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# RT-1 REMOTELY CONTROLLED ANTENNA TUNER

Article 1: An Initial Description

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In response to Ken Cornell's mention of varactor diode tuning in the October 1984 Lowdown, and as a follow-up to my article "Varactor Diode Applications for DXers" (earlier this year in DX News & DX Monitor), I feel that it's about time to take the wraps off a project that's been developed here at WA1ION DX Labs. This project, dubbed Remote Tuner 1 (RT-1), allows the remotely-controlled tuning of a loop or a wire antenna from distances of at least 50'/15 m. and possibly farther.

The heart of the tuner is an MVAM series (Motorola) varactor diode. I've used both the MVAM108 and the MVAM115 with equal success. Both diodes have a Cmax to Cmin ratio of about 15:1 and maximum capacitance of about 500 pF. The MVAM108 uses a bias of about 1 to 10 volts DC and the MVAM115 operates at a bias of 1 to 20 volts. Capacitance-wise, these varactors can perform admirably as stand-ins for the traditional "broadcast-variable" tuning capacitor.

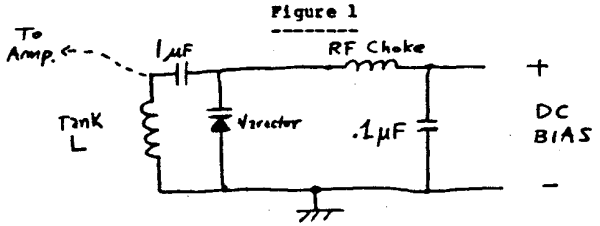
It is in the realm of strong-signal handling that one must use varactors with care. Overdriving these devices can produce nasty mixing spurs, so city-dwellers beware.

I obtained my limited supply of varactors from surplus junked PC boards of an obsolete satellite TV receiver. I'd guess the price of them to be in the $5 range but I can't immediately point the potential experimenter to a retail source.

The MVAM series of varactors is described in newer editions of Motorola's RF Data Manual.

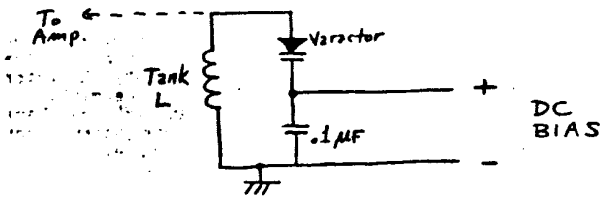
Ken Cornell suggests using the schematic of Figure 1:

Figure 1




If you realise that you can obtain DC ground from either end of the tank inductance, you can see that the circuit of Figure 1 can be re-cast in the form of Figure 2. This permits the elimination of one of the capacitors and of the RF choke. In Figure 2 the cathode of the varactor is at DC high / RF ground and the anode is at DC ground / RF high.

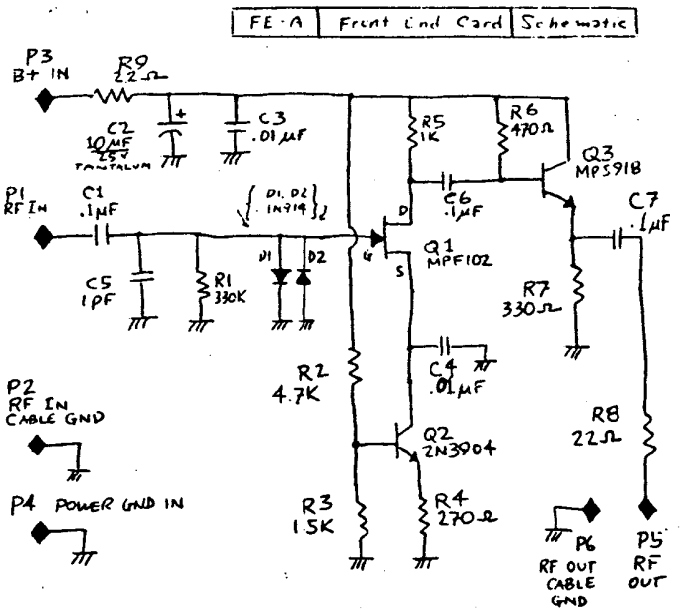
Figure 2




The DC bias is typically brought in through a resistor in the 1K to 20K range. (Remember that the varactor draws very little current, therefore, voltage drop across input resistors in this range is quite low.) The resistor, in conjunction with the .1 uF capacitor of Figure 2, acts to filter out any RF which may be riding into the tuner on the control-voltage line.

The aforementioned circuits are all well and good, but how does one get a useful signal out of this tank back to the "shack" where the operator, control box, power supply, and receiver are located ? Remember that a parallel-tuned LC network has a very high impedance (Z) at syntony, or resonance. An FET-input / bipolar-transistor-output amplifier at the tuner is a common-sense solution. The following circuit (Figure 3), dubbed Front End A (FE-A) works very well for me.

Figure 3




NOTES: Q1 (nominally MPF102) may also be 2N5484, 2N4416, or U310.

Component designations on this subassembly are a separate entity from the designations of components on the main assembly into which the FE-A card is installed.

FE-A is assembled on a 1.4" X 1.4" vectorboard with chassis-mounting hardware at four corners of a 1" X 1" square. Assembled FE-A card subassemblies may be obtained for $15 postpaid from me (address = 30 William Road - Billerica, MA 01866).

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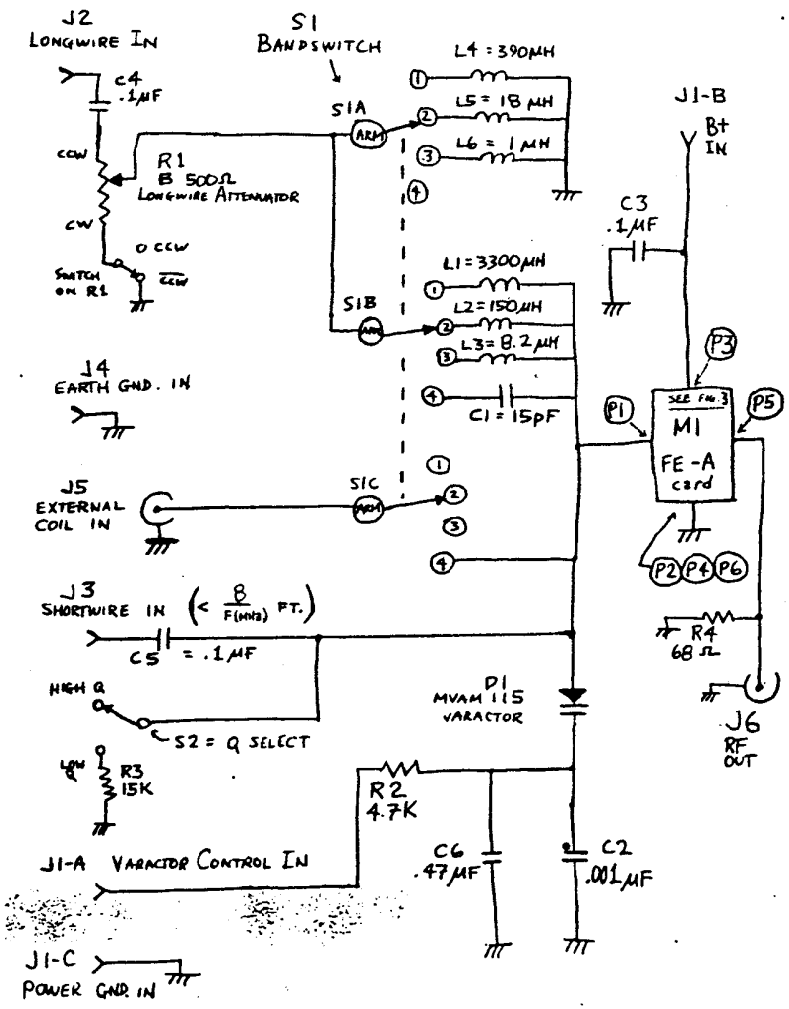
The front end card gives a good transfer between the high-Z input and a low-Z output suitable for feeding into a coaxial transmission line back to the operating position.

Prior to a full discussion of design concepts and features of the RT-1, it is worthwhile to present the full schematic of the tuner so that the reader will have a drawing for later reference. The RT-1 schematic is shown in Figure 4.

Figure 4

RT-1 | Remote Tuner | Schematic




RT-1 Operating Features, Design Concepts, and Limitations

Three controls on the RT-1 must be preset at the remote tuner box site (or on the box prior to "field installation"). These are S1, S2, and R1. A much more complicated remote tuner design could have been developed to adjust the functions of these three controls remotely; however, an article describing such a tuner would not be suitable as an introductory exposition of remote tuner concepts.

IN THE FOLLOWING DISCUSSIONS, REFER TO FIGURE 4.

Controls

S1 = Bandswitch

Positions 1, 2, & 3 of S1 provide internal tank inductances to permit wire tuning of three popular bands:

| | | |
|---|---|---|
| Position 1 | Longwave Broadcast | 140 - 300 kHz |
| " 2 | Mediumwave Broadcast | 520 - 1630 kHz |
| " 3 | Tropical Bands & 80/75 m. Ham | 2300 - 6300 kHz |

Position 4 permits the use of an external inductance connected at J5. This may be either a loophead designed to pick up signals on its own, or a smaller coil used to provide wire tuning capability on a range (e. g. 160 metres) not provided by S1 positions 1, 2, & 3.

If one only intends to use the RT-1 as a remote loop tuner, S1 & the internal inductors (L1 through L6) may be eliminated. Similarly, if the tuner is only going to be used to tune a wire aerial on one frequency range, S1 & four of the six internal coils may be eliminated.

S2 = Q switch

This switch permits normal High-Q tuning for most applications and Low-Q tuning necessary for stable phasing of the RT-1 against either another RT-1 or against some other Q-spoiled tuned source.

S2 and R3 may be omitted if the tuner will not be incorporated into a phasing system.

R1 = Longwire Attenuator

R1 is normally set to fully counterclockwise (CCW) to permit maximum signal transfer. In areas with strong local stations, this control may have to be adjusted to eliminate overloading and its unwelcome consequence, spurious signals. The pot should be set to provide maximum wanted-frequency signals throughout the tuning ranges, consistent with little or no incidence of "spurs".

The best time to check for overloading caused by MW BCB locals is during the daytime.

Decreasing L4, L5, and L6 to 270, 12, and 0.68 uH respectively may also be helpful for those anticipating that the majority of their RT-1 operation will be in strong-signal areas with wires of considerable length.

Inputs / Outputs

J1 = Control / Power Cable In

J1 is a stereo phone jack having two "hot" pins and a ground. The control / power cable (two conductors plus a shield) terminates in a stereo phone plug which mates to J1.

Pin A of J1 accepts the varactor control voltage: this should be adjustable from +1 volt DC to +28 volts DC. (Maximum capacitance - lowest frequency is at 1 volt; minimum capacitance - maximum

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frequency is at 20 volts.)

Pin B of J1 accepts B+ (power): a regulated, filtered supply of +8 volts minimum, +16 volts maximum should be used.

Pin C (ground) of J1 accepts return ground / minus-sides of the power supply and the varactor control voltage source.

J2 = Longwire In (banana jack)

A wire of length greater than (8/F) feet (where F is frequency in MHz) may be connected to J2. Adjustment of signal level coupled to the RT-1 from this jack is accomplished by using R1.

J3 = Shortwire In (banana jack)

Wires shorter than the specification for J2 may be connected to J3. If you are in an area of very strong TV & FM signals, don't use J3 as mix spurs may result: use J2 instead & tweak R1, if necessary, to remove spurious signals.

J4 = Earth Ground In (banana jack)

It is wise to connect a local ground at the remote tuner site, especially if more than 50'/15 m. from the operating "shack" ground. This will provide proper coaxial cable shielding and local electrical noise reduction. Ground rods, copper plate, AC mains or water-pipe ground (if available) should be used. If the RT-1 is tower-mounted, use the tower as a ground. Other impromptu grounds of lesser efficiency can include any large metallic object, such as a vehicle, tool shed, or a "dummy ground" longwire antenna other than the wire being tuned at the time.

J5 = External Coil In (BNC jack)

(See references to use of an external coil in the discussion of S1.)

J6 = RF Out (BNC jack)

Tuned output of the RT-1 is sent to this jack for transferral back to the operating position. Coaxial cable having an impedance from 50 ohms to 75 ohms must be utilised. The RF cable should be terminated in a 50 ohm to 75 ohm load at the receiver end.

Weatherproofing of Remote Tuners

When outdoor remote tuners are considered, one must devise suitable housings to prevent moisture damage and other problems related to an outdoor environment. A plastic box with cutouts for antenna wire, control/power cable, and RF-out cable may be employed if, after assembly, it is rendered suitably watertight by means of caulking material similar to that used on bathtubs. This is best done during cool, dry conditions to minimise later accumulation of condensation within the box.

Such a box may suffice in areas of moderate temperatures and precipitation. Those living in areas of extreme temperature, humidity, precipitation, pollution, and wind conditions will have to use a good deal more ingenuity in the construction of protective housings. Some form of heating may be necessary in cold areas (this could consist of a large power resistor connected to its own power supply though a heavy-gauge cable).

Control Unit Considerations

The control unit for the RT-1 should provide the varactor control voltage necessary for remote tuning.

Figure 5 illustrates a sample "shack" operating position control unit.

A single-turn 10K linear pot may be used, but tuning is apt to be very touchy. If a single-turn pot must be used, think about using a vernier reduction drive knob (Mouser # 45KN100 or # 556S50).

Phasing applications mandate the use of a 10-turn pot.

Conclusions

Article 1 on the RT-1 remotely-controlled tuner is meant to introduce the concept of varactor-controlled remote antenna-tuning systems in some detail.

Article 2 (and possible other subsequent articles) will deal with matters such as construction of the RT-1 and a control unit. Phasing of two remotely-tuned aerials may also be considered.

The chief merit of remote tuners is that they (and the antennae they tune) can be located in areas with (1) less RF shielding from buildings or vehicles than the immediate vicinity of the operating position, and with (2) lower levels of manmade RF noise (from TV's, dimmers, etc.) than the immediate vicinity of the operating position. Those living in steel-frame high-rise buildings and those operating from recreational vehicles/boats/house trailers have much to gain by the utilisation of remote tuning methods.

Figure 5