Lab Experiment 9

Short Circuits, Open Circuits, Switches & Relays

Part 1 - Short Circuits & Open Circuits

Short and open circuit are important circuit concept in electronics because they allow us to make or break connections. A **short circuit** is a path with very little resistance, close to zero resistance, such as a piece of wire. In some circuit application, a closed switch or a switch in ON position and a good fuse in a DMM (Figure 9.1) are examples of short circuits. Since a short circuit has very low resistance, current will flow through the path to the rest of the circuit. On the other hand, an **open circuit** is a broken connection or wire in a path that consequently will interrupt the current flow, and produce an extremely high resistance across it, usually mega or giga ohms. Examples of open circuit are the OFF position in a switch or a "blown" fuse of a DMM (Figure 9.1). Open circuit interrupts the current flow

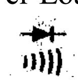
The following pictures of a "good" fuse and a "blown" fuse:

Good fuse (Short circuit) *Blown Fuse (Open Circuit)*

Figure 9.1 – Short and Open Circuit

1.1 Short and open circuit detection

A short or an open circuit may be detected using an ohmmeter or a continuity tester. When a test is placed to a short circuit using an ohmmeter, the resistance measurement will show very low resistance such as milliohms (Figure 9.2A). Instead, when an ohmmeter detects an open circuit, it usually displays the letters "OL" which stand for Over Load.

A continuity tester from the DMM  usually indicates a short circuit with either a sound or a small light bulb being lit, while the absence of a sound or the small light bulb being not lit is an indication of an open circuit.

Short Circuit Resistance (A)

Open Circuit Resistance (B)

Figure 9.2 – Short and Open Circuit Resistance Measurement using an Ohmmeter

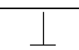
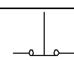
1.2 Switches

Switches are devices use to control the flow of current in through a circuit. They can turn electronic or electrical devices ON or OFF and enable circuits to perform various tasks. Some example of switches are doorbell switch, computer keyboard keys, car ignition key, an ON/OFF light switch, etc. Switches come in different shapes and mechanical or electrical operations. Examples of mechanical switches are momentary contact switches, slide switches, toggle switches, rotary switches and rocker switches. There are also electrical operate switches as relays.

1.2.1. Mechanical Operation Switches

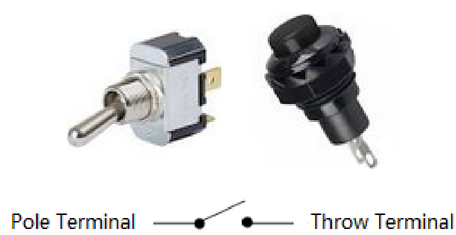
Momentary Contact Switches

Momentary contact switches are activated by pushing a button and come in two types; normally open (N/O) and normally closed (N/C). When the button is pushed on a N/O switch, the contact is made. When the button is pushed on a N/C switch, the contact is broken. The make or the break is active for the whole time that the button is held depressed. Figure 9.3 shows the circuit diagram for these two types of momentary contact switches.

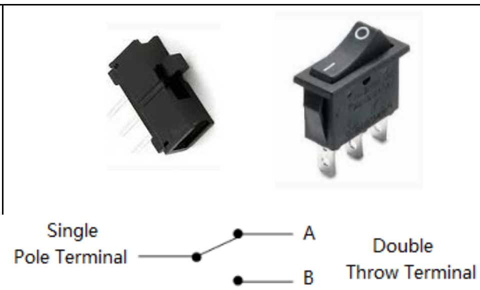
 N/O Pushbutton Make ***Normally Open***	 N/C Pushbutton Break ***Normally Closed***	 Image of a push-button switch
Figure 9.3 Momentary Contact Switches		

Pole and throw switches

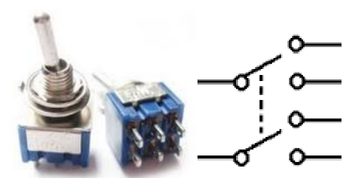
In a toggle switch, a rocker switch or a slide switch, one terminal of the switch is permanently connected to the traveling arm of the switch. This is called the **pole**. The other terminal of the switch is in contact with the traveling arm during a 'make', and is not in contact during a 'break'. This terminal is called the **through**. A switch that has one pole and one through is called a 'single pole single through' switch (SPST). A switch that has one pole and two through paths is called 'single pole double through' (SPDT). This kind of a switch is used when one point of the circuit has to be connected to two separate points (at different times of course). When the handle of a SPDT switch is "throw", the contact to one through-path is made while the contact to the other through path is broken. This can be accomplished in two ways. The break to the first contact can be accomplished before the contact to the second through path is made. This is called a 'break before make' switch. Alternately, the contact to the second through path can be made before the break to the first through path is accomplished. This is a 'make before break' switch. Usually, only 'make before break' switches are identified. If nothing is said, a 'break before make' switch is implied. When two SPST are built on the same switch body, usually, there is only one switch handle, which operates both switches at the same time. The switch is referred to as 'Double Pole Single Throw' (DPST). When two SPDT switches are built on the same switch body, the switch is called 'Double Pole Double Throw'(DPDT). See Figure 9.4 for reference.



Single Pole Single Throw (SPST)



Single Pole Double Throw (SPDT)



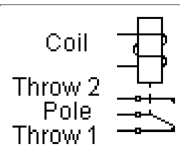
Double Pole Double Throw (DPST)

Figure 9.4 Switches

1.2.2. Electrical Operation Switches

Relays

Relays are switches that are operated electrically. Relays offer isolation between the control circuit and the load circuit. Relays allow a circuit to control other circuits without direct connection between them. A typical relay consist of a coil that when energized attracts the traveling arm of a SPDT switch. It opens the N/C contacts and it closes the N/O contacts. Figure 9.5 shows the schematic representation of a typical relay.



When the coil is energized the pole breaks from throw 1 and makes with throw 2

Figure 9.5 Typical Relay

Lab Experiment Procedure

Part 1 – Open and Short Circuit

- Set up the DMM as an ohmmeter to the lowest resistance range, and connect the DMM leads across a short piece of wire.
- Record your observations in Table 9.1.
- Disconnect one of the DMM leads from the wire. Record your observations in Table 9.1.

Some DMMs also have a 'continuity tester' built-in. If your DMM has this feature, put the DMM in this mode and first place the DMM leads across the wire, and then disconnect one of the leads. Record your observations in the continuity indication column of Table 9.1

Circuit Element	DMM reading	Resistance Value	Is it an *open* or *short* circuit?	Continuity indication (Yes / No)
Short piece of wire				
Wire Disconnected from meter lead				

Table 9.1 Short Circuit & Open Circuit Measurements

Part 2 – Protoboard connections

Use the DMM as an ohmmeter or a continuity tester, verify which holes are connected together on your protoboard, and fill up Table 9.2. With your results in Table 9.2, describe how the nodes in the protoboard is organized and fill up Table 9.2.

Test node	Measured Resistance	Short or Open Circuit?	Are they connected? (Yes/No)
A5 and A6			
D10 and F10			
C20 and D20			
F50 and I50			
+ 10 and + 20			
+30 and -30			

Table 9.2 – Protoboard connections

Part 3 – Switches

- Pick an ON/OFF (SPST) switch from your component kit. If you don't have a SPST switch, you can use a jumper wire to simulate the switch.
- Set the DMM either as an ohmmeter or as a continuity tester.
- Connect the meter across an ON/OFF switch.
- Operate the switch and fill your observation in Table 9.3

Switch Position	Measured Resistance	Short or Open?
ON		
OFF		

Table 9.3 On/Off Switch Operation

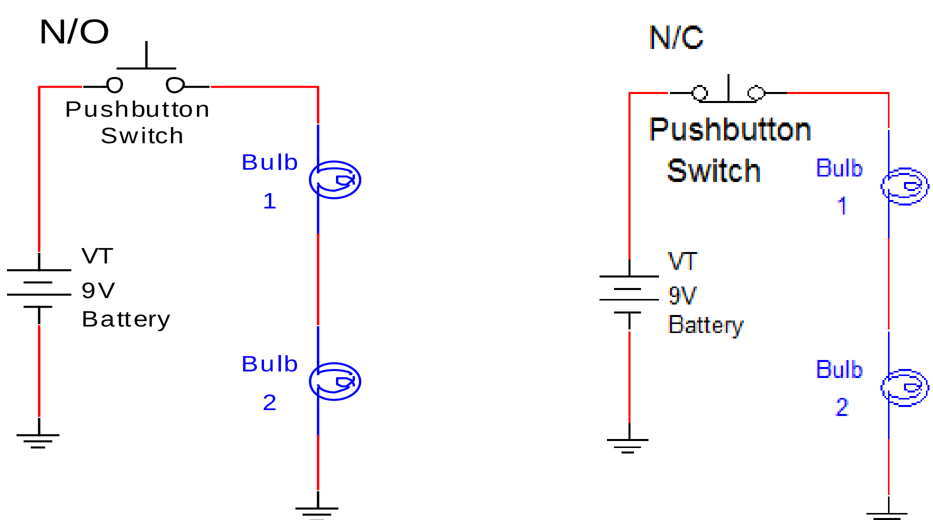
- Pick a SPDT switch from your component kit.
- Set the DMM either as ohmmeters or continuity testers.
- Connect the first ohmmeter from the pole of the switch to the first throw. Remember that the pole of the switch is the middle terminal.
- Connect the second ohmmeter from the pole to the second throw.
- Operate the switch and fill in Table 9.4

Switch Position	Measured Resistance	Short or Open?
Position 1		
Position 2		

Table 9.4 SPDT Switch Operation

Part 4 - Application of Momentary Contact Switches

- From you component kit, obtain two filament light bulb and build the circuit in Figure 9.6 on a protoboard.
- Build the circuit with the Normally Open push-button switch.



a) Normally Open Push-button Switch *b) Normally Closed Push-button Switch*

Figure 9.6 – Momentary contact switch

- Measure the voltage across the switch and the voltage across both bulbs and record in Table 9.5A
- Depress the switch and hold, and measure the voltage across the switch and the voltage across both bulbs. Record measurement in Table 9.5A

Figure 9.5A Push to make	Measured Voltage Across Switch	Measured Voltage Across both Bulbs	Light bulbs condition (ON or OFF?)
Pushbutton not depressed			
Pushbutton depressed			

Table 9.5A Switch & Bulb Voltages N/O Pushbutton Switch

- Change the switch to a Normally Closed Push-button Switch.
- Measure the voltage across the switch and the voltage across both bulbs and record in Table 9.5B.
- Depress the switch and hold, and measure the voltage across the switch and the voltage across both bulbs. Record measurement in Table 9.5B.

Figure 9.5B Push to make	Measured Voltage Across Switch	Measured Voltage Across both Bulbs	Light bulbs condition (ON or OFF?)
Pushbutton not depressed			Bulbs are ON
Pushbutton depressed			Bulbs are OFF

Table 9.5B Switch & Bulb Voltages N/C Pushbutton Switch

Part 5 - Application of ON/OFF Switches

- On your protoboard interconnect the circuit shown in Figure 9.7 by replacing the momentary contact switch with a SPST switch. If you don't have a SPST switch in your component kits, you can use a jumper wire to simulate the switch.
- With the switch in the OFF position, measure the voltage across the switch and the voltage across the bulbs. Record in Table 9.6 Turn the switch to the ON position, and repeat the measurements.
- Disassemble the circuit.

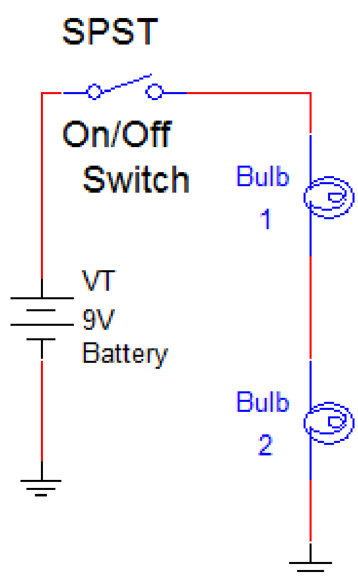


Figure 9.7 Operation of an ON/OFF Switch (SPST)

Figure 9.4 (Push to make)	Describe the bulb (ON or OFF?)	Measured Voltage Across Switch	Measured Voltage Across Bulbs
Switch in the OFF position			
Switch in the ON position			

Table 9.6 Switch & Bulb Voltages for on/off Switch

Note that the Momentary contact switches are stable only in one condition, while the ON/OFF switch (SPST) is stable in both the ON and the OFF condition.

Part 6 - Application of a Two-way Switch (SPDT)

— Obtain a red and green LED, and a SPDT switch from your component kit.
— Build the circuit in Figure 9.8 in a protoboard. Use the following LED connection as reference

— For this experiment, the SPDT switch used to control 2 separate circuits. Operate the switch and measure the voltage across the R_1 and R_2. For a SPDT switch, pick a position to be position 1 and 2.
— Record your observation and measurement in Table 9.7
— Disassemble the circuit.

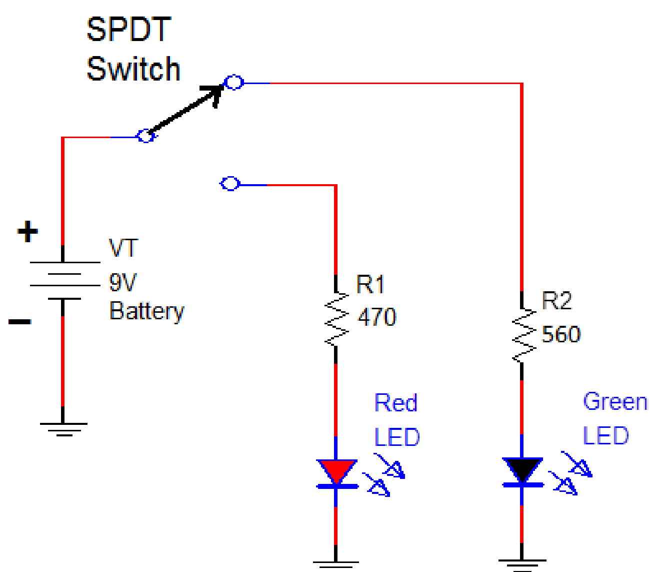


Figure 9.8 Two-way Switch (SPDT) Used to Control 2 Circuits

Switch Position	Green LED (on or off?)	Red LED (on or off?)	Voltage across R1, V_{R1} (Include unit)	Voltage across R2, V_{R2} (Include unit)
1				
2				

Table 9.7 Control of 2 circuits with a SPDT switch

Part 7 - Control of a Light from Two Different Locations

A light can be controlled from two different locations with the use of two SPDT switches as shown in Figure 9.9

- Obtain a red, green, and yellow LED and two SPDT switches from your component kits.
- Interconnect the circuit on your protoboard as shown in Figure 9.9. Make sure you connect the switches correctly. The pole is the center terminal on the SPDT switch while the throws are the two outside terminals.

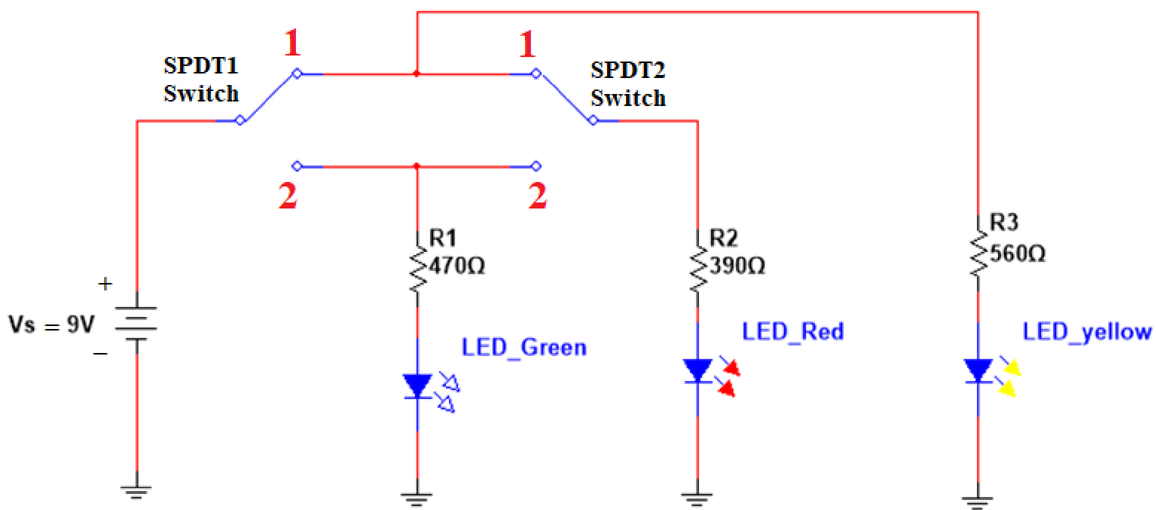


Figure 9.9 Controlling 3 LEDs From Two Separate Locations

- Operate the two SPDT switches as shown in Table 9.8 and record the LED operation (ON or OFF) in Table 9.8

SPDT1 Switch Position	SPDT2 Switch Position	Green LED (ON or OFF?)	Red LED (ON or OFF?)	Yellow LED (ON or OFF?)
1	1			
1	2			
2	1			
2	2			

Table 9.8 Control of 2 SPDT switch

- Disassemble the circuit.

Part 8 – Relays

- Obtain two 150 Ω resistor, one green and red LED, one N/O push-button, and one 5 V dc relay from your component kit.
- Built the circuit shown in Figure 9.8 and apply the indicated power supply.

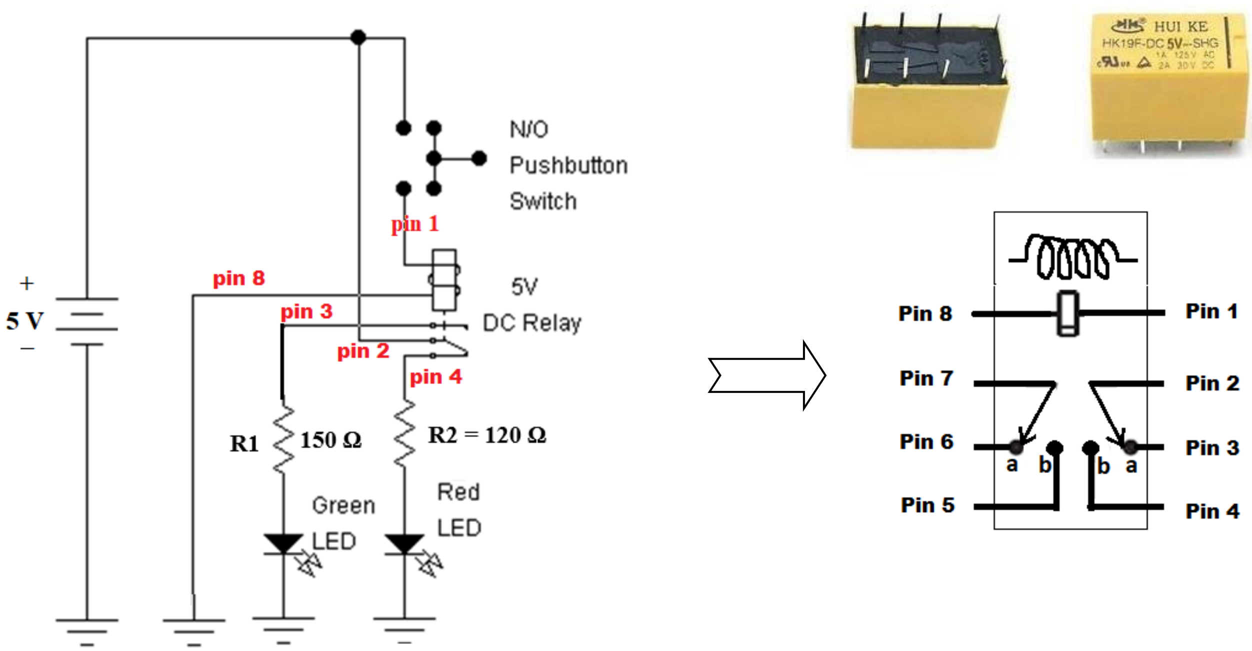


Figure 9.10 Control of 2 Separate Circuits With a SPDT Relay

- With the push button not depressed, observe which LED is ON, and measure the current and voltage through resistor R1 and R2. Record measurement in Table 9.10.
- Push the button of the switch, observe which LED is ON, and measure the current and voltage through resistor R1 and R2. Record measurement in Table 9.10.

Pushbutton Switch	Which LED turn ON?	Current through R1	Current through R2	Voltage across R1	Voltage across R2
Not Depressed					
Depressed					

Table 9.10 Control of 2 Separate Circuits With a SPDT Relay

- Disassemble the circuit.
- Place your components in your component kit.
- Disconnect all lab equipment.

Student's name: ___________________________Lab Instructor's Signature _________________________

--- **LAB EXPERIMENT ENDS HERE** --