A54 1 of 5

A54-5-1

The MWDX-2 Phasing Unit

Part 1

Mark Connelly - WA1ION DX Labs - 10 JAN 1984

There's been a renaissance in serious DXing in the '80s - truly fantastic catches by Neil Kazaross, George Hakiel, Brian Vernon, Bill Bailey, Pat Martin, and others frequently evoke memories of the late '60s Nelson era touted by some as the 'golden age of DXing'. Actually the current DX reported is of BETTER quality when you consider the increased domestic station & man-made noise QRM problems besetting us today.

Phased Beverages or phased longwires are an important part of many topnotch foreign-DX listening posts. As mentioned in previous discussions of phasing, it is not always a direct substitute for a good loop; simultaneously, a good loop is not always a substitute for phased wires. The serious modern MW DXer calls upon both methods of 'pest' nulling frequently and soon recognises which method will work better for a given kind of DX at his QTH.

A few years back, an article describing the construction & use of the 'MWDX-1' passive phasing unit was published. Several people have built variations of this unit and have generally had good luck with it.

Interest in phasing units has remained high, especially in light of the recent Kaz-lead African/northeastern Brazilian DX 'stampede'. Recent experimentation with phasers having dual active-tuner inputs has shown that aerials as short as 2 ft/ 0.6 m [e.g. car whips] may be phased to produce nulls of unwanted stations, reducing QRM to both weaker co-channel stations & to adjacent channel stations.

Q-Spoiling: Key to Phase Null Stability

Testing of both active & passive phasing systems has been done at my West Yarmouth (Cape Cod), MA. foreign-DX monitoring station/antenna lab. Also, Neil Kazaross has helped me greatly by testing phasing units at his superb DX QTH in Ogunquit Beach, Maine - the first permanently-occupied Atlantic seashore Beverage-equipped installation in many, many years. (As we should all know, salt water on desired paths coupled with poor-ground blockage on undesired paths can be as valuable to a knowledgeable low-angle [e.g. foreign] & groundwave DXer as the best receiver money can buy.)

Both Neil & I have established that steadiness of nulls is superior on phasers using dual passive-series-tuner (PST) inputs than on those using initial-design active-parallel-tuner (APT) inputs.

The reason for this turns out to be primarily a matter of tuner circuit Q [selectivity]. The APT-type input, unless deliberately Q-spoiled, is so sharply tuned that null stability, even on groundwave stations, is inferior to that of the older PST-inputs design. A sure sign of excessive Q in a phasing unit's input tuners is that, when a pest-station's carrier is nulled, the sidebands are still strong, producing the 'Donald Duck audio' reminiscent of ham SSB copied on a receiver in the AM mode. A proper phasing system must consist of tuners sufficiently broadband that when a moderate-strength station is phased, its audio & carrier go away together, leaving clean reception of subdominants which, initially, may have been 40 dB below the dominant station. Minor touch-up of the vernier null controls should remove all slop from 10 kHz adjacent stations which were originally 60 dB weaker than the now-nulled pest station.

A dual-APT-input type phaser (= active phaser) can be Q-spoiled to enhance null stability: this can be accomplished by installing a 0 to 100K pot in parallel with each APT's tuning capacitor. The same technique can be used to Q-spoil loops - an important consideration for stable loop vs. wire or loop vs. loop phasing arrangements. Some have assumed that the transistors in loop amps. & active wire tuners lacked phase/gain stability, hence causing unstable nulls. This is less likely to be the problem than the inherently high Q of such circuits.

Future articles are planned to deal with improved shortwire phasing using Q-spoilable active input tuners. Also under design: a dual Passive Parallel Tuner [PPT] longwire phaser of comparable performance to the MWDX-2 and having as benefits simpler operation & easier construction.

The PST-type input tuner design works well as Q is spoiled by adjustment of the series pot between the aerial's impedance & the impedance of the associated passive series input tuner. Of course, anytime the Q of a tuned circuit is degraded, system sensitivity decreases & the likelihood of spurs from off-channel stations increases. For the first reason, the use of an amplifier after the phaser is recommended: this is especially true when wires less than 328 ft/ 100 m are being used during low-signal conditions [e. g. daytime or auroral night-time]. For the second reason (spurs), a high-Q tuner should be inserted between the phasing unit output & the receiver input. In the first case, a broadband amplifier (cascaded MWA-120's for instance) could be used and in the second case a passive-parallel-tuner could be employed, but the most elegant solution to both the low signal & spur/low Q problems is the use of the APT-2 (Active Parallel Tuner with regeneration capability). Construction & use of the APT-2 tuner (including use as a tunable output amp. for phasing units & loops) was described in a recent DX Monitor/DX News article.

Neil Kazaross has reported good results by following his dual-PST-input passive phasing unit with the APT-2. The regeneration feature of the APT-2 is occasionally employed to enhance reception of the weaker Trans-Atlantic 'splits' after phasing has removed the bulk of the adjacent channel domestic-station interference.

MWDX-2: An Improved Passive Phaser

As most DXers who want to use phasing will be using aerials of length greater than 82 ft/ 25 m and because most have stated that a single-box design is more convenient, if less flexible, than the modular (3-box) approach, a unit equipped with dual PST-type input tuners will the subject of this article. This unit, the MWDX-2, offers substantial design improvements over the old MWDX-1.

Complete step-by-step construction details, of the sort offered with MWDX-1 & APT-2, take up much valuable space & are boring to many readers. Such documentation for MWDX-2 will be limited to bare essentials: schematic with itemisation of critical parts, hole list, and details of the 'floating' variable-capacitors and RF transformers subassemblies. Data supplied should be sufficient for the experienced 'homebrewer'. The author will supply more detailed information upon request as well as components at cost plus shipping to those who want to build the MWDX-2. The unit should be producible for about $100 if some of the parts are acquired at ham-radio 'flea-markets' rather than at commercial suppliers such as Radio Shack, Mouser, & Etco.

Experimentation with several toroidal core materials has shown that the Amidon FT-82-77 core provides good performance at reasonable cost (90 cents per core). The FT-82-61 cores used in previous designs exhibited some signal loss at frequencies below 800 kHz. The Miller F-87-1 cores work well, but are expensive (now $5.99 at Mouser). The next round of experimentation here will involve evaluation of pre-made phase-reverser & balun transformers produced by Mini-Circuits Labs, Vari-L, & several other firms. Suffice it to say, if well-performing, reasonably-priced, pre-fabricated RF transformers are found, you'll read about it shortly. Winding transformer toroids and mounting them on vectorboards is one of the more tedious aspects of phasing-unit construction.

Figures 1 through 4 are the schematics for the MWDX-2 one-box dual-PST-inputs type phasing unit. Note the Frequency Range switch charts accompanying Figures 2 & 3. Table 1 lists holes to be drilled in the chassis box. For required tools, construction tips, etc. those outlined in the recent APT-2 construction article should prove to be of assistance.

Figure 5 gives information which should be useful in fabricating the floating (=ungrounded) C1 & C2 tuning capacitor card subassemblies.

Figure 6 is the T1 Phase Reverser Card subassembly drawing and Figure 7 is the drawing for the T2 Balun Card.

A54 2 of 5

A54-5-2

2.1 Preliminary Setup

Power switch on loop to Off
Connect wire aerial(min. length 25 m)to J1 (Line 1 Wire In)
Connect grounding wire to J2 (Earth GND In)
Connect loop output cable to J3 (Line 2 Loop In)
NO CONNECTION TO J4
Connect output cable (to RX or amplifier) to either RF output jack J5 (BNC) or J6 (Motorola)

C1 (Line 1 Tune) will be adjusted in subsequent steps.
C2 (Line 2 Tune) NOT USED, position irrelevant
Set C3 (Null Vernier Cap.) to centre (half-meshed)
Set R1 (Line 1 Pot) to min. R / fully CCW
Set R2 (Line 2 Pot) to min. R / fully CCW
Set R3 (Null Vernier Pot) to min. R / fully CCW
Set S1 (Line 1 Freq. Range) to range called out in Figure2
S2 (Line 2 Freq. Range) NOT USED, position irrelevant
Set S3 (Function Switch) to 1
Set S4 (Line 2 Input Switch) to Loop
Set S5 (Null Mode Switch) to B

2.2 Line 1 Tune

Adjust C1 for peak signal at frequency of interest.
If C1 produces maximum signal when fully open, set S1 one position CW [next lowest inductor] & then peak-tune C1.
If C1 produces maximum signal when fully meshed, set S1 one position CCW [next highest inductor] & then peak-tune C1.

2.3 Line 2 (Loop) Tune

Set S3 to 2. Set loop's Q-pot to maximum Q setting.
Physically orient loop to favour the general direction of the desired DX station, even if such orientation would also bring in 'pests'.
Turn loop power on.
Adjust the loop's tuning cap. for peak signal at frequency of interest. Note the signal strength (on S-meter if possible). Tweak loop's Q-pot to reduce signal level about 6 to 12 dB.

2.4 Level Comparison

Set R3 to middle of its range.
Switch S3 back & forth between 1 & 2.
Note whether position 1 or 2 of S3 produces a stronger signal from the dominant station to be nulled.

2.5 Null (Line 1 Level greater than Line 2 Level)

If the station to be nulled is stronger with S3 on 1, put S3 on Null & tweak R1 to get a 'dip' (point at which moving the control either CW or CCW from the dip position increases signal). Leave R1 at dip-yielding position, or return to min. R/ fully CCW if no dip occurred.
Note C1 knob position. Tweak C1 for a dip. Leave C1 at dip-yielding position, or return to previous position if dip didn't occur.
In all probability, some nulling has been achieved; if so, go to step 2.7, Null Finalisation.
If no dipping occurred;set S5 to A & re-iterate this step.

2.6 Null (2 Level greater than 1 Level, or no difference)

If the station to be nulled is stronger with S3 on 2, or if the difference in the Line 1 & Line 2 levels is insignificant, put S3 on Null & tweak R2 to get a 'dip'. Leave R2 at dip-yielding position, or return to min. R/ fully CCW if no dip occurred.
Note loop tuning cap. knob position. Tweak loop cap. for a dip. Leave loop cap. at dip-yielding position, or return it to previous position if dip didn't occur.
In all probability, some nulling has been achieved; if so, go to step 2.7, Null Finalisation.
If no dipping occurred;set S5 to A & re-iterate this step.

2.7 Null Finalisation

Obtain as good a null as possible by successive fine adjustments of the loop's tuning cap., C1 of MWDX-2, the loop's Q-pot, and also of the MWDX-2 pot previously tweaked (R1 or R2).
Finish nulling by using the two null verniers: C3 & R3. (Play R3, then C3, then R3, then C3, etc.)

3.0 Amplification of MWDX-2 Phasing Unit Output

Often, especially with wires shorter than true Beverages, insufficient wanted-station signal remains after nulling a 'pest'. Several amplification schemes are possible.
For tunable amplifiers, MWDX-2 S3 can be initially switched to Pre-Tune (PT); the output amp. is tuned as if it were connected to a wire. After this is done, the amp. can be considered 'invisible' & can be left in the line while phasing proceeds from step 1.1 or 2.1. The same can be done with a broadband amp. having an input pot: with MWDX-2 S3 on PT, the pot is set to get the maximum signal at the frequency-of-interest, consistent with no spurious signals.
Alternately, the amplifier can be installed 'in-line' between phaser & receiver after phasing (by means of a direct MWDX-2 to RX connection) has been completed. Refer to the recent APT-2 article for ideas.

(END)

A54 3 of 5
A54-5-3

TABLE I

Hole list for MWDX-2 (passive) phasing unit
(X=horiz.distance from vert. centreline:- = left of CL,+ = right)
(Y=vertical distance from lower horizontal edge of side observed)
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LEFT SIDE

Hole	Comp.	Description	X(in.)	Y(in.)	DIA(in.)
1	J1	Line 1 Wire In	-1.75	1.0	0.3125
2	J2	Earth GND In	-1.0	1.0	0.3125
3	J3	(Line2)ActiveLoop/TunerIn	0.0	0.5	0.375
4	G1	GND screw, int.lug	1.0	1.0	0.113
5	J4	Line 2 Wire In	1.75	1.0	0.3125

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TOP

Hole	Comp.	Description	X(in.)	Y(in.)	DIA(in.)
1	C3	NullVernier Cap., screw 1	-3.766	4.5	0.113
2	C3	NullVernier Cap., shaft	-3.5	4.5	0.5
3	C3	NullVernier Cap., screw 2	-3.234	4.5	0.113
4	G2	GND screw, int.lug	-3.0	5.5	0.113
5	R1	Line 1 Pot, shaft	-2.1875	5.0	0.3125
6	R1	Line 1 Pot, tab	-1.875	5.0	0.14
7	S1	Line 1 Freq. Range, shaft	-1.0	4.5	0.375
8	S1	Line 1 Freq. Range, tab	-0.5	4.5	0.14
9	G3	GND screw, int.lug	0.0	4.5	0.113
10	C1	Line1TuneCapCard, screw 1	0.75	5.0	0.14
11	C1	Line1TuneCapCard, screw 2	0.75	4.0	0.14
12	C1	Line1TuneCapCard, shaft	1.75	4.5	0.5
13	C1	Line1TuneCapCard, screw 3	2.75	5.0	0.14
14	C1	Line1TuneCapCard, screw 4	2.75	4.0	0.14
15	G4	GND screw, int.lug	3.0	3.0	0.113
16	R3	NullVernier Pot, shaft	-3.75	2.5	0.3125
17	R3	NullVernier Pot, tab	-3.75	2.1875	0.14
18	G5	GND screw, int.lug	-2.625	3.0	0.113
19	S4	Line 2 InputSelect, shaft	-1.5625	3.0	0.375
20	S4	Line 2 InputSelect, tab	-1.25	3.0	0.14
21	S5	Null Mode Switch, shaft	3.75	3.0	0.25
22	S5	Null Mode Switch, tab	3.75	2.75	0.113
23	G6	GND screw, int.lug	-4.5	1.0	0.113
24	S3	Function Switch, tab	-4.0	1.0	0.14
25	S3	Function Switch, shaft	-3.5	1.0	0.375
26	G7	GND screw, int.lug	-2.75	0.5	0.113
27	R2	Line 2 Pot, shaft	-2.1875	1.0	0.3125
28	R2	Line 2 Pot, tab	-1.875	1.0	0.14
29	S2	Line 2 Freq. Range, shaft	-1.0	1.5	0.375
30	S2	Line 2 Freq. Range, tab	-0.5	1.5	0.14
31	G8	GND screw, int.lug	0.0	1.5	0.113
32	C2	Line2TuneCapCard, screw 1	0.75	2.0	0.14
33	C2	Line2TuneCapCard, screw 2	0.75	1.0	0.14
34	C2	Line2TuneCapCard, shaft	1.75	1.5	0.5
35	C2	Line2TuneCapCard, screw 3	2.75	2.0	0.14
36	C2	Line2TuneCapCard, screw 4	2.75	1.0	0.14

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RIGHT SIDE

Hole	Comp.	Description	X(in.)	Y(in.)	DIA(in.)
1	T2	Balun Card, screw 2	-2.25	0.5	0.113
2	T2	Balun Card, screw 4	-2.25	2.0	0.113
3	T2	Balun Card, screw 1	-1.25	0.5	0.113
4	T2	Balun Card, screw 3	-1.25	2.0	0.113
5	J6	RF to car RX, screw 1	-0.394	2.0	0.14
6	J6	RF to car RX, body	0.0	2.0	0.5
7	J6	RF to car RX, screw 2	0.394	2.0	0.14
8	G9	GND screw, int.lug	0.0	1.25	0.113
9	J5	RF Out (BNC)	0.0	0.5	0.375
10	T1	Phase Rev. Card, screw 2	1.25	0.5	0.113
11	T1	Phase Rev. Card, screw 4	1.25	2.0	0.113
12	T1	Phase Rev. Card, screw 1	2.25	0.5	0.113
13	T1	Phase Rev. Card, screw 3	2.25	2.0	0.113

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NOTES: C3=GC/Calectro A1-225. Box=Mouser # 537-TF-784 (LMB,10inX6inX3.5in)
C1 & C2 are Mouser # 524-A1-227 or GC/Calectro A1-227 mounted
on vectorboards to 'float' above chassis ground.

Using the MWDX-2 Phasing Unit

1.0 Two Wire Phasing

Use two aerials with a minimum length of 82 ft/ 25 m. The wires used should be of similar length if possible (this need is less critical if both wires exceed 656 ft/ 200 m). When wires shorter than 200 m are used, best phasing tends to occur when the wires are separated by a horizontal angle of 45 degrees minimum. Horizontally perpendicular wires, one running to the northeast for Europe and one running southeast for the Caribbean would comprise a good wire pair for the DXer in the northeastern USA.

Those with vaster expanses of available land, those able to install true Beverage-length aerials, may have best results with parallel Beverages separated by about 16 ft/ 5 m. Terminating one of the Beverages in salt marsh or other good ground, whilst letting the second one 'float' is supposed to be the last word in phased-Beverage setups. Two parallel unterminated Beverages would probably work just about as well in most cases, however. A pair of Beverages 'aimed' at Europe (also catching the more northerly-bearing Africans) and a second pair of Beverages favouring the eastern Caribbean/South America/southerly-bearing Africans is seen as the ultimate antenna farm for east coast US/Canadian international DXers. Add a loop and possibly a vertical & 'high-intensity DXing' should be greatly facilitated.

1.1 Preliminary Setup

Connect one wire to J1 (Line 1 Wire In)
Connect other wire to J4 (Line 2 Wire In)
Connect grounding wire to J2 (Earth GND In)
NO CONNECTION TO J3
Connect output cable (to RX or amplifier) to either RF output jack J5 (BNC) or J6 (Motorola)

C1 (Line 1 Tune) will be adjusted in subsequent steps.
C2 (Line 2 Tune) will be adjusted in subsequent steps.
Set C3 (Null Vernier Cap.) to centre (half-meshed)
Set R1 (Line 1 Pot) to min. R / fully CCW
Set R2 (Line 2 Pot) to min. R / fully CCW
Set R3 (Null Vernier Pot) to min. R / fully CCW
Set S1 (Line 1 Freq. Range) to range called out in Figure2
Set S2 (Line 2 Freq. Range) to same range as S1
Set S3 (Function Switch) to 1
Set S4 (Line 2 Input Switch) to Wire
Set S5 (Null Mode Switch) to A

1.2 Line 1 Tune

Adjust C1 for peak signal at frequency of interest.
If C1 produces maximum signal when fully open, set S1 one position CW [next lowest inductor] & then peak-tune C1.
If C1 produces maximum signal when fully meshed, set S1 one position CCW [next highest inductor] & then peak-tune C1.

1.3 Line 2 Tune

Set S3 to 2
Adjust C2 for peak signal at frequency of interest.
If C2 produces maximum signal when fully open, set S2 one position CW [next lowest inductor] & then peak-tune C2.
If C2 produces maximum signal when fully meshed, set S2 one position CCW [next highest inductor] & then peak-tune C2.

1.4 Level Comparison

Set R3 to middle of its range.
Switch S3 back & forth between 1 & 2.
Note whether position 1 or 2 of S3 produces a stronger signal from the dominant station to be nulled.

1.5 Null (Line 1 Level greater than Line 2 Level)

If the station to be nulled is stronger with S3 on 1, put S3 on Null & tweak R1 to get a 'dip' (point at which moving the control either CW or CCW from the dip position increases signal). Leave R1 at dip-yielding position, or return to min. R/ fully CCW if no dip occurred.
Note C1 knob position. Tweak C1 for a dip.
Leave C1 at dip-yielding position, or return to previous position if dip didn't occur.
In all probability, some nulling has been achieved; if so, go to step 1.7, Null Finalisation.
If no dipping occurred;set S5 to B & re-iterate this step.

1.6 Null (2 Level greater than 1 Level, or no difference)

If the station to be nulled is stronger with S3 on 2, or if the difference in the Line 1 & Line 2 levels is insignificant, put S3 on Null & tweak R2 to get a 'dip'. Leave R2 at dip-yielding position, or return to min. R/ fully CCW if no dip occurred.
Note C2 knob position. Tweak C2 for a dip.
Leave C2 at dip-yielding position, or return to previous position if dip didn't occur.
In all probability, some nulling has been achieved; if so, go to step 1.7, Null Finalisation.
If no dipping occurred;set S5 to B & re-iterate this step.

1.7 Null Finalisation

Obtain as good a null as possible by successive fine adjustments of C1, C2, and also of the previously-tweaked pot (R1 or R2).
Finish nulling by using the two null verniers: C3 & R3. (Play R3, then C3, then R3, then C3, etc.)

2.0 Wire vs. Loop Phasing

A wire may be successfully phased against a loop antenna. Radio direction finders (RDF's) used on ships and in aircraft have long made use of this principle to resolve the 180-degree 'ambiguity' of conventional figure-8-pattern loop direction finding. RDF's generally phase a vertical whip against a loop to produce a cardioid (single-direction null) pattern. Ron Schatz's 'LSCA' research project has also successfully worked out a scheme to 'uni-directionalise' a loop's null.

The MWDX-2 phasing unit will permit wire vs. active-loop phasing, permitting reception of stations which would have been substantially nulled along with the 'pest' by simple loop-rotation nulling. Such stations could either be on the same (+/- 30 deg.) bearing as the pest station, or on the opposite bearing ((pest bearing + 180 deg.)+/- 30 deg.).

In the MWDX-2 strategy, the loop takes the place of the Line 2 wire tuner when loop vs. wire phasing is to be done.

As mentioned previously in this article, the input tuners used for phasing should be of moderate, rather than high, Q. Most commercial & homebrew MW loops are designed to be high Q as this is what is desirable in normal stand-alone applications. A non-Q-spoiled loop CAN be phased against a wire, but null stability is 'less than spectacular'.

The DXer should modify the loop to be used by installing either a low-value (0 to 500 ohm, or less) pot in series with the loop coil or a large-value (e. g. 0 to 100K) pot across the loophead coil/ loop tuning capacitor parallel combination. If you opt for the large-value parallel pot, make sure that it has a switch so that at one position of the pot (usually CCW), the pot can be made to be an open circuit, allowing normal high-Q loop operation. Ensure that the installed Q-pot's shaft is tied to loop amplifier ground to prevent hand-capacitance detuning problems. A few loops come equipped with Q pots.

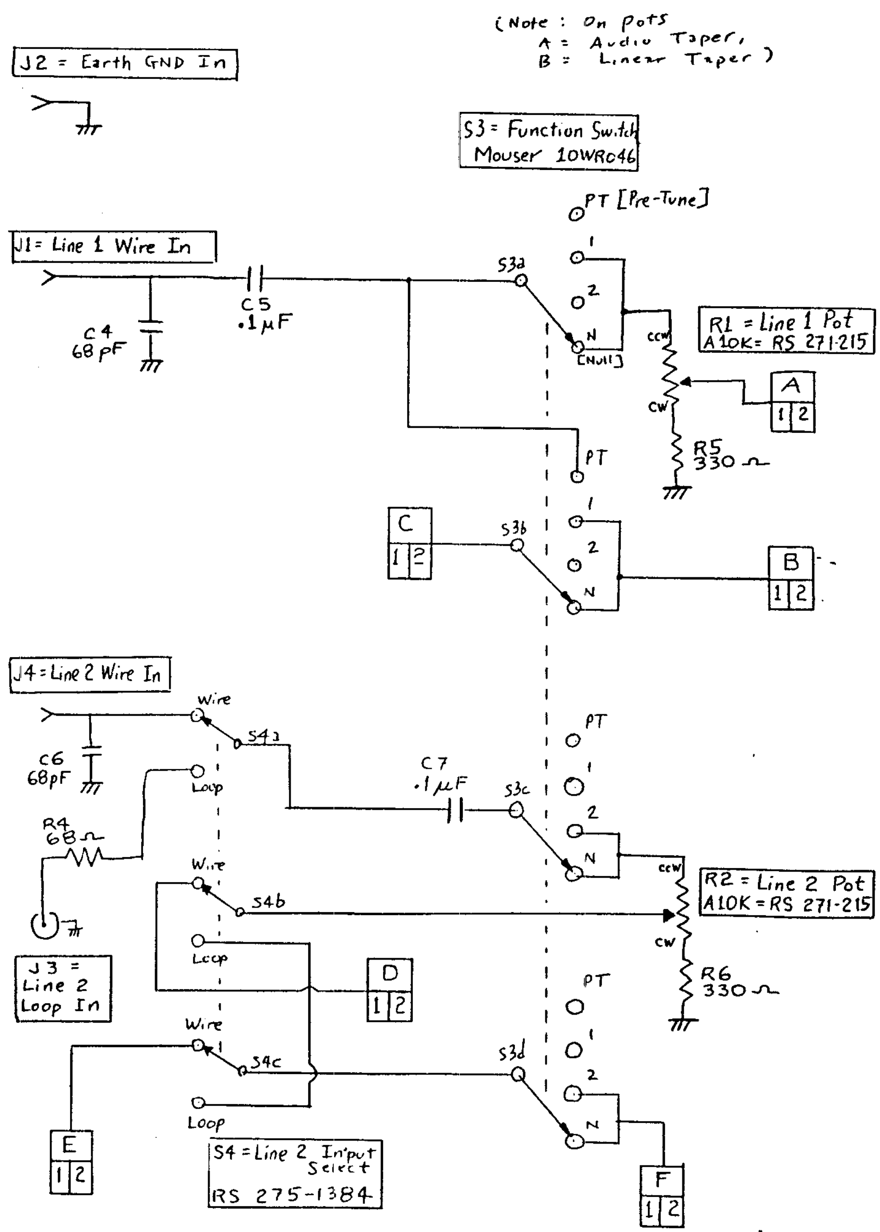
A vertical, of 30 m or greater length, phased against a good loop is an excellent low-angle DX antenna configuration for those with limited land and with high available supports. Such a setup, using a 40 m tall pine as a support for the vertical wire, sometimes surpassed phased Beverages for TA's at local sunset in tests done in Sudbury, MA in 1975 & 1976. Much can also be said for loop vs. Beverage (or longwire) phasing, especially when the wire is oriented for good pickup from a desired-DX target area.

A54-5-5

MWDX - 2

1 - Box Passive Phasing Unit
for Wire Aerials of Length ≥ 25m / 82 ft.

Figure 1 : Schematic, Input Switching



MWDX - 2
Phasing Unit

Figure 2 : Line 1 Wire Tuner

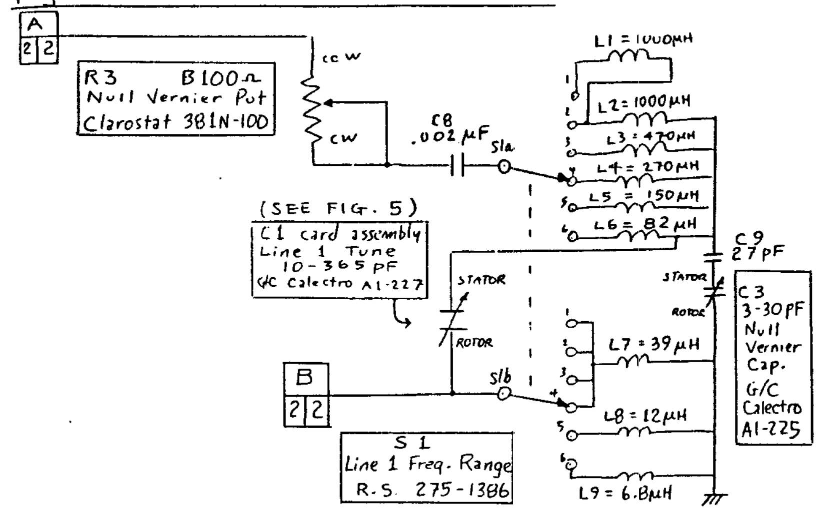
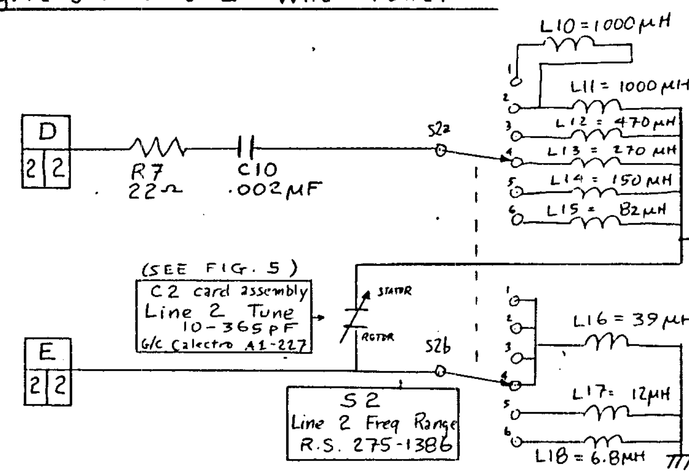


Figure 3 : Line 2 Wire Tuner



S1, S2 "Ballpark" Settings [30m/100 ft. wires]

Range #	Switch Pointer "O'Clock"	F min. KHz	F max. KHz	Range #	Switch Pointer "O'Clock"	F min. KHz	F max. KHz
1	9:30	450	530	4	12:30	950	1100
2	10:30	530	700	5	1:30	1100	1700
3	11:30	700	950	6	2:30	1700	2400

Inductors are Mouser 43LR series, or equivalent