Learning About Transistor Biasing

Demo Design Specs.:
Vcc = 6
LED = 1.7v @20mA
Driving from Arduino Digital I/O @ 5v (40mA max).

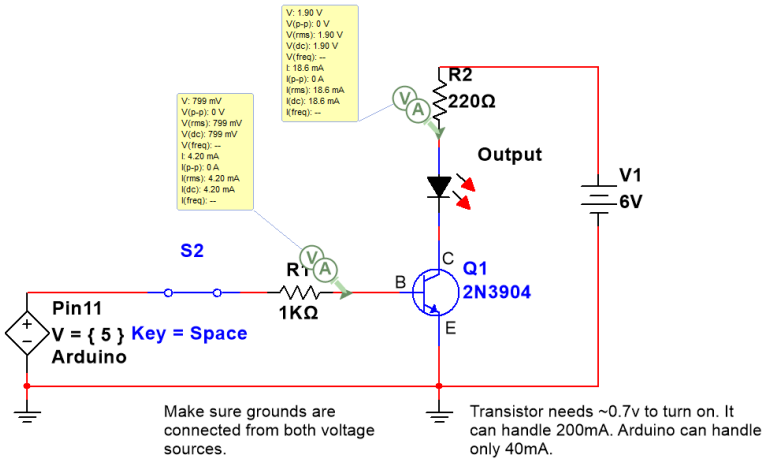


Figure 1: Our circuit in Multisim with the calculated values,

STEP 1: Compute value of our base resistor (R_b). This resistor controls current into the transistor to keep it from burning up. So always use one!

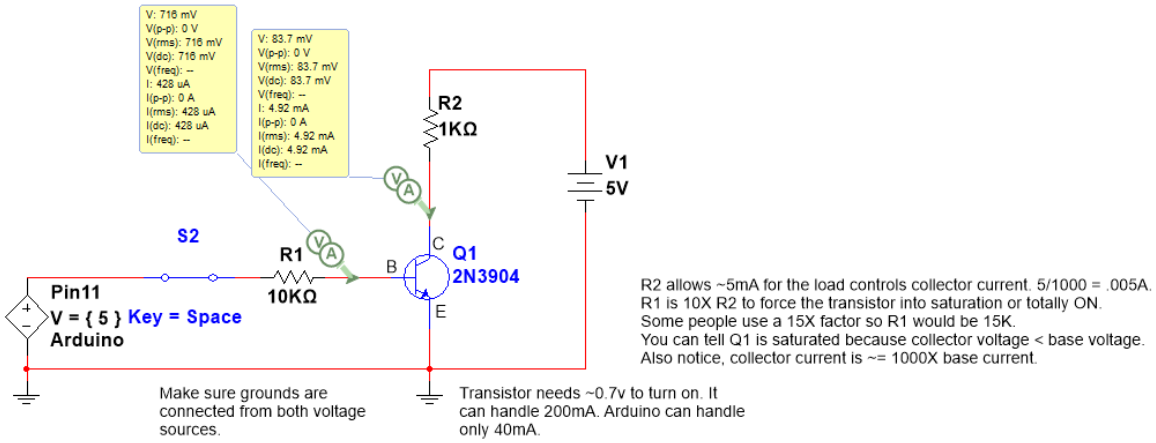
1. Design with these specs to drive the transistor into saturation.:
   - The output of the Arduino pin is ***5V***.
   - The transistor needs ***~.7V*** to turn on just like a diode.
   - Let's limit base-emitter current (I_{BE}) to ***5mA (.005A)*** to protect the Arduino.
2. Therefore, the base resistor value is:
   $R_b = \frac{5v - .7v}{.005A} = \underline{860\Omega}$. We can use a **1KΩ** because it is a more common value.
3. ***The simulation confirms a base voltage of 799mV (.79V) @ 4.20mA which is within our limit of 5mA when R_b = 1KΩ.***

STEP 2: Calculate value for current limiter resistor for the LED.

1. According to the datasheet, the voltage from collector to emitter is about ~200mV or .2v when the transistor is saturated or turned on all the way. See table below.
2. The LED draws 1.7v and 20mA, the $V_{ce(sat)}$ = 0.2v, and the V_{cc} = 6v. So that leaves 4.1v (6v – 1.7 - .2v) that the limiting resistor must drop. Therefore:
3. $R_{LED} = \frac{4.1v}{.020A} = 205$ so 220Ω is a safe value.
4. At 220Ω, V_{LED} = 1.9v @18.6mA (in Multisim).

STEP 3: Calculate power rating for R_{LED}.

1. From Ohm's law, Power $_{watts} = I^2R$.
2. Power consumed by the $R_{LED} = .02^2 \times 220\Omega = \underline{.09W}$.
3. So, what wattage resistor do we need? Well, since ¼ watt = .25, that should work fine.
4. Use a 220Ω ¼ watt or ½ watt resistor.



Title: STUDY GROUP LESSON 8: How to Use a Transistor as a Switch Biased for Saturation		
2N3904 Used to sink LED to ground (Q1 supplies a connection to ground or B-).		
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CHARACTERISTICS

T_{amb} = 25 °C.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{CBO}	collector-base cut-off current	V_{CB} = 30 V; I_E = 0 A	–	50	nA
I_{EBO}	emitter-base cut-off current	V_{EB} = 6 V; I_C = 0 A	–	50	nA
h_{FE}	DC current gain	V_{CE} = 1 V; note 1			
		I_C = 0.1 mA	60	–	
		I_C = 1 mA	80	–	
		I_C = 10 mA	100	300	
		I_C = 50 mA	60	–	
		I_C = 100 mA	30	–	
V_{CEsat}	collector-emitter saturation voltage	I_C = 10 mA; I_B = 1 mA; note 1	–	200	mV
		I_C = 50 mA; I_B = 5 mA; note 1	–	200	mV

Figure 2: Partial datasheet for 2N3904 used to compute currents