Antenna Tuners

What are they? How do they work? Do I need one?

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Impedance at end of coax

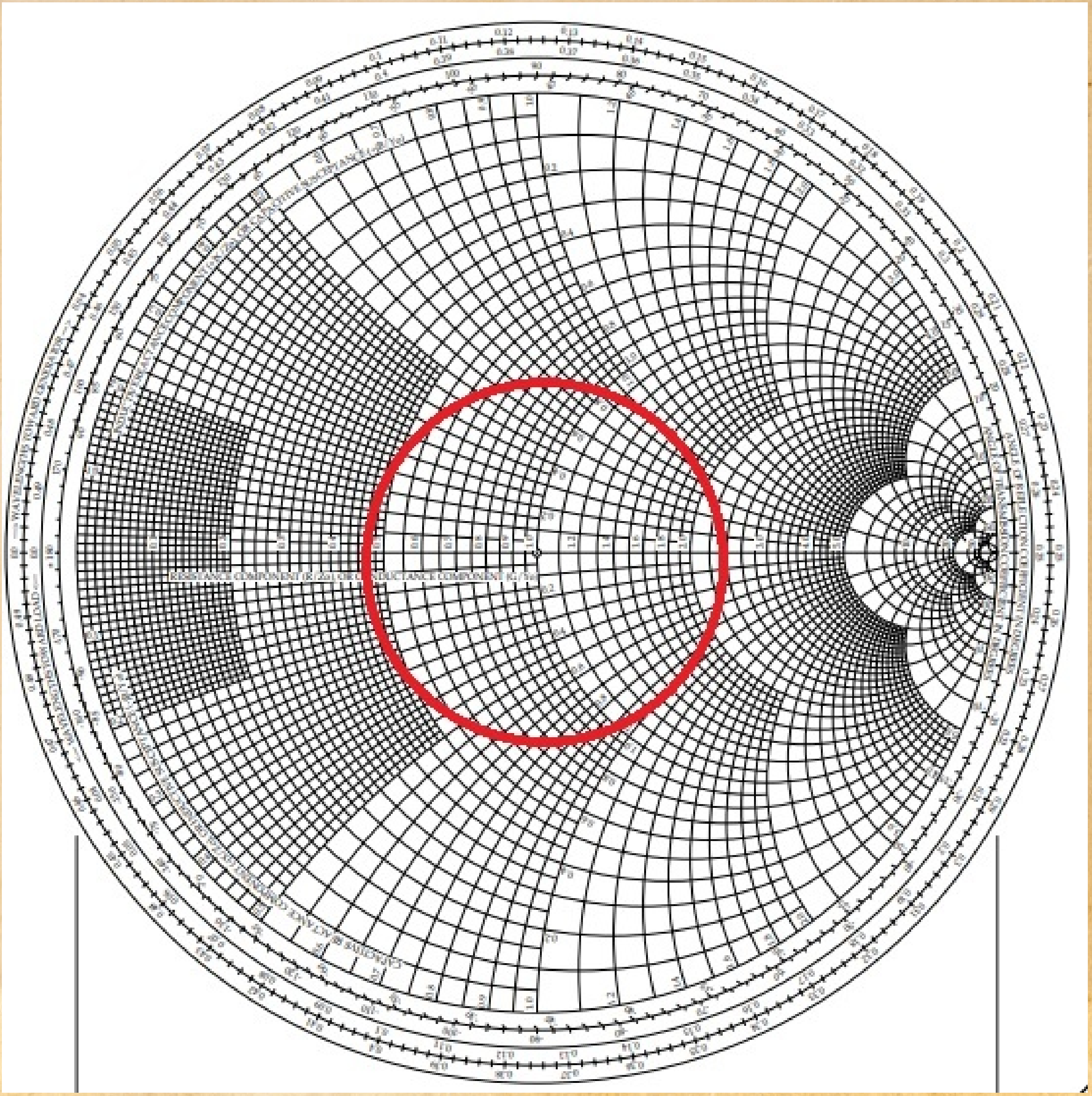
- If the impedance at the terminals of your antenna perfectly matches your coax….your SWR= 1:1 and all along your coax the ratio of RF Voltage to RF current will be 50:1 (hence, 50 ohms)
- You’ll measure an SWR of 1:1 at your end of the coax in your radio shack.

Impedance at end of unmatched coax

- If your antenna DOESNT present perfect 50 ohms to your coax...things are more confusing.
- The SWR on the coax will be the ratio of the antenna impedance to 50 ohms. (The antenna impedance may have a reactance, but the SWR is a plain old number.)
- The SWR will be the same everywhere on a LOSSLESS Coax.
- Since they don’t sell lossless coax, the SWR will slowly look better and better, the farther you get from the antenna as the reflected power is attenuated by losses.

- The IMPEDANCE however is constantly changing as you move further away from the antenna.
- It makes a CIRCLE on the SMITH CHART – always staying at the same SWR….but revolving through a myriad number of impedances, some inductive, some capacitive, some higher ohms, some lower ohms.
- Predicting what it will be at YOUR end of the coax….is a lot of work.

Around and Around!!



Transmitters

Marketing department tout the power their transmitter will put out INTO 50 PERFECT OHMS….not this weird impedance in real life.

- Weird impedances can cause your transmitter output stage to experience higher voltages or higher currents than it was designed to endure….
- High quality solid state transmitters will have “foldback” circuits to protect themselves...reduce power so the voltage & current are still acceptable

- Older vacuum tube transmitters’ pi network will just need different settings, but may still work up until the point the voltage becomes too high (then arc across the output cap….that gets your attention!)   Usually no permanent damage.
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Solid State Transmitters

- Output impedance of the final stage may be low – many amps at 13.8 VDC = maybe 2 ohms?
- Many use a simple broadband TRANSFORMER to step this up to 50 ohms (e.g. 1 turn, 3 turns = 9:1 impedance step up)
- Those transformers don’t have any way to deal with capacitive or inductive reactance presented by your end of the coax….

The Rise of the Antenna Tuner

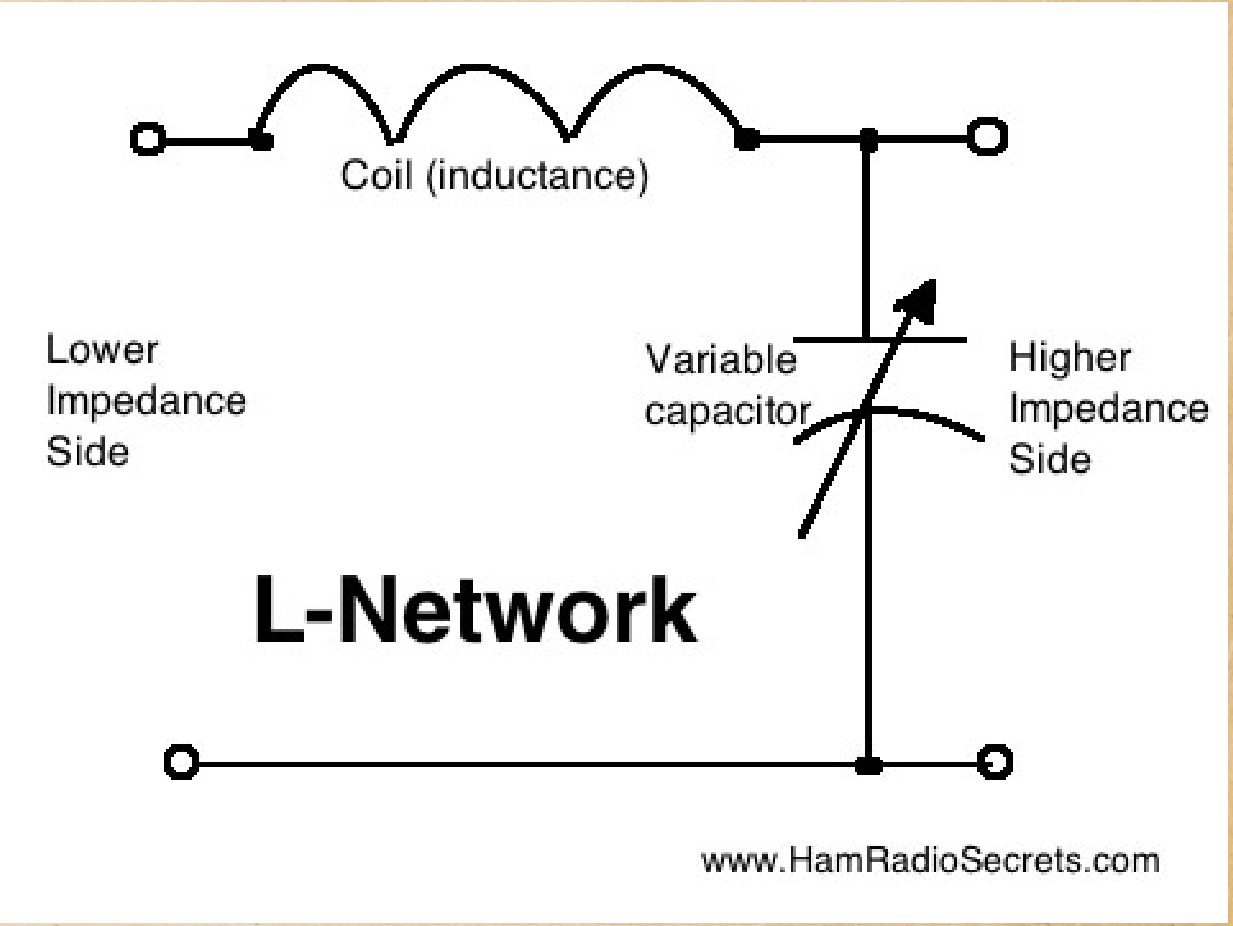
- Good Old Days: Tuners designed to connect to high impedance “window line” and wild impedances….convert to 50 ohms.
- Modern Day: All manner of “tuners” designed to handle mild to moderate impedances and get them to 50 ohms…. Some built into the transmitter!

Categories of Tuners

- We use a 49:1 “balun” as a “tuner” to handle our end-fed half-wave antennas…. (broad-band transformer)
- Simple L networks (one inductor, one capacitor) manual tuners – manually adjusted.
- Simple L networks automatically tuned by a microprocessor (“auto-tuner”)
- T networks, manually tuned.
- Not too many Pi networks being sold currently.

L tuner schematic

https://www.hamradiosecrets.com/homebrew-antenna-tuner.html



Easy to make homebrew L network

- Wind your own coil on any nonconductive form you like, even square.
- “taps” done with alligator clips
- Scrounged variable capacitor
- Can even MAKE a capacitor with aluminum foil and cardboard insulator (done many times)

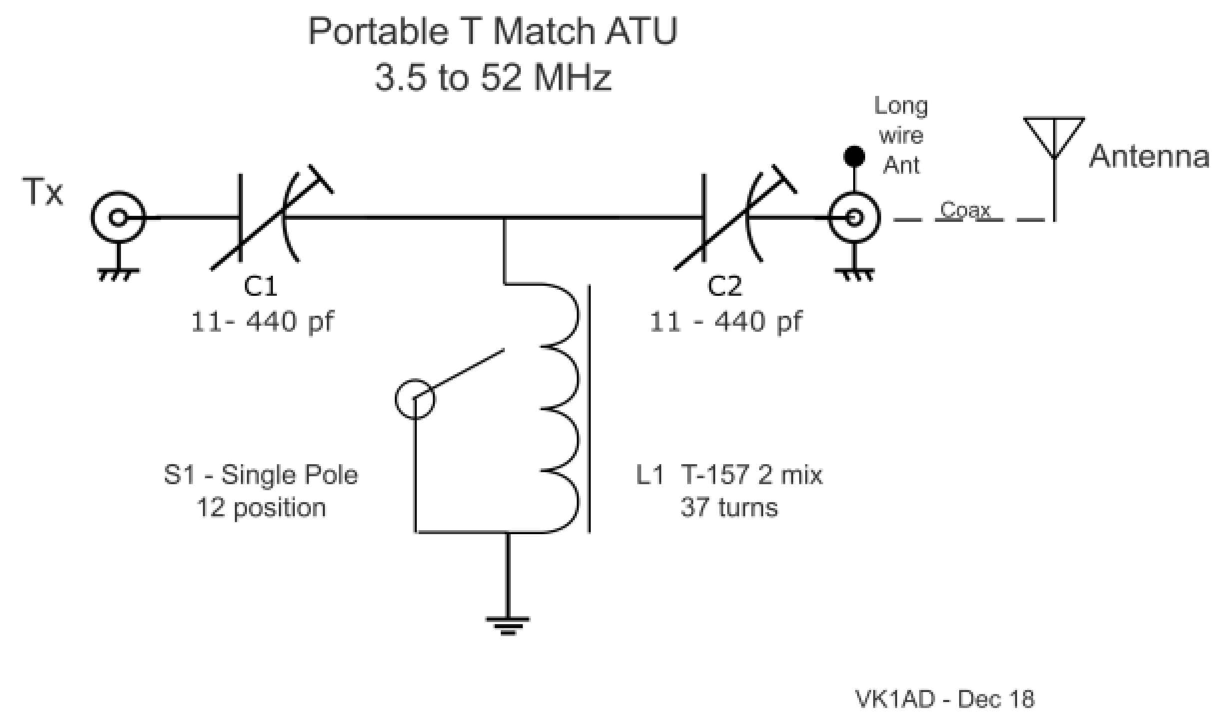
Almost every auto-tuner….

Makes & Models?

- Auto Tuners (L networks)
  - MFJ makes “intellituners” that have more LCD display and might tune faster
  - LDG makes somewhat more inscrutible interfaces but can generally tune under higher power
  - Both are sold at various “power levels” from 100 watts through 1000 watts
  -

T Tuner Schematic

https://vk1nam.wordpress.com/2018/12/08/homebrew-portable-t-match-atu/



Manual Tuners

- More often T networks because able to match almost ANYTHING that way...
- Several qrp models to go portable with
- A few HIGH POWER tuners esp. older Heathkits (SA2040 SA2060)
- $$$ Palstars


MFJ
DELUXE VERSA TUNER II
TRANSMITTER
ANTENNA
ANT. SELECTOR
COAX 1
COAX 2
BAL LINE WIRE
DUMMY LOAD
TUNED
BYPASS
Watts
FORWARD
REFLECTED
SWR
ON
OFF
300W
30W
PEAK
AVG
METER
ROLLER INDUCTOR
MFJ
MODEL MFJ-969

Advantages / Disadvantages

- L networks: Usually work, but the “Q” is determined by the impedances to be matched and may be “unusual”
- T networks: There is ALWAYS a solution with a three variable elements, and often MANY solutions – allowing more efficient transformation… but these are HIGH PASS systems that pass any spurious harmonics also.
- Pi networks – LO PASS

Mr. Market Makes Choices

Commonly available:

- Internal ("3:1") tuners L networks in many transceivers
- External auto-L network tuners may make it to 10:1
- External manual L network tuners handle most anything
- External manual T network tuners handle anything

Who needs a tuner?

- VHF/UHF – limited need unless you are forced to use a commercial antenna and need to match to keep your transmitter happy.
- HF –
  - a) if you can’t put up a resonant antenna
  - b) if you can’t put up a full sized antenna
  - c) if you need to work across wide frequency swaths

Tune Helps Antenna Bandwidth

- Resonant WIRE antennas tend to function over 5% frequency range with 2:1 or better SWR.
- So 1/3 of the 80 meter band, most or all of the 40 meter band, and cover most bands above that.
- 2:1 is an ARBITRARY decision point on “bandwidth” but fits well with the fold-back circuitry on many radios.
- At VHF/UHF – if you can get it to match at resonance, it will typically work over the entire band...

COMPROMISED ANTENNAS

- Shorter-than-full-sized antennas (e.g. loaded whips, dipoles, small loops) will have whackier impedances and much much narrower matching frequencies.
- Antenna tuner almost always needed for those….

Contrast: Loading Coil versus Antenna Tuner

- Trying to get the antenna itself to resonance at the operating frequency is a BETTER choice often…
- Screwdriver tuning inductors on HF whips
- Loading coils on CB antennas
- Base loading coils on “Flagpole Verticals”
- Best results if the loading inductor is heavy wire silver plated

Where to put the tuner?

- BEST if you can put a waterproof tuner nearest the antenna…
- Most people can do that….
- Relatively resonant antenna OK to feed with coax...put tuner inside the house.
- NON RESONANT – consider window line to reduce losses!   Then connect to tuner inside house.
- COAX from Tuner to radio… SWR meter (if used) goes on THIS part of the line...

Where to put the Amplifier?

- Between the SWR meter and the Tuner.
- Transceiver
- Amplifier (“Bypass” to allow tuning)
- SWR Meter (if used) – allows you to see what the Transceiver or Amplifier is going to experience
- Antenna Tuner (Often includes SWR measurement on the TRANSCEIVER SIDE
- Windowline or Coax to antenna…
- Antenna

It makes use of the works of
Kelly Loves Whales and Nick Merritt.