

A decorative graphic on the left side of the slide, consisting of a network of white lines and circles on a teal background, resembling a circuit board or antenna structure.

TRANSMATCHES

(AKA “ANTENNA TUNERS”)

BELLBROOK AMATEUR RADIO CLUB

FEBRUARY 15, 2018

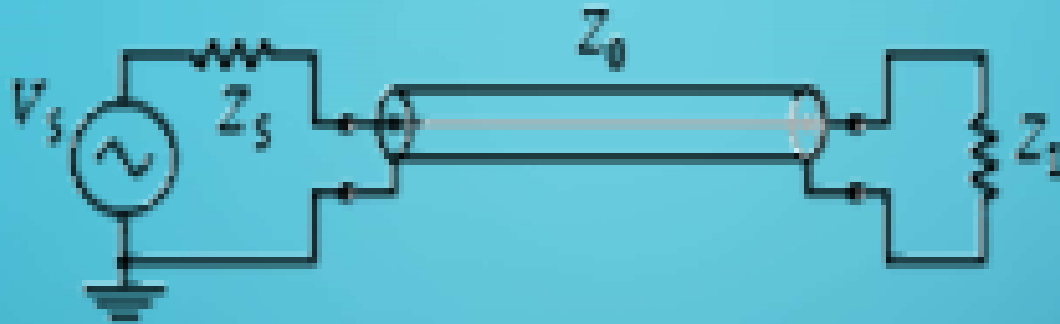
ROGER PARRETT / NQ8RP

- BARC member since July 2015
- Licensed in July 2015

- Primary ham interest:
 - (Very) remote portable operation
 - Operating with low power (generally no more than 10 watts)
 - Putting up portable antennas in bad weather

WHY USE AN ANTENNA TUNER?

- To ensure your antenna system sees as much power as your transmitter is trying to deliver.
- As a matter of convenience to the operator, allowing a single antenna system (such as a random long wire antenna) to operate across multiple bands.



In this diagram V_s represents the radio, Z_s represents the radio's output impedance, Z_o represents the feedline impedance, and Z_L represents the actual antenna impedance.

At each interface point, there exists the possibility of an impedance mismatch that produces reflected energy, minimizing how much energy actually gets through to the next stage.

An antenna tuner (typically) sits between Z_s and Z_o help match the transmitter's impedance to the equivalent Z_o and Z_L impedance combination.

SWR Equation

Note that the square root of the reflected power divided by the forward power is known as the Reflection Coefficient.

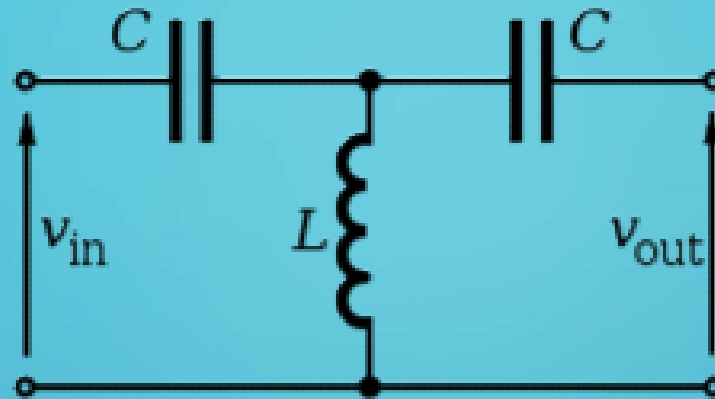
As more power is reflected, the numerator gets larger, while the denominator gets smaller, making the overall SWR larger.

When the reflected power is zero, the SWR is 1.

$$VSWR = \frac{1 + \sqrt{\frac{P_{rev}}{P_{fwd}}}}{1 - \sqrt{\frac{P_{rev}}{P_{fwd}}}}$$

CONCEPT BEHIND AN ANTENNA TUNER

- Matches the output impedance of your transmitter to the input impedance of the antenna system (feedline, balun, actual antenna).
- The antenna system's input impedance must have an impedance that matches (technically, the complex conjugate) the transmitter's output impedance. This is possible *without* an antenna tuner, but not always practical.
- The antenna tuner is basically a passive network that sits in between the transmitter and feedline that can be adjusted to compensate for antenna system (feedline/balun/antenna) impedance irregularities, thus presenting to the transmitter a feedline input impedance that's equivalent of it's output impedance.



This is an antenna tuner implemented as a T-Network. The capacitors and inductor are variable, though in many tuners the inductor is switch-selected between a half-dozen different inductance values - typically via multiple taps on a single large coil.

This circuit tunes out the mismatch seen by the transmitter, reducing the reflected power and thus allowing more power to be transferred to the antenna system.

WHAT WILL OCCUR WHEN THE TRANSMITTER / ANTENNA SYSTEM IMPEDANCE IS MISMATCHED?

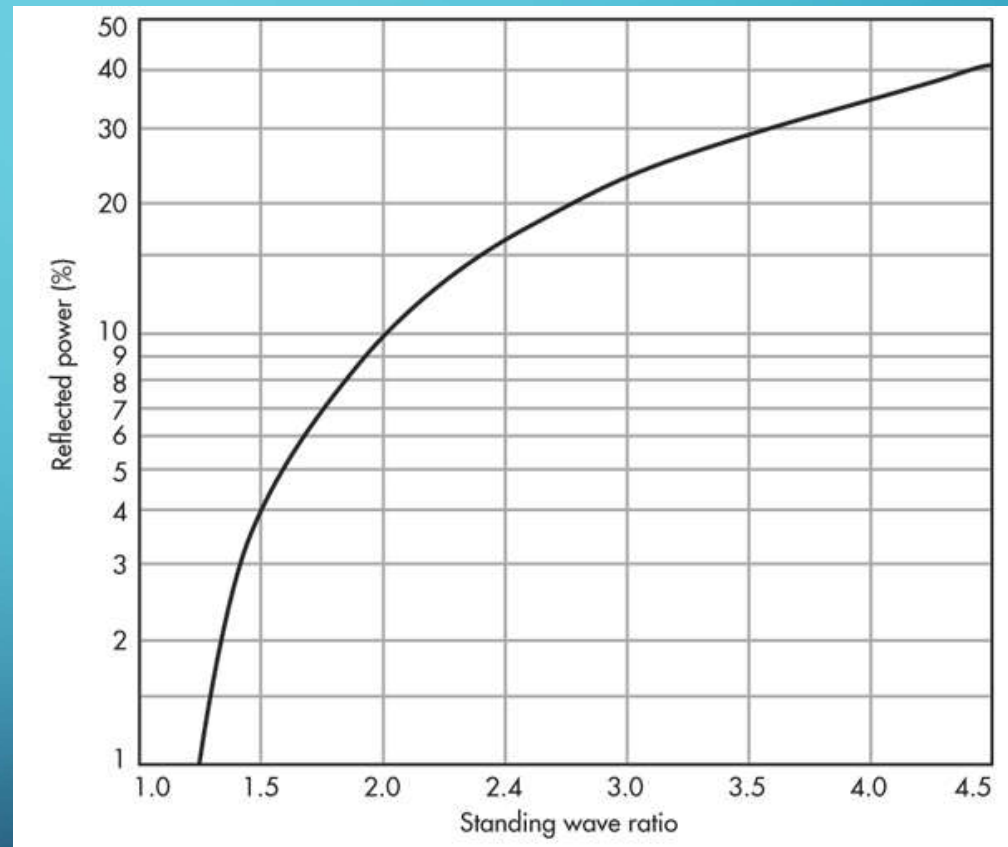
- When there is a mismatch, a portion of the transmitted energy (“forward or incident energy”) is reflected back (“reflected energy”) into the transmitter.
- During a mismatched – along with an inefficient power transfer – other things can happen, such as:
 - Your transmitter – depending on make and model – could automatically further limit the output power – typically proportional to the mismatch (SWR)
 - In extreme (but not uncommon) circumstances, you can damage the output stages of your transmitter.

SWR vs Output Power

Note that as the SWR goes up, more power is reflected – in other words not getting to your antenna system.

An SWR of 2:1 robs you of about 10% of your power.

An SWR of 3:1 will take almost 25% of your power.



WHAT DOES AN ANTENNA TUNER NOT DO?

- It does not make an antenna system “better”. It simply provides a matching network to the feedline so more energy can be transferred to the antenna system, and consequently radiated.

EXTERNAL VS INTERNAL ANTENNA TUNERS

- Built-in Antenna Tuners are good for “touching up” an already fairly decently matched antenna system but will typically not match an antenna with an SWR greater than 3:1.
- External Antenna Tuners (especially the manual ones) can handle upwards of a 10:1 mismatch (for instance a random long-wire antenna).

TYPES OF EXTERNAL ANTENNA TUNERS

- Manual – You have to manually dial in a combination of capacitors and inductors.
 - Advantages: Inexpensive, Does not require power (good for portable ops), Available for kilowatt-class stations, Many come with cross-meters to assist in tuning and power monitoring.
 - Disadvantages: Well, manual. Takes time to tune. Probably not a good option for band hopping and contest operators.

TYPES OF EXTERNAL ANTENNA TUNERS

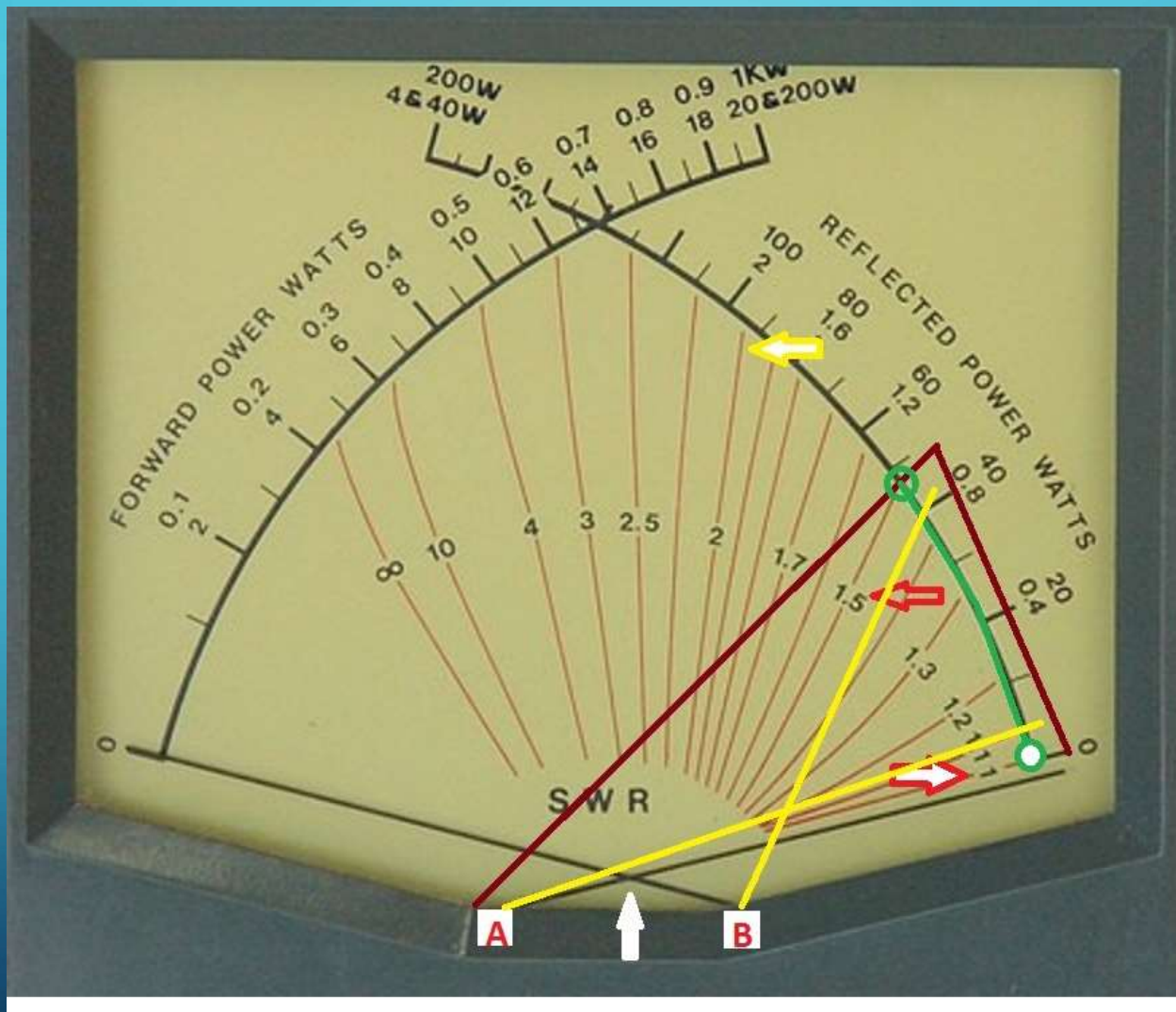
- Automatic – Typically you push a button on the radio (or tuner) and the tuner iterates thru a combination of capacitors and inductors (via electronic and/or mechanical switches) to find the best combination that yields the lowest SWR. This combination is then usually stored – by frequency – inside the tuner, so when you later come back to that same frequency, the tuner will know what combination of inductors and capacitors to start with.

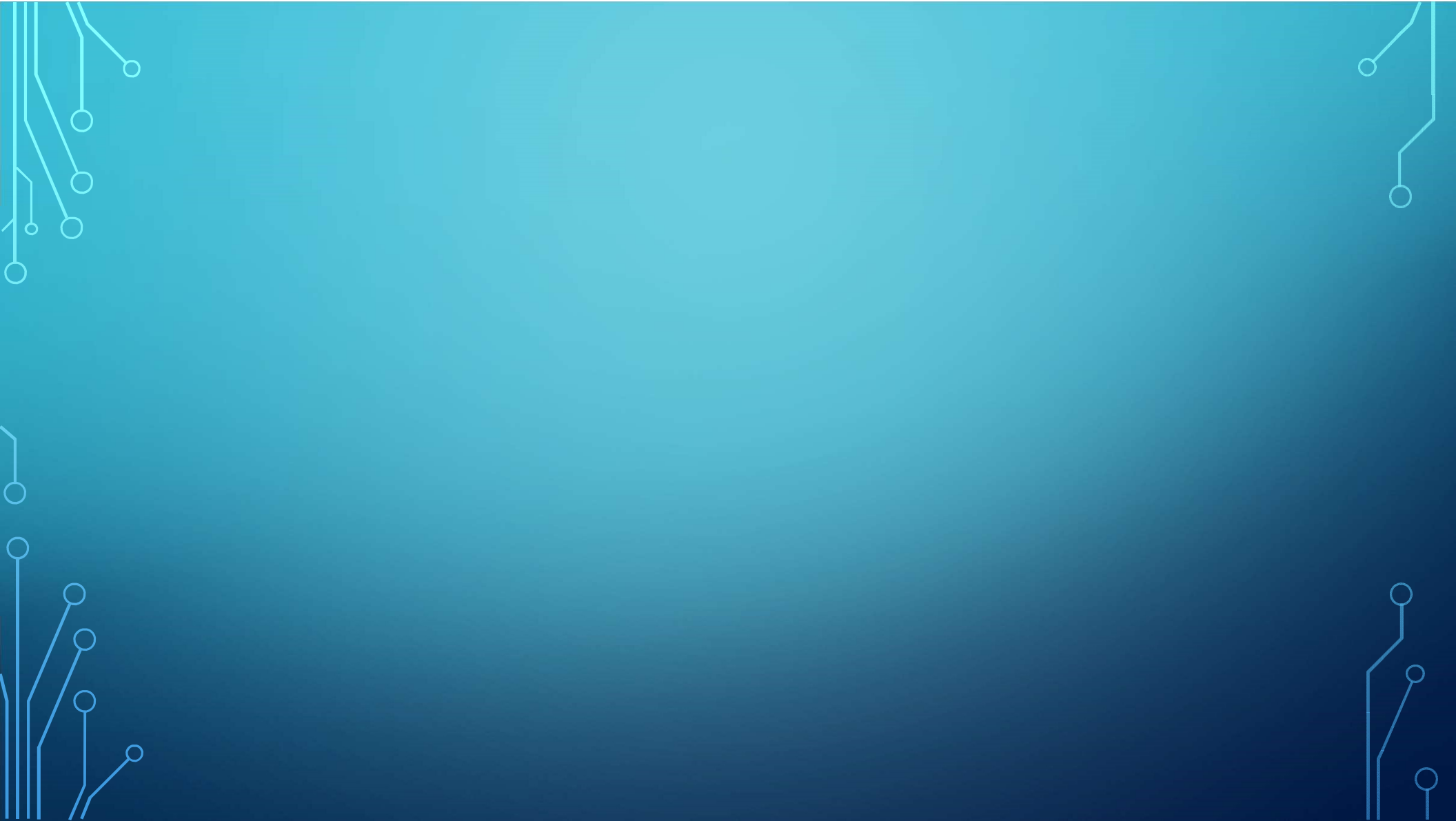
TYPES OF EXTERNAL ANTENNA TUNERS

- Advantages: Can be very quick. No manually tuning of anything, For tuners with a TXR interface, no need to manually drop power to tune.
- Disadvantages: Typically more expensive than manual – for the same power range, Many are for mid–power (or lower) transmitters, (In my opinion) not as reliable, No cross–meters, Requires a power source (bad for portable ops).

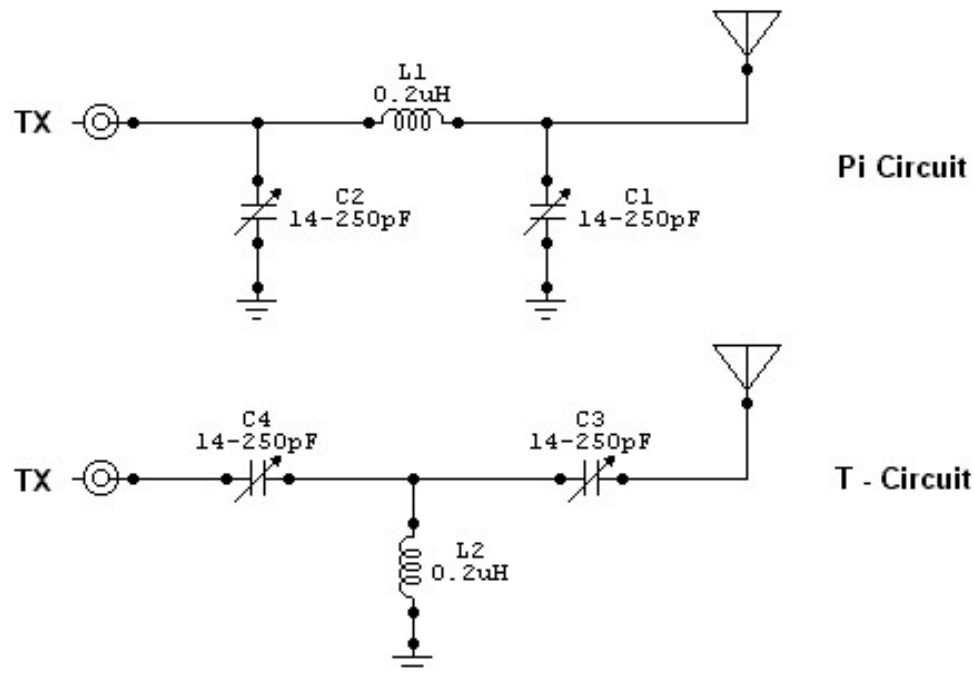
HOW TO USE A MANUAL ANTENNA TUNER

- Move to a quiet frequency close to where you want to operate and reduce power
- If your transmitter does not have a TRANSMIT button, set radio mode to CW
- Center controls on tuner and press the TRANSMIT button (or key transmitter)
- Tune (or select) the coil for the lowest SWR
- Tune “Antenna side” capacitor for the lowest SWR
- Tune “Transmitter side” capacitor for the lowest SWR
- Iterate between Antenna / Transmitter side tuning until lowest SWR is achieved (definitely below 2:1)
- Raise power to 20 watts then adjust the controls until you reach an acceptable SWR. Optionally, raise power again and repeat process
- Turn off the TRANSMIT button (or set the radio back to the proper mode)
- Record dial settings for this band / frequency for reference





50 MHz Antenna Tuners AA3SJ

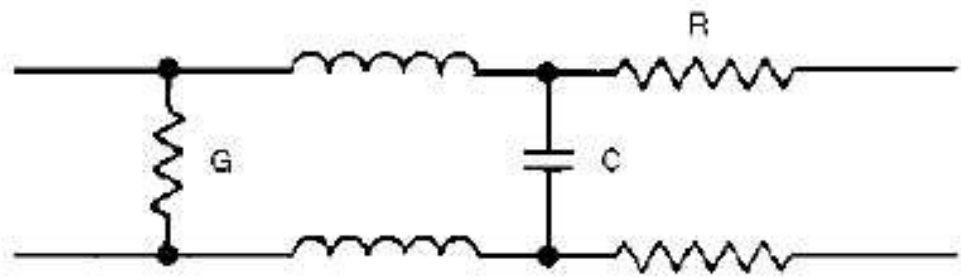


Note: L1, L2 = 3 - 4 turns, 0.75" diameter,
#14 solid copper wire.

L, R



A. SHORT SECTION OF TWO - WIRE LINE



B. EQUIVALENT CIRCUIT