.5	m
Power Density			1.0	mW/cm^2

Conclusions

The worse-case radiation hazards exist along the main beam axis. In the case of the proposed operations, it is highly unlikely that the antenna axis will be aligned with any uncontrolled area since the antenna will be mounted on an aircraft fuselage and transmit operations will only be conducted with a clear field of view towards the serving satellite. In this case, the safety radius outside the aircraft where the General Population/ Uncontrolled Exposure limits are satisfied is 3.5 meters. The general public does not have access to this area.

In addition, commissioning and testing of the Panasonic Single-Panel Antenna will only be conducted by trained personnel in a controlled environment. By maintaining an adequate safety radius during transmit operations, it can be guaranteed that the General Population/Uncontrolled Exposure limits will not be exceeded under any conditions. As required by Special Condition 90053, Panasonic will utilize appropriate labeling warning about the radiation hazard, including a diagram showing the regions around the terminal where the radiation levels could exceed 1.0 mW/cm^2.

VI. Pointing Accuracy Report

Panasonic

Panasonic Avionics Corporation

Antenna Development Center

SPA Pointing Accuracy Report

Document Number: DRD-PR000017-14-1985

Prepared by	Raviv Kiron	Date ________	Digitally signed by Raviv Kiron DN: cn=Raviv Kiron, email=Raviv.Kiron@panasonic.aero Date: 2015.06.14 16:33:38 +03'00'
Approved by	Eran Borenstein/Ilan Bitton	Date ________	Ilan Bitton 2015.06.14 16:43:24 +03'00'
Approved by	Josef Blumberger	Date ________	

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1 Introduction

This report presents a dynamic pointing accuracy analysis of the Panasonic Single Panel Antenna (“SPA”). The SPA was placed on a motion table and a laser beam was pointed to the antenna panel and reflected back to a target using a mirror attached to the antenna panel. The target is sized to indicate a 0.2° offset from the intended target (i.e., the serving satellite). The motion table was programmed for various changes in yaw, pitch and roll to reflect extreme changes in aircraft attitude relative to the target. The location of the laser beam relative to the 0.2° target during these movements was used to determine the pointing accuracy of the SPA.

2 Set Up

Figures 1 and 2 depict the test setup. The SPA was placed on 3-axis motion table, controlled by a PC and a motion controller (Motion Controller 1). On the table itself there are:

- 3 incremental encoders, which measure the 3-axis angles and their velocities.
- 3-axis accelerometers, which measure the initial angles (in stationary mode) in roll and pitch
- A motion controller (Motion Controller 2), which reads all sensors measurements, translates the motion into the antenna system and transmits the data in ARINC429 format to the SPA.

The PC also controls Motion Controller 2 for calibration purposes.

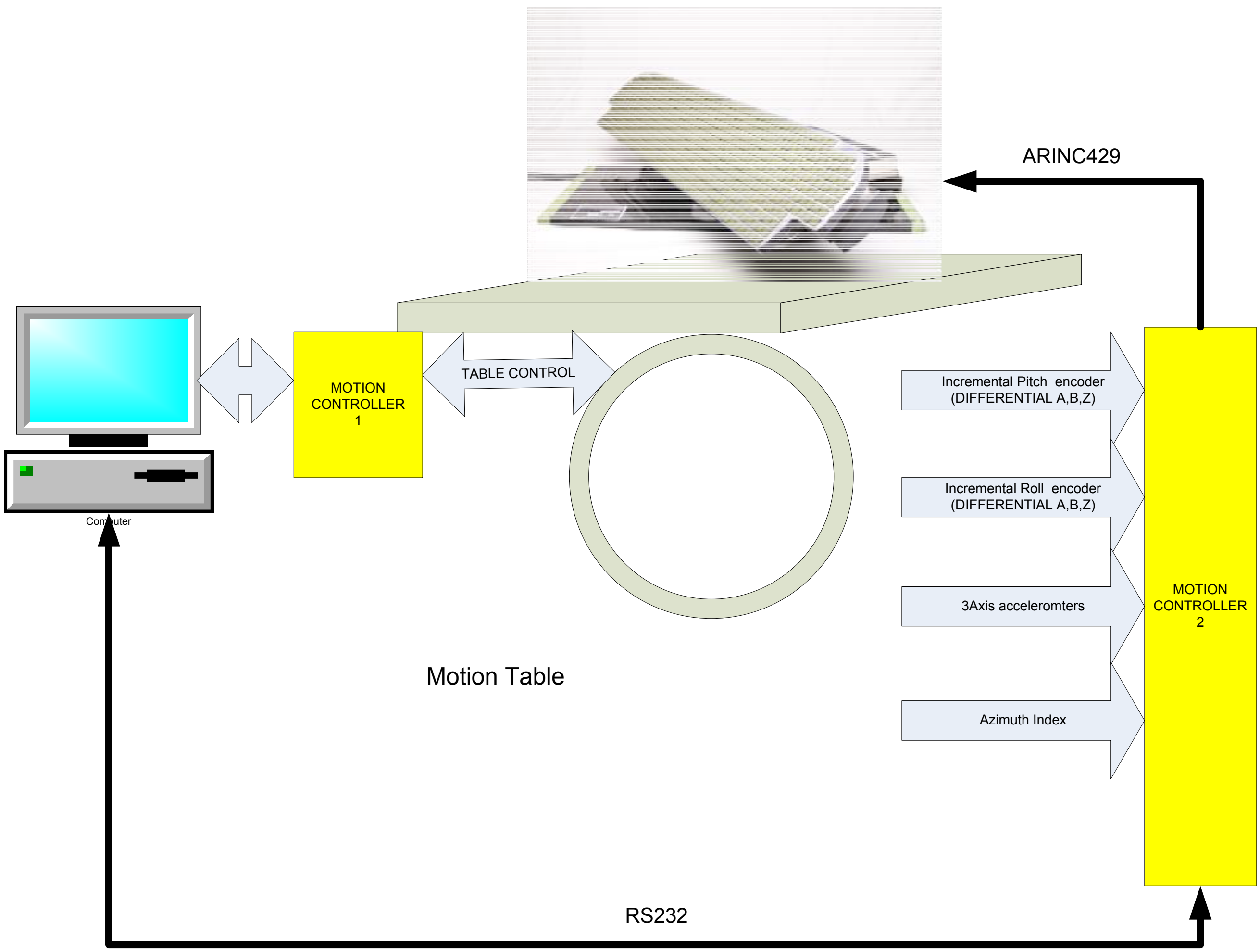

Figure 1: Motion table setup

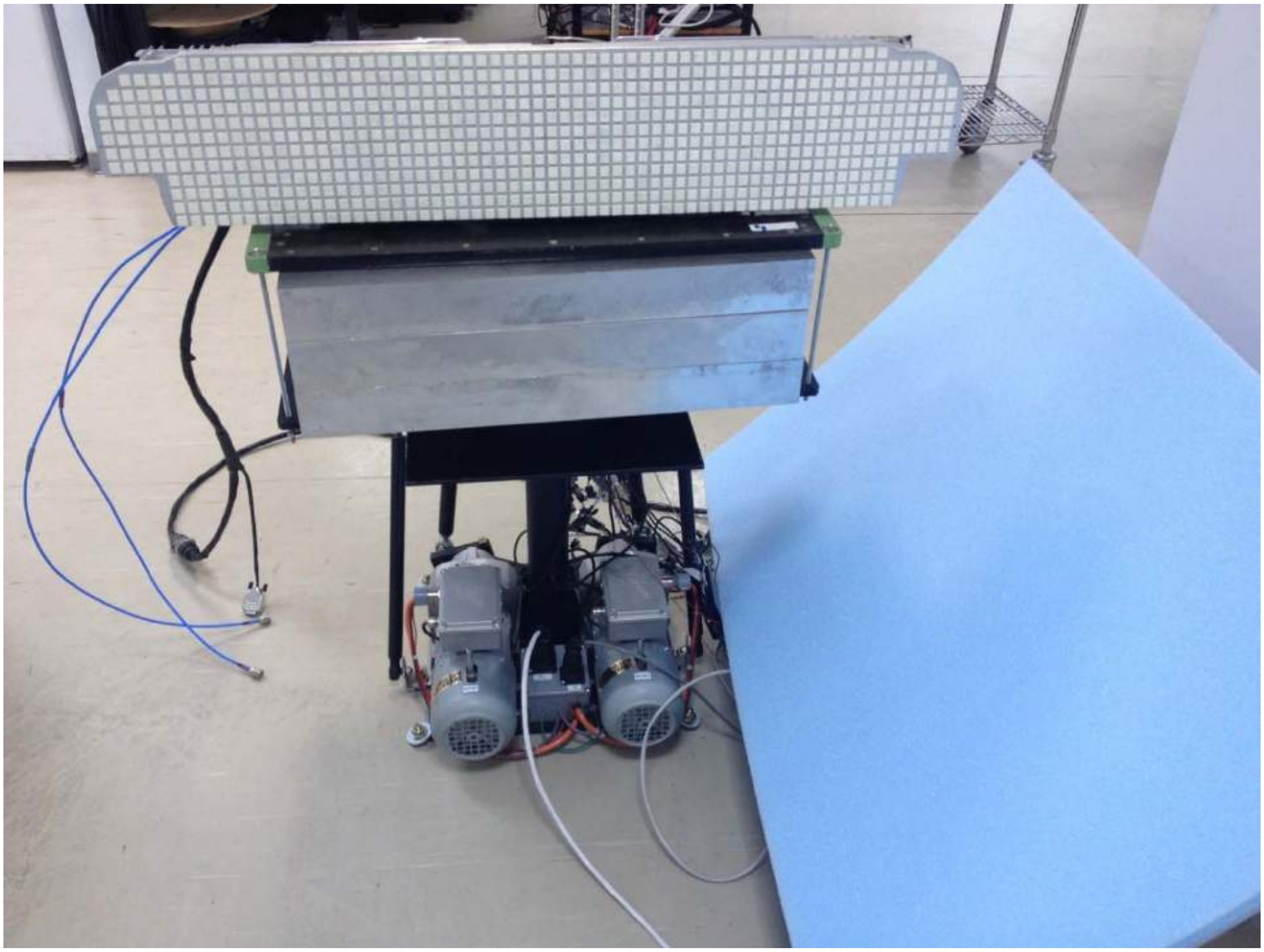

Figure 2 : Motion table

A laser source is mounted on the wall, and reflected back to the wall by the SPA panel (using a mirror) as shown in Figure 3.

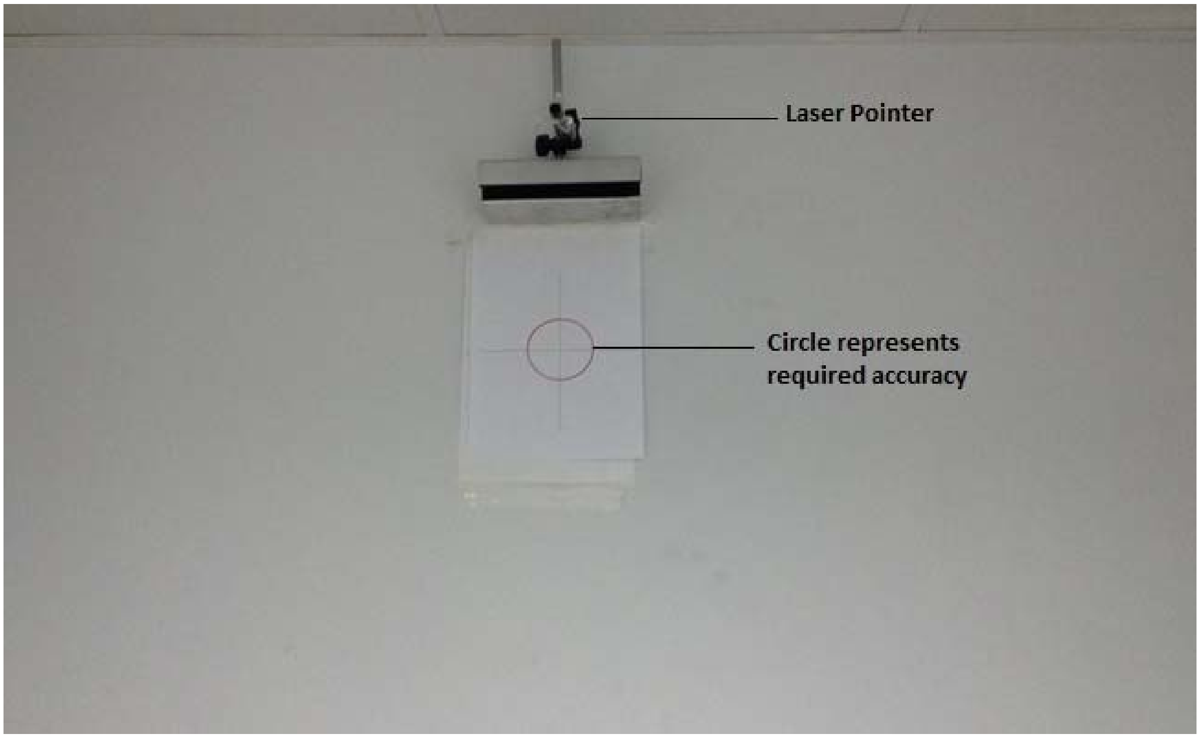

Figure 3 :LASER source & the reflection area

3 Calibration

3.1 Mounting calibration

When the SPA is mounted on the motion table, there are offsets between the antenna itself and the motion table. These offsets are being compensated by measuring the antenna tilt angles (using inclinometer) and the accelerometers readings and inserting these differences into the accelerometers memory.

3.2 Zero calibration

The purpose of this calibration is to set the laser beam in the center of the circle, see Figure 3. This is done by:

1. Averaging the accelerometers for 10 seconds to achieve accurate initial angles.
2. Initialize the azimuth axis by rotate the motion table until the beam is in its zero position, while the SPA is fixed (point mode).
3. Initialize the elevation axis by changing the SPA latitude (when satellite and SPA longitude are fixed).

3.3 Boundary radius calibration

While the laser beam is in the center of the circle, the azimuth and elevation were set to +/- 0.2°. The locations of the beam in each time determine the target circle radius.

4 Test Course

The SPA satellite and terminal longitude were set to 30°E and the SPA latitude was set to 65°S. The following tests were conducted:

The motion of the table was set to sine waves for the yaw, roll and pitch axes in the following combinations:

a. Each axis was set to 12°/sec while the other two are stationary.

b. Two axes were set to 8.5°/sec simultaneously while the third axis is stationary (yaw & pitch, yaw & roll, pitch & roll)

c. All three axes were set to 7°/sec simultaneously.

The behavior of the motion table in Test II is shown in Figures 4 and 5.

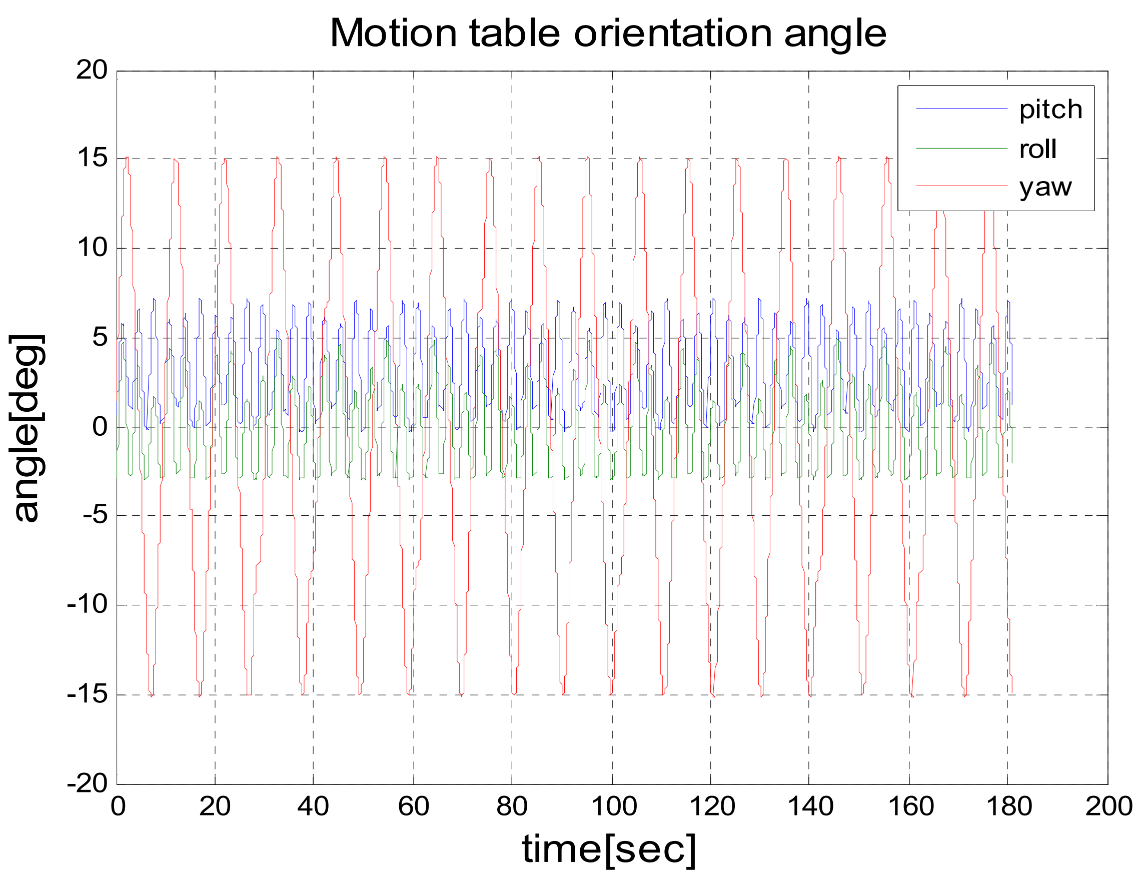

Figure 4 Motion table angles

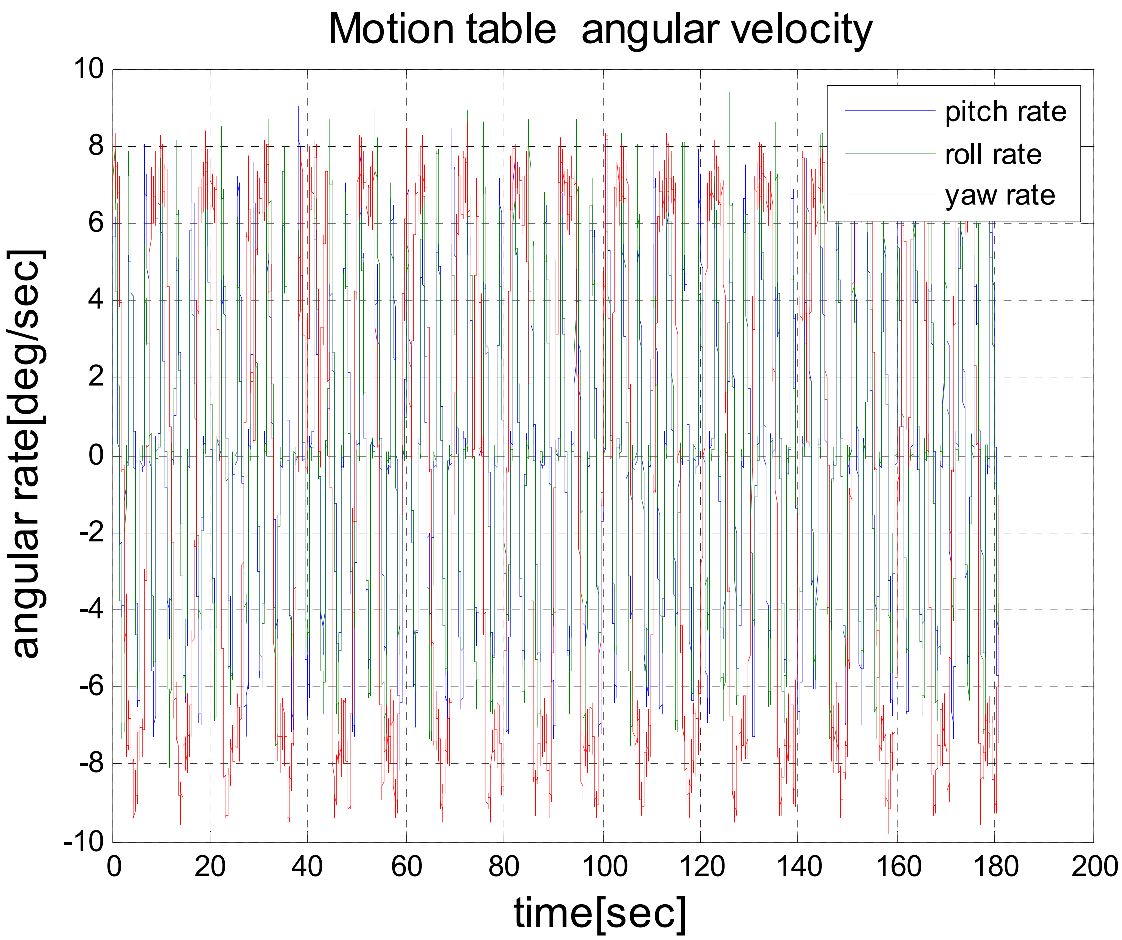

Figure 5 : Motion table angular velocity

5 Test Results

The SPA has a mechanism of knowing the setting angle vs. the actual angle. The difference is the antenna error angles. Antenna error angles for constellation 4.I.c (7°/sec for all axes) are shown in Figure 6.

Applicable document [2] shows the laser beam moving inside the circle.

The statistics of all test constellations are shown in Figures 7-19 and Tables 1-7:

- The frequency at the histograms y axis refers to the percentage of samples
- Accuracy = azimuth err * cos(skew angle) + elevation err *sin(skew err)

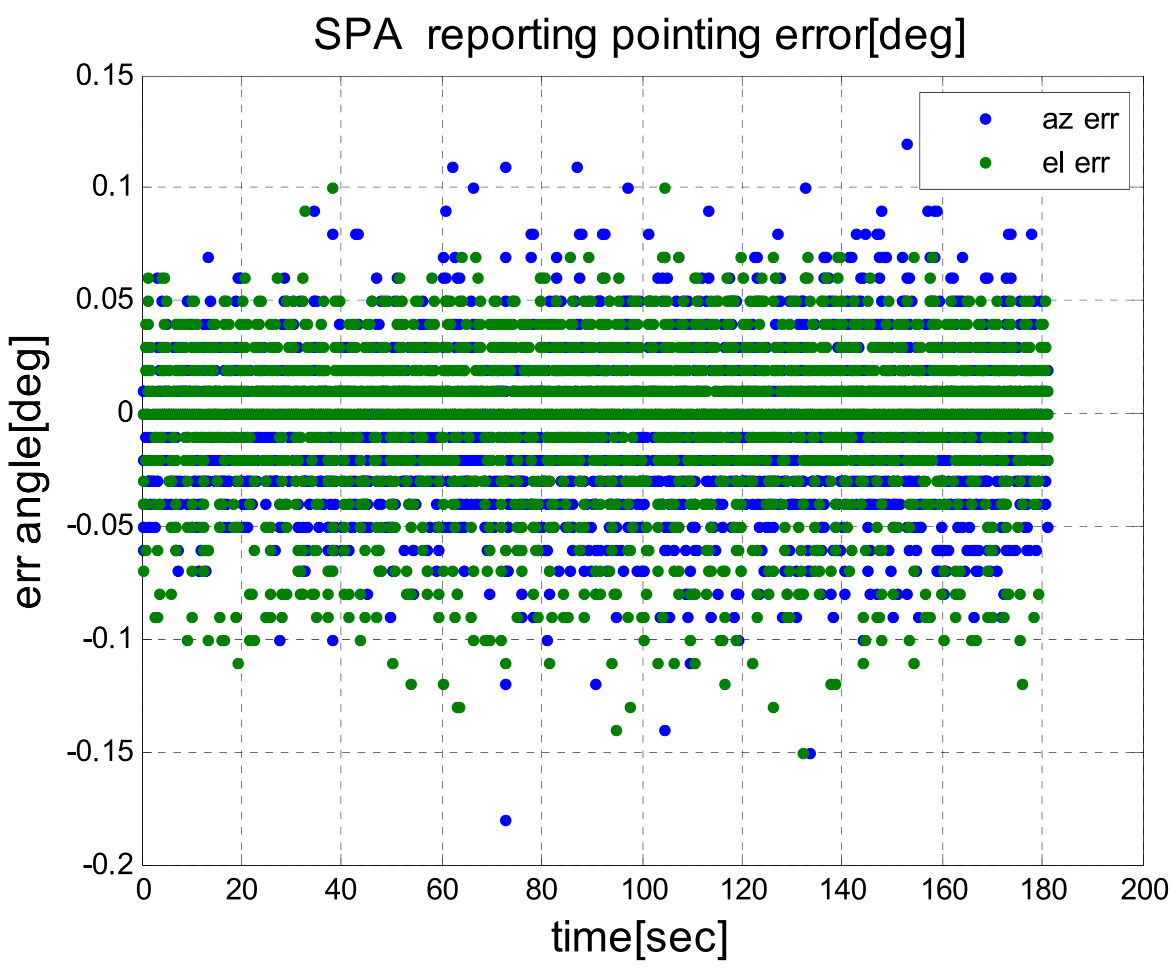

Figure 6: Antenna error report

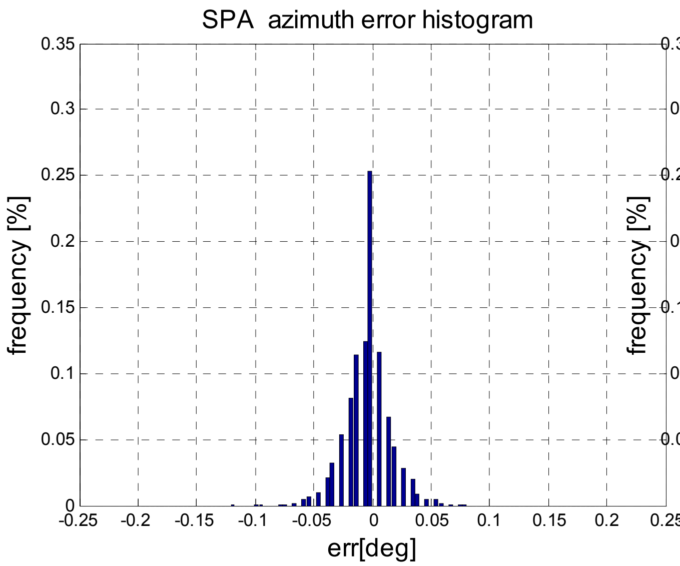

Figure 8: 3 axes@7deg/sec az err histogram

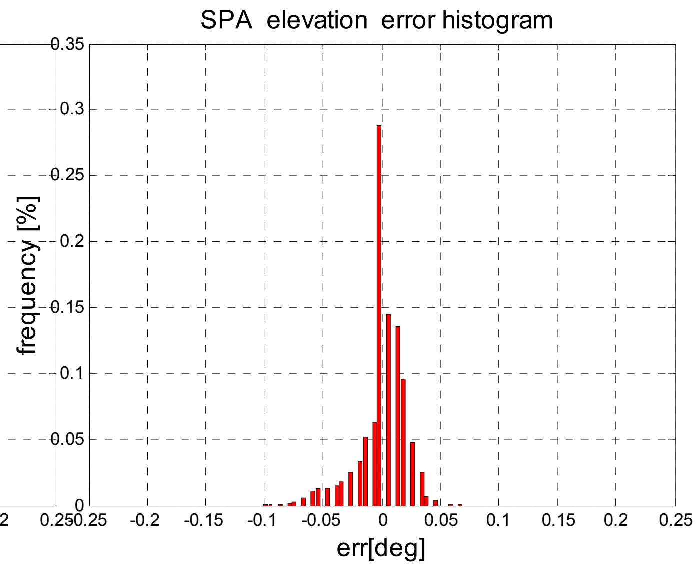

Figure 7: 3 axes@7deg/sec el err histogram

Yaw, Roll & Pitch rates @ 7°/sec		
	az err[°]	el err[°]
Mean	*-0.01*	*0*
STDev3σ	*0.09*	*0.09*
Min	*-0.18*	*-0.15*
Max	*0.12*	*0.1*
Accuracy (45°) 3σ	*0.12*	

Table 1: Yaw, roll & pitch @ 7°/sec statistics

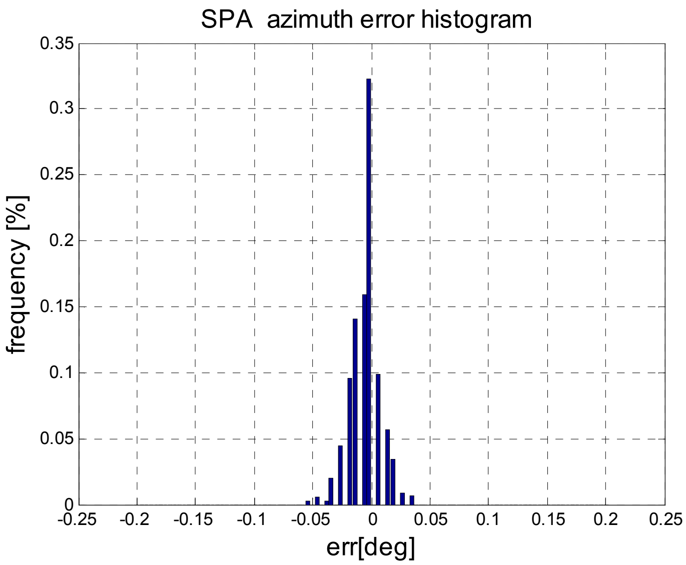

Figure 8: Yaw & pitch @8.5deg/sec az err histogram

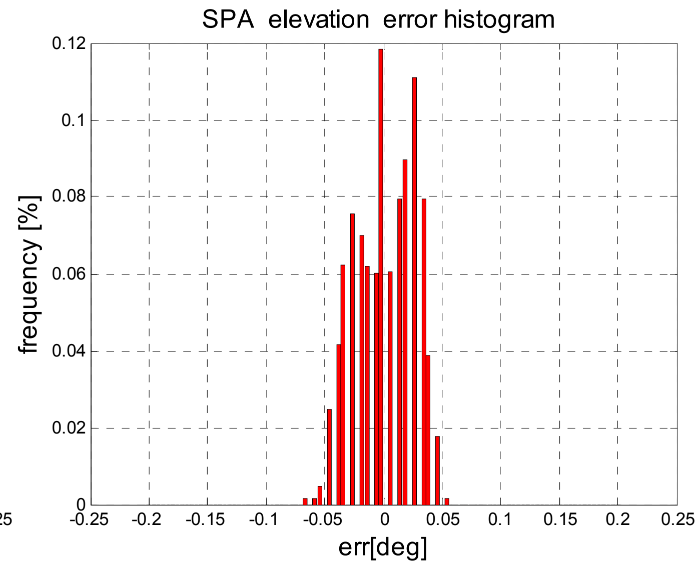

Figure 9: Yaw & pitch @8.5deg/sec el err histogram

Yaw & Pitch rates @ 8.5°/sec (Roll stationary)		
	az err[°]	el err[°]
Mean	*-0.01*	*0*
STDev3σ	*0.06*	*0.11*
Min	*-0.08*	*-0.1*
Max	*0.05*	*0.08*
Accuracy (45°) 3σ	*0.12*	

Table 2: Yaw & pitch @ 8.5°/sec statistics

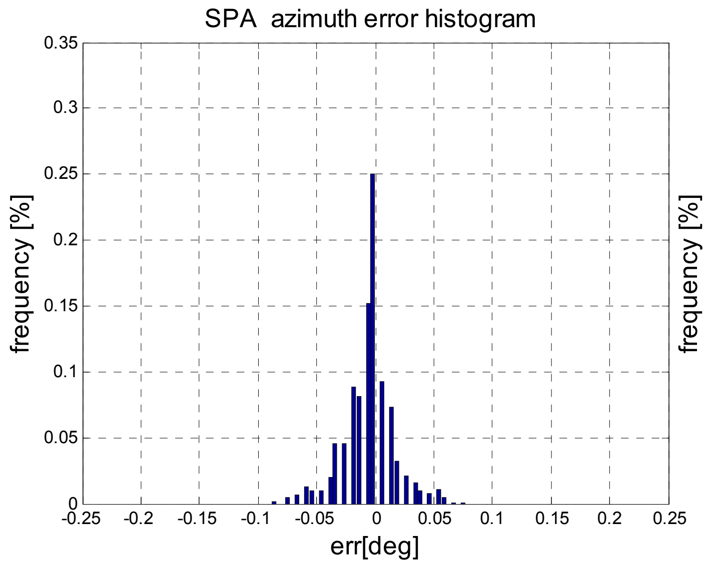

Figure 10: Yaw & roll @8.5deg/sec az err histogram

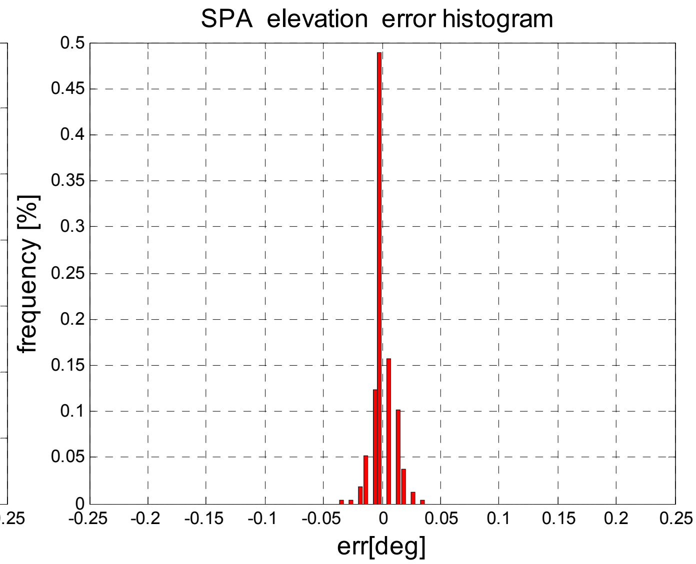

Figure 11: Yaw & roll @8.5deg/sec el err histogram

Yaw & Roll rates @ 8.5°/sec (Pitch stationary)		
	az err[°]	el err[°]
Mean	*-0.01*	*0*
STDev3σ	*0.1*	*0.04*
Min	*-0.13*	*-0.05*
Max	*0.11*	*0.05*
Accuracy (45°) 3σ	*0.1*	

Table 3: Yaw & roll @ 8.5°/sec statistics

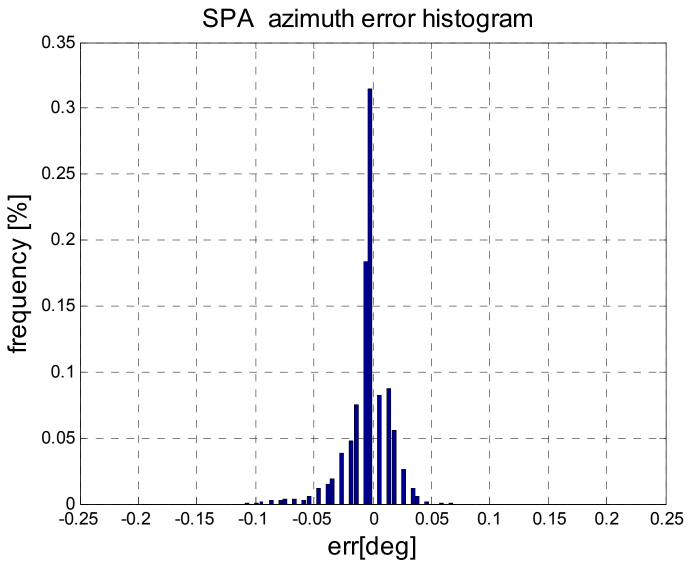

Figure 13: Pitch & roll @8.5deg/sec az err histogram

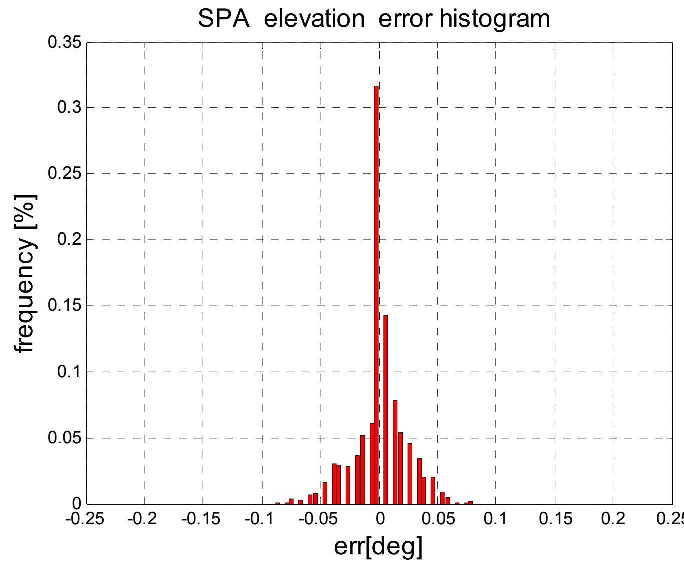

Figure 12: Pitch & roll @8.5deg/sec el err histogram

Pitch & Roll rates @ 8.5°/sec (Yaw stationary)		
	az err[°]	el err[°]
Mean	*0*	*0*
STDev3σ	*0.08*	*0.10*
Min	*-0.16*	*-0.13*
Max	*0.10*	*0.12*
Accuracy (45°) 3σ	*0.13*	

Table 4 : Pitch & Roll @ 8.5°/sec statistics

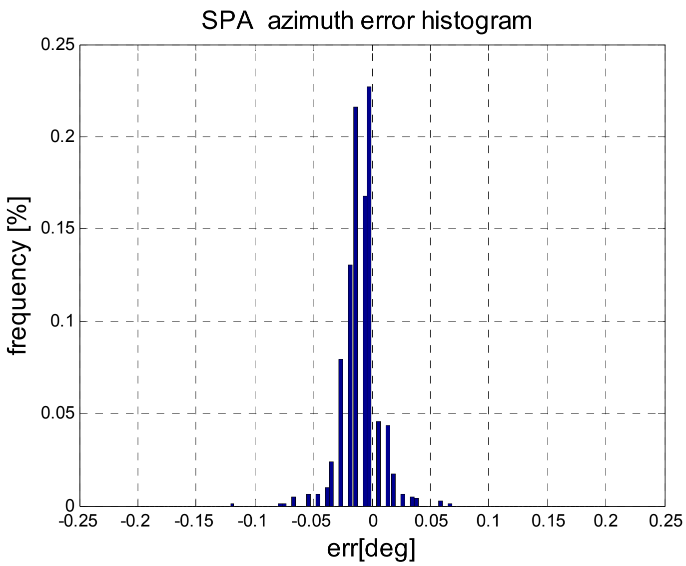

Figure 14: Yaw @12deg/sec az err histogram

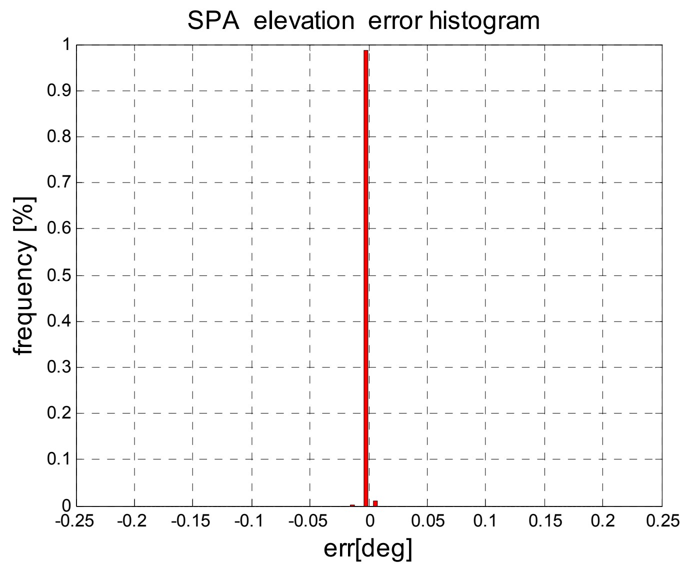

Figure 15: Yaw @12deg/sec el err histogram

Yaw rate @12°/sec (Pitch and Roll stationary)		
	az err[°]	el err[°]
Mean	*-0.01*	*0*
STDev3σ	*0.07*	*0*
Min	*-0.18*	*-0.02*
Max	*0.1*	*0.01*
Accuracy (45°) 3σ	*0.05*	

Table 5 : Yaw @ 12°/sec statistics

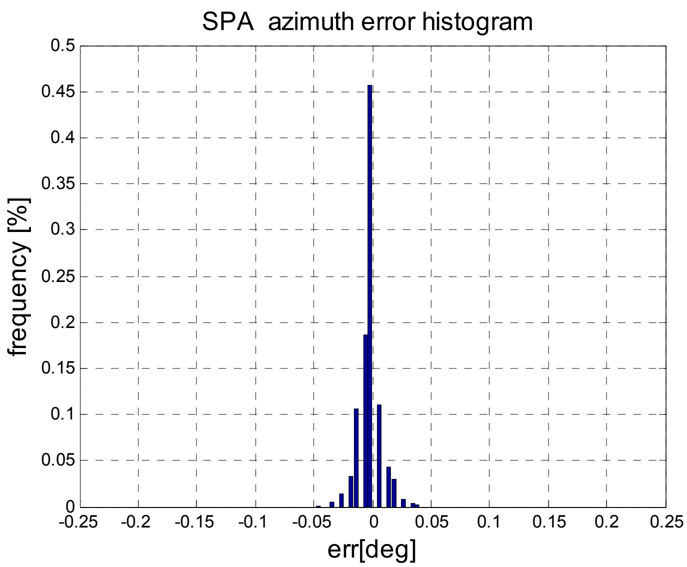

Figure 16: Pitch @12deg/sec az err histogram

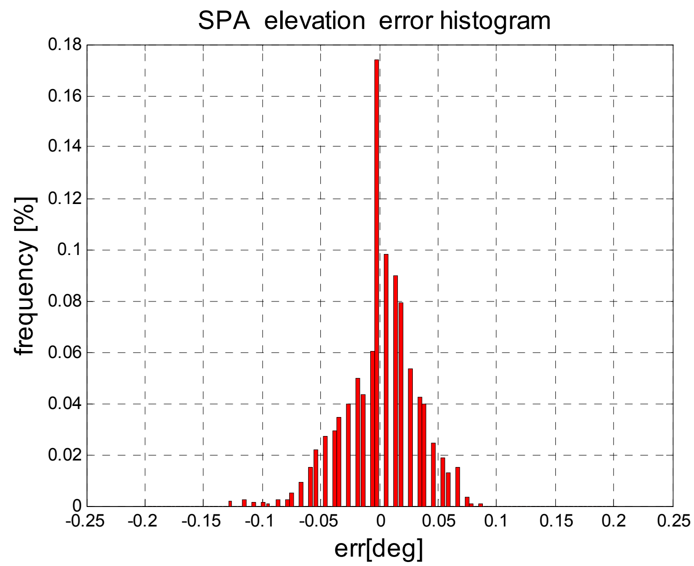

Figure 17: Pitch @12deg/sec el err histogram

Pitch rate @12°/sec (Roll & Yaw stationary)		
	az err[°]	el err[°]
Mean	*0*	*0*
STDev3σ	*0.04*	*0.14*
Min	*-0.07*	*-0.19*
Max	*0.06*	*0.13*
Accuracy (45°) 3σ	*0.13*	

Table 6 Pitch @ 12°/sec statistics

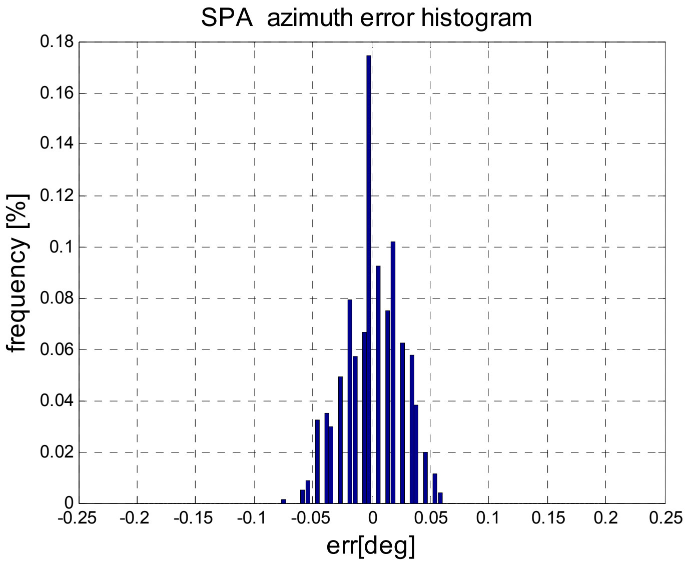

Figure 18: Roll @12deg/sec az err histogram

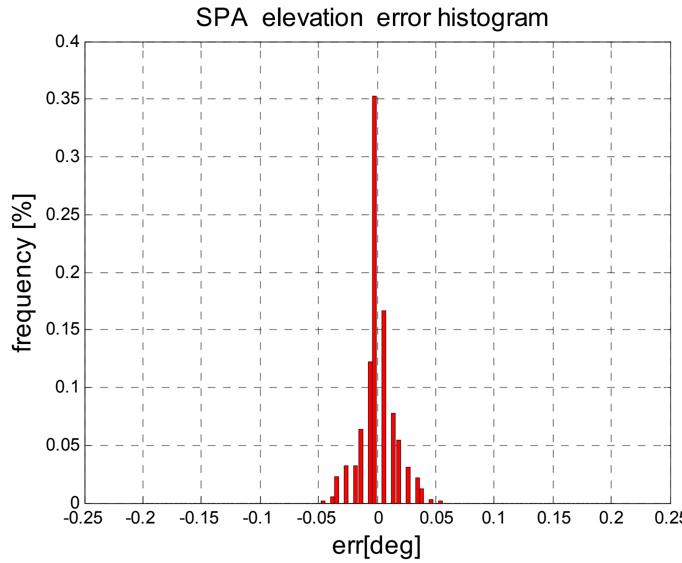

Figure 19: Roll @12deg/sec el err histogram

Roll rate @12°/sec (Pitch and Yaw stationary)		
	az err[°]	el err[°]
Mean	*0*	*0*
STDev3σ	*0.11*	*0.06*
Min	*-0.11*	*-0.07*
Max	*0.09*	*0.08*
Accuracy (45°) 3σ	*0.12*	

Table 7: Roll @ 12°/sec statistics

6 Conclusion

As shown in figures 6-19 and tables 1-7, the SPA meets the requirement of pointing accuracy of 0.2° 3σ in azimuth and elevation axes, and the projected total error at target satellite. A snapshot from the movie showing the laser beam within the boundary circle of 0.2 °radius is attached below:

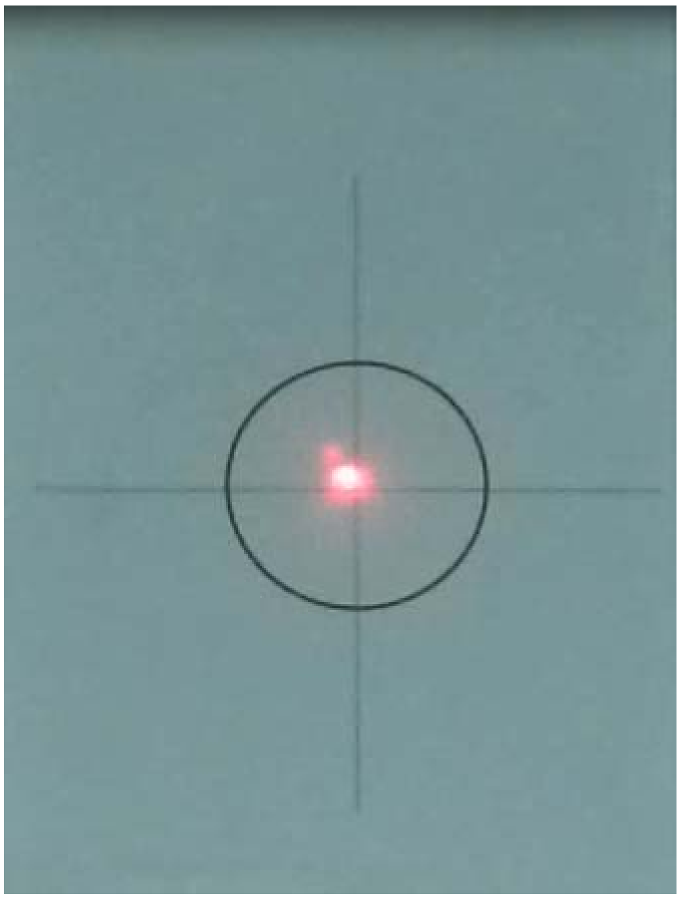

Figure 20 : Laser Beam within 0.2° Boundary

VII. Section 25.227 Certifications

CERTIFICATIONS

Panasonic Avionics Corporation ("Panasonic"), pursuant to Section 25.227 of the FCC's Rules, hereby certifies the following:

1. In accordance with Section 25.227(a)(15), as the operator of an ESAA system operating over international waters, Panasonic has confirmed with its target space station operators that its existing and proposed operations are within coordinated parameters for adjacent satellites up to six degrees away (+/- 6°) on the geostationary arc.

2. In accordance with Section 25.227(b)(7), Panasonic certifies that its existing and proposed operations comply with the following requirements of Section 25.227:
   - Per Section 25.227(a)(6), for each ESAA transmitter, Panasonic will time annotate and maintain a record for a period of not less than one year of the vehicle location (i.e., latitude/longitude/altitude), transmit frequency, channel bandwidth and satellite used. Records will be recorded at time intervals no greater than one (1) minute while the ESAA is transmitting. Panasonic will make this data available in the requisite format within 24 hours of a request from the Commission, NTIA, or a frequency coordinator for purposes of resolving harmful interference events.
   - Per Section 25.227(a)(9), each ESAA terminal will automatically cease transmitting within 100 milliseconds upon loss of reception of the satellite downlink signal or when it detects that unintended satellite tracking has happened or is about to happen.
   - Per Section 25.227(a)(10), each ESAA terminal will be subject to the monitoring and control by an NCMC. Each terminal will be able to receive "enable transmission" and "disable transmission" commands from the NCMC and must automatically cease transmissions immediately on receiving any "parameter change command", which may cause harmful interference during the change, until it receives an "enable transmission" command from its NCMC. In addition, the NCMC will be able to monitor the operation of an ESAA terminal to determine if it is malfunctioning.
   - Per Section 25.227(a)(11), each ESAA terminal shall be self-monitoring and, should a fault which can cause harmful interference to FSS networks be detected, the terminal will automatically cease transmissions.

By:

Mark DeFazio

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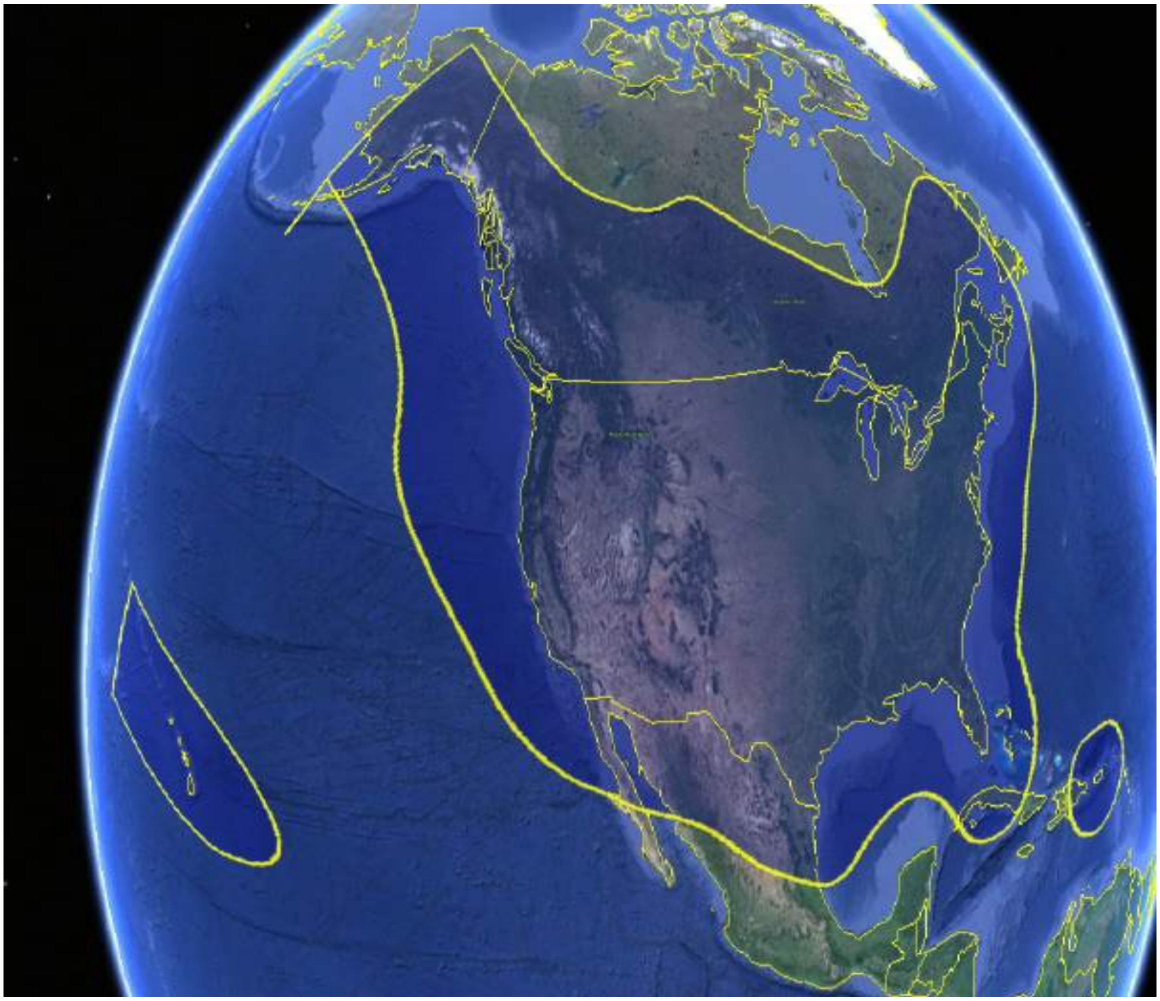
Manager, GCS Regulatory and Business Operations
Panasonic Avionics Corporation

February 16, 2016

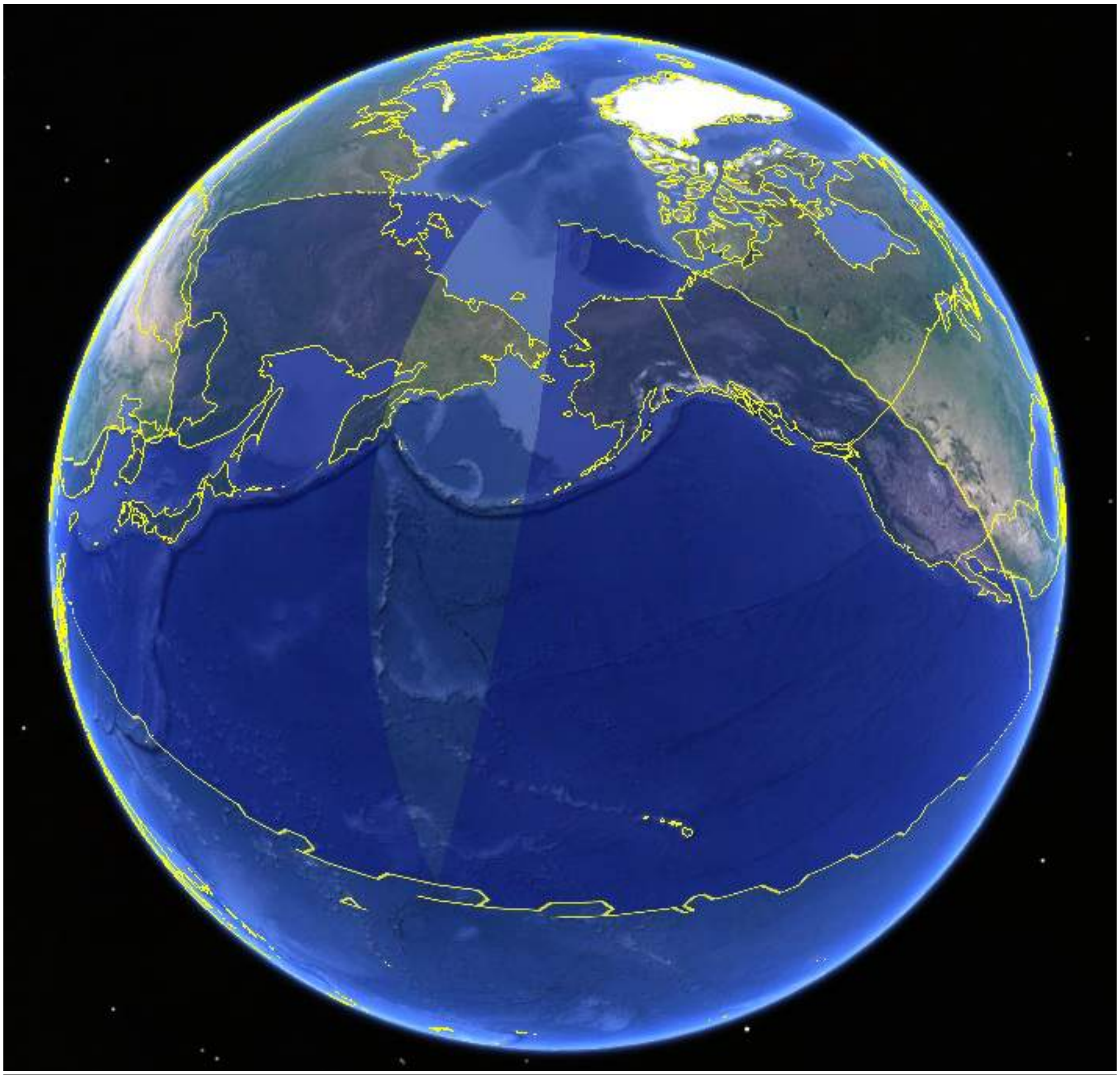
VIII. Satellite Coverage Maps

Galaxy 16 Coverage Map

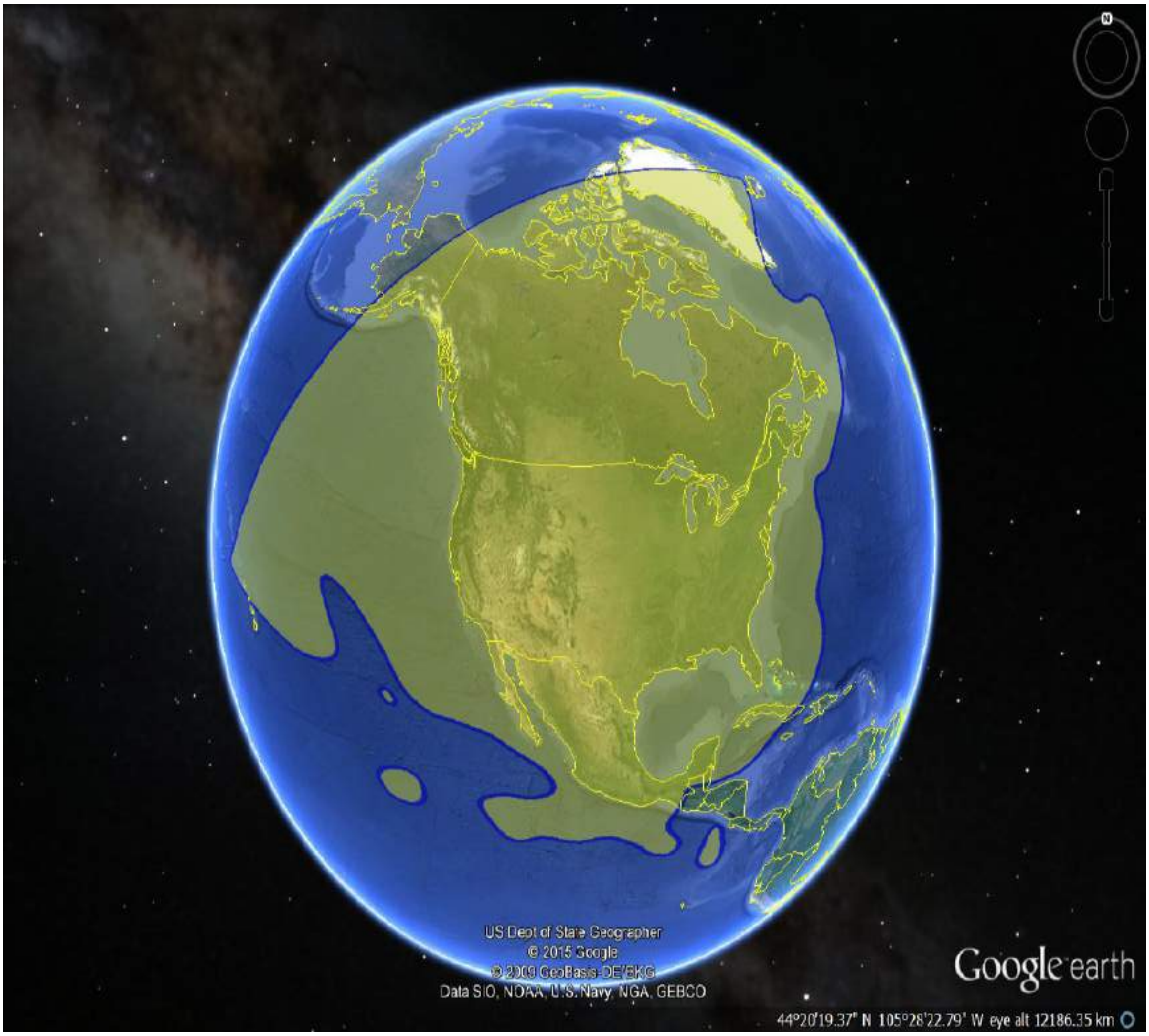
<u>**Galaxy 17 Coverage Map**</u>



Eutelsat 172A Coverage Map



AMC-16 Coverage Map



IX. FCC § 25.227 Compliance Matrix

Rule	Text	Application Citation
§ 25.227	§ 25.227 Blanket Licensing provisions for Earth Stations Aboard Aircraft (ESAAs) receiving in the 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), and 11.7-12.2 GHz (space-to-Earth) frequency bands and transmitting in the 14.0-14.5 GHz (Earth-to-space) frequency band, operating with Geostationary Satellites in the Fixed-Satellite Service.	
§ 25.227(a)	(a) The following ongoing requirements govern all ESAA licensees and operations in the 10.95-11.2 GHz (space-to-Earth), 11.45-11.7 GHz (space-to-Earth), 11.7-12.2 GHz (space-to-Earth) and 14.0-14.5 GHz (Earth-to-space) frequency bands receiving from and transmitting to geostationary orbit satellites in the Fixed-Satellite Service. ESAA licensees shall comply with the requirements in either paragraph (a)(1), (a)(2) or (a)(3) of this section and all of the requirements set forth in paragraphs (a)(4)-(a)(16) and paragraphs (c), (d), and (e) of this section. Paragraph (b) of this section identifies items that shall be included in the application for ESAA operations to demonstrate that these ongoing requirements will be met.	*See* Application, File No. SES-LIC-20100805-00992, Technical Appendix; File No. SES-MFS-20120913-00818, Technical Appendix (prior grant for PPA and MELCO ESAAs).
§ 25.227(a)(1)	(1) The following requirements shall apply to an ESAA that uses transmitters with off-axis EIRP spectral-densities lower than or equal to the levels in paragraph (a)(1)(i) of this subsection. ESAA licensees operating under this subsection shall provide a detailed demonstration as described in paragraph (b)(1) of this section. The ESAA transmitter also shall comply with the antenna pointing and cessation of emission requirements in paragraphs (a)(1)(ii) and (a)(1)(iii) of this subsection.	N/A. Authority requested under § 25.227(a)(2) (satellite operator certification)
§ 25.227(a)(1)(i)	(i) An ESAA licensee shall not exceed the off-axis EIRP spectral-density limits and conditions defined in paragraphs (a)(1)(A)-(D) of this subsection.	*Id.*

§ 25.227(a)(1)(i)(A)	(A) The off-axis EIRP spectral-density for co-polarized signals emitted from the ESAA, in the plane of the geostationary satellite orbit (GSO) as it appears at the particular earth station location, shall not exceed the following values: 15 - 10 log10(N) - 25 log10θ dBW/4 kHz For 1.5° ≤ θ ≤ 7° -6 - 10 log10(N) dBW/4 kHz For 7° < θ ≤ 9.2° 18 - 10 log10(N) - 25 log10θ dBW/4 kHz For 9.2° < θ ≤ 48° -24 - 10 log10(N) dBW/4 kHz For 48° < θ ≤ 85° -14 - 10 log10(N) dBW/4 kHz For 85° < θ ≤ 180° where theta (θ) is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite in the plane of the GSO. The plane of the GSO is determined by the focal point of the antenna and the line tangent to the arc of the GSO at the orbital location of the target satellite. For ESAA networks using frequency division multiple access (FDMA) or time division multiple access (TDMA) techniques, N is equal to one. For ESAA networks using multiple co-frequency transmitters that have the same EIRP density, N is the maximum expected number of co-frequency simultaneously transmitting ESV earth stations in the same satellite receiving beam. For the purpose of this subsection, the peak EIRP density of an individual sidelobe shall not exceed the envelope defined above for θ between 1.5° and 7.0°. For θ greater than 7.0°, the envelope shall be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the envelope given above by more than 3 dB.	*Id.*
§ 25.227(a)(1)(i)(B)	(B) In all directions other than along the GSO, the off-axis EIRP spectral-density for co-polarized signals emitted from the ESAA shall not exceed the following values: 18 - 10 log10(N)- 25log log10θ dBW/4 kHz For 3.0° ≤ θ ≤ 48° -24 - 10 log10(N) dBW/4 kHz For 48° < θ ≤ 85° -14- 10 log10(N) dBW/4kHz For 85° < θ ≤ 180° where θ and N are defined in (a)(1)(i)(A). This off-axis EIRP spectral-density applies in any plane that includes the line connecting the focal point of the antenna to the orbital location of the target satellite with the exception of the plane of the GSO as defined in paragraph (a)(1)(i)(A) of this section. For the purpose of this subsection, the envelope shall be exceeded by no more than 10% of the sidelobes provided no individual sidelobe exceeds the EIRP density envelope given above by more than 6 dB. The region of the main reflector spillover energy is to be interpreted as a single lobe and shall not exceed the envelope by more than 6 dB.	*Id.* (prior authority to operate conditioned on coordination with Ku-band NGSO systems).

§ 25.227(a)(1)(i)(C)	(C) The off-axis EIRP spectral-density for cross-polarized signals emitted from the ESAA shall not exceed the following values: In the plane of the geostationary satellite orbit as it appears at the particular earth station location: $5 - 10 \log10(N) - 25\log10\theta$ dBW/4kHz For $1.8° < \theta \leq 7°$ $-16 - 10 \log10(N)$ dBW/4kHz For $7° < \theta \leq 9.2°$ where θ and N are defined in (a)(1)(i)(A).	*Id.*
§ 25.227(a)(1)(ii)	(ii) Each ESAA transmitter shall meet one of the following antenna pointing requirements: (A) Each ESAA transmitter shall maintain a pointing error of less than or equal to 0.2° between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna; or (B) Each ESAA transmitter shall declare a maximum antenna pointing error that may be greater than 0.2° provided that the ESAA does not exceed the off-axis EIRP spectral-density limits in paragraph (a)(1)(i) of this section, taking into account the antenna pointing error.	*Id.* (ESAAs comply)
§ 25.227(a)(1)(iii)	(iii) Each ESAA transmitter shall meet one of the following cessation of emission requirements: (A) For ESAAs operating under paragraph (a)(1)(ii)(A) of this section, all emissions from the ESAA shall automatically cease within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds 0.5°, and transmission shall not resume until such angle is less than or equal to 0.2°, or (B) For ESAA transmitters operating under paragraph (a)(1)(ii)(B) of this section, all emissions from the ESAA shall automatically cease within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds the declared maximum antenna pointing error and shall not resume transmissions until such angle is less than or equal to the declared maximum antenna pointing error.	*Id.*

25.227(a)(2)	(2) The following requirements shall apply to an ESAA, or ESAA system, that uses off-axis EIRP spectral-densities in excess of the levels in paragraph (a)(1)(i) of this section. An ESAA, or ESAA network, operating under this subsection shall file certifications and provide a detailed demonstration as described in paragraph (b)(2) of this section. (i) The ESAA shall transmit only to the target satellite system(s) referred to in the certifications required by paragraph (b)(2) of this section. (ii) If a good faith agreement cannot be reached between the target satellite operator and the operator of a future satellite that is located within 6 degrees longitude of the target satellite, the ESAA operator shall accept the power-density levels that would accommodate that adjacent satellite. (iii) The ESAA shall operate in accordance with the off-axis EIRP spectral-densities that the ESAA supplied to the target satellite operator in order to obtain the certifications listed in paragraph (b)(2) of this section. The ESAA shall automatically cease emissions within 100 milliseconds if the ESAA transmitter exceeds the off-axis EIRP spectral-densities supplied to the target satellite operator and transmission shall not resume until ESAA conforms to the off-axis EIRP spectral densities supplied to the target satellite operator. (iv) In the event that a coordination agreement discussed in paragraph (b)(2)(ii) of this section is reached, but that coordination agreement does not address protection from interference for the earth station, that earth station will be protected from interference to the same extent that an earth station that meets the requirements of §25.209 of this title would be protected from interference.	Panasonic complies (no separate certification required); *see also* Section 25.227(b)(2).
§ 25.227(a)(3)(i)	(3) The following requirements shall apply to an ESAA system that uses variable power-density control of individual simultaneously transmitting co-frequency ESAA earth stations in the same satellite receiving beam. An ESAA system operating under this subsection shall provide a detailed demonstration as described in paragraph (b)(3) of this section. (i) The effective aggregate EIRP density from all terminals shall be at least 1 dB below the off-axis EIRP density limits defined in paragraph (a)(1)(i)(A)-(C), with the value of N=1. In this context the term "effective" means that the resultant co-polarized and cross-polarized EIRP density experienced by any GSO or non-GSO satellite shall not exceed that produced by a single transmitter operating 1 dB below the limits defined in paragraph (a)(1)(i)(A)-(C). The individual ESAA transmitter shall automatically cease emissions within 100 milliseconds if the ESAA transmitter exceeds the off-axis EIRP density limits minus 1 dB specified above. If one or more ESAA transmitters causes the aggregate off-axis EIRP-densities to exceed the off-axis EIRP density limits minus 1dB specified above, then the transmitter or transmitters shall cease or reduce emissions within 100 milliseconds of receiving a command from the system's network control and monitoring center. An ESAA system operating under this subsection shall provide a detailed demonstration as described in paragraph (b)(3)(i) of this section.	N/A

§ 25.227(a)(3)(ii)	(ii) The following requirements shall apply to an ESAA that uses off-axis EIRP spectral-densities in excess of the levels in paragraph (a)(3)(i) of this section. An ESAA system operating under this subsection shall file certifications and provide a detailed demonstration as described in paragraphs (b)(3)(ii) and (b)(3)(iii) of this section. (A) If a good faith agreement cannot be reached between the target satellite operator and the operator of a future satellite that is located within 6 degrees longitude of the target satellite, the ESAA shall operate at an EIRP density defined in (a)(3)(i) of this section. (B) The ESAA shall operate in accordance with the off-axis EIRP spectral-densities that the ESAA supplied to the target satellite operator in order to obtain the certifications listed in paragraph (b)(3)(ii) of this section. The individual ESAA terminals shall automatically cease emissions within 100 milliseconds if the ESAA transmitter exceeds the off-axis EIRP spectral-densities supplied to the target satellite operator. The overall system shall be capable of shutting off an individual transmitter or the entire system if the aggregate off-axis EIRP spectral-densities exceed those supplied to the target satellite operator. (C) The ESAA shall transmit only to the target satellite system(s) referred to in the certifications required by paragraph (b)(3) of this section.	*Id.*
§ 25.227(a)(4)	(4) An applicant filing to operate an ESAA terminal or system and planning to use a contention protocol shall certify that its contention protocol use will be reasonable.	*Id.*
§ 25.227(a)(5)	(5) There shall be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the ESAA.	*See* Technical Appendix, I.
§ 25.227(a)(6)	(6) For each ESAA transmitter, a record of the vehicle location (i.e., latitude/longitude/altitude), transmit frequency, channel bandwidth and satellite used shall be time annotated and maintained for a period of not less than one year. Records shall be recorded at time intervals no greater than one (1) minute while the ESAA is transmitting. The ESAA operator shall make this data available, in the form of a comma delimited electronic spreadsheet, within 24 hours of a request from the Commission, NTIA, or a frequency coordinator for purposes of resolving harmful interference events. A description of the units (i.e., degrees, minutes, MHz ….) in which the records values are recorded will be supplied along with the records.	*See* Technical Appendix, VII.
§ 25.227(a)(7)	(7) In the 10.95-11.2 GHz (space-to-Earth) and 11.45-11.7 GHz (space-to-Earth) frequency bands ESAAs shall not claim protection from interference from any authorized terrestrial stations to which frequencies are either already assigned, or may be assigned in the future.	Applicable regulatory status and protection provision. Panasonic complies.
§ 25.227(a)(8)	(8) An ESAA terminal receiving in the 11.7-12.2 GHz (space-to-Earth) bands shall receive protection from interference caused by space stations other than the target space station only to the degree to which harmful interference would not be expected to be caused to an earth station employing an antenna conforming to the referenced patterns defined in paragraphs (a) and (b) of section 25.209 and stationary at the location at which any interference occurred.	Applicable regulatory status and protection provision. Panasonic complies.

§ 25.227(a)(9)	(9) Each ESAA terminal shall automatically cease transmitting within 100 milliseconds upon loss of reception of the satellite downlink signal or when it detects that unintended satellite tracking has happened or is about to happen.	*See* Technical Appendix, VII.

§ 25.227(a)(10)	(10) Each ESAA terminal should be subject to the monitoring and control by an NCMC or equivalent facility. Each terminal must be able to receive at least “enable transmission” and “disable transmission” commands from the NCMC and must automatically cease transmissions immediately on receiving any “parameter change command”, which may cause harmful interference during the change, until it receives an “enable transmission” command from its NCMC. In addition, the NCMC must be able to monitor the operation of an ESAA terminal to determine if it is malfunctioning.	*Id.*
§ 25.227(a)(11)	(11) Each ESAA terminal shall be self-monitoring and, should a fault which can cause harmful interference to FSS networks be detected, the terminal must automatically cease transmissions.	*Id.*
§ 25.227(a)(12)	(12) Unless otherwise stated all ESAA system that comply with the off-axis EIRP spectral-density limits in (a)(1)(i) may request ALSAT authority.	Applicable regulatory status and protection provision.
§ 25.227(a)(13)	(13) ESAA providers operating in the international airspace within line-of-sight of the territory of a foreign administration where fixed service networks have primary allocation in this band, the maximum power flux density (pfd) produced at the surface of the Earth by emissions from a single aircraft carrying an ESAA terminal should not exceed the following values unless the foreign Administration has imposed other conditions for protecting its fixed service stations: $-132+0.5 \cdot \theta$ dB(W/(m2 · MHz)) For $\theta \leq 40°$ -112 dB(W/(m2 · MHz)) For $40° < \theta \leq 90°$ Where: θ is the angle of arrival of the radio-frequency wave (degrees above the horizontal) and the aforementioned limits relate to the pfd and angles of arrival would be obtained under free-space propagation conditions.	Applicable regulatory status and protection provision.
§ 25.227(a)(14)	(14) All ESAA terminals operated in U.S. airspace, whether on U.S.-registered civil aircraft or non-U.S.-registered civil aircraft, must be licensed by the Commission. All ESAA terminals on U.S.-registered civil aircraft operating outside of U.S. airspace must be licensed by the Commission, except as provided by Section 303(t) of the Communications Act.	Applicable regulatory status and protection provision.
§ 25.227(a)(15)	(15) For ESAA systems operating over international waters, ESAA operators will certify that their target space station operators have confirmed that proposed ESAA operations are within coordinated parameters for adjacent satellites up to 6 degrees away on the geostationary arc.	*See* Technical Appendix, VII.
§ 25.227(a)(16)	(16) Prior to operations within the foreign nation’s airspace, the ESAA operator will ascertain whether the relevant administration has operations that could be affected by ESAA terminals, and will determine whether that administration has adopted specific requirements concerning ESAA operations. When the aircraft enters	Panasonic complies (no specific certification required).

	foreign airspace, the ESAA terminal would be required to operate under the Commission's rules, or those of the foreign administration, whichever is more constraining. To the extent that all relevant administrations have identified geographic areas from which ESAA operations would not affect their radio operations, ESAA operators would be free to operate within those identified areas without further action. To the extent that the foreign administration has not adopted requirements regarding ESAA operations, ESAA operators would be required to coordinate their operations with any potentially affected operations.	
§ 25.227(b)	(b) Applications for ESAA operation in the 14.0-14.5 GHz (Earth-to-space) band to GSO satellites in the Fixed-Satellite Service shall include, in addition to the particulars of operation identified on Form 312, and associated Schedule B, the applicable technical demonstrations in paragraphs (b)(1), (b)(2) or (b)(3) and the documentation identified in paragraphs (b)(4) through (b)(8) of this section.	
§ 25.227(b)(1)	(1) An ESAA applicant proposing to implement a transmitter under paragraph (a)(1) of this section shall demonstrate that the transmitter meets the off-axis EIRP spectral-density limits contained in paragraph (a)(1)(i) of this section. To provide this demonstration, the application shall include the tables described in paragraph (b)(1)(i) of this section or the certification described in paragraph (b)(1)(ii) of this section. The ESAA applicant also shall provide the value N described in paragraph (a)(1)(i)(A) of this section. An ESAA applicant proposing to implement a transmitter under paragraph (a)(1)(ii)(A) of this section shall provide the certifications identified in paragraph (b)(1)(iii) of this section. An ESAA applicant proposing to implement a transmitter under paragraph (a)(1)(ii)(B) of this section shall provide the demonstrations identified in paragraph (b)(1)(iv) of this section.	N/A
§ 25.227(b)(1)(i)	(i) Any ESAA applicant filing an application pursuant to paragraph (a)(1) of this section shall file three tables and/or graphs depicting off-axis EIRP density masks defined by 25.227(a) and measured off-axis EIRP density levels of the proposed earth station antenna in the direction of the plane of the GSO; the co-polarized EIRP density in the elevation plane, that is, the plane perpendicular to the plane of the GSO; and cross-polarized EIRP density. Each table shall provide the EIRP density level at increments of 0.1° for angles between 0° and 10° off-axis, and at increments of 5° for angles between 10° and 180° off-axis. (A) For purposes of the off-axis EIRP density table in the plane of the GSO, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the plane of the GSO is determined by the focal point of the antenna and the line tangent to the arc of the GSO at the orbital position of the target satellite. (B) For purposes of the off-axis co-polarized EIRP density table in the elevation plane, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite, and the elevation plane is defined as the plane perpendicular to the plane of the GSO defined in paragraph (b)(1)(i)(A) of this section. (C) For purposes of the cross-polarized EIRP density table, the off-axis angle is the angle in degrees from the line connecting the focal point of the antenna to the orbital location of the target satellite and the plane of the GSO as defined in paragraph (b)(1)(i)(A) of this section will be used.	*Id.*
§ 25.227(b)(1)(ii)	(ii) An ESAA applicant shall include a certification, in Schedule B, that the ESAA antenna conforms to the gain pattern criteria of § 25.209(a) and (b), that, combined with the maximum input power density calculated from the EIRP density less the antenna gain, which is entered in Schedule B, demonstrates that the off-axis EIRP spectral density envelope set forth in paragraphs (a)(1)(i)(A) through (a)(1)(i)(C) of this section will be	*Id.*

	met under the assumption that the antenna is pointed at the target satellite.	
§ 25.227(b)(1)(iii)	(iii) An ESAA applicant proposing to implement a transmitter under paragraphs (a)(1)(ii)(A) of this section shall: (A) demonstrate that the total tracking error budget of their antenna is within 0.2º or less between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna. As part of the engineering analysis, the ESAA applicant must show that the antenna pointing error is within three sigma (б) from the mean value, *i.e.,* that there is a 0.997 probability the antenna maintains a pointing error within 0.2º; and (B) demonstrate that the antenna tracking system is capable of ceasing emissions within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds 0.5°.	*Id.* (ESAAs comply)
§ 25.227(b)(1)(iv)	(iv) An ESAA applicant proposing to implement a transmitter under paragraph (a)(1)(ii)(B) of this section shall: (A) declare, in its application, a maximum antenna pointing error and demonstrate that the maximum antenna pointing error can be achieved without exceeding the off-axis EIRP spectral-density limits in paragraph (a)(1)(i) of this section; and (B) demonstrate that the ESAA transmitter can detect if the transmitter exceeds the declared maximum antenna pointing error and can cease transmission within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds the declared maximum antenna pointing error, and will not resume transmissions until the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna is less than or equal to the declared maximum antenna pointing error.	*Id.*
§ 25.227(b)(2)	(2) An ESAA applicant proposing to implement a transmitter under paragraph (a)(2) of this section and using off-axis EIRP spectral-densities in excess of the levels in paragraph (a)(1)(i) of this section shall provide the following certifications and demonstration as exhibits to its earth station application: (i) A statement from the target satellite operator certifying that the proposed operation of the ESAA has the potential to create harmful interference to satellite networks adjacent to the target satellite(s) that may be unacceptable. (ii) A statement from the target satellite operator certifying that the power density levels that the ESAA applicant provided to the target satellite operator are consistent with the existing coordination agreements between its satellite(s) and the adjacent satellite systems within 6° of orbital separation from its satellite(s). (iii) A statement from the target satellite operator certifying that it will include the power-density levels of the ESAA applicant in all future coordination agreements. (iv) A demonstration from the ESAA operator that the ESAA system will comply with all coordination agreements reached by the satellite operator and is capable of detecting and automatically ceasing emissions within 100 milliseconds when the transmitter exceeds the off-axis EIRP spectral-densities supplied to the target satellite operator.	*See* Technical Appendix, VII.

§ 25.227(b)(3)(i)	(3) An ESAA applicant proposing to implement an ESAA system under paragraph (a)(3) of this section and using variable power-density control of individual simultaneously transmitting co-frequency ESAA earth stations in the same satellite receiving beam shall provide the following certifications and demonstration as exhibits to its earth station application: (i) The applicant shall make a detailed showing of the measures it intends to employ to maintain the effective aggregate EIRP density from all simultaneously transmitting cofrequency terminals operating with the same satellite transponder at least 1 dB below the off-axis EIRP density limits defined in paragraph (a)(1)(i)(A) through (C) of this section. In this context, the term "effective" means that the resultant co-polarized and crosspolarized EIRP density experienced by any GSO or non-GSO satellite shall not exceed that produced by a single ESAA transmitter operating at 1 dB below the limits defined in paragraphs (a)(1)(i)(A) through (C) of this section. The ESAA applicant shall provide a detailed showing that an individual ESAA terminal is self-monitoring and capable of shutting itself off automatically within 100 milliseconds if the ESAA transmitter exceeds the off-axis EIRP-density limit specified in paragraph (a)(3)(i) of this section. The ESAA applicant also shall provide a detailed showing that one or more transmitters are capable of automatically ceasing or reducing emissions within 100 milliseconds of receiving a command from the system's network control and monitoring center that the aggregate off-axis EIRP spectral-densities of the transmitter or transmitters exceed the off-axis EIRP-density limits specified in paragraph (a)(3)(i) of this section. The International Bureau will place this showing on public notice along with the application.	N/A
§ 25.227(b)(3)(ii)	(ii) An applicant proposing to implement an ESAA system under paragraph (a)(3)(ii) of this section that uses off-axis EIRP spectral-densities in excess of the levels in paragraph (a)(3)(i) of this section shall provide the following certifications, demonstration and list of satellites as exhibits to its earth station application: (A) A detailed showing of the measures the applicant intends to employ to maintain the effective aggregate EIRP density from all simultaneously transmitting co-frequency terminals operating with the same satellite transponder at the EIRP density limits supplied to the target satellite operator. The International Bureau will place this showing on Public Notice along with the application. (B) A statement from the target satellite operator certifying that the proposed operation of the ESAA has the potential to create harmful interference to satellite networks adjacent to the target satellite(s) that may be unacceptable. (C) A statement from the target satellite operator certifying that the aggregate power-density levels that the ESAA applicant provided to the target satellite operator are consistent with the existing coordination agreements between its satellite(s) and the adjacent satellite systems within 6° of orbital separation from its satellite(s). (D) A statement from the target satellite operator certifying that it will include the aggregate power-density levels of the ESAA applicant in all future coordination agreements. (E) A demonstration from the ESAA operator that the ESAA system is capable of detecting and automatically ceasing emissions within 100 milliseconds when an individual transmitter exceeds the off-axis EIRP spectral-densities supplied to the target satellite operator and that the overall system is capable of shutting off an individual transmitter or the entire system if the aggregate off-axis EIRP spectral-densities exceed those supplied to the target satellite operator. (F) An identification of the specific satellite or satellites with which the ESAA system will operate.	*Id.*

§ 25.227(b)(4)	(4) There shall be an exhibit included with the application describing the geographic area(s) in which the ESAA will operate.	*See* Technical Appendix, VIII.
§ 25.227(b)(5)	(5) Any ESAA applicant filing for an ESAA terminal or system and planning to use a contention protocol shall include in its application a certification that will comply with the requirements of paragraph (a)(4) of this section.	N/A
§ 25.227(b)(6)	(6) The point of contact referred to in paragraph (a)(5) of this section shall be included in the application.	*See* Technical Appendix, I.
§ 25.227(b)(7)	(7) Any ESAA applicant filing for an ESAA terminal or system shall include in its application a certification that will comply with the requirements of paragraph (a)(6), (a)(9), (a)(10), (a)(11) of this section.	*See* Technical Appendix, VII.
§ 25.227(b)(8)	(8) All ESAA applicants shall submit a radio frequency hazard analysis determining via calculation, simulation, or field measurement whether ESAA terminals, or classes of terminals, will produce power densities that will exceed the Commission's radio frequency exposure criteria. ESAA applicants with ESAA terminals that will exceed the guidelines in Section 1.1310 for radio frequency radiation exposure shall	*See* Technical Appendix, V.

	provide, with their environmental assessment, a plan for mitigation of radiation exposure to the extent required to meet those guidelines. All ESAA licensees shall ensure installation of ESAA terminals on aircraft by qualified installers who have an understanding of the antenna's radiation environment and the measures best suited to maximize protection of the general public and persons operating the vehicle and equipment. An ESAA terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm² in accessible areas, such as at the exterior surface of the radome, shall have a label attached to the surface of the terminal warning about the radiation hazard and shall include thereon a diagram showing the regions around the terminal where the radiation levels could exceed 1.0 mW/cm².	
§ 25.227(c)	(c) (1) Operations of ESAAs in the 14.0-14.2 GHz (Earth-to-space) frequency band in the radio line-of- sight of the NASA TDRSS facilities on Guam (latitude 13° 36' 55" N, longitude 144° 51' 22" E) or White Sands, New Mexico (latitude 32° 20' 59" N, longitude 106° 36' 31" W and latitude 32° 32' 40" N, longitude 106° 36' 48" W) are subject to coordination with the National Aeronautics and Space Administration (NASA) through the National Telecommunications and Information Administration (NTIA) Interdepartment Radio Advisory Committee (IRAC). Licensees shall notify the International Bureau once they have completed coordination. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. (2) When NTIA seeks to provide similar protection to future TDRSS sites that have been coordinated through the IRAC Frequency Assignment Subcommittee process, NTIA will notify the Commission's International Bureau that the site is nearing operational status. Upon public notice from the International Bureau, all Ku-band ESAA licensees shall cease operations in the 14.0-14.2 GHz band within radio line-of-sight of the new TDRSS site until the licensees complete coordination with NTIA/IRAC for the new TDRSS facility. Licensees shall notify the International Bureau once they have completed coordination for the new TDRSS site. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. The ESAA licensee then will be permitted to commence operations in the 14.0-14.2 GHz band within radio line-of-sight of the new TDRSS site, subject to any operational constraints developed in the coordination process.	*See* Section 1.65 Letter, File Nos. SES-LIC-20100805-00992, SES-AMD-20100914-01163 and SES-AMD-20101115-01432 (Call Sign E100089) (Notice of NASA Coordination Agreement dated Feb. 1, 2011).

§ 25.227(d)	(d) (1) Operations of ESAA in the 14.47-14.5 GHz (Earth-to-space) frequency band in the radio line-of- sight of radio astronomy service (RAS) observatories observing in the 14.47-14.5 GHz band are subject to coordination with the National Science Foundation (NSF). The appropriate NSF contact point to initiate coordination is Electromagnetic Spectrum Manager, NSF, 4201 Wilson Blvd., Suite 1045, Arlington VA 22203, fax 703-292-9034, email esm@nsf.gov. Licensees shall notify the International Bureau once they have completed coordination. Upon receipt of the coordination agreement from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. (2) A list of applicable RAS sites and their locations can be found in 25.226(d)(2) Table 1. (3) When NTIA seeks to provide similar protection to future RAS sites that have been coordinated through the IRAC Frequency Assignment Subcommittee process, NTIA will notify the Commission's International Bureau that the site is nearing operational status. Upon public notice from the International Bureau, all Ku-band ESAA licensees shall cease operations in the 14.47-14.5 GHz band within the relevant geographic zone of the new RAS site until the licensees complete coordination for the new RAS facility. Licensees shall notify the International Bureau once they have completed coordination for the new RAS site and shall submit the coordination agreement to the Commission. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. The ESAA licensee then will be permitted to commence operations in the 14.47-14.5 GHz band within the relevant coordination distance around the new RAS site, subject to any operational constraints developed in the coordination process.	*See* Application, File No. SES-LIC-20100805-00992, Technical Appendix at Att. C.