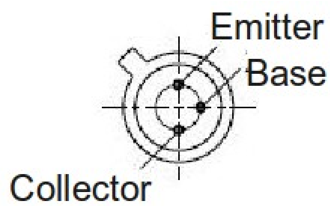
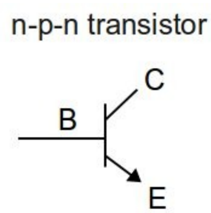
Lab 7: Transistors (version 1.2)

WARNING: Use electrical test equipment with care! Always double-check connections before applying power. Look for short circuits, which can quickly destroy expensive equipment.

The 2N2222A (PN2222A) bipolar junction transistor

The 2N2222A transistor has been used in amplification and switching applications for decades. The pin orientation is determined from the following sketch, looking at the bottom of the transistor:

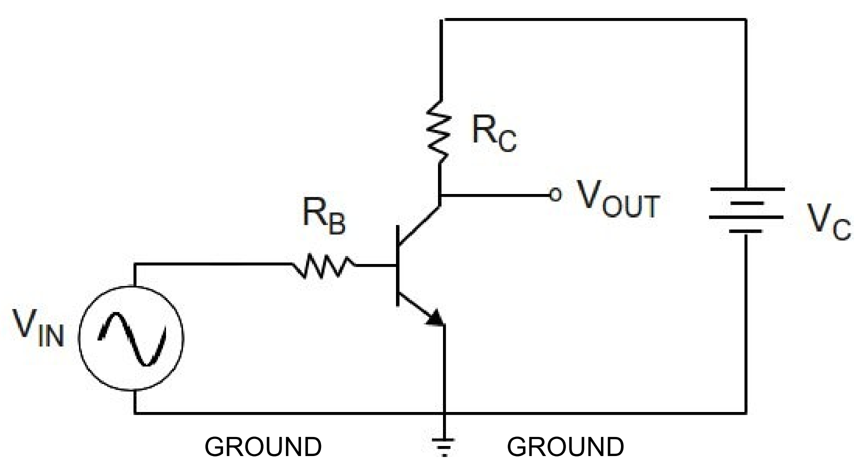




The emitter lead is located closest to the metal tab on the case. Note that the entire case (metal can) is at the potential of the collector and one must use caution to prevent accidentally shorting an electrical connection to it.

Transistor amplifier

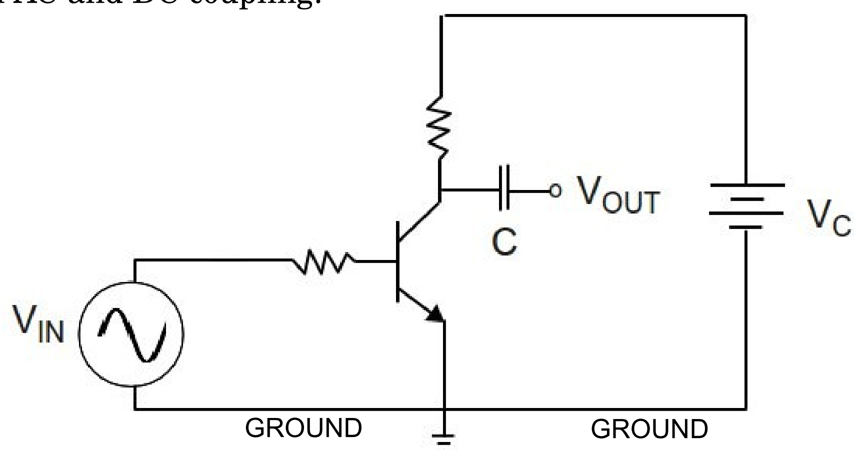
Build the following circuit:



Use R_B = 50 kΩ and R_C = 4.7 kΩ ; neither value is very critical, but always measure components before placing in the circuit. For V_C use the +15V supply located on the left-side of the Elvis board; be sure to connect the supply ground as shown (ground the emitter). The 15V collector voltage can be easily enabled/disabled with the switch located on the upper right corner of the Elvis board. V_{IN} is supplied by the external function generator. Select the high impedance (High Z) mode using Utility: Output Setup: High Z.

Then press Done. Setup the function generator to produce a 1 kHz sine wave with 100 mV p-p amplitude and a 1 V DC offset. Monitor the input signal on CH 1 of the external oscilloscope (use BNC T-connector if desired) and display V_{OUT} on CH 2 using a scope probe. Set both channels on AC coupling.

Measure the gain of this amplifier, which is the ratio V_{OUT}/V_{IN}. Also measure the phase of the two signals. Switch CH 2 to DC coupling and verify the presence of a DC offset signal on the collector. Now add a capacitor C = 100 nF (not critical) in series as indicated below and show that it removes the DC offset; CH 2 signal should be essentially unchanged with AC and DC coupling.

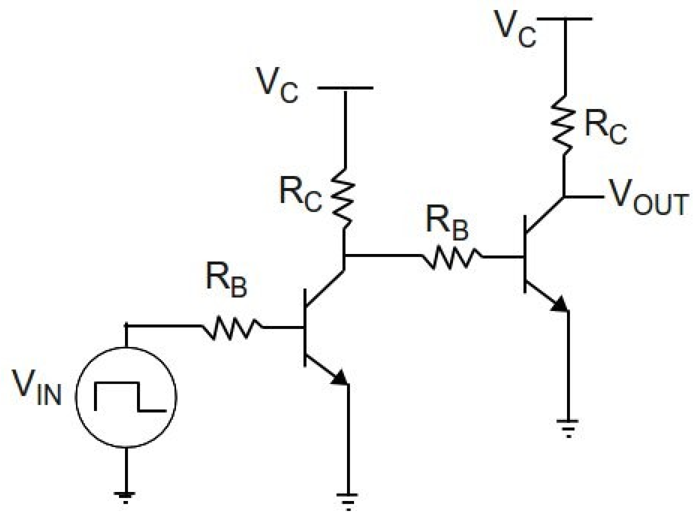


Next set the offset voltage on the function generator to zero and observe what happens. Explain this behavior in the context of the diode experiments done in Lab 6. At this point, show the amplifier results (gain, phase, capacitive coupling, base bias) to the instructor.

Transistor switch

Keep the circuit the same as above, except remove the output capacitor and connect V_C to 5V DC on the Elvis board (be sure to disable power on the board when you are working on it). The function generator is configured to produce an alternating sequence of digital states Logic 0 and Logic 1 at a frequency of 1 kHz. Logic 0 is defined as < 200 mV and Logic 1 is > 2 V. Set the output to be a Square Wave at 3 V p-p with a 1.5 V DC offset. Observe this signal on CH 1 with DC coupling and confirm the desired behavior (1 kHz sequence of 0's and 1's). Now power on the Elvis board and measure CH 2 with DC coupling. The signal should be inverted, i.e. the transistor switch should function as a logical NOT gate. Trigger the scope on the rising edge of CH 1 and measure the fall time of CH 2; you will need to expand the horizontal time base to get an accurate measurement. Try to measure the rise-time of CH 1.

Note: Rise- and fall-times of a signal transient are typically defined as the temporal separation of points at 0.1 and 0.9 of the signal maximum.



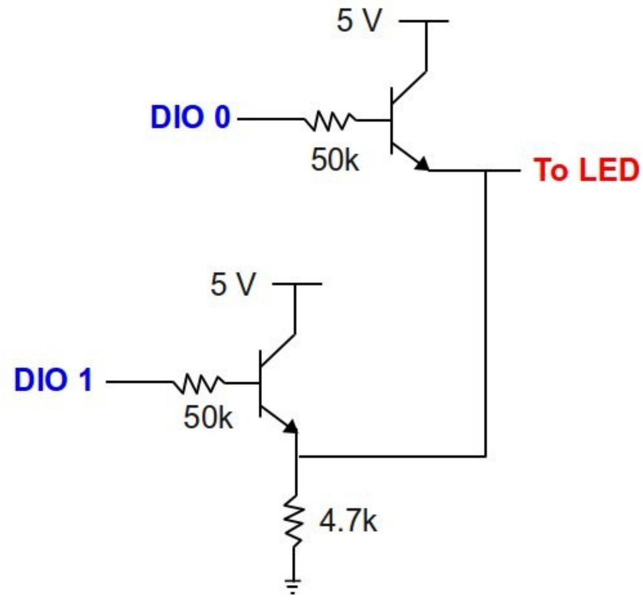
Turn off the Elvis board and add an identical transistor stage to the output of the first transistor as shown in the diagram above. Connect the CH 2 scope probe to the output of the second stage. Power on V_C = 5V and observe CH 1 and CH 2 on the scope (DC coupling). The second stage should undo the operation of the first, i.e. V_{OUT} should be the same waveform as V_{IN}. Two NOT gates in series will restore the input logic.

Show the results to the instructor. After doing this, turn off the scope and function generator as they will no longer be needed. Disconnect the signal generator from the input and remove the second NOT gate.

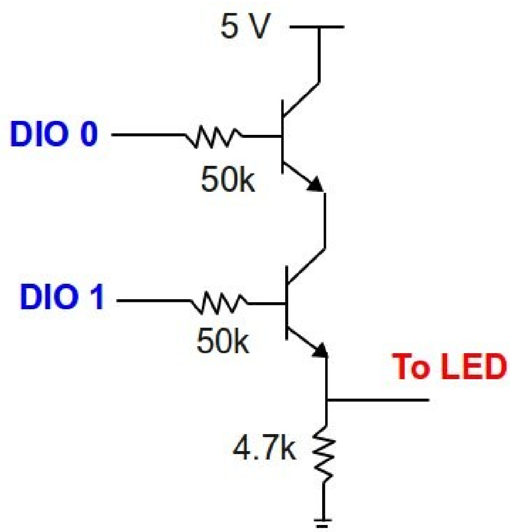
Boolean logic

The Elvis board can be used to evaluate electronic logic gates. Start the NI Elvis Launcher program and enable the Digital Writer (Dig Out). Locate pin **DIO 0** on the upper right of the Elvis board and wire it to the input resistor (R_B). You will likely need two long jumper wires to make the connection. Connect the single transistor output to one of the surface mount LEDs accessed on pins 35—42 on the right side of the board. When the LED is off it indicates Logic 0 and when illuminated it shows Logic 1. With the Elvis board powered on, run the Digital Writer continuously. Switch **DIO 0** from HI to LO and confirm the correct NOT gate logic with the LED.

Build and test the OR Gate as shown in the circuit diagram below. Using the HI and LO states of **DIO 0** and **DIO 1**, produce a Boolean logic table for all four possible combinations of input states and demonstrate circuit operation to the instructor.



Construct the AND gate shown below and generate the Boolean logic table for all four input combinations.



Writeup

There is no writeup required for this lab.