

### OVERVIEW

The SM8580AM is a real-time clock IC based on a 32.768kHz crystal oscillator, which features a 4-bit parallel interface for communication with an external microcontroller. It comprises second-counter to year-counter clock and calendar circuits that feature automatic leap-year adjustment up to year 2099, alarm and timer interrupt functions, clock counter change detect functions,  $\pm 30$ -second correction function, time error correction function, and built-in temperature sensor. The 4-bit parallel interface is compatible with general-purpose SRAM over a high-speed bus.

### FEATURES

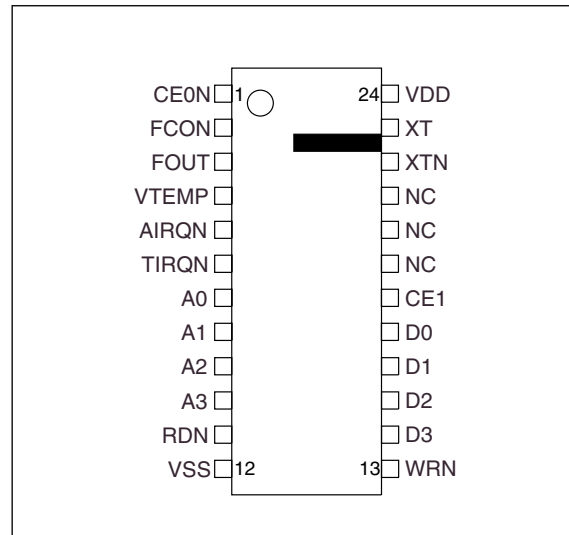
- High-speed bus 4-bit parallel interface
- Date, day, hour, minute, and second-counter pre-settable alarm interrupt
- 1/4096 seconds to 255 minutes presetable interval timer interrupt function
- 2 software-maskable alarm and timer interrupt outputs
- Clock counter change detect functions
- 4-digit western calendar display
- Automatic leap year correction up to year 2099
- $\pm 30$ -second adjust function
- $-195$  to  $+192$ ppm time error correction range
- Built-in temperature sensor (analog voltage output)
- 2.4 to 5.5V interface voltage range
- 1.6 to 5.5V clock voltage range
- $0.6\mu\text{A}/3\text{V}$  (typ) current consumption

### ORDERING INFORMATION

| Device   | Package     |
|----------|-------------|
| SM8580AM | 24-pin SSOP |

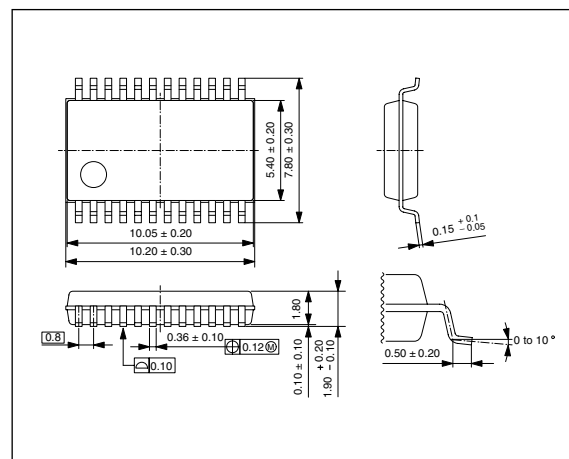
### PINOUT

(Top view)

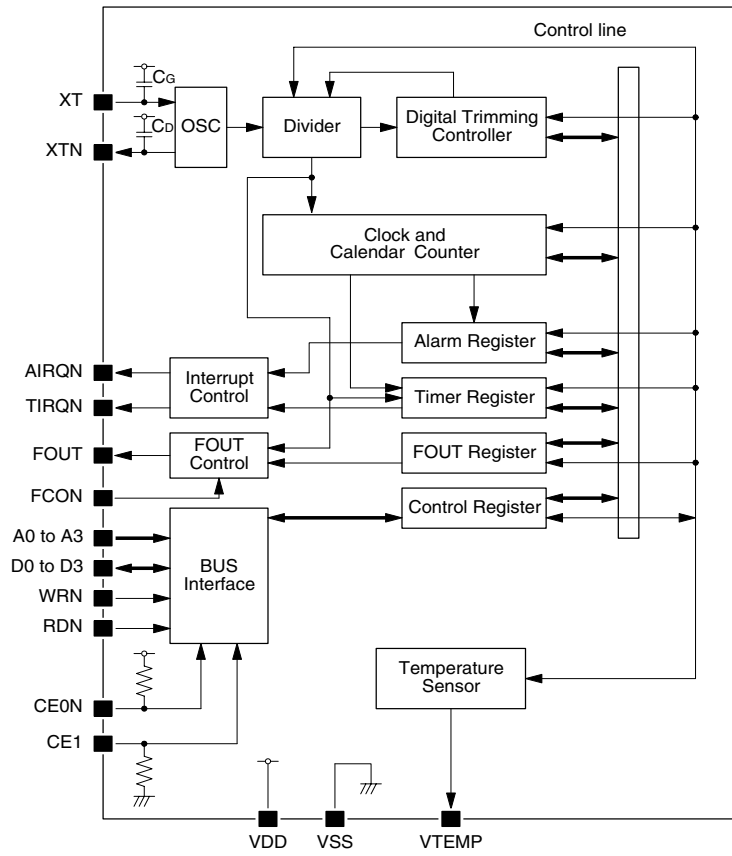


### PACKAGE DIMENSIONS

(Unit: mm)



BLOCK DIAGRAM



## SM8580AM

### PIN DESCRIPTION

| Number | Name  | I/O | Function <sup>1</sup>   |
|--------|-------|-----|---|
| 1      | CE0N  | I   | Chip enable 0 input with built-in pull-up resistor.<br>The SM8580AM can be accessed when CE0N is LOW and CE1 is HIGH.   |
| 2      | FCON  | I   | FOUT output frequency select control input (when CE1 is HIGH).<br>32.768kHz fixed frequency output when FCON is LOW.<br>Output frequency determined by bit FD when FCON is HIGH (when FE bit is 1).<br>Note that a HIGH-level voltage should be applied to FCON to avoid unwanted 32.768kHz output during backup. |
| 3      | FOUT  | O   | Frequency set register, frequency output (CMOS output)  |
| 4      | VTEMP | O   | Temperature voltage output (analog output)  |
| 5      | AIRQN | O   | Alarm interrupt output (N-channel open-drain output)  |
| 6      | TIRQN | O   | Timer interrupt output (N-channel open-drain output)  |
| 7      | A0    | I   | Address inputs.<br>Connect to the microcontroller address bus.<br>The selected register address is input on this bus when accessing the SM8580AM (positive logic).  |
| 8      | A1    | I   |   |
| 9      | A2    | I   |   |
| 10     | A3    | I   |   |
| 11     | RDN   | I   | Read strobe input. Data can be read from SM8580AM when RDN is LOW and WRN is HIGH.<br>An error will occur if both RDN and WRN are simultaneously LOW.   |
| 12     | VSS   | –   | Ground  |
| 13     | WRN   | I   | Write strobe input. Data can be written to SM8580AM when RDN is HIGH and WRN is LOW.<br>An error will occur if both RDN and WRN are simultaneously LOW.   |
| 14     | D3    | I/O | Data bus input/outputs.<br>Connect to the microcontroller data bus.   |
| 15     | D2    | I/O |   |
| 16     | D1    | I/O |   |
| 17     | D0    | I/O |   |
| 18     | CE1   | I   | Chip enable 1 input with built-in pull-down resistor.<br>The SM8580AM can be accessed when CE0N is LOW and CE1 is HIGH.<br>FOUT is in output mode when CE1 is HIGH, regardless of the state of CE0N. FOUT is high impedance when CE1 is LOW.  |
| 19     | NC    | –   | No connection   |
| 20     | NC    | –   | No connection   |
| 21     | NC    | –   | No connection   |
| 22     | XTN   | O   | Oscillator output, with built-in oscillator capacitance $C_D$   |
| 23     | XT    | I   | Oscillator output, with built-in oscillator capacitance $C_G$   |
| 24     | VDD   | –   | Supply  |

1. Connect a 0.1 $\mu$ F capacitor between VDD and VSS.

## FOUT Output and SM8580AM Access Relationship

| CE0N | CE1  | FCON | FE bit | FOUT output                    | SM8580AM accessible |
|------|------|------|--------|--------------------------------|---------------------|
| HIGH | LOW  | ×    | ×      | High impedance                 | No                  |
| LOW  | LOW  | ×    | ×      | High impedance                 | No                  |
| HIGH | HIGH | LOW  | 0      | 32.768kHz output               | No                  |
|      |      | LOW  | 1      | 32.768kHz output               | No                  |
|      |      | HIGH | 0      | High impedance                 | No                  |
|      |      | HIGH | 1      | FD bit select frequency output | No                  |
| LOW  | HIGH | LOW  | 0      | 32.768kHz output               | Yes                 |
|      |      | LOW  | 1      | 32.768kHz output               | Yes                 |
|      |      | HIGH | 0      | High impedance                 | Yes                 |
|      |      | HIGH | 1      | FD bit select frequency output | Yes                 |

## SPECIFICATIONS

### Absolute Maximum Ratings

$V_{SS} = 0V$

| Parameter                 | Symbol     | Condition             | Rating                           | Unit |
|---------------------------|------------|-----------------------|----------------------------------|------|
| Supply voltage range      | $V_{DD}$   |                       | -0.3 to 7.0                      | V    |
| Input voltage range       | $V_{IN}$   | All inputs, D0 to D3  | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V    |
| Output voltage range      | $V_{OUT1}$ | TIRQN, AIRQN          | $V_{SS} - 0.3$ to 8.0            | V    |
|                           | $V_{OUT2}$ | FOUT, D0 to D3, VTEMP | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V    |
| Storage temperature range | $T_{stg}$  |                       | -55 to 125                       | °C   |

### Recommended Operating Conditions

$V_{SS} = 0V$

| Parameter                   | Symbol    | Condition | Rating     | Unit |
|-----------------------------|-----------|-----------|------------|------|
| Supply voltage range        | $V_{DD}$  |           | 2.4 to 5.5 | V    |
| Clock supply voltage range  | $V_{CLK}$ |           | 1.6 to 5.5 | V    |
| Operating temperature range | $T_{opr}$ |           | -40 to 85  | °C   |

SM8580AM

DC Electrical Characteristics

$V_{SS} = 0V$ ,  $V_{DD} = 1.6$  to  $5.5V$ ,  $T_a = -40$  to  $85^{\circ}C$  unless otherwise noted.

| Parameter                   | Symbol     | Condition   | Rating         |      |                | Unit       |
|-----------------------------|------------|---|----------------|------|----------------|------------|
|                             |            |   | min            | typ  | max            |            |
| Current consumption 1       | $I_{DD1}$  | $V_{DD} = 5V$<br>CE0N = RDN = WRN = $V_{DD}$ ,<br>A0 to A3 = D0 to D3 = $V_{DD}$ or $V_{SS}$ ,  | –              | 1.0  | 2.0            | $\mu A$    |
| Current consumption 2       | $I_{DD2}$  | $V_{DD} = 3V$<br>CE1 = FCON = $V_{SS}$ ,<br>AIRQN = TIRQN = FOUT = $V_{DD}$ ,<br>VTEMP output OFF (TEMP bit = 0)                                    | –              | 0.6  | 1.0            | $\mu A$    |
| Current consumption 3       | $I_{DD3}$  | $V_{DD} = 5V$<br>Ta = 25°C,<br>CE0N = RDN = WRN = $V_{DD}$ ,<br>A0 to A3 = D0 to D3 = $V_{DD}$ or $V_{SS}$ ,  | –              | 50   | 75             | $\mu A$    |
| Current consumption 4       | $I_{DD4}$  | $V_{DD} = 3V$<br>CE1 = FCON = $V_{SS}$ ,<br>AIRQN = TIRQN = FOUT = $V_{DD}$ ,<br>VTEMP output ON (TEMP bit = 1)                                     | –              | 40   | 60             | $\mu A$    |
| Current consumption 5       | $I_{DD5}$  | $V_{DD} = 5V$<br>CE0N = CE1 = RDN = WRN = $V_{DD}$ ,<br>A0 to A3 = D0 to D3 = $V_{SS}$ ,  | –              | 3.0  | 7.5            | $\mu A$    |
| Current consumption 6       | $I_{DD6}$  | $V_{DD} = 3V$<br>FCON = $V_{SS}$ ,<br>AIRQN = TIRQN = FOUT = VTEMP = Hi-Z,<br>VTEMP output OFF (TEMP bit = 0),<br>FOUT = 32kHz output, $C_L = 0pF$  | –              | 1.7  | 4.5            | $\mu A$    |
| Current consumption 7       | $I_{DD7}$  | $V_{DD} = 5V$<br>CE0N = CE1 = RDN = WRN = $V_{DD}$ ,<br>A0 to A3 = D0 to D3 = $V_{SS}$ ,  | –              | 8.0  | 20             | $\mu A$    |
| Current consumption 8       | $I_{DD8}$  | $V_{DD} = 3V$<br>FCON = $V_{SS}$ ,<br>AIRQN = TIRQN = FOUT = VTEMP = Hi-Z,<br>VTEMP output OFF (TEMP bit = 0),<br>FOUT = 32kHz output, $C_L = 30pF$ | –              | 5.0  | 12             | $\mu A$    |
| HIGH-level input voltage 1  | $V_{IH1}$  | $V_{DD} = 4.5$ to $5.5V$ ,<br>CE0N, FCON, RDN, WRN, A0 to A3, D0 to D3  | 2.2            | –    | $V_{DD} + 0.3$ | V          |
| LOW-level input voltage 1   | $V_{IL1}$  |   | $V_{SS} - 0.3$ | –    | 0.8            | V          |
| HIGH-level input voltage 2  | $V_{IH2}$  | $V_{DD} = 2.4$ to $3.6V$ ,<br>CE0N, FCON, RDN, WRN, A0 to A3, D0 to D3  | $0.8V_{DD}$    | –    | $V_{DD} + 0.3$ | V          |
| LOW-level input voltage 2   | $V_{IL2}$  |   | $V_{SS} - 0.3$ | –    | $0.2V_{DD}$    | V          |
| HIGH-level input voltage 3  | $V_{IH3}$  | $V_{DD} = 1.6$ to $5.5V$ ,<br>CE1   | $0.8V_{DD}$    | –    | $V_{DD} + 0.3$ | V          |
| LOW-level input voltage 3   | $V_{IL3}$  |   | $V_{SS} - 0.3$ | –    | $0.2V_{DD}$    | V          |
| Input leakage current       | $I_{LEAK}$ | CE0N = $V_{DD}$ , CE1 = $V_{SS}$ ,<br>FCON = RDN = WRN = A0 to A3 = $V_{DD}$ or $V_{SS}$  | –0.5           | –    | 0.5            | $\mu A$    |
| Pull-up resistance 1        | $R_{UP1}$  | $V_{DD} = 5V$<br>CE0N = $V_{SS}$  | 75             | 150  | 300            | k $\Omega$ |
| Pull-up resistance 2        | $R_{UP2}$  |   | $V_{DD} = 3V$  | 150  | 300            | 600        |
| Pull-down resistance 1      | $R_{DWN1}$ | $V_{DD} = 5V$<br>CE1 = $V_{DD}$   | 20             | 40   | 80             | M $\Omega$ |
| Pull-down resistance 2      | $R_{DWN2}$ |   | $V_{DD} = 3V$  | 42.5 | 85             | 170        |
| Pull-down resistance 3      | $R_{DWN3}$ | $V_{DD} = 5V$<br>CE1 = 0.5V   | 30             | 60   | 120            | k $\Omega$ |
| Pull-down resistance 4      | $R_{DWN4}$ |   | $V_{DD} = 3V$  | 55   | 110            | 220        |
| HIGH-level output voltage 1 | $V_{OH1}$  | $V_{DD} = 5V$<br>$I_{OH} = -1mA$ , D0 to D3, FOUT   | 4.5            | –    | 5.0            | V          |
| HIGH-level output voltage 2 | $V_{OH2}$  |   | $V_{DD} = 3V$  | 2.0  | –              | 3.0        |
| HIGH-level output voltage 3 | $V_{OH3}$  | $V_{DD} = 3V$<br>$I_{OH} = -100\mu A$ , D0 to D3, FOUT  | 2.9            | –    | 3.0            | V          |
| LOW-level output voltage 1  | $V_{OL1}$  | $V_{DD} = 5V$<br>$I_{OL} = 1mA$ , D0 to D3, FOUT  | 0              | –    | 0.5            | V          |
| LOW-level output voltage 2  | $V_{OL2}$  |   | $V_{DD} = 3V$  | 0    | –              | 0.8        |
| LOW-level output voltage 3  | $V_{OL3}$  | $V_{DD} = 3V$<br>$I_{OL} = 100\mu A$ , D0 to D3, FOUT   | 0              | –    | 0.1            | V          |
| LOW-level output voltage 4  | $V_{OL4}$  | $V_{DD} = 5V$<br>$I_{OL} = 1mA$ , AIRQN, TIRQN  | 0              | –    | 0.25           | V          |
| LOW-level output voltage 5  | $V_{OL5}$  |   | $V_{DD} = 3V$  | 0    | –              | 0.4        |
| Output leakage current      | $I_{OZ}$   | D0 to D3, AIRQN, TIRQN, FOUT, $V_{OUT} = V_{DD}$ or $V_{SS}$  | –0.5           | –    | 0.5            | $\mu A$    |

## Terminal Capacitance Characteristics

Ta = 25°C, f = 1MHz

| Parameter                 | Symbol            | Condition | Rating |     |     | Unit |
|---------------------------|-------------------|-----------|--------|-----|-----|------|
|                           |                   |           | min    | typ | max |      |
| Address input capacitance | C <sub>ADD</sub>  | A0 to A3  | –      | –   | 8   | pF   |
| Data output capacitance   | C <sub>DATA</sub> | D0 to D3  | –      | –   | 15  | pF   |

## Oscillator Characteristics

Ta = 25°C, NPC's standard crystal (C<sub>1</sub> = 30kΩ, C<sub>L</sub> = 10pF) unless otherwise noted.

| Parameter                        | Symbol           | Condition                     | Rating |     |     | Unit  |
|----------------------------------|------------------|-------------------------------|--------|-----|-----|-------|
|                                  |                  |                               | min    | typ | max |       |
| Oscillator start time            | t <sub>STA</sub> | V <sub>DD</sub> = 1.6 V       | –      | –   | 3.0 | s     |
| Oscillator stop voltage          | V <sub>STO</sub> |                               | –      | –   | 1.5 | V     |
| Frequency voltage characteristic | f/V              | V <sub>DD</sub> = 1.6 to 5.5V | –2     | –   | +2  | ppm/V |
| Frequency accuracy               | ε <sub>IC</sub>  | V <sub>DD</sub> = 3.0V        | –20    | –   | +20 | ppm   |
| Input capacitance                | C <sub>G</sub>   | V <sub>DD</sub> = 3.0V        | –      | 15  | –   | pF    |
| Output capacitance               | C <sub>D</sub>   | V <sub>DD</sub> = 3.0V        | –      | 10  | –   | pF    |

## AC Characteristics (1)

V<sub>SS</sub> = 0V, Ta = –40 to 85°C unless otherwise noted.

| Parameter                         | Symbol           | Condition                  | Rating |     |     | Unit |
|-----------------------------------|------------------|----------------------------|--------|-----|-----|------|
|                                   |                  |                            | min    | max | min |      |
| FOUT duty                         | Duty             | V <sub>DD</sub> = 5V ± 10% | 40     | –   | 60  | %    |
|                                   |                  | V <sub>DD</sub> = 3V ± 10% | 40     | –   | 60  | %    |
| Oscillator failure detection time | t <sub>OSC</sub> | V <sub>DD</sub> = 5V ± 10% | 10     | –   | –   | ms   |
|                                   |                  | V <sub>DD</sub> = 3V ± 10% | 10     | –   | –   | ms   |

**AC Characteristics (2)**

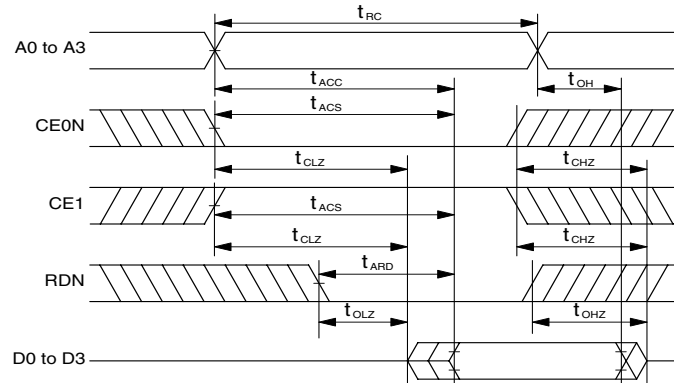
$V_{DD} = 2.4$  to  $3.6V$ ,  $V_{SS} = 0V$ ,  $T_a = -40$  to  $85^{\circ}C$ , inputs  $V_I = 0.5V_{DD}$ , outputs  $V_O = 0.5V_{DD}$ , output load capacitance  $C_L = 100pF$  ( $t_{ACC}$ ,  $t_{ACS}$ ,  $t_{ARD}$ )

| Parameter                     | Symbol    | Rating |     | Unit |
|-------------------------------|-----------|--------|-----|------|
|                               |           | min    | max |      |
| Read cycle time               | $t_{RC}$  | 150    | –   | ns   |
| Address access time           | $t_{ACC}$ | –      | 150 | ns   |
| CE access time                | $t_{ACS}$ | –      | 150 | ns   |
| RD access time                | $t_{ARD}$ | –      | 100 | ns   |
| CE output set time            | $t_{CLZ}$ | 5      | –   | ns   |
| CE output floating            | $t_{CHZ}$ | –      | 60  | ns   |
| RD output set time            | $t_{OLZ}$ | 5      | –   | ns   |
| RD output floating            | $t_{OHZ}$ | –      | 60  | ns   |
| Output hold time              | $t_{OH}$  | 10     | –   | ns   |
| Write cycle time              | $t_{WC}$  | 150    | –   | ns   |
| Chip select time              | $t_{CW}$  | 140    | –   | ns   |
| Address valid to end-of-write | $t_{AW}$  | 140    | –   | ns   |
| Address setup time            | $t_{AS}$  | 0      | –   | ns   |
| Address hold time             | $t_{WR}$  | 0      | –   | ns   |
| Write pulsewidth              | $t_{WP}$  | 130    | –   | ns   |
| Input data set time           | $t_{DW}$  | 80     | –   | ns   |
| Input data hold time          | $t_{DH}$  | 0      | –   | ns   |

$V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $T_a = -40$  to  $85^{\circ}C$ , inputs  $V_I = 0.5V_{DD}$ , outputs  $V_O = 0.5V_{DD}$ , output load capacitance  $C_L = 100pF$  ( $t_{ACC}$ ,  $t_{ACS}$ ,  $t_{ARD}$ )

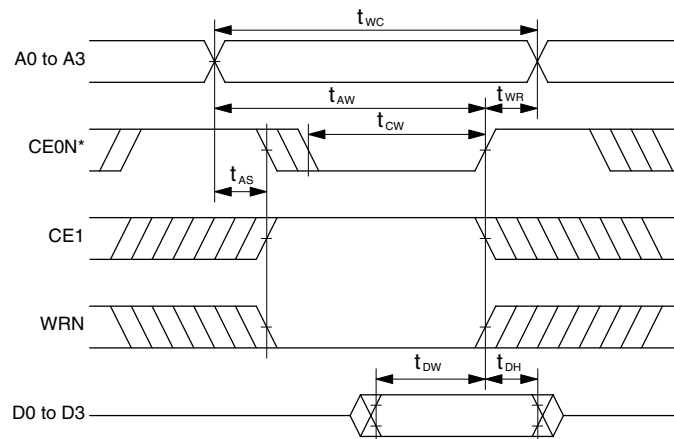
| Parameter                     | Symbol    | Rating |     | Unit |
|-------------------------------|-----------|--------|-----|------|
|                               |           | min    | max |      |
| Read cycle time               | $t_{RC}$  | 85     | –   | ns   |
| Address access time           | $t_{ACC}$ | –      | 85  | ns   |
| CE access time                | $t_{ACS}$ | –      | 85  | ns   |
| RD access time                | $t_{ARD}$ | –      | 45  | ns   |
| CE output set time            | $t_{CLZ}$ | 3      | –   | ns   |
| CE output floating            | $t_{CHZ}$ | –      | 30  | ns   |
| RD output set time            | $t_{OLZ}$ | 3      | –   | ns   |
| RD output floating            | $t_{OHZ}$ | –      | 30  | ns   |
| Output hold time              | $t_{OH}$  | 5      | –   | ns   |
| Write cycle time              | $t_{WC}$  | 85     | –   | ns   |
| Chip select time              | $t_{CW}$  | 70     | –   | ns   |
| Address valid to end-of-write | $t_{AW}$  | 70     | –   | ns   |
| Address setup time            | $t_{AS}$  | 0      | –   | ns   |
| Address hold time             | $t_{WR}$  | 0      | –   | ns   |
| Write pulsewidth              | $t_{WP}$  | 65     | –   | ns   |
| Input data set time           | $t_{DW}$  | 35     | –   | ns   |
| Input data hold time          | $t_{DH}$  | 0      | –   | ns   |

Data read

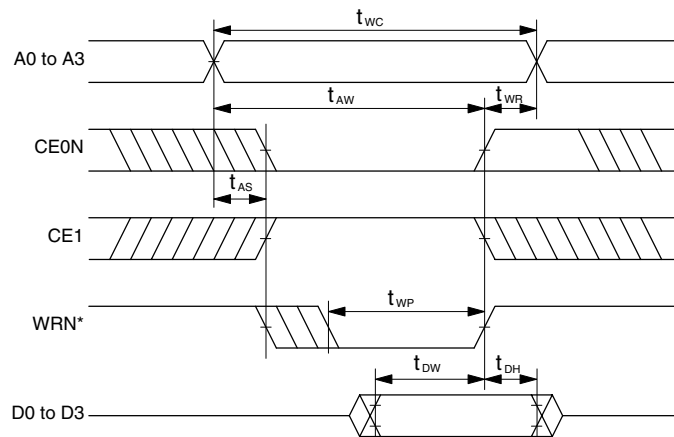


Data write

CE control



WR control



\*: When writing data, CE0N or WRN should be held HIGH level while the address changes.

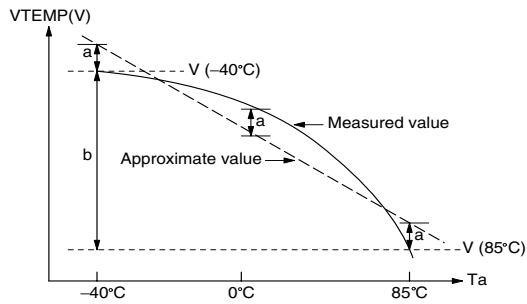


### Temperature Sensor

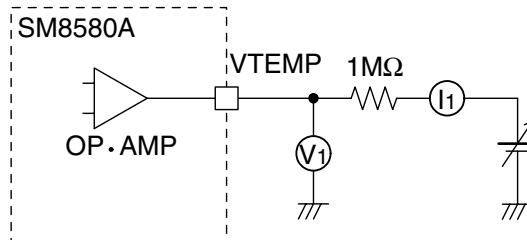
$V_{SS} = 0V$ ,  $T_a = -40$  to  $85^\circ C$  unless otherwise noted.

| Parameter                            | Symbol      | Condition   | Rating |       |           | Unit           |
|--------------------------------------|-------------|---|--------|-------|-----------|----------------|
|                                      |             |   | min    | max   | min       |                |
| Temperature sensor output voltage    | $V_{OUT}$   | $T_a = 25^\circ C$ , $V_{SS}$ reference output voltage, $V_{DD} = 2.7$ to $5.5V$ , $V_{TEMP}$ | -      | 1.470 | -         | V              |
| Output accuracy                      | $T_{ACR}$   | $T_a = 25^\circ C$  | -      | -     | $\pm 5$   | $^\circ C$     |
| Temperature sensitivity <sup>1</sup> | $V_{SE}$    | $-40^\circ C \leq T_a \leq 85^\circ C$ , $V_{DD} = 2.7$ to $5.5V$                             | -7.3   | -7.8  | -8.3      | mV/ $^\circ C$ |
| Linearity <sup>2</sup>               | $\Delta NL$ | $-40^\circ C \leq T_a \leq 85^\circ C$ , $V_{DD} = 2.7$ to $5.5V$                             | -      | -     | $\pm 2.0$ | %              |
| Temperature detection range          | $T_{OPR}$   | $\Delta NL \leq \pm 2.0\%$ , $V_{DD} = 2.7$ to $5.5V$   | -40    | -     | 85        | $^\circ C$     |
| Output resistance <sup>3</sup>       | $R_O$       | $T_a = 25^\circ C$ , $V_{DD} = 2.7$ to $5.5V$ , $V_{TEMP}$                                    | -      | 1.0   | 3.0       | k $\Omega$     |
| Output load capacitance              | $C_L$       | $V_{DD} = 2.7$ to $5.5V$  | -      | -     | 100       | pF             |
| Output load resistance               | $R_L$       | $V_{DD} = 2.7$ to $5.5V$  | 500    | -     | -         | k $\Omega$     |
| Response time                        | $t_{RSP}$   | $V_{DD} = 3.0V$ , $R_L = 500k\Omega$ , $C_L = 100pF$  | -      | -     | 200       | $\mu s$        |

- Temperature sensitivity  $V_{SE} = (V(85^\circ C) - V(-40^\circ C)) \div 125$  [mV/ $^\circ C$ ]
- Linearity  $\Delta NL = a \div b \times 100$  [%], where  
 a = maximum deviation between the measured value and the approximated value of  $V_{TEMP}$ , and  
 b = difference between the measured values at temperatures of  $-40$  and  $85^\circ C$



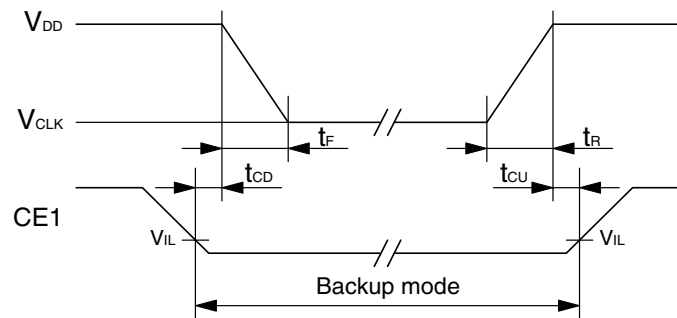
- Output resistance  $R_O = \Delta V_1 \div \Delta I_1$  [ $\Omega$ ]



### Backup Transfer and Return

| Parameter <sup>1</sup>                    | Symbol   | Condition                             | Rating |     |     | Unit            |
|---|----------|---------------------------------------|--------|-----|-----|-----------------|
|   |          |                                       | min    | max | min |                 |
| Supply voltage falling edge CE setup time | $t_{CD}$ |                                       | 0      | -   | -   | $\mu\text{s}$   |
| Supply voltage fall time                  | $t_F$    | $(V_{DD} - V_{CLK}) \leq 2.0\text{V}$ | 2      | -   | -   | $\mu\text{s/V}$ |
|   |          | $(V_{DD} - V_{CLK}) > 2.0\text{V}$    | 50     | -   | -   | $\mu\text{s/V}$ |
| Supply voltage rise time                  | $t_R$    |                                       | 1      | -   | -   | $\mu\text{s/V}$ |
| Supply voltage rising edge CE hold time   | $t_{CU}$ |                                       | 0      | -   | -   | $\mu\text{s}$   |

1. Before switching the supply, confirm that the chip enable CE1 is LOW and that SM8580AM is deselected.



## FUNCTIONAL DESCRIPTION

### Register Tables

#### Bank 0 (clock, calendar registers)

| Address | Register             | Bit 3            | Bit 2     | Bit 1     | Bit 0 |
|---------|----------------------|------------------|-----------|-----------|-------|
| 0       | Second registers     | 8                | 4         | 2         | 1     |
| 1       |                      | FOS              | 40        | 20        | 10    |
| 2       | Minute registers     | 8                | 4         | 2         | 1     |
| 3       |                      | #                | 40        | 20        | 10    |
| 4       | Hour registers       | 8                | 4         | 2         | 1     |
| 5       |                      | #                | #         | 20        | 10    |
| 6       | Day of week register | #                | 4         | 2         | 1     |
| 7       | Date registers       | 8                | 4         | 2         | 1     |
| 8       |                      | #                | #         | 20        | 10    |
| 9       | Month registers      | 8                | 4         | 2         | 1     |
| A       |                      | #                | #         | #         | 10    |
| B       | Year registers       | 8                | 4         | 2         | 1     |
| C       |                      | 80               | 40        | 20        | 10    |
| D       |                      | 800              | 400       | 200       | 100   |
| E       |                      | TEST             | TEMP      | 2000      | 1000  |
| F       |                      | Control register | Bank SEL1 | Bank SEL0 | STOP  |

#### Bank 1 (alarm, FOUT registers)

| Address | Register                    | Bit 3     | Bit 2     | Bit 1 | Bit 0    |
|---------|-----------------------------|-----------|-----------|-------|----------|
| 0       | Second registers            | 8         | 4         | 2     | 1        |
| 1       |                             | AE        | 40        | 20    | 10       |
| 2       | Minute registers            | 8         | 4         | 2     | 1        |
| 3       |                             | AE        | 40        | 20    | 10       |
| 4       | Hour registers              | 8         | 4         | 2     | 1        |
| 5       |                             | AE        | *         | 20    | 10       |
| 6       | Day of week register        | AE        | 4         | 2     | 1        |
| 7       | Date registers              | 8         | 4         | 2     | 1        |
| 8       |                             | AE        | *         | 20    | 10       |
| 9       | –                           | *         | *         | *     | *        |
| A       | –                           | *         | *         | *     | *        |
| B       | CE1 control                 | CTEMP     | CDT_ON    | *     | *        |
| C       | FOUT divider set register   | #         | FD2       | FD1   | FD0      |
| D       | FOUT frequency set register | FE        | #         | FD4   | FD3      |
| E       | Alarm control               | TEST      | TEMP      | AF    | AIE      |
| F       | Control register            | Bank SEL1 | Bank SEL0 | STOP  | BUSY/ADJ |

#### Bank 2 (digital correction, timer registers)

| Address | Register                       | Bit 3     | Bit 2     | Bit 1 | Bit 0    |
|---------|--------------------------------|-----------|-----------|-------|----------|
| 0       | Digital correction registers   | DT3       | DT2       | DT1   | DT0      |
| 1       |                                | DT_ON     | DT6       | DT5   | DT4      |
| 2       | –                              | #         | #         | #     | #        |
| 3       | –                              | #         | #         | #     | #        |
| 4       | Timer counter set registers    | 8         | 4         | 2     | 1        |
| 5       |                                | 128       | 64        | 32    | 16       |
| 6       | Timer counter output registers | 8         | 4         | 2     | 1        |
| 7       |                                | 128       | 64        | 32    | 16       |
| 8       | Timer setting                  | TE        | TI/TP     | TD1   | TD0      |
| 9       | –                              | #         | #         | #     | #        |
| A       | –                              | #         | #         | #     | #        |
| B       | –                              | *         | *         | *     | *        |
| C       | –                              | *         | *         | *     | *        |
| D       | –                              | *         | *         | *     | *        |
| E       | Timer control                  | TEST      | TEMP      | TF    | TIE      |
| F       | Control register               | Bank SEL1 | Bank SEL0 | STOP  | BUSY/ADJ |

- All bits in register F and bits 2 to 3 in register E are common to all register banks.
- When alarm interrupts are not used, registers 0 to 8 in bank 1 can be used as RAM (total 36 bits).
- When timer interrupts are not used, registers 4 to 8 in bank 2 can be used as RAM (total 8 bits).
- When digital correction is not used, registers 0 to 1 in bank 2 can be used as RAM, excluding bit 3 (DT\_ON) in register 1 (total 7 bits).
- The BUSY/ADJ bit function is BUSY when reading, and ADJ when writing.
- The BUSY flag is set to 1 an interval of 244μs before clock counter update timing.
- Registers 6 and 7 in bank 2 are read-only registers, and cannot be written to.
- When power is applied, all register bits are undefined, with the exception of bits FOS, TEST and TEMP. Accordingly, these bits need to be initialized. TEST and TEMP are automatically reset to 0 and FOS is automatically reset to 1 when power is applied.
- Bits marked # are all read-only bits fixed to 0. These bits cannot be written to.
- Bits marked \* can be used as RAM bits.

## Control Registers (All Banks, Register E (bits 2, 3) and F)

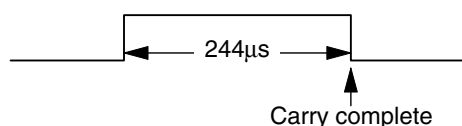
| Bank    | Address | Bit 3     | Bit 2     | Bit 1 | Bit 0    |
|---------|---------|-----------|-----------|-------|----------|
| 0, 1, 2 | E       | TEST      | TEMP      |       |          |
|         | F       | Bank SEL1 | Bank SEL0 | STOP  | BUSY/ADJ |

- TEST bit  
Factory test bit.  
This bit should be set to 0. Take care when writing to other E register bits not to accidentally write 1 to the TEST bit. Automatically resets to 0 when power (VDD) is applied.
- TEMP bit  
When set to 1, it enables the temperature sensor voltage output on pin VTEMP. When set to 0, VTEMP is high impedance. Automatically resets to 0 when power is applied.
- Bank SEL bits  
Bank select bits for read/write operations.

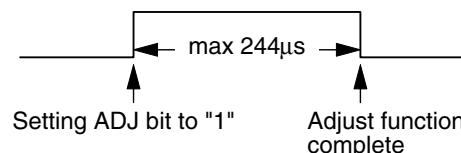
| Bank SEL1 | Bank SEL0 | Accessed bank |
|-----------|-----------|---------------|
| 0         | 0         | Bank 0        |
| 0         | 1         | Bank 1        |
| 1         | 0         | Bank 2        |
| 1         | 1         | Bank 1        |

- STOP bit  
When set to 1, the clock 32Hz frequency divider counter stops and is reset. When set to 0, the clock restarts.
- BUSY/ADJ bit  
This bit functions as a BUSY function in read mode, and as an ADJ function in write mode.
  - ADJ function ( $\pm 30$  seconds adjust bit)  
The following processes are operated when a logic 1 is written to ADJ, however a logic 0 cannot be written to.  
Second registers are reset to 00 and minute registers not incremented when the clock counter is reset and the second registers are currently 00 to 29.  
Second registers are reset to 00 and minute registers are incremented when the clock counter is reset and the second registers are currently 30 to 59.  
The ADJ bit is automatically reset to 0 a maximum of 244 $\mu$ s after it is set to 1.
  - BUSY function (second registers increment or  $\pm 30$  seconds adjust busy indicator bit)  
When BUSY is 1, the counters are being updated (incremented or reset). To read or write to clock and calendar registers, the BUSY flag has to be 0. If reading data when BUSY is set to 1, there is a possibility that incorrect (intermediate) data will be output.  
BUSY is set to 1 under the following two circumstances.

### Normal seconds digit carry



### $\pm 30$ seconds digit adjust (when ADJ is set to 1)



■ Function operation table

| Bit  |     | Function                    |                                |                        |                                |
|------|-----|-----------------------------|--------------------------------|------------------------|--------------------------------|
| STOP | ADJ | Clock                       | Timer                          | Alarm                  | FOUT                           |
| 0    | 0   | Operating                   | Operating <sup>3</sup>         | Operating              | Operating <sup>7</sup>         |
| 0    | 1   | Adjust <sup>1</sup>         | Operating <sup>4</sup>         | Operating <sup>6</sup> | Operating <sup>8</sup>         |
| 1    | 0   | Stopped                     | Operating/stopped <sup>5</sup> | Stopped                | Operating/stopped <sup>9</sup> |
| 1    | 1   | Stopped/adjust <sup>2</sup> | Operating/stopped <sup>5</sup> | Stopped                | Operating/stopped <sup>9</sup> |

1. ±30 seconds adjust function
2. The clock stops, and the ±30 seconds adjust function operates.
3. If the timer source clock frequency is ≤ 1Hz, the timer cycle changes when the digital correction function is used.  
If the timer source clock frequency is ≥ 64Hz, the timer cycle is not affected when the digital correction function is used.
4. If the timer source clock frequency is ≤ 1Hz, the timer cycle changes.  
If the timer source clock frequency is ≥ 64Hz, the timer cycle does not change.
5. If the timer source clock frequency is ≤ 1Hz, the timer is stopped.  
If the timer source clock frequency is ≥ 64Hz, the timer operates.
6. An alarm interrupt is not generated by the 30-second adjust function (ADJ) even if all other alarm conditions are met.  
However, an alarm interrupt is generated 1 second later if the alarm conditions are still met.
7. If the FOUT source clock frequency is ≤ 1Hz, the cycle changes when the digital correction function is used.  
If the FOUT source clock frequency is ≥ 32Hz, the cycle is not affected when the digital correction function is used.
8. If the FOUT source clock frequency is ≤ 1Hz, the cycle changes.  
If the FOUT source clock frequency is ≥ 32Hz, the cycle does not change.
9. If the FOUT source clock frequency is ≤ 1Hz, the timer is stopped.  
If the FOUT source clock frequency is ≥ 32Hz, the timer operates.

## Clock and Calendar Registers (Bank 0, Registers 0 to E)

### Clock counters (registers 0 to 5)

| Bank | Address | Register         | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|------------------|-------|-------|-------|-------|
| 0    | 0       | Second registers | 8     | 4     | 2     | 1     |
|      | 1       |                  | FOS   | 40    | 20    | 10    |
|      | 2       | Minute registers | 8     | 4     | 2     | 1     |
|      | 3       |                  |       | 40    | 20    | 10    |
|      | 4       | Hour registers   | 8     | 4     | 2     | 1     |
|      | 5       |                  |       |       | 20    | 10    |

- Data in these registers is interpreted in BCD format. For example, if the seconds registers 1 and 0 contain 0101 1001, then the contents are interpreted as the value 59 seconds.
- Hour register contents are values expressed in 24-hour mode.

### FOS (oscillator failed detect bit (register 1, bit 3))

- The FOS bit is the oscillator failure flag. It indicates that the oscillator has stopped due to supply voltage reduction during operation. It is set to 1 when the oscillator stops, and remains 1 until reset by writing 0 to FOS. It is not affected by the function of other bits. A 1 is written to FOS when power is applied.

### Day-of-week counter (register 6)

| Bank | Address | Register             | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|----------------------|-------|-------|-------|-------|
| 0    | 6       | Day of week register |       | 4     | 2     | 1     |

- The day-of-week register contains values representing the day of the week as shown in the following table.

| Bit 2 | Bit 1 | Bit 0 | Weekday   |
|-------|-------|-------|-----------|
| 0     | 0     | 0     | Sunday    |
| 0     | 0     | 1     | Monday    |
| 0     | 1     | 0     | Tuesday   |
| 0     | 1     | 1     | Wednesday |
| 1     | 0     | 0     | Thursday  |
| 1     | 0     | 1     | Friday    |
| 1     | 1     | 0     | Saturday  |

### Calendar registers (registers 7 to E)

| Bank | Address | Register        | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|-----------------|-------|-------|-------|-------|
| 0    | 7       | Date registers  | 8     | 4     | 2     | 1     |
|      | 8       |                 |       |       | 20    | 10    |
|      | 9       | Month registers | 8     | 4     | 2     | 1     |
|      | A       |                 |       |       |       | 10    |
|      | B       | Year registers  | 8     | 4     | 2     | 1     |
|      | C       |                 | 80    | 40    | 20    | 10    |
|      | D       |                 | 800   | 400   | 200   | 100   |
|      | E       |                 | TEST  | TEMP  | 2000  | 1000  |

- Registers B to E are 4 digits forming the western calendar year.
- Leap-year adjustment is automatic for years 1901 to 2099.

## Alarm Registers (Bank 1, Registers 0 to 8, E)

### Alarm control register (register E)

| Bank | Address | Register      | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|---------------|-------|-------|-------|-------|
| 1    | E       | Alarm control |       |       | AF    | AIE   |

- AF bit (alarm flag)

The AF bit is set to 1 when an alarm event is occurred, when the settings in the alarm set registers (bank 1, registers 0 to 8) match the settings in the day, clock and calendar registers (bank 0, registers 0 to 8). A logic 0 cannot be written to AF for 1 $\mu$ s maximum after AF is set to 1. The AF bit remains 1 until reset by writing 0 to AF. A logic 1 cannot be written to AF.

- AIE bit (alarm interrupt enable)

This bit enables the output on AIRQN when an alarm interrupt is occurred. If the AIE is not set to 1, then no output occurs even if the AF bit is set to 1. The AIRQN output is high impedance when AIE is set to 0.

### Alarm set registers (registers 0 to 8)

| Bank | Address | Register             | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|----------------------|-------|-------|-------|-------|
| 1    | 0       | Second registers     | 8     | 4     | 2     | 1     |
|      | 1       |                      | AE    | 40    | 20    | 10    |
|      | 2       | Minute registers     | 8     | 4     | 2     | 1     |
|      | 3       |                      | AE    | 40    | 20    | 10    |
|      | 4       | Hour registers       | 8     | 4     | 2     | 1     |
|      | 5       |                      | AE    | *     | 20    | 10    |
|      | 6       | Day of week register | AE    | 4     | 2     | 1     |
|      | 7       | Date registers       | 8     | 4     | 2     | 1     |
| 8    | AE      |                      | *     | 20    | 10    |       |

- These registers set the alarm time and date.

- When the corresponding bank 0 registers match these bank 1 registers, an alarm event occurs and AIRQN goes LOW if AIE is set to 1.

- An alarm can be set for date, day-of-week, hour, minute, and second. Each of these have a corresponding AE (alarm enable) bit which allows easy combination to create alarm events every second, every minute, hourly, daily, and weekly alarms.

- Note that alarms cannot be set for multiple days within the same week (such as an alarm on Mondays and Fridays only).

- When an AE bit is set to 0, the relevant register and corresponding bank 0 register are compared. When an AE bit is set to 1, the data is disregarded and all bits considered as “don’t care” bits.

### Day-of-week alarm bits (register 6)

- The day-of-week register contains values representing the day of the week as shown in the following table.

| Bit 2 | Bit 1 | Bit 0 | Weekday   |
|-------|-------|-------|-----------|
| 0     | 0     | 0     | Sunday    |
| 0     | 0     | 1     | Monday    |
| 0     | 1     | 0     | Tuesday   |
| 0     | 1     | 1     | Wednesday |
| 1     | 0     | 0     | Thursday  |
| 1     | 0     | 1     | Friday    |
| 1     | 1     | 0     | Saturday  |

## Timer Registers (Bank 2, Registers 4 to 8, E)

### Timer control registers (registers 8, E)

| Bank | Address | Register      | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|---------------|-------|-------|-------|-------|
| 2    | 8       | Timer setting | TE    | TI/TP |       |       |
|      | E       | Timer control |       |       | TF    | TIE   |

- TE bit (timer enable)  
Timer countdown stop/start control bit.  
When set to 1, the timer starts counting down. When set to 0 during countdown, the timer stops.
- TF bit (timer flag)  
The timer flag is set to 1 when the timer counter counts down to zero, occurring a timer event. A logic 0 cannot be written to TF for 1 $\mu$ s maximum after TF is set to 1. It is held at 1 until 0 is written to this bit. A 1 cannot be written to TF.
- TIE bit (timer interrupt enable)  
This bit enables the timer interrupt output on TIRQN when a timer event is occurred. If the TIE is not set to 1, then no output occurs even if the TF bit is set to 1. The TIRQN output is high impedance when TIE is set to 0.
- TI/TP bit (level/periodic interrupt mode select bit)  
Sets the timer interrupt signal output mode.  
The SM8580AM supports two timer function modes.
  - TI/TP = 0 (level interrupt mode)  
When a timer interrupt is occurred, TIRQN goes LOW (if TIE = 1) and TF is set to 1. TIRQN remains LOW and TF is held at 1 until a 0 is written to the TF bit.  
The timer operates by counting down until the data is zero, then the TE bit is cleared and the count stops automatically. However, if the timer is started when the TF bit is 1, then the TE bit is not cleared. The timer count register contents remain zero after the count down stops.
  - TI/TP = 1 (periodic interrupt mode)  
When a timer interrupt is occurred, TIRQN goes LOW (if TIE = 1) and TF is set to 1. TIRQN subsequently goes high impedance after a fixed interval, but TF is held at 1 until a 0 is written to the TF bit.  
The timer operates by counting down until the data is zero, then the timer register data is reloaded automatically after a fixed interval, and the countdown restarts. This mode can be used as a repetitive interval timer.

### Timer source clock set register (register 8)

| Bank | Address | Register      | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|---------------|-------|-------|-------|-------|
| 2    | 8       | Timer setting |       |       | TD1   | TD0   |

- The register 8 bits 0 and 1 set the timer source clock to one of four frequencies listed in the following table.

| TD1 | TD0 | Timer source clock |
|-----|-----|--------------------|
| 0   | 0   | 4096Hz             |
| 0   | 1   | 64Hz               |
| 1   | 0   | 1Hz                |
| 1   | 1   | 1/60Hz (1 minute)  |



### Timer counter set registers (registers 4 to 7)

| Bank | Address | Register                       | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|--------------------------------|-------|-------|-------|-------|
| 2    | 4       | Timer counter set registers    | 8     | 4     | 2     | 1     |
|      | 5       |                                | 128   | 64    | 32    | 16    |
|      | 6       | Timer counter output registers | 8     | 4     | 2     | 1     |
|      | 7       |                                | 128   | 64    | 32    | 16    |

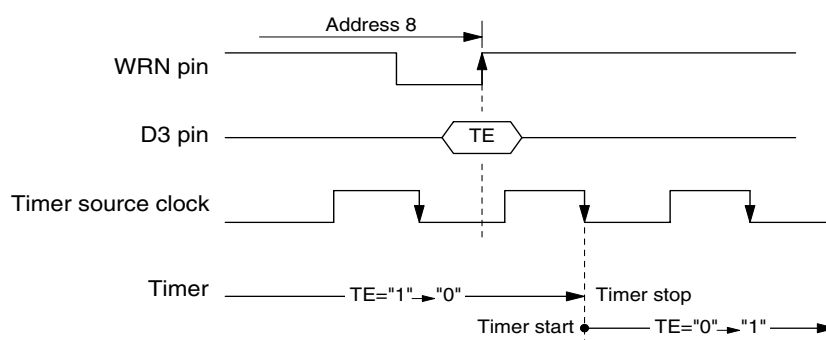
- Registers 4 and 5 set an 8-bit presetable binary down-counter value for the timer interrupt function.
- The value of the count can be determined by reading the values of registers 6 and 7 during the count.
- The presetable binary down-counter is updated when the data is written to registers 4 and 5.
- The data written to registers 4 and 5 are stored and are not changed until replacement data is written. This allows these bits to function as RAM bits if the timer interrupt mode is not used (when TIE = 0).
- When TE is set to 1, periodic interrupts are not output on TIRQN, even if registers 4 and 5 are set to zero.

### Timer interrupt function example

Example of an hourly periodic timer interrupt

| Bank | Address | Register                    | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|-----------------------------|-------|-------|-------|-------|
| 2    | 4       | Timer counter set registers | 1     | 1     | 0     | 0     |
|      | 5       |                             | 0     | 0     | 1     | 1     |
|      | 8       | Timer set register          | TE    | 1     | 1     | 1     |
|      | E       | Timer control               | TEST  | TEMP  | TF    | 1     |

- The timer error, when the timer starts, is an interval of 0 to 1 cycles of the source clock selected during the first timer operation. Specifically, if the source clock is 1/60Hz (1 minute cycle) and with TE bit = 1 write timing, the maximum error that can occur is +60 seconds. Also, timer operations that last less than 1 source clock cycle are not normally counted.
- The timer count start timing in data write mode occurs on the first falling edge of the source clock after the WRN rising edge that sets the TE bit, shown in the timing diagram below. Also, when the timer is stopped by changing the setting of TE bit from 1 to 0, the count stops after the countdown operation a maximum of 1 clock cycle of the selected source clock later. Specifically, if the source clock is 1/60Hz (1 minute cycle) and with TE bit = 0 write timing, the timer count is decremented and the timing stops a maximum of 60 seconds later. At this point, there is a possibility that the timer count has decremented to zero and generated an interrupt. Therefore, if interrupts are not required, the TIE interrupt enable bit should be set to avoid unwanted interrupts from occurring.



**CE1 Control Register (Bank 1, Register B)**

| Bank | Address | Register    | Bit 3 | Bit 2  | Bit 1 | Bit 0 |
|------|---------|-------------|-------|--------|-------|-------|
| 1    | B       | CE1 control | CTEMP | CDT_ON |       |       |

- This register determines whether the temperature sensor function and digital correction function in combination with the CE1 input pin. CTEMP determines the temperature sensor operation, and CDT\_ON determines the digital correction function operation.

- **CTEMP bit**

When CTEMP is set to 0, the temperature sensor operates only when the CE1 pin is HIGH.

When CTEMP is set to 1, the temperature sensor operates without any relationship to the CE1 input state.

Note that the temperature sensor operation also depends on the bank 2 TEMP bit to be active.

- **CDT\_ON bit**

When CDT\_ON is set to 0, the digital correction function operates only when the CE1 pin is HIGH.

When CDT\_ON is set to 1, the digital correction function operates without any relationship to the CE1 input state.

Note that the digital correction function also depends on the bank 2 DT\_ON bit to be active.

- **Function operation tables**

| CE1 pin | CTEMP bit | TEMP bit | Temperature sensor |
|---------|-----------|----------|--------------------|
| ×       | ×         | 0        | Not operating      |
| LOW     | 0         | 1        | Not operating      |
| HIGH    | 0         | 1        | Operating          |
| LOW     | 1         | 1        | Operating          |
| HIGH    | 1         | 1        | Operating          |

| CE1 pin | CDT_ON bit | DT_ON bit | Digital correction |
|---------|------------|-----------|--------------------|
| ×       | ×          | 0         | Not operating      |
| LOW     | 0          | 1         | Not operating      |
| HIGH    | 0          | 1         | Operating          |
| LOW     | 1          | 1         | Operating          |
| HIGH    | 1          | 1         | Operating          |

### Frequency Set Registers (Bank 1, Registers C, D)

| Bank | Address | Register                    | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|-----------------------------|-------|-------|-------|-------|
| 1    | C       | FOUT divider set register   |       | FD2   | FD1   | FD0   |
|      | D       | FOUT frequency set register | FE    |       | FD4   | FD3   |

#### ■ FD3, FD4 bit

FOUT source clock frequency set bits.

| FD4 | FD3 | Source clock |
|-----|-----|--------------|
| 0   | 0   | 32768Hz      |
| 0   | 1   | 1024Hz       |
| 1   | 0   | 32Hz         |
| 1   | 1   | 1Hz          |

#### ■ FD0 to FD2 bits

Frequency divider set bits for the FOUT source clock set by FD3 and FD4.

| FD2 | FD1 | FD0 | Frequency divider ratio | FOUT output duty |
|-----|-----|-----|-------------------------|------------------|
| 0   | 0   | 0   | 1/1                     | 1/2              |
| 0   | 0   | 1   | 1/2                     | 1/2              |
| 0   | 1   | 0   | 1/3                     | 1/3              |
| 0   | 1   | 1   | 1/6                     | 1/2              |
| 1   | 0   | 0   | 1/5                     | 1/5              |
| 1   | 0   | 1   | 1/10                    | 1/2              |
| 1   | 1   | 0   | 1/15                    | 1/3              |
| 1   | 1   | 1   | 1/30                    | 1/2              |

#### ■ FE bit

FOUT frequency signal set by FD0 to FD4 output enable bit.

When FCON is HIGH and FE is set to 1, then the frequency signal set by FD0 to FD4 is output on FOUT.

When FE is set to 0, the FOUT output is high impedance.

When FCON is LOW, a standard 32.768kHz signal is output on FOUT without reference to the settings in the C and D registers.

## Digital Correction Registers (Bank 2, Registers 0, 1)

| Bank | Address | Register                     | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------|---------|------------------------------|-------|-------|-------|-------|
| 2    | 0       | Digital correction registers | DT3   | DT2   | DT1   | DT0   |
|      | 1       |                              | DT_ON | DT6   | DT5   | DT4   |

- These registers enable and set the level of digital correction applied to oscillator clock. DT\_ON enables the correction function, and bits DT0 to DT6 set the level of correction to be applied. This function adjusts the number of 1 second cycles which occur every 10 seconds.
- When digital correction is not used, a 0 should be written to DT\_ON to disable correction.
- Correction range and resolution (correction range depends on the frequency)

| Correction range      | Correction resolution | Correction cycle |
|-----------------------|-----------------------|------------------|
| -195.20 to +192.15ppm | 3.05ppm               | 10 seconds       |

- DT bits and digital correction (correction value depends on the frequency)

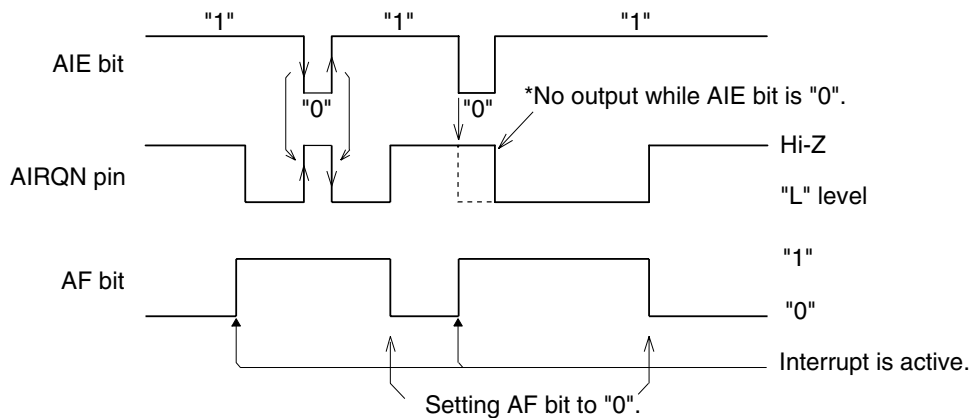
| Digital correction bits |     |     |     |     |     |     | Correction (ppm) |
|-------------------------|-----|-----|-----|-----|-----|-----|------------------|
| DT6                     | DT5 | DT4 | DT3 | DT2 | DT1 | DT0 |                  |
| 0                       | 1   | 1   | 1   | 1   | 1   | 1   | +192.15          |
| 0                       | 1   | 1   | 1   | 1   | 1   | 0   | +189.10          |
| ↓                       |     |     |     |     |     |     | ↓                |
| 0                       | 0   | 0   | 0   | 0   | 1   | 0   | +6.10            |
| 0                       | 0   | 0   | 0   | 0   | 0   | 1   | +3.05            |
| 0                       | 0   | 0   | 0   | 0   | 0   | 0   | ±0.00            |
| 1                       | 1   | 1   | 1   | 1   | 1   | 1   | -3.05            |
| 1                       | 1   | 1   | 1   | 1   | 1   | 0   | -6.10            |
| ↓                       |     |     |     |     |     |     | ↓                |
| 1                       | 0   | 0   | 0   | 0   | 0   | 1   | -192.15          |
| 1                       | 0   | 0   | 0   | 0   | 0   | 0   | -195.20          |

- Correction value calculation
  - Positive correction (leading time)
    - [DT6:0] = correction ÷ 3.05 (with decimal round-off)
    - Example: for correction of 192.15ppm
    - [DT6:0] =  $192.15 \div 3.05 = 63_{10} = 0111111_2$
  - Negative correction (lagging time)
    - [DT6:0] = 128 + correction ÷ 3.05 (with decimal round-off)
    - Example: for correction of -158.6ppm
    - [DT6:0] =  $128 + (-158.6 \div 3.05) = 76_{10} = 1001100_2$

## INTERRUPT OPERATION

### Alarm Interrupt

When AIE is 1 and an alarm event occurs (AF bit is set to 1), AIRQN output goes LOW. If AIE is 0, however, AIRQN is in a high-impedance state. The alarm interrupt is output when a carry from the seconds register to the minute register occurs.

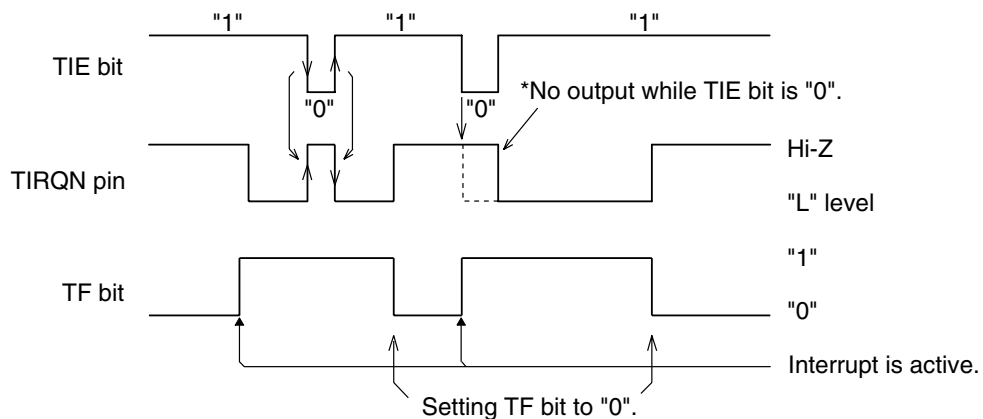


### Timer Interrupt

The timer interrupt mode (level interrupt or periodic interrupt) is selected by the setting of TI/TP.

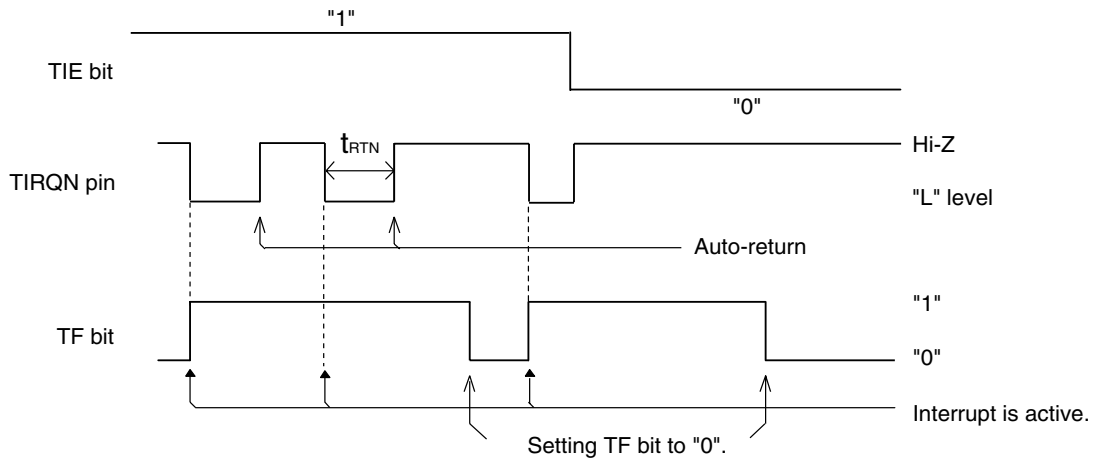
#### Level interrupt mode (TI/TP = 0)

When TIE is 1 and a timer interrupt event occurs (TF bit is set to 1), TIRQN goes LOW. When TIE is 0, however, TIRQN is in a high-impedance state.

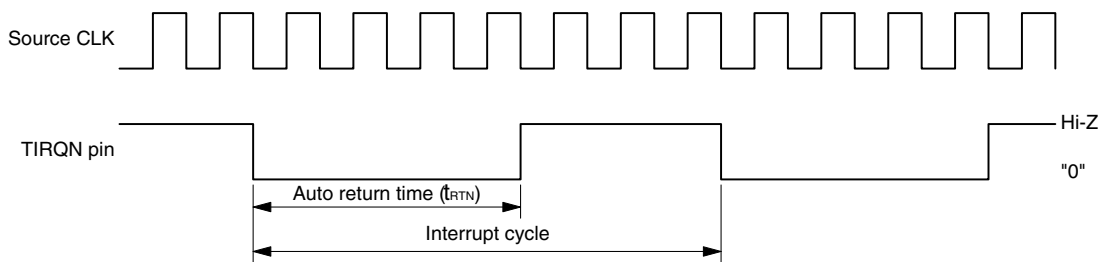


**Periodic interrupt mode (TI/TP = 1)**

When TIE is 1 and a timer interrupt event occurs (TF bit is set to 1), TIRQN goes LOW. If TIE is 0, however, TIRQN is in a high-impedance state, and the TF bit remains set to 1.



The auto-return time ( $t_{RTN}$ ), shown in the following figure and table, is determined by the source clock frequency set by register 8 in bank 2 bits TD0 and TD1.



| TD1 | TD0 | Source clock | Auto-return time ( $t_{RTN}$ ) |
|-----|-----|--------------|--------------------------------|
| 0   | 0   | 4096Hz       | 0.122ms                        |
| 0   | 1   | 64Hz         | 7.81ms                         |
| 1   | 0   | 1Hz          | 7.81ms                         |
| 1   | 1   | 1/60Hz       | 7.81ms                         |

## APPLICATION NOTES

### Setting the Alarm

Alarms can be set for day, weekday, hour, minute, and second. However, it is not possible to set an alarm for more than one weekday.

Note that it is recommended that AF and AIE be set to 0 at the same time to avoid accidental hardware interrupts while setting the alarm. After the alarm data is entered, initialization occurs when AF is again set to 0.

If the interrupt output is not used by setting AIE set to 0, an alarm can still be controlled by software monitoring of the AF bit.

#### Example 1

To set an alarm for 6pm of the following day:

- Set bits AIE and AF to 0.
- Set the day register AE bit to 1.
- Acquire the current weekday setting from bank 0 register 6, add 1 to the current value (except in the case of Saturday), and write the updated data. Note that the day following 6<sub>H</sub> (Saturday) is 0<sub>H</sub> (Sunday).
- Write 18<sub>H</sub> to the hour alarm register.
- Write 00<sub>H</sub> to the minute alarm register.
- Write 00<sub>H</sub> to the seconds alarm register.
- Set bit AF to 0.
- Set bit AIE to 1.

#### Example 2

To set an alarm for 6am on every for Sunday:

- Set bits AIE and AF to 0.
- Set the day alarm register AE bit to 1.
- Write 0<sub>H</sub> to the weekday alarm register.
- Write 06<sub>H</sub> to the hour alarm register.
- Write 00<sub>H</sub> to the minute alarm register.
- Write 00<sub>H</sub> to the seconds alarm register.
- Set bit AF to 0.
- Set bit AIE to 1.

### Using the Temperature Sensor

The SM8580AM temperature sensor can be used to monitor the surrounding temperature. The temperature sensor information can then be used to adjust the clock for any temperature variations in the oscillator frequency which affect the accuracy of the clock. One method of utilizing the temperature sensor to adjust timing errors is by using the clock error correction function (digital correction), as described below.

1. Based on the known temperature characteristics of the oscillator crystal, store temperature correction values for various temperatures in an external non-volatile EEPROM.
2. Use an A/D converter, such as in a general-purpose CPU, to convert the VTEMP temperature sensor output voltage into a digital value.
3. Use the digital value of the current temperature to access the temperature correction data stored in the EEPROM, and then write the corresponding data into the digital correction registers.

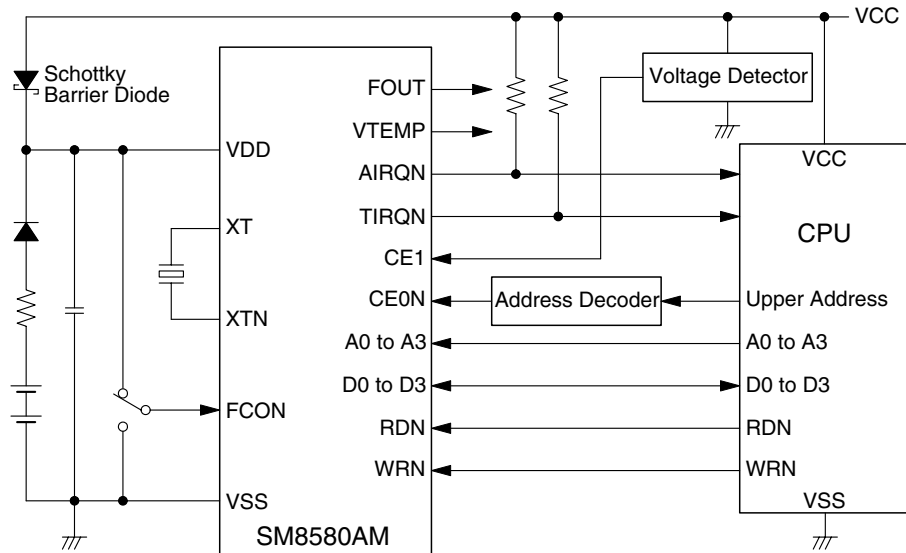
This procedure is useful in implementing a high-accuracy clock function.

## Monitoring Digital Correction

Using the test mode allows the 64Hz digital correction clock to be output on pin FOUT. The test mode works as follows.

1. Apply a HIGH-level on FCON.
2. Set the FOUT frequency set register FE bit to 1.
3. Set the CE1 control register CDT\_ON bit to 1.
4. Set correction data in the digital correction register DT0 to DT6 bits, and then set DT\_ON to 1.
5. Set the bank 2 register C, bit 1 to 1.
6. When CE0N is LOW and CE1 is HIGH and the test mode set register TEST bit is set to 1, the digital correction cycle changes from 10 seconds to 1/64 seconds, and the clock output on FOUT is the 64Hz clock after timing correction. The output is the corrected timing for the set digital correction value corresponding to a 64Hz clock  $\times$  64[ppm]. Measuring this output provides a quick method for monitoring the digital correction function.
7. When CE0N goes HIGH, the TEST bit is reset to 1 and test mode is released.

## TYPICAL APPLICATION CIRCUIT



Note. Because all the circuit components, except the crystal unit, are built in the SM8580AM chip, the oscillation circuit is realized just by the connection of the 32.768kHz crystal unit between XT and XTN terminals. The digital correction function is used to adjust the accuracy of clock time.



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