

Switching type 2 to 10 lithium battery series charging management chips**Function Characteristics-1**

- * Suitable for 2-3 to 4 sections, 5-7-9 or 6-8-10 sections of lithium-ion/lithium polymer high-efficiency synchronous Buck chargers
- * 8V-60V wide input voltage range
- * 20mΩ charging current detection resistor
- * Maximum charging current 10A
- * 0.5% charging voltage control accuracy
- * Optional number of battery cells:
 - HCR9776A-2/3/4 series connected batteries
 - HCR9776B-5/7/9 series connected batteries
 - HCR9776C-6/8/10 series connected batteries
- * HCR9776D- 12V/18V/24V lead-acid battery
- * 4% programmable charging current control accuracy
- * Fine tune the external resistance to control the constant voltage charging value
- * Intelligent battery detection
- * Support resistance compensation between charger output and battery
- * Built in soft start
- * Switching frequency: 300KHz-400KHz

Function Characteristics-2

- * LED charging status indication
- * Battery short circuit detection and protection
- * Built in over temperature shutdown
- * Output charging current information
- * Battery charging overvoltage protection
- * Cycle-by-cycle current limiting
- * External battery temperature detection
- * External ISET charging enable
- * Sleep mode power consumption: >15uA
- * External charging time limit
- * Working Temp-range: -20°C to 85°C
- * TSSOP-20EP Package

General Description

The HCR9776x is a synchronous switch type high-efficiency lithium-ion/lithium polymer battery charging management chip, which is very suitable for charging management applications in portable devices.

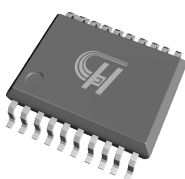
The HCR9776x integrates high-precision voltage, input current, and charging current regulators, pre charging, charging status indication, and charging cutoff functions. It has packaged in TSSOP-20EP

HCR9776x divides battery charging into three stages: per charge current (Pre charge), constant charging current is determined by an external voltage divider, and the constant voltage charging voltage can be fine tuned by an external resistor.

The HCR9776x integrates battery temperature detection, overvoltage and short circuit protection to ensure the safe operation of the charging chip. The HCR9776x integrates intelligent battery detection function and timeout error recovery function, making it convenient for users to use.

Application

- * Handheld devices
- * PDVD, PDA, and Smartphones
- * Laptop computer
- * Self charging battery pack
- * Independent charger



TSSOP-20EP

Figure 1. Package Type of HCR9776x

Switching type 2 to 10 lithium battery series charging management chips

Pin Configuration:

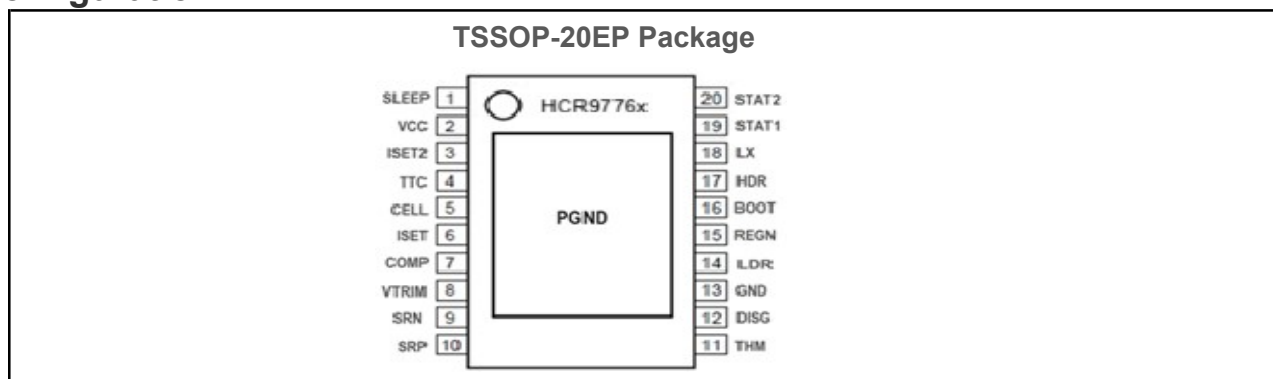


Figure 2. Pin Configuration of HCR9776x (Top View)

Pin Function Description:

Pin No	Name	I/O	Function Description		
19	STAT1	O	(STAT1) Green	(STAT2) Red	State Description
20	STAT2	O	light off	light off	No charging or no battery
			light off	bright	Charging
			bright	light off	Charging completed
			light off	0.5Hz pulse	Fault status (timeout and overvoltage)
			light off	2Hz pulse	Fault status (battery over temperature)
1	SLEEP	O	Input voltage below battery voltage indication		
2	VCC	P	Power Input		
3	ISET2	I	Cutoff charging current setting		
4	TTC	I	Connect the external capacitor of the oscillator to determine the charging time limit. When the pin is grounded, remove the limit		
5	CELL	I	Battery section selection		
			HCR9776A, -When using two battery the Cell pin Connected to ground, When using three batteries the Cell pin is empty feet, When using four batteries the Cell pin Connected to high level, Per battery voltage is 4.2V as reference		
			HCR9776B, -When using five battery the Cell pin Connected to ground, When using seven batteries the Cell pin is empty feet, When using nine batteries the Cell pin Connected to high level, Per battery voltage is 4.2V as reference		
			HCR9776C, -When using six batteries the Cell pin Connected to ground, When using eight batteries the Cell pin is empty feet, When using ten batteries the Cell pin Connected to high level, Per battery voltage is 4.2V as reference		
			HCR9776D, -When charging a 12V lead-acid battery the Cell pin Connected to ground, When charging a 18V lead-acid battery the Cell pin is empty feet, When charging a 24V lead-acid battery the Cell pin Connected to high level, Per lead-acid battery voltage is 12V as reference		
6	ISET	I	Charging current setting, external resistance set to ground, when the external resistance exceeds a certain value, charging stops		
7	COMP	O	Compensation pin		
8	VTRIM	I	External resistor to ground or SRN, fine tune CV voltage		
9	SRN	I	Charging current detection negative terminal input&battery detection terminal		
10	SRP	I	Charging current detection positive input		

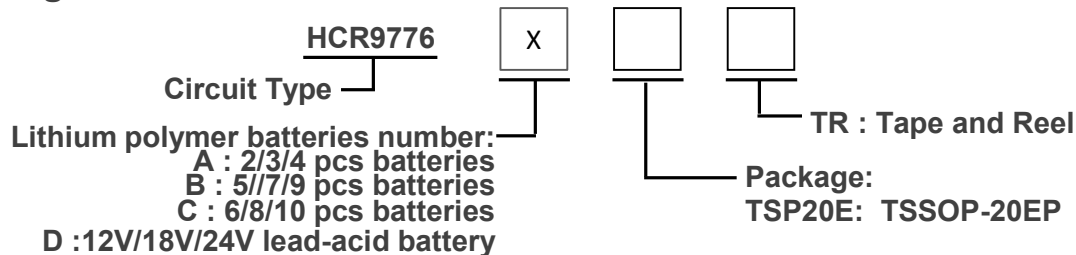
Pin Function Description(Con.)

Pin No.	Name	I/O	Function Description
11	THM	I	Battery temperature detection
12	DISG	O	Battery terminal discharge pins
13	GND	P	Ground
14	LDR	O	Low level synchronous rectifier drive
15	REGN	P	5V stabilized output power supply with external filtering capacitor
16	BOOT	P	Connect a 0.22uF capacitor between BOOT and LX at the positive end of the high position switch tube driving power supply
17	HDR	O	High level switch tube drive
18	LX	P	High position switch tube drive power supply negative terminal

Figure 3. Function Block Diagram

Switching type 2 to 10 lithium battery series charging management chips

Ordering Information



Model name	Marking	Battery Number	Package	Quantity Tape&Reel
HCR9776ATSP20EPTR	G9776A	2/3/4-pcs	TSSOP-20EP	2500pcs/Reel
HCR9776BTSP20EPTR	G9776B	5/7/9-pcs	TSSOP-20EP	2500pcs/Reel
HCR9776CTSP20EPTR	G9776C	6/8/10-pcs	TSSOP-20EP	2500pcs/Reel
HCR9776DTSP20EPTR	G9776D	12V/18V/24V Lead-acid battery	TSSOP-20EP	2500pcs/Reel

Typical application schematic diagram -1

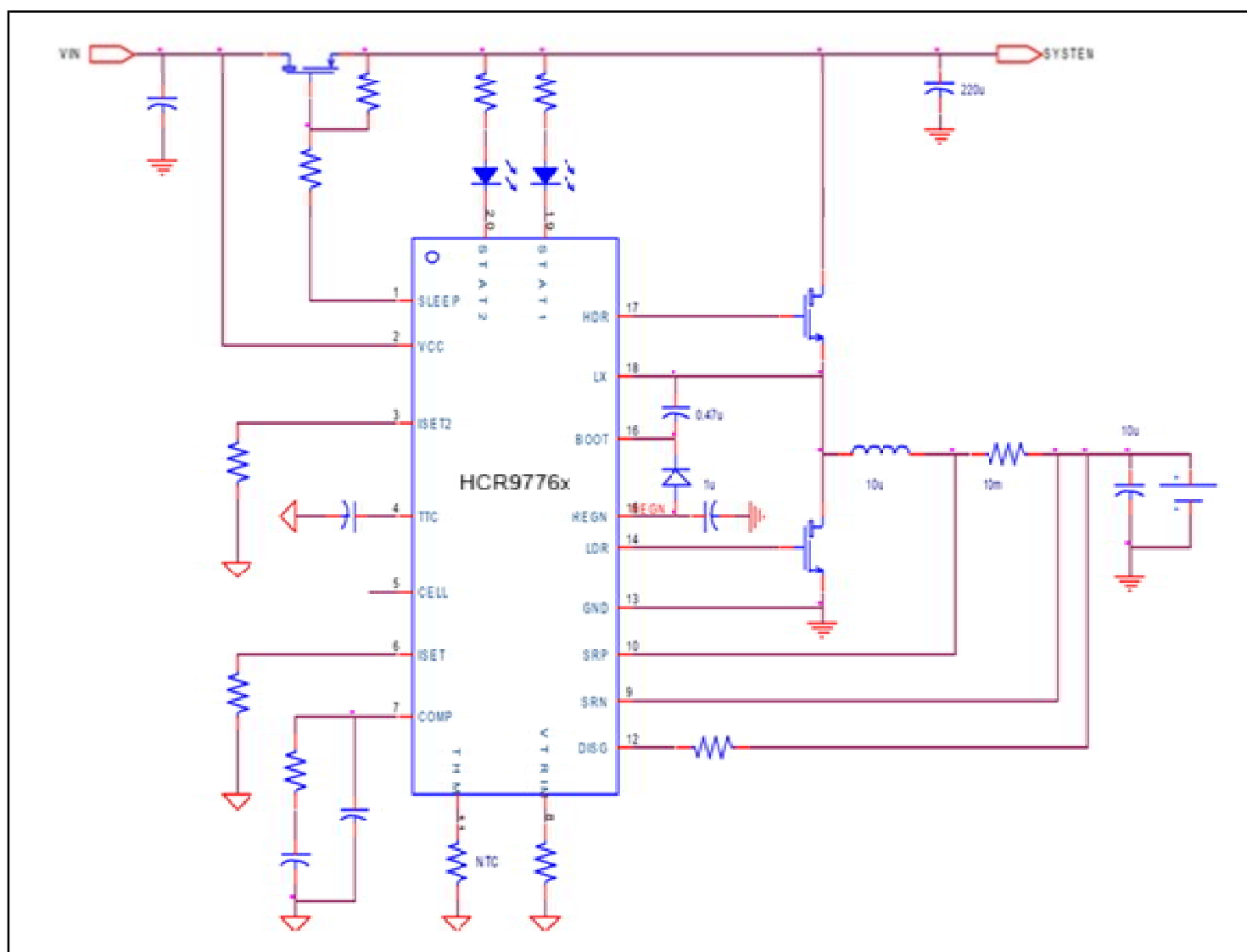


Figure 4. Typical application schematic diagram

Switching type 2 to 10 lithium battery series charging management chips

Maximum operating range

Describe		Min.	Max.	Unit
Voltage Range	VCC, SLEEP, STAT2, STAT1	-0.3	60	V
	LX, SRN, SRP, VTRIM, DISG	-2.0	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 Junction Temperature Range		-40	155	'C

Electrical Characteristics

8V<VCC<60V, 0'C<Tj<125'C, (TC=25'C, VCC=20V Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Voltage						
Input Voltage Range	VCC		8	-	60	V
Input Current						
VCC Supply Current	Ivcc	Turn on	-	15	-	mA
		Static mode	-	2.5	-	mA
Battery SLEEP discharge current	ISLP	VCC<VSRN+200mV or UVLO	-	15	-	uA
Constant pressure adjustment						
Output constant voltage at HCR9776A	VOREG	2 batteries, CELL grounded	-	8.4	-	V
		3 batteries, CELL floating	-	12.6	-	V
		4 batteries, CELL connected to high	-	16.8	-	V
Output constant voltage at HCR9776B	VOREG	5 batteries, CELL grounded	-	21.0	-	V
		7 batteries, CELL floating	-	29.4	-	V
		9 batteries, CELL connected to high	-	37.8	-	V
Output constant voltage at HCR9776C	VOREG	6 batteries, CELL grounded	-	25.2	-	V
		8 batteries, CELL floating	-	33.6	-	V
		10 batteries, CELL connected to high	-	42.0	-	V
Output constant voltage at HCR9776D	VOREG	12V lead-acid battery, CELL grounded	-	14.4	-	V
		18V lead-acid battery, CELL floating	-	21.6	-	V
		24V lead-acid battery, CELL connected to high	-	28.8	-	V
Output Voltage Accuracy			-0.5	-	+0.5	%
Fast charging current						
Set fast charging current	KISET	RSense=10mΩ, ISET resistor corresponds to charging current value	-	200	-	A*KΩ
Fast charging current accuracy			-4.0	-	+4.0	%
Fast charging stop threshold	VISET_CO	ISET 下降	-	50	-	mV
Fast charging enable threshold	VISET_CE	ISET 上升	-	100	-	mV

Switching type 2 to 10 lithium battery series charging management chips

Electrical Characteristics(Con.)

8V<VCC<60V, 0°C<Tj<125°C, (TC=25°C, VCC=20V Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Pre charging						
Set pre charge current	KISET	RSENSE=10mΩ	-	40	-	A*KΩ
Pre charging current Accuracy			-25	-	+25	%
Pre charge to fast charge threshold voltage	VLOWV	SRN Voltage increase(HCR9776A/B/C)	-	3	-	V /CELL
		SRN Voltage increase(lead-acid battery HCR9776D)	-	5.2	-	
Conversion delay time		Voltage rise and fall	-	30	-	mS
Charging cut-off						
Charging cut-off current setting coefficient	KITERM	RSENSE=10mΩ	-	40	-	A*KΩ
Cut off current accuracy			-25	-	+25	%
delay time	TITERM	Voltage rise and fall	-	30	-	mS
Charging TAPE cut-off current setting coefficient	KTAPE	RSENSE=10mΩ	-	60	-	A*KΩ
TAPE current accuracy			-25	-	+25	%
TAPE Deadline	TTAPE		-	20	-	min
Recharging voltage						
Recharge threshold voltage	VRCH	HCR9776A/B/C	-	4	-	V /CELL
		Lead acid HCR9776D	-	6.4	-	
delay time		Voltage rise and fall	-	30	-	mS
STAT1, STAT2, and SLEEP drive outputs						
Low level output saturation current	ISTAT	Output voltage 0.5V	-	10	-	mA
REGN output						
REGN Output Voltage	VREGN	-	-	5.4	-	V
REGN output current limiting	IREGN		-	50	-	mA
REGN Accuracy			-1.0	-	+1.0	%
ACOV and ACUV						
Vcc input overvoltage threshold	VACOV	-	-	63	-	V
Vcc input undervoltage threshold	VACUV	-	-	8	-	V
Delay time		Voltage rise and fall edges	-	30	-	mS
TTC Input						
TTC coefficient	KTTC	-	-	3.3	-	H /25nF
CTTC capacitance	CTTC	-	-	25	-	nF
Time enabled threshold	VTTC_EN	VTTC Increases	-	500	-	mV
Battery temperature detection						
High temperature threshold	VTHM-HOT	VTHM descending edge	-	0.2	-	V
High temperature threshold-1	VTHM-COLD1	VTHM rising edge	-	1.45	-	V
High temperature threshold-2	VTHM-COLD2	VTHM rising edge	-	2.3	-	V

Switching type 2 to 10 lithium battery series charging management chips

Electrical Characteristics(Con.)

8V<VCC<60V, 0°C<Tj<125°C, (TC=25°C, VCC=20V Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Battery temperature detection						
delay time		Voltage rise and fall edges	-	30	-	mS
Temperature enabled threshold	VTHM_EN	VTHM rise	-	0.05	-	V
Enter UVLO and sleep mode						
VCC undervoltage lock	VUVLO	Vcc rise	-	4.5	-	V
UVLO hysteresis	VHYS	VCC Fall	-	400	-	mV
Sleep mode	VSLPR	VCC-VSRN rise	-	400	-	V
	VSLPF	VCC-VSRN fall	-	200	-	
PWM controller						
Switching oscillation frequency	FOSC	VCC<30V	-	400	-	KHz
		VCC>30V	-	300	-	
Synchronize to asynchronous threshold	Isyn-asyn	VSRP-SRN fall	-	4	-	mV
Battery testing						
Timeout error detection current	IDETECT	VSRN<VRCH	-	3	-	mA
Discharge current	IDISCHRG1	Depending on outer resistor value	-	50	-	mA
Discharge time	TDISCHRG1	-	-	0.375	-	S
Wake-up Current	IWAKE	-	-	30	-	mA
Wake up time	TWAKE	-	-	0.375	-	S
Cut off discharge current	IDISCHRG2	Charging cut-off, VSRN=<VOREG	-	10	-	mA
Deadline for discharge	TDISCHRG2	-	-	160	-	mS
Protect						
Overvoltage protection threshold	VOVP	-	-	109	-	%VOREG
Cycle-By-Cycle Overcurrent	VOCP	SRP-SRN	-	130	-	mV
Short circuit SRN voltage threshold	VSHORT	SRN rise	-	3.4	-	V
Short-circuit current	ISHORT	VSRN<=VSHORT	-	30	-	mA
Built in over temperature protection threshold	TTEMP	-	-	160	-	'C
Over temperature protection hysteresis	THYS	-	-	20	-	
HIDRV and LODRV drive outputs						
Rise time	TR	CGATE=5nF, 10% to 90%	-	20	-	nS
Fall time	TF	CGATE=5nF,90% to 10%	-	20	-	
Dead Time	TDEAD	HDR和LDR开关切换时	-	40	-	
Refras pulse width	TREFRESH		-	120	-	nS

Switching type 2 to 10 lithium battery series charging management chips

Workflow diagram

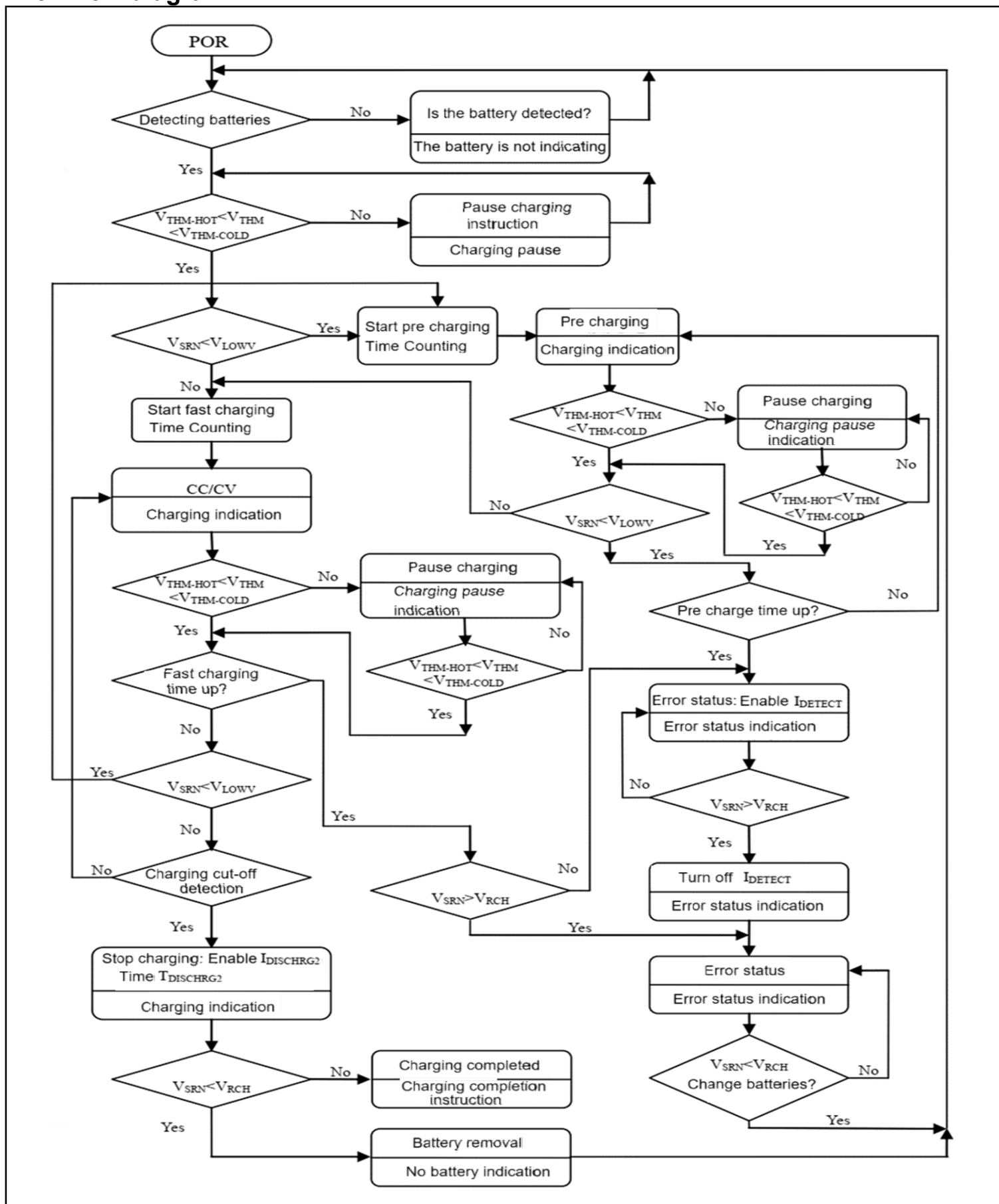


Figure 5. Workflow diagram of HCR9776x

Switching type 2 to 10 lithium battery series charging management chips

Function Description

*Charging process

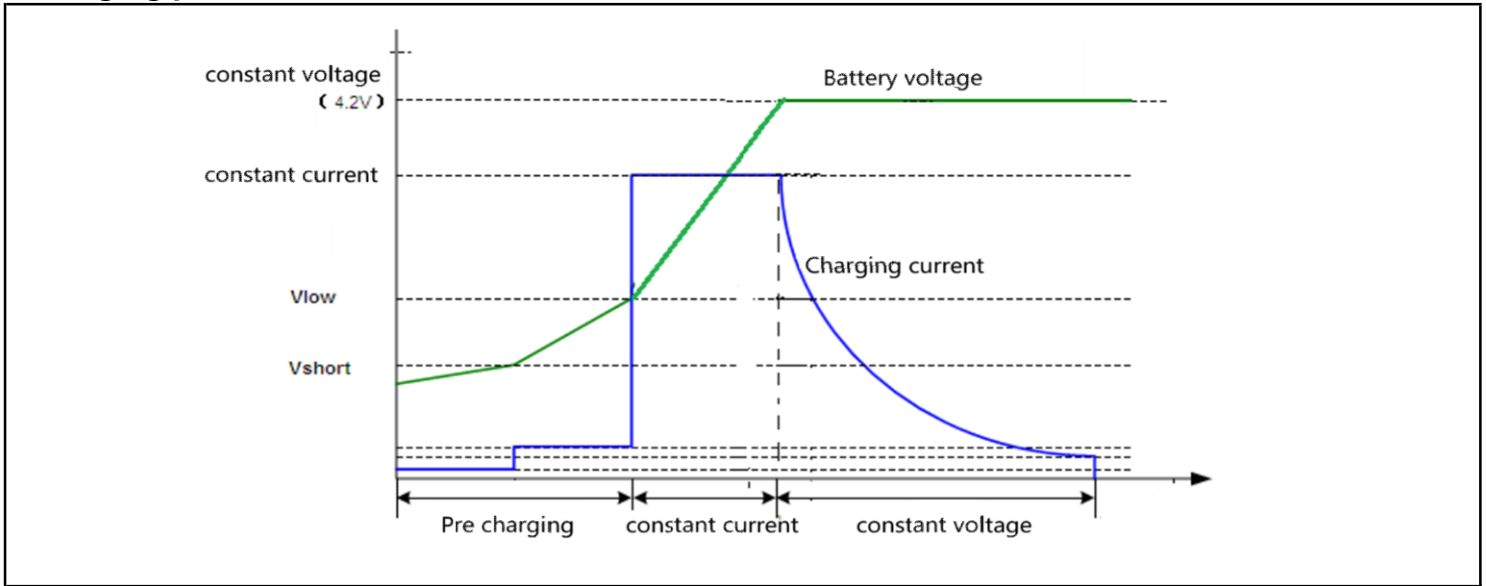


Figure 6. Charging process of HCR9776x

Voltage difference between SRN and GND pins for battery voltage detection

When the SRN pin voltage is lower than 3.4V, enter the short-circuit current detection mode; When the SRN pin voltage is greater than 3.0V and lower than 3.4V/CELL, it enters the pre charging mode; When the SRN pin voltage is greater than 3.4V/CELL and lower than 4.2V/CELL, it enters fast charging mode; When the SRN pin voltage is equal to 4.2V/CELL, it enters constant voltage charging mode. After charging is completed, if the SRN pin voltage drops below 4V/CELL due to current leakage, it enters the recharging cycle.

*Battery testing

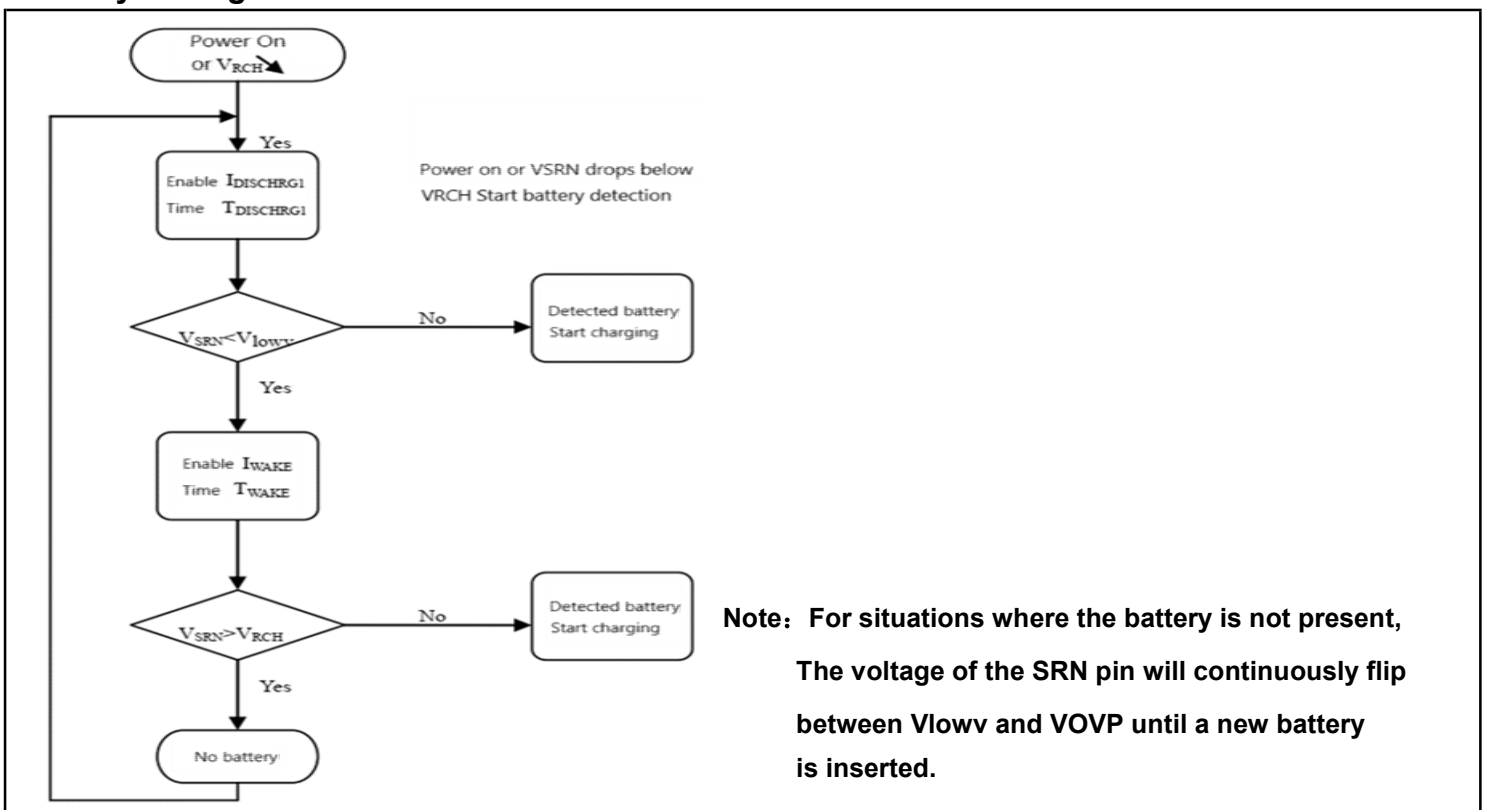


Figure 7. Battery detection flowchart for HCR9776x

Switching type 2 to 10 lithium battery series charging management chips

Function Description(Con.)

*Battery testing (Con.)

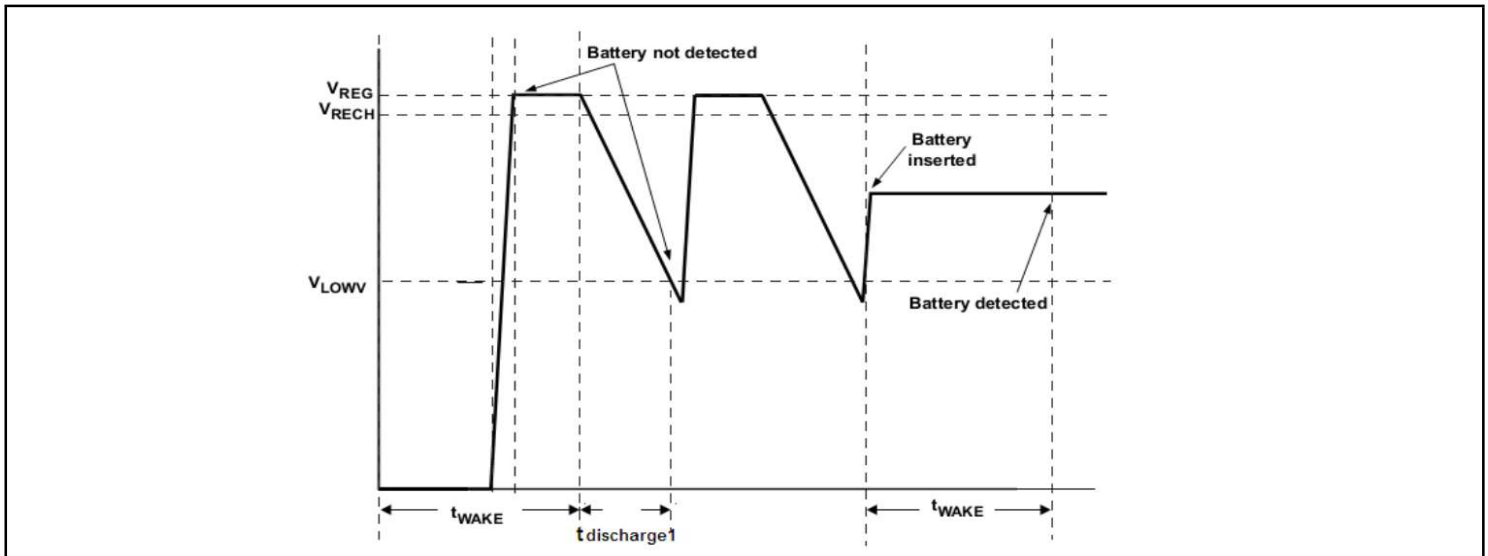


Figure 8. Battery Detect Timing Diagram

*Sleep mode

Remove the input power and enter sleep mode. When the VCC voltage is below the UVLO threshold or VCC is below VSRN+200mV, HCR9776x enters sleep mode and the battery discharge current reaches its minimum.

* Set charging current

The constant current charging current value I_{CHARGE} of the battery can be calculated by the following formula:

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

VISET is the output voltage of ISET pin, which is 1V during constant current charging stage and 0.2V during pre charging stage. RISET is an external ISET pin resistor. RSNS is an external current detection resistor. RSNS is an external current detection resistor, usually taken as 10mΩ. (When RISET=40K, Icharge=5A; when RISET=20K, Icharge=10A; when RISET=40K, Icharge=5A.) When RISET is greater than 800KΩ, charging stops; When RISET is less than 800KΩ, charging is enabled. After determining the constant current charging current, the pre charging current is: 20%*I_{CHARGE}.

* Set the cut-off charging current

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

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

During the constant voltage phase, when the voltage drop across the RSNS resistor is lower than the cut-off charging current, an EOC signal is generated inside HCR9776x, and charging is cut off. When the voltage drop of the charging current across the RSNS resistor is 150% of the cut-off charging current, a TAPE signal will be generated inside the chip. If the charging current still does not drop to I_{term} after half an hour, the charging will be stopped.

Switching type 2 to 10 lithium battery series charging management chips

Function Description(Con.)

*Detecting battery temperature

HCR9776x is connected to an external NTC thermistor to ground, monitoring the battery temperature and stopping charging when the temperature exceeds the threshold. When the THM pin voltage is below 50mV, HCR9776x charges normally and the temperature pin does not work. When the THM pin voltage is below 200mV at high temperature, HCR9776x will pause charging and the internal clock will stop timing. When the NTC detects that the voltage returns to the normal range, continue charging and resume timing. When the Vthm voltage is higher than 1.45V at low temperatures, the charging current decreases to 50% of the maximum current. When the Vthm voltage is higher than 2.3V at low temperatures, the charging current decreases to 20% of the maximum current. NTC thermistors should be placed adjacent to the battery packaging.

Cancel the battery temperature detection function, simply ground the THM pin.

The IC is equipped with a constant current source of 50ua, and the high-temperature equivalent R is $200\text{mv}/50\text{ua}=5\text{K}$ ohms, which means that if it is below 5K, it is equivalent to high-temperature protection. Low temperature equivalent $R=1.45\text{V}/50\text{ua}=29\text{K}$. This means that when the equivalent resistance is greater than 29K, the charging current decreases to 50% of the maximum current, and low temperature protection is implemented. At low temperatures, the Vthm voltage is higher than 2.3V, the equivalent resistance is $R=2.3\text{V}/0.05=46\text{K}$, and the charging current decreases to 20% of the maximum current.

In order to obtain the required high and low temperature protection values, a resistor R1 should be connected in series from NTC to pin 11 of the IC (* * To protect the IC from electrostatic discharge (ESD) damage, a resistor 680 ohms or more should also be connected in series), and a resistor R2 should be connected to NTC to adjust the low temperature protection value.

For example: a: Using a 10K NTC with a B value of 3950, corresponding to 52 ° C, the NTC resistance value is 3.325K, which is $R1=4\text{k}-3.325\text{K}=0.675\text{K}$. R1 is taken as 680 to 1.0K (without considering the influence of R2 for now).

b: Low temperature $R=R_{ntc}/R2$, for example, using 10K, B value 3950, at -10 ° C (assuming we require protection at this point), the resistance value is 55.6K, $R1+R_{ntc}=49.87+0.68\text{K}=50.55\text{K}$, Equivalent resistance $R=R2 * 50.55/(R2+50.55)=46\text{K}$, resulting in $R2=251\text{K}$, taken as 250K.

* Limit charging time

HCR9776 has programmable limitations on pre charging and total charging time, with a total charging time limit of:

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

Among them, CTTC is the external capacitance value of pin TTC, and KTTC 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.

Cancel the charging time limit function by simply grounding the TTC pin.

Switching type 2 to 10 lithium battery series charging management chips**Function Description(Con.)***** Charging status indication**

The open leakage output pins STAT1 (green light) and STAT2 (red light) indicate the following table.

STAT1(Green)	STAT2(RED)	Indicate status
No Bright	No Bright	No charging, no battery or sleep mode
No Bright	bright	Charging in progress
bright	No Bright	Charging completed
No Bright	0.5Hz pulse	Fault status (timeout or overvoltage)
No Bright	2Hz pulse	Fault state (charging paused)

***Timeout error recovery**

As shown in the workflow diagram, HCR9776x provides a recovery mechanism for charging timeout errors (including pre charge timeout and total charging time timeout). The summary is as follows:

1): The VSRN voltage is greater than the recharge threshold voltage and a timeout error occurs.

Recovery mechanism: Due to the discharge, self discharge, or removal of the battery from the load, the battery detection voltage drops below the recharge threshold voltage. At this point, HCR9776x clears the error state and enters the no battery detection process. In addition, power on reset can clear this timeout error state.

2): The VSRN voltage is lower than the recharge threshold voltage and a timeout error occurs.

Recovery mechanism: When this situation occurs, HCR9776x enables an IDETECT current. This small current can be used to detect whether the battery is present or not. As long as the battery voltage is lower than the recharge voltage, this current remains constant. If the battery voltage is higher than the recharge voltage, then HCR9776x cancels the IDETECT current and implements the recovery mechanism of situation 1. Once the battery voltage falls below the recharge threshold voltage again, HCR9776x clears the timeout error and enters the no battery detection process.

Power on reset can also clear this timeout error state.

*** Battery overvoltage protection**

HCR9776x has built-in overvoltage protection function. When the battery voltage is too high, such as the overvoltage generated when the battery is suddenly removed, this function can protect the device itself and other components. When overvoltage is detected, this function immediately shuts down the HIDRV and LODRV of the charger and indicates an error. When the battery voltage is lower than the recharge threshold voltage, the error is resolved.

*** Cycle By Cycle current limiting protection**

HCR9776x has built-in Cycle By Cycle current limiting protection function. When the voltage drop across the SRP and SRN detection resistors exceeds 130mV, immediately turn off the PWM until the voltage drop across the SRP and SRN detection resistors is less than the current limit value in the next cycle.

Switching type 2 to 10 lithium battery series charging management chips**Function Description(Con.)***** Refresh pulse**

When the BOOT-LX voltage difference is less than 3.65V/3.9V, the lower tube is turned on for 120ns, the LX pin is pulled down, and the external bootstrap capacitor is charged.

*** Built in over temperature protection**

When the internal junction temperature of HCR9776x exceeds 160 °C, charging stops and chip power consumption is reduced; When the internal junction temperature drops to 140 °C, the charging will restart.

*** Fine tune constant voltage output**

Measure the voltage value VCV of the SRN pin constant voltage output, adjust VCV upwards, and connect the adjustment resistor RTRIM between the VTRIM pin and ground; Fine tune VCV downwards and connect the fine-tuning resistor RTRIM between the VTRIM pin and the SRN pin. The formula for the resistance value of RTRIM resistor is (negative indicates connection to SRN, positive indicates connection to ground):

$$\begin{aligned}\text{lithium battery: } R_{TRIM} &= \left(\frac{V_{single} \times Cell}{V_{single} \times Cell - V_{CV}} \right) \times R \\ \text{Lead acid battery: } R_{TRIM} &= \left(\frac{V_{single} \times Cell}{V_{single} \times Cell - V_{CV}} \right) \times R\end{aligned}$$

Version A: R=60KΩ; Version B: R=87.5KΩ; Version C: R=100KΩ; Version D: R=120KΩ.

Note 1: Vcv is the constant voltage value without a resistor connected to pin 8. Vsngle represents the design value of the cut-off voltage for charging a single cell battery, while Vsngle * cell represents the design value of the cut-off voltage for charging a battery pack. For a typical 6-cell lithium battery, the recommended cut-off voltage design value is 6 * 4.2=25.2V, which can be referred to in the battery cell parameters.

Note 2: If the calculated value is positive, it means that the 8th pin pulls down the resistor to ground. If the calculated value is negative, it means that the resistor RTRIM is connected to SRN

Switching type 2 to 10 lithium battery series charging management chips

Package size

