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Real-time Clock Module

Features

- Low current consumption: 0.3μA typ. (V_{DD}=3.0V, T_A = 25°C)
- Wide operating voltage range: 1.35 to 5.5 V
- Minimum time keeping operation voltage: 1.25 V
- Built-in clock adjustment function
- Built-in free user register
- 2-wire (I^2C-bus) CPU interface
- Built-in alarm interrupter
- Built-in flag generator at power down or power on
- Auto calendar up to the year 2099, automatic leap year calculation function
- Built-in constant voltage circuit
- Built-in 32 kHz crystal oscillator circuit
- Built-in 32 kHz crystal for PT7C43390C
- Package: SOIC-8L, TSSOP-8L, and TDFN2x3-8L for PT7C43390; TDFN4x4-8L for PT7C43390C

Applications

- Mobile game device, mobile phone
- Industrial control
- Electronic power meter
- DVD recorder
- Car navigation
- IP Camera, DVR, NVR

Description

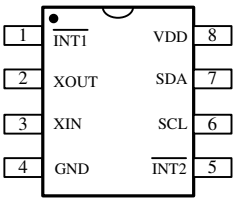
The PT7C43390 is a CMOS I^2C-bus real-time clock IC, which operates with the very low current consumption and in the wide range of operation voltage. The operation voltage is 1.35 V to 5.5 V so that the RTC can be used for various power supplies from main supply to backup battery. In the system which operates with a backup battery, the included free registers can be used as the function for user's backup memory. Users always can take back the information in the registers which is stored before power-off the main power supply, after the voltage is restored.

The IC has the function to correct advance / delay of the clock data speed, in the wide range, which is caused by the oscillation circuit's frequency deviation. Correcting according to the temperature change by combining this function and a temperature sensor, it is possible to make a high precise clock function which is not affected by the ambient temperature.

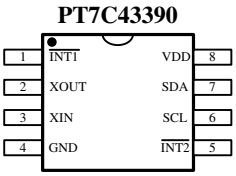
Function Table

Item	Function			PT7C43390	PT7C43390C
1	Oscillator	Source	Crystal*	External crystal	Integral crystal
2	Time	Time display	12-hour	ı	ı
			24-hour	ı	ı
3	Interrupt	Alarm interrupt pin output		ı 2	ı 2
		Timer interrupt output		ı	ı
4	Programmable square wave output (Hz)			1Hz,2Hz,4Hz 8Hz,16Hz 32kHz	1Hz,2Hz,4Hz 8Hz,16Hz 32kHz
5	Communication	2-wire I^2C bus		ı	ı
		Burst mode		ı	ı
6	Control	IC test mode		ı	ı
		Power-on detector		ı	ı
		Power supply voltage detector		ı	ı
7	Clock calibration			ı	ı
80	Free register access			ı	ı

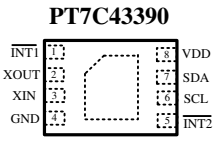
Pin Configuration



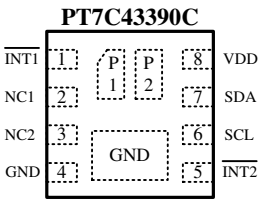
SOIC-8L



TSSOP-8L



TDFN2x3-8L

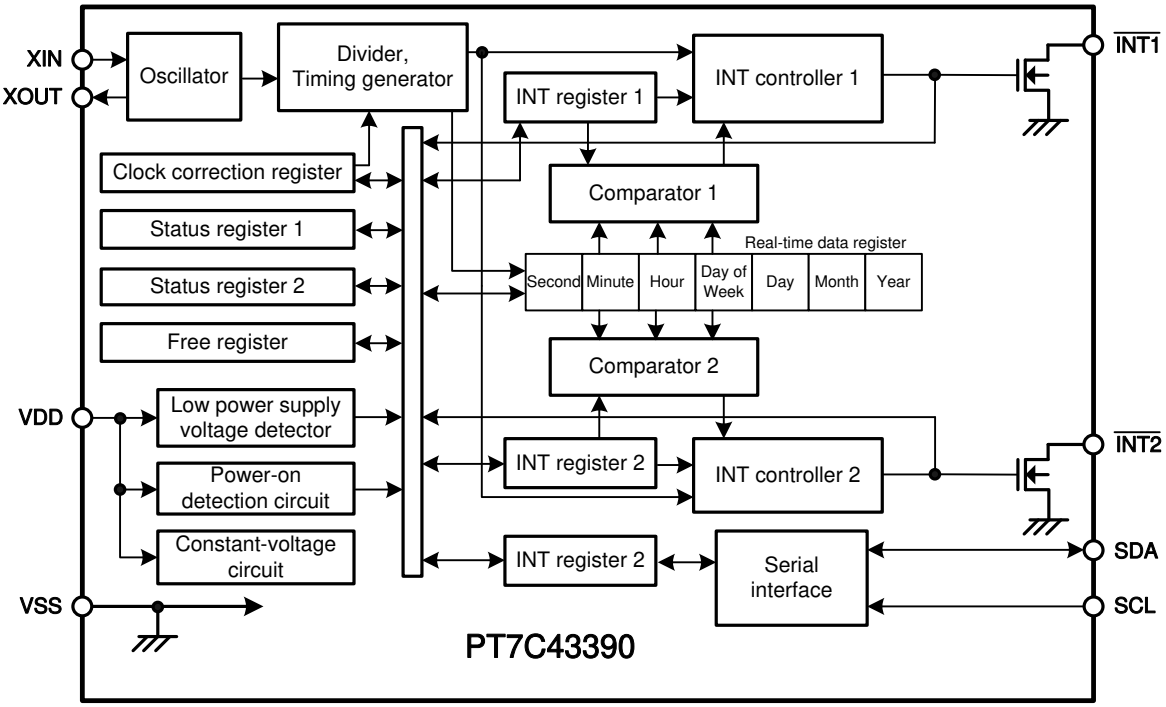


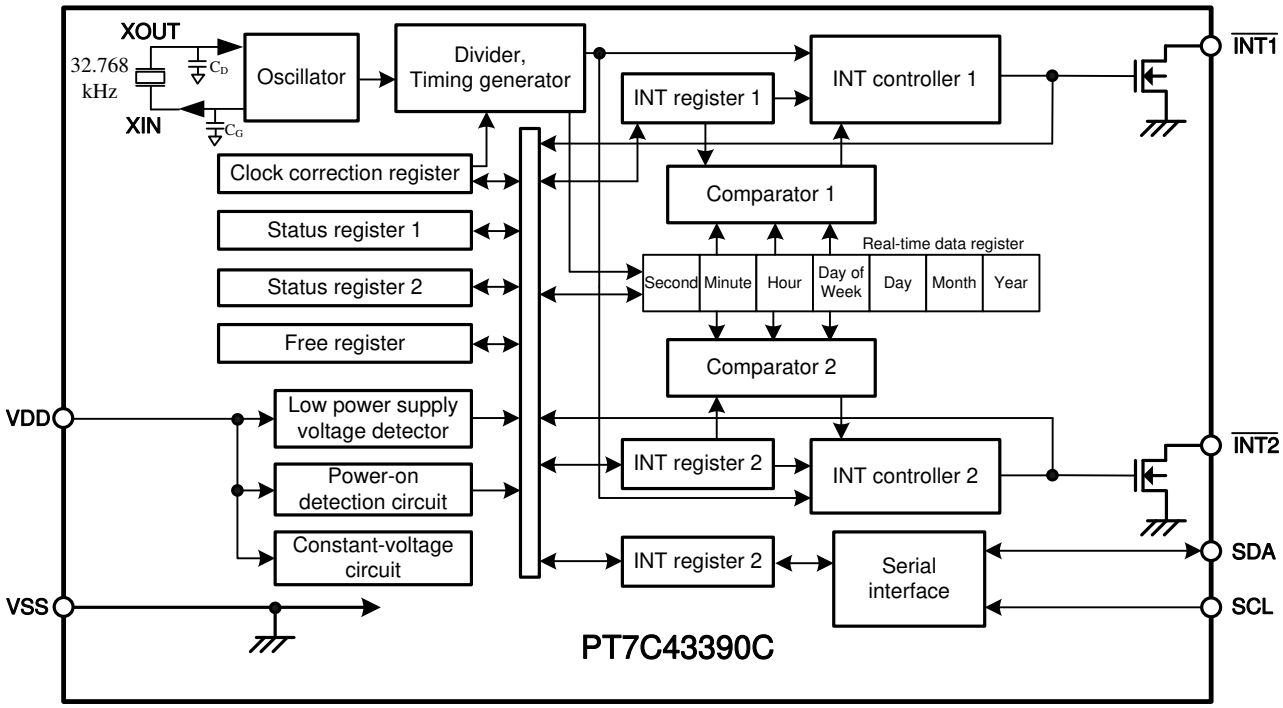
TDFN4x4-8L

Pin Description

Pin No.		Pin Name	Type	Description
43390	43390C			
1	1	$\overline{\text{INT1}}$	O	**Output for Interrupt Signal 1.** This pin outputs a signal of interrupt, or a clock pulse. By using the status register 2, users can select either of: alarm 1 interrupt, output of user-set frequency, per-minute edge interrupt, minute-periodical interrupt 1, minute-periodical interrupt 2, or 32.768 kHz output. This pin has NCH open drain output.
2	-	XOUT	O	**Oscillator Circuit Output.** Together with X1, 32.768kHz crystal is connected between them. When 32.768kHz external input, X2 must be float.
-	2	NC1	-	**No connected.**
3	-	XIN	I	**Oscillator Circuit Input.** Together with X1, 32.768kHz crystal is connected between them. Or external clock input.
-	3	NC2	-	**No connected.**
4	4	VSS	P	**Negative power supply pin.** Connects to GND.
5	5	$\overline{\text{INT2}}$	O	**Output for Interrupt Signal 2.** This pin outputs a signal of interrupt, or a clock pulse. By using the status register 2, users can select either of: alarm2 interrupt, output of user-set frequency, or minute-periodical interrupt 1. This pin has NCH open drain output.
6	6	SCL	I	**Serial clock input pin.** This pin is to input a clock pulse for I^2C-bus interface. The SDA pin inputs/outputs data by synchronizing with the clock pulse.
7	7	SDA	I/O	**Serial Data Input/Output.** This is a data input / output pin of I^2C-bus interface. This pin inputs / outputs data by synchronizing with a clock pulse from the SCL pin. This pin has CMOS input and NCH open drain output. Generally in use, pull up this pin to the V_{DD} potential via a resistor, and connect it to any other device having open drain or open collector output with wired-OR connection.
8	8	VDD	P	**Positive power supply pin.** Connect this VDD pin with a positive power supply.

Block Diagram





Maximum Ratings

Storage Temperature	-55°C to +125°C
Operating Temperature	-40°C to +85°C
Power Supply Voltage	Vss-0.3V to Vss+6.5V
DC Input Voltage(SCL, SDA)	Vss-0.3V to Vss+6.5V
DC Output Voltage(SDA, INT1, INT2)	Vss-0.3V to Vss+6.5V
Power Dissipation	250mW (depend on package)

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	Parameter	CONDITIONS	Min	Typ	Max	Unit
V_{DD}	Power supply voltage	T_A = Б40 to +85éC	1.35	3.0	5.5	V
T_{opr}	Operating temperature	V_{DD} =1.3 to 5.5 V	Б40	+25	+85	°C
V_{DDT}	Time keeping voltage range	T_A = Б40 to +85éC	1.25	-	5.5	V
V_{DDR}	Register hold voltage	T_A = Б40 to +85éC	0.9	-	5.5	V
V_{DET}	Power supply voltage detection voltage *1	T_A = Б40 to +85éC	0.70	1.05	1.40	V
C_L	Crystal oscillator C_L value	-	-	6	12.5	pF

*1. Power supply voltage detection voltage: Constantly maintains the relation of $V_{DET} > V_{DDRM}$ (minimum data hold voltage).

Oscillation Characteristics

(For PT7C43390: T_A = 25°C, V_{DD} = 3.0 V, V_{SS} = 0 V, crystal oscillator (C_L = 6pF, 32.768 kHz).)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{STA}	Oscillation start voltage	Within 10 seconds	1.1	-	5.5	V
-	Oscillation start time	-	-	-	3	s
IC	IC to IC frequency deviation	-	-10	-	+10	ppm
V	Frequency voltage deviation	V_{DD} =1.35 to 5.5 V	-3	-	+3	ppm

(For PT7C43390C: T_A = 25°C, V_{DD} = 3.0 V, V_{SS} = 0 V.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{STA}	Oscillation start voltage	Within 10 seconds	1.1	-	5.5	V
-	Oscillation start time	-	-	-	3	s
IC	IC to IC frequency deviation	-	-10	-	+10	ppm
Df / f	Frequency tolerance	-	-30	-	+30	ppm
V	Frequency voltage deviation	VDD =1.3 to 5.5 V	-3		+3	ppm
fa	Aging	First year			± 5	ppm/year

DC Electrical Characteristics

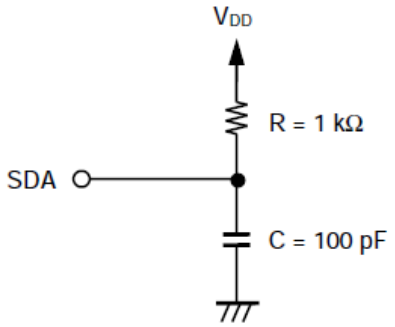
(T_A = -40°C to +85°C; V_{SS} = 0V, crystal oscillator C_L = 6pF, 32.768KHz, unless otherwise noted.)

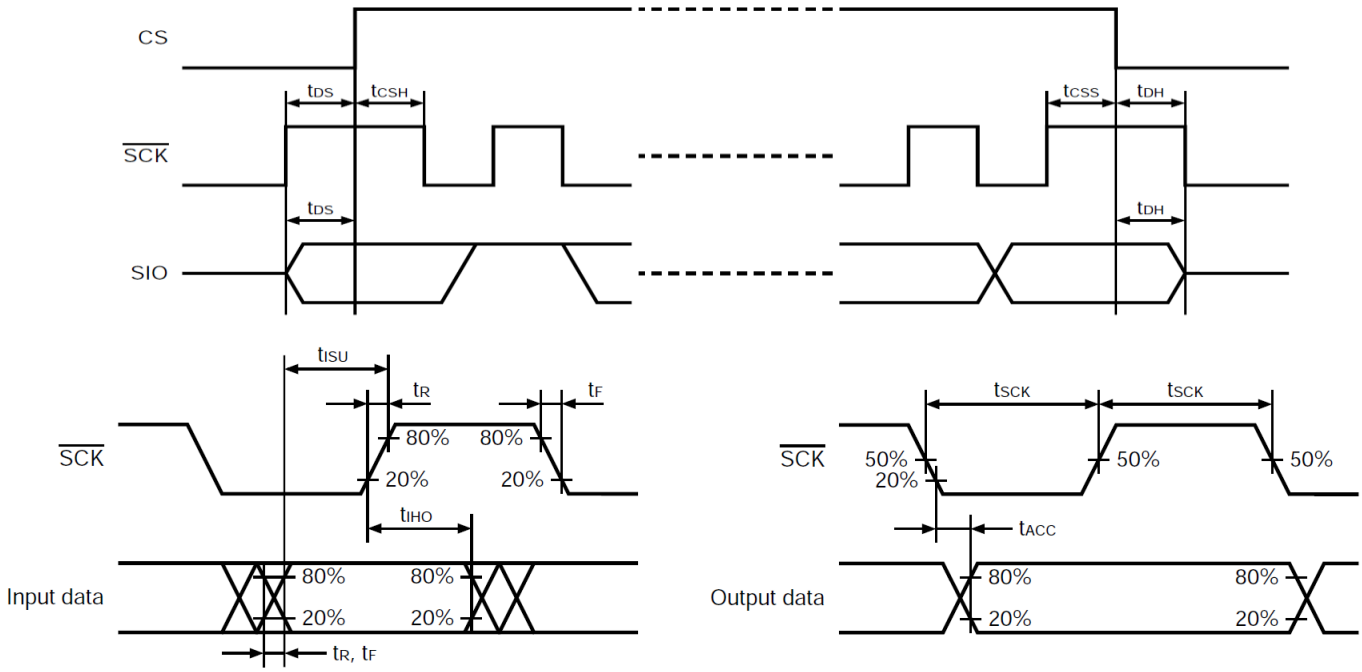
Symbol	Parameter	Pin	Test Conditions	Min	Typ	Max	Unit
V_{DD} = 3.0V							
I_{DD1}	Current consumption 1	VDD	Out of communication	-	0.3	0.6	µA
I_{DD2}	Current consumption 2	VDD	During communication (SCL=100kHz)	-	3.5	8	µA
I_{IZH}	Input high leakage current	SCL,SDA	$V_{IN} = V_{DD}$	-0.5	-	+0.5	µA
I_{IZL}	Input low leakage current	SCL,SDA	$V_{IN} = V_{SS}$	-0.5	-	+0.5	µA
I_{OZH}	Output high leakage current	SDA,INT1, INT2	$V_{OUT} = V_{DD}$	-0.5	-	+0.5	µA
I_{OZL}	Output low leakage current	SDA,INT1, INT2	$V_{OUT} = V_{SS}$	-0.5	-	+0.5	µA
V_{IH}	Input high voltage	SCL,SDA	-	$0.8V_{DD}$	-	-	V
V_{IL}	Input low voltage	SCL,SDA	-	-	-	$0.2V_{DD}$	V
I_{OL1}	Output low current 1	INT1	V_{OUT} = 0.4V	1.0	1.6	-	mA
		INT2	V_{OUT} = 0.4V	5	8	-	mA
I_{OL2}	Output low current 2	SDA	V_{OUT} = 0.4V	5	8	-	mA
V_{DD} = 5.0V							
I_{DD1}	Current consumption 1	VDD	Out of communication	-	0.35	0.7	µA
I_{DD2}	Current consumption 2	VDD	During communication (SCK=100kHz)	-	7	14	µA
I_{IZH}	Input high leakage current	SCL,SDA	$V_{IN} = V_{DD}$	-0.5	-	+0.5	µA
I_{IZL}	Input low leakage current	SCL,SDA	$V_{IN} = V_{SS}$	-0.5	-	+0.5	µA
I_{OZH}	Output high leakage current	SDA,INT1, INT2	$V_{OUT} = V_{DD}$	-0.5	-	+0.5	µA
I_{OZL}	Output low leakage current	SDA,INT1, INT2	$V_{OUT} = V_{SS}$	-0.5	-	+0.5	µA
V_{IH}	Input high voltage	SCL,SDA	-	$0.8V_{DD}$	-	-	V
V_{IL}	Input low voltage	SCL,SDA	-	-	-	$0.2V_{DD}$	V
I_{OL1}	Output low current 1	INT1	V_{OUT} = 0.4V	1.0	1.6	-	mA
		INT2		6	10	-	mA
I_{OL2}	Output low current 2	SDA	V_{OUT} = 0.4V	6	10	-	mA

AC Electrical Characteristics

Measure conditions

Input pulse voltage	$V_{IH} = 0.9 \times V_{DD}$, $V_{IL} = 0.1 \times V_{DD}$
Input pulse rise/fall time	20ns
Output determination voltage	$V_{OH} = 0.5 \times V_{DD}$, $V_{OL} = 0.5 \times V_{DD}$
Output load	100pF + pull-up resistance 1k⏐

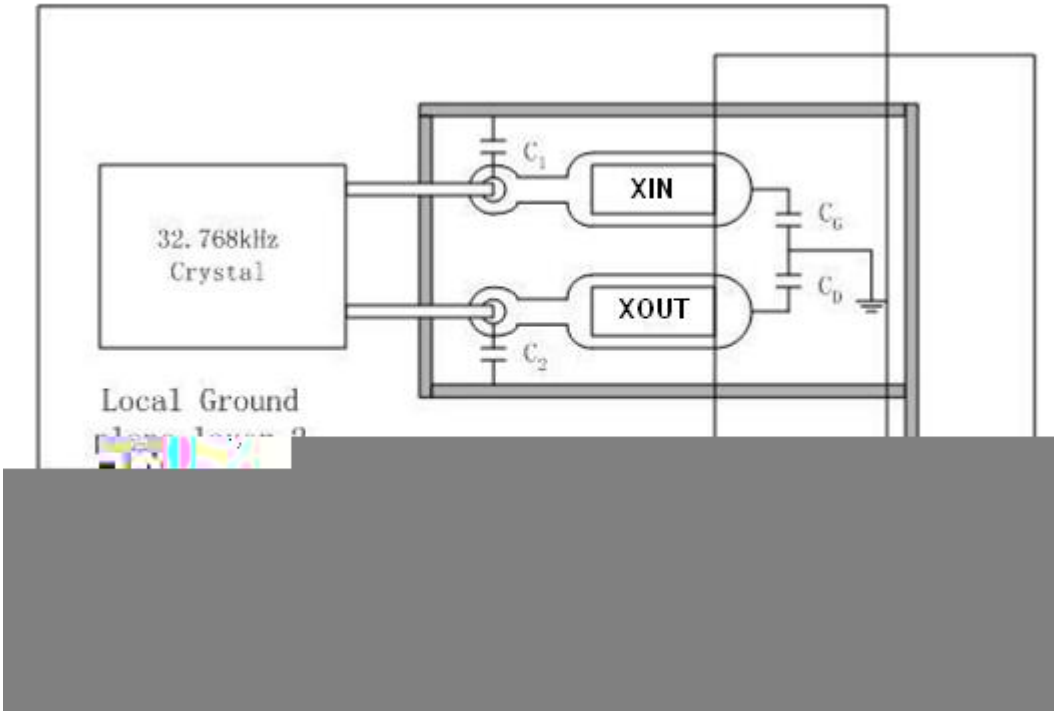




Symbol	Parameter	V_{DD} > 1.35 V*2			V_{DD} > 3.0 V*2			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
F_{SCL}	SCL clock frequency	0	-	100	0	-	400	kHz
t_{LOW}	SCL clock low time	4.7	-	-	1.3	-	-	µs
t_{HIGH}	SCL clock high time	4	-	-	0.6	-	-	µs
t_{PD}	SDA output delay time	-	-	3.5	-	-	0.9	µs
$t_{SU.STA}$	Start condition setup time	4.7	-	-	0.6	-	-	µs
$t_{HD.STA}$	Start condition hold time	4	-	-	0.6	-	-	µs
$t_{SU.DAT}$	Data input setup time	250	-	-	100	-	-	ns
$t_{HD.DAT}$	Data output hold time	0	-	-	0	-	-	µs
$t_{SU.STO}$	Stop condition setup time	4.7	-	-	0.6	-	-	µs
t_R	SCL, SDA rise time	-	-	1	-	-	0.3	µs
t_F	SCL, SDA fall time	-	-	0.3	-	-	0.3	µs
t_{BUF}	Bus release time	4.7	-	-	1.3	-	-	µs
t_I	Noise suppression time	-	-	100	-	-	50	ns

*1. Since the output format of the SDA pin is Nch open-drain output, output data definition time is determined by the values of the load resistance (R_L) and load capacity (C_L) outside the IC. Therefore, use this value only as a reference value.
*2 Regarding the power supply voltage, refer to `**Recommended Operating Conditions**_.

Recommended Layout for Crystal (for PT7C43390)



Built-in Capacitors Specifications and Recommended External Capacitors

Parameter		Symbol	Typ.	Unit
Build in capacitors	XIN to GND	C_G	5	pF
	XOUT to GND	C_D	5	pF
Recommended External capacitors for crystal C_L=12.5pF	XIN to GND	C1	18	pF
	XOUT to GND	C2	18	pF
Recommended External capacitors for crystal C_L=6pF	XIN to GND	C1	7	pF
	XOUT to GND	C2	7	pF

Note: The frequency of crystal can be optimized by external capacitor C1 and C2, for frequency=32.768 kHz, C1 and C2 should meet the equation as below: $Cpar + [(C1+C_G)*(C2+C_D)]/ [(C1+C_G) + (C2+C_D)] = C_L$

Cpar is all parasitical capacitor between X1 and X2.

C_L is crystal˙s load capacitance.

Crystal Specifications

Parameter	Symbol	Min.	Typ.	Max.	Unit

Functional Description

1. Overview of Functions

1.1. 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 2099.

1.2. Alarm function

This device has two alarm system (Alarm 1 and Alarm 2) that outputs interrupt signals from INT1 pin or INT2 pin to CPU 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.

1.3. Programmable square wave output

For PT7C43390, square wave output at pin 1or pin 5. Six frequencies are selectable: 1, 2, 4, 8, 16, 32768 Hz.

1.4. Interface with CPU

PT7C43390: I^2C bus interface.

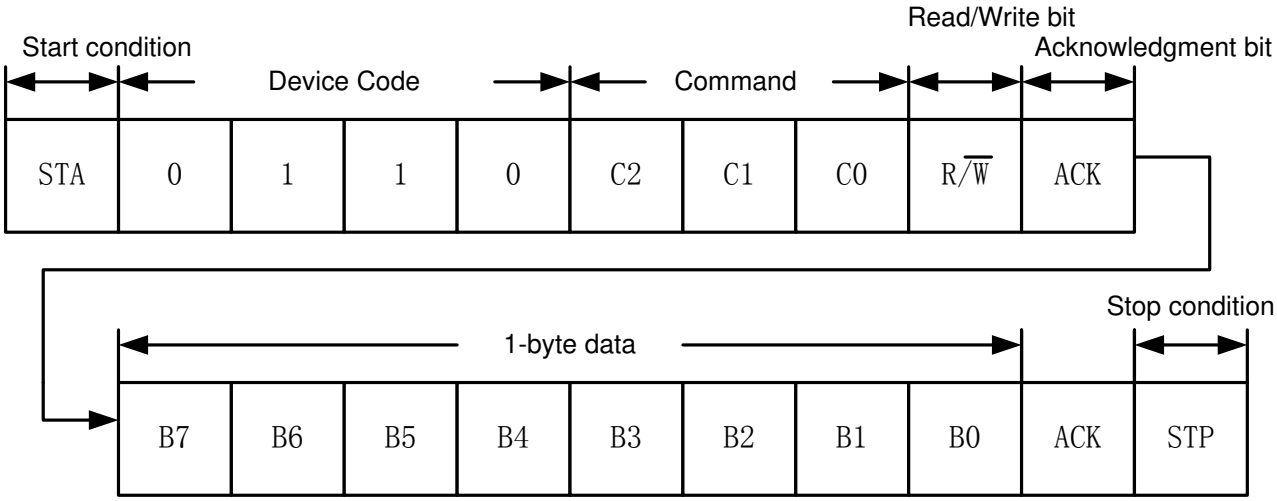
1.5. Calibration function

With the calibration bits properly set, the accuracy can be improved to better than ±2 ppm at 25°C.

2. Configuration of Data Communication

2.1. Data Communication

For data communication, the master device in the system generates a start condition for the IC. Next, the master devices transmits 4-bit device code `0110_, 3-bit command and 1-bit read / write command to the SDA line. After that, output or input is performed from B7 of data. If data I/O has been completed, finish communication by inputting a stop condition to the IC. The master device generates an acknowledgment signal for every 1-byte. Regarding details refer to "**I^2C-bus Serial Interface**".



Year data (00 to 99): Y1, Y2, Y4, Y8, Y10, Y20, Y40, Y80
Sets the lower two digits of the Western calendar year (00 to 99) and links together with the auto calendar function until 2099.
Example: 2053 (Y1, Y2, Y4, Y8, Y10, Y20, Y40, Y80) = (1, 1, 0, 0, 1, 0, 1, 0)
Month data (01 to 12): M1, M2, M4, M8, M10
Example: December (M1, M2, M4, M8, M10, 0, 0, 0) = (0, 1, 0, 0, 1, 0, 0, 0)
Day data (01 to 31): D1, D2, D4, D8, D10, D20
The count value is automatically changed by the auto calendar function.
1 to 31: Jan., Mar., May, July, Aug., Oct., Dec., 1 to 30: April, June, Sep., Nov.
1 to 29: Feb. (leap year), 1 to 28: Feb. (non-leap year)
Example: 29 (D1, D2, D4, D8, D10, D20, 0, 0) = (1, 0, 0, 1, 0, 1, 0, 0)
Day of the week data (00 to 06): W1, W2, W4
Day of the week is counted in the order of 00, 01, 02, 03, 04, 05, 06, and 00. Set up day of the week and the count value.
Hour data (00 to 23 or 00 to 11): H1, H2, H4, H8, H10, H20, AM / PM
In 12-hour mode, write 0; AM, 1; PM in the AM / PM bit. In 24-hour mode, users can write either 0 or 1. 0 is read when the hour data is from 00 to 11, and 1 is read when from 12 to 23.
Example (12-hour mode): 11 p.m. (H1, H2, H4, H8, H10, H20, AM / PM, 0) = (1, 0, 0, 0, 1, 0, 1, 0)
Example (24-hour mode): 22 (H1, H2, H4, H8, H10, H20, AM / PM, 0) = (0, 1, 0, 0, 0, 1, 1, 0)

Minute data (00 to 59): m1, m2, m4, m8, m10, m20, m40
Example: 32 minutes (m1, m2, m4, m8, m10, m20, m40, 0) = (0, 1, 0, 0, 1, 1, 0, 0)
Example: 55 minutes (m1, m2, m4, m8, m10, m20, m40, 0) = (1, 0, 1, 0, 1, 0, 1, 0)
Second data (00 to 59): s1, s2, s4, s8, s10, s20, s40
Example: 19 seconds (s1, s2, s4, s8, s10, s20, s40, 0) = (1, 0, 0, 1, 1, 0, 0, 0)

3.2. Status Register 1

Status register 1 is a 1-byte register that is used to display and set various modes. The bit configuration is shown below.

B1: BLD
This flag is set to "1" when the power supply voltage decreases to the level of detection voltage (VDET) or less. Users can detect a drop in the power supply voltage. This flag is set to "1" once, is not set to "0" again even if the power supply increases to the level of detection voltage (VDET) or more. This flag is read-only. When this flag is "1", be sure to initialize. Regarding the operation of the power supply voltage detection circuit, refer to "**Low Power Supply Voltage Detection Circuit**".
B2: INT2, B3: INT1
This flag indicates the time set by alarm and when the time has reached it. This flag is set to "1" when the time that users set by using the alarm interrupt function has come. The INT1 flag at alarm 1 interrupt mode and the INT2 flag at alarm 2 interrupt mode are set to "1". Set "0" in INT1AE (B5 in the status register 2) or in INT2AE (B1 in the status register 2) after reading "1" in the INT1 flag or in the INT2 flag. This flag is read-only. This flag is read once, is set to "0" automatically.
B4: SC1, B5: SC0
These flags are SRAM type registers, they are 2 bits as a whole, can be freely set by users.
B6: 12 / 24
This flag is used to set 12-hour or 24-hour mode. Set the flag ahead of write operation of the real-time data register in case of 24-hour mode.
0: 12-hour mode
1: 24-hour mode
B7: RESET
The internal IC is initialized by setting this bit to "1". This bit is write-only. It is always "0" when reading. When applying the power supply voltage to the IC, be sure to write "1" to this bit to initialize the circuit. Regarding each status of data after initialization, refer to "**Register Status after Initialization**".

3.3. Status Register 2

Status register 2 is a 1-byte register that is used to display and set various modes. The bit configuration is shown below.

B7	B6	B5	B4	B3	B2	B1	B0
INT1FE	INT1ME	INT1AE	32kE	INT2FE	INT2ME	INT2AE	TEST
R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$

R/$\overline{W}$: Read/Write

B0: TEST
This is a test flag. Be sure to set this flag to "0" in use. If this flag is set to "1", be sure to initialize to set "0".

B1: INT2AE, B2: INT2ME, B3: INT2FE
These bits are used to select the output mode for the INT2 pin. Below **Table** shows how to select the mode. To use an alarm 2 interrupt, set alarm interrupt mode, then access the INT2 register.
Table: Output Modes for INT2 Pin

***1.** Don't care (both of 0 and 1 are acceptable).

B4: 32kE, B5: INT1AE, B6: INT1ME, B7: INT1FE
These bits are used to select the output mode for the INT1 pin. Below **Table** shows how to select the mode. To use alarm 1 interrupt, access the INT1 register after setting the alarm interrupt mode.
Table: Output Modes for INT1 Pin

***1.** Don't care (both of 0 and 1 are acceptable).

3.4. INT Register 1 and INT Register 2

The INT1 and INT2 registers are to set up the output of user-set frequency, or to set up alarm interrupt. Users are able to switch the output mode by using the status register 2. If selecting to use the output mode for alarm interrupts by status register 2; these registers work as alarm-time data registers. If selecting the output of user-set frequency by status register 2; these registers work as data registers to set the frequency for clock output. From each INT1 and INT2 pin, a clock pulse and alarm interrupt are output.

a. Alarm interrupt
Users can set the alarm time (the data of day of the week, hour, minute) by using the INT1 and INT2 registers which are 3-byte data registers. The configuration of register is as well as the data register of day of the week, hour, minute, in the real-time data register; is expressed by the BCD code. Do not set a nonexistent day. Users are necessary to set up the alarm-time data according to the 12 / 24 hour mode that they set by using the status register 1.

INT Register 1 and INT Register 2 (Alarm-Time Data)

The INT register 1 has A1WE, A1HE, and A1mE at B0 in each byte. It is possible to make data valid; the data of day of the week, hour, minute which are in the corresponded byte; by setting these bits to "1". This is as well in A2WE, A2HE, and A2mE in the INT register 2.
Setting example: alarm time "7:00 pm" in the INT register 1

(1) 12-hour mode (status register 1 B6 = 0)
Set up 7:00 PM
Data written to INT register 1

	B7							B0
Day of the Week	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	0
Hour	1	1	1	0	0	0	1	1
Minute	0	0	0	0	0	0	0	1

***1.** Don't care (both of 0 and 1 are acceptable).

(2) 24-hour mode (status register 1 B6 = 1)
Set up 19:00 PM
Data written to INT register 1

	B7							B0
Day of the Week	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	_(*1)	0
Hour	1	0	0	1	1	0	1(*2)	1
Minute	0	0	0	0	0	0	0	1

***1.** Don't care (both of 0 and 1 are acceptable).
***2**. Set up AM / PM flag along with the time setting.

b. INT Register 1 and INT Register 2
Ð Output of user-set frequency
The INT1 and INT2 registers are 1-byte data registers to set up the output frequency. Setting each bit B7 to B3 in the register to "1", the frequency which corresponds to the bit is output in the AND-form. SC2 to SC4 in the INT1 register, and SC5 to SC7 in the INT2 register are 3-bit SRAM type registers that can be freely set by users.

B7	B6	B5	B4	B3	B2	B1	B0
1Hz	2Hz	4Hz	8Hz	16Hz	SC2	SC3	SC4
R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$

R/$\overline{W}$: Read/Write

INT Register 1 (Data Register for Output Frequency)

B7	B6	B5	B4	B3	B2	B1	B0
1Hz	2Hz	4Hz	8Hz	16Hz	SC5	SC6	SC7
R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$

R/$\overline{W}$: Read/Write

INT Register 2 (Data Register for Output Frequency)

Example of Output from INT1 and INT2 Registers (Data Register for Output Frequency)

3.5. Clock Correction Register

The clock correction register is a 1-byte register that is used to correct advance / delay of the clock. When not using this function, set this register to "00h". Regarding the register values, refer to "**Function to Clock Correction**".

B7	B6	B5	B4	B3	B2	B1	B0
V0	V1	V2	V3	V4	V5	V6	V7
R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$

R/$\overline{W}$: Read/Write

3.6. Free Register

This free register is a 1-byte SRAM type register that can be set freely by users.

B7	B6	B5	B4	B3	B2	B1	B0
V0	V1	V2	V3	V4	V5	V6	V7
R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$	R/$\overline{W}$

R/$\overline{W}$: Read/Write

4. Power-on Detection Circuit and Register Status

The power-on detection circuit operates by power-on the RTC, as a result each register is cleared; each register is set as follows.
Real-time data register: 00 (Y), 01 (M), 01 (D), 0 (day of the week), 00 (H), 00 (M), 00 (S)
Status register 1: "01h"
Status register 2: "80h"
INT register 1: "80h"
INT register 2: "00h"
Clock correction register: "00h"
Free register: "00h"
"1" is set in the POC flag (B0 in the status register 1) to indicate that power has been applied. To correct the oscillation frequency, the status register 2 goes in the mode the output of user-set frequency, so that 1 Hz clock pulse is output from the INT pin. When "1" is set in the POC flag, be sure to initialize. The POC flag is set to "0" due to initialization so that the output of user-set frequency mode is cleared. (Refer to "**Register Status After Initialization**".)

For the regular operation of power-on detection circuit, as seen in below **Figure**, the period to power-up the RTC is that the voltage reaches 1.3 V within 10 ms after setting the IC's power supply voltage at 0 V. When the power-on detection circuit is not working normally is; the POC flag (B0 in the status register) is not in "1", or 1 Hz is not output from the INT pin. In this case, power-on the RTC once again because the internal data may be in the indefinite status.
Moreover, regarding the processing right after power-on, refer to "**Flowchart of Initialization and Example of Real-time Data Set-up**".

***1.** 0 V indicates that there are no potential differences between the VDD pin and VSS pin.
How to Raise the Power Supply Voltage

5. Register Status After Initialization

The status of each register after initialization is as follows.
Real-time data register: 00 (Y), 01 (M), 01 (D), 0 (day of the week), 00 (H), 00 (M), 00 (S)
Status register 1: "0 B6 B5 B4 0 0 0 0 b"
(In B6, B5, B4, the data of B6, B5, B6 in the status register 1 at initialization is set. Refer to below **Figure**.)
Status register 2: "00h"
INT1 register: "00h"
INT2 register: "00h"
Clock correction register: "00h"
Free register: "00h"

Ð **Status Register 1 Data at Initialization**

6. Low Power Supply Voltage Detection Circuit

The RTC has a low power supply voltage detection circuit, so that users can monitor drops in the power supply voltage by reading the BLD flag (B1 in the status register 1). There is a hysteresis width of approx. 0.15 V (typ.) between detection voltage and release voltage (refer to "**Characteristics (Typical Data)**"). The low power supply voltage detection circuit does the sampling operation only once in one sec for 15.6 ms. If the power supply voltage decreases to the level of detection voltage (VDET) or less, "1" is set to the BLD flag so that sampling operation stops. Once "1" is detected in the BLD flag, no sampling operation is performed even if the power supply voltage increases to the level of release voltage or more, and "1" is held in the BLD flag. If the BLD flag is "1" even after the power supply voltage is recovered, the internal circuit may be in the indefinite status. In this case, be sure to initialize the circuit. After reading the BLD flag, the sampling operation is restarted. Without initializing, if the next BLD flag reading is done after sampling, the BLD flag gets reset to "0". In this case, be sure to initialize although the BLD flag is in "0" because the internal circuit may be in the indefinite status.

Timing of Low Power Supply Voltage Detection Circuit

7. Circuits Power-on and Low Power Supply Voltage Detection

Below Figure shows the changes of the POC flag and BLD flag due to VDD fluctuation.

POC Flag and BLD Flag

8. Nonexistent Data and End-of-Month

When users write the real-time data, the RTC checks it. In case that the data is invalid, the RTC does the following procedures.

Ð **Processing of nonexistent data**

***1.** In 12-hour mode, write the AM / PM flag (B1 in hour data in the real-time data register). In 24-hour expression, the AM / PM flag in the real-time data register is omitted. However in the flag of reading, users are able to read 0; 0 to 11, 1; 12 to 23.
***2.** Processing of nonexistent data, regarding second data, is done by a carry pulse which is generated in 1 second, after writing. At this point the carry pulse is sent to the minute-counter.

Ð **Correction of end-of-month**

A nonexistent day, such as February 30 and April 31, is set to the first day of the next month.

9. Alarm and Interrupt Output

9.1. INT1 Pin and INT2 Pin Output Mode

These are selectable for the output mode for INT1 and INT2 pins; Alarm interrupt, the output of user-set frequency, per-minute edge interrupt output, minute-periodical interrupt output 1. In the INT1 pin output mode, in addition to the above modes, minute-periodical interrupt output 2 and 32.768 kHz Output are also selectable. To switch the output mode, use the status register 2. Refer to "**Status register 2**" in "**Configuration of Registers**". When switching the output mode, be careful of the output status of the pin. Especially, when using alarm interrupt / output of frequency, switch the output mode after setting "00h" in the INT1 / INT2 register. In 32.768 kHz output / per-minute edge interrupt output / minute-periodical interrupt output, it is unnecessary to set data in the INT1 / INT2 register for users. Refer to the followings regarding each operation of output modes.

a. Alarm Interrupt Output

Alarm interrupt output is the function to output "L" from the INT1 / INT2 pin, at the alarm time which is set by user has come. If setting the pin output to "H", turn off the alarm function by setting "0" in INT1AE / INT2AE in the status register 2. To set the alarm time, set the data of day of the week, hour and minute in the INT1 / INT2 register. Refer to "**INT1 register and INT2 register**" in "**Configuration of Registers**".

a) Alarm setting of "W (day of the week), H (hour), m (minute)"

***1.** If users clear INT1AE / INT2AE once; "L" is not output from the INT1 / INT2 pin by setting INT1AE / INT2AE enable again, within a period when the alarm time matches real-time data.

Alarm Interrupt Output Timing

b) Alarm setting of "H (hour)"

***1.** If users clear INT1AE / INT2AE once; "L" is not output from the INT1 / INT2 pin by setting INT1AE / INT2AE enable again, within a period when the alarm time matches real-time data.
***2.** If turning the alarm output on by changing the program, within the period when the alarm time matches real-time data, "L" is

***1.** Pin output is set to "H" by disabling the output mode within 7.81 ms, because the signal of this procedure is maintained for 7.81 ms. Note that pin output is set to "L" by setting enable the output mode again.

Timing of Per-Minute Edge Interrupt Output

d. Minute-periodical interrupt output 1

The minute-periodical interrupt 1 is the function to output the one-minute clock pulse (Duty 50%) from the INT1 **/** INT2 pin, when the first minute-carry processing is done, after selecting the output mode.

***1.** Setting the output mode disable makes the pin output "H", while the outputs from the INT1 **/** INT2 pin is in "L". Note that pin output is set to "L" by setting enable the output mode again.

Timing of Per-Minute Steady Interrupt Output 1

e. Minute-periodical interrupt output 2 (only in the INT1 pin output mode)

The output of minute-periodical interrupt 2 is the function to output "L", for 7.81 ms, from the INT1 pin, synchronizing with the first minute-carry processing after selecting the output mode. However, during reading in the real-time data register, the procedure delays at 0.5 seconds max. Thus output "L" from the INT1 pin also delays at 0.5 seconds max. During writing in the real-time data register, some delay is made in the output period due to write timing and the second-data during writing.

(1) During normal operation

a. Alarm 1 function and Alarm 2 Interrupt

Alarm 2 interrupt output is the function to set the INT2 flag "H" by the output "L" from the INT2 pin, at the alarm time which is set by user has come. If setting the pin output to "H", turn off the alarm function by setting "0" in INT2AE in the status register 2. By reading, the INT2 flag is once cleared automatically. In the alarm 1 function, the INT1 flag (B3 in the status register 1) is set to "H" when the set time has come. The INT1 flag is also cleared once by reading. In the alarm 1 function, set the data of day of the week, hour, minute of the alarm time in the INT1 register. In alarm 2 interrupt, set in the INT2 register.

1) Alarm setting of "W (day of the week), H (hour), m (minute)"

***1.** If users clear INT2AE once; "L" is not output from the INT2 pin by setting INT2AE enable again, within a period when the alarm time matches real-time data.

Alarm Interrupt Output Timing

2) Alarm setting of "H (hour)"

***1.** If users clear INT2AE once; "L" is not output from the INT2 pin by setting INT2AE enable again, within a period when the alarm time matches real-time data.
***2.** If turning the alarm output on by changing the program, within the period when the alarm time matches real-time data, "L" is output again from the INT2 pin when the minute is counted up.

Alarm Interrupt Output Timing

b. Output of user-set frequency

The output of user-set frequency is the function to output the frequency which is selected by using data, from the INT2 pin, in the AND-form. Set up the data of frequency in the INT2 register. Refer to "**INT1 register and INT2 register**" in "**Configuration of Registers**".

Output Timing of User-set Frequency

c. Per-minute edge interrupt output

Per-minute edge interrupt output is the function to output "L" from the INT2 pin, when the first minute-carry processing is done, after selecting the output mode. To set the pin output to "H", in the INT2 pin output mode, input "0" in INT2ME in the status register 2 in order to turn off this mode.

***1.** Pin output is set to "H" by disabling the output mode within 7.81 ms, because the signal of this procedure is maintained for 7.81 ms. Note that pin output is set to "L" by setting enable the output mode again.

Timing of Per-minute Edge Interrupt Output

d. Minute-periodical interrupt output 1

The minute-periodical interrupt 1 is the function to output the one-minute clock pulse (Duty 50%) from the INT2 pin, when the first minute-carry processing is done, after selecting the output mode.

***1.** Setting the output mode disable makes the pin output "H", while the output from the INT2 pin is in "L".
Note that pin output is set to "L" by setting enable the output mode again.

Timing of Minute-periodical Interrupt Output 1

10. Function to Clock Correction

The function to clock correction is to correct advance / delay of the clock due to the deviation of oscillation frequency, in order to make a high precise clock. For correction, the RTC adjusts the clock pulse by using a certain part of the dividing circuit, not adjusting the frequency of the crystal oscillator. Correction is performed once every 20 seconds (or 60 seconds). The minimum resolution is approx. 3 ppm (or approx. 1 ppm) and the RTC corrects in the range of −195.3 ppm to 192.2 ppm (or of −65.1 ppm to 64.1 ppm). Users can set up this function by using the clock correction register. Regarding how to calculate the setting data, refer to "**15.2. How to calculate**". When not using this function, be sure to set "00h".

Function to Clock Correction

Item	B0 = 0	B0 = 1
Correction	Every 20 seconds	Every 60 seconds
Minimum resolution	3.052 ppm	1.017 ppm
Correction range	−195.3 ppm to +192.2 ppm	−65.1 ppm to +64.1 ppm

10.1. Setting values for registers and correction values

Setting Values for Registers and Correction Values (Minimum Resolution: 3.052 ppm (B0 = 0))

B7	B6	B5	B4	B3	B2	B1	B0	Correction Value [ppm]	Rate [s / day]
1	1	1	1	1	1	0	0	192.3	16.61
0	1	1	1	1	1	0	0	189.2	16.35

Setting Values for Registers and Correction Values (Minimum Resolution: 1.017 ppm (B0 = 1))

								Correction Value	Rate