UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2011/2012

Jun 2012

EEE 322 – KEJURUTERAAN GELOMBANG MIKRO DAN RF

Masa : 2 Jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi SEPULUH muka surat beserta Lampiran TUJUH muka surat bercetak sebelum anda memulakan peperiksaan ini.

Kertas soalan ini mengandungi **ENAM** soalan.

Jawab **EMPAT** soalan.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Agihan markah bagi setiap soalan diberikan di sudut sebelah kanan soalan berkenaan.

Kertas soalan ini mengandungi dua bahagian, **Bahagian A** dan **Bahagian B**. Jawab **DUA** soalan dalam Bahagian A dan **DUA** soalan dalam Bahagian B.

Gunakan dua buku jawapan yang diberikan supaya jawapan-jawapan bagi soalan-soalan **Bahagian A** adalah di dalam satu buku jawapan dan bagi **Bahagian B** di dalam buku jawapan yang lain.

Jawab semua soalan dalam Bahasa Malaysia atau Bahasa Inggeris atau kombinasi kedua-duanya.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai].

"In the event of any discrepancies, the English version shall be used".

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BAHAGIAN A: Jawab <u>DUA</u> (2) soalan
PART A: Answer TWO (2) question

1. (a) Lukiskan gambaran elemen tergumpal bagi litar dua-garisan asas dengan komponen R, L, C dan G.

Draw the equivalent lumped-element representation of a general two-line circuit with R, L, C and G component.

(5 markah/*marks*)

(i) Dari gambarajah tersebut, buktikan bahawa pemalar perambatan .

From the diagram, prove that propagation constant .

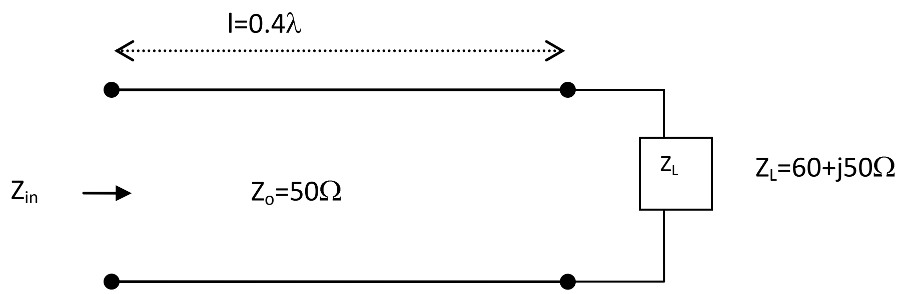
(10 markah/*marks*)

(ii) Tentukan nilai α dan β dengan menggunakan R, L, G dan C.
Determine using R, L, G and C, the value of α and β.

(5 markah/*marks*)

(b) Satu beban bernilai Z_L=60+j50Ω disambungkan ke talian penghantar dengan galangan Ciri 50Ω. Gunakan carta smith (hanya satu sahaja diperlukan) untuk mencari kuantiti yang termaktub bagi litar talian penghantar yang ditunjukkan di bawah,

A load with a value of Z_L=60+j50Ω is connected to a transmission line with characteristic impedance of 50Ω. Use the smith chart (only one smith chart required) to find the following quantities for the transmission line circuit shown below,



(i) SWR pada talian.
The SWR on the line.

(10 markah/*marks*)

(ii) Pekali pantulan dari beban.
The reflection coefficient at the load.

(10 markah/*marks*)

(iii) Lepasan Beban.
The load admittance.

(10 markah/*marks*)

(iv) Hilangan Kebalikan.
Return Loss.

(10 markah/*marks*)

(c) Secara matematik, berikan justifikasi bagi jawapan pada soalan (b).

Mathematically, justify the answers to question (b).

(40 markah/*marks*)

2. (a) Satu beban galangan Z_L = 30-j40 akan diselaraskan kepada talian 50Ω dengan menggunakan sebuah siri punting boleh laras.

A load impedance Z_L = 30-j40 is to be matched to a 50Ω line using single series stub tuner.

(i) Lukiskan dan labelkan sebuah punting bersiri litar pintas. Terangkan label-label tersebut.

Draw and label the series short circuited stub. Explain the labels.

(5 markah/*marks*)

(ii) Cari dua penyelesaian dengan menggunakan punting litar pintas. Di atas carta smith, mengapakah jarak yang pendek diperlukan antara beban dan bulatan 1+jX.

Find two solutions using short circuited stubs. On the smith chart, why is the distance between the load to the 1+jX circle should be as short as possible?

(35 markah/*marks*)

(b) Sebuah rangkaian dua-liang masukan mempunyai matrik serakan seperti berikut:

Given that a two-port network that have a following scattering matrix:

(i) Tentukan bahawa rangkaian tersebut tiada kehilangan.

Determine that the network is lossless.

(15 markah/*marks*)

(ii) Buktikan bahawa rangkaian tersebut bersalingan.

Prove that the network is reciprocal.

(15 markah/*marks*)

(iii) Gambarkan situasi apabila liang masukan 1 adalah berpadanan dengan menggunakan isyarat keluar masuk (gambarkan a_n dan b_n mempunyai n bilangan liang masukan) apabila a_2 tiada sumber isyarat, dan;

Describe the situation when port 1 is matched using wave input output (a_n and b_n description with n is the number of ports) when a_2 has no signal source, and;

(20 markah/*marks*)

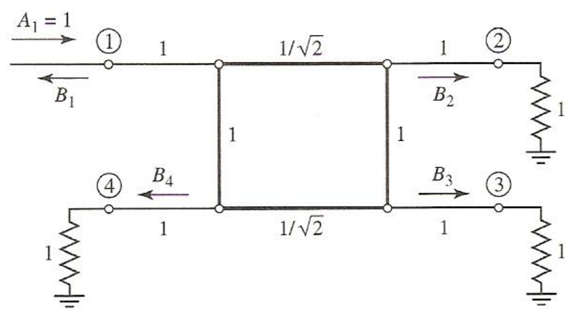
(iv) Hitung Kehilangan Kembali, RL.

Calculate the Return Loss, RL.

(10 markah/*marks*)

3. (a) Sebuah pengganding 4-liang masukan boleh dijelaskan dengan menggunakan litar Rajah 3(a) di bawah.

A 4-port branch-line coupler can be represented using the circuit shown in Figure 3(a) below.



Rajah 3(a) Pengganding Beranting 4-liang
Figure 3(a) 4-port Branch-Line Coupler

(i) **Nyatakan** Rangkaian Serakan 4-liang masukan umum bagi litar di atas dengan menggunakan gambaran 4 x 4 matrik.

State *a general 4-port scattering network parameters for the circuit above using 4 x 4 matrix representation.*

(5 markah/*marks*)

(ii) Dalam keadaan rangkaian tersebut berpadanan, dan bersalingan, **nyatakan** keadaannya (dalam format matematik) dan **tulis semula** matrik dari (i).

Consider the network to be matched, and reciprocal, ***state*** *the conditions (in mathematical format) and* ***rewrite*** *the matrix from (i).*

(5 markah/*marks*)

(iii) Jika litar berada dalam **penyisihan** yang baik, i.e. $S_{14}=S_{23}=0$, perbaiki parameter-S di matrik (ii).

*If the circuit has good **Isolation** i.e. , improve the S-parameter matrix in (ii).*

(5 markah/*marks*)

(iv) Dalam keadaan kuasa masuk = kuasa keluar, ia dapat dijelaskan dengan , dan mempunyai . Hubungan antara θ dan φ diberikan sebagai $\theta + \varphi = \pi \pm 2n\pi$ dan dapat menghasilkan dua kumpulan pengganding, iaitu Pengganding Simetrik (apabila $\theta = \varphi = \pi/2$) dan Pengganding Antisimetrik ($\theta = 0$; $\varphi = \pi$). Perkenalkan **Kedua-dua** jenis pengganding 4 x 4 matrik baru dengan gabungan α dan β. Berikan **satu** contoh untuk setiap jenis pengganding.

*In as situation where the input power = output power, it can be represented by , and having . The relationship between θ and φ is given by $\theta + \varphi = \pi \pm 2n\pi$ will give rise to two groups of coupler, namely Symmetrical Coupler (when $\theta = \varphi = \pi/2$) and Antisymmetrical Coupler ($\theta = 0$; $\varphi = \pi$). Present **BOTH** types of couplers new 4 x 4 matrix incorporating α and β. Give **an example** for each type of coupler.*

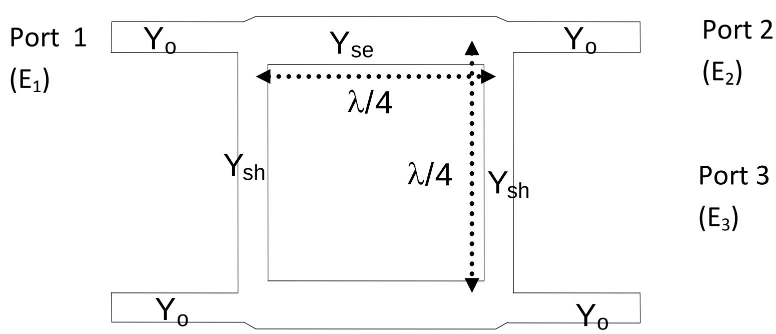
(35 markah/*marks*)

(b) Pengganding beranting boleh direkabentuk sebagai pengganding hibrid mempunyai 3dB faktor salingan yang bermaksud $\alpha = \beta = 1/\sqrt{2}$. Rekabentuk sebuah **Pengganding 3dB** dengan menggunakan mikrostrip yang mempunyai Z_0= 50Ω ($Y_{sh,\ ternormal}$ = 1), Kuasa Keluaran @liang 1 = Kuasa Keluaran @liang 2 (90^o fasa bersilang), ketinggian dielektrik h = 1.6mm, pemalar dielektrik ε_r=4.5. **Lukiskan** pengganding tersebut dan hitung nilai-nilai di Rajah 3(b). Andaikan Y_{sh} = 1. Buktikan ia berfungsi sebagai pengganding 3dB melalui E_1,E_2 dan E_3.

The branch-line coupler can be design as a hybrid coupler having 3dB coupling factor that implies that $\alpha = \beta = 1/\sqrt{2}$. Design a ***3dB Coupler*** *using a microstrip line with Z_0= 50Ω ($Y_{sh,\ normalized}$ = 1), Output power @port 1 = Output power @ port 2 (90^0 out of phase), height of dielectric h = 1.6mm, dielectric constant ε_r=4.5.* ***Draw*** *the coupler and calculate the values given in Figure 3(b). Assume Y_{sh} = 1. Justify the coupler as a 3dB using E_1,E_2 and E_3.*

(50 markah/*marks*)

f_o=1.5 GHz



Rajah 3(b) Pengganding Beranting Mikrostrip
Figure 3(b) Microstrip Branch-Line Coupler

BAHAGIAN B: Jawab <u>DUA</u> (2) soalan
PART B: Answer TWO (2) question

4. Transistor NE34018 mempunyai parameter-S seperti di Jadual 1. Parameter S tersebut diukur menggunakan sistem 50Ω pada V_{DS} = 3V dan I_{DS} = 10 mA.

A transistor NE34018 has the S-parameters as tabulated in Table 1. The S parameter was measured on 50Ω systems at V_{DS} = 3V and I_{DS} = 10 mA.

Jadual 1 Parameter-S Transistor NE 34018 diukur pada 5 GHz.
Table 1 NE 34018 Transistor S-parameters measured at 5 GHz.

S_{11}		S_{21}		S_{12}		S_{22}	
Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
0.56	146.7	2.74	10.5	0.168	-43.00	0.37	-140.5

Galangan masukan adalah Z_S = 38Ω dan galangan beban adalah Z_L = 44Ω. Hitung:
The source impedance is Z_S = 38Ω and the load impedance is Z_L = 44Ω. Calculate:

(i) Kuasa Gandaan.
Power Gain. (20 markah/*marks*)

(ii) Gandaan Terada.
Available Gain. (20 markah/*marks*)

(iii) Kuasa Gandaan Transducer.
Transducer power gain. (20 markah/*marks*)

(iv) Dapatkan kestabilan transistor
Determine the transistor stability. (40 markah/*marks*)

5. AVAGO PHEMT ATF 33143 mempunyai parameter-S dan parameter hingar seperti di Lampiran 1. Rekabentuk penguat rendah hingar yang beroperasi pada frekuensi 8 GHz. Gunakan Γ_{in} pada titik C_i yang telah kira dengan FR 1.5 dB. PCB mempunyai ketebalan 0.38 mm dengan ε_r 3.38.

PHEMT ATF 33143 have the S-parameter and noise parameter as in Appendix 1. Design a low noise amplifier operating at a frequency of 8 GHz. Use the Γ_{in} at the point of the calculated C_i with FR of 1.5 dB.

(100 markah/*marks*)

6. (a) Terangkan konsep pengayun rintangan negatif. Apakah kriteria penting untuk pengayun berayun?

Explain the concept of a negative resistance oscillator. What are the important criteria for the oscillator to oscillate?

(20 markah/*marks*)

(b) Rekabentuk pencampur diod gelombang mikro menggunakan pengganding talian cabang beroperasi pada frekuensi 5 GHz menggunakan Duroid 3003 dengan ketebalan 1.27mm dan ε_r 3.8.

Design a microwave mixer using branch line coupler operating at a frequency of 5 GHz using Duroid 4003 having a thickness of 1.27mm with ε_r 3.8.

(60 markah/*marks*)

(c) Terangkan konsep stesen pengulang gelombang mikro jenis RF.

Explain the concept of IF microwave repeater station.

(20 markah/*marks*)

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APPENDIX 1

$$Y_{se}^2 = Y_0^2 + Y_{sh}^2$$

$$\frac{E_3}{E_2} = \frac{2Y_{sh}}{1 - Y_{sh}^2 + Y_{se}^2}$$

$$\frac{E_3}{E_1} = 10^{(-x/20)} \quad \textit{with} \quad \textit{xdB coupling}$$

$$w/h = \frac{377}{\sqrt{\varepsilon_r}\, Z_o} - 1.57$$

$$\ell = \frac{\lambda_o}{4\sqrt{\varepsilon_r}}$$

APPENDIX 2

$$\Gamma_S = \left(\frac{Z_S - Z_O}{Z_S + Z_O} \right)$$

$$\Gamma_L = \left(\frac{Z_L - Z_O}{Z_L + Z_O} \right)$$

$$\Gamma_{in} = \left(S_{11} + \frac{S_{12} S_{21} \Gamma_L}{1 - S_{22} \Gamma_L} \right)$$

$$\Gamma_{out} = \left(S_{22} + \frac{S_{12} S_{21} \Gamma_S}{1 - S_{11} \Gamma_S} \right)$$

Stability:

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |D|^2}{2|S_{12} S_{21}|}$$

$$D = S_{11} S_{22} - S_{12} S_{21}$$

APPENDIX 3

Power gain:

$$G = \left(\frac{|S_{21}|^2 (1 - |\Gamma_L|^2)}{(1 - |\Gamma_{in}|^2)|1 - S_{22}\Gamma_L|^2} \right)$$

Available Power gain:

$$G_A = \frac{P_{avn}}{P_{avs}} = \frac{|S_{21}|^2 (1 - |\Gamma_S|^2)}{(1 - |\Gamma_{OUT}|^2)|1 - S_{11}\Gamma_S|^2}$$

Transducer Power Gain:

$$G_T = \frac{P_L}{P_{avs}} = \frac{|S_{21}|^2 (1 - |\Gamma_S|^2)(1 - |\Gamma_L|^2)}{|1 - \Gamma_S\Gamma_{in}|^2 |1 - S_{22}\Gamma_L|^2}$$

$$G_T = G_S G_o G_L$$

$$G_S = \frac{1 - |\Gamma_S|^2}{|1 - \Gamma_{in}\Gamma_S|^2}$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$G_o = |S_{21}|^2$$

LAMPIRAN 4

APPENDIX 4

$$C_i = \frac{\Gamma_{opt}}{(1 + N_i)}$$

$$Zo \approx \frac{377}{\sqrt{\varepsilon_r}}\left(\frac{W}{h} + 2\right)$$

$$R_i = \frac{1}{1 + N_i}\sqrt{N_i^{\ 2} + N_i\,(1 - \left|\Gamma_{opt}\right|^2)}$$

$$Ni = \frac{\left[(Fr - F\min)\right]\left|1 + \Gamma_{opt}\right|^2}{4\,\dfrac{R_n}{Z_o}}$$

$$\Gamma_L = \left(S_{22} + \frac{S_{12}S_{21}\Gamma_{in}}{1 - S_{11}\Gamma_{in}}\right)^*$$

APPENDIX 5

ATF-33143 Typical Scattering Parameters, V_{DS} = 2V, I_{DS} = 40 mA

Freq.	S_{11}		S_{21}			S_{12}			S_{22}		MSG/MAG
(GHz)	Mag.	Ang.	dB	Mag.	Ang.	dB	Mag.	Ang.	Mag.	Ang.	(dB)
0.5	0.88	-72.70	22.08	12.81	134.40	-27.02	0.045	54.50	0.28	-118.70	24.54
0.8	0.79	-112.10	19.46	9.41	111.20	-24.13	0.062	40.70	0.37	-149.90	21.81
1.0	0.78	-119.80	18.86	8.86	106.50	-23.93	0.064	38.00	0.38	-155.40	21.41
1.5	0.75	-149.60	16.11	6.44	88.30	-22.57	0.075	29.80	0.42	-176.20	19.34
1.8	0.74	-162.80	14.70	5.47	79.80	-22.14	0.079	26.80	0.45	174.70	18.40
2.0	0.74	-170.10	13.84	4.94	74.80	-21.84	0.082	24.90	0.46	169.40	17.80
2.5	0.74	172.30	11.98	3.98	63.00	-21.24	0.088	20.80	0.49	160.10	16.56
3.0	0.75	159.10	10.37	3.31	53.10	-20.68	0.094	17.10	0.51	152.10	15.46
4.0	0.75	137.00	7.95	2.50	35.00	-19.59	0.106	9.30	0.53	139.20	13.73
5.0	0.76	117.20	6.20	2.05	17.20	-18.56	0.119	-0.70	0.54	124.70	11.44
6.0	0.78	98.10	4.69	1.73	-1.30	-17.83	0.129	-12.80	0.54	108.00	9.80
7.0	0.80	80.10	3.12	1.44	-19.30	-17.42	0.135	-26.00	0.57	90.40	8.35
8.0	0.83	64.50	1.68	1.22	-35.20	-17.29	0.137	-37.30	0.60	74.80	7.43
9.0	0.83	50.30	0.48	1.07	-49.30	-17.08	0.140	-46.80	0.63	62.70	6.45
10.0	0.86	36.30	-0.46	0.96	-64.30	-16.59	0.148	-58.30	0.65	50.90	6.41
11.0	0.88	21.50	-1.50	0.85	-80.20	-16.53	0.149	-71.30	0.68	37.40	6.14
12.0	0.90	7.20	-2.70	0.74	-95.80	-16.81	0.144	-83.90	0.72	21.40	5.64
13.0	0.91	-5.00	-4.24	0.62	-110.20	-17.38	0.135	-95.60	0.75	5.80	4.60
14.0	0.91	-15.50	-5.49	0.54	-121.90	-17.78	0.129	-103.90	0.77	-5.70	3.64
15.0	0.92	-27.50	-6.42	0.49	-134.20	-18.00	0.126	-113.70	0.80	-15.80	3.44
16.0	0.93	-40.50	-7.26	0.44	-146.80	-17.87	0.128	-124.20	0.82	-25.70	3.22
17.0	0.94	-52.30	-8.20	0.40	-160.40	-18.07	0.125	-136.40	0.83	-37.90	3.11
18.0	0.93	-61.20	-9.51	0.34	-171.00	-18.79	0.115	-145.10	0.85	-49.70	1.79

ATF-33143 Typical Noise Parameters

V_{DS} = 2V, I_{DS} = 40 mA

Freq.	F_{min}	Γ_{opt}		$R_{n/50}$	G_a
GHz	dB	Mag.	Ang.	-	dB
0.5	0.26	0.45	26.00	0.07	24.74
0.9	0.30	0.38	42.20	0.07	21.02
1.0	0.31	0.36	44.80	0.07	20.36
1.5	0.34	0.31	69.50	0.06	17.40
1.8	0.34	0.26	93.60	0.04	16.50
2.0	0.39	0.27	108.60	0.05	15.82
2.5	0.51	0.28	150.70	0.03	14.59
3.0	0.53	0.32	165.60	0.03	13.13
4.0	0.61	0.41	-162.10	0.04	11.27
5.0	0.70	0.49	-136.80	0.06	9.92
6.0	0.82	0.53	-113.60	0.11	8.70
7.0	0.93	0.59	-91.50	0.23	7.71
8.0	1.04	0.62	-72.60	0.38	6.69
9.0	1.12	0.67	-55.90	0.59	6.04
10.0	1.21	0.69	-42.20	0.77	5.73

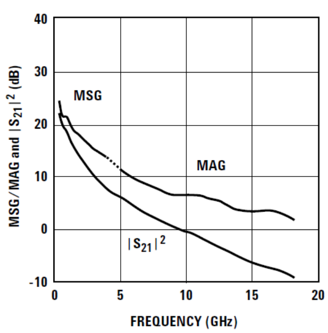

Figure 21. MSG/MAG and $|S_{21}|^2$ vs. Frequency at 2V, 40 mA.

Notes:

1. The F_{min} values are based on a set of 16 noise figure measurements made at 16 different impedances using an ATF NP5 test system. From these measurements a true F_{min} is calculated. Refer to the noise parameter application section for more information.
2. S and noise parameters are measured on a microstrip line made on 0.025 inch thick alumina carrier. The input reference plane is at the end of the gate lead. The output reference plane is at the end of the drain lead. The parameters include the effect of four plated through via holes connecting source landing pads on top of the test carrier to the microstrip ground plane on the bottom side of the carrier. Two 0.020 inch diameter via holes are placed within 0.010 inch from each source lead contact point, one via on each side of that point.