# M41T56C64

## Serial Real Time Clock with 56 bytes of NVRAM + 64 Kbit (8192 bit x 8) EEPROM

## Feature summary

- 5V ±10% supply voltage
- $I^2C$ bus compatible
- Operating temperature of –40 to 85°C
- Packaging includes:
  - 18-lead SOIC (with embedded crystal)
- RoHS compliant

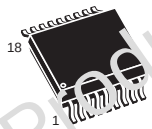
### Serial RTC features

- Counters for seconds, minutes, hours, day, date, month, years, and century
- Embedded crystal package
- Software clock calibration
- Automatic power-fail detect and switch circuitry
- 56 bytes of general purpose SRAM
- Ultra-low battery supply current of 450nA
- Automatic leap year compensation
- Special software programmable output
- Two-wire $I^2C$ serial interface supports 100kHz protocol

### Serial EEPROM features

- 8192 bytes of general purpose EEPROM (more than 1e6 erase/write cycles)
- Two-wire $I^2C$ serial interface supports 400kHz protocol
- Byte and page write (up to 32 bytes)
- More than 40 year data retention
- Self-timed programming cycle

**Embedded crystal**




**SOX18(MY)**
**18-pin (300mil) SOIC**

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# 1 Summary description

The M41T56C64 is a low power, Serial Real Time Clock with 56 bytes of NVRAM plus a 64Kb EEPROM (see *Figure 3*). A built-in 32,768Hz oscillator (crystal controlled) and the first 8 bytes of the RAM are used for the clock/calendar function and are configured in binary coded decimal (BCD) format. Addresses and data are transferred serially via a two-line, bi-directional bus. The built-in address register is incremented automatically after each WRITE or READ data byte.

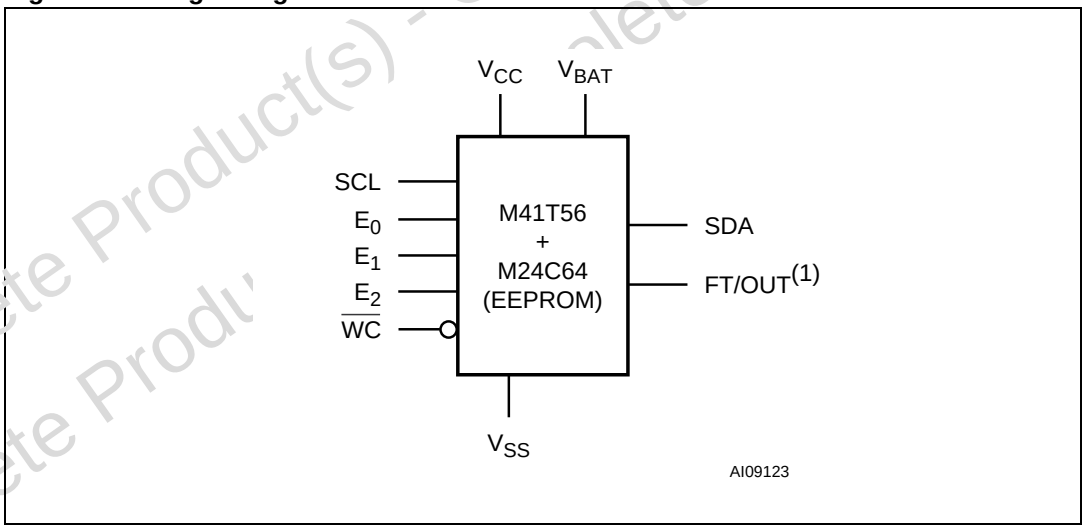
The M41T56C64 clock has a built-in power sense circuit which detects power failures and automatically switches to the battery supply during power failures. The energy needed to sustain the RAM and clock operations can be supplied from a small lithium coin cell.

Typical data retention time for the Serial RTC is in excess of 10 years with a 50mAh, 3V lithium cell. The M41T56C64 is supplied in an 18-lead Plastic SOIC package.

## 1.1 Calibration

As the crystal is molded together with the silicon in this package, ST can program the appropriate calibration value necessary to achieve ±5 ppm accuracy at 25°C after two SMT reflows (see *Figure 4*). This calibration value will be written into address 1550h of the EEPROM. This clock accuracy can then be guaranteed to drift no more than ±3 ppm the first year, and ±1 ppm for each following year due to crystal aging.

**Figure 1. Logic diagram**




1. Open drain output

# 2 Pin settings

## 2.1 Pin description

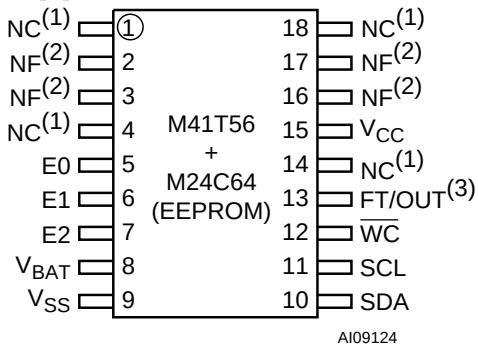
**Table 1. Signal names**

| | |
|---|---|
| FT/OUT (1) | Frequency test / output driver (open drain) |
| SDA | Serial data address input / output |
| SCL | Serial clock |
| $\overline{WC}$ | Write control |
| E0, E1, E2 | Chip enables |
| $V_{BAT}$ | Battery supply voltage |
| $V_{CC}$ | Supply voltage |
| $V_{SS}$ | Ground |
| NC (2) | No connect |
| NF (3) | No function |

1. Open drain output
2. No connect (NC) pins should be tied to $V_{SS}$.
3. No function (NF) pins should be tied to $V_{SS}$. Pins 2 and 3, and pins 16 and 17 are internally shorted together.

## 2.2 Pin connections

**Figure 2. 18 pin SOIC connection**




1. No connect (NC) pins should be tied to $V_{SS}$
2. No function (NF) pins should be tied to $V_{SS}$. Pins 2 and 3, and pins 16 and 17 are internally shorted together.
3. Open drain output

# 3 Application

**Figure 3. Block diagram**

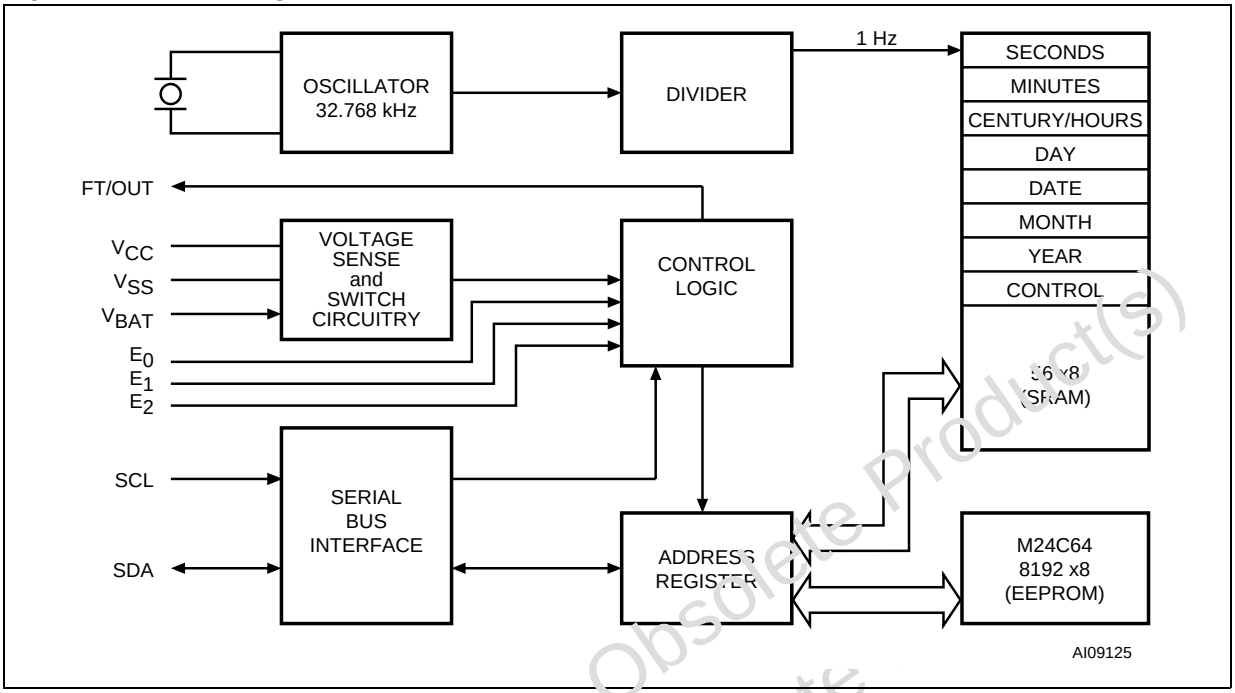



**Figure 4. Crystal accuracy across temperature**

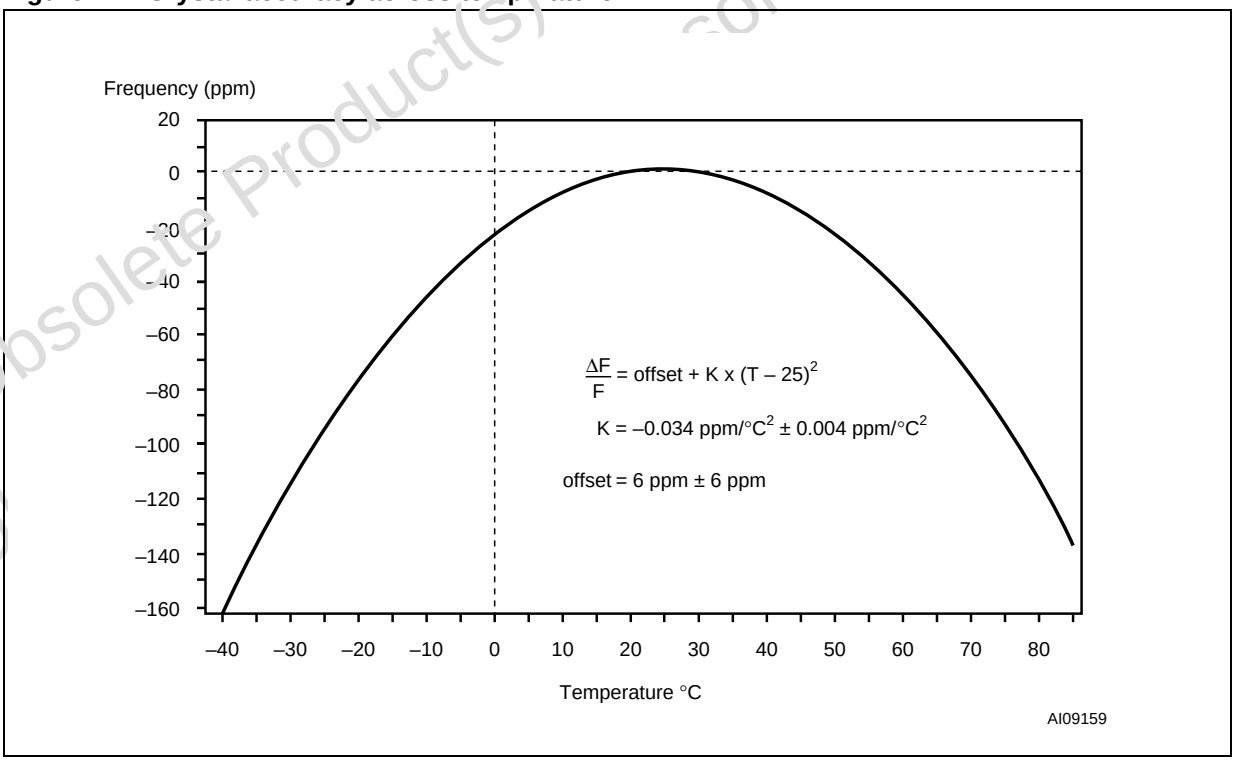


**Table 2. Device select code**

| | Device type identifier(1) | | | | Chip enable address(2) | | | RW |
|---|---|---|---|---|---|---|---|---|
| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| M24C64 | 1 | 0 | 1 | 0 | E2 | E1 | E0 | RW |
| M41T56 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | RW |

1. The most significant bit, b7, is sent first.
2. E0, E1, and E2 are compared against the respective external pins on the memory device.

# 4 Operation

## 4.1 Serial RTC device

The M41T56C64 contains one Serial RTC (M41T56). For detailed information on how to use the devices, see the M41T56 datasheet, which is available from your local STMicroelectronics distributor or from the STMicroelectronics website, **http://www.st.com/rtc/**.

## 4.2 EEPROM device

The M41T56C64 contains a 64 Kbit Serial EEPROM (M24C64). For detailed information on how to use the devices, see the M24C64 datasheet, which is available from your local STMicroelectronics distributor or from the STMicroelectronics website, http://www.st.com/eeprom/.

# 5 Maximum rating

Stressing the device above the rating listed in the “absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE program and other relevant quality documents.

**Table 3. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $T_A$ | Ambient operating temperature | –40 to 85 | °C |
| $T_{STG}$ | Storage temperature ($V_{CC}$ off, oscillator off) | –55 to 125 | °C |
| $T_{SLD}$(1) | Lead solder temperature for 10 seconds | 260 | °C |
| $V_{IO}$ | Input or output voltages | –0.3 to 6.5 | V |
| $V_{CC}$ | Supply voltage | –0.3 to 6.5 | V |
| $I_O$ | Output current | 20 | mA |
| $P_D$ | Power dissipation | 0.25 | W |

1. For SOX18 package, Lead-free (Pb-free) lead finish. Reflow at peak temperature of 240°C (total thermal budget not to exceed 180°C for between 90 to 150 seconds). No direct exposure to infrared (IR) reflow, or IR preheat allowed, to avoid damaging the embedded 32KHz crystal.

**Caution:** *Negative undershoots below –0.3V are not allowed on any pin while in the battery back-up mode.*

# 6 DC and AC parameters

This section summarizes the operating and measurement conditions, as well as the DC and AC characteristics of the device. The parameters in the following DC and AC characteristic tables are derived from tests performed under the measurement conditions listed in the relevant tables. Designers should check that the operating conditions in their projects match the measurement conditions when using the quoted parameters.

**Table 4. Operating and AC measurement conditions(1)**

| Parameter | Value | Unit |
|---|---|---|
| Supply voltage ($V_{CC}$) | 4.5 to 5.5 | V |
| Ambient operating temperature ($T_A$) | –40 to 85 | °C |
| Load capacitance ($C_L$) | 100 | pF |
| Input rise and fall times | 50 (max) | ns |
| Input pulse voltages | $0.2V_{CC}$ to $0.8V_{CC}$ | V |
| Input and output timing ref. voltages | $0.3V_{CC}$ to $0.7V_{CC}$ | V |

1. Output Hi-Z is defined as the point where data is no longer driven.

**Figure 5. AC measurement I/O waveform**

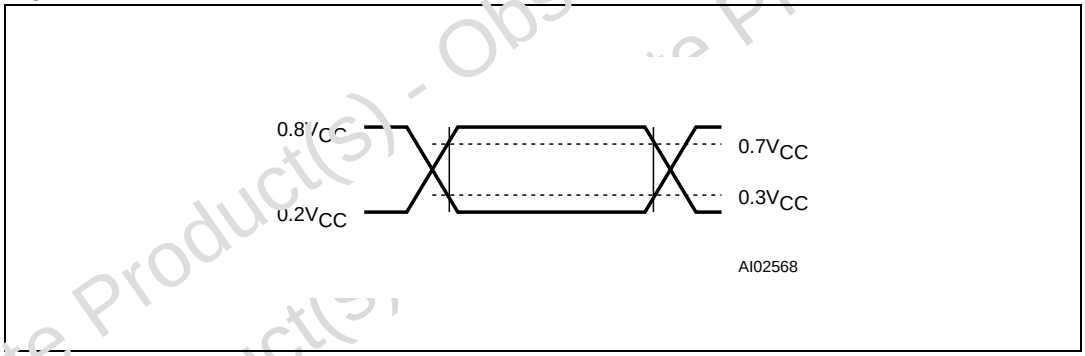


**Table 5. Capacitance and input parameters**

| Symbol | Parameter (1) (2) | Test condition | Min | Max | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input capacitance (SCL) | | | 13 | pF |
| | Input capacitance (SDA) | | | 18 | pF |
| | Input Capacitance (Other pins) | | | 6 | pF |
| $Z_{WCL}$ | $\overline{WC}$ input impedance | $V_{IN} < 0.5V$ | 5 | 20 | kΩ |
| $Z_{WCH}$ | $\overline{WC}$ input impedance | $V_{IN} < 0.7V_{CC}$ | 500 | | kΩ |
| $C_{OUT}$(3) | Output capacitance (SDA) | | | 18 | pF |
| | Output capacitance (FT/OUT) | | | 10 | pF |

1. Effective capacitance measured with power supply at 5V; sampled, not 100% tested.
2. At 25°C, f = 400kHz..
3. Outputs deselected.

**Table 6. DC characteristics**

| Symbol | Parameter | Test Condition(1) | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{LI}$ | Input leakage current | $0V \le V_{IN} \le V_{CC}$ | | | ±3 | µA |
| $I_{LO}$ | Output leakage current | $0V \le V_{OUT} \le V_{CC}$ | | | ±3 | µA |
| $I_{CC1}$ | Supply current (Serial RTC active) | Switch frequency = 100kHz | | | 310 | µA |
| | Supply current (Serial EEPROM active) | $V_{CC}$ = 5V, $f_c$=400kHz (rise/fall time < 30ns) | | | 2.2 | mA |
| $I_{CC2}$ | Supply current (standby) | SCL, SDA = $V_{CC}$ – 0.3V | | 100 | | µA |
| $V_{IL}$ | Input low voltage (SCL, SDA) | | –0.3 | | 1.5 | V |
| | Input low voltage (E2, E1, E0) | | –0.45 | | $0.3V_{CC}$ | V |
| | Input low voltage ($\overline{WC}$) | | –0.45 | | 0.5 | V |
| $V_{IH}$ | Input high voltage (SCL, SDA) | | 3 | | $V_{CC}$ + 0.8 | V |
| | Input high voltage (E2, E1, E1, $\overline{WC}$) | | $0.7V_{CC}$ | | $V_{CC}$ + 1 | V |
| $V_{OL}$ | Output low voltage | $I_{OL}$ = 3mA, $V_{CC}$ = 5V | | | 0.4 | V |
| $V_{BAT}$(2) | Battery supply voltage | | 2.5 | 3 | 3.5 | V |
| $I_{BAT}$ | Battery supply current | $T_A$ = 25°C, $V_{CC}$ = 0V, Oscillator ON, $V_{BAT}$ = 3V | | 450 | 550 | nA |

1. Valid for ambient operating temperature: $T_A$ = –40 to 85°C; $V_{CC}$ = 4.5 to 5.5V (except where noted).
2. STMicroelectronics recommends the RAYOVAC BR1225 or BR1632 (or equivalent) as the battery supply.

**Figure 6. AC Bus timing requirements sequence (serial RTC)**

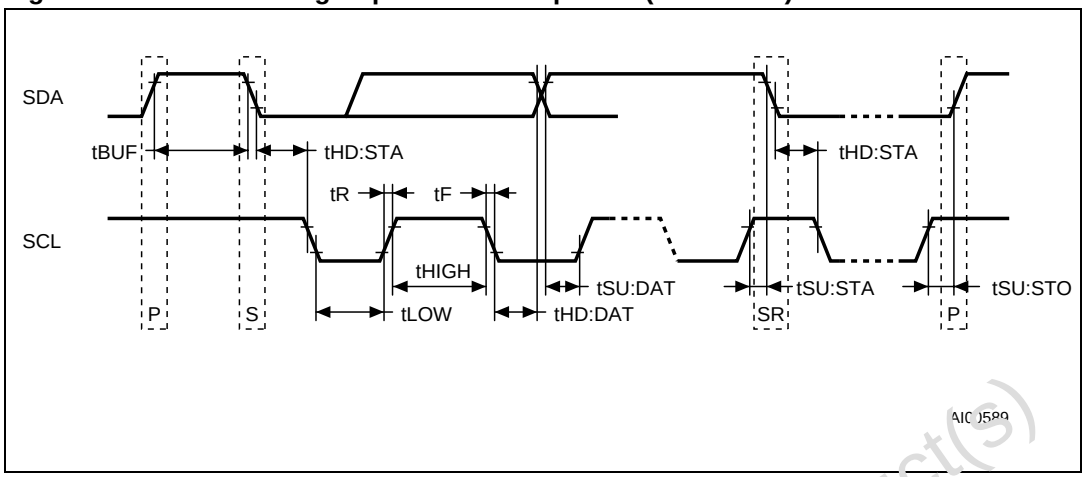



**Table 7. AC characteristics, (serial RTC, M41T56)**

| Symbol | Parameter (1) | Min | Max | Unit |
|---|---|---|---|---|
| $f_{SCL}$ | SCL clock frequency | 0 | 100 | kHz |
| $t_{LOW}$ | Clock low period | 4.7 | | µs |
| $t_{HIGH}$ | Clock high period | 4 | | µs |
| $t_R$ | SDA and SCL rise time | | 1 | µs |
| $t_F$ | SDA and SCL fall time | | 300 | ns |
| $t_{HD:STA}$ | START condition hold time (after this period the first clock pulse is generated) | 4 | | µs |
| $t_{SU:STA}$ | START condition setup time (only relevant for a repeated start condition) | 4.7 | | µs |
| $t_{SU:DAT}$ | Data setup time | 250 | | ns |
| $t_{HD:DAT}$ (2) | Data hold time | 0 | | µs |
| $t_{SU:STO}$ | STOP condition setup time | 4.7 | | µs |
| $t_{BUF}$ | Time the bus must be free before a new transmission can start | 4.7 | | µs |
| $t_{LP}$ | Low-pass filter input time constant (SDA and SCL) for Serial RTC | 0.25 | 1 | µs |

1. Valid for ambient operating temperature: $T_A$ = –40 to 85°C; VCC = 4.5 to 5.5V (except where noted).
2. Transmitter must internally provide a hold time to bridge the undefined region (300ns max.) of the falling edge of SCL.

**Table 8. AC characteristics (Serial EEPROM, M24C64)**

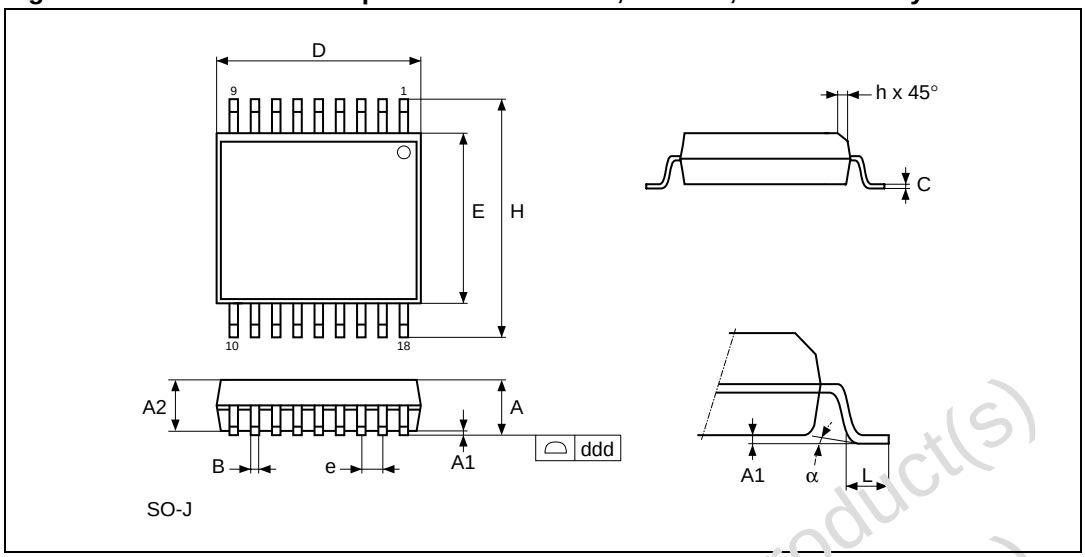
| Symbol | Alt. | Parameter | Test condition | Min. | Max. | Unit |
|---|---|---|---|---|---|---|
| $f_C$ | $f_{SCL}$ | Clock frequency | | | 400 | kHz |
| $t_{CHCL}$ | $t_{HIGH}$ | Clock pulse width high | | 600 | | ns |
| $t_{CLCH}$ | $t_{LOW}$ | Clock pulse width low | | 1300 | | ns |
| $t_{DL1DL2}$(1) | $t_F$ | SDA fall time | | 20 | 300 | ns |
| $t_{DXCX}$ | $t_{SU:DAT}$ | Data in set up time | | 100 | | ns |
| $t_{CLDX}$ | $t_{HD:DAT}$ | Data in hold time | | 0 | | ns |
| $t_{CLQX}$ | $t_{DH}$ | Data out hold time | | 200 | | ns |
| $t_{CLQV}$(2) | $t_{AA}$ | Clock low to next data valid (access time) | | 200 | 900 | ns |
| $t_{CHDX}$(3) | $t_{SU:STA}$ | Start condition set up time | | 600 | | ns |
| $t_{DLCL}$ | $t_{HD:STA}$ | Start condition hold time | | 600 | | ns |
| $t_{CHDH}$ | $t_{SU:STO}$ | Stop condition set up time | | 600 | | ns |
| $t_{DHDL}$ | $t_{BUF}$ | Time between stop condition and next start condition | | 1300 | | ns |
| $t_W$ | $t_{WR}$ | Write time | | | 5 | ms |
| $t_{NS}$ | | Pulse width ignored (input filter on SCL and SDA for serial EEPROM) | Single glitch | | 100 | ns |

1. Sampled only, not 100% tested.
2. To avoid spurious START and STOP conditions, a minimum delay is placed between SCL=1 and the falling or rising edge of SDA.
3. For a reSTART condition, or following a Write cycle.

# 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com

**Figure 7. SOX18 – 18-lead plastic small outline, 300mils, embedded crystal**




1. Drawing is not to scale.

**Table 9. SOX18 – 18-lead plastic small outline, 300mils, embedded crystal, package mech.**

| Symbol | millimetres | | | inches | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | | 2.44 | 2.69 | | 0.096 | 0.106 |
| A1 | | 0.15 | 0.31 | | 0.096 | 0.012 |
| A2 | | 2.29 | 2.39 | | 0.090 | 0.094 |
| B | | 0.41 | 0.51 | | 0.016 | 0.020 |
| C | | 0.20 | 0.31 | | 0.008 | 0.012 |
| D | 11.61 | 11.56 | 11.66 | 0.457 | 0.455 | 0.459 |
| ddd | | | 0.10 | | | 0.004 |
| E | | 7.57 | 7.67 | | 0.298 | 0.302 |
| e | 1.27 | – | – | 0.050 | – | – |
| H | | 10.16 | 10.52 | | 0.400 | 0.414 |
| L | | 0.51 | 0.81 | | 0.020 | 0.032 |
| a | | 0° | 8° | | 0° | 8° |
| N | 18 | | | 18 | | |

# 8 Order codes

**Table 10. Ordering information scheme**

Example: M41T 56 C64 MY 6 E

**Device type**

M41T = Serial RTC

**Supply voltage and write protect voltage**

56 = $V_{CC}$ = 4.5 to 5.5V

**EEPROM density**

C64 = 64 Kbit (8192 bit x 8)

**Package**

MY(1)= SOX18

**Temperature range**

6 = –40°C to 85°C

**Shipping method**

E = ECOPACK® package, tubes

F = ECOPACK® package, tape & reel

1. The SOX18 package includes an embedded 32,768Hz crystal.

For other options, or for more information on any aspect of this device, please contact the ST Sales Office nearest you.

# 9 Revision history

**Table 11. Revision history**

| Date | Version | Description |
|---|---|---|
| 14-Sep-2004 | 1 | First Edition |
| 25-Mar-2005 | 2 | Clarify pin connections, maximum rating |
| 4-Sep-2006 | 3 | Datasheet status updated to full datasheet; changed title on page 1; small text changes to *Section 1: Summary description*; reformatted figure in the *Feature summary*, reformatted *Figure 1*, *Figure 2*, *Table 2* and *Table 9*; ecopack compliant; updated disclaimer |
| 22-Sep-2006 | 4 | Added information on EEPROM density *Table 10: Ordering information scheme* |

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