

# HSMM / 2.4 GHz and Antenna Building Project Night

Brought to you by  
The Other Keith (N8XD)

# Microwave Topics



- ◆ Devices
- ◆ Amplifiers
- ◆ Locations
- ◆ Test Equipment
- ◆ Transmission Lines
- ◆ Connectors
- ◆ Software
- ◆ Antennas

# 2.4 GHz Devices

- ◆ Cordless Phones



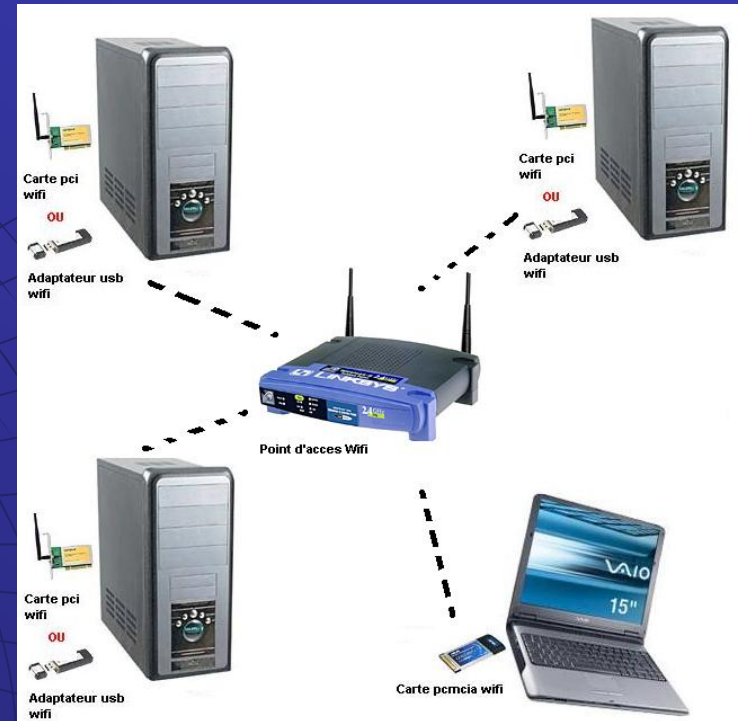
# 2.4 GHz Devices

- ◆ Video Senders



# 2.4 GHz Devices

## ◆ WiFi



# 2.4 GHz Devices

- ◆ Bluetooth and ZigBee



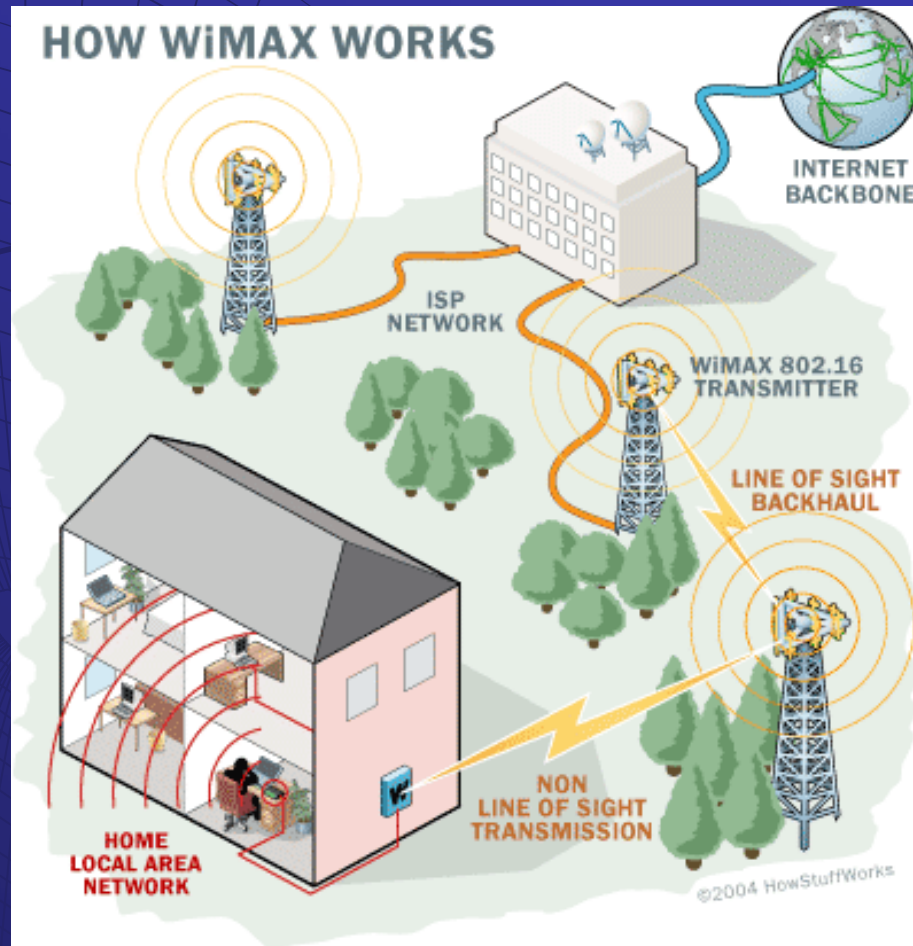
# 2.4 GHz Devices

- ◆ Wireless Cameras



# 2.4 GHz Devices

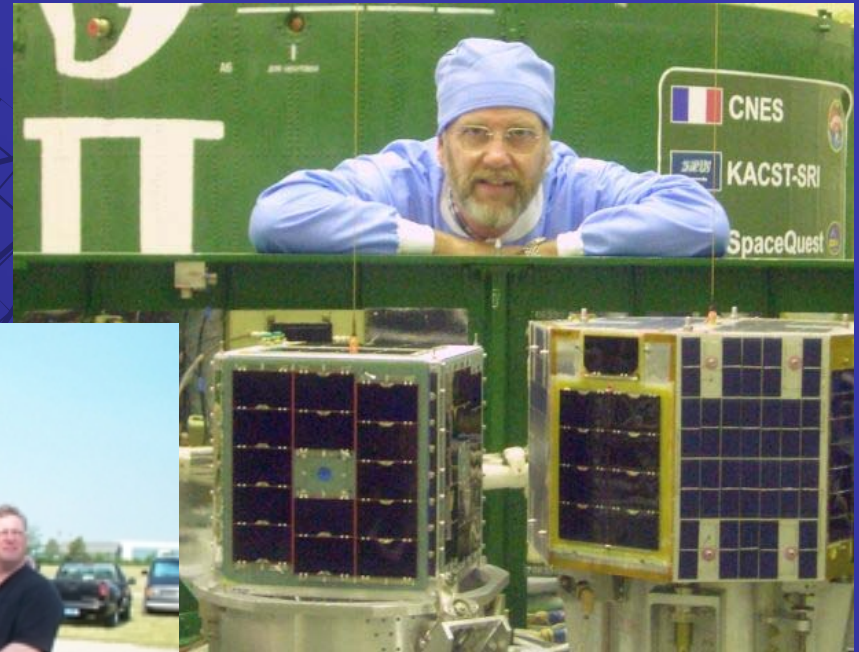
## ◆ WiMax





# 2.4 GHz Devices

- ◆ Satellites

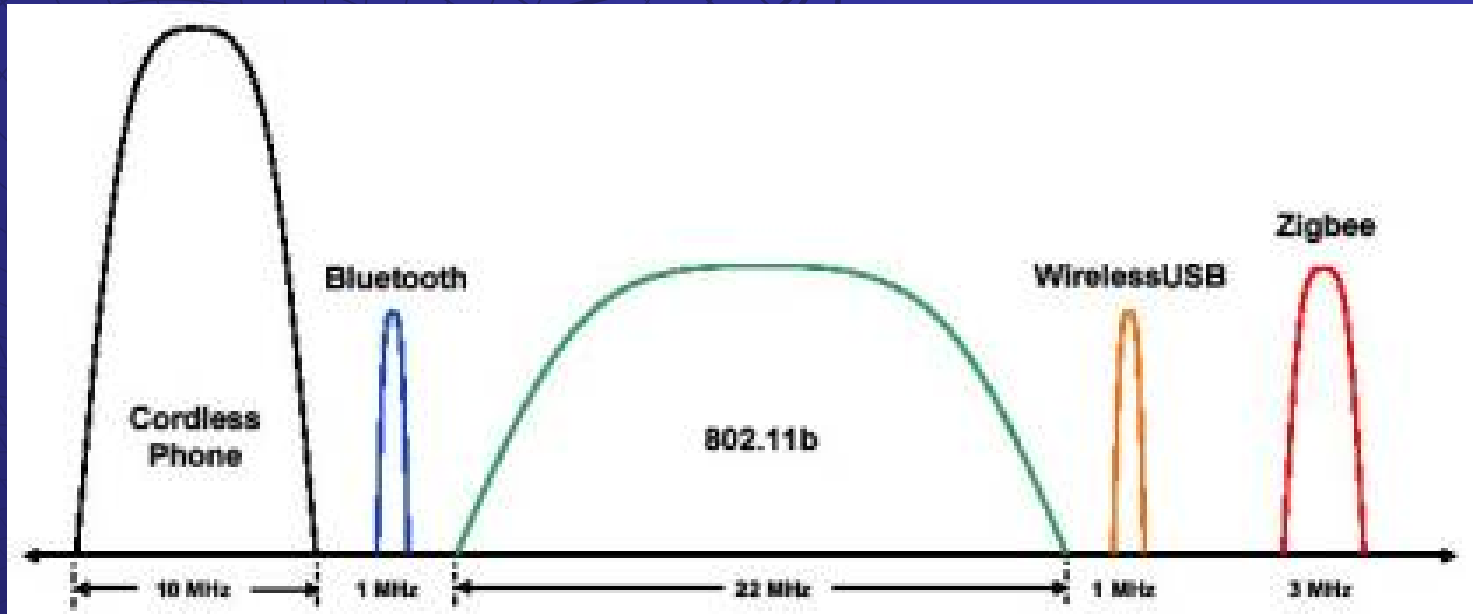


# 2.4 GHz Devices

- ◆ Microwave Ovens

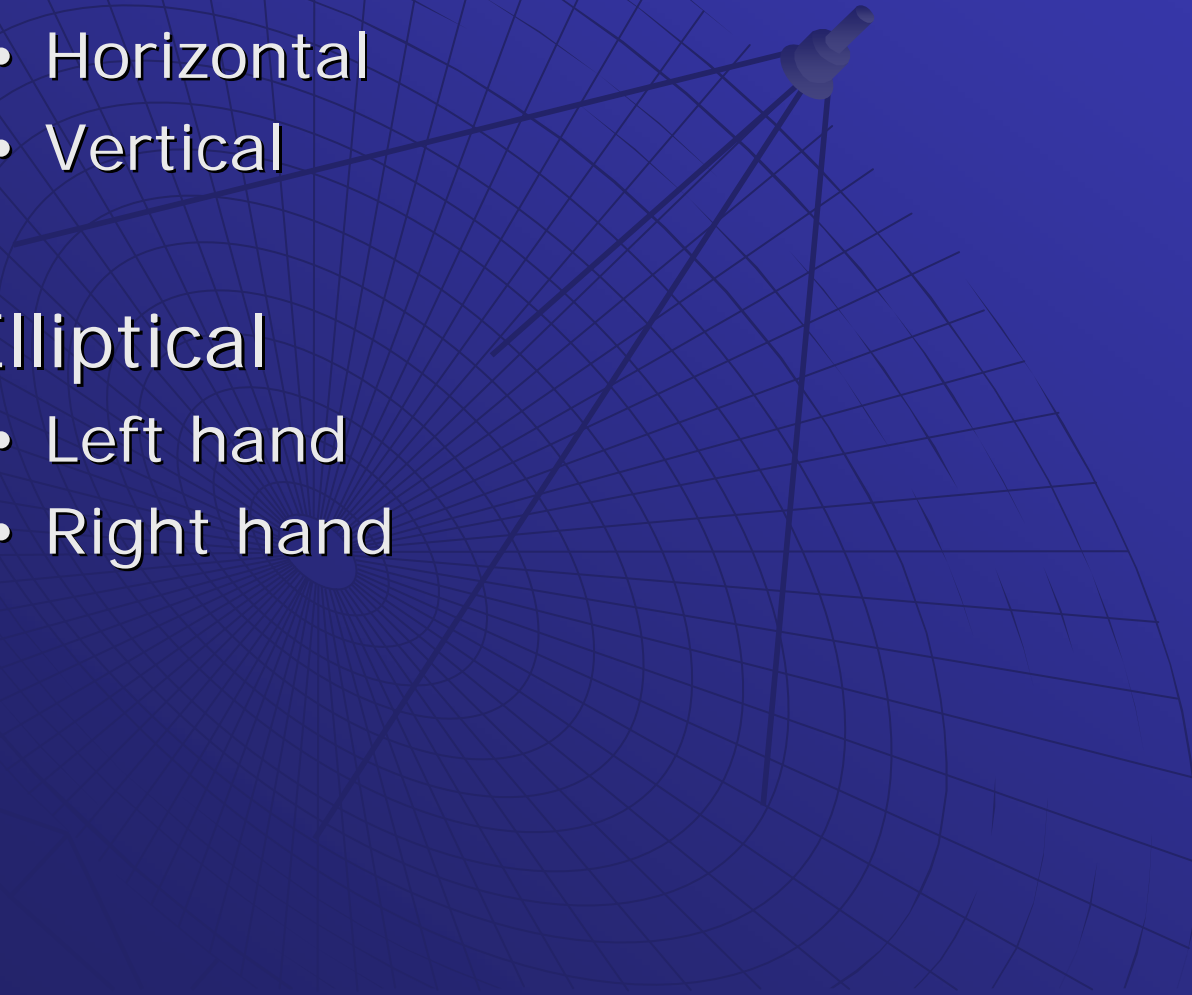


# Signal Bandwidth



# Polarization

- ◆ Linear
  - Horizontal
  - Vertical
- ◆ Elliptical
  - Left hand
  - Right hand



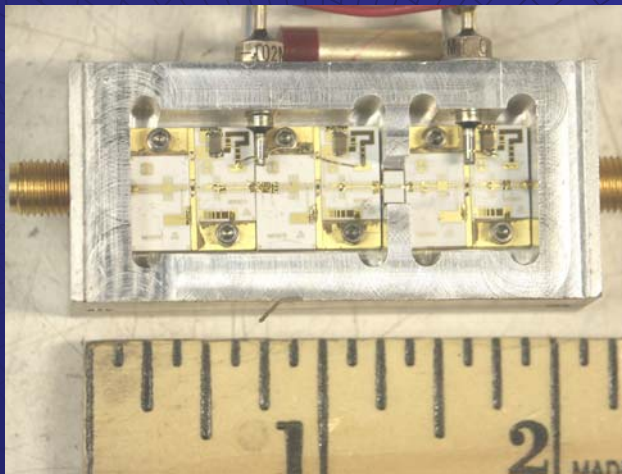
# Mis-Polarization

- ◆ Linear
  - Horizontal
  - Vertical
- ◆ Elliptical (circular)
  - Left hand
  - Right hand
- ◆ Horiz. vs Vert. (20db loss)
- ◆ Elliptical vs Linear (3db loss)
- ◆ Left vs Right (20db loss)

# Amplifiers

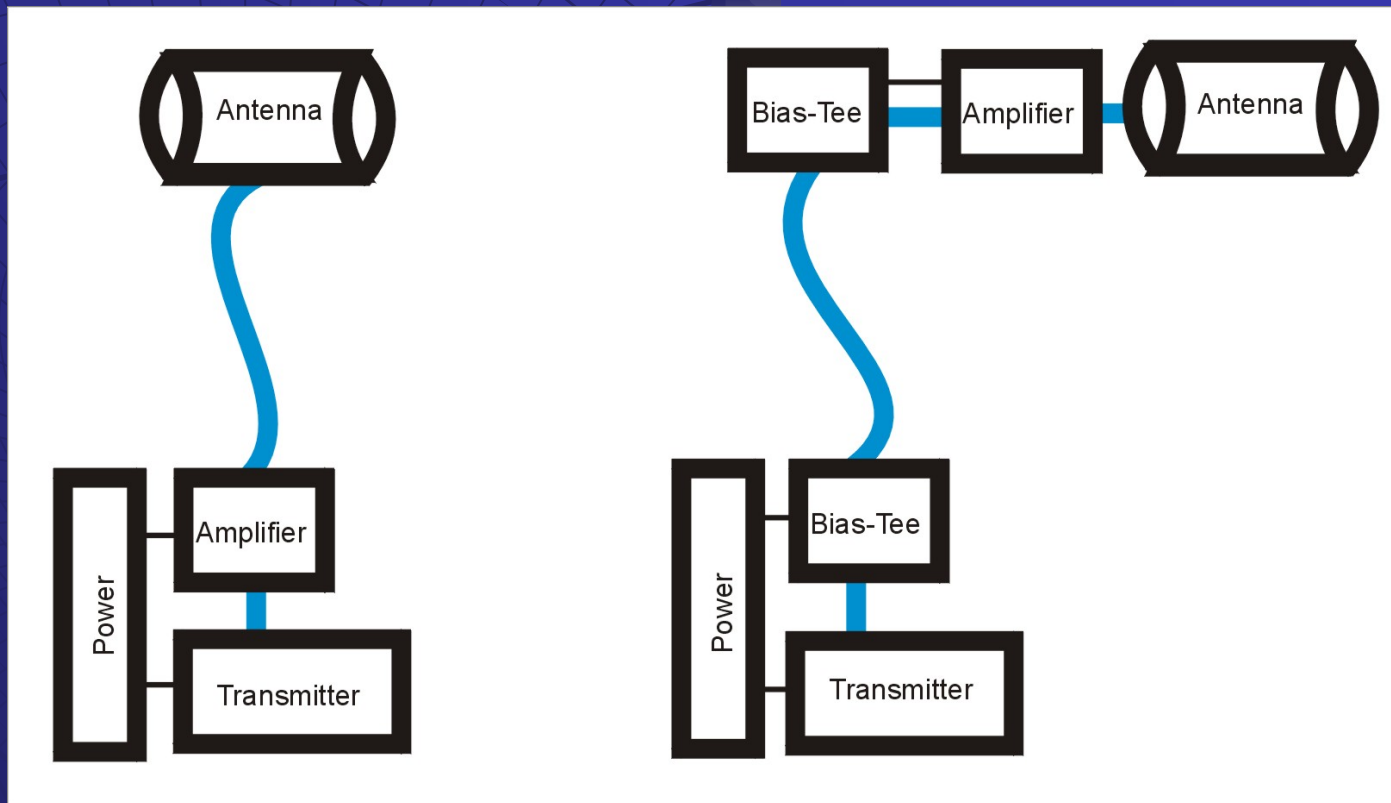
## ◆ RF Amplifiers

- Low Noise Amplifiers (LNA) for receiving small signals
- Power Amplifiers for transmitting



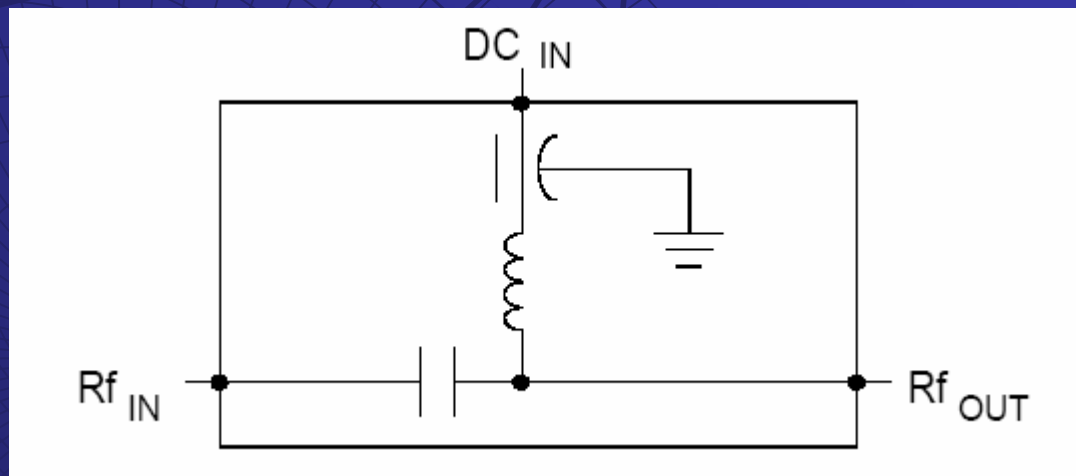
# Amplifiers

- ◆ Location



# Amplifiers

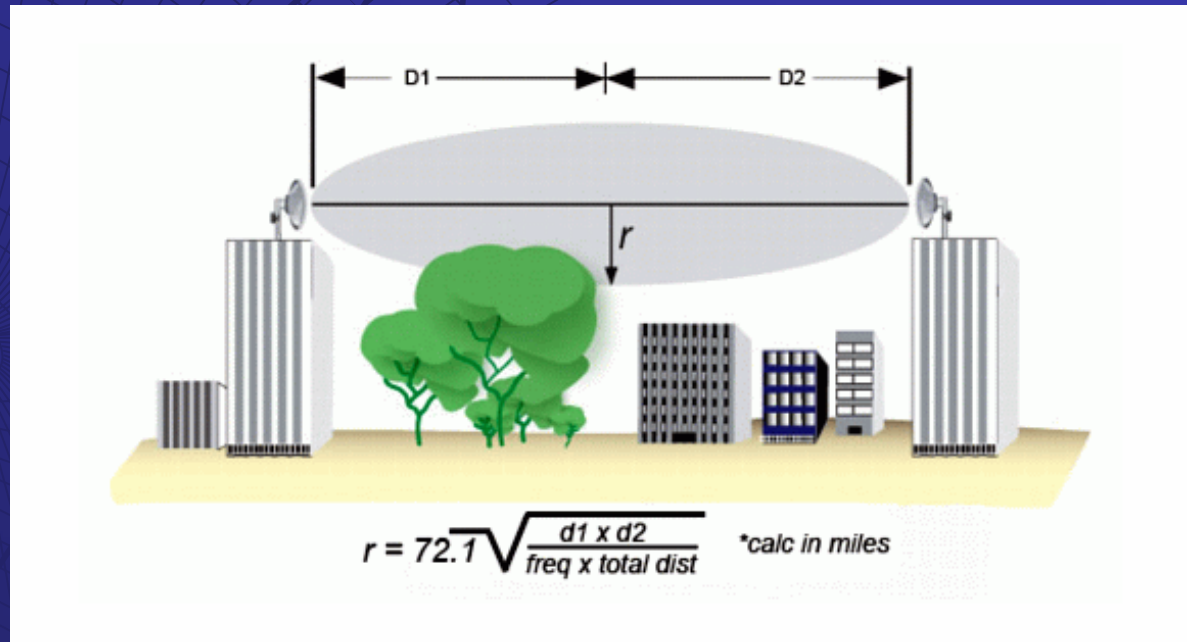
- ◆ Bias-Tee (Power Injector, etc)



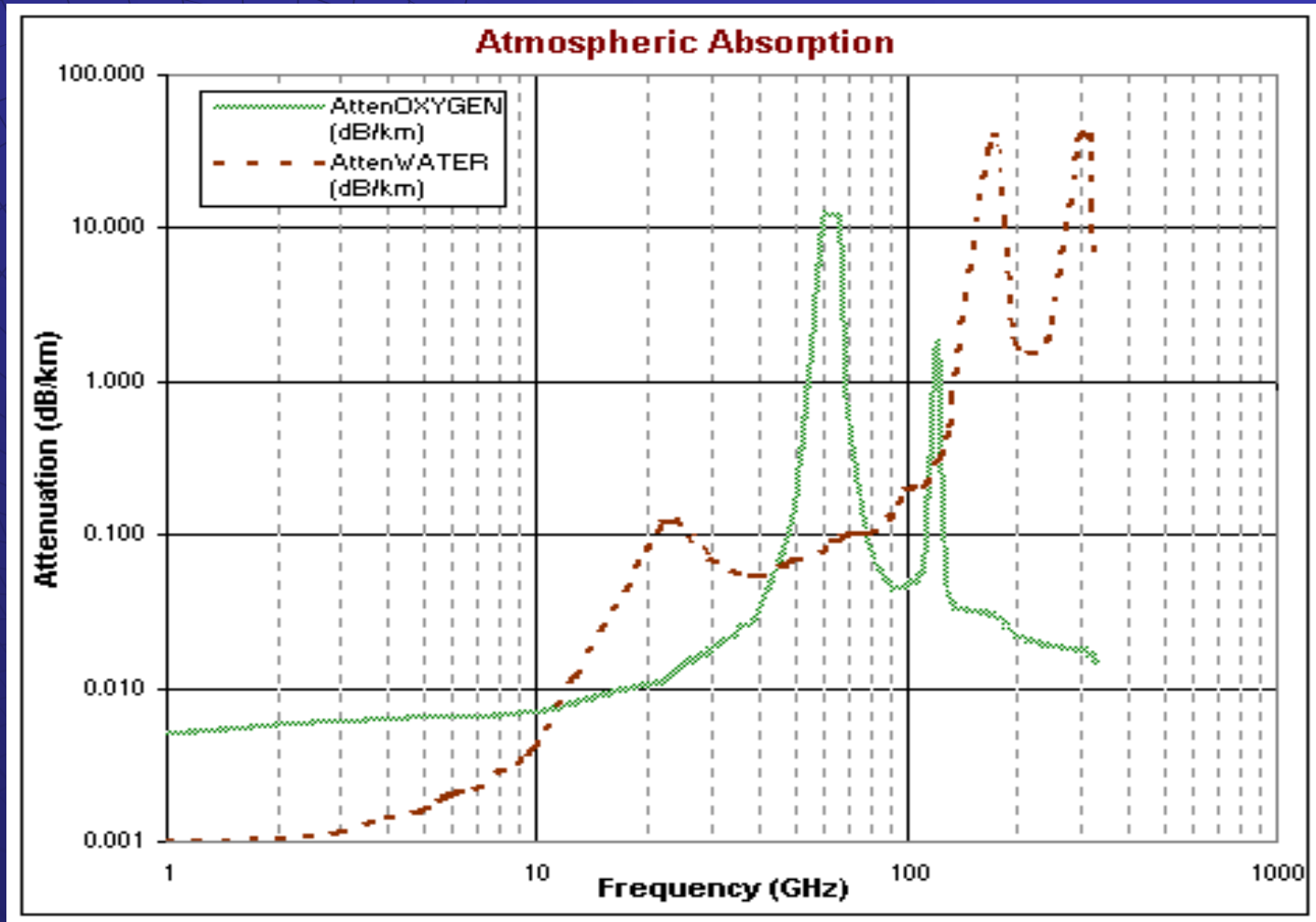


# Obstacles at 2.4 GHz

- ◆ Anything Solid
  - Trees / Leaves
  - Buildings
  - Water?



# Water Vapor



# Test Equipment

- ◆ Wave Meter



- ◆ Frequency Counter



# Test Equipment

- ◆ RF Power Meter

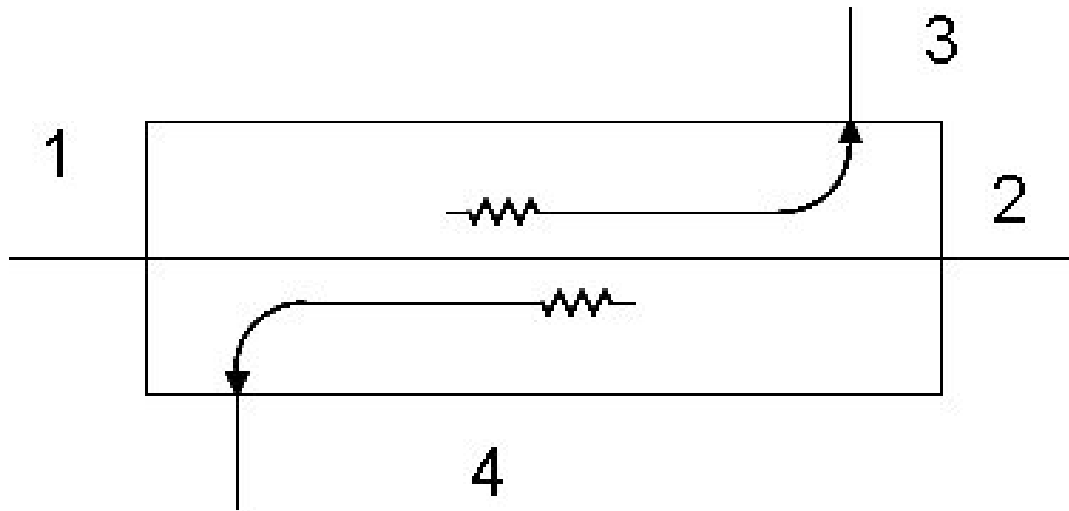


# Test Equipment

- ◆ Signal Source
  - VCO
  - Harmonic Multiplier
  - Gunn Diode
  - Video Sender
  - Cordless Phone

# VSWR

- ◆ Directional Coupler



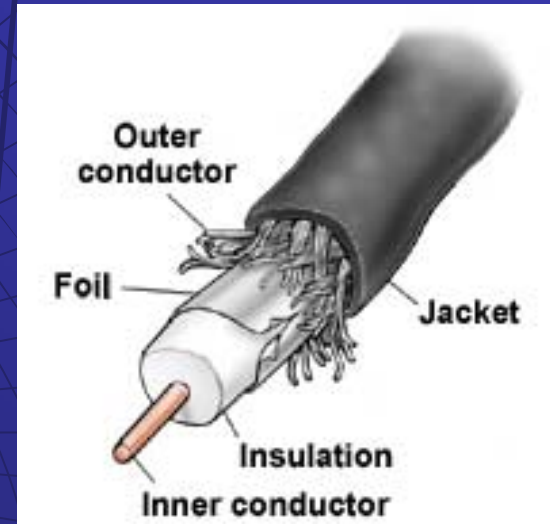
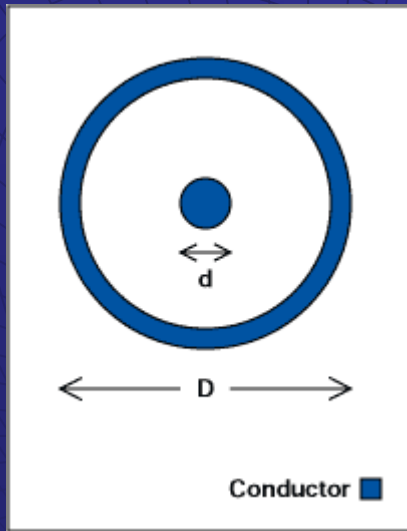
# Transmission Lines

- ◆ Waveguide



# Transmission Lines

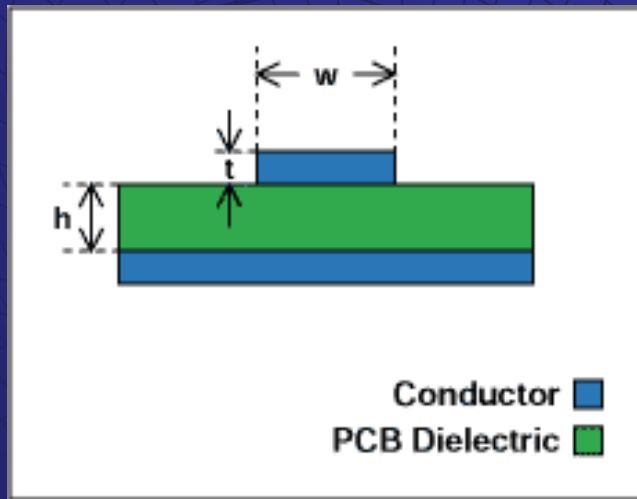
## ◆ Coax



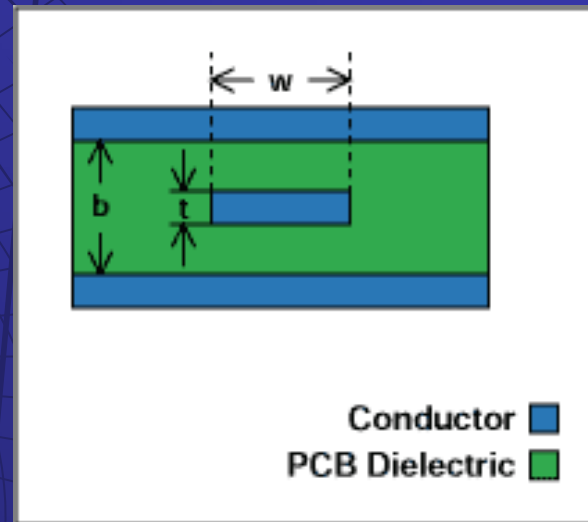


# Transmission Lines

## ◆ Microstrip



## ◆ Stripline



# RF Connectors

- ◆ SMA

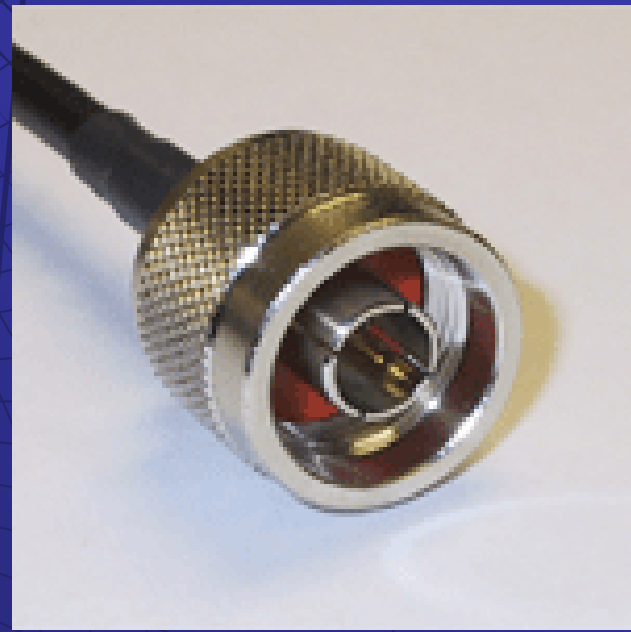


- ◆ RP-SMA



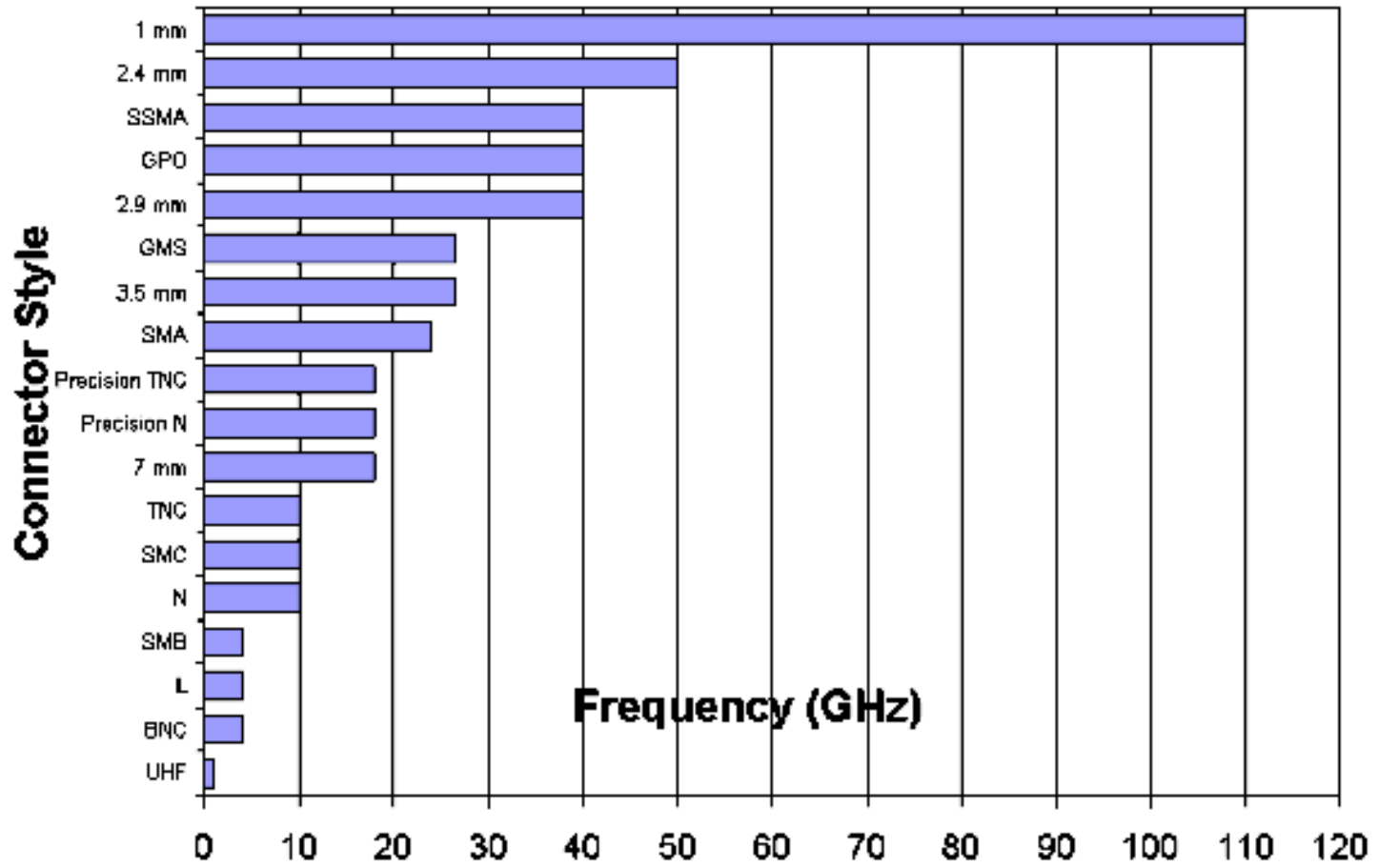
# RF Connectors

- ◆ N – Connector



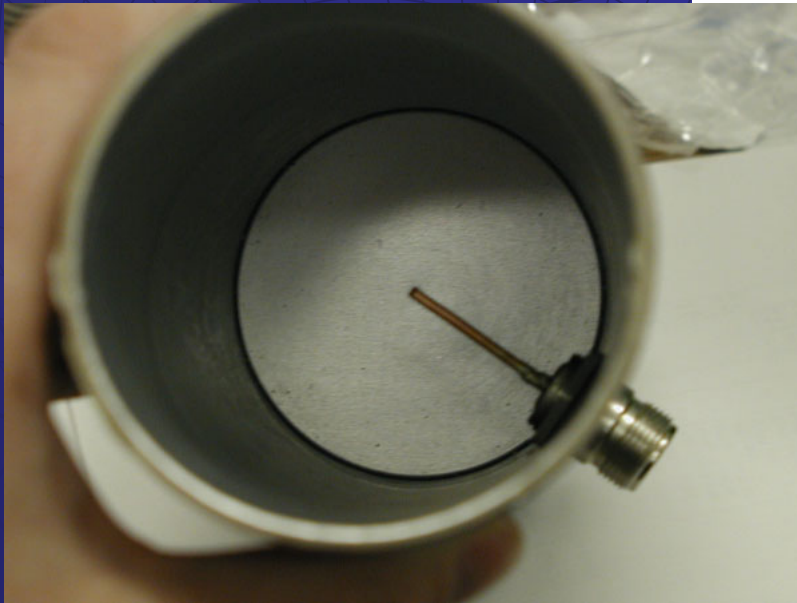
# RF Connectors

## Coax Connector Frequency Usage



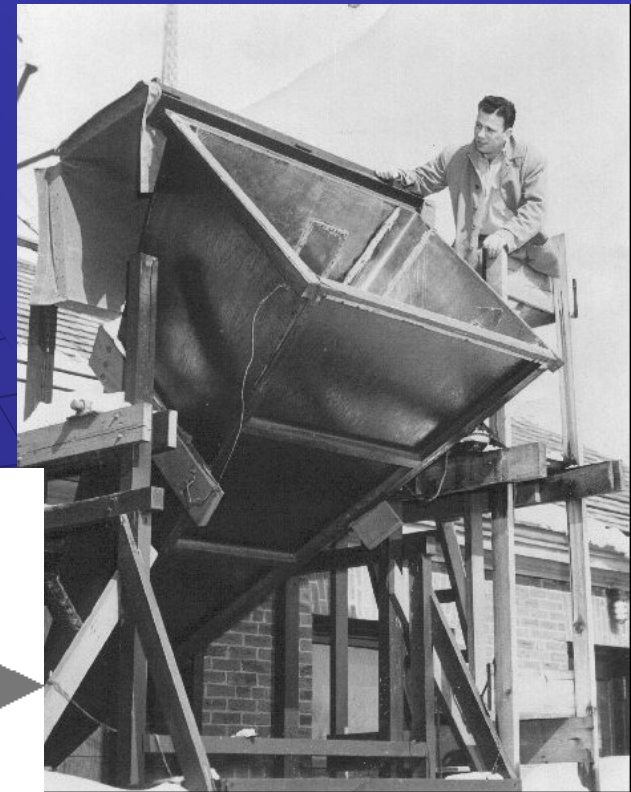
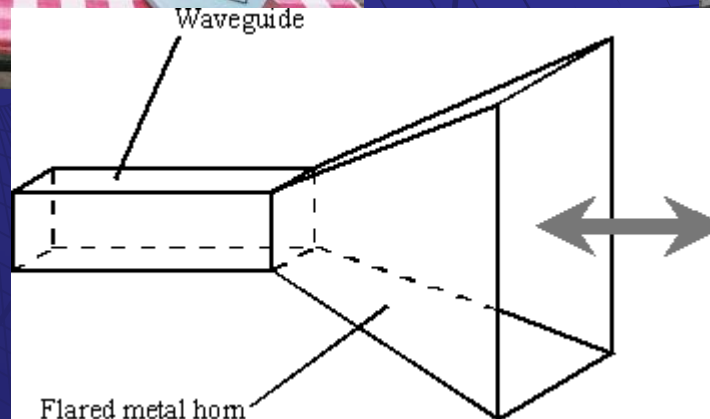
# Antennas

- ◆ Waveguide Antennas



# Antennas

- ◆ Waveguide Antennas (Horns)



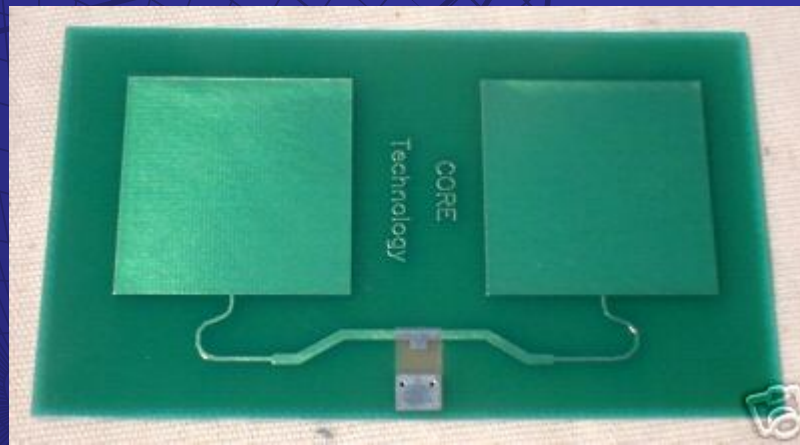
# Antennas

- ◆ PCB Yagi



# Antennas

- ◆ PCB Patch





# Antennas

- ◆ PCB Log Periodic



# Antennas

- ◆ 1/4 Wave (31 mm)



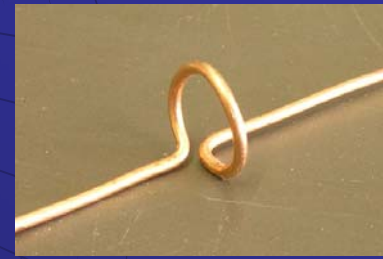
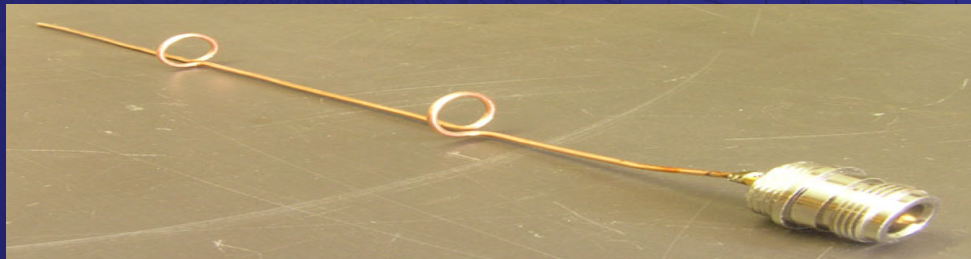
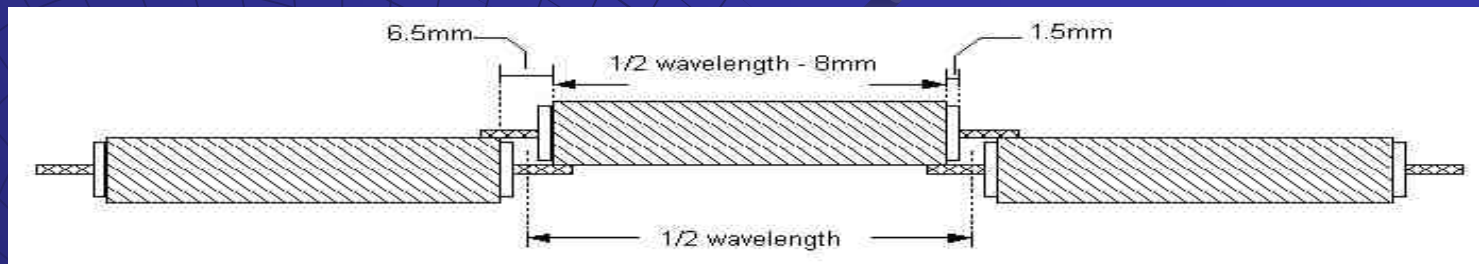
# Antennas

- ◆ Helical



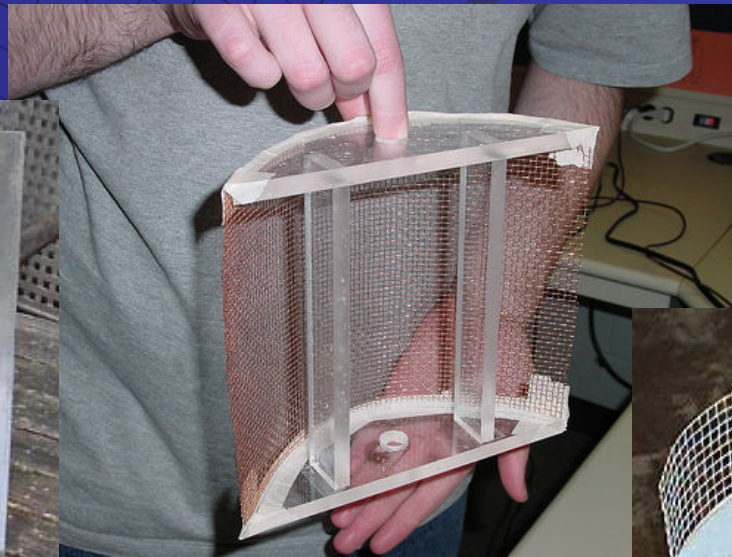
# Antennas

## ◆ Collinear



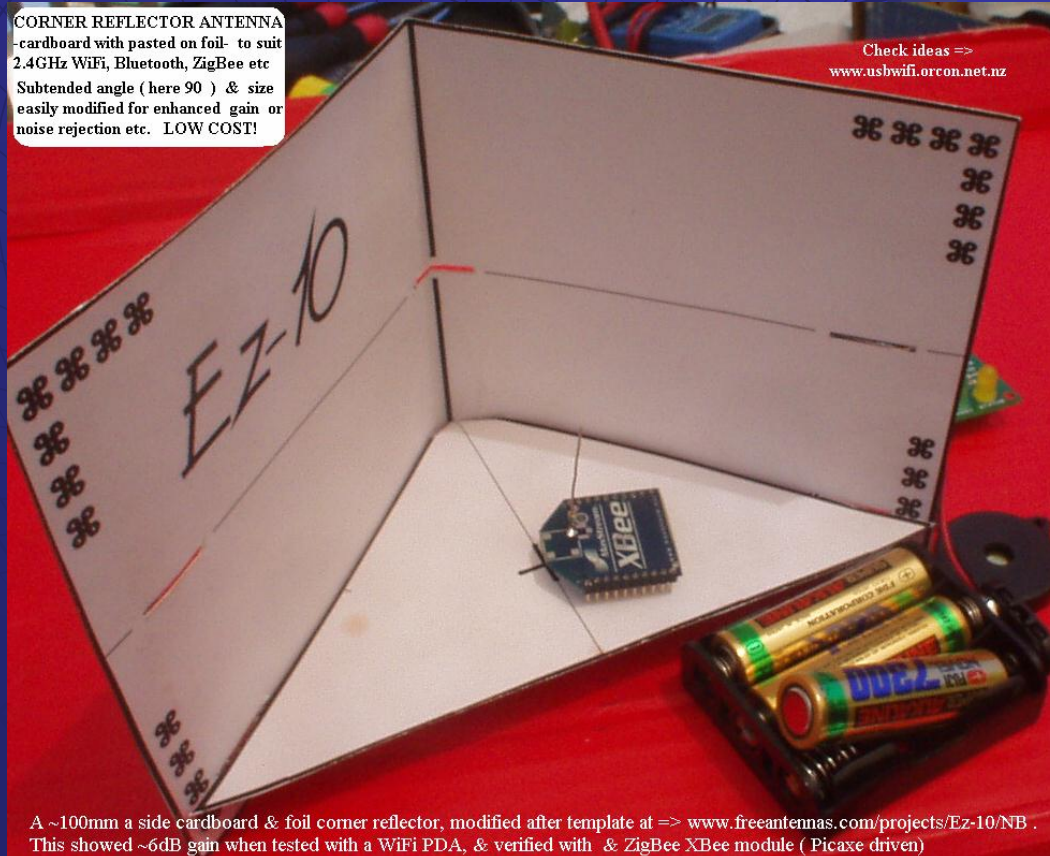
# Antennas

- ◆ Parabolic Cylinder



# Antennas

## ◆ Corner Reflector



# Antennas

## ◆ Dish

Since many PDAs, cell phones & IP Wireless devices now have sealed INBUILT antenna, there's not much possible in the way of external connections to enhance weak signals.

Using a DIY parabolic dish such as this simply concentrates the weak wireless signals onto the antenna sited at the focal point - flexible mounting allows positioning for the best reception.

Conveniently ANY microwave signals come to the same FP - so the design will enhance 900/1800MHz cell phones, 2GHz IPWireless & "b/g" 2.4GHz & even "a" 5.4 GHz WiFi. Tests with PDA utility **WiFiFoFum** indicate 12dB gain readily achieved = 4 times range!

**Dell Axim X5 PDA with Socket low power CF WiFi card at focal point (~75mm out) of cheap 320mm diam "parabolic" wok.**

This wok 320mm diam & ~85mm depth to centre

Verify focal point position by perhaps bringing the sun's reflection to a point - line the wok with aluminium foil for the trial if it's matt as here.

Of course the parabola formula for FP position can be used too

$$F = \frac{\text{Diam}^2}{16 \times C} = \frac{320\text{mm} \times 320\text{mm}}{16 \times 85\text{mm}} \approx 75\text{mm from centre}$$

Cheap compact camera tripod

Floppy disk case makes convenient cradle & allows swap out with cell phones etc too!

Spring paper clip allows secure but quick fit to dish. Clip bolted to back of cradle - if need be

Respect GSM cell phones have 35km distance limit.

Although hard to talk like this (unless you've a Blue Tooth headset!) in marginal locations inward text messages at least can get thru!

Via Stan SWAN => s.t.swan@massey.ac.nz <- June 2004  
See full "Parabolic Cookware" WiFi details => www.usbwifi.orcon.net.nz

Mmm- certainly cost effective- NZ\$8 ! A 300mm diam ( 12" ) Chinese cooking vat scoop that closely approximates a shallow parabola. It's mesh holes (~5mm) are well under the min. .1 wavelength at 2.4GHz ( 1 wave= 125mm ) & it gives little wind resistance & rust.

Diam = 300 mm, with 60mm depth (D) (c) to centre

$$f = \frac{D^2}{16c}$$

$$= \frac{300 \times 300}{16 \times 60}$$

$$= \frac{1500}{16}$$

(So focus ~94mm out)

-which is beyond screen rim & may give weak signal pickup from sources not being looked at

f / D ratio desirably 0.25-0.55 for such 2.4GHz parabolas

(Here = 94/300 ~ 0.31)

This setup could look very professional spray painted black & maybe mounted on a simple photographic tripod

Suitable support for the USB WiFi adaptor ( here a ~US\$40 "ZyDAS ZD 1201" sold in NZ by DSE ) will of course be needed, maybe fed thru' the mesh from the back ? USB dongle then can be removed until needed

Parabolic reflective performance of similar "appropriate technology" dishes can be quickly verified by Al foil curved around the mesh to direct the sun, or a bright light, to a focus

Experiences show mesh equiv. to "0.8" of a dish of similar size. Hence this equates to a solid dish 0.8 x 300 ~240mm & is likely to have gain ~15dB (A trial verified >12dB ! )

With one at each end of a link, the 30dB system gain could give >10km LOS

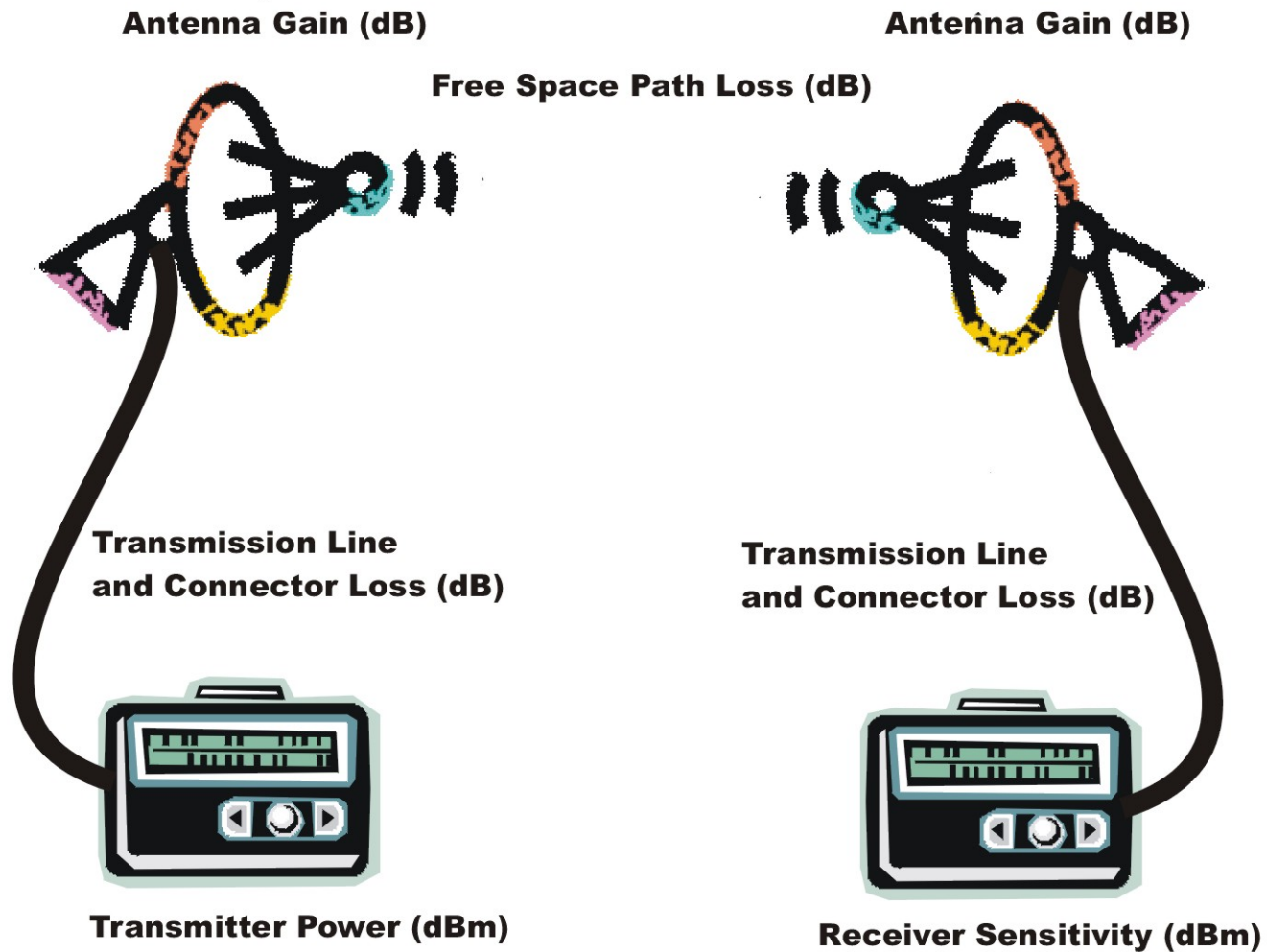
Other simple DIY reflectors abound - with "BBQ grill" style likely better gain. Doubling dish diam gives 6dB gain & doubles range

POOR MANS WIFI ?

Cheap & "lossless" long run (3m+) USB cables mean reception "sweet spots" more easily exploited than normal costly microwave cable & connectors can justify. Great !

Stan. Swan -MU@W - 2nd May 2004  
=> s.t.swan@massey.ac.nz

# Link Budget





# Link Budget Software

## RF Link Budget Calculator



<http://www.afar.net>

Input:

Frequency:  MHz

Transmit Power:  dBm

Cable 1 loss:  dB

Antenna 1 gain:  dBi

Distance:  Km

Antenna 2 gain:  dBi

Cable 2 loss:  dB

Receiver Sensitivity:  dBm

Fade Margin:

Compute:

Distance

Transmit Power

Fade Margin

Units:

Km

Miles

Output:

**Fade Margin: 39.8 dB**

Free Space Loss: 115.8 dB

Receive Signal Strength: -48.2 dBm

## Cable Loss Calculator

Cable Type:

Cable Length:  meters

No. of Connectors:

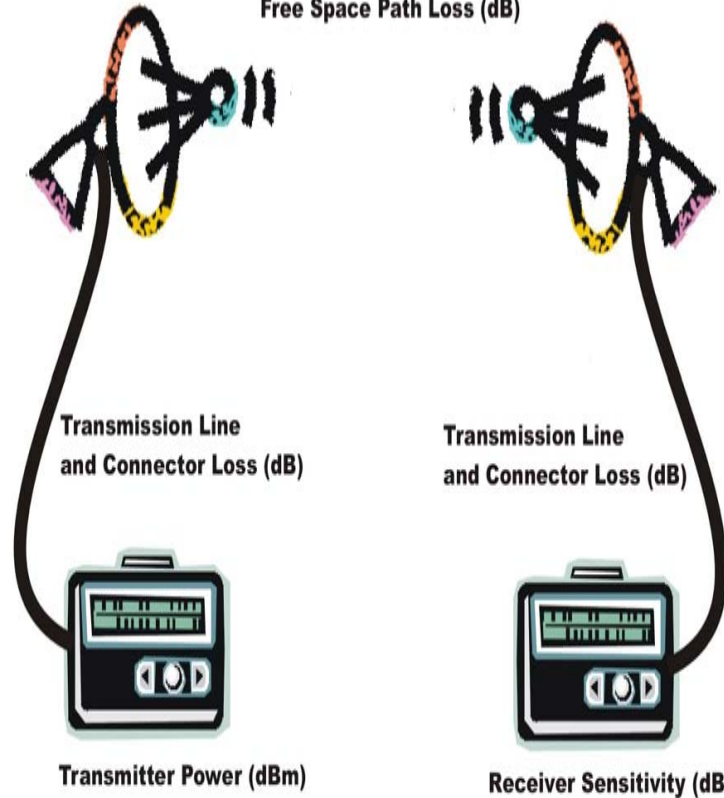
Loss per 100 meters:  dB (at 2450 MHz)

**Total Cable Loss: 1.7 dB**

Antenna Gain (dB)

Antenna Gain (dB)

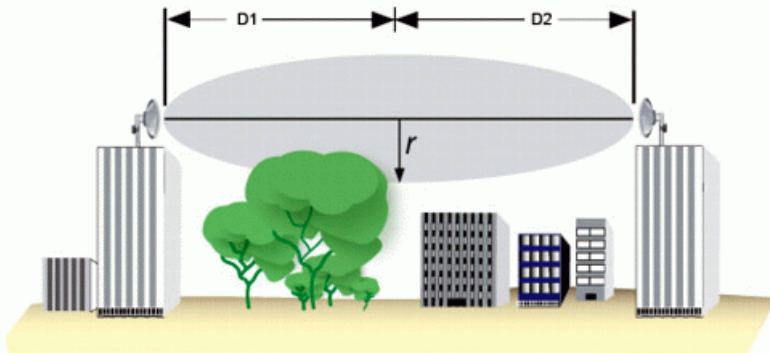
Free Space Path Loss (dB)



# Software

## ◆ Fresnel Zone (60%)

**FRESNEL ZONE CLEARANCE CALCULATOR**



$$r = 72.1 \sqrt{\frac{d1 \times d2}{\text{freq} \times \text{total dist}}} \quad \text{*calc in miles}$$

Distance A (D1) in Km <input type="text" value="1"/> (Km)	Distance B (D2) in Km <input type="text" value="1"/> (Km)	Frequency in GHz <input type="text" value="2.4"/> (GHz)
Convert It	Equals	
<input type="button" value="Convert"/>	The 1st Fresnel Zone is <input type="text" value="7.9"/> meters across to radius. <input type="text" value="25.9"/> feet across to radius.	60% of 1st Fresnel Zone is <input type="text" value="4.7"/> meters across to radius. <input type="text" value="15.6"/> feet across to radius.

# Construction

- ◆ Measurements for a 3-1/4" diameter
  - Probe Length = 1.21" (31mm)
  - Set 2.49" from back of can (63mm)

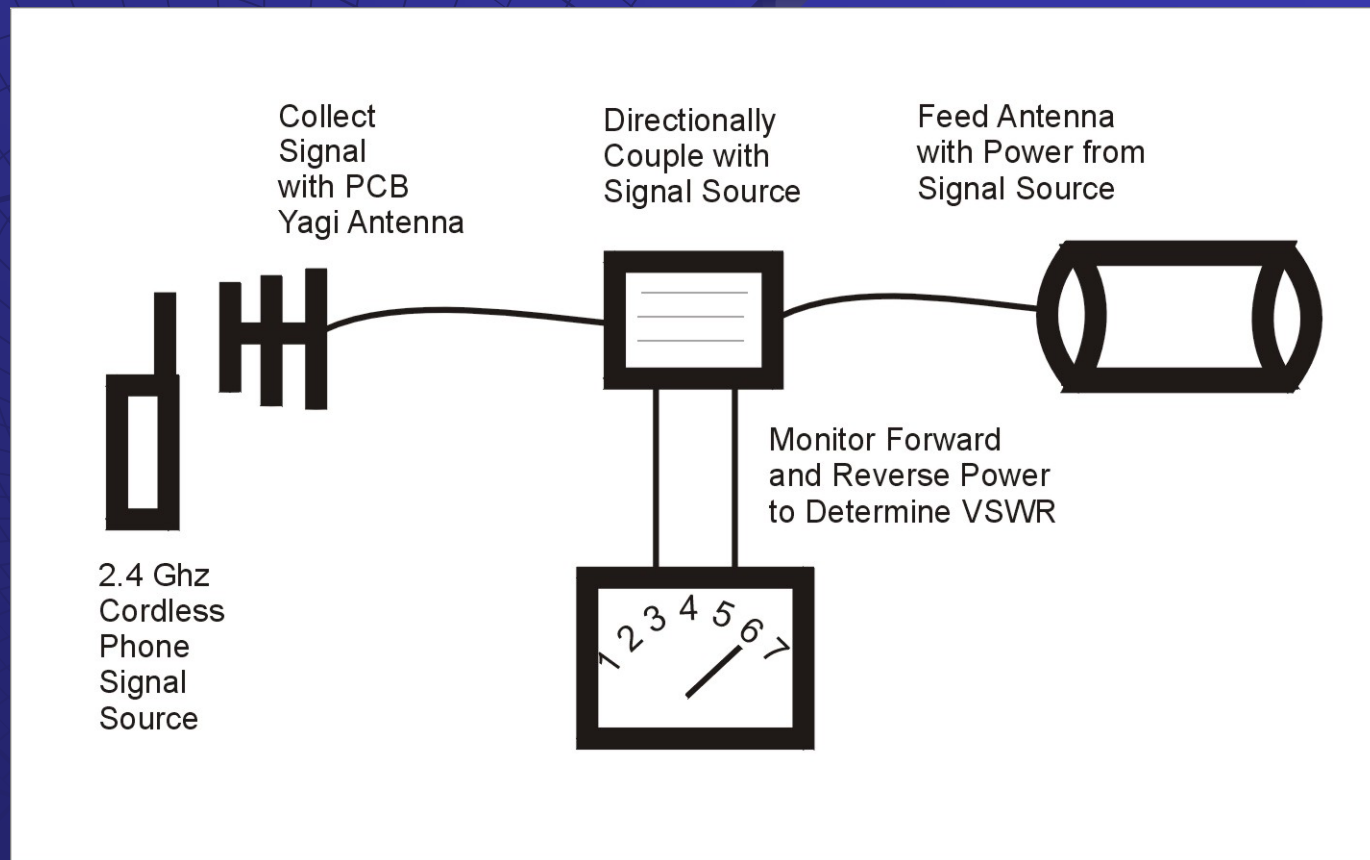


# Multimedia Software

- ◆ Conf (NetMeeting)
  - Windows Start Button
  - Find "Run" on the menu
  - Type in "conf" and press enter
- ◆ Sends Voice and Video over a network – in this case, wireless.

# Testing Methods

## ◆ VSWR



# Testing Methods

- ◆ VSWR Measurement
  - FP = Forward Power
  - RP = Reverse Power

$$\text{VSWR} = \frac{1 + \text{sqr}(\text{RP}/\text{FP})}{1 - \text{sqr}(\text{RP}/\text{FP})}$$

Definition: impedance mismatch between transmission line and load

# Testing Methods

## ◆ VSWR Measurement Example

- FP = .18 mW
- RP = .05 mW

$$\text{VSWR} = \frac{1 + \text{sqr}(.05/.18)}{1 - \text{sqr}(.05/.18)} = 3.25:1$$

# Testing Methods

## ◆ VSWR Mismatch Effects

VSWR	Antenna Impedance $\Omega$	Gain Reduction	Gain Reduction (10 dB antenna)
1.0:1	50	0.00%	0 dB
1.5:1	75, 33	4.00%	.20 dB
2.0:1	100, 25	11.10%	.51 dB
3.0:1	150, 16.67	25.00%	1.28 dB
5.0:1	250, 10	44.50%	2.59 dB
10.0:1	500, 5	67.00%	4.81 dB