DESIGN OF A DOUBLE PATCH MICROSTRIP FILTER

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SPECIFICATIONS FOR THE FILTER

The specifications for this bandpass filter [1] are

return loss > 20 dB

insertion loss < 0.04 dB

i.e.,

$|S11| < -20$ dB

$|S21| > -0.04$ dB

for 2.7 GHz < f < 3.6 GHz.

DESIGN PROCEDURES

The filter was first synthesized by a lumped LC circuit prototype [1]. Then microstrip structures are used to replace the lumped circuit components as shown in Fig. 1.

(1) Match individual microstrip structures to their corresponding lumped circuit parts at center frequency, i.e., at 3.15 GHz. Initial good starting points for optimization were obtained by manual estimations and adjustments.

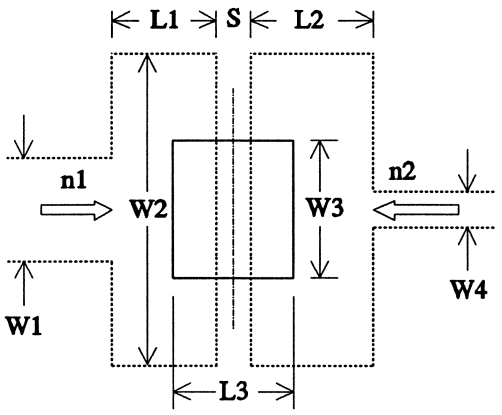
(2) Optimize the complete filter to meet the design specifications.

The microstrip structures are simulated by an EM simulator [2] and OSA90/hope is used as a (circuit) optimization engine [3].

OPTIMIZATION OF INDIVIDUAL MICROSTRIP COMPONENTS

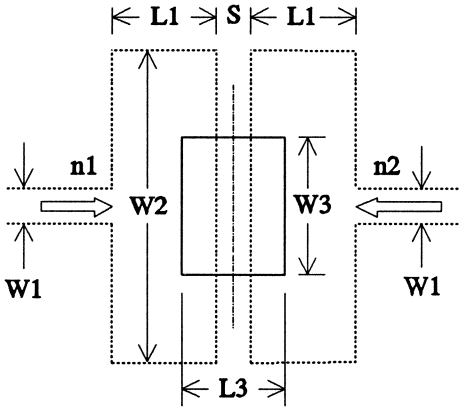
There are three distinctive microstrip structures in this filter: two overlaid double patch capacitors and a spiral inductor. The substrate parameters are listed in Table I.

(1) Overlaid double-patch capacitor 1



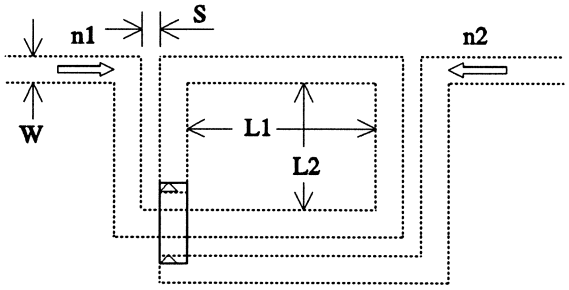
This structure is used to replace an asymmetric π capacitor two-port with shunt capacitors 0.4161 pF and 0.3004 pF and series capacitor 1.926 pF. The geometrical parameters after optimization are shown in Table II.

(2) Overlaid double-patch capacitor 2



This structure is used to replace a symmetric π capacitor two-port with shunt capacitors of 0.7444 pF and series capacitor 0.9665 pF. The geometrical parameters after optimization are shown in Table II.

(3) Spiral inductor



This spiral inductor is connected by a 7.5 mil long and 2 mil wide microstrip line at node 1 and a 5 mil long and 2 mil wide microstrip line at node 2. The complete structure is used to replace a symmetric π two-port with shunt capacitors of 0.1157 pF and series inductor of 3.758 nH.

The geometrical parameters after optimization are shown in Table III.

OPTIMIZATION OF THE COMPLETE FILTER

The filter responses after individual component optimization are shown in Fig. 2. Compared with the specifications, the results are quite good. However, due to the frequency dependency of microstrip structures, the filter does not meet the specifications near the frequency band edges.

We performed an optimization which directly optimized the filter responses. We set the specifications to

$|S11| < -20$ dB

$|S21| > -0.3$ dB

for 2.7 GHz < f < 3.6 GHz with 0.05 GHz step. EM simulation was done for 2.7 GHz < f < 3.6 GHz with 0.1 GHz step. Fig. 3 shows the frequency responses at the solution. The microstrip structure parameters are shown in Tables II and III. The optimization took about 20 hours of real clock time on a SUN SPARCstation.

REFERENCES

[1] D.G. Swanson, Jr., Watkins-Johnson Company, 3333 Hillview Ave., Stanford Research Park, Palo Alto, CA 94304-1204, Private communication, 1992.

[2] *Em User's Manual*, Sonnet Software, Inc., Suite 203, 135 Old Cove Rd., Liverpool, NY 13090-3774, May 1992.

[3] *OSA90/hope™ Version 2.0 User's Manual*, Optimization Systems Associates Inc., P.O. Box 8083, Dundas, Ontario, Canada L9H 5E7, 1992.

TABLE I
SUBSTRATE PARAMETERS FOR FILTER-2

Layer	Thickness (mils)	Rel. Dielectric Const.
Air	120	1.0
Level 1	0.1439	3.2
Level 2	15	9.8

TABLE II
OVERLAY DOUBLE-PATCH CAPACITOR PARAMETERS

	Stage 1 optimization		Stage 2 optimization	
Parameter	Cap.1	Cap.2	Cap.1	Cap.2
W1	14.0	2.0	14.0	2.0
W2	75.82	120.0	73.36	120.0
W3	62.0	52.24	63.74	54.00
W4	2.0	N/A	2.0	N/A
L1	25.0	28.81	25.0	28.00
L2	16.11	N/A	15.66	N/A
L3	24.0	22.0	24.0	22.0
S	2.0	2.0	2.0	2.0

Unit in mil.
Some of the parameters were fixed in the optimization, e.g., S.

TABLE III
SPIRAL INDUCTOR STRUCTURE PARAMETERS

Parameter	Stage 1 optimization	Stage 2 optimization
W	2.0	2.0
L1	24.0	24.0
L2	16.8	16.68
S	1.0	1.0

Unit in mil.
Some of the parameters were fixed in the optimization, e.g., S and W.

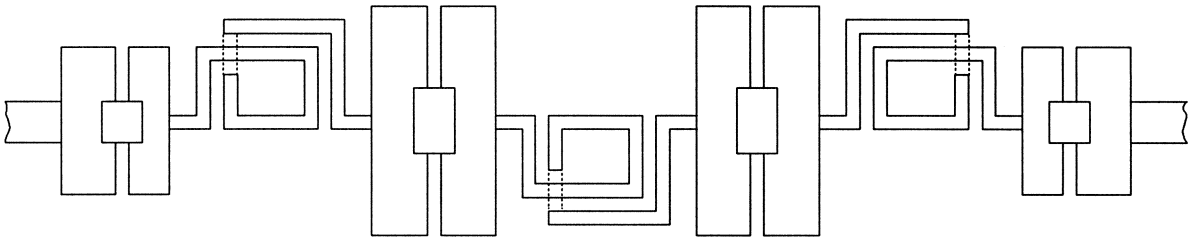
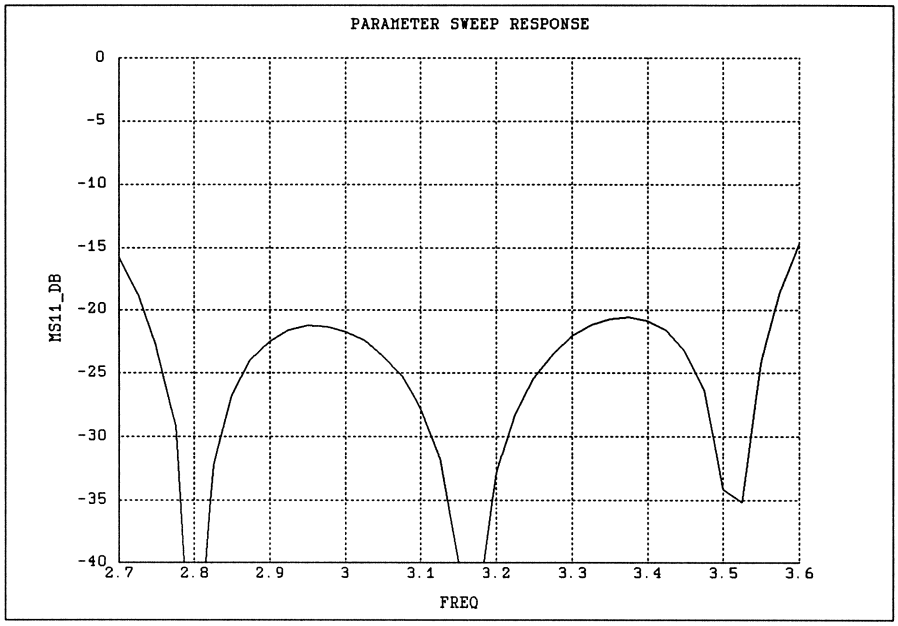
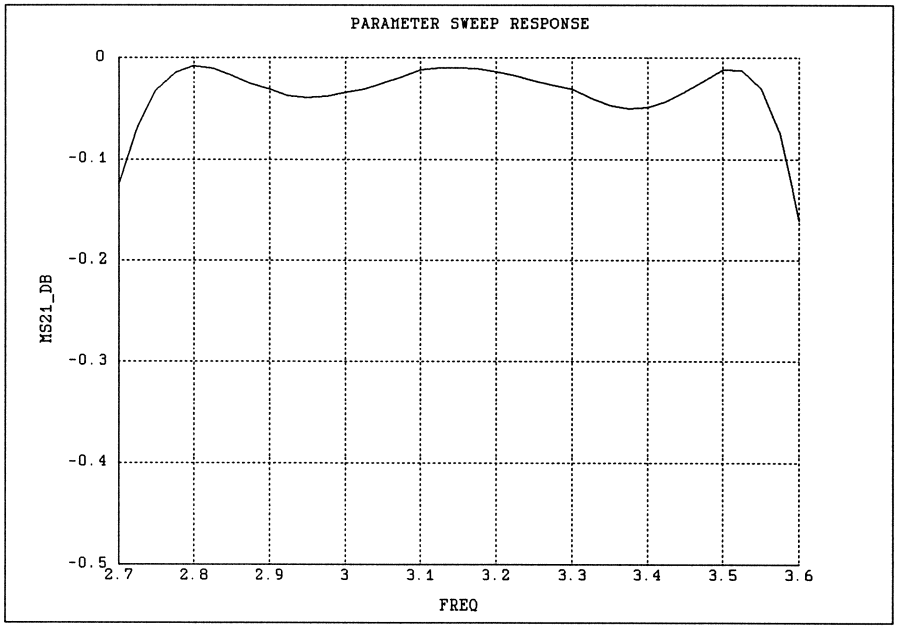


Fig. 1 Schematic diagram of the 2.7-3.6 GHz bandpass filter [1].

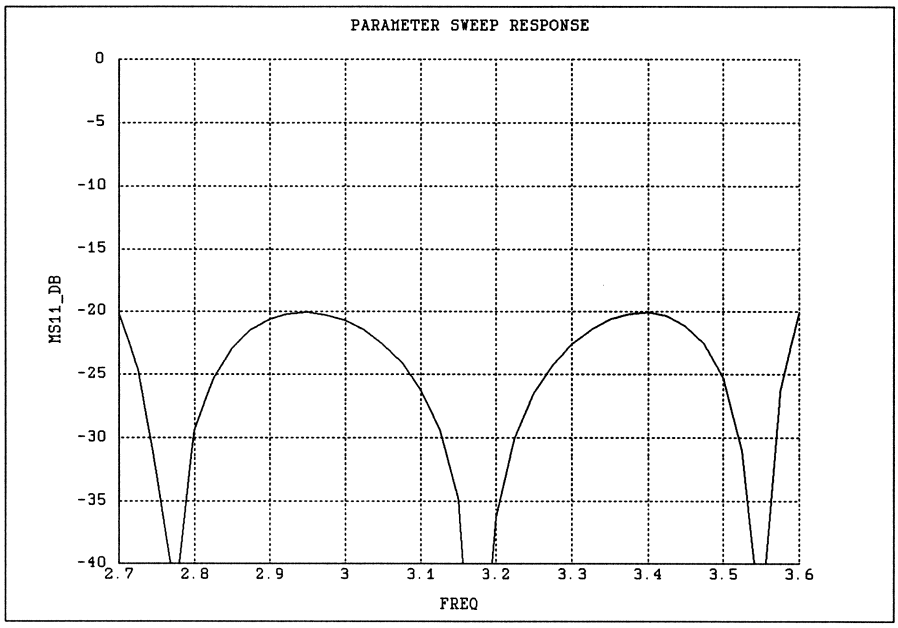


(a)

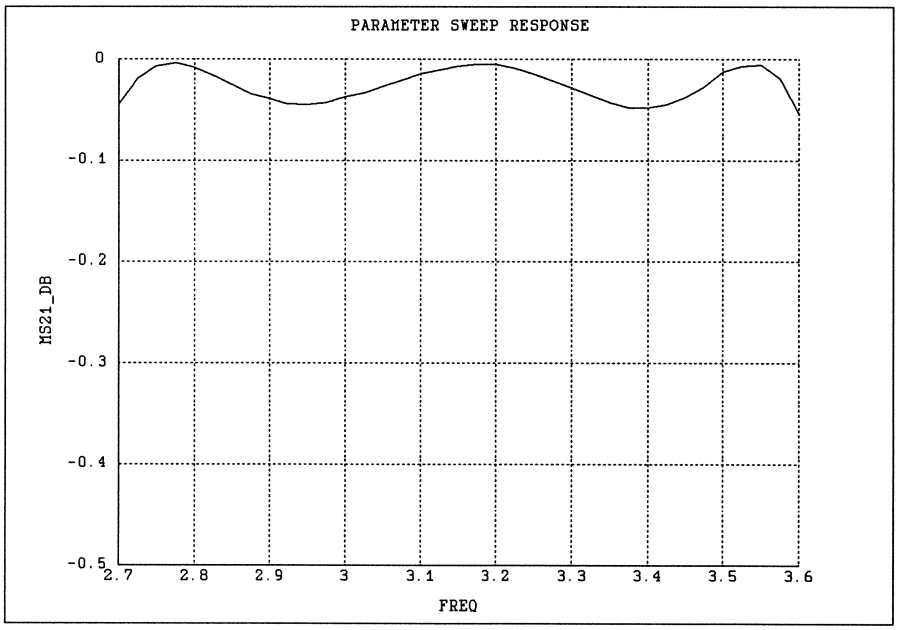


(b)

Fig. 2 2.7-3.6 GHz bandpass filter after optimizing individual microstrip component to match corresponding lumped circuit components: (a) return loss in dB and (b) insertion loss in dB.



(a)



(b)

Fig. 3 2.7-3.6 GHz bandpass filter after optimizing the complete filter: (a) return loss in dB and (b) insertion loss in dB.