A MONOLITHIC CHANNELIZED PRESELECTOR FOR EW RECEIVER APPLICATIONS

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ABSTRACT

A switched preselector, consisting of monolithic bandpass filters, multi-throw switches and broadband amplifiers has demonstrated excellent selectivity and low loss characteristics in considerably less volume than conventional microstrip designs. The switches employ series and shunt FETs in 1P4T and 1P2T configurations, while the filters were designed using semi-lumped element techniques.

INTRODUCTION

The growth in enemy RADAR threats, both in spectral density and operating frequency, has increased the bandwidth and selectivity demands on modern EW receivers. Although, the bandwidths have been broadened, the requirements for large dynamic range have not been diminished. To meet these conflicting requirements, many systems employ receiver architectures based around spectrum channelization, which requires multi-throw switches and high order bandpass filters.

However, when the channelization bandwidths are less than an octave, as required in spurious free receiver designs, the first few filters in the channelization bank must be centered at relatively low microwave frequencies, hence they tend to be quite large if realized with conventional microstrip techniques. Spurious filter responses are also troublesome when distributed transmission line synthesis is employed because the filter stop bands usually must extend many octaves above their center frequencies. By employing monolithic lumped-element circuit design methods, multi-order spurious free responses can be obtained with circuit sizes of only a few square millimeters.

DESIGN

In order to demonstrate this concept, a preselector filter bank with post amplification was designed. The filter array consisted of four, 5 pole Chebyshev bandpass topologies, with center frequencies of 1.5, 2.8, 4.9, and 9.2 GHz and bandwidths of slightly less than an octave. The L-C filter realizations were designed using monolithic parallel plate (MIM) capacitors (C's) and high impedance transmission lines for inductors (L's). Realization of the inductor values was simplified by using tapped inductor techniques simulating an auto transformer, thus, enabling the designer to select a variety of transforming ratios. In this case, a 4 to 1 impedance transform (2 to 1 voltage transform) was selected since it yielded convenient element values. For example, a bandpass filter network with a 50 to 12.5 ohm transforming tap is shown in Figure 1. The element values for LT1, and LT2 are found from tapped resonant circuit design procedures [1]. However, the tapped inductor circuit is not exact since the filter passband is on the order of an octave in width, which causes the resonators to exhibit a lower Q than required for proper transforming action. This can easily be remedied by adjusting the tap location

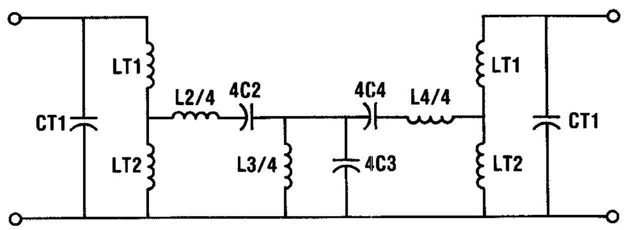

Figure 1. Five Pole Bandpass Filter Using Autotransformers.

to simulate the performance of the untapped case. In the tapped low band filter design, the maximum inductor size becomes 4.4 nH compared to 17.6 nH obtained from conventional 5 pole Chebyshev filter synthesis. The capacitor values range from 0 3 pf to 16 pf.

The designs for the single-pole-double-throw and single-pole-four- throw switches were based on series-shunt FET configurations. In this configuration, each of the switch arms is composed of a series FET followed by two shunt devices (Figure 2). The desired path is determined by selecting the proper FET bias. For example, in the arm that is biased for minimum attenuation, the series FET is in the low resistance state (Vgs = 0 Vdc), and the shunt FET's are biased at pinch-off (Vgs < - 5 Vdc). Conversely, when the switch arms are in the attenuated state, the series FET is

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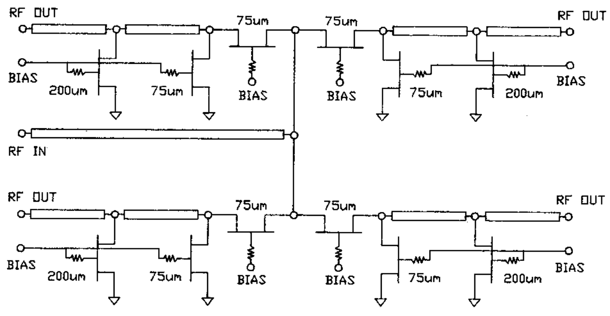

Figure 2. Single Pole Four-Throw Switch Schematic.

biased at pinch-off, while the shunt devices are biased for minimum channel resistance.

The complete switch topology is designed using low pass filter synthesis techniques. In the low attenuation state, the shunt FET parasitics form the shunt C's of the filter while the series inductances are simulated by high impedance transmission lines (Figure 3). However, it should be remembered that the series FETs, which are biased at pinch-off, place a shunt reactance at the junction of the switch that must be accounted for in the low pass synthesis and matching approach. The drain-to-source capacitance of these series FETs also impact isolation; the smaller the FET, the greater the isolation since the parasitic capacitance is minimized. Unfortunately, the parasitic resistances of small FET's biased in the linear region tend to be high, degrading the insertion loss of the switch. Therefore, the FET sizes must be selected so that a compromise between insertion loss, isolation and bandwidth is obtained.

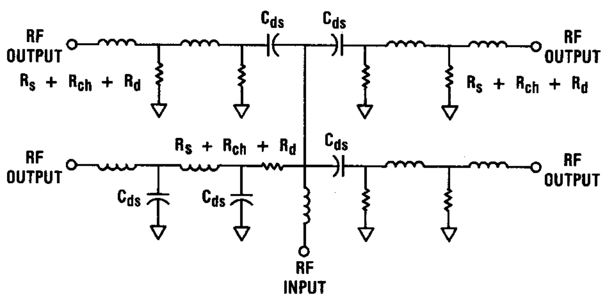

Figure 3. Low Pass Filter Model of Four-Throw Switch.

RESULTS

The complete preselector bank with its equivalent circuit diagram is shown in Figure 4. Post amplification for each RF channel was provided by monolithic distributed amplifiers designed for either

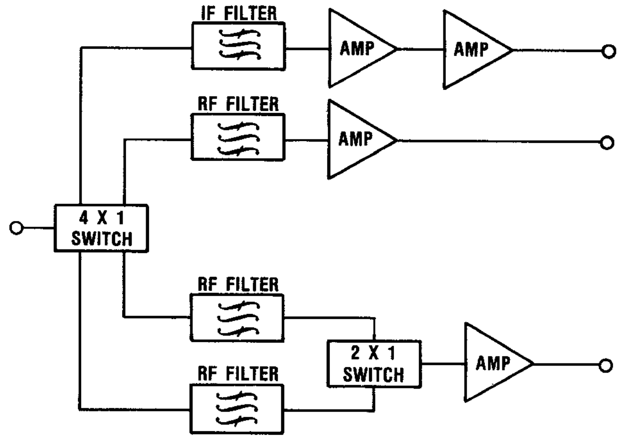

Figure 4a. Preselector Filter Bank Block Diagram.

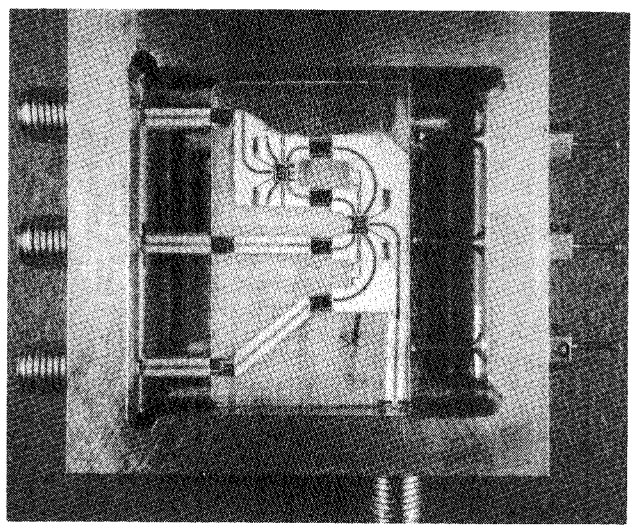

Figure 4b. Preselector Filter Bank Module.

0.1 to 8 GHz or 2 to 18 GHz depending on the frequency band of interest. The monolithic bandpass filters with their separate response characteristics are shown in Figure 5. The filters exhibit true lumped element performance, specifically, no harmonic related responses. The multi-throw switches (Figure 6) also exhibit excellent performance. The switch isolation, insertion loss and return loss characteristics are shown as a function of frequency in Figure 7. The complete preselector performance is shown in Figure 8.

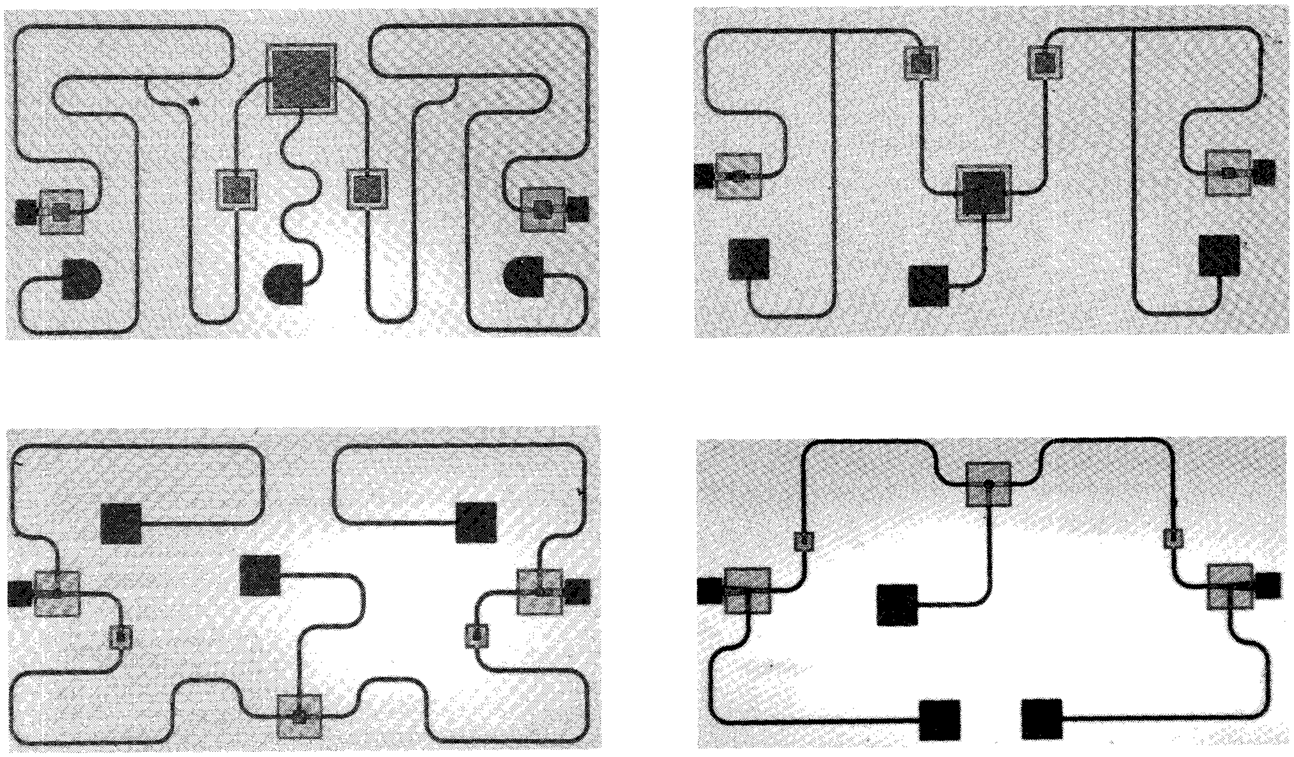

Figure 5a. Monolithic Bandpass Filters.

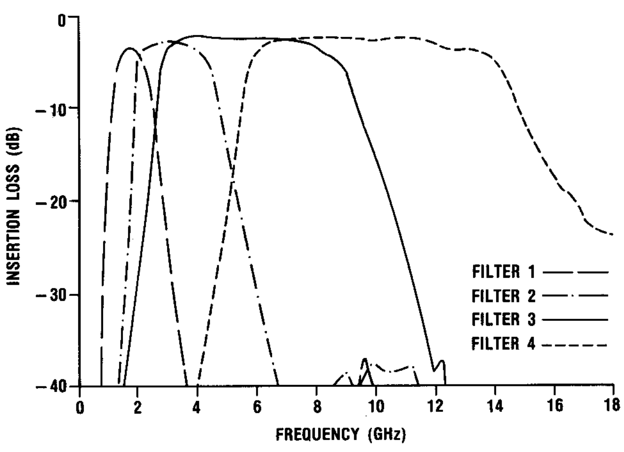

Figure 5b. Frequency Response Characteristics.

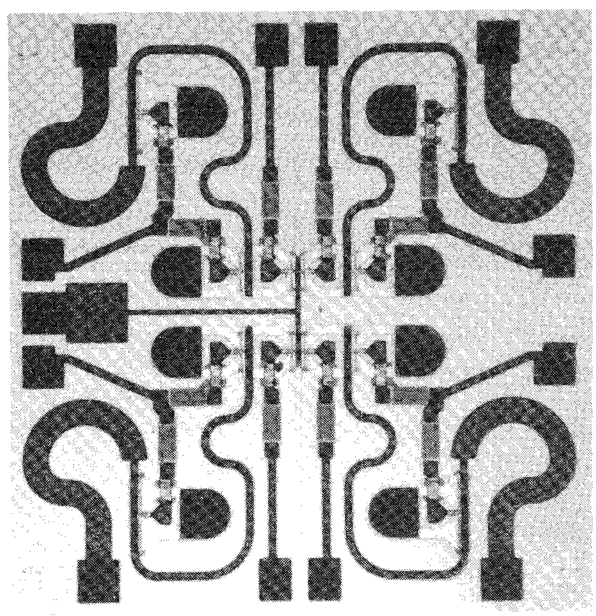

Figure 6. Monolithic Four-Throw Switch.

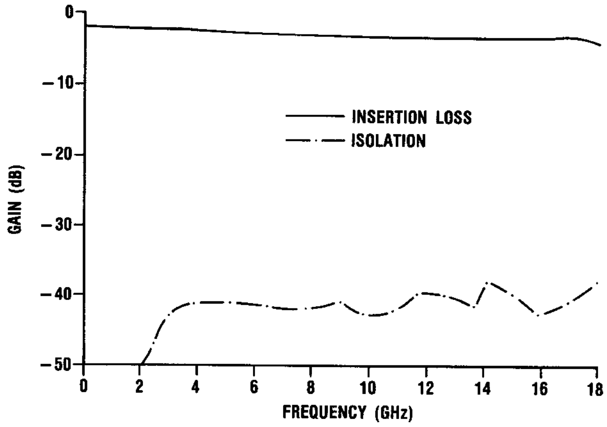

Figure 7a. Monolithic Four-Throw Switch Performance Insertion Loss and Isolation

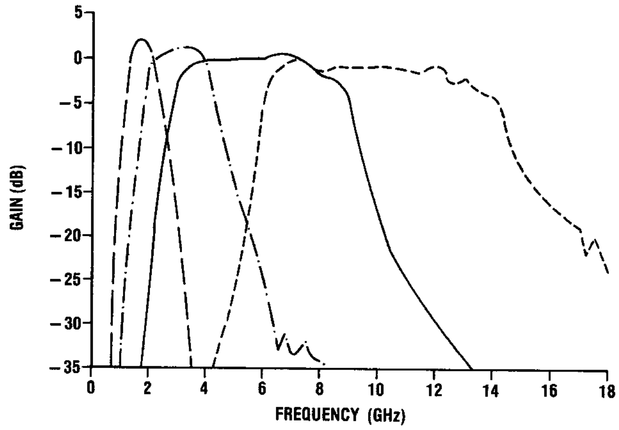

Figure 8. Complete Preselector Performance.

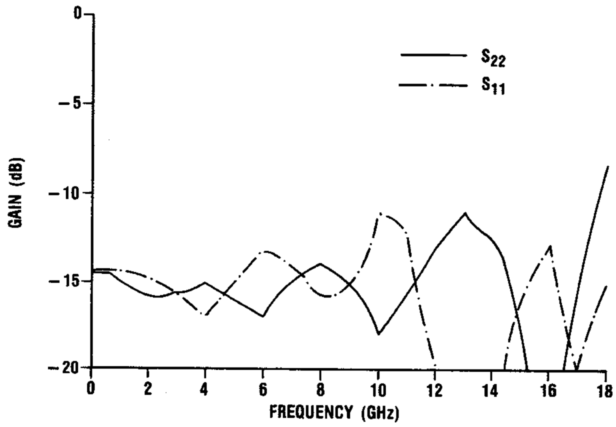

Figure 7b. Monolithic Four-Throw Switch Performance Input and Output Return Loss.

CONCLUSION

By employing monolithic lumped-element filters, GaAs FET switches and amplifiers, extremely small EW receivers with full RF channelization capability can be designed. Excellent channel- to-channel isolation, switching speed, and sensitivities, comparable to other much larger hybrid approaches, can be obtained.

REFERENCE

[1] H. L. Krauss, C. W. Bostian, and F. H. Raab, Solid State Radio Engineering, John Wiley & Sons, New York, 1980, pp. 48-54.