

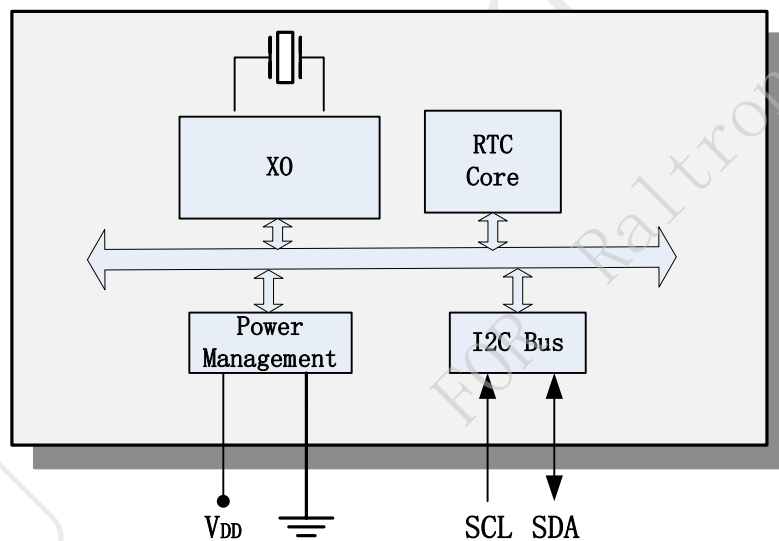


INS5710A —Low Power Consumption I²C RTC

Key Features

- Low current consumption: 1.2uA (Typ.)
- High stability:
< 5±23ppm @ +25°C
- Communication Interface: I²C bus
- Power Supply Voltage: 1.6V~5.0V
- Operation Temperature Range: -40°C ~ +85°C
- Build-in XO: 32.768KHz
- Build-in temperature sensor
- Leap years autocorrection
- Package: 4.9mm × 6.0mm × 1.6mm

Block Diagram



Overview

INS5710A is an I²C bus interface real-time clock with low power consumption. It embeds a 32.768KHz XO. It supports calendar (year, month, day, hour, minute, second) function. The SOP8 package makes it suitable to be used in portable electronic devices.



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1 Overview

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2 Block Diagram

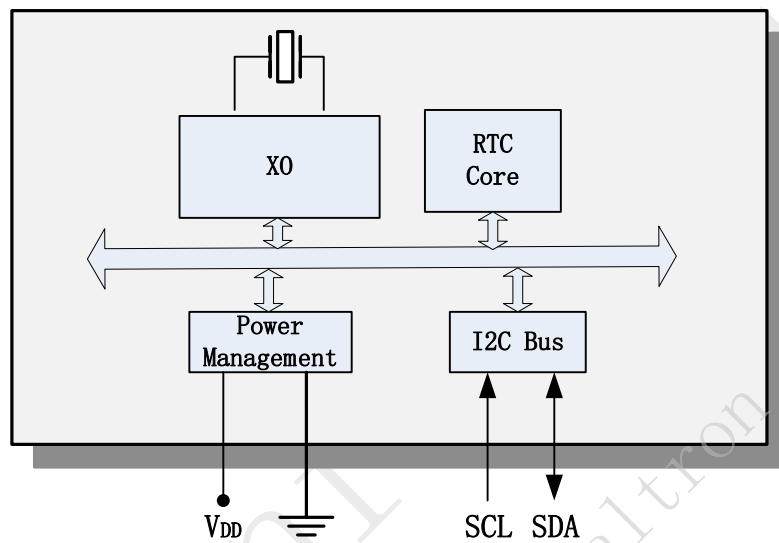


Figure 1. Block Diagram

3 Features

- Low current consumption: 1.2 uA (Typ.)
- High stability:
< 5±23ppm @ +25°C
- Communication Interface: I2C bus
- Power Supply Voltage: 1.6V ~ 5.0V
- Build-in XO: 32.768KHz
- Operation Temperature Range: -40°C ~ +85°C
- Build-in temperature sensor
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4 Pin definition

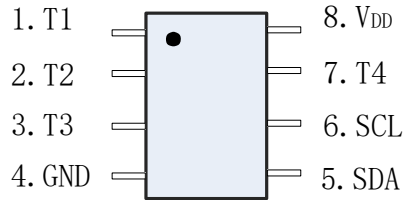


Table1. Pin Definition

| Pin Number | Pin Name | I/O | Description |
|------------|-----------------|--------|---|
| 1 | T1 | | Manufacturer test only. Ensure to be floating |
| 2 | T2 | | Manufacturer test only. Ensure to be floating |
| 3 | T3 | | Manufacturer test only. Ensure to be floating |
| 4 | GND | - | Ground |
| 5 | SDA | In/Out | I ² C data signal |
| 6 | SCL | In | I ² C clock signal |
| 7 | T4 | | Manufacturer test only. Ensure to be floating |
| 8 | V _{DD} | - | Power supply |



5 Electrical Characteristics

5.1 Absolute Maximum Ratings

Table2. Absolute Maximum Ratings

| Parameter | Symbol | Value | | | Unit | Notes |
|----------------------|-------------------|---------|------|------|------|----------------|
| | | Min. | Typ. | Max. | | |
| Power Supply Voltage | V _{DD} | -0.3 | | 5.5 | V | |
| Input Voltage | V _{IN} | GND-0.3 | | 5.5 | V | SCL, SDA input |
| Output Voltage | V _{OUT2} | GND-0.3 | | 5.5 | V | SDA output |
| Storage temperature | T _{STG} | -55 | | 125 | °C | |

5.2 Recommended Operating Conditions

Table3. Recommended Operating Conditions

| Parameter | Symbol | Value | | | Unit | Notes |
|---|------------------|-------|------|------|------|-------|
| | | Min. | Typ. | Max. | | |
| Power Supply Voltage (normal mode) | V _{DD} | 2.5 | 3.0 | 5.0 | V | |
| Power Supply Voltage (Time keeping) (Note 1) | V _{DD} | 1.6 | 3.0 | 5.0 | V | |
| Operation temperature | T _{OPR} | -40 | 25 | 85 | °C | |

Note 1: V_{DD} need to be supplied with more than 2.5V at least for the oscillation to stabilize (oscillation start time t_{STA}).

5.3 Frequency Characteristics

Table4. Frequency Characteristics

| Parameter | Symbol | Value | | | Unit | Notes |
|-----------------------------|------------------|-------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Frequency stability | $\Delta f_1/f$ | 5±23 | | | ppm | V _{DD} =3.0V; @+25°C |
| | $\Delta f_2/f$ | -120 | | +10 | ppm | V _{DD} =3.0V; -20°C ~ +70°C; Reference frequency @ +25°C |
| Oscillation start time | t _{STA} | | | 1 | s | @25°C |
| Year Aging | f _a | | | ±3 | ppm | |
| Temperature Sensor Accuracy | T _{emp} | | | ±5 | °C | V _{DD} =3.0V |



5.4 DC Characteristics

Table5. DC Characteristics

| Parameter | Symbol | Value | | | Unit | Notes | |
|------------------------------|------------------|---------------------|------|---------------------|------|--|--|
| | | Min. | Typ. | Max. | | | |
| Average Current consumption1 | I _{DD1} | 0.91 | | 5.1 | uA | V _{DD} =5.0V | f _{SCL} =0Hz, /INT = V _{DD} ; Compensation interval 2s |
| Average Current consumption2 | I _{DD2} | 0.6 | 1.2 | 4.9 | | V _{DD} =3.0V | |
| High-level input voltage | V _{IH} | 0.8*V _{DD} | | 5.0 | V | SCL, SDA pin | |
| Low-level input voltage | V _{IL} | GND-0.3 | | 0.2*V _{DD} | V | | |
| Low-level output | V _{OL1} | GND | | GND+0.4 | V | V _{DD} ≥3.0V, I _{OL} = 3mA | SDA pin |
| Input leakage current | I _{LK} | -0.5 | | 0.5 | uA | SDA, SCL pin, V _{IN} = V _{DD} or GND | |
| Output leakage current | I _{OZ} | -0.5 | | 0.5 | uA | SDA pin, V _{IN} = V _{DD} or GND | |



5.5 AC Characteristics

Table6. AC Characteristics

V_{DD}=2.5V ~ 5.0V; Ta=-40°C ~ +85°C

| Parameter | Symbol | Value | | | Unit |
|--|---------------------|-------|------|------|------|
| | | Min. | Typ. | Max. | |
| SCL clock frequency | f _{SCL} | | | 400 | kHz |
| SCL low level time | t _{LOW} | 1.3 | | | us |
| SCL high level time | t _{HIGH} | 0.6 | | | us |
| Start condition setup time | t _{HD;STA} | 0.6 | | | us |
| Start condition hold time | t _{SU;STA} | 0.6 | | | us |
| Stop condition setup time | t _{SU;STO} | 0.6 | | | us |
| Bus idle time between start condition and stop condition | t _{RCV} | 1.3 | | | us |
| Data setup time | t _{SU;DAT} | 100 | | | ns |
| Data hold time | t _{HD;DAT} | 0 | | | ns |
| SCL, SDA rising time | t _r | | | 0.4 | us |
| SCL, SDA falling time | t _f | | | 0.4 | us |

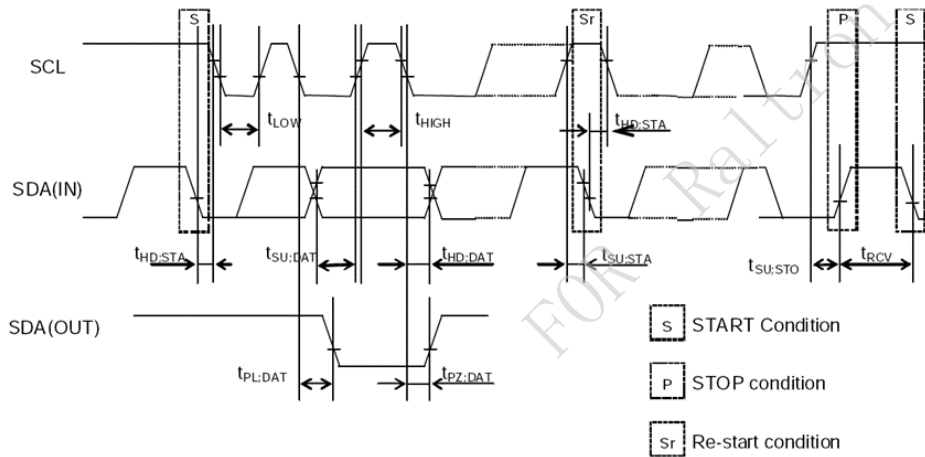


Figure 2. I²C bus Timing Chart



6 Registers

6.1 Register Lists

Address 0x00~0x0F: Basic Time and Calendar Registers

Address 0x10~0x1F: Extended Register Group 1

Address 0x20~30: Extended Register Group 2

Note: 0x10~16 and 0x00~06 with the same function, 0x1B~1F and 0x0B~0F with the same function

Table7. Basic Time and Calendar Registers

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | R/W |
|---------|--------------------|--------------------------------|----------------------------------|--------------------------------|---------------------------------|----------------------------------|------|----------|----------|-----|
| 0x00 | SEC | ○ | BCD code, Second tens place, 0-5 | | | BCD code, Second ones place, 0-9 | | | | R/W |
| 0x01 | MIN | ○ | BCD code, Minute tens place, 0-5 | | | BCD code, Minute ones place, 0-9 | | | | R/W |
| 0x02 | HOUR | ○ | ○ | BCD code, Hour tens place, 0-2 | | BCD code, Hour ones place, 0-9 | | | | R/W |
| 0x03 | WEEK | ○ | 6 | 5 | 4 | 3 | 2 | 1 | 0 | R/W |
| 0x04 | DAY | ○ | ○ | BCD code, Day tens place, 0-3 | | BCD code, Day ones place, 0-9 | | | | R/W |
| 0x05 | MONTH | ○ | ○ | ○ | BCD code, Month tens place, 0-1 | BCD code, Month ones place, 0-9 | | | | R/W |
| 0x06 | YEAR | BCD code, Year tens place, 0-9 | | | | BCD code, Year ones place, 0-9 | | | | R/W |
| 0x07 | RAM | ● | ● | ● | ● | ● | ● | ● | ● | R/W |
| 0x08 | RSV | Reserved | | | | | | | | R |
| 0x09 | RSV | Reserved | | | | | | | | R |
| 0x0A | RSV | Reserved | | | | | | | | R |
| 0x0B | RSV | Reserved | | | | | | | | R |
| 0x0C | RSV | Reserved | | | | | | | | R |
| 0x0D | Extension Register | TEST | Reserved | | | ● | ● | Reserved | | R/W |
| 0x0E | Flag Register | ○ | ○ | Reserved | | | ○ | VLF | Reserved | R/W |
| 0x0F | Control Register | Reserved | | | | ○ | ○ | RESET | | R/W |

Table8. Extended Register Group 1

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | R/W |
|---------|----------|------|----------------------------------|--------------------------------|------|----------------------------------|------|------|------|-----|
| 0x10 | SEC | ○ | BCD code, Second tens place, 0-5 | | | BCD code, Second ones place, 0-9 | | | | R/W |
| 0x11 | MIN | ○ | BCD code, Minute tens place, 0-5 | | | BCD code, Minute ones place, 0-9 | | | | R/W |
| 0x12 | HOUR | ○ | ○ | BCD code, Hour tens place, 0-2 | | BCD code, Hour ones place, 0-9 | | | | R/W |
| 0x13 | WEEK | ○ | 6 | 5 | 4 | 3 | 2 | 1 | 0 | R/W |



| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | R/W |
|---------|--------------------|--------------------------------|----------|-------------------------------|---------------------------------|---------------------------------|------|----------|----------|-----|
| 0x14 | DAY | ○ | ○ | BCD code, Day tens place, 0-3 | | BCD code, Day ones place, 0-9 | | | | R/W |
| 0x15 | MONTH | ○ | ○ | ○ | BCD code, Month tens place, 0-1 | BCD code, Month ones place, 0-9 | | | | R/W |
| 0x16 | YEAR | BCD code, Year tens place, 0-9 | | | | BCD code, Year ones place, 0-9 | | | | R/W |
| 0x17 | TEMP | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | R |
| 0x18 | RSV | ○ | ○ | ○ | ○ | Reserved | ● | ● | ● | R/W |
| 0x19 | Not use | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | R |
| 0x1A | Not use | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | R |
| 0x1B | RSV | Reserved | | | | | | | | R/W |
| 0x1C | RSV | Reserved | | | | | | | | R/W |
| 0x1D | Extension Register | TEST | Reserved | | | ● | ● | Reserved | | R/W |
| 0x1E | Flag Register | ○ | ○ | Reserved | | | ○ | VLF | Reserved | R/W |
| 0x1F | Control Register | Reserved | | | | ○ | ○ | RESET | R/W | |

Table9. Extended Register Group2

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | R/W |
|---------|--------------------|-----------------------------|------|------|------|-------------|------|------|------|-----|
| 0x20 | Device ID | Vendor ID[3:0] | | | | Ver[3:0] | | | | R |
| 0x21 | Control Register 1 | Reserved: Ensure to be 0x8 | | | | ○ | ○ | ○ | ● | R/W |
| 0x22-26 | RSV | Reserved: Ensure to be 0x00 | | | | | | | | R |
| 0x27 | SubSEC | Reserved | | | | SubSEC[3:0] | | | | R |
| 0x28-30 | RSV | Reserved: Ensure to be 0x00 | | | | | | | | R/W |

Note:

1, After power-up reset or in case VLF bit returns "1", make sure to initialize all registers to default state before using the RTC. Ensure all inputs are in the required range and the defined values are set for the reserved bits in case the clock cannot work normally.

- ✓ During the initial power-up, below bits will be in the state as below:
 - Initial 0: TEST, CSEL[1], RESET.
 - Initial 1: VLF, CSEL[0].
- ✓ All other register values are undefined, so make sure to reset the module before using it.
- ✓ The bits marked with "○" can be read out "0" only after initializing.
- ✓ The bits marked with "●" are RAM bits which can be used to write or read any data.
- ✓ Only 0 can be written to VLF bits.
- ✓ Make sure "0" to be written for TEST bits which are used for testing only.
- ✓ Reserved bits must be set to the defined values accordingly.



6.2 Details of Registers

6.2.1 Clock counter registers

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|------|----------------------------------|--------------------------------|------|----------------------------------|------|------|------|---------|
| 0x00/10 | SEC | ○ | BCD code, Second tens place, 0-5 | | | BCD code, Second ones place, 0-9 | | | | 0x25 |
| 0x01/11 | MIN | ○ | BCD code, Minute tens place, 0-5 | | | BCD code, Minute ones place, 0-9 | | | | 0x36 |
| 0x02/12 | HOUR | ○ | ○ | BCD code, Hour tens place, 0-2 | | BCD code, Hour ones place, 0-9 | | | | 0x01 |

SEC: BCD format, Value: 0~59

MIN: BCD format, Value: 0~59

HOUR: BCD format, Value: 0~23

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|------|------|------|------|------|------|------|------|---------|
| 0x03/13 | WEEK | ○ | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 0x40 |

WEEK: Value 01h, 02h, 04h, 08h, 10h, 20h, 40h. Only one bit can be set to 1 each time, all others must be set to 0.

Table10. WEEK Register

| WEEK | Data | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|-----------|------|------|------|------|------|------|------|------|------|
| Sunday | 01h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Monday | 02h | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Tuesday | 04h | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Wednesday | 08h | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Thursday | 10h | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Friday | 20h | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Saturday | 40h | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|------|------|-------------------------------|------|-------------------------------|------|------|------|---------|
| 0x04/14 | DAY | ○ | ○ | BCD code, Day tens place, 0-3 | | BCD code, Day ones place, 0-9 | | | | 0x01 |

DAY: BCD format, the value range will be adjusted automatically according to the month setting and if a leap year or not .

Table11. DAY Register Value

| Month | Day Value Range |
|-------------------------|-----------------|
| 1, 3, 5, 7, 8, 10, 12 | 1~31 |
| 4, 6, 9, 11 | 1~30 |
| February in normal year | 1~28 |
| February in leap year | 1~29 |



| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|--------------------------------|------|------|------------------------------------|---------------------------------|------|------|------|---------|
| 0x05/15 | MONTH | ○ | ○ | ○ | BCD code, Month tens place, 0-1 | BCD code, Month ones place, 0-9 | | | | 0x01 |
| 0x06/16 | YEAR | BCD code, Year tens place, 0-9 | | | BCD code, Year ones place, 0-9 | | | | | 0x00 |

MONTH: BCD format, Value1~12

YEAR: BCD format, Value0~99(2000~2099)

Example: 2020/01/01 Wednesday 21:18:36

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---------|----------|------|------|------|------|------|------|------|------|
| 0x00/10 | SEC | ○ | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 0x01/11 | MIN | ○ | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0x02/12 | HOUR | ○ | ○ | 1 | 0 | 0 | 0 | 0 | 1 |
| 0x03/13 | WEEK | ○ | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0x04/14 | DAY | ○ | ○ | 0 | 0 | 0 | 0 | 0 | 1 |
| 0x05/15 | MONTH | ○ | ○ | ○ | 0 | 0 | 0 | 0 | 1 |
| 0x06/16 | YEAR | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

6.2.2 Extension registers

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|--------------------|------|----------|------|------|------|------|----------|------|---------|
| 0x0D/1D | Extension Register | TEST | Reserved | | | • | • | Reserved | | 0x02 |

TEST: Test bit, must be set to “0”

6.2.3 Flag registers

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|---------------|------|------|----------|------|------|------|------|----------|---------|
| 0x0E/1E | Flag Register | ○ | ○ | Reserved | | | ○ | VLF | Reserved | 0x23 |

VLF: Voltage Low Flag bit. When supply voltage is lower than 1.6V, it will be set to “1” and keeps “1” until a “0” is written to it.

6.2.4 Control registers

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default | |
|---------|------------------|----------|------|------|------|------|------|------|-------|---------|------|
| 0x0F/1F | Control Register | Reserved | | | | | ○ | ○ | RESET | | 0x40 |

RESET: Reset IC, prepared for the synchronized starting of time or timer.

6.2.5 Temperature register

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|------|------|------|------|------|------|------|------|---------|
| 0x17 | TEMP | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | 0xa9 |



Read digital temperature data, $Temp [^{\circ}C] = (TEMP[7:0] * 2 - 187.19) / 3.218$.

6.2.6 RSV register

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|------|------|------|------|----------|------|------|------|---------|
| 0x18 | Reserved | ○ | ○ | ○ | ○ | Reserved | ● | ● | ● | 0x00 |

Bit3 is the reserved bit, suggest being clear to '0'.

6.2.7 Device ID register

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|-----------|---------------|------|------|------|----------|------|------|------|---------|
| 0x20 | Device ID | VendorID[3:0] | | | | Ver[3:0] | | | | 0xd2 |

VendorID[3:0]: The fixed value is defined as VendorID[3:0]=1101b=Dh to represent DAPU.

Ver[3:0]: version of the IC

6.2.8 Control Register 1

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|--------------------|-----------------------|------|------|------|------|------|------|------|---------|
| 0x21 | Control Register 1 | Reserved: must be 0x8 | | | | ○ | ○ | ○ | ● | 0x80 |

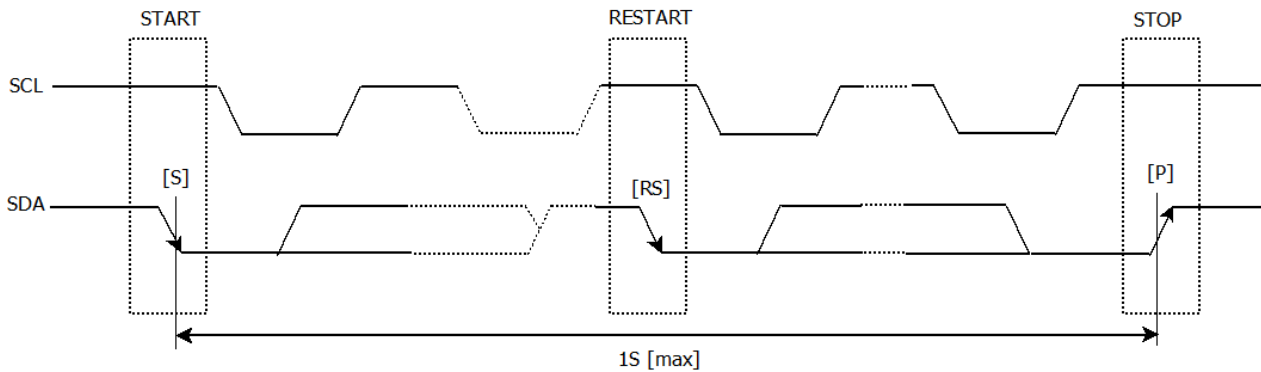
6.2.9 Sub-second timer register

| Address | Function | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 | Default |
|---------|----------|----------|------|------|------|-------------|------|------|------|---------|
| 0x27 | SubSEC | Reserved | | | | SubSEC[3:0] | | | | 0x00 |

SubSEC[3:0]: sub second bit, and unit is 1/16s.



7 I²C Bus Interface



I²C bus supports bi-directional communications through a serial clock line SCL and a serial data line SDA. I²C bus device can be defined as “Master” and “Slave”. INS5710A can only be used as Slave.

7.1 Cautions

I²C bus includes START, RESTART, STOP conditions, the duration between START and STOP must be less than 1 second just in case the bus to be set to standby mode automatically. A new START condition must be transferred before restarting of any communications.

INS5710A I²C bus interface supports single byte read/write operations as well as multiple bytes incremental access. After 0x7F address, the next one will be 0x00.

7.2 Slave Address

Table12. I²C Bus Slave Address

| Transfer data | Slave address | | | | | | | R/W |
|---------------|---------------|------|------|------|------|------|------|-----------|
| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
| 65h (Read) | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 (Read) |
| 64h (Write) | | | | | | | | 0 (Write) |

INS5710A I²C bus Slave Address is [0110 010*].

7.3 I²C bus protocol

It is assumed CPU is master and INS5710A is slave in this section.

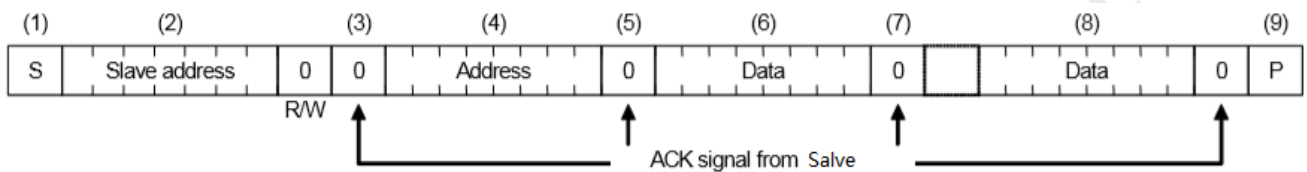
7.3.1 Write process

I²C bus includes an address auto-increment function, once the initial address has been specified, the



INS5710A increments (+1) the address automatically after each data is sent, then to write next data.

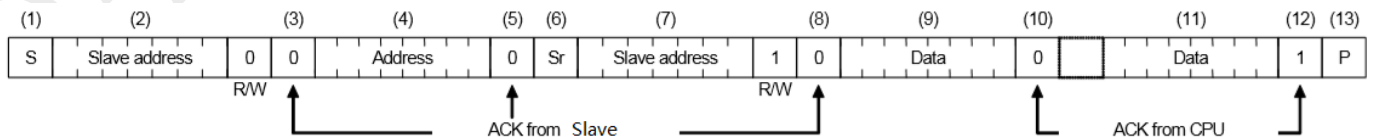
- (1) CPU sends start condition[S]
- (2) CPU sends INS5710A's slave address with R/W bit to set to write mode
- (3) CPU verifies ACK signal from INS5710A
- (4) CPU sends write address to INS5710A
- (5) CPU verifies ACK signal from INS5710A
- (6) CPU sends write data to the address specified at step (4)
- (7) CPU verifies ACK signal from INS5710A
- (8) Repeat (6) (7) if multiple bytes need to be written, address will be incremented automatically
- (9) CPU ends stop condition[P]



7.3.2 Read process

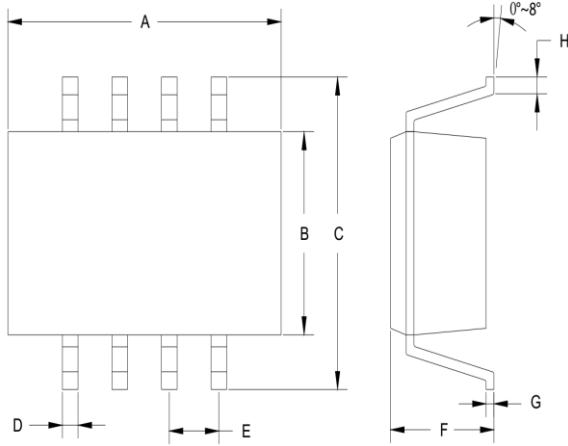
Writing the address to be read with write mode firstly, then reading the data with read mode.

- (1) CPU sends start condition[S]
- (2) CPU sends INS5710A's slave address with R/W bit to set to write mode
- (3) CPU verifies ACK signal from INS5710A
- (4) CPU sends address for reading from INS5710A
- (5) CPU verifies ACK signal from INS5710A
- (6) CPU sends RESTART condition [Sr]
- (7) CPU sends INS5710A's slave address with R/W bit to set to read mode
- (8) CPU verifies ACK signal from INS5710A
- (9) CPU reads data from the specified address in step (4)
- (10) CPU verifies ACK signal from INS5710A
- (11) Repeat (9) (10) if multiple bytes need to be read, address will be incremented automatically
- (12) CPU sends ACK signal for "1"
- (13) CPU sends stop condition[P]





8 Dimensions



| Dimension | Min. | Typ. | Max. |
|-----------|-------|------|-------|
| A | 4.8 | 4.9 | 5.0 |
| B | 3.8 | 3.9 | 4.0 |
| C | 5.8 | 6.0 | 6.2 |
| D | 0.356 | -- | 0.456 |
| E | -- | 1.27 | -- |
| F | 1.3 | -- | 1.6 |
| G | 0.203 | -- | 0.233 |
| H | 0.4 | 0.6 | 0.8 |

(Unit: mm)

Figure 3. Dimension