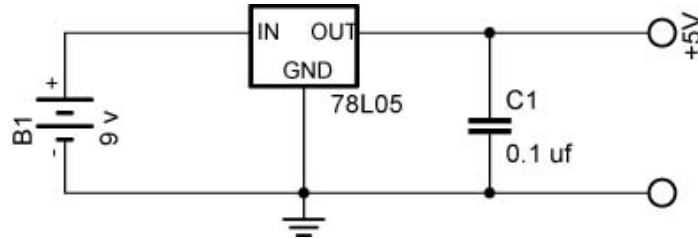
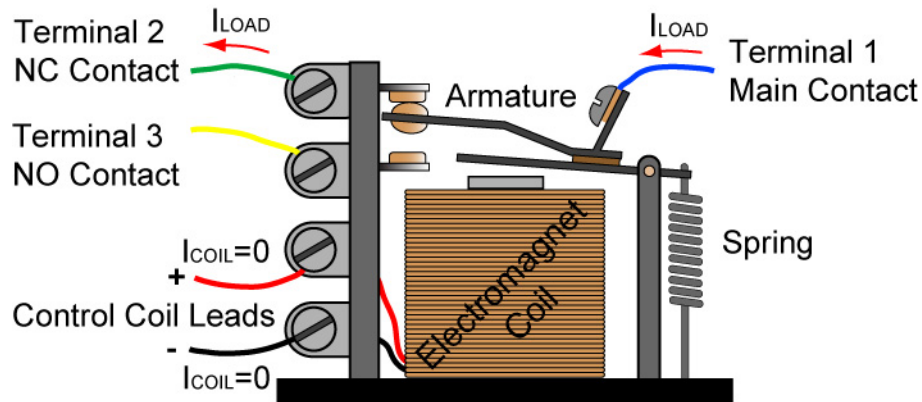


Cornerstone Electronics Technology and Robotics I Week 19 Electrical Relays

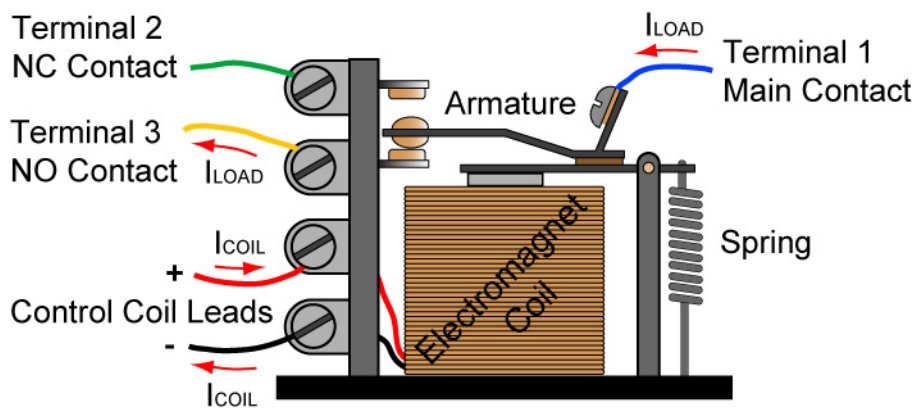
- Administration:
 - Prayer
 - Turn in quiz
 - Review voltage regulators:



- Review SPST, SPDT, DPST, DPDT switches
http://cornerstonerobotics.org/curriculum/lessons_year1/ER%20Week8,%20Switches,%20Fuses.pdf
- Electricity and Electronics, Section 9.3, **Relays:**
 - Introduction: In many cases, it is impractical to use a manual switch in a circuit. For instance, you would not want to wait for the temperature in your house to rise above a certain level and then manually turn the air conditioning by throwing a manual switch. An automatic switching device would better serve the purpose.
 - General: A relay is a device that is used to control a large voltage, large current circuit by means of a low voltage, low current circuit. A relay is a magnetized switch that uses a mechanical lever to separate two interactive circuits.
 - Major Parts:
 - Coil which serves as an electromagnet
 - Armature – the lever arm
 - Contact points
 - Spring



**De-energized SPDT Relay – Spring Holds Armature in Position
Continuity from Terminal 1 (Main Contact) to Terminal 2 (NC Contact)**



**Energized SPDT Relay – Electromagnet Pulls Armature into Other Position
Continuity from Terminal 1 (Main Contact) to Terminal 3 (NO Contact)**

- Action: When the control circuit of a relay energizes the coil, the coil's attraction force pulls a lever arm called an armature toward the coil. This action turns the secondary circuit on and off. See Figures 2 and 3.

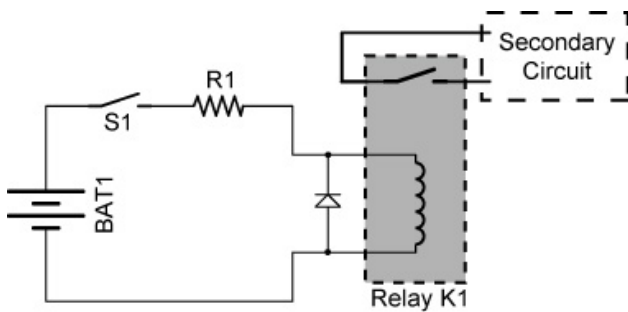


Figure 2

With S1 open, the relay coil is not energized the relay switch remains open.

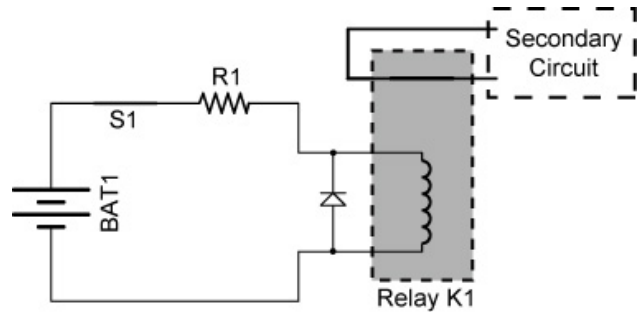
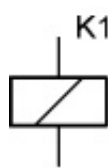


Figure 3

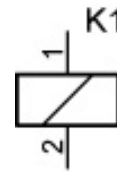
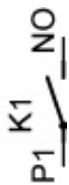
S1 is closed and the relay coil is energized. This causes switch in the relay K1 to close, turning on the secondary circuit.

- The two different voltages can be connected mechanically by a relay. They are not connected electrically.

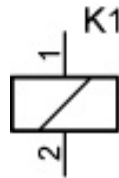
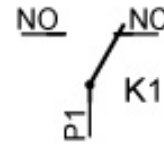
- Schematic Symbols:



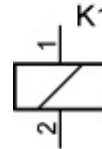
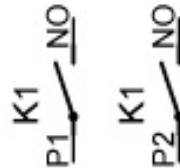
SPST Relay



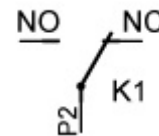
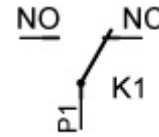
SPDT Relay



DPST Relay



DPDT Relay



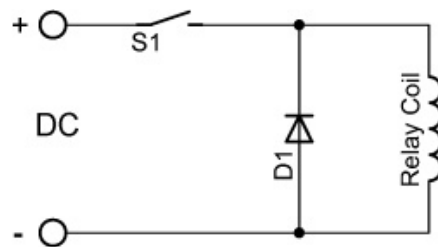
- Show samples
- Perform Electrical Relay Lab 1 – Voltage Separation
- Normally Open (NO) and Normally Closed (NC) Relays:
 - NO/NC relays are similar to NO/NC switches in their operation.
 - NC relays are closed when the relay coil is de-energized.
 - NO relays are open when the relay coil is de-energized.
 - SPDT & DPDT relays have both NO & NC contacts.
 - See: <http://tams-www.informatik.uni-hamburg.de/applets/hades/webdemos/05-switched/20-relays/relay.html>
- Just as a SPDT switch can act as a SPST switch, a SPDT relay can serve as a SPST relay by not making connection to one of the contacts.
- Advantages:
 - An electrical equipment operator is exposed to lower, safer control voltages rather than high equipment voltages.
 - Equipment can be controlled from remote locations.
 - Smaller wires can be run from the control room to the equipment.
 - Relays can have a rapid switching action.
- Using Relays vs. Transistor Switches:
 - Transistors cannot switch AC or high voltages (such as mains electricity) and they are not usually a good choice for switching large currents (> 5A).
 - Advantages of relays compared to a transistor:
 - Relays can switch AC and DC, transistors can only switch DC.
 - Relays can switch high voltages, transistors cannot.
 - Relays are a better choice for switching large currents (> 5A).
 - Relays can switch many contacts at once.

- Disadvantages of relays compared to a transistor:
 - Relays are bulkier than transistors for switching small currents.
 - Relays cannot switch rapidly, transistors can switch many times per second.
 - Relays use more power due to the current flowing through the coil.
 - Relays require more current than many ICs can provide, so a low power transistor may be needed to switch the current for the relay's coil.

(Relay/transistor comparison from: <http://www.kpsec.freeuk.com/trancirc.htm>)

- Notes:

- The voltage across the relay coil should be within 25% of the relay specification.
- If current flow through a relay coil is suddenly interrupted, the coil will produce a very large voltage spike in the reverse direction of the applied voltage. To handle these reverse voltage spikes, place a transient suppressor diode across the relay's coil.

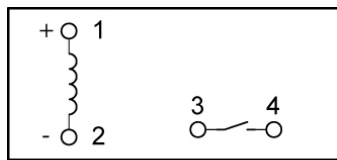


Transient Suppressor Diode D1 for a DC Driven Relay Coil

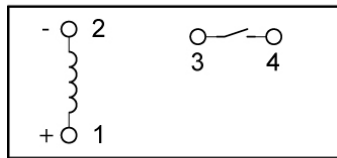
- Perform Electrical Relay Lab 2 – Relay Application 1
- Reed Relays:
 - External permanent magnet or electromagnet
- Buzzers:
 - Demonstrate an AC buzzer using a function generator.
 - Perform Electrical Relay Lab 3 – Relay as a Buzzer
- Magnetic Circuit Breakers:
 - Operation: Once a fault is detected, contacts within the circuit breaker must open to interrupt the circuit; some mechanically stored energy within the breaker is used to separate the contacts. The stored energy may be in the form of springs.
 - Show samples.
- Magnetic Shields:
 - Magnetic shields prevent magnetic fields from interfering with electrical circuits.
 - The magnetic lines of force follow the path of least resistance.
- Perform Electrical Relay Lab 4 – Relay Application 2

Electronics Technology and Robotics I Week 19 Electrical Relay LAB 1 – Voltage Separation

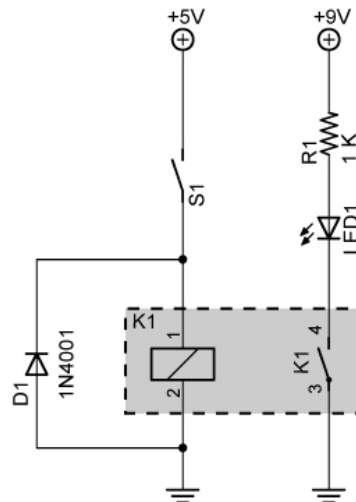
- **Purpose:** The purpose of this lab is to demonstrate that the voltage source which controls a relay coil can be separate from the voltage source that controls the secondary circuit.
- **Apparatus and Materials:**
 - 1 – Breadboard with a +5 V and +9 V Power Supplies
 - 1 – 1N4004 Diode
 - 1 – SPST Relay (Digikey # Z945-ND)
<http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=Z945-ND>
 - 1 – SPST Switch
 - 1 – 1K Resistor
 - 1 – LED
- **Procedure:**
 - Build Relay Circuit 1 on your breadboard. The circuit uses a voltage source of +5 V to energize the relay coil and a separate a voltage source of +9 V to power the LED circuit.
 - Notice that the two circuits in Relay Circuit 1 are not connected electrically. Their interaction is by the coil generating a magnetic field which closes the contacts (switch) in the relay.



K1 (Z945-ND Top View)



K1 (Z945-ND Bottom View)



Relay Circuit 1

SPST Relay Wiring Diagram

- **Results:**

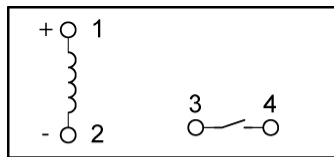
Position of Switch	LED Response
S1 Open	
S1 Closed	

- **Conclusions:**
 - The data sheet for the relay states, “When mounting two or more relays side by side, provide a minimum space of 3 mm between relays.” Why?

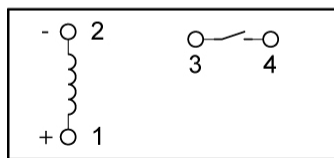
Electronics Technology and Robotics I Week 19 Electrical Relay LAB 2 – Relay Application 1

- **Purpose:** The purpose of this lab is to demonstrate an application of a relay.
- **Apparatus and Materials:**
 - 1 – Breadboard with a +5 V Power Supply
 - 1 – 1 K Tripot
 - 1 – Photoresistor
 - 1 – 4.7 K Resistor
 - 2 – 1 K Resistors
 - 1 – 2N2222A NPN Transistor
 - 1 – 1N4001 Diode
 - 1 – LED
 - 1 – SPST Relay (Digikey # Z945-ND)

<http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=Z945-ND>
- **Procedure:**
 - Wire the following light activated relay circuit:

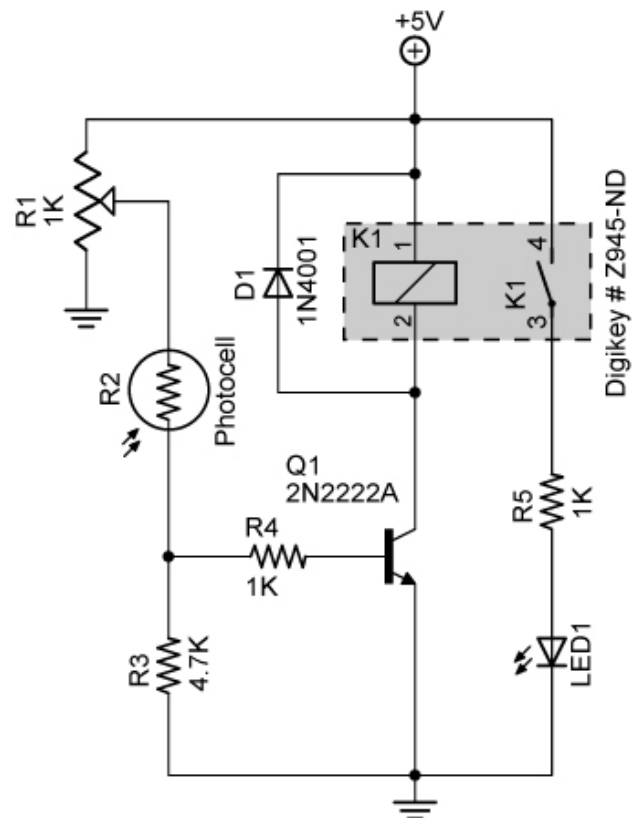


K1 (Z945-ND Top View)



K1 (Z945-ND Bottom View)

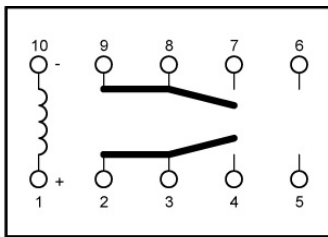
SPST Relay Wiring Diagram



Light Activated Relay Circuit

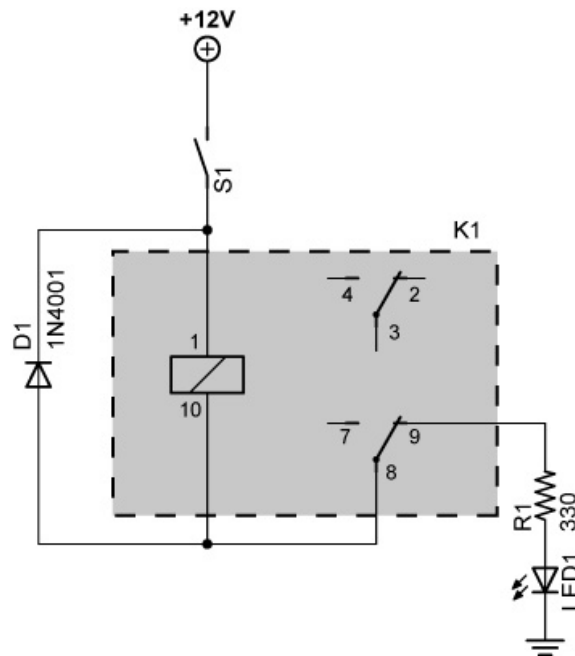
Electronics Technology and Robotics I Week 19 Electrical Relay LAB 3 – Relay as a Buzzer (Oscillator)

- **Purpose:** The purpose of this lab is to demonstrate that a relay can act as a buzzer (oscillator). Also the student must design and build a relay circuit.
- **Apparatus and Materials:**
 - 1 – Breadboard with +12 V Power Supply
 - 1 – SPST Switch
 - 1 – 1N4001 Diode
 - 1 – 470 uF Capacitor
 - 1 – DPDT Relay (Digikey # 255-1002-5-ND)
<http://search.digikey.com/scripts/DkSearch/dksus.dll?vendor=0&keywords=255-1002-5-nd>
- **Procedure:**
 - Wire a DPDT relay to become a buzzer using the following circuit.
Note that Pin 1 on the relay coil is the positive connection. Also note that Pin 10 is not connected directly to ground but to Pin 8.
Close the switch for only a short period of time since the buzzing action will create excessive wear on the relay contacts. Complete the explanation in the conclusions.



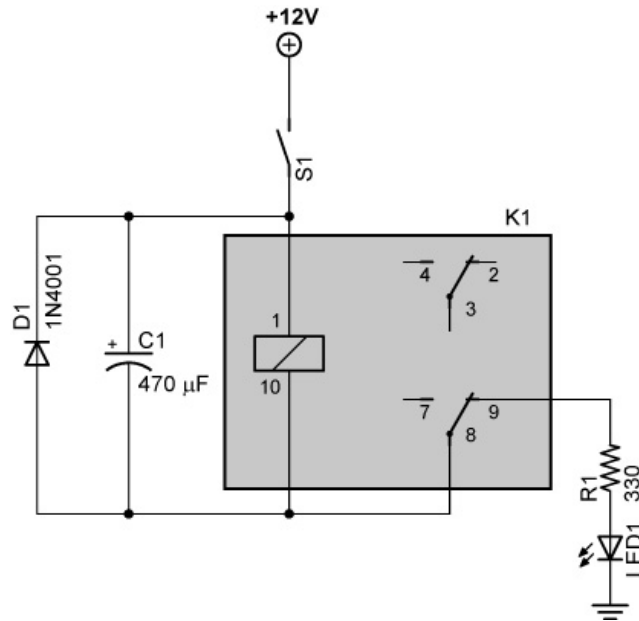
255-1002-5-ND Top View (12V)

DPDT Relay Wiring Diagram



Relay Buzzer Circuit

- Now add a capacitor to the circuit as shown in the following schematic.

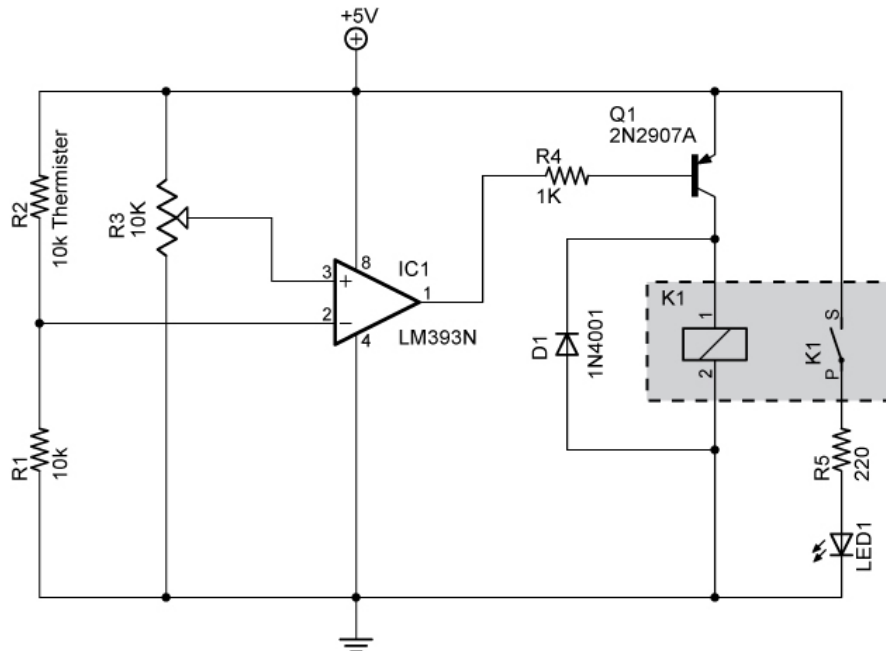


- **Conclusions:**

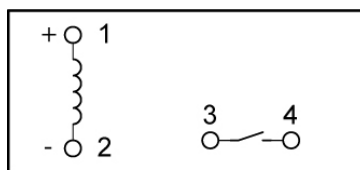
- Explain the electrical process that makes the relay turns on and off creating the sound of a buzzer.

Electronics Technology and Robotics I Week 19 Electrical Relay LAB 4 – Relay Application 2

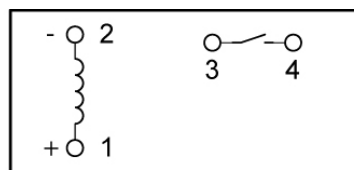
- **Purpose:** The purpose of this lab is to demonstrate another application of a relay.
- **Apparatus and Materials:**
 - 1 – Breadboard with a +5 V Power Supply
 - 1 – LM393N Comparator
 - 1 – 220 Resistor
 - 1 – 1 K Resistor
 - 1 – 10 K Resistor
 - 1 – 10 K Tripot
 - 1 – 10 K Thermistor
 - 1 - LED
 - 1 – 2N2907A PNP Transistor
 - 1 – 1N4001 Diode
 - 1 – SPST Relay (Digikey # Z945-ND)
- **Procedure:**
 - Build the temperature activated relay below:



Temperature Activated Relay Circuit



K1 (Z945-ND Top View)



K1 (Z945-ND Bottom View)

SPST Relay Wiring Diagram