II-4 WIDEBAND, HIGH SELECTIVITY DIPLEXERS UTILIZING DIGITAL-ELLIPTIC FILTERS *

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The high selectivity and compact form of digital-eliptic filters [1-2] makes them attractive for use in wideband diplexers. The theory of diplexers has been described in several references [3-6] where it is shown that a perfect match at the input of a diplexer requires the component filters to be complementary. Filters with equal-ripple response in both pass band and stop band can be designed to be complementary; however, it has been pointed out [4] that this places an undesirable restriction on the isolation characteristic. The use of "pseudo-complementary" filters [4-5] allows the achievement of equal-ripple designs with high isolation characteristics at the cost of a slight increase in input VSWR. The performance of such filters is discussed in detail in [4] where it is shown that for proper operation the component filters should:

(1) be designed on a single-terminated or transfer immitance basis ($|Z_{12}|^2$ for series connection and $|Y_{12}|^2$ for parallel connection),
(2) Have attenuation characteristics that "cross over" at the 3-db level,
(3) have component attenuation characteristics whose slopes are equal and of opposite sign at the croes over point, and
(4) have a total real part input immitance that is approximately constant (to within 20%, for example) and devoid of extremely rapid variations.

Under the above conditions, the maximum input VSWR of the resultant network is given approximately by [4].

$$VSWR_{max} \approx \text{antilog}_{10} \frac{\alpha}{10} \tag{1}$$

where α is the transfer immitance prototype ripple value in db.

Digital-elliptic filter prototypes contain only distributed L-C type elements (i.e., no unit elements) and a suitable diplexer prototype can be obtained by bandwidth scaling the appropriate low-pass and high-pass transfer immitance values in the conventional manner [3-5] to produce the required 3-db level cross over. Element values for singly-terminated elliptic-function filters are given in [7] for filters of three through seven branches(from one to three finite transmission zeros). The particular filter configuration to be described used a parallel connection of digital-elliptic component filters and thus requires the input admittances to be minimum susceptive [4]. This requires the low-pass prototype filter to begin with a series inductance and the high-pass prototype filter to begin with a series capacitance and consequently limits the basic prototype to filters with an even number of branches (i.e., 4, 6, etc.). Although filters of four or six branches are of sufficient complexity to satisfy most requirements, higher-order filters are sometimes needed. To satisfy these requirements, element value tables for even-order prototype filters with greater than six branches are being obtained by synthesis [8]. Because the

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digital-elliptic filter prototype contains only L-C elements, the basic design is bandwidth scalable in a simple manner and only a few tables are required. The computer generated tables of element values [8] are bandwidth scaled to achieve the required 3-db level cross over and also include the maximum theoretical input VSWR as computed by direct analysis. In all cases computed, this maximum input VSWR was in agreement with equation (1) demonstrating the validity of conditions (1) through (4) given above.

As an example, the basic prototype circuit and typical response characteristics for n = 6 branches are shown in Figure 1. An element value table for the six branch prototype is given in Figure 2. An experimental diplexer has been constructed using the above table for the case of 2.25:1 bandwidth and selectivity parameter k = 0.7065. The design procedure is quite simple, a detailed description of the applicable techniques being given in [2]. The experimental filter was designed to have cross over frequencies at 1.5 and 3.375 GHz. A perspective drawing of the diplexer is shown in Figure 3, and a photograph of the trial device is shown in Figure 4. The results are seen to be in excellent agreement with theory at the first cross over and are quite good even beyond the second cross over. The structure is extremely compact in comparison with previous diplexers of comparable characteristics and provides an attractive solution to the wideband, high selectivity diplexer problem.

References

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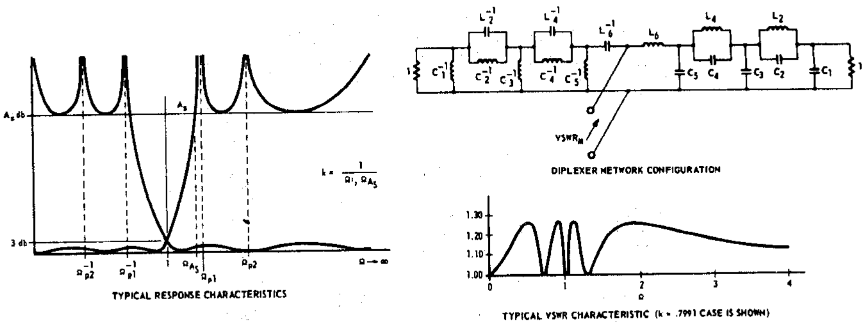

FIG. 1 - Digital-Elliptic Diplexer Prototype Circuit and Response Characteristics for n-6 Branches

$|Y_{12}|^2$ PROTOTYPE PASS-BAND RIPPLE = 1.00 DB (ACTUAL TRANSMISSION RIPPLE ≈ 0.06 db)

k	C_1	C_2	L_2	C_3	C_4	L_4	C_5	L_6	Ω_{p2}	Ω_{p1}	A_s db	$VSWR_M$	Ω_{k_s}
0,2996	0.8715	0.0282	1.5834	1.7022	0.0457	1.9169	1.6716	1.7093	4.7293	3.3778	112	1.2685	1.0240
0,3469	0.8602	0.0386	1.5658	1.6795	0.0624	1.8828	1.6574	1.7097	4.0698	2.9172	103	1.2687	1.0236
0,4038	0.8437	0.0537	1.5404	1.6470	0.0869	1.8340	1.6371	1.7101	3.4767	2.5051	96	1.2689	1.0230
0,4516	0.8273	0.0690	1.5153	1.6151	0.1116	1.7861	1.6172	1.7106	3.0925	2.2397	89	1.2689	1.0224
0.4997	0.8082	0.0872	1.4861	1.5784	0.1411	1.7310	1.5942	1.7111	2.7774	2.0237	83	1.2687	1.0218
0,5481	0.7858	0.1090	1.4520	1.5362	0.1783	1.6679	1.5679	1.7117	2.5136	1.8443	77	1.2679	1.0210
0,6008	0.7538	0.1411	1.4036	1.4773	0.2283	1.5798	1.5312	1.7124	2.2469	1.6652	72	1.2659	1.0200
0,6563	0.7216	0.1745	1.3554	1.4201	0.2826	1.4941	1.4955	1.7131	2.0560	1.5389	66	1.2664	1.0189
0,7065	0.6830	0.2165	1.2980	1.3536	0.3512	1.3948	1.4540	1.7139	1.8844	1.4289	61	1.2698	1.0177
0,7472	0.6459	0.2589	1.2435	1.2921	0.4210	1.3030	1.4156	1.7145	1.7625	1.3503	55	1.2708	1.0165
0,7991	0.5881	0.3290	1.1601	1.2017	0.5390	1.1677	1.3591	1.7153	1.6185	1.2616	50	1.2702	1.0148
0,8526	0.5106	0.4335	1.0509	1.0897	0.7166	1.0000	1.2888	1.7159	1.4816	1.1813	44	1.2676	1.0127
0,8970	0.4217	0.5706	0.9308	0.9756	0.9606	0.8274	1.2165	1.7159	1.3723	1.1217	38	1.2587	1.0104
0,9564	0.2148	0.9973	0.6741	0.7683	1.7072	0.5048	1.0830	1.7113	1.2196	1.0498	30	1.2673	1.0063

FIG. 2 - Element Value Table for n-6 Branches

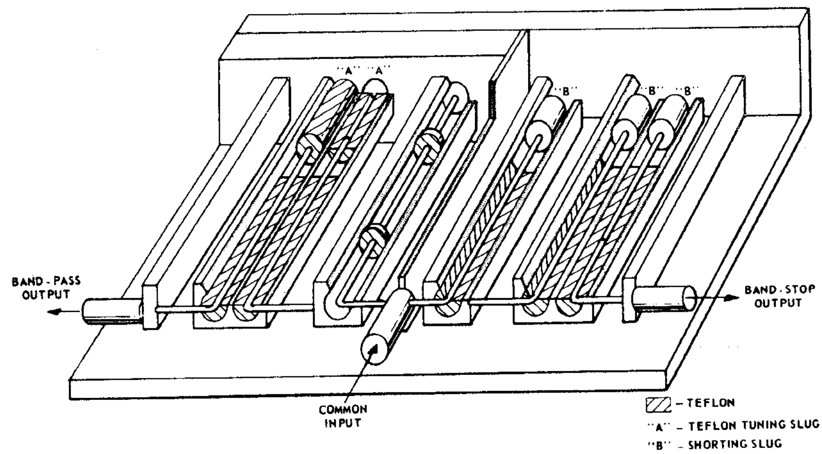

FIG. 3 - Perspective Drawing of Experimental Wideband Digital-Elliptic Diplexer

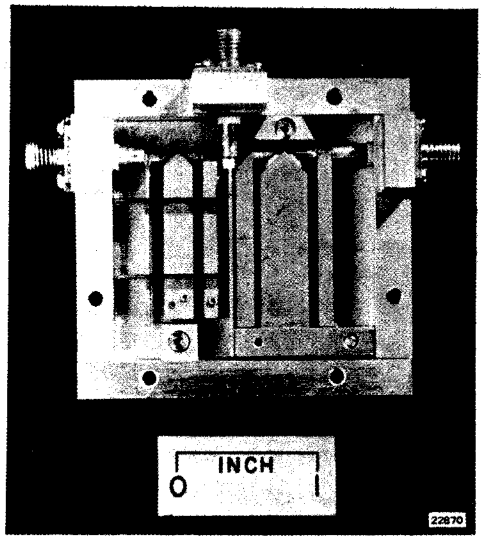

FIG. 4 - Experimental Digital-Elliptic Diplexer

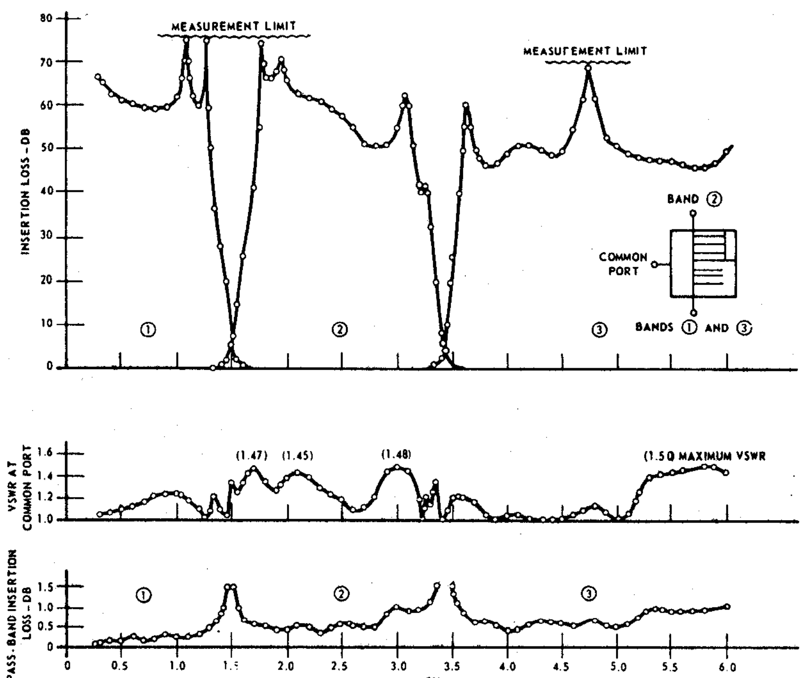

FIG. 5 - Measured Response of Experimental Digital-Elliptic Diplexer