AnalogTek

AT8563

——A low power RTC chip with I^2C

Document No.： AT8563DS001V1.2E

Issued Date： 2009.2.23

February 25, 2009

CONTENTS

1 Chip Overview

AT8563 is a CMOS real-time clock/calendar chip optimized for low power consumption. The timing counter consists of century, year, month, day, date, hour, minute and second bits. External MPU can read or set the time as well as timer or alarmer when it is necessary. As exchanging data by the advance serial bus I^2C, lines number on PCB can be reduced dramatically, which is very suitable in a complicated system.

The chip has the following features:

- An external 32.768 kHz crystal is needed to generated time base
- Wide operating supply voltage range: 1.0 to 5.5 V
- Low back-up current; typical 0.25 μA at V_{DD} = 3.0 V and T_{amb} = 25 ℃
- 400 kHz two-wire I^2C-bus interface (at V_{DD} = 1.8 to 5.5 V)
- Programmable clock output for peripheral devices: 32.768 kHz, 1024 Hz 32 Hz and 1 Hz
- Alarm and timer functions
- Voltage-low detector
- Integrated oscillator capacitor
- Internal power-on reset
- I^2C-bus slave address: read A3H; write A2H

Typical Applications:

- Mobile telephones
- Portable instruments
- OA equipments such as Fax machines
- Battery powered products

Table 1 shows our ordering information for AT8563.

Table1 Ordering information

Type number	Package		
Name	Name	Description	Version
AT8563P	DIP8	plastic dual in-line package; 8 leads (300 mil)	SOT97-1
AT8563T	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1
AT8563TS	SSO8	plastic small outline package; 8 leads; body width 3.0 mm	SOT505-1
AT8563S	MSOP8	plastic small outline package; 8 leads; body width 3.0 mm	

Table 2 Quick reference data

Symol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage operating mode	I^2C-bus inactive; T_{amb} = 25 °	1.0	5.5	V
		I^2C-bus active; f_{SCL} = 400 kHz; T_{amb} = −30 to +85°C	1.8	5.5	V
I_{DD}	supply crrent; timer and CLKOUT disabled	f_{SCL} = 200 kHz		800	μA
		f_{SCL} = 100 kHz		200	μA
		f_{SCL} = 0 Hz; T_{amb}= 25 °C			
		V_{DD} = 5 V		550	μA
		V_{DD} = 2 V		450	μA
T_{amb}	operating ambient temperature	-	−30	+85	°C
T_{stg}	storage temperature	-	−65	+150	°C

2 Functional Description

2.1 Summary

The device's structure is shown in Fig 1.

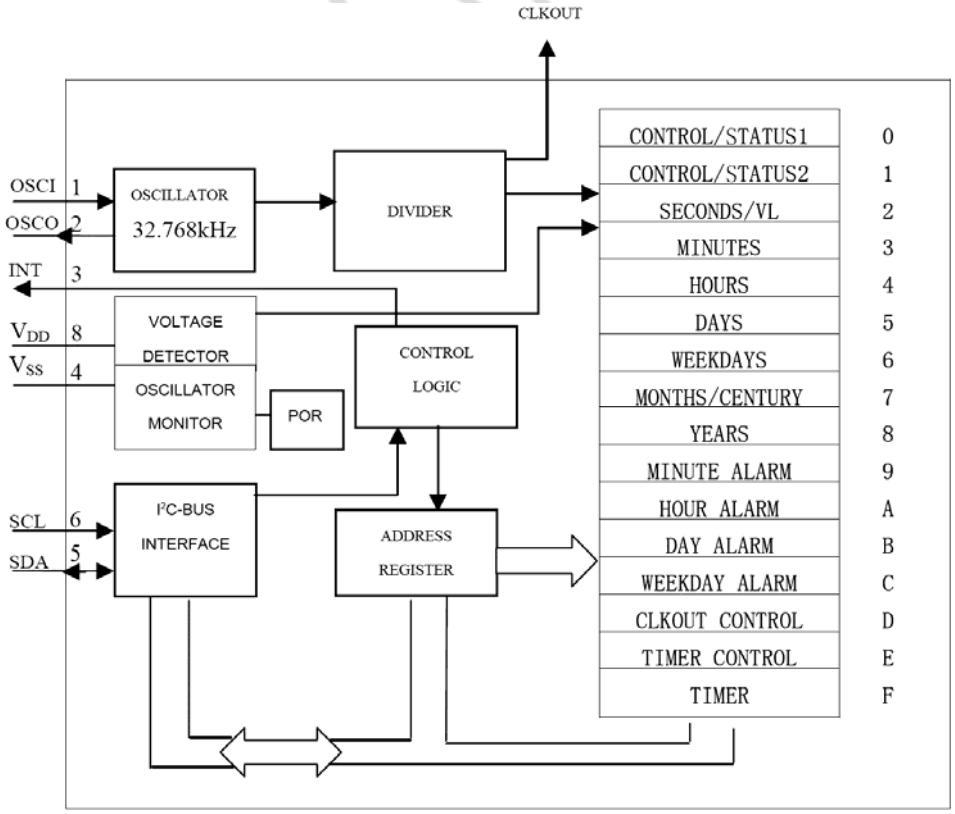


Fig 1 Block diagram

AT8563's pin layout and its protection network are shown in Fig 2 and Fig 3.

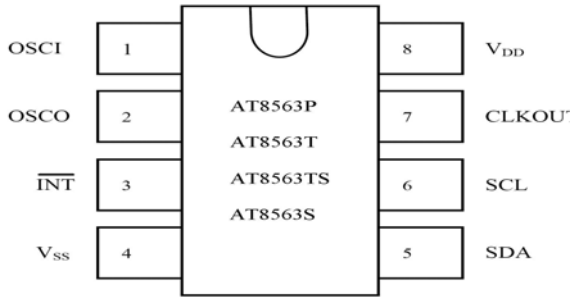


Fig 2 Pin Layout

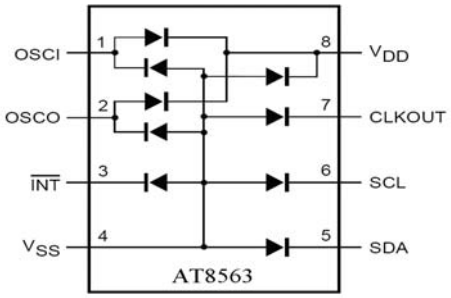


Fig 3 Device diode protection diagram

Table 3 gives the pins' description.

Table 3: Pin description

Symbol	Pin	Description
OSCI	1	oscillator input
OSCO	2	oscillator output
INT	3	interrupt output (open-drain; active LOW)
VSS	4	ground
SDA	5	serial Data I/O (open-drain)
SCL	6	serial Clock in
CLKOUT	7	clock output (open-drain)
VDD	8	positive power supply

AT8563 contains sixteen 8-bit registers with an auto-increasing address register, an on-chip 32.768 kHz oscillator with an integrated capacitor, a frequency divider which provides source clock for the Real-Time Clock (RTC), a programmable clock output, a timer, an alarm, a voltage-low detector and a I^2C-bus interface.

The 16 registers are mapped into a memory block, which is addressable, but not all bits are implemented. The first two registers (memory address 00H and 01H) are used as control and/or status registers. The memory addresses 02H through 08H are used as counters for the clock function (seconds up to year counters). Address locations 09H through 0CH contain alarm registers which define the conditions for an alarm. Address 0DH controls the frequency of CLKOUT output. 0EH and 0FH are timer control, timer counter register, respectively.

The Seconds, Minutes, Hours, Days, Months, Years as well as the Minute alarm, Hour alarm and Day alarm registers are all coded in BCD format. The Weekdays and Weekday alarm register are not coded in BCD format.

When one of the RTC registers is read the contents of all counters are frozen. Therefore, faulty reading of the clock/calendar during a carry condition is prevented.

2.2 Alarm function modes

By clearing the MSB (bit $\overline{AE}$= Alarm Enable) of one or more of the alarm registers, the corresponding alarm condition(s) will be active. In this way an alarm can be generated from once per minute up to once per week. The alarm condition sets the alarm flag, AF (bit 3 of Control/Status 2 register). The asserted AF can be used to generate an interrupt (INT). Bit AF can only be cleared by software.

2.3 Timer

The 8-bit countdown timer (address 0FH) is controlled by the Timer Control register (address 0EH; see Table 25). The Timer Control register selects one of 4 source clock frequencies for the timer (4096, 64, 1, or 1⁄60 Hz), and enables/disables the timer. The timer counts down from a software-loaded 8-bit binary value. At the end of every countdown, the timer sets the timer flag TF (see Table 7). The timer flag TF can only be cleared by software. The asserted timer flag TF can be used to generate aninterrupt (INT). The interrupt may be generated as a pulsed signal every countdownperiod or as a permanently active signal which follows the condition of TF. TI/TP (seeTable 7) is used to control this mode selection. When reading the timer, current countdown value is returned.

2.4 CLKOUT output

A programmable square wave is available at the CLKOUT pin. Operation is controlled by the CLKOUT frequency register (address 0DH; see Table 23). Frequencies of 32.768 kHz (default), 1024, 32 and 1 Hz can be generated for use as a system clock, microcontroller clock, input to a charge pump, or for calibration of the oscillator. CLKOUT is an open-drain output and enabled at power-on. If disabled it becomes high-impedance.

2.5 Reset

AT8563 includes an internal reset circuit which is active whenever the oscillator is stopped. In the reset state the I^2C-bus logic is initialized and all registers, including the address pointer, are cleared with the exception of bits FE, VL, TD1, TD0, TESTC and $\overline{AE}$which are set to logic 1.

2.6 Voltage-low detector

AT8563 has an on-chip voltage-low detector. When V_{DD} drops below Vlow the VL bit (Voltage Low, bit 7 in the Seconds register) is set to indicate that reliable clock/calendar information is no longer guaranteed. The VL flag can only be cleared by software.

The VL bit is intended to detect the situation when V_{DD} is decreasing slowly for example under battery operation. Should V_{DD} reach Vlow before power is re-asserted then the VL bit will be set. This will indicate that the time may have been corrupted.

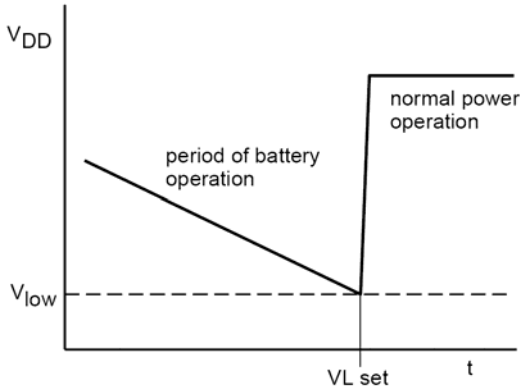


Fig 4 Voltage-low detection

2.7 Register organization

Table 4 Registers overview

Address	Register name	b7	b6	b5	b4	b3	b2	b1	b0
00H	Control/Status 1	TEST1	0	STOP	0	TESTC	0	0	0
01H	Control/Status 2	0	0	0	TI/TP	AF	TF	AIE	TIE
0DH	CLKOUT frequency	FE	-	-	-	-	-	FD1	FD0
0EH	Timer control	TE	-	-	-	-	-	TD1	TD0
0FH	Timer countdownvalue	<timer countdown value>							

Note: Bit positions labeled as '– 'are not implemented; those labeled with '0' should always be written with logic 0.

Table 5 BCD formatted registers overview

Address	Register name	b7	b6	b5	b4	b3	b2	b1	b0
02H	Seconds	VL	ten seconds（0-5）			seconds（0-9）			
03H	minutes	—	ten minutes（0-5）			minutes（0-9）			
04H	hours	—	—	ten hours（0-2）		hours（0-9）			
05H	days	—	—	ten days（0-3）		days（0-9）			
06H	weekday	—	—	—	—	—	weekdays（0-6）		
07H	months/century	C	—	—	ten month（0-1）	month（0-9）			
08H	years	ten years（0-9）				years（0-9）			
09H	minute alarm	$\overline{AE}$	ten minutes（0-5）			minutes（0-9）			
0AH	hour alarm	$\overline{AE}$	—	ten hours（0-2）		hours（0-9）			
0BH	day alarm	$\overline{AE}$	—	ten days（0-3）		days（0-9）			
0CH	weekday alarm	$\overline{AE}$	—	—	—	—	weekdays（0-6）		

Note: Bit positions labelled as '– 'are not implemented.

2.7.1 Control/Status 1 register

Table 6 Control/Status 1 register bits description

00H	Symbol	Description
b7	TEST1	TEST1 = 0; normal mode. TEST1 = 1; EXT_CLK test mode; see Section 8.7.
b5	STOP	STOP = 0; RTC source clock runs. STOP = 1; all RTC divider chain flip-flops are asynchronously set to logic 0; the RTC clock is stopped (CLKOUT at 32.768 kHz is still available).
b3	TESTC	TESTC = 0; power-on reset override facility is disabled (set to logic 0 for normal operation). TESTC = 1; power-on reset override is enabled.
b6, b4, b2..0	-	By default set to logic 0.

2.7.2 Control/Status 2 register

Table 7 Description of Control/Status 2 register bits description

01H	Symbol	Description
b7..5	0	By default set to logic 0
b4	TI/TP	TI/TP = 0: INT is active when TF is active (subject to the status of TIE). TI/TP = 1: INT pulses active according to Table 8 (subject to the status of TIE). Note that if AF and AIE are active then INT will be permanently active.
b3	AF	When an alarm occurs, AF is set to logic 1. Similarly, at the end of a timer countdown, TF is set to logic 1. These bits maintain their value until overwritten by software. If both timer and alarm interrupts are required in the application, the source of the interrupt can be determined by reading these bits. To prevent one flag being overwritten while clearing another, a logic AND is performed during a write access. See Table 9 for the value descriptions of bits AF and TF.
b2	TF	
b1	AIE	Bits AIE and TIE activate or deactivate the generation of an interrupt when AF or TF is asserted, respectively. The interrupt is the logical OR of these two conditions when both AIE and TIE are set. AIE = 0: alarm interrupt disabled; AIE = 1: alarm interrupt enabled. TIE = 0: timer interrupt disabled; TIE = 1: timer interrupt enabled.
b0	TIE	

Table 8 $\overline{\text{INT}}$ operation (bit TI/TP = 1)

Source clock (Hz)	$\overline{\text{INT}}$ period(s)	
	n=1	n>1
4096	1/8192	1/4096
64	1/128	1/64
1	1/64	1/64
1/60	1/64	1/64

Note:

[1] TF and $\overline{\text{INT}}$ become active simultaneously.

[2] n = loaded countdown timer value. Timer stopped when n = 0.

Table 9 Value descriptions for bits AF and TF

R/W	Bit: AF		Bit: TF	
	Value	Description	Value	Description
Read	0	alarm flag inactive	0	timer flag inactive
	1	alarm flag active	1	timer flag active
Write	0	alarm flag is cleared	0	timer flag is cleared
	1	alarm flag remains unchanged	1	timer flag remains unchanged

2.7.3 Seconds, Minutes and Hours registers

Table 10: Seconds/VL register bits description

02H	Symbol	Description
b7	VL	VL = 0: reliable clock/calendar information is guaranteed; VL = 1: reliable clock/calendar information is no longer guaranteed.
b6..0	<seconds>	These bits represent the current seconds value coded in BCD format; value = 00 to 59. Example: <seconds> = 101 1001, represents the value 59 s.

Table 11 Minutes register bits description

03H	Symbol	Description
b7	-	not implemented
b6..0	<minutes>	These bits represent the current minutes value coded in BCD format; value = 00 to 59.

Table 12 Hours register bits description

04H	Symbol	Description
b7..6	-	not implemented
b5..0	<hours>	These bits represent the current hours value coded in BCD format; value = 00 to 23.

2.7.4 Days, Weekdays, Months/Century and Years registers

Table 13 Days register bits description

05H	Symbol	Description
b7..6	-	not implemented

b5..0	<days>	These bits represent the current day value coded in BCD format; value = 01 to 31. AT8563 compensates for leap years by adding a 29th day to February if the year counter contains a value which is exactly divisible by 4, including the year '00'.

Table 14 Weekdays register bits description

06H	Symbol	Description
b7..3	-	not implemented
b2..0	<weekdays>	These bits represent the current weekday value 0 to 6, whose meaning is customized by users. However, we recommend a way to specify the weekday number, see Table 15. These bits may be re-assigned by the user.

Table 15 Suggested Weekday assignments

Day	Bit 2	Bit 1	Bit 0
Sunday	0	0	0
Monday	0	0	1
Tuesday	0	1	0
Wednesday	0	1	1
Thursday	1	0	0
Friday	1	0	1
Saturday	1	1	0

Table 16 Months/Century register bits description

07H	Symbol	Description
b7	C	Century bit. C = 0; indicates the century is 20xx. C = 1; indicates the century is 19xx. 'xx' indicates the value held in the Years register; see Table 18. This bit is toggled when the Years register overflows from 99 to 00. These bits may be re-assigned by the user
b6..5	-	not implemented
b4..0	<months>	These bits represents the current month value coded in BCD format; value = 01 to 12; see Table 17.

Table 17 Month assignments

Month	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
January	0	0	0	0	1
February	0	0	0	1	0
March	0	0	0	1	1
April	0	0	1	0	0
May	0	0	1	0	1
June	0	0	1	1	0

July	0	0	1	1	1
August	0	1	0	0	0
September	0	1	0	0	1
October	1	0	0	0	0
November	1	0	0	0	1
December	1	0	0	1	0

Table 18 Years register bits description

08H	Symbol	Description
b7..0	<years>	This register represents the current year value coded in BCD format; value = 00 to 99.

2.7.5 Alarm registers

When one or more of the alarm registers are loaded with a valid minute, hour, day or weekday and its corresponding $\overline{AE}$(Alarm Enable) bit is a logic 0, then that information will be compared with the current minute, hour, day and weekday. When all enabled comparisons first match, the bit AF (Alarm Flag) is set.

AF will remain set until cleared by software. Once AF has been cleared it will only be set again when the time increments to match the alarm condition once more. Alarm registers which have their $\overline{AE}$ bit set at logic 1 will be ignored.

Table 19 Minute alarm register bits description

09H	Symbol	Description
b7	$\overline{AE}$	$\overline{AE}$= 0; minute alarm is enabled. $\overline{AE}$= 1; minute alarm is disabled.
b6..0	<minute alarm>	These bits represents the minute alarm information coded in BCD format; value = 00 to 59.

Table 20 Hour alarm register bits description

0AH	Symbol	Description
7	$\overline{AE}$	$\overline{AE}$= 0; hour alarm is enabled. $\overline{AE}$= 1; hour alarm is disabled.
6 to 0	<hour alarm>	These bits represents the hour alarm information coded in BCD format; value = 00 to 23.

Table 21: Day alarm register bits description

0BH	Symbol	Description
b7	$\overline{AE}$	$\overline{AE}$= 0; day alarm is enabled. $\overline{AE}$= 1; day alarm is disabled.

b6..0	<day alarm>	These bits represents the day alarm information coded in BCD format; value = 01 to 31.

Table 22 Weekday alarm register bits description

0CH	Symbol	Description
b7	$\overline{AE}$	$\overline{AE}$= 0; weekday alarm is enabled. $\overline{AE}$= 1; weekday alarm is disabled.
b6..0	<Weekday alarm>	These bits represents the weekday alarm information value 0 to 6.

2.7.6 CLKOUT frequency register

Table 23 CLKOUT frequency register bits description

0DH	Symbol	Description
b7	FE	FE = 0; the CLKOUT output is inhibited and the CLKOUT output is set to high-impedance. FE = 1; the CLKOUT output is activated.
b6..2	-	not implemented
b1	FD1	These bits control the frequency output (f_{CLKOUT}) on the CLKOUT pin; see Table 24.
b0	FD0	

Table 24 CLKOUT frequency selection

FD1	FD0	f_{CLKOUT}
0	0	32.768 kHz
0	1	1 024 Hz
1	0	32 Hz
1	1	1 Hz

2.7.7 Countdown timer registers

The Timer register is an 8-bit binary countdown timer. It is enabled and disabled via the Timer control register bit TE. The source clock for the timer is also selected by the Timer control register. Other timer properties, e.g. interrupt generation, are controlled via the Control/status 2 register. For accurate read back of the countdown value, the I^2C-bus clock SCL must be operating at a frequency of at least twice the selected timer clock.

Table 25 Timer control register bits description

0EH	Symbol	Description
b7	TE	TE = 0; timer is disabled. TE = 1; timer is enabled.
b6～b2	-	not implemented

0EH	Symbol	Description
b1	TD1	Timer source clock frequency selection bits. These bits determine the source clock for the countdown timer, see Table 26. When not in use, TD1 and TD0 should be set to '11' (1⁄60 Hz) for power saving.
b0	TD0	

Table 26 Timer source clock frequency selection

TD[1:0]	Timer source clock frequency（Hz）
00	4096
01	64
10	1
11	1/60

Table 27 Timer countdown value register bits description

0FH	Symbol	Description
b7～b0	<timer countdown value>	countdown value n, the counter's period is ""n/f_{CLK}"

2.8 EXT_CLK test mode

A test mode is available which allows for on-board testing. In this mode it is possible to set up test conditions and control the operation of the RTC.

The test mode is entered by setting bit TEST1 in the Control/Status1 register. The CLKOUT pin then becomes an input. The test mode replaces the internal 64 Hz signal with the signal that is applied to the CLKOUT pin. Every 64 positive edges applied to CLKOUT will then generate an increment of one second.

The signal applied to the CLKOUT pin should have a minimum pulse width of 300 ns and a minimum period of 1000 ns. The internal 64 Hz clock, now sourced from CLKOUT, is divided down to 1 Hz by a 26 divide chain called a pre-scaler. The pre-scaler can be set into a known state by using the STOP bit. When the STOP bit is set, the pre-scaler is reset to 0. STOP must be cleared before the pre-scaler can operate again. From a STOP condition, the first 1 s increment will take place after 32 positive edges on CLKOUT. Thereafter, every 64 positive edges will cause a 1 s increment.

Remark: Entry into EXT_CLK test mode is not synchronized to the internal 64 Hz clock. When entering the test mode, no assumption as to the state of the pre-scaler can be made.

You can operate in the following steps:

1. Enter the EXT_CLK test mode; set bit 7 of Control/Status 1 register (TEST = 1)
2. Set bit 5 of Control/Status 1 register (STOP = 1)
3. Clear bit 5 of Control/Status 1 register (STOP = 0)
4. Set time registers (Seconds, Minutes, Hours, Days, Weekdays, Months/Century and Years) to desired value

5. Apply 32 clock pulses to CLKOUT
6. Read time registers to see the first change
7. Apply 64 clock pulses to CLKOUT
8. Read time registers to see the second change.

Repeat steps 7 and 8 for additional increments if necessary.

2.9 Power-On Reset override mode

The POR duration is directly related to the crystal oscillator start-up time. Due to the long start-up times experienced by these types of circuits, a mechanism has been built in to disable the POR and hence speed up on-board test of the device. The setting of this mode requires that the I^2C-bus pins, SDA and SCL, be toggled in a specific order as shown in Fig 5. All timing values are required minimum.

Once the override mode has been entered, the chip immediately stops being reset and normal operation starts i.e. entry into the EXT_CLK test mode via I^2C-bus access. The override mode is cleared by writing a logic 0 to bit TESTC. Re-entry into the override mode is only possible after TESTC is set to logic 1. Setting TESTC to logic 0 during normal operation has no effect except to prevent entry into the POR override mode.

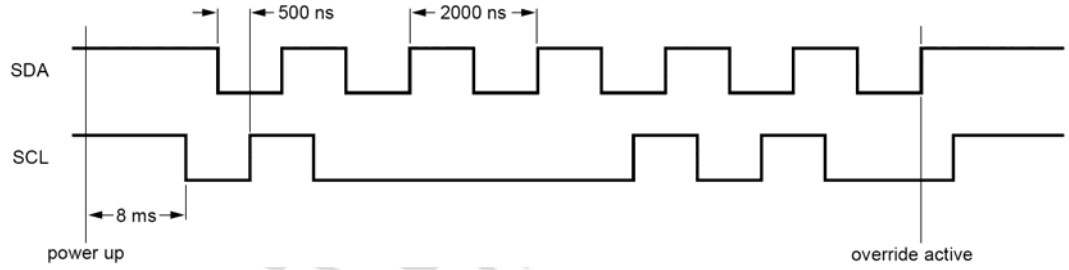


Fig 5 POR override sequence.

3 Serial interface

The serial interface of AT8563 is the I^2C -bus, which requires minimum connections between MPU and it peripherals ——.a serial Data I/O line and a serial CLK line driven by MPU.

3.1 I^2C Specification

The I^2C -bus is for bidirectional, two-line communication between different ICs or modules. The two lines are a serial data line (SDA) and a serial clock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor. Data transfer may be initiated only when the bus is idle.

The I^2C -bus system configuration is shown in Fig 6. A device generating a message is a ‘transmitter’, a device receiving a message is the ‘receiver’. The device that controls the message is the ‘master’ and the devices which are controlled by the master are the ‘slaves’.

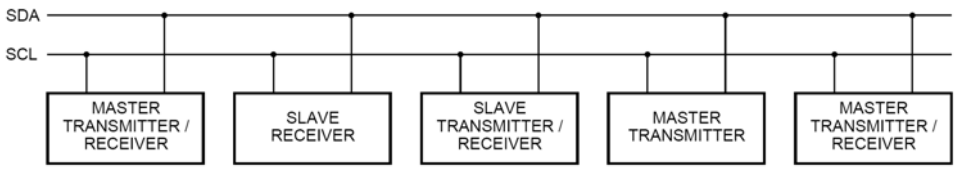


Fig 6 I²C-bus system configuration.

Both data and clock lines remain HIGH when the bus is not busy. A HIGH-to-LOW transition of the data line, while the clock is HIGH is defined as the start condition (S). A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the stop condition (P); see Fig 7.

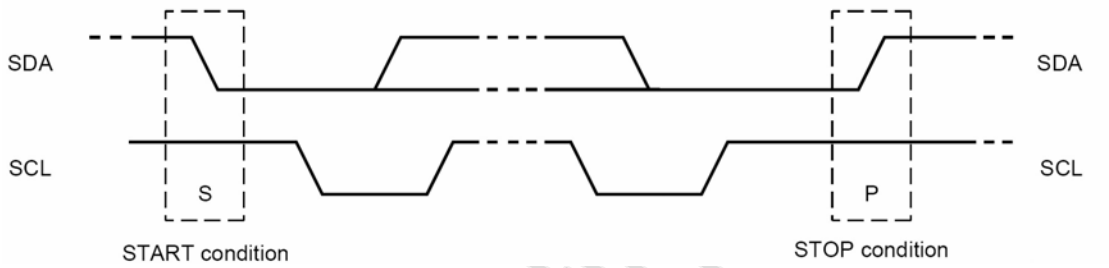


Fig 7 START and STOP conditions on the I²C-bus

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as a control signal; see Fig 8.

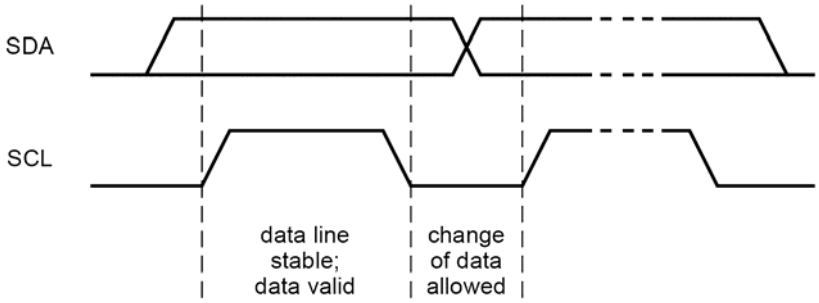


Fig 8 Bit transfer on the I²C-bus

The number of data bytes transferred between the START and STOP conditions from transmitter to receiver is unlimited. Each byte of eight bits is followed by an acknowledge bit. The acknowledge bit is a HIGH level signal put on the bus by the transmitter during which time the master generates an extra acknowledge related clock pulse.

A slave receiver which is addressed must generate an acknowledge after the

reception of each byte. Also a master receiver must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter.

The device that acknowledges must pull down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse (set-up and hold times must be taken into consideration).

A master receiver must signal an end of data to the transmitter by not generating an

acknowledge on the last byte that has been clocked out of the slave. In this event the transmitter must leave the data line HIGH to enable the master to generate a STOP condition.

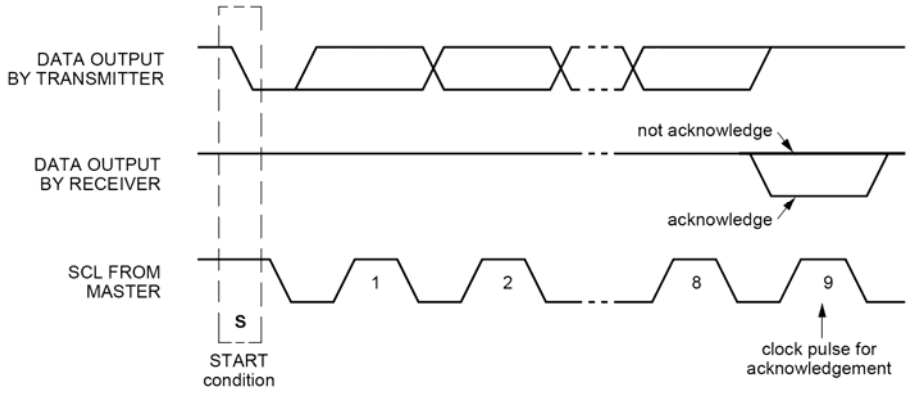


Fig 9 Acknowledge on the I²C -bus

3.2 I²C of AT8563

Before any data is transmitted on the I²C -bus, the device which should respond is addressed first. The addressing is always carried out with the first byte transmitted after the start procedure.

AT8563 acts as a slave receiver or slave transmitter. Therefore the clock signal SCL is only an input signal, but the data signal SDA is a bidirectional line.

AT8563 slave address is shown in Fig 10.

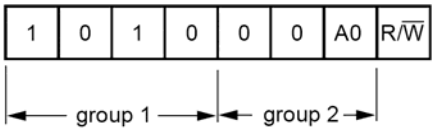


Fig 10 Slave address

The I²C -bus configuration for the different AT8563 read and write cycles are shown in Fig 11, 12 and 13. The word address is a four bit value that defines which register is to be accessed next. The upper four bits of the word address are not used.

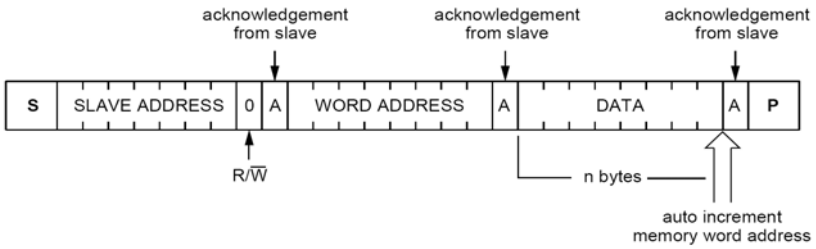


Fig 11 Master transmits to slave receiver (write mode)

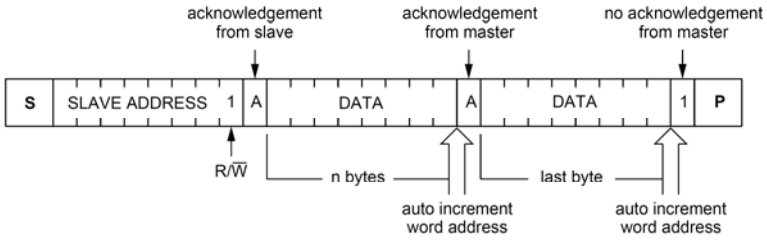


Fig 12 Master reads after setting word address (write word address; read data)

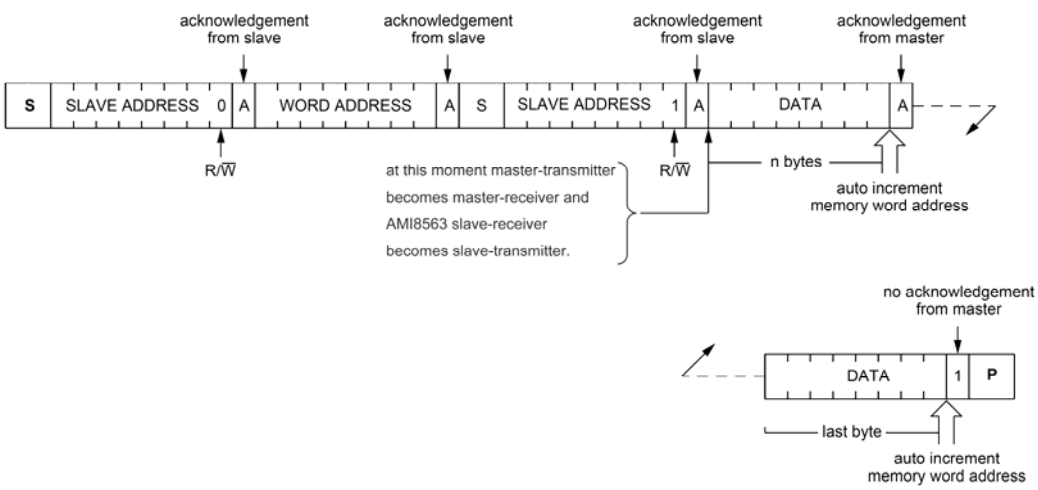


Fig 13 Master reads slave immediately after first byte (read mode)

4 Parameters

Table 28 Absolute Parameters

Symbol	Parameter	Min	Max	Unit
V_{DD}	supply voltage	-0.5	+6.5	V
I_{DD}	supply current	-50	+50	mA
V_I	input voltage on inputs SCL and SDA	-0.5	6.5	V
	input voltage on input OSCI	-0.5	V_{DD} + 0.5	V
V_O	output voltage on outputs CLKOUT and INT	-0.5	6.5	V
I_I	DC input current at any input	-10	+10	mA
I_O	DC output current at any output	-10	300	mA

P_{tot}	total power dissipation	-	+85	mW
T_{amb}	operating ambient temperature	-40	+150	°C
T_{stg}	storage temperature	-65	-0.5	°C

Please refer Table 29 and Table 30 for DC or AC characteristics.

Table 29: Static characteristics

(Test condition: V_{DD} = 1.8 to 5.5 V; V_{SS} = 0 V; T_{amb} =− 40 to 85° C; f_{OSC} = 32.768 kHz; quartz R_S = 40 kΩ; C_L = 8 pF; unless otherwise specified.)

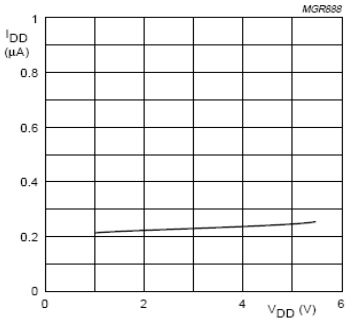
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supplies						
V_{DD}	supply voltage	I^2C bus inactive; T_{amb} = 25 °C	1.0[1]	–	5.5	V
		I^2C bus active; f_{SCL} = 400 kHz	1.8[1]	–	5.5	V
	supply voltage for reliable clock/calendar information	T_{amb}=25 °C	V_{LOW}	–	5.5	V
I_{DD1}	supply current; CLKOUT disabled(FE=0)	f_{SCL}=200kHz	–[2]	–	800	μA
		f_{SCL}=100kHz	–	–	200	μA
		f_{SCL}=0Hz	[2]			
		V_{DD}=5V	–	700	900	nA
		V_{DD}=3V	–	650	750	nA
		V_{DD}=2V	–	600	650	nA
I_{DD2}	supply current; CLKOUT enabled (f_{CLKOUT} = 32 kHz; FE = 1)	f_{SCL}=200kHz	–[2]	–	800	μA
		f_{SCL}=100kHz	–	–	200	μA
		f_{SCL}=0kHz	[2]			
		V_{DD}=5V	–	1000	1100	nA
		V_{DD}=3V	–	810	900	nA
		V_{DD}=2V	–	720	800	nA
Inputs						
V_{IL}	LOW-level input voltage		V_{SS}	–	0.3V_{DD}	V
V_{IH}	HIGH-level input voltage		0.7V_{DD}	–	V_{DD}	V
I_{LI}	input leakage current	V_I= V_{DD} or V_{SS}	-1	–	+1	μA
C_i	input capacitance		–[3]	–	7	pF
Outputs						
$I_{OL(SDA)}$	LOW-level output current;pin SDA	V_{OL}=0.4V; V_{DD}=5V	-3	–	–	mA
$I_{OL(\overline{INT})}$	LOW-level output current;pin INT		-1	–	–	mA

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{OL(CLKOUT)}$	LOW-level output current; pin CLKOUT		-1	–	–	mA
$I_{OH(CLKOUT)}$	HIGH-level output current; pin CLKOUT	V_{OH}=4.6V; V_{DD}=5V	1	–	–	mA
I_{LO}	output leakage current	$V_O=V_{DD}$ or V_{SS}	-1	–	+1	μA
Voltage detector						
V_{LOW}	voltage-low detection level	T_{amb}=25℃	–	0.9	1.0	V

[1] For reliable oscillator start-up at power-up: $V_{DD(min)\ power\text{-}up} = V_{DD(min)} + 0.3$ V.

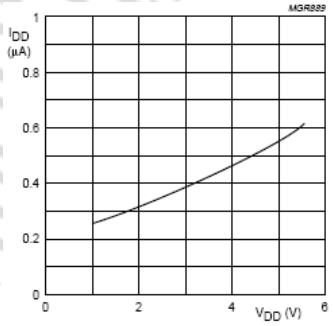
[2] Timer source clock = 1⁄60 Hz; SCL and SDA = V_{DD}.

[3] Tested on sample basis.



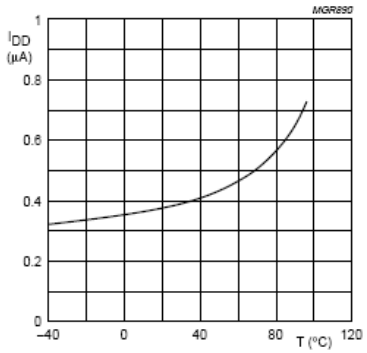
T_{amb}=25℃;Timer=1 minute.

Fig 14 I_{DD} as a function of V_{DD}; CLKOUT disabled



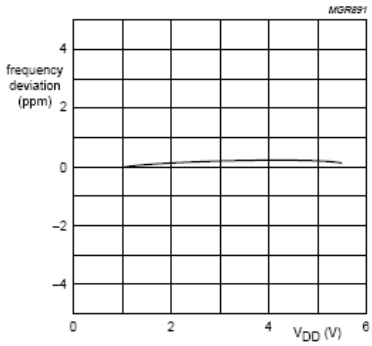
T_{amb}=25℃;Timer=1 minute.

Fig 15 I_{DD} as a function of V_{DD}; CLKOUT = 32 kHz



V_{DD}=3V;Timer=1 minute.

Fig 16 I_{DD} as a function of T_{amb}; CLKOUT = 32 kHz



T_{amb}=25℃;normalized to V_{DD}=3V.

Fig 17 Frequency deviation as function of V_{DD}

Table 30 AC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Oscillator						
C_L	integrated load capacitance		15	25	35	pF
$\Delta f_{osc}/f_{osc}$	oscillator stability	ΔV_{DD}=200mV	–	2×10^{-7}	–	

		T_{amb}=25℃				
Quartz crystal parameters(f_{OSC}=32.768kHz)						
R_S	serial resistance		–	–	40	kΩ
C_L	parallel load capacitance		–	10	–	pF
C_T	trimmer capacitance	Version B	2	–	10	pF
		Version C	8	–	12	
CLKOUT output						
δ_{CLKOUT}	CLKOUT duty factor		[1] –	50	–	%
I^2C-bus timing characteristics[2]						
f_{SCL}	SCL clock frequency		[3] –	–	400	kHz
$t_{HD;STA}$	START condition hold time		0.6	–	–	μs
$t_{SU:STA}$	set-up time for a repeated START condition		0.6	–	–	μs
t_{LOW}	SCL LOW time		1.3	–	–	μs
t_{HIGH}	SCL HIGH time		0.6	–	–	μs
t_r	SCL and SDA rise time		–	–	0.3	μs
t_f	SCL and SDA fall time		–	–	0.3	μs
C_b	capacitive bus line load		–	–	400	pF
$t_{SU;DAT}$	data set-up time		100	–	–	ns
$t_{H\ D;DAT}$	data hold time		0	–	–	ns
$t_{SU:STO}$	set-up time for STOP condition		4.0	–	–	μs
t_{SW}	tolerable spike width on bus		–	–	50	ns

[1] Unspecified for f_{CLKOUT} = 32.768 kHz.

[2] All timing values are valid within the operating supply voltage range at T_{amb} and referenced to V_{IL} and V_{IH} with an input voltage swing of V_{SS} to V_{DD}.

[3] I^2C -bus access time between two STARTs or between a START and a STOP condition to this device must be less than one second.

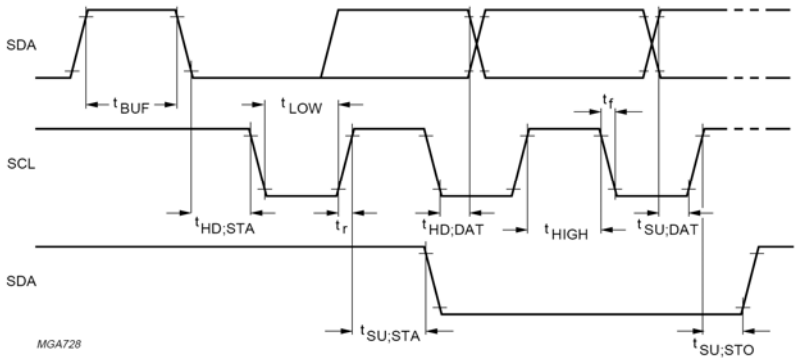


Fig 18 I^2C -bus timing waveforms.

5 Application Reference

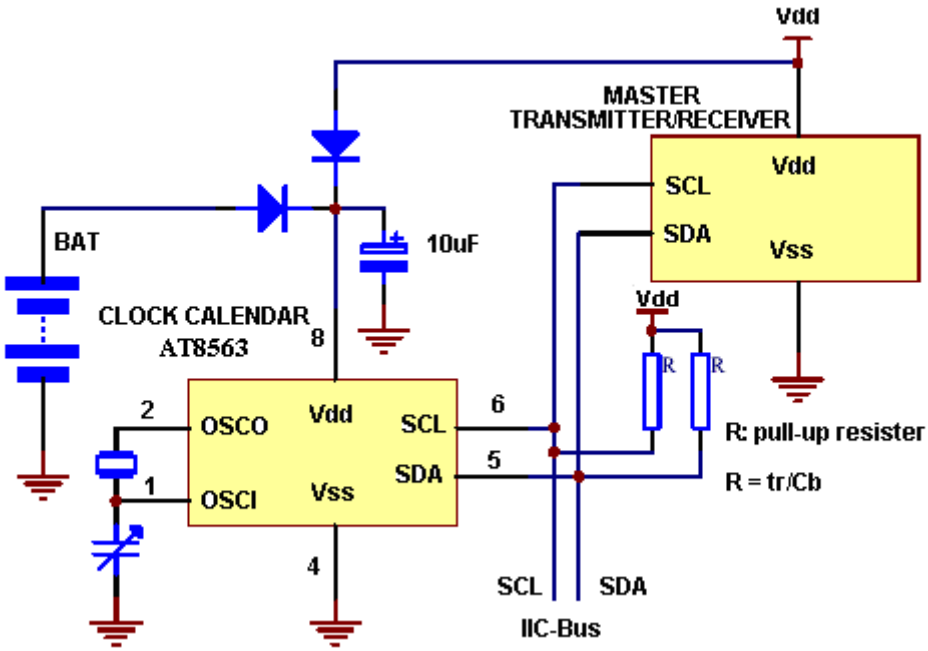


Fig 19 Typical Application diagram

5.1 Crystal frequency adjustment

- Method 1: Fixed OSCI capacitor — By evaluating the average capacitance necessary for the application layout a fixed capacitor can be used. The frequency is best measured via the 32.768 kHz signal available after power-on at the CLKOUT pin. The frequency tolerance depends on the quartz crystal tolerance, the capacitor tolerance and the device-to-device tolerance (on average ±5 × 10-6).

  Average deviations of ±5 minutes per year can be easily achieved.
- Method 2: OSCI trimmer — The oscillator is tuned to the required accuracy by adjusting a trimmer capacitor on pin OSCI and measuring the 32.768 kHz signal available after power-on at the CLKOUT pin.
- Method 3: OSCO output — Direct output measurement on pin OSCO (accounting for test probe capacitance).

6 Package outline

6.1 DIP-8

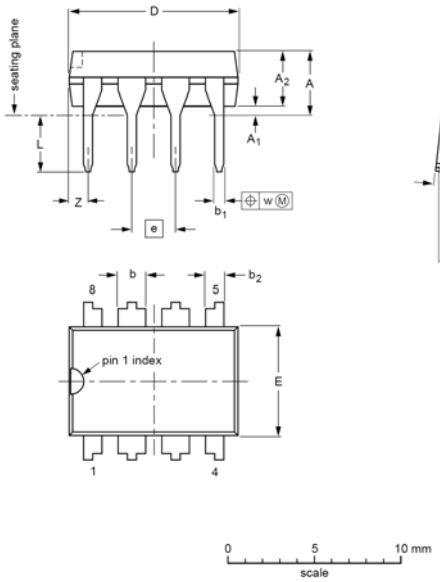


Table 20 DIP-8

Table 31 Dimension noted in Fig 20

Unit	A max	A1 min	A2 max	b	b1	b2	c	D	E	e	e1	L	M_E	M_H	w	z max
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.26 7.80	10.0 8.3	0.254	1.15
inch	0.17	0.020	0.13	0.068 0.045	0.021 0.016	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

6.2 SO8

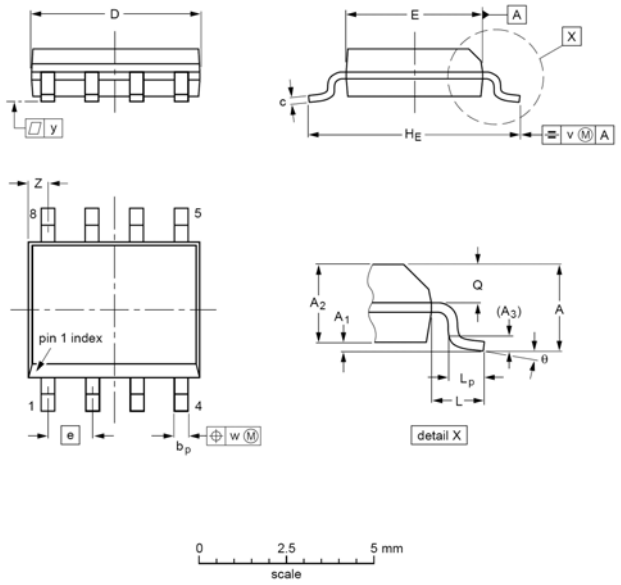


图 21 SO-8

Table 32 Dimension noted in Fig 21

Unit	A max	A_1	A_2	A_3	bp	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_P	Q	v	w	y	z	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°°
inch	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

6.3 TSSOP8

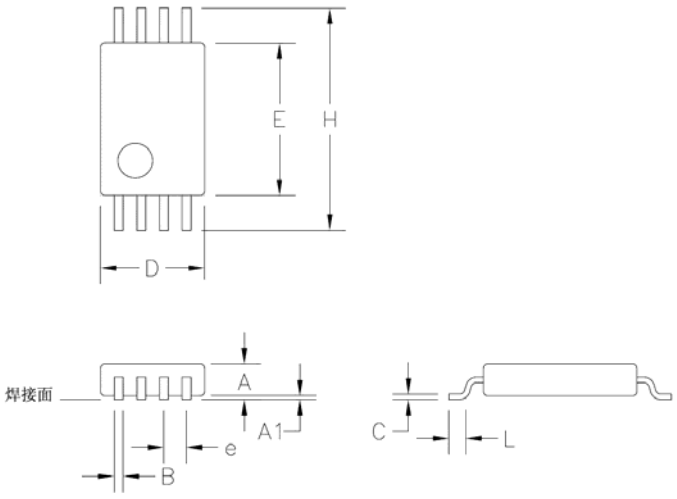
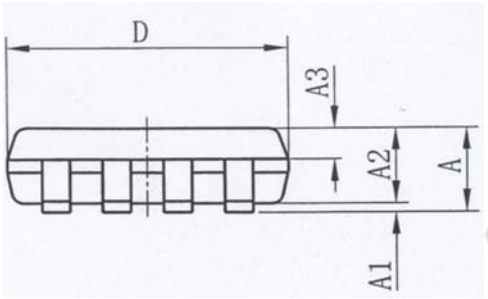


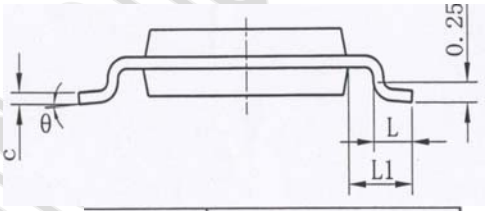
Fig 22 TSSOP-8

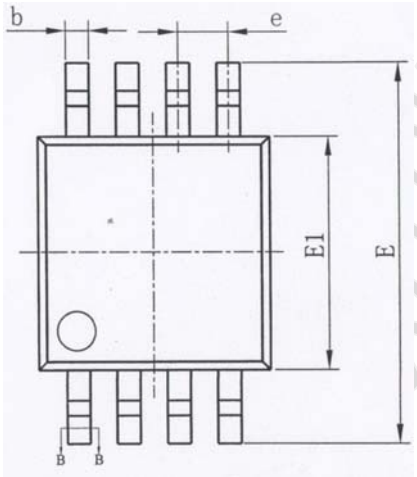
Table 33 Dimension noted in Fig 22

Unit	A	A1	B	C	D	E	e	H
mm	0.043	0.006 0.002	0.012 0.007	0.007 0.004	0.122 0.114	0.176 0.169	0.0256	0.256 0.246
inch	1.10	0.15 0.05	0.30 0.18	0.18 0.09	3.10 2.90	4.48 4.30	0.65	6.50 6.25

6.4 MSOP8







SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.10
A1	0.05	—	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.29	—	0.38
b1	0.28	0.30	0.33
c	0.15	—	0.20
c1	0.14	0.152	0.16
D	2.90	3.00	3.10
E	4.70	4.90	5.10
E1	2.90	3.00	3.10
e	0.65BSC		
L	0.40	—	0.70
L1	0.95BSC		
θ	0	—	8°
L/F载体尺寸 (mil)	71*96		