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Touch Technology for Printed Circuit Board (PCB) Ready Automated Switch: A Smart Home Device

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Abstract: Electronics in nowadays endeavor are of 85% necessity that make its highly adopted by a lot of personnel varying from hobbyist to professional. The PCB ready touch switch was aimed at providing easier mains of deploying a touch activated switch for both hobbyist and professional in an electrical field. This paper focuses on implementation such a great device using PIC microcontroller embedded with several special functions resulting to a perfect and stable system. The PIC microcontroller (PIC16F877A) is initially programmed to handle the whole operation involved in the operation of this device making it major in this system. In respect to this simplicity, this device can be coupled and put in use by even an unskilled personal. The device can be deployed for both industrial and domestic usage dependent on the type of touch sensor incorporated with the PIC16F877A microcontroller and TTP224 4-ways capacitive sensor.

Keywords: Home, Microcontroller, Sensor Smart, Touch.

1. Introduction

This paper, as named "PCB ready automated switch", focused on achieving a touch activated switch. A touch switch primarily works when an object or individual gets in physical contact with touch surface. Unlike a button or other more manual control, touch sensors are more sensitive, and are often able to respond differently to different kinds of touch, such as tapping, swiping and pinching. Touch sensors are used in consumer tech devices such as smartphones and tablet computers. Typically, touch sensors are used as a means to take input from the user (1). The crucial interest of this paper is to design a package touch activated switch that can even be put into use by an unskilled personnel, provide an electronic work delivery at the tip of a finger, to ease the stress of complex circuitry and ensure a fast means of producing a touch activated switch. This paper work is based on the production of a PCB ready touch automated switch. These provide a means of achieving a touch activated touch. This paper work gives even an unskilled personnel opportunity to produce a touch activated switch. As the paper is based on microcontroller which is programmed to do the specified operation, the system is only prone to just 4 input and output lines. Means of modification is only achievable by skilled electronic personnel.

This is ideally useful for making touch operated doorbells, buzzer and toys. It also used in door knobs. This device is also applicable in remote operated switch, light operated switch & clap switch. This touch switch when compared with other relevant touch switch in the outside world was considered to have the following merits.

i. The switch can be used for switching AC as well as DC.
ii. Switching of heavy current device i.e. could switch a load up to 50A.
iii. It is used in various applications due to its quicker response.
iv. Low cost.
v. Highly flexible due to simplicity of circuit.

2. Literature Review

The first printed circuit boards (PCBs) can be traced all the back to the early 1900s and a patent for "printed wire." It was in 1925 that Charles Ducas first submitted a patent that involved creating an electrical path directly on an insulated surface (2). It was a revolutionary idea because it could eliminate complex wiring and provide consistent results. Still, they didn't really catch on until after WWII, when Dr. Paul Eisler in Austria began making the first real operational printed circuit boards in 1943. The early PCB material could be almost anything, from Bakelite and Masonite to plain old thin pieces of wood. Holes could be drilled into the material and flat brass wires would be riveted onto it. It may not have been pretty, but the concept was there, and it worked. It was often used in radios and gramophones at the time. In 1947, the first double sided PCB's with plated through holes was produced (2). In 1950, the types of materials used for the board was shifting to different resins and other materials, but they could still only be printed on a single side. The wiring would be printed on one side and the electrical components would be on the other. Still, it was a much more efficient option than bulky wiring, so it was starting to see a wider adoption.

One of the biggest steps forward came in 1956 when the U.S. Patent Office granted a patent to a small group of scientists representing the U.S. Army for the "Process of Assembling Electrical Circuits." At the time, the process involved drawing the wiring pattern and then photographing it onto a zinc plate. This plate could then be used to create a printing plate for an offset printing press. This is what was used to print the wire in acid resistant ink on the copper foil, which could then be etched by an acid solution. In 1960's, multilayer PCB's begin production. (3)

2.1. Types of PCB

There are several overall types of PCB boards each with their own particular manufacturing specifications, material types and usages. The different types of PCB will be explained in latter sub section.

2.1.1 Single-Layer PCBs

A single-layer or single-sided PCB, Figure1, is one that is made out of a single layer of base material or substrate. One side of the base material is coated with a thin layer of metal. Copper is the most common coating due to how well it functions as an electrical conductor. Once the copper base plating is applied, a protective solder mask is usually applied, followed by the last silk-screen to mark out all of the elements on the board (4).

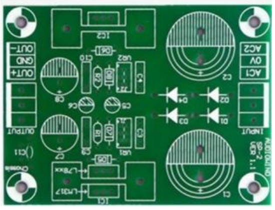

Figure 1: Single sided PCB (5)

2.1.2 Double-Layer PCBS

Double sided PCB (Figure 2) is the type of printed circuit that has tracks for interconnection on both side of the board. Double Sided PCBs (also known as Double-Sided Plated Thru or DSPT) circuits are the gateway to higher technology applications.

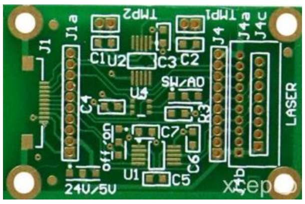

Figure 2: double sided PCB (6)

They allow for closer (and perhaps more) routing traces by alternating between a top and bottom layer using vias. Today, double sided printed circuit board technology is perhaps the most popular type of PCB in the industry (7).

2.1.3 Multilayer PCBs

Multi-layer PCBs (Figure 3) consist of a series of three or more double-layered PCBs. These boards are then secured together with specialized glue and sandwiched between pieces of insulation to ensure that excess heat doesn't melt any of the components. Multi-layer PCBs come in a variety of sizes, going as small as four layers or as large as ten or twelve. The largest multi-layer PCB ever built was 50 layers thick. (4)

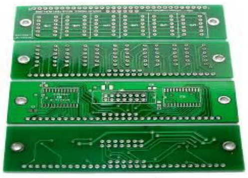

Figure 3: Multilayer PCB (8)

A capacitive touchscreen panel uses an insulator, like glass, that is coated with a transparent conductor such as indium tin oxide (ITO). The "conductive" part is usually a human finger, which makes for a fine electrical conductor. The invention was also binary in its interpretation of touch—the interface registered contact or it didn't register contact. Pressure sensitivity would arrive much later (9). University of Kentucky tried to file a patent on his behalf to protect this accidental invention from duplication, but its scientific origins made it seem like it wasn't that applicable outside the laboratory (9). Bill Buxton has played a huge role in the development of multitouch technology, he deemed Mehta's invention important enough to include in his informal timeline of computer input devices (9). Krueger introduced Video Place (later called Video Desk) in 1983, though he'd been working on the system since the late 1970s. It used paperors and video cameras to track hands, fingers, and the people they belonged to. Unlike multitouch, it wasn't entirely aware of who or what was touching, though the software could react to different poses. The display depicted what looked like shadows in a simulated space (9). The 2000s were also the era when touchscreens became the favorite tool for design collaboration (9). Adoption of touch sensors was fueled by the creation of smart phones and devices equipped with touch-screen technology including ATMs and Point of Sale systems. Technology advancements of the decade included Apple’s Newton handwriting recognition and IBM’s Simon touch-screen interface (10). Each of the touch sensor technologies detects touch differently, and some can detect gestures without direct contact or by the absence of touch. There are various touch sensor types such as 5-wire (or 4-wire) resistive, surface capacitive, papered capacitive, surface acoustic wave and infrared sensors (11).

3. The Technology Used

The practical approach and the methodology applied in realizing the work is as shown in block diagram Figure 4. The system development embroils software and hardware stages.

3.1 Hardware Development Stages

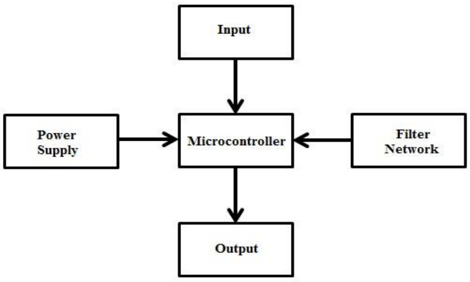

Figure 4: Block diagram of the developed system

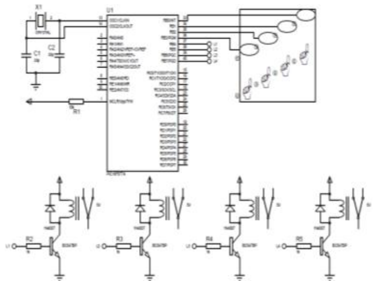

Figure 5: Circuit diagram of the developed system

3.1.1 The Input TTP224 4-ways Capacitive Sensor

The input sensor is TTP224 4-ways Capacitive (see Figure 6) that sends signal to the microcontroller that decides the output channel to be energized and likewise de-energized. This touch sensor is made up of different material depending on the manufacturer. The touch sensor as relate to the design sends a high logic level each and every instant the touch sensitive pad felt a touch.

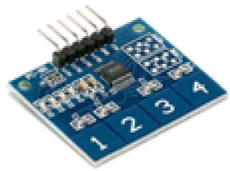

Figure 6: TTP224 4-ways capacitive touch sensor (12)

3.1.2 Microcontroller (PIC16F877A)

PIC16F877A microcontroller is a self-contained system with peripherals, memory and a processor that can be used as an embedded system. The PIC16F877A, Figure 7, controls the system and conveys instruction to line to activate or deactivate.

Figure 7: Microcontroller (13)

Programmable microcontrollers are designed to be used for embedded applications. Microcontrollers are used in automatically controlled devices including power tools, toys, implantable medical devices, office machines, engine control systems, appliances, remote controls and other types of embedded systems (14).

3.1.3 The Output Circuitry

Output (Figure 8) as referred to this work is the channel (home electrical appliances) that is controlled by the microcontroller. The output channel consists of relay and relay drivers where the loads are attached. The capacity of the relay (amperage) determines the overall ampere capacity of the system. It is advisable to introduce power relay (contactor) in case of a heavy load for closing and opening of the output channel.

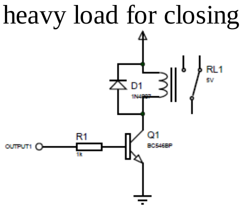

Figure 8: One channel output with relay driver

3.1.4 The Device PCB Circuit Design and Production

The system circuit diagram was drawn using proteus schematic software, with the following procedures for PCB production for the designed system.

Step 1: Printing out of PCB layout
Step 2: Cutting the copper plate
Step 3: Make it smooth by rubbing the copper side of PCB using steel wool or abrasive spongy scrubs
Step 4: Transferring Methods

Transfer the printed image (Figure 9) from the photo paper to the board. Make sure to flip top layer horizontally. Put the copper surface of the board on the printed layout. Ensure that the board is aligned correctly along the borders of the printed layout. Put Cello along the two sides of the board non-copper side. This will help to hold the board and the printed layout in position.

i. After printing on glossy paper, it is being ironed image side down to copper side. Heat up the Electric iron to the maximum temperature.
ii. Put the board and photo paper arrangement on a clean wooden table and clothes with the back of the photo paper facing you.
iii. Hold one end of it by the Towel and put the hot iron on the other end for about 10 seconds. Now, iron the photo paper all along using the tip and applying little pressure for about 5 to 15 min.
iv. Pay attention towards the edges of the board – you need to apply pressure, do the ironing slowly.
v. Long hard press seems to work better than moving iron around.
vi. Iron heat melts ink printed on glossy paper and get transfer to copper plate.

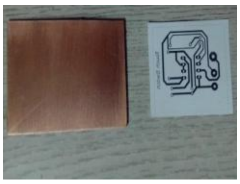


Figure 9: Transferring Method **Figure 10:** Peeling process

Step 5: Peeling (Figure 10)
After ironing, place printed plate in lukewarm water for around 10 minutes. Paper will dissolve and remove paper gently. Remove the Paper off at low angle & traces. In some cases while removing paper some of track get fainted .See figure below in white box black line track is light in colour hence, we can use black marker to dark lighted track as shown in Figure 11.

Figure 11: Soldering track adjustment

Step 6: Etchings

i. First put rubber or plastic gloves.
ii. Place some newspaper so that etching solution do not spoil floor.
iii. Take a plastic box and fill it up with some water.
iv. Dissolve 2-3 tea spoon of ferric chloride power in the water.
v. Dip the PCB into the Etching solution (Ferric chloride solution, $FeCl_3$) for approximately 30 minutes.
vi. The Fecl3 reacts with the unmasked copper and removes the unwanted copper from the PCB.
vii. This process is called as Etching. Use pliers to take out the PCB and check if the entire unmasked area has been etched or not. In case it is not etched leave it for some more time in the solution.

Gently move plastic box to and fro so that etching solution react with exposed copper and form iron and copper chloride. After every 2-3 minutes check whether all copper is etched or not.

Step 7: Disposal
The etching solution is toxic to fish and other water organisms. Don't pour it in the sink when you are done. It is illegal to do so and might damage your pipes. Dilute etching solution and then dispose the solution.

Step 8: Final touch
A few drops of thinner (nail polish remover works well) on a pinch of cotton wool will remove completely the toner, bringing back the copper surface. Rinse carefully and dry with a clean cloth or kitchen paper. Trim to final size and refine edges with sandpaper. Acetone help glossy paper stick to rough paper. The last step is accompanied by drilling hole and solder the entire component.

3.2 The Device Software Development

Figure 12 illustrates flowchart of the system.

3.2.1 Algorithm

i. Start the microcontroller
ii. Assume align input function and output function from input and output device respectively
iii. Scan through input device pin continuous (continuous scanning)
iv. If any of the input pin is on high logic level stage activate the corresponding output channel related to such input pin
v. Continue the scanning
vi. If such active output channel get high at the input channel once again deactivate the output channel

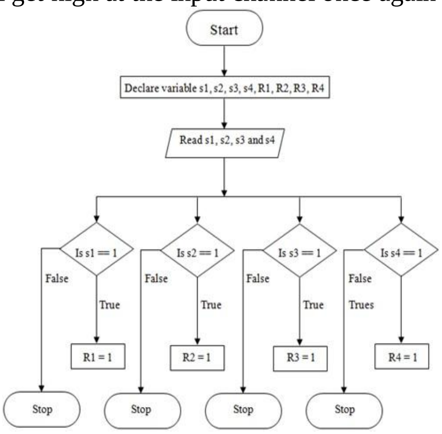

Figure 12: Flowchart of the system

3.2.2 Program Code

```
int cnt1=0, cnt2=0, cnt3=0, cnt4=0;
#define s_1 RB0_bit
#define s_2 RB1_bit
#define s_3 RB2_bit
#define s_4 RB3_bit
#define R_1 RB4_bit
#define R_2 RB5_bit
#define R_3 RB6_bit
#define R_4 RB7_bit
void condition(){
        if(s_1 == 1){
        delay_ms(100); cnt1++;if(cnt1==2)cnt1=0;
        if(cnt1==1)R_1=1;
        if(cnt1==0)R_1=0;
        }while (s_1 == 1);
        if(s_2 == 1){
        delay_ms(100); cnt2++;if(cnt2==2)cnt2=0;
        if(cnt2==1)R_2=1;
        if(cnt2==0)R_2=0;
        }while (s_2 == 1);
        if(s_3 == 1){
        delay_ms(100); cnt3++;if(cnt3==2)cnt3=0;
        if(cnt3==1)R_3=1;
        if(cnt3==0)R_3=0;
        }while (s_3 == 1);
        if(s_4 == 1){
        delay_ms(100); cnt4++;if(cnt4==2)cnt4=0;
        if(cnt4==1)R_4=1;
        if(cnt4==0)R_4=0;
        }while (s_4 == 1);
        }
void main() {
TRISB=0x0f;portb=0x00;
do{
  condition();
}
while(1);
}
```

4. Result and Discussion

In the course of testing and verifying the performance of this work, various processes were put in place which includes the PCB fabrication continuity testing, soldering and the device testing. The first step of assembling is to produce a printed circuit board. The fabrication part plays an important role as it interconnects all components together. The success of a circuit is also dependent on the PCB. The board is designed using a personal computer. The layout is drawn using the software “ARES PCB layout suite”. The layout is printed on a photo paper using a laser procedure. Then the copper clad sheet is prepared for usage. The printed material is whereby heated to a prepared copper clad.

The etching medium is prepared with the un-hydrous ferric chloride water. The printed board is kept in this solution till the exposed copper dissolves in the solution fully. After that the board is taken out and rinsed in flowing water under a tap. The ink is removed in order to prevent oxidation (15). Finally a standard PCB (with layout as in Figure 13 and 14) is produced.

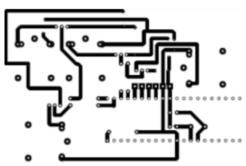

Figure 13: Soldered Side of the PCB (Bottom side)

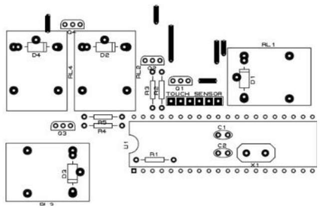

Figure 14: Component side of the PCB (Top side)

The Figure 15 shows the paper work during production in the course of mounting the component on the printed circuit board.

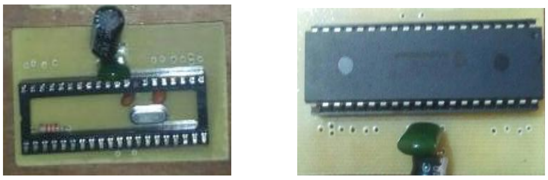

Figure 15: Paper work under construction

Figure 16 illustrates the device operation flowchart.

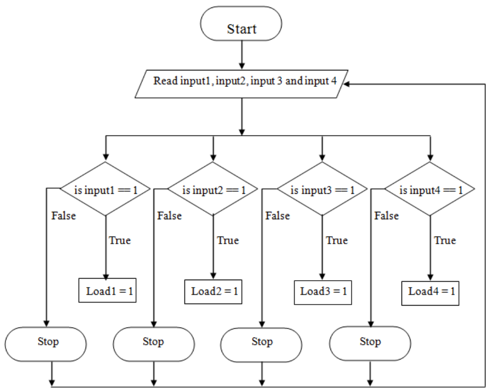

Figure 16: Device operation flowchart

No work can be too superior for upgrade, which make the designed vulnerable to upgrade at any instant. The functionality could be enhanced by incorporating motion sensor to provide luminescence immediately the device is active with face recognition mechanism for unique switching.

5. CONCLUSION

Several electrical devices can be connected to this developed switching device. It is used in various applications because it gives quicker response without arcing. It is very simple. The conductive material connects our body's capacitance directly to the circuit making detection easy while the non-conductive materials separate our body from the circuit to the point where the capacitance may not be detected. The change in capacitance detected by the circuit needed to break some threshold in order to trigger detection depends on the touchpad material used. The capacitance seen by the circuit when touched by a human finger may or may not break that threshold. By touching several surfaces simultaneously or within a pre-defined time, the switching function is activated. This development concerns a multiple touch switch for operating lighting; this is in contrast to the current systems in which only a single button in a multiple switch can be used to turn lights on or off or in which a separate button for each light circuit has to be pressed. This automated switch is easy to operate as it senses touches even at a very slight touch on the sensor hence smart home. This system can be used for switching of different appliance at a time. The developed device can be used both domestic and industrial mechanism.

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