FEEDLINES

Perfect Feedline (ya, really)

A perfect feedline will have:

– No radiation from the feedline itself

– No loss of signal while passing along the line

– Constant electrical characteristics throughout
Such a feedline will pass 100% of the RF energy
through it.

NOTE: This situation does not ever exist! (yet)!!

Feedline (transmission line)

2 CONDUCTORS

–Capacitance because of 2 parallel lines (plates) Inductance because of the length of the lines and their proximity to each other.

–Resistance in the metal itself slowing the flow

–Therefore a feedline is a circuit which has reactance to the passage of AC current and which varies inversely as the operating frequency which means the value stays approximately the same over any given length. This value is called the characteristic impedance of the circuit.   (Z_o)

–At HF frequencies, the signal passes through the conductor while at frequencies above 10 MHz, the signal passes along the surface, or skin of the wire. This is known as 'skin effect' where the losses increase with the frequency

Balanced feedlines

Open wire feedlines

Characteristic impedance of 200 – 600 Ω depending on the diameter of the wire and the distance between them.

$$Z_o = 276 \log 2(S/D)$$
S=Distance between and
D=diameter

Unbalanced feedlines
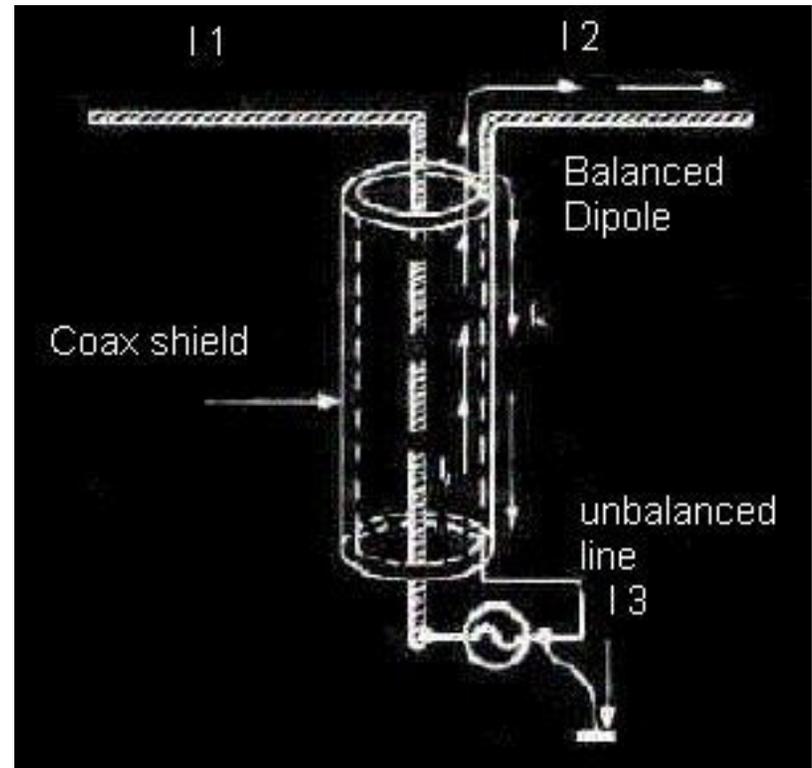
One side to ground

Other side carries

RF to antenna

Coaxial cable is waterproof

Hardline or Heliax is best for
VHF/UHF and up (Heliax uses
copper not braid for the shield)
– hard to bend -

$Z_o = 138/\sqrt{e} \log D/d$

e=dielectric constant

D=diameter of the outer conductor

D=diameter of the inner conductor

Feed Lines

Feedlines connect a radio to an antenna

They must be matched to the radio system - they should have like impedence

Radios usually have a 50 ohm output

Antenna feedpoints have a very wide impedence range

Velocity factor   .66 - .95

Feed Lines

Feedlines can be easily made

The two favourite for amateur radio are the coaxial cable and open wire feedlines

Feed Line Questions

What connects your transceiver to your antenna?
Feed Line

What kind of feed line can be buried in the ground for some distance without adverse effects? **Coaxial Cable**

A transmission line differ from an ordinary circuit or network in communications or signal devices in one important way. That important way is **Propagation Delay**

Feed Line Questions

The characteristics of a transmission line is determined by the **Physical dimensions and relative positions of the conductors**

The characteristics of a transmission line is equal to the **Pure Resistance which, if connected to the end of the line, will absorb all the power arriving along it**

Think of the paper towel absorbsion advertisment

The characteristic impedence of a coaxial antenna feed line is determined by the **Ratio of the diameter of the inner conducter to the diameter of the braid**

Feed Line Questions

The characteristic impedance of a parallel wire transmission line does <u>not</u> depend on the **velocity of energy on the line**

What factors determine the characteristic impedance of a parallel-conductor antenna feed line? **The distance between the centres of the conductors and the radius of the conductors**

Any length of transmission line may be made to appear as an infinitely long line by: **Terminating the line in its characteristic impedance**

The characteristic impedance of a 20 metre piece of transmission line is **52 ohms**

Feed Line Questions

The impedance of a coaxial line:

can be the same for different diameter line

Balanced & Unbalanced Feed Lines

A balanced transmission line: **is made of two parallel wires**

What is parallel-conductor feed line?   Two wires side-by-side held apart by insulating rods

What kind of antenna feed line is made of two conductors held apart by insulated rods? **Open-conductor ladder line**

What kind of antenna feed line can be constructed using two conductors which are maintained a uniform distance apart using insulated spreaders? **600 ohm open-wire**

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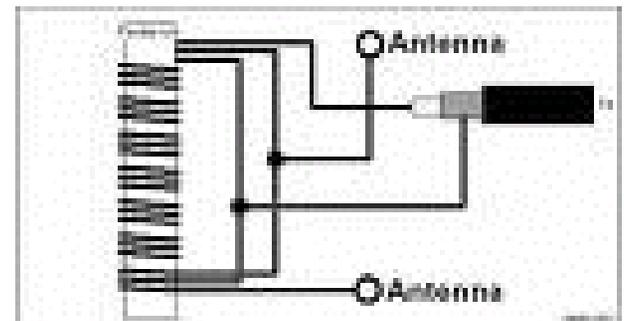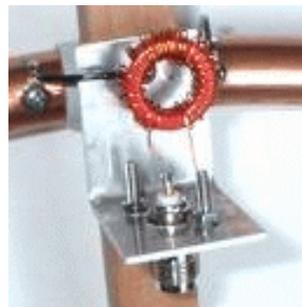
Balanced & Unbalanced Feed Lines - 2

What is an unbalanced line? **Feed line with one conductor connected to ground**

What is a coaxial cable? **A center wire inside an insulating material which is covered by a metal sleeve or shield**

A flexible coaxial line contains: **Braid and insulation around a central conductor**

What device can be installed to feed a balanced antenna with an unbalanced feed line? **A balun**

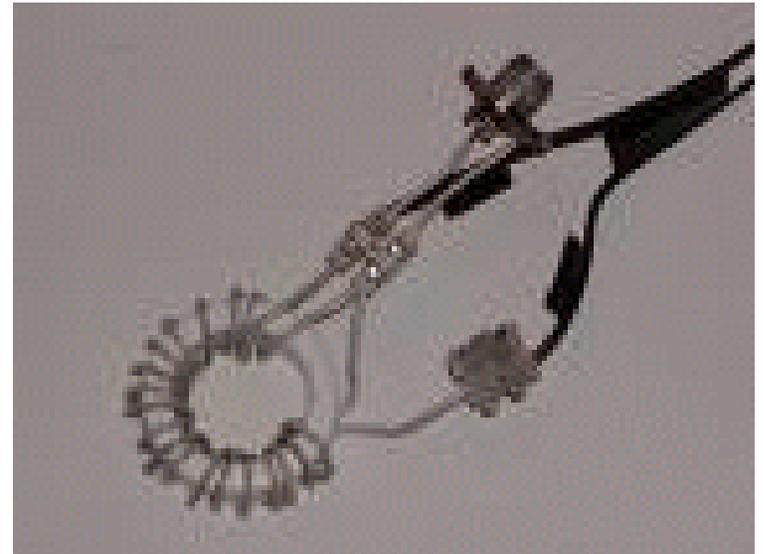What does the term "balun" mean? **Balanced to unbalanced**

Balanced & Unbalanced Feed Lines - 3

Where would you install a balun to feed a dipole antenna with 50-ohm coaxial cable? **Between the coaxial cable and the antenna**

A 75 ohm transmission line could be matched to the 300 ohm feedpoint of an antenna: **by using a 4 to 1 balun**

Popular Antenna Feed Lines

Why does coaxial cable make a good antenna feed line? **It is weatherproof, and its impedance is higher than that of most amateur antennas**

What is the best antenna feed line to use, if it must be put near grounded metal objects? **Coaxial cable**

What commonly available antenna feed line can be buried directly in the ground for some distance without adverse effects? **Coaxial cable**

If you install a 6 metre Yagi antenna on a tower 50 metres from your transmitter, which of the following feed lines is best? **RG-213**

What are some reasons not to use parallel-conductor feed line? **It does not work well when tied down to metal objects, and you must use an impedance-matching device with your transceiver**

TV twin-lead feed line can be used for a feed line in an amateur station. The impedance of this line is approximately: **300 ohms**

Connectors

What common connector usually joins RG-213 coaxial cable to an HF transceiver? A **PL-259** connector

What common connector usually joins a hand-held transceiver to its antenna? A **BNC** connector

Which of these common connectors has the lowest loss at UHF? A **type-N** connector

Why should you regularly clean, tighten and re-solder all antenna connectors? **To help keep their resistance at a minimum**

Line Losses

Why should you use only good quality coaxial cable and connectors for a
UHF antenna system? **To keep RF loss low**

In what values are RF feed line losses expressed?
 dB per unit length

Losses occurring on a transmission line between transmitter and antenna
results in: **less RF power being radiated**

If the length of coaxial feed line is increased from 20 metres (65.6 ft) to 40
metres (131.2 ft), how would this affect the line loss? **It would be
increased by 100%**

What are some reasons to use parallel conductor feed line? **It will
operate with a high SWR, and has less loss than coaxial cable**

Line Losses

If your transmitter and antenna are 15 metres apart, but are connected by 65 metres of RG-58 coaxial cable, what should be done to reduce feed line loss? **Shorten the excess cable**

The lowest loss feed line on HF is: **300 ohm twin- lead**

As the length of a feed line is changed, what happens to signal loss? **Signal loss increases as length increases**

As the frequency of a signal is changed, what happens to signal loss in a feed line? **Signal loss increases with increasing frequency**

Standing Waves

If the characteristic impedance of the feedline does not match the antenna input impedance then: **standing waves are produced in the feedline**

The result of the presence of standing waves on a transmission line is: **reduced transfer of RF energy to the antenna**

What does the standing wave ration means? **ratio of maximum to minimum voltages on a feed line**

What does an SWR reading of 1:1 mean?
The best impedance match has been attained

What does an SWR reading of less than 1.5:1 mean? **A fairly good impedance match**

A resonant antenna having a feed point impedance of 200 ohms is connected to a feed line and transmitter which have an impedance of 50 ohms. What will the standing wave ratio of this system be? 4:1

What kind of SWR reading may mean poor electrical contact between parts of an antenna system?   **A jumpy reading**

Standing Waves

What does a very high SWR mean? **The antenna is the wrong length, or there may be an open or shorted connection somewhere in the feed line**

If your antenna feed line gets hot when you are transmitting, what might this mean? **The SWR may be too high, or the feed line loss may be high**

The type of feed line best suited to operating at a high standing wave ratio is: **600 ohm open-wire**

SWR meter measures the degree of match between transmission line and antenna by: **comparing forward and reflected voltage**

Impedence Matching

What device might allow use of an antenna on a band it was not designed for? **An antenna tuner**
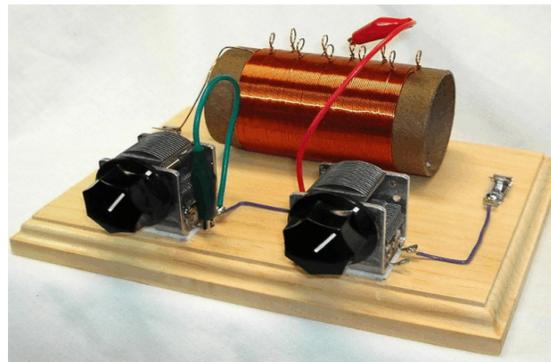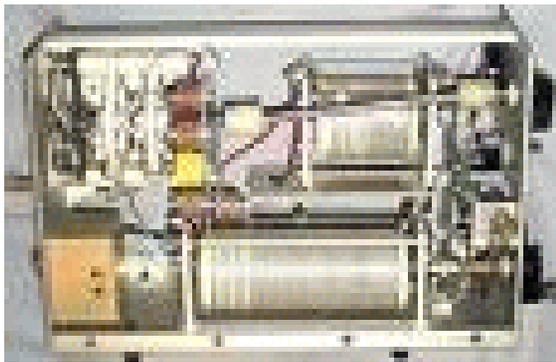
What does an antenna matching unit do? **It matches a transceiver to a mismatched antenna system**

What would you use to connect a coaxial cable of 50 ohms impedance to an antenna of 35 ohms impedance? **An impedance-matching device**

When will a power source deliver maximum output to the load? **When the impedance of the load is equal to the impedance of the source**

Impedence Matching

What happens when the impedance of an electrical load is equal to the internal impedance of the power source? **The source delivers maximum power to the load**

Why is impedance matching important? **So the source can deliver maximum power to the load**

To obtain efficient power transmission from a transmitter to an antenna requires: **matching of impedances**

If an antenna is correctly matched to a transmitter, the length of transmission line: **will have no effect on the matching**

If the centre impedance of a folded dipole is approximately 300 ohms, and you are using RG8U (50 ohms) coaxial lines, what is the ratio required to have the line and the antenna matched? **6:1**

Impedance

DEFINITIONS

Impedance, denoted Z, is an expression of the opposition that an electronic component, circuit, or system offers to alternating and/or direct electric current.Impedance is a vector (two-dimensional)quantity consisting of two independent scalar (one-dimensional) phenomena: resistance and reactance.

Resistance, denoted R, is a measure of the extent to which a substance opposes the movement of electrons among its atoms.The more easily the atoms give up and/or accept electrons, the lower the resistance, which is expressed in positive real number ohms.Resistance is observed with alternating current (AC) and also with direct current (DC). Examples of materials with low resistance, known as electrical conductors, include copper, silver, and gold.High-resistance substances are called insulators or dielectrics, and include materials such as polyethylene, mica, and glass.A material with an intermediate levels of resistance is classified as a semiconductor. Examples are silicon, germanium, and gallium arsenide.

Reactance, denoted X, is an expression of the extent to which an electronic component, circuit, or system stores and releases energy as the current and voltage fluctuate with each AC cycle.Reactance is expressed in imaginary number ohms.It is observed for AC, but not for DC.When AC passes through a component that contains reactance, energy might be stored and released in the form of a magnetic field, in which case the reactance is inductive (denoted $+jXL$); or energy might be stored and released in the form of an electric field, in which case the reactance is capacitive (denoted $-jXC$). Reactance is conventionally multiplied by the positive square root of -1, which is the unit imaginary number called the j operator, to express Z as a complex number of the form $R + jXL$ (when the net reactance is inductive) or $R - jXC$ (when the net reactance is capacitive).

The illustration shows a coordinate plane modified to denote complex-number impedances.Resistance appears on the horizontal axis, moving toward the right.(The left-hand half of this coordinate plane is not normally used because negative resistances are not encountered in common practice.)Inductive reactance appears on the positive imaginary axis, moving upward.Capacitive reactance is depicted on the negative imaginary axis, moving downward.As an example, a complex impedance consisting of 4 ohms of resistance and $+j5$ ohms of inductive reactance is denoted as a vector from the origin to the point on the plane corresponding to $4 + j5$.

Impedance

In series circuits, resistances and reactances add together independently. Suppose a resistance of 100.00 ohms is connected in a series circuit with an inductance of 10.000 ?H.At 4.0000 MHz, the complex impedance is:

ZRL = R + jXL = 100.00 + j251.33

If a capacitor of 0.0010000 ?F is put in place of the inductor, the resulting complex impedance at 4.0000 MHz is:

ZRC = R - jXC = 100.00 - j39.789

If all three components are connected in series, then the reactances add, yielding a complex impedance of:

ZRLC = 100 + j251.33 - j39.789 = 100 + j211.5

This is the equivalent of a 100-ohm resistor in series with an inductor having +j211.5 ohms of reactance.At 4.0000 MHz, this reactance is presented by an inductance of 8.415 ?H, as determined by plugging the numbers into the formula for inductive reactance and working backwards.(See the definition of for this formula, and for the corresponding formula for capacitive reactance.)

Parallel RLC circuits are more complicated to analyze than are series circuits.To calculate the effects of capacitive and inductive reactance in parallel, the quantities are converted to inductive susceptance and capacitive susceptance.Susceptance is the reciprocal of reactance.Susceptance combines with conductance, which is the reciprocal of resistance, to form complex admittance, which is the reciprocal of complex impedance.

Appendix

Impedance matching

Levers do it.
Pulleys do it.
Ramps, transformers, gears, megaphones, and wheelbarrows do it.
Even screws do it.

Match impedance, that is.

Impedance is the opposition to the flow of energy.

If you try to lift your refrigerator, you will experience an opposition to the flow of energy. The refrigerator will just sit there, and you will get tired. The ability of your muscles to lift the weight is not matched to the weight.

There are a number of ways you can lift a 500 pound refrigerator by matching the impedance of your muscles to the impedance of the load. You could push the load up a ramp. You could use a lever, or a block and tackle, or a hydraulic jack, or a screw jack. Each of these devices allows you to trade lifting the 500 pound load for lifting a smaller load, say 50 pounds. You generally trade off time, pushing 50 pounds for ten seconds instead of 500 pounds in one second. The same amount of energy is expended, but at a much lower power level.

Appendix

When impedances are mismatched, energy put into the system is reflected back. If you jump on a see-saw with a refigerator on the other end, you will bounce back off as if you were on a diving board. But if you move the fulcrum closer to the refrigerator, you can jump onto the see-saw, and your end will move down, lifting the heavy load at the other end.

You can line up a row of billiard balls, and hit the row with the cue ball, and the last ball in the row will shoot off down the table. But if one of the balls is made of steel, the cue ball will simply bounce off of it, and most of the energy will be reflected.

We can match the impedances to get the steel ball to move. We put a row of balls in front of it, each one made of a slightly lighter weight material than the last, until the ball nearest us is almost the same mass as the cue ball. Now the speeding cue ball will stop dead when it hits the row of balls, and the steel ball will slowly move off down the table, having absorbed all of the energy.

When you shout to a friend who is underwater in a swimming pool, the sound from your voice bounces off the water, and very little sound energy gets to your friend's ears. But take a traffic cone and put the narrow end of it into the water and shout into the large end. Now your friend can hear you, because the low pressure sound waves over a large area are converted into high pressure waves over a small area, and the water moves from the high power sound. Here we are not trading time. Instead, we are trading a large area for a smaller one.

An electrical transformer also matches impedance. It takes high voltage, low current energy, and matches it to a load the needs low voltage, high current. It also works the other way around. Without the transformer, most of the energy is reflected back to the source, and little work gets done.

A water nozzle is an impedance matcher. So is cupping your hand behind your ear. A telescope is an impedance matcher. So is a magnifying glass, or a winding mountain road, or the gears on your bicycle. Now that you are aware of impedance matchers, you will start to see them everywhere.