Quasi-Optimum Filters - A series of Articles

*Note: This work was presented by R. V. Snyder at the European Microwave Conference, October, 1998, The Netherlands*

Given maximum values for available volume and unloaded Q, and with maximum insertion loss, minimum stopband attenuation, maximum VSWR as specifications: how does one best utilize the arsenal of available reactive elements to satisfy the specifications? We will herein define an “optimum” filter network as one most closely approximating the specifications with the minimum usage of volume and number of resonant elements. A “quasi-optimum” filter is defined as one having some of the characteristics of the optimum network. In the last few years, several developments have contributed to moving “quasi-optimum” a bit closer to “optimum”. These include contributions in synthesis and implementation. Among the most important are:

1. Synthesis of circuit canonic blocks which are then cascaded (e.g. Cascade Triplet, Cascade Quad, Chained, etc.)
2. Synthesis of cross-coupled filters (both symmetric and asymmetric types), and the implementation of the syntheses into convenient software packages.
3. Combination of lumped, evanescent and distributed elements in the same network, using the differing characteristics of each as appropriate and necessary.
4. Electromagnetic simulation as applied to the extraction of equivalent circuits to enable fast, repetitive and accurate simulation of networks.

This series of articles will provide examples of the above and show that filter networks are approaching optimality, but that advances in technology will still provide plenty of room for improved performance in the future. In this latter regard, it is suggested that embedment of active elements into passive structures can further reduce size and enhance performance. In the future, such active elements might include quantum-dot based resonators.

**CANONIC BLOCKS**

In [1], R. Levy discusses the use of a subsystem or diakoptic approach to filter implementation, in which block triplets or quadruplets containing a single cross coupling are synthesized and then cascaded. Of course, the cascade of identical sections is analogous to the coupling of synchronously tuned resonant sections and is conceptually familiar. However, implementation using more optimum blocks containing a single cross coupling improves the efficiency of element usage by obtaining specified stopband levels with lower passband losses and group delay. Fig. 1 illustrates the response of a cascade of 4 5th order bandstop filters, each of which is in itself a quasi-elliptic bandstop network. The cascade of these sections provides equivalent attenuation slope to a 26th order Chebychev filter so the economy of design is apparent.
The specifications for the previous bandstop filter are as follows:

P/N 71321A-5
Minimum passband: 891 to 960 MHz
Max. insertion loss over above passband: 2.75 dB (less than 1 dB 895-960 MHz)
Average insertion loss over above passband: less than 1.5 dB, 1 dB typical
Min. -40 dBc rejection: 870 to 888.75 MHz
Min. -35 dBc rejection: 888.75 to 889 MHz
Min. -30 dBc rejection: 889 to 889.9 MHz

Figure 2 is an outline drawing for the filter described above. Figure 3 depicts the interior configuration for one of the four identical blocks within the filter. Although this bandstop example does not use cross-coupling as in a bandpass filter, the center section varies in impedance along its length, and a short length of non-50 ohm slabline connects each 5th order element, with the combination such as to provide the analogous bandstop quasi-elliptic response.
The next example of a CQ bandpass filter is P/N 71782A-2. This is a cascade of two CQ sections, each with a single inductive cross coupling element. The simulated response of the filter is shown in Fig. 4, with actual data in Fig. 5, outline in Fig. 6.
RS Microwave has produced many such filters, with implementation in coax, dielectric resonator, waveguide, stripline and lumped element. We will be happy to apply this exciting technique to your particular problem.

[Rev. 12/08 figs 5&6]