The University Of Sheffield.

**DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING**

January 2014 (2 hours)

EEE225 ANALOGUE AND DIGITAL ELECTRONICS MID YEAR TEST

Answer **ALL** questions. **The numbers given after each question indicate the relative weighting of that question. A total of 50 marks can be obtained from the eight questions.**

# REGISTRATION NUMBER:......................................................................

WRITE YOUR ANSWERS ON THIS QUESTION PAPER

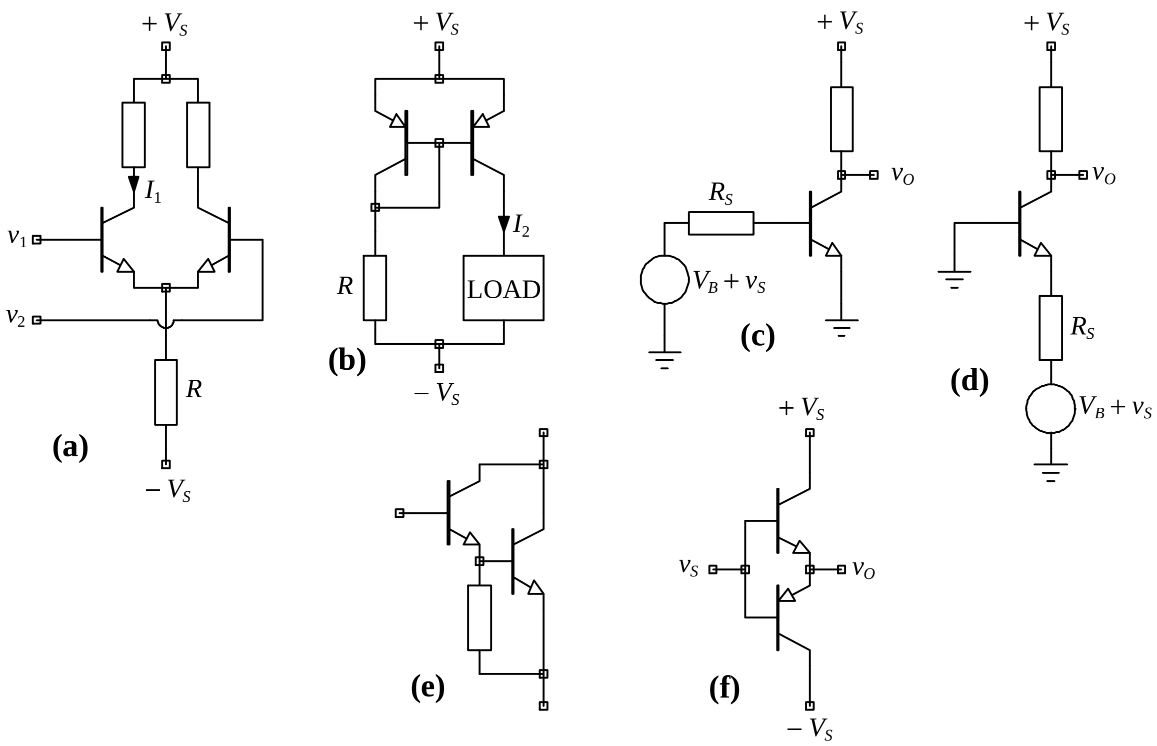


**Figure 1**

**1** Figure 1 shows six transistor circuits. Complete the table below by identifying the circuits (a) to (f) each with one of the names in the table below. Note that there are more names than circuits. ***{6 marks}***

| | | | | | |
|---|---|---|---|---|---|
| emitter follower | | common base amplifier | | current mirror | |
| differential amplifier | | cascode pair | | voltage regulator | |
| push-pull output stage | | Darlington pair | | common emitter | |

**2** How many p-n-p transistors are shown in total in figure 1? ***{1 mark}***

**Q2 ANS:**

**3** In all the circuits of Figure 1 $+V_S = 5$ V, $-V_S = -5$ V and $R = 10$ kΩ. Estimate

**(i)** the value of $I_1$ in figure 1a when $v_1 = v_2 = 0$ V. What two assumptions have you had to make in order to estimate $I_1$? ***{5 marks}***

**Q3 (i) ANS:**

**(ii)** the value of $I_2$ in figure 1b. What three assumptions have you had to make in order to estimate $I_2$? ***{5 marks}***

**Q3 (ii) ANS:**

**4** Using a transistor model consisting of a current source and an input resistance, draw a small signal equivalent circuit of figure 1c. Label all your components. ***{4 marks}***

**Q4 ANS:**

**5** The three standard forms of a first order transfer function are:

$$\textbf{(a)}\ \frac{v_o}{v_i} = k\,\frac{1}{1 + j\dfrac{\omega}{\omega_0}}, \qquad \textbf{(b)}\ \frac{v_o}{v_i} = k\,\frac{j\dfrac{\omega}{\omega_0}}{1 + j\dfrac{\omega}{\omega_0}} \quad \text{and} \quad \textbf{(c)}\ \frac{v_o}{v_i} = k\,\frac{1 + j\dfrac{\omega}{\omega_1}}{1 + j\dfrac{\omega}{\omega_0}}$$

Identify the names of each of these transfer functions by putting the appropriate letter (a, b or c) against the names in the table below. There might be more than one correct answer for each transfer function. ***{4 marks}***

| | | | |
|---|---|---|---|
| band stop | | lead - lag | |
| underdamped | | all pass | |
| pole - zero | | high pass | |
| low pass | | band pass | |

**6** An op-amp connected as a non-inverting amplifier with resistive feedback has a – 3 dB bandwidth of 2 MHz when wired to give a low frequency gain of 20 V/V. What – 3 dB bandwidth would be expected for the same amplifier if its feedback resistors were modified to give a low frequency gain of 500 V/V? ***{3 marks}***

**Q6 ANS:**

**7** A certain op-amp has a slew rate specified as 10 V $\mu s^{-1}$. What is the maximum frequency at which a 4 Vpk-pk sinusoid can be supported in undistorted form at its output? ***{3 marks}***

**Q7 ANS:**

**REGISTRATION NUMBER:**.....................................................................

**8** Complete the table below by identifying each of the twenty statements as either true or false.

| | | |
|---|---|---|
| 1 | You can never have two electrons with exactly the same energy. | |
| 2 | The valence band contains only holes. | |
| 3 | At room temperature, only a small fraction of dopant atoms are normally ionised. | |
| 4 | Wider (or larger) band-gap semiconductors emit shorter wavelength light. | |
| 5 | A p-n junction is essential to make a photo-detector. | |
| 6 | Optical fibres are typically more expensive than copper cables. | |
| 7 | All metal-semiconductor junctions are Schottky junctions. | |
| 8 | You need to have a direct band-gap semiconductor to make a laser. | |
| 9 | It is possible to use a solar cell as a photodiode. | |
| 10 | In a p-type semiconductor, the Fermi level is close to the conduction band. | |
| 11 | Indirect band-gap semiconductors cannot detect light. | |
| 12 | Schottky diodes usually have higher switching speeds than p-n junction diodes. | |
| 13 | Conduction in a semiconductor requires you to have both electrons and holes. | |
| 14 | The spectral linewidth of emission from a LED is much larger than that from a laser. | |
| 15 | The semiconductor workfunction in an n-type semiconductor has to be less than the metal workfunction to form a Schottky junction. | |
| 16 | In an intrinsic semiconductor, the Fermi level is at the mid point of the band-gap. | |
| 17 | At very high temperatures an n-type semiconductor can become intrinsic. | |
| 18 | Compensation doping results in a decrease in the acceptor and donor concentrations. | |
| 19 | Electrons in a semiconductor will normally occupy the lowest energy level. | |
| 20 | Doping a semiconductor with donors makes the overall net charge negative. | |

**9** Silicon has an intrinsic carrier concentration of $10^{16}$ m$^{-3}$ at room temperature. Given that the electron and hole mobilities in silicon at room temperature are 0.15 m$^{2}$ V$^{-1}$ s$^{-1}$ and 0.05 m$^{2}$ V$^{-1}$ s$^{-1}$ respectively;

**(i)** What is the conductivity of intrinsic silicon at room temperature?

**Q9 pt (i) ANS:**

**(ii)** If the silicon was doped with donors to the level of $3 \times 10^{23}$ m$^{-3}$, what is the electron and hole concentration in the silicon?

**Q9 pt (ii) ANS:**

**(iii)** What is the resistivity of the silicon for the conditions of Q9 part **(ii)** above?

**Q9 pt (iii) ANS:**

**10** A metal with a work function of 0.7 eV and a n-type semiconductor with a work function of 1 eV form a junction. When 0 V is applied to the metal and + 2 V is applied to the n-type semiconductor, a current of 1 mA flows. What magnitude of current would flow if 0 V was applied to the metal and – 2 V was applied to the n-type semiconductor?

**Q10 ANS:**

**Q10 ANS cont . . .**

**11** A silicon Metal Oxide Transistor (MOST) in a circuit is known to have the following properties: an electron mobility of 0.15 $m^2 V^{-1} s^{-1}$, a drain - source voltage of 20 V and a gate capacitance of 0.2 pF. This MOST has a transconductance of 5 mS.

**(i)** What is the gate length?

**Q11 pt (i) ANS:**

**(ii)** What is the saturated drain - source current under this operating condition?

**Q11 pt (ii) ANS:**