TCN75A

2-Wire Serial Temperature Sensor

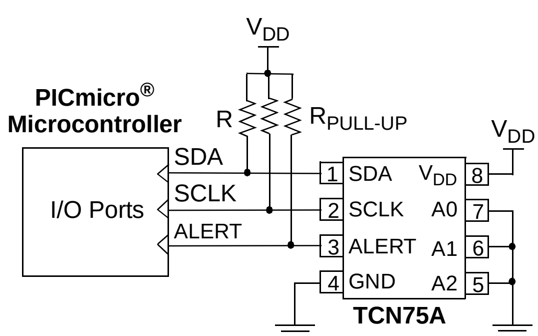
Features

- Temperature-to-Digital Converter
- Accuracy with 12-bit Resolution:
  - ±0.5°C (typ.) at +25°C
  - ±3°C (max.) from +25°C to +100°C
- User-selectable Resolution: 9 – 12 bits
- Operating Voltage Range: 2.7V to 5.5V
- 2-wire Interface: I^2C™ Compatible
- Operating Current: 200 µA (typ.)
- Shutdown Current: 2 µA (max.)
- Power-saving One-shot Temperature Measurement
- Available Packages: MSOP-8, SOIC-8

Typical Applications

- Personal Computers and Servers
- Hard Disk Drives and Other PC Peripherals
- Entertainment Systems
- Office Equipment
- Data Communication Equipment
- General-purpose Temperature Monitoring

Typical Application



Description

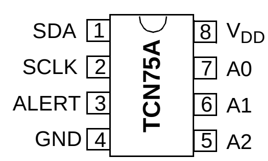
Microchip Technology Inc.'s TCN75A digital temperature sensor converts temperatures between -40°C and +125°C to a digital word, with ±1.5°C (typ.) accuracy.

The TCN75A product comes with user-programmable registers that provide flexibility for temperature-sensing applications. The register settings allow user-selectable, 9-bit to 12-bit temperature measurement resolution, configuration of the power-saving Shutdown and One-shot (single conversion on command while in Shutdown) modes and the specification of both temperature alert output and hysteresis limits. When the temperature changes beyond the specified limits, the TCN75A outputs an alert signal. The user has the option of setting the alert output signal polarity as an active-low or active-high comparator output for thermostat operation, or as temperature event interrupt output for microprocessor-based systems.

This sensor has an industry standard 2-wire, I^2C™ compatible serial interface, allowing up to eight devices to be controlled in a single serial bus. These features make the TCN75A ideal for low-cost, sophisticated multi-zone temperature-monitoring applications.

Package Types

8-Pin SOIC, MSOP



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

V_{DD} 6.0V

Voltage at all Input/Output pins .... GND – 0.3V to 5.5V

Storage temperature ....-65°C to +150°C

Ambient temp. with power applied .....-55°C to +125°C

Junction Temperature (T_J)................................. 150°C

ESD protection on all pins (HBM:MM)....... (4 kV:400V)

Latch-up current at each pin .... ±200 mA

†Notice: Stresses above those listed under "Maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground, and T_A = -40°C to +125°C.

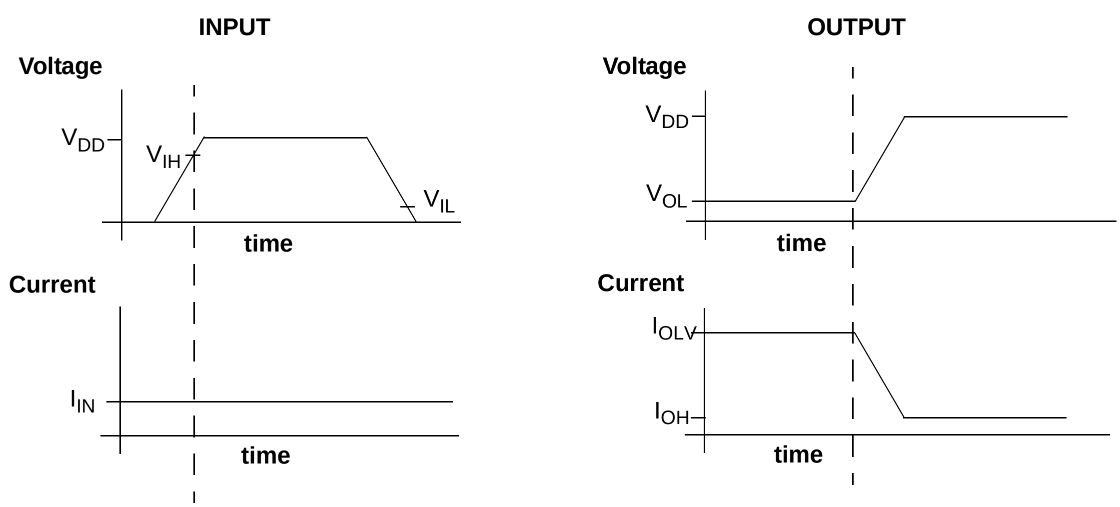
Parameters	Sym	Min	Typ	Max	Unit	Conditions
Power Supply						
Operating Voltage Range	V_{DD}	2.7	—	5.5	V	
Operating Current	I_{DD}	—	200	500	µA	Continuous operation
Shutdown Current	I_{SHDN}	—	0.1	2	µA	Shutdown mode
Power-On Reset (POR) Threshold	V_{POR}	—	1.7	—	V	V_{DD} falling edge
Temperature Sensor Accuracy						
Accuracy with 12-bit Resolution:						
T_A = +25°C	T_{ACY}	—	±0.5	—	°C	V_{DD} = 3.3V
+25°C < $T_A \le$ +100°C	T_{ACY}	-3.0	—	+3.0	°C	V_{DD} = 3.3V
-40°C < $T_A \le$ +125°C	T_{ACY}	—	±1.5	—	°C	V_{DD} = 3.3V
Internal ΣΔ ADC						
Conversion Time:						
9-bit Resolution	t_{CONV}	—	30	—	ms	33 samples/sec (typ.)
10-bit Resolution	t_{CONV}	—	60	—	ms	17 samples/sec (typ.)
11-bit Resolution	t_{CONV}	—	120	—	ms	8 samples/sec (typ.)
12-bit Resolution	t_{CONV}	—	240	—	ms	4 samples/sec (typ.)
Alert Output (Open-drain)						
High-level Current	I_{OH}	—	—	1	µA	V_{OH} = 5V
Low-level Voltage	V_{OL}	—	—	0.4	V	I_{OL}= 3 mA
Thermal Response						
Response Time	t_{RES}	—	1.4	—	s	Time to 63% (89°C) 27°C (air) to 125°C (oil bath)

DIGITAL INPUT/OUTPUT PIN CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground and T_A = -40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Serial Input/Output (SCLK, SDA, A0, A1, A2)						
Input						
High-level Voltage	V_{IH}	0.7 V_{DD}	—	—	V	
Low-level Voltage	V_{IL}	—	—	0.3 V_{DD}	V	
Input Current	I_{IN}	-1	—	+1	µA	
Output (SDA)						
Low-level Voltage	V_{OL}	—	—	0.4	V	I_{OL}= 3 mA
High-level Current	I_{OH}	—	—	1	µA	V_{OH} = 5V
Low-level Current	I_{OL}	6	—	—	mA	V_{OL} = 0.6V
Capacitance	C_{IN}	—	10	—	pF	
SDA and SCLK Inputs						
Hysteresis	V_{HYST}	0.05 V_{DD}	—	—	V	

Graphical Symbol Description



2.0 TYPICAL PERFORMANCE CURVES

Note:	The graphs and tables provided following this note are a statistical summary based on a limited nun samples and are provided for informational purposes only. The performance characteristics listed are not tested or guaranteed. In some graphs or tables, the data presented may be outside the sp operating range (e.g., outside specified power supply range) and therefore outside the warranted ra

Note: Unless otherwise noted: V_{DD} = 2.7V to 5.5V.

FIGURE 2-1: *Average Temperature Accuracy vs. Ambient Temperature, V_{DD} = 3.3V.*

FIGURE 2-2: *Average Temperature Accuracy vs. Ambient Temperature.*

FIGURE 2-3: *Average Temperature Accuracy vs. Ambient Temperature, V_{DD} = 3.3V.*

FIGURE 2-4: *Temperature Accurac Histogram, T_A = +25°C.*

FIGURE 2-5: *Supply Current vs. An Temperature.*

FIGURE 2-6: *Shutdown Current vs. Ambient Temperature.*

Note: Unless otherwise noted: V_{DD} = 2.7V to 5.5V.

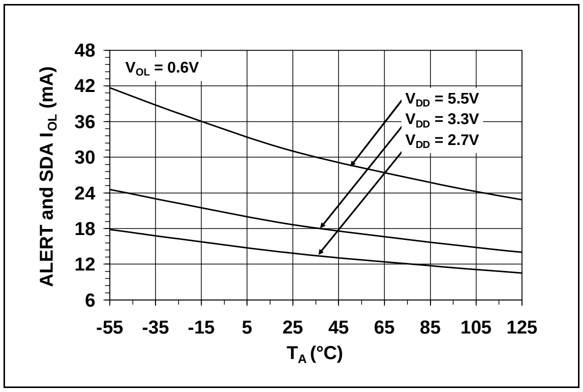


FIGURE 2-7: *ALERT and SDA I_{OL} vs. Ambient Temperature.*

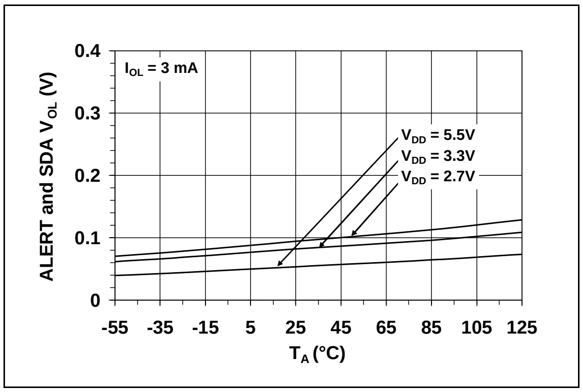


FIGURE 2-8: *ALERT and SDA Output V_{OL} vs. Ambient Temperature.*

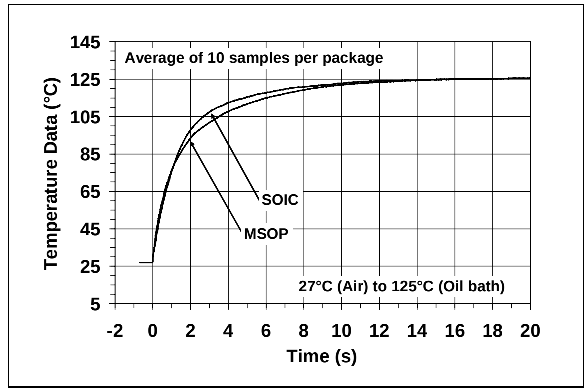


FIGURE 2-9: *TCN75A Thermal Response vs. Time.*

3.0 PIN DESCRIPTION

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

MSOP, SOIC	Symbol	Function
1	SDA	Bidirectional Serial Data
2	SCLK	Serial Clock Input
3	ALERT	Temperature Alert Output
4	GND	Ground
5	A2	Address Select Pin (bit 2)
6	A1	Address Select Pin (bit 1)
7	A0	Address Select Pin (bit 0)
8	V_{DD}	Power Supply Input

3.1 Serial Data Pin (SDA)

SDA is a bidirectional input/output pin, used to serially transmit data to and from the host controller. This pin requires a pull-up resistor to output data.

3.2 Serial Clock Pin (SCLK)

SCLK is a clock input pin. All communication and timing is relative to the signal on this pin. The clock is generated by the host controller on the bus.

3.3 Power Supply Input (V_{DD})

V_{DD} is the power pin. The operating voltage, as specified in the DC electrical specification table, is applied on this pin.

3.4 Ground (GND)

GND is the system ground pin.

3.5 ALERT Output

The TCN75A's ALERT pin is an open-drain output. The device outputs an alert signal when the ambient temperature goes beyond the user-programmed temperature limit.

3.6 Address Pins (A2, A1, A0)

A2, A1 and A0 are device or slave address input pins.

The address pins are the Least Significant bits (LSb) of the device address bits. The Most Significant bits (MSb) (A6, A5, A4, A3) are factory-set to <`1001`>. This is illustrated in Table 3-2.

TABLE 3-2: SLAVE ADDRESS

Device	A6	A5	A4	A3	A2	A1	A0
TCN75A	1	0	0	1	X	X	X

Note: User-selectable address is shown by X.

4.0 FUNCTIONAL DESCRIPTION

The TCN75A temperature sensor consists of a band-gap type temperature sensor, a ΣΔ Analog-to-Digital Converter (ADC), user-programmable registers and a 2-wire I^2C protocol-compatible serial interface.

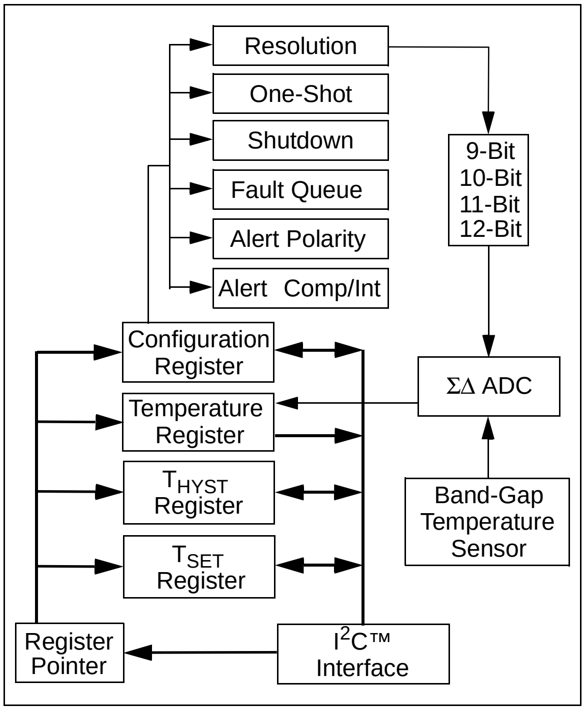


FIGURE 4-1: *Functional Block Diagram.*

4.1 Temperature Sensor

The TCN75A uses the difference in the base-emitter voltage of a transistor while its collector current is changed from IC_1 to IC_2. With this method, the ΔV_{BE} depends only on the ratio of the two currents and the ambient temperature, as shown in Equation 4-1.

EQUATION 4-1:

$$\Delta V_{BE} = \left(\frac{kT}{q}\right) \times ln(IC_1/IC_2)$$

Where:

T	=	temperature in kelvin
ΔV_{BE}	=	change in diode base-emitter voltage
k	=	Boltzmann's constant
q	=	electron charge
IC_1 and IC_2	=	currents with n:1 ratio

4.2 ΣΔ Analog-to-Digital Converter

A sigma-delta ADC is used to convert ΔV_{BE} to a digital word that corresponds to the transistor temperature. The converter has an adjustable resolution from 9-bits (at 30 ms conversion time) to 12-bits (at 240 ms conversion time). Thus, it allows the user to make trade-offs between resolution and conversion time. Refer to **Section 4.3.4 "Sensor Configuration Register (CONFIG)"** and **Section 4.3.4.7 "ΣΔ ADC Resolution"** for details.

4.3 Registers

The TCN75A has four registers that are user-accessible. These registers are specified as the Ambient Temperature (T_A) register, the Temperature Limit-set (T_{SET}) register, the Temperature Hysteresis (T_{HYST}) register and device Configuration (CONFIG) register.

The Ambient Temperature register is a read-only register and is used to access the ambient temperature data. The data from the ADC is loaded in parallel in the register. The Temperature Limit-set and Temperature Hysteresis registers are read/write registers that provide user-programmable temperature limits. If the ambient temperature drifts beyond the programmed limits, the TCN75A outputs an alert signal using the ALERT pin (refer to **Section 4.3.4.3 "ALERT Output Configuration"**). The device Configuration register provides access for the user to configure the TCN75A's various features. These registers are described in further detail in the following sections.

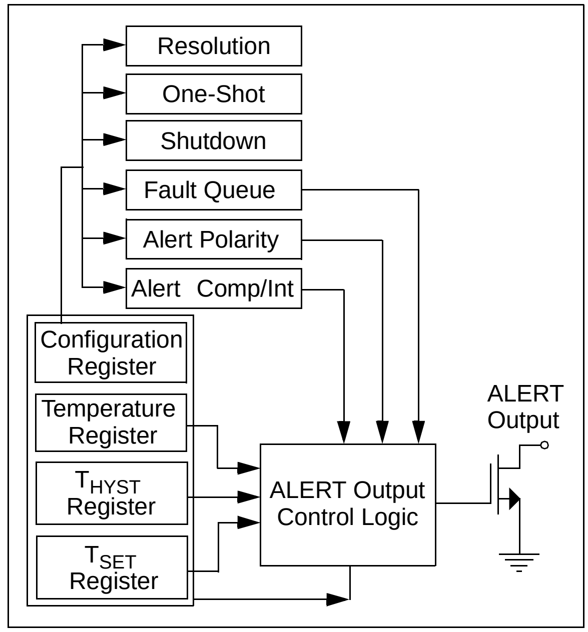


FIGURE 4-2: *Register Block Diagram.*

The registers are accessed by sending register pointers to the TCN75A using the serial interface. This is an 8-bit pointer. However, the two Least Significant bits (LSbs) are used as pointers and all other bits need to be cleared <0>. This device has additional registers that are reserved for test and calibration. If these registers are accessed, the device may not perform according to the specification. The pointer description is shown below.

REGISTER 4-1: REGISTER POINTER

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
0	0	0	0	0	0	P1	P0
bit 7							bit 0

bit 7-3 **Unimplemented:** Read as '0'

bit 2-0 **Pointer bits**

00 = Temperature register
01 = Configuration register
10 = Temperature Hysteresis register
11 = Temperature Limit-set register

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

4.3.1 AMBIENT TEMPERATURE REGISTER (T_A)

The TCN75A has a 16-bit read-only Ambient Temperature register that contains 9-bit to 12-bit temperature data. This data is formatted in two's complement. The bit assignments, as well as the corresponding resolution, is shown in the register assignment below.

The refresh rate of this register depends on the selected ADC resolution. It takes 30 ms (typ.) for 9-bit data and 240 ms (typ.) for 12-bit data. Since this register is double-buffered, the user can read the register while the TCN75A performs analog-to-digital conversion in the background. The decimal code to ambient temperature conversion is shown in Equation 4-2:

EQUATION 4-2:

$$T_A = Code \times 2^{-4}$$

Where:

T_A = Ambient Temperature (°C)

Code = TCN75A output in decimal (Table 4-1)

REGISTER 4-2: AMBIENT TEMPERATURE REGISTER (T_A)

Upper Half:

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
Sign	2^6 °C/bit	2^5 °C/bit	2^4 °C/bit	2^3 °C/bit	2^2 °C/bit	2^1 °C/bit	2^0 °C/bit
bit 15							bit 8

Lower Half:

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
2^{-1} °C/bit	2^{-2} °C/bit	2^{-3} °C/bit	2^{-4} °C/bit	0	0	0	0
bit 7							bit 0

Note: When the 9-bit, 10-bit or 11-bit resolutions are selected, bit 6, bit 7 or bit 8 will remain clear <0>, respectively.

Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

TABLE 4-1: CODE CONVERSION

Resolution	TCN75A Output (Binary)	Hexadecimal	Decimal	T_A (°C)
9-Bit	0111 1101 0uuu uuuu(1)	0FA	250	+125
	0001 1001 0uuu uuuu	032	50	+25
	0000 0000 1uuu uuuu	001	1	+0.5
10-Bit	0111 1101 00uu uuuu	1F4	500	+125
	0001 1001 01uu uuuu	065	101	+25.25
	0000 0000 01uu uuuu	001	1	+0.25
11-Bit	0111 1101 000u uuuu	3E8	1000	+125
	0001 1001 011u uuuu	0CB	203	+25.375
	0000 0000 001u uuuu	001	1	+0.125
12-Bit	0111 1101 0000 uuuu	7D0	2000	+125
	0001 1001 0111 uuuu	197	407	+25.4375
	0000 0000 0001 uuuu	001	1	+0.0625
0°C	0000 0000 0000 uuuu	000	0	0
12-Bit	1111 1111 1111 uuuu(2)	001(3)	-1	-0.0625
	1110 0110 1001 uuuu	197	-407	-25.4375
	1100 1001 0000 uuuu	370	-880	-55

Note 1: 'u' represents unused bits. The TCN75A clears <0> the unused bits.

2: This data is in two's complement format, which indicates ambient temperature below 0°C.

3: Negative temperature magnitude in hexadecimal. This conversion is accomplished by complimenting each binary bit and adding 1.

4.3.2 TEMPERATURE LIMIT-SET REGISTER (T_{SET})

The TCN75A has a 16-bit read/write Temperature Limit-Set register (T_{SET}) which contains a 9-bit data in two's compliment format. This data represents a maximum temperature limit. If the ambient temperature exceeds this specified limit, the TCN75A asserts an alert output. (Refer to **Section 4.3.4.3 "ALERT Output Configuration"**).

This register uses the nine Most Significant bits (MSbs) and all other bits are don't cares.

The power-up default value of the T_{SET} register is 80°C, or `<0 1010 0000>` in binary.

REGISTER 4-3: TEMPERATURE LIMIT-SET REGISTER (T_{SET})

Upper Half							
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
Sign	2^6 °C/bit	2^5 °C/bit	2^4 °C/bit	2^3 °C/bit	2^2 °C/bit	2^1 °C/bit	2^0 °C/bit
bit 15							bit 8

Lower Half							
R/W-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
2^{-1} °C/bit	0	0	0	0	0	0	0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

4.3.3 TEMPERATURE HYSTERESIS REGISTER (T_{HYST})

The TCN75A has a 16-bit read/write Temperature Hysteresis register that contains a 9-bit data in two's compliment format. This register is used to set a hysteresis for the T_{SET} limit. Therefore, the data represents a minimum temperature limit. If the ambient temperature drifts below the specified limit, the TCN75A asserts an alert output (refer to **Section 4.3.4.3 "ALERT Output Configuration"**).

This register uses the nine Most Significant bits (MSbs) and all other bits are don't cares.

The power-up default value of T_{HYST} register is 75°C, or `<0 1001 0110>` in binary.

REGISTER 4-4: TEMPERATURE HYSTERESIS REGISTER (T_{HYST})

Upper Half:

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
Sign	2^6 °C/bit	2^5 °C/bit	2^4 °C/bit	2^3 °C/bit	2^2 °C/bit	2^1 °C/bit	2^0 °C/bit
bit 15							bit 8

Lower Half:

R/W-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
2^{-1} °C/bit	0	0	0	0	0	0	0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
- n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

4.3.4 SENSOR CONFIGURATION REGISTER (CONFIG)

The TCN75A has an 8-bit read/write Configuration register that allows the user to select the different features. These features include shutdown, ALERT output select as comparator or interrupt output, ALERT output polarity, fault queue cycle, temperature measurement resolution and One-shot mode (single conversion while in shutdown). These functions are described in detail in the following sections.

REGISTER 4-5: CONFIGURATION REGISTER (CONFIG)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
One-Shot	Resolution		Fault Queue		ALERT Polarity	COMP/INT	Shut-down
bit 7							bit 0

bit 7 **ONE-SHOT bit**
1 = Enabled
0 = Disabled (Power-up default)

bit 5-6 **ΣΔ ADC RESOLUTION bits**
00 = 9 bit (Power-up default)
01 = 10 bit
10 = 11 bit
11 = 12 bit

bit 3-4 **FAULT QUEUE bits**
00 = 1 (Power-up default)
01 = 2
10 = 4
11 = 6

bit 2 **ALERT POLARITY bit**
1 = Active-high
0 = Active-low (Power-up default)

bit 1 **COMP/INT bit**
1 = Interrupt mode
0 = Comparator mode (Power-up default)

bit 0 **SHUTDOWN bit**
1 = Enable
0 = Disable (Power-up default)

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
- n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

4.3.4.1 Shutdown Mode

The Shutdown mode disables all power-consuming activities (including temperature sampling operations) while leaving the serial interface active. The device consumes 2 µA (max.) in this mode. It remains in this mode until the Configuration register is updated to enable continuous conversion or until power is recycled.

In Shutdown mode, the CONFIG, T_A, T_{SET} and T_{HYST} registers can be read or written to; however, the serial bus activity will increase the shutdown current.

4.3.4.2 One-Shot Mode

The TCN75A can also be used in a One-shot mode that can be selected using bit 7 of the CONFIG register. The One-shot mode performs a single temperature measurement and returns to Shutdown mode. This mode is especially useful for low-power applications where temperature is measured upon command from a controller. For example, a 9-bit T_A in One-shot mode consumes 200 µA (typ.) for 30 ms and 0.1 µA (typ.) during shutdown.

To access this feature, the device needs to initially be in Shutdown mode. This is done by sending a byte to the CONFIG register with bit 0 set <1> and bit 7 cleared <0>. Once the device is in Shutdown mode, the CONFIG register needs to be written to again, with bit 0 and bit 7 set <1>. This begins the single conversion cycle of t_{CONV}, 30ms for 9-bit data. Once the conversion is completed, T_A is updated and bit 7 of CONFIG becomes cleared <0> by the TCN75A.

TABLE 4-6: SHUTDOWN AND ONE-SHOT MODE DESCRIPTION

Operational Mode	One-Shot (Bit 7)	Shutdown (Bit 0)
Continuous Conversion	0	0
Shutdown	0	1
Continuous Conversion (One-shot is ignored)	1	0
One-shot	1	1

Note: The shutdown command <01> needs to be programmed before sending a one-shot command <11>.

4.3.4.3 ALERT Output Configuration

The ALERT output can be configured as either a comparator output or as Interrupt Output mode using bit 1 of CONFIG. The polarity can also be specified as an active-high or active-low using bit 2 of CONFIG. The following sections describe each output mode, while Figure 4-3 gives a graphical description.

4.3.4.4 Comparator Mode

In Comparator mode, the ALERT output is asserted when T_A is greater than T_{SET}. The pin remains active until T_A is lower than T_{HYST}. The Comparator mode is useful for thermostat-type applications, such as turning on a cooling fan or triggering a system shutdown when the temperature exceeds a safe operating range.

In Comparator mode, if the device enters the Shutdown mode with asserted ALERT output, the output remains active during shutdown. The device must be operating in continuous conversion, with T_A below T_{HYST}, for the ALERT output to be deasserted.

4.3.4.5 Interrupt Mode

In Interrupt mode, the ALERT output is asserted when T_A is greater than T_{SET}. However, the output is deasserted when the user performs a read from any register. This mode is designed for interrupt-driven, microcontroller-based systems. The microcontroller receiving the interrupt will have to acknowledge the interrupt by reading any register from the TCN75A. This will clear the interrupt and the ALERT pin will become deasserted. When T_A drifts below T_{HYST}, the TCN75A outputs another interrupt and the controller needs to read a register to deassert the ALERT output. Shutting down the device will also reset, or deassert, the ALERT output.

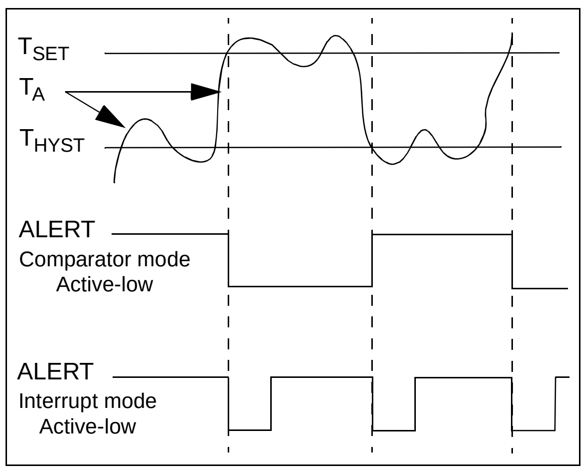


FIGURE 4-3: *Alert Output.*

4.3.4.6 Fault Queue

The fault queue feature can be used as a filter to lessen the probability of spurious activation of the ALERT pin. T_A must remain above T_{SET} for the consecutive number of conversion cycles selected using the Fault Queue bits. Bit 3 and bit 4 of CONFIG can be used to select up to six fault queue cycles. For example, if six fault queues are selected, T_A must be greater than T_{SET} for six consecutive conversions before ALERT is asserted as a comparator or an interrupt output.

This queue setting also applies for T_{HYST}. If six fault queues are selected, T_A must remain below T_{HYST} for six consecutive conversions before ALERT is deasserted (Comparator mode) or before another interrupt is asserted (Interrupt mode).

4.3.4.7 ΣΔ ADC Resolution

The TCN75A provides access to select the ADC resolution from 9-bit to 12-bit using bit 6 and bit 5 of the CONFIG register. The user can gain better insight into the trends and characteristics of the ambient temperature by using a finer resolution. Increasing the resolution also reduces the quantization error. Figure 2-4 shows accuracy versus resolution.

Table 4-1 shows the T_A register conversion time for the corresponding resolution.

TABLE 4-1: RESOLUTION AND CONVERSION TIME

Bits	Resolution °C/bit (typ.)	t_{CONV} (typ.)
9	0.5	30 ms
10	0.25	60 ms
11	0.125	120 ms
12	0.0625	240 ms

4.4 Summary of Power-up Condition

The TCN75A has an internal Power-on Reset (POR) circuit. If the power supply voltage V_{DD} glitches down to the 1.7V (typ.) threshold, the device resets the registers to the power-up default settings.

Table 4-2 shows the power-up default summary.

TABLE 4-2: POWER-UP DEFAULTS

Register	Data (Hex)	Power-up Defaults
T_A	0000	0°C
T_{SET}	A000	80°C
T_{HYST}	9600	75°C
Pointer	00	Temperature register
CONFIG	00	Continuous Conversion Comparator mode Active-low Output Fault Queue 1 9-bit Resolution

At power-up, the TCN75A has an inherent 2 ms (typ.) power-up delay before updating the registers with default values and start a conversion cycle. This delay reduces register corruption due to unsettled power. After power-up, it takes t_{CONV} for the TCN75A to update the T_A register with valid temperature data.

5.0 SERIAL COMMUNICATION

5.1 2-Wire I^{2}C™ Compatible Interface

The TCN75A serial clock input (SCLK) and the bidirectional Serial Data (SDA) line form a 2-wire bidirectional serial port for communication.

The following bus protocol has been defined:

TABLE 5-1: SERIAL BUS CONVENTIONS

5.1.1 DATA TRANSFER

Data transfers are initiated by a START condition, followed by a 7-bit device address and a 1-bit read/write. Acknowledge (ACK) from slave confirms the

5.2 Graphical Representation of the TCN75A Serial Protocols

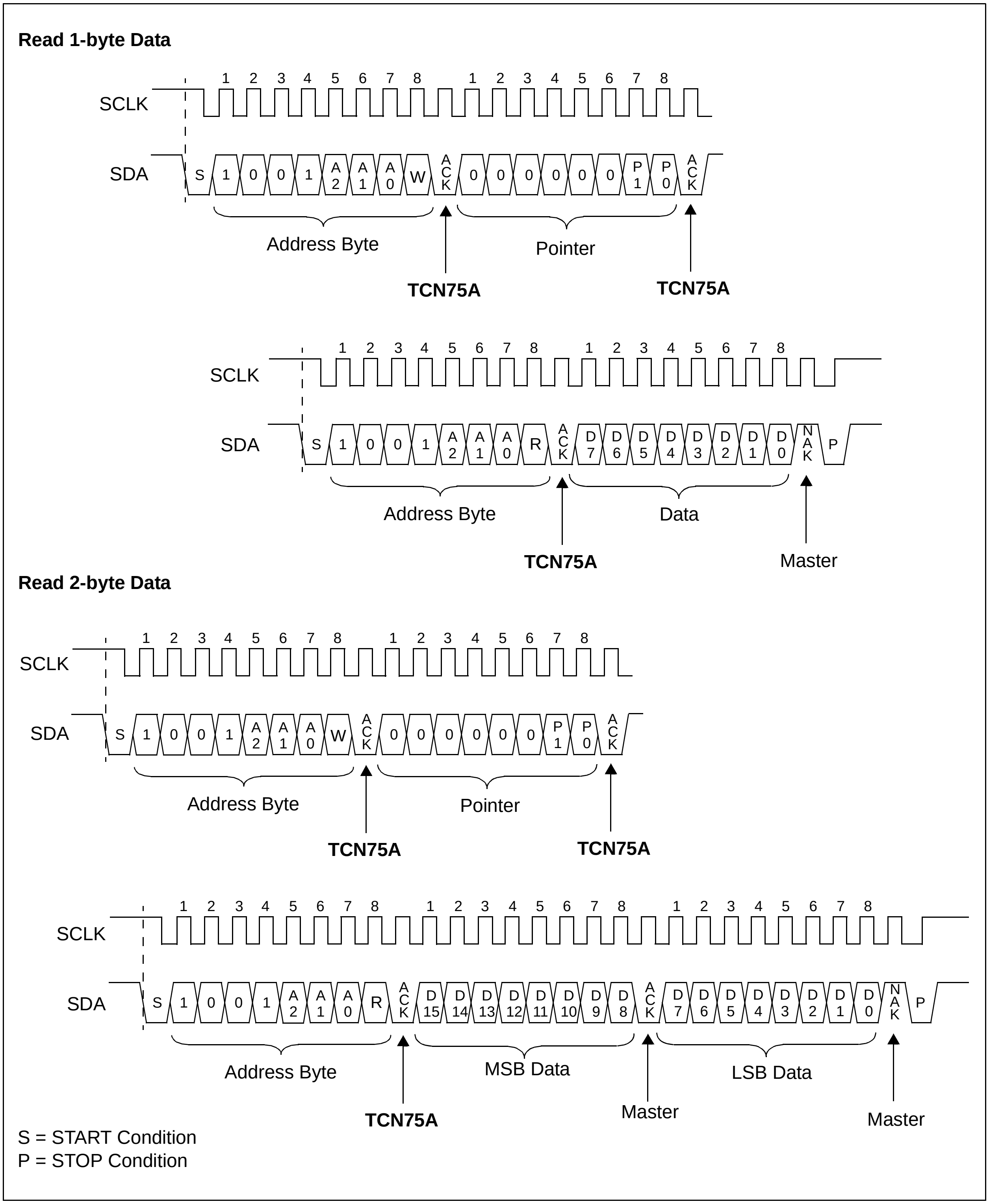


FIGURE 5-2: *Read 1-byte and 2-byte data from a register.*

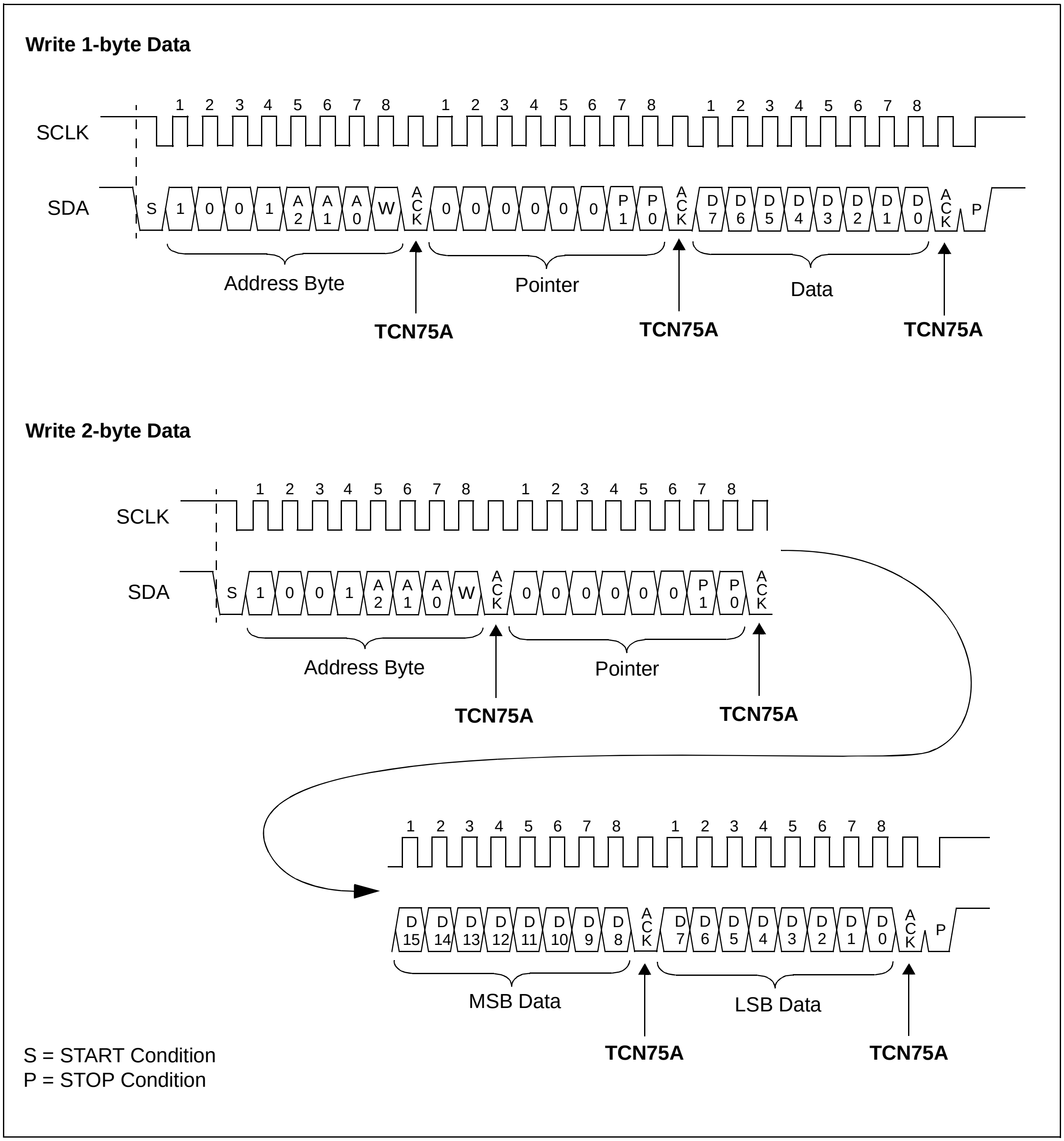


FIGURE 5-3: *Write 1-byte and 2-byte data from a register.*

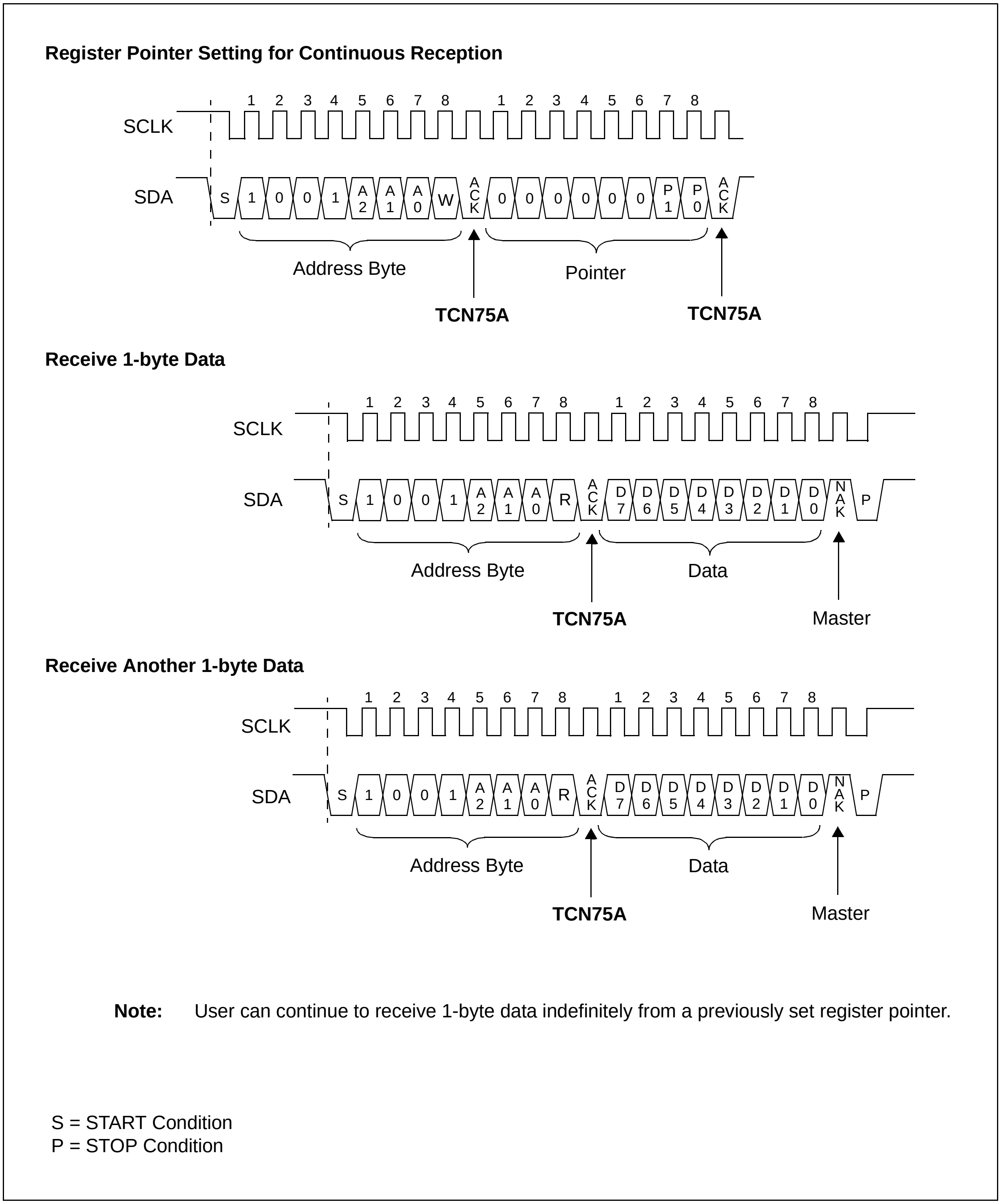
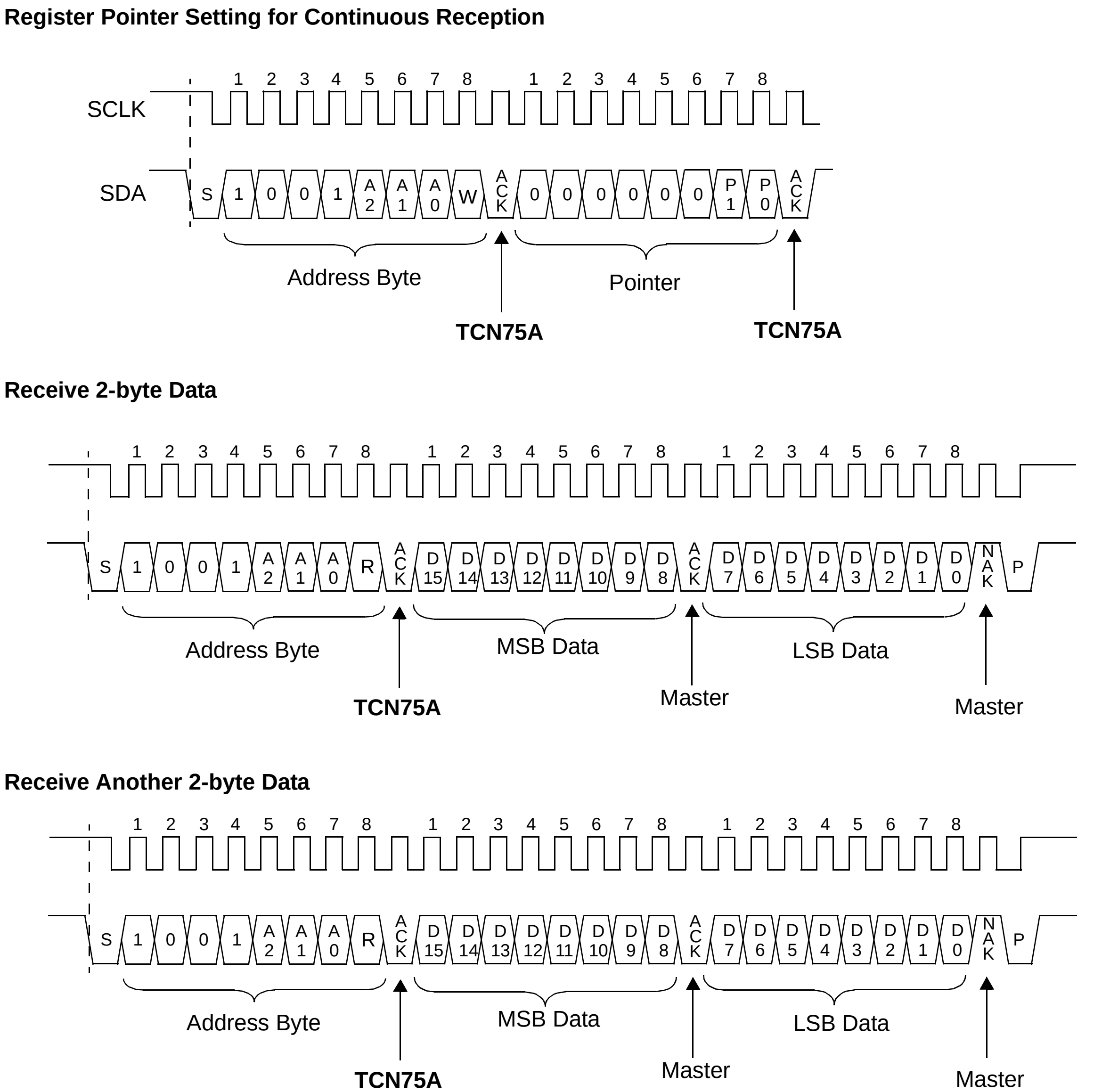


FIGURE 5-4: *Receive 1-byte data from previously set pointer.*



Note: User can continue to receive 2-byte data indefinitely from a previously set register pointer.

S = START Condition
P = STOP Condition

FIGURE 5-5: *Receive 2-byte data from previously set pointer.*

6.0 APPLICATIONS INFORMATION

6.1 Connecting to the Serial Bus

The SDA and SCLK serial interface are open-drain pins that require pull-up resistors. This configuration is shown in Figure 6-1.

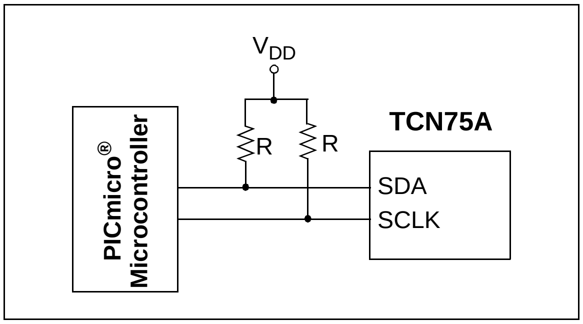


FIGURE 6-1: *Pull-up Resistors On Serial Interface.*

The TCN75A is designed to meet 0.4V (max.) voltage drop at 3 mA of current. This allows the TCN75A to drive lower values of pull-up resistors and higher bus capacitance. In this application, all devices on the bus must meet the same pull-down current requirements.

6.2 Typical Application

Microchip provides several microcontroller product lines with Master Synchronous Serial Port Modules (MSSP) that include the I^2C interface mode. This module implements all master and slave functions and simplifies the firmware development overhead. Figure 6-2 shows a typical application using the PIC16F737 as a master to control other Microchip slave products, such as EEPROM, fan speed controllers and the TCN75A temperature sensor connected to the bus.

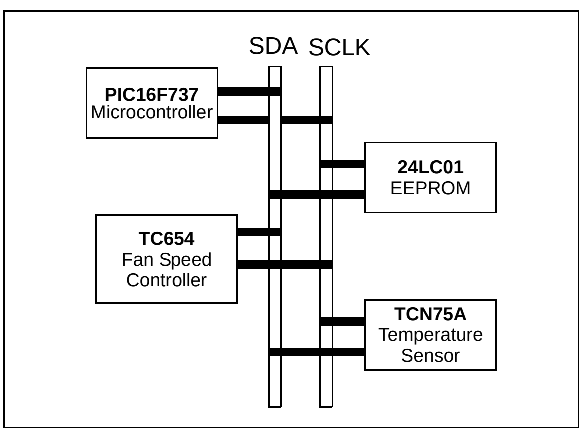


FIGURE 6-2: *Multiple Devices on I^2C™ Bus*

The ALERT output can be wire-ORed with a number of other open-drain devices. In such applications, the output needs to be programmed as an active-low output. Most systems will require pull-up resistors for this configuration.

6.3 Layout Considerations

The TCN75A does not require any additional components besides the master controller in order to measure temperature. However, it is recommended that a decoupling capacitor of 0.1 µF to 1 µF be used between the V_{DD} and GND pins. A high-frequency ceramic capacitor is recommended. It is necessary for the capacitor to be located as close as possible to the power pins in order to provide effective noise protection.

6.4 Thermal Considerations

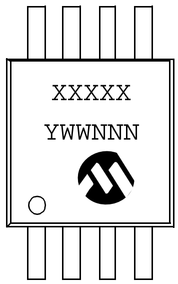
The TCN75A measures temperature by monitoring the voltage of a diode located in the die. A low-impedance thermal path between the die and the Printed Circuit Board (PCB) is provided by the pins. Therefore, the TCN75A effectively monitors the temperature of the PCB. However, the thermal path for the ambient air is not as efficient because the plastic device package functions as a thermal insulator.

A potential for self-heating errors can exist if the TCN75A SDA and SCLK communication lines are heavily loaded with pull-ups. Typically, the self-heating error is negligible because of the relatively small current consumption of the TCN75A. However, in order to maximize the temperature accuracy, the SDA and SCLK pins need to be lightly loaded.

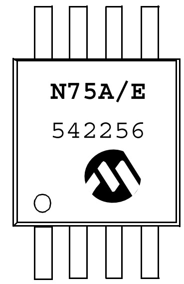
7.0 PACKAGING INFORMATION

7.1 Package Marking Information

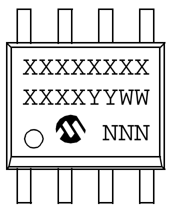
8-Lead MSOP



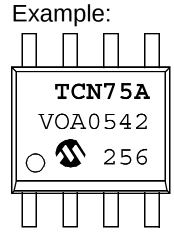
Example:



8-Lead SOIC (150 mil)



Example:

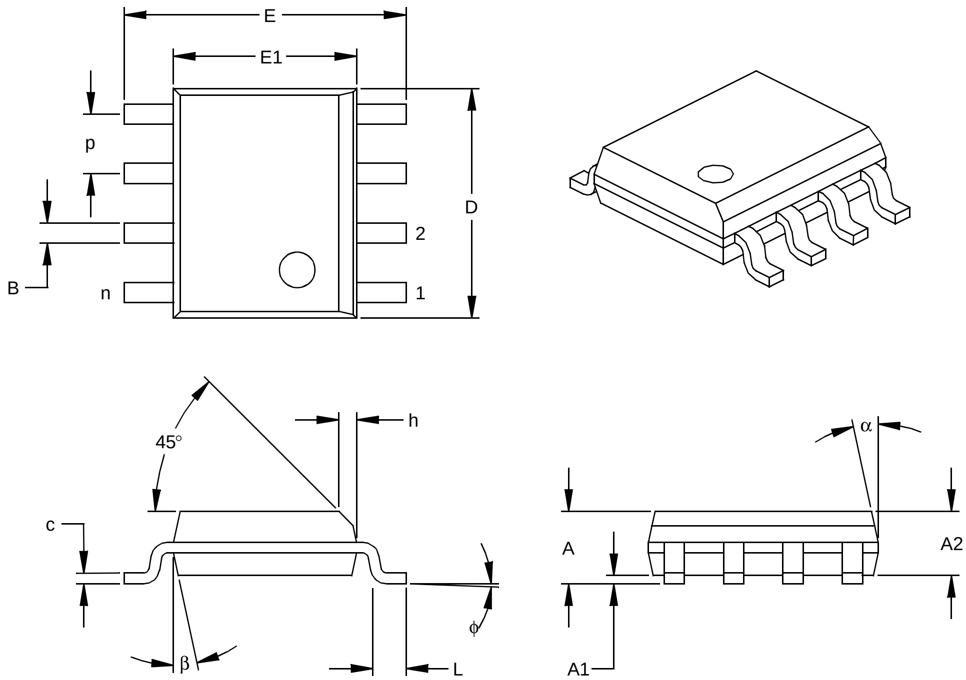


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

8-Lead Plastic Micro Small Outline Package (UA) (MSOP)

8-Lead Plastic Small Outline (OA) – Narrow, 150 mil Body (SOIC)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.050			1.27	
Overall Height	A	.053	.061	.069	1.35	1.55	1.75
Molded Package Thickness	A2	.052	.056	.061	1.32	1.42	1.55
Standoff §	A1	.004	.007	.010	0.10	0.18	0.25
Overall Width	E	.228	.237	.244	5.79	6.02	6.20
Molded Package Width	E1	.146	.154	.157	3.71	3.91	3.99
Overall Length	D	.189	.193	.197	4.80	4.90	5.00
Chamfer Distance	h	.010	.015	.020	0.25	0.38	0.51
Foot Length	L	.019	.025	.030	0.48	0.62	0.76
Foot Angle	φ	0	4	8	0	4	8
Lead Thickness	c	.008	.009	.010	0.20	0.23	0.25
Lead Width	B	.013	.017	.020	0.33	0.42	0.51
Mold Draft Angle Top	α	0	12	15	0	12	15
Mold Draft Angle Bottom	β	0	12	15	0	12	15

* Controlling Parameter
§ Significant Characteristic

Notes:
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.
JEDEC Equivalent: MS-012
Drawing No. C04-057

APPENDIX A: REVISION HISTORY

Revision A (January 2005)

- Original release of this document.

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	X	/XX
Device	Temperature Range	Package

Device:	TCN75A:	Temperature Sensor
Temperature Range:	V =	-40°C to +125°C
Package:	OA =	Plastic SOIC, (150 mil Body), 8-lead
	UA =	Plastic Micro Small Outline (MSOP), 8-lead

Examples:

a) TCN75AVOA 8LD SOIC package.
b) TCN75AVUA 8LD MSOP package.

NOTES:

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

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Tel: 770-640-0034
Fax: 770-640-0307

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Fax: 978-692-3821

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Fax: 630-285-0075

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Fax: 972-818-2924

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Fax: 949-462-9608

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Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

China - Qingdao
Tel: 86-532-502-7355
Fax: 86-532-502-7205

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India - Bangalore
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

Japan - Kanagawa
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

Taiwan - Taipei
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Fax: 886-2-2508-0102

Taiwan - Hsinchu
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France - Massy
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Fax: 44-118-921-5820

10/20/04