Bessel low pass filter in mixed planar waveguide techniques

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Bessel Filter

Application: High speed optical data transmission

Requirements: Low group delay variation

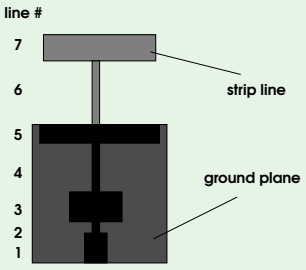
Group delay: $\tau = -\frac{d\Phi(S_{21})}{d\omega}$

Group delay variation: $\Delta\tau < 20\,ps @ 12\,GHz$

Corner frequency: $f_c = 7.5\,GHz (-3\,dB)$

Chebyshev Filter

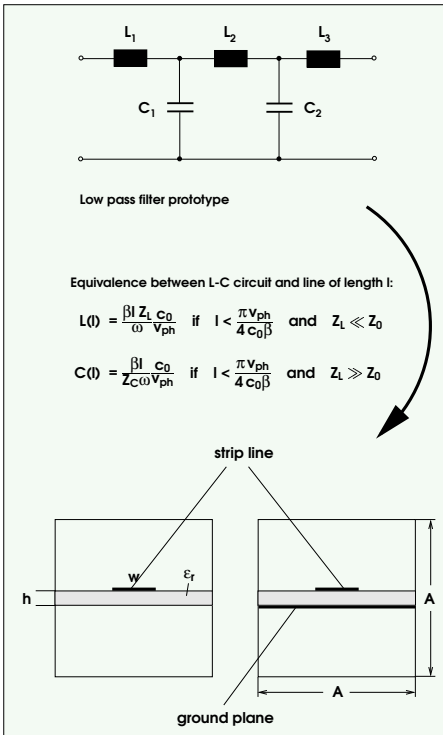
(for comparison)



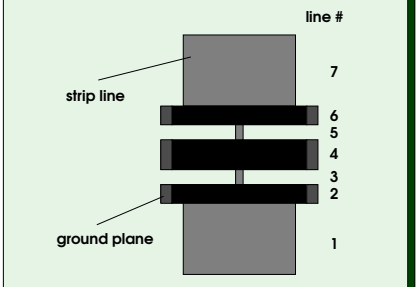
Layout of the planar Bessel filter

line #	line type	reactance	Z_L/Ω	width w/mm	length l/mm	ε_{eff}
1	MSL	feed line	50	0.77	1.00	1.86
2	MSL	L_1=0.185 nH	95	0.25	0.44	1.76
3	MSL	C_1=215 fF	24.4	2.00	1.12	1.96
4	MSL	L_2=0.853 nH	105	0.20	1.84	1.75
5	MSL	C_2=471 fF	11.9	4.40	0.67	1.98
6	SSL	L_3=2.396 nH	209	0.20	2.37	1.29
7	SSL	feed line	50	4.00	1.00	1.19

Comparison between lumped elements and equivalent transmission lines



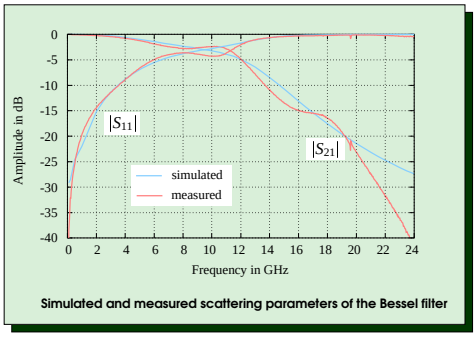
Cross sections of suspended stripline and thin film microstrip employes for the filter
Substrate: RT/Duroid: ε_r=2.2, h = 0.254 mm, A = 5 mm



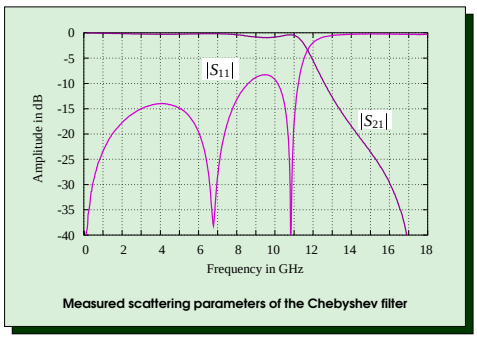
Layout of the planar Chebyshev filter

line #	line type	reactance	Z_L/Ω	width w/mm	length l/mm	ε_{eff}
1	SSL	feed line	50	4.00	5.634	1.19
2	MSL	C_{l1}=487 fF	11.3	4.60	0.668	1.98
3	SSL	L_{l1}=1.455 nH	209	0.20	0.692	1.29
4	MSL	C_{l2}=838 fF	11.3	4.60	1.012	1.98
5	SSL	L_{l2}=1.455 nH	209	0.20	0.692	1.29
6	MSL	C_{l3}=487 fF	11.3	4.60	0.668	1.98
7	SSL	feed line	50	4.00	5.634	1.19

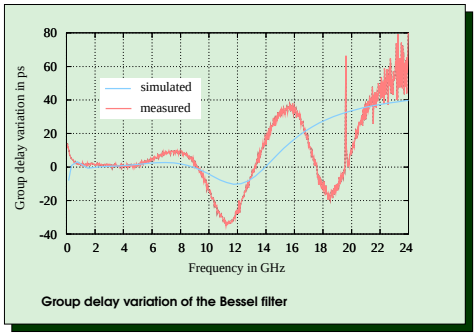
Comparison between lumped elements and equivalent transmission lines of the Chebyshev filter



Simulated and measured scattering parameters of the Bessel filter



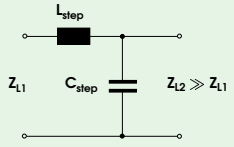
Measured scattering parameters of the Chebyshev filter



Group delay variation of the Bessel filter

Discontinuities

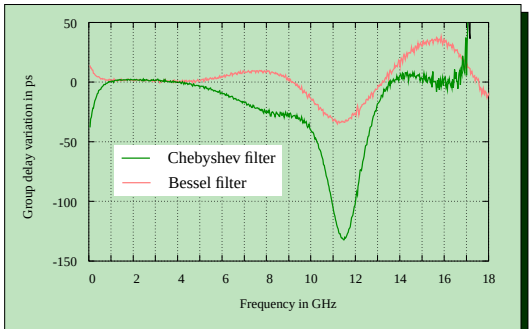
- Full-wave calculations with mode matching techniques
- Equivalent circuits for discontinuities



Transition	L_{step}	C_{step}
line 5 - line 6	453 pH	208 fF
line 6 - line 7	66 pH	65 fF

Equivalent circuit and reactance elements for a step in width (Bessel filter)

- Full-wave calculations of the whole filter structure with mode matching techniques



Comparison of the group delay variation of the two filter types