1. (a) Draw the cross-sectional diagram of an NMOS transistor operated in saturation region and give the drain current equation for it to include the channel-length modulation effect. What is the relationship between Early voltage and output resistance ? (10%)
   (b) Given a diode, how to determine the SPICE parameters emission coefficient N, ohmic resistance $R_S$, and junction grading coefficient M from experiment ? (10%)

2. Explain briefly (a) what is the totem-pole output structure for a TTL NAND gate? (4%) (b) what is the advantage of this structure. (2%)

3. (a) For the logic diagram of the digital counter shown in Fig. 1, please write the truth table for $Q_0$, $Q_1$, $Q_2$, and $Q_3$ (starting with 0000) after each pulse. If no connection is shown to a J or K input, then this terminal is understood to be high (a 1). (10%)
   (b) If this system can be used as a N:1 counter, please evaluate the value of N. (4%)

4. In the circuit of Fig. 2, $Q_1$ and $Q_2$ are identical and have $\beta_o = \beta_F = 200$ and $V_A = \infty$. (20%)
   (a) Explain the function of current source $I_{EE}$ with $R_E$ in this circuit.
   (b) The current source is realized by a simple current mirror. Design the mirror. Transistor used for the mirror have $\beta_o = \beta_F = 200$. Estimate the Early voltage.
   (c) Evaluate $A_{DM}$, $A_{CM}$, and CMRR.
   (d) determine $R_{id}$ and $R_{iC}$.

5. (a) Draw a NOR-gate astable multivibrator and derive the period of the output voltage. (4%)
   (b) Draw the circuit diagram of a $V_{BE}$ multiplier and explain its operation. (4%)

6. (a) Draw the circuit model of a two-pole feedback amplifier and derive the gain-crossover frequency. What will happen if the magnitude of loop gain at the phase-crossover frequency is grater than unity ? (8%)
   (b) For a single-loop feedback oscillator, what starts the oscillation and what determine the oscillation frequency. (4%)

7. The normalized magnitude of the Butterworth filter function is $|H(j\omega)| = \frac{1}{\sqrt{1+(\frac{\omega}{\omega_p})^{2N}}}$. A low-pass Butterworth filter is to be designed to have a 3-dB bandwidth of 100Hz and an attenuation of 60 dB at 350Hz. Determine the order of the Butterworth filter required. (10%)

8. Draw the architectures of (a) a 2-bit flash A/D converter (5%) and (b) a 3-bit R-2R D/A converter. (5%)

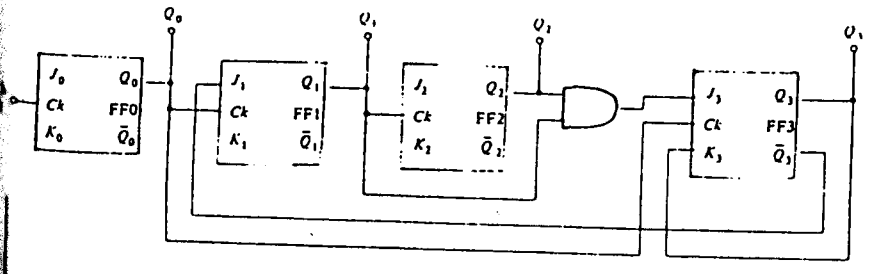


Fig. 1

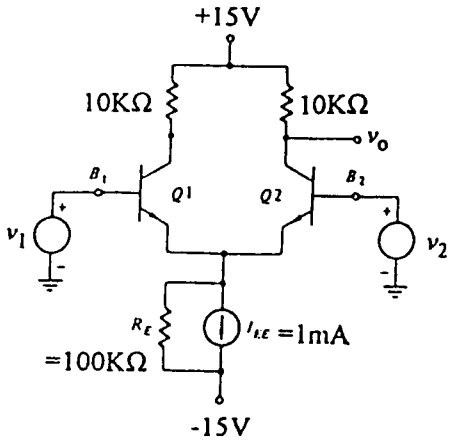


Fig. 2