

Universal Remote Controlled Lamp Dimmer V5 - Construction

Filename: "Universal Remote Controlled Lamp Dimmer V5-Construction.doc"
Created: Dec.3, 2000 Revised: Jan.6, 2001
By: William J. Boucher, 40 Timmins Cr. Unit#1, Chatham, Ontario, N7L4E1
<mailto:boucher@mnsi.net>, <http://www.mnsi.net/~boucher/index.htm>

For further information not contained in this document, refer to the User's Manual filename "Universal-Remote-Controlled-Lamp-Dimmer.pdf".

Disclaimer: Because the electronic device described herein operates directly on household line voltage, extreme caution is required to avoid personal injury, fire, etc. This project information is provided for educational use only. The author assumes absolutely no responsibility for its content or application or any damages resulting directly or indirectly from its use or misuse.



To build this project, you will need the following files:

Note: All 'pdf' files require Adobe Acrobat Reader V4.0 to view & print. All PCB layer files are viewed from top.

Filename	Description
IRCLD5-Schematic.pdf	The Lamp Controller Schematic Version 5
IRCLD5-PCB-Copper-Bottom.pdf	The PCB copper pattern for the bottom (solder) side.
IRCLD5-PCB-Silkscreen-Top.pdf	The PCB silkscreen pattern for the top (component) side. This is the parts layout.
IRCLD5-PCB-Drill-Map.pdf	The PCB drill drawing. It shows hole size & location for all holes you must drill.
IRCLD5-Enclosure-Drill-Template.pdf	Use this template drawing to accurately create all of the required holes in the Serpac enclosure.
Universal-Remote-Controlled-Lamp-Dimmer.pdf	The User's Manual
IRLCD501.SRC, IRLCD501.OBJ	The microcontroller source and object code files in Parallax ascii format.

Also required:

- A chip programmer capable of programming the Microchip PIC16F84-10/P microcontroller.
- Various hand tools for PCB work: Flush cutters, wire stripper, screwdrivers, soldering iron, etc.
- Machine tools: band saw, scroll saw, drill press, dremel motor & dremel drill stand, various drill & countersink bits.
- PCB etching equipment.
- PC & laser printer required for toner-transfer media (300dpi minimum).
- PC & high resolution printer require to reproduce required drawings (300dpi minimum).

PCB Bill of Materials:

Note: The following table provides part numbers, manufacturer names, and supplier part numbers. Often, more than one source is provided for your convenience. Many components are available from many other manufacturers and distributors not listed here. Data sheets for all components can be downloaded for free from the component manufacturers. Distributors usually provide links to the manufacturer sites.

Item	Qty	Ref	Description	Value	Manufacturer	Manufacturer Part Number	Supplier	Supplier Part Number	Price (USD)
1	1	C3	Capacitor, non-polarized, Radial Metallized Polyester Film or Polypropylene Capacitor, 250V 1.0µF	1µF 250V	Xicon Panasonic	MF250V ECW-F2105JB	Mouser Digikey	146-250V1.0K PF2105-ND	\$0.64 \$2.63
2	1	C1	Capacitor, aluminum, electrolytic 0.2" pin spacing, 0.4" (10mm) diameter, 0.65" (16mm) height	1000µF 10V	United Chemicon United Chemicon Samsung Samsung Panasonic Panasonic	SME10VB102M10X16LL KME10VB102M10X16LL SSL10V1000 STX10V1000 ECA-1AM102 ECE-A1AGE102	Electrosonic Electrosonic Mouser Mouser Digikey Digikey	SME10VB102M10X16LL KME10VB102M10X16LL 630-SSL10V1000 630-STX10V1000 P5127-ND P5221-ND	\$0.64 \$0.69 \$0.18 \$0.19 \$0.47 \$0.79
3	1	C2	Capacitor, radial, monolithic, molded case, 0.2" lead spacing	100nF 50V	Mallory	CK05104K CK06104K	Mouser	539-CK05104K 539-CK06104K	\$0.56 \$0.59
4	1	J2	Terminal Blocks, 4-pole, 5.08mm/90°	-	Weidmuller Thomas & Betts Augat	995132 999392 2MV-04 2MV-04	Newark Digikey Newark Newark	16F4126 281-1437-ND 46F862 46F862	\$1.35 \$1.20 \$1.88 \$1.88
5	1	J1	40kHz Infrared demodulator module	-	Lite-On Inc.	LT1060 LTM-8834-7	Digikey	160-1060-ND	\$3.06
6	1	D1	Diode, axial, DO-201AE case	1A 1000V	General Semi Rectron	1N4007	Mouser Mouser	625-1N4007 583-1N4007	\$0.04 \$0.04
7	1	Z1	Diode, zener, axial, DO-41 case	5.1V 1W	General Semi Rectron	1N4733A	Mouser Mouser	625-1N4733A 583-1N4733A	\$0.14 \$0.17
8	1	Z2	Diode, zener, axial, DO-41 case	6.2V 1W	General Semi Rectron	1N4735A	Mouser Mouser	625-1N4735A 583-1N4735A	\$0.14 \$0.17
9	1	L1	LED, Red, T1-3/4 case LED, Red, T1-3/4 case LED, Red, T1-3/4-RA case LED, Red, T1-RA case LED, Red, T1-3/4-RA case	-	Hewlett Packard LiteOn Chicago Miniature Chicago Miniature Lumex	HLMP-4700 160-1127 5380E1 5600F1 SSF-LXH101ID-1	Mouser Digikey Digikey Digikey Digikey	512-HLMP4700 160-1127-ND L20301-ND L20321-ND 67-1317-ND	\$0.18 \$0.25 \$0.62 \$0.62 \$0.85
10	1	TH1	Triac, 400V, 12A, TO-220 case, non-isolated Triac, 600V, 12A, TO-220 case, non-isolated Triac, 400V, 12A, TO-220 case, isolated Triac, 400V, 15A, TO-220 case, isolated Triac, 600V, 15A, TO-220 case, isolated Alternistor, 400V, 15A, TO-220 case, isolated Alternistor, 600V, 15A, TO-220 case, isolated	-	Motorola Motorola STMicroelectronics Teccor Teccor Teccor Teccor	MAC12D MAC12M BTA12-400B Q4015L5 Q6015L5 Q4015L6 Q6015L6	Newark Newark Mouser Digikey Digikey Digikey Digikey	66F3612 66F3613 511-BTA12-400B Q4015L5-ND Q6015L5-ND Q4015L6-ND Q6015L6-ND	\$0.80 \$0.80 \$0.98 \$2.65 \$3.08 \$2.75 \$3.22

Item	Qty	Ref	Description	Value	Manufacturer	Manufacturer Part Number	Supplier	Supplier Part Number	Price (USD)
11	1	U3	+5V monitor, TO-92 case	-	Motorola Telcom Semi Telcom Semi	MC34064P-5 TC54VN4502EZB TC54VN4302EZB	Newark Digikey Digikey	66F1319 158-1087-ND 158-1090-ND	\$0.77 \$1.07 \$1.07
12	1	U2	Opto-coupler, triac output, 5mA LED, 6-pin DIP case, 250VAC, non-zero	-	QT-Opto QT-Opto Toshiba	MOC3012 MOC3023QT TLP3023	Mouser Digikey Digikey	512-MOC3012M MOC3023QT-ND TLP3023-ND	\$0.60 \$0.75 \$1.25
13	1	V1	ZNR varistor, surge suppressor, 0.2" pin spacing, 130Vrms, 200Vclamp	1250A surge	Panasonic	ERZ-V07D201	Digikey	P7188-ND	\$0.34
14	4	Sw1-4	Momentary push-button, NO, 0.5"x0.5", with cap-stud	-	Omron Omron E-Switch	B3F-4050 B3F-4050 TL1100F160Q	Mouser Digikey Digikey	653-B3F-4050 SW413-ND EG1821-ND	\$0.35 \$0.48 \$0.47
15	12	Sw1-4	12mm Push-button cap, black	-	Omron Omron E-Switch	B32-1310 B32-1310 4J-Black	Mouser Digikey Digikey	653-B32-1310 SW455-ND EG1080-ND	\$0.21 \$0.29 \$0.24
16	1	U1	8-bit micro-controller, 18-pin DIP case, flash program memory, EEPROM	-	Microchip	PIC16F84-10/P	Digikey Newark	PIC16F84-10/P-ND 23C5011	\$6.75 \$7.75
17	1	F1	Fuse, 0.2" pin spacing	5A, 125V	Wickmann	Fast = WK4363BK Slow = WK4463BK	Digikey Digikey	Fast = WK4363BK-ND Slow = WK4463BK-ND	\$0.60 \$0.66
18	1	F1	Fuse PCB socket, 0.2" pin spacing		Wickmann	WK0009	Digikey	WK0009-ND	\$0.44
19	1	R2	Resistor, axial, 2W, 5%, metal oxide	330Ω 2W	Yageo Panasonic	RSF-200JB-330R ERG-2SJ331	Digikey Digikey	330W-2-ND P330W-2BK-ND	\$0.25 \$0.29
20	2	R4-5	Resistor, 1/4W, axial, 1%, metal film	10 kΩ	Yageo	MFR-25FBF-10K0	Digikey	10.0KXBK-ND	\$0.57/5
21	1	R8	Resistor, 1/4W, axial, 1%, metal film	182 Ω	Yageo	MFR-25FBF-182R	Digikey	182XBK-ND	\$0.57/5
22	1	R9	Resistor, 1/4W, axial, 1%, metal film	1.0 MΩ	Yageo	MFR-25FBF-1M00	Digikey	1.00MXBK-ND	\$0.57/5
23	1	R1	Resistor, 1/4W, axial, 1%, metal film	2.74 kΩ	Yageo	MFR-25FBF-2K74	Digikey	2.74KXBK-ND	\$0.57/5
24	1	R6	Resistor, 1/4W, axial, 1%, metal film	221 Ω	Yageo	MFR-25FBF-221R	Digikey	221XBK-ND	\$0.57/5
25	1	R3	Resistor, 1/4W, axial, 1%, metal film	562 Ω	Yageo	MFR-25FBF-562R	Digikey	562XBK-ND	\$0.57/5
26	1	XTAL1	Crystal, 0.2" pin spacing, HC49 case, tall or short can	10 MHz	ECS Inc. ECS Inc. CTS	ECS-100-S-1 ECS-100-S-4 MP100	Digikey	X057-ND X422-ND CTX057-ND	\$0.90 \$1.38 \$1.00
27	1	RFC1	Axial RF Power Choke	2.7μH, 5A	Delevan	2474-06L	Digikey	DN7406-ND	\$2.36
28	1	-	6-pin DIP socket for U2, Dual Leaf, Low Profile, Gold	-	AMP	2-641296-4	Digikey	A9406-ND	\$0.27
29	1	-	18-pin DIP socket for U1, Dual Leaf, Low Profile, Gold	-	AMP	2-640359-4	Digikey	A9418-ND	\$0.56
30	1	-	Heat sink with tabs for mounting TO-220 case triac TH1	-	Thermalloy Aavid	6107B-14-MT 6110 576602T00000	FAI Digikey	- HS208-ND	- \$2.19

Item	Qty	Ref	Description	Value	Manufacturer	Manufacturer Part Number	Supplier	Supplier Part Number	Price (USD)
31	1	HS1	TO-220 Mounting kit to mount TH1 to heat sink: Nylon shoulder washer, screw, nut, lock washer, optional insulator	-	Keystone	4724	Digikey	4724K-ND	\$0.96
32	4	-	Rubber self-adhesive foot, 0.5" round x 0.275". Feet will serve as soft top for buttons	-	Mode 3M		Electrosonic Newark		
33	1	-	PCB material, single sided, 2.5" x 3.8", 1 oz, FR4, 1/16" thick	-	M.G. Chemicals Injectorall Ele.		Electrosonic Newark Digikey		

Other Parts:

Item	Qty	Ref	Description	Value	Manufacturer	Manufacturer Part Number	Supplier	Supplier Part Number	Price
1	1		ABS Plastic enclosure, 3.35"x5.3"x1.5", black, Box comes with rubber feet & screws	-	Serpac	A-27B	Digikey	SRA27B-ND	\$8.78
2	1		Box infrared end panel	-	Serpac	2010IR	Digikey	SRA27-IR-ND	\$2.33
3	4		Box plastic standoff, screw, glue, Bag contains 100 units, order 1 bag.		Serpac	60 KIT	Digikey	SR60KIT-ND	\$30.60 /100
4	1		110VAC polarized power cord, 6' long, black		- Qualtek	- 221001-01	Mouser Digikey	173-11112 Q114-ND	- \$1.63
5	2		Polarized 110VAC/15A snap-in inlet, panel mount, solder lug		H.H. Smith Schurter	- 4300.0705	Electrosonic Newark	1284 92F3539	- \$0.83
6	1		Rubber grommet, 0.5" OD, 0.2" ID Fits 0.312" (5/16") hole		Mode Keystone - Richco	- - - -	Electrosonic Newark McMaster-Carr Digikey	- - - RP452-ND	- - - \$1.67/ pkg (10)
7	1		22ga, 600V, stranded hookup wire, black, 6" required, 100' roll		Alpha Wire	3071	Newark Digikey Mouser	- A2101B-100-ND 602-3071-100-02	- \$14.83 \$8.78
8	1		22ga, 600V, stranded hookup wire, white, 6" required, 100' roll		Alpha Wire	3071	Newark Digikey Mouser	- A2101W-100-ND 602-3071-100-01	- \$14.83 \$8.78

Alternates:

Rubber Grommet: Keystone cat# 777 at <http://www.keyelco.com/kec/standpro/stdframe.htm>
 Richco strain relief: Digikey PN: RP460-ND for 11.1mm hole, RP461-ND for 9.52mm hole

J1, IR Demodulator: Digikey PN: 160-1164-ND, \$2.66

Nylon PCB Spacers with 4-40 thread (PCB standoff to replace Serpac "60 KIT"):
 Digikey PN: 1902AK-ND, \$4.65/pkg(10), Keystone hex standoff
 Digikey PN: 8440AK-ND, \$5.15/pkg(10), Keystone flame-retardant hex standoff
 Newark PN: 30F1457, \$17.82/pkg(100), H.H.Smith type 4050, 4-40 threaded, 0.25", nylon

Black wire: Digikey PN: General Cable, C2101B-100-ND, \$9.43/100'roll
 Alpha type 3051

White wire: Digikey PN: General Cable, C2101W-100-ND, \$9.43/100'roll
 Alpha type 3051

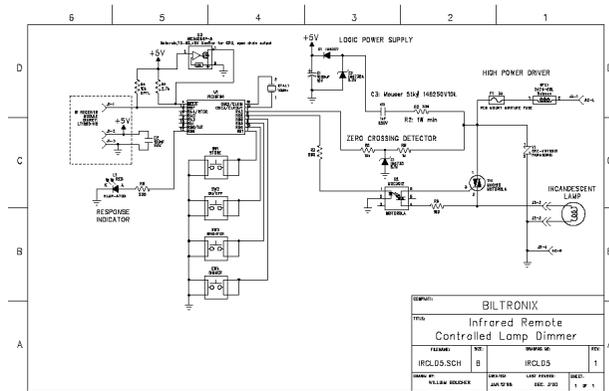
Thermopad: NTE TP0006, 5/pkg, replaces mica insulator & grease, Allied Electronics, Newark

Assembly Procedure:

Note: This procedure assumes you know how to etch & drill PCBs, solder, use hand tools, identify electronic components, etc. If you do not, you must refer to other sources for such information.

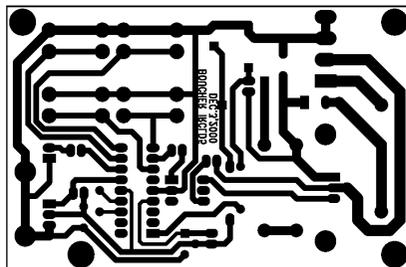
Step 1 - Schematic:

Print the schematic from the provided 'pdf' file. You will need it throughout most of the assembly procedure.



Step 2 - Etch the PCB:

You must use the provided 'pdf' file for the PCB copper pattern to produce a 1:1 scale image on whatever media you plan to make your PCB from. 'Press'N'Peel Blue' or 'Toner Transfer' sheets work great in any laser printer. Be sure to clean the image mask (toner or emulsion) from the PCB before drilling. To remove toner, use an SOS pad or other fine steel wool with dish soap. Avoid using chemicals at this stage as it is unnecessary and is bad for the environment as well as you.

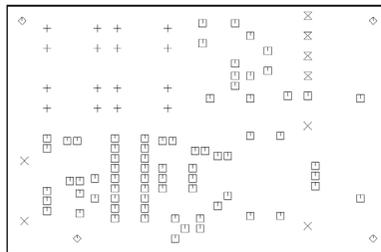


Step 3 - Drill the PCB:

Print the drill pattern from the provided 'pdf' file. Refer to it for hole locations and sizes. Don't try to attach the paper pattern to the PCB to drill it. It will not likely produce accurate results. Just refer to the drawing visually while punching the PCB. Use a small center-punch and a very small hammer to make a tiny mark at the center of each hole's location. You should be able to eye-ball these marks close enough (within 0.025").

Drill all the holes with a 0.040" (#60) drill bit. Carbide bits are best but they cost more and break easier than 'high speed steel' bits. You should use a variable speed dremel motor mounted in a small 'drill press' stand. Set the speed to the lowest setting (about 5000 rpm) for the 0.040" holes. If you use a higher speed, it is much more likely that you will prematurely dull and/or break the bit.

Drill all holes that are supposed to be larger than 0.040" using the appropriate size bits as indicated by the drill map drawing. Do not use a dremel motor for these holes. It is too fast and will just burn your bits. Also, it lacks sufficient torque for the larger holes. Use a small drill press or a standard variable speed handheld drill. Use 500 to 1000 rpm. It is a good idea to debur the larger holes using a deburring tool, a countersink bit (my favorite deburring tool), or a larger drill bit.



SIZE	QTY	SYM	PLTD
62	16	+	x
94	4	×	x
40	73	□	x
125	4	◇	x
50	4	⊗	x

Step 4 - Machine the enclosure:

Note: You will need a drill press for this stage. It is very unlikely that you will be able to accurately locate all the holes using a hand-held drill. It's a good idea to place a paper towel between the plastic part and the drill press table to prevent marring while clamping or drilling. It's also a good idea to thoroughly clean the drill press table before working to remove oils and small hard bits of debris.

Note: You will get better results and have a much easier time drilling if you drill all holes first with a 0.125" bit and then size up all of the holes using countersink bits or a step-drill bit.

First, use a pair of flush side-cutters to remove all of the Serpac enclosure's molded PCB standoffs. None of them are needed and some will get in the way of new holes and components.

Print the enclosure drill template drawing to scale (pdf). Cut out both sections and place them on the box top and rear panel as shown below. Use a soldering iron (set the iron temperature to about 500°F) to make 'center marks' for all the box top holes and for the center hole in the rear panel. Also, make about 6 small marks around the inside of the rear panel rectangular holes to help hold the paper down flat to the panel. Keep the marks well within the rectangular hole boundary (about 2mm).

It is a good idea to use some clear tape to hold the pattern to the rear panel. It doesn't hurt to use tape on the top pattern, but it usually is not required because the soldering tip marks will usually hold it in place well enough.

Drill all the circular holes using a 0.125" bit. Also drill just one hole within the rectangular hole areas. This hole will serve as a starting point for the scroll saw used to complete the hole. Do not try to drill out a corner. The scroll saw will do a much better job on the corner.

Use a scroll saw (variable speed electric is by far the best) to cut out the rectangular holes in the rear panel. You can deburr the rectangular holes using an X-acto knife or a standard deburring tool.

Now you must 'size up' the circular holes. The templates indicate the sizes. You should use a 'step-drill' or a 'countersink bit' to increase the size of holes in thin plastic materials. If you try to use standard steel bits (intended for metal), the bit will very like grab the work piece. This will chew up the panel, crack it, or even tear the piece from your hand (if you drill without and clamps). For the top panel, place a 1/2" countersink bit or a step-drill bit that goes up to 1/2" into your drill-press. Before turning on the drill press, locate the holes exactly by lowering the tip of the bit into the hole and then clamping the work piece using a standard vice-grip 'big-C' clamp. It doesn't need to be excessively tight to hold these plastic parts. After you've 'sized up' all the holes, use a large countersink bit or a deburring tool to produce a small chamfer around all the circular holes to improve their appearance.

Removing the molded PCB bosses:



Template placement:

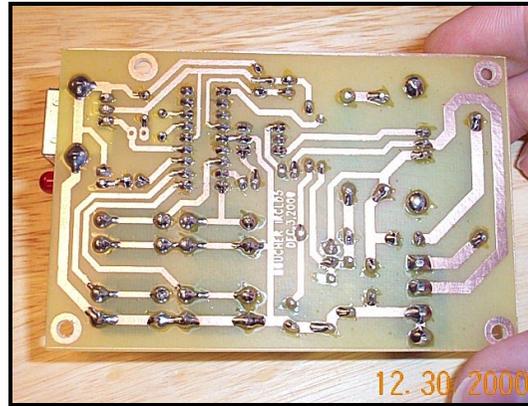
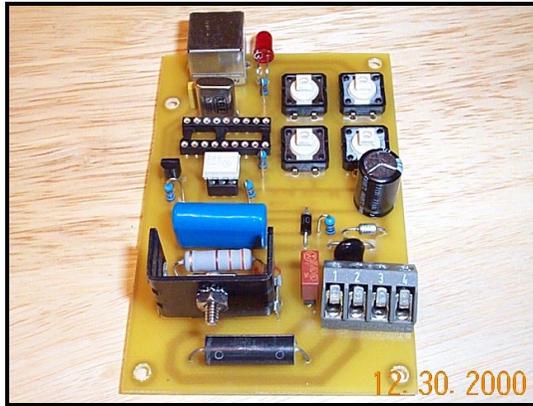


Marking the holes:



Countersink bits (1/2" & 5/16"):





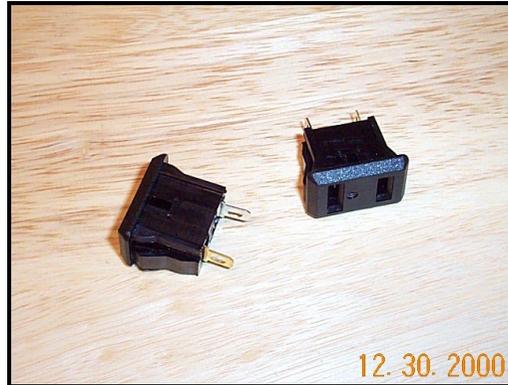
To install the Triac (TH1), first install and solder the heat sink. Then insert the triac, along with an insulator or thermopad if appropriate. Then secure the triac with a 4-40 x 1/4" machine screw and nut. Solder the triac terminals last. If the triac is an 'isolated' type, you don't need an insulator behind it or a nylon shoulder washer for the mounting screw. If the triac is not isolated, then you do need the insulator and nylon shoulder washer. These components prevent the heat sink itself from ever becoming 'live'. If you install the triac without an insulator or a thermopad, you should apply a small amount of white thermal-grease (heat sink compound) to the back of the triac before installing it. If you do use an insulator, you must apply a little heat sink grease to both sides of the insulator. If you mount the triac with a thermopad, you don't need any grease at all. You might want to apply a little bit of soft adhesive to the triac retaining screw and nut to make sure it will never come loose. The adhesive can be seen in a photo in a following section.

To complete the PCB assembly, program U1 (PIC16F84-10/P) with the object file compiled from source code file IRCLD501.SRC and install the chip into its socket. Observe the polarity. The chip notch must go towards the outer edge of the PCB, away from the button keys. Also install the opto-coupler chip U2. Make sure that pin #1 of U2 points towards the button keys. Note that pin #1 of both chips is indicated by a rectangular pad on the copper pattern.

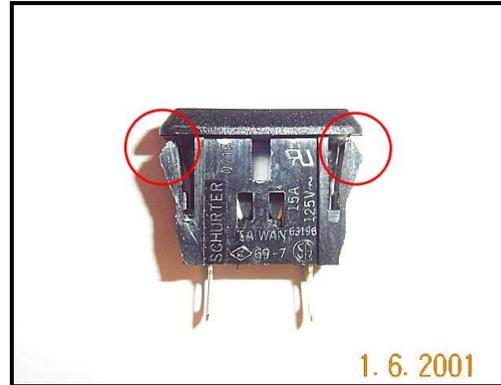
Step 6 - Machine the Power Outlets:

Unfortunately, the 2-prong polarized panel-mounted power outlets are manufactured for a steel panel that is thinner than the Serpac enclosure's plastic panel. To make the outlets 'snap in' properly, you must remove some material from the snap-tangs on each side. This is very easy to do if you have a small band saw. Alternately, you could use a hacksaw blade or even just a file. The idea is to remove just enough material from the snap-tangs to allow them to expand after the outlets are pressed into their rectangular holes. If the tangs do not spread after the outlet is pressed into the hole, the outlet will pull out of the panel whenever you try to unplug any lamp that was plugged into it.

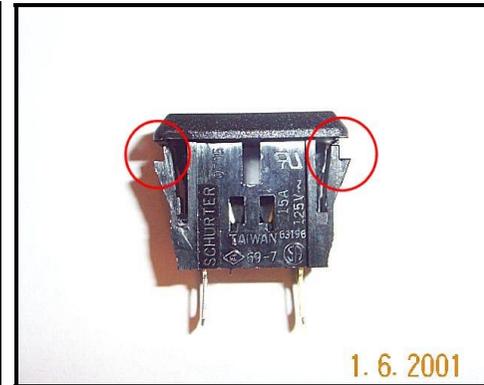
Two 110VAC snap-in outlets:



Snap-tangs before cutting:



Snap-tangs after machining:



Step 7 - Making the pushbutton switch caps:

You need to make extended push-button caps in order for the buttons to reach the top of the enclosure. This is very easy to do. Simply super-glue together three square button caps. Using a jig helps maintain exact alignment between the pieces so you can reliably produce straight stacks. A piece of wood, plastic, or metal with a 90° step in it is all you need for a jig. Place the first cap on its side into the step of the jig so the bottom of the cap is exposed. Put a little bit of super-glue on the snap area on the bottom of the next cap as shown below. Place that cap into the corner and slide it sideways, straight toward the first cap. Hold the two caps together a few seconds until the glue sets. Repeat this process one more time to make a stack of three caps. Make a total of four such cap stacks. Press the cap stacks onto the four push-button switches on the PCB.

Gluing the middle cap:



Gluing the top cap:



All caps glued together:



Step 8 - Installing the PCB:

Installation using Serpac '60 Kit' standoffs:

1. Apply the self-adhesive rubber feet that came with the enclosure to the bottom of the enclosure.
2. Using the screws supplied with the plastic PCB mounting standoffs, attach four of the standoffs to the PCB located at the four 0.125" mounting holes.
3. Place the assembled PCB onto the enclosure bottom section in the position it will rest when fully installed. Place the enclosure top section on top of the bottom section so the top and bottom sections are properly fitted together. Do not install the end panels.
4. Look through the top four holes. Using your fingers through the end-panel areas, align the PCB such that the key-caps are best aligned directly under the holes. So far, you've performed a test fit. The IR receiver and LED should be located very near where the inside surface of the front panel will be, but they cannot protrude beyond this limit.
5. Remove the box top. Put some glue on the bottom of all four PCB standoffs. Place the PCB back onto the enclosure bottom as near to the previously determined position as you can. Replace the box top, look through the holes again and align the PCB as before. Allow the assembly to sit long enough for the glue to completely set.

Installation using standard 4-40 threaded standoffs:

1. If you would like to glue the standoffs to the enclosure bottom, use the same procedure as for the Serpac '60 Kit'. If you wish to screw the standoffs to the enclosure bottom, continue with this procedure.
2. Place the PCB assembly onto the enclosure bottom section. Place the enclosure top section onto the bottom section such that the sections are fitted together. Do not install the end panels.
3. Using your fingers through the end-panel areas, align the PCB so that the key-caps are best aligned directly under the holes in the top section.
4. Carefully remove the enclosure top section without disturbing the position of the PCB assembly. Using a soldering iron set to 500°F, point straight through the four 0.125" mounting holes of the PCB to make a center mark in the plastic enclosure bottom.
5. Remove the PCB assembly and drill four 0.125" holes in the enclosure bottom where you marked it. Decide now if you would like to use flat head mounting screws or pan-head screws. If you want to use flat-head screws so the heads will lie flush with the enclosure surface, you must use a countersink bit to countersink the holes.
6. Attach four standoffs to the enclosure bottom using 1/4" 4-40 thread stainless steel machine screws.
7. Apply the self-adhesive rubber feet that came with the enclosure to the bottom of the enclosure.
8. Place the PCB assembly over the standoffs and secure it with four pan-head 1/4" 4-40 thread stainless steel machine screws.

Step 9 - Install the grommet in the rear panel:

Most rubber grommets this size are not made for plastic panels as thick as the Serpac enclosure panel. Using flush side-cutters, remove the rubber flange from one side of the grommet. Put a little super-glue around the inside of the remaining flange and press the grommet into the center hole of the rear panel. Allow the glue to set thoroughly.

Step 10 - Install the power outlets:

Snap two 110VAC polarized outlets into the rectangular holes in the rear panel. Refer to the photo below to determine the position of the large and small 'prong holes'. The polarity is important to maintain safety.

Step 11 - Wiring

1. Note: If your outlets have terminals that are not 'brass' and 'silver' in color, then consider the narrow or short prong hole to be the brass terminal and the wide or long prong hole to be the silver terminal.
2. Cut four pieces of 22ga stranded wire, each about 2" long, two black and two white. Strip about 5mm of insulation off of each end of the wires. String a black wire from the brass terminal of one outlet to the brass terminal of the other. String a white wire from the silver terminal on one outlet to the silver terminal on the other outlet. At this point, the bare wire ends should be bent snugly around the terminals, entering through the solder-lug hole, but they should not yet be soldered.
3. Attach one black wire to the brass terminal of the socket that is nearest the PCB terminal block by inserting the bare wire end through the solder-lug hole and wrapping it around. Leave the other end free for now. Add a white wire to the silver terminal of the same socket the same way as the black wire.
4. Solder all four of the outlet solder-lug terminals. Be sure all wires are thoroughly wetted with solder to provide strong connections.
5. Insert the free end of the black wire into the terminal block at pin #2. If your terminal block is not numbered, note that pin #1 is the rectangular pad on the bottom of the PCB. Note that the black wires represent 'live' or 'L' 110VAC power and the white wires are the neutral or 'N' wires.
6. Insert the free end of the white wire into the terminal block at pin #3.
7. Route the 2-conductor 110VAC power cord through the rubber grommet keeping the 'N' or neutral conductor towards the right hand outlet. Ribs traveling along the insulation of the cord usually mark the 'N' conductor. The 'N' conductor is always connected to the 'wide prong' of the plug. You can make sure you know which wire is which by using a continuity meter across each prong and wire end. Route about 3" of the power cord into the enclosure.
8. Insert the 'N' wire-end into the PCB terminal block at pin #4 and secure.
9. Insert the 'L' wire-end into the PCB terminal block at pin #1 and secure. This wire is always connected to the small or narrow prong of the plug. This is the terminal that provides 'live' power to the system. The polarity of the power cord wires is very important to safety.



Step 12 - Final Assembly

Install the front IR panel.

Attach the enclosure top section using the screws provide with it.

To complete the assembly, you must now install the rubber 'feet' that will become the round push-button soft tops. The rubber feet not only provide an attractive top to the button switches, they also make the transition from square to round, and they also allow you to correct for any small errors in the placement of the enclosure holes or the PCB. Just pick up the self-adhesive rubber foot with a pair of fine tweezers and lower it straight down through the hole until it contacts the cap-stack below. Press it down firmly to make it stick. Repeat this process for the other two buttons. You should strive to make the rubber feet sit in the center of the holes, not the center of the cap-stacks. This is exactly why the rubber feet were not installed until now. The cap-stack under the smaller hole is not supposed to have a protruding top because it is the 'program' button. It remains recessed to prevent accidental programming.

The Completed Lamp Controller



The rubber button tops and cap-stacks.



Testing the Lamp Controller:

1. Plug the Lamp Controller into a standard 110VAC wall outlet. The LED should flash for a few seconds, then settle to a continuous dim glow. Then demonstrates the night-lite function and indicates that the microcontroller is operating. If the LED does not blink or glow, unplug the unit immediately and check the entire assembly to find the fault. The problem could be that the microcontroller U1 is not properly programmed so check that first. Check all wiring. Check that all installed components are the proper values and are installed with the proper polarity. Check all solder joints. Do not troubleshoot the circuit while it is live unless you are an expert at handling and testing high-voltage circuits. If you do this, I suggest you use an isolation transformer for safety. Also, you could use a variac to greatly reduce the power supply voltage to about 40VAC peak for an extra safety margin. The microcontroller circuit will still operate normally even with the reduced AC supply voltage applied.
2. Unplug the Lamp Controller. Start with a standard 60W lamp. Plug the lamp into the wall outlet and turn it on. Unplug the lamp. Plug the lamp into one of the Lamp Controller's two outlets. Plug the Lamp Controller back into the wall outlet. The LED should blink for a few seconds.
3. Test the three protruding buttons by pressing them. The rear-most button should toggle the lamp on and off. The front-left button makes the lamp dimmer. The front-right button makes the lamp brighter. If you unplug the Lamp Controller and then plug it back in, it should resume running the lamp at the previous setting. This demonstrates the 'power failure' function.
4. Note that there is a 'minimum turn-on' level. If you set the Lamp Controller to a very low level, then toggle it off and then back on, it will turn on at a level higher than the previous dim setting. This is intentional. It a method used to guarantee a visible level a light when pressing the On/Off key repeatedly. You can turn on the lamp at a lower level than the 'minimum turn on' level simply by raising the level using the 'Brite' key instead of the 'On/Off' key.
5. Test the IR functions by first programming a universal remote control transmitter to act as an RCA Cable box. The default data in the chip is for this setting so the remote may work at this point. The default setting is #1-Dim, #2-On/Off, #3-Brite. Whenever the Lamp Controller receives a 40kHz modulated IR signal, the LED blinks to indicate the presence of the signal. If the Lamp Controller detects a signal that matches a function code, the LED glows brightly and steadily to indicate that the Lamp Controller has locked onto the signal.
6. To change the function codes stored in the Lamp Controller, you must teach it the new codes. Only RCA type codes are compatible but many other manufactures use a similar code structure that will work. You may find other brand names that work okay by trial & error. To reprogram the function codes, first press the 'program' key under the recessed key hole using a long narrow object. Within a few seconds of pressing the program key, press a function key. Then send the code to the box using the remote by pressing the desired key for the function being programmed. Repeat the process for the other two functions. You may program any of the three functions independently and as many times as you wish. If you have problems programming, try holding the remote closer or farther away from the Lamp Controller while sending the code. If that also fails, you probably need to program the remote for another device or brand. Removing power from the Lamp Controller will not make it lose the codes because they are stored in the microcontroller's non-volatile memory.
7. Simply point the remote at the front panel and press one of the three function keys to operate the Lamp Controller.
8. If the Lamp Controller seems to be working properly, leave it running for a while, driving the 60W lamp at 100%. After about 30 minutes, carefully feel the top of the box. It should feel a little warm. This is normal. If it feels like the box is about to melt (or if it actually has melted), then unplug the unit, and check it thoroughly for possible faults.
9. If the Lamp Controller has proven itself up to this point, try plugging in another 60W lamp in the other outlet. Allow it to run for about 30 minutes at 100%. Again, feel the box top. It should be a bit warmer than before, but not severely hot. There is a certain amount of heat generated by the 330Ω, 2W resistor, but the rest of the heat comes from the triac. The better the quality of the triac and the heat sink, the cooler it will run. A very cheap, underrated triac may run excessively hot and should not be used. The triacs listed in the PCB Bill of Materials will work fine.
10. The maximum practical and safe total load should not exceed 300W. Do not use the Lamp Controller to control motors or florescent lamps.