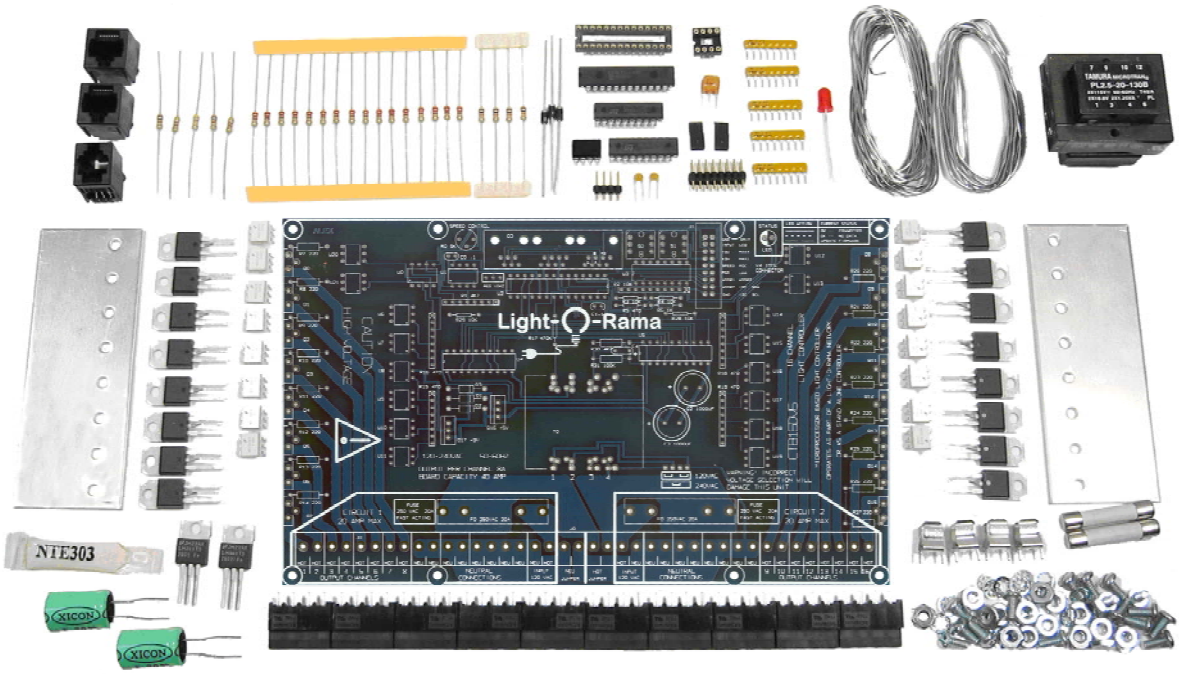
Light-O-Rama



CTB-16KV6

Hobbyist Line Kit
40 Amp 16 Channel Light Controller
Assembly Manual

Version 2.03
February 15, 2007

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1 Introduction

Congratulations on your purchase of a genuine Light-O-Rama Hobbyist Kit. This kit contains all the parts necessary to construct a fully functional 16 channel lighting controller. As with all Light-O-Rama micro-processor controlled devices, this unit is field firmware upgradeable. You can be sure it will work with current and future releases of the Light-O-Rama ShowTime PC software. And, you will be able to take advantage of future upgrades planned for the effects supported by Light-O-Rama controllers.

This kit contains the light duty heatsinks. They limit the total current carrying capability of the controller to 15 amps. 7.5 amps for each of the two 8-channel banks. If you opted to purchase the regular heatsinks, then the full 40 amp current carrying capacity of the controller can be used. 20 amps for each of the two 8-channel banks.

If you opted to purchase one of the *CTB-16K Deluxe Kits,* your controller will also include unit id selection switches, a speed control and the ability to run stand-alone sequences. Stand-alone support means that the controller can be downloaded with an animation sequence that it can run on its own. This stand-alone sequence can control the channels on this controller as well as other controllers connected to it.

Please take the time to read the following sections on soldering and parts. Also, make sure to do a parts inventory before starting. This not only helps make sure you won't be stopped unexpectedly, but also familiarizes you with the various parts and their preparation, minimizing assembly errors. We are committed to your success, please take your time and read everything – we won't let you fail.

Remember to read the CTB-16D Users Guide after completing assembly. It contains information necessary to safely connect and use this controller.

2 Required Tools

- Long nose pliers
- Wire nippers (or diagonal cut pliers)
- ¼ inch flat blade screw driver
- #2 Phillips screw driver
- 5/16 inch nut driver for heat sink bolts
- 25 watt pencil soldering iron (Use 650º F if temperature controller soldering iron)
- 40 watt pencil soldering iron (Use 800º F if temperature controller soldering iron)
- Lighted magnifying glass

CAUTION: This product requires that you have an understanding of electrical wiring. This board requires connection to 120 or 240 Volts AC. It has many exposed high voltage connections that are potentially dangerous. This board should be placed in a safe enclosure to protect against electrocution whenever it is powered.

3 Soldering

A 40 watt soldering iron should be used to solder the triacs, screw terminal strips and fuse holders. This is because these joints are large and the solder must flow through the hole in the board to the other side. A smaller soldering iron may make this difficult or even impossible.

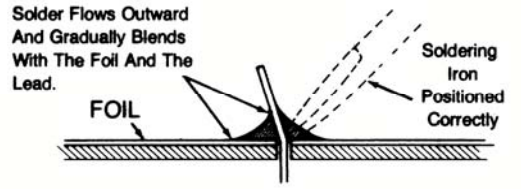
A 25 watt pencil tip soldering iron should be used to solder the rest of this board. This will help prevent component damage from over heating. Also, the small tip will help prevent solder bridges (unwanted connections) from forming between adjacent components and/or foil traces.

Use a wet sponge or cloth to clean the tip of the soldering iron frequently. Wipe the hot iron on the wet sponge to clean off solder and flux, then coat the tip with a small amount of solder. This process will maximize heat transfer and help make your solder joints clean and neat.

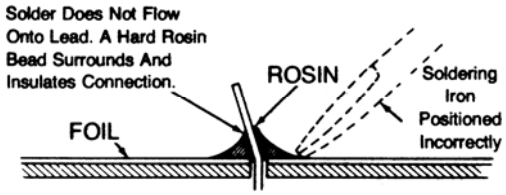
You should not need additional solder, but if you do, always use the thin shiny rosin core solder designed for electronics. Using acid core solder (plumbing solder) will damage everything.

If you need to remove a soldered part, RadioShack sells a few desoldering tools. The cheapest is simply a small bulb ($3) that you use to suck the melted solder out of the joint. They have a more effective solder sucker available for $7. Lookup “Desoldering” at www.radioshack.com.

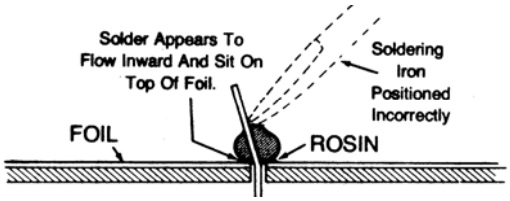
The picture on the right shows proper soldering technique. You must heat the lead and the board foil at the same time. Touch the solder to the other side of the lead and board foil from the soldering iron. The solder should flow evenly onto the lead and the foil making a good electrical connection between them. Then bring the soldering iron straight up from the joint along the lead.



The picture at the right shows one bad soldering technique. Here the soldering iron is only touching the board foil. The component lead is not being heated and it is very likely that the rosin in the solder will insulate the lead from the solder.



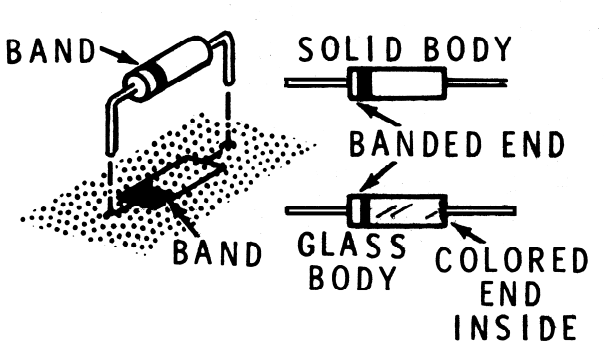
The picture at the right shows another bad soldering technique. Here the soldering iron is only touching the lead and not the board foil. The likely result is that the solder will only bond to the lead and a rosin barrier will form, insulating the solder from the board foil.



4 Part Descriptions

4.1 Diodes

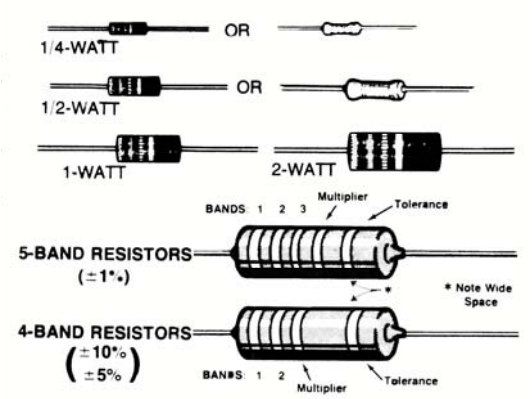
Diodes will be specified by the designation printed in the side of the part. Always match the band on the end of the diode with the graphic printed on the circuit board. Orientation IS important and the diode will NOT work if it is installed backwards. The band is painted on the outside of the diode.



4.2 Resistors

Resistors will be specified by their resistance value in Ω (ohms), KΩ (kilo-ohms or thousands of ohms) or MΩ (mega-ohms or millions of ohms). Some resistors have their value printed on them, most use a color coding scheme. Orientation of the resistor when installing it is NOT important.

Both the resistance and the color bands will be specified in the assembly steps. The table below is for information purposes only.



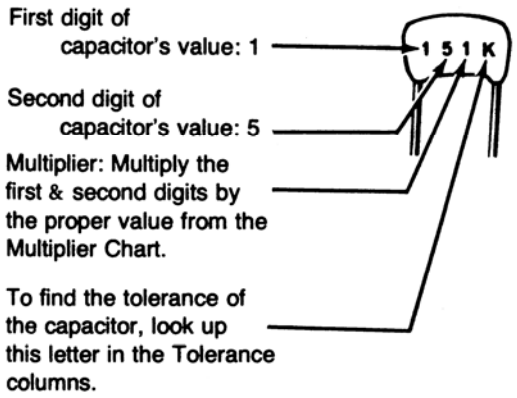
Band 1 1st digit		**Band 2** 2nd digit		**Band 3** (opt) 3rd digit		**Multiplier**		**Resistor Tolerance**	
Color	Digit	Color	Digit	Color	Digit	Color	Multiplier	Color	Tolerance
Black	0	Black	0	Black	0	Black	1	Silver	± 10%
Brown	1	Brown	1	Brown	1	Brown	10	Gold	± 5%
Red	2	Red	2	Red	2	Red	100	Brown	± 1%
Orange	3	Orange	3	Orange	3	Orange	1,000		
Yellow	4	Yellow	4	Yellow	4	Yellow	10,000		
Green	5	Green	5	Green	5	Green	100,000		
Blue	6	Blue	6	Blue	6	Blue	1,000,000		
Violet	7	Violet	7	Violet	7	Silver	0.01		
Gray	8	Gray	8	Gray	8	Gold	0.1		
White	9	White	9	White	9				

Example use of the resistor color chart for a Triac resistor (220 Ω 5%):
This is a 5% tolerance 4-band resistor, so we use the bottom most resistor pictured above. If you hold the resistor with the gold band on your right, then the colored bands will be red, red and brown starting from the left. Using the chart above, the first band (1st digit) is red, meaning '2,' the second band (2nd digit) is also red, meaning '2' again. The third band (the multiplier) is brown, meaning 10 times the first two digits. This makes the resistance 220 Ω. The rightmost band, gold, is the resistor's tolerance, in this case accuracy of the resistance is within 5%. Resistors accurate to 1% will have an additional 3rd color band before the multiplier.

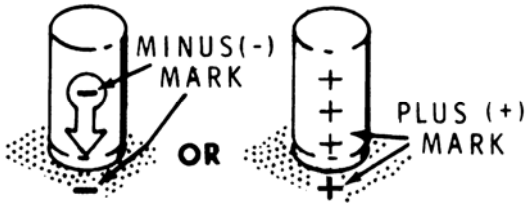
4.3 Capacitors

Capacitors will be specified by their type (ceramic or electrolytic) and their value as printed on them. The table below is used to convert the markings on a ceramic capacitor to its value and is included only for informational purposes.

The orientation does not matter when installing a ceramic capacitor as depicted to the right.



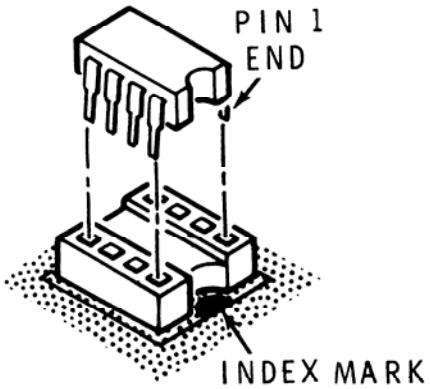
The capacitor show to the right is an electrolytic and you must align the minus/plus on the capacitor with the equivalent marking on the circuit board. The circuit board has the "+" marked. If your capacitor only has the minus marked, then put the unmarked lead of the capacitor in the "+" hole.

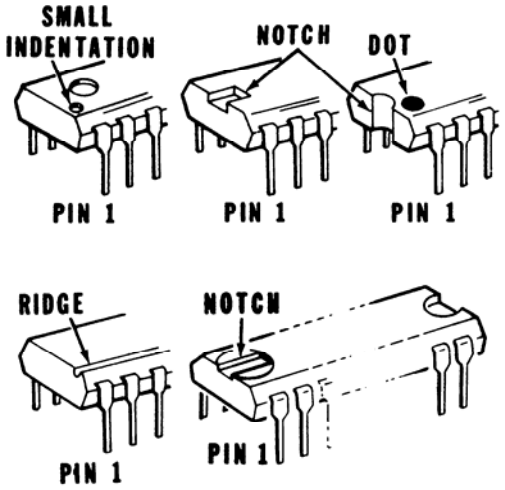


Multiplier			Tolerance		
Printed on capacitor	Multiply by		10 pF or less capacitor (in pF)	Letter on capacitor	Over 10 pF capacitor
0	1		± 0.1	B	
1	10		± 0.25	C	
2	100		± 0.5	D	
3	1,000		± 1.0	F	± 1%
4	10,000		± 2.0	G	± 2%
5	100,000			H	± 3%
				J	± 5%
8	0.01			K	± 10%
9	0.1			M	± 20%

4.4 DIP Integrated Circuits and Sockets

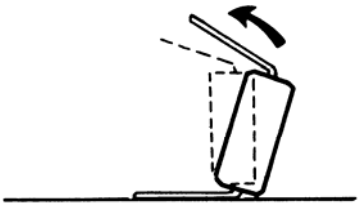
Most Integrated Circuits (ICs) in this kit are DIPs (Dual In-line Package) as pictured below. ICs and their sockets have a “pin 1” end. This is indicated by either a notch (IC or socket) or a dot stamped or printed on the IC. It is very important to orient both sockets and ICs correctly. Note that if there is a notch and a dot, the notch takes precedence.

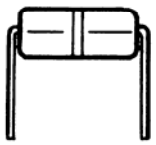




Before installing an IC, either directly into the circuit board or into a socket, you must straighten the pins. Examine the IC carefully, making sure that the pins are straight and bow outward slightly as show by the picture to the right.

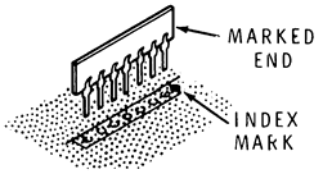
To bend the IC’s pins so that it can be easily inserted into the circuit board or socket, lay the IC down on a hard surface on its side as shown in the picture to the right. Roll the IC towards the pins so that pins are at a 90º angle from the case. Turn the IC over and do the same thing to the other row of pins. The IC should now look as depicted in the lower picture to the right.





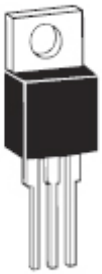
4.5 Resistor Networks

Resistor networks are Single In-line Packages (SIPs) that have multiple resistors in the package. Orientation of the component **MAY** be important. The resistor network will have a dot at one end. Read the installation steps carefully – one of the resistor networks MUST be installed with the proper orientation.



4.6 TO-220 Package Triac and Voltage Regulators

The picture to the right shows a TO-220 package. The 5V and 10V voltage regulators and Triacs come in this package.



5 Parts Lists

- *Standard Kit (Low power heat sinks)* includes all the necessary parts to make a functioning CTB-16D light controller capable of handling a total of 15 amps.
- *Standard Kit (High power heat sinks)* upgrades the current capacity from 15 to 40 amps.
- *Deluxe Kit (Low power heat sinks)* adds unit selection switches, a speed control, the ability to run stand-alone sequences and a current capacity of 15 amps.
- *Deluxe Kit (High power heat sinks)* includes unit selection switches, a speed control, the ability to run stand-alone sequences and a current capacity of 40 amps.

5.1 Standard Parts Kit

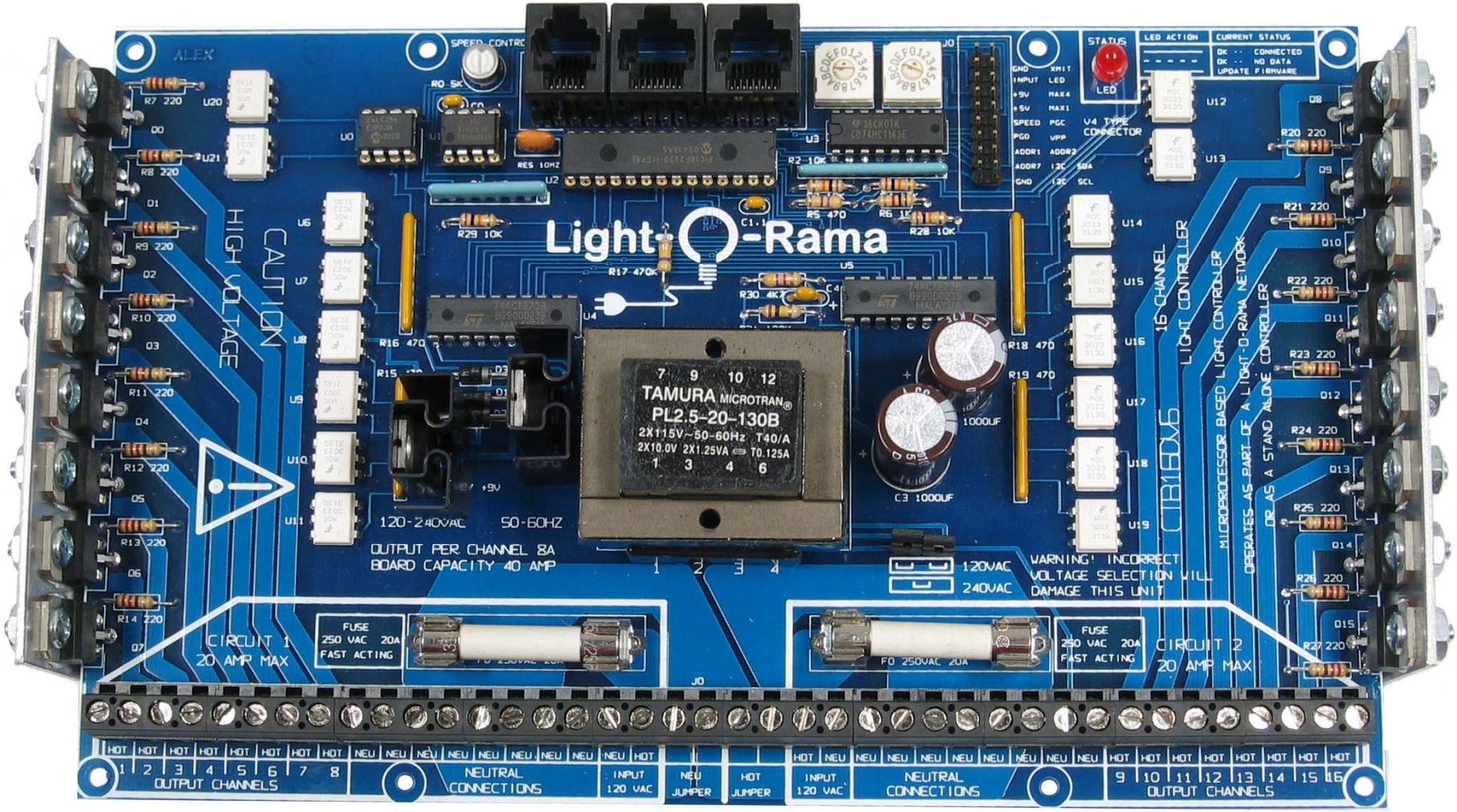
Quantity	Identification	Description	Part Markings
1	PCB	Printed circuit board	
2	No-clean solder	Fine gauge spool Medium gauge spool	
16+16	R7, R8, R9, R10, R11, R12, R13, R14, R20, R21, R22, R23, R24, R25, R26, R27	220 Ω, ¼ watt, 5% resistor 330 Ω, ¼ watt, 5% resistor (220 Ω for 120 VAC, 330 Ω for 240 VAC)	red-red-brown-gold orange-orange-brown-gold
4	R3, R4, R28, R29	10 KΩ, ¼ watt, 5% resistor	brown-black-orange-gold
1	R5	470 Ω, ¼ watt, 5% resistor	yellow-violet-brown-gold
1	R6	1 KΩ, ¼ watt, 5% resistor	brown-black-red-gold
1	R17	470 KΩ, ¼ watt, 5% resistor	yellow-violet-yellow-gold
1	R30	4.7 KΩ, ¼ watt, 5% resistor	Yellow-violet-red-gold
1	R31	100 KΩ, ¼ watt, 5% resistor	Brown-black-yellow-gold
1	R1	4.7 KΩ, Resistor network 8 pin SIP, Isolated	8X-2-472 -or- CTSK055177083472
1	R2	10 KΩ, Resistor network 10 pin SIP, Bussed	10X-1-103LF
4	R15, R16, R18, R19	470 Ω, Resistor network 8 pin SIP, Isolated	8X-2-471
3	D1, D2, D3	100 V, 1 Amp Diode	1N4002 or 1N4003
1	J0 (top of board)	Male header, dual row, 18 contacts	
40	J0 (bottom of board)	AC power screw terminals 4 or 6 screws per block Total of 40 screw terms	
1	J1	Male header, single row, 4 contacts	
1	T0	Transformer	
1	Res 10 MZ	Resonator (3 leads, looks like ceramic cap)	100Cm512 or ZIT 10.0MT
1	LED	Round red LED	

16	Q0, Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15	Triac, 16A, 600V, TO-220 case, snubberless, isolated – center lead pre-bent for insertion into the circuit board	BTA16-600BW
1	Q16	5V, 1.5A Voltage regulator TO-220 case – center lead is not bent like triacs	TL7805C –or- LM340TS7805
1	Q17	10V, 1.5A, Voltage regulator, TO-220 case	UA7810C
1	C0	.1uF 50V 10% Ceramic capacitor	104
1	C1	1uF 50V 10% Ceramic capacitor	105Z
2	C2, C3	1000uF 35V Electrolytic capacitor	1000 uF 35v
1	C4	.47 uF 50V 10% Ceramic capacitor	474Z
1	U1 socket	8 pin IC socket	
1	U1	485 skewlimited driver 8 pin DIP	MAX3082EEPA or ISL81487LIP
1	U2 socket	28 pin IC socket	
1	U2	Micro-processor	PIC18F2620
1	U3	8 bit shift register 16 pin DIP	74HCT165
2	U4, U5	8 bit flip-flop 20 pin DIP	74ACT273
16	U6, U7, U8, U9, U10, U11, U12, U13, U14, U15, U16, U17, U18, U19, U20, U21	400V Triac opto-isolator 6 pin DIP	MOC3023
2 sets	F0a, F0b, F1a, F1b	Fuse clips	
2	RJ1, RJ2	Female RJ45 connector 8 contacts	
1	RJ3	Female RJ12 connector 6 contacts	
2	Fuse0, Fuse1	15A, 250V, Ceramic Fast acting	
3	Jumper1, Jumper2, Jumper3	Small black plastic tabs with copper inside that are used on J0 and J1	
2	Light duty heat sink triac heat sink	Flat metal with 8 triac screw holes – use as an installation guide	
1	Thermal compound	Heat transfer paste if using light duty heat sinks	Packet tube
16	Screw/Washer/Nut set	Triac to heat sink screw, washer & nut sets	
2	Voltage regulator heat sink	Black metal for TO-220 voltage regulators	Approximately ¾" x ¾" x ½"

5.2 Deluxe Add-on Parts Kit

Quantity	Board Identification	Description	Part Markings
1	U0 socket	8 pin IC socket	
1	U0	Serial EEPROM 256K 8 pin DIP	24LC256I/P
1	R0	5 KΩ Potentiometer	
2	S0, S1	Rotary switch	0,1,2,3,…F

6 Completed CTB-16KV6 Deluxe w/Light Duty Heat Sinks

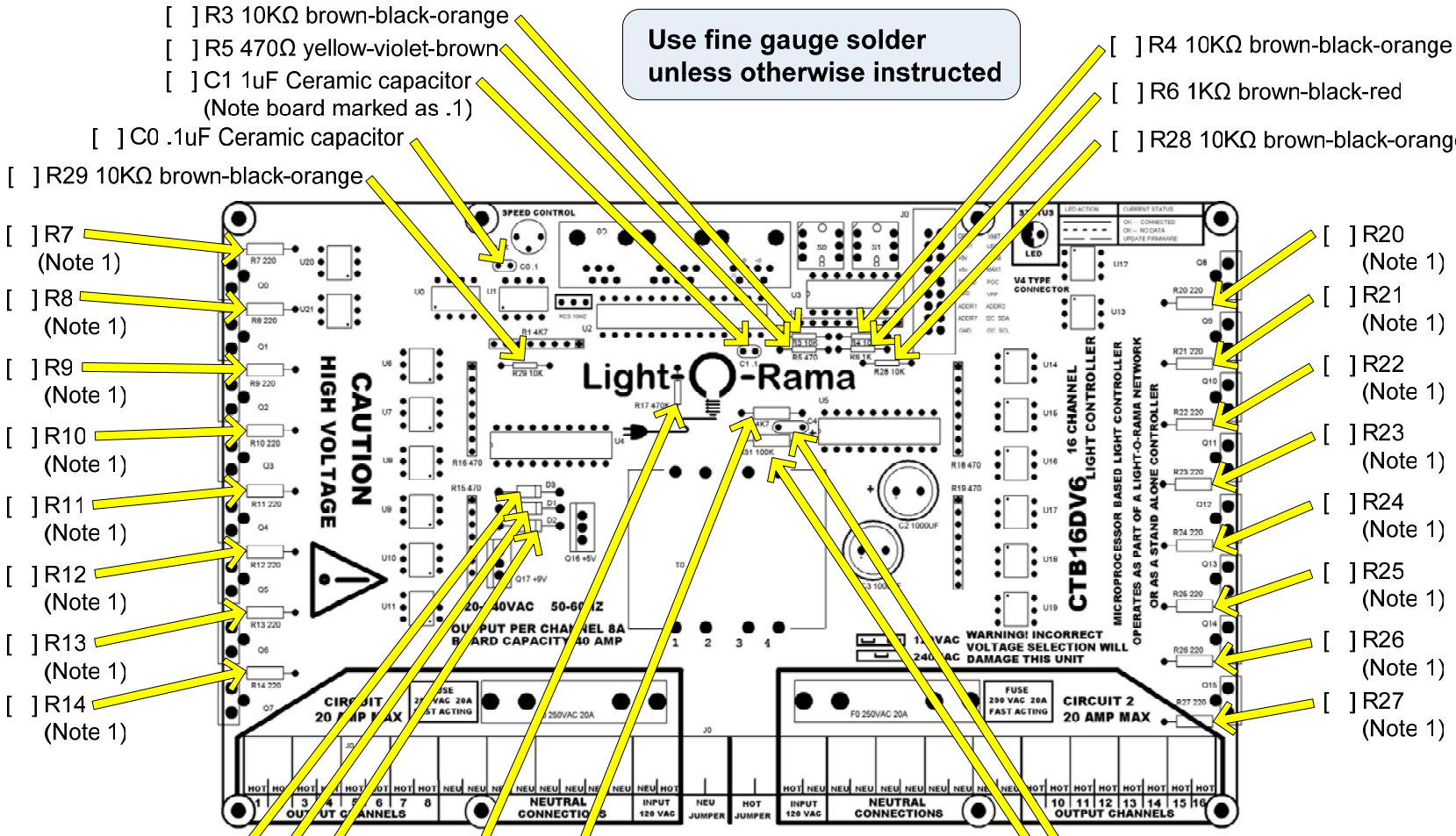


7 Assembly Instructions

7.1 Pre-Assembly Notes

1. Resistors, diodes and capacitors must have their leads bent so they can be pushed through the circuit board. After pushing the component leads through the board, bend the leads slightly outward on the solder side of the board as depicted in Section 3 on Soldering. This will hold the component in place while you solder.
2. When installing integrated circuits (ICs), make sure no pins are bent underneath, to the side or outward. Straighten the IC pins as explained in Section 4.4. After inserting the IC either into the board or socket, check again that no pins have been bent underneath, etc. Use a lighted magnifying glass to be sure all pins come through the board for ICs that are soldered to the board.
3. Blue painter's tape is a good way to hold some components on the board so you can turn it over and solder them. The blue tape is not very sticky so it comes off easily with no residue.
4. Use the wire nippers or diagonal cut pliers to nip off the leads on the solder side of the board after soldering.
5. Before you put a check in the box next to each component make sure it is properly installed (soldered, leads nipped off, no pins bent, etc…)
6. Avoid static electricity when handling the integrated circuits. There is a potential for damage to them if you have not discharged any static electricity from yourself when handling them.
7. **If you are building the kit for use in a country that uses 120 VAC power (e.g. US, Canada), use the sixteen 220 Ω resistors for R7 though R14 and R20 through R27. If you are building the kit for use in a country that uses 240 VAC power (e.g. UK, Australia), use the sixteen 330 Ω resistors for R7 though R14 and R20 through R27.**
8. **When nipping off leads after soldering, wear eye protection or hold the leads so they cannot hit you in the eye.**

7.2 Assembly[1 of 7]: Resistors, Diodes, Ceramic Capacitors



7.3 Assembly[2 of 7]: Resistor Networks, U3 IC, IC Sockets

[ ] U2 **Socket** (28 pins)
Notch on RIGHT

[ ] U1 **Socket** (8 pins)
Notch on LEFT

[ ] U0 **Socket** (8 pins)
Notch on LEFT
(Deluxe kit only)

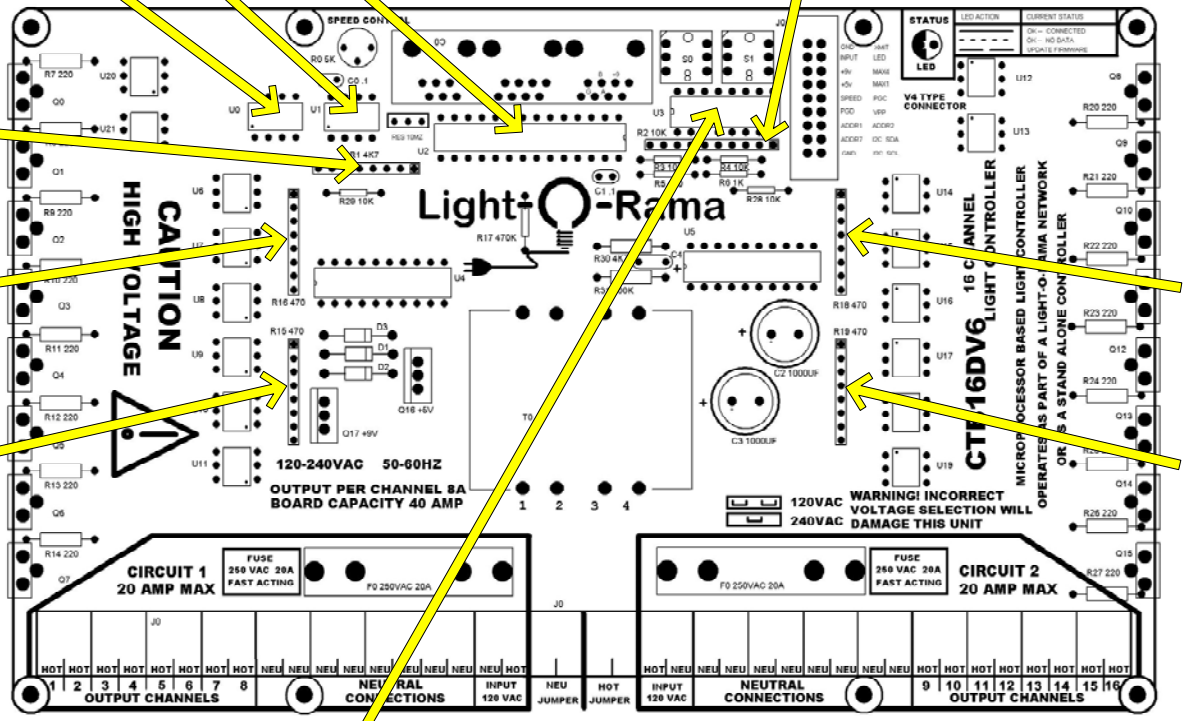
Use fine gauge solder unless otherwise instructed

[ ] R2 10 KΩ (put in U3 first, bottom of page)
Resistor Network
Dot MUST BE on RIGHT
Marking 10X-1-103

[ ] R1 4.7 KΩ
Resistor Network
Marking 8X-2-472

[ ] R16 470 Ω
Resistor Network
Marking 8X-2-471

[ ] R15 470 Ω
Resistor Network
Marking 8X-2-471



[ ] R18 470 Ω
Resistor Network
Marking 8X-2-471

[ ] R19 470 Ω
Resistor Network
Marking 8X-2-471

NOTE:
The orientation of resistor networks R1, R15, R16, R18 & R19 is NOT important.

[ ] U3 IC (16 pin)
Pin 1 on Left (If IC has a notch, this is pin 1; if no notch, then a dot marks pin 1
Solder directly into the board
Marking 74HCT165
Refer to Section 4.5 to straighten IC's pins

7.4 Assembly[3 of 7]: Soldered in Integrated Circuits, Switches

Use fine gauge solder unless otherwise instructed

[ ] R0 5 KΩ Potentiometer (Deluxe kit only)

[ ] S0 Rotary Switch Install '0' at top (Deluxe kit only)

[ ] S1 Rotary Switch Install '0' at top (Deluxe kit only)

[ ] U20 IC (6 pins) Pin 1 on BOTTOM

[ ] U21 IC (6 pins) Pin 1 on BOTTOM

[ ] U6 IC (6 pins) Pin 1 on BOTTOM

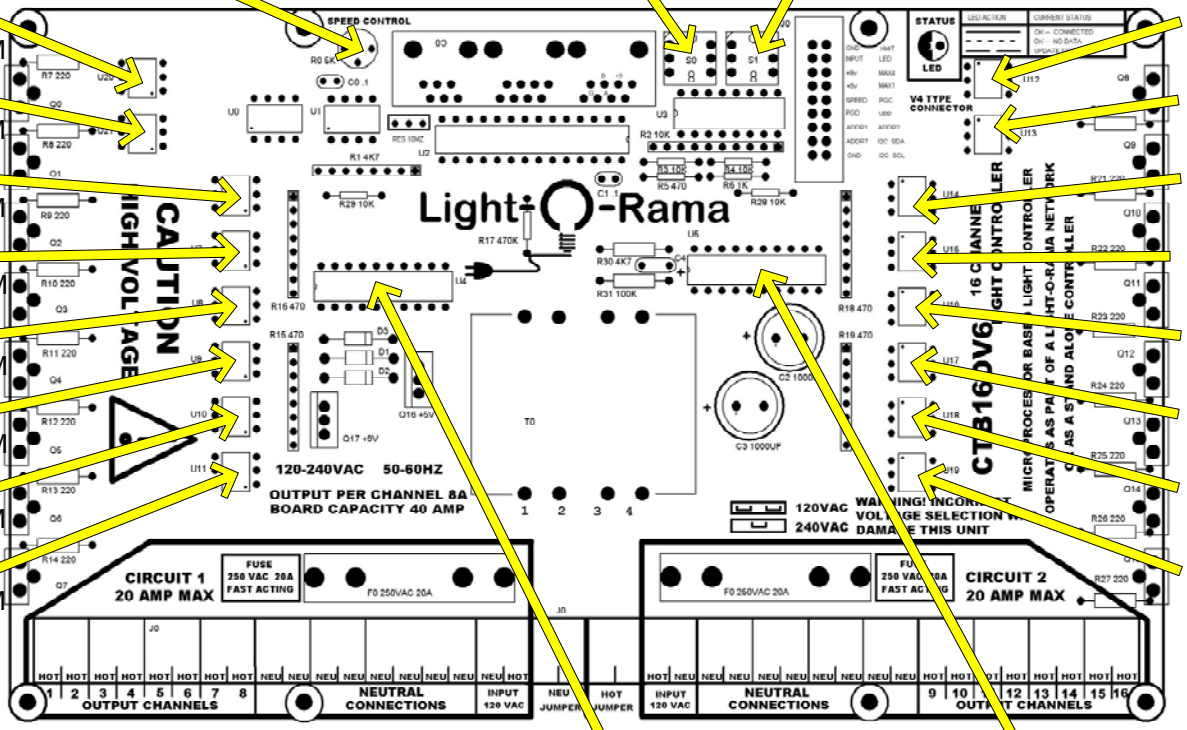
[ ] U7 IC (6 pins) Pin 1 on BOTTOM

[ ] U8 IC (6 pins) Pin 1 on BOTTOM

[ ] U9 IC (6 pins) Pin 1 on BOTTOM

[ ] U10 IC (6 pins) Pin 1 on BOTTOM

[ ] U11 IC (6 pins) Pin 1 on BOTTOM



[ ] U12 IC (6 pins) Pin 1 on TOP

[ ] U13 IC (6 pins) Pin 1 on TOP

[ ] U14 IC (6 pins) Pin 1 on TOP

[ ] U15 IC (6 pins) Pin 1 on TOP

[ ] U16 IC (6 pins) Pin 1 on TOP

[ ] U17 IC (6 pins) Pin 1 on TOP

[ ] U18 IC (6 pins) Pin 1 on TOP

[ ] U19 IC (6 pins) Pin 1 on TOP

[ ] U4 IC (20 pins) Pin 1 (Notch/Dot) on LEFT Marking 74ACT273

[ ] U5 IC (20 pins) Pin 1 (Notch/Dot) on LEFT Marking 74ACT273

READ FIRST:

1) All ICs on this page are soldered directly into the board.
2) Refer to Section 4.5 to straighten the pins of the ICs.
3) **Pin 1 on an IC may be marked by a notch or dot, notch takes precedence over a dot if both appear.**

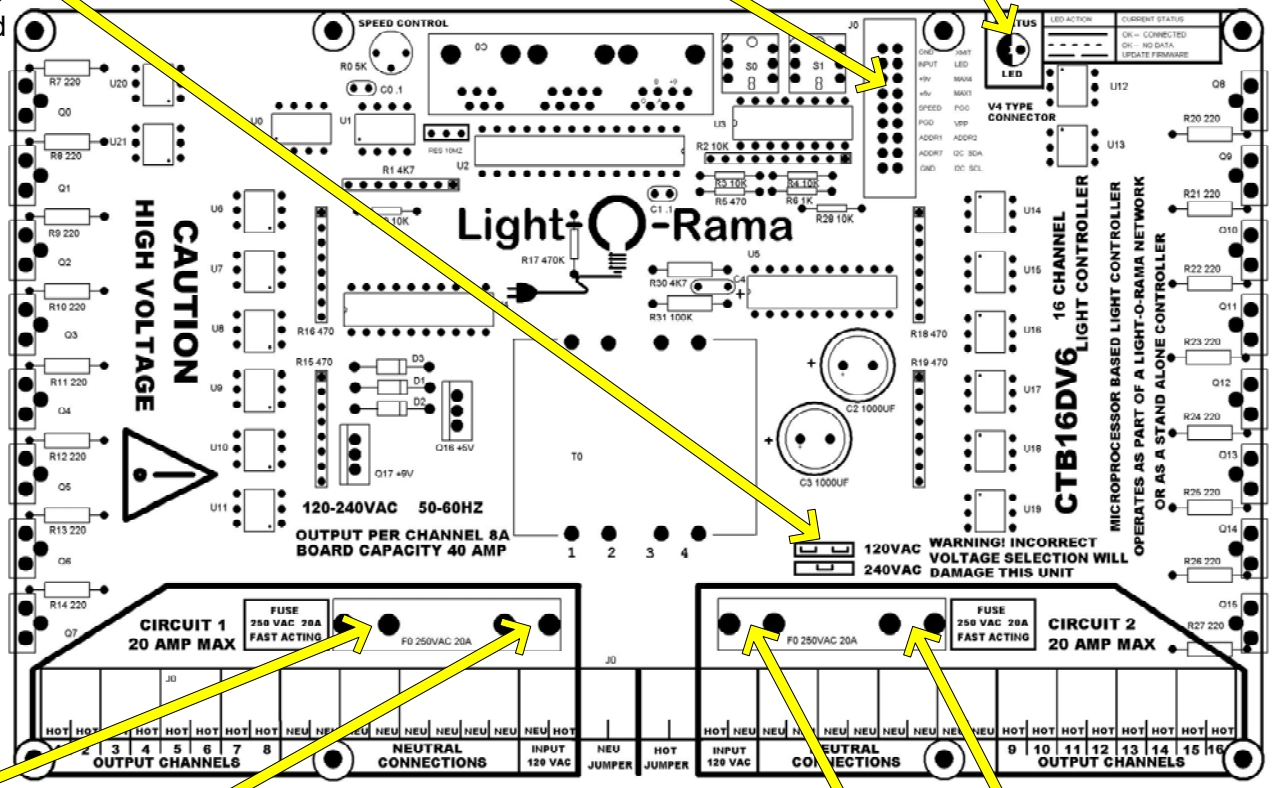
7.5 Assembly[4 of 7]: LED, Headers, Fuse holders

Use fine gauge solder unless otherwise instructed

[ ] J0 18 Pin Header
Install short pins into circuit board

[ ] LED Status
Flat side of LED must match board pattern
(Flat side to LEFT)

[ ] J1 4 Pin Header
Install short pins into circuit board



[ ] Fuse holder
Edge with cuts on LEFT

[ ] Fuse holder
Edge with cuts on RIGHT

Use medium gauge solder for the fuse holders

[ ] Fuse holder
Edge with cuts on RIGHT

[ ] Fuse holder
Edge with cuts on LEFT

Note: The four fuse holder components have and ‘outside’ and and ‘inside’ edge. The ‘outside’ edge has small cuts to prevent the fuse from sliding out of the holder. Use a 40 watt soldering iron for these components. Make sure you completely fill the fuse holders’ circular solder pads with solder.

7.6 Assembly[5 of 7]: Voltage Regs, Jacks, Screw Strips, Electrolytic Caps, Resonator

Use fine gauge solder unless otherwise instructed

PUT THE SCREW TERMINAL STRIPS ON FIRST

Note: Jacks have two plastic tabs that snap into the board.

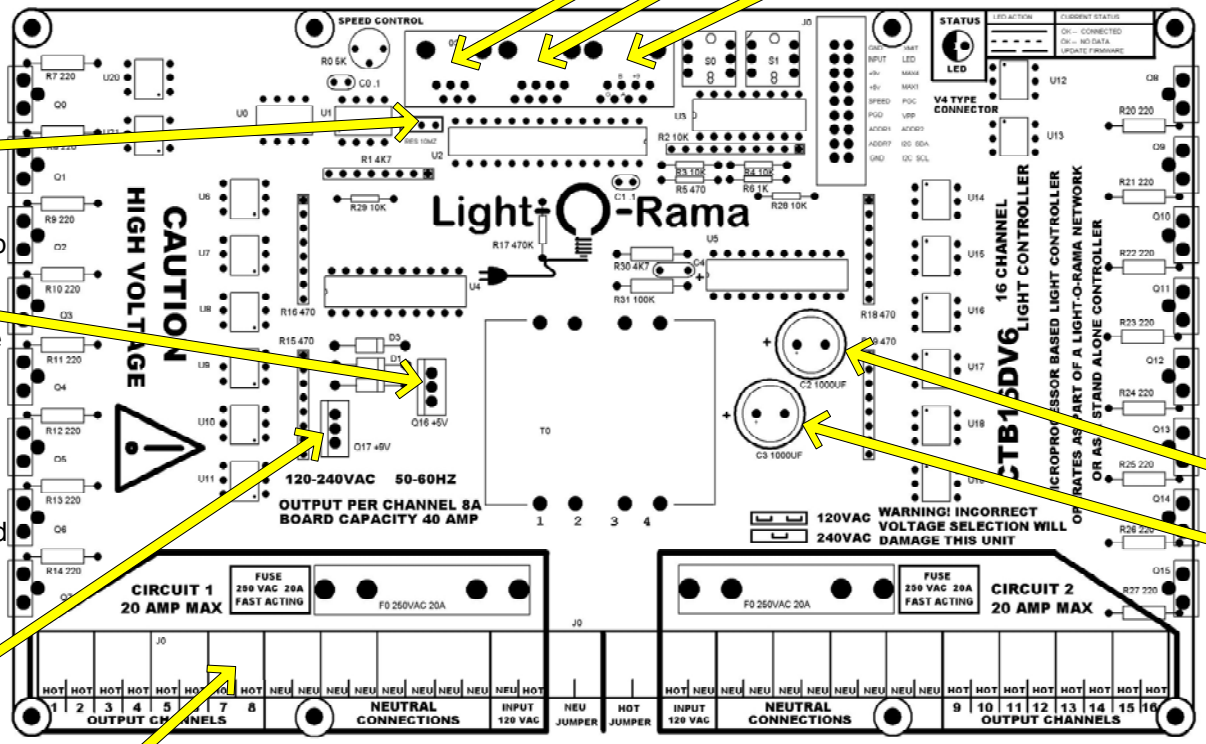
[ ] RJ3 RJ12 (6 pin) Jack

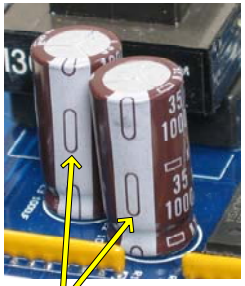
[ ] RJ1 RJ45 (8 pin) Jack

[ ] RJ2 RJ45 (8 pin) Jack

[ ] RES 10MZ
Put in jacks first
Looks like a 3 lead ceramic cap

[ ] Q16 5v Reg
TO-220 package
Marking TL780-05C
Make sure the tab on the regulator is on the LEFT as shown on the board





Minus marked electrolytic caps. Install with minus lead to the RIGHT

[ ] C2 1000uF 35v Electrolytic cap

[ ] C3 1000uF 35v Electrolytic cap

[ ] Q17 10v Reg
(Board is marked 9v)
TO-220 package
Marking UA7810C
Make sure the tab on the regulator is on the LEFT as shown on the board

[ ] Screw terminal strips come in blocks of 2, 4 or 6 screws. Slip the blocks together to make a strip of 40 and insert the strip into the board. Be sure the wire holes face the edge of the board. Use a 40 watt soldering iron and MEDIUM gauge solder for these components. Some of the silver solder pads are large ovals – make sure that the silver part of the pad is heated and solder flows over the entire silver surface.

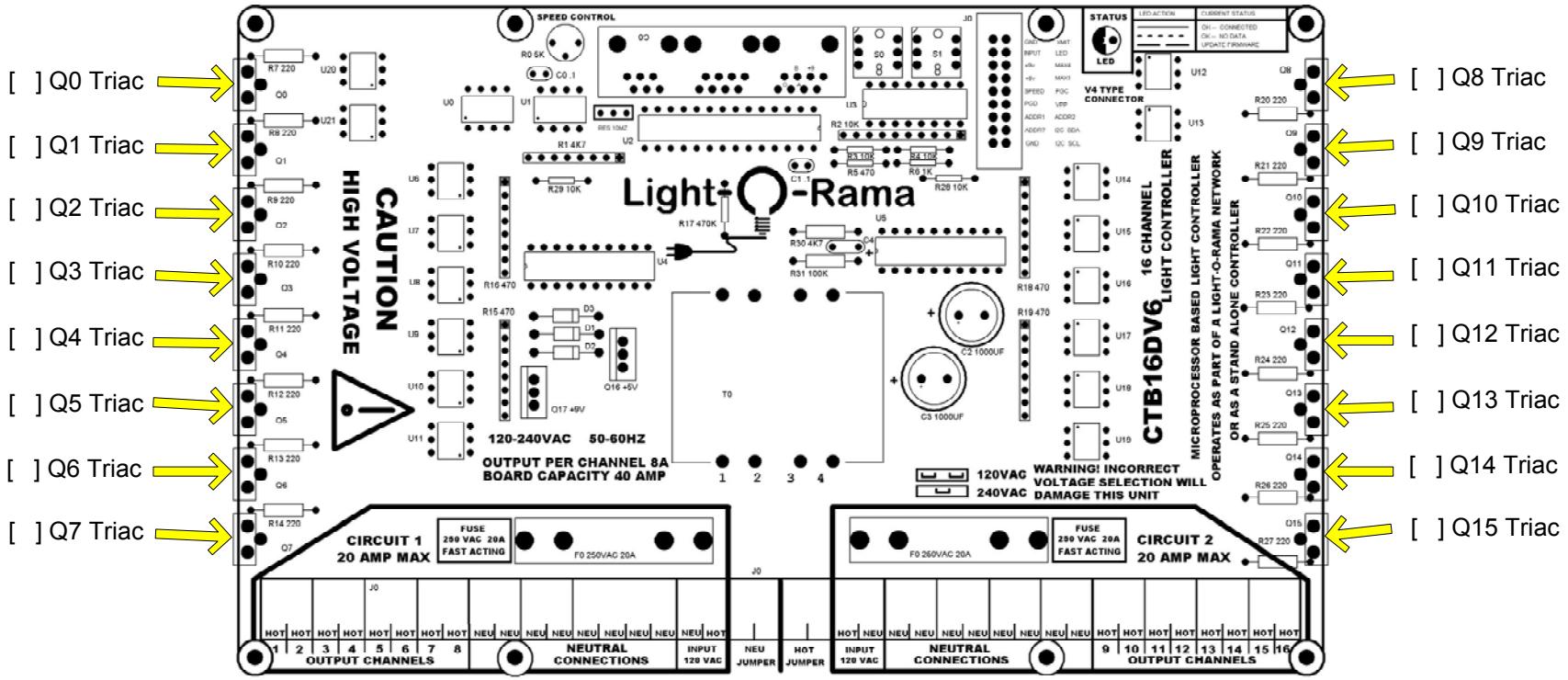
7.7 Assembly[6 of 7]: Triacs

READ NUMBERED STEPS FIRST

(1) All of the Triacs have had their leads machine bent for insertion into the circuit board. If the leads have not been altered, the Triacs will fit into the board with their metal side towards the outside of the board.

(2) Insert Triacs Q0 through Q15 into the board. Use a pliers to pull the triac's outer two leads tight against the board if necessary and then bend the two outer leads on each Triac slightly outward to hold the Triac in place.

TO-220 package Triac marking: BTA16-600BW



(3) If you are going to use the Light Duty Heat Sinks as heat sinks, spread a small amount of thermal compound on the outer surface of the Triacs' metal tabs. Otherwise, skip this step, because the Light Duty Heat Sinks will be used only as soldering guides.

(4) Position the Light Duty Heat Sinks so that they extend about 3/8 inch above the Triacs' metal tabs. Put a screw with the head on the inside through each Triac and then through the heat sink. Use a lock washer and bolt on on the outside of the heat sink. Tighten the screws.

(5) Use a 40 watt soldering iron and MEDIUM gauge solder to solder all triacs.

7.8 Assembly[7 of 7]: Transformer, Socketed ICs, Fuses, Jumpers

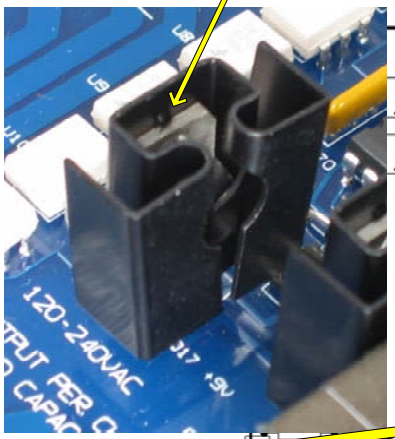
The three ICs listed to the right already have their sockets installed. They are to be pushed into these sockets, not soldered. Straighten their leads as shown in section 4.5

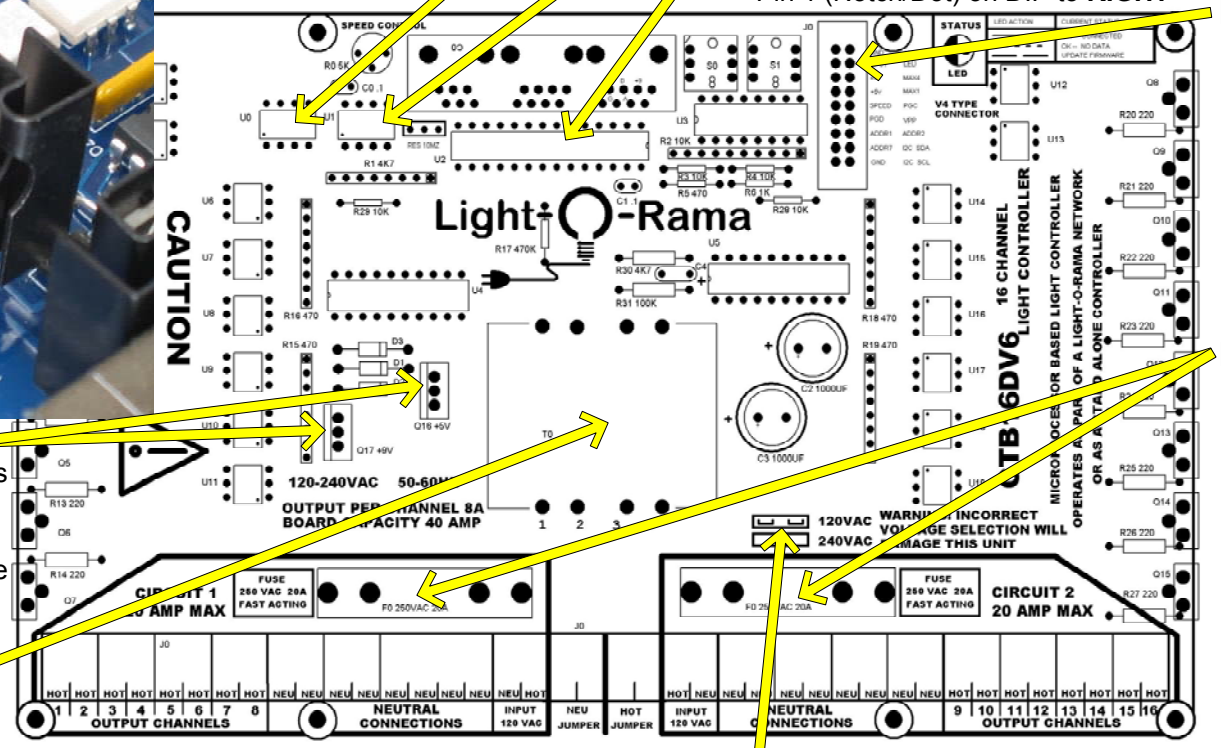
[ ] U0 EEPROM (8 pin) Marking 24LC256I/P
Pin 1 (Notch/Dot) on DIP to **LEFT**
(Deluxe kit only)

[ ] U1 RS485 (8 pin) Marking MAX3082EEPA or ISL81487LIP
Pin1 (Notch/Dot) on DIP to **LEFT**

[ ] U2 Micro-processor (28 pin) Marking PIC18F2620
Pin 1 (Notch/Dot) on DIP to **RIGHT**

Small projection on heat sink





[ ] Install a jumper across the second row from the top two pins (INPUT, LED) if you **DON'T** have the Deluxe Upgrade

[ ] Install two quick blow fuses

[ ] Install small metal heat sinks on voltage regulators as shown in picture

[ ] T0 Transformer, The board is designed to accept several different transformers. The one you have will only fit in one of the sets of holes. Pin 1 is always on the lower left, be sure the transformer's label is right-side up as depicted on page 12. Solder with medium gauge solder.

[ ] Install voltage selection jumpers as shown on circuit board. Two jumpers next to each other for 120 VAC, one jumper on center two pins for 240 VAC

If you purchased the regular (high power) heat sinks, do not install them until you test the board. They cover most of the bottom of the board and would have to be removed if you have a soldering error.

Assembly Completed

7.9 Post-Assembly Checks

Use a lighted magnifying glass

- Check that all diodes, resistor networks, ICs and the electrolytic capacitor are properly oriented.
- Check that all components are actually soldered, that the joints are smooth and shiny and that there are no solder bridges.
- Verify that R17 is really the 470 KΩ (yellow-violet-yellow-gold) resistor – an error here will fry the micro-processor.
- Check that the jumpers next to the power transformer are set for the proper line voltage.
- If you have the Standard Kit, make sure the jumper is across the second row from the top of J0, otherwise software unit selection will not work.
- The low voltage electronics on the board are powered by the right bank power feed, so connecting only the left side of the board to AC power will not power the micro-processor.

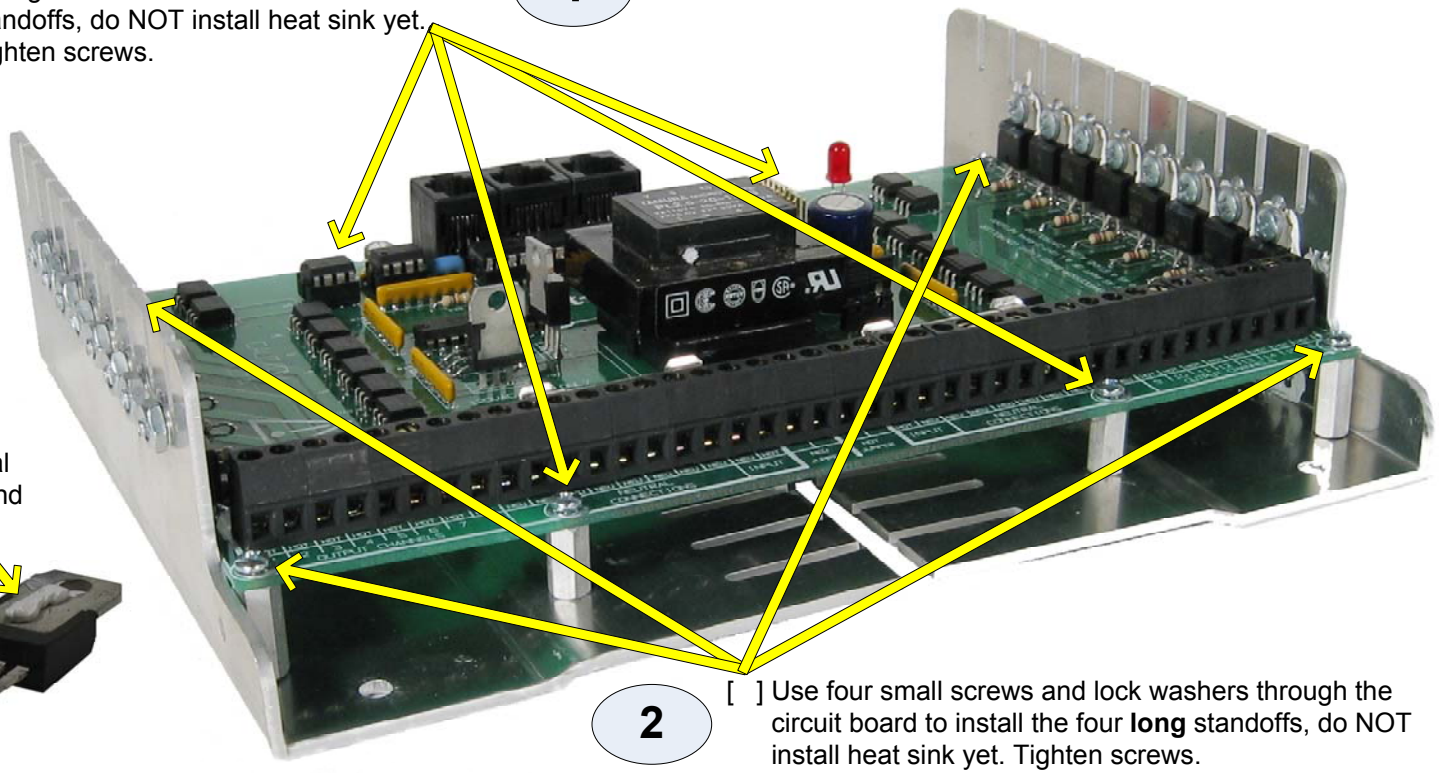
Refer to the CTB16D Users Guide to test your unit.

CAUTION: This product requires that you have an understanding of electrical wiring. This board requires connection to 120 or 240 Volts AC. It has many exposed high voltage connections that are potentially dangerous. This board should be placed in a safe enclosure to protect against electrocution whenever it is powered.

7.10 Installation of the (optional) Regular (High-power) Heat Sinks

[ ] Use four small screws and lock washers through circuit board to install the four **short** standoffs, do NOT install heat sink yet. Tighten screws.

1



Thermal compound

2

[ ] Use four small screws and lock washers through the circuit board to install the four **long** standoffs, do NOT install heat sink yet. Tighten screws.

3 [ ] Put a small amount of thermal compound on each triac on the left bank of eight triacs. Slide the heat sink against the triacs. Put a screw through each triac and then the heat sink. Put a lock washer and bolt on the screws. Do not tighten bolts yet.

4 [ ] Turn the board with heat sink over and use two small screws with lock washers to secure the short mounting standoffs to the left heat sink. Do not tighten these screws yet.

5 [ ] Repeats steps 3 and 4 for the right bank of triacs, then tighten all triac bolts and finally, tighten the four small screws on the bottom of the heat sink.