AN ANTENNA PHASING UNIT FOR SHORTWAVE

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I've done quite a bit of work in the area of phasing, primarily on medium wave (500-2000 kHz). Most of my units use simple circuit elements and antenna of uncritical lengths: performance of these systems has been adequate for most of my DX applications. The purpose of phasing is to combine the signals from two antennas in such a manner that a dominant station is nulled, thereby enabling other co-channel signals to be heard. I haven't found phasing to be quite as beneficial on shortwave as it is on longwave and mediumwave. On the higher frequencies vertical angle-of-arrival (and even sometimes horizontal bearing-of-arrival) can vary rapidly for a given station. Several skip modes (e.g. 2-hop and 3-hop) may be simultaneously operative. Still, at least on the tropical bands, useful nulls can often be obtained.

Active devices, at least at the front end of the phasing unit, can be troublesome in that strong signals will make them act like spur-generating mixers instead of amplifiers/buffers. Unless your antenna is very short (e.g. whips), stick to passive devices. The output of the phasing unit (generally a lower level signal than the input) can then be amplified, preferably by a tunable preamp/preselector rather than by broadband means.

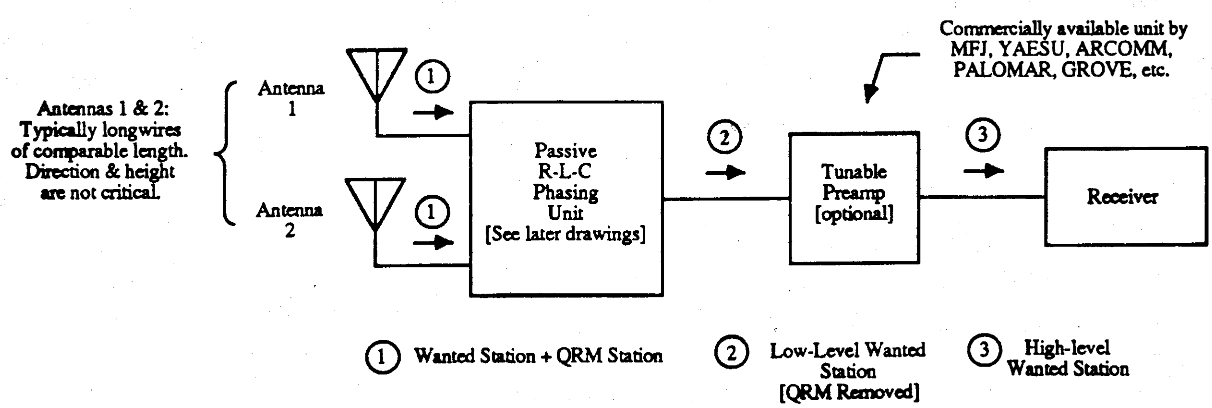


FIGURE 1. TYPICAL BLOCK DIAGRAM

Antenna 1 and 2 should be of similar length, they should be at least 50 feet/15 meters long, and separated either by a distance of 20 feet/6 meters minimum (if parallel) or by an angle of at least 60 degrees if originating at the same point. I find two wires at a right angle (90 degrees) to be quite effective; this is true whether one wire is vertical and the other is horizontal, or both are horizontal (e.g. on east, one south). Two broadband active whips mounted on the roof at least 20 feet/6 meters apart may be an alternative to the longwires for the city dweller (as long as they can be operated in the RF-intense urban environment without overload). Indoor antennas are not recommended because of (1) excessive noise pick-up and (2) insufficient diversity in pick-up. An exception to this rule would be with regards to loops. If you're limited to indoor antenna, just go with a loop such as that made by Palomar (rather than using phasing). The loop should give some nulling capability (unless you're in a steel frame building).

Well, assuming you can put up two outdoor longwires, let's look into the particulars of phasing unit design using passive components. Each wire is routed to an L-C tank shunted by a "Q-spoiling" potentiometer. The output of one of the 2 tanks goes through a switchable 0 degree/180 degree (phase-reversal) transformer and is combined with the output of the other tank. The phase-angle fine-variation is accomplished by adjustment of the tuning capacitors (slightly) off of their peak-signal settings. The pots are used for amplitude-equalization and to "spoil" the Q of the tanks somewhat: this is necessary so that change-in-phase per change-in-capacitance (and per change in frequency) is not too rapid/too "touchy". Too high a tank Q would make it difficult to null out an undesired "pest" station completely: the carrier should be removed, but not necessarily both sidebands. Of course, reducing Q reduces system gain (increases system loss), hence the need, in most cases, for the tunable active preselector between the phasing unit's output and the receiver's input. A basic phasing unit is depicted schematically in Figure 2.

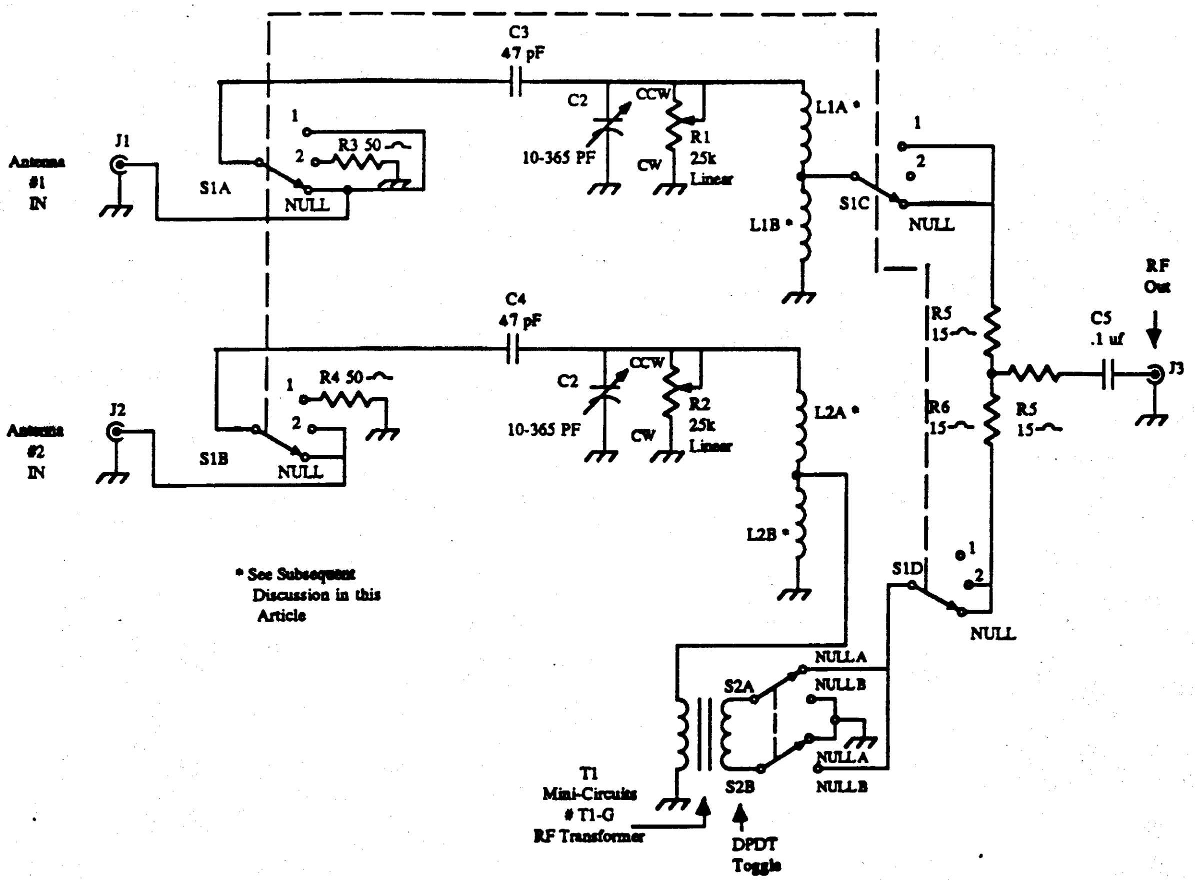


FIGURE 2. PHASING UNIT SCHEMATIC

For a single band (maximum to minimum frequency range ratio of about 2, e.g. 2.7 MHz to 5.4 MHz), a toroidal inductor for tank 1 and a second toroidal inductor of identical characteristics for tank 2 should be fabricated. ARRL publications (Radio Amateur's Handbook, Doug DeMaw's books, etc) go into the particulars of toroidal inductor design. Basically you've got to select the appropriate core material and physical size for the frequency range and inductance desired, and then determine the number of windings of thin magnet wire that will be required to get the proper inductance (that's where the ARRL books come in handy). Amidon, Ferroxcube, Fair-Rite, Palomer, Indiana General, Coil-Craft, and J.W. Miller all make toroids. Amidon and Palomar have the most reasonable prices; the others deal more with big-spending defense contractors and computer companies rather than with hobbyists. The toroids should each be wound so that the 'B' tap is approximately 1/8 as many turns from ground as the 'A' end:

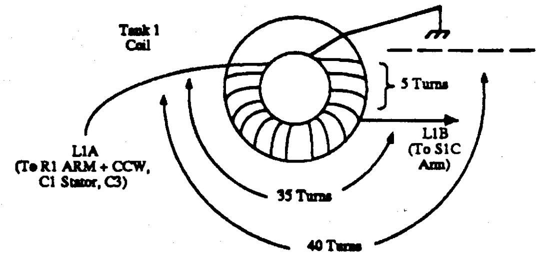
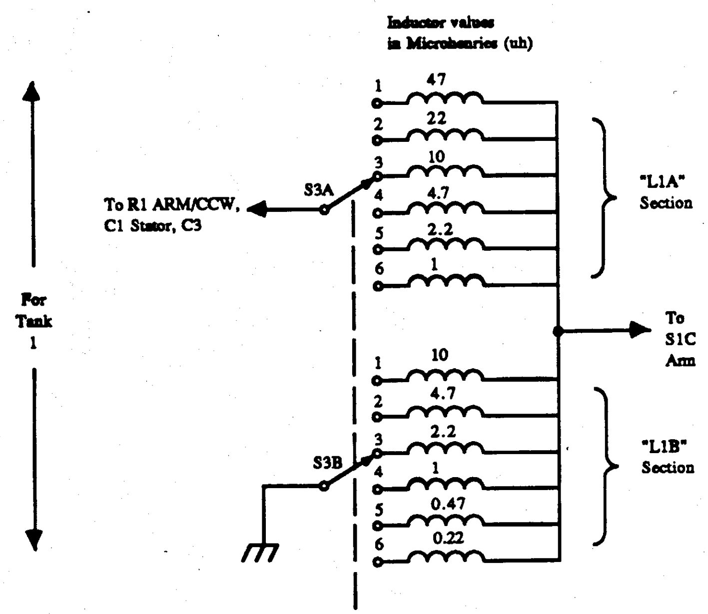


FIGURE 3. TOROID CONSTRUCTION
Amidon T-106-1 or T-130-2 powdered iron cores should work on the Tropical Bands (2-6 MHz)
Number of turns varies with desired freq. range

If more than a 2:1 frequency range is to be covered, switchable inductors are necessary. Either multiple toroids (of the above style) or molded miniature inductors may be used. A switchable frequency-range design using molded miniature inductors is shown below (ranges listed in table next to schematic).



Switch = 4-Pole,
6 - Position
(MOUSER # 10WR046)

[There will actually be more overlap between bands than shown.]

Band (Switch Position)	Range Khz Approx
1	1450-2030
2	2030-2840
3	2840-3980
4	3980-5570
5	5570-7800
6	7800-10900

Other Bands/Ranges are possible by using other inductors.

FIGURE 4a. SWITCHABLE FREQUENCY DESIGN

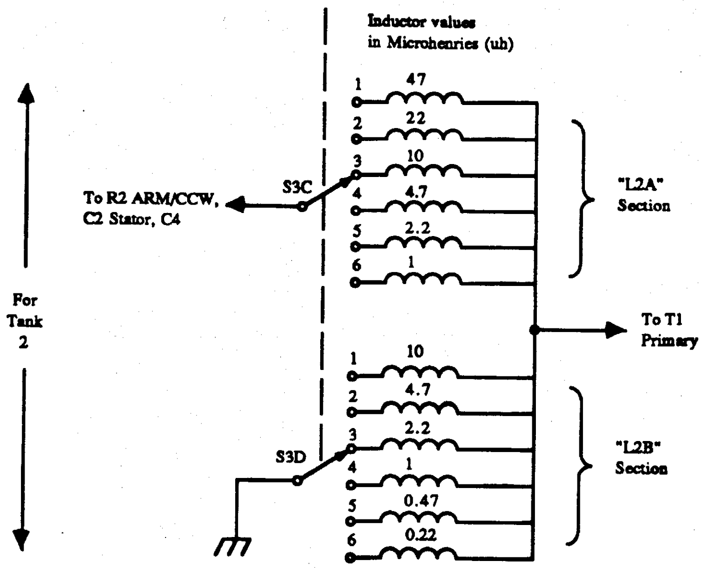
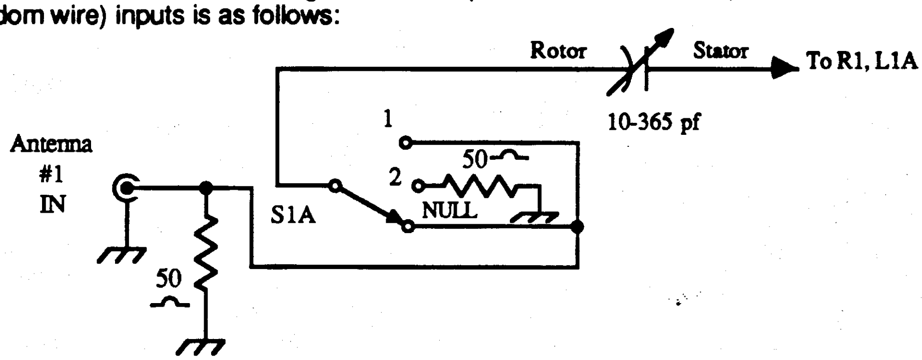


FIGURE 4b.

A variation on the tank design for better operation with 50-ohm (rather than "unknown-ohm" random wire) inputs is as follows:



If broadband active whips are used, this is the recommended set-up.

FIGURE 5a. VARIATION ON TANK DESIGN

Better termination for the 50-ohm antenna source and more efficient coupling of low-impedance inputs (than using the 47 pf input capacitor of the other design) is the result. The antenna #2 circuit should be configured similarly/S1B would be:

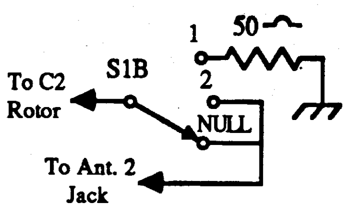


FIGURE 5b.

This style tuner/phaser would be a bit more difficult to build because C1 and C2 would have to be "floated" from chassis ground.

All of these circuits are fine, but up until this point I haven't discussed how you use them.

● PHASING UNIT OPERATION ●

Refer to figure 2: (Note: Standard lettering in #7-13 refer to the case after step #6 where antenna #1 is stronger than #2, or there is no difference. **Bold lettering refers to the case wher antenna #2 is stronger than #1.)**

Put preselector in bypass mode until done. If a bandswitch (S3) is used, set it to the appropriate frequency range.

1. Set R1 and R2 to max Q = fully counterclockwise.

2. Set S1 to 1 (antenna 1); S2 position doesn't matter.

3. Adjust C1 for maximum signal at desired frequency

4. Set S1 to 2 (antenna 2).

5. Adjust C2 for maximum signal.

6. Switch S1 between position 1 and position 2; note which position yields the stronger signal to be nulled.

7. Adjust R1 to make S1 position 1 strength equal S1 position 2 strength.
   Adjust R2 to make S1 position 2 strength equal S1 position 1 strength.

8. Set S1 to "null".
   Set S1 to "null".

9. Switch S2 from "null A" to "null B", leave it on position causing greater reduction in dominant station or noise to be nulled.
   Same.

10. Adjust C2 for null.
    Adjust C1 for null.

11. Adjust R1 for more null.
    Adjust R2 for more null.

12. Repeat steps 10 & 11 in a "looped" fashion until maximum null is obtained.
    Same.

13. Use tunable preamp (between phasing unit and receiver) as required, to bring up level of desired DX station(s) left after nulling out "pest" station or noise source. One more iteration of steps 10 and 11 may be needed to "nail-down" the best null now that more sensitivity is available.
    Same.

Results on nulling groundwave and low-angle skip stations are generally better than on high-angle/multiple-angle skip.

Many articles on phasing unit design and construction have been written and published in the medium-wave DX press. Send an SASE and a couple of extra stamps to each of the following (in both cases ask for a "reprint list"):

International Radio Club of America (IRCA)
"Goodie Factory"
PO Box 21074
Seattle, WA 98111

National Radio Club (NRC)
Publication Center c/o Ken Chatterton
PO Box 164
Mansville, NY 13661

Good luck and good DX!