Fully-Integrated Bidirectional PD3.0 and Fast Charge Power Bank SOC with Multiple Input and Output Ports

Features

- **Supports multiple ports simultaneously**
  - ✧ 1 USB A output port
  - ✧ 1 USB B input port
  - ✧ 1 USB C input/output port
- **Fast charge**
  - ✧ Every port supports fast charge
  - ✧ Supports QC2.0/QC3.0 output
  - ✧ Supports FCP input/output
  - ✧ Supports AFC input/output
  - ✧ Supports SFCP output
  - ✧ Supports MTK PE1.1&2.0 output
  - ✧ Supports USB C DRP input/output
  - ✧ Supports BC1.2, Apple, Samsung
- **Integrated USB Power Delivery (PD2.0/PD3.0) protocol**
  - ✧ Supports PD2.0 bidirectional input/output protocol
  - ✧ Supports PD3.0 input/output protocol
  - ✧ Supports 5V, 9V, 12V voltage input
  - ✧ Supports 5V, 9V, 12V voltage output
  - ✧ Integrated with hardware BMC protocol
  - ✧ Integrated with physical layer protocol (PHY)
  - ✧ Integrated with hardware CRC
  - ✧ Supports hard reset
- **Charge**
  - ✧ Up to 5.0A charging current at battery port
  - ✧ Adaptive charging current adjustment
  - ✧ Supports 4.20V, 4.35V, 4.40V, 4.50V batteries
- **Discharge**
  - ✧ Output capacity:
    5V: 3.1A 9V: 2.0A 12V: 1.5A
  - ✧ Up to 95% discharge efficiency @ 5V/2A with Synchronous switch
  - ✧ Supports line compensation
- **Battery level display**
  - ✧ Integrated 14-bit ADC and coulometer
  - ✧ Supports 1/2/3/4 LED battery indicators
  - ✧ Auto recognition of LED number
  - ✧ Adjustable battery level curve, power display more uniform
- **Others**
  - ✧ Integrated torch-light driver
  - ✧ Supports auto detection of plug in and out
  - ✧ Fast charge status indicator
  - ✧ Supports key control
  - ✧ Enter standby mode automatically in light load
- **Multiple protection, high reliability**
  - ✧ Input overvoltage and under voltage protection
  - ✧ Output overcurrent, overvoltage and short circuit protection
  - ✧ Battery overcharge, over discharge and overcurrent protection
  - ✧ Over temperature protection
  - ✧ Battery NTC protection
  - ✧ 4KV ESD, input voltage up to 25V (including CC pins)
- **Simplified BOM**
  - ✧ Integrated switch power MOSFET
  - ✧ Single inductor for charging and discharging
- **In-depth customization**
  - ✧ I2C interface for flexible and low cost customized solution
- **Package size: 5mm*5mm, 0.5mm pitch, QFN32**

Applications

- **Power Bank, Portable Charger**
- **Smart Phones, Tablets and Portable devices**

Description

IP5332 is a multifunctional power management SOC for total solution on quick charge Power Bank that supports QC2.0/QC3.0/MTK_PE+ 1.1&2.0/SFCP output, FCP/AFC/USB_C/PD2.0/PD3.0 input/output, and BC1.2/Apple/Samsung. It also integrates Li-battery charging and discharging management, and supports battery level display, etc. It is designed for device that supports three USB ports: USB A + USB B + USB C. Fast charge can be supported by any single USB port, and only 5V can be supported by two or more ports at the same time.

IP5332 is highly integrated with abundant functions, supports Buck and Boost with one single inductor, along with few peripheral devices make the total solution size minimized and BOM cost down.

IP5332 supplies up to 18W output ability using synchronous switch boost system, and efficiency is higher than 90% for 18W output even when the battery voltage is low. If no load is detected, the system enters standby mode automatically.

IP5332's synchronous switch charging system supplies 5.0A charging current. According to the IC temperature, battery temperature and input voltage, intelligently adjust charging current.

IP5332 integrates USB C standard, PD2.0/PD3.0 protocol.

IP5332 integrates 14-bit ADC, whoes data can be accessed through I2C interface. Together with internal coulometer, accurate battery voltage and current can be measured. Battery level curve can be customized for precise battery level display.

IP5332 supports battery level display on 1/2/3/4 LED and auto-detect display mode; supports torch light; supports key function.

Typical Application

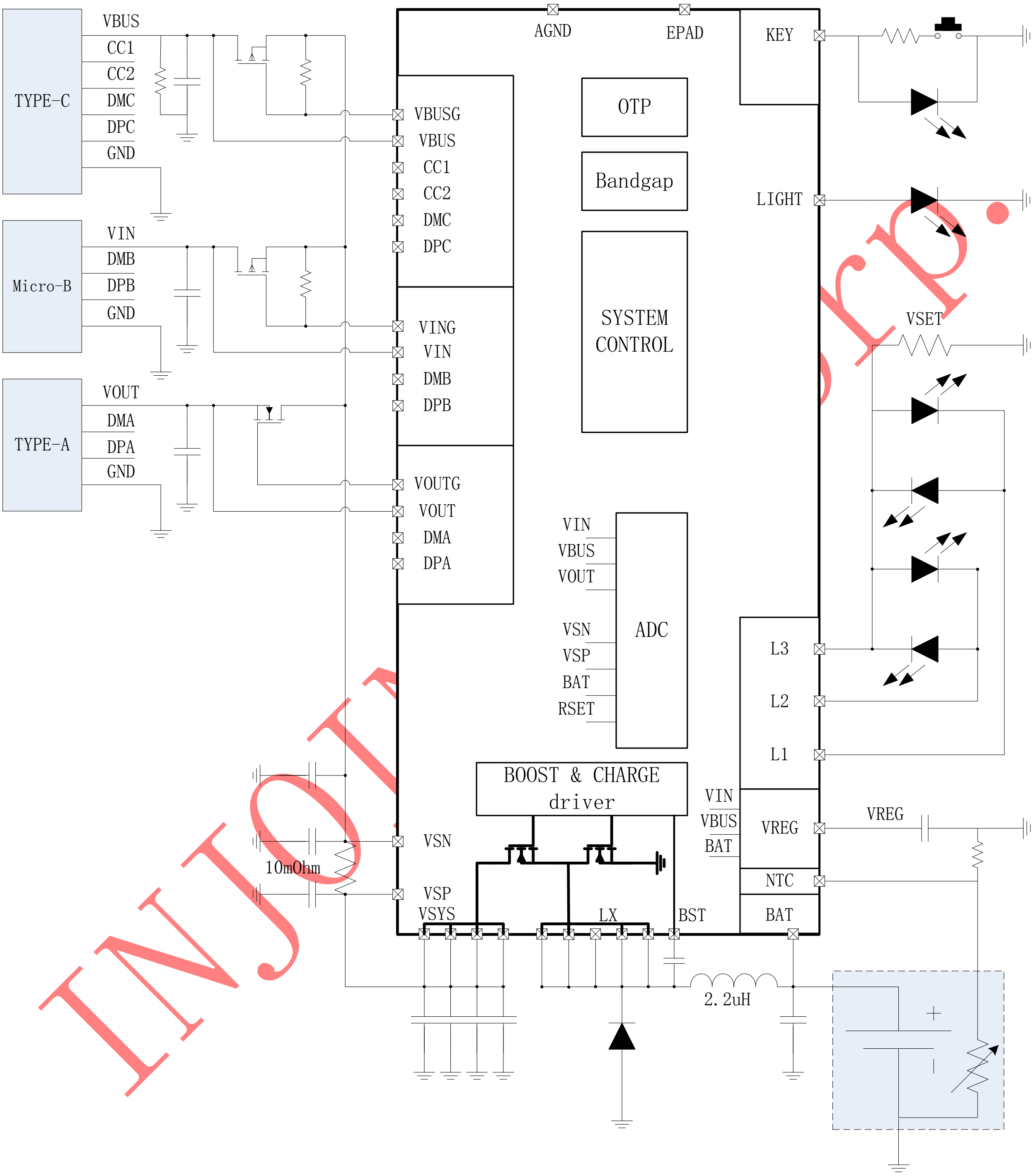


Figure 1 Simplified Application Diagram (4 LED for Battery Level Display)

1. Pin Definition

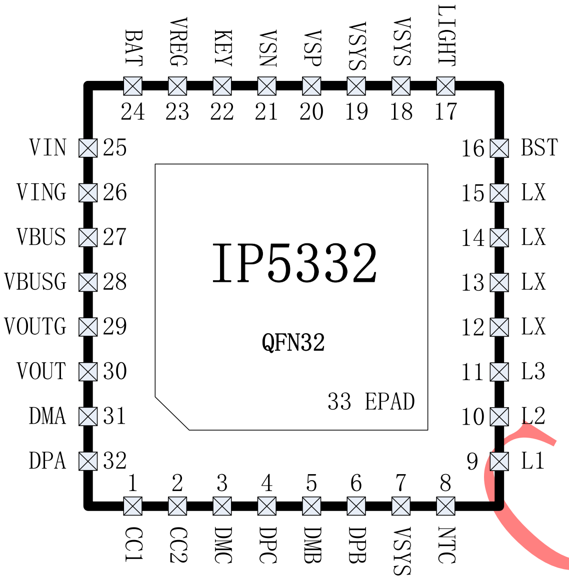


Figure 2 IP5332 Pin Assignments

Pin Num	Pin Name	Description
1	CC1	CC1 line on USB C port
2	CC2	CC2 line on USB C port
3	DMC	DM data line on USB C port
4	DPC	DP data line on USB C port
5	DMB	DM data line on Micro USB port
6	DPB	DP data line on Micro USB port
7/18/19	VSYS	Public Node of system input and output
8	NTC	NTC Resistor input for battery temperature sense
9	L1	Battery level display drive pin L1, reused as I2C SCK
10	L2	Battery level display drive pin L2, reused as I2C SDA
11	L3	Battery level display drive pin L3, reused as VSET, used for MCU wake up pin during I2C mode
12/13/14/15	LX	DCDC switch node, connect to inductor
16	BST	Internal high voltage driver, serial capacitor to LX
17	LIGHT	Fast charge mode indicator
20	VSP	Positive sample node of VSYS current, separate layout with VSYS
21	VSN	Negative sample node of VSYS current
22	KEY	Key detect pin, reused as WLED torch light function.

23	VREG	3.3V voltage output
24	BAT	Battery supply pin
25	VIN	VIN charge detect pin
26	VING	VIN charge input PMOS control pin
27	VBUS	VBUS charge detect pin
28	VBUSG	VBUS charge input PMOS control pin
29	VOUTG	VOUT discharge NMOS control pin
30	VOUT	VOUT discharge load detect pin
31	DMA	DM data line on USB A port
32	DPA	DP data line on USB A port
33(EPAD)	GND	Power and dissipation ground

2. IP Series Products List

Power Bank IC

IC Part No.	Charge /Discharge		Features								Package	
	Charge	Dis-charge	LED Num	Lighting	Keys	I2C	DCP	USB C	QC Certificate	PD3.0	Package	Compatibility
IP5303	1.0A	1.2A	1,2	√	√	-	-	-	-	-	eSOP8	PIN2PIN
IP5305	1.0A	1.2A	1,2,3,4	√	√	-	-	-	-	-	eSOP8	
IP5306	2.4A	2.1A	1,2,3,4	√	√	-	-	-	-	-	eSOP8	
IP5206	2A(Max)	1.5A	3,4,5	√	√	-	-	-	-	-	eSOP16	PIN2PIN
IP5108E	2.0A	1.0A	3,4,5	√	√	-	-	-	-	-	eSOP16	
IP5108	2.0A	2.0A	3,4,5	√	√	√	-	-	-	-	eSOP16	
IP5207	1.2A	1.2A	3,4,5	√	√	-	-	-	-	-	QFN24	PIN2PIN
IP5207T	1.2A	1.2A	1,2,3,4	√	√	√	√	-	-	-	QFN24	
IP5109	2.1A	2.1A	3,4,5	√	√	√	-	-	-	-	QFN24	
IP5209	2.4A	2.1A	3,4,5	√	√	√	√	-	-	-	QFN24	
IP5219	2.4A	2.1A	1,2,3,4	√	√	√	√	√	-	-	QFN24	
IP5310	3.1A	3.0A	1,2,3,4	√	√	√	√	√	-	-	QFN32	
IP5312	15W	3.6A	2,3,4,5	√	√	√	√	-	-	-	QFN32	
IP5318Q	18W	4.0A	2,3,4,5	√	√	√	√	-	√	-	QFN40	PIN2 PIN
IP5318	18W	4.0A	2,3,4,5	√	√	√	√	√	√	-	QFN40	
IP5322	18W	4.0A	1,2,3,4	√	√	√	√	-	√	-	QFN32	
IP5328	18W	4.0A	1,2,3,4	√	√	√	√	√	√	-	QFN40	PIN2 PIN
IP5328P	18W	4.0A	1,2,3,4	√	√	√	√	√	√	√	QFN40	
IP5332	18W	4.0A	1,2,3,4	√	√	√	√	√	√	√	QFN32	

USB Charging Port Control IC

IC Part No.	Channel	Standards Supported											Package
		BC1.2 & APPLE	QC3.0 & QC2.0	FCP	SCP	AFC	SFCP	MTK PE+ 2.0&1.1	USB C	NTC	QC Certi-ficate	PD3.0	
IP2110	1	√	-	-	-	-	-	-	-	-	-	-	SOT23-5
IP2111	1	√	-	-	-	-	-	-	-	-	-	-	SOT23-6
IP2112	2	√	-	-	-	-	-	-	-	-	-	-	SOT23-6
IP2161	1	√	√	√	-	√	√	-	-	-	√	-	SOT23-6
IP2163	1	√	√	√	-	√	√	√	-	√	√	-	SOP8
IP2701	1	√	√	√	-	√	√	-	√	-	-	-	SOP8
IP2703	1	√	√	√	-	√	√	√	√	√	-	-	DFN10

IP2705	**1**	**√**	**√**	**√**	**-**	**√**	**√**	**√**	**√**	**√**	**-**	**-**	DFN12
IP2707	**2**	**√**	**√**	**√**	**-**	**√**	**√**	**√**	**√**	**√**	**-**	**-**	QFN16
IP2716	**1**	**√**	**√**	**√**	**√**	**√**	**-**	**1.1**	**√**	**-**	**√**	**√**	QFN32

3. Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input Voltage Range	V_{IN}, V_{BUS}	-0.3 ~ 16	**V**
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Thermal Resistance (Junction to Ambient)	θ_{JA}	26	℃**/W**
ESD (Human Body Model)	ESD	4	**KV**

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

*Voltages are referenced to GND unless otherwise noted.

4. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}, V_{BUS}	4.5	5	14	V
Battery Voltage	Vbat	3.0	3.7	4.5	V

*Devices' performance cannot be guaranteed when working beyond those Recommended Operating Conditions.

5. Electrical Characteristics

Unless otherwise specified, TA=25℃， L=2.2uH

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input voltage	V_{IN} V_{BUS}		4.5	5/7/9/12	13	V
Input Over Voltage	V_{IN} V_{BUS}		13	14	15	V
Constant Charge Voltage	V_{TRGT}	R_{VSET} = NC	4.16	4.2	4.24	V
		R_{VSET} = 120k	4.31	4.35	4.39	V
		R_{VSET} = 68k	4.36	4.4	4.44	V
		R_{VSET} = 10k	4.46	4.5	4.54	V
Charge Current	I_{CHRG}	VIN =5V, input current		2.0		A

		VBUS =5V, input current		2.6		A
		VIN or VBUS >=7V, input power		18		W
Trickle Charge Current	I_{TRKL}	VIN=5V， BAT<1.5V	50	100	150	mA
		VIN=5V， 1.5V<=BAT<3.0V	100	250	400	mA
Trickle Charge Stop Voltage	V_{TRKL}		2.9	3	3.1	V
Charge Stop Current	I_{STOP}		200	300	400	mA
Recharge Voltage Threshold	V_{RCH}		4.08	4.1	4.13	V
Charge Safety Time	T_{END}		20	24	27	Hour
Boost System						
Battery operation voltage	V_{BAT}		3.0		4.5	V
Battery input current	I_{BAT}	VBAT=3.7V，VOUT=5.1V，fs=375KHz	3	5		mA
DC output voltage	QC2.0 V_{OUT}	V_{OUT}=5V@1A	4.95	5.12	5.23	V
		V_{OUT}=9V@1A	8.75	9	9.25	V
		V_{OUT}=12V@1A	11.75	12	12.25	V
	QC3.0 V_{OUT}	@1A	4.95		12.25	V
	QC3.0 Step			200		mV
Output voltage ripple	ΔV_{OUT}	VBAT=3.7V，VOUT=5.0V，fs=375KHz		100		mV
Boost output current	I_{out}	V_{OUT}=5V		3.1		A
		V_{OUT}=9V		2.0		A
		V_{OUT}=12V		1.5		A
Boost efficiency	η_{out}	V_{BAT}=3V，V_{OUT}=5V，I_{OUT}=2A		95		%
		V_{BAT}=3V，V_{OUT}=9V，I_{OUT}=2A		92		%
		V_{BAT}=3V，V_{OUT}=12V，I_{OUT}=1.5A		90.8		%
Boost overcurrent shut down threshold	I_{shut}	VBAT=3.7V, 10mohm sample resistor at output	3.5	3.8	4.0	A
Load overcurrent detect time	T_{UVD}	Duration of output voltage under 4.2V		30		ms
Load short circuit detect time	T_{OCD}	Duration of output current above 4.2A	150		200	us
Control System						

Switch frequency	fs	Discharge switch frequency	325	375	425	KHz
		Charge switch frequency	450	500	550	KHz
NMOS on resistance	r_{DSON}	Upper NMOS		9	11	mΩ
NMOS on resistance		Lower NMOS		9	11	mΩ
VREG output voltage	V_{REG}	VBAT=3.7V	3.2	3.3	3.4	V
Battery port standby current	I_{STB}	VIN=0V, VBAT=3.7V, average current		100		uA
LDO output current	I_{LDO}		20	30	40	mA
LED light driving current	I_{WLED}		10	15	20	mA
LED display driving current	I_{L1} I_{L2} I_{L3}	Voltage decrease 10%	5	7	9	mA
Light load shut down detect time	$T1_{load}$	Total load power lower than 300mW	25	32	44	s
Output port light load shut down detect time	$T2_{load}$	Duration of voltage drop from VSN to VOUT (or VBUS) less than 1.8mV		$T1_{load}/2$		s
Short press on key wake up time	$T_{OnDebounce}$		60		500	ms
Time of WLED turn on	$T_{Keylight}$		1.2	2	3	s
Thermal shut down temperature	T_{OTP}	Rising temperature	130	140	150	℃
Thermal shut down hysteresis	ΔT_{OTP}			40		℃

6. Function Description

Low power lock out and activation

When the first time IP5332 accesses to the battery, whatever the battery voltage is, IC is in lock out state, and the lowest position LED of the battery level indicators will flash 4 times. If the battery voltage is too low to trigger the low power shutdown at no charging state, IP5332 will enter lock out state too.

Under the lock out state, IP5332 do not support plug in detection or key press activation to decrease the static power. During which, key press action will not trigger boost output, but battery level indicator LED will flash 4 times.

Under the lock out state, only entering charging status can activate IP5332's full function.

Charge

IP5332 integrates a constant current and constant voltage Li battery charging management system with synchronous switch. It can automatically match different charging voltage.

When the battery voltage is lower than 3V, trickle charging which is less than 250mA is applied; when the battery voltage is higher than 3V, enters constant current charging stage, and the maximum charging current at battery port is 5.0A; when the battery voltage is closed to the preset battery voltage, enters constant voltage charging stage; when the charging current is less than 300mA and battery voltage is closed to the constant voltage charging stage, the charging process is stopped. After the charging process is accomplished, battery charging stage will be restarted once the battery voltage falls lower than 4.1V.

IP5332 adopts switch charging technology, and switch frequency is 500kHz. With 5V input voltage, maximum input power is 10W; during the fast charging state, maximum input power is 18W. The highest charging current is up to 5.0A with 94% charging efficiency, such can reduce 3/4 charging time.

IP5332 can adjust charge current automatically applicable to adaptors with different load capacity.

IP5332 supports charging the battery and phone at the same time with 5V input/output voltage.

Boost

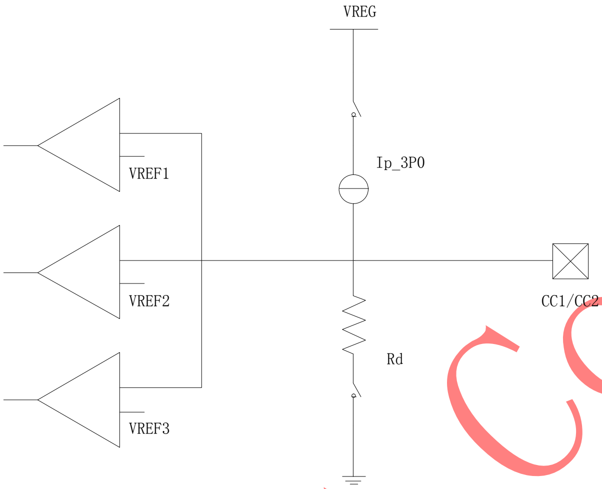
IP5332 integrates a synchronous switch converter which supports 5V~12V voltage output. Load capacity is 5V—3.1A，7V—2.4A，9V—2.0A，12V—1.5A. Switch frequency is 375KHz. In avoid of large rush current causing device failure at start up stage, soft start is built-in. Integrates over current, short circuit, over voltage and over temperature protection function, to make insurance of the system stability and reliability.

Output current of Boost system can be auto-modulated according to the temperature, ensuring the IC is under the preset temperature.

USB C

IP5332 integrates USB C input and output identification, auto-switching the internal pull-up and pull-down circuit on CC1 and CC2 by distinguishing the role of the attached device. Supports Try.SRC function, when the attached device is DRP device, IP5332 will take precedence to supply power for the attached device .

When work as DFP, the output current can be set at 3A capability; when work as UFP, the current capability from the opposite device can be detected .



Pull-up and pull-down ability:

Name	Value
Ip_3P0	330uA
Rd	5.1K

Comparator Threshold of pull-up Ip:

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		

Comparator Threshold of Pull-down Resistor Rd:

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	

USB C detects cycle:

Figure 4-36 DRP Timing

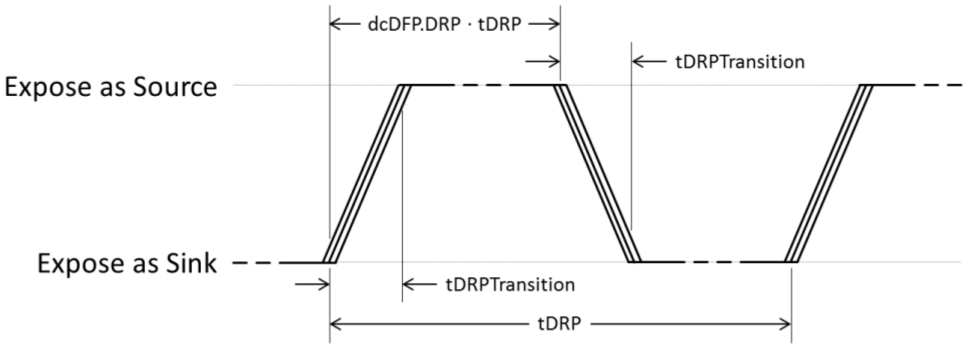
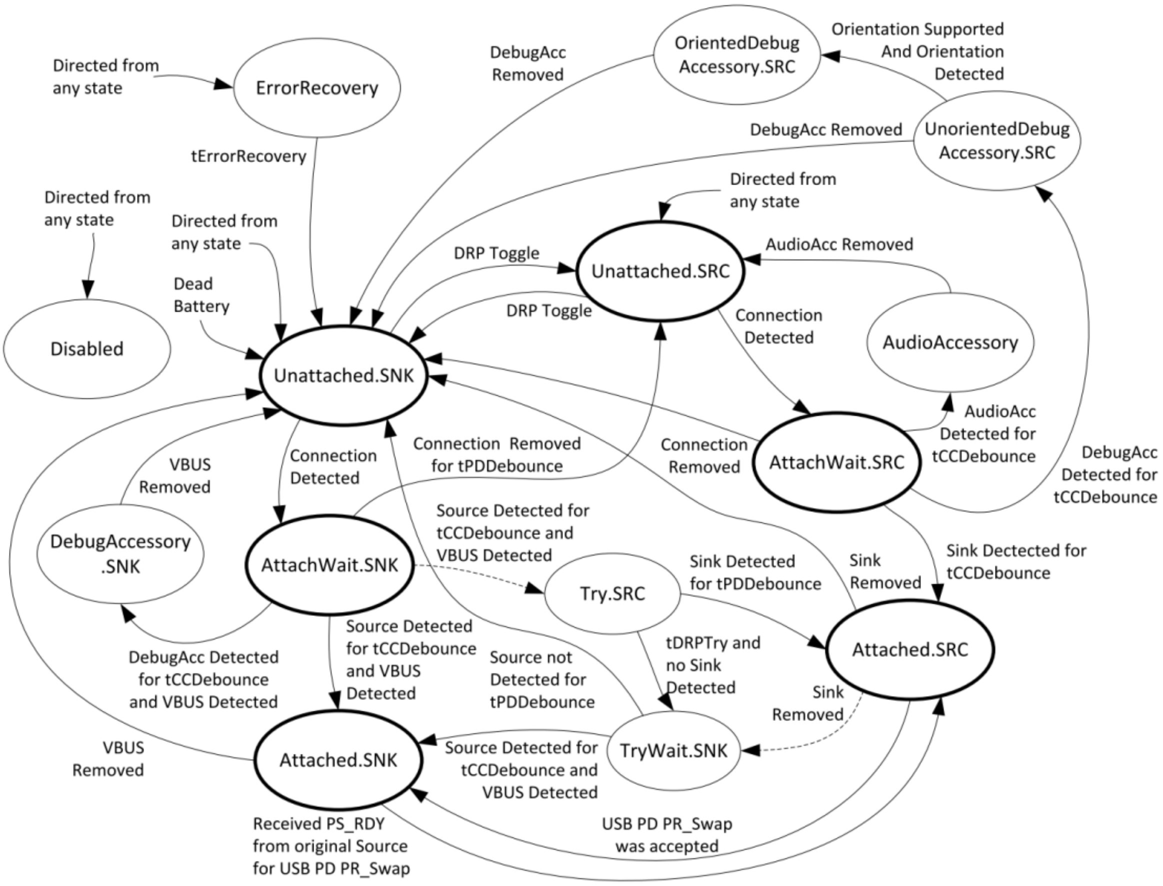


Table 4-21 DRP Timing Parameters

	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.

USB C detects state transition:

Figure 4-16 Connection State Diagram: DRP with Accessory and Try.SRC Support



USB C PD

IP5332 integrates USB C Power Delivery PD2.0/PD3.0 protocol, and integrates PHY and BMC modules.

Supports PD2.0/PD3.0 bidirectional input/output protocol. Input supports 5V, 9V, 12V voltage. Output supports 5V, 9V, 12V voltage by broadcasting capacity 5V 2.4A, 9V 2.0A, 12V 1.5A. Supports 18W output.

Fast Charge

IP5332 supports several fast charge standards: QC2.0/QC3.0, FCP, AFC, SFCP, MTK, Apple, Samsung.

QC2.0, QC3.0 and MTK are not supported when charging Power Bank, and external quick-charging protocol IC is not supported.

Charging Power Bank can support FCP and AFC. Since FCP and AFC request fast charging handshake through DP/DM, external fast charging protocol IC can no longer support fast charging of FCP and AFC.

When IP5332 enters discharge mode, it will detect the fast charge type and request on DP/DM, which supports fast charge of QC2.0/QC3.0, FCP, AFC, SFCP, MTK, and Apple 2.4A mode, Samsung 2.0A mode and BC1.2 1.0A mode.

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

For Samsung 2.0A mode: DP=DM=1.2V.

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

In BC1.2 mode, when the DP voltage is detected in the range of 2V~0.325V for 1.25s, quick charge will be initially determined, then the short status between DP and DM will be disconnected, and DM pull-down 20kOhm to GND at the same time. After which, if the DP voltage is in the range of 2V~0.325V and DM lower than 0.325V in the following 2ms, quick charge handshake is accomplished successfully. Then QC2.0/QC3.0 device can request for desired voltage according to the QC standards. Any time DP lower than 0.325V will force to exit the quick charge mode, the ouput voltage will fall back to default 5V.

QC2.0/QC3.0 output voltage request rule:

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	sustain

Continuous mode is supportsed by QC3.0. Voltage can be adjusted by 0.2V/step according to QC3.0 request under the continuous mode.

Charge and Discharge Path Management

Standby:

If VIN or VBUS is attached to charge, IP5332 will start the charging process directly.

If USB C UFP device is attached on VBUS or sink device is attached on VOUT port, IP5332 will start discharge function automatically.

If key is pressed, whether or not load is on VOUT port, VOUT port output will be force to open; but USB C port will open only when load is detected on the port, or else the output will be closed.

Discharge:

If key is not pressed, only when sink device attached will the output port open, non-attached output port will not open. If the opened output port current is less than 180mA @ 10mOhm, it will wait for a period of time before close the port automatically. The output current is detected by the voltage drop between VSN to output, 180mA current is equivalent to 1.8mV on 10mOhm, when the resistance (including MOSFET internal resistance) between VSN and ouput is larger than 10mOhm, the current threshold will be decreased proportionally.

When only VOUT port output is turned on, a single short press of the key has no effect. When USB C port output is on and in non-quick charge mode, single short press key can force VOUT port to be opened. When USB C port output is turned on and in quick charge mode, the first short press button will turn off the quick charge function of USB C output, and the second short press button will force the VOUT output to be turned on. The interval between the two short press should be longer than 1s, otherwise the forced shutdown function will be triggered.

Any one of the VOUT or USB C port supports the fast charge standards separately. But due to the single inductor design, only under single port opened situation fast charge is allowed. Two or more output ports open at the same time, fast charge will be disabled automatically.

According to ‘Typical Application Diagram’, when one port is already in fast charge mode, if sink device is attached on another port (key press action is equal to VOUT load attached), all the output port together with the fast charge mode will be disabled firstly. Then open the ports with sink device attached, after which all the ports only support Apple, Samsung and BC1.2 mode. If the sink devices decreased from multiple to one and keep this situation for 8s, all the output ports will be closed firstly, and then the high voltage fast charge function is enabled. Then the output port of the only one sink device attached will be opened, such that will re-activate the sink device to send fast charge request . When only one port is opened and the charging power is lower than 300mW for 32s, the output port and discharge function will be closed and the system enters low standby mode.

Charging:

Either VIN port or VBUS port can be plugged in for charging. If both are plugged in at the same time, the first plugged in power supply will be given priority for charging.

If an external input fast-charging protocol IC is needed to be added, two back-to-back PMOS should be used for partition control for the input port of the input fast-charging protocol chip, so as to prevent the high-voltage charging port from flowing back to the ordinary charging port when the two ports are simultaneously plugged in for charging.

In the single charging mode, the quick charge mode of the power supply will be automatically identified, and the appropriate charging voltage and current will be automatically matched.

Charging and discharging at the Same Time:

When the charging power supply and sink device are attached at the same time, IP5332 will charge the battery and sink device at the same time. Under this mode, IP5332 will disable the input fast charge function. When VSYS is only 5V, the discharge path will be enabled for the sink device. If the VSYS voltage is higher than 5.8V, for safety consideration, the discharge path will be disabled. To make insurance of the normal charging and high priority of charging the sink device, IP5332 will reduce the charging current to around 500mA and increase the charging under voltage threshold to 4.9V.

During the process of charging and discharging at the same time, if the input charging power supply is unplugged, IP5332 will disable the input charging function and restart the discharging function for the sink device. For safety consideration and to re-activate the sink device to send fast charge request, the voltage will fall to 0V during this conversion process.

During the process of charging and discharging at the same time, if the sink device is unplugged or the sink device stop to sink current for 8s, the discharging path will be closed automatically. When all the discharging paths are disabled and return to single port charging state, the under voltage threshold will be decreased, and fast charge for the power bank will be auto re-activated.

Auto detection on sink device

Auto detection on sink device/phone attachment:

IP5332 supports auto detection on sink device/phone attachment/ plug in. Once the attachment is detected, the boost will be turned on charging the sink device/phone, so non-key solution are supportsed.

Auto detection on sink device/phone fully charged:

IP5332 detects the output current through off-chip 10mOhm resistor. When the total power is lower than 300mW for 32s, all output phones are considered to have been filled or pulled out, and the boost output will be automatically closed.

Key

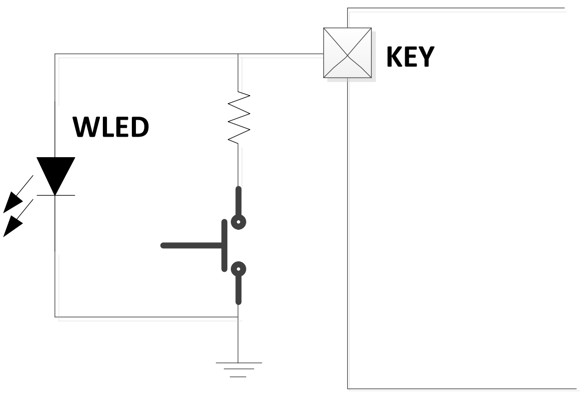


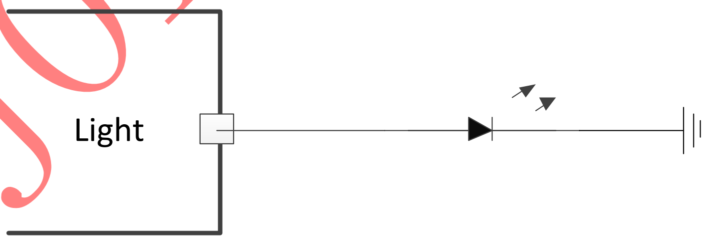
Figure 3 Key circuit

Key circuit is illustrated in Figure 3, which can recognize short press or long press operation.

- Short press (pressed time in range of 60ms~2s): turn on the battery level display LED and BOOST output.
- Long press (pressed time longer than 2s): turn on or turn off the torch light WLED.
- No response on press time less than 30ms.
- Two short press in 1s: turn off boost output, battery level display LED and torch light WLED.
- Long 10s press will reset the whole system.

Fast Charge state indication

Light can indicate the current fast charging mode, no matter charging or discharging. When entering the fast charging mode and in the state of non-5V, the indicator will automatically light up.



Coulombmeter and battery level display

IP5332 built-in coulombmeter, can achieve accurate battery calculation without measuring the current on the BAT.

IP5332 supports automatic selection of 4, 3, 2 and 1 LED mode.

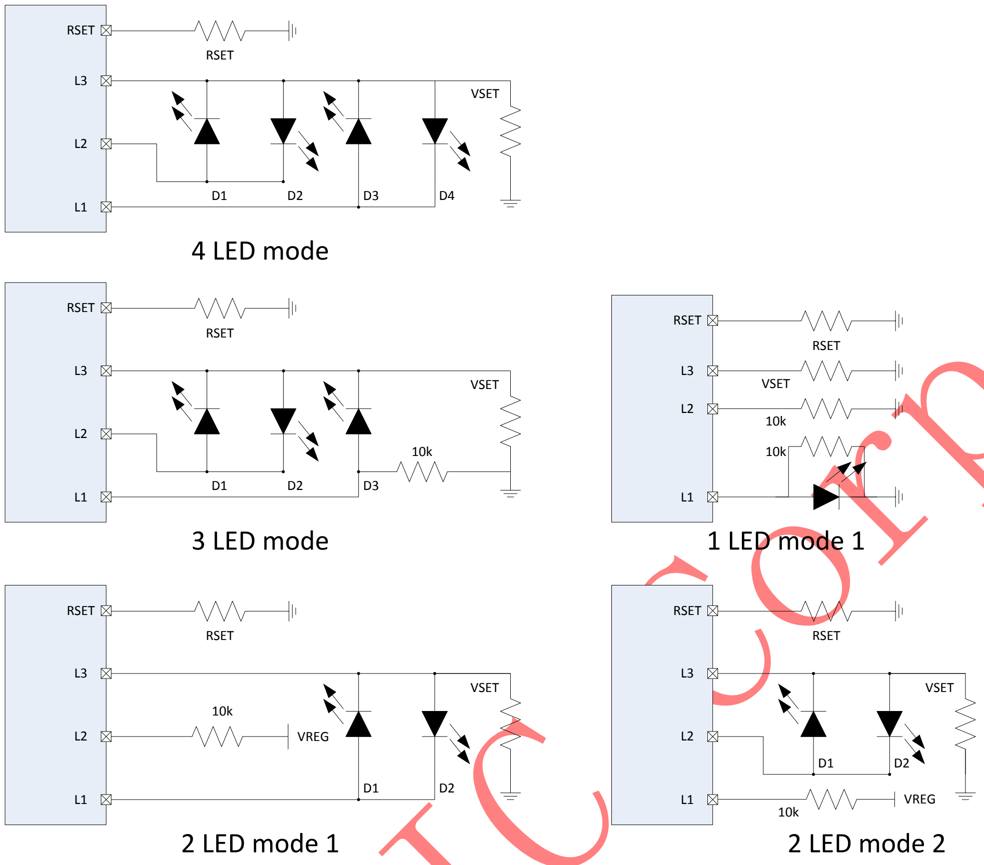


Figure 4 1/2/3/4 LED circuit

4 LED display:

During charging:

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

During discharging:

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

3 LED display:

During charging:

Battery capacity (C) (%)	D1	D2	D3
Fully charged	ON	ON	ON
66%≤C	ON	ON	1.5Hz Flash
33%≤C＜66%	ON	1.5Hz Flash	OFF
C＜25%	1.5Hz Flash	OFF	OFF

During discharging:

Battery capacity (C) (%)	D1	D2	D3
C≥66%	ON	ON	ON
33%≤C＜66%	ON	ON	OFF
3%≤C＜33%	ON	OFF	OFF
0%＜C＜3%	1.0Hz Flash	OFF	OFF
C=0%	OFF	OFF	OFF

2 LED display mode 1 is bi-color LED:

During charging:

Battery capacity (C) (%)	D1	D2
Fully charged	OFF	ON
66%≤C＜100%	OFF	1.5Hz Flash
33%≤C＜66%	1.5Hz Flash	1.5Hz Flash
C＜33%	1.5Hz Flash	OFF

During discharging:

Battery capacity (C) (%)	D1	D2
66%≤C＜100%	OFF	ON
33%≤C＜66%	ON	ON
C＜33%	ON	OFF
C＜3%	1.0Hz Flash	OFF

2 LED mode 2 display:

Charging: D1 LED flash on cycle of 2s (1s on and 1s off). When fully charged, constantly on.

Discharging: D2 LED is constantly on. When voltage lower than 3.2V, flash on cycle of 1s (0.5s on and 0.5s off). When voltage is lower than 3.0V, system powers down.

1 LED mode 1 display:

Charging: LED flash on cycle of 2s (1s on and 1s off). When fully charged, constantly on.
Discharging: LED is constantly on, when voltage is lower than 3.2V, flash on cycle of 1s (0.5s on and 0.5s off). When voltage is lower than 3.0V, system powers down.

VSET (battery type set)

IP5332 can set the battery type through the VSET pin, so as to change the display threshold of electric quantity, the constant voltage to charge the battery and the protection voltage. The VSET resistance and battery type are shown in the following table:

VSET resistor (Kohm)	Battery type
NC	4.2V
120	4.35V
68	4.4V
10	4.5V

NTC

IP5332 integrated NTC function, can detect the battery temperature; When IP5332 is working, the NTC PIN outputs the current of 20uA, and the voltage of the NTC PIN is detected to determine the current battery temperature.

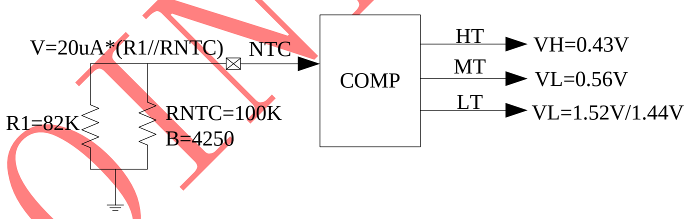


Figure 5 Battery NTC comparator

Under charging state:

Voltage on NTC pin is 1.44V meaning the battery temperature is low -10 centigrade, stop charging the battery.

Voltage on NTC pin is 0.56V meaning the battery temperature is medium 45 centigrade, charging current half down.

Voltage on NTC pin is 0.43V meaning the battery temperature is high 55 centigrade, stop charging the battery.

Under discharging state:

Voltage on NTC pin is 1.52V meaning the battery temperature is low -20 centigrade, stop discharging.

Voltage on NTC pin is 0.43V meaning the battery temperature is high 55 centigrade, stop discharging.

* The above temperature range refers to murata NTC resistance NXRS15WF104FA3A016 (B=4250).

There are differences in other models, which need to be adjusted.

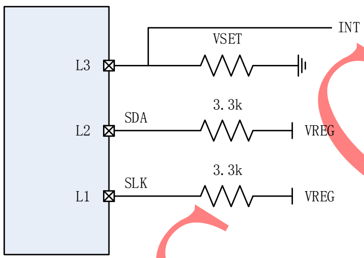
If NTC is not needed, NTC should serial a 51kOhm resistor to ground, do not float NTC or tie it to ground directly.

VREG

VREG is a normally opened 3.3V LDO with a load capacity of 30mA.

I2C

I2C connection:



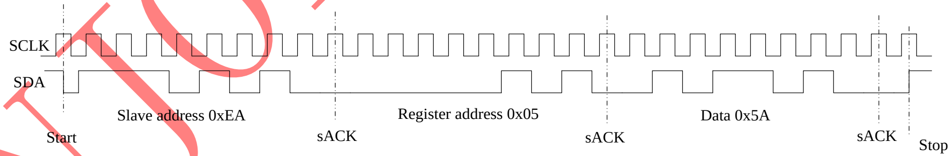
I2C model

Connection according to the corresponding way will automatically turn off the other Function, automatically enter the I2C mode. When connected to I2C mode, INT signal is in high resistance state when standby and high level state when working, which can be used to wake up MCU.

I2C mode supports 400Kbps, 8bits register address, 8bits register data. Sending and receiving are all in high order (MSB). I2C device address: write as 0xEA, read as 0xEB.

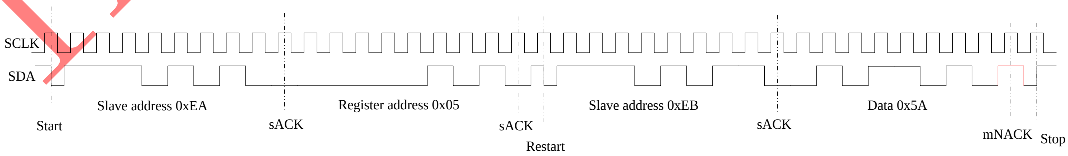
For example:

Writing 0x5A into 0x05 register:



I2C Write

Reading data from 0x05 register:



I2C Read

7. PCB Layout

Here below lists essential precautions that may affect the function and performance on PCB layout, more details will be attached in another document if any.

Location of VSYS capacitor

The power and current of the chip are large, and the position of capacitor in VSYS network will affect the stability of DCDC. The capacitance of VSYS network should be as close as possible to the VSYS pin and EPAD of IC, and copper coating should be carried out in a large area with more through holes, so as to reduce the area of current circulation between capacitor and IC to reduce parasitic parameters.

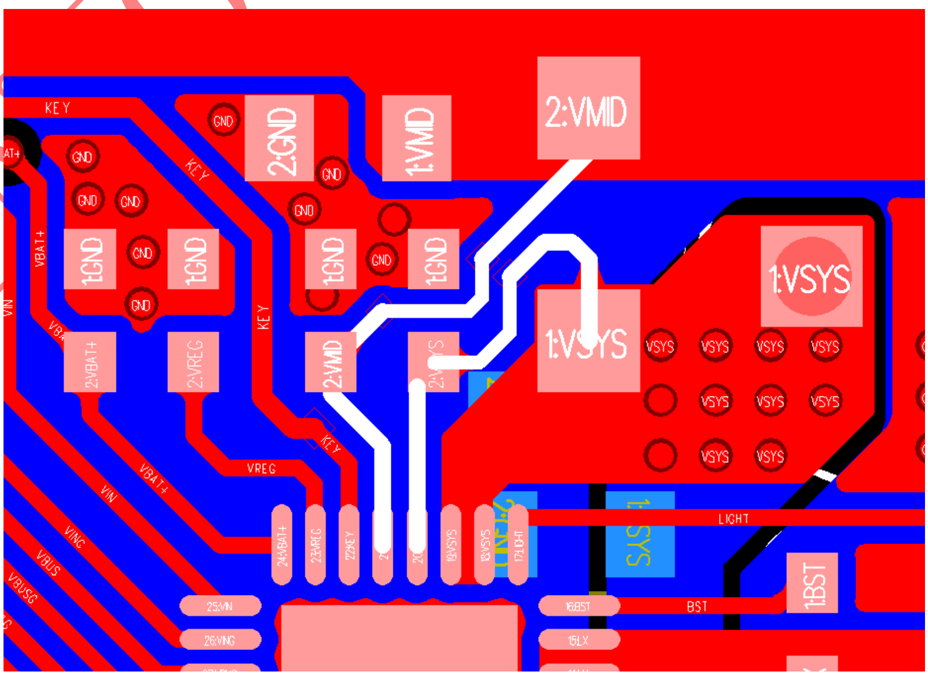
VSYS pins are distributed on both sides of the chip. Capacitors need to be placed on both sides of the pins nearby, and the VSYS pins on both sides are connected together by a wide copper coating (no less than 100mil) on the PCB.

10mOhm sample resistor

The IP5332 samples the current through the 10mOhm resistance by VSN and VSP pins, so as to control the input charging current, output overcurrent protection and output light load shutdown function. Therefore, when drawing PCB, the wiring requirements of VSN and VSP pins are relatively high. It is necessary to avoid the signal with large interference, and the wiring should be conducted to the inside of the two pads of the sampling resistance of 10mOhm independently, without any overlapping wiring with the path of VSYS and other current. Although VSP and VSYS are on the same network on PCB, the wiring of pins must be separated.

Filter capacitance of 100nF is required for VSN and VSP pins respectively, which should be placed as close to IC pins as possible to enhance anti-interference ability of sampling signal.

The layout is illustrated below:



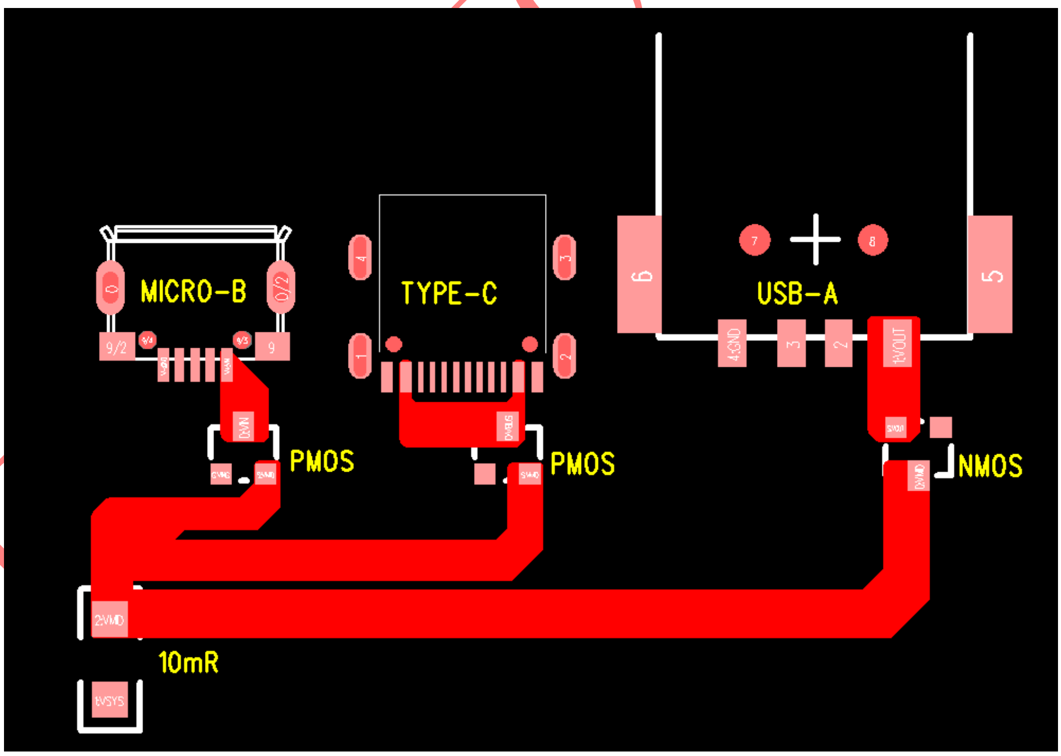
Layout from 10mOhm sample resistor to input/output MOSFET

Application example: mobile phone that do not support fast charging are plugged in VOUT, and mobile phone that supports fast charging is plugged in VBUS port. Due to multiple ports output at the same time, the system can only output 5V to charge two mobile phones at the same time. When the mobile phone on the VOUT is pulled out, or the power consumption is lower than the set value, the system will close the VOUT outlet, and then only keep the VBUS port output. In this case, the system can automatically restore the VBUS port quick charging function.

To realize the above automatic recovery quick charging function, it is necessary to accurately detect the output current on the VOUT port. The output current detection on the VOUT port is realized by detecting the voltage difference between VSN and VOUT pin. The threshold condition for closing the VOUT port is that the voltage difference is less than 1.8mV. Therefore, when there is no current on VOUT, no other current can flow through any section of the line from VSN to VOUT. Otherwise, once there is a current flowing through, the voltage difference will be formed, and it will be misjudged as the current flowing out of VOUT. The same principle applies to other output.

To sum up, PCB wiring from 10mOhm to VOUT, from 10mOhm to VBUS, from 10mOhm to VIN needs to be wired separately at 10mOhm. Any two wiring lines flowing in the same direction should not overlap, otherwise the automatic recovery and quick charging function described in the "application example" will be invalid, which may be sometimes or sometimes not.

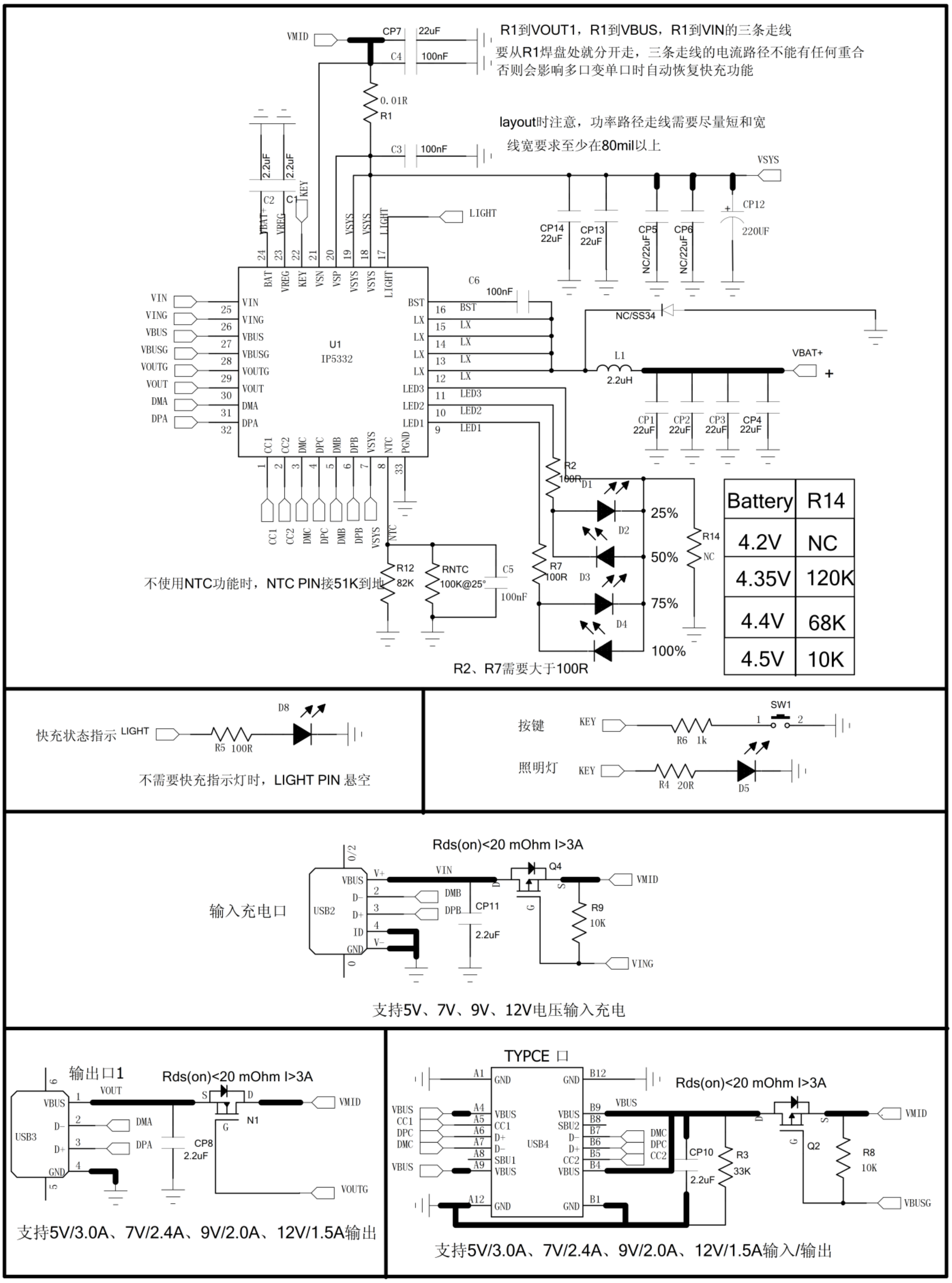
The layout example is demonstrated below:



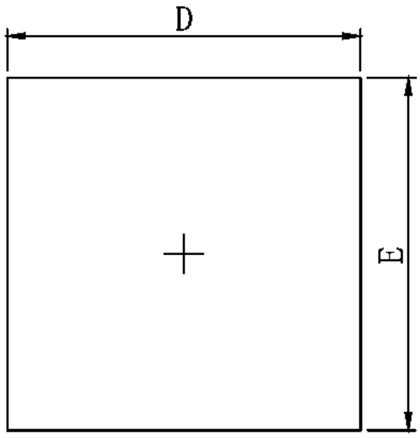
If the wrong Layout leads to 1 milliohm coincident wiring of VOUT and VBUS output current, when there is 2A current output on VBUS, 1 milliohm coincident wiring will produce a voltage difference of 2mV. In this case, even if the device on VOUT is pulled out, it cannot be judged that the device on VOUT has been pulled out, and the quick charging function of VBUS output cannot be restored. It is necessary to wait for the current at the VBUS outlet to be less than 1.8A, and the voltage difference generated by the overlapping 1-milliohm line to be less than 1.8mV for 16ms before the quick charging function of the VBUS outlet can be automatically restored.

8. Typical Application Diagram

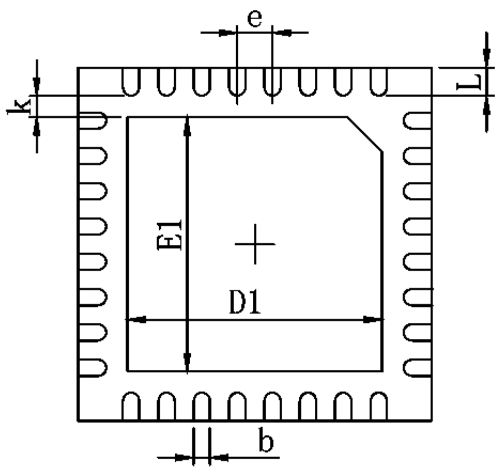
Total solution of fast charge power bank is realized by merely passive devices of MOSFET, inductor, capacitor and resistor.



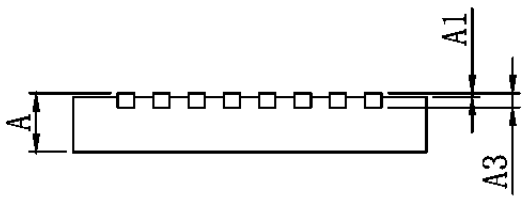
9. Package



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	4.924	5.076	0.194	0.200
E	4.924	5.076	0.194	0.200
D1	3.300	3.500	0.130	0.138
E1	3.300	3.500	0.130	0.138
k	0.200MIN.		0.008MIN.	
b	0.200	0.300	0.008	0.012
e	0.500TYP.		0.020TYP.	
L	0.324	0.476	0.013	0.019

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