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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	RF & MICROWAVE ENGINEERING
COURSE CODE	:	BEB 40803/ BEX 43803
PROGRAMME	:	BEJ / BEE
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

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Q1 A transmission line is a distributed parameter network, where voltages and currents can vary in magnitude and phase over its length.

(a) Sketch and label the lumped-element equivalent circuit of a transmission line.

(4 marks)

(b) Describe intrinsic impedance in term of travelling wave. Show that,

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

(4 marks)

(c) A load impedance of 130 + j90 Ω terminate a 50 Ω transmission line that is 0.3λ long. Find the reflection coefficient at the load, reflection coefficient at input, SWR on the line, return loss and the impedance seen at the input to the line.

(12 marks)

Q2 (a) Show that the ABCD parameter for the circuit in **FIGURE Q2 (a)** is.

$$\begin{bmatrix} \mathbf{1} & \boldsymbol{Z} \\ \mathbf{0} & \mathbf{1} \end{bmatrix}$$

(5 marks)

(b) Consider a two-port network consisting of a transmission line and a series resistance as illustrated in **FIGURE Q2 (b)**. Find the generalised scattering parameters of this network.

(15 marks)

Q3 Impedance matching network is usually placed between a load impedance and a transmission line where both systems are not having the same impedance value.

(a) Explain the importance of having impedance matching network in such a system?

(3 marks)

(b) Input impedance of an antenna is found as Z_{in} = 200 – j100 Ω. The antenna is to be connected to a transmission line with characteristic impedance of 100 Ω. Design a quarter wave transformer to match the antenna and the transmission line at 2 GHz, and determine the resulting bandwidth if $SWR \leq 1.5$.

(12 marks)

(c) From Q3(b), if the quarter wave transformer is made of a microstrip line with $\varepsilon_r = 2.2$, and thickness $h = 1.2$ mm, calculate the microstrip line width of the transformer.

(5 marks)

Q4 (a) Briefly describe **THREE (3)** practical responses of a microwave low pass filter, by referring to the corresponding frequency response plot.

(6 marks)

(b) A seventh order lowpass 0.5 dB Chebyshev filter with a cut-off frequency of 3GHz exhibits a stop band insertion loss of -30 dB at 4GHz. The source and load impedance are 50 Ohm. The filter is implemented on a microstrip board with a relative permittivity = 12.1, h= 0.32 mm and Tanδ = 0.0001. Determine:

(i) equivalent circuit of the filter

(5 marks)

(ii) the value of series reactances

(5 marks)

(iii) the value of first and second shunt reactance components

(4 marks)

Q5 (a) A coaxial cable uses polyethylene as the dielectric insulator with $\varepsilon_r = 2.1$. The ratio of the outer and inner layer is $b/a = 3.38$.

(i) The cable is used to connect a device with a source. To ensure maximum power delivery, calculate the ideal input impedance value Z_{in} of the device. Explain your answer.

(5 marks)

(ii) Determine the highest usable frequency before the TE_{11} waveguide mode starts to propagate if $b < 1.5$ cm.

(3 marks)

(b) Design a microstrip transmission line using a substrate board with $\varepsilon_r = 2.2$ and thickness of $h = 0.127$ cm that can match well with the coaxial cable in Q5(a).

(5 marks)

(c) Sketch the field patterns of the propagating fields in coaxial cable and strip line. Analyze the pattern and explain about their similarities and determine the corresponding propagation modes.

(7 marks)

Q6 (a) For an amplifier, give a brief description for the **THREE (3)** types of gain below:

(i) Transducer gain

(ii) Power gain

(iii) Available gain

(3 marks)

(b) The S-parameter for HP HFET-102 GaAs FET at 2 GHz with a bias voltage $V_{gs} = 0$ are given as follows ($Z_0 = 50\ \Omega$).

$$S_{11} = 0.894\ \angle -60.6^o$$

$$S_{21} = 3.122\ \angle 123.6^o$$

$$S_{12} = 0.02\ \angle 62.4^o$$

$$S_{22} = 0.781\ \angle -27.6^o$$

The source impedance is $Z_s = 20\ \Omega$ and the load impedance is $Z_L = 30\ \Omega$.

(i) Compute the power gain, available gain and the transducer gain.

(9 marks)

(ii) Determine the stability of this transistor.

(8 marks)

- END OF QUESTION –

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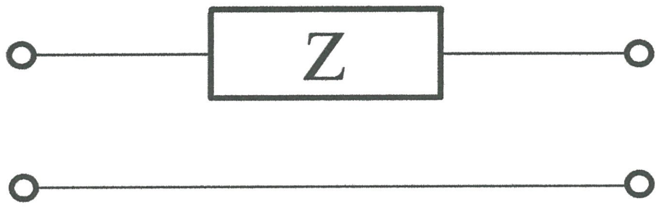

FIGURE Q2 (a)

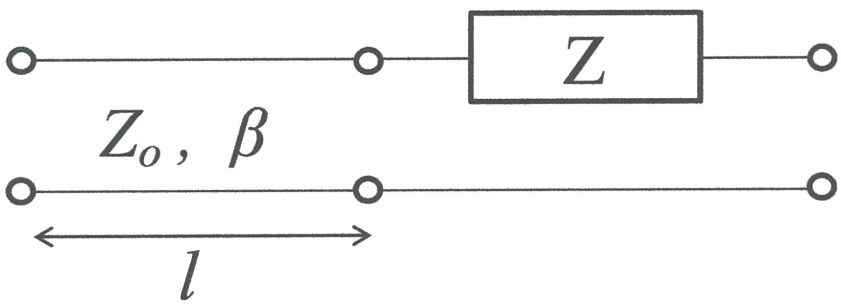

FIGURE Q2 (b)

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TABLE 1

The *ABCD* Parameters of Some Useful Two-Port Circuits.

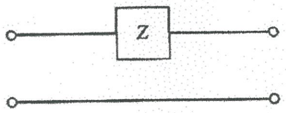
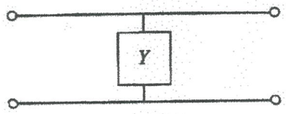
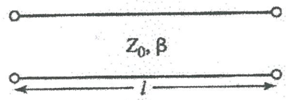
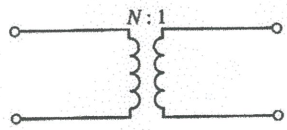
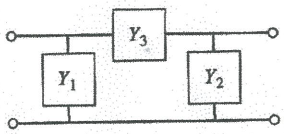
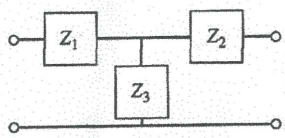
Circuit	*ABCD* Parameters	
	$A = 1$ $C = 0$	$B = Z$ $D = 1$
	$A = 1$ $C = Y$	$B = 0$ $D = 1$
	$A = \cos \beta l$ $C = jY_0 \sin \beta l$	$B = jZ_0 \sin \beta l$ $D = \cos \beta l$
	$A = N$ $C = 0$	$B = 0$ $D = \frac{1}{N}$
	$A = 1 + \frac{Y_2}{Y_3}$ $C = Y_1 + Y_2 + \frac{Y_1 Y_2}{Y_3}$	$B = \frac{1}{Y_3}$ $D = 1 + \frac{Y_1}{Y_3}$
	$A = 1 + \frac{Z_1}{Z_3}$ $C = \frac{1}{Z_3}$	$B = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$ $D = 1 + \frac{Z_2}{Z_3}$

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TABLE 2

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}
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	1.000		
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

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}
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

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TABLE 3

	S	Z	Y	$ABCD$
S_{11}	S_{11}	$\frac{(Z_{11}-Z_0)(Z_{22}+Z_0)-Z_{12}Z_{21}}{\Delta Z}$	$\frac{(Y_0-Y_{11})(Y_0+Y_{22})+Y_{12}Y_{21}}{\Delta Y}$	$\frac{A+B/Z_0-CZ_0-D}{A+B/Z_0+CZ_0+D}$
S_{12}	S_{12}	$\frac{2Z_{12}Z_0}{\Delta Z}$	$\frac{-2Y_{12}Y_0}{\Delta Y}$	$\frac{2(AD-BC)}{A+B/Z_0+CZ_0+D}$
S_{21}	S_{21}	$\frac{2Z_{21}Z_0}{\Delta Z}$	$\frac{-2Y_{21}Y_0}{\Delta Y}$	$\frac{2}{A+B/Z_0+CZ_0+D}$
S_{22}	S_{22}	$\frac{(Z_{11}+Z_0)(Z_{22}-Z_0)-Z_{12}Z_{21}}{\Delta Z}$	$\frac{(Y_0+Y_{11})(Y_0-Y_{22})+Y_{12}Y_{21}}{\Delta Y}$	$\frac{-A+B/Z_0-CZ_0+D}{A+B/Z_0+CZ_0+D}$
Z_{11}	$Z_0\frac{(1+S_{11})(1-S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$	Z_{11}	$\frac{Y_{22}}{\|Y\|}$	$\frac{A}{C}$
Z_{12}	$Z_0\frac{2S_{12}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$	Z_{12}	$\frac{-Y_{12}}{\|Y\|}$	$\frac{AD-BC}{C}$
Z_{21}	$Z_0\frac{2S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$	Z_{21}	$\frac{-Y_{21}}{\|Y\|}$	$\frac{1}{C}$
Z_{22}	$Z_0\frac{(1-S_{11})(1+S_{22})+S_{12}S_{21}}{(1-S_{11})(1-S_{22})-S_{12}S_{21}}$	Z_{22}	$\frac{Y_{11}}{\|Y\|}$	$\frac{D}{C}$
Y_{11}	$Y_0\frac{(1-S_{11})(1+S_{22})+S_{12}S_{21}}{(1+S_{11})(1+S_{22})-S_{12}S_{21}}$	$\frac{Z_{22}}{\|Z\|}$	Y_{11}	$\frac{D}{B}$
Y_{12}	$Y_0\frac{-2S_{12}}{(1+S_{11})(1+S_{22})-S_{12}S_{21}}$	$\frac{-Z_{12}}{\|Z\|}$	Y_{12}	$\frac{BC-AD}{B}$
Y_{21}	$Y_0\frac{-2S_{21}}{(1+S_{11})(1+S_{22})-S_{12}S_{21}}$	$\frac{-Z_{21}}{\|Z\|}$	Y_{21}	$\frac{-1}{B}$
Y_{22}	$Y_0\frac{(1+S_{11})(1-S_{22})+S_{12}S_{21}}{(1+S_{11})(1+S_{22})-S_{12}S_{21}}$	$\frac{Z_{11}}{\|Z\|}$	Y_{22}	$\frac{A}{B}$
A	$\frac{(1+S_{11})(1-S_{22})+S_{12}S_{21}}{2S_{21}}$	$\frac{Z_{11}}{Z_{21}}$	$\frac{-Y_{22}}{Y_{21}}$	A
B	$Z_0\frac{(1+S_{11})(1+S_{22})-S_{12}S_{21}}{2S_{21}}$	$\frac{\|Z\|}{Z_{21}}$	$\frac{-1}{Y_{21}}$	B
C	$\frac{1}{Z_0}\frac{(1-S_{11})(1-S_{22})-S_{12}S_{21}}{2S_{21}}$	$\frac{1}{Z_{21}}$	$\frac{-\|Y\|}{Y_{21}}$	C
D	$\frac{(1-S_{11})(1+S_{22})+S_{12}S_{21}}{2S_{21}}$	$\frac{Z_{22}}{Z_{21}}$	$\frac{-Y_{11}}{Y_{21}}$	D

$|Z| = Z_{11}Z_{22} - Z_{12}Z_{21}$; $|Y| = Y_{11}Y_{22} - Y_{12}Y_{21}$; $\Delta Y = (Y_{11}+Y_0)(Y_{22}+Y_0) - Y_{12}Y_{21}$; $\Delta Z = (Z_{11}+Z_0)(Z_{22}+Z_0) - Z_{12}Z_{21}$; $Y_0 = 1/Z_0$

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$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\frac{1}{\sqrt{1 + 12\,d/W}}$$

$$Z_o = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_e}} ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & for\ W/d \le 1 \\ \dfrac{120\pi}{\sqrt{\varepsilon_e}[W/d + 1.393 + 0.667 ln(W/d + 1.444)]} & for\ W/d \ge 1 \end{cases}$$

$$\frac{W}{d} = \begin{cases} \dfrac{8\varepsilon^A}{e^{2A} - 2} & for\ W/d < 2 \\ \dfrac{2}{\pi}\left[B - 1 - ln(2B - 1) + \dfrac{\varepsilon_r - 1}{2\varepsilon_r}\left\{ln(B - 1) + 0.39 - \dfrac{0.61}{\varepsilon_r}\right\}\right] & for\ W/d > 2 \end{cases}$$

Where

$$A = \frac{Z_o}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$$

$$B = \frac{377\pi}{2Z_o\sqrt{\varepsilon_r}}$$

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$$\frac{\Delta f}{f_0} = 2 - \frac{4}{\pi} cos^{-1}\left[\frac{\Gamma_m}{\sqrt{1-{\Gamma_m}^2}} \frac{2\sqrt{Z_o Z_L}}{|Z_L - Z_o|}\right]$$