ENGIN 365 Final Project:

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Objective: The purpose of this final project is to build a rectifier circuit that contains a voltage regulator to feed a logic circuit. This design project will encompass components and devices used in the course.

Equipment:

1. Keithley 2230-30-1 Triple Channel DC Power Supply
2. Tektronix DPO 2004B Oscilloscope
3. Tektronix AFG3022C Function Generator
4. Tektronix DMM 4020 Digital Multimeter
5. Four 1N4005 diode
6. Two 1000 μF capacitors
7. One 2N3904 NPN transistor

Introduction:

BJT can be utilized within circuits as rectifiers, amplifiers, filters, a switch, or many other applications within circuit schematics. Our npn BJT transistor will operate as a switch once biased in the cut-off or active region. Current either continues to flow or is shunted (halted) from following within the circuit. This makes our circuit behave akin to an inverter gate (NOT gate).

Description:

The function generator will feed the rectifier, outputting a voltage close to 8.6V AC voltage, a pure DC signal would require a voltage regulator to output a constant 8V DC voltage. This configuration will continue onwards feeding a logic circuit using a simple inverter gate built with an NPN BJT.

Lab Measurements:

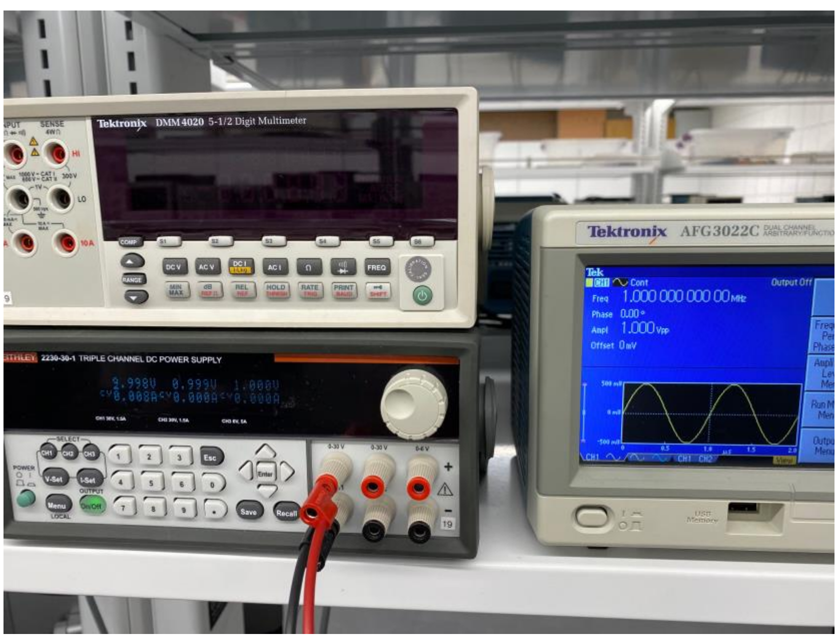

Figure 1: DC supply for testing of the logic circuit.

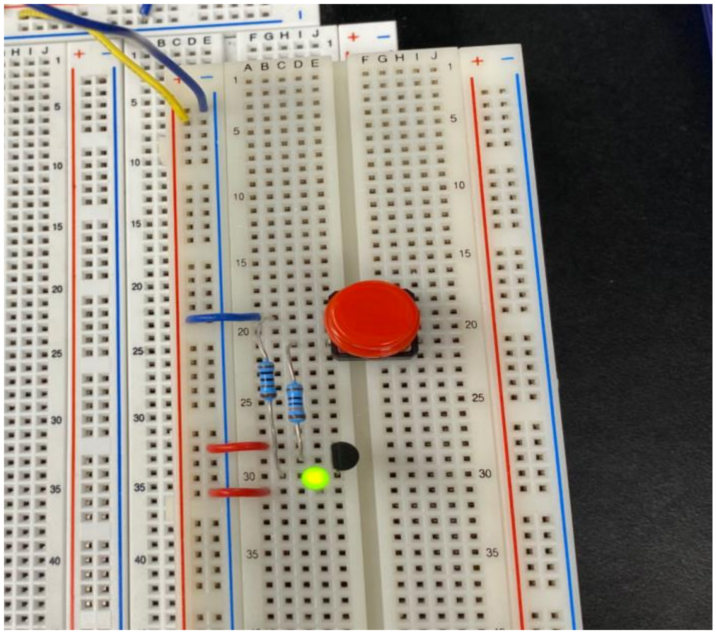

Figure 2: Logic circuit connected to 10 V DC for testing of the inverter gate.

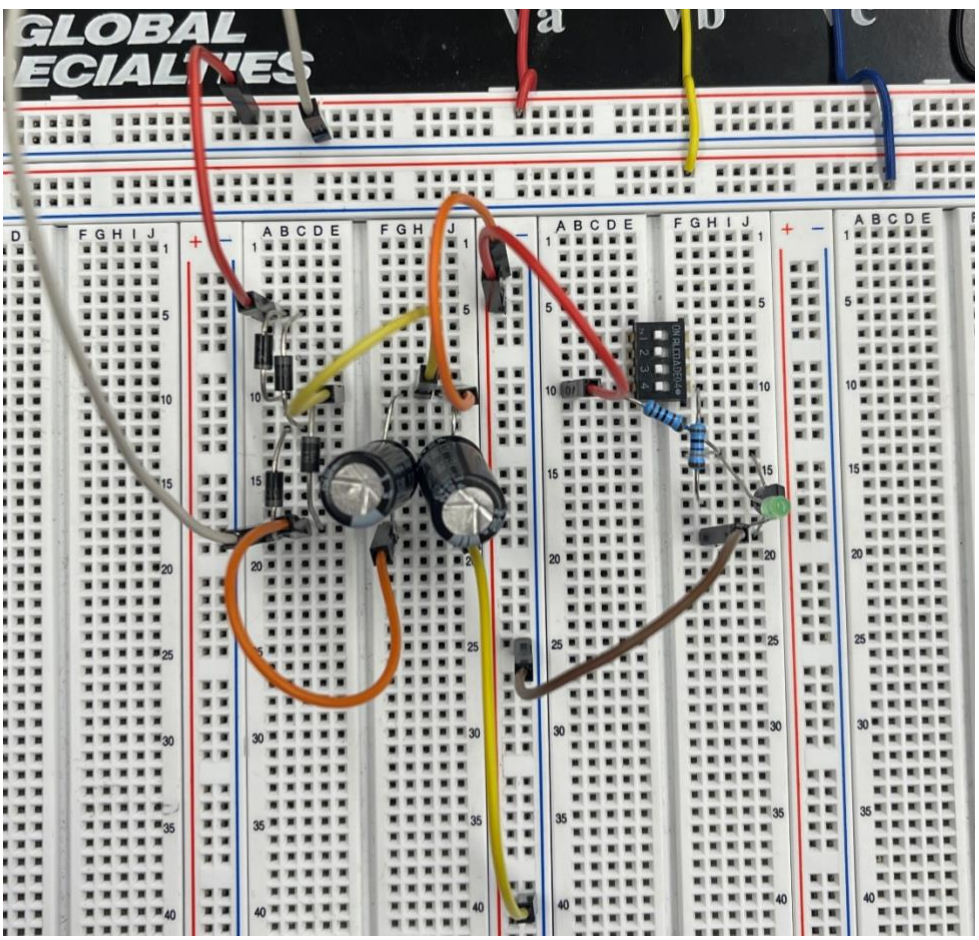

Figure 3: Completed circuit with rectifier stage, filter stage, and logic gate for the output.

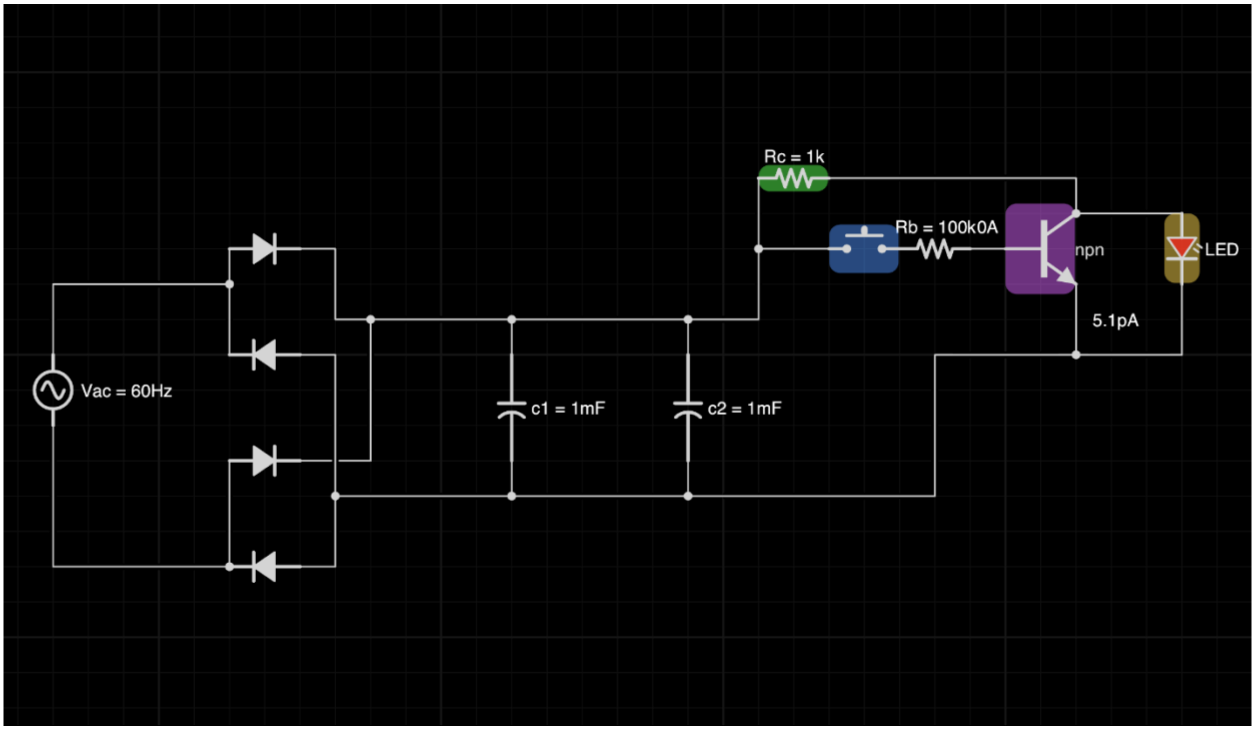

Figure 4: Schematic of our rectifier and inverter gate circuits. The V_{AC} has 10 V amplitude.

Results and Analysis:

The project circuit utilizes a rectifier circuit containing a voltage regulator that feeds a logic circuit. 10 V DC from the power supply is inputted into the circuit and gets rectified. From the class, we know that once we introduce a load to the rectifier circuit, we get a ripple in the output of the rectifier. To avoid a large ripple, we introduced a filter stage to smooth out the ripple. This smooth, rectified voltage is connected to our inverter gate circuit built with a BJT.

We chose to use an inverter gate configuration because it could be built with only one BJT, instead of multiple of them. This BJT's collector is connected to a 1 $k\Omega$ resistor and to the LED showing the output of the system. Once there is current flowing through the base, the BJT becomes active and shunts the LED, turning it off. To drive current through the base, we use a push-button that acts as the input of the circuit.

Within our schematic simulation, our circuit demonstrates:
There is 8.3 V at the switch connected to the base. We also see the resistor connected to the collector and LED to have a 6.7 V drop, meaning our LED has a current of 6.72 mA flowing through it. In the normal state of the system, the BJT is in cutoff mode.

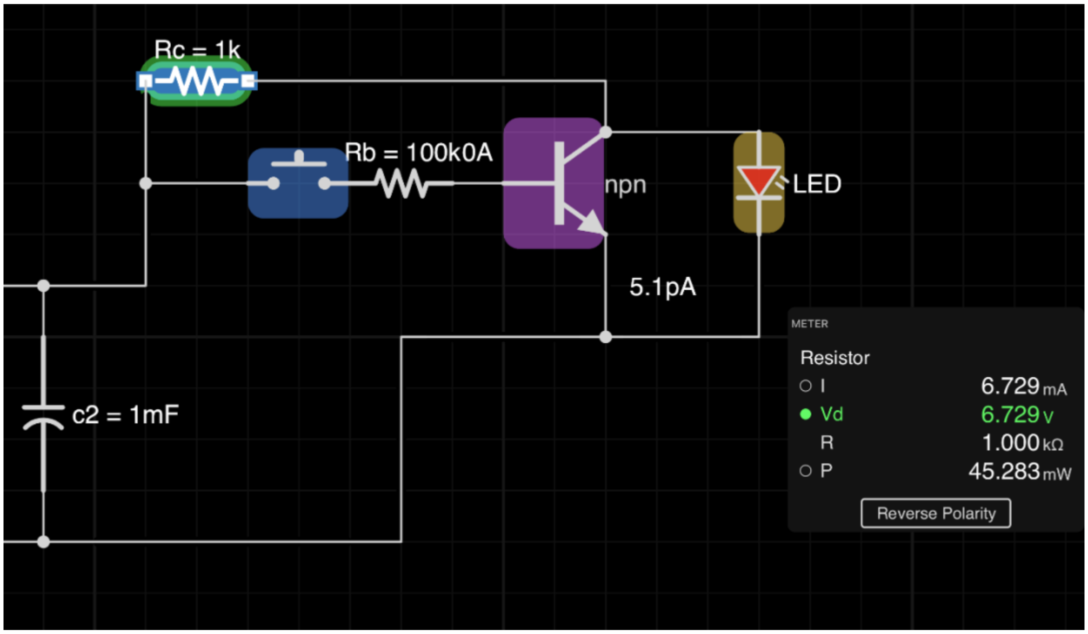

Figure 5: Voltage drop on resistor connected to the collector.

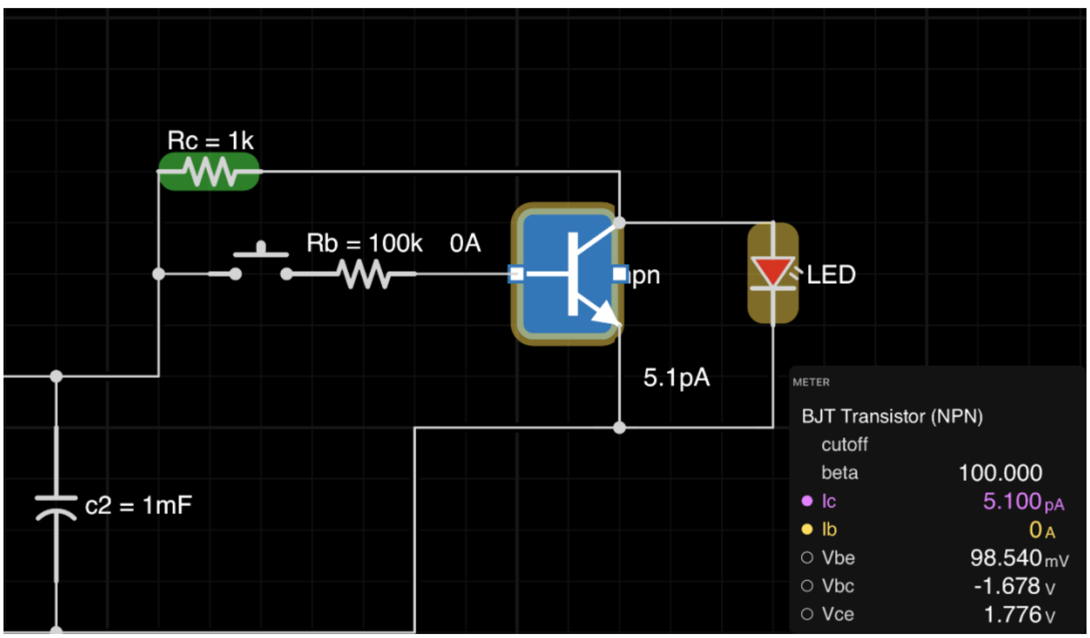

Figure 6: Schematic simulation showing transistor in cutoff mode. This is when the push button is not pressed and the LED is on.

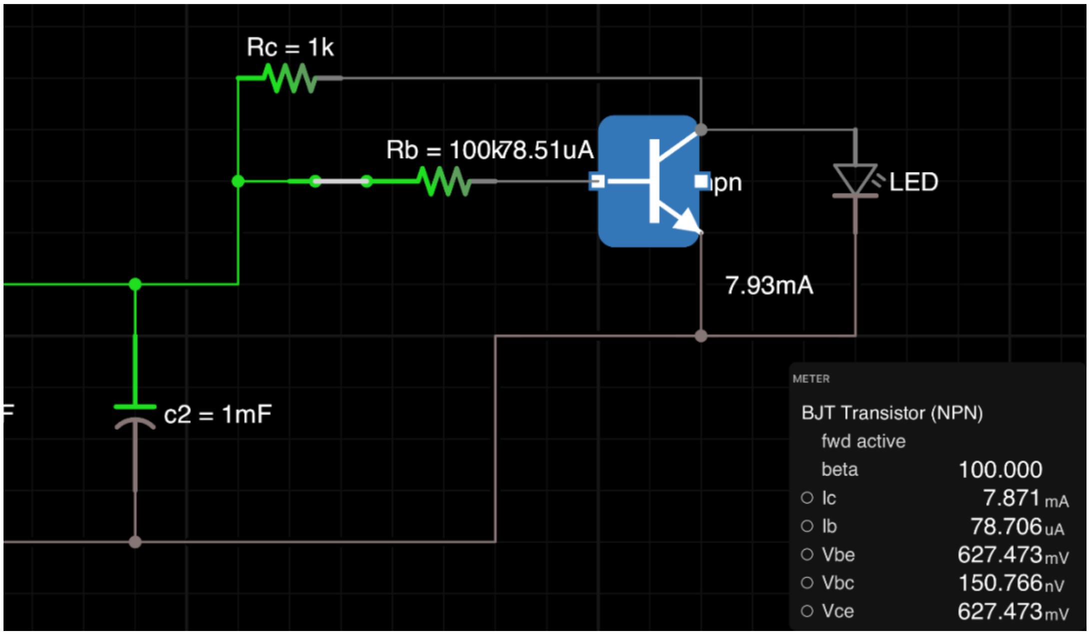

Figure 7: Simulation showing the BJT state when the input is 1. This state is active mode and the LED is off.

When the push switch is pressed:

- $i_c = 7.871\ mA$
- $i_b = 78.706\ \mu A$
- $i_{LED} \approx 0\ A$
- Input to the circuit = 1

We calculated the ripple voltage to be 30.93 $mV_{p\text{-}p}$ from our circuit simulations. The theoretical value of the ripple was calculated to be:

$$V_r = \frac{V_{rectified} - 2V_d}{2fRC} = \frac{10\ V - 2(0.7\ V)}{2 \cdot 60\ Hz \cdot 2\ mF \cdot 1\ k\Omega} = \ 0.0358\ V_{p-p} = 35.8\ mV_{p-p}$$

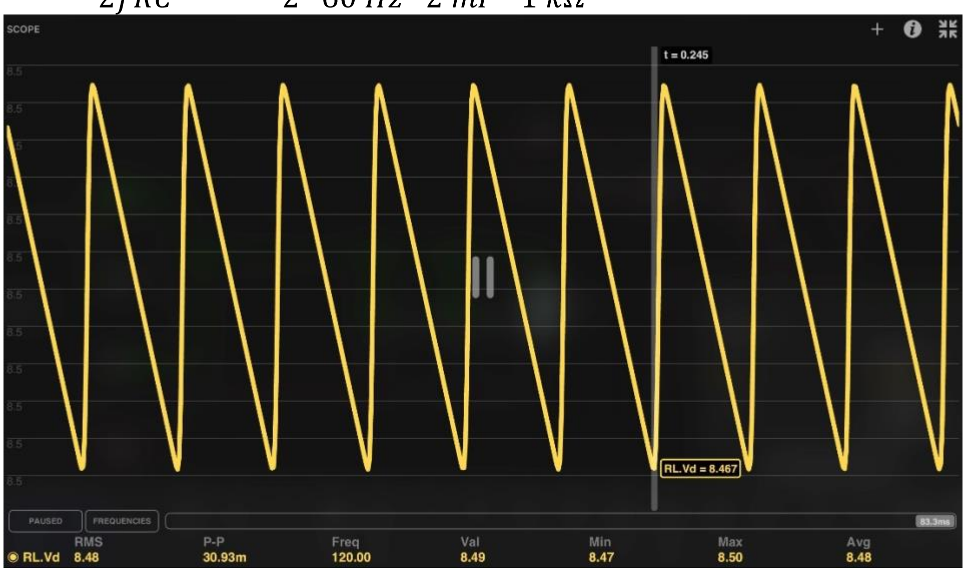

Figure 8: Ripple voltage measured in our simulations. We can see that our ripple has small magnitude. This is preferred as we want our rectified voltage to have a small ripple.