A REMOTELY TUNED LOOP ANTENNA
For The Tropical Bands

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This article describes the construction of a remotely tuned, amplified loop antenna which has been found suitable for DXing the Tropical Bands. The tuning range of the loop is typically 1850-5200 kHz without bandchanging. Since it is tuned remotely, the loop may be sited outdoors for enhanced reception. A single coaxial cable is used to power the loop amplifier, tune the resonant loop, and return the signal to the shack. The loop system consists of three elements: the loop windings and support frame, an amplifier/tuner, and a variable DC power supply to power the loop amp and provide a means of tuning. The construction of each element will be described in the following sections.

●LOOP

The loop I built is pictured in Fig. 1. The windings consist of 6 turns of #20 AWG center-tapped, forming a square 18" on a side (approximately 25" diagonally). Spacing between turns is 0.5", and a 3" gap is maintained in the middle of the winding between turns 3 and 4. In earlier versions, I was using "abrupt junction" varactors before I acquired the MVAM115 "hyper-abrupt" devices. The gap in the winding was found to be more effective in reducing parasitic capacitance than was spreading the turns "radially." This being so, the gap could probably be eliminated with only minimal effect on the top-end tuning range.

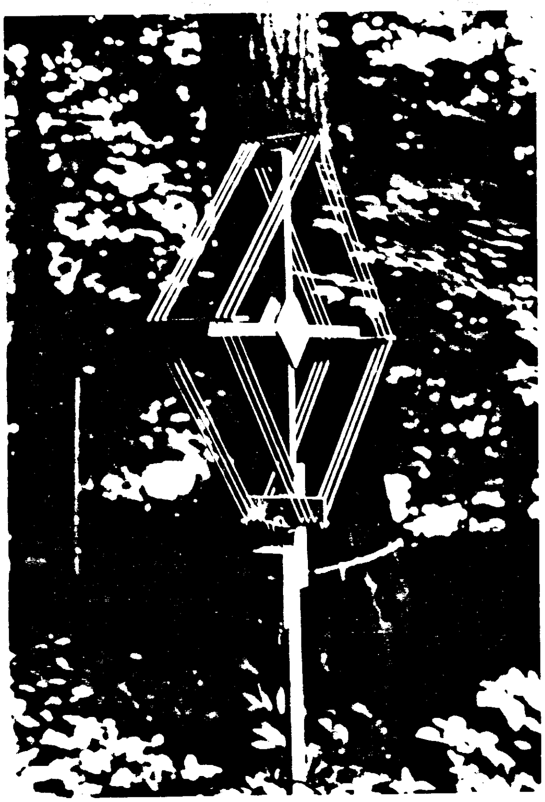


FIG. 1 REMOTE LOOP

The frame I used has arms made from 0.75 x 1" hard maple stock, cross-lapped and epoxied at the joint. 4 x 4 x 0.25" maple plates were used to reinforce the center joint. A 2.25 x 6.25" maple plate with holes drilled to accept the windings was screwed and epoxied to the end of each arm.

I milled a 2 x 2 x 10" block of oak to mate with the lower arm as pictured, and the other end was bored to accept a 1.25" heavy-duty broomstick as a mast; the joints were then screwed for rigidity. The oak block serves also as a place to mount the loop amp.

For weather protection, all wooden parts were given a coat of external-grade polyurethane. Marine varnish would also have sufficed.

For brevity's sake, no other frame construction details or dimensions will be given; the reader can refer to various excellent publications such as the NRC Antenna Reference Manuals for very helpful construction hints. Besides, your preferences and your imagination should help considerably. Make it strong, make it light.

Another method of construction using 0.75" Schedule 40 PVC pipe and fittings may be more suitable for exterior loops. Four 12" lengths of the pipe could serve as the support arms. One end of each could be cemented into the four ports of a standard cross fitting. At the other end of three of these arms, the perpendicular port of a tee fitting could be cemented, and short stubs of pipe then cemented into each inline port. These stubs would serve as wire supports. At the fourth (bottom) arm, another cross fitting with stubs could similarly be used. Here, the extra port could be mated to a companion flange (or whatever) as a means of mounting.

Holes can be drilled through the stubs (or slots cut in them) to hold the windings in place, or they could simply be wound around the stubs and fixed in place with RTV or similar adhesive.

●AMPLIFIER/TUNER

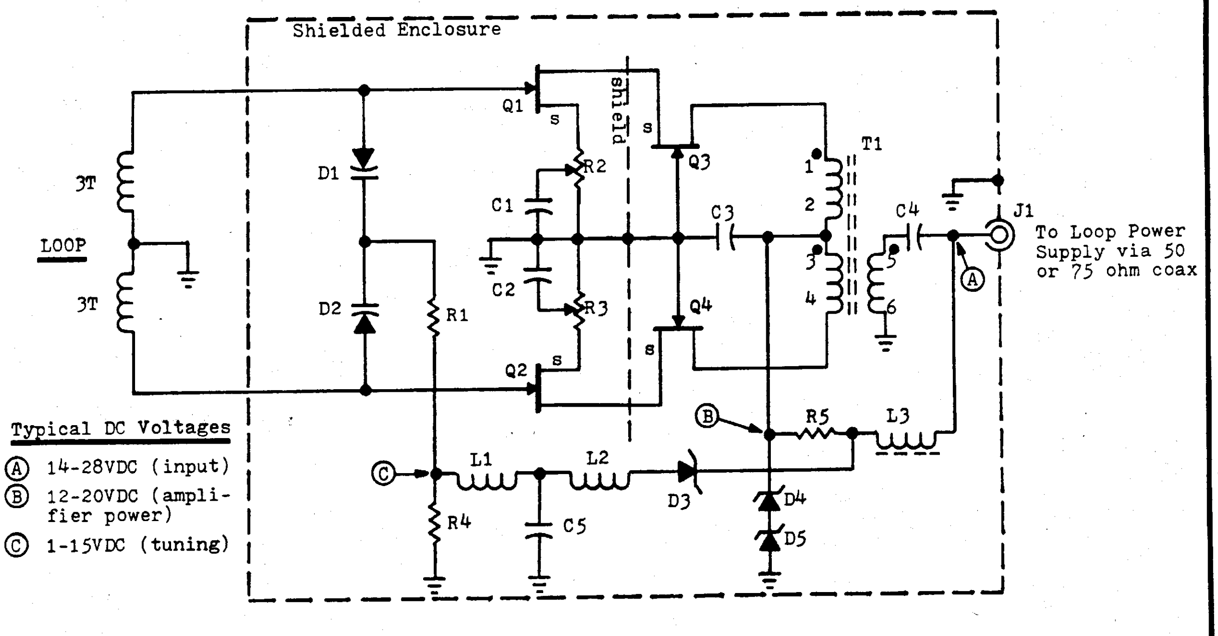
In the prototypes, parallel resonance was chosen, and an amplifier was necessary to match the high impedance of the resonant loop to coaxial cable. This also increased the relatively low output of the small loop.

The prototype amps were built on small (1.5 x 4") PC boards, and were enclosed in 2.25 x 2.25 x 5" aluminum miniboxes. Connections to the loop were made through three box-mounted tip jacks, with mating connectors on the loop ends and center-tap. The coaxial connection was made by a BNC jack.

The loop schematic diagram and parts list are presented in Fig. 2 and I will only make a few comments. A variable DC voltage of 14-28 volts is available at the BNC jack, and the network L3-R5-D4-D5-C3 is used to supply a filtered and clamped drain voltage for the balanced cascode amp Q1 through Q4. The cascode configuration was chosen for its predictable performance as a loop amplifier; it is tried and tested. This version has proven to be unconditionally stable over the entire frequency range.

The network D3-L1-L2-C5-R4-R1 strips and filters a portion of the input voltage for use as varactor reverse bias; this effects loop tuning. The typical range of voltages present at this and other important circuit nodes is noted on the schematic.

The MPF102 or equivalent JFETs should be selected and reasonably well matched for zero-gate drain current (Idss) to ensure proper biasing of the cascode pairs. A suitable simple test circuit is shown in Fig. 3. The Idss of Q3 and Q4 should be matched (to within 2 mA) and an ideal target value would lie



C1-4	.05 uF, 50V, disc	Q1-4	MPF102 JFET (see text)
C5	.01 uF, 50V, disc	R1	22KΩ, ¼W, 5%
D1,2	MVAM115 tuning diode	R2,3	200Ω trimpot
D3	13V, 500mW Zener (1N5243B)	R4	10KΩ, ¼W, 5%
D4,5	10V, 1W Zener (1N4740A)	R5	240Ω, 1W, 5% (see text)
J1	BNC bulkhead jack	T1	10T #32AWG trifilar on Amidon FT-50A-77
L1,2	270 uH molded inductor		
L3	270 uH inductor (15T on Amidon FT-50A-77)		

FIG. 2 LOOP AMPLIFIER SCHEMATIC

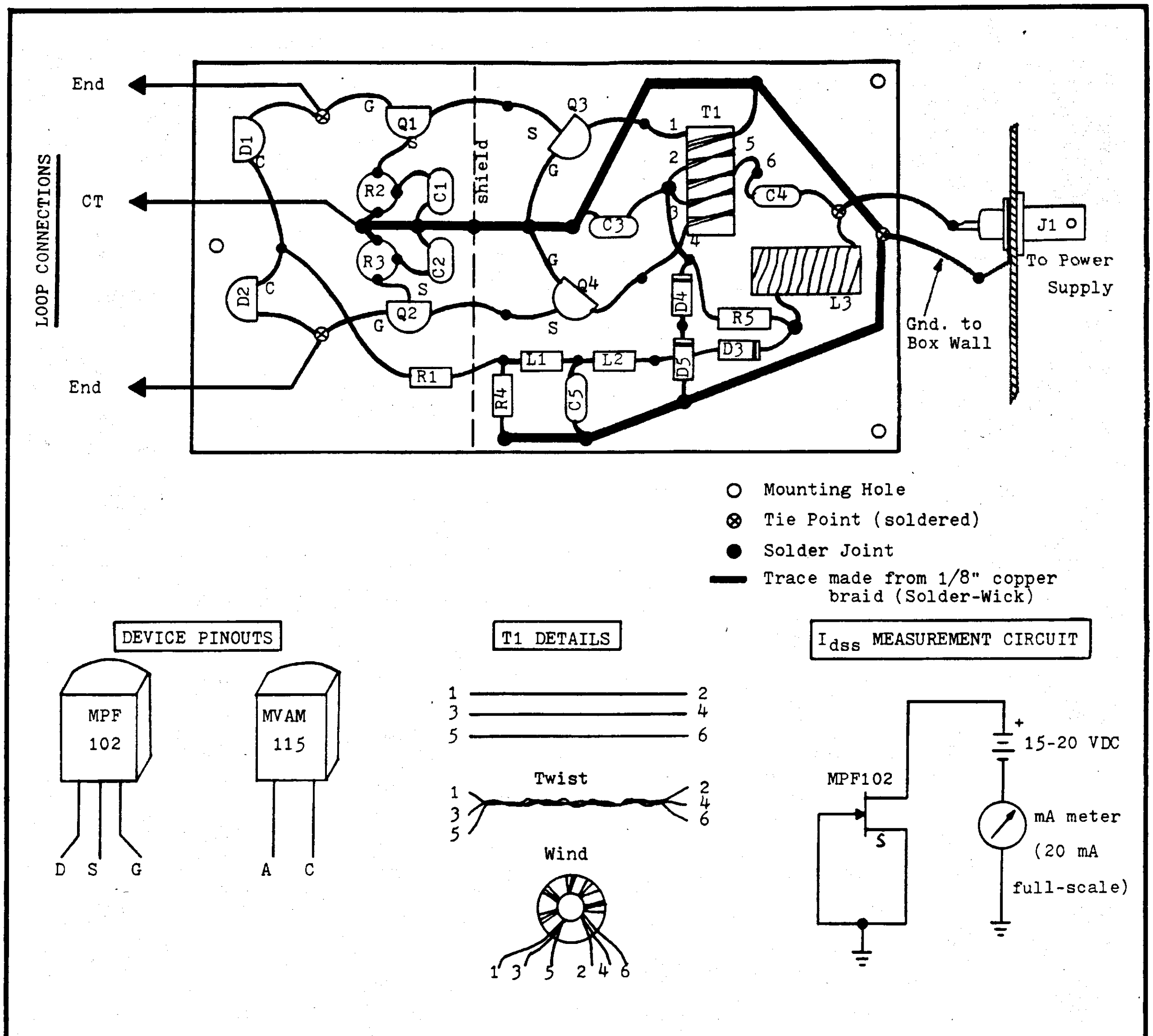


FIG. 3 LOOP AMPLIFIER LAYOUT

between 12 and 15 mA. Q1 and Q2 should be similarly matched, and an acceptable Idss would fall between 6 and 9 mA. It would be a very wise idea to buy about ten of the JFETs (MPF102s are 10/$4.30 from Digi-Key) to ensure that matching can be done.

Construction of the amp should be fairly straightforward for a builder with some experience. PCB construction would be ideal, but point-to-point assembly on perf board should work fine also. Fig. 3 gives one suggested layout for PTP wiring.

The trimpots R2 and R3 in Fig. 2 are used to adjust the gain of the loop amplifier. 8-10 dB of gain adjustment is typically available across the tuning range. Adjusting the pot wipers towards the FET source terminals increases gain and vice versa. You should initially set these pots at mid-rotation. If you desire, you may match the wiper-to-ground resistances in each half of the amp at 100 ohms.

The MVAM115 tuning diode is a very critical component in this design. It has a maximum to minimum capacitance ratio of 15 (typical) which allows this loop to be tuned over a very wide frequency range. Although it is inexpensive (about $0.90) it may be very difficult for the hobbyist to obtain. One approach which generally works is to call a local Motorola Semiconductor Products distributor such as Newark, Hall-Mark, or Kierulff Electronics. They will be VERY reluctant (even with a corporate account) to sell this device in small quantities. If you are clever (and marginally ethical) you should be able to get the salesperson to "sample-out" a few parts to you without charge.

Alternatively, you may contact me (5252 Lee Avenue, Downers Grove, IL

60515) if you have difficulty in procuring the parts. I hope to acquire a small stock of the MVAM115 for further experiments, and I would be happy to supply them if I am able. An SASE would be appreciated.

●POWER SUPPLY

The power supply I used is a variable regulated DC supply whose output can be adjusted over the nominal range of 14 to 28 volts by the 10-turn pot R3. This pot is the loop tuning control, and with the amp described, resonance between 1850 and 5200 kHz was achieved. The two loops I made had measured Qs of 90 and 110 at 5000 kHz, and tuning is rather sharp. I strongly suggest that you use a 10-turn pot and a turns-counting skirt for this control. The schematic diagram for the power supply is shown in Fig. 4.

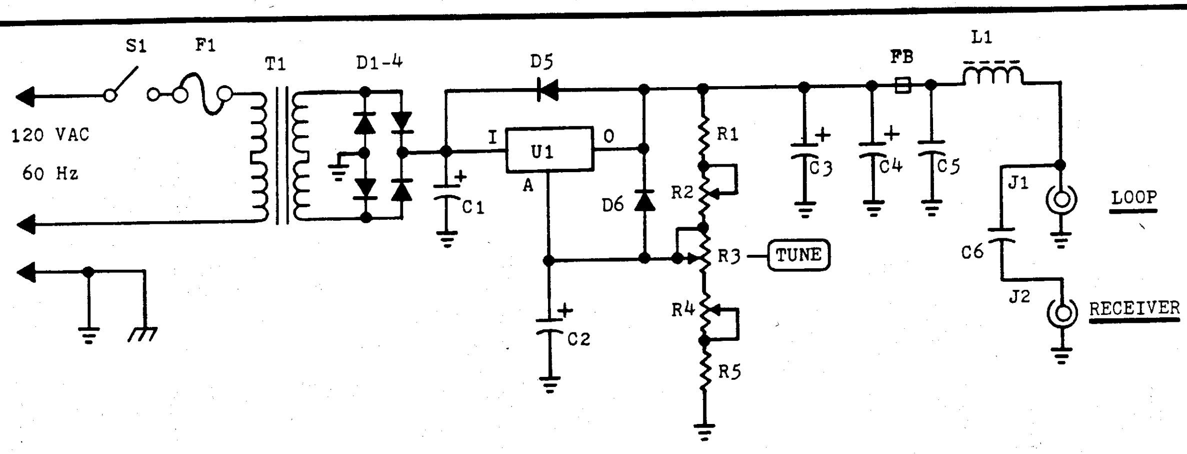
The noise output of a 317 type regulator typically shows a spectral peak below 100 kHz. However, a bit of additional filtering (C3-C4-C5-FB-L1) was necessary to remove higher frequency noise components and keep them below audibility.

As with the amp, this circuit should not pose any great construction problems. The circuit can be built per the layout in Fig. 5 and housed in an enclosure or minibox of your choosing. The power switch and fuseholder can be box mounted, as well as the two BNC jacks.

Just a couple of quick notes to aid construction: the heavy traces shown on the Fig. 5 layout are fashioned from 1/8" solder wick or copper braid. These help to keep noise to a minimum. The transformer I used is a PC mount, low-profile, split-bobbin type; this was a junkbox item. Radio Shack and others offer suitable lug-mount transformers which would be entirely adequate. The use of BNC jacks is not mandatory; should other connector types be more suitable for you, use 'em.

●SET-UP AND CALIBRATION

Prior to firing up, the power supply should be checked for proper operation and it must also be calibrated. With power off, connect a 1000 ohm, 1 watt resistor between J1 center conductor and ground. Connect an accurate DC



C1,3	1000 uF, 50V, electrolytic	R1	910Ω, ¼W, 5%
C2	10 uF, 50V, electrolytic	R2	200Ω trimpot
C4	1 uF, 50V, tantalum	R3	10KΩ, 10-turn pot with turns-counting dial
C5,6	.05 uF, 50V, disc	R4	1KΩ trimpot
D1-6	1N4002 or equivalent	R5	9.1KΩ, ¼W, 5%
F1	3AG, ½ Amp	S1	suitable line switch
FB	Ferrite bead (Amidon FB-43-801 or equivalent)	T1	Stancor SW-328 or equiv. (28 VAC, 85 mA secondary)
J1,2	BNC bulkhead jack	U1	LM317T voltage regulator
L1	270 uH inductor (15T on Amidon FT-50A-77)		

FIG. 4 POWER SUPPLY SCHEMATIC

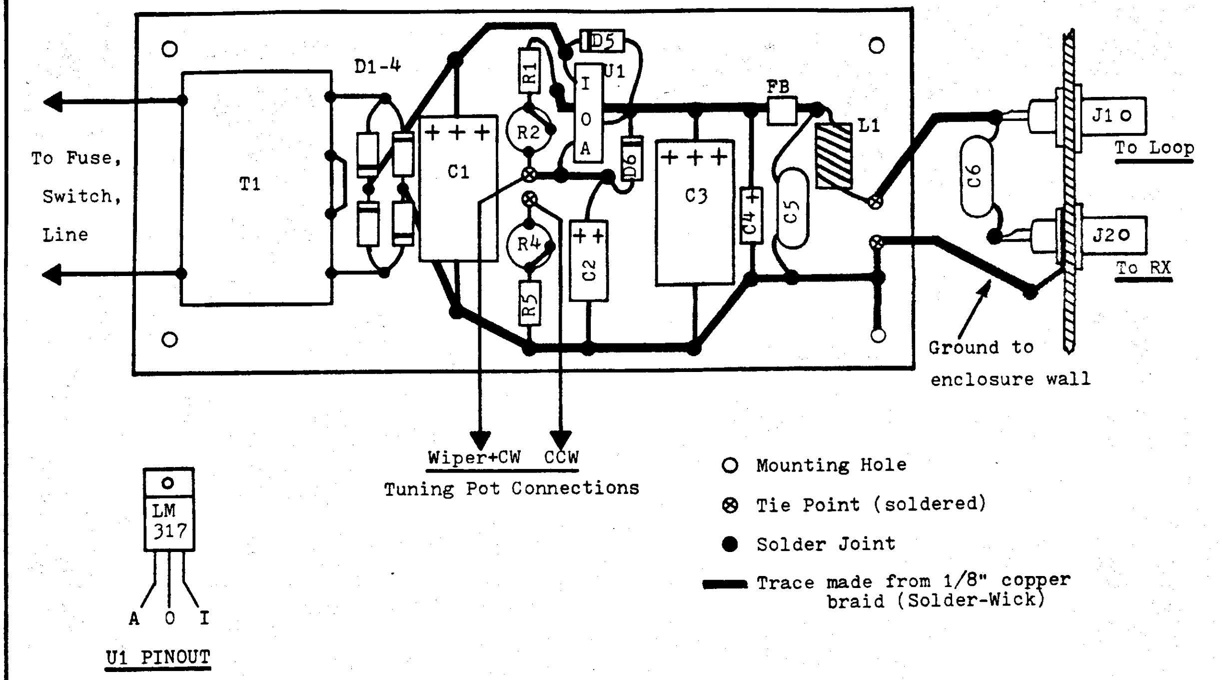


FIG. 5 POWER SUPPLY LAYOUT

voltmeter across this resistor. With the tuning control (R3) set at minimum (full CCW) turn the power on. The voltmeter should now read 14 volts. With the tuning control at maximum (full CW) the meter should read about 28 volts. Your initial readings probably will not agree with these values, and the trimpots R2 and R4 must be adjusted to calibrate the supply. R2 is used to adjust the supply minimum voltage and R4 sets the maximum. These adjustments are interactive, and several iterations may be necessary.

Between minimum and maximum tuning pot rotation, the output should be a smooth linear function of knob rotation (about 1.4 volts/turn.)

The length of the coaxial cable between the power supply and the loop should be kept to a minimum for several obvious reasons. In addition to losses, noise, and shield pick-up, the resistance of the coax will affect the tuning range due to voltage drops. This will show up as reduced top-end tuning range. You must compensate for this. (The loops I made have been used with up to 80 meters of coax. The tuning range mentioned earlier was maintained at this length once the loop was calibrated.) Connect (with the power off and the tuning at minimum) the coax length you'll need between the power supply and the loop amp while it is still indoors. Connect the loop to the amp. Connect a high impedance (10 Megohm) DC voltmeter between the junction of the amplifier varactor cathodes and ground. (A lower impedance meter connected to the junction of R1-R4-L1 in the amp would also be OK.) R2 and R4 may now be adjusted in the manner previously described to obtain 1 volt at tuning minimum and 15 volts at tuning maximum as observed on the voltmeter. This accomplished, you're ready to go.

A note of caution: the MVAM115 is specified for 15 volts reverse bias operating and 18 volts MAX. It would be wise to make adjustments in small increments.

The loop may now be mounted outdoors according to your preferences. If you used connectors (e.g. BNC) be certain that mating surfaces are clean and securely mated, as the maximum load current will be on the order of 30 mA. It is advisable to use a bit of Coax Seal to protect the connection.

Because this antenna is a loop, there is a general depression in reception sensitivity in directions perpendicular to the plane of the loop. Since the loop is rather "wide" and not optimized for balance between loop halves, these depressions (especially pattern nulls) are not pronounced. For best reception you should align the plane of the loop with the azimuth of the area which you wish to DX.

I made no special attempt to protect components from the environment. Instead, a 30 gallon trash liner was placed over the loop and amp and was sealed with duct tape. This has been effective in protecting the loops against wind, rain, snow, fog, sleet, severe fog, sunlight, dust, snowballs, kids, and birds. Two loops have made it through three winter months here without a breakdown or change of calibration. In future versions, I hope to address this issue with a bit more elegance. The idea here is to protect the amplifier absolutely against rain while still allowing some venting so that condensation cannot take place.

The RF output from the power supply should be connected to the low (50 ohm) unbalanced input of the receiver via coax and suitable connectors.

●OPERATION

Operation is very simple. Turn the power on and peak the signal with the tuning control. Even with a 10-turn pot the signal will peak sharply, but this should be a blessing rather than a handicap.

It will be found that with a Q of about 100, it will be necessary to re-peak tuning every 30-40 kHz as you scan a band. The response is not so sharp, however, that you will lose stations between peaks.

A typical tuning curve is shown in Fig. 6. The two loops I made (when calibrated at the endpoints) tracked to within 50 kHz of each other across the entire range. You might consider making such a curve for yourself while you get accustomed to the tuning; within a short time you will find that you won't need it.

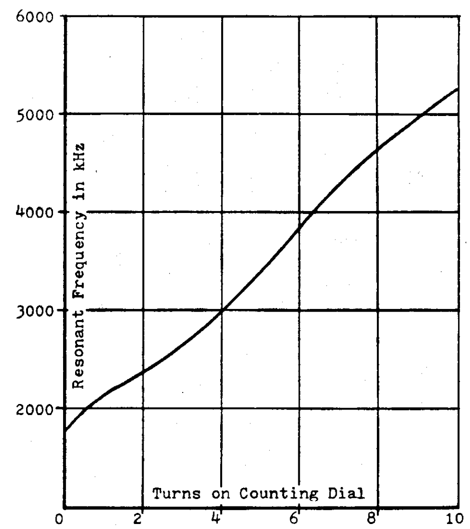


FIG. 6 TYPICAL TUNING CURVE

●SOME PERSONAL COMMENTS

While this loop was primarily designed as an element for array use, I have been very pleasantly surprised by its stand-alone DX capabilities. I have not been able to compare it against a "long" (75-100') longwire, but I have used it in conjunction with a T2FD cut for 40 meters. In nearly every listening comparison in the Tropical Bands, the loop had equal or better sensitivity than the T2FD. On difficult signals, the edge went to the loop more often than not.

This is primarily due to the fact that the loop is generally the quieter antenna, although I previously thought that the folded dipole was the quietest antenna I had ever built. The loop seems far more immune to noise from power line leakage, which is an occasional problem at my location in humid conditions. Noise coming from other neighborhood sources also seems to bother the loop to a lesser degree. In this respect, I have been most impressed and my expectations have been exceeded.

A very important caveat: whenever semiconductors are used in the RF signal path ahead of the receiver, there exists the possibility of generating various distortion products. The capacity of the varactors can be modulated by high levels of RF energy, generating some really nasty mixing products. Distortion can be generated in the cascode pairs, also.

Your success with a loop will depend on many factors, the most important being your location. Your receiver may also be a factor. In some locations an amplified loop may be virtually useless due to excessive signal levels from nearby BCB stations. Try to judge this for yourself before you build, or you may be in for a big disappointment.

My location is in very far southwest suburban Chicago, and I am well out of the main metropolitan RF corridor. I do live within 3 miles of 50kW WLUP-1000. Even so, I have not noted a single spurious signal over and above those noted on the passive T2FD.

In the event that you encounter spurious signals, it is most probably due to excessive loop output. The following actions should be taken as required:

1) Drop the loop gain. The amp trimpot wipers should be rotated towards ground so that the FET source resistances are not bypassed.

2) Use an attenuator between the power supply RF output and the receiver.

Every shack should have one, anyway.

3) Drop the loop output by spoiling the loop Q. This can be accomplished by putting a 100K resistor across the varactor anodes in the loop amp. Use less resistance if the problem persists.

Hopefully the first action will clear the problem. The second remedy should be effective in those cases which require more gain reduction than is available in the amp. The last action may be necessary for very stubborn cases in which the varactors are possibly being modulated by excessive RF levels. The overall philosophy is to tailor the gain so that the loop presents signal powers to your receiver which are comparable to an antenna with which your receiver has consistently worked well.

In the event that the initial loop operation is satisfactory, don't be shy about experimenting with higher gain settings. Using an R7 receiver, I have been able to run the loop at full gain (typically 6-12 dB "hotter" than a T2FD) with no problems.

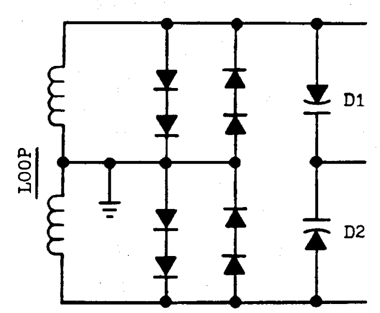


FIG. 7 PROTECTION

A second caveat which must be mentioned concerns protecting the front end of the loop (varactors and JFETs) against possible damage from static or nearby electrical storms. The MPF102 JFET seems to be a surprisingly rugged device, far more so than insulated-gate types. I do not have any basis on which to judge the MVAM115. I prefer to run without protection and, luckily, I have no failures to date. Protection may be an important consideration in some geographical areas, especially if you intend to mount the loop at a considerable height above ground.

The protection scheme illustrated in Fig. 7 should provide a measure of protection against nuisance failures, although it will probably not be very effective against direct or nearby lightning strikes. 1N914 or 1N4148 signal diodes are suitable. Two diodes are used in series in each path to minimize the possibility of generating distortion products and to lessen the amount of capacitance added to the loop. Even so, expect to lose 75-100 kHz at the top end with this scheme. If you are making a PVC pipe frame, you might want to hold off on cementing the arms until you verify the tuning range. Should you want more top-end range, the arms can be shortened incrementally to drop the loop inductance and recapture the design tuning range.

●REFERENCES AND RECOMMENDED READING

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