









TMP126-Q1 SNIS227C – MAY 2021 – REVISED JUNE 2022

TMP126-Q1 Low-Power, 0.25°C SPI Temperature Sensor With 175°C Operation, CRC and Slew Rate Alert

## 1 Features

- AEC-Q100 qualified for automotive applications
  - Device temperature grade-0: -55°C to 175°C ambient operating temperature
  - Device HBM classification level 2
  - Device CDM classification level C2b
- Function Safety Capable
  - Documentation available to aid functional safety system design
- High accuracy
  - ±0.25°C (maximum) from 20°C to 30°C
  - ±0.3°C (maximum) from –20°C to 85°C
  - ±0.4°C (maximum) from –40°C to 125°C
  - ±0.5°C (maximum) from –55°C to 150°C
  - ±0.75°C (maximum) from 150°C to 175°C
- Fast measurement intervals with no self-heating concerns
- Supply range: 1.62 V to 5.5 V
- Factory-calibrated
  - NIST traceability
- Low power consumption
- · Programmable temperature alert limits
- Temperature slew rate warning
- Optional Cyclic Redundancy Check (CRC)
- 3-wire SPI interface

## 2 Applications

- Transmission Control Units
- On-board Chargers (OBC)
- Brake Systems
- Traction Inverters
- Vehicle Control Units (VCU)
- DC/DC Converters
- Power Distribution Units (PDU)
- Powertrain Exhaust Sensors



## **3 Description**

The TMP126-Q1 is a  $0.25^{\circ}$ C accuracy digital temperature that supports an ambient temperature range of  $-55^{\circ}$ C to  $175^{\circ}$ C. The TMP126-Q1 features a 14-bit signed temperature resolution ( $0.03125^{\circ}$ C per LSB) while operating over a supply range of 1.62 V to 5.5 V. With a fast conversion rate, low supply current, and a simple 3-wire SPI compatible interface, the TMP126-Q1 is designed for a wide range of applications.

The TMP126-Q1 includes additional advanced features for increased reliability in harsh environments such as optional CRC checksum for data integrity, programmable alert limits, a temperature slew rate warning, and an enhanced operational temperature range. The device utilizes a NIST traceable factory calibration for guaranteed accuracy and comes in a small SOT package for close placement to heat sources along with fast response times.

#### **Device Information**

PART NUMBER	PACKAGE <sup>(1)</sup>	BODY SIZE (NOM)		
TMP126-Q1	SOT-SC70 (6)	2.00 mm × 1.25 mm		
	SOT-23 (6)	2.90 mm × 1.60 mm		

(1) For all available packages, see the orderable addendum at the end of the data sheet.





# **Table of Contents**

1 Features	1
2 Applications	1
3 Description	1
4 Revision History	2
5 Device Comparison	3
6 Pin Configuration and Functions	3
7 Specifications	4
7.1 Absolute Maximum Ratings	4
7.2 ESD Ratings	4
7.3 Recommended Operating Conditions	4
7.4 Thermal Information	4
7.5 Electrical Characteristics	5
7.6 SPI Interface Timing	7
7.7 Typical Characteristics	7
8 Detailed Description	10
8.1 Overview	10
8.2 Functional Block Diagram	10
8.3 Feature Descriptions	11
8.4 Device Functional Modes	14

8.5 Programming	. 18
8.6 Register Map	.25
9 Application and Implementation	. 36
9.1 Application Information	. 36
9.2 Typical Application	. 36
10 Power Supply Recommendations	.37
11 Layout	.37
11.1 Layout Guidelines	. 37
11.2 Layout Example	. 37
12 Device and Documentation Support	39
12.1 Documentation Support	. 39
12.2 Receiving Notification of Documentation Updates.	.39
12.3 Support Resources	. 39
12.4 Trademarks	.39
12.5 Electrostatic Discharge Caution	.39
12.6 Glossary	.39
13 Mechanical, Packaging, and Orderable	
Information	. 39

## **4 Revision History**

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

С	hanges from Revision B (March 2022) to Revision C (June 2022)	Page
•	Changed the resistance between the VDD and ALERT pins in the Simplified Application key graphic on	the
	first page from: 5 k $\Omega$ to: 10 k $\Omega$	1
•	Added the Average Temperature Accuracy (DBV) key graphic to the first page	1
•	Changed Device Comparison table.	3
•	Added Response Time specification to the <i>Electrical Characteristics</i> table	5
•	Added new graphs to the Typical Characteristics section	7
•	Added note to the Slew Rate Warning section	12
•	Added the response time (stirred liquid) parameter for the DBV package to the Electrical Characteristics	s table
		23
•	Corrected bit range for the Reserved section of configuration register	25
c	hanges from Povision A (March 2022) to Povision B (March 2022)	Dogo

Changes from Revision A (March 2022) to Revision B (March 2022)	Page
Changed data sheet status from: Advanced Information to: Production Data	1
Changes from Revision * (May 2021) to Revision A (March 2022)	Page
Changed the Layout Example	



## **5 Device Comparison**

Feature	TMP126	TMP126N	TMP126-Q1	TMP127-Q1
Best accuracy (maximum)	0.25 °C	0.8 °C	0.25 °C	0.8 °C
Packages	DCK	DCK	DBV, DCK	DBV
Continuous and shutdown mode	•	•	•	•
175°C operation	•		•	•
Automotive Grade-0			•	•
NIST Traceable	•	•	•	
Alert pin functionality	•	•	•	
Slew rate warning	•	•	•	
CRC option	•	•	•	

## Table 5-1. Device Comparison

# **6** Pin Configuration and Functions





Figure 6-2. DCK 6-pin SC70 Top View

Figure 6-1. DBV 6-pin SOT-23 Top View

### Table 6-1. Pin Functions

PIN		1/0	DESCRIPTION	
NAME	NO.		DESCRIPTION	
CS	1	I	Chip select signal to activate SPI interface	
GND	2	-	Ground	
SIO	3	I/O	System input/output	
SCLK	4	I	System clock input	
ALERT	5	0	Alert open-drain output. Can be left floating or grounded when not used.	
VDD	6	-	Supply voltage	



## 7 Specifications

## 7.1 Absolute Maximum Ratings

Over free-air temperature range unless otherwise noted<sup>(1)</sup>

		MIN	MAX	UNIT
Supply voltage	VDD	-0.3	6	V
I/O voltage	SIO	-0.3	V <sub>DD</sub> + 0.2 V	V
I/O voltage	CS,ALERT, SCLK	-0.3	6	V
Operating junction temperature, T <sub>J</sub>		-65	180	°C
Storage temperature, T <sub>stg</sub>		-65	180	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## 7.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup> HBM classification level 2	±2000	V
		Charged-device model (CDM), per AEC Q100-011 CDM classification level C2b	±750	V

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

## 7.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V <sub>DD</sub>	Supply voltage	1.62	3.3	5.5	V
V <sub>I/O</sub>	SIO	0		$V_{DD}$	V
V <sub>I/O</sub>	CS,ALERT, SCLK	0		5.5	V
T <sub>A</sub>	Operating ambient temperature <sup>(1)</sup>	-55		175	°C

(1) HTOL was performed at 175 °C for 1410 hours

## 7.4 Thermal Information

		TMP1		
	THERMAL METRIC <sup>(1)</sup>	DBV	DCK	UNIT
		6-pins	6-pins	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	168.2	183.4	°C/W
R <sub>0JC(top)</sub>	Junction-to-case (top) thermal resistance	85.5	136.4	°C/W
R <sub>0JC(bot)</sub>	Junction-to-case (bottom) thermal resistance	-	-	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	48.1	74.2	°C/W
Ψ <sub>JT</sub>	Junction-to-top characterization parameter	27.5	57.9	°C/W
Ψ <sub>JB</sub>	Junction-to-board characterization parameter	47.9	74.0	°C/W

(1) For more information about traditional and new thermal metrics, see the IC Package Thermal Metrics application report, SPRA953.



#### 7.5 Electrical Characteristics

Over free-air temperature range and  $V_{DD}$  = 1.62 V to 5.5 V (unless otherwise noted); Typical specifications are at T<sub>A</sub> = 25 °C and  $V_{DD}$  = 3.3 V (unless otherwise noted)

PARAMETER		TEST CO	NDITIONS	MIN	TYP	MAX	UNIT
TEMPERA	TURE SENSOR						
		20 °C to 30 °C		-0.25		0.25	°C
		-20 °C to 85 °C		-0.3		0.3	°C
T <sub>ERR</sub> <sup>(1)</sup>	Temperature accuracy	-40 °C to 125 °C		-0.4		0.4	°C
		-55 °C to 150 °C		-0.5		0.5	°C
		-55 °C to 175 °C		-0.75		0.75	°C
PSR	DC power supply rejection	One-shot mode			12.7		m°C/V
-		Including sign bit			14		Bits
RES		LSB			31.25		m°C
T <sub>REPEAT</sub>	Repeatability <sup>(2)</sup>	V <sub>DD</sub> = 3.3 V 1-Hz conversion cycle			±1		LSB
T <sub>LTD</sub>	Long-term stability and drift <sup>(3)</sup>	1000 hours at 175 °C			0.07		°C
t <sub>LIQUID</sub>	Response time (Stirred Liquid)	Single layer Flex PCB 0.2032 mm thickness	т = 63 % 25 °С to 75 °С		0.8		s
	DBV Package	2-layer FR4 PCB 1.5748 mm thickness			1.8		s
	Response time (Stirred Liquid) DCK Package	Single layer Flex PCB 0.2032 mm thickness	τ = 63 % 25 °C to 75 °C		0.6		s
		2-layer FR4 PCB 1.5748 mm thickness			1.3		s
	Temperature cycling and hysteresis <sup>(4)</sup>				±0.5		LSB
t <sub>CONV</sub>	Active conversion time			4.5	6	7.5	ms
t <sub>VAR</sub>	Timing variation	Conversion Period Slew Rate Result Slew Rate Limit		-15		15	%
DIGITAL I	NPUT/OUTPUT						
C <sub>IN</sub>	Input capacitance	f = 1 MHz				20	pF
V <sub>IH</sub>	Input logic high level	SCLK, SIO, $\overline{CS}$		0.7 * V <sub>DD</sub>		$V_{DD}$	V
VIL	Input logic low level	SCLK, SIO, CS		0		0.3 * V <sub>DD</sub>	V
I <sub>IN</sub>	Input leakage current	SCLK, SIO, CS		-0.5		0.5	μΑ
V <sub>OH</sub>	SIO output high level	I <sub>OH</sub> = 3 mA		V <sub>DD</sub> - 0.4		$V_{DD}$	V
V <sub>OL</sub>	SIO output low level	I <sub>OL</sub> = -3 mA		0		0.4	V
V <sub>OL</sub>	ALERT output logic low level	I <sub>OL</sub> = -3 mA		0		0.4	V



Over free-air temperature range and  $V_{DD}$  = 1.62 V to 5.5 V (unless otherwise noted); Typical specifications are at T<sub>A</sub> = 25 °C and  $V_{DD}$  = 3.3 V (unless otherwise noted)

	PARAMETER	TEST CC	MIN	ТҮР	MAX	UNIT		
POWER SUF	PPLY	1				1		
			T <sub>A</sub> = 25 °C		77	87	μA	
I <sub>DD_ACTIVE</sub>	Supply current during active conversion	$\overline{CS} = V_{DD}$	$T_A = -55 \text{ °C to } 150 \text{ °C}$			135		
			T <sub>A</sub> = 175 °C			160		
I <sub>DD</sub>			T <sub>A</sub> = 25 °C Conversion cycle time: 1 Hz		1	1.2		
	Average current consumption	<del>CS</del> = V <sub>DD</sub>	$T_A$ = -55 °C to 150 °C Conversion cycle time: 1 Hz			16	μA	
			T <sub>A</sub> = 175 °C Conversion cycle time: 1 Hz			35		
		$\overline{CS} = V_{DD}$	T <sub>A</sub> = 25 °C		0.5	0.75	μΑ	
I <sub>SB</sub>	Standby current <sup>(5)</sup>		$T_A$ = -55 °C to 150 °C			15		
			$T_A = -55 \text{ °C to } 175 \text{ °C}$			34		
			T <sub>A</sub> = 25 °C		0.35	0.5		
I <sub>SD</sub>	Shutdown current	$\overline{\text{CS}} = \text{V}_{\text{DD}}$	$T_A = -55 \ ^\circ C$ to 150 $^\circ C$			15	μA	
			$T_A = -55 \ ^\circ C$ to 175 $^\circ C$			34		
V <sub>POR</sub>	Power-on reset threshold voltage	Supply rising			1.3		V	
	Brownout detect	Supply falling			1.1		V	
t <sub>RESET</sub>	Reset Time	Time required by devi		0.5		ms		

(1) Temperature Accuracy (averaging on or averaging off) guaranteed in both continuous conversion mode and one-shot mode with a conversion period greater than or equal to 31.25 ms.

(2) Repeatability is the ability to reproduce a reading when the measured temperature is applied consecutively, under the same conditions.

(3) Long term stability is determined using accelerated operational life testing at a junction temperature of 150 °C.

(4) Hysteresis is defined as the ability to reproduce a temperature reading as the temperature varies from room → hot →room→cold→room. The temperatures used for this test are -40 °C, 25 °C, and 150 °C.

(5) Quiescent current between conversions



## 7.6 SPI Interface Timing

Over free-air temperature range and  $V_{DD}$  = 1.62 V to 5.5 V (unless otherwise noted)

		SPI BUS	
		MIN MAX	
f <sub>CLK</sub>	SCLK frequency	10	MHz
t <sub>CLK</sub>	SCLK Period	100	ns
t <sub>LEAD</sub>	Falling edge of $\overline{CS}$ to rising edge of SCLK setup time	100	ns
t <sub>LAG</sub>	Rising edge of SCLK to rising edge of $\overline{\text{CS}}$ setup time	20	ns
t <sub>su</sub>	SIO to SCLK rising edge setup time	10	ns
t <sub>HOLD</sub>	SIO hold time after rising edge of SCLK	20	ns
t <sub>VALID</sub>	Time from falling edge of SLCK to valid SIO data	35	ns
t <sub>SIO(DIS)</sub>	Time from rising edge of $\overline{\text{CS}}$ to SIO high-impedance	200	ns
t <sub>RISE</sub>	SIO, SCLK, CS rise time	100	ns
t <sub>FALL</sub>	SIO, SCLK, CS fall time	100	ns
t <sub>INTERFRAME</sub>	Delay between two SPI communication sequences (CS high)	100	ns
<b>t</b> INITIATION	Delay between valid $V_{DD}$ voltage and initial SPI communication	0.5	ms

## 7.7 Typical Characteristics













## 8 Detailed Description

## 8.1 Overview

The TMP126-Q1 is a factory calibrated digital output temperature sensor designed for thermal management and thermal protection applications. The device has a 3-wire SPI compatible interface with multiple operating modes including continuous, one-shot, and shutdown mode. The TMP126-Q1 features an ALERT output with temperature threshold settings for autonomous monitoring and system alerts. In addition the TMP126-Q1 also includes a temperature slew rate warning feature that alerts the system to temperature spikes, allowing for corrective action before reaching thermal limits.

For data integrity an optional Cyclic Redundancy Check (CRC) is available that will validate communication with the device.

## 8.2 Functional Block Diagram





#### 8.3 Feature Descriptions

#### 8.3.1 Temperature Limits

The TMP126-Q1 includes a temperature limit warning that can be enabled or disabled in the configuration register. If enabled, at the end of every completed conversion the TMP126-Q1 will compare the result against the limits stored in the low limit register and the high limit register. When exceeding these limits the ALERT pin will be set. The ALERT pin behavior will change depending on which mode the device is configured to as described in the *Interrupt and Comparator Mode* section.

The Alert functionality can allow the system to set the desired operating thermal limits of the system with the TMP126-Q1 and allow autonomous monitoring of temperature without the need for the system to read the temperature. When a thermal limit is exceeded the system will receive a warning through the ALERT pin and can react accordingly to adjust the operating temperature back to within normal system operation.



Figure 8-1. Temperature Limit Alert



#### 8.3.2 Slew Rate Warning

The slew rate warning is an adjustable alert option that can be adjusted with the Slew\_Limit register.

The slew rate warning will notify the system of temperature spikes as they occur, allowing the system to react and correct for the increase in temperature before reaching thermal operating limits. Compared to throttling a system after crossing a thermal limit, the slew rate warning will allow a more safe system operation and greater reliability by not exceeding specified system operating conditions.



Figure 8-2. Slew Rate Warning

The Slew\_Limit register is used to set the unsigned limit. The TMP126-Q1 will monitor the temperature slew rate and compare the positive change of temperature from the current conversion to the previous against the Slew\_Limit. If the slew rate exceeds the Slew\_Limit, the respective bits in the Alert\_Status register will be set to indicate the warning. Figure 8-3 depicts the timing of the Slew Rate Warning relative to the temperature conversions. The slew rate check is always applied to the current temperature conversion and the previous temperature conversion.

Note the following considerations when using the Slew Rate Warning feature:

- Calculating the slew rate requires a fixed time period and is only available in continuous mode.
- Similar to other timing parameters of the device, consider that the slew rate calculation interval is impacted by the timing variation (t<sub>VAR</sub>) of the device.
- Slew rate calculation is supported for positive temperature changes (temperature increase) only.
- Take the sensor response time into account when using the Slew Rate Warning feature as the response time impacts how quickly the sensor responses to temperature changes.





Figure 8-3. Slew Rate Warning Timing Diagram

## 8.3.3 Cyclic Redundancy Check (CRC)

The TMP126-Q1 has integrated optional CRC that can be used to determine the integrity of the SPI communication to the TMP126-Q1. The CRC is enabled by setting the CRC\_Enable bit in the command word to 1 with an appropriate data block length. During a read, the TMP126-Q1 will append a 16 bit CRC checksum to the data block for the host to compare with its own checksum. In this manner the host can validate the data sent by TMP126-Q1 and read from the device again if necessary. During write operations, the host will send the CRC word that the TMP126-Q1 will compare against its own checksum. If the TMP126-Q1 determines that the data sent during the write transaction was corrupted, the TMP126-Q1 will discard the write and set the CRC\_Flag in the Alert\_Status register to alert the host that the register settings must be sent again.

This allows the system to ensure the data integrity of the SPI communication in both write and read operations.

Writing to the configuration register with a CRC enabled transaction is currently not supported.

### 8.3.4 NIST Traceability

The accuracy of temperature testing is verified with equipment that is calibrated by an accredited lab that complies with ISO/IEC 17025 policies and procedures. Each device is tested and trimmed to conform to its respective data sheet specification limits.

### 8.3.5 Fast Measurement Intervals With No Self-Heating Concerns

The TMP126-Q1 is optimized to minimize the effects of self-heating and maintain the temperature accuracy if the conversion period is greater than 31.25 ms in continuous conversion or one-shot mode. This eliminates measurement waiting time normally needed for self-heating avoidance.



#### 8.4 Device Functional Modes

The TMP126-Q1 can be configured to operate in various conversion modes by using the Mode bit in the configuration register. These modes provide flexibility to operate the device in the most power efficient way necessary for the intended application.

#### 8.4.1 Continuous Conversion Mode

When the Mode bit is set to 0 in the Configuration register, the device operates in continuous conversion mode. Figure 8-4 shows that the device continuously performs temperature conversions in this mode. The TMP126-Q1 does not wait until the end of the conversion period to update the temperature, instead the temperature result register is updated at the end of the temperature conversion. After a completed active conversion, the Data\_Ready flag bit is set to 1. The user can read the interrupt/status register or the temperature result register to clear the Data\_Ready flag. Therefore, the Data\_Ready\_Flag can be used to determine when the conversion completes so that an external controller can synchronize reading the result register with conversion result updates. The user can set the Data\_Ready\_Flag\_En bit in the configuration register to monitor the state of the Data\_Ready\_Flag on the ALERT pin.

Every conversion period consists of an active temperature conversion followed by a standby period. During standby the TMP126-Q1 will de-activate all measurement circuitry to conserve power but will remain available for any SPI communication. The device typically consumes 75  $\mu$ A during the temperature conversion and only 1  $\mu$ A during the low-power standby period. The duration of the temperature conversion will remain fixed, but the conversion period can be configured using the Conv\_Period[2:0] bit field in the Configuration register, allowing the average current consumption of the device to be optimized based on the application requirements. Changing the conversion period also affects the temperature result update rate due to the temperature result register being updated at the end of every temperature conversion.

Use Equation 1 to calculate the average current consumption of the device in continuous conversion mode.



Figure 8-4. Conversion Period Timing Diagram

### 8.4.2 Shutdown Mode

When the Mode bit is set to 1 in the Configuration register, the device immediately enters the low-power shutdown mode. If the TMP126-Q1 is making a temperature conversion, the device will stop the conversion and discard the partial result. In this mode, the device powers down all active circuitry and can be used in conjunction with the One\_Shot bit to perform temperature conversions. Engineers can use the TMP126-Q1 for battery-operated systems and other low-power consumption applications because the device typically only consumes 350 nA in Shutdown Mode.

Changing between continuous and shutdown will not clear any active alerts in the Alert\_Status register and the ALERT pin will continue to be asserted until cleared by the host. The slew rate alert will not be triggered again in shutdown mode but will not clear until read if it is already set.



#### 8.4.3 One-Shot Mode

When One\_Shot bit is set to 1 in the Configuration register the TMP126-Q1 will immediately start a new temperature conversion, referred to as a one-shot conversion, and discard any partial conversion results. After the device completes a one-shot conversion, the device will enter the low power shutdown mode. The Mode bit will be set to 1 and the One\_Shot bit will be set to 0 automatically. Figure 8-5 shows a current consumption timing diagram for this mode. At the end of a one-shot conversion, the Data\_Ready\_Flag in the Alert\_Status register is set and can be used to determine when the conversion completes.



Figure 8-5. One-Shot Timing Diagram

If the One\_Shot bit is continuously written to faster than the active conversion time of the TMP126, the device will continue to restart the temperature conversion with each new write. It is recommended to avoid this behavior as the temperature result does not update until a conversion finishes. If continuous one-shots are being triggered by the system Figure 8-6 depicts how the device would continually partially finish new conversions and not update the Temp\_Result register.



Figure 8-6. One-Shot Continuous Trigger Timing Diagram

#### 8.4.4 Interrupt and Comparator Mode

The ALERT pin of the TMP126-Q1 can be programmed to operate in two different modes. In the interrupt mode the TMP126-Q1 will assert the ALERT pin if the temperature exceeds the limits set by temperature limit registers and the flags are enabled. After the Alert\_Status is read and the interrupt bits cleared, the ALERT pin will be de-asserted. In the Comparator mode, the ALERT pin will assert if any enabled status bits of the Alert\_Status are set. Changes to the Alert\_Enable register will be reflected on the ALERT pin after the completed conversion or device read.



#### 8.4.4.1 Interrupt Mode

When the INT\_COMP bit in the Configuration register is set to 0, the device is in interrupt mode. Changing the device to Interrupt mode from Comparator mode will immediately clear the Alert\_Status register and reset the ALERT pin. The TMP126-Q1 will then behave as described in this section at the next temperature conversion. In this mode, the device compares the temperature result at the end of every conversion with the values in the TLow\_Limit register and THigh\_Limit register. If the temperature result is higher the value in the THigh\_Limit register, the THigh\_Status and THigh\_Flag bits in the Alert\_Status register will be set and the ALERT pin will assert. After a read of the Alert\_Status register the flag bit will clear and the ALERT pin will de-assert. Subsequent temperature results above the hysteresis value (THigh\_Limit - THigh\_Hysteresis), where THigh\_Hysteresis is the Most Significant Byte (MSB) in the Hysteresis register, will not set the THigh\_Flag bit. The status bit will not clear until a temperature result is below (THigh Limit - THigh Hysteresis).

After a temperature result below (THigh\_Limit - THigh\_Hysteresis), the THigh\_Status bit will clear, the THigh\_Flag bit will be set, and the ALERT pin will be asserted to indicate the change.

If the THigh\_Flag bit is not enabled in the Alert\_Enable register, the flag bit will be set when the measured temperature crosses the THigh\_Limit or hysteresis but the ALERT pin will not assert. The behavior for the TLow\_Limit and Slew rate will be the same as the previously described high limit. Figure 8-7 shows a diagram depicting the behavior.







#### 8.4.4.2 Comparator Mode

When the INT\_COMP bit in the Configuration register is set to 0, the device is in comparator mode. Changing the device to Comparator mode from Interrupt mode will immediately clear the Alert\_Status register and reset the ALERT pin. The TMP126-Q1 will then behave as described in this section at the next temperature conversion. In this mode, the device compares the temperature result at the end of every conversion with the limit registers. If the flag is enabled to assert the ALERT, the ALERT will reflect the status bit of the limits. For example, if the THigh\_Flag alert is enabled and the THigh\_Limit is exceeded, the ALERT will assert while the THigh\_Status bit is 1. If the THigh\_Flag alert is not enabled in the Alert\_Enable register, the ALERT will not assert when THigh\_Status bit is 1.

After a conversion below the Hysteresis the Status bit will be set to '0' and the ALERT will de-assert. Unlike the interrupt mode, the ALERT behavior is not affected when reading the Alert\_Status register. If the Alert flag is disabled in the Alert\_Enable register, the ALERT pin will de-assert immediately if the respective bit is causing an alert. If there are two statuses that are affecting the ALERT such as a THigh\_Limit and Slew\_Rate\_Limit and one of the alerts is disabled, the ALERT will remain asserted until the other limit is not exceeded. For example, if the ALERT has asserted due to a high slew rate and a high temperature and the slew rate alert is then disabled, the ALERT will only de-assert when the temperature drops below the hysteresis value. If both alerts were disabled the ALERT would then de-assert.

Thus, this mode effectively makes the device behave like a high-limit threshold detector. This mode can be used in applications where detecting if the temperature has exceeded a desired threshold is necessary. Figure 8-8 shows a timing diagram of this mode.







## 8.5 Programming

## 8.5.1 Temperature Data Format

Temperature data is represented by a 14-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.03125 °C. The last two bits of the register are always 00.

Tomporatura	Digital Output					
Temperature	Binary	Hex				
175°C	0101 0111 1000 0000	5780				
150°C	0100 1011 0000 0000	4B00				
125°C	0011 1110 1000 0000	3E80				
25°C	0000 1100 1000 0000	0C80				
0.03125°C	0000 0000 0000 0100	0004				
0°C	0000 0000 0000 0000	0000				
-0.03125°C	1111 1111 1110	FFFC				
-25°C	1111 0011 1000 0000	F380				
-40°C	1110 1100 0000 0000	EC00				
-55°C	1110 0100 1000 0000	E480				

## Table 8-1. 14-Bit Temperature Data Format

The first data byte is the most significant byte with most significant bit first, permitting only as much data as necessary to be read to determine temperature condition. For example, if the first four bits of the temperature data indicate an over temperature condition, the host controller could immediately abort communication and take action to remedy the excessive temperature condition.

#### 8.5.2 Serial Bus Interface

Figure 8-9 shows an overview of the TMP126-Q1 protocol. The  $\overline{CS}$  pin must be taken low between communication transactions. Data is clocked out on the falling edge of the serial clock (SCLK), while data is clocked in on the rising edge of SCLK. The 16-bit write words are latched to the respective registers after the 16th rising clock edge including during burst write mode. If a software reset is enabled, the device will immediately reset after the 16th rising clock edge and will not respond to SPI communication until a new falling edge of the  $\overline{CS}$  is observed. If a software reset is triggered during burst write, any data after the configuration register write will be ignored. The SIO buffer is high impedance during reset.

Each transaction with the TMP126-Q1 will consist of a command word, followed by the data block, and the optional CRC that is enabled in the command word.





#### 8.5.2.1 Command Word Structure

Figure 8-10 shows that the command word can be divided into 6 discrete sections detailed below.



Figure 8-10. TMP126 Command Word

#### 8.5.2.1.1 Don't Care

Bit 15 of the command word is a don't care and the TMP126-Q1 will ignore this bit.

#### 8.5.2.1.2 CRC Enable

Bit 14 of the command word is the CRC enable bit. Setting this bit to 1 will enable the CRC checksum at the end of the communication as described in the CRC section.

#### 8.5.2.1.3 CRC Data Block Length

Bits [13:10] of the command word is the CRC data block length. These bits are used to indicate how long the transaction will be when the CRC checksum is used. If these bits are all set to 0 or the combination of the bits set to 1 exceeds 1010 (i. e. 1011, 1100, 1101, 1110 or 1111), the CRC enable will be ignored.

#### 8.5.2.1.4 Auto Increment

Bit 9 of the command word is the auto-increment bit.

Setting this bit to 1 will cause the address pointer of the TMP126-Q1 to increment by after every word of data on a read or write transaction. If the bit is set to 0, the address pointer is not incremented and reads/writes will continue to only apply the Sub-Address specified in the command word.

#### 8.5.2.1.5 Read/Write

Bit 8 of the command word is the read/write bit.

Setting this bit to 1 will issue a read command. During a read command the TMP126-Q1 will control the SIO pin after the command word. Setting this bit to 0 will issue a write command. During a write command the controller will control the SIO pin and the TMP126-Q1 will internally set the SIO pin to high impedance.

#### 8.5.2.1.6 Sub-Address

Bits [7:0] of the command word make up the register Sub-Address.

This is the register map address that will be used for reading or writing data depending on the read/write bit. Writes to Sub-Addresses outside the register map will be ignored. Reads from Sub-Addresses outside the register map will return all '0's.

#### Copyright © 2022 Texas Instruments Incorporated



#### 8.5.2.2 Communication

Communication is initiated by taking the  $\overline{CS}$  pin low and clocking the SCLK pin. The first 16 bits of the communication are the command word for the TMP126-Q1. The following data will depend on the command byte. If a write command is issued, the TMP126-Q1 will store the data input during the next 16 bits into the appropriate Sub-Address set in the command byte. If the auto-increment bit is set to 1, the address pointer is incremented after every 16-bit word. This allows the system to program all the registers of the TMP126-Q1 in a single burst write command. If the auto-increment is set to 1 for a read command, after each 16-bit word the address pointer is incremented and the next word of data will be from the next Sub-Address.

The following sections denote example write and read operations with the TMP126-Q1.

#### 8.5.2.3 Write Operations

Data is transmitted to the TMP126-Q1 by setting the R/W bit of the command word to 0. Data can be continuously written to a single register by setting the auto-increment bit to 0 in the command register. Figure 8-11 shows an example of a repeated data write to a single register.



Figure 8-11. Repeated Data Write to a Single Register

Figure 8-12 shows how setting the auto increment to logic 1 to can enable a write from multiple registers in a single transaction.





Figure 8-12. Burst Data Write to Multiple Registers

### 8.5.2.4 Read Operations

Data is read from the TMP126-Q1 by setting the R/W bit of the command word to 1. Data can be continuously read from a single register by setting the auto-increment bit to 0 in the command register. Figure 8-13 shows an example of a repeated data read from a single register. Repeated temperature reads are not supported.



## Figure 8-13. Repeated Data Read from a Single Register

Figure 8-14 shows how setting the auto increment to 1 to can enable a read from multiple registers in a single transaction.



Figure 8-14. Burst Data Read from Multiple Registers

## 8.5.2.5 Cyclic Redundancy Check (CRC)

The TMP126-Q1 has an optional CRC feature to determine the integrity of the data that has been transmitted across the SPI communication interface. The CRC for the TMP126-Q1 is enabled by setting the CRC bit in the command word to 1. When enabled, the TMP126-Q1 will append a 16-bit CRC checksum to the end the data block for read transactions. The controller can then compare this checksum to their own calculation and determine if the transaction was valid. During a write transaction, the host will append the 16-bit CRC checksum. The TMP126-Q1 will compare this to its own checksum. If there is a mismatch, the TMP126 will discard the write transaction and set a CRC fault ALERT to indicate to the host that the transaction failed. The host will need to send the register settings again to correctly program the TMP126-Q1. Reading the Alert\_Status register will clear the CRC\_Fault bit and de-assert the ALERT pin.

An overview of a CRC enabled write transaction is shown below with a data block length of 2.



An overview of a CRC enabled read transaction is shown below with a data block length of 2.





### Figure 8-16. CRC Enabled Read

#### 8.5.2.5.1 Cyclic Redundancy Check Implementation

Table 8-2 defines the CRC calculation rule.

#### Table 8-2. CRC Rule Table

Temperature	Digital Output
CRC Width	16 bits
Polynomial	X <sup>16</sup> + X <sup>12</sup> + X <sup>5</sup> + 1 (1021h)
Initial seed value	FFFFh
Input data reflected	No
Result data reflected	No
XOR value	0000h
Example	CRC of 0xABCD = 0xD46A

Figure 8-17 shows the CRC Module block diagram. The CRC calculation is done on the command word and the data block. The module consists of a 16-bit shift register and 3 exclusive-OR gates. The register starts with the seed value FFFFh and the module performs an XOR function and shifts its content until the last bit of the register string is used. The final value of the shift register checksum is output onto the SIO line by the TMP126-Q1 at the end of the data block for the host to validate the transaction.



Figure 8-17. CRC Module



The following is an example of C code programming example to calculative the communication CRC:

# #include <stdio.h>

```
void main(int argc, char *argv[]){
 unsigned short crc = 0xFFFF;
 unsigned int msg[20];
 int msglen = (argc > 1) ? (argc - 1) : 1;
msg[0] = 0x0CE8;
 for (int i = 1; i < \arg c; i++){
  sscanf(argv[i], "%X", &msg[i-1]);
 }
 for (int byte = 0; byte < msglen; byte++){</pre>
  crc ^= msg[byte];
  printf("msgbyte: 0x%X\n", msg[byte]);
  for (int bit = 0; bit < 16; bit++){
// printf("crc: 0x%X byte: %d bit: %d\n", crc, byte, bit);
   if (crc & 0x8000)
    crc = (crc << 1) ^ 0x1021;
   else
    crc = (crc << 1);</pre>
  }
 printf("crc: 0x%X\n",crc);
}
```

Figure 8-18. CRC Calculation C Code Example



## 8.6 Register Map

ADDRESS	TYPE	RESET	ACRONYM	REGISTER NAME	SECTION
00h	R	0000h	Temp_Result	Temperature result register	Go
01h	R	0000h	Slew_Result	Slew rate result register	Go
02h	R/RC	0000h	Alert_Status	Alert status register	Go
03h	R/W	0006h	Configuration	Configuration register	Go
04h	R/W	0016h	Alert_Enable	Alert enable register	Go
05h	R/W	F380h	TLow_Limit	Temperature low limit register	Go
06h	R/W	2A80h	THigh_Limit	Temperature high limit register	Go
07h	R/W	0A0Ah	Hysteresis	Hysteresis register	Go
08h	R/W	0500h	Slew_Limit	Temperature slew rate limit register	Go
09h	R	xxxxh	Unique_ID1	Unique ID1 register	Go
0Ah	R	xxxxh	Unique_ID2	Unique ID2 register	Go
0Bh	R	xxxxh	Unique_ID3	Unique ID3 register	Go
0Ch	R	2126h	Device_ID	Device ID register	Go
10h-2Ah	R	xxxxh	Reserved	Reserved	

## Table 8-3. TMP126-Q1 Registers

## Table 8-4. TMP126-Q1 Access Type Codes

Access Type	Code	Description						
Read Type	Read Type							
R	R	Read						
RC	R C	Read to Clear						
R-0	R -0	Read Returns 0s						
Write Type		-						
W	W	Write						
Reset or Default Value								
-n		Value after reset or the default value						

#### 8.6.1 Temp\_Result Register (Address = 00h) [reset = 0000h]

This register stores the latest temperature conversion result in a 14-bit two's complement format with a LSB (Least Significant Bit) equal to 0.03125°C.

#### Return to Register Map.

Figure 8-19. Temp_Result Register							
15	14	13	12	11	10	9	8
Temp_Result[13:6]							
R-00h							
7	6	5	4	3	2	1	0
Temp_Result[5:0] Reserved							erved
R-00h						R-0	)0b

#### Table 8-5. Temp\_Result Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:2	Temp_Result[13:0]	R	0000h	14-bit temperature conversion result. Temperature data is represented by a 14-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.03125°C.
1:0	Reserved	R	00b	These two bits will always read 00b

#### 8.6.2 Slew\_Result Register (Address = 01h) [reset = 0000h]

This register shows the latest slew rate calculation. Two consecutive measurements in continuous conversion mode are required before a result is shown. When not in continuous conversion mode the register will return to the default value.

The slew rate result is depicted in 14-bit twos-complement format with the LSB equal to 0.03125°C/s. The TMP126 does not accurately report negative slew rate values and bit 13 of the output result can be used to indicate a negative slew rate but the output value cannot be guaranteed.

#### Return to Register Map.

Figure 8-20. Slew_Result Register							
15	14	13	12	11	10	9	8
Slew_Rate_Result[13:6]							
R-00h							
7	6	5	4	3	2	1	0
Slew_Rate_Result[5:0] Reserved							rved
R-00h						R-0	)0b

#### Table 8-6. Slew\_Result Register Field Descriptions

Bit	Field	Туре	Reset	Description		
15:2	Slew_Rate_Result[13:0]	R	0000h	Temperature slew rate result.		
				Temperature slew rate is represented by a 14-bit, twos-		
				complement word with an LSB (Least Significant Bit) equal to		
				0.03125°C/s. Format is°C/s.		
1:0	Reserved	R	00b	Reserved		



## 8.6.3 Alert\_Status Register(Address = 02h) [reset = 0000h]

This register show the current alert status of the TMP126-Q1. This register will currently only clear with a single register read without auto increment.

#### Return to Register Map.

#### Figure 8-21. Alert\_Status Register

15	14	13	12	12 11		9	8		
	Reserved								
R-00h									
7	6	5	4	3	2	1	0		
CRC_Flag	Slew_Status	Slew_Flag	THigh_Status	TLow_Status	THigh_Flag	TLow_Flag	Data_Ready_Fl ag		
RC-0b	R-0b	RC-0b	R-0b	R-0b	RC-0b	RC-0b	RC-0b		

### Table 8-7. Alert\_Status Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:8	Reserved	R	00h	Reserved
7	CRC_Flag	RC	Ob	CRC checksum error flag indicator. This indicates that the write transaction CRC checksum failed and the register settings were discarded. 0b = The most recent CRC enabled write transaction was successful. 1b = The most recent CRC enabled write transaction failed.
6	Slew_Pos_Status	R	0b	Positive slew rate status indicator. This bit is set if there is a positive slew rate exceeding the Slew_Rate_Limit. 0b: The most recent temperature conversion result is below the Slew_Rate_Limit. 1b: The most recent temperature conversion result is above the Slew_Rate_Limit.
5	Slew_Flag	RC	Ob	Slew rate flag indicator. This indicates that the current there was a temperature slew rate beyond the slew rate limit threshold. Reading Alert_Status register will clear this bit. 0b = The most recent temperature conversion has not crossed the Slew_Rate_Limit threshold. 1b = A temperature conversion has crossed the Slew_Rate_Limit threshold.
4	THigh_Status	R	Ob	High temperature status indicator. 0b: The most recent temperature conversion result is below the Thigh_Limit 1b: The most recent temperature conversion is above the THigh_Limit. Once set, this bit will not clear until a temperature conversion is below THigh_Limit - THigh_Hyst
3	TLow_Status	R	Ob	Low temperature status indicator. 0b: The most recent temperature conversion result is above the TLow_Limit 1b: The most recent temperature conversion is below the THigh_Limit. Once set, this bit will not clear until a temperature conversion is above TLow_Limit + TLow_Hyst

TMP126-Q1 SNIS227C – MAY 2021 – REVISED JUNE 2022



Table 8-7. Alert_Status Register Field Descriptions (continued)							
Bit	Field	Туре	Reset	Description			
2	THigh_Flag	RC	0Ь	High temperature flag indicator. This indicates that the latest temperature conversion has cross above the THigh_Limit register threshold or crossed below the THigh_Limit - THigh_Hyst threshold. Reading Alert_Status register will clear this bit.         0b = The most recent temperature conversion has not crossed the THigh_Limit or the hysteresis threshold.         1b: A temperature conversion crossed the THigh_Limit or crossed below the THigh_Limit or the THigh_Limit - THigh_Hyst threshold. Once the THigh_Flag is set, THigh_Flag will not be set again until a temperature conversion is below THigh_Limit - THigh_Hyst			
1	TLow_Flag	RC	Ob	Low temperature flag indicator. This indicates that the latest temperature conversion has cross below the TLow_Limit register threshold or crossed above the Tlow_Limit + TLow_Hyst threshold. Reading Alert_Status register will clear this bit. 0b = The most recent temperature conversion has not crossed the TLow_Limit or the hysteresis threshold. 1b: A temperature conversion crossed below the TLow_Limit. Once the TLow_Flag is set, TLow_Flag will not be set again until temperature conversion is above TLow_Limit + TLow_Hyst			
0	Data_Ready_Flag	RC	0Ь	Data Ready flag indicator. This indicates that there is an unread temperature conversion. Reading Alert_Status register or the Temperature Results register will clear this bit. 0b = Data in Temp_Result has been read already 1b = Data in Temp_Result is unread			



## 8.6.4 Configuration Register (Address = 03h) [reset = 0006h]

This register is used to configuration the operation of the TMP126-Q1.

Return to Register Map.

#### Figure 8-22. Configuration Register

15	14	13	12	11	10	9	8
			Reserved				Reset
			R-00h				R/W-0b
7	6	5	4	3	2	1	0
AVG	Reserved	Int_Comp	One_Shot Mode Conv_Period[2:0]				
R/W-0b	R-0b	R/W-0b	R/W-0b	R/W-0b		R/W-110b	

#### Table 8-8. Configuration Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:9	Reserved	R	00h	Reserved
8	Resets	R/W	Ob	Software reset bit. When set to 1b it triggers software reset with a duration of 0.5 ms. This bit will always read back 0b
7	AVG	R/W	ОЬ	Averaging enable bit. Averaging will force every measurement including one-shot measurements to be averaged with eight conversions. 0b: Averaging is disabled 1b: Averaging is enabled
6	Reserved	R	0b	Reserved
5	Int_Comp	R/W	Ob	Interrupt or comparator mode select 0b = Interrupt mode 1b = Comparator mode
4	One_Shot	R/W	Ob	One-shot conversion trigger. Triggering a one-shot conversion will place the TMP126-Q1 into shutdown mode after the conversion completes. This bit will always read 0h. 0b = Default 1b = Trigger a one-shot conversion
3	Mode	R/W	Ob	Conversion mode selection bit. 0b = Continuous conversion mode 1b = Shutdown mode
2:0	Conv_Period[2:0]	R/W	110b	Conversion period setting. This bit field changes the conversion period of the TMP126-Q1. 000b = 6  ms 001b = 31.25  ms / 32  Hz 010b = 62.5  ms / 16  Hz 011b = 125  ms / 8  Hz 100b = 250  ms / 4  Hz 101b = 500  ms / 2  Hz 110b = 1  s / 1  Hz 111b = 2  s / 0.5  Hz

## 8.6.5 Alert\_Enable Register(Address = 04h) [reset = 0016h]

This register configures which flags of the Alert\_Status register are enabled or disabled. Disabling an Alert flag will cause the  $\overline{\text{ALERT}}$  pin to not assert when that flag bit is set. If the flag is enabled the  $\overline{\text{ALERT}}$  pin will assert when that flag is set. The flag bit will still be set in the register when the Alert functionality is disabled for that bit.

Currently if there is an active alert on the ALERT pin and the enable for that alert is set to 0b, the TMP126-Q1 will not the de-assert the pin until the status register is read or a new conversion occurs.

#### Return to Register Map.

	Figure 8-23. Alert_Enable Register											
15	14	13	12	12 11 10		9	8					
	Reserved											
R-00h												
7	6	5	4	3	2	1	0					
	Reserved		CRC_Alert_En	Slew_Alert_En	THigh_Alert_En	TLow_Alert_En	Data_Ready_Al ert_En					
	R-000b		R/W-1b	R/W-0b	R/W-1b	R/W-1b	R/W-0b					

#### Table 8-9. Alert\_Enable Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:5	Reserved	R	000h	Reserved
4	CRC_Alert_En	R/W	1b	Enables the CRC_Flag alert to assert the ALERT pin. 0b = CRC_Flag ALERT disabled 1b = CRC_Flag ALERT enabled
3	Slew_Alert_En	R/W	ОЬ	Enables the Slew_Flag assert the ALERT pin while in interrupt mode. When in comparator mode, enables the Slew_Status to assert the ALERT. 0b = Slew_Flag ALERT disabled 1b = Slew_Flag ALERT enabled
2	THigh_Alert_En	R/W	1b	Enables the THigh_Flag assert the ALERT pin while in interrupt mode. When in comparator mode, enables the THigh_Status to assert the ALERT. 0b = THigh_Flag Alert disabled 1b = THigh_Flag Alert enabled
1	TLow_Alert_En	R/W	1b	Enables the TLow_Flag assert the ALERT pin while in interrupt mode. When in comparator mode, enables the TLow_Status to assert the ALERT. 0b = TLow_Flag Alert disabled 1b = TLow_Flag Alert enabled
0	Data_Ready_Alert_En	R/W	Ob	Enables the Data_Ready_Flag to assert the ALERT pin. 0b = Data_Ready Alert disabled 1b = Data_Ready Alert enabled



#### 8.6.6 TLow\_Limit Register(Address = 05h) [reset = F380h]

This register is used to configuration the low temperature limit of the TMP126-Q1. The limit is formatted in a 14-bit two's complement format with a LSB (Least Significant Bit) equal to  $0.03125^{\circ}$ C. This is the same format as the TEMP\_RESULT register. The range of the register is ±256°C. The default value on start-up is F380h or -25°C. If the THigh\_Limit register is equal to or less than the TLow\_Limit register the temperature limits will be ignored until configured such that THigh\_Limit is greater than TLow\_Limit.

#### Return to Register Map.

Figure 8-2	24. TLow_	Limit Register

15	14	13	12	11	10	9	8
R/W-F3h							
7	6	5	4	3	2	1	0
			Rese	erved			
		R/W	-20h			R-0	)0b

#### Table 8-10. TLow\_Limit Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:2	TLow_Limit[13:0]	R/W	3CE0h	14-bit temperature low limit setting. Temperature low limit is represented by a 14-bit, two's complement word with an LSB (Least Significant Bit) equal to 0.03125°C. The default setting for this is -25°C.
1:0	Reserved	R	00b	These two bits will always read 00b

### 8.6.7 THigh\_Limit Register(Address = 06h) [reset = 2A80h]

This register is used to configuration the high temperature limit of the TMP126-Q1. The limit is formatted in a 14-bit two's complement format with a LSB (Least Significant Bit) equal to 0.03125°C. This is the same format as the Temp\_Result register. The range of the register is  $\pm 256$ °C. The default value on start-up is 2A80h or 85°C. If the THigh\_Limit register is equal to or less than the TLow\_Limit register the temperature limits will be ignored until configured such that THigh\_Limit is greater than TLow\_Limit.

#### Return to Register Map.

Figure 8-25. THigh_Limit Register										
15	14	13	12	11	10	9	8			
	THigh_Limit[13:6]									
	R/W-2Ah									
7	6	5	4	3	2	1	0			
	THigh_Limit[5:0] Reserved									
		R/W	′-20h			R-0	)0b			

#### Table 8-11. THigh\_Limit Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:2	THigh_Limit[13:0]	R/W	0AA0h	14-bit temperature high limit setting. Temperature high limit is represented by a 14-bit, two's
				complement word with an LSB (Least Significant Bit) equal to 0.03125°C.
1:0	Reserved	R	00b	These two bits will always read 00b

### 8.6.8 Hysteresis Register (Address = 07h) [reset = 0A0Ah]

This register sets the hysteresis for the THigh\_Limit threshold and the TLow\_Limit threshold. The default hysteresis value for both the high and low limits is equal to 5 °C.

The Hysteresis is in a 8-bit unsigned format with the LSB equal to 0.5°C. This gives a maximum value of 127.5°C of hysteresis.

#### Return to Register Map.

Figure 8-26. Hysteresis Register											
15	14	13	12 11 10 9 8								
	THigh_Hyst[7:0]										
R/W-0Ah											
7	6	5	4	3	2	1	0				
	TLow_Hyst[7:0]										
			R/W	-0Ah							

#### Table 8-12. Hysteresis Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:8	THigh_Hyst[7:0]	R/W	0Ah	THigh_Limit Hysteresis setting. Hysteresis value is represented by a unsigned Byte with the LSB equal to 0.5°C. The High temperature limit hysteresis threshold is equal to (THigh_Limit - THigh_Hyst). The default hysteresis value is 5 °C.
7:0	TLow_Hyst[7:0]	R/W	0Ah	TLow_Limit Hysteresis setting. Hysteresis value is represented by a unsigned Byte with the LSB equal to 0.5°C. The Low temperature limit hysteresis threshold is equal to (TLow_Limit + TLow_Hyst). The default hysteresis value is 5 °C.



#### 8.6.9 Slew\_Limit Register (Address = 08h) [reset = 0500h]

This register is used to configure the temperature slew rate limit of the TMP126-Q1. The limit is formatted in a 13-bit unsigned format with the LSB (Least Significant Bit) equal to 0.03125°C/s. The range of the register is 0°C to +256°C. The default value on start-up is 0140h or 10°C/s. The slew rate limit will trigger a slew rate alert on positive slew rates that are greater than the unsigned limit as enabled by the Alert\_Enable register.

#### Return to Register Map.

Figure 8-27. Slew_Limit Register										
15	14	13	12	11	10	9	8			
Reserved		Slew_Rate_Limit[12:6]								
R-0b		R/W-05h								
7	6	5	4	3	2	1	0			
			Rese	erved						
		R/W	/-00h			R-0	00b			

#### Table 8-13. Slew\_Limit Register Field Descriptions

Bit	Field	Туре	Reset	Description
15	Reserved	R	00b	Reserved
14:2	Slew_Rate_Limit[12:0]	R/W	0140h	13-bit temperature slew rate limit setting. Temperature low limit is represented by a 13-bit unsigned word with a LSB (Least Significant Bit) equal to 0.03125°C/s. The default setting for this is 10°C/s.
1:0	Reserved	R	00b	Reserved

### 8.6.10 Unique\_ID1 register (Address = 09h) [reset = xxxxh]

This register contains bits 47:32 of the Unique ID for the device. The Unique ID of the device is used for NIST traceability purposes.

#### Return to Register Map.

Figure 8-28. Unique_ID1 Register										
15	14	13	12	11	10	9	8			
	Unique_ID[47:40]									
R-xxh										
7	6	5	4	3	2	1	0			
	Unique_ID[39:32]									
			R-:	xxh						

#### Table 8-14. Unique\_ID4 Register Field Descriptions

				· · · · · · · · · · · · · · · · · · ·
Bit	Field	Туре	Reset	Description
15:0	Unique_ID[47:32]	R	xxxxh	Bits 47:32 of the device Unique ID

## 8.6.11 Unique\_ID2 register (Address = 0Ah) [reset = xxxxh]

This register contains bits 31:16 of the Unique ID for the device.

Return to Register Map.

Figure 8-29. Unique_ID2 Register										
15	14	13	12	11	10	9	8			
	Unique_ID[31:24]									
R-xxh										
7	6	5	4	3	2	1	0			
	Unique_ID[23:16]									
	R-xxh									

#### Table 8-15. Unique\_ID2 Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:0	Unique_ID[31:16]	R	xxxxh	Bits 31:16 of the device Unique ID

### 8.6.12 Unique\_ID3 register (Address = 0Bh) [reset = xxxxh]

This register contains bits 15:0 of the Unique ID for the device.

Return to Register Map.

Figure 8-30. Unique_ID3 Register										
15	14	13	12	11	10	9	8			
Unique_ID[15:8]										
R-xxh										
7	6	5	4	3	2	1	0			
Unique_ID[7:0]										
			R->	xh						

#### Table 8-16. Unique\_ID3 Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:0	Unique_ID[15:0]	R	xxxxh	Bits 15:0 of the device Unique ID.



## 8.6.13 Device\_ID register (Address = 0Ch) [reset = 2126h]

This register indicates the device ID and device revision.

Return to Register Map.

Figure 8-31. Device_ID Register											
15	14	13	12	11	10	9	8				
	Rev	[3:0]		ID[11:8]							
R-2h			R-1h								
7	6	5	4	3	2	1	0				
			ID[7	7:0]							
	R-26h										

#### Table 8-17. Device\_ID Register Field Descriptions

Bit	Field	Туре	Reset	Description
15:12	Rev[3:0]	R	2h	Device revision indicator.
11:0	ID[11:0]	R	126h	Device ID indicator.

35



## 9 Application and Implementation

#### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

## 9.1 Application Information

The TMP126-Q1 can be operated with a 4-wire SPI bus in a 3-wire bus configuration with the use of a isolation resistor for a typical application. The wide supply and temperature range support of the TMP126-Q1 allow the device to support a wide variety of use cases. The integrated optional CRC ensures data integrity during communication and the slew rate alert allows the device to autonomously monitor for rapid temperature changes.

## 9.2 Typical Application

The TMP126-Q1 features a 3-wire SPI interface that can easily be connected to a 4-wire SPI MCU with the use of a isolation resistor.



Figure 9-1. TMP126-Q1 Typical Connections

### 9.2.1 Design Requirements

For this design example, use the parameters listed below.

PARAMETER	Value
Supply (V <sub>DD</sub> )	1.62 V to 5.5 V
Isolation Resistor	10 kΩ

#### 9.2.2 Detailed Design Procedure

The TMP126-Q1 will convert temperature at a default 1 s interval with an adjustable conversion period between 6 ms and 2 s. Reading faster than the conversion period will not disrupt device operation and can safely be done if desired.

The TMP126-Q1 should be placed as close to the temperature source as possible with a proper layout for thermal coupling. Placing the device as close as possible ensures that temperature changes are captured in the shortest possible time interval.



## **10 Power Supply Recommendations**

The operates from a single supply VDD. This pin operates with a wide range of 1.62 V to 5.5 V and maintains accuracy across the entire supply range. A de-coupling capacitor of 0.1  $\mu$ F is recommended for the VDD pin. Place the capacitor as close to the pin as possible.

## 11 Layout

### 11.1 Layout Guidelines

Place the power-supply de-coupling capacitor as close as possible to the supply and ground pins. The recommended value of this de-coupling capacitor is 0.1  $\mu$ F. Separation between the SCLK trace and the SIO traces is recommended to reduce coupling of the clock onto the data line.

#### 11.2 Layout Example









Figure 11-2. DCK Package Layout Example



## 12 Device and Documentation Support

### **12.1 Documentation Support**

### 12.1.1 Related Documentation

For related documentation see the following:

- Temperature Slew Rate Warning Overview (SNIA042)
- TMP126EVM User's Guide (SNIU049)

## **12.2 Receiving Notification of Documentation Updates**

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### **12.3 Support Resources**

TI E2E<sup>™</sup> support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

#### 12.4 Trademarks

TI E2E<sup>™</sup> is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

#### 12.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 12.6 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.



## PACKAGING INFORMATION

Orderable Device	Status	Package Type	Package	Pins	Package	Eco Plan	Lead finish/	MSL Peak Temp	Op Temp (°C)	Device Marking	Samples
	(1)		Drawing		Qty	(2)	Ball material	(3)		(4/5)	
							(6)				
PTMP126EDCKTQ1	ACTIVE	SC70	DCK	6	250	TBD	Call TI	Call TI	-55 to 175		Samples
TMP126EDBVRQ1	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 175	2NLA	Samples
TMP126EDCKRQ1	ACTIVE	SC70	DCK	6	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 175	2SWA	Samples

<sup>(1)</sup> The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> RoHS: TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (CI) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.



# PACKAGE OPTION ADDENDUM

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

#### OTHER QUALIFIED VERSIONS OF TMP126-Q1 :

• Catalog : TMP126

NOTE: Qualified Version Definitions:

• Catalog - TI's standard catalog product



Texas

STRUMENTS

## TAPE AND REEL INFORMATION





#### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal													
Γ	Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
	TMP126EDBVRQ1	SOT-23	DBV	6	3000	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
	TMP126EDCKRQ1	SC70	DCK	6	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3



www.ti.com

# PACKAGE MATERIALS INFORMATION

9-Aug-2022



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TMP126EDBVRQ1	SOT-23	DBV	6	3000	190.0	190.0	30.0
TMP126EDCKRQ1	SC70	DCK	6	3000	180.0	180.0	18.0

DCK (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-203 variation AB.



# **DBV0006A**



# **PACKAGE OUTLINE**

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



NOTES:

- 1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.2. This drawing is subject to change without notice.3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.

- 4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation. 5. Refernce JEDEC MO-178.



# **DBV0006A**

# **EXAMPLE BOARD LAYOUT**

# SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



# **DBV0006A**

# **EXAMPLE STENCIL DESIGN**

# SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

9. Board assembly site may have different recommendations for stencil design.



## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2022, Texas Instruments Incorporated