

Support High Voltage SCP、Bi-directional PD3.0 and Fast Charge protocol Power Bank SOC

1 Features

- **Support multiple ports simultaneously**
 - AABC scheme
 - ✧ 1 USB C input / output port
 - ✧ 2 USB A output ports
 - ✧ 1 USB B input port
- AACL scheme
 - ✧ 1 USB C input / output port
 - ✧ 2 USB A output ports
 - ✧ 1 Lightning input port
- ABCL scheme
 - ✧ 1 USB C input / output port
 - ✧ 1 USB A output ports
 - ✧ 1 USB B input port
 - ✧ 1 Lightning input port
- **Fast charge**
 - ✧ Support 5V、9V、12V voltage input / output
 - ✧ Support QC2.0 / QC3.0 output
 - ✧ Support FCP input / output
 - ✧ Support AFC input / output
 - ✧ Support 10V@2.25A high voltage SCP output
 - ✧ Support USB C DRP input / output
 - ✧ Support BC1.2 / Apple / Samsung
- **Integrated USB PD2.0 / PD3.0 protocol**
 - ✧ Support PD2.0 input / output protocol
 - ✧ Support PD3.0 input / output and PPS output protocol
 - ✧ PPS support 3.3V~11V adjustable voltage with 20mV / Step
 - ✧ Integrate BMC protocol
 - ✧ Integrate Physical Layer protocol
 - ✧ Integrate hardware CRC
 - ✧ Support Hard Reset
- **Charger**
 - ✧ Support 18W charging power, Up to 5.0A charging current at battery port
 - ✧ Adaptive charging current adjustment

- ✧ Support 4.20V、4.30V、4.35V、4.40V battery
- **Boost**
 - ✧ Output current:
 - ✧ 5V@3.1A 9V@2.22A 12V@1.67A
 - ✧ Up to 95%@5V@2A efficiency with synchronous switching
 - ✧ Support line compensate
- **Battery level display**
 - ✧ Support 4 LED battery level indicator
- **Others**
 - ✧ Support auto detect of plug in and out
 - ✧ Fast charge status indicator
 - ✧ Enter standby mode automatically in light load
 - ✧ Support Battery NTC
 - ✧ Integrated torch-light driver
 - ✧ Support I2C interface
- **Multiple protection,high reliability**
 - ✧ Input overvoltage and undervoltage protection
 - ✧ Output overcurrent, overvoltage and short circuit protection
 - ✧ Battery overcharge, over discharge and overcurrent protection
 - ✧ Over temperature protection
 - ✧ Input / Output battery temperature protection
 - ✧ 4kV ESD
- **Low BOM cost**
 - ✧ Integrated switch power MOSFET
 - ✧ Single inductor for charging and discharging
- **Package size: 6mm x 6mm 0.5pitch QFN40**

2 Applications

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

3 Description

IP5353 is a power management SOC. It integrates QC2.0/ QC3.0/SCP output fast charging protocol, FCP/ AFC input and output fast charging protocol, USB C/PD2.0/PD3.0 input and output protocol, USB C PD3.0 PPS output protocol, and BC1.2/Apple/ Samsung mobile phone charging protocol. It integrates the functions of synchronous up / down converter, lithium battery charging management, battery power indication, etc. to provide a complete power solution for fast charging mobile power bank. Any single USB port can support fast charging. When two or more output ports are used at the same time, only 5V is supported.

Only one inductor is needed to realize the function of buck and boost, and only a few peripheral devices are needed in the application, which effectively reduces the size of the overall PCB and reduces the cost of BOM.

The synchronous switch boost system of IP5353 can provide the maximum output capacity of 22.5W(10V@2.25A). When boost has no load, it will automatically enter the sleep mode.

IP5353 charger provides 18W charging power and charging current up to 5.0A. Built in IC temperature, battery temperature and input voltage control loop, intelligent regulation of charging current.

IP5353 supports 4LED battery level indicator. IP5353 supports lightning function and supports buttons.

IP5353 supports I2C control interface.

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4 Reversion History

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

First Release V1.00 (July 2022)

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Modified version V1.00 (Jul 2022) to V1.01 (Aug 2022)

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5 Simplified Application

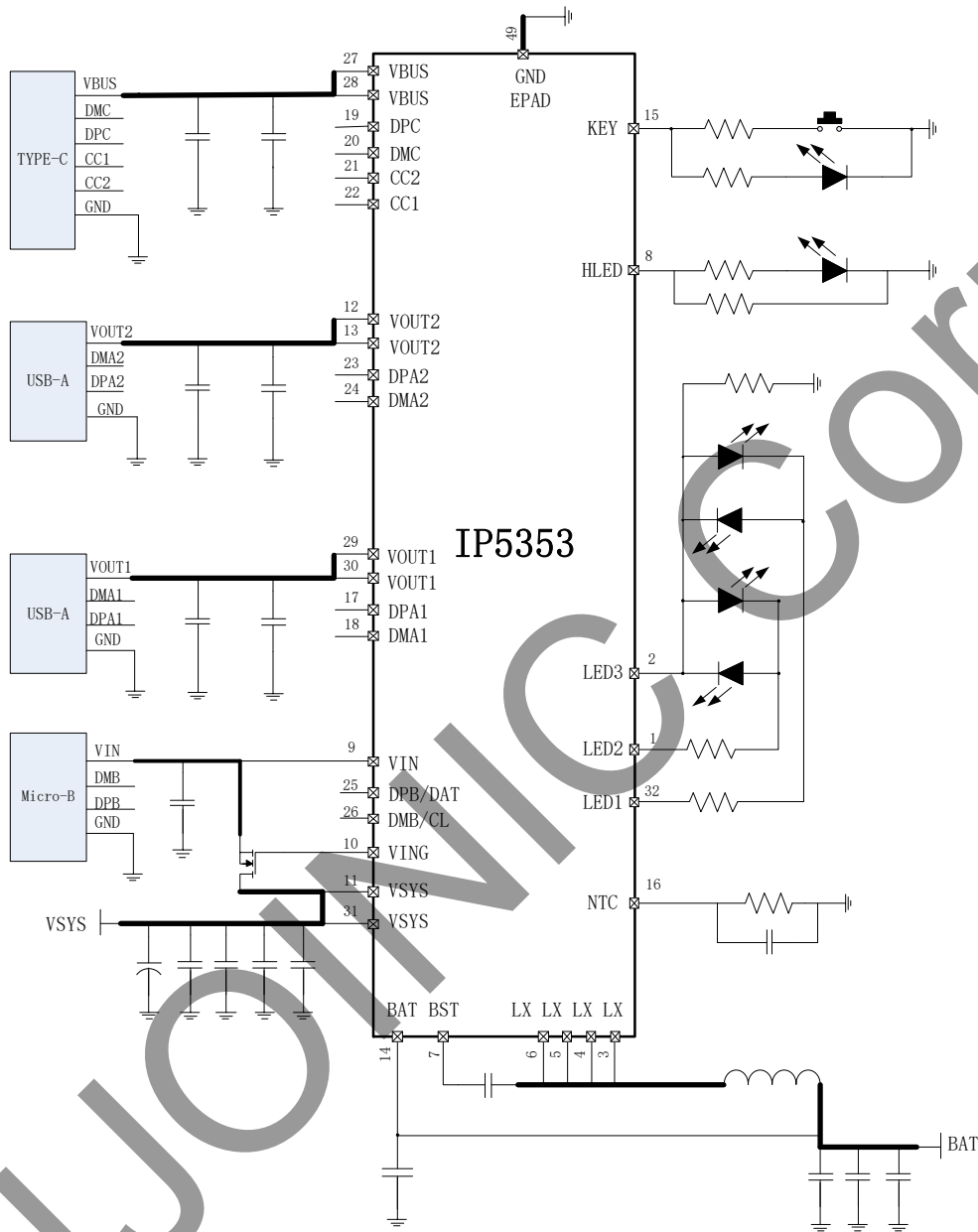


Figure 1 Simplified Application

6 IP Series Products List

6.1 Power Bank IC

IC Part No.	boost / charge		Main feature								Package	
	boost	charge	LED number	light	key	I2C	DCP	US B C	QC Certificate	PD3.0 /PPS	Package	Compatibility
IP5303T	1.0A	1.2A	1,2	√	√	-	-	-	-	-	ESOP8	
IP5305T	1.0A	1.2A	1,2,3,4	√	√	-	-	-	-	-	ESOP8	PIN2
IP5306	2.4A	2.1A	1,2,3,4	√	√	√	-	-	-	-	ESOP8	PIN
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	PIN2
IP5209	2.4A	2.1A	3,4,5	√	√	√	√	-	-	-	QFN24	PIN
IP5209U	2.4A	2.1A	3,4,5	√	√	√	√	-	-	-	QFN24	
IP5207T	1.2A	1.2A	1,2,3,4	√	√	√	√	-	-	-	QFN24	PIN2
IP5189T	2.1A	2.1A	1,2,3,4	√	√	√	√	-	-	-	QFN24	PIN
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 Tube	√	√	-	√	√	√	√	QFN40	
IP5568	22.5W	5.0A	Nixie Tube	√	√	-	√	√	√	√	QFN64	
IP5353	22.5W	5.0A	4	√	√	-	√	√	√	√	QFN32	
IP5389	100W	8.0A	Nixie Tube	√	√	-	√	√	√	√	QFN64	
IP5386	45W	8.0A	1,2,4	√	√	-	√	√	√	√	QFN48	

6.2 IP5353 Common Customized Model Description

IC Part No.	Function description
IP5353_AABC	Support AABC USB port
IP5353_AAACL	Support AAACL USB port
IP5353_ABCL	Support ABCL USB port
IP5353_LSCP_AABC	Enable the low-voltage SCP based on IP5353_AABC
IP5353_LSCP_AAACL	Enable the low-voltage SCP based on IP5353_AAACL

IP5353_LSCP_ABCL	Enable the low-voltage SCP based on IP5353_AACL
IP5353_I2C_AABC	Configured as I2C function, support AABC USB port
IP5353_I2C_AACL	Configured as I2C function, support AACL USB port

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7 Pin Configuration and Functions

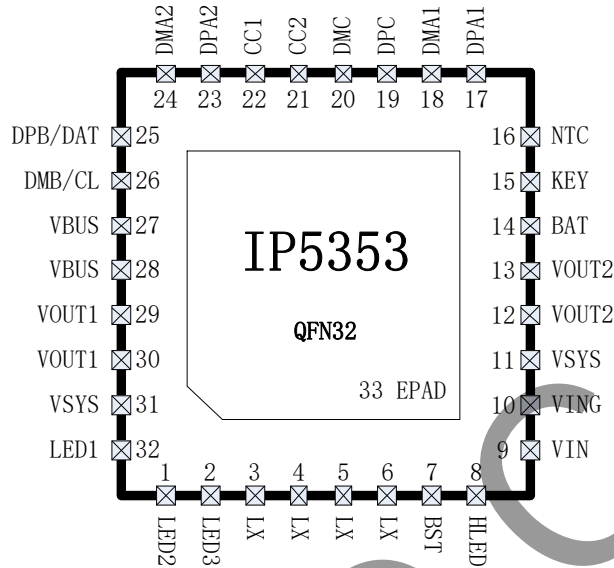


Figure 2 IP5353 Top View

7.1 IP5353 Pin Functions

PIN Num	PIN Name	PIN description
1	LED2	Battery level display drive pin LED2; I2C SDA
2	LED3	Battery level display drive pin LED3; reused as VSET and I2C INT functions
3、4、5、6	LX	DCDC switch node, connect to inductor
7	BST	Internal high voltage drive, serial capacitor to LX
8	HLED	Fast charge mode indicator
9	VIN	VIN power pin
10	VING	Used to control input path NMOS of VIN port
11、31	VSYS	Public Node of system power input and output
12、13	VOUT2	VOUT2 output port power pin
14	BAT	Battery supply pin
15	KEY	Key detect pin, reused as WLED torch light function.
16	NTC	NTC pin
17	DPA1	VOUT1 port DP pin
18	DMA1	VOUT1 port DM pin
19	DPC	VBUS port DP pin
20	DMC	VBUS port DM pin

21	CC2	VBUS CC2 pin
22	CC1	VBUS CC1 pin
23	DPA2	VOUT2 port DP pin
24	DMA2	VOUT2 port DM pin
25	DPB/DAT	VIN port DP pin or Lightning decoding pin
26	DMB/CL	VIN port DM pin or Lightning port detection and fast charging communication pin
27、28	VBUS	USB Type-C port power pin
29、30	VOUT1	VOUT1 output port power pin
32	LED1	Battery level display drive pin LED1; I2C SCK
33 (EPAD)	GND	GROUND

8 Functional Block Diagram

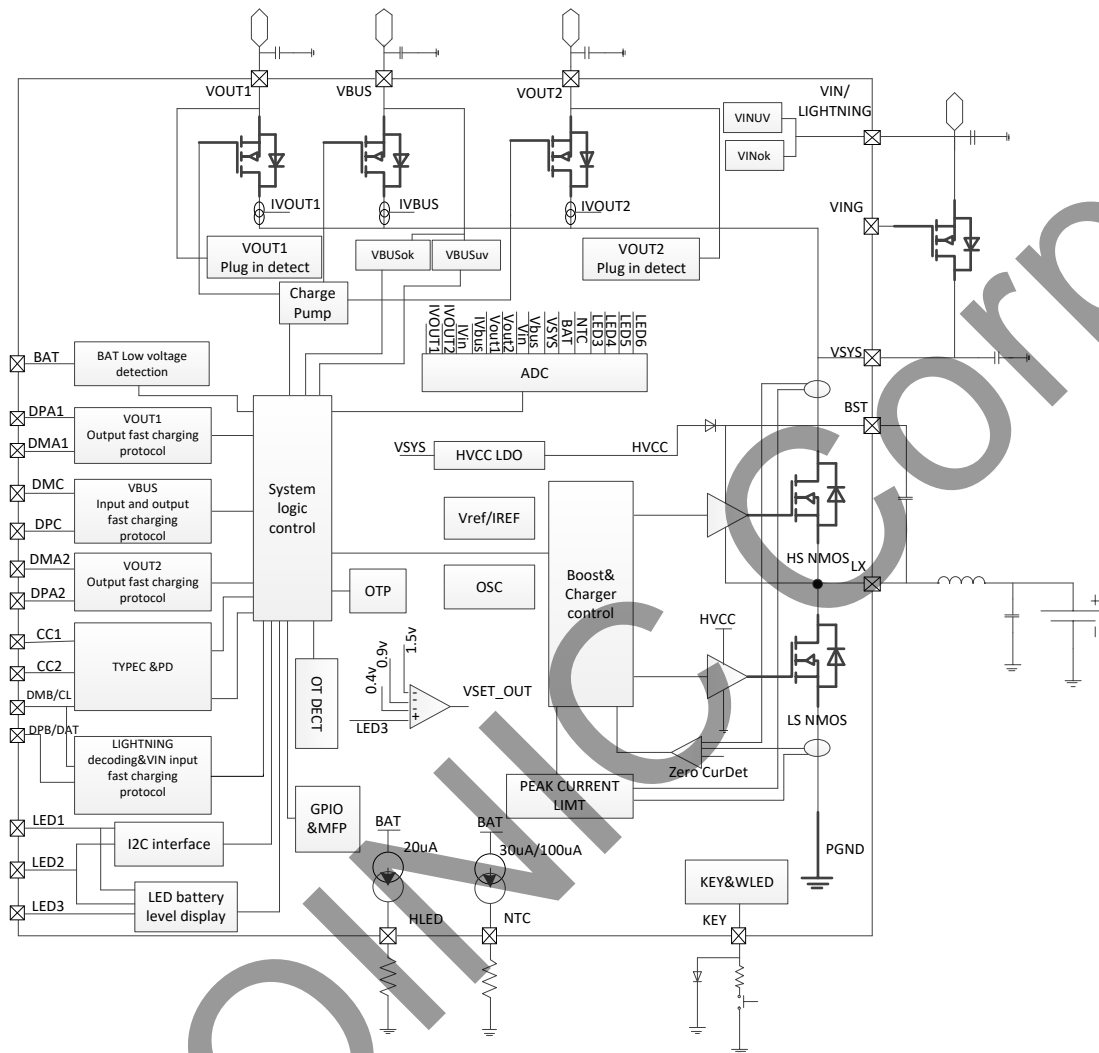


Figure 3 Functional Block Diagram

9 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	°C
Storage Temperature Range	T_{stg}	-60 ~ 150	°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	35	°C / 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.

10 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}, V_{BUS}	4.5	5 / 9 / 12	13.0	V
Battery Voltage	Vbat	3.0	3.7	4.4	V

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

11 Electrical Characteristics

Unless otherwise specified, $T_A=25^{\circ}\text{C}$, $L=2.2\mu\text{H}$, $V_{BAT}=3.8\text{V}$

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input voltage	V_{BUS} / V_{IN}		4.5	5/9/12	13	V
Input Voltage Over	V_{BUS} / V_{IN}		13.0	13.5	14.0	V
Constant Charge Voltage	V_{TRGT}	4.20V	4.19	4.22	4.25	V
		4.30V	4.29	4.32	4.35	V
		4.35V	4.34	4.37	4.39	V
		4.40V	4.39	4.42	4.45	V
Charge Current	I_{CHRG}	$V_{IN}=5\text{V}$, battery current	2.0	2.4	2.8	A
		$V_{IN}=9\text{V}/12\text{V}$, battery current	3.8	4.4	5.0	A
		$V_{BUS}=5\text{V}$, input current	2.5	2.8	3.1	A
		$V_{BUS}=9\text{V}$, input current	1.7	2.0	2.3	A
		$V_{BUS}=12\text{V}$, input current	1.3	1.5	1.7	A
Trickle Charge Current	I_{TRKL}	$BAT < 2.5\text{V}$, input current	50	75	100	mA
		$2.5\text{V} \leq V_{BAT} < 3.0\text{V}$, input current	100	200	300	mA
Trickle Charge Stop Voltage	V_{TRKL}		2.9	3.0	3.1	V
Charge Stop Current	I_{STOP}		250	400	550	mA
Recharge Voltage Threshold	V_{RCH}		4.05	4.10	4.15	V
Charge Safety	T_{END}		20	24	27	Hour

Time						
Boost System						
Battery operation voltage	V_{BAT}		3.0		4.4	V
DC output voltage	QC2.0 V_{OUT}	$V_{OUT}=5V@1A$	4.95	5.05	5.15	V
		$V_{OUT}=9V@1A$	8.90	9.10	9.30	V
		$V_{OUT}=12V@1A$	11.90	12.10	12.30	V
	QC3.0 V_{OUT}	@1A	4.95		12.45	V
	QC3.0 Step			200		mV
Output voltage ripple	ΔV_{OUT}	$V_{BAT}=3.7V, V_{OUT}=5.0V, fs=350kHz$		100		mV
		$V_{BAT}=3.7V, V_{OUT}=9.0V, fs=350kHz$		150		mV
		$V_{BAT}=3.7V, V_{OUT}=12.0V, fs=350kHz$		200		mV
Boost output current	I_{out}	$V_{OUT}=5V$		3.1		A
		$V_{OUT}=9V$		2.22		A
		$V_{OUT}=12V$		1.67		A
Boost efficiency	η_{out}	$V_{BAT}=3.7V, V_{OUT}=5V, I_{OUT}=2A$		94		%
		$V_{BAT}=3.7V, V_{OUT}=9V, I_{OUT}=2A$		93		%
		$V_{BAT}=3.7V, V_{OUT}=12V, I_{OUT}=1.5A$		92		%
Boost overcurrent shut down threshold	I_{shut}	$V_{BAT}=3.7V, V_{OUT}=5V$	3.4	4.0	4.4	A
		$V_{BAT}=3.7V, V_{OUT}=9V$	2.25	2.60	2.90	A
		$V_{BAT}=3.7V, V_{OUT}=12V$	1.7	1.9	2.2	A
Output light load shutdown current	I_{load}	$V_{BAT}=3.7V$		80		mA
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 4.4A	150		200	μs
Control System						
Switch frequency	fs	Discharge switch frequency	300	350	400	kHz
		Charge switch frequency	300	350	400	kHz
NMOS on resistance	r_{DSON}	Upper NMOS		9	11	m Ω

NMOS on resistance		Lower NMOS		9	11	mΩ
Battery port standby current	I_{STB}	$V_{IN}=0V$, $V_{BAT}=3.7V$, average current		100		μA
LED light driving current	I_{WLED}	Voltage decrease 10%	10	15	20	mA
LED display driving current	I_{L1} I_{L2} I_{L3}		3			mA
Total load Light load shut down detect time	T_{1load}	The load current is consistently less than 80mA	25	32	44	s
Output port light load shut down detect time	T_{2load}		14	16	18	s
Short press on key wake up time	$T_{OnDebounce}$		60	100	200	ms
Time of WLED turn on	$T_{Keylight}$		1.2	2	3	s
Thermal shut down temperature	T_{OTP}	Rising temperature	130	140	150	°C
Thermal shut down hysteresis	ΔT_{OTP}			40		°C

12 Function Description

12.1 Low power lock out and activation

The first time IP5353 access to the battery, IC is in lock out state, battery level indicator LED will flash 5s; Under non-charging state, if the battery voltage is too low to trigger the low power shutdown, IP5353 will enter lock out state too.

In low battery state, to decrease the quiescent power, IP5353 do not support plug in detect function or key press activation function. During which, key press action will not trigger boost output, and battery level indicator LED will flash 5s.

Under the lock out state, only by entering charging status can activate IP5353 's full function.

12.2 Charge

IP5353 integrated a constant current and constant voltage Li battery charging management system with synchronous switch, adaptive to various charging voltage.

When the battery voltage is lower than 3V, trickle charging less than 200mA charging current is applied;

when the battery voltage is higher than 3V, enters constant current charging stage, the maximum charging current at battery port is 5.0A; During 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, charging efficiency can be up to 94%, such can reduce 3 / 4 charging time.

when the battery voltage is near the preset battery voltage, enters constant voltage charging stage; when the charging current is less than 400mA and battery voltage is near the constant voltage charging stage, the charging process is stopped. When the charging stage is accomplished, once the battery voltage falls under 4.1V, battery charging stage will be restarted.

IP5353 supports charging the battery and phone at the same time, output voltage is 5V.

12.3 Boost

IP5353 Integrated a synchronized switch converter which supports high voltage output, providing 3.3V ~ 12V output voltage output, load capacity can be: 5V@3.1A, 9V@2.22A and 12V@1.67A. 350kHz switching frequency. Internal soft start function. In avoid of large rush current causing device failure at start up stage, built-in overcurrent, short circuit, overvoltage and over temperature protection function, make insurance of the stability and reliability of power system.

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

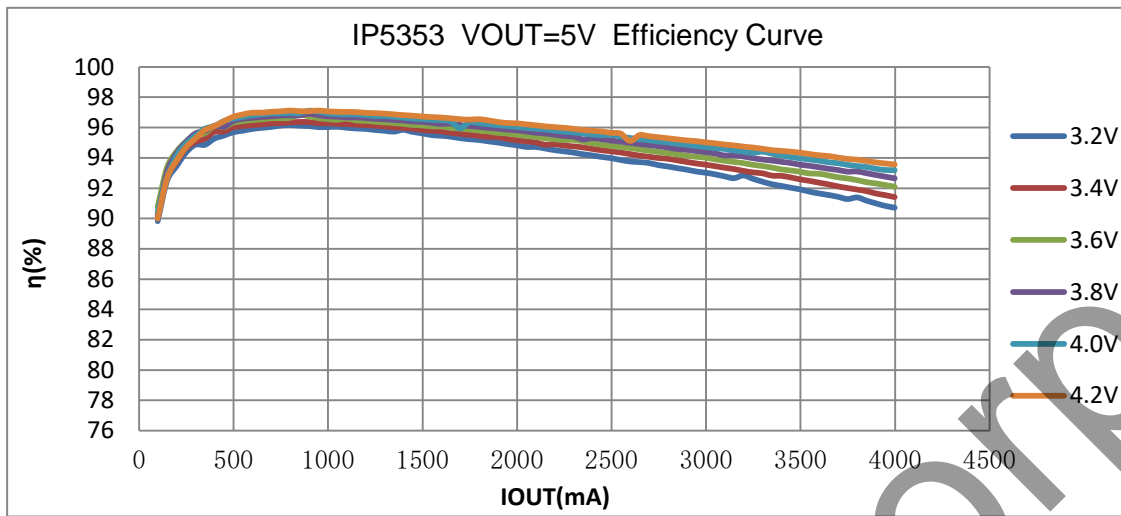


Figure 4 IP5353 VOUT=5V Efficiency Curve

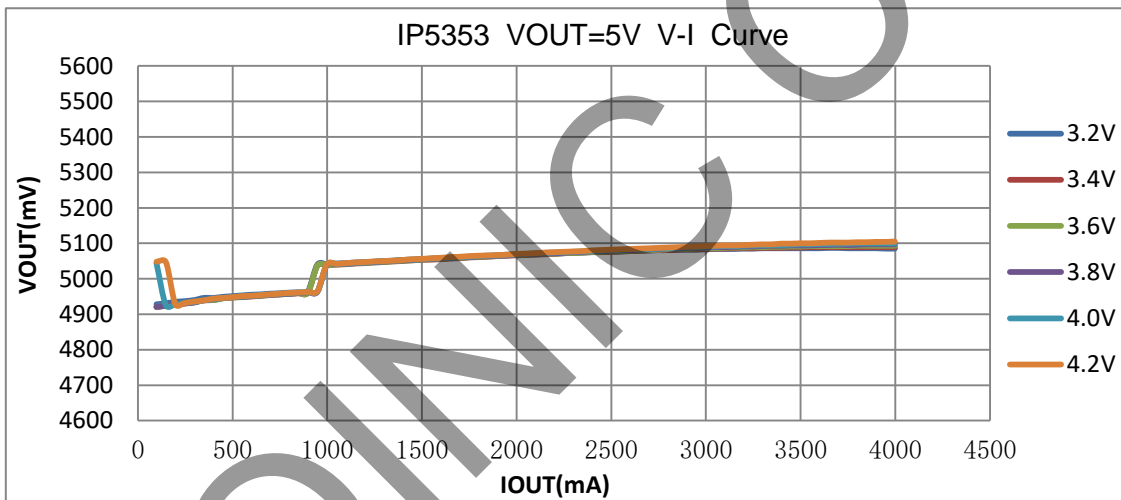


Figure 5 IP5353 VOUT=5V V-I Curve

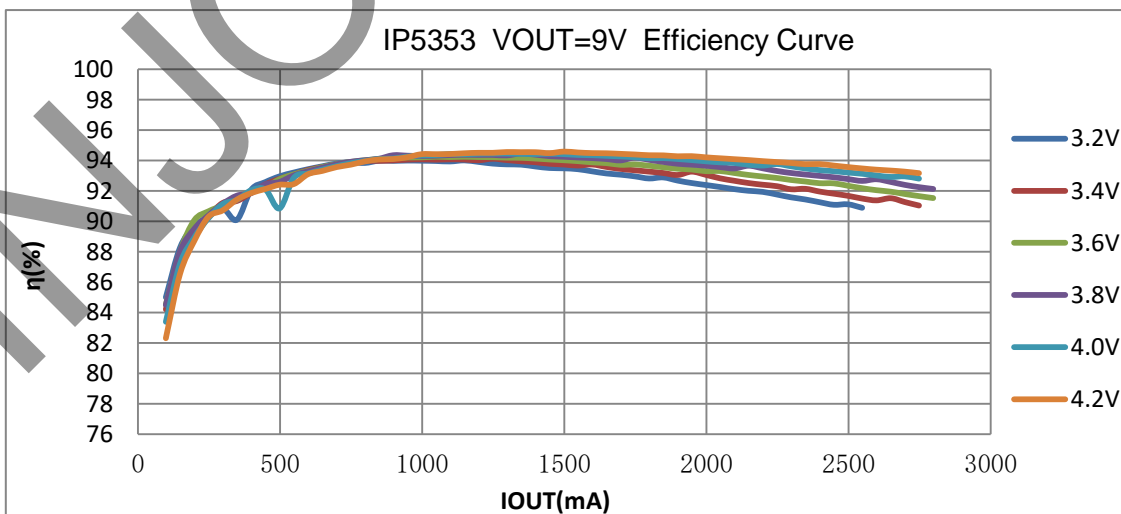


Figure 6 IP5353 VOUT=9V Efficiency Curve

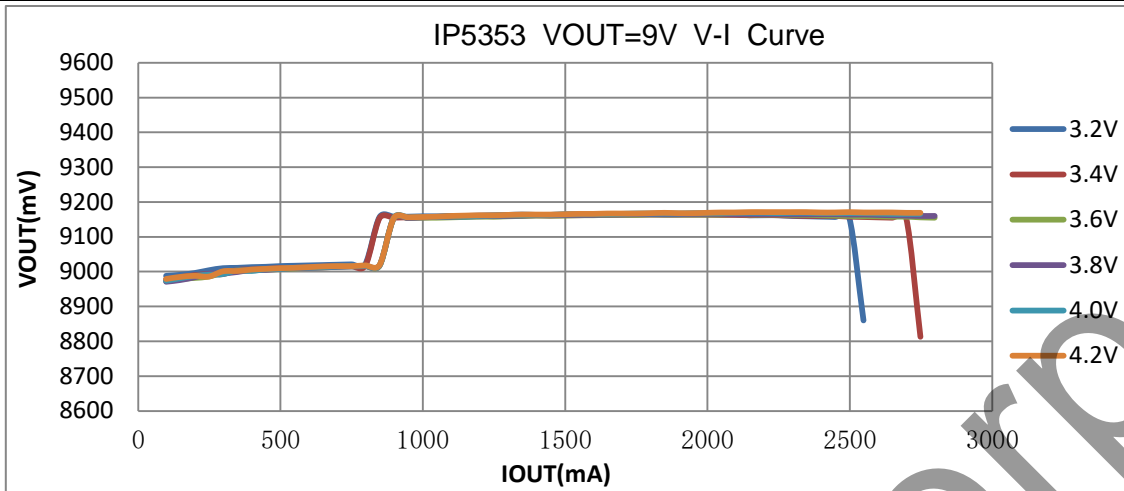


Figure 7 IP5353 VOUT=9V V-I Curve

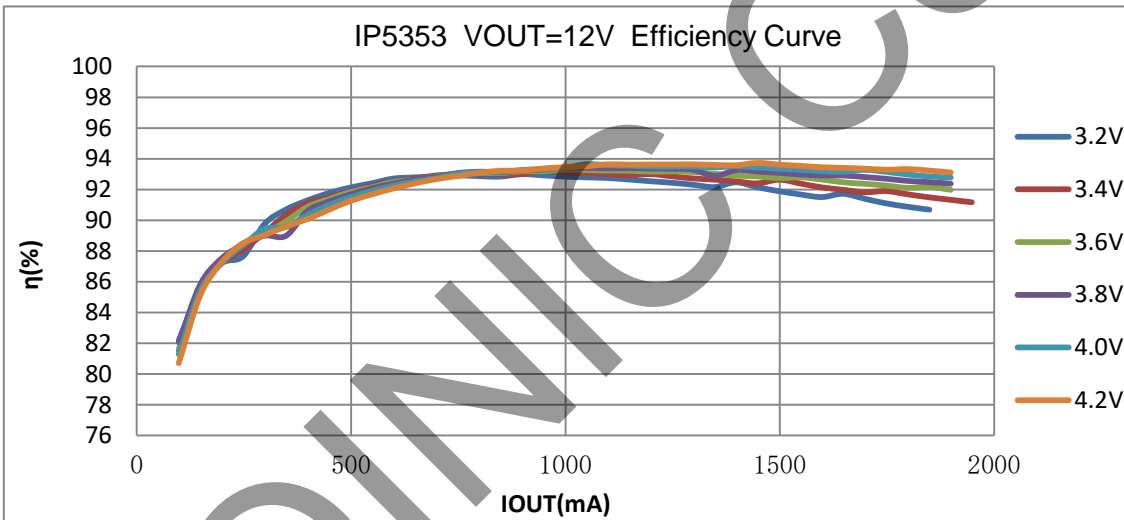


Figure 8 IP5353 VOUT=12V Efficiency Curve

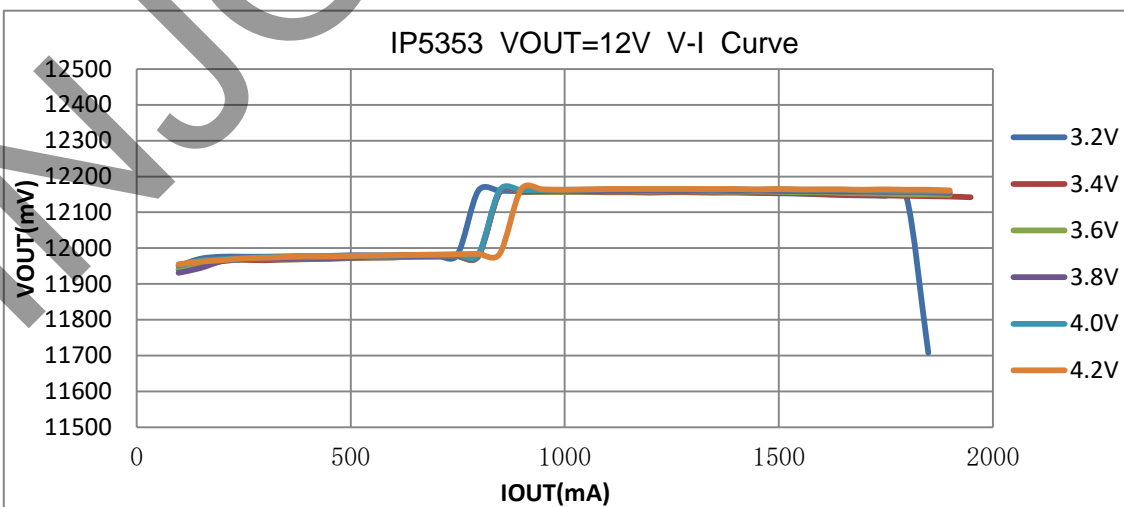


Figure 9 IP5353 VOUT=12V V-I Curve

12.4 USB C

IP5353 integrated USB C DRP port, auto-switching the internal pull-up and pull-down circuit on CC1 and CC2 by distinguishing the role of the attached device. Support Try.SRC function, when the attached device is also DRP device, IP5353 will supply power for the opposite device.

When worked as DFP, the output current can be set as three levels; when worked as UFP, the current capability from the opposite device can be detected.

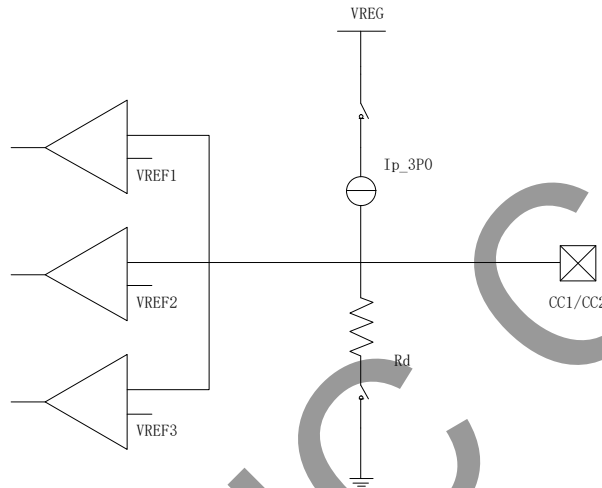


Figure 10 CC internal circuit

Table 1 Pull-up and pull-down ability

Name	Value
Ip_3P0	330 μ A
Rd	5.1k Ω

Table 2 Comparator Threshold of pull-up Ip

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

Table 3 Comparator Threshold of Pull-down Resistor Rd

Detection	Min voltage	Max voltage	Threshold
vRa	-0.25V	0.15V	0.20V
vRd-Connect	0.25V	2.04V	
vRd-USB	0.25V	0.61V	0.66V
vRd-1.5	0.70V	1.16V	1.23V
vRd-3.0	1.31V	2.04V	

Figure 4-36 DRP Timing

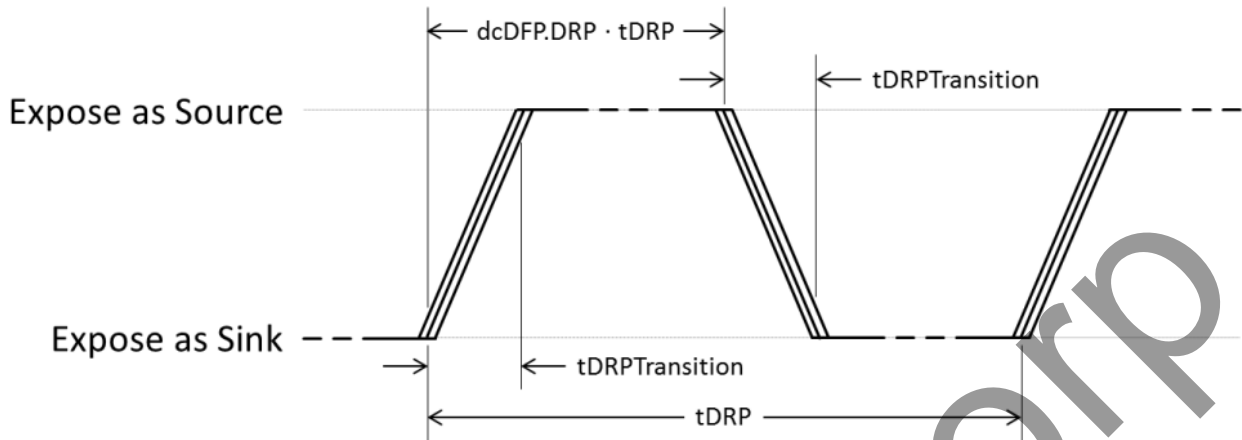


Figure 11 USB C detects cycle

Table 4 USB C detects cycle

	Minimum	Maximum	Description
t_{DRP}	50ms	100ms	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 t_{DRP}
$t_{DRPTransition}$	0ms	1ms	The time a DRP shall complete transitions between Source and Sink roles during role resolution
t_{DRPTry}	75ms	150ms	Wait time associated with the Try.SRC state
$t_{DRPTryWait}$	400ms	800ms	Wait time associated with the Try.SNK state

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

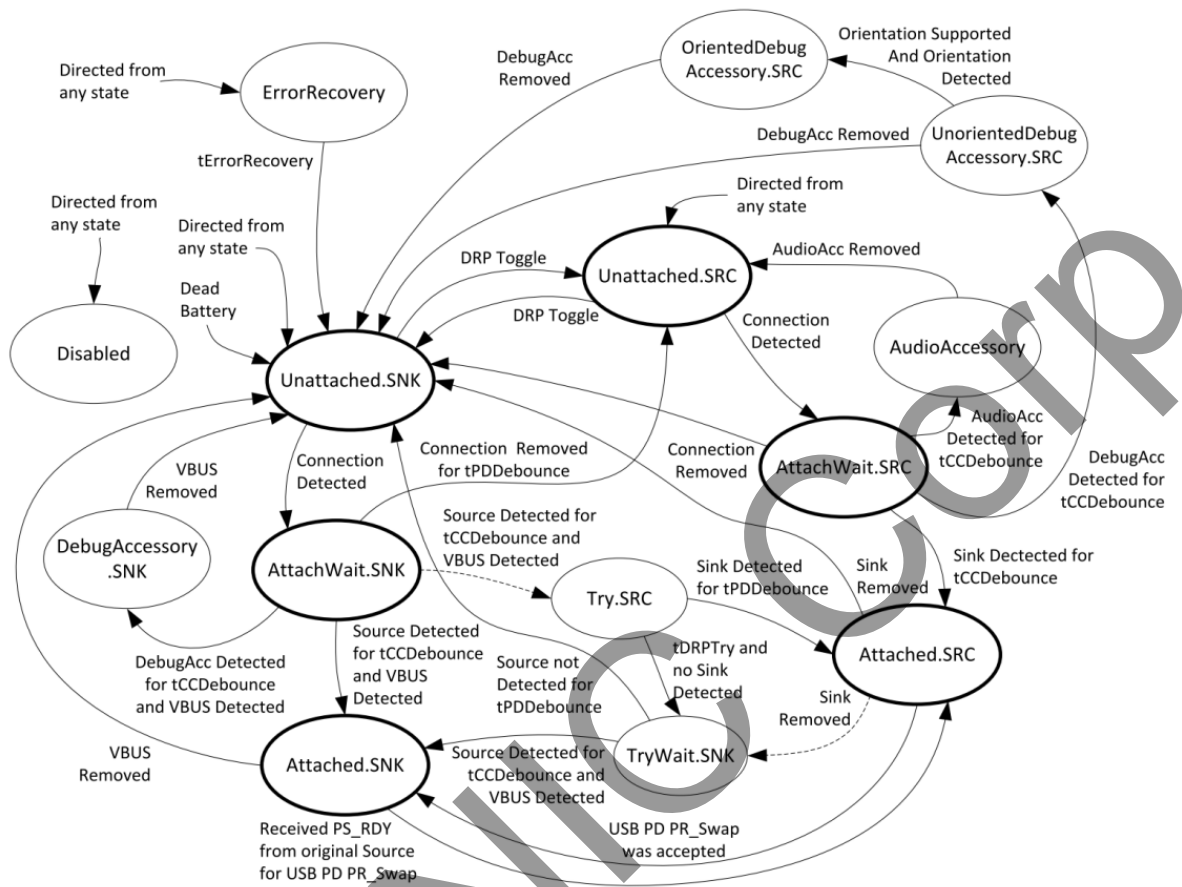


Figure 11 USB C detects state transition

12.5 USB C PD

IP5353 integrated USB C Power Delivery PD2.0/PD3.0 / PPS (Programmable Power Supply) protocol, integrate physical (PHY) layer for data transmitting/receiving across the cc wire, hardware biphasic mark coding (BMC) module and hardware CRC protect the data integrity.

Support PD2.0 / PD3.0 bi-directional input/output and PPS output protocol. Input and output voltage support 5V、9V、12V. Output source cap: 5V@3.0A、9V@2.22A、12V @1.67A、PPS 3.3~11V@2A output voltage adjustable with 20mV / step. Support up to 20W power level.

12.6 Fast Charge Protocol

IP5353 support multi fast charge protocols: PD2.0 / PD3.0 / PPS、QC2.0 / QC3.0、FCP、AFC、Apple、Samsung.

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

Input fast charge protocol of FCP、AFC、PD2.0、PD3.0 are supported for charging the power bank. If the power bank is to charge for the phone, when IP5353 enter discharge mode, it will detect the fast

charge type and request on DP, DM, which support fast charge for devices of QC2.0/QC3.0、FCP、AFC 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

Under BC1.2 mode, when the DP voltage is detected in the range of 2V ~ 0.325V for 1.25s, fast 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 in the following 2ms the DP voltage is in range of 2V ~ 0.325V and DM lower than 0.325V, fast 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 fast charge mode, the output voltage will fall back to default 5V.

Table 5 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	Continue Mode
3.3V	3.3V	Hold

Continuous mode is supported by QC3.0, voltage can be adjusted by 0.2V / step according to QC3.0 request under the continues mode.

Table 6 Fast charging protocol supported by each port of IP5353

protocols	VOUT1 output	VBUS output	VBUS input	VOUT2 output	VIN input
QC2.0	√	√	-	√	-
QC3.0	√	√	-	√	-
AFC	√	√	√	√	√
FCP	√	√	√	√	√
SCP	√	√	√	√	√
PD2.0	-	√	√	-	√
PD3.0	-	√	√	-	√
PPS	-	√	-	-	-

supported: √

not supported: -

12.7 Charge and Discharge Path Management

Standby:

If VIN or VBUS is attached, IP5353 will start the charging process directly.

If USB C UFP device is attached on VBUS or sink device is attached on VOUT port, IP5353 will start discharge function automatically.

If key is pressed, the VOUT1, VOUT2 and VBUS port will open only when load is detected on the according port, or the output on these port will be closed.

Discharge:

In the case of no key action, only the output path of the output port plugged in the electrical equipment will be opened; the output path of the output port not connected to the equipment will not be opened. When the output current of the opened output port is less than about 80mA, it will automatically close after a period of time.

Any port of VOUT1, VOUT2 and VBUS can support the output fast charging protocol. However, since this application is a single inductance application, it can only support one voltage output, so it can only support the fast charging output when only one output port is open. When two or three outlets are used at the same time, the quick charge function will be automatically turned off.

According to the connection shown in the "typical application diagram", when any output port has entered the fast charging output mode, when the other output port is plugged in with electrical equipment, all the output ports will be closed first, the high-voltage fast charging function will be closed, and then the output ports with equipment will be opened. In this case, all the output ports only support the charging of apple, Samsung and bc1.2 modes. When the number of electrical equipment is reduced to only one, all output ports will be closed first, the high-voltage fast charging function will be turned on, and then the output port of the last electrical equipment will be turned on, so as to reactivate the equipment to request fast charging. When only one output port is open and the total output current is less than about 80mA for about 32s, the output port and discharge function will be closed and the standby mode will be entered.

Charging:

Any port of VIN port and VBUS port can be charged by inserting the power supply. If both ports are connected to the power supply for charging, the first inserted power supply will be used for charging.

In the single charging mode, the fast charging 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 the electrical equipment are plugged in at the same time, the charging and discharging mode will be automatically entered. In this mode, the chip will automatically turn off the internal fast charge input request. When the vsys voltage is only 5V, turn on the discharge path to supply power to the electrical equipment; if the vsys voltage is greater than 6.0V, for safety reasons, the discharge path will not be turned on.

In the process of charging and discharging, if the charging power is unplugged, IP5353 will turn off the charging function and restart the discharging function to supply power to the electric equipment. For the sake of safety, and in order to be able to reactivate the mobile phone to request fast charging, the voltage will drop to 0V for a period of time during the conversion process.

In the process of charging and discharging, if the electric equipment is unplugged, or the electric equipment is full and stops pumping for 16s, the corresponding discharge path will be automatically closed. When the discharge paths are closed and the state returns to single charging mode, the charging undervoltage loop will be reduced, and the fast charging will be automatically reactivated to accelerate the charging of mobile power supply.

12.8 Automatic Detection of Mobile Phone

Auto detection on sink device / phone attachment:

IP5353 support 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 supported.

Auto detection on sink device / phone fully charged:

When the output current of a single port is less than about 80mA and lasts for about 16s, the output port will be closed. When the total current is less than about 80mA for about 32s, it is considered that all output cell phones are full or unplugged, and the boost output will be automatically turned off.

12.9 KEY

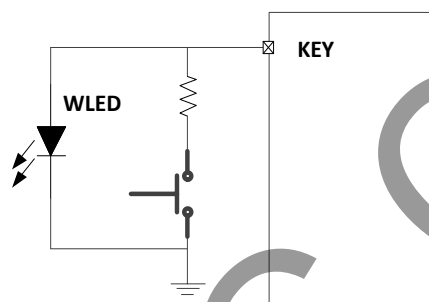


Figure 13 KEY circuit

Key circuit is illustrated in Figure 13, which can recognize short press or long press operation.

- Short press : pressed time in range of 100ms~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

12.10 Fast Charge State Indication

HLED PIN is used for indication for the present fast charge mode, either in fast charging or discharging mode, when the system enters fast charge , the light LED will turn on.

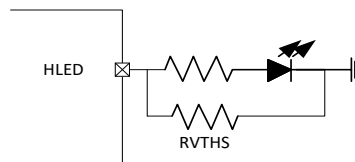


Figure 14 fast charge state indication

12.11 Selection of Battery Charge Discharge Curve

IP5353 selects different battery charging and discharging curves by pulling down the resistors with different resistance values (RVTHS) on the HLED pin. The connection mode is shown in Figure 14.

The following table lists the relationship between the state of power indicator and battery voltage

when RVTHS with different resistance values are pulled down at HLED pin;

It should be noted that the rotating lamp voltage (OCV) in the table is not the actual voltage of the battery, but the voltage after compensation of the internal resistance of the battery. The calculation formula is as follows:

During charging, turn lamp voltage (OCV) = actual battery voltage (voltage from IP5353 BAT (14th pin) to ground) - IBAT (battery terminal charging current measured by IP5353) * RSET (40mΩ);

When discharging, turn lamp voltage (OCV) = actual battery voltage (voltage from IP5353 BAT (14th pin) to ground) + IBAT (battery terminal discharge current measured by IP5353) * RSET (40mΩ);

Table 7 Charge discharge OCV threshold

	Resistance	Power Indicator Status	Battery charging and discharging voltage (4.20V)	Charge and discharge rotating lamp voltage (4.30V/4.35V/4.40V battery)
1	20kΩ 1%	4 lights to 3 lights	4020 mV	4020 mV
		3 lights to 2 lights	3780 mV	3780 mV
		2 lights to 1 lights	3600 mV	3600 mV
2	43kΩ 1%	4 lights to 3 lights	4020 mV	4020 mV
		3 lights to 2 lights	3900 mV	3900 mV
		2 lights to 1 lights	3660 mV	3660 mV
2	62kΩ 1%	4 lights to 3 lights	4020 mV	4020 mV
		3 lights to 2 lights	3900 mV	3900 mV
		2 lights to 1 lights	3780 mV	3780 mV
4	NC (Register setting)	4 lights to 3 lights	3900 mV	4020 mV
		3 lights to 2 lights	3720 mV	3900 mV
		2 lights to 1 lights	3600 mV	3720 mV

12.12 Battery Level Display

Battery level display for LED mode

IP5353 4LED battery level display solution, the connection method is as follows.

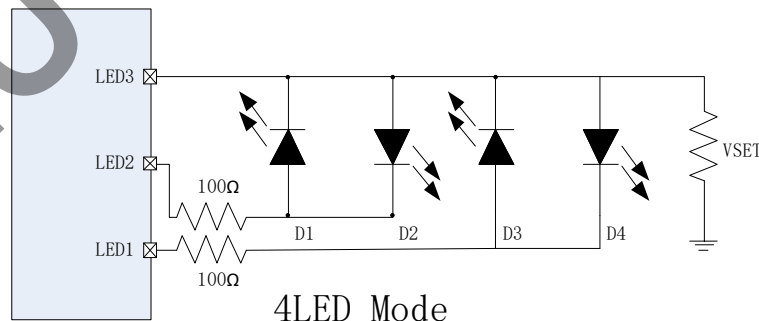


Figure 15 4LED circuits

4LED display mode:

Table 8 Charging lamp display

Battery capacity (C) (%)	D1	D2	D3	D4
Fully charged	ON	ON	ON	ON
$75\% \leq C$	ON	ON	ON	0.5Hz Flash
$50\% \leq C < 75\%$	ON	ON	0.5Hz Flash	OFF
$25\% \leq C < 50\%$	ON	0.5Hz Flash	OFF	OFF
$C < 25\%$	0.5Hz Flash	OFF	OFF	OFF

Table 9 Boost lamp display

Battery capacity (C) (%)	D1	D2	D3	D4
$C \geq 75\%$	ON	ON	ON	ON
$50\% \leq C < 75\%$	ON	ON	ON	OFF
$25\% \leq C < 50\%$	ON	ON	OFF	OFF
$3\% \leq C < 25\%$	ON	OFF	OFF	OFF
$0\% < C < 3\%$	1.0Hz Flash	OFF	OFF	OFF
$C = 0\%$	OFF	OFF	OFF	OFF

12.13 Abnormal prompt

IP5353 supports abnormal light display. When abnormal conditions such as NTC high and low temperature, VIN/VBUS overvoltage, and BAT low power are triggered, the power indicator light will alarm.

Table 10 Boost lamp display

Abnormal state	D1	D2	D3	D4
NTC high temperature / NTC low temperature	1.25Hz Flash	1.25Hz Flash	1.25Hz Flash	1.25Hz Flash
VIN/VBUS overvoltage	1.25Hz Flash	1.25Hz Flash	1.25Hz Flash	1.25Hz Flash
BAT low voltage	1.25Hz Flash 4 times	OFF	OFF	OFF

12.14 VSET (Battery voltage selection)

IP5353 can set battery specifications and configure parameters of different battery specifications through VSET pin (LED3 pin). The resistance threshold of VSET and the set battery specifications are shown in the table below.

Table 11 Battery voltage selection

Resistance	Battery Type
NC	4.20V
68kΩ	4.30V
33kΩ	4.35V
10kΩ	4.40V

12.15 NTC function

IP5353 integrates NTC function, which can detect battery temperature. When IP5353 is working, NTC pin output current, and generate voltage through external NTC resistance. IC internal detects the voltage of NTC pin to determine the current battery temperature.

* The 100nF capacitance of NTC must be close to IC PIN.

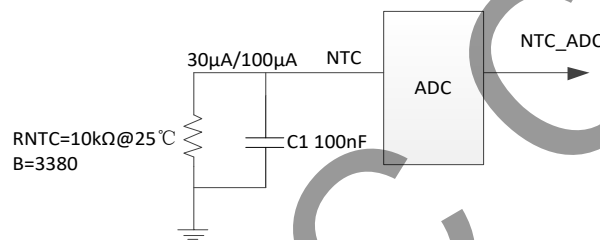


Figure 16 NTC circuit

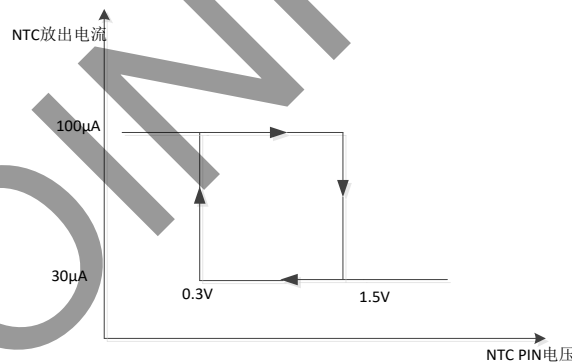


Figure 17 Relationship between NTC voltage and output current

When the NTC discharge current is 80µA, if the NTC voltage is higher than 1.5V, the current becomes 30µA;

When the NTC discharge current is 30µA, if the NTC voltage is lower than 0.3V, the current changes to 100µA.

In the state of charge:

When the NTC voltage is lower than 0.49V, it means the battery temperature is higher than 45°C, the charging is stopped.

When the NTC voltage is higher than 0.82V, it means the battery temperature is lower than 0°C, the charging is stopped.

In the state of discharge:

When the NTC voltage is lower than 0.30V, it means the battery temperature is higher than 60°C, the discharging is stopped.

When the NTC voltage is higher than 2.08V, it means the battery temperature is lower than -20°C, the discharging is stopped.

If NTC is not required in the application, 10kΩ resistance shall be connected to the ground at NTC pin, and floating or direct grounding is not allowed.

12.16 I2C

I2C connection mode

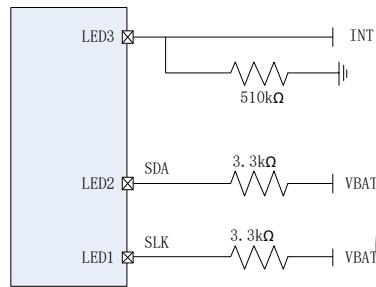


Figure 18 I2C Application method

The IP5353 does not support I2C connection by default. If the I2C connection is required, the customized IP5353_I2C_XXXX is used for design. In I2C mode, the INT signal is in high resistance state in standby mode and high level state in working state, which can be used to wake up MCU.

12.17 Apple lightning line communication

IP5353 integrated lightning communication circuit, external connection mode is shown in Figure 19.

Since the communication circuit needs to be pulled up to bat through an external 510Ω resistor, the communication can be successful only when the battery voltage is above 3V. If the communication can succeed when the battery voltage is lower than 3V, it is recommended to add lightning communication chip.

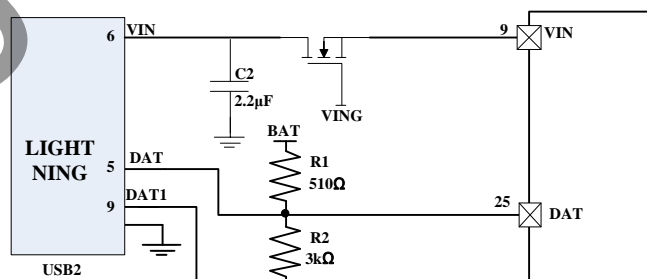


Figure 19 Lightning communication circuit

13 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.

13.1 Location of VOUT1 / VOUT2 / VBUS capacitor

IP5353 integrated USB output power path, VOUT1 / VOUT2 / VBUS 2.2 μ F capacitor must be placed close to the chip pin. If the layout allows, the closer the capacitor is to the chip, the better.

At the same time, place a 100nF capacitor close to the USB seat, and the capacitor is close to the USB seat in parallel.

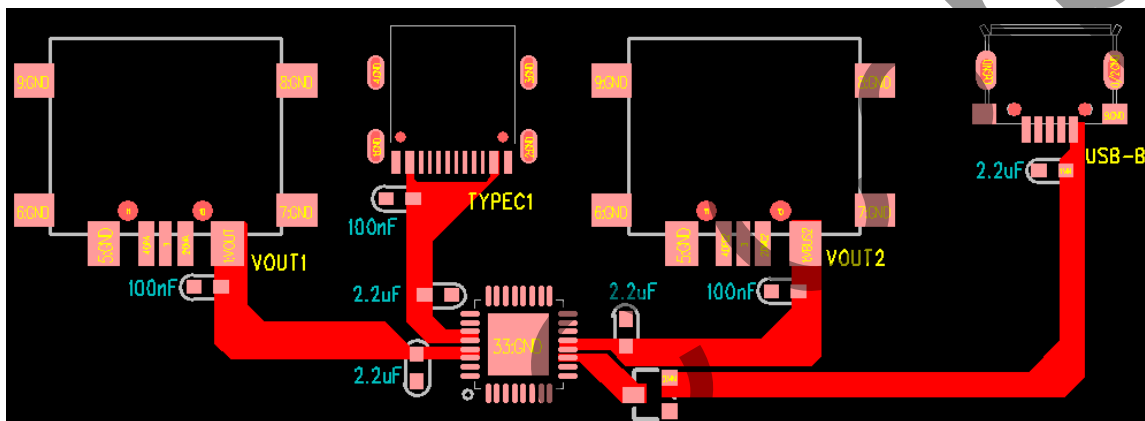


Figure 20 Output capacitance

13.2 Location of VSYS capacitor

The power and current of the chip are relatively large, and the position of the capacitor on the VSYS network will affect the stability of the DCDC. The capacitors on the VSYS network need to be as close to the VSYS pin and EPAD of the IC as possible, and copper is laid on a large area, and more vias are added to reduce the area of current loop between the capacitors and the IC and reduce parasitic parameters.

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

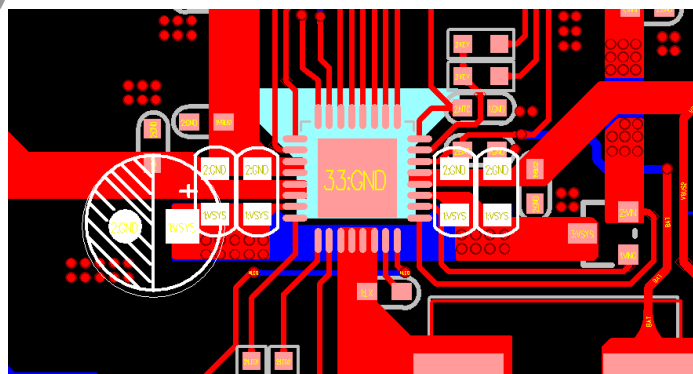


Figure 21 VSYS capacitance

13.3 Location of BAT/NTC capacitor

The filter capacitors of BAT pin and NTC pin should be placed as close as possible to the pin of the chip, and some holes should be drilled near the capacitors GND pin.

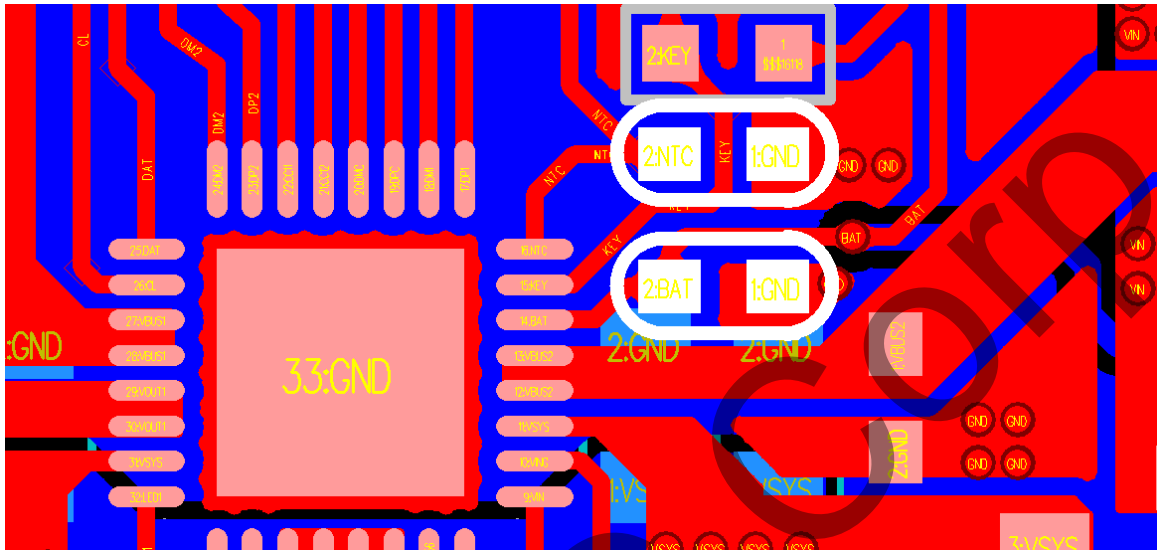


Figure 22 BAT/NTC capacitance

14 Typical Application Diagram

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

14.1 IP5353_AABC

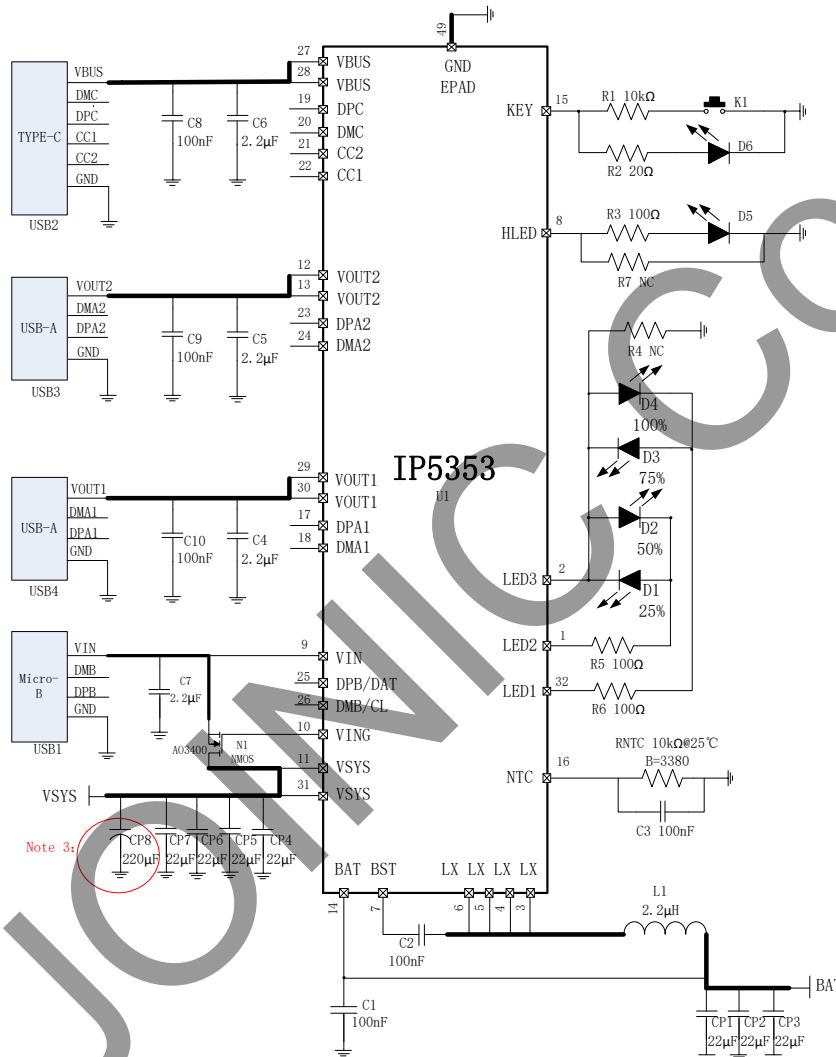


Figure 23 IP5353_AABC application circuit

Note:

1. C3 capacitor needs to be close to NTC pin. When NTC is not used, NTC pin is grounded through 10kΩ resistance;
2. When VIN port is not required, it can be directly suspended; When VOUT1 or VOUT2 ports are not required, the 2.2µF capacitor needs to be kept close to the chip pin.
3. IP5353 VSYS 220µF capacitor: VSYS capacitor needs to be close to the chip pin, if the capacitor is too far to add 220µF electrolytic capacitor. If the structure allows, we suggest adding 220µF electrolytic capacitor. If no electrolytic capacitor is added, the VSYS capacitor should be close to the chip pin.
4. If the solution has only A+A+C USB port, IP5353_AABC is recommended.

BOM

No.	Part Name	Type	Location	Num	Note
1	SMT IC	QFN32 IP5353	U1	1	
2	SMT capacitor	0603 100nF 10% 16V	C1	1	
3	SMT capacitor	0603 100nF 10% 25V	C2 C8 C9 C10	4	
4	SMT capacitor	0603 2.2μF 10% 25V	C4 C5 C6 C7	4	
5	SMT capacitor	0805 22μF 10% 16V	CP1 CP2 CP3	3	
6	SMT capacitor	0805 22μF 10% 25V	CP4 CP5 CP6 CP7	4	
7	capacitor	220uf 10% 25V	CP8	1	
8	SMT resistor	0603 10kΩ 1%	R1	2	
9	SMT resistor	0603 NC 1%	R4 R7	2	
10	SMT resistor	0603 100Ω 1%	R3 R5 R6	3	
11	SMT LED	0603 BLUE	D1 D2 D3 D4	4	
12	SMT LED	0603 RED	D5	1	
13	LED	5MM LED	D6	1	
14	SMT resistor	0603 20Ω 1%	R2	1	
15	NTC	10kΩ@25°C B=3380	RNTC	1	
16	SMT capacitor	0603 100nF 10% 16V	C3	1	
17	SMT NMOS	SOT23-3 AO3400	N1	1	
18	Inductor	2.2μH 10*10	L1	1	
19	KEY	SMT 3*6	K1	1	
20	OUTPUT USB	AF10 8 USB	USB3 USB4	2	
21	USB C CONNECTOR	USB C CONNECTOR	USB2	1	
22	INPUT USB	MICRO-7-DIP-5.9	USB1	1	

Recommended inductance model

DARFON PIN	Thickness (mm)	Inductance (μH)	Tolerance	DC Resistance (mΩ)	Heat Rating Current DC Amp.	Saturation Current DC Amps.	Measuring Condition
				Max.	Idc(A)Max.	Isat(A)Max.	
SPA1040-2R2M	4.0	2.2	±20%	7.0	14.0	16.0	100kHz/1.0V

14.2 IP5353_AACL

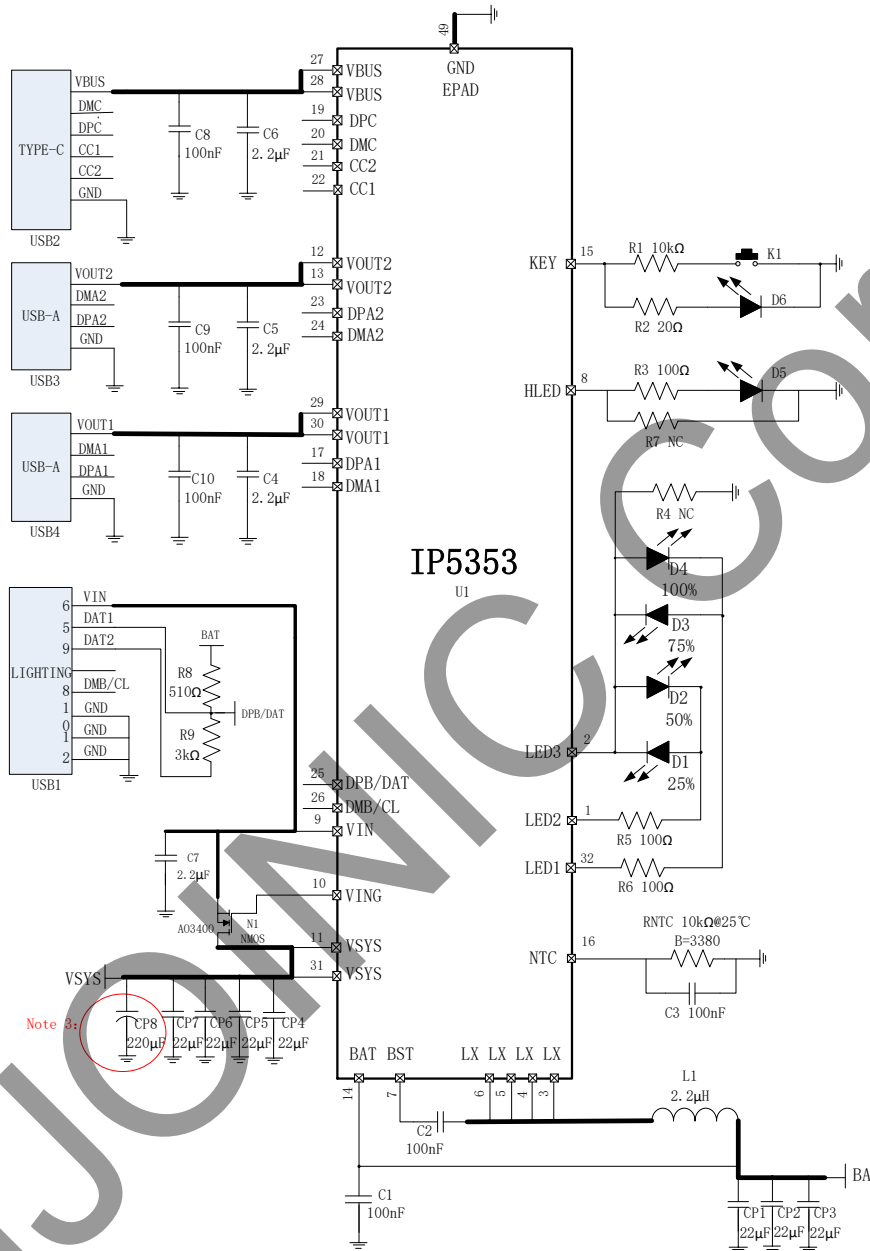


Figure 24 IP5353_AACL application circuit

Note:

1. C3 capacitor needs to be close to NTC pin. When NTC is not used, NTC pin is grounded through 10kΩ resistance;
2. When VIN port is not required, it can be directly suspended; When VOUT1 or VOUT2 ports are not required, the 2.2μF capacitor needs to be kept close to the chip pin.
3. IP5353 VSYS 220μF capacitor: VSYS capacitor needs to be close to the chip pin, if the capacitor is too far to add 220μF electrolytic capacitor. If the structure allows, we suggest adding 220μF electrolytic capacitor. If no electrolytic capacitor is added, the VSYS capacitor should be close to the chip pin.

BOM

No.	Part Name	Type	Location	Num	Note
1	SMT IC	QFN32 IP5353	U1	1	
2	SMT capacitor	0603 100nF 10% 16V	C1	1	
3	SMT capacitor	0603 100nF 10% 25V	C2 C8 C9 C10	4	
4	SMT capacitor	0603 2.2μF 10% 25V	C4 C5 C6 C7	4	
5	SMT capacitor	0805 22μF 10% 16V	CP1 CP2 CP3	3	
6	SMT capacitor	0805 22μF 10% 25V	CP4 CP5 CP6 CP7	4	
7	capacitor	220uf 10% 25V	CP8	1	
8	SMT resistor	0603 10kΩ 1%	R1	2	
9	SMT resistor	0603 NC 1%	R4 R7	2	
10	SMT resistor	0603 100Ω 1%	R3 R5 R6	3	
11	SMT LED	0603 BLUE	D1 D2 D3 D4	4	
12	SMT LED	0603 RED	D5	1	
13	LED	5MM LED	D6	1	
14	SMT resistor	0603 20Ω 1%	R2	1	
15	NTC	10kΩ@25°C B=3380	RNTC	1	
16	SMT capacitor	0603 100nF 10% 16V	C3	1	
17	SMT NMOS	SOT23-3 AO3400	N1	1	
18	inductor	2.2μH 10*10	L1	1	
19	KEY	SMT 3*6	K1	1	
20	OUTPUT USB	AF10 8 USB	USB3 USB4	2	
21	USB C CONNECTOR	USB C CONNECTOR	USB2	1	
22	INPUT USB	LIGHTNING	USB1	1	
23	SMT resistor	0603R 510Ω 1%	R8	1	
24	SMT resistor	0603R 3kΩ 1%	R9	1	

Recommended inductance model

DARFON PIN	Thickness (mm)	Inductance (μH)	Tolerance	DC Resistance (mΩ)	Heat Rating Current DC Amp.	Saturation Current DC Amps.	Measuring Condition
				Max.	Idc(A)Max.	Isat(A)Max.	
SPA1040-2R2M	4.0	2.2	±20%	7.0	14.0	16.0	100kHz/1.0V

14.3 IP5353_ABCL

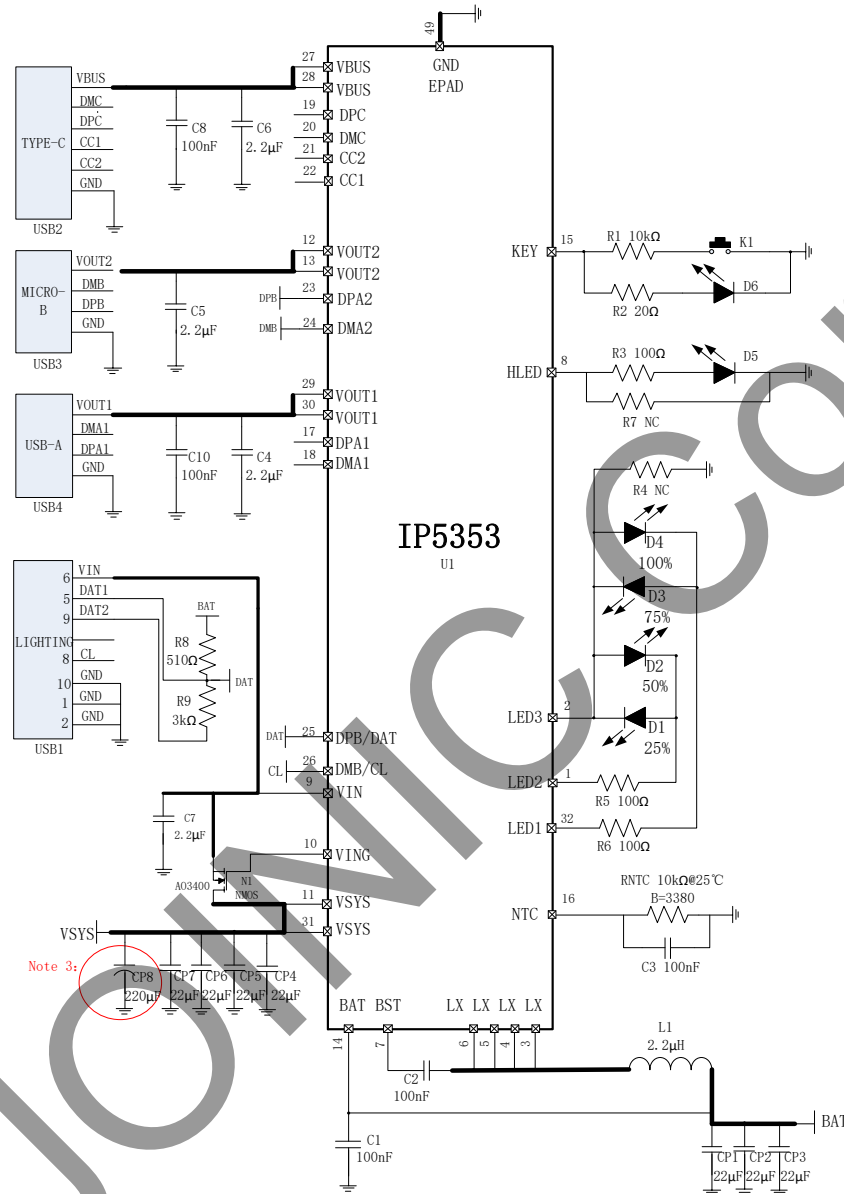


Figure 25 IP5353_ABCL application circuit

Note:

1. C3 capacitor needs to be close to NTC pin. When NTC is not used, NTC pin is grounded through 10kΩ resistance;
2. When VIN port is not required, it can be directly suspended; When VOUT1 or VOUT2 ports are not required, the 2.2μF capacitor needs to be kept close to the chip pin.
3. IP5353 VSYS 220μF capacitor: VSYS capacitor needs to be close to the chip pin, if the capacitor is too far to add 220μF electrolytic capacitor. If the structure allows, we suggest adding 220μF electrolytic capacitor. If no electrolytic capacitor is added, the VSYS capacitor should be close to the chip pin.
4. If there is only A+B+C USB port in the scheme, IP5353_ABCL model is recommended, and the MOS tube with external expansion can be omitted to save cost.

BOM

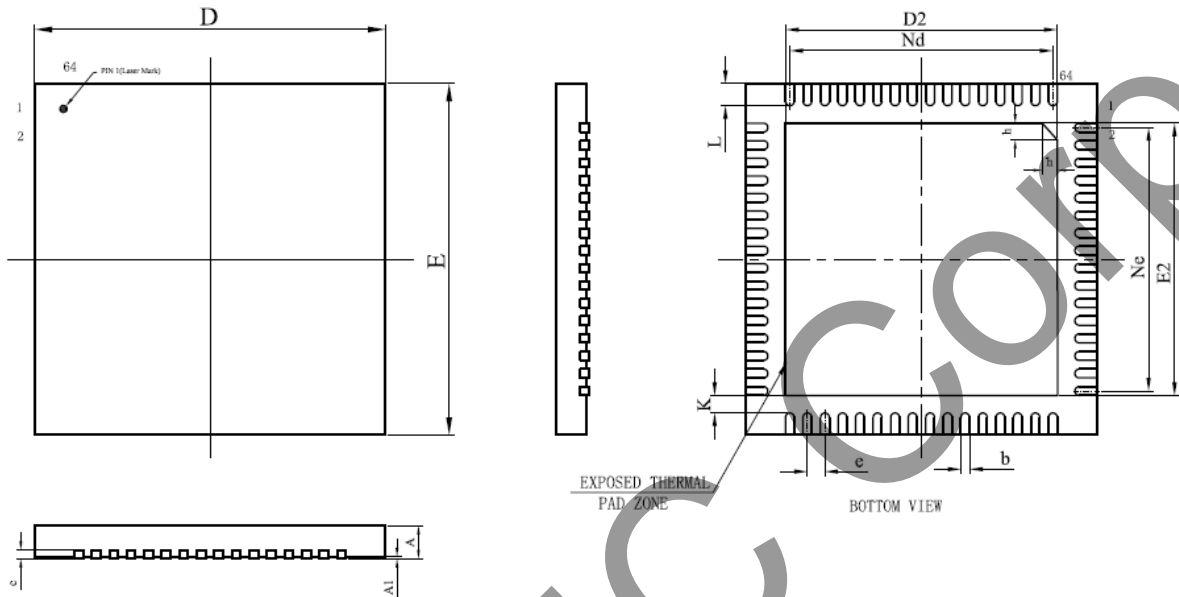
No.	Part Name	Type	Location	Num	Note
1	SMT IC	QFN32 IP5353	U1	1	
2	SMT capacitor	0603 100nF 10% 16V	C1	1	
3	SMT capacitor	0603 100nF 10% 25V	C2 C8 C10	4	
4	SMT capacitor	0603 2.2μF 10% 25V	C4 C5 C6 C7	4	
5	SMT capacitor	0805 22μF 10% 16V	CP1 CP2 CP3	3	
6	SMT capacitor	0805 22μF 10% 25V	CP4 CP5 CP6 CP7	4	
7	capacitor	220uf 10% 25V	CP8	1	
8	SMT resistor	0603 10kΩ 1%	R1	2	
9	SMT resistor	0603 NC 1%	R4 R7	2	
10	SMT resistor	0603 100Ω 1%	R3 R5 R6	3	
11	SMT LED	0603 BLUE	D1 D2 D3 D4	4	
12	SMT LED	0603 RED	D5	1	
13	LED	5MM LED	D6	1	
14	SMT resistor	0603 20Ω 1%	R2	1	
15	NTC	10kΩ@25°C B=3380	RNTC	1	
16	SMT capacitor	0603 100nF 10% 16V	C3	1	
17	SMT NMOS	SOT23-3 AO3400	N1	1	
18	inductor	2.2μH 10*10	L1	1	
19	KEY	SMT 3*6	K1	1	
20	OUTPUT USB	AF10 8 USB	USB4	1	
21	USB C CONNECTOR	USB C CONNECTOR	USB2	1	
22	INPUT USB	MICRO-7-DIP-5.9	USB3	1	
23	INPUT USB	LIGHTNING	USB1	1	
24	SMT resistor	0603R 510Ω 1%	R8	1	
25	SMT resistor	0603R 3kΩ 1%	R9	1	

Recommended inductance model

DARFON PIN	Thickness (mm)	Inductance (μH)	Tolerance	DC Resistance (mΩ)	Heat Rating Current DC Amp.	Saturation Current DC Amps.	Measuring Condition
				Max.	Idc(A)Max.	Isat(A)Max.	
SPA1040-2R2M	4.0	2.2	±20%	7.0	14.0	16.0	100kHz/1.0V

15 Package

15.1 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

Figure 26 package

15.2 Marking Description



Note:


- 1、 --Injoinic Logo
- 2、IP5353 --Part Number
- 3、XXXXXXXX --Manufacture number
- 4、○ --PIN1 location

Figure 27 Marking description

16 IMPORTANT NOTICE

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