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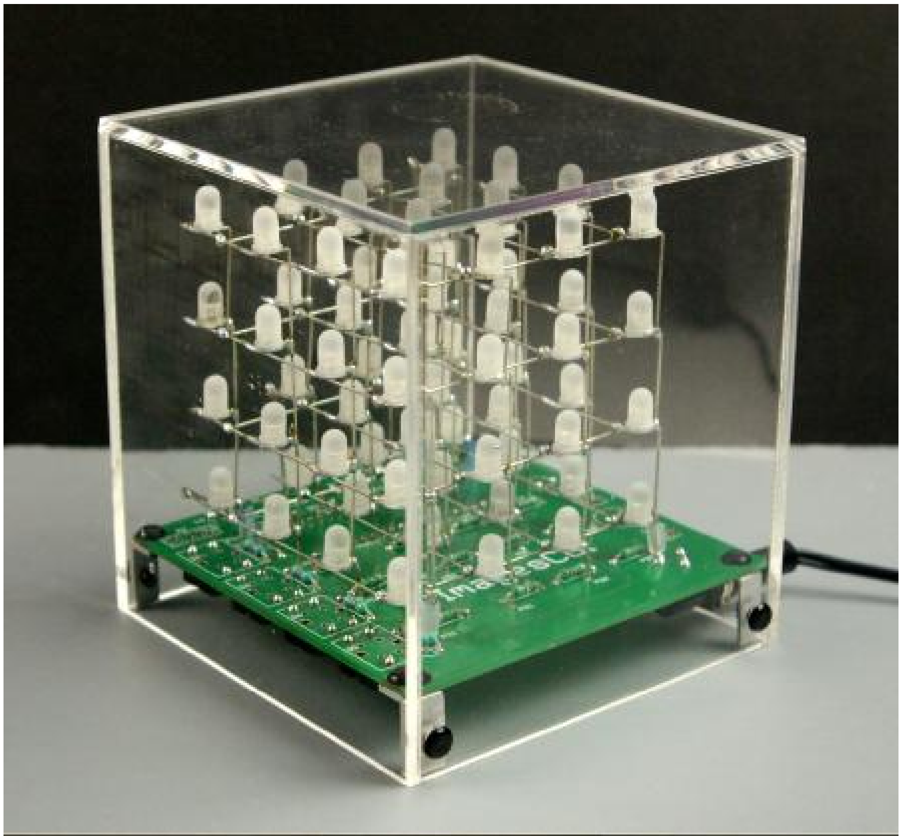
3D LED Cube Matrix



This Manual shows step by step instructions for building Images 3D LED Cube. The LED matrix we decided to use is a 4 x 4 x 4 monochromatic LED Matrix. This is a total of 64 LEDs. The reason we chose this size, is that it provides the best of overall cube size, construction time & easier programming.

The advantage to using mono-chromatic LEDs allows us to use bright LEDs. Bright LEDs in our LED cube are viewable in a well lighted room. Mono-chromatic LEDs from well known manufacturer are cheap and affordable, usage of mono-chromatic LEDs allows easier construction and programming of Cube. While the obvious disadvantage of not using RGB LEDs is that the Cube is only limited to one color. The current crop of RGB LED's don't have the light intensity punch and when used in a 3D LED cube must be viewed in a dark room. If you look at an RGB 3D cube in a well lighted room chances are you can't even tell that it's on. In addition affordable RGB LEDs are four times costlier than the mono-chromatic ones, the usage of RGB LEDs would increase the difficulty level of construction and programming.

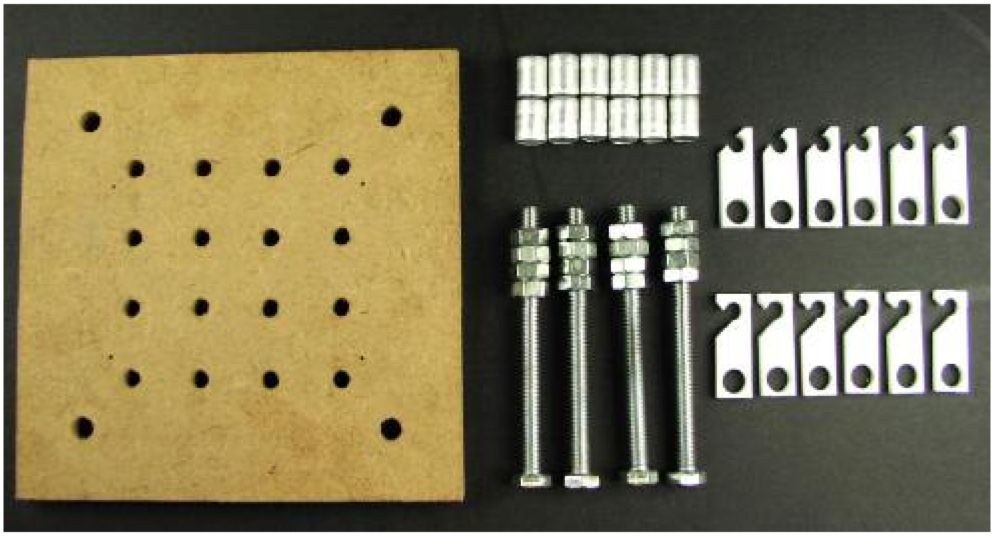
With monochromatic LEDs you have the choice of four mono-chromatic colors blue, red, green and yellow.

The kit is supplied with a preprogrammed microcontroller, that includes 29 pre-programmed patterns that automatically play. Playtime for the 29 patterns is approximately 6-1/2 minutes. However instructions to program the 3D Matrix yourself are provided towards the end of this manual.

LED Cube Construction: Step by Step Guide

To build an accurate 3D LED Cube Matrix with evenly spaced and aligned LEDs we recommend either building or renting a jig, see figure 1. The instructions for using a jig will be provided in this article. If you do not wish to use a jig, you may fabricate the LED Matrix in any manner you find convenient.

The jig contains the following parts: wood base, (4) 1/4-20 bolts, 4 inches in length, (16) 1/4-20 nuts, (12) LED Holders (2-styles), and (12) spacers, see figure 2.



The lead photography shows the optional transparent case enclosing the LED Matrix. Unless you have purchased the transparent case, it is not included in your kit. Visit our website http://www.imagesco.com/led/cube.html for the latest information.

Getting Started: Components & Tools

We will need following tools for building LED Cube using Jig.

1. Soldering Iron and Solder.
2. Nose Pliers
3. Diagonal (Lead) Cutters.
4. 20 gauge solid wire, 1 meter in length.
5. 1 qty - 2AAA Battery Holder.
6. 2 qty AAA Batteries.
7. 1k 1/4 Watt Resistor.

Physical Layout

The LED Cube has 64 LEDs in a 4 x 4 x 4 LED matrix, see figure 3. Four LEDs each across length, width and height. Each of the 4 layers contains 16 LEDs. Physical Dimension of Cube is approximately 2.5" x 2.5" x 2.5", consecutive LEDs are separated by 3/4".

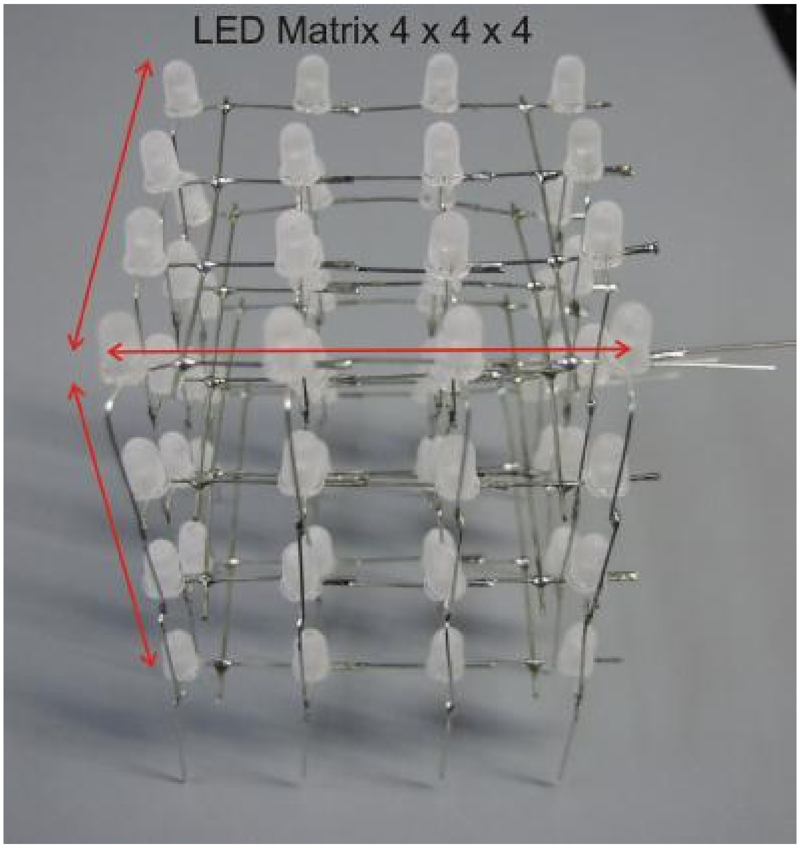


Figure 3

LEDs

LEDs used are 5mm (T1-3/4), round of any color, see figure 4. Rectangular/Oval Shaped LEDs can be used but may be a problem to hold in jig during construction. Diffused LENs mean a wider viewing angle, better for side viewing. LED Leads should be 1” long, leads themselves are used to connect consecutive LEDs which are 0.75 " apart.

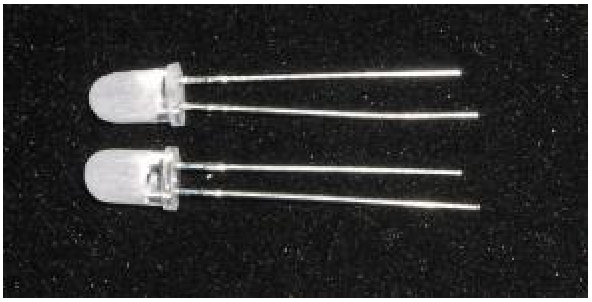


Figure 4

Electrical Connection

The schematic for the 3D LED cube is shown in figure 5. The 3D LED Cube is a 16 x 4 multiplexed display, with 16 common Cathode connections and 4 common Anode connections. Each LED layer has 16 LEDs, with one common Anode. Total of 4 layers means 4 common Anode connections. Each of 4 LEDs in a Physical Vertical Line of Cube (not schematics) has a common Cathode connection. 16 vertical lines means 16 common cathode connections see figure 5.

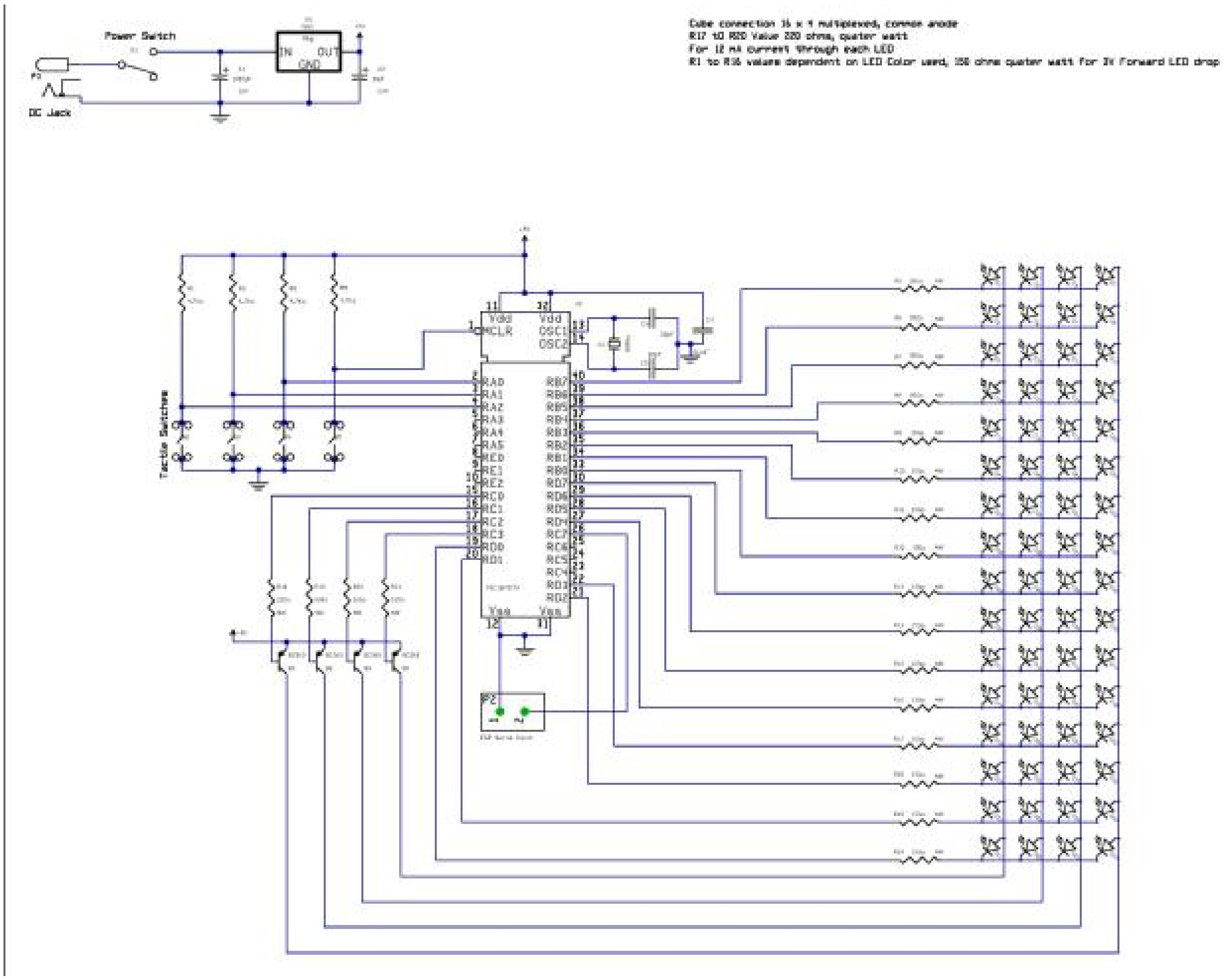


Figure 5

Check LEDs

While the failure rate of new LED's is extremely low, I recommend checking your LEDs before soldering them in 3D Matrix structure. It is very difficult to replace a faulty LED once the matrix is constructed. A simple LED Tester can be made, see figures 6 and figures 7. Take a two battery (AA/AAA) battery holder, solder a 1 K resistor in series with the black lead to limit current to the LEDs. This is shown as –ve terminal and red wire probe is the +ve terminal. Connect +ve to LED's Anode (longer lead) and –ve to LED's Cathode, to test LEDs.

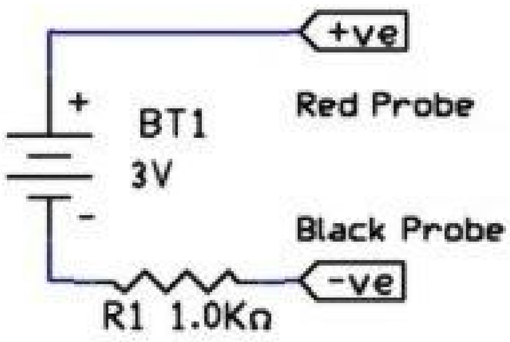


Figure 6

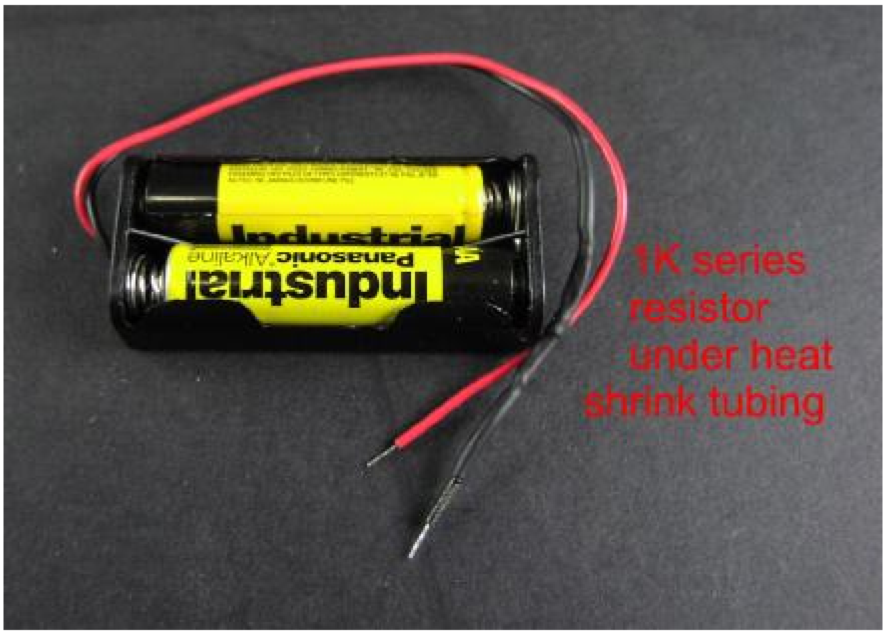


Figure 7

Cube Jig

See the layout of the jig below in figure 8. Jig is made of 6” x 6” , 3/8”-1/2” thick wood. There is a separate construction manual for jig available, if you wish to build jig by yourself.

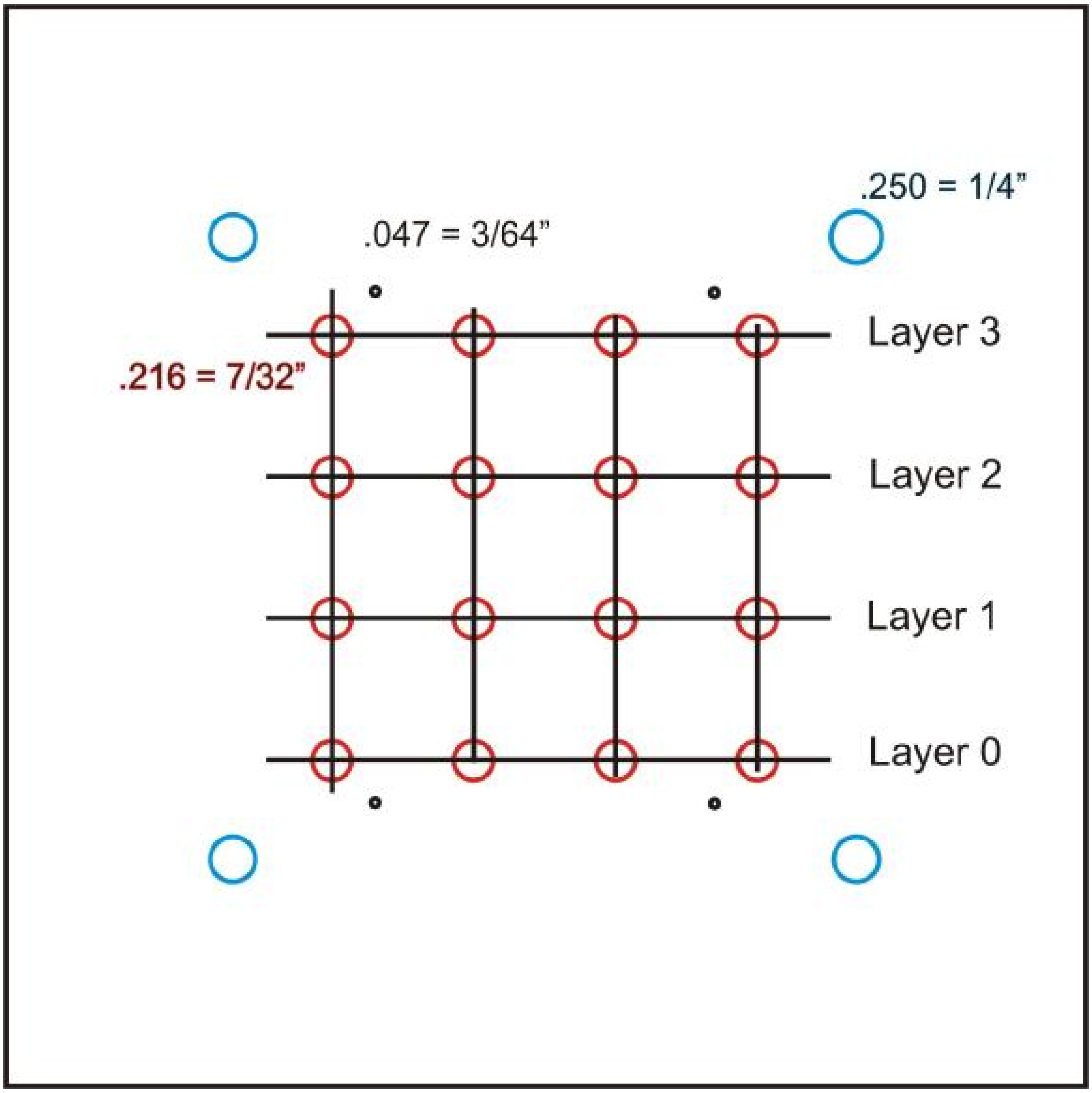


Figure 8

The sixteen red colored circles are holes with 7/32” diameter (drilled using #7 drill bit). LEDs will be inserted upside down into these holes.

The four black circles are holes with .047/3/64” diameter(drilled using #56 drill bit). These holes are used to hold thick tinned wires (about 0.8 mm wire without sleeve) in place.

The sixteen 7/32” holes and four 3/64” holes will be used to make individual layers, while the sixteen 7/32” holes will also aid in constructing cube by joining individual layers.

The four blue circles are holes with 0.25" in diameter(drilled using 1/4” drill bit). These holes hold 1/4 – 20 bolts at required positions. Diameter Numbers for holes in jig should be readable to you if jig is oriented in correct way. Nuts come in standard heights. Depending on the local availability you can get nuts of any height. The jig comes with spacers and nuts and when used achieve a height of 0.75" between layers.

If you do not rent the jig your goal is to stack up 3 to 4 nuts to achieve height of 2 cm (0.75”). The four 1/4" holes hold bolts, see figure 9, to which the LED holders attach to hold the layers one above the other at accurate positions. This is not as complicated as it sounds, the pictures will explain. Bolts are a minimum of 4 in long**.**

Figure 10 is the picture of jig base. Also note that this is the correct orientation of jig while construction.

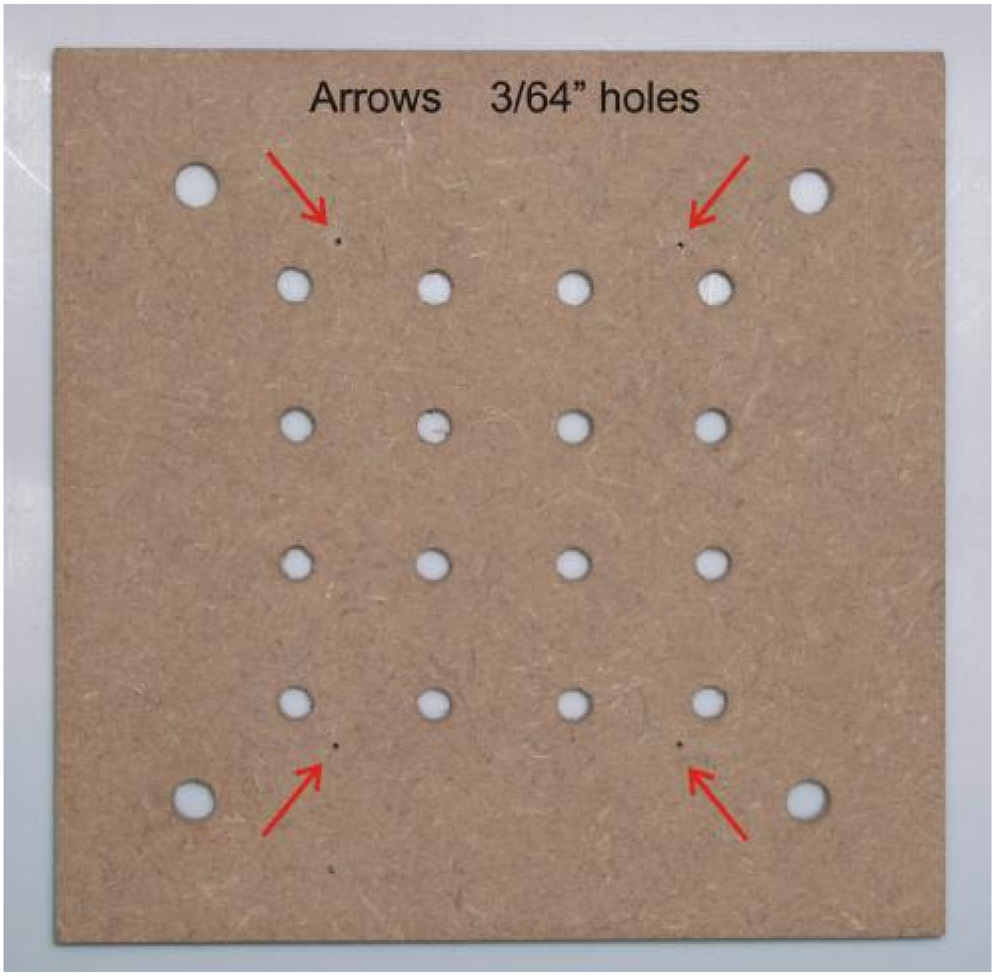


Figure 10

LED Layer holders & Tube Spacers

These holders are included with the jig and are used to hold layers at their required position above one another. We need total of 12 holders, divided into two groups of 6. Both groups have minor differences. See the figure 11 for strip designs.

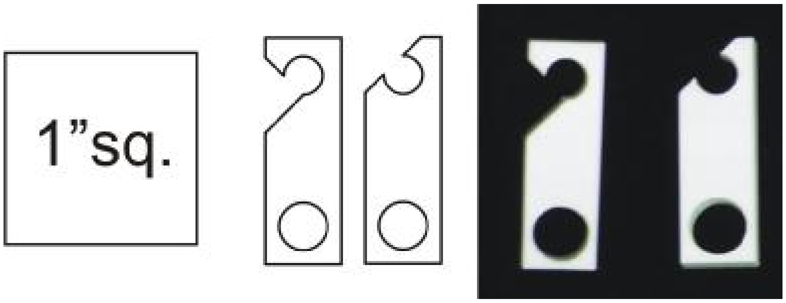


Figure 11

To make these strips use the above layout. Glue layout on 16 gauge sheet metal. Cut the sheet metal along the borderlines with tin snips. Then use a hole-punch to mark the centers where the cross lines intersect and drill holes with required drill bits. The hole in the LED Holders are 17/64” as opposed to 1/4” in the Jig base. This slight increase in this hole allows for adjustments in jig when positioning the LED layers. I THE holders provided with the jig are made from 1/8" acrylic.

Tube Spacers are used to maintain required height of 3/4" between two layers. These spacers are made from 3/8” OD hollow aluminum tubes, having height around 0.5”.

Jig Construction manual shows how to make jig base, LED holders & tube spacers.

Figure 12 shows the 12 holders and 12 spacers.

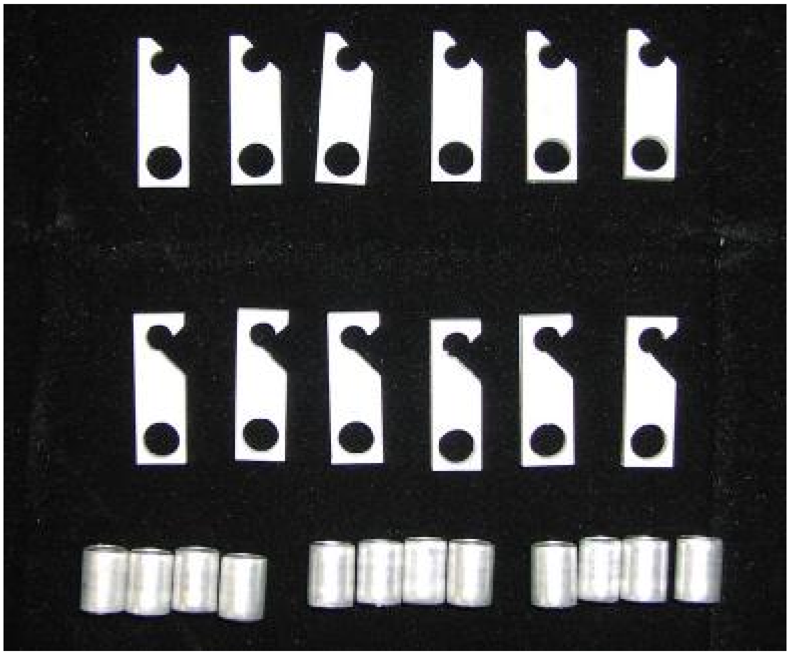


Figure 12

Tin Copper Wires

We will need 2 pieces of 20 AWG tin wire, 3.25" in length per layer, total of 8 wires for the entire LED cube construction, see figure 13. If you are using wire from a reel, cut to length and it should be straightened for proper and easy soldering. Try straightening the wires as much as possible by hand. Then put the wires on firm surface (eg. Desk), and use the Jig base to roll over the wires, with some pressure. This will straighten them out perfectly.

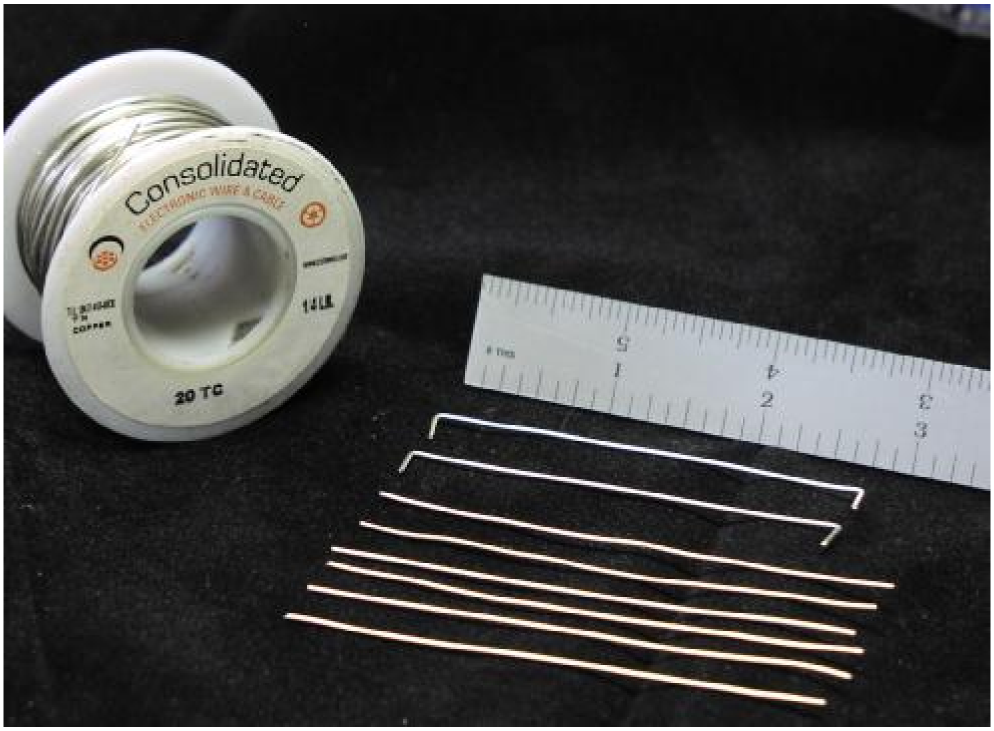


Figure 13

Tin Wire Forming

Orient the jig in correct direction as per Figure 10 . Each of the 8 tin wire pieces needs to be formed into “C” shape for accurate and easy soldering. There are 4 small 3/64" Holes drilled into jig, with correct orientation, a pair of them will be in a vertical lines perpendicular to you. Take a tin wire piece and make a 90 degree bend at 0.25" from one end. Insert 0.25" bent portion in one of the 3/64" holes and align wire with the other 3/64" hole along the vertical line. Hold the wire over the second hole with Nose Pliers, lift bent end from previous hole and make a 90 degree bend at the position where the Nose Pliers holds the wire. This will give the C shape to the Wire. Repeat the process for rest of the 8 wire pieces. Figure 14 shows the jig with two tin wires preset in the 3/64" holes, ready to start accepting LEDs.

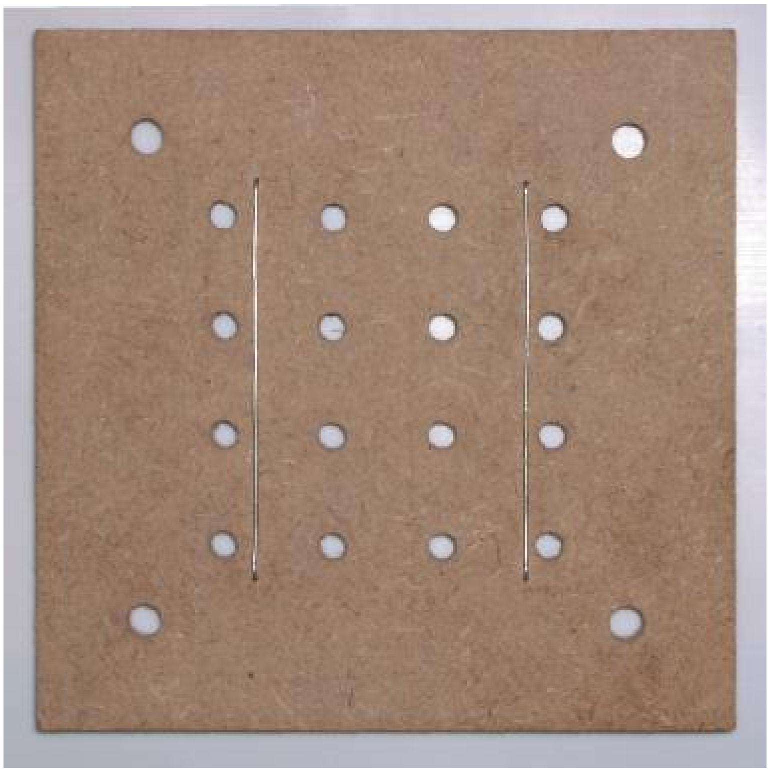


Figure 14

LED Leads Forming

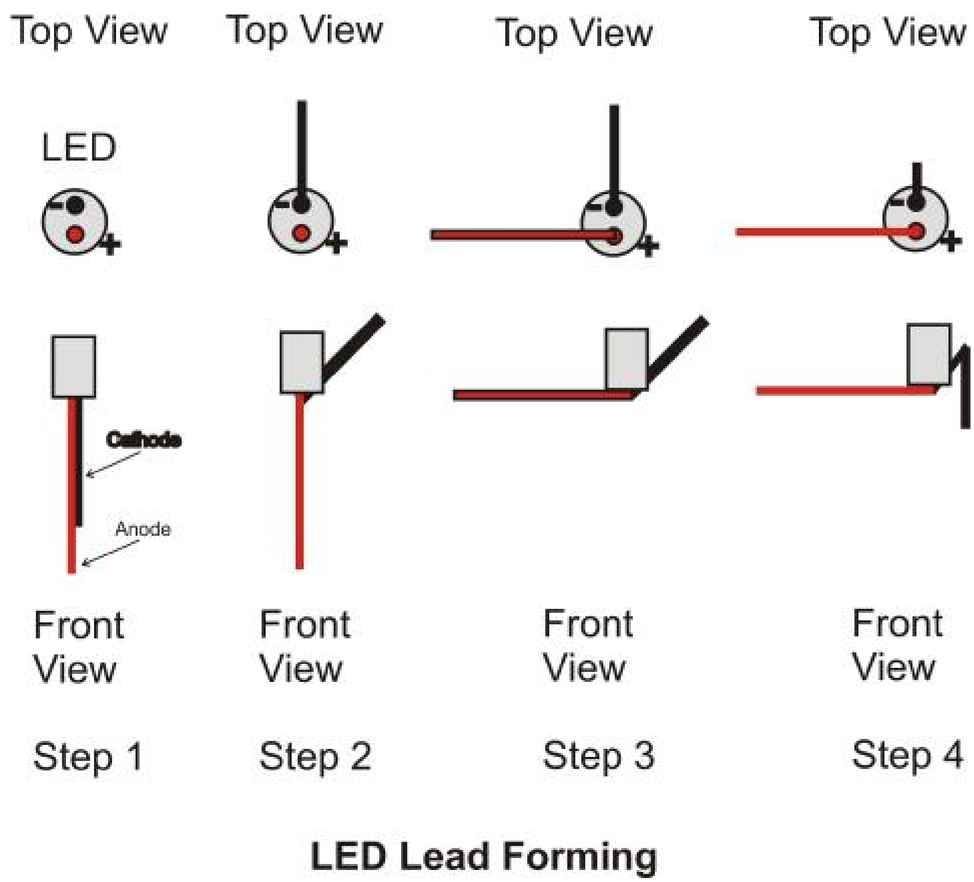


Figure 15

We are going to use LED leads to help solder LED's in each layer. The most important step is bending the LED leads properly. Figure 15 is a graphic that provides an overview of the four steps. The longer lead of the LED is the anode and is colored red. The shorter lead is the cathode, shown as black. All 64 LEDs leads will be formed in the following manner. Let's proceed in a step by step manner.

Step 1, hold the LED in your hand so that anode and cathode leads are along a line perpendicular to you see figure 16.

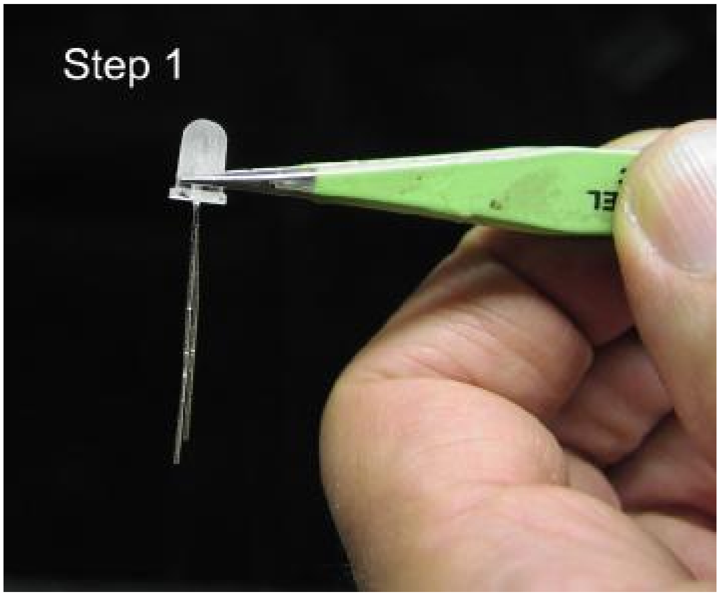


Figure 16

The anode should be closer to you while the Cathode should face outwards. From the base of cathode lead, bend the lead outwards by 90 degrees, along the line perpendicular to you, see figure 17.

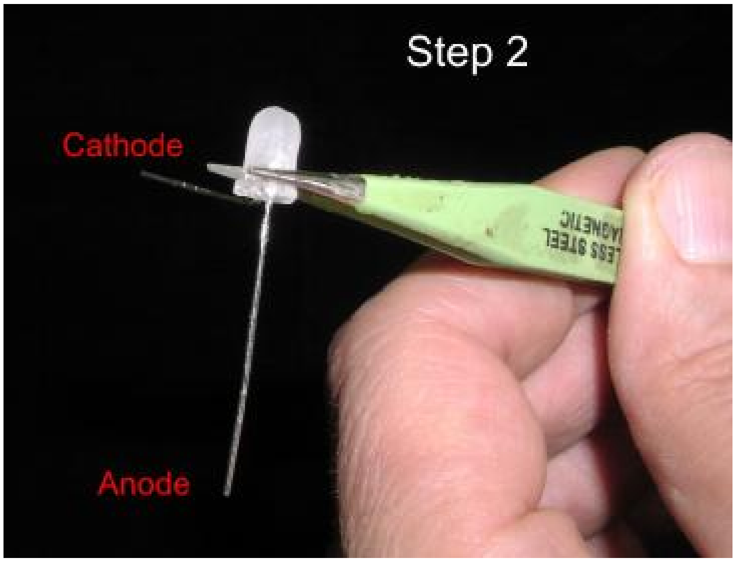


Figure 17

Next bend the anode lead from its base by 90 degrees to the left, along a line parallel to you, see figure 18. Holding the leads from the middle portion is an efficient way of bending them. Now the anode and cathode leads are perpendicular to each other.

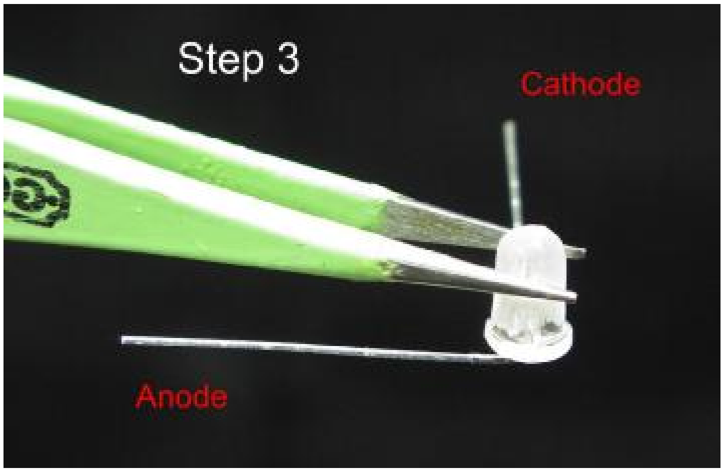


Figure 18

Now hold the bent Cathode Lead 0.25" from its base using needle nose pliers and make a **90** degree downward bend where the Nose Pliers are holding the Cathode Lead, see figure 19.

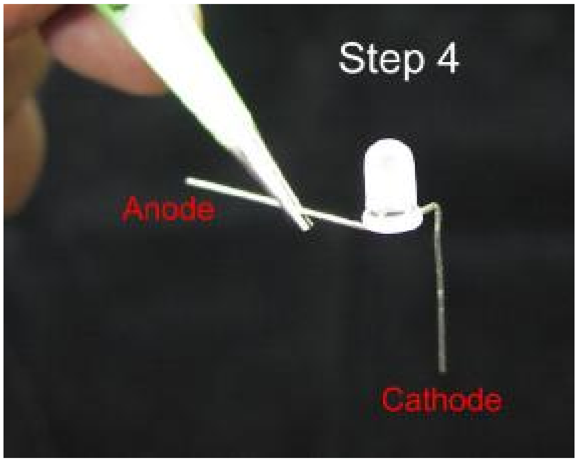


Figure 19

After bending the 64 LEDs in the above manner, we are ready to begin building the LED cube layers.

Making Individual Layers

Orient Jig, so that the 3/64" holes are on the top and bottom of the jig facing you, as shown in figure 10. Each layer is made of 16 LEDs.

Put two C shaped tin wires in place along the four 3/64" holes, see figure 20. The small bent sections of each tin wire should go inside 3/64" holes,

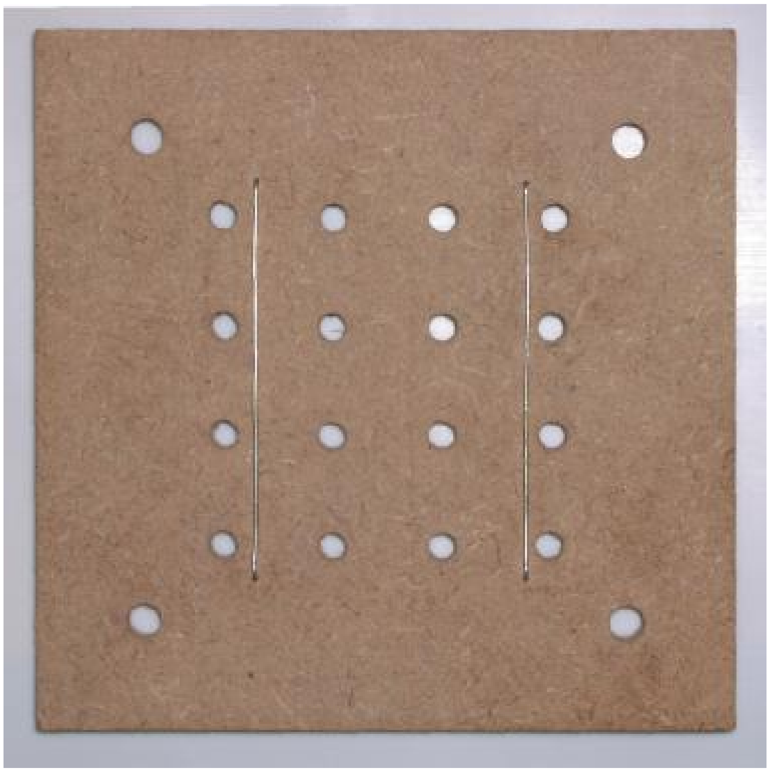


Figure 20

Insert bent LEDs upside down into top right corner 7/32" hole, see figure 21. LED should be oriented such that bent Anode Lead (which rests parallel with Jig surface) is along the horizontal line parallel to you.

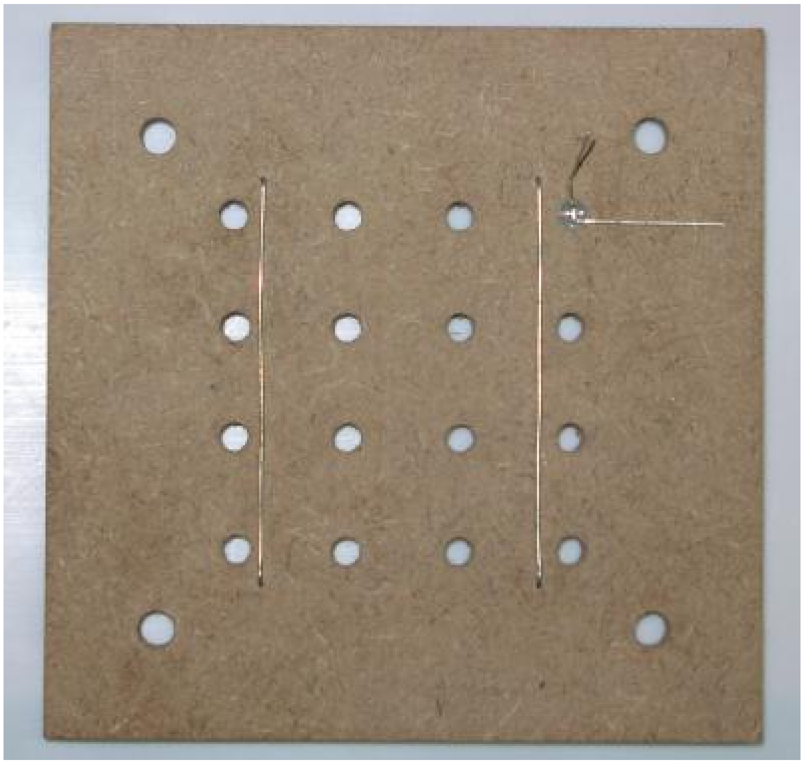


Figure 21

Insert second LED into the hole to the left of the previous one using the same orientation. Repeat this process for rest of the LEDs. When all 16 LEDs are inserted (for each row of 4 LEDs), their bent Anode leads should overlap some and form a horizontal line.

The LEDs are soldered together at the overlaps as shown in Figure 22.

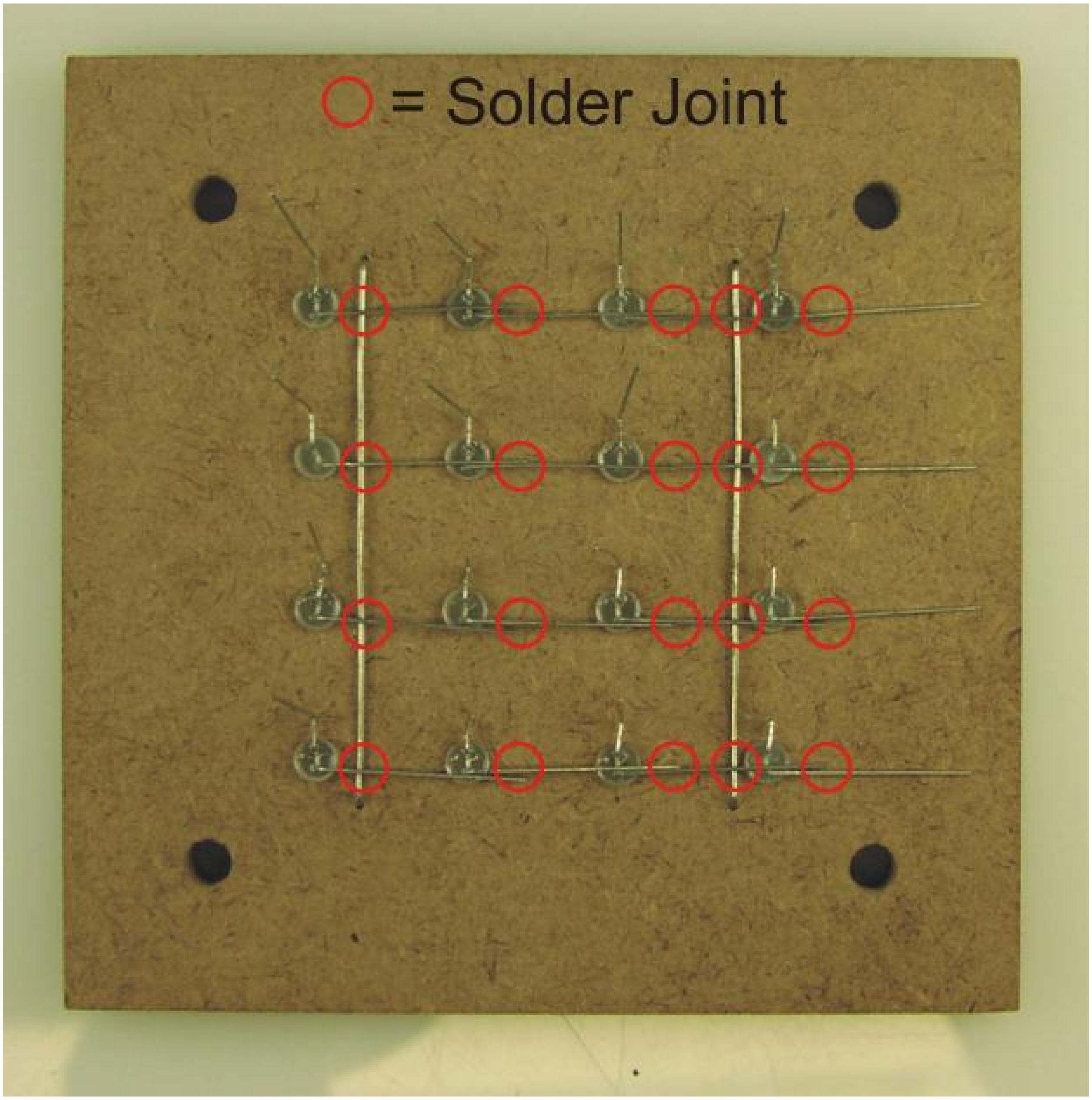


Figure 22

Solder the overlapping Anode portions, a total of 12 solder joints. Solder LED Leads quickly since longer contact period between the Solder Iron and LED Leads could damage the LED.

Also remember to solder the 8 solder joints where the two tin wires overlap the four Horizontal Anode Lead Lines. When you are finished the LED layer may be removed from the Jig, by gently pulling the upwardly bent Cathode leads, as shown in figure 23.

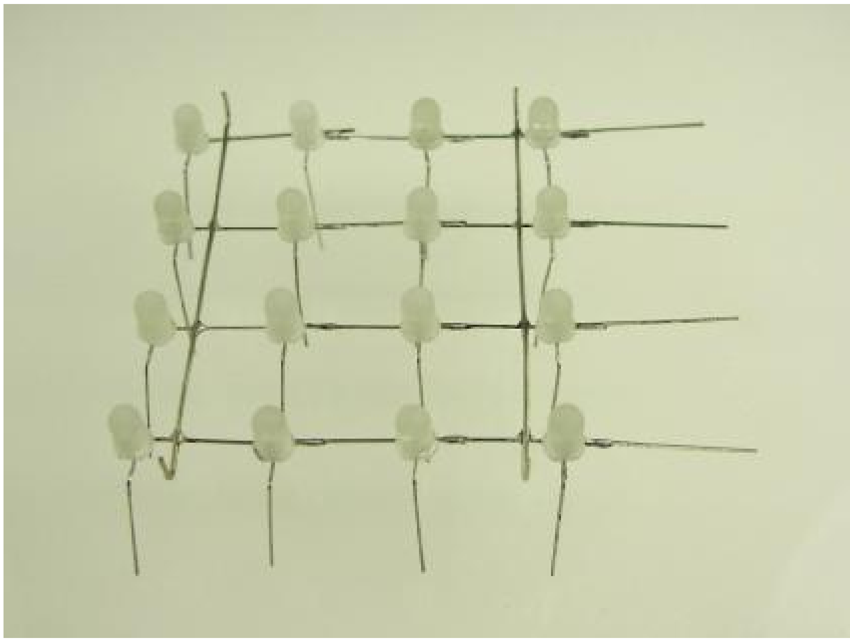


Figure 23

Cut off the extra portion of tin wire that went into the 3/64" holes, see figure 24.

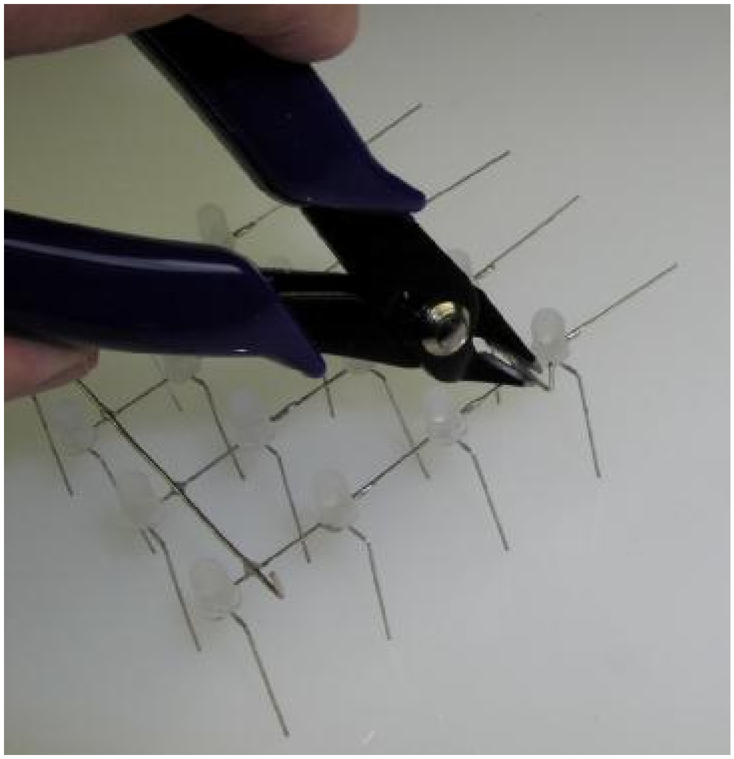


Figure 24

At this point you can use the LED tester to test LEDs in the completed layer. To do so, touch the positive terminal to the uncut Common Anode Lead on the right and negative terminal to upwardly bent cathodes one by one.

Continue building three more layers and testing each of them in the same manner as described. Figure 25 shows a completed LED layer removed from jig.

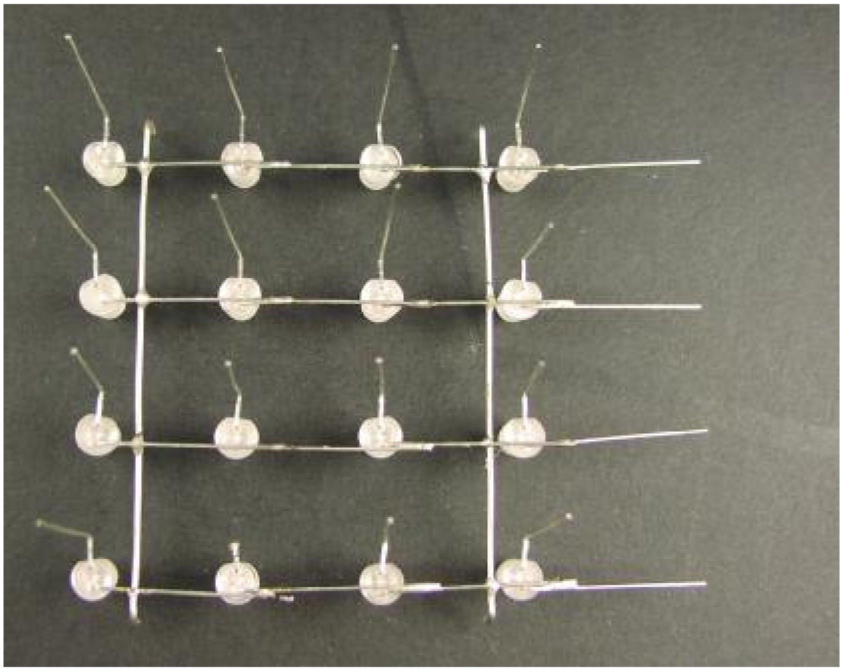


Figure 25

Notice in figure 25, on the right hand side of the layer we have four extended anode leads. Each layer only needs one extended anode lead, rest of them should be removed. Each layer differs from another in terms of position of uncut Common Anode Layer Lead and that is how we will be referring to the different layers from now onwards. Arrows in figure 26 indicate uncut common anode layer leads.

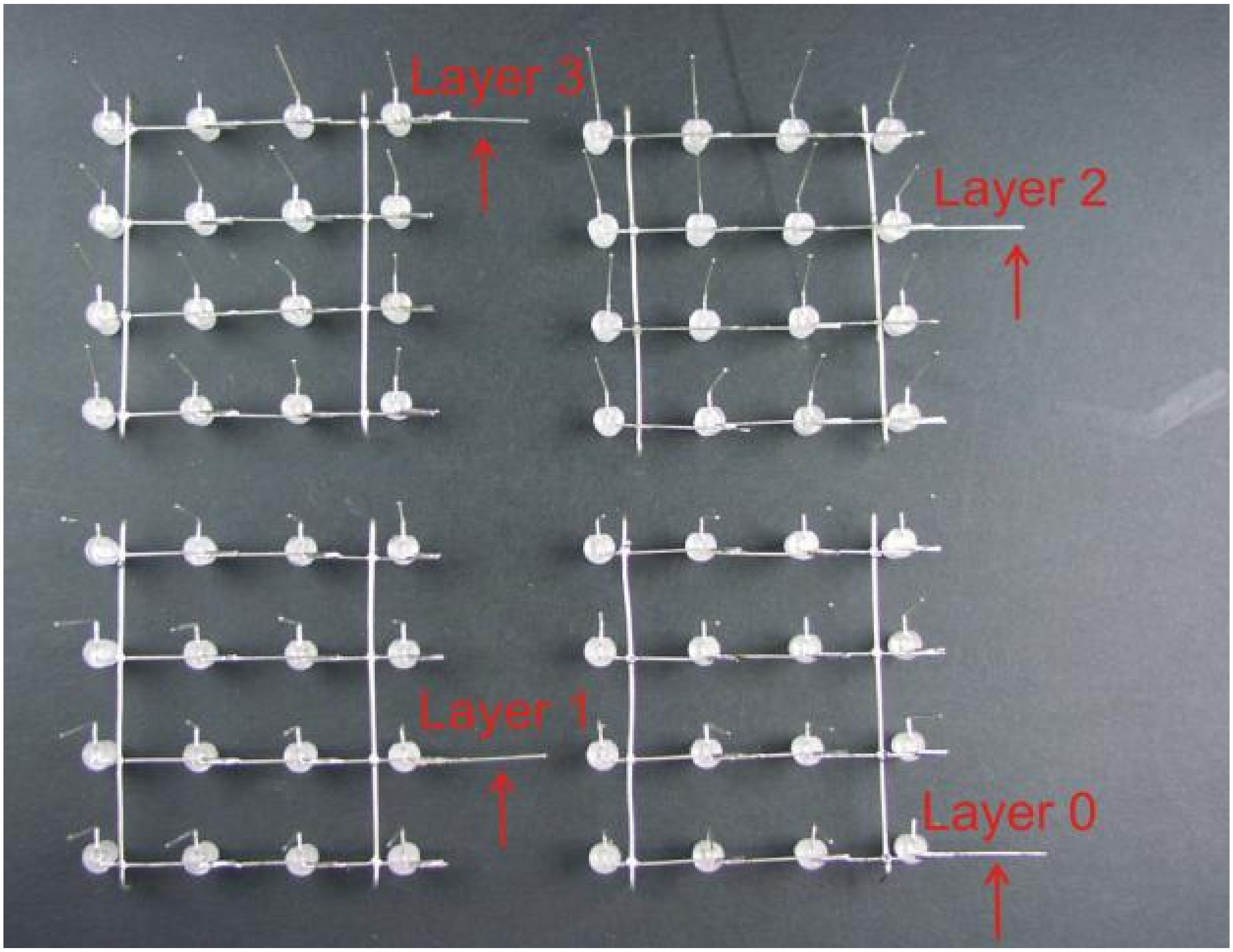


Figure 26

Soldering Layers to form Cube

Insert 4 bolts into the 4 corner 1/4 holes. Secure each bolt to jig using nut.

Place LED Layer 0 in the jig holes. Pay attention to which side is the side with the extended anode lead.

Go to each bolt. On top of the existing nut place a spacer, then on top of the spacer, place a LED layer holder, then on top of the LED holders another 1/4-20 nut to secure everything down.

Secure Layer 1 into the LED holders, keep the extended anode leads on the same side as of Layer 0, see figure 27.

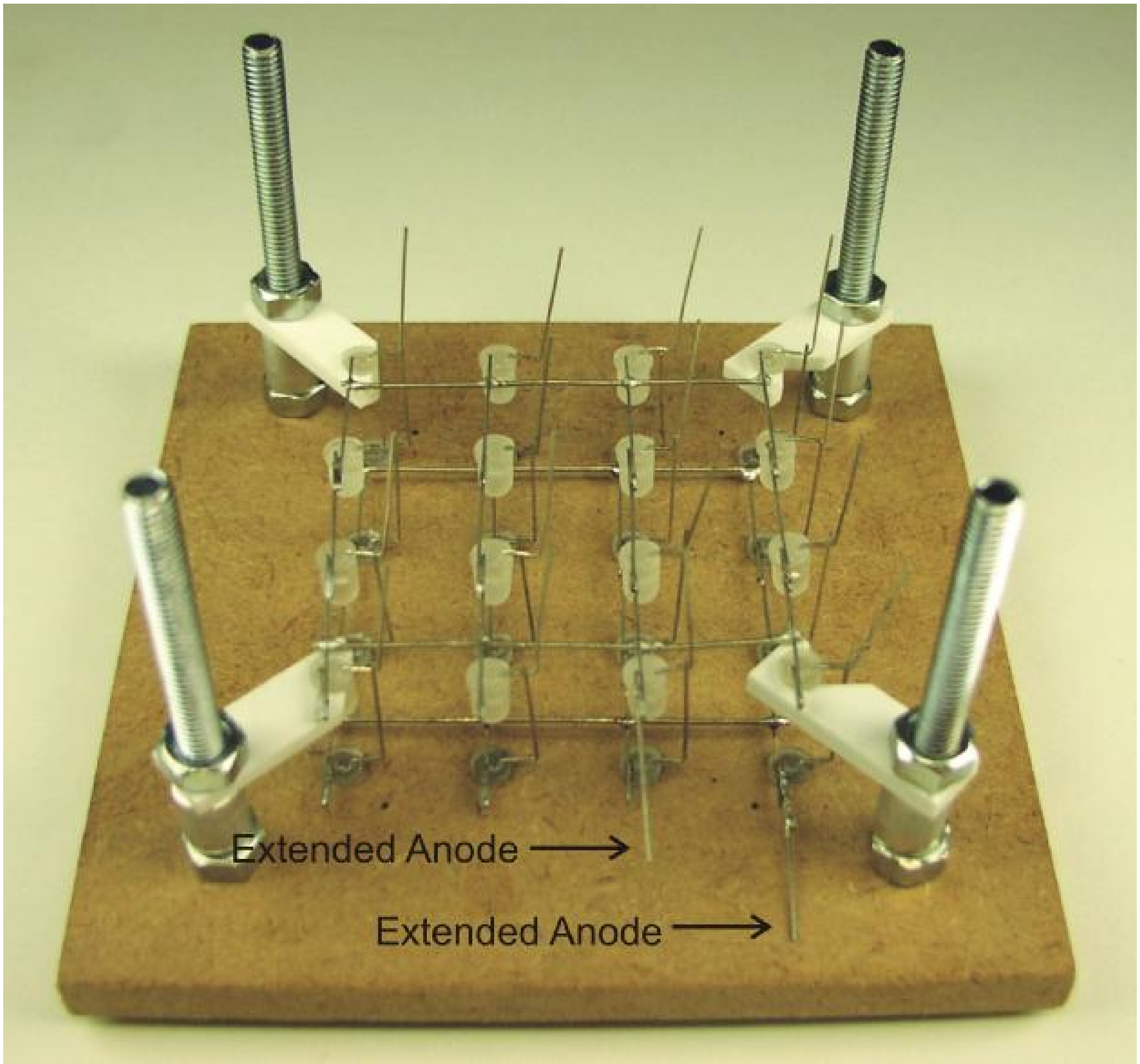


Figure 27

The bent cathode leads of the LEDs layers should overlap. If the cathode leads don’t touch each other, use narrow tweezers to bend cathode leads so they are in contact with previous layers LED. Solder the overlapping cathode leads, a total of 16 cathode solder joints, per layer as shown in figure 28. The red circles highlight the vertical cathode solder joints for layers 0 and l.

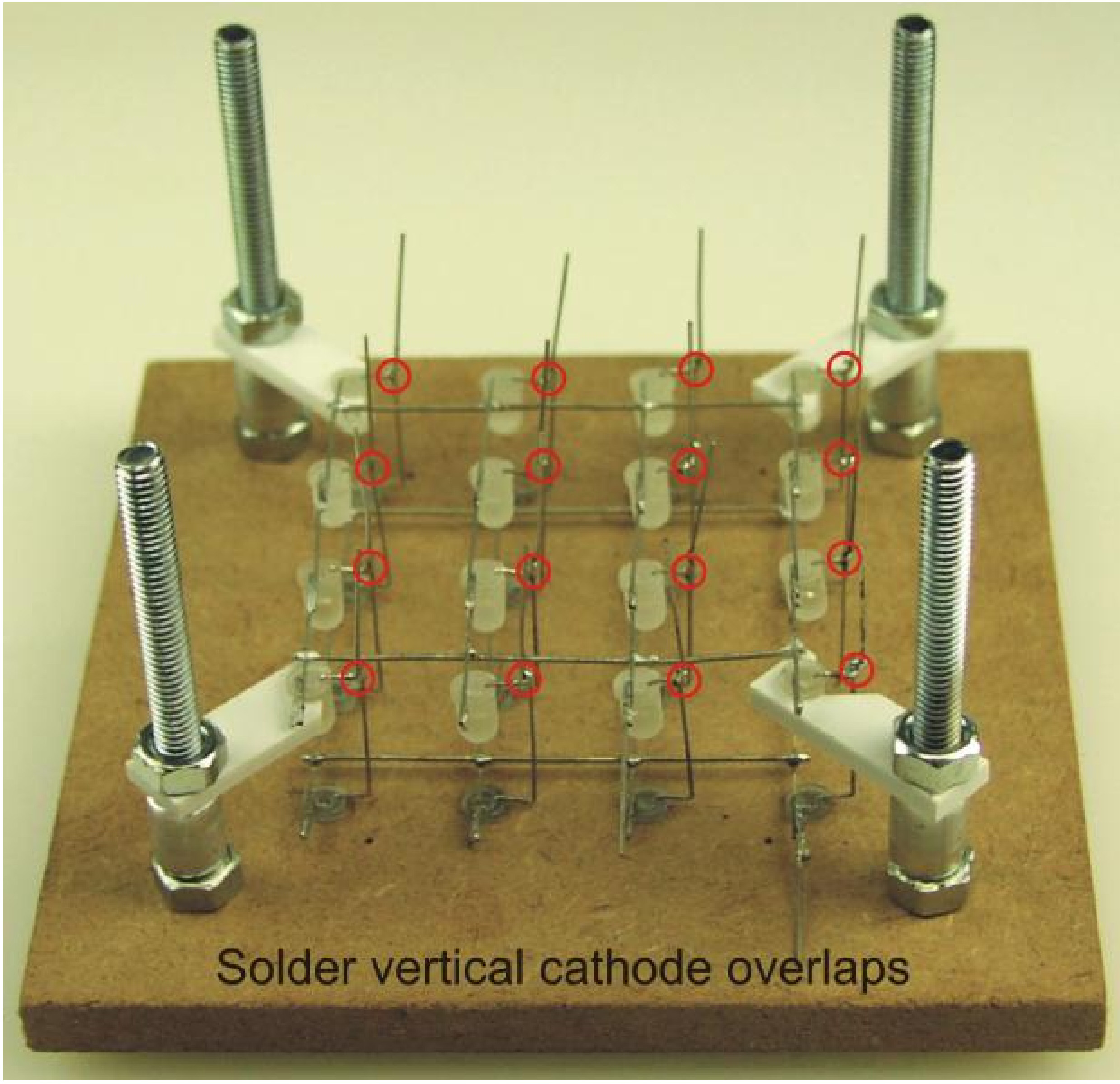


Figure 28

Place Layer 2 with 4 Corner LEDs into 4 corner holes LED holders, as shown in figure 29. Solder vertical cathode leads as before.

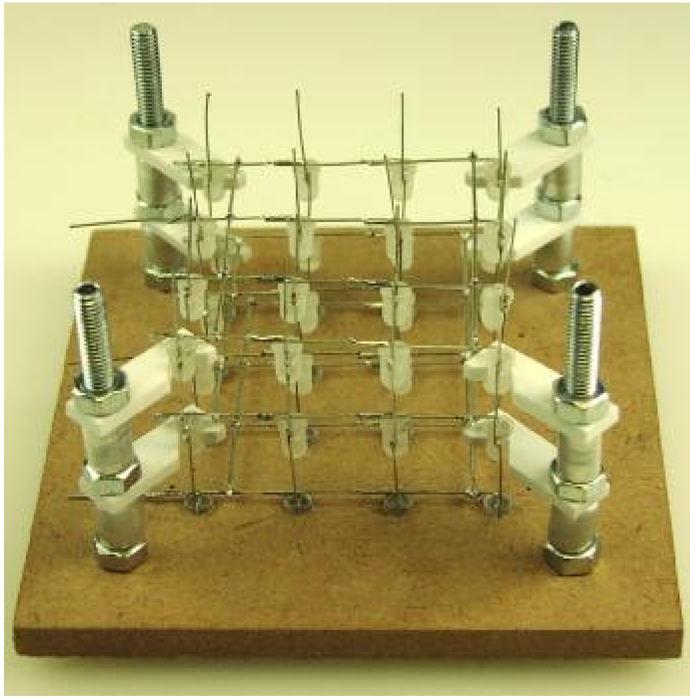


Figure 29

Place Layer 3 with 4 Corner LEDs into 4 corner holes LED holders, as shown in figure 30. Solder vertical cathode leads as before. Notice how the extended anode leads are position on one side of the 3D LED matrix. The 4 extended common anode layer leads, one for each layer, end up in staircase manner (arrows). This is important when we solder the matrix to the pc board.

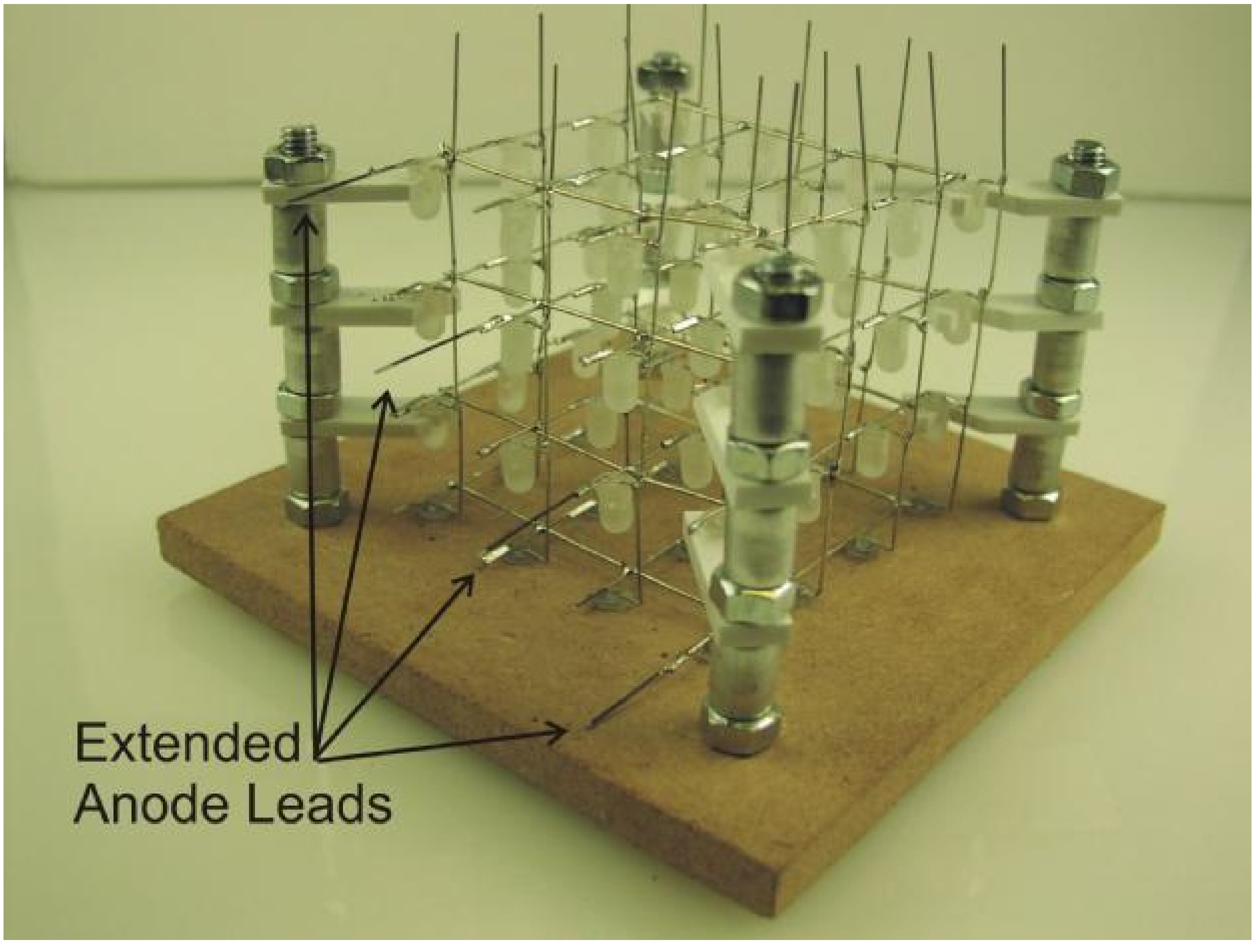


Figure 30

You can use the LED Tester to test LEDs before mounting the 3D LED matrix to the PCB. Unscrew all the nuts, and remove spacers and LED holders before you can get the LED matrix cube out of the jig. You 3D matrix should look like figure 3.

Cube PCB Construction

We are going to mount components on both sides of the pcb. The LED pcb is shown in figure 31. The side with the text “Images Co” is the top side of the pcb.

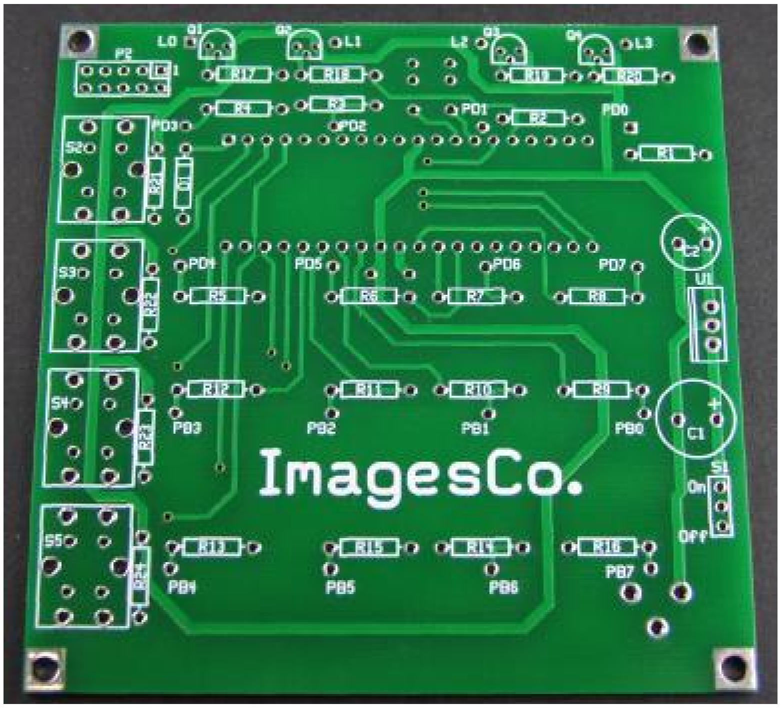


Figure 31

Mount and solder the components as described. Depending upon which color cube you purchase the resistors R1, R2-R4 and R5-R16, will be of different values. For the RED cube these resistor values are 220 ohms. For the YELLOW and GREEN Cubes these resistor values are 180 ohms and for the BLUE cube these resistor values are 150 ohms.

On top side of PCB

1. Mount Resistors R1 **(150/180/220 ohms)**, R5 – R16 **(150/180/220 ohms),** R21 – 24 **(4.7K ohms)**, D1 **(Tin Wire Jumper in its place)** on Top side.
2. Mount Resistors R2 **–** R4 **(150/180/220 ohms)**,

See figure 32:

Figure 32

On bottom side of PCB:

3. Mount and solder: R17 – R20 (220 ohms), and Crystal X1 (16 MHz).
4. DIP 40 Pin Socket on Bottom Side.
5. Capacitors C3, C4 (22 pf).
6. Capacitor C5 (0.1 uF) .
7. Mount Transistors Q1 – Q4 (BC 369) on Bottom Side. Flat side of transistor faces intowards the PCB. Curve / Arc of TO-92 transistor package faces outward from the PCB.

See close up of transistors figure 33.

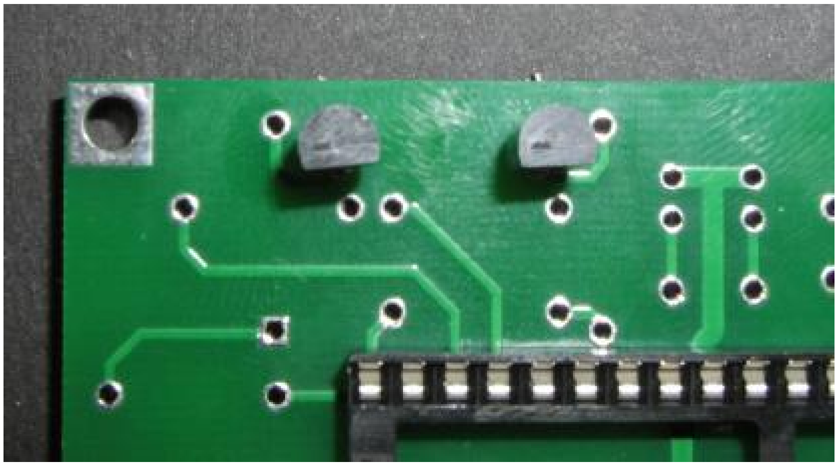


Figure 33

8. Mount Tactile Switches S2 – S5 on Bottom Side.

9. Mount Slide SPDT Switch S1 on Bottom Side. Footprint is smaller than Switch Lead Pitch, so you will have to bend the outer Leads slightly inwards using a Nose Pliers.

10. Mount Electrolytic Capacitor C2 (4.7uF/ 50V).

11. Mount Electrolytic Capacitor C1(1000uF/ 16V).

12. Mount Regulator U1(7805) on Bottom Side. Bend the Regulator inwards from the Bottom Side fully so that it touches the PCB. Cut extra unwanted Leads from the Top side, and then Solder Leads from Top side.

13. P2 10 Pin Header is optional and doesn't require to be mounted**. P1 DC Barrel Jack should be soldered after LED Matrix is mounted on Top Side.**

See figure 34

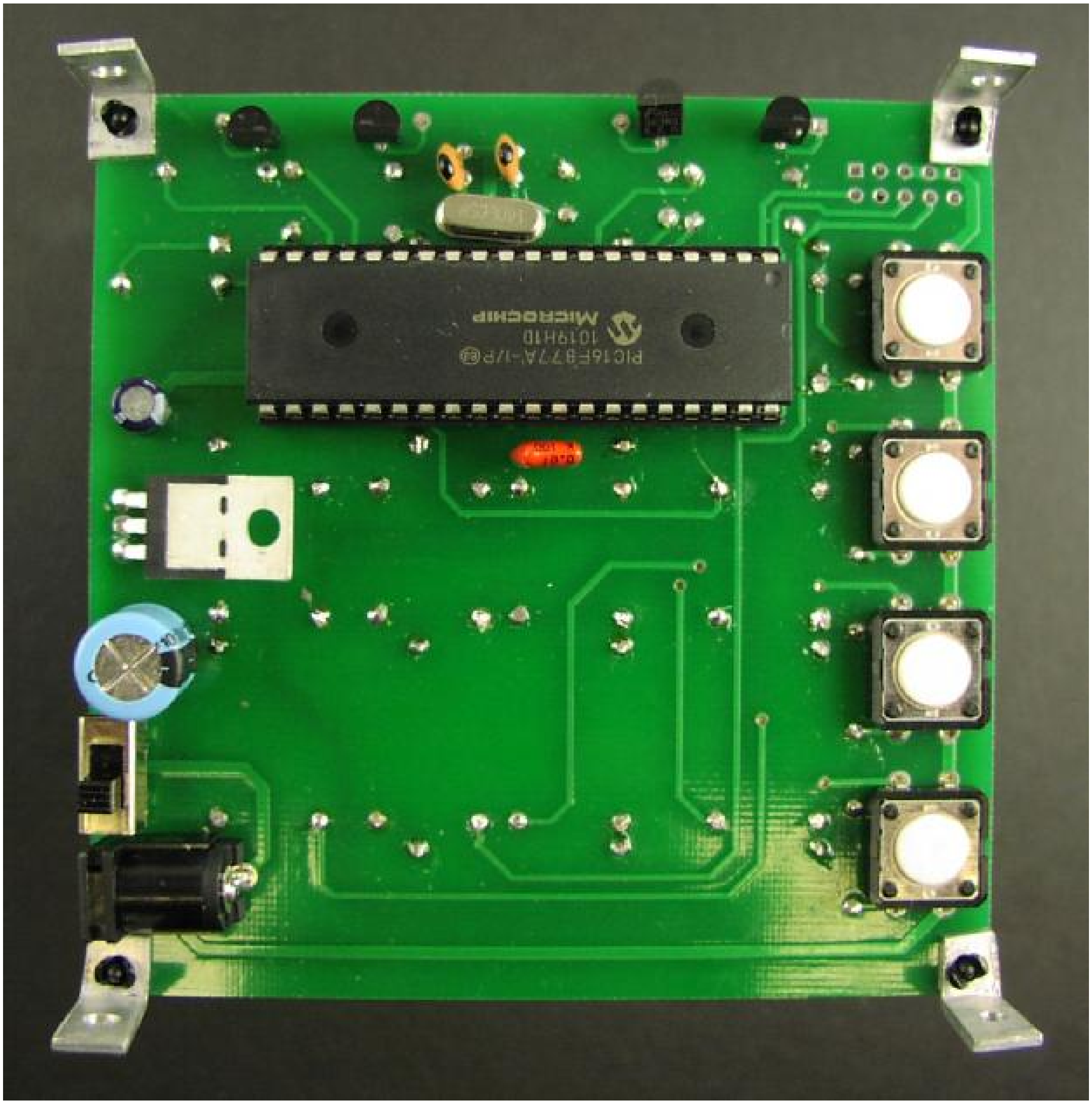
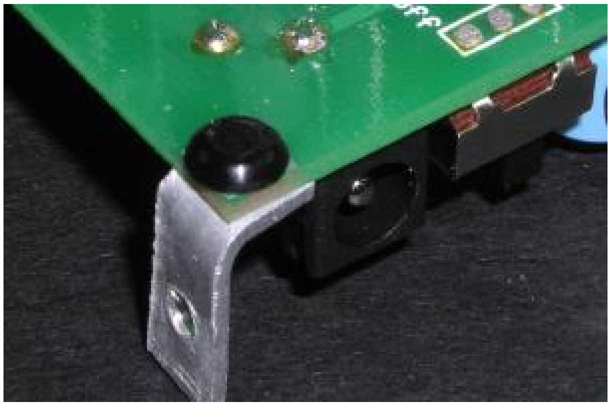


Figure 34

14. Insert Programmed PIC16F877A in 40 PIN DIP Socket with correct polarity on bottom side of PCB.

15. Mount the 4 L Brackets on the bottom side of the PCB with 4 small Snap Rivets. With Correct Orientation of L Bracket as shown in figure 35, align the hole on **small** arm of L bracket to that of the Mounting hole on bottom side of the PCB. Place the small Pop

Rivet from the topside into the mounting hole and press it until the rivet head touches the PCB. This will secure the L bracket into its place. See Figure 35.



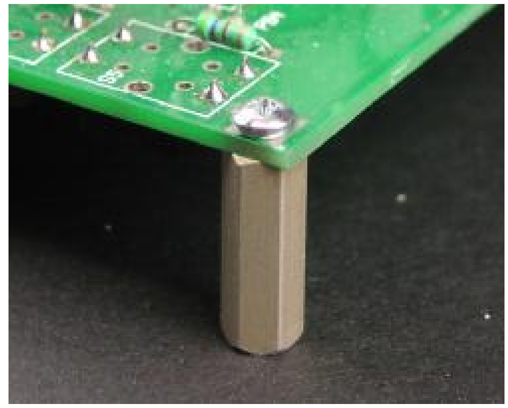


Figure 35　　*** Alternative with Hex feet spacers**

*** For those who did not purchase transparent case, you will be supplied with hex spacers to be used as feet instead of "L" brackets. Also note "L" brackets themselves will be changed to small wood blocks in future kits.**

Soldering Cube to PCB

Place the LED Cube on the Top side of PCB with correct orientation as shown in picture below. Uncut common layer anode leads should be facing the side of the board where the transistors are mounted. See figure 36. (The edge of PCB with 4 Pads named L0, L1, L2, L3.)

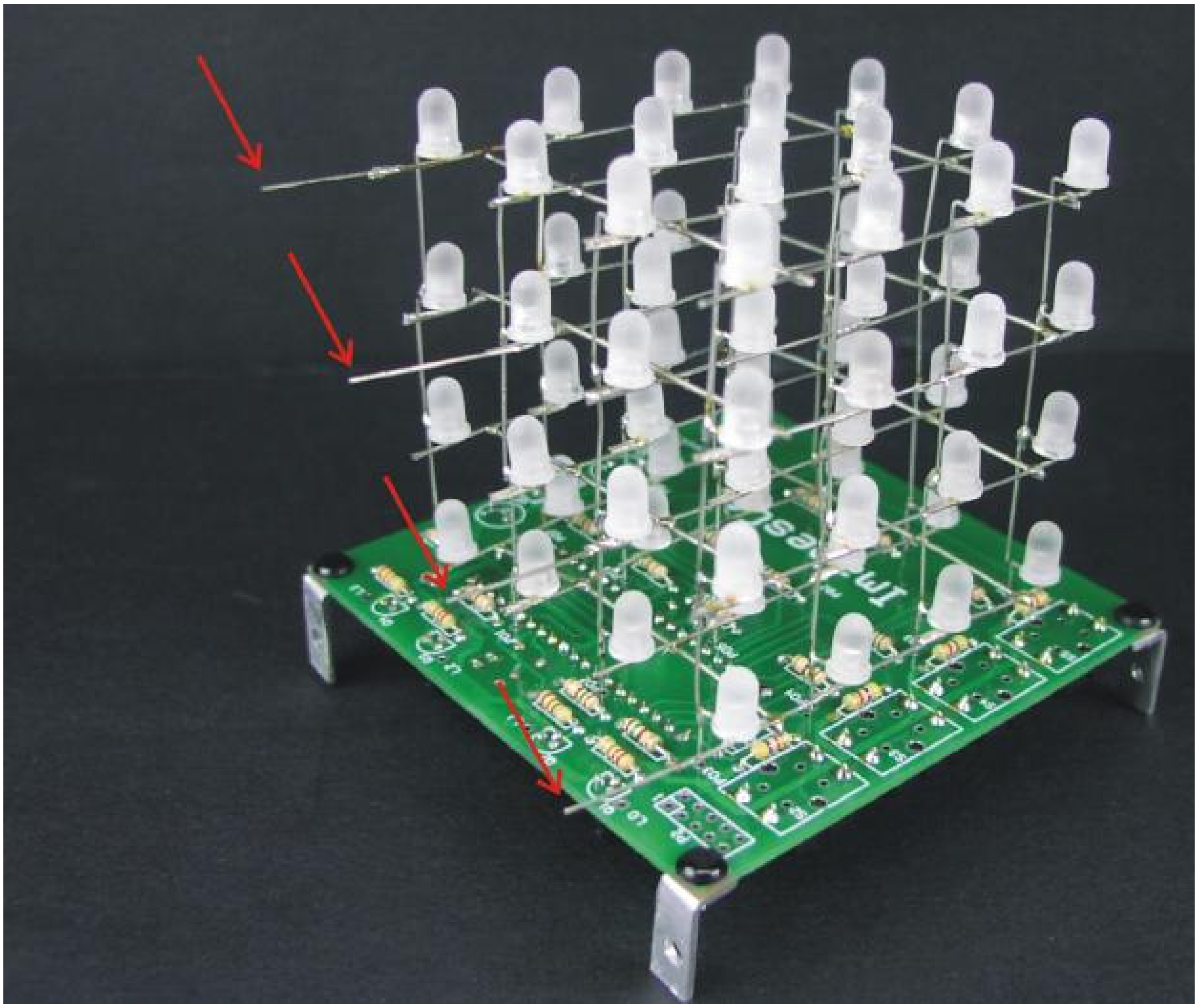


Figure 36

Now there will 16 pads named PD0 to PD7 and PB0 to PB7 for connection of common cathode lines. The 16 Common Cathode Leads of the Cube should be inserted into these pads, using narrow tweezers. It would be helpful to tilt the cube a little and then insert the leads row by row (each row of 4 common cathode leads). See close up in figure 37.

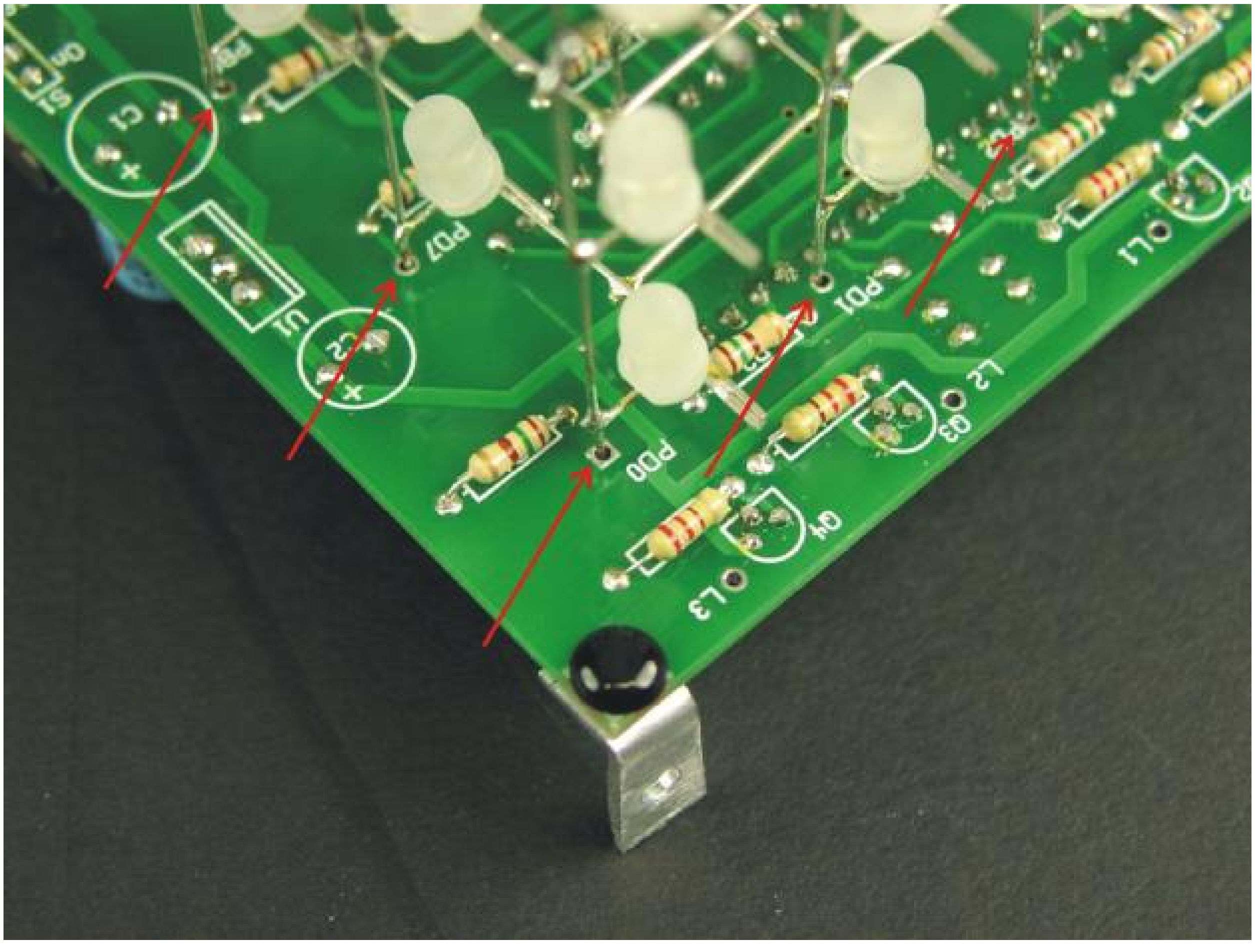


Figure 37

Try to keep a distance of 1/2" between the PCB and the LEDs to avoid unwanted short circuits between cube connections and PCB pads. Make sure the Cube is symmetrically placed on the PCB. Now, **with the exception of the Pins PB7, PD2 and PD1**, the Common Cathode Leads will be soldered on the bottom side.

To Solder Common Cathode Pins on the bottom of PCB, you will need to turn the cube upside down, see figure 38. There will be weight on delicate cube by PCB and yours (when soldering), handle things with care, do not to exert too much pressure while soldering or cube may get deformed.

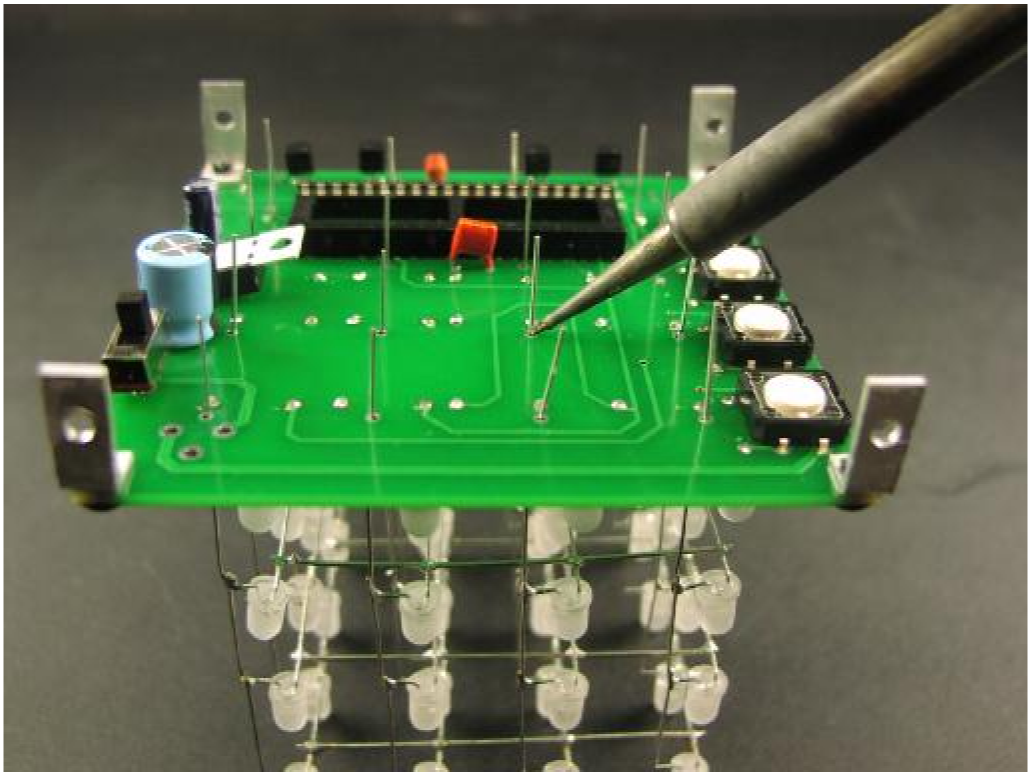


Figure 38

Trim the excess wire from the soldered common cathode leads, leaving a tiny portion from the roots and then solder the pins Cut PB7, flush to the PCB, and the PD1 & PD2 leads as short as you can, don’t solder these leads..

Place the P1 DC Barrel Jack on the bottom side. Since PB7 pin overlaps the P1 Jack, it is necessary that PB7 pin is cut flush to the PCB, or else the Jack won’t sit flush to the PCB.

Turn the PCB upside down and solder P1 Jack, PB7, PD1 and PD2 leads from top side of the PCB.

Now the 4 common layer anode leads (uncut staircase type leads, figure 36 again) need to be joined to their corresponding pads (L0, L1, L2, L3) on the PCB. Use straightened tin wire pieces to make the connections. The common anode to bottom Layer 0 is connected to pad L0. The layer above this Layer 1 common anode is connected to pad L1. The common anode to Layer 2 is connected to pcb pad L2. And finally the top Layer 3 common anode lead should be connected to pcb pad L3. Next trim the extended anode leads to the solder joint, see figure 39.

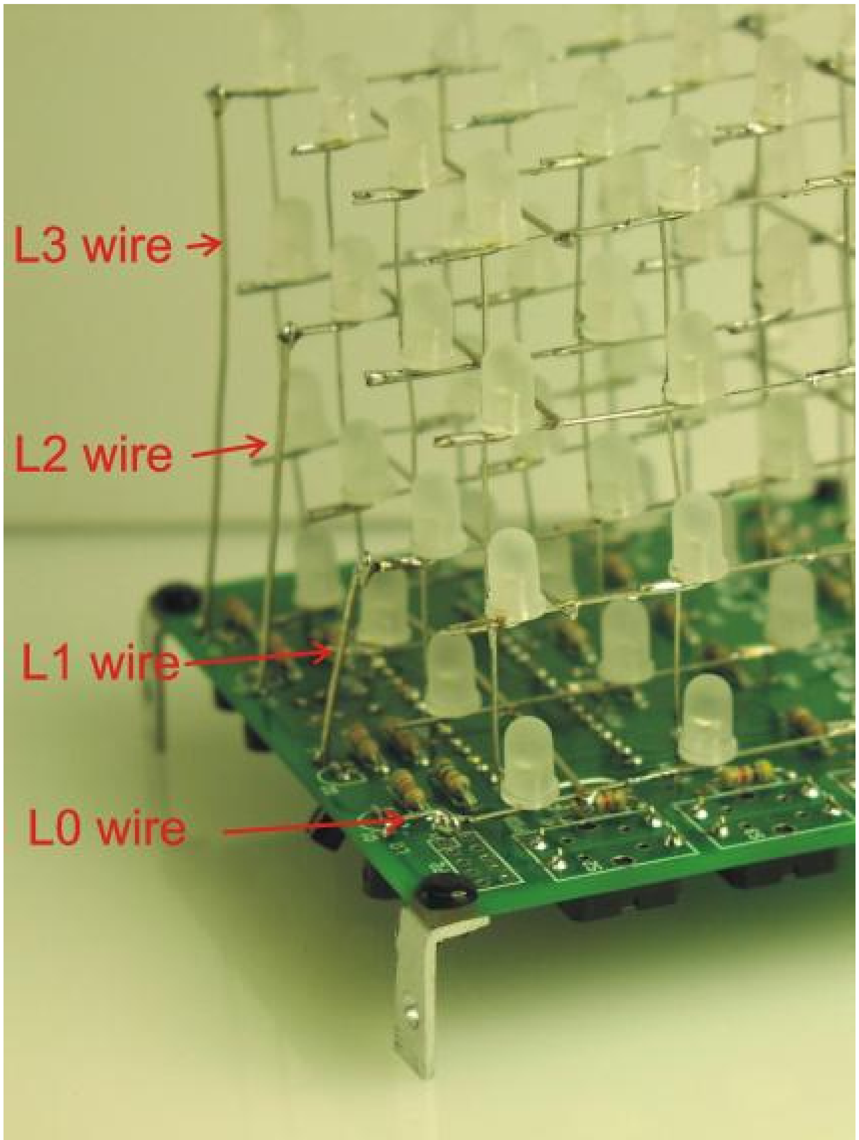


Figure 39

Close up figure of anode connection wires going into pcb pads, see figure 40.

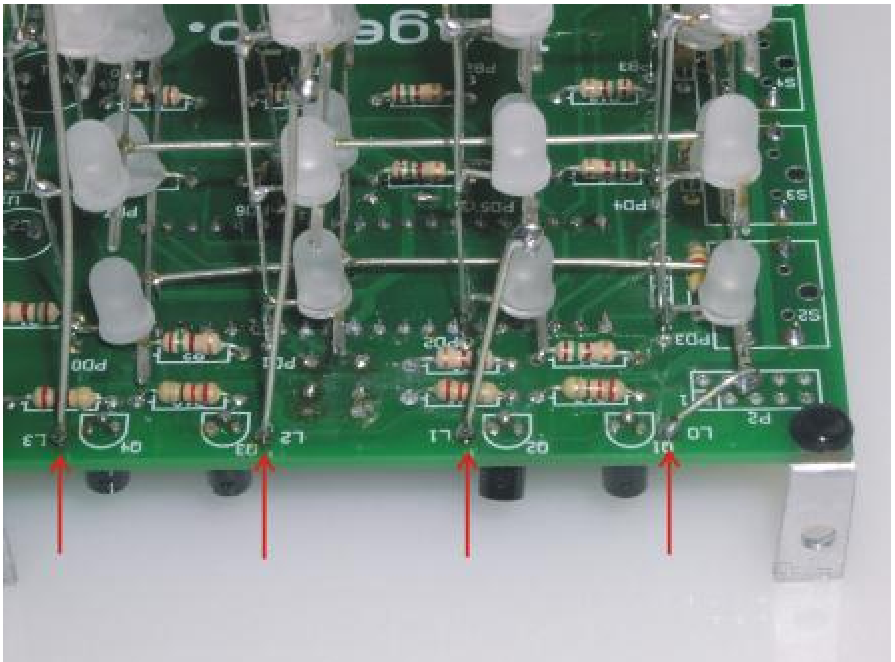


Figure 40

Transparent Case Mounting

There is an optional transparent case available for the LED cube. The case may be purchased assembled or in a kit for you to assemble, see figure 41. The instructions for the case assembly are provided in separate manual so I will not repeat them here. The holes in the transparent case line up with the holes for L Brackets and DC Jack on the lower end.

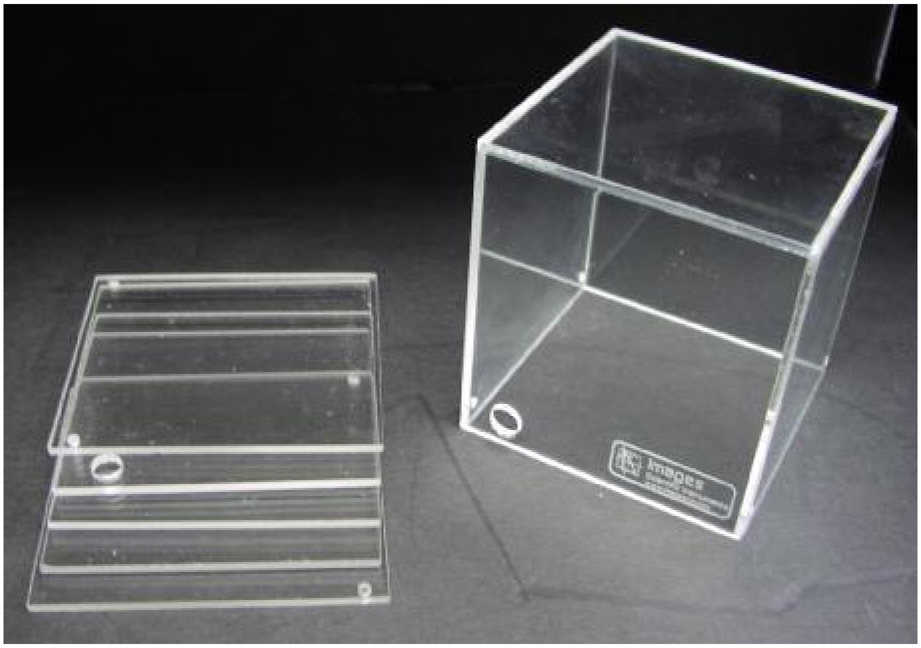


Figure 41

Slide the Case onto the Cube (with PCB) with correct orientation so that holes for L Brackets and DC Jack match with those on PCB. Insert large pop rivets from outside of the case into the holes on Case that matches with L Bracket Long Arm Hole.

Operation

Insert the DC Female Jack into the Male Socket (make sure about correct polarity, voltage/current ratings of DC adaptor), see figure 42. Slide the Switch S1 to On position by lifting the cube. On powered on, cube will blink all the LEDs five times before beginning to display other patterns in the demo mode. Once all patterns have been run, process will start again.

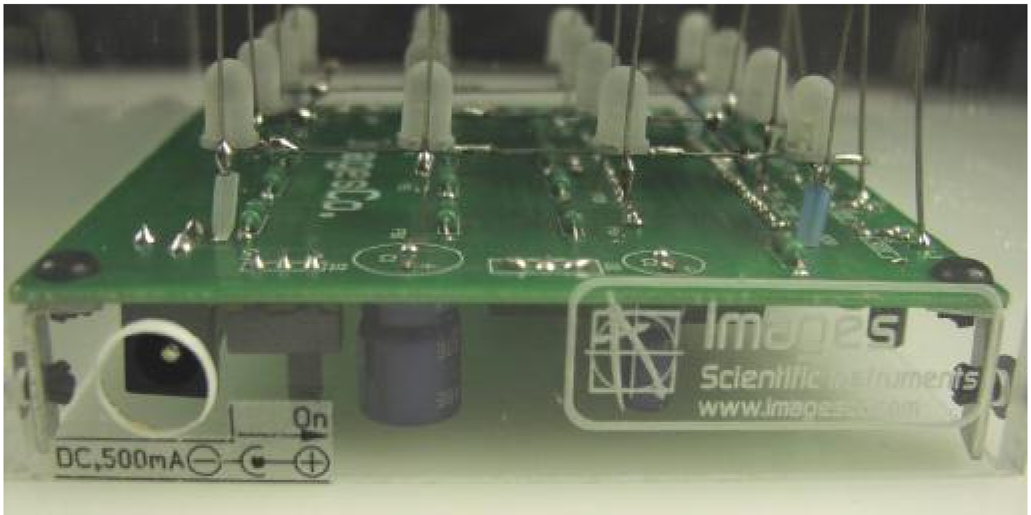


Figure 42

Push Button Controls.

There are 4 Pushbutton switches S2 to S5 for various functions. These buttons can be accessed by lifting the cube (switches mounted on bottom side of PCB), see figure 43.

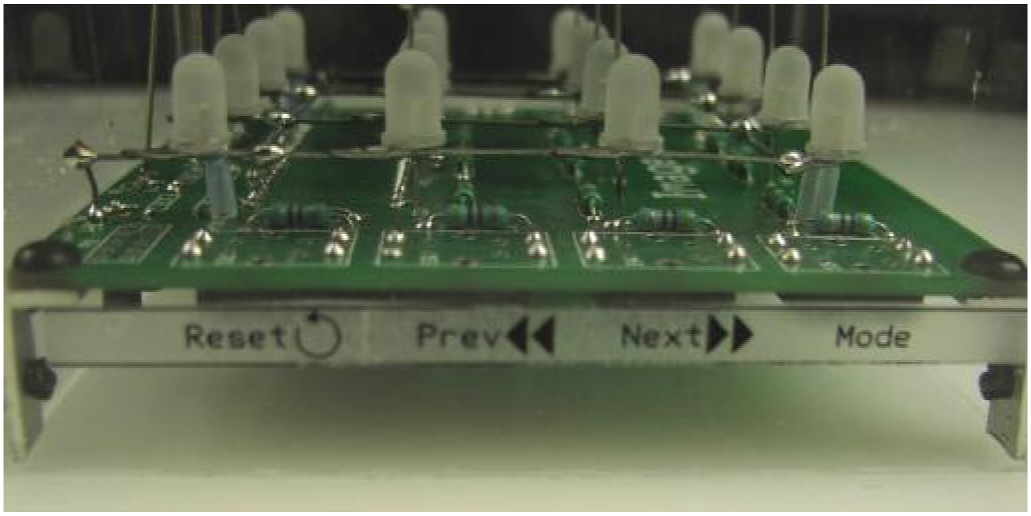


Figure 43

S2 switch is for reset.

S5 switch is mode switch. Pressing it will toggle between demo mode and user mode. In demo mode all pre programmed patterns will run in predefined order one after another. In user mode a single pattern will run over and over again.

S3 and S4 act as previous / next (cycle) pattern switches in user mode for selecting a particular pattern. These switches have no effect in demo mode.

DIY 3D LED Cube Programming

If you are not satisfied with the canned patterns provided in the PIC microcontroller you may want to try your hand at programming the LED cube yourself.

Programming the LED Cube is not very difficult, but takes some thought. Look at figure 44. Here's how our LED's are wired inside the cube. We have common anode lines for each of the four layers. Each physical vertical column (1-16), consists of four vertical LEDs tied to a common cathode. We turn on and off individual LED's by bringing the I/O lines of the PIC high or low. We control the current to the common anode lines using four I/O lines (RC0-RC3) connected to four power transistors. Bringing this line low, will turn on the transistor allowing current to flow into the common anode line to the LEDs. The individual LEDs are controlled by the I/O lines on PortB and PortD. Bringing a Port I/O line low will turn on that LED.

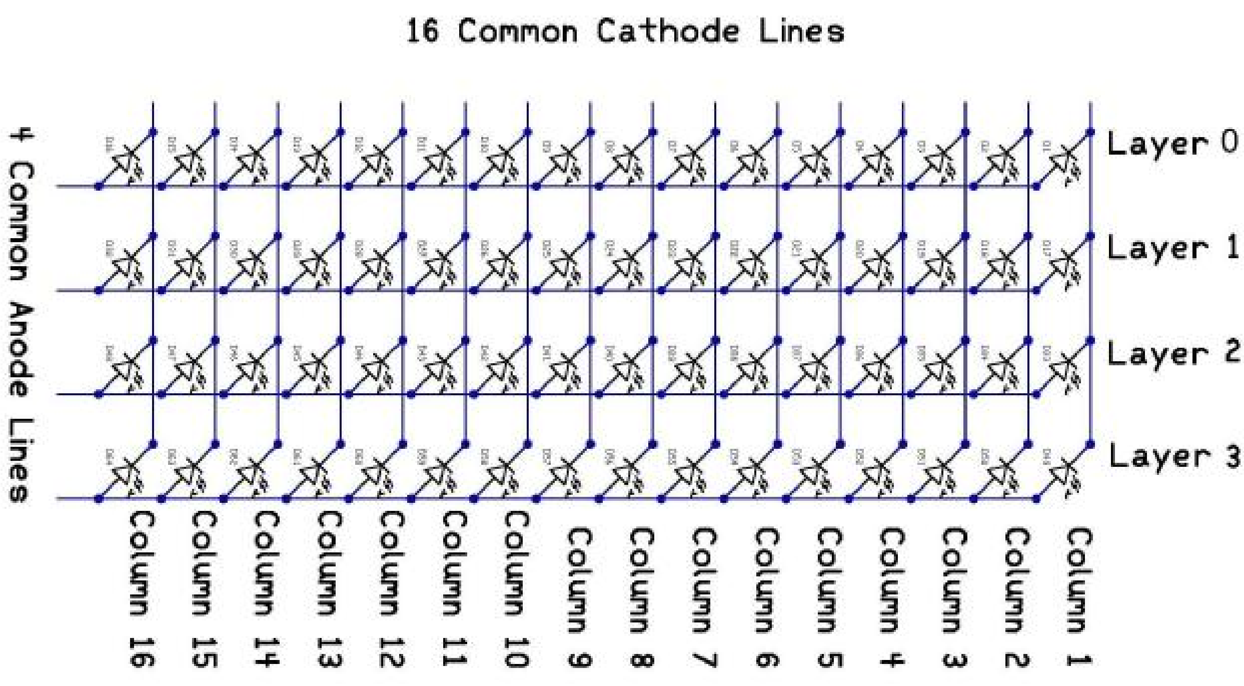


Figure 44

Essentially by controlling the I/O lines we can turn on any individual LED inside the 3D matrix, any group of LEDs inside the 3D matrix or all of the LEDs inside the matrix. Patterns are created by sequencing LED patterns on and off rapidly.

Here are some general rules:

A high output (1) on an I/O line on Port D or Port B will turn LED off, low (0) will turn LED on.
A low (0) on Port C will make PNP layer transistor turn on, a high (1) will turn it off.
16 Cathode Rows made on/off by Port Pins directly - PORT B and PORT D
4 Anode Columns made on/off by Port Pins via PNP drivers – PORTC

LED Cube is a 16 x 4 multiplexed display. All 16 LEDs of a layer are simultaneously turned on (or off as per pattern). A 16 bit word is put in form of 2 bytes on Port B and Port D. Then the layer is turned on by making the common anode line active via corresponding Port C pin. After a layer is displayed, it is switched off and the next layer is displayed in similar fashion. Layers are switched on and off, one by one, so fast that persistence of vision makes us see as if whole Cube is on (as per pattern) all the time, even though in reality at any time only one layer is on.

Test Program Function:

Layers are scanned one by one, when a particular layer is active, 2 byte / 16 bit Word is simultaneously outputted on Cathode Pins
byte sized variables
a[0] & a[1] are cathode data for Layer 0
a[2] & a[3] are cathode data for Layer 1
a[4] & a[5] are cathode data for Layer 2
a[6] & a[7] are cathode data for Layer 3
Layer 0 is bottom most, Layer 3 is Topmost
Variable with even index are outputted on Port D, odd index are outputted on Port B.
To create a pattern - set frame repetition rate - time one frame stays on. Load appropriate frame data in array variable and use subroutine frameout for outputting frame
Load next frame data in array variable and follow the same procedure.

TEST Program

```
'PIC 16F877A
Define OSC 16            'oscillator 16 MHz, HS mode
adcon1 = 6               'make ports digital I/O

alloff con %11111111       'all cathodes off
allon con %00000000        'all cathodes on
cubeoff con %00001111      'all anodes off
layer0 con %00001110       'layer 0 Floor enabled
```

```
layer1 con %00001101      'layer 1 enabled
layer2 con %00001011      'layer 2 enabled
layer3 con %00000111      'layer 3 Top enabled

x var byte              'x,z general variables
z var byte
a var byte [8]          'array variable stores current frame data for LED cathodes
frame var byte          'single frame repetition rate variable

trisb = 0               'portb, pord connects to cathode, portc connects to anode
trisd = 0
trisc = 0

portc = cubeoff         'disable all layers (pnp drivers)
portd = alloff          'initialize all cathode driving ports to off condition
portb = alloff

inout:                  'inout pattern - a subset square and outermost square turn on alternately
frame = 24              'set frame repetition rate
a[0] = %11111111        'set initial frame data
a[1] = %11111111
a[2] = %10011111
a[3] = %11111001
a[4] = %10011111
a[5] = %11111001
a[6] = %11111111
a[7] = %11111111
inouti:                 'main loop of pattern
gosub frameout          'ouput current frame
for z = 0 to 7          'invert frame data to interchange squares
   a[z] = ~a[z]
next z
goto inouti             'go back to main loop

frameout:               'main frame out subroutine
for x = 0 to frame      'display pattern as per set frame repetition rate
   portd = a[0]         'set ports connected to cathode pins for Layer 0 frame data
   portb = a[1]
   portc = layer0       'enable layer 0 anodes
   pause 4              'pause for layer on time - set refresh rate to avoid flickering
   portc = cubeoff      'disable all layers while changing cathode data from one layer to another
   portd = a[2]         'set ports connected to cathode pins for Layer 1 frame data
   portb = a[3]
   portc = layer1       'enable layer 1 anodes
   pause 4              'pause for layer on time - set refresh rate to avoid flickering
   portc = cubeoff      'disable all layers while changing cathode data from one layer to another
   portd = a[4]         'set ports connected to cathode pins for Layer 2 frame data
   portb = a[5]
   portc = layer2       'enable layer 2 anodes
   pause 4              'pause for layer on time - set refresh rate to avoid flickering
   portc = cubeoff      'disable all layers while changing cathode data from one layer to another
   portd = a[6]         'set ports connected to cathode pins for Layer 3 frame data
   portb = a[7]
   portc = layer3       'enable layer 3 anodes
```

```
   pause 4            'pause for layer on time - set refresh rate to avoid flickering
   portc = cubeoff             'disable layers while changing cathode data from one layer to another
next x
return              'return to main program
end
```

Going Further:

The test program shows how to display a simple repeating pattern with stored patterns. Programs can also run live. Meaning that the running program determines which LED or group of LED's to light next, without reading the information from stored data within the program.

Parts List

(1) PCB
(70) LED (color Blue, Red, Green or Yellow)
(4) RES-220 Ohm 1/4 watt
(4) RES-4.7K 1/4 watt
(1) RES-1K 1/4 watt
(16) RES-1/4 watt (150 ohm Blue, 220 ohm Red, 180 ohm Green and Yellow)
(2) CAP-22pf Mono
(1) CAP-10uf - 16V
(1) CAP-1000uf - 10V
(1) CAP- .01uf - 100V
(1) PIC16F877A
(1) ICS-40
(1) SW-06
(4) SW-25
(1) Xtal-16
(1) PJ-102B
(1) 7805
(4) BC369
(4) Hex Feet / L Brackets
(36") Tin Wire
(4) 440 x 3/8 Screws Pop Rivets Small
(4) Pop Rivets Large
(1) ACA-9V DC 300mA Power Supply