Functional features in brief

- For 2-3-4, 5-7-9 or 6-8-10 cell Li-Ion/Li-Polymer high efficiency Synchronized Buck Chargers
- Wide input voltage range of 8V-60V
- 20mΩ charging current detection resistor
- Maximum charging current 10A.
- 0.5% charging voltage control accuracy
- Selectable number of battery sections:
  HM4089A-2,3 or 4 sections
  HM4089B-5,7 or 9 sections
  HM4089C-6,8 or 10 sections
  HM4089D- 12V, 18V, 24V Lead Acid
- 4% programmable charge current control accuracy
- Constant-voltage charging voltage value can be fine-tuned by external resistor
- Intelligent Battery Detection
- Supports resistance compensation between charger output and battery
- Built-in soft start
- Switching frequency 400/300KHz
- LED Charging Status Indication
- Battery short circuit detection, protection
- Built-in over-temperature shutdown
- Output charging current information
- Battery charging over-voltage protection
- Cycle-by-cycle current limiting
- External battery temperature detection
- External ISET pin charge enable
- Sleep mode battery power consumption less than 15uA
- External charging time limit
- Operating ambient temperature range: -20℃～85℃
- TSSOP-20 or QFN-20 package

appliance

- handheld device
- PDVD, PDA and Smartphone
- notebook computers
- Self-charging battery packs
- Independent Charger

summarize

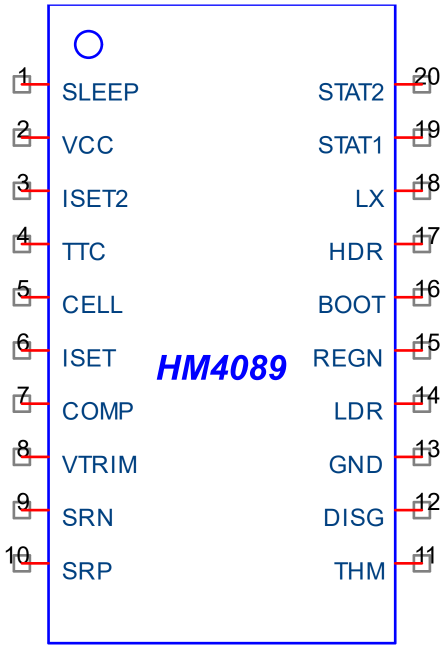
The HM4089 is a synchronous switching high-efficiency lithium-ion/lithium-polymer battery charge management chip, which is ideal for portable device charge management applications.

The HM4089 combines high-precision voltage and input current with a charge current regulator, pre-charge, charge status indication and charge cut-off in a TSSOP-20 or QFN-20 package.

HM4089 charges the battery in three stages: Pre-charge, Constant Current and Constant Voltage. Constant Current is determined by an external partial voltage resistor and Constant Voltage can be fine-tuned by an external resistor.

HM4089 integrates battery temperature detection, over-voltage and short-circuit protection to ensure the safe operation of the charging chip. HM4089 integrates intelligent battery detection function and time-out error recovery function, which is convenient for users to use.

Pin Definitions

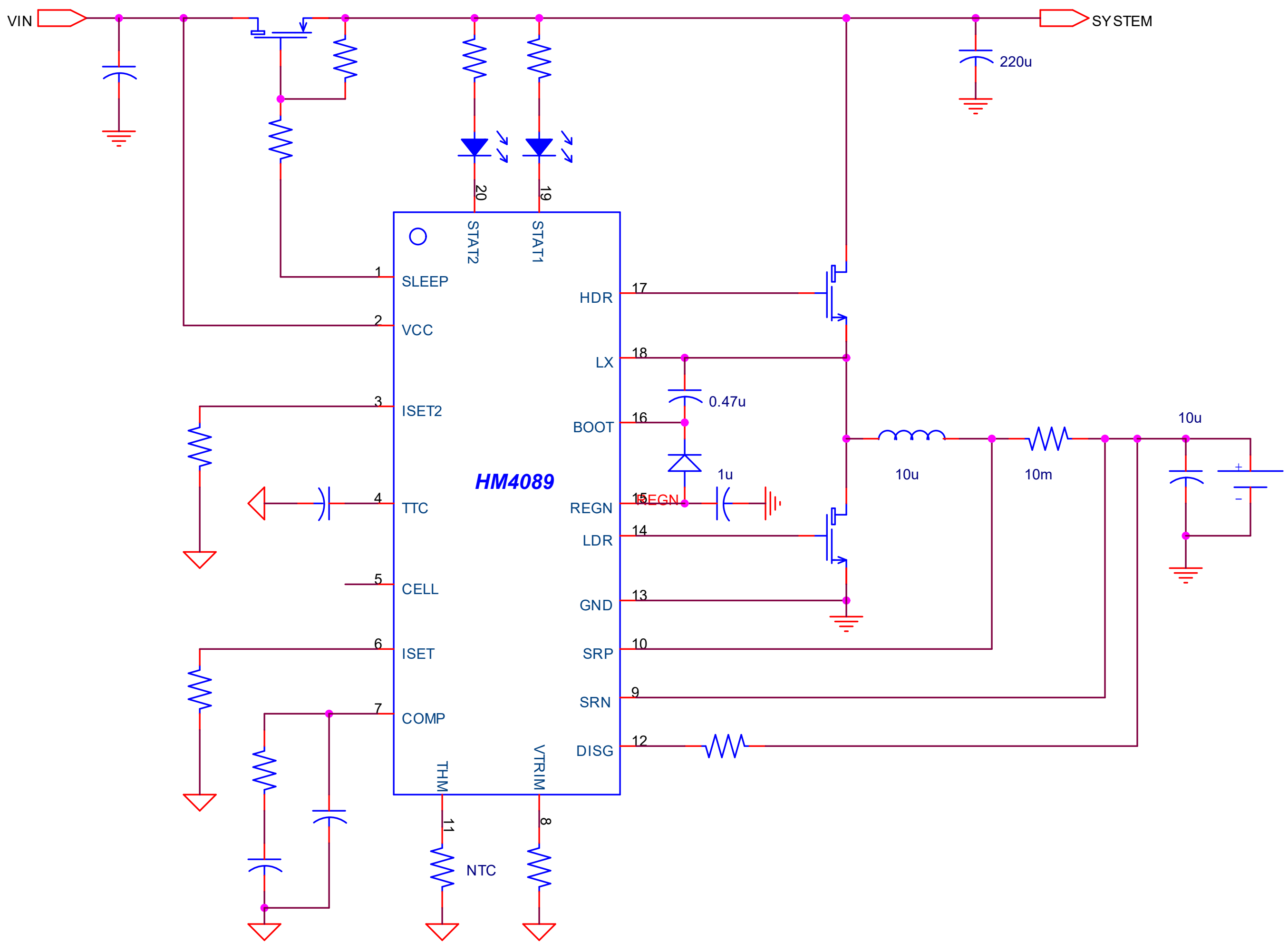


TSSOP-20 package

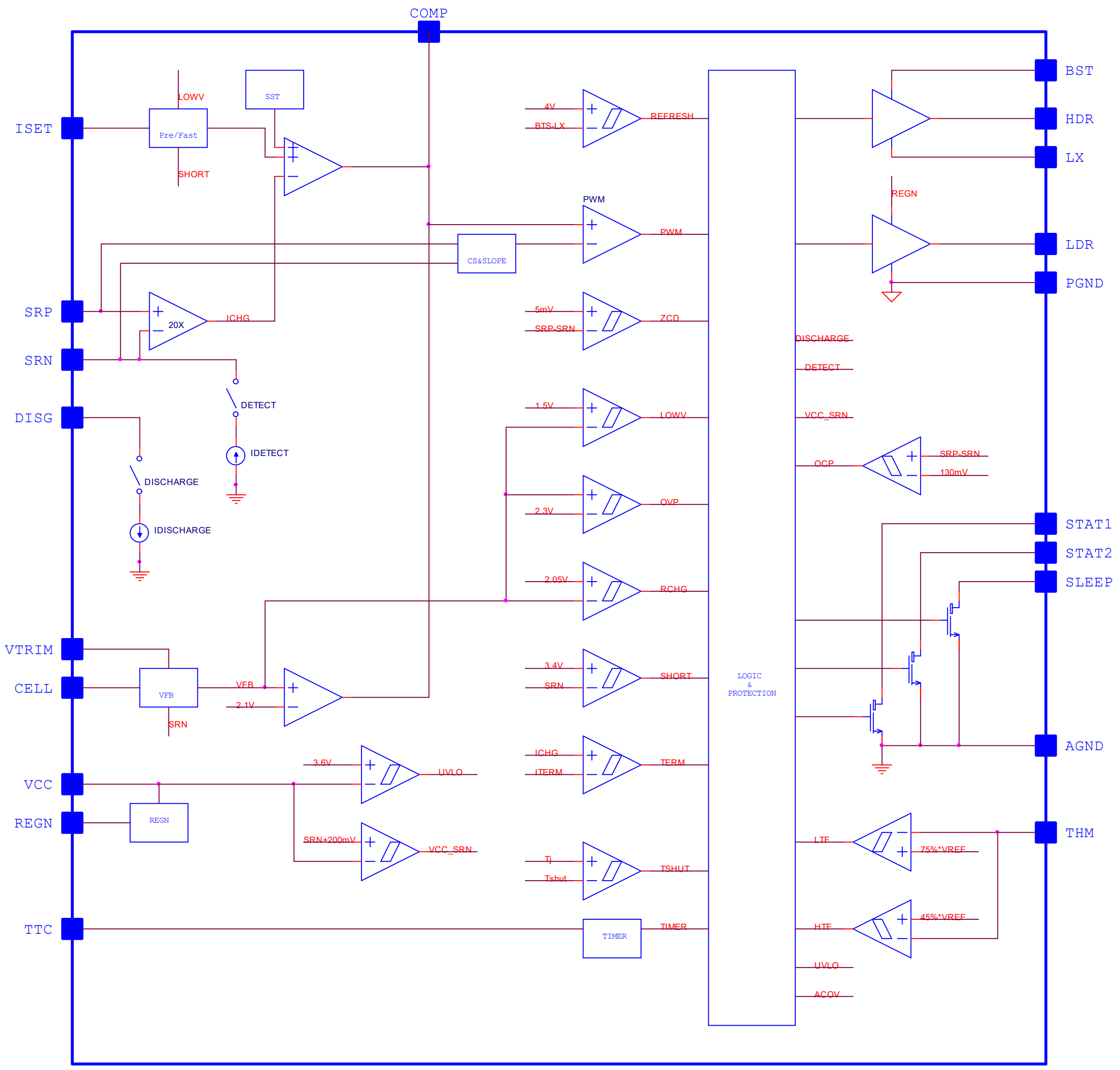
serial number	notation	I/O	descriptive		
19	STAT1	o	(STAT1) Green	(STAT2) Red	descriptive
20	STAT2	O	go out (of a fire etc)	go out (of a fire etc)	No charge or no battery
			go out (of a fire etc)	resounding	Charging.
			resounding	go out (of a fire etc)	Charging complete
			go out (of a fire etc)	0.5Hz pulse	Fault condition (timeout and overvoltage)
			go out (of a fire etc)	2Hz pulse	Fault condition (battery over temperature)
1	SLEEP	o	Input voltage below battery voltage indication		
2	VCC	P	Power Input		
3	ISET2	I	Cut-off charge current setting		
4	TTC	I	Oscillator external capacitor to determine charging time limit, when the pin is grounded, the limit is canceled		
5	CELL	I	Battery section selection: HM4089A-Ground 2 sections, float 3 sections, connect high 4 sections, single constant voltage 4.2V; HM4089B-Grounding 5 sections, floating 7 sections, connecting high 9		

			sections, single constant voltage 4.2V HM4089C-Grounded 6 sections, floating 8 sections, connected to high 10 sections, single constant voltage 4.2V HM4089D-Ground 12V, Float 18V, Connect to High 24V Lead-Acid Battery
6	ISET	I	Charging current setting, external setting resistor to ground; charging stops when external resistor is greater than a certain value
7	COMP	O	Compensation pin
8	VTRIM	I	External resistor to ground or SRN to fine tune CV voltage
9	SRN	I	Negative Charge Current Detect Input & Battery Detect Terminal
10	SRP	I	Charge current detection positive input
11	THM	I	Battery Temperature Detection
12	DISG	o	Battery side discharge pin
13	GND	P	ground
14	LDR	o	Low-side synchronous rectifier driver
15	REGN	P	5V Regulated Output Power Supply, External Filter Capacitor
16	BOOT	P	The high switching tube drives the positive side of the power supply, and a 0.22uF capacitor is connected between BOOT and LX.
17	HDR	o	High level switching tube driver
18	LX	P	Negative side of high level switching tube driver power supply

Typical Application Circuit



Module Function Block Diagram



Maximum working range

		minimal	greatest	unit (of measure)
voltage range	vcc, sleep, stat2, stat1	-0.3	60	V
	LX, SRN, SRP, VTRIM, DISG	-2	44	
	OVPSET, TTC, CELL, ISET, COMP, THM, LDR, REGN	-0.3	6.5	
	BTS, HDR	-0.3	65	
	SRP-SRN	-0.4	0.4	
operating temperature		-40	155	℃

Electrical parameters

8V<VCC<60V, 0° C<T_j <125° C, Typical Temp=25° C VCC=20V

parameters	notation	test condition	minimal	typical case	greatest	unit (of measure)
Input Voltage						
VCC supply voltage	VCC		8		60	V
Input Current						
VCC supply current	I_{VCC}	switching mode		15		mA
		static mode		2.5		mA
Battery SLEEP discharge current	I_{SLP}	VCC<V_{SRN} +200mV or UVLO		15		μA
constant voltage adjustment						
Output Constant Voltage HM4089A	V_{OREG}	2 batteries, CELL grounded		8.4		V
		3 Cell, CELL Float		12.6		
		4 batteries, CELL connected high		16.8		
Output Constant Voltage HM4089B		5 cells, CELL grounded		21.0		
		7 Cells, CELL Float		29.4		
		9 batteries, CELL to high		37.8		
Output constant voltage HM4089C		6 cells, CELL grounded		25.2		
		8 Cells, CELL Float		33.6		
		10 batteries, CELL high		42		
Output Constant Voltage HM4089D		12V Lead Acid, CELL Grounded		14.4		
		18V Lead Acid, CELL		21.6		

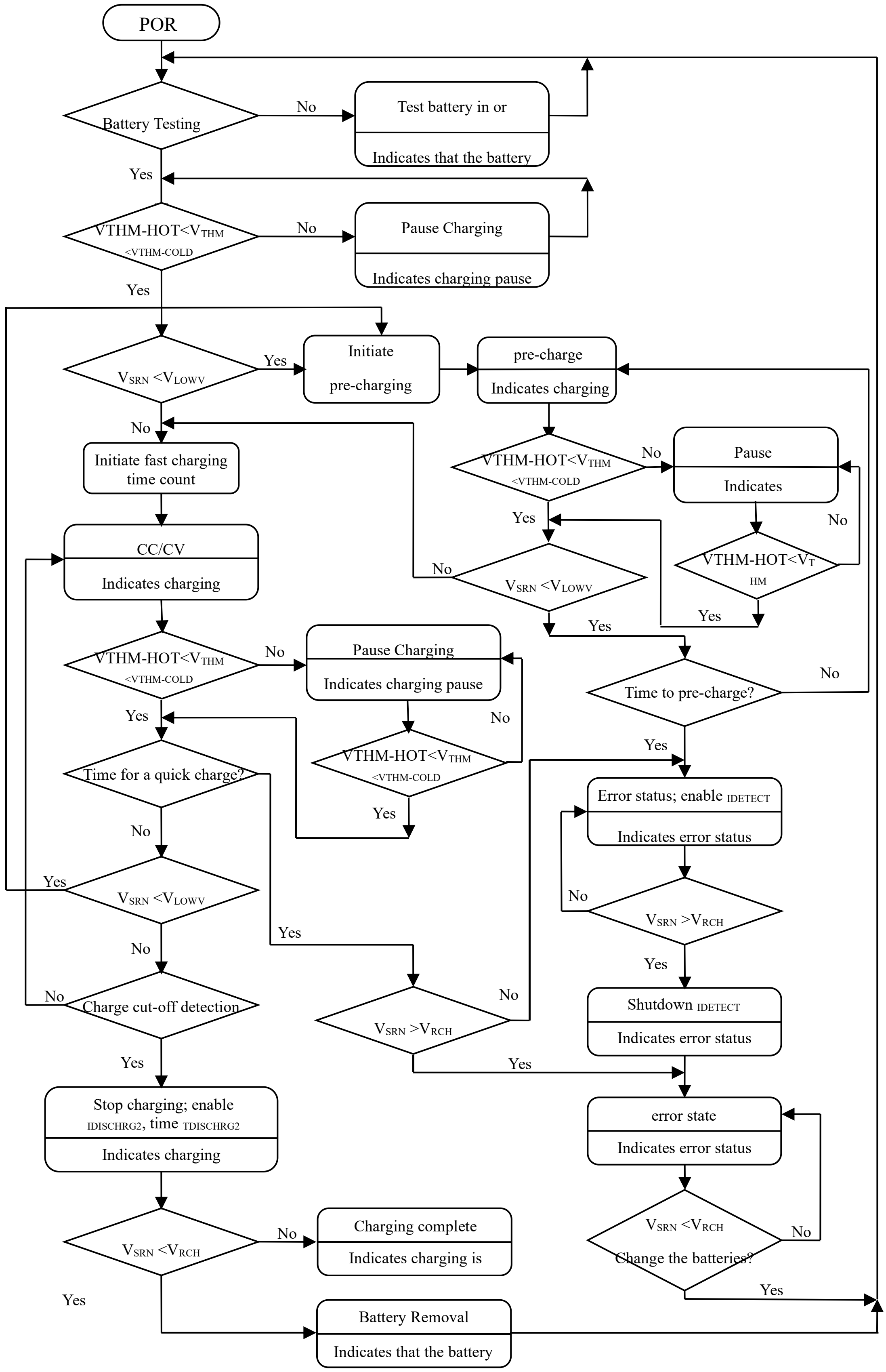
		Float				
		24V Lead Acid, CELL Connected High		28.8		
Output constant voltage accuracy			-0.5%		+0.5%	
fast charging current						
Fast charge current setting factor	K_{ISET}	Detection resistor R_{SENSE} = 10mΩ, ISET resistor corresponding to charging current value		200		A*Kohm
Fast Charge Flow Accuracy			-4%		+4%	
Charge Stop Threshold	V_{ISET_CO}	ISET declines		50		mV
Charge Enable Threshold	V_{ISET_CE}	ISET rising		100		mV
pre-charge						
Precharge current setting factor	K_{ISET}	Detection resistance R_{SENSE} = 10mΩ		40		A*Kohm
Precharge current accuracy			-25%		+25%	
Pre-charge to fast-charge threshold voltage	V_{LOWV}	SRN voltage rise (HM4089A,B,C)		3		V/CELL
		SRN voltage rise (lead acid HM4089D)		5.2		
Conversion delay time		Voltage rise and fall		30		ms
Charge cut-off						
Charge cutoff current setting factor	K_{ITERM}	Detection resistance R_{SENSE} = 10mΩ		40		A*Kohm
Cutoff Current Accuracy			-25%		+25%	
latency		Voltage rise and fall		30		ms
Charging TAPE cutoff current setting factor	K_{TAPE}	Detection resistance R_{SENSE} = 10mΩ		60		A*Kohm
TAPE Current Accuracy			-25%		+25%	
TAPE Deadline	T_{TAPE}			20		min
Recharge voltage						
Recharge	V_{RCH}	HM4089A,B,C		4		V/CELL

threshold voltage		Lead acid HM4089D		6.4		
latency		Voltage rise and fall		30		ms
STAT1, STAT2 and SLEEP drive outputs						
Low level output saturation current	I_{STAT}	Output Voltage 0.5V		10		mA
REGN Output						
REGN Output Voltage	V_{REGN}			5.4		V
REGN output current limit	I_{REGN}			50		mA
REGN Accuracy			-1%		-1%	
ACOV and ACUV						
VCC input overvoltage threshold	V_{ACOV}			63		V
VCC input undervoltage threshold	V_{ACUV}			8		V
latency		Voltage rising and falling edges		30		ms
TTC Input						
TTC coefficient	K_{TTC}			3.3		H/25nF
C_{TTC} capacitance	C_{TTC}			25		nF
time enable threshold	VTTC_EN	V_{TTC} up		500		mV
Battery Temperature Detection						
elevation threshold	VTHM-HOT	V_{THM} Falling edge		0.2		V
Low Temperature Threshold 1	VTHM-COLD1	V_{THM} rising edge		1.45		V
Cryogenic threshold2	VTHM-COLD2	V_{THM} rising edge		2.3		V
latency		Voltage rising and falling edges		30		ms
Temperature Enable Threshold	VTHM_EN	V_{THM} up		0.05		V
Input UVLO and sleep mode						
VCC undervoltage lockout	V_{UVLO}	VCC rising		4.5		V
UVLO	V_{HYS}	VCC down		400		mV

hysteresis						
sleep mode	V_{SLPR}	VCC-V_{SRN} up		400		mV
	V_{SLPF}	VCC-V_{SRN} down		200		
PWM Controller						
Switching Oscillation Frequency	F_{OSC}	VCC<30V		400		kHz
		VCC>30V		300		kHz
Synchronous to Asynchronous Threshold	Isyn-asyn	VSRP-SRN Down		4		mV
Battery Testing						
Timeout error detection current	IDETECT	V_{SRN} <V_{RCH}		3		mA
discharge current	IDISCHRG1	Depending on outer resistor value		50		mA
discharging time	TDISCHRG1			0.375		s
Wake-up current	I_{WAKE}			30		mA
wake-up time	T_{WAKE}			0.375		s
Cut-off discharge current	IDISCHRG2	Charge cutoff, V_{SRN} =<V_{OREG}		10		mA
Cut-off discharge time	TDISCHRG2			160		ms
safeguard						
Overvoltage protection threshold	V_{OVP}			109		%V_{OREG}
Cycle-By-Cycle Overcurrent	V_{OCP}	SRP-SRN		130		mV
Short-circuit SRN voltage threshold	V_{SHORT}	SRN rising		3.4		V
short-circuit current	I_{SHORT}	V_{SRN} <=V_{SHORT}		30		mA
Built-in over-temperature protection threshold	T_{TEMP}			160		℃
Over-temperature protection hysteresis	T_{HYS}			20		
HIDRV and LODRV drive outputs						
rising time	T_R	C_{GATE} =5nF,10% to 90%		20		ns

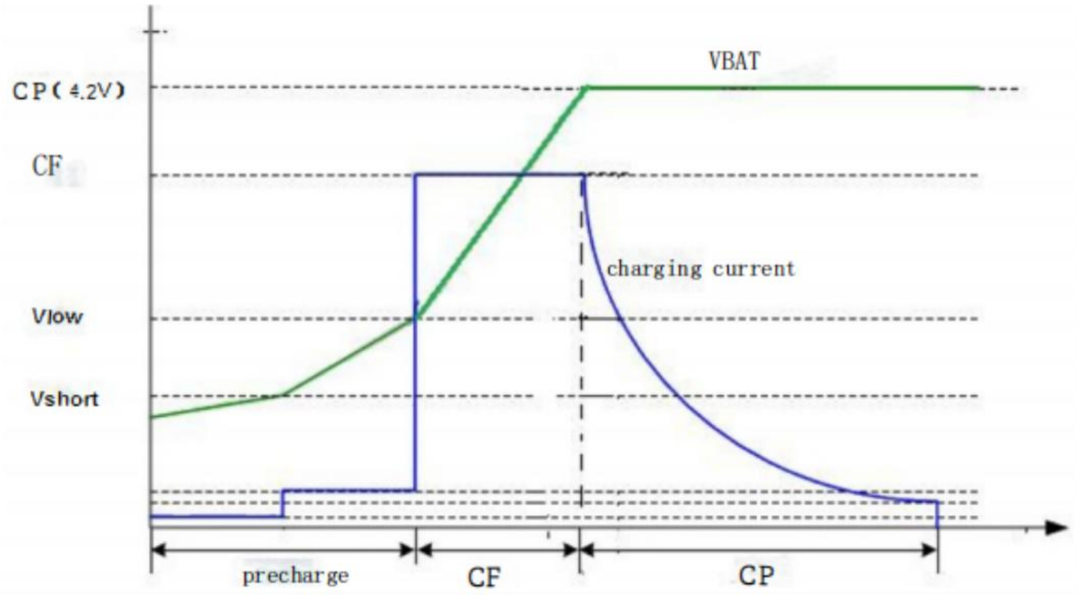
descent time	T_F	C_{GATE} =5nF,90% to 10%		20		
dead time	T_{DEAD}	When switching between HDR and LDR		40		ns
Refres pulse width	TREFRESH			120		ns

workflow chart



Functional Description

Charging process

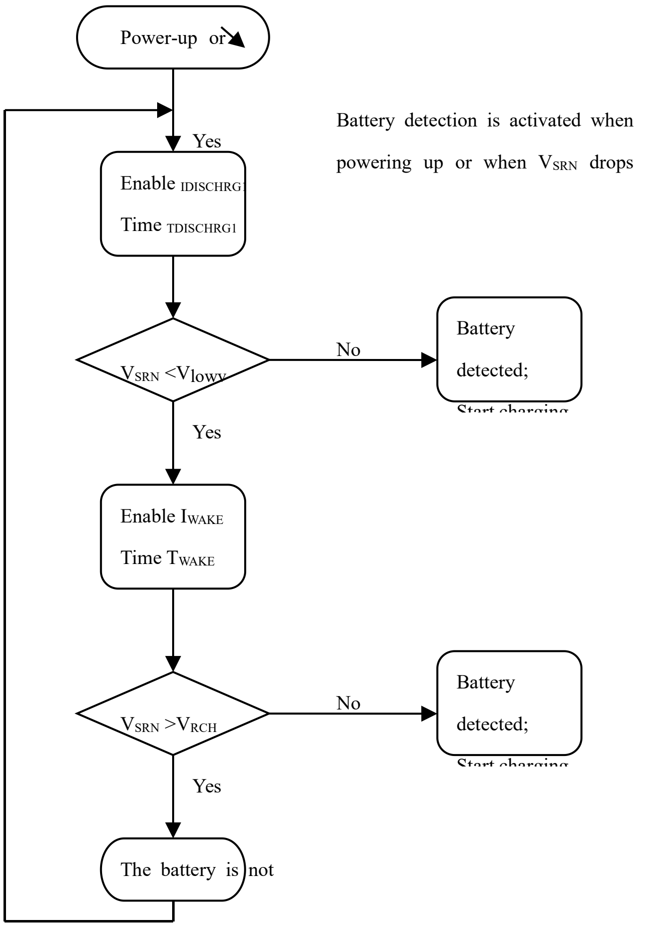


The battery voltage detects the voltage difference between the SRN and GND pins.

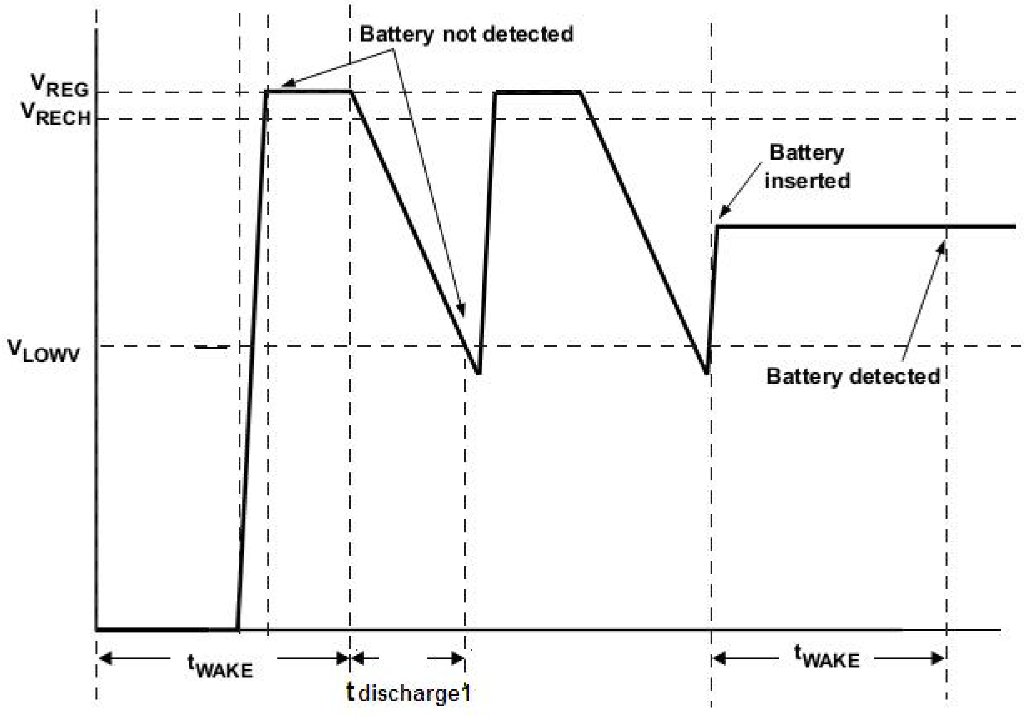
When SRN pin voltage is lower than 3.4V, it enters into short-circuit current detection mode; when SRN pin voltage is greater than 3.4V and lower than 3V/CELL, it enters into pre-charge mode; when SRN pin voltage is greater than 3V/CELL and lower than 4.2V/CELL, it enters into fast charging mode; and when SRN pin voltage is equal to 4.2V/CELL, it enters into constant voltage charging mode.

After charging is completed, if the SRN pin voltage drops below 4V/CELL on current leakage, it enters the re-charge cycle.

Battery Testing



For the battery-absent scenario, the voltage at the SRN pin will keep flipping between Vlowv and V_{OVP} until a new battery is inserted.



Battery Detect Timing Diagram

sleep mode

Remove input power to enter sleep mode. When the VCC voltage is below the UVLO threshold, or VCC is below V_{SRN} +200mV, the HM4089 enters sleep mode and the battery discharge current is minimized.

Charge current setting

The battery constant current charging current value ICHARGE is calculated from the following equation:

$$I_{CHARGE} = \frac{2000}{R_{SNS} \times R_{ISET}}$$

Where, V_{ISET} is the output voltage of ISET pin, 1V in constant current charging stage, and 0.2V in pre-charging stage. RISET is the external ISET pin resistor. R_{SNS} is the external current detecting resistor. R_{SNS} is the external current detecting resistor, which is generally taken as 10mΩ. (When RISET=40K, Icharge=5A; when RISET=20K, Icharge=10A, when RISET=40K, Icharge=5A) RISET is greater than 800KΩ, charging stops; when RISET is less than 800KΩ, Icharge enables. (When RISET=40K, Icharge=5A; when RISET=20K, Icharge=10A; when RISET=40K, Icharge=5A) When RISET is larger than 800KΩ, charging stops; when RISET is smaller than 800KΩ, charging is enabled.

After the constant current charging current is determined, the pre-charge current is 20%*ICHARGE.

Cut-off charging current setting

The battery cut-off charging current value Iterm is calculated by the following formula:

$$I_{TERM} = \frac{400}{R_{SNS} \times R_{ISET2}}$$

During the constant voltage phase, when the voltage drop of the charging current across the R_{SNS} resistor is lower than the cut-off charging current, the HM4089 internally generates an EOC signal and the charging cuts off.

Meanwhile, when the voltage drop of the charging current across the R_{SNS} resistor is 150% of the cut-off charging current, a TAPE signal is generated inside the chip, and the charging is as of if the charging current still does not drop to Iterm after half an hour.

Battery Temperature Detection

The HM4089 has an external NTC thermistor connected to ground that monitors the battery temperature and suspends charging when the temperature is outside of the threshold. HM40896 When the THM pin voltage falls below 200mV at high temperatures, the HM4089 suspends charging and the internal clock stops timing. When the THM detection voltage returns to the normal range, charging continues and timing resumes. When Vthm voltage is above 1.45V at low temperature, the charging current is reduced to 50% of the maximum current, and when Vthm voltage is above 2.3V at low temperature, the charging current is reduced to 20% of the maximum current, and the NTC thermistor should be placed next to the battery package.

To cancel the battery temperature detection function, simply ground the THM pin.

Battery Temperature Detection

The HM4089 has an external NTC thermistor to ground that monitors the battery temperature and aborts charging when the temperature is outside the threshold. When the THM pin voltage is below 50mV, the HM4089 charges normally and the temperature pin does not function. When the THM pin voltage falls below 200mV at high temperatures, the HM4089 will suspend charging and the internal clock will stop. When the NTC detection voltage returns to normal range, charging continues and timing resumes. When the Vthm voltage is above 1.45V at low temperature, the charging current is reduced to 50% of the maximum current, and when the Vthm voltage is above 2.3V at low temperature, the charging current is reduced to 20% of the maximum current, and the NTC thermistor should be placed next to the battery package.

To cancel the battery temperature detection function, simply ground the THM pin.

IC internal is 50ua constant current source, high temperature equivalent R=200mv/50ua=5K ohm, that is to say below 5K is equivalent high temperature protection. Low temperature equivalent R=1.45V/50ua=29K. That is to say when the equivalent resistance is greater than 29K, the charging current is reduced to 50% of the maximum current, then low temperature protection. When Vthm voltage is higher than 2.3V at low temperature, equivalent resistance R=2.3V/0.05=46K, charging current is reduced to 20% of maximum current.

In order to get the high and low temperature protection value we need, in the NTC to IC pin 6 to string a resistor R1, (** in order to protect the IC from electrostatic ESD bad, also need to string a resistor 680 ohms or more), at the same time in the NTC and a resistor R2, to regulate the value of low temperature protection.

For example: a: with a 10K, B-value 3950 NTC, corresponding to 52° C, the NTC resistor value is 3.325K, which R1 = 4K - 3.325K = 0.675K, and R1 is taken to be 680 to 1.0K (disregarding the effect of R2 for now).

b: low-temperature R = Rntc / / R2, for example, with 10K, B value of 3950, at -10 ° C (assuming that we require protection at this point) resistance value is 55.6K, R1 + Rntc = 49.87 + 0.68K = 56.3K, the equivalent resistance of R = R2 * 56.3 / (R2 + 56.3) = 46K, to get the R2 = 251K, take 250K.

Charging time limit

The HM4089 has programmable limits on pre-charge and total charge time, and a total charge time limit:

$$T_{CHARGE} = C_{TTC} \times K_{TTC}$$

Where C_{TTC} is the value of external capacitance of pin TTC and K_{TTC} is the coefficient.

The pre-charging time is 1/8 of the total charging time. If a charging timeout occurs, the chip enters the FAULT state and pin 20 outputs a pulse indication.

To cancel the charge time limit function, simply ground the TTC pin.

Charging status indication

The open-drain output pins STAT1 (green light) and STAT2 (red light) are indicated in the table below.

STAT1 (green light)	STAT2 (red light)	status of an instruction
go out (of a fire etc)	go out (of a fire etc)	No charging, no battery or sleep mode
go out (of a fire etc)	resounding	Charging.
resounding	go out (of a fire etc)	Charging complete
go out (of a fire etc)	0.5Hz pulse	Fault condition (timeout or overvoltage)
go out (of a fire etc)	2Hz pulse	Fault condition (charging suspended)

Timeout Error Recovery

As shown by the workflow diagram, the HM4089 provides a recovery mechanism for charging timeout errors (including pre-charge timeout and total charge timeout). It is summarized as follows:

Case 1: V_{SRN} voltage is greater than the recharge threshold voltage and a timeout error occurs.

Recovery Mechanism: When the battery detection voltage drops below the recharge threshold voltage due to battery discharge to load, self-discharge or battery removal, the HM4089 clears the error state and enters the no-battery detection process. In addition, a power-on reset clears this time-out error state.

Case 2: V_{SRN} voltage is below the recharge threshold voltage and a timeout error occurs.

Recovery Mechanism: When this occurs, the HM4089 enables an IDETECT current. This small current can be used to detect if the battery is in or out. This current remains as long as the battery voltage is below the recharge voltage. If the battery voltage is higher than the re-charge voltage, then the HM4089 deactivates the IDETECT current and performs the recovery mechanism of case 1. It is once the battery voltage is again below the recharge threshold voltage that the HM4089 clears the timeout error and enters the no-battery detection process. A power-on reset also clears this timeout error state.

Battery overvoltage protection

The HM4089 has a built-in overvoltage protection function. This feature protects the device itself and other components when the battery voltage is too high, such as an overvoltage generated when the battery is suddenly removed. When an overvoltage is detected, the function immediately shuts down the charger's HIDRV and LODRV and indicates an error. The error is lifted when the battery voltage falls below the recharge threshold voltage.

Cycle-By-Cycle Current Limit Protection

The HM4089 has a built-in over Cycle-By-Cycle current limit protection function. When the voltage drop across the SRP and SRN detection resistors is detected to be greater than 130mV, the PWM is turned off immediately until the voltage drop across the SRP and SRN detection resistors is less than the current limit value in the next cycle.

Refresh Pulse

When the BOOT-LX voltage difference is less than 3.65V/3.9V, the lower tube opens 120ns, the LX pin pulls down, and the external bootstrap capacitor charges.

Built-in over-temperature protection

When the internal junction temperature of the HM4089 exceeds 160°C, charging stops to reduce the power consumption of the chip; when the internal junction temperature drops to 140°C, charging restarts.

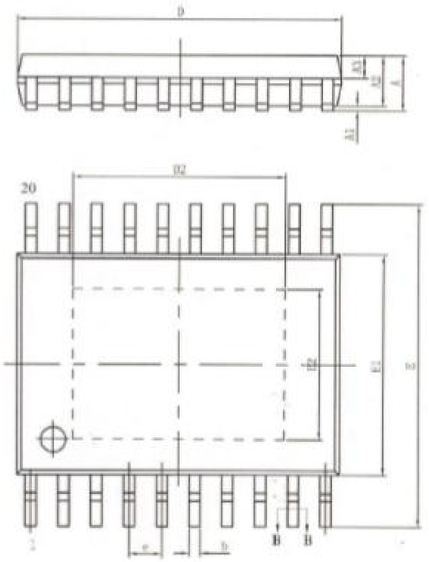
Fine tuning of constant voltage output

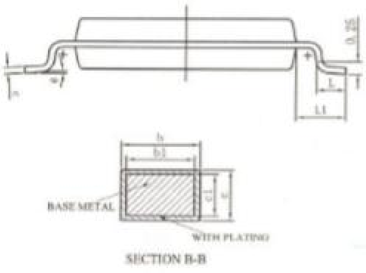
Measure the constant voltage output of SRN pin V_{CV} , adjust V_{CV} upward, connect the trimmer resistor R_{TRIM} between VTRIM pin and ground; adjust V_{CV} downward, connect the trimmer resistor R_{TRIM} between VTRIM pin and SRN pin. The formula for the resistance value of resistor R_{TRIM} is (negative means connect to SRN, positive means connect to ground):

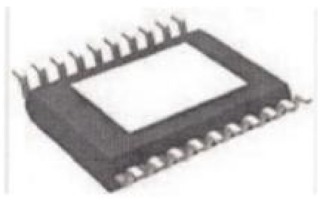
Lithium batteries: $$R_{TRIM} = \left(\frac{4.2 \times Cell}{4.2 \times Cell - V_{CV}}\right) \times R$$

Lead-acid batteries: $$R_{TRIM} = \left(\frac{7.2 \times Cell}{7.2 \times Cell - V_{CV}}\right) \times R$$

For version A, R = 60 KΩ; version B, R = 87.5 KΩ; version C, R = 100 KΩ; and version D, R = 120 KΩ.







SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.80	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	—	0.29
b1	0.19	0.22	0.25
c	0.13	—	0.28
c1	0.12	0.13	0.14
D	6.40	6.50	6.60
D2	4.10	4.20	4.30
E2	2.90	3.00	3.10
E1	4.30	4.40	4.50
E	6.20	6.40	6.60
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	—	8°
L/F载体尺寸 (mil)	118*165 (C)		