EE3019 - Integrated Electronics Tutorial 10

1. **A bias source is depicted in Figure 10.1 where Q_2 is twice the size of Q_1. The other transistors are the same size as Q_1.**

(a) **State the basic mechanism of this bias source.**

(b) **Derive the variation of the fractional temperature coefficient for the output current.**

(c) **Determine the resistance R_2 for the current bias reference circuit to obtain an output of 100μA and the resultant TC_F at room temperature (T=300K). Assume that the resistor temperature coefficient is 1500 ppm/°C.**

[(c) 180Ω, 1800ppm/°C]

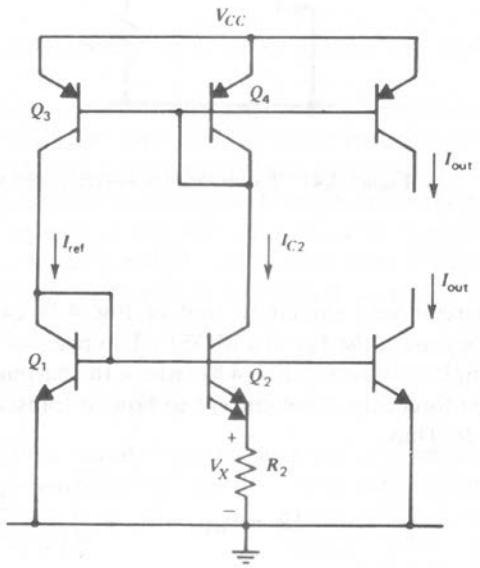


Figure 10.1

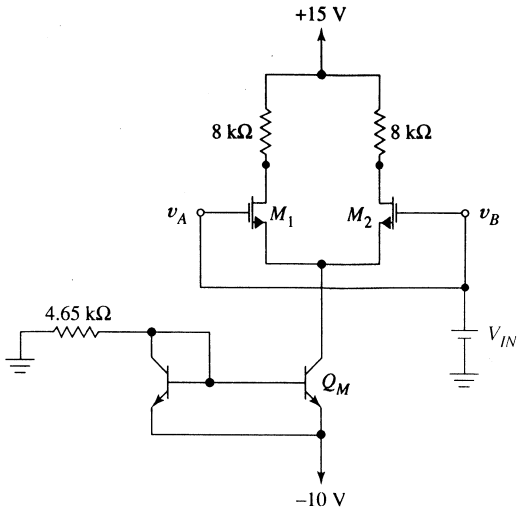


Figure 10.2

2. **A differential amplifier depicted in Figure 10.2 comprises 4 transistors where**

MOS transistors: $\mu_n C_{ox} W/L = 0.2 \times 10^{-3}$ A/V^2, $V_t = 0.5$ V

Bipolar transistors: $V_{CE(sat)} = 0.2$ V.

Assume that the two MOSFETs have an identical aspect (i.e. W/L) ratio and that the two BJTs have identical emitter areas.

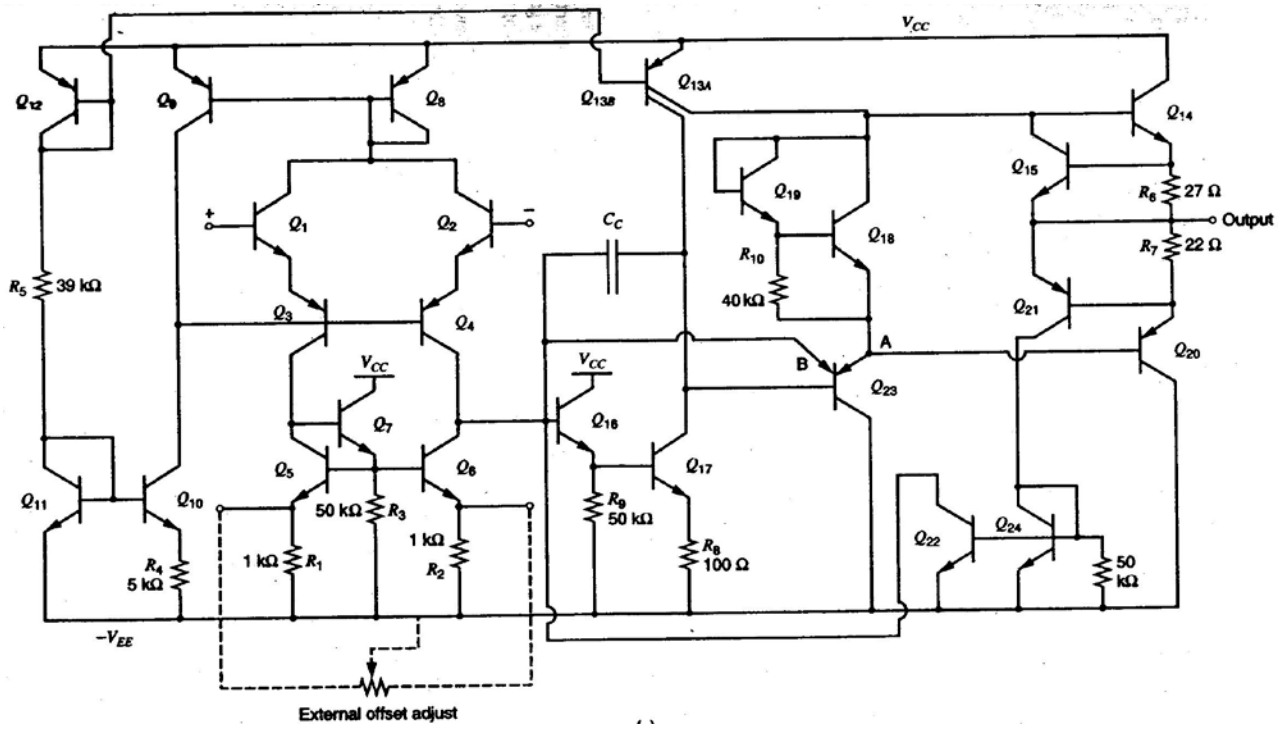
(d) **Show that all the MOSFETs and BJTs are active for the zero-input condition, i.e. $V_{in} = 0$.**

(e) **Find the maximum and minimum common-mode input voltages, i.e. the limits of operation where the circuit remains in active operation.**

[(b) -6.14V ≤ V_{in}≤ 7.5V]

3. **Explain the function of each transistor in the op amp shown in Figure 10.3.**

Figure 10.3


V_{CC}
Q_{13A}
Q_{13B}
Q_{12}
Q_9
Q_8
Q_{14}
Q_{15}
Q_{19}
R_6 27 Ω
Output
R_7 22 Ω
Q_1
Q_2
C_C
Q_{18}
R_{10}
40 kΩ
R_5 39 kΩ
Q_3
Q_4
Q_{21}
Q_{20}
A
B
Q_{23}
V_{CC}
Q_7
Q_{16}
Q_{17}
Q_5
Q_6
Q_{11}
Q_{10}
50 kΩ R_3
1 kΩ R_1
1 kΩ R_2
R_9 50 kΩ
R_8 100 Ω
Q_{22}
Q_{24}
50 kΩ
R_4 5 kΩ
$-V_{EE}$
External offset adjust