

Features

- Using external 32.768kHz quartz crystal
- Supports I²C-Bus's high speed mode(400kHz)
- Includes time (Hour/Minute/Second) and calendar (Year/Month/Date/Day) counter functions (BCD code)
- Programmable square wave output signal
- Oscillator stop flag
- Low backup current: typ. 400nA at V_{DD}=3.0V and T_A=25°C
- Operating range: 1.7V to 5.5V
- Operating Temperature Range: -40~125 °C

Applications

- Digital still camera
- Digital video camera
- Printers
- Copy machines
- Mobile equipment
- Battery powered devices

Description

The PCF8563TS-NF serial real-time clock is a low-power clock/calendar with a programmable square-wave output.

Address and data are transferred serially via a 2-wire bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in the 24-hour format indicator.

Table 1 shows the basic functions of PCF8563TS-NF. More details are shown in section: overview of functions.

Ordering Information

Part Number 1	Package	Description	Part Number 2
FRTC8563M		MSOP8	PCF8563TS-NF
FRTC8563S		SOP8	PCF8563T-NF

Green Package

Table 1. Basic functions of PCF8563TS-NF

Item	Function		PCF8563TS-NF	
1	Oscillator	Source: Crystal: 32.768kHz	√	
		Oscillator enable/disable	-	
		Oscillator fail detect	√	
2	Time	Time display	12-hour	-
			24-hour	√
		Century bit		√
		Time count chain enable/disable		√
3	Interrupt	Alarm interrupt	√	
4	Programmable square wave output (Hz)		1, 32, 1.024k, 32.768k	
5	Communication	2-wire I ² C bus	√	
		Burst mode	-	
6	Control	Write protection	-	
		External clock test mode	√	
		Power-on reset override	√	

Function Block

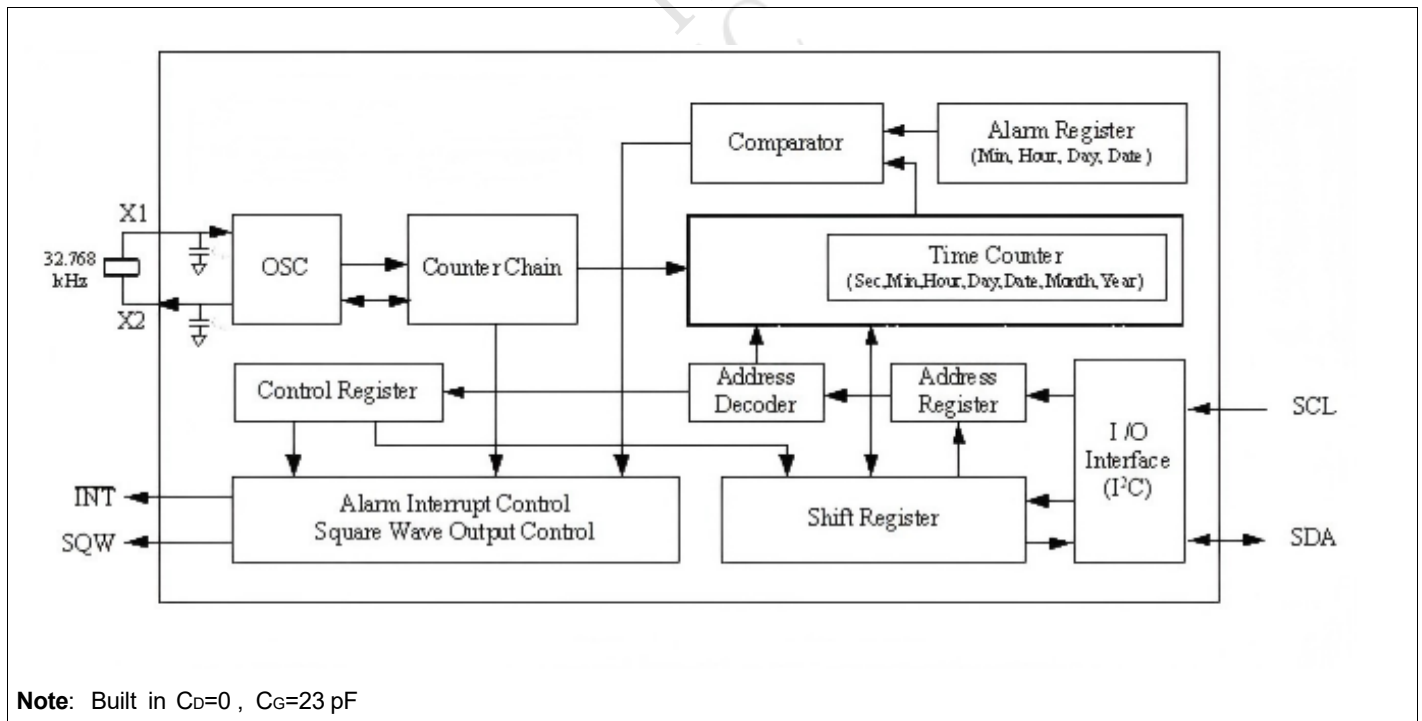
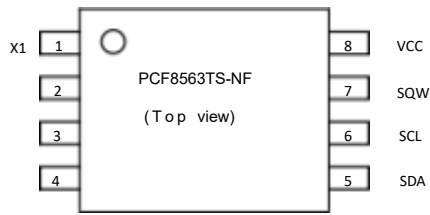


Figure 1. Function Block of PCF8563TS-NF

Pin Configuration



Pin Description

Pin No.	Pin Name	Type	Description
1	X1	I	Oscillator Circuit Input. Together with X2 , 32 .768 kHz crystal is connected between them .
2	X2	O	Oscillator Circuit Output. Together with X1 , 32 .768kHz crystal is connected between them .
3	/INT	O	Interrupt Output. Open drain, active low.
4	GND	P	Ground.
5	SDA	I/O	Serial Data Input/output SDA is the input/output pin for the 2-wire serial interface .The SDA pin is open-drain output and requires an external pull-up resistor.
6	SCL	I	Serial Clock Input. SCL is used to synchronize data movement on the I ² C serial interface.
7	SQW	O	Clock Output. Open drain. Four frequencies selectable: 32.768 k , 1.024k, 32, 1Hz when SQWE bit is set to 1.
8	VCC	P	Power.

Function Description

1. Clock function

CPU can read or write data including the year (last two digits), month, date, day, hour, minute, and second. Any (two - digit) year that is a multiple of 4 is treated as a leap year and calculated automatically as such until the year 2100 .

2. Alarm function

These devices have one alarm system that outputs interrupt signals from INT of PCF8563TS-NF when the date, day of the week, hour, minute or second correspond to the setting.

Each of them may output interrupt signal separately at a specified time .

The alarm may be selectable between on and off for matching alarm or repeating alarm.

3 . Programmable square wave output

A square wave output enable bit controls square wave output at pin 7 . 4 frequencies are selectable: 1 , 32 , 1 .024k , 32.768k Hz.

4. Interface with CPU

Data is read and written via the I²C bus interface using two signal lines: SCL (clock) and SDA (data).

Since the output of the I/O pin SDA is open drain, a pull-up resistor should be used on the circuit board if the CPU output I/O is also open drain.

The SCL's maximum clock frequency is 400 kHz, which supports the I²C bus's high-speed mode .

5. Oscillator fail detect

When oscillator fail, OSF bit will be set.

6. Oscillator enable/disable

Only time count chain can be enable or disable by STOP bit.

7. Reset function

The PCF8563TS-NF includes an internal reset circuit which is active whenever the oscillator is stopped. In the reset state the I²C-bus logic is initialized and all registers, including the address pointer, are cleared with the exception of bits FE, OSF, TD1 , TD0 , TESTC and AE which are set to logic 1 .

Registers

001. Allocation of registers

Addr. (hex) *1	Function (time range BCD format)	Register definition							
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
00	Control/status 1	x	x	x	x	x	x	x	x
01	Control/ status 2	x	x	x	x	AF*2	x	AIE*3	x
02	Seconds (00-59)	OSF*4	S40	S20	S10	S8	S4	S2	S1
03	Minutes (00-59)	x	M40	M20	M10	M8	M4	M2	M1
04	Hours (00-23)	x	x	H20	H10	H8	H4	H2	H1
05	Dates (01-31)	x	x	D20	D10	D8	D4	D2	D1
06	Days of the week (00-06)	x	x	x	x	x	W4	W2	W1
07	Months (01-12)	x	x	x	MO10	MO8	MO4	MO2	MO1
08	Years (00-99)	Y80	Y40	Y20	Y10	Y8	Y4	Y2	Y1
09	Alarm: Minutes (00-59)	AE*5	M40	M20	M10	M8	M4	M2	M1
0A	Alarm: Hours (01-12)	AE*5	x	H20	H10	H8	H4	H2	H1
0B	Alarm: Dates (01-31)	AE*5	x	D20	D10	D8	D4	D2	D1
0C	Alarm: Weekday (00-06)	AE*5	x	x	x	x	W4	W2	W1
0D	SQW control	SQWE	x	x	x	x	x	RS1	RS0

Caution points:

- *1 . PCF8563TS-NF uses 8 bits for address. For excess 0FH address, PCF8563TS-NF will not respond
- *2 . Alarm interrupt flag bits.
- *3 . Alarm interrupt enable bits.
- *4 . Oscillator fail indicates. Indicate clock integrity.
- *5 . Alarm enable bit. Alarm will be active when related time is matching if AE = 0 .
- *6 . All bits marked with " x " are not implemented.

Control and status register

Addr. (hex)	Description	D7	D6	D5	D4	D3	D2	D1	D0
00	Control/ status 1	x	x	x	x	x	x	x	x
	(default)	0	Undefined	0	Undefined	1	Undefined	Undefined	Undefined
01	Control/ status 2	x	x	x	x	AF	x	AIE	x
	(default)	Undefined	Undefined	Undefined	0	Undefined	Undefined	0	0
0D	SQW control	SQWE	x	x	x	x	x	RS1	RS0
	(default)	1	Undefined	Undefined	Undefined	Undefined	Undefined	0	0

a) Alarm Interrupt

- **AIE:** Alarm Interrupt Enable bit.

AIE	Data	Description	
Read / Write	0	Alarm interrupt disabled	Default
	1	Alarm interrupt enabled	

- **AF:** Alarm Flag

AF	Data	Description
Read	0	Alarm flag inactive
	1	Alarm flag active
Write	0	Alarm flag is cleared
	1	Alarm flag remains unchanged

b) SQW control

- **SQWE:** SQW output clock enable bit.

SQWE	Data	Description	
Read / Write	0	the SQW output is inhibited and SQW output is set to high impedance	
	1	the SQW output is activated	Default

- **RS1 RS0:** SQW output frequency select

RS1, RS0	Data	SQW output freq. (Hz)	
Read / Write	00	32.768k	Default
	01	1.024k	
	10	32	
	11	1	

5. Alarm Register

PCF8563TS-M-TR:

Addr.	Description	D7	D6	D5	D4	D3	D2	D1	D0
09	Alarm: Minutes	AE*1	M40	M20	M10	M8	M4	M2	M1
	(default)	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
0A	Alarm: Hours	AE*2	x	H20	H10	H8	H4	H2	H1
	(default)	Undefined	0	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
0B	Alarm: Dates	AE*3	x	D20	D10	D8	D4	D2	D1
	(default)	Undefined	0	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
0C	Alarm: Weekday	AE*4	x	x	x	x	W4	W2	W1
	(default)	Undefined	0	0	0	0	Undefined	Undefined	Undefined

* 1 Note: Minute alarm enable bit. *2 Note: Hour alarm enable bit. *3 Note: Date alarm enable bit.

*4 Note: Weekday alarm enable bit.

Alarm Function

Related register

	Function	Register definition							
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
01	Control/status 2	x	x	x	x	AF	x	AIE	x
02	Seconds	OSF	S40	S20	S10	S8	S4	S2	S1
03	Minutes	x	M40	M20	M10	M8	M4	M2	M1
04	Hours	x	x	H20	H10	H8	H4	H2	H1
05	Dates	x	x	D20	D10	D8	D4	D2	D1
06	Days of the week	x	x	x	x	x	W4	W2	W1
09	Alarm: Minutes	AE	M40	M20	M10	M8	M4	M2	M1
0A	Alarm: Hours	AE	x	H20	H10	H8	H4	H2	H1
0B	Alarm: Dates	AE	x	D20	D10	D8	D4	D2	D1
0C	Alarm: Weekday	AE	x	x	x	x	W4	W2	W1

When one or more of these registers are loaded with a valid minute, hour, day or weekday and its corresponding bit Alarm Enable (AE) is logic 0, then that information will be compared with the current minute, hour, day and weekday. When all enabled comparisons first match, the Alarm Flag (AF) is set. AF will remain set until cleared by software.

Once AF has been cleared it will only be set again when the time increments to match the alarm condition once more. Alarm registers which have their bit AE at logic 1 will be ignored.

I²C Bus Interface

1. I²C Bus Protocol

a) Overview of I²C- BUS

The I²C bus supports bi-directional communications via two signal lines: the SDA (data) line and SCL (clock) line. A combination of these two signals is used to transmit and receive communication start/stop signals, data signals, acknowledge signals, and so on.

Both the SCL and SDA signals are held at high level whenever communications are not being performed. The starting and stopping of communications is controlled at the rising edge or falling edge of SDA while SCL is at high level. During data transfers, data changes that occur on the SDA line are performed while the SCL line is at low level, and on the receiving side the data is captured while the SCL line is at high level. In either case, the data is transferred via the SCL line at a rate of one bit per clock pulse. The I²C bus device does not include a chip select pin such as is found in ordinary logic devices. Instead of using a chip select pin, slave addresses are allocated to each device and the receiving device responds to communications only when its slave address matches the slave address in the received data.

b) System Configuration

All ports connected to the I²C bus must be either open drain or open collector ports in order to enable AND connections to multiple devices.

SCL and SDA are both connected to the VDD line via a pull-up resistance. Consequently, SCL and SDA are both held at high level when the bus is released (when communication is not being performed).

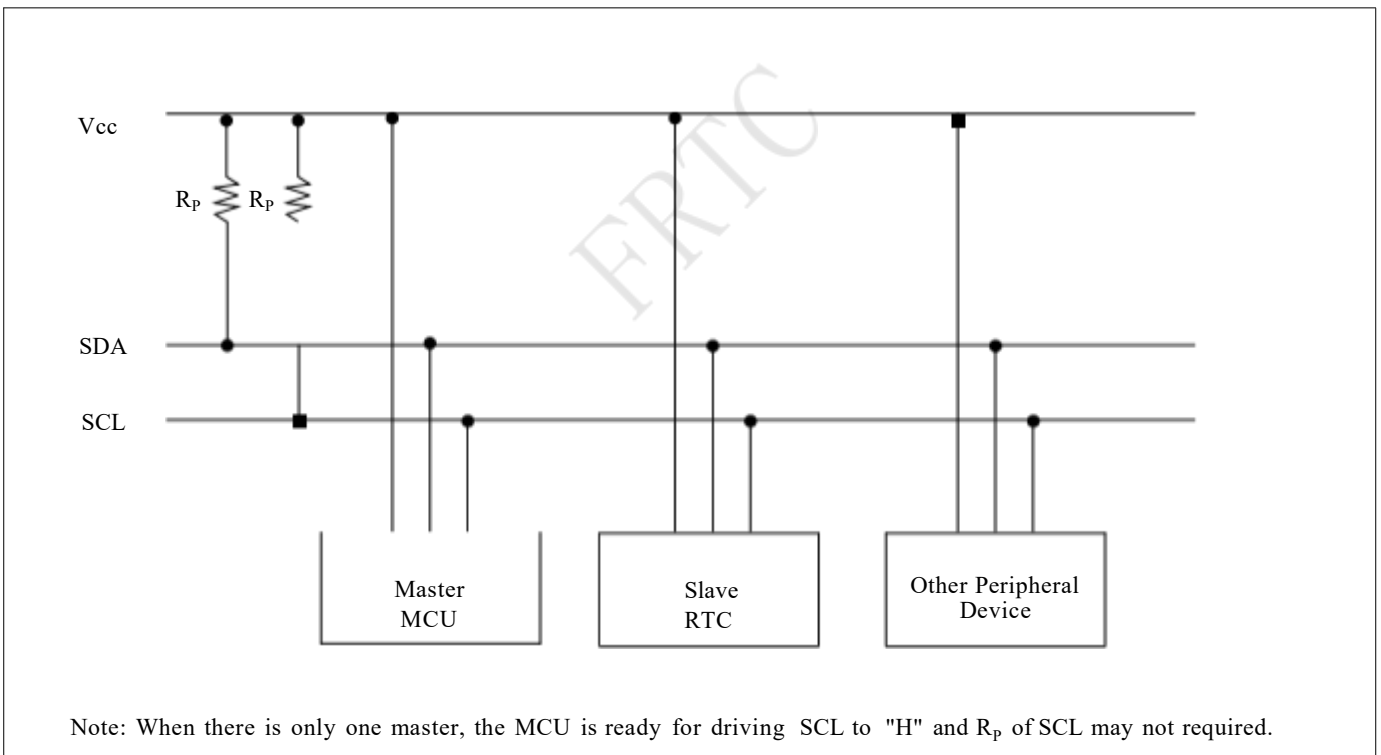


Fig.1 System configuration

c) Starting and Stopping I²C Bus Communications

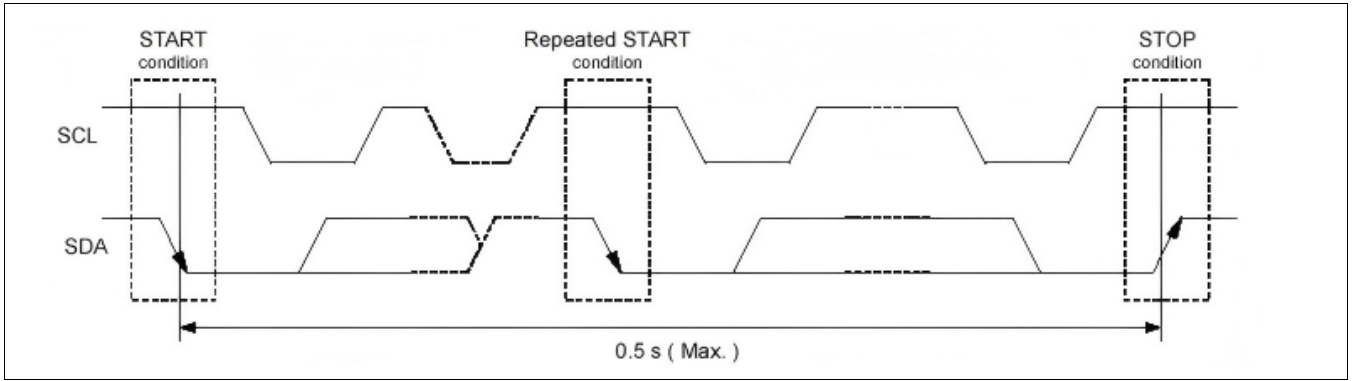


Fig.2 Starting and stopping on I²C bus

START condition ,repeated START condition ,and STOP condition

- **START condition**
SDA level changes from high to low while SCL is at high level
- **STOP condition**
SDA level changes from low to high while SCL is at high level
- **Repeated START condition (RESTART condition)**

In some cases, the START condition occurs between a previous START condition and the next STOP condition, in which case the second START condition is distinguished as a RESTART condition. Since the required status is the same as for the START condition, the SDA level changes from high to low while SCL is at high level.

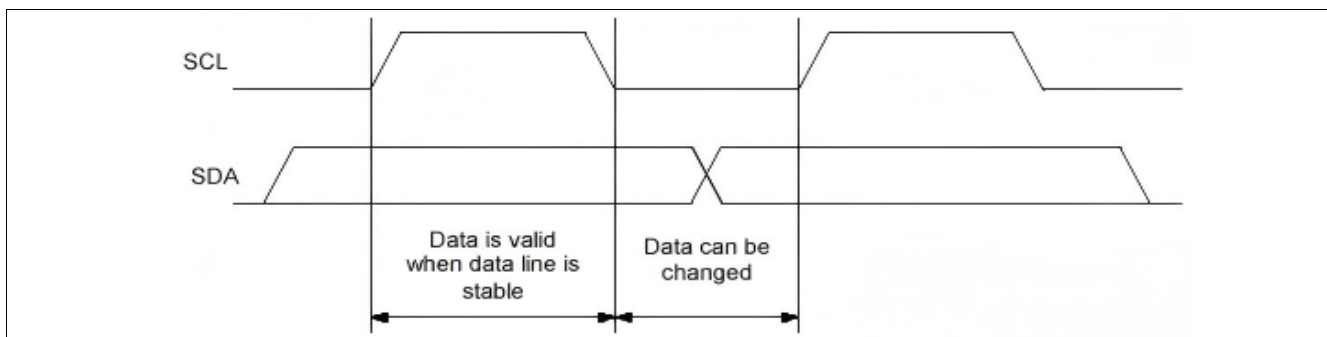
d) Data Transfers and Acknowledge Responses during I²C-BUS Communication

• Data transfers

Data transfers are performed in 8-bit (1 byte) units once the START condition has occurred. There is no limit on the amount (bytes) of data that are transferred between the START condition and STOP condition.

The address auto increment function operates during both write and read operations.

Updating of data on the transmitter (transmitting side)'s SDA line is performed while the SCL line is at low level. The receiver (receiving side) captures data while the SCL line is at high level.

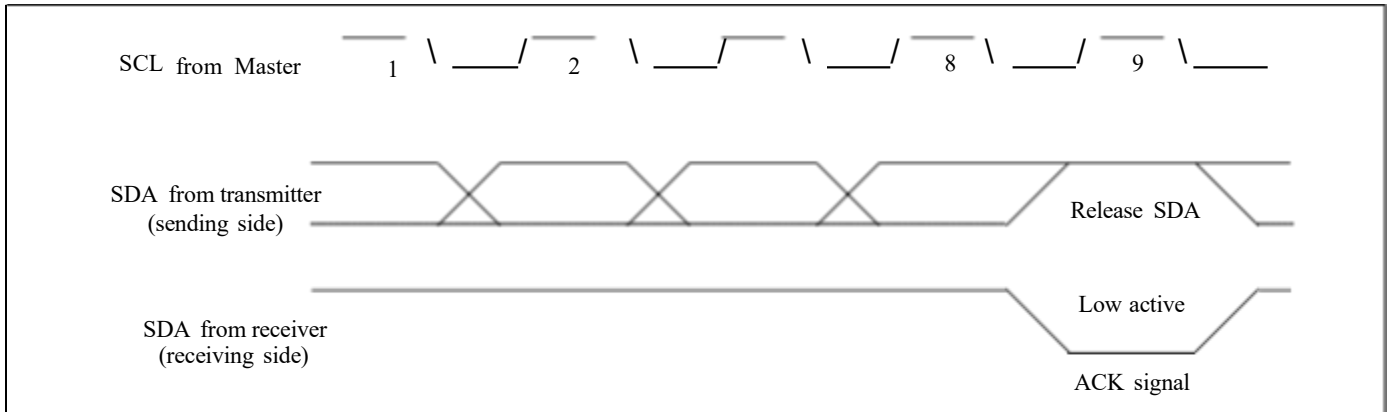


*Note with caution that if the SDA data is changed while the SCL line is at high level, it will be treated as a START, RESTART, or STOP condition.

- **Data acknowledge response (ACK signal)**

When transferring data, the receiver generates a confirmation response (ACK signal, low active) each time an 8-bit data segment is received. If there is no ACK signal from the receiver, it indicates that normal communication has not been established. (This does not include instances where the master device intentionally does not generate an ACK signal.)

Immediately after the falling edge of the clock pulse corresponding to the 8th bit of data on the SCL line, the transmitter releases the SDA line and the receiver sets the SDA line to low (= acknowledge) level.



After transmitting the ACK signal, if the Master remains the receiver for transfer of the next byte, the SDA is released at the falling edge of the clock corresponding to the 9th bit of data on the SCL line. Data transfer resumes when the Master becomes the transmitter.

When the Master is the receiver, if the Master does not send an ACK signal in response to the last byte sent from the slave, that indicates to the transmitter that data transfer has ended. At that point, the transmitter continues to release the SDA and awaits a STOP condition from the Master.

e) Slave Address

The I2C bus device does not include a chip select pin such as is found in ordinary logic devices. Instead of using a chip select pin, slave addresses are allocated to each device.

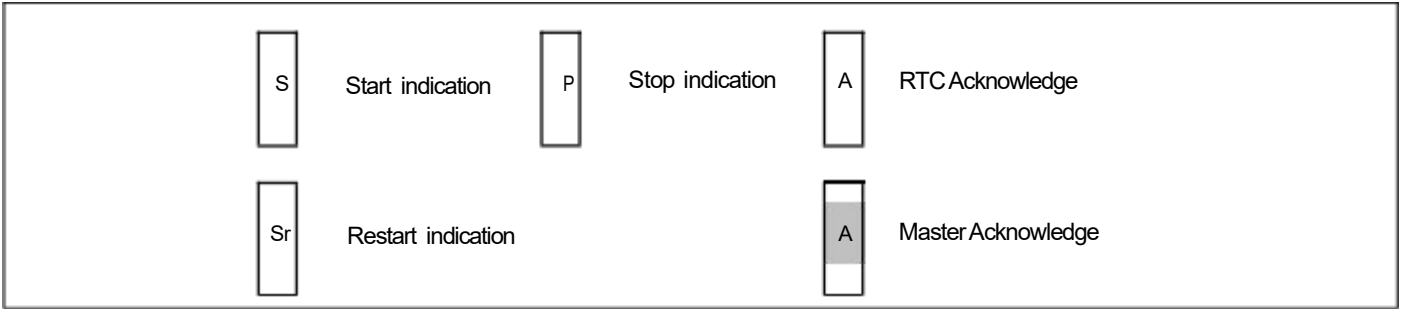
All communications begin with transmitting the [START condition] + [slave address (+ R/W specification)]. The receiving device responds to this communication only when the specified slave address it has received matches its own slave address.

Slave addresses have a fixed length of 7 bits. See table for the details.

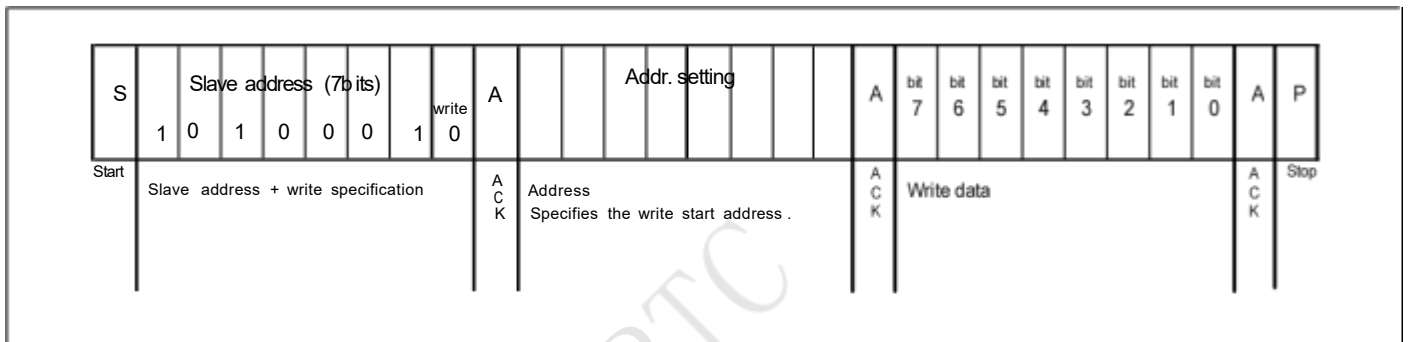
An R/W bit is added to each 7-bit slave address during 8-bit transfers.

Operation	Transfer data	Slave address							R / W bit
		bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Read	A3 h	1	0	1	0	0	0	1	1 (= Read)
Write	A2 h								0 (= Write)

2. I²C Bus's Basic Transfer Format

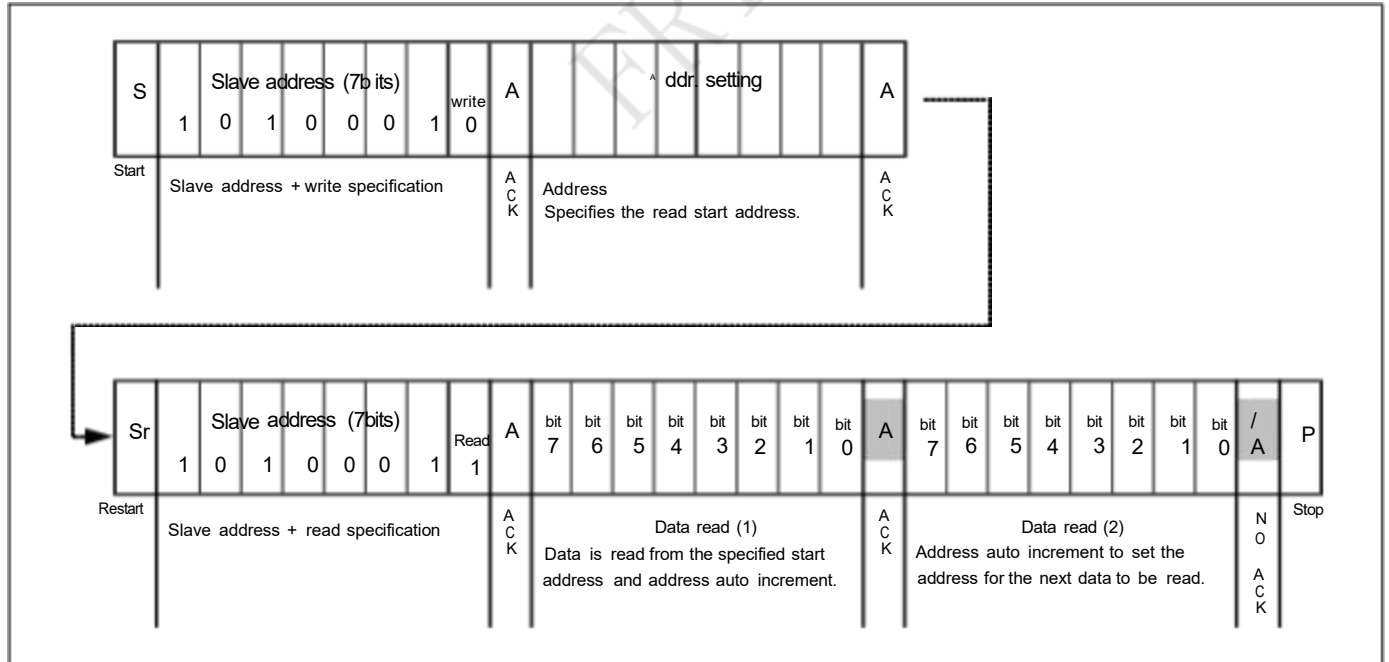


a) Write via I²C bus

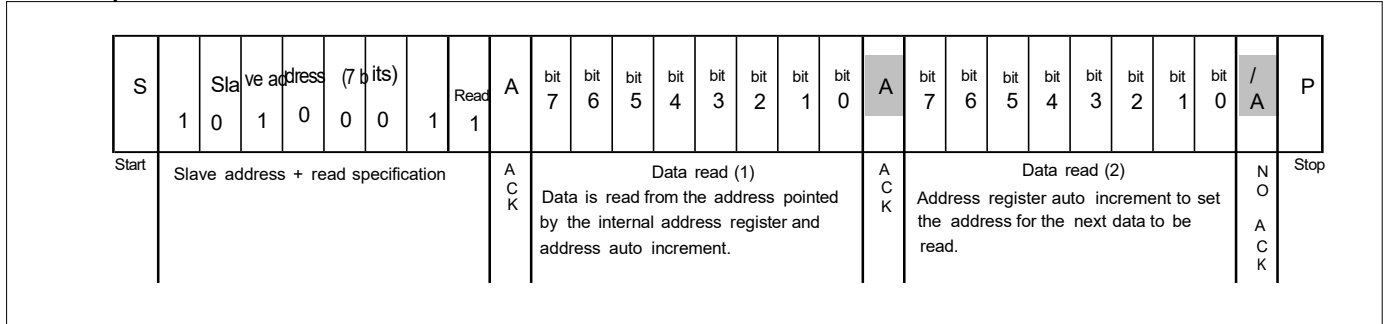


b) Read via I²C bus

- Standard read



• **Simplified read**



Note:

1. The above steps are an example of transfers of one or two bytes only. There is no limit to the number of bytes transferred during actual communications .
2. 49 H , 4AH are used as test mode address. Customer should not use the addresses.

FRTC

Absolute Maximum Ratings

Storage Temperature	-65oCto +150oC
Ambient Temperaturewith PowerApplied	-40oCto +125oC
Supply Voltage to Ground Potential (VcctoGND)	-0.3Vto +6.5V
DC Input (All Other Inputs exceptVcc& GND)	-0.3Vto (Vcc+0.3V)
DC OutputVoltage (SDA,/INTA,/INTB pins)	-0.3Vto +6.5V
Power Dissipation	320mW(Depend on package)

Note:

Stresses greater than those listed under MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended Operating Conditions

Symbol	Description	MIN	TYP	MAX	Unit
V _{CC}	Power voltage	1.7	-	5.5	V
V _{IH}	Input high level	0.7 V _{CC}	-	V _{CC} +0.3	
V _{IL}	Input low level	-0.3	-	0.3 V _{CC}	
T _A	Operating temperature	-40	-	125	°C

FRTC

DC Electrical Characteristics

Unless otherwise specified, GND = 0V, V_{CC} = 1.7 ~ 5.5 V, T_A = -40 °C to +125 °C, f_{osc} = 32.768kHz.

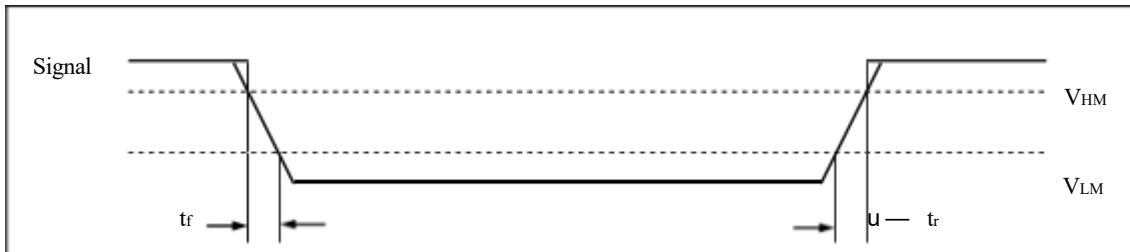
Symbol	Description	Pin	Conditions	MIN	TYP	MAX	Unit	
V _{CC}	Supply voltage	V _{CC}	Interface inactive. T _A = 25 °C ¹⁾	1.5	-	5.5	V	
			Interface active. f _{SCL} = 400kHz ¹⁾	1.7	-	5.5		
	Supply voltage for clock data integrity	V _{CC}	-	1.5	-	5.5		
I _{CC}	Supply current	V _{CC}	Interface active	f _{SCL} = 400kHz	-	-	25	μA
				f _{SCL} = 100kHz	-	-	15	
			Interface inactive (f _{SCL} = 0 Hz), pin 7 disabled T _A = -40~125 °C	V _{CC} = 5.0V	-	450	900	nA
				V _{CC} = 3.0V	-	400	800	
			Interface inactive (f _{SCL} = 0 Hz), pin 7 enabled at 32kHz T _A = -40~125 °C	V _{CC} = 5.0V	-	650	900	nA
				V _{CC} = 3.0V	-	600	850	
V _{IL1}	Low-level input voltage	SCL	-	0	-	0.3V _{CC}	V	
V _{IH1}	High-level input voltage	SCL	-	0.7V _{CC}	-	V _{CC}		
I _{OL}	Low-level output voltage	SDA	V _{OL} = 0.4V, V _{CC} = 5V	-3	-	-	mA	
		/INT, SQW	V _{OL} = 0.4V, V _{CC} = 5V	-1	-	-		
I _{IL}	Input leakage current	SCL	-	-	-	±1	μA	
I _{oz}	Output current when OFF	-	-	-	-	±1	μA	

Note:

1) For reliable oscillator start-up at power-up: V_{CC(min)power-up} = V_{CC(min)} + 0.3 V

AC Electrical Characteristics

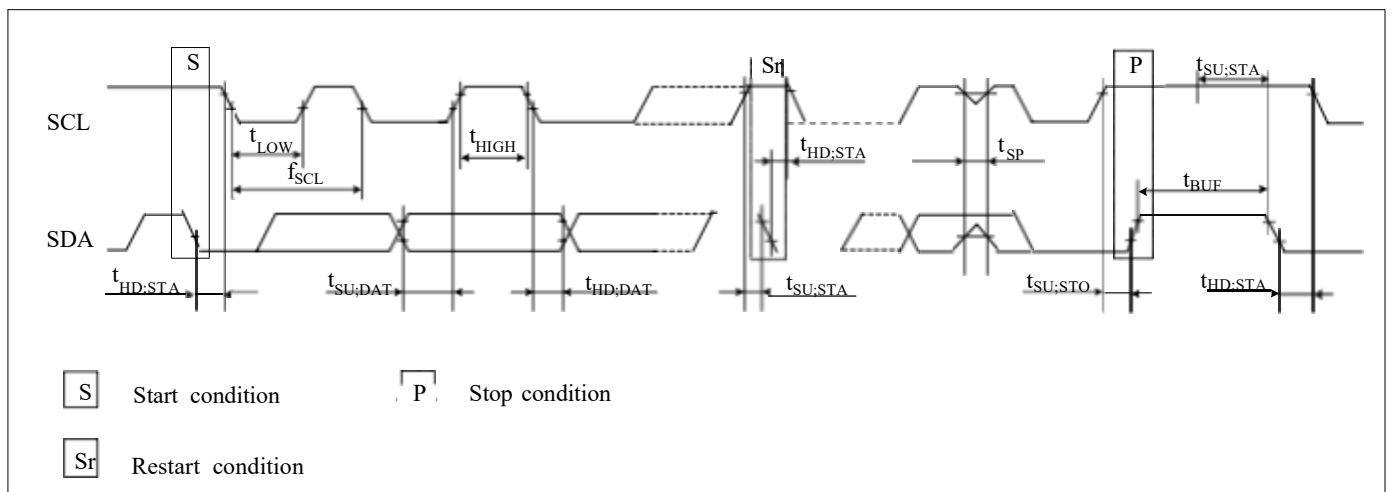
Symbol	Description	Value	Unit
V_{HM}	Rising and falling threshold voltage high	0.8 V_{CC}	V
V_{HL}	Rising and falling threshold voltage low	0.2 V_{CC}	V



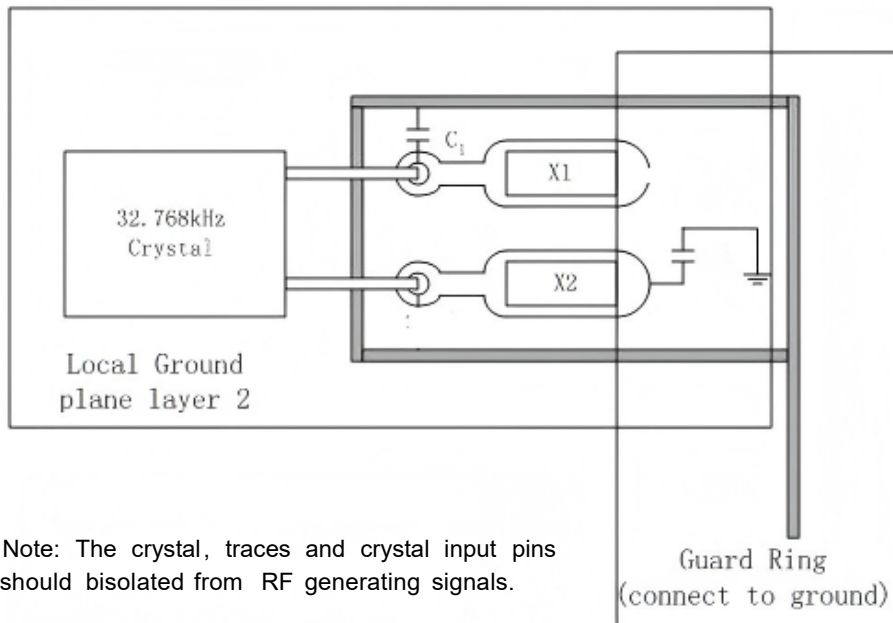
Over the operating range

Symbol	Description	MIN	TYP	MAX	Unit
f_{SCL}	SCL clock frequency	-	-	400	kHz
$t_{SU:STA}$	START condition set-up time	0.6	-	-	μ s
$t_{HD:STA}$	START condition hold time	0.6	-	-	μ s
$t_{SU:DAT}$	Data set-up time (RTC read/write in Fast mode)	100	-	-	ns
$t_{HD:DAT1}$	Data hold time (RTC write)	35	-	-	ns
$t_{HD:DAT2}$	Data hold time (RTC read)	0	-	-	μ s
$t_{SU:STO}$	STOP condition setup time	0.6	-	-	μ s
t_{BUF}	Bus idle time between a START and STOP condition	1.3	-	-	μ s
t_{LOW}	When SCL = "L"	1.3	-	-	μ s
t_{HIGH}	When SCL = "H"	0.6	-	-	μ s
t_r	Rise time for SCL and SDA	-	-	0.3	μ s
t_f	Fall time for SCL and SDA	-	-	0.3	μ s
t_{SP}^*	Allowable spike time on bus	-	-	50	ns
C_B	Capacitance load for each bus line	-	-	400	pF

* **Note:** Only reference for design.



Recommended Layout for Crystal



Note: The crystal, traces and crystal input pins should be isolated from RF generating signals.

Built-in Capacitors Specifications and Recommended External Capacitors

Symbol	Parameter		TYP	Unit
CD	Build-in capacitors	X1 to GND	0	pF
CG		X2 to GND	23	pF
C1	Recommended External capacitors for crystal CL= 12.5 pF	X1 to GND	22	pF
C2		X2 to GND	0	pF
C1	Recommended External capacitors for crystal CL= 6 pF	X1 to GND	7	pF
C2		X2 to GND	0	pF

Note: The frequency of crystal can be optimized by external capacitor C1 and C2, for frequency= 32.768 Hz, C1 and C2 should meet the equation as below:

$$C_{par} + \frac{[(C1+CG) \cdot (C2+CD)]}{[(C1+CG) + (C2+CD)]} = CL$$

C_{par} is all parasitical capacitor between X1 and X2.

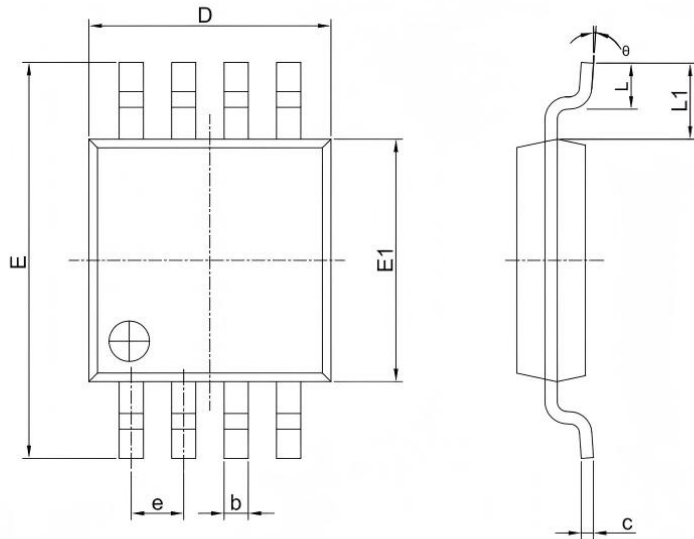
CL is crystal's load capacitance.

Crystal Specifications

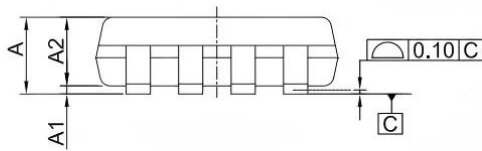
Symbol	Parameter	MIN	TYP	MAX	Unit
f ₀	Nominal Frequency	-	32.768	-	kHz
ESR	Series Resistance	-	-	70	kΩ
CL	Load Capacitance	-	6/12.5	-	pF

Package Information

PCF8563TS-NF (MSOP8) package



PKG DIMENSIONS(MM)		
SYMBOL	Min.	Max.
A	--	1.10
A1	0.00	0.15
A2	0.75	0.95
b	0.22	0.38
c	0.08	0.23
D	2.80	3.20
E	4.65	5.15
E1	2.80	3.20
e	0.65 BSC	
L	0.40	0.80
L1	0.95 REF	
θ	0°	8°

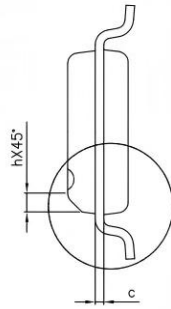
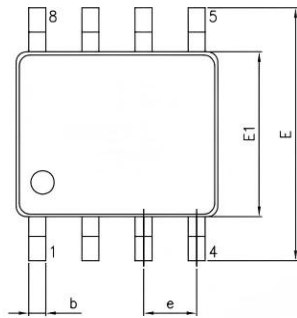


Note:

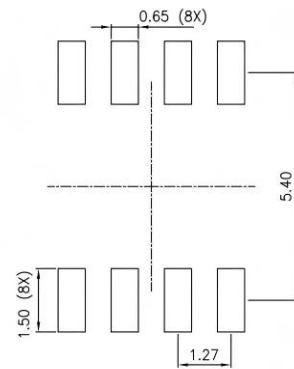
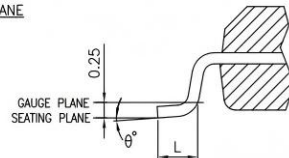
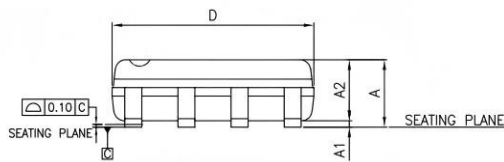
- 1.All dimensions are in mm. Angles in degrees.
- 2.Refer Jedec MO-187
- 3.Dimensions exclude burrs, mold flash or protrusions.

MSOP08 POD Rev.0

PCF8563T-NF (SOP-8) package



SYMBOLS	MIN.	NOM.	MAX.
A	—	—	1.75
A1	0.10	—	0.25
A2	1.25	—	—
b	0.31	—	0.51
c	0.10	—	0.25
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.40	—	1.27
h	0.25	—	0.50
θ°	0	—	8



Recommended Land Pattern

Note:

1. All dimensions are in mm. Angles in degrees.
2. Dimensions exclude burrs, mold flash or protrusions.
3. Refer Jeduc MS-012
4. Recommended land pattern is for reference only.

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