*Cray Valley Radio Society*

# Real Life Wire Antennas

# The basic dipole

- The size of an antenna is determined by the wavelength of operation
- In free space: Frequency x Wavelength = Speed of Light, $\sim 3x10^8$m/s

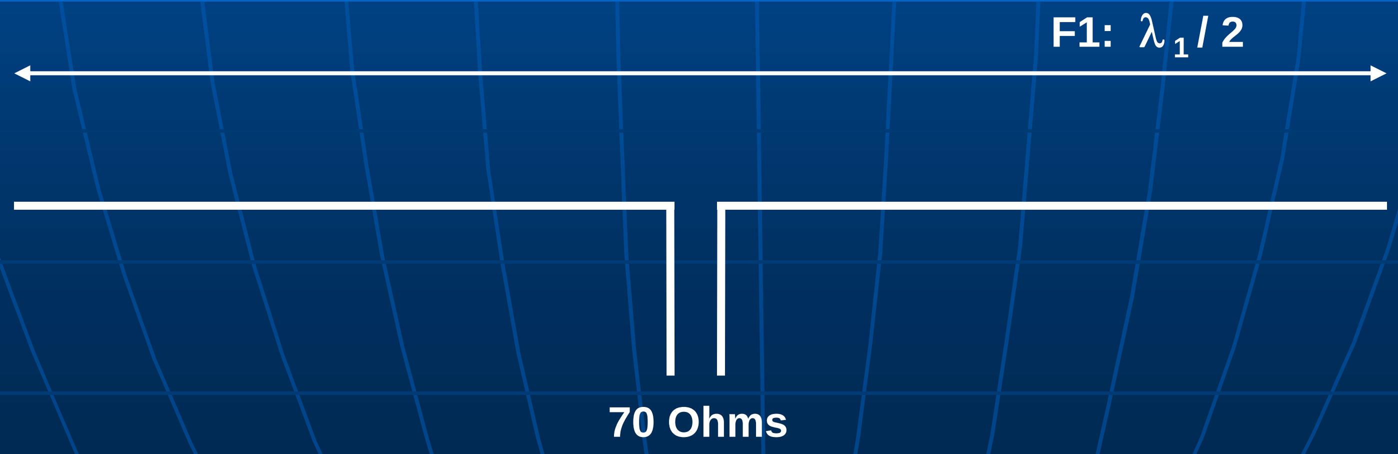
$$v = F \times \lambda = 3 \times 10^8 \quad \text{or} \quad \lambda = 3 \times 10^8 / F$$

where F is in Hertz and $\lambda$ in metres

- A wavelength for 14MHz would be $3 \times 10^8 / 14.05 \times 10^6 = 21.35$ metres
- Therefore a half wavelength = 10.67 metres and as the feed-point for a DIPOLE is in the centre, each wire should be 5.33 metres long
- BUT . . .
- The velocity of an RF wave in wire is slight lower than that in free space, and the terminations introduce an 'end effect'
- End factor correction means the physical wire can be cut 5% shorter
- 10.67 x 0.95 = 10.14 metres

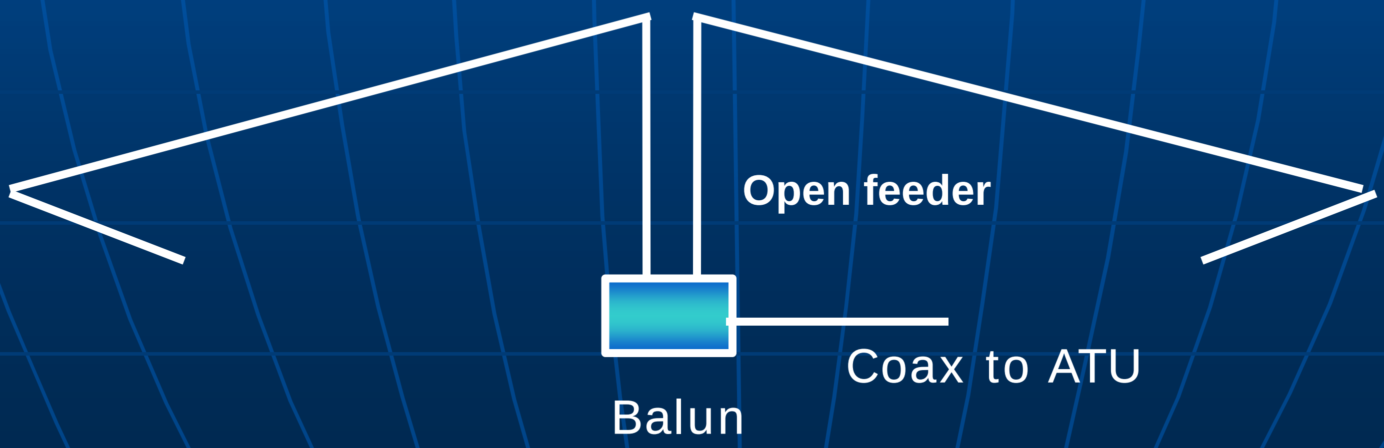
# The basic dipole cont..

- So……
- We have a basic antenna which works on one band well
- It can be directly fed with Coax ideally via a balun
- It needs no ATU on the band it is designed for
- We can do better by being a little more ingenious



# The doublet or un-tuned dipole

- Each total  length around 3/8 λ at the lowest frequency desired but can be less but not a quarterwave on each leg
- Fed for as much of the feedline as possible with open wire feeder.
- Covert to coax with a Balun as near as possible to the ATU
- Configure as inverted V and bend in the legs if needed to fit the space

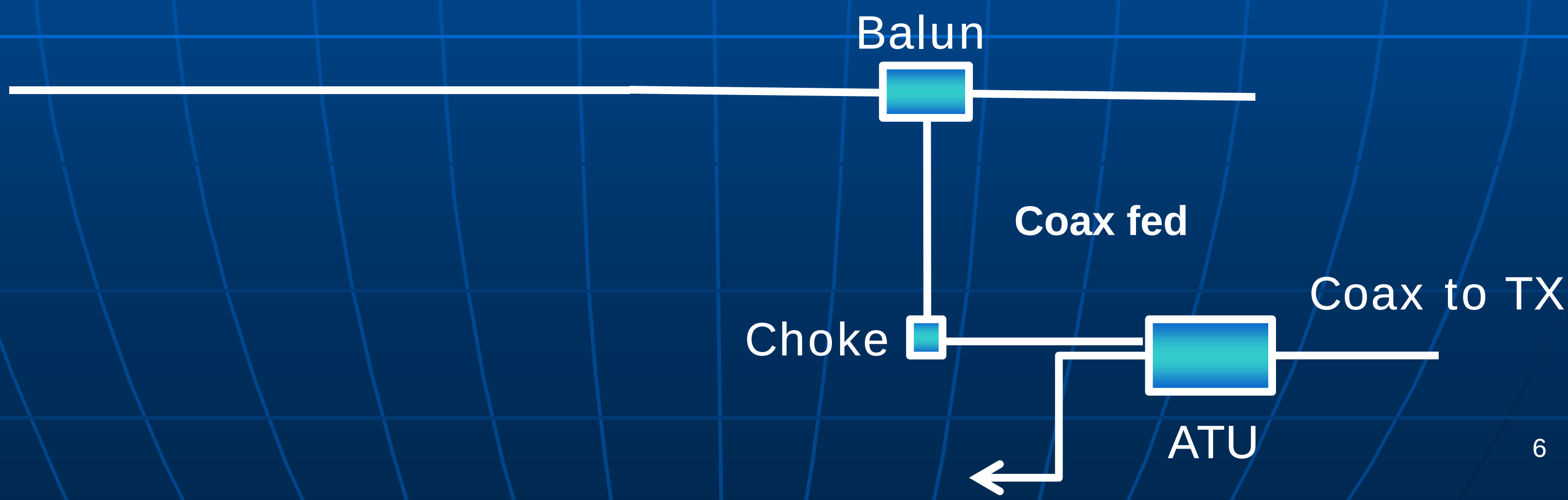


# The Windom

- A dipole has not got to be fed in the middle-That just happens to be the point of lowest impedance and highest current
- That low impedance point will be very high harmonically related bands hampering multiband operation
- The original idea was to pick a point with about 600OHMS on the lowest bnd and all the harmonically related bands would be similar and you could feed with a single wire and also radiate from that too
- That point was found by Loren G Windom (W8GZ) to be about a third of the way along

# The Carolina Windom

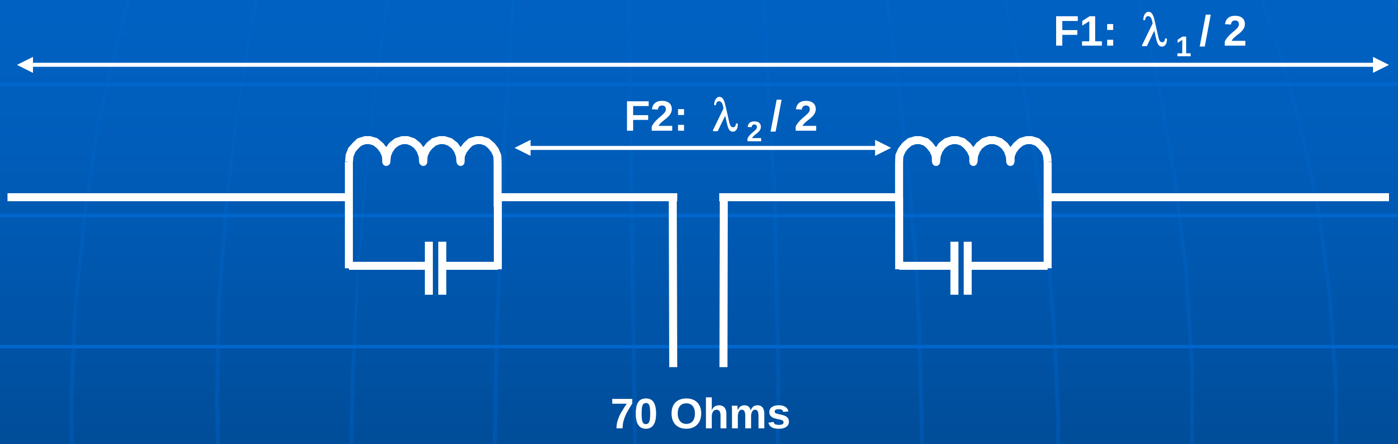
- Feeding an antenna with a single wire has EMC implications
- If you find a 450ish ohm point on your harmonically related bands why not put a balun at that point and feed with coax – The point is near quarter of the way along
- Allow the feeder to radiate on the vertical section but choke them off with Ferrite outside the property
- This is a much better arrangement from an EMC point of view



# The Remote Tuned Inverted L

- Total length vertical + Horizontal  as long as posible but not a quarterwave on any desired band
- Tuned by a remote ATU against ground to minimise EMC issues
- A good ground with multiple radials needed

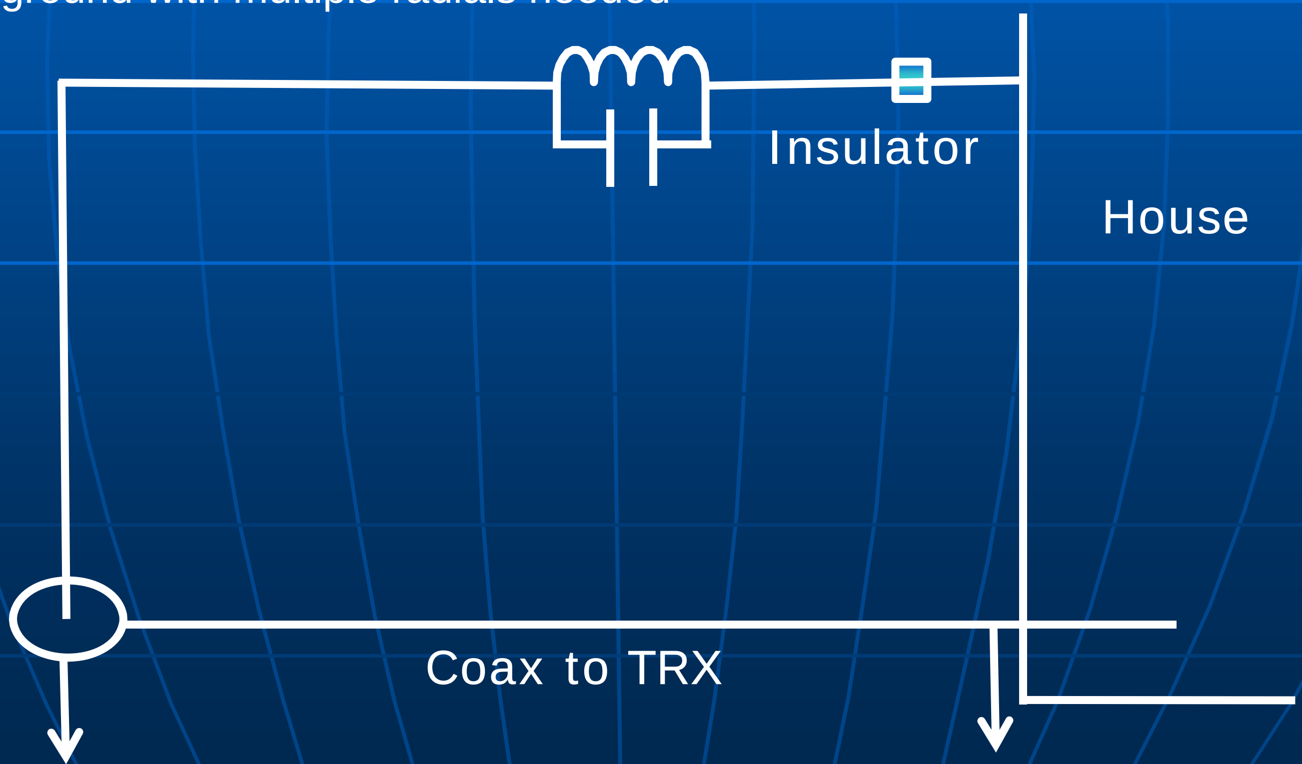
# Trap Dipole



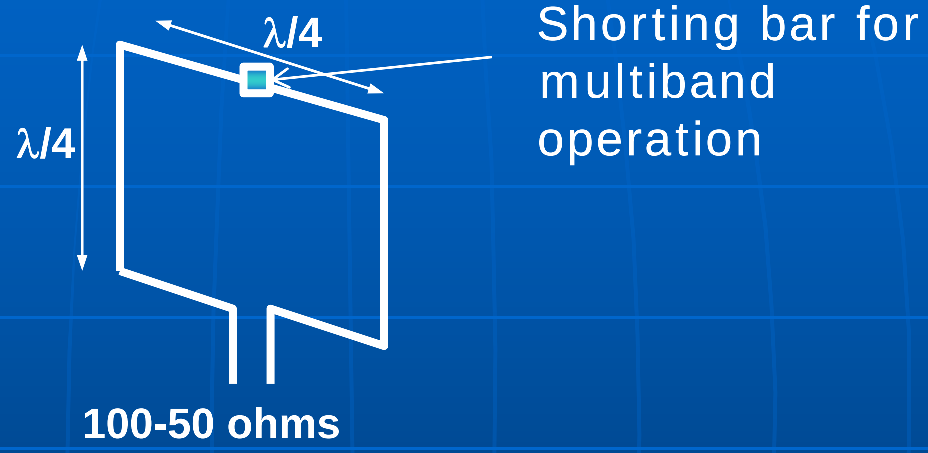

- One dipole can be turned into two or three by the addition of parallel tuned circuits called TRAPS
- The trap has a high impedance at F2 – looks like an open circuit
- The trap principle is frequently use in beam antennas to get 2- or 3-band operation out of a single element

# The Trapped Tuned Inverted L

- A combination of the Trap dipole and the inverted L
- Half a trap dipole tuned against a good ground
- Will work without ATU on 2 or more bands depending on the traps
- A good ground with multiple radials needed



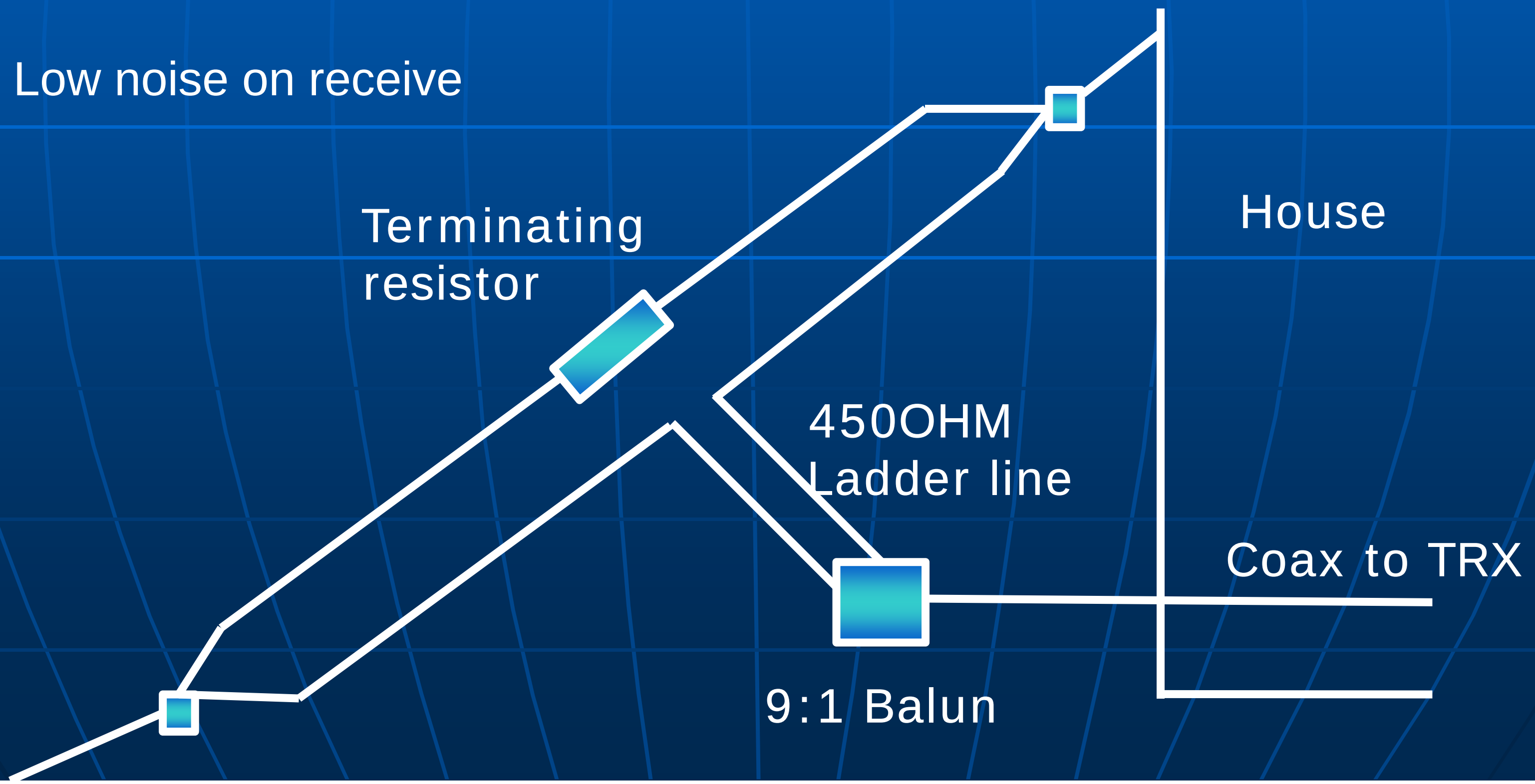
# The Quad Loop




- A single full wave loop is a big step up from a dipole
- Has a very low radiation angle at the design frequency, making it good for HF DX
- A removable shorting bar opposite the feedpoint will make it usable at around half the design frequency and others with an ATU
- Use a 1:1 Balun at the feedpoint
- Never use insulated wire on a quad loop

# The T2FD Sloper

- A compromise much favoured by the US military
- Will work without ATU from the design frequency upward with a low SWR
- Some losses in the terminating resistor
- A low angle of radiation
- Low noise on receive

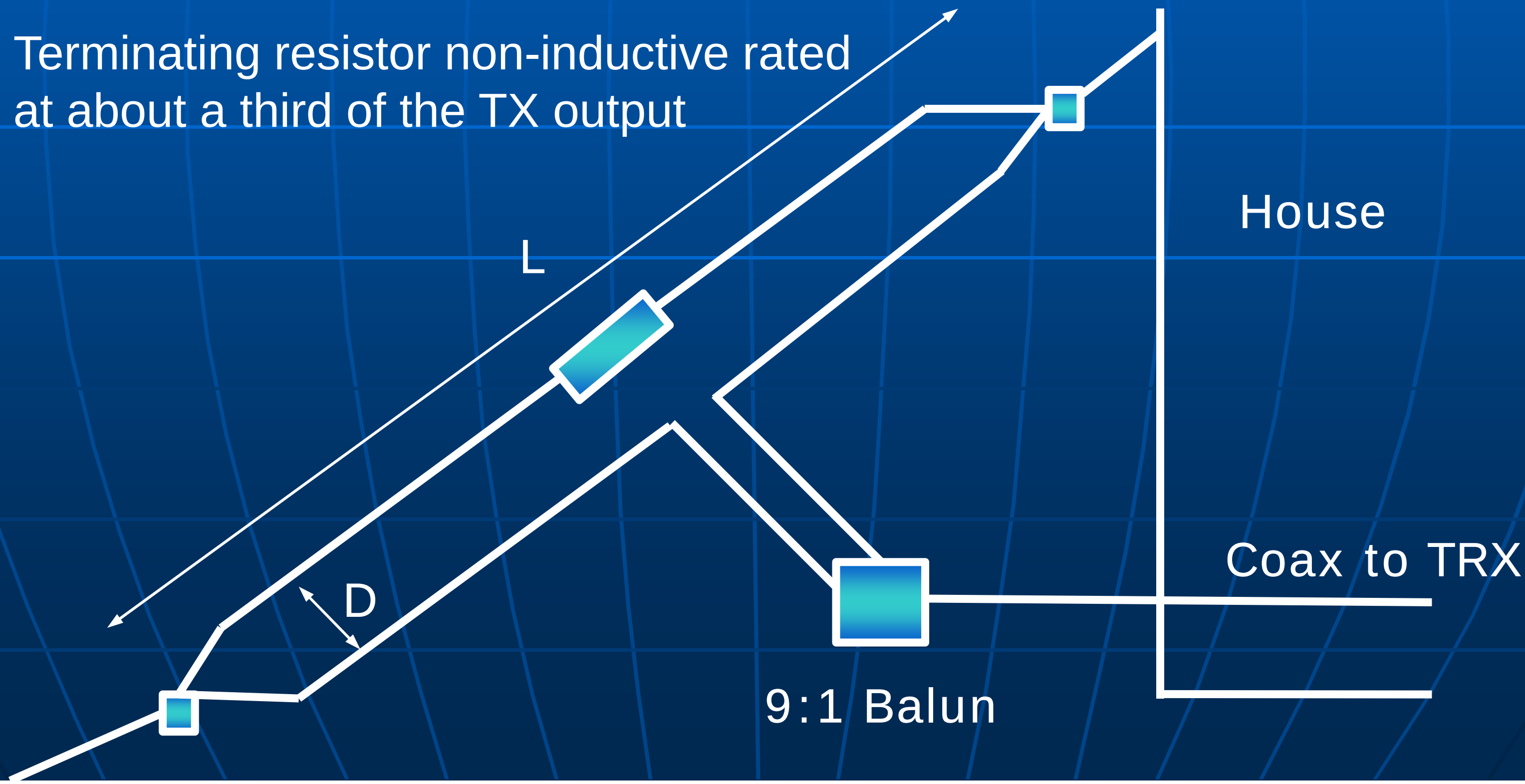


# The T2FD Sloper

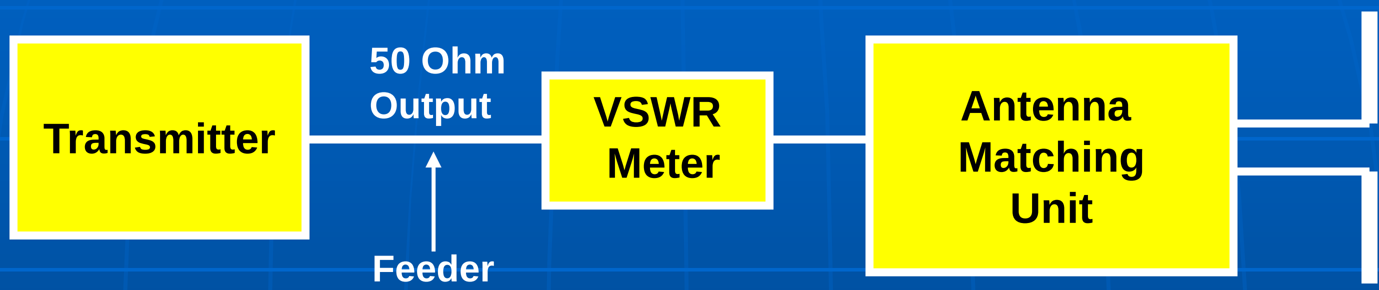
The formulae for use when constructing of a T2FD :
L (m) = 50/***f*** MHz (14M or 47feet for 80m Band upward)
D (m) = 1.55/***f*** MHz (44cm or 17 inches for 80m band upward)
***(f is the lowest operating frequency required)***

- Terminating resistor of c. the feed point impedance so 450 OHM if using ladder line and a 9:1 BALUN

- Terminating resistor non-inductive rated at about a third of the TX output

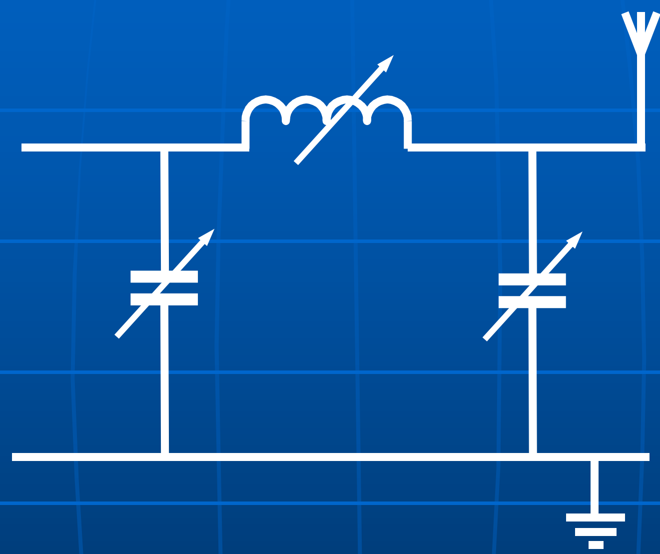


# Antenna Matching Unit

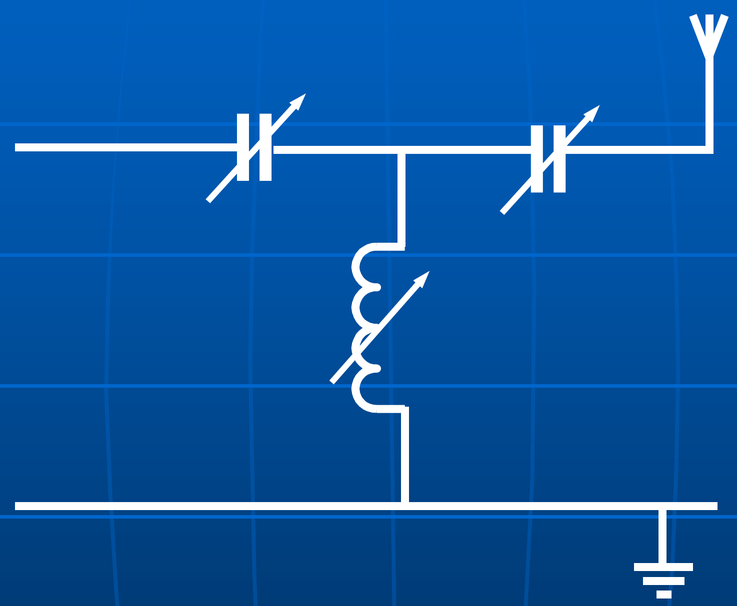



- An ATU ('AMU') tunes out the reactive component of an antenna (an antenna off resonance) in order to present a 50 ohm resistance to the transmitter
- If the ATU is located at the transmitter, it will have no effect on the SWR on the feeder between the ATU and the antenna itself

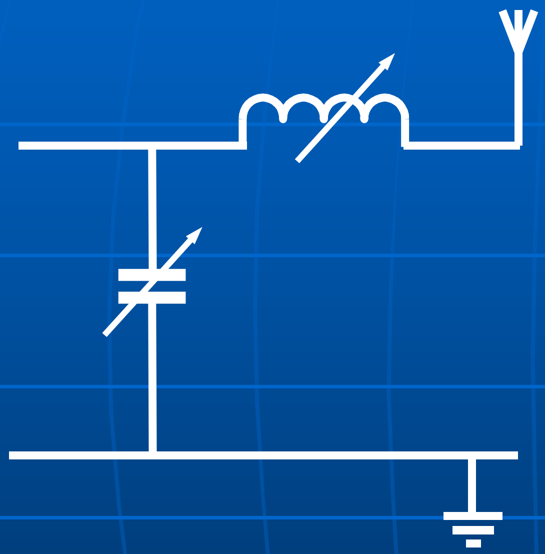
# Pi Network ATU

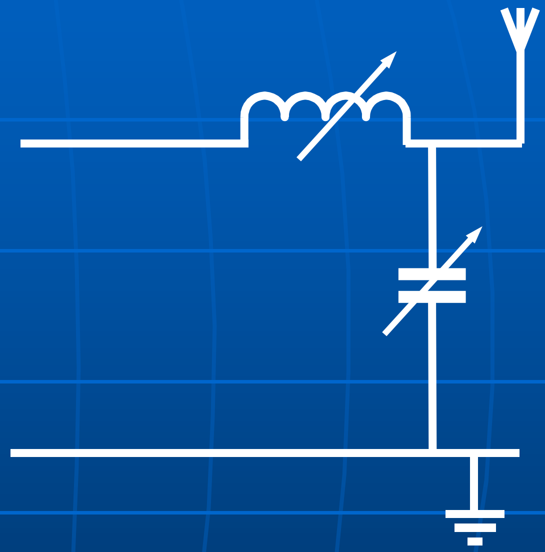


# T-Match ATU



# L Network





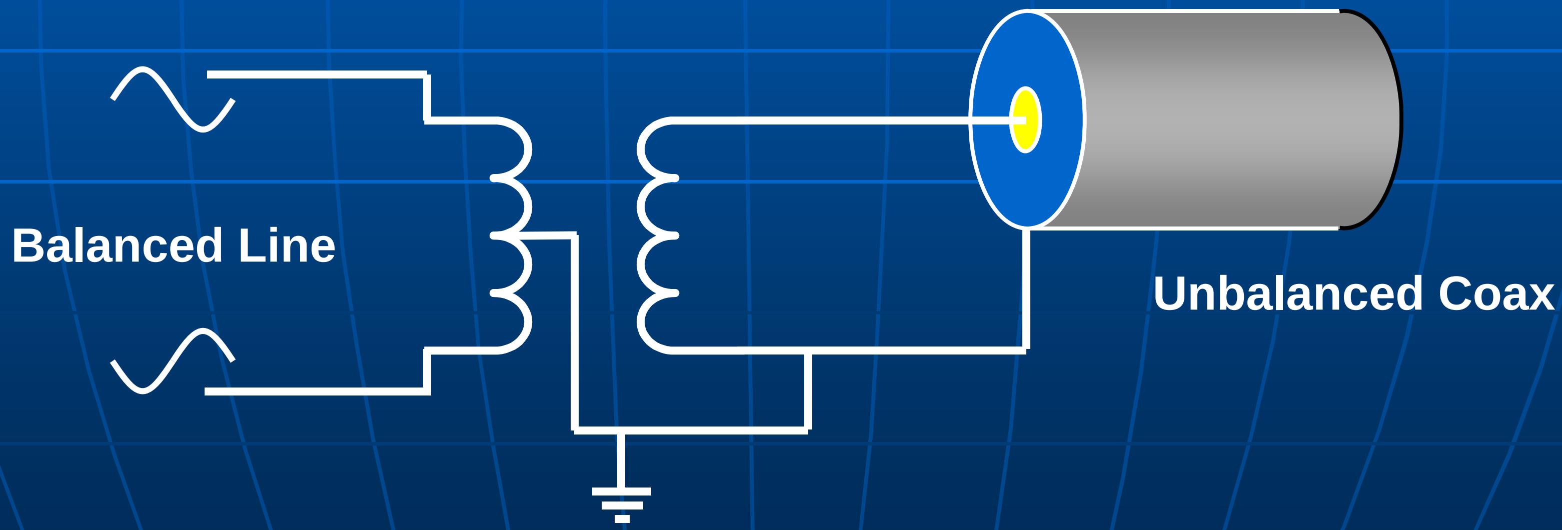
- **Low impedance antenna**
- **High impedance antenna**

# Baluns

- Remember BALUN = Balanced Unbalanced
- Many antennas are balanced devices, such as dipoles etc
- Connecting a dipole to an unbalanced coax cable causes currents to flow in the outer sheath
- These currents give rise to unwanted radiation which may cause EMC problems
- A solution is to match the balanced antenna to the unbalanced line using a BALUN
- Or use twin feeder!

# Transformer Balun

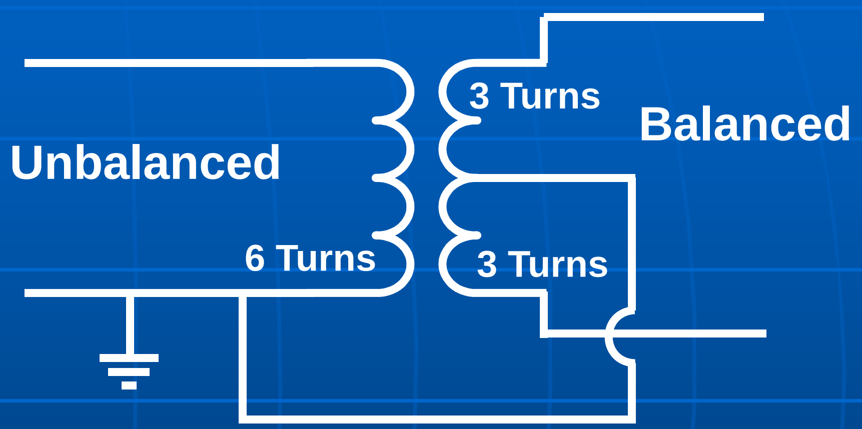
- Normally wound on a ferrite core
- Used to match a balanced system such as ladder line or a dipole to an unbalanced line such as a coaxial cable
- Operate over a wide frequency range



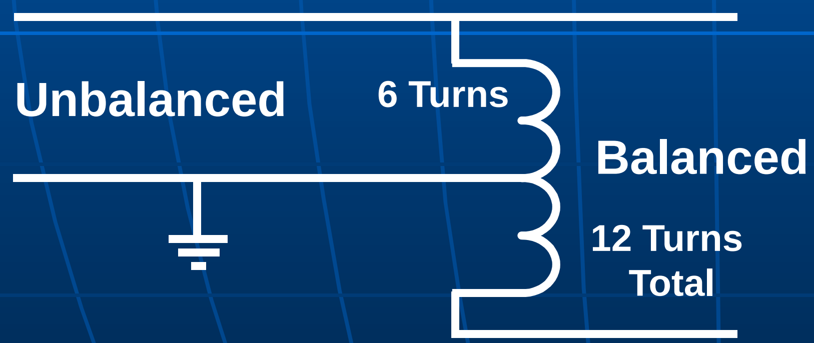
# Transformer Ratios

**1:1 Transformer BALUN**

**Primary turns equals Secondary Turns**

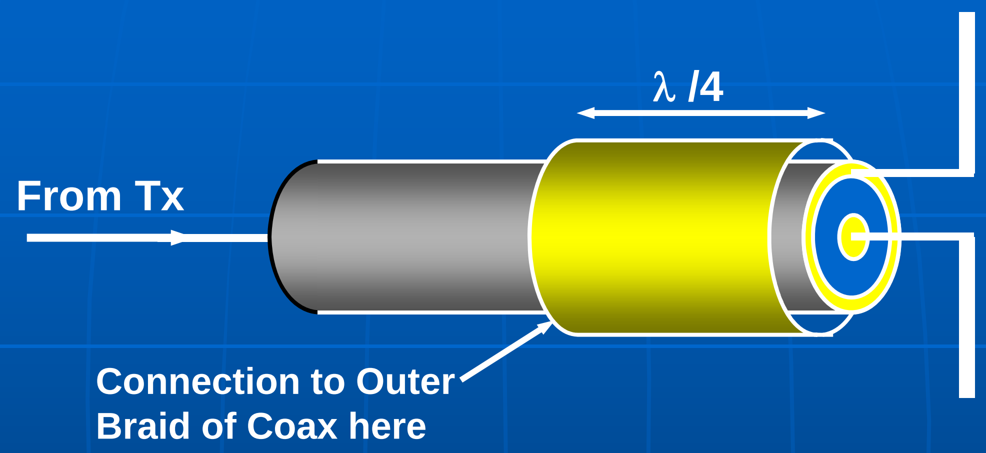



**1:4 Transformer BALUN**



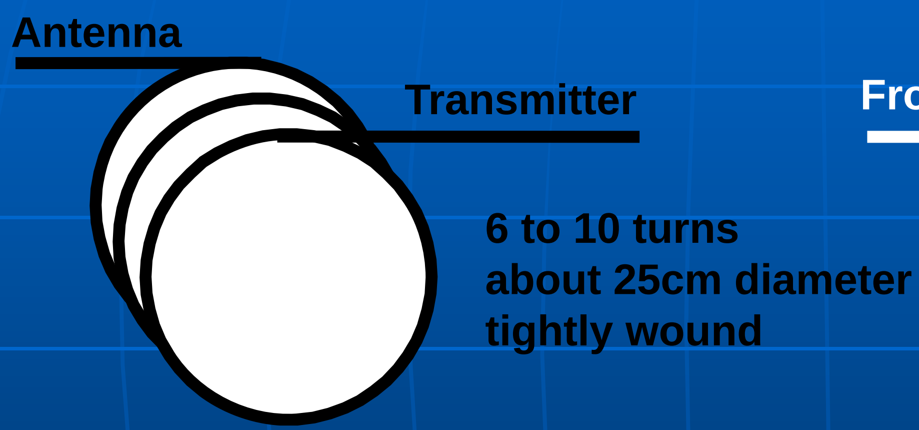

- **Recall: $Zp = Zs \cdot (Np / Ns)^2$**
- **1:2 Turns Ratio will create a 1:4 Impedance Transformation**

# Sleeve Balun




- A λ/4 long braided or solid extra outer conductor positioned around and insulated from the coax screen and connected to the screen at the rear
- The high impedance of the open circuit prevents currents flowing back down the coax screen
- As it is based upon λ/4 on one band, this is a single band device

# Choke Baluns

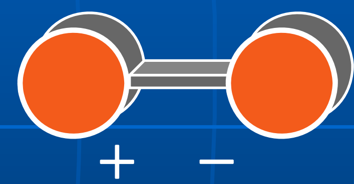




- Current or Choke Balun prevents current flowing on the screen of the coaxial feeder cable
- Operates over a broad frequency range

# Feeders

- Feeder types: Coaxial, Twin




Inner Conductor is shrouded by dielectric, with outer (braided) screen.

50 ohm used for radio, domestic TV uses 75 ohm

Two conductors kept at constant separation by insulation - no screen

Balanced Feeder is available in 75-300 ohm

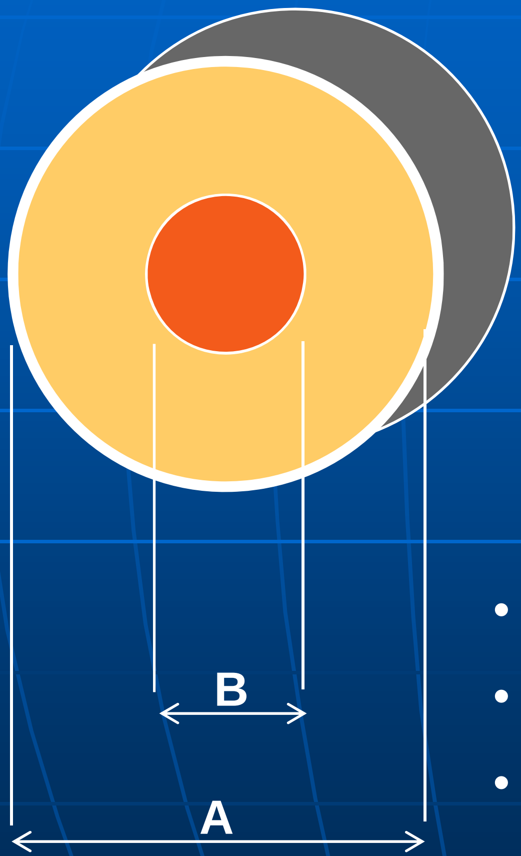
# Balanced/Unbalanced

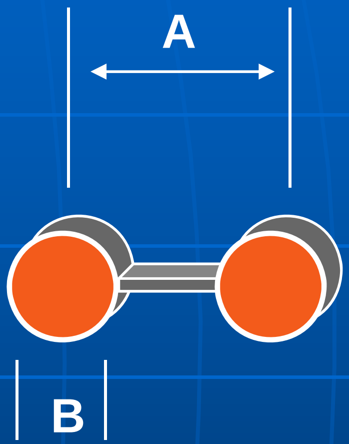
- Coax is unbalanced - Inner has signal, Outer is at ground.
- Twin feeder is balanced - conductors have equal and opposite voltages/currents/fields.
- Mounting Twin Feeder near to conducting objects will cause an imbalance in the conductors and unwanted radiation

# Velocity Factor, VF

- In Free Space, waves travel at the speed of light - $3x10^8$ m/s
- In other media such as coax they slow down depending on the construction and dielectric constant - by the Velocity Factor, VF
- VF for open twin feeder is ~0.95, low loss airspaced coax ~0.8-0.9
- Solid Polythene filled Coax typically has VF 0.67
- Since Frequency stays constant, wavelength shrinks by the VF
- VF is important when using quarterwave coax stubs, transformers etc.

# Feeder Impedance



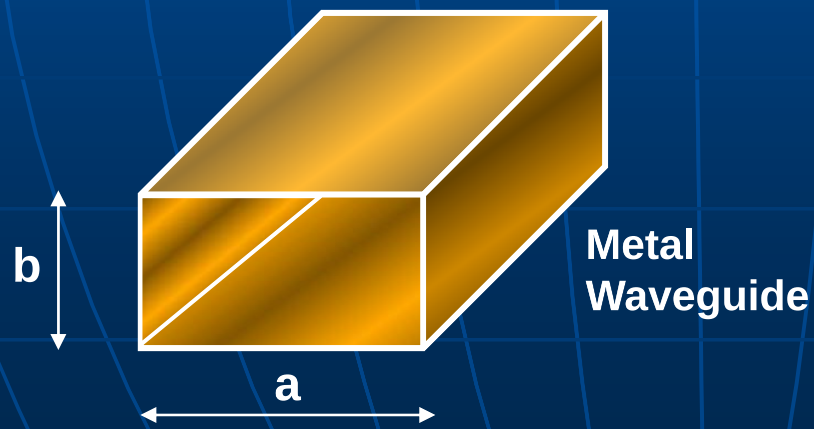

- Feeder Impedance is a form of AC Resistance
- Impedance is based on the Ratio of A and B
- Impedance derives from the series Inductance and the shunt capacitance

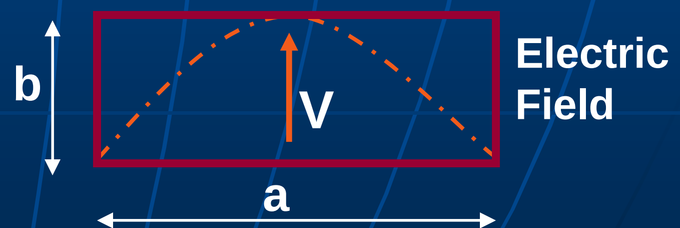
# Feeder Losses

- ALL feeders have loss, the longer the feeder the greater the loss. Twin feeder has a lower loss than Coaxial cable
- Loss occurs in the conductors and the insulating dielectric
- Coax losses are critical at VHF, UHF and especially Microwaves
- Coax Loss can appear to hide a bad match at a remote distance. SWR is reduced by twice the loss in dB
- Example:-   A 5dB Insertion loss makes a Short circuit look like
  a 2:1 (10dB) match, rather than an infinitely bad one

# Waveguide

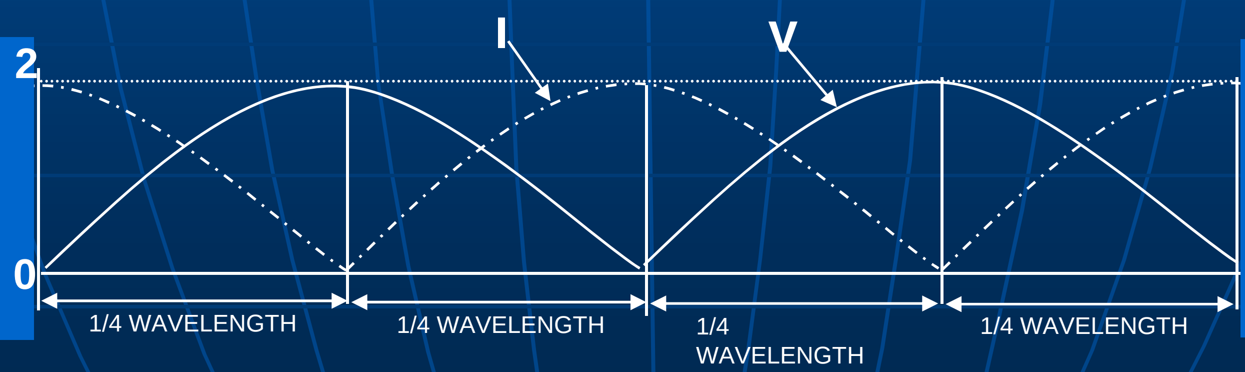
- At microwave frequencies coax is very lossy
- Lowest loss material is air; thus the concept of guiding waves in a hollow metal pipe - a waveguide
- Propagation inside starts when dimension a is a half wavelength
- E.g.  a=15mm cuts on at 10GHz
- For a given size, usage range is 1.25 - 1.9 times the cuton frequency
- Example: WG17 a=19.05 (0.75”) -  Cuton= 7.868GHz, Used for 10-15GHz
- Sizes available for 1GHz to 300GHz



# Voltage Standing Wave Ratio

- If the feed point impedance does not match the impedance of the feeder then some energy will be reflected back down the feeder.
- When this reflected energy is returned to the transmitter it is again reflected back to the antenna and is radiated
- The combined energy is known as the forward and reflected power and gives rise to standing waves on the feeder



# Standing Wave Ratio - SWR

- SWR = Standing Wave Ratio
- SWR is the ratio of the maximum and minimum values of a standing wave.
- It can be expressed in terms of the forward and reverse voltages or currents
- It is usually based on voltages, thus Voltage Standing Wave Ratio - VSWR

$$SWR = V_{MAX} / V_{MIN}$$

or

$$SWR = (V_{FORWARD} + V_{REVERSE}) / (V_{FORWARD} - V_{REVERSE}) \quad : 1$$

- No reverse voltage, SWR is 1:1 – perfect match

# Return Loss

- Return Loss is an alternative expression for match based on ratio of forward and reflected power and is expressed in dB

$$\text{Return Loss, dB} = 10 \times \text{Log}\ (P_{REVERSE} / P_{FORWARD})$$

or

$$20 \times \text{Log}\ (V_{REVERSE} / V_{FORWARD})$$

- Relation of return loss to SWR:

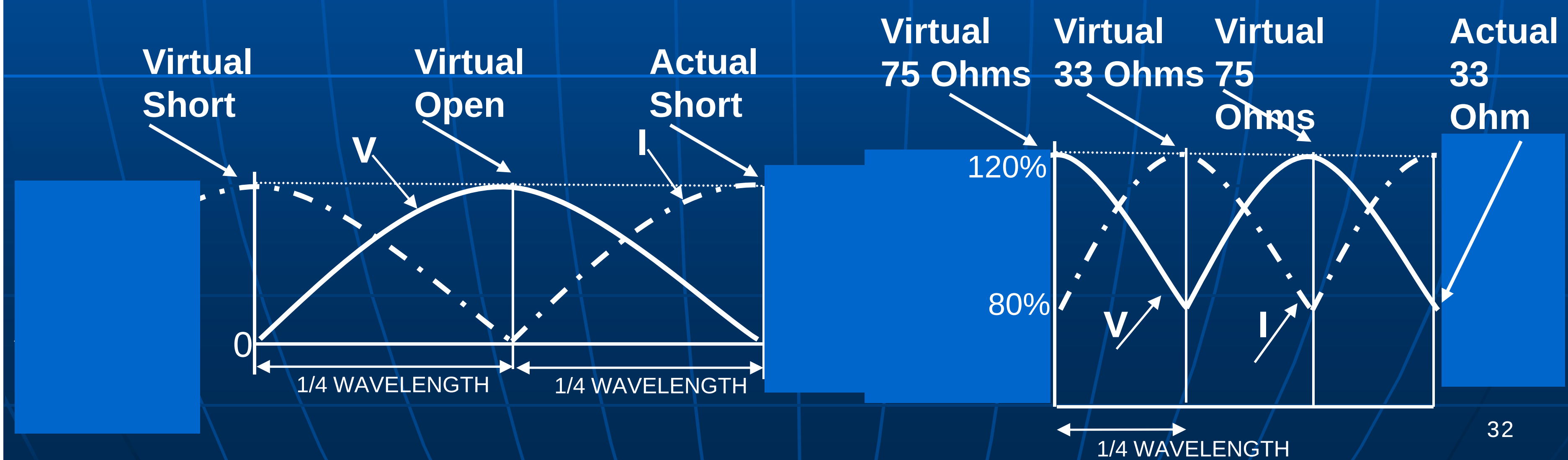
$$\text{Return Loss, dB} = 20 \times \text{Log}\ (\ (SWR-1)\ /\ (SWR+1)\ )$$

# Loss

- Low SWR is good
- Low SWR = high return loss
- High SWR = low return loss
- Lossy feeder makes the SWR appear good
- TX return loss = antenna return loss + twice feeder loss

# Impedance Transformation

- Successive quarter waves on a coax (or balanced) line exhibit virtual short and open circuits
- Similar to the radials at the base of a quarterwave antenna
- Can can be used more generally for any impedance



# Quarterwave Transformers

- Quarterwave coax transformers can transform impedance
- To match a load $Z_{IN}$ to a source $Z_{OUT}$ a quarterwave of intermediate impedance $Z_O$ can be used as follows

$$Z_O^2 = Z_{IN} \times Z_{OUT}$$

or

$$Z_O = \sqrt{(Z_{IN} \times Z_{OUT})}$$

- Example:- to match a 100 ohm antenna to 50 ohm coax . . . . . . a quarterwave of 70 Ohms is needed
- Remember to take account of the velocity factor

# End of Antennas and feeders