A Power Bank SOC With Integrated Buck-Boost Driver Supporting Bi-directional Fast Charging Protocol Such As SCP, VOOC, PD3.0, Supporting 2~5 Series Batteries and Supporting Maximum Power 100W

1 Feature

- **Supporting Multiple USB Ports Simultaneously**
  - ✧ 2 USB A output ports
  - ✧ 1 USB C input/output port
  - ✧ 1 USB B input port or Lightning input port or C input/output port
- **Fast Charging**
  - ✧ Every port supports fast charging
  - ✧ Support QC2.0/QC3.0/QC3+ output
  - ✧ Support FCP input/output
  - ✧ Support AFC input/output
  - ✧ Support SCP input/output
  - ✧ Support VOOC input/output
  - ✧ Support DRP try.SRC, PD3.0 input/output
  - ✧ Support BC1.2,Apple
- **Integrated USB PD2.0/PD3.0 Protocol**
  - ✧ Support PD2.0 input/output protocol
  - ✧ Support PD3.0 input/output and PPS output protocol
  - ✧ Support 5V/9V/12V/15V/20V input
  - ✧ Support 5V/9V/12V/15V/20V output
  - ✧ Support adjustable voltage in 20mV increments in PPS Mode
  - ✧ Integrate hardware Bi-phase mark codec (BMC) protocol
  - ✧ Integrate Physical Layer protocol
  - ✧ Integrate hardware CRC
  - ✧ Support Hard Reset
  - ✧ Integrates recognition and support of emark cable
- **Power Control**
  - ✧ Integrated bidirectional BUCK-BOOST NMOS driver
  - ✧ Integrated charge-pump to control external NMOS
- **Charge**
  - ✧ Adaptive charging current adjustment
  - ✧ Support 3.65V/4.15V/4.2V/4.3V/4.35V/4.4V battery
  - ✧ Support 2/3/4/5 batteries in series
  - ✧ Support charging Lithium Iron Phosphate Battery（3.65V）
- **Boost**
  - ✧ Maximum output power 100W
  - ✧ Up to 97%@5V/2A efficiency with synchronous switching
  - ✧ Support line compensation
- **Battery Level Display**
  - ✧ Integrated 14-bit ADC and coulombmeter
  - ✧ Support 4 LEDs to indicate battery level
  - ✧ Support 88/188 nixie tube
  - ✧ Support choosing nixie tube or LED for battery level indicator by external pin
  - ✧ Self-learning coulombmeter, more uniform power display
  - ✧ Support configuring initial battery capacity by external pin
- **Other Functions**
  - ✧ Automatic detection of mobile phone plugging and unplugging
  - ✧ Fast charging status indication
  - ✧ Battery temperature detection
  - ✧ Enter standby mode automatically in light load
  - ✧ Support multiple key mode selections
  - ✧ Integrated lighting driver
- **Multiple Protections,High Reliability**
  - ✧ Input overvoltage and undervoltage protection
  - ✧ Output overcurrent, overvoltage, short circuit protection
  - ✧ Battery overcharge, overdischarge, overcurrent protection
  - ✧ Overtemperature protection
  - ✧ NTC protection for charging and discharging battery
  - ✧ ESD 4kV, input (including CC/DP/DM pins) withstand voltage 30V
- **Low BOM Cost**
  - ✧ Integrated switch power MOSFET driver
  - ✧ Single inductor for charging and discharging
- **Package Size：8mm × 8mm 0.4pitch QFN64**

2 Description

IP5389 is a power management SOC that integrates QC2.0 / QC3.0 / QC3+ output fast charging protocol, AFC/FCP/SCP/ VOOC input and output fast charging protocol, USB C PD2.0/PD3.0 input and output fast charging protocol and PPS output protocol, BC1.2/iPhone protocol, synchronous bi-directional buck-boost converter, lithium battery charging management and battery power indicator, providing a complete power solution for fast charging mobile power supplies. It can support four USB ports such as two USB A ports, one USB C port and one USB B port (lightning port or USB C port)at the same time and fast charging when any USB port is connected alone. When two or more output ports are used at the same time, every port's output voltage is 5V.

Due to the high integration of IP5389, only one inductor is needed to realize the bidirectional buck-boost function. Only a few peripheral components are needed in the application, which effectively reduces the size of the overall solution and reduces the BOM cost.

IP5389 supports 2/3/4/5 series batteries and the synchronous switch buck-boost system can provide a maximum output capacity of 100W. When there is no load, it automatically enters the dormant state.

IP5389 synchronous switch charging system provides up to 8.0A charging current. The built-in IC temperature, battery temperature and input voltage control loop intelligently adjust the charging current.

IP5389 built-in 14-bit ADC can accurately measure battery voltage and current. Built-in power calculation method can accurately obtain battery power information. The battery power curve can be customized to accurately display the battery power.

IP5389 supports 4-LED power display, supports 88, 188 and other nixie tube power display; supports lighting function; supports keys.

3 Application Product

- Power bank, power storage device
- Portable devices such as mobile phones and tablets

Contents

4 Revision record

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Updated from Revision V1.2 (Augest 2022) to Revision V1.21	Page
● Updated the format of the datasheet.	

Updated from Revision V1.21 (November 2022) to Revision V1.22	Page
● Updated the description of six battery applications.	1

Updated from Revision V1.22 (March 2023) to Revision V1.23	Page
● Updated the Standby current at the battery terminal	17

5 Typical Application

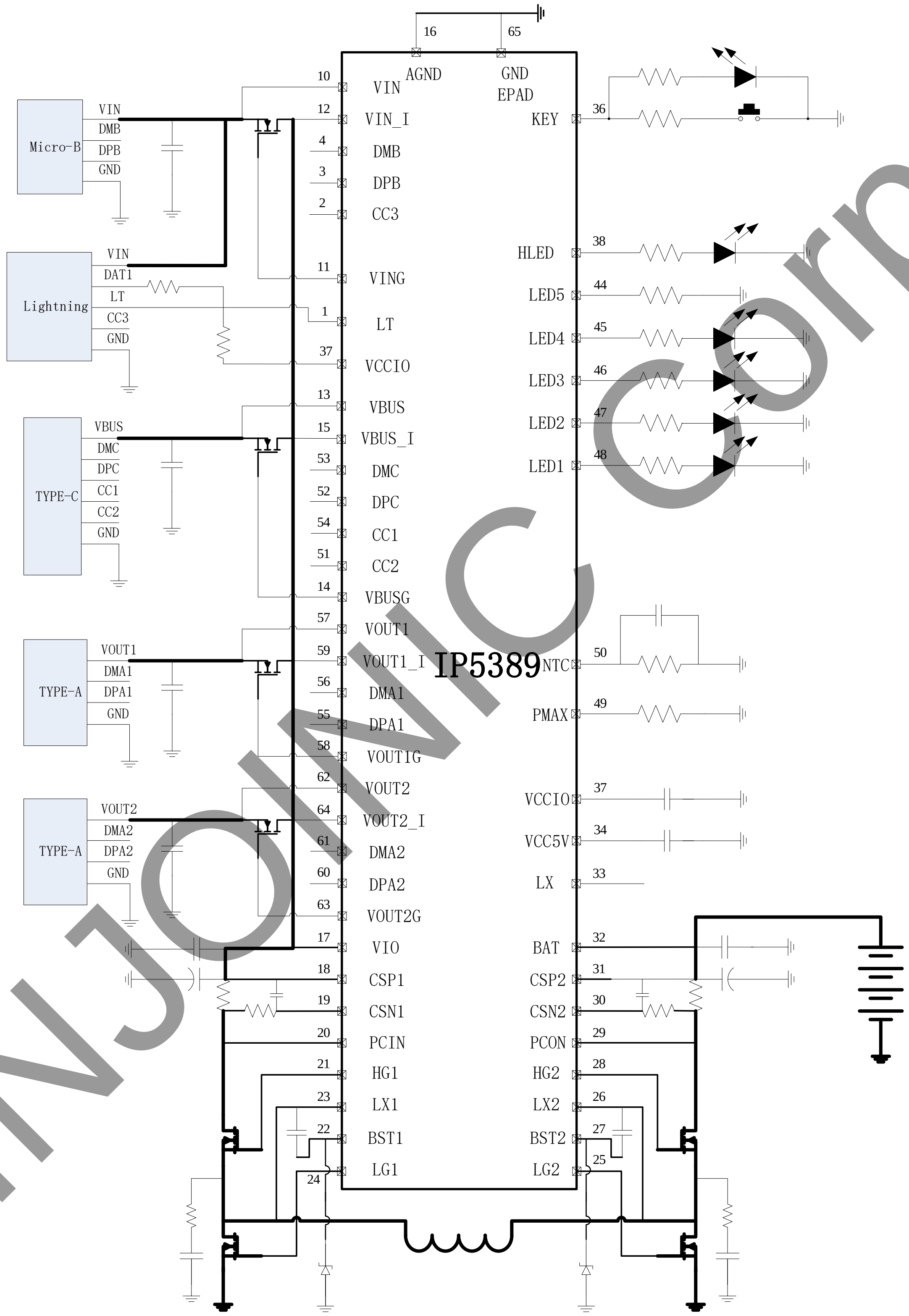


Figure 1 Simplified application schematic

6 IP Series Products List

6.1 Power Bank IC

IC Part No.	boost/charge		Main features								Package	
	Discharge	Charge	LED number	light	key	I2C	DCP	USB C	QC Certificate	PD3.0/PPS	Package	Compatibility
IP5303T	1.0A	1.2A	1,2	√	√	-	-	-	-	-	ESOP8	PIN2PIN
IP5305T	1.0A	1.2A	1,2,3,4	√	√	-	-	-	-	-	ESOP8	
IP5306	2.4A	2.1A	1,2,3,4	√	√	√	-	-	-	-	ESOP8	
IP5306H	2.4A	2.1A	1,2,3,4	√	√	√	-	-	-	-	ESOP8	
IP5406T	2.4A	2.1A	1,2,4	√	√	-	-	-	-	-	ESOP8	
IP5407	2.4A	2.1A	1,2,4	√	√	-	-	-	-	-	ESOP8	
IP5207	1.2A	1.2A	3,4,5	√	√	-	√	-	-	-	QFN24	PIN2PIN
IP5209	2.4A	2.1A	3,4,5	√	√	√	√	-	-	-	QFN24	
IP5209U	2.4A	2.1A	3,4,5	√	√	√	√	-	-	-	QFN24	
IP5207T	1.2A	1.2A	1,2,3,4	√	√	√	√	-	-	-	QFN24	PIN2PIN
IP5189T	2.1A	2.1A	1,2,3,4	√	√	√	√	-	-	-	QFN24	
IP5189TH	2.1A	2.1A	1,2,3,4	√	√	√	√	-	-	-	QFN24	
IP5310	3.1A	3.0A	1,2,3,4	√	√	√	√	√	-	-	QFN32	
IP5320	3.1A	3.0A	Nixie Tube	√	√	√	√	√	-	-	QFN28	
IP5506	2.4A	2.1A	Nixie Tube	√	√	-	-	-	-	-	ESOP16	
IP5508	2.4A	2.1A	Nixie Tube	√	√	-	√	-	-	-	QFN32	
IP5330	3.1A	3.0A	Nixie Tube	√	√	-	√	√	-	-	QFN32	
IP5566	3.1A	3.0A	1,2,3,4	√	√	-	√	√	-	-	QFN40	
IP5332	18W	4.0A	1,2,3,4	√	√	√	√	√	√	√	QFN32	
IP5328P	18W	4.0A	1,2,3,4	√	√	√	√	√	√	√	QFN40	
IP5356	22.5W	5.0A	Nixie	√	√	-	√	√	√	√	QFN40	

			Tube									
IP5568	22.5W	5.0A	Nixie Tube	√	√	-	√	√	√	√	QFN64	
IP5353	22.5W	5.0A	4	√	√	-	√	√	√	√	QFN32	
IP5355	22.5W	5.0A	4	√	√	-	√	√	√	√	QFN32	
IP5389	100W	8.0A	Nixie Tube	√	√	-	√	√	√	√	QFN64	
IP5386	45W	8.0A	1,2,4	√	√	-	√	√	√	√	QFN48	

Table 1 IP series products list

6.2 IP5389 Common Custom Product Description

Part No.	Function description
IP5389_BZ	Standard IP5389, support 2-5 batteries, maximum power 100W, support AABCL interface
IP5389_AACC	Support 2-5 batteries, maximum power 100W, support AACC interface, 2 bidirectional Type-C ports

Table 2 IP5389 common custom product description

7 Pin Description

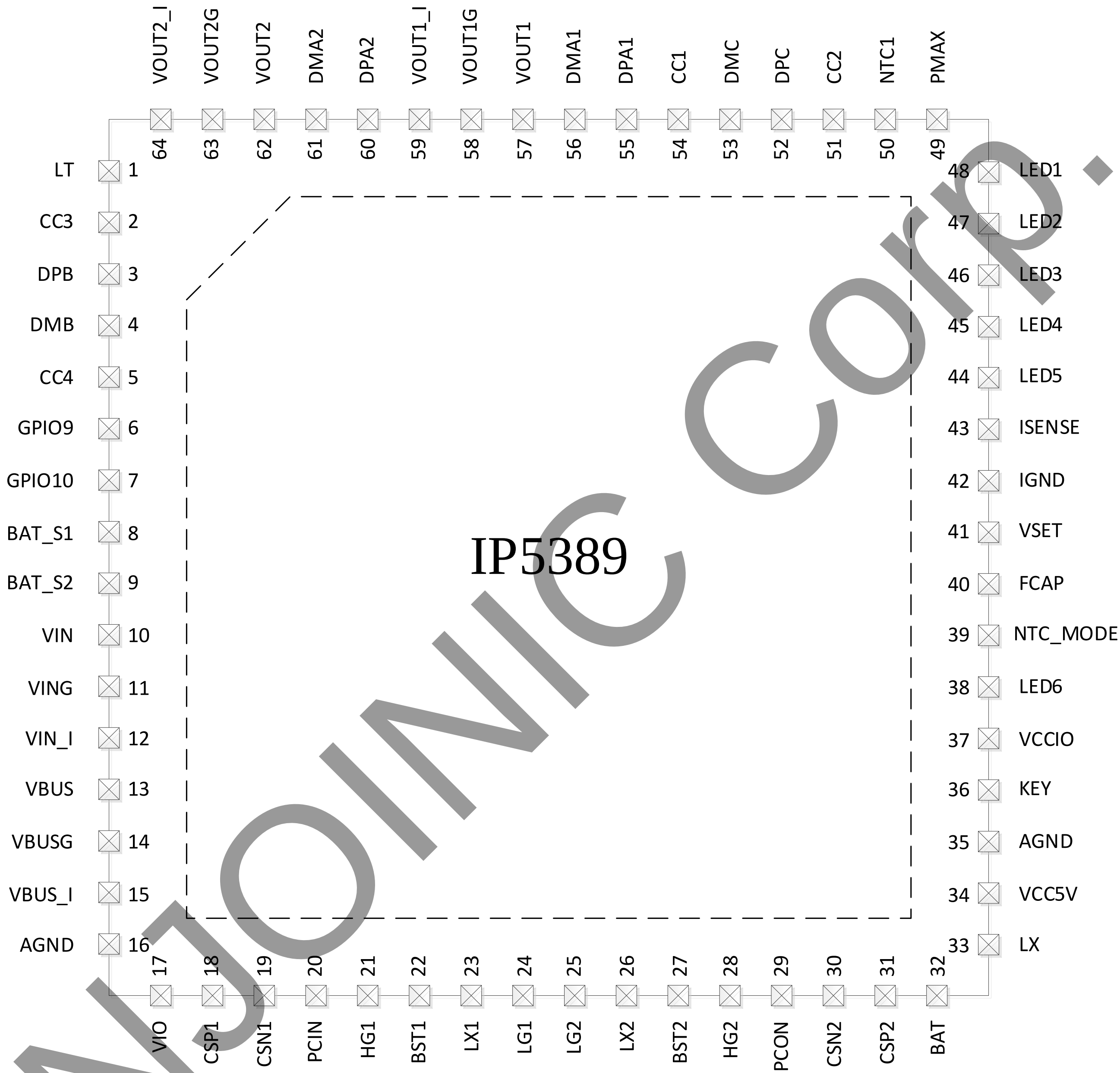


Figure 2 IP5389 pin diagram

7.1 IP5389 Pin Description

Pin Num	Pin Name	Pin definition
1	LT	Lightning decoding pin
2	CC3	The second USB C port CC detection and fast charging communication pin CC3
3	DPB	Fast charging intelligent identification pin of micro USB port

4	DMB	Fast charging intelligent identification pin of micro USB port
5	CC4	The second USB C port CC detection and fast charging communication pin CC4
6	GPIO9	GPIO
7	GPIO10	GPIO
8	BAT_S1	Used for battery number selection. Different numbers can be selected by connecting this pin to ground or not.
9	BAT_S2	Used for battery number selection. Different numbers can be selected by connecting this pin to ground or not.
10	VIN	VIN input charging power pin of micro USB port
11	VING	Used to control input path NMOS of micro USB port
12	VIN_I	Used to detect current of micro USB port path
13	VBUS	VBUS input/output power supply pin of USB C port
14	VBUSG	Used to control input/output path NMOS of USB C port
15	VBUS_I	Used to detect current of USB C port path
16	AGND	Analog ground
17	VIO	Mobile power input/output pin
18	CSP1	Current sampling positive terminal of mobile power input/output terminal
19	CSN1	Current sampling negative terminal of mobile power input/output terminal
20	PCIN	Mobile power input/output peak current sampling pin
21	HG1	Input/output terminal upper tube control pin of H-bridge power tube
22	BST1	Input/output terminal bootstrap voltage pin of H-bridge power tube
23	LX1	Inductor connection pin of mobile power input/output terminal
24	LG1	Input/output terminal lower tube control pin of H-bridge power tube
25	LG2	Battery terminal lower tube control pin of H-bridge power tube
26	LX2	Inductance connection pin of mobile power battery terminal
27	BST2	Battery terminal bootstrap voltage pin of H-bridge power tube
28	HG2	Battery terminal upper tube control pin of H-bridge power tube
29	PCON	Battery peak current sampling pin
30	CSN2	Current sampling negative terminal of battery terminal
31	CSP2	Current sampling positive terminal of battery terminal
32	BAT	Battery terminal pin
33	LX	System 5V power supply,BUCK output inductor connection point,dangling by default
34	VCC5V	System 5V power supply, to supply power to the internal analog circuit of the IC
35	AGND	Analog ground
36	KEY	Key and light pin

37	VCCIO	System 3.3V power supply, to supply power to the internal digital circuit of the IC
38	LED6	Used for driving power indicator LED6
39	NTC_MODE	You can choose different NTC function by connecting different resistors. It is used as an I/O driver in nixie tube solutions.
40	FCAP	Used for battery capacity selection.You can choose different battery capacities by connecting different resistors.
41	VSET	Used for battery voltage selection. You can choose different battery charging voltage by connecting different resistors.
42	IGND	Differential current sampling negative terminal
43	ISENSE	Differential current sampling positive terminal
44	LED5	Used to drive power indicator LED5
45	LED4	Used to drive power indicator LED4
46	LED3	Used to drive power indicator LED3
47	LED2	Used to drive power indicator LED2
48	LED1	Used to drive power indicator LED1
49	PMAX	Used for system input and output maximum power selection. You can set PMAX by connecting a resistor to ground.
50	NTC	Used for NTC resistance detection.
51	CC2	Used for USB C port detection and fast charging communication
52	DPC	Used for USB C port fast charging intelligent recognition
53	DMC	Used for USB C port fast charging intelligent recognition
54	CC1	Used for USB C port detection and fast charging communication
55	DPA1	Used for USB A1 port fast charging intelligent recognition
56	DMA1	Used for USB A1 port fast charging intelligent recognition
57	VOUT1	USB A1 port power output from this pin
58	VOUT1G	Used to control NMOS in USB A1 port output path
59	VOUT1_I	Used for current detection of the USB A1 port
60	DPA2	Used for USB A2 port fast charging intelligent recognition
61	DMA2	Used for USB A2 port fast charging intelligent recognition
62	VOUT2	USB A2 port power output from this pin
63	VOUT2G	Used to control NMOS in USB A2 port output path
64	VOUT2_I	Used for current detection of the USB A2 port
65(EPAD)	GND	Ground

Table 3 IP5389 Pins description

8 Internal Block Diagram of the Chip

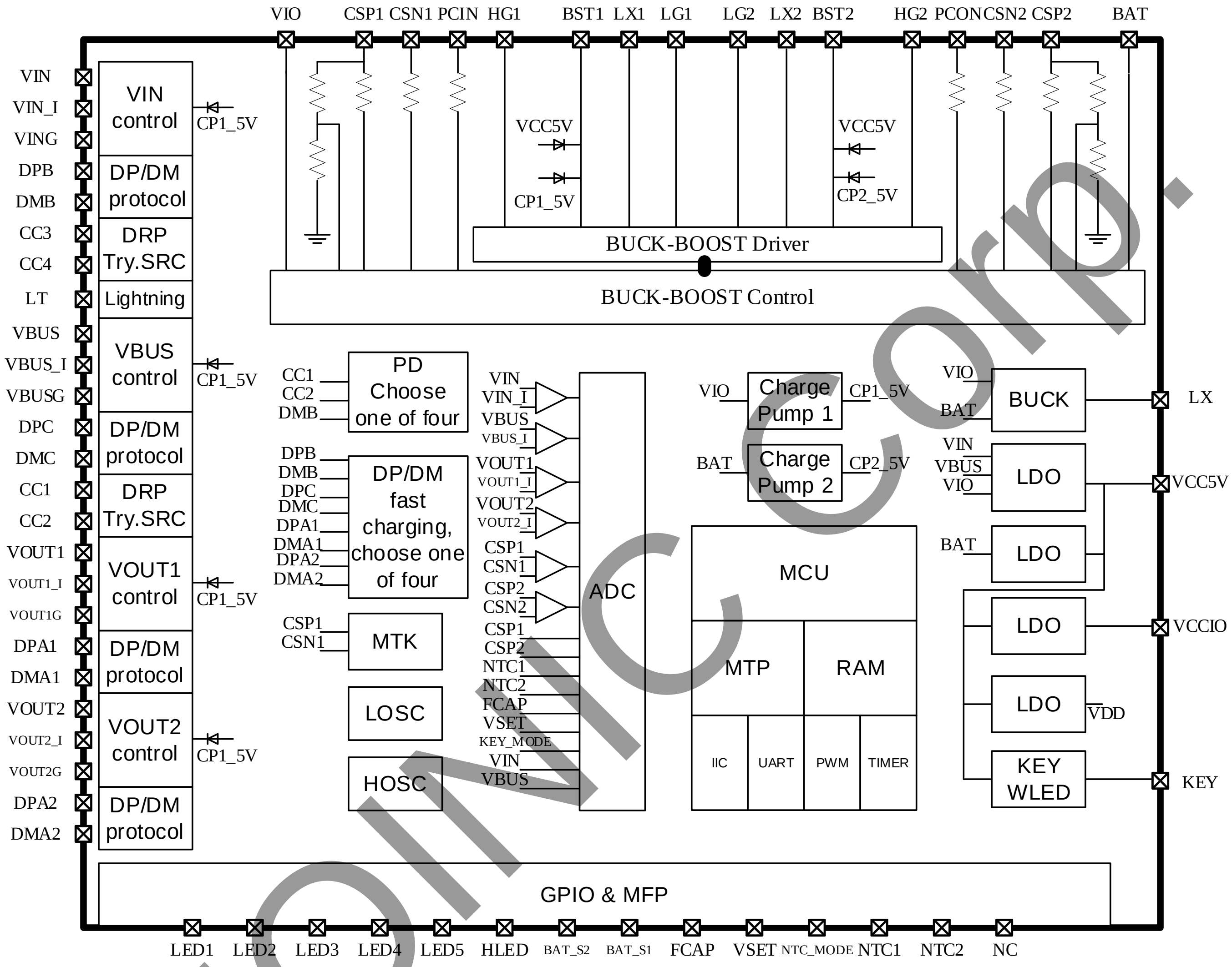


Figure 3 Internal block diagram of the chip

9 Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input Voltage Range	VBAT/VIN/VBUS	-0.3 ~ 35	V
Protocol Port Voltage Range	DP/DM/CC	-0.3 ~ 30	V
Digital GPIO voltage range	LED/FCAP	-0.3 ~ 8	V
Junction Temperature Range	T_J	-40 ~ 125	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Thermal Resistance (Junction to Ambient)	θ_{JA}	26	℃/W
Human Body Model (HBM)	ESD	4	kV

Table 4 Absolute maximum ratings

*Stresses higher than the values listed in the Absolute Maximum Ratings section may cause permanent damage to the device. Excessive exposure under any absolute maximum rating conditions may affect the reliability and service life of the device.

10 Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Battery Voltage	VBAT	5.6		25	V
Input Voltage	VIN/VBUS	4.5		25	V
Output Voltage	VOUT1/VOUT2/VBUS	3		22	V
Working temperature	TA	-40		85	℃

* Beyond these operating conditions, device operating characteristics cannot be guaranteed.

11 Electrical Characteristics

Unless otherwise specified, TA=25℃, L=10uH

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Charging System						
Input voltage	V_{IN}/V_{BUS}		4.5	5/9/12/15/20	25	V
Input overvoltage	V_{IN}				15	V
	V_{BUS}				25	V
Charging constant voltage	V_{TRGT}	The number of battery is N，R_{VSET} = 27k	N*4.16	N*4.20	N*4.24	V
		The number of battery is N，R_{VSET} = 18k	N*4.26	N*4.30	N*4.34	V
		The number of battery is N，R_{VSET} = 13k	N*4.31	N*4.35	N*4.39	V
		The number of battery is N，R_{VSET} = 9.1k	N*4.36	N*4.40	N*4.44	V
		The number of battery is N，R_{VSET} = 6.2k	N*4.11	N*4.15	N*4.19	V
		The number of battery is N，R_{VSET} = 3.6k	N*3.6	N*3.65	N*3.7	V
Charging Current	I_{CHRG}	VIN=5V, input current	1.7	2.0	2.3	A
		VIN=9V, input current	1.7	2.0	2.3	A
		VIN=12V, input current	1.2	1.5	1.8	A
		VBUS=5V, input current	2.7	3.0	3.3	A
		VBUS=9V，input current, Not PD	1.7	2.0	2.3	A
		VBUS=9V，input current, PD	2.7	3.0	3.3	A
		VBUS=12V，input current, Not PD	1.2	1.5	1.8	A
		VBUS=12V，input current, PD	2.7	3.0	3.3	A
		VBUS = 15V，input current	2.7	3.0	3.3	A
		VBUS = 20V，input current	2.7	3.0	3.3	A
		VBUS = 20V，PMAX=65W	2.9	3.25	3.6	A
		VBUS = 20V，PMAX=100W	4.2	4.7	5.2	A
Charging Current	I_{CHRG}	VIN=5V, input current	1.8	2.0	2.2	A
		VIN=9V, input current	1.8	2.0	2.2	A
		VIN=12V, input current	1.3	1.5	1.7	A
		VBUS=5V, input current	2.7	3.0	3.3	A
		VBUS=9V ，PD，input current, PMAX>=27W	2.7	3.0	3.3	A
		VBUS=9V，not PD, PMAX>=27W	1.8	2.0	2.2	A

		input current					
		VBUS=12V，PD，Input current	PMAX=27W	2.0	2.25	2.5	A
			PMAX=30W	2.2	2.5	2.8	
			PMAX>=45W	2.7	3.0	3.3	
		VBUS=12V，not PD, input current	PMAX>=27W	1.3	1.5	1.7	A
		VBUS=15V，PD and not PD, input current	PMAX=27W	1.6	1.8	2.0	A
			PMAX=30W	1.8	2.0	2.2	
			PMAX>=45W	2.7	3.0	3.3	
		VBUS =20V，PD，input current	PMAX=30W	1.3	1.5	1.7	A
			PMAX=45W	2.0	2.25	2.5	
			PMAX=60W	2.7	3.0	3.3	
			PMAX=65W	3.0	3.25	3.6	
			PMAX=100W	4.3	4.7	5.1	
		VBUS=20V, not PD，input current	PMAX=30W	1.3	1.5	1.7	A
			PMAX=45W	2.0	2.25	2.5	
			PMAX>=60W	2.7	3.0	3.3	
Trickle Charging Current	I_{TRKL}	VIN=5V, VBAT<2.5V		50	100	150	mA
		VIN=5V, 2.5V<=VBAT<N*3.0V		100	200	300	mA
Trickle cut-off voltage	V_{TRKL}	The number of battery is N, V_{TRGT} is not 3.6V.		N*2.9	N*3	N*3.1	V
	V_{TRKL}	The number of battery is N, V_{TRGT} is 3.6V.		N*2.7	N*2.75	N*2.85	V
Charging stop current	I_{STOP}			100	0.025*FCAP		mA
Recharging Voltage Threshold	V_{RCH}	The number of battery is N.			V_{TRGT} – N*0.1		V
Charging cut-off time	T_{END}			45	48	51	Hour
Discharge System							
Battery operation voltage	V_{BAT}	The number of battery is N.		N*2.75		N*4.5	V
Battery input current	I_{BAT}	VBAT=4*3.7V, VOUT=5.0V, fs=250kHz, Iout=0mA		3	7		mA
DC output voltage	QC2.0 V_{OUT}	V_{OUT}=5V@1A		4.75	5.00	5.25	V
		V_{OUT}=9V@1A		8.70	9	9.30	V

		V_{OUT}=12V@1A	11.60	12	12.40	V
	QC3.0/ QC3+ V_{OUT}	@1A	3.6		12	V
	QC3.0 Step			200		mV
	QC3+ Step			20		mV
Output voltage ripple	ΔV_{OUT}	VBAT=4*3.7V, VOUT=5.0V, fs=250kHz, Iout=1A		120		mV
		VBAT=4*3.7V, VOUT=9.0V, fs=250kHz, Iout=1A		135		mV
		VBAT=4*3.7V, VOUT=12V, fs=250kHz, Iout=1A		370		mV
Maximum output power of discharge system	Pmax	Under the PD protocol, different PMAX resistance values correspond to different Pmax.	20		100	W
Discharge efficiency	η_{out}	V_{BAT}=8V, V_{OUT}=5V, I_{OUT}=2A		94.69		%
		V_{BAT}=8V, V_{OUT}=9V, I_{OUT}=2A		95.36		%
		V_{BAT}=8V, V_{OUT}=12V, I_{OUT}=2A		95.86		%
		V_{BAT}=15V, V_{OUT}=5V, I_{OUT}=2A		91.55		%
		V_{BAT}=15V, V_{OUT}=9V, I_{OUT}=2A		95.05		%
		V_{BAT}=15V, V_{OUT}=12V, I_{OUT}=2A		95.37		%
Discharge system shutdown current	I_{shut}	VBAT=N*3.7V,multiple ports output 5V	4.1	4.4	4.7	A
		VBAT= N *3.7V,single port outputs 5V	3.1	3.4	3.8	A
		VBAT= N *3.7V, single port outputs 9V，not under PD protocol condition	2.7	3	3.3	A
		VBAT= N *3.7V, single port outputs 12V，not under PD protocol condition	2	2.2	2.5	A
		VBAT= N *3.7V, single port		PDO * 1.1		A

		outputs， under PD protocol condition				
Shutdown power threshold under light load condition	P_{out}	VBAT=3.7V		350		mW
Detection time for overcurrent load	T_{UVD}	The output voltage is continuously lower than 2.4V.		30		ms
Detection time for short-circuit load	T_{OCD}	The output voltage is continuously lower than 2.2V.		40		us
Control System						
Switch frequency	fs	Discharging switch frequency		250		kHz
		Charging switch frequency		250		kHz
VCCIO output voltage	V_{CCIO}		3.15	3.3	3.45	V
Standby current at the battery terminal	I_{STB}	VBAT=14.8V. The average current after the key is turned off.		180	400	uA
LDO output current	I_{LDO}		25	30	35	mA
The current that drives LED lighting	I_{WLED}		10	15	20	mA
The current that drives LED display	I_{L1} I_{L2} I_{L3}	Voltage decreases 10%.	5	7	9	mA
Detection time for automatic shutdown when total load is light	$T1_{load}$	The load power is continuously less than 350mW.	30	32	34	s
Detection time for automatic shutdown of output port under light load	$T2_{load}$		14	16	18	s
Detection time	$T_{OnDebounce}$		60		500	ms

of short press on key for waking						
The time of opening WLED	$T_{Keylight}$		1.2	2	3	s
Temperature which leads to power off	T_{OTP}	heating	110	125	140	℃
Temperature hysteresis after power off	ΔT_{OTP}			40		℃

Table 6 Electrical Characteristics

12 Description of Function

12.1 Lock State and Activation

When the IP5389 is connected to the battery for the first time, no matter what the battery voltage is, the chip is in a lock state, and the lowest digit of the battery indicator will flash 4 times, or the nixie tube 0% will flash 4 times to indicate. When not in the charging state, if the battery voltage is too low, the shutdown will be triggered, and IP5389 will go into lock state at this time.

In the low battery state, in order to reduce static power consumption, IP5389 can't detect the insertion of the load and it can't be activated by pressing the key. At this time, pressing the key can't activate the buck-boost output, but the lowest battery indicator will flash 4 times to prompt.

In the lock state, the chip can be activated only after entering the charging state.

12.2 Charging

IP5389 has a constant current and constant voltage lithium battery charging management system that supports a synchronous switch structure. It can automatically match different charging voltage.

When the battery voltage is less than V_{TRKL}, it will apply 200mA trickle charging; when the battery voltage is greater than V_{TRKL}, it will apply constant current charging, and the maximum charging current of the battery terminal is 8.0A; when the battery voltage is close to the setting value, it will apply constant voltage charging; when the battery terminal charging current is less than the stop charging current I_{STOP} and the battery voltage is close to the constant voltage, the charging is stopped. After the charging is completed, if the battery voltage is lower than (V_{TRGT}-N*0.1)V, it will restart the battery charging.

IP5389 has switch charging technology with a switching frequency of 250kHz. When charging with ordinary 5V input, the input power is 10W; when charging with fast charging input, the maximum input power is 100W. The charging efficiency can reach 96%, which can shorten the charging time by 3/4.

IP5389 will automatically adjust the charging current to adapt to adapters with different load capacities.

IP5389 supports simultaneous charging and discharging. When charging and discharging simultaneously, both input and output are 5V.

12.3 Discharging

IP5389 integrates a synchronous switching converter system that supports high-voltage output and supports a wide voltage range of 3.0V~21V. The synchronous switching buck-boost system can provide a maximum output capacity of 100W. The built-in soft-start function prevents malfunctions caused by excessive inrush current during start-up.It also has output overcurrent, short circuit, overvoltage, overtemperature and other protective functions to ensure the stable and reliable operation of the system.

The current of the discharging system can be automatically adjusted with the temperature to ensure that the IC temperature is below the set temperature.

VBAT = 8V，VOUT = 5/9/12/15V，the boost efficiency curve is as follows：

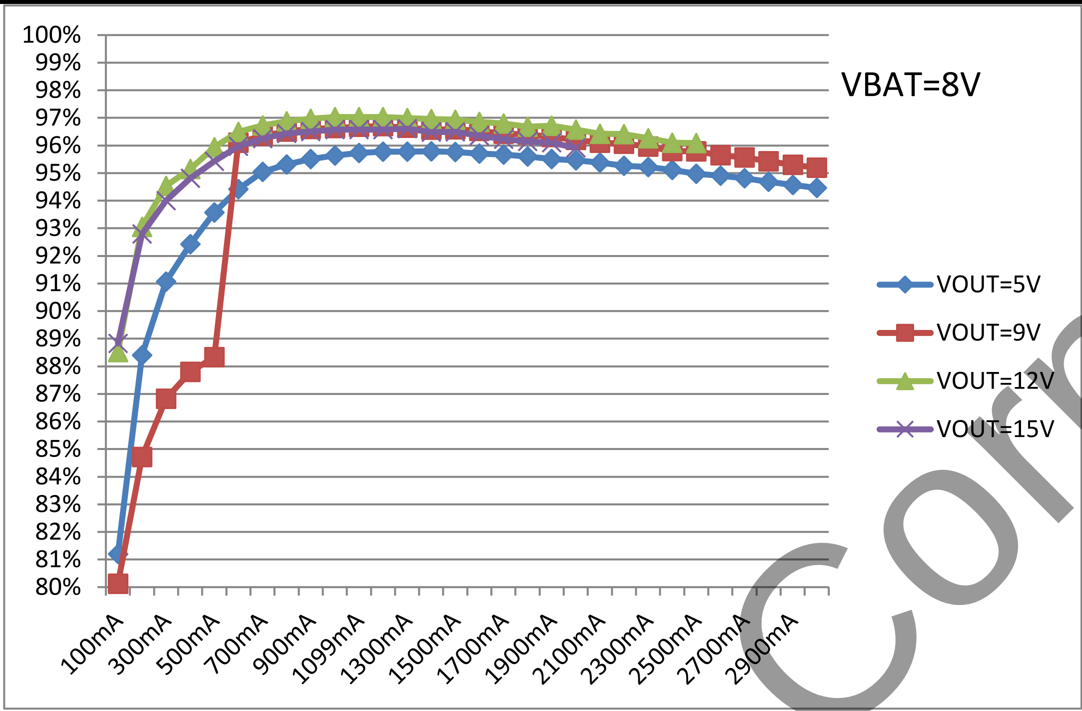


Figure 4 Boost efficiency curve under the condition of VBAT=8V

VBAT=15V，VOUT=5/9/12/15V，the boost efficiency curve is as follows：

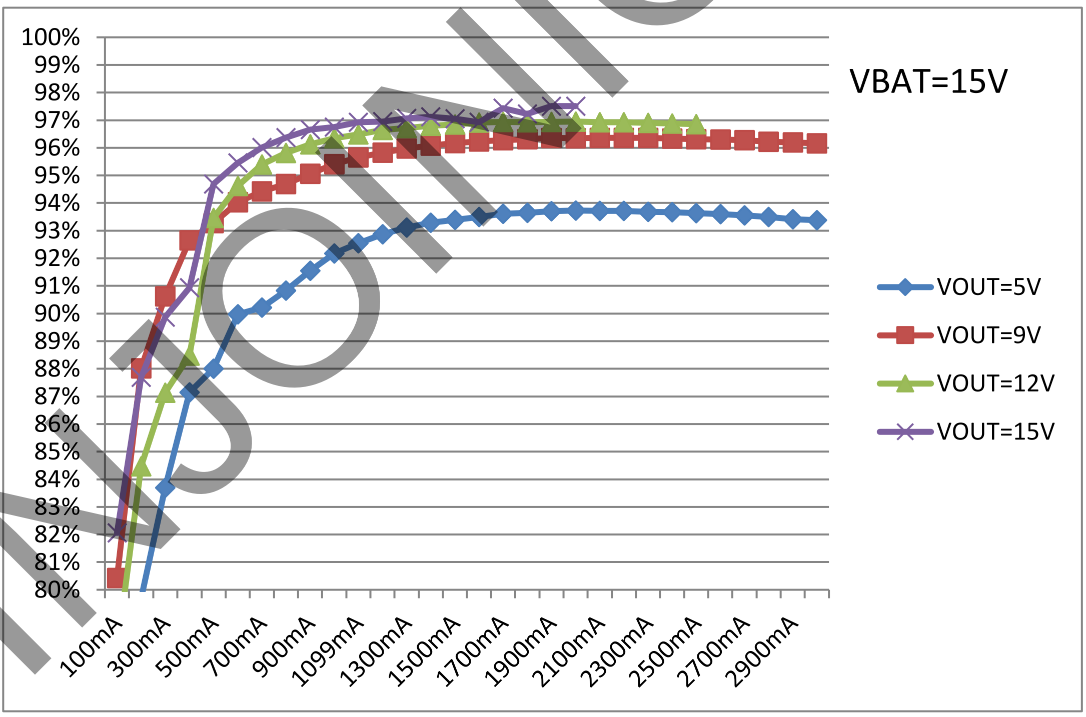


Figure 5 Boost efficiency curve under the condition of VBAT=15V

12.4 USB C

IP5389 integrates USB C input and output recognition interfaces, automatically switches the built-in pull-up and pull-down resistors, and automatically recognizes charging and discharging properties of the inserted device. With Try.SRC function, when the attached device is also DRP device, IP5389 will supply power for the opposite device.

When it works as a DFP, it will output 3A current capability information through CC pin; when it works as a UFP, it can identify the output current capability of the opposite device.

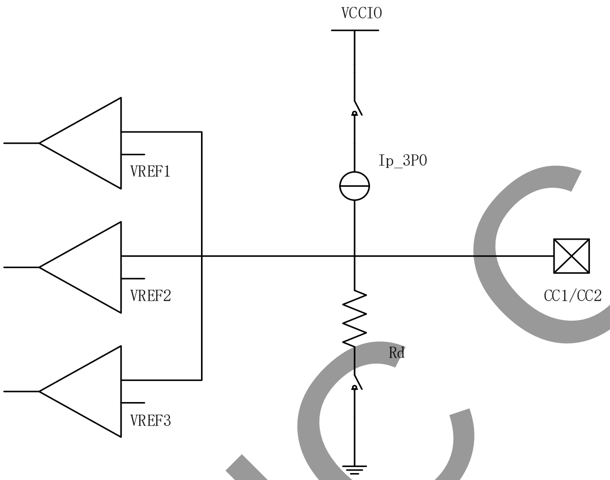


Figure 6 CC internal circuit

Name	Value
Ip_3P0	330uA
Rd	5.1k

Table 7 Pull-up and pull-down ability

Table 4-23 CC Voltages on Source Side – 3.0 A @ 5 V

	Minimum Voltage	Maximum Voltage	Threshold
Powered cable/adapter (vRa)	0.00 V	0.75 V	0.80 V
Sink (vRd)	0.85 V	2.45 V	2.60 V
No connect (vOPEN)	2.75 V		

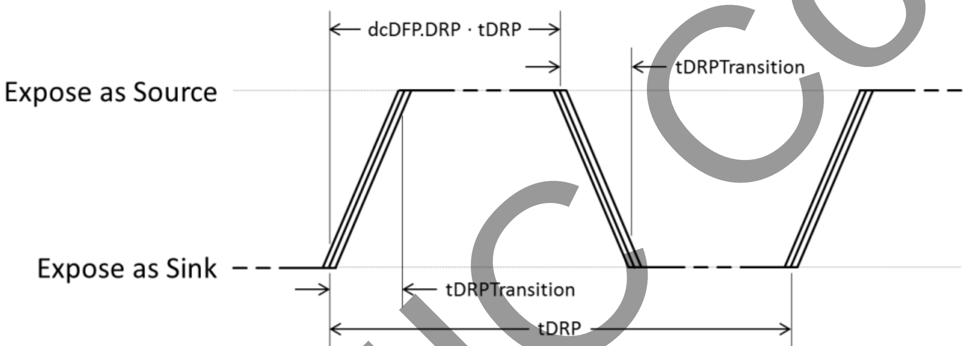
Table 8 Comparator threshold of pull-up Ip

Table 4-25 Voltage on Sink CC pins (Multiple Source Current Advertisements)

Detection	Min voltage	Max voltage	Threshold
vRa	−0.25 V	0.15 V	0.2 V
vRd-Connect	0.25 V	2.04 V	
vRd-USB	0.25 V	0.61 V	0.66 V
vRd-1.5	0.70 V	1.16 V	1.23 V
vRd-3.0	1.31 V	2.04 V	

Table 9 Comparator threshold of pull-down resistor Rd

Figure 4-36 DRP Timing



	Minimum	Maximum	Description
tDRP	50 ms	100 ms	The period a DRP shall complete a Source to Sink and back advertisement
dcSRC.DRP	30%	70%	The percent of time that a DRP shall advertise Source during tDRP
tDRPTransition	0 ms	1 ms	The time a DRP shall complete transitions between Source and Sink roles during role resolution
tDRPTry	75 ms	150 ms	Wait time associated with the Try.SRC state.
tDRPTryWait	400 ms	800 ms	Wait time associated with the Try.SNK state.
tTryTimeout	550 ms	1100 ms	Timeout for transition from Try.SRC to TryWait.SNK.
tVPDDetach	10 ms	20 ms	Time for a DRP to detect that the connected Charge-Through VCONN-Powered USB Device has been detached, after VBUS has been removed.

Table 10 USB C detection cycle

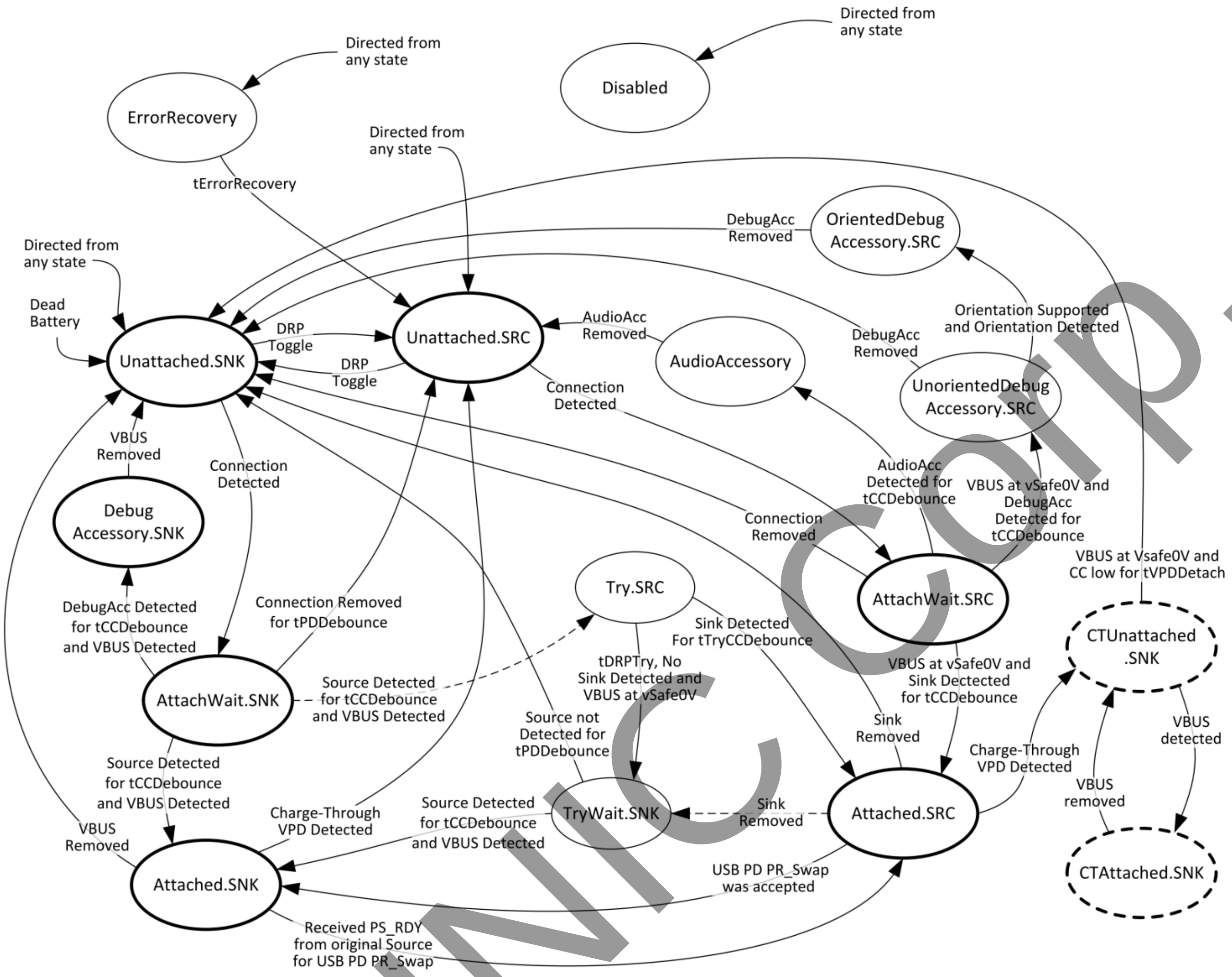


Figure 7 USB C detection state transition

12.5 USB C PD

IP5389 integrates USB C Power Delivery PD2.0/PD3.0/PPS (Programmable Power Supply) protocol,physical (PHY) layer for data transmitting/receiving across the CC wire and hardware biphase mark coding (BMC) module.

IP5389 supports PD2.0/PD3.0 bidirectional input/output protocol and PPS output protocol. The maximum output power is 100W.Input voltage gears includes 5V, 9V, 12V, 15V, 20V.Output voltage gears includes 5V, 9V, 12V, 15V, 20V. When the E-MARK cable is recognized, it broadcasts capacities:5V/3A, 9V/3A, 12V/3A, 15V/3A, 20V/5A, PPS 3.3~21V/3A; when the E-MARK cable is not recognized, it broadcasts capabilities: 5V/3A, 9V/3A, 12V/3A, 15V/3A, 20V/3A, PPS 3.3~21V/3A.

12.6 Fast Charging Protocol

IP5389 supports multiple fast charging protocols: QC2.0/QC3.0/QC3+、FCP、AFC、SCP、VOOC、 Apple.

Input QC2.0/QC3.0/ QC3+ protocol is not supported for charging the power bank. External fast charging protocol IC is not supported.

Input fast charging protocol FCP, AFC are supported for charging the power bank. Since FCP and AFC perform fast charging requests through DP/DM, when other fast charging protocol ICs are added, FCP and AFC fast charging can no longer be supported.

When the mobile power bank charges the mobile phone, it will automatically detect the fast charging sequence on the DP and DM pins after entering the discharge mode, and intelligently identify the type of mobile phone， which support QC2.0/QC3.0/QC3+, FCP, AFC, SCP, VOOC protocol, Apple 2.4A mode, BC1.2 ordinary 1A mode.

For Apple 2.4A mode: DP=DM=2.7V.

For BC1.2 1.0A mode: DP short to DM.

In the BC1.2 mode, when the DP voltage is detected to be greater than 0.325V and less than 2V for 1.25s, the initial judgment is that there is a fast charging request. At this time, the short circuit between DP and DM will be disconnected, and DM will be pulled down to ground by a 20k resistor. If it is satisfied that the DP voltage is greater than 0.325V and less than 2V, and the DM voltage is less than 0.325V for 2ms, the fast charging connection is considered successful. After that, the requested voltage can be output according to the requirements of QC2.0/QC3.0/QC3+. As long as the DP voltage is less than 0.325V, the fast charge mode is forced to exit, and the output voltage immediately returns to the default 5V.

DP	DM	Result
0.6V	GND	5V
3.3V	0.6V	9V
0.6V	0.6V	12V
0.6V	3.3V	Continuous Mode
3.3V	3.3V	hold

Table 11 QC2.0/QC3.0 rules for requesting output voltage

Continuous Mode is the unique working mode of QC3.0/QC3+. In this mode, the output voltage can be adjusted in a 0.2V step according to the QC3.0 protocol requirements, or it can be adjusted in a 20mV step after the QC3+ handshake is successful.

The fast charging protocol supported by each port of IP5389:

Protocols	VOUT1 output	VOUT2 output	Micro USB input	TYPEC output	TYPEC input
QC2.0	√	√	-	√	-
QC3.0	√	√	-	√	-
QC3+	√	√	-	√	-
AFC	√	√	√	√	√
FCP	√	√	√	√	√
SCP	√	√	√	√	√
VOOC	√	√	√	-	√

PD2.0	-	-	-	√	√
PD3.0	-	-	-	√	√
PPS	-	-	-	√	-

Table 12 The fast charging protocol supported by each port of IP5389

supported：√

not supported：-

12.7 Charging and Discharging Path Management

Standby:

If VIN or VBUS is connected to a power supply, charging can be started directly.

If a USB C UFP device is inserted into VBUS or an electrical device is inserted into VOUT, the discharging function can be automatically turned on.

IP5389 will turn on when the key is pressed or there is a load on VOUT1, VOUT2, or USB C, otherwise it will keep standby state.

Discharging:

When the key is not pressed, only the path of the output port that is connected to electrical device will be opened, and the path of the output port that is not connected to electrical device will be closed.

Any port of VOUT1, VOUT2, USB C can support output fast charging protocol, but because of a single inductor solution, it can only support one voltage output. In other words, It only supports fast charging output when only one output port is turned on. When two or three output ports are used at the same time, the fast charging function will be automatically turned off.

According to the connection shown in the "Simplified application schematic", when any output port has entered fast charging output mode, if another output port is plugged in with an electrical device, it will first close all the output ports, turn off the high-voltage fast charge function, and then turn on the output port where the device exists. At this time, all the output ports only support Apple and BC1.2 charging. When in the multi-port output mode, if the output current of any output port is less than about 80mA (MOS Rds_ON@10mohm), the port will be automatically closed after 16s. When it is detected that the number of electrical device is reduced from multiple to one, after about 16s, all output ports will be closed first, then the high-voltage fast charging function will be turned on, and the output port connected to the electrical device will be turned on. In this way, the device can be reactivated to request a fast charging. When only one output port is turned on, and total output power is less than about 350mW for about 32s, IP5389 will close the output port, stop discharging and enter standby state.

Charging:

Any one of VIN and VBUS can be plugged into a power source to charge the battery. If they are all connected to the power source, the first plugged-in power source will be used first for charging.

In the case of charging only, it will automatically recognize the fast charging mode of the power supply and automatically match the appropriate charging voltage and charging current.

Charge while discharging

When the charging power supply and the electrical device are plugged in at the same time, the chip will automatically enter the charging and discharging mode. In this mode, it will automatically close the internal fast charging input request. When the VIO voltage is only 5V, the discharging path is opened to supply power to the electrical device; if the VIO voltage is greater than 5.6V, for safety reasons, the discharging path will not be opened. In order to charge the electrical device normally, IP5389 will increase the charging undervoltage loop to above 4.925V to ensure that the electrical device is given priority to supply power.

During the charging and discharging process, if the charging power is unplugged, IP5389 will turn off the charging and restart discharging to supply power to the electrical device. For safety reasons, and to reactivate the mobile phone to request fast charging, the voltage will drop to 0V for a period of time during the conversion process.

During the charging and discharging process, if the electrical device is unplugged, or the electrical device is fully charged and stops drawing power, the corresponding discharging path will be automatically closed after about 16s. When the discharging paths are closed and the state returns to the charging only mode, the charging undervoltage loop will be lowered and the fast charging will be automatically reactivated, then the charging of the mobile power supply will be accelerated.

12.8 Automatic Detection for Mobile Phone

12.8.1 Automatic detection for mobile phone insertion

If an inserted phone has been automactically detected by IP5389, IP5389 will wake up from standby state immediately and turn on the boost to charge the phone by 5V. This design can save the step of turning on the key and support the mold scheme without key.

12.8.2 Automatic detection for fully charged mobile phone

IP5389 samples the output current of each port through the on-chip ADC. When the output current of a single port is less than about 80mA (MOS Rds_ON@10mohm) and lasts for about 16s, the output port will be closed. When the total output power is less than about 350mW and lasts for about 32s, it is considered that the mobile phones of all output ports are fully charged or unplugged, and the buck-boost output will be automatically turned off.

12.9 Key Function

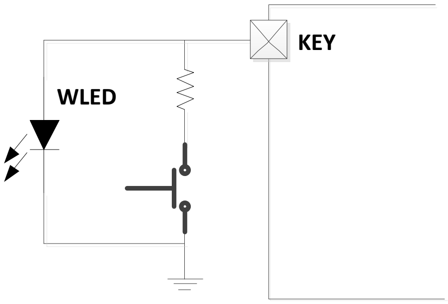


Figure 8 Key circuit

Key circuit is illustrated in Figure 7, which can recognize short press or long press operation.

- Pressing the key for longer than 60ms but less than 2s is a short press action
- Pressing the key for longer than 2s is a long press action.
- There will be no response when the key is pressed for less than 60ms.
- Long press for 10s to reset the entire system.

12.10 Fast Charging Status Indicator

HLED is used to indicate the current fast charging mode. Regardless of charging or discharging, the indicator will automatically light up when entering the fast charging mode and the output is not 5V.

It can be used as the 6th pin driver for the 6-pin nixie tube application. When 6-pin nixie tube is selected, there is no fast charging light LED display.

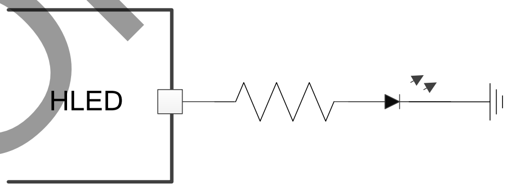


Figure 9 Fast charging state indication

12.11 Coulombmeter and Battery Level Display

IP5389 has a built-in coulombmeter, which can realize accurate battery power calculation.
IP5389 supports LED5 pin to select LED mode or nixie tube mode.
IP5389 supports 4-LED mode.
IP5389 supports 188 nixie tube to display power.

12.11.1 Coulombmeter

IP5389 supports externally setting the initial capacity of the battery, and uses the integral of the current and time of the battery terminal to manage the remaining capacity of the battery. When a 5 mohm detection resistor is used between the battery current detection pins CSP2 and CSN2, the current battery capacity can be accurately displayed. When the battery current detection pins CSP2 and CSN2 are shorted, the battery current can be estimated to display the estimated current battery capacity; IP5389 supports the automatic calibration of the total capacity of the current battery in a complete charging process from 0% to 100%, and more reasonable management of the actual capacity of the battery.

The formula for setting the initial capacity of the battery through the IP5389 external pin: battery capacity=R17*0.8 (mAH). The minimum value is 2000mAH, and the maximum value is 25000mAH.

When the voltage on the FCAP pin is less than 100mV or greater than 2700mV, it will be recognized as a short-circuit or open-circuit abnormality in the R17 resistor.

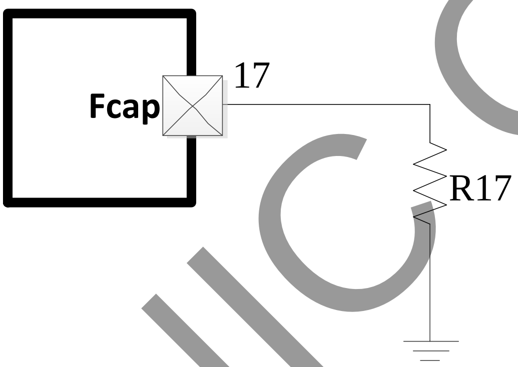


Figure 10 Battery capacity configuration circuit

Typical battery capacity configuration table:

R17 (ohm)	battery initial capacity (mAH)
6.2k	5000mAH
12.4k	10000mAH
18.7k	15000mAH
24.9k	20000mAH
30.9K	25000mAH

Table 13 Typical battery capacity configuration table

Note: The capacity in the table refers to the capacity of a single battery.

12.11.2 LED Power Display Mode

IP5389 4-LED mode to display the capacity of the battery is as follows:

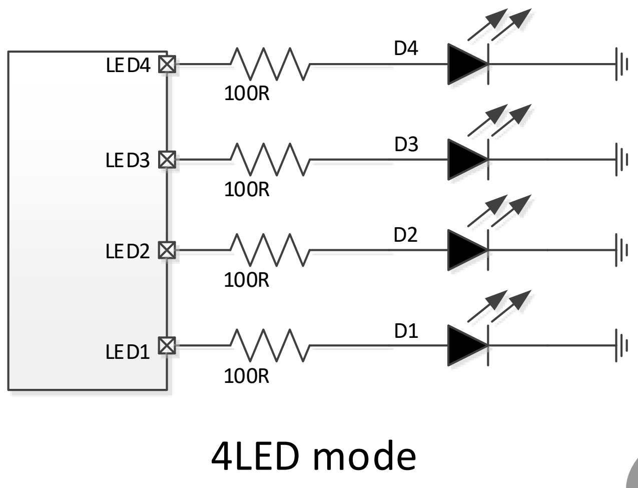


Figure 11 4-LED connection

Battery capacity C(%)	D1	D2	D3	D4
Fully charged	ON	ON	ON	ON
75%≤C	ON	ON	ON	1.5Hz Flash
50%≤C＜75%	ON	ON	1.5Hz Flash	OFF
25%≤C＜50%	ON	1.5Hz Flash	OFF	OFF
C＜25%	1.5Hz Flash	OFF	OFF	OFF

Figure 14 4-LED display mode during charging

Battery capacity C(%)	D1	D2	D3	D4
C≥75%	ON	ON	ON	ON
50%≤C＜75%	ON	ON	ON	OFF
25%≤C＜50%	ON	ON	OFF	OFF
3%≤C＜25%	ON	OFF	OFF	OFF
0%＜C＜3%	1.0Hz Flash	OFF	OFF	OFF
C=0%	OFF	OFF	OFF	OFF

Figure 15 4-LED display mode during discharging

12.11.3 188 Nixie Tube Display Mode

Nixie Tube	During charging		During discharging	
	Not fully charged	Fully charged	Battery capacity <5%	Battery capacity>5%
188（YF2252SR-5）	0-99% ones place 0.5Hz Flash	100% always on	0-5% ones place 1Hz Flash	5%-100% always on

Table 16 The nixie tube supported by IP5389

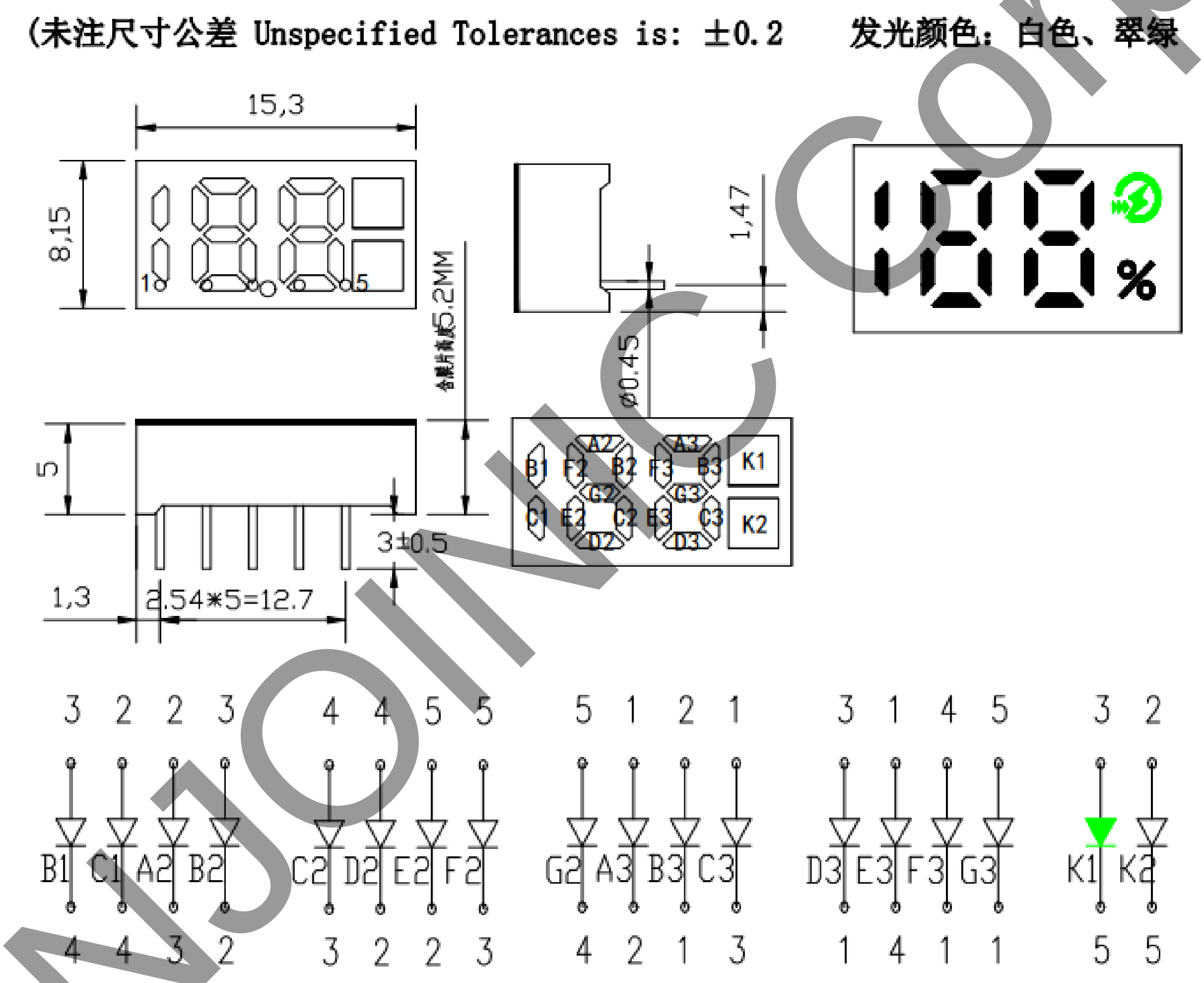


Figure 12 5-pin 188 nixie tube circuit

IP5389 driver pin	nixie tube pin	remarks
LED1(48 pin)	1 pin	
LED2(47 pin)	2 pin	
LED3(46 pin)	3 pin	
LED4(45 pin)	4 pin	
LED5(44 pin)	5 pin	
HLED(38pin)	6 pin	choosable，6-pin nixie tube scheme

Table 17 The sequence mapping relationship between IP5389 display driver and nixie tube pin

12.12 Setting the System Input/Output Maximum Power

IP5389 sets the maximum input and output power of the system by judging the resistance value connected to the PMAX pin.

PMAX R14（ohm 1%）	Maximum power PMAX
27k	65W(In the case of emark cable, the output power is 65W.)
18k	60W
13k	45W
9.1k	30W
6.2k	27W
3.6k	100W(In the case of emark cable, the output power is 100W.)

Table 18 Input and output maximum power configuration table

Note: For emark cable identification, please refer to the demo application schematic to add emark power supply circuit.

12.13 Setting the Number of Batteries in Series

IP5389 sets the number of batteries in series by judging whether the BAT_S1 or BAT_S2 pins is connected to GND, thereby changing the battery display threshold, the constant voltage for charging the battery, and the protection voltage.

BAT_S1 R18(ohm)	BAT_S2 R19(ohm)	the number of batteries in series
0	0	2
NC	0	3
0	NC	4
NC	NC	5

Table 19 Configuration table of the number of batteries in series

12.14 VSET(Battery Type Setting)

IP5389 sets the battery type by outputting 80uA current to the resistor connected to GND on the VSET pin and judging the voltage on the VSET, thereby changing the battery display threshold, the constant voltage for charging the battery, and the protection voltage. The different resistances to GND connected to VSET and the corresponding different battery types are shown in the following table. Note that the accuracy of the external resistance should be 1% and the voltage of VSET should be in the middle of the judgment range. When the voltage of VSET exceeds all judgment ranges, the chip will recognize the circuit as a short circuit or an abnormal open circuit.

Resistance from VSET to GND(ohm)	VSET (theoretical voltage) (mV)	VSET Voltage judgment range (mV)	Corresponding battery type
27k	2160	1750~2550	4.2V
18k	1440	1220~1750	4.3V
13k	1040	860~1220	4.35V
9.1k	728	600~860	4.4V
6.2k	496	384~600	4.15V
3.6k	288	216~384	3.65V

Table 20 Battery charging voltage settings

Note: 3.65V refers to lithium iron phosphate battery and corresponding turn-off voltage is 2.75V.

12.15 NTC Function and Threshold Selection

IP5389 integrates NTC function, which can detect battery temperature. After IP5389 is powered on, NTC pin outputs 80uA current at high temperature and 20uA current at low temperature, and generates voltage through external NTC resistor.The IC internally detects the voltage of the NTC pin to determine the current battery temperature.

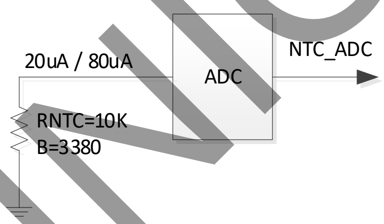


Figure 13 NTC circuit

IP5389 discharges 80uA current on the NTC_MODE pin. If this pin is connected with different resistors, different voltages can be obtained. The IC will detect the NTC_MODE voltage and select different NTC functions according to the NTC_MODE voltage.Note that the accuracy of the external resistance should be 1% and the voltage of NTC_MODE should be in the middle of the judgment range. When the voltage of NTC_MODE exceeds all judgment ranges, the chip will recognize the circuit as a short circuit or an abnormal open circuit.

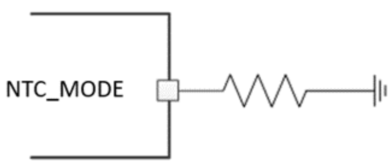


Figure 14 NTC threshold selection

NTC_MODE External Resistance(ohm)	NTC_MODE Theoretical Voltage(mV)	NTC_MODE Voltage Judgment Range(mV)	NTC Function
27k	2160	1750~2550	NTC first gear
18k	1440	1220~1750	NTC second gear
13k	1040	860~1220	NTC third gear
9.1k	728	600~860	NTC fourth gear
6.2k	496	380~600	NTC fifth gear
3.6k	288	216~380	NTC sixth gear

Table 21 NTC functions

IP5389 has six built-in NTC functions. By changing the resistance between NTC_MODE pin and GND, the corresponding NTC function can be set. The functions are as follows:

NTC first gear:

In the charging state, the charging is normal between 0 and 45 degrees Celsius, but when the temperature is lower than 0 degrees Celsius (greater than 0.55V) or the temperature exceeds 45 degrees Celsius (less than 0.39V), the charging stops.

In the discharge state, the discharge is normal between -20 and 60 degrees Celsius, but when the temperature is lower than -20 degrees Celsius (greater than 1.39V) or higher than 60 degrees Celsius (less than 0.24V), the discharge stops.

NTC second gear:

In the charging state, the charging is normal between 2 and 43 degrees Celsius, but when the temperature is lower than 2 degrees Celsius (greater than 0.50V) or the temperature exceeds 43 degrees Celsius (less than 0.42V), the charging stops.

In the discharge state, the discharge is normal between -10 and 55 degrees Celsius, but when the temperature is lower than -10 degrees Celsius (greater than 0.86V) or higher than 55 degrees Celsius (less than 0.28V), the discharge stops.

NTC third gear:

In the charging state, the charging is normal between 0 and 45 degrees Celsius, but when the temperature is lower than 0 degrees Celsius (greater than 0.55V) or the temperature exceeds 45 degrees Celsius (less than 0.39V), the charging stops.

In the discharge state, the discharge is normal between -10 and 55 degrees Celsius, but when the temperature is lower than -10 degrees Celsius (greater than 0.86V) or higher than 55 degrees Celsius (less than 0.28V), the discharge stops.

NTC fourth gear:

In the charging state, the charging is normal between 0 and 45 degrees Celsius, but when the temperature is lower than 0 degrees Celsius (greater than 0.55V) or the temperature exceeds 45 degrees Celsius (less than 0.39V), the charging stops.

In the discharge state, the discharge is normal between -10 and 55 degrees Celsius, but when the temperature is lower than -10 degrees Celsius (greater than 0.86V) or higher than 55 degrees Celsius (less than 0.28V), the discharge stops.

NTC fifth gear:

In the charging state, the charging is normal between 17 and 43 degrees Celsius, but when the temperature is lower than 2 degrees Celsius (greater than 0.50V) or the temperature exceeds 43 degrees Celsius (less than 0.39V), the charging stops. The charging current limit value of the BAT terminal between 2~17 degrees Celsius (0.27V) is 0.1C, and C is equal to the battery capacity set by FCAP.

In the discharge state, the discharge is normal between -20 and 60 degrees Celsius, but when the temperature is lower than -20 degrees Celsius (greater than 1.39V) or higher than 60 degrees Celsius (less than 0.24V), the discharge stops.

NTC sixth gear:

In the charging state, the charging is normal between 0 and 45 degrees Celsius, but when the temperature is lower than -10 degrees Celsius (greater than 0.86V) or the temperature exceeds 55 degrees Celsius (less than 0.28 V), the charging stops. The charging current limit value of the BAT terminal is 0.2C between -10~0 degrees Celsius (0.55V) or between 45~55 degrees Celsius (0.28V), and C is equal to the battery capacity set by FCAP.

In the discharge state, the discharge is normal between -20 and 55 degrees Celsius, but when the temperature is lower than -20 degrees Celsius (greater than 1.39V) or higher than 55 degrees Celsius (less than 0.28V), the discharge stops.

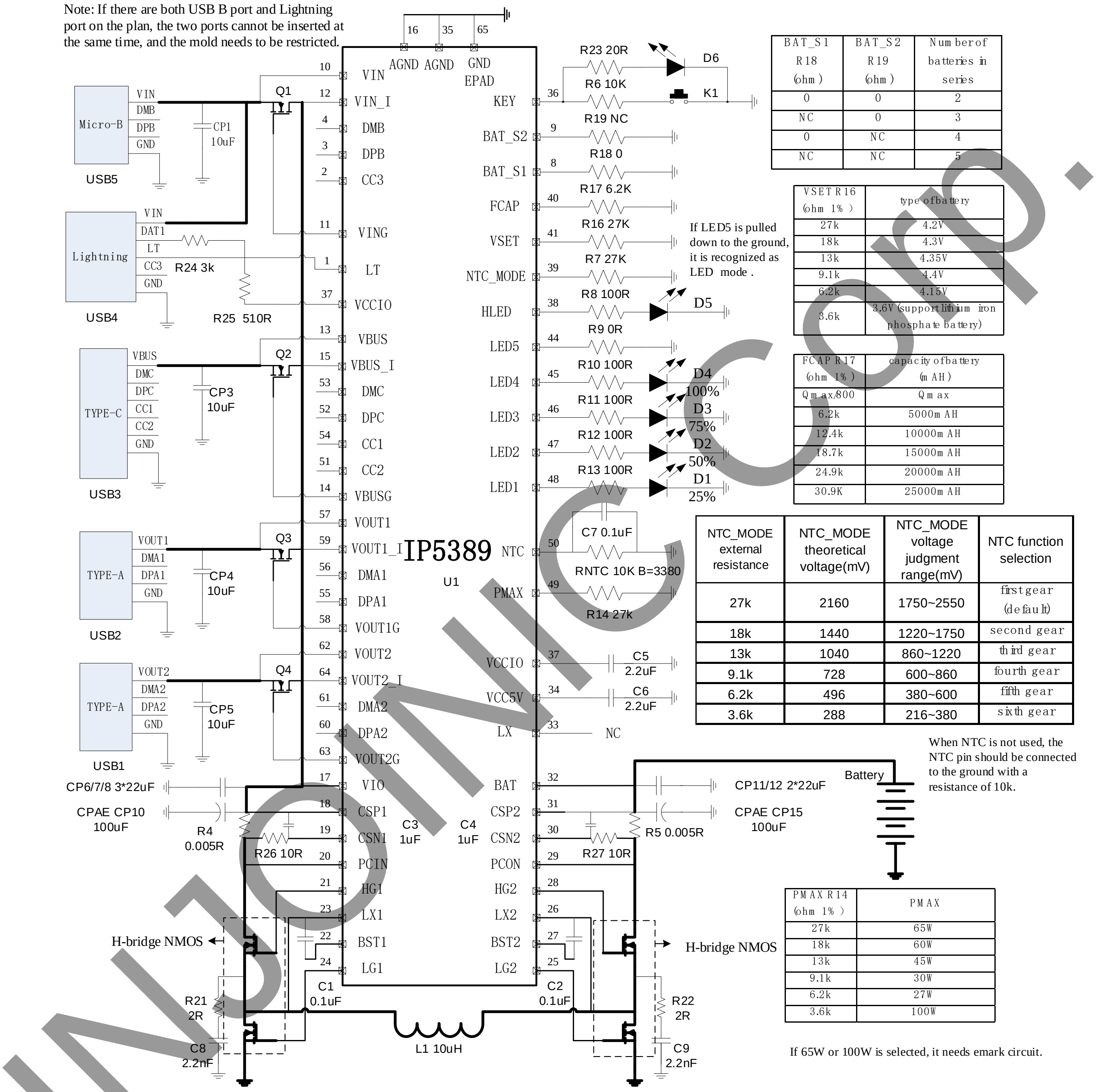
*Note:

After detecting the abnormal temperature of the NTC, it resumes normal operation when the temperature is ±5 degrees Celsius of the protection temperature. In the brackets after the above temperature, the NTC pin voltage corresponding to the temperature is written. The calculation method is: the current discharged by the NTC pin * the NTC resistance value at the temperature.

The NTC resistance parameter referenced in the above temperature range is 10K@25℃ B=3380. Other models are different and need to be adjusted.

If the scheme does not require NTC, the NTC pin should be connected to the ground with a 10k resistor, and cannot be left floating or grounded directly.

13 Application Schematic



BAT_S1 R18 (ohm)	BAT_S2 R19 (ohm)	Number of batteries in series
0	0	2
NC	0	3
0	NC	4
NC	NC	5

VSET R16 (ohm 1%)	type of battery
27k	4.2V
18k	4.3V
13k	4.35V
9.1k	4.4V
6.2k	4.15V
3.6k	3.6V (support lithium iron phosphate battery)

FCAP R17 (ohm 1%)	capacity of battery (mAH)
Qmax/800	Qmax
6.2k	5000mAH
12.4k	10000mAH
18.7k	15000mAH
24.9k	20000mAH
30.9K	25000mAH

NTC_MODE external resistance	NTC_MODE theoretical voltage(mV)	NTC_MODE voltage judgment range(mV)	NTC function selection
27k	2160	1750~2550	first gear (default)
18k	1440	1220~1750	second gear
13k	1040	860~1220	third gear
9.1k	728	600~860	fourth gear
6.2k	496	380~600	fifth gear
3.6k	288	216~380	sixth gear

PMAX R14 (ohm 1%)	PMAX
27k	65W
18k	60W
13k	45W
9.1k	30W
6.2k	27W
3.6k	100W

Figure 15 Application schematic

14 BOM

Serial number	Part name	Type	Location	Number	Remarks
1	SMT IC	QFN64 IP5389	U1	1	
2	SMT capacitor	0603 100nF 10% 50V	C1 C2 C7	3	
3	SMT capacitor	0603 1uF 10% 16V	C3 C4	2	
4	SMT capacitor	0603 2.2uF 10% 16V	C5 C6	2	
6	SMT capacitor	0805 10uF 10% 25V	CP1 CP3 CP4 CP5	4	
7	SMT capacitor	0805 22uF 10% 25V	CP6 CP7 CP8 CP11 CP12	5	
8	CPAE capacitor	100uF 35V 10%	CP10 CP15	2	
9	SMT resistor	1206 0.005R 1%	R4 R5	2	
10	SMT resistor	0603 10K 5%	R6	1	
11	SMT resistor	0603 27K 1%	R7 R14 R16	3	
12	SMT resistor	0603 6.2K 1%	R17	1	
13	SMT resistor	0603 0R 1%	R18	1	
14	NTC thermal resistor	10K@25 ℃ B=3380	RNTC	1	
15	SMT resistor	0603 100R 1%	R10 R11 R12 R13	4	choosable，LED application circuit
16	SMT LED	0603 blue	D1 D2 D3 D4	4	
17	SMT LED	0603 red	D5	1	
18	SMT resistor	0603 100R 1%	R8	1	
19	SMT resistor	0603 0R 5%	R9	1	
20	SMT resistor	0603 100R 1%	R9 R10 R11 R12 R13	5	choosable，nixie tube application circuit
21	SMT Schottky	YFTD1508SWPG-5D	SMG1	1	
22	LED	5MM LED	D6	1	
23	One-piece inductor	10Uh 7A R_{DC}<0.01R	L1	1	
24	KEY	SMT 3*6	K1	1	
25	SMT MOSFET	RU3030M2	Q1 Q2 Q3 Q4	4	
26	Output USB	AF10 8 pins USB	USB1 USB2	2	
27	USB C	USB C connector	USB3	1	

	connector				
28	LIGHTING connector	Apple lightning connector	USB4	1	
29	Input USB	MICRO-7-DIP-5.9	USB5	1	
30	SMT resistor	0603 20R 1%	R23	1	
31	SMT resistor	0603 3k 1%	R24	1	
32	SMT resistor	0603 510R 1%	R25	1	
33	SMT resistor	0603 10R 1%	R26 R27	2	
34	SMT MOSFET	RU30J51M	H-bridge NMOS	2	
35	TVS	30V TVS	T1 T2	2	
36	SMT resistor	0603 2R 1%	R21 R22		
37	SMT capacitor	0603 2.2nF 10% 50V	C8 C9		
36			R19		NC

Table 22 BOM of IP5389 application schematic

15 Package

15.1 Package of the Chip

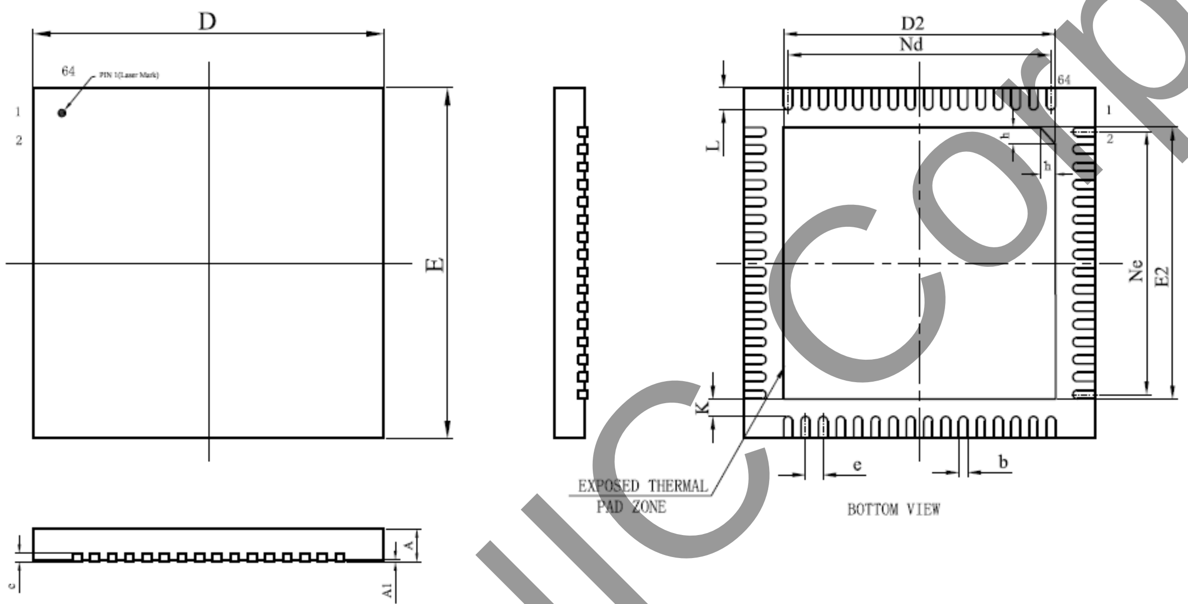


Figure 16 Package of the chip

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.15	0.20	0.25
c	0.18	0.20	0.25
D	7.90	8.0	8.10
D2	6.10	6.20	6.30
e	0.4 BSC		
Nd	6.00BSC		
E	7.90	8.0	8.10
E2	6.10	6.20	6.30
Ne	6.00BSC		
L	0.45	0.50	0.55
K	0.20	-	-
h	0.30	0.35	0.40

Table 23

15.2 Example of Pad Design

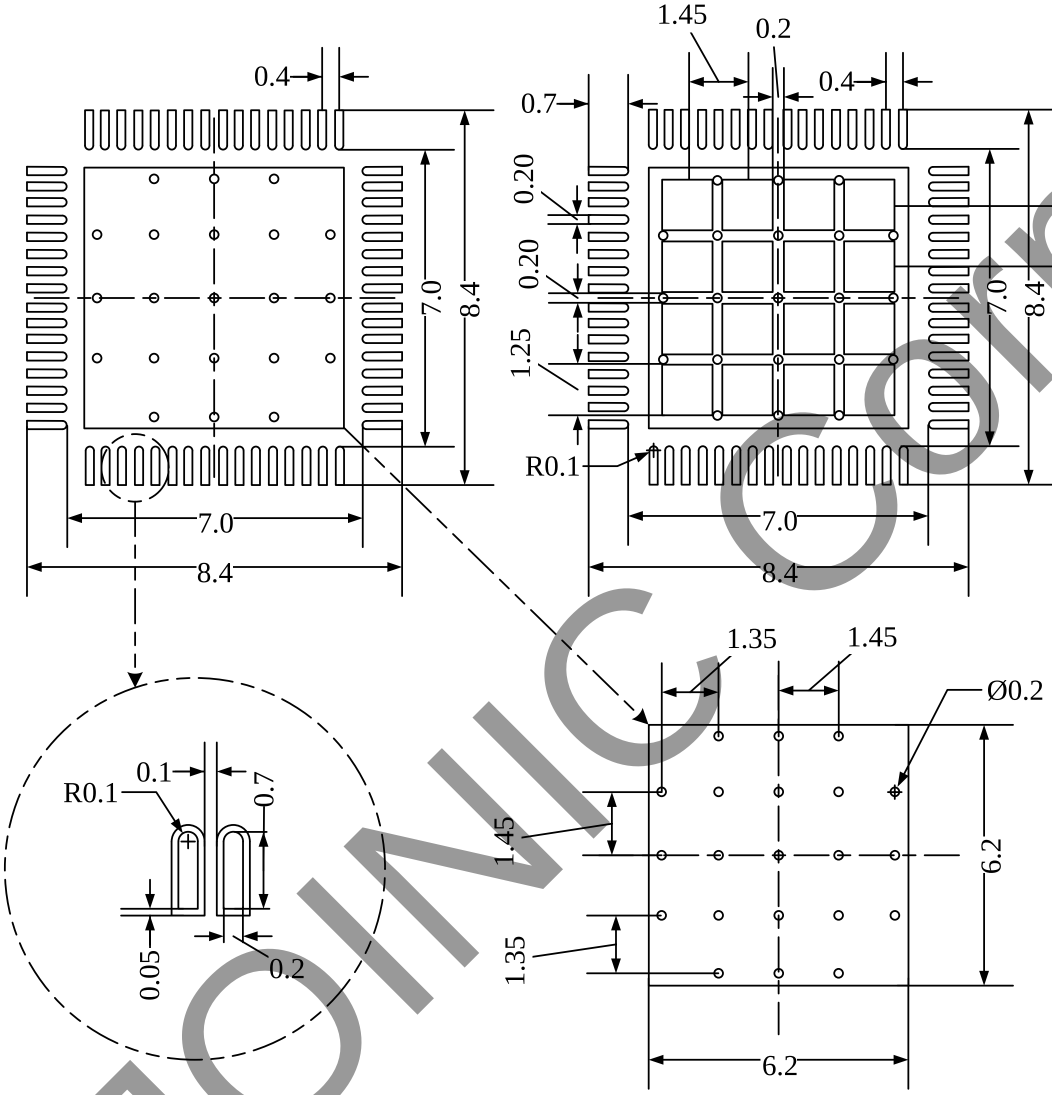


Figure 17 Example of pad design

16 Marking Description

16.1 Chinese Version of Silk Screen

Figure 18 Chinese version of silk screen

16.2 English Version of Silk Screen

Figure 19 English version of silk screen

17 Important Notice

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