

CTB-16K

Hobbyist Line Kit

40 Amp 16 Channel Light Controller

Assembly Manual

***** Preliminary *****

Version 1.0

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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 the *CTB-16K Deluxe Upgrade Kit* 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
- 25 watt pencil soldering iron
- 40 watt pencil 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 is 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.

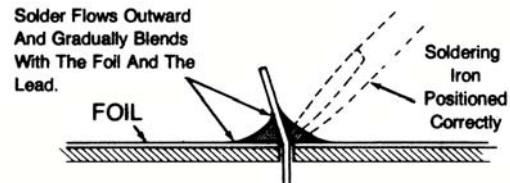
A 25 watt pencil tip soldering iron should be used to solder the rest of this board. This will help prevent component damage from over heating. Also, the small tip will help prevent solder bridges (unwanted connections) from forming between adjacent components and/or foil traces.

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.

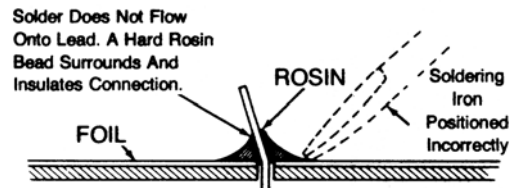
You should not need additional solder, but if you do, always use the thin shiny rosin core solder designed for electronics. Using acid core solder (plumbing solder) will damage everything.

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.

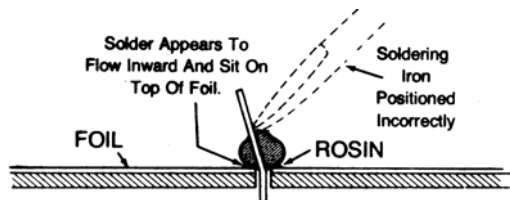
The picture on the right shows proper soldering technique. You must heat the lead and the board foil at the same time. Touch the solder to the other side of the lead and board foil from the soldering iron. The solder should flow evenly onto the lead and the foil making a good electrical connection between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



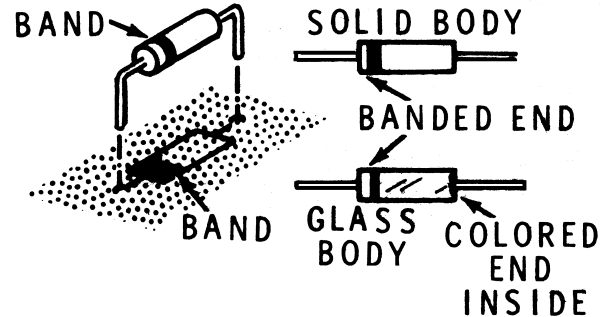
The picture at the right shows another bad soldering technique. Here the soldering iron is only touching the lead and not the board foil. The likely result is that the solder will only bond to the lead and a rosin barrier will form, insulating the solder from the board foil.



4 Part Descriptions

4.1 Diodes

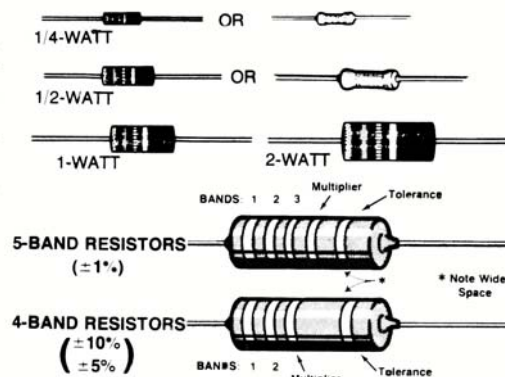
Diodes will be specified by the designation printed in the side of the part. Always match the band on the end of the diode with the graphic printed on the circuit board. Orientation IS important and the diode will NOT work if it is installed backwards. The band is painted on the outside of the diode.



4.2 Resistors

Resistors will be specified by their resistance value in Ω (ohms), K Ω (kilo-ohms or thousands of ohms) or M Ω (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 1 st digit		Band 2 2 nd digit		Band 3 (opt) 3 rd 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%):

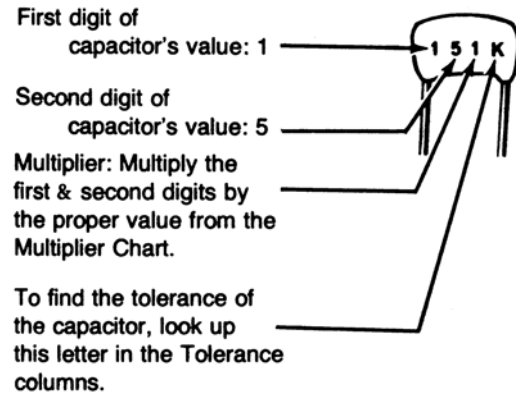
This is a 5% tolerance 4-band resistor, so we use the bottom most resistor pictured above. If you hold the resistor with the gold band on your right, then the colored bands will be red, red and brown starting from the left. Using the chart above, the first band (1st digit) is red, meaning '2,' the second 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.

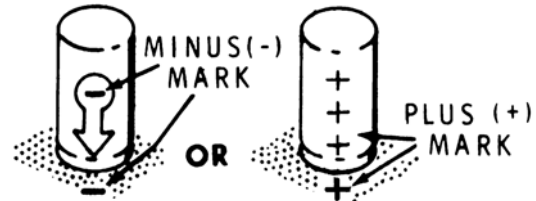
4.3 Capacitors

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.



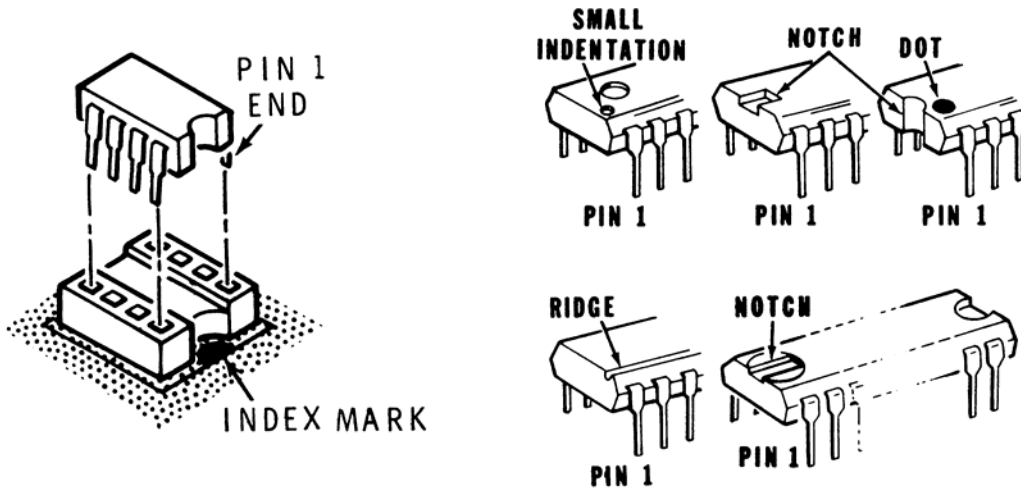
The capacitor show to the right is an electrolytic and you must align the minus/plus on the capacitor with the equivalent marking on the circuit board.



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	$\pm 1\%$
4	10,000	± 2.0	G	$\pm 2\%$
5	100,000		H	$\pm 3\%$
			J	$\pm 5\%$
8	0.01		K	$\pm 10\%$
9	0.1		M	$\pm 20\%$

4.4 DIP Integrated Circuits and Sockets

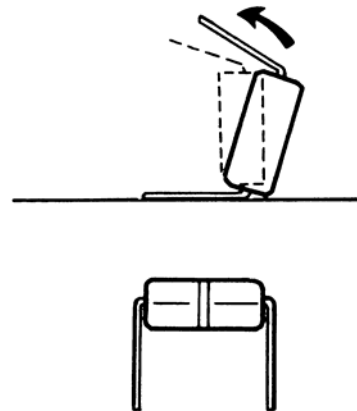
Most Integrated Circuits (ICs) in this kit are DIPs (Dual In-line Package) as pictured below. ICs and their sockets have a “pin 1” end. This is indicated by either a notch (IC or socket) or a dot stamped or printed on the IC. It is very important to orient both sockets and ICs correctly.



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 shown by the picture to the right.

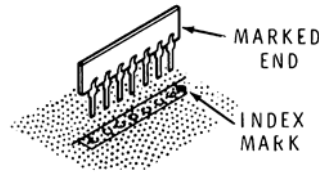


To bend the IC's pins so that it can be easily inserted into the circuit board or socket, lay the IC down on a hard surface on its side as shown in the picture to the right. Roll the IC towards the pins so that pins are at a 90° angle from the case. Turn the IC over and do the same thing to the other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



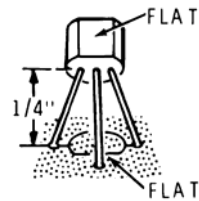
4.5 Resistor Networks

Resistor networks are Single In-line Packages (SIPs) that have multiple resistors in the package. Orientation of the component IS important. The network will have a dot at one end. This dot must be matched up with the white spot on the graphic on the circuit board.



4.6 TO-92 Package Voltage Regulator

The picture to the right shows a TO-92 package. The 9 V voltage regulator comes in this package. The device should be installed $\frac{1}{4}$ inch above the circuit board.



4.7 TO-220 Package Triac and Voltage Regulator

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



5 Parts Lists

The CTB-16K is sold as three parts kits. The *Standard Parts Kit* (CTB-16K) includes all the necessary parts to make a functioning CTB-16D light controller capable of handling a total of 15 amps. The *Deluxe Add-On Parts Kit* (CTB-16KD) adds unit selection switches, a speed control and the ability to run stand-alone sequences. The *Heat Sink Kit* upgrades the standard unit's power handling capability from 15 amps to 40 amps.

5.1 Standard Parts Kit

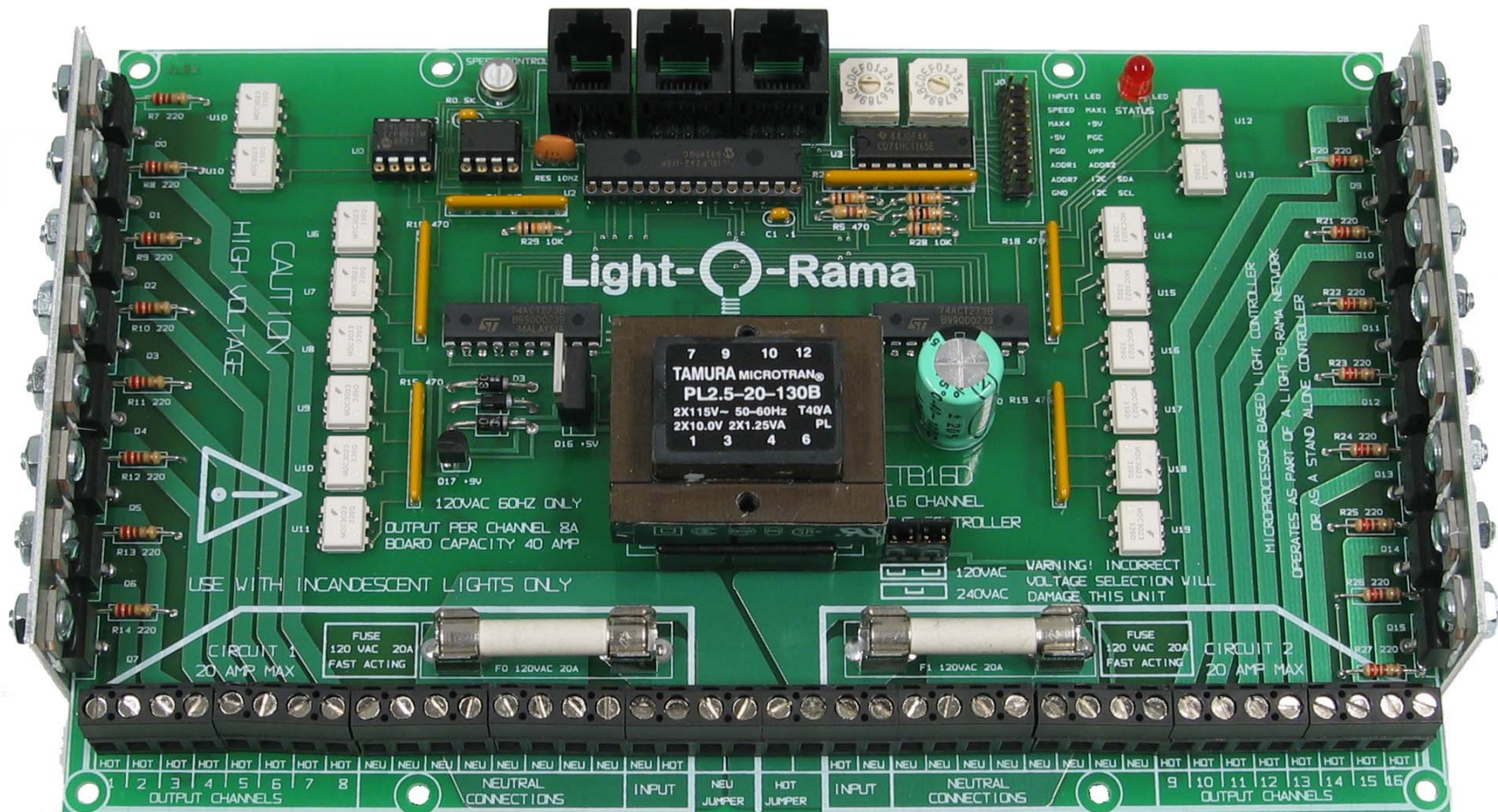
Quantity	Identification	Description	Part Markings
1	PCB	Printed circuit board	
2	No-clean solder	Fine gauge spool Medium gauge spool	
16	R7, R8, R9, R10, R11, R12, R13, R14, R20, R21, R22, R23, R24, R25, R26, R27	220 Ω , ¼ watt, 5% resistor	red-red-brown-gold
4	R3, R4, R28, R29	10 K Ω , ¼ watt, 5% resistor	brown-black-orange-gold
1	R5	470 Ω , ¼ watt, 5% resistor	yellow-violet-brown-gold
1	R6	1 K Ω , ¼ watt, 5% resistor	brown-black-red-gold
1	R17	470 K Ω , ¼ watt, 5% resistor	yellow-violet-yellow-gold
1	R1	4.7 K Ω , Resistor network 8 pin SIP, Isolated	8X-2-472
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, 16 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	BTA16-600BW
1	Q16	5V, 1.5A Voltage regulator TO-220 case	TL780-05C
1	Q17	9V, 100mA, Voltage regulator TO-92 case	LM78L09ACZ

2	C0, C1	.1uF 50V 10% Ceramic capacitor	104
1	C2	1000uF 35V Electrolytic capacitor	1000 uF 35v
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	PIC18F242
2	U4, U5	8 bit flip-flop 20 pin DIP	74ACT273
16	U6, U7, U8, U9, U10, U10, U10, U11, U12, U13, U14, U15, U16, U17, U18, U19	400V Triac opto-isolator 6 pin DIP	MOC3023 NOTE: board mis- marked – U10, U10, U10
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	
2	Jumper1, Jumper2	Small black plastic tabs with copper inside that are used on J1 to select voltage	
2	Light duty heat sink	Flat metal with 8 triac holes Use as 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	

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	U3	8 bit shift register 16 pin DIP	74HCT165
1	R0	5 KΩ Potentiometer	
1	R2	10 KΩ, Resistor network 10 pin SIP, Bussed	10X-1-103
2	S0, S1	Rotary switch	0,1,2,3,...F

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

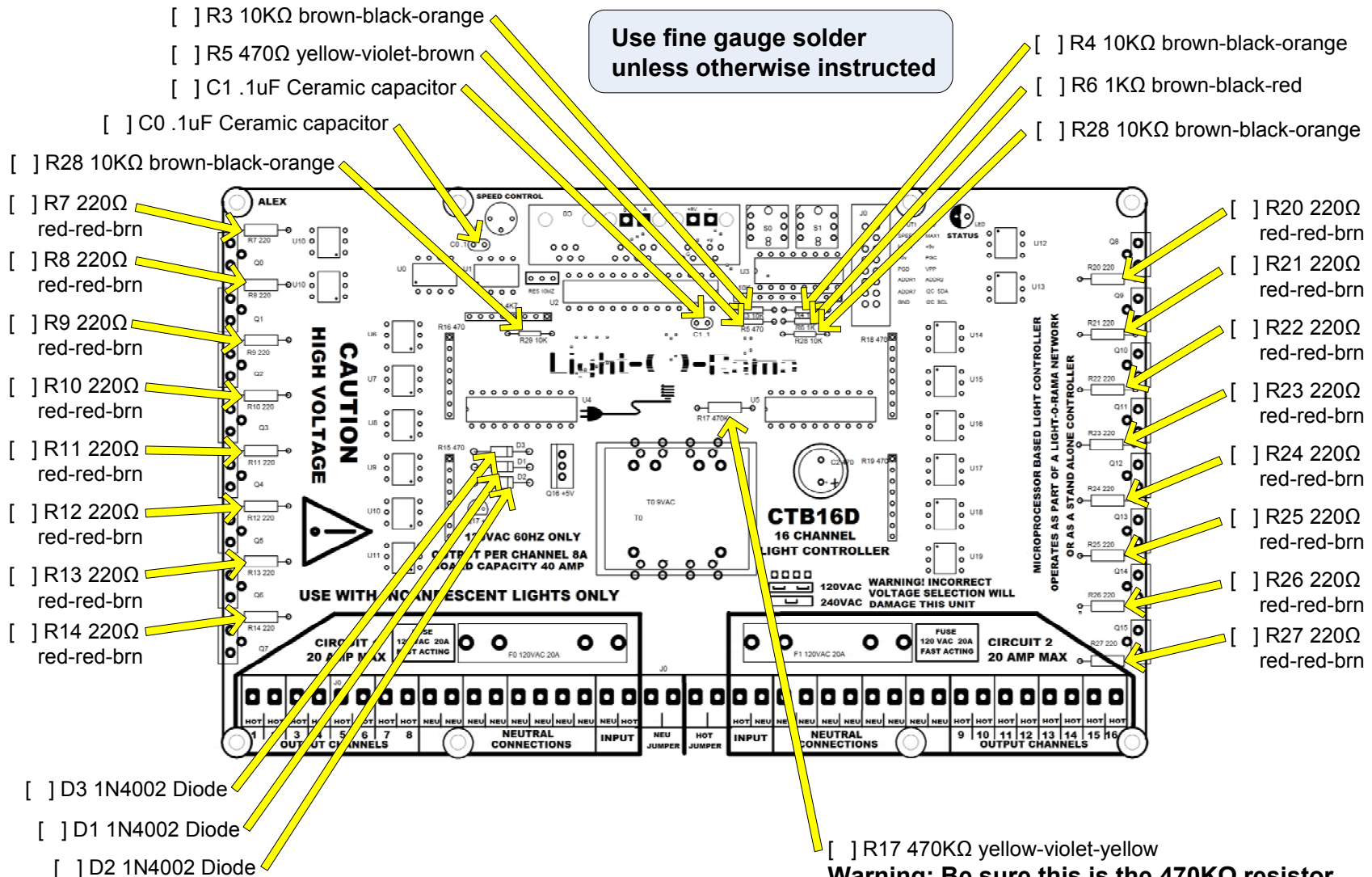


7 Assembly Instructions

7.1 Pre-Assembly Notes

- 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.
- 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.
- 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.
- The 9 volt regulator in the TO-92 package has very close lead spacing, be extra careful when soldering it in place to avoid solder bridges.
- Use the wire nippers or diagonal cut pliers to nip off the leads on the solder side of the board after soldering.
- 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...)
- 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.
- **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



Match the board markings with the diode's markings
Orientation is important

Warning: Be sure this is the 470KΩ resistor
An error here WILL fry the micro-processor

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

Use fine gauge solder unless otherwise instructed

[] U2 Socket (28 pins)
Notch on RIGHT

[] U1 Socket (8 pins)
Notch on LEFT

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

[] R1 4.7 K Ω
Resistor Network
Dot on RIGHT
Marking 8X-2-472

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

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

[] R2 10 K Ω (put in U3 first, bottom of page)
Resistor Network
Dot on RIGHT
Marking 10X-1-103
(Deluxe kit only)

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

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

[] U3 IC (16 pin)
Pin 1 (Notch/Dot) on LEFT
Solder directly into the board
Marking 74HCT165
Refer to Section 4.5 to straighten IC's pins
(Deluxe kit only)

CAUTION HIGH VOLTAGE

CTB16D 16 CHANNEL LIGHT CONTROLLER

WARNING! INCORRECT VOLTAGE SELECTION WILL DAMAGE THIS UNIT

USE WITH INCANDESCENT LIGHTS ONLY

CIRCUIT 1 20 AMP MAX

CIRCUIT 2 20 AMP MAX

OUTPUT PER CHANNEL 8A BOARD CAPACITY 40 AMP

120VAC 60HZ ONLY

120VAC 20A FAST ACTING

120VAC 20A FAST ACTING

NEUTRAL CONNECTIONS

INPUT

OUTPUT CHANNELS

NEUTRAL CONNECTIONS

INPUT

OUTPUT CHANNELS

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

Use fine gauge solder unless otherwise instructed

[] R0 5 K Ω Potentiometer (Deluxe kit only)

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

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

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

[] U10 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) Board is mis-marked, there are three U10 ICs.
- 3) Refer to Section 4.5 to straighten the pins of the ICs.
- 4) Pin 1 on an IC may be marked by a notch or dot.

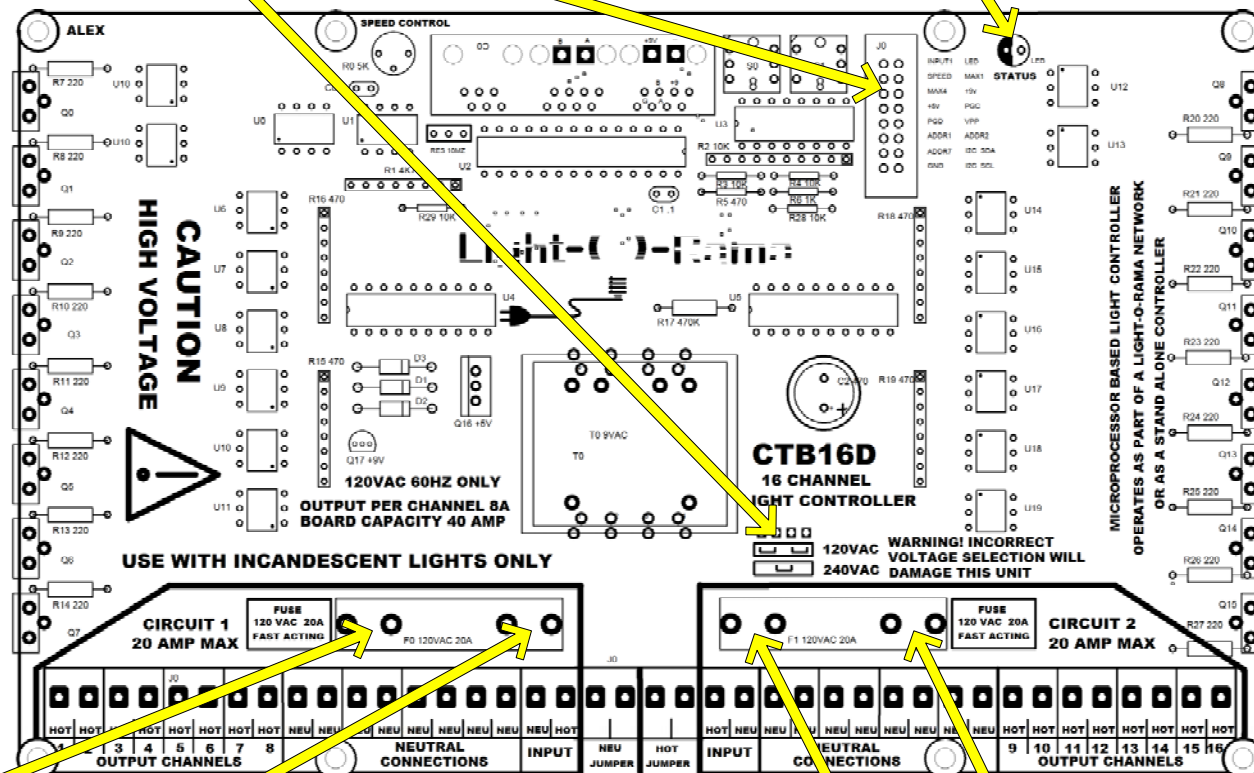
7.5 Assembly[4 of 7]: LED, Headers, Fuse holders

Use fine gauge solder
unless otherwise instructed

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

[] J0 16 Pin Header

[] J1 4 Pin Header



[] 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 an 'outside' and an '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.

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

Use fine gauge solder unless otherwise instructed

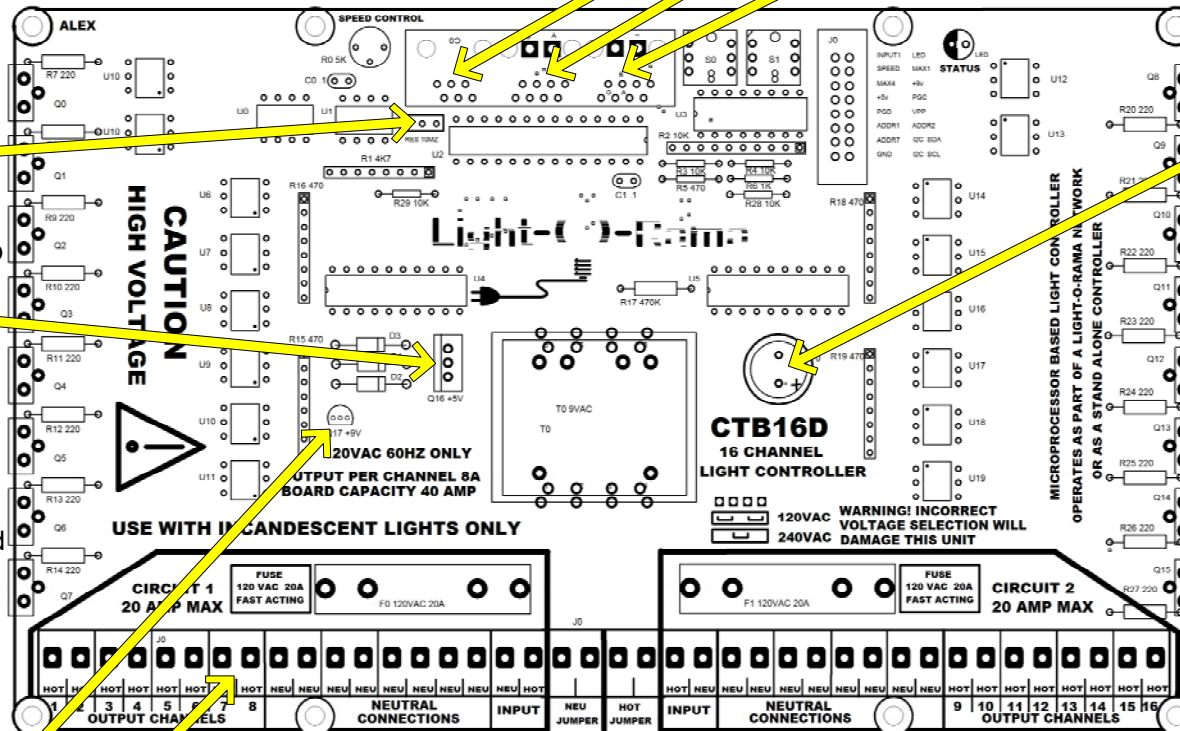
PUT THE SCREW TERMINAL STRIPS ON FIRST

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 10M Ω
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

- [] C2 1000uF 35v
Electrolytic cap
Make sure polarity markings on cap match the writing on the board. Plus or minus may be marked on the cap



- [] Q17 9v Reg
TO-92 package
Marking LM78L09ACZ
Make sure the flat side of the regulator is facing towards you as shown on the board.
The leads of this component are very close together. Be very careful when soldering to avoid solder bridges.
After soldering a lead, move the tip of the soldering iron up along the lead to draw the solder up the lead.
Be careful when you nip off the excess lead after soldering, the wire may spread and bridge.
- [] Screw terminal strips. Come in blocks of 4 or 6 screws. Use the blocks in any order to fill all 40 positions. Be sure you install them with the wire holes facing 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.

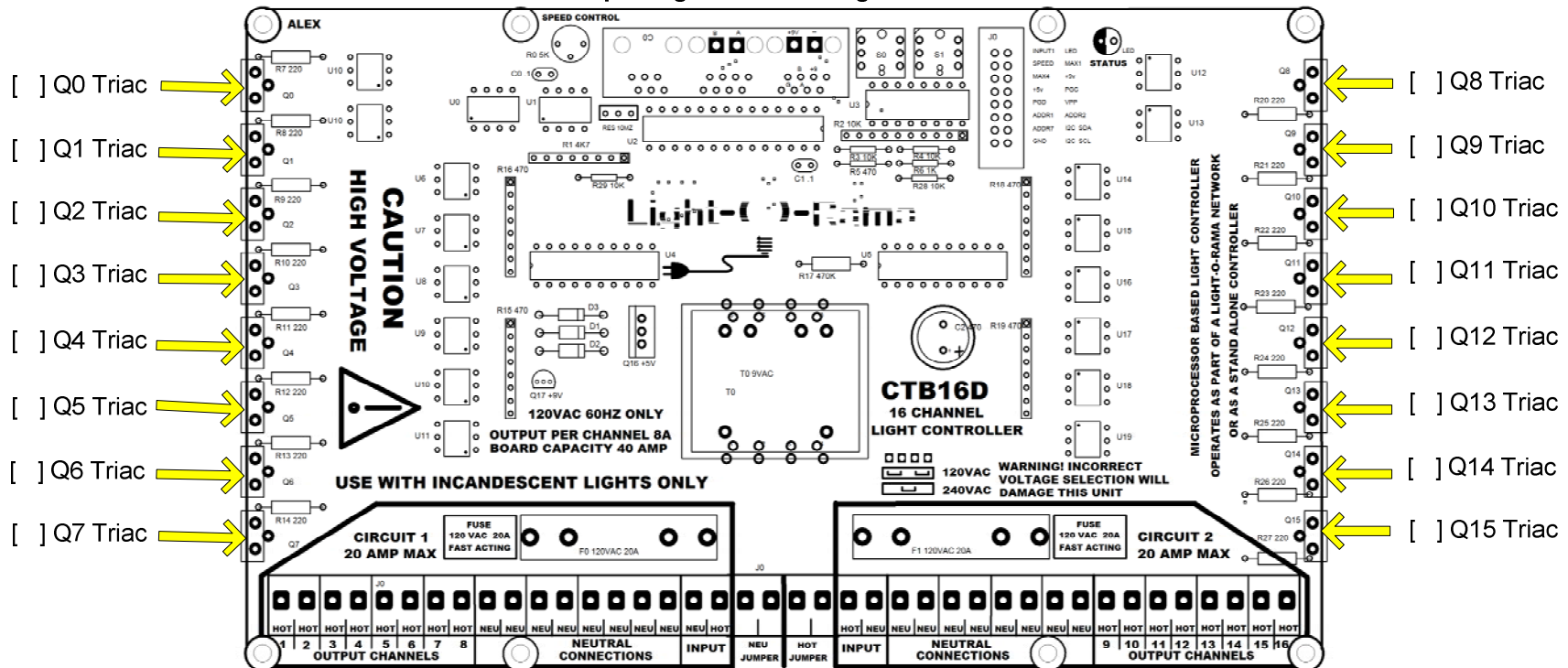
7.7 Assembly[6 of 7]: Triacs

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.

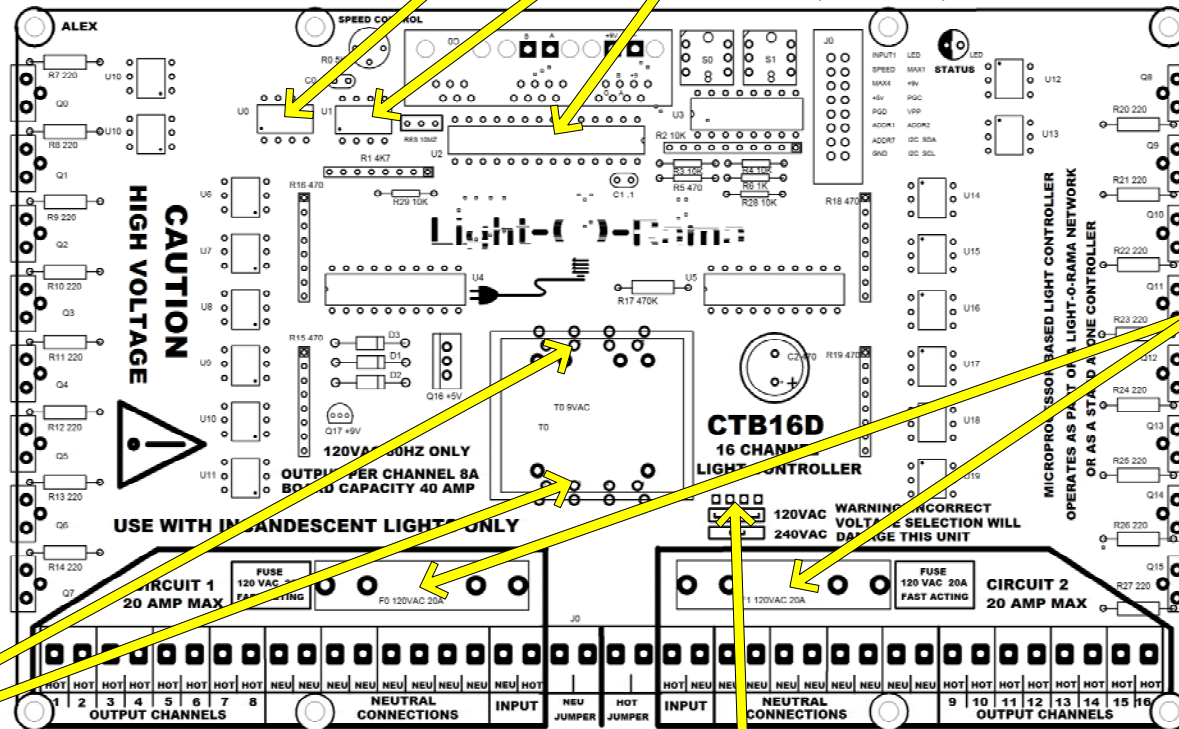
(4) Position the Light Duty Heat Sinks so that they extend about 3/8 inch above the Triacs' metal tabs. Put a screw with the head on the inside through each Triac and then through the heat sink. Use a lock washer and bolt on on the outside of the heat sink. Tighten the screws.

(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 PIC18F242
Pin 1 (Notch/Dot) on DIP to **RIGHT**



- [] Install two quick blow fuses

- [] T0 Transformer, Insert so the markings on it are NOT upside down. Use the two rows of four holes that are between the adjacent rows of holes as indicated by the arrows. 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

Assembly Completed

7.9 Post-Assembly Checks

- 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. Use a lighted magnifying glass. Pay careful attention to the TO-92 9 volt regulator Q17.
- Verify that R17 is really the 470 K Ω (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.
- 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.