*i*NTELLICOM

Technical Brief for

On-The-Move SATCOM Permanent Licensing

July 28, 2010

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Revision History

Revision History:	Date	Document Revision Description
V08pm	2006 10 27	First external release to satellite operators and FCC.
V09pm	2006 11 06	Modified treatment of PSD into the antenna as a function of relative rotation of the antenna with the geostationary arc. Added Table 8-1. Modified conclusion.
V10pm	2007 01 10	Add comment on effective diameter of antenna (Ch. 3) Add comments in chapters 6, 7 to clarify which antenna model they are from, the antenna dimensions, and the effective diameter. Added AMC-9 adjacent satellites to Appendix-10
V11	2008 08 29	Satellite points of communication have been added. Chapters 2 and 10 have been updated to cover the additional satellites. Chapter 4 – added 25.134 Added Appendix on link budgets and spectral spreading.
V12	2008 09 05	Minor modifications – spelling, grammar
V13	2009 01 20	Add antenna plots for +-/90 degrees
V14	2009 02 04	Update antenna plots and add coordination reference models.
V21	2010 07 27	Add technical content to support VSAT / blanket license. • Data Logging • Contention Channel • Skew Angle • Disable Provisions Update antenna plots with new data.

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2 INTRODUCTION

L3 is seeking a permanent FCC VSAT/blanket license for the operation of its vehicle mounted on-the-move SATCOM system. Verification of the system has been performed since June/2005 under an FCC experimental license.

This document provides technical information regarding the intended operations of the L3 system. Operations are such that they comply with FCC rulings for off-axis Power Spectral Density.

The system utilizes advanced antenna pointing technology, spread spectrum modulation, and centralized and distributed controls to ensure that interferences to others meet the requirements of the FCC and the ITU.

L3 is seeking a permanent VSAT/blanket FCC license for:

- **L3/Linkabit MPM-1000 Modem and Controller Assembly**
- **L3/Datron FSS-4180-LP Antenna Assembly**
- **Ku Band (14-14.5 GHz, 11.7-12.2 GHz)**
- **All CONUS operation**
- **Many US Satellites**
- **Mobile operation**

Intellicom Technologies, Inc. is representing L3 in this matter; please feel free to contact the following for additional information, comments, or clarifications:

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3 SYSTEM DESCRIPTION

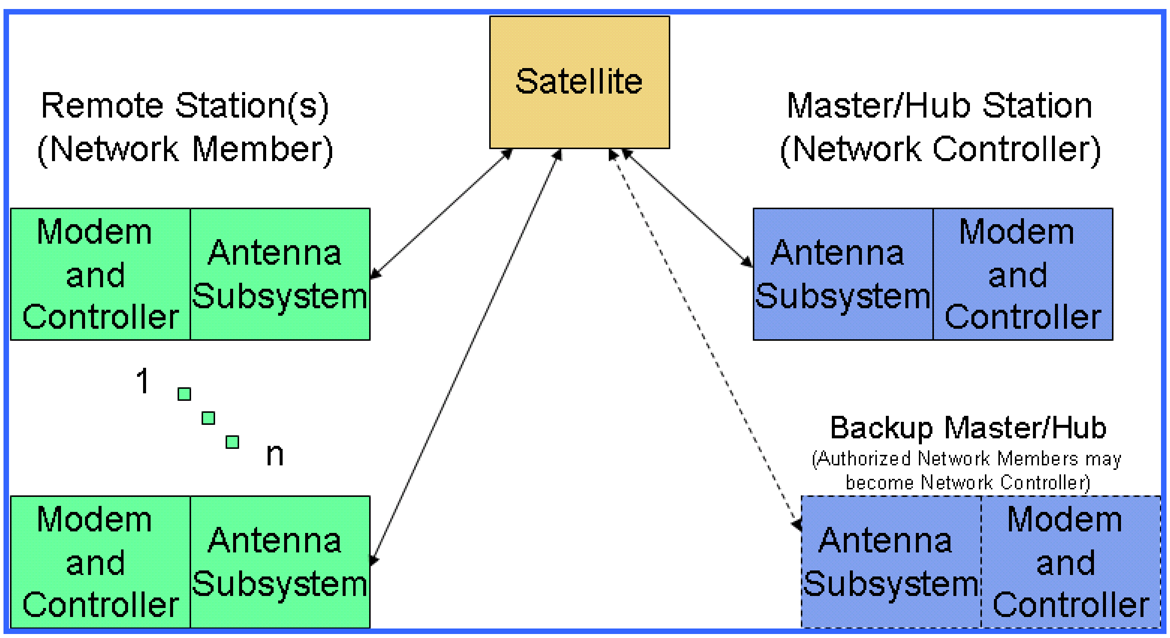
3.1 Network Configuration

The network provides point-to-point 32 kbps to 2 Mbps duplex satellite data links while using a small (<1m) antenna operated in a mobile environment.

The network consists of:

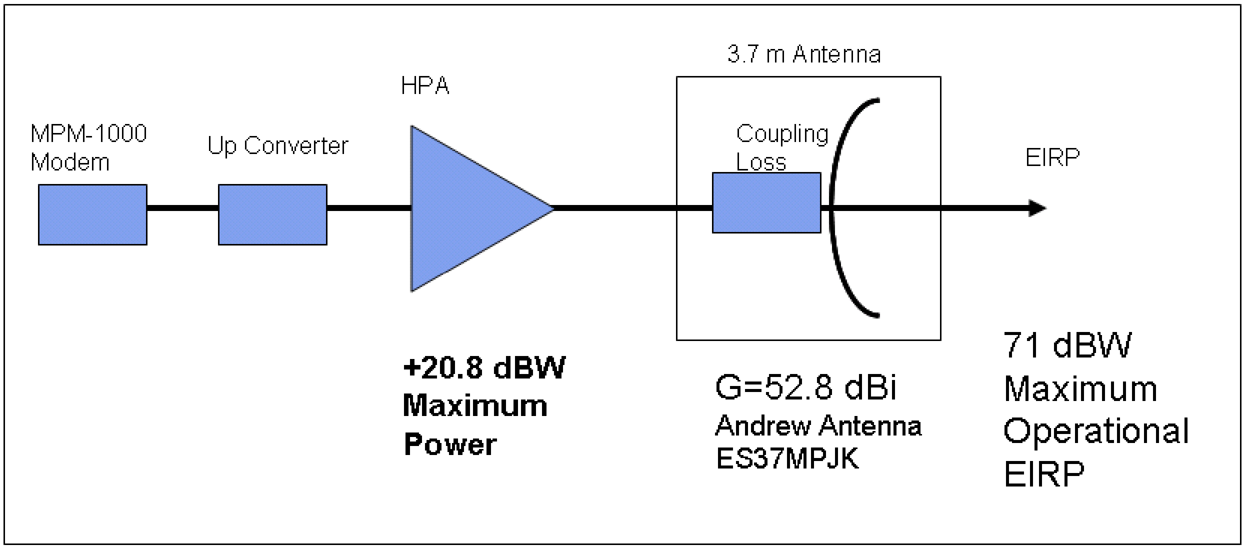
- **Network Members:** These stations are under continuous (remote) control and monitoring from the Network Controller. Network members can not transmit unless they receive the signaling channel from the Network Controller.
- **Geostationary Satellite:** Space segment resources are leased from the available commercial satellite operators.
- **Network Controller**: The network controller provides resource management of the leased space segment and continuously monitors and controls the Network Members. The network operator will either provide on-site 24x7 support or on-call rapid responses for the Network Controller. The satellite space segment operations center shall be provided with the network operator's phone number for rapid fault resolution.
- **Back-Up Network Controller**: If the Network Controller fails, then all transmissions will cease unless the failed Network Controller recovers or a back-up pre-authorized Network Member detects the failure and becomes configured as the new Network Controller.

Power, Frequency, Timing Control
Modems and frequency converters are phase locked to an accurate and stable 10 MHz reference. If any converters loose lock, then their transmitter is muted. In addition to managing all Network Members, the Network Controller monitors and adjusts their power, frequency and timing accuracy.



3.2 Master/Hub Station

The master/hub earth station consists of an L3/Linkabit MPM-1000 Modem, and an RF transmitter consisting of a TWT and a 3.7m antenna. The earth station is capable of producing 71 dBW EIRP. The hub earth station is licensed under FCC call sign E000002[1].



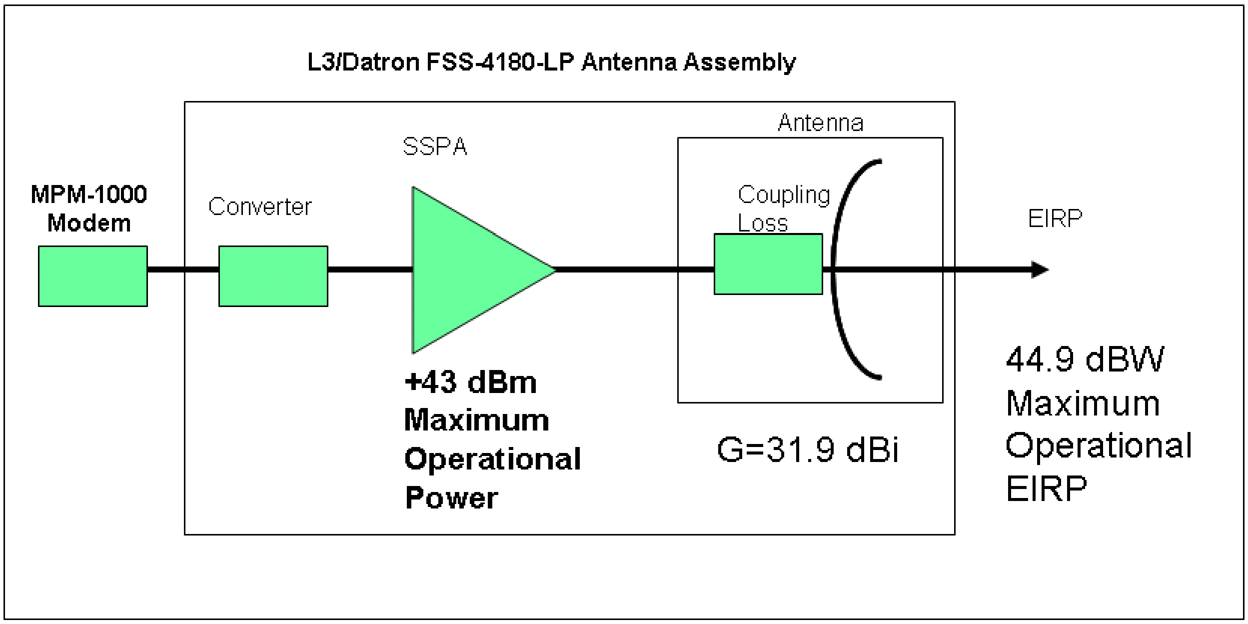
[1] Radio Station Authorization, Call Sign E000002, File SES-MOD-20090908-01131, 11/24/2009.

3.3 Mobile Earth Station

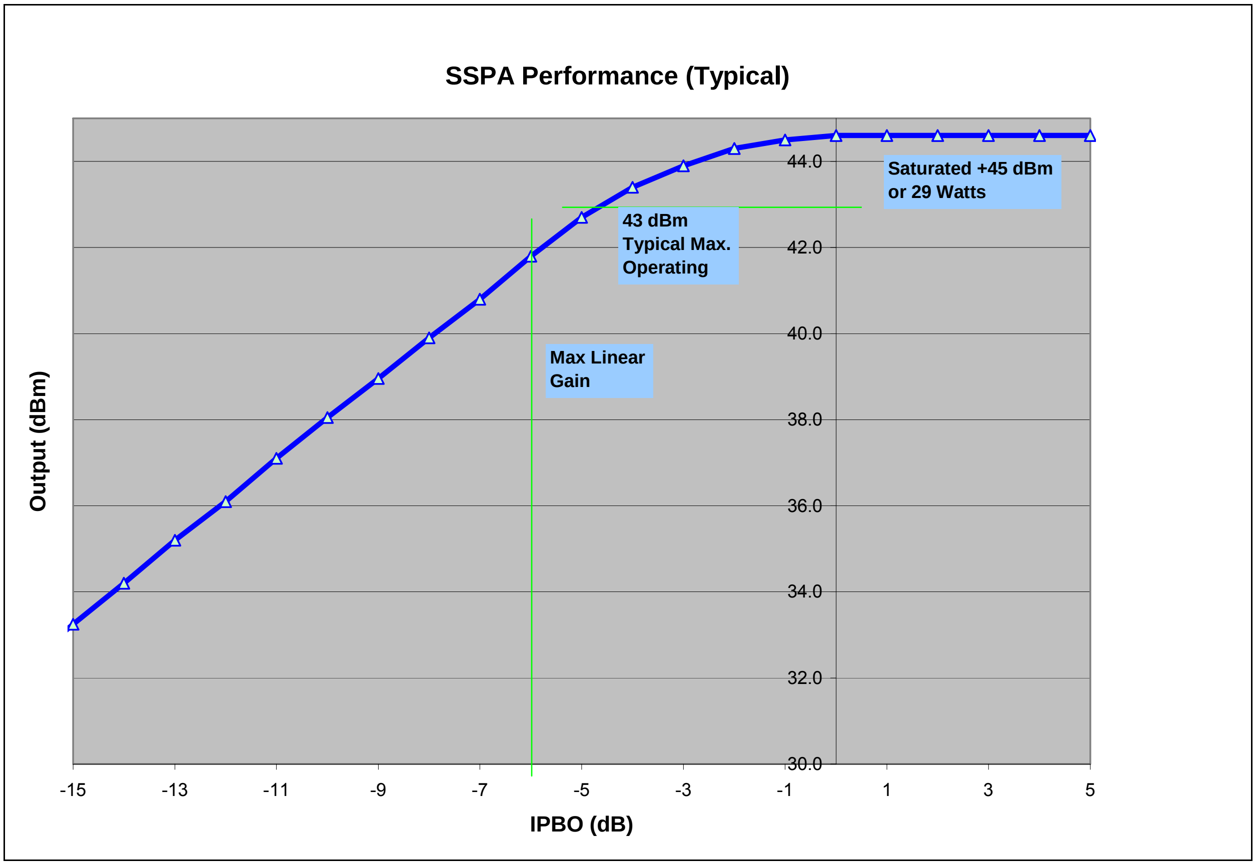
The mobile earth station consists of:

- an L3/Linkabit MPM-1000 Modem, and
- an L3/Datron FSS-4180-LP antenna assembly.

The earth station is capable of producing up to 44.9 dBW EIRP. The mobile earth station has been licensed as a single earth station under FCC call sign E060390[2]. We are now seeking a VSAT/blanket permanent license to operate a network consisting of up to 254 mobile earth stations.



[2] Radio Station Authorization, Call Sign E060390, File SES-LIC-20070322-00396, 03/16/2009.



3.3.1 L3/Linkabit MPM-1000 Modem and Controller Assembly

The Modem and Controller Assembly consists of:

- Modulator
- Demodulator
- Turbo codec
- Stable clock, reference, and distribution
- Frequency conversion to/from IF
- Controller, configurable as a:
    - Network Member, or
    - Network Controller (including resource manager)
- Ethernet Interface/Switch
- QOS manager
- Human Machine Interface

Each ground station includes a modem and controller assembly. The modem provides data conversion, error correction encoding/decoding, and modulation/demodulation. The controller provides fault, configuration, account/resource, performance, and security management (FCAPS - FM, CM, AM, PM, SM).

Modulation

Stations modulate using BPSK or QPSK. If the station has an antenna less than 1m in diameter, then DSSS (direct sequence spread spectrum) BPSK is transmitted if required to keep the EIRP density within FCC spectral density limits. The range of data rates, modulation, and coding include:

Modulation: BPSK (R ½), OQPSK (R ½, ¾)
Data Rates: 32kbps to 1024kbps
Coding: Turbo Coding
BPSK Spreading: 1-16x

Typically DSSS BPSK, R ½ FEC will be utilized to ensure that the EIRP density meets FCC limits.

Access Scheme

The access scheme used is Multi-Frequency Time Division Multiple Access (MF-TDMA). The Network Controller provides real-time resource management through time slot, frequency center, and carrier bandwidth assignments to the Network Members via a common signaling channel. In the leased bandwidth, the Network Controller may assign multiple frequency slots for each burst time. All stations can hop frequencies from burst to burst, but there will only be one transmit carrier per frequency slot per burst.

While spread spectrum is used as a method to reduce transmitted power spectral density, it is NOT USED as a multiple access scheme. Multiple access is achieved using MF-TDMA and is under control of the Network Controller.

N is equal to one[3] for this time division multiple access (TDMA) technique.

---

[3] Per FCC 25.226 Blanket licensing provisions for domestic, U.S. Vehicle-Mounted Earth Stations (VMESs) 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.

3.3.2 L3/Datron FSS-4180-LP Antenna Assembly

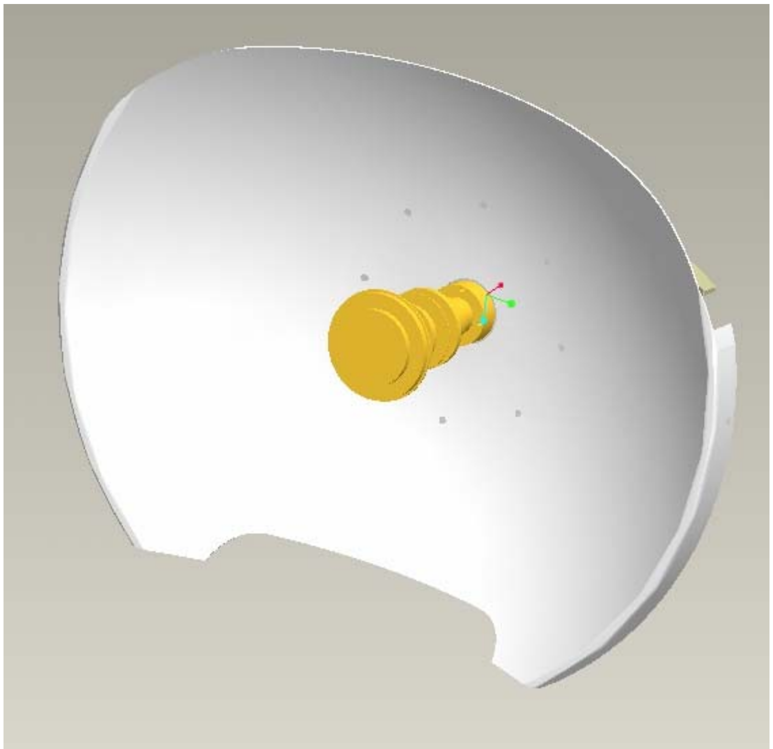
The antenna subsystem consists of:

- Antenna Reflector
- Linear Cross Polarized Feed
- SSPA
- LNB
- Block Upconverter
- Antenna Controller
  - Antenna Controller computer
  - Human Machine Interface
  - GPS
  - Inertial Navigation system
  - Signal Tracking Assistance

The antenna controller utilizes GPS, an advanced inertial navigation system (INS), and knowledge of the satellite ephemeris (knowledge box) to compute the pointing for the antenna.

The L3/Datron FSS-4180-LP Antenna Assembly is a two axis (Azimuth, Elevation) antenna and Polarization feed adjusting pedestal. The antenna is wider in its azimuth plane than it is in its elevation plane in order to support military size requirements. The wide dimension of the antenna remains level with the vehicle that it is mounted to.

The Antenna Reflector, shown below, is approximately 17.4" x 12" (0.44m x 0.30m). The reflector is elliptical in shape with an effective diameter (as if it were circular) of 0.36m.



3.3.3 Management

The Master/Hub fixed earth station acts Network Controller (NC) and mobile earth stations will be Network Members (NM). The operation of the mobile earth station or Network Member (NM) is fully managed by master/hub earth station Network Controller (NC).

No transmission occurs without the NM locking on to a NC carrier and receiving assignments. Transmissions are burst from NM as assigned and transmission ceases if assignment are not needed or not granted.

Mobile earth station performance will be monitored by personnel during operations. Personnel have the ability to disable transmission of the earth station if necessary.

3.3.4 Contention Channel

A contention access channel is used for signaling communications between the mobile earth station and the hub. A detailed analysis of the contention channel performance is provided in Chapter **Error! Reference source not found.** APPENDIX-CONTENTION CHANNEL. FCC rules and proposed rules have been reviewed in order to determine requirements for usage of contention channels.

During steady state operation contention channel registrations occur seldom but collisions could occur. These collisions would be occasional bursts of duration 1.3 to 42 mS (less than the 100 mS recommended[4] [para 71].

The contention channel use complies with Table-5[5] and thus should be considered "reasonable use" per the FCC guidelines.

3.3.5 Data Logging

In support of FCC rules, the NM will log[6] time, location, and transmission details that could be made available in support of resolving interference events. This capability may be disabled by the network operator should the operator of the system seek and receive a waiver from the FCC of the data logging requirement for national security reasons.

The MPM-1000 modem will comply with the FCC requirements for data logging. Data logs will be recorded locally at the earth station on a PC which is interlocked with the modem. If the PC is removed or fails, transmission will shutdown. Data will be retrieved if it is requested by an appropriate party.

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[4] FCC 08-246, "Eighth Report and Order on Reconsideration, 2000 Biennial Regulatory Review Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations", IB Docket No. 00-248, IB Docket No. 95-117, FCC Document, October 17, 2008

[5] FCC 08-246 EIGHTH REPORT AND ORDER [1]

[6] Data logging capability is not available at the time of writing this document, but is intended to be available in a future revision. Only mobile earth stations with the data logging will be used under the requested license.

Additional information on the data logging provisions is included in Chapter 11 APPENDIX - DATA LOGGING.

3.3.6 Disable Provisions

The following disable provisions described in the Chapter 14 APPENDIX – DISABLE PROVISIONS are available and enabled by default:

- RF Mute on Pointing Error
- Self-Monitor Conditions for Modem Transmission
- Mute on Loss of Lock
- Temporarily Disable Remote NM
- Permanent Disable Remote NM

4 ANTENNA

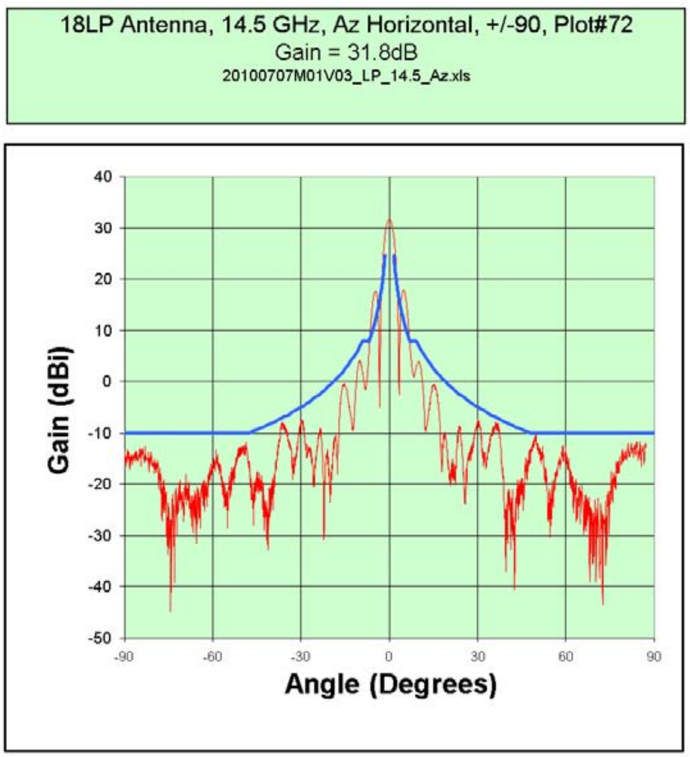
The antenna is a center fed feed controlled by a high performance positioner utilizing inertial navigation and GPS.

4.1 Gain Patterns

Gain patterns for the mobile antenna are included in

- Chapter 17 APPENDIX – ANTENNA AZIMUTH PLOTS
- Chapter 18 APPENDIX – ANTENNA ELEVATION PLOTS

A sample plot is provided below. The antenna gain plotted in red, the FCC 25.209 gain curve is plotted in blue.



4.2 Pointing Error

A detailed discussion on antenna pointing is provided in the Chapter 15 APPENDIX – ANTENNA POINTING. The FSS-4180 antenna system maintains **0.2 degrees pointing accuracy** 95% of the time in a ground mobile operation on the Churchville B course. The antenna system is designed to mute the transmitter if the pointing error exceeds a configurable limit (factory set to 0.5 degrees).

5 TRANSMIT CARRIERS

Then MPM-1000 is capable of operation at many bit rates, code rates, modulation types and rates, and spreading factors. Described here are the carriers that cover the extremities in power and bandwidth for this system.

The **Mobile Earth Station (NM)** transmits three carrier types:

- Contention Reverse Orderwire (CROW)
- Assigned Reverse Orderwire (AROW)
- Data Communications (DCOM)

Only one carrier type is transmitted at a time as defined by the multi-frequency time division multiple access MF-TDMA frame structure (N=1).

The **Master/Hub (NC) Earth Station** transmits two carrier types:

- Forward Orderwire (FOW)
- Data Communications (DCOM)

Only one carrier type is transmitted at a time as defined by the multi-frequency time division multiple access MF-TDMA frame structure (N=1).

5.1 Mobile Earth Station Carriers

5.1.1 Assigned Carriers (AROW, DCOM)

Assigned carriers include the AROW and the DCOM. Details are provided in Chapter 12 APPENDIX – CONTENTION CHANNEL.

Transmit carriers from the mobile earth station will be BPSK with spread spectrum to ensure compliance with the FCC 25.226 ruling. The emission designations follow:

Carrier Type	Transmit	Receive	Emission	Emission BW (Hz)
min bit rate, min spread	1T	1R	45K0G7D	45,000
min bit rate, max spread	2T	2R	717KG7D	717,000
max bit rate, min spread	3T	3R	1M4G7D	1,430,000
max bit rate, max spread	5T	5R	11M5G7D	11,500,000

5.1.2 Contention Carrier (CROW)

The contention carrier is the CROW. A slotted Aloha scheme with collision detection is used. Details are provided in Chapter 12 APPENDIX – CONTENTION CHANNEL.

The contention transmit carrier types from the mobile earth station are identical to the assigned carrier types. If collisions are detected in the contention channel, then the spread factor may be increased and/or the number of contention channel time slots may be increased. The increase in aggregate EIRP density is within the FCC guidelines discussed in Chapter 12 APPENDIX – CONTENTION CHANNEL.

The contention channel use complies with Table-5[7] and thus should be considered "reasonable use" per the FCC guidelines.

5.2 Master/Hub Earth Station Carriers

Assigned carriers include the FOW and the DCOM. Details are provided in the appendix (see Chapter 12 APPENDIX – CONTENTION CHANNEL).

Transmit carriers from the master/hub earth station will be BPSK or QPSK. The emission designations follow:

Transmit	Receive	Emission	Emission BW (Hz)
1T	1R	45K0G7D	45,000
2T	2R	717KG7D	717,000
3T	3R	1M4G7D	1,430,000
5T	5R	11M5G7D	11,500,000

[7] FCC 08-246 EIGHTH REPORT AND ORDER [1]

6 LINK BUDGETS and SPECTRAL SPREADING

Satellite parameters have been examined for CONUS operation with the satellite list shown in Chapter 8 SATELLITE POINTS OF COMMUNICATION. In addition, link budgets have been examined for operation within CONUS. A sample link budget is included in Chapter 10 APPENDIX – SAMPLE LINK BUDGET.

The solid lines in the graph below show the spreading necessary as a function of bit rate and station EIRP. The solid lines are based on the PSD into the antenna so as not to exceed the required -21.7 dBW/4KHz. The MPM-1000 Network Controller configures the spreading factor for the Network Members from 1x to 16x.

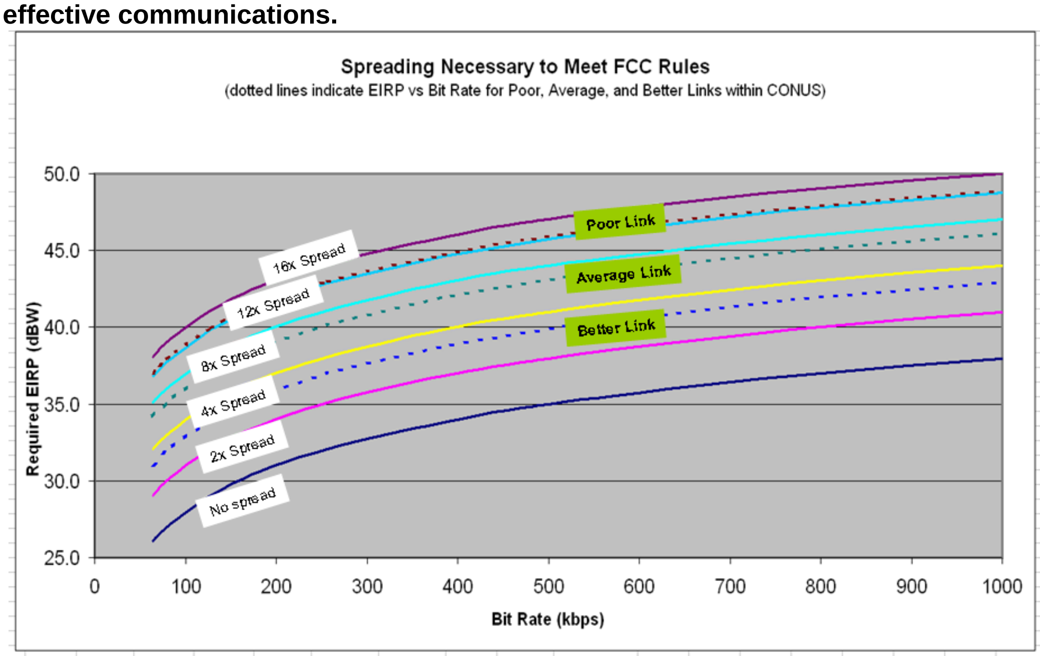
For the sub-meter dish, the link is uplink limited and thus the G/T of the satellite is a dominant factor in the quality of the link. The following list shows the range of G/Ts available from the desired satellites listed in Chapter 8 SATELLITE POINTS OF COMMUNICATION.

Satellite Performance Range	National EIRP	National G/T	National SFD
Better	48	4	-107
Average	47	1	-97
Poor	46	-1	-92

The dotted lines show the EIRP required for a "poor link", an "average link", and a "better link" from within CONUS to the satellites listed in Chapter 8.

As an example, for a "poor link", more EIRP would be required from the ground terminal and thus 16x spreading is required. For a "better link" only 4x spreading is required. For this antenna size spreading will always be required.

This range of links demonstrates that the spreading options available from the MPM-1000 ensure that the off-axis spectral density will not exceed the FCC requirement for the desired EIRP and bit rate for effective communications.



7 MAXIMUM POWER SPECTRAL DENSITY

7.1 MAXIMUM POWER SPECTRAL DENSITY - ELEVATION

Maximum Antenna Gain in Excess of FCC 25.209

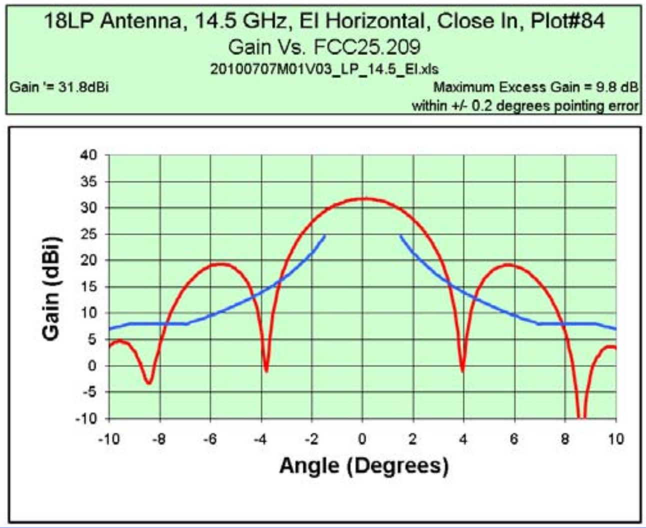
Antenna plots of the **L3/Datron FSS-4180-LP Antenna Assembly** have been examined for the maximum gain in excess of the FCC 25.209 profile. The maximum allowable transmit carrier energy density will be reduced by the **excess gain**.

The Antenna Reflector is approximately 17.4" x 12" (0.44m x 0.30m). The reflector is elliptical in shape with an effective diameter (as if it were circular) of 0.36m.

Since small antenna pointing errors will occur as a result of the antenna dynamics, we have examined the maximum **excess gain** resulting from pointing errors.

PATTERN #	FREQ	BORESITE	AXIS	PLANE	Gain (dbi)	+/- 0.2 Off-Axis Excess Gain (dB)	Max off axis PSD Into Antenna (dBW/4kHz)
L0167A.082	13.75	HOR	EL	E	31.4	8.6	-22.6
L0167A.058	13.75	VERT	EL	H	31.1	8.2	-22.2
L0167A.083	14.125	HOR	EL	E	31.5	8.9	-22.9
L0167A.059	14.125	VERT	EL	H	31.4	7.9	-21.9
L0167A.084	14.5	HOR	EL	E	31.8	9.8	-23.8
L0167A.060	14.5	VERT	EL	H	31.9	8.3	-22.3

The maximum excess gain including pointing error is **9.8** dB and occurs at 14.5 GHz, vertical polarization, elevation profile with a 0.2° degree pointing error (see the following antenna plot).

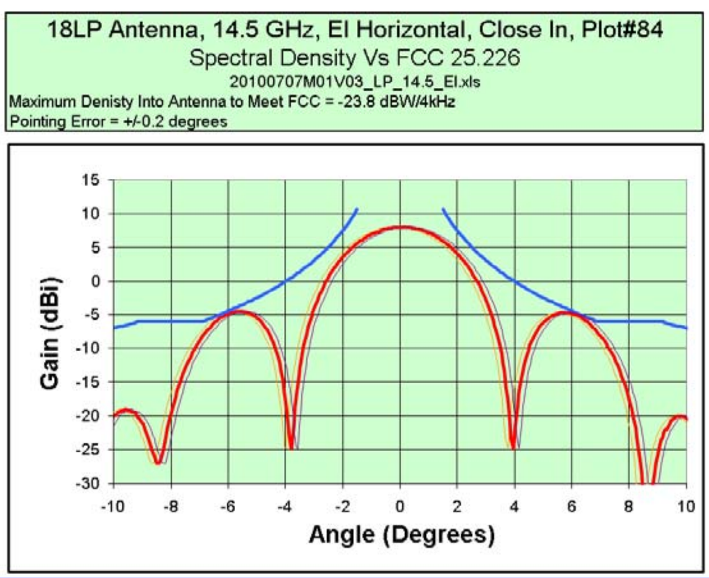


Maximum Power Spectral Density Allowed To Meet FCC Rulings

For an FCC 25.209 compliant antenna, the maximum input power density into the antenna shall not exceed -14 dBW/4 kHz.

This energy density must be reduced by the maximum excess gain of the “non-compliant” antenna.

Elevation Pattern		
Maximum Excess Gain (above FCC 25.209 compliant antenna)	9.8	dB
Maximum Power Spectral Density allowed into FCC 25.209 compliant antenna	-14	dBW/4 kHz
Maximum Power Spectral Density allowed into the “non-compliant” antenna	-23.8	dBW/4 kHz
On axis gain	31.8	dBi
On Axis EIRP Density - On Axis	8.0	dBW/4 kHz
Horizon Gain at 20 degrees Elevation	3	dBi
EIRP Density at Horizon	-20.8	dBW/4 kHz
EIRP Density at Horizon	-56.8	dBW/Hz



7.2 MAXIMUM POWER SPECTRAL DENSITY - AZIMUTH

Maximum Antenna Gain in Excess of FCC 25.209

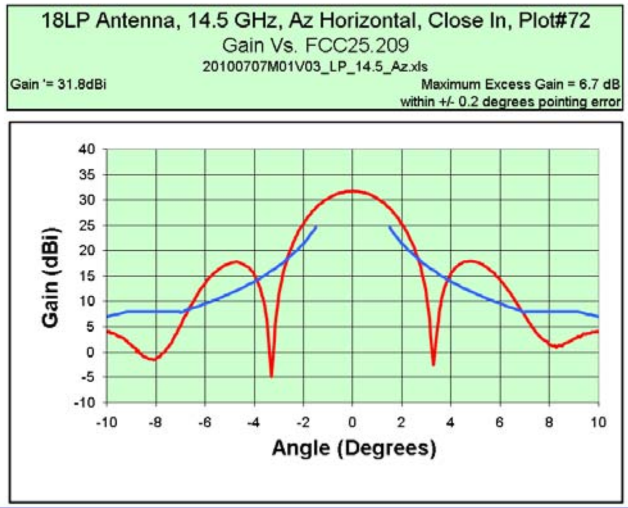
Antenna plots of the **L3/Datron FSS-4180-LP Antenna Assembly** have been examined for the maximum gain in excess of the FCC 25.209 profile. The maximum allowable transmit carrier energy density will be reduced by the **excess gain**.

The Antenna Reflector is approximately 17.4” x 12” (0.44m x 0.30m). The reflector is elliptical in shape with an effective diameter (as if it were circular) of 0.36m.

Since small antenna pointing errors will occur as a result of the antenna dynamics, we have examined the maximum **excess gain** resulting from pointing errors.

PATTERN #	FREQ	BORESITE	AXIS	PLANE	Gain (dbi)	+/- 0.2 Off-Axis Excess Gain (dB)	Max off axis PSD Into Antenna (dBW/4kHz)
L0167A.071	14.125	HOR	AZ	E	31.5	5.8	-19.8
L0167A.047	14.125	VERT	AZ	H	31.4	6.1	-20.1
L0167A.070	13.75	HOR	AZ	E	31.4	5.9	-19.9
L0167A.046	13.75	VERT	AZ	H	31.1	5.7	-19.7
L0167A.072	14.5	HOR	AZ	E	31.8	6.7	-20.7
L0167A.048	14.5	VERT	AZ	H	31.9	6.3	-20.3

The maximum excess gain including pointing error is **6.7** dB and occurs at 14.5 GHz, horizontal polarization, elevation profile with a 0.2° degree pointing error (see the following antenna plot).

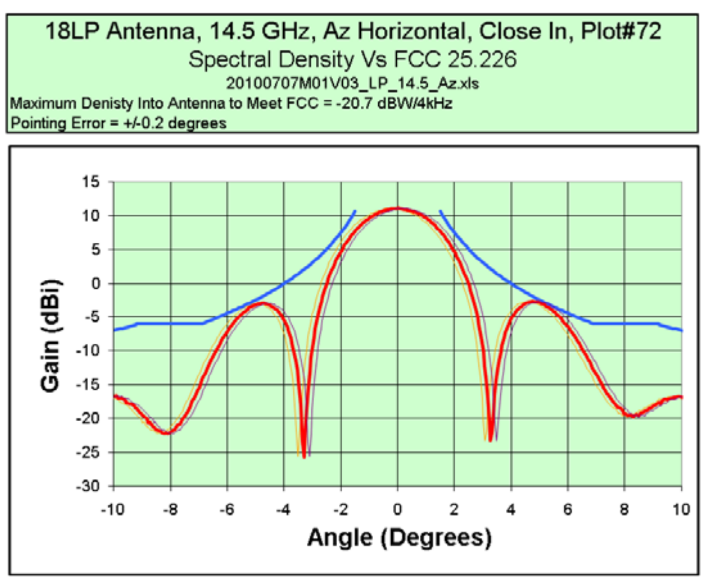


Maximum Power Spectral Density Allowed To Meet FCC Rulings

For an FCC 25.209 compliant antenna, the maximum input power density into the antenna shall not exceed -14 dBW/4 kHz.

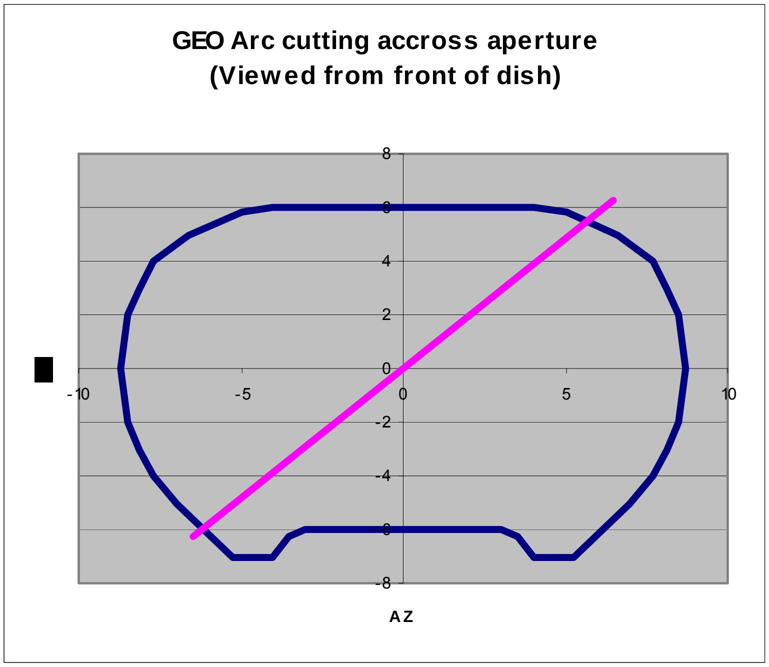
This energy density must be reduced by the maximum excess gain of the “non-compliant” antenna.

Azimuth Pattern		
Maximum Excess Gain (above FCC 25.209 compliant antenna)	6.7	dB
Maximum Power Spectral Density allowed into FCC 25.209 compliant antenna	-14	dBW/4 kHz
Maximum Power Spectral Density allowed into the “non-compliant” antenna	-20.7	dBW/4 kHz
On axis gain	31.8	dBi
On Axis EIRP Density	11.1	dBW/4 kHz
Gain at backlobe	-10	dBi
EIRP Density at backlobe	-33.8	dBW/4 kHz
EIRP Density at backlobe	-69.8	dBW/Hz



7.3 MAXIMUM POWER SPECTRAL DENSITY – SKEW ANGLE

The L3/Datron FSS-4180-LP Antenna Assembly is a two axis (Azimuth, Elevation) antenna and Polarization feed adjusting pedestal. The antenna is wider in its azimuth plane than it is in its elevation plane in order to support military size requirements. The wide dimension of the antenna remains level with the vehicle. In general the wide dimension of the antenna will not be tangent to the geostationary arc for the desired satellite as seen in the figure below. To a first order approximation, the actual illumination on the geostationary arc is the vector addition of the azimuth and elevation gain profiles adjusted by the angle between the wide dimension of the antenna and the geostationary arc (relative rotation).



At **0°** relative rotation (polarization), the illumination on the geostationary arc is the **azimuth** gain profile. At **90°** relative rotation, the illumination on the geostationary arc is the **elevation** gain profile. As seen in the previous two sections, the worst case gain difference between azimuth and elevation excess gain is 3.1 dB.

		Excess Gain (dB)	
az pattern	max	6.7	dB
el pattern	max	9.8	dB
	difference	**3.1**	dB

Excess gain increases as a function of relative rotation are shown in Table 7-1. Thus it is conservative to utilize the **azimuth** antenna pattern, **reduced by the increase in excess gain** per Table 7-1 to determining the allowable PSD into the antenna.

Table 7-1 Excess Gain and PSD vs. Skew Angle or Relative Rotation (Note 1)

Skew Angle (degrees)	Increase in Excess Gain (dB)	Maximum Power Spectral Density allowed into the Non-Compliant Antenna dBW/4kHz
0	0	-20.7
0	0.0	-20.7
10	0.2	-20.9
20	0.7	-21.4
30	1.3	-22.0
40	1.8	-22.5
50	2.3	-23.0
60	2.6	-23.3
70	2.9	-23.6
80	3.0	-23.7
90	3.1	-23.8
90	3.1	-23.8

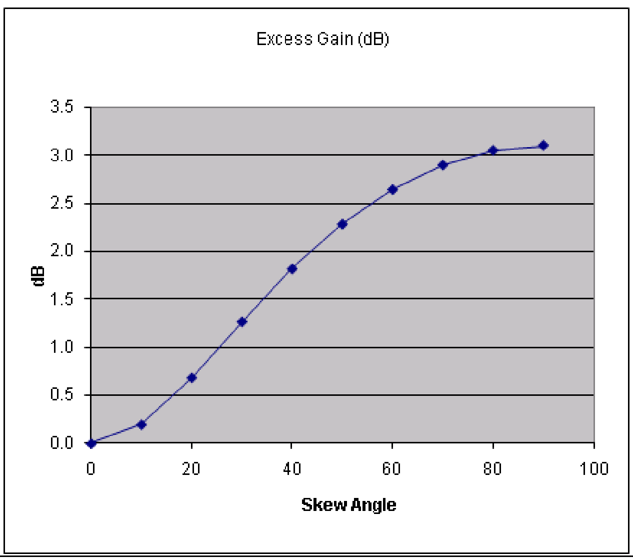
Note 1: The LP antenna radiation patterns have a different AZ and EL half power beamwidth (HPBW) due to its asymmetric reflector. As the reflector has an approximately elliptical shape, to a first approximation so also does the resulting antenna main beam. The resulting radiation pattern E(Φ) is given by:

$$E(\Phi) = F_{EL} * \sin(\Phi) + F_{AZ} * \cos(\Phi)$$

where F_{EL} is the elevation pattern and F_{AZ} is the azimuth pattern

This is the parametric equation for a perfect ellipse. The resulting pattern amplitude at any arbitrary pattern cut at angle Φi is given by:

$$| E(\Phi i) | = \sqrt{[F_{EL}^2 * \sin^2(\Phi i) + F_{AZ}^2 * \cos^2(\Phi i)]}$$



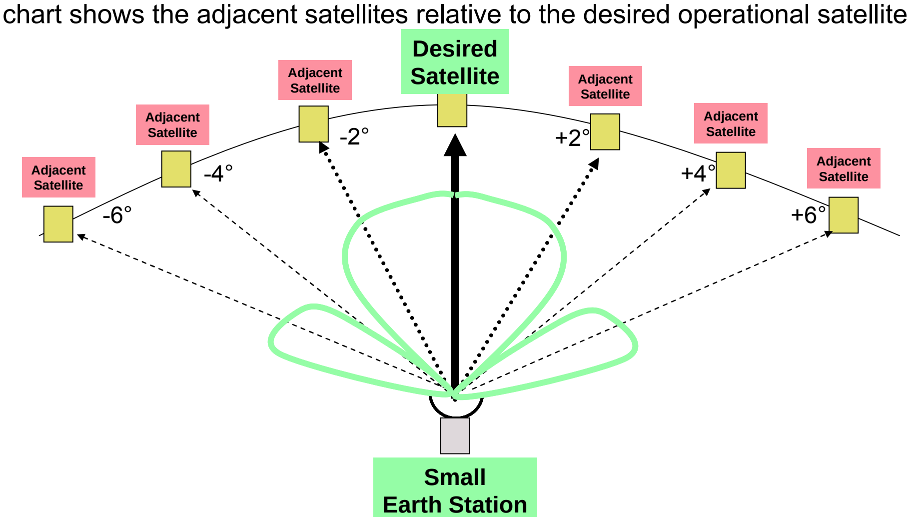
8 SATELLITE POINTS OF COMMUNICATION

The following table shows the list of desired satellites or points of communications:

Orbit (WL)	Operator	Decription
63	Telesat	T14
72	AMC	6
74	Intelsat	H2
79	AMC	5
83	AMC	9
89	Intelsat	G28
91	Intelsat	G17
93	Intelsat	G26
99	Intelsat	G16
101	AMC	2
103	AMC	1
105	AMC	15
125	AMC	21
127	Intelsat	H1
129	Intelsat	G27
188	AMC	23
191	Intelsat	IS2

The FSS4180-LP antenna is not compliant with the FCC Part 25 rules with regard to off-axis gain. The antenna exhibits its non-compliance in the region from **1.0 to 7.0 degrees off axis** from maximum gain in the transmit band, due to the width of the main and second lobes. The antenna is compliant with the side lobe pattern requirements specified in Section 25.209 of the Commission's Rules for off-axis angles starting at 7.0 degrees in the transmit band. The off-axis EIRP values generated by the terminal in the transmit band are reduced to that of a compliant antenna by decreasing the antenna flange power spectral density[8] of –14 dBW/4KHz by the amount of the non-compliance (excess gain). Through the use of spectral spreading, the mobile earth station is compliant with FCC25.226.

The following chart shows the adjacent satellites relative to the desired operational satellite.



[8] 47 CFR § 25.134, 47 CFR § 25.212

9 CONCLUSION

L3 has developed methods to protect adjacent satellite operations. These methods have been under development and refinement for several years and have been verified in laboratory and operational conditions. A conservative analysis has been performed and has and will continue to be used to protect adjacent satellite operations.

Power Spectral Density (PSD) into the antenna shall be managed within the required FCC limits by limiting transmit power and/or utilizing spread spectrum modulation.

Contention channel usage is reasonable per FCC guidelines.

The actual EIRP required, in order to achieve a reliable data link, will depend on

- the site location within CONUS,
- the associated weather conditions,
- the satellite performance,
- the receiving station performance.

If the communications link requires more power, additional spreading will be required. If the communications link requires less power and the spreading factor may be reduced.

The L3/Datron FSS-4180-LP Antenna Assembly controls pointing of the antenna through the use of

- advanced control systems utilizing Kalman filters,
- GPS,
- inertial navigation systems,
- signal tracking assistance, and
- various sensors.

This antenna pointing technology has been engineered over many years and has been verified in both lab and operational environments.

- **Adjacent Satellite Interference effects will be less than or equal to those of an FCC 25.209 compliant antenna and are compliant with FCC25.226.**
- **The earth station will be operated within CONUS such that the PSD into the antenna will be less than -20.7 dBW/4 kHz and will be further reduced to account for the relative rotation of the non-circular antenna with the geostationary arc (per Table 7-1).**
- **Antenna pointing will be maintained within +/-0.2°. Under extreme mobile environments, the transmitter will be MUTED within 100ms when pointing error exceeds +/-0.5°.**

10 APPENDIX – SAMPLE LINK BUDGET

A link budget has been prepared below for the following remote to hub carrier:

- 512 kbps
- R1/2 FEC
- BPSK
- Required Eb/No = 3.3 dB
- An uplink EIRP of 40.05 dBW is required
- A spreading factor of 4x or larger is required

Digital Link Budget

Produced using Satmaster Pro

Wednesday, January 20, 2010

Service Name	Link 121E
Coverage	CONUS, Turbo Coded
Uplink earth station	Fort Lewis, Washington
Downlink earth station	Fort Lewis, Washington
Satellite name	Generic

Link Input Parameters	Up	Down	Units
Site latitude	42.12N	42.12N	degrees
Site longitude	122.52W	122.52W	degrees
Site altitude	0	0	km
Frequency	14.250	11.950	GHz
Polarization	Horizontal	Vertical	
Rain model	Crane (C)	Crane (C)	(mm/h or zone)
Availability (average year)	97.50	97.50	%
Antenna aperture	.4	3.8	metres
Antenna efficiency / gain	31.9	65	% (+ prefix dBi)
Coupling loss	0.5	.5	dB
Antenna tracking / mispoint error	0.1	0.1	dB
LNB noise figure / temp		.8	dB (+ prefix K)
Antenna noise		55	K
Adjacent carrier interference	25	25	dB
Adjacent satellite interference	25	25	dB
Cross polarization interference	25	25	dB
Uplink station HPA output back-off	0		dB
Number of carriers / HPA	1		
HPA C/IM (up)	50		dB
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	MIN		W

Satellite Input Parameters	Value	Units
Satellite longitude	63.00W	degrees
Transponder type	TWTA	
Receive G/T	4	dB/K
Saturation flux density	-107	dBW/m2
Satellite attenuator pad	0	dB
Satellite ALC	0	dB
EIRP (saturation)	48	dBW
Transponder bandwidth	36	MHz
Input back off total	7	dB
Output back off total	4	dB
Intermodulation interference	16.5	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-8	
Required Eb/No without FEC coding	11.97	dB
Required Eb/No with FEC coding	3.3	dB
Information rate	.512	Mbps
Overhead	0	%
FEC code rate	0.5	
Spreading gain	0	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.4	
Bandwidth allocation step size	.01	MHz
System margin	3.0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.53	dB/m2
Uplink C/No	81.07	dB.Hz
Downlink C/No	99.62	dB.Hz
Total C/No	81.01	dB.Hz
Uplink EIRP for saturation	56.83	dBW

General Calculations	Up	Down	Units
Elevation	13.71	13.71	degrees
True azimuth	111.54	111.54	degrees
Compass bearing	95.55	95.55	degrees
Path distance to satellite	40199.18	40199.18	km
Propagation time delay	0.134090	0.134090	seconds
Antenna efficiency	31.90	65.00	%
Antenna gain	30.56	51.68	dBi
Availability (average year)	97.50	97.50	%
Link downtime (average year)	219.150	219.150	hours
Availability (worst month)	93.674	93.674	%
Link downtime (worst month)	46.210	46.210	hours
Spectral power density	-51.40	-26.67	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	40.05	40.05	40.05	dBW
Transponder input back-off (total)	7.00	7.00	7.00	dB
Input back-off per carrier	16.77	17.27	16.77	dB
Mispoint loss	0.10	0.10	0.10	dB
Free space loss	207.61	207.61	207.61	dB
Atmospheric absorption	0.27	0.27	0.27	dB
Tropospheric scintillation fading	0.38	0.38	0.38	dB
Atmospheric losses total	0.65	0.65	0.65	dB
Total path loss (excluding rain)	208.26	208.26	208.26	dB
Rain attenuation	0.00	0.50	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	0.50	0.00	dB
C/No (thermal)	64.29	63.80	64.29	dB.Hz
C/N (thermal)	3.40	2.90	3.40	dB
C/ACI	25.00	24.50	25.00	dB
C/ASI	25.00	24.50	25.00	dB
C/XPI	25.00	24.50	25.00	dB
C/IM	50.00	50.00	50.00	dB
Eb/(No+Io)	7.11	6.61	7.11	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	48.00	48.00	48.00	dBW
Transponder output back-off (total)	4.00	4.00	4.00	dB
Output back-off per carrier	13.77	14.27	13.77	dB
Satellite EIRP per carrier	34.23	33.73	34.23	dBW
Mispoint loss	0.10	0.10	0.10	dB
Free space loss	206.08	206.08	206.08	dB
Atmospheric absorption	0.23	0.23	0.23	dB
Tropospheric scintillation fading	0.31	0.31	0.31	dB
Atmospheric losses total	0.54	0.54	0.54	dB
Total path loss (excluding rain)	206.62	206.62	206.62	dB
Rain attenuation	0.00	0.00	0.28	dB
Noise increase due to precipitation	0.00	0.00	0.43	dB
Downlink degradation (DND)	0.00	0.00	0.71	dB
Total system noise	139.21	139.21	153.86	K
Figure of merit (G/T)	29.64	29.64	29.21	dB/K
C/No (thermal)	85.85	85.35	85.13	dB.Hz
C/N (thermal)	24.95	24.46	24.24	dB
C/ACI	25.00	24.50	25.00	dB
C/ASI	25.00	24.50	25.00	dB
C/XPI	25.00	24.50	25.00	dB
C/IM	16.50	16.00	16.50	dB
Eb/(No+Io)	18.35	17.85	18.28	dB

Totals per Carrier (End-to-End)	Clear	Rain Up	Rain Dn	Units
C/No (thermal)	64.26	63.77	64.26	dB.Hz
C/N (thermal)	3.37	2.87	3.36	dB
C/ACI	21.99	21.49	21.99	dB
C/ASI	21.99	21.49	21.99	dB
C/XPI	21.99	21.49	21.99	dB
C/IM	16.50	16.00	16.50	dB
C/(No+Io)	63.89	63.39	63.89	dB.Hz
C/(N+I)	3.00	2.50	2.99	dB
Eb/(No+Io)	6.80	6.30	6.79	dB
System margin	3.00	3.00	3.00	dB
Net Eb/(No+Io)	3.80	3.30	3.79	dB
Required Eb/(No+Io)	3.30	3.30	3.30	dB
Excess margin	0.50	0.00	0.49	dB

Earth Station Power Requirements	Value	Units
EIRP per carrier	40.05	dBW
Antenna gain	30.56	dBi
Antenna feed flange power per carrier	9.49	dBW
Uplink power control	0.00	dB
HPA output back off	0.00	dB
Waveguide loss	0.5	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	9.9906	dBW
Required HPA power capability	9.9784	W
Spectral power density	-51.40	dBW/Hz

Space Segment Utilization	Value	Units
Overall link availability	95.062	%
Information rate (inc overhead)	0.5120	Mbps
Transmit rate	1.0240	Mbps
Symbol rate	1.0240	Mbaud
Occupied bandwidth	1.2288	MHz
Noise bandwidth	60.89	dB.Hz
Minimum allocated bandwidth required	1.4336	MHz
Allocated transponder bandwidth	1.4400	MHz
Percentage transponder bandwidth used	4.00	%
Used transponder power	34.23	dBW
Percentage transponder power used	10.54	%
Max carriers by transponder bandwidth	25.00	
Max carriers by transponder power	9.49	
Max transponder carriers limited by:-	Power	[9.49]
Power equivalent bandwidth usage	3.79	MHz

11 APPENDIX - DATA LOGGING

This section provides a review of FCC requirements for data logging within a sub-meter satcom-on-the-move system.

Requirements

FCC requirements for the satcom on the move system are stated in the single earth station license grant[9],[10] and numbered here for convenience. FCC precedence for these data logging requirements has been established[11] for earth stations on vessels. Related FCC documents[12],[13],[14],[15] have been reviewed for rules, implications, or precedent related to data logging.

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[9] DA09-587, "Application for Authority to Operate a Mobile Earth Station to Provide Land Mobile Satellite Service in the Ku-Band", FCC Document, March 16, 2009.

[10] [1] DA09-587, "Application for Authority to Operate a Mobile Earth Station to Provide Land Mobile Satellite Service in the Ku-Band", FCC Document, March 16, 2009.

[11] 47CFR25.221, "Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving in the 3700–4200 MHz (space-to-Earth) frequency band and transmitting in the 5925–6425 MHz (Earth-to-Space) frequency band, operating with Geostationary Satellites in the Fixed-Satellite Service", 70 FR 4784, Jan. 31, 2005, as amended at 70 FR 33377, June 8, 2005.

[12] 47CFR25.222, "Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving 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) frequency bands and transmitting in the 14.0–14.5 GHz (Earth-to-space) frequency band, operating with Geostationary", 0 FR 4786, Jan. 31, 2005, as amended at 70 FR 33377, June 8, 2005.

[13] "2000 Biennial Regulatory Review Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations", IB Docket No. 00-248, IB Docket No. 95-117

[14] "Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum and Adopt Service Rules and Procedures to Govern the Use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service", IB Docket No. 07-101, *Notice of Proposed Rule Making*, 22 FCC Rcd 9649 (2007) (*VMES Notice*), May 9, 2007.

[15] RM-11336, "Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum in the Ku- and Extended Ku-Bands to the Vehicle Mounted Earth Station Satellite Service ("VMES") on a Shared Primary Basis and to Adopt Licensing and Service Rules for VMES Operations in the Ku- and Extended Ku-Bands", General Dynamics petition, May 24, 2006.

FCC-D001: The earth station operator shall maintain records of the location of its mobile earth station in longitude and latitude; transmit frequency, channel bandwidth, and satellite used for a period of not less than one year.

FCC-D002: Records shall be recorded at time intervals no greater than every 5 minutes while the mobile earth station is transmitting.

FCC-D003: The earth station operator shall make this data available upon request to a coordinator, fixed system operator, fixed-satellite system operator, NTIA, or the Commission within 24 hours of the request.

FCC-D004: The earth station operator shall maintain logs of all alleged incidences of interference, the stations involved, and the outcome of the incident.

The L3 system will comply with the FCC requirements for data logging. Data logs will be recorded locally at the earth station on a PC which is interlocked with the modem. If the PC is removed or fails, transmission will shutdown. Data will be retrieved if it is requested by an appropriate party.

12 APPENDIX - CONTENTION CHANNEL

This section provides an analysis of the contention channel performance within a sub-meter satcom-on-the-move system. FCC rules and proposed rules have been reviewed in order to determine requirements for usage of contention channels.

12.1 FCC Rulings

Following are extracts of FCC rules and proposed rule changes related to the use of contention channels. Key phrases are highlighted.

12.1.1 Current Commission Proposals

FCC 08-246 EIGHTH REPORT AND ORDER [1]
IV. OTHER ISSUES
A. Contention Protocols

81. Accordingly, **we adopt an exception to Section 25.134 that allows VSAT system operators to exceed the -14 dBW/4 kHz power limit, in the aggregate when multiple earth stations simultaneously transmit, for purposes of "reasonable use" of a contention protocol.** In this Order, we do not define "reasonable use" in terms of specific limits for probability of collision, length of collision, or increase in power during collisions, as the Commission has proposed in the past. Instead, we allow licensees flexibility in their contention protocol usage. We anticipate that we will resolve any issues regarding "reasonableness" of contention protocol usage in the complaint process. If a Commission licensee believes that its operations are experiencing harmful interference as the result of another licensee's unreasonable contention protocol usage, that licensee will have the burden of showing that it is experiencing harmful interference, and that the other licensee is the cause of that interference. If the complainant can meet this burden of proof, the burden will then shift to the defendant to show that its use of contention protocols is reasonable. By requiring reasonable contention protocol use rather than specifying limits for length of collision and increase in power allowed during a collision, we expect that our contention protocol rule will not interfere with technological developments in the area of contention protocols. We also expect that requiring contention protocol usage to be reasonable will provide sufficient regulatory certainty to address the concern raised by ViaSat.244

FCC 08-246 EIGHTH REPORT AND ORDER [1]
APPENDIX B
Rule Changes

2. In Section 25.115, add paragraphs (h) and (i) to read as follows:
25.115 Application for earth station authorizations.
* * * * *

(h) Any earth station applicant filing an application pursuant to 25.218 of this chapter must file three tables showing the off-axis EIRP level of the proposed earth station antenna of the plane of the geostationary orbit, the elevation plane, and towards the horizon. In each table, the EIRP level must be provided 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.

(1) For purposes of the off-axis EIRP table in the plane of the geostationary orbit, the offaxis angle is the angle in degrees from the line connecting the focal point of the antenna to the target satellite, within the plane determined by the focal point of the antenna and the line tangent to the arc of the geostationary satellite orbit at the position of the target satellite.
(2) For purposes of the off-axis EIRP 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 target satellite, within the plane perpendicular to the plane determined by the focal point of the antenna and the line tangent to the arc of the geostationary satellite orbit at the position of the target satellite.
(3) For purposes of the off-axis EIRP table towards the horizon, the off-axis angle is the angle in degrees from the line determined by the intersection of the horizontal plane and the elevation plane described in paragraph (h)(2) of this Section, in the horizontal plane.

The horizontal plane is the plane determined by the focal point of the antenna and the horizon.
(4) In addition, in an attachment to its application, the earth station applicant must certify that it will limit its pointing error to 0.5° or demonstrate that it will comply with the applicable off-axis EIRP envelopes in Section 25.218 of this Part when the antenna is mispointed at its maximum pointing error.

(i) Any earth station applicant filing an application for a VSAT network made up of FSS earth stations and planning to use a **contention protocol** must include in its application a certification that it will comply with the requirements of **25.134(g)(4).**

FCC 08-246 EIGHTH REPORT AND ORDER [1]
APPENDIX B
Rule Changes

3. In Section 25.134, add paragraph (g)(4) to read as follows:
25.134 Licensing provisions of Very Small Aperture Terminal (VSAT) and C-band Small Aperture Terminal (CSAT) networks.
* * * * *
(g) * * *

(4) Any earth station applicant filing an application to operate a VSAT network after **[Insert effective date of rule]** in the Ku-band and planning to use a contention protocol must certify that its contention protocol usage will be reasonable.

12.1.2 Past Commission Proposals

The following were proposed (para 68, 71) but not adopted. They are provided here to provide some quantitative comparison with the L3 contention channel.

FCC 08-246 EIGHTH REPORT AND ORDER [1]
IV. OTHER ISSUES
A. Contention Protocols

68. In the *Third Further Notice*, the Commission observed that all the new contention protocol rule proposals suggested by commenters in response to the *Further Notice* had four elements:
(i) a power density limit on individual earth stations in the VSAT network;
(ii) a limit on the power generated during collisions,
(iii) a limit on the probability of collisions, and
(iv) a limit on the duration of any collision.
The Commission also found that the record at that time provided an adequate basis to adopt some of these contention protocol elements, but needed further development on other elements.

12.2 L3/Linkabit NCW Contention Channel Approach

12.2.1 Network Architecture

The Network Centric Waveform (NCW) system consists of a hub terminal or Network Controller (NC) and remote terminals or Network Members (NM). Up to 254 NMs are possible in one network. Any NM with sufficient RF performance may be configured as NC capable. NC capable terminals can take over NC duties if the active NC fails. Any terminal may communicate with any other terminal as long as they have sufficient RF performance.

FCC 08-246 EIGHTH REPORT AND ORDER [1]
IV. OTHER ISSUES
A. Contention Protocols

71. In summary, the Commission requested comment on the following proposal:

(i) For VSAT networks using a contention protocol, the aggregate off-axis EIRP shall not exceed the applicable off-axis EIRP envelope by more than the amounts set forth in Table 5 below;
(ii) The maximum duration of any single collision is **less than 100 milliseconds.**

Table 4 is the off-axis EIRP envelope adopted in this Order for digital transmissions from a single earth station in the Ku-band in the plane of the geostationary satellite orbit as it appears at the particular earth station location:

Table 4
Off-Axis EIRP Envelope for Ku-Band Digital Earth Station Applications for an Individual Earth Station

$15 - 25\log_{10}\theta$	dBW/4 kHz	For	$1.5° \leq \theta \leq 7°$
-6	dBW/4 kHz	For	$7° < \theta \leq 9.2°$
$18 - 25\log_{10}\theta$	dBW/4 kHz	For	$9.2° < \theta \leq 48°$
- 24	dBW/4 kHz	For	$48° < \theta \leq 85°$
- 14	dBW/4 kHz	For	$85° < \theta \leq 180°$

where θ is the angle in degrees from the line connecting the focal point of the antenna to the target satellite, within the plane determined by the focal point of the antenna and the line tangent to the arc of the geostationary satellite orbit at the position of the target satellite.

Table 5 below allows VSAT network operators to exceed the aggregate off-axis EIRP envelope by 2 dB for each decrease in order of magnitude in percentage of time. This was based on proposals from SIA and Spacenet. However, SIA and Spacenet recommended allowing VSAT network operators to exceed the off-axis EIRP envelope for as much as 10 percent of the time. Therefore, the Commission modified the proposal to allow VSAT network operators to exceed the envelope for no more than 1 percent of the time, as set forth in Table 5 below.

Table 5
EIRP Limits For VSAT Networks Using Contention Protocols Proposed By the Commission in the *Third Further Notice*[213]

Percentage of Time	Increase in Aggregate EIRP Allowed
10% (10^{-1})	0 dB
1% (10^{-2})	2 dB
0.1% (10^{-3})	4 dB
0.01% (10^{-4})	6 dB
0.001% (10^{-5})	8 dB
0.0001% (10^{-6})	10 dB
0.00001% (10^{-7})	12 dB
0.000001% (10^{-8})	14 dB
0.0000001% (10^{-9})	16 dB

12.2.2 Resource Management

The Network Centric Waveform (NCW) system is a Multi-Frequency Time Division Multiple Access (MF-TDMA) system. Carriers are BPSK, QPSK, or n-PSK modulation. The TDMA frame is 400 mS. In some cases Direct Sequence (DS) spread spectrum is applied as an energy dispersal method to reduce power spectral density.

The NCW system manages its assigned spectrum by partitioning and distributing frequency, time, and power resources. All resources are controlled by the Network Controller (NC). No resources may be used by remote stations called Network Members (NM) unless the active NC has assigned the resources for use.

12.2.3 Communications Channels

The NCW system uses the following channel types:

- **FOW** – Forward Order Wire – The FOW is the heartbeat of the system and is broadcast by the NC at regular intervals. The FOW contains information needed by the NMs for their effective operation. No NM may transmit until it has received the FOW. The FOW provides information on all resource assignments.

- **CROW** – Contention Reverse Order Wire – A slotted Aloha scheme with collision detection is used. Resources are assigned by the NC for unregistered NMs to signal to the NC for registration purposes. In each TDMA frame, up to 7 (15 future) time slots are assigned for unregistered NMs to signal to the NC with their registration information. CROW slots are available for signaling from any unregistered NM. Since there may be more than one unregistered NM attempting to register, collision is possible. Depending on the burst data rate configured a CROW burst is from 1.3 mS (1024 kbps) to 42 mS (32 kbps) of the 400 mS frame.

- **AROW** – Assigned Reverse Order Wire – When a NM has achieved registration via the CROW channel; it is assigned reverse orderwire AROW timeslots by the NC. During these AROW timeslots, the NM may maintain its registration and make resource requests.

- **DCOM** – Data Communications – DCOM timeslots are used for user data transmissions. All DCOM assignments are made by the NC.

12.2.4 CROW Communications Scenario

Following is a typical NM registration and resource request. The NM will continue to make registration requests via the CROW channel until registration is confirmed by the NM through the FOW channel.

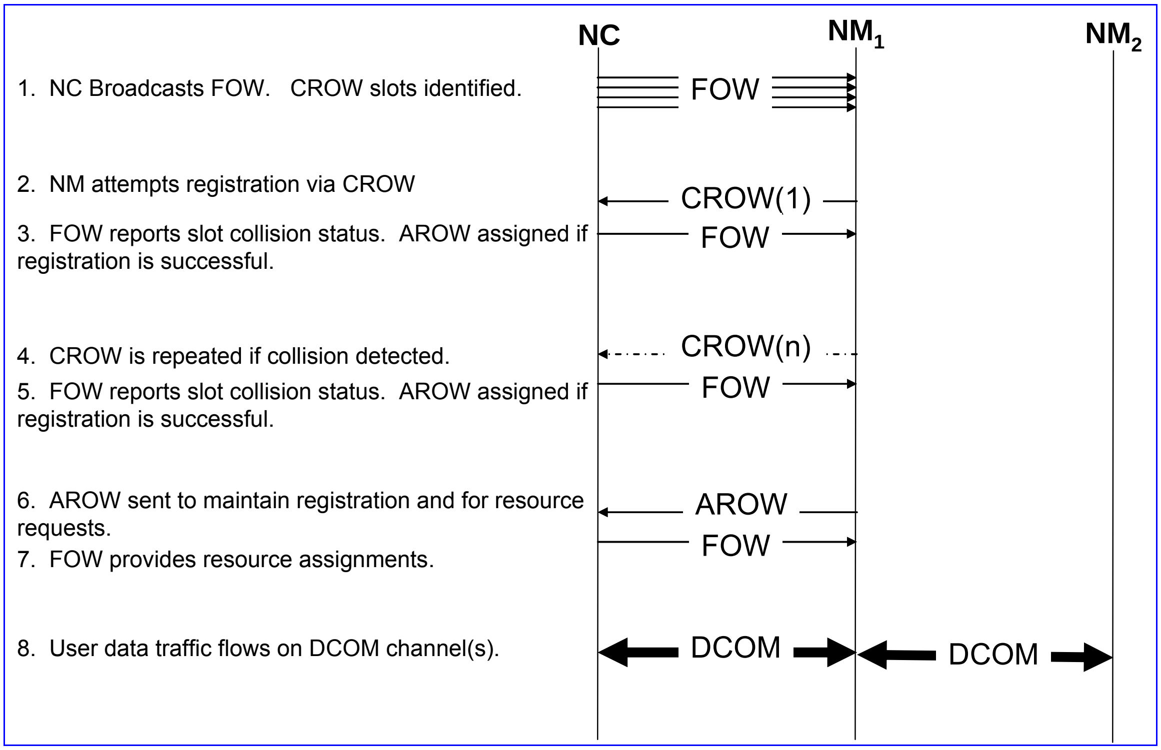

Figure 8.2.4-1 NM Registration and Resource Request

12.2.5 Spectrum Management

All spectrum use is controlled by the NC and all usage is on an assigned basis with the exception of the CROW channels. In each 400 mS TDMA frame, bandwidth and power resources are segmented and assigned to the pool of NMs.

Spread spectrum is used as an energy dispersal method and is **never** used by multiple transmitters as a CDMA access scheme. With the exception of the CROW channels, bandwidth segments are never accessed by more than one transmitter at any one time period.

12.2.6 Collision Detection and Management

The NCW system has several methods for managing the CROW channel.

CROW Slots: The NC can assign from 1 to 7 (15 future) CROW time slots in each 400 mS frame. If registration activities are high, then more CROW time slots should be used to reduce collisions. The number of slots per frame is a configurable parameter set by the system operator based on the number of NMs in the network and the anticipated registration activity. An NM attempting registration will randomly select one of the 7 CROW slots available

Contention Backoff: The NC detects energy in CROW slots. If CROW transmissions are successful, then registration requests will be received for each slot containing energy. If there are collisions in the slot, then the NC may not be able to recover a registration request and thus has detected a collision. When collisions are detected, the NC may request unregistered NMs to randomly defer registration to later frames. The NC sets the contention back off from 1 to 31 frames as necessary to reduce collisions. If the Contention Backoff is set to 31 and there are 7 CROW slots, then each NM must randomly select from 31 frames x 7 slots, or 217 possible slots to attempt registration.

CROW Spreading Factor: CROW transmissions can utilize a direct sequence spreading factor from 1 to 16 to allow EIRP spectral density limits to be met. Power Spectral Density (PSD) reduction is typically necessary in sub-meter terminals to reduce adjacent satellite interference PSD and in the hub terminal to reduce downlink PSD.

CROW Registration Scenarios:
When the CROW channel has collisions, the EIRP PSD in the CROW slot will be increased by the number of transmissions that occur in the slot. Analysis has been done to determine the probability of collisions and the probability distribution as a function of the number of simultaneous transmissions in a CROW slot. Several registration scenarios are considered:

1. **Network Installation and Start-up** – When a network is first being constructed, hub and remote stations will be installed and turned on as each station becomes available. A network with 20 or more terminals could take days, weeks or even months to install and bring up all stations. Due to the extended installation time, the progress and schedules of each site, its is improbable that a large number of stations will attempt to register using the same CROW slot in the same 400 mS frame. If a situation arose that required all stations to be turned on simultaneously, the random timing of human intervention across several minutes would very likely distribute registration requests enough to avoid or reduce collisions. If all NMs were ready for registration before an NC was established, it might be possible to have all NMs attempt registration within a few frames and thus have collisions. This situation could be mitigated by ensuring that the NC is operational before manually enabling terminals for registration. An NC that starts operation establishes 7 (15 future) CROW slots per frame and sets the contention backoff to the maximum. It is also recommended that installers plan to stagger terminal start up to avoid a large number of terminals attempting registration simultaneous.

2. **Hub (NC) Failure**

    a. **Back-up Hub Available** - if a NC fails and a back up NC is online and available, the backup NC takes over without the need for any terminal re-registration. All back-up NCs maintain registration data.

b. **Back-up Hub Not Available** – Any NCW Modem that has both NC and NM capabilities with sufficient RF performance can be a backup NC, it is unlikely and not recommended that a network be establish without a back-up NC. It is possible in a small network that a back-up NC cannot or has not been established. In this case the number of NMs is also small and thus the number of registration collisions that could occur is also small. Equipment MTBF of the NCW modem is better than 20,000 hours or about 2 years. Thus failure events could occur every 2 years. If the system requires manual intervention for recovery, start up of the remote terminals may be staged to avoid all terminals attempting to register in a short time period. If the station recovers without manual intervention, then all terminals in the network may attempt to register in a short time period. An NC that starts operation establishes 7 (15 future) CROW slots per frame and sets the contention backoff to the maximum. This case is extremely unlikely, but analysis of this scenario is provided below to show the CROW channel performance. This is believed to be a worst case scenario, but is also a low probability of occurrence.

3. **Steady State Operation** – Under steady state operation, most NMs will be registered with the NC and thus the CROW channel will only have traffic for recovery or registration of new NMs.

   a. **Remote Station (NM) Outage and Recovery** – If a single NM fails, resets, and/or recovers, it will re-register via the CROW channel. Since this is a single station registration, collision is unlikely.

   b. **New Remote Station (NM) Added** - If a new single NM registers, it will register via the CROW channel. Since this is a single station registration, collision is unlikely.

12.2.7 Worst Case (Scenario)

The worst case registration scenario occurs when all NMs attempt registration in a short time period. The probability of this occurring is extremely unlikely but is analyzed here to show that the collision time period and effect is limited.

A simulation of the access algorithm was performed and the results are shown in figures 8.7-2A and 2B. The plots show the probability of occurrence of 1 to 8 accesses per slot. There is less than 1% probability of exceeding 4 transmissions in one slot for n=50, 5 for n=100, 6 for n=150, and 7 for n=254.

CROW slots = 7
Contention Backoff = 31
Number of remote terminals (NMs) = n = {50, 100, 150, 254}

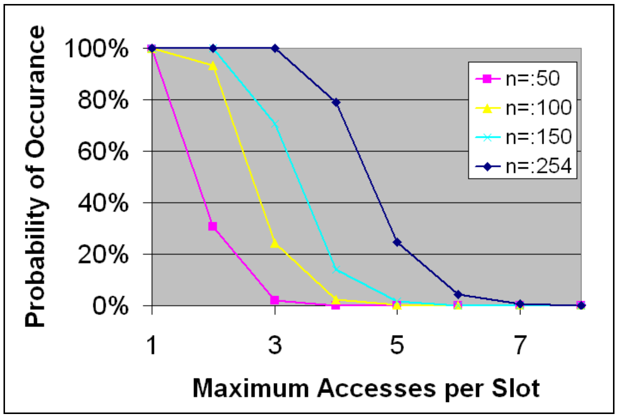

Figure 8.7- 2A
CROW Channel Probability

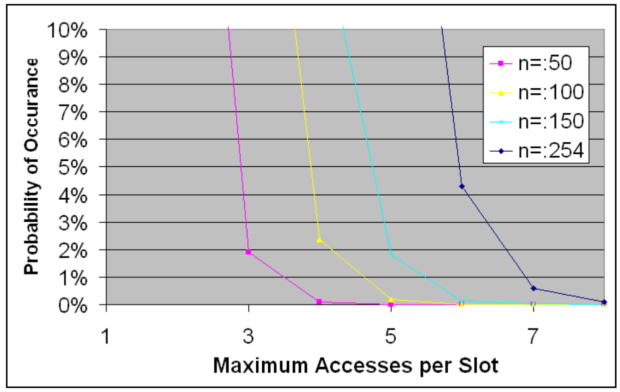

Figure 8.7– 2B
CROW Channel Probability

If a 1024 kbps BSPK CROW transmission is used, then the bandwidth will be 1331 kHz (3.7% of a transponder) and the burst duration will be 1.3 mS. If a 32 kbps BSPK CROW transmission is used, then the bandwidth will be 42 kHz (0.1 % of a transponder and the burst duration will be 42 mS (less than the 100 mS identified in [1 para 71])

Additional simulations were done to determine the time for all terminals to complete registration if all attempted to do so at once. Figure–8.2.7-3 shows that for n=254 terminals, the registration time period takes from 65 to 85 seconds.

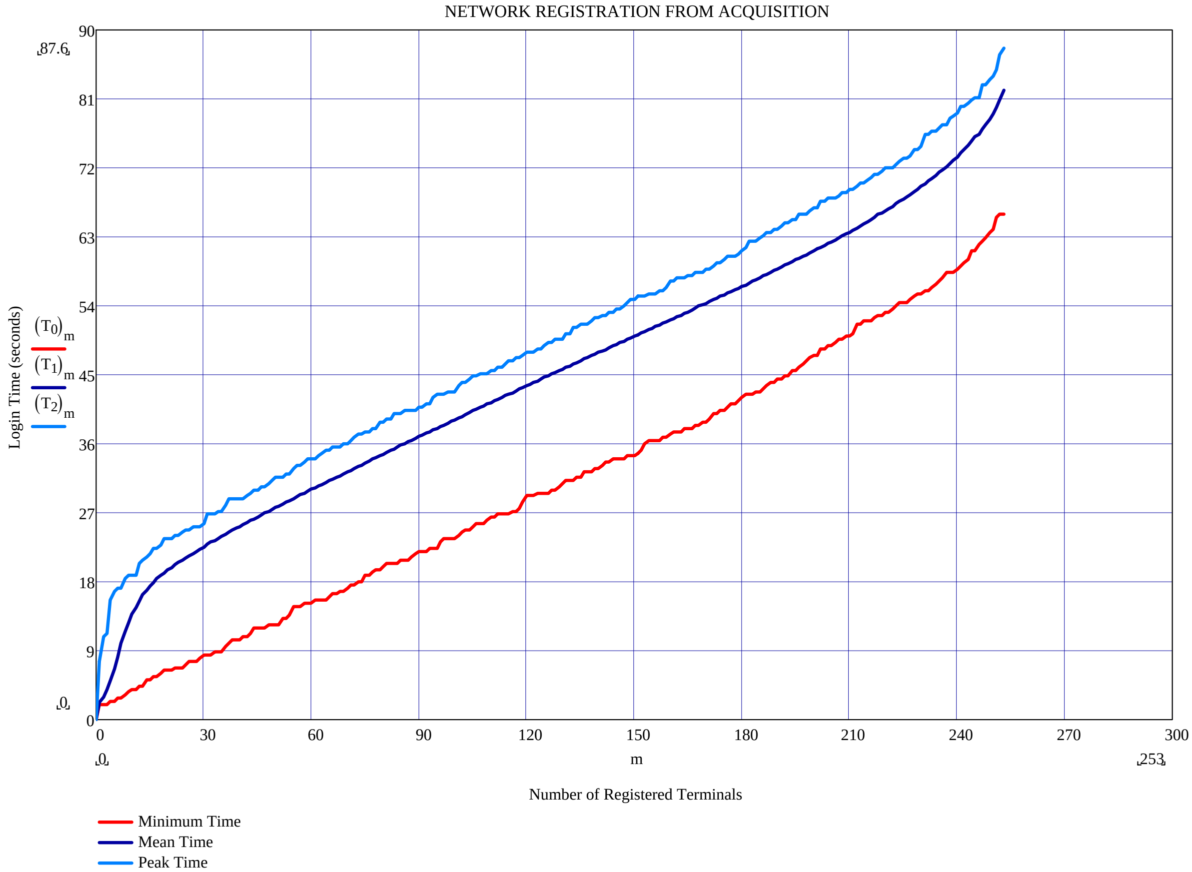

Figure 8.2.7– 3 Registration Time Duration (Maximum, Average, Minimum)

The FCC chose not to adopt Table-5 [1] [16] and instead allowed the applicant "reasonable use" of contention channels. Table-5 [1] [17] is convenient for providing a quantitative limit for comparison. Figure 8.2.7-4 shows the increase in aggregate EIRP for the NCW system resulting from the worst case scenario of all terminals attempting registration at the same time.

CROW slots = {7, 15}
Contention Backoff = 31
Number of remote terminals (NMs) = n = 254
Time Period = 1 hour

[16] FCC 08-246 EIGHTH REPORT AND ORDER [1]

[17] FCC 08-246 EIGHTH REPORT AND ORDER [1]

As noted previously, this worst case scenario is unlikely to occur and possibly no more than every few years. The chart below shows that the NCW contention channel can comply with Table-5 [1] even if all terminals had to simultaneously register using contention channels every hour (rather than every 2 years).

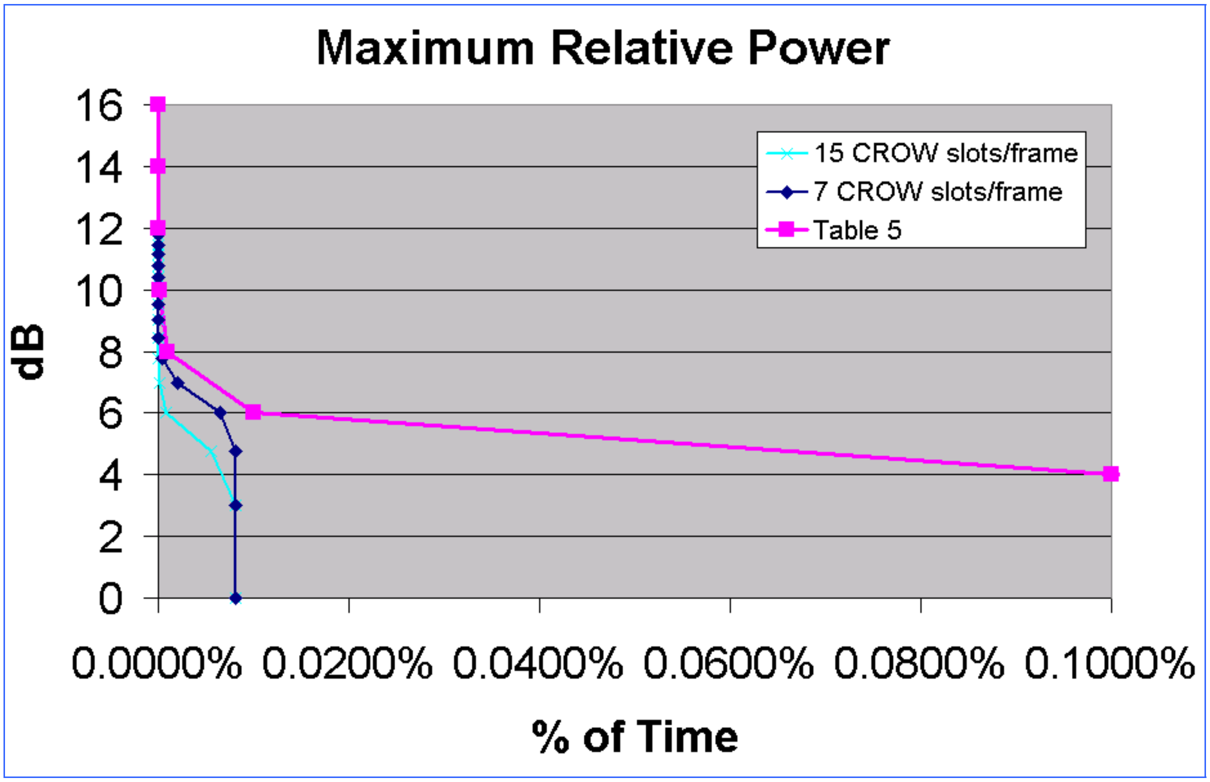

Figure 8.2.7–4 Increase in Aggregate EIRP for the NCW Contention Channel

12.3 Summary

Registration scenarios have been evaluated. The worst case scenario might occur every 2 years if no NC backup has been configured. If the NC recovered without manual intervention, then a network could be subject to re-registration of all terminals. If this event were to occur, the event would be for 85 seconds or less, it would use less than 4% of a transponders bandwidth and 99% of the time would be 7 or less simultaneous transmissions in the CROW slots. Total transponder power utilized by the simultaneous CROW transmissions would be less than 7 * 4% = 28%. Allocated power on the satellite might be increased by 24% which could cause degradation to other carriers. Without additional spreading, multiple CROW transmissions from the remote terminals could increase adjacent satellite interference above the FCC recommendations for non-contention channels.

To recap, an interference event impacting spectrum of 1331 kHz or less, lasting 85 seconds or less could occur every two years if no back-up NC were available and no human interaction was possible resulting from a fault recovery. This is a worst case scenario.

During a steady state operation registrations occur seldom but collisions could occur. These collisions would be occasional bursts of duration 1.3 to 42 mS (less than the 100 mS recommended[18] [para 71].

The NCW contention channel use complies with Table-5[19] and thus should be considered "reasonable use" per the FCC guidelines.

[18] FCC 08-246, "Eighth Report and Order on Reconsideration, 2000 Biennial Regulatory Review Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations", IB Docket No. 00-248, IB Docket No. 95-117, FCC Document, October 17, 2008

[19] **FCC 08-246 EIGHTH REPORT AND ORDER [1]**

13 APPENDIX - SKEW ANGLE MANAGEMENT

This section provides an analysis of the Skew Angle and methods of adjusting the EIRP PSD within a sub-meter satcom-on-the-move system.

FCC Rulings

The FCC does not appear to have addressed skew angle directly. It is reasonable to assume the EIRP PSD limits[20] must be met at any skew angle.

Analysis

Skew Angle Definition

Elliptical antennas used for SOTM applications are generally mounted to a vehicle with the wide dimension (azimuth plane) parallel to the vehicle roof top. The (off-axis) gain pattern of an elliptical antenna is not rotationally symmetric and is a function of its relative rotation or skew angle with the geostationary arc. Circular antennas are rotationally symmetric and as such their (off-axis) gain patterns are essentially the same at any rotation to the geostationary arc.

Skew angle is defined as the angle between the antenna azimuth plane and the plane of the geostationary arc (see Figure-1). The wanted satellite is centered on the antenna reflector.

Factors which affect the skew angle are:

- the Latitude, Longitude, and Elevation of the SOTM antenna,
- wanted satellite selection
- tilt and orientation of the SOTM vehicle relative to level ground

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[20] 47CFR25.222, “Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving 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) frequency bands and transmitting in the 14.0–14.5 GHz (Earth-to-space) frequency band, operating with Geostationary”, 0 FR 4786, Jan. 31, 2005, as amended at 70 FR 33377, June 8, 2005.

* Skew Angle is the same as the term Relative Rotation which has been used in previous documentation.

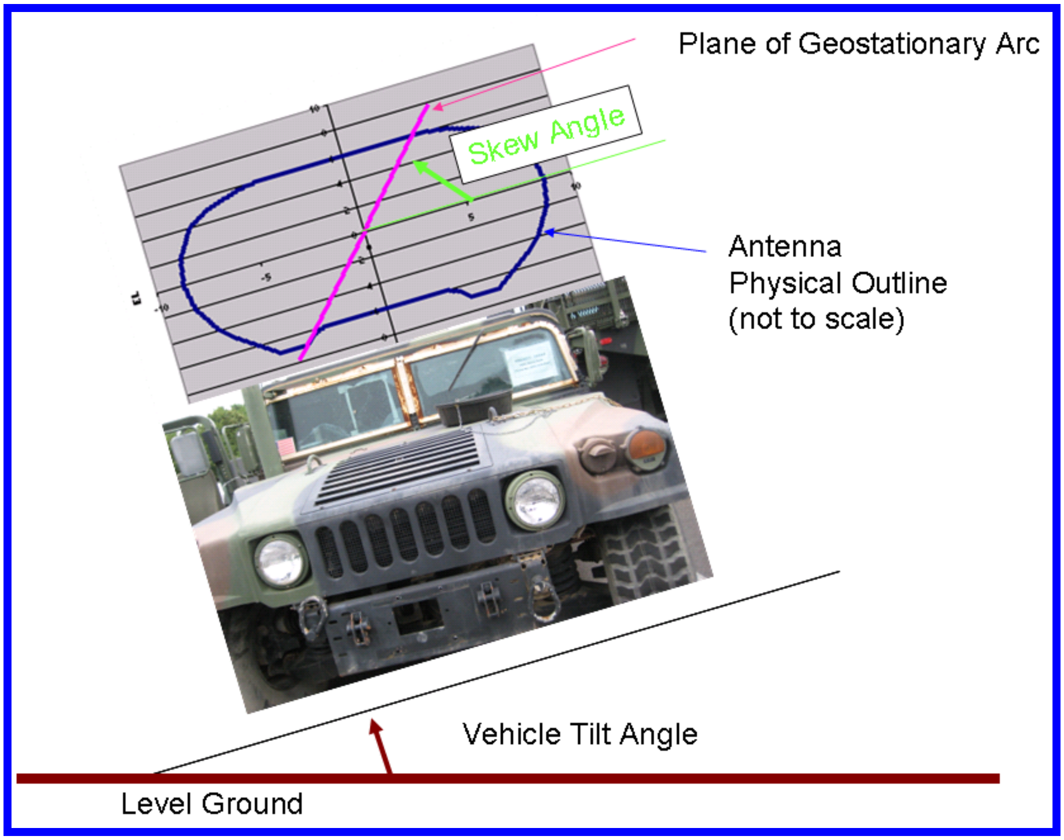


Figure -1 Skew Angle

Change in Skew Angle vs. Location

The skew angle within CONUS is evaluated here. For simplification, skew angle is evaluated for three satellites (east, west, and center of CONUS) and at four location extremities within CONUS. For this scenario, skew varies from -59 to + 38 degrees within CONUS (see Figures 3 through 5).

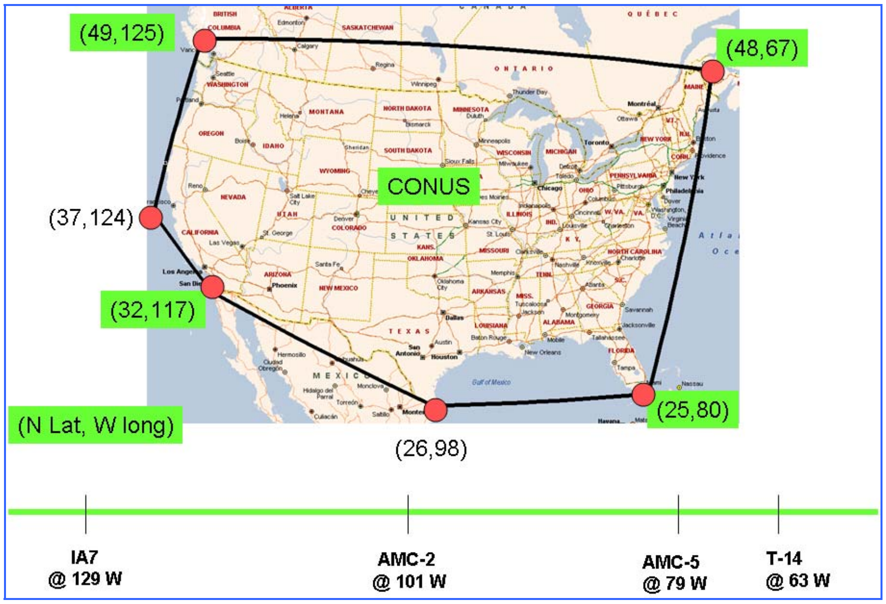


Figure-2 CONUS Simplification Map

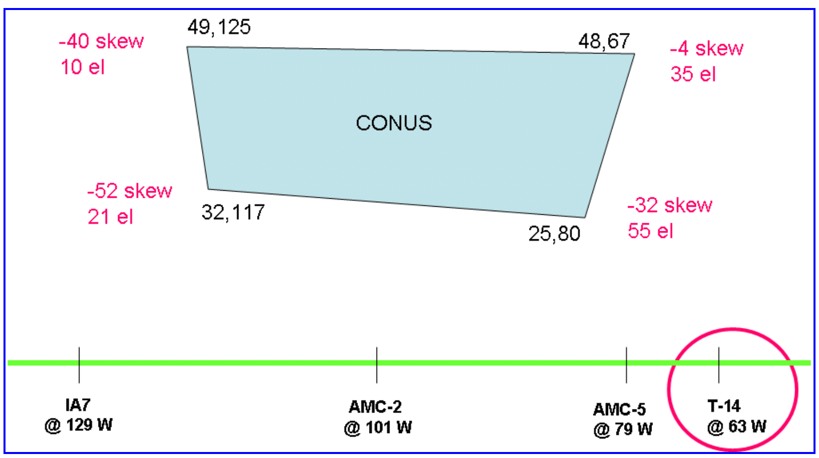


Figure-3 Skew Across CONUS for T-17

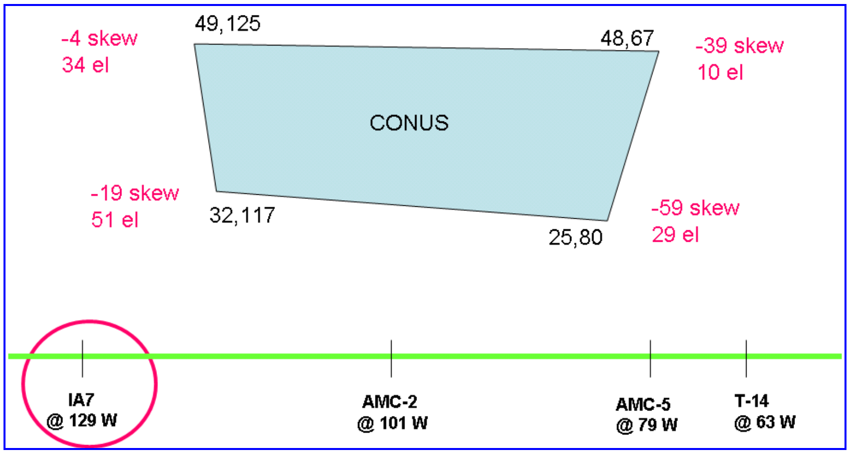


Figure-4 Skew Across CONUS for IA7

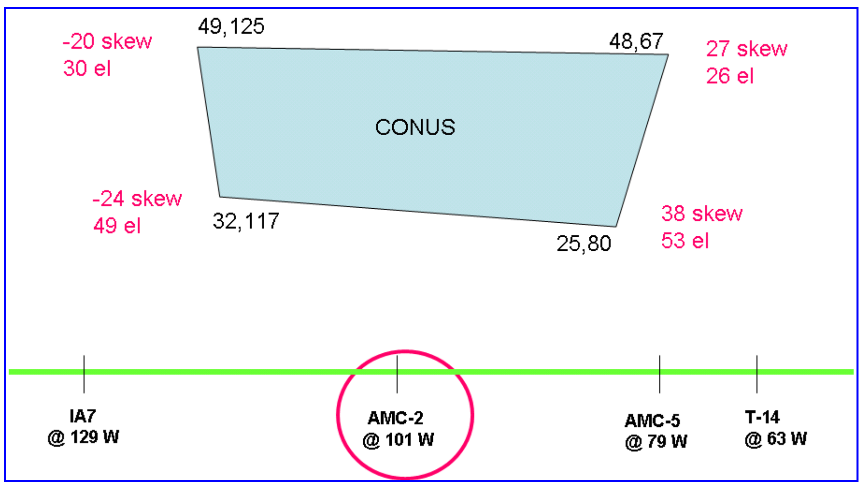


Figure-5 Skew Across CONUS for AMC-2

It is desired to estimate the distance a vehicle can travel before the skew angle changes by 5 degrees. This has been calculated and the results shown in Figure-6 and Figure-7. A vehicle can travel about **100 miles** before the skew angle changes by **+/- 5 degrees**. If automatic PSD compensation for skew angle is set for the worst case in a +/-5 degree area, a vehicle can travel 100 miles before needing to be shut down or PSD compensation adjusted.

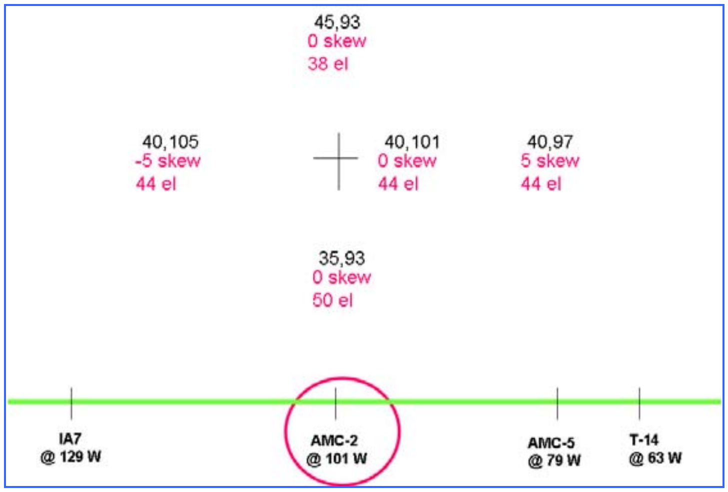


Figure-6 Skew Angle Change for 5 degree Longitude Change

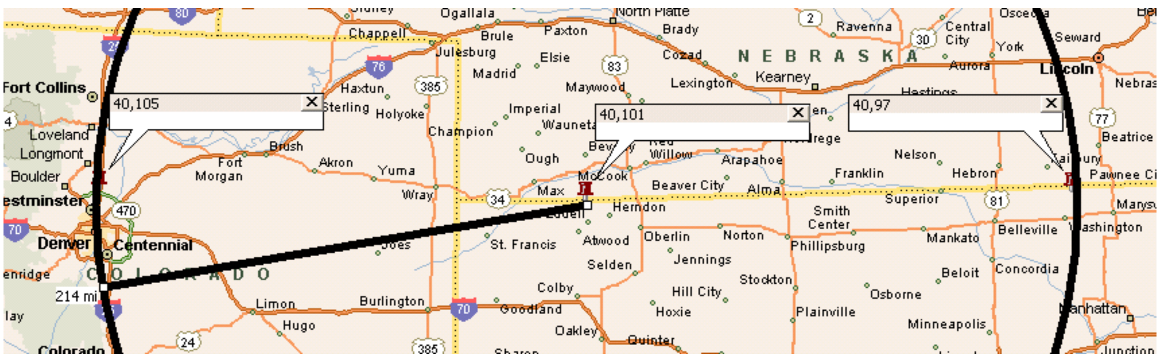


Figure-7 Distance Change for 5 degree Longitude Change

L3/Linkabit NCW Skew Angle Management Approach

Antenna Compensation

Tracking antenna systems such as the L3/Datron FSS4180 utilize GPS and inertial references in order to establish accurate pointing in azimuth, elevation, and polarization. Generally the antenna pointing system has the ability to determine the skew angle, but while it is technically possible, it is not assumed that this information is provided to the modem for EIRP spectral density compensation.

MPM-1000 Manual Compensation

The MPM-1000 requires that the operator provide local coordinates before operation may begin. These coordinates are used for several functions including estimation of skew angle, estimation of effective beamwidth, and ultimately the amount of spectral spreading that is required.

Since tilt angle changes as the vehicle moves across terrain, the tilt angle must be considered when calculating the skew angle. In estimating the skew angle, the MPM-1000 assumes an **8 degree** vehicle tilt to be conservative.

If the EIRP spectral density compensation is configured for the worst case skew angle in a region of operation, then the vehicle should be free to travel within that region without exceeding the EIRP spectral density limits. If the vehicle travels outside these limits, the operator must reconfigure the modem coordinates or shut down the transmitter.

This skew angle compensation method is available in all MPM-1000 modems, but requires operational procedures to ensure compliance.

Example:

- Operator enters local coordinates
- MPM-1000 calculates skew angle (including 8 degree vehicle tile) based on the worst case in 10 degree steps
- MPM-1000 calculates effective beamwidth of antenna at that skew
- MPM-1000 communicates effective beamwidth to Network Controller (NC or Hub)
- The NC provides resource assignments and spectral spreading to NM in all assignments.
- If vehicle travels outside the 10 degree diameter (+/-5 degrees) or +/- 100 miles, then the operator must reconfigure the modem coordinates or shut down the transmitter.

MPM-1000 Automatic Compensation – GPS Updates

If regular updates of GPS coordinates are available to the MPM-1000, then it may update its skew angle calculations regularly and thus the area of uncertainty can be reduced from that possible with manual operation. This helps to minimize the spectral spreading and thus provides more bandwidth efficiency. In estimating the skew angle, the MPM-1000 assumes an 8 degree vehicle tilt to be conservative.

This skew angle compensation method is available in certain models of the MPM-1000 modems.

MPM-1000 Automatic Compensation – Skew Angle from Antenna Controller

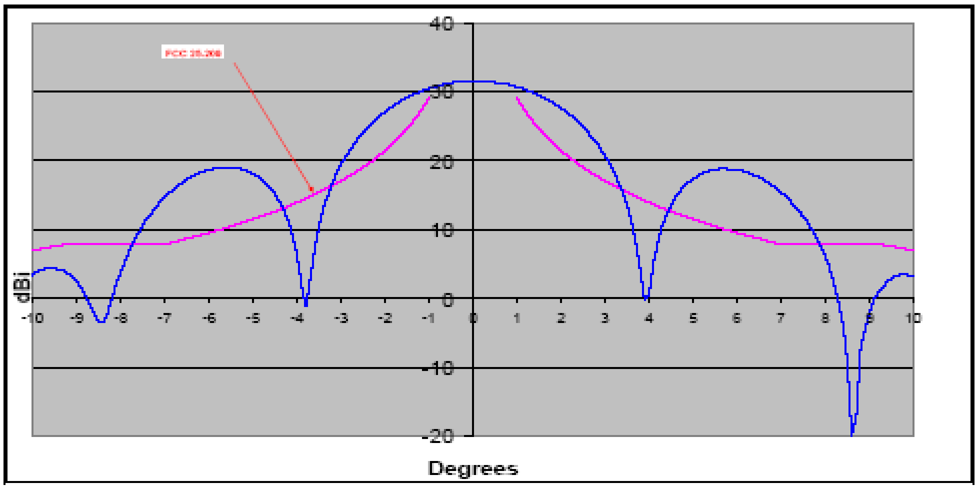
If the antenna controller can report skew angle in real time to the MPM-1000, then spectral spreading can be minimized. Since the antenna controller would be able to include real-time vehicle tilt in the skew angle, the conservative 8 degree vehicle is not required.

Since the vehicle tilt may change rapidly over fractions of a second, it is proposed that the skew angle be calculated as the running average over 2 seconds (TBD) to allow for delays in communicating the skew to the MPM-1000, the MPM-1000 processing time, propagation time of 240 mS each way, and the resource assignment rate of 400 mS.

This skew angle compensation method is under development and will be available in certain models of the MPM-1000 modems. For this compensation method to work, the MPM-1000 must be connected to a compatible antenna system such as the L3/Datron FSS4180.

Skew Angle Calculations

A ku band antenna smaller than 1m will typically have an antenna gain profile (Figure-1) that exceeds the FCC ruling (25.209). FCC will routinely license antennae that do not meet 25.209 if the operator reduces the Power Spectral Density (PSD) into this antenna from **-14 dBW/4 kHz** by the amount that an antenna exceeds 25.209 (described in this document as **excess gain**). The power spectral density may be reduced by dropping the carrier power or by adding or increasing spectral spreading.



Antenna gain patterns have been reviewed to identify the maximum excess gain for azimuth and elevation patterns.

		Excess Gain (dB)	
az pattern	max	6.7	dB
el pattern	max	9.8	dB
	difference	**3.1**	dB

The following formula may be used to estimate the antenna pattern of an elliptical antenna when only azimuth and elevation pattern slices are available. Similarly, this formula may be used to estimate the effect on excess gain vs. skew angle.

Note 1: The LP antenna radiation patterns have a different AZ and EL half power beamwidth (HPBW) due to its asymmetric reflector. As the reflector has an approximately elliptical shape, to a first approximation so also does the resulting antenna main beam. The resulting radiation pattern E(Φ) is given by:

$$E(\Phi) = F_{EL} * \sin(\Phi) + F_{AZ} * \cos(\Phi)$$

where F_{EL} is the elevation pattern and F_{AZ} is the azimuth pattern

This is the parametric equation for a perfect ellipse. The resulting pattern amplitude at any arbitrary pattern cut at angle Φi is given by:

$$| E(\Phi i) | = \sqrt{[F_{EL}^2 * \sin^2(\Phi i) + F_{AZ}^2 * \cos^2(\Phi i)]}$$

The following table shows the resulting excess gain as a function of skew angle in 10 degree steps.

Skew Angle (degrees)	Increase in Excess Gain (dB)	Maximum Power Spectral Density allowed into the Non-Compliant Antenna dBW/4kHz
0	0	-20.7
0	0.0	-20.7
10	0.2	-20.9
20	0.7	-21.4
30	1.3	-22.0
40	1.8	-22.5
50	2.3	-23.0
60	2.6	-23.3
70	2.9	-23.6
80	3.0	-23.7
90	3.1	-23.8
90	3.1	-23.8

References

[1] 47CFR25.222, "Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving 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) frequency bands and transmitting in the 14.0–14.5 GHz (Earth-to-space) frequency band, operating with Geostationary", 0 FR 4786, Jan. 31, 2005, as amended at 70 FR 33377, June 8, 2005.

[2] 47CFR25.221, "Blanket Licensing provisions for Earth Stations on Vessels (ESVs) receiving in the 3700–4200 MHz (space-to-Earth) frequency band and transmitting in the 5925–6425 MHz (Earth-to-Space) frequency band, operating with Geostationary Satellites in the Fixed-Satellite Service", 70 FR 4784, Jan. 31, 2005, as amended at 70 FR 33377, June 8, 2005.

14 APPENDIX - DISABLE PROVISIONS

This section provides a description of the provisions to disable a terminal to avoid interference should it become defective.

Per FCC DA-09-587A1[21]:

g) L-3 Communications's mobile earth station must be able to receive "enable transmission" and "disable transmission" commands from the network control center and must cease transmission immediately after receiving any "parameter change" command until it receives an "enable transmission" command from the network control center. The network control center will monitor operation of the L-3 Communications's mobile earth station to determine if it is malfunctioning, and the L-3 Communications's mobile earth station will self-monitor and automatically cease transmission upon detecting an operational fault that could cause harmful interference to the fixed-satellite service network.

14.1 RF Mute on Pointing Error

- The antenna system RF chain is muted upon power up.
- The Transmitter is only enabled if:
  - There are no faults
  - The upconverter is locked to the modem 10 MHz reference
  - The Inertial Navigation Unit is reporting that it is aligned
  - The antenna is pointed above a defined elevation horizon mask
  - The antenna is pointed at the target satellite
  - The feed is properly polarized
  - The servo interlock is not active
  - The antenna is enabled
  - The transmitter is enabled from the GUI

14.2 Self-Monitor Conditions for Modem Transmission

- The MPM-1000 modem is muted during power up.
- An NM (Network Member) will not transmit until it has received and decoded the Forward Order Wire (FOW) broadcast. For this to be achieved, the terminal must be:

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[21] DA09-587, "Application for Authority to Operate a Mobile Earth Station to Provide Land Mobile Satellite Service in the Ku-Band", FCC Document, March 16, 2009.

    - configured with the correct satellite, frequency, polarization, and security parameters
    - pointed to the correct satellite
    - aligned on the correct polarization
    - receiving on the correct frequency
    - able to establish correct timing
    - able to decrypt the Forward Order Wire (FOW) channel with the correct MSK key
- The NM obtains the frequency and time slots for the Contention Return Order Wire (CROW) channel
- An NM may transmit on the CROW channel subject to the controls placed on the use of the channel by the NC. Channel use is granted through messages in the FOW.
- Using the CROW channel, the NM may register with the NC. A correct Pass Key is required.
- If registration is successful, the NC grants the NM an Assigned Reverse Order Wire (AROW) for maintaining registration and for requesting assignments.
- No transmissions are permitted without assignments. All transmissions from NMs are assigned by the NC through the AROW (if registered) or the CROW (if not registered).

14.3 Mute on Loss of Lock

- If an NM can not receive the FOW from the NC, then it is not permitted to transmit.

14.4 Temporarily Disable Remote NM

- The NC maintains a list of all registered Network Members (NMs).
- An operator at the NC may disconnect a registered NM to prevent it from transmitting
- The NM will not transmit without action from a local operator.
- The local operator may review the terminal condition, make a repair, and if appropriate may configure the terminal to re-connect or re-register if appropriate.

14.5 Permanent Disable Remote NM

- The NC maintains a list of all registered Network Members (NCs).
- An operator at the NC may disable a remote NM by zeroizing its MSK key
- Without an MSK key, the NM can not recover the FOW, will never receive transmission assignments, and is not able to transmit
- A local operator will not be able to re-connect or re-register the NM without seeking a new and different MSK key from the network administrator.

15 APPENDIX - ANTENNA POINTING

The L3/Datron FSS-4180-LP Antenna Assembly controls pointing of the antenna through the use of advanced control systems utilizing Kalman filters, GPS, inertial navigation systems, signal tracking assistance, and various sensors. This antenna pointing technology has been engineered over several years and has been verified in both lab and operational environments.

For the military applications foreseen, vehicles may be subjected to a worst case environment described as the **Churchville B** test course (extreme rugged terrain). The L3/Datron FSS-4180-LP Antenna Assembly meets or exceeds its pointing objectives while subjected to the shock and vibration of this test course. It should be noted that while the system is designed and tested to this environment, vehicles will typically be subjected to a substantially less severe environment (paved or dirt roads) and as such the antenna pointing system will typically maintain pointing to tighter tolerances.

Antenna pointing errors arise from:

- **S = Signal Tracking Assistance Errors** – A signal tracking mechanism will measure signal strength and peak the antenna signal strength using receive signal strength measurements resulting from dynamic motion or dithering. Tracking error is +/-0.1° and this eliminates Antenna Static errors (A) and Navigational errors (N).

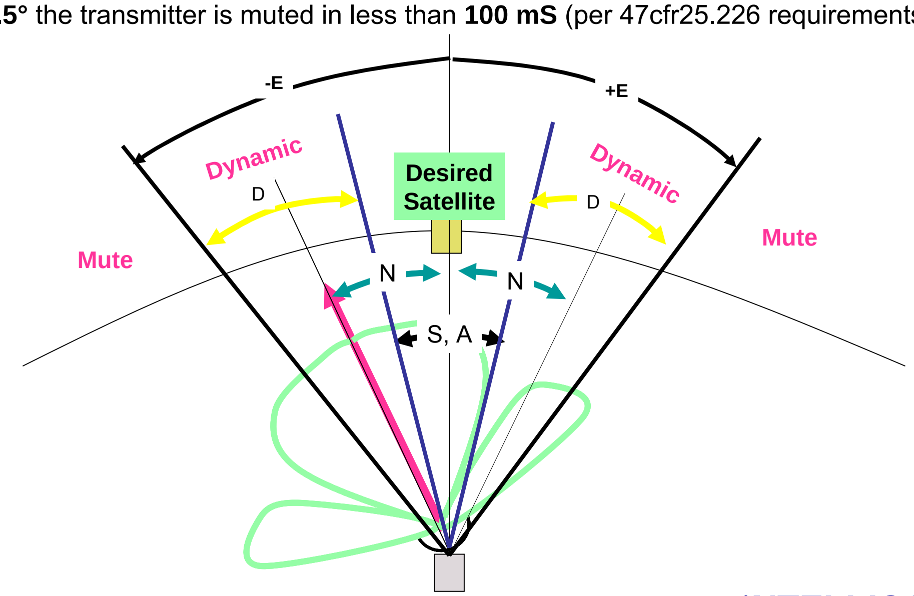
- **A = Antenna** static errors due to mechanical alignment of the feed, reflector, and its relation to the inertial navigation system. Typically this error is +/-0.2°, but this is +/-0.0° through the use of signal tracking assistance.

- **N = Navigational** system dynamic errors due to the motion of the inertial navigation system. Typically this error is +/-0.25°, but this is +/-0.0° through the use of signal tracking assistance.

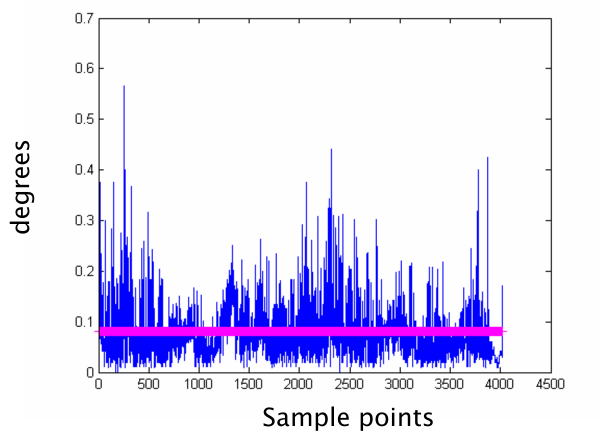
- **D = Dynamic** pointing errors between the desired pointing angle and the antenna pointing while in motion. (+/-0.19°**,** 95%)

Total Error E = expected value of the uncorrelated events (S, A, N, D)
= square root($S^2 + A^2 + N^2 + D^2$)
= square root($(0.1)^2 + 0^2 + 0^2 + (0.19)^2$)
= **+/-0.2°**

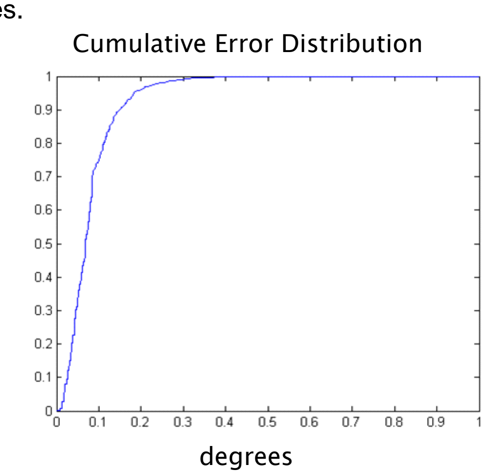
Beyond **+/-0.5°** the transmitter is muted in less than **100 mS** (per 47cfr25.226 requirements).



Following is a chart showing actual measured pointing error for 4000 sample points under simulated Churchville B mobile vehicle conditions.



Following is the resulting Cumulative Distribution Function (CDF). 95% of the time the dynamic pointing error is less than +/-0.19°degrees.

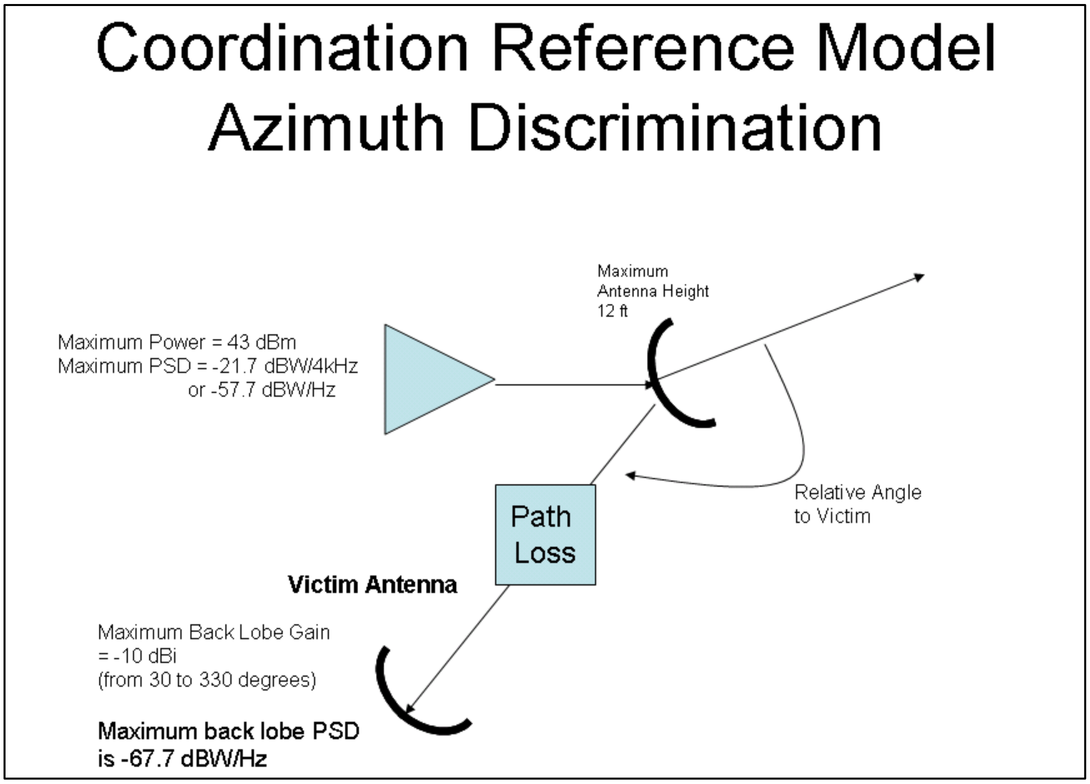


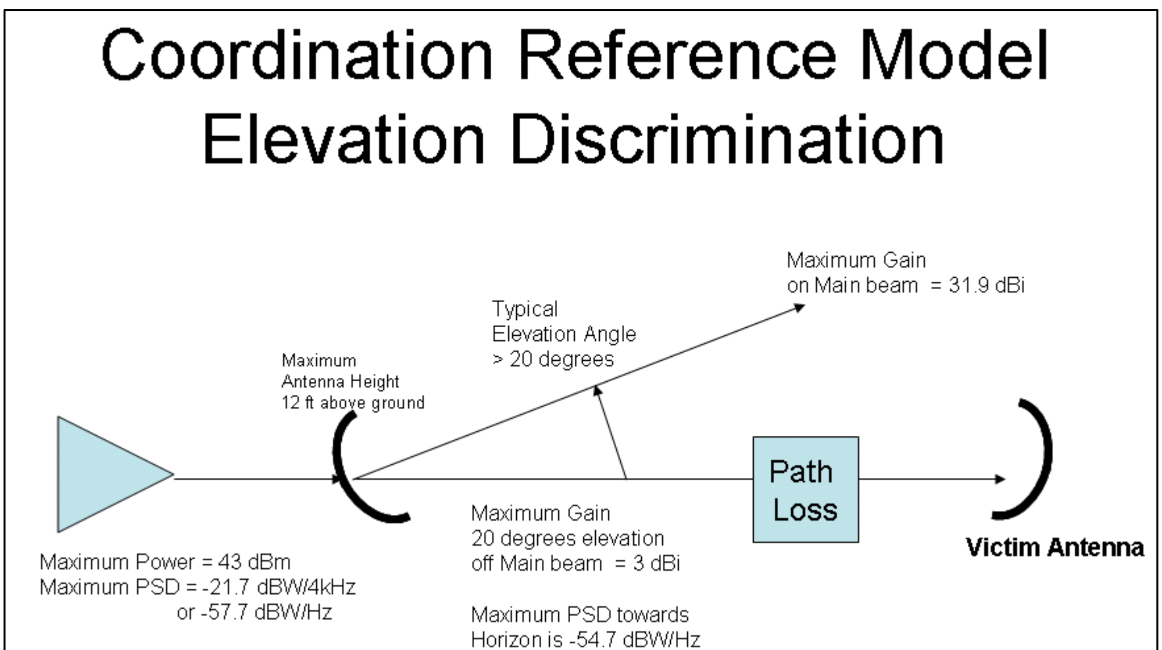
Through the use of advanced control systems utilizing Kalman filters, GPS, inertial navigation systems, and various sensors, the total antenna pointing errors are maintained to the following absolute error +/-E:

Antenna/Vehicle are NOT in motion	**E<0.1°,** 100% of the time Transmitter is **Enabled**
Antenna/Vehicle are in motion (paved or dirt roads)	**E<0.2°** Transmitter is **Enabled**
Extreme Terrain **Churchville B mobile vehicle conditions**	**E<0.2°,** 95% of the time Transmitter is **Enabled**
Antenna/Vehicle are in motion	**E>0.5°** Transmitter is **MUTED**

Note: Churchville B mobile vehicle conditions are the anticipated most extreme operational conditions. Typically the operational environment will be less severe.

16 APPENDIX – COORDINATION REFERENCE MODELS





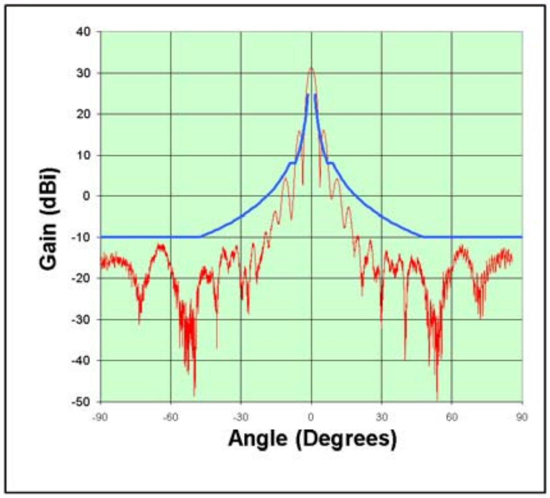
17 APPENDIX - ANTENNA AZIMUTH PLOTS

L3/Datron FSS-4180-LP
AZIMUTH PLOTS

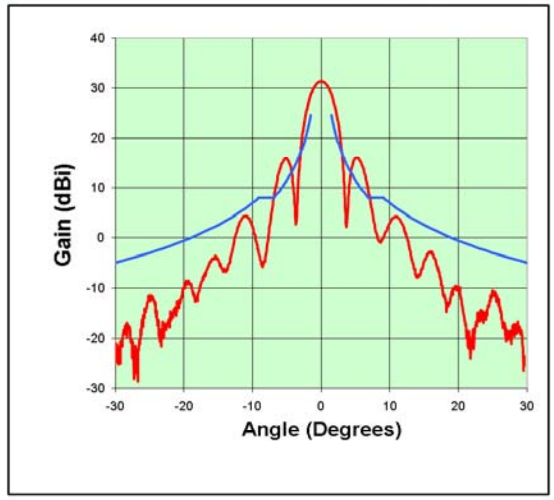
PATTERN #	FREQ	BORESITE	AXIS	PLANE	Gain (dbi)	+/- 0.2 Off-Axis Excess Gain (dB)	Max off axis PSD Into Antenna (dBW/4kHz)
L0167A.071	14.125	HOR	AZ	E	31.5	5.8	-19.8
L0167A.047	14.125	VERT	AZ	H	31.4	6.1	-20.1
L0167A.070	13.75	HOR	AZ	E	31.4	5.9	-19.9
L0167A.046	13.75	VERT	AZ	H	31.1	5.7	-19.7
L0167A.072	14.5	HOR	AZ	E	31.8	6.7	-20.7
L0167A.048	14.5	VERT	AZ	H	31.9	6.3	-20.3

17.1 Azimuth Horizontal

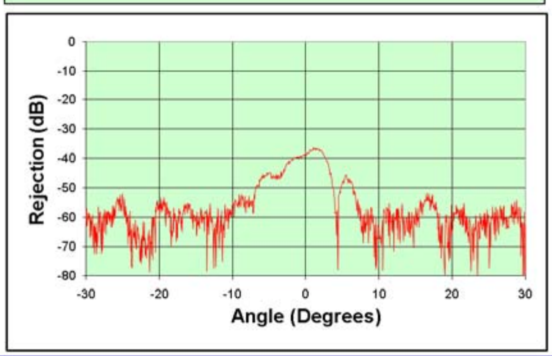
18LP Antenna, 13.75 GHz, Az Horizontal, +/-90, Plot#70
Gain = 31.4dB
20100707M01V03_LP_13.75_Az.xls



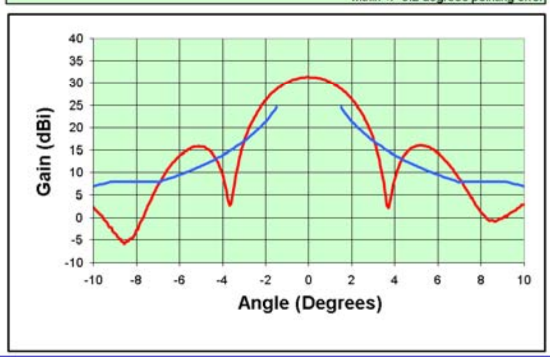
18LP Antenna, 13.75 GHz, Az Horizontal, Close In, Plot#70
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_Az.xls
Gain '= 31.4dBi
Maximum Excess Gain = 5.9 dB within +/- 0.2 degrees pointing error



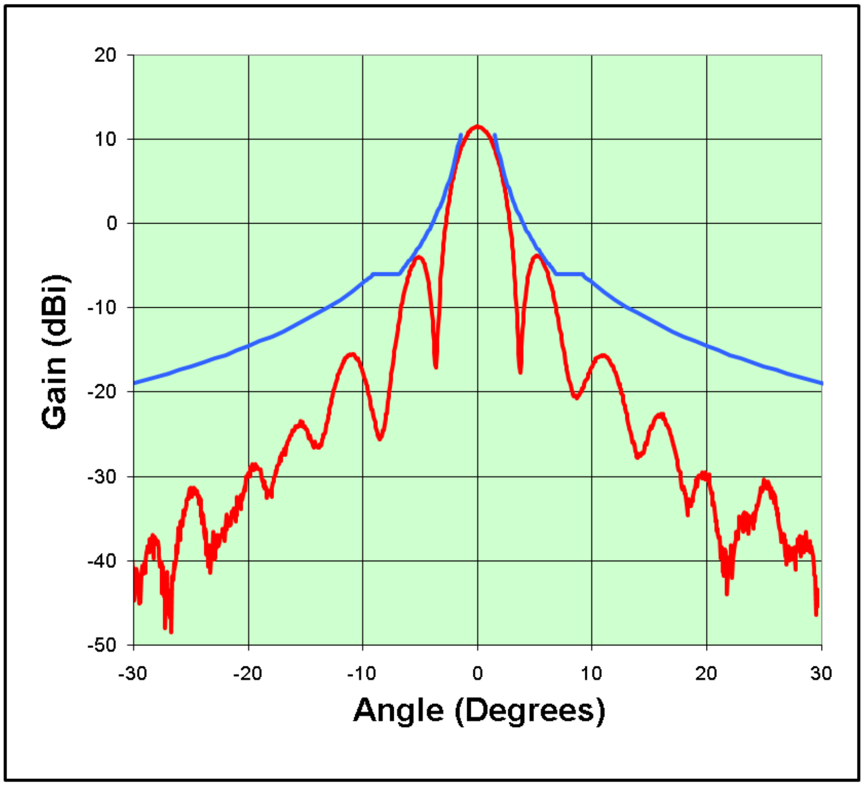
18LP Antenna, 13.75 GHz, Az Horizontal, Cross-Polarization, Plot#73
Minimum Cross Pol = -36.5dB
20100707M01V03_LP_13.75_Az.xls



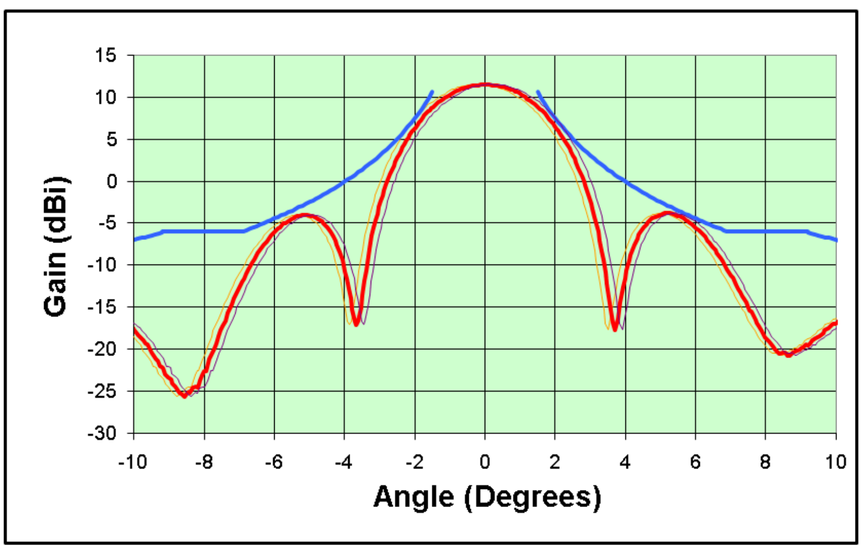
18LP Antenna, 13.75 GHz, Az Horizontal, Close In, Plot#70
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_Az.xls
Gain '= 31.4dBi
Maximum Excess Gain = 5.9 dB within +/- 0.2 degrees pointing error

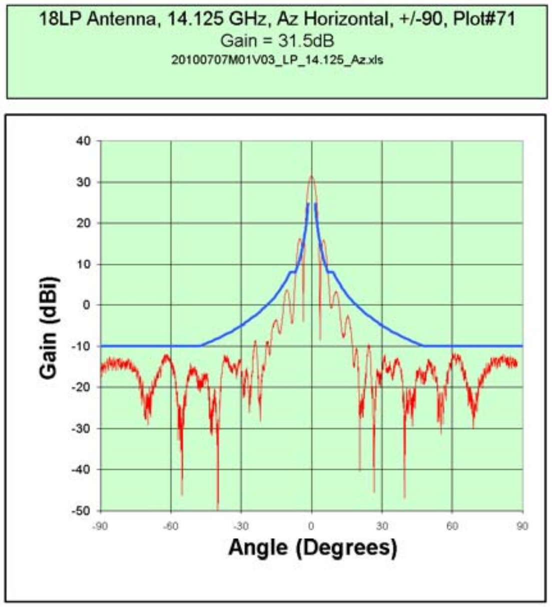


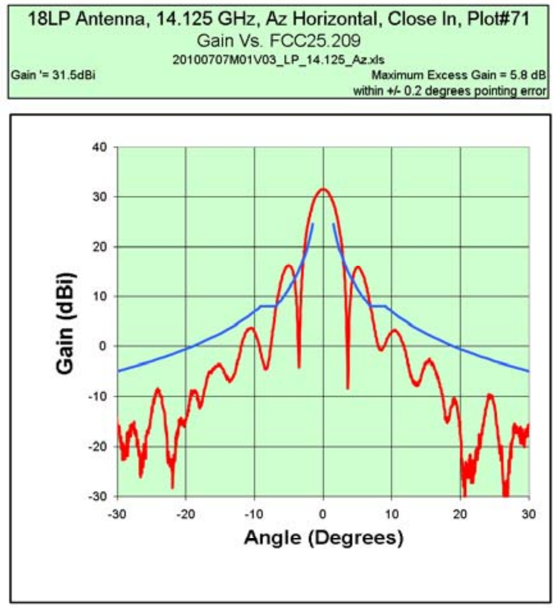
18LP Antenna, 13.75 GHz, Az Horizontal, Close In, Plot#70
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.9 dBW/4kHz
Pointing Error = +/-0.2 degrees

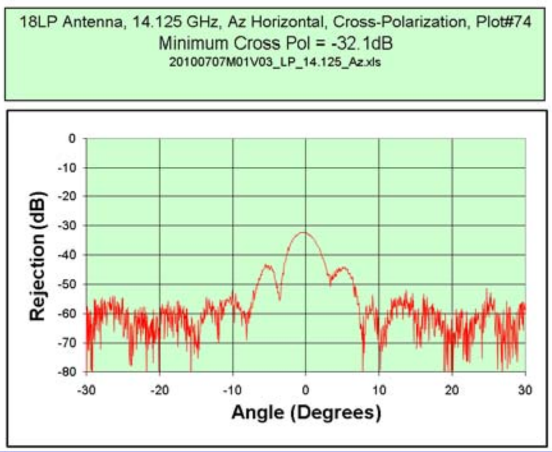


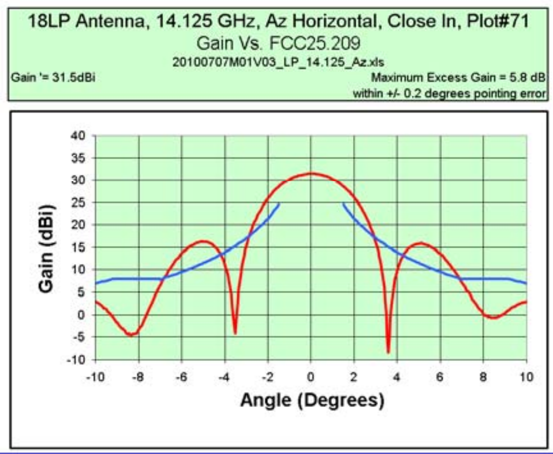
18LP Antenna, 13.75 GHz, Az Horizontal, Close In, Plot#70
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.9 dBW/4kHz
Pointing Error = +/-0.2 degrees



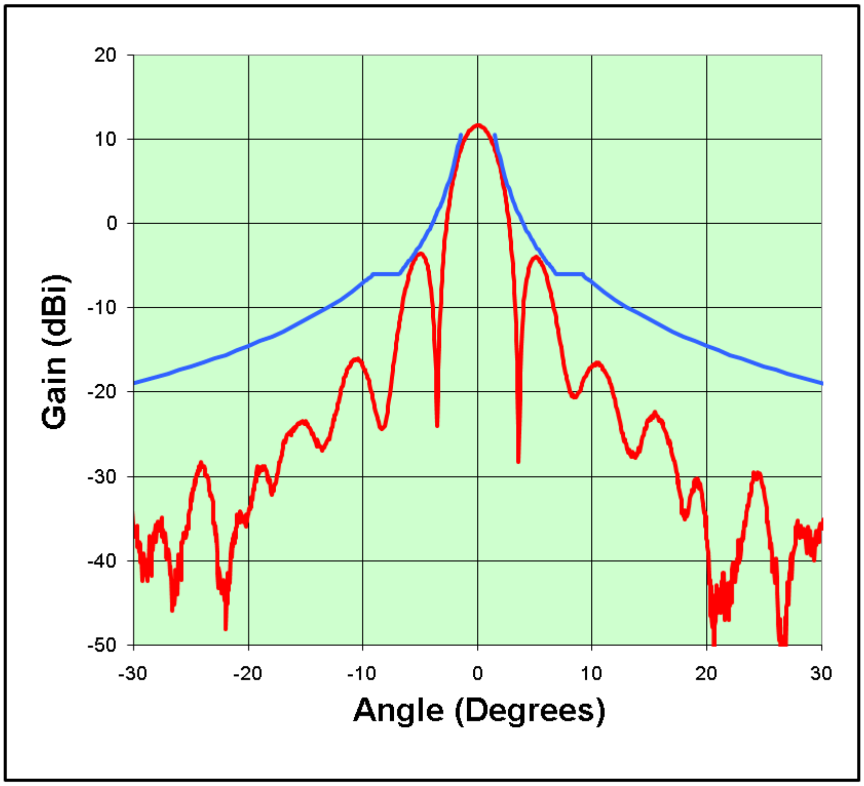

18LP Antenna, 14.125 GHz, Az Horizontal, +/-90, Plot#71
Gain = 31.5dB
20100707M01V03_LP_14.125_Az.xls
Gain (dBi)
40
30
20
10
0
-10
-20
-30
-40
-50
-90
-60
-30
0
30
60
90
Angle (Degrees)


18LP Antenna, 14.125 GHz, Az Horizontal, Close In, Plot#71
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_Az.xls
Gain '= 31.5dBi
Maximum Excess Gain = 5.8 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
40
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
Angle (Degrees)

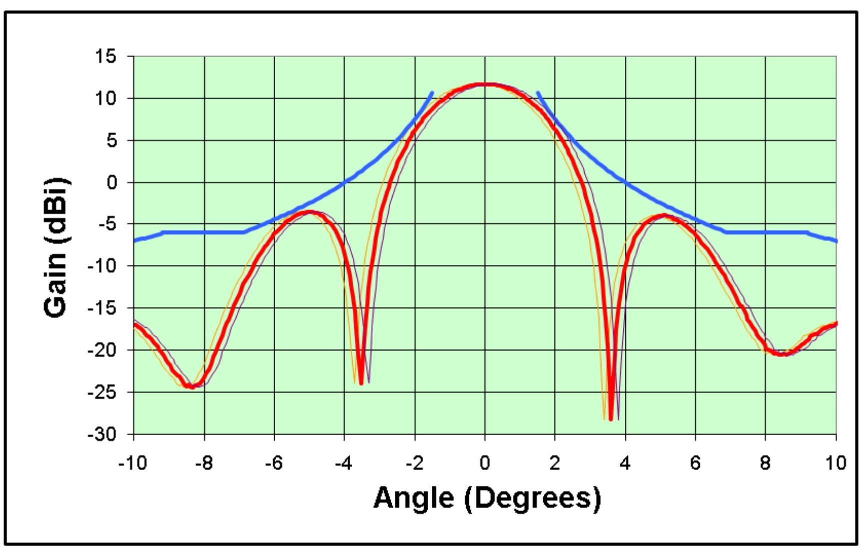

18LP Antenna, 14.125 GHz, Az Horizontal, Cross-Polarization, Plot#74
Minimum Cross Pol = -32.1dB
20100707M01V03_LP_14.125_Az.xls
Rejection (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-30
-20
-10
0
10
20
30
Angle (Degrees)


18LP Antenna, 14.125 GHz, Az Horizontal, Close In, Plot#71
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_Az.xls
Gain '= 31.5dBi
Maximum Excess Gain = 5.8 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
40
35
30
25
20
15
10
5
0
-5
-10
-10
-8
-6
-4
-2
0
2
4
6
8
10
Angle (Degrees)

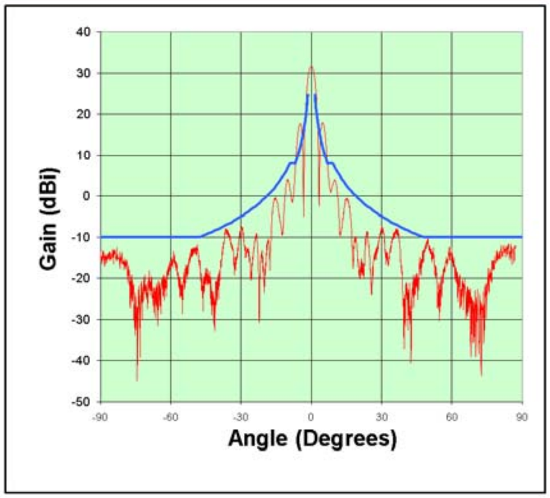
18LP Antenna, 14.125 GHz, Az Horizontal, Close In, Plot#71
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.8 dBW/4kHz
Pointing Error = +/-0.2 degrees



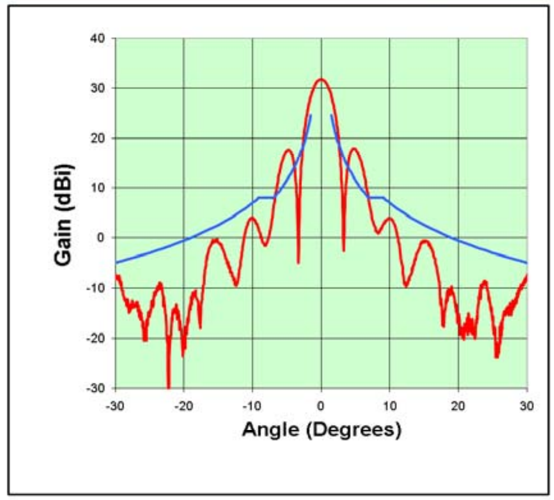
18LP Antenna, 14.125 GHz, Az Horizontal, Close In, Plot#71
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.8 dBW/4kHz
Pointing Error = +/-0.2 degrees



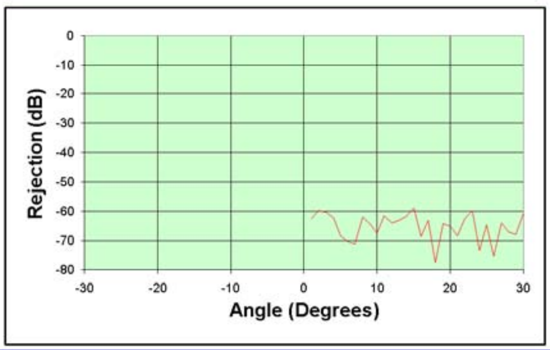
18LP Antenna, 14.5 GHz, Az Horizontal, +/-90, Plot#72
Gain = 31.8dB
20100707M01V03_LP_14.5_Az.xls



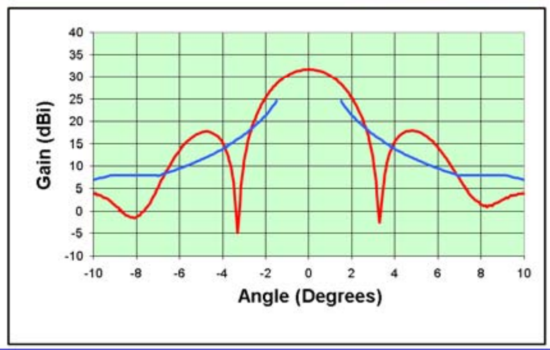
18LP Antenna, 14.5 GHz, Az Horizontal, Close In, Plot#72
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_Az.xls
Gain '= 31.8dBi
Maximum Excess Gain = 6.7 dB within +/- 0.2 degrees pointing error



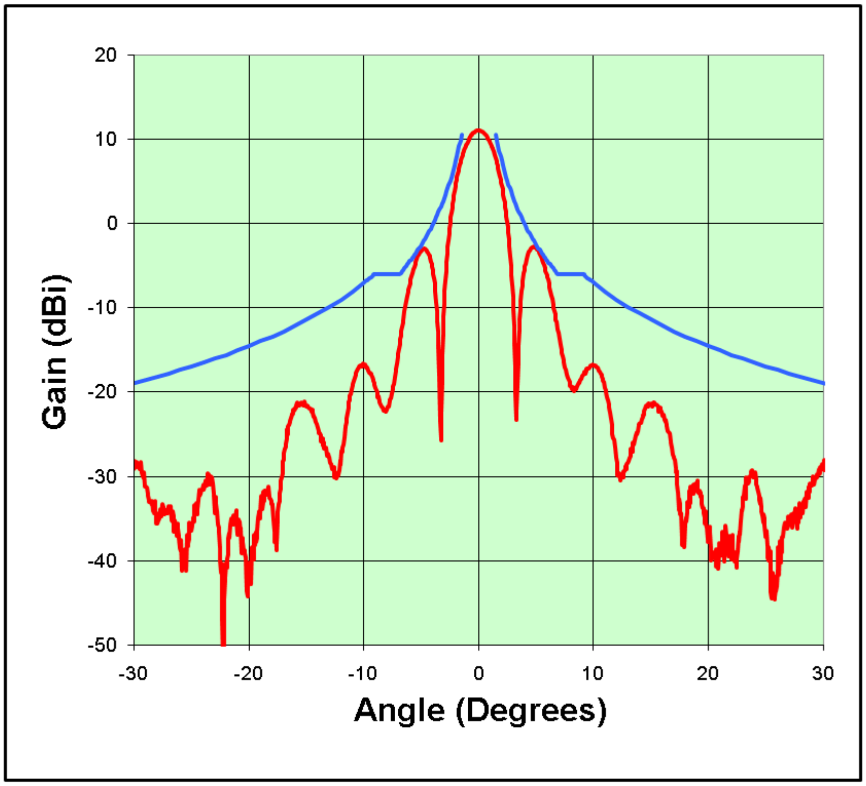
18LP Antenna, 14.5 GHz, Az Horizontal, Cross-Polarization, Plot#75
Minimum Cross Pol = -32.4dB
20100707M01V03_LP_14.5_Az.xls



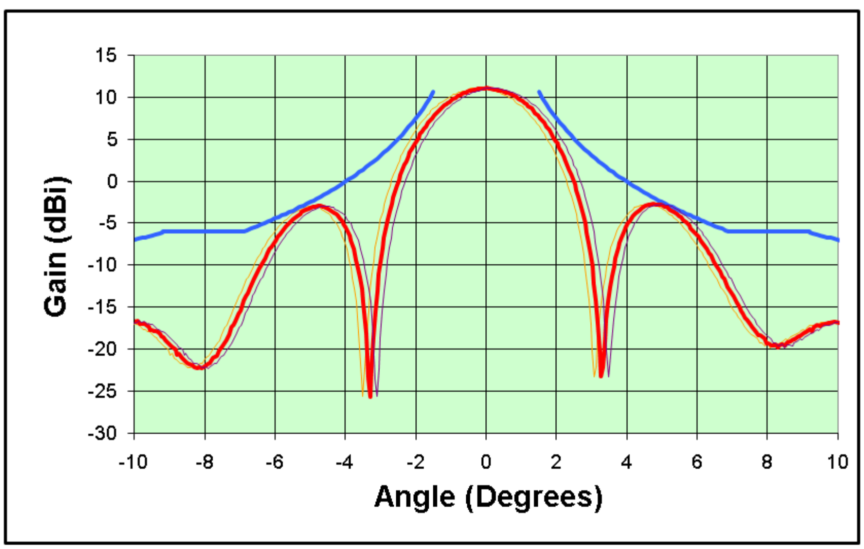
18LP Antenna, 14.5 GHz, Az Horizontal, Close In, Plot#72
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_Az.xls
Gain '= 31.8dBi
Maximum Excess Gain = 6.7 dB within +/- 0.2 degrees pointing error



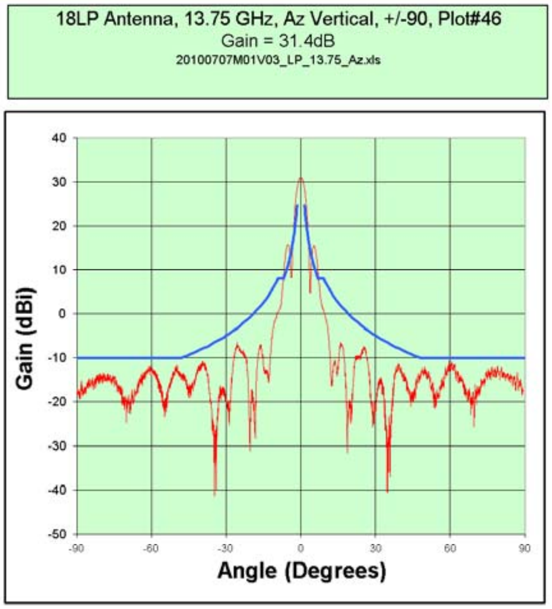
18LP Antenna, 14.5 GHz, Az Horizontal, Close In, Plot#72
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.7 dBW/4kHz
Pointing Error = +/-0.2 degrees

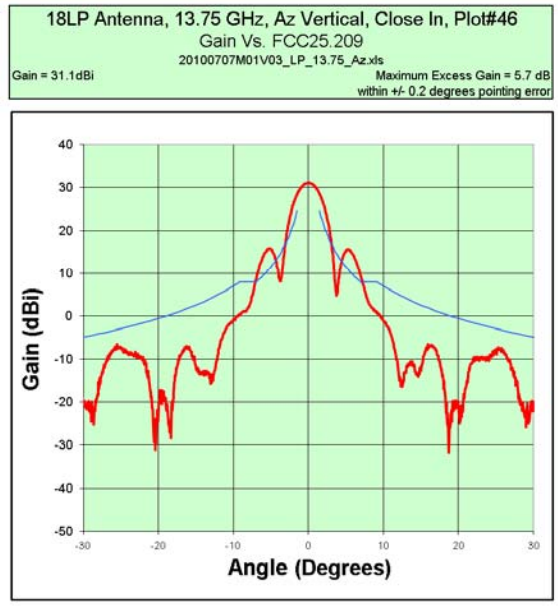


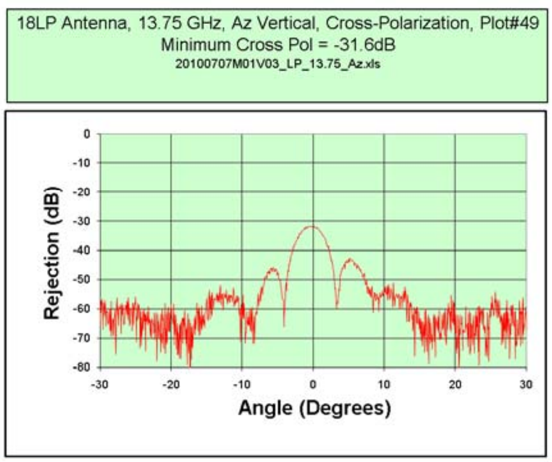
18LP Antenna, 14.5 GHz, Az Horizontal, Close In, Plot#72
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.7 dBW/4kHz
Pointing Error = +/-0.2 degrees

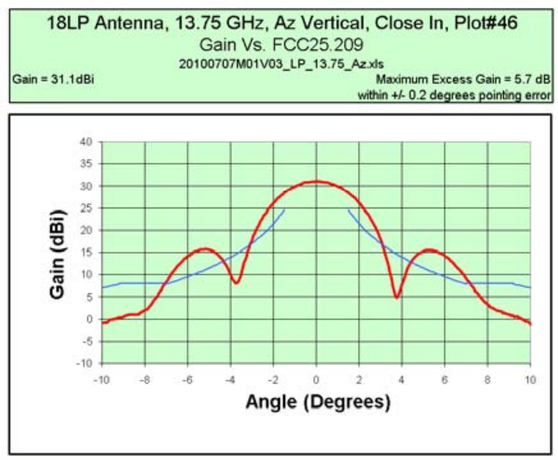


17.2 Azimuth Vertical

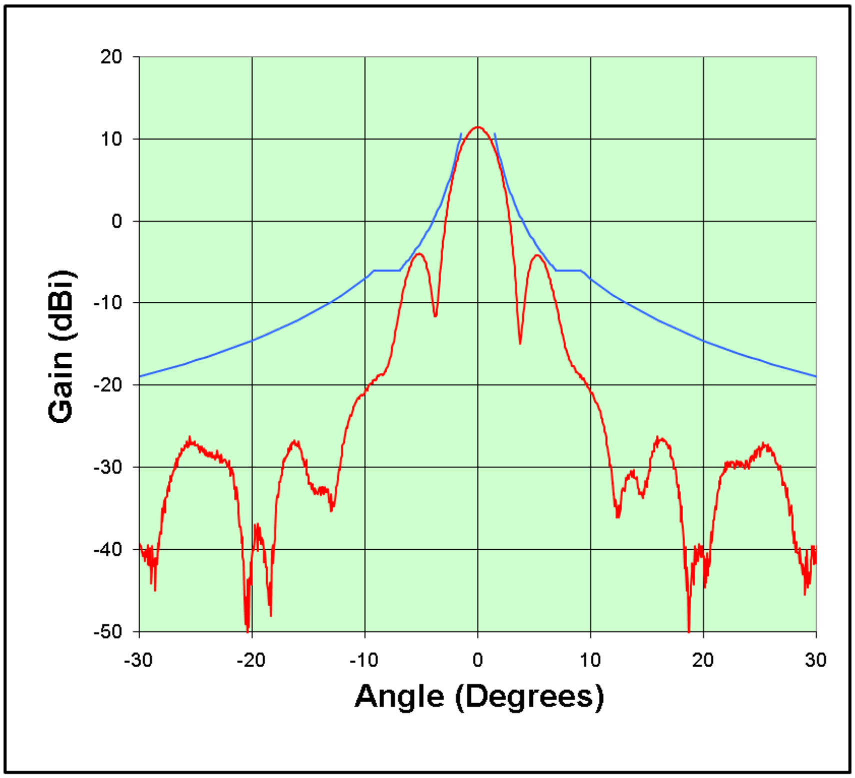

18LP Antenna, 13.75 GHz, Az Vertical, +/-90, Plot#46
Gain = 31.4dB
20100707M01V03_LP_13.75_Az.xls
Gain (dBi)
Angle (Degrees)


18LP Antenna, 13.75 GHz, Az Vertical, Close In, Plot#46
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_Az.xls
Gain = 31.1dBi
Maximum Excess Gain = 5.7 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)

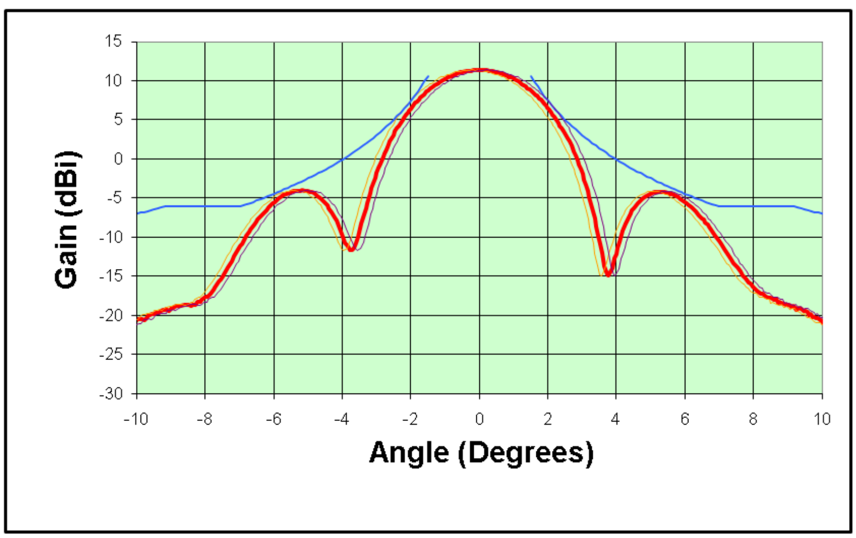

18LP Antenna, 13.75 GHz, Az Vertical, Cross-Polarization, Plot#49
Minimum Cross Pol = -31.6dB
20100707M01V03_LP_13.75_Az.xls
Rejection (dB)
Angle (Degrees)


18LP Antenna, 13.75 GHz, Az Vertical, Close In, Plot#46
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_Az.xls
Gain = 31.1dBi
Maximum Excess Gain = 5.7 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)

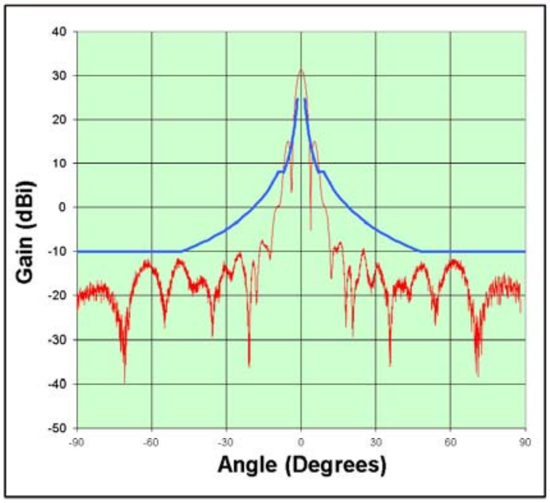
18LP Antenna, 13.75 GHz, Az Vertical, Close In, Plot#46
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.7 dBW/4kHz
Pointing Error = +/-0.2 degrees



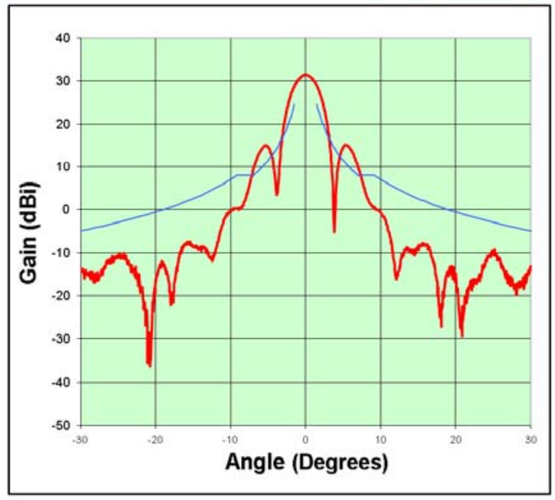
18LP Antenna, 13.75 GHz, Az Vertical, Close In, Plot#46
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -19.7 dBW/4kHz
Pointing Error = +/-0.2 degrees



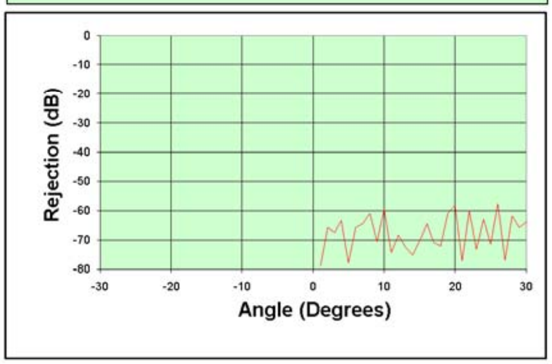
18LP Antenna, 14.125 GHz, Az Vertical, +/-90, Plot#47
Gain = 31.5dB
20100707M01V03_LP_14.125_Az.xls



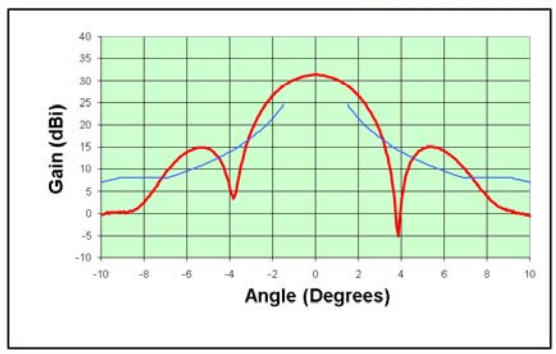
18LP Antenna, 14.125 GHz, Az Vertical, Close In, Plot#47
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_Az.xls
Gain = 31.4dBi
Maximum Excess Gain = 6.1 dB within +/- 0.2 degrees pointing error



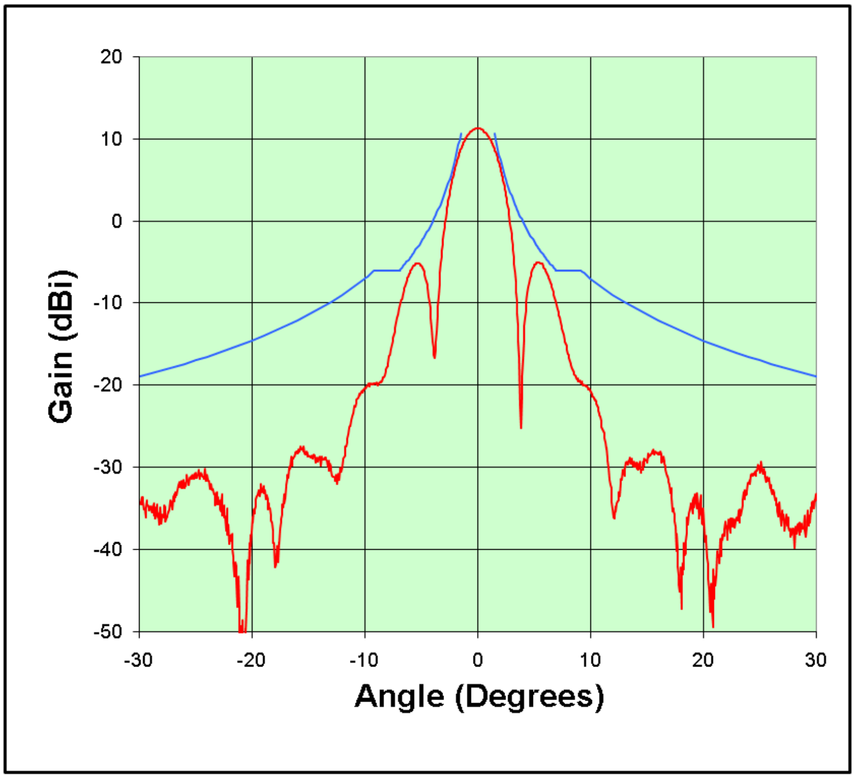
18LP Antenna, 14.125 GHz, Az Vertical, Cross-Polarization, Plot#50
Minimum Cross Pol = -29.3dB
20100707M01V03_LP_14.125_Az.xls



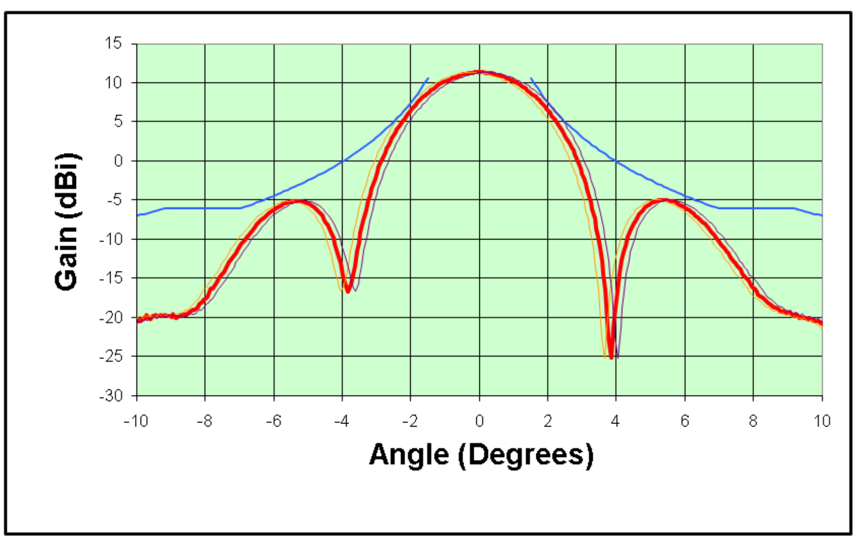
18LP Antenna, 14.125 GHz, Az Vertical, Close In, Plot#47
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_Az.xls
Gain = 31.4dBi
Maximum Excess Gain = 6.1 dB within +/- 0.2 degrees pointing error



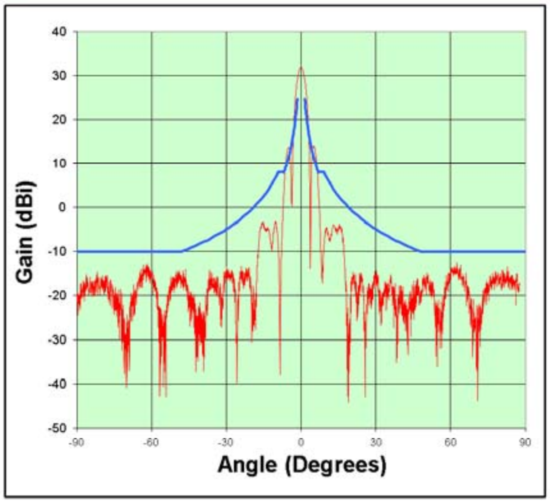
18LP Antenna, 14.125 GHz, Az Vertical, Close In, Plot#47
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.1 dBW/4kHz
Pointing Error = +/-0.2 degrees



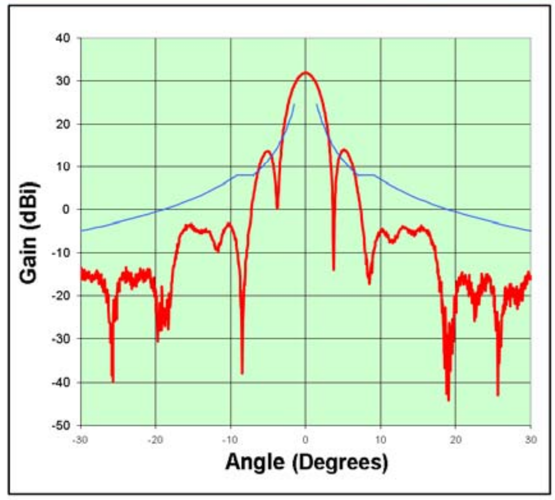
18LP Antenna, 14.125 GHz, Az Vertical, Close In, Plot#47
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.1 dBW/4kHz
Pointing Error = +/-0.2 degrees



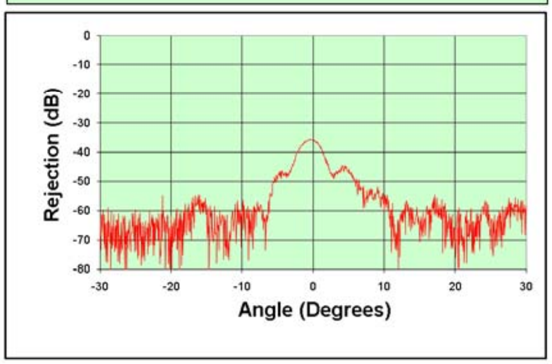
18LP Antenna, 14.5 GHz, Az Vertical, +/-90, Plot#48
Gain = 31.8dB
20100707M01V03_LP_14.5_Az.xls



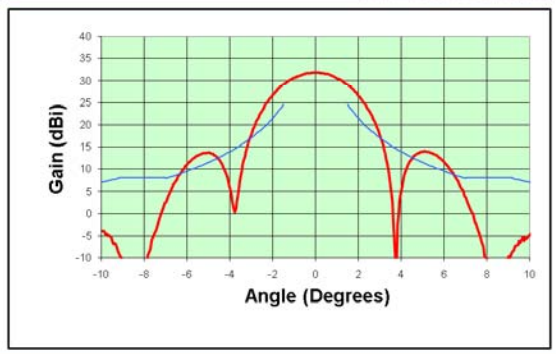
18LP Antenna, 14.5 GHz, Az Vertical, Close In, Plot#48
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_Az.xls
Gain = 31.9dBi
Maximum Excess Gain = 6.3 dB
within +/- 0.2 degrees pointing error



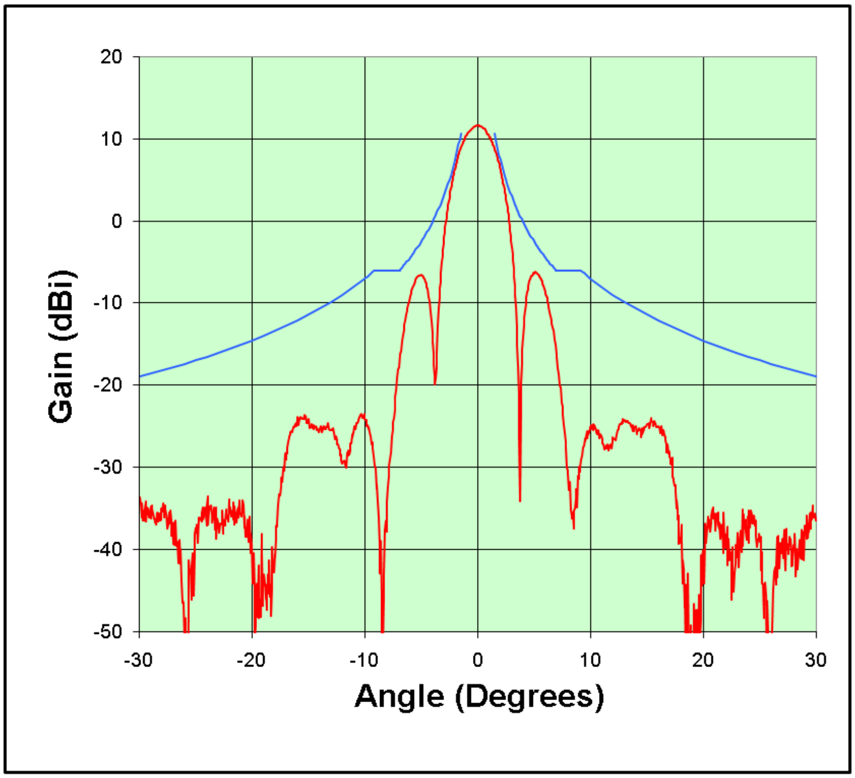
18LP Antenna, 14.5 GHz, Az Vertical, Cross-Polarization, Plot#51
Minimum Cross Pol = -35.7dB
20100707M01V03_LP_14.5_Az.xls



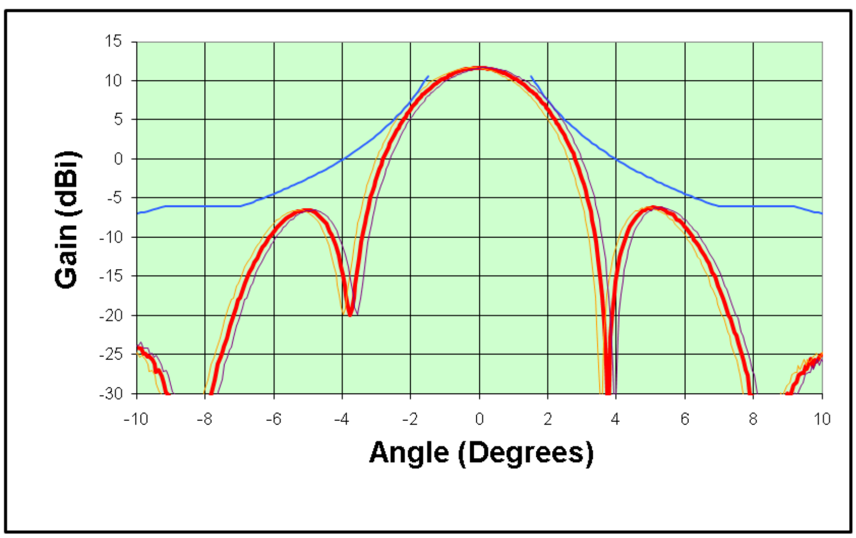
18LP Antenna, 14.5 GHz, Az Vertical, Close In, Plot#48
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_Az.xls
Gain = 31.9dBi
Maximum Excess Gain = 6.3 dB
within +/- 0.2 degrees pointing error



18LP Antenna, 14.5 GHz, Az Vertical, Close In, Plot#48
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.3 dBW/4kHz
Pointing Error = +/-0.2 degrees



18LP Antenna, 14.5 GHz, Az Vertical, Close In, Plot#48
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_Az.xls
Maximum Denisty Into Antenna to Meet FCC = -20.3 dBW/4kHz
Pointing Error = +/-0.2 degrees



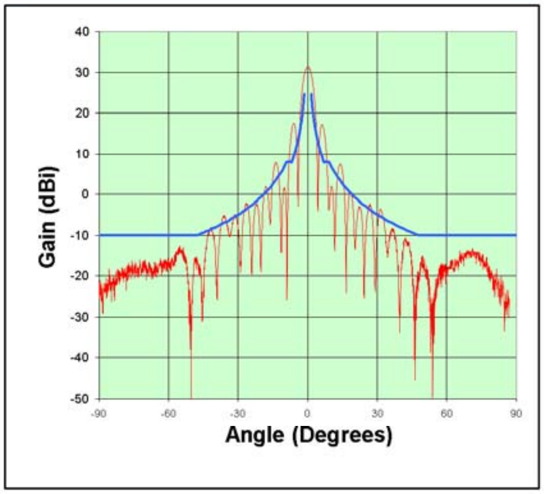
18 APPENDIX - ANTENNA ELEVATION PLOTS

L3/Datron FSS-4180-LP
ELEVATION PLOTS

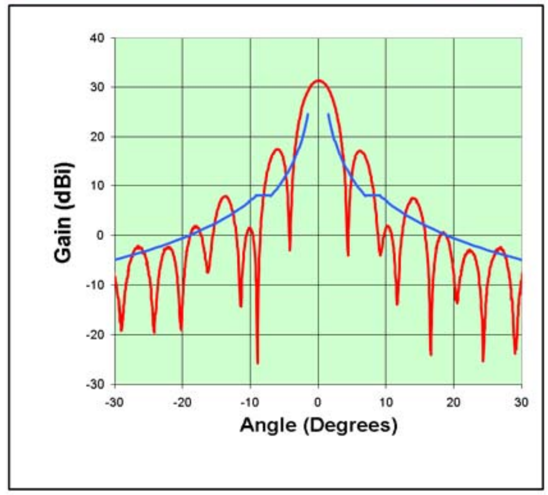
PATTERN #	FREQ	BORESITE	AXIS	PLANE	Gain (dbi)	+/- 0.2 Off-Axis Excess Gain (dB)	Max off axis PSD Into Antenna (dBW/4kHz)
L0167A.082	13.75	HOR	EL	E	31.4	8.6	-22.6
L0167A.058	13.75	VERT	EL	H	31.1	8.2	-22.2
L0167A.083	14.125	HOR	EL	E	31.5	8.9	-22.9
L0167A.059	14.125	VERT	EL	H	31.4	7.9	-21.9
L0167A.084	14.5	HOR	EL	E	31.8	9.8	-23.8
L0167A.060	14.5	VERT	EL	H	31.9	8.3	-22.3

18.1 Elevation Horizontal

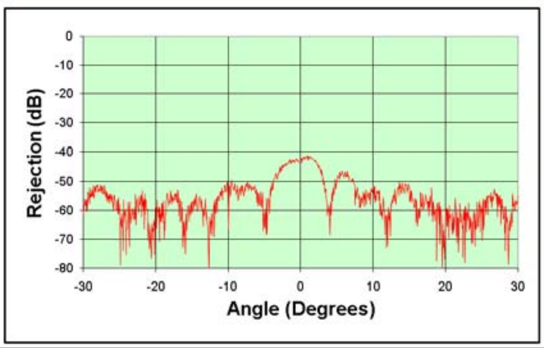
18LP Antenna, 13.75 GHz, El Horizontal, +/-90, Plot#82
Gain = 31.4dB
20100707M01V03_LP_13.75_El.xls



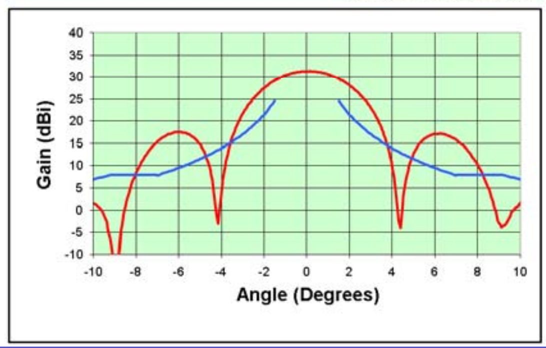
18LP Antenna, 13.75 GHz, El Horizontal, Close In, Plot#82
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_El.xls
Gain '= 31.4dBi
Maximum Excess Gain = 8.6 dB within +/- 0.2 degrees pointing error



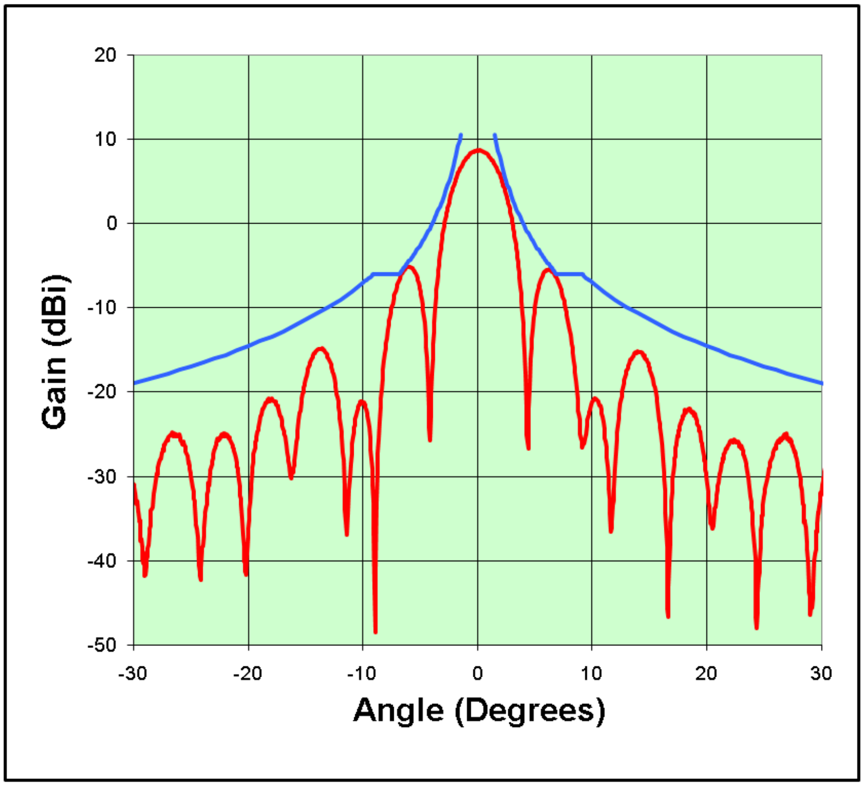
18LP Antenna, 13.75 GHz, El Horizontal, Cross-Polarization, Plot#85
Minimum Cross Pol = -41.2dB
20100707M01V03_LP_13.75_El.xls



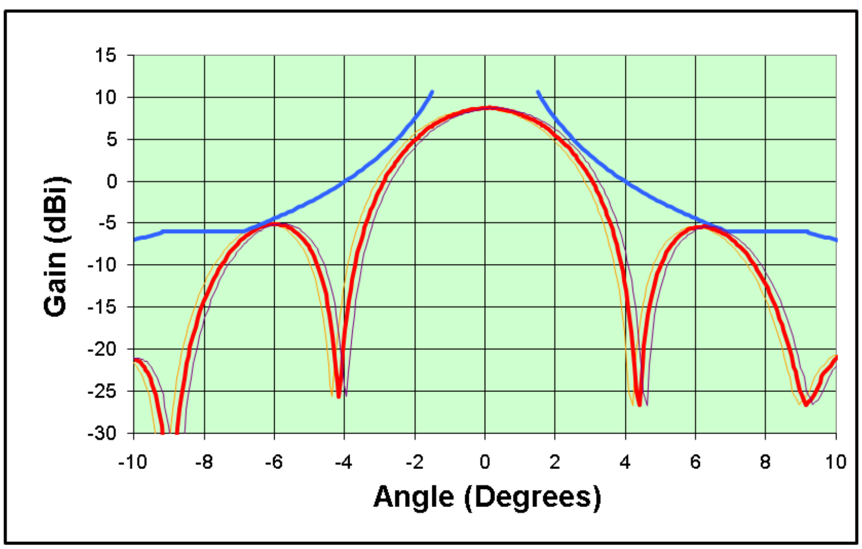
18LP Antenna, 13.75 GHz, El Horizontal, Close In, Plot#82
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_El.xls
Gain '= 31.4dBi
Maximum Excess Gain = 8.6 dB within +/- 0.2 degrees pointing error

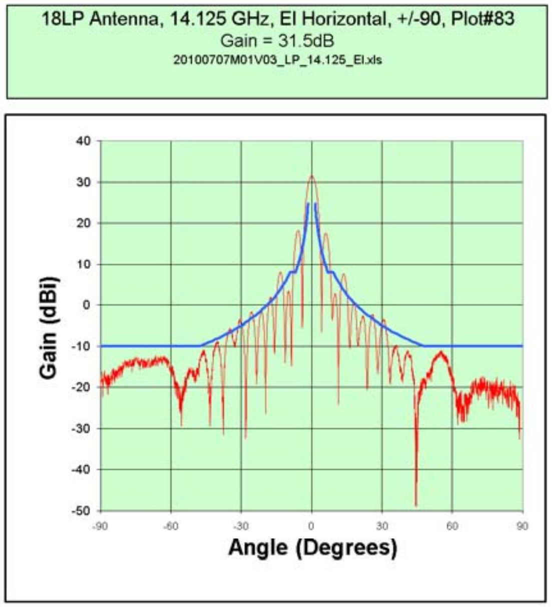


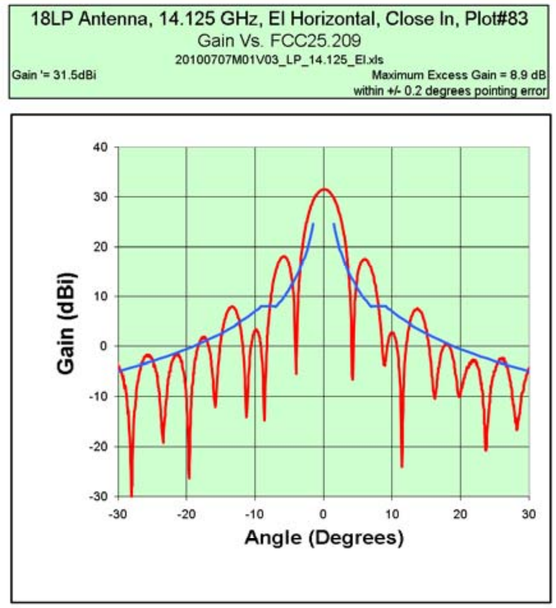
18LP Antenna, 13.75 GHz, El Horizontal, Close In, Plot#82
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.6 dBW/4kHz
Pointing Error = +/-0.2 degrees

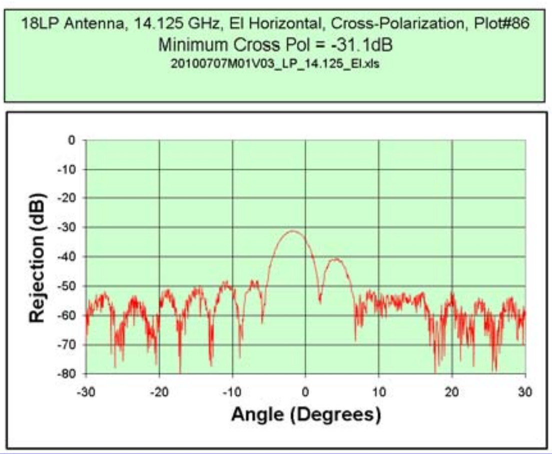


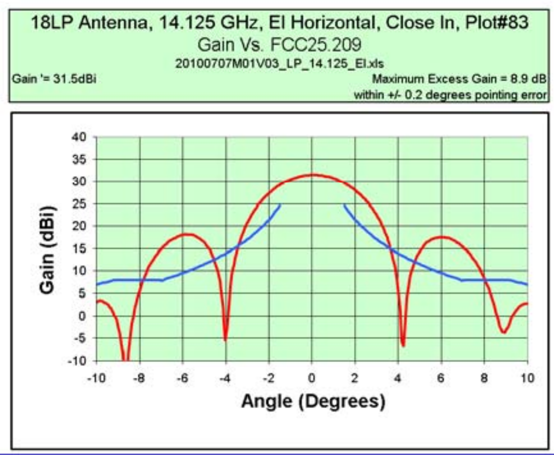
18LP Antenna, 13.75 GHz, El Horizontal, Close In, Plot#82
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.6 dBW/4kHz
Pointing Error = +/-0.2 degrees




18LP Antenna, 14.125 GHz, El Horizontal, +/-90, Plot#83
Gain = 31.5dB
20100707M01V03_LP_14.125_El.xls
Gain (dBi)
Angle (Degrees)


18LP Antenna, 14.125 GHz, El Horizontal, Close In, Plot#83
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_El.xls
Gain '= 31.5dBi
Maximum Excess Gain = 8.9 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)


18LP Antenna, 14.125 GHz, El Horizontal, Cross-Polarization, Plot#86
Minimum Cross Pol = -31.1dB
20100707M01V03_LP_14.125_El.xls
Rejection (dB)
Angle (Degrees)


18LP Antenna, 14.125 GHz, El Horizontal, Close In, Plot#83
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_El.xls
Gain '= 31.5dBi
Maximum Excess Gain = 8.9 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)

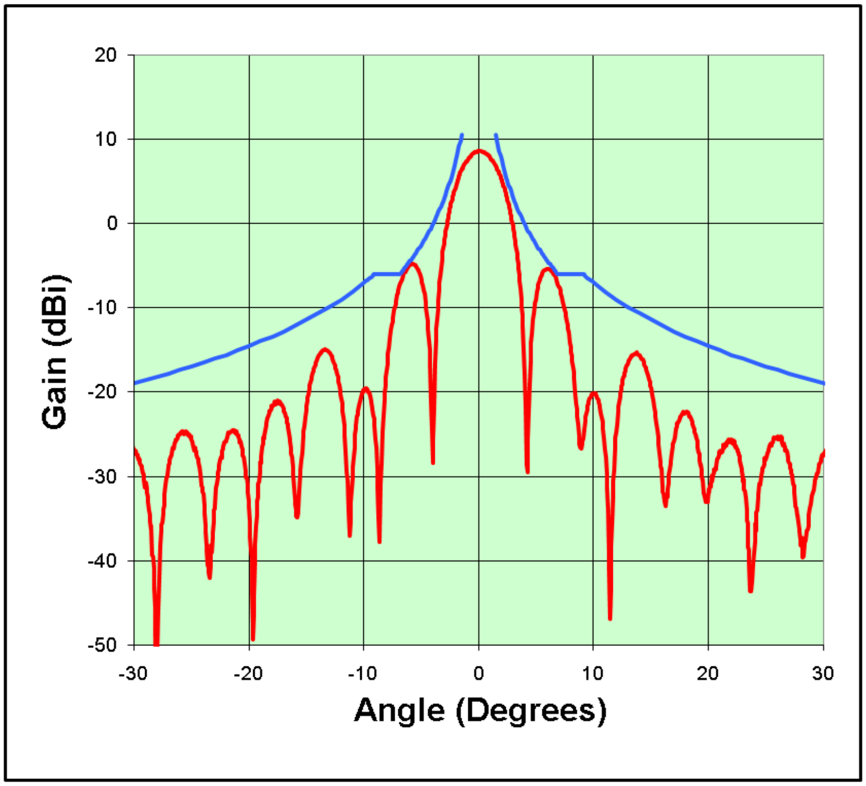
18LP Antenna, 14.125 GHz, El Horizontal, Close In, Plot#83

Spectral Density Vs FCC 25.226

20100707M01V03_LP_14.125_El.xls

Maximum Denisty Into Antenna to Meet FCC = -22.9 dBW/4kHz

Pointing Error = +/-0.2 degrees



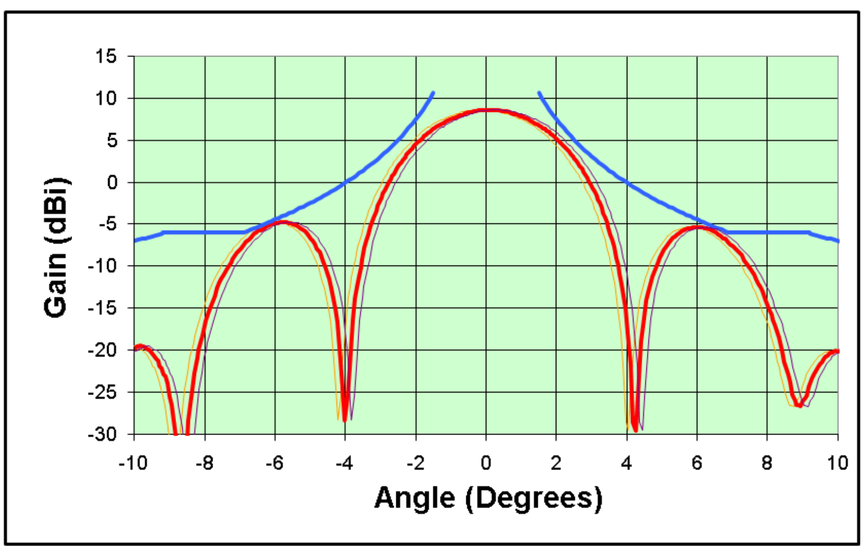
18LP Antenna, 14.125 GHz, El Horizontal, Close In, Plot#83

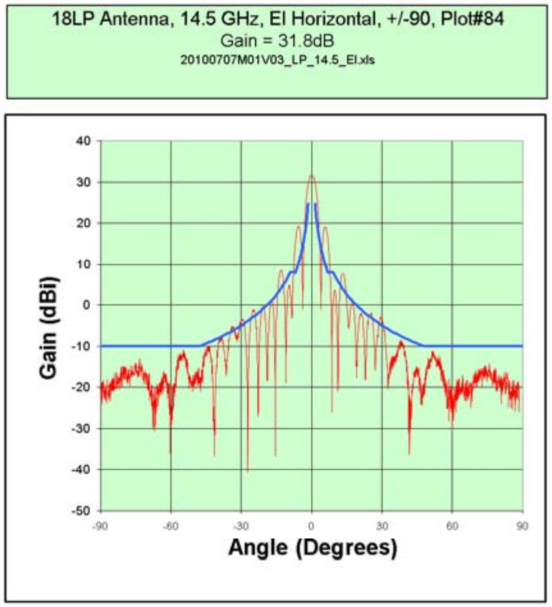
Spectral Density Vs FCC 25.226

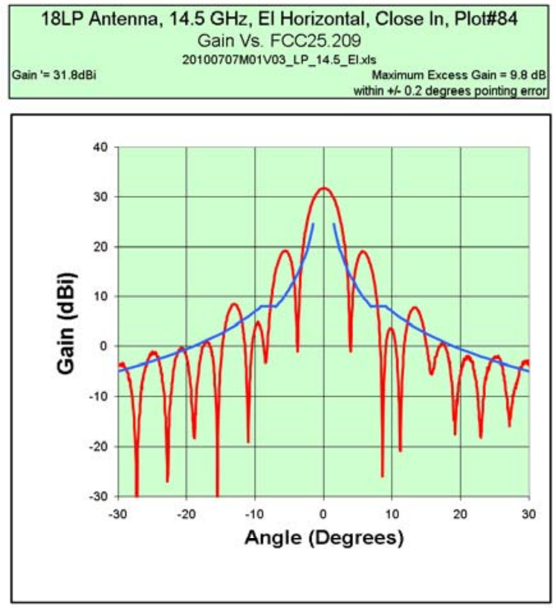
20100707M01V03_LP_14.125_El.xls

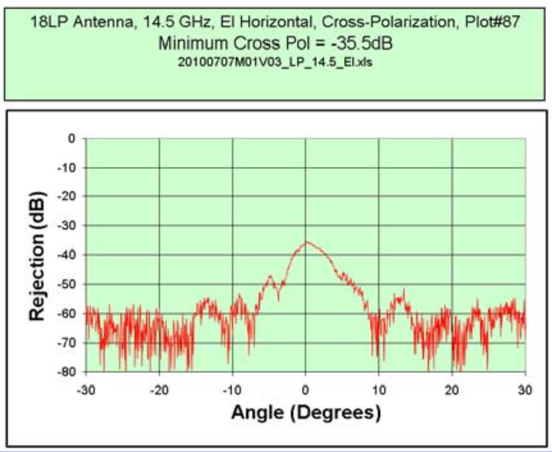
Maximum Denisty Into Antenna to Meet FCC = -22.9 dBW/4kHz

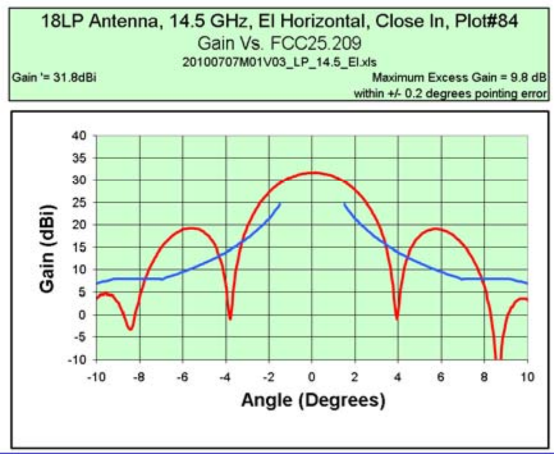
Pointing Error = +/-0.2 degrees



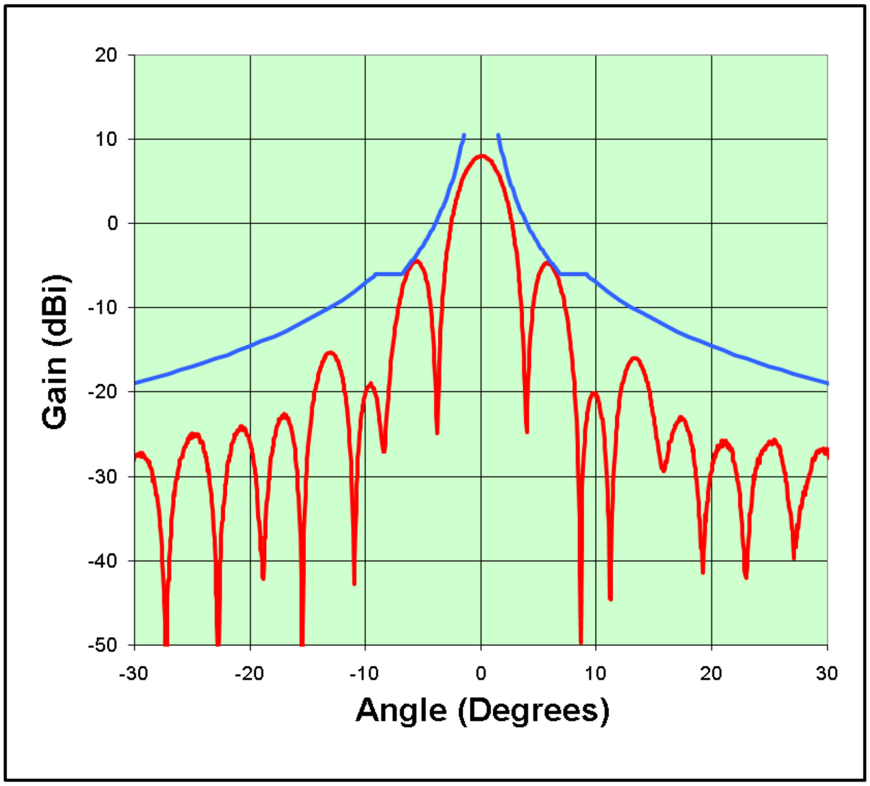

18LP Antenna, 14.5 GHz, El Horizontal, +/-90, Plot#84
Gain = 31.8dB
20100707M01V03_LP_14.5_El.xls
Gain (dBi)
Angle (Degrees)


18LP Antenna, 14.5 GHz, El Horizontal, Close In, Plot#84
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_El.xls
Gain '= 31.8dBi
Maximum Excess Gain = 9.8 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)

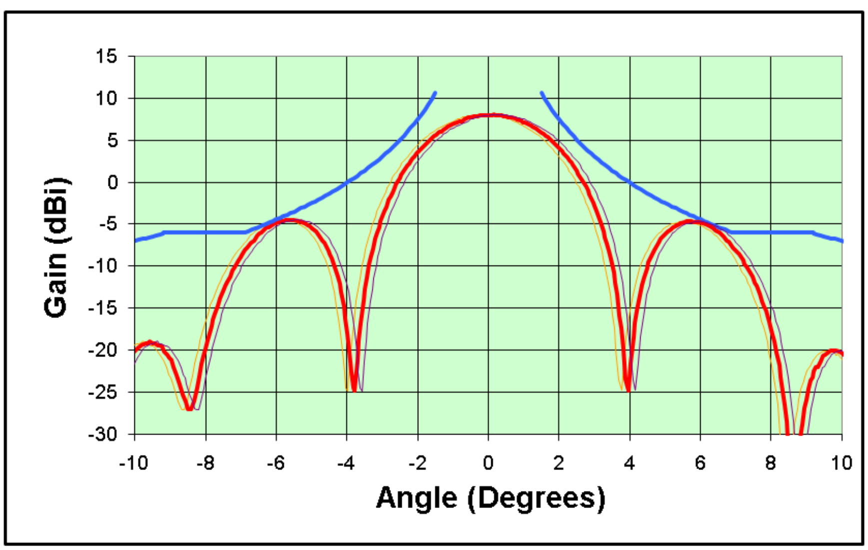

18LP Antenna, 14.5 GHz, El Horizontal, Cross-Polarization, Plot#87
Minimum Cross Pol = -35.5dB
20100707M01V03_LP_14.5_El.xls
Rejection (dB)
Angle (Degrees)


18LP Antenna, 14.5 GHz, El Horizontal, Close In, Plot#84
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_El.xls
Gain '= 31.8dBi
Maximum Excess Gain = 9.8 dB
within +/- 0.2 degrees pointing error
Gain (dBi)
Angle (Degrees)

18LP Antenna, 14.5 GHz, El Horizontal, Close In, Plot#84
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_El.xls
Maximum Denisty Into Antenna to Meet FCC = -23.8 dBW/4kHz
Pointing Error = +/-0.2 degrees

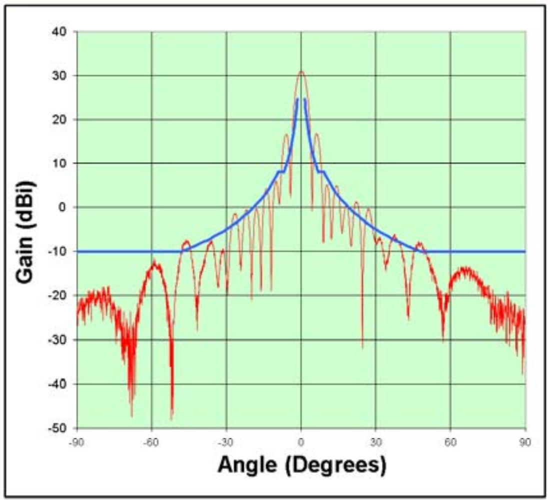


18LP Antenna, 14.5 GHz, El Horizontal, Close In, Plot#84
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_El.xls
Maximum Denisty Into Antenna to Meet FCC = -23.8 dBW/4kHz
Pointing Error = +/-0.2 degrees

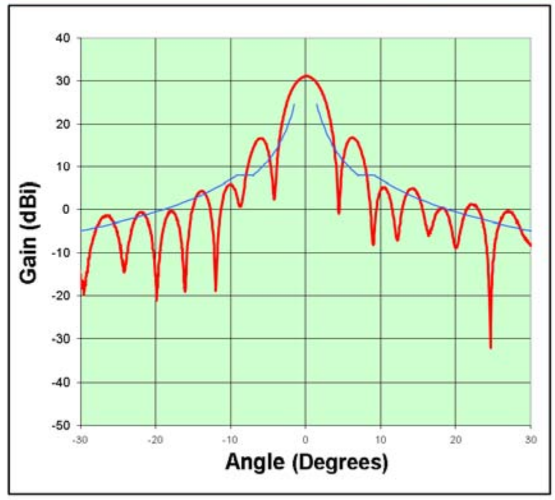


18.2 Elevation Vertical

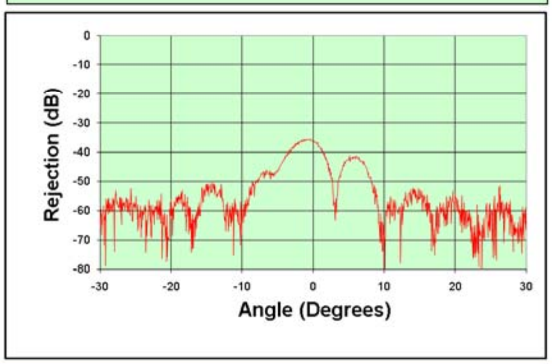
18LP Antenna, 13.75 GHz, El Vertical, +/-90, Plot#58
Gain = 31.4dB
20100707M01V03_LP_13.75_El.xls



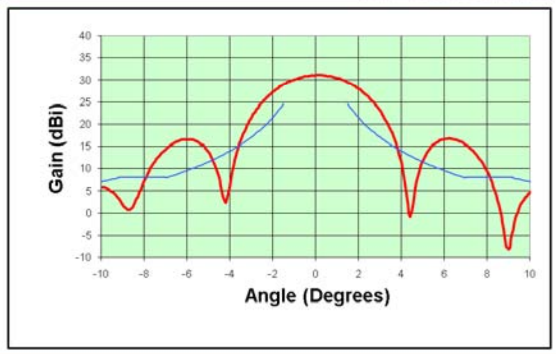
18LP Antenna, 13.75 GHz, El Vertical, Close In, Plot#58
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_El.xls
Gain = 31.1dBi
Maximum Excess Gain = 8.2 dB within +/- 0.2 degrees pointing error



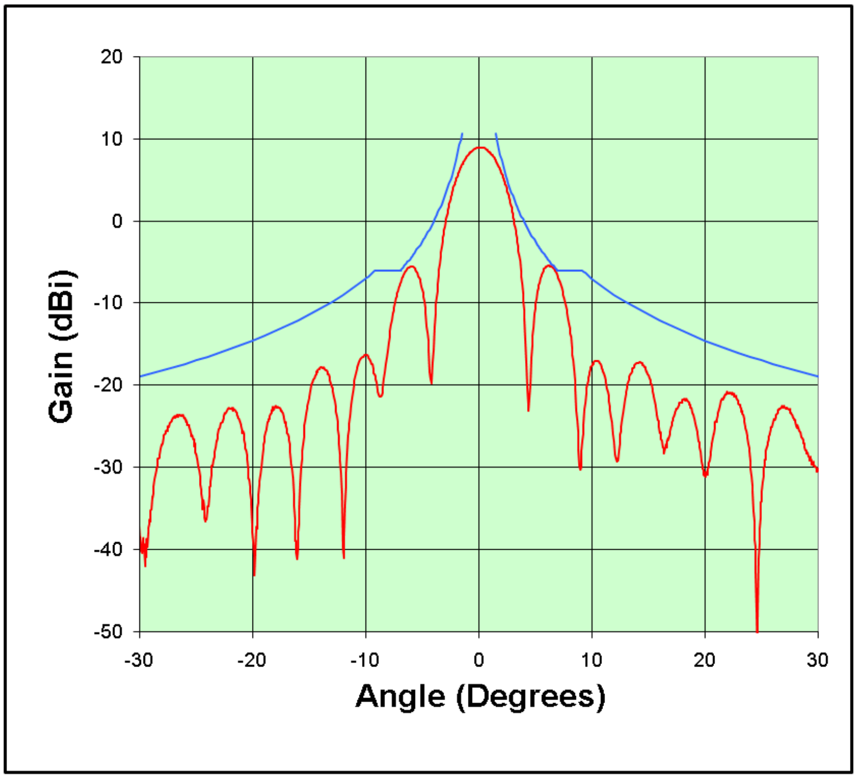
18LP Antenna, GHz, El Vertical, Cross-Polarization, Plot#61
Minimum Cross Pol = -35.6dB
20100707M01V03_LP_13.75_El.xls



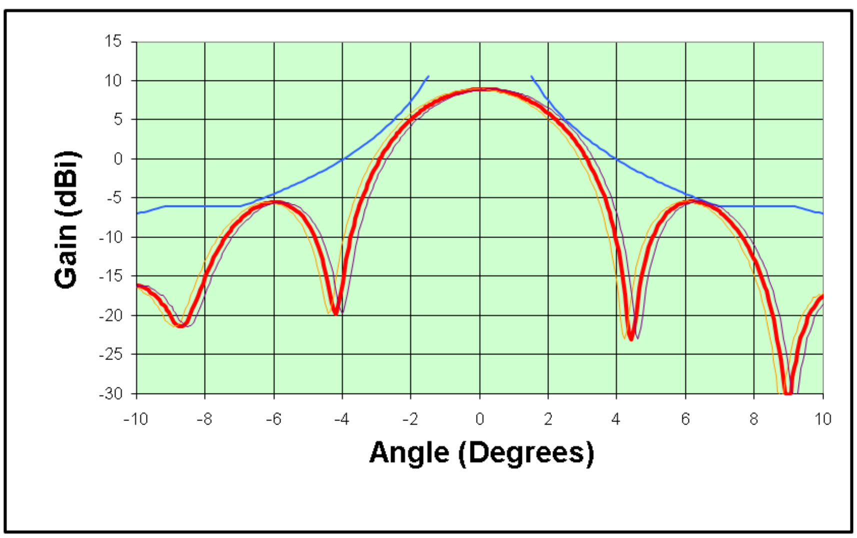
18LP Antenna, 13.75 GHz, El Vertical, Close In, Plot#58
Gain Vs. FCC25.209
20100707M01V03_LP_13.75_El.xls
Gain = 31.1dBi
Maximum Excess Gain = 8.2 dB within +/- 0.2 degrees pointing error



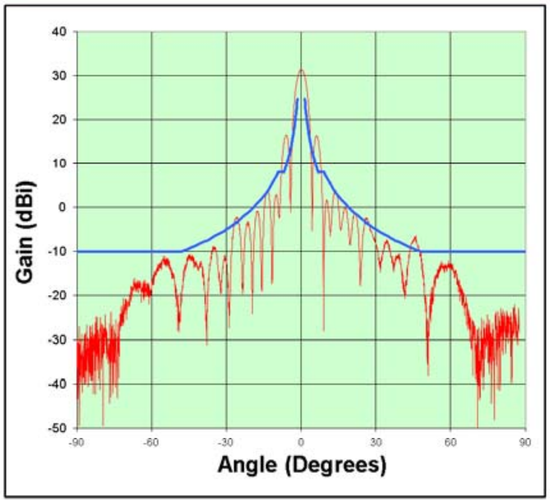
18LP Antenna, 13.75 GHz, El Vertical, Close In, Plot#58
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.2 dBW/4kHz
Pointing Error = +/-0.2 degrees



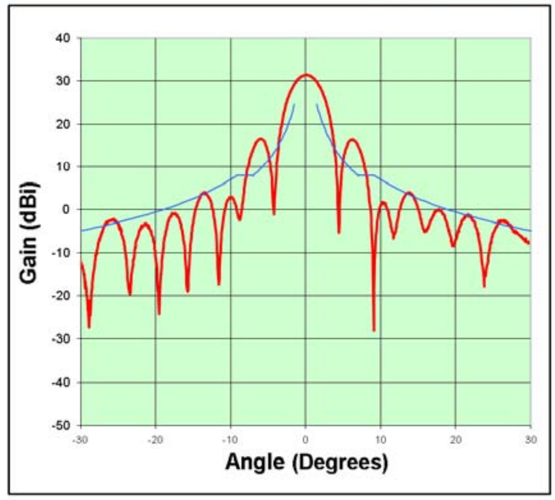
18LP Antenna, 13.75 GHz, El Vertical, Close In, Plot#58
Spectral Density Vs FCC 25.226
20100707M01V03_LP_13.75_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.2 dBW/4kHz
Pointing Error = +/-0.2 degrees



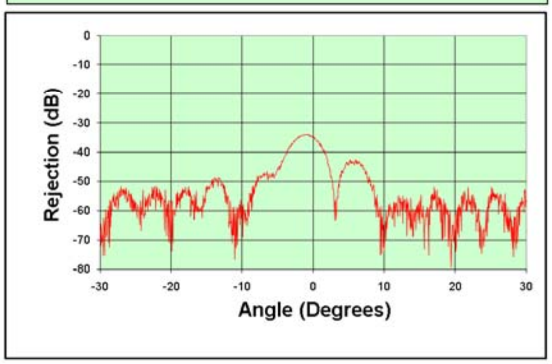
18LP Antenna, 14.125 GHz, El Vertical, +/-90, Plot#59
Gain = 31.5dB
20100707M01V03_LP_14.125_El.xls



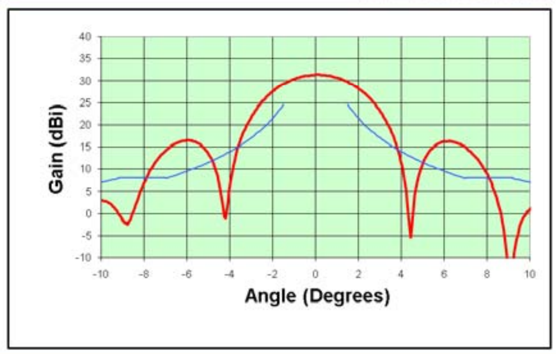
18LP Antenna, 14.125 GHz, El Vertical, Close In, Plot#59
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_El.xls
Gain = 31.4dBi
Maximum Excess Gain = 7.9 dB within +/- 0.2 degrees pointing error



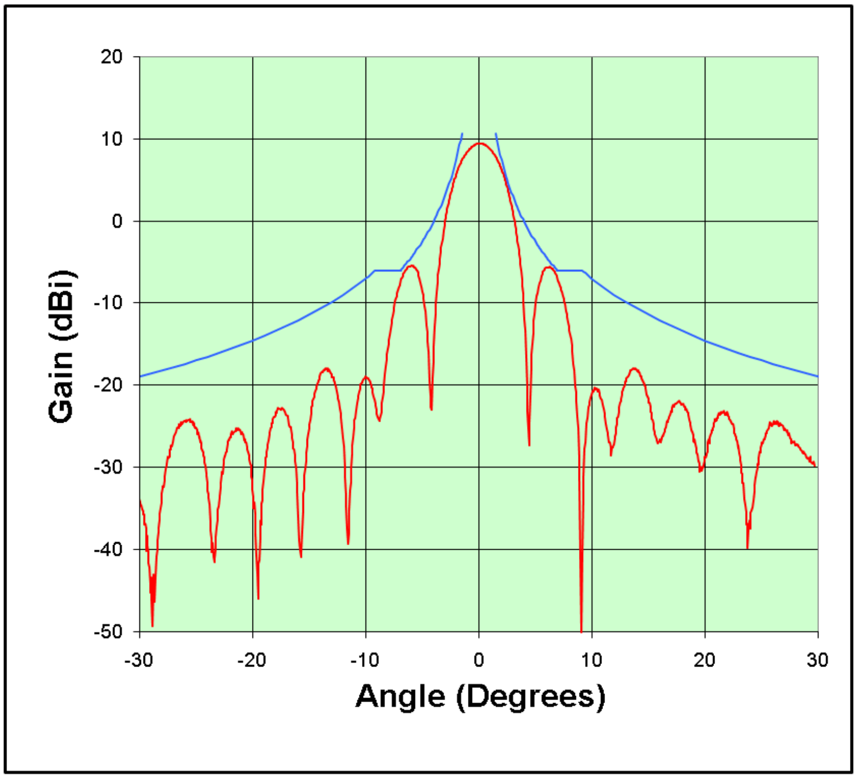
18LP Antenna, 14.125 GHz, El Vertical, Cross-Polarization, Plot#62
Minimum Cross Pol = -33.9dB
20100707M01V03_LP_14.125_El.xls



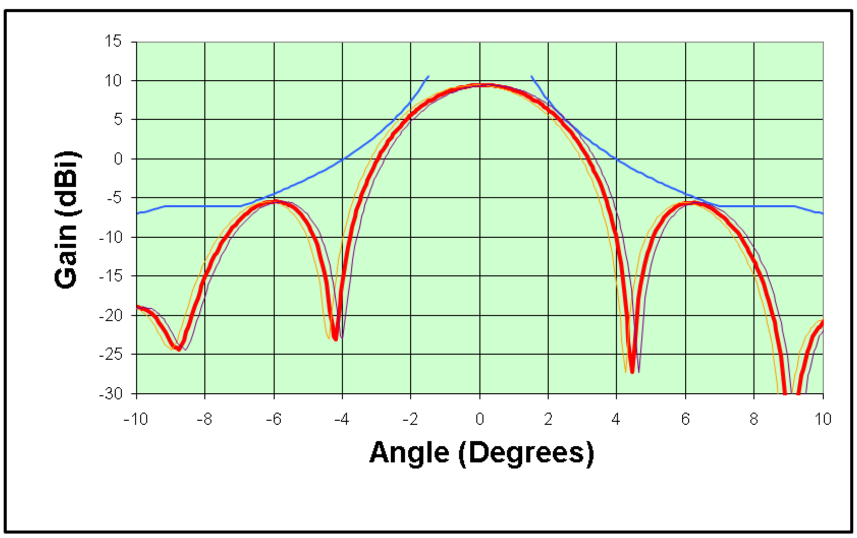
18LP Antenna, 14.125 GHz, El Vertical, Close In, Plot#59
Gain Vs. FCC25.209
20100707M01V03_LP_14.125_El.xls
Gain = 31.4dBi
Maximum Excess Gain = 7.9 dB within +/- 0.2 degrees pointing error



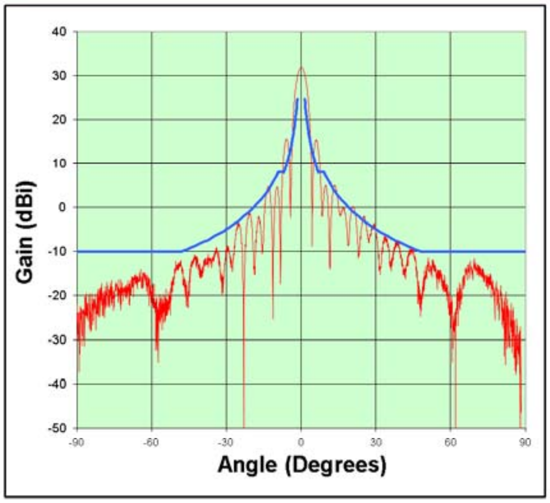
18LP Antenna, 14.125 GHz, El Vertical, Close In, Plot#59
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_El.xls
Maximum Denisty Into Antenna to Meet FCC = -21.9 dBW/4kHz
Pointing Error = +/-0.2 degrees



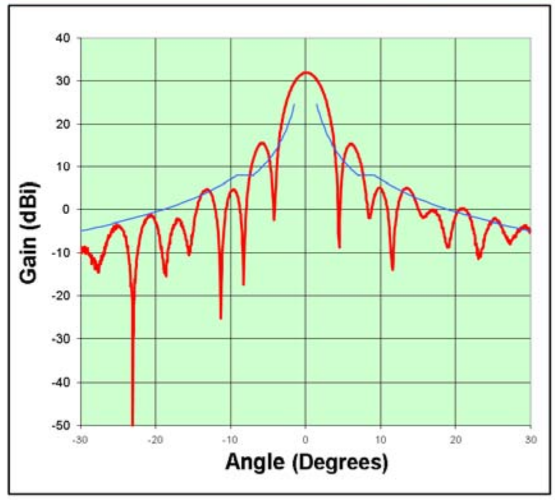
18LP Antenna, 14.125 GHz, El Vertical, Close In, Plot#59
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.125_El.xls
Maximum Denisty Into Antenna to Meet FCC = -21.9 dBW/4kHz
Pointing Error = +/-0.2 degrees



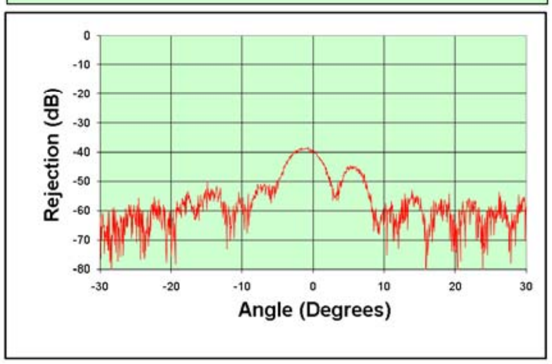
18LP Antenna, 14.5 GHz, El Vertical, +/-90, Plot#60
Gain = 31.8dB
20100707M01V03_LP_14.5_El.xls



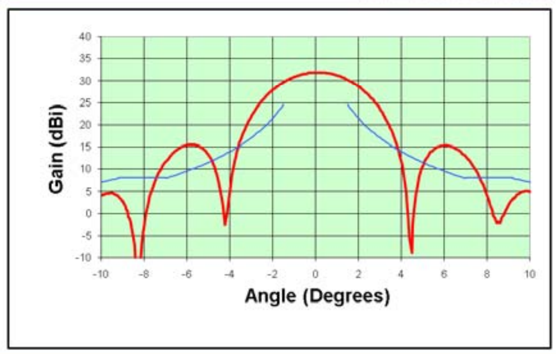
18LP Antenna, 14.5 GHz, El Vertical, Close In, Plot#60
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_El.xls
Gain = 31.9dBi
Maximum Excess Gain = 8.3 dB within +/- 0.2 degrees pointing error



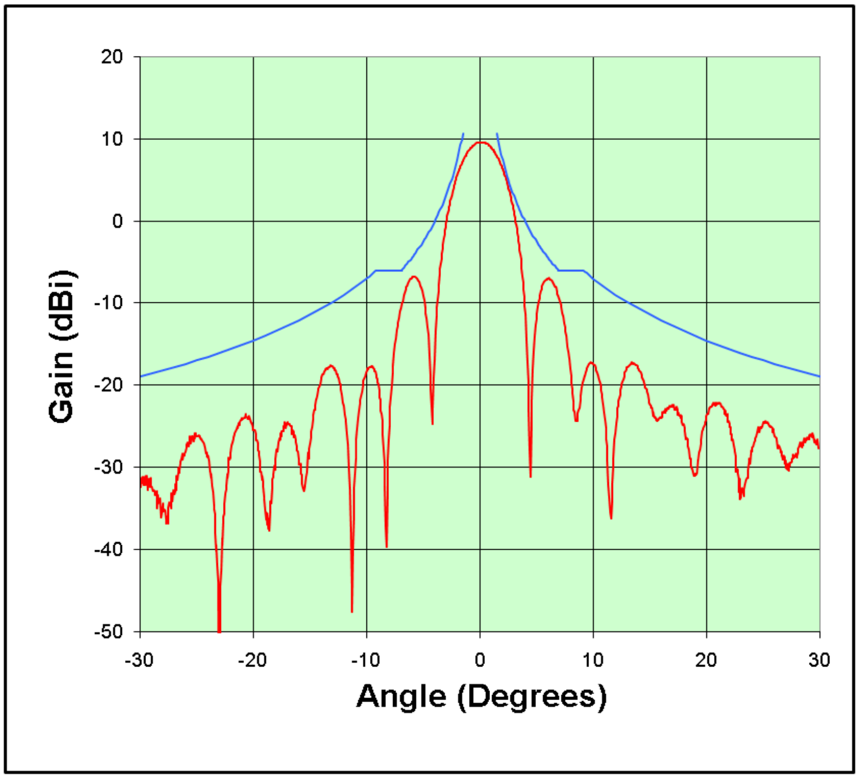
18LP Antenna, 14.5 GHz, El Vertical, Cross-Polarization, Plot#63
Minimum Cross Pol = -38.5dB
20100707M01V03_LP_14.5_El.xls



18LP Antenna, 14.5 GHz, El Vertical, Close In, Plot#60
Gain Vs. FCC25.209
20100707M01V03_LP_14.5_El.xls
Gain = 31.9dBi
Maximum Excess Gain = 8.3 dB within +/- 0.2 degrees pointing error



18LP Antenna, 14.5 GHz, El Vertical, Close In, Plot#60
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.3 dBW/4kHz
Pointing Error = +/-0.2 degrees



18LP Antenna, 14.5 GHz, El Vertical, Close In, Plot#60
Spectral Density Vs FCC 25.226
20100707M01V03_LP_14.5_El.xls
Maximum Denisty Into Antenna to Meet FCC = -22.3 dBW/4kHz
Pointing Error = +/-0.2 degrees