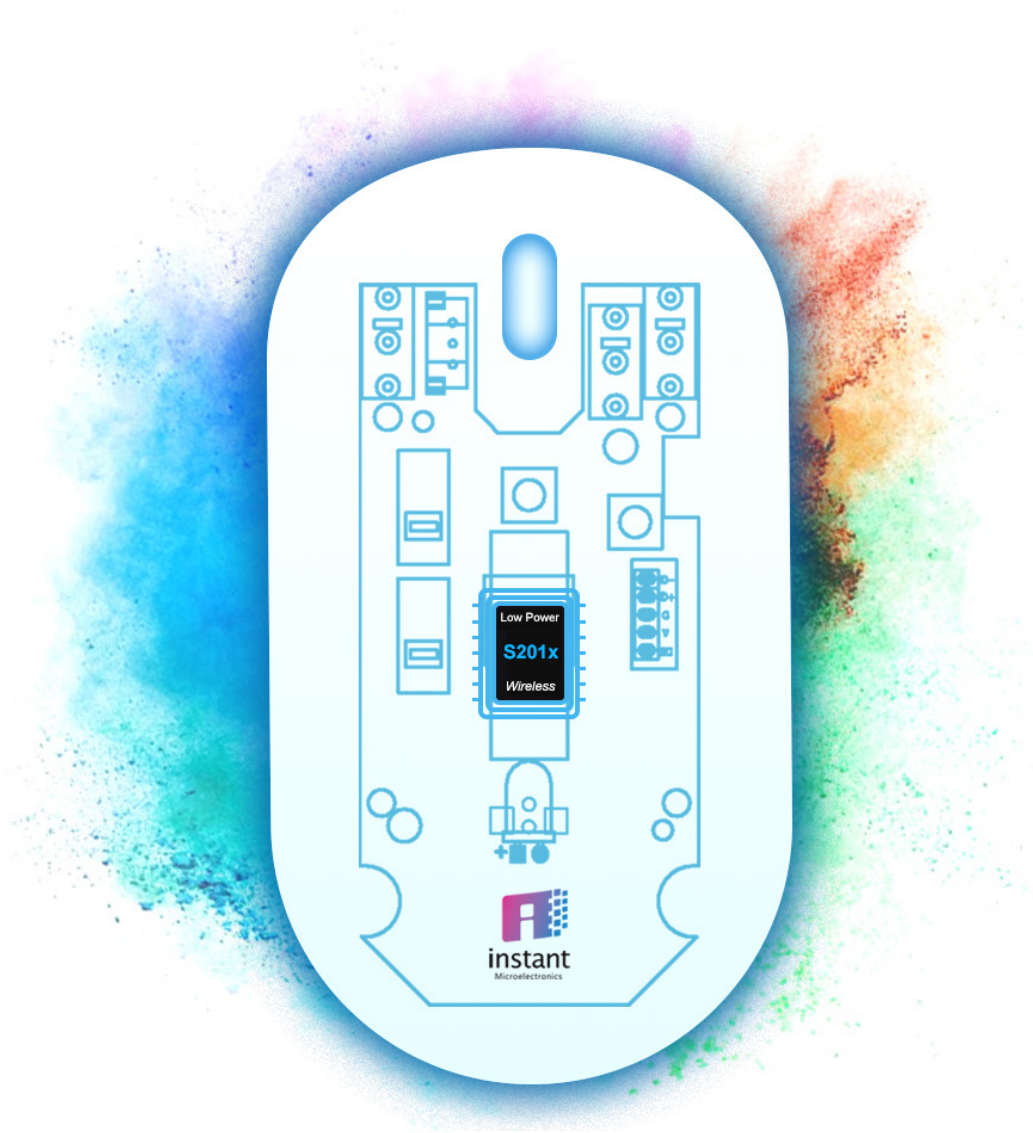


# S201x Datasheet

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Low Power Wireless Mouse Sensor(*S201B/S201C*)



Version V1.01

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## 1. General Description

S201x is a low power optical sensor for wireless mouse application. It is based on high precision surface tracking algorithm and has built-in LED drive circuit and OSC circuit. It can provide high precision positioning ability with low power consumption. The length of motion data(DX/DY) can be selected as 8bit or 16 bit by register setting. We can avoid data overflow and improve moving accuracy by using 16bit motion data.

S201B can select three sets of resolution by CPI\_SEL pin without updating MCU configuration. It also supports extra input keys (SW1/SW2) by multiplexing pins. The user can get the status of the key by reading the value of register 0x02. The resource of MCU is saved.

S201C is the high CPI version of S201B by default, and is compatible with S201B.

## 2. Feature

- High precision surface tracking algorithm
- 2-wired SPI serial interface
- Single power with wide voltage range: 2.1V~3.6V(VDD)
- Built-in OSC circuit
- Built-in LED drive circuit
- Support multiple CPI resolution:
  - Compatible: 600/800/1000(default)/1200/1600
  - Extended: 200~3200
  - Others: Three CPI resolutions selected by CPI\_SEL (S201B) . Default is 1200/2400/3200 (S201C)
- Max Frame rate 3400 fps
- Max acceleration 10g, Max speed 40ips
- Low power LED control algorithm.
- Support 8bit and 16bit motion data formats, selected by register setting.
- Pin1 and Pin2 can be reused as SW1 and SW2 input key functions, saving I/O resource of MCU(see register description for details)
- Max resolution 3200 CPI
- Advanced power control method:
  - 2.1mA @ Mouse moving (Normal)
  - 101uA @ Mouse not moving (Sleep1)
  - 14uA @ Mouse not moving (Sleep2)
  - 1uA @ Power down mode (not include LED)
- SDIP-8 package, ROHS standard

Typical application: wireless mouse, bluetooth mouse

### 3. Block Diagram

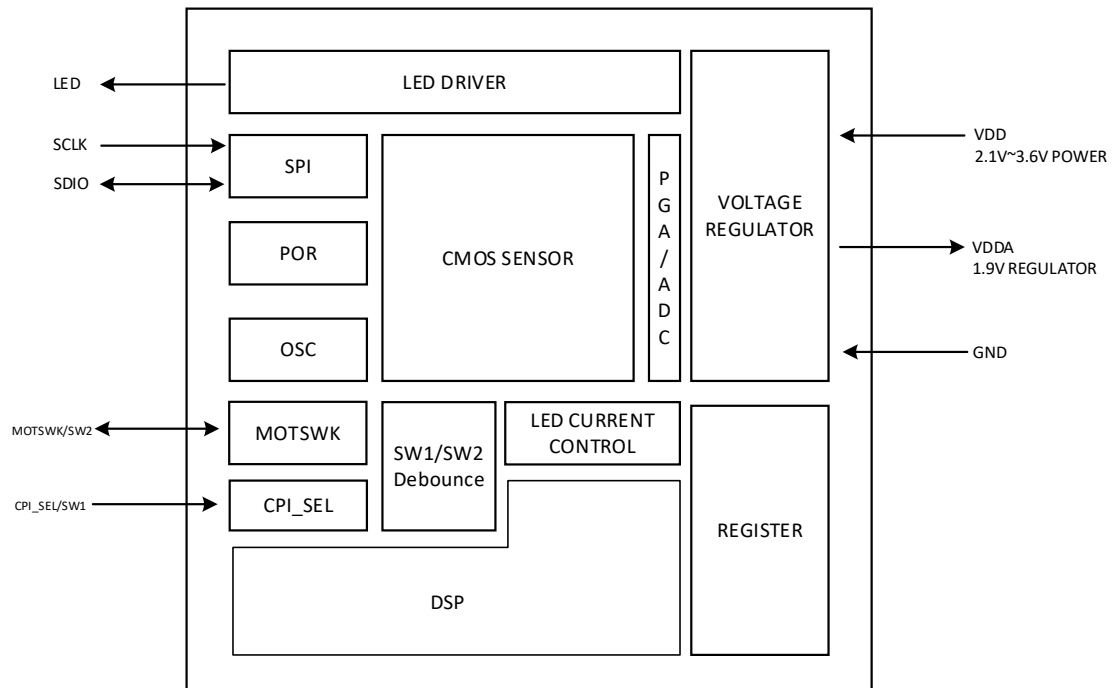


Figure3-1 Block Diagram

### 4. Pin

#### 4.1 Pin Arrangement

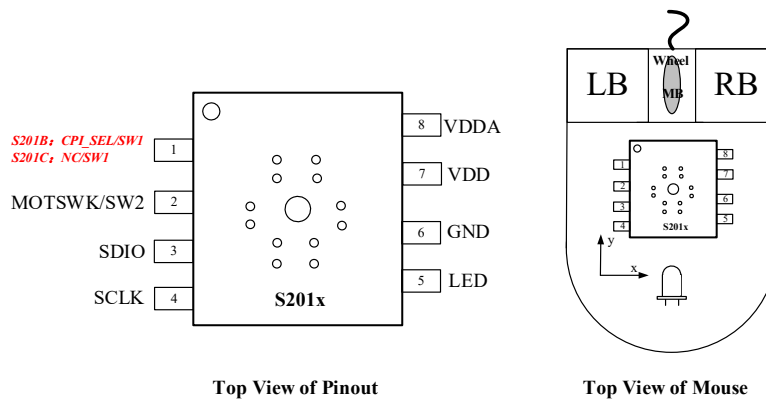


Figure4-1 Pinout

## 4.2 Pin Description

Pin	Name	Type	Definition
1	CPI_SEL/SW1	IN	CPI selection input of S201B, or SW1 input key
	NC/SW1	IN	NC of S201C, or SW1 input key
2	MOTSWK/SW2	IN/OUT	Motion detection output, or SW2 input key
3	SDIO	IN/OUT	Bi-directional I/O for SPI
4	SCLK	IN	Clock input for SPI
5	LED	OUT	LED control
6	GND	GND	Chip ground
7	VDD	PWR	Power supply input (2.1V~3.6V)
8	VDDA	PWR	VDDA is 1.9V regulator output and should connect a 4.7u capacitor to GND.

Table 4-1 Pin Description

## 5. Serial Interface

### 5.1 Serial Interface Protocol

S201x uses 2-wire SPI half-duplex transmission mode. It uses 2 bytes for read and write operations. The first byte consists of 1 bit read / write control and 7 bit address, and the second byte is data.

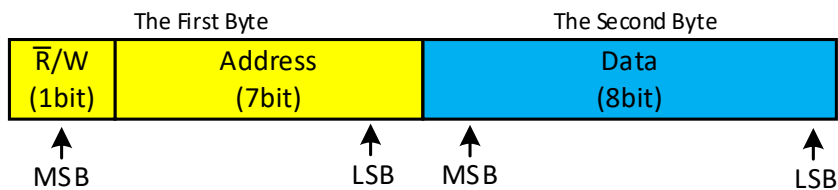


Figure 5-1 Serial Interface Transmission Format

#### 5.1.1 Write Operation

The write operation contains two bytes, the highest bit of the first byte is 1, the last 7 bits are the address, and the second byte is the data. A write operation writes data into the register corresponding to s201x address. SDIO changes at the falling edge of SCLK, and s201B / C reads SDIO data at the rising edge of SCLK.

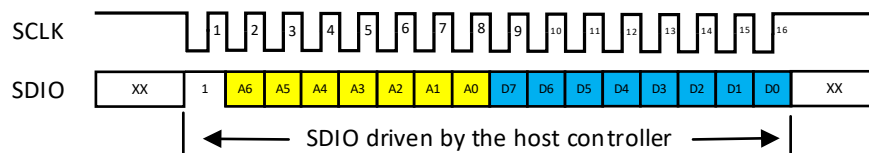


Figure 5-2 Write Operation

#### 5.1.2 Read Operation

The read operation contains two bytes, the highest bit of the first byte is 0, the rest 7bit is the address, and the second byte is the data. The register value of s201x corresponding address can be

read out by one read operation. After SDIO changes and writes to address bit when SCLK falls, the host controller releases SDIO to high resistance state, s201b/c outputs data at the edge of SCLK, and the host controller reads data at the rising edge of SCLK.

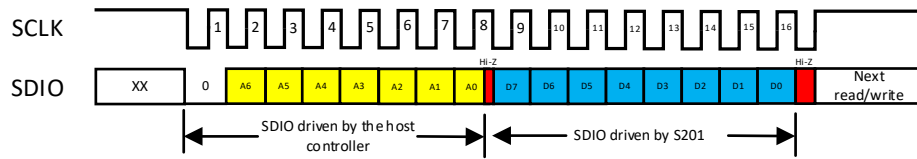


Figure 5-2 Read Operation

## 5.2 ReSync Serial Interface

In the process of serial interface transmission, the clock and data may be out of sync, resulting in read / write exception. If this happens, the host controller should change the SCLK signal from high to low for more than 1 US, and then from low to high for more than 3 ms. This operation can reset the internal interface of s201x and re-synchronize the clock and data.

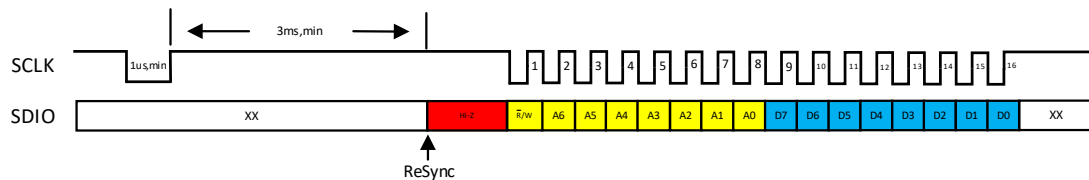


Figure 5-3 ReSync Operation

## 6. CPI\_SEL/SW1 Pin

CPI\_SEL/SW1 is the Pin1 of S201B. It has two functions and can be configured by register 0x5F.

1. It is used as CPI\_SEL pin to select different CPI resolution(Default);
2. It is used as SW1 to realize input key function.

NC/SW1 is the Pin1 of S201C. It can be configured as NC(not connect) or SW1(input key function) by setting register 0x5F.

Different usage of CPI\_SEL(pin1) and CPI settings of register 0x06 can select different resolutions. See the table below for details:

CPI[2:0]	S201B			S201C
	Pin1 connect to HI-Z	Pin1 connect to GND	Pin1 connect to VDD	
000	600			
001	800	3200	3200	3200
010(default)	1000			
011	1200	1200	1200	1200
100	1600	2400	2000	2400
101-111	RSV	RSV	RSV	RSV

Users can realize three CPI resolution schemes by changing the voltage level of PIN1. The method is as follows:

1200(default) — 1600 — 1000/800/600	[ Pin1 connect to HI-Z ]
1200(default) — 2400 — 3200	[ Pin1 connect to GND(S201B)/ (S201C) ]
1200(default) — 2000 — 3200	[ Pin1 connect to VDD ]

Usually MCU provide six key input functions. In order to save MCU IO resources, users can configure PIN1 as SW1 input key function by setting register 0x5F. And the status of this input key can be read by register 0x02.

## 7. MOTSWK/SW2

MOTSWK/SW2 has two functions:

### A. MOTSWK function.

MOTSWK has two working mode: Level mode and Interrupt mode. Through the configuration of register 0x06 (see register for details), the level mode is that when s201x detects movement, MOTSWK pin outputs 0. When the host controller reads out all the moving data, MOTSWK pin outputs 1. The interrupt mode is that MOTSWK pin outputs 1 when s201x enters sleep. After exiting from sleep state, MOTSWK pin outputs 0 for a while and then returns to 1, and wakes up the host controller through the rising edge or falling edge of the interrupt signal, which can reduce the power consumption.

### B. SW2 key input function.

MCU generally provides 6 keys function. This pin can be changed to SW2 key input function through register 0x5f to save the IO resource of MCU pin. After internal processing, the input key signal can be read out through register 0x02. (see register description for details)

## 8. Register

### 8.1 Register Summary

Address	Name	Description	R/W	Default
0x00	PID1	Product identifier 1 of S201x	R	0x30
0x01	PID2	Product identifier 2 of S201x	R	0xD1
0x02	Motion_St	Motion Status and the input key signal of SW1/SW2	R	-
0x03	DeltaX	Low 8bit X-axis motion data (dx[7:0])	R	-
0x04	DeltaY	Low 8bit Y-axis motion data (dy[7:0])	R	-
0x05	Op_Mode	Operation mode selection	W/R	0xB8
0x06	Config	Configuration item	W/R	0x02
0x07	Img_Qa	Quality of image	R	-
0x08	Op_St	Status of sleep and frame rate	R	-
0x09	Write_Protect	Write enable for other registers	W/R	0x00
0x0A	Sleep1_Setting	Frequency settings of Sleep1 mode	W/R	0x70
0x0B	Enter_Time	Entering time from working mode to sleep1 mode	W/R	0x10
0x0C	Sleep2_Setting	Frequency settings of Sleep1 mode	W/R	0x70
0x20	DeltaX_Hi	High 8bit X-axis motion data (dx[15:8])	R	-
0x21	DeltaY_Hi	High 8bit Y-axis motion data (dy[15:8])	R	-
0x22	DxDy_16bit	16bit or 8bit length selection of DX/DY motion data output (default 8 bit)	W/R	0x00
0x23	CPI2_Setting	The extend settings of CPI2	W/R	0x02
0x49	PID3	Product identifier 3 of S201x	R	0xA1
0x5F	Key_Setting	Function settings of Pin1 and Pin2	W/R	0x00

### 8.2 Register Descriptions

**PID1** Address: 0x00

Access: Read Default: 0x30

Bit	7	6	5	4	3	2	1	0
Field	PID1[7:0]							

Data Type: 8bit unsigned integer

Usage: It can be used to verify if the serial interface clock and data are synchronized.



**PID2**

Address: 0x01

Access: Read

Default: 0xD1

Bit	7	6	5	4	3	2	1	0
Field	PID2[7:0]							

Data Type: 8bit unsigned integer

Usage: It can be used to verify if the serial interface clock and data are synchronized.

**Motion\_St**

Address: 0x02

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	Motion	SW2	SW1	DYOVF	DXOVF	RES[2:0]		

Data Type: Bit Field

Usage: In typical applications, the host controller will poll the sensor for valid motion data by checking the Motion bit. If the Motion bit is set, the motion data in Delta\_X and Delta\_Y registers are valid and ready to be read. Be sure to read Motion bit first before reading out Delta\_X and Delta\_Y registers. DXOVF bit and DYOVF bit show whether if the motion report buffers have overflowed since last read out.

Field Name	Description
	<b>0: No motion (Default)</b>
Motion	1: Motion detected. data in Delta_X and Delta_Y registers are valid and ready to be read out
SW2	<b>0: No SW2 function or the status of releasing the SW2 button(Default)</b> 1: The status of pressing down the SW2 button.
SW1	<b>0: No SW1 function or the status of releasing the SW2 button(Default)</b> 1: The status of pressing down the SW2 button.
DYOVF	<b>0: Y-axis motion data is not overflow. (Default)</b> 1: Y-axis motion data is overflow
DXOVF	<b>0: X-axis motion data is not overflow. (Default)</b> 1: X-axis motion data is overflow
-----	
	S201B
	000=600CPI
	001=800CPI
CPI[2:0]	<b>010=1000CPI(Default)</b>
(Pin1 floating)	011=1200CPI
	100=1600CPI
	101-111:Reserved
	(See CPI_SEL/SW1 Pin description for details)
	S201C
	000=3200CPI
	001=3200CPI
	<b>010=3200CPI(Default)</b>
	011=1200CPI
	100=2400CPI
	101-111:Reserved
	(See CPI_SEL/SW1 Pin description for details)

### DeltaX

Address: 0x03

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	DeltaX[7:0]							

Data Type: 8bit data

Usage: Delta\_X register is the X-axis motion in counts after reading Motion\_Status register.

Absolute value is determined by the resolution setting CPI. If motion data mode is 16bit, this byte is the low 8 bits X-axis data. If motion data mode is 8bit, this byte reports X-axis data ranged from -127 to 128, and DeltaX[7] is the sign bit.

### DeltaY

Address: 0x04

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	DeltaY[7:0]							

Data Type: 8bit data

Usage: Delta\_Y register is the Y-axis motion in counts after reading Motion\_Status register.

Absolute value is determined by the resolution setting CPI. If motion data mode is 16bit, this byte is the low 8 bits Y-axis data. If motion data mode is 8bit, this byte reports Y-axis data ranged from -127 to 128, and DeltaY[7] is the sign bit.

### Op\_Mode

Address: 0x05

Access: Write/Read

Default: 0xB8

Bit	7	6	5	4	3	2	1	0
Field	1	0	1	Slp_en	Slp2_en	Slp2For	Slp1For	Wakeup

Data Type: Bit Field

Usage: This register is used to configure sleep function.

Field Name					Description
Slp_en	Slp2_en	Slp2For	Slp1For	Wakeup	
0	x	x	x	x	Disable Sleep function
1	0	x	x	x	Enable Sleep1, disable Sleep2
1	1	x	x	x	Enable Sleep1, enable Sleep2(Default)
1	1	1	0	0	Force to enter sleep2 mode
1	x	0	1	0	Force to enter sleep1 mode
1	x	0	0	1	Wake up from sleep mode

### Config

Address: 0x06

Access: Write/Read

Default: 0x02

Bit	7	6	5	4	3	2	1	0
Field	Rst	Mot	0	0	PD_en	CPI[2:0]		

Data Type: Bit Field

Usage: This register allows users to change the settings.

Field Name	Description
Rst	<b>0: Normal operation mode(Default)</b> 1: Reset the full chip
Mot	<b>0: Set MotSwk to level mode(default)</b> 1: Set MotSwk to interrupt mode
PD_en	<b>0: Normal operation mode(Default)</b> 1: Power Down
S201B	
S201C	
CPI[2:0] (Pin1 floating)	000=600CPI
	001=800CPI
	<b>010=1000CPI(Default)</b>
	011=1200CPI
	100=1600CPI
	101-111:Reserved
	(See CPI_SEL/SW1 Pin description for details)
	000=3200CPI
	001=3200CPI
	<b>010=3200CPI(Default)</b>
	011=1200CPI
	100=2400CPI
	101-111:Reserved
	(See CPI_SEL/SW1 Pin description for details)

### Img\_Qa

Address: 0x07

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	PID1[7:0]							

Data Type: 8bit unsigned integer

Usage: This register represents the image quality of the sensor

### Op\_St

Address: 0x08

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	Rsv[3:0]				Slp_st	Op_st[2:0]		

Data Type: Bit Field

Usage: This register allows users to get status of Sleep mode and frame rate.

Field Name	Description
Slp_St	0:Sleep1 1:Sleep2
Op_st[2:0]	000: normal work, 3400 fps(disable Sleep) 001: normal work, 3400 fps(enable Sleep) 011: normal work, 1700 fps(enable Sleep) 101: normal work, 1133 fps(enable Sleep) 110: Sleep

### Write\_Protection

Address: 0x09

Access: Write/Read

Default: 0x00

Bit	7	6	5	4	3	2	1	0
Field	WP[7:0]							

Data Type: 8bit unsigned integer

Usage: This register is used to configure the writing protection of 0x0A~0x7F registers.

Field Name	Description
WP[7:0]	<b>0x00:</b> The registers(0x0A~0x7F) are read only (Default) 0x5A: The registers (0x0A~0x0C) are read /write <b>0xC3:</b> The registers (0x0A~0x7F) are read /write

### Sleep1\_Setting

Address: 0x0A

Access: Write/Read

Default: 0x70

Bit	7	6	5	4	3	2	1	0
Field	Slp1_freq[3:0]				0	0	0	0

Data Type: 8bit unsigned integer

Usage: This register is used to set the frequency of Sleep1. The frequency of Sleep1 equals  $4ms * (Slp1\_freq[3:0] + 1)$ , default value is 32ms ( $Slp1\_freq[3:0] == 7$ ).

### Enter\_Time

Address: 0x0B

Access: Write/Read

Default: 0x10

Bit	7	6	5	4	3	2	1	0
Field	Slp1_ent[3:0]				Slp2_ent[3:0]			

Data Type: Bit Field

Usage: This register is used to configure the waiting time before sensor enters sleep mode.

Field Name	Description
Slp1_ent[3:0]	$128ms * (Slp1\_ent[3:0] + 1)$ <b>default=0001,256ms</b>
Slp2_ent[3:0]	$20480ms * (Slp1\_ent[3:0] + 1)$ <b>default=0000,20480ms</b>

### Sleep2\_Setting

Address: 0x0C

Access: Write/Read

Default: 0x70

Bit	7	6	5	4	3	2	1	0
Field	Slp2_freq[3:0]				0	0	0	0

Data Type: 8bit unsigned integer

Usage: This register is used to set the frequency of Sleep1. The frequency of Sleep1 equals  $64\text{ms} * (\text{Slp2\_freq}[3:0] + 1)$ , default value is 512ms ( $\text{Slp2\_freq}[3:0] = 7$ ).

### DeltaX\_Hi

Address: 0x20

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	DeltaX_Hi[15:8]							

Data Type: 8bit data

Usage: **Only worked when DxDy\_16bit is enabled.** This byte provides high 8 bits motion data of X-axis. When using high CPI resolution, it is recommended to turn on 16bit data mode. DeltaX\_Hi[7] is the sign bit.

### DeltaY\_Hi

Address: 0x21

Access: Read

Default: --

Bit	7	6	5	4	3	2	1	0
Field	DeltaY_Hi[15:8]							

Data Type: 8bit data

Usage: **Only worked when DxDy\_16bit is enabled.** This byte provides high 8 bits motion data of Y-axis. When using high CPI resolution, it is recommended to turn on 16bit data mode. DeltaY\_Hi[7] is the sign bit.

### DxDy\_16bit

Address: 0x22

Access: Write/Read

Default: 0x00

Bit	7	6	5	4	3	2	1	0
Field	Rsv[7:1]							16bit_en

Data Type: Bit Field

Usage: When bit 16bit\_en is set to 1, the motion data reports from 8bit mode to 16bit mode. The host controller can read DeltaX\_Hi[7:0] and DeltaX data and combine them to a complete X-axis motion data. Y-axis motion data can be get by the same way.

### CPI2\_Setting

Address: 0x23

Access: Write/Read

Default: 0x02

Bit	7	6	5	4	3	2	1	0
Field	CPI2_en		Rsv[6:4]			CPI2[3:0]		

Data Type: Bit Field

Usage: This register is used to enable the extend CPI resolutions configuration.

Field Name	Description
CPI2_en	<b>0: Using CPI( register Config)as configuration value(Default)</b> <b>1: Using CPI2 as configuration value</b>
Rsv[6:4]	Reserved
CPI2[3:0]	0000=200CPI 0001=400CPI <b>0010=2000CPI(Default)</b> 0011=2400CPI 0100=3200CPI 0101~0110:Reserved 0111=600CPI 1000=800CPI 1001=1000CPI 1010=1200CPI 1011=1600CPI 1100-1111:Reserved

### PID3

Address: 0x49

Access: Read

Default: 0xA1

Bit	7	6	5	4	3	2	1	0
Field	PID3[7:0]							

Data Type: 8bit unsigned integer

Usage: This register is used as a ID to check whether the chip is S201x or not.

### Key\_Setting

Address: 0x5f

Access: Write/Read

Default: 0x00

Bit	7	6	5	4	3	2	1	0
Field	Rsv[7:2]						SW2Func	SW1Func

Data Type: Bit Field

Usage: This register is used to configure the function of CPI\_SEL/SW1 and MOTSWK/SW2 pins. The key status can be read from register 0x02 when this register is set as input key function.

Field Name	描述
Rsv[7:2]	Reserved
SW2Func	<b>0: Set Pin2 as MOTSWK function(Default)</b> 1: Set Pin2 as SW2 input key function
SW1Func	<b>0: Set Pin1 as CPI_SEL(S201B) or NC (S201C) function(Default)</b> 1: Set Pin1 as SW1 input key function

## 9. Electrical Characteristic

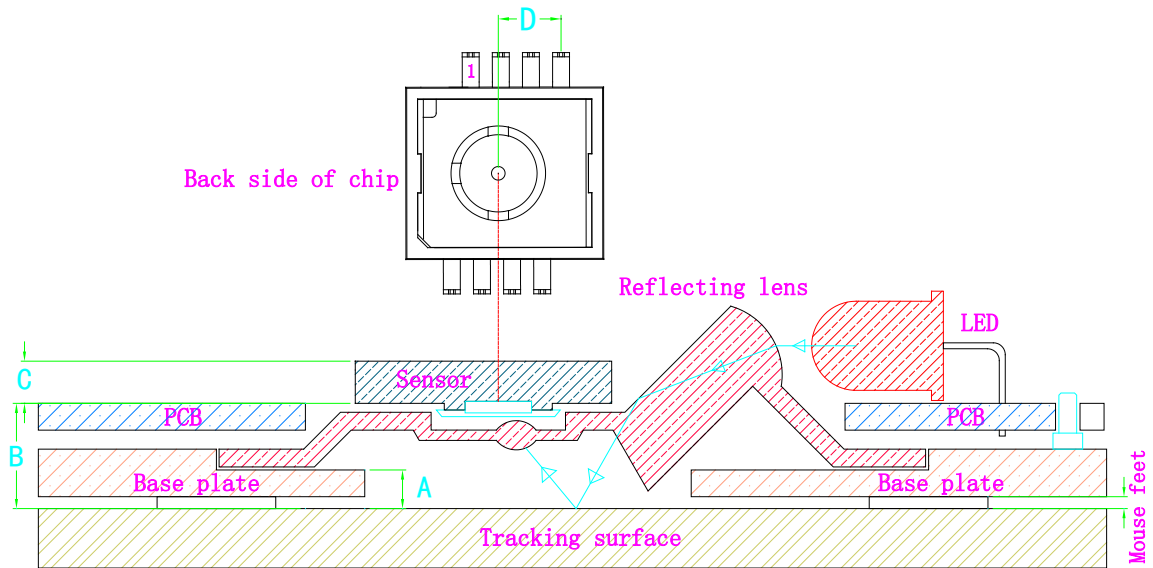
### 9.1 Absolute Maximum Rating

Parameter	Symbol	Min	Max	Unit	Notes
Supply Voltage	VDD	-0.5	3.6	V	
Operating Temperature	TO	-20	70	°C	
Storage Temperature	TS	-50	125	°C	
Lead Solder Temperature	TSOLDE R	-	260	°C	
Input Voltage	Vin	-0.5	VDD	V	All I/O pins
ESD	VESD	-	2	KV	All pins, human body model

### 9.2 Recommend Operation Conditions

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Supply Voltage	V <sub>DD</sub>	2.1	2.7	3.6	V	
Operating Temperature	T <sub>O</sub>	0	-	40	°C	
Supply Noise	V <sub>npp</sub>	-	-	100	mV	Peak to Peak 10K~80MHz
Distance from the Bottom of Lens to the Working Surface	Z	2.0	2.1	2.2	mm	
SCLK Clock	F <sub>sclk</sub>	-	-	1	MHz	
Resolution	R	200	-	3200	CPI	
Frame Rate	Fr	-	-	3400	FPS	
Speed	S	0	-	40	IPS	
Acceleration	A	0	-	10	g	

## 10. Assembly Drawing





## 11. Typical application circuit(nRF24LE1+S201x)

### 11.1 6KEY+CPI SEL Typical Application

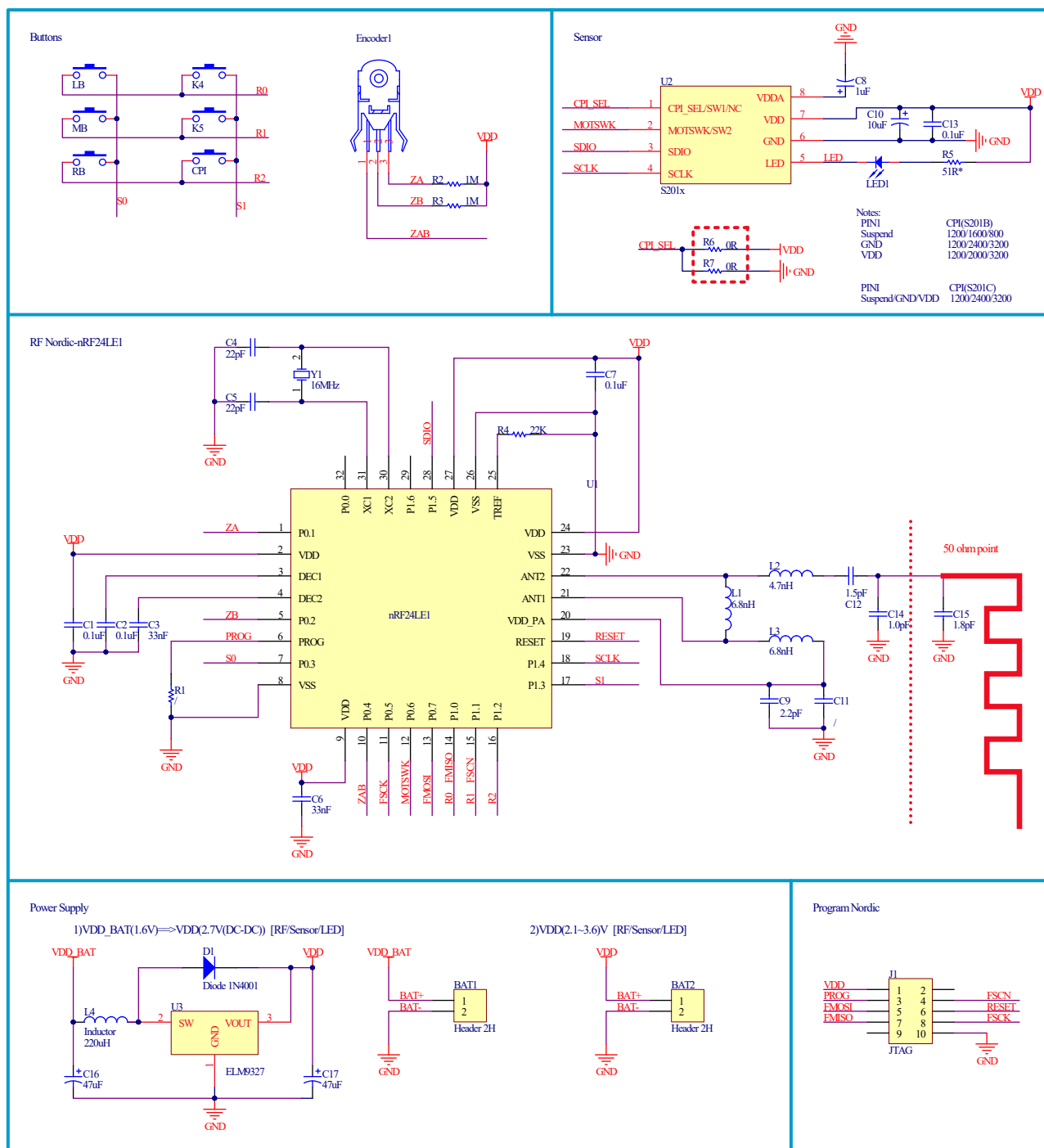


Figure 11-1 6KEY+CPI SEL Typical Application circuit

## 11.2 6KEY+2KEY Typical Application

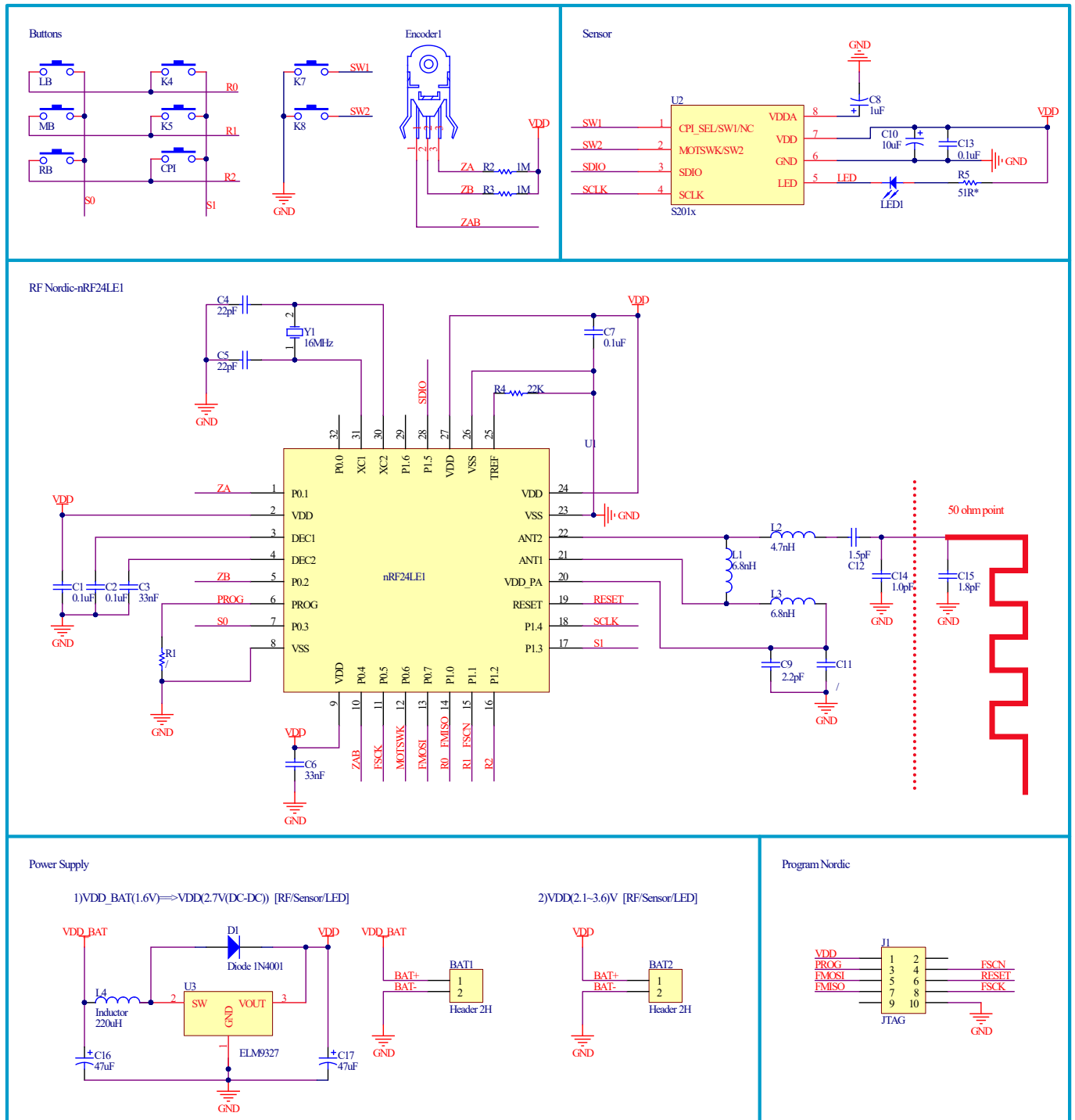
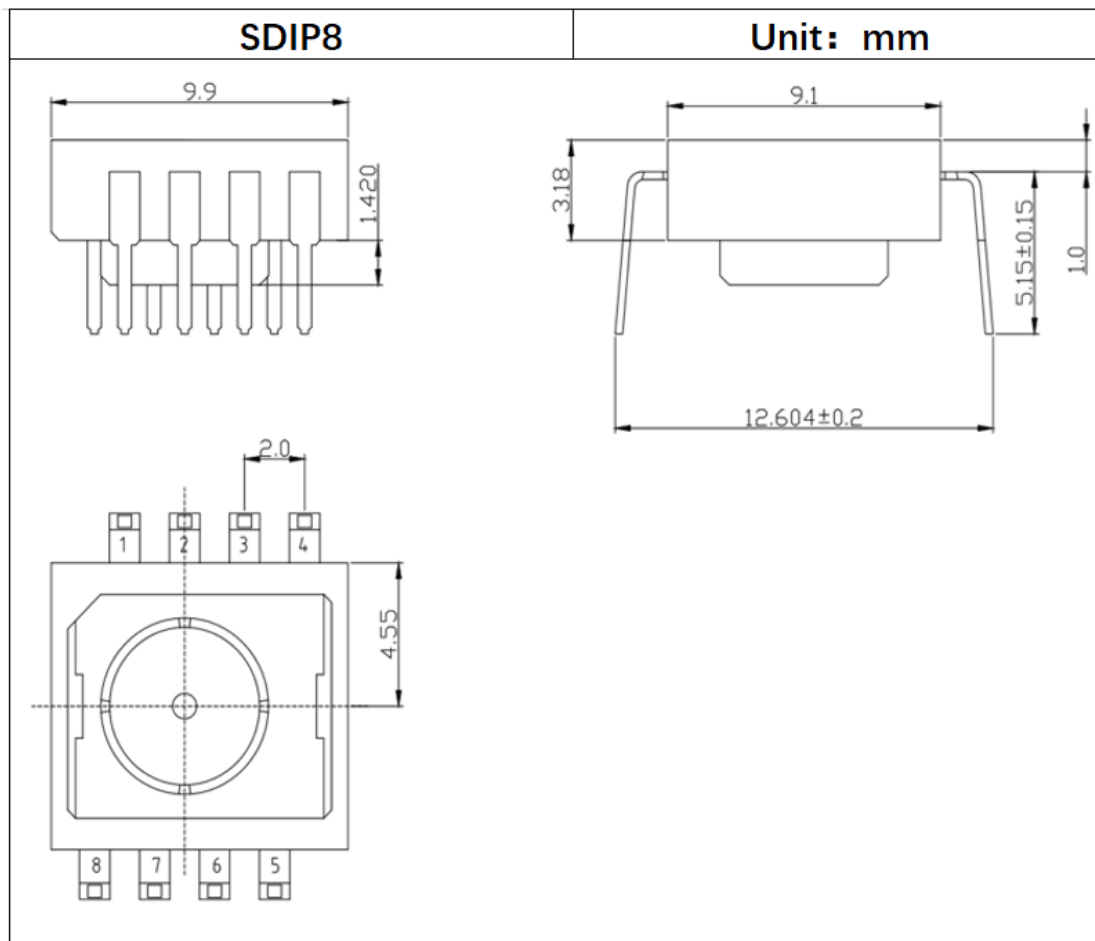


Figure 11-2 6KEY+2KEY Typical Application circuit

## 12.Package



## 13.Revision

Versions	Date	Reviser	Description
S201x_Spec_CN.V1.00	2020/10/17	Thomas	Create Preliminary Version
S201x_Spec_CN.V1.01	2021/05/12	Kaniel	Modify CPI Description