Synthesis of Nonreciprocal Lossless Two-Port Networks Using Coupling Matrix Techniques

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The coupling matrix technique has been mainly used to synthesize microwave filters with quasi-elliptic responses in the past. However, its application is not limited to filters, and may generally apply to all the two-port networks. All the schemes involving the coupling matrix technique reported to date have been concerned with reciprocal networks. In the area of nonreciprocal networks, the only reported synthesis technique consisted in directly cascading networks including gyrators to realize nonreciprocal lossless networks.

In this paper, a coupling matrix technique is presented for the synthesis of nonreciprocal lossless two-port networks. This technique introduces complex inverters to build the nonreciprocal transversal network corresponding to the nonreciprocal coupling matrix. It subsequently transforms this matrix into canonical topologies through complex similarity transformations. The complex inverters in the final topology are transformed into real inverters and gyrators for implementation simplicity. A second order example is then given to illustrate the proposed technique. Fig. 1 shows the synthesized coupling matrix and topology of the second-order example. Note that it consists of three real couplings corresponding to conventional impedance inverters, and one imaginary coupling corresponding to a gyrator. Fig. 2 shows the calculated group delay and magnitude of the scattering parameters. Note that the group delay response is nonreciprocal, whereas the magnitude response is reciprocal. The magnitude reciprocity is a fundamental property of all the lossless two-port networks.

	S	1	2	L
S	0	1.613	0	0
1	1.613	0	− j 1.806	− 1.240
2	0	j 1.806	0	1.030
L	0	− 1.240	1.030	0

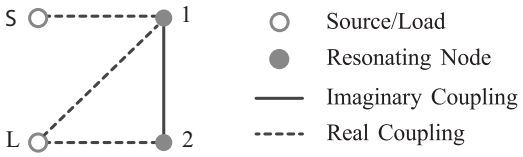

Fig. 1 Coupling matrix and topology of the second-order example.

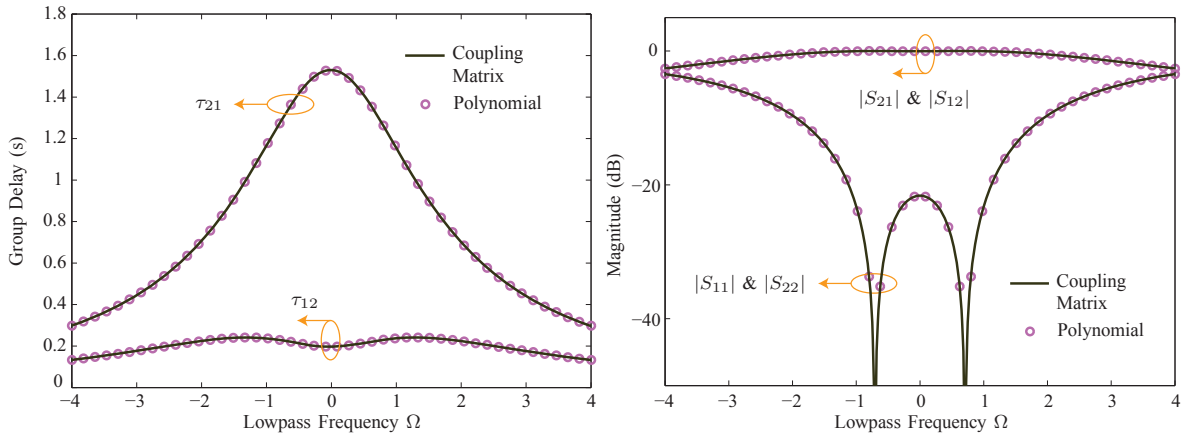

Fig. 2 Calculated scattering parameters of the second-order example.