UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	RF AND MICROWAVE ENGINEERING
COURSE CODE	:	BEB 40803
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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) Show that, for a transmission line terminated with Z_L, characteristic impedance of Z_0 and length $l = \frac{\lambda}{4}$, the input impedance Z_{in} is,

$$Z_{in} = \frac{{Z_0}^2}{Z_L}$$

(4 marks)

(c) **Figure Q1(c)** shows frequency response of an antenna. At the frequency of 9.75 GHz, calculate :

(i) the reflection coefficient

(3 marks)

(ii) the signal to wave ratio

(3 marks)

(iii) the return loss, and

(3 marks)

(iv) the percentage of power transmitted

(3 marks)

Q2 (a) Show that the S-parameter for the circuit in **Figure Q2(a)** is

$$\begin{bmatrix} \frac{Z}{2Z_0+Z} & \frac{2Z_0}{2Z_0+Z} \\ \frac{2Z_0}{2Z_0+Z} & \frac{Z}{2Z_0+Z} \end{bmatrix}$$

(5 marks)

(b) Consider a two-port network as illustrated in **Figure Q2(b)**. Determine the S-Parameter of the system.

(15 marks)

Q3 Microwave and radio frequency (RF) system relied on transmission lines for low loss transmission of power at high frequency.

a) Sketch the field pattern of the propagating fields in a coaxial cable, stripeline and microstrip line. Label the fields accordingly.

(6 marks)

b) Design a microstrip line on a 0.5 mm alumina substrate (ε_r= 9.9 , Tan δ = 0.001) for a 50 Ω characteristic impedance. The line is to be operated at 10 GHz range.

(10 marks)

c) The frequency response of the microstrip line in **Q3(b)** is measured using a network analyzer. Construct the expected transmission coefficient and the reflection coefficient response if the measurement is performed from 7 GHz to 11 GHz frequency range. Label the graph accordingly.

(4 marks)

Q4 (a) Briefly describe the properties of filter characteristics in (i) to (iii) and sketch the corresponding frequency response. Label them clearly.

(i) Butterworth filter

(2 marks)

(ii) Chebyshev filter

(2 marks)

(iii) Bessel filter

(2 marks)

(b) A microstrip low-pass filter with cut-off frequency of 2 GHz and 30 dB attenuation at 3.5 GHz is to be designed. The filter have Chebyshev response characteristic with 0.5 dB ripple. The filter is to be implemented on a microstrip board with a relative permittivity, ε_r = 9.9, thickness, h = 0.63 mm and loss tangent, Tan δ = 0.001.

(i) Draw the lump element prototype of the filter and determine the element values.

(5 marks)

(ii) Using the stepped impedance technique, calculate the value of series and shunt reactance components, if the high impedance transmission line value of, Z_{High} = 100 Ω and low impedance transmission line value of Z_{Low} = 30 Ω are used to realized the filter practically.

(9 marks)

Q5 (a) Doppler radar can be used for the detection of moving objects and determine its velocity. A simple Doppler radar can be designed using components listed in Table 2. Draw the schematic diagram of a Doppler radar using only the component listed.

(10 marks)

(b) The parabolic reflector antenna used in **Q5(a)** is 50 cm in diameter and operates at 12.4 GHz. Calculate the far field distance of this antenna.

(5 marks)

(c) An object is detected from a distance.

(i) Calculate the distance of the detected object if the time travel of the wave is $\Delta t = 0.1$ ms.

(2 marks)

(ii) If the object is moving with a velocity of v_0 = 60 km/h towards the radar, calculate the Doppler frequency shift.

(3 marks)

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

(i) transducer gain

(1 mark)

(ii) power gain

(1 mark)

(iii) available gain

(1 mark)

(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_o=50 Ω).

$$S_{11} = 0.38\angle -158^o \;,\; S_{12} = 0.11\angle 54^o$$

$$S_{21} = 3.50\angle 80^o \;,\; S_{22} = 0.40\angle -43^o$$

The source impedance is Z_s= 25 Ω and the load impedance is Z_L = 40 Ω.

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

(12 marks)

(ii) Determine the stability of this transistor.

(5 marks)

- END OF QUESTION –

CONFIDENTIAL

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2018/2019 PROGRAMME : BEJ
COURSE NAME : RF AND MICROWAVE ENGINEERING COURSE CODE: BEB 40803

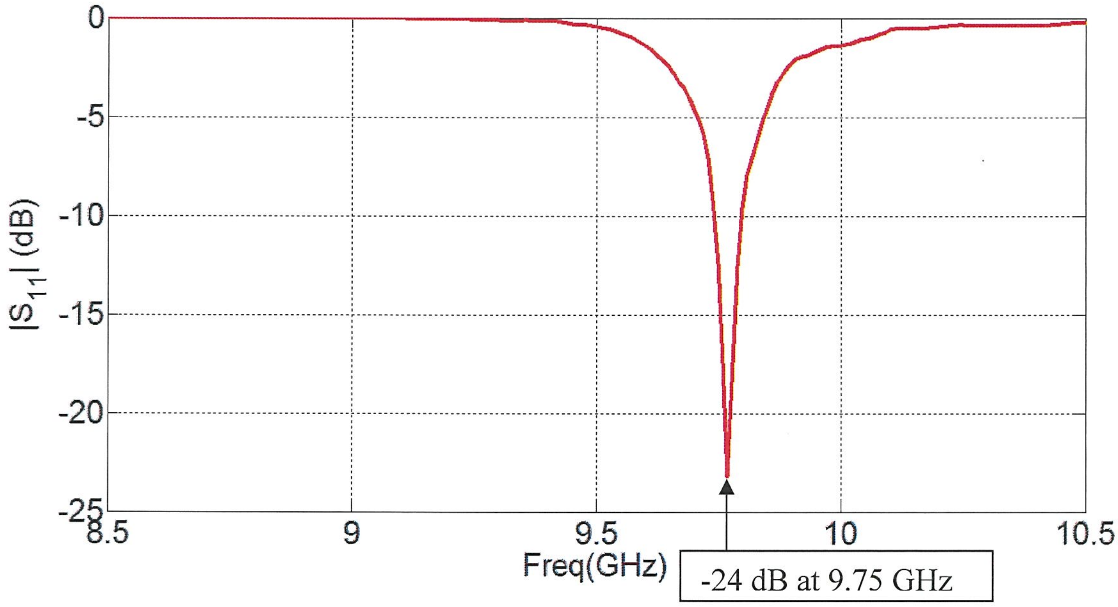

Figure Q1 (c)

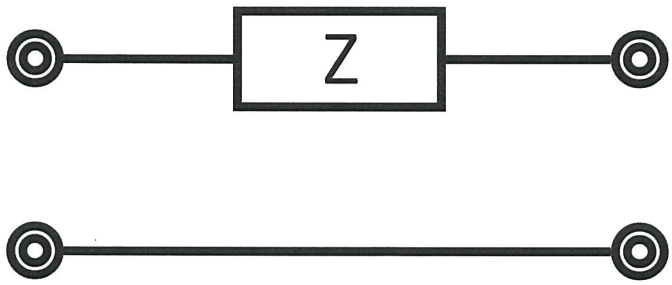

Figure Q2 (a)

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2018/2019 PROGRAMME : BEJ
COURSE NAME : RF AND MICROWAVE ENGINEERING COURSE CODE: BEB 40803

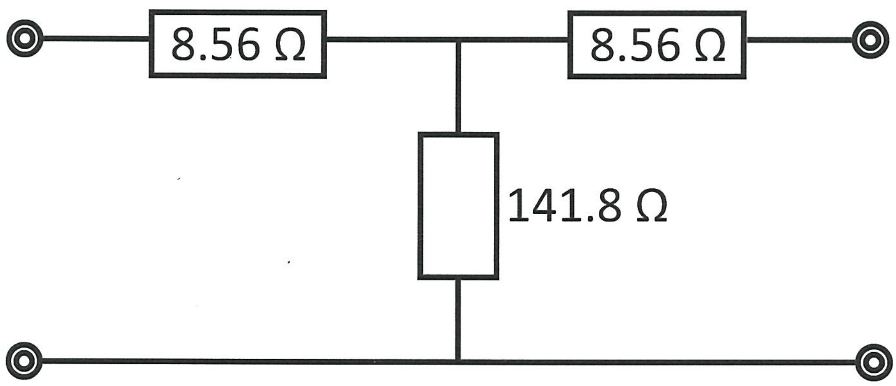

Figure Q2 (b)

CONFIDENTIAL

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2018/2019 PROGRAMME : BEJ
COURSE NAME : RF AND MICROWAVE ENGINEERING COURSE CODE: BEB 40803

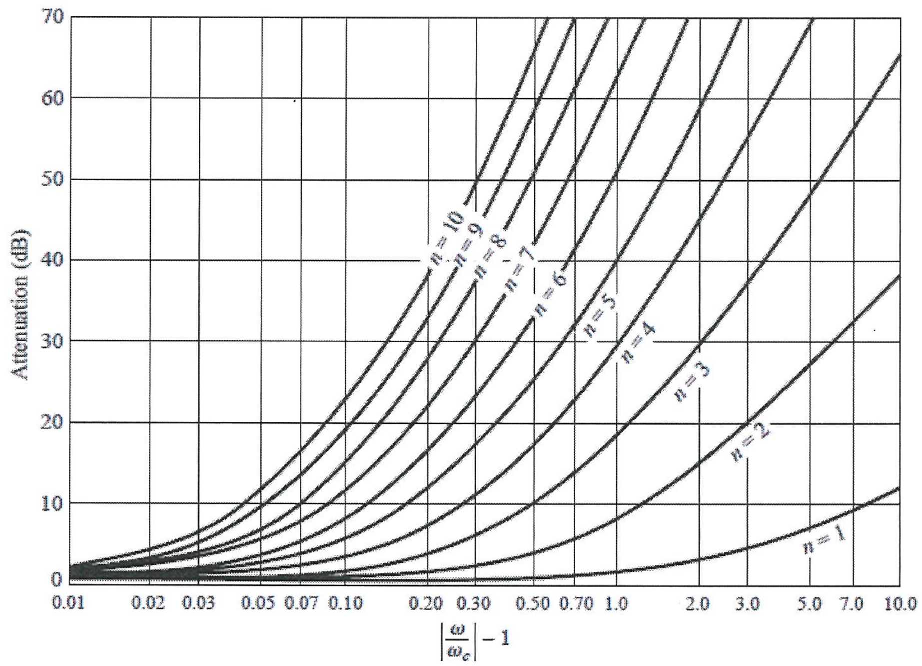

Figure Q4 (b)

TABLE 1

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

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2018/2019 PROGRAMME : BEJ
COURSE NAME : RF AND MICROWAVE ENGINEERING COURSE CODE: BEB 40803

TABLE 2

Item	Quantity
Frequency modulator	1
Oscillator	1
Low Noise Amplifier	1
Power Amplifier	1
Splitter	1
Mixer	1
Reflector antenna	2

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2018/2019 PROGRAMME : BEJ
COURSE NAME : RF AND MICROWAVE ENGINEERING COURSE CODE: BEB 40803

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

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

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

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

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