One for the grey nomads

50A Battery Charger Controller

For 12/24V "house" batteries

Are you one of the many thousands doing the grand trek around Oz in an RV, caravan or campervan? Then you will know the problems with trying to charge up your "house" batteries during a long trip. This heavy-duty charger controller will enable you to charge those batteries much more quickly using your portable generator and a low-cost 40A or 50A charger.

Even if your RV, caravan or campervan has a couple of solar panels on the roof, getting your "house" batteries (ie, the one[s] in the aforementioned RV, caravan or camper, as distinct from your vehicle battery) quickly up to charge can be a real problem, especially if you arrive at the remote campsite late in the day.

If you want power, there is no alternative to dragging out your portable generator and using it to charge your batteries.

The big problem is that the limited 12V, typically 5A DC output from the generator's inbuilt charger can take forever to bring house batteries up to charge.

That means running the generator for many hours – and that is not desirable at all.

The idea for this project came to us from a "grey nomad" some time ago. Instead of trying to charge from his generator's 12V output, he suggested using a cheap 40A charger, powered by the 230VAC from the generator. That would bring the batteries up to charge in a fraction of the time. Consequently, the generator would only need to run for a much shorter time.

Design by JOHN CLARKE

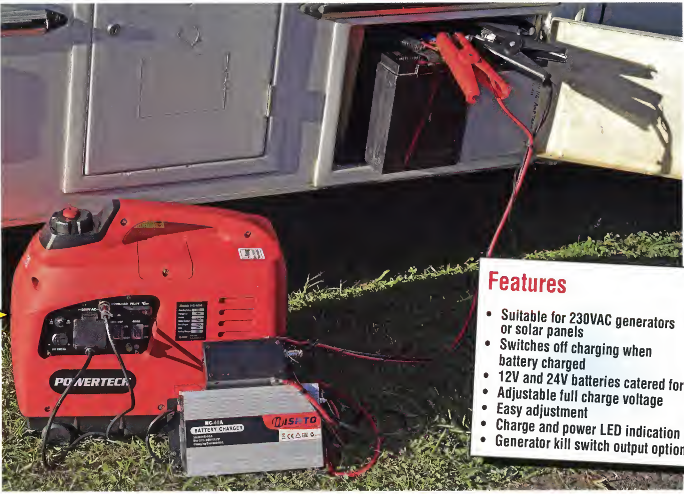
What a great idea! The portable generator is used much more efficiently, it uses a *lot* less fuel and you don't have to listen to the generator droning away for hours on end (nor do the other people who may be camping at the same site).

However, there is a drawback with the idea (which was noted by the "grey nomad"). If you don't monitor the battery voltage closely, there is a considerable risk of over-charging and ultimately, boiling the batteries.

A multi-stage charger won't necessarily solve this since, depending on its design, during the absorption phase it may hold the battery at a high enough voltage for long enough to cause vigorous boiling of the electrolyte.

There is even a danger of a battery explosion with the emission of hydrogen during over-charging.

Our project removes those risks. It monitors the battery while it is being charged and



Features

- Suitable for 230VAC generators or solar panels
- Switches off charging when battery charged
- 12V and 24V batteries catered for
- Adjustable full charge voltage
- Easy adjustment
- Charge and power LED indication
- Generator kill switch output option

when the voltage comes up to a preset value, say 14.4V, it disconnects the charger.

Better still, about five seconds after that, it switches off the generator to restore the serenity.

And best of all, it removes the need to watch the batteries yourself, so you can get back to the more serious campsite task . . . of relaxing and enjoying yourself!

We should note that many modern switchmode chargers do incorporate proper 3-state or multi-state charging and so they may safely terminate the charge in a float condition.

However, if you have large house batteries, say 200Ah or more, then even with a 40A charger it will take many hours to bring them up to full charge. In that case, you might elect to only bring the batteries up to the "bulk charge" state, then terminate the charge and switch off the generator. Our Charger Controller will allow you to do that.

Of course, this 50A charger controller can be used if you *do* have mains power on the campsite. Then you don't need to fire up the generator – just hook up the high current charger and our Charger Controller to your house batteries and you can be sure that they will be brought up to full charge while you enjoy your idyllic surroundings.

Naturally, you don't have to be a grey nomad on the grand tour to consider building our Charger Controller. It can be used at any time with any basic charger which does not have "end-of-charge" detection; most lower-priced ones don't.

So why don't basic battery chargers limit charging when the battery reaches full charge? The answer is that most, especially the lower-cost models, are *too* simple: all most have is a transformer and rectifier diodes.

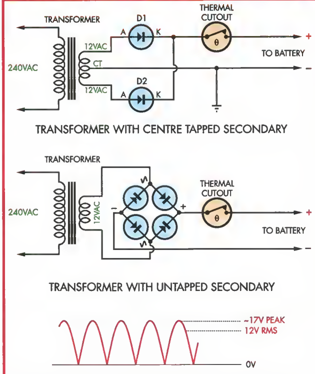


Fig.1: most simple battery chargers *are* this simple, with only a transformer, rectifier and thermal cutout. It's the peak voltage that actually does the charging.

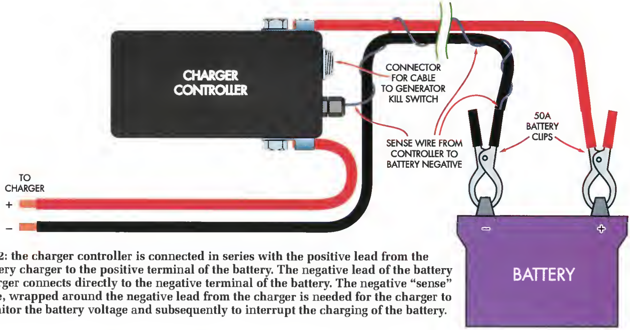


Fig.2: the charger controller is connected in series with the positive lead from the battery charger to the positive terminal of the battery. The negative lead of the battery charger connects directly to the negative terminal of the battery. The negative "sense" wire, wrapped around the negative lead from the charger is needed for the charger to monitor the battery voltage and subsequently to interrupt the charging of the battery.

Fig.1 shows two typical battery charger circuits, one using a centre-tapped transformer and two rectifier diodes or a single winding transformer with a four-diode bridge rectifier.

Both feed rectified but unfiltered DC to the battery.

The batteries are quite happy to be charged with this pulsating DC; the problem occurs when charging is complete. The charger doesn't know so keeps on pushing current in. The battery overcharges and . . .

Similarly, if you have a bank of solar panels to charge a 12V or 24V battery, there is the same risk of over-charging. Our Charger Controller can also prevent that from happening.

Circuit concept

In essence, the 50A Charger Controller is connected in series with the positive lead of the charger to the battery. The controller has a 60A automotive relay which disconnects the charger when the battery comes up to charge, all under the control of a PIC12F675 microcontroller. A second, smaller relay shorts a pair of wires from the kill switch on the generator. So it's a pretty simple concept, as shown in Fig.2.

Fig.3 shows the full circuit. You can see the red conductor from the charger positive output at the top right-hand corner of the diagram. It passes through the contacts of the 60A relay and then out to the positive terminal of the battery being charged. The output to the battery is also fed to an LM2940CT-12 3-terminal 12V regulator which produces 12V to power the two relays, RLY1 & RLY2.

On the left-hand side of the circuit, the charger output is fed via diode D3 to an LM317 adjustable 3-terminal regulator, which provides 5V DC to run the PIC12F675 microcontroller, IC1.

The PIC monitors the battery voltage to detect the end-of charge and it controls the relays and drives the charge indicator, LED2.

12V or 24V batteries

This controller works with 12V or 24V chargers and lead acid batteries. The battery voltage is measured using a voltage divider comprising a 100kΩ resistor from the battery positive and two series-connected 22kΩ resistors connecting to 0V. Total resistance is 144kΩ. The 22kΩ resistors provide a reduced voltage suitable for IC1 to measure battery voltage at its AN1 input. IC1 requires a voltage at its AN1 input of less than the supply of 5V and the voltage divider caters for both 12V and 24V batteries by changing over a jumper link that selects one of two positions in the voltage divider. Diode D4 protects against reverse battery connection.

In the 12V position, the divider connection with the jumper (JP1) in the 12V position, comprises a 44kΩ resistance (with the two 22kΩ in series) and the 100kΩ resistor with a division ratio of 44/144. This reduces 12V down to 3.666V. At full charge, the battery is around 14.4V and so the divided voltage is 4.4V.

For the 24V position, the jumper selects the lower 22kΩ resistor and so the division ratio is 22/144. The reduced voltage becomes 3.666V when the battery is at 24V. At full charge of 28.8V, the divided voltage is once again 4.4V.

Note that the reduced voltage that is applied to the AN1 input of IC1 is the same for both 12V and 24V batteries. This means that IC1 can detect full charge for either a 12V or 24V battery just by changing the position of link JP1.

Instead of using a jumper shunt to select 12V or 24V, an SPDT toggle switch on the front panel could be used in its place.

The battery is deemed to be fully charged when the AN1 input rises above the AN0 input. The AN0 input is connected to a voltage divider across the 5V supply, comprising a 5kΩ trimpot

SPECIFICATIONS

Supply: .... 12V or 24V battery charger
Charger Current: .... Up to 50A
Charge voltage: .... Adjustable from 13.87V to 16.36V for 12V battery and 27.74V to 32.73V for 24V battery
Battery drain: .... With charger off, ~10mA
Kill switch output: ...... Contacts close for 5s, 5s after charging is completed

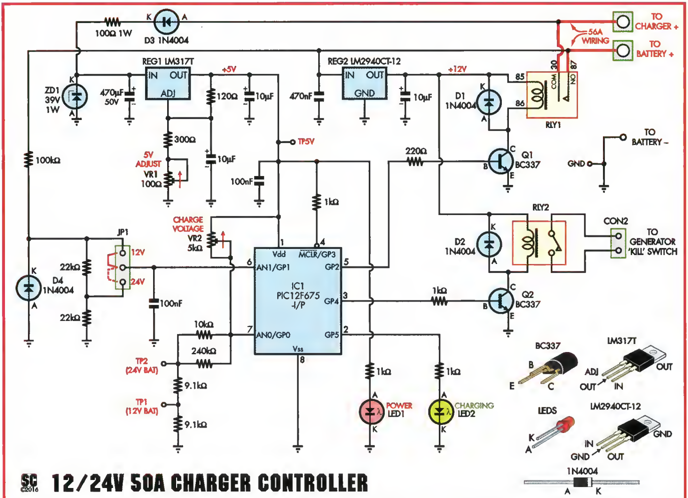


Fig.3: the microcontroller in this circuit (IC1) primarily acts as a comparator. It compares a sample of the battery voltage (at its AN1 input, pin 6) with a reference voltage its AN0 input, pin 7. When the voltage at pin 6 rises above that at pin 7, IC1 switches on transistor Q1, to actuate relay RLY1 and interrupt the charge.

(VR2) and the associated resistors in series to 0V.

VR2 is adjusted to set the required full charge voltage for the battery. For a 12V battery, VR2 is adjusted to obtain 1.44V, measured between TP1 and GND, resulting in 4.4V at the AN0 input. For a 24V battery, (with a full charge voltage of 28.8V) set VR2 for 2.88V between TP2 and GND.

Note that the GND terminal is connected to the negative terminal of the battery. Without this connection, the Charge Controller cannot work.

Relay RLY1 is controlled by the GP2 output of IC1 and this drives the base of transistor Q1 which turns on the relay.

Relay RLY2 is controlled by via the GP4 output and transistor Q2. Diodes D1 & D2 are included to clamp the voltage spikes which are generated when the relays are turned off. If the diodes were omitted, there would be a risk that Q1 & Q2 could be damaged by the high voltage spikes.

Charging sequence

IC1 monitors the battery at the AN1 input and switches on relay RLY1 if the battery voltage is over 9V (or over 18V for a 24V battery). The relay contacts then pass the charging current from the charger to the battery.

When the battery reaches full charge, the relay switches off to disconnect the charger. The battery is then continuously monitored and relay RLY1 will be switched on again if the battery voltage drops to 12.5V or below, for a 12V battery, or below 25V for a 24V battery.

Of course, if the charger is fed by a portable generator and the kill switch lead is connected, the generator will have been turned off and will have to be manually restarted for charging to re-commence.

The charging indicator (LED2) flashes once each second during charging and stays fully on once the battery is fully charged. LED2 is off when the battery is disconnected (ie, below 10V or 20V). LED1 is on while ever the charger is on.

Kill switch relay

Relay RLY2 is included to switch off the generator once the battery charger has been disconnected by the main relay, RLY1. Relay RLY2 is switched on five seconds after RLY1 switches off, for five seconds. The kill switch lead is connected to a socket (which needs to be installed) on the generator, in parallel with the contacts of the generator's engine (kill) switch.

Construction

All the components of the Charger Controller are assembled onto a PCB coded 11111161 and measuring 122 x 53.5mm. It is housed in a UB3 plastic case measuring 130 x 68 x 44mm.

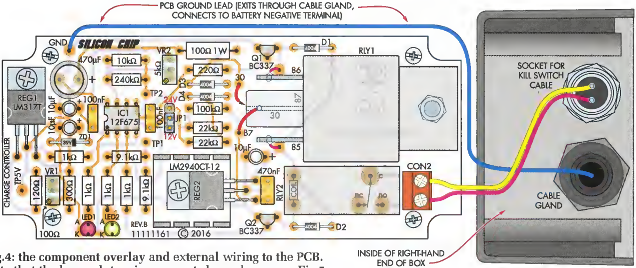


Fig.4: the component overlay and external wiring to the PCB. Note that the heavy duty wires are not shown here – see Fig.5.

Before installing any components on the PCB, place it in the plastic case and mark out the position for each of the corner mounting points on the base.

Fig.4 shows the component overlay of the PCB and the battery negative terminal and the kill switch socket. Fig.5 shows the heavy duty wiring for the connections to the battery and charger.

You can begin assembly by installing the resistors, using a multimeter to check the value of each before inserting it. (The table also shows the colour codes for each resistor value). Diodes D1-D4 and the zener diode ZD1 can be installed. These must be oriented as shown and be careful not to mix the diode types.

(By the way, if you don't want to use the kill switch facility, you can omit the components associated with it, ie, connector CON2, the 2-pin socket, relay RLY2, diode D2, transistor Q2 and its 1kΩ base resistor). On second thoughts, you probably should install them because after you use it, you'll wonder why you didn't have the auto-kill facility!

PC stakes can then be installed at test points GND, TP5V, TP1, TP2 and the relay terminal connections labelled 30, 87, 85 and 86 and the four LED connections.

Install the 3-way header for JP1. (Normally a jumper shunt is placed on the 12V or 24V battery position). If you intend to use the Charger Controller for 12V and 24V batteries, you may prefer to install an SPDT switch instead. Wire the switch directly to the header or via a 3-way plug.

Make sure you orient the socket for IC1 correctly and then install the capacitors. The electrolytic types must be oriented with the shown polarity.

The two 3-terminal regulators are mounted horizontally onto the PCB with their leads bent to fit into the PCB holes. REG2 is installed onto a small heatsink. Both regulators are secured using an M3 x 6mm screw and M3 nut.

The trimpots can be mounted next. VR1 is 100Ω (coded 101) and VR2 is 5kΩ (coded 502). Make sure they are oriented with the adjusting screw as shown in Fig.4; that gives increasing voltages with clockwise rotation of the adjustment screws.

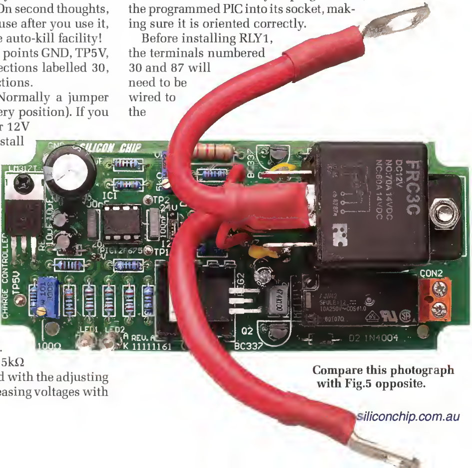
Relay RLY2 goes in next but leave the main relay, RLY1, until the heavy duty wiring is done.

Next, install the two LEDs. We mounted ours so that the top of the LEDs are 34mm above the PCB, which makes them visible through holes in the top lid of the case.

Before installing IC1, we recommend adjusting trimpot VR1 for a 5V output. To do this, connect a 12V supply between GND and the anode of diode D3. Then adjust VR1 for a reading of 5.0V between GND and TP5V.

If you intend to program IC1 yourself, hex file 1111116A.hex can be downloaded from the SILICON CHIP website (PICs for this project purchased from SILICON CHIP will already be programmed). Install the programmed PIC into its socket, making sure it is oriented correctly.

Before installing RLY1, the terminals numbered 30 and 87 will need to be wired to the



Compare this photograph with Fig.5 opposite.

56A red cable.

Cut two 90mm lengths of the cable and strip back the ends of insulation by about 5mm. Solder or crimp (or crimp and solder) one end of each wire to a large eyelet connector. The other ends of the cable are soldered to terminals 30 and 87.

Note that the soldering to the No.30 relay terminal should be made on the side that is near to the No.86 terminal to avoid any possible shorting to the No.87 PC stake on the PCB. Wire as shown in Fig.6. At the same time, solder short (30mm) lengths of hookup wire to each of the 30, 85, 86 and 87 terminals ready to solder to the PC stakes on the PCB. Cover the bare terminals with 10mm diameter heatshrink tubing and solder the hookup wires to the PC stakes before securing the relay with an M5 bolt and nut.

The PCB is mounted on four 6.3mm standoffs at each corner of the PCB. Use the M3 x 5mm pan head screws to secure to the PCB. If you are wiring the kill switch output, its socket can be installed on the end of the case now.

Drilling the case

Drill out the four 3mm corner mounting holes in the base of the case where marked previously. Countersink the holes if you intend to use countersunk screws. Drill out holes in the sides for the two M8 screws and the cable gland. You may need to use a reamer to open out to the required diameter if you do not have a drill large enough.

The centre of the holes need to be near to the top edge of the box but no closer than 12mm from the top. See Fig.5 for details.

As previously mentioned, the battery charger red (positive) wire for the positive connection on the battery needs to be cut and each end terminated to a large eyelet. These attach to the Charger Controller, as shown in Fig.2. The sense wire from negative battery charger clip is passed through the end of the case via a cable gland. The wire wraps around the 0V charger wire and is connected to the charger's 0V battery clip. You should be able to solder or crimp the sense wire to the battery clip or connect it via a crimp eyelet that is attached to the battery clip with a screw and nut.

Panel label

Front panel artwork can be downloaded from www.siliconchip.com.au We have provided two versions: one as we show overleaf and the other with provision for a 12V/24V battery switch.

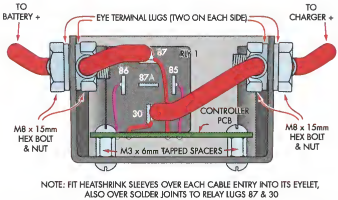


Fig.5: this diagram shows the heavy-duty cables running from the relay (RLY1) to the eye terminal lugs, thence to the charger and the battery.

Parts list – 50A Charger/Controller

1 PCB coded 11111161, 122 x 53.5mm
1 UB3 plastic case, 130 x 68 x 44mm
1 panel label, 120 x 60mm
1 12V 60A automotive relay (Jaycar SY4074, Altronics S4339) (RLY1)
1 SPDT 12V 10A relay (Jaycar SY4050, Altronics S4170A) (RLY2)
1 2-way screw terminal, 5.08mm spacing (CON2)
4 eye terminals with 8mm eyelet hole, for 10mm^2 wire (Jaycar PT-4936)
1 180mm length of 56A red automotive cable
1 2m length of medium duty black hookup wire
1 TO-220 heatsink, 19 x 19 x 9.5mm
1 8-pin DIL IC socket
1 cable gland for 3-6.5mm diameter cable
1 3-way header with 2.54mm spacings (JP1)
1 pin header shunt (for JP1)
1 SPDT toggle switch (S1) (optional – used instead of JP1 shunt)
2 2-pin chassis-mount male microphone sockets (Jaycar PP-2013 or equivalent)
2 2-pin female microphone plugs (Jaycar PS-2014 or equivalent)
2 M8 x 16mm bolts and nuts (NB: NOT PASSIVATED)
1 M5 x 10mm bolt and nut (to secure RLY1)
4 M3 tapped 6.3mm standoffs (for PCB mounting)
8 M3 x 5mm pan head screws (or 4 M3 x 5mm countersunk and 4 M3 x 5mm pan head) (for PCB mounting)
2 M3 x 6mm pan head screws (for REG1 and REG2)
2 M3 nuts (for REG1 and REG2)
12 PC stakes
1 200mm length of red 10mm diameter heatshrink tubing
2m (or more) of double-sheathed 2-core cable (for kill switch cable from charger to generator)

Semiconductors

1 PIC12F675-I/P microcontroller programmed with 1111116A.hex (IC1)
1 LM317T adjustable regulator (REG1)
1 LM2940CT-12 low dropout 12V regulator (REG2)
2 BC337 NPN transistors (Q1,Q2)
1 39V 1W zener diode (ZD1)
4 1N4004 1A diodes (D1-D4)
1 3mm red LED (LED1)
1 3mm green LED (LED2)

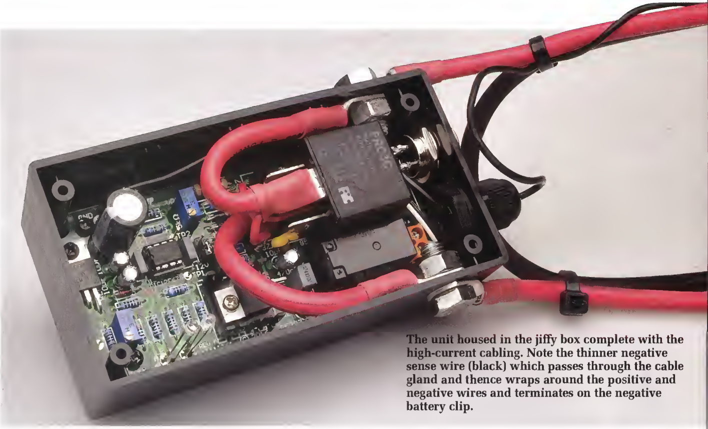
Capacitors

1 470µF 50V PC electrolytic
3 10µF 16V PC electrolytic
1 470nF 63V or 100V MKT polyester (code 473)
2 100nF MKT polyester (code 103)

Resistors (0.5W, 1%)

1 240kΩ	1 100kΩ	2 22kΩ	1 10kΩ	2 9.1kΩ
4 1kΩ	1 300Ω	1 220Ω	1 120Ω	1 100Ω 1W

1 100Ω multi-turn top adjust trimpot (VR1)
1 5kΩ multi-turn top adjust trimpot (VR2)



The unit housed in the jiffy box complete with the high-current cabling. Note the thinner negative sense wire (black) which passes through the cable gland and thence wraps around the positive and negative wires and terminates on the negative battery clip.

You have several options for producing a front panel label. One is to print it onto clear overhead projector film, using film suitable for your type of printer, and as a mirror image so the printed side is protected against the lid. With a black lid you need to attach the label with a light coloured silicone sealant, so the printing can be seen against the silicone.

Alternatively, you can print onto an A4-sized synthetic "Dataflex" sticky label that is suitable for inkjet printers or a "Datapol" sticky label for laser printers. (Google "Dataflex" or "Datapol" for more information).

Then affix the label using the sticky back label adhesive and cut out the required holes with a hobby knife.

Setting the full-charge voltage

As mentioned, you would typically set the voltage at TP1 and TP2 to 1.44 and 2.88V. That's gives a full-charge voltage of 14.4V for a 12V battery and 28.8V for a 24V battery.

However, the manufacturer of the battery you are using may recommend a higher (say 14.8V) or a lower (say 13.9V) voltage for a 12V battery (and twice those figures for a 24V battery) and it might need to be reduced for elevated temperatures. Check with the manufacturers' specifications for details on how much reduction with temperature is required.

You can check the charge voltage by measuring the battery voltage as it reaches full charge and charging stops and the charge LED continuously lights.

If you missed the full charge point, switch off the charger and then reapply power and measure the battery again at the point where charging ceases. Increase the voltage setting for TP1 or TP2 if the battery charge voltage is set too low.

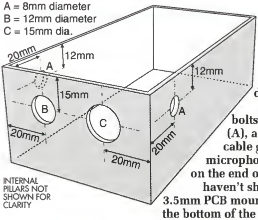
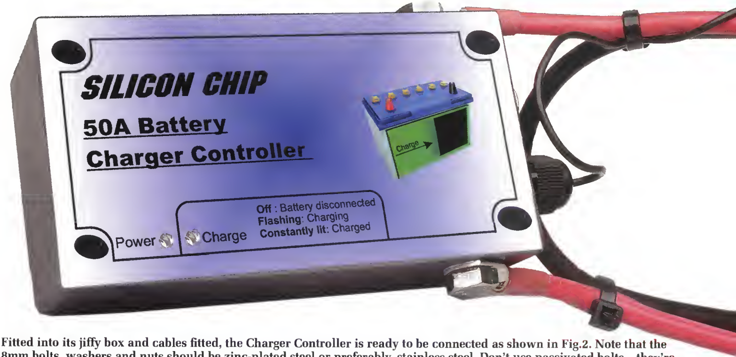


Fig.6: drilling detail for the 8mm bolts on each side (A), along with the cable gland (B) and microphone socket (C) on the end of the box. We haven't shown the four 3.5mm PCB mounting holes in the bottom of the box – use the PCB itself as a template for these.

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	240kΩ	red yellow yellow brown	red yellow black orange brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	2	9.1kΩ	white brown red brown	white brown black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	300Ω	orange black brown brown	orange black black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	1	100Ω*	brown black brown brown	brown black black black brown
		*1W		



Fitted into its jiffy box and cables fitted, the Charger Controller is ready to be connected as shown in Fig.2. Note that the 8mm bolts, washers and nuts should be zinc-plated steel or preferably, stainless steel. Don't use passivated bolts – they're usually not good conductors.

Modifying your generator for a controlled kill!

As explained in the text, one of the best features of this Charger Controller is that it will automatically turn your generator off when charging is complete.

But to do this, a small "mod" is necessary – you need to parallel the generator's "kill" switch with a two-wire cable back to the charge controller "kill" relay (RLY2).

Exactly how you do this depends to a large extent on your generator. Basically, you need to find space on the control panel to mount a two-pin socket – its mating plug carries the "kill" command from the charger/controller.

Five seconds after the charge is completed, it shorts out the kill switch for five seconds (to ensure the generator really does turn off!).

We modified a Powertech 1kW AC/DC generator which we obtained from Jaycar Electronics some time ago. Unfortunately, this model is not stocked any more – but the basic arrangement is the same for most small generators.

All you need do is find somewhere on the panel to mount the socket so that it doesn't foul anything inside when the panel is replaced on the generator.

We used two-pin microphone sockets on both the charger controller and the generator. They're about the smallest we could find but the big advantage is they have captive (screw-in) plugs and so ensure a reliable connection.

It's then simply a matter of soldering on a short length of two-wire cable from the socket to the terminals on the kill switch (which may be labelled as "ENG SW" or similar), making sure that the kill switch operation is not disturbed.

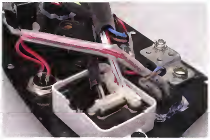
Make up a cable as long as is required with mating plugs and you're ready to rock and roll . . . in silence!

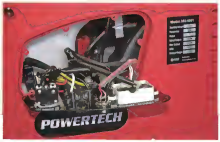
Building it in

Most RVs, caravans, etc, these days have a separate "battery box", more often than not accessible from outside. Unless yours is really crammed full of batteries, it seems like a good idea to mount the charger/controller inside the same box.

Whatever you do, make sure the mounting is solid – you don't want the unit shaking loose halfway up the Oodnadatta track! An extra strap around the box would be a worthy "belts and braces" approach.

Naturally, you'd run the generator outside the van (watch those carbon monoxide fumes!) but connecting cables could stay readily accessible in the battery box. SC





The modified control panel of the Powertech (Jaycar) 1kW Generator. At left is the two-pin microphone socket we added (about the only spot possible!). Centre is a close-up of the wiring and right is the panel about to go back in.

Notes & Errata

12-24V High Current Speed Controller, March & April 2008: the component overlay (page 65, April 2008) shows a 100μF capacitor immediately to the right of LK14. This should be a 470μF 16V electrolytic. Similarly, the component overlay shows a 220nF MKT capacitor in parallel with zener diode ZD6. This should be a 100nF MKT capacitor.

Notes & Errata

50A Battery Charger Controller, November 2016: the Online Shop (page 80) shows the microcontroller as a PIC16F88; it should be a PIC12F675 (the parts list is correct).

24V & 6V versions of battery charge controller

Undoubtedly, some readers will want to use the Charge Controller from the April 2008 issue with a 24V or 6V charger. We are not in favour of this, since the adaptor has been optimised for 12V operation but here is how it could be done.

This partial version of the circuit shows the component changes needed (in red) for 24V operation. For 24V use, REG1 must be changed to an LM317HV to cope with the higher input voltage; a 1N4004 diode must be connected between the input and output of REG1 (anode to the output, cathode to the input); ZD1 must be changed to two 24V zener diodes in series; and the 470µF and 10µF capacitors at the input to REG1 must be 50V types. In addition, R1 and R2 should be 130kΩ and 24kΩ respectively. This changes the division ratio so that IC1 sees the voltages for a 12V battery.

Note that when setting the adjustable values, use voltages that are 0.5 of the required value. So a 30V cut-off would be set for 15V (1.5V on VR2). Similarly, a -50mV/°C temperature compensation would be set at -25mV using a 2.5V setting for VR4.

For 6V operation, use a low dropout adjustable regulator (LD1117V) for REG1, a 10Ω resistor instead of the 100Ω resistor supplying REG1, and a 15V zener for ZD1. R1 should be 22kΩ and R2 should be 10kΩ.

In the 6V case, you must only use the adjustable parameters because the preset ones are for 12V batteries. You must use a 6V charger and the 6V battery must not be much less than 6V unloaded.

When the cut-off voltage for the selected charge cycle is less than 12V, the burst charging for a flat battery that's at less than 10.5V becomes inoperative. This enables the 6V charging. The adjustable cut-off and float voltages are set at, for example, 7.2V and 6.9V respectively, with 0.72V and 0.69V at TP2 and TP3 respectively. The temperature compensation is set to the mV/°C value for the battery.

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