A Commercial Triplexer Design

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The June 2010 issue of *QST* had an article on a home-made triplexer that allows two or three transmitters to feed a single triband antenna.[1] (This article is provided in the supplemental files section of the *ARRL Handbook* CD-ROM.) This design works well and was built by many people for Field Day and the WRTC championship activities. The author of the article, Gary Gordon, W6KV, was contacted and he had no intention of going commercial with his design. It seemed like a natural idea for a commercial product, so the folks at Inrad (International Radio — **www.inrad.net**) set out to make one.

As designed, the triplexer consists of three series-tuned circuits connected together at the output. Each is resonant on a different band; 20, 15 and 10 meters. The property of a series-tuned circuit that allows the triplexer to work is that the impedance is minimum at resonance and increases for frequencies above and below resonance. So, when connected together at the output or antenna input, the three circuits act nearly independently. The actual component values were selected as a compromise between insertion loss and adjacent band rejection. The resulting rejection is between 13 and 20 dB. *External band-pass filters must be used — the isolation provided by the triplexer by itself is not sufficient to prevent receiver damage!*

Looking at it as a commercial product showed two factors that were problematic. First, the *QST* design used variable capacitors, which are expensive. Also, the capacitor was not grounded, so it needed to be insulated from the enclosure and from the person adjusting it.

Second, analysis of the circuit indicated that the voltage on the capacitor shaft would be 140 volts peak and between the capacitor and inductor it would be about 2000 volts peak for 200 watts input on each single band. This level of voltage could be dangerous to the operator and an ungrounded shaft adjustment is never a good idea.

Both of these concerns were addressed by using three band-pass filters connected together at their outputs to replace the tuned circuits. Various circuit arrangements were tried in *ELSIE*, the filter design program from Tonne Software (**www.tonnesoft.com**) that is provided on the CD-ROM included with this book. The mesh circuit has two positive characteristics for this job. It has series elements so the input and output impedances rise out of the pass band. Also, the element values are perfect for the task at hand. Two tuned circuits provide 15 to 40 dB adjacent band rejection and minimum insertion loss.

Once the schematic was firmed up, circuit analysis was performed with *LTspice* (**www.linear.com/designtools/software**) to determine the component voltage and current requirements for 200 watts per band. The coil voltage requirements allowed selection of powdered-iron toroids that would not overheat and the currents were used to select the wire size. Capacitors were a bit harder to find until multi-layer ceramic capacitors (MLCC) were tried. These capacitors are presently available with up to 500-volt ratings and also have maximum current vs frequency plots. In some cases, series-parallel capacitors were used to meet desired voltage and current requirements. A safety factor of 1.5 to 2 allowed for some variations in antenna SWR.

Capacitors and toroid cores were obtained to verify the selections made from manufacturer's data. Various coils were wound and tested on a Q meter. Type 17 cores had the best Q over the range of 14 to 30 MHz. The -130 size was initially selected. Q was over 200 on all three bands.

Several types of capacitor were tested using the Q meter. The leaded KG-type capacitors tested slightly better than DUR micas, but MLCC surface mount capacitors turned out to be substantially better than both DUR mica and KGE types. An added bonus is that there is actual data on their current performance over the frequency range of interest. This adds a degree of design confidence over other types.

Next, breadboard circuits were built up in a form very close to an actual PC board design. Extensive testing was done with a dummy load and triband Yagi antennas to determine if the design worked in real-world conditions. Some changes in SWR occurred, but the maximum value did not greatly exceed what the antennas showed by themselves.

Power testing followed. Most testing was done at 50% duty cycle for time periods that allowed the temperature to stabilize at a maximum level. The capacitors stayed well within maximum temperature specifications but the coils heated a bit more than desired. Larger cores were obtained and the power testing was repeated. This time the temperature rise was less.

The PC board was designed and a prototype was built. SWR and frequency response looked good, so we went into power testing again. With a full ground plane the temperature rise of the capacitors was much lower. Temperature rise in the coils was 25 °C over ambient. Otherwise performance was similar to the breadboard testing. In production there was some adjusting required to account for component tolerances. This was accomplished by spreading or compressing the toroid windings a small amount.

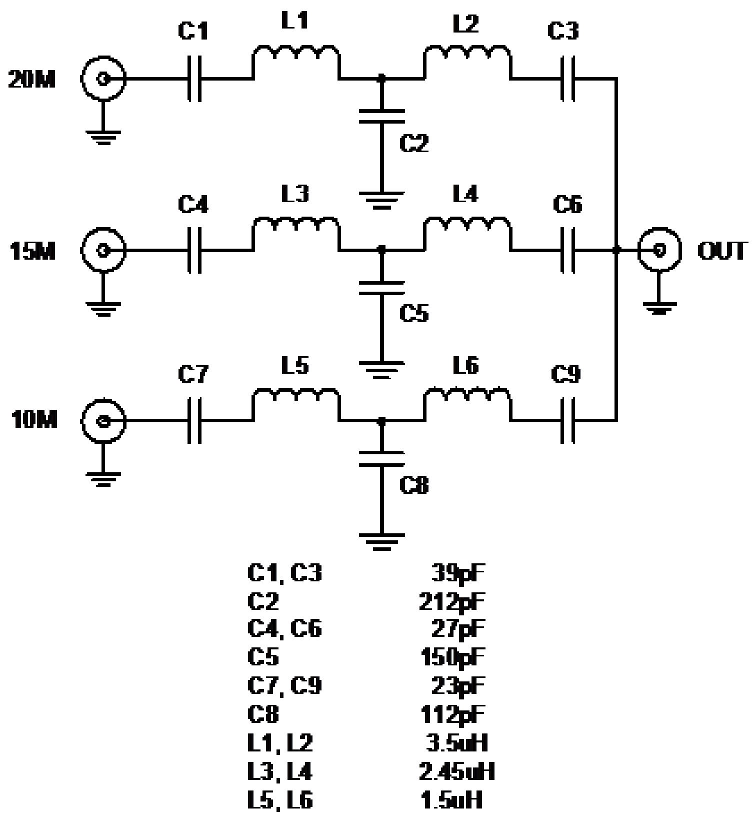

Figure 1 — The commercial triplexer schematic.

The basic schematic of the triplexer is shown in **Figure 1**. Each band consists of a 2-element mesh-type band-pass filter designed in *ELSIE*. The outputs are connected together and there is little interaction between them. Since MLCC capacitors are limited to 100 pF and 500 volts peak, each capacitor is made up of a series-parallel combination.

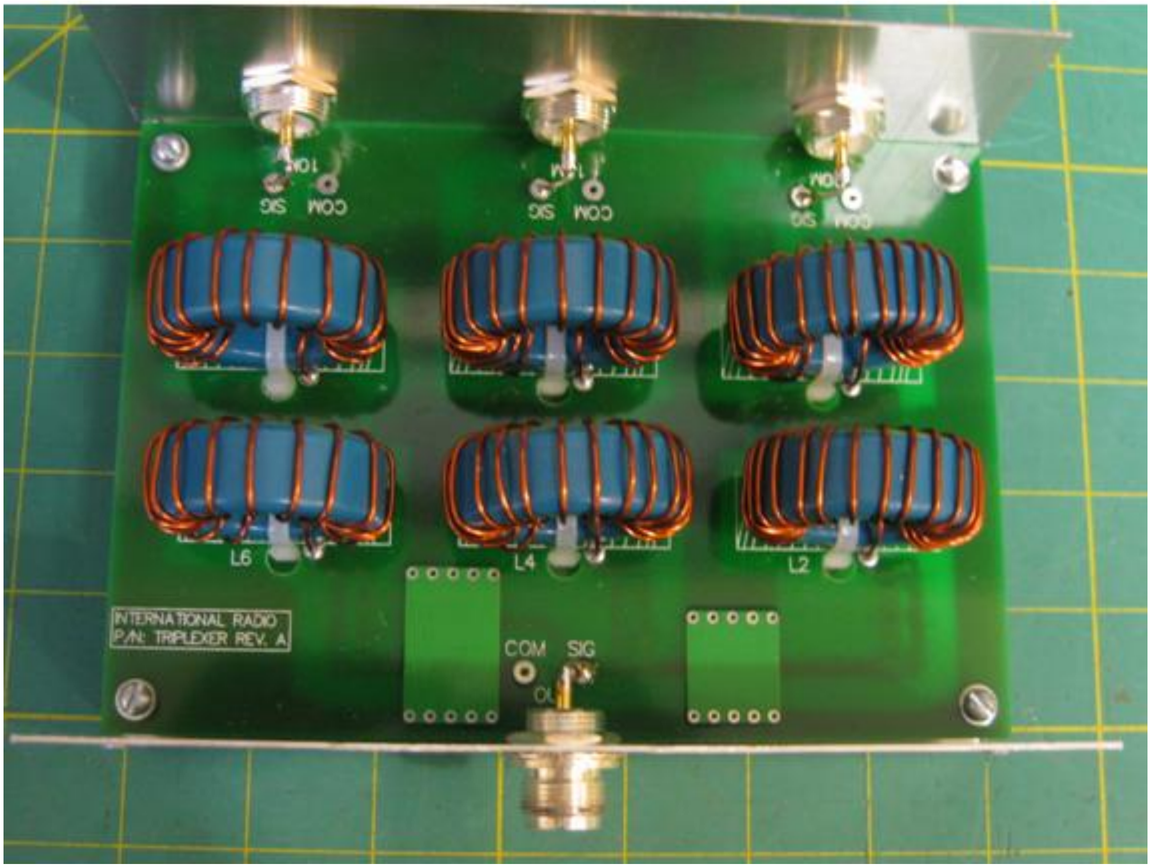

Figure 2 — The inside of the commercial production triplexer.

Figure 2 shows the inside view of a production triplexer. The values in the production unit vary slightly from those in Figure 1 to account for PC board strays. The basic schematic could be built with DUR mica capacitors and used for lower power operation.

References

1. G. Gordon, K6KV, "HF Yagi Triplexer Especially for ARRL Field Day," *QST*, June 2010, p. 37.