Two-Cell Li-Ion and Li-Polymer Charge Management IC

PRODUCT SUMMARY

Charge management for two-cell Li-Ion or Li-Polymer battery packs
Individual cell monitoring - avoids over-charging
Pin-selectable charging current
Cell-balancing control circuit - maximizes pack useful life

FEATURES

Optional external thermistor monitors the pack temperature
Conditioning charging for reviving deeply discharged cells
Timer function available to limit the charging time
Pb-free, RoHS compliant SO-20 package

DESCRIPTION

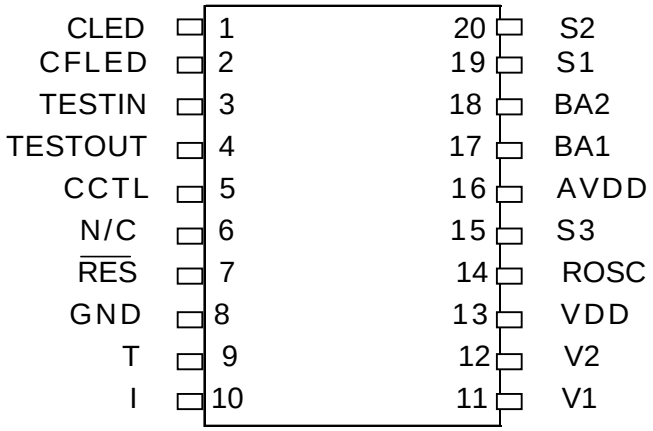
The SS4035G is a charging control IC designed for battery packs with two cells in series. When multiple cells in a battery pack are connected in series, the weakest cell determines the overall pack capacity. The SS4035G has a cell-balance control circuit to solve this problem, and monitors the voltage of each cell to ensure that no cell is over-charged. The pulse width modulation (PWM) output can be used as either a linear or switching charge-control circuit. Three digital input pins determine the charge current. All these features make the charging circuit design easy and flexible.

The SS4035G continuously monitors each cell voltage, cell current and the battery temperature. Any unspecified condition will stop the charging to protect the battery cells. An external negative-temperature-coefficient thermistor is used as a sensor to monitor the battery pack temperature. To be safe, charging is suspended if the voltage of the temperature sense input pin is higher than *Min Temp Threshold* (VTmin) or lower than *Max Temp Threshold* (VTmax). When the battery temperature is within the safe zone, the SS4035G charges the battery in three phases: pre-charging, constant-current, or constant-voltage. If the voltage of the temperature sense input pin is higher than *Low Temp Threshold* (Vtlow), or the battery voltage is less than 3.1V, the SS4035G pre-charges the battery with a low current.

After the precharging, the SS4035G applies a constant current to the battery. The value of this constant current is determined by the levels of pins S1, S2 and S3 during power up. When the battery voltage is above the threshold, the SS4035G begins constant-voltage charging until the battery is fully charged. The battery is fully charged when the current drops down to the termination threshold.

When the cell voltage is higher than the *Balancing Threshold* (Vbal), the cell balancing circuit is triggered if one cell voltage is higher than the other by more than 0.02V.

PIN CONFIGURATION



PIN DESCRIPTION

Pin Name	Pin No	I/O	Description
CLED	1	O	Charge control LED
CFLED	2	O	Charge Full control LED
TESTIN	3	I	Test input
TESTOUT	4	O	Test output
CCTL	5	O	Charging Control, PWM output
N/C	6	O	Not connected
$\overline{RES}$	7	I	Reset
GND	8	G	Ground
T	9	A	Temperature-sense voltage input
I	10	A	Current-sense voltage input
V1	11	A	Cell 1 voltage (low side)
V2	12	A	Cell 2 voltage (high side)
V_{DD}	13	P	Operating voltage input
ROSC	14	I	Frequency control resistor
S3	15	I	Selection no.3
AVDD	16	P	Operating voltage for analog circuit
BA1	17	O	Balancing control for cell 1
BA2	18	O	Balancing control for cell 2
S1	19	I	Selection no.1
S2	20	I	Selection no.2

ABSOLUTE MAXIMUM RATINGS

DC Voltage …… -0.3V to +7.0V
I/O Voltage…... (GND-0.3V) TO (V_{DD}+0.3V)
Storage Temperature……... -55°C to +125°C
Operating Temperature……... -40°C to +85°C

* Stresses beyond those listed as "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied or intended. Exposure to the absolute maximum rating condition for an extended period may affect device reliability.

ELECTRICAL CHARACTERISTICS

V_{DD} = 4.5V – 5.5V, GND = 0V, T_A = 25°C, f_{osc} = 8MHz, unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max	Unit	Condition
Operating Voltage	V_{DD}	4.5	5.0	5.5	V	
Operating Current	I_{OP}	-	1.5	2	mA	No load, no ADC
Standby Current	I_{SB}	-	-	1	uA	No load, no ADC, no WDT, no LVR
Input Low Voltage	V_{IL1}	GND	-	0.2* V_{DD}	V	All I/O, except $\overline{RES}$
Input Low Voltage	V_{IL2}	GND	-	0.15* V_{DD}	V	$\overline{RES}$
Input High Voltage	V_{IH1}	0.8*V_{DD}	-	V_{DD}	V	All I/O, except $\overline{RES}$
Input High Voltage	V_{IH2}	0.85*V_{DD}	-	V_{DD}	V	$\overline{RES}$
Input Leakage Current	I_{IL}	-1	-	1	uA	Input pins, Vin=V_{DD} or GND
Output High Voltage	V_{OH}	V_{DD}-0.7	-	-	V	All I/O, I_{OH}=-10mA
Output Low Voltage	V_{OL}	-	-	GND +0.6	V	All I/O, I_{OL}=20mA
Analog Input	Ain	GND		V_{DD}	V	T, I, V1, V2

ELECTRICAL CHARACTERISTICS (continued)

V_{DD} = 5V, GND = 0V, T_A = 25°C, f_{osc} = 8MHz, R_{sens}=100mΩ, unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max	Unit	Description
Voltage Control						
Pre-charge Threshold	V_{low}	-	3.10	-	V	
CC/CV Threshold	V_{cv}	-	4.135	-	V	Switch to CV mode above this value
Maximum Cell Voltage	V_{max}	-	4.235	-	V	
Balancing Threshold	V_{bal}	-	4.135	-	V	
Bad Battery Threshold	V_{bad}	-	0.5	-	V	Difference between Cell1 and Cell 2 voltage
Temperature Sensing						
Min Temp Threshold	V_{tun}	-	4.31	-	V	Suspend charging if greater than this value
Low Temp Threshold	VT_{low}	-	3.82	-	V	Precharge if greater than this value
High Temp Threshold	VT_{high}	-	1.90	-	V	Decrease current if less than this value
MaxTemp Threshold	VT_{over}	-	1.54	-	V	Suspend charging if less than this value
Resume Temp Threshold	VT_{rsm}	-	2.10	-	V	After maximum temperature is reached, resume charging if greater than this value.
Current Control						
Precharge Current	I_{pre}	-	300	-	mA	
Taper Current	I_{taper}	-	250	-	mA	Fully charged if the taper current is below this value.
Time Control						
Maximum Charge Time	T_{chg}		340		Min	

FUNCTIONAL DESCRIPTION

A well-known Li-Ion charge algorithm is used by the the SS4035G to control the charging. Figure 1 shows shows the typical charge profile. Figure 2 is the control flow chart. During the process of charging, the SS4035G continuously monitors each cell voltage, current and the battery temperature. Any unqualified condition will stop the charging to protect the battery cells.

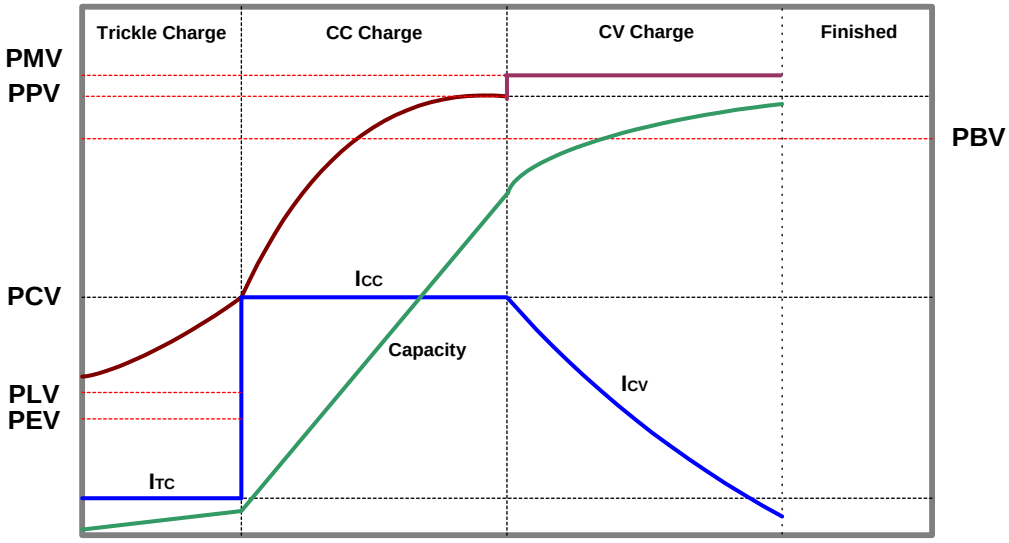


Figure 1. Typical Charge Profile

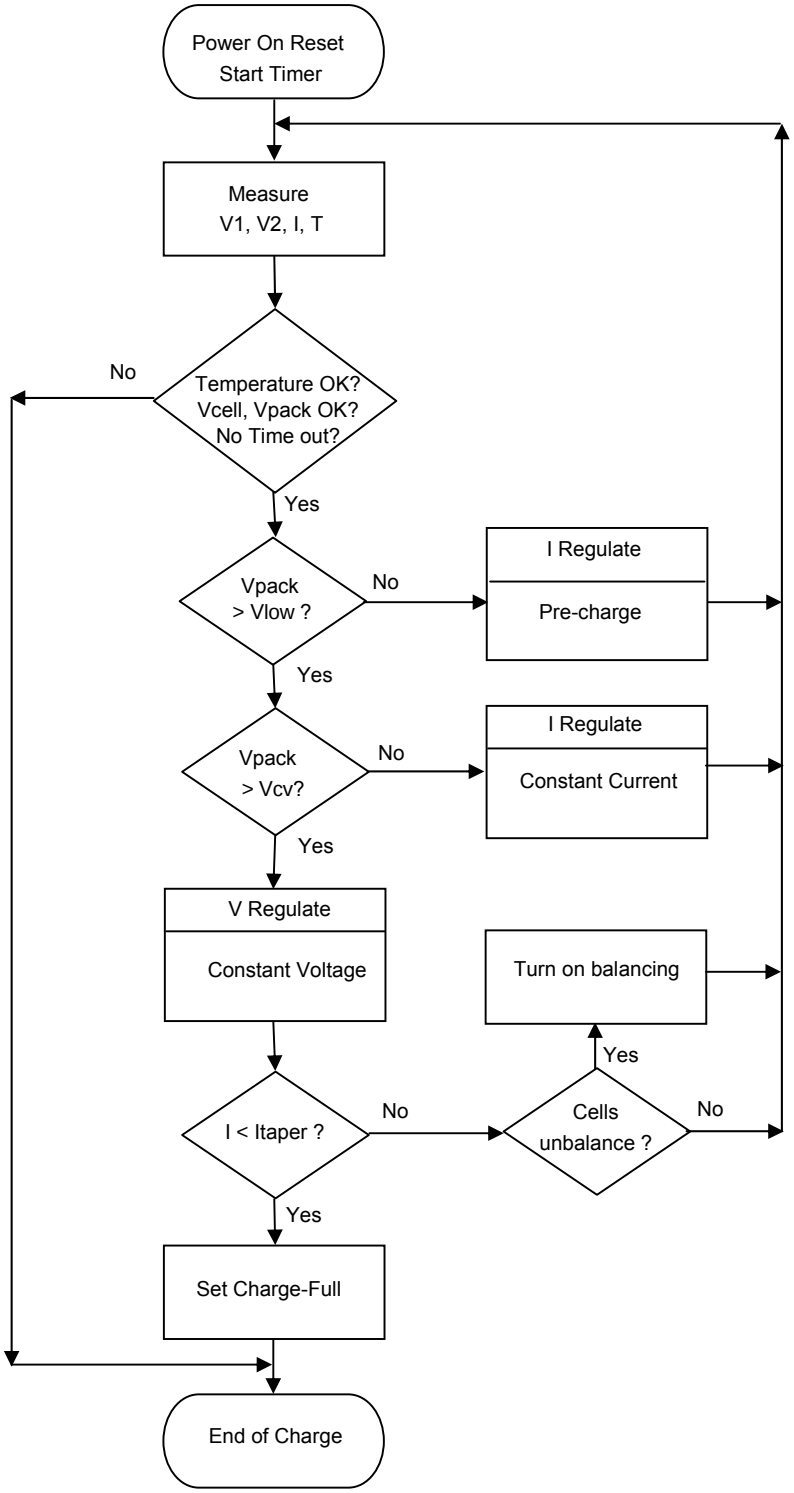


Figure 2. Control Flow Chart

CURRENT AND TEMPERATURE SENSING

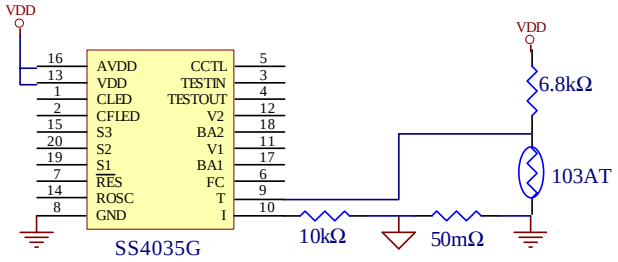


Figure 3. Current Sense and Temperature Sensor

Figure 3 shows the current sense and temperature detect circuit. The SS4035G monitors the charging current by sensing at pin I (10) the voltage drop across a small resistor, connected between VSS (battery negative) and GND (charger ground). The value of this resistor should be between 50mΩ and 150mΩ. To detect the temperature, a negative temperature coefficient thermistor is used as a . sensor. When a 103AT thermistor and a 6.8k resistor are used as recommended, the maximumum temperature, high temperature, resume temperature, low temperature and minimum temperature are 60°C, 50°C, 45°C, 5°C and 10°C respectively. The value of the resistor must be changed if a different thermistor is used. To disable temperature sensing, pin T (9) must be connected to V_{DD}.

CELL VOLTAGE DETECTION AND BALANCING CONTROL

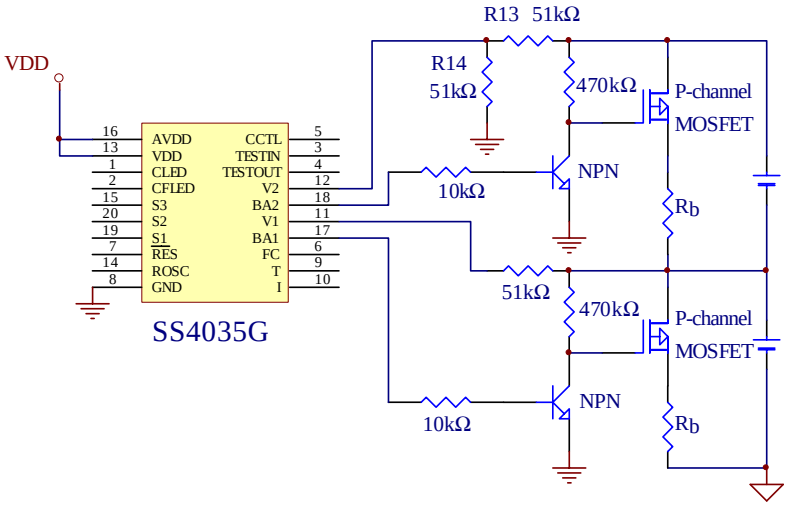


Figure 4. Voltage Sense and Balancing Control

Figure 4 shows the cell voltage detection and cell balancing circuit. The pack voltage is divided by two (by using equal value resistors, R13 and R14). This guarantees that the input voltage on pin V2 (12) will not exceed VDD. When the cell voltage is above the "Balancing Threshold", balance control is activated.

If any cell voltage is greater than the other by 0.02V or more, the corresponding balance control output goes high. It then turns on the corresponding by-pass transistor and sends a small current through resistor Rb. This slows down charging of the corresponding cell. The balance circuit turns off when the cells are balanced.

CHARGING CONTROL

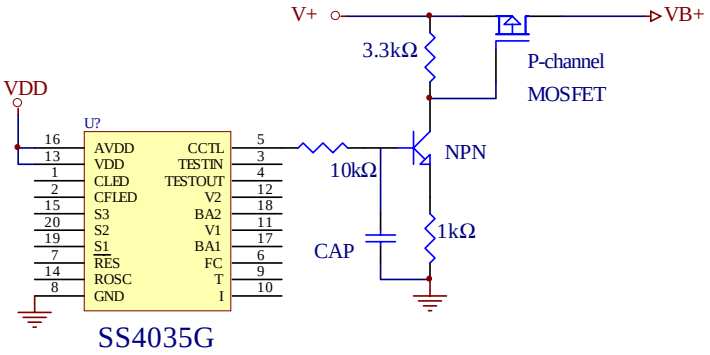


Figure 5. Charging Control

Figure 5 shows the linear charger mode for the SS4035G. The output of pin CCTL (5) is a pulse-width modulated (PWM) signal. This signal is translated to a DC voltage to control the P-channel MOSFET which is operating in the active region. This P-channel MOSFET must be chosen carefully to handle the required power dissipation.

DIGITAL CONTROLS

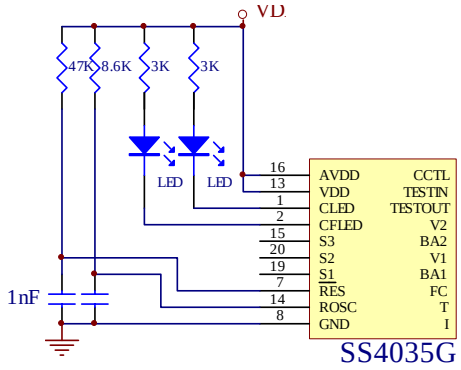


Figure 6. Current Selection and Logic Control

Figure 6 shows the connections for the digital pins for the SS4035G. Selection pins S1, S2 and S3 have internal pull-ups. Table 1 shows the options for selecting the required voltage for Isense.

Table 1. Current Selection Table

S3	S2	S1	I_{sense} Voltage
L	L	L	240 mV
L	L	H	200 mV
L	H	L	160 mV
L	H	H	120 mV
H	L	L	40 mV
H	L	H	60 mV
H	H	L	80 mV
H	H	H	100 mV

$\overline{RES}$ (7) is the reset control. A low voltage on this pin will reset the device. Connect to V_{DD} if not used.

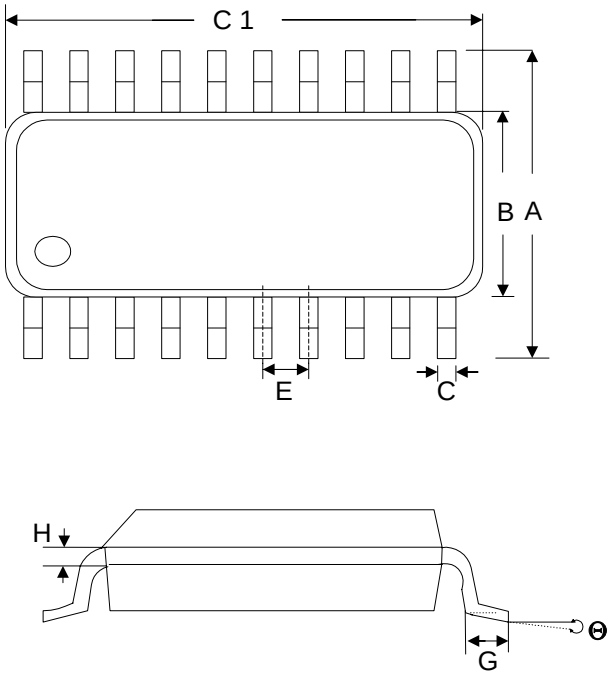
ROSC (14) is the frequency control input. For the SS4053G to work at 8MHz, this pin must be connected to V_{DD} through an 8.6kΩ resistor.

CLED (1) is the "charging" indication output. This pin goes low when the SS4035G is operating.

CFLED (2) is the "fully charged" indication output. This pin goes low when the battery is fully charged.

PHYSICAL DIMENSIONS (units: inches)

SO-20



Symbol	Dimensions in inches		
	min.	nom.	max.
A	0.394	-	0.419
B	0.290	-	0.300
C	0.014	-	0.020
C1	0.480	-	0.520
D	0.092	-	0.104
E	-	0.050	-
F	0.004	-	-
G	0.032	-	0.038
H	0.004	-	0.012
Q	0 º	-	10 º