UNIVERSITI SAINS MALAYSIA

First Semester Examination
2013/2014 Academic Session

December 2013 / January 2014

EEE 532/4 – Microwave Circuit Design

Duration : 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages printed material and **TWO (2)** pages of Appendix before you begin the examination.

Instructions: This question paper consists of **SIX (6)** questions. Answer **FOUR (4)** questions. **TWO (2)** from Part A and **TWO (2)** from Part B.

Please use different booklet for Part A and Part B.

All questions carry the same marks.

Part A : Answer <u>TWO</u> questions

1. With reference to Figure 1, the input to an RF transceiver requires a suitable matching network to connect port 1 to port 2. The design is fabricated using microstrip. The first matching network, M1 network is required matching to match Z_{01} to Z_{02}. Whereas, the second matching network, M2, is required to match Z_{02} to Z_{03}. The design is fabricated for the frequency of 1.4 GHz. Use the Smith Chart where necessary. The width of the line is not required. (ε_r=3.08)

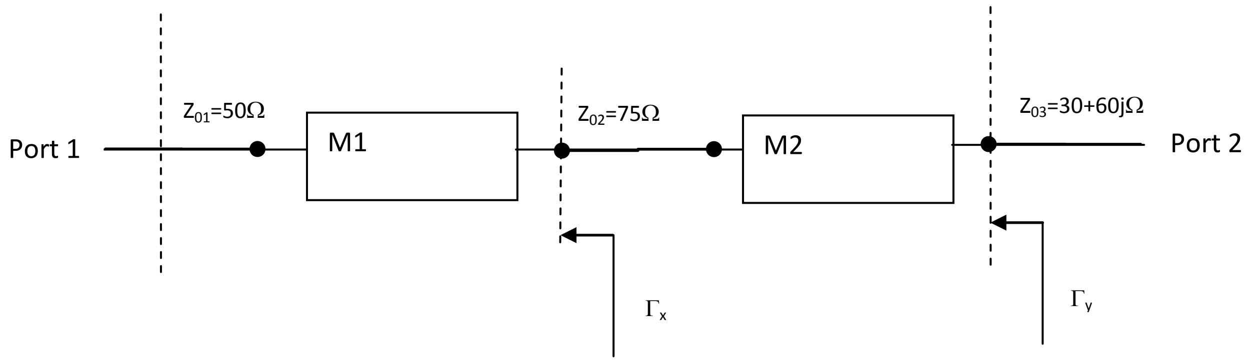

Figure 1

(a) Determine a suitable matching arrangement for M1 and calculate the necessary information for the chosen match. Justify your reason for selecting the solution (matching arrangement).

(40 marks)

(b) Determine a suitable matching arrangement for M2 and calculate the necessary information for the chosen match. (only 1 solution required). Justify your reasons for selecting the solution (matching arrangement).

(60 marks)

2. The simulation for noise analysis requires a low pass filter prototype. The schematic design requires element value, N = 5. The design should have a maximally flat passband respond extending up to -3 dB point at ω_c. The noise analysis is to be carried-out at 1.5 GHz. Use Table 2(a) or (b) as a guide. Assume that $Z_o = 50\ \Omega$ and the impedance and frequency scaling equations are:

$$L_k^{'} = \frac{R_0 L_k}{\omega_c} \qquad C_k^{'} = \frac{C_k}{R_0 \omega_c}$$

(a) Present the prototype schematic circuit for impedance of 50 Ω and at least 15 dB insertion loss at 2.7 GHz.

Element Values for Maximally Flat Low-Pass Filter Prototypes ($g_0 = 1$, $\omega_c = 1$, $N = 1$ to 10)

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	2.0000	1.0000									
2	1.4142	1.4142	1.0000								
3	1.0000	2.0000	1.0000	1.0000							
4	0.7654	1.8478	1.8478	0.7654	1.0000						
5	0.6180	1.6180	2.0000	1.6180	0.6180	1.0000					
6	0.5176	1.4142	1.9318	1.9318	1.4142	0.5176	1.0000				
7	0.4450	1.2470	1.8019	2.0000	1.8019	1.2470	0.4450	1.0000			
8	0.3902	1.1111	1.6629	1.9615	1.9615	1.6629	1.1111	0.3902	1.0000		
9	0.3473	1.0000	1.5321	1.8794	2.0000	1.8794	1.5321	1.0000	0.3473	1.0000	
10	0.3129	0.9080	1.4142	1.7820	1.9754	1.9754	1.7820	1.4142	0.9080	0.3129	1.0000

Source: Reprinted from G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Artech House, Dedham, Mass., 1980, with permission.

Table 2(a)

(60 marks)

(b) The present prototype is transformed into bandpass filter. Using Table 2(c) as a guide, design the bandpass filter with center frequency at 5.4 GHz and 10% bandwidth while the impedance is kept at 50 Ω.

Element Values for Equal-Ripple Low-Pass Filter Prototypes ($g_0 = 1, \omega_c = 1, N = 1$ to 10, 0.5 dB and 3.0 dB ripple)

					0.5 dB Ripple						
N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	0.6986	1.0000									
2	1.4029	0.7071	1.9841								
3	1.5963	1.0967	1.5963	1.0000							
4	1.6703	1.1926	2.3661	0.8419	1.9841						
5	1.7058	1.2296	2.5408	1.2296	1.7058	1.0000					
6	1.7254	1.2479	2.6064	1.3137	2.4758	0.8696	1.9841				
7	1.7372	1.2583	2.6381	1.3444	2.6381	1.2583	1.7372	1.0000			
8	1.7451	1.2647	2.6564	1.3590	2.6964	1.3389	2.5093	0.8796	1.9841		
9	1.7504	1.2690	2.6678	1.3673	2.7239	1.3673	2.6678	1.2690	1.7504	1.0000	
10	1.7543	1.2721	2.6754	1.3725	2.7392	1.3806	2.7231	1.3485	2.5239	0.8842	1.9841
					3.0 dB Ripple						
N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	1.9953	1.0000									
2	3.1013	0.5339	5.8095								
3	3.3487	0.7117	3.3487	1.0000							
4	3.4389	0.7483	4.3471	0.5920	5.8095						
5	3.4817	0.7618	4.5381	0.7618	3.4817	1.0000					
6	3.5045	0.7685	4.6061	0.7929	4.4641	0.6033	5.8095				
7	3.5182	0.7723	4.6386	0.8039	4.6386	0.7723	3.5182	1.0000			
8	3.5277	0.7745	4.6575	0.8089	4.6990	0.8018	4.4990	0.6073	5.8095		
9	3.5340	0.7760	4.6692	0.8118	4.7272	0.8118	4.6692	0.7760	3.5340	1.0000	
10	3.5384	0.7771	4.6768	0.8136	4.7425	0.8164	4.7260	0.8051	4.5142	0.6091	5.8095

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Table 2(b) : Element Values for (a) Butterworth and (b) Chebyshev Low-pass filters prototype

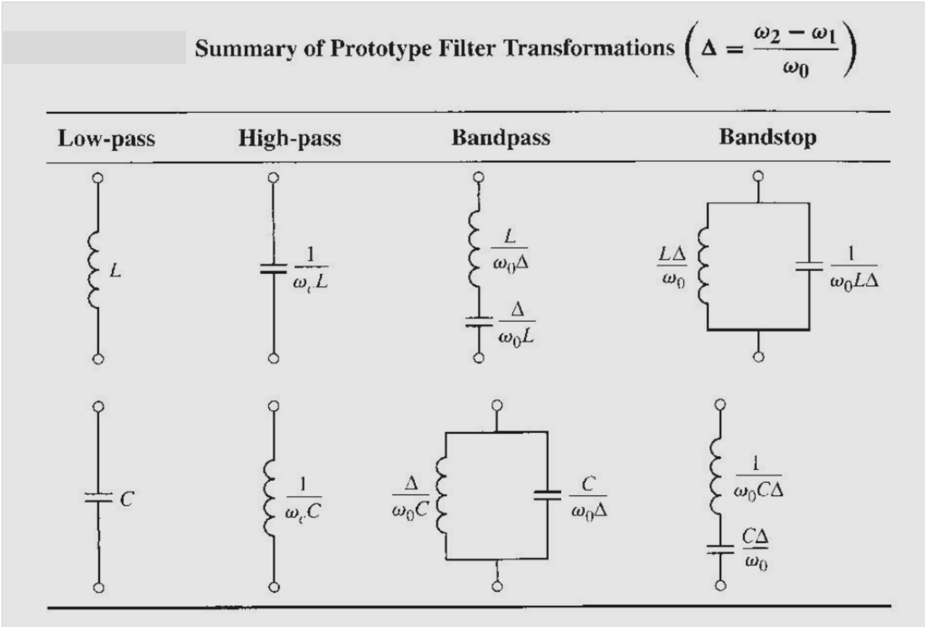

Table 2(c) : Summary of prototype filter transformation (excluding scaling i.e. Z_o)

(40 marks)

3. A simple divider using microstrip line has 75 Ω transmission lines at all ports. The power delivered to port 2 and port 3 are equal. A quarter wavelength transformer matches input port 1 for frequency of 5 GHz.

   (a) Analyze the matching occurrance at port 2 and port 3. Conclude your findings.

   (60 marks)

   (b) Does the simple divider performs efficiently at all ports? Justify your reasons using return loss and power efficiency.

   (40 marks)

Part B: Answer <u>TWO</u> questions

4. (a) An engineer establishing the 7 GHz microwave radio link to transmit the data for distance of 2 km. The transmitting power is 27 dBm with the parabolic antenna gain of 20 dB for each transmitter and receiver respectively.

    (i) Calculate the receive power in dBm
    (ii) What will be the transmitting power if the frequency is 10 GHz.

(15 marks)

(b) Briefly explain the block diagram of the IF type microwave repeater station.

(10 marks)

5. A transistor ATF 34143 has the S parameters as tabulated in Table 5. The S parameter was measured on 50 Ω systems with biasing at V_{ds} = 1.5 V and I_d = 10 mA.

S_{11}		S_{21}		S_{12}		S_{22}	
Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
0.58	148.9	2.43	13.5	0.167	-49.00	0.27	-140.00

Table 5 : ATF 34143 S parameters measured at 5 GHz.

The source impedance is Z_S = 35 Ω and the load impedance is Z_L = 37 Ω. Calculate:

(i) Power Gain.

(5 marks)

(ii) Available Gain.

(5 marks)

(iii) Transducer power gain.

(5 marks)

(iv) Determine the transistor stability.

(10 marks)

6. (a) Referring to Figure 6(a), show that the reflection coefficients Γ_L and Γ_{in} are related as $\Gamma_L\Gamma_{in} = 1$ for steady-state oscillation of the negative resistance oscillator.

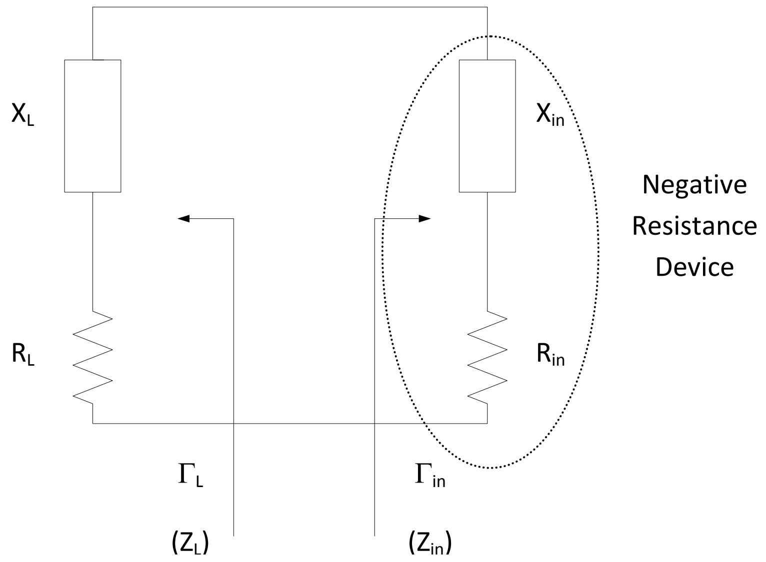

Figure 6(a)

(10 marks)

(b) Explain about the phase noise in the oscillator or explain the type of phase noise in the oscillator.

(5 marks)

(c) Explain the resonator type and name three type of resonator that is typically used in an oscillator design.

(5 marks)

(d) Briefly describe the feedback type oscillator topology and provide descriptions of what used normally in the form of questions not as statements the important criterion in the oscillator.

(5 marks)

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