Review

- Wavelength in meters = 300/Freq in MHz

or

Wavelength in ft = 983.6/Freq

MHz

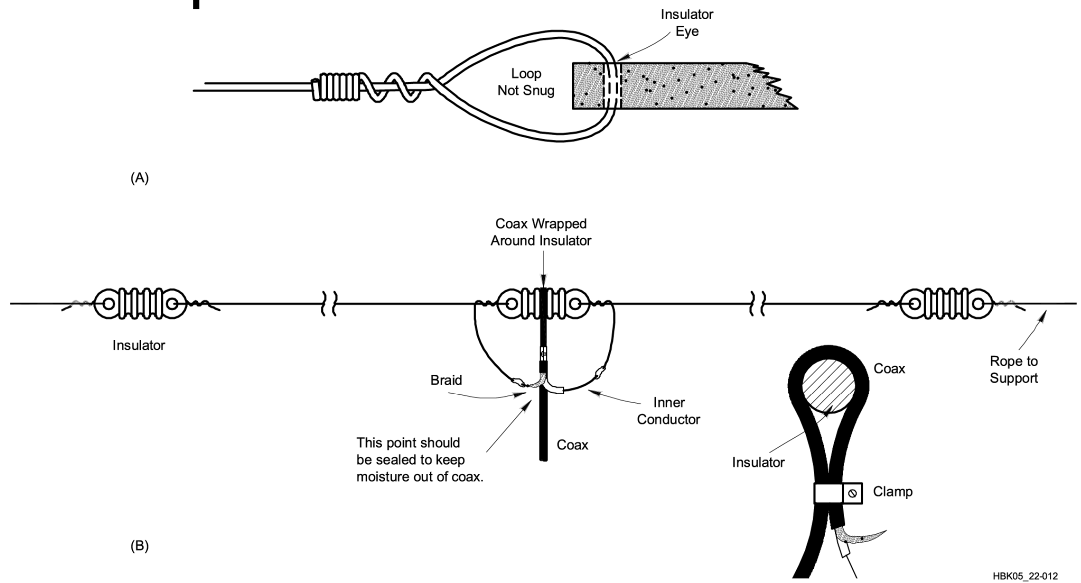
- Velocity factor is multiplied times the wavelength for coax cable.
- Resonance is when Capacitive reactance (X_C) = Inductive reactance (X_L)
- Reactance has a real component and an imaginary component (-j X_C or j X_L)
- Power = Voltage * Current (E*I)
- Voltage = Current * Resistance (I*R)
- Power is also = I*I/R or $= I^2$*R

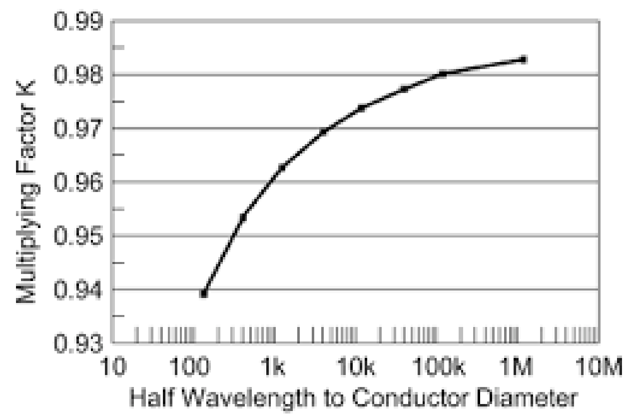
The Half-Wave Dipole Antenna

- Start with excess length (492 * K / f in MHz) and adjust

- The K factor is based on length of wire to wire diameter ratio.

- To raise resonant frequency, shorten each half equally





Dipole Impedance

For the input impedance, we anticipate both a real and imaginary part, since the near-fields of the dipole will contribute to a reactive component. The input resistance can be found as follows:

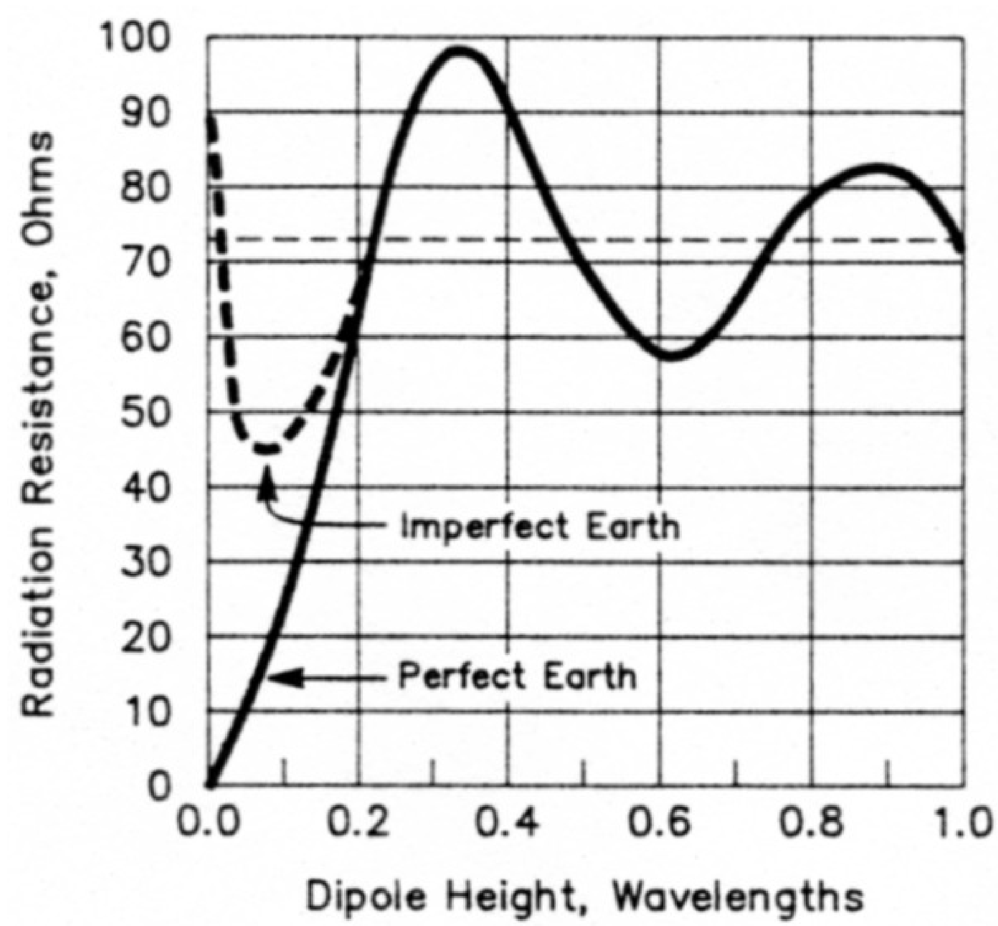
Then,

$$R_{rad} = 2W_{rad}/Im^2 = 73.1280 \text{ Ohms}$$

The calculation of the reactive part of the input impedance is much more involved and beyond the scope of the discussion here. The final result for the dipole's input impedance is

$$Z_{dipole} = 73 + j42.5 \text{ Ohms}$$

Dipole impedance over “ground”



VSWR of a Dipole Antenna using a 50 Ohm transmission line

$$\Gamma = \frac{73 - 50}{73 + 50} = 0.187$$

$$VSWR = \frac{1 + 0.187}{1 - 0.187} = 1.46 : 1$$

SWR	LOSS	ERP
1.0:1	0.0%	100.0%
1.1:1	0.2%	99.8%
1.2:1	0.8%	99.2%
1.3:1	1.7%	98.3%
1.4:1	2.8%	97.2%
1.5:1	4.0%	96.0%
1.6:1	5.3%	94.7%
1.7:1	6.7%	93.3%
1.8:1	8.2%	91.8%
2.0:1	11.1%	88.9%
2.2:1	14.1%	85.9%
2.4:1	17.0%	83.0%
2.6:1	19.8%	80.2%
3.0:1	25.0%	75.0%
4.0:1	36.0%	64.0%
5.0:1	44.4%	55.6%
6.0:1	51.0%	49.0%
7.0:1	56.3%	43.8%
8.0:1	60.5%	39.5%
9.0:1	64.0%	36.0%
10.0:1	66.9%	33.1%

SWR or Standing Wave Ratio is a measurement of antenna efficiency.

Too Balun or not Too Balun
That is the question

1. A review of why a balun (<u>bal</u>anced/<u>un</u>balanced) is used.
   1. A balun us used typically to stop or reduce common mode current from coming back at the transmitter due to a VSWR mismatch.
   2. A balun is a transmission line device.
   3. Although it can be configured as a transformer, it typically is not. It is more of an impedance converter.
   4. It is used to match the impedance of multi-band dipole antennas or other dipole antenna configurations such as off center fed dipoles.
   5. Although a balun consist of a core using a toroid and wire, it is a complex antenna element.
   6. There are two configurations: Current and Voltage

How Balun works

- A balun is not a transformer!! It is a not an inductor of the true sense.
- Some terminology need to be understood.
  - A bifilar (2 wires) wound balun in the winding process. You can have three wires, five wires or more to do this type of winding for a balun.
  - The electric fields the wires generate only couple between the wires not the core.
  - The core material will effect the frequency response of the balun.
  - Core types
    - Powdered iron
    - Ferrite
    - Air

Balun used to eliminate common mode current

- Open line feeders can prevent common mode current on both wires. This can be 450 Ohm or 300 Ohm open line feeder wires.
- The simplest balun is an air core. This consists of 10 to 20 turns of coax cable wound on a 6” to 10” core made of pvc pipe. This is to prevent common mode current from reflecting back from an antenna mismatch.
- The next type is a one to one balun. This has two configurations. A current balun and voltage balun.
- A one to one balun is made by winding a coaxial cable on a toroid core. The coaxial cable is a 50 Ohm transmission line so it will have a 50 Ohm impedance. This type is a current balun.

Balun Construction

- A one to one voltage balun has two windings on the toroid core. It is not bifilar wound. It is wound like a transformer.
- If two wires are bifilar wound the input and output impedance will be 100 Ohms.
- To match a 200 Ohm impedance to 50 Ohm impedance, a 4 to 1 impedance conversion is needed.
- Two 1 to 1 bifilar wound baluns are needed. The baluns have two of the outputs wired in series and two inputs wired in parallel.
- How does this work. The series wired output are two 100 ohms wired in series (200 Ohms). The two inputs are two 100 Ohms in parallel (50 Ohms).

Balun Application

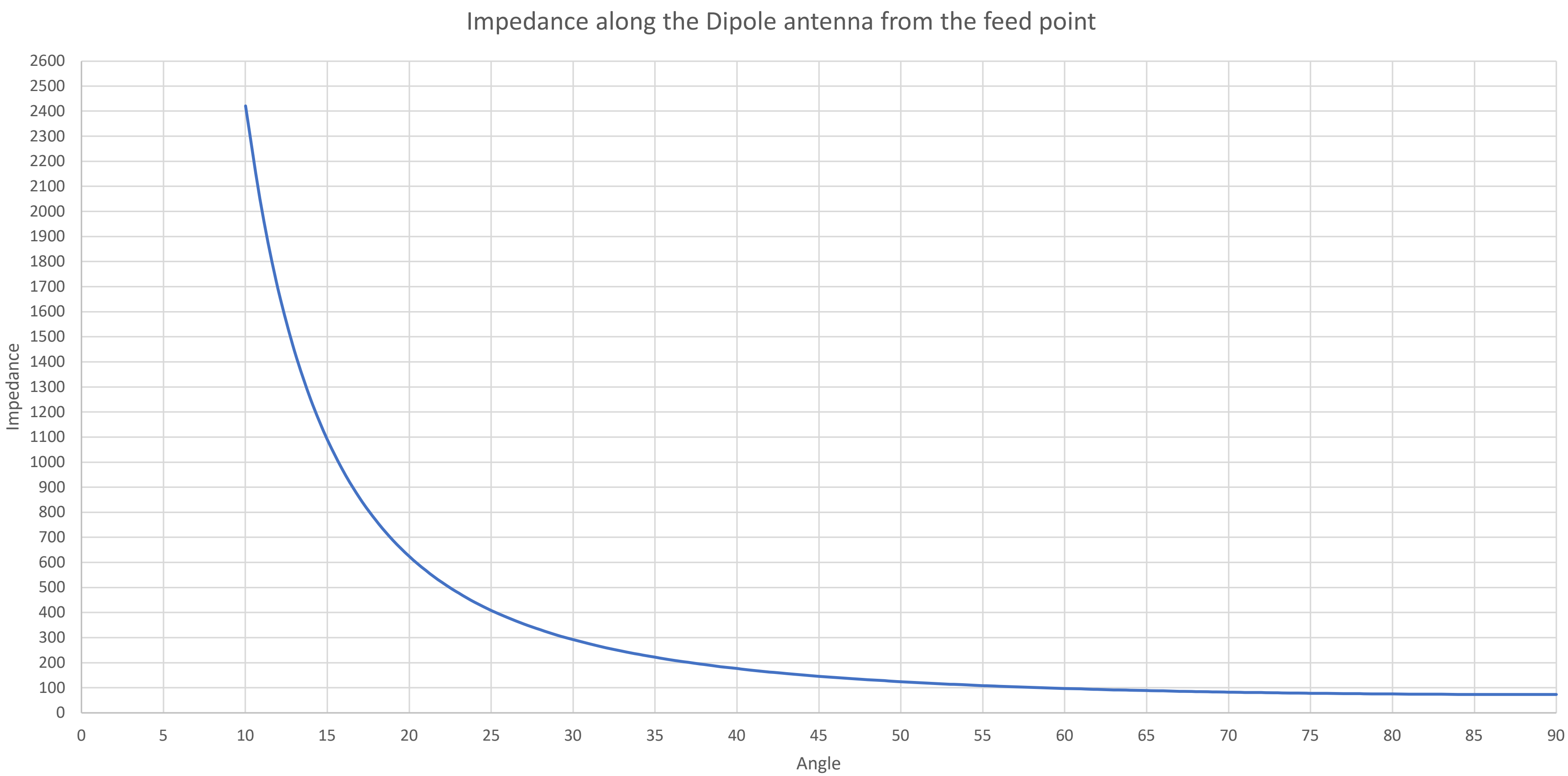
- A 4 to 1 balun can also be used a 1 to 4 balun.
- We need to review information about a dipole antenna characteristic
  - The impedance as the antenna driving point is 73 +j42 Ohms. (slightly inductive)
  - If the antenna is at 0.15 to 0.2 wavelength above ground the impedance may drop to 60 Ohms or less.
- The following are two examples of using a 4:1 balun:
  - A multiband dipole antenna will need an impedance converter to produce approx. 50 Ohms impedance.
  - If we make a 5 band antenna at 0.2 wavelength above the ground, the impedance would be approximately 60 Ohms divided by 5 or an impedance of 12 Ohms. We can use a 1:4 balun to convert the 12 Ohms to 48 Ohms which is close to 50 Ohms needed for coaxial cable. We will also need a 1:1 balun for blocking common mode current.

Balun Application

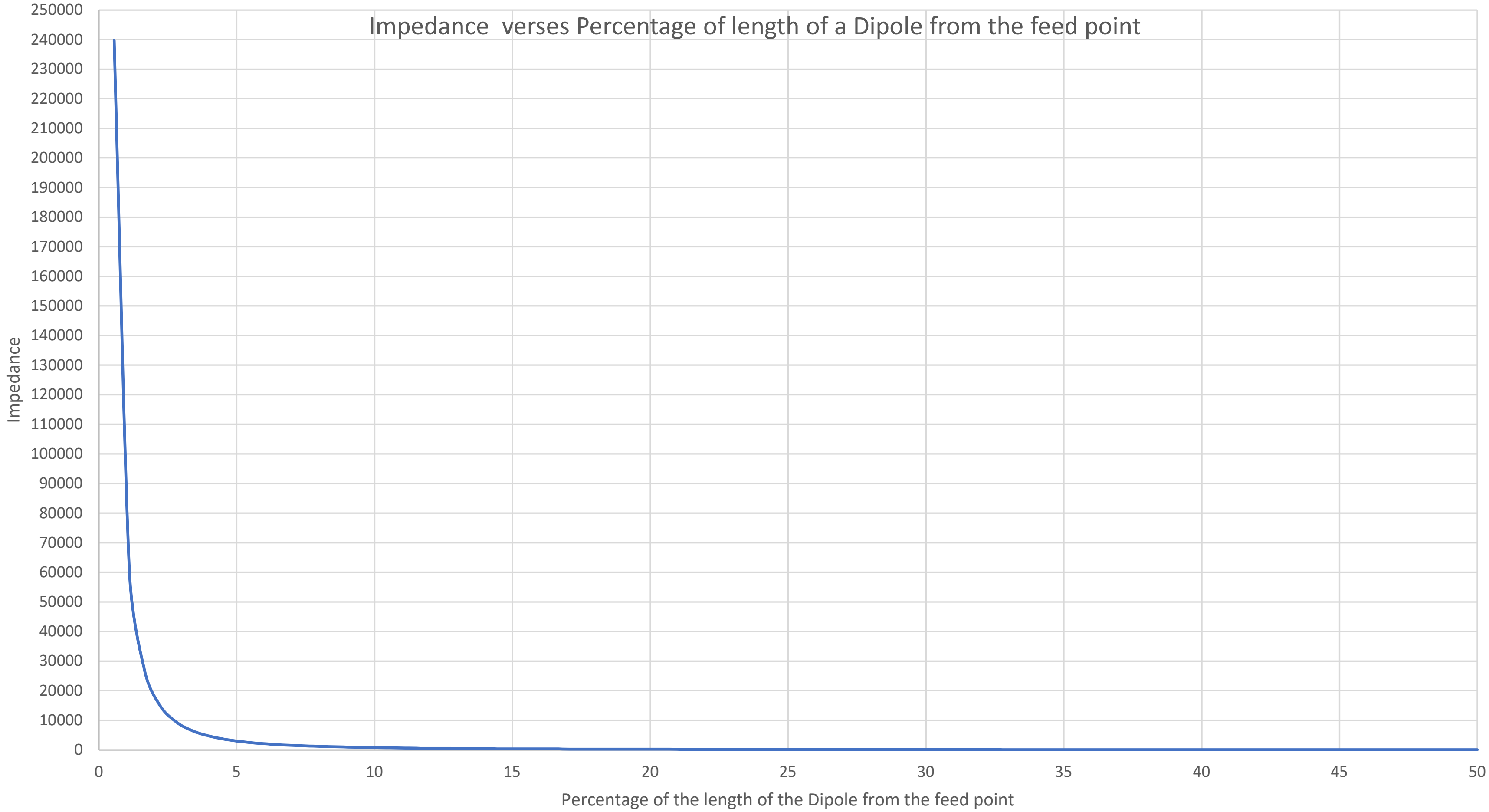
- The second example is for an off center fed dipole.
- An off center fed dipole with a 36%/64% configuration would require a 200 Ohm impedance at the driving point.
- A 4:1 balun is required to match the 200 Ohms back to 50 Ohms for the coaxial cable (4 times 50 Ohms = 200 Ohms)

- In both of these examples a 1:1 balun may be necessary to eliminate common mode current on the coaxial cable back at the radio.

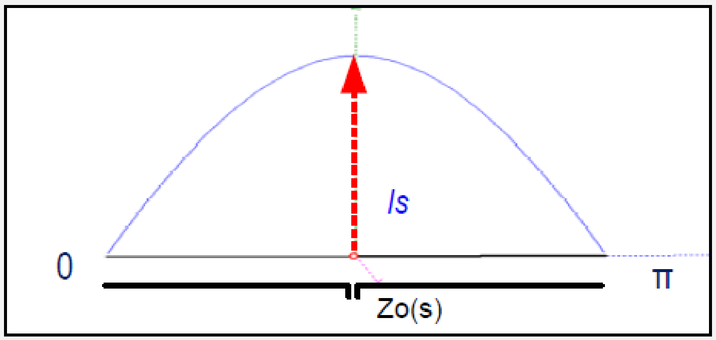
Balun Application

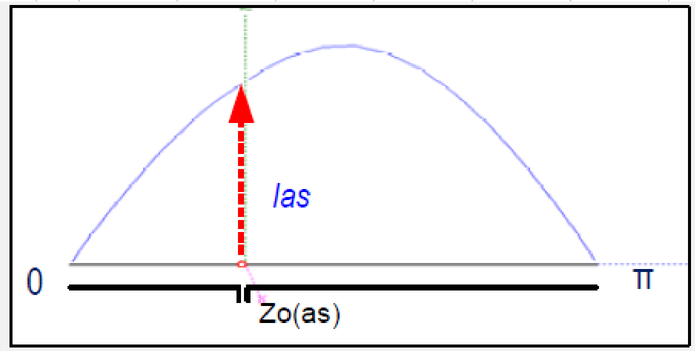


Balun Application



Off Center Fed Dipole Impedance Calculations





				Rs =73 Ohms		Rs =50 Ohms	
ODF Ratio		percent of 1/2 wave length	angle in degrees	impedance (Ras)	Balun Ratio(Zo = 75 ohms)	impedance (Ras)	Balun Ratio(Zo = 50 ohms)
	$Is^2Rs = Ias^2Ras$			73/sin(x*pi/180)^2	X:1	73/sin(x*pi/180)^2	X:1
16%/84%	Ias = Is sin(x°)	16.6666666	29.99999988	292.0000021	3.893333	292	3.893333
20%/80%		20	36	211.2931849	2.817242	211.2932	2.817242
25%/75%	$Ras = Rs\ (Is^2)/(Is^2 \sin^2(x°))$	25	45	146	1.946667	146	1.946667
33%/66%	$Ras = Rs\ /(\sin^2(x°))$	33.33333333	59.99999999	97.33333335	1.297778	97.33333	1.297778
		36	64.8	89.16444422	1.188859	89.16444	1.188859
		0.5	0.9	295882.1908			

Balun Limitation or Issues

- The core material will effect the frequency bandwidth.
  - Type 31, 43, 52, 61
    - Ferrite Type 61 for the top end of the HF frequency range
    - Type 43 for the bottom end of the frequency range
    - Type 31 for the best compromise across the frequency range
- Single core balun can handle a couple of hundred watts. To handle higher wattage, you can stack 2 or 3 cores and wind them with the bifilar wire.
- The balun will cause some loss of rf energy and will heat up. This may be in the order of 1% to 2% of your output power. To much heat will exceed the curie temperature of the core.

Balun Limitations

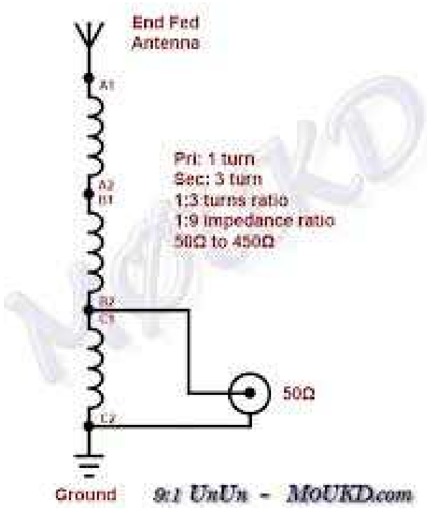
- What is the curie temperature ?
  - **Curie Temperature** is the temperature at which certain magnetic materials undergo a sharp change in their magnetic properties.
- The core material has a curie temperature which cause the magnet properties to change causing the VSWR to rise quickly.

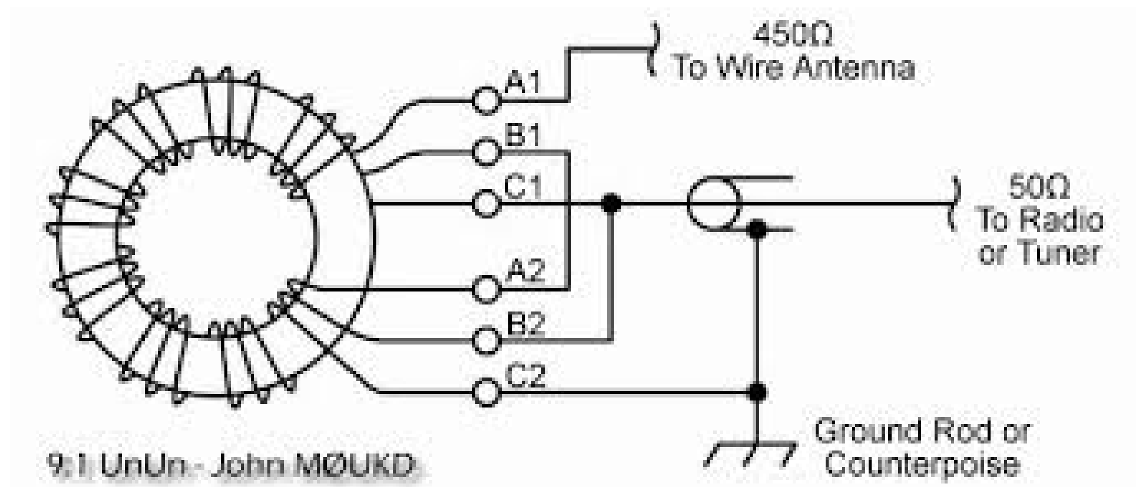
UNUNs

- UNUN stands for UNbalanced to UNbalanced
- Unlike a BALUN, an UNUN is basically an autotransformer.
- The UNUN is used for end fed antennas that are ½ wavelength where the impedance at the end of the wire is on the order of 2300 to 3500 Ohms.
- In order for a radio which is driving its output power into a transmission line of 50 Ohms, an impedance converter of 2450/50 or 49:1 is needed. If the impedance is higher such as 3200, the impedance converter needs to be 64:1.

UNUNs

- For end fed antennas that are random wire lengths, you would use a 9:1 UNUN. A 9:1 UNUN is converting an impedance of 450 Ohms to 50 Ohms.





9 : 1 UNUN


LONGWIRE ANTENNA
DX - RECEIVER
T130-6 RF TOROID
TOROID YELLOW / CLEAR 33 mm x 19.8 mm x 11.1 mm
9 turns for each wire
Use 3 wires
Enameled Wire 1 mm diameter
Protective tape not damage the wire
You may use balun to 9:1, 4:1 and 1:1
I use balun only for DX reception
my balun mounted
1
2
3
4
5
6
Balun
Solder 2 with 4
Solder 3 with 5
Youtube channel
Sergio Tech

UNUNs

- The 49 to 1 and 64 to 1 UNUNs are use for ½ wave end fed antennas. These are considered voltage fed antennas. They have impedances in the order of several thousand ohms.
- Since the 49 to 1 UNUN is an auto transformer, the impedance is increased by the turns ratio squared.
- The following picture shows two turns that are twisted wires and 14 turns including the 2 turns that are twisted. 14 divide by 2 = 7. N*N = 7*7 = 49. The result is a 49 to 1 UNUN. 50*49 = 2450 Ohms
- Using two turns that are twisted wires and 16 turns including the 2 turns that are twisted. 16 divide by 2 = 8. N*N = 8*8 = 64. The result is a 64 to 1 UNUN. 50*64 = 3200 Ohms.

49 : 1 Current UNUN Construction