1-6 CELL Hybrid Power Synchronous Battery Charge Controller

1 Features

- **Power path management：**
  - ✧ Adapter and Battery Provides Power to System Together
  - ✧ Battery LEARN Function
- **Input voltage range：**
  - ✧ Hybrid Power Boost Mode from 4.5 to 36V System
  - ✧ Charge 1 to 6 Cell Battery Pack from 4.5 to 36V Adapter
- **High Accuracy Power and Current Monitoring:**
  - ✧ ±3% Input Current Monitor Accuracy
  - ✧ Comprehensive PROCHOTB profile
  - ✧ ±3% Discharge Current Monitor Accuracy
  - ✧ ±5% System Power Monitor Accuracy
- **External setting of charging parameters**
  - ✧ Pin ILIM sets the charging current
  - ✧ Pin INILIM sets the input current
  - ✧ Select the number of cells from 1 to 6 by CELL0 to CELL2 pins
- **Charge status indicator CHG_STAT and input adapter status indicator ACOK**
- **Supports external NTC 5-stage (JEITA) charging and the parameters are factory set**
- **Support 0V charging, pre-charging, fast charging, full and full charge lithium charging characteristics**
- **Pre-charge threshold, cut-off charge current, pre-charge current and threshold, recharge threshold, boost discharge enable and discharge** status and adapter status via the status pi **voltage threshold can be set before the factory**
- **Protection function: input overvoltage, overcurrent, output overvoltage, overcurrent, NTC high and low temperature protection, charge timeout protection, junction temperature OTP protection**
- **PWM Frequency setting with SMBus register：400kHz, 600kHz, 800kHz and MHz**
- **Support protection output indication PROCHOTB**
- **High precision 3.3V reference output**
- **Package：QFN28(0404)**

2 Applications

- **Notebook, Tablet PC**
- **Industrial and Medical Equipment**
- **Portable Equipment**

3 Overview

IP2348 is a 1-6 cells synchronous battery charger, supports hybrid power boost mode that allows battery discharge energy to system when system power demand is temporarily higher than adapter maximum power level.

IP2348 uses two charge pumps to separately drive N-channel MOSFETs (ACFET, RBFET, and BATFET) for automatic system power source selection.

The charging and protection parameters can be flexibly configured through external pins and factory Settings to adapt to various applications. IP2348 provides feedback on the charging.

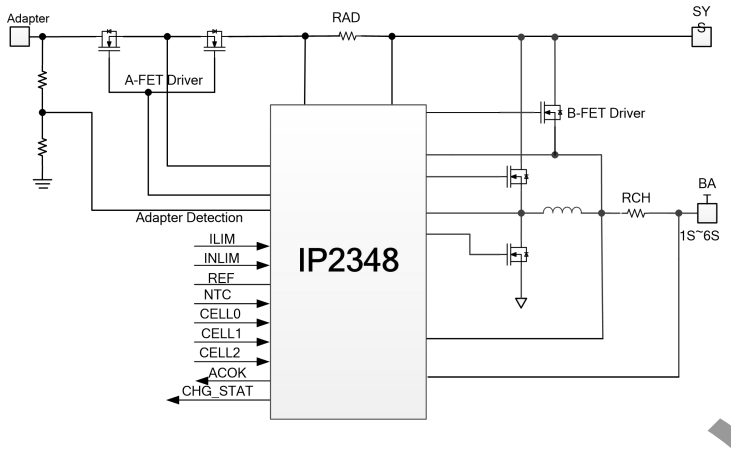

Figure 1: IP2348 Typical Application Circuit

Contents

4 Record

Note: The page numbers of previous versions may be different from those of the current version.

Change page numbers for version V1.32 to V1.33 (April 2024) **Page**

- Modify the model description....4
- Added the description of electrical parameters....12

Change page numbers for version V1.31 to V1.32 (February 2024) **Page**

- Modify the model description....4

Change page numbers for version V1.30 to V1.31 (January 2025) **Page**

- Modify limit parameter....6

Change page numbers for version V1.20 to V1.30 (December 2024) **Page**

- Modify the model description....4

Change page numbers for version V1.10 to V1.20 (December 2024) **Page**

- Modify the model description....4

Change page numbers for version V1.06 to V1.10 (October 2024) **Page**

- Modify the model description....4
- Modify the limit parameters of CDM and HBM to 2kV....6
- Modify the parameters of electrical characteristics....7
- Update schematic....26

Change page numbers for version V1.05 to V1.06 (October 2024) **Page**

- Modified model description of IP2348_SC_3V65....6
- Change the static power consumption when only the battery is present....7
- Added on/off logic for tubes and BATFEET....13

Change page numbers for version V1.04 to V1.05 (August 2024) **Page**

- Modify the crystallization temperature range....6

Change page numbers for version V1.03 to V1.04(July 2024) **Page**

- Add the description of common product models....4

Change page numbers for version V1.02 to V1.03(June 2024) **Page**

- Add the description of common product models....4
- Delete the factory configuration options table....

Change page numbers for version V1.01 to V1.02(May 2024) **Page**

- Modified the description of battery protection overvoltage delay....15

Change page numbers for version V1.00 to V1.01(April 2024) **Page**

- Added descriptions of common product models....3
- Modify datasheet format....

5 Model selection

Model name	Description
IP2348_STANDALONE_H	1、The IP2348 standard product has the following specific electrical parameters: 2、1. It supports charging of 1 to 6 battery strings, and the full charge voltage of each cell is 4.2V; 3、2. The number of battery strings can be set through peripheral pins, as well as the input current limit and charging current; 4、3. The voltage for switching from pre-charge to constant current charging mode is 3V/cell (with a hysteresis of 100mV/cell), and the pre-charge current is 1/10 CC; 5、4. The stop charging current is 1/10 CC, and the recharging threshold voltage for full charging is 97.5% CV (only LED indication, when the battery voltage is less than the output voltage, charging starts when the constant voltage output is enabled); 6、5. The OCP protection threshold for charging and discharging is 120mV (the voltage on the sampling resistor), and the over-discharge voltage of the battery is 70% CV; 7、6. The NTC function is enabled, and the PWM mode operating frequency is 600KHz; 8、7. There is no limit on charging timeout; 9、8. The charging indicator light supports lighting when the battery voltage is less than the recharging threshold, and the output terminal supports constant voltage output; 10、The VCC overvoltage value is 40V.
IP2348_SMBUS_H	1、Add I2C functionality on the basis of the standard product, which can be used as an I2C slave device. 2、Disable the boost discharge function. 3、Enable the comparator, with a reference voltage of 2.3V. When the input is higher than the reference voltage, the output is low level.
IP2348_STANDALONE_NTC_H	Based on the standard model, the following functions have been modified: 1. The high-temperature protection threshold for NTC is set at 45° C, and the low-temperature protection threshold is 0° C. Moreover, in the Cool and Warm states, the CV and CC gears are not reduced. 2. The gear that requires maintaining a pressure difference between the input and output during normal operation of BUCK has been lowered.

6 Pin Configuration and Functions

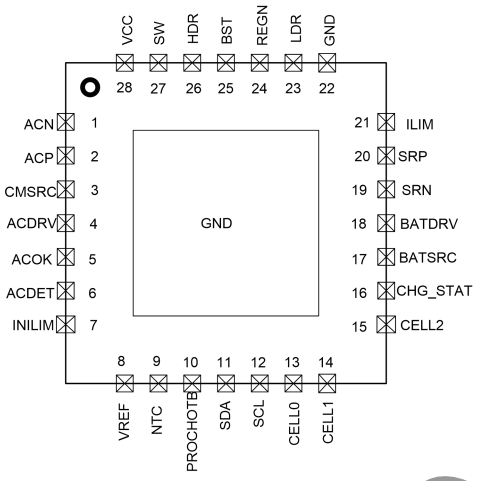

Figure 2:IP2348 QFN28(0404)pin configuration

Pin	Name	I/O	Type	Description
1	ACN	AI	Analog	Input current sense resistor positive input.
2	ACP	AI	Analog	Input current sense resistor negative input.
3	CMSRC	AO	Analog	ACDRV charge pump source input.
4	ACDRV	AI	Analog	Charge pump output to drive both ACFET and RBFET.
5	ACOK	AO	Analog	Active HIGH AC adapter detection open drain output.
6	ACDET	AI	Analog	Adapter detection input.
7	INLIM	AI	Analog	Input current setting，IAC=V_{INLIM}/(20*RAD)
8	VREF	AI	Analog	3.3V LDO output, 1uF capacitor to ground, divider resistor for NTC,INLIM,ILIM, not for other external applications
9	NTC	AI	Analog	NTC temperature sampling
10	PROCHOTB	DO	Digital	Active low, open-drain output of the processor hot indicator.
11	SDA	DIO	Digital	I2C data
12	SCL	DI	Digital	I2C clock
13	CELL0	AI	Analog	The number of batteries is set to 0
14	CELL1	AI	Analog	The number of batteries is set to 1
15	CELL2	AI	Analog	The number of batteries is set to 2
16	CHG_STAT	OD	Digital	Charge status indication
17	BATSRC	AI	Analog	Connect to the source of N-channel BATFET.
18	BATDRV	AO	Analog	Charge pump output to drive N-channel MOSFET.
19	SRN	AI	Analog	Charge current sense resistor negative input.
20	SRP	AI	Analog	Charge current sense resistor positive input.
21	ILIM	AI	Analog	Charge current and discharge current limit,Small value in the charging current selector pin setting and SMBus setting, pull to GND to disable charging,ICHG=VILIM/(20*RCH).
22	GND	GND	Power	IC ground.
23	LDR	AO	Analog	Low-side power MOSFET driver output.
24	REGN	P	Power	5.4V linear regulator output supplied from VCC.Connect a2.2-μF ceramic capacitor from REGN to GND.
25	BST	P	Power	High-side power MOSFET driver power supply.
26	HDR	AP	Power	High-side power MOSFET driver output.
27	SW	P	Power	High-side power MOSFET driver source.
28	VCC	P	Power	IC input supply from adapter or battery.
Epad	GND	GND	Power	EPAD ground.

7 Absolute maximum ratings

Parameter	Symbol	Value	Unit
Voltage	BST, HDR, ACDRV, BATDRV,ACN, ACP, CMSRC, VCC, BATSRC, SW	-0.3~45	V
	ACDET, ILIM, LDR, REGN, INLIM, VREF,NTC,ACOK,CELL0,CELL1,CELL2, CHG_STATUS, PROTHOTB	-0.3~7	V
	SPR,SRN	-0.3~36	V
Differential voltage	BST-SW, HDR-SW, ACDRV-CMSRC, BATDRV-BATSRC	-0.3~7	V
Differential voltage	SRP–SRN, ACP–ACN	-0.3~0.3	V
Junction Temperature Range	T_J	-40 ~ 125	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
HBM (Human Body Model)	ESD	2	KV
CDM (Charged-Device Model)	ESD	2	KV

*Stresses beyond these listed parameter may cause permanent damage to the device.
Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

8 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Voltage	BST, HDR, ACDRV, BATDRV,SRN,SRP, ACN, ACP, CMSRC, VCC, BATSRC, SW	0	--	36	V
	ACDET, ISET, SDA, SCL, LDR, REGN, IADP, IDCHG, PMON,ACOK,CMPIN, CMPOUT, BATPRESB, TB_STATB,PROTHOTB	-0.3	--	6	V
Differential voltage	BST-SW, HDR-SW, ACDRV-CMSRC, BATDRV-BATSRC	-0.3	--	6	V
Differential voltage	T_A	-40	--	85	℃

*Device performance cannot be guaranteed when working beyond these Recommended Operating Conditions.

9 Electrical Characteristics

Unless otherwise specified, **4.5 V ≤ V_{VCC} ≤ 36 V, –40°C ≤ T_J ≤ 125°C,** typical value @TA=25**°C**.

Parameter	Test Conditions	Range			Unit
		Min.	Typ.	Max.	
OPERATING CONDITIONS					
$V_{VCC(OP)}$ VCC/ACP/ACN operating voltage		4.5		36	V
CHARGE VOLTAGE REGULATION					
$V_{BAT(REG\_RNG)}$ Battery voltage		1.024		26.4	V
$V_{BAT(REG\_ACC)}$ Charge voltage regulation accuracy	6cells		25.2, 25.8, 26.1, 26.4		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.6%		0.6%	
	5 cells		21, 21.5 21.75, 22		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.6%		0.6%	
	4 cells		16.8, 17.2 17.4, 17.6		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.6%		0.6%	
	3 cells		12.6, 12.9 13.05,13.2		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.6%		0.6%	
	2 cells		8.4, 8.6 8.7, 8.8		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.6%		0.6%	
	1 cells		4.2, 4.3 4.35, 4.4		V
	–10°C-85°C	–0.5%		0.5%	
	–40°C-125°C	–0.8%		0.8%	
CHARGE CURRENT REGULATION					
$V_{IREG(CHG\_RNG)}$ Charge current regulation differential voltage	$V_{IREG(CHG)} = V_{SRP} – V_{SRN}$	0		81.28	mV
$V_{IREG(CHG\_RNG)}$ Charge current regulation differential voltage	$I_{CHG}=V_{ILIM}/(20*RCH)$; VILIM indicates the ILIM pin voltage	-3%	4A(V_{ILIM}=0.8V)	3%	mA
		-5%	2A(V_{ILIM}=0.1V)	5%	
DISCHARGE CURRENT REGULATION					
$V_{IREG\_CHG\_RNG}$ Discharge current regulation differential voltage	$V_{IREG(IDISCHG)} = V_{SRN} – V_{SRP}$	0		322.56	mV
$I_{DCHRG\_REG\_ACC}$ Discharge current regulation accuracy with 10mohm RCH resistor	$I_{DCHG}=V_{ILIM}/(20*RCH)$; VILIM indicates the ILIM pin voltage	-3%	4A(V_{ILIM}=0.8V)	3%	mA
		-5%	2A (V_{ILIM}=0.1V)	5%	
INPUT CURRENT REGULATION					
$V_{IREG\_DPM\_RNG}$ Input current regulation differential voltage	$V_{IREG\_DPM} = V_{ACP} – V_{ACN}$	0		80.64	mV
I_{AC_LIMIT} Input current regulation accuracy with 10mohm RCH resistor	$I_{AC}=V_{INLIM}/(20*RAD)$; VILIM indicates the ILIM pin voltage	-3%	4A(V_{INILIM}=0.8V)	3%	mA
		-5%	2A(V_{ILIM}=0.1V)	5%	
REGN/REF 参考电压					
V_{REGN_REG} REGN regulator voltage	V_{VCC}> $V_{(UVLO)}$, $V_{(ACDET)}$ > $V_{(wakeup\_RISE)}$	5.1	5.4	5.7	V
I_{REGN_LIM} REGN current limit	$V_{(REGN)}$ = 0 V, V_{VCC}> $V_{(UVLO)}$	80	100		mA
C_{REGN} REGN output capacitor			2.2		μF
REF voltage		3.27	3.3	3.33	V
VCC UNDER VOLTAGE LOCKOUT COMPARATOR					
$V_{VCC(UVLO)}$ Input under voltage rising threshold		3.6	3.8	4	V
$V_{VCC(UVLO\_HYS)}$ Input under voltage falling hysteresis			200		mV
QUIESCENT CURRENT					
IBAT Current with battery only, T_J = 0 to 85°C, I_{SRN} + I_{SRP} + I_{BATSRC} + I_{PHASE} + I_{VCC} + I_{ACP} + I_{ACN}	V_{BAT} = 16.8 V, VCC disconnected from battery, REG0x12[15] = 1			5	μA

	The battery is a four-string battery, VCC connected from battery, REG0x12[15] = 1		47	50	
	The battery consists of five to six batteries,VCC connected from battery, REG0x12[15] = 1		55	70	
	V_{BAT} = 16.8 V, VCC connect to battery, BATFET on, REG0x12[15] = 0, REGN = 5.4V, Comparator and PROCHOTB enabled, PMON disabled, T_J = 0 to 85°C		700	800	
I_{AC} 适配器电流，I_{VCC} + I_{ACP} + I_{ACN} + I_{ACDRV} + I_{CMSRC}	$V_{(VCC\_ULVO)}$< V_{VCC}< $V_{(ACOVP)}$, $V_{(ACDET)}$> 2.4 V, charge disabled		0.65	0.8	mA
	$V_{(VCC\_ULVO)}$< V_{VCC}< $V_{(ACOVP)}$, $V_{(ACDET)}$> 2.4 V, charge enabled, no switching		1.6	3	
	$V_{(VCC\_ULVO)}$< V_{VCC}< $V_{(ACOVP)}$, $V_{(ACDET)}$ > 2.4 V, charge enabled, switching, MOSFET Qg 4nC		10		
ACOK COMPARATOR					
$t_{ACOK\_RISE\_DEG}$ ACOK Enable ACFET delay；V_{ACDET}> 2.4V	V_{VCC}> V_{VCC_UVLO}, ACDET boost	100	150	200	ms
$t_{ACOK\_FALL\_DEG}$ ACOK Disables the ACFET [GBD] delay	V_{VCC}> V_{VCC_UVLO}, ACDET buck			3	μs
INPUT OVERCURRENT COMPARATOR (ACOC)					
t_{ACOC_DEG} Disable the ACFET delay		9	12	15	ms
PWM					
F_{SW}PWM switching frequency	Factory configuration 400kHz	340	400	460	KHz
	Factory configuration 600kHz	510	600	690	
	Factory configuration 800kHz	680	800	920	
	Factory configuration 1000kHz	850	1000	1150	
BATFET GATE DRIVER (BATDRV) and ACFET GATE DRIVER (ACDRV)					
Gate drive voltage on BATFET and ACFET	$V_{BAT(DRV)}$ – $V_{BAT(SRC)}$)	5.0	5.3	5.7	V
$R_{BAT(DRV\_OFF)}$ BATDRV and $R_{AC(DRV\_OFF)}$ ACDRV turn-off resistance		5	6.2	7.4	kΩ
PWM HIGH SIDE DRIVER (HIDRV)					
$R_{DS(HI\_ON)}$ High-side driver (HSD) turn-on resistance	$V_{(BTST)}$ – $V_{(PH)}$ = 5.4 V		6	10	Ω
$R_{DS(HI_OFF)}$High-side driver (HSD) turn-off Resistance	$V_{(BTST)}$ – $V_{(PH)}$ = 5.4 V		0.9	1.4	Ω
$V_{BTST\_REFRESH}$ Bootstrap refresh comparator threshold voltage	$V_{(BTST)}$ – $V_{(PH)}$	3.85	4.3	4	V
PWM LOW SIDE DRIVER (LODRV)					
$R_{DS(LO_ON)}$Low-side driver (LSD) turn-on resistance			7.5	12	Ω
$R_{DS(LO\_OFF)}$ Low-side driver (LSD) turn-off resistance			0.75	1.25	Ω
PROCHOTB					
V_{ICRIT}ICRIT comparator threshold		147%	150%	153%	
V_{INOM}INOM comparator threshold		107%	110%	112%	
V_{VSYS}VSYS comparator threshold		5.88	6	6.12	V
Logic input level **(CELL0,CELL1,CELL2)**					
$V_{IN(LO)}$Logic low level				0.8	V
$V_{IN(HI)}$Logic high level		2.1			V
LOGIC OUTPUT OPEN DRAIN (ACOK, CHG_STAT)					
$V_{O(LO)}$Output saturation voltage	5-mA drain current			500	mV
NTC Protection					
NTC voltage (and VREF percentage)	$V_{NTC\_HOT\_TH}$	VNTC decreases, REG08<2:1>=00, corresponding to a temperature of 60°C	32.5	34.5	36.5	%

	$V_{NTC\_HOT\_TH\_HSY}$	VNTC rises, REG08<2:1>=00, corresponding to temperature 5°C		3.25		%
	$V_{NTC\_WT\_TH}$	VNTC drops, corresponding to a temperature of 45°C	42.7	44.7	46.7	%
	$V_{NTC\_WT\_TH\_HSY}$	VNTC rises, corresponding to a temperature of 5°C		3.75		%
	$V_{NTC\_COOL\_TH}$	VNTC rises, REG08<0>=0, corresponding to temperature 10°C	66.25	68.25	70.3	%
	$V_{NTC\_COOL\_TH\_HSY}$	VNTC drops, corresponding to a temperature of 5°C		3		%
	$V_{NTC\_COLD\_TH}$	VNTC rises, corresponding to a temperature of 0°C	71.25	73.25	75.3	%
	$V_{NTC\_COLD\_TH\_HSY}$	VNTC drops, corresponding to a temperature of 5°C		2.5		%
Input Overvoltage Comparator (ACOVP)						
$V_{(ACOV)}$VCC overvoltage threshold (ACOVP gear pin select 6.4V)		VCC boost voltage		6.30		V
$V_{(ACOV)}$VCC overvoltage threshold (ACOVP gear pin select 17.6V)		VCC boost voltage		17.26		
$V_{(ACOV)}$VCC overvoltage threshold (ACOVP gear pin select 24V)		VCC boost voltage		23.46		
$V_{(ACOV)}$VCC overvoltage threshold (ACOVP gear pin select 30.4V)		VCC boost voltage		29.65		
$V_{(ACOV)}$VCC overvoltage threshold (ACOVP gear pin select 40V)		VCC boost voltage		38.83		
$V_{(ACOV\_HYS)}$ VCC overvoltage hysteresis		VCC depressurization		0.85		

10 FUNCTIONAL DESCRIPTION

10.1 System Diagram

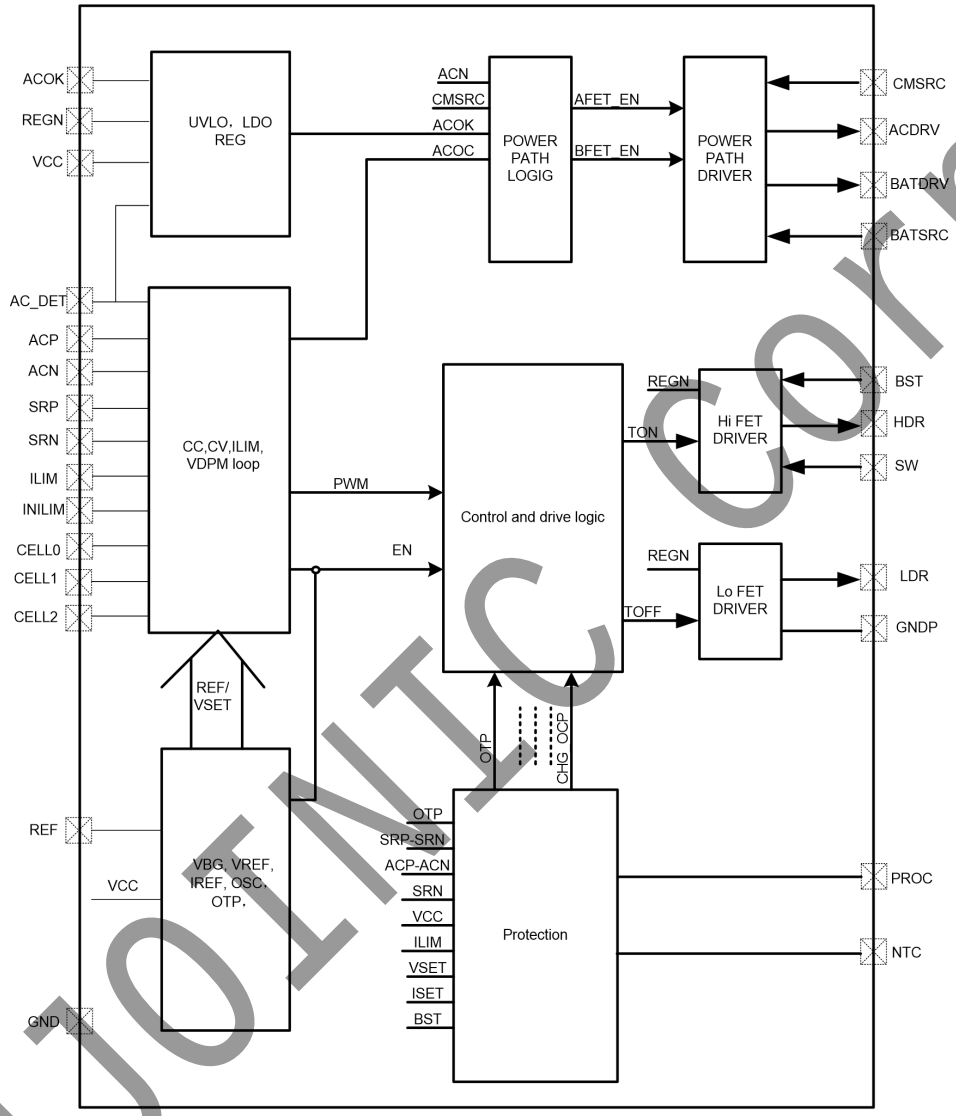

Figure 3: Internal structure block diagram

10.2 Overview

IP2348 is a 1-6 cells synchronous battery charger, supports hybrid power boost mode that allows battery discharge energy to system when system power demand is temporarily higher than adapter maximum power level.

IP2348 uses two charge pumps to separately drive N-channel MOSFETs (ACFET, RBFET, and BATFET) for automatic system power source selection.

Through SMBus, system power management micro controller programs input current, charge current, discharge current, and charge voltage with high regulation accuracies.

The charging and protection parameters can be flexibly configured through external pins and factory Settings to adapt to various applications. The IP2348 provides feedback on the charging status and adapter status via the status pin.

10.3 System power

10.3.1 System power

The IP2348 gets power from VCC. After VCC is above its UVLO threshold, the device wakes up, REGN is enabled when VCC present, and power for digital and analog block inside.

If power path latches off, VCC input is the higher voltage between adapter and battery through an external diode, if battery only, IP2348 stays in low power mode with lowest quiescent current(50uA typical),BFET driver enabled.If power path latch off is disabled, VCC only connect to the adapter.

10.3.2 Adapter Detect and ACOK Output

The device detect adapter through AC_DET pin. ACOK is enable if the adapter is present, and the charge pump drivers of ACFET and RBFET both work.If the adapter does not exist, ACFET and RBFET are off and BATFET is on. The switching logic is to turn on the MOS tube that needs to work when the MOS tube V_{GS} is less than 100us of 3V.

10.3.3 Battery Only

When only the battery is present, the battery supplies power to the VCC and enters the low-power mode. Only the UVLO module and digital module of the VCC are enabled. The power consumption is controlled at 70uA and the REGN LDO is 0. If the path management function is not included, the VCC is not connected to the battery. When the adapter is removed, the battery consumption is less than 5uA.

10.4Adapter Detect, ACOK and Adapter Overvoltage (ACOVP)

10.4.1 ACDET

Program adapter valid input voltage threshold by connecting a resistor divider from adapter input to ACDET pin. When ACDET is above 2.4V, and VCC is above SRN but below ACOV, ACOK goes HIGH.

10.4.2 ACOK

The open drain ACOK output can be pulled to external rail under the following conditions:

1. V_{ACDET}>2.4V
2. V_{VCC_UVLO}<VCC<ACOVP
3. VCC- VSRN>$V_{VCC\_SRN\_FALL}$+$V_{VCC\_SRN\_HYST}$(The pressure difference that needs to be maintained depends on the value 0X32[1])

Such as：当 0x32[1]=0，VSRN=12.8V，VCC-VSRN>260mV；0x32[1]=1，VCC-VSRN>1.47V。

If any of the above conditions are not met, it is considered that the adapter is not present, ACOK is

pulled low, and charging is disabled. ACFET/RBFET are turned off to disconnect the adapter to system. BATFET is turned on if turn-on conditions are valid.

10.4.3 ACOVP

ACOVP is threshold is divided into five gears, according to the VCC voltage 6.4 V, 17.6 V, 24 V, 30.4 V, 40 V, hysteresis of 0.85 V. During ACOVP, ACFET and RBFET are turned off, BATFET is turned on (to meet battery voltage supply), system power is battery powered and VAC overvoltage protection is released when the VAC returns below the overvoltage recovery value.

10.5 Processor Hot Indication

The PROCHOTB triggering events include:

- ICRIT: adapter peak current
- INOM: adapter average current (110% of input current limit)
- IDCHG: battery discharge current
- VSYS: system voltage on SRN lower than 6V for 2s - 6s battery
- ACOK: upon adapter removal (ACOK pin HIGH to LOW)
- BATPRES: upon battery removal (BATPRES pin LOW to HIGH)
- CMPOUT: Independent comparator output (CMPOUT pin HIGH to LOW).

10.6 DCM

If the average inductor current below 125 mA (on 10 mohm), the converter enters DCM mode, if the average inductor current above 250mA(on 10mohm), the converter enters CCM mode.

10.7 Protection

10.7.1 Input Overcurrent Protection (ACOC)

When the input current exceeds 1.25x or 2x of ICRIT set point (with 12-ms deglitch time), ACFET/RBFET is latches off and an adapter removal is required to force ACDET < 0.6 V to reset IC. After IC reset from latch off, ACFET/RBFET can be turned on again. The ACOC function threshold can be set or disabled through REG0x37 [10:9].

10.7.2 Charge Overcurrent Protection (CHGOCP)

IP2348 has cycle-by-cycle peak overcurrent protection. It monitors the voltage across SRP and SRN, and prevents the current from exceeding the threshold based on the charge current set point. The high-side gate drive turns off for the rest of the cycle when over current is detected, and resumes when the next cycle starts. The charge OCP threshold can be set through REG0x35[2:1].

10.7.3 Battery Overvoltage Protection (BATOVP)

IP2348 does not allow the high-side and low-side MOSFET to turn-on when the battery voltage at SRN exceeds 104% of the regulation voltage set point. Charger is completely disabled.

10.7.4 Battery Short

When battery voltage on SRN falls below 2.4 V, the converter begins to pulse charging with 200ns turns on and period can be setting by registers.

10.7.5 Input over-voltage and UVLO

Input overvoltage protection occurs when the input VCC exceeds the set overvoltage value. Input undervoltage protection is triggered when the input VCC UVLO threshold is lower. No charge occurs after input overvoltage and undervoltage protection, and both ACFET and RBFET are turned off.

10.8 Hybrid Power Boost Mode

IP2348 supports the hybrid power boost mode by allowing battery discharge energy to system when system power demand is temporarily higher than adapter maximum power level.

Hybrid power boosts mode setting:

- Whether to enable or not can be factory selected Settings；
- Input current is higher than 107% of input current limit;
- Discharge current depends on system current requirement and adapter current limit
- The boost voltage is equal to system voltage
- Boost Discharge current exceeds the set limit. The system current continues to increase. The input current exceeds a certain threshold, and the output protection state is PROCHOTB, reminding the system to reduce the power.

10.9 Charge

IP2348 supports the typical charging mode and typical charging process of lithium batteries. For deeply discharged batteries whose terminal voltage is below the pre-charge threshold (V_{LOW_TH}*N), the IP2348 will start precharging with a precharge Current. When the battery voltage reaches the pre-threshold, the chip starts charging with a constant current at the current value set by the ILIM pin. Once the battery voltage reaches the set CV value, the chip will operate in constant voltage (CV) mode until the battery is fully charged. In CV mode, the charging current drops and stops charging when the charging current in CV mode drops to EOC current.

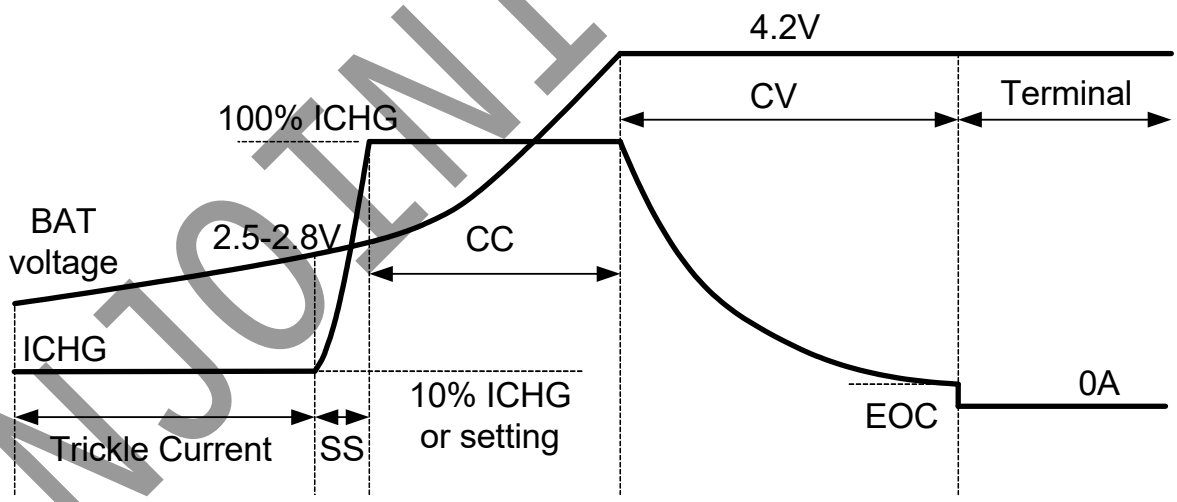

Figure 4: Charging process diagram

IP2348 can set the end of charge threshold (EOC) current. When entering the charging process in CV mode, the charging current will gradually drop to the end of charge current threshold, and the chip will stop charging. When the battery voltage is lower than the set recharging threshold, the chip automatically restarts to charge.

CC can be set by ILIM pin, CV, EOC, precharge threshold, recharge threshold can be set by factory configuration, charging status can be displayed by CHG_STAT. Input current limit is set by external pin INILIM, and battery node number can be selected by internal factory or external pin.

10.9.1 Precharge

Precharge threshold setting:

Precharge/quick charge threshold can be factory selected 2.8V or 3V per section, default is 3V;

Precharge current setting:

Precharge current can be factory selected 1/10 CC current value or 1/5 CC current value, default is 1/10 CC.

10.9.2 CC, CV, input current limiting settings

CC, IAC by pin ILIM, IINLIM set:

ILIM pin set formula: ICG = VILIM / (20 * RCH), VILIM by REF through the voltage divider set;

IINLIM set formula: IAC = VINLIM / (20 * RAD), VINLIM by REF through the voltage divider set.

CV by register set single section CV voltage, section number by CELLx pin set;

single cell CV fixed voltage: 4.2V/CELL, 4.3V/CELL, 4.35V/CELL, 4.4V/CELL;

battery section number can be set by internal or external pin selection (CELL0, CELL1, CELL2), external setting method is:

PIN	LOGIC							
CELL2	L	L	L	L	H	H	H	H
CELL1	L	L	H	H	L	L	H	H
CELL0	L	H	L	H	L	H	L	H
CELLS SET	1CELL	2CELL	3CELL	4CELL	5CELL	6CELL	6CELL	6CELL

10.9.3Full charge and recharge

When the charging current in CV stage is reduced below the full charge current, the battery is considered to have been charged, and the threshold of full charge current is 1/20 CC or 1/10 CC, which is set by the factory and defaults to 1/20 CC current.

The recharge voltage threshold can be set from the factory to 97.5% CV or 95% CV.

10.9.4 Time out

Charging timer counts the charging time, including a pre-charging charging timer and a fast charging timer. When the timer times out and triggers, the charging stops. The charging conditions are as follows: reinsert the adapter and reinsert the battery. The charging timer can be factory set to disable or enable, and the timer time can also be factory set. The details are as follows:

Options	Precharge time	Fast charge（CC+CV）time
1	disable	disable
2	30m	4h
3	1h	8h
4	2h	16h

10.9.5 NTC sampling and 5-stage JEITA charging standard

IP2348 has a negative temperature coefficient (NTC) resistance to detect battery temperature and enable JEITA standard charging. When the battery temperature rises to the hot threshold VNTC_HOT_TH or decreases to the cold threshold VNTC_COLD_TH, the chip will turn off the charging function. When the battery temperature rises between the warm threshold VNTC_WT_TH and the hot threshold VNTC_HOT_TH, the CV voltage can be reduced according to the factory configuration. When the battery temperature is between

the cool threshold VNTC_COOL_TH and the cold threshold VNTC_COLD_TH, CV and CC are reduced according to the factory Settings. The NTC function and parameters can be disabled by factory Settings. VNTC_WT_TH and VNTC_COLD_TH correspond to temperatures of 45°C and 0°C, respectively.5 段式 JEITA 充电标准 As shown in Figure 5 below:

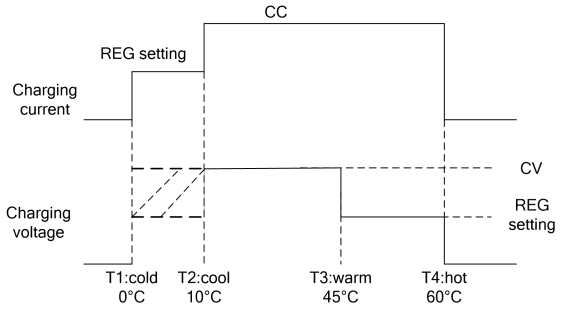

Figure 5: JEITA charging diagram

The NTC principle of the following figure is shown in Figure 6, where the NTC resistance is selected NCP18XH103, B25/50=3380K, and the values of RT1 and RT2 can be determined using the following formula:

$$RT2 = \frac{V_{IN} \times RTH_{COLD} \times RTH_{HOT} \times \left(\frac{1}{VT1} - \frac{1}{VT5}\right)}{RTH_{HOT} \times \left(\frac{V_{IN}}{VT5} - 1\right) - RTH_{COLD} \times \left(\frac{V_{IN}}{VT1} - 1\right)}$$

$$RT1 = \frac{\left(\frac{V_{IN}}{VT1} - 1\right)}{\frac{1}{RT2} + \frac{1}{RTH_{COLD}}}$$

Select 60°C as the Hot temperature，R_{THCOLD}= 27.22 kΩ，R_{THHOT}= 3.01kΩ
VT1=73.25% x VIN，VT5=34.37% x VIN， RT2=30.18kΩ, RT1=5.23kΩ

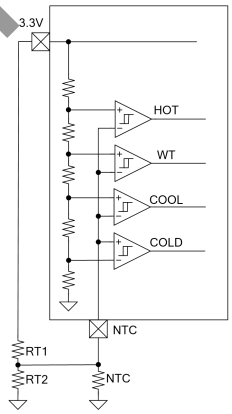

Figure 6:principles of NTC setting

10.9.6 Charging status indicates CHG_STAT

CHG_STAT is the open leakage output. When charging, CHG_STAT is low and the external LED is on. When charging is complete, CHG_STAT output high resistance, LED off; When charge protection occurs, including NTC high and low temperature protection, charge timeout, etc., CHG_STAT outputs square waves at 1Hz, 50% duty cycle, and the LED light flashes.

10.9.7 Enable and Disable Charging

Charging Enable:

- ACOK is active high
- ILIM pin voltage is higher than 100 mV
- Not in protection state(including battery OVP, junction temperature protection, input over-current protection

Charging disable:

- ILIM pin voltage is lower than 60 mV
- ACOK is pulled low
- In protection state(including battery OVP, junction temperature protection, input over-current protection)

11 Typical Application Circuit

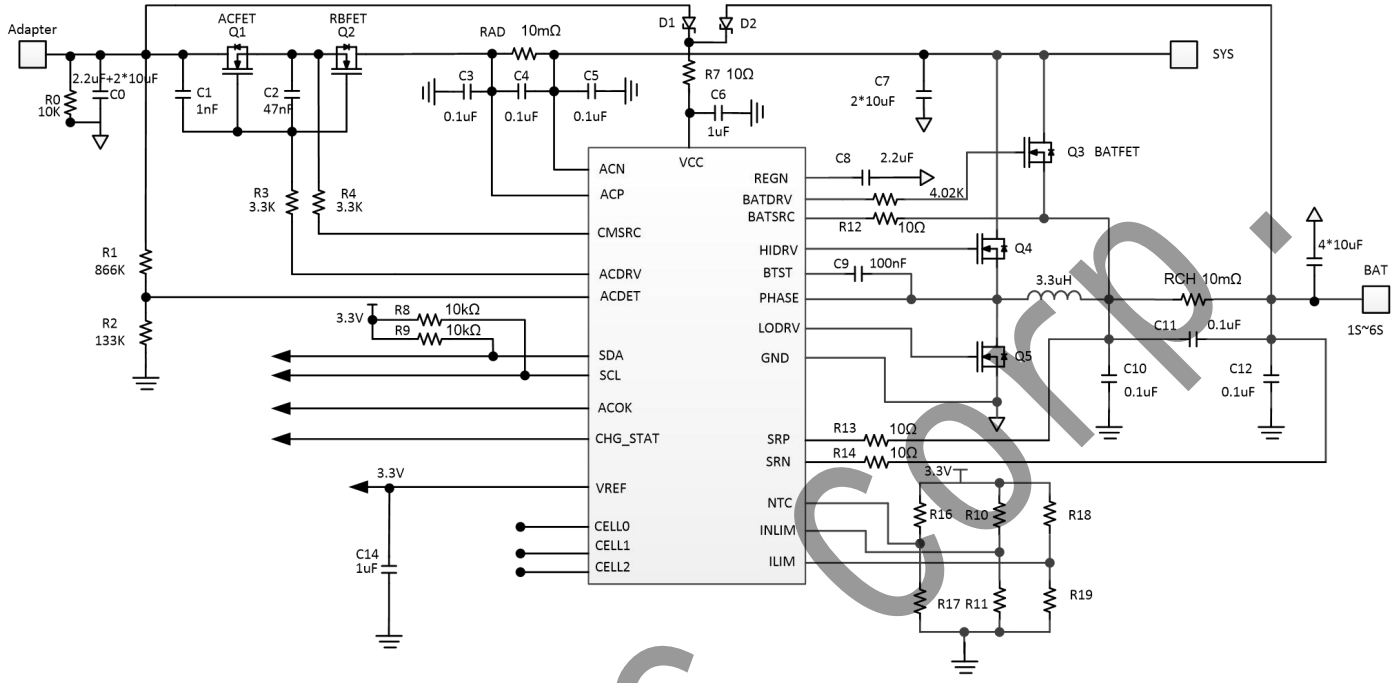

Figure 7: IP2348 Typical Application Circuit

12 Package Information

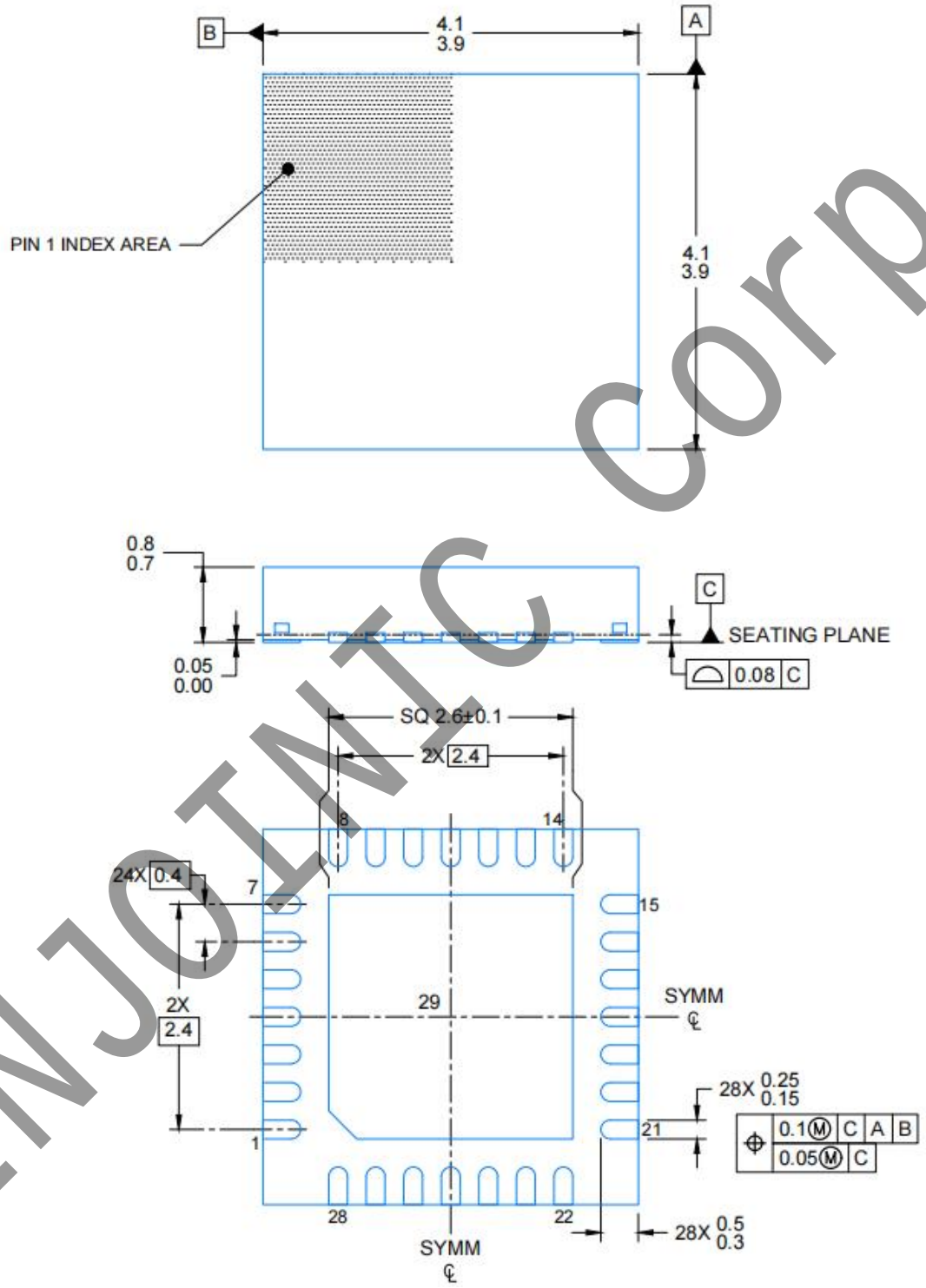

Figure 8: QFN28 (0404)

13 IC IC Silk-screen Information

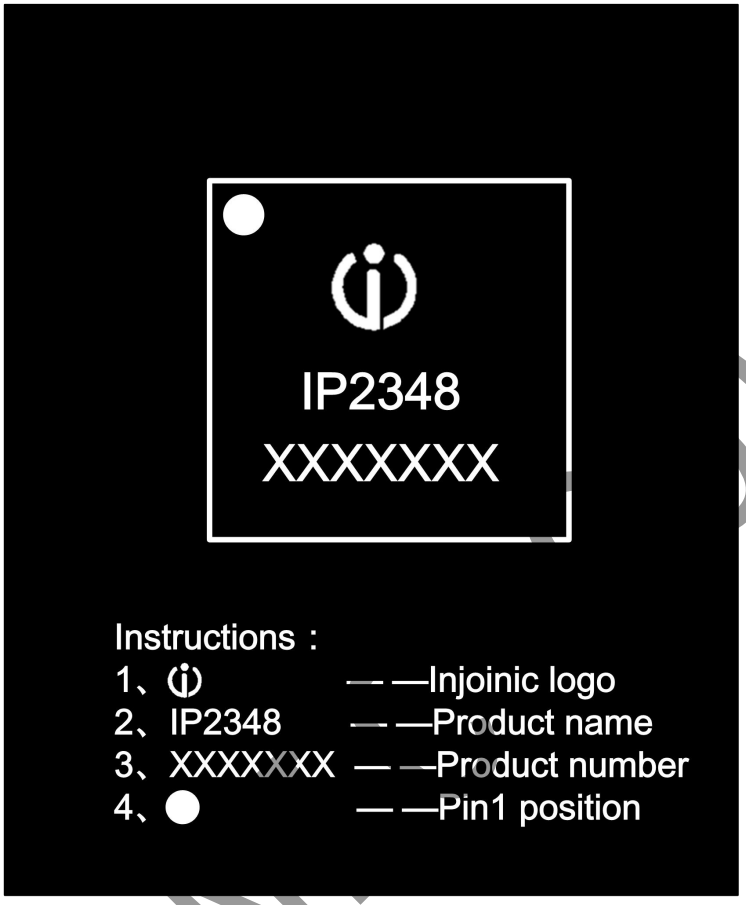

Figure 9: IP2348 IC silk-screen information

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