Smart Battery Charging with GC3001A-00

Content

GC3001A-00

Quick Charge Control IC for NiCd / NiMH Battery

1. OVERVIEW

The GC3001A-00 is a quick charge control IC for Nickel Metal Hydride (NiMH) and Nickel-Cadmium (NiCd) rechargeable batteries. Quick charging ends in response to negative delta voltage detection (–ΔV), delta temperature (ΔTemp), max temperature or maximum charging time detection functions. Also, the charge mode is placed on hold if the battery voltage and temperature become abnormal. The GC3001A-00 requires few external components to realize a high-stability quick charge battery charger.

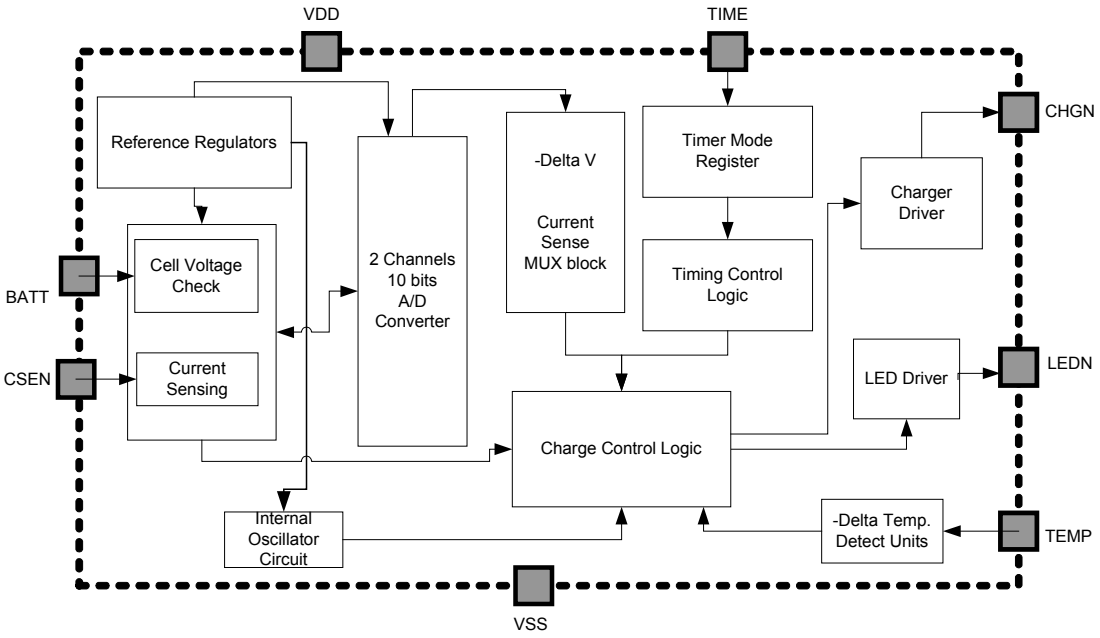
2. FEATURES

- Ni-MH/Ni-Cd battery quick charge control for batteries.
- −ΔV, ΔTemp, maximum Temperature and maximum charge time cutoffs
- 6min (typ) −ΔV detection invalid time
- −4mV (typ) −ΔV detection accuracy
- Charge status LED indicator output (on, pulse, off)
- High PWM Charging Output to simplify the charging circuit with limited components.
- 8-pin SOP package

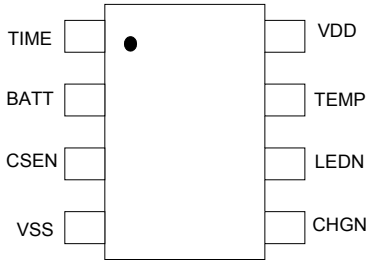
3. APPLICATIONS

- Chargers for MP3, Digital Camera, Hand-Held home appliance.

4. BLOCK DIAGRAM



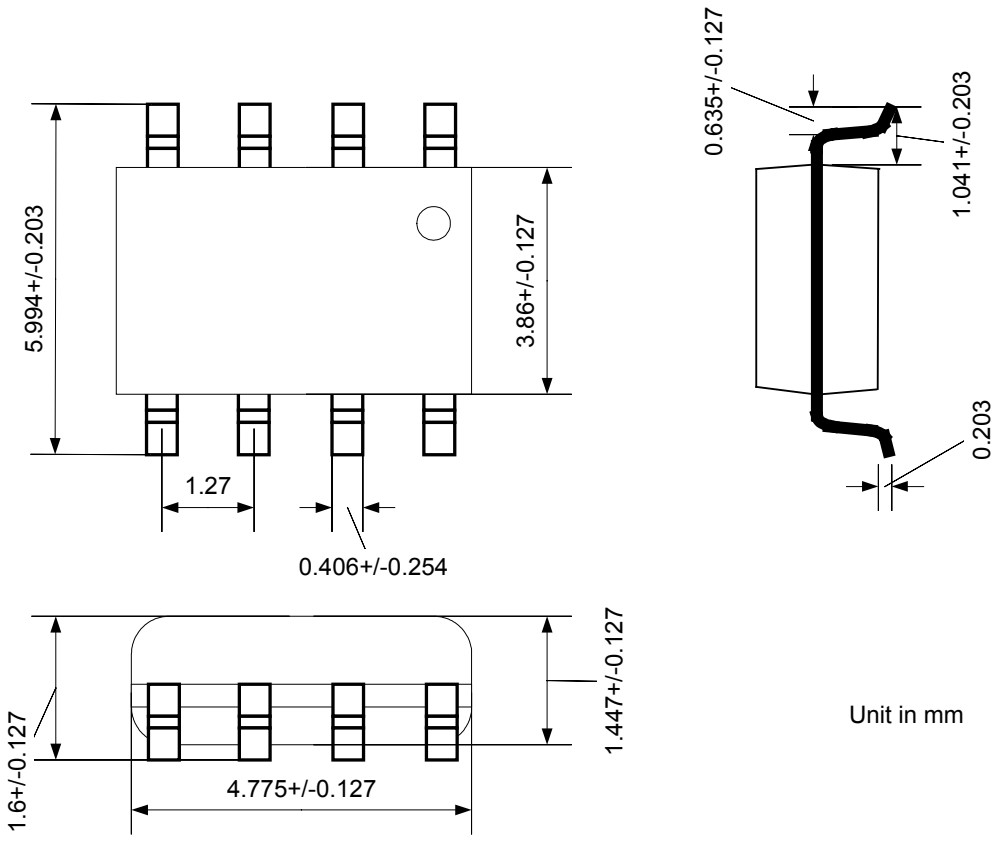
5. PINOUT



6. DESCRIPTION

Number	Name	I/O	Description
1	TIME	I	Timer mode select input (4-level) High and Low levels are applied using pull-up and pull-down, respectively. 2/3VDD and 1/3VDD are applied using a voltage divider resistor network.
2	BATT	I	Battery voltage detector input. Connect a high-impedance resistor voltage divider between the poles of the battery for voltage detection.
3	CSEN	I	Charge current sensing input.
4	VSS	-	Ground
5	CHGN	O	Charge control PWM Output . PWM pulse outputs when charging current is flowing. Low level outputs when charging current stops.
6	LEDN	O	Charge status display LED driver output High level outputs in quick charge or in battery wake up trickle charging mode. 1Hz pulse outputs when abnormal battery voltage or surroundings temperature protect . Low level outputs when charging finishes or the battery is not inserted.
7	TEMP	I	Temperature detection pin to detect the battery temperature during the charging process.
8	VDD	-	Supply

7. PACKAGE DIMENSIONS



Unit in mm

8. Absolute Maximum Ratings : VSS = 0V

Operating Temperature	:	-55°C to +125°C
Storage Temperature	:	-65°C to +150°C
Voltage on any Pin except TIME with respect to Ground	:	-1.0V to VCC+0.5V
Voltage on TIMER with respect to Ground	:	-1.0V to +10.0V
Maximum Operating Voltage	:	6.0V
DC Current per I/O Pin	:	40.0 mA
DC Current VCC and GND Pins	:	200.0 mA

9. DC Characteristic 1

V_{DD}=2.7 TO 5.5V,V_{SS}=0V,Ta=25℃

DESCRIPTION	INDEX	MIN	TYP	MAX	UNIT	NOTE
Maximum Delta Temperature rate	MAXDT		1.0		℃/Min	The charging is over when the ΔTemp is higher than MAXDT, but The battery temperature must be higher than 43 ℃ at the same time
Battery Low Voltage, V_{MNV}	VBATLOW	-	0.60	-	V	V_{BATT}<V_{MNV} quick charge cutoff or prohibition
Battery High Voltage, V_{MXV}	VBATHIGH	-	1.90	-	V	V_{BATT}>V_{MXV} quick charge cutoff or prohibition
No battery Voltage ,Vnov	VBATNO		2.20		V	V_{BATT}>=Vnov quick charge cutoff or prohibition and the battery is not inserted
Maximum Delta Voltage	DVSET		-4		mV	
Max quick charging current	Imax	970	1070	1170	mA	
Middle speed charging current	Imid	97	107	117	mA	
Trickle charging current	Itrickle	40	50	60	mA	The Trickle charging is prohibited forever after the battery temperature is higher than Maximum Temperature.
Maximum Temperature	MAXTEMP		55		℃	When the battery temperature is higher than MAXTEMP and the Surroundings protect temperature is invalid, The system stops charging and the charging is over The middle speed and trickle charging will not be conducted if the charging is over for Maximum Temperature protect .
Surroundings protect temperature	PRTTEMP		45		℃	In the first 30s after the battery is inserted, if temperature is higher than PRTTEMP, The system stops charging and LED starts to flash in 1Hz and enter abnormal temperature lock mode, which will be held until the system is power off or the battery is inserted again
Wake up trickle charging max time	WAKETIME		2		Min	0.30V<=V_{BATT}<0.60V,wake up trickle charging
Abnormal battery lock	Vbattlock					1、 The battery voltage is lower than 0.30V 2、 The battery voltage is higher than 1.90V and lower than 2.20V 3、 The battery voltage is still lower than 0.60V after the wake up trickle charging for 2 minutes The abnormal battery lock will be held until the system is power off or the battery is inserted again
Max charging time	MaxTime	1		10	Hour	The max charging time is divided into four types： Type1：1 hour type2：2 hours type3：4 hours type4：10hours The max charging time must be set before the charging system is power on and keep unchanged before the system is power off.

10.DC Characteristic 2

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
VIL	Input Low Voltage		-0.5		0.2VCC	V
VIH	Input High-voltage	Except TIME pin	0.6VCC		VCC+0.5	V
VIH2	Input High-voltage	TIME pin	0.9VCC		VCC+0.5	V
VOL	Output Low Voltage Except VDD & VSS	IOL=10mA, VCC=5V;			0.6	V
VOH	Output High-voltage Except VDD & VSS	IOH=-10mA, VCC=5V;	4.3			V
IIL	Input Leakage Current I/O Pin	Vcc=5.5V, pin low (absolute value)			8	µA
IIH	Input Leakage Current I/O Pin	Vcc=5.5V, pin high(absolute value)			8	µA
ICC	Power Supply Current	Active at VCC			12	mA

10. Charging Mode and Detection

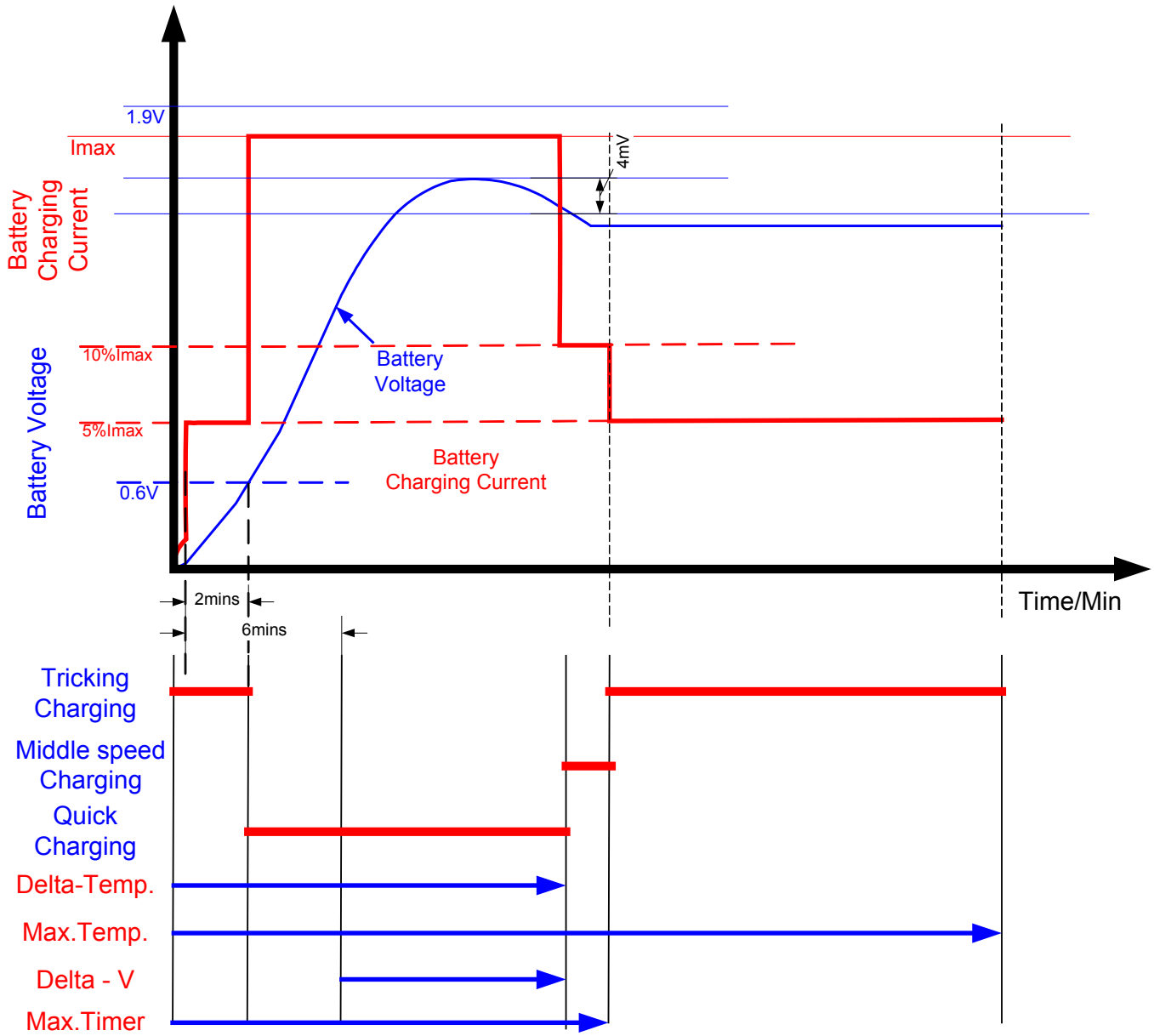


Fig. Charging Mode and Detection Methods.

10.1. Initialization

Detect the battery existing. State in the idle mode when battery is not detected.

10.2. Idle Mode

When battery is not detected (V_{BATT}>=2.20V), the system will enter the Idle and keep scanning the battery.

10.3. Middle Speed charging Mode

After the quick charging, If the max timer isn't overflow, the Middle Speed charging will be conducted, and it will be stopped when the Max timer is overflow. The Middle speed charging Current is about 10% of the quick charging current.

10.4. Trickle Charging Mode

When the battery voltage is between 0.30V and 0.60V, the batteries are charged by the trickle current for 2 minutes (the max time). It is considered as battery wake up trickle charging mode (the charging current is About 5% of the quick charging current). After that, supposing the battery voltage is still lower than 0.60V, the system will enter the abnormal battery lock mode. Otherwise, the system will enter the quick charging mode. After the quick charging, Middle Speed charging and the trickle charging will be conducted if the temperature is lower than the MAXTEMP. The trickle charging Current is about 5% of the quick charging current.

10.5. Quick Charging Mode

If the battery voltage is between 0.6V and 1.9V, the quick charging will start. The Quick Charging will be terminated by the negative delta voltage (-4mV), or max. temperature rising rate (1.0℃/ minute), or max. charging timer or the battery temperature higher than MAXTEMP.

10.6. Abnormal Mode

The LED will keep 1 Hz flashing when the system enters this mode.

NOTE :

MAX. TEMP IS MONITORING IN THE WHOLE TRICKLING/QUICK CHARGING MODE. DELTA V DETECTION IS VALID AFTER 6 MINUTES AFTER THE BATTERY IS INSERTED

10.7. Battery surroundings Temperature Detection

If the battery temperature is higher than 45 ℃ in the first 30 seconds of the batteries inserted the system will have LED flashing in 1Hz. When The battery temperature is lower than 45 ℃ the system will enter the quick charging mode. Otherwise, the system will enter the abnormal temperature lock mode.

11. Functions and Pin Description

11.1. Power Supply

Name	Pin No	I/O	Description
Reset and Power			
VDD	8	-	Supply
VSS	4	-	Ground

The voltage supply of the system is from the external voltage regulator, IC 7805 with following connection.

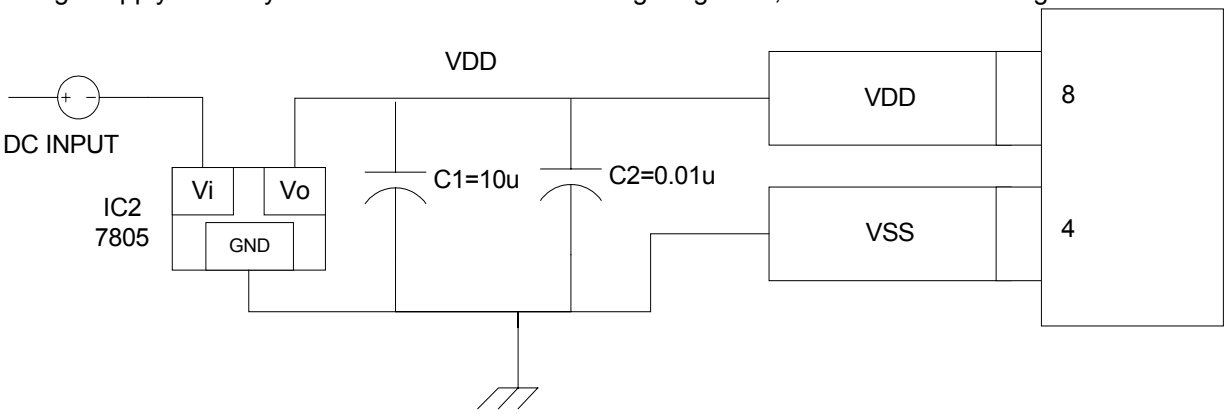


Fig. Power Supply circuit with voltage regulator IC7805

11.2. Charging Control

Name	Pin No	I/O	Description
GC3001A-00 Charging Control			
CHGN	5	OUT	Charging current control pin and PWM output pin (HIGH=open the charging FET, LOW=close the charging FET)

CHGN output PWM wave during charging. CHGN goes LOW in abnormal mode
The charging circuit unit is controlled by CHG

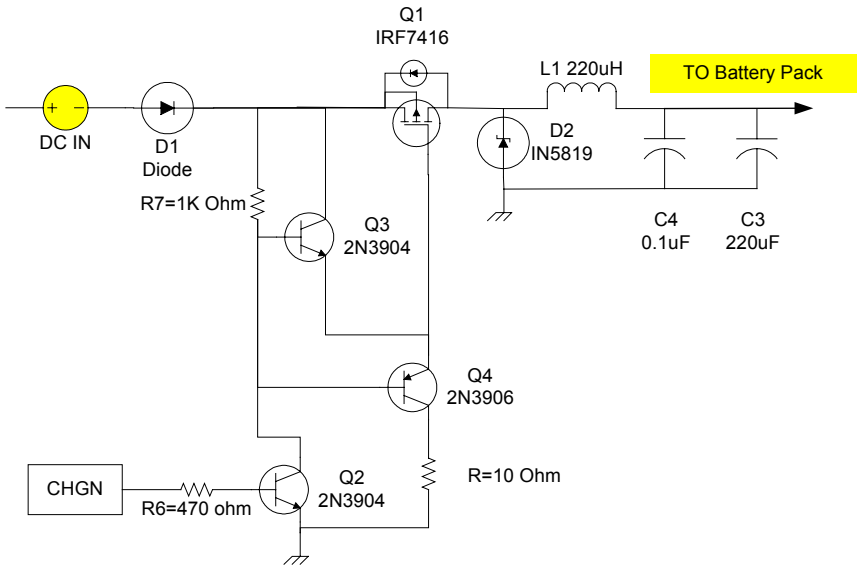


Fig. High Speed PWM charging control circuit.

11.3. LED Display Indication

Name	Pin No	I/O	Description
LED Display			
LEDN	6	OUT	Switch control to LED.

LEDN outputs High level or low level or pulse to indicate the charging status.

LEDN	LED Status		Description
Low level	RED=ON	GREEN=OFF	The charging is over for delta-T or delta-V or max charging time or the battery temperature high than MAXTEMP
Low level	RED=ON	GREEN=OFF	No battery inserted . that is to say: V_{BATT}>=2.2V
High level	RED=OFF	GREEN=ON	The charging is going (wake up trickle charging or quick charging)
1Hz pulse	RED=flash	GREEN=flash	1.9V<V_{BATT}<2.2V or V_{BATT}<0.6V
1Hz pulse	RED=flash	GREEN=flash	The battery temperature is higher than PRTTEMP in the first 30s after the battery is inserted

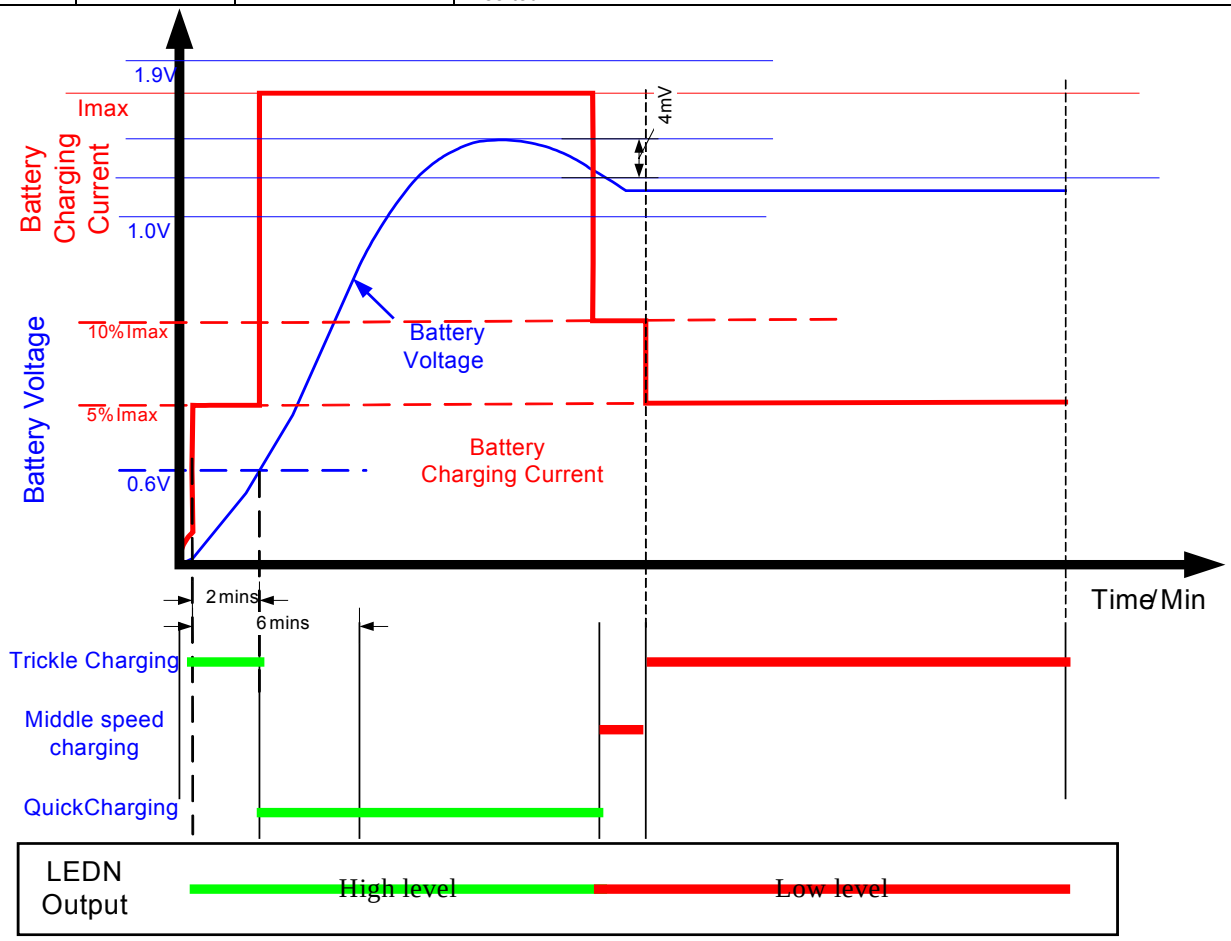


Fig. The LEDN controls the LED output status

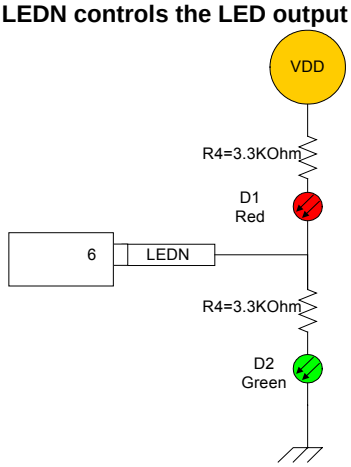


Fig. LEDN circuit control.

11.4. Thermal Sensing

Name	Pin No	I/O	Description
GC3001A-00 Thermal Sensing			
TEMP	7	IN	Temperature Sensing input from the battery cell.

When the battery temperature is higher than the MAXTEMP, the charging active will be stopped. The battery temperature is detected by the thermal resistor closely to the battery pack. NTC resistor, RT1 is in 103J-AT-2 type.

In selecting NTC resistor, it must guarantee the following conditions:

Temperature	VRT1
0 ℃	0.76 VDD
45 ℃	0.33 VDD
50 ℃	0.29 VDD
55 ℃	0.26 VDD

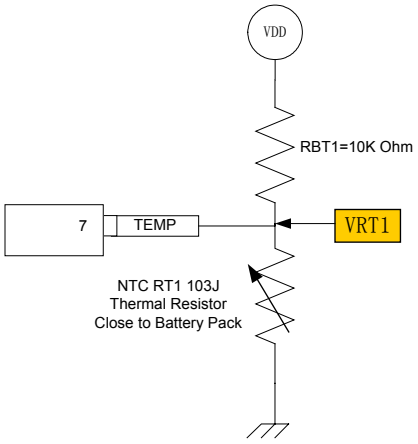


Fig. Thermal Sensing circuit.

11.5. Maximum Charging Timer Setting

Name	Pin No	I/O	Description
GC3001A-00 Charging Time Setting			
TIME	1	IN	The maximum charging timer is set by the voltage input from the TIME Pins by the voltage divider.

TIME	Connection	Charging Timer (Max. in minutes)		
			Typical	
VDD	VDD		10 Hours	
2/3VDD	RTS2/RTS1=2		4 Hours	
1/3VDD	RTS2/RTS1=1/2		2 Hours	
VSS	VSS		1 Hour	

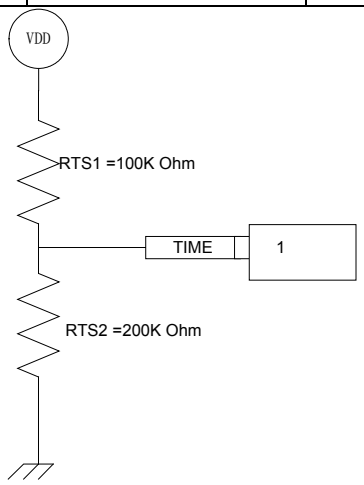


Fig. Max. Charging Timer setting

11.6. Battery Voltage and Current Detection

Name	Pin No	I/O	Description
GC3001A-00 Battery Voltage and Current Detection			
BATT	2	IN	Battery Cell voltage detection pin.
CSEN	3	IN	Battery Cell current detection pin.

In the current sensing, the maximum current is detected by the sensing resistor, RSES. By detecting the voltage difference, the charging current value is calculated by CSEN/RSES.

Charging Current = 107mV / RSES

Item	RSES Voltage Difference (Unit : mV)		
	Min.	Typical	Max.
CSEN Voltage	97	107	117

In the application circuit, RSES is 0.1Ohm, then the maximum charging current is shown as follows.

RSES	Detect Current (Unit: mA) -Imax		
	Min.	Typical	Max.
0.1ohm	970	1070	1170

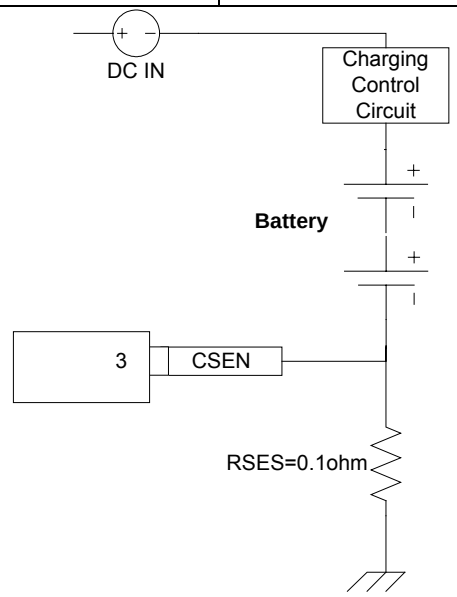


Fig. Current Sensing Circuit Application.

The voltage applied to the BATT input, used for battery voltage detection, is a voltage potential, derived by a voltage divider resistor network (100k or higher recommended) or other means, that represents the voltage of a single battery cell during charging.

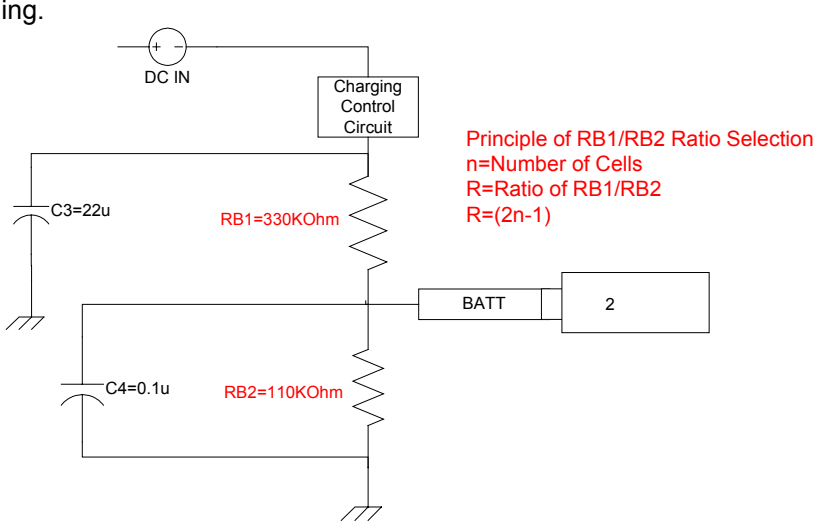


Fig. Battery Voltage Detection Circuit by a voltage divider resistor network.

12. Difference between GC3001A-00 and GC3001

In design consideration, GC3001A-00 has following improvement from GC3001.

a. Saving the OPAmp and other extra component in the constant current charging circuit.

b. In CHGN, the high speed PWM output as the charging control signal. The design has simplified the control circuit, improved the efficiency of the charging, and reduced the charging FET temperature. Meanwhile, due to the high speed (over 35KHz) PWM, the audio noise from the inductor is reduced.

c. Saving the external components.

d. Improving battery -ΔV detection from 15 minutes to 6 minutes.

e. Adding the battery temperature sensing and the temperature-rising-rate (-ΔTemp). Be more safe in the high current charging.

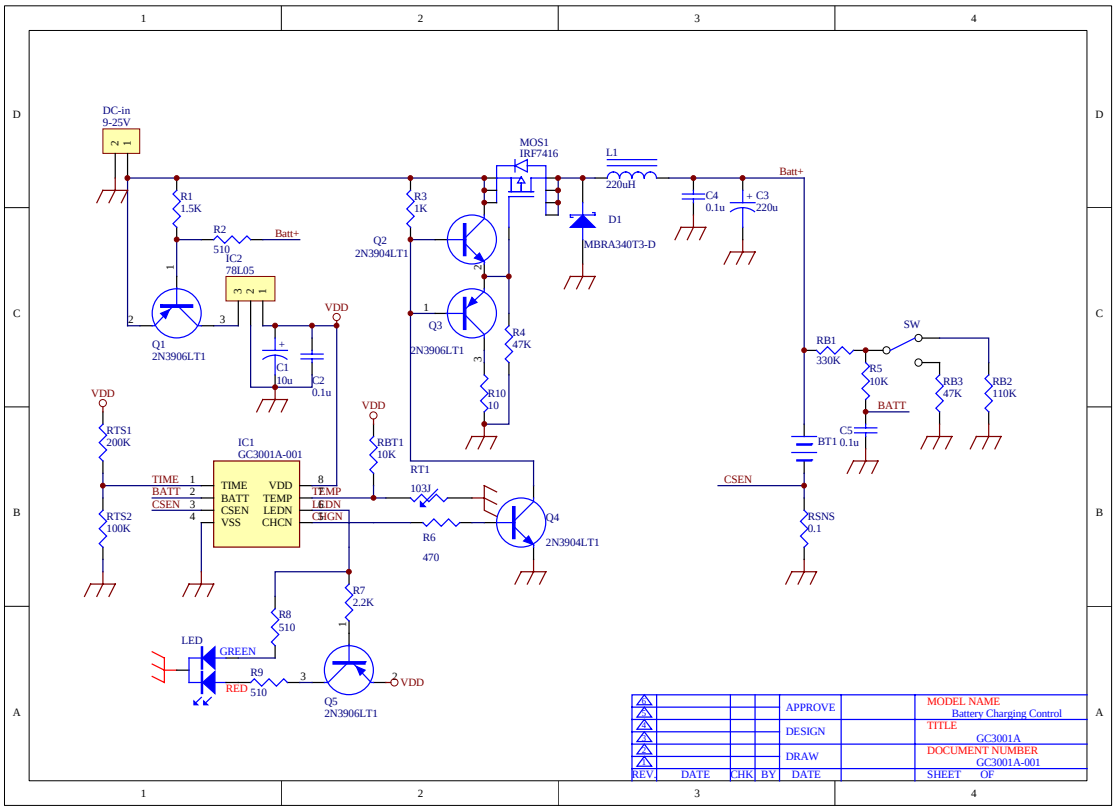
f. Adding the current sensing for the charging.

g. Adding the trickling charging when battery is lower than 0.6V.

h. Adding the trickling charging after the battery is full charge, so as to maintain the full capacity when the battery is taken out from the charger.

i. Improving the timer accuracy(+/-2%).

13. Application Circuit



Documents Amended History

Date	Details	By	File Name
July 3, 2004	Application Circuit is modified.	**CF SO**	**GC3001A-00-10**
July 16, 2004	Application Circuit is modified.	**CF SO**	**GC3001A-00-11**
Aug. 19, 2004	Modify the temperature protection and add the illustration in the charging mode	**CF SO**	**GC3001A-00-12**

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