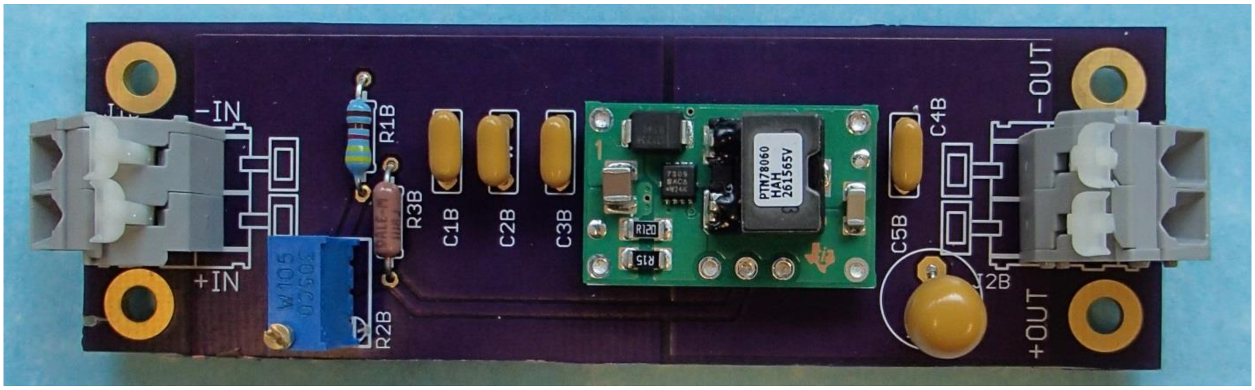
ASSEMBLY & OPERATION PROCEDURE FOR A DC/DC CONVERTER TO POWER A PIT TAG READER



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Introduction:

Since the 1980s, passive integrated transponder (PIT) tags have been used to support the collection of various biological and population demographic data in a variety of animal models (Gibbons and Andrews 2004). For example, this technology has been used extensively in the Pacific Northwest for monitoring the behavior and survival of juvenile and adult salmonids in the Columbia River Basin (Zabel et al. 2005). Over 33 million salmon and trout have been PIT tagged in the Columbia River Basin since 1987 (Pacific States Marine Fisheries Commission 2012). Fish are not recaptured but are remotely detected via a fixed or mobile antenna, which is is particularly valuable for monitoring threatened or endangered species.

Increasingly, PIT tag technology is applied at remote locations where grid power is not available and solar panels are the power source of choice. Currently, 24V solar panels are the most available and least expensive per Watt. Because solar energy is not continuously available, energy storage (typically two 12V AGM lead-acid batteries in series) is required, and the voltage supplied by the system varies between 21VDC and 28VDC. This voltage variation is undesirable, since reader performance and power consumption vary with supply voltage. Also, this voltage range is incompatible with many PIT tag readers. For example, the Allflex® RM310 requires a supply between 6VDC and 12VDC, and the Oregon RFID® readers require a supply between 12VDC and 24VDC. Therefor a voltage regulator or DC/DC converter is required. Refer to Figure 1 below for a schematic of a typical system. In order to minimize system cost (size and number of solar panels and batteries), a switching converter is preferred, but most of them operate at a frequency (below 300 kHz) which interferes with the PIT tag reader. Further, the output voltage of the converter should be adjustable to allow optimization of the tradeoff between power consumption and read performance. This document describes implementing such a converter. It can be configures as a single or dual supply with adjustable output of 6VDC to 12VDC and/or 12VDC to 18VDC at up to three Amps from an input from 21VDC to 36VDC.

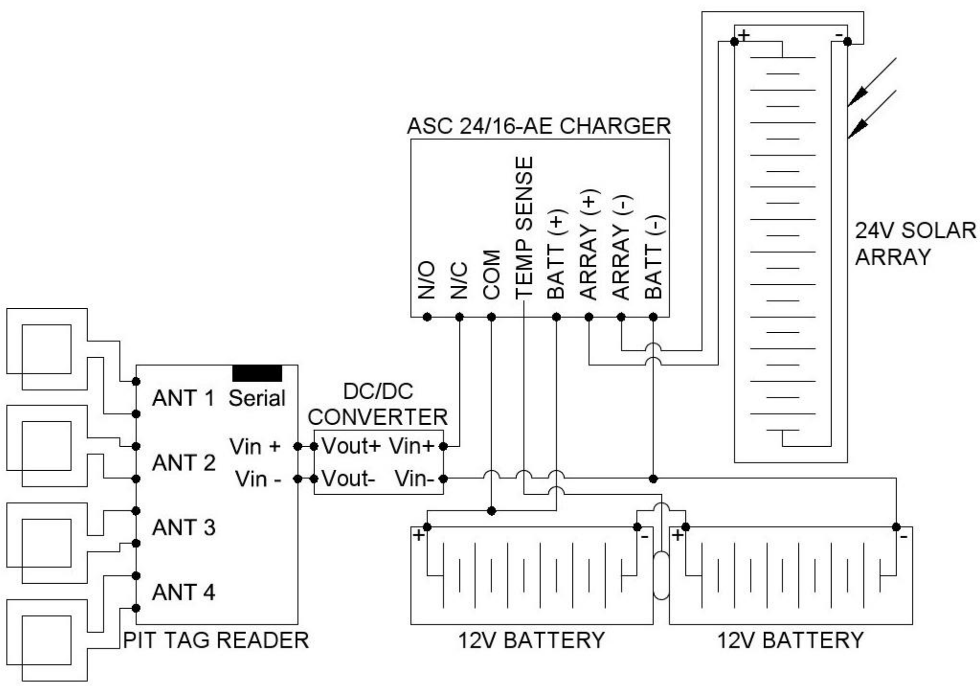


Figure 1: Schematic of a Typical System

The DC/DC converter can also be used to minimize the length of the antenna cable to improve the read range of the antenna. That is accomplished by placing the PIT tag reader close to the antenna and locating the DC/DC converter at the PIT tag reader. The power source and other equipment such as a data logger, computer, or modem can be located hundreds of feet from the PIT tag reader. If a DC/DC converter is located at the reader, the higher voltage supplying the DC/DC converter draws less current for the same amount of power. That reduces resistive losses in the power cable and allows much longer cable runs between the power source and the DC/DC converter than would be practical or possible between the reader and the antenna.

Objective:

To provide instructions for the assembly and implementation of a DC/DC converter for use with Pit tag systems operating from 24V solar panel arrays.

CONSIDERATIONS

The DC/DC converter PCB (Printed Circuit Board) is laid out "two-up". The PCB can be assembled with two DC/DC converters if the system requires two different voltages, or if more than 3 Amps is required. The PCB can be assembled with a single DC/DC converter to provide better cooling for applications that require high power and/or high ambient temperatures. For most applications the PCB can be cut in half with a table saw or band saw and assembled as two separate DC/DC converters. By choosing different resistor values, a DC/DC converter can be built with an adjustment range other than 6VDC to 12VDC or 12VDC to 18VDC, or with a fixed output from 2.5VDC to 22VDC. Note that a 22VDC output can only be achieved with an input voltage to the DC/DC converter of 25VDC or higher, and the "end of discharge" voltage for a pair of 12V lead-acid batteries in series is about 21VDC, which would limit the output of the DC/DC converter to 18VDC maximum. Refer to the TI data sheet for the PTN78060 for information on setting up the DC/DC converter for output voltages other than the ranges defined herein.

Reference Materials:

- PTN78060W, PTN78060H, 3-A, WIDE-INPUT ADJUSTABLE SWITCHING REGULATOR, data sheet SLTS229B–NOVEMBER 2004–REVISED JUNE 2009, Texas Instruments (http://www.ti.com/lit/ds/slts229b/slts229b.pdf).
- PTN78060-R03.sch and PTN78060-R03.brd, Eagle PCB schematic and layout files
- NASA Training Program Student Workbook for Hand Soldering, December 1998, (https://www.protostack.com/download/NASA%20Student%20Handbook%20for%20Hand%20Soldering.pdf).

Tools:

- Optional (if you wish to separate the boards): Table saw or band saw with:
  - Fence
  - Pusher

- Needle-nose pliers
- Soldering iron with fine pencil-point temperature controlled (~700˚F) tip
- Flush cutter pliers
- Magnifying glass, loupe, or stereo microscope
- Voltmeter or digital multimeter
- Small flat blade screwdriver
- 6 Ohm 50 Watt resistor mounted to an aluminum panel or heatsink, or other suitable resistance to load test the DC/DC converter.
- Electric drill
    - and a 3/32" bit for mounting with sheet metal or wood screws
    - or #36 drill and 6-32 tap for mounting with machine screws

Consumables:

- Sn63 "No Clean" or water soluble flux core wire solder .032" or smaller diameter
- "No Clean" or RMA fluxed desoldering braid 0.1" or smaller width

Ordering the parts:

1. Order the PCBs: The PCB has been laid out in Eagle and Gerber files are available from kurt_steinke@fws.gov that can be sent to virtually any PCB fabricator. It has also been set up as an Shared Project (PTN78060-R03) at OSH park (http://www.oshpark.com) that anyone can order for about $46.00 for three board pairs (enough for six individual DC/DC converters), shipping included. It may take three weeks or so to get PCBs from OSH Park.

2. Order the Electronic Parts: The quantities in the parts list are for a single DC/DC converter. If the board is assembled with two DC/DC converters, the parts required are the sum of the parts listed for each less one of the terminal blocks (either the J1a or J1b connector can supply both converters if the board is not cut in half) and only 4 spacers are required. Note that some of the parts and quantities are different for the 12-18V (Oregon RFID®) version of the DC/DC converter and the 6-12V (Allflex®) version. All the parts can be ordered from Newark Electronics (http://www.newark.com/), but their minimum order quantity for spacers is a package of 100. If you don't need to mount 25 boards, spacers can be ordered from Digi-Key in increments of one, or you can order a pack 100 of ¼" long spacers (# 93N1004) from Newark and use two spacers on each screw (8 total per board) to get the spacing necessary for air circulation around the board. For the 6-12V version of the board, C1 and C2 may be omitted. If the device you are supplying power to from the DC/DC converter requires a power supply with a tolerance of +/-10% or less, it is recommended that you use a fixed, as opposed to adjustable, output voltage. For a fixed output at the maximum output voltage of the range, R2 and R3 may be omitted. Connect R1 between the furthest apart holes for R1 and R3. For other fixed output voltages, refer to Table 2, 3, or 4 in the TI data sheet for the PTN78060 for

the appropriate resistor value, which should be installed between the furthest apart holes for R1 and R3.

PCB Assembly:

The PCBs shown below have solder mask and silkscreen. (***Figure 2*** below).

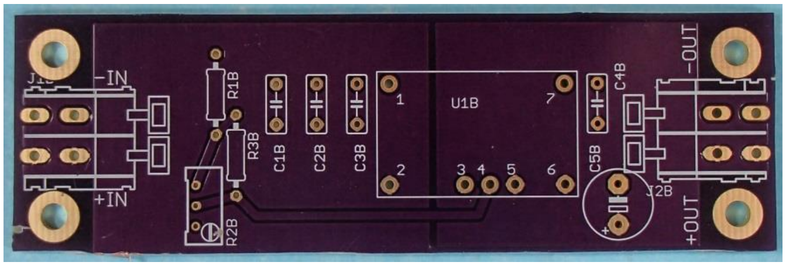


Figure 2: PCB cut in half for a single DC/DC converter..

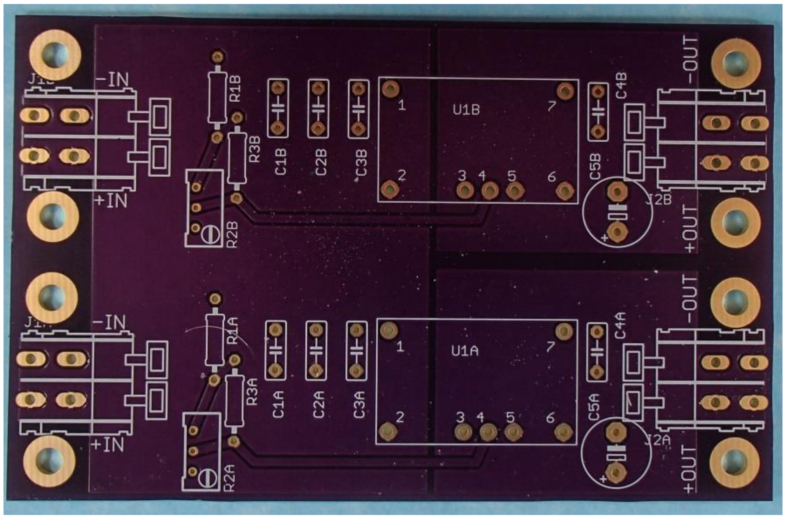


Figure 3: Undivided PCB for two DC/DC converters, to supply two different voltages or more than 3 Amps of current, or to provide better cooling for a single DC/DC converter in a high-temperature environment.

Install and solder the passive components:

Install the passive components (J1-J2, R1-R3, and C1-C5) per Figure 4 below. Solder the leads to the pads on the back side of the PCB (the side opposite the components) by holding the tip of the soldering iron against the lead and the pad, and touching the solder wire to the lead until it melts and flows over the pad.

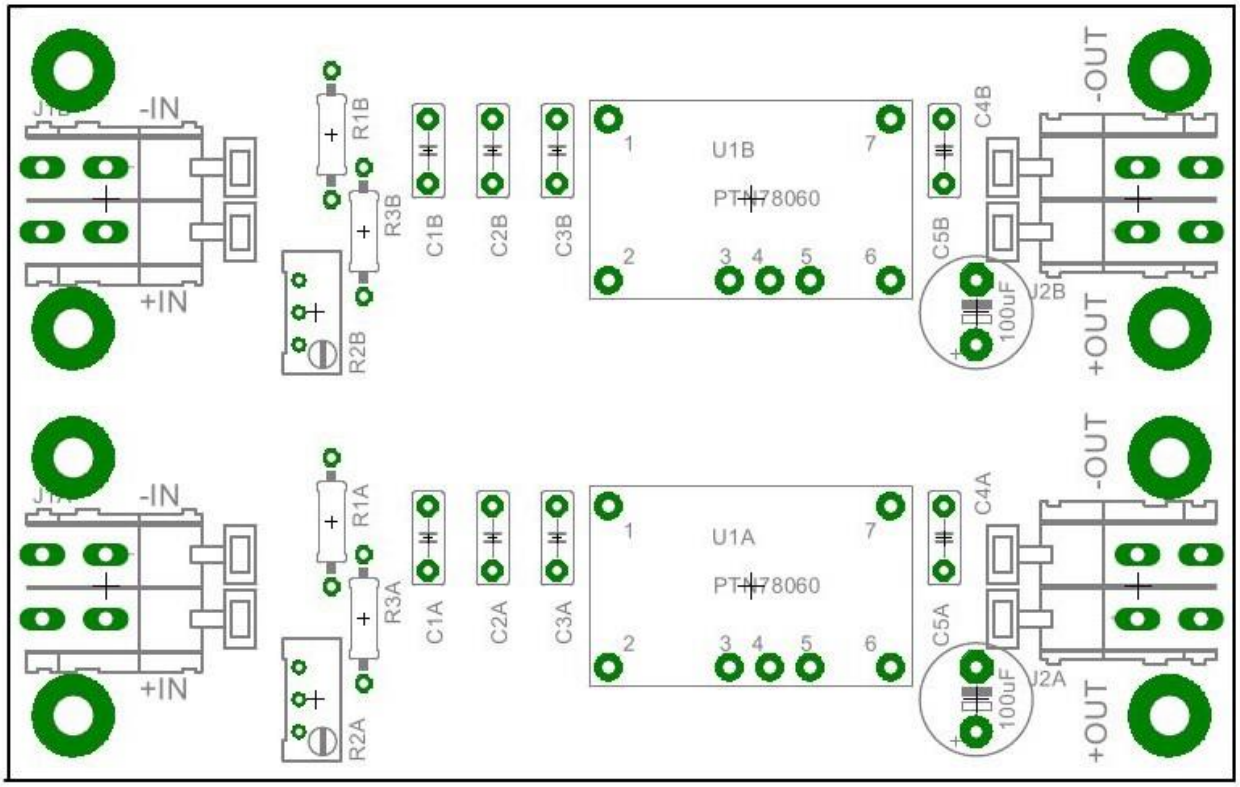


Figure 4: Component locations

Component orientation:

The terminal blocks should be oriented so the wire connections are toward the outside of the board, **the positive terminal (the side marked "+") of capacitor C5 MUST be "down" toward the "+" on the board** (otherwise it will be destroyed!), and the adjustment screw of potentiometer R2 should be toward the lower left when the PCB is oriented as shown in Figure 5 below. Resistors R1 and R3, and capacitors C1-C4 may be oriented either end up as shown.

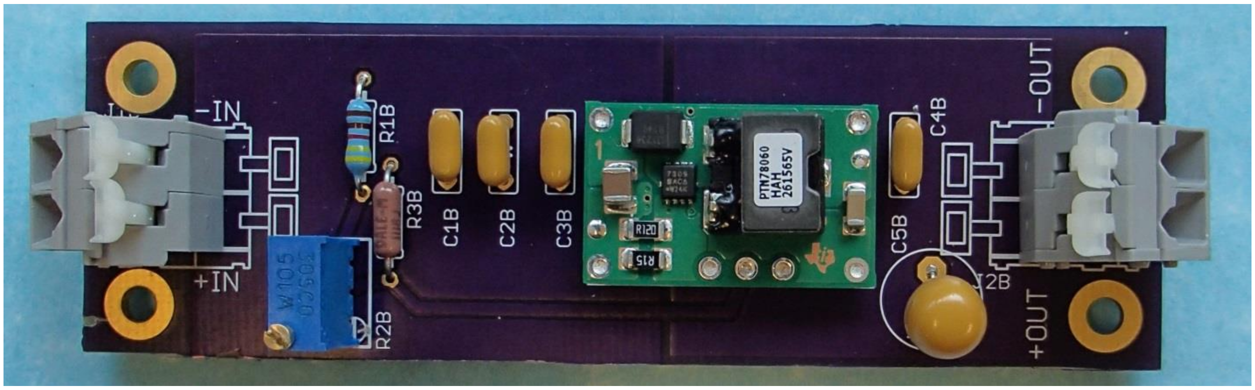


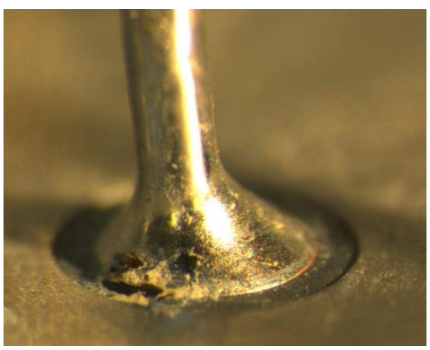
Figure 5: Assembled adjustable DC/DC converter

Install and solder the PTN78060:

Install the PTN78060 per Figure 4 and Figure 5 above. Solder the leads to the pads on the back side of the PCB by holding the tip of the soldering iron against the lead and the pad, and touching the solder wire to the lead until it melts and flows over the pad. When hand soldering, it is preferable to install "active" components (semiconductors which may be subject to damage from ESD (Electrostatic Discharge) to minimize their handling and opportunities for damage.

Inspect the PCB:

DO NOT SKIP OR SKIMP THIS STEP: the commonest failure of these assemblies is poor solder joints! Use a magnifying glass, loupe, or stereomicroscope to inspect the solder joints. Each solder joint should be smooth, shiny (other than flux residue), and continuous all the way around the lead as shown in the picture on the left in Figure 6, not like the poor solder joints shown in the picture at the right. Note that it is extremely difficult to hand solder "good" joints with any solder other than the SN63 specified, and the "lead free" solder sold at the local hardware store is suitable for plumbing, not electronics. Resolder any joints that are not smooth, shiny, or which do not completely encircle the lead on the solder pad.



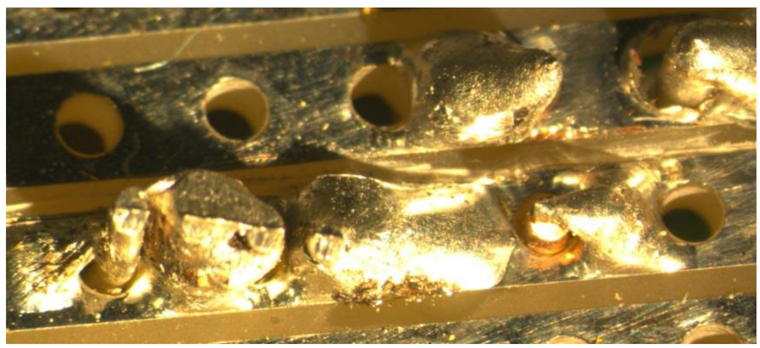


Figure 6: Good solder joint ***Poor solder joints***

Care must be taken to inspect for solder bridges, even though solder mask prevents almost all of them, they are still possible between a pad and the adjacent ground plane or adjacent pads. The solder pads for the component leads are surrounded by copper within 0.010". There are two types of solder pads on these PCBs: electrically isolated pads (see Figure 7 below) which have no electrical connection to the surrounding plane, and thermally isolated pads (see Figure 8 below) which are electrically connected to the surrounding plane. Most of the pads are electrically isolated on one side of the board, and thermally isolated on the other. A few are electrically isolated on both sides.

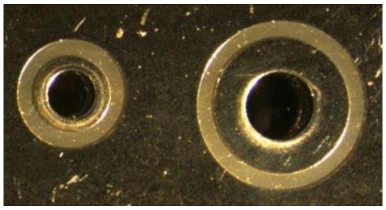


Figure 7: Electrically isolated pads

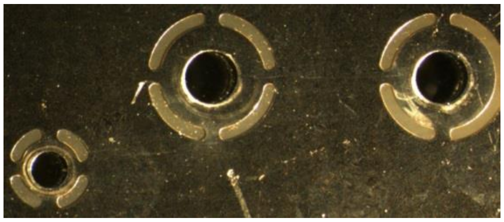


Figure 8: Thermally isolated pads

Any solder bridges to electrically isolated pads must be corrected. To correct a solder bridge to an electrically isolated pad, press a piece of desoldering braid against the defective joint or solder splash with a hot soldering iron until the soldert melts and is wicked into the braid, then resolder the joint. Solder bridges to thermally isolated pads are sometimes unavoidable and do not need to be corrected

Test the PCB:

Connect two 12V lead acid batteries in series (the “+” terminal of the first battery to the “-“ terminal of the second), the “-“ terminal of the first battery to the “-“ of the “IN” terminal block at the right side of Figure 5, and the “+” terminal of the second battery to the “+” of the “IN” terminal block. Press down the lever at the position on the terminal block to open the contacts and insert the wire. Release the lever to grip the wire. Measure the voltage between the terminals of the “OUT” terminal block with a voltmeter or digital multimeter. Check the full adjustment range (if applicable) both open circuit (no load) and with a load. Six ohms will draw a little more than 3 Amps at 18 Volts. The output should be between 12VDC and 18VDC, or 6VDC and 12VDC, depending on whether the parts installed were installed for an Oregon RFID reader or an Allflex reader. If not, inspect all the solder joints, check the values of R1-R3, and verify that the orientation of C5 is correct.

Adjust the output voltage:

Turn the screw on the top of potentiometer R2 clockwise to increase the output voltage, or counter clockwise to decrease it to the desired value. If R2 is installed backwards, the voltage adjustments will be reversed. Higher voltage to the PIT tag reader generally increases the read range, but also increases power consumption and may require a larger solar array and batteries.

Orientation and Mounting:

The assembled board should be mounted on standoffs to a vertical surface with its long axis horizontal and sufficient space below and above it to allow for convective cooling using four #6 wood, sheet metal, or machine screws, depending on the surface to which it is attached.

Literature Cited

Gibbons, J. W. and K. M. Andrews. 2004. PIT tagging: simple technology at its best. BioScience 54:447-454.

Pacific States Marine Fisheries Commission (PSMFC). 2012. PIT tag information system (PTAGIS). Pacific States Marine Fisheries Commission, Gladstone, Oregon. Online database (Available through Internet: www.ptagis.org).

Zabel, R. W., Wagner, T., Congleton, J. L., Smith, S. G., and J. G. Williams. 2005. Survival and selection of migration salmon from capture-recapture models with individual traits. Ecological Applications 15:1427-1439.

Appendix A

Parts List

Parts List:

Parts*	**Qty**	**Vendor**	**Vendor Part# (Description)**
PCB	1/2	ExpressPCB.com	
U1	1	Newark	33K5377 (PTN78060HAH for 12-18V output) or 71J7324 (PTN78060WAH for 6-12V output)
R1	1	Newark	58K9239 (4.42kΩ for 12-**18**V output) or 94C5227 (732Ω for 6-**12**V output)
R2	1	Newark	62J1429 (1MΩ trimmer for 12-18V output) or 62J1439 (20kΩ trimmer for 6-12V output)
R3	1	Newark	94C3678 (806kΩ for 12-18V output) or 83F1433 (32.4kΩ for 6-12V output)
C1-C4 C3-C4	4 2	Newark	43K3241 (4.7µF 10% 50V Z5U) (for 12-1V output) (for 6-12V output)
C5	1	Newark	67H3509 (100µF 10% 20V Tantalum capacitor)
J1-J2	2	Newark	79K2068 (WAGO 0256-0402 terminal block)
Spacer	4	Digi-Key Newark	492-1107-ND (#6 nylon or PVC spacer 7/16" min L) 93N1005 (1/2" pack of 100)
Solder	A/R	Newark	20M4919 Sn/Pb 63/27 .033Dia RA flux wire solder
Desolder Braid	A/R	Newark	09WX5472 Desoldering braid 1.5mmx1.5M no clean flux

* Refer to the schematic in Appendix B

Appendix B

Schematic