

Total Solution for Bidirectional Fast Charge Power Bank

1. General Description

The SW6121 is a highly integrated power management IC for fast charge power bank application. It integrates 4A switching charger, 18W synchronous boost, QC/AFC/FCP/PE/SFCP fast charge protocol, fuel gauge and power controller. With simple external components, The SW6121 provides a turn-key high efficiency solution for fast charge battery management.

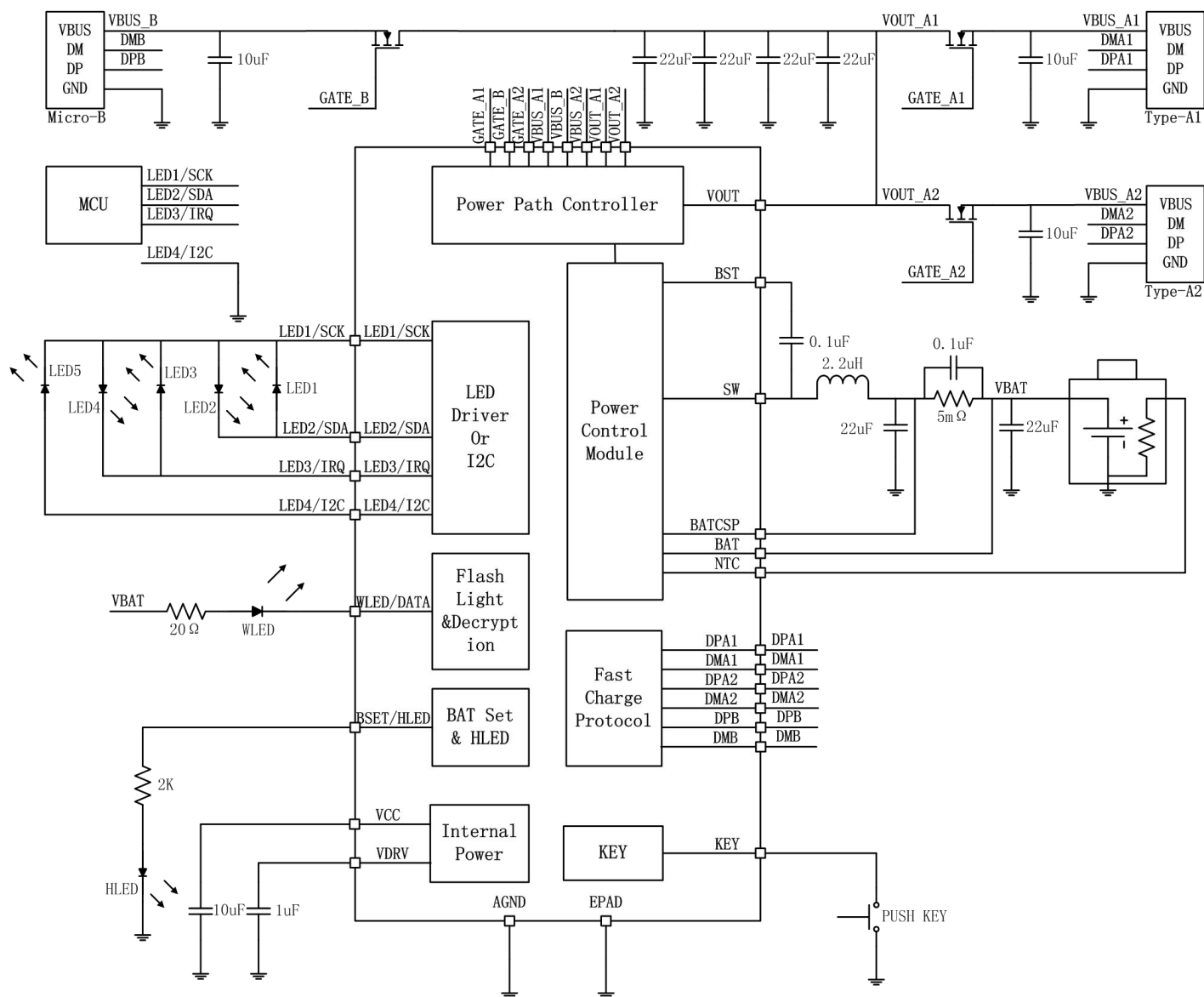
2. Applications

- Power Bank
- Battery Powered Device

3. Features

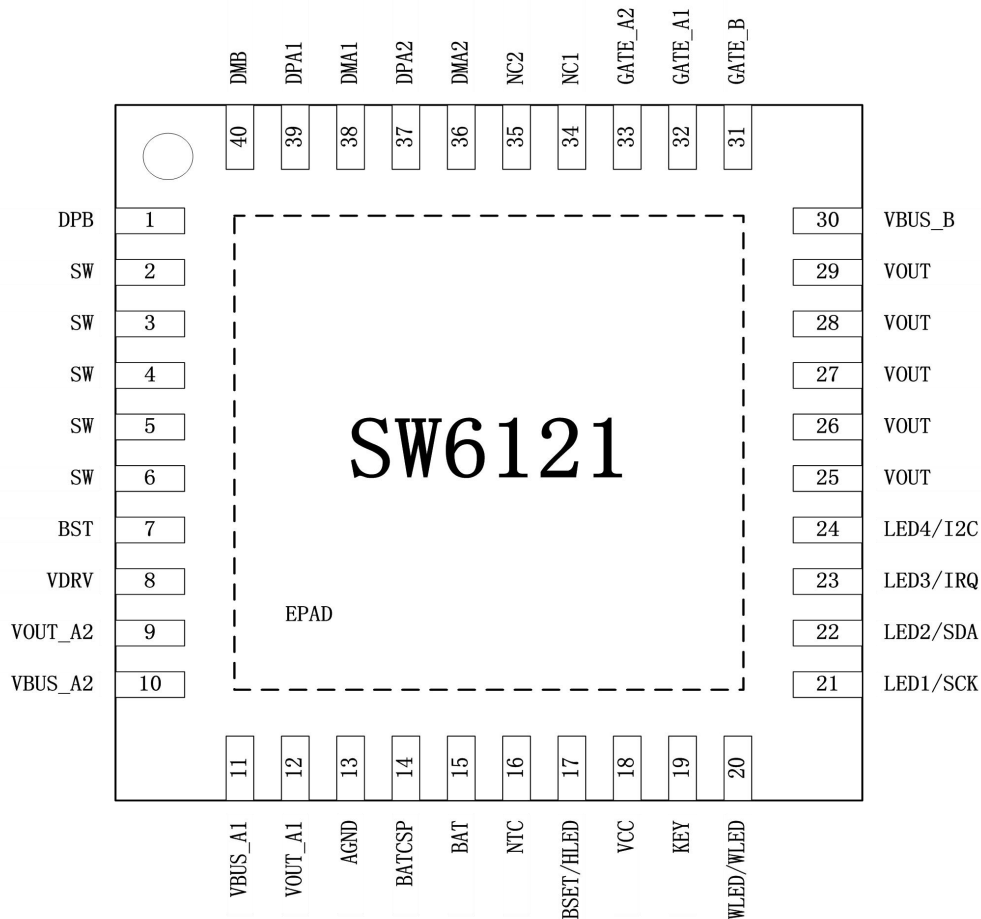
- **Switching Charger**
 - Current up to 4A , Efficiency up to 96%
 - Support 4.2/4.3/4.35/4.4 Battery Voltage
 - Support Battery NTC Protection
 - Thermal Regulation
- **Synchronous Boost**
 - Power up to 18W, Efficiency up to 95%
 - Support Wire Drop Compensation
 - Load Insert Detect and Auto Turn on
 - Light Load Detect and Auto Turn off
- **Output Fast Charge Protocol**
 - Support QC3.0/QC2.0
 - Support AFC
 - Support FCP
 - Support PE2.0/PE1.1
 - Support SFCP
- **Input Fast Charge Protocol**
 - Support AFC
 - Support FCP
- **BC1.2 Module**
 - Support BC1.2 DCP
 - Support Apple & Samsung Device
- **Lightning Decryption**
 - Support Lightning Decryption
- **Fuel Gauge**
 - Include 12bit ADC
 - Support Percent Display
 - Support Various Battery Voltage
 - Support 3~5 LEDs
 - Automatic Recognition of LED Number
- **WLED Driver**
 - Support WLED Driver
- **Fast Charge LED**
 - Support Fast Charge LED Driver
- **Key Support**
 - Support Push Key
- **Protection**
 - Input Over Voltage Protection
 - Output Over Current Protection
 - Output Short Protection
 - Charger Over Time Protection
 - Charger Over Voltage Protection
 - Over Temperature Protection
- **I2C Interface**
- **QFN-40(5x5mm) Package**

4. Functional Block Diagram



5. Pin Configuration and Function

5.1 Pin Configuration



5.2 Pin Descriptions

Pin	Name	Function Description
1	DPB	Micro-B port DP pin.
40	DMB	Micro-B port DM pin.
2, 3, 4, 5, 6	SW	Switching node.
7	BST	Bootstrap pin for high side NMOS.
8	VDRV	Driver power.
9	VOUT_A2	Type-A2 port current sense pin.
10	VBUS_A2	Type-A2 port current/voltage sense pin.
11	VBUS_A1	Type-A1 port current/voltage sense pin.
12	VOUT_A1	Type-A1 port current sense pin.
13	AGND	Analog ground.
14	BATCSP	Battery current sense pin.
15	BAT	Battery current/voltage sense pin.
16	NTC	Negative temperature coefficient (NTC) thermistor input.

17	BSET/HLED	Battery voltage set and fast charge led driver.
18	VCC	Internal power.
19	KEY	Push key input.
20	WLED/DATA	Flash led driver or lightning decryption pin.
21	LED1/SCK	Led1 for battery capacity indicator or i2c clock.
22	LED2/SDA	Led2 for battery capacity indicator or i2c data.
23	LED3/IRQ	Led3 for battery capacity indicator or irq.
24	LED4/I2C	Led4 for battery capacity indicator or i2c/led set.
25, 26, 27, 28, 29	VOUT	Boost output and charger input.
30	VBUS_B	Micro-B port input.
31	GATE_B	Micro-B port power path control pin.
32	GATE_A1	Type-A1 port power path control pin.
33	GATE_A2	Type-A2 port power path control pin.
34	NC1	Floating.
35	NC2	Floating.
36	DMA2	Type-A2 port DM pin.
37	DPA2	Type-A2 port DP pin.
38	DMA1	Type-A1 port DM pin.
39	DPA1	Type-A1 port DP pin.
	EPAD	Exposed pad.

6. Absolute Maximum Ratings

Parameters	Symbol	MIN	MAX	UNIT
Input Voltage	VBUS_B	-0.3	16	V
Output Voltage	VOUT /VOUT_A1/VOUT_A2 /VBUS_A1/VBUS_A2	-0.3	16	V
SW Voltage	SW	-0.3	16	V
BST Voltage	BST-SW	-0.3	6	V
Power Path Control Voltage	GATE_A1/GATE_B /GATE_A2	-0.3	24	V
Other Pin Voltage		-0.3	6	V
Junction Temperature		-40	+150	°C
Storage Temperature Range		-60	+150	°C
ESD(HBM)		-4	+4	KV

【Notice】Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other

conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7. Recommended Operating Conditions

Parameters	Symbol	MIN	Typical	MAX	UNIT
Input Voltage	VBUS B	4.5		13.5	V
Battery Voltage	BAT	2.8		4.5	V

8. Electrical Characteristics

($V_{IN} = 5V$, $V_{BAT} = 3.7V$, $T_A = 25^\circ C$, unless otherwise specified.)

Parameters	Symbol	Test Conditions	MIN	TYP	MAX	UNIT
Power Supply						
VBUS_B Input Voltage	V _{BUSB}		4		13.5	V
VBUS_B Input UVLO Threshold	V _{BUSB_UVLO}	Voltage Falling		4		V
VBUS_B Input UVLO Hysteresis	V _{BUSB_UVLO_HYS}	Voltage Rising		400		mV
VCC Output Voltage	V _{CC}	Boost or V _{BUSB} Insert		5		V
		Power Off		V _{BAT}		V
VCC Output current	I _{CC}	Boost or V _{BUSB} Insert		60		mA
		Power Off		60		mA
Power MOS Rdson						
High Side NMOS	R _{DSON_H}			22		m Ω
Low Side NMOS	R _{DSON_L}			16		m Ω
Charge Mode						
Trickle Charge End Voltage	V _{TC}			3		V
Trickle Charge Current	I _{TC}	1.5V<V _{BAT} <3V		300		mA
		V _{BAT} <1.5V		200		mA
Constant Current Charge Current	I _{CC}	V _{BUSB} = 5V		2.5		A
		V _{BUSB} = 9V/12V		4		A
Termination Charge Current	I _{END}			10		%
Target Charge Voltage	V _{BAT_FULL}			4.2		V
Recharge Threshold	V _{BAT_RECH}			4.1		V
Switching Frequency	F _{CHG}			400		KHz
Trickle Charge Over Time	t _{TC_OT}			40		Min
Constant Charge Over Time	t _{CC_OT}			33		Hour
Thermal Regulation Threshold	T _{REGU_CHG}			115		℃
Boost Mode						
VBAT Input Voltage	V _{BAT}		2.9		4.5	V
VBAT Input UVLO Threshold	V _{BAT_UVLO}	Voltage Falling		2.9		V
VBAT Input UVLO Hysteresis	V _{BAT_UVLO_HY}	Voltage Rising		500		mV

	S					
VOUT Output Voltage	VOUT	VOUT=5V		5.05		V
		VOUT=9V		9.05		V
		VOUT=12V		12.05		V
VOUT Output Current	IOUT	VOUT=5V		3		A
		VOUT=9V		2		A
		VOUT=12V		1.5		A
Light Load Current	ILIGHT_LOAD	RDS_PATH=10mΩ		60		mA
Light Load Time	tLIGHT_LOAD			32		S
Quiescent Current	IQ	VBAT=3.7V		40		uA
Wire Drop Compensation	VOUT_WDC	0A<IOUT<1A		0		mV
		1A<IOUT<2A		50		mV
		IOUT>2A		100		mV
Switching Frequency	FBST			400		KHz
Thermal Regulation Threshold	TREGU_BST			115		°C
BC1.2						
DP/DM Voltage	DP	Apple 2.4A Mode		2.7		V
	DM	Apple 2.4A Mode		2.7		V
PE						
Current Threshold	IREF			300		mA
Quit Time	tPLUG_OUT			200		mS
LED						
LED Source Current	ILED			4		mA
LED Flicker Frequency	fLED			1		Hz
WLED						
WLED Resistor	RWLED			20		Ω
KEY						
Short Key Time	TSHORT			32		mS
Long Key Time	TLONG			2		S
I2C						
Rate	fCLK			400		Kbit/S
Thermal Shutdown						

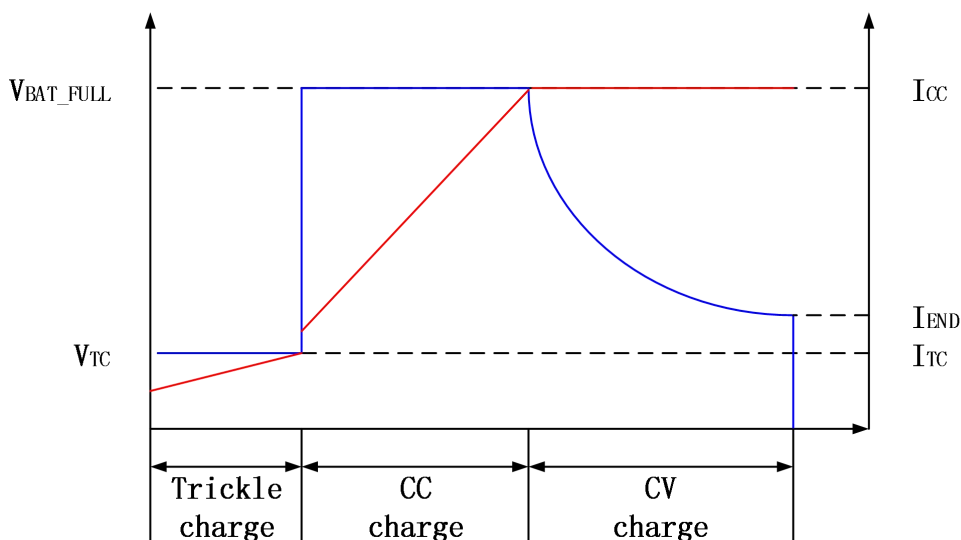
Thermal Shutdown Threshold	T _{SHDT}	Temperature Rising		150		°C
Thermal Shutdown Hysteresis	T _{SHDT_HYS}	Temperature Falling		70		°C

9. Functional Description

9.1 Charge Mode

The SW6121 integrates a switching charger with charge current up to 4A and efficiency is up to 96%. The switching charger supports 4.2V/4.3V/4.35V/4.4V battery voltage. Its switching frequency is up to 400KHz, so a small size inductor with inductance of 2.2uH can be used.

The switching charger charges battery in three charge phases: trickle charge(TC), constant current charge(CC) and constant voltage charge(CV). When battery voltage is lower than 3V, charger enters into trickle charge while the charge current is 200mA when battery voltage is lower than 1.5V and 300mA when battery voltage is between 1.5V and 3.0V. When battery voltage rises to 3V, charge enters into constant current charge while charge current is fast charge current. When battery voltage rises to target charge voltage, charger enters into constant voltage charge while charge current falls so as battery voltage stays to target voltage. When charge current falls to termination charge current, charge cycle completes and charger stops. When battery voltage is lower than recharge threshold, charger automatically restarts.



The battery target voltage can be set by BSET/HLED pin. When BSET/HLED is floating, 4.2V is set; when connecting a 62K Ω resistor to ground, 4.35V is set; when connecting a 30K Ω resistor to ground, 4.4V is set; when connecting a 10K Ω resistor to ground, 4.3V is set.

The charge current varies with input voltage. When input voltage is 5V, charge current is set to 2.5A; When input voltage is high than 5V, charge current is set to 4A.

The switching charger has battery temperature protection. It monitors battery temperature by measuring the voltage of NTC pin which connects to a negative temperature coefficient (NTC) thermistor. When battery temperature is abnormal, charger will reduce charge current or stop to protect battery. While using a typical

NTC thermistor of 103AT, When battery temperature is lower than 5°C, charger will reduce charge current by half; When battery temperature continues to fall to lower than 0°C, charger will stop; When battery temperature rises to 5°C, charger will restart and reduce charge current by half; When battery temperature continues to rise to higher than 10°C, charge current will return to normal; When battery temperature is higher than 45°C, charger will reduce charge current by half; When battery temperature continues to rise to higher than 50°C, charger will stop; When battery temperature falls to 45°C, charger will restart and reduce charge current by half; When battery temperature continues to fall to lower than 40°C, charge current will return to normal. Resistors can be in series or parallel with the NTC thermistor to change the protection temperature range. If not needing NTC protection, connect NTC pin to GND.

The switching charger integrates thermal regulation. When die temperature rises to the charge thermal regulation threshold, charge current will automatically fall down so the die temperature stops increasing. If temperature continues rising to thermal shutdown temperature, charger will stop and the SW6121 powers off.

The switching charger integrates over time protection. When charging remains in trickle charge beyond the trickle charge over time, t_{TC_OT} , or charging remains in constant current charge beyond the constant current charge over time, t_{CC_OT} , charger will terminate. Charger will restart only when re-inserting the adapter.

9.2 Boost Mode

The SW6121 integrates a synchronous boost with output power up to 18W and efficiency is up to 95%.

The synchronous boost works in PSM/PWM mode. It works in PSM mode when in light load and in PWM mode in heavy load to make a better efficiency. It will automatically change in these two modes base on output current.

The synchronous boost supports 18W power output. When output voltage is lower than 6V, its current is up to 3A. When output voltage is higher than 6V, its power output is limited to 18W. When output voltage is 9V, its current is up to 2A; When output voltage is 12V, its current is up to 1.5A.

The synchronous boost has battery temperature protection. When battery temperature is abnormal, boost will stop to protect battery. While using a typical NTC thermistor of 103AT, When battery temperature is lower than -15°C or higher than 58°C, boost will stop and turn off. When battery temperature enters into normal range, boost will not automatically restart except a start condition such as short key or load detect occur. Resistors can be in series or parallel with the NTC thermistor to change the protection temperature range. If not needing NTC protection, connect NTC pin to GND.

The synchronous boost integrates thermal regulation. When die temperature rises to boost thermal regulation threshold, output voltage will automatically fall down so as die temperature stop increasing. If die temperature still rises to thermal shutdown threshold, boost will stop and turn off. When die temperature falls to thermal shutdown hysteresis, boost will not automatically restart except a start condition such as short key or load detect occur.

The synchronous boost integrates input under voltage, output over voltage, output overload and short protection.

9.3 Power Path

The SW6121 supports dual Type-A+Micro-B. Type-A port supports QC3.0/QC2.0/AFC/FCP/PE2.0/PE1.1/SFCP fast charge output. Micro-B supports AFC/FCP fast input, and can be used as Type-C input by connecting CC to ground through 5.1K resistors.

When short key occurs or load inserts, Type-A port will turn on to power supply extern device, and light load detection will turn off Type-A port. Light load current is related to power path MOS of Type-A port. if power path MOS $R_{ds(on)}$ is $10m\Omega$, the light load current will be about 60mA. When adapter inserts, Micro-B port will turn on and charger will automatically turn on.

The SW6121 supports charging the battery and supplying extern device simultaneously. When only one port turns on, it supports fast charge input and output; when two or three ports turn on, it only supports 5V input and output.

The SW6121 supports dual Type-A ports supply extern devices simultaneously and only supports 5V output.

9.4 QC3.0/QC2.0 Fast Charge

The SW6121 integrates QC3.0/QC2.0 fast charge protocol. It supports Class A, while QC2.0 supporting 5V/9V/12V output voltage and QC3.0 supporting 5V~12V output voltage, 200mV/Step.

QC2.0/QC3.0 will output voltage base on DP/DM voltage:

Device		SW6121	
DP	DM	VOUT	Note
3.3V	3.3V	previous voltage	not respond
0.6V	0.6V	12V	
3.3V	0.6V	9V	
0.6V	3.3V	continuous mode	0.2V/Step
0.6V	GND	5V	

9.5 AFC Fast Charge

The SW6121 integrates AFC fast charge protocol, supports 5V/9V/12V output voltage and 5V/9V input voltage.

9.6 FCP Fast Charge

The SW6121 integrates FCP fast charge protocol, supports 5V/9V/12V output voltage and 5V/9V input voltage.

9.7 PE Fast Charge

The SW6121 integrates PE2.0/PE1.1 fast charge protocol. PE1.1 supports 5V/7V/9V/12V output voltage. PE2.0 supports 5V~12V output voltage, 500mV/Step.

9.8 SFCP Fast Charge

The SW6121 integrates SFCP fast charge protocol, supports 5V/9V/12V output voltage.

9.9 BC1.2 Module

The SW6121 integrates BC1.2 controller, and automatically detects apple and samsung devices:

Apple 2.4A mode: DP=2.7V, DM=2.7V;

Samsung 2A mode: DP=1.2V, DM=1.2V;

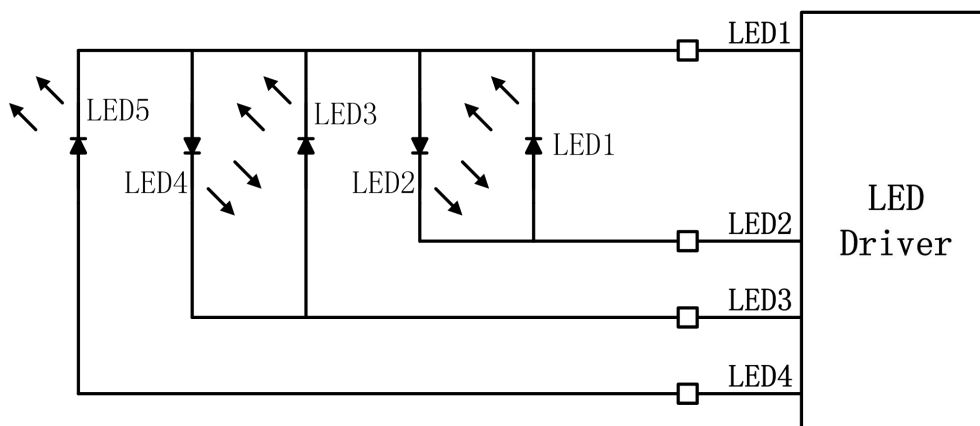
9.10 Lightning Decryption

The SW6121 integrates lightning decryption. Lightning decryption function and WLED driver is shared with WLED/DATA pin, so only one of these two functions can be used in one application.

9.11 Led Driver

The led driver supports 3/4/5 LEDs.

When connecting 5 LEDs, the LEDs connect way is as below:



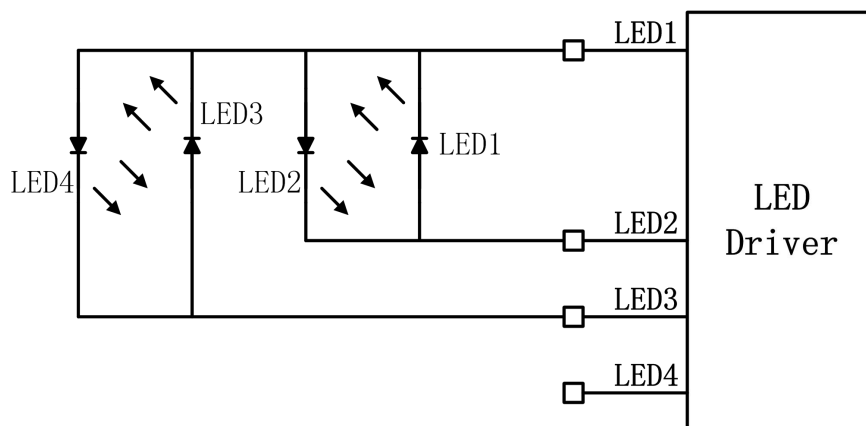
When discharging, battery capacity is shown as:

Capacity	LED1	LED2	LED3	LED4	LED5
80~100%	On	On	On	On	On
60~80%	On	On	On	On	Off
40~60%	On	On	On	Off	Off
20~40%	On	On	Off	Off	Off
5~20%	On	Off	Off	Off	Off
1~5%	Flicker	Off	Off	Off	Off
0%	Off	Off	Off	Off	Off

When charging, battery capacity is shown as:

Capacity	LED1	LED2	LED3	LED4	LED5
100%	On	On	On	On	On
80~99%	On	On	On	On	Flicker
60~80%	On	On	On	Flicker	Off
40~60%	On	On	Flicker	Off	Off
20~40%	On	Flicker	Off	Off	Off
0~20%	Flicker	Off	Off	Off	Off

When connecting 4 LEDs, the LEDs connect way is as below:



When discharging, battery capacity is shown as:

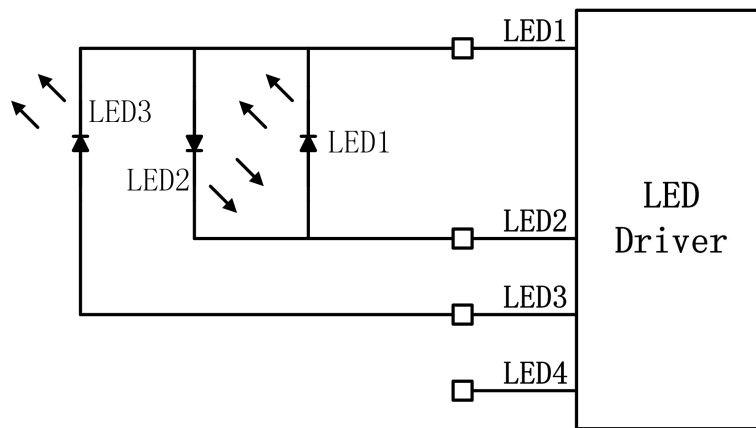
Capacity	LED1	LED2	LED3	LED4
75~100%	On	On	On	On
50~75%	On	On	On	Off
25~50%	On	On	Off	Off
5~25%	On	Off	Off	Off

1~5%	Flicker	Off	Off	Off
0%	Off	Off	Off	Off

When charging, battery capacity is shown as:

Capacity	LED1	LED2	LED3	LED4
100%	On	On	On	On
75~99%	On	On	On	Flicker
50~75%	On	On	Flicker	Off
25~50%	On	Flicker	Off	Off
0~25%	Flicker	Off	Off	Off

When connecting 3 LEDs, the LEDs connect way is as below:



When discharging, battery capacity is shown as:

Capacity	LED1	LED2	LED3
66~100%	On	On	On
33~66%	On	On	Off
5~33%	On	Off	Off
1~5%	Flicker	Off	Off
0%	Off	Off	Off

When charging, battery capacity is shown as:

Capacity	LED1	LED2	LED3
100%	On	On	On
66~99%	On	On	Flicker
33~66%	On	Flicker	Off
0~33%	Flicker	Off	Off

The led driver supports low power indication. When battery is low power, LED1 will flicker 5 times to indicate battery needs to charge, and boost will also not turn on.

9.12 WLED Driver

The SW6121 integrates flash light driver. WLED pin is connected to flash light to drives flash light.

9.13 Fast Charge Led

The SW6121 integrates fast charge LED driver through BSET/HLED pin. When being in input or output fast charge status, BSET/HLED pin will drive high to turn on fast charge led.

9.14 KEY

The SW6121 integrates key function. It supports push key, and supports short key, long key and double short key.

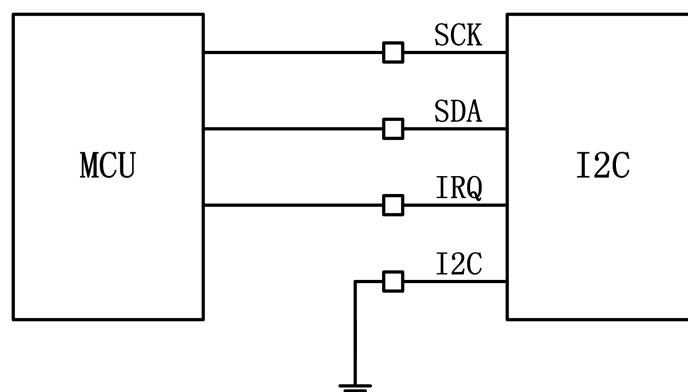
Short key: Type-A1 port, Type-A2 port and led driver will turn on;

Long key: WLED driver will turn on or turn off;

Double short key: Type-A 1port, Type-A2 port and led driver will turn off ;

9.15 I2C Interface

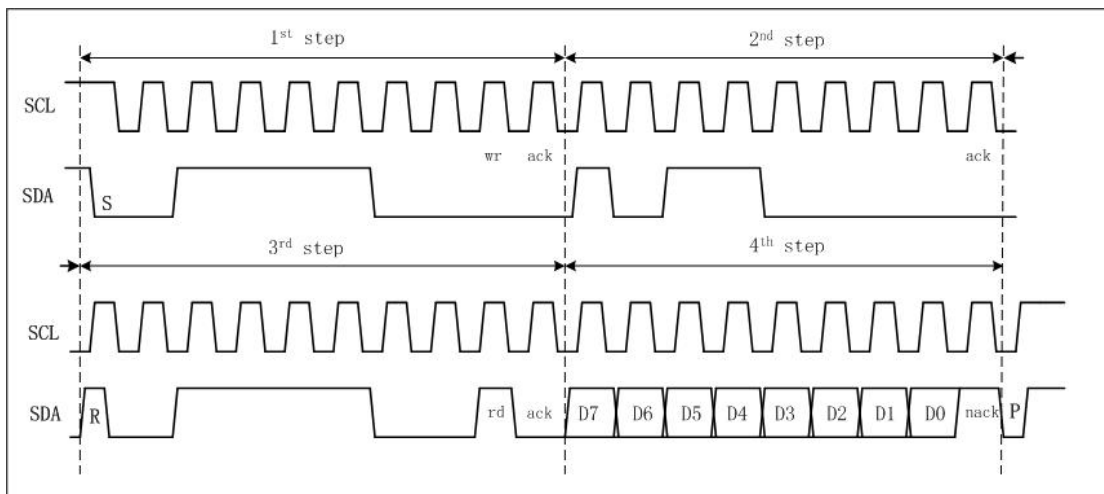
The SW6121 integrates I2C interface, supports 100K/400K rate. I2C interface and LED driver are shared the same four pins, identifying by seting led4/i2c pin. When using as I2C interface, LED4/I2C should connect to ground.



Read Timing:

Slave address : 0x3C

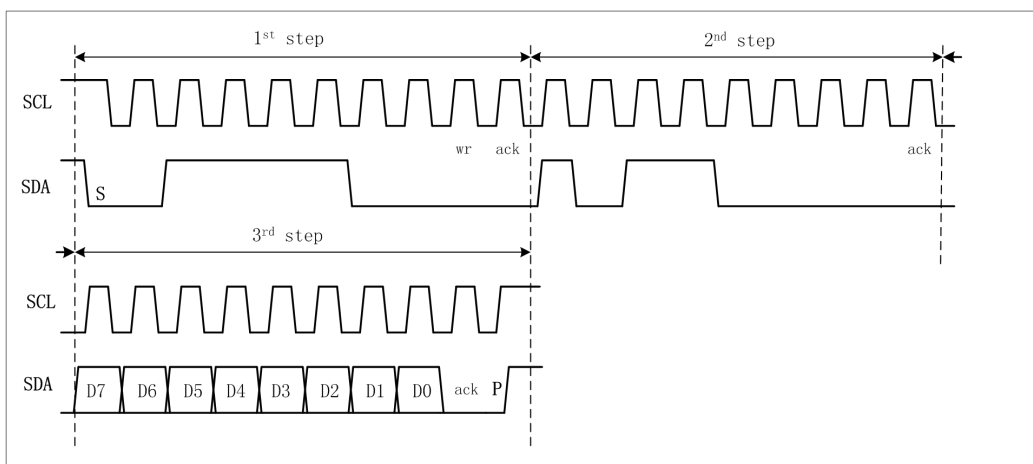
Register address: 0xB0



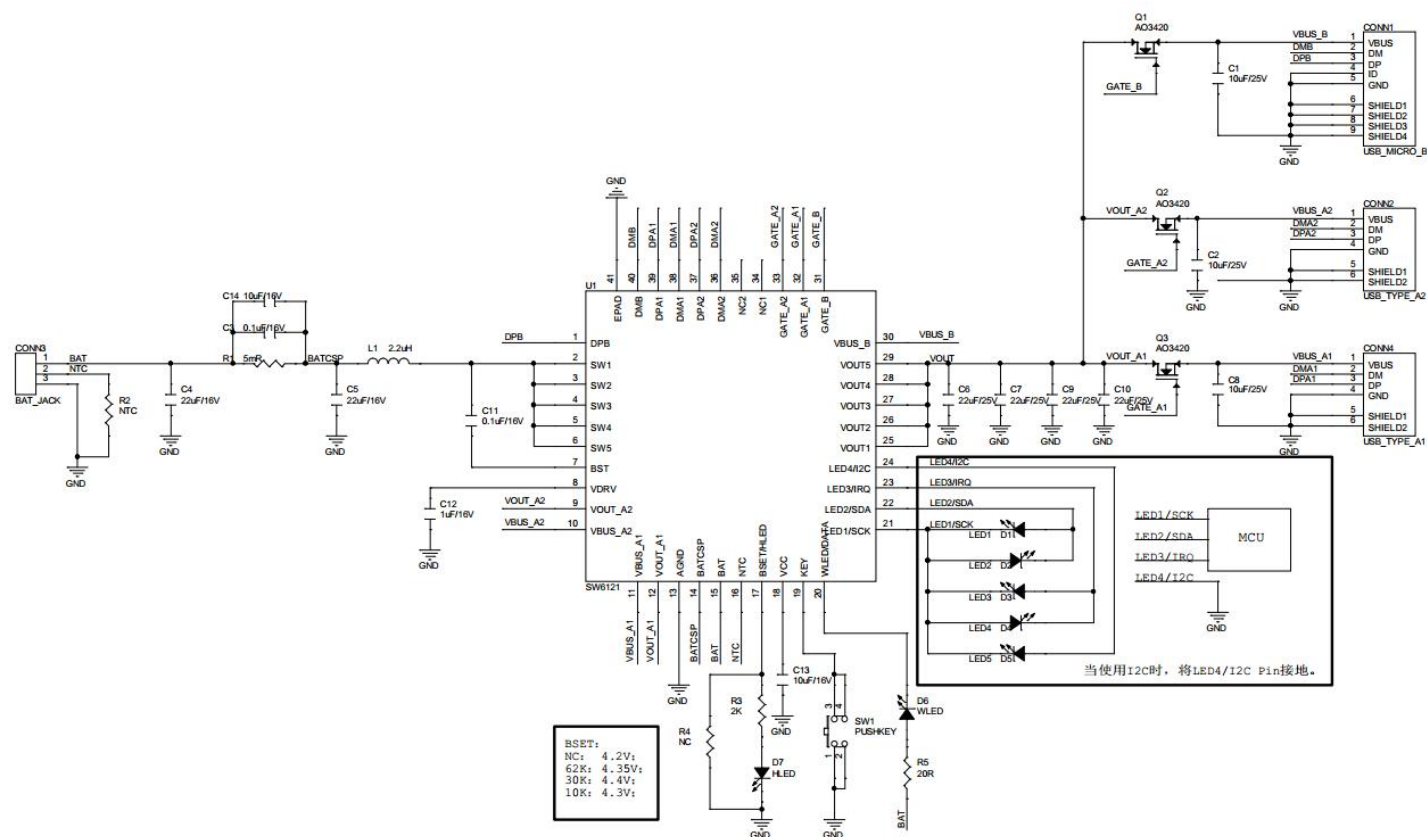
Write Timing:

Slave address : 0x3C

Register address: 0xB0



10. Typical Application Circuits



12. Revision History

V1.0 Initial version.

V1.1 Add description of key action.

V2.0 Add description of afc/fcp protocol, lightning decryption and other functions.