
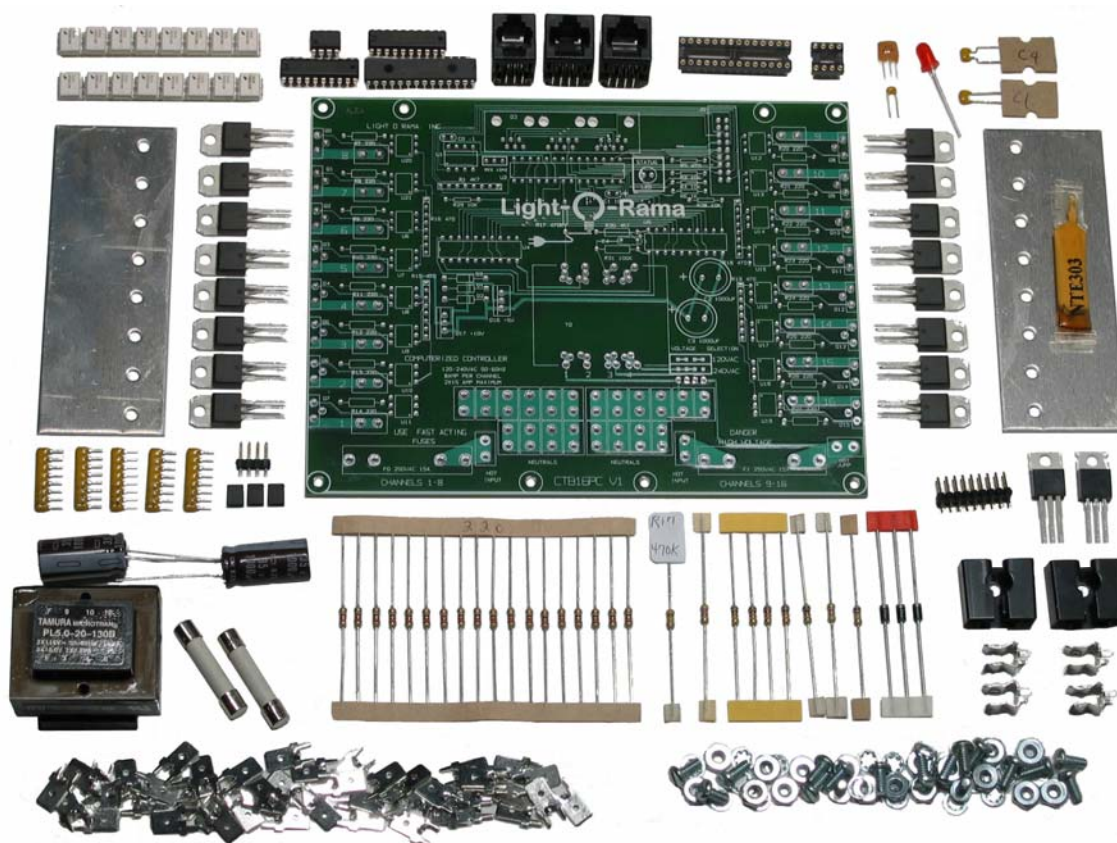




Light--Rama

CTB16Kpcv1



**Hobbyist Line Kit**  
**30 Amp 16 Channel Light Controller**  
**Assembly Manual**

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February 15, 2007  
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## 1 Introduction

Congratulations on your purchase of this genuine Light-O-Rama Hobbyist Kit brought to you in concert with PlanetChristmas. 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 low power heat sinks. They limit the total current carrying capability of the controller to 16 amps. 8 amps for each of the two 8-channel banks. If you opted to purchase the regular heatsinks, then the full 30 amp current carrying capacity of the controller can be used. 15 amps for each of the two 8-channel banks.

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 CTB16PC User's 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 650° F if temperature controller soldering iron)
- 40 watt pencil soldering iron (Use 800° F if temperature controller soldering iron)
- [optional but desirable] 100 watt soldering gun to solder the quick-connect terminals – these are effectively little heat sinks and the high power gun really helps here
- 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, spade lug terminals 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.

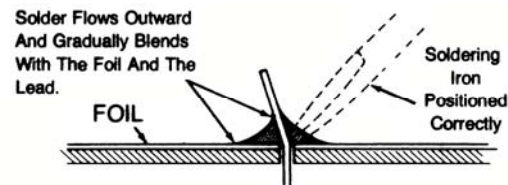
A 25 watt pencil tip soldering iron should be used to solder the rest of this board. This will help prevent component damage from over heating. Also, the small tip will help prevent solder bridges (unwanted connections) from forming between adjacent components and/or foil traces.

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.

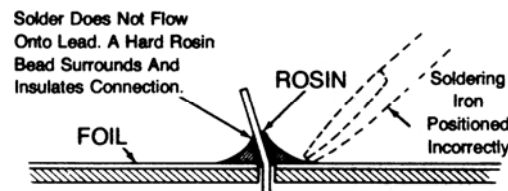
You should not need additional solder, but if you do, always use the thin shiny rosin core solder designed for electronics. Using acid core solder (plumbing solder) will damage everything.

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](http://www.radioshack.com).

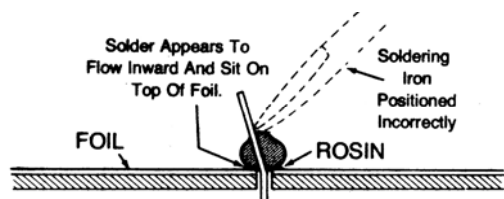
The picture on the right shows proper soldering technique. You must heat the lead and the board foil at the same time. Touch the solder to the other side of the lead and board foil from the soldering iron. The solder should flow evenly onto the lead and the foil making a good electrical connection between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

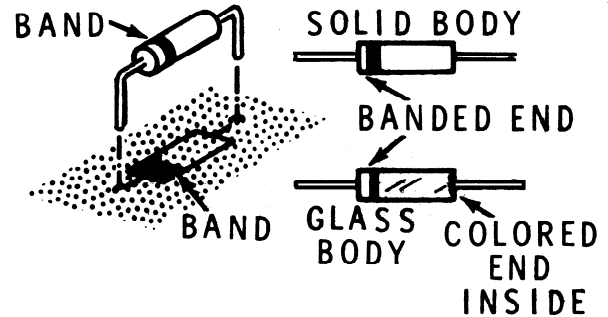


When soldering large foil areas such as those used to distribute the AC power or neutrals, start at the end with the smallest area and work toward the largest area. This will make the job go more quickly by utilizing the heat from the previous solder joint. Be sure to properly heat the foil, resistance caused by cold solder joints here can cause the board to burn when used.

## 4 Part Descriptions

### 4.1 Diodes

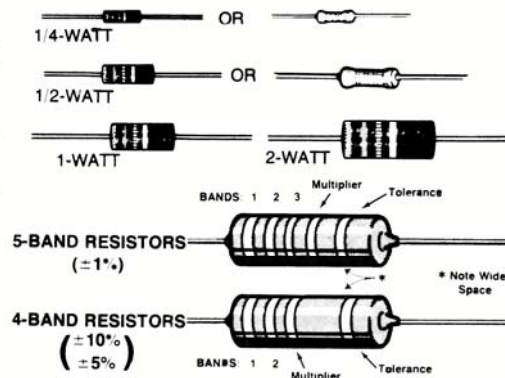
Diodes will be specified by the designation printed in the side of the part. Always match the band on the end of the diode with the graphic printed on the circuit board. Orientation IS important and the diode will NOT work if it is installed backwards. The band is painted on the outside of the diode.



### 4.2 Resistors

Resistors will be specified by their resistance value in  $\Omega$  (ohms), K $\Omega$  (kilo-ohms or thousands of ohms) or M $\Omega$  (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 <sup>st</sup> digit		Band 2 2 <sup>nd</sup> digit		Band 3 (opt) 3 <sup>rd</sup> 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  $\Omega$  5%):

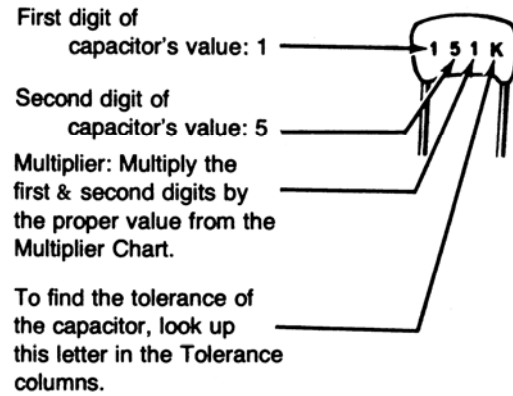
This is a 5% tolerance 4-band resistor, so we use the bottom most resistor pictured above. If you hold the resistor with the gold band on your right, then the colored bands will be red, red and brown starting from the left. Using the chart above, the first band (1<sup>st</sup> digit) is red, meaning '2,' the second band (2<sup>nd</sup> 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  $\Omega$ . 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 3<sup>rd</sup> color band before the multiplier.

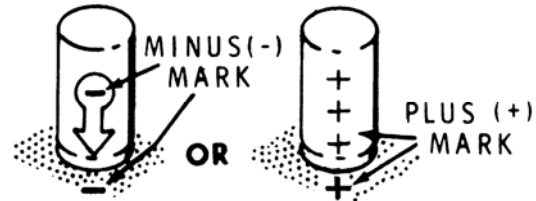
### 4.3 Capacitors

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.

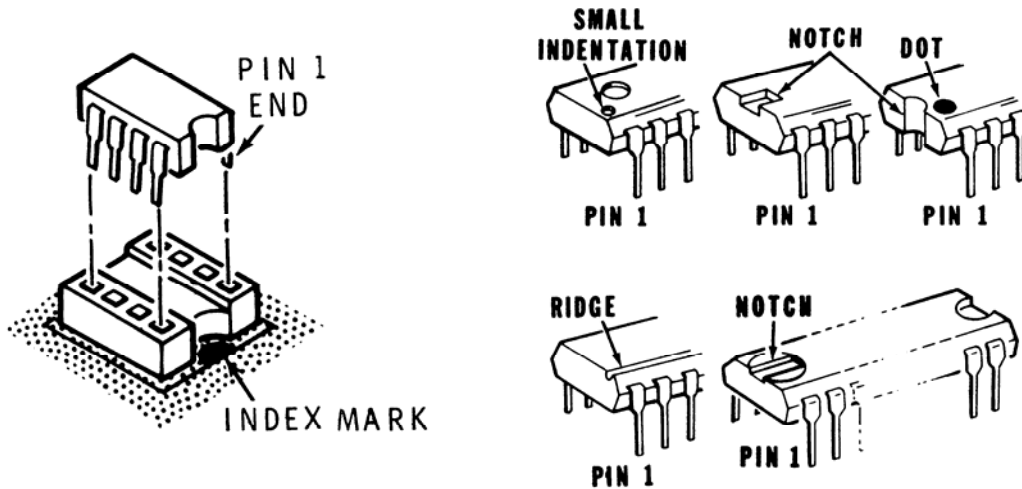


Multiplier		Tolerance		
Printed on capacitor	Multiply by	10 pF or less capacitor (in pF)	Letter on capacitor	Over 10 pF capacitor
0	1	$\pm 0.1$	B	
1	10	$\pm 0.25$	C	
2	100	$\pm 0.5$	D	
3	1,000	$\pm 1.0$	F	$\pm 1\%$
4	10,000	$\pm 2.0$	G	$\pm 2\%$
5	100,000		H	$\pm 3\%$
			J	$\pm 5\%$
8	0.01		K	$\pm 10\%$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



#### 4.4 DIP Integrated Circuits and Sockets

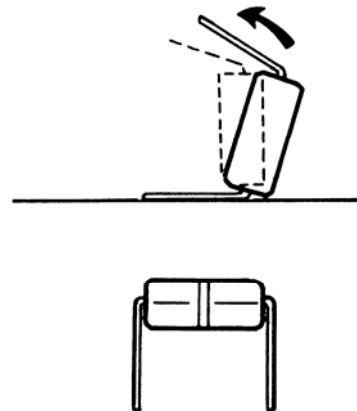
Most Integrated Circuits (ICs) in this kit are DIPs (Dual In-line Package) as pictured below. ICs and their sockets have a “pin 1” end. This is indicated by either a notch (IC or socket) or a dot stamped or printed on the IC. It is very important to orient both sockets and ICs correctly. Note that if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

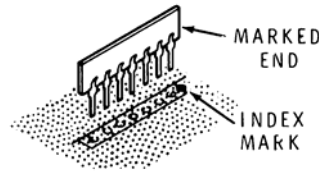


To bend the IC's pins so that it can be easily inserted into the circuit board or socket, lay the IC down on a hard surface on its side as shown in the picture to the right. Roll the IC towards the pins so that pins are at a 90° angle from the case. Turn the IC over and do the same thing to the other 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 **MAY** be important. The resistor network will have a dot at one end. Read the installation steps carefully.



#### 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.





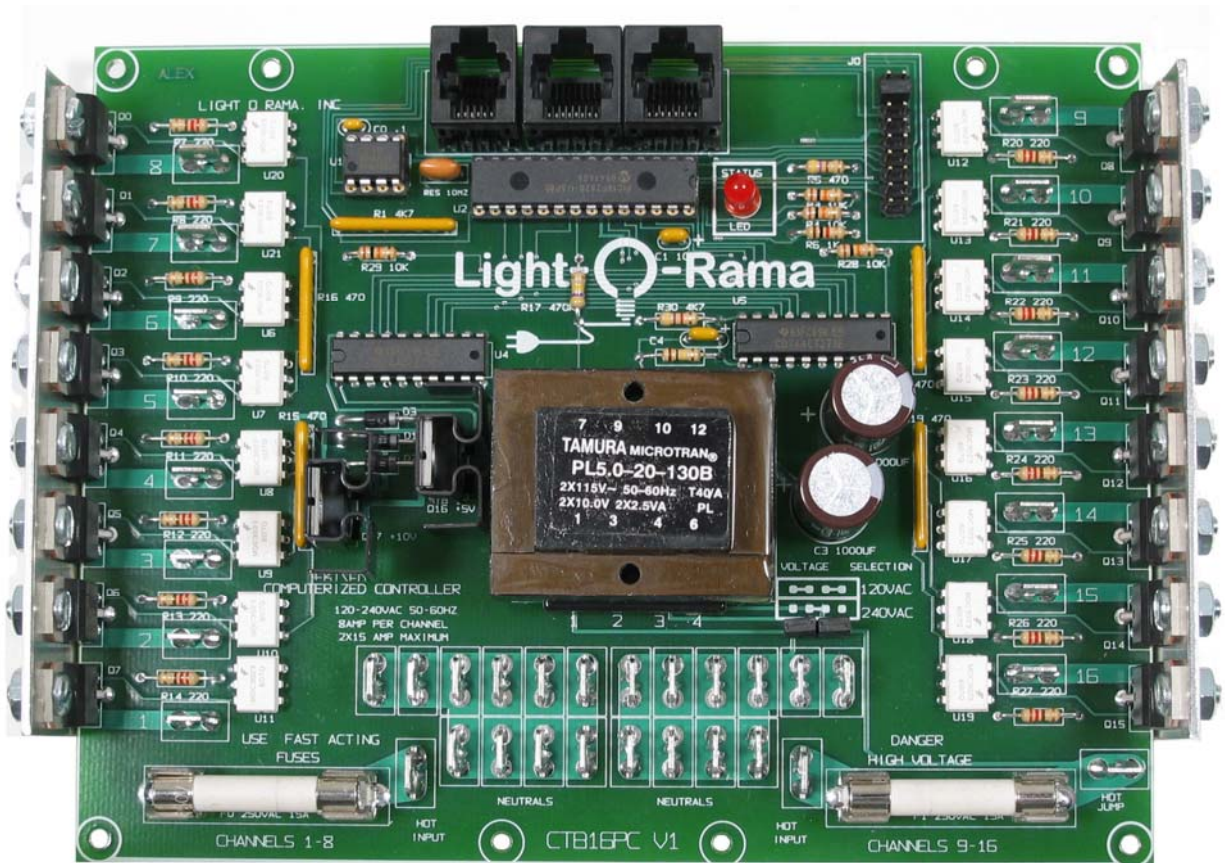
## 5 Parts List

- **Kit with low power heat sinks** includes all the necessary parts to make a functioning CTB16PC light controller capable of handling a total of 16 amps.
- **Kit with regular heat sinks** upgrades the current capacity from 16 to 30 amps.
- **Optional Plastic Enclosure** includes box, mounting screws and cable strain relief/grounding bar.
- **Optional Unit Power Cord(s)** includes one AC controller power cord and two jumpers or two AC controller power cords.
- **Optional Lighting Power Pigtails** includes eight 18" pigtail receptacles. Two sets required for 16 channels.

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 $\Omega$ , ¼ watt, 5% resistor 330 $\Omega$ , ¼ watt, 5% resistor (220 $\Omega$ for 120 VAC, 330 $\Omega$ for 240 VAC)	red-red-brown-gold orange-orange-brown- gold
4	R3, R4, R28, R29	10 K $\Omega$ , ¼ watt, 5% resistor	brown-black-orange-gold
1	R5	470 $\Omega$ , ¼ watt, 5% resistor	yellow-violet-brown-gold
1	R6	1 K $\Omega$ , ¼ watt, 5% resistor	brown-black-red-gold
1	R17	470 K $\Omega$ , ¼ watt, 5% resistor	yellow-violet-yellow-gold
1	R30	4.7 K $\Omega$ , ¼ watt, 5% resistor	Yellow-violet-red-gold
1	R31	100 K $\Omega$ , ¼ watt, 5% resistor	Brown-black-yellow-gold
1	R1	4.7 K $\Omega$ , Resistor network 8 pin SIP, Isolated	8X-2-472 -or- CTSK055177083472
4	R15, R16, R18, R19	470 $\Omega$ , 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	
39	1287-ST	Quick connect terminals	(Spade lugs)
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- sent 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	10uF 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 skew limited driver 8 pin DIP	MAX3082EEPA or ISL81487LIP
1	U2 socket	28 pin IC socket	
1	U2	Micro-processor	PIC18F2620
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	
2	Fuse0, Fuse1 covers	Translucent blue vinyl fuse covers	
3	Jumper1, Jumper2, Jumper3	Small black plastic tabs with copper inside that are used on J0 and J1	
2	Low power 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 low power 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 $\frac{3}{4}$ " x $\frac{3}{4}$ " x $\frac{1}{2}$ "

## 6 Completed CTB16Kpcv1 with Low Power 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  $\Omega$  resistors for R7 through 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  $\Omega$  resistors for R7 through 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 8 ]: Resistors, Diodes, Ceramic Capacitors

Use fine gauge solder unless otherwise instructed

[ ] R5 470Ω yellow-violet-brown

[ ] R3 10KΩ brown-black-orange

[ ] C1 10uF Ceramic capacitor  
(Note board marked as .1)

[ ] C0 .1uF Ceramic capacitor

[ ] R29 10KΩ brown-black-orange

[ ] R7 (Note 1)

[ ] R8 (Note 1)

[ ] R9 (Note 1)

[ ] R10 (Note 1)

[ ] R11 (Note 1)

[ ] R12 (Note 1)

[ ] R13 (Note 1)

[ ] R14 (Note 1)

[ ] D3 1N4002 Diode

[ ] D1 1N4002 Diode

[ ] D2 1N4002 Diode

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

[ ] R4 10KΩ brown-black-orange

[ ] R6 1KΩ brown-black-red

[ ] R28 10KΩ brown-black-orange

[ ] R20 (Note 1)

[ ] R21 (Note 1)

[ ] R22 (Note 1)

[ ] R23 (Note 1)

[ ] R24 (Note 1)

[ ] R25 (Note 1)

[ ] R26 (Note 1)

[ ] R27 (Note 1)

[ ] R30 4.7K yellow-violet-red

[ ] R17 470KΩ yellow-violet-yellow

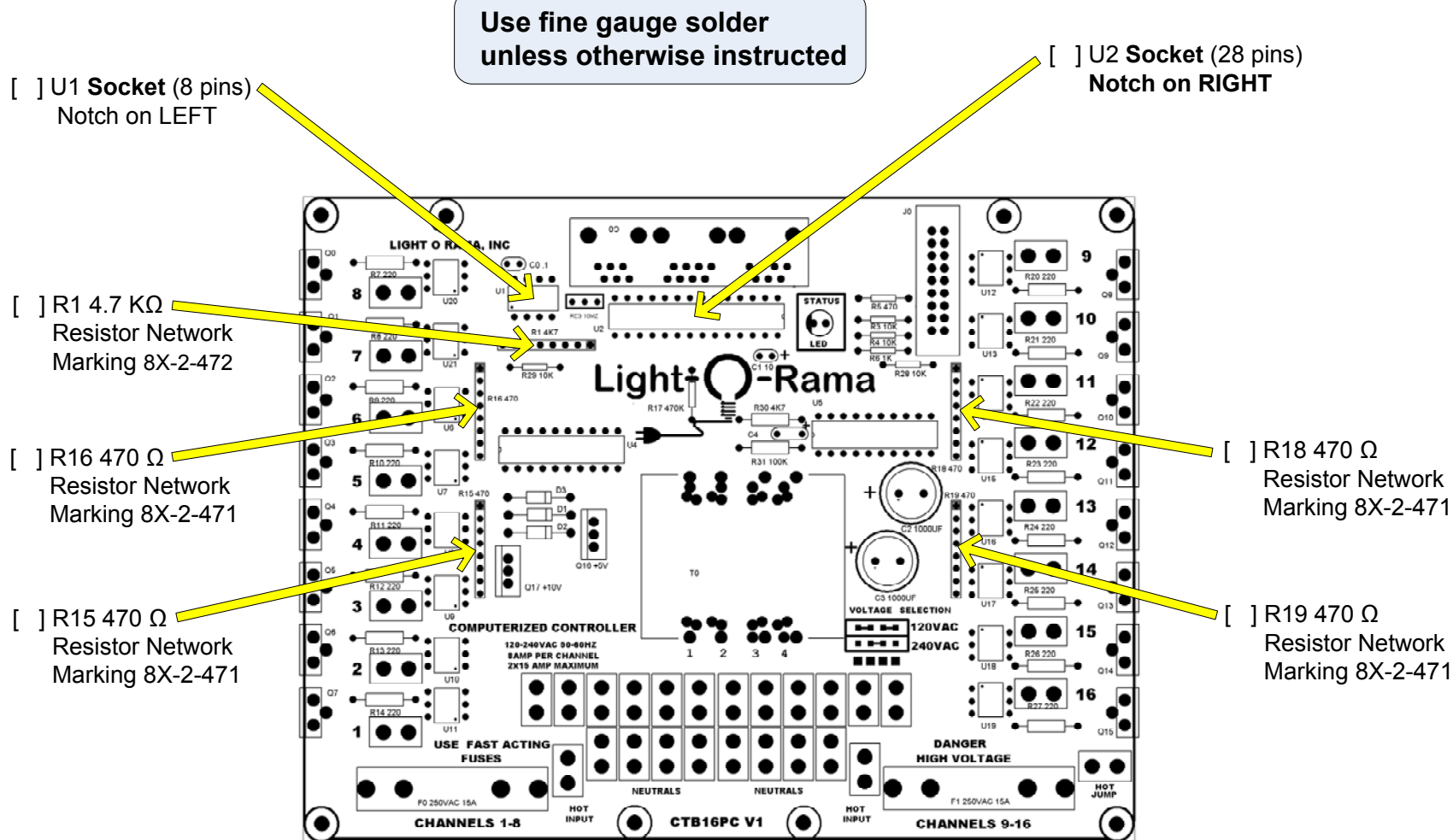
[ ] C4 .47uF Ceramic capacitor

[ ] R31 100K brown-black-yellow

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

**Note 1: Read (7) on page 12**  
**Use 220 Ω red-red-brn for 120 VAC**  
**Use 330 Ω org-org-brn for 240 VAC**

### 7.3 Assembly[ 2 of 8 ]: Resistor Networks, U3 IC, IC Sockets

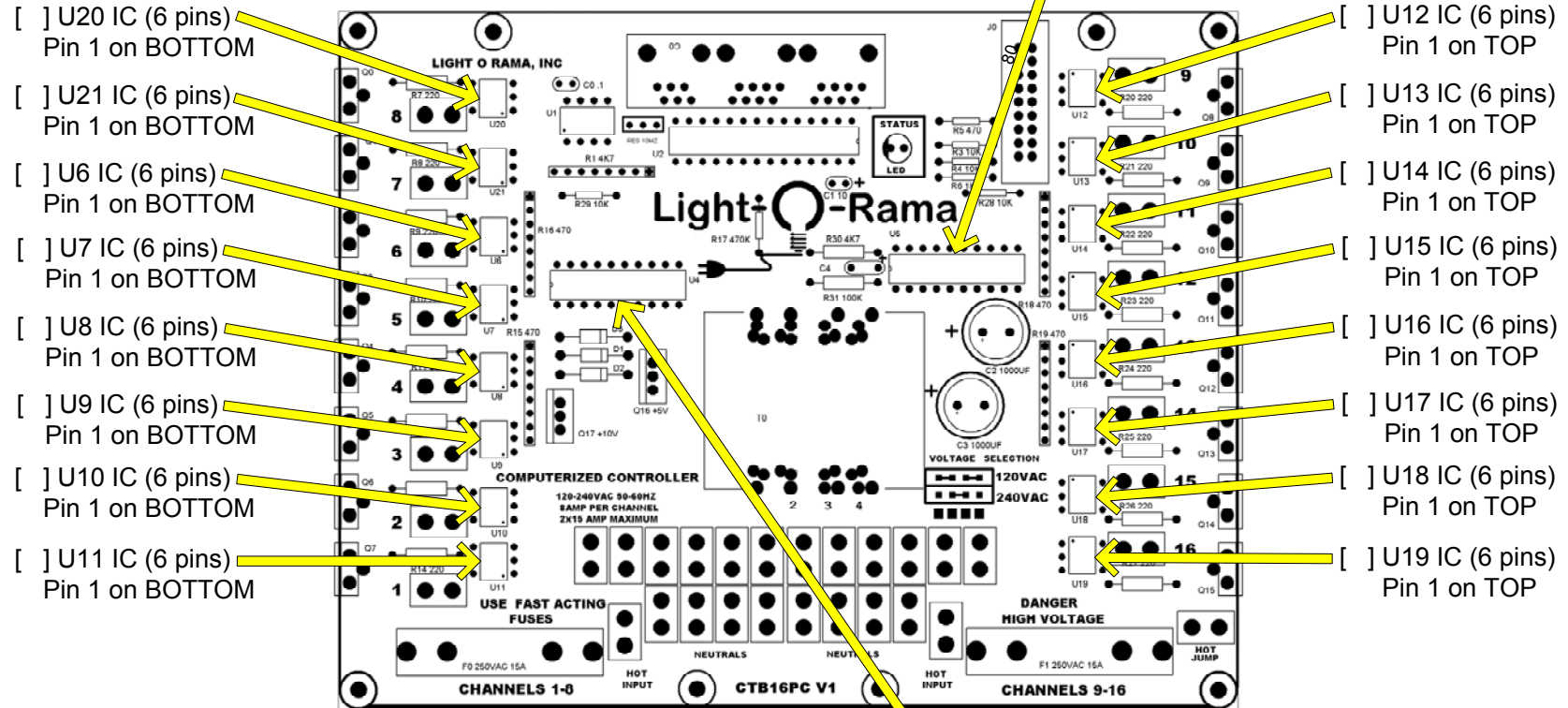


**NOTE:**  
The orientation of resistor  
networks R1, R15, R16, R18 & R19  
is NOT important.



## 7.4 Assembly[ 3 of 8 ]: Soldered in Integrated Circuits, Switches

Use fine gauge solder  
unless otherwise instructed



### 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.



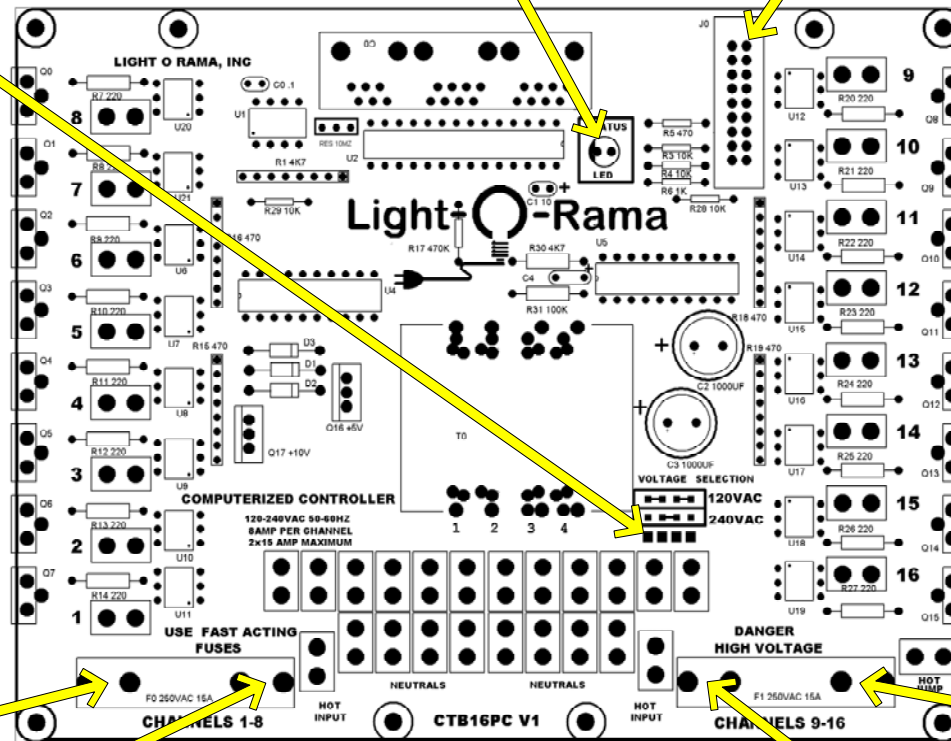
## 7.5 Assembly[ 4 of 8 ]: LED, Headers, Fuse holders

**Use fine gauge solder unless otherwise instructed**

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

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

[ ] 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

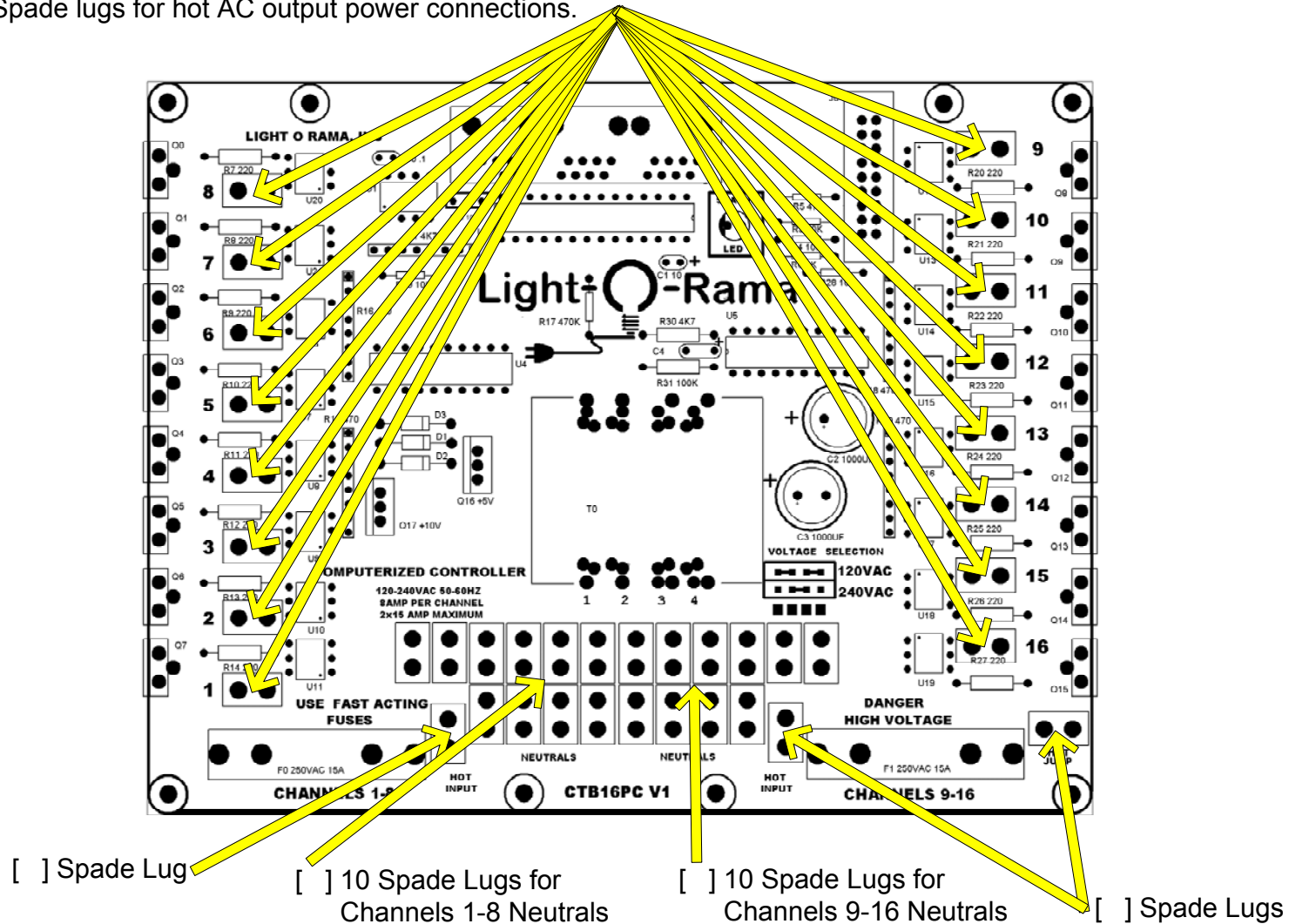
[ ] Fuse holder  
Edge with cuts on LEFT

**Note:** The four fuse holder components have 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. Make sure you completely fill the fuse holders' circular solder pads with solder.

## 7.6 Assembly[ 5 of 8 ]: Quick Connects (Spade Lugs)

Use a 40 watt soldering iron or 100 watt soldering gun and MEDIUM gauge solder. Some of the silver solder pads are large – make sure that the silver part of the pad is heated and solder flows over the entire silver surface.

[ ] Spade lugs for hot AC output power connections.



## 7.7 Assembly[ 6 of 8 ]: Voltage Regs, Jacks, Spade Lugs, Electrolytic Caps, Resonator

Use fine gauge solder  
unless otherwise instructed

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

[ ] RJ3 RJ12 (6 pin) Jack

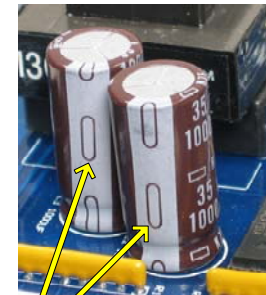
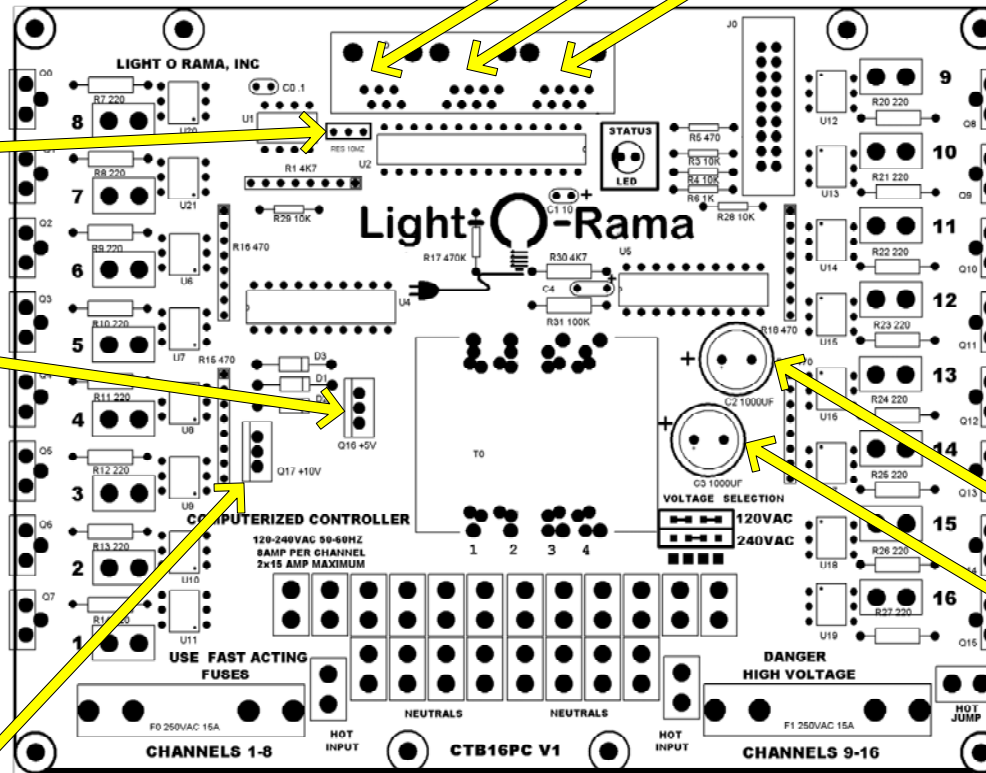
[ ] RJ1 RJ45 (8 pin) Jack

[ ] 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

[ ] 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



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

[ ] C2 1000uF 35v  
Electrolytic cap

[ ] C3 1000uF 35v  
Electrolytic cap

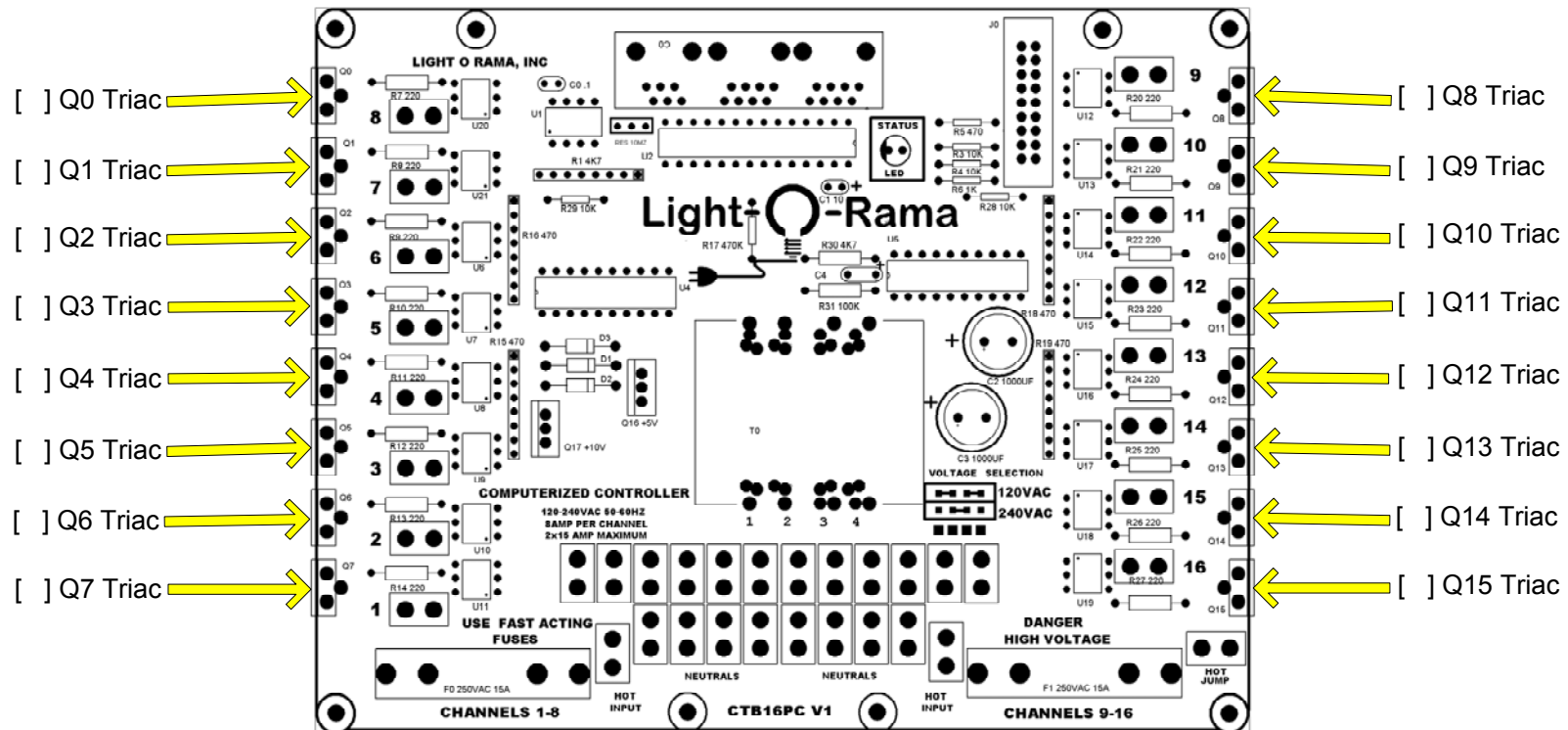
## 7.8 Assembly[ 7 of 8 ]: Triacs

### 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 the outside of the heat sink. Tighten the screws.

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

## 7.9 Assembly[ 8 of 8 ]: Transformer, Socketed ICs, Fuses, Jumpers

The two 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

Small projection on heat sink

[ ] 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**

[ ] Install a jumper across the second row from the top two pins

[ ] Install two quick blow fuses  
[ ] Install two vinyl fuse covers

[ ] 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.

**Assembly Completed**

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.



## 7.10 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 K $\Omega$  (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.
- Make sure the jumper is across the second row from the top of J0, otherwise the board will continuously reset. (To reset microprocessor: Power off, remove jumper, power on for a few seconds, power off, replace jumper)
- 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.
- There is a kit troubleshooting guide on the Light O Rama support page.

### Refer to the CTB16PC User's Guide to:

- Test your unit
- Mount it in the optional enclosure
- Attach AC the power cords

**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.

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

