

## MSM58321

### REAL TIME CLOCK/CALENDAR

#### DESCRIPTION

The MSM 58321 is a metal gate CMOS Real Time Clock/Calendar with a battery backup function for use in bus-oriented microprocessor applications.

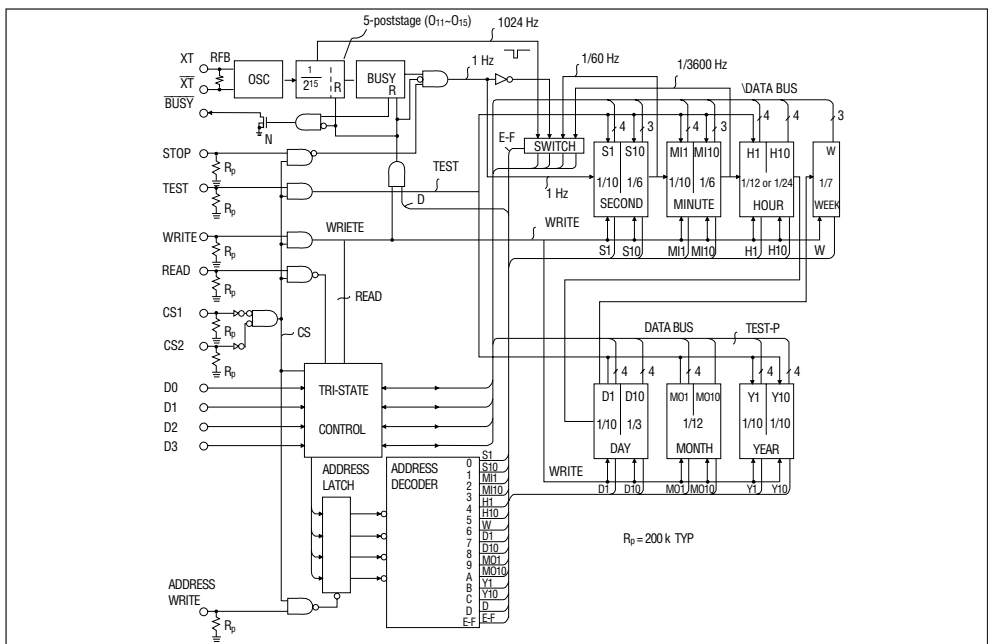
The 4-bit bidirectional bus line method is used for the data I/O circuit; the clock is set, corrected, or read by accessing the memory.

The time is read with 4-bit DATA I/O, ADDRESS WRITE, READ, and  $\overline{\text{BUSY}}$ ; it is written with 4-bit DATA I/O, ADDRESS WRITE, WRITE, and  $\overline{\text{BUSY}}$ .

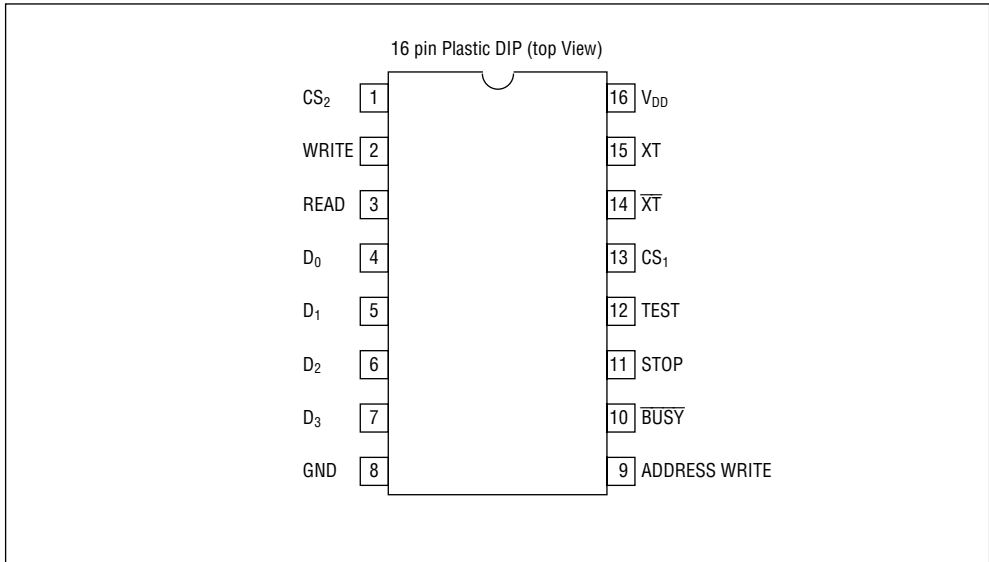
#### FEATURES

- 7 Function-Second, Minute, Hour, Day, Day-of-Week, Month, Year
- Automatic leap year calendar
- 12/24 hour format
- Frequency divider 5-poststage reset
- Reference signal output
- 32.768 kHz crystal controlled operation
- Single 5V power supply
- Back-up battery operation to  $V_{DD} = 2.2V$
- Low power dissipation
  - 90  $\mu W$  max. at  $V_{DD} = 3V$
  - 2.5 mW max. at  $V_{DD} = 5V$
- 16 pin plastic DIP (DIP 16-P-300)

#### FUNCTIONAL BLOCK DIAGRAM



## PIN CONFIGURATION



## REGISTER TABLE

Address	Address input				Register Name	Data input/output				Count value	Remarks
	D <sub>0</sub> (A <sub>0</sub> )	D <sub>1</sub> (A <sub>1</sub> )	D <sub>2</sub> (A <sub>2</sub> )	D <sub>3</sub> (A <sub>3</sub> )		D <sub>0</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>		
0	0	0	0	0	S <sub>1</sub>	*	*	*	*	0 to 9	
1	1	0	0	0	S <sub>10</sub>	*	*	*	*	0 to 5	
2	0	1	0	0	MI <sub>1</sub>	*	*	*	*	0 to 9	
3	1	1	0	0	MI <sub>10</sub>	*	*	*	*	0 to 5	
4	0	0	1	0	H <sub>1</sub>	*	*	*	*	0 to 9	
5	1	0	1	0	H <sub>10</sub>	*	*	*	⊙	0-1 or 0-2	D <sub>2</sub> = 1 specifies PM, D <sub>2</sub> = 0 specifies AM, D <sub>3</sub> = 1 specifies 24-hour timer, and D <sub>3</sub> = 0 specifies 12-hour timer. When D <sub>3</sub> = 1 is written, the D <sub>2</sub> bit is reset inside the IC.
6	0	1	1	0	W	*	*	*	*	0 to 6	
7	1	1	1	0	D <sub>1</sub>	*	*	*	*	0 to 9	
8	0	0	0	1	D <sub>10</sub>	*	*	⊙	⊙	0 to 3	The D <sub>2</sub> and D <sub>3</sub> bits in D <sub>10</sub> are used to select a leap year.
9	1	0	0	1	MO <sub>1</sub>	*	*	*	*	0 to 9	
A	0	1	0	1	MO <sub>10</sub>	*	*	*	*	0 to 1	
B	1	1	0	1	Y <sub>1</sub>	*	*	*	*	0 to 9	
C	0	0	1	1	Y <sub>10</sub>	*	*	*	*	0 to 9	
D	1	0	1	1							A selector to reset 5 poststages in the 1/2 <sup>15</sup> frequency divider and the BUSY circuit. They are reset when this code is latched with ADDRESS LATCH and the WRITE input goes to 1.
E-F	0/1	1	1	1							A selector to obtain reference signal output. Reference signals are output to D <sub>0</sub> – D <sub>3</sub> when this code is latched with ADDRESS LATCH and READ input goes to 1.

Calendar	D <sub>2</sub>	D <sub>3</sub>	Remainder obtained by dividing the year number by 4
Gregorian calendar	0	0	0
	1	0	3
	0	1	2
	1	1	1

- Note:**
- (1) There are no bits in blank fields for data input/output. 0 signals are output by reading and data is not stored by writing because there are no bits.
  - (2) The bit with marked ⊙ is used to select the 12/24-hour timer and the bits marked ⊙ are used to select a leap year. These three bits can be read or written.
  - (3) When signals are input to bus lines D<sub>0</sub> – D<sub>3</sub> and ADDRESS WRITE goes to 1 for address input, ADDRESS information is latched with ADDRESS LATCH.

**ELECTRICAL CHARACTERISTICS****Absolute Maximum Ratings**

Rating	Symbol	Condition	Value	Unit
Power voltage	$V_{DD}$	$T_a = 25^\circ\text{C}$	-0.3 to 6.5	V
Input voltage	$V_I$	$T_a = 25^\circ\text{C}$	-0.3 to $V_{DD}+0.3$	V
Output voltage	$V_O$	$T_a = 25^\circ\text{C}$	-0.3 to $V_{DD}+0.3$	V
Storage temperature	$T_{stg}$	-	-55 to +150	$^\circ\text{C}$

**Operating Conditions**

Rating	Symbol	Condition	Value	Unit
Power voltage	$V_{DD}$	-	4.5 to 6	V
Data hold voltage	$V_{DH}$	-	2.2 to 6	V
Crystal frequency	$f(XT)$	-	32.768	kHz
Operating temperature	$T_{OP}$	-	-30 to +85	$^\circ\text{C}$

**Note:** The data hold voltage guarantees the clock operations, though it does not guarantee operations outside the IC and data input/output.

**DC Characteristics**

( $V_{DD} = 5V \pm 5\%$ ,  $T_a = -30 \sim +85^\circ\text{C}$ )

Rating	Symbol	Condition	Min.	Typ.	Max.	Unit
H input voltage	$V_{IH1}$	- Note 1	3.6	-	-	V
	$V_{IH2}$	- Note 2	$V_{DD}-0.5$	-	-	
L input voltage	$V_{IL}$	-	-	-	0.8	V
L output voltage	$V_{OL}$	$I_O = 1.6 \text{ mA}$	-	-	0.4	V
L output current	$I_{OL}$	$V_O = 0.4 \text{ V}$	1.6	-	-	mA
H input current	$I_{IH1}$	$V_I = V_{DD}$ Note3	10	30	80	$\mu\text{A}$
	$I_{IH2}$	$V_I = V_{DD}$ Note4	-	-	1	
L input current	$I_{IL}$	$V_I = 0\text{V}$	-	-	-1	$\mu\text{A}$
Input capacity	$C_I$	$f = 1 \text{ MHz}$	-	5	-	pF
Current consumption	$I_{DD}$	$f = 32.768 \text{ kHz}$ $V_{DD} = 5\text{V}/V_{DD} = 3\text{V}$	-	100/15	500/30	$\mu\text{A}$

**Note:**

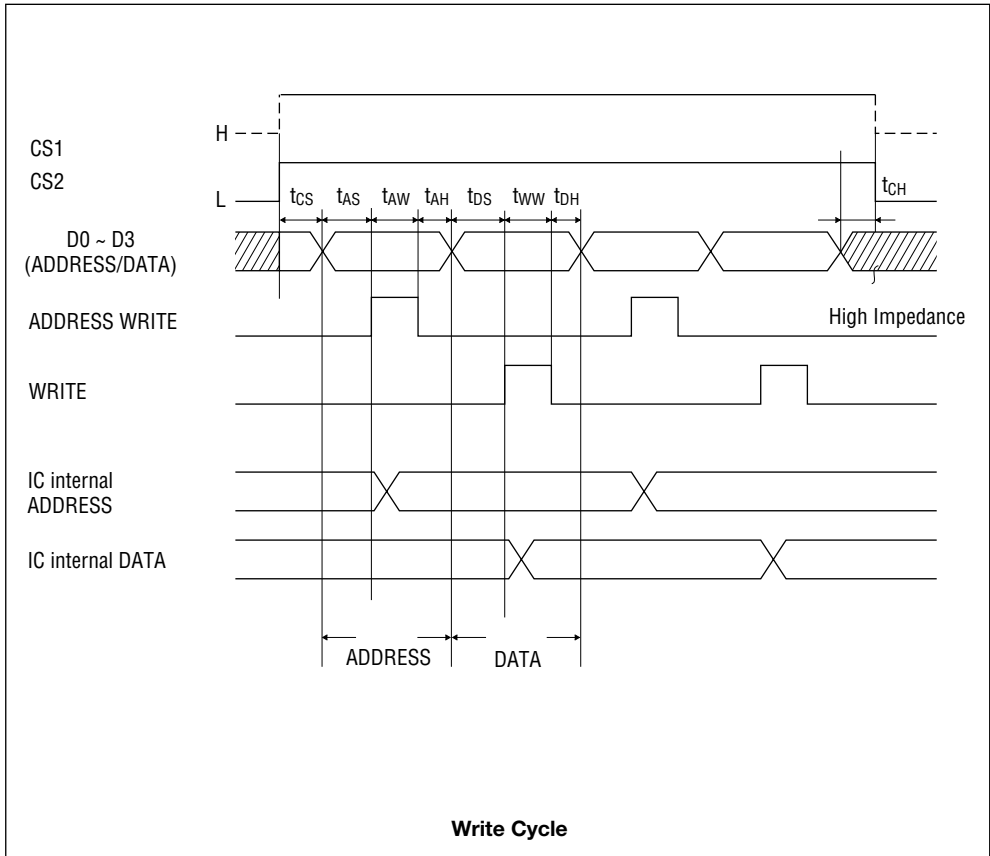
1.  $CS_2$ , WRITE, READ, ADDRESS WRITE, STOP, TEST,  $D_0 \sim D_3$
2.  $CS_1$
3.  $CS_1$ ,  $CS_2$ , WRITE, READ, ADDRESS WRITE, STOP, TEST
4.  $D_0 \sim D_3$

### Switching Characteristics

#### (1) WRITE mode

( $V_{DD} = 5V \pm 5\%$ ,  $T_a = 25^\circ C$ )

Rating	Symbol	Condition	Min.	Typ.	Max.	Unit
CS setup time	$t_{CS}$	-	0	-	-	$\mu s$
CS hold time	$t_{CH}$	-	0	-	-	$\mu s$
Address setup time	$t_{AS}$	-	0	-	-	$\mu s$
Address write pulse width	$t_{AW}$	-	0.5	-	-	$\mu s$
Address hold time	$t_{AH}$	-	0.1	-	-	$\mu s$
Data setup time	$t_{DS}$	-	0	-	-	$\mu s$
Write pulse width	$t_{WW}$	-	2	-	-	$\mu s$
Data hold time	$t_{DH}$	-	0	-	-	$\mu s$



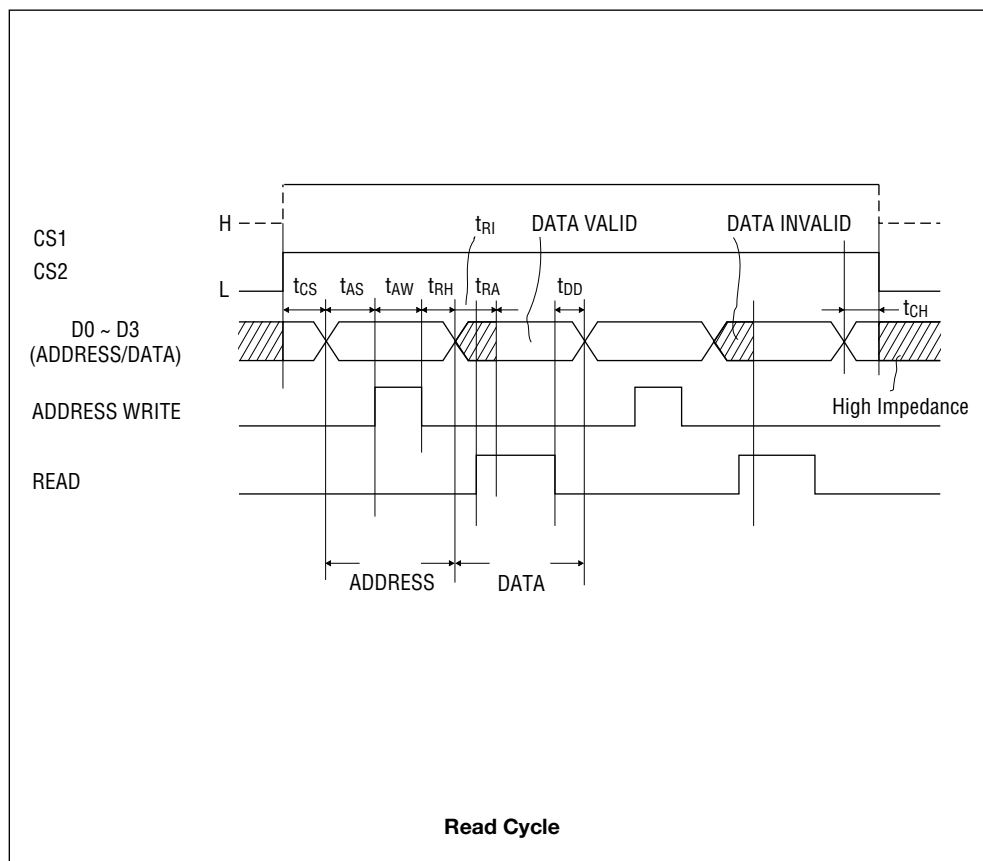
**Note:** ADDRESS WRITE and WRITE inputs are activated by the level, not by the edge.

(2) READ mode

(V<sub>DD</sub> = 5V ±5%, T<sub>a</sub> = 25°C)

Rating	Symbol	Condition	Min.	Typ.	Max.	Unit
CS setup time	t <sub>CS</sub>	-	0	-	-	μs
CS hold time	t <sub>CH</sub>	-	0	-	-	μs
Address setup time	t <sub>AS</sub>	-	0	-	-	μs
Address write pulse width	t <sub>AW</sub>	-	0.5	-	-	μs
Address hold time	t <sub>AH</sub>	-	0.1	-	-	μs
Read access time	t <sub>RA</sub>	-	-	-	see Note 1	μs
Read delay time	t <sub>DD</sub>	-	-	-	1	μs
Read inhibit time	t <sub>RI</sub>	-	0	-	-	μs

**Note 1.**  $t_{RA} = 1 \mu s + CR \ln \left( \frac{V_{DD}}{V_{DD} - V_{IH \min}} \right)$



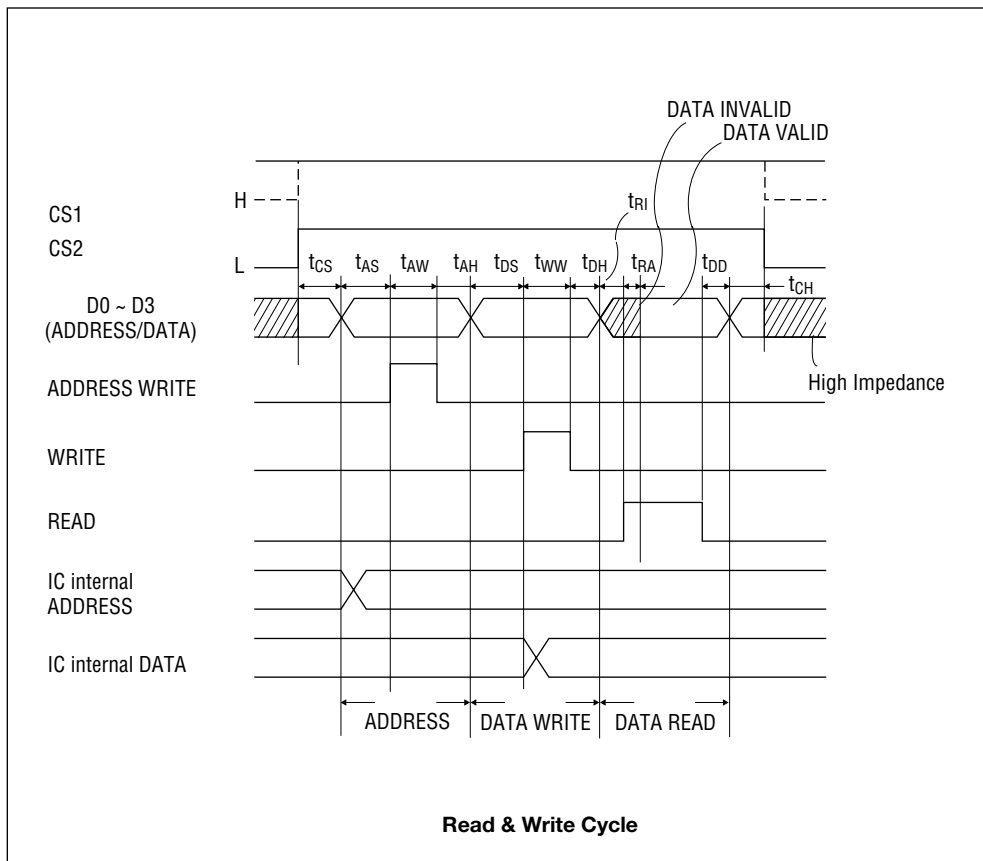
**Note:** ADDRESS WRITE and READ inputs are activated by the level, not by the edge.

(3) WRITE & READ mode

(V<sub>DD</sub> = 5V ±5%, Ta = 25°C)

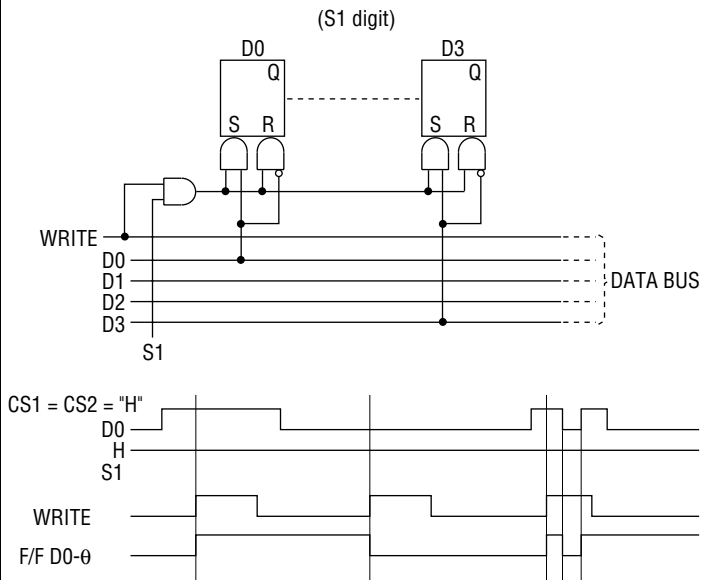
Rating	Symbol	Condition	Min.	Typ.	Max.	Unit
CS setup time	t <sub>CS</sub>	—	0	—	—	μs
CS hold time	t <sub>CH</sub>	—	0	—	—	μs
Address setup time	t <sub>AS</sub>	—	0	—	—	μs
Address write pulse width	t <sub>AW</sub>	—	0.5	—	—	μs
Address hold time	t <sub>AH</sub>	—	0.1	—	—	μs
Data setup time	t <sub>DS</sub>	—	0	—	—	μs
Write pulse width	t <sub>WW</sub>	—	2	—	—	μs
Data hold time	t <sub>DH</sub>	—	0	—	—	μs
Read access time	t <sub>RA</sub>	—	—	—	see Note 1	μs
Read delay time	t <sub>DD</sub>	—	—	—	1	μs
Read inhibit time	t <sub>RI</sub>	—	0	—	—	μs

**Note 1.** t<sub>RA</sub> = 1 μs + CR ln (  $\frac{V_{DD}}{V_{DD} - V_{IH \text{ min}}}$  )



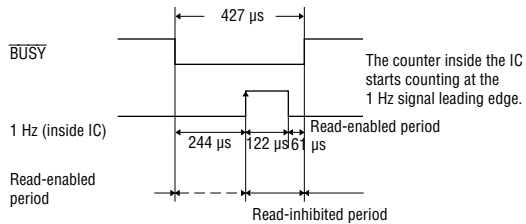
**PIN DESCRIPTION**

Name	Pin No.	Description
CS <sub>2</sub>	1	Chip select pins. These pins enable the interface with the external circuit when both of these pins are set at H level simultaneously.
CS <sub>1</sub>	13	If one of these pins is set at L level, STOP, TEST, WRITE, READ, ADDRESS WRITE pins and D <sub>0</sub> ~ D <sub>3</sub> pins are inactivated. Since the threshold voltage V <sub>T</sub> for the CS <sub>1</sub> pin is higher than that for other pins, it should be connected to the detector of power circuit and peripherals and CS <sub>2</sub> is to be connected to the microcontroller.
WRITE	2	WRITE pin is used to write data; it is activated when it is at the H level. Data bus data inside the IC is loaded to the object digit while this WRITE pin is at the H level, not at the WRITE input edge. Refer to Figure 1 below.



**Figure 1**

Name	Pin No.	Description
READ	3	<p>READ pin is used to read data; it is activated when it is at the H level. Address contents are latched with ADDRESS LATCH inside the IC at the D<sub>0</sub> ~ D<sub>3</sub> and ADDRESS WRITE pins to select the object digit, then an H-level signal is input to the READ pin to read data.</p> <p>If a count operation is continued by setting the STOP input to the L level, read operation must be performed, in principle, while the BUSY output is at the H level. While the <math>\overline{\text{BUSY}}</math> output is at the L level, count operations are performed by digit counters and read data is not guaranteed, therefore, read operations are inhibited in this period. Figure 2 shows a time chart of the BUSY output, 1 Hz signal inside the IC, and READ input.</p> <p>A read operation is stopped temporarily within a period of 244 <math>\mu\text{s}</math> from the <math>\overline{\text{BUSY}}</math> output trailing edge and it is restarted when the BUSY output goes to the H level again.</p>



Read operation is enabled in this period; however, it is used for program switching.

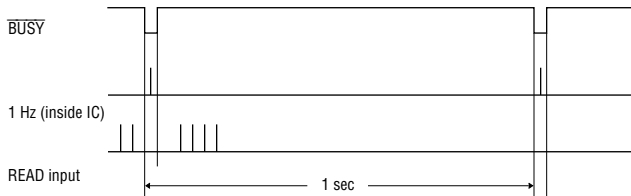


Figure 2

If the counter operation is stopped by setting the STOP input to the H level, read operations are enabled regardless of the  $\overline{\text{BUSY}}$  output.

A read operation is enabled by microcomputer software regardless of the  $\overline{\text{BUSY}}$  output during the counter operation by setting the STOP input to the L level.

In this method, read operations are performed two or more times continuously and data that matches twice is used as guaranteed data.



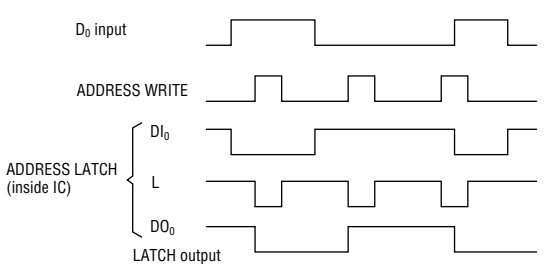
Name	Pin No.	Description
D <sub>0</sub> ~ D <sub>3</sub>	4 ~ 7	Data input/output pins. (Bidirectional bus). The output is a open-drain type and 4.7 kΩ ~ 10 kΩ pull-up registers are required utilize these pins as output pins.
GND	8	Ground pin.
ADDRESS WRITE	9	<p>ADDRESS WRITE pin is used to load address information from the D<sub>0</sub> ~ D<sub>3</sub> I/O bus pins to the ADDRESS LATCH inside the IC; it is activated when it is at the H level. This input is activated by the level, not by the edge. Figure 3 shows the relationships between the D<sub>0</sub> address input, ADDRESS WRITE input, and ADDRESS LATCH input/output.</p> 

Figure 3

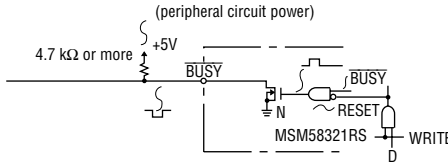
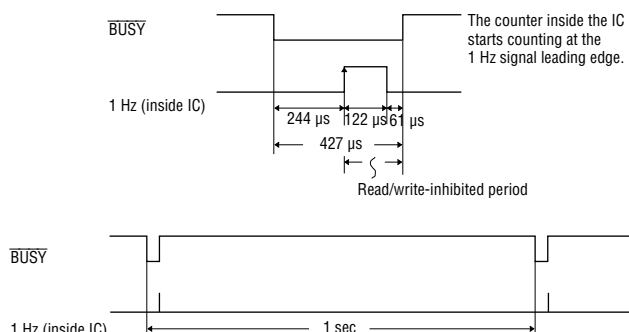
$\overline{\text{BUSY}}$	10	<p><math>\overline{\text{BUSY}}</math> pin outputs the IC operation state. It is N-channel MOSFET open-drain output. An external pull-up resistor of 4.6 kΩ or more must be connected (see Figure 4) to use the <math>\overline{\text{BUSY}}</math> output. The signals are output in negative logics. If the oscillator oscillates at 32.768 kHz, the frequency is always 1 Hz regardless of the CS1 and CS2 unless the D output of the ADDRESS DECODER inside the IC is H (CODE = H•L•H•H) and CS1 = CS2 = WRITE = H. Figure 5 shows the <math>\overline{\text{BUSY}}</math> output time chart.</p> 
		

Figure 5

Name	Pin No.	Description
STOP	11	The STOP pin is used to input on/off control for a 1 Hz signal. When this pin goes to the H level, 1 Hz signals are inhibited and counting for all digits succeeding the S1 digit is stopped. When this pin goes to the L level, normal operations are performed; the digits are counted up. This STOP input controls stopping digit counting. Writing of external data in digits can be assured by setting the STOP input to the H level to stop counting, then writing sequentially from the low-order digits.

TEST	12	<p>The TEST pin is used to test this IC; it is normally open or connected to GND. It is recommended to connect it to GND to safeguard against malfunctions from noise.</p> <p>The TEST pulse can be input to the following nine digits: S1, S10, MI10, H1, D1 (W), M01, Y1 and Y10</p> <p>When a TEST pulse is input to the D1 digit, the W digit is also counted up simultaneously.</p> <p>Input a TEST pulse as follows:                      Set the address to either digit explained above, then input a pulse to the TEST pin while CS1 = CS2 = STOP = H and WRITE = L. The specified and succeeding digits are counted up. (See Figure 6)</p>
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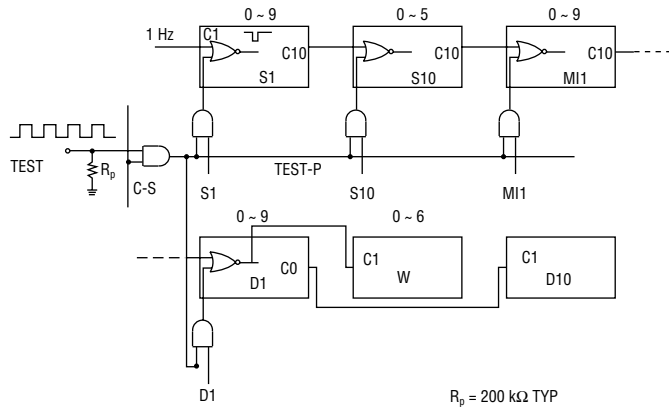


Figure 6

A digit is counted up at the leading edge (changing point from L to H) of a TEST pin input pulse. The pulse condition for TEST pin input at  $V_{DD} = 5V \pm 5\%$  is described in Figure 7 below.

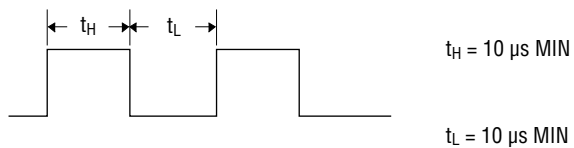
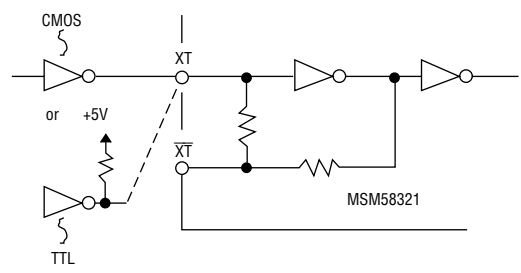


Figure 7

Name	Pin No.	Description
$\overline{XT}$	14	Oscillator pin. A 32.768 kHz crystal oscillator, capacitor and trim capacitor for frequency adjustment are to be connected as shown in Figure 8 below.
XT	15	
		<p><b>Figure 8</b></p>
		<p>If an external clock is to be used for MSM58321's oscillation source, the external clock is to be input to XT, while <math>\overline{XT}</math> should be left open. Refer to the Figure 9 below.</p>
		
		<p><b>Figure 9</b></p>
$V_{DD}$	16	Power supply pin. Refer to the application circuit.

### REFERENCE SIGNAL OUTPUT

Reference signals are output from the D<sub>0</sub> ~ D<sub>3</sub> pins under the following conditions:

Conditions	Output pin	Reference signal frequency	Pulse width	Output logic
WRITE = L	D <sub>0</sub>	1024 Hz	488.3 μs	Positive logic
READ = H	D <sub>1</sub>	1 Hz	122.1 μs	Negative logic
CS1 = CS2 = H	D <sub>2</sub>	1/60 Hz	122.1 μs	Negative logic
ADDRESS = E or F	D <sub>3</sub>	1/3600 Hz	122.1 μs	Netgative logic

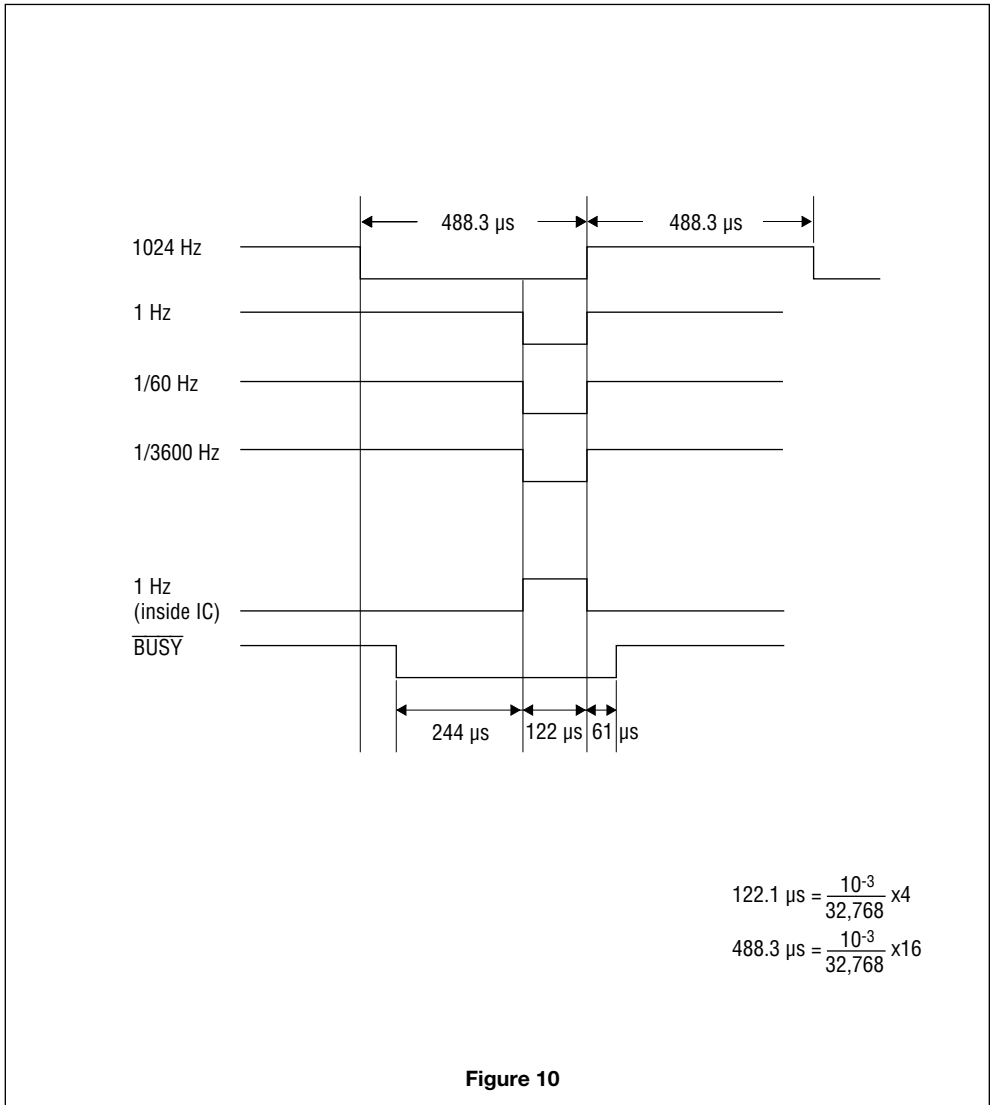
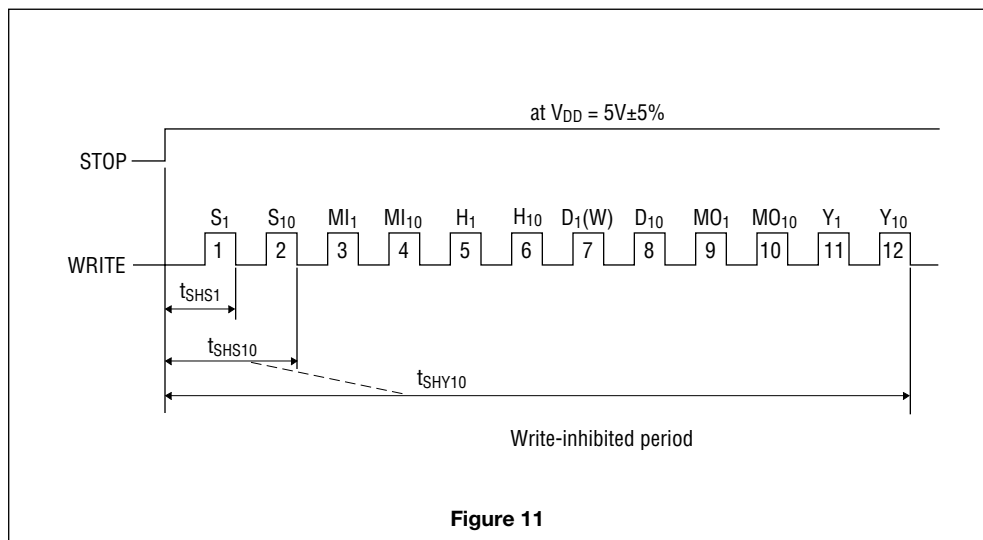


Figure 10

## APPLICATION NOTES

### WRITE and STOP

Note that the timing relationship between the STOP and WRITE inputs vary by the related digit when counting is stopped by the STOP input to write data. The time ( $t_{SH}$ ) between the STOP input leading edge and WRITE input trailing edge for each digit is limited to the minimum value. (See Figure 11)



$t_{SHS1} = 1 \mu s$ ,  $t_{SHS10} = 2 \mu s$ ,  $t_{SHMI1} = 3 \mu s$ ,  $t_{SHMI10} = 4 \mu s$ ,  $t_{SHH1} = 5 \mu s$   
 $t_{SHH10} = 6 \mu s$ ,  $t_{SHD1} = 7 \mu s$ ,  $t_{SHW} = 7 \mu s$ ,  $t_{SHD10} = 8 \mu s$ ,  $t_{SHMO1} = 9 \mu s$   
 $t_{SHMO10} = 10 \mu s$ ,  $t_{SHY1} = 11 \mu s$ ,  $t_{SHY10} = 12 \mu s$ .

If a count operation is continued by setting the STOP input to the L level, write operation must be performed, in principle, while the  $\overline{\text{BUSY}}$  output is at the H level. While the  $\overline{\text{BUSY}}$  output is at the L level, count operations are performed by the digit counters and write operation is inhibited, but there is a marginal period of 244  $\mu\text{s}$  from the  $\overline{\text{BUSY}}$  output trailing edge. If the  $\overline{\text{BUSY}}$  output goes to the L level during a write operation, the write operation is stopped temporarily within 244  $\mu\text{s}$  and it is restarted when the  $\overline{\text{BUSY}}$  output goes to the H level again. Figure 12 shows a time chart of  $\overline{\text{BUSY}}$  output, 1 Hz signal inside the IC, and WRITE input.

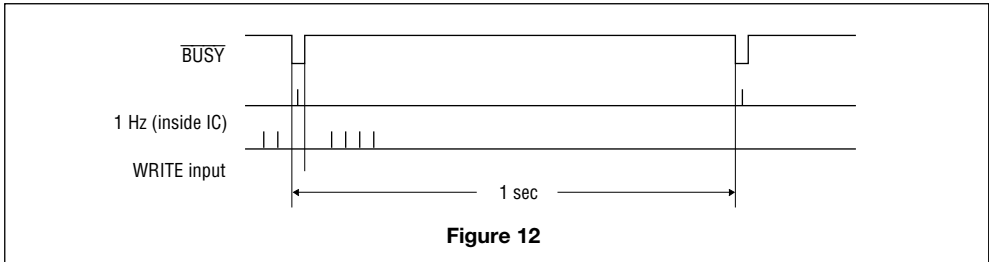


Figure 12

### Frequency divider and $\overline{\text{BUSY}}$ circuit reset

If  $A0 \sim A3 = H \cdot L \cdot H \cdot H$  is input to ADDRESS DECODER, the DECODER output (D) goes to the H level. If  $CS1 = CS2 = H$  and  $\text{WRITE} = H$  in this state, the 5 poststage in the 15-stage frequency divider and the  $\overline{\text{BUSY}}$  circuit are reset.

In this period, the  $\overline{\text{BUSY}}$  output remains at the H level and the 1 Hz signal inside the IC remains at the L level, and counting is stopped. If this reset is inactivated while the oscillator operates, the  $\overline{\text{BUSY}}$  output goes to the L level after  $1000.1221 \pm 31.25 \text{ ms}$  and the 1 Hz signal inside the IC goes to the H level after  $1000.3663 \pm 31.25 \text{ ms}$ . These times are not the same because the first ten stages in the 15-stage frequency divider are not reset. (See Figure 13)

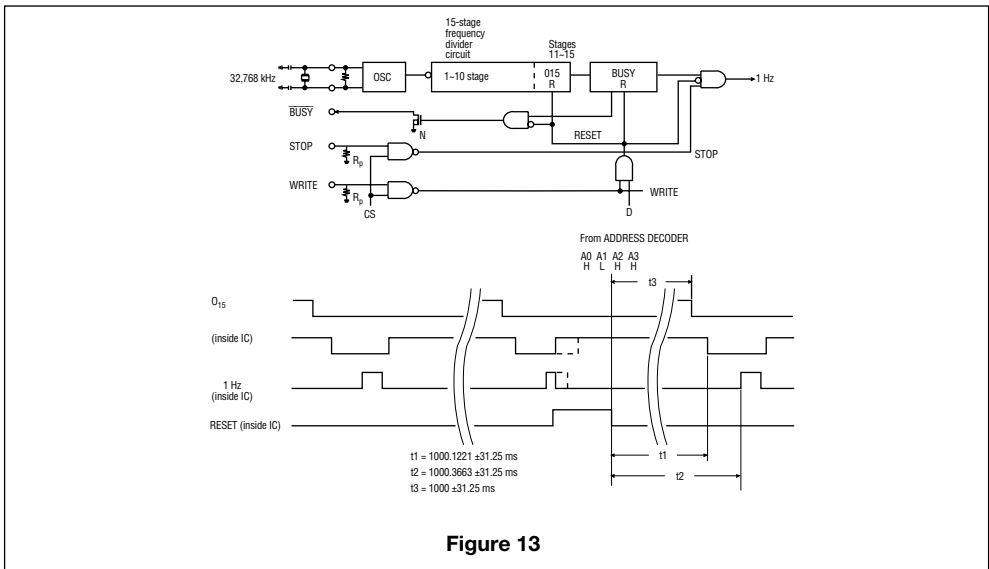


Figure 13

### Selection of leap year

This IC is designed to select leap year automatically.

Four types of leap years can be selected by writing a select signal in the D2 and D3 bits of the D10 digit (CODE = L•L•L•H). (See table 1 for the functions.)

Gregorian calendar or other calendars can be set arbitrarily in the Y1 and Y10 digits of this IC. There is a leap year every four years and the year number varies according to the calendar used. There are four combinations of year numbers and leap years. (See the Table below).

No. 1: Gregorian calendar year. The remainder obtained by dividing the leap year number by 4 is 0.

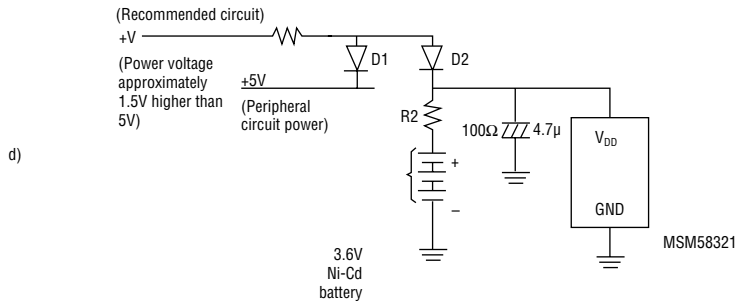
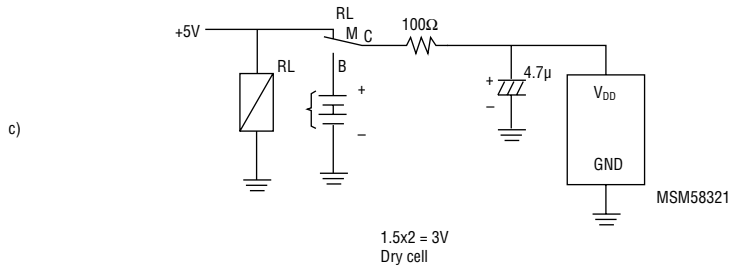
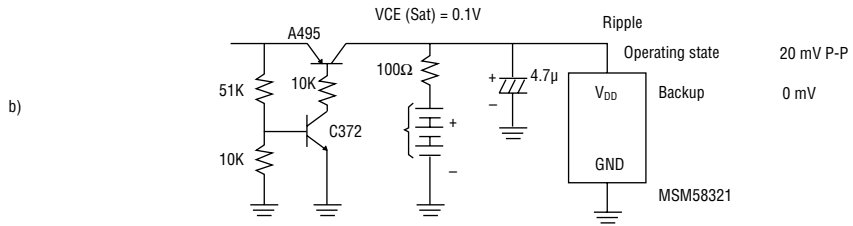
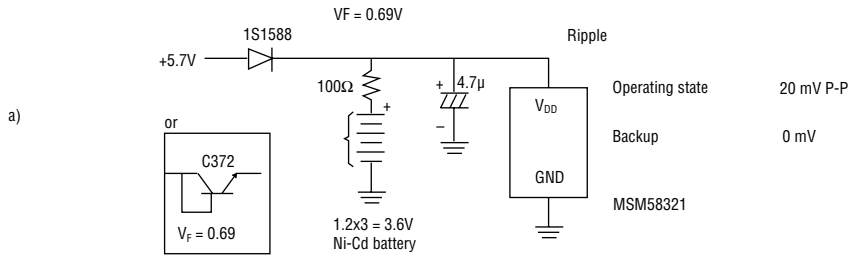
No. 2: The remainder obtained by dividing the leap year number by 4 is 3.

No. 3: The remainder obtained by dividing the leap year number by 4 is 2.

No. 4: The remainder obtained by dividing the leap year number by 4 is 1.

No.1	Calendar	D10 digit		Remainder obtained by dividing the leap year number by 4	Leap years (examples)
		D2	D3		
1	Gregorian	L	L	0	1980, 1984, 1988, 1992 1996, 2000, 2004
2		H	L	3	(83) (87) (91) (95) (99) 55, 59, 63, 67, 71, 75, 79
3		L	H	2	82, 86, 90, 94, 98, 102, 106
4		H	H	1	81, 85, 89, 93, 97, 101, 105

APPLICATION EXAMPLE – POWER SUPPLY CIRCUIT



**Note:** Use the same diodes for D1 and D2 to reduce the level difference between +5V and V<sub>DD</sub> of the MSM58321.