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Outline

- Decibel
- Antenna Radiation Pattern
- 2.4 GHz Antennas





Decible

- A measurement unit
 - In logarithmic
 - Relative value (Ratio)
 - For power / intensity / sound level / voltage
 - dB
- $L_{bB} = \text{ratio in decible} = \text{Gain}$

$$L_{bB} = 10 \log_{10}\left(\frac{P_1}{P_2}\right)$$

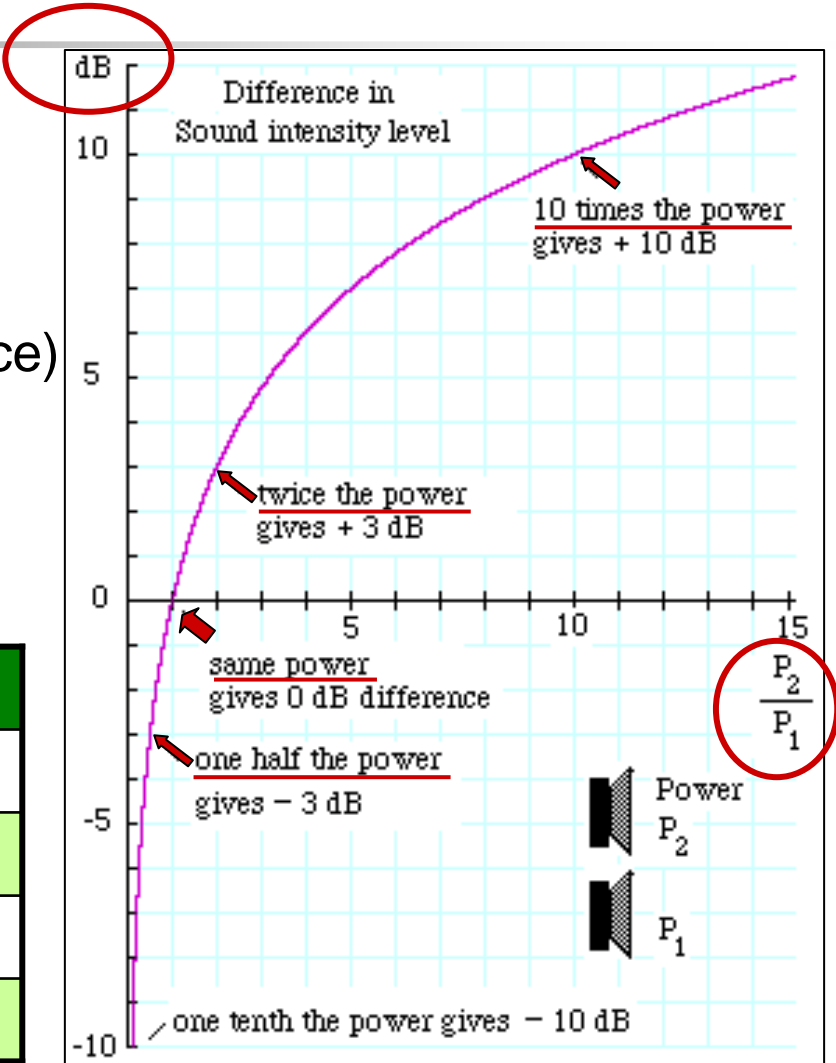


Example

- 2 Loudspeakers  
- Speaker 1: play sound with Power P_1
- Speaker 2: play sound with Power P_2
- Same environment (frequency, distance)

$$L_{\text{dB}} = 10 \log_{10}\left(\frac{P_1}{P_2}\right)$$

Condition	Calculation	Decible
$P_2 = P_1$	$10 \log_{10}(1)$	0 dB
$P_2 = 2 P_1$	$10 \log_{10}(2)$	+3 dB
$P_2 = 0.5 P_1$	$10 \log_{10}(0.5)$	- 3 dB
$P_2 = 10 P_1$	$10 \log_{10}(10)$	+10 dB





For Electric Power

- Power Gain (G_{dB})

- Calculate 1W relative to **1 W**

$$\rightarrow G_{dB} = 10 \log_{10}\left(\frac{1000 \text{ W}}{1 \text{ W}}\right) = 30 \text{ dB} \quad \rightarrow \quad 30 \text{ dBW}$$

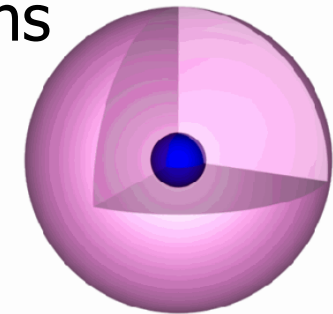
- Calculate 0.1W relative to **1 mW (milliwatt)**

$$\rightarrow G_{dB} = 10 \log_{10}\left(\frac{100 \text{ mW}}{1 \text{ mW}}\right) = 20 \text{ dB} \quad \rightarrow \quad 20 \text{ dBm}$$



Isotropic Antenna

- Radiate same power in all directions
- In practice, no 100% isotropic antennas
- A perfect isotropic antenna, called "**isotropic radiator**"
- Used for measuring the signal strength of real antennas
- Contrast with "**Anisotropic Antenna**"
 - A directional antenna
 - Power level is not the same in all directions

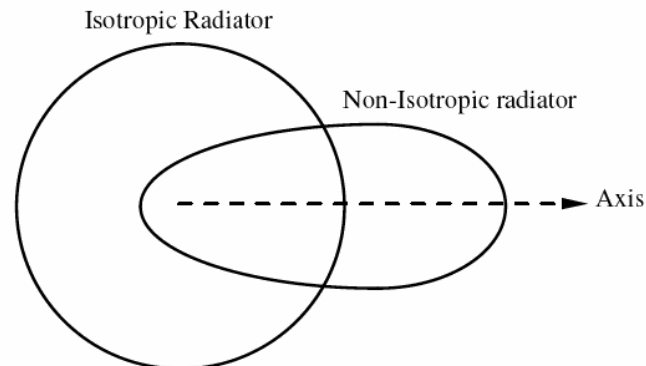


<http://partnerwiki.cisco.com/ViewWiki/images/2/2b/Omni-vs-direct2-82068.gif>



Antenna Gain

- Ratio of the power density of an **antenna's radiation pattern** in the direction of strongest radiation to that of a reference antenna
- **dB*i*** (DeciBel Isotropic)
 - The measurement of (forward) gain of a directional antenna
 - compared with the **Hypothetical Isotropic Antenna**





Example

- A directivity of **0 dBi** (dB relative to isotropic)
 - The radiator equally transmits (or receives) electromagnetic radiation to/from any arbitrary direction



Antenna Gain

- usually represent graphically in polar coordinates
- As antenna's energy conservation
 - positive gain in some directions
 - must have negative gain in other directions



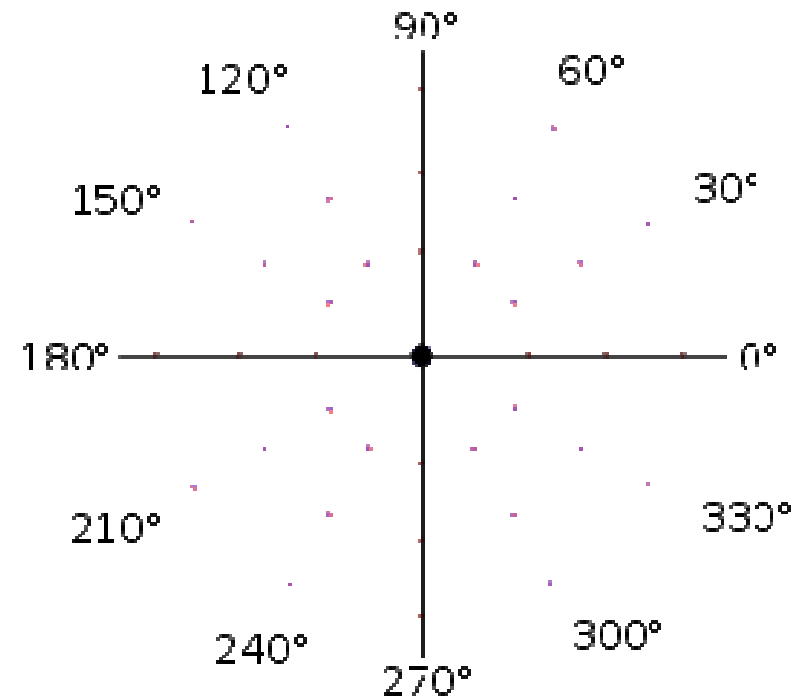
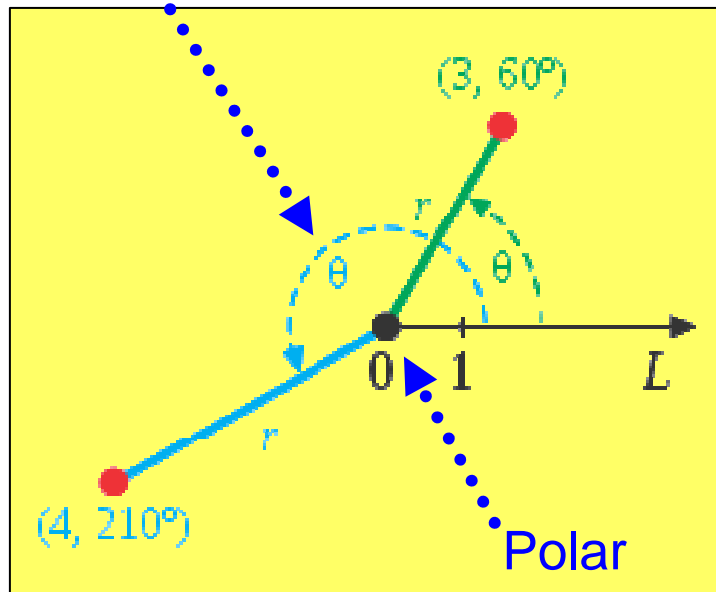
Polar Coordinate system

- A two-dimensional coordinate system
- Each point on a plane is determined by
 - A distance from a fixed point (pole)
 - And an angle from a fixed direction (polar angle or azimuth)



Polar Grid

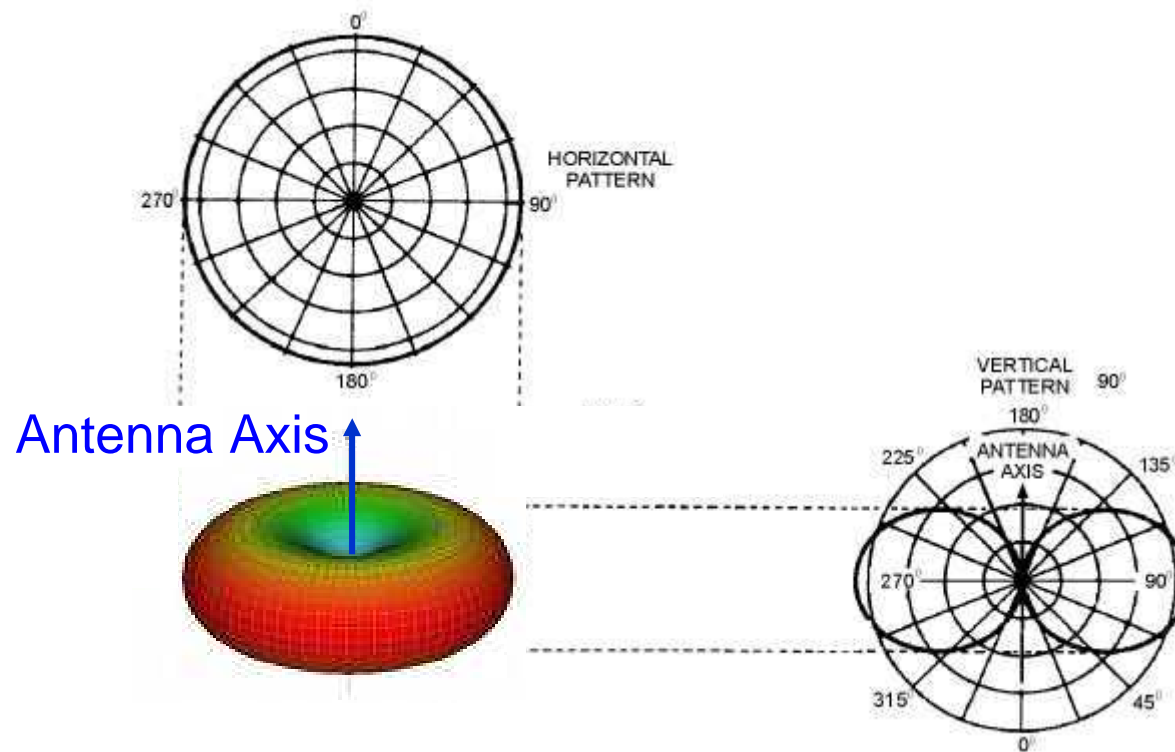
Azimuth (polar angle)



http://en.wikipedia.org/wiki/Polar_coordinate_system



Antenna Radiation Pattern



Modified from: www.ece.nus.edu.sg/.../Teaching/EE4101/index.htm



2.4 GHz Antennas

- Dipole Antennas
- Multiple Element Dipole Antennas
- Yagi Antennas
- Flat Panel antennas
- Parabolic Dish antennas
- Slotted Antennas
- Microstrip Antennas

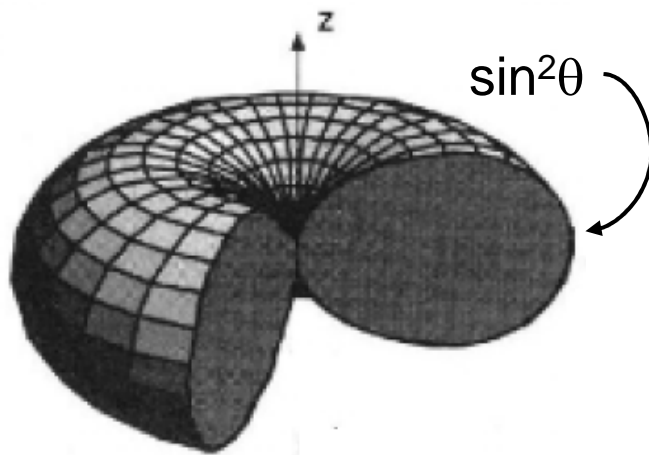
Partial document from:
Aerocomm, Lenexa, KS
"Antenna Tutorial"



Dipole

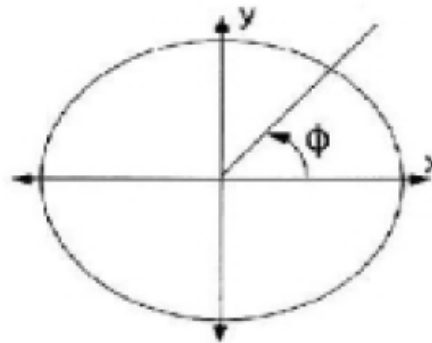


- Best used for Tx/Rx from broadside
- Not a directive antenna



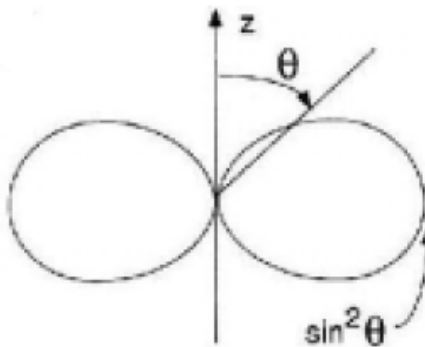
Generic Dipole

<http://www.engnetbase.com/>



Elevation Pattern
(Horizontal Pattern)

Works well 360°
around antenna



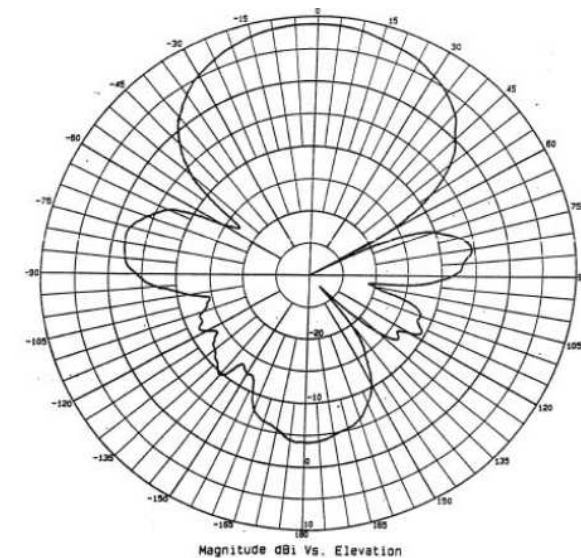
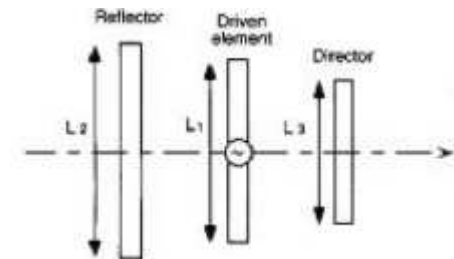
Azimuth Pattern
(Vertical Pattern)



Yagi



- Directional Antenna
 - Not as directional as parabolic dish antenna
- An array of independent antenna (director) elements
 - Only one element driven to transmit electromagnetic waves
 - The other determines the gain and directivity



Elevation Pattern

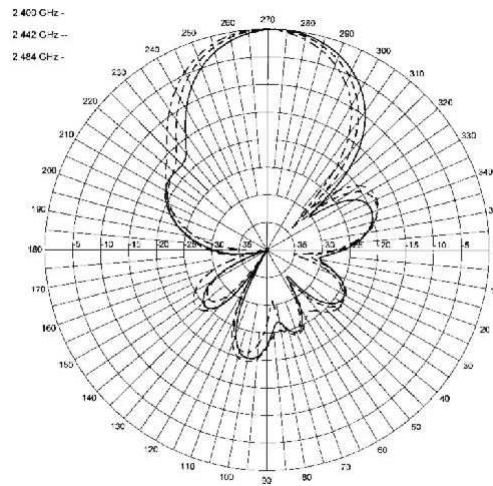


Flat Panel

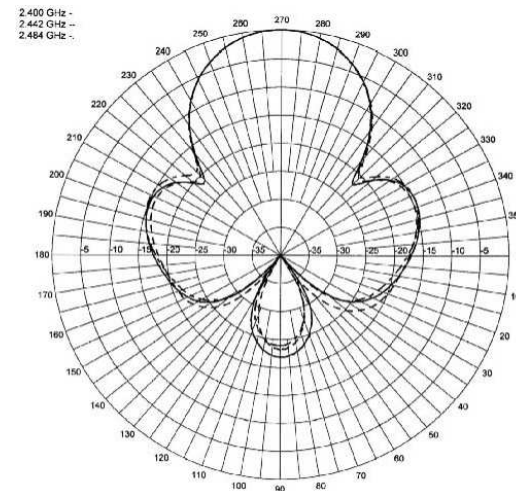
- physically in the shape of a square or rectangle
- quite directional



<http://www.frontierpc.com/ProductImages/Large/1010892869.jpg>



Elevation Pattern



Azimuth Pattern



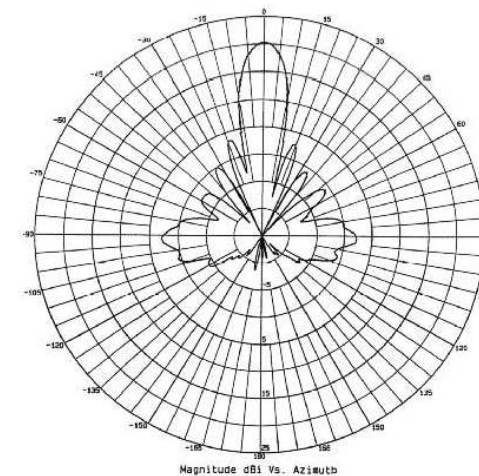
Parabolic Dish

- Extremely high gain and sharp directivity
 - Very directional
- Use a reflective parabola dish
 - to focus all received electromagnetic waves on the antenna to a single point



<http://www.wlan.org.uk/astra%2060cms%20dish.jpg>

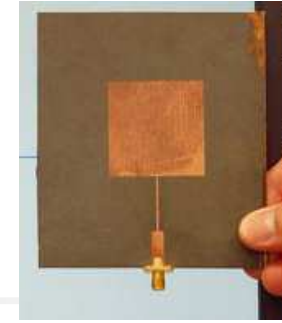
Elevation Pattern of a Parabolic Dish Antenna
(Source: Maxrad, Inc.)



Azimuth Pattern



Microstrip

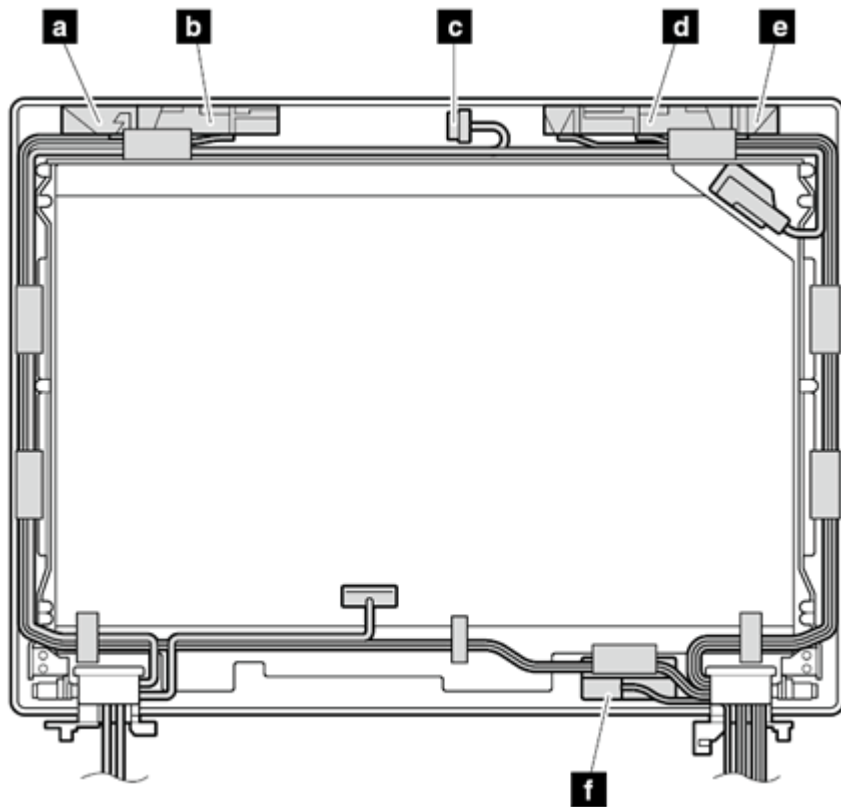


http://www.emtalk.com/mwt_mpa.htm

- Manufactured with PCB traces on actual PCB boards
- Very small and lightweight
- Small output power
- microstrip antennas are not well suited for wideband communications systems



Notebook Antenna



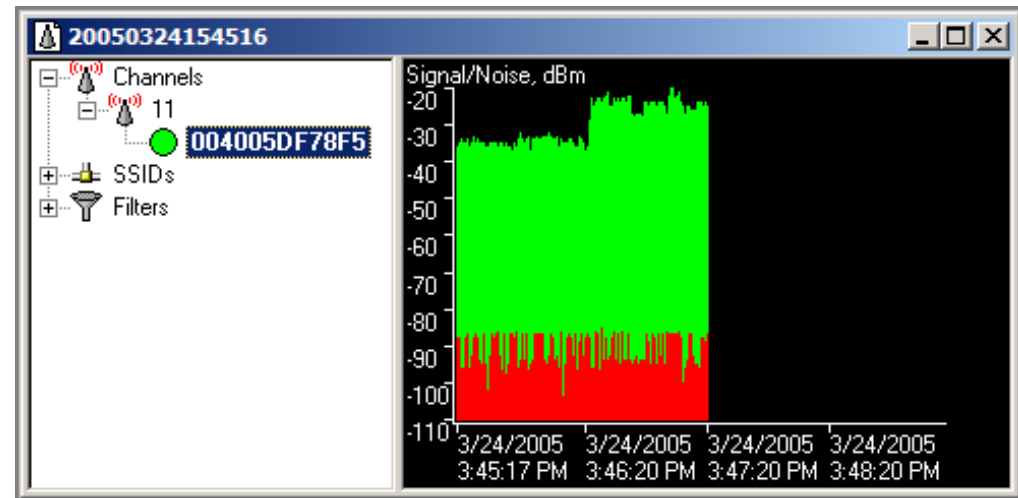
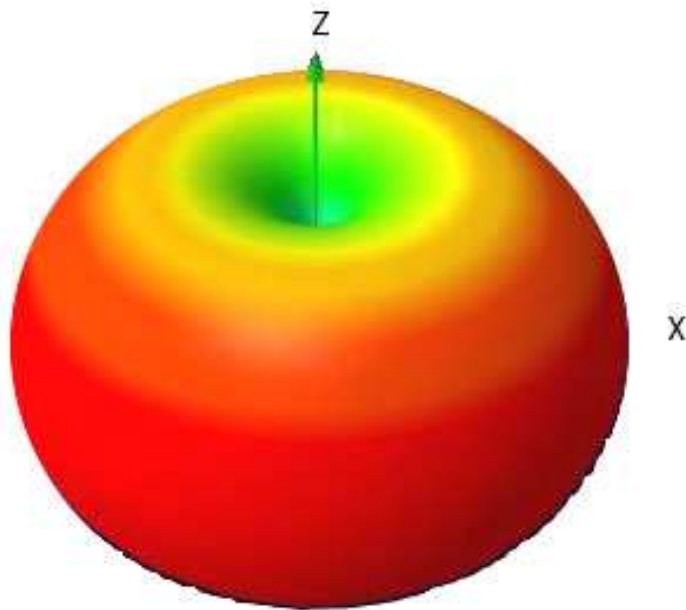
- (a) Wireless LAN antenna, AUX (black)
- (b) Wireless WAN antenna, AUX (blue)
- (c) Camera cable (some models)
- (d) Wireless WAN antenna, MAIN (red)
- (e) Wireless LAN antenna, MAIN (gray)
- (f) MIMO antenna (white)

Lenovo: ThinkPad

www-307.ibm.com/.../site.wss/MIGR-71582.html

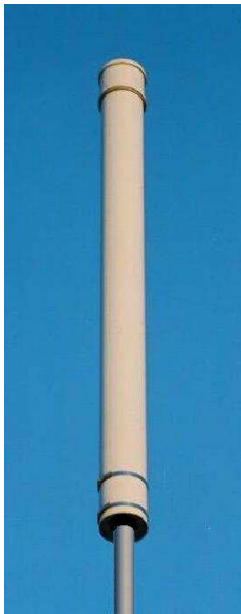


Omni-directional Antenna



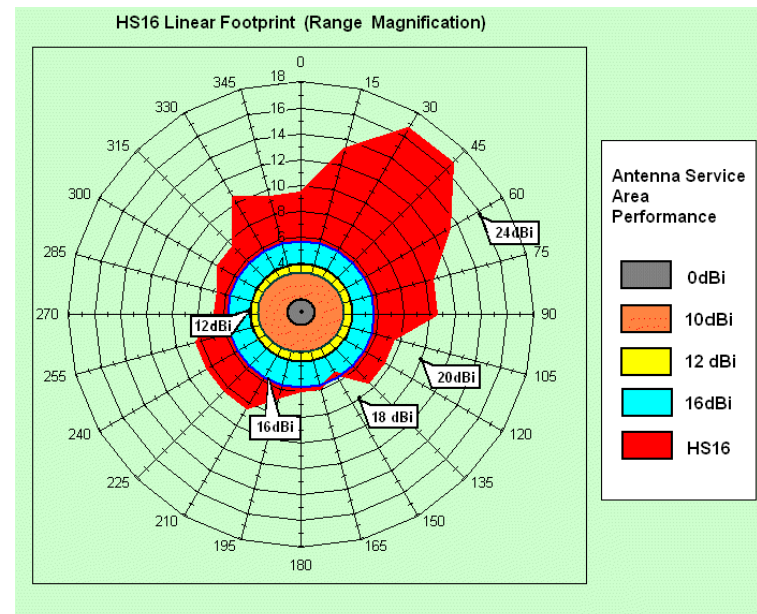


WLAN Service Antenna for 2.4GHz



"HOT SPOT 16"

- 16dBi
- Omnidirectional horizontal polarisation





Poor Man's WiFi



http://askyourpc.com/media/blogs/a/images/wifi_projects.jpg