IP5513A datasheet

Contents

1. Product Brief

1.1 Features

- **MCU**
  - ✧ 8051-Compatible Core
  - ✧ 12K Bytes OTP
  - ✧ 256 Bytes RAM, supports direct addressing, indirect addressing, etc.
  - ✧ System Clock: Low speed 32KHz; High speed 12MHz
  - ✧ 3*16bits Timer: Timer0, Timer1, Timer2
  - ✧ 2 PWM Multiplex Timer: Timer1, Timer2
  - ✧ 7 Channel, 10bit ADC: 4 built-in voltage sampling channels, 2 external sampling channels, and 1 current sampling channel
  - ✧ I/O: Supports up to 6 ordinary I/O ports
- **Discharge**
  - ✧ 600mA Synchronous Boost Conversion
  - ✧ Boost Voltage adjust within 4.6V~5.2V
  - ✧ Boost efficiency up to 93%
- **Charge**
  - ✧ 12.5mA~500mA linear charger, adjustable charging current 12.5mA/Step
  - ✧ Supports 4.20V, 4.30V 4.35V, 4.40V batteries
  - ✧ Supports automatic recharging
  - ✧ Supports feedback charging status
- **Low-power dissipation**
  - ✧ Standby power consumption up to 15uA minimum
- **Simplified BOM**
  - ✧ Built-in power MOS
- **Multiple protection, high reliability**
  - ✧ Output: over current and short circuit protection
  - ✧ Input: over voltage protection and Battery over charged protection
  - ✧ Over temperature protection
  - ✧ Vin pin can withstand up to 15V (transient voltage)
  - ✧ ESD 4KV
- **Package: SOP16**

1.2 Description and Application Diagram

IP5513A is an 8-bit MCU SOC for high-integration solution on small electronic devices. It integrates with 5V boost converter, lithium battery charging management and negative terminal NMOS.

IP5513A has 8051-compatible core, built-in 8-bit MCU, up to 12MHz main frequency clock. It also has built-in 256 Byte RAM and 12K OTP ROM, which provide sufficiently programming space for portable electronic devices.

The synchronous 5V-boost system of IP5513A provides rated 300mA output current with conversion efficiency up to 93%. DC-DC converter operates at 1.5MHz frequency, can support low-cost inductors and capacitors.

IP5513A's linear charger supplies max 500mA charging current. With input under voltage, over voltage, over current, over temperature and the change of input under voltage, IP5513A can automatically adjust the charging current, provide safe and reliable charging management.

IP5513A has built-in negative terminal PH1_L, PH2_R and MOS current detection. It also has high and low level change detection, multi resistance switching.

IP5513A has built-in 20uA/100uA constant current source and 10-bit ADC, which can achieve custom NTC function.

IP5513A is highly integrated with abundant functions, which makes the total solution with minimized-size and low-cost BOM. Figure 1 shows the system functional block diagram.

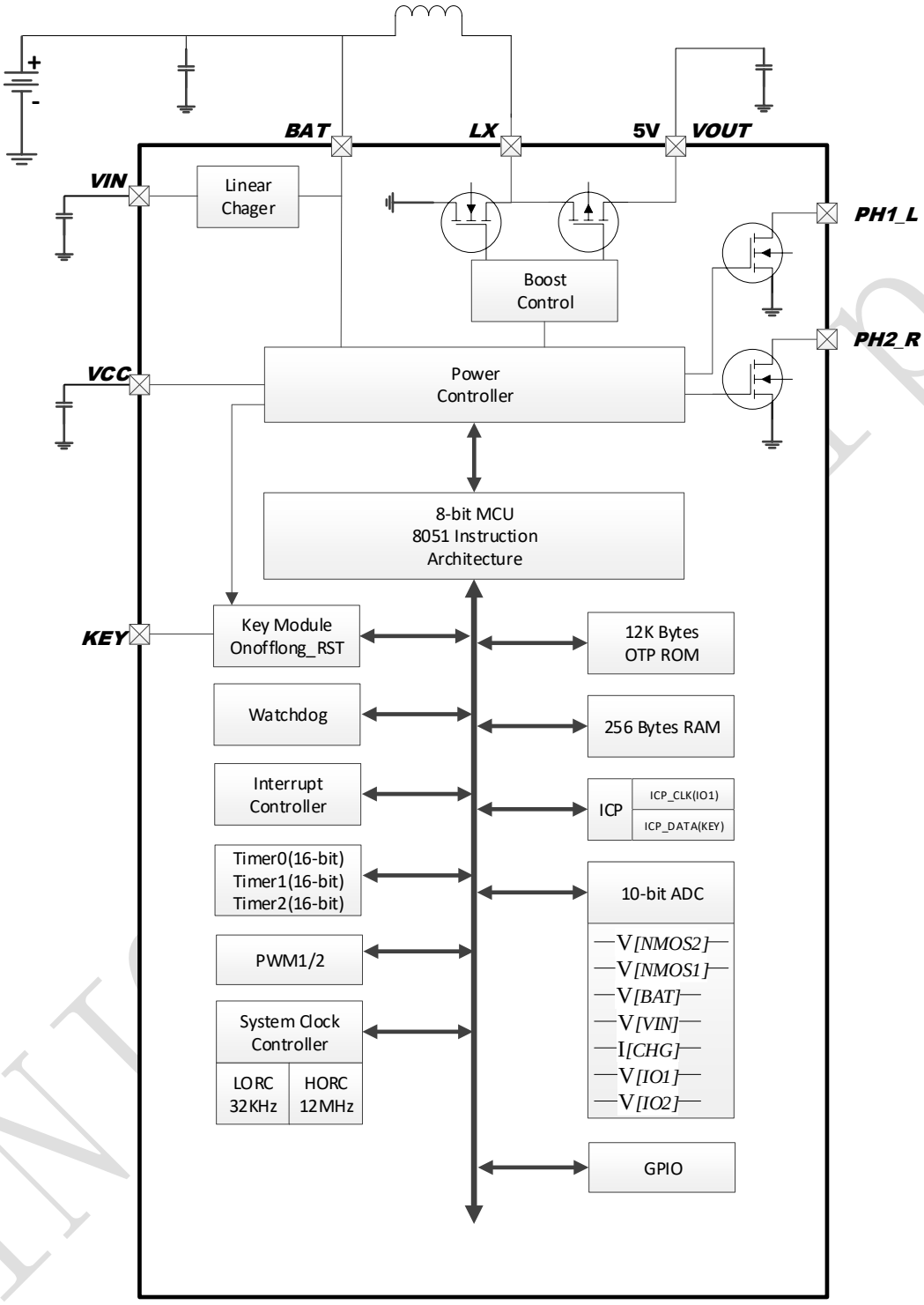


Figure 1 IP5513A Functional Block System Diagram

1.3 Pin Configuration and Function

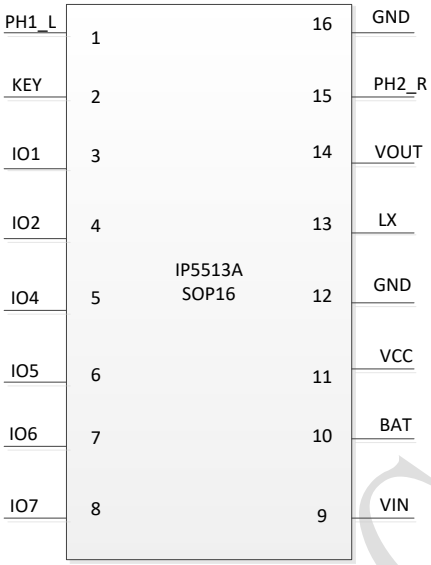


Figure 2 IP5513A Pin Assignments

Pin Num	Pin Name	Description			
		F1	F2	F3	F4
1	PH1_L	PH1_L	ADC-VPH1_L	PWM1 open drain	-
2	KEY	KEY	General IO8	SIRQ0	PWM1
3	IO1	General IO1	ADC0 voltage detection	20uA constant current source	-
4	IO2	General IO2	ADC1 voltage detection	20uA constant current source	100uA constant current source
5	IO4	General IO4	SIRQ0	PWM1	-
6	IO5	General IO5	SIRQ1	PWM2	-
7	IO6	General IO6	SIRQ0	PWM1	-
8	IO7	General IO7	SIRQ1	PWM2	-
9	VIN	5V input pin	-	-	-
10	BAT	Line charging output, connecting battery voltage positive pin	-	-	-
11	VCC	System power, no output driver, connect to 2.2uF inductor	-	-	-
12	GND	Ground	-	-	-
13	LX	DCDC switch node	-	-	-
14	VOUT	Boost 5V output	-	-	-
15	PH2_R	PH2_R	ADC-VPH2_R	PWM2 open drain	-
16	GND	Ground	-	-	-

2. Electrical Parameters

2.1 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage Range	V_{IN}	-0.3 ~ 15	**V**
Junction Temperature Range	T_J	-40 ~ 150	℃
Storage Temperature Range	Tstg	-60 ~ 150	℃
Thermal Resistance (Junction to Ambient)	θ_{JA}	50	**℃/W**
ESD (Human Body Model)	ESD	4	**KV**

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

2.2 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input Voltage	V_{IN}	4.5	5	6.0	**V**
Operating Temperature	T_A	-20	--	85	℃

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

2.3 Electrical Characteristics

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

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Charging System						
Input Voltage	V_{IN}	VBAT=3.7V	4.5	5	6.0	V
Input Over Voltage	V_{INOV}		5.8	6	6.2	V
VIN Activation Voltage	V_{INOK}		3.0	3.2	3.4	V
Input Under Voltage	V_{INUV}		4.0	4.2	4.4	V
Constant Charge Voltage	$CV_{4.2V}$	4.2V battery	4.16	4.20	4.24	V
	$CV_{4.30V}$	4.3V battery	4.28	4.30	4.34	V
	$CV_{4.35V}$	4.35V battery	4.33	4.35	4.4	V
	$CV_{4.4V}$	4.4V battery	4.38	4.40	4.44	V
Charge Stop Current	$IVIN_{stop}$	VIN=5V	30	30	40	mA
Charge Current	I_{VIN}	VIN=5V, VBAT=3.7V, Set the charge current=350mA	320	350	380	mA
Trickle Charge Current	I_{TRKL}	VIN=5V, BAT=2.7V	20	25	30	mA
Trickle Charge Stop Voltage	V_{TRKL}		2.9	3	3.1	V
Recharge Voltage Threshold	V_{RCH}		4.07	4.1	4.13	V
Charge Cut-Off Time	T_{END}		20	24	28	Hours
Boost System						
Battery Operation Voltage	V_{BAT}		3.0	3.7	4.4	V
Low Power Shutdown Voltage	V_{BATLOW}	IOUT=200mA	2.9	2.95	3.0	V
Switching Battery Input Current	I_{BAT}	VBAT=3.7V, VOUT=5.0V, fs=1.5MHz (without LED indicator, VOUT without load)		4	6	mA
DC Output Voltage	V_{OUT}	VBAT=3.7V @0A	5.0	5.05	5.15	V
		VBAT=3.7V @300mA	4.75	5.00	5.15	V
Output Voltage Ripple	ΔV_{OUT}	VBAT=3.0V~4.4V	50	100	150	mV
Boost Output Current	I_{VOUT}	VBAT=3.0V~4.4V	0		800	mA
Boost Overcurrent Shut Down Threshold	I_{SHUT}	VBAT=3.0V~4.4V	0.6	0.8	0.9	A

Load Overcurrent Detect Time	T_{UVD}	Duration of output voltage under 4.2V		30		ms
Control System						
Switch Frequency	fs	Discharge switch frequency	1.3	1.5	1.6	MHz
PMOS on Resistance	r_{DSON}			185		mΩ
NMOS on Resistance				200		mΩ
VCC Voltage	VCC	VCC unloaded. VCC = VBAT. (When no VBAT is connected, only VIN supplys power and the charger is disabled, then the VCC is 3.3V)	VBAT-0.1	VBAT	VABT	V
Battery Input Standby Current	I_{STB}	VIN=0V， VBAT=3.7V, no support hall switch	10	15	25	uA
IO Driving Current	I_{Gpio}		4	6	8	mA
Light Load Shut Down Detect Time	T_{loadD}	Load current less than 4mA	5	6	8	s
Short Press on Key Wake Up Time	$T_{OnDebounce}$		100		300	ms
Long Press on Key Wake Up Time	$T_{Keylight}$		2		3	s
Thermal Shut Down Temperature	T_{OTP}	Rising temperature	130	140	150	℃
Thermal Shut Down Hysteresis	ΔT_{OTP}		30	40	50	℃

*The above data is based on demo program testing, and multiple parameter specifications can be configured by software.

3. MCU and Storage

3.1 Overview

3.1.1 MCU Instruction Set

- IP5513A is equipped with an 8-bit MCU, and its instruction set is compatible with 8051.

3.1.2 Program Storage Space

- IP5513A has a built-in 12K Bytes OTP program storage space, which is used to store user code and program storage.
- Program storage space is addressed by the program counter, also includes data, tables, interrupt entries, etc.
- Some addresses in the program storage space are used for special purposes, such as reset and interrupt entry.

3.1.3 Data Storage Space

- The internal SRAM space consists of 256 bytes, with addresses ranging from 00h to FFh.
- Low 128 Bytes (addresses 0x00~0x7f) support direct and indirect addressing methods. High 128 Bytes (addresses 0x80~0xff) only support indirect addressing methods.

3.1.4 Special Function Register (SFR)

- The space address of special function register occupies a data space of up to 128 Bytes (addresses 0x80~0xff), and only supports indirect addressing.

3.1.5 IC Programming (ICP)

- IC programming port contains 2 signal wires: ICP_ DATA (multiplex KEY) and ICP_ CLK (multiplex GPIO1).

4. System Controller Module

4.1 Normal Working State and Low-power Consumption

- Under normal working conditions of the chip, all clocks are enabled.
- The sleep mode of the chip is low-power consumption mode, and only the LOSC clock operates.
- Executing the STOP command can put the system into low-power consumption mode.

4.2 Wake-up Source

There are two situations when waking up IP5513A:

- The chip is powered on for the first time, in this case, the IC needs to activate wake-up, and the only way to activate the IP5513A is to insert the VIN.
- After the activated IC enters the standby state again, the CPU can be awakened through the following 4 wake-up sources, and the program will resume execution from the startup file.

The Wakeup signal source of IP5513A system includes:

- VIN insertion;
- Key pressed (including short press/long press/rising edge/falling edge, choose any one);
- SIRQ0/SIRQ1;
- PH1_L/PH2_R external load access;
- Watchdog;
- VOUT insertion;
- Boost output overcurrent short circuit.

After waking up IP5513A, users can query the wake-up method through a read-only register.

5. Interrupt

The interrupt sources of IP5513A system include:

- Boost abnormal interrupt (under-voltage (Lowpot) or short circuit (SCDT));
- Battery low (Batlow) (automatically block the signal when there is a VIN inserted):
  When the hardware detects low battery power, it will automatically shut down and enter Standby mode. The voltage of Batlow can be selected in four levels: 2.7/2.8/2.9/3.0V, and has a hysteresis range of 0.1V to prevent false triggering.
- Key (include long press, double click, short press, long press, and lift);
- Watchdog;
- Timer (Timer0, Timer1, Timer3);
- External interrupt (SIRQ0, SIRQ1);
- Over temperature (OT);
- VIN over voltage (VINOV), VIN under voltage (VINUV), VIN insertion (VIN_IN), VIN unplugged (VIN_OUT);
- PH1_L/PH2_R underloading, connect or remove loads.

6. System Clock

The clock source required for chip operation is provided by oscillator, and there are two types of oscillators provided by this chip:

- 12MHz high-frequency RC oscillator (HOSC);
- 32KHz low-frequency RC oscillator (LOSC);

The clock source of the CPU is fixed to the system master clock HOSC, and the clock frequency (F_{CLK}) of the CPU is fixed to 4 divisions of the HOSC.

6.1 High-frequency Clock

The chip is equipped with a high-precision oscillator (HOSC) with an oscillation frequency of 12MHz, and its frequency division clock is used as the main clock source of the system.

6.2 Low-frequency Clock

The chip is equipped with a built-in oscillator (LOSC) with an oscillation frequency of 32KHz, which provides a clock for the relevant circuits in both working and low-power states.

The clock source of the WDT (watchdog) circuit is a low-frequency oscillator (LOSC).

7. I/O Port

7.1 I/O Port Function

The universal IO port supports three states: input, output, and high resistance state.

When pushing and pulling output, there are two types of driving currents: strong and weak (10mA/5mA).

Each IO has weak pull-up or weak pull-down (100K) internally;

As shown in the table below:

- IO1~IO2, IO4~IO7 ports can all be used as universal IO ports;
- IO1 can be reused as ADC and 20uA constant current source, which can be turned on simultaneously;
- IO2 can be reused as ADC and 20uA/100uA constant current source, ADC and constant current source can be turned on simultaneously.
- KEY can be multiplexed as a universal IO port.

Pin Name	General Functions	Multiplex function			IC Programming
IO7	GPIO7	SIRQ1	PWM2	-	-
IO6	GPIO6	SIRQ0	PWM1	-	-
IO5	GPIO5	SIRQ1	PWM2	-	-
IO4	GPIO4	SIRQ0	PWM1	-	-
IO2	GPIO2	ADC1	-	-	-
IO1	GPIO1	ADC0	-	-	ICP_CLK
KEY	KEY	GPIO8	SIRQ0	PWM1	ICP_DAT

Chart 1 IP5513A IO Port Function List

8. Hardware Key

8.1 Key Module Description

IP5513A supports specialized Key detection pin. Whether key is pressed can be queried through read-only register. When the hardware reads read-only register change, it will also trigger the corresponding status interrupt flag bit. The key actions include:

- Short press: Low level within 60ms~1s;
- Double click: Two short presses appear within 1s;
- Long press: Continuously low level for more than 2s;
- Extra long press: Continuously low level exceeding 15s;
- Press down: The level changes from high to low, lasts for 60ms;
- Lift up: The level changes from low to high, lasts for 60ms;
- Rising edge + falling edge: Debounce 2ms.

Except “Extra long press 15s”, the other six key actions all have corresponding interrupt functions. For interrupts and interrupt flags, please refer to the interrupt related registers. In addition, it also supports 50ms short press reset function.

The hardware key function can be configured to be turned off.

9. Timer

9.1 Watchdog Timer (WDT)

The chip has a built-in watchdog timer that can reset the chip in the event of a software failure. When enabling the watchdog, if the user program is abnormal or clearing the watchdog timer fails, the watchdog will issue an interrupt signal or directly reset the system after the predetermined time has expired.

IP5513A integrates a Watchdog Timer (WDT) with the following characteristics:

- Timer clock source is an internal 32KHz RC clock;
- 8-speed WDT;
- Interrupt function;
- Reset function;
- Wake-up function.

9.2 Timer0/Timer1/Timer2

The chip supports 3 timers: Timer0, Timer1, and Timer2, all with a 16bit bit width. The 3 timers are identical and all support 3 counting modes:

- Normal Mode: Timer starts counting from 0 and automatically stops when it reaches Timer_Val.
- Circle Mode: Timer starts counting from 0, and after the count value reaches the target value, interrupt flag is issued. And the counter continues to accumulate, until it reaches the maximum value of 0xFFFF and reaches the overflow state. Afterwards, it accumulates from 0 and issues interrupt flag after reaching the target value, continuously cycling.
- Reload Mode: Timer starts from 0 and accumulates the count. After the count value is added to the target value, interrupt flag is issued. And then the count value is cleared to 0, the timer starts counting again from zero.

9.3 PWM

The chip has two built-in PWM outputs that can be multiplexed to multiple IOs, supporting 16bit duty cycle classification.

- PWM0 is multiplexed with Timer1.
- PWM1 is multiplexed with Timer2.

10. Analog-to-digital Conversion (ADC)

10.1 ADC Module Description

IP5513A integrates a 10-bit SAR ADC to detect 7-channel input signals. After updating all enabled channels each time, ADC raw values measured by each channel are saved in their respective digital registers, with a data type of 10bits unsigned. Users can read the ADC value of the target channel and calculate the measurement result through a formula.

ADC has a working clock of 1M, with 7 channels for VIN voltage, VIN current, VBAT voltage, ADC0, ADC1, VPH1_L and VPH2_R.

Among them, ADC0 is the multiplexing function of IO1, and IC can release a 20uA constant current source from IO0. A resistor can be attached to the ADC pin, and the voltage drop of the resistor at 20uA can be measured through the ADC to achieve PIN selection function. For example, IP5513A can select the constant current charging current of the battery by connecting different resistors to the ADC pin.

ADC1 is the multiplexing function of IO2. IC can release 20uA/100uA constant current source from IO1, a resistor can be attached to the ADC pin to measure the voltage drop of the resistor at 20uA/100uA through the ADC, thus achieving the function of detecting the external resistance value. For example, IP5513A can detect the NTC resistance value by connecting an NTC resistor to the ADC pin. By comparing the R-T table of NTC resistance, the current NTC temperature can be obtained.

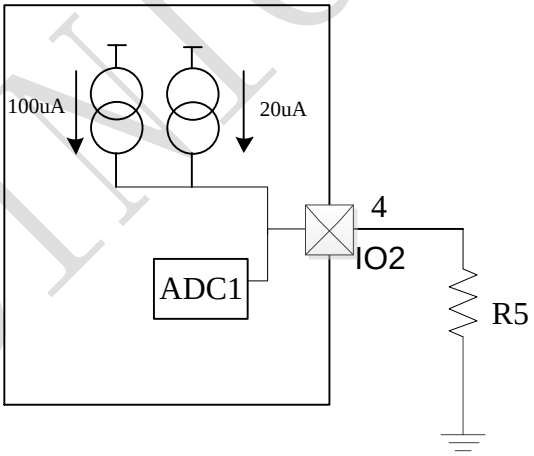


Figure 3 Constant Charging Current Setting Circuit

VPH1_L and VPH2_R is used to sense internal MOS current, and can perform light and heavy load detection when external loads are connected.

ADC has built-in preamplifier. The entire ADC input clock is 1MHz, and the DOUT[9:0] data clock is 71.4KHz (a set of ADC data is generated every 14 clock cycles). The time it takes to refresh all channel data each time depends on the number of enabled channels and the number of averaging times. For example, when 7-way is fully open, ADC data is output every 14 * 7 = 98 us. If the average of 128 times is taken, all ADC channel data is updated every 12.5ms. Therefore, the software needs to determine the number of channels to be opened and the average number of times based on the actual situation.

11. Charger Module

11.1 Charger Module Description

IP5513A integrates a linear Charger charging module, with a maximum charging current of 500mA and an adjustable charging current of 12.5mA/step. The maximum transient withstand voltage of VIN pin is 15V. When the input voltage exceeds the overvoltage threshold, overvoltage protection will be activated and Charger charging will be automatically turned off. The VIN pin undervoltage threshold is divided into four adjustable levels: 4.2V/4.3V/4.4V/4.5V. Similarly, when the VIN voltage is below the undervoltage threshold, the CPU will automatically turn off charging.

When BAT is not connected to the battery and the circuit board is directly inserted into VIN, the Charger circuit will enter a pre-charging state, and BAT terminal voltage will rise to the CV level (full battery voltage) to ensure that Batlow will not be triggered at this time.

When BAT battery voltage is less than 3V, IP5513A adopts 0.1CC trickle charging.

When the battery voltage is greater than 3V, it enters constant current CC charging.

When the battery voltage approaches the CV voltage, it enters constant voltage charging.

After entering constant voltage charging, ADC detects that the charging current is less than 0.1CC and can stop charging.

When the ADC detects that the battery voltage is less than 4.1V after stopping charging, the software can start the charging cycle again.

12. Boost Module

12.1 Boost Module Description

IP5513A integrates a boost dc-dc converter with 5V/600mA output, 1.5MHz switching frequency. To avoid large rush current causing device failure, it is built in overcurrent, short circuit, overvoltage and over temperature protection function, ensuring the reliability and stability of system operation.

The following are Boost's efficiency curves and V-I curves:

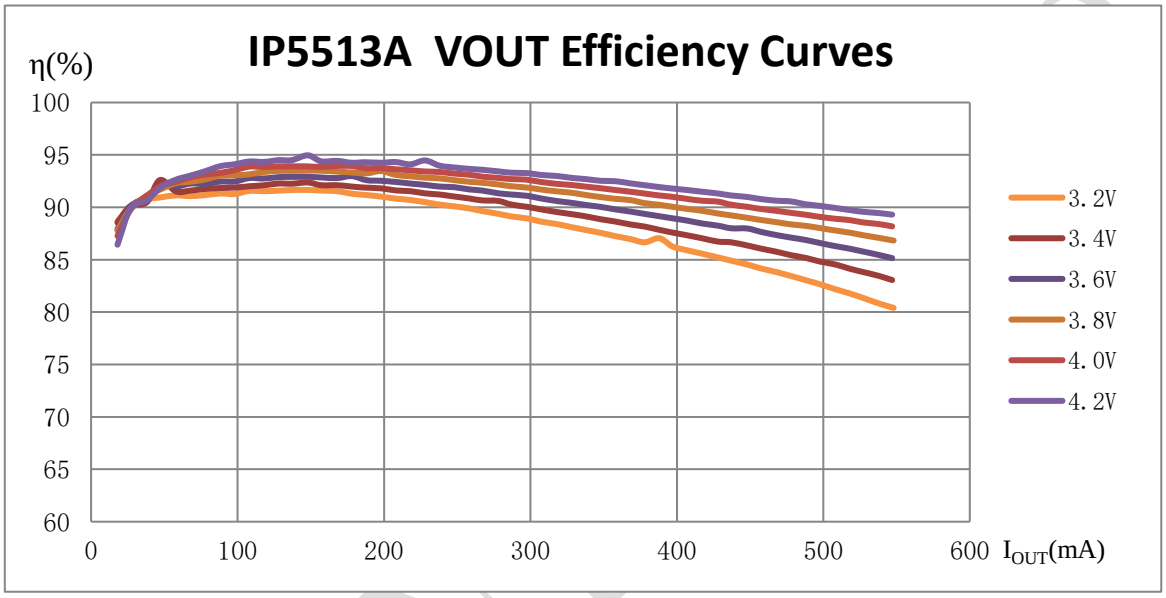


Figure 4 IP5513A Boost Efficiency Curves

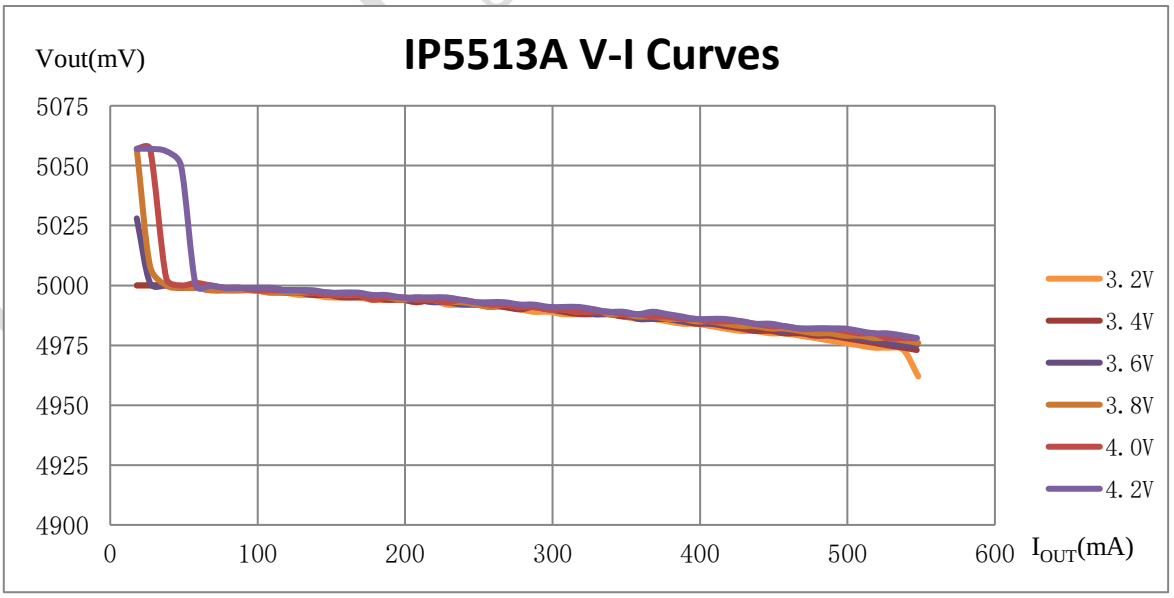


Figure 5 IP5513A Boost Output V-I Curve

In the Boost output 5V mode, the adjustable voltage range is 4.6V~5.2V. In non 5V mode, it can output voltages such as 2.4V/VBAT/0V. When IP5513A enters the sleep state, Boost can output standby voltage at the VOUT pin. The standby voltage can be 0V, 2.4V, battery voltage, or 5V (the sleep 5V has a load capacity of about 1mA).

12.2 Boost Light Load Detection

Boost supports output light load detection. When the load current of VOUT is less than the light load threshold, the hardware light load flag is set, and the software reads and processes it, such as light load entering standby.

12.3 VOUT Insertion Detection

IP5513A has a built-in VOUT load insertion detection circuit, which can wake up the system software to turn on Boost to supply power to the load when VOUT load insertion is detected in standby mode.

13. NMOS Module

13.1 NMOS Module Description

The chip is equipped with 2 high-power NMOSs, and these 2 pins (PH1_L and PH2_R) can only be used as open drain outputs and cannot be used as inputs. The circuit structure is shown in the following figure:

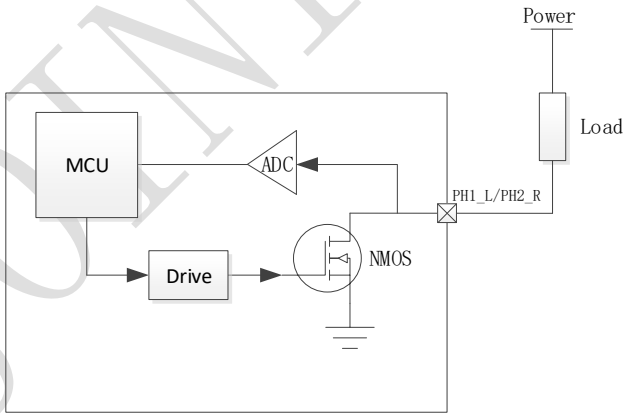


Figure 6 IP5513A NMOS Module Schematic Diagram

- When driving an external high-power load, the load is connected between Power and NMOS, and the Power voltage can reach up to 10V. The built-in NMOS transistor has a rated current of 300mA and a peak current of 500mA.
- The built-in NMOS impedance is adjustable, with a minimum of 0.4 ohms and a maximum of 12.8 ohms. The maximum ADC range of NMOS is 244.4mV.
- Short circuit/overcurrent/light load detection can be carried out through the combination of ADC and NMOS impedance.
- Support the multiplexing of PWM controlled NMOS driver switches to achieve power control.

13.1.1 PH Heavy and Light Load Detection

By detecting the current flowing through PH1_L/PH2_R, the internal comparator will use 4mA as the comparison threshold. If the current is less than 4mA, the light load flag of the corresponding NMOS will be set.

13.1.2 PH Overcurrent Detection in Software Mode

Output overcurrent detection is a built-in hardware detection of Boost, which has a high overcurrent threshold. For different applications, the overcurrent threshold can be flexibly adjusted by the software-side overcurrent detection method. The software implementation principle is as follows:

- Enable PH1_L and PH2_R two ADC.
- The NMOS internal resistance is dynamically adjusted according to the load pumping situation (the internal resistance needs to be adjusted according to the equivalent impedance of the load to prevent excessive voltage sharing from causing load undervoltage protection and not pumping).
- The NMOS dual ADC detects the NMOS voltage drop in real-time and calculates the current based on the internal resistance.
- If the current is greater than the overcurrent threshold, the software will shut down the 5V boost.

14. Typical Application Diagram

Total solution of IP5513A charging Box is merely realized by passive devices of inductor, capacitor capacitors and resistors.

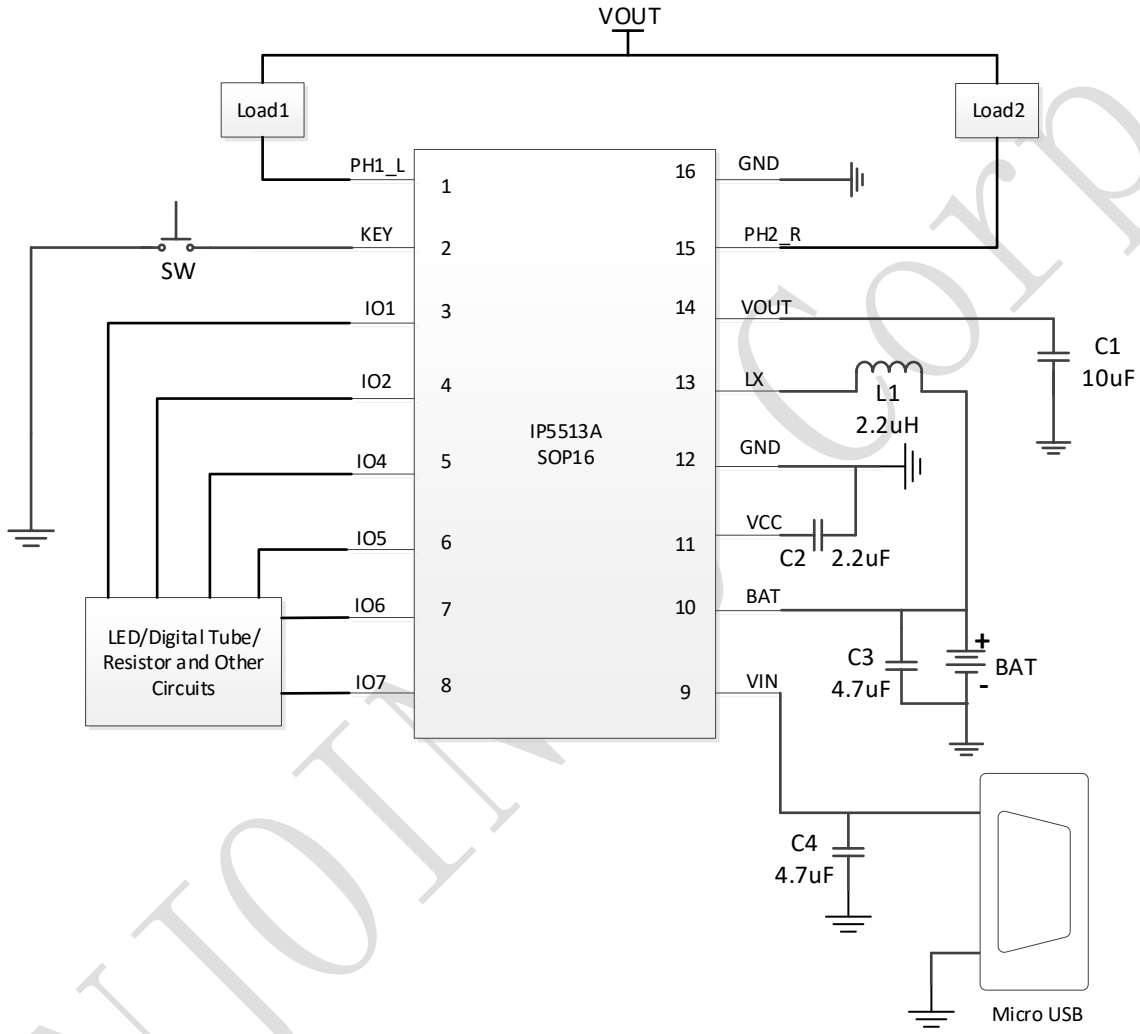
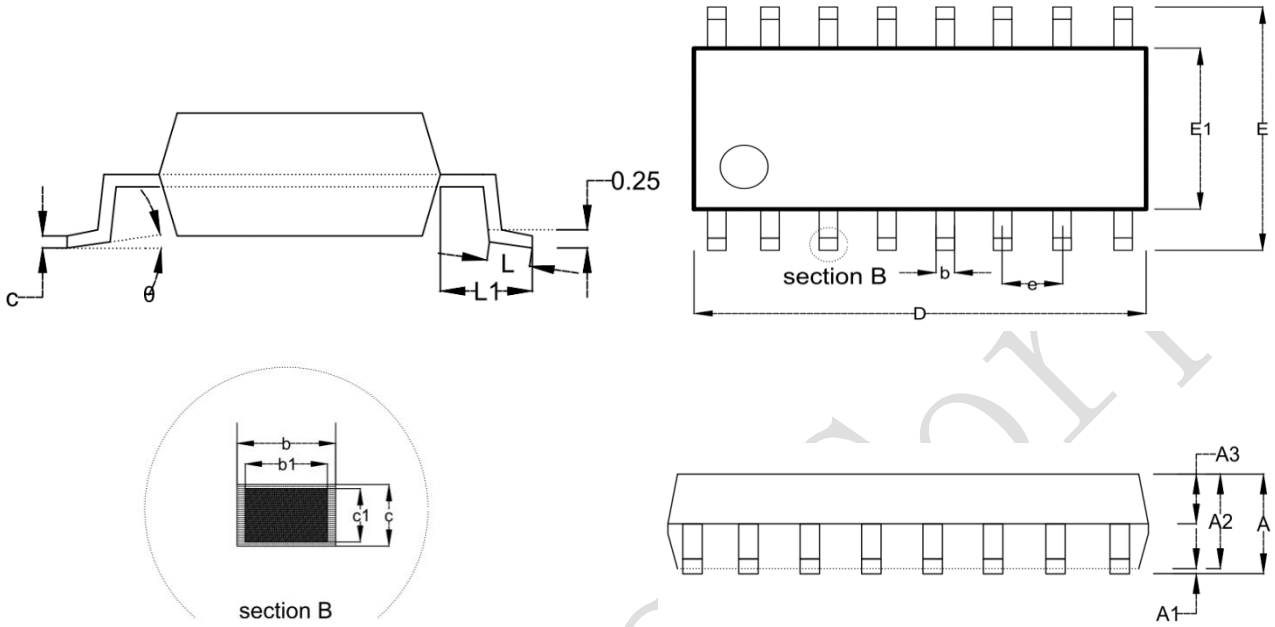


Figure 7 IP5513A Typical Application Diagram

15. Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.75
A1	0.05	--	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.48
b1	0.38	0.41	0.43
c	0.21	--	0.26
c1	0.19	0.20	0.21
D	9.70	9.90	10.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
h	0.25	--	0.50
L	0.50	--	0.80
L1	1.05BSC		
θ	0	--	8°

16.IC Mark Description

Note:
1、 --Injoinic Logo
2、IP5513A --Part Number
3、XXXXXXXX --Manufacture Number
4、 ○ --PIN1 Location

Figure 8 IP5513A Mark Description

17.IMPORTANT NOTICE

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