ULTRA-COMPACT SERIAL REAL-TIME CLOCK ICs WITH 32.768kHz

RS5C321A/B

APPLICATION MANUAL

RICOH

ELECTRONIC DEVICES DIVISION

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June 1995

RS5C321A/B

APPLICATION MANUAL

CONTENTS

URTRA-COMPACT ALARM REAL-TIME CLOCK ICs WITH 32.768kHz

RS5C321A/B

OUTLINE

The RS5C321A/B are CMOS type real-time clock ICs which are connected to the CPU via three signal lines and capable of serial transmission of clock and calendar data to the CPU.

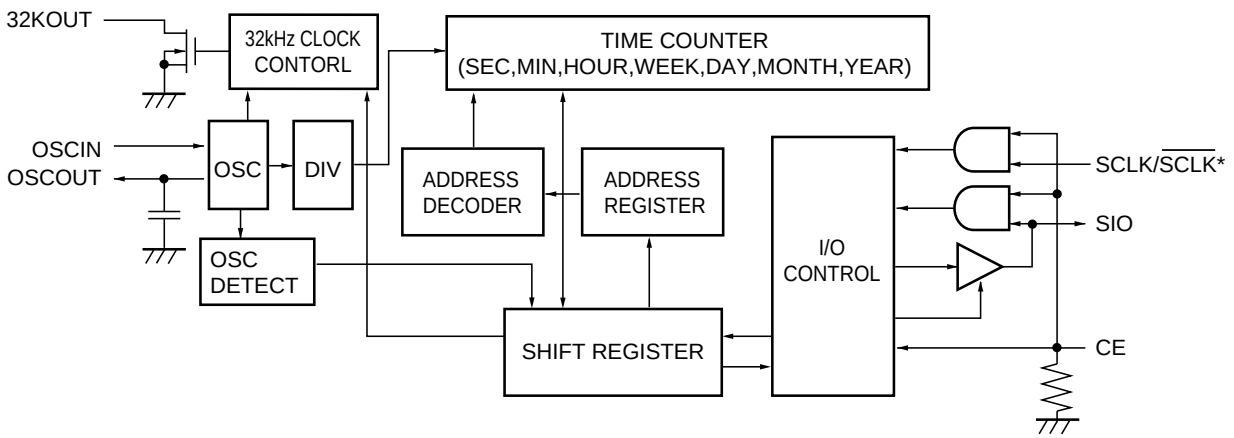
The RS5C321A/B can generate 32.768kHz clock pulse controled by register. Driving an oscillation circuit at constant voltage, the circuit presents less fluctuations in frequency and current consumption thank to its minimal voltage fluctuations consequently realizes low current consumption (0.6µA at 3V). It also provides an oscillator halt sensing function for application to data validity at power-on and other occasions. Integrated into an ultra compact and ultra thin 8pin SSOP (0.65mm pitch), the RS5C321A/B are the optimum choice for equipment requiring small size and low power consumption.

The RS5C321A and the RS5C321B reads/writes data at falling and rising edge of serial clock respectively.

FEATURES

- Time keeping voltage 1.6V to 6.0V
- Lowest supply current 0.6µA TYP. (1.5µA MAX.) at 3V
- Connection to the CPU via only three pins: CE, SCLK/$\overline{\text{SCLK}}$ and SIO for addressing and data read/write
- A clock counter (counting hours, minutes, and seconds) and a calendar counter (counting leap years, years, months, days, and days of the week) in BCD code
- 32.768kHz clock pulse controled by register.
- Oscillator halt sensing to judge internal data validity
- Second digit adjustment by ±30 seconds
- 12-hour or 24-hour time display selectable
- Automatic leap year recognition up to the year 2099
- CMOS logic
- Package: 8pin SSOP (0.65mm pitch)

BLOCK DIAGRAM



*) RS5C321A: SCLK RS5C321B: $\overline{\text{SCLK}}$

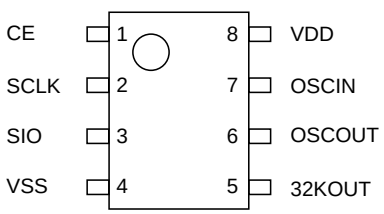
APPLICATIONS

- Communication equipment (Multi-function telephone, portable telephone, PHS, pager)
- Business machines (Facsimile, portable facsimile)
- Personal computer (Desktop type, notebook type, word processor, PDA, electronic notebook, TV games)
- Audio visual equipment (Portable audio equipment, video camera, camera, digital camera, remote control equipment)
- Home use (Rice cooker, microwave range)

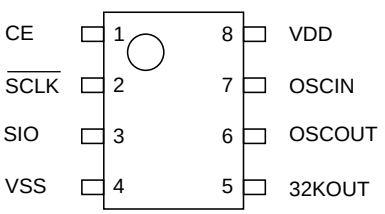
PIN CONFIGURATION

• 8pin SSOP (0.65mm pitch)

RS5C321A



RS5C321B



PIN DESCRIPTIONS

Pin No.	Symbol	Name	Description
1	CE	Chip enable input	The CE pin is used to interface the CPU and is accessible when held at the high level. This pin is connected to a pull-down resistor. It should be switched to the low level or opened when not accessed or when powering off the system.
2	SCLK (RS5C321A) $\overline{\text{SCLK}}$ (RS5C321B)	Serial clock input	This pin is used to input shift clock pulses to synchronize data input to, and output from, the SIO pin. SCLK and $\overline{\text{SCLK}}$ are for writing data at falling and rising edge of clock pulses respectively and also reading data at rising and falling edge of clock pulses respectively.
3	SIO	Serial input/output	The SIO pin inputs and outputs written or read data in synchronization with shift clock pulses from the SCLK/$\overline{\text{SCLK}}$ pin. The SIO pin causes high impedance when CE pin is held at the low level (CMOS input/output). After the CE pin is switched to the high level and the control bits and the address bits are input from the SIO, the SIO pin performs serial input and output operations.
5	32KOUT	32.768kHz clock output	The 32KOUT pin outputs 32.768kHz clock pulses when activated. This pin functions as an Nch open drain output.
7 6	OSCIN OSCOUT	Oscillator circuit input/output	These pins configure an oscillator circuit by connecting a 32.768kHz crystal oscillator between the OSCIN and OSCOUT pins and by connecting a capacitor between the OSCIN and Vss pins. (Any other oscillator circuit components are built into the RS5C321A/B.)
8 4	VDD VSS	Positive/Negative power supply input	The VDD pin and Vss pin are connected to the positive power supply and to the ground level respectively.

ABSOLUTE MAXIMUM RATINGS

(V_{SS}=0V)

Symbol	Item	Conditions	Ratings	Unit
V_{DD}	Supply voltage		–0.3 to +7.0	V
V_I	Input voltage		–0.3 to V_{DD}+0.3	V
V_{O1}	Output voltage 1	SIO	–0.3 to V_{DD}+0.3	V
V_{O2}	Output voltage 2	32KOUT	–0.3 to +12	V
P_D	Power dissipation	Topt=25°C	300	mW
Topt	Operating temperature		–40 to +85	°C
Tstg	Storage temperature		–55 to +125	°C

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

RECOMMENDED OPERATING CONDITIONS

(V_{SS}=0V, Topt=–40 to +85°C)

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD}	Supply voltage		2.5		6.0	V
V_{CLK}	Time keeping voltage		1.6		6.0	V
f_{XT}	Oscillation frequency			32.768		kHz
C_G	External oscillation capacitance	C_L value of crystal=6 to 8pF	5	10	24	pF
V_{PUP}	Pull-up voltage	32KOUT			10	V

DC CHARACTERISTICS

Unless otherwise specified: V_{SS}=0V, V_{DD}=3V, Topt=–40 to +85°C, Oscillation frequency=32.768kHz, (C_L=6pF, R_1=30kΩ), C_G=10pF

Symbol	Item	Pin name	Conditions	MIN.	TYP.	MAX.	Unit
V_{IH}	"H" input voltage	CE, SCLK/$\overline{SCLK}$, SIO		0.8V_{DD}		V_{DD}	V
V_{IL}	"L" input voltage	CE, SCLK/$\overline{SCLK}$, SIO		0		0.2V_{DD}	V
I_{OH}	"H" output current	SIO	V_{OH}=V_{DD} –0.5V			–0.5	mA
I_{OL1}	"L" output current	SIO	V_{OL1}=0.5V	0.5			mA
I_{OL2}		32KOUT	V_{OL2}=0.4V	1			
R_{DN}	Pull-down resistance	CE		45	150	450	kΩ
I_{ILK}	Input leakage current	SCLK/$\overline{SCLK}$	V_I=V_{DD} or V_{SS}	–1		1	µA
I_{OZ1}	Output off-state leakage current	SIO	V_O=V_{DD} or V_{SS}	–2		2	µA
I_{OZ2}		32KOUT	V_O=10V	–5		5	
I_{DD1}	Standby current 1*	V_{DD}	V_{DD}=3V Input/Output: open		0.6	1.5	µA
I_{DD2}	Standby current 2*	V_{DD}	V_{DD}=6V Input/Output: open		0.8	2.0	µA
C_D	Internal oscillation capacitance	OSCOUT			10		pF

*) I_{DD1}, I_{DD2} is specified when 32kHz output is off ($\overline{CLEN}$=1)

AC CHARACTERISTICS

(V_{SS}=0V, Topt=–40 to +85°C, C_L=50pF)

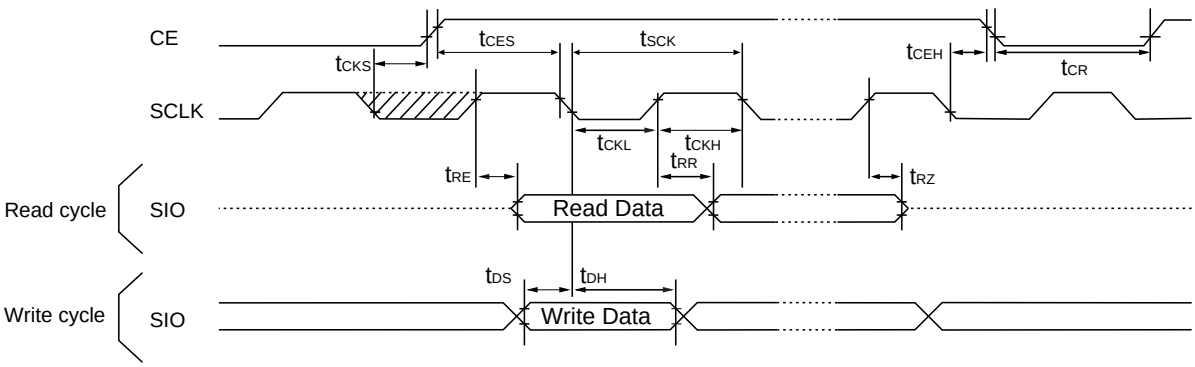
Symbol	Item	V_{DD}≥4.5V		V_{DD}≥4.0V		V_{DD}≥2.5V		Unit
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
t_{CES}	CE set-up time	175		200		400		ns
t_{CEH}	CE hold time	175		200		400		ns
t_{CR}	CE inactive time	350		400		800		ns
t_{SCK}	SCLK clock cycle time	350		400		800		ns
t_{CKH}	SCLK high time	175		200		400		ns
t_{CKL}	SCLK low time	175		200		400		ns
t_{CKS}	SCLK to CE set-up time	60		80		120		ns
t_{RE}	Data output start time (from rising of SCLK) (from falling of $\overline{SCLK}$)		120		135		300	ns
t_{RR}	Data output delay time (from rising of SCLK) (from falling of $\overline{SCLK}$)		120		135		300	ns
t_{RZ}	Output floating time		120		135		300	ns
t_{DS}	Input data set-up time	50		60		120		ns
t_{DH}	Input data hold time	50		50		80		ns

TIMING CHARTS

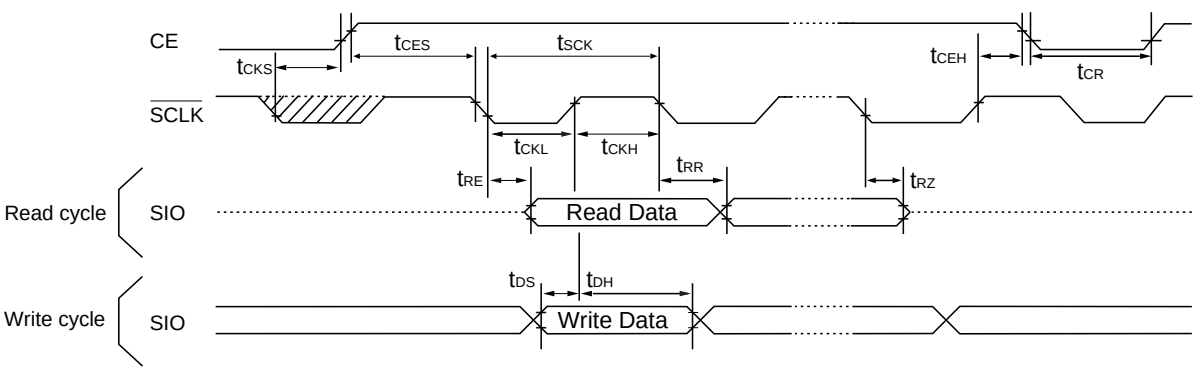
Input/Output conditions: V_{IH}=0.8×V_{DD}, V_{IL}=0.2×V_{DD}, V_{OH}=0.8×V_{DD}, V_{OL}=0.2×V_{DD}

*) Any SCLK/$\overline{\text{SCLK}}$ state is allowed in the hatched area.

• RS5C321A



• RS5C321B



FUNCTIONAL DESCRIPTIONS

1. Addressing

	Address				Registers		Data *1			
	A3	A2	A1	A0			D3	D2	D1	D0
0	0	0	0	0	1-second counter	(BANK=0)	S_8	S_4	S_2	S_1
1	0	0	0	1	10-second counter	(BANK=0)	—*2	S_{40}	S_{20}	S_{10}
2	0	0	1	0	1-minute counter	(BANK=0)	M_8	M_4	M_2	M_1
3	0	0	1	1	10-minute counter	(BANK=0)	—	M_{40}	M_{20}	M_{10}
4	0	1	0	0	1-hour counter	(BANK=0)	H_8	H_4	H_2	H_1
5	0	1	0	1	10-hour counter	(BANK=0)	—	—	$P/\overline{A}$, H_{20}	H_{10}
6	0	1	1	0	Day of the week counter	(BANK=0)	—	W_4	W_2	W_1
7	0	1	1	1	Scratch register*8	(BANK=0, 1)	Scratch*8	Scratch*8	Scratch*8	Scratch*8
8	1	0	0	0	1-day counter	(BANK=0)	D_8	D_4	D_2	D_1
9	1	0	0	1	10-day counter	(BANK=0)	—	—	D_{20}	D_{10}
A	1	0	1	0	1-month counter	(BANK=0)	MO_8	MO_4	MO_2	MO_1
					32kHz clock pulse control register	(BANK=1)	—	—	—	$\overline{CLEN}$*7
B	1	0	1	1	10-month counter	(BANK=0)	—	—	—	MO_{10}
C	1	1	0	0	1-year counter	(BANK=0)	Y_8	Y_4	Y_2	Y_1
D	1	1	0	1	10-year counter	(BANK=0)	Y_{80}	Y_{40}	Y_{20}	Y_{10}
E	1	1	1	0	Control register 1	(BANK=0, 1)	—	—	WTEN*6/XSTP*4	ADJ/BSY *3
F	1	1	1	1	Control register 2	(BANK=0, 1)	$\overline{12}/24$	—	BANK *5	$\overline{TEST}$ *6

⋆1) All the listed data can be read and written.
⋆2) The "—" mark indicates data which can be read only and set to "0" when read.
⋆3) The ADJ/BSY bit of the control register is set to ADJ for write operation and BSY for read operation.
⋆4) The WTEN/XSTP bit of the control register is set to WTEN for write operation and XSTP for read operation.
⋆5) The clock/calendar counter and the 32kHz clock pulse control register can be selected when the BANK=0 and BANK=1 respectively. To designate the BANK is unnecessary for scratch register and control register 1/2.
⋆6) The WTEN bit and $\overline{TEST}$ bit are set to "1" when CE is "L".
⋆7) The $\overline{CLEN}$ bit is set to 0, when initial power-on or XSTP is set to 1.
⋆8) Data may be written and read into/from the Scratch register, which actually is not used.

2. Registers

2.1 Control Register 1 (at Eh)

D3	D2	D1	D0	
—	—	WTEN	ADJ	(For write operation)
0	0	XSTP	BSY	(For read operation)

±30-second Adjustment Bit

ADJ	Description
0	Ordinary operation
1	Second digit adjustment

Clock/Counter Busy-state Indication Bit

BSY	Description
0	Ordinary operation
1	Second digit carry or adjustment

Clock Counter Enable/Disable Setting Bit

WTEN	Description
0	Disabling of 1-second digit carry for clock counter
1	Enabling of 1-second digit carry for clock counter

Oscillator Halt Sensing Bit

XSTP	Description
0	Ordinary oscillation
1	Oscillator halt sensing

2.1-1 (ADJ)

The following operations are performed by setting the ADJ bit to 1.

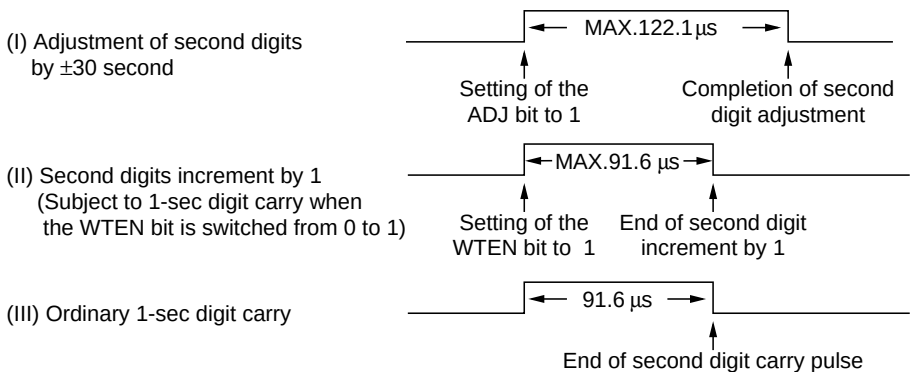
After this bit is set to 1, the BSY bit is set to 1 for the maximum duration of 122.1µs.

If the WTEN bit is 0, these adjustment operations are started after the WTEN bit is set to 1.

1) For second digits ranging from “00” to “29” seconds:
   Time counters smaller than seconds are reset and second digits are set to “00”.
2) For second digits ranging from “30” to “59” seconds:
   Time counters smaller than seconds are reset and second digits are set to “00”. Minute digits are incremented by 1.

2.1-2 (BSY)

When the BSY bit is 1, the clock and calendar counter are being updated. Consequently, write operation should be performed for the counters when the BSY bit is 0. Meanwhile, read operation is normally performed for the counters when the BSY bit is 0, but can be performed without checking the BSY bit as long as appropriate software is provided for preventing read errors. (Refer to 13. Typical Software-based Operations.) The BSY bit is set to 1 in the following three cases:



2.1-3 (WTEN)

The WTEN bit should be set to 0 to check that the BSY bit is 0 when performing read and write operations for the clock and calendar counters. For read operation, the WTEN bit may be left as 1 without checking the BSY bit as long as appropriate measures such as read repetition are provided for preventing read errors. The WTEN bit should be set to 1 after completing read and write operations, or will automatically be set to 1 by switching the CE pin to the low level. If 1-second digit carry occurs when the WTEN bit is 0, a second digit increment by 1 occurs when the WTEN bit is set to 1. There may be a possibility causing a time delay when it takes 1/1024 second or more to set WTEN bit from 0 to 1, Read data in state of WTEN=1 in such a case. (Refer to the item 13.3)

2.1-4 (XSTP)

The XSTP bit senses the oscillator halt. When the CE pin is held at the low level, the XSTP bit is set to 1 once the crystal oscillator is stopped after initial power-on or supply voltage drop and left to be 1 after it is restarted. When the CE pin is held at the high level, the XSTP bit is left as it was when the CE pin was held at the low level without checking oscillation stop. As such, the XSTP bit can be used to validate clock and calendar count data after power-on or supply voltage drop. When the XSTP is set to 1, $\overline{\text{CLEN}}$ is set to 0 and 32.768kHz clock pulse is output from 32KOUT pin. The XSTP bit is set to 0 when any data is written to the control register 1 (at Eh) with ordinary oscillation.

2.2 Control Register 2 (at Fh)

D3	D2	D1	D0	
$\overline{12}/24$	—	BANK	$\overline{TEST}$	(For write operation)
$\overline{12}/24$	0	BANK	$\overline{TEST}$	(For read operation)

Bit for Testing *1

$\overline{TEST}$	Description
0	Testing mode
1	Ordinary operation mode

Bank Selection Bit *2

BANK	Description
0	Clock/calendar counter
1	$\overline{CLEN}$ bit

$\overline{12}$/24-hour Time Display System Selection Bit *3

$\overline{12}/24$	Description
0	12-hour time display system (separate for mornings and afternoons)
1	24-hour time display system

*1) ($\overline{TEST}$) Set the $\overline{TEST}$ bit to 1 in ordinary operation. $\overline{TEST}$ bit is set automatically to 1 when the CE pin is "L".
*2) (BANK) There is no need to designate BANK bit for scratch register and Control register 1/2.
*3) ($\overline{12}/24$) The $\overline{12}/24$ bit specifies time digit display in BCD code.

24-hour time display system	12-hour time display system	24-hour time display system	12-hour time display system
00	12 (AM12)	12	32 (PM12)
01	01 (AM 1)	13	21 (PM 1)
02	02 (AM 2)	14	22 (PM 2)
03	03 (AM 3)	15	23 (PM 3)
04	04 (AM 4)	16	24 (PM 4)
05	05 (AM 5)	17	25 (PM 5)
06	06 (AM 6)	18	26 (PM 6)
07	07 (AM 7)	19	27 (PM 7)
08	08 (AM 8)	20	28 (PM 8)
09	09 (AM 9)	21	29 (PM 9)
10	10 (AM10)	22	30 (PM10)
11	11 (AM11)	23	31 (PM11)

Either the 12-hour or 24-hour time display system should be selected before time setting.

2.3 32kHz clock pulse Control Register (BANK1, at Ah)

D3	D2	D1	D0	
*	*	*	$\overline{\text{CLEN}}$	(For read/write operation)

1) The "" mark indicates data which are set to 0 for read cycle and not written for write cycle.
*2) ($\overline{\text{CLEN}}$)
32kHz clock pulse control bit
When the $\overline{\text{CLEN}}$ bit is set to 0, 32.768kHz clock pulse is output from 32KOUT pin.
When the $\overline{\text{CLEN}}$ bit is set to 1, 32KOUT pin is high impedance.
The $\overline{\text{CLEN}}$ bit is set to 0 when the XSTP=1 (Oscillator halt sensing).

3. Counters

3.1 Clock counter (BANK 0, at 0h-5h)

D3	D2	D1	D0			
S_8	S_4	S_2	S_1	(For read/write)	1-second time digit	(at 0h)
*	S_{40}	S_{20}	S_{10}	(For read/write)	10-second time digit	(at 1h)
M_8	M_4	M_2	M_1	(For read/write)	1-minute time digit	(at 2h)
*	M_{40}	M_{20}	M_{10}	(For read/write)	10-minute time digit	(at 3h)
H_8	H_4	H_2	H_1	(For read/write)	1-hour time digit	(at 4h)
*	*	P/$\overline{\text{A}}$ or H_{20}	H_{10}	(For read/write)	10-hour time digit	(at 5h)

1) The "" mark indicates data which are set to 0 for read cycle and not set for write cycle.
*2) Any carry to 1-second digits from the second counter is disabled when the WTEN bit (of the control register 1) is set to 0.
*3) Time digit display (BCD code):
Second digits : Range from 00 to 59 and carried to minute digits when incremented from 59 to 00.
Minute digits : Range from 00 to 59 and carried to hour digits when incremented from 59 to 00.
Hour digits : Range as shown in the section on the $\overline{12}$/24 bit and carried to day and day-of-the-week digits when incremented from 11 p.m. to 12 a.m. or 23 to 00.
*4) Any registered imaginary time should be replaced with actual time as carrying to such registered imaginary time digits from lower-order ones cause the clock counter to malfunction.

3.2 Day-of-the-week counter (BANK 0, at 6h)

D3	D2	D1	D0		
*	W_4	W_2	W_1	(For read/write)	Day-of-the-week counter

1) The "" mark indicates data which are set to 0 for read cycle and not set for write cycle.
*2) Day-of-the-week digits are incremented by 1 when carried to 1-day digits.
*3) Day-of-the-week digits display (incremented in septimal notation):
(W_4, W_2, W_1)=(000) → (001) → ·····→ (110) → (000)
The relation between days of the week and day-of-the-week digits is user changeable (e.g. Sunday=000).
*4) The (W_4, W_2, W_1) should not be set to (111).

3.3 Calendar counter (BANK 0, at 8h-Dh)

D3	D2	D1	D0			
D_8	D_4	D_2	D_1	(For read/write)	1-day calendar digit	(at 8h)
*	*	D_{20}	D_{10}	(For read/write)	10-day calendar digit	(at 9h)
MO_8	MO_4	MO_2	MO_1	(For read/write)	1-month calendar digit	(at Ah)
*	*	*	MO_{10}	(For read/write)	10-month calendar digit	(at Bh)
Y_8	Y_4	Y_2	Y_1	(For read/write)	1-year calendar digit	(at Ch)
Y_{80}	Y_{40}	Y_{20}	Y_{10}	(For read/write)	10-year calendar digit	(at Dh)

1) The "" mark indicates data which are set to 0 for read cycle and not set for write cycle.

*2) The automatic calendar function provides the following calendar digit displays in BCD code.

Day digits : Range from 1 to 31 (for January, March, May, July, August, October, and December).
Range from 1 to 30 (for April, June, September, and November).
Range from 1 to 29 (for February in leap years).
Range from 1 to 28 (for February in ordinary years).
Carried to month digits when cycled to 1.

Month digits : Range from 1 to 12 and carried to year digits when cycled to 1.

Year digits : Range from 00 to 99 and counted as 00, 04, 08, ..., 92, and 96 in leap years.

*3) Any registered imaginary time should be replaced with actual time as carrying to such registered imaginary time digits from lower-order ones cause the clock counter to malfunction.

USAGES

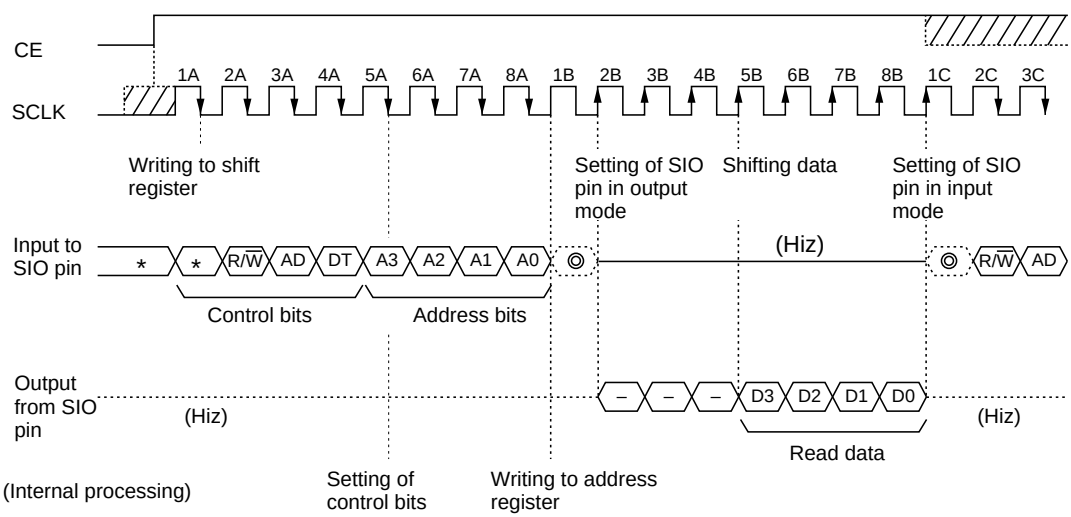
1. Read Data (For the RS5C321A)

The real-time clock becomes accessible by switching the CE pin from the low level to high level to enable interfacing with the CPU and then inputting setting data (control bits and address bits) to the SIO pin in synchronization with shift clock pulses from the SCLK pin. The input data are registered in synchronization with the falling edge of the SCLK. When the data is read, the read cycle shall be set by control bits then registered data can be read out from SIO pin in synchronization with the rising edge of the SCLK.

- **Control bits** R/$\overline{W}$: Establishes the read mode when set to 1, and the write mode when set to 0.
  AD: Writes succeeding addressing bits (A3-A0) to the address register when set to 1 with the DT bit set to 0 and performs no such write operation in any other case.
  DT: Writes data bits to counter or register specified by the address register set just before when set to 1 with the R/$\overline{W}$ and AD bits set equally to 0 and performs no such write operation in any other case.
- **Address bits** A3-A0: Inputs the bits MSB to LSB in the address table describing the functions.

1.1 Read Cycle Flow

1. The CE pin is switched from "L" to "H".
2. Four control bits (with the first bit ignored) and four read address bits are input from the SIO pin. At this time, control bits R/$\overline{W}$ and AD are set equally to 1 while a control bit DT is set to 0. (see the SCLK 1A-8A)
3. The SIO pin enters the output mode at the rising edge of the shift clock pulse 2B from the SCLK pin while the four read bits (MSB → LSB) at designated addresses are output at the rising edge of the shift clock pulse 5B. (see the figure below)
4. Then, the SIO pin returns to the input mode at the rising edge of the shift clock pulse 1C. Afterwards control bits and address bits are input at the shift clock pulses 1C in the same manner as at the shift clock pulse 1A.
5. At the end of read cycle, the CE pin is switched from "H" to "L" (after t_{CEH} from the falling edge of the eighth shift clock pulse from the SCLK pin). Following on read cycle, write operation can be performed by setting control bits in the write mode at the shift clock pulse 1C and later with the CE pin held at "H".



) In the above figure, the "" mark indicates arbitrary data; the "–" mark indicates unknown data.
The "◎" mark indicates data which are available when the SIO pin is held at "H", "L", or Hiz level.
The diagonally shaded area of the CE and the SCLK pins indicate "H" or "L".

2. Write Data (For the RS5C321A)

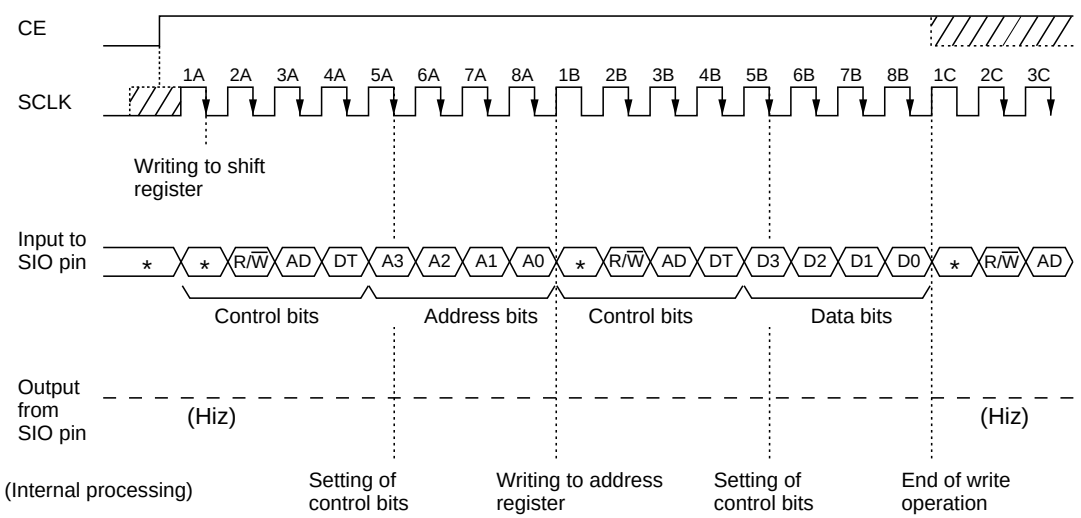
Writing data to the real-time clock requires inputting setting data (control bits, address bits and data bits) to the SIO pin and then establishing the write mode by using a control bit R/$\overline{W}$ in the same manner as in read operation.

*) Control bits and address bits are described in the previous section on read cycle.

• Data bits D3-D0: Inputs the data bits MSB to LSB in the addressing table describing the functions.

2.1 Write Cycle Flow

1. The CE pin is switched from "L" to "H".
2. Four control bits (with the first bit ignored) and four write address bits are input from the SIO pin. At this time, control bits R/$\overline{W}$ and DT are set equally to 0 while a control bit AD is set to 1. (see the SCLK 1A-8A)
3. Four control bits and four bits of data to be written are input in the descending order of their significance. At this time, control bits R/$\overline{W}$ and AD are set equally to 0 while a control bit DT is set to 1. (see the clock 1B-8B)
4. When write cycle is continued, control bits and address bits are input at the shift clock pulse 1C and later in the same manner as at the shift clock pulse 1A.
5. At the end of write operation, control bits R/$\overline{W}$, AD, and DT are set equally to 0 (at the falling edge of shift clock pulse 5A and later from the SCLK pin) or the CE pin is switched from "H" to "L" (after t_{CEH} from the falling edge of the eighth shift clock pulse from the SCLK pin). Following on write cycle, read operation can be performed by setting control bits in the read mode at the shift clock pulse 1C and later with the CE pin held at "H".



) In the above figure, the "" mark indicates arbitrary data; and the diagonally shaded area of CE and SCLK indicates "H" or "L".

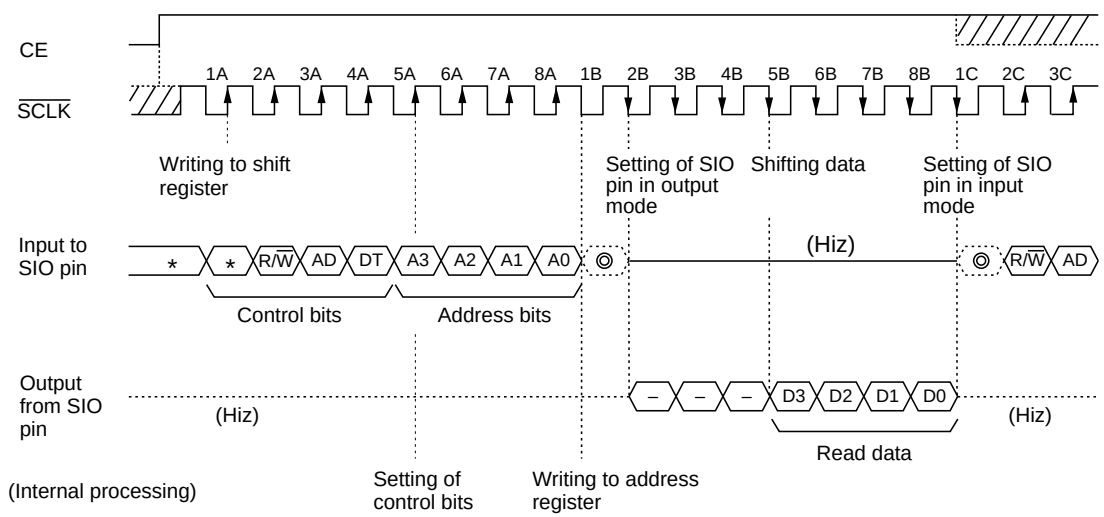
3. Read Data (For the RS5C321B)

The real-time clock becomes accessible by switching the CE pin from the low level to high level to enable interfacing with the CPU and then inputting setting data (control bits and address bits) to the SIO pin in synchronization with shift clock pulses from the $\overline{SCLK}$ pin. The input data are registered in synchronization with the rising edge of the $\overline{SCLK}$. When the data is read, the read cycle shall be set by control bits then registered data can be read out from SIO pin in synchronization with the falling edge of the $\overline{SCLK}$.

- **Control bits** R/$\overline{W}$: Establishes the read mode when set to 1, and the write mode when set to 0.
  AD: Writes succeeding addressing bits (A3-A0) to the address register when set to 1 with the DT bit set to 0 and performs no such write operation in any other case.
  DT: Writes data bits to counter or register specified by the address register set just before when set to 1 with the R/$\overline{W}$ and AD bits set equally to 0 and performs no such write operation in any other case.
- **Address bits** A3-A0: Inputs the bits MSB to LSB in the address table describing the functions.

3.1 Read Cycle Flow

1. The CE pin is switched from "L" to "H".
2. Four control bits (with the first bit ignored) and four read address bits are input from the SIO pin. At this time, control bits R/$\overline{W}$ and AD are set equally to 1 while a control bit DT is set to 0. (see the $\overline{SCLK}$ 1A-8A)
3. The SIO pin enters the output mode at the falling edge of the shift clock pulse 2B from the $\overline{SCLK}$ pin while the four read bits (MSB → LSB) at designated addresses are output at the falling edge of the shift clock pulse 5B. (see the figure below)
4. Then, the SIO pin returns to the input mode at the falling edge of the shift clock pulse 1C. Afterwards control bits and address bits are input at the shift clock pulses 1C in the same manner as at the shift clock pulse 1A.
5. At the end of read cycle, the CE pin is switched from "H" to "L" (after t_{CEH} from the rising edge of the eighth shift clock pulse from the $\overline{SCLK}$ pin). Following on read cycle, write operation can be performed by setting control bits in the write mode at the shift clock pulse 1C and later with the CE pin held at "H".



) In the above figure, the "" mark indicates arbitrary data; the "–" mark indicates unknown data.
The "◎" mark indicates data which are available when the SIO pin is held at "H", "L", or Hiz level.
The diagonally shaded area of the CE and the $\overline{SCLK}$ pins indicate "H" or "L".

4. Write Data (For the RS5C321B)

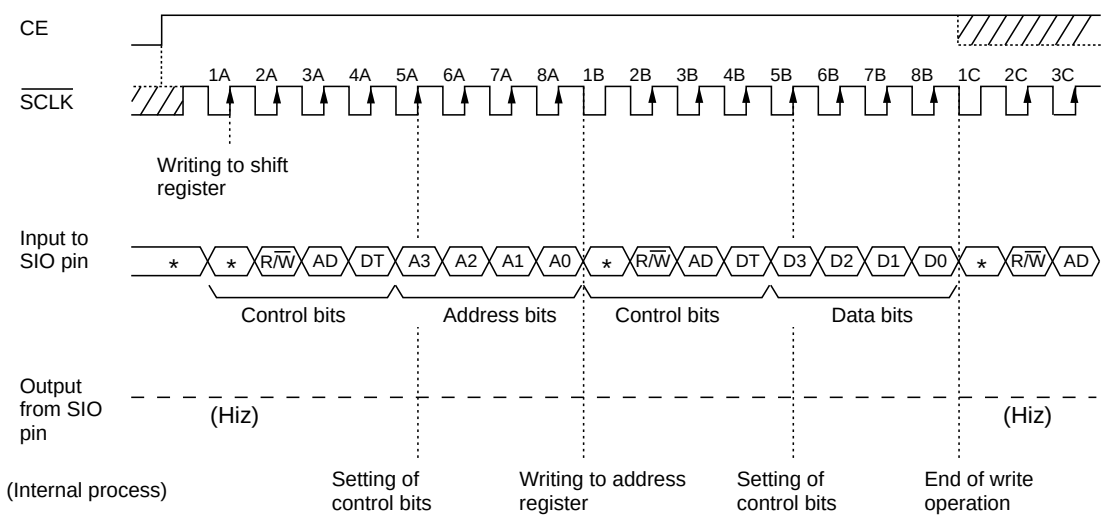
Writing data to the real-time clock requires inputting setting data (control bits, address bits and data bits) to the SIO pin and then establishing the write mode by using a control bit R/$\overline{W}$ in the same manner as in read operation.

*) Control bits and address bits are described in the previous section on read cycle.

• Data bits D3-D0: Inputs the data bits MSB to LSB in the addressing table describing the functions

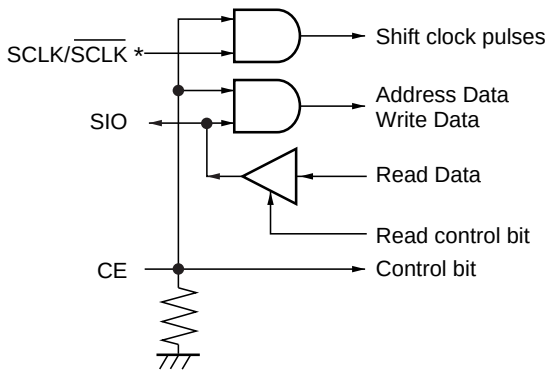
4.1 Write Cycle Flow

1. The CE pin is switched from "L" to "H".
2. Four control bits (with the first bit ignored) and four write address bits are input from the SIO pin. At this time, control bits R/$\overline{W}$ and DT are set equally to 0 while a control bit AD is set to 1. (see the $\overline{SCLK}$ 1A-8A)
3. Four control bits and four bits of data to be written are input in the descending order of their significance. At this time, control bits R/$\overline{W}$ and AD are set equally to 0 while a control bit DT is set to 1. (see the SCLK 1B-8B)
4. When write cycle is continued, control bits and address bits are input at the shift clock pulse 1C and later in the same manner as at the shift clock pulse 1A.
5. At the end of write operation, control bits R/$\overline{W}$, AD, and DT are set equally to 0 (at the rising edge of shift clock pulse 5A and later from the $\overline{SCLK}$ pin) or the CE pin is switched from "H" to "L" (after t_{CEH} from the rising edge of the eighth shift clock pulse from the $\overline{SCLK}$ pin). Following on write cycle, read operation can be performed by setting control bits in the read mode at the shift clock pulse 1C and later with the CE pin held at "H".



) In the above figure, the "" mark indicates arbitrary data; and the diagonally shaded area of CE and $\overline{SCLK}$ indicates "H" or "L".

5. CE Pin

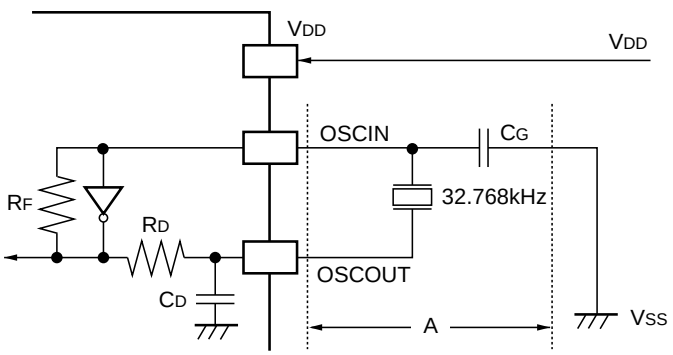


*) RS5C321A: SCLK
RS5C321B: $\overline{\text{SCLK}}$

1) Switching the CE pin to the high level enables the SCLK/$\overline{\text{SCLK}}$ and SIO pins, allowing data to be serially read from and written to the SIO pin in synchronization with shift clock pulses input from the SCLK/$\overline{\text{SCLK}}$ pin.
2) Switching the CE pin to the low level or opening disables the SCLK/$\overline{\text{SCLK}}$ and SIO pins, causing high impedance and resetting the internal interfacing circuits such as the shift register. While data of the address register and bank bit which have been written just before should be preserved.
3) The CE pin should be held at the low level or open state when no access is made to the RS5C321A/B.
   The CE pin incorporates a pull-down resistor.
4) During system power-down (being back-up battery powered), the low-level input of the CE pin should be brought as close as possible to the VSS level to minimize the loss of charge in the battery.
5) The CE pin should be held at the low level in order to be enable oscillator halt sensing. Holding the CE pin at the high level, therefore, disables oscillator halt sensing, retaining the value of the XSTP (oscillator halt sensing) bit which exists immediately before the CE pin is switched to the high level.

Considerations
When the power turns on from 0V, the CE pin should be set low or open once.

6. Configuration of Oscillating Circuit



Typical external device:
X'tal : 32.768kHz
(R_1=30kΩ TYP.)
(C_L=6pF to 8pF)
C_G=8pF to 20pF
Typical values of internal devices
R_F=15MΩ (TYP.)
R_D=60kΩ (TYP.)
C_D=10pF (TYP.)

*) The oscillation circuit is driven at a constant voltage of about 1.5V relative to the Vss level.
Consequently, it generates a wave form having a peak-to-peak amplitude of about 1.5V on the positive side of the Vss level.

Considerations in Mounting Components Surrounding Oscillating Circuit

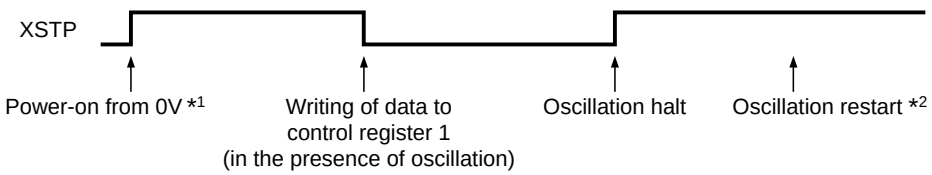
1) Mount the crystal oscillators and C_G in the closest possible position to the IC.
2) Avoid laying any signal or power line close to the oscillation circuit (particularly in the area marked with "← A →" in the above figure).
3) Apply the highest possible insulation resistance between the OSCIN or OSCOUT pin and the PCB.
4) Avoid using any long parallel line to wire the OSCIN or OSCOUT pin.
5) Take extreme care not to cause condensation, which leads to various problems such as oscillation halt.

Other Relevant Considerations

1) When applying an external input of clock pulses (32.768kHz) to the OSCIN pin:
DC coupling .....Prohibited due to mismatching input levels.
AC coupling.....Permissible except that unpredictable results may occur in oscillator halt sensing due to possible sensing errors caused by noises, etc.
2) Avoid using the oscillator output of the RS5C321A/B (from the OSCOUT pin) to drive any other IC for the purpose of ensuring stable oscillation.

7. Oscillator Halt Sensing

Oscillation Halt can be sensed through monitoring the XSTP bit with preceding setting of the XSTP bit to 0 by writing any data to the control register 1. Upon oscillator halt sensing, the XSTP bit is switched from 0 to 1. This function can be applied to judge clock data validity. The $\overline{\text{CLEN}}$ bit is set to 0 when XSTP=1, and 32KOUT pin is forced to output 32.768kHz clock pulses.



*1) While the CE pin is held at the low level, the XSTP bit is set to 1 upon power-on from 0V.
Note that any instantaneous power disconnection may cause operational failure. When the CE pin is held at the high level, oscillation halt is not sensed and the value of the XSTP bit when the CE pin is held at the low level is retained.

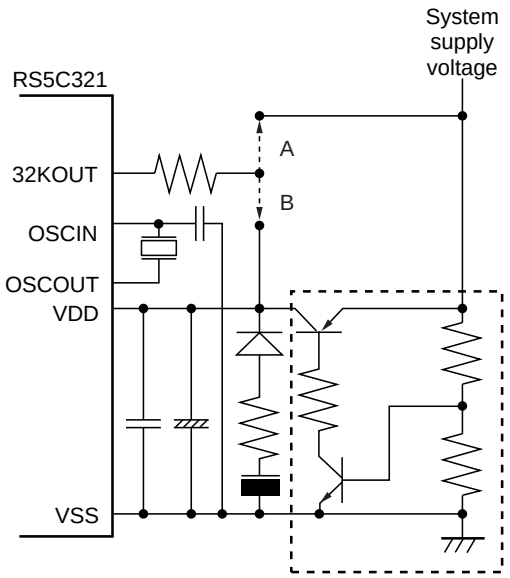
*2) Once oscillation halt has been sensed, the XSTP bit is held at 1 even if oscillation is restarted.

Considerations in Use of XSTP Bit

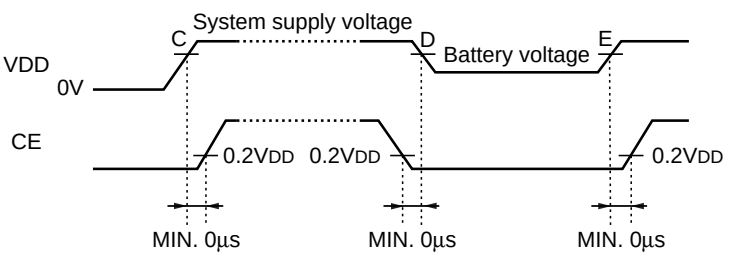
Ensure error-free oscillation halt sensing by preventing the following:

1) Instantaneous disconnection of VDD
2) Condensation on the crystal oscillator
3) Generation of noise on the PCB in the crystal oscillator
4) Application of voltage exceeding prescribed maximum ratings to the individual pins of the IC

8. Typical Power Supply Circuit



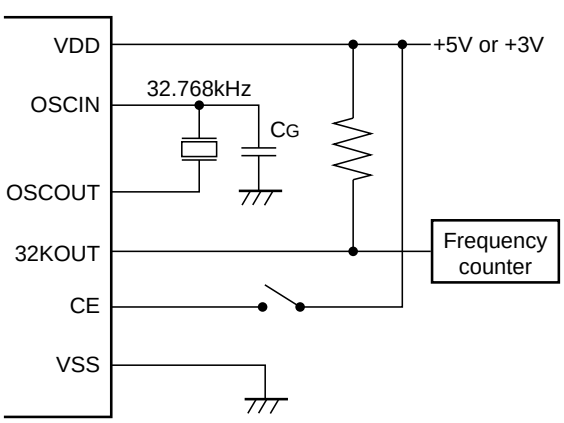
1) Connect the capacitance of the oscillation circuit to the Vss pin.
2) Mount the high-and low-frequency by-pass capacitors in parallel and very close to the RS5C321.
3) Connect the pull-up resistor of the 32KOUT pin to two different positions depending on whether the resistor is in use during battery back-up.
   - When not in use during battery back-up
     .....Position A in the left figure
   - When in use during battery back-up
     .....Position B in the left figure
4) Timing of power-on, power-off and CE pin refer to following figure.
5) When a diode are in use in place of the components surrounded by dotted lines, note that applying voltage to any input pins should be less than the rating of V_{DD} +0.3V by using of schottky diode.



C, D, E: Minimum operating voltage for CPU

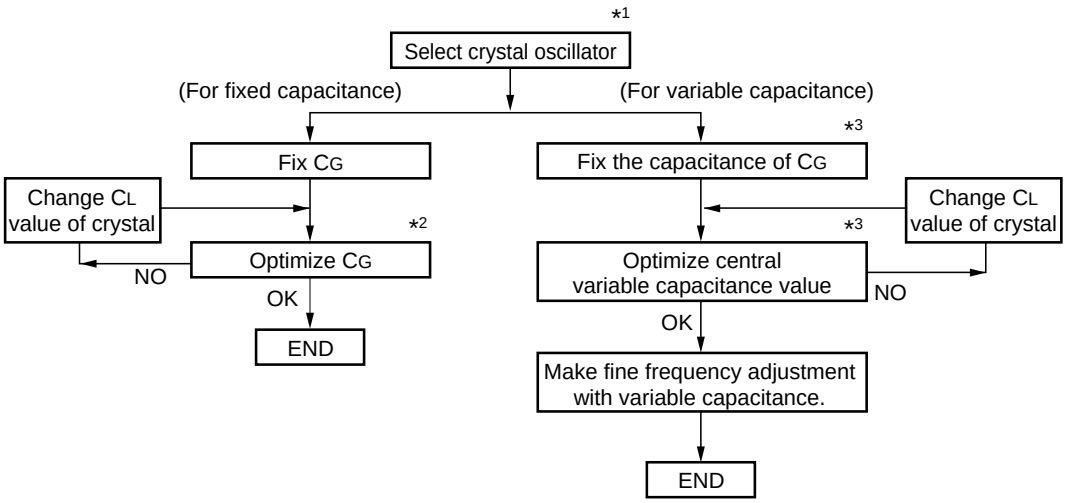
9. Oscillation Frequency Adjustment

9.1 Oscillation Frequency Measurement



1) After initial power-on (XSTP=1), 32KOUT pin outputs 32.768kHz clock pulse, which is measured with a frequency counter.
2) Ensure that the frequency counter has more than six digits (on the order of 1 ppm).
3) Place the C_G between the OSCIN pin and the VSS level and pull up the 32KOUT pin output to the VDD.

9.2 Oscillation Frequency Adjustment



*1) To ensure that the crystal is matched to the IC, inquire its crystal supplier about its C_L (load capacitance) and R_1 (equivalent series resistance) values. It is recommended that the crystal should have the C_L value range of 6 to 8pF and the typical R_1 value of 30kΩ.

*2) To allow for the possible effects of floating capacitance, select the optimum capacitance of the C_G on the mounted PCB. The standard and recommendable capacitance values of the C_G range from 5 to 24pF and 8 to 20pF, respectively. When you need to change the frequency to get higher accuracy, change the C_L value of the crystal.

*3) Collate the central variable capacitance value of the C_G with its oscillation frequency by adjusting the angle of rotation of the variable capacitance of the C_G in such a manner that the actual variable capacitance value is slightly smaller than the central variable capacitance value. (It is recommended that the central variable capacitance value should be slightly less than one half of the actual variable capacitance value because the smaller is variable capacitance, the greater are fluctuations in oscillation frequency.) In the case of an excessive deviation of the oscillation frequency from its required value, change the C_L value of the crystal.

After adjustment, oscillation frequency is subject to fluctuations of an ambient temperature and supply voltage. See "12. Typical Characteristic Measurements".

Note

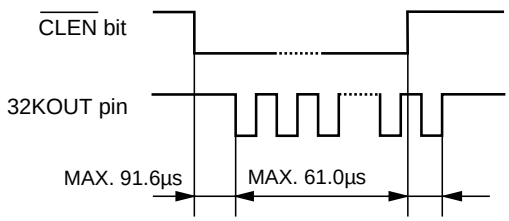
Any rise or fall in ambient temperature from its reference value ranging from 20 to 25 degrees Celsius causes a time delay for a 32.768kHz crystal oscillator. It is recommendable, therefore, to set slightly high oscillation frequency at room temperature.

10. 32.768kHz Clock Output

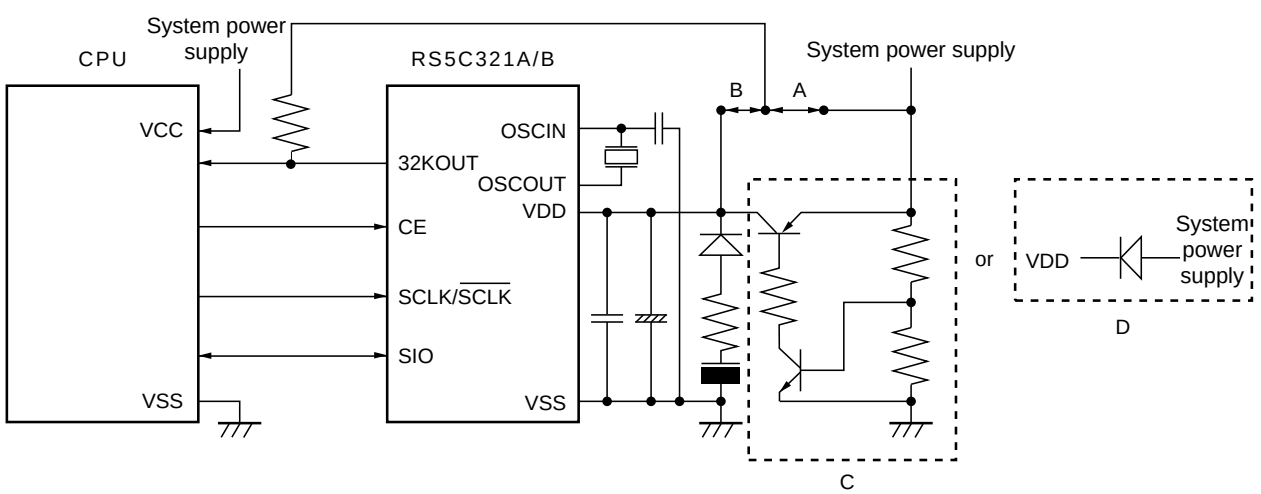
32KOUT outputs 32.768kHz clock pulse, the pin switches to high impedance when no output is made. 32.768kHz clock is controllable by $\overline{\text{CLEN}}$ bit. Set the CE pin to "L" after power-on.

$\overline{\text{CLEN}}$ bit	32KOUT pin
0	32.768kHz clock pulse
1	High Inpedance

$\overline{\text{CLEN}}$ bit is set to 0 when XSTP is set to 1. (oscillation halt detecting or initial power on)



11. Typical Application



⋆1) Connect the capacitance of the oscillation circuit to the VSS pin.

⋆2) Mount the high-and low-frequency by-pass capacitors in parallel and very close to the RS5C321.

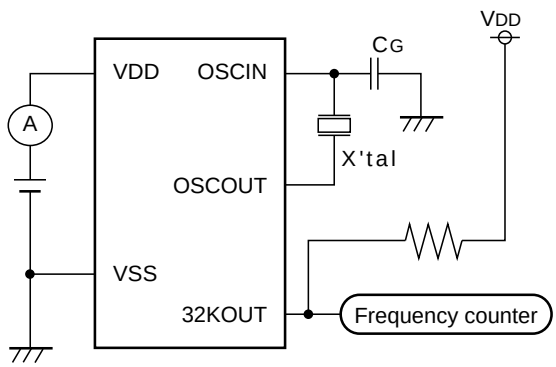
⋆3) Connect the pull-up resistor of the 32KOUT pin to two different positions depending on whether the resistor is in use during battery back-up:

(I) When not in use during battery back-up .....Position A in the above figure

(II) When in use during battery back-up .....Position B in the above figure

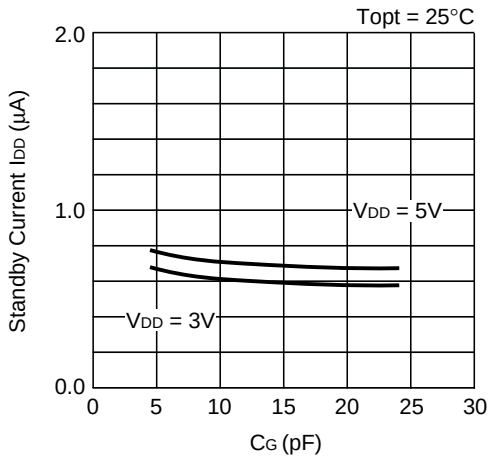
⋆4) When using a "D" circuit in place of "C", note that forward voltage of diode should be minimized to eliminate applying excess voltage to input pins. (Take the utmost care on system powering-ON and-OFF).

12. Typical Characteristic Measurements

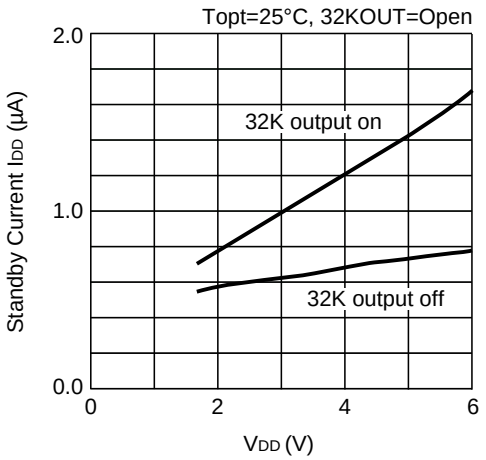


C_G=10pF
X'tal : R_1=30kΩ
Topt=25˚C
Input Pin : VDD or VSS
Output Pin : Open

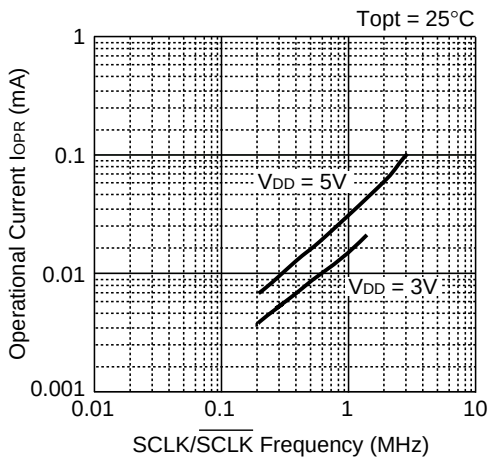
12.1 Standby Current vs. C_G



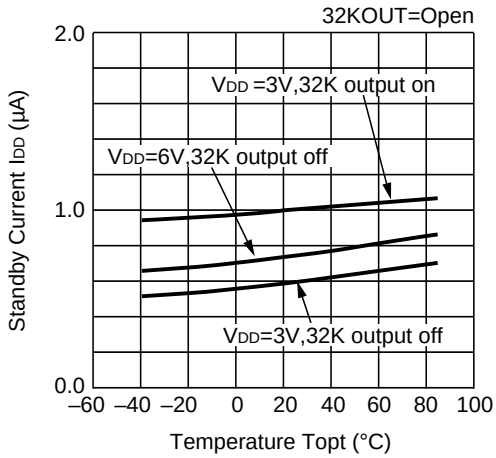
12.2 Standby Current vs. V_{DD}



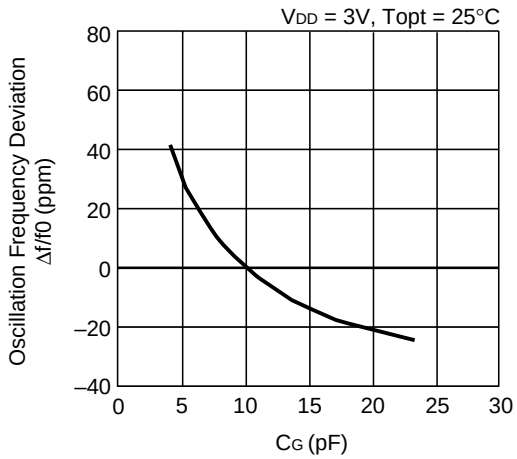
12.3 Operational Current vs. SCLK/$\overline{\text{SCLK}}$ Frequency



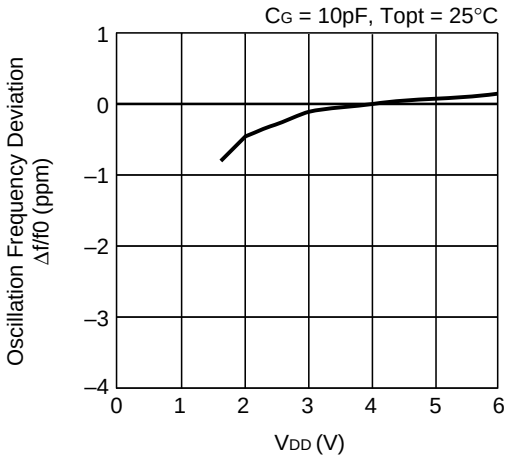
12.4 Standby Current vs. Temperature



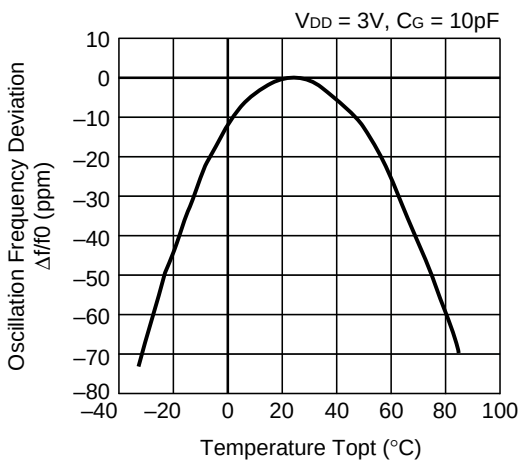
12.5 Oscillation Frequency Deviation vs. C_G (f0: C_G=10pF reference)



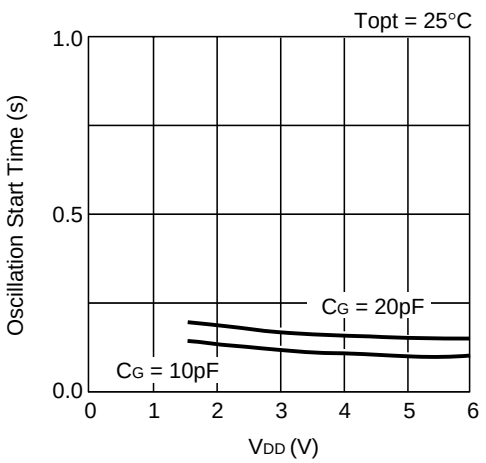
12.6 Oscillation Frequency Deviation vs. V_{DD} (f0: V_{DD}=4V reference)



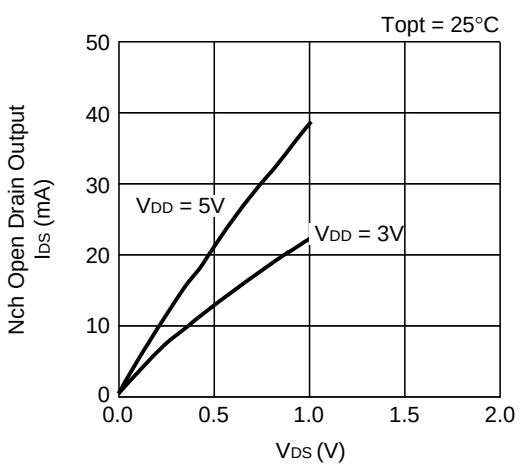
12.7 Oscillation Frequency Deviation vs. Temperature (f0: Topt=25°C reference)



12.8 Oscillation Start Time vs. V_{DD}

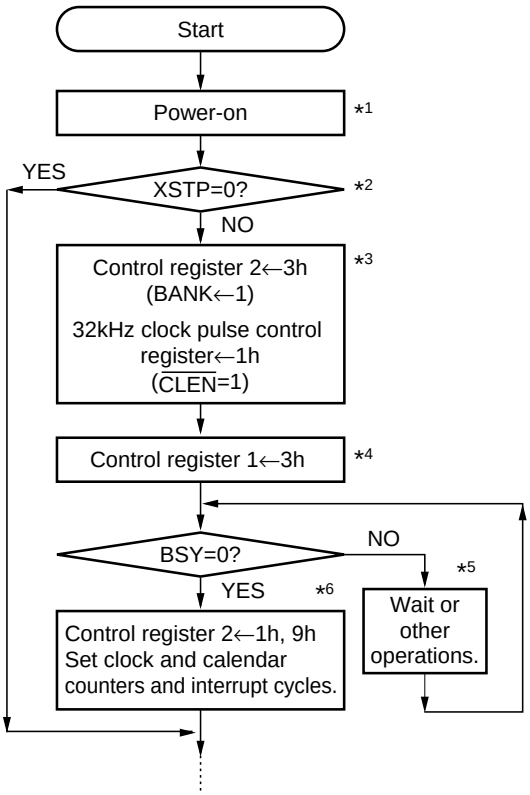


12.9 V_{DS} vs. I_{DS} for Nch Open Drain Output



13. Typical Software-based Operations

13.1 Initialization upon Power-on



*1) Switch the CE pin to the low level immediately after power-on.

*2) When not making oscillation halt sensing (data validity), the XSTP bit need not be checked.

*3) On powering on from 0V, 32KOUT pin outputs 32.768kHz clock pulses. Set $\overline{CLEN}$←1 when turning 32.768kHz off during initialization.

*4) Set the ADJ bit to 1. When writing control register 1, if the oscillator has operated, the XSTP bit is changed from 1 to 0.

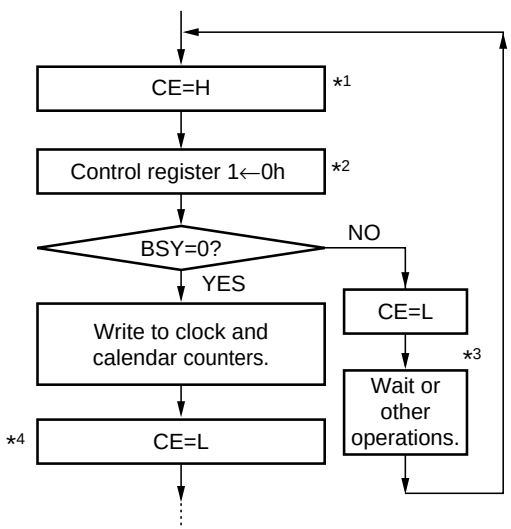
*5) It takes about 0.1 to 2 seconds to be set the BSY bit to 0 from oscillation starting upon power-on from 0V. Provide an exit from an oscillation start loop to prepare for oscillation failure.

*6) Set the XSTP bit to 0 by writing data to the control register 1, and set to the control register 2,
0h for the 12-hour time display system.
4h for the 24-hour time display system.

When Using the XSTP Bit

Ensure stable oscillation by preventing the following:
1) Condensation on the crystal oscillator
2) Instantaneous disconnection of power
3) Generation of clock noises, etc, in the crystal oscillator
4) Charge of voltage exceeding prescribed maximum ratings to the individual pins of the IC

13.2 Write Operation to Clock and Calendar Counters



*1) After switching the CE pin to the high level, hold it at the high level until any subsequent operation requires switching it to the low level. (Note that switching the CE pin to the low level sets the WTEN bit to 1.)

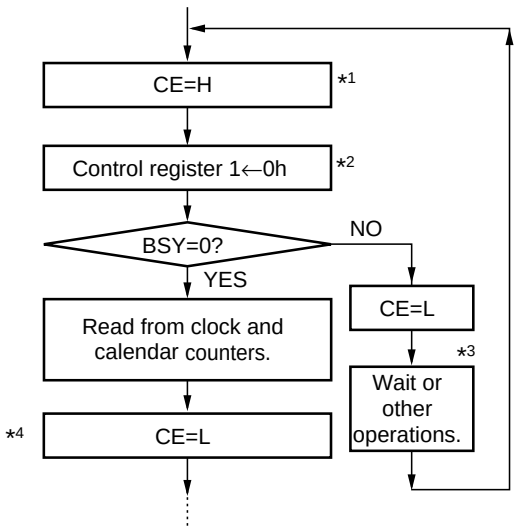
*2) WTEN bit is set to 0.

*3) The BSY bit is held at 1 for a maximum duration of 122.1µs.

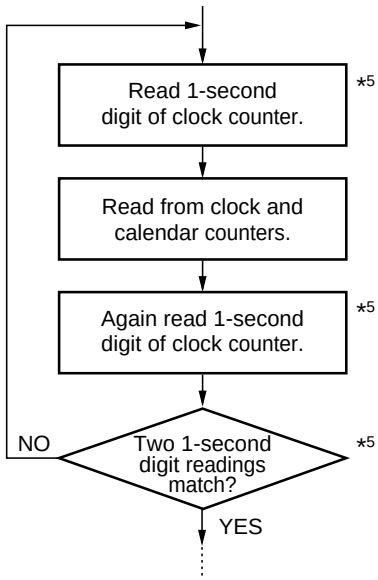
*4) Switch the CE pin to the low level to set the WTEN bit to 1. During write operation to the clock and calendar counters, one 1-second digit carry causes a 1-second increment while two 1-second digit carries also cause only a 1-seconds increment, which, in turn, causes a time delay.

13.3 Read Operation from Clock and Calendar Counters

13.3-1



13.3-2



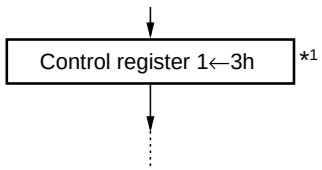
*1) to *4) These notes are the same as 13.2 notes *1) to *4).

*5) When needing any higher-order digits than the minute digits, replace second digits with minute digits. (Reading LSD one of the required digits twice.)

Note

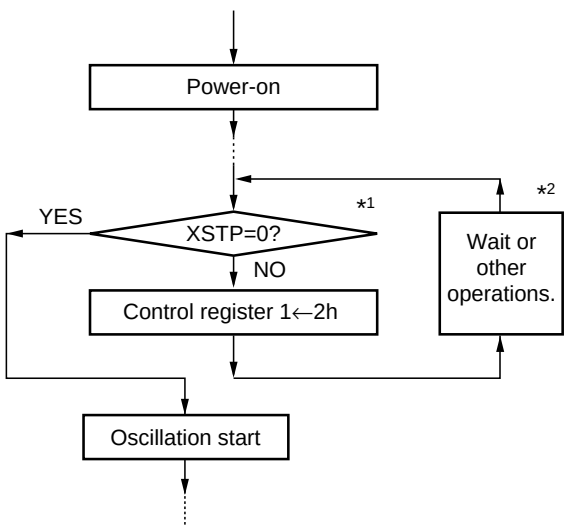
Read data as described in 13.3-2 when it takes (1/1024) sec or more to set the WTEN bit from 0 to 1 (CE=L), the read operation described in 13.3-1 is prohibited as such a case.

13.4 Second-digit Adjustment by ±30 seconds



*1) Set the ADJ bit to 1.
(The BSY bit is held at 1 for a maximum duration of 122.1µs after the ADJ bit is set to 1.)

13.5 Oscillation Start Judgment



*1) The XSTP bit is set to 1 upon power-on from 0V.

*2) It takes approximately 0.1 to 2 seconds to start oscillation. Provide an exit from an oscillation start loop to prepare for oscillation failure.

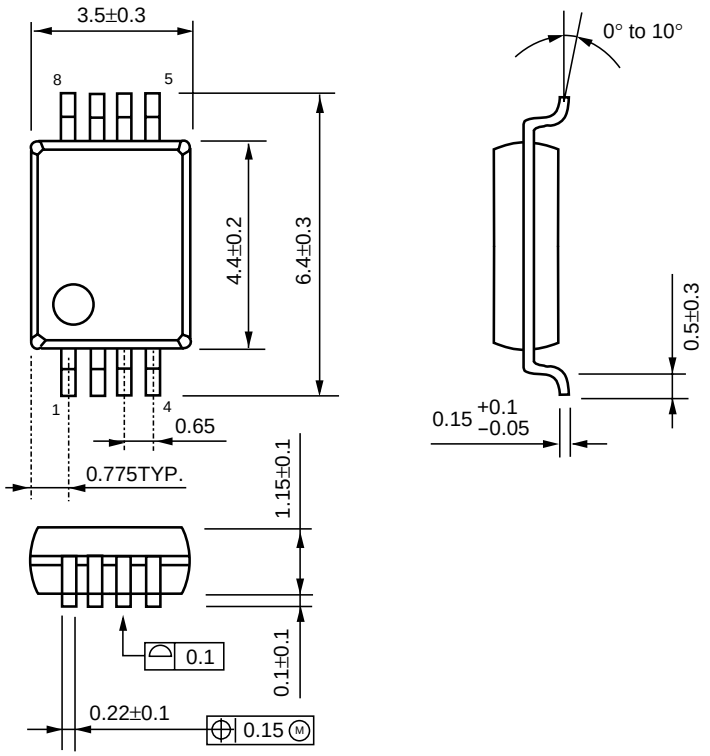
When Using the XSTP Bit

Ensure stable oscillation by preventing the following:

1) Condensation on the crystal oscillator
2) Instantaneous disconnection of power
3) Generation of clock noises, etc, in the crystal oscillator
4) Charge of voltage exceeding prescribed maximum ratings to the individual pins of the IC

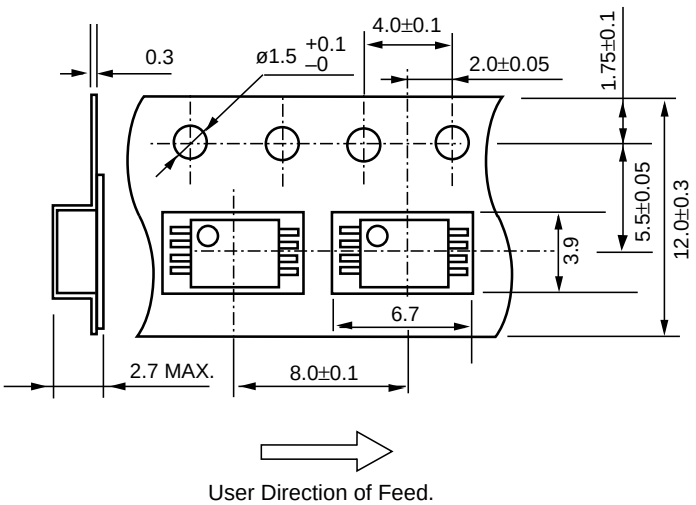
PACKAGE DIMENSIONS (Unit: mm)

• RS5C321A/B (8pin SSOP, 0.65mm pitch)



TAPING SPECIFICATION (Unit: mm)

The RS5C321A/B have one designated taping direction. The product designations for the taping components are "RS5C321A-E2" and "RS5C321B-E2".



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