Phy 415/515 Lab #6 2009   Simple transistor circuits

Prelab: Predict answers to all the questions asked in lab sections 2.2, 3.4, 4.2-4, 5.2-5, 6.3, and 7.2-6.

__1.Set up the breadboard

___1.1. Power supply and wavetek

Create columns on the breadboard for the Kepco power supply and the wavetek. Adjust the Kepco power supply voltage to +10 V. Create a "probe" column.

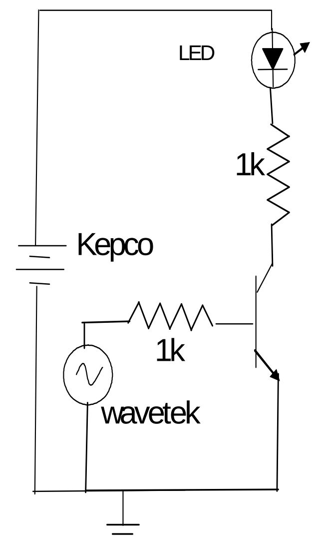

Figure 1. The LED indicator circuit.

___1.2. Voltmeter

Connect the voltmeter to the Wavetek column. Make sure the voltmeter is on the 20 V scale.

__2. Transistor as switch

___2.1. LED indicator

Wire the LED indicator circuit shown in Figure 2, using an LED and a 2N2102 npn transistor (the pin connections are in lab 5). The Wavetek adjusts the base voltage. Set it to dc output. Set the dc bias to around zero, as read on the voltmeter.

___2.2. On and off

Adjust the wavetek DC offset. **Use the voltmeter at the Wavetek column to measure the value at which the LED turns on__________**

___2.3. Current

With the LED lit, measure the voltage across each of the two 1k resistors. **What is the ratio of collector to base current for the transistor? __________**

___2.4. Amusing Blink

Turn the DC bias off. Set the Wavetek to sine or square wave output and adjust the amplitude and frequency until the LED blinks on and off. Return the Wavetek to dc and turn the dc bias off.

__3.Unbiased Emitter follower with dc input

___3.1.Transistor circuit

Wire the emitter follower as shown in Figure 2, with the 10 V V_{cc} supplied by the Kepco, and V_{in} is supplied by the Wavetek. Connect V_{out} to the probe column.

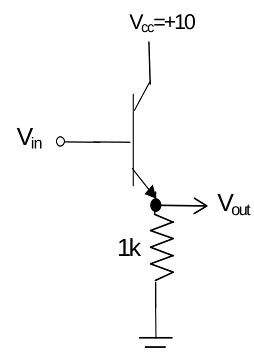

Figure 2. Unbiased emitter follower.

___3.2. Avoiding collector breakdown

If the base is made more positive than the collector, the base-to-collector pn junction diode will be forward biased. Since there is no resistor in that part of the circuit, this will result in potentially large currents flowing from the wavetek into the power supply through the transistor, which could be bad for all three (and will generally cause the transistor to fail). Do not turn the base voltage above V_{cc}.

___**3.3.Set up the oscilloscope**

Connect the first input (channel 1) on the oscilloscope to the wavetek. Connect the second input (channel 2) of the oscilloscope to the probe column of the breadboard (and therefore V_{out}). Observe both the wavetek output and the probe column on the oscilloscope. (select "alternate" between channel 1 and channel 2). Making a trace appear is described in lab 1--since these are dc inputs, use "internal" or “line and auto" scope triggering. Make sure both inputs are on "dc". Be sure to use the same voltage scale for each channel, and by switching briefly to the "ground" input, make sure that the 0 level is the same for each. If you become confused as to which trace is which, you can momentarily set the input to ground or change the voltage scale.

___**3.4.Observe the effect of V_{in}**

Slowly change the input (wavetek dc bias) voltage between -5 and 5 volts, observing the output. **What is the minimum input voltage for the output to move away from ground? What is the relationship between the input and output voltages?**

___**3.5.Save the circuit**

Don't change this circuit, it is used in the next part.

__4.Unbiased Emitter follower with ac input

___**4.1.AC input**

Turn off the dc bias on the wavetek. Switch to a 10 kHz sine wave output. Adjust the scope triggering to trigger on the wavetek signal. Observe the output of the emitter follower as you adjust the amplitude on the wavetek (remember not to exceed +10 V input).

___**4.2. DC bias**

Adjust the wavetek amplitude to about 2 Volts (4V peak-to-peak). Turn on the dc bias. **What bias voltage (dc bias on the wavetek) is necessary to avoid clipping (so that the output looks like a sine wave)?** (You can read the dc bias by taking the average of the high and low values of the channel 1 signal on the scope.)

___**4.3. Gain**

What is the peak to peak voltage of the output? What is the ac gain (ratio of the output to input amplitudes) of the emitter follower?

___**4.4.Output bias**

What is the output bias voltage? (You can read the output dc bias by taking the average of the high and low values of the output channel 2 signal on the scope.) Increase the input bias voltage on the wavetek by 1 Volt. **How much does the output bias voltage change?**

__5.Biased Emitter Follower

___**5.1.Biased follower**

Wire in the bias resistors and the coupling capacitor, as shown in Figure 3.

___**5.2.Coupling capacitor**

Observe the effect one the output signal of changing the dc bias on the wavetek—**does changing the bias voltage change the bias of**

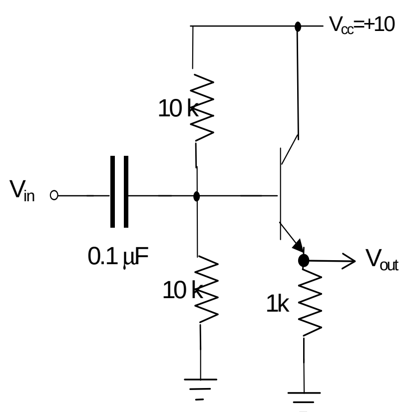

Figure 3. Biased emitter follower.

the output? Set the input bias voltage to zero. **What is the theoretical magnitude of the impedance of the coupling capacitor at 10 kHz? What is the theoretical cutoff frequency of the capacitor in series with a 10k resistor?** Observe the amplitude of the output if you reduce the frequency of the input. **At what input frequency is the output 70% of the 10kHz output?** Restore the output to 10 kHz.

___5.3.Amplitude

What is the effect of changing the input amplitude (remember not to turn the amplitude to more than 10V)? **What range of amplitudes give good (sinusoidal) outputs?** (To predict this, remember that the base has a minimum turn on voltage)

___5.4.Gain

What is the amplitude of the output for a 2 volt amplitude input? What is the gain?

___5.5.Bias point

Move the wire connecting the scope input column from the collector to the base of the transistor. **What is the dc bias voltage on the base?** Increase the upper bias resistor to 20 k and decrease the lower one to 1 k, so that the bias point is less than 0.5 Volts. Return the scope input to the emitter and observe the output of the follower as you change the amplitude of the input. **Does any range of input amplitudes give good sinusoidal outputs?**

___6.Unbiased amplifier

___6.1.Adjust Vcc

Adjust the power supply voltage to +20 volts.

___6.2. Wire the amplifier

Wire the amplifier circuit shown in Figure 4. Note that there is a resistor between Vcc and the transistor. Make sure that you do not short the wavetek or power supply while you are moving the wires around (turning the supplies off works). The emitter is grounded (this is sometimes referred to as a "common", i.e. "grounded", emitter amplifier).

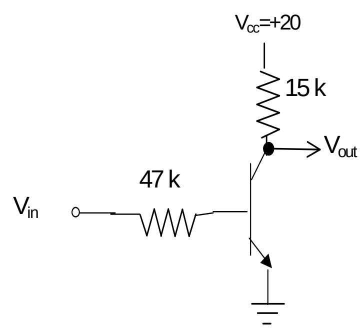

Figure 4. Unbiased amplifier.

___6.3. Adjust the dc offset.

Set the input voltage from the wavetek to about 0.2 volts amplitude. What dc bias on the wavetek is required to avoid clipping?

___6.4. Gain and β

What is the gain of the amplifier? Given that the gain is expected to be $g = \beta \frac{R_c}{R_b}$**, what is the β of the transistor**?

___6.5. Change the gain

Change the collector resistor to 10k Ω. **What is the gain now? Is it as expected?**

___7. Biased amplifier

___7.1. Wire the circuit

Add the coupling capacitor, bias network and emitter resistor, as shown in Figure 5.

___7.2. Gain

Set the wavetek amplitude to 1 V. Set the dc bias to zero. **What range of input amplitudes give good (sinusoidal) outputs? What is the gain of the amplifier?**

___7.3.Bias point

Set the input amplitude to zero. **Measure the dc voltage of the base. Measure the dc emitter voltage**.

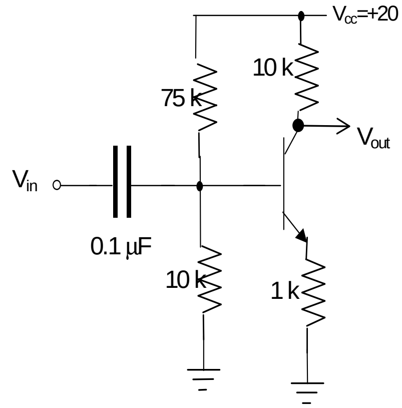

Figure 5. Biased amplifier.

___7.4.DC offset and quiescent current

Measure the dc output voltage. What is V_{CE}, the voltage drop across the transistor?

___7.5. Consider the gain

At first glance it seems the gain could be increased by increasing Rc from 10k to 30k. **But what is the expected voltage drop across the collector resistor if you increase the collector resistor in the equation for part ___7.4 without decreasing the collector current? Is that possible?** Change Rc to 30 k. **What is the difference between the collector and emitter voltages? Is the transistor saturated? What is the output voltage? What is the gain with a sinusoidal input**?

___7.6. Consider the gain again

To make the higher collector resistor work, it should be possible to decrease the quiescent base voltage by reducing the R2=10k base resistor so the transistor is barely on. **What value of R2 gives a base voltage of 0.8 volts?** Change R2 to this value. **What is the output voltage? What range of input amplitudes give sinusoidal outputs**?