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MWDX-5 Phasing Unit

Mark Connelly - WA1ION - 01 OCT 1991, updated 14 SEP 1993

The MWDX-5 phasing unit, like the earlier 'MWDX' models, is used to create a phase shift between the signal contributions from two longwire antennae in order to null a dominant station (or noise source) which interferes with co-channel or nearby- channel DX stations. After creating such a null, the (formerly- covered) desired DX station(s) may often be heard clearly. Unlike a loop having a bi-directional null, the phasing unit's null is of a single direction nature. Therefore, a station to the west can be nulled and signals from the east will be received well.

At the end of this article is a list of recommended reading material which includes previous phasing unit designs. These works will do much to introduce phasing unit principles to the "uninitiated".

The MWDX-5 has as an advantage the ability to use both the series-tuned method of MWDX-1 and MWDX-2 (/2A/2B/2C) and the parallel-tuned method of (Mini-)MWDX-3 and MWDX-4(A, etc.) units. Longer wires usually work better with the series-tuned input arrangement (less signal loss) and shorter wires will only work with the parallel-tuned scheme. Refer to Figures 1A and 1B.

<All figures are placed after the end of the article's text>

MWDX-5 can use either the BBA-C or BBA-B broadband amplifier. The BBA-C, as used in the DCP-1 Controller and in the Super-MWDX-5 Phasing Unit, has higher dynamic range than the BBA-B used on MWDX-4 style phasers. The older design BBA-B may be substituted for reduced battery drain; performance in rural areas will not differ greatly. Figures 6 and 7 show the BBA-B schematic and assembly. For BBA-C, refer to the Super-MWDX-5 article. One of Dallas Lankford's "crunchproof" 2N5109-based amplifiers could also be used.

A plastic chassis box is used for MWDX-5. The big advantage to this is that the tuning capacitors can be "floated" from ground without any special insulating hardware. This keeps the size and cost of the unit reasonable. MWDX-5 has been designed with the essential features needed for medium-wave DXing. Two other members of the MWDX-5 "family" - the Mini-MWDX-5 and the Super-MWDX-5 - provide reduced and enhanced capabilities respectively. Separate articles describe these units.

MWDX-5 Two Wire Phasing Procedure

Figures 2, 3, & 4 are the schematics of the MWDX-5. Please refer to them during this discussion of phasing procedure.

A desired effect of two-wire phasing is to receive stations in the opposite direction of the station to be nulled out: this is something a loop generally cannot do. Wires to be used should be at least 15m./50 ft. long. I have found that wires separated by 45 to 135 (or 225 to 315) degrees work best at the shorter lengths (less than 50m./164 ft.). Layout of longer wires is less critical. Beverages can be in parallel or close to parallel; some have recommended that one be terminated and the other one floating; distance between two parallel Beverages should be at least 5m./16ft.

[See Table 8 for physical positioning of switches]

1.0 Phasing Steps (2-wire)

1.1 Set frequency-range switch S1 to the correct range for the frequency of operation (see Table 2). Set length switch S2 to Normal. Set Line 1 function switch S3 to Tuned; set Line 2 function switch S4 to Tuned. Null-mode switch S5 may be put in either position: it doesn't matter yet. Set amplifier switch S6 to Off.

1.2 Set Q-balance pot R1 to fully counterclockwise (CCW) = maximum resistance shunting C1. Set level pot R2 to fully CCW (maximum resistance arm to ground).

1.3 Connect longwire #1 to J1 and connect longwire #2 to J2. Connect earth ground, if available, to J3 or J4. Connect phaser's output (J5), via coaxial cable, to the input of the receiver to be used, or to a tunable pre-amp. between phaser and receiver. Connect a 9V battery to the J7 battery holder and plug P1 into J6, or connect the plug of an 8V to 15V DC power source to J6.

1.4 Tune Line 1 by peaking desired-frequency signal strength with C1. At this time, leave C1 at its peaked-signal position.

[At this time, other positions of length switch S2 (Short, Long, Terminated) can be tried to see if greater signal transfer is possible. Re-adjustment of C1, and possibly S1, may be needed to re-establish a peaked condition. In any event, the peak should have reasonable Q (be well defined) and C1 should not be set too close to fully CW or fully CCW. In most cases, S2 on Normal will provide good enough signal levels and reasonably sharp tuning not overly affected by differences in length between the two wires to be phased.]

1.5 Turn R1 to fully clockwise (CW). Tune Line 2 by peaking desired-frequency signal strength with C2. At this time, leave C2 at its peaked-signal position.

1.6 Set S5 to Null-a. Adjust R1 to search for a null of the dominant ("pest") station or noise. Try this again with S5 set to Null-b. Leave S5 on the position yielding the better-defined null (or if nulls were obtained both ways, put S5 on the position which gave a null with R1 set closer to its center position). Set R1 to the null-yielding position. If a null was not found by adjusting R1, or if the final R1 setting is fully CW or fully CCW, do step 1.7 - otherwise skip to step 1.8a/b.

1.7 Adjust R1 so that the signal level observed with (S3 = Tuned & S4 = Off) is the same as that noted with (S3 = Off & S4 = Tuned). When this has been done, set both S3 and S4 to Tuned and then set S5 to the position (Null-a or Null-b) giving the greater reduction in signal level of the station to be nulled.

1.8a If R1 is at center, or CCW from center, adjust C1 then R1 alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of C2 and R1.

< OR >

1.8b If R1 is CW from center, adjust C2 then R1 alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of C1 and R1.

1.9 If more gain is required, set S6 to Amplifier On and adjust R2, as required, to prevent overloading / spurs. Slight re-adjustment of C1, R1, and C2 may be needed to get the best possible null.

MWDX-5 Two Wire Phasing Procedure: ALTERNATE METHOD

1.0 Phasing Steps (2-wire)

SET-UP

1.1 Set frequency-range switch S1 to the correct range for the frequency of operation (see Table 2 of MWDX-5 article or see label next to S1 on the unit). Set length switch S2 to Normal. Set Line 1 function switch S3 to Tuned (up); set Line 2 function switch S4 to Off (center). Null-mode switch S5 may be put in either position: it doesn't matter yet. Set amplifier switch S6 to Off (down).

1.2 Set Q-balance pot R1 to center position (pointer at 12 o'clock). Set level pot R2 to fully CCW (maximum resistance arm to ground - maximum signal output).

1.3 Connect longwire #1 to J1 and connect longwire #2 to J2. Connect earth ground or a third antenna, if available, to J3 or J4. Connect phaser's output (J5), via coaxial cable, to the input of the receiver to be used, or to a tunable pre-amp. between phaser and receiver. Connect a 9V battery to the J7 battery holder and plug P1 into J6, or connect the plug of an 8V to 15V DC power source to J6.

LINE 1 TUNE

1.4 Tune Line 1 by peaking desired-frequency signal strength with C1. At this time, leave C1 at its peaked-signal position. Observe the Line 1 signal strength of the station (or noise) to be nulled.

LINE 2 TUNE

1.5 Set Line 2 function switch S4 to Tuned (up); set Line 1 function switch S3 to Off (center). Tune Line 2 by peaking desired-frequency signal strength with C2. At this time, leave C2 at its peaked-signal position. Observe the Line 2 signal strength of the station (or noise) to be nulled.

EQUALIZE

1.6a If the signal observed in step 1.5 is about the same (e. g. within 3 dB of) the signal observed in step 1.4, proceed to Step 1.7.

1.6b Adjust R1 so that the signal level observed with (S3 = Tuned & S4 = Off) is the same as that noted with (S3 = Off & S4 = Tuned).

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NULL

1.7 Set Line 1 function switch S4 to Tuned (up); set Line 2 function switch S3 to Tuned (up). Set S5 to Null-a then set S5 to Null-b. Leave S5 on the position yielding the better-defined null.

1.8a If R1 is at center, or CCW from center, adjust C1 then R1alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of C1, C2, and R1.

< OR >

1.8b If R1 is CW from center, adjust C2 then R1 alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of C1, C2, and R1.

1.9 If more gain is required, set S6 to Amplifier On and adjust R2, as required, to prevent overloading / spurs. Slight re-adjustment of C1, R1, and C2 may be needed to get the best possible null.

This guide to two wire phasing is a starting point. Often it takes experience to get the correct "feel" for a given nulling situation: experience that will allow the minimum number of control manipulations and the quickest route to the desired null. If signal levels are considerably different between Antenna 1 and Antenna 2, nulling is likely to be more difficult. Using wires of comparable lengths tends to minimize this problem.

2.0 Phasing Steps (Loop vs. Wire)

NOTE: Loop must be equipped with a Q-spoiling pot of 25K or 50K across its parallel-tuned LC tank. This will be called the "loop pot" for the purpose of this procedure. A loop used in a phasing application is usually oriented for best directivity toward desired DX signals, whether or not that position reduces the "pest" station.

2.1 Set frequency-range switch S1 to the correct range for the frequency of operation (see Table 2). Set length switch S2 to Normal. Set Line 1 function switch S3 to Tuned; set Line 2 function switch S4 to Off. Null-mode switch S5 may be put in either position: it doesn't matter yet. Set amplifier switch S6 to Off.

2.2 Set Q-balance pot R1 to fully counterclockwise (CCW) = maximum resistance shunting C1. Set level pot R2 to fully CCW (maximum resistance arm to ground).

2.3 Connect longwire to J1 and connect the loop output to J2 (high) and J4 (ground). Connect earth ground, if available, to J3 or J4. Connect phaser's output (J5), via coaxial cable, to the input of the receiver to be used, or to an tunable pre-amp. between phaser and receiver. Connect a 9V battery to the J7 battery holder and plug P1 into J6, or connect the plug of a 8V to 15V DC power source to J6. Initially, turn off loop power.

2.4 Tune Line 1 by peaking desired-frequency signal strength with C1. At this time, leave C1 at its peaked-signal position.

2.5 Set S3 to Off. Set loop pot to maximum resistance position, set S4 to Bypass, turn loop power on, and peak the loop's output at the desired frequency.

2.6 Observe the strength of the dominant station (this is the signal from the loop). Then set S4 to Off and S3 to Tuned. Now the signal from the wire can be checked for strength.

2.7a If the signal from the wire exceeded that from the loop in Step 2.6, adjust R1 such that the strengths are closely matched (e. g. within 5 dB) if you compare observed strength (S3=Tuned/S4=Off) vs. (S3=Off/S4=Bypass) as done in Step 2.6.

<OR>

2.7b If the signal from the loop exceeded that from the wire in Step 2.6, adjust the loop pot so that the strengths are closely matched when you compare observed strength (S3=Tuned/ S4=Off) vs. (S3=Off/S4=Bypass) as done in Step 2.6.

2.8 Set S5 to Null-a (up); then set S5 to Null-b (down). Leave S5 on the position yielding the better null of the dominant ("pest") station or noise.

2.9a If R1 had been adjusted to equalize strengths (Step 2.7a), adjust R1 and the loop tuning capacitor alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of C1 and R1.

< OR >

2.9b If the loop pot had been adjusted to equalize strengths (Step 2.7b), adjust the loop pot and C1 alternately to improve the null until no further improvement can be accomplished. Then do the final null "touch-up" with an interactive adjustment of the loop tuning capacitor and the loop pot.

2.10 If more gain is required, set S6 to Amplifier On and adjust R2, as required, to prevent overloading / spurs. Touching up the loop's position may be done to get the best final null.

2.11 (NOTE) Different S2 length switch positions (other than Normal) may provide more efficient coupling and/or sharper tuning in some circumstances.

Table 1: MWDX-5 Controls and Input / Output Connectors

Controls

location	designation	operational description
top	C1	Line 1 tuning capacitor
top	C2	Line 2 tuning capacitor
top	R1	Q-balance pot
top	R2	Output level pot
top	S1	Bandswitch
top	S2	Length (coupling) switch
top	S3	Line 1 Function switch
top	S4	Line 2 Function switch
top	S5	Phase-reverse (Null A/B) switch
top	S6	Amplifier on/off switch

Input / Output Connectors

location	designation	operational description	connector type
left side	J1	Line 1 wire input	banana jack
left side	J2	Line 2 wire input	banana jack
left side	J3	earth ground input 1	banana jack
left side	J4	earth ground input 2	banana jack
right side	J5	RF output	BNC jack
right side	J6	B+ in	phono jack
right side	J7	9V battery holder	Keystone 1290

Table 2: S1 Bandswitch Settings Chart

(Ranges are usually a bit greater than those shown.)

S1 Position #	S1 Knob Pointer "o'clock"	Min. Freq. kHz	Max. Freq. kHz	Tank Inductor Values "Main" L # uH	"Tap" L # uH
[S2 on Short or Normal: Aerial < 60 m. / 200 ft.]					
1	10:30	400	590	L1/9 470	L5/13 100
2	11:30	590	830	L2/10 220	L6/14 47
3	12:30	830	1230	L3/11 100	L7/15 22
4	1:30	1230	1750	L4/12 47	L8/16 10
[S2 on Long or Terminated: Aerial > 30 m. / 100 ft.]					
1	10:30	750	1050	L1/9 470	L5/13 100
2	11:30	1050	1550	L2/10 220	L6/14 47
3	12:30	1550	1850	L3/11 100	L7/15 22
4	1:30	1850	2700	L4/12 47	L8/16 10

Building the MWDX-5 Phasing Unit

The documentation (schematics, assembly drawings, parts lists, hole lists, etc.) serves as the starting point. The following procedure should serve as an outline for the builder.

1. Gather all necessary parts (see parts lists to follow). Prepare work area with appropriate tools.
2. Drill out chassis box, ~~in accordance with Table 3.~~ TABLE 3 DELETED
3. Assemble each of the two circuit card subassemblies, per references listed at the end of this article:
   * TA1 Phase Reversing Transformer Card
   * A1 BBA-B or BBA-C Broadband Amplifier Card

4. Mount each of the circuit cards ~~at the hole locations noted in Table 3.~~
5. Install jacks, pots, and switches. Solder inductors onto S1 per Figure 3 and Tables 2 & 4.
6. Install wiring and other components per Figures 2,3,4,5 and Tables 1, 3~~,~~ Install knobs on C1, C2, R1, R2, S1, and S2. Place labels near controls and jacks.
7. Follow Two-Wire Phasing Procedure or Loop-vs.-Wire Phasing Procedure steps previously given in this article.

Table 4: "upper level" parts list

TABLES 3 & 7 DELETED

Vendor codes for this and subsequent parts lists:

AE = Antique Electronics /688 W. First St. /Tempe, AZ 85281 /Tel. 1-602-894-9503

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

MCL = Mini-Circuits Lab. / P. O. Box 350166 / Brooklyn, NY 11235-0003 /Tel. 1-800-654-7949

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	Stock #	QTY
1	-	chassis box	RS	270-224	1
2	A1	BBA-B or BBA-C amp. card		(Table 9 = BBA-B)	1
3	(for C1,C2,R1,R2)	knob	MOU	45KN013	4
4	(for S1,S2)	knob	RS	274-416	2
5	B1	9V alkaline battery	RS	23-553	1
6	C1,C2	variable cap.,10-365pF	AE	CV-235	2
7	C3,C4,C9	capacitor, 0.1 uF	RS	272-109	3
8	C5,C6	capacitor, 100 pF	MOU	21CB100	2
9	C7,C8	capacitor, 36 pF	MOU	21CB036	2
10	C10	capacitor, 0.001 uF	RS	272-126	1
11	J1,J2	red banana jack	RS	274-662	2
12	J3,J4	black banana jack	RS	274-662	2
13	J5	BNC jack	RS	278-105	1
14	J6	phono jack	RS	274-346	1
15	J7	battery holder (Keystone 1290)	MOU	534-1290	1
16	L1,L9	inductor, 470 uH	MOU	43LR474	2
17	L2,L10	inductor, 220 uH	MOU	43LR224	2
18	L3,L5,L11,L13	inductor, 100 uH	MOU	43LR104	4
19	L4,L6,L12,L14	inductor, 47 uH	MOU	43LR475	4
20	L7,L15	inductor, 22 uH	MOU	43LR225	2
21	L8,L16	inductor, 10 uH	MOU	43LR105	2
22	P1	phono plug	RS	274-339	1
23	R1	pot., 50K, linear	MOU	31CT405	1
24	R2	pot., 1K, linear	MOU	31CT301	1
25	R3,R4	resistor, 470 ohm	RS	271-1317	2
26	R5,R6	resistor, 100 ohm	RS	274-1311	2
27	R7,R8	resistor, 4.7 ohm	MOU	29SJ500-4.7	2
28	R9	resistor, 1 ohm	MOU	29SJ500-1.0	1
29	S1,S2	switch/4pole/6pos.rotary	MOU	10WR046	2
30	S3,S4	switch, DPDT, on-off-on	RS	275-620	2
31	S5	switch, DPDT, on-on toggle	RS	275-636	1
32	S6	switch,3PDT,on-on toggle	MOU	10TC280	1
33	TA1	phase-rev. transformer		(see Table 5)	1

Misc. items: hook-up wire, buss wire, solder, labels "AS REQUIRED"

Table 5: TA1 phase-reversing transformer card parts list

See Table 4 for vendor codes.

Item	Designator	Description/Value	Vendor	Vendor Stock #	QTY
1	-	perfboard(0.6"X1.2")	RS	276-1396 (cut)	1
2	H1,H2	screw, 4-40 X.25"	MOU	572-01880	2
3	H1,H2	spacer, 4-40 X .5"	MOU	534-1450C	2
4	H1	split lockwasher,#4	MOU	572-00649	1
5	H2	solder lug, #4	MOU	534-7311	1
6	P1-P4	flea-clip for .042 hole	MOU	574-T42-1/100	4
7	T1	RF transformer,1:1	MCL	T1-6-X65	1

Table 6: small hardware parts list

See Table 4 for vendor codes.

Note: Mounting hardware is supplied with the following components: J1, J2, J3, J4, J5, R1, R2, S1, S2, S3, S4, S5, S6. A lug is added to the normal J5 hardware. Also, hardware is required by the following component designators: A1, C1, C2, G1, G2, J7, and TA1.

Used on	Description/Value	Vendor	Vendor Stock #	QTY
J5(1)	solder lug, .375"ID	DK	ARF1068-ND	1
A1(4),G1(1), G2(1),J7(2),TA1(2)	screw, 4-40 X .25"	MOU	572-01880	10
C1(2),C2(2)	screw, 6-32 X .25"	MOU	572-01888	4
A1(4),TA1(2)	split lockwasher, #4	MOU	572-00649	6
C1(1),C2(1)	split lockwasher, #6	MOU	572-00650	2
C1(1),C2(1)	solder lug, #6	MOU	534-7312	2
G1(1),G2(1)	solder lug, #4	MOU	534-7311	2
G1(1),G2(1)	hex nut, 4-40	MOU	572-00486	2

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Table 8: control orientation conventions

Ensure that components are mounted and wired in accordance with this table; align knob pointers to clock positions indicated. Orientations are as viewed from outside the chassis box assembly.

Side	Control	Orientation Conventions
top	C1	CCW = minimum C = maximum freq. = 9:00 CW = maximum C = minimum freq. = 3:00
top	C2	CCW = minimum C = maximum freq. = 9:00 CW = maximum C = minimum freq. = 3:00
top	R1	CCW = min. Q Line 2 / max. Q Line 1 = 7:00 CW = min. Q Line 1 / max. Q Line 2 = 5:00
top	R2	CCW = maximum output level = 7:00 CW = minimum output level = 5:00
top	S1	[see Table 2]
top	S2	"Short" = 10:30; "Normal" = 11:30; "Long" = 12:30; "Terminated" = 1:30
top	S3	"Tuned" = up; "Off" = middle; "Bypass" = down
top	S4	"Tuned" = up; "Off" = middle; "Bypass" = down
top	S5	"Null-a" = up; "Null-b" = down
top	S6	"Amplifier on" = up; "Amplifier off" = down

Table 9: BBA-B Broadband Amplifier Card [A1] parts list

See Table 4 for vendor codes.

Schematic = Figure 6 / Assembly = Figure 7

Item	Designator	Description/Value	Vendor	Vendor Stock #	QTY
1	-	perfboard:1.4"X1.4"	RS	276-1396 (cut)	1
2	C1,4,5,6	capacitor, 0.1 uF	MOU	539-CK05104K	4
3	C2	capacitor, 10uF tant	MOU	581-10K35	1
4	C3	capacitor, 0.01 uF	MOU	539-CK05103K	1
5	H1-H4	screw, 4-40 X .25"	MOU	572-01880	4
6	H1-H4	spacer, 4-40 X .5"	MOU	534-1450C	4
7	H1-H3	split lockwasher, #4	MOU	572-00649	3
8	H4	solder lug, #4	MOU	534-7311	1
9	P1-P6	flea clip, .042"hole	MOU	574-T42-1/100	6
10	Q1	NPN, 2N3904	MOU	570-2N3904	1
11	Q2	NPN, MPS918	MOU	526-NTE108	1
12	R1,5,9	resistor, 10 ohm	RS	271-001	3
13	R2	resistor, 6.8K	MOU	30BJ250-6.8K	1
14	R3	resistor, 1.8K	MOU	30BJ250-1.8K	1
15	R4	resistor, 270 ohm	RS	271-1314	1
16	R6	resistor, 1K	RS	271-1321	1
17	R7	resistor, 470 ohm	RS	271-1317	1
18	R8	resistor, 330 ohm	RS	271-1315	1

+ Buss wire, solder: "AS REQUIRED"

FIGURE 1: TUNING CONFIGURATIONS

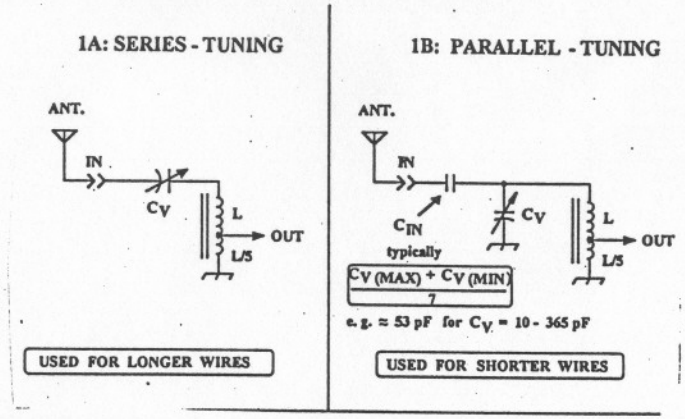

FIGURE 2 : MWDX-5 PHASING UNIT (INPUT SECTION)

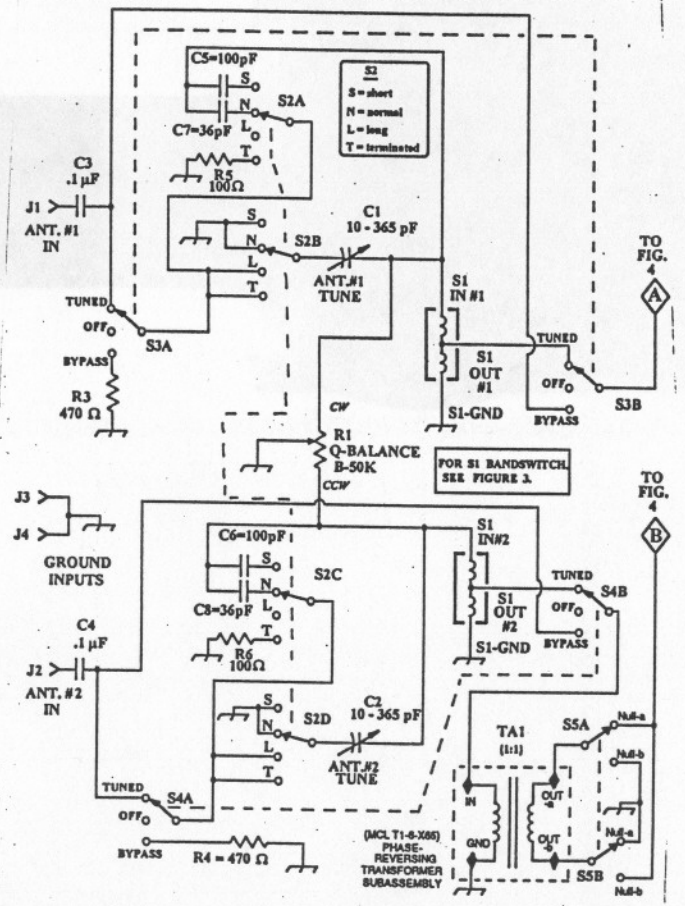

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FIGURE 3 : S1 BANDSWITCH FOR MWDX-5

(For connections, refer to Figure 2.)

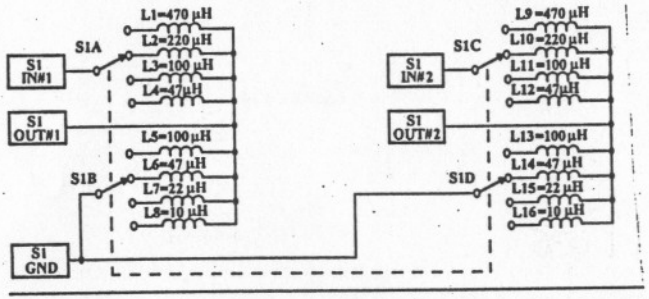

FIGURE 4 : MWDX-5 PHASING UNIT (OUTPUT SECTION)

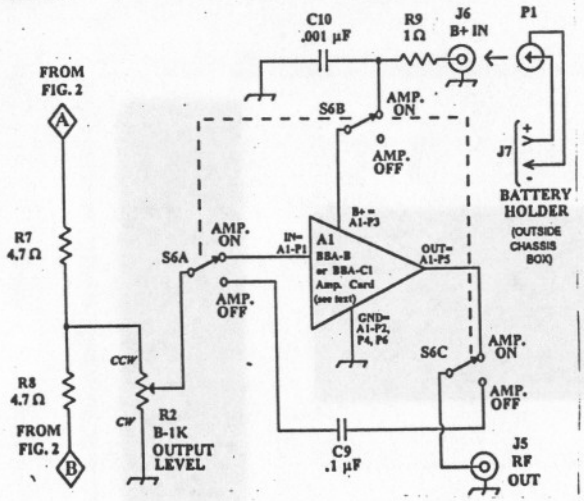

FIGURE 5: PHYSICAL LOCATIONS OF ARMS OF ROTARY SWITCHES S1 & S2

NOTES: VIEW IS LOOKING INTO BOTTOM (BACK) OF BOX WITH COVER REMOVED. DESIGNATIONS IN PARENTHESES - E.G. (S1B) - ARE ON THE SWITCH WAFER CLOSER TO THE INNER SURFACE ON THE BOX, THOSE NOT IN PARENTHESES - E.G. S1A - ARE ON THE WAFER CLOSER TO THE VIEWER LOOKING INTO THE BOX WITH THE COVER REMOVED.

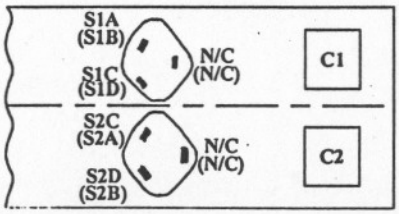

FIGURE 6 MWDX-5 PHASING UNIT - A1 SUBASSEMBLY BBA-B BROADBAND AMPLIFIER CARD - SCHEMATIC DWG.

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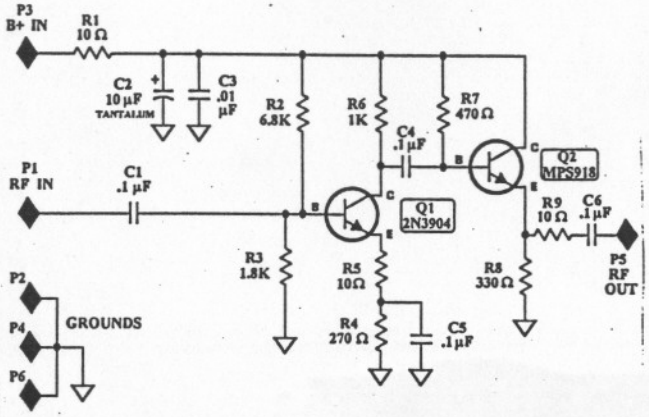
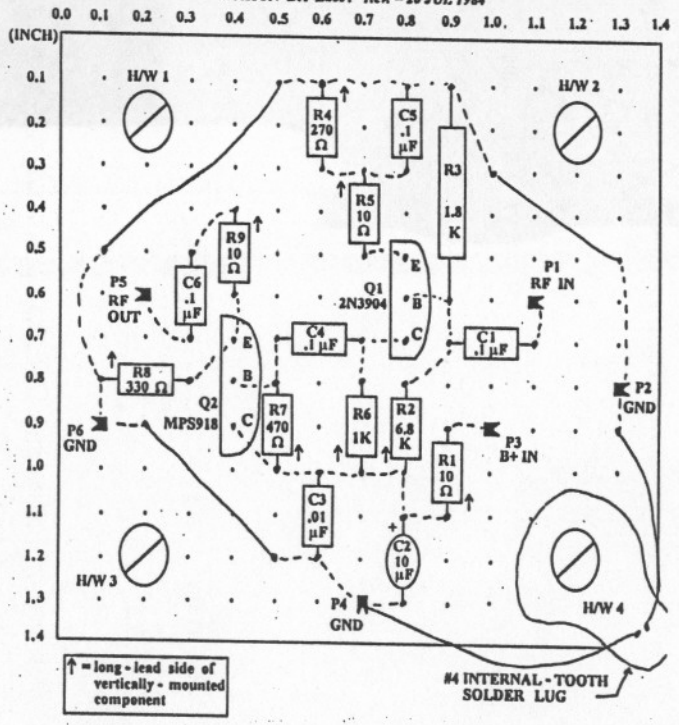


FIGURE 7 - MWDX-5 PHASING UNIT - A1 BBA-B BROADBAND AMPLIFIER CARD: ASSEMBLY

WA1ION DX Labs: Rev. = 20 JUL 1984



A112-6-6

FIGURE 8 - TA1 PHASE - REVERSING TRANSFORMER CARD SUBASSEMBLY
(FOR PARTS LIST, SEE TABLE 5.)

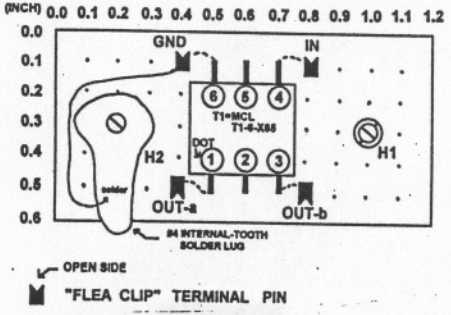
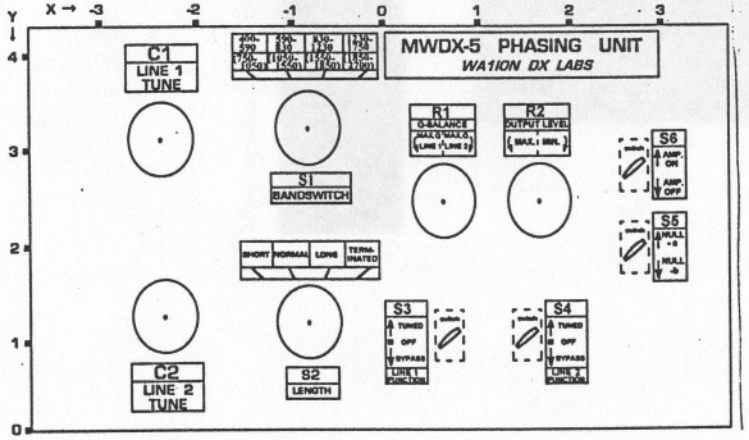


FIGURE 9: MWDX-5 FRONT PANEL - SUGGESTED LABELS



Supplementary Articles and Publications

Additional information on construction practices and DX-related circuit design may be obtained from the following: (* = NRC / IRCA reprints)

The Beverage Antenna Handbook - Victor A. Misek - 1987

ARRL Handbook, ARRL Antenna Book

various articles in 'fine tuning' "Proceedings"

* Super-MWDX-5 Phasing Unit - Mark Connelly - 7 FEB 1993 (includes documentation of BBA-C Broadband Amplifier)
* Mini-MWDX-5 Phasing Unit - Mark Connelly - 29 JUN 1992, updated 4 JUN 1993 (simple unamplified phasing unit)
* The RTL-2 Remotely-Tuned Loop - Mark Connelly - 23 AUG 1993 (construction practices)
* The MWT-3 Regenerative Tuner / Controller - Mark Connelly - 17 MAY 1993 (construction practices)
* The DCP-1 Dual Controller / Phaser - Mark Connelly - 30 JUL 1991 (phasing active, remotely-tuned antennae)
* LIL-3 - Dallas Lankford - APR 1991 (loop vs. wire phasing)
* Phasing Unit Designs: Simple to Complex - Mark Connelly - 20 MAR 1990 (discussion of phasing principles)
* Micro-MWDX-4A Loop vs. Wire Phaser - Mark Connelly - 15 MAR 1989 (loop vs. wire phasing principles)
* LIL-1 - Dallas Lankford - 14 FEB 1989 (loop vs. wire)
* Phase One - Gerry Thomas - 1988 (a delay-line phasing unit)
* MWDX-4 and Mini-MWDX-4 series Phasing Units - Mark Connelly - 11 OCT 1985 (predecessor of MWDX-5)
* The Mini-MWDX-3: A Simple, Effective Phasing Unit - Mark Connelly - 5 DEC 1984 (construction practices)

The following articles describe series-tuned phasers:

* MWDX-2B & MWDX-2C Phasers - Mark Connelly - 11 FEB 1985
* The MWDX-2A Phasing Unit - Mark Connelly - 25 JUN 1984
* The MWDX-2 Phasing Unit - Mark Connelly - 10 JAN 1984
* Modular Phasing Systems - Mark Connelly - 1983
* Amplified Phased Shortwires - Mark Connelly - 1982
* Phasing Unit Construction & Use (MWDX-1) - Mark Connelly - 23 NOV 1981
* Practical Phased Beverages - Chuck Hutton - 1981

Some of the articles include further lists of reference material which may also be of value.