Passive Broadband Phasing

including **Mini-DXP-5** phasing unit design

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Phasing units that have been used widely in the medium-wave (AM broadcast band) DXing and 160-meter amateur radio communities have largely been either of a broadband design using active circuitry (e.g. ANC-4, MFJ-1026, Quantum Phaser, DXP-3) or of a tuned design using passive or active circuits (MWDX-5, Superphasers, etc.). What has not been generally available is a phaser encompassing broadband shifting and passive circuitry. Broadband and tuned approaches both have advantages and disadvantages. The same can be said of passive versus active circuits.

Broadband phasing allows the operator to move about the band without needing to make continual adjustments of the phasing unit controls. This also helps when checking for the same broadcast on parallel frequencies. With some antenna combinations, a null set up on one frequency in a given direction may be fairly effective plus or minus 100 kHz (or more) from that operating frequency.

Tuned phasing can sometimes provide better sensitivity and, more importantly for urban users, reduction in the strengths of off-frequency stations that could otherwise cause mixing spurs / images.

Passive circuits are recommended in areas where overloading is likely to be a problem. Passive and tuned would be the way to go in the most hostile urban receiving situations. The MWDX-5 [***reference 1***] offers this capability. In addition it has an amplifier that can be switched in for more sensitivity at sites with a less aggressive blend of incoming signals. Up to now, most passive phasing designs have been of the R-L-C tuned style.

Active circuits offer higher sensitivity, gain, and - if properly designed - improved noise figure. Since all variations of the phasing process involve some signal loss, having amplifier gain - preferably ahead of the shifting components - will preserve the ability to hear threshold-level signals presented from the antenna system components. Low-noise FET's used with L-C tuning in a preselector configuration on each of the two antenna inputs give the best possible signal-to-noise ratio: in some cases superior to that of the receiver itself. The penalty is the lack of frequency agility inherent to tuned-circuit approaches. Broadband active phasing - to now the only common implementation of the broadband approach - has many advantages. Amplifier gain can largely mitigate the deleterious effects of phase-shifter insertion loss. The result is a noise figure nearly as good as what could be had with a direct antenna to receiver connection. The broadband phasing advantages of frequency agility and potentially wideband nulls towards a noise or "pest station" direction can be obtained. In recent years, some very popular phasing units using broadband active operation (notably the Quantum Phaser and the MFJ-1026) have become available. Many of these are in use throughout the world and results are usually positive. Hams and broadcast DXers can now create directive patterns and null out interference in ways that were not always achievable with loops or other previous methods.

The big “caveat” with all of the active broadband designs is the likelihood of spurious signals (intermodulation distortion products) caused by the overloading of amplifier circuitry. This has been the single biggest complaint raised by users of these units. Some have, of necessity, been driven back to the tuned R-L-C approach as the only feasible method in their high-RF areas.

Passive Broadband Phasing: another solution

If the advantages of broadband phasing can be presented in a circuit that is passive (and therefore overload-proof), users in strong signal areas can have the benefits of frequency agility / wideband nulls without the “headache” of spurious responses popping up all over the place. This concept is introduced in the Mini-DXP-5 Phasing Unit, described in this article.

Mini-DXP-5 Phasing Unit (and variants: DXP-5, DXP-5A, DXP-5B, Super-DXP-5)

The Mini-DXP-5 is similar to the previous DXP-3 design [***reference 2***] except that a 9:1 stepdown transformer replaces the buffer amplifier used to convert the high impedance at the summing junction (arm of R3 phase shift potentiometer) to a low impedance suitable for a 50-ohm receiver input. To provide a lower probability of spurious responses, homebrew transformers using binocular cores are used in place of the small Mini-Circuits types used in the DXP-3 and some of the other similar designs. Figure 3 shows the binocular core and Figure 4 shows the method of winding transformers on one of these cores. The 2-turn primary and 2-turn secondary shown in Figure 4 are merely for illustration. Different numbers of windings are used on the Mini-DXP-5’s actual transformers (T1, T2, and T3) as noted on the second schematic page (Figure 2). Figure 1 is the first of the two Mini-DXP-5 schematic drawings. This is such a simple circuit that parts lists and hole-drilling tables are not included. Those provided with DXP-3 should give a reasonable starting point for the experienced homebrewer.

As noted in other articles, the object of a phasing unit is to combine the contributions of two antennas at a 180 degree phase relation in order to null out a dominant signal (or noise) and let otherwise-inaudible weaker co-channel and adjacent channel signals come through from directions away from the general compass bearing of the null.

Mini-DXP-5, as shown, is optimized for medium wave (300 to 3000 kHz) operation. Reducing the values of C6 and C7 from 820 pF to something like 330 pF will give better nulling adjustment at frequencies above 3 MHz. Increasing the values of these capacitors to something on the order of 2200 pF each and increasing transformer turns some (while keeping roughly the same ratios) will improve usability down in the longwave range (i.e. 125 to 500 kHz).

Phase shifting is wideband in nature: tuning is not required. With broadband phasing, a null set up in a given direction is often effective plus or minus 100 kHz or more from the set-up frequency.

The two antennas used should be somewhat different in directional pick-up characteristics (e.g. loop versus whip) if physically close to each other. Similar antenna types may be used if they are separated by at least 30 m / 100 ft. along the axis pointing towards signals to be nulled.

The Mini-DXP-5 allows independent observation of each input line as well as providing two combined signal (null) positions. This enables the user to balance amplitudes accurately, at least if the receiver has an S-meter, before adjusting the phase for a null. For good null depth, each of the two input lines must have a similar strength of the signal to be nulled.

There is an input (J6) for DC power on the Mini-DXP-5 even though the unit is passive. This is provided so that power may be provided to external active antennas (such as the MFJ-1024 whip) or to line amplifiers following low-gain antennas such as Pennants. If you never expect to use active antennas, you can simplify the design by deleting C3, C4, C5, J3, J4, J6, RFC1, and RFC2: all of these components are used to support the operation of active antennas or external line-amps.

In high-signal urban areas, one could benefit from passive L-C preselection on each of the two input lines ahead of the unit. This can be accomplished with an **MWTU-1** outboard accessory on each input (see **Accessories**, an appendix to this article). In most cases, this isn't necessary.

Another accessory that may be usable is an external antenna amplifier, at least when you're using the Mini-DXP-5 in rural areas or with low-signal antennas such as Flags, Pennants, or BOG's (Beverage-on-ground). The **XA-1 Transfer Amplifier**, shown in the **Accessories** section, can fulfill this need. Its transfer feature couples the antenna through passively if DC power is not provided via choke-coupling to the coaxial center conductor. If power is provided, the amplifier, with about 20 dB of gain, kicks in. XA-1 has different input transformers to accommodate a variety of antennas including those in the terminated-loop family (Pennant, Flag, Kaz, Ewe, K9AY, etc.), broadband closed loops, noise-reduced slopers, verticals, Beverages, random wires, etc.

OPERATING THE MINI-DXP-5

Practicing on stable daytime medium wave groundwave signals is the best way to become familiar with the unit's operation. When starting out, choose a frequency having some evidence of a second station under the dominant one.

Initial set-up:

Connect a passive (unpowered) antenna to J1, or connect an active antenna (such as an MFJ-1024 whip) to J3.

Connect the second antenna to J2 (if passive) or J4 (if active).

Connect a DC power source of +12 volts (min.) to +18 volts (max.) to J6 if you had connected anything to J3 or J4.

Connect the receiver, via coaxial cable, to J5.

Set R1 and R2 fully clockwise.

Amplitude Balancing:

Set R3 to center.

With S1 on 1, observe the level of the dominant signal (or noise) to be nulled. Also do this with S1 on 2.

If the signal level had been greater in the S1 = 1 position, adjust R1 so that the signal level measured with S1 on 1 is equal to that obtained with S1 on 2.

Conversely, if the signal level had been greater in the S1 = 2 position, adjust R2 so that the signal level measured with S1 on 2 is equal to that obtained with S1 on 1.

Nulling:

Set S1 to Null-a and adjust R3 for the best reduction of the dominant signal to be removed. Also do this R3 adjustment with S1 set to Null-b. Leave S1 on the null position which gave the deeper, better-defined null.

Finish up the null by small interactive adjustments of R3, R1, and R2.

Occasionally it may help to set R1 and R2 "fully clockwise minus 1 hour" (e.g. pointers at "4 o'clock" if fully clockwise is "5 o'clock") and then go back to the "Amplitude Balancing" section and proceed forward from there.

Variants: DXP-5, DXP-5A, DXP-5B, Super-DXP-5

DXP-5 is a more complex version that contains two switchable input amplifiers similar to what would be used in the external XA-1 accessory. **DXP-5A** contains a switchable output amplifier which can be selected instead of T3 after the summing junction. This is of a high-to-low impedance / gain type such as BBVA-A or BUF-B. **DXP-5B** contains a pair of switchable input amps and the single switchable output amplifier (i.e. features of both the DXP-5 and DXP-5A). **Super-DXP-5** contains all the above and also provides switchable L-C tank circuits on each input, similar to what using the MWTU-1 external accessory would achieve.

REFERENCES CITED

Links to Internet based references may change over time. If a specified link does not work, articles may still be accessible by contacting me directly so I can mail a disk of the article or suggest an updated Web link. Web search engines may also help to find versions archived by various clubs. Also, in some cases, articles may be available in "hard copy" from the National Radio Club reprints service.

[1] MWDX-5: web = “http://hometown.aol.com/MarkWA1ION/mwdx5.pdf”

[2] DXP-3: web = “http://www.qsl.net/wa1ion/dxp/dxp3.pdf”

Many other articles may be found via links from “http://www.qsl.net/wa1ion/index.html”

DRAWINGS

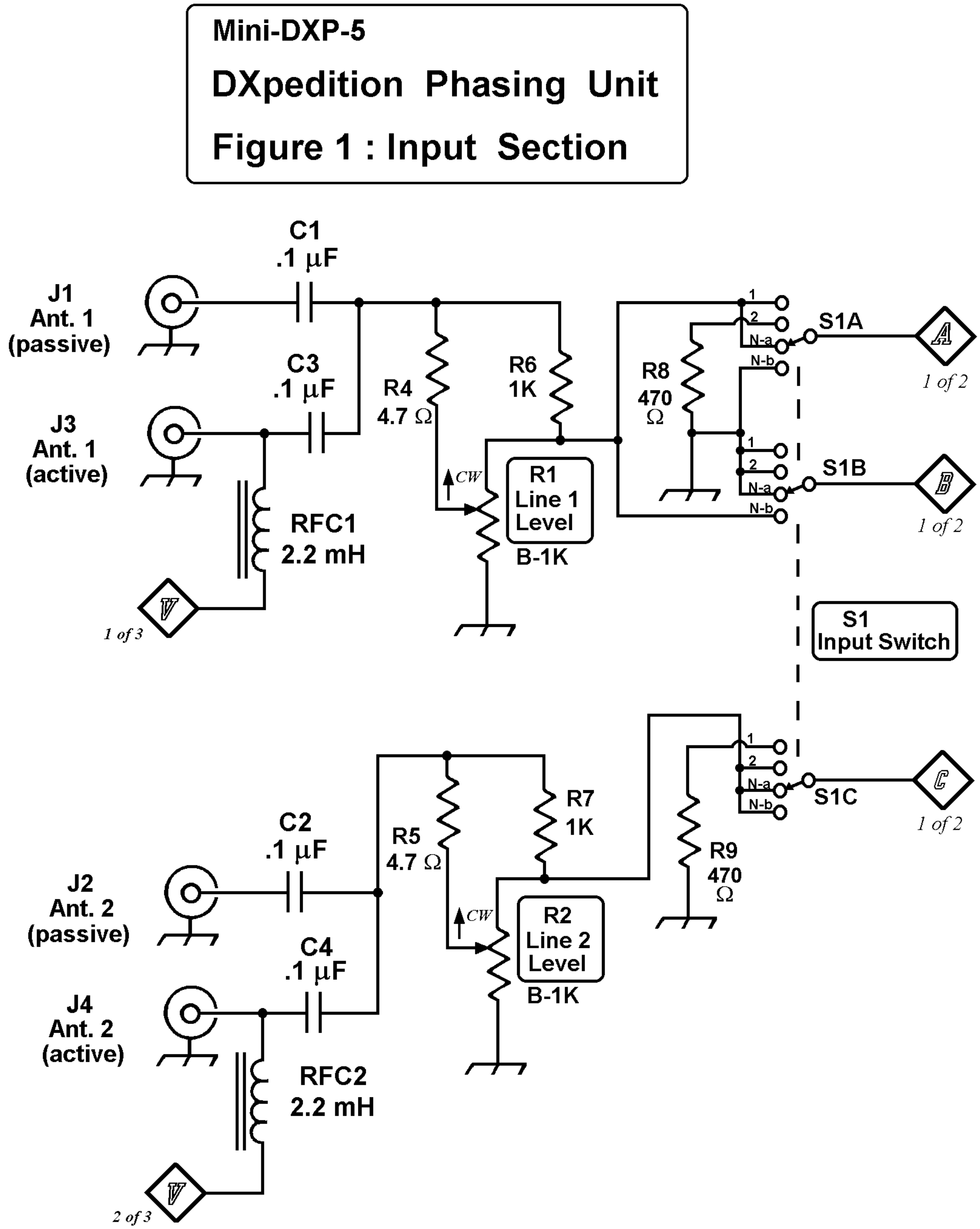


Figure 1: input section Mini-DXP-5 schematic

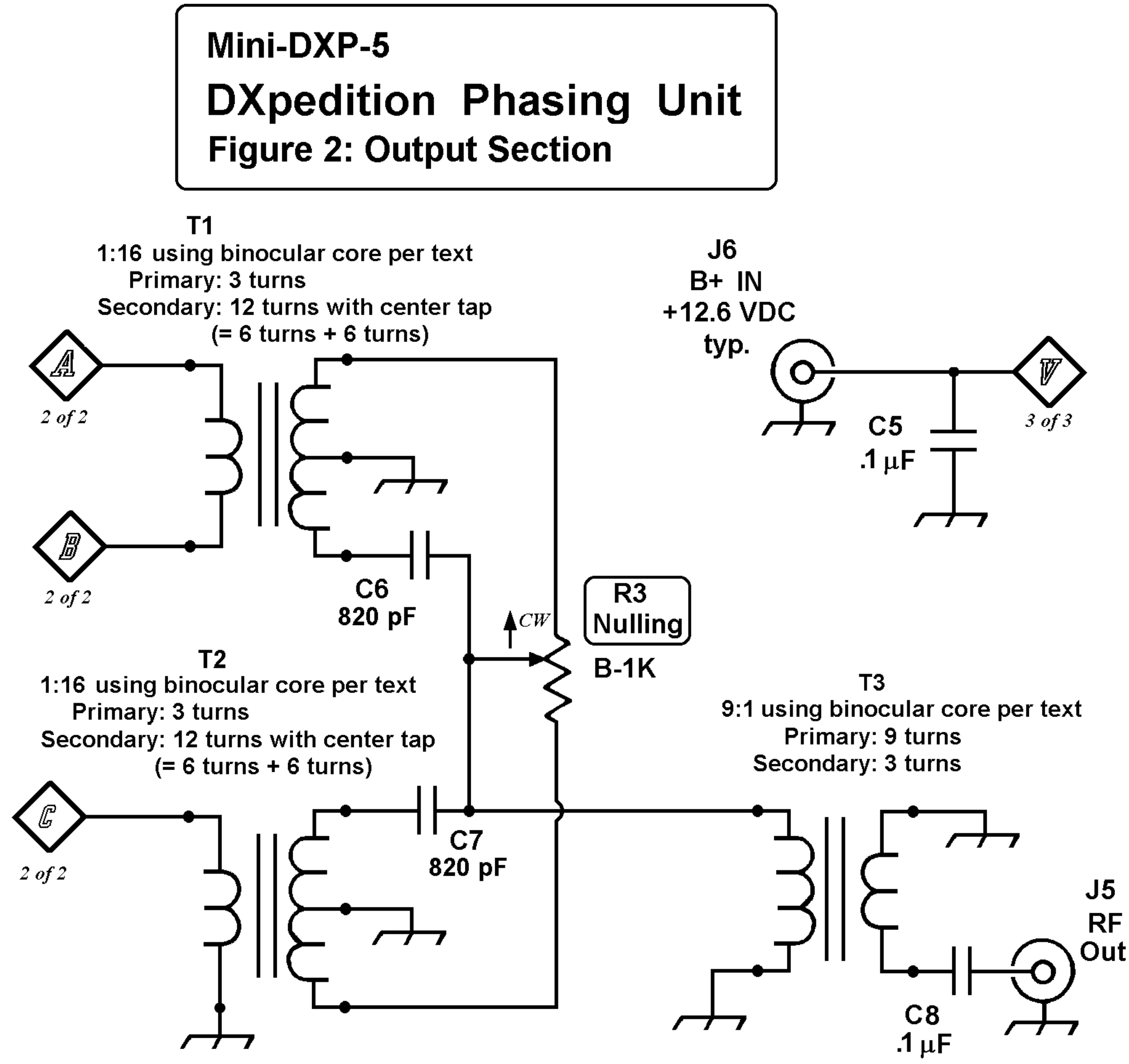
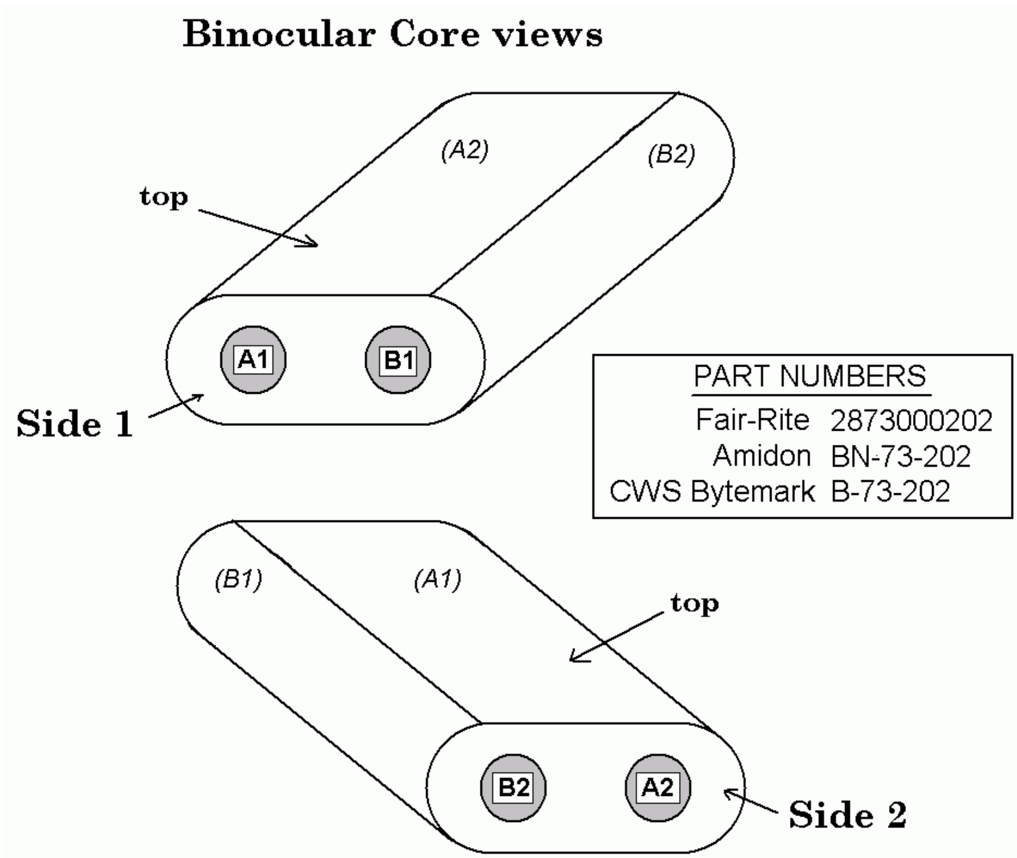
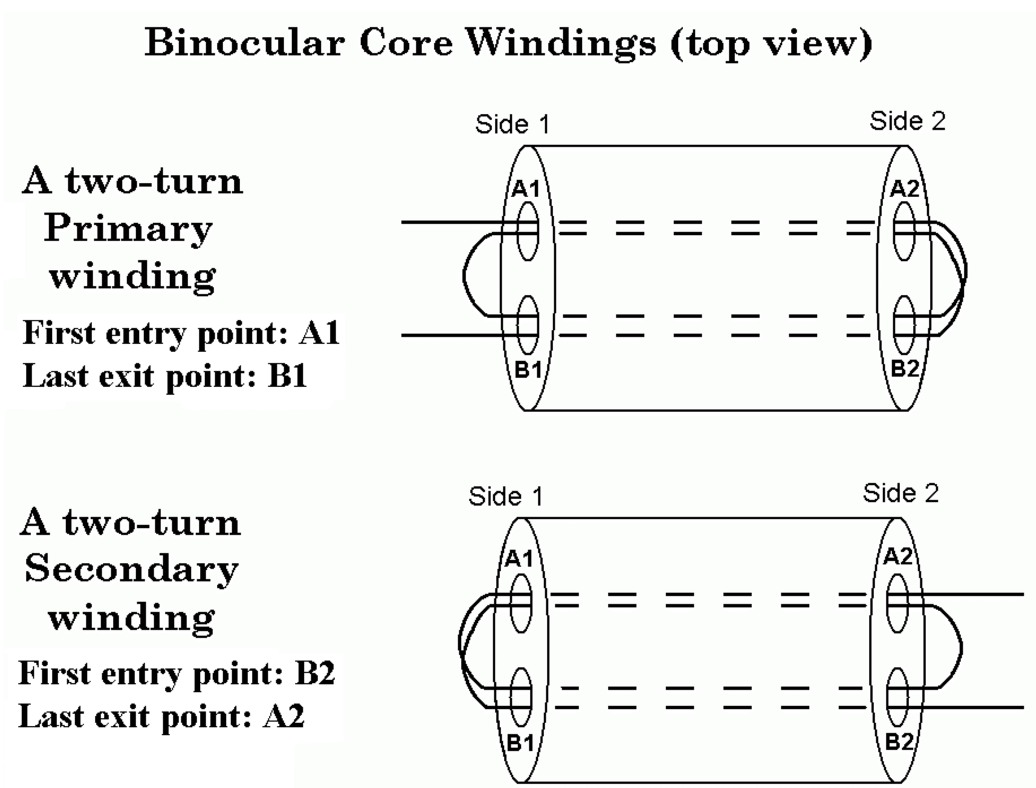


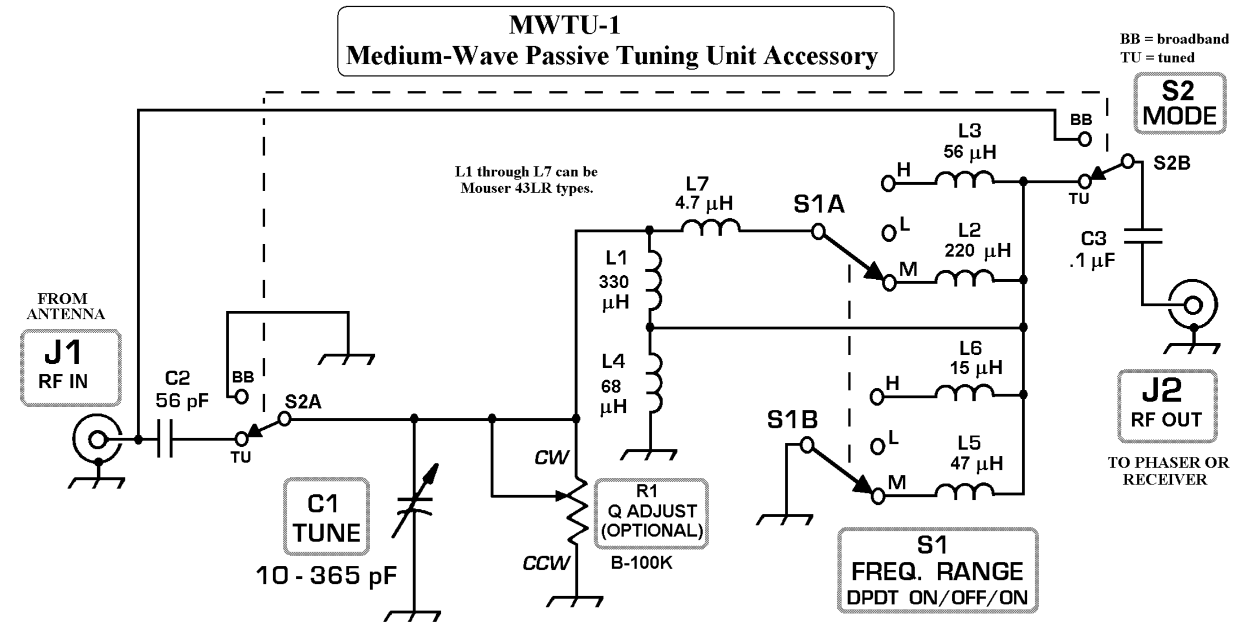
Figure 2: output section Mini-DXP-5 schematic





<u>above - Figure 3: binocular core views and Figure 4: winding method</u>

APPENDIX: ACCESSORIES



Freq. Range, kHz	S1 position
460 - 740	Lowband (L)
740 - 1170	Midband (M)
1170 - 1860	Highband (H)

Ranges may vary slightly.

Figure 5: MWTU-1 passive medium-wave tuner accessory

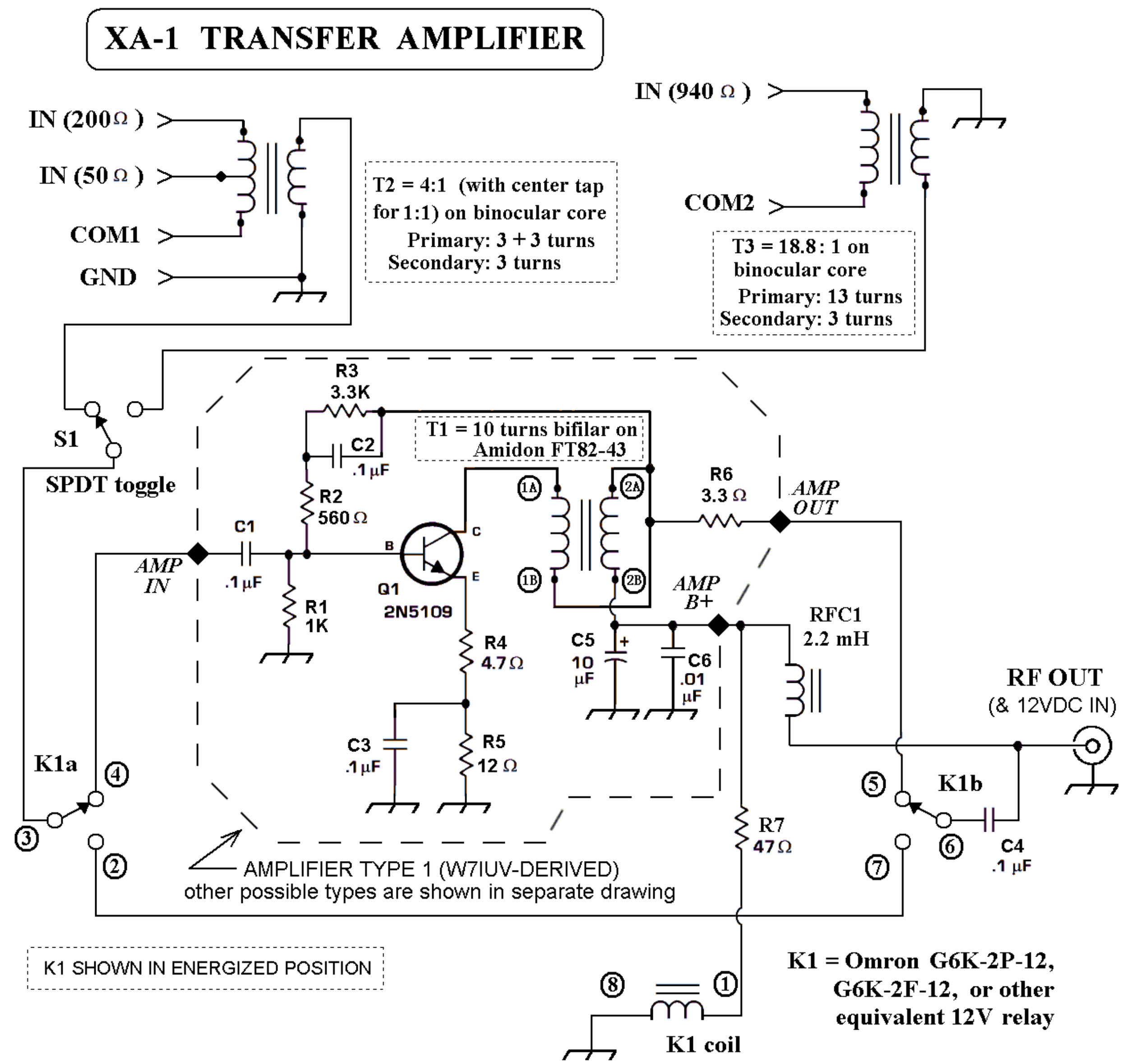
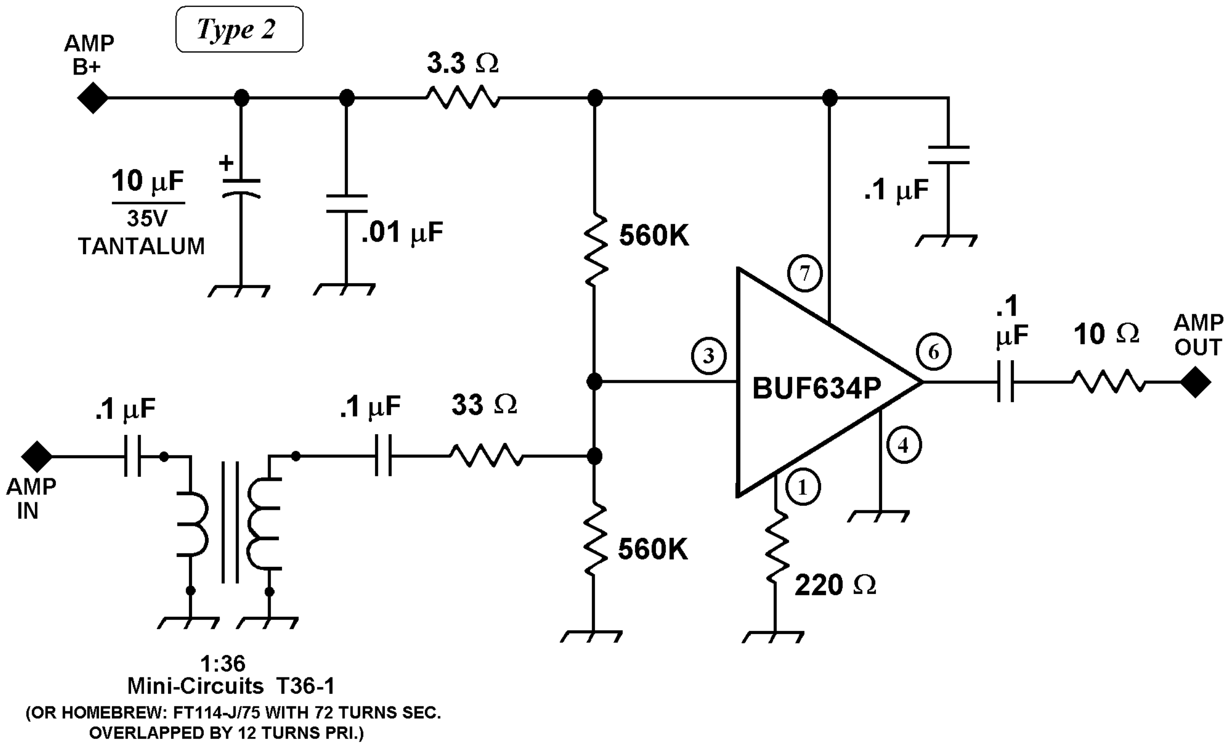


Figure 6: XA-1 transfer amplifier accessory

OTHER AMPLIFIERS THAT CAN BE USED IN THE XA-1



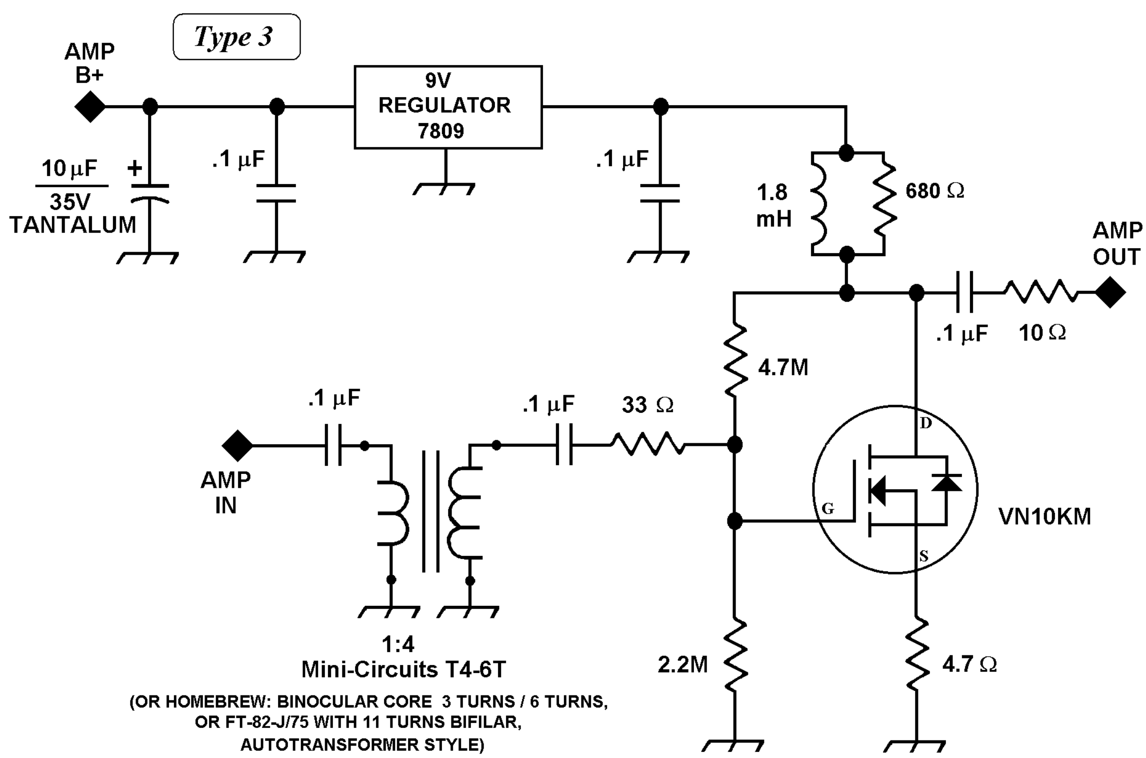


Figure 7: other amplifiers that can be used in the XA-1 box