165

UNIVERSITY OF SWAZILAND

MAIN EXAMINATION 2004/2005

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER:	ELECTRONICS III - PAPER 2
COURSE CODE:	E510
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. Answer any FOUR (4) of the following six questions.
2. Each question carries 25 marks.
3. Unless otherwise stated, $V_{BE(ON)} = 0.7$ V and $V_T = 0.026$ V.
4. If you think not enough data has been given in any question you may assume reasonable values.
5. In design, when necessary, use the following E24 range of values:

   10 11 12 13 15 16 18 20 22 24 27 30 33 36 39 43
   47 51 56 62 68 75 82 91

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(25 marks)***

(a) Briefly outline the special advantages that current-differencing (Norton) amplifiers have over ordinary voltage operational amplifiers. *(10 marks)*

(b) A schematic diagram of a Norton amplifier is shown in Fig. Q.1b

(i) Explain how a current-difference is obtained. *(3 marks)*

(ii) What is the purpose of the current sources I_1 and I_2? *(3 marks)*

(iii) What limitation, if any, exists on the voltages at the input? *(3 marks)*

(iv) Obtain a relationship between the input currents and the current at the output terminal. *(6 marks)*

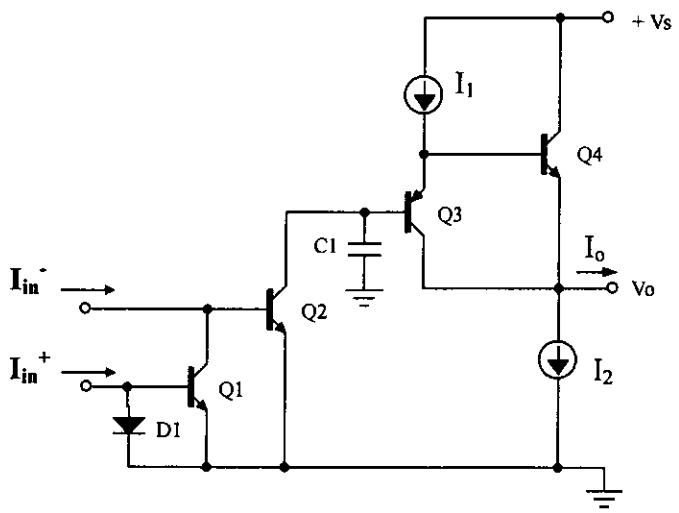

Fig. Q.1b

QUESTION TWO ***(25 marks)***

(a) Figure Q.2a shows the internal schematic of an operational transconductance amplifier (OTA) like the type CA3080. **It is not necessary to redraw this circuit in your answer. Refer to voltages and currents using appropriate device terminals.**

(i) Neglecting base currents derive a relationship between the input voltages and output current. *(5 marks)*

(ii) Show that $g_m = 19.2\ I_{abc}$ mS, where I_{abc} is in mA. *(2 marks)*

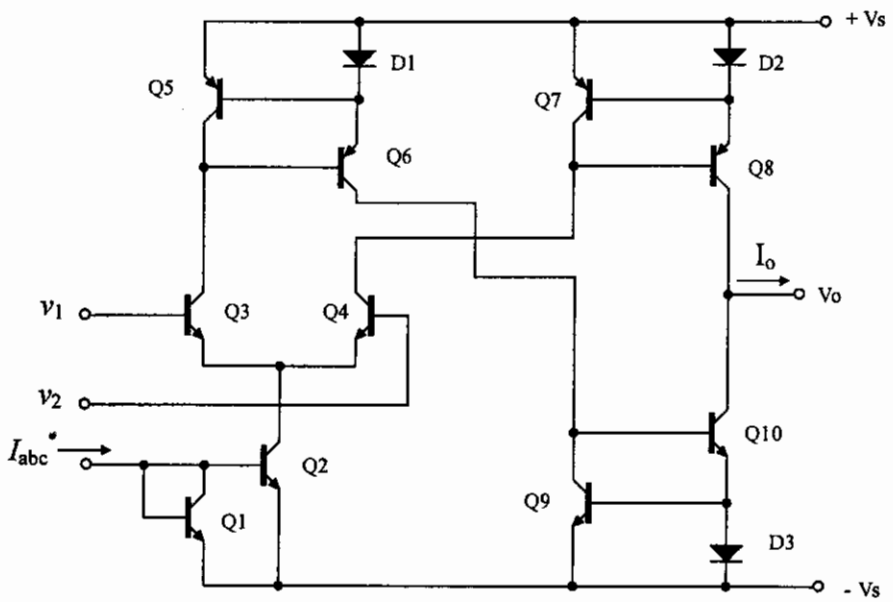

Fig. Q.2a

(b) The CA3080 OTA has the following key specifications:

V_{cc}	=	4 to 30 V or ±2 to ±15 V
$V_{in\ max}$	=	± 5 V
I_{abc}	=	0.1 mA to 1 mA
g_m	=	19.2 I_{abc} mS, where I_{abc} is in mA

Design an amplifier using this IC to give a voltage gain of 100 with load resistance of 10 kΩ and power supplies of ±10 V. *(8 marks)*

(c) State three advantages that OTAs have over ordinary op-amps. *(5 marks)*

(d) Explain how the OTA can be used as an analogue switch. *(5 marks)*

QUESTION THREE ***(25 marks)***

(a) Fig. Q.3a shows a circuit of a very simple op-amp. **It is not necessary to redraw this circuit in your answer. Use the device labels and refer to voltages and currents using appropriate device terminals.**

(i) Briefly discuss the operation of the circuit. *(10 marks)*

(ii) Identify with reasons the inverting input of the amplifier. *(3 marks)*

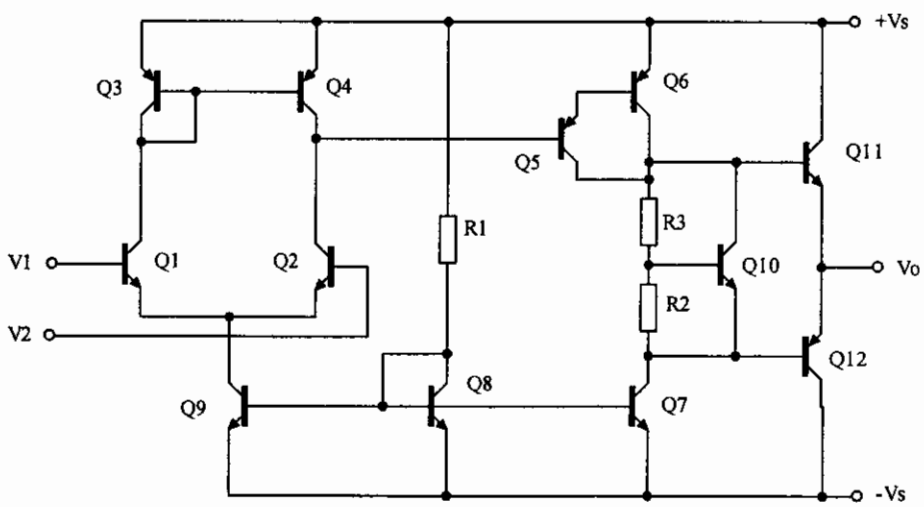

Fig. Q.3a

(b) Calculate the voltage gain $v_o/(v_1-v_2)$ of the amplifier in Fig. Q.3b. Assume that all transistors are matched with $V_A = 100$ and $\beta = 100$. *(12 marks)*

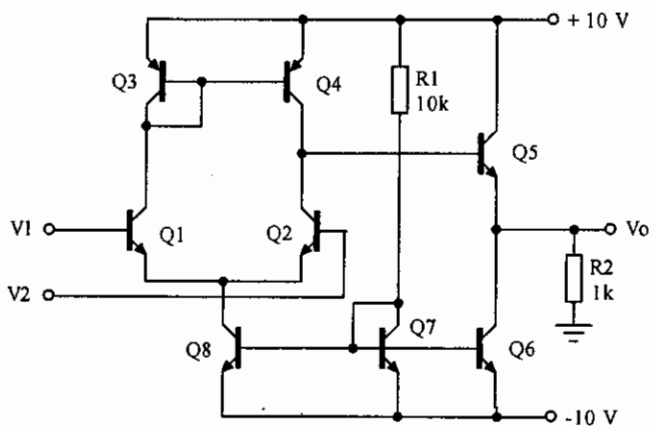

Fig. Q.3b

QUESTION FOUR *(25 marks)*

(a) Explain analytically how the circuit configuration in Fig Q.4a can be used as the basis for a two-quadrant voltage multiplier circuit. *(10 marks)*

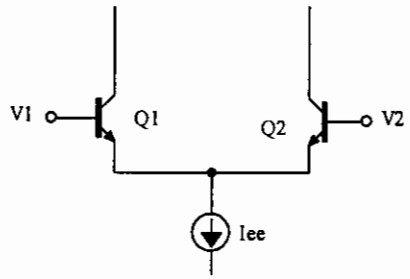

Fig. Q4a

(b) It is suggested that two-quadrant multiplier circuits of type similar to Fig. Q.4a may be used to implement a four-quadrant multiplier. Show how the four-quadrant multiplier may be realized, deriving any equations necessary.

(15 marks)

QUESTION FIVE *(25 marks)*

(a) Explain the terms 'capture range' and 'lock range' as used in the description of phase-locked loops (PLLs). *(4 marks)*

(b) Explain how a frequency synthesizer can be realized using a PLL. *(5 marks)*

(c) Figure Q.5c shows a functional diagram of the AD835 four-quadrant multiplier.

(i) Explain what is meant by 'four-quadrant'. *(1 mark)*

(ii) Show by means of illustrations and explanations how this chip may be used to implement each of the following operations:

1. Voltage-controlled amplification *(5 marks)*
2. Amplitude amplification *(5 marks)*
3. Frequency doubling. *(5 marks)*

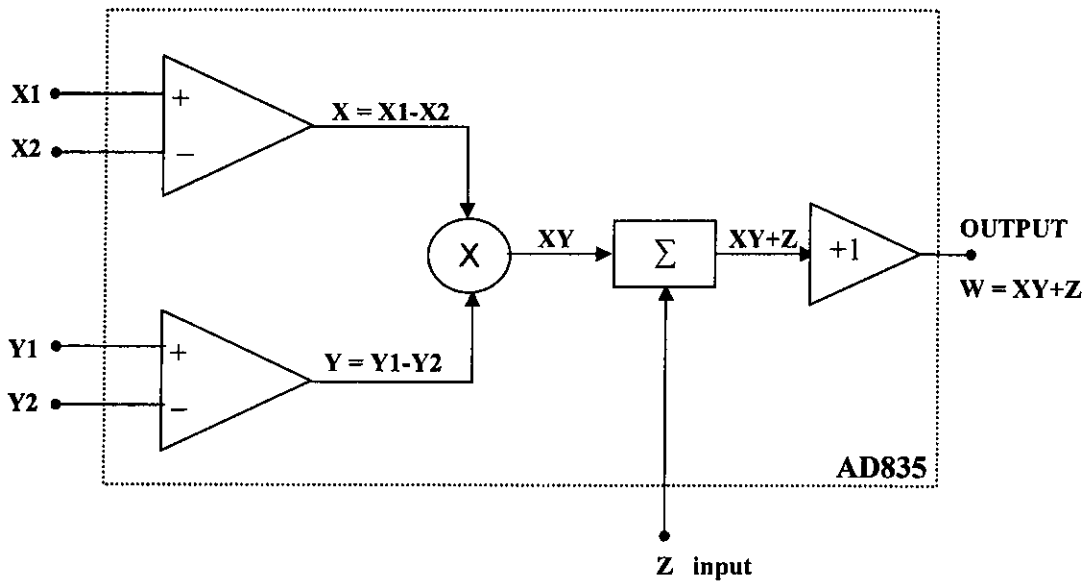

Fig. Q.5c Functional diagram of AD835 4-quadrant multiplier

QUESTION SIX *(25 marks)*

(a) For a particular series-voltage feedback amplifier, measurement of the output resistance with and without feedback shows a change of the output resistance by a factor of 50.

(i) Is the output resistance with feedback lower or higher than the resistance without feedback? *(2 marks)*

(ii) What is the value of the loop gain? *(2 marks)*

(iii) If the input resistance of the forward amplifier without feedback is 50 kΩ what is the closed-loop input resistance? *(2 marks)*

(b) (i) Which feedback is employed in the current source of Fig. Q.6b. *(1 mark)*

(ii) Obtain an expression for β *(2 marks)*

(iii) Show that if βA >> 1 then $\frac{I_o}{V_{in}} \simeq \frac{1}{R_e}$ *(2 marks)*

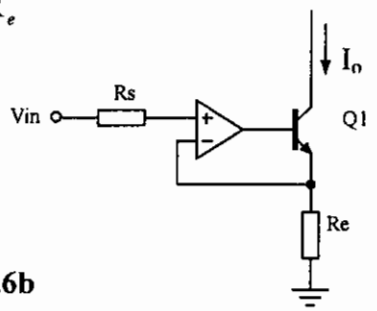

Fig. Q.6b

(c) The step-up chopper shown in Fig. Q.6c. has an inductance L = 10 mH and a load resistance of 10 Ω. The MOSFET switches at a frequency of 2 kHz with a duty cycle of 0.5.

(i) Calculate the average output voltage. *(2 marks)*

(ii) Calculate the average load current. *(2 marks)*

(iii) Calculate the average load power. *(2 marks)*

(iv) Calculate the average the supply current. *(2 marks)*

(v) Find and sketch the inductor current showing maximum and minimum current values. *(6 marks)*

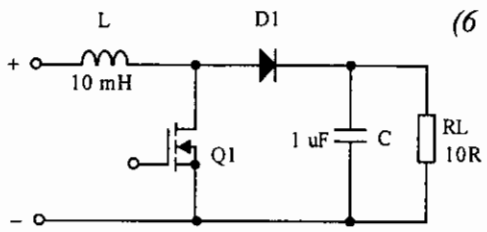

Fig. Q.6c

END OF QUESTION PAPER