19-1485; Rev 0; 4/99

MAXIM

SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

MAX6575L/H

General Description

The MAX6575L/H is a low-cost, low-current temperature sensor with a single-wire digital interface. It features accuracy of ±3°C at +25°C, ±4.5°C at +85°C, and ±5°C at +125°C. The MAX6575L/H is a monostable, externally triggered temperature sensor that allows a microprocessor (µP) to interface with up to eight temperature sensors using a single control line. Temperatures are sensed by measuring the time delay between the falling edge of the external triggering pulse and the falling edge of the subsequent pulse delays reported from the devices. Different sensors on the same I/O line use different timeout multipliers to avoid overlapping signals.

The MAX6575L/H features eight different timeout multipliers; these are selectable by using the two time-select pins on each device and choosing the "L" or "H" version. The "L" version provides four delay ranges less than 50ms. The "H" version provides four delay ranges greater than 50ms. The MAX6575L/H is available in a space-saving 6-pin SOT23 package.

Applications

Critical µP and µC Temperature Monitoring

Portable Battery-Powered Equipment

Cell Phones

Battery Packs

Hard Drives/Tape Drives

Networking and Telecom Equipment

Medical Equipment

Automotive

Features

♦ **Simple Single-Wire Interface to µP or µC**

♦ **Multidrop up to Eight Sensors on One Wire**

♦ **±0.8°C Accuracy at +25°C (±3°C max)**

♦ **Operates from +2.7V to +5.5V Supply Voltage**

♦ **Low 150µA (typ) Supply Current**

♦ **Standard Operating Temperature Range: -40°C to +125°C**

♦ **Small 6-Pin SOT23 Package**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	SOT TOP MARK
MAX6575LZUT	-40°C to +125°C	6 SOT23	AABG
MAX6575HZUT	-40°C to +125°C	6 SOT23	AABH

Selector Guide

PART	TIMEOUT MULTIPLIERS (µs/°K)
MAX6575L	5, 20, 40, 80
MAX6575H	160, 320, 480, 640

Pin Configurations appear at end of data sheet.

Typical Operating Circuit
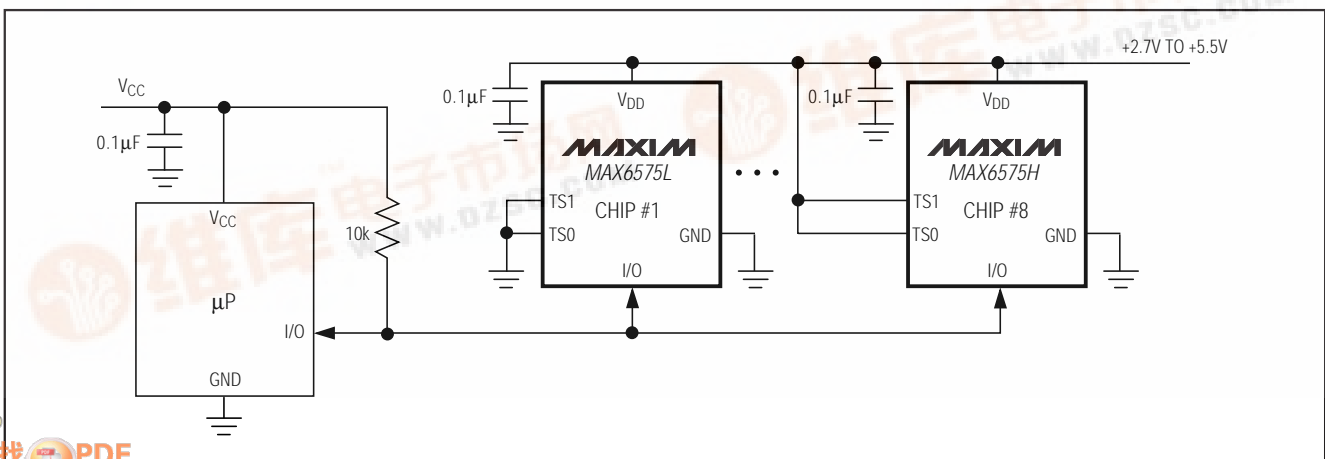
For free samples & the latest literature: http://www.maxim-ic.com, or phone 1-800-998-8800.

SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

MAX6575L/H

ABSOLUTE MAXIMUM RATINGS

Terminal Voltage (with respect to GND)
  V_{DD} ....-0.3V to +6V
  TS1, TS0 ....-0.3V to (V_{DD} + 0.3V)
  I/O ....-0.3V to +6V
Input/Output Current, All Pins ....±20mA

Continuous Power Dissipation (T_A = +70°C)
  6-Pin SOT23 (derate 7.10mW/°C above +70°C)...........571mW
Operating Temperature Range ....-40°C to +125°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10sec) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{DD} = +2.7V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are specified at T_A = +25°C and V_{DD} = +5V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
V_{DD} Range	V_{DD}			2.7		5.5	V
Supply Current	I_{DD}	V_{DD} = 5.5V	T_A = -40°C to +85°C		150	250	µA
			T_A = -40°C to +125°C			400	
Temperature Sensor Error (Note 1)		T_A = -20°C		-7.5	±1.1	+7.5	°C
		T_A = 0°C		-5.5	±0.9	+5.5	
		T_A = +25°C		-3.0	±0.8	+3.0	
		T_A = +85°C		-4.5	±0.5	+4.5	
		T_A = +125°C		-5.0	±0.5	+5.0	
Output Pulse Delay	t_{D1}	MAX6575L, T (temp) in °K, Figure 1	V_{TS1} = GND, V_{TS0} = GND		5T		µs
	t_{D2}		V_{TS1} = GND, V_{TS0} = V_{DD}		20T		
	t_{D3}		V_{TS1} = V_{DD}, V_{TS0} = GND		40T		
	t_{D4}		V_{TS1} = V_{DD}, V_{TS0} = V_{DD}		80T		
	t_{D5}	MAX6575H, T (temp) in °K, Figure 1	V_{TS1} = GND, V_{TS0} = GND		160T		
	t_{D6}		V_{TS1} = GND, V_{TS0} = V_{DD}		320T		
	t_{D7}		V_{TS1} = V_{DD}, V_{TS0} = GND		480T		
	t_{D8}		V_{TS1} = V_{DD}, V_{TS0} = V_{DD}		640T		
Output Pulse Low Time	t_{L1-8}	Figure 1			5T		µs
Reset Pulse Width (Note 2)	t_{RESET}	Figure 1		4.6		16.0	ms
Setup Time	t_{SETUP}	Figure 1			10		µs
Start Pulse (Note 3)	t_{START}	Figure 1, T_A = +25°C		2.5			µs
Delay Time from Trigger to Ready (Note 4)	t_{READY}	Figure 1				520	ms
Glitch Immunity on I/O Input					500		ns
Time-Select Pin Logic Levels	V_{IL}					0.8	V
	V_{IH}			2.3			
I/O Output Voltage Low	V_{OL}	V_{DD} > 4.5V, I_{SINK} = 3.2mA				0.4	V
		V_{DD} > 2.7V, I_{SINK} = 1.2mA				0.3	
I/O Input Voltage Low	V_{IL}					0.8	V
I/O Input Voltage High	V_{IH}			2.3			V

Note 1: See Temperature Accuracy histograms in *Typical Operating Characteristics*.
Note 2: Guaranteed by design. Not production tested.
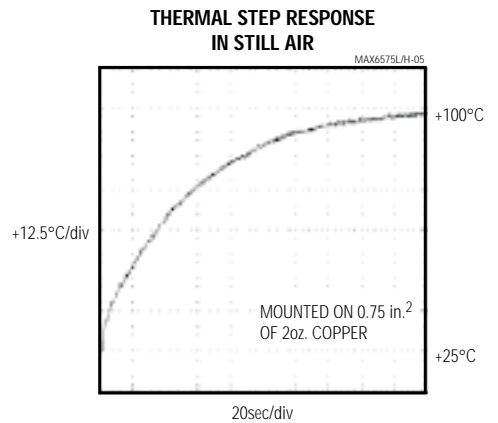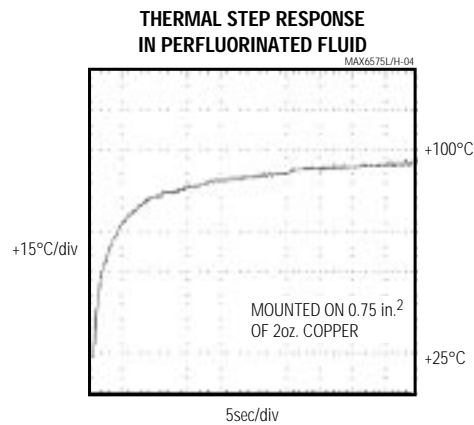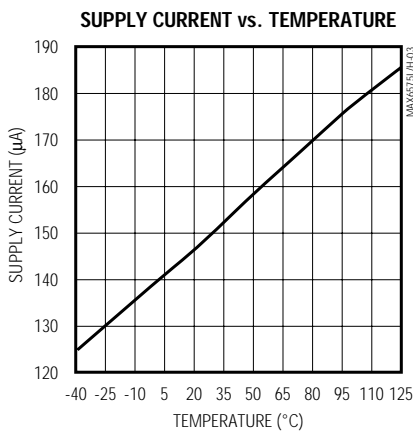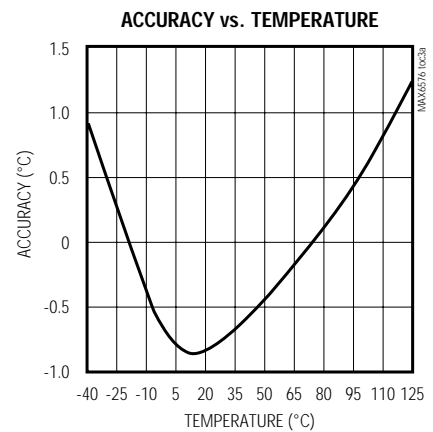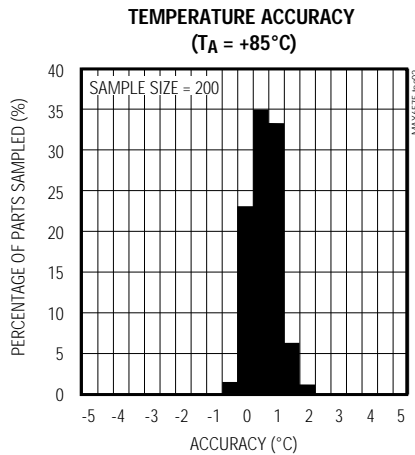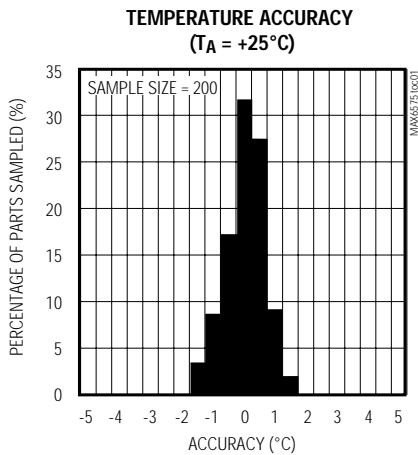**Note 3:** Limit maximum start pulse at 1ms to avoid timing overlap.
Note 4: If no reset pulse is applied.

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SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

Typical Operating Characteristics

(V_{DD} = +5V, T_A = +25°C, unless otherwise noted.)

TEMPERATURE ACCURACY
(T_A = +25°C)

SAMPLE SIZE = 200

MAX6575 toc01

- PERCENTAGE OF PARTS SAMPLED (%): 0, 5, 10, 15, 20, 25, 30, 35
- ACCURACY (°C): -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5

TEMPERATURE ACCURACY
(T_A = +85°C)

SAMPLE SIZE = 200

MAX6575 toc02

- PERCENTAGE OF PARTS SAMPLED (%): 0, 5, 10, 15, 20, 25, 30, 35, 40
- ACCURACY (°C): -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5

ACCURACY vs. TEMPERATURE

MAX6576 toc3a

- ACCURACY (°C): -1.0, -0.5, 0, 0.5, 1.0, 1.5
- TEMPERATURE (°C): -40, -25, -10, 5, 20, 35, 50, 65, 80, 95, 110, 125

SUPPLY CURRENT vs. TEMPERATURE

MAX6575L/H-03

- SUPPLY CURRENT (µA): 120, 130, 140, 150, 160, 170, 180, 190
- TEMPERATURE (°C): -40, -25, -10, 5, 20, 35, 50, 65, 80, 95, 110, 125

THERMAL STEP RESPONSE
IN PERFLUORINATED FLUID

MAX6575L/H-04

+100°C

+15°C/div

+25°C

MOUNTED ON 0.75 in.^{2}
OF 2oz. COPPER

5sec/div

THERMAL STEP RESPONSE
IN STILL AIR

MAX6575L/H-05

+100°C

+12.5°C/div

+25°C

MOUNTED ON 0.75 in.^{2}
OF 2oz. COPPER

20sec/div

Pin Description

PIN	NAME	FUNCTION
1	V_{DD}	Positive Supply Voltage
2	GND	Ground
3	N.C.	No Connect. Connect pin to GND or leave open.
4, 5	TS0, TS1	Time-Select Pins. Set the time delay factor by connecting TS1 and TS0 to either V_{DD} or GND. See Table 1.
6	I/O	Bidirectional Interface Pin. A time delay between when the part is initiated externally by pulling I/O low and when the part subsequently pulls I/O low, is proportional to absolute temperature (°K).

SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

_____Detailed Description

The MAX6575L/H low-cost, low-current (150µA typ) temperature sensor is ideal for interfacing with micro-controllers or microprocessors. The MAX6575L/H is a monostable, externally triggered temperature sensor that uses a Temp→Delay conversion to communicate with a µP over a single I/O line. Time-select pins (TS1, TS0) permit the internal temperature-controlled oscilla-tor (TCO) to be scaled by four preset timeout multipli-ers, allowing eight separate temperature sensors to share one I/O line. Different sensors on the same I/O line will use different timeout multipliers to avoid over-lapping signals.

Operating the MAX6575L/H

Figure 1 illustrates the timing for the MAX6575L/H. When the device is powered up, it assumes a ready state where it awaits an external trigger at the I/O pin. The I/O pin of the MAX6575L/H has an open-drain out-put structure that requires a pull-up resistor to maintain the proper logic levels. Once the I/O pin is pulled low and then released, control of the I/O pin is transferred to the MAX6575L/H. The temperature conversion begins on the falling edge of the externally triggered pulse. The I/O line is pulled low at a later time. That time is determined by the device temperature and the Time Select pins (TS1, TS0). The I/O line remains low for 5Tµs, where T is the temperature in degrees Kelvin. The temperature of the device is represented by the edge-to-edge delay of the externally triggered pulse and the falling edge of the subsequent pulse originating from the device. The device can be manually reset by pulling the I/O line low for more than t_{RESET} (16ms max). The device will automatically reset after a maxi-

Table 1. Time-Select Pin Configuration

TIME-SELECT PINS		TIMEOUT MULTIPLIERS (µs/°K)	
TS1	TS0	MAX6575L	MAX6575H
GND	GND	5	160
GND	V_{DD}	20	320
V_{DD}	GND	40	480
V_{DD}	V_{DD}	80	640

mum delay of 520ms, at which point it will again be in a ready state awaiting a start pulse.

Definition of Terms:

t_{RESET}: Time I/O must be externally pulled low to guar-antee the MAX6575L/H is in a ready state awaiting external trigger. (Part will assume a ready state after 520ms without a reset pulse.)

t_{SETUP}: Time I/O must be high prior to a start pulse.

t_{START}: Trigger pulse which starts the on-chip timing sequence on its falling edge.

t_{Dx}: Timing delay between the falling edge of the start pulse and the falling edge initiated by CHIP#x.

t_{Lx}: I/O pulse low time (5Tµs).

t_{READY}: Time after falling edge of start pulse when the MAX6575L/H will reset itself and await the next external trigger.

The temperature, in degrees Celsius, may be calculat-ed as follows:

$$T(°C) = [t_{Dx}(µs) / \text{timeout multiplier}(µs/°K)] - 273.15°K$$
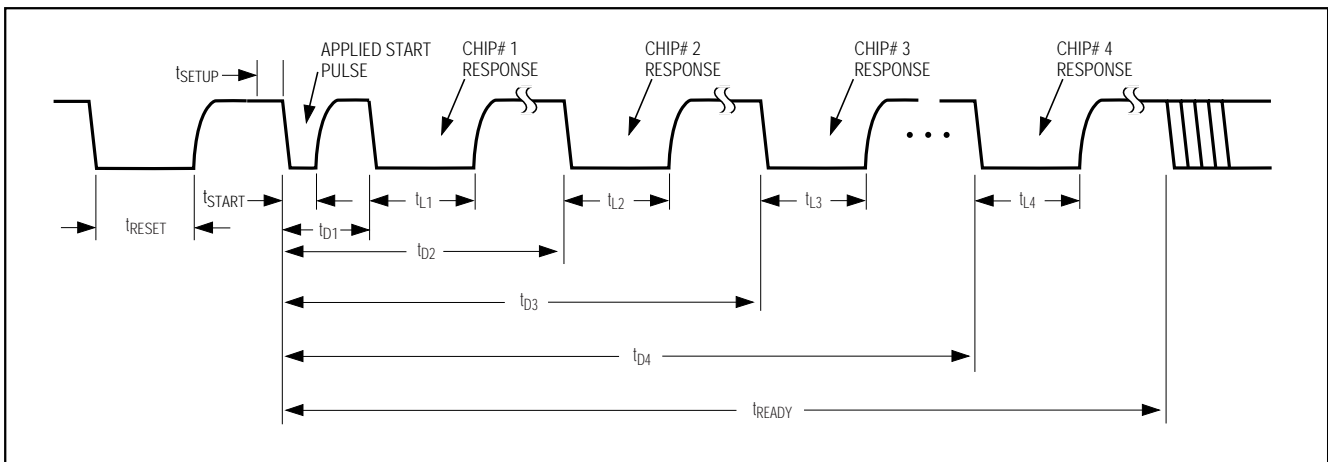
Figure 1. Timing Diagram

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Table 2. Allowable Temperature Differential (°C)

TIMEOUT MULTIPLIER	MAX6575L				MAX6575H			
	5	20	40	80	160	320	480	640
5		>165	>165	>165	>165	>165	>165	>165
20			95.5	>165	>165	>165	>165	>165
40				132.0	>165	>165	>165	>165
80					153.5	>165	>165	>165
160						>165	>165	>165
320							70.2	>165
480								37.9
640								

Table 3. Typical Peak Noise Amplitude

PARAMETER	MAX6575L				MAX6575H			
Timeout Multiplier	5	20	40	80	160	320	480	640
Noise Amplitude (°C)	±0.33	±0.15	±0.15	±0.098	±0.091	±0.063	±0.043	±0.037

Time-Select Pins (TS1, TS0)

Table 1 shows the configuration of the Time-select pins for the MAX6575L/H. Each device allows four selectable timeout multipliers intended to prevent overlapping when multiple devices are used on the same I/O line. Tie TS1 and TS0 to either GND or V$_{DD}$ to select the desired temperature multiplier.

To monitor several chips on the same I/O line, different timeout multipliers should be selected using the TS1 and TS0 pins. The timeout periods are then scaled so that the response times will not overlap (see *Timeout Selection*).

Applications Information

Timeout Selection

Under extreme temperature conditions, it is possible for an overlap to occur between the timeout delays of different sensors in a multidrop configuration. This overlap can occur only if the temperature differential recorded between two devices is very large. Timeout overlaps can be avoided in multidrop configurations by selecting the appropriate timeout multipliers. Table 2 illustrates the allowable temperature differential between devices when the maximum error is present on each device. Allowable temperature differentials greater than 165°C indicate no overlap.

For example, if the maximum temperature differential in a system is 80°C, the only combinations of timeout multipliers that could result in timeout overlap would be a 320:480µs/°K (70.2°C) or a 480:640µs/°K (37.9°C) combination. As long as these combinations of timeout multipliers are not used in the same multidrop configuration, no overlap can occur. Thus, seven MAX6575L/H parts can be used in the same multidrop configuration if the maximum temperature differential between parts is 80°C. A similar analysis shows that four MAX6575L/H parts can be used when the maximum temperature differential extends over the entire 165°C range of the part.

Noise Considerations

The accuracy of the MAX6575L/H timeout delay is susceptible to noise generated both internally and externally. The effects of external noise can be minimized by placing a 0.1µF ceramic bypass capacitor close to the device's supply pin. Internal noise is inherent in the operation of the device and is detailed in Table 3. Internal averaging minimizes the effect of this noise when using longer timeout multipliers. The effects of this noise are included in the overall accuracy of the device as specified in the *Electrical Characteristics* table.

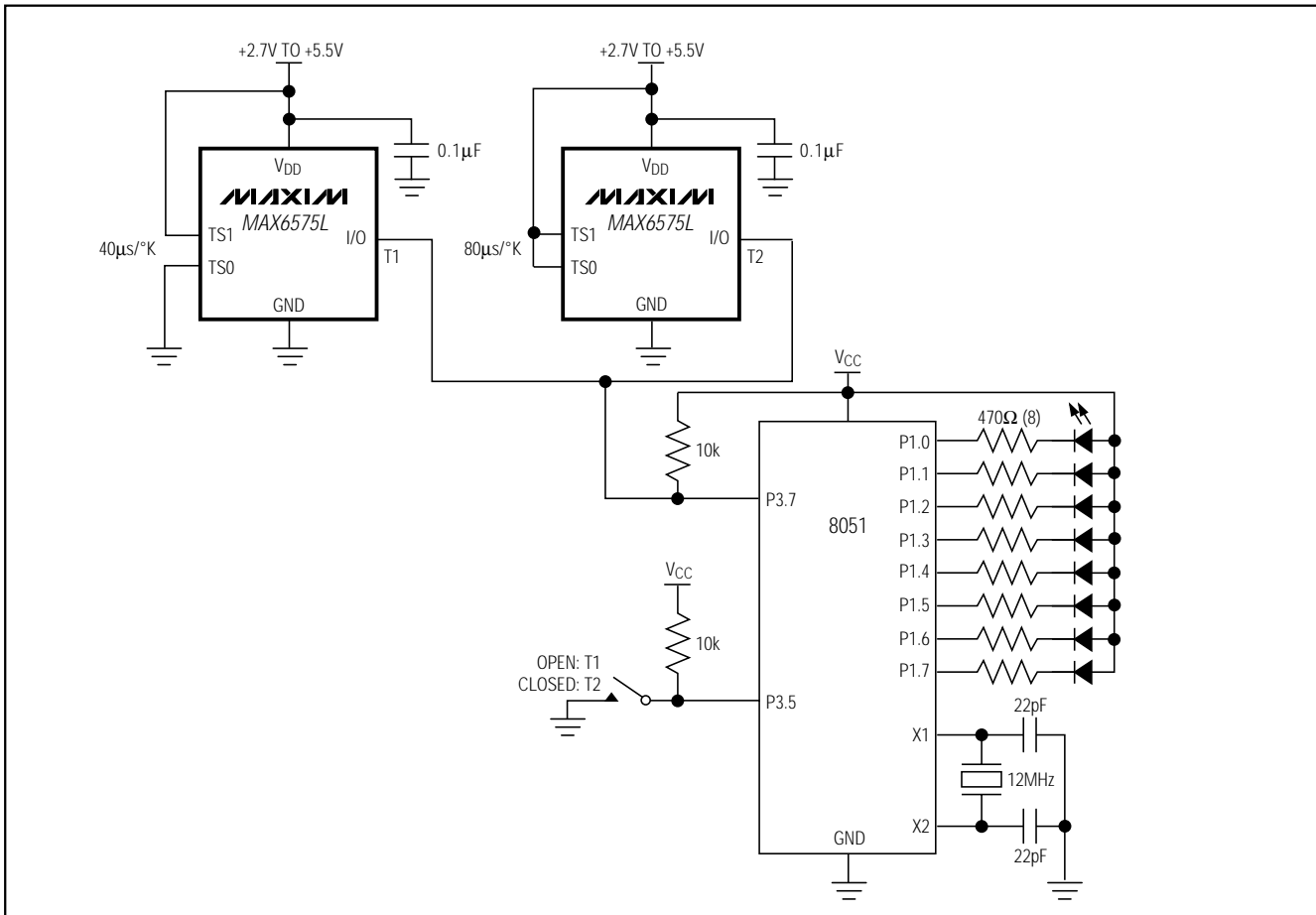# SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

Figure 2. Interfacing Multiple Devices with a Microcontroller

Interfacing Multiple Devices with a Microcontroller

Figure 2 shows how to interface multiple MAX6575L/H devices with an 8051 microcontroller. The first device, T1, is configured for a timeout multiplier of 40µs/°K, while the second device, T2, is configured for a timeout multiplier of 80µs/°K to avoid overlap. The microcontroller takes in temperature values from both sensors, T1 and T2, on a single port pin, P3.7. The microcontroller displays five times the temperature in degrees Celsius in binary on Port 1. A switch connected to a pull-up resistor at Port 3.5 selects which temperature is displayed: open = T1, closed = T2. Code is provided for this application as Listing 1.

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Listing 1. 8051 Code Example

```
        ;***********************************************************
        ; Demonstration and test code for MAX6575 Temp to Delay
        ; Takes in temperature values from 2 sensors on single
        ; port pin, P3.7 and displays temp as 5 times C in binary on
        ; port 1. port 3.5 selects which temp displayed- H=1, L=2.
        ; example: room temp= 21 C, display 105 or 01101001 on P1
        ;***********************************************************
        ;EQUATES
TEMP1H          EQU     10H             ;TEMPERATURE 1
TEMP1L          EQU     11H
TEMP2H          EQU     12H             ;TEMPERATURE 2
TEMP2L          EQU     13H

D1              EQU     30H             ;delay scratch registers
D2              EQU     31H
D3              EQU     32H

        ;PINS
IOPIN           BIT     P3.7            ;single pin interface
SLCT            BIT     P3.5            ;select display 1/2= H/L
        ;MAIN
                ORG     0               ;note one isr's used- timer overflow
                AJMP    BEGIN           ;jump over isr's

                ORG     0BH             ;timer 0 overflow- error
                CLR     TF0             ;clear timer overflow
                POP     ACC             ;unstack return address
                POP     ACC             ;unstack return address
                PUSH    LOW(DOTMP)      ;return to top on error
                PUSH    HIGH(DOTMP)     ;return to top on error
                CLR     TR0             ;clear timer run
                RETI                    ;error

                org     30h
BEGIN:          MOV     SP,#70h         ;set sp at 70H
;setup timer0 to do timing
                MOV     TMOD,#01H       ;t0 timer 16 bit
                MOV     IE,#82H         ;enable tf0 irq- error
;
;inits done- measure 2 temps
DOTMP:          MOV     TH0,#0          ;zero counter
                MOV     TL0,#0          ;zero counter
                SETB    TR0             ;start timer
                CLR     IOPIN           ;write pin low- start
                CALL    DLYP1           ;100 uS min low
                SETB    IOPIN           ;bring high
;do temp 1
                MOV     R0,#TEMP1H      ;point at temp1- high byte
                CALL    GTTP            ;get temp1
;do temp 2
                MOV     R0,#TEMP2H      ;point at temp2- high byte
                CALL    GTTP            ;get temp2

                CLR     TR0             ;stop timer- acquistion done
```

MAX6575L/H

Listing 1. 8051 Code Example (continued)

```
; 2 temps are stored- display bin value of selected on P1
; temps are 40T,80T- times are in us

                MOV   R0,#TEMP1L          ;get temp1- low byte (40T)
                MOV   R4,#3 ;shift right 3x for 5x temp, div 8
                CALL  TMTOC ;convert delay to degrees C x 5
                JNB   P3.5,DSP2           ;if select low, display temp2
                MOV   A,TEMP1L            ;get temperature
                CPL   A                   ;invert it for active low led's
                MOV   P1,A                ;display this temp

DSP2:           MOV   R0,#TEMP2L          ;get temp2- low byte (80T)
                MOV   R4,#4               ;shift right 4x for 5x temp, div 16
                CALL  TMTOC               ;convert delay to degrees C x 5
                JB    P3.5,DSP1           ;if select high, display temp1 above
                MOV   A,TEMP2L            ;get temperature
                CPL   A                   ;invert it for active low led's
                MOV   P1,A                ;display this temp
;done

;wait for 600 ms and do it again
DSP1:           MOV   D3,#60
DLL1:           MOV   D2,#100
DLL2:           MOV   D1,#50              ;inner loop
DLLLP:          DJNZ  D1,DLLLP            ;loop 100 us
                DJNZ  D2,DLL2             ;loop 10 ms
                DJNZ  D3,DLL1             ;loop 600ms
                JMP   DOTMP               ;loop forever


;*********************************************************
;subroutines
;*********************************************************
;GET TEMP- main, capture timer0 to @r0 after pin low edge
GTTP:           JB    IOPIN,GTTP          ;wait for low- irq gets hangs
                MOV   A,TH0               ;get high- quick
                MOV   B,TL0               ;get low- quick
                CJNE  A,TH0,ROLL          ;check rollover msb
                JMP   NOROL               ;no
ROLL:           MOV   A,TH0               ;get high again
                MOV   B,TL0               ;get low again
NOROL:          MOV   @R0,A               ;stash msb
                INC   R0                  ;point next
                MOV   @R0,B               ;stash lsb
WAITH:          JNB   IOPIN,WAITH         ;wait for low- irq gets hangs
                RET


;sub; converts uS to degrees c x 5, R4 is # of right shifts
TMTOC:          CALL  SHR0                ;shift right
                DJNZ  R4,TMTOC            ;loop til shifted= 5x
                MOV   A,@R0               ;get x5 lsb
                CLR   C                   ;ready for subb
                SUBB  A,#055H             ;low byte of 273 x 5- offset
                MOV   @R0,A               ;stash back
                DEC   R0                  ;point hi
                MOV   A,@R0               ;get hi- prop carry
```

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Listing 1. 8051 Code Example (continued)

```
                SUBB   A,#05H          ;sub high of 273 x 5- offset
                MOV    @R0,A           ;stash back- degrees c x 5 in temp
                RET                    ;done

        ;shift right routine- "divide by 2" - point low on enter/exit
        SHR0:   DEC    R0             ;point high
                MOV    A,@R0          ;get high
                CLR    C              ;roll 0 into msbit
                RRC    A              ;shift right
                MOV    @R0,A          ;stash back
                INC    R0             ;point low
                MOV    A,@R0          ;get low- prop carry
                RRC    A              ;shift right
                MOV    @R0,A          ;stash back
                RET                   ;pointing at lsb on exit

        ;short delay-  100 uS
        DLYP1:  MOV    D1,#50         ;~100 uS
        D1LP:   DJNZ   D1,D1LP        ;delay- also entry
                RET                   ;return after .1 ms

                END
```
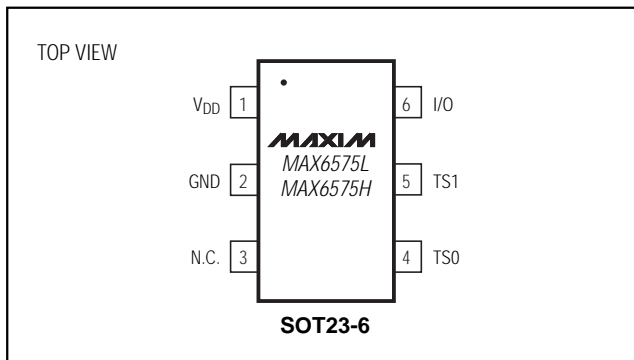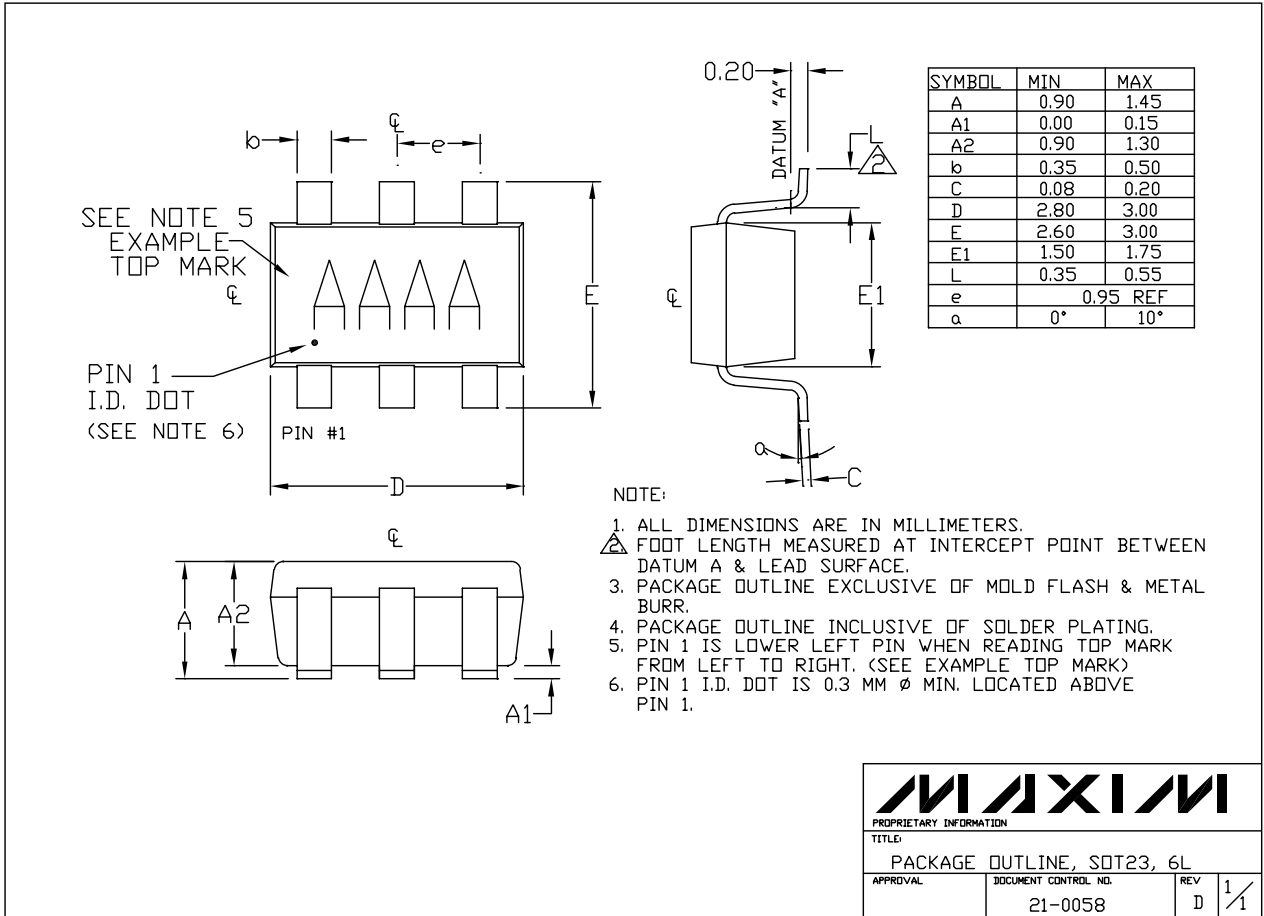
Pin Configuration

SOT23-6

Chip Information

TRANSISTOR COUNT: 302

SOT Temperature Sensor with Multidrop Single-Wire Digital Interface

MAX6575L/H

6LSOT.EPS

SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.55
e	0.95 REF	
α	0°	10°

SEE NOTE 5
EXAMPLE
TOP MARK

PIN 1
I.D. DOT
(SEE NOTE 6)

PIN #1

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3 MM Ø MIN. LOCATED ABOVE PIN 1.

MAXIM
PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT23, 6L			
APPROVAL	DOCUMENT CONTROL NO. 21-0058	REV D	1/1

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NOTES

MAX6575L/H

SOT Temperature Sensor with
Multidrop Single-Wire Digital Interface

NOTES