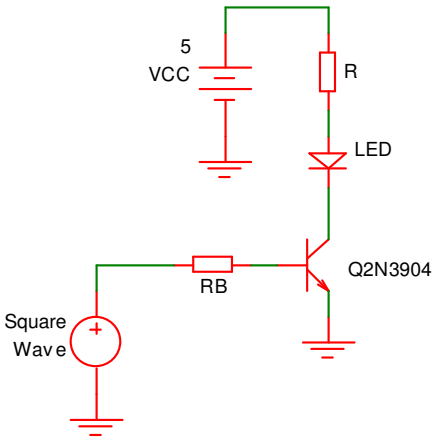
ECE 363 EXAM 1 Practice Problems

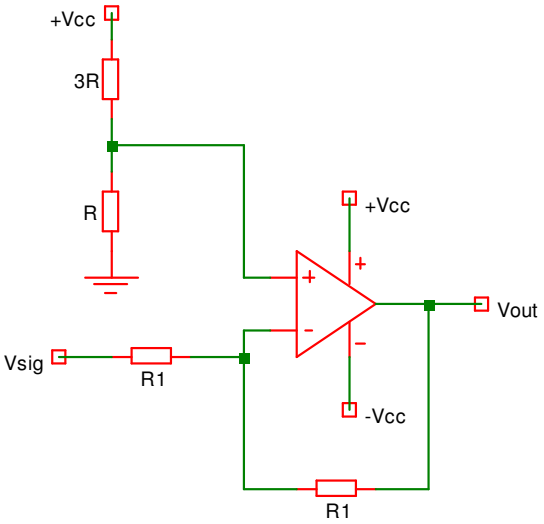
Problem #1: Transistor Switch Design



Design a npn BJT switch to drive a green LED (V_F = 2.5 V) with 30 mA of current. The control signal is 0 to +5V square wave with 75% duty cycle, and V_{CC} = +5 V. Use a 2N3904 transistor – check the datasheet (see attachment) for worst-case values of β, $V_{BE,sat}$, and $V_{CE,sat}$.

(a) Choose standard 5% resistor values (see attachment for table) for R and R_B. Choose R such that I_{LED} is NOT < 30 mA.
(b) Would you use a 1/8, 1/4, or 1/2 watt resistor for R?
(c) Sketch the LED power dissipation. Label important features!

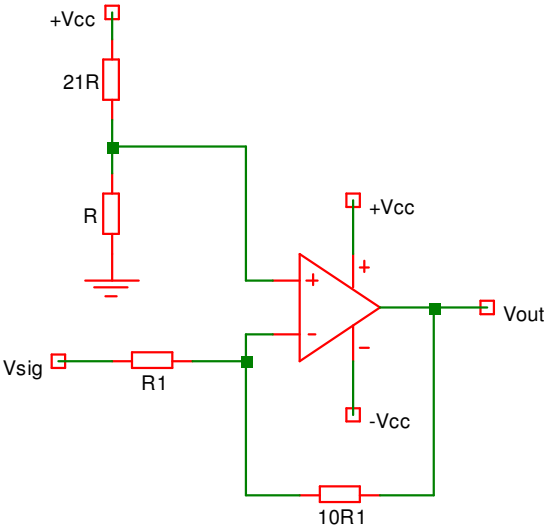
Problem #2: Op Amp Analysis



Consider a level-shifting amplifier. The (+) input is connected to a voltage divider consisting of 3R and R. The op amp feedback network consists of two identical resistors R1.

(a) Use the Golden Rules to show that $V_{OUT} = 0.5V_{CC} - V_{SIG}$. Show all work.
(b) Let R = 10 kohm, R1 = 100 kohm, V_{CC} = 12V. The input V_{SIG} is a $8V_{PP}$ sine wave at 2 kHz. Sketch the input and output voltages over a 2 ms interval. Label important features!
(c) Compute the total power dissipation in the voltage divider formed by 3R and R.

Problem #3: Op Amp Output Error



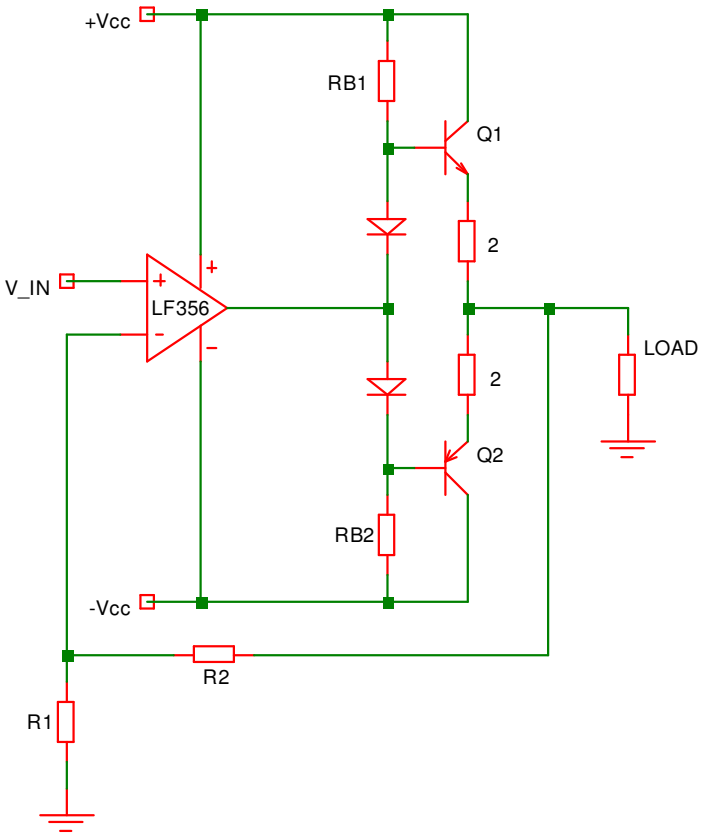
Consider a level-shifting amplifier using a LM318 op amp. The (+) input is connected to a voltage divider consisting of 21R and R. The op amp feedback network consists of two resistors R1 and R2 = 10R1.

(a) Use the Golden Rules to show that $V_{OUT} = 0.5V_{CC} - 10V_{IN}$. Show all work.
(b) Let R = 10 kohm and R1 = 100 kohm. When V_{SIG} = 0, the output is ideally $V_{OUT} = 0.5V_{CC}$. In reality, the output is $V_{OUT} = 0.5V_{CC} + \Delta V$. Given the worst-case values for $I_{in(bias)}$, $I_{in(offset)}$, and $V_{in(offset)}$, compute ΔV due to each parameter.
(c) Is the main source of error due to input bias current, input offset current, or input offset voltage?

Problem #4: Class AB Design

Design a non-inverting voltage amplifier to drive up to 500 mW (or slightly higher) into a 50 ohm load. The input signal is a sine wave with a maximum amplitude of $0.5V_{PP}$. The suggested schematic is shown in the figure, where an LF356 op amp is used. Q1 is a 2N4401, and Q2 is a 2N4403.

(a) V_{CC} must be 4.5, 6, 9, or 12V. Choose one and explain why.
(b) Choose RB1 and RB2. Pick standard 5% values.
(c) Show that the op amp can provide the required output voltage and current.
(d) Choose R1 and R2. Remember that R1 should be more than a few kohm and R2 is typically less than 1 Mohm. Pick standard 5% values.
(e) Do your transistors need heat sinks? Use T_A = 60℃ for your power rating calculations.



Problem #5: Current Booster Analysis

Suppose V_{IN} is a 10% duty cycle square wave that alternates between +10V (HIGH) and -10V (LOW). The load is R_L = 75 ohm. Both transistors have $V_{BE,ON}$ = 0.75V, $V_{CE,SAT}$ = 0.4V, and β = 80.

(a) You must choose between V_{CC} = 9, 12, or 15V. Which is the best choice? Show all work.
(b) Sketch V_{IN}, V_{OUT}, i_{E1} (Q1 emitter current), and i_{E2} (Q2 emitter current). Label important features.
(c) Given your choice of V_{CC}, estimate the power dissipation in Q1 and Q2.