ZS6PTA Branch Project – 2/2008

12 Volt Lead Acid (LA) Accumulator

3 LED Monitor

1 Introduction

This device can be used to monitor the voltage of a 12V lead acid accumulator.

This monitor has three states representing three different typical lead acid battery voltage ranges

- **Red** – the battery voltage is below 11V (considered the absolute minimum voltage to which a lead acid battery can be discharged)
- **Green** - the battery voltage is between 11V and 14,5V (considered the typical operating range to which a lead acid battery can be subjected)
- **Yellow** - the battery voltage is above 14,5V (considered the absolute maximum voltage to which a lead acid battery can be subjected during charging)

- If during operation of your equipment either the red or yellow LEDs are illuminated you should immediately disconnect the load (typically your expensive radio) as the battery and equipment is in danger of being permanently damaged due to OVER (yellow) or UNDER (red) voltage conditions.

Remember your battery should always be tested under loaded condition to obtain a real indication of the battery status. Testing under open circuit or no load conditions does not give a real indication of the battery charge condition.

2 Principle of operation

The battery monitor makes use of two voltage comparators implemented using two operational amplifiers IC1A and IC1B. A comparator compares the voltages at its two inputs, the inverting input (-) and the non-inverting input (+). One of these inputs is the reference input, while the other is the sense or measurement input.

This circuit uses the + inputs (pins 3, 5) as the measurement input and are coupled together so that the same voltage is presented at each + input.

The reference inputs V1 [+-3,5V], V2 [+-4,5V] (pins 2, 6) are provided from a stabilized voltage divider chain R1, R4, R5. This stabilized voltage is provided by the resistor/zener series regulator R9, ZD1 which provides a 6.8V reference voltage Vz. This voltage is also used to power the op-amp package via pins 4 and 8.

As the reference voltages are less than the battery to be measured voltage Vb, this voltage needs to be scaled to the same order as the reference voltages so that the one to one comparison can occur. This scaling is provided by the measured voltage divider chain R7, R8 giving the measurement scaled voltage V3.

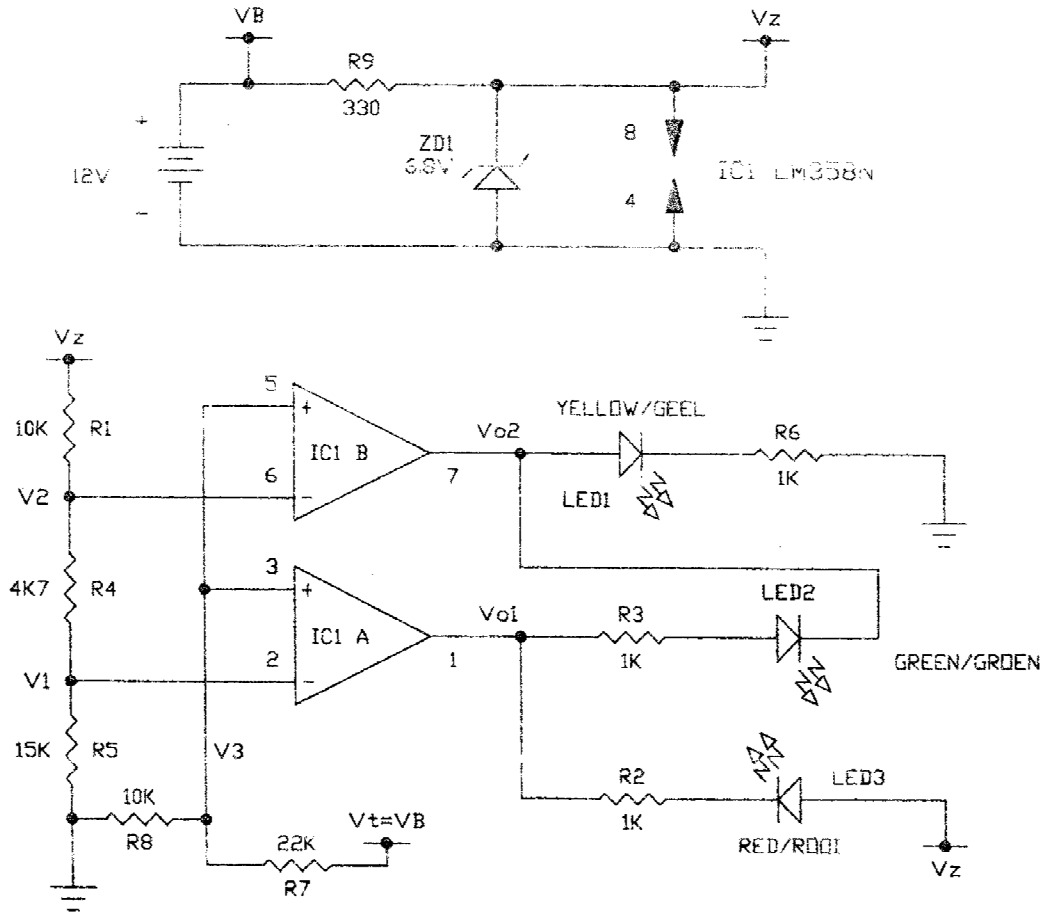
IC1B thus compares V3 to V1 while IC1A compares V3 to V2. The result of these comparisons are presented as voltages at Vo1 and Vo2.

If V3 > V1, Vo1= Vz = 6,8V – LED3 has no voltage across it and is thus not illuminated
If V3 < V1, Vo1 = GND = 0V – LED3 is forward biased and thus illuminated

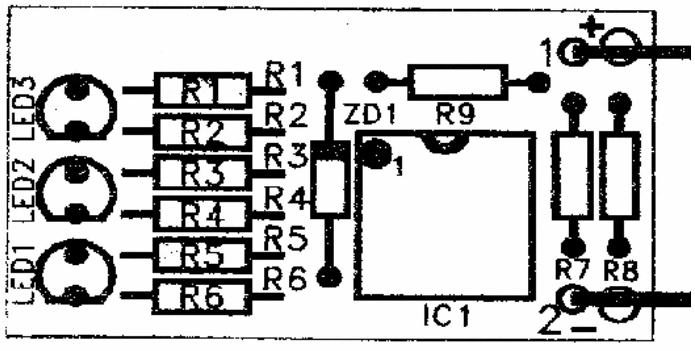
See the table below for the derivation of the other voltages and LED illuminations

V3	Vo1	Vo2	LED1 Yellow	LED2 Green	LED3 Red	Voltage Range
< V1, < V2	0V	0V	off	off	**ON**	4 -11V
> V1, < V2	6,8V	0V	off	**ON**	off	11 – 14,5V
> V1, >V2	6,8V	6,8V	**ON**	off	off	> 14,5V

3 Circuit Diagram



4 Component Overlay



5 Parts List

R1, R8	10k 0,25W	IC1	LM358N
R2, R3, R6	1k 0,25W		
R4	4k7 0,25W	ZD1	6,8V 500mW
R5	15k 0,25W		
R7	22k 0,25W	LED1	Yellow 3mm
R9	330E 0,25W	LED2	Green 3mm
		LED3	Red 3mm

6 Recommended Construction Order

6.1 Insert and solder the nine quarter watt resistors R1 – R9 in their correct positions.

6.2 Insert and solder the zener diode ZD1 – take note of the polarity (stripe on diode corresponds to stripe on layout)

6.3 Insert and solder the dual operational amplifier IC1 – take note of the orientation matching pin1 and/or the cutout and/or the depressed dot.

6.4 Insert either

6.4.1 LEDs (LEDs mounted directly on PCB)

- Insert and solder the LEDs at the chosen distance for mounting allowing clearance from the case for all components – take note of the orientation.

- If installing the LEDs on a metal panel, ensure that the PCB and its components are isolated from the metal panel. Insulation can be provided by self-adhesive PVC sheeting used for covering books or shelving.

OR

6.4.2 LED fly leads (LEDs mounted remotely from PCB)

- Insert and solder 6 wires on the PCB. These wires should have sufficient length to allow the PCB and the LEDs to be mounted in their desired remote positions.

- It is recommended that different coloured wires be used for at least anode and cathode leads of the LEDs e.g. red for anodes and black for cathodes.

6.5 Insert and solder the battery supply fly leads ensuring they are long enough to route between the PCB mounting location and the battery measurement point.

- If desired use appropriate connectors if the PCB and measurement point are remote from each other

7 Pre-Test Check

7.1 Before powering up the circuit perform the following visual checks

- All components are in the correct positions
- All polarity sensitive components are soldered with the correct orientation
- All solder joints are well soldered (no dry joints)
- There are no solder bridges between tracks on the PCB creating short circuits

8 Testing & Calibration

- Ensuring that the power supply is turned off, connect the monitor to the output terminals of a variable output (0 – 15V) DC power supply making sure of the correct lead polarity - the circuit has no reverse voltage protection.
- Set the output voltage for zero volt output.
- Switch on the power supply.
- No LEDs should be illuminated.
- Increase the voltage to approximately 4V – the RED LED should illuminate.
- Measure and make a note of this voltage – if you connect the monitor to a battery and no LEDs illuminate the battery has at least 5 dead cells and the battery voltage is below 4V.
- Slowly increase the voltage to around 11V.
- The red LED should turnoff and the green LED should illuminate.
- Measure and make a note of this voltage – this is the absolute minimum level to which you should discharge your battery.
- Discharging a battery below this level is likely to cause performance loss and can lead to permanent damage
- Continue slowly increasing the voltage to around 14,5V.
- The green LED should turn off and the yellow LED should illuminate.
- Measure and make a note of this voltage – this is the absolute maximum voltage at which your battery can be charged.
- Any voltage above this will lead to over charging, excessive gassing with loss of electrolyte and probable damage

9 Summary

This project provides an inexpensive, easy to construct and use 12V LA battery monitor.

If the yellow or red LEDs are illuminated you are running great risk of damaging your battery and equipment and the total load, including the battery monitor (it also consumes power from the battery) should be disconnected until the problems are corrected.

If the green LED is illuminated your battery is operating within its **TYPICAL RANGE**.

NOTE 1 - Even though the monitor is indicating green your battery voltage is anywhere between 11V and 14,5V.
As transmitter power varies as the square of the supply voltage there is a marked decrease in your output power when the voltage is at 11V as compared to 14,5V.

Note 2 - If you require a more accurate voltage measurement it is recommended that you also consider another forthcoming ZS6PTA project, the 10 LED voltmeter (0,5V steps) currently under development.