SWITCHMODE LI-ION CHARGE CONTROLLER

HB6293

Features

- High-Accuracy Current Regulation PWM Charger Suitable for 1-, or 2-Cell Li-Ion and Li-Polymer Battery Packs
- 0.5％ Charge Voltage Accuracy
- Programmable Charge Current Control
- Constant Charge Voltage fine-tuned by External Resistance
- Intelligent Battery Detection
- Integrated Soft Start
- Switching Frequency 600KHz
- LED Charge Status Outputs
- Short Circuit Detection & Protection
- Battery Charging Voltage Protection
- 20-V Absolute Maximum Voltage Rating on IN Pins
- Charge Termination Time adjusted by External Capacitance
- Operating junction temperature range： -20℃～70℃
- MSOP-10 Package

Applications

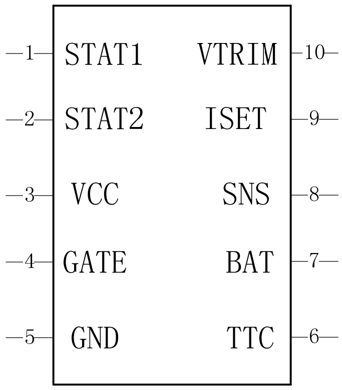
- Handheld Products
- Charger
- Mobile Devices

Description

The HB6293 series are highly integrated Li-ion and Li-polymer switch-mode charge management devices targeted at a wide range of portable applications. The HB6293 series offers high-accuracy current and voltage regulation, charge preconditioning, charge status, and charge termination, in a small, thermally enhanced MSOP-10 package. The HB6293 charges the battery in three phases: pre-charge, constant current and constant voltage, constant current is decided by the external resistance, and the constant voltage can be fine-tuned by external resistance. Protections of over voltage and short circuit provide a safety backup for charge termination. The HB6293 automatically restarts the charge cycle if the battery voltage falls below an internal threshold and enters sleep mode when VCC supply is removed.

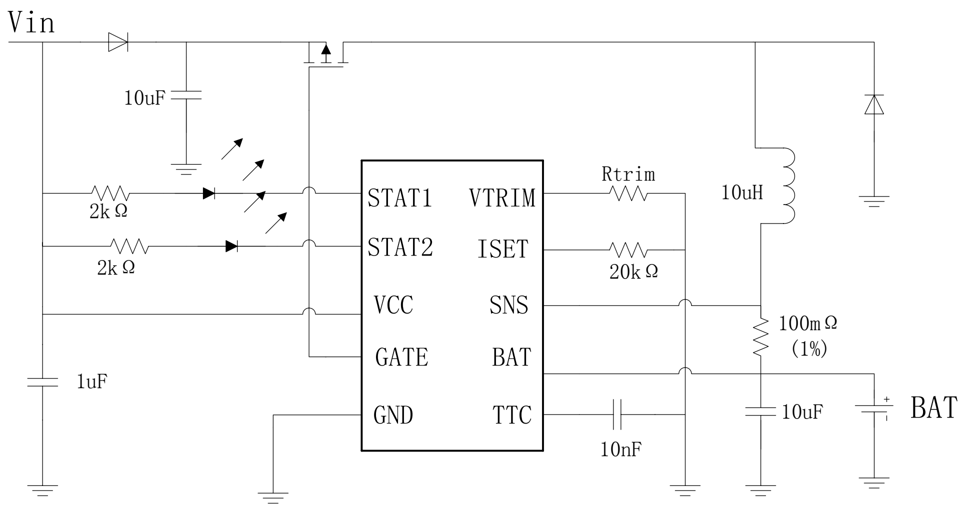
Connection Diagrams

HB6293 MSOP-10 Package

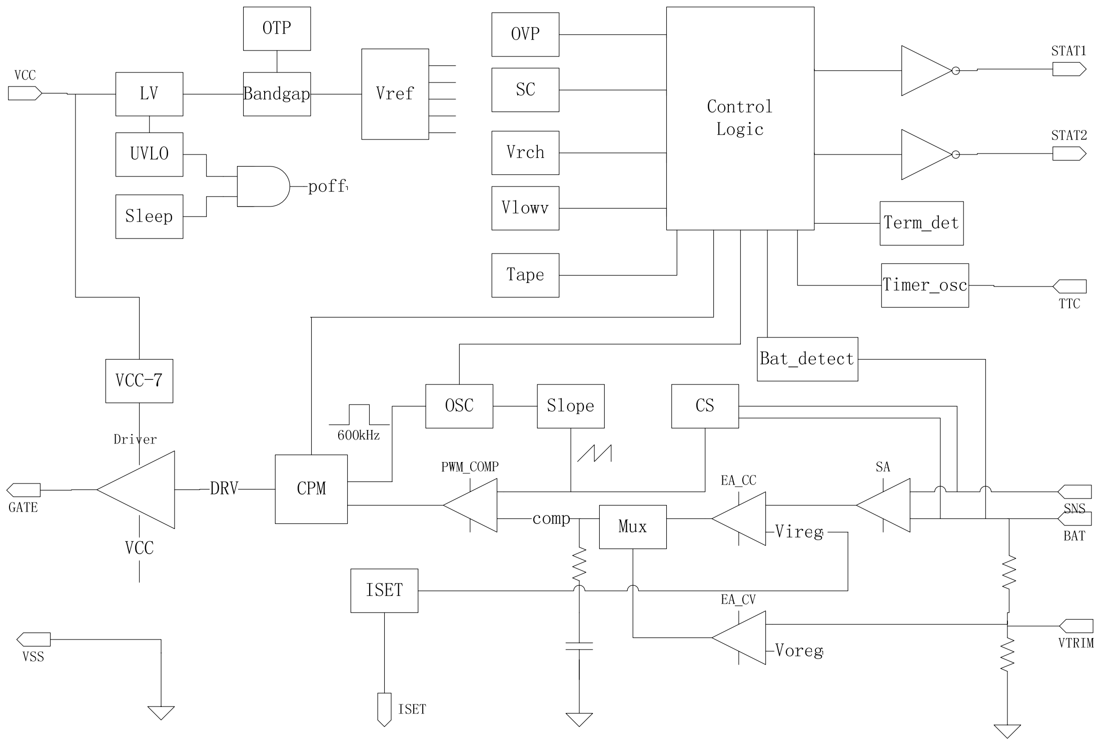


Pin	Name	I/O	Description		
1	STAT1	O	(STAT1) Green	(STAT2) Red	Description
2	STAT2	O	OFF	OFF	Charge suspend, battery absent
			OFF	ON	Charge-in-progress
			ON	OFF	Charge complete
			OFF	0.5Hz pulse	Fault condition(timer fault and overvoltage)
3	VCC	I	Input power pin		
4	GATE	O	Switch drive output		
5	GND	-	Analog ground input		
6	TTC	-	Connect a capacitor from this node to VSS to set the charge timer. When this input is low, the timer and termination detection are disabled.		
7	BAT	I	Battery voltage sense input &Charge current sense negative		
8	SNS	I	Charge current sense positive		
9	ISET	I	Charger current set point of pre-charge, constant current charge and charge termination current. Use a resistor to ground to set this value		
10	VTRIM	I	Use a resistor to ground or to BAT pin to set constant voltage value slightly		

Typical Application



Block Diagram



Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
Voltage range	STAT1, STAT2, VCC	0		20	V
	VCC-GATE	0		8	V
	VTRIM, BAT, SNS	0		14	V
	ISET, TTC	0		6	V
	SNS-BAT	-0.2		0.2	V
Operating junction temperature range		0		125	℃

Electrical Characteristics

Typical values are Temp=25℃ VCC=10V

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Currents						
V_{CC} Supply Current	I_{VCC}	Switching Mode		10		mA
Battery discharge sleep current	I_{SLP}	VCC<V_{BAT}+250mV or UVLO		10		μA
Voltage Regulation						
Output voltage	V_{OREG}	1-Cell		4.2		V
		2-Cell		8.4		
Voltage regulation accuracy			-0.5%		+0.5%	
Current Regulation						
Voltage regulated across R_{SNS}	V_{IREG}	Fast Charge and R_{ISET}=20kΩ		100		mV
Output current set voltage	V_{ISET}	V_{LOWV}<V_{BAT}<V_{OREG}		1		V
Output current set factor	K_{ISET}			2000		V/A
Pre-charge						
Voltage regulated across R_{SNS} of pre-charge detection	V_{IPRE}	Pre-charge and R_{ISET}=20kΩ		20		mV
Voltage value for pre-charge to fast charge transition	V_{LOWV}	1-Cell		3		V
		2-Cell		6		
Deglitch time for pre-charge to fast charge transition		Rising Voltage		30		ms
Charge Termination						
Voltage regulated across	V_{ITERM}	Fast charge		10		mV

R_{SNS} of charge termination detection		and R_{ISET}=20kΩ				
Deglitch time for charge termination		Both rising and falling voltages		30		ms
Voltage regulated across R_{SNS} of charge termination timing	V_{ITAPE}			20		mV
Deglitch time for charge termination		Falling voltage		30		ms
TAPE termination timer	T_{TAPE}			1800		s
Battery Recharge Threshold						
Recharge threshold voltage	V_{RCH}	1-Cell		4.1		V
		2-Cell		8.2		
Deglitch time		Falling voltage		30		ms
STAT1 and STAT2 Drive Outputs						
Low-level output saturation voltage, STATx	I_O	Output voltage 0.5V		10		mA
TTC Input						
TTC Timer multiplier	K_{TTC}			4.66		H/10nF
C_{TTC} Capacitor	C_{TTC}			10		nF
TTC enable threshold voltage	V_{TTC_EN}	V_{TTC} rising		200		mV
UVLO and Sleep Mode						
IC active threshold voltage	V_{UVLO}	VCC rising，1-Cell		4.2		V
		2-Cell		8.4		
IC active hysteresis	V_{HYS}	1-Cell		200		mV
		2-Cell		400		
Sleep Mode	V_{SLPR}	VCC-V_{BAT} rising		400		mV
	V_{SLPF}	VCC-V_{BAT} falling		200		
PWM						
Switching frequency	F_{OSC}			600		kHz
Maximum duty cycle	D_{MAX}			98		%
Minimum duty cycle	D_{MIN}			0		%
Battery Detection						
Battery detection current during time-out fault	I_{DETECT}	V_{BAT}<V_{RCH}		2		mA
Discharge current	$I_{DISCHRG1}$			400		μA
Discharge time	$T_{DISCHRG1}$			1		s
Wake current	I_{WAKE}			2		mA
Wake time	T_{WAKE}			0.5		s
Termination discharge current	$I_{DISCHRG2}$	Begins after termination detected		400		μA

		$V_{BAT}=<V_{OREG}$				
Termination discharge time	$T_{DISCHRG2}$			250		ms
Protection						
OVP threshold voltage	V_{OVP}			117		$\%V_{OREG}$
Short-circuit voltage threshold, BAT	V_{SHORT}	BAT voltage falling，1-Cell		2		V
		2-Cell		4		
Short-circuit current	I_{SHORT}	$V_{BAT}<=V_{SHORT}$		25		mA
Thermal trip	T_{TEMP}			125		℃
Thermal hysteresis	T_{HYS}			20		
GATE Drive Output						
Rising time	T_R	C_{GATE}=2nF,10% to 90%		20		ns
Falling time	T_F	C_{GATE}=2nF,90% to 10%		50		
Output clamp voltage level	V_{CLAMP}	VCC>8		VCC-7		V
		VCC<8		0		

Typical Operating Performance

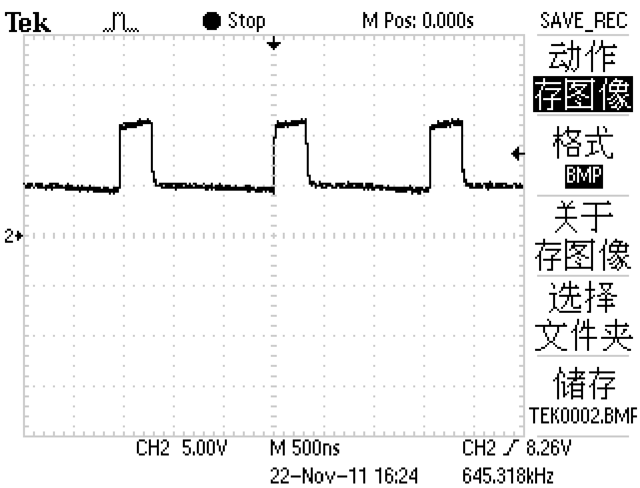


Fig. 1 Switching Waveforms in Fast Charge Mode

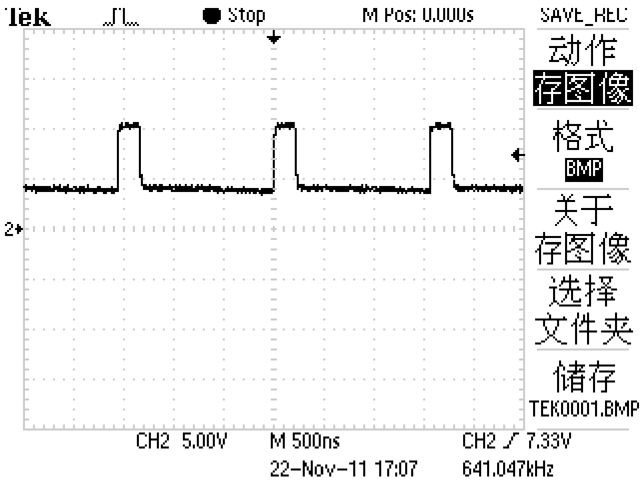
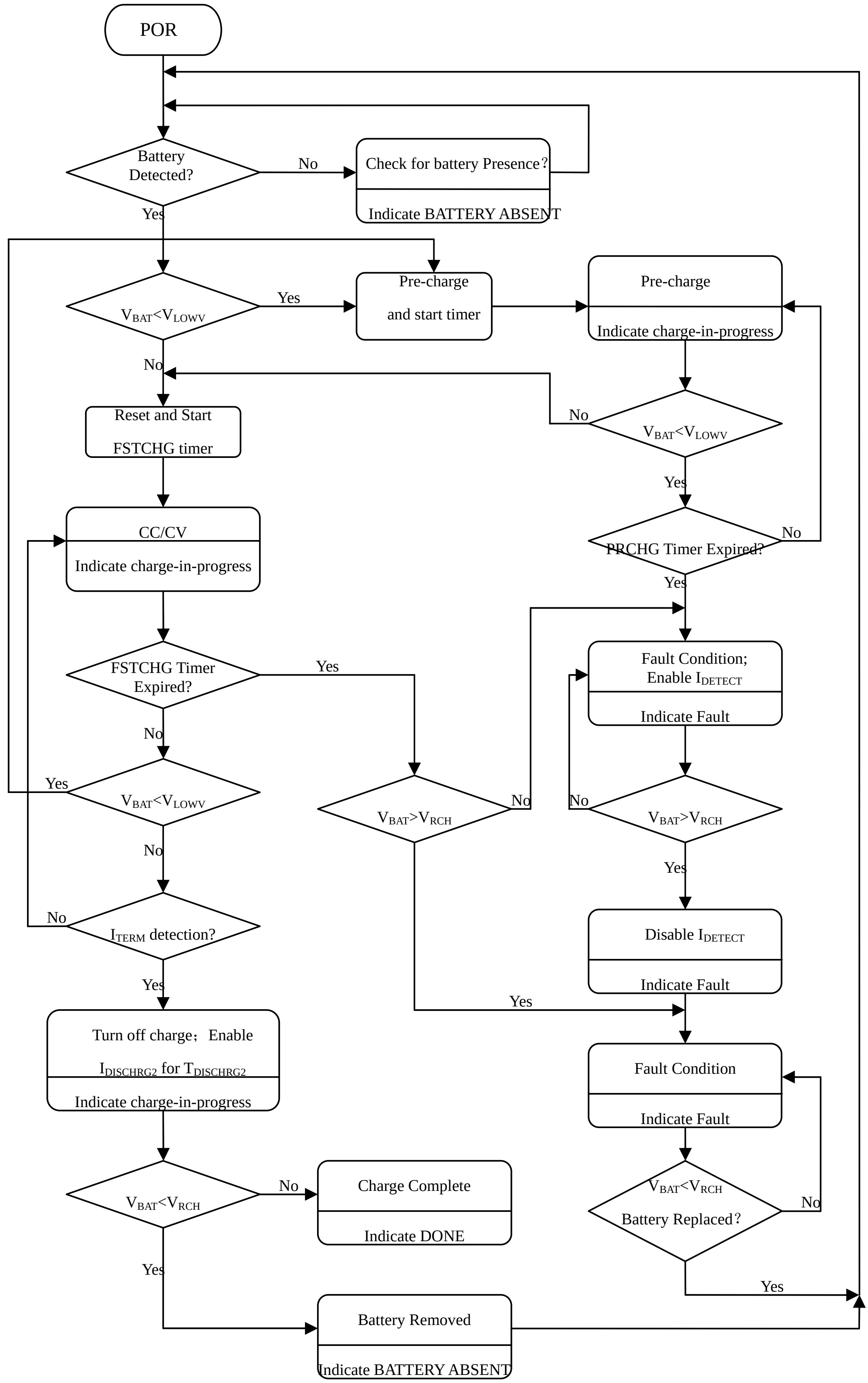


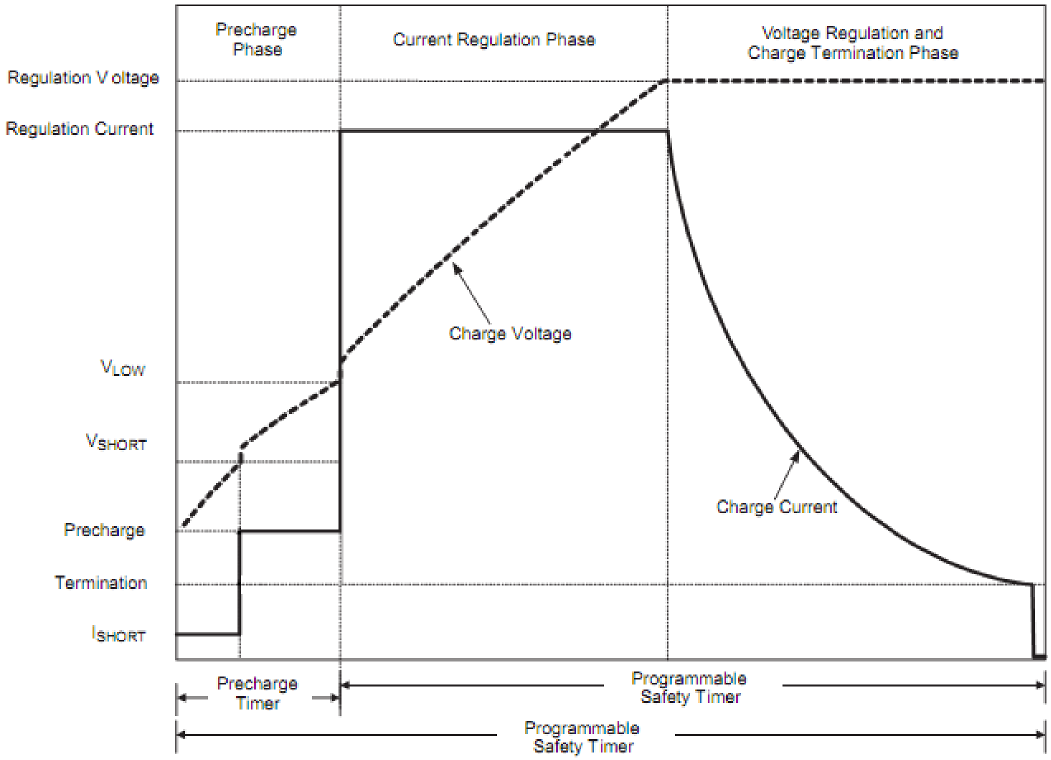
Fig. 2 Switching Waveforms in Constant Voltage Mode

Operational Flow Chart

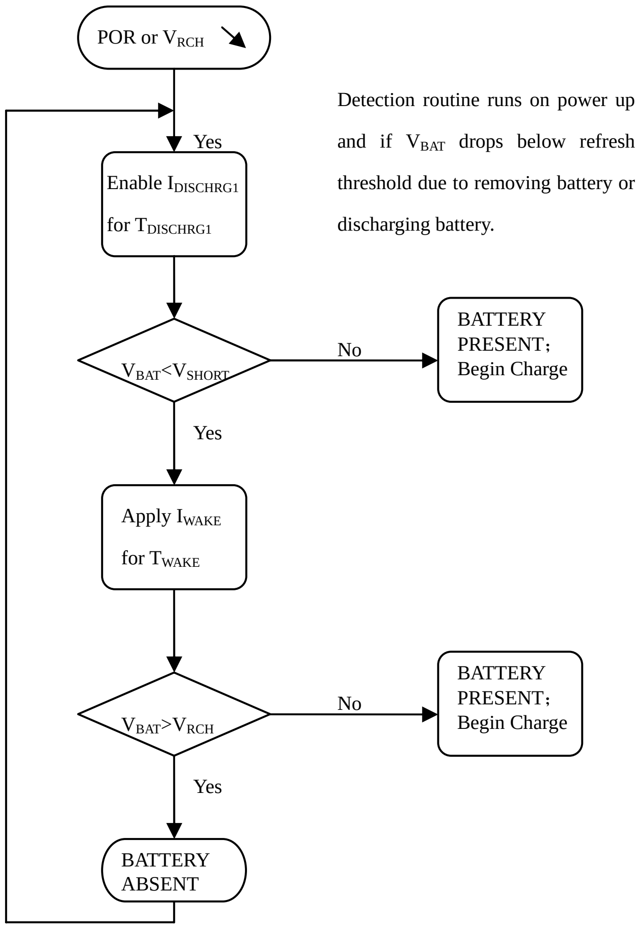


Detail Description

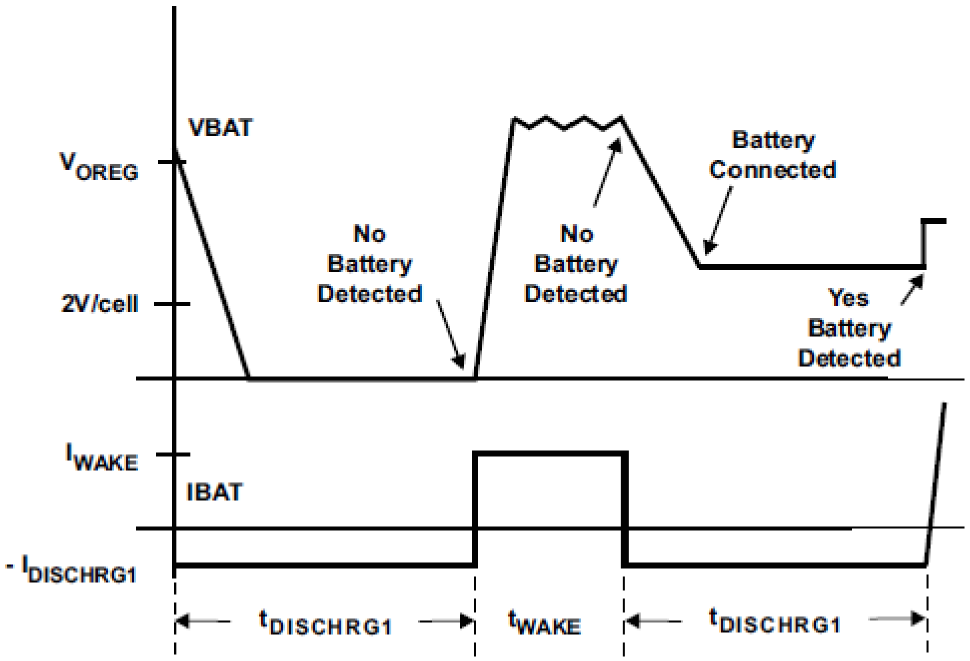
Typical Charge Profile



Battery Detection



For the absent battery condition, typically the voltage on the BAT pin rises and falls between 0V and V_{OVP} thresholds indefinitely.



Sleep Mode

The HB6293 enters the low-power sleep mode if the VCC pin is removed from the circuit. When VCC falls below UVLO threshold or V_{BAT}+250mV, the HB6293 enters the sleep mode, and minimum discharge current.

Charge Current Set

The value of constant current I_{CHARGE} can be calculated using the following equation:

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

Where, V_{ISET} is the output voltage of ISET pin, 1V in the constant current phase, 0.2V in the pre-charge phase. R_{SNS} is the external current-sense resistor; K_{ISET} is the A/V gain factor.

After the determination of constant current, the current of pre-charge becomes to 20%*I_{CHARGE}, and the current of charge termination becomes to 10%* I_{CHARGE}.

Charge Termination Current

Once the termination threshold, V_{ITERM} across R_{SNS}, is detected, the HB6293 inside generates EOC signal and terminates charge, during the voltage regulation phase.

Meanwhile, the chip generates a TAPE signal when the voltage across RSNS falls bellow twice V_{ITERM}, terminates charge when the voltage still not falls bellow V_{ITERM}.

Battery Voltage Regulation

The HB6293 monitors the battery-pack voltage between the BAT and GND pins.

The HB6293 enters short circuit detection mode when the battery voltage falls bellow 2V 1-Cell and 4V 2-Cell, pre-charge mode when the battery falls bellow 3V 1-Cell and 6V 2-Cell. The charge termination voltage is 4.2V 1-Cell, 8.4V 2-Cell.

After the charge completed, the HB6293 enters recharge period, if the battery falls bellow 4.1V 1-Cell and 8.2V 2-Cell as a result of current leakage.

Charge Time Limit

The HB6293 provides a programmable charge timer for pre-charge and total charge time, the total charge time is programmed by the following formula:

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

Where, C_{TTC} is the capacitor connected to the TTC pin, K_{TTC} is the multiplier.

The pre-charge time is 1/8 of total charge time, the chip enters FAULT state and STAT2 outputs pulse wave, if there is a timeout fault.

Charge Status Outputs

The open-drain STAT1 and STAT2 outputs indicate various charger operations as shown in fallowing table.

STAT1（Green）	STAT2（Red）	Charge State
OFF	OFF	Charge suspend, battery absent

		or sleep mode
OFF	ON	Charge-in-process
ON	OFF	Charge complete
OFF	0.5Hz pulse	Fault state（overtime or over voltage）

Timer Fault Recovery

As shown in Operational Flow Chart, the HB6293 provides a recovery method to deal with timer fault conditions. The following summarizes this method:

Condition 1: V_{BAT} above recharge threshold and timeout fault occurs.

Recovery method: HB6293 waits for the battery voltage to fall below the recharge threshold. This could happen as a result of a load on the battery, self-discharge or battery removal. Once the battery falls below the recharge threshold, the HB6293 clears the fault and enters the battery absent detection routine. A POR also clears the fault.

Condition 2: V_{BAT} below recharge threshold and timeout fault occurs.

Recovery method: Under this scenario, the HB6293 applies the I_{DETECT} current. This small current is used to detect a battery removal condition and remains on as long as the battery voltage stays below the recharge threshold. If the battery voltage goes above the recharge threshold, then the HB6293 disables the I_{DETECT} current and executes the recovery method described in Condition1. Once the battery falls below the recharge threshold, the HB6293 clears the fault and enters the battery absent detection routine. A POR also clears the fault.

Output Overvoltage Protection

The HB6293 provides a built-in overvoltage protection to protect the device and other components against damages if the battery voltage gets too high, as when the battery is suddenly removed. When an overvoltage condition is detected, this feature turns off the PWM and shows fault. The fault is cleared once V_{BAT} drops to the recharge threshold.

Constant Charge Voltage Fine-tuned

According to the tested value of constant voltage output V_{CV}, using R_{TRIM} between VTRIM pin to GND pulls up V_{CV}, otherwise between VTRIM pin to BAT pin pulls down V_{CV}. Determine the value for R_{TRIM} using the following equations:

a. One-Cell

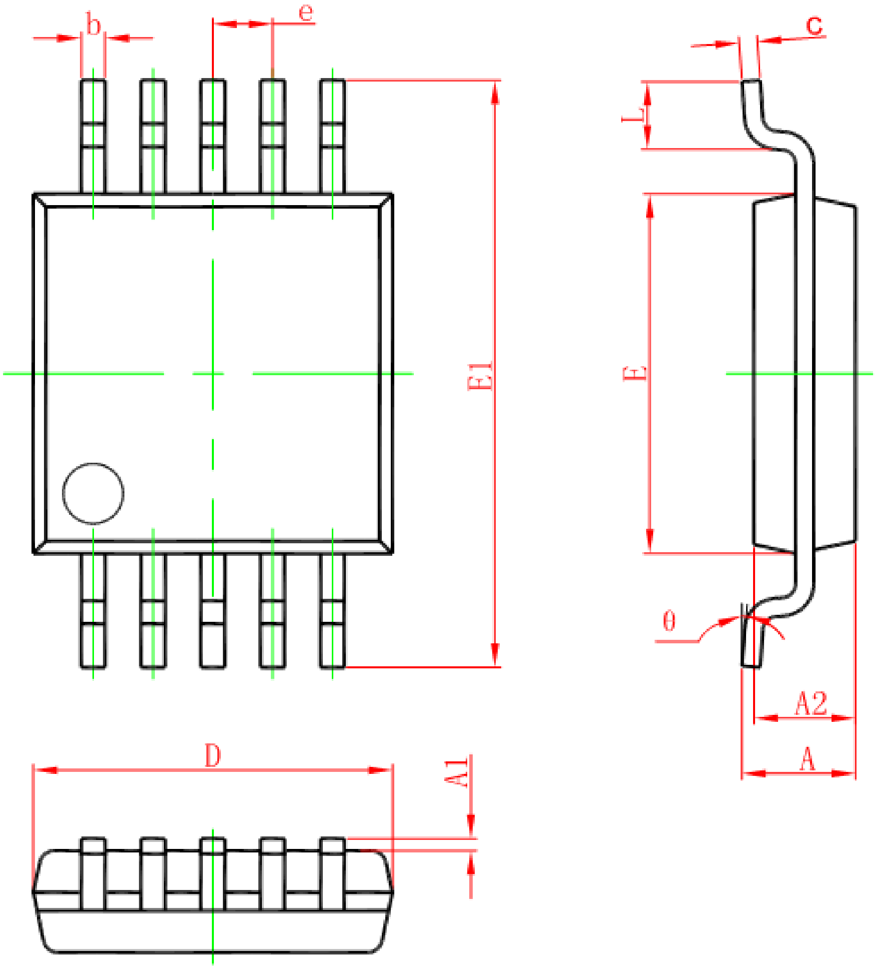
$$R_{TRIM} = \left(\frac{V_{CV}}{4.2 - V_{CV}} \right) R$$

b. Two-Cell

$$R_{TRIM} = \left(\frac{V_{CV}}{8.4 - V_{CV}} \right) 2R$$

Where R=40kΩ。

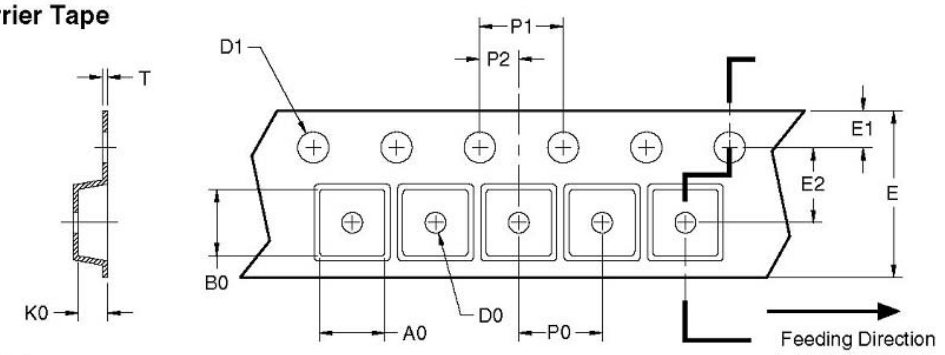
Tape and Reel Information



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.50(BSC)		0.020(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

SOP-10 Tape and Reel Dimensions

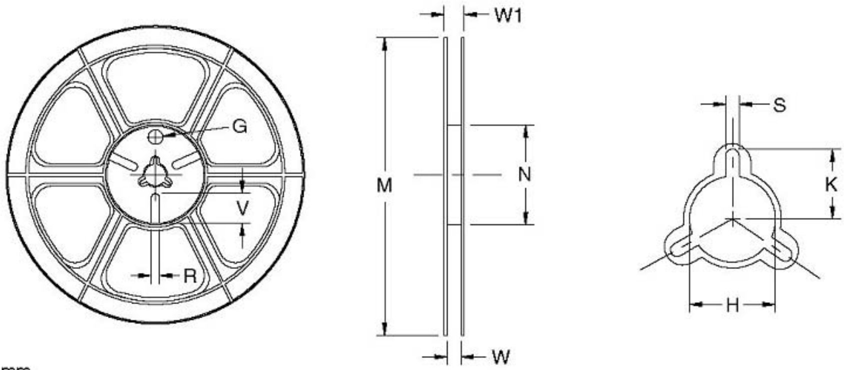
Carrier Tape



UNIT: mm

Package	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
SO-10 (12mm)	5.00 ±0.10	5.00 ±0.10	1.50 ±0.10	1.60 ±0.10	1.50 ±0.10	12.00 ±0.10	1.75 ±0.10	5.50 ±0.10	7.00 ±0.10	4.00 ±0.10	2.00 ±0.10	0.25 ±0.10

Reel



UNIT: mm

Tape Size	Reel Size	M	N	W	W1	H	K	S	G	R	V
12mm	ø330	ø330.00 ±0.50	ø97.00 ±0.10	13.00 ±0.30	17.40 ±1.00	ø13.00 +0.50/-0.20	10.60	2.00 ±0.50	—	—	—

Leader/Trailer and Orientation