



5V, 64 Kbit (8 Kb x 8) TIMEKEEPER® SRAM

FEATURES SUMMARY

- INTEGRATED ULTRA LOW POWER SRAM, REAL TIME CLOCK, POWER-FAIL CONTROL CIRCUIT, and BATTERY
- BYTEWIDE™ RAM-LIKE CLOCK ACCESS
- BCD CODED YEAR, MONTH, DAY, DATE, HOURS, MINUTES, and SECONDS
- TYPICAL CLOCK ACCURACY OF ± 1 MINUTE A MONTH, AT 25°C
- AUTOMATIC POWER-FAIL CHIP DESELECT and WRITE PROTECTION
- WRITE PROTECT VOLTAGES (V_{PFD} = Power-fail Deselect Voltage):
 - M48T08: $V_{CC} = 4.75$ to $5.5V$
 $4.5V \leq V_{PFD} \leq 4.75V$
 - M48T18: $V_{CC} = 4.5$ to $5.5V$
 $4.2V \leq V_{PFD} \leq 4.5V$
- SOFTWARE CONTROLLED CLOCK CALIBRATION FOR HIGH ACCURACY APPLICATIONS
- SELF-CONTAINED BATTERY and CRYSTAL IN THE CAPHAT™ DIP PACKAGE
- PACKAGING INCLUDES A 28-LEAD SOIC and SNAPHAT® TOP (to be Ordered Separately)
- SOIC PACKAGE PROVIDES DIRECT CONNECTION FOR A SNAPHAT TOP WHICH CONTAINS THE BATTERY and CRYSTAL
- PIN and FUNCTION COMPATIBLE WITH DS1643 and JEDEC STANDARD 8K x 8 SRAMs

Figure 1. 28-pin PCDIP, CAPHAT™ Package

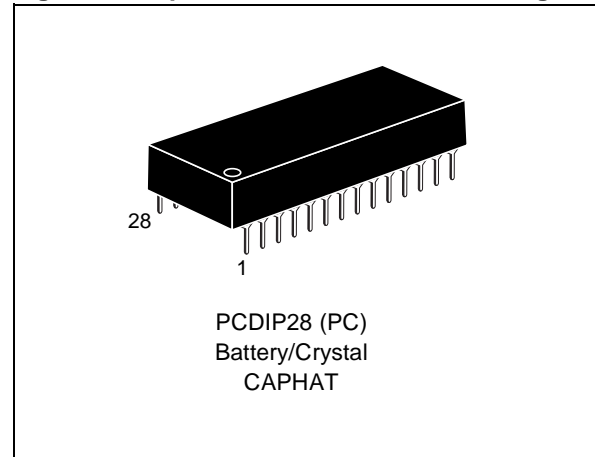


Figure 2. 28-pin SOIC Package

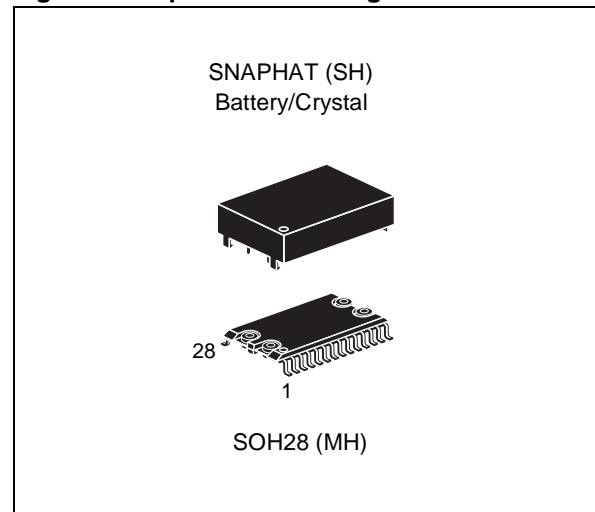


TABLE OF CONTENTS

SUMMARY DESCRIPTION **4**

- Logic Diagram (Figure 3.) 4
- Signal Names (Table 1.) 4
- DIP Connections (Figure 4.) 5
- SOIC Connections (Figure 5.) 5
- Block Diagram (Figure 6.) 5

MAXIMUM RATING **6**

- Absolute Maximum Ratings (Table 2.) 6

DC AND AC PARAMETERS **7**

- Operating and AC Measurement Conditions (Table 3.) 7
- AC Testing Load Circuit (Figure 7.) 7
- Capacitance (Table 4.) 7
- DC Characteristics (Table 5.) 8

OPERATION MODES **9**

- Operating Modes (Table 6.) 9
- READ Mode 10
- READ Mode AC Waveforms (Figure 8.) 10
- READ Mode AC Characteristics (Table 7.) 11
- WRITE Mode 12
- WRITE Enable Controlled, WRITE AC Waveform (Figure 9.) 12
- Chip Enable Controlled, WRITE AC Waveforms (Figure 10.) 13
- WRITE Mode AC Characteristics (Table 8.) 14
- Data Retention Mode 15
- Power Down/Up Mode AC Waveforms (Figure 11.) 15
- Power Down/Up AC Characteristics (Table 9.) 16
- Power Down/Up Trip Points DC Characteristics (Table 10.) 16
- System Battery Life 17
- Predicted Battery Storage Life versus Temperature (Figure 12.) 17

CLOCK OPERATIONS	19
Reading the Clock	19
Setting the Clock	19
Register Map (Table 11.)	19
Stopping and Starting the Oscillator	20
Calibrating the Clock	20
Crystal Accuracy Across Temperature (Figure 13.)	21
Clock Calibration (Figure 14.)	21
Power Supply Decoupling and Undershoot Protection	22
Supply Voltage Protection (Figure 15.)	22
PART NUMBERING	23
SNAPHAT Battery Table (Table 13.)	23
PACKAGE MECHANICAL INFORMATION	24
REVISION HISTORY	28

SUMMARY DESCRIPTION

The M48T08/18 TIMEKEEPER[®] RAM is an 8K x 8 non-volatile static RAM and real time clock which is pin and functional compatible with the DS1643. The monolithic chip is available in two special packages to provide a highly integrated battery backed-up memory and real time clock solution.

The M48T08/18 is a non-volatile pin and function equivalent to any JEDEC standard 8K x 8 SRAM. It also easily fits into many ROM, EPROM, and EEPROM sockets, providing the non-volatility of PROMs without any requirement for special WRITE timing or limitations on the number of WRITES that can be performed.

The 28-pin, 600mil DIP CAPHAT[™] houses the M48T08/18 silicon with a quartz crystal and a long-life lithium button cell in a single package.

The 28-pin, 330mil SOIC provides sockets with gold plated contacts at both ends for direct connection to a separate SNAPHAT[®] housing containing the battery and crystal. The unique design allows the SNAPHAT battery package to be mounted on top of the SOIC package after the completion of the surface mount process. Insertion of the SNAPHAT housing after reflow prevents potential battery and crystal damage due to the high temperatures required for device surface-mounting. The SNAPHAT housing is keyed to prevent reverse insertion.

The SOIC and battery/crystal packages are shipped separately in plastic anti-static tubes or in Tape & Reel form. For the 28 lead SOIC, the battery/crystal package (e.g., SNAPHAT) part number is "M4T28-BR12SH" (see Table 13, page 23).

Figure 3. Logic Diagram

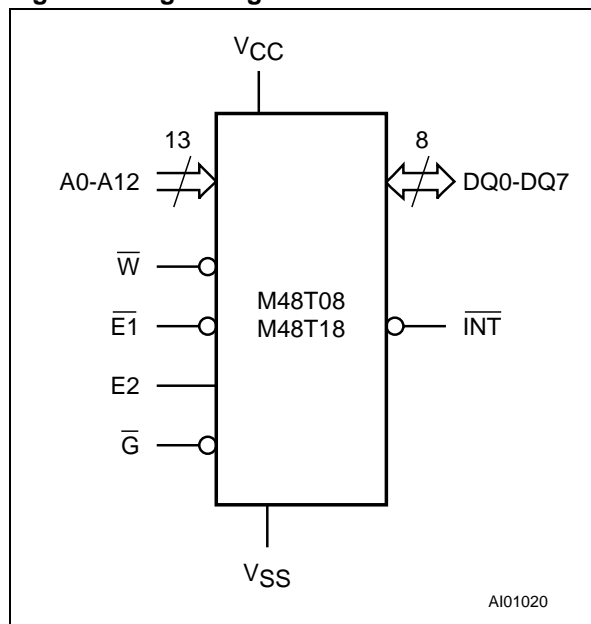


Table 1. Signal Names

A0-A12	Address Inputs
DQ0-DQ7	Data Inputs / Outputs
$\overline{\text{INT}}$	Power Fail Interrupt (Open Drain)
$\overline{\text{E1}}$	Chip Enable 1
E2	Chip Enable 2
$\overline{\text{G}}$	Output Enable
$\overline{\text{W}}$	WRITE Enable
VCC	Supply Voltage
VSS	Ground

Figure 4. DIP Connections

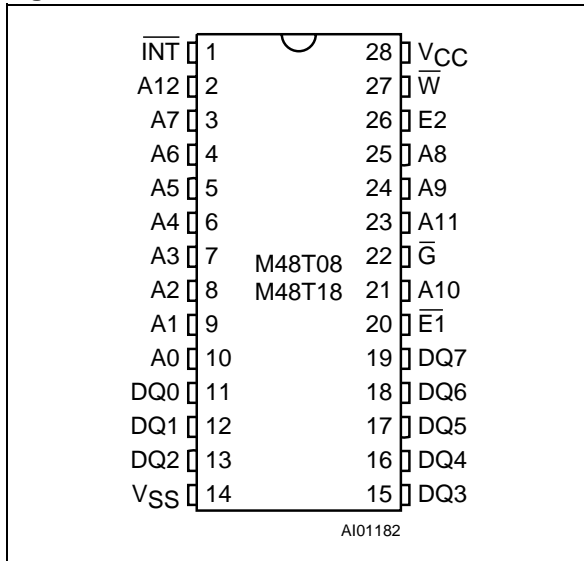


Figure 5. SOIC Connections

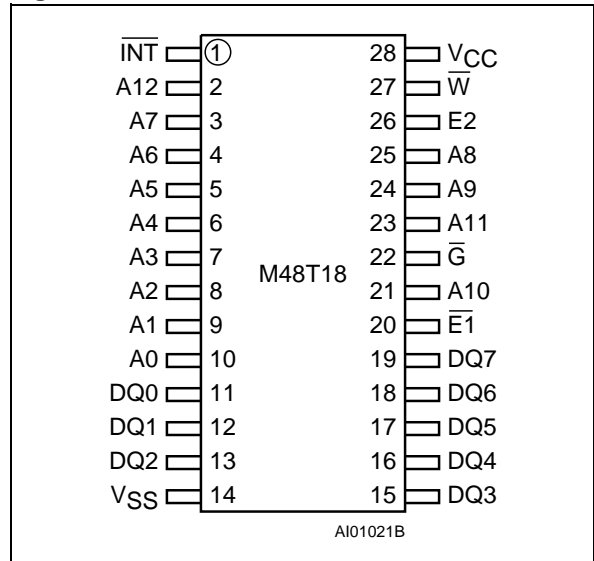
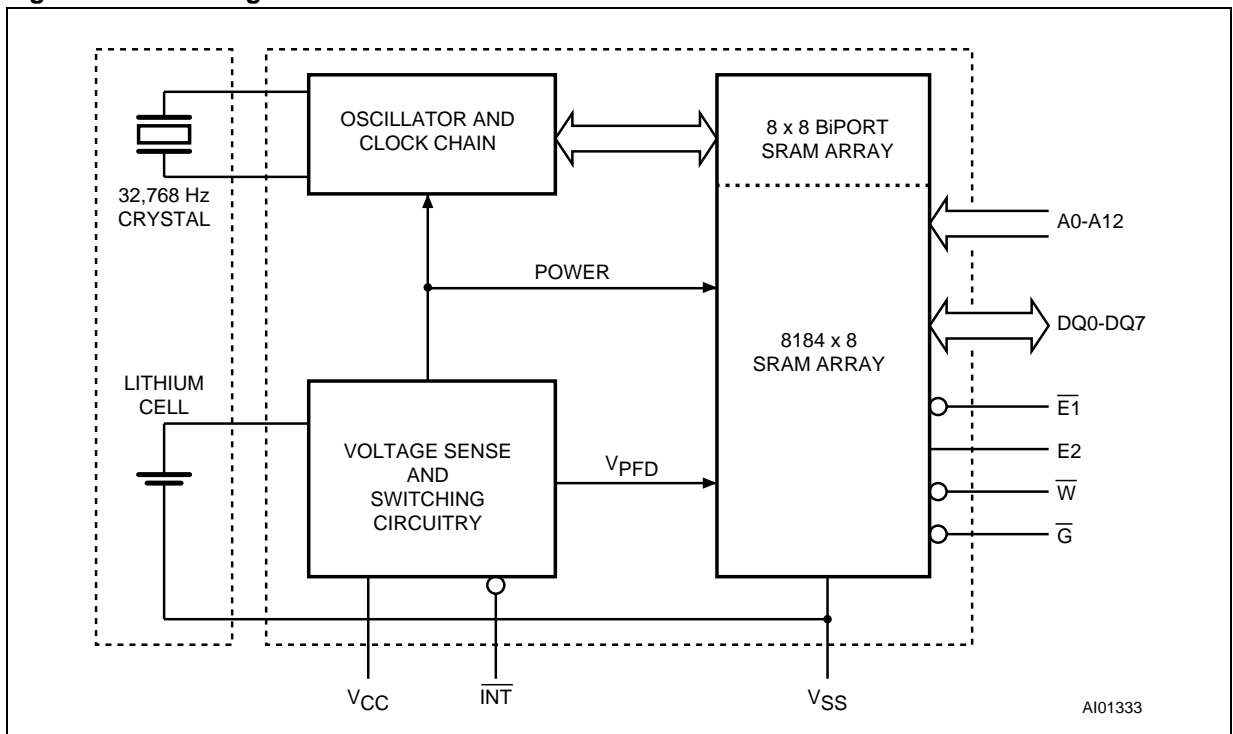


Figure 6. Block Diagram



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 2. Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
T_A	Ambient Operating Temperature	0 to 70	°C
T_{STG}	Storage Temperature (V_{CC} Off, Oscillator Off)	-40 to 85	°C
$T_{SLD}^{(1)}$	Lead Solder Temperature for 10 seconds	260	°C
V_{IO}	Input or Output Voltages	-0.3 to 7	V
V_{CC}	Supply Voltage	-0.3 to 7	V
I_O	Output Current	20	mA
P_D	Power Dissipation	1	W

Note: 1. Soldering temperature not to exceed 260°C for 10 seconds (total thermal budget not to exceed 150°C for longer than 30 seconds).

CAUTION: Negative undershoots below -0.3V are not allowed on any pin while in the Battery Back-up mode.

CAUTION: Do NOT wave solder SOIC to avoid damaging SNAPHAT sockets.

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 Measure-

ment 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 3. Operating and AC Measurement Conditions

Parameter	M48T08	M48T18	Unit
Supply Voltage (V_{CC})	4.75 to 5.5	4.5 to 5.5	V
Ambient Operating Temperature (T_A)	0 to 70	0 to 70	°C
Load Capacitance (C_L)	100	100	pF
Input Rise and Fall Times	≤ 5	≤ 5	ns
Input Pulse Voltages	0 to 3	0 to 3	V
Input and Output Timing Ref. Voltages	1.5	1.5	V

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

Figure 7. AC Testing Load Circuit

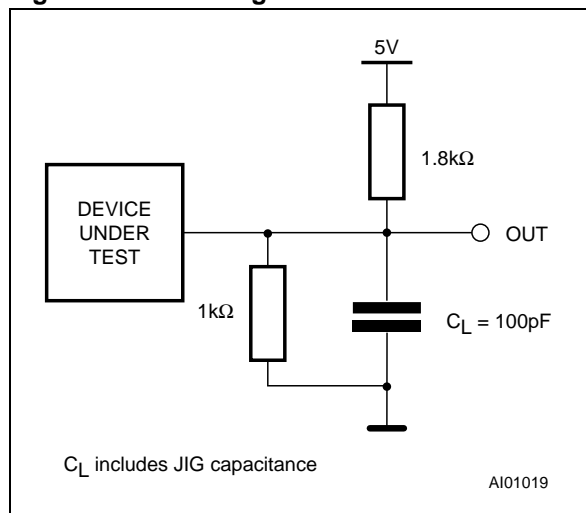


Table 4. Capacitance

Symbol	Parameter ^(1,2)	Min	Max	Unit
C_{IN}	Input Capacitance		10	pF
$C_{IO}^{(3)}$	Input / Output Capacitance		10	pF

Note: 1. Effective capacitance measured with power supply at 5V. Sampled only, not 100% tested.

2. At 25°C, $f = 1\text{MHz}$.

3. Outputs deselected.

Table 5. DC Characteristics

Symbol	Parameter	Test Condition ⁽¹⁾	M48T08/M48T18		Unit
			-100 / -150		
			Min	Max	
I _{LI}	Input Leakage Current	0V ≤ V _{IN} ≤ V _{CC}		±1	μA
I _{LO} ⁽²⁾	Output Leakage Current	0V ≤ V _{OUT} ≤ V _{CC}		±1	μA
I _{CC}	Supply Current	Outputs open		80	mA
I _{CC1} ⁽³⁾	Supply Current (Standby) TTL	$\overline{E1} = V_{IH}, E2 = V_{IL}$		3	mA
I _{CC2} ⁽³⁾	Supply Current (Standby) CMOS	$\overline{E1} = V_{CC} - 0.2V,$ $E2 = V_{SS} + 0.2V$		3	mA
V _{IL} ⁽⁴⁾	Input Low Voltage		-0.3	0.8	V
V _{IH}	Input High Voltage		2.2	V _{CC} + 0.3	V
V _{OL}	Output Low Voltage	I _{OL} = 2.1mA		0.4	V
	Output Low Voltage (\overline{INT}) ⁽⁵⁾	I _{OL} = 0.5mA		0.4	V
V _{OH}	Output High Voltage	I _{OH} = -1mA	2.4		V

Note: 1. Valid for Ambient Operating Temperature: T_A = 0 to 70°C; V_{CC} = 4.75 to 5.5V or 4.5 to 5.5V (except where noted).
 2. Outputs deselected.
 3. Measured with Control Bits set as follows: R = '1'; W, ST, FT = '0.'
 4. Negative spikes of -1V allowed for up to 10ns once per Cycle.
 5. The \overline{INT} pin is Open Drain.

OPERATION MODES

As Figure 6, page 5 shows, the static memory array and the quartz-controlled clock oscillator of the M48T08/18 are integrated on one silicon chip. The two circuits are interconnected at the upper eight memory locations to provide user accessible BYTEWIDE™ clock information in the bytes with addresses 1FF8h-1FFFh.

The clock locations contain the year, month, date, day, hour, minute, and second in 24 hour BCD format. Corrections for 28, 29 (leap year - valid until 2100), 30, and 31 day months are made automatically. Byte 1FF8h is the clock control register. This byte controls user access to the clock information and also stores the clock calibration setting.

The eight clock bytes are not the actual clock counters themselves; they are memory locations consisting of BiPORT™ READ/WRITE memory

cells. The M48T08/18 includes a clock control circuit which updates the clock bytes with current information once per second. The information can be accessed by the user in the same manner as any other location in the static memory array.

The M48T08/18 also has its own Power-fail Detect circuit. The control circuitry constantly monitors the single 5V supply for an out of tolerance condition. When V_{CC} is out of tolerance, the circuit write protects the SRAM, providing a high degree of data security in the midst of unpredictable system operation brought on by low V_{CC} . As V_{CC} falls below the Battery Back-up Switchover Voltage (V_{SO}), the control circuitry connects the battery which maintains data and clock operation until valid power returns.

Table 6. Operating Modes

Mode	V_{CC}	$\overline{E1}$	E2	\overline{G}	\overline{W}	DQ0-DQ7	Power
Deselect	4.75 to 5.5V or 4.5 to 5.5V	V_{IH}	X	X	X	High Z	Standby
Deselect		X	V_{IL}	X	X	High Z	Standby
WRITE		V_{IL}	V_{IH}	X	V_{IL}	D_{IN}	Active
READ		V_{IL}	V_{IH}	V_{IL}	V_{IH}	D_{OUT}	Active
READ		V_{IL}	V_{IH}	V_{IH}	V_{IH}	High Z	Active
Deselect	V_{SO} to $V_{PFD(min)}^{(1)}$	X	X	X	X	High Z	CMOS Standby
Deselect	$\leq V_{SO}^{(1)}$	X	X	X	X	High Z	Battery Back-up Mode

Note: X = V_{IH} or V_{IL} ; V_{SO} = Battery Back-up Switchover Voltage.

1. See Table 10, page 16 for details.

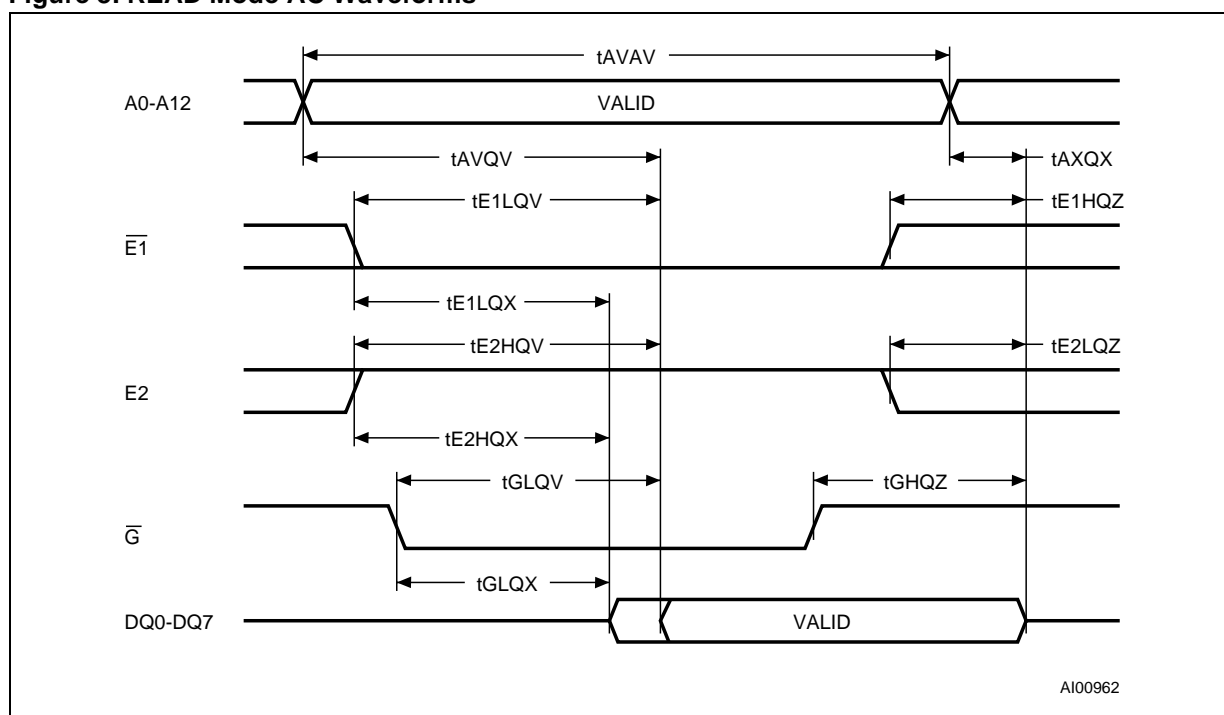
READ Mode

The M48T08/18 is in the READ Mode whenever \overline{W} (WRITE Enable) is high, $\overline{E1}$ (Chip Enable 1) is low, and E2 (Chip Enable 2) is high. The device architecture allows ripple-through access of data from eight of 65,536 locations in the static storage array. Thus, the unique address specified by the 13 address inputs defines which one of the 8,192 bytes of data is to be accessed. Valid data will be available at the Data I/O pins within address access time (t_{AVQV}) after the last address input signal is stable, providing that the $\overline{E1}$, $\overline{E2}$, and \overline{G} access times are also satisfied. If the $\overline{E1}$, $\overline{E2}$ and \overline{G} access times are not met, valid data will be

available after the latter of the Chip Enable Access times (t_{E1LQV} or t_{E2HQV}) or Output Enable Access time (t_{GLQV}).

The state of the eight three-state Data I/O signals is controlled by $\overline{E1}$, E2 and \overline{G} . If the outputs are activated before t_{AVQV} , the data lines will be driven to an indeterminate state until t_{AVQV} . If the address inputs are changed while $\overline{E1}$, E2 and \overline{G} remain active, output data will remain valid for Output Data Hold time (t_{AXQX}) but will go indeterminate until the next address access.

Figure 8. READ Mode AC Waveforms



Note: WRITE Enable (\overline{W}) = High.

Table 7. READ Mode AC Characteristics

Symbol	Parameter ⁽¹⁾	M48T08/M48T18				Unit
		-100		-150		
		Min	Max	Min	Max	
t _{AVAV}	READ Cycle Time	100		150		ns
t _{AVQV}	Address Valid to Output Valid		100		150	ns
t _{E1LQV}	Chip Enable 1 Low to Output Valid		100		150	ns
t _{E2HQV}	Chip Enable 2 High to Output Valid		100		150	ns
t _{GLQV}	Output Enable Low to Output Valid		50		75	ns
t _{E1LQX}	Chip Enable 1 Low to Output Transition	10		10		ns
t _{E2HQX}	Chip Enable 2 High to Output Transition	10		10		ns
t _{GLQX}	Output Enable Low to Output Transition	5		5		ns
t _{E1HQZ}	Chip Enable 1 High to Output Hi-Z		50		75	ns
t _{E2LQZ}	Chip Enable 2 Low to Output Hi-Z		50		75	ns
t _{GHQZ}	Output Enable High to Output Hi-Z		40		60	ns
t _{AXQX}	Address Transition to Output Transition	5		5		ns

Note: 1. Valid for Ambient Operating Temperature: T_A = 0 to 70°C; V_{CC} = 4.75 to 5.5V or 4.5 to 5.5V (except where noted).

WRITE Mode

The M48T08/18 is in the WRITE Mode whenever \overline{W} , $\overline{E1}$, and E2 are active. The start of a WRITE is referenced from the latter occurring falling edge of \overline{W} or $\overline{E1}$, or the rising edge of E2. A WRITE is terminated by the earlier rising edge of \overline{W} or $\overline{E1}$, or the falling edge of E2. The addresses must be held valid throughout the cycle. $\overline{E1}$ or \overline{W} must return high or E2 low for a minimum of t_{E1HAX} or t_{E2LAX} from Chip Enable or t_{WHAX} from WRITE Enable

prior to the initiation of another READ or WRITE Cycle. Data-in must be valid t_{DVWH} prior to the end of WRITE and remain valid for t_{WHDX} afterward. \overline{G} should be kept high during WRITE Cycles to avoid bus contention; however, if the output bus has been activated by a low on $\overline{E1}$ and \overline{G} and a high on E2, a low on \overline{W} will disable the outputs t_{WLQZ} after \overline{W} falls.

Figure 9. WRITE Enable Controlled, WRITE AC Waveform

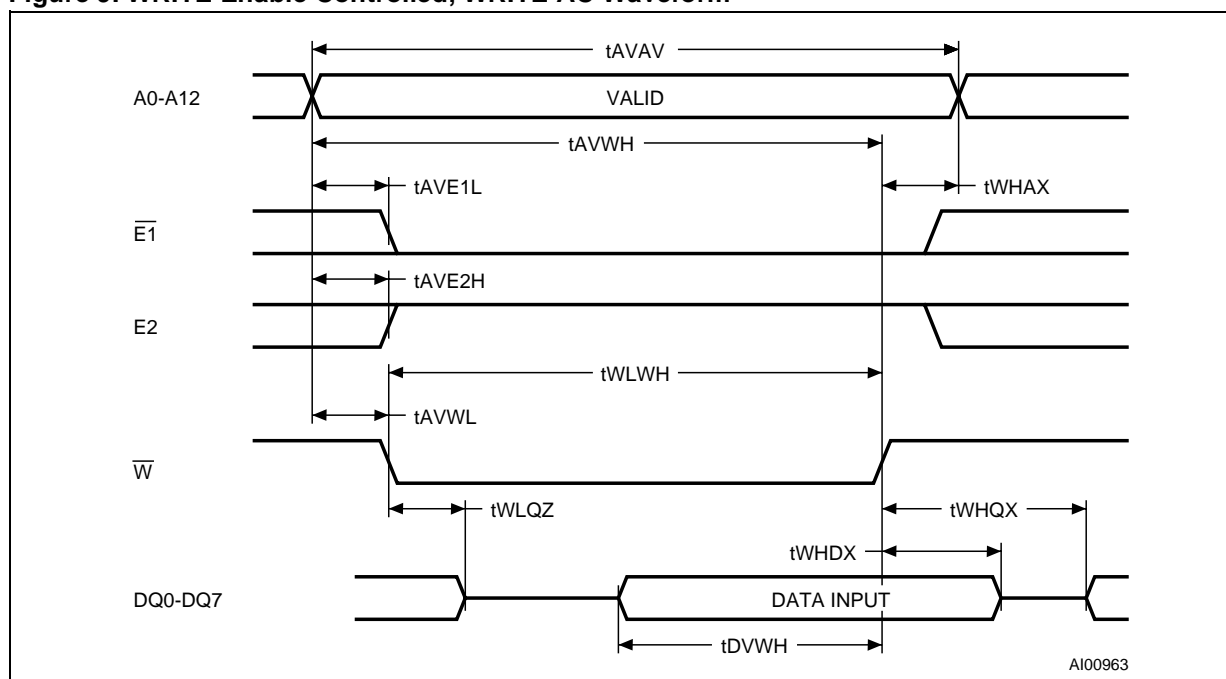


Figure 10. Chip Enable Controlled, WRITE AC Waveforms

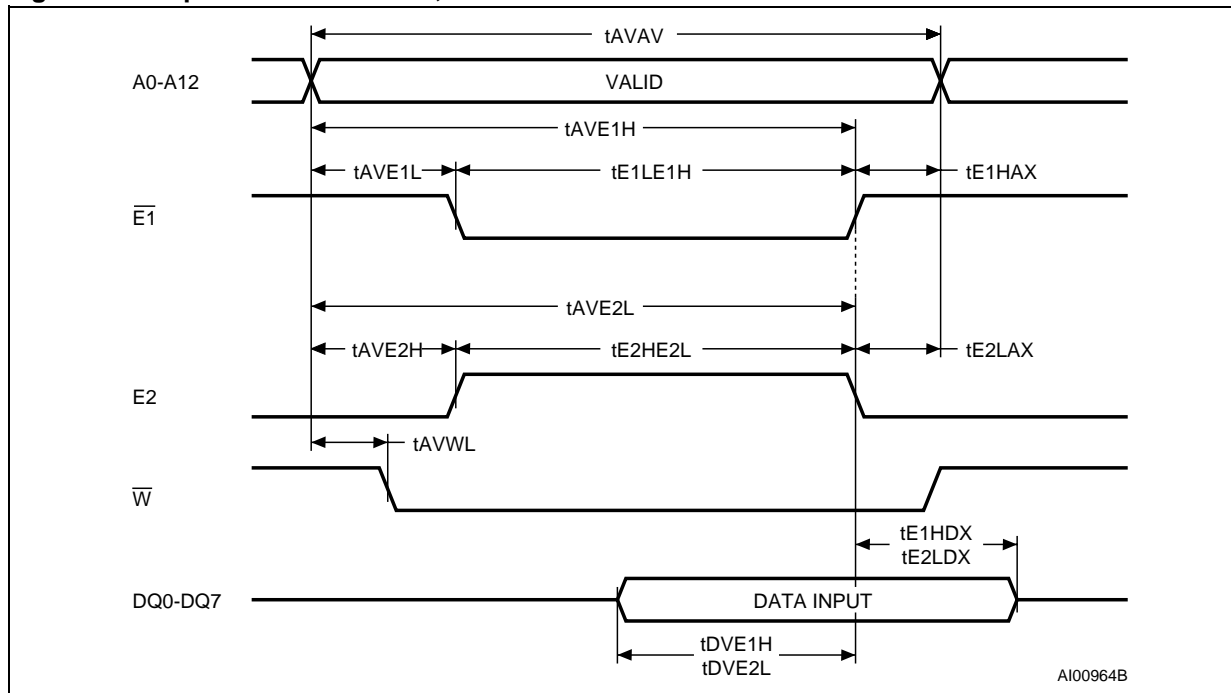


Table 8. WRITE Mode AC Characteristics

Symbol	Parameter ⁽¹⁾	M48T08/M48T18				Unit
		-100		-150		
		Min	Max	Min	Max	
t _{AVAV}	WRITE Cycle Time	100		150		ns
t _{AVWL}	Address Valid to WRITE Enable Low	0		0		ns
t _{AVE1L}	Address Valid to Chip Enable 1 Low	0		0		ns
t _{AVE2H}	Address Valid to Chip Enable 2 High	0		0		ns
t _{WLWH}	WRITE Enable Pulse Width	80		100		ns
t _{E1LE1H}	Chip Enable 1 Low to Chip Enable 1 High	80		130		ns
t _{E2HE2L}	Chip Enable 2 High to Chip Enable 2 Low	80		130		ns
t _{WHAX}	WRITE Enable High to Address Transition	10		10		ns
t _{E1HAX}	Chip Enable 1 High to Address Transition	10		10		ns
t _{E2LAX}	Chip Enable 2 Low to Address Transition	10		10		ns
t _{DVWH}	Input Valid to WRITE Enable High	50		70		ns
t _{DVE1H}	Input Valid to Chip Enable 1 High	50		70		ns
t _{DVE2L}	Input Valid to Chip Enable 2 Low	50		70		ns
t _{WHDX}	WRITE Enable High to Input Transition	5		5		ns
t _{E1HDX}	Chip Enable 1 High to Input Transition	5		5		ns
t _{E2LDX}	Chip Enable 2 Low to Input Transition	5		5		ns
t _{WLQZ}	WRITE Enable Low to Output Hi-Z		50		70	ns
t _{AVWH}	Address Valid to WRITE Enable High	80		130		ns
t _{AVE1H}	Address Valid to Chip Enable 1 High	80		130		ns
t _{AVE2L}	Address Valid to Chip Enable 2 Low	80		130		ns
t _{WHQX}	WRITE Enable High to Output Transition	10		10		ns

Note: 1. Valid for Ambient Operating Temperature: T_A = 0 to 70°C; V_{CC} = 4.75 to 5.5V or 4.5 to 5.5V (except where noted).

Data Retention Mode

With valid V_{CC} applied, the M48T08/18 operates as a conventional BYTEWIDE™ static RAM. Should the supply voltage decay, the RAM will automatically power-fail deselect, write protecting itself when V_{CC} falls within the V_{PFD} (max), V_{PFD} (min) window. All outputs become high impedance, and all inputs are treated as “Don’t care.”

Note: A power failure during a WRITE cycle may corrupt data at the currently addressed location, but does not jeopardize the rest of the RAM’s content. At voltages below V_{PFD} (min), the user can be assured the memory will be in a write protected state, provided the V_{CC} fall time is not less than t_F . The M48T08/18 may respond to transient noise spikes on V_{CC} that reach into the deselect window during the time the device is sampling V_{CC} . Therefore, decoupling of the power supply lines is recommended.

When V_{CC} drops below V_{SO} , the control circuit switches power to the internal battery which preserves data and powers the clock. The internal button cell will maintain data in the M48T08/18 for an accumulated period of at least 10 years when

V_{CC} is less than V_{SO} . As system power returns and V_{CC} rises above V_{SO} , the battery is disconnected and the power supply is switched to external V_{CC} .

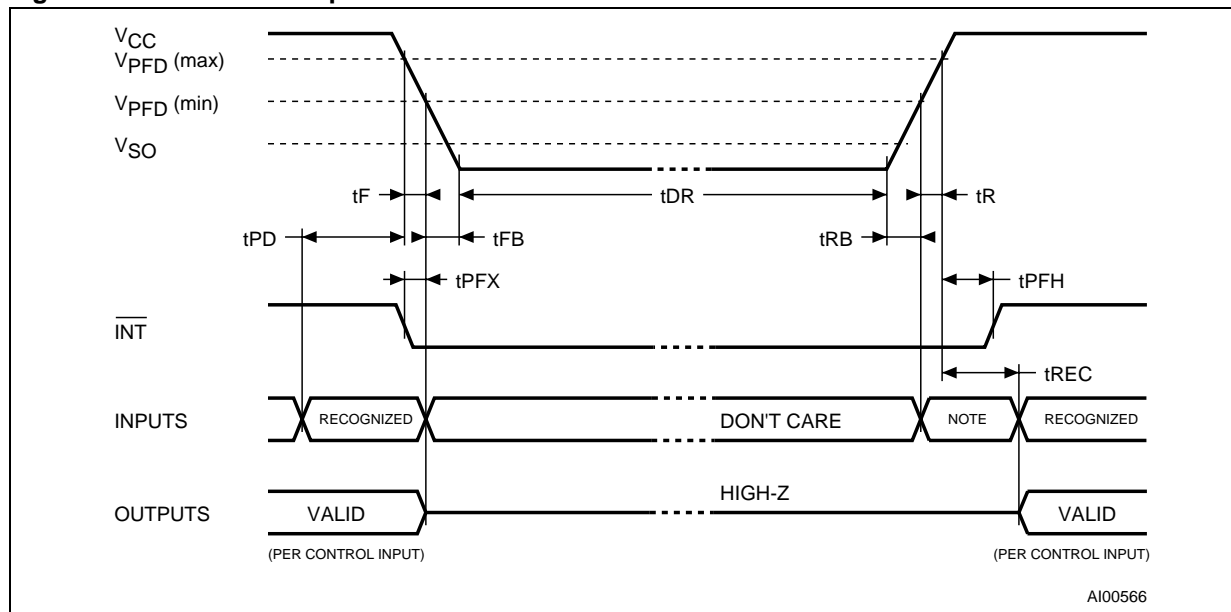
Write protection continues until V_{CC} reaches V_{PFD} (min) plus t_{REC} (min). $\overline{E1}$ should be kept high or $E2$ low as V_{CC} rises past V_{PFD} (min) to prevent inadvertent WRITE cycles prior to system stabilization. Normal RAM operation can resume t_{REC} after V_{CC} exceeds V_{PFD} (max).

For more information on Battery Storage Life refer to the Application Note AN1012.

Power-fail Interrupt Pin

The M48T08/18 continuously monitors V_{CC} . When V_{CC} falls to the power-fail detect trip point, an interrupt is immediately generated. An internal clock provides a delay of between 10 μ s and 40 μ s before automatically deselecting the M48T08/18. The \overline{INT} pin is an open drain output and requires an external pull up resistor, even if the interrupt output function is not being used.

Figure 11. Power Down/Up Mode AC Waveforms



Note: Inputs may or may not be recognized at this time. Caution should be taken to keep $\overline{E1}$ high or $E2$ low as V_{CC} rises past V_{PFD} (min). Some systems may perform inadvertent WRITE cycles after V_{CC} rises above V_{PFD} (min) but before normal system operations begin. Even though a power on reset is being applied to the processor, a reset condition may not occur until after the system clock is running.

Table 9. Power Down/Up AC Characteristics

Symbol	Parameter ⁽¹⁾	Min	Max	Unit
t _{PD}	$\overline{E1}$ or \overline{W} at V _{IH} or E2 at V _{IL} before Power Down	0		μs
t _F ⁽²⁾	V _{PFD} (max) to V _{PFD} (min) V _{CC} Fall Time	300		μs
t _{FB} ⁽³⁾	V _{PFD} (min) to V _{SS} V _{CC} Fall Time	10		μs
t _R	V _{PFD} (min) to V _{PFD} (max) V _{CC} Rise Time	0		μs
t _{RB}	V _{SS} to V _{PFD} (min) V _{CC} Rise Time	1		μs
t _{REC}	$\overline{E1}$ or \overline{W} at V _{IH} or E2 at V _{IL} before Power Up	1		ms
t _{PFX}	\overline{INT} Low to Auto Deselect	10	40	μs
t _{PFH}	V _{PFD} (max) to \overline{INT} High		120	μs

Note: 1. Valid for Ambient Operating Temperature: T_A = 0 to 70°C; V_{CC} = 4.75 to 5.5V or 4.5 to 5.5V (except where noted).
 2. V_{PFD} (max) to V_{PFD} (min) fall time of less than t_F may result in deselection/write protection not occurring until 200μs after V_{CC} passes V_{PFD} (min).
 3. V_{PFD} (min) to V_{SS} fall time of less than t_{FB} may cause corruption of RAM data.

Table 10. Power Down/Up Trip Points DC Characteristics

Symbol	Parameter ^(1,2)	Min	Typ	Max	Unit	
V _{PFD}	Power-fail Deselect Voltage	M48T08	4.5	4.6	4.75	V
		M48T18	4.2	4.3	4.5	V
V _{SO}	Battery Back-up Switchover Voltage		3.0		V	
t _{DR}	Expected Data Retention Time	10			YEARS	

Note: 1. All voltages referenced to V_{SS}.
 2. Valid for Ambient Operating Temperature: T_A = 0 to 70°C; V_{CC} = 4.75 to 5.5V or 4.5 to 5.5V (except where noted).

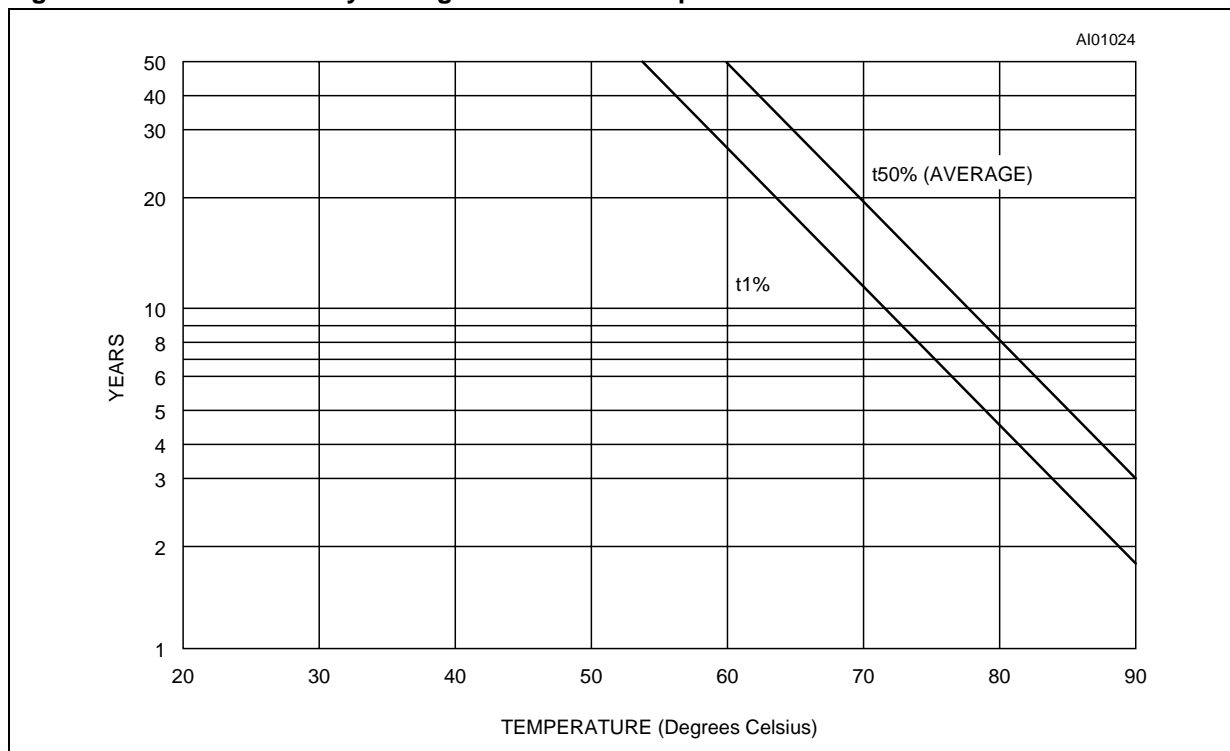
System Battery Life

The useful life of the battery in the M48T08/18 is expected to ultimately come to an end for one of two reasons: either because it has been discharged while providing current to the RAM and clock in the battery back-up mode, or because the effects of aging render the cell useless before it can actually be completely discharged. The two effects are virtually unrelated, allowing discharge or Capacity Consumption, and the effects of aging or Storage Life, to be treated as two independent but simultaneous mechanisms. The earlier occurring failure mechanism defines the battery system life of the M48T08/18.

Cell Storage Life. Storage life is primarily a function of temperature. Figure 12 illustrates the approximate storage life of the M48T08/18 battery

over temperature. The results in Figure 12 are derived from temperature accelerated life test studies performed at STMicroelectronics. For the purpose of the testing, a cell failure is defined as the inability of a cell stabilized at 25°C to produce a 2.4V closed circuit voltage across a 250 kΩ load resistor. The two lines, $t_{1\%}$ and $t_{50\%}$, represent different failure rate distributions for the cell's storage life. At 70°C, for example, the $t_{1\%}$ line indicates that an M48T08/18 has a 1% chance of having a battery failure 11 years into its life while the $t_{50\%}$ shows the part has a 50% chance of failure at the 20 year mark. The $t_{1\%}$ line represents the practical onset of wear out and can be considered the worst case Storage Life for the cell. The $t_{50\%}$ can be considered the normal or average life.

Figure 12. Predicted Battery Storage Life versus Temperature



Calculating Storage Life

The following formula can be used to predict storage life:

$$\frac{1}{\{[(TA1/TT)/SL1] + [(TA2/TT)/SL2] + \dots + [(TAN/TT)/(SLN)]\}}$$

where,

- TA1, TA2, TAN = time at ambient temperature 1, 2, etc.
- TT = total time = TA1+TA2+...+TAN
- SL1, SL2, SLN = storage life at temperature 1, 2, etc.

For example:

An M48T08/18 is exposed to temperatures of 55°C or less for 8322 hrs/yr, and temperatures greater than 60°C but less than 70°C for the remaining 438 hrs/yr. Reading predicted $t_{1\%}$ values from Figure 12, page 17,

$$\frac{1}{\{[(8322/8760)/41] + [(438/8760)/11.4]\}}$$

where,

- SL1 = 41 yrs, SL2 = 11.4 yrs
- TT = 8760 hrs/yr
- TA1 = 8322 hrs/yr, TA2 = 438 hrs/yr

or 36 years.

Cell Capacity Life. The M48T08/18 internal cell has a rated capacity of 48mAh. The device places a nominal RAM and TIMEKEEPER[®] load of less than 520nA on the battery at room temperature. At this rate, the capacity consumption life is $48E-3/520E-9 = 96,153$ hours or about 10.5 years. Capacity consumption life can be extended by applying V_{CC} or turning off the clock oscillator prior to system power down.

Calculating Capacity Life. The RAM and TIMEKEEPER load remains relatively constant over the operating temperature range. Thus, worst-case cell capacity life is essentially a function of one variable, V_{CC} duty cycle. For example, if the oscillator runs 100% of the time with V_{CC} applied 60% of the time, the capacity consumption life is $10/(1-0.6)$, or 25 years.

Estimated System Life. Since either storage life or capacity consumption can end the battery's life, the system life is marked by which ever occurs first. In the above example, this would be 25 years.

Reference for System Life. Each M48T08/18 is marked with a nine digit manufacturing date code in the form of H99XXYYZZ. For example, H995B9431 is:

H = fabricated in Carrollton, TX,

9 = assembled in Muar, Malaysia,

9 = tested in Muar, Malaysia,

5B = lot designator, and

9431 = assembled in the year 1994, work week 31.

CLOCK OPERATIONS

Reading the Clock

Updates to the TIMEKEEPER® registers should be halted before clock data is read to prevent reading data in transition. The BiPORT™ TIMEKEEPER cells in the RAM array are only data registers and not the actual clock counters, so updating the registers can be halted without disturbing the clock itself.

Updating is halted when a '1' is written to the READ Bit, the seventh bit in the control register. As long as a '1' remains in that position, updating is halted. After a halt is issued, the registers reflect the count; that is, the day, date, and the time that were current at the moment the halt command was issued.

All of the TIMEKEEPER registers are updated simultaneously. A halt will not interrupt an update in progress. Updating is within a second after the bit is reset to a '0.'

Setting the Clock

The eighth bit of the control register is the WRITE Bit. Setting the WRITE Bit to a '1,' like the READ Bit, halts updates to the TIMEKEEPER registers. The user can then load them with the correct day, date, and time data in 24 hour BCD format (on Table 11). Resetting the WRITE Bit to a '0' then transfers the values of all time registers (1FF9h-1FFFh) to the actual TIMEKEEPER counters and allows normal operation to resume. The FT Bit and the bits marked as '0' in Table 11 must be written to '0' to allow for normal TIMEKEEPER and RAM operation.

See the Application Note AN923, "TIMEKEEPER® Rolling Into the 21st Century" for information on Century Rollover.

Table 11. Register Map

Address	Data								Function/Range BCD Format	
	D7	D6	D5	D4	D3	D2	D1	D0		
1FFFh	10 Years				Year				Year	00-99
1FFEh	0	0	0	10 M	Month				Month	01-12
1FFDh	0	0	10 Date		Date				Date	01-31
1FFCh	0	FT	0	0	0	Day			Day	01-07
1FFBh	0	0	10 Hours		Hours				Hours	00-23
1FFAh	0	10 Minutes			Minutes				Minutes	00-59
1FF9h	ST	10 Seconds			Seconds				Seconds	00-59
1FF8h	W	R	S	Calibration				Control		

Keys: S = SIGN Bit

FT = FREQUENCY TEST Bit (Set to '0' for normal clock operation)

R = READ Bit

W = WRITE Bit

ST = STOP Bit

0 = Must be set to '0'

Stopping and Starting the Oscillator

The oscillator may be stopped at any time. If the device is going to spend a significant amount of time on the shelf, the oscillator can be turned off to minimize current drain on the battery. The STOP Bit is the MSB of the seconds register. Setting it to a '1' stops the oscillator. The M48T08/18 is shipped from STMicroelectronics with the STOP Bit set to a '1.' When reset to a '0,' the M48T08/18 oscillator starts within one second.

Calibrating the Clock

The M48T08/18 is driven by a quartz-controlled oscillator with a nominal frequency of 32,768 Hz. A typical M48T08/18 is accurate within 1 minute per month at 25°C without calibration. The devices are tested not to exceed ± 35 ppm (parts per million) oscillator frequency error at 25°C, which equates to about ± 1.53 minutes per month. With the calibration bits properly set, the accuracy of each M48T08/18 improves to better than $+1/-2$ ppm at 25°C.

The oscillation rate of any crystal changes with temperature. Figure 13, page 21 shows the frequency error that can be expected at various temperatures. Most clock chips compensate for crystal frequency and temperature shift error with cumbersome "trim" capacitors. The M48T08/18 design, however, employs periodic counter correction. The calibration circuit adds or subtracts counts from the oscillator divider circuit at the divide by 256 stage, as shown in Figure 14, page 21. The number of times pulses are blanked (subtracted, negative calibration) or split (added, positive calibration) depends upon the value loaded into the five-bit Calibration Byte found in the Control Register. Adding counts speeds the clock up, subtracting counts slows the clock down.

The Calibration Byte occupies the five lower order bits in the Control register. This byte can be set to represent any value between 0 and 31 in binary form. The sixth bit is the Sign Bit; '1' indicates positive calibration, '0' indicates negative calibration. Calibration occurs within a 64 minute cycle. The first 62 minutes in the cycle may, once per minute, have one second either shortened by 128 or lengthened by 256 oscillator cycles. If a binary '1' is loaded into the register, only the first 2 minutes in the 64 minute cycle will be modified; if a binary 6 is loaded, the first 12 will be affected, and so on.

Therefore, each calibration step has the effect of adding 512 or subtracting 256 oscillator cycles for every 125,829,120 actual oscillator cycles; that is +4.068 or -2.034 ppm of adjustment per calibration step in the calibration register. Assuming that the oscillator is in fact running at exactly 32,768Hz, each of the 31 increments in the Calibration Byte would represent +10.7 or -5.35 seconds per month which corresponds to a total range of +5.5 or -2.75 minutes per month.

Two methods are available for ascertaining how much calibration a given M48T08/18 may require. The first involves simply setting the clock, letting it run for a month and comparing it to a known accurate reference (like WWV broadcasts). While that may seem crude, it allows the designer to give the end user the ability to calibrate his clock as his environment may require, even after the final product is packaged in a non-user serviceable enclosure. All the designer has to do is provide a simple utility that accesses the Calibration Byte.

The second approach is better suited to a manufacturing environment, and involves the use of standard test equipment. When the Frequency Test (FT) Bit, the seventh-most significant bit in the Day Register, is set to a '1,' and the oscillator is running at 32,768 Hz, the LSB (DQ0) of the Seconds Register will toggle at 512 Hz. Any deviation from 512 Hz indicates the degree and direction of oscillator frequency shift at the test temperature. For example, a reading of 512.01024 Hz would indicate a +20 PPM oscillator frequency error, requiring a -10 (WR001010) to be loaded into the Calibration Byte for correction.

Note: Setting or changing the Calibration Byte does not affect the Frequency Test output frequency. The device must be selected and addresses must be stable at Address 1FF9h when reading the 512 Hz on DQ0.

The FT Bit must be set using the same method used to set the clock: using the WRITE Bit. The LSB of the Seconds Register is monitored by holding the M48T08/18 in an extended READ of the Seconds Register, but without having the READ Bit set. The FT Bit MUST be reset to '0' for normal clock operations to resume.

For more information on calibration, see the Application Note AN934, "TIMEKEEPER[®] Calibration."

Figure 13. Crystal Accuracy Across Temperature

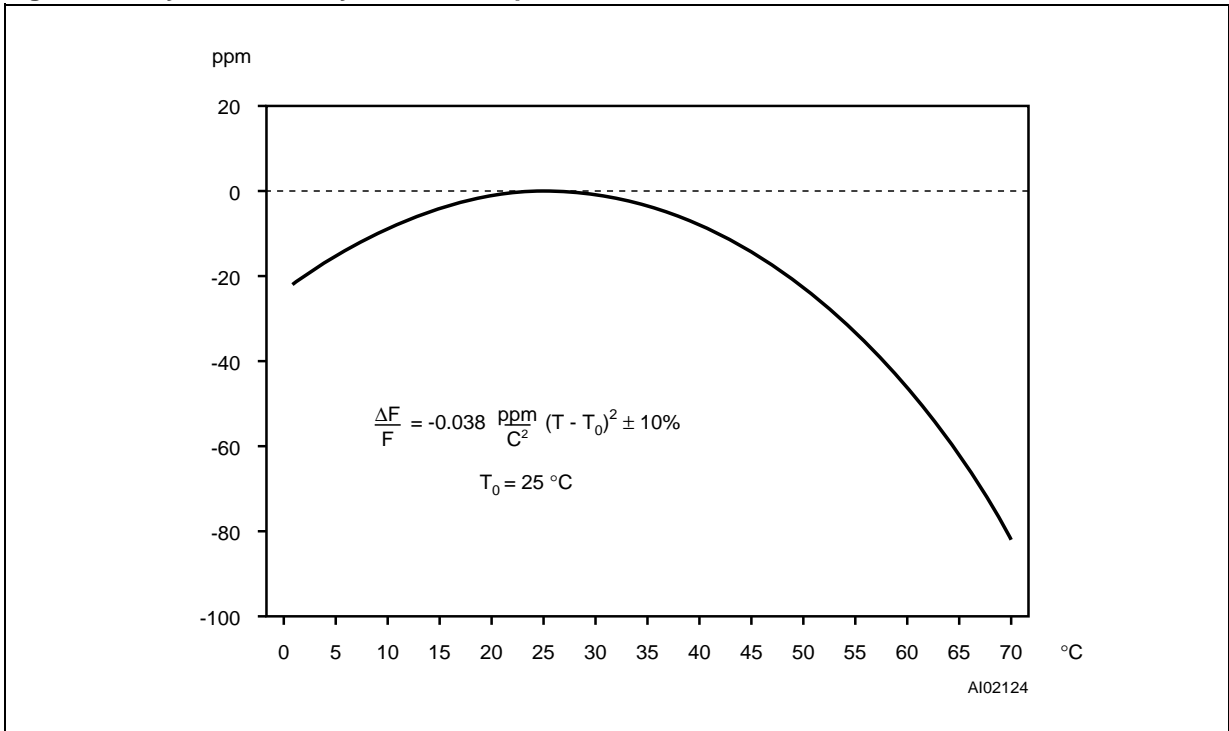
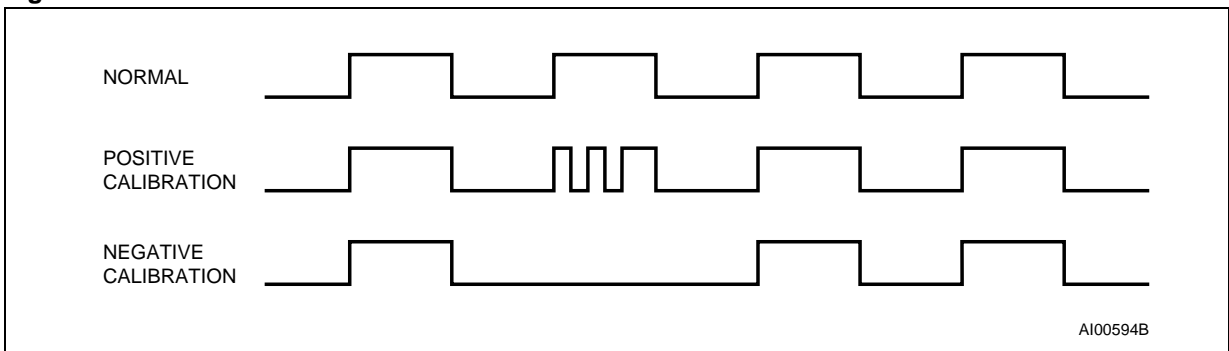


Figure 14. Clock Calibration

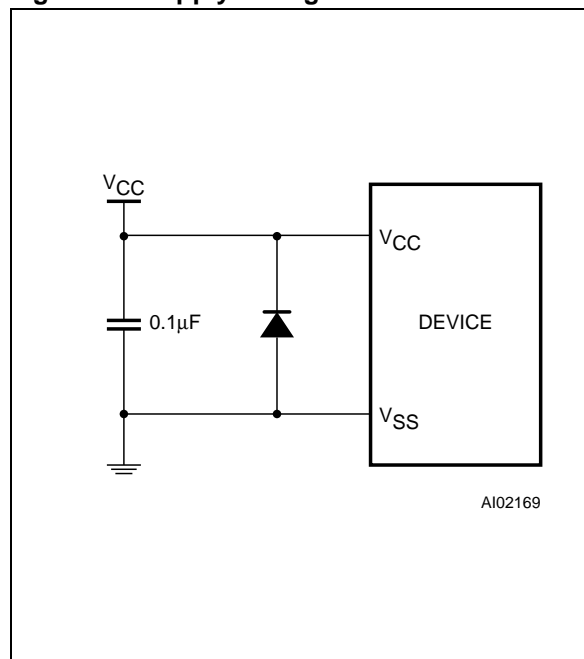


Power Supply Decoupling and Undershoot Protection

I_{CC} transients, including those produced by output switching, can produce voltage fluctuations, resulting in spikes on the V_{CC} bus. These transients can be reduced if capacitors are used to store energy which stabilizes the V_{CC} bus. The energy stored in the bypass capacitors will be released as low going spikes are generated or energy will be absorbed when overshoots occur. A ceramic bypass capacitor value of $0.1\mu F$ (as shown in Figure 15) is recommended in order to provide the needed filtering.

In addition to transients that are caused by normal SRAM operation, power cycling can generate negative voltage spikes on V_{CC} that drive it to values below V_{SS} by as much as one Volt. These negative spikes can cause data corruption in the SRAM while in battery backup mode. To protect from these voltage spikes, it is recommended to connect a schottky diode from V_{CC} to V_{SS} (cathode connected to V_{CC} , anode to V_{SS}). Schottky diode 1N5817 is recommended for through hole and MBRS120T3 is recommended for surface mount.

Figure 15. Supply Voltage Protection



PART NUMBERING

Table 12. Ordering Information Scheme

Example:	M48T	18	-100	MH	1	TR
Device Type						
M48T						
Supply Voltage and Write Protect Voltage						
08 ⁽¹⁾ = V _{CC} = 4.75 to 5.5V; V _{PFD} = 4.5 to 4.75V						
18 = V _{CC} = 4.5 to 5.5V; V _{PFD} = 4.2 to 4.5V						
Speed						
-100 = 100ns (M48T08)						
-150 = 150ns (M48T18)						
Package						
PC = PCDIP28						
MH ⁽²⁾ = SOH28						
Temperature Range						
1 = 0 to 70°C						
Shipping Method for SOIC						
blank = Tubes						
TR = Tape & Reel						

Note: 1. The M48T08 part is offered with the PCDIP28 (e.g., CAPHAT™) package only.
 2. The SOIC package (SOH28) requires the battery/crystal package (SNAPHAT®) which is ordered separately under the part number "M4T28-BR12SH" in plastic tube or "M4T28-BR12SHTR" in Tape & Reel form.

Caution: Do not place the SNAPHAT battery package "M4TXX-BR12SH" in conductive foam as it will drain the lithium button-cell battery.

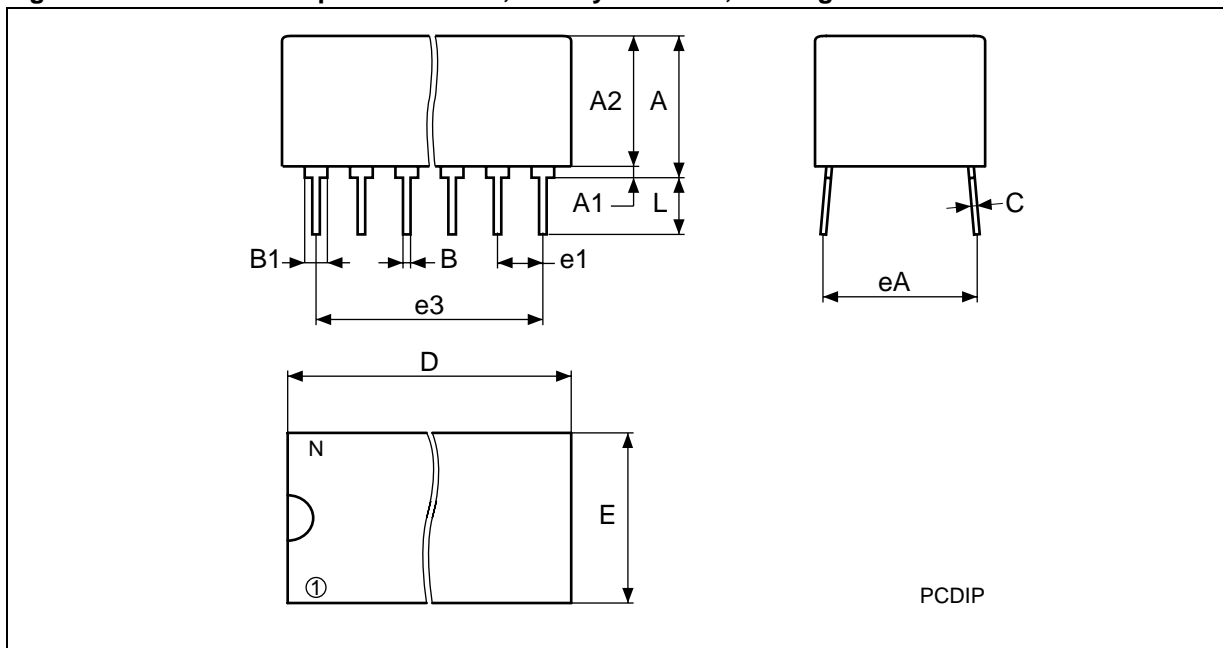
For a list of available options (e.g., Speed, Package) or for further information on any aspect of this device, please contact the ST Sales Office nearest you.

Table 13. SNAPHAT Battery Table

Part Number	Description	Package
M4T28-BR12SH	Lithium Battery (48mAh) SNAPHAT	SH
M4T32-BR12SH	Lithium Battery (120mAh) SNAPHAT	SH

PACKAGE MECHANICAL INFORMATION

Figure 16. PCDIP28 – 28-pin Plastic DIP, battery CAPHAT, Package Outline

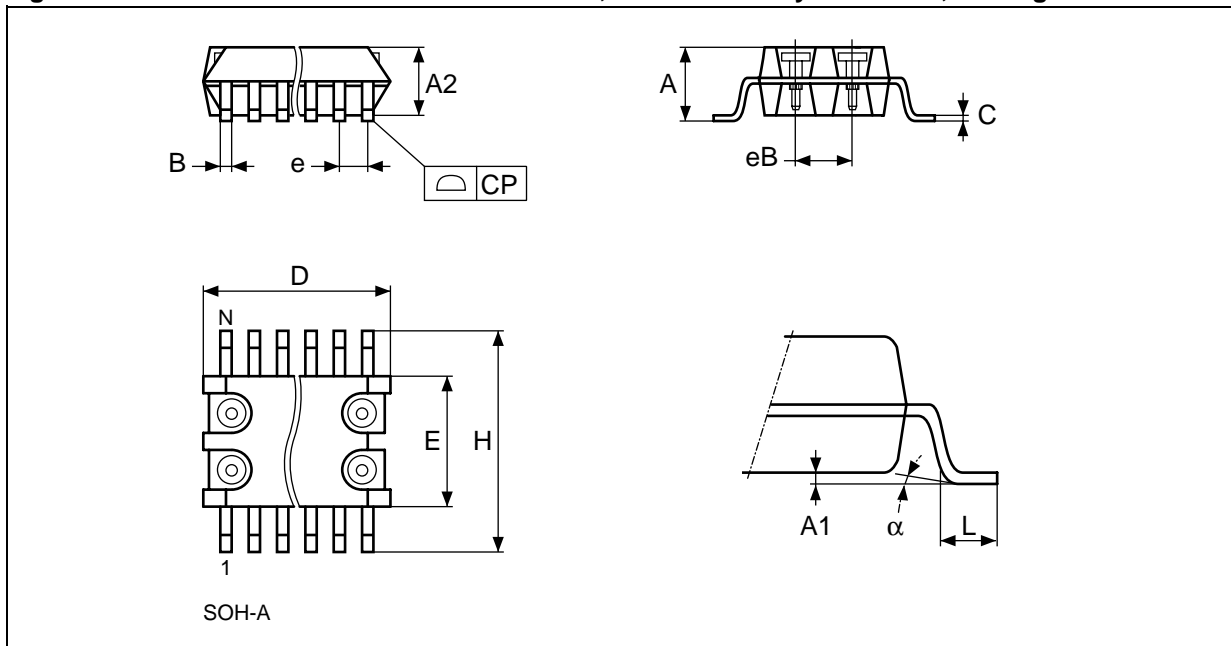


Note: Drawing is not to scale.

Table 14. PCDIP28 – 28-pin Plastic DIP, battery CAPHAT, Package Mechanical Data

Symb	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A		8.89	9.65		0.350	0.380
A1		0.38	0.76		0.015	0.030
A2		8.38	8.89		0.330	0.350
B		0.38	0.53		0.015	0.021
B1		1.14	1.78		0.045	0.070
C		0.20	0.31		0.008	0.012
D		39.37	39.88		1.550	1.570
E		17.83	18.34		0.702	0.722
e1		2.29	2.79		0.090	0.110
e3		29.72	36.32		1.170	1.430
eA		15.24	16.00		0.600	0.630
L		3.05	3.81		0.120	0.150
N		28			28	

Figure 17. SOH28 – 28-lead Plastic Small Outline, 4-socket battery SNAPHAT, Package Outline

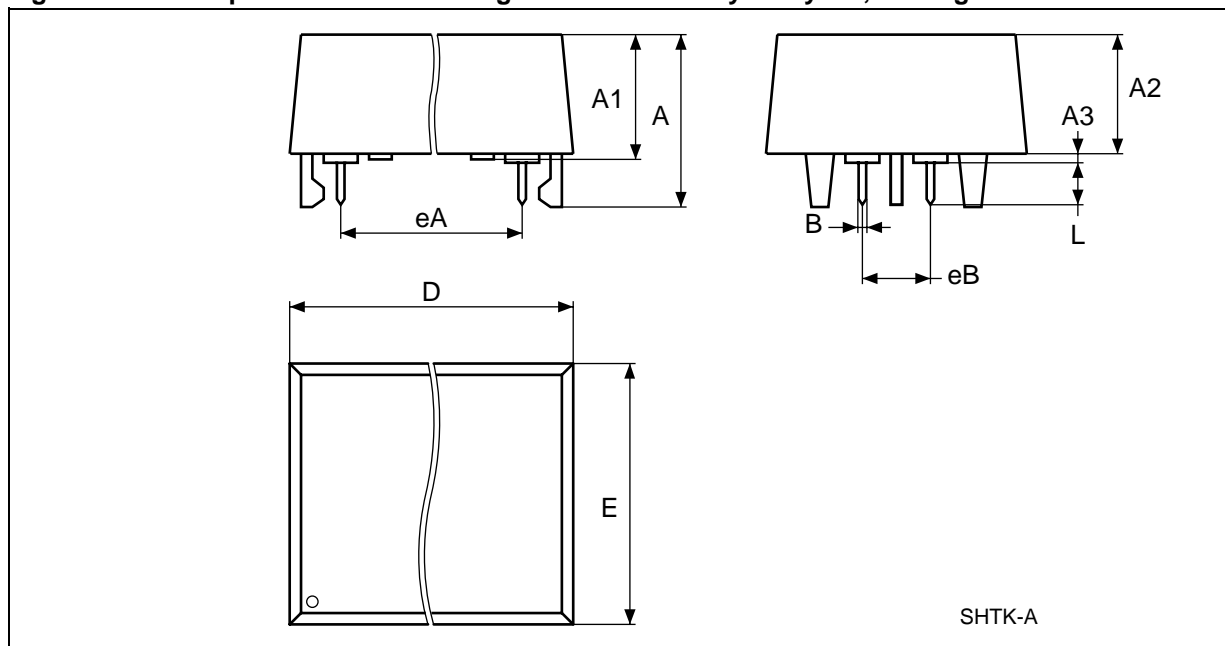


Note: Drawing is not to scale.

Table 15. SOH28 – 28-lead Plastic Small Outline, 4-socket battery SNAPHAT, Package Mechanical Data

Symb	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A			3.05			0.120
A1		0.05	0.36		0.002	0.014
A2		2.34	2.69		0.092	0.106
B		0.36	0.51		0.014	0.020
C		0.15	0.32		0.006	0.012
D		17.71	18.49		0.697	0.728
E		8.23	8.89		0.324	0.350
e	1.27	–	–	0.050	–	–
eB		3.20	3.61		0.126	0.142
H		11.51	12.70		0.453	0.500
L		0.41	1.27		0.016	0.050
α		0°	8°		0°	8°
N	28			28		
CP			0.10			0.004

Figure 18. SH – 4-pin SNAPHAT Housing for 48mAh Battery & Crystal, Package Outline

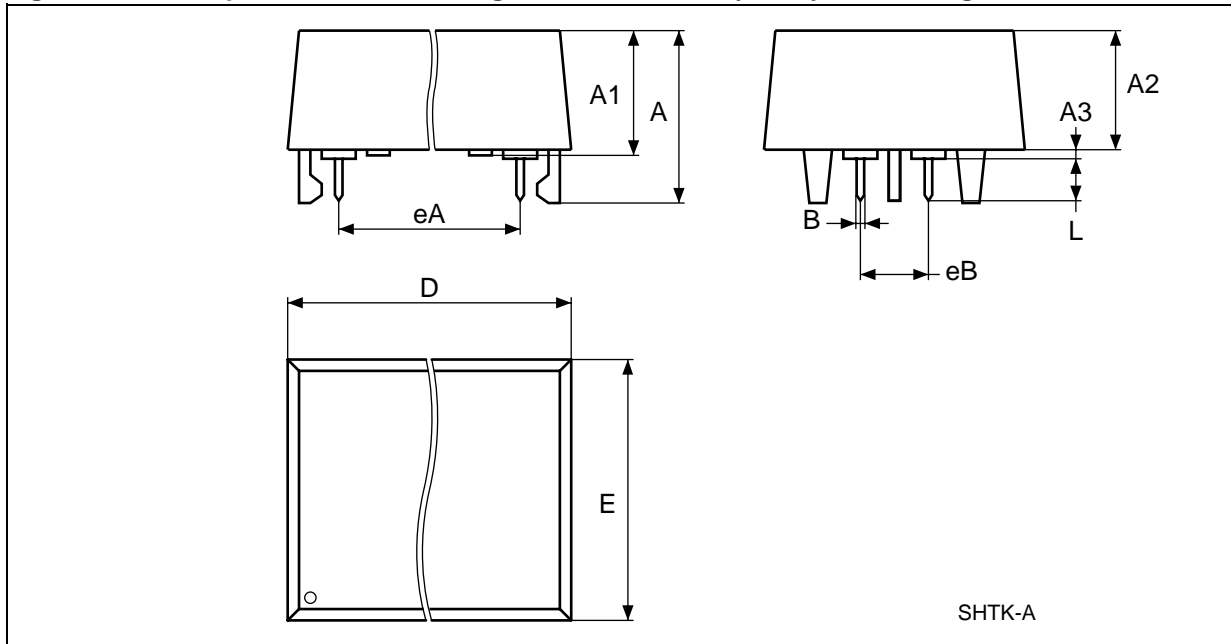


Note: Drawing is not to scale.

Table 16. SH – 4-pin SNAPHAT Housing for 48mAh Battery & Crystal, Package Mechanical Data

Symb	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A			9.78			0.385
A1		6.73	7.24		0.265	0.285
A2		6.48	6.99		0.255	0.275
A3			0.38			0.015
B		0.46	0.56		0.018	0.022
D		21.21	21.84		0.835	0.860
E		14.22	14.99		0.560	0.590
eA		15.55	15.95		0.612	0.628
eB		3.20	3.61		0.126	0.142
L		2.03	2.29		0.080	0.090

Figure 19. SH – 4-pin SNAPHAT Housing for 120mAh Battery & Crystal, Package Outline



Note: Drawing is not to scale.

Table 17. SH – 4-pin SNAPHAT Housing for 120mAh Battery & Crystal, Package Mechanical Data

Symb	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A			10.54			0.415
A1		8.00	8.51		0.315	.0335
A2		7.24	8.00		0.285	0.315
A3			0.38			0.015
B		0.46	0.56		0.018	0.022
D		21.21	21.84		0.835	0.860
E		17.27	18.03		0.680	.0710
eA		15.55	15.95		0.612	0.628
eB		3.20	3.61		0.126	0.142
L		2.03	2.29		0.080	0.090

REVISION HISTORY**Table 18. Document Revision History**

Date	Revision Details
December 1999	First Issue
02/07/00	From Preliminary Data to Data Sheet Battery Low Flag paragraph changed 100ns speed class identifier changed (Tables 7, 8)
07/11/00	t _{FB} changed (Table 9) Watchdog Timer paragraph changed
07/16/01	Reformatted; SNAPHAT battery table added (Table 13); added temp./voltage info. to tables (Tables 4, 5, 7, 8, 9, 10)
08/01/01	Reference to App. Note corrected in "Calibrating the Clock" section

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