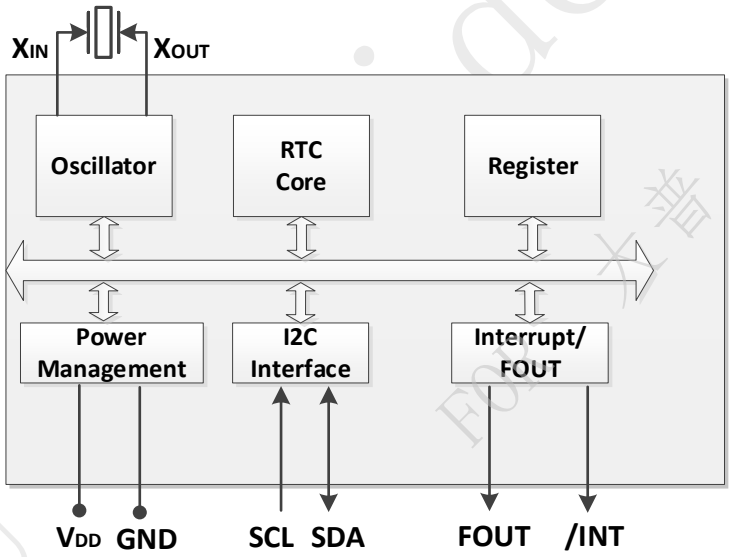
INS58563 — Low Power Consumption I²C RTC

Key Features

- Low Current Consumption: 0.9uA (Typ.)
- Timer, Alarm and Interrupt
- Frequency Output
- Communication Interface: I²C bus
- External 32K crystal
- Integrated Oscillator Configurable Capacitors
- Power Supply Voltage: 1.2V~5.5V
- Operation Temperature Range: -40℃ ~ +85℃
- Leap Years Autocorrection
- Package: 4.9mm × 6.0mm × 1.6mm (SOP8)

Block Diagram



Overview

INS58563 is an I²C bus interface real-time clock with low power consumption. It supports calendar (Century, year, month, day, hour, minute, second), timer and alarm function. The SOP8 package makes it suitable to be used in portable electronic devices.

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Revision History

Version	Change Contents	Prepared by	Revised Date
V1.0	Released Version		2023.03.09

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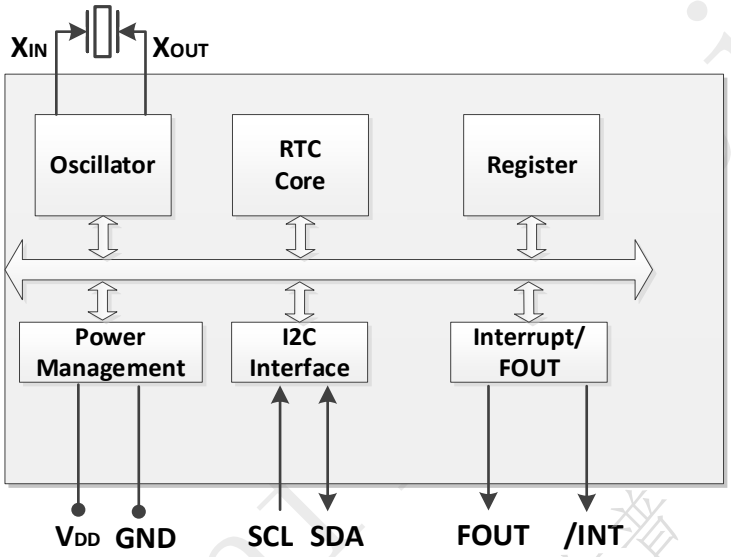

Figure 1. Block Diagram

3 Features

- Low Current Consumption: 0.9uA (Typ.)
- Communication Interface: I²C bus
- Alarm, Timer and Interruption
- Frequency Out
- External 32K crystal
- Integrated Oscillator Configurable Capacitors
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4 Pin Definition

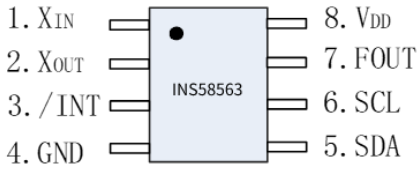


Table1. Pin Definition

Pin Number	Pin Name	I/O	Description
1	X_{IN}		Oscillator Input
2	X_{OUT}		Oscillator Output
3	/INT	Out	Alarm、Timer Output. (Open-Drain).
4	GND	-	Ground
5	SDA	In/Out	I2C data signal
6	SCL	In	I2C clock signal
7	CLKOUT	Out	Frequency Output. (Open-Drain).
8	V_{DD}	-	Power in

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		6.5	V	
I/O Input Voltage	V_{IN}	GND-0.3		6.5	V	SCL, SDA Input
Clock Output Voltage	V_{OUT}	GND-0.3		6.5	V	SDA，/INT Output, FOUT
Storage Temperature	T_{STG}	-55		125	℃	

5.2 Recommended Operating Conditions

Table3. Recommended Operating Conditions

Parameter	Symbol	Value			Unit	Notes
		Min.	Typ.	Max.		
Power Supply Voltage (normal mode)	V_{DD}	1.6	3.0	5.5	V	
Power Supply Voltage (Time keeping)	V_{DD}	1.2	3.0	5.5	V	
Operation Temperature	T_{OPR}	-40	25	85	℃	

Note 1: V_{DD} need to be supplied with more than 1.6V at least for the oscillator to work until stabilization.

Note 2: Ensure that the power on time from 0 to VDD is less than 100ms

5.3 Oscillator Characteristics

Table4. Oscillator Characteristics

Parameter	Symbol	Value			Unit	Notes
		Min.	Typ.	Max.		
Oscillator						
Integrated Load Capacitance	C_L		6		pF	
			7(Default)			
			9			
			12.5			
External Crystal(32.768KHz)						
Series Resistance	R_S			100	kΩ	
FOUT Duty cycle	t_W/t	40	50	60	%	FOUT

5.4 DC Characteristics

Table5. DC Characteristics

Parameter	Symbol	Value			Unit	Notes	
		Min.	Typ.	Max.			
Average Current1	I_{DD1}		1.0	3.0	uA	V_{DD}=5.0V	f_{SCL} = 0 Hz, /INT = OFF, FOUT = OFF, SDA="L", SCL="L"
Average Current2	I_{DD2}		0.9	2.8		V_{DD}=3.0V	
Average Current3	I_{DD3}		1.9	3.8		V_{DD}=5.0V	FOUT = 32.768KHz (CL=15PF), /INT=OFF , SDA="L", SCL="L"
Average Current4	I_{DD4}		1.7	3.5		V_{DD}=3.0V	
Input High Voltage	V_{IH}	0.8*V_{DD}		5.5	V	SCL， SDA	
Input Low Voltage	V_{IL}	GND		0.2*V_{DD}	V		
Output Low Voltage	V_{OL1}	GND		GND+0.25	V	VDD =5V, IOL=1mA	/INT
	V_{OL2}	GND		GND+0.4		VDD =3V, IOL=1mA	
	V_{OL3}	GND		GND+0.5		VDD =5V, IOL=1mA	FOUT
	V_{OL4}	GND		GND+0.3		VDD =3V, IOL=0.5mA	
Input Leak Current	I_{LK}	-0.1		0.1	uA	SDA, SCL， V_{IN} = V_{DD} or GND	
Output Leak Current	I_{OZ}	-0.1		0.1	uA	SDA, V_{IN} = V_{DD} or GND	

5.5 AC Characteristics

Table6. AC Characteristics

V_{DD}=1.6V ~ 5.5V; Ta=-40℃ ~ +85℃

Parameter	Symbol	Value			Unit
		Min.	Typ.	Max.	
SCL clock frequency	f_{SCL}			400	kHz
SCL Low Voltage Time	t_{LOW}	1.3			us
SCL How Voltage Time	t_{HIGH}	0.6			us
Start condition hold time	$t_{HD;\ STA}$	0.6			us
Start condition setup 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

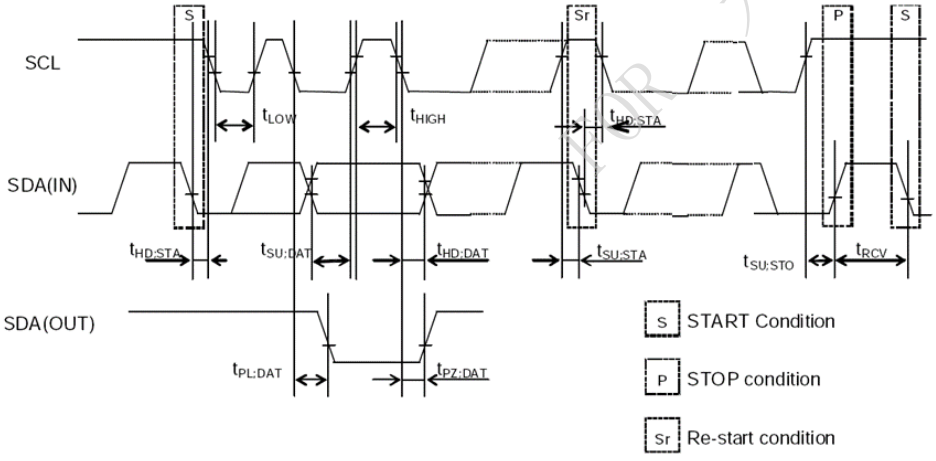


Figure 2. I^2C bus Timing Chart

Note：When the master device gets access to this slave device through I2C, the whole operation duration should be less than 1s, otherwise it will be reset by the I2C bus through the internal bus overtime function.

6 Registers

6.1 Register Lists

Address 0x00~0x01: Control and Flag Registers Group

Address 0x02~0x08: Time Register Group

Address 0x09~0x0C: Alarm Register Group

Address 0x0D: CLKOUT Control Register

Address 0x0E~0x0F: Timer Register Group

Address 0x10: Capacity Config Register

Address 0x11: Offset Register

Table7. Basic Time and Calendar Registers

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
0x00	Control Register_1	EXT_TEST	○	STOP	○	○	○	○	○	R/W
0x01	Control Register_2	○	○	○	TI_TP	AF	TF	AIE	TIE	R/W
0x02	SEC	VLF	BCD code, Second tens place, 0-5			BCD code, Second ones place, 0-9				R/W
0x03	MIN	○	BCD code, Minute tens place, 0-5			BCD code, Minute ones place, 0-9				R/W
0x04	HOUR	○	○	BCD code, Hour tens place, 0-2		BCD code, Hour ones place, 0-9				R/W
0x05	DAY	○	○	BCD code, Day tens place, 0-3		BCD code, Day ones place, 0-9				R/W
0x06	WEEK	○	○	○	○	○	BCD code, Week ones place, 0-6			R/W
0x07	MONTH	Century	○	○	BCD code, Month tens place, 0-1	BCD code, Month ones place, 0-9				R/W
0x08	YEAR	BCD code, Year tens place, 0-9				BCD code, Year ones place, 0-9				R/W
0x09	MIN Alarm	AE	BCD code, Minute tens place, 0-5			BCD code, Minute ones place, 0-9				R/W
0x0a	HOUR Alarm	AE	○	BCD code, Hour tens place, 0-2		BCD code, Hour ones place, 0-9				R/W
0x0b	DAY Alarm	AE	○	BCD code, Day tens place, 0-3		BCD code, Day ones place, 0-9				R/W
0x0c	WEEK Alarm	AE	○	○	○	○	BCD code, Week ones place, 0-6			R/W
0x0d	CLKOUT_Control Register	FE	○	○	○	○	○	FD[1:0]		R/W
0x0e	Timer_Control Register	TE	○	○	○	○	○	TD[1:0]		R/W
0x0f	Timer Counter	128	64	32	16	8	4	2	1	R/W
0x10	Capacitor_Control Register	○	○	○	○	○	CAP_EN	CAP_SEL [1:0]		R/W

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
0x00	Control Register_1	EXT_TEST	○	STOP	○	○	○	○	○	R/W
0x01	Control Register_2	○	○	○	TI_TP	AF	TF	AIE	TIE	R/W
0x11	Offset Control 1	MODE	OFFSET_CFG[6:0]							R/W

Note:

1, After power-up reset or in case VLF bit returns “1”, make sure to initialize all registers before using the RTC.

2. The default value of register after power on:

Initial 0: AF、TF、AIE、TIE、FD[1:0]、TD[1:0] 、CAP_SEL[1]、CAP_EN.

Initial 1: VLF、AE、FE、TE、CAP_SEL[0].

3.The bits marked with “○” can be read out “0” after initializing.

4.Only 0 can be written to TF、AF and VLF bits.

6.2Details of Registers

6.2.1 Clock counter registers

Table8. Second、Minute and Hour Registers

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x02	SEC	VLF	BCD code, Second tens place, 0-5			BCD code, Second ones place, 0-9				0x80
0x03	MIN	○	BCD code, Minute tens place, 0-5			BCD code, Minute ones place, 0-9				0x00
0x04	HOUR	○	○	BCD code, Hour tens place, 0-2		0x00				0x00

SEC: BCD format, Value: 0~59

MIN: BCD format, Value: 0~59

HOUR: BCD format, Value: 0~23

VLF（Voltage Low Flag）：Voltage Low Flag, when voltage is lower than 1.3V ,this bit will be set to”1”, and keep this value until written to “0” by software.

Table9. Day Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x05	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.

Table10. DAY Register Value Range

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

Table11. Week Registers

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x06	WEEK	○	○	○	○	○	BCD code, Week ones place, 0-6			0x00

Table12. WEEK Register Value table

	Bit2	Bit1	Bit0
Sunday	0	0	0
Monday	0	0	1
Tuesday	0	1	0
Wednesday	0	1	1
Thursday	1	0	0
Friday	1	0	1
Saturday	1	1	0

Table13. Month and Year Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x07	MONTH	Century	○	○	BCD code, Month tens place, 0-1	BCD code, Month ones place, 0-9				0x01
0x08	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)
Century: 0-Century is X, 1-Century is X+1
Example: 2000/01/01 Wednesday 21:18:36

Table14. Example of time setting

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0x10	SEC	○	0	1	1	0	1	1	0
0x11	MIN	○	0	0	1	1	0	0	0
0x12	HOUR	○	○	1	0	0	0	0	1
0x13	WEEK	○	0	0	0	0	0	1	1
0x14	DAY	○	○	0	0	0	0	0	1
0x15	MONTH	○	○	○	0	0	0	0	1
0x16	YEAR	0	0	1	0	0	0	0	0

6.2.2 Alarm registers

Table15. Alarm Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x01	Control Register_2	○	○	○	TI_TP	AF	TF	AIE	TIE	0x00
0x09	MIN Alarm	AE	BCD code, Minute tens place, 0-5			BCD code, Minute ones place, 0-9				0x80
0x0a	HOUR Alarm	AE	○	BCD code, Hour tens place, 0-2		BCD code, Hour ones place, 0-9				0x80
0x0b	DAY Alarm	AE	○	BCD code, Day tens place, 0-3		BCD code, Day ones place, 0-9				0x80
0x0c	WEEK Alarm	AE	○	○	○	○	BCD code, Week ones place, 0-6			0x80

Alarm interruption can be generated with the setting of these registers and the cooperation of AIE and AF.

AE（Alarm Enable）：Alarm Enable bit，0-Enable；1-Disable.

AF function refer to 0x01 register bit3.

AIE function refer to 0x01 register bit1.

6.2.3 Timer registers

Table16. Timer Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x01	Control Register_2	○	○	○	TI_TP	AF	TF	AIE	TIE	0x00
0x0e	Timer_Control Register	TE	○	○	○	○	○	TD[1]	TD[0]	0x80
0x0f	Timer Counter	128	64	32	16	8	4	2	1	0x00

Timer interruption can be generated with the setting of these registers and the cooperation of TE、TF 、TIE and TD[1:0].

TE function refer to 0x0e register bit7.

TF function refer to 0x01 register bit2.

TIE function refer to 0x01 register bit0.

TD[1:0] function refer to 0x0e register bit1 and bit0.

6.2.4 CLKOUT control registers

Table17. CLKOUT Control Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x0D	CLKOUT_Control Register	FE	○	○	○	○	○	FD[1]	FD[0]	0x80

Used for the CLKOUT Frequency function.

FE（Fout Enable）：0- Disable CLKOUT Frequency function, 1-Enable CLKOUT Frequency function。

FD[1]，FD[0] to config the output frequency. Shown as below table：

Table18. FD Table

FD [1]	FD [0]	CLKOUT Frequency
0	0	32768Hz Output
0	1	1024Hz output
1	0	32Hz output
1	1	1Hz Output

6.2.5 Timer control registers

Table19. Timer Control Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x0E	Timer_Control Register	TE	○	○	○	○	○	TD[1]	TD[0]	0x80

Used for the specified functions, including Time Update Interruption.

TE（Timer Enable）：0- Disable Timer Interrupt function, 1-Enable Timer Interrupt function。

TD[1]，TD[0]：Timer/Counter Clock configuration bits, just as below table：

Table20. TD Table

TD [1]	TD [0]	Timer/Counter Clock	Interruption duration
0	0	4096Hz（244.14us）	122uS
0	1	64Hz（15.625ms）	7.813mS
1	0	1Hz（Second）	7.813mS
1	1	1/60Hz（Min）	7.813mS

6.2.6 Control register

Table21. Control Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x00	Control Register_1	EXT_ TEST	○	STOP	○	○	○	○	○	0x00
0x01	Control Register_2	○	○	○	TI_TP	AF	TF	AIE	TIE	0x00

EXT_TEST: 1:Test Mode, 0: Normal Mode.

STOP: 1: RTC Clock is Stop, 0: RTC Clock is normal.

AF（Alarm Flag）：Alarm Flag, when Alarm Interruption generation, this bit will change from “0”to “1”,and keep this value until written to “0” by software;

TF（Timer Flag）：Timer Flag, when timer interruption generates, this bit will change from “0”to “1”,and keep this value until written to “0” by software;

AIE（Alarm Interrupt Enable）：When AF changes from“0”to“1”，this bit can control if the interruption generates or not. 0-Did not generate（/INT maintain high resistance），1-generate the interruption（/INT changes from high resistance to low voltage）。

TIE（Timer Interrupt Enable）：When TF changes from“0”to“1”，this bit can control if the interruption generates or not. 0-Did not generate（/INT maintain high resistance），1-generate the interruption（/INT changes from high resistance to low voltage）。

6.2.7 Capacitor control register

Table22. Capacitor Control Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x10	Capacitor_Control Register	○	○	○	○	○	CAP_EN	CAP_SEL [1]	CAP_SEL [0]	0x01

CAP_EN: Enable capacitor control, 0: disable, 1: enable.

CAP_SEL[1:0]: Select the capacitor.

Table23. CAP_SEL Table

CAP_SEL[1:0]	Capacitor
00	6pF
01	7pF
10	9pF
11	12.5pF

6.2.8 Offset control register

Table24. Offset Control Register

Address	Function	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	Default
0x11	Offset Control 1	MODE	OFFSET_CFG[6:0]							0x00

Mode: Offset mode bit. See Table25

Offset_cfg[6:0]: For MODE = 0, each LSB introduces an offset of 4.069 ppm. For MODE = 1, each LSB introduces an offset of 4.34 ppm. The offset value is coded in two’s complement giving a range of +63 LSB to –64 LSB. See Table26

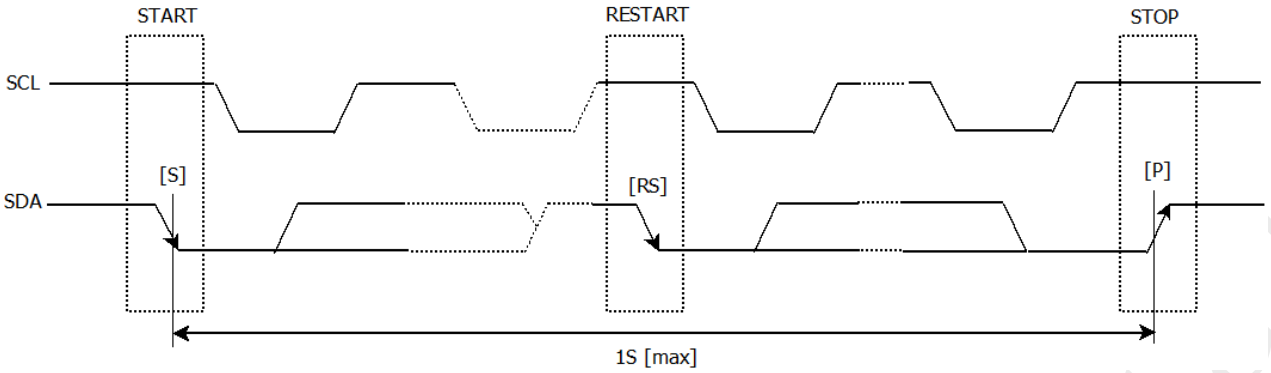
Table25. Mode

Symbol	Value	Description
Mode	0	Offset is made once every 4 minutes
	1	Offset is made once every 2 hours

Table26. Offset_Cfg

Offset_cfg[6:0]	O ffset value in decimal	Offset value in ppm	
		Mode 0	Mode 1
011 1111	+63	+256.347	+273.42
011 1110	+62	+252.278	+269.080
……	……	……	……
000 0010	+2	+8.138	+8.680
000 0001	+1	+4.069	+4.34
000 0000	0	0	0
111 1111	-1	-4.069	-4.34
111 1110	-2	-8.138	-8.680
……	……	……	……
100 0001	-62	-252.278	-269.080
100 0000	-63	-256.347	-273.42

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". INS58563 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. If the time is more than 1S, INS58563 will reset I²C Interface.

INS58563 I²C bus interface supports single byte read/write operations as well as multiple bytes incremental access. After 0xFF address, the next one will be 0x00.

7.2 Slave Address

Table27. I²C Bus Slave Address

Transfer data	Slave address							R/W
	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
A3h (Read)	1	0	1	0	0	0	1	1 (Read)
A2h (Write)								0 (Write)

INS58563 I²C bus Slave Address is [1010 001*].

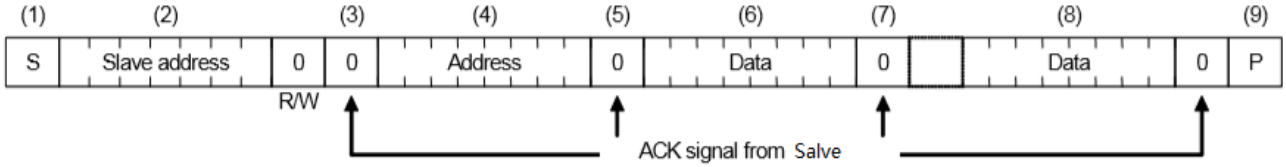
7.3 I²C bus protocol

It is assumed CPU is master and INS58563 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 INS58563 increments (+1) the address automatically after each data is sent, then to write next data.

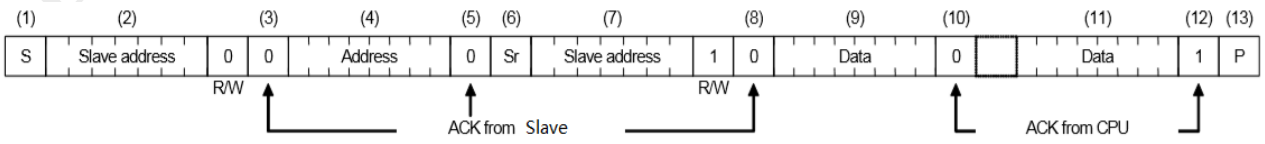
(1) CPU sends start condition[S]
(2) CPU sends INS58563's slave address with R/W bit to set to write mode
(3) CPU verifies ACK signal from INS58563
(4) CPU sends write address to INS58563
(5) CPU verifies ACK signal from INS58563
(6) CPU sends write data to the address specified at step (4)
(7) CPU verifies ACK signal from INS58563
(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 INS58563's slave address with R/W bit to set to write mode
(3) CPU verifies ACK signal from INS58563
(4) CPU sends address for reading from INS58563
(5) CPU verifies ACK signal from INS58563
(6) CPU sends RESTART condition [Sr]
(7) CPU sends INS58563's slave address with R/W bit to set to read mode
(8) CPU verifies ACK signal from INS58563
(9) CPU reads data from the specified address in step (4)
(10) CPU sends ACK signal for "0"
(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 Reflow Soldering Curve

Standard: IPC/JEDEC J-STD-020

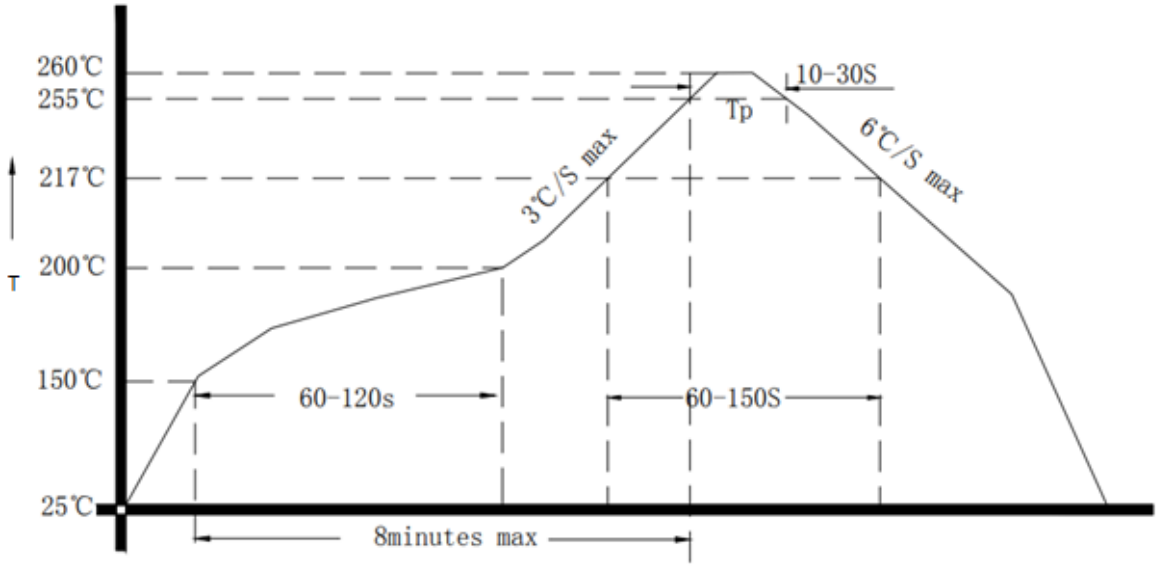


Figure 3. Reflow Soldering Curve

Note: It is suggested to solder IC under the condition shown in the curve above. Must pay attention to the temperature and time when manual soldering, if the temperature over +260℃, or you will make the xo performance bad, even damage it.

9 Dimensions

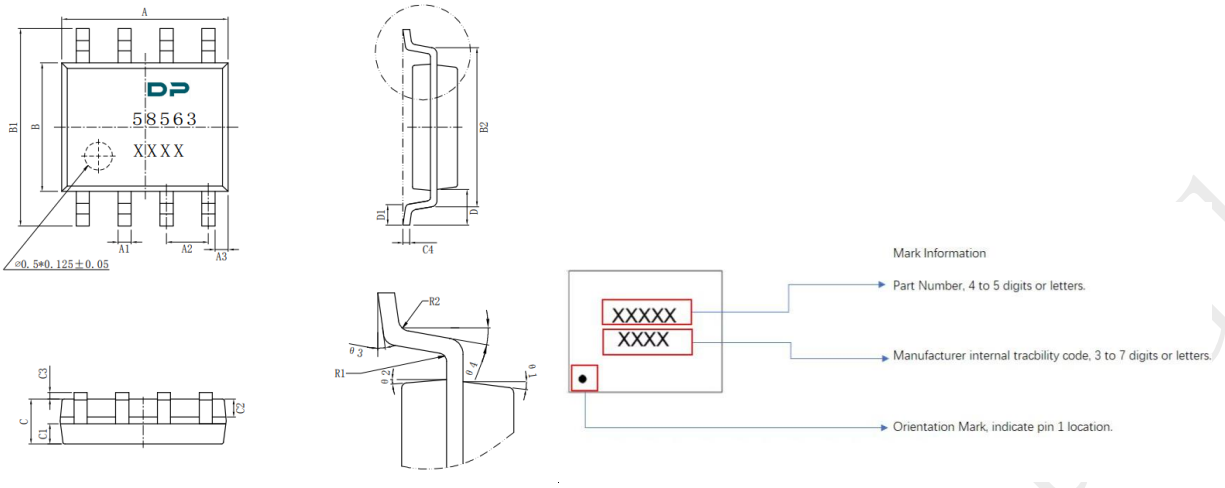


Figure 4. Dimension and Mark information

Dimension	Min.	Typ.	Max.
A	4.8	4.9	5.0
A1	0.356	--	0.456
A2	--	1.27	--
A3	--	0.345	--
B	3.8	3.9	4.0
B1	5.8	6.0	6.2
B2	--	5.00	--
C	1.3	--	1.6
C1	0.55	--	0.65
C2	0.55	--	0.65

(Unit: mm)

Dimension	Min.	Typ.	Max.
C3	0.05	--	0.20
C4	0.203	--	0.233
D	--	1.05	--
D1	0.4	--	0.8
R1	--	0.2	--
R2	--	0.2	--
θ1	17°		
θ2	13°		
θ3	0°~8°		
θ4	4°~12°		

(Unit: mm)

10 Package Information

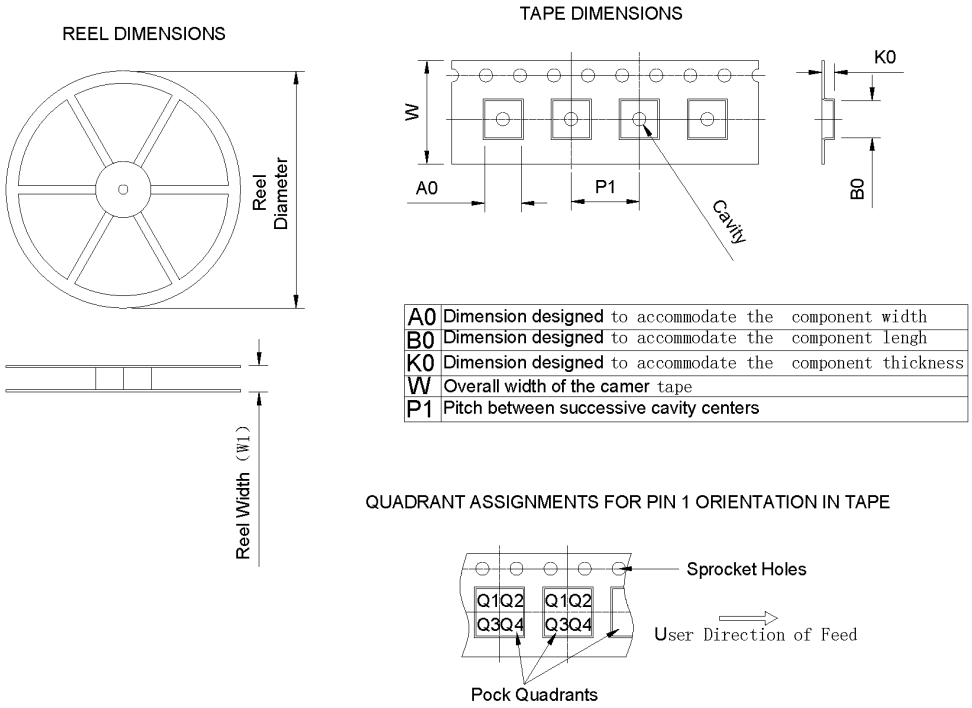


Figure 5. Package information

Device	Package Type	Pins	SPQ	Reel Diameter (mm)	Reel Width W1(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	PIN1 Quadrant
INS58563	SOP	8	3000	330±1	12.4±0.2	6.40	5.30	2.10	8.00±0.1	12.00±0.1	Q1