UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

Department of Electronic and Electrical Engineering

MAIN EXAMINATION 2015

Title of the Paper:

Analogue Design I

Course Code: **EE321**

Time Allowed: **Three Hours.**

Instructions:

1. To answer, pick any to sum a total of 100% from 8 questions in the following pages.
2. The answer must be written in the space provided in the question book. Use the answer book as a scratch pad.
3. This paper has 11 pages, including this page.

DO NOT OPEN THE PAPER
UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

Q1: (20 pts) Give low and high frequency equivalent circuits respectively of BJT and FET. All component values must be marked correctly according to the given data from the data-sheet and each circuit must have its title. So all together, there are 4 circuits. (5pts each ckt).

Q2: (10 pts) From the given input and output characteristics respectively of BJT (2N3904) and FET (2N3819), find the BJT and the FET low frequency equivalent circuit parameters. (5 pts for each)

Q3: (20 pts) List R_{in}, R_{ot}, A_i, and A_v of the single BJT amplifier of all three configurations, CE, CB, and CC. Pick any 5 to answer.

	R_{in}	R_{ot}
CE		
CB		
CC		

	A_v	A_i
CE		
CB		
CC		

Q4: (20 pts) Use SCTC method, estimate ω_L, for the CE amplifier shown in Fig. Q4-1. The BJT parameters is given in the attached data-sheet. (5 pts for each time constant and 5 pts for the final result)

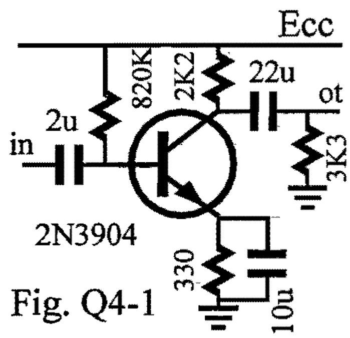
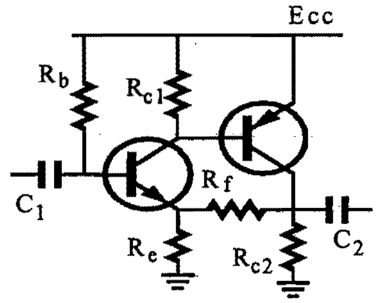
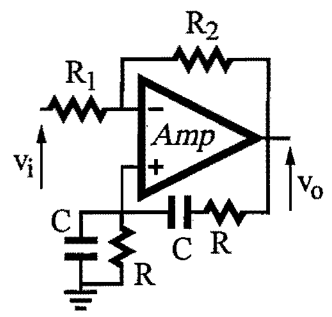


Fig. Q4-1



Q5: (20 pts) A 2-BJT linear feedback amplifier is shown on the right. (5 pts) Identify whether the feedback is positive or negative and its feedback topology (s-s, s-p, p-s, p-p). Find (i). (5 pts) A_o and (5 pts) A_f, and (ii). (5 pts) β and check if $\beta = R_e/(R_e+R_f)$. For numerical calculation, the component values are given as the following: Signal source: $R_s=0$; Circuit components in Ohms: $R_{C1}=8K$, $R_{C2}=2K$, $R_e=0.2K$, $R_f=8K$ and BJT parameters $h_{ie}=2K$, $h_{fe}=120$. Consider the two BJT has the same parameters. (hint: First, set R_f symbolical and all the rest numerical and calculate voltage gain. Secondly, calculate open loop gain A_o as $R_f \rightarrow \infty$. Calculate A_f as $R_f=8K$) (10 pts each)



Q6: (10 pts) A Wien amplifier is shown on the right. (i). Derive the voltage amplification factor in terms of the component symbols, given R_s=0. (ii). Discuss the stability of the amplifier in terms of the resistor ratio, $R_2/R_1=\eta$; that is, discuss the boundary of η. On one side of the boundary, the circuit is a stable BPF amplifier; while on the other side the circuit is a frequency oscillator. (5 pts each)

Q7: (10 pts) 2N3055 has a power dissipation rating 115 Watts at case temperature 25°C, a maximum junction temperature 200°C, and thermal resistance from junction to case θ_{jc}=1.25 C/W. To maintain a case temperature 25°C needs an infinitively large heat sink, which is not possible. (i) Study the relationship between the power dissipation rating, P_D, and case temperature, T_C. Draw the curve P_D~T_C. (ii) Design a practical heat sink to dissipate the heat to the air at a temperature 25°C. Assume the transistor case and heat sink have a perfect thermal contact. Case temp may be around 45°C; calculate sink θ_{ca} , where ca is between the case and the air. Find the new power dissipation again, (5 pts for curve, 5 pts for sink θ_{ca} and new P_D)

Q8: (20 pts) An amplifier has a voltage amplification factor:

$$A(s)=\frac{2\pi\cdot 10^{9}\cdot s}{(s+2\pi\cdot 10^{3})(s+2\pi\cdot 10^{5})}$$

(i). Draw the frequency response in Bode form; find mid-band gain; and find the dominant ω_L and ω_H. (ii). If use feedback technique and reduce the mid-band gain to 200, what are the new dominant ω_L and ω_H. (10 pts for each)

NPN General Purpose Transistor

UMT3904 / SST3904 / MMST3904 / 2N3904

●Electrical characteristics (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Collector-base breakdown voltage	BV_{CBO}	60	-	-	V	I_C = 10μA
Collector-emitter breakdown voltage	BV_{CEO}	40	-	-	V	I_C = 1mA
Emitter-base breakdown voltage	BV_{EBO}	6	-	-	V	I_E = 10μA
Collector cutoff current	I_{CES}	-	-	50	nA	V_{CB} = 30V
Emitter cutoff current	I_{EBO}	-	-	50	nA	V_{EB} = 3V
Collector-emitter saturation voltage	$V_{CE(sat)}$	-	-	0.2	V	I_C/I_B = 10mA/1mA
		-	-	0.3		I_C/I_B = 50mA/5mA
Base-emitter saturation voltage	$V_{BE(sat)}$	0.65	-	0.85	V	I_C/I_B = 10mA/1mA
		-	-	0.95		I_C/I_B = 50mA/5mA
DC current transfer ratio	h_{FE}	40	-	-	-	V_{CE} = 1V , I_C = 0.1mA
		70	-	-		V_{CE} = 1V , I_C = 1mA
		100	-	300		V_{CE} = 1V , I_C = 10mA
		60	-	-		V_{CE} = 1V , I_C = 50mA
		30	-	-		V_{CE} = 1V , I_C = 100mA
Transition frequency	f_T	300	-	-	MHz	V_{CE} = 20V , I_E = −10mA, f = 100MHz
Collector output capacitance	Cob	-	-	4	pF	V_{CB} = 10V , f = 100kHz
Emitter input capacitance	Cib	-	-	8	pF	V_{EB} = 0.5V , f = 100kHz
Delay time	td	-	-	35	ns	V_{CC} = 3V , $V_{BE(OFF)}$ = 0.5V , I_C = 10mA , I_{B1} = 1mA
Rise time	tr	-	-	35	ns	V_{CC} = 3V , $V_{BE(OFF)}$ = 0.5V , I_C = 10mA , I_{B1} = 1mA
Storage time	tstg	-	-	200	ns	V_{CC} = 3V , I_C = 10mA , I_{B1} = −I_{B2} = 1mA
Fall time	tf	-	-	50	ns	V_{CC} = 3V , I_C = 10mA , I_{B1} = −I_{B2} = 1mA

●Electrical characteristic curves

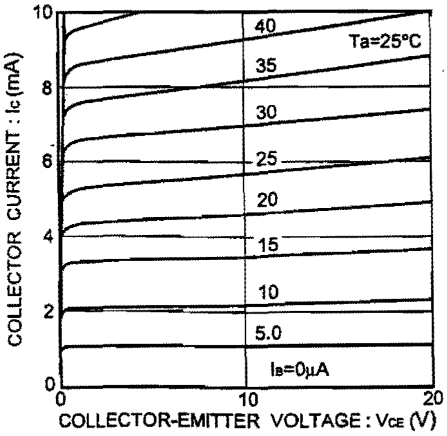


Fig.1 Grounded emitter output characteristics

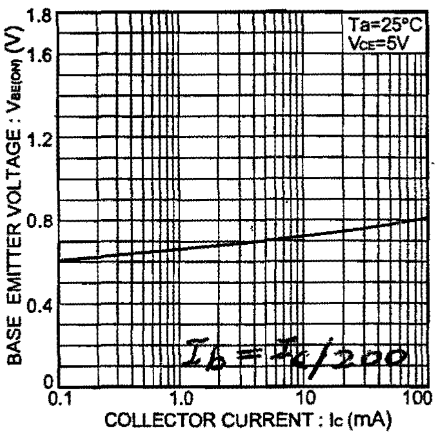


Fig.7 Grounded emitter propagation characteristics

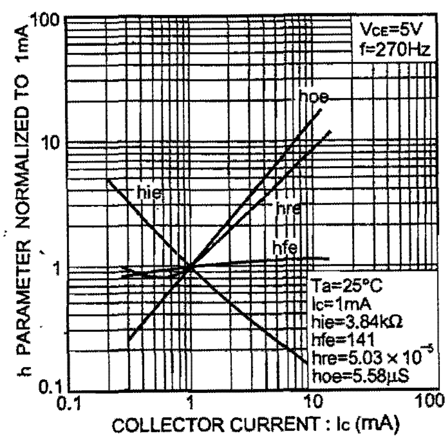


Fig.15 h parameter vs. collector current

SPECIFICATIONS (T_A = 25°C UNLESS OTHERWISE NOTED)

Parameter	Symbol	Test Conditions		Min	Typ[a]	Max	Unit
				Limits			
Static							
Gate-Source Breakdown Voltage	$V_{(BR)GSS}$	I_G = –1 µA, V_{DS} = 0 V		–25	–35		V
Gate-Source Cutoff Voltage	$V_{GS(off)}$	V_{DS} = 15 V, I_D = 2 nA			–3	–8	V
Saturation Drain Current[b]	I_{DSS}	V_{DS} = 15 V, V_{GS} = 0 V		2	10	20	mA
Gate Reverse Current	I_{GSS}	V_{GS} = –15 V, V_{DS} = 0 V			–0.002	–2	nA
			T_A = 100°C		–0.002	–2	µA
Gate Operating Current[c]	I_G	V_{DG} = 10 V, I_D = 1 mA			–20		pA
Drain Cutoff Current	$I_{D(off)}$	V_{DS} = 10 V, V_{GS} = –8 V			2		pA
Drain-Source On-Resistance	$r_{DS(on)}$	V_{GS} = 0 V, I_D = 1 mA			150		Ω
Gate-Source Voltage	V_{GS}	V_{DS} = 15 V, I_D = 200 µA		–0.5	–2.5	–7.5	V
Gate-Source Forward Voltage	$V_{GS(F)}$	I_G = 1 mA, V_{DS} = 0 V			0.7		V
Dynamic							
Common-Source Forward Transconductance[c]	g_{fs}	V_{DS} = 15 V, V_{GS} = 0 V	f = 1 kHz	2	5.5	6.5	mS
			f = 100 MHz	1.6	5.5		mS
Common-Source Output Conductance[c]	g_{os}	V_{DS} = 15 V, V_{GS} = 0 V	f = 1 kHz		25	50	µS
Common-Source Input Capacitance	C_{iss}	V_{DS} = 15 V, V_{GS} = 0 V, f = 1 MHz			2.2	8	pF
Common-Source Reverse Transfer Capacitance	C_{rss}	V_{DS} = 15 V, V_{GS} = 0 V, f = 1 MHz			0.7	4	pF
Equivalent Input Noise Voltage[c]	$\bar{e}_n$	V_{DS} = 10 V, V_{GS} = 0 V, f = 100 Hz			6		nV/√Hz

Notes
a. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
b. Pulse test: PW ≤300 µs, duty cycle ≤2%.
c. This parameter not registered with JEDEC.

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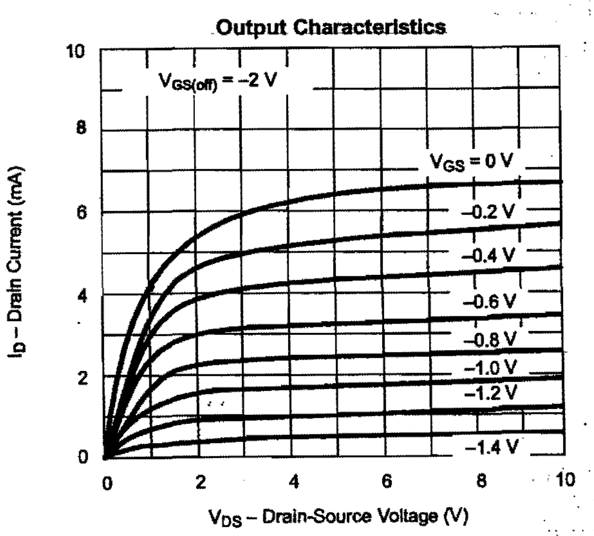
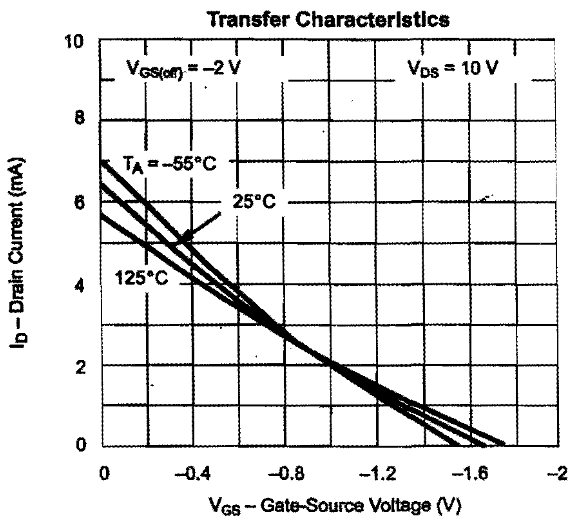
TYPICAL CHARACTERISTICS (T_A = 25°C UNLESS OTHERWISE NOTED)





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