FOLDED-LINE AND HYBRID FOLDED-LINE BANDSTOP FILTERS†

by

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Abstract

The feasibility of a new, compact bandstop filter geometry is demonstrated theoretically and experimentally. The filter geometry is particularly suited for stripline and MIC fabrications in that grounding is not required for any part of the filter. Hybrid folded-line geometries allow the filter designer substantial flexibility in choosing a suitable shape factor without significantly effecting the filter's electrical characteristics. The filter geometry is suitable for narrow bandwidth (provided capacitive coupled stubs are used) to wide bandwidth applications.

Introduction

Stripline and microwave-integrated-circuit (MIC) fabrication of microwave components and systems is preferred to alternative realizations with respect to size, weight and (usually) reproducibility. To minimize the number of substrates in a given system, or sub-system, the number of components per substrate should be maximized consistent with isolation requirements between components. The compact bandstop filter geometry described in this paper (referred to as a folded-line geometry) utilizes the substrate surface area very efficiently, and the design theory allows the filter designer to utilize alternative hybrid geometries that give essentially the same electrical performance.

The folded-line bandstop filter is shown in Fig. 1. The filter is based on an extension of techniques used previously for bandpass filter[1,2] and distributed transformers.[3] Conceptually, the folded-line bandstop filter may be thought of as a meander-line with quarter-wave stubs connected to the meander-line turns, or as a conventional quarter-wave bandstop filter (hereafter referred to as a linear bandstop filter) which has been folded in an accordian fashion. The distance between folded quarter-wave lines is sufficiently small that considerable coupling between turns can exist. This has the effect of moving the transmission zeros, normally at $S = \pm 1$*, to elsewhere in the complex plane. Consequently, new designs are required.

For a given filter degree (equal the sum of stubs and connecting lines) folded-line and linear bandstop filters have nearly identical electrical characteristics. Figure 2 shows the theoretical attenuation responses for linear and folded-line filters for a representative case in which the stop bandwidth is 67 percent and the filter degree is 9. The principal differences are seen to be a shift in the ripple extremes in the passband, and an increased selectivity for the folded-line filter. The shift of ripple extremes in the passband is inconsequential. However, although the differences in stopband selectivity are not important for narrow band filters, they tend to become appreciable as the bandwidth increases. For example, for the N = 5 (degree 9) case, a folded-line filter having an bandwidth of 0.5 has approximately 14% greater selectivity than its corresponding linear filter at the 50 dB attenuation points. Figure 3 gives more detailed comparisons of selectivities between the linear and folded-line filters. The curves are the ratio of electrical degrees (or frequencies) at 50 dB (or 10 dB) attenuation to the equiripple band edge.

* $S = j \tan(\Theta)$ [Richards transformation]

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Hybrid Geometries

Several hybrid geometries are illustrated in Fig. 4. These are obtained by folding some sections of the linear filter while not folding others. Hybrid geometries offer the filter designer more choices in choosing a suitable shape factor without significantly changing the filter responses. The same design procedure is used for hybrid as for folded-line filters. Again, coupling between folded turns is generally significant and must be accounted for in the design process.

Experimental Results

Thirty and 67 percent bandwidth folded-line bandstop filters were designed, constructed in stripline and tested. Figure 5 shows the 67 percent bandwidth filter, which was of degree 9, and had a 0.1 dB ripple in the passband. Coupling between folded-lines was between 12 and 18 dB. There was no significant coupling between stubs, a requirement in this particular design. The center frequency was selected to be 1.5 GHz. The measured attenuation and return loss data are presented in Fig. 6. There is seen to be reasonable agreement between the data and the desired specifications.

Conclusions

Folded-line bandstop filters have been designed, analyzed, and constructed. Theoretical calculations showed that the folded-line filter has comparable passband performance and superior bandstop performance. Experimental results adequately confirmed the designs and feasibility of the filter. Folded-line and hybrid geometries together with linear geometries should provide the filter designer with increased flexibility for stripline or MIC realizations.

References

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3. E.G. Cristal, "Meander-line and hybrid meander-line transformers," IEEE Trans. on Microwave Theory and Techniques, pp. 69-76, February 1973.

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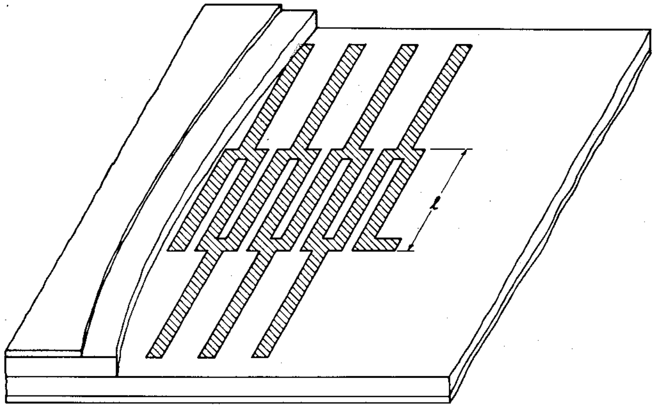

Fig. 1. Folded-Line Bandstop Filter

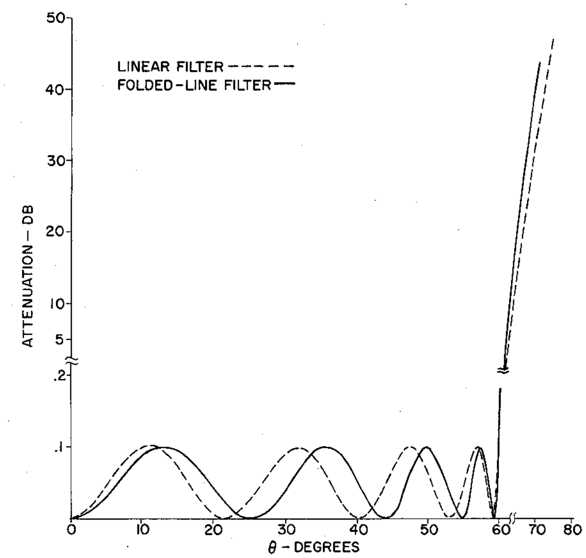

Fig. 2. Attenuations of a Linear and Folded-Line Bandstop Filter

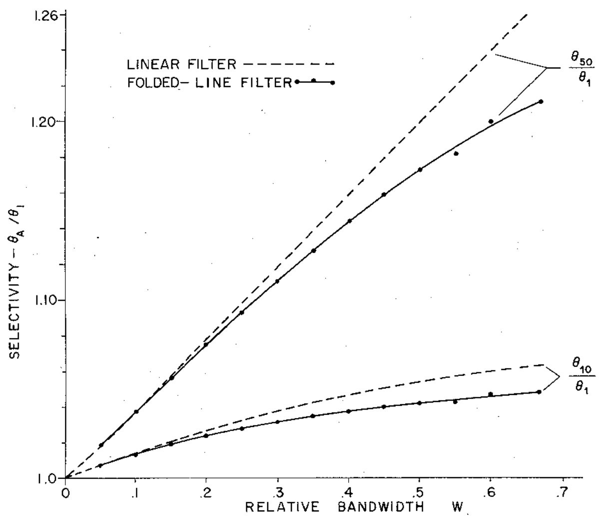

Fig. 3. Selectivities of a Linear and Folded-Line Filter

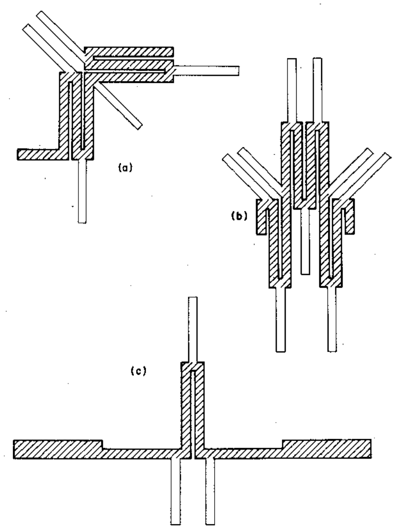

Fig. 4. Examples of Hybrid Folded-Line Bandstop Filters

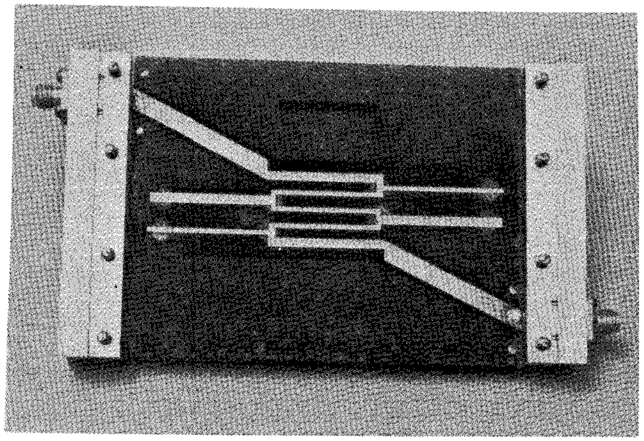

Fig. 5. Trial Octave-Bandwidth Folded-Line Bandstop Filter

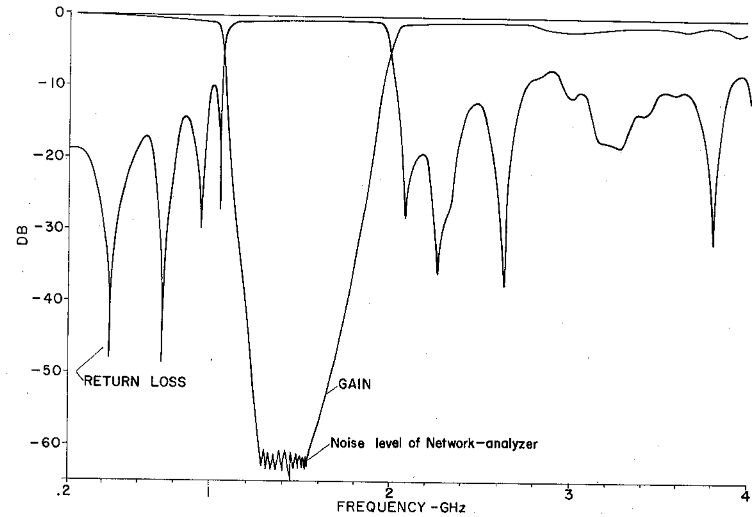

Fig. 6. Measured Responses of the Trial Octave-Bandwidth Folded-Line Filter