UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences
NTU IC-776CA

	Homework 3	**EECS 247**
B. E. BOSER	**Due Wed., March 7, 2001**	**Spring 2001**

Design an elliptic filter with the following specifications:

f_{corner}	20 MHz
f_{stop}	35 MHz
ripple	< 0.2 dB
attenuation	> 65 dB

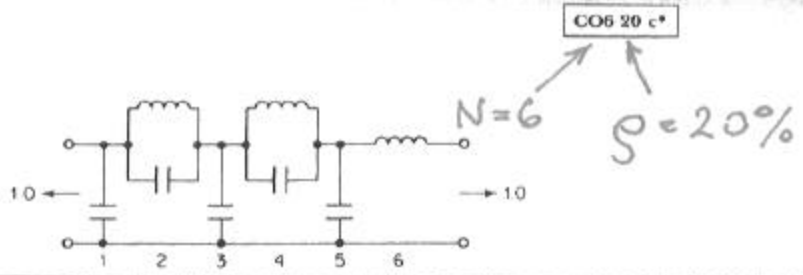
a) What is the required filter order?

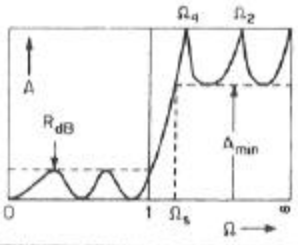
b) Obtain the doubly-terminated, denormalized LC ladder prototype using a table (e.g. the attached copy from Williams) or a synthesis program.

c) Synthesize a parasitic insensitive Gm-C filter based on the ladder prototype. Note all element values. You may use SPICE G-elements for the transconductors. Add a resistor in series with the input to simulate the noise ($4k_BT/G_m$). Do not use resistors for any other purpose — synthesize them from transconductors.

d) Scale the filter elements to obtain a peak gain of unity from the filter input to each integrator output and to achieve a total integrated noise at the output of 100μV rms integrated from DC to 100MHz. Choose the same capacitance in all integrators for simplicity. Verify your design with a SPICE AC analysis that you compare to the LC ladder. Show the output of each integrator and indicate the filter output. Note all element values on your filter schematic.

e) Consider the effect of finite amplifier bandwidth f_u. Using the first order pole cancellation, determine the minimum unity gain frequency that meets specifications and explain why some poles are not cancelled.





θ	Ω_s	A_{min}	C_1	C_2	L_2	Ω_2	C_3	C_4	L_4	Ω_4	C_5	L_6	θ
T	∞	∞	1.159	0.0000	1.529	∞	1.838	0.0000	1.838	∞	1.529	1.159	T
16	3.878298	112.5	1.138	0.0209	1.500	5.644802	1.790	0.0350	1.769	4.020935	1.500	1.158	16
17	3.655090	109.3	1.135	0.0237	1.496	5.314073	1.784	0.0396	1.761	3.788961	1.496	1.158	17
18	3.456975	106.3	1.132	0.0266	1.492	5.020165	1.777	0.0445	1.751	3.583033	1.492	1.158	18
19	3.279996	103.4	1.129	0.0297	1.488	4.757266	1.770	0.0497	1.742	3.399040	1.488	1.158	19
20	3.120982	100.7	1.125	0.0330	1.483	4.520722	1.763	0.0552	1.731	3.233693	1.483	1.158	20
21	2.977369	98.1	1.122	0.0365	1.478	4.306769	1.756	0.0611	1.720	3.084330	1.479	1.158	21
22	2.847060	95.6	1.118	0.0401	1.473	4.112326	1.748	0.0673	1.709	2.948774	1.474	1.157	22
23	2.728322	93.3	1.114	0.0440	1.468	3.934847	1.739	0.0738	1.697	2.825225	1.469	1.157	23
24	2.619709	91.0	1.110	0.0480	1.463	3.772213	1.731	0.0807	1.685	2.712184	1.464	1.157	24
25	2.520009	88.8	1.106	0.0523	1.457	3.622641	1.722	0.0879	1.672	2.608393	1.458	1.157	25
26	2.428196	86.7	1.102	0.0568	1.451	3.484624	1.712	0.0955	1.658	2.512785	1.452	1.157	26
27	2.343395	84.6	1.097	0.0614	1.445	3.356877	1.702	0.1035	1.644	2.424454	1.446	1.156	27
28	2.264858	82.6	1.092	0.0663	1.439	3.238301	1.692	0.1118	1.630	2.342621	1.440	1.156	28
29	2.191939	80.7	1.087	0.0714	1.432	3.127945	1.682	0.1205	1.615	2.266617	1.433	1.156	29
30	2.124078	78.9	1.082	0.0767	1.425	3.024987	1.671	0.1297	1.599	2.195860	1.427	1.156	30
31	2.060787	77.1	1.077	0.0822	1.418	2.928712	1.660	0.1392	1.583	2.129845	1.420	1.155	31
32	2.001642	75.3	1.071	0.0880	1.410	2.838492	1.648	0.1492	1.567	2.068129	1.413	1.155	32
33	1.946266	73.6	1.065	0.0940	1.403	2.753776	1.636	0.1597	1.550	2.010323	1.405	1.155	33
34	1.894331	72.0	1.059	0.1003	1.395	2.674079	1.624	0.1706	1.532	1.956085	1.398	1.154	34
35	1.845543	70.4	1.053	0.1068	1.386	2.598969	1.611	0.1820	1.514	1.905110	1.390	1.154	35

TABLE 11-56 Elliptic-Function *LC* Element Values (*Continued*)

θ	Ω_s	A_{min}	C_1	C_2	L_2	Ω_2	C_3	C_4	L_4	Ω_4	C_5	L_6	θ
T	∞	∞	1.159	0.0000	1.529	∞	1.838	0.0000	1.838	∞	1.529	1.159	T
36	1.799643	68.8	1.047	0.1135	1.378	2.528063	1.598	0.1939	1.496	1.857129	1.382	1.154	36
37	1.756398	67.3	1.040	0.1206	1.369	2.461022	1.585	0.2063	1.477	1.811902	1.374	1.153	37
38	1.715603	65.8	1.033	0.1279	1.360	2.397538	1.571	0.2192	1.457	1.769212	1.365	1.153	38
39	1.677070	64.3	1.026	0.1355	1.351	2.337337	1.557	0.2328	1.437	1.728868	1.356	1.152	39
40	1.640634	62.8	1.019	0.1434	1.341	2.280174	1.543	0.2469	1.417	1.690696	1.348	1.152	40
41	1.606142	61.4	1.012	0.1516	1.332	2.225824	1.528	0.2617	1.396	1.654538	1.338	1.151	41
42	1.573460	60.0	1.004	0.1601	1.321	2.174087	1.513	0.2772	1.374	1.620254	1.329	1.151	42
43	1.542462	58.7	0.9963	0.1689	1.311	2.124779	1.498	0.2933	1.352	1.587714	1.319	1.150	43
44	1.513038	57.3	0.9882	0.1781	1.300	2.077734	1.482	0.3103	1.330	1.556804	1.309	1.150	44
45	1.485086	56.0	0.9798	0.1877	1.289	2.032800	1.466	0.3280	1.307	1.527416	1.299	1.149	45
46	1.458511	54.7	0.9712	0.1976	1.278	1.989839	1.450	0.3465	1.284	1.499453	1.289	1.148	46
47	1.433230	53.4	0.9624	0.2079	1.266	1.948725	1.433	0.3659	1.260	1.472828	1.278	1.148	47
48	1.409164	52.2	0.9533	0.2187	1.255	1.909340	1.416	0.3863	1.235	1.447459	1.267	1.147	48
49	1.386241	50.9	0.9439	0.2298	1.242	1.871578	1.399	0.4078	1.211	1.423273	1.256	1.146	49
50	1.364398	49.7	0.9343	0.2414	1.230	1.835340	1.381	0.4303	1.185	1.400200	1.245	1.146	50
51	1.343572	48.5	0.9244	0.2535	1.217	1.800536	1.363	0.4540	1.160	1.378179	1.234	1.145	51
52	1.323710	47.3	0.9142	0.2661	1.204	1.767082	1.345	0.4790	1.133	1.357152	1.222	1.144	52
53	1.304759	46.1	0.9037	0.2792	1.190	1.734901	1.327	0.5054	1.107	1.337064	1.210	1.143	53
54	1.286672	45.0	0.8929	0.2929	1.176	1.703919	1.308	0.5333	1.080	1.317868	1.197	1.142	54
55	1.269406	43.8	0.8819	0.3072	1.162	1.674071	1.289	0.5628	1.052	1.299518	1.185	1.141	55
56	1.252921	42.7	0.8705	0.3221	1.147	1.645294	1.269	0.5941	1.024	1.281971	1.172	1.140	56
57	1.237179	41.5	0.8587	0.3377	1.132	1.617530	1.249	0.6274	0.9957	1.265189	1.159	1.139	57
58	1.222145	40.4	0.8466	0.3541	1.116	1.590725	1.229	0.6629	0.9668	1.249136	1.145	1.138	58
59	1.207787	39.3	0.8342	0.3712	1.100	1.564828	1.209	0.7008	0.9375	1.233777	1.131	1.137	59
60	1.194077	38.1	0.8214	0.3892	1.084	1.539791	1.188	0.7413	0.9077	1.219083	1.117	1.136	60
61	1.180985	37.0	0.8081	0.4081	1.067	1.515571	1.167	0.7848	0.8775	1.205023	1.103	1.134	61
62	1.168486	35.9	0.7945	0.4280	1.049	1.492126	1.146	0.8317	0.8468	1.191572	1.088	1.133	62
63	1.156557	34.8	0.7804	0.4490	1.032	1.469414	1.125	0.8823	0.8157	1.178704	1.074	1.131	63
64	1.145175	33.7	0.7659	0.4712	1.013	1.447401	1.103	0.9372	0.7843	1.166396	1.058	1.130	64
65	1.134320	32.6	0.7509	0.4947	0.9940	1.426049	1.081	0.9970	0.7524	1.154626	1.043	1.128	65
66	1.123973	31.5	0.7354	0.5196	0.9744	1.405326	1.059	1.062	0.7201	1.143375	1.026	1.126	66
67	1.114116	30.4	0.7193	0.5462	0.9542	1.385199	1.037	1.134	0.6874	1.132624	1.010	1.125	67
68	1.104733	29.3	0.7027	0.5746	0.9332	1.365637	1.014	1.213	0.6543	1.122356	0.9932	1.123	68
69	1.095809	28.2	0.6854	0.6050	0.9115	1.346613	0.9915	1.301	0.6208	1.112555	0.9759	1.120	69
70	1.087329	27.1	0.6674	0.6377	0.8891	1.328096	0.9680	1.400	0.5870	1.103207	0.9582	1.118	70