HANDS-ON LAB INSTRUCTION SHEET – MODULE 4

VOLTAGE REGULATION AND TRANSISTOR SWITCHING

NOTES:

1) To conserve the life of the Multimeter's 9 volt battery, be sure to turn the meter off if not in use for over 5 minutes. Always double check the unit is off when finishing your work, or leaving the classroom.
2) All work is to be done individually and submitted before you leave
3) If you did not finish earlier Hands-on Modules, be sure to finish them in their number order prior to starting this Module. If you don't finish by the end of the class, consult instructor.
4) Always keep the Instruction sheets.
5) Enter your Kit # in the upper right corners of ALL RESULTS sheets.
6) You should still have the DPDT switch and indicator LED wired as in Module 4. Test to be sure LED goes on when switch moved up. Turn switch off while wiring.

BILL OF MATERIALS

Radio Shack Electronic Learning Lab Console, AC Adapter (*9 volts at 150 mA*), Digital Multimeter, Wire Stripper, Miscellaneous Connecting leads and wires (Standard for all labs)
(1) **Green** LED
(1) **1N4007** Rectifier Diode
(1) **2N5551** NPN Silicon Transistor
(1) **7805** IC Voltage Regulator
(1) **10Kohm**, ½ Watt Resistor *with color code:* ***brown black orange gold*** (*10KΩ at 5%*)
(1) **1000 Ohm**, ½ Watt Resistors *with color code:* ***brown black red gold*** (*1KΩ at 5%*)
(1) **1µF** Electrolytic Capacitor

Wiring a 5 Volt Voltage Regulator Circuit Using the MC7805 (LM340)

Re-read page 70 in Electronics Workbook 1 (7805 Voltage Regulator)

NOTE: In general we will not specify every Spring # or breadboard point but it is helpful with the regulator to reduce the chance of blowing everything out <grin>.

Observe our wiring color code for circuit troubleshooting:

red = positive supply voltage (*regulated or unregulated*)
yellow = signals and all other wiring
black = ground ⏚

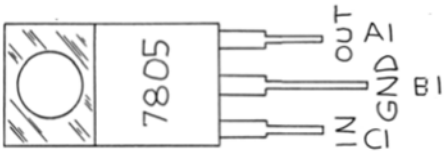

Figure 4.1 7805 Voltage Regulator (TO-220 Case)

4.a) Your AC Adapter connector should be connected to the back of the Console. Be sure that the Power Switch is **OFF** when you are wiring your circuits!

NOTE: ***The +5 volt regulator circuit will NOT be removed until the end of the semester! Therefore we will cut component leads as needed to fit the circuit in a small area…***

4.b) Insert the **7805 voltage regulator** into Breadboard holes **A1**, **B1**, **C1** with the lettering "**7805**" **facing to the right** and with the **metal heat sink** of the device **facing to the left**.

4.c) Use a **black** wire to connect **B4** (*the **7805** center lead is **B1***) to ground **4**. Put a bare wire loop from ground **3** to ground **5** for connecting to ground with meter leads, etc.

4.d) Connect a **red** wire from one of the top left five +V connections (e.g., **+2**) to **C2** to connect the AC adapter unregulated **+voltage** (+13 to 17 V) to the **7805 "IN"** lead at **C1**.

4.d) Connect a **1 µF** electrolytic capacitor with its minus lead in connection **B3** and its positive lead in **A2** (*prevents unwanted oscillations*).

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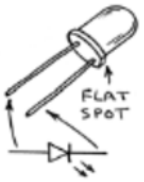

4.e) Create an **ON** indicator for the **+5 regulated voltage** by connecting a **1KΩ** resistor between **A5** (the regulator output lead) and **T5**. Then connect a **Green LED** between **T2** (the resistor) and ground **2** to complete the circuit of Figure 4.2.

Test the circuit to see if the LED turns **ON** when the **Power** switch is moved **UP**. ***If the LED it does not light, check your wiring, and then call the instructor.***

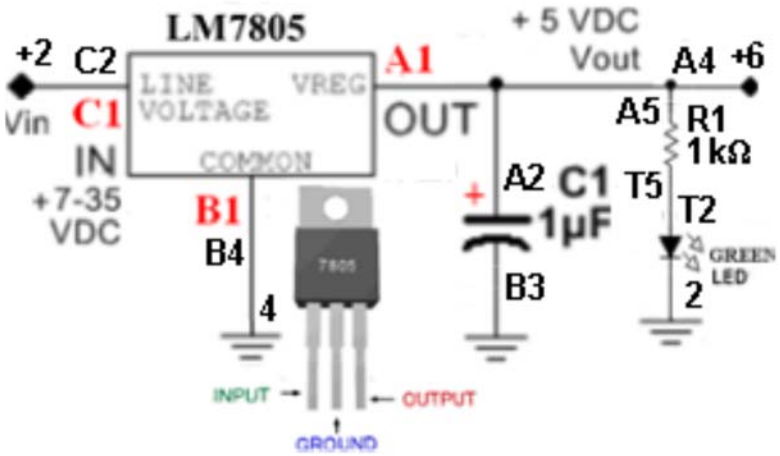

Figure 4.2. 7805 Voltage Regulator Circuit

ABOUT THE REGULATOR CIRCUIT

This is a functional voltage regulator. In the text you note the addition of an electrolytic capacitor at the circuit's input to 'filter' or remove unwanted stray AC voltages from the regulator to make it better resemble a battery voltage output. *Most designs also suggest the need for a 10 µF electrolytic capacitor from the input to ground, but as we know our AC Adapter has a 1000 µF or greater capacitor in its output an additional input capacitor is not required.*

4.f) Connect pin **A4** to **+6** (the **6**th voltage connection at the top of the Console Breadboard). Voltage connections **+6** through **+30** across the top are shorted together internally. You should put a bare wire loop between voltage connections **10** and **11** to permit easy checking of the regulated **+5** Volt supply.

DO NOT REMOVE THIS REGULATOR CIRCUIT FROM CONSOLE!
It will be used throughout the rest of the semester

Measuring the Unregulated and Regulated Power Supply Voltages

4.1a) The **unregulated**, unloaded supply voltage (expect 13 – 17 volts DC) _____ V.
4.1b) The **regulated** supply voltage (expect 4.5 to 5.5 volts; *i.e., approximately 5.0 volts*) _____ V.

Measuring the Relay Coil Resistance

4.2a) Turn OFF console power.

Use your Multimeter, on the **200 Ohms range** (green lower left) to measure the coil resistance of the relay on the Console between **Spring #57** and **Spring #58**.

The Relay Coil resistance is _____ ohms

This is Instructor check point 4A

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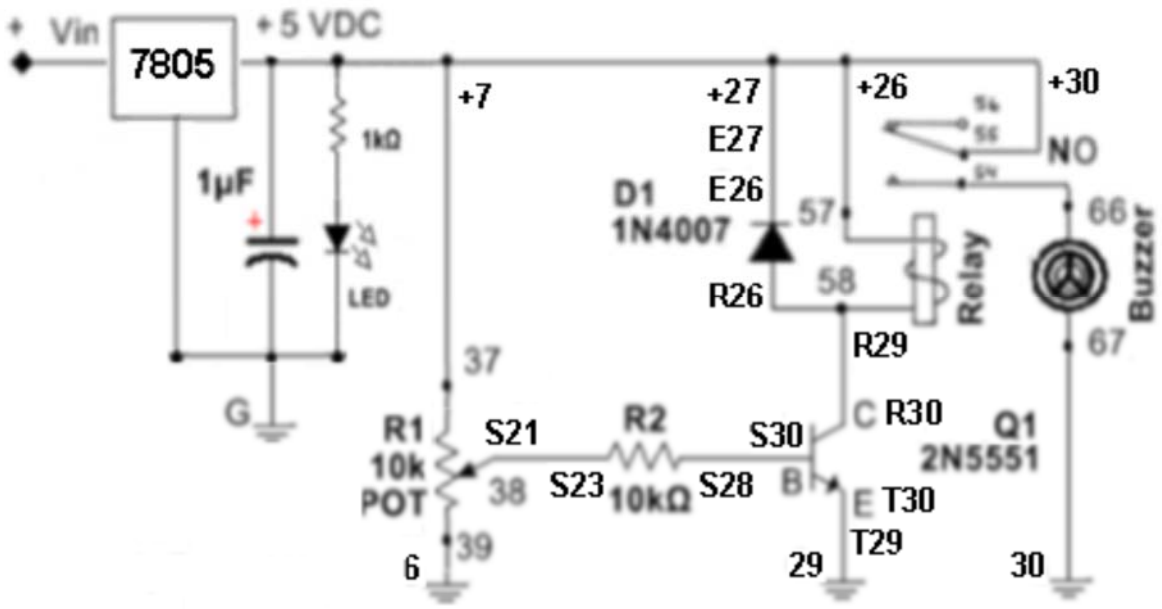


Figure 4.3. 7805 Voltage Regulator and Transistor Switch Circuit

Measuring the Transistor Switch Input and Output Voltages

4.3) Starting with the **10Kohm pot**, **R_1**, and the **2N5551** NPN transistor **Q_1** ***connected as you had wired them in Module 3,*** remove the **1K** resistor and **LED** from that circuit, ***replace the 100K resistor with R_2 = 10Kohm, and add the 1N4007 diode, the relay and the buzzer***, to complete Figure 4.3, above. NOTE: In future schematics we will NOT repeat the voltage regulator, but use its +5 Volt output unless otherwise indicated

4.3a) Measuring the voltage between **Spring #57** and **Spring #58**, adjust the **10Kohm** pot to find the lowest relay coil voltage **$V_{relayON}$** which causes the relay to close sounding the buzzer.

$V_{relayON}$ = _____ volts to close the relay and operate the buzzer

4.3b) Now measure the **10Kohm** pot voltage **V_{potON}** from **Spring #38** to **Spring #39** which creates this voltage.

V_{potON} = _____ volts that closes the relay and operates the buzzer

(Note that a high current DC or AC device – even a 120volt AC motor could be operated by the relay even if the motor current is well beyond the transistor's voltage rating.)

Measuring the Transistor Release Voltages

4.4) Once the relay closes, the relay voltage must be lowered below the **$V_{relayON}$** value above to cause the relay to reset and for the switch to re-open.

4.4a) Find **$V_{relayOFF}$** – the voltage at which the relay opens and buzzer goes off.

$V_{relayOFF}$ = _____ volts to open the relay (equals relay dropout voltage)

4.4b) Find **V_{potOFF}** – the voltage at the pot which corresponds to this turn off voltage.

V_{potOFF} = _____ volts gives the above result (equals pot dropout voltage)

This is **instructor check point 5B.**

***BEFORE** you break the transistor switching circuit apart, please have your instructor review your setup and the last data set of measurements.*

NOTES ON THE TRANSISTOR SWITCHING CIRCUIT:

About The RELAY

The relay is hidden under the panel. Note from the schematic drawing of the relay how *the moveable arm , connected to* ***Spring #55****, will be pulled toward the contact connected to* ***Spring #54*** *when the electromagnet is activated. Note how the inductance of the relay coil will try to keep current constant when you turn off the transistor. This inductance will RAISE the collector voltage, even higher than the supply.*

About The Diode

Note how the diode will limit the collector voltage to no more than 0.6V above the supply instead of possibly over 100 volts. Note the direction of the ***1N4007*** *diode. The "cathode" as indicated by a black band on a glass encased device or a grey band on a black plastic encased device, goes to the +5V supply.*

About The Transistor Switch

Use a ***2N5551*** *NPN transistor located as in Module 3* ***with flat side of transistor facing right*** *inserted into breadboard holes RST 30 yielding* ***Collector R30, Base S30*** *and* ***Emitter T30****.*

About The 7805 Voltage Regulator

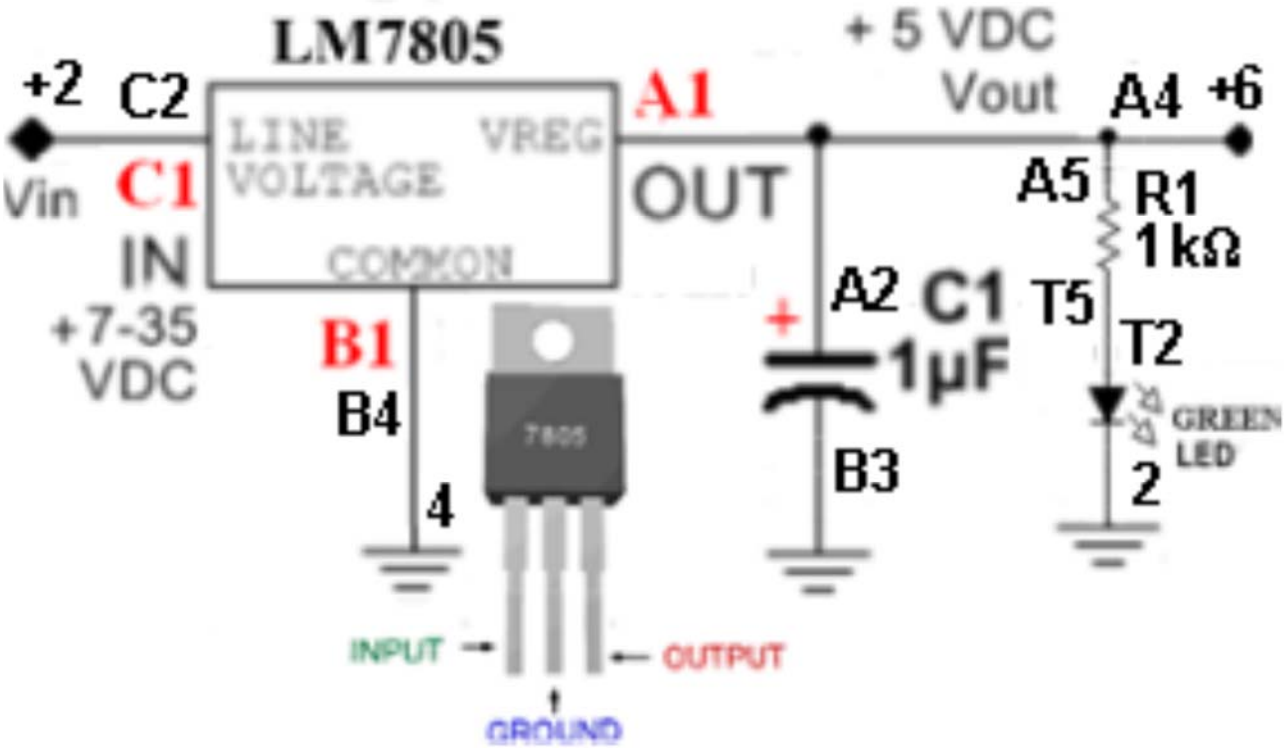
The 7805 voltage regulator circuit will be useful in stabilizing ANY DC input voltage between 7.5 and 35 volts to give a power supply output level of +5 volts (+/-0,2 volts) at up to one ampere of current when the TO-220 case is properly connected to a heat sink. This is convenient for analog circuits, but critical for digital circuits…

Therefore:

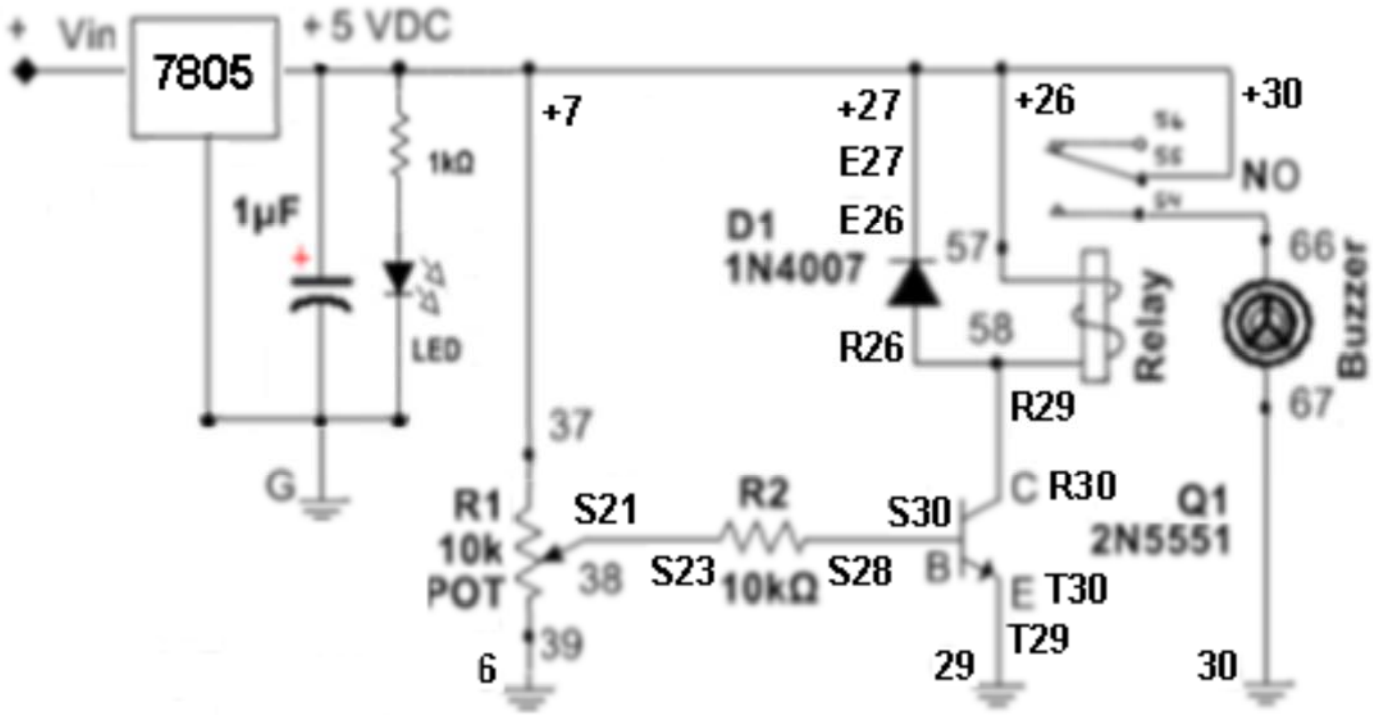
Unregulated Power is only available at the first five connections at the top left (+1, +2. +#, +4, and +5) of the Console Breadboard.

The remaining 25 connection points (+6 through +30) are internally connected and, after constructing the 7805 IC regulator circuit provide a source of regulated +5 Volts

Keep this circuit wired to provide +5 volt regulated power through the end of the course!



LM7805 IC +5 Volt Regulator Circuit



Transistor Switching Circuit