Automatic Antenna Tuners

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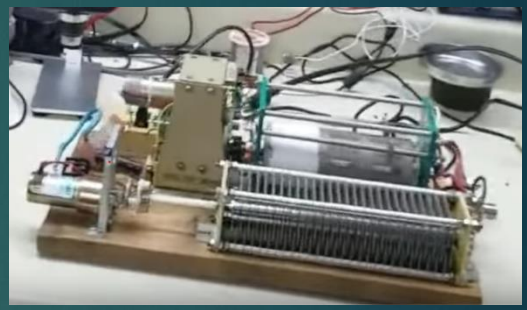
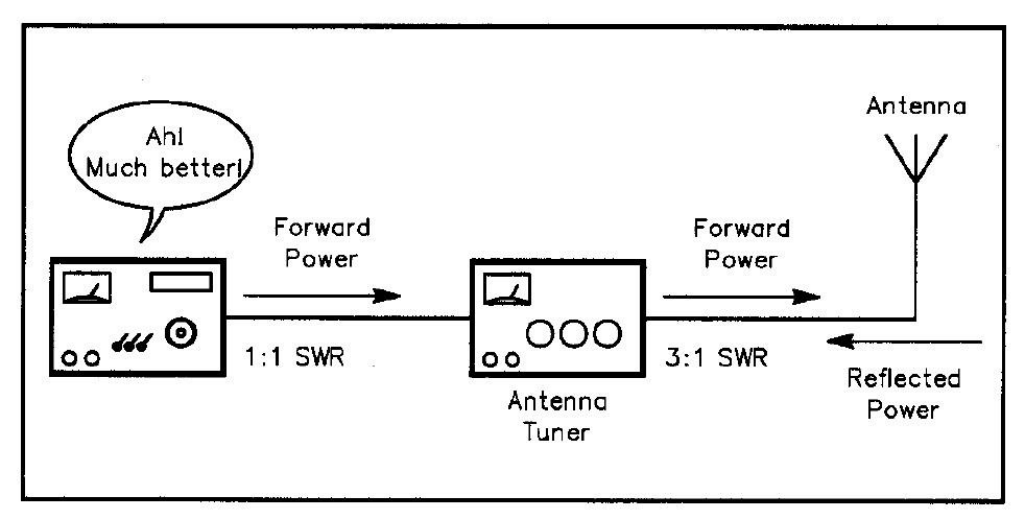


What is an Antenna Tuner?

- Anything called a tuner, coupler, matchbox, transmatch, ATU, etc
- Adjustable impedance transformer that goes between the radio and antenna
- Helps provide maximum power transfer from radio to antenna system
- Makes the radio happy!

And why do I need one?

- An antenna tuner transforms the impedance of an antenna and/or feed line to a value (50 ohms) so that the transceiver can produce the maximum amount of RF power.



A History of Tuners

- Started as fixed matching networks Add a capacitor or inductor someplace to get the light-bulb to be the brightest.
- Variable networks became popular with the Johnson KW Matchbox 1950s
- Autotuners were available in the early 90's. SGC Kenwood
- AT-11 Desktop in 1996 QST

Three Types of Autotuners

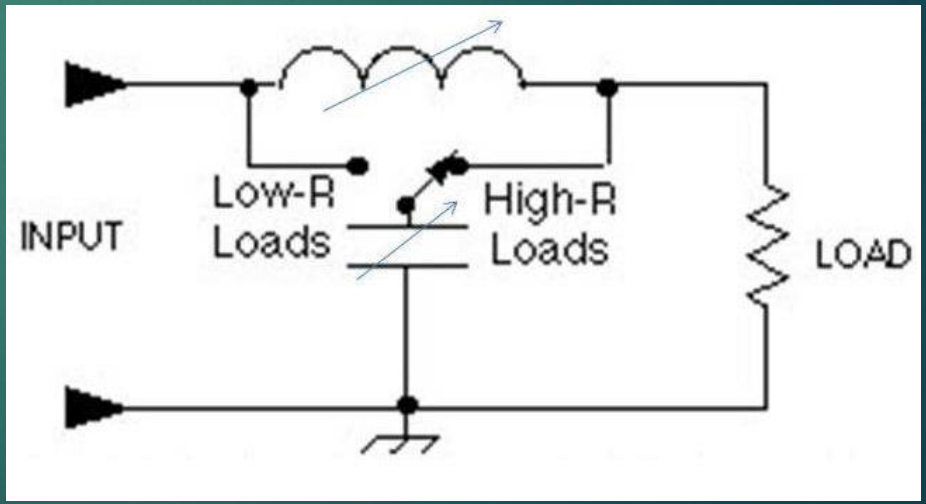
- Inside the radio. Miniature motors or relays. Limited tuning range. Can't measure SWR or RF watts externally.
- Long wire. Wide tuning range up to 50:1. Weatherproof. Heavy. Expensive. Control Cables.
- Desktop. Most popular since the 90's. 10:1 range. Scalable from 5 to 1000 watts.

Tuner Location

- If you use a Variable Matching Device, putting it closer to the feed point is more efficient
- Coax loss becomes more noticeable above 30 MHz, with SWR above 10:1, or for lengths above 150 feet
- It's more convenient to have the tuner on the desktop. Laziness usually wins!

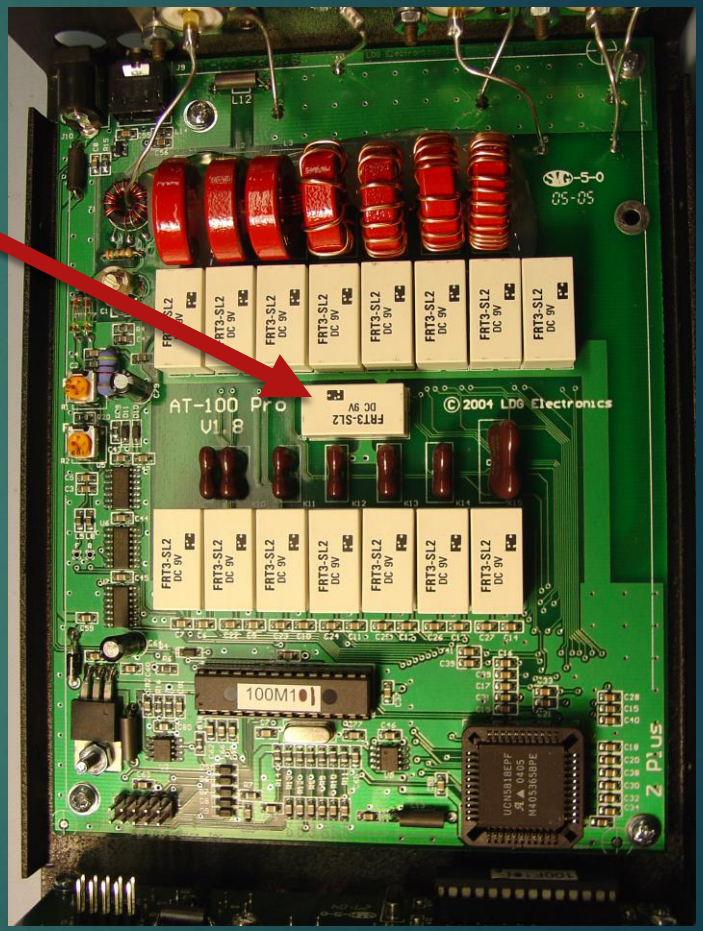
The Switched "L" Network

- Transforms R + jX to 50 ohms (50+ j0)
- Good 10 to 1 tuning range
- Only needs SWR
- Has single solution
- Conjugate Match
- 30% less parts



Hi and Lo-Z

- Software is used to detect if the antenna is High-impedance or Low-Z. Configures capacitor to input or output.
- When antenna is over 50 ohms, the antenna is Hi-impedance. Capacitor is on antenna side.
- When antenna is under 50 ohms, it's Lo-Z. Capacitor is on radio side.



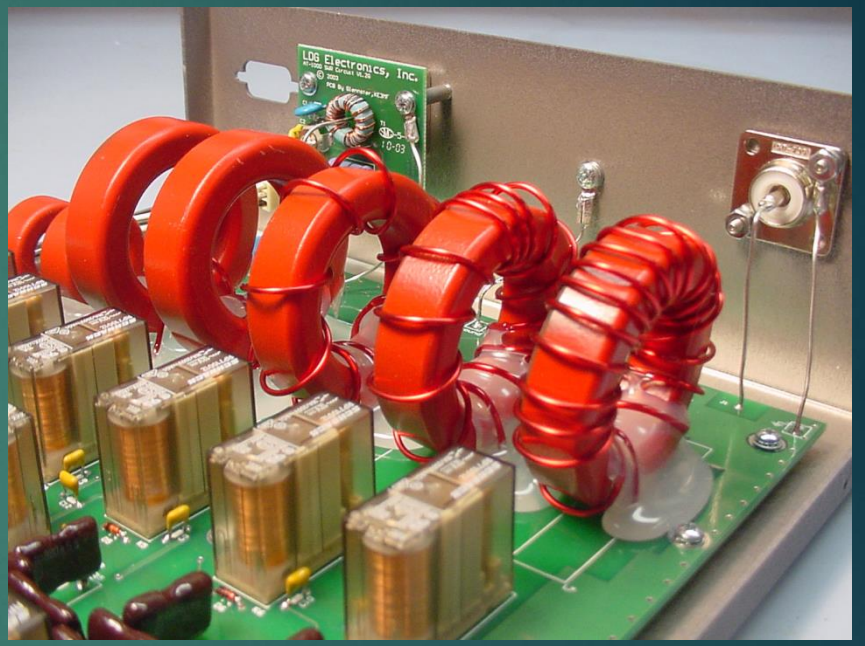
Measuring SWR

- Simple Bruene SWR detector gives Forward and Reverse power
- Then use Math to get SWR
- Don't forget, Minimum SWR = maximum power transfer for the single-solution Switched-L Network

$$VSWR = \frac{1+\sqrt{\frac{\text{REFLECTED POWER}}{\text{FORWARD POWER}}}}{1-\sqrt{\frac{\text{REFLECTED POWER}}{\text{FORWARD POWER}}}}$$

Adding Power

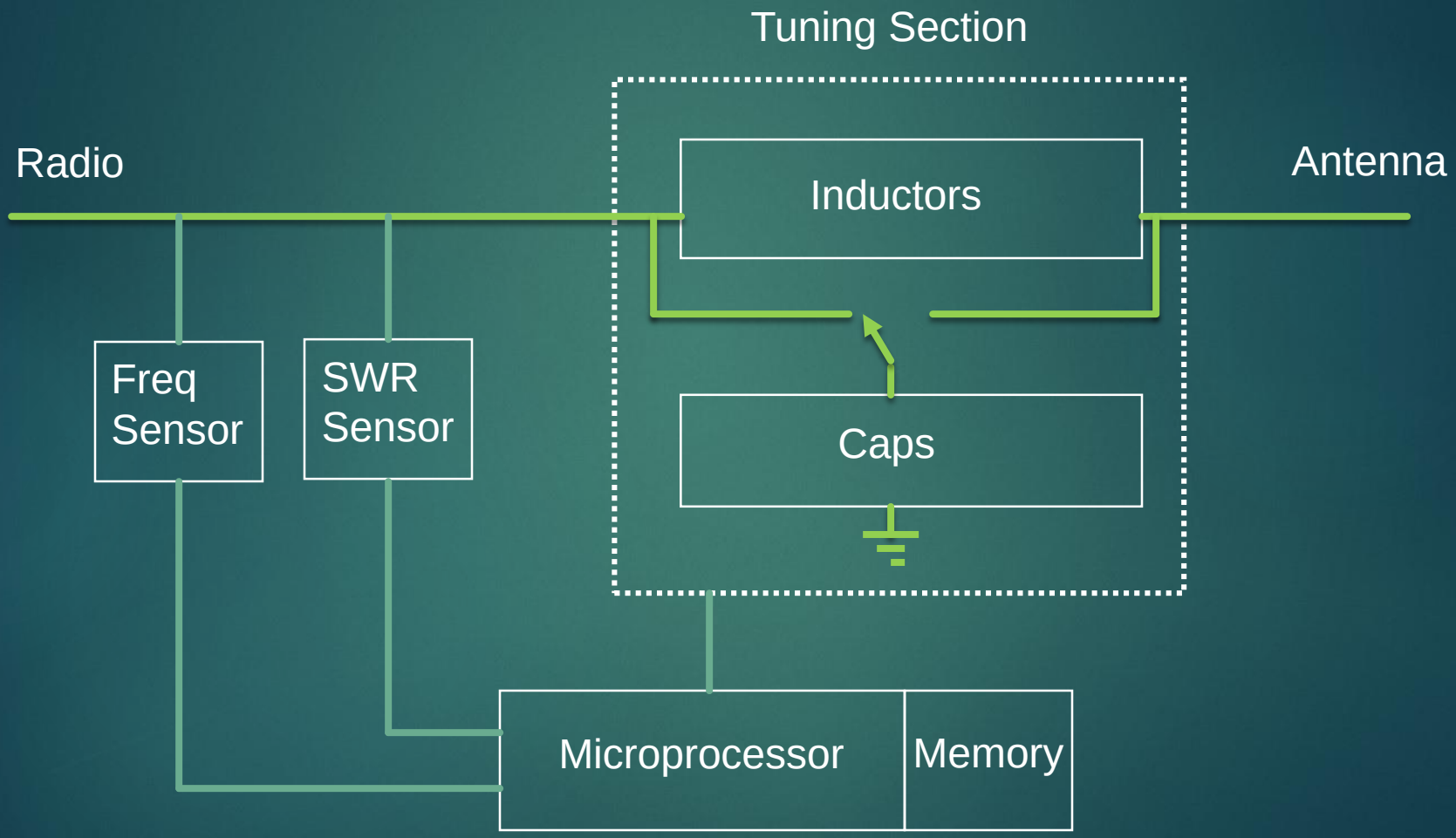
- Capacitor Voltage
  - 100 watts = 500V
  - 1000 watts = 2500V
- Upper limit is 16A relays
- Inductors Get Bigger



Speed

- Limited by relay de-bounce time
- 10 mSec per setting modified Bubble-Sort
- Up to 300 settings for a tune (3 Seconds)
  - 10 for Hi/Lo-Z
  - 100 for Inductors
  - 100 for Caps
  - 25 for fine tuning
- 3 settings for a memory tune (<100 mSec)

Automating it All



Future

- Wider desktop tuning range 15:1
- Better sensor array
- Analog meters for RF and SWR
- USB interface for remote operation
- Simple Operation (Mind reading option)

Sources

- ARRL Antenna Book
- http://www.ab4oj.com/atu/main.html
- http://fermi.la.asu.edu/w9cf/index.html
- https://en.wikipedia.org/wiki/Antenna_tuner
- Alan Wolke W2AEW https://www.qsl.net/w2aew/
- W5KUB Show https://www.w5kub.com