INTERDIGITAL BANDPASS FILTERS FOR AMATEUR V.H.F./U.H.F. APPLICATIONS

High-Q Filter Construction Made Easy

BY REED E. FISHER W2CQH,* ex-W3VSB

THE v.h.f. enthusiast often uses a high-Q coaxial filter ahead of his converter, to prevent blocking and crosstalk from nearby TV or f.m. stations. Another v.h.f. man may want a similar filter to "remove the garbage" from his homebrew 2-meter s.s.b. exciter. These single or multiple-section filters are usually laboriously fabricated using conventional circular coaxial construction, and may give questionable results, since the optimum degree of coupling at input and output, and between filters, is usually arrived at by tedious experiment.

The strip-line interdigital [1] filter, designed by modern filter theory, eliminates most of the above trials and tribulations. Multiple-section filters are easily constructed in a few hours, and will work the first time with little or no adjustment. Their low midband insertion loss is comparable with the best circular coaxial filter and their out-of-band attenuation properties are just what theory predicts.

This article will not discuss the design of these filters since this has already been elegantly covered in the literature.[2] Instead, two basic models will be described which, when scaled to other frequencies, will satisfy the filtering requirements of most v.h.f. men. Both filters are constructed of stock size brass and aluminum which can be purchased at most supply houses. No milling is required, although a small lathe is convenient for squaring the resonator ends.

The first filter, Fig. 1, is a four-resonator model centered near 432 Mc., with a 3-db. bandwidth of 2 per cent. The measured insertion loss vs. frequency in a 50-ohm system is shown in Fig. 2.

* 2 Forum Court, Morris Plains, N.J. 07950.

[1] Webster: "Interdigitate — To interlock, as with the fingers of folded hands."

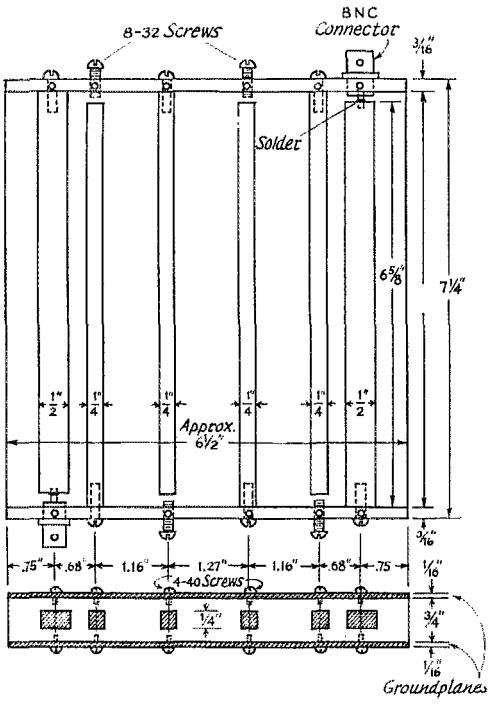


Fig. 1—Mechanical details of the 432-Mc. bandpass filter.

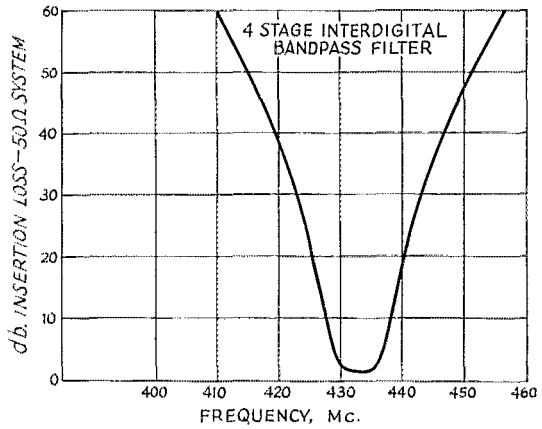


Fig. 2—Bandwidth and insertion loss with the 432-Mc. filter.

The filter has a "maximally flat" or Butterworth response, which means that there are no loss ripples in the passband. It was used to reject the oscillator and image frequencies of the author's s.s.b. upconverter for 28 to 432 Mc.

The filter consists of six interdigitated rectangular rods centrally located between two ground planes. The four ¼-inch square open ended rods

[2] G. L. Matthaei, "Interdigital Band-Pass Filters", *IRE Trans. on Microwave Theory and Techniques*, vol. MTT-10, Nov. 1962, pp. 479-491. Also, W. S. Metcalf, "Graphs Speed Design of Interdigital Filters," *Microwaves*, Feb. 1967, pp. 91-95.

approximately ¼ wavelength long constitute the high-*Q* resonators. The two larger rods, whose open ends are soldered to BNC coaxial connectors, are low-*Q* coupling sections. One end of each rod is drilled and tapped for an 8-32 machine screw so that it may be securely attached to an end wall. The top and bottom ground planes are 1/16" brass or aluminum, fastened to the drilled and tapped end walls by several 4-40 or 6-32 machine screws. It is important that a ground-plane screw be located near the center-line of each rod, since large r.f. currents are flowing in this region. Note that no "side walls" are required. The ground planes overlap the coupling rods by an amount sufficient to prevent any radiation loss.

In the first model built, the rods were plain

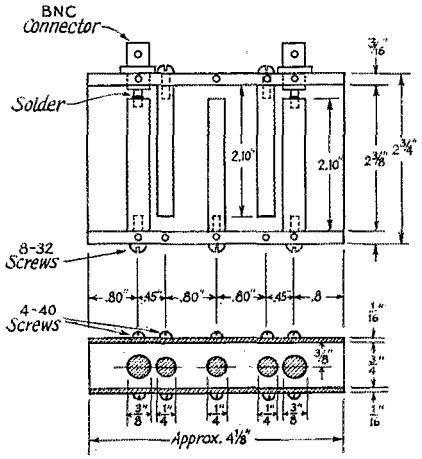


Fig. 3—Structural details of the 1296-Mc. filter are similar to those of the 432-Mc. model, except that three circuits and cylindrical conductors are used.

stock brass and the ground planes were 1/16 inch thick aluminum. This gave a 1.4-db. midband (432 Mc.) insertion loss. A second model, constructed by W2CCY, with silver-plated brass rods and ground planes exhibited a 0.5-db. insertion loss. Tuning screws were included in the first model, but it was later found that if all four resonators were made precisely the same length subsequent tuning was unnecessary.

The filter can be scaled to any other frequency by changing the rod length, but keeping the center-to-center and ground plane spacings the same. For example, the rods would be approximately 20 inches long in a filter tuned for 144 Mc. The 3-db. bandwidth would remain at 2 percent, i.e. 2.9 Mc.

Since the resonators open ends are loaded by "fringing capacitance", their lengths are always slightly less than one quarter wavelength. It is difficult to compute this capacitance and hence accurately predict what the reduction of rod length will be. However since the resonators are easily removed, they can be pruned to the correct length after the filter is initially tested.

When the 3-db. bandwidth of a filter is made

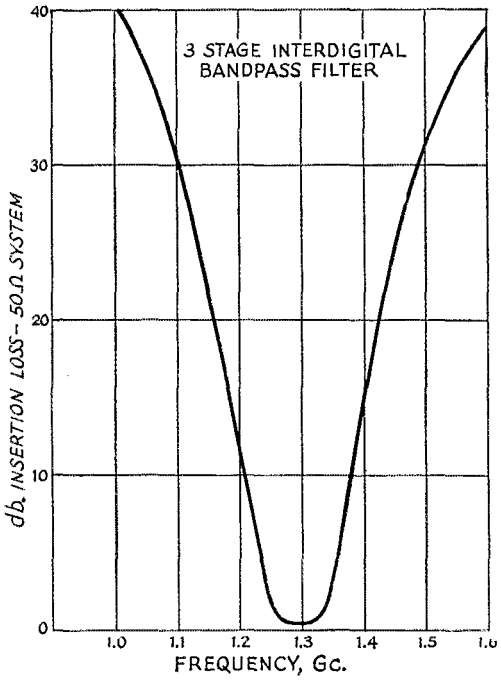
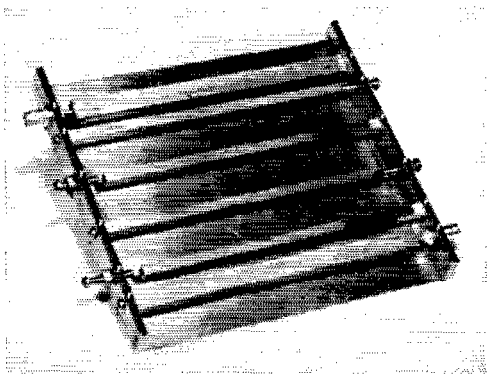


Fig. 4—Performance characteristics of the 1296-Mc. filter

larger, the midband insertion loss will decrease. A three-resonator filter centered near 1296 Mc., with an 8.5 per cent 3-db. bandwidth, is shown in Figs. 3 and 4. This filter gives a 0.4 db. insertion loss, using plain brass round rod construction. It is placed at the output of a 2C39 tripler to remove the 432-Mc. feedthrough. This was a "four-hour special" that worked the first time with no tuning.

It is hoped that this article will remove most of the heartaches usually associated with the construction of v.h.f. and u.h.f. bandpass filters.

QST



Interior view of the 432-Mc. filter, with the top cover removed. Four square brass rods, grounded at alternate ends, comprise the tuned circuits. Larger rectangular rods at each end are the input and output coupling devices, connected to BNC fittings. End plates are 3/16-inch brass. Top and bottom covers are 1/16-inch. Sides are left open.