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.)

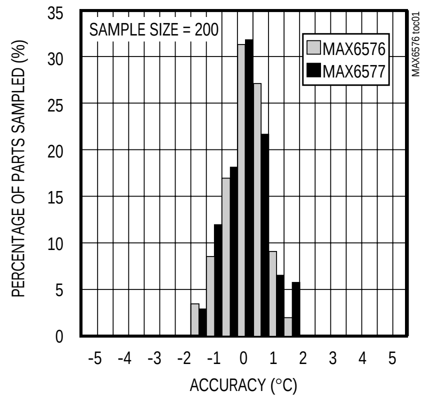
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
V_{DD} Range	V_{DD}			2.7		5.5	V
Supply Current	I_{DD}	V_{DD} = 5.5V	T_A = -40°C to +85°C		140	250	µA
			T_A = -40°C to +125°C			400	
Temperature Sensor Error (Note 1)		MAX6576	T_A = -20°C	-7.5	±1.1	+7.5	°C
			T_A = 0°C	-5.5	±0.9	+5.5	
			T_A = +25°C	-3.0	±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.

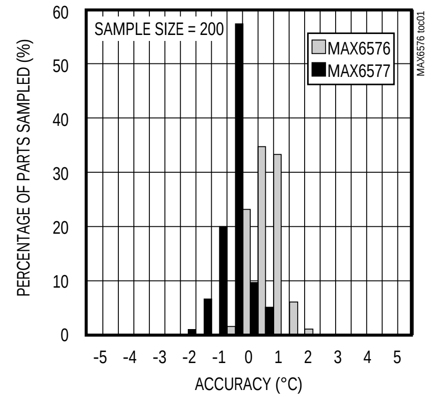
Typical Operating Characteristics

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

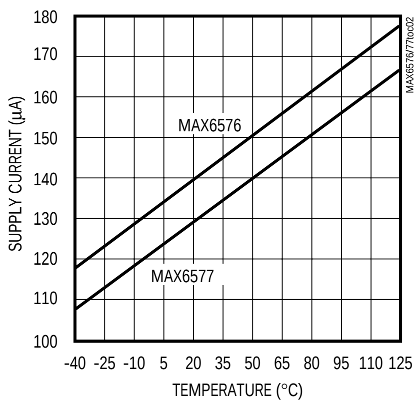
TEMPERATURE ACCURACY (T_A = +25°C)



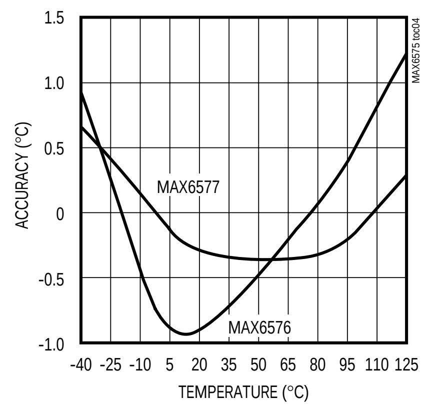
TEMPERATURE ACCURACY (T_A = +85°C)



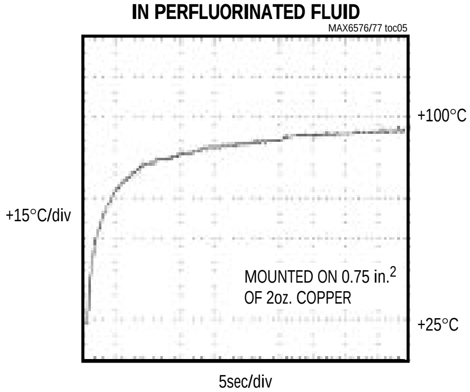
SUPPLY CURRENT vs. TEMPERATURE



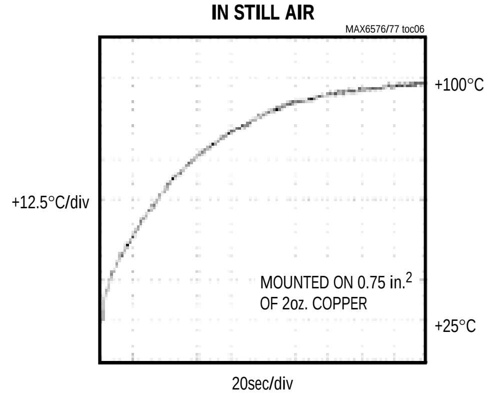
ACCURACY vs. TEMPERATURE



THERMAL STEP RESPONSE IN PERFLUORINATED FLUID



THERMAL STEP RESPONSE IN STILL AIR



SOT Temperature Sensors with Period/Frequency Output

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:*

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

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:*

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

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.

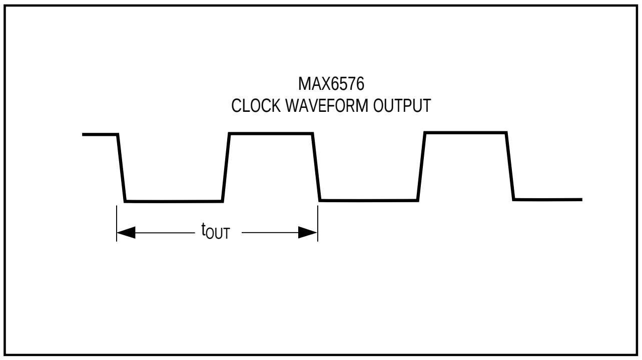


Figure 1. MAX6576 Timing Diagram

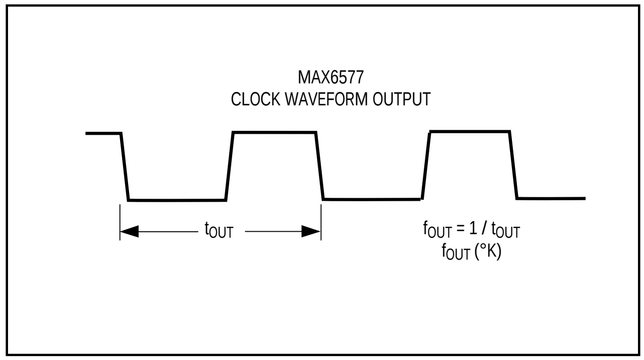


Figure 2. MAX6577 Timing Diagram

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*.

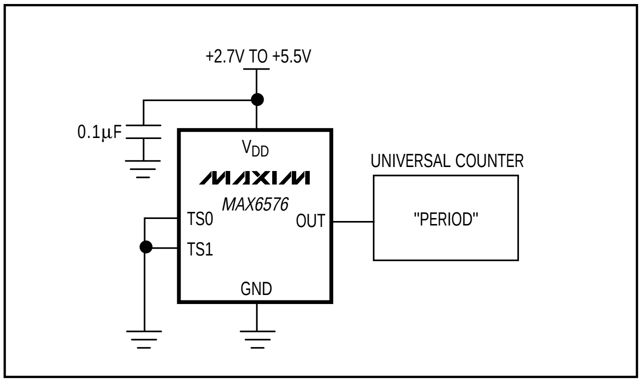


Figure 3. MAX6576 Quick-Look Circuit

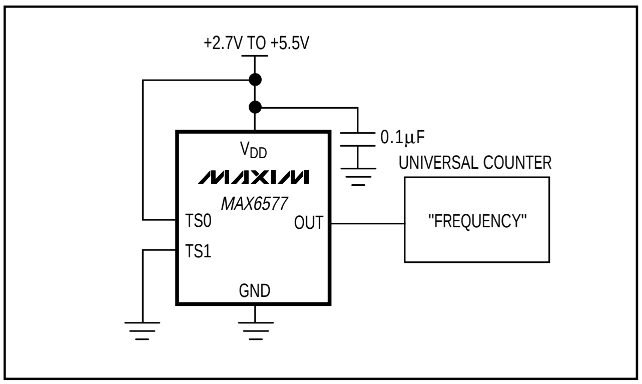


Figure 4. MAX6577 Quick-Look Circuit

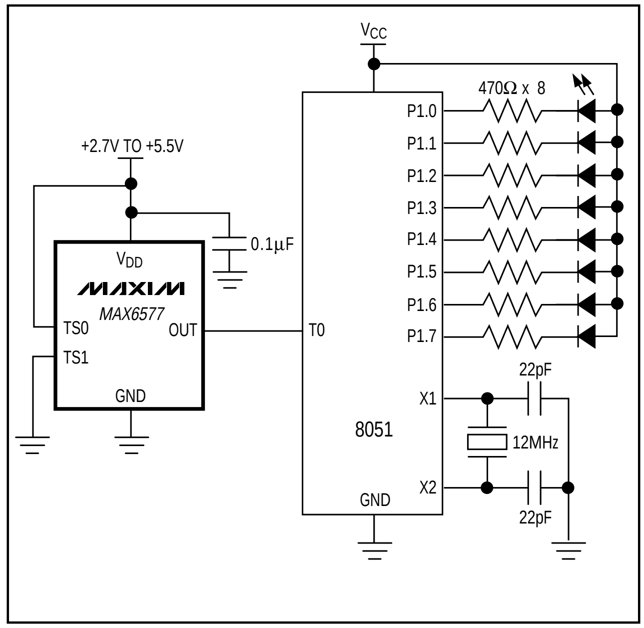


Figure 5. Interfacing with a µC

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

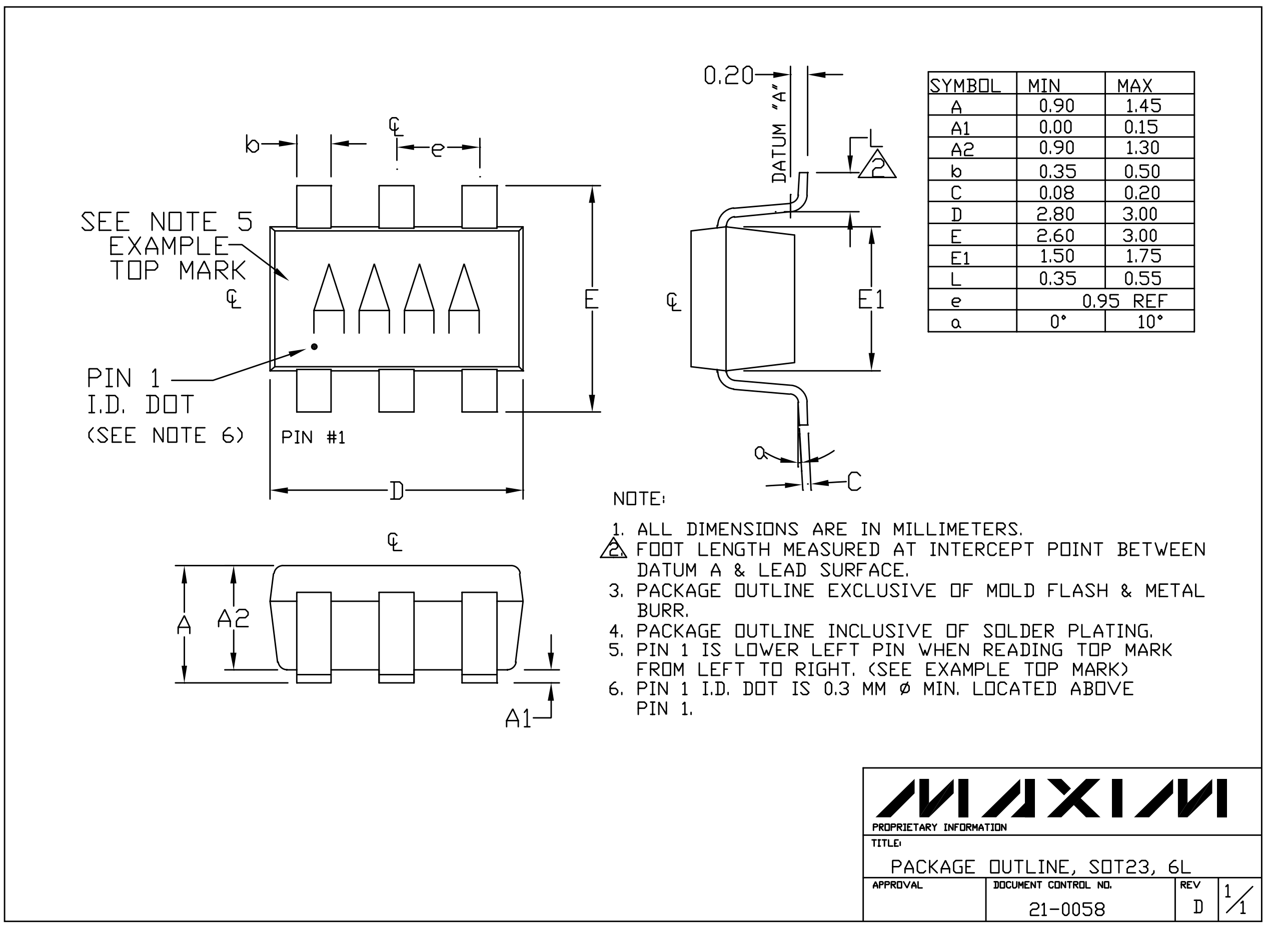
Listing 1. 8051 Code Example

```
;*************************************************************
; 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
```

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°

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