EE 204 - Analog Circuits
Lecture 10

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Contents

1 Transistor Amplifier

We have already discussed the Transistor Amplifier circuit a lot of times, but here we will approach the same circuit from a different point of view. Here, given our input conditions, we will try to design the circuit i.e. assign circuit parameters such values that help us get our desired values.

Throughout this discussion, we will stick through the following initial parameters/specifications:

- Input Signal = 0.1 V
- Signal Frequency = 1 kHz
- Amplification Factor = 10
- Supply Voltage = 10 V
- Load Resistance = 10 $k\Omega$

The equivalent box diagram would look something like this:

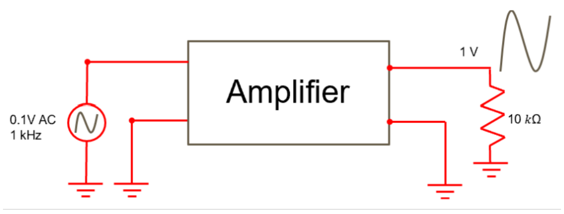

Figure 1: Transistor Amplifier Box

1.1 Designing the Circuit

By designing the circuit, what we are trying to convey is that we find out the values of the components that have been used in the circuit to get the desired outputs corresponding to out initial specifications.

This is the original circuit without any modifications

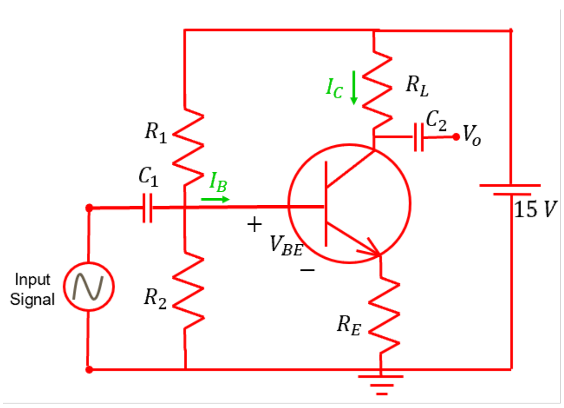

Figure 2: Amplifier

Maintain C = $V_2/2$ = 5V when there is no input voltage $V_{in} = 0$.

Current flowing through load R_L is flowing through R_1 hence we have to make sure that R_1 is much smaller than 10 $k\Omega$ so that the loading effect will be minimized. Hence, consider the load and fix R_1 at least 10 times smaller than R_L.

Therefore, $R_1 = 1k\Omega$

As, we defined gain $g = \frac{R_1}{R_E}$, and here since gain is 10, therefore indicating $R_E = 0.1k\Omega = 100\Omega$

We know $R_E = 100\Omega$, what is the voltage at emitter E. We already defined the voltage at emitter $E = 5V$ and hence voltage across R_1 would be 5V since the supply voltage is 10V. Then the current through R_1 would be 5 mA.

The current through R_E would be 5 mA by neglecting base current.

Therefore, current through R_1 = Current through $R_E = \frac{10V-5V}{1k\Omega} = 5mA$

Voltage drop across $R_E = 0.5V$ = Voltage at point 'E'. If 'E' is at 0.5V, then 'B' must be at 1.1V because $V_{BE} = 0.6V$

Now, although we assumed the base current is negligible but there is a very small amount of current flowing through the base. If we know the emitter current (I_E) then we can find the base current (I_B) if we know the β (or h_{FE}) = max. current gain = $\frac{I_C \approx I_E}{I_B}$.

So, $I_B = \frac{I_C \approx I_E}{\beta} = \frac{5mA}{100} = 50\mu A$ as β is assumed to be 100.

Once base current is known then we can decide current through R_2 and R_3. The current through R_2 and R_3 to be kept 10 times more than the base current = 500μA. The voltage across R_3 is 1.1V = V_{BE}.

So, $R_3 = \frac{1.1V}{500\mu A} = 2.2k\Omega$ and similarly R_3 will become 17.8kΩ using V_B and V_S as calculated and instantiated above.

Now, we need to calculate the input impedance of amplifier. Input impedance is parallel combination of R_3 and R_2 and the reflected resistance of $R_E(100 * \beta)$ which on calculation gives 2kΩ.

Impedance of C_{in} should be smaller than the input impedance (assuming 10 times smaller).

On solving this, we get $C_{in} = 1\mu F$.

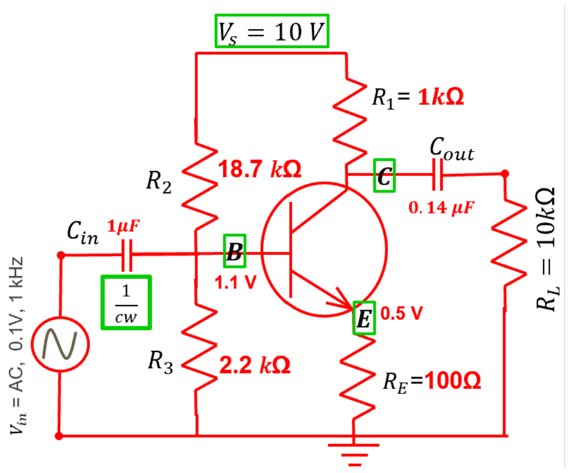

Figure 3: Transistor Amplifier

2 Transistor Relay Circuit

The initial conditions are :

- V_{out} of the OpAmp is +15V, relay to be ON

Goal:

- To find R_1 and R_2?

In order to find $R_1 and R_2$, we need to find base current. To find base current we need to obtain collector current. Collector current is nothing but the load current is relay current. Relay current will be given by the manufacturer.

Assume: Relay current = 100 mA

Once relay current is known then the I_C = 100 mA. Base current: $I_B = \frac{I_C}{\beta} = 1$ mA.

Assume: $\beta = 100$.

We know if transistor is ON then the base voltage would be 0.6V.

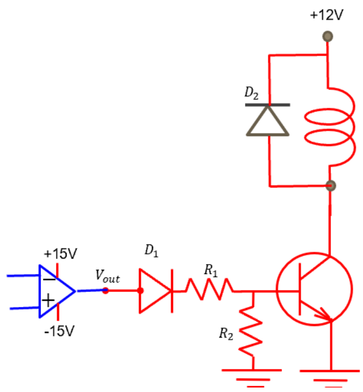

Figure 4: Transistor Relay Circuit

In R_2 is used to discharge the base emitter capacitance of the transistor while no output available from D1 and OPAMP will be in negative saturation state. The R_2 can be large as the base emitter capacitance approximate 100 pF. If $R_2 = 10\text{k}\Omega$ then OFF time is equal to R × C = $10^{-10} \times 10^4 = 10^{-6}s$. Current through $R_2 = \frac{0.6}{10^4} = 0.06mA$.

$I_b = 1$ mA and $I_{R_2} = 0.06$ mA. Hence the total current flowing through $R_1 = 1 + 0.06 = 1.06$ mA.

3 Relay Drive using MOSFET

Then we did Relay Drive using MOSFET the circuit for which is given below:

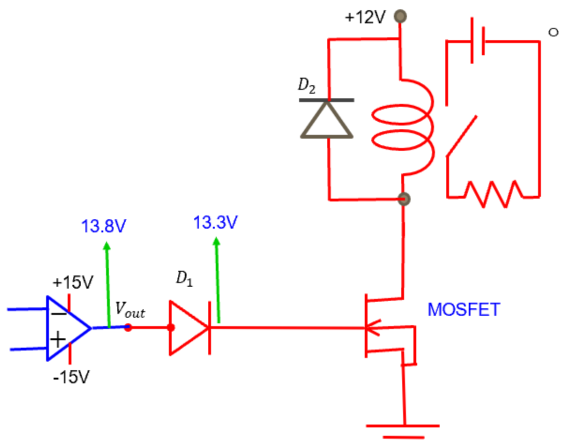

Figure 5: Relay Drive using MOSFET