

# K193 – Smart SLA Battery Charger

## INTRODUCTION

K193 is a Smart Sealed Lead Acid (SLA) Battery Charger with Current Limiting. The charger uses a two step process for charging SLA batteries – a current limited 'fast' mode followed by a constant voltage 'float' mode.

An onboard LED indicates when the charger is in 'fast' mode. When the LED goes out the battery is charged and the charger has switched to 'float' mode.

## BACKGROUND INFORMATION

The best way to charge a Sealed Lead Acid (SLA) battery is with a current limited voltage regulator, allowing fast charging while limiting heat buildup and gassing.

SLA batteries are made up of 2V (nominal) cells. Therefore a 12V battery has 6 cells.

The following parameters were used for this charger:

1. The charging current should be approximately 0.1 times the battery capacity. So, a 10Ah battery should be charged with a 1A current ( $10 \times 0.1 = 1$ ). This helps to ensure battery life.
2. The charging voltage is 2.45V per cell = 14.7V
3. Float charging voltage is 2.275V per cell = 13.65V

## HOW IT WORKS

This two step battery charger works as follows:

**Step 1.** Charging starts at the maximum current limit. The battery terminal voltage will gradually increase until it reaches the regulator set voltage.

**Step 2.** As the battery becomes fully charged the current will start to decrease. When the charging current drops to around 140mA (see later) the regulator voltage is decreased to a safe float voltage at which the battery can be left on indefinitely.

## CIRCUIT DESCRIPTION

The charger is based around an LM317 (IC1) adjustable voltage regulator. Resistors R2 and R4 and trimpot P1 are used to set the charging voltage.

When setting the output voltage it is important to remove IC2 (LM393) from the circuit. The IC causes the charger to switch to float mode when the battery is fully charged (more on that later).

### How does the LM317 set the output voltage?

The LM317 has a fixed voltage of 1.25V across its OUT and ADJ pins. This fixed voltage is applied across fixed resistor R2, giving a constant current of ~10.4mA ( $1.25/120$ ).

Ignore transistor Q1 for the moment. The current flows through resistor R4 and trimpot P1. This causes a voltage drop across them ranging from 12.5 to 17.7 volts (depending on the value of P1). Add this to the 1.25 volts across the regulator and you get an output voltage in the range of 13.75 - 18.95 volts.

The battery voltage will be 0.7V less than this due to the drop across output diode D3, giving a battery charging voltage range of approximately 13.0 - 18.25 volts.

### How does the current limit work?

The current limit is set by resistors R10A and R10B. The value of these resistors is calculated by

$$R = 0.6V/I_{max}$$

where **0.6V** is the transistor turn on voltage (nominal)  
**R** is the parallel combination of R10A & R10B  
**I<sub>max</sub>** is the charging current limit.

For a 1A current  $R = 0.6 \text{ ohms}$  ( $0.6V/1A$ ) which means each resistor will be 1.2 ohms ( $1.2/1.2 = 0.6 \text{ ohms}$ ).

The voltage across these resistors is used to turn on transistor Q1. The transistor will be turned on when the voltage reaches 0.6 volts (nominally). When the transistor turns on it lowers the voltage at the ADJ pin of the regulator and therefore the output voltage will drop. As the output voltage drops so will the current and the circuit will 'stabilize' to maintain the current limit.

### What is the purpose of IC2?

IC2 is an LM393 – Dual Voltage Comparator. One comparator, IC2:A, is used to set the float voltage while the other half, IC2:B, is used to drive the charge indicator LED.

A voltage comparator compares an unknown input voltage to a set reference voltage. In this case the reference voltage is set by resistors R6 and R7. This reference voltage is varying as the regulator output voltage changes. However, once the battery is charging at less than the current limit the output voltage will be fixed so the reference voltage will also be fixed.

The unknown voltage is the voltage across the current limit resistors (R10A & R10B). This voltage is feed into the comparator via resistor R8.

For a battery charging voltage of 14.7V the regulator output will be 15.4V ( $14.7 + 0.7$  across D3). Using the voltage divider rule the reference voltage at pins 2 & 5 of IC2 will be ~85mV.

While the voltage across the current limit resistors is more than 85mV the output of IC2:A will be high (pin3 > pin 2) and R5/P2 will have no effect on the regulator output.

The current required to cause an 85mV drop across the current limiting resistors is ~142mA. This means the battery is fully charged. Comparator IC2:A will switch and its output will go low. This puts resistor R5 and trimpot P2 in parallel with R4 and P1, dropping the total resistance and therefore the regulator output voltage, which will be around 14.35 volts. Allowing for the 0.7V drop across D3 the battery float charging voltage will be 13.65 volts.

While the battery is charging the LED will be ON. When the charger switches to float mode the LED will go out.

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### ASSEMBLY

**NOTE:** 1.2 ohm resistors have been supplied for the current limit resistors R10A and R10B. These will set the charging current limit to 1A. If you require a different current limit then you need to work out the new values for these resistors and supply them yourself.

First check and identify all the components against the parts list. Follow the overlay on the PCB (or below) when inserting components. Start with the lowest height components first – resistors, diodes, IC socket, etc.. Leave the heatsink and regulator IC until last. Make sure that the polarised components, diodes and electrolytic capacitors, are inserted the correct way round. Fit the trimpots, screw terminal blocks and 1000uF capacitor.

Lightly secure the regulator IC to the heatsink using the screw and nut provided. Use some heatsink compound if available. Fit the whole assembly to the PCB and solder into position. Tighten the screw and nut.

Do not insert the IC into the socket – this will be done after setting the output voltage (see below).

### POWER SUPPLY SPECIFICATION

The minimum DC input voltage is set by the charging voltage (14.7) plus 3V regulator voltage drop plus the voltage drop (0.7) across the input and output diodes. This works out at 19.1V (14.7 + 3.0 + 0.7 + 0.7).

A 19VDC supply with a current rating of at least 2A should work fine. This is a common power supply used with many laptop/notebook computers and will be readily available from your local computer store or even your local computer swap meet.

### THE HEATSINK GETS HOT!

The current limiting resistors, regulator and heatsink will get hot when charging a flat battery ie. charging current is around 1A. The voltage across the regulator will be approximately 3 volts which means the power dissipated will be around 3 watts. **The heatsink will be too hot to touch.** However the charger has been tested in this condition for hours at a time without any problem. If mounted in a box it should be well ventilated. If worried about the heat then mount the regulator offboard on a larger heatsink.

### SETTING THE OUTPUT VOLTAGE

Setting the output voltage is done with IC2 not inserted.

Connect a voltmeter to the battery charging terminals. Adjust trimpot P1 until the voltage reads 14.7 volts.

Disconnect power and insert the IC into its socket. The notch end should be towards the heatsink. Make sure none of IC leads are bent up underneath the IC body when inserting into the socket (a common problem). Connect power again and adjust trimpot P2 until the voltage reads 13.65 volts.

The charger is now ready for use!

### PARTS LIST – K193

#### Resistors (0.25W, 5%, carbon)

1R2 (metal film).....	R10A,B .....	2
120.....	R2.....	1
1K.....	R1,7.....	2
1K2.....	R3,4.....	2
1K5.....	R9.....	1
12K.....	R5.....	1
15K.....	R8.....	1
180K.....	R6.....	1
Trimpot, 500R 10-turn P1 .....		1
Trimpot, 5K 10-turn.... P2 .....		1

#### Capacitors

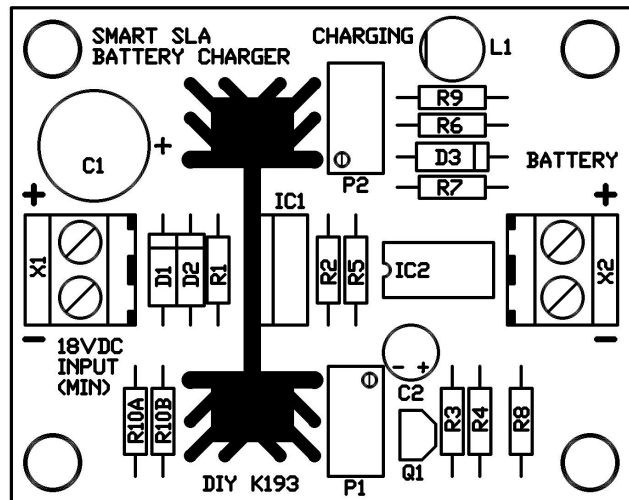
1uF 25V electro .....	C2.....	1
1000uF 35V electro....	C1.....	1

#### Semiconductors

1N4004.....	D1-3 .....	3
LM317T.....	IC1 .....	1
LM393.....	IC2 .....	1
BC547.....	Q1 .....	1
LED, 5mm red .....	L1 .....	1

#### Miscellaneous

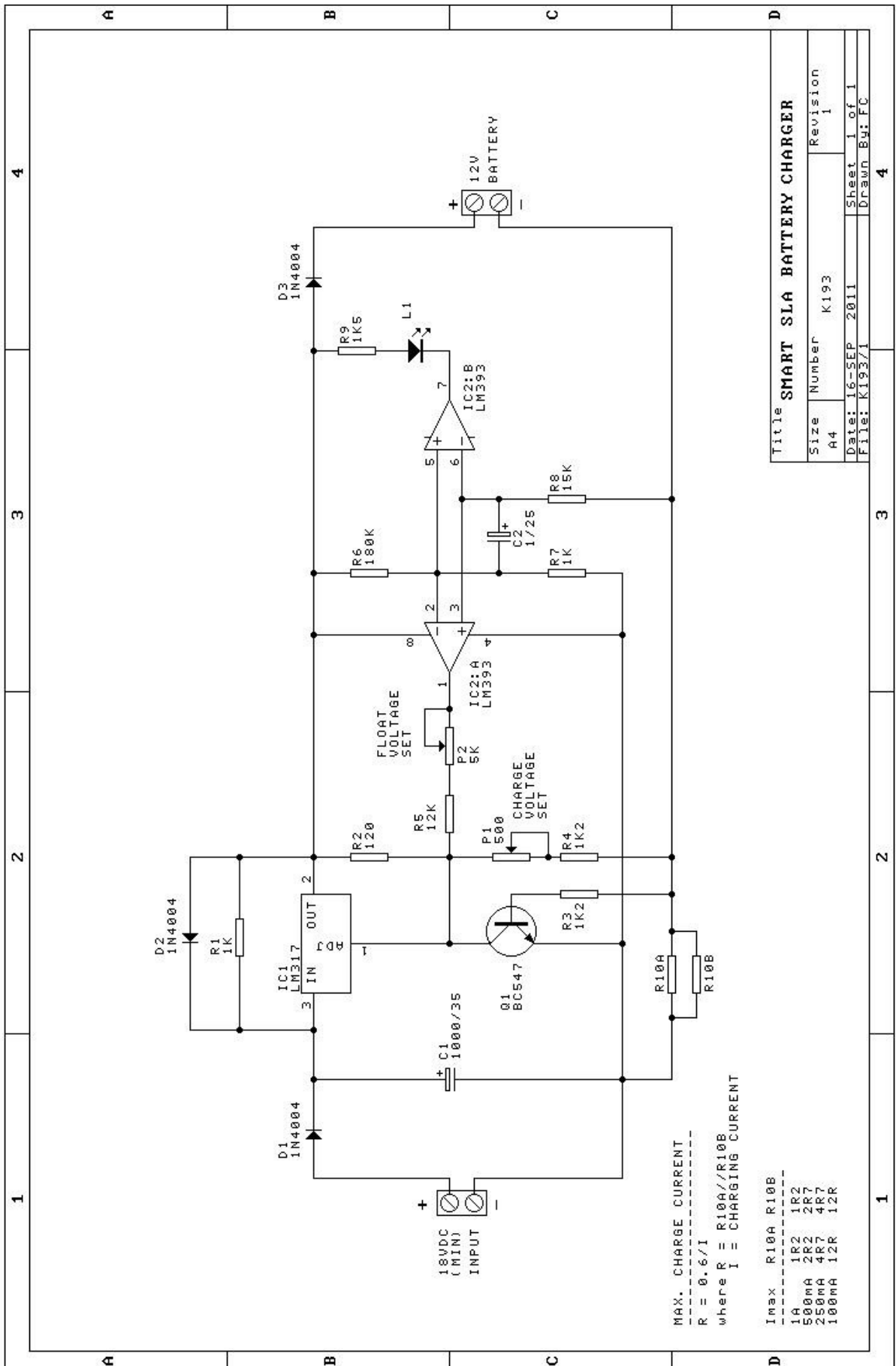
IC socket, 8 pin .....	for IC2.....	1
Screw terminal block... X1,2 .....		2
	2 way	
Heatsink.....		1
Screw, 3 x 8mm .....		1
Nut, 3mm.....		1
PCB, K193.....		1



### CONTACT DETAILS

You can contact the developer directly at [www.ozitronics.com](http://www.ozitronics.com)

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Title **SMART SLA BATTERY CHARGER**

Size	Number	Revision
A4	K193	1
Date:	16-SEP-2011	Sheet 1 of 1
File:	K193/1	Drawn By: FC

MAX. CHARGE CURRENT -----  
 $R = 0.6/I$   
 where  $R = R10A/R10B$   
 where  $I =$  CHARGING CURRENT

$I_{max}$	R10A	R10B
1A	1R2	1R2
500mA	2R2	2R7
250mA	4R7	4R7
100mA	12R	12R