REALIZATION OF ELLIPTIC FUNCTION BANDSTOP FILTERS BY MEANS OF A RESONATED PROTOTYPE

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Abstract. Elliptic function bandstop filter realizability is normally improved by the use of a resonated prototype. It is indicated that if unit element transforms are performed before the bandstop transform is performed, a simpler procedure results, as well as exact realizations for cases of $N = 5$ or higher.

INTRODUCTION

In the design of elliptic function bandstop filters using unit element transforms (the Kuroda- and Kuroda-Levy transforms) on lumped element prototypes, the resultant element values are often found difficult or impossible to realize. Levy and Whiteley[1] suggest that the lowpass prototype first be resonated before performing unit element transforms. This procedure results in element values that are much more easily realized. Where unit elements have to be transformed across Foster sections that result from transformed simple L or C elements only, the resultant networks are again Foster sections together with unit elements, as would be the case for filters of order 3 or 4. If, however, such transforms are performed over Foster sections that result from resonated Foster sections, such as occurs in filters of $N = 5$ or higher, the resulting networks are almost-degenerate Brune sections, that can in the narrowband case be approximated by Foster sections.

It will be shown that with unit element transforms performed on the unresonated prototype, and the resultant network than resonated, a substantial simplification in the procedure is obtained, as well as degenerate sections without approximations for any order of network.

TRANSFORM

Under the transform[2]

$$p = j \tan \theta/2,$$

the input impedances of an open- and a short-circuited stub of electrical length θ become, respectively,

$$Z_{so} = pL + 1/(pC) \quad , \quad L = Z_0/2 \quad , \quad C = 2/Z_0$$
$$Z_{sc} = pL/(1 + p^2LC) \quad , \quad L = 2Z_0 \quad , \quad C = 1/(2Z_0)$$

The physical networks shown in Fig. 1 (a) will consequently give identical performance. In the case of the Foster sections shown in Fig. 1 (b), identical performance is obtained if

$$Z_A = \tfrac{1}{2}Z_1(1 + 1/f^2) = Z_D \ , \ Z_B = \tfrac{1}{2}Z_1(1 + f^2) = Z_C \ ,$$
with $f = \sqrt{k+1} + \sqrt{k}$, $k = Z_2/Z_1$.

A unit element of impedance Z_0, length θ transforms to two unit elements, impedance Z_0 and length $\theta/2$ each.

DESIGN PROCEDURE

As an example, the steps in the design procedure for a 5th order bandstop filter with $\rho = 20\%$, $\theta = 30^0$, $\Omega_s = 2.00$ from [3] and 10% bandwidth will be illustrated. Fig. 2 (a) shows the lumped element prototype, while the prototype, scaled to 50 Ω and $B = 10\%$ is shown in Fig. 2 (b) after the application of the unit element transforms[4]. Application of the p-transform yields the network shown in Fig. 2 (c). The final filter is realizable by means of coupled line sections as shown in Fig. 2 (d). Table I shows the dimensions for the various sections, for $b = 10$ mm, $t/b = 0.4$.

TABLE I

DIMENSIONS OF COUPLED LINE CONSTRUCTION

	1	2	3	4	5	6	7	8
w_1	4.13	4.12	5.07	4.91	4.94	4.91	4.42	4.22
s	1.60	1.85	2.00	1.65	1.65	2.00	2.20	1.65
w_2	3.21	4.38	3.46	3.30	3.30	4.77	3.40	3.38

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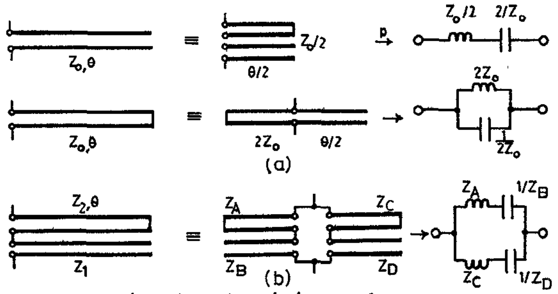

Fig. 1. Identities under $\rightarrow p$.

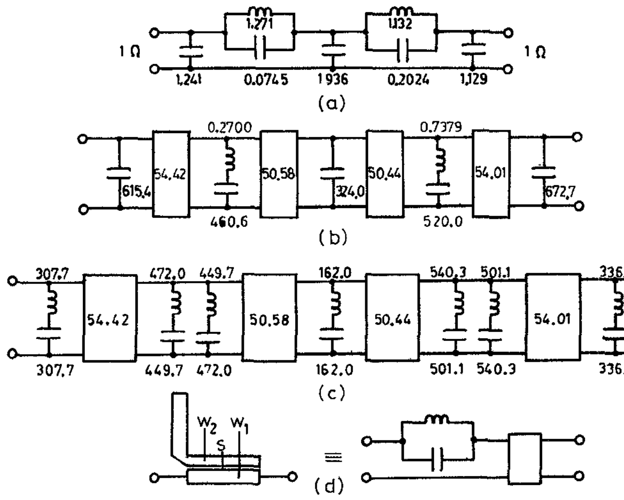

Fig. 2. Development of a prototype.

Note that, to ease realizability, the central Foster section is realized as two shunt sections of double the impedance. The additional unit element needed for this is available in the network in any case.

CONCLUSION

The modified design procedure described, simplifies the design of elliptic function bandstop filters while removing the necessity for approximations. Although the transform doubles the complexity of the structure, the same physical space is occupied, without any increase in mass. The described design would not previously have been realizable by means of commensurate lines.

REFERENCES

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