A Li-Ion BATTERY CHARGER USING TSM102A

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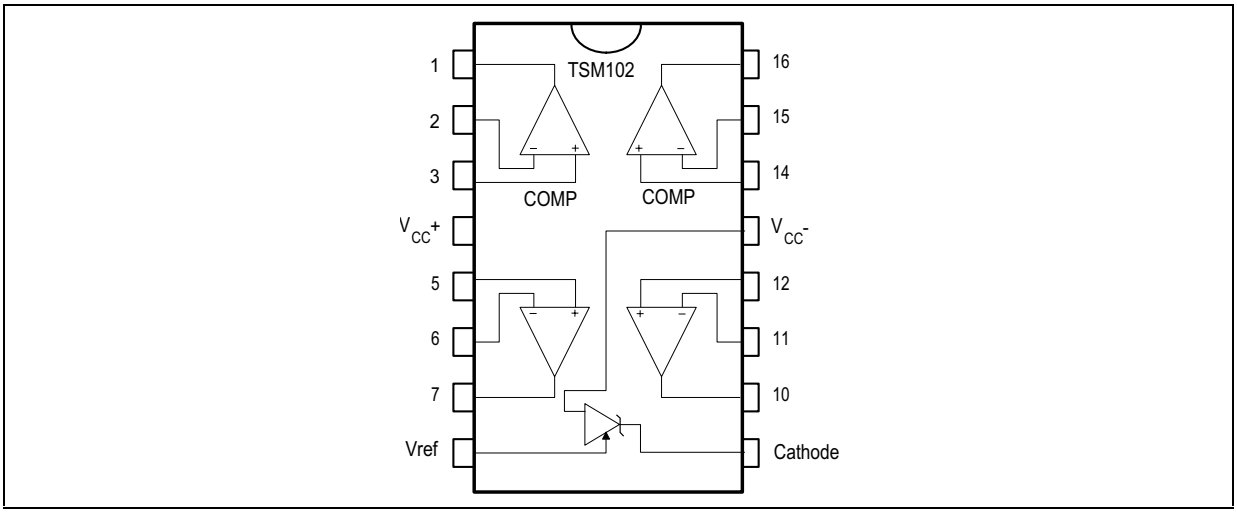
This application note explains how to use the TSM102 in an SMPS-type battery charger which features :

- ❑ Voltage Control
- ❑ Current Control
- ❑ Low Battery Detection and End Of Charg Detection

1 - TSM102 PRESENTATION

The **TSM102** integrated circuit includes two Operational Amplifiers, two Comparators and one adjustable precision Voltage Reference (2.5V to 36V, 0.4% or 1%).
TSM102 can sustain up to 36V power supply voltage.

Figure 1 : TSM102 Pinout



2 - APPLICATION CONTEXT AND PRINCIPLE OF OPERATION

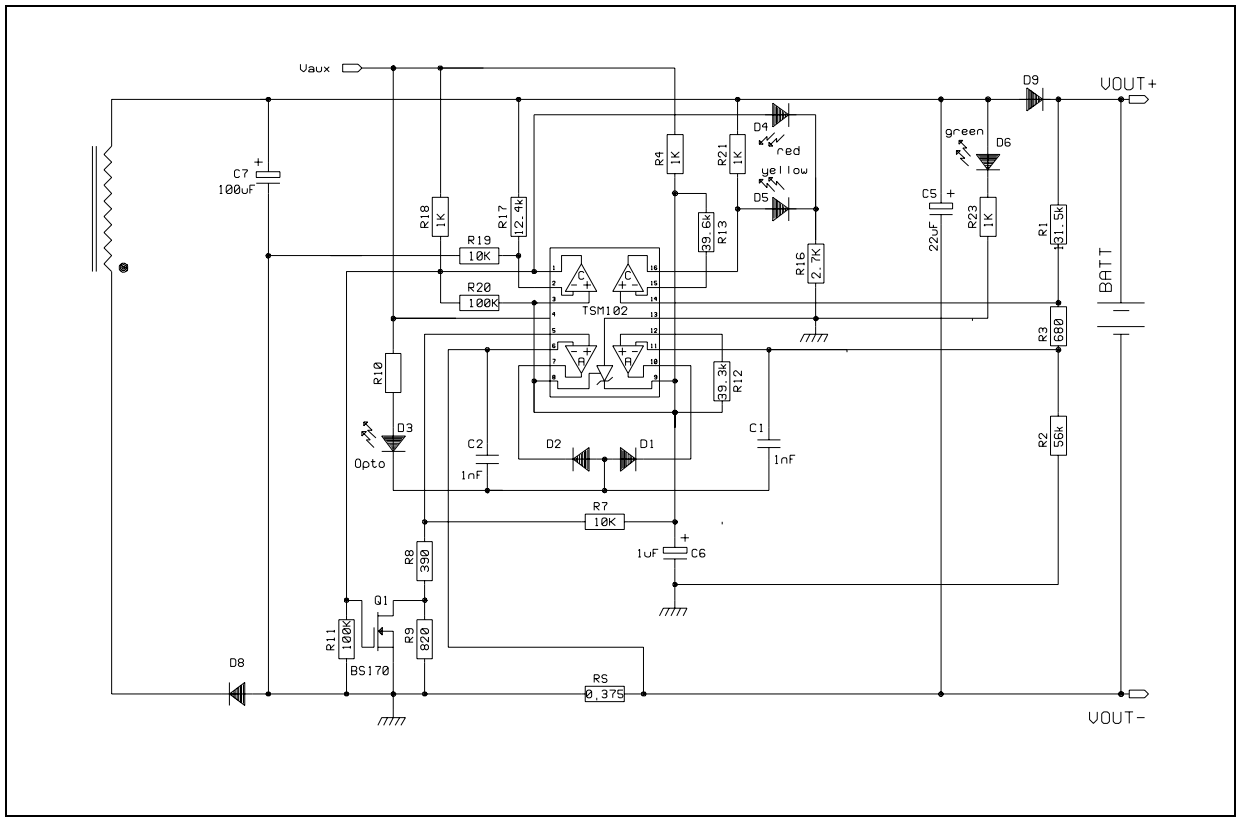
In the battery charging field which requires ever increasing performances in more and more reduced space, the TSM102A provides an attractive solution in terms of PCB area saving, precision and versatility.
Figure 2 shows the secondary side of a battery charger (SMPS type) where TSM102A is used in optimised conditions : the two Operational Amplifiers perform current and voltage control, the two Comparators provide “End of Charge” and “Low Battery” signals and the Voltage Reference ensures precise reference for all measurements.
The TSM102A is supplied by an auxiliary power supply (forward configuration - D7) regulated by a bipolar transistor and a zener diode on its base (Q2 and DZ), and smoothed by the capacitors C3 and C4. R15 polarizes the base of the transistor and at the same time limits the current through the zener diode during regulation mode of the auxiliary power supply.

The current and voltage regulations are made thanks to the two Operational Amplifiers.

The first amplifier senses the current flow through the sense resistor Rs and compares it with a part of the reference voltage (resistor bridge R7, R8, R9). The second amplifier compares the reference voltage with a part of the charger’s output (resistor bridge R1, R2, R3).

When either of these two operational amplifiers tends to lower its ouput, this linear information is propagated towards the primary side via two OR-ing diodes (D1, D2) and an optocoupler (D3). The compensation loops of these regulation functions are ensured by the capacitors C1 and C2.

Figure 2 : The Application Schematic - Battery Charger Secondary Side



The first comparator ensures the “Low Battery” signal generation thanks to the comparison of a part of the charger’s output voltage (resistor bridge R17, R19) and the reference voltage. Proper hysteresis is given thanks to R20. An improvement to the chargers security and to the battery’s life time optimization is achieved by lowering the current control measurement thanks to Q1 that shunts the resistor R9 when the battery’s voltage is below the “Low Battery” level.

The second comparator ensures the “End of Charge” signal generation thanks to the comparison of a part of the charger’s output voltage (resistor bridge R1, R2, R3) and the reference voltage.

When either of these two signals is active, the corresponding LED is polarized for convenient visualization of the battery status.

3 - CALCULATION OF THE ELEMENTS

All the components values have been chosen for a two-Lithium-Ion batteries charge application :

- ❑ Current Control : 720mA (Low Battery current control : 250mA)
- ❑ Voltage Control : 8.4V (= 2x 4.2V)
- ❑ Low Battery : 5.6V (= 2x 2.5V + 0.6V)
- ❑ End of Charge : 8.3V (= 2x 4.15V)

Current Control:

The voltage reference is polarized thanks to the R4 resistor (2.5mA), and the cathode of the reference gives a fixed 2.500V voltage.

I = U / R= [Vref (R8 + R9) / (R7 + R8 + R9)] / Rs

= [2.5 x (390 + 820) / (10000 + 390 + 820)] / 0.375

= 720mA

I = 720mA

P = power dissipation through the sense resistor = R I2 = 0.375 x 0.7202 = **194mW**

In case of “Low Battery” conditions, the current control is lowered thanks to the following equation:

I = U / R= = [Vref R8 / (R7 + R8)] / Rs

= [2.5 x 390 / (10000 + 390)] / 0.375

= 250mA

I (LoBatt) = 250mA

Voltage Control:

Vout = Vref / [R2 / (R1 + R2 + R3)]

= 2.5 / [56 / (131.5 + 56 + 0.68)]

= 8.400V

Vout = 8.400V

Low Battery signal:

If R5 = 0Ω and R6 = open:

Vout(LoBatt)= Vref / [R19 / (R17 + R19)]

= 2.5 / [10 / (12.4 + 10)]

= 5.6V

Vout(LoBatt) = 5.6V

End of Charge signal:

Vout(EOC) = Vref / [(R2 + R3) / (R1 + R2 + R3)]

= 2.5 / [(56 + 0.68) / (131.5 + 56 + 0.68)]

= 8.300V

Vout (EOC)= 8.300V

Notes:

The current control values must be chosen in accordance with the elements of the primary side. The performances of the battery charger in their globality are highly dependent on the adequation of the primary and the secondary elements.

The addition of the diode D9 is necessary to avoid dramatic discharge of the battery cells in case of the charger disconnection from the mains voltage, and therefore, the voltage measurement is to be operated on the cathode side of the diode not to take its voltage drop into account. The total bridge value of R1, R2, R3 must ensure low battery discharge if the charger is disconnected from main, but remains connected to the battery by mistake. The chosen values impose a 44µA discharge current max.

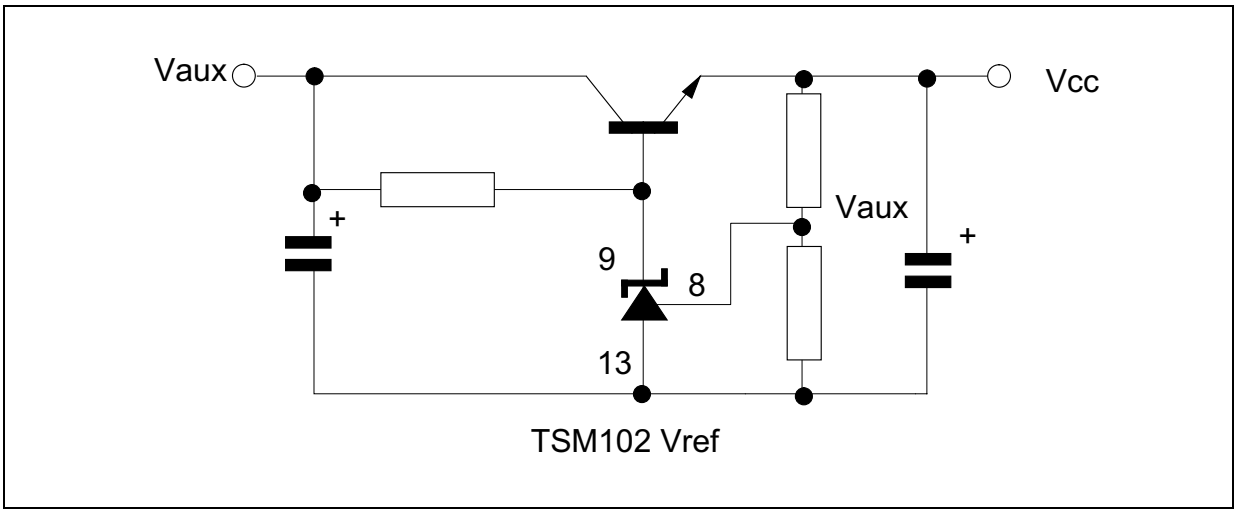
R12 and R13 are the equivalent resistors seen from the opamp and from the comparator.

A hysteresis resistor can be connected to the “End Of Charge” comparator to ensure proper hysteresis to this signal, but this resistor must be chosen carefully not to degrade the output voltage precision. It might be needed to impose unidirectionnal hysteresis (by inserting a diode on the positive feedback of the comparator).

Figure 3 shows how to use the integrated Voltage Reference to build a precise Power Supply for theTSM102A (and other components if necessary).

Pin 8 remains the reference for all voltage measurements for the rest of the application.

Figure 3 : A precise power supply for the TSM102A and other components



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