Application Note

LM75B and TMP1075 Industry-Standard Devices: Design Guidelines and Spec Comparison

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ABSTRACT

The LM75B and TMP1075 are now industry-standard benchmarks in digital temperature sensors with an I2C® interface. Originating from the LM75, first introduced by National Semiconductor in the 1990s, these devices are now key components of TI's digital temperature sensor portfolio. Their long-lived popularity lies in their flexibility, widespread availability, and cost efficiency.

Before integrating these sensors into your design, it is crucial to understand their nuances and the subtle yet important differences. This is particularly vital in designs requiring compatible pin-to-pin alternate parts. The information in this application note is aimed to help you make informed choices, simplifying the selection process and promoting first-time success in your LM75-based designs.

Including LM75A, TMP75, TMP75-Q1, TMP75B, TMP75B-Q1, TMP75C, TMP75C-Q1, TMP175, TMP175-Q1, TMP275, TMP275-Q1, TMP102, TMP102-Q1, TMP112, TMP112-Q1, TMP110.

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1 Introduction

Texas Instruments provides a range of different digital temperature sensors compatible with two-wire, SMBus, and I2C interfaces. These temperature sensors are included under the TI 75 family of sensors. This application note guides customers in selecting the appropriate sensor within the 75-family series of TI Temperature sensors and helps them optimize newer features offered in devices such as TMP1075, TMP110, and TMP112-Q1.

This document provides simplified comparison tables for customers to consider the main differences when replacing components. These specs were carefully chosen to provide the best side-by-side comparison. This document provides a high overview comparison but does not reveal all specs. Further investigation of the data sheets is necessary before making a switch to one of these devices.

To provide additional clarity in hardware and software variations, this article discusses Linux driver compatibility, conversion time, resolution compatibility, and data encoding compatibility.

2 Devices Covered in Application Note: Package Pinout and Spec Compatibility

Within the LM75/TMP1075 family of temperature sensors there are 14 devices to consider. Figure 2-1 shows the size comparison between the different package options available between the devices.Table 2-1 describes the corresponding package available for the 75-temperature sensors in Figure 2-1.

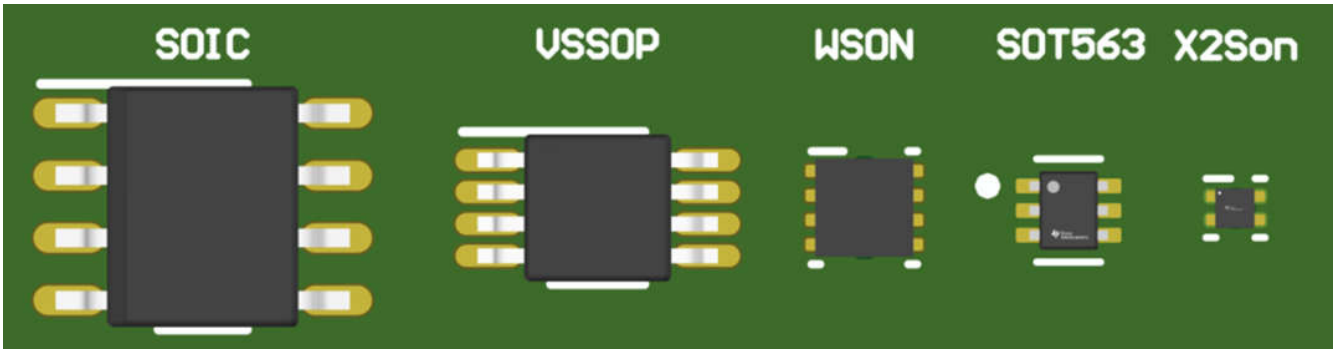

Figure 2-1. Package Size Comparison

Table 2-1. Devices Available in Each Package Type

SOIC	VSSOP	WSON	SOT-563	X2SON
TMP1075, TMP275, TMP175, TMP75, TMP75B, TMP75C, LM75A, LM75B, TMP175-Q1, TMP75-Q1, TMP75B-Q1, TMP75C-Q1	TMP1075, TMP275, TMP175, TMP75, TMP75B, TMP75C, LM75A, LM75B, TMP175-Q1, TMP75-Q1, TMP75B-Q1, TMP75C-Q1	TMP1075	TMP1075N, TMP112, TMP112-Q1	TMP110, TMP112

This section highlights TI's newer temperature sensors along with tables providing information on the hardware requirements to consider when switching to the TMP1075, TMP110, or TMP112-Q1.

2.1 TMP1075: Latest Generation LM75 Sensor in Industry-Standard Packages for Cost-Optimized Designs

The TMP1075 sensor provides the most accurate, lowest-power replacement option when comparing the sensor to older sets of TI LM75/TMP1075-family sensors (Table 2-2). TMP1075 comes in four different package options:

- VSSOP (8)
- SOIC (8)
- WSON (8)
- SOT563 (6)

The majority of 75-family devices are pin-to-pin compatible with VSSOP (8) and SOIC (8).

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2.2 TMP110: LM75-Based Temp Sensor in Small X2SON Package for the Highest Cost-Efficiency

TMP110 sensor provides a considerable cost savings, high accuracy, and low power I2C temperature design (Table 2-2). TMP110 comes in the X2SSON package. TMP110 is not P2P compatible, but dual sourcing is an option for TMP110. For more information about the dual source option, please refer to Section 4 in this document.

2.3 TMP112-Q1: Functional Safety-Capable, LM75-Based Sensor for Automotive Designs

When considering automotive-rated 75-family sensors, TMP112-Q1 is advantageous for two-wire, SMBus, I2C-interface, digital temperature sensor (Table 2-3). This sensor is designed for high accuracy and low power. TMP112-Q1 is not P2P compatible with most of the 75 family, but TMP112-Q1 is an option for saving on power consumption. TMP112-Q1 is only available in the SOT563 package.

Table 2-2. Catalog 75-Family Comparison

Devices[1]	SOIC and VSSOP Compatible	Rating	# of ADDR	FS	UL	NIST	Tmin	Tmax	Vmax	IQ	Accuracy MAX (°C)								
											-55	-40	-20	0	25	50	85	100	125
TMP110	no	Catalog	4				-40°C	125°C	1.14V - 5.5	10µA	---	±1	±1	±1	±1	±1	±1	±1	±1
TMP1075	yes	Catalog	32			✓	-55°C	125°C	1.7V - 5.5V	4µA	±2	±1	±1	±1	±1	±1	±1	±1	±2
TMP1075N	no	Catalog	4			✓	-40°C	125°C	1.62V - 3.6V	10µA	---	±2	±2	±1	±1	±1	±2	±2	±2
TMP112	no	Catalog	4			✓	-40°C	125°C	1.4V - 3.6V	10µA	---	±1	±1	±0.5	±0.5	±0.5	±1	±1	±1
TMP102	no	Catalog	4			✓	-40°C	125°C	1.4V - 3.6V	10µA	---	±3	±2	±2	±2	±2	±2	±3	±3
TMP275	yes	Catalog	8				-40°C	125°C	2.7V - 5.5V	85µA	---	±1	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±1
TMP175	yes	Catalog	27				-40°C	125°C	2.7V - 5.5V	85µA	---	±2	±1.5	±1.5	±1.5	±1.5	±1.5	±2	±2
TMP75	yes	Catalog	8			✓	-40°C	125°C	2.7V - 5.5V	85µA	---	±3	±2	±2	±2	±2	±2	±3	±3
TMP75B	yes	Catalog	8				-55°C	125°C	1.4V - 3.6V	89µA	±3	±3	±2	±2	±2	±2	±2	±3	±3
TMP75C	yes	Catalog	8				-55°C	125°C	1.4V - 3.6V	37µA	±3	±3	±2	±2	±2	±2	±2	±3	±3
LM75A	yes	Catalog	8		✓		-55°C	125°C	2.7V - 5.5V	500µA	±3	±3	±2	±2	±2	±2	±2	±2	±3
LM75B	yes	Catalog	8		✓		-55°C	125°C	3.0V - 5.5V	1000µA	±3	±3	±2	±2	±2	±2	±2	±2	±3

Table 2-3. Automotive 75-Family Comparison

Devices[1]	SOIC and VSSOP Compatible	Rating	# of ADDR	FS	UL	NIST	Tmin	Tmax	Vmax	IQ	Accuracy MAX (°C)							
											-40	-20	0	25	50	85	100	125
TMP112-Q1	no	Automotive	4	✓		✓	-40°C	125°C	1.4V - 3.6V	10µA	±1	±1	±0.5	±0.5	±0.5	±1	±1	±1
TMP275-Q1	yes	Automotive	8				-40°C	125°C	2.7V - 5.5V	85µA	±1.5	±1.5	±0.75	±0.75	±0.75	±0.75	±1.5	±1.5
TMP175-Q1	yes	Automotive	27				-40°C	125°C	2.7V - 5.5V	85µA	±2	±1.5	±1.5	±1.5	±1.5	±1.5	±2	±2
TMP75-Q1	yes	Automotive	8			✓	-40°C	125°C	2.7V - 5.5V	86µA	±3	±2	±2	±2	±2	±2	±3	±3
TMP75B-Q1	yes	Automotive	8	✓			-40°C	125°C	1.4V - 3.6V	89µA	±3	±2	±2	±2	±2	±2	±3	±3
TMP75C-Q1	yes	Automotive	8	✓			-40°C	125°C	1.4V - 3.6V	37µA	±3	±2	±1	±1	±1	±2	±3	±3

(1) Functional safety compliant, UL certified, and NIST traceable.

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3 Software Compatibility

The software specs shown in Table 3-1 were chosen based on the following criteria:

- TMP275, TMP175, and TMP75 have programmable ADCs. Users can choose a 9-bit resolution mode up to a 12-bit resolution mode.
- I2C *Data Hold Times* t(HDDAT) are different between the devices. The t(HDDAT) listed in the table below refers to the minimum spec during *Fast Frequency Mode*.
- All 75 devices have temperature and limit registers in the exact same locations with the same format.
- The main changes in registers are Configuration and ID Registers. The Configuration Register holds either 16 or 8 bits of data. The data stored in the Configuration Register is shown in Table 3-1.

Table 3-1. Software Compatibility Table

Devices \Categories	Resolution	t(HDDAT)-FS Min	ID Register Location	Config Register															
				D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
TMP1075	0.0625°C (12 bits)	0 ns	0 x F	OS	R1	R0	F1	F0	POL	TM	SD	1	1	1	1	1	1	1	1
TMP1075N	0.0625°C (12 bits)	100 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	1	0	X	0	0	0	0	0
TMP112	0.0625°C (12 bits)	100 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	CR1	CR0	AL	EM	0	0	0	0
TMP102	0.0625°C (12 bits)	100 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	CR1	CR0	AL	EM	0	0	0	0
TMP110	0.0625°C (12 bits)	0 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	CR1	CR0	AL	EM	0	0	0	0
LM75A	0.5°C (9 bits)	100 ns	0 x 7	0	0	0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
LM75B	0.5°C (9 bits)	100 ns	n/a	0	0	0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TMP275	Selectable 0.5°C (9 bits) - 0.0625 °C (12 bits)	4 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TMP175	Selectable 0.5°C (9 bits) - 0.0625 °C (12 bits)	4 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TMP75	Selectable 0.5°C (9 bits) - 0.0625 °C (12 bits)	4 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TMP75B	0.0625°C (12 bits)	0 ns	n/a	OS	CR	CR	FQ	FQ	POL	TM	SD	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)
TMP75C	0.0625°C (12 bits)	0 ns	n/a	*(1)	*(1)	OS	FQ	FQ	POL	TM	SD	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)
TMP112-Q1	0.0625°C (12 bits)	100 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	CR1	CR0	AL	EM	0	0	0	0
TMP75-Q1	0.0625°C (12 bits)	4 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TMP75B-Q1	0.0625°C (12 bits)	0 ns	n/a	OS	CR	CR	FQ	FQ	POL	TM	SD	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)
TMP75C-Q1	0.0625°C (12 bits)	0 ns	n/a	*(1)	*(1)	OS	FQ	FQ	POL	TM	SD	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)	*(1)
TMP175-Q1	0.0625°C (12 bits)	4 ns	n/a	OS	R1	R0	F1	F0	POL	TM	SD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

(1) The * symbol denotes a reserved configured register.

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4 TMP1075 Cost-Optimized Dual-Source Layout Using TMP110

The TMP110 is a very accurate, cost-effective, and low-power I2C temperature sensor. The dual sourcing feature offers a low-cost advantage, boosts supply chain flexibility, and minimizes risk by allowing more devices in a given circuit design. Dual sourcing incorporates the footprint of two distinct devices within one footprint.

TMP110 is a 5 pin X2Son package, which is a smaller design than the common 8 pin VSSOP and SOIC package typical of the 75 devices. This means that the TMP110 fits within the common 8 pin package. The TMP110 comes in 5 different orderables (Table 4-1). The orderables offer the choice between an alert pin and an address pin. Within the address pin orderables, users can choose between different addresses on the I2C bus. The different orderables are listed in the Table 4-1. The TMP110 has a minimum via drill diameter of 4 mils and a minimum via diameter of 13.78 mils. There are multiple dual source options depending on the number of layers within your PCB.

Table 4-1. Different Orderables in the TMP110

GPN	Function	OPN	Device Target Address
TMP110	Alert	TMP110D0IDPWR	1001000
		TMP110D1IDPWR	1001001
		TMP110D2IDPWR	1001010
		TMP110D3IDPWR	1001011
	Address	TMP110DIDPWR	1000000 (GND), 1000001 (VDD), 1000010 (SDA), 1000011 (SCL)

Table 4-2 demonstrates a dual source footprint option between the TMP1075 VSSOP package and the TMP110 which contains an alert pin orderable. Table 4-2 shows the footprint connections between the TMP1075 and the TMP110. The pinouts between the devices are also displayed for reference.

Table 4-2. Dual Source Footprint Connections

LM/TMPx75 VSSOP	TMP110
Pin 1 – SDA	Pin 4 – SDA
Pin 2 – SCL	Pin 2 – SCL
Pin 3 – Alert	Pin 3 – Alert
Pin 4 – GND	Pin 1 – GND
Pin (5-7) – A0, A1, A2	Pin 1 – GND
Pin 8 – VDD	Pin 5 -VDD

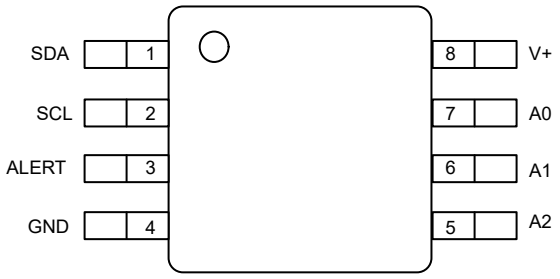

Figure 4-1. 8-Pin VSSOP Top View

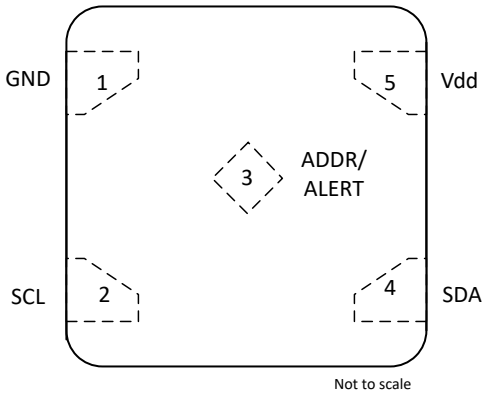

Figure 4-2. 5-Pin X2Son Top View

Figure 4-3 and Figure 4-4 show a 3D and a 2D layout trace of the top overview of a 4-layer dual source solution. For simplicity, the displayed boards follow a common four-layer board configuration containing the following layers: Signal, VDD, GND, and Signal. The alert pin on the TMP110 is traced on the bottom layer of the PCB.

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The vias shown in the 3D and 2D views have a diameter of 16 mil and a hole size of 8 mil. A two layer option is achievable with the aid of the layout trace depicted.

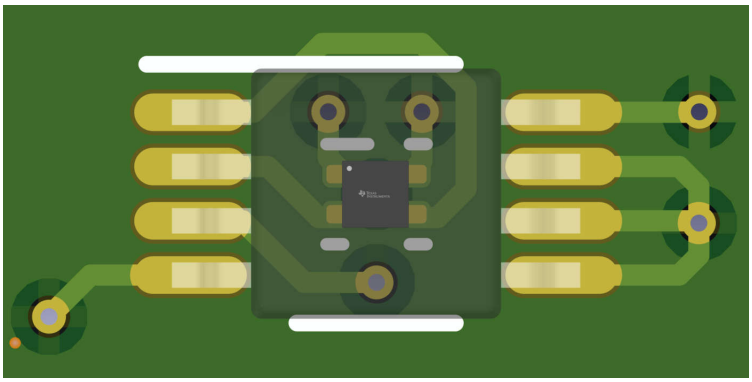

Figure 4-3. 3D Board Image

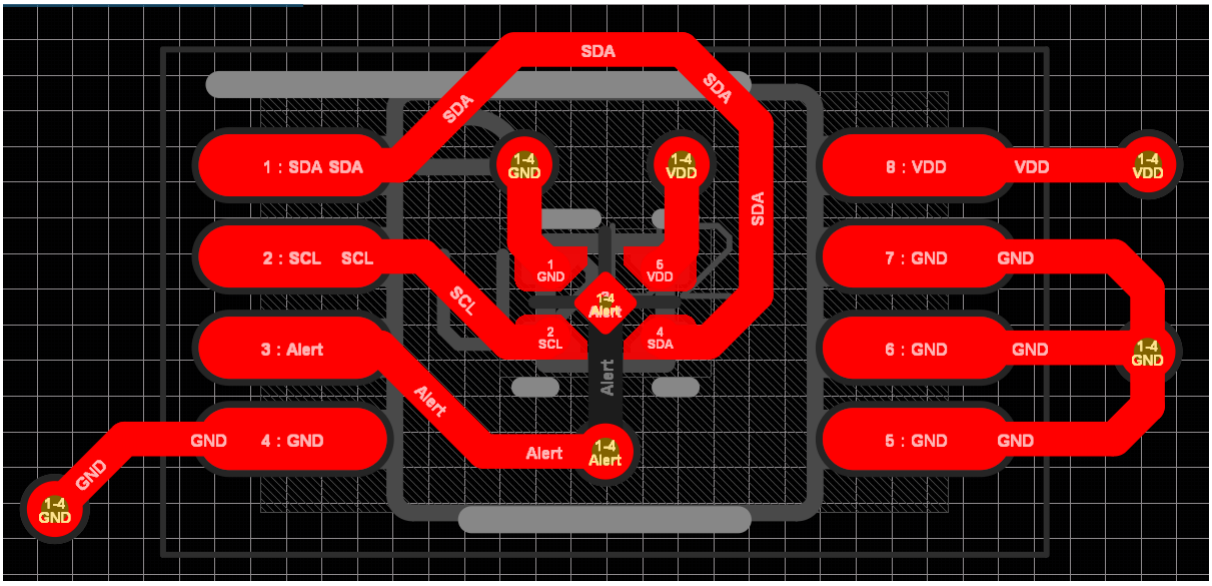

Figure 4-4. Top Layer Layout

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5 Linux Driver

The common Linux driver provides one source of compatibility between the 75 family of devices (Table 5-1). The Linux driver is not created by TI, but by the general public. The Linux Driver provides the software the MCU needs to communicate with the sensors over I2C, along with the ability to read and write registers. The Linux Driver GitHub is found here.

Table 5-1. Devices Supported by the Linux Driver lm75.c

Devices(1)								
adt75	at30ts74	ds1775	ds75	ds7505	g751	lm75	lm75a	lm75b
max6625	max6626	max31725	mcp980x	pct2075	stds75	stlm75	tcn75	tcn75
tmp100	tmp101	tmp105	tmp112	tmp175	tmp275	tmp75b	tmp75c	tmp1075

(1) Devices supported at the time of this writing.

Software compatibility is not an issue when utilizing the Linux driver because all these devices are supported directly by the same driver. Q variants are software compatible with their corresponding commercial variants. Currently, TI's new device TMP110 is not listed in the public source code. As shown in Section 3, TMP112 is software compatible with TMP110. All 75-Family device communication is regulated by the Linux driver.

6 Conversion Time and Resolution Setting Highlights

Texas Instruments is making new technology that improves conversion outcomes. *Conversion time* describes the time it takes to make a new temperature measurement. The device resolution and conversion time are inversely related. In general, the higher the resolution, the more time required for the device to output a new temperature measurement. This relationship is described with TMP275, TMP175, and TMP75 in Table 6-1. TMP275, TMP175, and TMP75 have programmable ADCs, where users can choose from a 9-bit resolution mode to a 12-bit resolution mode. The resolution selection is made by modifying R0 and R1 in the configuration register. TI's older LM75 devices use technology that requires more time to convert data for 9-bit resolution. TMP1075 has a 12-bit resolution where the user selects a different conversion time by changing the R0 and R1 bits in the configuration register. TMP1075 sleeps between measurements to save power. TMP1075 provides the best conversion time results when comparing the devices. Figure 6-1 shows a diagram detailing the wait time before a new temperature occurs.

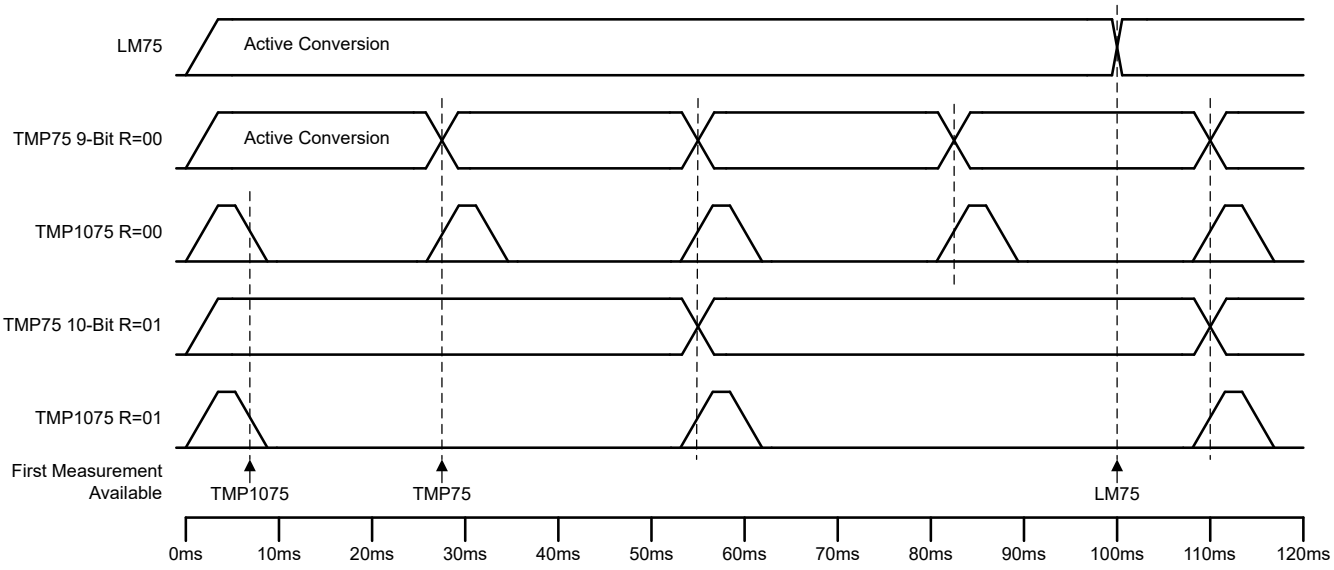

Figure 6-1. Conversion Time

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Table 6-1. TMP275, TMP175, and TMP75 Conversion Time

Bit Selection	Resolution	Conversion Time
R0 = 0, R1 = 0	9 bits	27.5 ms
R0 = 0, R1 = 1	10 bits	55 ms
R0 = 1, R1 =0	11 bits	110 ms
R0 = 1, R1 = 1	12 bits	220 ms

7 Interpreting Digital Temperature Output: Data Encoding Compatibility

As shown in Figure 6-1, the 14 devices have different resolution values; however, the temperature output remains compatible. Resolution defines the available bit-depth when reading the temperature value. Figure 7-1 demonstrates calculating the temperature value from the I2C data at 12-bit resolution and at 9-bit resolution. I2C gives you a 2-byte value but only the first 12 bits will be used to translate the data. The compatibility takes place in the bit weight distribution. Each bit is assigned a fractional value and then added together to form the temperature result. The first byte portrays the sign and the integer value. All TI temperature sensors stated in this document with a resolution greater than 8 bits have a compatible first byte. The difference in resolution takes place in the second byte. The second byte portrays the limited precision of the device. As shown in Figure 7-1, a 12-bit resolution displays more data accuracy than a 9-bit resolution but still remains compatible.

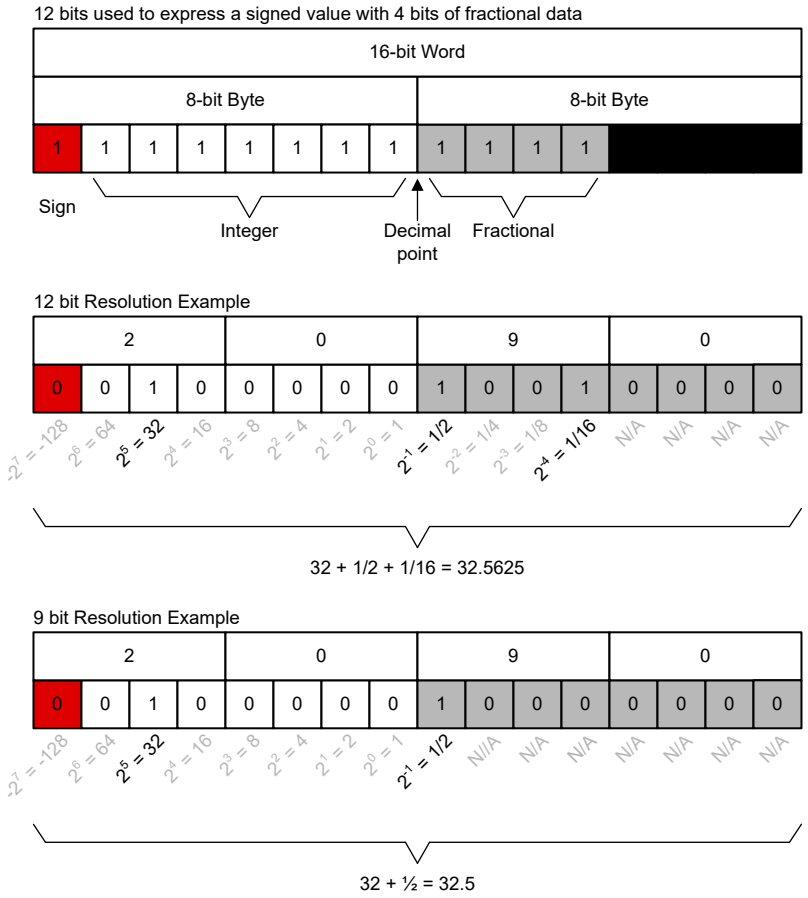

Figure 7-1. Temperature Conversion Calculations

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8 Summary

Texas Instruments provides a range of different digital temperature sensors compatible with two-wire, SMBus, and I2C interfaces known as the 75-family devices. Thanks to the guidance in this application note, readers now have a general understanding of the hardware and software changes across the 75-family devices. Readers can use this application note to evaluate the benefits of the TMP1075, TMP110, and TMP112-Q1 devices. In addition, readers are now aware of the available Linux driver, the advantages of conversion times, and the data encoding capabilities. Overall, the content in this application note guides customers in selecting the appropriate sensor within the 75-family series of TI temperature sensors for their applications.

9 References

For more information on the devices referenced in this application note, see also:

- Texas Instruments, *I2C-Designer*, designer tool.
- *Linux Driver GitHub*.
- Texas Instruments, *SMBus Made Simple*, application note.
- Texas Instruments, *TMP1075 Temperature Sensor With I2C and SMBus Interface in Industry Standard LM75 Form Factor and Pinout*, data sheet.
- Texas Instruments, *TMP112-Q1 Automotive Grade High-Accuracy, Low-Power, Digital Temperature Sensor in SOT563*, data sheet.
- Texas Instruments, *TMP275 ±0.5°C Temperature Sensor With I 2C and SMBus Interface in Industry Standard LM75 Form Factor and Pinout*, data sheet.
- Texas Instruments, *TMPx75 Temperature Sensor With I2C and SMBus Interface in Industry Standard LM75 Form Factor and Pinout*, data sheet.
- Texas Instruments, *TMPx75 Temperature Sensor With I2C and SMBus Interface in Industry Standard LM75 Form Factor and Pinout*, data sheet.
- Texas Instruments, *TMP75B 1.8-V Digital Temperature Sensor With Two-Wire Interface and Alert*, data sheet.
- Texas Instruments, *TMP75C 1.8-V Digital Temperature Sensor With Two-Wire Interface and Alert*, data sheet.
- Texas Instruments, *LM75A Digital Temperature Sensor and Thermal Watchdog With Two-Wire Interface*, data sheet.
- Texas Instruments, *LM75x Digital Temperature Sensor and Thermal Watchdog With Two-Wire Interface*, data sheet.
- Texas Instruments, *TMPx75-Q1 Automotive Grade Temperature Sensor With I 2C and SMBus Interface in Industry-Standard LM75 Form Factor and Pinout*, data sheet.
- Texas Instruments, *TMP75B-Q1 1.8-V Digital Temperature Sensor With Two-Wire Interface and Alert*, data sheet.
- Texas Instruments, *TMP75C-Q1 1.8-V Digital Temperature Sensor With Two-Wire Interface and Alert*, data sheet.

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10 Revision History

Changes from Revision * (November 2023) to Revision A (March 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Updated document title from *TMP LM 75 Comparison Common FAQs* to *LM75B and TMP1075 Industry-Standard Devices: Design Guidelines and Spec Comparison*	1
• Added additional Abstract text	1
• Updated title from *Hardware Compatibility* to *Devices Covered in Application Note: Package Pinout and Spec Compatibility*	2
• Changed title from *TMP1075* to *TMP1075: Latest Generation LM75 Sensor in Industry-Standard Packages for Cost-Optimized Designs*	2
• Changed title from *TMP110* to *TMP110: LM75 Influenced Sensor in Small X2SON Package for the Highest Cost-Efficiency*	3
• Updated title from *TMP112-Q1* to *TMP112-Q1: Functional Safety-Capable, LM75 Influenced Sensor for Automotive Designs*	3
• Updated title from *Data Encoding Compatibility* to *Interpreting Digital Temperature Output: Data Encoding Compatibility*	8

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