Robust Metropolitan Area Millimeter Wave Network

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28 JAN 08

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Project Summary

The primary objectives of this experimental project are the investigation of the effects of localized weather events on 18/23 GHz and 70/80/90 GHz[1] millimeter wave wireless network performance, and the creation of management and control mechanisms to preserve network performance during these events.

Current generation 70/80/90 GHz commercial wireless systems provide data rates in excess of 1Gbps, but to maintain high reliability during periods of atmospheric precipitation, links paths have historically been limited to short distances, with a maximum range of a few kilometers. Transceivers operating in this frequency range are under consideration for use over longer distances, in parallel with 18/23 GHz systems, to support expanding broadband service needs.

Project goals include the development of novel signaling, routing, and performance evaluation techniques designed to maintain seamless communication across a metropolitan area during events that severely impact one or more individual wireless links.

The project is an interdisciplinary effort, with the involvement of meteorological, wireless systems, and telecommunications network researchers. Experiments are currently being conducted using registered 70/80/90 GHz commercial wireless transceivers at three locations in Lawrence, KS. (Figure 1)

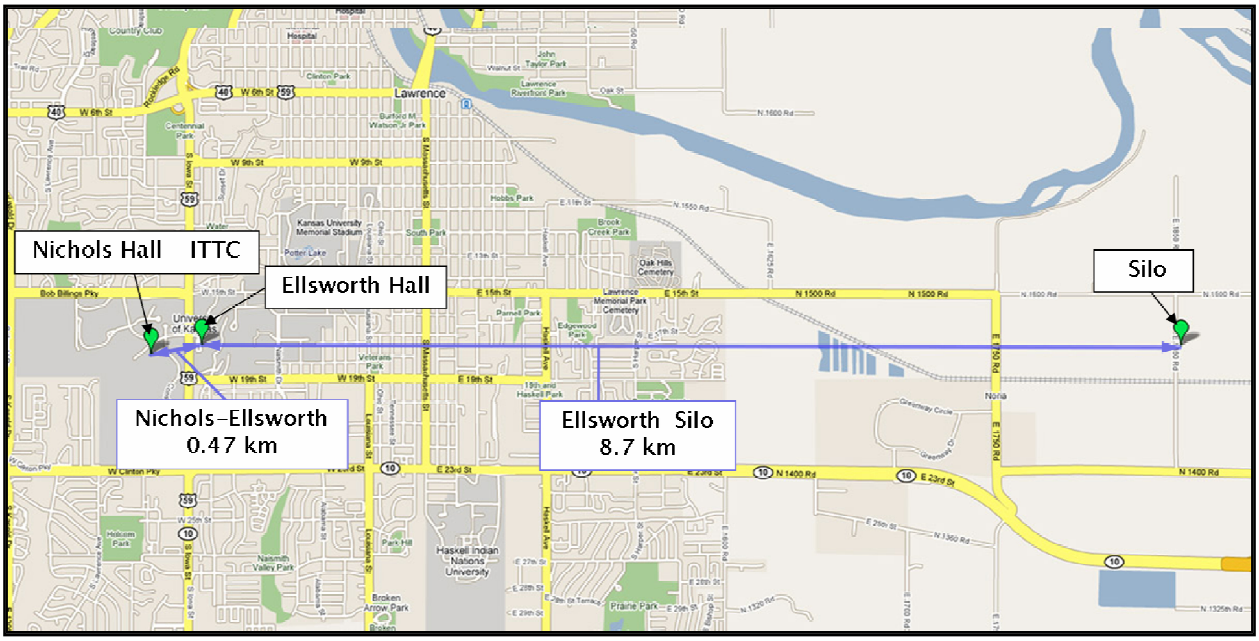


Figure 1

[1] 71-76 GHz, 81-86 GHz and 92-95 GHz bands

In order to provide a comparative benchmark for performance analysis and to support advanced network configuration research, it is desirable to collocate commercial quality 18/23 GHz wireless network systems, and operate these radios in parallel with the transceivers currently in use.

Link Information

Licensing is requested for three site locations to allow the operation of a two 23 GHz wireless links. The first proposed link would bridge a 0.47 kilometer path between a transceiver located on the roof of Nichols Hall on the University of Kansas (KU) west campus, and another on the roof of Ellsworth Hall located on the KU east campus. A second transceiver on the roof of Ellsworth Hall, and a companion radio mounted to a farm silo 8.7 kilometers to the east would complete the second link. Experiments along the Ellsworth Hall to silo path would be conducted with both 30cm (35 dBi) and 60cm (41 dBi) antennas. One set of antennas would be exchanged for another, using the same radio hardware.

To ensure optimal installations and compliance with applicable rules and regulations, the 23 GHz equipment vendor, DragonWave, Inc., has planned to provide installation support and operational training for this effort.

Site Images

Nichols Hall

Ellsworth Hall

Silo

Nichols Hall – Ellsworth Hall Link

Site:	Nichols Hall	Ellsworth Hall
Latitude (NAD 83)	38 ° 57' 7.67" N	38 ° 57' 10.00" N
Longitude (NAD 83)	95 ° 15' 52.25" W	95 ° 15' 33.00" W
Ground Elevation (m/ft-AMSL)	301.0 / 987.53	304.7 / 999.67
Path Azimuth	81.11°	261.12°
Path Length (km / miles)	0.47 / 0.29	
Transceiver Information		
Manufacturer	DragonWave, Inc.	DragonWave, Inc.
Model	AP-200-23	AP-200-23
Model Description	AirPair 200	AirPair 200
Transmit Frequency Range (GHz)*	21.800 – 22.120	23.000-23.352
Channel Bandwidth (MHz)	50	50
Modulation	64 QAM	64 QAM
Stability (%)	0.0001	0.0001
Power (dBm) / (mW)	12.0 / 15.85	12.0 / 15.85
EIRP (dBm) / (W)	46.4 / 43.65	46.4 / 43.65
Transmit / Receive Antenna		
Manufacturer	Andrew	Andrew
Model	VHLP1-23-DW1	VHLP1-23-DW1
Gain (dBi) / Beamwidth / Tilt	35 / 3.00° / -0.8°	35 / 3.00° / 0.8°
Centerline (m / ft – AGL)	64.01 / 210.0	18.29 / 60.0

*A single channel within this range will be selected per FCC Part 101.147 (a)(12)

Ellsworth Hall – Silo Link

Site:	Ellsworth Hall	Silo
Latitude (NAD 83)	38 ° 57' 10.00" N	38 ° 57' 12.00" N
Longitude (NAD 83)	95 ° 15' 33.00" W	95° 9' 31.87" W
Ground Elevation (m / ft-AMSL)	304.7 / 999.67	238.0 / 780.84
Path Azimuth	89.57°	269.63°
Structure Height (m / ft)		
Path Length (km / miles)	8.696 / 5.403	
Transceiver Information		
Manufacturer	DragonWave, Inc.	DragonWave, Inc.
Model	AP-50-23	AP-50-23
Model Description	AirPair 50	AirPair 50
Transmit Frequency Range (GHz)*	23.000-23.352	21.800 – 22.120
Channel Bandwidth (MHz)	50	50
Modulation	QPSK	QPSK
Stability (%)	0.0001	0.0001
Power (dBm) / (mW)	17.0 / 50.1	17.0 / 50.1
Antenna 1 EIRP (dBm) / (W)	52 / 158.5	52 / 158.5
Antenna 2 EIRP (dBm) / (W)	58 / 631	58 / 631
Transmit / Receive Antenna 1		
Manufacturer	Andrew	Andrew
Model	VHLP1-23-DW1	VHLP1-23-DW1
Gain (dBi) / Beamwidth / Tilt	35 / 3.00° / -0.5°	35 / 3.00° / 0.5°
Centerline (m / ft – AGL)	21.0 / 68.9	15.2 / 50.0
Transmit / Receive Antenna 2		
Manufacturer	Andrew	Andrew
Model	VHLP2-23	VHLP2-23
Gain (dBi) / Beamwidth / Tilt	41 / 1.70° / -0.5°	41 / 1.70° / 0.5°
Centerline (m / ft – AGL)	21.0 / 68.9	15.2 / 50.0

*A single channel within this range will be selected per FCC Part 101.147 (a)(12)

AIRPAIR™

North America

Mechanical

Radio (without antenna)	12 cm x 19 cm (diameter); 3.2 kg 4.7 in x 7.5 in (diameter); 7 lbs
Modem (ODU) - Post/Mast Mount	40 cm x 19.6 cm x 8.1 cm; 5.4 kg 15.7 in x 7.7 in x 3.2 in; 12 lbs
Modem (IDU) - Rack Mountable	4.3 cm x 25.4 cm x 42.5 cm; 4.1 Kg 1.7 in x 10 in x 16.7 in; 9 lbs
Antenna Wind Loading	110 kph (70 mph) Operational 200 kph (125 mph) Survival
Antenna Mount Adjustment	+/- 45° Az; +/- 22° El

Payloads

Capacity	Variable from 10 to 200 Mbps full duplex CIR (1522 Byte Packet); 250 Mbps (64 Byte Packet)
Max Capacity (1522 Byte Packet)	(28 MHz-27.5 MHz) 120 Mbps (40 MHz) 170 Mbps (50/55/56 MHz) 200 Mbps
Interface	1000/100/10 BaseT
Latency 100 BT	< 400µs, Typical < 200µs FastE
Latency GigE	< 200µs, Typical 120µs GigE
Packet Size	64 to 1600 Bytes, up 9600 (GigE Mode)
Flow Control	Yes (GigE mode only)
802.1p	Yes – 8 levels served by 4 queues
802.1q	Yes
Modulation Shifting	Current to Lowest – 5 sec

Power

Input	-36 VDC to -60 VDC
Optional Adapter	110/240 VAC
Consumption	50 Watts (per link end) 70 Watts High Power (per link end)

System Gain

AirPair 50	Up to 98 dB
AirPair 50 High Power	Up to 108 dB
AirPair 100	Up to 90 dB
AirPair 100 High Power	Up to 100 dB
AirPair 200	Up to 82 dB
AirPair 200 High Power	Up to 92 dB

Connections ODU

Power	-48V, Cable Supplied
Payload (+ Inband NMS)	MIL Circular (outdoor) RJ45 (indoor)
Craft Terminal	RS 232
IF Cable	N-Type Connector
NMS (when out-of-band)	MIL Circular (outdoor) RJ45 (indoor)

Connections IDU

Power	Dual 48V
Payload (+ Inband NMS)	RJ45 (1000/100 BaseT) or MM Fiber
Craft Terminal	RS 232
IF Cable	N-Type Connector
NMS (when out-of-band)	RJ45 (10 BaseT)

Network Management (NMS)

Alarm Management	SNMP Traps, Enterprise MIB
NMS Compatibility	OpenView, or any SNMP based network manager
Security	3 Level Authentication; Any NOC, Unique Peer to Peer
S/W Update	Remote update to flash, via management channel
EMS	Web Based Management System, SSL HTTP

Environmental

ODU Operating Temperature (Modem + Radio)	
Standard Power	-40°C to + 50°C (-40°F to +122° F)
High Power	-40°C to + 45°C (-40°F to +113° F)
Standard Power + Solar Shield	-40°C to + 60°C (-40°F to +140° F)
IDU Operating Temperature (Modem Only)	0°C to + 40°C (0°F to +104° F)
Humidity	100 % Condensing
Altitude	4500 m (14,760 ft)

Standards

System	FCC Part 101, FCC Part 15, EN 302 217
EMC	EN 301 489, EN 300 385
Safety	CSA 22.2/ANSI 60950,

Specifications subject to change without notice.
* Note: High Stability Tower/Mount Required

General	11 GHz (30 MHz)	11 GHz (40 MHz)	15 GHz	15 GHz	18 GHz	23 GHz	24 GHz UL	24 GHz UL	24 GHz DEMS
Standards	FCC/IC	FCC/IC	IC	Mexico	FCC/IC	FCC/IC	FCC	IC	FCC/IC
Frequency Range (GHz)	10.700-10.970	10.710-10.955	14.500 – 14.780	14.501 – 14.585	17.78-18.14	21.8-22.4	24.05-24.25	24.05-24.25	24.25-24.45
	11.200-11.460	11.200-11.445	14.975 – 15.225	15.229-15.313	19.34-19.68	23.0-23.6			25.05-25.25
T/R Spacing (MHz)	500 & 490	490	475	728	1560	1200	X Polarized	X Polarized	800
Channel Bandwidth (MHz)	30	40	40	28	40/50	50	50	50	20/40
Max Duplex Capacity (Mbps)	120	170	170	120	170/200	200	200	200	67/170
Modulation									
10 – 50 Mbps	N/A	N/A	QPSK	16 QAM	QPSK	QPSK	QPSK	QPSK	QPSK
50-100 Mbps	32 QAM	N/A	16 QAM	32 QAM	16 QAM	16 QAM	16 QAM	16 QAM	32/16 QAM
100-200 Mbps	64 QAM	32/64QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM
Radio	**11 GHz (30 MHz)**	**11 GHz (40 MHz)**	**15 GHz**	**15 GHz**	**18 GHz**	**23 GHz**	**24 GHz UL**		**24 GHz DEMS**
RF Power									
10-50 Mbps	N/A	N/A	27	23	17	17	+5/0	0	17
(Optional High Power)	N/A	N/A	N/A	N/A	27	27	N/A	N/A	N/A
50-100 Mbps	22.5	N/A	23	21	13	13	+3/-2	0	11/13
(Optional High Power)	N/A	N/A	N/A	N/A	23	23	N/A	N/A	N/A
100-200 Mbps	23.5	22 / 22.5	20	22	10/12	12	+2/-3	0	10
(Optional High Power)	N/A	N/A	N/A	N/A	20/22	22	N/A	N/A	N/A
Threshold @ 10-6 BER									
10 – 50 Mbps	N/A	N/A	-82	-79	-81	-81	-78	-78	-81
50-100 Mbps	-75	N/A	-75	-74	-77	-77	-74	-74	-73-/-77
100-200 Mbps	-71	-73 / -69	-70	-70	-69/-68	-68	-65	-65	-69
Antenna Gain(dBi) / Beamwidth (°)	**11 GHz (30 MHz)**	**11 GHz (40 MHz)**	**15 GHz**	**15 GHz**	**18 GHz**	**23 GHz**	**24 GHz UL**	**24 GHz UL**	**24 GHz DEMS**
30 cm / 12" Antenna	N/A	N/A	N/A	N/A	N/A	35.1 / 2.7	35.3 /2.6	35.3 /2.6	35.7 /2.6
60 cm / 24" Antenna	N/A	N/A	36.5 / 2.4	36.5 / 2.4	38.6 / 2.0	40.2/ 1.7	40.7 / 1.4	40.7 / 1.4	41.1 / 1.4
91 cm / 36" Antenna	N/A	N/A	40.0 / 1.6	40.0 / 1.6	42 / 1.3	43.7 / 1.1	N/A	44.2/1.0	44.6 / 1.0
121 cm / 48" Antenna	39.4/1.7	39.4/1.7	42.5 / 1.2	42.5 / 1.2	44.5 / 1.2	46.2 / 0.8	N/A	46.5/0.7	46.5/0.7
182 cm / 72" Antenna*	42.5/1.0	42.5/1.0	45.7 / 0.8	45.7 / 0.8	48 / 0.7	N/A	N/A	N/A	N/A

Product Specifications

ANDREW
A CommScope Company

VHLP1-23

1 ft ValuLine® High Performance Low Profile Antenna, single-polarized, 21.2–23.6 GHz, UG flange, white antenna, white radome

CHARACTERISTICS

General Specifications

Antenna Type	VHLP - ValuLine® High Performance Low Profile Antenna, single-polarized
Diameter, nominal	0.3 m | 1 ft
Antenna Input	UG-595
Polarization	Single
Reflector Construction	One-piece reflector
Antenna Color	White
Radome Color	White
Radome Material Description	Polymer
Flash Included	No
Packing	Standard pack

Electrical Specifications

Operating Frequency Band	21.200 – 23.600 GHz
Gain, Top Band	35.9 dBi
Gain, Mid Band	35.3 dBi
Gain, Low Band	34.7 dBi
Front-to-Back Ratio	62 dB
Cross Polarization Discrimination (XPD)	30 dB
Beamwidth, Vertical	3.0 °
VSWR	1.30
Return Loss	17.7 dB
Radiation Pattern Envelope Reference (RPE)	7014
Electrical Compliance	US FCC Part 101A | Brazil Anatel Class 2 | Canada SRSP 321.8 Part B | ETSI 302 217 Class 3

Mechanical Specifications

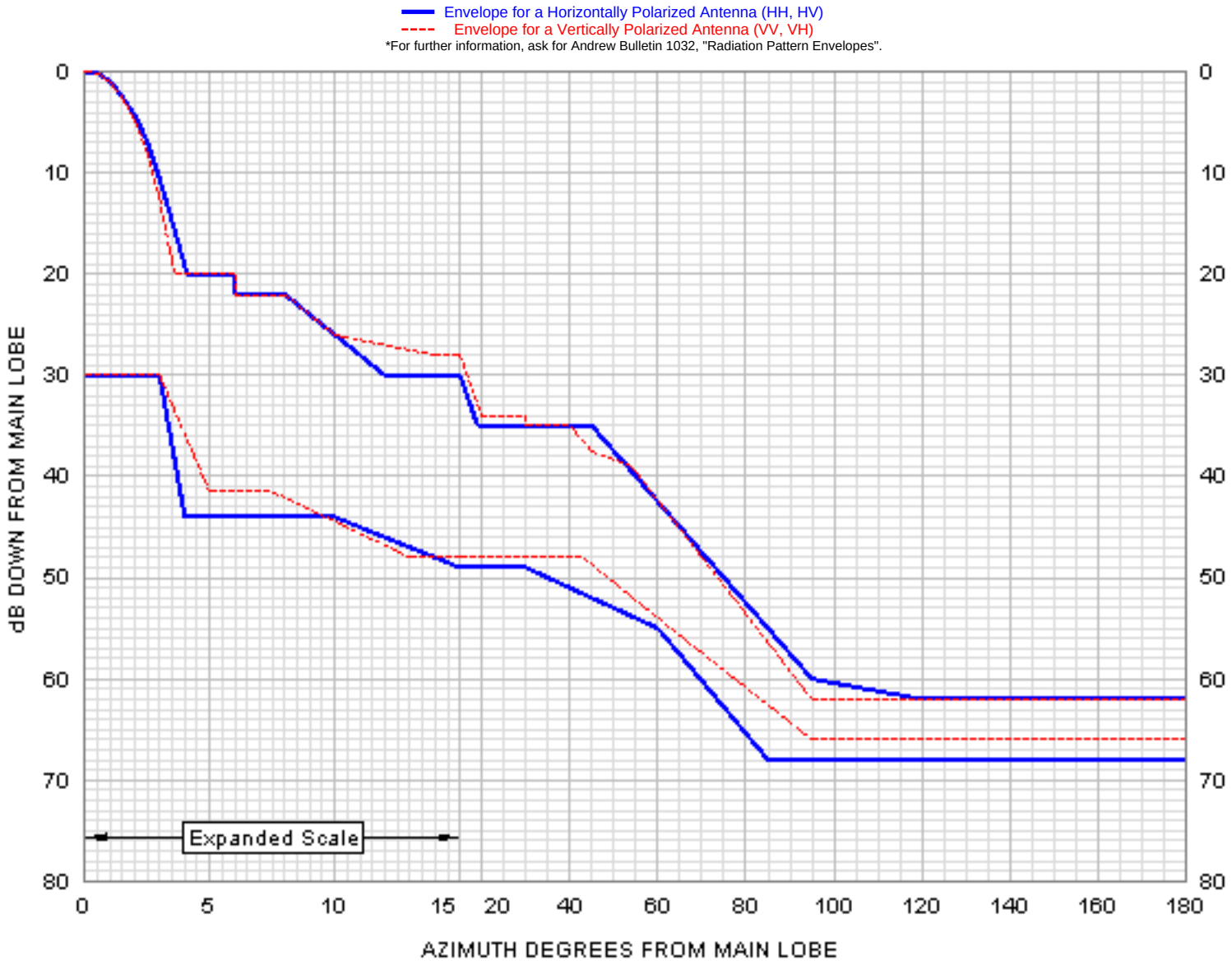
From North America, toll free
Telephone: 1-800-255-1479
Fax: 1-800-349-5444

Outside North America
Telephone: +1-708-873-2307
Fax: +1-770-435-8579

VHLP1-23 - Radiation Pattern Envelope

RPE: 7014

Engineering Approved:
26 October 2004



VHLP1-23 - Radiation Pattern Envelope

RPE: 7014

Engineering Approved:
26 October 2004

H/H		H/V		V/V		V/H	
Angle	**dB**	**Angle**	**dB**	**Angle**	**dB**	**Angle**	**dB**
0.00	0.00	0.00	-30.00	0.00	0.00	0.00	-30.00
0.52	-0.14	3.00	-30.00	0.52	-0.14	3.00	-30.00
1.00	-0.90	4.00	-44.00	1.00	-1.01	5.00	-41.50
1.50	-2.40	10.00	-44.00	1.50	-2.50	7.50	-41.50
2.03	-4.36	15.00	-49.00	2.03	-5.00	13.00	-48.00
2.50	-6.90	30.00	-49.00	2.50	-8.00	15.00	-48.00
3.00	-10.60	60.00	-55.00	3.00	-12.50	43.00	-48.00
3.44	-14.30	85.00	-68.00	3.60	-20.00	60.00	-54.00
4.10	-20.00	180.00	-68.00	6.00	-20.00	95.00	-66.00
6.00	-20.00			6.00	-22.00	180.00	-66.00
6.00	-22.00			8.00	-22.00		
8.00	-22.00			10.00	-26.00		
10.00	-26.00			14.00	-28.00		
12.00	-30.00			15.00	-28.00		
15.00	-30.00			20.00	-34.00		
19.00	-35.00			30.00	-34.00		
45.00	-35.00			30.00	-35.00		
95.00	-60.00			40.00	-35.00		
120.00	-62.00			45.00	-37.50		
180.00	-62.00			54.00	-39.00		
				95.00	-62.00		
				180.00	-62.00		

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Suite 900
Westchester, Illinois 60154 USA

Corporate Web Site: http://www.andrew.com

Customer Service Center: 1-800-255-1479
Outside North America Telephone +1 708 873-2307

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A CommScope Company

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Radome Color	White
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Packing	Standard pack

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Cross Polarization Discrimination (XPD)	30 dB
Beamwidth, Vertical	3.0 °
VSWR	1.30
Return Loss	17.7 dB
Radiation Pattern Envelope Reference (RPE)	7014
Electrical Compliance	US FCC Part 101A | Brazil Anatel Class 2 | Canada SRSP 321.8 Part B | ETSI 302 217 Class 3

Mechanical Specifications

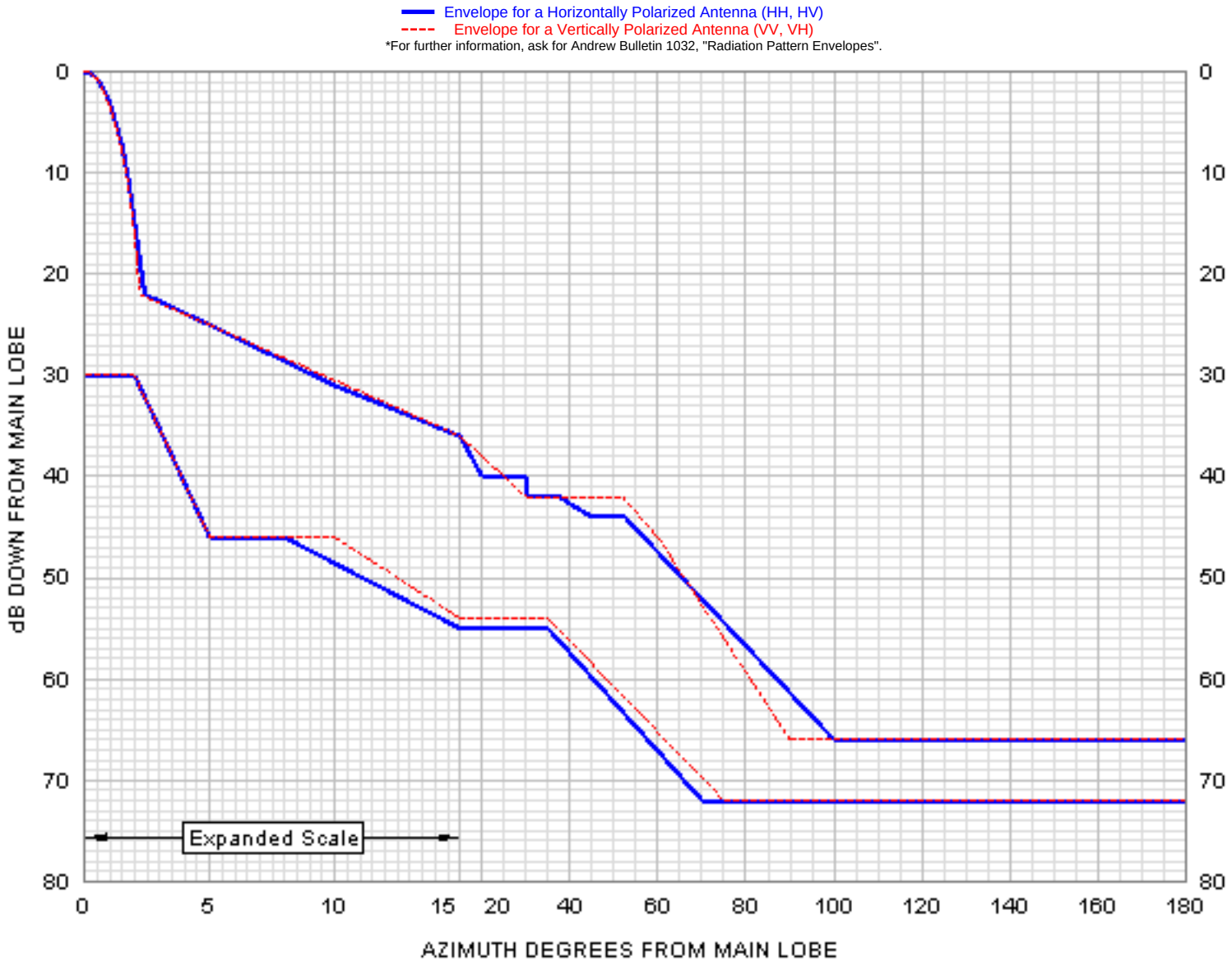
From North America, toll free
Telephone: 1-800-255-1470
Fax: 1-800-349-5444

Outside North America
Telephone: +1-708-873-2307
Fax: +1-779-435-8579

VHLP2-23 - Radiation Pattern Envelope

RPE: 7016

Engineering Approved:
25 October 2004



VHLP2-23 - Radiation Pattern Envelope

RPE: 7016

Engineering Approved:
25 October 2004

H/H		H/V		V/V		V/H	
Angle	**dB**	**Angle**	**dB**	**Angle**	**dB**	**Angle**	**dB**
0.00	0.00	0.00	-30.00	0.00	0.00	0.00	-30.00
0.25	-0.14	2.00	-30.00	0.25	-0.14	2.00	-30.00
0.50	-0.68	5.00	-46.00	0.50	-0.68	5.00	-46.00
0.75	-1.68	8.00	-46.00	0.75	-1.88	10.00	-46.00
1.00	-3.00	15.00	-55.00	1.00	-3.28	15.00	-54.00
1.25	-5.11	30.00	-55.00	1.25	-5.41	35.00	-54.00
1.50	-7.31	35.00	-55.00	1.50	-7.71	75.00	-72.00
1.75	-10.70	70.00	-72.00	1.75	-11.16	180.00	-72.00
2.00	-15.00	180.00	-72.00	2.00	-15.90		
2.40	-22.00			2.20	-22.00		
5.00	-25.00			5.00	-25.00		
10.00	-31.00			15.00	-36.00		
15.00	-36.00			30.00	-42.00		
20.00	-40.00			52.00	-42.00		
30.00	-40.00			60.00	-46.00		
30.00	-42.00			90.00	-66.00		
37.50	-42.00			180.00	-66.00		
45.00	-44.00						
52.50	-44.00						
100.00	-66.00						
180.00	-66.00						

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