A105-6-1

The RTU-1 Remote Tuning Unit for Active Whips

Mark Connelly - WA1ION - 14 MAY 1991

The RTU-1 varactor tuner is meant to tune an active whip remotely so that the benefits of tuned-circuit selectivity and dynamic range / gain enhancement can be realized. The result: better DX than when the whip is used in its customary broadband mode.

The DX role of a remotely-sited active antenna

The active whip antenna is useful in many DXing situations.

Two come to mind immediately:

(1) when DXing from an apartment or a hotel where in-room operation of a loop is not feasible because of shielding and/or electrical noise. Also, for legal or logistical reasons, installation of an outdoor longwire is not possible. It *is* possible, however, to place an active whip in a window or on an outside balcony.

(2) on mobile DXpeditions where the in-vehicle receiving set-up must be fed from an antenna mounted on the vehicle. A loop won't work inside a vehicle; furthermore, the specific situation may rule out a longwire (either because DXing is to be done while the vehicle is in motion or because the site chosen for stationary listening has no available space, is too crowded, etc.). A busy beach, park, street, or shopping-mall parking lot could be a good place for listening but an impossible place for a wire antenna.

The active whip also has merit at more conventional sites (e. g. at a wood-frame house in a suburban neighborhood where other antennae could be used) because it can be tower-mounted for improved signal pick-up and local noise rejection.

Limitations of Existing Remote Active Antennas

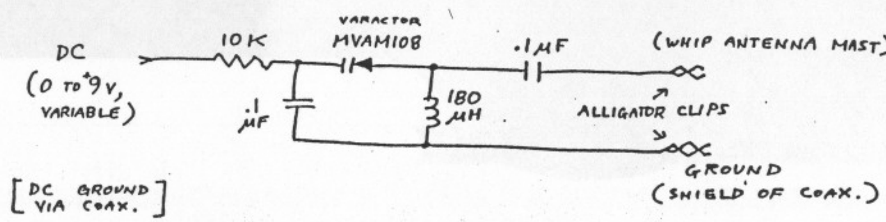
The vast majority of remote active antennae sold, whether of a loop or whip design, utilize broadband techniques. Both the active antenna's amplifier and the receiver's front end are exposed to a wide spectrum of signals, quite likely including those of high enough strength to cause intermodulation distortion ("spurs") and cross-modulation (strong-station audio super-imposed on the audio of weaker stations). Some companies (e. g. Grove) offer tuners or attenuators to place in the coax. path from the antenna-head amplifier to the receiver input. In many cases, though, the worst overloading occurs at the front end of the remotely-sited antenna-head amplifier. "The damage has already been done" so to speak: in-shack tuners and attenuators offer no fix. A remedy must be applied where the problem exists: this is at the remote site, whether it's at the top of a tower or at a mounting bracket bolted to the exterior of a car, plane, boat, or truck.

Early experiments with the MFJ 1024: I have used the MFJ 1024 active whip with a great deal of success. Typically, the RF output is passed through a passive or active preselector enroute to the receiver in order to reduce the likelihood of receiver-front-end-generated spurs. A DXpedition to the Marblehead, MA waterfront last January went well other than the distracting addition of WBZ-1030 audio in the background of some DX stations' audio (e. g. on BBC/Albania/Saudi-648). WBZ, at about 15 miles distance over salt water from the DXing site, was overloading the MOSFET front end in the MFJ 1024's amplifier. Additionally, "intermod." (mix spurs) showed up on a few channels due to the potent signals from WBZ-1030, WESX-1230, WROL-950, WSSH-1510, WJDA-1300, WLYN-1360, WEZE-1260, WEEI-590, WRKO-680, WXKS-1430, WILD-1090, and WHDH-850. The "RF hot" location by the sea in a large metropolitan area was a bit more than the broad-band front end on the active whip could comfortably handle. A few shortwave spurs got into the act too, both from SW broad-casters and from powerhouse RTTY/CW utility stations such as WCC. Harmonics of LORAN-C (Nantucket, 100 kHz) showed up also. All in all, considering the pounding the MFJ's front end was taking, it held up fairly well. Most frequencies were spur-free and perfectly DXable. 15 to 20 MW countries were logged in a less-than-2-hour session that started over an hour before sunset. Still, I thought improvements would help and that a tuned-tank-circuit approach, applied directly at the whip antenna, would be the solution. Selectivity, rather than added gain, was the desired objective, but if a few more dB of gain were to be had, all the better.

The RTU-1 Remote Tuning Unit

The simplest approach to tuning a remotely-sited antenna system is to construct a tank circuit consisting of a varactor diode, an inductor, and a few other needed components. The varactor diode, when biased by a DC voltage sent on a control line from the "shack", acts like a variable capacitor. My previous articles on "Varactor Diode Applications for DXers" and on the "RT-1 Remotely - Controlled Antenna Tuner" (1984) give an introduction to these useful devices. The articles are available through the reprints services of NRC and IRCA. A crude experimental set-up (Figure 1) was quickly "kluged" up and alligator-clipped onto the MFJ 1024. The results were impressive !

FIGURE 1 : "KLUGE" TUNER SCHEMATIC



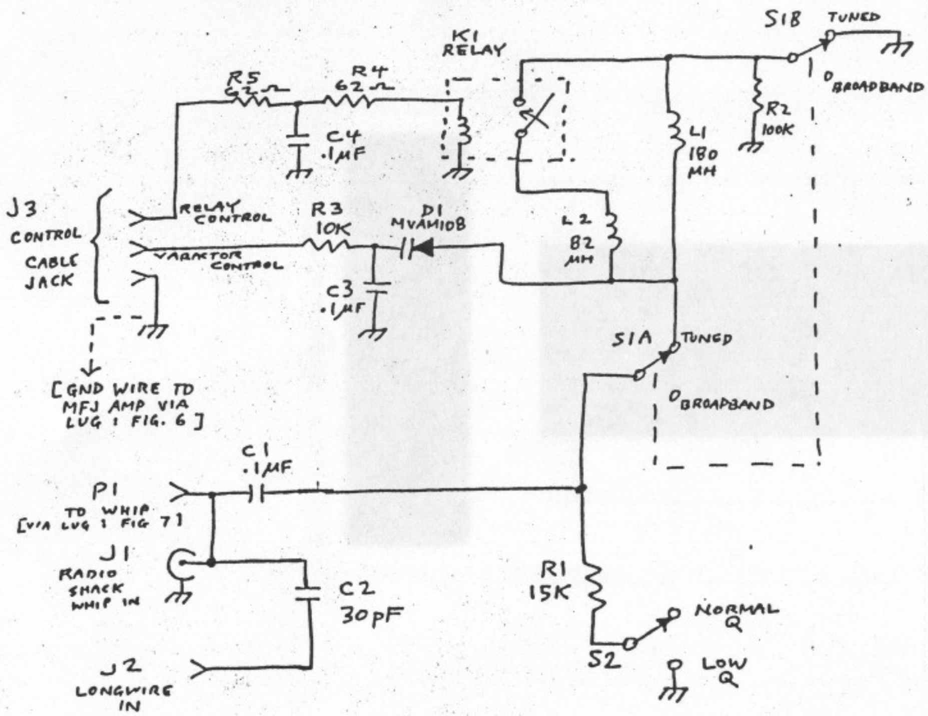
With the tuner, received signals were about 10 to 12 dB (2 S-units) stronger than when the MFJ 1024 was run in the normal broadband mode. When the set-up is properly tuned for the frequency of interest, no spurs are noted. By comparison, in the broadband mode, at the suburban home QTH (Billerica, MA), spurs are noted on:

770 = (WSSH)1510-(WLVG)740 and (WRKO)680-[WRKO(680)-WEEI(590)]
830 = (WSSH)1510 - (WRKO)680
1360 = (WRKO)680 X 2
1530 = (WRKO)680 + (WHDH)850

The sensitivity of the MFJ 1024 with the Figure 1 "kluge" tuner rivalled unamplified longwires of considerable length. Weak daytime signals used for sensitivity tests in this area include WLIX[NY] (o/WDMV/CJSB/CBT)-540, WMCA[NY] (o/WSYR/CJEM)-570, WCHP[NY] (o/WJR)-760, WNYC[NY] (o/unID "Love 82")-820, WCLZ[ME] (o/WSSR/CKDH/CKTS)-900, WOGL[PA] -1210, WQXR[NY] -1560, and WLIM[NY] (o/CBJ)-1580. At a low-RF-noise field site (near Shawsheen River marsh / Tew-Mac Airport: Tewksbury, MA), all of these were detectable and, in most cases, easily readable with the tuned MFJ 1024 feeding the Sony ICF-2010 receiver used for

DXpeditions. One thing I noted about the "kluge" tuner is that its tuning range with a single inductance value did not quite cover the entire MW band. The ratio of maximum capacitance to minimum capacitance with the varactor diode is not as great as the comparable ratio of an air-variable capacitor. The Motorola MVAM108 varactor gives about 550 pF max. to 55 pF min. (10:1 ratio) versus 360 pF max. to 15 pF. min. (24:1) typical of the air-variable. I wanted coverage from 500 kHz or less through 2 MHz or greater. A second inductance, switched in parallel with the first by means of a relay, accomplished the complete band coverage. At this juncture I decided that the results of tuning the whip were so good that a tuner box to be mounted to the MFJ head unit on a permanent basis would be a good idea. After some experimentation, the circuit of Figure 2 evolved:

FIGURE 2 : RTU-1 SCHEMATIC



J1 is used for a Radio Shack 20-008 whip. This can be used instead of the normal MFJ whip section with only a slight penalty to sensitivity. Doing this makes the mated MFJ amp / RTU-1 assembly much easier to pack into a suitcase for air travel. It also permits simpler operation on the roof of a car or other vehicle.

J2 is used if tuning a longwire or tree-height vertical is to be done (typically at a campsite or similar QTH). Using a 100 ft. / 30 m. wire instead of a whip can give tremendous (Beverage-like) sensitivity. Because of overload considerations, this should only be done at rural locations and in the tuned mode.

J3 connects the control cable from the shack. Control cable functions are varactor tuning (by means of a 0 to +9 volt variable DC supply) and tuning-range-relay switching (by means of a switched 0 V / +12 V DC source).

Toggle-switch S1 sets either the tuned mode for the active antenna or the normal broadband mode. Switch S2 selects normal or low Q (selectivity). Low Q is only used if two tuned-mode whips are to be phased. The functions of S1 and S2 could be implemented with relays if the active antenna is to be mounted permanently at a remote location (e. g. on a tower). Also, in such a circumstance, greater attention would have to be paid to weatherproofing. As my use of this system is primarily for set-it-up / take-it-down beach or mountain DXpeditions of (typically) 2 hours duration, switches are preferable for their simplicity. Generally, S1 is left on Tuned Mode and S2 is left on Normal Q.

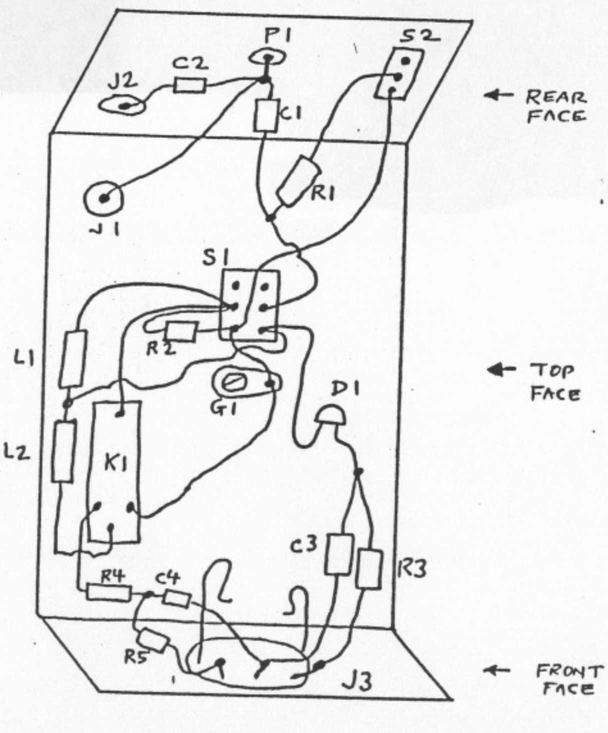
P1 is used for the wire that is to be connected to the MFJ 1024 head-unit whip antenna input. A ground wire is connected to the MFJ 1024 circuit-card ground (/ coax. shield) from a lug on RTU-1 J3. Assembly instructions of greater detail follow in this article.

==

Construction Information

Figure 3 gives a pictorial of the components inside the RTU-1 box. Figure 4 shows hole locations. Table 1 is a parts list for the RTU-1 assembly.

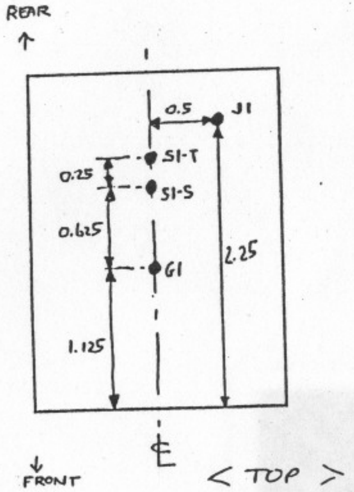
FIGURE 3 : RTU-1 COMPONENT LAYOUT
(VIEW INSIDE BOX WITH BOTTOM COVER OFF)

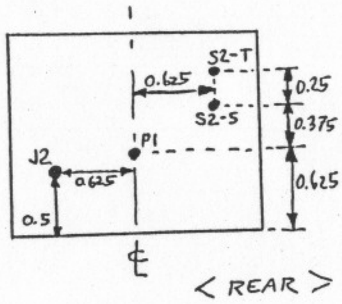


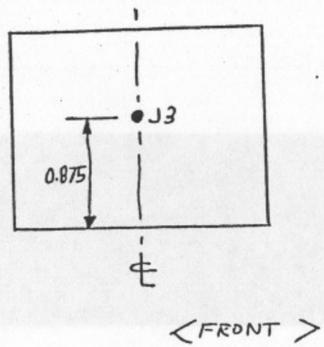
A105-6-3

FIGURE 4 : RTU-1 HOLE DRILLING GUIDE

(EXTERIOR VIEWS -- DIMENSIONS IN INCHES)







HOLE DIAMETER REFERENCE

HOLE	DIA	
J1	0.375	TOP
S1-Tab	0.14	TOP
S1-Shaft	0.25	TOP
G1	0.125	TOP
J2	0.3125	REAR
P1	0.25	REAR
S2-Tab	0.14	REAR
S2-Shaft	0.25	REAR
J3	0.375	FRONT

++

Table 1: RTU-1 remote tuning unit / parts list

Vendor codes:

ACT = Active Electronics /11 Cummings Park
/Woburn, MA 01801
/Tel. 1-800-677-8899

DK = Digi-Key /P. O. Box 677
/Thief River Falls,MN 56701-0677
/Tel. 1-800-344-4539

Table 1 (continued)

...

HOS = Hosfelt Electronics/2700 Sunset Boulevard
/Steubenville, OH 43952
/Tel. 1-800-524-6464

MOU = Mouser Electronics / 11433 Woodside Ave.
/ Santee, CA 92071
/Tel. 1-800-346-6873

RS = Radio Shack / Many locations worldwide

Item	Designator	Description/Value	Vendor	Vendor Stock #	QTY
1	-	chassis box	RS	270-235	1
2	C1,C3,C4	capacitor, 0.1 uF	RS	272-109	3
3	C2	capacitor, 30 pF	MOU	ME-232-1000-030	1
4	D1	MVAM108 varactor	ACT	2 10MOR	1
5	G1	ground hardware -- including:			
5a	-	screw, 4-40 X.375"	MOU	572-01881	1
5b	-	hex nut, 4-40	MOU	572-00484	1
5c	-	solder lug, #4	MOU	534-7311	1
6	H	box-mounting hardware (Fig. 9) -- including:			
6a	-	hex nut, 6-32	MOU	572-00486	2
6b	-	split lockwasher,#6	MOU	572-00650	2
7	J1	BNC jack	RS	278-105	1
8	J2	red banana jack	RS	274-662	1
9	J3	stereo headphone jack	RS	272-312	1
10	(for J3)	solder lug, .375"ID	DK	ARF1068-ND	2
11	K1	relay (12V)	RS	275-233	1
12	L1	inductor, 180 uH	MOU	43LR184	1
13	L2	inductor, 82 uH	MOU	43LR825	1
14	P1	feedthrough terminal	HOS	885B	1
15	R1	resistor, 15K	RS	271-1337	1
16	R2	resistor, 100K	RS	271-1347	1
17	R3	resistor, 10K	RS	271-1335	1
18	R4,R5	resistor, 62 ohm	MOU	29SJ500-62	2
19	S1	switch,DPDT,on-on	RS	275-614	1
20	S2	switch,SPDT,on-on	RS	275-662	1

++

Some minor modifications are to be made to the MFJ 1024's amplifier box to facilitate use of the tuner. Table 2 is a parts list for modifying the MFJ amplifier (head) assembly.

++

Table 2: modification kit for MFJ 1024 / parts list

Vendor codes: see Table 1

Item	Designator	Description/Value	Vendor	Vendor Stock #	QTY
[Hardware to connect antenna line to RTU-1] (see Fig. 7)					
1	-	screw, 4-40 X .5"	MOU	572-01882	1
2	-	hex nut, 4-40	MOU	572-00484	1
3	-	solder lug, #4	MOU	534-7311	2
[Hardware for mating RTU-1 bottom cover to MFJ amp. cover](Fig.5)					
4	-	screw, 6-32 X .5"	MOU	572-01890	2
5	-	hex nut, 6-32	MOU	572-00486	2
6	-	split lockwasher,#6	MOU	572-00650	2
[other associated hardware is considered part of RTU-1 (Table 1)]					

A105-6-4

Table 2 (continued)

-

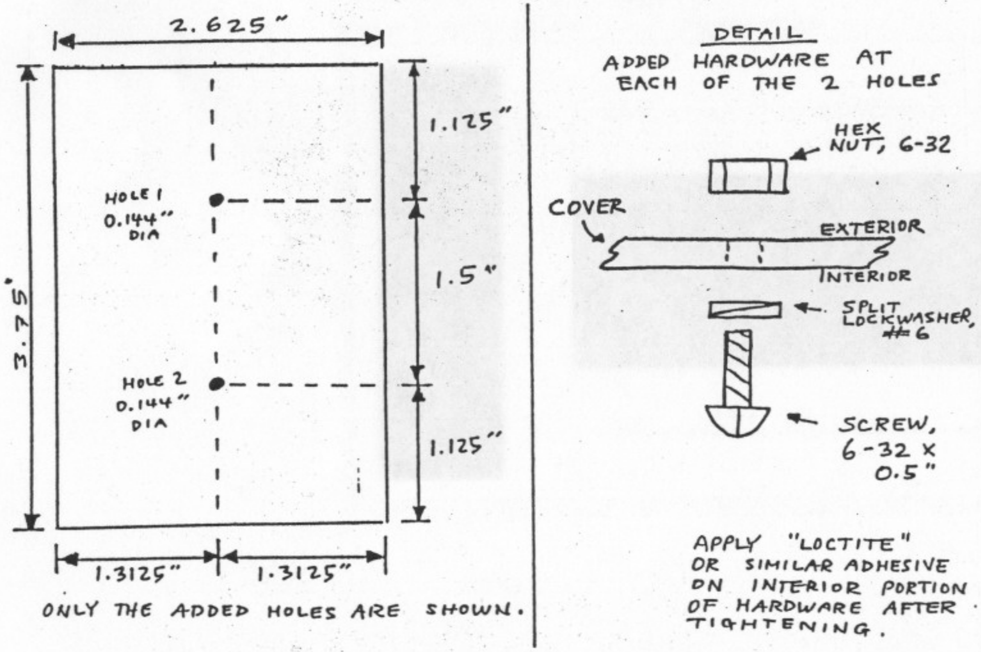
[BNC jack & associated hardware] (see Fig. 6)

7	-	BNC jack (w/ nut)	RS	278-105	1
8	-	solder lug, .375"ID	DK	ARF1068-ND	2

-

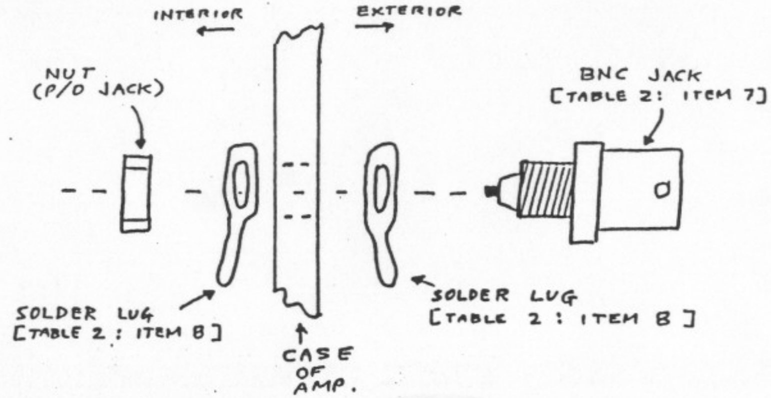
MFJ 1024 amp. box modification #1: Remove the four screws on the amplifier cover. Set these aside. Separate the cover from the amplifier box. Drill 2 holes on the cover and install hardware in accordance with Figure 5.

FIGURE 5: PREPARATION OF MFJ 1024 AMPLIFIER COVER



MFJ 1024 amp. box modification #2: Remove the coaxial cable from the MFJ amp. circuit board (make a note as to where the shield and the center conductor of the coax. had been soldered). Enlarge the hole through which the coax. cable had passed out of the box: the diameter should be 0.375 inch when done. Install a BNC jack (Table 2: Item 7) and 2 solder lugs (Table 2: Item 8), in accordance with Figure 6.

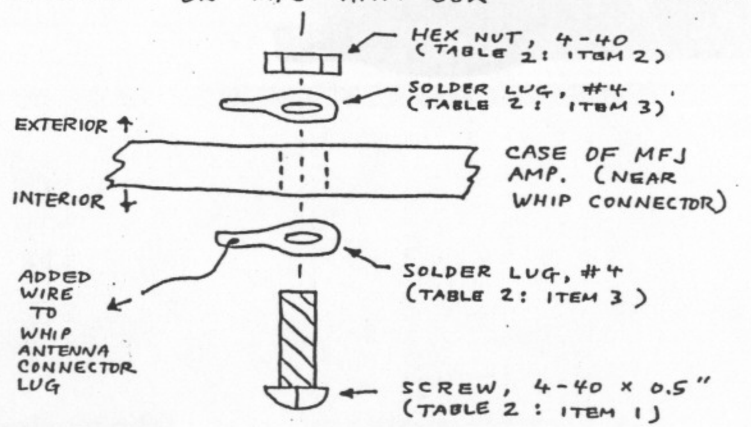
FIGURE 6 : ASSEMBLY OF RF JACK ONTO MFJ AMPLIFIER BOX AT FORMER CABLE HOLE



Use minimum length wires to connect the BNC jack's center pin to the circuit board location of the former coax. cable center conductor solder connection. Connect the added interior solder lug (that is on the BNC jack) to the circuit board location of the former coax. cable shield connection: again, use a wire of minimum possible length.

MFJ 1024 amp. box modification #3: Drill a 0.125 inch hole on the amp. box surface where the whip antenna connects. Install a screw, 2 solder lugs, and a nut (Table 2: Items 1,2,3) in accordance with Figure 7. Solder a minimum-length wire from the added interior lug to the wire which connects the whip mating hardware to the amplifier board.

FIGURE 7 : ASSEMBLY OF ANTENNA-WIRE CONNECTOR ON MFJ AMP. BOX

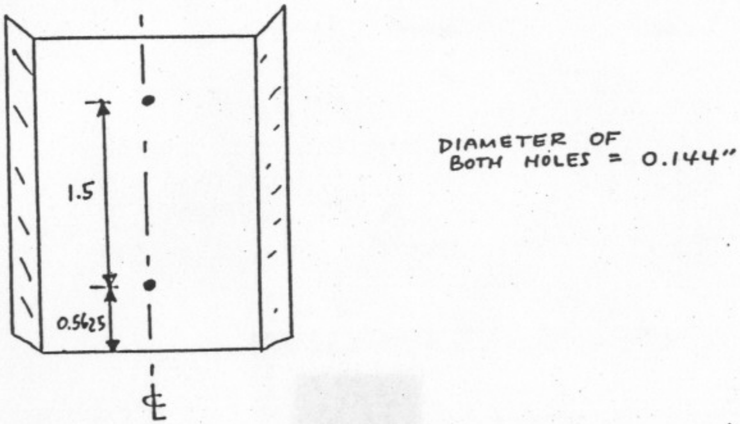


===

When done constructing the RTU-1 and modifying the MFJ 1024, re-attach the MFJ 1024's head unit cover (now equipped with hardware per Figure 5 above). Prepare the RTU-1 bottom cover (see Figure 8).

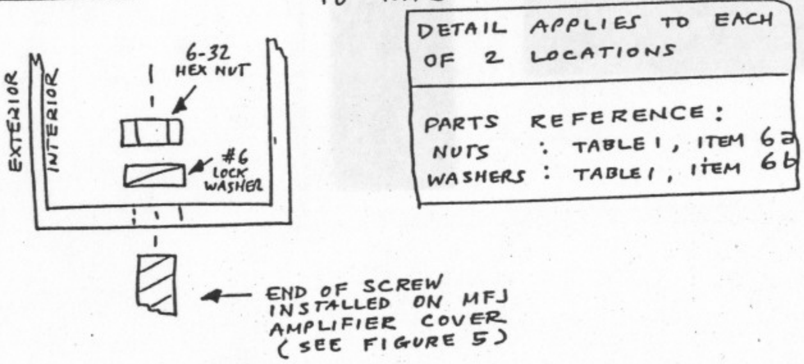
A105-6-5

FIGURE 8: PREPARATION OF RTU-1 BOTTOM COVER



Attach the RTU-1 bottom cover to the two screws added to the MFJ head unit cover: see Figure 9.

FIGURE 9: CONNECTING RTU-1 BOTTOM COVER TO MFJ AMP. COVER



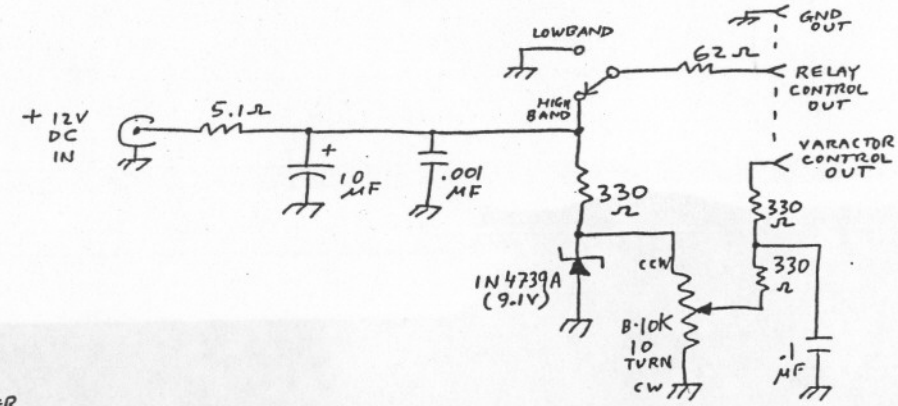
Re-assemble the RTU-1 chassis with the screws originally supplied with the box. Connect a minimum-length insulated wire from the solder lug on the MFJ amp. BNC jack to the lug on RTU-1 J3. Solder both ends. Connect a minimum-length insulated wire from the #4 lug near the antenna end of the MFJ box to RTU-1 P1. Assembly is now complete.

A length of coaxial cable may be run from the standard MFJ base unit to the modified head unit BNC jack. Use appropriate adapters, if necessary, for correct connector mating. Being able to separate the feedline from the amp. head allows for improved portability. You don't always need the 50-ft. cable that MFJ supplies permanently attached to the head unit. For mobile or motel-room use, a 10-ft / 3-m. cable makes more sense.

A separate pair of leads can be fed to RTU-1 J3. A stereo headphone plug should be used: tip = varactor bias (0 to +9 VDC, variable), & middle = relay control (0 VDC / +12 VDC switched). The connector shell can be used for a ground lead: this is only needed on long runs; a reasonable DC ground is provided by the coax. shield on shorter runs.

Figure 10 illustrates a simple control unit. Filtering is provided to reduce RF noise and AC hum.

FIGURE 10: A SIMPLE CONTROL UNIT



Other control units, including MWT-2 Option 5 and a two-whip controller / phaser will be presented in a companion article. MWT-2 Option 5 and the dual controller / phaser both eliminate the need for the MFJ 1024's base-unit box.

==

Possible Variations on the RTU-1 Design

1. bandswitching for more than 2 ranges or for 2 non-MW ranges

Switching and/or relays with additional inductors can provide more tunable frequency ranges. If only 2 ranges (but not MW) are desired, change L1 & L2. L1 = 2700 uH & L2 = 1200 uH should provide longwave (130 - 520 kHz) coverage. L1 = 12 uH & L2 = 5.6 uH should provide tropical band (1900 - 7600 kHz) coverage. Of course, the whip can always be switched to broadband for full 0.1 to 30 MHz coverage (albeit with less sensitivity and more spurs).

2. completely remote operation

Relays (or conceivably diode or FET switches) could be used in place of all-mechanical switches. Tuned / broadband mode, normal / low Q, and frequency range could all be set from the "shack". Remotely switching the input from whip to longwire to ground (for a degree of lightning protection) could also be done. Fully-remote operation would be advisable for a whip antenna mounted on a tower. The RTU-1 box would have to be considerably larger. A different control-lines connector (DB-25 computer connector, military-style round Cannon or DIN connector, etc.)

would have to be used to accommodate the larger number of control lines. Computer-type ribbon cable would be the obvious choice for the shack-to-antenna control link. Such an elaborate set-up, while certainly feasible, is beyond the scope of this article.

==

Use of the RTU-1 with other active whips

Besides the MFJ 1024, I have used the RTU-1 with a homebrew active whip. Improvements in gain and reductions in spurious responses were similar. There is no reason to suspect that the RTU-1 could not deliver comparable results with other commercial active whips (Dressler, et al) having high-input-impedance front-end amplifiers.

The results of other DXers' experiments along these lines are always welcome - whether as formal articles, Musings / Forum contributions, or personal correspondence.

==

APPENDIX

FIGURE 11: MFJ AMP. BOX WITH MARK-UPS

MFJ-1024 REMOTE ACTIVE ANTENNA