High-Power Harmonic Filters

George Cutsogeorge, W2VJN
13620 Tyee Road, Umpqua, OR 97486
w2vjn@rosenet.net

Building filters for high power has always been a problem because the capacitors required are expensive and very hard to find. This article describes several filters created through methods that produce excellent harmonic attenuation without using any capacitors at all.

The first type of filter uses inductor-coupled quarter-wave shorted stubs. Figure 1 shows the schematic and parts values. The inductance value is a compromise between insertion loss and harmonic attenuation. A short length of open coax acting as a capacitor provides SWR compensation. Loss in the coax is minimal and RG-8X is adequate for full-power operation.

The 80-meter filter can be packaged in a 7×12×3 inch chassis. SWR of the 80-meter unit is 1.08 at the low end, 1.02 in the middle and 1.2 at the top of the band. Insertion loss is 0.28 dB. Plots of harmonic attenuation are shown in Figures 2 through 5. The plots show a substantial improvement over a single RG-213 stub. Note that it is possible to resonate the inductor at one specific harmonic and boost the attenuation into the 60 or 70 dB range for that frequency. This has been tried with two 500-V dur-mica capacitors in parallel. Since the current involved is low, the small capacitors are adequate for 1.5 kW.

The 20-meter unit fits into a 7×7×2 inch chassis. SWR is 1.1 at 13 and 15 MHz, and it dips to 1.03 at 14.020 MHz. Loss is 0.2 dB. Figure 6 shows the 2nd harmonic response for this filter. When the stubs are coiled up and put into a shield box, they should be coiled in opposite directions. This will minimize the null frequency shift.

The lengths shown in Figure 1 should be taken as a guide, as cable from different reels will have slightly different propagation velocities. These filters, along with a similar 40-meter unit, have been in use at N3RS through a number of 48-hour contests at full legal power.

Next is a somewhat different design for 40 meters. The objective was a 5-element filter with open-circuit stubs replacing the capacitors. First, open-circuit ¼-wave stubs were cut for 20, 15 and 10 meters. Next, the capacitance of the 20-meter stub and that of the 15 and 10 in parallel were measured. The 20-meter stub measured 407 pF, and the other two in parallel were 338 pF. A suitable filter circuit is shown in Figure 7. The element values shown are the normalized values for a Butterworth filter. The values can be denormalized to any desired cutoff frequency. Working backward using 407 pF as the denormalized capacitance, a cutoff frequency of 12.6 MHz was obtained. Using this frequency, the inductor values were determined to be 0.387 μH for L1, L5 and 1.25 μH for L3. These inductors were wound with #14

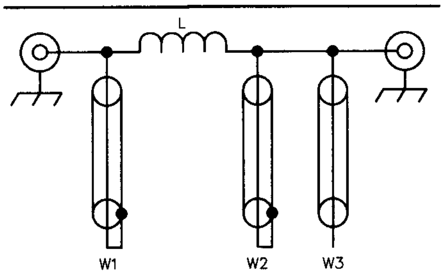

Figure 1 – Inductively coupled stub filter.

	80 meters
L	**7t #16, ¾ in diam × 1 in long**
W1, W2	**¼ λ shorted stub (51 ft, 3 in RG-8X)**
W3	**SWR compensation (6 ft, 1 in RG-8X)**
	20 meters
L	**4t #16, ⅜ in diam × ½ in long**
W1, W2	**14 ft, 4 in RG-8X**
W3	**3 ft, 1 in RG-8X**

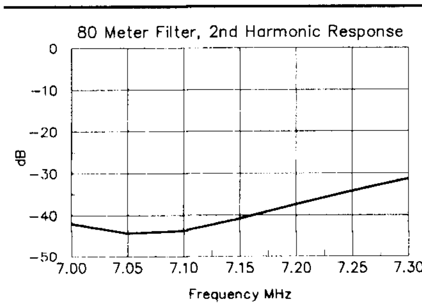

Figure 2 – 80-meter filter, 2nd harmonic response.

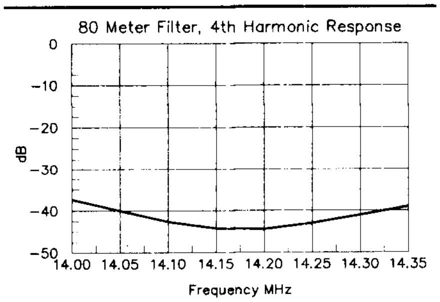

Figure 3 – 80-meter filter, 4th harmonic response.

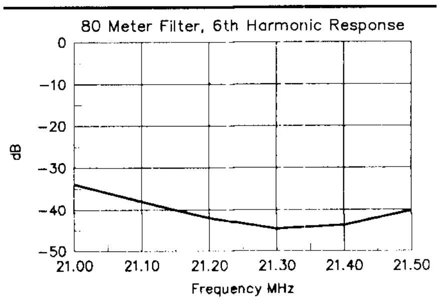

Figure 4 – 80-meter filter, 6th harmonic response.

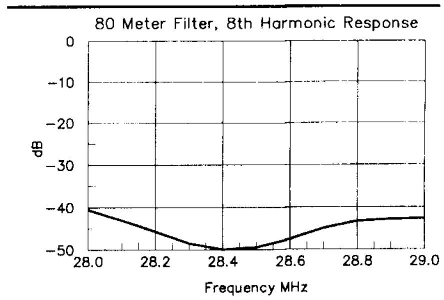

Figure 5 – 80-meter filter, 8th harmonic response.

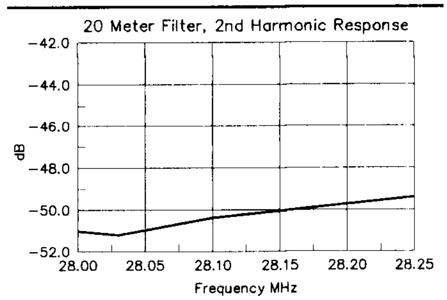

Figure 6 – 20-meter filter, 2nd harmonic response.

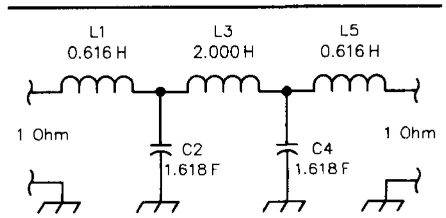

Figure 7 – Normalized 5-element Butterworth low-pass filter.

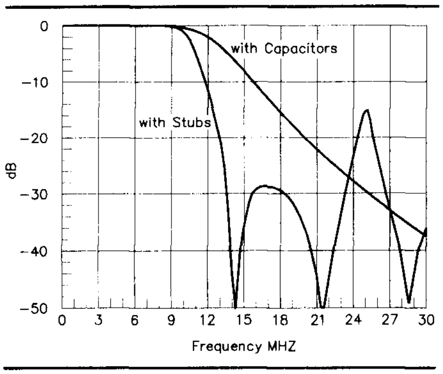

Figure 8 – ARRL Radio Designer calculated response for the filter in Figure 7 "with capacitors", and the measured result for the stub version "with stubs".

wire. C2 was replaced with the 20-meter stub. C4 was replaced with the 15 and 10-meter stubs in parallel. A network analyzer was used to check the response at this point. It looked so good that the compensating capacitor was not added to bring C4 up to 407 pF. Figure 8 shows a RF Designer plot for the filter in Figure 7 with the measured result penciled in for the stub version.

The capacitor version shows attenuation of approximately 7, 24 and 35 dB for 14, 21 and 28 MHz respectively while the stub version has 50-dB attenuation for each of the three bands. The SWR of the filter is less than 1.15 from 7.3 MHz down through 1.8 MHz. Thus, the filter could be used on 1.8, 3.5 and 7 MHz.

The breadboard version using RG-8X stubs was run at 1.5 kW on 7 MHz and it was found that the 20-meter stub got a bit warm. Unlike the shorted stub filters, this filter has fundamental current flowing in the stubs. The 20-meter stub was replaced with RG-213 and the heating was minimized. Since the current was shared with two stubs for the C4 part, heating was not a problem. This filter will take 1.5 kW with ease.

Similar filters could be built for other bands. They could be synthesized from Chebyshev tables as well as Butterworth if some passband ripple can be tolerated.

For further information, see "Stub Filters Revisited," by John Regnault, G4SWX, on the Nov 1994 *Radio Communication.* ■

Remote Beverage Switching

Bill Loviska, N4RN
n4rn@gate.net

This project came to light in the mid 1980s when I noticed that all I needed was 100 countries on 80 meters for the 5BDXCC that I never would submit. Ed, K8OT, suggested using Beverages on receive because "there are all kinds of stations out there — all you have to do is hear 'em." After kicking it around for a couple days during our lunch breaks, we came up with a pretty good plan of attack. All I had to do was put things together. Everything for the controls came out of my junk box, and I don't think any of the values were very critical.

The objective was to switch antennas by injecting a control voltage onto the feed line to power the relays. The chokes keep the selected Beverage's RF out of the power supply and the relay coils, while the caps block the control voltage from the antennas and the radio. Up to four antennas can be controlled by using diodes and a low-voltage power source to feed the two relays. I used a 12-V ac plug-in power pack from some long-gone cassette recorder. The relays were 12 V DPDT. I saw them at Radio Shack for a couple of dollars now. I used a six-position rotary switch with two positions locked out. Position 1 allows no power to the relays (NC) so Antenna 1 is selected. Position 2 is – dc and Antenna 2 is connected. Position 3 is + dc for Antenna 3, and Position 4 is ac for Antenna 4. The original T1 was taken from some book source material and was later replaced with the "KM1H Beverage Transformer." It was the best transformer of the several that I tried. RFC1 and RFC2 were each wound on 1/2-inch toroids. I used about 30 turns of green Radio Shack enameled wire on FT cores in the 71-75 mix range.

A nice looking enclosure is used in the shack and a weatherproof one is used out at the antennas. You are now set to go!

Please refer any questions to me at **n4rn@gate.net**.

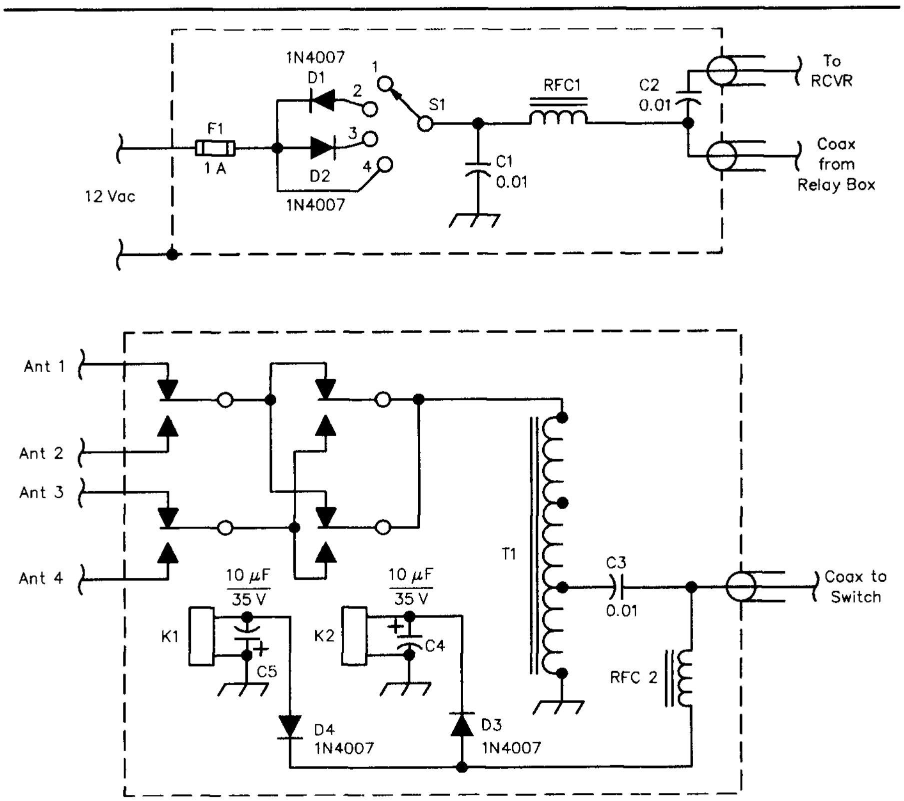

Figure 1 – Schematic diagram of the Beverage switching system. The 12-V ac power source is a "wall cube" from an old cassette recorder.

RFC1, RFC2—See text.
T1—9:1 transformer (KM1H Beverage transformer; see text).
K1, K2—DPDT relays, 12 V dc coil.
S1—4-6 position rotary switch.

Thanks to the Florida Contest Group for allowing us to use this great article from their July 1998 issue of the club newsletter "Contest Gazette" *and pass it on to our readers.– K7BV* ■