TOUCH SENSOR LAMP

CONTENTS:

DESCRIPTION

The *TOUCH SENSOR LAMP* works by connecting the input to a metal plate or metal object. When the plate or object is touched the switch will operate and turn on a LED strip or LED array of your design.

This means that a touch sensitive lamp can be designed.

This circuit enables the student to explore the design and control of a wide range of lamp designs.

SECTION 1: GENERAL AND PLANNING INFORMATION

1. DESIGN CONSIDERATIONS

1.1 GENERAL

This project allows the student to design and construct a LED Lamp whose operation can be controlled by simply touching anywhere on a sensor plate. The lamp can operate a LED strip or the student can design and construct their own LED array. Any type of lamp can be designed. Although the touch switch can operate from batteries they will soon go flat after a couple of hours operation so it is more practical to run the lamp from a small 12 volt DC 0.5 amp plugpack. A plugpack of 12 volts DC with a higher current capacity can also be used.

1.2 ITEMS FOR INVESTIGATION

This project provides a number of different aspects of the uses of the *TOUCH SENSOR SWITCH PCB* .

Ideas for investigation of touch operated projects. Some ideas are listed below.

- Investigate different types of Lamp designs. Ideas can be found at the following sites.
- http://freshome.com/2008/10/19/40-of-the-most-creative-lamp-designs-ever/
- https://www.pinterest.com/explore/lamp-design/
- http://wonderfulengineering.com/15-super-cool-lamp-designs-that-you-can-make-at-home/
- http://www.architectureartdesigns.com/30-amazing-diy-bottle-lamp-ideas/
- Investigate LEDs and their operating voltage and current.

SECTION 2: COMPONENTS & MATERIAL REQUIRED

2.1 The following components are supplied for one *TOUCH SENSOR LAMP*

The following components are supplied in the kit:

2.2 ADDITIONAL REQUIREMENTS

The following material is to be supplied by the student / designer:

- Hook-up wire
- All material required to make the lamp's base, stand and light unit.

2.3 TOOLS REQUIRED

The following tools are required:

- Soldering iron
- Solder
- Side cutters
- Wire strippers

SECTION 3: ASSEMBLY OF THE TOUCH SENSOR LAMP PCB

3.1 Printed Circuit Board

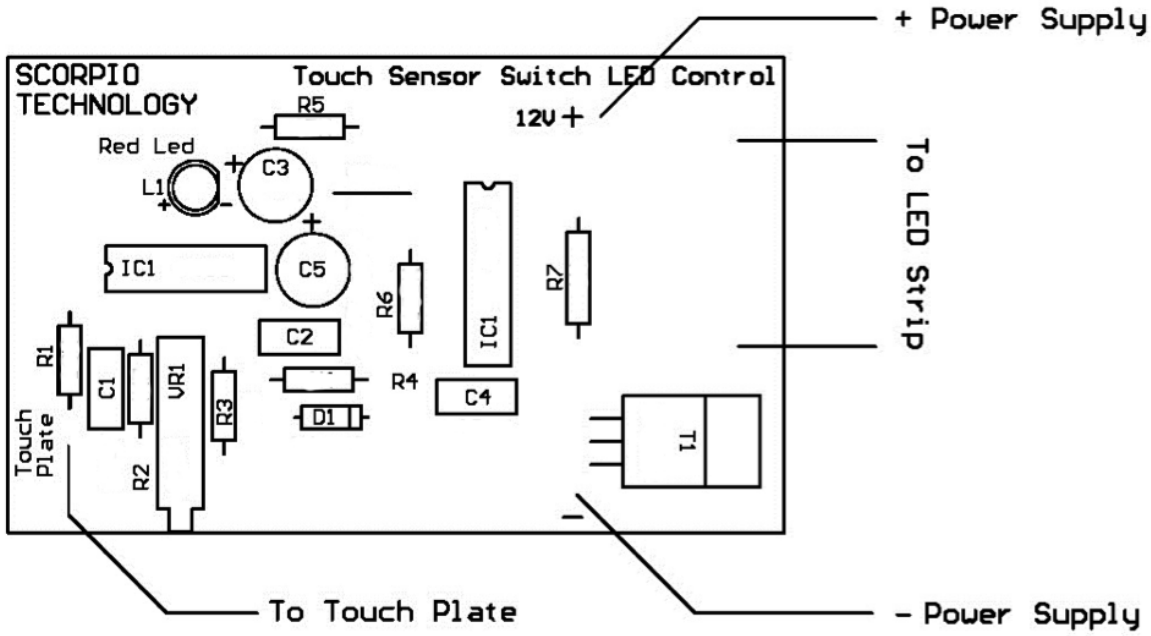


Figure 1.

3.2 Resistors

WARNING: Soldering irons and molten solder are very hot and can burn you. The soldering iron should either be, in your hand or in the stand. Never place the soldering iron on the bench even briefly, because someone can inadvertently put their hand on the iron or lean on the iron, causing severe burns.

Identify each of the three resistors using their colour codes. If required, use a multimeter to check the value of each resistor.

- Insert the resistors in the positions shown on the PCB overlay. The direction of the resistors is not critical as they will work in any direction.
- Turn the PCB over. Make sure the body of the resistor is firmly against PCB, splay the legs slightly after insertion to hold them in place then solder the resistor leads to the pads.
- Using side-cutters, trim the leads off at the solder.

3.3 Trimpot

- The trimpot is a 10 turn device. It takes 10 turns of the screw thread to be adjusted from minimum to maximum resistance. I has the code 104 printed on it.
- The trimpot has 3 legs and can only be inserted into the PCB in one way. Place the trimpot into the holes and carefully press it down until it is mounted flat on the PCB. Turn over the PCB. The trimpot should be a neat fit and should not move.
- Solder the trimpot leads and cut them off level with the solder.

3.4 Capacitors

- Insert the disc ceramic capacitors (C1, C2 & C4) in the positions shown on the PCB overlay. The direction of the disc ceramic capacitors is not critical.
- Insert the electrolytic capacitors (C3 & C5). These have appositive and negative connection unless they are inserted correctly the circuit will not work. The stripe on the capacitor indicates the negative (-) terminal; the other terminal is positive (+). Insert the positive terminal to the "+" indicated on the PCB.
- Make sure the capacitors are placed against the PCB, splay the legs slightly after insertion to hold them in place. Solder the resistor leads to the pads.

3.5 IC Sockets

- Insert the IC sockets. Gently splay two opposite corners to hold the socket in place when you turn it over to solder. The notch at the end of the socket must be at the same end as the notch on the PCB overlay.
- Do not trim the legs of the IC sockets.
- Do <u>not</u> insert the IC's at this stage. They will be inserted before testing.

3.6 LED

- Insert the LED L1. Align the flat on the LED as shown on the PCB overlay. The circuit will not work if the LED is facing in the wrong direction.

3.7 Diode

- Insert the diode with the band facing in the direction shown on the PCB overlay. The circuit will not work if the diode is facing in the wrong direction.

3.8 Transistor

- The transistor is the last component to be inserted. Position the leads in their holes so that the metal back is facing towards the left hand end of the PCB. Press on the plastic section of the transistor and carefully bend it down on to the PCB, so the metal face of the transistor faces the PCB.

3.9 Touch Sensor Plate

- The sensor plate needs to be connected by a wire to the PCB. Refer to Section 6.2.2 you will find further information regarding the sensor plate.

  NOTE: The kit comes with a plate made from PCB material.
  You can use another type of sensor plate if you wish. You might choose to use a brass plate because it will enhance the appearance of your lamp. You could also choose to make the base and lamp itself out of metal. The touch sensor plate could then in fact become the lamp sensor plate by connecting the lamp body to the input of the PCB.
  HINT: When mounting the sensor plate you will need to think carefully how you will hide the connection of the wire to the sensor plate so it isn't in visible when the lamp is assembled.

SECTION 4: WIRING UP THE PCB

4.1 Power Socket

- Solder a red wire from positive (12v+) location on the PCB, making sure it is long enough to reach to where the power socket will be located.
- Join the red wire to the largest terminal on the DC socket as shown on the right. Before soldering check that the terminal the red wire is connected to is the one that connects to the centre pin on the other end of the DC Socket.
- Solder a black wire to the negative (-) location at the bottom of the PCB.
- Join the black wire to the terminal on the DC socket as shown. Solder both wires to the terminals and cut off any bare wire level to the solder.

NOTE: While it is possible to run the *TOUCH SENSOR LAMP* from batteries it isn't practical for two reasons:

- the batteries will flatten in a relatively short period of time and become an on-going expense. For this reason using a plugpack is a more practical option.
- ongoing adjustment of VR1. If you use a battery you will need to continually readjust the setting as the battery voltage falls under use.

SECTION 5: POWER-UP TESTING OF THE PCB

- Do not insert the ICs. If you have already inserted them gently lever them out.
- Plug the plugpack connector into the DC socket.
- Plug the plugpack into a power point and turn on the power switch.
- Use a multimeter to measure the voltage:
  - on IC1 between pin 14 and pin 7. The voltage should be above close to 12 volts and pin 14 should be positive.

- on IC2 between pin 16 and pin 8. The voltage should be above close to 12 volts and pin 16 should be positive.

- Turn off the power switch.

5.1 Insert both Integrated Circuits (IC's)

- These components look like beetles with lots of legs! They have a notch (or dimple) at one end.
- Care must be taken with the IC's as this type can be damaged by static electricity. If possible you should not handle them but use a special tool called an IC inserter to plug the IC's into their sockets. If you don't have this tool available you should make sure that you discharge any build up of static electricity in your body by touching an earthed point (such as an earthed appliance or water pipe). You can then pick up and insert the IC's.
- The ICs must be placed on the PCB with the notch facing in the same direction as shown on the PCB.
  WARNING: If power is connected to the PCB with these facing the wrong way, the PCB will not work and the Integrated Circuit will be permanently damaged.
- Turn on the power switch. The circuit is now ready to be adjusted.

5.1 Adjustment

The trimpot VR1 must be adjusted for maximum sensitivity. The trimpot is 10 turns from minimum setting to maximum setting. You will need a small jeweller's screwdriver to adjust the trimpot.

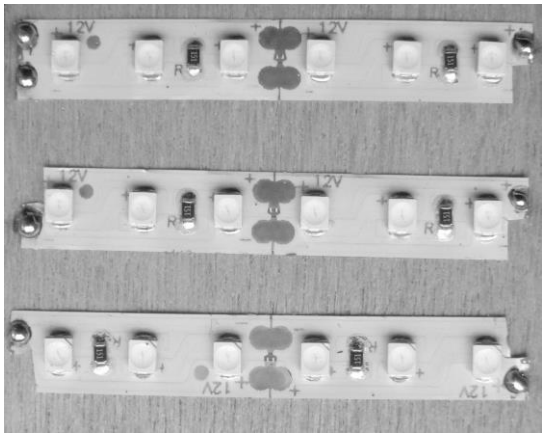
- Turn the trimpot anti clockwise until L1 comes on, then turn the trimpot clockwise until L1 just turns off.
- Touch the sensor plate and the LEDs should light when you take your hand off the sensor.
- Touch the sensor plate again and the LEDs should turn off.

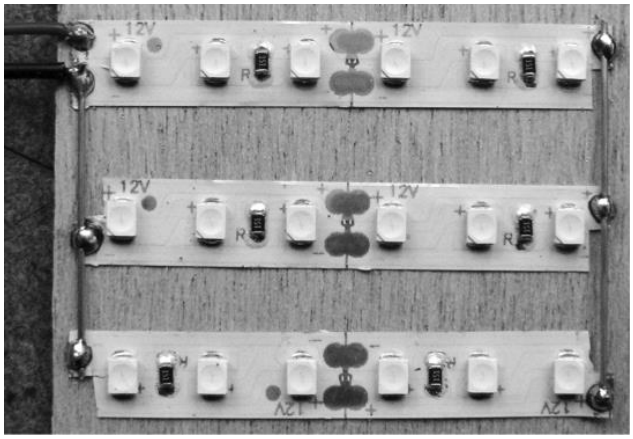
It may take a bit of trial and error to get the setting just right. If the lamp goes on when you touch the sensor and then goes off as you move your hand away, then turn the trimpot clockwise a little more and touch the sensor again. Continue until it responds properly to touch on and touch off operation.

5.2 LED Strip

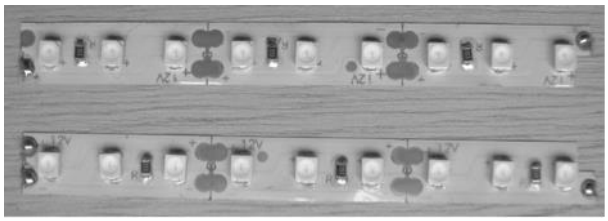
The LED strip supplied with the kit runs directly from 12 Volts. No other components are needed for the operation of the LED strip.
NOTE: For successful operation of the LED Strip it is necessary to make sure that the positive and negative connections to the strip are correct.

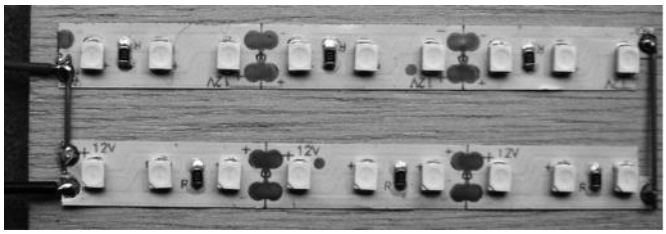
THE POSSIBLE CONFIGURATIONS USING A STRIP OF 18 LEDs:
3 x 6 LED Strip





2 x 9 LED Strip





1 x 18 LED Strip

SOLDERING THE LED STRIPS

- Cut the LED strip into the lengths required.

5.2.1 Using the 18 LEDs as one strip

If using the 18 LEDs in one strip, no pads need to be removed - solder 2 wires to the pads (as in section 5.2.3).

5.2.2 Other configurations

That is - using either 2 rows of 9 LEDs or 3 rows of 6 LEDs. The simplest way to connect these is as shown above in the photographs.

- The other alternative involves wires joining the pads, which increases the complexity of assembly.

- Arrange the strips and carefully cut the pads off the strips as shown.

Note: The pad sections cut off are different for each strip.

5.2.3 Soldering and wiring the LEDs

- Tin the pads as shown for each strip.

- Remove the adhesive protection tape from the LED strip and carefully fix them in place in the same directions shown in the picture.

SUGGESTION: Use 0.7mm tinned copper wire and solder the tinned wire to the LED strips.

- Cut red and black wires long enough to reach to the PCB in the base of the lamp.
- Remove 5mm of plastic from one end of each wire.
- Tightly twist the exposed bare wires and tin them.
- Cut the tinned wires to 3mm long.
- Solder them onto the LED strip.

5.3 Fault Finding

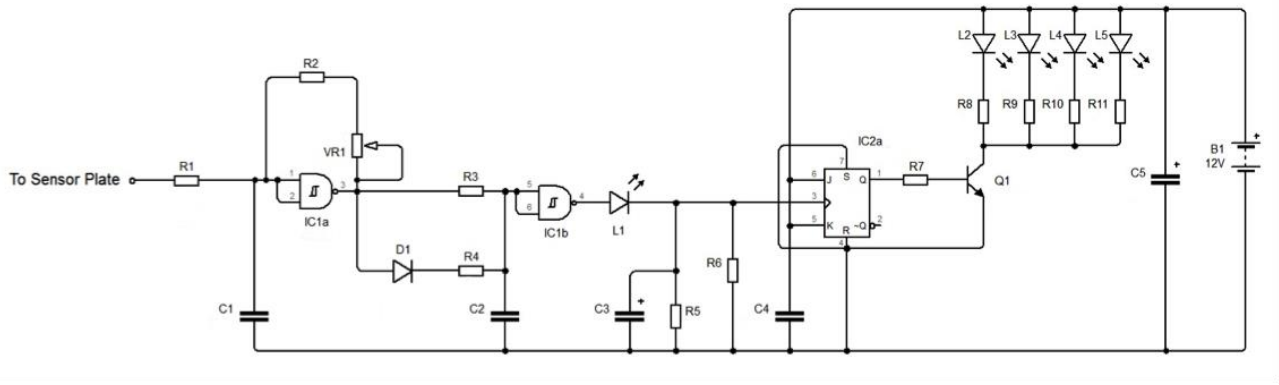
LED L1 cannot be adjusted

- Check that the LED is facing in the correct direction.
- Check that D1 is facing in the correct direction.
- Check the values of resistors R1, R2, R3, R4 and R5.

- Check the values of C1, C2 and C3 and C5. Check that C3and C5 have their positive and negative leads in the correct direction.
- Check for short circuits (solder bridges). Check that solder joints are not “frosty” – possible dry joint.
- Check the orientation of the IC1. The dimple or notch should face upwards towards the top of the PCB
- Check battery voltage. It should be around 12 Volts.
- Measure the voltage between pin 1 and pin 14 on IC1 and pin 1 and pin 16 on IC2. It should be the same as the power supply voltage (12 Volts). Pin 14 should be positive.
- Using a multimeter check the resistance between the centre leg of trimpot VR1 and the lead near the bottom edge of the PCB. The measurement should read around 50K (this is around the setting needed for correct adjustment).
    - If a low reading is measured, the trimpot is turned too far clockwise. Turn the trimpot anti clockwise until you measure somewhere near 50K and the adjust the trimpot as described in Section 5.1
- LED1 operates but the LED Strip does not light. Check for short circuits (solder bridges) these can occur more easily between soldered leads that are close together, so carefully check around IC1. Check that solder joints are not “frosty” – possible dry joint.
- Check the orientation of the IC2. The dimple or notch should face upwards towards the top of the PCB
- Measure the voltage between pin 1 and pin 16 on IC2. It should be the same as the power supply voltage (12 Volts). Pin 16 should be positive.
- Check that the LED strip is connected the correct way round with the positive connection to the top of the PCB and the negative connection just above T1 as shown in Figure 1.
- Check the value of resistors R6 and R7. Check the value of C4.
- Check the orientation of T1 is correct. When T1 is mounted as shown on the PCB, the metal side should be facing down to the PCB.

SECTION 6: THEORY

6.1 Schematic Diagram



6.2 Circuit Operation

6.2.1 Description

The Touch Sensor works by connecting the input to a metal plate or metal object. When the plate or object is touched the switch will operate and turn on any of the following type of components, LEDs, motor, solenoid or relay connected to the transistor. LEDs are shown on the circuit 1 as an example of how the Touch Sensor Switch could be wired to act as a *TOUCH OPERATED LAMP*.

Note: in order to understand the following description of how the circuit operates, you need to understand the following. Low: is a voltge lower than 3.6 volts. High: is a voltage above 8.4 volts

IC1a is a Schmitt trigger NAND gate. The gate IC1a, with R1 and C1 works as an oscillator. The frequency can be found by using the following formula:

Frequency = 1/RC

The frequency the oscillator works at keeps capacitor C2 fully charged.

The sensor plate is connected to resistor R1 acts as a sensor that detects the electric field surrounding a human body. When you place your hand near the sensor, the electric field acts so the capacitance of your body is added in parallel to the value of C1. The circuit sees this as an apparent increase in the value of C1.This increase in capacitance will cause the frequency of the oscillator to drop.

The lower frequency allows enough time for capacitor C2 to discharge through R3. This will cause the voltage at the inputs of the Schmitt trigger IC1b to low. This causes the output of the Schmitt trigger to go high. The high output of the Schmitt trigger is connected to LED, L1. L1 will light momentarily as capacitor C3 charges. When capacitor C3 is charged, L1 will go out.

A short voltage pulse will be sent to the input of IC2a. IC2 is a dual J-K flip-flop. IC2a is one of the two J-K flip-flops inside the package, the other is not used. In this circuit the J-K flip-flop is wired so that its output will change every time it receives a pulse at its input. So the first time it receives a voltage pulse at its input its output will go high. This high output voltage will then be sent via resistor R7 to the base of transistor T1, causing the transistor to turn on and cause the LEDs to light. The next voltage pulse at its input (when you touch the sensor plate for the second time) will cause the output of the J-K flip-flop to go low. This will turn off the transistor and cause to LEDs to go out. Touching the plate again will turn on the LEDs. Each time the sensor plate is touched the LEDs will either light or be turned off.

6.2.2 Sensor Plate

The metal part of the touch sensor plate does not actually have to be touched. In the prototypes that were built, the touch sensor was actually a piece of single sided PCB. The wire from the input of the touch sensor circuit was soldered to the copper plate of the PCB and the reverse side was mounted upper most and it was the fibreglass side that was touched. It is possible to mount the sensor plate on the inside of a window and allow someone on the other side of the window to place their hand over the sensor plate to light a sign or to illuminate a section of the shop. Increasing the size of the plate makes it more sensitive.

In fact the Touch Sensor Lamp PCB (switch) can be used to operate other devices.

SECTION 7: LAMP DESIGN

7.1 LAMP DESIGN

It is recommended that you investigate different types of Lamp Designs before you begin the design of your Lamp. Some internet sites for Lamp Designs are given at the start of this teaching unit. These can be used as a starting point for your research. There are many sites where different examples of Lamp Designs can be found.

To help you decide which design you might wish to make, you should produce a number of sketches of different designs. Once you have settled on your design you should aim to produce a more thorough and detailed drawing.

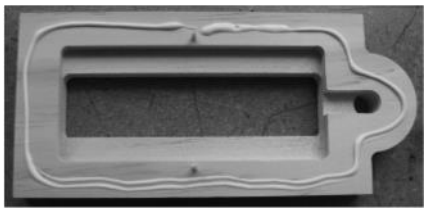
- Your drawing should not only represent what your Lamp will look like but should also contain all the details needed to make the Lamp.
- It should show measurements, how parts fit together, materials you will use, any parts that will be needed ie. nuts and bolts, screws, springs, nails.

The complexity of your design will depend upon many factors including your skill and experience with making things, and the tools and equipment available to you. The Lamp you design and make will be different if all you have available are simple hand tools, compared to a design that has a 3D Printer or milling machine available. Even if these are available it will depend upon your willingness and skill to learn how to use a CAD program to produce drawings that can be used by them. Keep in mind that having this type of equipment does not mean you will produce a better project than one made using simple hand tools, it will simply be different.

No matter what equipment is available, you have the opportunity to produce a unique attractive and useful project.

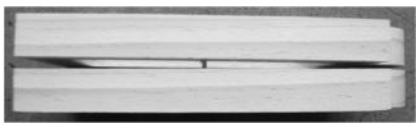
In the prototypes shown (at the start of the unit and below) both the base and lamp head were made from two 18mm thick pieces of wood joined together.

The base cut out of 2 pieces of 18mm thick wood. Note the hole for the gooseneck and the routered path for the wires to be fed from the lamp head through the gooseneck and into the cavity where the PCB is mounted.



Apply glue to one part of the base. Note the small holes shown in the previous picture now have small pins inserted to allow accurate alignment of the 2 parts.

The pins are actually 2mm bamboo tooth picks cut to size.



The pins are used to align the 2 parts and they are pressed together. If you are not going to use the pins for alignment you will need to need to carefully align the edges of the 2 parts.

Clamp the base together until the glue is dry. Use a couple of flat pieces of wood on the outside to prevent damage to the wood faces. Make sure that any excess glue id cleaned up with a damp cloth.

Repeat this procedure for the lamp head

The cavity in the base must be at least 18mm deep, 100mm long and 60mm wide.

If using a circular base and cavity as shown in the picture below, then the cavity must be a minimum of 115mm.