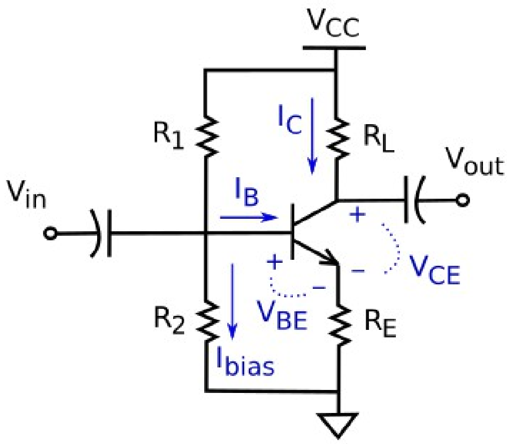
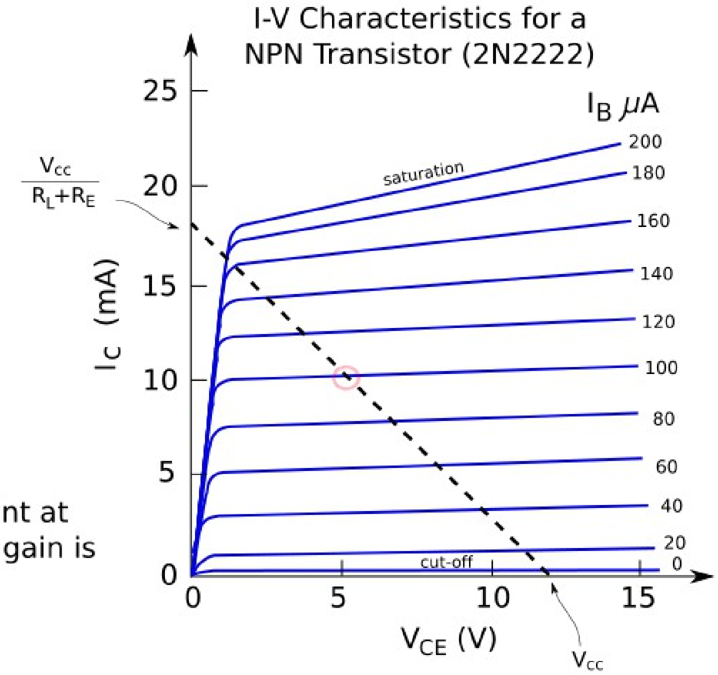
Transistor Circuits

Ying Sun's Lecture Notes

An Example of Common-Emitter NPN Transistor Amplifier





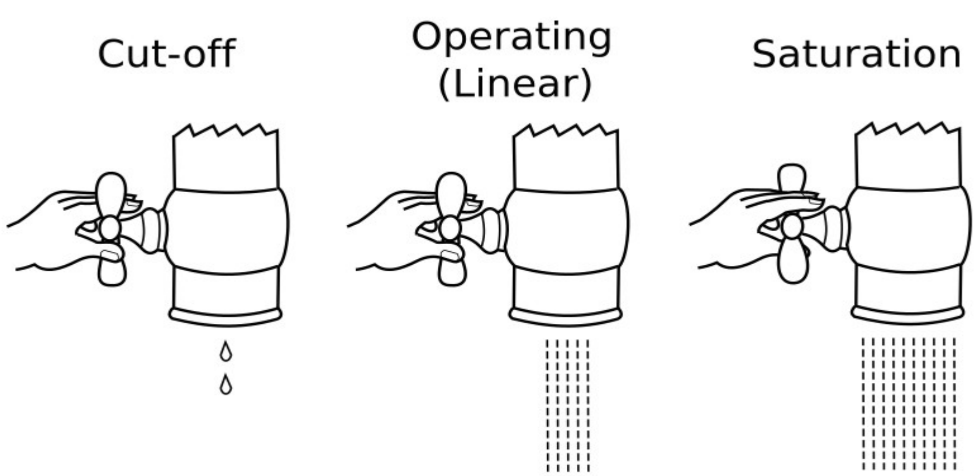
Choose V_{CC} = 12 V. Set the operating point at I_C = 10 mA and I_B = 100 μA. The current gain is

$$\beta = h_{FE} = \frac{\Delta I_C}{\Delta I_B} = 100$$

Choose $R_L = 620\,\Omega$, voltage across R_L is 10 mA x 620 = 6.2 V. V_{CE} = 5 V at the operating point, voltage across R_E is given by V_{CC} – 6.2 V – V_{CE} = 0.8 V. Thus, R_E should be set at 0.8 V / 10 mA = 80 Ω. The bias current I_{bias} is typically set at 10 times of I_B, or 1 mA. V_{BE} is a constant voltage of 0.7 V. Thus, R_2 is (0.8 V + 0.7 V) / 1 mA = 1.5 KΩ. R_1 should be set at (12 V - 1.5 V) / (1 mA + 100 uA) = 9.5 KΩ. The voltage gain is given by:

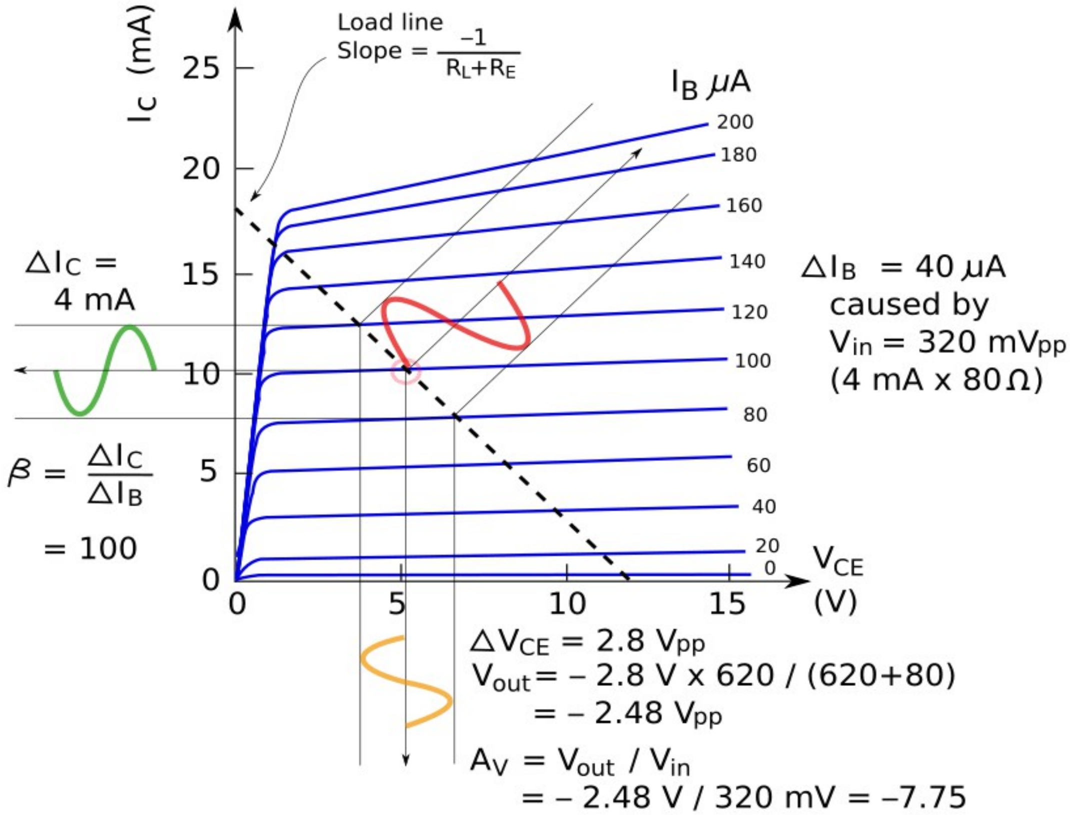
$$A_V = \frac{V_{out}}{V_{in}} = \frac{\Delta V_C}{\Delta V_B} = -\frac{R_L}{R_E} = -620\Omega \;/\; 80\Omega = -7.75$$

For the AC part (small-signal analysis), the two capacitors block the DC bias voltages from the input and the output. V_{out} is 180^{o} out of phase with V_{in}. R_E serves as a negative feedback for this amplifier. More on next page.



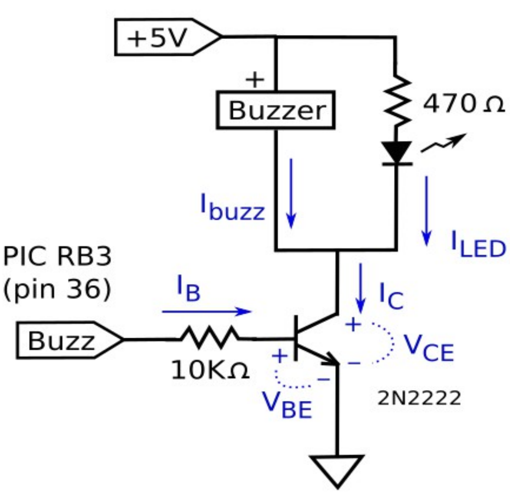
Small-Signal Analysis

The I-V characteristics of a transistor is highly nonlinear. However, if the transistor is biased at an appropriate operating point with DC voltages, a linear input-output relationship can be achieved for small-magnitude AC signals. Thus, this is called the small-signal analysis.



Transistor as a Switch

We use the buzzer circuit on our PIC board as an example. V_{BE} is always 0.7 V. So I_B = (5V – 0.7V) / 10 KΩ = 430 µA, which sets the transistor into saturation or “turns it on”. At saturation, V_{CE} is 0.2 V and I_C is about 20 mA. I_{LED} = (5V – 0.7V – 0.2V) / 470 Ω = 2.5 mA. I_{buzz} = 20 mA – 2.5 mA = 17.5 mA. A 5V buzzer is typically rated at 20 mA. Thus, this transistor switch provides a sufficient current to turn on the buzzer as well as the LED.



The transistor can operate in the nonlinear regions (cut-off and saturation), which acts like an on-off switch.