SDSU MASTERS of HOMELAND SECURITY

GEOL600 SENSOR NETWORKS

LONG DISTANCE LINKS

- Microwave cable guide
- Microwave connector guide
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MICROWAVE CABLE GUIDE

Not all coaxial cable is suitable for 2.4GHz, tv coaxial cable is useless for microwave applications. Due to **signal loss**, type and length of cable is as important as good antenna selection.

From left to right: LMR, Heliax, 9913

LMR (manufacturer: Times Microwave)
-braided outer shield and solid core inner conductor
-most popular cable used for extending 802.11b networks

Heliax (manufacturer: Andrew)
-semi rigid corrugated outer shell / solid or corrugated inner tube conductor
-can handle loads much greater than legal 802.11 installations
-extremely low loss, very expensive, can be difficult to work with
-LDF (foam dielectric type heliax)

9913 (manufacturer: Belden)
-common coax for 2.4GHz applications

Cable	Diameter (inches)	Loss in dB/100' at 2.5GHz	Approx.Price (per foot)
LMR-200	0.195	16.9	$ 0.37
LMR-400	0.405	6.8	$ 0.64
LMR-600	0.509	4.4	$ 1.30
LMR-900	0.870	3.0	$ 3.70
LMR-1200	1.2	2.3	$ 5.50
Belden 9913	0.405	8.2	$ 0.97
LDF1-50	0.250	6.1	$ 1.66
LDF4-50A	0.5	3.9	$ 3.91
LDF5-50A	0.875	2.3	$ 2.27
LDF6-50	1.250	1.7	$10.94
LDF7-50A	1.625	1.4	$15.76

Generally speaking, the thicker and better built the cable, the smaller the signal loss and the greater the cost. Cable in excess of ½ inch in diameter can be unwieldy and hard to find connectors.

Order the cable as close to the specific length required to minimize loss, and if possible have the proper connectors professionally attached.

If mounting the antenna externally, consider waterproof housings for radio equipment and mount it close to the antenna, and run ethernet cable (up to 100m) to the radios.

Flickenger, Wireless Hacks, O'Reilly

MICROWAVE CONNECTOR GUIDE

BNC *'Bayonet Neill Concelmann' connector*

used for 10base2 connectors,
not suited for 2.4GHz use due to leakage.
DO NOT USE

TNC *'Threaded BNC'*

fine thread eliminates leakage at microwave frequencies
TNCs work well up through 12GHz

N *'Neill's connector'*

commonly used large threaded connector, works well on thicker cable (LMR400)
Operates well up to 10GHz

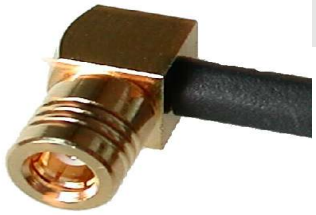
UHF connector

looks like coarse threaded N type connector, larger conductor plug and socket
Not designed for use at 2.4GHz

DO NOT USE

SMA *Subminiature version A*

Good through 18GHz

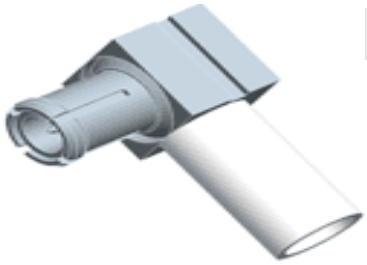


SMB *Subminiature version B*

smaller version of SMA, with snap-on coupling
good broadband capability through 4GHz

SMC *Subminiature version C*

Threaded coupling
Good through 10GHz



MCX

30% smaller than SMB,
Good through 6GHz

MMCX: micro miniature version

RP-connectors

Reverse polarity (reverse gender) connectors are as above but with reversed male/female connectors and same or reversed threads. There are many variations so be aware of what your equipment requires.

www.amphenolrf.com/products.asp

PIGTAILS

MCX to BNC

MMCX to N male

Pigtail adapters allow radio equipment with external small size antenna connectors to be hooked up to larger less lossy cables for longer cable runs or to additional signal conditioning hardware.

Pigtails are extremely lossy compared to larger cable, so it is generally a good idea to keep them as short as possible.

The small connectors are fragile, anchor the pigtail in some manner to minimize strain on the connector.

ANTENNAS

Selection of Antennas
Omni,grid dish, solid dishes,
panel and sector

www.tiltek.com/products/products.html

Antenna gain is used to indicate the increase in power of one antenna (transmitting or receiving) as compared to another antenna. Gain is actually a ratio of power levels and is stated in decibels dBi.

The reference level is the strength of the signal that would be transmitted by a non-directional isotropic antenna (radiates equally in all directions).
Such an antenna exists as a mathematical concept used only as a known reference to measure antenna gain. An isotropic antenna has a **dBi gain** of **0**

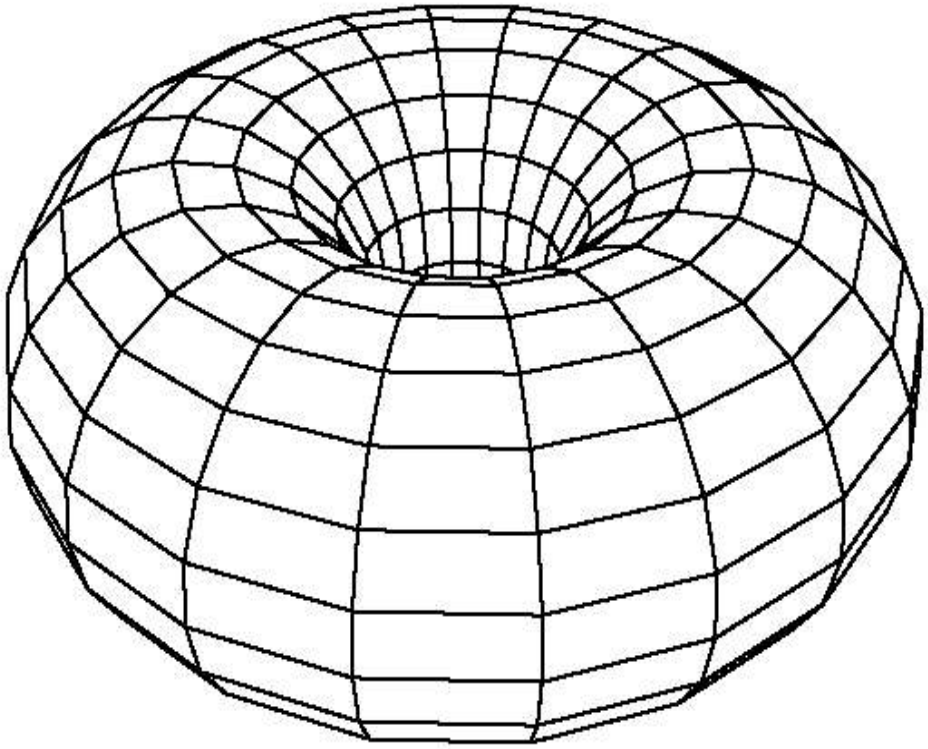
The dipole or basic antenna concentrates it signals in two directions.. The dipole has a 2.1 dBi measurement gain over an isotropic radiator.

Every 3 dBi of improvement added to an antenna results in a noticeable improvement at the receiving station.

OMNI Omnidirectional antenna

Radiate horizontally in roughly equal manner.
Good for covering large area when location of clients is unknown.
Receive noise from every direction as well, so are less efficient than directional antennas.

Mounted vertically, gain is in horizontal plane at detriment of vertical, worst reception is directly above / below antenna.

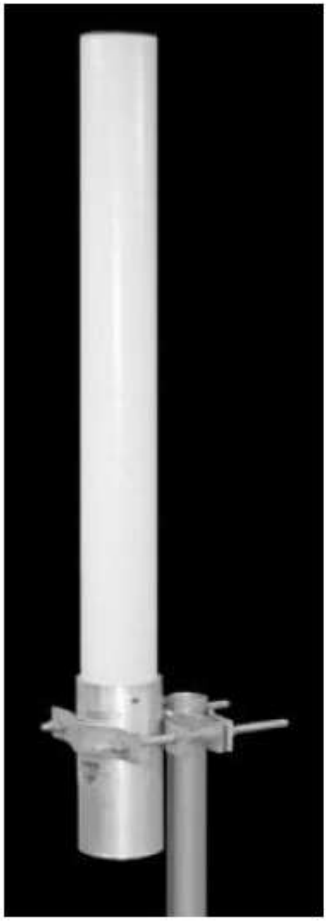


TIL-TEK

LANtenna Series

TA-2450H Omnidirectional

2400-2483 MHz



The TA-2450H is a 9.5 dBi horizontally polarized omnidirectional antenna designed specifically for the 2.4 GHz ISM band. Pattern shaping and null fill provide optimum coverage while superior cross polarization discrimination allows operators to provide service in areas congested with vertically polarized systems. The antenna is at DC ground to aid in lightning protection.

Electrical Specifications

Frequency Range: 2400-2483 MHz
Gain: 9.5 dBi
VSWR: 1.6:1 max.
Polarization: Horizontal
Power Rating: 1 Watt
H-Plane Beamwidth: 360 degrees
E-Plane Beamwidth: 7 degrees
Cross Pol. Discrimination: 20 dB min.
Impedance: 50 ohms nominal
Termination: N female

Typical mid band values. (For details , contact factory)

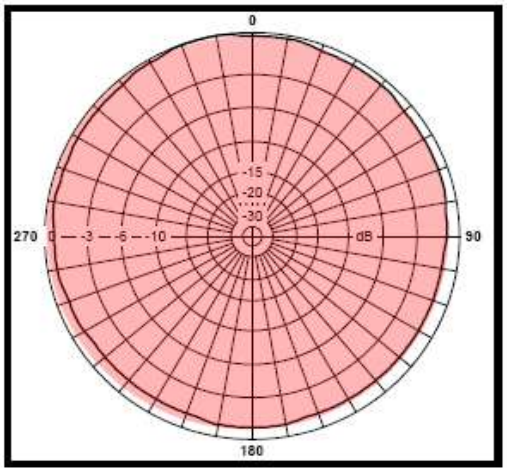
Mechanical Specifications

Length: 51 in. (1295 mm)
Diameter: 3 in. (76 mm)
Weight (Incl. Clamps): 12 lb. (5.4 kg)
Rated Wind Velocity: 125 mph (200 km/h)
Hor. Thrust at rated wind: 44 lb (19.9 kg)
Mounting (O.D.): 1.75 - 4.0 in. (44.5 - 102 mm)

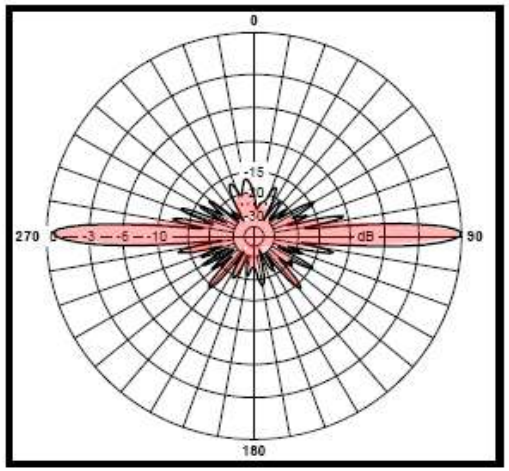
Materials

Radiating Elements: Plated Copper on PCB
Radome: Gray UV stabilized fiberglass
Clamps: EDZ steel

E-Plane



H-Plane



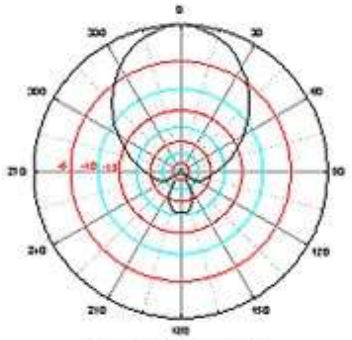
SECTOR Sectoral antenna

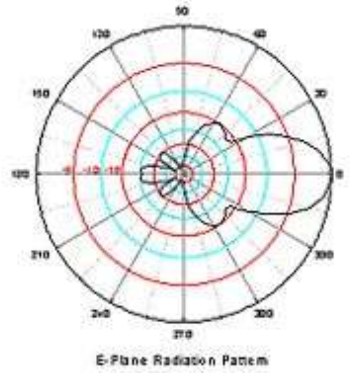
Sector antennas come in all shapes and sizes, from flattened omnis to small flat panels.

They can be ceiling mounted to provide access to a single room.

Beam pattern can be thought of as an omni with a reflector behind it. Beam width can be as wide as 180 degrees or as narrow as required.

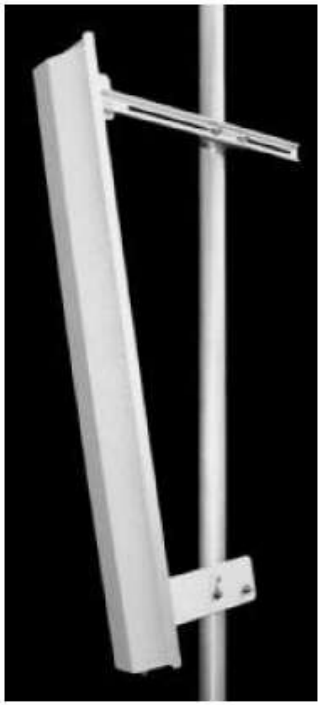
Useful in point-to-multipoint applications where multiple clients will be accessing network from the same general direction.





TIL-TEK

LANtenna Series
TA-2404-8-120 Sector
2400-2483 MHz



The TA-2404-8-120 is a vertically polarized 120 degree sectoral antenna. It was designed specifically for wireless data and point-to-multipoint radio applications. Radiating elements are protected by a weatherproof radome for operation under severe weather conditions (icing, salt air, acid rain, etc.) and are at DC ground to aid in lightning protection.

Electrical Specifications

Frequency Range: 2400-2483 MHz
Gain: 14 dBi
VSWR: 1.5:1 max.
Front to Back Ratio: 20 dB typical
Polarization: Vertical
Power Rating: 100 Watts
H-Plane Beamwidth: 120 degrees
E-Plane Beamwidth: 7 degrees
Cross Pol. Discrimination: 15 dB min.
Impedance: 50 ohms nominal
Termination: N female

Typical mid band values. (For details , contact factory)

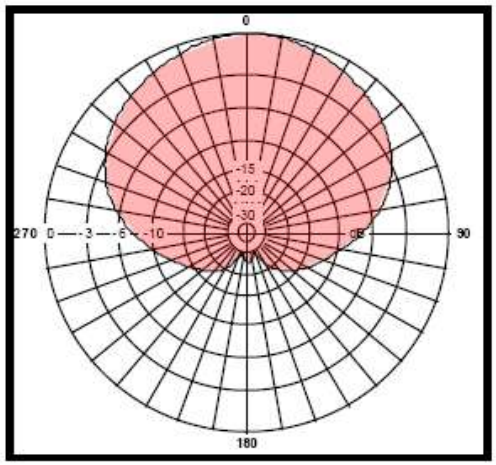
Mechanical Specifications

Length: 40 in. (1016 mm)
Width: 5.1 in. (129 mm)
Depth: 3 in. (76 mm)
Weight (incl. Clamps): 7.5 lb. (3.4 kg)
Rated Wind Velocity: 125 mph (200 km/h)
Hor. Thrust at rated wind: 87 lb. (39.5 kg)
Mechanical Tilt: 0 - 15 degrees
Mounting (O.D.):0.75 - 2.0 in. (19 - 50 mm)

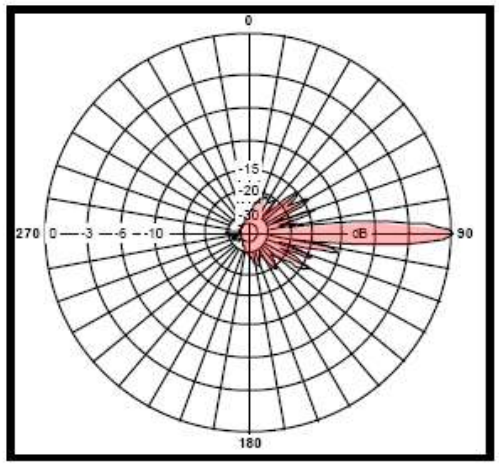
Materials

Radiating Elements: Tin plated copper on PCB
Reflector: Irridited aluminum
Radome: Gray UV stabilized ASA
Clamps:HDG steel

H-Plane

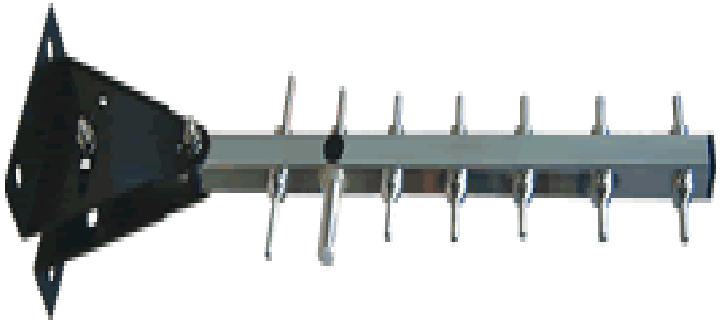


E-Plane



YAGI-UDA Directional antenna

Can have elements exposed or encased in protective housings.
Good for point-to-point or point-to-multipoint

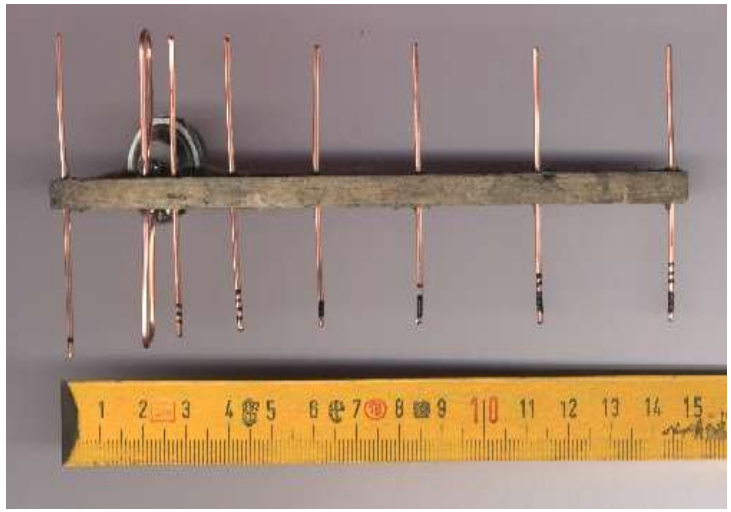


Beamwidth can vary from 15 to 60 degrees depending on construction.

Consists of an array of a dipole and additional parasitic elements. (passive radiators)

The dipole in the array is driven, and another element, slightly longer, operates as a reflector.
Other shorter parasitic elements can be added in front of the dipole as directors.

A parasitic element does not have any wired input, it absorbs radio waves radiated from another active antenna element in close proximity, and re-radiates it.
This same effect happens in everyday life, as anything metal near a receiver can distort signals in this manner.
People and pets are parasitic elements, as body water also conducts radio waves.

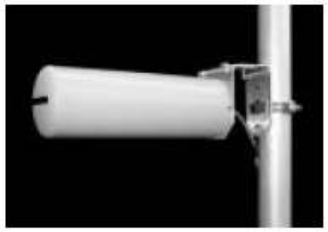


TIL-TEK

LANtenna Series

TA-2411 Yagi

2400-2483 MHz



The TA-2411 is a vertically or horizontally polarized yagi antenna. The antenna consists of a printed broadband yagi enclosed in a UV stabilized ASA radome for superior weatherability. It is designed for wireless data in the ISM band and is at DC ground to aid in lightning protection.

Electrical Specifications

Frequency Range: 2400-2483 MHz
Gain: 11.5 dBi
VSWR: 1.5:1 max.
Front to Back Ratio: 15 dB min.
Polarization: Vertical or Horizontal
Power Rating: 100 Watts
H-Plane Beamwidth: 47 degrees
E-Plane Beamwidth: 42 degrees
Cross Pol. Discrimination: 15 dB
Impedance: 50 ohms nominal
Termination: N female

Typical mid band values. (For details , contact factory)

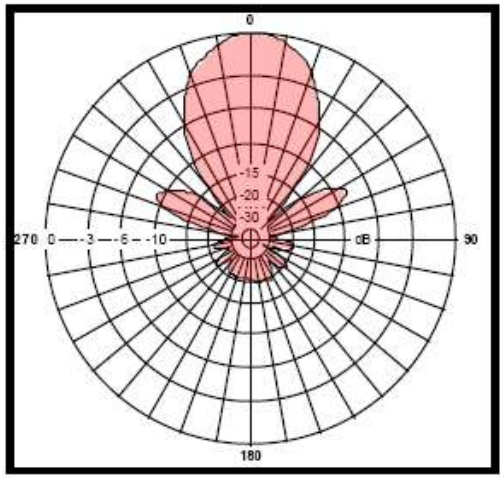
Mechanical Specifications

Length: 10.5 in. (267 mm)
Diameter: 3 in. (76 mm)
Weight (Incl. Clamps): 2 lb. (0.9 kg)
Rated Wind Velocity: 125 mph (200 km/h)
Hor. Thrust at rated wind: 9 lb. (4 kg)
Mechanical Tilt: 0 - 30 degrees
Mounting (O.D.): 0.75 - 3.0 in. (19 - 76 mm)

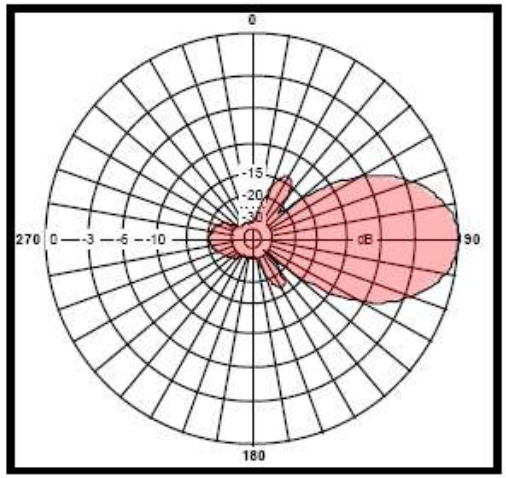
Materials

Radiating Elements: Plated copper on PCB
Reflector: Irridited aluminum
Radome: Gray UV stabilized ASA
Clamps: Aluminum and HDG steel

H-plane



E-Plane



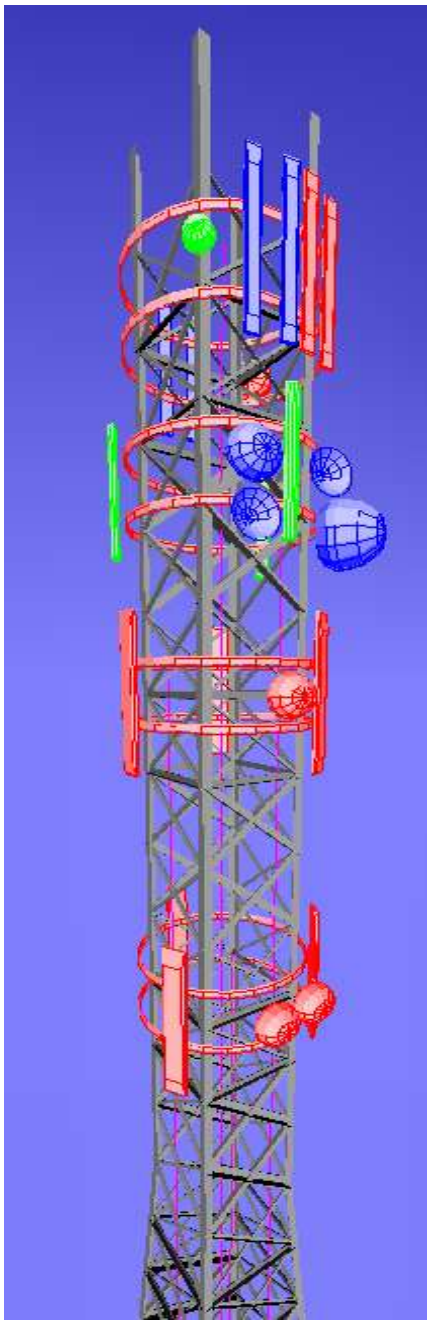
SOLID PARABOLIC

Dishes are highly focussed directional antennas. They typically have highest gain and most directionality of any antenna.

Best suited for point-to-point links.

Can be fitted with protective covers.

Mounting should take into account wind effects, solid dishes pick up more load than grid dishes.



TIL-TEK

LANtenna Series
TA-2424 Solid Parabolic
2400-2483 MHz

TA-2424

TA-2424R

The TA-2424 is a 24 inch diameter solid parabolic antenna. The antenna feed is bolted to the aluminum reflector so the polarization can easily be changed in the field by rotating the antenna through 90 degrees. A full radome (TA-2424R) is also available for extreme weather conditions.

Electrical Specifications

Frequency Range: 2400-2483 MHz
Gain: 21 dBi
VSWR: 1.5:1 max.
Front to Back Ratio: 25 dB min.
Polarization: Vertical or Horizontal
Power Rating: 100 Watts
H-Plane Beamwidth: 13.5 degrees
E-Plane Beamwidth: 15 degrees
Cross Pol. Discrimination: 25 dB min.
Impedance: 50 ohms nominal
Termination: N female

Typical mid band values. (For details , contact factory)

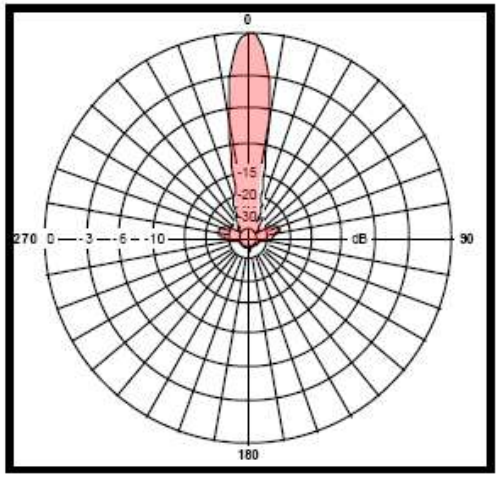
Mechanical Specifications

Diameter: 25.25 in. (489 mm)
Depth: 8.0 in. (204 mm)
Weight (Incl. Clamps): 20 lb. (9.1 kg)
Rated Wind Velocity: 125 mph (200 km/h)
Hor. Thrust at rated wind: 234 lb. (106.4 kg)
with radome 120 lb (54.4 kg)
Mechanical Tilt: 0 - 15 degrees
Mounting (O.D.): 1.75 - 4.0 in. (44.5 - 102 mm)

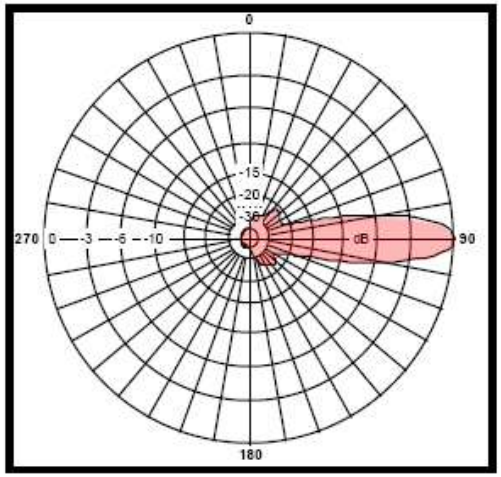
Materials

Radiating Elements: Plated Copper on PCB
Reflector: Irridited aluminum
Radome: Gray UV stabilized ASA
Clamps: Aluminum and HDG steel

H-Plane



E-Plane



GRID PARABOLIC

Parabolic grid antennas are similar in gain to solid parabolic dishes.
They are designed for harsh wind environments, as the open grid catches less wind than a solid dish.

2.4GHz antennas can also be obtained for some video transmission systems which also operate in this frequency band. Pictured right, a small form factor 2.4GHz half parabolic grid.

TIL-TEK

LANtenna Series

TA-2448 Grid Parabolic

2400-2483 MHz

The TA-2448 is a grid parabolic antenna with a broadband dipole horn feed which is sealed for superior weatherability. The antenna is at DC ground to aid in lightning protection. This antenna is extremely rugged and is designed to provide superior performance in any conditions.

Electrical Specifications

Frequency Range: 2400-2483 MHz
Gain: 27 dBi
VSWR: 1.5:1 max.
Front to Back Ratio:
Polarization: Vertical or Horizontal
Power Rating: 200 Watts
H-Plane Beamwidth: 8.6 degrees
E-Plane Beamwidth: 7.5 degrees
Cross Pol. Discrimination: 30 dB min.
Impedance: 50 ohms nominal
Termination: N female

Typical mid band values. (For details , contact factory)

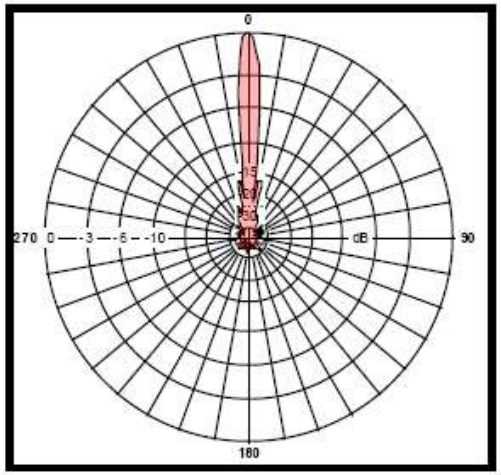
Mechanical Specifications

Diameter: 50.5 in. (1283 mm)
Weight (Incl. clamps): 50 lb. (22.7 kg)
Rated Wind Velocity: 125 mph (200 km/h)
Hor. Thrust at rated wind: 304 lb. (138.2 kg)
Mechanical Tilt: 0 - 15 degrees
Mounting (O.D.): 1.75 - 4.5 in. (44.5 - 114 mm)

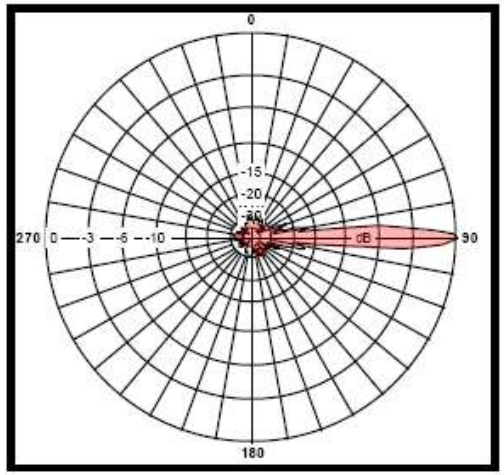
Materials

Radiating Elements: Aluminum
Reflector: Irridited aluminum
Clamps: HDG steel

H-Plane



E-Plane



CANTENNA (directional waveguide antenna)

COMMERCIAL VENDOR:
www.cantenna.com

12 dBi gain
30 degree beamwidth

advantage of commercial version:
connectors / pigtails assembled professionally

BUILD YOUR OWN:
variety of websites available, eg:
www.turnpoint.net/wireless/cantennahowto.html

How To Build A Tin Can Waveguide WiFi Antenna

for 802.11(b or g) Wireless Networks or other 2.4GHz Applications

Got no dough for a commercial WiFi antenna? Looking for an inexpensive way to increase the range of your wireless network? A tin can waveguide antenna, or Cantenna, may be just the ticket. This design can be built for under $5 U.S. and reuses a food, juice, or other tin can.

I am not an electrical engineer, nor do I have access to any fancy test equipment. I've built some antennas that worked for me and thought I would share what I learned. I have no idea if this is safe for your radio or wireless network equipment. The risk to you and your equipment is yours.

Building your Cantenna is easy, just follow these steps.

1. **Collect the parts**
2. **Drill or punch holes in your can to mount the probe**
3. **Assemble the probe and mount in can**

WOKTENNA (directional antenna)

BUILD YOUR OWN:

www.usbwifi.orcon.net.nz

COMMERCIAL VENDOR:

www.keybola.com

(Czech)

WIRELESS NIC CAPABILITIES

Wide range of vendors and products available

Name	Interface	Tx power (mW)	Rx sensitivity 11/5.5/2/1Mbps (dBm)	Connector
3com Airconnect	PCMCIA	30	-81/-84/-85/-87	Dual MMCX
Cisco 340	PCMCIA	20	-83/-87/-88/-90	Aironet
Cisco 350	PCMCIA	100	-85/-89/-91/-94	Aironet
Dlink DWL250	PCI	30	-80/-83/-86/-89	RP-SMA
Dlink DWL650	PCMCIA	30	-84/-87/ x /-90	None
Senao 2511	PCMCIA	200	-89/-91/-93/-95	Dual MMCX
Senao 2011	PCMCIA	100	-87/-89/-91/-93	Dual MMCX
Linksys WPC11	PCMCIA	25	-76/ x / x /-80	None
Linksys WMP11	PCI	30	-82/ x / x / x	RP-SMA
Netgear MA101	USB	20	-84/-87/-89/-91	None
Orinoco silver/gold	PCMCIA	30	-82/-87/-91/-94	Lucent
ZcomMax Xi-325	PCMCIA	100	-92/ x / x / -85	MMCX

Flickenger, Wireless Hacks, O'Reilly

When choosing WiFi NICs (or any hardware for that matter), choose product that provides greatest functionality within budget.
(unless you plan to do nothing with your equipment)
Select for maximum transmit power, best receiver sensitivity and presence of external antenna connector

SeattleWireless.net provides comprehensive hardware comparison guide kept up to date with current offerings, covering

- 802.11b Client Adapters
- 802.11b Access Points/Routers
- 802.11b bridges
- 802.11g Client Adapters
- 802.11g Access Points/Routers
- 802.11g bridges
- 802.11a bridges
- 802.11a Client Adapters
- 802.11a/802.11b/802.11g Dual & Triple Band (2.4GHz/5GHz) Client Adapters
- Dedicated Routers
- ISA/PCI adapters

FreeNetworks.org also lists RX sensitivity for known devices

www.seattlewireless.net/index.cgi/HardwareComparison

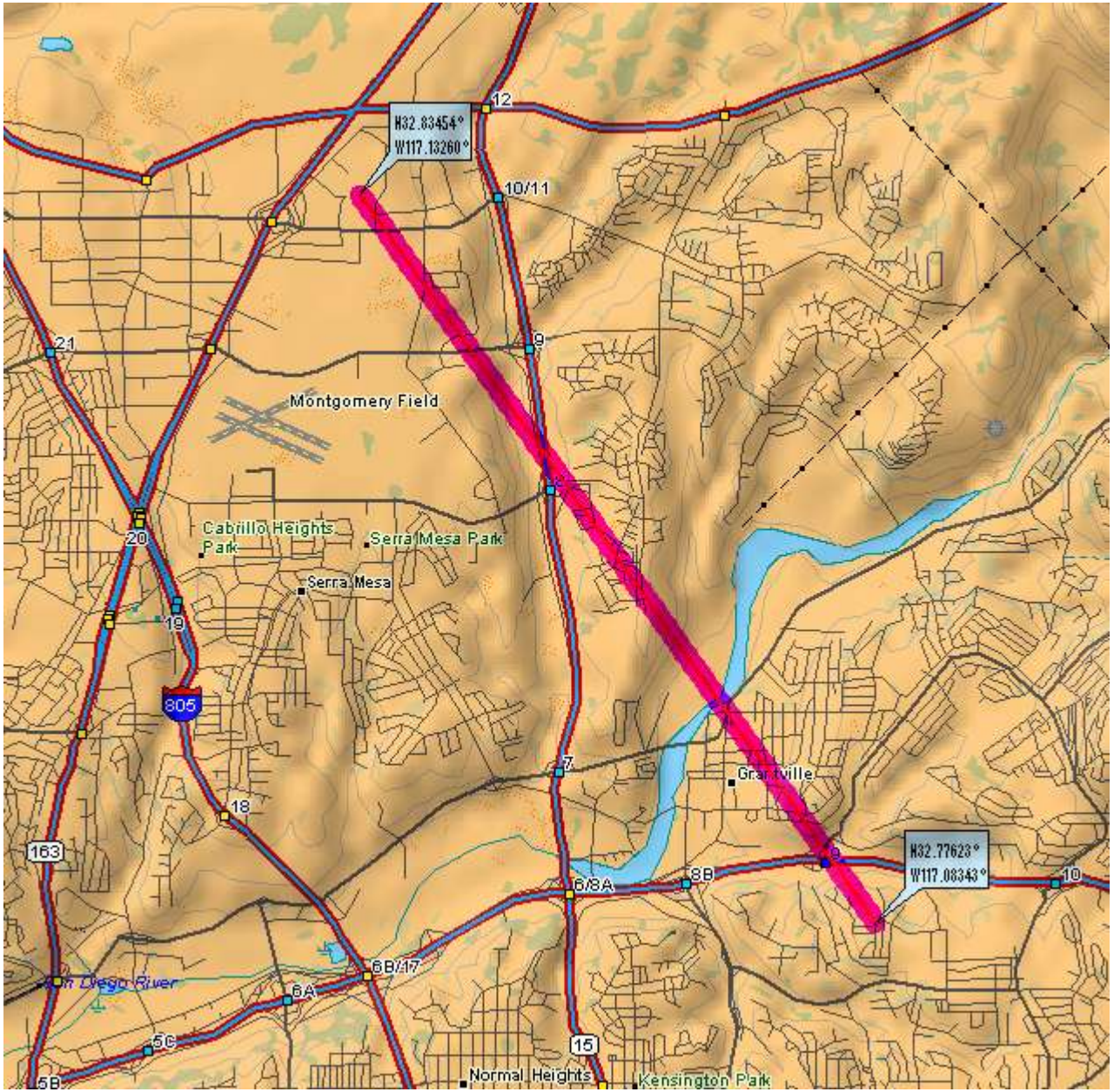
freenetworks.org/moin/index.cgi/ReceiveSensitivity

1 802.11b Client Adapters

Card Name	Interface type(s)	Power	Price(s)	Ant. Connector	Comments	Chipset	Drivers for
1stWave Wavemaxxpro	PCMCIA	100 mW	98 Euros	NO	--	Prism ?	[LinuxDrivers | Linux] - BSD?
Actiontec HWC01170-01	PCMCIA	?	32ukp	None	Poor range	Prism 3	Windows Linux BSD
3com AirConnect	PCMCIA	30 mw	$150	2xMMCX!!!	AirconnectComments	Prism?/Symbol?	Linux/[open|free]BSD
3e-110	PCMCIA	200 mw	$60	None (Int. Antenna)	physically identical to Senao, but different driver; RF Manager (adjusts TX power) is available for ~$10	Prism 2.5	Windows NT/2000/ME/CE/XI
AddtronCard	PCMCIA	30mw	$130	None	AddtronCardComments?	IntersilPrism	Linux
Belkin F5D6001	PCI 2.1	Version 2: 31dBm	$104 F5D6001? PCI Card - $24.99 F5D6900? Desktop antenna	External Detachable Rubber Antenna unscrews to SMA connector	Optional desktop omni antenna with 5 foot cable (F5D6900)	Version 1: Prism2.5 Version 2101: ADM8211	Driver Windows 95 , 98SE,Me NOTE:- No Linux drivers sup open-source driver for NetBSI
Belkin F5D6020? (Ver. 1)	PCMCIA Pic	13 dBm ~ 20 dBm (50mW) (max)	?	PCB mount for optional SMA/MMCX jack	Discontinued, Rebranded Eumitcom (Now Accton) WL11000-1 card, Optional PCI Adapter F5d6000 (Also discontinued, only works w/ Ver.1 card)	Intersil HF3841CN Prism 2 Chipset	Works beautifully w/linux :-)
Belkin F5d6020 Ver.2	PCMCIA 16 Pic	17 dBm (50mW)	$50(Amazon), $25 (PriceGrabber), $29 (Sears until 10/25/03)	U.FL jack? connector and other pics	same as SMC 2632W V2	Atmel AT76C502A	Works w/linux driver HOW TO belkin_howto
Belkin F5D6020? Ver.3	Cardbus	16 dBm - 18 dBm (40 mW - 63 mW)	?	None	Rebranded EDIMAX EW-7106PC	RealTek Rtl8180	Win98,Win2k, WinXP
Belkin F5d6050 (Ver.1)	USB 1.1	13dBm?	?	Dual Dipole Antennas (Int. PCB U.FL jack? and mount for SMA/MMCX End Launch Jack)	Same Chipset as Netgear MA101	Atmel AT76C503A	Windows 9x/ME/2000/XP/
Belkin F5d6050 (Ver.2 / F5d6051)	USB 2.0	?	?	Single Antenna	?	?	?
Belkin F5d6060	Compact Flash	?	?	?	?	?	?
Cisco AIR-LMC352	PCMCIA	100mw	$105(Amazon), $102 (PriceGrabber)	Dual MMCX		Aironet	Linux, BSD, OSX
Cisco AIR-PCM352	PCMCIA	100mw	$115(Amazon), $106 (PriceGrabber)	No		Aironet	Linux, BSD, OSX
Cisco AIR-PCI352	PCI	100mw	$199(Amazon), $188 (PriceGrabber)	RP TNC		Aironet	Linux, BSD, OSX

LONG DISTANCE LINE OF SIGHT (LOS)

Objective: Connect SD County EOC to SDSU Chapultepec



Wireless buffs are demonstrating use of 802.11 devices for reliable data links of 10 miles or more. Long distance links are dependent on having a clear line of sight (LOS) between stations.

When scouting prospective locations, be sure to have a GPS to obtain accurate lat/lon and elevation.

Positions can be entered into topographic mapping software to allow determination of terrain LOS characteristics.
(buildings and vegetation obviously are not known)

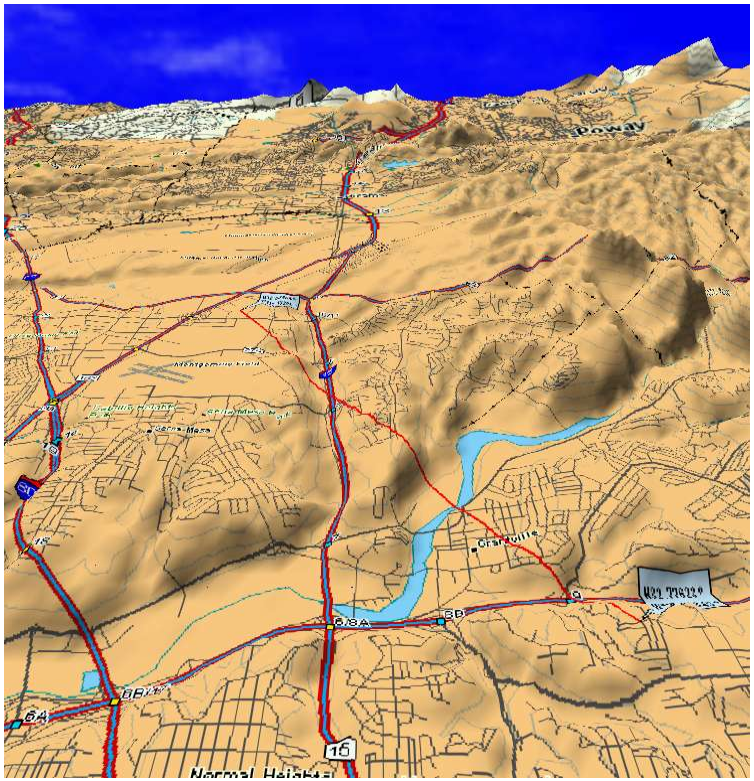
Topographic software:
maps.nationalgeographic.com/topo/

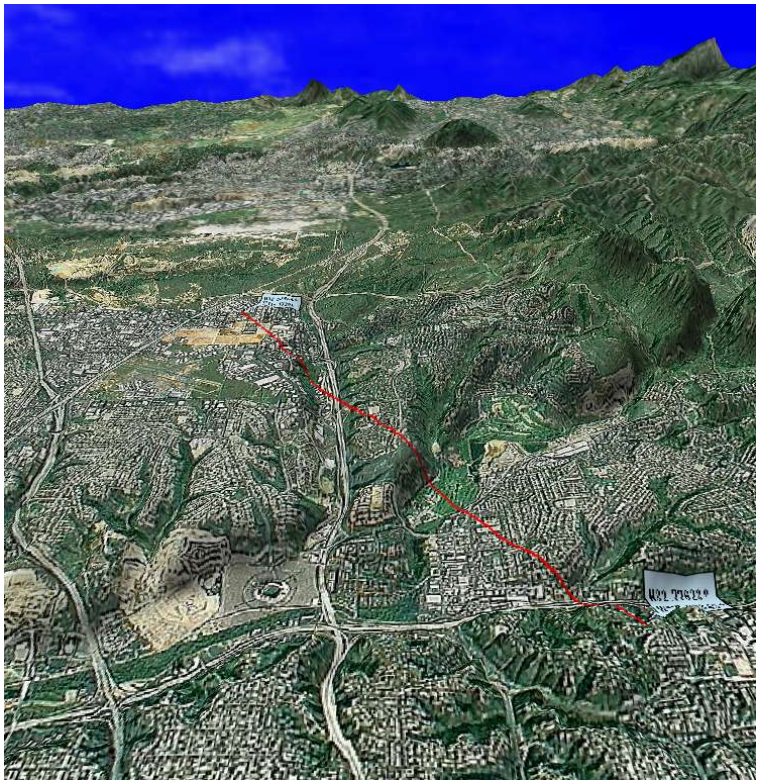
www.delorme.com/topousa/

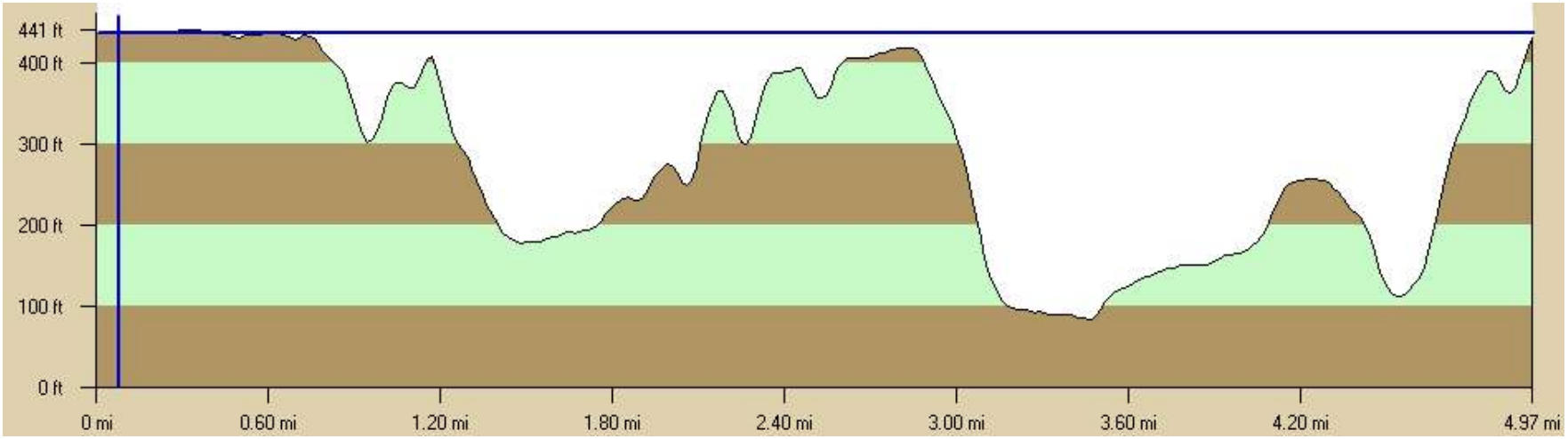
TopoUSA provides ability to view 3d terrain models, which provides for additional capability to comprehend surrounding terrain and locate other high points if necessary. 3D view does not provide good information about baseline LOS.

Software provides ability to calculate topography between two points on the map, and generates terrain profile.

Terrain profile for objective shows that both locations at ground level are at the same elevation and that there are no geographic obstacles between the two points. Path length is 4.97 miles.
In addition, as locations are atop a radio tower and a multi level building, have more elevation at the locations that is not taken into account by topographic terrain model, so clean LOS shot between the two points should be attainable.






441 ft
400 ft
300 ft
200 ft
100 ft
0 ft
0 mi
0.60 mi
1.20 mi
1.80 mi
2.40 mi
3.00 mi
3.60 mi
4.20 mi
4.97 mi

FREE SPACE PATH LOSS

Determine how much signal loss will occur in transmitting between both sites.
Common formula for Path loss at 2.4 GHz

L = 20 log(d) + 20 log(f) +36.6

where L is loss in dB, d is distance in miles, f is frequency in MHz

Path loss for a 4.97 mile hop using
Channel 11 (2.462 GHz)

L = 20 log(4.97) + 20 log(2462) +36.6

= 13.9 + 67.8 + 36.6

= 118.3 dB

Objective link will incur 118.3 dB of loss between both locations. Connection must be able to tolerate that much loss (plus a bit extra to account for weather and interference) or it will be unreliable.

Approximate Path loss for various distances at 2.412GHz

Distance (miles)	Loss (dB)	Distance (miles)	Loss (dB)
0.5	98		
1	104	10	124
2	110	15	128
3	114	20	130
4	116	25	132
5	118	30	134

TOTAL LINK COST

In addition to free space path loss, take into account other gains and losses within the system.
Add up all gains (radios + amplifiers + antennas) and;
subtract all losses (- cable length – connectors – lightning arrestors – misc)

Assume we are using Orinoco Silver cards (15dBm), no amplifiers, a 12 dBi sector on one end and a 15dBi yagi on the other, with 1m of LMR400, 1 lightning arrestor, and allowing 0.25 dB loss per connector and 1dB per pigtail at each end.

	Radio	–	Pigtail	–	Arrestor	–	Connector	–	Cable	–	Connector	+	Antenna	
A:	15	-	1	-	1.25	-	0.25	-	0.22	-	0.25	+	12	= 24.03
B:	15	-	1	-	1.25	-	0.25	-	0.22	-	0.25	+	15	= 27.03

Total gain of system is : A+B = **51.06 dB**

Perceived signal level at either end of the link
Subtract path loss from total gain: 51.06 – 118.3 = **-67.24 dBm**

IS THIS SUFFICIENT FOR COMMUNICATION ?

Orinoco silver receiver sensitivity specifications:
(11/5.5/2/1Mbps) : **-82/-87/-91/-94 dBm**

Our signal of -67.24 dBm provides a margin error of 14.76 dB, which should theoretically work at 11Mbps in good weather, and should have no problem connecting at 5.5Mbps (19.76dB margin)

Typically, a margin of error of 20dB or more is good enough to account for weather fluctuations. Using amplifiers or more powerful and more sensitive radios (Cisco350@ 20dBm ; Senao@ 23dBm) and/or higher gain antennas would help further stabilize the link.

Be aware of FCC limits on power and gain when using higher power equipment.

Flickenger, Wireless Hacks, O'Reilly

Interactive Wireless Network Design Analysis Utilities

Green Bay Professional Packet Radio website provide advanced CGI scripts to help you model wireless network.

www.qsl.net/n9zia/wireless/page09.html

dBm

dBm is an abbreviation for the power ratio in dB of the measured power referenced to one milliwatt.
The term dB is mainly used for an attenuation or an amplification, but dBm for a measured power.

$$x = 10\log_{10}(P/(1\,\mathrm{mW}))$$

$$P = (1\,\mathrm{mW})10^{(x/10)}$$

dBm is used in communication work as a measure of absolute power values. Zero dBm equals one milliwatt. A 3 dBm increase represents roughly doubling the power, which means that 3 dBm equals 2 milliwatt. For a 3 dBm decrease the power is reduced by one half, making -3 dBm equal to 0.5 milliwatt.

dBm	**0**	**1**	**5**	**10**	**15**	**20**	**21**	**22**	**23**	**24**	**27**	**30**	**36**
mW	1	1.3	3.2	10	32	100	130	160	200	250	500	1W	4W

ANTENNA ALIGNMENT

Aligning antennas over distances can be a tricky process, which can be simplified by observing some /all of the following techniques:

Deploy 2 competent people equipped with radios/cellphones at either end to allow real time modifications to antenna orientation.
Using hands free headsets for voice coms is beneficial.

Set up, configure and test all network equipment in close proximity prior to field deployment. Verify that network functionality exists at close range.

Short of an spectrum analyzer, use a good wireless configuration client or netstumbler to display signal strength and noise readings in real time.
Work on one end of the link at a time, change one variable at a time , until highest signal and lowest noise are observed. Repeat at other end.

Offset dish antennas and yagis can appear to be aimed too low or too far left/right from the other end of the link. Use signal strength rather than visual appearance as an indicator of connection status.

Sweep slowly, and test beyond best perceived signal. Antennas have small side lobes which can give false positives. The main lobe will be distinctly stronger than the side lobes.

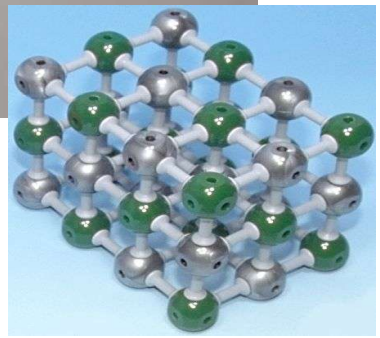
Do not touch antenna while taking readings, as you will interfere with the radiation pattern.

Compare Horizontal and Vertical polarization, and use that with the least noise.

STUPID IDEAS FILE

“Sniper Yagi”

www.shmoocon.org/sniperyagi/



ANTENNA POLARIZATION

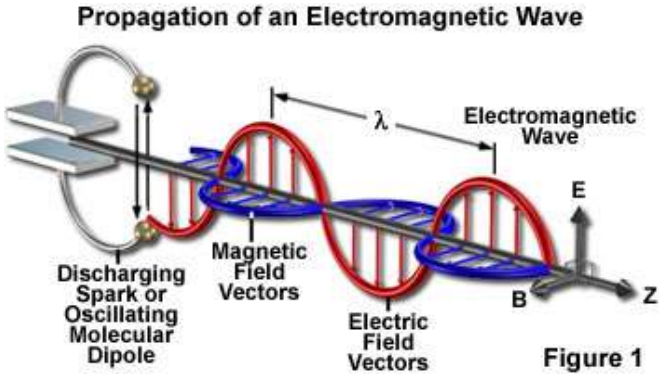


Figure 1

Electric and magnetic fields in an EM wave are perpendicular to each other, and both are perpendicular to the direction of propagation.

Antennas must be oriented to match the polarization of the incoming energy, or they will only receive a portion of it: antennas with matching polarization will "see" each other well, antennas with opposite polarization will not.

Horizontally and vertically polarized antennas are common, circular polarization (clockwise/counter-clockwise) is also possible.
Omnis and sectors are generally vertically polarized.

For long distance point-to-point links, try both horizontal and vertical polarization. Try the link with the antennas in one orientation, then rotate both dishes by 90 degrees and measure again. Dish polarization is determined by the position of the forward radiating element.

It is theoretically possible to use multiple radios on a single point-to-point link, by running 2 parallel links on the same channel, one vertically polarized and the other horizontally polarized. Dishes placed a few feet apart can operate on the same channel without substantial interference to each other, thus allowing for twice the bandwidth using the same channel. (receiver configuration notwithstanding)

AMPLIFERS / REPEATERS

Amplifiers can be used to boost transmission signal power.
Repeaters can be deployed on multi-hop links to extend range. Currently half duplex, but WiDeFi, inc is working on full duplex repeater chips for WiFi repeaters, due some time in 2005. www.widefi.com

Passive repeaters, principally two antennas connected together, receive mixed reviews, and are deemed more suitable for multi hop links where the segments are of different lengths.

Amplifiers can be obtained from a number of commercial vendors, for instance:

HyperAmp® designs bi-directional WiFi RF amplifiers for wireless LAN. Consisting of a low-noise receive amplifier and a transmit power amplifier, HyperAmp offers significant improvement in operating range and performance. HyperAmp is compatible with spread spectrum wireless gear including IEEE 802.11a/b/g

100 mW to 50 Watt Amp Models
2.4GHz and 900MHz models
Automatic Gain Control and Fixed-Gain models available
Indoor and Outdoor industrial grade versions
Custom configurations available

Available for export, military, licensed amateur radio (ham radio) and OEM component sales only and as part of complete FCC Certified Systems.
Individual amplifier products are not offered for sale in the USA.
HyperLink Technologies also offers complete Certified amplified antenna systems for professional installation.

www.hyperlinktech.com/web/wifi_amplifiers.php

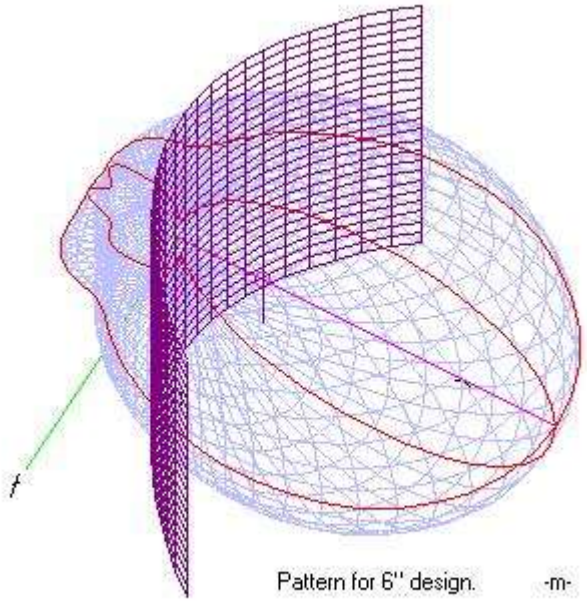
HOME PARABOLIC REFLECTOR FOR AP

Michael Erskine
www.freeantennas.com/projects/template/

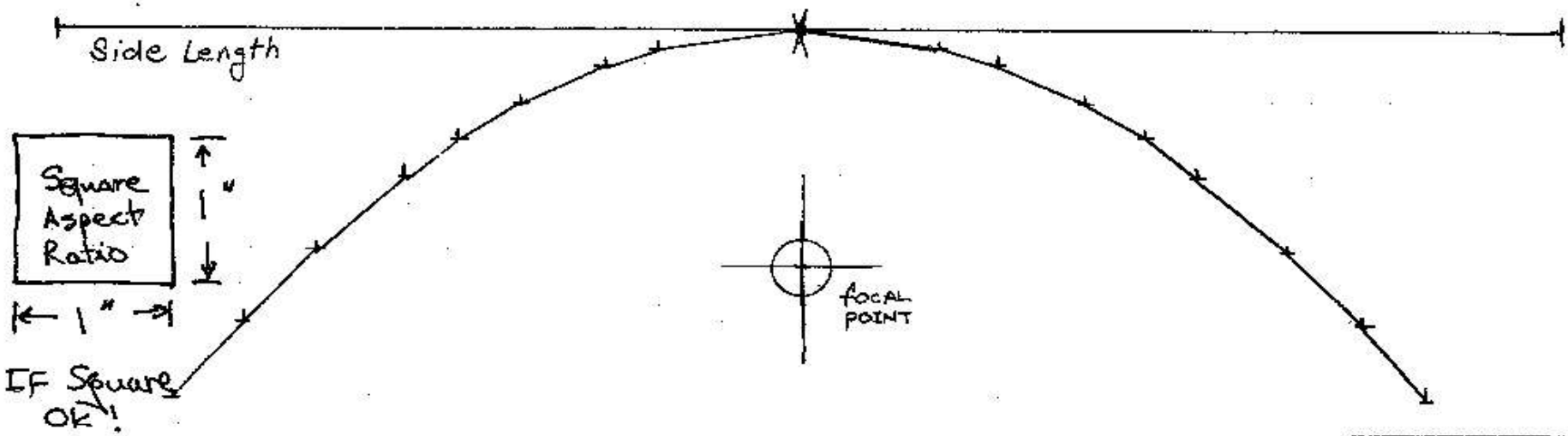
Advantages over other antennas:

No Pigtail Required
No Modification to AP (No voiding of warranty)
No Matching (SWR) Problems
No Purchased Parts
Trivially Easy Construction
Very Low Probability of Error
Superior Front to Back/Front to Rear Ratio
Improves Wireless LAN Privacy
Reduces Interference

Construction template available at website



PARABOLIC REFLECTOR TEMPLATE V 3.0 (FINAL)

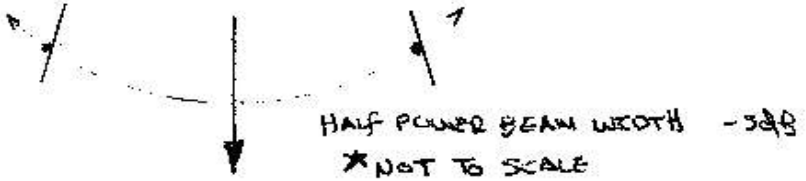


USAGE:

(1) MAKE SQUARE REFLECTOR

(2) BEND CURVE

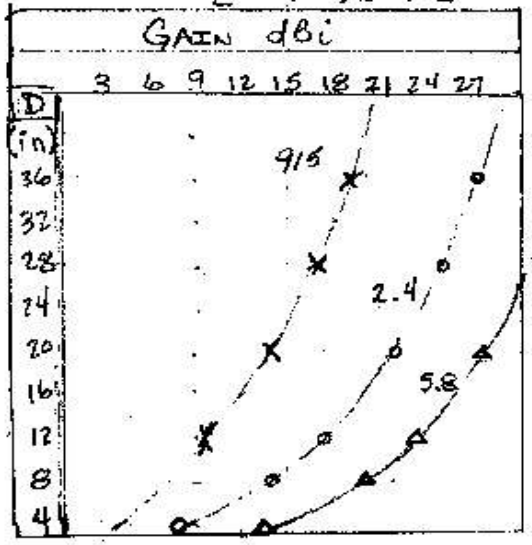
(3) PLACE AT FOCAL POINT



Let $k = .65$

$\mathring{A}$ = Projected Aperature

$$GdBi = 10 \log\left[k\left(\frac{4\pi \mathring{A}}{\lambda^2}\right)\right]$$



Let $K = 64.0$

$\alpha = K/(D/\lambda)$