



# Charge Controller for 12V lead-acid or SLA batteries

Upgrade your standard 12V lead-acid battery charger or solar cell booster to a complete 2 or 3-step charger using this Charge Controller. It includes temperature compensation and LED indication. All parameters are adjustable for charging lead-acid or sealed lead-acid (SLA) batteries.

**M**OST lead-acid chargers are very basic, and simply pump current into the battery until it is switched off. The main problem with this type of charger is that ultimately it will overcharge the battery and may seriously damage it.

Adding a fully automatic Charge Controller to a basic charger will overcome these shortcomings. It will also prolong the life of your batteries and allow a battery to be left on a 'float' or 'trickle' charge, ready for use when required.

A typical lead-acid battery charger is shown in Fig.1. It comprises a mains transformer with a centre-tapped secondary output. The output is rectified using two power diodes to provide raw

DC for charging the battery. A thermal cutout opens if the transformer is delivering too much current.

### On charge

Battery-charging indication may be as simple as a Zener diode, LED and resistor. The LED lights when the voltage exceeds the breakdown voltage of the Zener diode (12V) and the forward voltage of the green LED (at around 1.8V). Thus, the LED begins to glow at 13.8V and increases in brightness as the voltage rises. Some chargers may also have an ammeter to show the charging current.

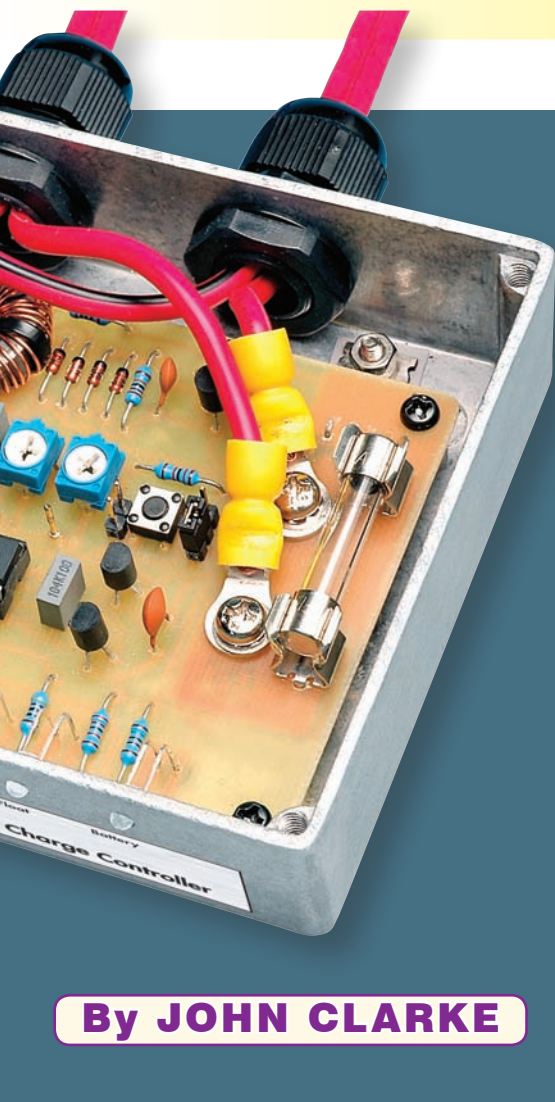
The charging current to the battery is provided in a series of high-

### Main Features

- Suits 12V battery chargers up to 10A rating
- Lead-Acid and SLA charging
- Cyclic and float charging
- Optional absorption phase
- LED indication
- Fixed and adjustable parameters
- Temperature compensation

current pulses at 100Hz, as shown in Fig.2a.

The nominal 17V output from the charger will eventually charge a battery to over 16V if left connected long enough – this is sufficient to damage the battery. This is shown in Fig.2b, where the battery voltage required for full charge (called the 'cut-off voltage') is exceeded when left on charge for too long. By adding in the Charge Controller, we can do much better.



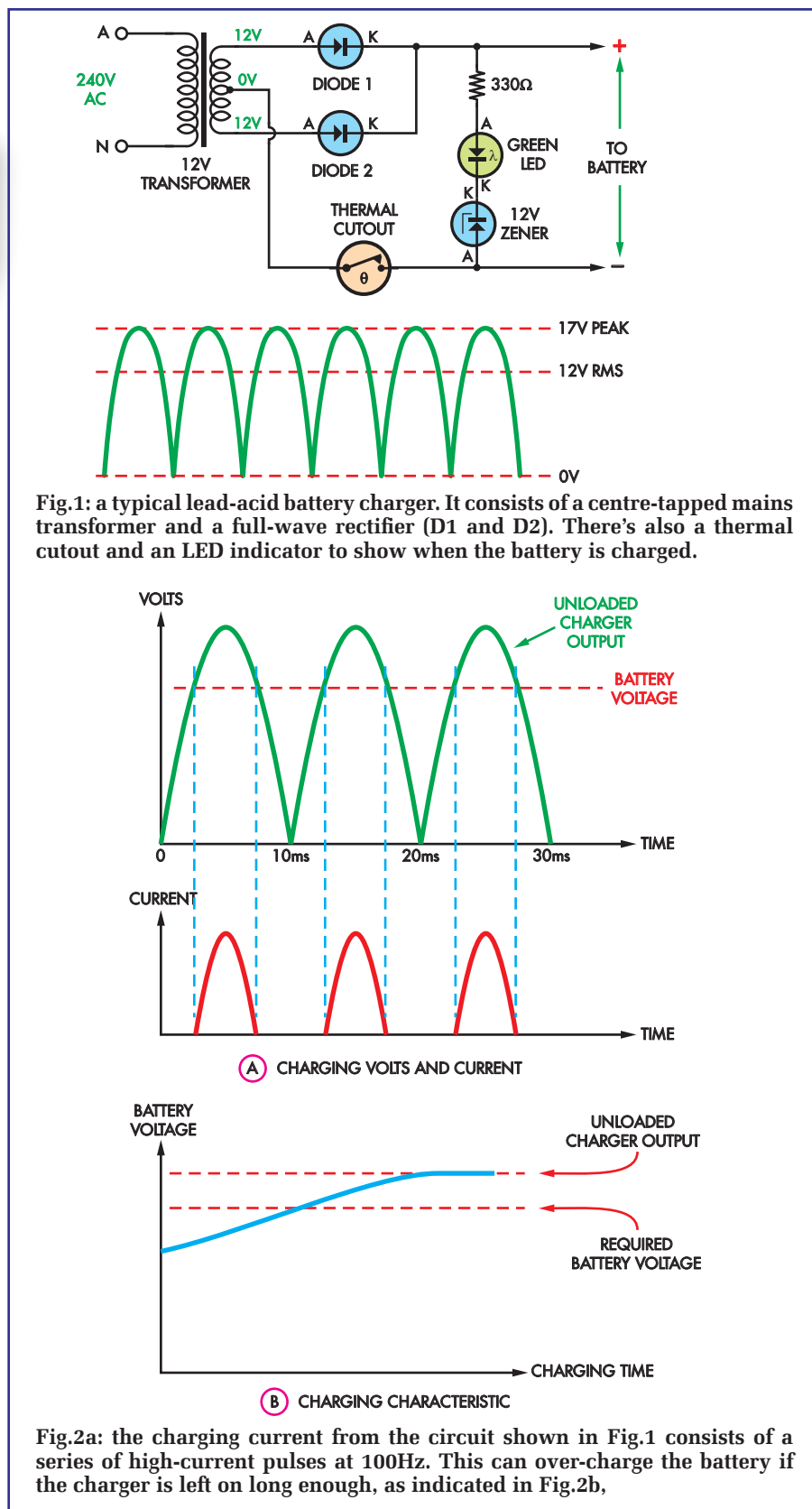
By JOHN CLARKE

## Charge control

Fig.3 shows how the Charge Controller is connected in between the charger and the battery. The controller is housed in a compact diecast aluminium case. However, if your charger has plenty of room inside its case, the controller could be built into it.

In effect, the Charge Controller is a switching device that can connect and disconnect the charger to the battery. This allows it to take control over charging and to cease charging at the correct voltage. The various charging phases are shown in Fig.4.

The Charge Controller can switch the current on or off, or apply it in a series of bursts ranging from 20ms every two seconds through to continuously on. During the first phase, called 'bulk charge', current is normally applied continuously to charge as fast as possible. However, with low-capacity batteries, where the main charging current is too high, reducing the burst width will reduce the average current. So, for example, if you have a 4A battery charger, the current can be reduced

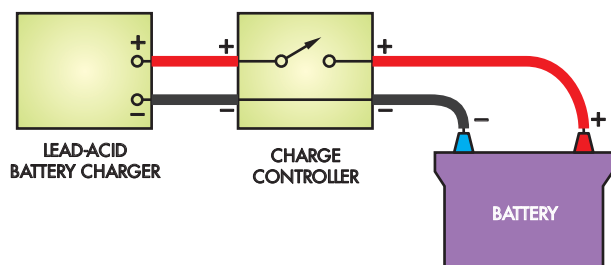


from 100% (4A) anywhere down to 1% (40mA) in 1% steps, using the charge rate control.

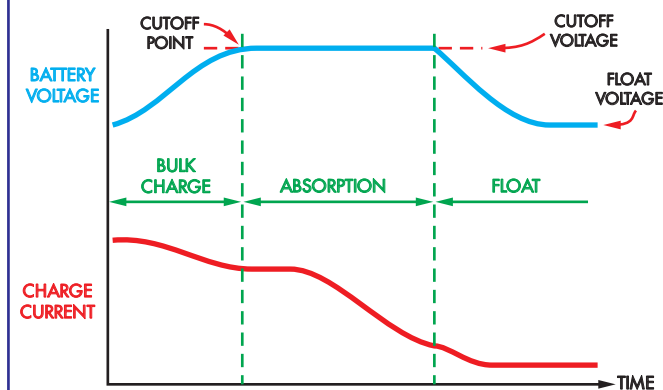
After the 'bulk charge' phase, the controller switches to the 'absorption'

phase. This maintains the cut-off voltage for an hour by adjusting the burst width and it brings the battery up to almost full charge. After that, the controller switches to 'float charge'.





**Fig.3:** the Charge Controller is connected between the battery charger and the battery. This allows it to take control of charging and to cease charging at the correct voltage.



**Fig.4:** this diagram shows the three charging phases. It starts with a 'bulk' charge, then switches to the 'absorption' phase for an hour and then finally switches to 'float charge'.

This uses a lower cut-off voltage and a low charge rate.

If the charge rate control is set to less than 100%, the switch from absorption to float will occur when the burst width drops to 1% or after an hour, whichever comes first. The absorption phase is an option that can either be incorporated in everyday charging, or you can opt to just go to float charge after the bulk charge phase. When absorption is selected, this phase will be bypassed if the bulk charge takes less than an hour.

This bypassing prevents excessive absorption phase charging with an already fully charged battery.

## Cut-off and float voltages

The actual cut-off and float voltages are dependent on the particular battery, its type and the operating temperature. For lead-acid batteries, typical cut-off and float voltages at 20°C are 14.4V and 13.8V, respectively. For sealed lead-acid (SLA) batteries, the voltages are lower at 14.1V and 13.5V, respectively.

These values are preset within the Charge Controller using the internal Lead-Acid/SLA jumper shunt. Alternative values are possible, and can be set manually from 0V to 16V in 48.8mV steps.

These voltage settings can be compensated for as temperature changes; as the temperature rises, the voltages should be reduced. Lead-acid batteries typically require  $-20\text{mV}/^\circ\text{C}$  compensation, while SLA types typically require  $-25\text{mV}/^\circ\text{C}$  compensation. These values can be set from 0 to  $-50\text{mV}/^\circ\text{C}$  in 256 steps.

For our Charge Controller, temperature compensation is applied for temperatures between 0°C and 60°C. No charging is allowed at temperatures below 0°C. A negative temperature coefficient (NTC) thermistor inside the controller is used for temperature measurement. Four trimpots are used to make the various settings.

## LED indicators

There are five LED indicators. LED1 (orange) flashes when the temperature is below 0°C, but otherwise does not light unless the thermistor connection is broken.

LED2 (red) indicates the 'bulk charge' phase, while LED3 (orange) and LED4 (green) are for the 'absorption' and 'float' phases. Note that there is an option for the Charge LED to indicate when charge is being applied to the battery during the absorption and float charge phases. If this is not required, it can be disabled so that

the Charge LED only lights during the bulk charge.

LED5 (green) indicates that a battery is connected, but is *not* an indication that charging is occurring.

## Circuit description

The complete circuit diagram of the Charge Controller is shown in Fig.5. It uses a PIC16F88-I/P microcontroller (IC1) to monitor the battery voltage and adjust the switching of an N-channel MOSFET (Q1) to control the rate of charging.

Q1 connects in the positive supply line between the charger output and the battery. Gate drive for Q1 comes from a transformer-coupled supply that can typically provide 15V to the gate (G) when it is required to switch Q1 on.

The transformer-coupled gate drive arrangement allows us to use an extremely rugged, low-cost N-channel MOSFET rated at 169A, 55V and with a 5.3mΩ on-resistance.

To switch on Q1, IC1 delivers a 500kHz square-wave signal from its pin 9 (PWM) output to a complementary buffer stage using transistors Q2 and Q3. These drive the primary winding of toroidal transformer T1 via a 3.3nF capacitor.

The secondary windings of T1 step up the voltage by just over three times, and the resulting AC waveform is rectified by diodes D2 to D5, and then filtered with a 120pF capacitor. This process delivers a nominal 16V DC to Q1's gate via diode D6. This turns Q1 on to feed current to the external battery. Zener diode ZD2 is included to prevent the gate-to-source voltage of Q1 exceeding 18V.

## Switch-off

While turning MOSFET Q1 on is fairly straightforward, turning it off is more involved because we want the switch-on and switch-off to be as fast as possible, to keep switching losses to a minimum.

Hence, to turn off Q1, the 500kHz signal from IC1 is switched off. With no signal at T1's secondary, the voltage across the 120pF capacitor is discharged via the 220kΩ resistor.

This discharge does not directly bring the gate of Q1 to 0V because it is isolated via diode D6. Instead, transistor Q4 discharges the gate capacitance of Q1, as its base is pulled low via the 220kΩ resistor. As a result, Q1 can be switched on in 56μs and off in 69μs.

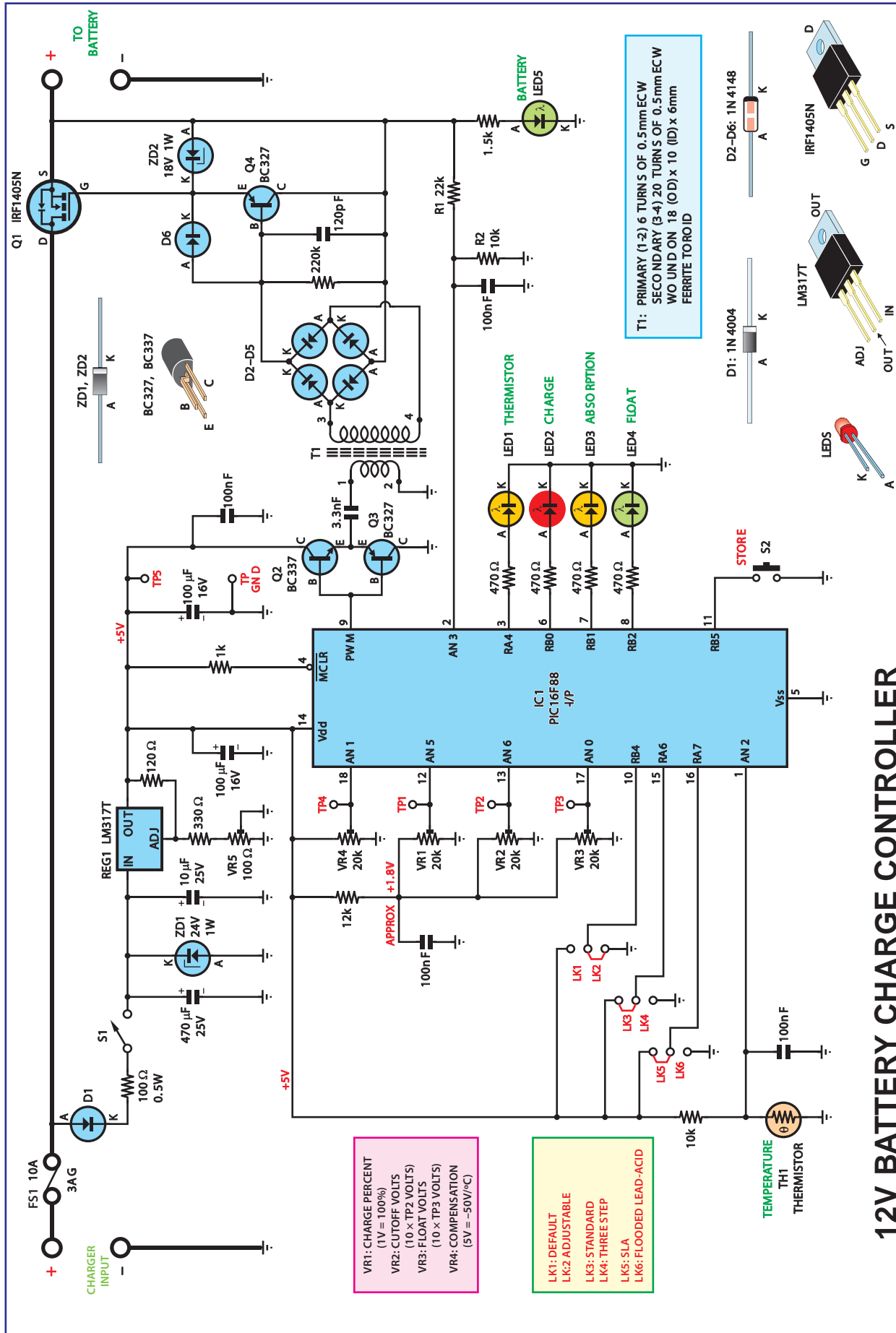
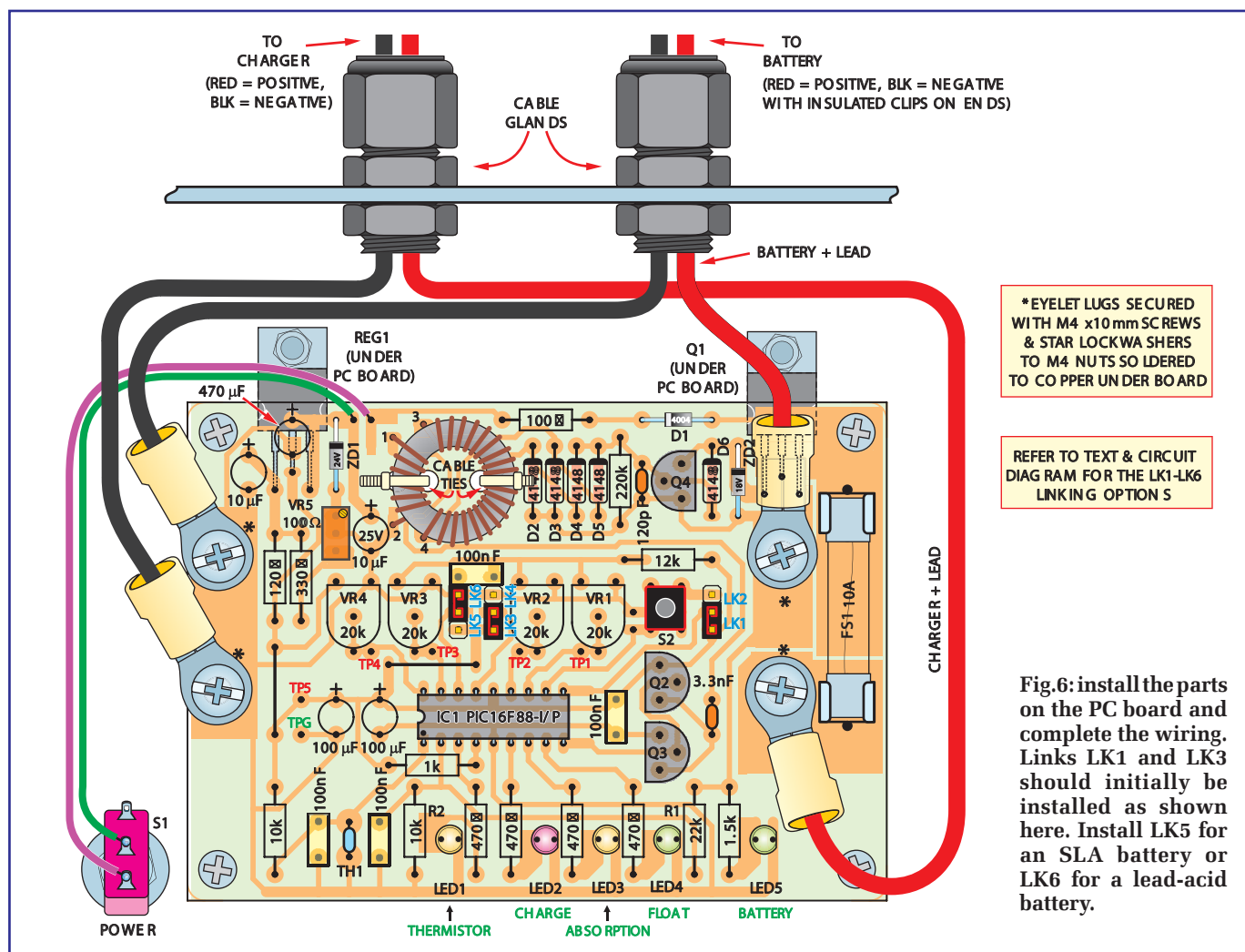


Fig.5: the circuit of the 12V Battery Charge Controller is based on a PIC16F88-I/P microcontroller (IC1). This monitors the battery voltage and pulse width modulates N-channel MOSFET Q1 to control the rate of charging. Pin 9 is the PWM output from the microcontroller and this drives Q1's gate via buffer stage Q2 and Q3, transformer T1, bridge rectifier D2-D5 and diode D6. Transistor Q4 turns the MOSFET off.



## Power supply

Power for the circuit is obtained from the charger via diode D1, or it can come from the battery via the reverse diode within Q1. However, the latter is a spurious mode which has no useful function.

Diode D1 prevents reverse current to the controller circuit should the charger or battery be connected with incorrect polarity. The incoming supply from diode D1 and switch S1 is filtered using a 470 $\mu$ F 25V electrolytic

capacitor and fed to an adjustable voltage regulator (REG1) that is set to deliver a precise 5.0V. This feeds IC1 and buffer stage transistors Q2 and Q3.

IC1 monitors the battery voltage via a voltage divider comprising R1 and R2, and converts it to a 10-bit digital value via the AN3 input, pin 2. The signal is filtered with a 100nF capacitor to remove noise from the measurement. Furthermore, the battery voltage measurements are made after the 500kHz

signal from pin 9 is switched off.

In addition, having Q1 switched off also prevents voltage fluctuations due to charging current in the leads to the battery 'under charge'.

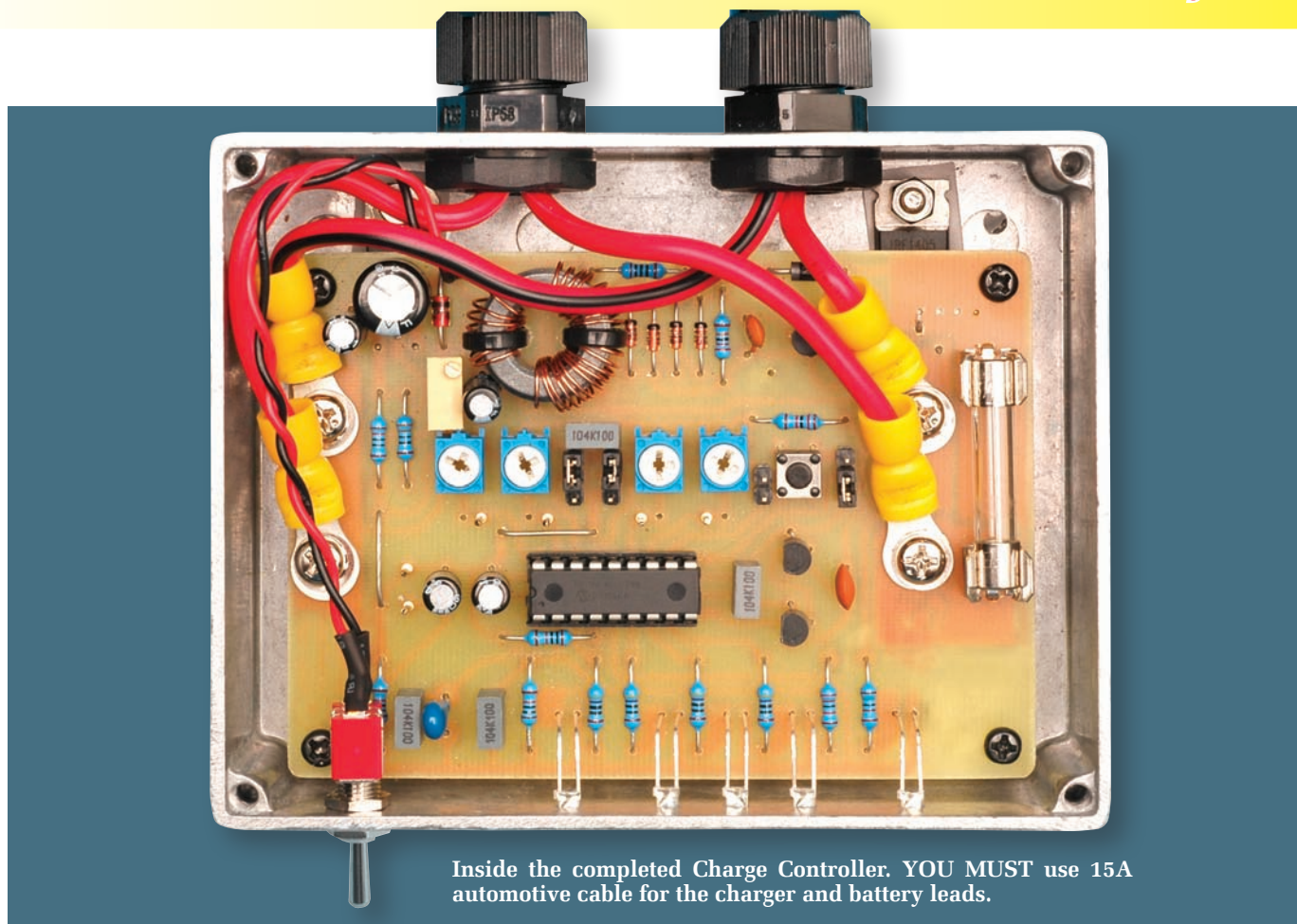
## Temperature measurement

As mentioned, an NTC thermistor (TH1) is used to measure temperature. It is connected in series with a 10k $\Omega$  resistor across the 5V supply. The resulting voltage across the thermistor is fed to IC1

## Table 1: Resistor Colour Codes

<input type="checkbox"/>	No.	Value	4-Band Code (1%)	5-Band Code (1%)
<input type="checkbox"/>	1	220kΩ	red red yellow brown	red red black orange brown
<input type="checkbox"/>	1	22kΩ	red red orange brown	red red black red brown
<input type="checkbox"/>	1	12kΩ	brown red orange brown	brown red black red brown
<input type="checkbox"/>	2	10kΩ	brown black orange brown	brown black black red brown
<input type="checkbox"/>	1	1kΩ	brown black red brown	brown black black brown brown
<input type="checkbox"/>	4	470Ω	yellow violet brown brown	yellow violet black black brown
<input type="checkbox"/>	1	330Ω	orange orange brown brown	orange orange black black brown
<input type="checkbox"/>	1	100Ω	brown black brown brown	brown black black black brown





Inside the completed Charge Controller. YOU MUST use 15A automotive cable for the charger and battery leads.

AN2 input (pin 1) and converted to an 8-bit digital value. IC1 then computes the temperature with a look-up table. It can also sense whether the thermistor is disconnected (pin 1 at +5V) or shorted (pin 1 at 0V).

Analogue inputs AN5, AN6, AN0 and AN1 monitor the settings for charge rate percentage, cut-off voltage, float voltage and temperature compensation, as set by trimpots VR1-VR4.

Switch S2 stores the settings in IC1. S2 is normally open, and an internal pull-up resistor within IC1 holds the RB5 input (pin 11) at 5V.

When S2 is pressed, the pin 11 input of IC1 is pulled low (0V), this signals the program within IC1 to store the settings for VR2, VR3 and VR4 as the adjustable values for either SLA or lead-acid batteries. Where the values are stored depends on links LK5 and LK6, connected to the RA7 input at pin 16.

### Link settings

If LK5 is in, pin 16 will be high (5V) and IC1 will store the settings as SLA parameters. If LK6 is in place, pin 16 will be low and the settings will be stored for the lead-acid parameters.

Links LK1 and LK2 determine whether the Charge Controller uses the

standard Default (LK1) or Adjustable setting referred to above.

Links LK3 and LK4 set the standard or three-step option. The standard charge selection switches charging to float charge directly after the main charge is complete.

The three-step selection will run the absorption phase after the main charge, provided that the full charging process takes more than one hour. For a main charge of less than one hour, the charging will switch directly to float charge.

**Note that these link combinations cannot be used together you must use one or the other. For example, you can use LK1 or LK2, LK3 or LK4, and LK5 or LK6.**

### Software

The software files are available via the *EPE* Library site, accessed via [www.epemag.com](http://www.epemag.com). Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

### Construction

The Charge Controller is built using a PC board, code 741, measuring 102mm × 72mm. This board is available from the *EPE PCB Service*. The PCB is

housed in a diecast box measuring 118 × 93 × 35mm.

Start construction by checking the PC board for any defects such as shorted copper tracks, breaks in the copper areas and for correct sizes for each hole. The holes for the four-corner mounting screws and the toroidal transformer cable tie mounts need to be 3mm diameter, while the four mounting points for the crimp eyelets need to be 4mm diameter.

Check also that the PC board is cut and shaped to size so that it fits into the box.

That done, the first step is to secure the four M4 nuts to the underside of the PC board in the four eyelet mounting positions using M4 screws. Preheat each nut with a soldering iron and solder it to the PC board. When cool, the screws can be removed.

Construction can now be continued by installing the two wire links and the resistors. Take care to place each resistor in its correct position. A colour code table is provided as a guide to finding each value, but use your DMM (digital multimeter) to check each resistor before inserting it into the PC board.

Next, install the PC stakes for the test points TP GND and TP1 to TP5. Install the 2-way header for switch

## Shortcomings of the Charge Controller

To round out our description of this project, we should also mention its possible shortcomings. In most cases these will not be a problem, but in special charging applications they could be significant.

### 1) Pulsed operation

The pulsed current can cause extra heating within the battery because losses and therefore heat build up are related to the square of the current. So, for example, to develop a 1A charge current from a 4A charger, the duty cycle may be set to 25% so that there is 4A pulsed for 25% of the time. This averages to 1A. However, by pulsing at 4A and 25% duty cycle, the current squared value is 16. When multiplied by the 25% duty cycle, the average current squared value reduces to 4. So the power losses and heating within the battery are four times greater compared to a charger that produces a continuous 1A.

### 2) Absorption and float charge

Because we pulse the charge current, the battery voltage fluctuates and rises with the current pulse and falls when the pulse is off. We measure the voltage just after the charge pulse is switched off. Compared to a charger that has a continuous lower current, the battery voltage may be maintained at a different value.

### 3) Charging indication

Due to the battery supplying the circuit power supply via the reverse diode in Q1, it can appear that charging is taking place even when the charger is not connected. It is important to check that the charger is connected and is switched on.

### 4) Battery discharge

If the charger is switched off with the battery connected, then the battery will eventually discharge due to the 30mA load of the Charge Controller.

is close to the battery and the metal box will not normally heat up. As a consequence, its temperature should be similar to the battery temperature if we ignore heat rise due to charge current within the battery.

If the thermistor is to be mounted externally, then wires can be connected where the thermistor mounts on the PCB, and passed through a cable gland in the box. Alternatively, use a 3.5mm jack socket and plug. For external use, the thermistor can be covered in heat-shrink tubing and attached to the side of the battery using Velcro or similar tape.

The capacitors can be installed next. Note that the electrolytic types must be oriented with the polarity shown. Install transistors Q2 to Q4 and trimpots VR1 to VR5, then install switch S2.

Fuse FS1 comprises two fuse-clips and the fuse. The fuse clips must be oriented so that the end stops are facing outwards, so that the fuse can be clipped into place – see Fig.6 and photos.

## Mounting the LEDs

The LEDs are mounted at right angles to the PC board. Bend the leads 12mm back from the front lens of each LED, taking care to have the anode (a) (longer lead) to the left and then bend the leads downward. The LEDs then insert into the PC board and sit 8mm above the top of the board – see Fig.7.

Voltage regulator REG1 and MOSFET Q1 mount under the PC board with their leads bent up at right angles, as shown in Fig.7. They are placed so that the metal face sits at the same depth below the bottom face of the PC board as the spacers (at 9mm).

## Transformer

Transformer T1 is made up using a ferrite ring-core toroid and some 0.5mm enamelled copper wire. There are two separate windings. Wind on the primary with six turns and the secondary with 20 turns. The winding direction is not important. The wire ends can be passed through the holes in the PC board, taking care to place the six-turn winding wire ends in the '1' and '2' holes and the 20-turn winding in the '3' and '4' holes.

The enamel insulation on the wire ends can be stripped away using a hobby knife, and the leads soldered to the PC board. Cut off excess wire, then secure the T1 assembly using two cable ties, which pass through the PC board as shown.

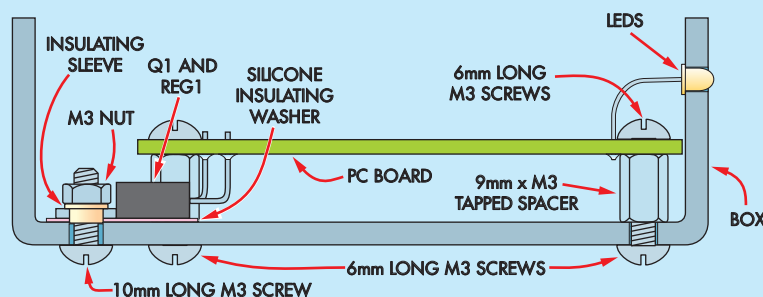


Fig.7 (above): here's how the PC board is mounted in the case. Note that the metal tabs of Q1 and REG1 must be isolated from the case using insulating washers and bushes (see text).

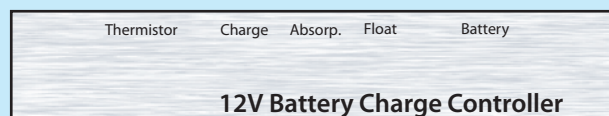


Fig.8: this is the full-size front panel artwork for the specified case.

S1 and the 3-way headers for link LK1 to LK6.

Now install the diodes and the Zener diodes, with the orientation as shown. IC1's socket can then be mounted, and this must also be oriented correctly. Note that IC1 is not inserted in its socket

until certain voltage checks have been carried out at the testing stage.

## Thermistor mounting

Normally, the NTC thermistor (TH1) can be mounted directly on the PC board because the Charge Controller

## Casing up

Work can now commence on the metal box. First, position the PC board in the box with the edge closest to the LEDs sitting 3mm away from the edge of the box. Mark out the four corner mounting hole positions, then drill (and deburr) these holes to 3mm and mount the four 9mm stand-offs.

Now mount the PC board in position and secure it using M3 x 6mm screws. Mark out the mounting holes for Q1 and REG1, and mark out the LED and S1 positions. Also mark out the two holes for the cable glands. That done, remove the PC board and drill out the holes. Be sure to deburr, especially the two holes for Q1 and REG1.

The PC board can now be mounted inside the box. Isolate the tabs of Q1 and REG1 from the case, using insulating washers and mounting bushes – see Fig.5 and Fig.7. Now check that the tabs for REG1 and Q1 are insulated from the metal box by measuring the resistance with a multimeter. The reading should be high; above 1MΩ. **The box is totally isolated from the electrical connections so that accidental contact of the box to a battery terminal will not cause a short circuit.**

Install the two cable glands and pass the figure-8 cable through them, ready to attach the crimp eyelets. We used the striped wire as the negative and the plain red wire as the positive.

Connect the crimp eyelets using a crimping tool and secure them to the PC board using the M4 screws and star washers. Make sure the eyelets are not shorting to adjacent parts, especially the fuseholder. The battery leads will need the large insulated clips connected to the end – use red for positive and black for negative.

The Charge Controller leads can simply be bared at their ends and connected to the charger clips or they can be permanently wired to the charger.

Switch S1 can now be wired to the PC stakes on the PC board and covered with heatshrink tubing. Finally, fit the stick-on rubber feet to the underside of the box.

## Testing

Install links LK1, LK3 and either LK5 (SLA) or LK6 (lead-acid). Do not place a link onto the 2-way header adjacent to S2, as this is for an optional front panel-mounting switch for S2.

## Specifications

**Under-voltage burst charge:** 10.5V (inoperative if the selected cut-off voltage is below 12V).

**Under-voltage burst rate:** approx. 200ms burst every 2s with charge rate set to 100%. Burst width is reduced with a lower charge rate. Charge, Absorption and Float LEDs all flash. Battery LED flashes with no battery and charger connected. The LED lights continuously when battery connected.

**Under temperature:** 0°C; no charge; thermistor LED flashes on and off at 1s rate.

**Temperature measurement resolution:** 0-60°C in 1°C steps.

**Thermistor out:** Thermistor LED fully lit; no charge.

**Compensation:** 0°C to 60°C

**Adjustable compensation:** 0-50mV/°C in 256 steps (separate SLA and lead-acid battery adjustments)

**Adjustable cut-off and float voltage:** 0-16V in 48.8mV steps. Separate SLA and lead-acid battery adjustments

**Fixed value:** SLA cut-off 14.1V, float 13.5V and -25mV/°C compensation with respect to 20°C. Lead-acid 14.4V, 13.8V and -20mV

**Charge rate:** adjustable from 100% to 0% in 1% steps. Pulses are adjusted in approximately 20ms steps.

**PWM drive signal:** 500kHz.

**MOSFET gate rise-time for an on pulse:** 56μs (10-90%) for a 16V gate voltage

**MOSFET gate fall time for an off pulse:** 69μs

### LEDs

**Bulk Charge:** Charge LED flashes at a duty that equals the % charge rate.

**Absorption:** Absorption LED lit (optional Charge LED shows whenever charge is on to maintain battery voltage).

**Float:** Float LED lit (optional Charge LED indication).

### Charging

**Charge:** charges at the charge rate (%) until the cut-off voltage is reached.

**Absorption:** adjusts current pulse duty cycle to maintain cut-off voltage.

**Float:** adjusts current pulse duty to maintain float voltage.

### Float and absorption current control

Charge duty cycle is reduced fast (15% every 2s) if the battery voltage is above the required value by more than 0.25V, and reduced by 1% every 2s if the battery voltage is above the required value by up to 0.25V. Conversely, charge duty cycle is increased fast (3% per 2s) if the battery voltage is less than 0.25V below the required value and increased at a slow rate (1% per 2s) if the battery voltage is no more than 0.25V below the required voltage.

Now connect a multimeter, set to read 5V DC, between 'test points' TP GND and TP5. Connect a supply to the charger input and adjust VR5 for a 5.0V reading on the multimeter. Check that the voltage between pin 5 and pin 14 pin on IC1's socket is also 5V. If so, switch off power and insert IC1, taking care to orient it correctly.

## Charging

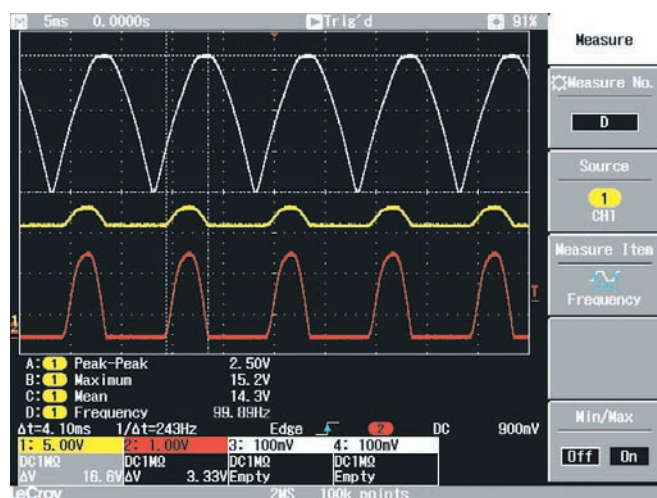
For most large batteries you would set the charge rate to 100%. In this case, simply set VR1 fully clockwise. You can use the 100% setting for all batteries that can accept the charge rate from your charger. Most batteries can accept up to 30% of the quoted Ah capacity as a current. So a 100Ah battery can accept 30A.

If your charger supplies less than 30A, then the 100% setting can be used. If your battery is rated in RC (reserve capacity) you will need to convert to Ah.

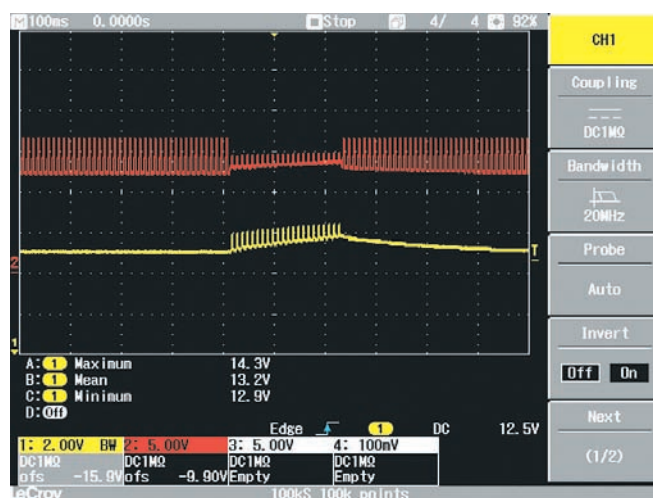
Reserve capacity is a specification in minutes, and specifies how many minutes a fully-charged battery can deliver 25A before the voltage drops to 10.5V. A battery with an RC of 90 will supply 25A for 90 minutes. The amp-hour specification (Ah) refers to the current that can be supplied (usually over a 20 hour period). So a 100Ah battery can supply 5A for 20 hours.

To convert from RC to Ah, multiply the RC value by 0.42 (derived by multiplying by 25A to get the capacity in Amp minutes and dividing by





**Fig.9:** this scope shot duplicates the waveforms shown in Fig.2a. The white trace is the charger input, while the red trace shows the 100Hz current pulses into the battery.



**Fig.10:** this shot shows the Charge Controller operation. The red trace is the 100Hz input from the charger, while the yellow trace shows the current into the battery.

60 to convert from minutes to hours). In practice, because the RC capacity specification uses 25A, the conversion from RC to Ah often gives a lower Ah value than the battery's actual Ah capacity. This is because the Ah capacity often requires much less current from the battery over a longer period.

For batteries that require a lower current than that supplied by the charger, the charge rate can be reduced from 100%. So, for a charger that is rated at 4A and a battery that can only accept a 2A charge current, set the charge rate to 50%.

The charge rate is set using VR1, where the voltage at test point TP1

represents the percentage. Voltages of 1V or more give 100%, while values below 1V provide lower percentage charge rates. For example, a 0.5V reading gives a 50% charge rate duty cycle.

Note that when charging a battery that has less than 10.5V across its terminals, the charging will be in a specific burst mode, with the burst at 200ms every two seconds when the charge rate is set to 100%. At lower charge rates, the burst length will be reduced accordingly. During under-voltage burst, the Charge, Absorption and Float LEDs flash.

As mentioned earlier, the charge LED can be set to flash when charge is applied during the absorption and float phases. This is the initial setting.

If you do not require the charge LED to show during these phases, you can disable this. Switching off power and pressing S2 while the power is re-applied will disable this feature. The change is acknowledged by a minimum of two fast (two/second) flashes of the Charge LED. The acknowledgement flashing continues until the switch is released.

You can re-enable the feature by pressing S2 at power up again.

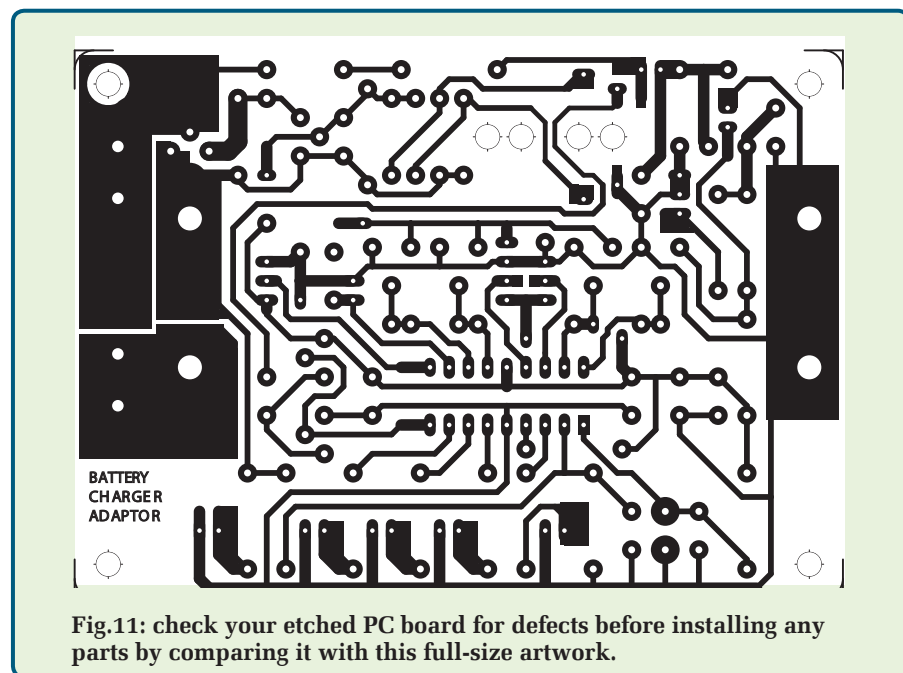
## Setting the parameters

Most battery manufacturers will specify the required cut-off (also called the cyclic voltage), the float (also called the trickle voltage) and the temperature compensation for each battery. Note that the cut-off and float voltages must be the values for 20°C.

The temperature compensation required by manufacturers is usually shown as a graph of voltage versus temperature. You need to convert this to mV/°C. To do this, take the difference between the voltages at two different temperatures and divide by the temperature difference.

For example, a battery graph may show the cut-off or cyclic voltage at 0°C to be 14.9V. At 40°C it may be 14.2V. So  $(14.2 - 14.9)/40$  is  $-17.5\text{mV/°C}$ .

Where the float temperature compensation is different to the cyclic temperature compensation, a compromise between the two values will have to be made. Note that the graph can be interpreted over a smaller temperature range that is consistent with the temperatures under which you expect to be using the charger.



**Fig.11:** check your etched PC board for defects before installing any parts by comparing it with this full-size artwork.

## Parts List – Charge Controller

1 PC board, code 741, available from the *EPE PCB Service*, size, 102 × 72mm  
1 diecast box, 118 × 93 × 35mm  
1 SPDT toggle switch (S1)  
1 SPST micro tactile switch, with 0.7mm actuator (S2)  
2 cable glands for 4-8mm diameter cable  
2 TO-220 silicone insulating washers and mounting bushes  
4 small adhesive rubber feet  
2 PC-mount fuse clips  
1 10A fuse (FS1)  
1 ferrite ring-core, 18 × 10 × 6mm (Jaycar LO-1230 or equivalent) (T1)  
1 NTC thermistor (10kΩ at 25°C) (TH1)  
1 18-pin IC socket  
4 9mm long M3 tapped spacers  
8 M3 × 6mm screws  
2 M3 × 10mm screws  
2 M3 nuts  
4 M3 × 10 screws  
4 M4 nuts  
4 M4 star washers  
4 insulated crimp eyelets

2 100mm cable ties  
1 1m length of 15A figure-8 automotive cable  
1 100mm length of medium-duty red hook-up wire  
1 100mm length of medium-duty black hook-up wire  
3 3-way headers with 2.54mm spacing  
1 2-way header with 2.54mm spacings  
3 jumper plugs  
8 PC stakes  
2 insulated battery clips (red and black)  
1 600mm length of 0.5mm enamelled copper wire  
1 50mm length of 0.7mm tinned copper wire

### Semiconductors

1 PIC16F88-I/P microcontroller, pre-programmed – see text (IC1)  
1 IRF1405 *N*-channel MOSFET (Q1)  
1 BC337 *NPN* transistor (Q2)  
2 BC327 *PNP* transistors (Q3, Q4)

1 24V 1W Zener diode (ZD1)  
1 18V 1W Zener diode (ZD2)  
1 1N4004 1A diode (D1)  
5 1N4148 diodes (D2 to D6)  
1 LM317T adjustable voltage regulator (REG1)  
2 orange 3mm LEDs (LED1 and 3)  
1 red 3mm LED (LED2)  
2 green 3mm LEDs (LED 4 and 5)

### Capacitors

1 470μF 25V PC radial elect.  
2 100μF 16V PC radial elect.  
1 10μF 25V PC radial elect.  
4 100nF MKT polyester  
1 3.3nF ceramic  
1 120pF ceramic

### Resistors (0.25W, 1% metal film)

1 220kΩ      4 470Ω  
1 22kΩ        1 330Ω  
1 12kΩ        1 120Ω  
2 10kΩ        1 100Ω 1/2W  
1 1kΩ

### Trimpots

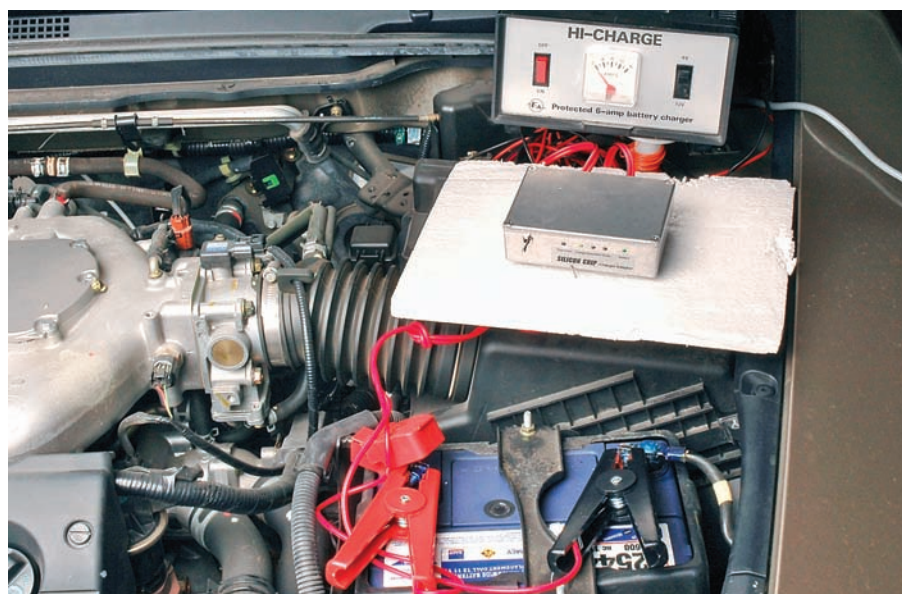
4 20kΩ horizontal mount trimpots (VR1-VR4)  
1 100Ω multiturn top adjust trimpot VR5)

To set the adjustable parameters, apply power to the Charge Controller via a battery or charger and select the battery type with link LK5 or LK6. That done, connect a multimeter between TP GND and TP2 and adjust the required cut-off voltage using trimpot VR2.

Each volt represents a 10V cut-off, so 1V at TP2 sets a 10V cut-off, 1.44V sets a 14.4V cut-off, and so on. Now connect the multimeter to TP3 and adjust VR3 for the required float voltage. Each volt at TP3 represents 10V float.

For the temperature compensation, monitor TP4 and adjust VR4 for the required compensation. Here, 5V represents -50mV/°C and 2V represents -20mV/°C. Press switch S2 to store the values. The Thermistor, Charge and Float LEDs will all flash twice to acknowledge the setting and that the cut-off, float and compensation values have been stored.

You can store the parameters for the second battery type by changing the settings for links LK5 and LK6, and



**You will need to fit a couple of heavy-duty clips to make the connections to the battery. And yes, you can use it to charge your car's battery.**

readjusting the trimpots. Store the values using switch S2. Note that adjusting the trimpots without pressing the store switch will not store new values. *EPE*

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