●应用与设计

采用 MAX6577 设计的多点测温系统

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摘要:介绍了单线输出温度传感器 MAX6577 的特性,给出了应用 MAX6577 设计多点分布式测温系统的具体方法。

关键词:MAX6577;　温度测量;　分布式

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Adopting MAX6577 to Design Multipoint Measure Temperature System

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Abstract: The characteristic of the output temperature sensor - MAX6577 is introduced, and the concrete methods adopting MAX6577 to design multipoint distributed measure temperaturement system is given in this paper.

Key words: temperature system; MAX6577

1 MAX6577 简介

MAX6577 是 MAXIM 公司推出的低成本、微功耗新型温度传感器。其主要特点如下:

- ●可实现温度/频率变换;
- ●采用单引脚频率输出,只占用一个 I/O 口;
- ●测温范围为 -40~+125℃;
- ●典型误差为 ±0.8℃,最大为 ±4.5℃;
- ●不用外接其它元件;
- ●电源电压为 2.7~5.5V;
- ●典型电源电流为 140μA;
- ●采用小型 6 脚 SOT23 封装。

MAX6577 的引脚排列如图 1 所示。其中引脚 VDD 为电源输入引脚;TS1、TS0 分别为逻辑 1、0 引脚;OUT 为输出引脚;NO 为空脚。

接通电源后,MAX6577 即可处于自发工作状态,输出占空比为 1:1 的方波,但方波的频率受环境温度的调制,具体表达式为:

$$T = f/k - 273.15K$$

其中 T 为环境温度(℃);f 为输出频率(Hz);K 为输出系数(K/Hz);K 为开氏温度。输出系数 k 由引脚 TS1、TS0 接 VDD 或 GND 设定,具体如表 1 所列。

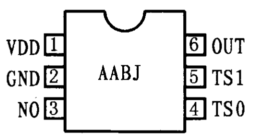

图 1　MAX6577 引脚图

MAX6577 的频率输出为推挽输出,在 5V 电源情况下,该输出符合 TTL 电平标准,可直接与单片机连接,也可以在相应的电压下与低电压版本的单片机直接连接。

为了方便使用,将常用温度与输出频率之间的对应关系列于表 2。表中的 k 越大,传感器的灵敏度越高,但噪声的幅值也越大。

2 与 MCS-51 系列单片机的接口

2.1 单点测温

MAX6577 与 MCS-51 系列单片机的接口连接方法如图 2 所示。一般可将频率输出接到定时/计数器 I/O 口 T0 或 T1 上,这样可以在规定的时间内对

表 1　输出系数 k 的设定

TS1	TS0	k
GND	GND	4
GND	VDD	1
VDD	GND	1/4
GND	VDD	1/16

表 2　温度与输出频率的对应关系

	0℃	25℃	100℃
k=4	1092.6	1192.6	1492.6
k=1	273.15	298.15	373.15
k=1/4	68.29	74.54	93.29
k=1/16	17.07	18.63	23.32

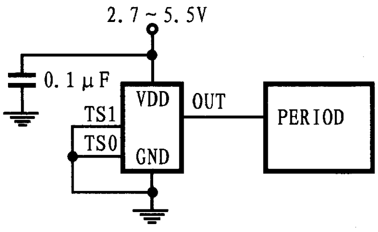

图2 MAX6577与单片机的连接

频率脉冲进行计数,计数值即反映频率的高低,对计数值进行简单的计算可以得到需要的温度信号。为了保证测量精度,应使用频率测量法测温,且输出频率应尽量高,即k应大一些。

2.2 多点测温

因为单片机内的定时/计数器资源有限,所以采用多点切换的方法。本文以一个8路温度测量系统的设计为例来加以说明,其设计方案见图3。图中选用74LS151构成8选1开关,并将输出接到T0,由P1口的3根I/O线进行地址选择。P1.3接发光二极管,用于指示单片机系统的工作状态。X25045提供电源监控、看门狗和512字节的EEPROM,该设计由于将X25045的片选线和写保护线接到单片机的一个I/O口上,因此,只有在X25045被选中时才可以对EEPROM进行写入,从而避免了各种干扰对数据的破坏。TXD、RXD接SN75LBC184可构成RS485总线半双工通讯网络,而P3.7用于收发控制,利用SN75LBC184可以抑制由于雷击或其它原因在通讯线路中产生的各种瞬时过电压,从而使系统免遭损坏。

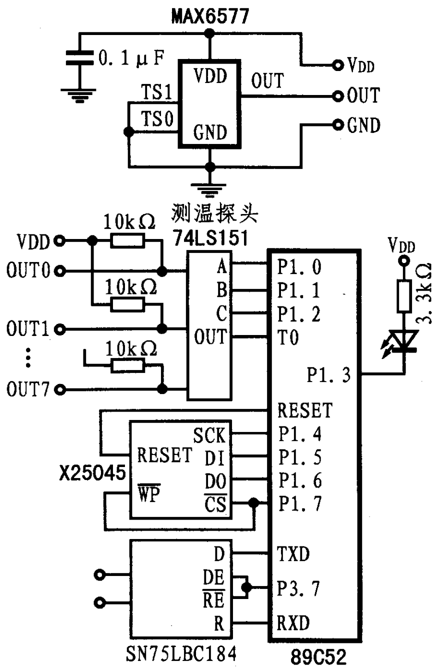

图3 多路测温示意图

该设计是将MAX6577和一个电容焊接在很小的电路板上,并用环氧树脂和铝质外壳封装在一起构成测温探头。由于传感器输出的低频脉冲信号具有很强的抗干扰能力,故可以远距离传输。在频率信号线上接上拉电阻,可以使脉冲以电流信号方式传输,进一步提高抗干扰性,增加传输距离。但该上拉电阻不能过小,若太小,其传输电流将引起传感器自身温度的变化。

为了提高测量的分辨率和缩短每一路的测量时间,MAX6577的系数k应设置成4。这样,在-25~125℃的温度范围内,频率变化范围为992.6~1592.6Hz,若对每一路脉冲信号取2秒的计数时间,则计数范围可在1985-2985之间变化,测量的分辨率可以达到0.125℃,这样系统的测温准确度只取决于传感器。

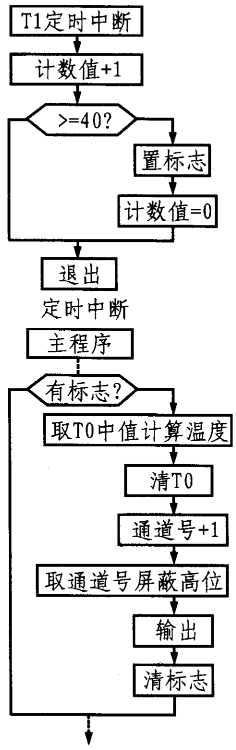

图4 程序流程

该系统选89C52单片机,并用定时/计数器T0作为脉冲计数器,T1作为定时器。T1的定时间隔为50ms,如果另设计一个以40为周期的软件计数器,则可产生2s的时间间隔。T2作为波特率发生器。

系统软件包括主程序、定时中断、通讯中断几个部分。其程序关键部分的流程框图见图4所示。

3 结束语

用MAX6577作为温度传感器可在保证测温准确度的前提下,简化设计,降低成本。该系统有着广泛的应用,如电子元件和设备的工作温度检测、智能环境温度监测、粮仓温度监测、大棚温度监测等。

参考文献

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DESIGN IDEAS

将温度转换为电压的固态电路

图1 电路是一个固态温度计，可用于-40°C至+125°C的温度测量。通过调节R_{ZERO}和R_{SCALE}，你可以按照任何温度计量单位对输出电压(V_{OUT})进行调零和刻度。例如，采用摄氏温度计量时，需要输出电压随温度的变化比例为10mV/°C。则当温度为0°C时，调节R_{ZERO}使输出电压为0.0V，温度为-10°C时，调节R_{SCALE}使输出电压为-100mV。

集成温度传感器(IC1，MAX6577)输出信号为频率正比于绝对温度的方波。为利用该信号，电路采用了一个集成在波形发生器IC2(MAX038)内部的锁相环(PLL)。由于IC2的线性频率调谐特性，其检相器输出(PDO)正比于输入频率，因而也正比于温度。将PDO输出施加到频率调节输入FADJ便可实现锁相。由于IC2的VCO增益为负，需利用外部运算放大器将最终输出电压倒相。

校准时，可将环境温度置为0°C(或0°F)，调节R_{ZERO}使V_{OUT}=0。然后，将环境温度置为室温(+25°C)，调节R_{SCALE}使V_{OUT}与温度值相对应(例如当标定刻度为10mV/°C时，将V_{OUT}调至250mV)。对于10mV/°C的刻度，温度误差低于±1.5°C(图2)。

温度传感IC采用微型6引脚SOT23封装，易于在PC板上与其它元件一起安装。该温度计的宽温范围和微小尺寸对于工业和商业应用都很适合。

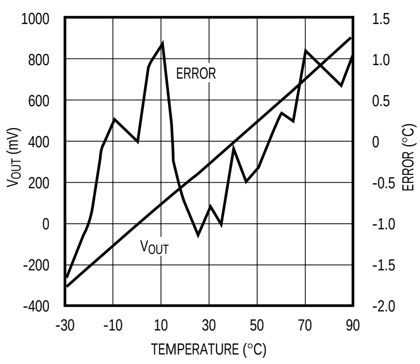


图2. 图1电路的输出误差保持在±1.5°C以内。

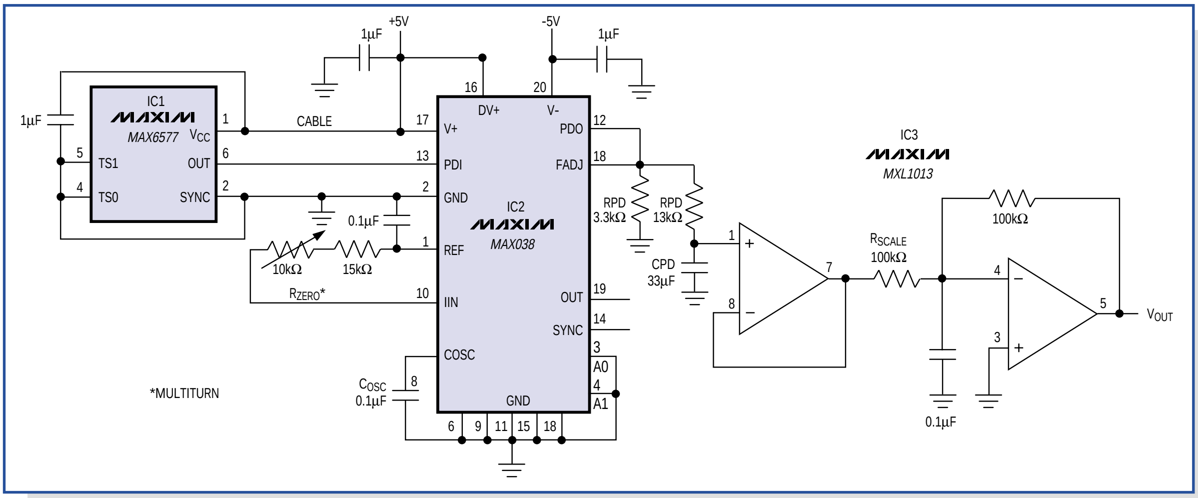


图1. 三片IC组成的电路提供正比于IC1温度的输出电压。

19-1484; Rev 0; 4/99

MAXIM

SOT Temperature Sensors with Period/Frequency Output

MAX6576/MAX6577

General Description

The MAX6576/MAX6577 are low-cost, low-current temperature sensors with a single-wire output. The MAX6576 converts the ambient temperature into a square wave with a period proportional to absolute temperature (°K). The MAX6577 converts the ambient temperature into a square wave with a frequency proportional to absolute temperature. The MAX6576 offers accuracy of ±3°C at +25°C, ±4.5°C at +85°C, and ±5°C at +125°C. The MAX6577 offers accuracy of ±3°C at +25°C, ±3.5°C at +85°C, and ±4.5°C at +125°C.

Both devices feature a single-wire output that minimizes the number of pins necessary to interface with a microprocessor. The period/frequency range of the output square wave can be selected by hard-wiring the two time-select pins (TS0, TS1) to either V_{DD} or GND. The MAX6576/MAX6577 are available in space-saving 6-pin SOT23 packages.

Features

- **Simple Single-Wire Output**
- **Two Output Types Available**
  - **Temperature to Period (µs) (MAX6576)**
  - **Temperature to Frequency (Hz) (MAX6577)**
- **±0.8°C Accuracy at +25°C (±3°C max)**
- **No External Components**
- **Operates from +2.7V to +5.5V Supply Voltage**
- **Low 140µA Typical Supply Current**
- **Standard Operating Temperature Range: -40°C to +125°C**
- **Small 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

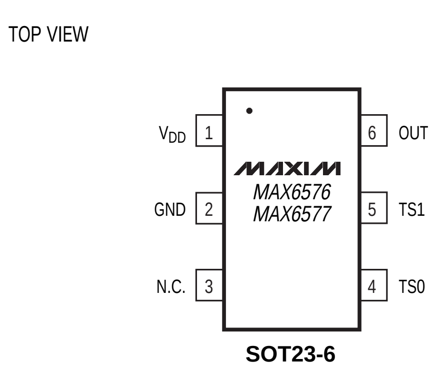
Medical Equipment

Automotive

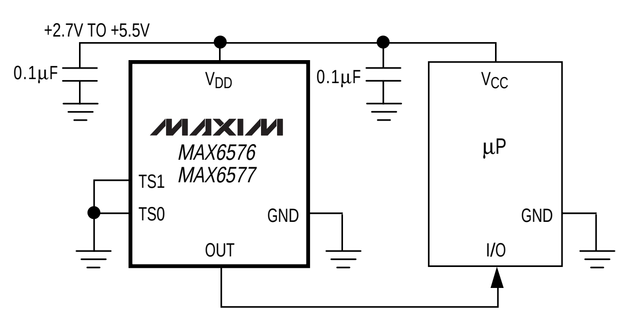
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	SOT TOP MARK
MAX6576ZUT	-40°C to +125°C	6 SOT23	AABI
MAX6577ZUT	-40°C to +125°C	6 SOT23	AABJ

Pin Configuration



Typical Operating Circuit



SOT Temperature Sensors with Period/Frequency Output

ABSOLUTE MAXIMUM RATINGS

Terminal Voltage (with respect to GND)
V_{DD} ....-0.3V to +6V
TS1, TS0, OUT.......................................-0.3V to (V_{DD} + 0.3V)
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.)

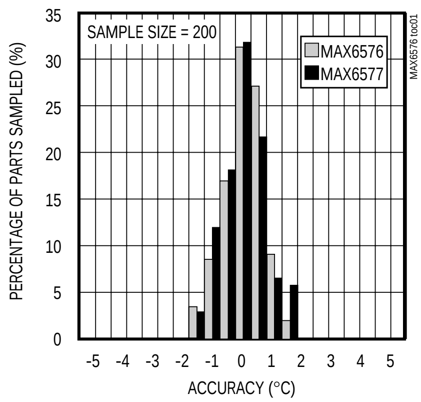
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
V_{DD} Range	V_{DD}			2.7		5.5	V
Supply Current	I_{DD}	V_{DD} = 5.5V	T_A = -40°C to +85°C		140	250	µA
			T_A = -40°C to +125°C			400	
Temperature Sensor Error (Note 1)		MAX6576	T_A = -20°C	-7.5	±1.1	+7.5	°C
			T_A = 0°C	-5.5	±0.9	+5.5	
			T_A = +25°C	-3.0	±0.8	+3.0	
			T_A = +85°C	-4.5	±0.5	+4.5	
			T_A = +125°C	-5.0	±0.5	+5.0	
		MAX6577	T_A = -20°C	-7.5	±1.1	+7.5	°C
			T_A = 0°C	-6.5	±0.9	+6.5	
			T_A = +25°C	-3.0	±0.8	+3.0	
			T_A = +85°C	-3.5	±0.5	+3.5	
			T_A = +125°C	-4.5	±0.5	+4.5	
Output Clock Period	t_{OUT}	MAX6576, T (temp) in °K, Figure 1	V_{TS1} = GND, V_{TS0} = GND		10T		µs
			V_{TS1} = GND, V_{TS0} = V_{DD}		40T		
			V_{TS1} = V_{DD}, V_{TS0} = GND		160T		
			V_{TS1} = V_{DD}, V_{TS0} = V_{DD}		640T		
Output Clock Frequency	f_{OUT}	MAX6577, T (temp) in °K, Figure 2	V_{TS1} = GND, V_{TS0} = GND		4T		Hz
			V_{TS1} = GND, V_{TS0} = V_{DD}		1T		
			V_{TS1} = V_{DD}, V_{TS0} = GND		T/4		
			V_{TS1} = V_{DD}, V_{TS0} = V_{DD}		T/16		
OUT Duty Cycle (Note 2)					0.5		
Time-Select Pin Logic Levels	V_{IL}					0.8	V
	V_{IH}			2.3			
OUT Voltage	V_{OL}	V_{DD} > 4.5V, I_{SINK} = 3.2mA				0.4	V
		V_{DD} > 2.7V, I_{SINK} = 1.2mA				0.3	
	V_{OH}	V_{DD} > 4.5V, I_{SRC} = 800µA		V_{DD} - 1.5			
		V_{DD} > 2.7V, I_{SRC} = 500µA		0.8V_{DD}			

Note 1: See the Temperature Accuracy histograms in the *Typical Operating Characteristics*.
Note 2: The output duty cycle is guaranteed to be 50% by an internal flip-flop.

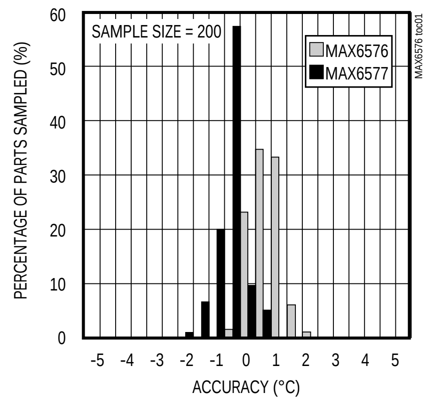
Typical Operating Characteristics

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

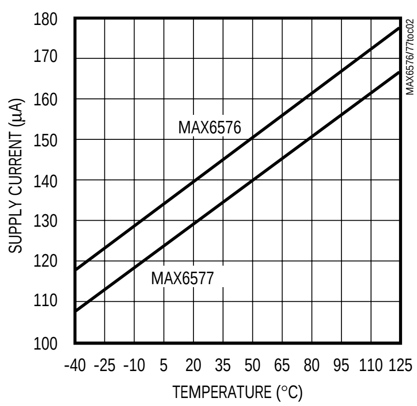
TEMPERATURE ACCURACY (T_A = +25°C)



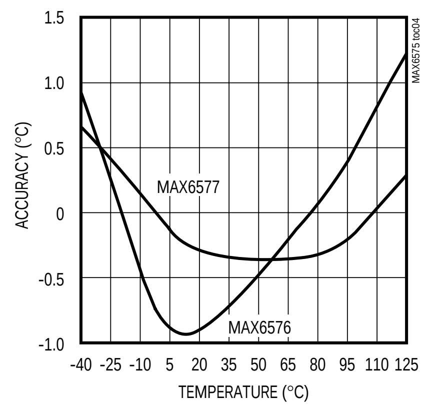
TEMPERATURE ACCURACY (T_A = +85°C)



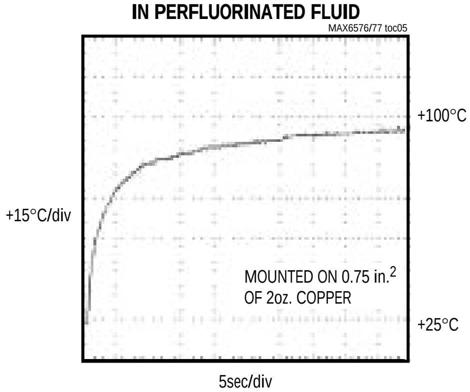
SUPPLY CURRENT vs. TEMPERATURE



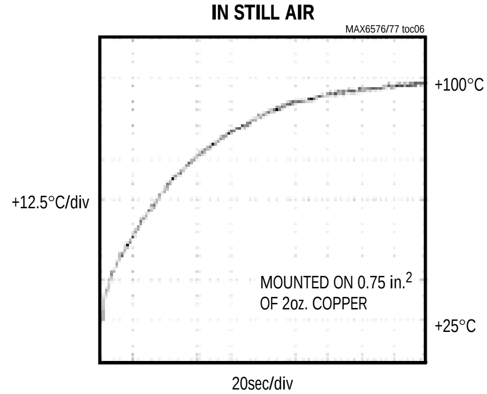
ACCURACY vs. TEMPERATURE



THERMAL STEP RESPONSE IN PERFLUORINATED FLUID



THERMAL STEP RESPONSE IN STILL AIR



Pin Description

PIN	NAME	FUNCTION
1	V_{DD}	Positive Supply Voltage
2	GND	Ground
3	N.C.	No Connection. Connect pin to GND or leave open.
4, 5	TS1, TS0	Time-Select Pins. TS1 and TS0 set the temperature scale factor by connecting TS1 and TS0 to either V_{DD} or GND. See Tables 1 and 2.
6	OUT	Square-Wave Output with a Clock Period Proportional to Absolute Temperature (°K) (MAX6576)
		Square-Wave Output with a Clock Frequency Proportional to Absolute Temperature (°K) (MAX6577)

Table 1. MAX6576 Time-Select Pin Configuration

TS1	TS0	SCALAR MULTIPLIER (µs/°K)
GND	GND	10
GND	V_{DD}	40
V_{DD}	GND	160
V_{DD}	V_{DD}	640

Note: *The temperature, in °C, may be calculated as follows:*

$$T(°C) = \frac{\text{period}(\mu s)}{\text{scalar mulitplier}(\mu s/°K)} - 273.15°K$$

Table 2. MAX6577 Time-Select Pin Configuration

TS1	TS0	SCALAR MULTIPLIER (Hz/°K)
GND	GND	4
GND	V_{DD}	1
V_{DD}	GND	1/4
V_{DD}	V_{DD}	1/16

Note: *The temperature, in °C, may be calculated as follows:*

$$T(°C) = \frac{\text{frequency}(Hz)}{\text{scalar mulitplier}(Hz/°K)} - 273.15°K$$

Detailed Description

The MAX6576/MAX6577 low-cost, low-current (140µA typ) temperature sensors are ideal for interfacing with microcontrollers (µCs) or microprocessors (µPs). The MAX6576 converts ambient temperature into a 50% duty-cycle square wave with a period proportional to absolute temperature. The MAX6577 converts ambient temperature into a 50% duty-cycle square wave with a frequency proportional to absolute temperature. Time-select pins (TS1, TS0) permit the internal temperature-controlled oscillator (TCO) to be scaled by four preset multipliers. The MAX6576/MAX6577 feature a single-wire interface to minimize the number of port pins necessary for interfacing with a µP.

MAX6576 Characteristics

The MAX6576 temperature sensor converts temperature to period. The output of the device is a free-running, 50% duty-cycle square wave with a period that is proportional to the absolute temperature (°K) of the device (Figure 1). The MAX6576 has a push/pull CMOS output with sharp edges. The speed of the output square wave can be selected by hard-wiring TS1 and TS0 as shown in Table 1. One of four scaled output periods can be selected using TS1 and TS0.

MAX6577 Characteristics

The MAX6577 temperature sensor converts temperature to frequency. The output of the device is a free-running, 50% duty-cycle square wave with a frequency that is proportional to the absolute temperature (°K) of the device (Figure 2). The MAX6577 has a push/pull CMOS output with sharp edges. The speed of the output square wave can be selected by hard-wiring TS1 and TS0 as shown in Table 2. One of four scaled output frequencies can be selected using TS1 and TS0.

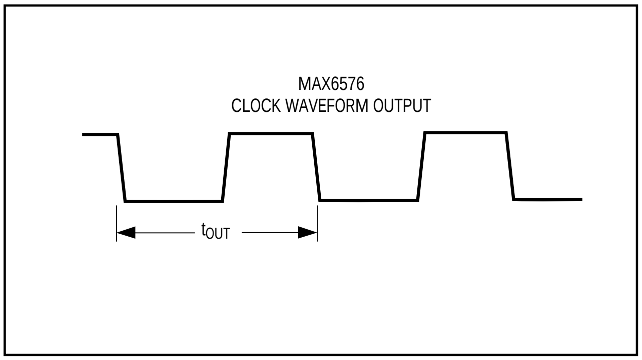


Figure 1. MAX6576 Timing Diagram

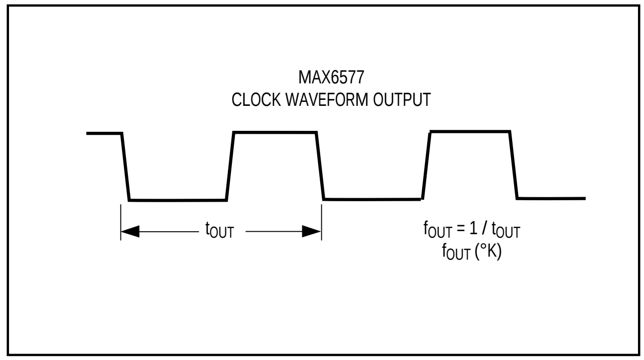


Figure 2. MAX6577 Timing Diagram

Applications Information

Quick-Look Circuits

Figure 3 shows a quick-look application circuit for the MAX6576 using a universal counter measuring period. TS1 and TS0 are both tied to ground to select a scalar multiplier of 10µs/°K. The MAX6576 converts the ambient temperature into a square wave with a period that is 10 times the absolute temperature of the device in µs. At room temperature, the universal counter will display approximately 2980µs.

Figure 4 shows a quick-look application circuit for the MAX6577 using a universal counter measuring frequency. TS1 is tied to ground and TS0 is tied to V_{DD} to select a scalar multiplier of 1Hz/°K. The MAX6577 converts the ambient temperature into a square wave with a frequency that is equal to the absolute temperature of the device in Hertz. At room temperature, the universal counter will display approximately 298Hz.

Interfacing with a Microcontroller

Figure 5 shows the MAX6577 interfaced with an 8051 µC. In this example, TS1 is tied to ground and TS0 is tied to V_{DD} to select a scalar multiplier of 1Hz/°K. The MAX6577 converts the ambient temperature into a square wave with a frequency that is equal to the absolute temperature of the device in Hertz. The 8051 µC reads the frequency of the square-wave output of the MAX6577 into Timer 0 and displays the temperature as degrees Celsius in binary on Port 1. Listing 1 provides the code for this application. The interface is similar for the MAX6576, except the µC will perform a period measurement.

Noise Considerations

The accuracy of the MAX6576/MAX6577 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 supply pin of the devices. Internal noise is inherent in the operation of the devices and is detailed in Table 3. Internal averaging minimizes the effect of this noise when using longer scalar timeout multipliers. The effects of this noise are included in the overall accuracy of the devices as specified in the *Electrical Characteristics*.

SOT Temperature Sensors with Period/Frequency Output

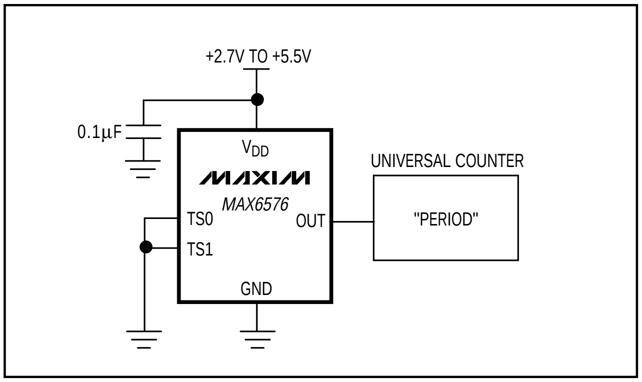


Figure 3. MAX6576 Quick-Look Circuit

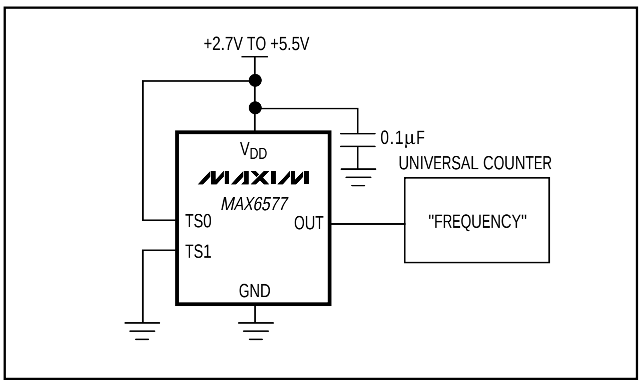


Figure 4. MAX6577 Quick-Look Circuit

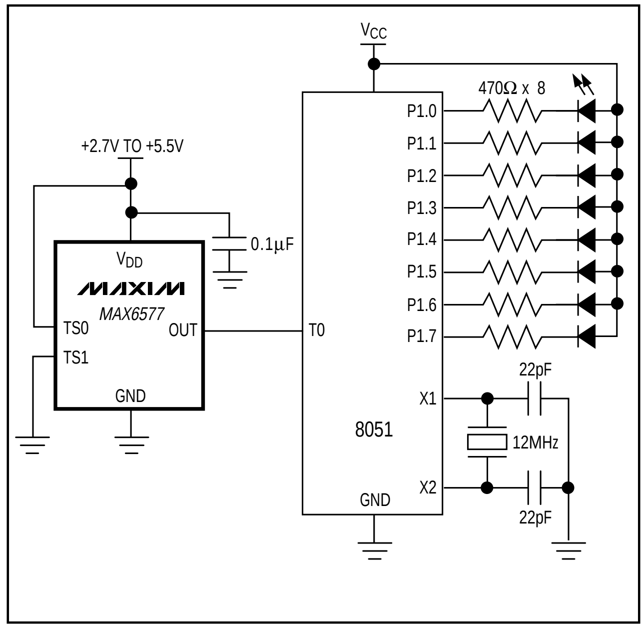


Figure 5. Interfacing with a μC

Chip Information

TRANSISTOR COUNT: 302

Table 3. Typical Peak Noise Amplitude

PARAMETER	MAX6576				MAX6577			
Scalar Multiplier	10	40	160	640	4	1	1/4	1/16
Noise Amplitude (°C)	±0.38	±0.17	±0.11	±0.094	±0.13	±0.066	±0.040	±0.028

Listing 1. 8051 Code Example

```
;**********************************************************
; Demonstration and test code for MAX6577 Temp to Frequency
; Takes in temperature values from a sensor into timer 0
; and displays temp as degrees C in binary on port 1.
; example: room temp= 21 C, display 21 or 00010101 on P1
;**********************************************************
;EQUATES
TEMPH       EQU   10H               ;TEMPERATURE
TEMPL       EQU   11H
TICKS       EQU   12H               ;number of 50 ms- counts to 1 second

NEWT        BIT   00h               ;new temp flag- bit address in 20h
;MAIN
            ORG   0                 ;note one isr's used- timer overflow
            AJMP  BEGIN             ;jump over isr's
            ORG   1BH               ;TF1 ISR
TICK:       PUSH  ACC               ;stash acc
            PUSH  PSW               ;stash psw
; reload timer- 50 ms
            CLR   C                 ;clear for subb
            MOV   A,#0B0H           ;latency fix
            SUBB  A,TL1             ;subtract timer low latency < 20
            MOV   TL1,A             ;50 ms reload value- low
            MOV   TH1,#03CH         ;50 ms reload value- high
            DJNZ  TICKS,NORL        ;jump over  counter code
            MOV   TICKS,#20         ;reload ticks
;read counter to templ and temp high if 1 second
GTAG:       MOV   A,TH0             ;get timer high
            MOV   B,TL0             ;grab timer low
            CJNE  A,TH0,GTAG        ;get again if rollover
            MOV   TEMPH,A           ;stash high
            MOV   TEMPL,B           ;stash low
            MOV   TH0,#0            ;zero counter
            MOV   TL0,#0            ;zero counter
            SETB  NEWT              ;set data ready flag
NORL:       POP   PSW
            POP   ACC
            RETI                    ;done

BEGIN:            MOV   SP,#70h     ;set sp at 70H
;setup timers to do timing- t0 input, t1 timer 50 ms
            MOV   TMOD,#15H         ;t1 timer- t0 counter
            MOV   TH1,#03CH         ;50 ms reload value- high
            MOV   TL1,#0B0H         ;50 ms reload value- low
            MOV   TL0,#0            ;reset counter low
            MOV   TH0,#0            ;reset counter high
            MOV   TCON,#50H         ;start both timers
            MOV   TICKS,#20         ;20 x 50 ms = 1 sec
            MOV   IE,#88H           ;enable t1 ints and global
;
;inits done- measure
DOTMP:      CLR   NEWT              ;clear data flag
WAITT:      JNB   NEWT,WAITT        ;wait for data

; temp is stored- display bin value of selected on P1
```

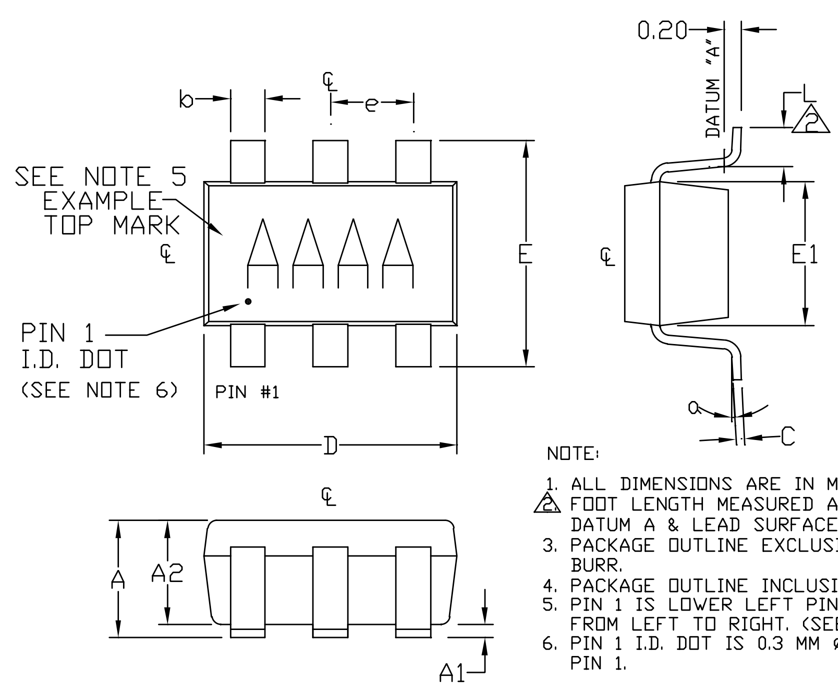
SOT Temperature Sensors with Period/Frequency Output

Listing 1. 8051 Code Example (continued)

```
; temp is in kelvin- subtract 273
            MOV    A,TEMPL           ;get temp (K)
            CLR    C                 ;ready for subb
            SUBB   A,#011H           ;sub low byte of 273
            MOV    TEMPL,A           ;stash back
            MOV    A,TEMPH           ;get high byte for completeness
            SUBB   A,#01H            ;sub high byte and prop carry
            MOV    TEMPH,A           ;stash
;display it
            MOV    A,TEMPL           ;get temp (C)
            CPL    A                 ;compliment for led's- active low
            MOV    P1,A              ;output it
            JMP    DOTMP

            END
```

Package Information



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°

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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