LM57-Q1 Resistor-Programmable Temperature Switch and Analog Temperature Sensor

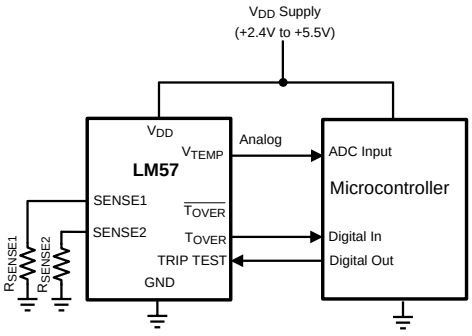
1 Features

- Qualified for Automotive Applications, for Commercial Device See LM57 Data Sheet
- AEC-Q100 Qualified with the Following Results:
  - Temperature Grade 0 Extended: −50°C to +160°C with Excursions up to 170°C Operating Temperature Range
  - Temperature Grade 0: −50°C to +150°C Operating Temperature Range
  - Temperature Grade 1: −50°C to +125°C Operating Temperature Range
  - HBM ESD Component Classification Level 2
  - CDM ESD Component Classification Level C5
- Trip Temperature Set by External Resistors with Accuracy of ±2.3°C from −40°C to +150°C
- Resistor Tolerance Contributes Zero Error
- Push-Pull and Open-Drain Switch Outputs
- Wide Operating Temperature Range of −50°C to 160°C
- Very Linear Analog V_{TEMP} Temp Sensor Output with ±1.3°C Accuracy from −50°C to +150°C
- Short-Circuit Protected Analog and Digital Outputs
- Latching Function for Digital Outputs
- TRIP-TEST Pin Allows In-System Testing
- Low Power Minimizes Self-Heating to Under 0.02°C

2 Applications

- Automotive
- Down Hole and Avionics

LM57-Q1 Overtemperature Alarm



3 Description

The LM57-Q1 device is a precision, dual-output, temperature switch with analog temperature sensor output for wide temperature applications such as automotive grade. The trip temperature (T_{TRIP}) is selected from 256 possible values in the range of –40°C to 160°C. The V_{TEMP} is a class AB analog voltage output that is proportional to temperature with a programmable negative temperature coefficient (NTC). Two external 1% resistors set the T_{TRIP} and V_{TEMP} slope. The digital and analog outputs enable protection and monitoring of system thermal events.

Built-in thermal hysteresis (T_{HYST}) prevents the digital outputs from oscillating. The T_{OVER} and $\overline{T_{OVER}}$ digital outputs will assert when the die temperature exceeds T_{TRIP} and will de-assert when the temperature falls below a temperature equal to T_{TRIP} minus T_{HYST}.

T_{OVER} is active-high with a push-pull structure. $\overline{T_{OVER}}$ is active-low with an open-drain structure. Tying T_{OVER} to TRIP-TEST will latch the output after it trips. The output can be cleared by forcing TRIP-TEST low. Driving the TRIP-TEST high will assert the digital outputs. A processor can check the state of T_{OVER} or $\overline{T_{OVER}}$, confirming they changed to an active state. This allows for in situ verification that the comparator and output circuitry are functional after system assembly. When TRIP-TEST is high, the trip-level reference voltage appears at the V_{TEMP} pin. The system could then use this voltage to calculate the threshold of the LM57-Q1.

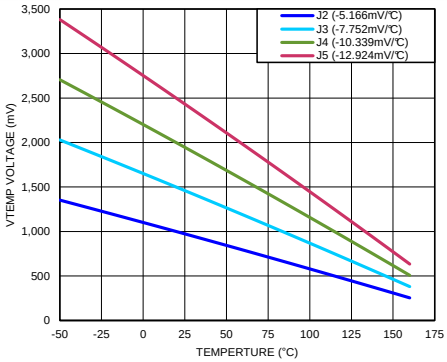
Device Information (1) (2)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM57 -Q1	TSSOP (8)	3.00 mm × 6.40 mm

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

(2) For device comparison see *Device Comparison Table* .

Temperature Transfer Function



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Changes from Revision Initial Release (July 2015) to Revision A **Page**

- Changed feature bullet automotive description and added description of the automotive grades and ESD classifications ... 1

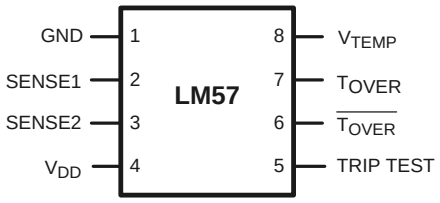
4 Device Comparison Table

ORDER NUMBER	PACKAGE	GRADE (TEMP RANGE)	V_{TEMP} ACCURACY	TRIP POINT ACCURACY	HYSTERESIS
LM57BISD-5, LM57BISDX-5 (1)	WSON/SD/NGR /DFN (8)	Commercial (-50°C to 150°C)	±0.8°C	±1.5°C	5°C
LM57BISD-10, LM57BISDX-10 (1)	WSON/SD/NGR /DFN (8)	Commercial (-50°C to 150°C)	±0.8°C	±1.5°C	10°C
LM57CISD-5, LM57CISD-5 (1)	WSON/SD/NGR /DFN (8)	Commercial (-50°C to 150°C)	±1.3°C	±2.3°C	5°C
LM57CISD-10, LM57CISDX-10 (1)	WSON/SD/NGR /DFN (8)	Commercial (-50°C to 150°C)	±1.3°C	±2.3°C	10°C
LM57FPW, LM57FPWR (1)	PW/TSSOP (8)	Commercial (-50°C to 150°C)	±1.3°C	±2.3°C	5°C
LM57TPW, LM57TPWR (1)	PW/TSSOP (8)	Commercial (-50°C to 150°C)	±1.3°C	±2.3°C	10°C
LM57FSPWQ1, LM57FSPWRQ1	PW/TSSOP (8)	Automotive Grade 0 Extended (-50°C to 160°C)	±1.3°C	±2.3°C	5°C
LM57TSPWQ1, LM57TSPWRQ1	PW/TSSOP (8)	Automotive Grade 0 Extended (-50°C to 160°C)	±1.3°C	±2.3°C	10°C
LM57FEPWQ1, LM57FEPWRQ1	PW/TSSOP (8)	Automotive Grade 0 Standard (-50°C to 150°C)	±1.3°C	±2.3°C	5°C
LM57TEPWQ1, LM57TEPWRQ1	PW/TSSOP (8)	Automotive Grade 0 Standard (-50°C to 150°C)	±1.3°C	±2.3°C	10°C
LM57FQPWQ1, LM57FQPWRQ1	PW/TSSOP (8)	Automotive Grade 1 Standard (-50°C to 125°C)	±1.3°C	±2.3°C	5°C
LM57TQPWQ1, LM57TQPWRQ1	PW/TSSOP (8)	Automotive Grade 1 Standard (-50°C to 125°C)	±1.3°C	±2.3°C	10°C

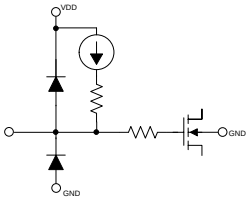
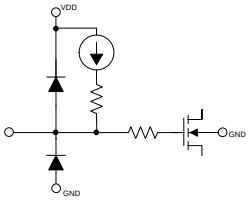
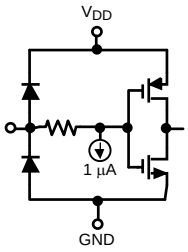
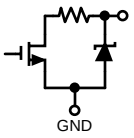
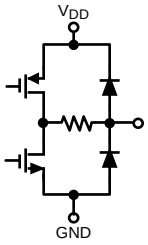
(1) For Commercial grade device complete datasheet see LM57.

5 Pin Configuration and Functions

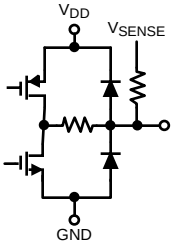
TSSOP/PW Package
8-Pin
Top View



Pin Functions

PIN		TYPE	EQUIVALENT CIRCUIT	DESCRIPTION
NAME	NO.			
GND	1	Ground	—	Power supply ground
SENSE1	2	—		Trip-point resistor sense. One of two sense pins which selects the temperature at which T_{OVER} and $\overline{T_{OVER}}$ will assert.
SENSE2	3	—		Trip-point resistor sense. One of two sense pins which selects the temperature at which T_{OVER} and $\overline{T_{OVER}}$ will assert.
V_{DD}	4	Power		Supply voltage
TRIP TEST	5	Digital Input		TRIP TEST pin. Active High input. If TRIP TEST = 0 (default), then the V_{TEMP} output has the analog temperature sensor output voltage. If TRIP TEST = 1, then T_{OVER} and $\overline{T_{OVER}}$ outputs are asserted and V_{TEMP} = V_{TRIP}, the temperature trip voltage. Tie this pin to ground if not used.
$\overline{T_{OVER}}$	6	Digital Output		Overtemperature switch output Active low, open-drain (see *LM57-Q1 V_{TEMP} Voltage-to-Temperature Equations* regarding required pullup resistor.) Asserted when the measured temperature exceeds the Trip Point Temperature or if TRIP TEST = 1 This pin may be left open if not used.
T_{OVER}	7	Digital Output		Overtemperature switch output Active high, push-pull Asserted when the measured temperature exceeds the trip point temperature or if TRIP TEST = 1 This pin may be left open if not used.

Pin Functions (continued)

PIN		TYPE	EQUIVALENT CIRCUIT	DESCRIPTION
NAME	NO.			
V_{TEMP}	8	Analog Output		V_{TEMP} analog voltage output If TRIP TEST = 0, then $V_{TEMP} = V_{TS}$, temperature sensor output voltage If TRIP TEST = 1, then $V_{TEMP} = V_{TRIP}$, temperature trip voltage This pin may be left open if not used.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1) (2)

	MIN	MAX	UNIT
Supply voltage	−0.3	6	V
Voltage at $\overline{T_{OVER}}$	−0.3	6	V
Voltage at T_{OVER} , V_{TEMP}, TRIP-TEST, SENSE1, and SENSE2	−0.3	(V_{DD} + 0.3 V)	V
Current at any pin		5	mA
Storage temperature for LM57FSPWQ1 and LM57TSPWQ1	−65	175	°C
Storage temperature for all LM57-Q1 except LM57FSPWQ1 and LM57TSPWQ1	−65	150	°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.
(2) Soldering process must comply with Reflow Temperature Profile specifications. Refer to www.ti.com/packaging.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 (1)	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±750	

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

6.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
FOR ALL PARTS GRADE 0 AND GRADE 1 EXCEPT GRADE 0 EXTENDED (LM57FSPWQ1 and LM57TSPWQ1)					
Supply voltage		2.4		5.5	V
Free air temperature range ($T_{MIN} \le T_A \le T_{MAX}$)	LM57FEPWQ1, and LM57TEPWQ1	−50		150	°C
	LM57FQPWQ1, LM57TQPWQ1	-50		125	°C
GRADE 0 EXTENDED (LM57FSPWQ1 AND LM57TSPWQ1)					
Supply voltage		2.4		5.5	V
Free air temperature range ($T_{MIN} \le T_A \le T_{MAX}$)	Temperature Profile for LM57-Q1 Automotive Grade 0 Extended *High Temperature Operational Life Test (HTOL) - Hours of Operation:* (1) 1700 hours at $T_J = T_C$ = 160°C 10 hours at $T_J = T_C$ = 170°C	−50		170	°C

(1) Except for HTOL testing, which was conducted as described, all other testing was to AEC-Q100 Grade 0 flow. Full details on reliability testing are available upon request.

6.4 Thermal Information

THERMAL METRIC (1)		LM57-Q1 PW (TSSOP) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	183	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	66	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	111	°C/W
ψ_{JT}	Junction-to-top characterization parameter	8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	110	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

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

6.5 Electrical Characteristics

Unless otherwise noted, these specifications apply for V_{DD} = 2.4 to 5.5 V and over free air temperature range. These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in Table 1.

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
TRIP POINT ACCURACY FOR ALL LM57-Q1 EXCEPT LM57FSPWQ1 AND LM57TSPWQ1							
Trip Point Accuracy (Includes 1% set-resistor tolerance)	J2	T_A = −41°C to 52°C	V_{DD} = 2.4 V to 5.5 V			±2.3	°C
	J3	T_A = 52°C to 97°C	V_{DD} = 2.4 V to 5.5 V			±2.3	°C
	J4	T_A = 97°C to 119°C	V_{DD} = 2.4 V to 5.5 V			±2.3	°C
	J5	T_A = 119°C to free air temperature max	V_{DD} = 2.4 V to 5.5 V			±2.3	°C
TRIP POINT ACCURACY FOR LM57-Q1 AUTOMOTIVE GRADE 0 EXTENDED (LM57FSPWQ1 and LM57TSPWQ1)							
Trip point accuracy (Includes 1% set-resistor tolerance)	J2	T_A = −41°C to 52°C	V_{DD} = 2.4 V to 5.5 V			±2.3	°C
	J3	T_A = 52°C to 97°C					
	J4	T_A = 97°C to 119°C					
	J5	T_A = 119°C to 160°C					
	J5	T_A = 150°C to 160°C	V_{DD} = 2.4 V to 5.5 V			±2.5	

Electrical Characteristics (continued)

Unless otherwise noted, these specifications apply for V_{DD} = 2.4 to 5.5 V and over free air temperature range. These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in Table 1.

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{TEMP} ANALOG TEMPERATURE SENSOR OUTPUT ACCURACY FOR ALL LM57-Q1 EXCEPT LM57FSPWQ1 and LM57TSPWQ1							
V_{TEMP} Accuracy (These stated accuracy limits are with reference to the values in Table 1, LM57-Q1 V_{TEMP} Temperature-to-Voltage.)	J2	T_A = −50°C to free air temperature max	V_{DD} = 2.4 V to 5.5 V			±1.3	°C
	J3	T_A = −50°C to free air temperature max	V_{DD} = 2.4 V to 5.5 V			±1.3	°C
	J4	T_A = 20°C to 50°C	V_{DD} = 2.4 V to 5.5 V			±1.3	°C
		T_A = 0°C to free air temperature max	V_{DD} = 2.7 V to 5.5 V			±1.3	
		T_A = −50°C to 0°C	V_{DD} = 3.1 V to 5.5 V			±1.3	
	J5	T_A = 60°C to free air temperature max	V_{DD} = 2.4 V to 5.5 V			±1.3	°C
		T_A = 20°C to 50°C	V_{DD} = 2.9 V to 5.5 V			±1.3	
		T_A = 0°C to free air temperature max	V_{DD} = 3.2 V to 5.5 V			±1.3	
		T_A = −50°C to 0°C	V_{DD} = 4 V to 5.5 V			±1.3	
V_{TEMP} ANALOG TEMPERATURE SENSOR OUTPUT ACCURACY FOR LM57-Q1 AUTOMOTIVE GRADE 0 EXTENDED (LM57FSPWQ1 and LM57TSPWQ1)							
V_{TEMP} accuracy (These stated accuracy limits are with reference to the values in Table 1, LM57-Q1 V_{TEMP} temperature-to-voltage.)	J2	T_A = 150°C to 160°C	V_{DD} = 2.4 V to 5.5 V			±1.5	°C
		T_A = –50°C to 150°C				±1.3	
	J3	T_A = 150°C to 160°C	V_{DD} = 2.4 V to 5.5 V			±1.5	°C
		T_A = –50°C to 150°C				±1.3	
	J4	T_A = 20°C to 50°C	V_{DD} = 2.4 V to 5.5 V			±1.3	°C
		T_A = 0°C to 150°C	V_{DD} = 2.7 V to 5.5 V			±1.3	
		T_A = 150°C to 160°C				±1.5	
		T_A = –50°C to 0°C	V_{DD} = 3.1 V to 5.5 V			±1.3	
	J5	T_A = 150°C to 160°C	V_{DD} = 2.4 V to 5.5 V			±1.5	°C
		T_A = 60°C to 150°C				±1.3	
		T_A = 20°C to 50°C	V_{DD} = 2.9 V to 5.5 V			±1.3	
		T_A = 0°C to 150°C	V_{DD} = 3.2 V to 5.5 V			±1.3	
		T_A = –50°C to 0°C	V_{DD} = 4 V to 5.5 V			±1.3	

Electrical Characteristics (continued)

Unless otherwise noted, these specifications apply for V_{DD} = 2.4 to 5.5 V and over free air temperature range. These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in Table 1.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OTHER TEMPERATURE SENSOR SPECIFICATIONS						
	V_{TEMP} sensor gain	J2: −50°C to 52°C		−5.166		mV/°C
		J3: 52°C to 97°C		−7.752		
		J4: 97°C to 119°C		−10.339		
		J5: 119°C to 160°C		−12.924		
	Line regulation DC: supply-to-V_{TEMP} (1)	Temp = 90°C		0.18		mV
				58		µV/V
				−84		dB
	Load regulation: V_{TEMP} output (2)	Source ≤ 240 µA, (V_{DD} – V_{TEMP}) ≥ 200 mV; T_A = −50°C to 150°C			−1	mV
		Sink ≤ 300 µA, V_{TEMP} ≥ 360 mV; T_A = −50°C to 150°C			1	
		Source or sink = 100 µA; T_A = −50°C to 150°C		1		Ω
	Maximum Load capacitance: V_{TEMP} output	No output series resistor required; (See *V_{TEMP} Capacitive Loads*)		1100		pF
I_S	Supply current: quiescent (3)	for all LM57-Q1 for T_A ≤ 150°C		24	28	µA
		T_A = 150°C to 160°C for LM57FSPWQ1 and LM57TSPWQ1		24	29	µA
		T_A = 170°C for LM57FSPWQ1 and LM57TSPWQ1		26		µA
TRIP-TEST INPUT						
V_{IH}	Logic 1 threshold voltage		V_{DD} – 0.5			V
V_{IL}	Logic 0 threshold voltage				0.5	V
I_{IH}	Logic 1 input current			1.4	3	µA
I_{IL}	Logic 0 input leakage current (4)	T_A = −50°C to 150°C		0.001	1	µA
T_{OVER} (PUSH-PULL, ACTIVE-HIGH) OUTPUT						
V_{OH}	Logic 1 push-pull output voltage	Source ≤ 600 µA	V_{DD} – 0.2			V
		Source ≤ 1.2 mA	V_{DD} – 0.45			
V_{OL}	Logic 0 output voltage	Sink ≤ 600 µA			0.2	V
		Sink ≤ 1.2 mA			0.45	
$\overline{T_{OVER}}$ (OPEN-DRAIN, ACTIVE-LOW) OUTPUT						
V_{OL}	Logic 0 output voltage	Sink ≤ 600 µA			0.2	V
		Sink ≤1.2 mA			0.45	
I_{OH}	Logic 1 output leakage current (4)	Temperature = 30°C;		0.001	1	µA

(1) Line regulation (DC) is calculated by subtracting the output voltage at the highest supply voltage from the output voltage at the lowest supply voltage. The typical DC line regulation specification does not include the output voltage shift discussed in *V_{TEMP} Voltage Shift*.
(2) Source currents are flowing out of the LM57-Q1. Sink currents are flowing into the LM57-Q1. Load Regulation is calculated by measuring V_{TEMP} at 0 µA and subtracting the value with the conditions specified.
(3) Supply current refers to the quiescent current of the LM57-Q1 only and does not include any load current
(4) This current is leakage current only and is therefore highest at high temperatures. Prototype test indicate that the leakage is well below 1 µA over the full temperature range. This 1 µA specification reflects the limitations of measuring leakage at room temperature. For this reason only, the leakage current is not specified at a lower value.

Electrical Characteristics (continued)

Unless otherwise noted, these specifications apply for V_{DD} = 2.4 to 5.5 V and over free air temperature range. These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in Table 1.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
HYSTERESIS						
T_{HYST}	Hysteresis temperature	5°C hysteresis option (all LM57F for $T_A \leq$ 150°C)	4.7	5	5.4	°C
		10°C hysteresis option (all LM57T for $T_A \leq$ 150°C)	9.6	10	10.6	°C
		5°C hysteresis option (LM57FSPWQ1); T_A = 150°C to 160°C	4.6	5	5.4	°C
		10°C hysteresis option (LM57TSPWQ1); T_A = 150°C to 160°C	9.4	10	10.6	°C

6.6 Switching Characteristics

Unless otherwise noted, these specifications apply for V_{DD} = 2.4 to 5.5 V over the free air temperature range.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{EN}	Maximum time from power on to digital output enabled			1.5		ms
t_{VTEMP}	Maximum time from power on to analog temperature (V_{TEMP}) valid			1.5		ms

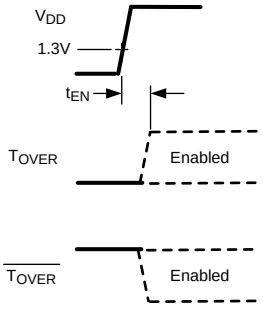


Figure 1. Definition of t_{EN}

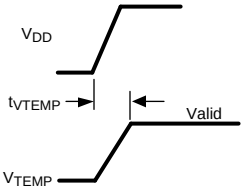


Figure 2. Definition of t_{VTEMP}

6.7 Typical Characteristics

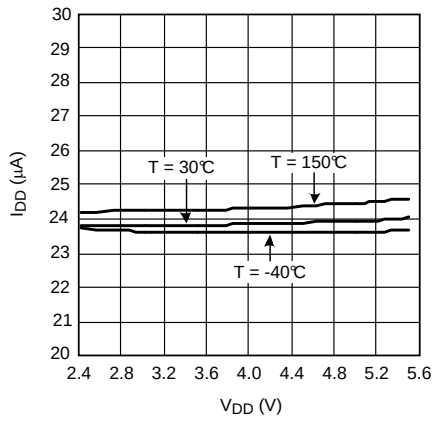


Figure 3. Supply Current vs Supply Voltage

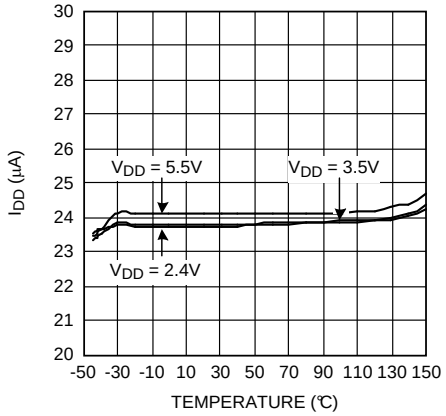


Figure 4. Supply Current vs Temperature

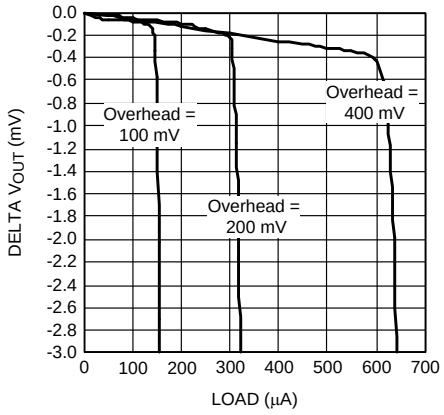


Figure 5. Load Regulation: Change In V_{TEMP} vs Source Current Overhead Is Vdd-Vtemp

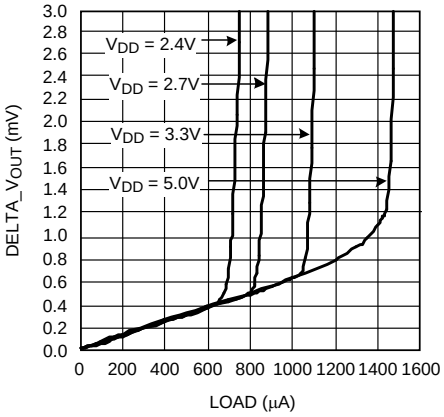


Figure 6. Load Regulation: Change In V_{TEMP} vs Sink Current

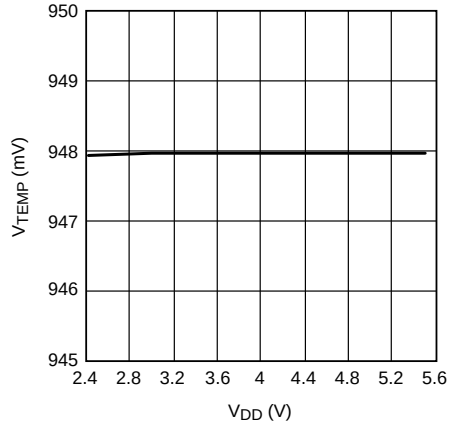


Figure 7. Line Regulation: V_{TEMP} vs Supply Voltage

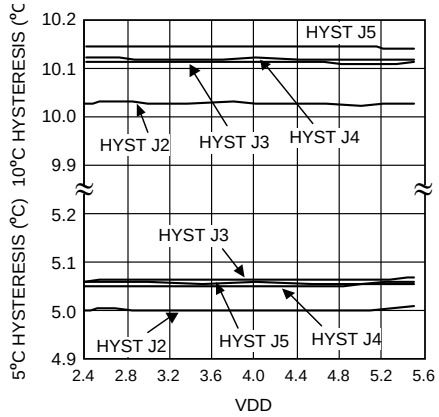


Figure 8. Line Regulation: Hysteresis vs Supply Voltage 30°C

Typical Characteristics (continued)

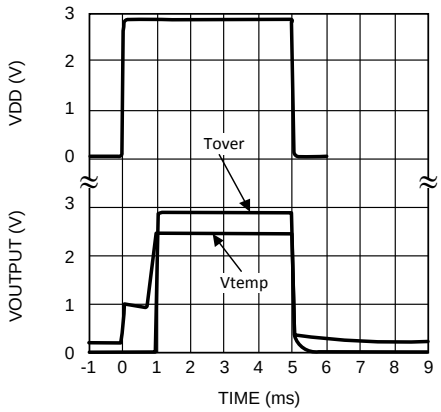


Figure 9. Start-Up Response

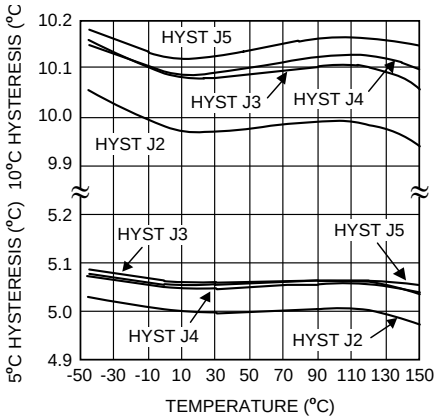


Figure 10. Hysteresis vs Temperature

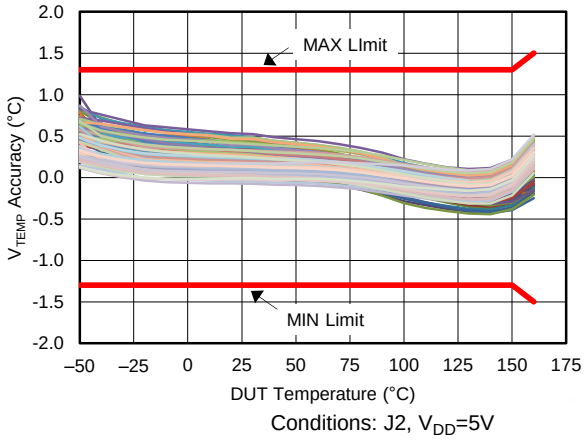


Figure 11. J2 Accuracy Specification Over Temperature

7 Detailed Description

7.1 Overview

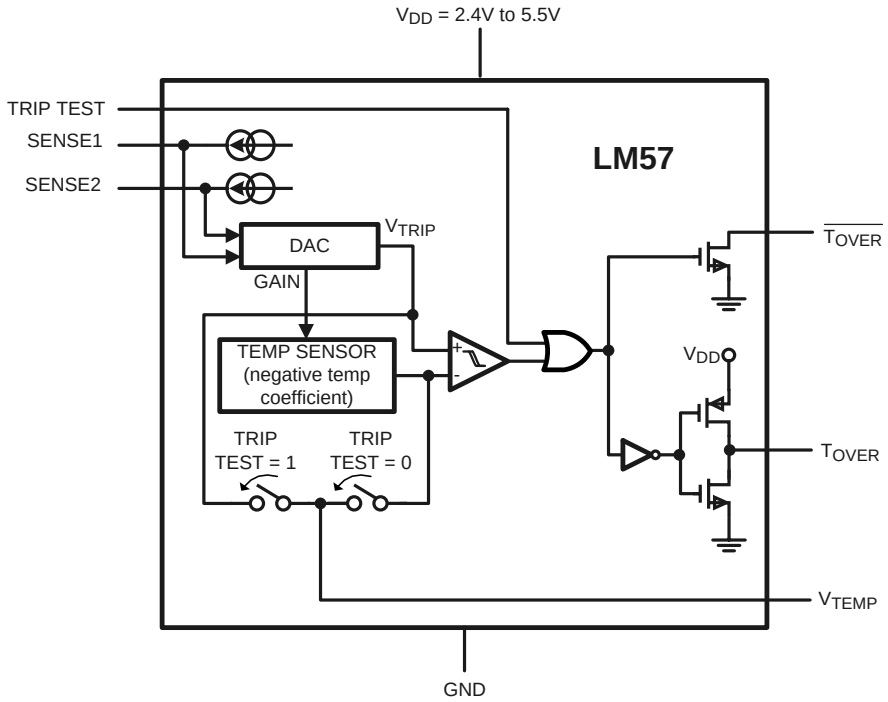
The LM57-Q1 is a precision, dual-output, temperature switch with analog temperature sensor output. The trip temperature (T_{TRIP}) is selected from 256 possible values by using two external 1% resistors. The V_{TEMP} class AB analog output provides a voltage that is proportional to temperature. The LM57-Q1 includes an internal reference DAC, analog temperature sensor and analog comparator. The reference DAC is connected to one of the comparator inputs. The reference DAC output voltage (V_{TRIP}) is controlled by the value of resistance applied to the SENSE pins. The resistance value sets one of 16 "logic" levels at the SENSE pins. These "logic" levels are then decoded and applied to the DAC input, thus the actual resistance tolerance does not directly affect the threshold level accuracy. The result of the reference DAC voltage and the temperature sensor output comparison is provided on two output pins $\overline{T_{OVER}}$ and T_{OVER}.

The V_{TEMP} output has a programmable gain. The output gain has 4 possible settings as described in Figure 12. The gain setting is dependent on the trip point selected by resistance applied to the SENSE pins.

Built-in temperature hysteresis (T_{HYST}) prevents the digital outputs from oscillating. The T_{OVER} and $\overline{T_{OVER}}$ will activate when the die temperature exceeds T_{TRIP} and will release when the temperature falls below a temperature equal to T_{TRIP} minus T_{HYST}. T_{OVER} is active-high with a push-pull structure. $\overline{T_{OVER}}$, is active-low with an open-drain structure. There are two different hysteresis options available that are factory preset. The preset hysteresis can be selected by purchasing the proper order number as described in *Device Comparison Table* .

Driving the TRIP-TEST high will activate the digital outputs. A processor can check the logic level of the T_{OVER} or $\overline{T_{OVER}}$, confirming that they changed to their active state. This allows for system production testing verification that the comparator and output circuitry are functional after system assembly. When the TRIP-TEST pin is high, the trip-level reference voltage appears at the V_{TEMP} pin. Tying T_{OVER} to TRIP-TEST will latch the output after it trips. It can be cleared by forcing TRIP-TEST low or powering off the LM57-Q1.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 LM57-Q1 V_{TEMP} Temperature-to-Voltage Transfer Function

The value of the R_{SENSE} resistors select a trip point and a corresponding V_{TEMP} gain (J2, J3, J4, or J5).The trip point range associated with a given gain is shown in bold green or bold red italics in Table 1. Temperatures above 150°C apply to the LM57FSPWQ1 and LM57TSPWQ1 only and are highlighted in red and italics in Table 1. The V_{TEMP} gain is selected by the R_{SENSE} resistors. V_{TEMP} is valid over the entire temperature range. The V_{TEMP} gain is selected by the R_{SENSE} resistors. V_{TEMP} is valid over the entire temperature range.

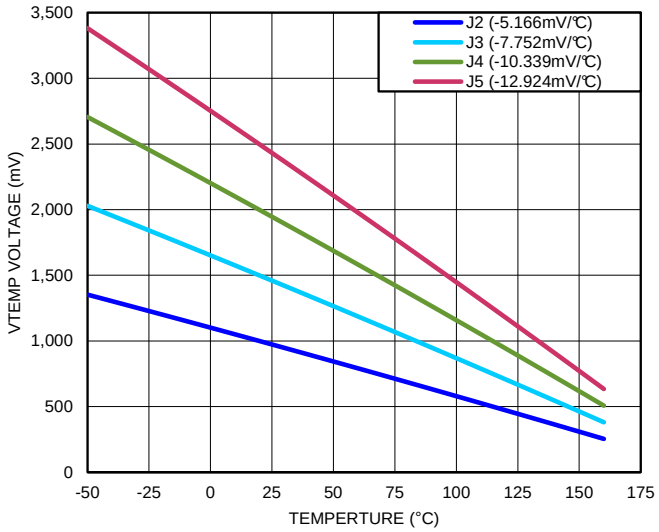


Figure 12. Temperature Transfer Characteristics

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage (1)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
–50	1352.56	2028.80	2705.20	3381.40
–49	1347.60	2021.35	2695.26	3368.98
–48	1342.64	2013.90	2685.32	3356.55
–47	1337.67	2006.44	2675.38	3344.12
–46	1332.70	1998.98	2665.43	3331.68
–45	1327.73	1991.52	2655.47	3319.23
–44	1322.76	1984.05	2645.51	3306.78
–43	1317.78	1976.58	2635.54	3294.32
–42	1312.81	1969.11	2625.57	3281.85
–41	**1307.82**	1961.63	2615.60	3269.38
–40	**1302.84**	1954.15	2605.62	3256.90
–39	**1297.86**	1946.66	2595.63	3244.41
–38	**1292.87**	1939.17	2585.64	3231.92
–37	**1287.88**	1931.68	2575.64	3219.42
–36	**1282.88**	1924.18	2565.64	3206.92
–35	**1277.89**	1916.68	2555.63	3194.41
–34	**1272.89**	1909.17	2545.62	3181.89

(1) The R_{SENSE} resistors select a trip point and a corresponding V_{TEMP} gain (J2, J3, J4, or J5). The trip point range associated with a given gain is shown in bold green or red on this table. Temperatures above 150°C apply to the LM57FSPWQ1 and LM57TSPWQ1 only and are italicized and highlighted in red. The V_{TEMP} gain is selected by the R_{SENSE} resistors. V_{TEMP} is valid over the entire temperature range.

Feature Description (continued)

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage [1] (continued)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
–33	**1267.88**	1901.66	2535.60	3169.37
–32	**1262.88**	1894.15	2525.58	3156.84
–31	**1257.87**	1886.63	2515.56	3144.30
–30	**1252.86**	1879.11	2505.52	3131.76
–29	**1247.85**	1871.59	2495.49	3119.21
–28	**1242.84**	1864.06	2485.44	3106.66
–27	**1237.82**	1856.53	2475.40	3094.10
–26	**1232.80**	1848.99	2465.34	3081.53
–25	**1227.78**	1841.45	2455.29	3068.96
–24	**1222.75**	1833.91	2445.23	3056.38
–23	**1217.73**	1826.36	2435.16	3043.79
–22	**1212.70**	1818.81	2425.09	3031.20
–21	**1207.67**	1811.26	2415.01	3018.60
–20	**1202.63**	1803.70	2404.93	3006.00
–19	**1197.59**	1796.13	2394.84	2993.38
–18	**1192.55**	1788.57	2384.74	2980.77
–17	**1187.51**	1781.00	2374.65	2968.14
–16	**1182.46**	1773.42	2364.54	2955.51
–15	**1177.42**	1765.85	2354.44	2942.87
–14	**1172.37**	1758.26	2344.32	2930.23
–13	**1167.31**	1750.68	2334.20	2917.58
–12	**1162.26**	1743.09	2324.08	2904.93
–11	**1157.20**	1735.50	2313.95	2892.26
–10	**1152.14**	1727.90	2303.82	2879.60
–9	**1147.07**	1720.30	2293.68	2866.92
–8	**1142.01**	1712.69	2283.54	2854.24
–7	**1136.94**	1705.09	2273.39	2841.55
–6	**1131.87**	1697.47	2263.24	2828.86
–5	**1126.79**	1689.86	2253.08	2816.16
–4	**1121.72**	1682.24	2242.91	2803.45
–3	**1116.64**	1674.61	2232.74	2790.74
–2	**1111.56**	1666.99	2222.57	2778.02
–1	**1106.47**	1659.35	2212.39	2765.30
0	**1101.39**	1651.72	2202.21	2752.57
1	**1096.30**	1644.08	2192.02	2739.83
2	**1091.20**	1636.44	2181.82	2727.08
3	**1086.11**	1628.79	2171.62	2714.33
4	**1081.01**	1621.14	2161.42	2701.58
5	**1075.91**	1613.48	2151.21	2688.82
6	**1070.81**	1605.83	2141.00	2676.05
7	**1065.71**	1598.16	2130.78	2663.27
8	**1060.60**	1590.50	2120.55	2650.49
9	**1055.49**	1582.83	2110.32	2637.70
10	**1050.38**	1575.15	2100.09	2624.91
11	**1045.26**	1567.48	2089.85	2612.10

Feature Description (continued)

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage (1) (continued)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
12	**1040.14**	1559.80	2079.60	2599.30
13	**1035.02**	1552.11	2069.35	2586.48
14	**1029.90**	1544.42	2059.10	2573.66
15	**1024.77**	1536.73	2048.84	2560.84
16	**1019.65**	1529.03	2038.57	2548.01
17	**1014.51**	1521.33	2028.30	2535.17
18	**1009.38**	1513.63	2018.03	2522.32
19	**1004.25**	1505.92	2007.75	2509.47
20	**999.11**	1498.21	1997.46	2496.61
21	**993.97**	1490.49	1987.17	2483.75
22	**988.82**	1482.77	1976.88	2470.88
23	**983.68**	1475.05	1966.58	2458.00
24	**978.53**	1467.32	1956.27	2445.12
25	**973.38**	1459.59	1945.96	2432.23
26	**968.22**	1451.86	1935.64	2419.34
27	**963.07**	1444.12	1925.32	2406.43
28	**957.91**	1436.38	1915.00	2393.53
29	**952.74**	1428.63	1904.67	2380.61
30	**947.58**	1420.88	1894.33	2367.69
31	**942.41**	1413.13	1883.99	2354.76
32	**937.24**	1405.37	1873.64	2341.83
33	**932.07**	1397.61	1863.29	2328.89
34	**926.90**	1389.84	1852.94	2315.94
35	**921.72**	1382.07	1842.57	2302.99
36	**916.54**	1374.30	1832.21	2290.03
37	**911.36**	1366.52	1821.84	2277.07
38	**906.17**	1358.74	1811.46	2264.10
39	**900.98**	1350.96	1801.08	2251.12
40	**895.79**	1343.17	1790.69	2238.14
41	**890.60**	1335.38	1780.30	2225.15
42	**885.41**	1327.58	1769.90	2212.15
43	**880.21**	1319.78	1759.50	2199.15
44	**875.01**	1311.98	1749.09	2186.14
45	**869.81**	1304.17	1738.68	2173.12
46	**864.60**	1296.36	1728.26	2160.10
47	**859.39**	1288.54	1717.84	2147.07
48	**854.18**	1280.72	1707.41	2134.04
49	**848.97**	1272.90	1696.98	2121.00
50	**843.75**	1265.07	1686.54	2107.95
51	**838.53**	1257.24	1676.10	2094.90
52	**833.31**	1249.41	1665.65	2081.84
53	828.09	**1241.57**	1655.20	2068.77
54	822.86	**1233.73**	1644.74	2055.70
55	817.63	**1225.88**	1634.28	2042.62
56	812.40	**1218.03**	1623.81	2029.54

Feature Description (continued)

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage [1] (continued)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
57	807.17	**1210.18**	1613.34	2016.44
58	801.93	**1202.32**	1602.86	2003.35
59	796.69	**1194.46**	1592.38	1990.24
60	791.45	**1186.60**	1581.89	1977.13
61	786.20	**1178.73**	1571.40	1964.02
62	780.96	**1170.86**	1560.90	1950.89
63	775.71	**1162.98**	1550.40	1937.76
64	770.46	**1155.10**	1539.89	1924.63
65	765.20	**1147.22**	1529.37	1911.49
66	759.94	**1139.33**	1518.86	1898.34
67	754.68	**1131.44**	1508.33	1885.19
68	749.42	**1123.54**	1497.80	1872.02
69	744.16	**1115.64**	1487.27	1858.86
70	738.89	**1107.74**	1476.73	1845.68
71	733.62	**1099.83**	1466.19	1832.50
72	728.35	**1091.92**	1455.64	1819.32
73	723.07	**1084.01**	1445.08	1806.13
74	717.79	**1076.09**	1434.53	1792.93
75	712.51	**1068.17**	1423.96	1779.72
76	707.23	**1060.24**	1413.39	1766.51
77	701.94	**1052.31**	1402.82	1753.30
78	696.65	**1044.38**	1392.24	1740.07
79	691.36	**1036.44**	1381.65	1726.84
80	686.07	**1028.50**	1371.07	1713.61
81	680.77	**1020.55**	1360.47	1700.36
82	675.48	**1012.60**	1349.87	1687.11
83	670.17	**1004.65**	1339.27	1673.86
84	664.87	**996.69**	1328.66	1660.60
85	659.56	**988.73**	1318.04	1647.33
86	654.25	**980.77**	1307.42	1634.05
87	648.94	**972.80**	1296.80	1620.77
88	643.63	**964.83**	1286.17	1607.49
89	638.31	**956.85**	1275.53	1594.19
90	632.99	**948.87**	1264.89	1580.89
91	627.67	**940.89**	1254.25	1567.59
92	622.35	**932.90**	1243.60	1554.28
93	617.02	**924.91**	1232.94	1540.96
94	611.69	**916.92**	1222.28	1527.63
95	606.36	**908.92**	1211.61	1514.30
96	601.02	**900.91**	1200.94	1500.97
97	595.69	892.91	**1190.27**	1487.62
98	590.34	884.90	**1179.59**	1474.27
99	585.00	876.88	**1168.90**	1460.92
100	579.66	868.87	**1158.21**	1447.55
101	574.31	860.84	**1147.52**	1434.18

Feature Description (continued)

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage (1) (continued)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
102	568.96	852.82	**1136.81**	1420.81
103	563.61	844.79	**1126.11**	1407.43
104	558.25	836.76	**1115.40**	1394.04
105	552.89	828.72	**1104.68**	1380.65
106	547.53	820.68	**1093.96**	1367.24
107	542.17	812.63	**1083.23**	1353.84
108	536.80	804.59	**1072.50**	1340.42
109	531.43	796.53	**1061.77**	1327.01
110	526.06	788.48	**1051.02**	1313.58
111	520.69	780.42	**1040.28**	1300.15
112	515.31	772.35	**1029.53**	1286.71
113	509.93	764.29	**1018.77**	1273.26
114	504.55	756.21	**1008.01**	1259.81
115	499.17	748.14	**997.24**	1246.36
116	493.78	740.06	**986.47**	1232.89
117	488.39	731.98	**975.69**	1219.42
118	483.00	723.89	**964.91**	1205.95
119	477.61	715.80	**954.12**	1192.46
120	472.21	707.70	943.33	**1178.98**
121	466.81	699.61	932.53	**1165.48**
122	461.41	691.50	921.73	**1151.98**
123	456.00	683.40	910.92	**1138.47**
124	450.60	675.29	900.11	**1124.96**
125	445.19	667.18	889.29	**1111.44**
126	439.78	659.06	878.47	**1097.91**
127	434.36	650.94	867.64	**1084.38**
128	428.94	642.81	856.81	**1070.84**
129	423.52	634.68	845.97	**1057.29**
130	418.10	626.55	835.13	**1043.74**
131	412.67	618.41	824.28	**1030.18**
132	407.25	610.27	813.43	**1016.62**
133	401.82	602.13	802.57	**1003.05**
134	396.38	593.98	791.71	**989.47**
135	390.95	585.83	780.84	**975.89**
136	385.51	577.67	769.97	**962.30**
137	380.07	569.51	759.09	**948.70**
138	374.63	561.35	748.20	**935.10**
139	369.18	553.18	737.32	**921.49**
140	363.73	545.01	726.42	**907.87**
141	358.28	536.84	715.52	**894.25**
142	352.83	528.66	704.62	**880.62**
143	347.37	520.48	693.71	**866.99**
144	341.91	512.29	682.80	**853.35**
145	336.45	504.10	671.88	**839.70**
146	330.99	495.91	660.95	**826.05**

Feature Description (continued)

Table 1. LM57-Q1 V_{TEMP} Temperature to Voltage (1) (continued)

Temperature (°C)	V_{TEMP} VOLTAGE (mV)			
	J2 (-5.166 mV/°C)	J3 (–7.752 mV/°C)	J4 (–10.339 mV/°C)	J5 (–12.924 mV/°C)
147	325.52	487.71	650.03	**812.39**
148	320.05	479.51	639.09	**798.73**
149	314.58	471.30	628.15	**785.05**
150	309.10	463.09	617.21	**771.38**
151	*303.63*	*454.88*	*606.26*	***757.69***
152	*298.15*	*446.66*	*595.30*	***744.00***
153	*292.66*	*438.44*	*584.35*	***730.30***
154	*287.18*	*430.22*	*573.38*	***716.60***
155	*281.69*	*421.99*	*562.41*	***702.89***
156	*276.20*	*413.76*	*551.44*	***689.17***
157	*270.71*	*405.52*	*540.46*	***675.45***
158	*265.22*	*397.28*	*529.47*	***661.72***
159	*259.72*	*389.04*	*518.48*	***647.99***
160	*254.22*	*380.79*	*507.49*	***634.25***
161	*248.71*	*372.54*	*496.49*	***620.50***
162	*243.21*	*364.28*	*485.48*	*606.75*
163	*237.70*	*356.02*	*474.47*	*592.98*
164	*232.19*	*347.76*	*463.46*	*579.22*
165	*226.68*	*339.50*	*452.44*	*565.45*
166	*221.16*	*331.23*	*441.41*	*551.67*
167	*215.64*	*322.95*	*430.38*	*537.88*
168	*210.12*	*314.67*	*419.35*	*524.09*
169	*204.60*	*306.39*	*408.31*	*510.29*
170	*199.07*	*298.11*	*397.26*	*494.59*
171	*193.54*	*289.82*	*386.21*	*480.52*
172	*188.01*	*281.52*	*375.15*	*466.44*
173	*182.48*	*273.23*	*364.09*	*452.36*
174	*176.94*	*264.92*	*353.03*	*438.27*
175	*171.40*	*256.62*	*341.96*	*424.17*

7.3.1.1 LM57-Q1 V_{TEMP} Voltage-to-Temperature Equations

$$V_{TEMP} = a\,(T-30)^2 + b\,(T-30) + c \quad (1)$$

where

- V_{TEMP} is in mV and T is in °C

$$T = \frac{-b - \sqrt{b^2 - 4a(c - V_{TEMP})}}{2a} + 30°C \quad (2)$$

where

- T is in °C and V_{TEMP} is in mV

Table 2. LM57-Q1 V_{TEMP} Voltage-to-Temperature Equations Coefficients

Trip-Point Region	LM57-Q1 Trip Point Range	a	b	c
J2	−41°C to 52°C	– 0.00129	− 5.166	947.6
J3	52°C to 97°C	– 0.00191	− 7.752	1420.9
J4	97°C to 119°C	– 0.00253	− 10.339	1894.3
J5	119°C to 160°C	– 0.00316	− 12.924	2367.7

7.3.2 R_{SENSE}

The LM57-Q1 uses the voltage at the two SENSE pins to set the trip point for the temperature switch. It is possible to drive the two SENSE pins with a voltage equal to the value generated by the resistor and the internal current-source and have the same switch point. Thus one can use an external DAC to drive each SENSE pin, allowing for the temperature trip point to be set dynamically by the system processor. Table 3 shows the R_{SENSE} value and its corresponding generated SENSE pin voltage (the center value).

Table 3. R_{SENSE} Values (kΩ) vs SENSE Pin Voltage (mV)

R_{SENSE} (kΩ)	SENSE Pin Voltage (mV)
	Center Value
976	1875
825	1585
698	1341
590	1134
499	959
412	792
340	653
280	538
226	434
178	342
140	269
105	202
75	146
46.4	87
22.6	43
0.01	0

7.3.3 Resistor Selection

Table 4. Trip Point (°C) vs Sense Resistor (R_{SENSE}) Values (Ω) (1)

		R_{SENSE2}													
		J2 (2)				J3 (2)			J4 (2)		J5				
		976 kΩ	825 kΩ	698 kΩ	590 kΩ	499 kΩ	412 kΩ	340 kΩ	280 kΩ	226 kΩ	178 kΩ	140 kΩ	105 kΩ	75 kΩ	46.4 kΩ
R_{SENSE1}	976 kΩ	–40.68	–16.26	7.33	30.38	52.73	67.77	82.74	97.47	108.61	119.62	128.46	137.28	146.08	*154.77*
	825 kΩ	–39.13	–14.76	8.79	31.81	53.68	68.71	83.67	98.17	109.30	120.18	129.01	137.83	146.62	*155.31*
	698 kΩ	–37.57	–13.27	10.24	33.24	54.62	69.65	84.60	98.86	110.00	120.73	129.56	138.38	147.16	*155.85*
	590 kΩ	–36.03	–11.78	11.70	34.67	55.56	70.59	85.53	99.56	110.70	121.28	130.12	138.93	147.71	*156.39*
	499 kΩ	–34.49	–10.29	13.15	36.10	56.50	71.52	86.46	100.25	111.39	121.84	130.67	139.49	148.25	*156.93*
	412 kΩ	–32.95	–8.81	14.60	37.53	57.44	72.46	87.40	100.95	112.09	122.39	131.22	140.04	148.80	*157.46*
	340 kΩ	–31.41	–7.32	16.05	38.95	58.39	73.40	88.33	101.64	112.79	122.94	131.77	140.59	149.34	*158.00*
	280 kΩ	–29.88	–5.83	17.49	40.38	59.33	74.33	89.26	102.34	113.48	123.50	132.32	141.14	149.88	*158.54*
	226 kΩ	–28.34	–4.35	18.93	41.81	60.27	75.27	90.19	103.03	114.18	124.05	132.87	141.69	150.43	*159.08*
	178 kΩ	–26.83	–2.88	20.36	43.23	61.21	76.20	91.12	103.73	114.87	124.60	133.43	142.24	*150.97*	*159.62*
	140 kΩ	–25.32	–1.42	21.79	44.65	62.15	77.14	92.05	104.42	115.57	125.15	133.98	142.79	*151.51*	*160.16*
	105 kΩ	–23.80	0.04	23.22	46.07	63.08	78.07	92.99	105.11	116.26	125.71	134.53	143.34	*152.06*	
	75 kΩ	–22.29	1.50	24.65	47.50	64.02	79.01	93.92	105.81	116.95	126.26	135.08	143.89	*152.60*	
	46.4 kΩ	–20.77	2.96	26.08	48.92	64.96	79.94	94.84	106.50	117.65	126.81	135.63	144.44	*153.14*	
	22.6 kΩ	–19.26	4.42	27.51	50.33	65.90	80.87	95.77	107.19	118.34	127.36	136.18	144.99	*153.68*	
	0.01 kΩ	–17.75	5.88	28.94	51.75	66.84	81.81	96.70	107.89	119.04	127.91	136.73	145.54	*154.23*	

(1) Temperatures above 150°C apply to the LM57FSPWQ1 and LM57TSPWQ1 only and are italicized.
(2) There are four gains corresponding to each of the four Temperature Trip Point Ranges:
J2 (-5.166 mV/°C) is the temperature sensor output gain used for Temperature Trip Points −40.68°C to 51.8°C.
J3 (-7.752 mV/°C) is for Trip Points 52°C to 97°C.
J4 (-10.339 mV/°C) for 97°C to 119°C.
J5 (-12.924 mV/°C) for 119°C to 160°C.

Table 5. V_{TEMP} (mV) at the Trip Point vs Sense Resistor (R_{SENSE}) Value (Ω) (1)

		R_{SENSE2}													
		J2 (2)				J3 (2)			J4 (2)		J5 (2)				
		976 kΩ	825 kΩ	698 kΩ	590 kΩ	499 kΩ	412 kΩ	340 kΩ	280 kΩ	226 kΩ	178 kΩ	140 kΩ	105 kΩ	75 kΩ	46.4 kΩ
R_{SENSE1}	976 kΩ	1306.23	1183.77	1064.00	945.63	1243.67	1125.34	1006.75	1185.27	1066.00	1184.05	1064.59	944.83	824.96	*705.99*
	825 kΩ	1298.50	1176.23	1056.56	938.23	1236.27	1117.93	999.34	1177.83	1058.52	1176.57	1057.10	937.33	817.53	*698.60*
	698 kΩ	1290.72	1168.70	1049.13	930.83	1228.88	1110.52	991.92	1170.40	1051.03	1169.10	1049.62	929.83	810.09	*691.20*
	590 kΩ	1283.03	1161.16	1041.69	923.43	1221.48	1103.10	984.51	1162.96	1043.55	1161.63	1042.13	922.33	802.66	*683.81*
	499 kΩ	1275.33	1153.62	1034.26	916.02	1214.09	1095.69	977.09	1155.52	1036.07	1154.16	1034.65	914.83	795.22	*676.41*
	412 kΩ	1267.64	1146.09	1026.82	908.62	1206.69	1088.28	969.66	1148.09	1028.59	1146.68	1027.16	907.33	787.78	*669.02*
	340 kΩ	1259.94	1138.55	1019.38	901.22	1199.30	1080.87	962.22	1140.65	1021.10	1139.21	1019.67	899.83	780.35	*661.62*
	280 kΩ	1252.25	1131.02	1011.99	893.82	1191.90	1073.45	954.78	1133.22	1013.62	1131.74	1012.19	892.33	772.91	*654.22*
	226 kΩ	1244.55	1123.48	1004.62	886.42	1184.50	1066.04	947.35	1125.78	1006.14	1124.27	1004.70	884.83	765.48	*646.83*
	178 kΩ	1236.99	1116.05	997.26	879.02	1177.11	1058.63	939.91	1118.35	998.66	1116.79	997.22	877.33	*758.04*	*639.43*
	140 kΩ	1229.38	1108.61	989.89	871.61	1169.71	1051.22	932.48	1110.91	991.17	1109.32	989.73	869.82	*750.61*	*632.04*
	105 kΩ	1221.76	1101.18	982.53	864.21	1162.32	1043.80	925.04	1103.48	983.69	1101.85	982.25	862.32	*743.17*	
	75 kΩ	1214.15	1093.74	975.16	856.81	1154.92	1036.39	917.61	1096.04	976.21	1094.38	974.76	854.82	*735.74*	
	46.4 kΩ	1206.53	1086.30	967.80	849.41	1147.53	1028.98	910.17	1088.60	968.73	1086.90	967.28	847.32	*728.30*	
	22.6 kΩ	1198.92	1078.87	960.43	842.01	1140.13	1021.57	902.74	1081.17	961.24	1079.43	959.79	839.82	*720.86*	
	0.01 kΩ	1191.30	1071.43	953.07	834.62	1132.74	1014.15	895.30	1073.73	953.76	1072.04	952.31	832.32	*713.43*	

(1) Items italicized and highlighted in red apply to the LM57FSPWQ1 and LM57TSPWQ1 only.
(2) There are four gains corresponding to each of the four Temperature Trip Point Ranges:
J2 (-5.166 mV/°C) is the temperature sensor output gain used for Temperature Trip Points −40.68°C to 51.8°C.
J3 (-7.752 mV/°C) is for Trip Points 52°C to 97°C.
J4 (-10.339 mV/°C) for 97°C to 119°C.
J5 (-12.924 mV/°C) for 119°C to 160°C.

7.3.4 T_{OVER} and $\overline{T_{OVER}}$ Digital Outputs

The T_{OVER} active high, push-pull output and the $\overline{T_{OVER}}$ Active Low, Open-Drain Output both assert at the same time whenever the Die Temperature reaches the Trip Point. They also assert simultaneously whenever the TRIP TEST pin is set high. Both outputs de-assert when the die temperature goes below the (Temperature Trip Point) - (Hysteresis). These two types of digital outputs enable the user the flexibility to choose the type of output that is most suitable for his design.

Either the T_{OVER} or the $\overline{T_{OVER}}$ Digital Output pins can be left open if not used.

The $\overline{T_{OVER}}$ Active Low, Open-Drain Digital Output, if used, requires a pullup resistor between this pin and V_{DD}.

7.3.4.1 T_{OVER} and $\overline{T_{OVER}}$ Noise Immunity

The LM57-Q1 has some noise immunity to a premature trigger due to noise on the power supply. With the die temperature at 1°C below the trip point, there are no premature triggers for a square wave injected into the power supply with a magnitude of 100 mV_{PP} over a frequency range of 100 Hz to 2 MHz. Above the frequency a premature trigger may occur.

With the die temperature at 2°C below the trip point, and a magnitude of 200 mV_{PP}, there are no premature triggers from 100 Hz to 300 kHz. Above that frequency a premature trigger may occur.

Therefore if the supply line is noisy, it is recommended that a local supply decoupling capacitor be used to reduce that noise.

7.3.5 Trip Test Digital Input

The TRIP TEST pin provides a means to test the digital outputs by causing them to assert, regardless of temperature.

In addition, when the TRIP TEST pin is pulled high the V_{TEMP} pin will be at the V_{TRIP} voltage.

7.3.6 V_{TEMP} Analog Temperature Sensor Output

The V_{TEMP} push-pull output provides the ability to sink and source significant current. This is beneficial when, for example, driving dynamic loads like an input stage on an analog-to-digital converter (ADC). In these applications the source current is required to quickly charge the input capacitor of the ADC. See the *Typical Application* section for more discussion of this topic. The LM57-Q1 is ideal for this and other applications which require strong source or sink current.

7.3.6.1 V_{TEMP} Noise Considerations

A load capacitor on V_{TEMP} can help to filter noise.

For noisy environments, TI recommends a 100 nF supply decoupling capacitor placed closed across V_{DD} and GND pins of LM57-Q1.

7.3.6.2 V_{TEMP} Capacitive Loads

The V_{TEMP} Output handles capacitive loading well. In an extremely noisy environment, or when driving a switched sampling input on an ADC, it may be necessary to add some filtering to minimize noise coupling. Without any precautions, the V_{TEMP} can drive a capacitive load less than or equal to 1100 pF as shown in Figure 13. For capacitive loads greater than 1100 pF, a series resistor is required on the output, as shown in Figure 14, to maintain stable conditions.

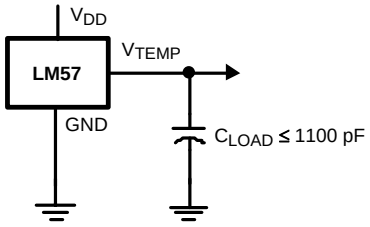


Figure 13. LM57-Q1 With No Isolation Resistor Required

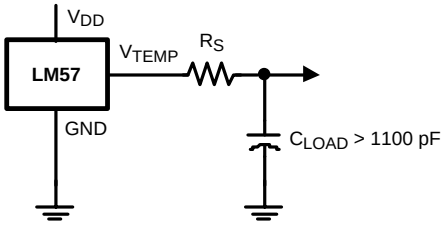


Figure 14. LM57-Q1 With Series Resistor for Capacitive Loading Greater than 1100 pF

Table 6. C_{LOAD} and R_S Values of Figure 14

C_{LOAD}	Minimum R_S
1.1 to 99 nF	3 kΩ
100 to 999 nF	1.5 kΩ
1 µF	750 Ω

7.3.6.3 V_{TEMP} Voltage Shift

The LM57-Q1 is very linear over temperature and supply voltage range. Due to the intrinsic behavior of an NMOS/PMOS rail-to-rail buffer, a slight shift in the output can occur when the supply voltage is ramped over the operating range of the device. The location of the shift is determined by the relative levels of V_{DD} and V_{TEMP}. The shift typically occurs when $V_{DD} - V_{TEMP} = 1$ V.

This slight shift (a few millivolts) takes place over a wide change (approximately 200 mV) in V_{DD} or V_{TEMP}. Since the shift takes place over a wide temperature change of 5°C to 20°C, V_{TEMP} is always monotonic. The accuracy specifications in the *Electrical Characteristics* table already includes this possible shift.

7.4 Device Functional Modes

The LM57-Q1 has several modes of operation as detailed in the following drawings.

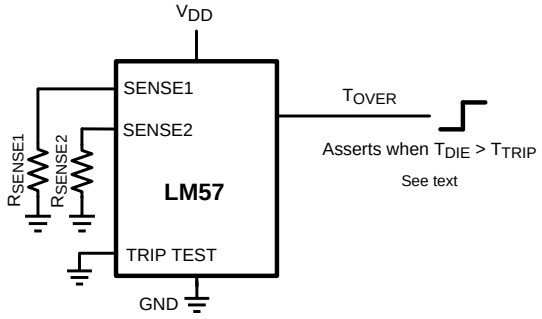


Figure 15. Temperature Switch Using Push-Pull Output

Device Functional Modes (continued)

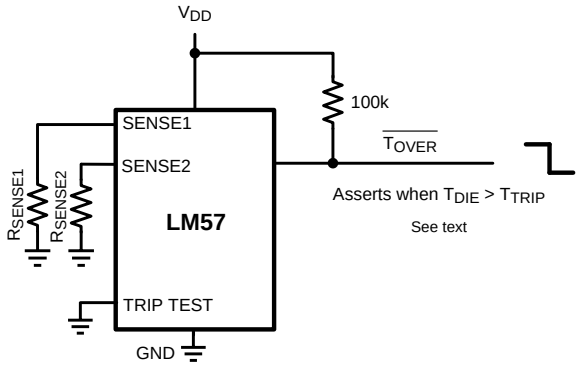


Figure 16. Temperature Switch Using Open-Drain Output

As shown in Figure 17 the LM57-Q1 has a TRIP Test input simplifying in situ board conductivity testing. Forcing TRIP TEST pin "HIGH" will drive the $\overline{T_{OVER}}$ pin "LOW" and the T_{OVER} pin "HIGH".

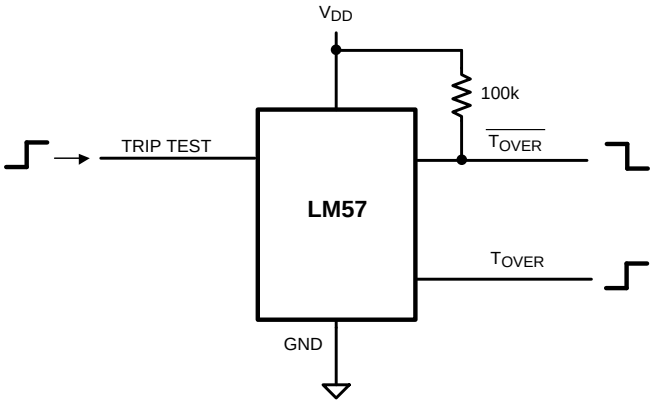


Figure 17. Trip Test Digital Output Test Circuit

In the circuit shown in Figure 18 when T_{OVER} goes active high, it drives trip test high. Trip test high causes T_{OVER} to stay high. It is therefore latched. To release the latch, power down, then power up. The LM57-Q1 always comes up in a released condition.

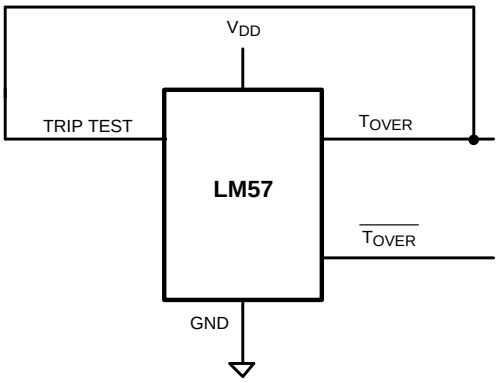


Figure 18. Simple Latch Circuit

Device Functional Modes (continued)

The TRIP TEST pin, normally used to check the operation of the T_{OVER} and $\overline{T_{OVER}}$ pins, may be used to latch the outputs whenever the temperature exceeds the programmed limit and causes the digital outputs to assert. As shown in Figure 19, when T_{OVER} goes high, the TRIP TEST input is also pulled high and causes T_{OVER} output to latch high and the $\overline{T_{OVER}}$ output to latch low. Momentarily switching the TRIP TEST input low will reset the LM57-Q1 to normal operation. The resistor limits the current out of the T_{OVER} output pin.

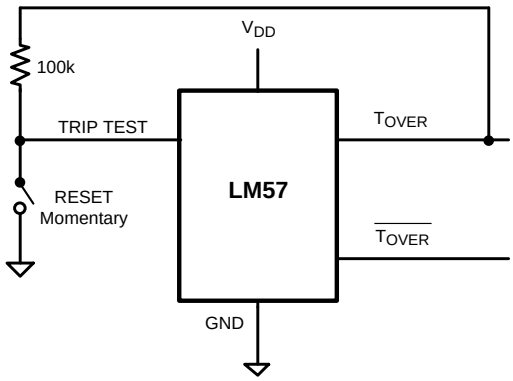


Figure 19. Latch Circuit Using T_{OVER} Output

8 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. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM57-Q1 has several outputs allowing for varying system implementations.

8.1.1 ADC Input Considerations

The LM57-Q1 has an analog temperature sensor output (V_{TEMP}) that can be directly connected to an ADC (Analog to Digital Converter) input. Most CMOS ADCs found in microcontrollers and ASICs have a sampled data comparator input structure. When the ADC charges the sampling cap, it requires instantaneous charge from the output of the analog source such as the LM57-Q1 temperature sensor and many op amps. This requirement is easily accommodated by the addition of a capacitor (C_{FILTER}). The size of C_{FILTER} depends on the size of the sampling capacitor and the sampling frequency. Because not all ADCs have identical input stages, the charge requirements will vary. The general ADC application shown in Figure 20 is an example only.

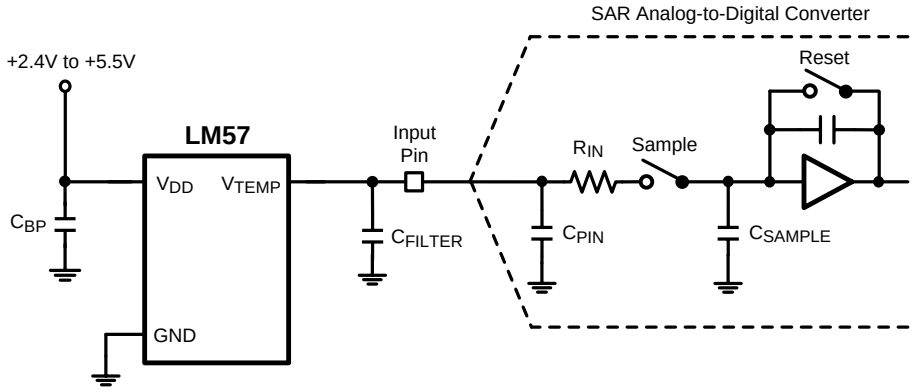


Figure 20. Suggested Connection to a Sampling Analog-to-Digital Converter Input Stage

8.2 Typical Application

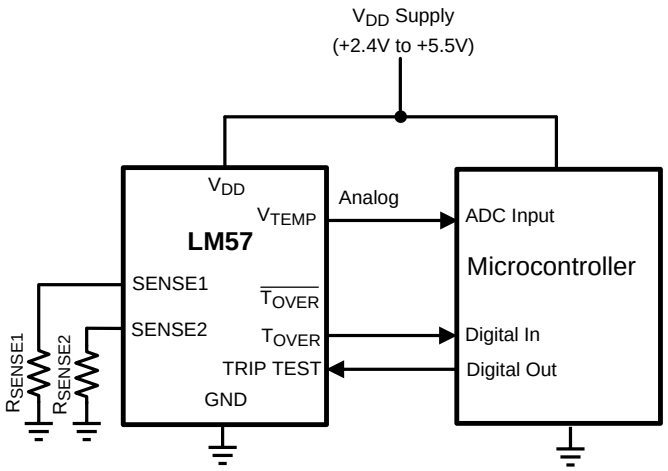


Figure 21. Typical Application Schematic with Microcontroller TRIP TEST Control

Typical Application (continued)

8.2.1 Design Requirements

By simply selecting the value of two resistors the trip point of the LM57-Q1 can easily be programmed as described in the following section. If standard 1% values are used the actual trip point threshold is not degraded and stands as described in the Electrical Characteristics section ( ).

8.2.2 Detailed Design Procedure

8.2.2.1 Selection of R_{SENSE} Resistors

To set the trip point:

1. Locate the desired trip temperature in .
2. Identify the corresponding R_{SENSE2} value by following the column up to the resistor value.
3. Identify the corresponding R_{SENSE1} value by following the row leftwards to the resistor value.
4. Use only the EIA E96 standard resistor values from the list.
5. Use only a resistor with 1% tolerance and a temperature coefficient of 100 ppm (or better). These restrictions are necessary to stay at the selected setting, and not to slip into an adjacent setting.
6. This is consistent with using resistors from the thick film chip resistors CRCW0402 family. These are available with very small dimensions of L = 1 mm, W = 0.5 mm, H = 0.35 mm.
7. Note that the resistor tolerance does not diminish the accuracy of the trip point. As can be seen in the block diagram these inputs drive the logic inputs of a DAC thus their tolerance does affect the trip point accuracy unless the DAC setting slips into an adjacent level. See patent number 6924758.

8.2.3 Application Curves

The typical performance of the LM57TSPWQ1 temperature sensor output can be seen in Figure 22. Figure 23 shows the output behavior of the LM57-Q1 T_{OVER} output.

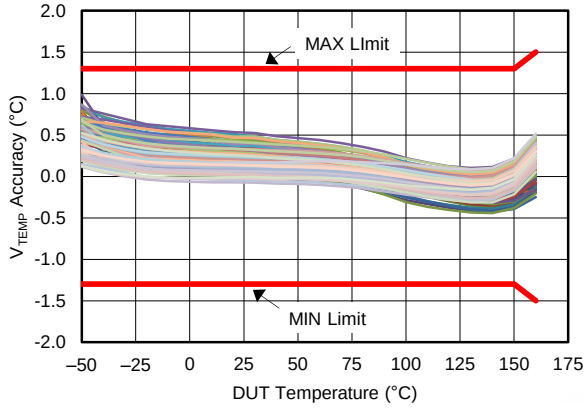


Figure 22. J2 V_{TEMP} Accuracy Characteristics

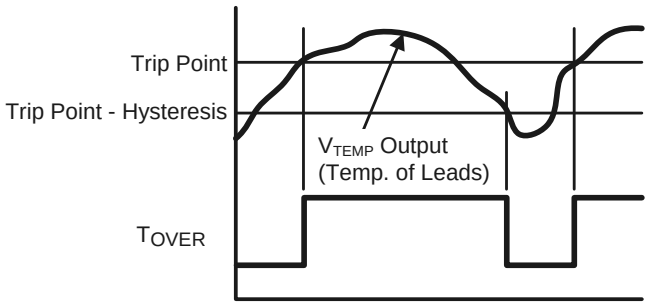


Figure 23. Output Transfer Characteristic

Typical Application (continued)

8.2.4 Grounding of the TRIP TEST Pin

The circuit in Figure 24 shows the TRIP TEST pin grounded. This allows the LM57-Q1 to function autonomously without microcontroller intervention. In all other respects this circuit functions similarly to the circuit shown in Figure 21.

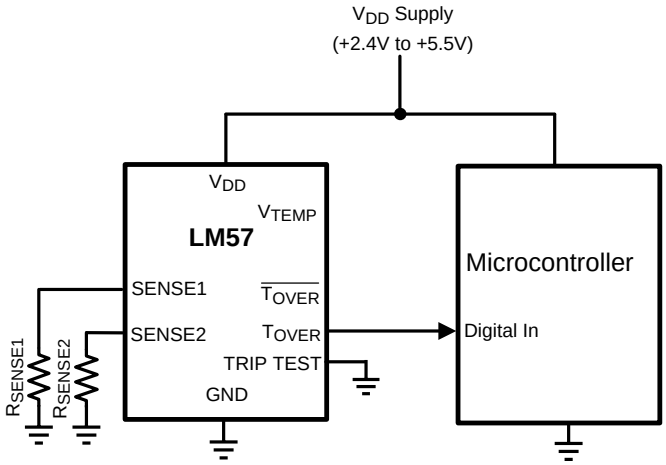


Figure 24. Typical Application Schematic without Microcontroller TRIP TEST Control

9 Power Supply Recommendations

Power supply bypass capacitors are optional and may be required if the supply line is noisy. TI recommends that a local supply decoupling capacitor be used to reduce noise. For noisy environments, TI recommends a 100-nF supply decoupling capacitor placed closed across V_{DD} and GND pins of LM57-Q1.

10 Layout

10.1 Layout Guidelines

The LM57-Q1 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface. The temperatures of the lands and traces to the other leads of the LM57-Q1 will also affect the temperature reading.

Alternatively, the LM57-Q1 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM57-Q1 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. If moisture creates a short circuit from the V_{TEMP} output to ground or V_{DD}, the V_{TEMP} output from the LM57-Q1 will not be correct. Printed-circuit coatings are often used to ensure that moisture cannot corrode the leads or circuit traces.

10.2 Layout Example

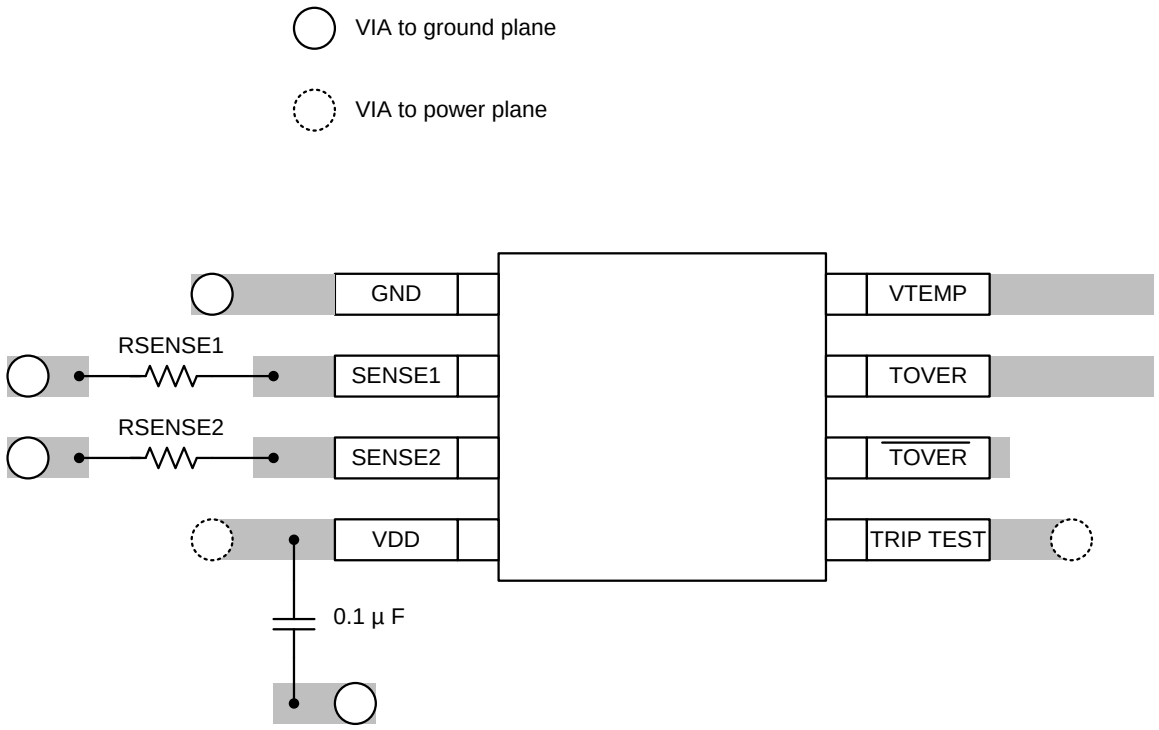


Figure 25. PW (TSSOP) Package Layout Example

10.3 Temperature Considerations

The junction temperature of the LM57-Q1 is the actual temperature being measured. The thermal resistance junction-to-ambient ($R_{\theta JA}$) is the parameter (from) used to calculate the rise of a device junction temperature due to its power dissipation. Equation 3 is used to calculate the rise in the die temperature of the LM57-Q1.

$$T_J = T_A + R_{\theta JA} \left[(V_{DD} I_Q) + (V_{DD} - V_{TEMP}) \; I_L \right] \quad (3)$$

where

- T_A is the ambient temperature.
- I_Q is the quiescent current.
- I_L is the load current on V_{TEMP}.
- $R_{\theta JA}$ can be found in

For example using an LM57-Q1 in the PW (TSSOP) package, in an application where T_A = 30°C, V_{DD} = 5.5 V, I_{DD} = 28 µA, J5 gain, V_{TEMP} = 2368 mV, and I_L = 0 µA, the total temperature rise would be [183°C/W × 5.5 V × 28 µA] = 0.028°C. To minimize self-heating, the load current on V_{TEMP} should be minimized.

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- LM57 Commercial Data Sheet.
- *Reflow Temperature Profile* specifications, www.ti.com/packaging.
- *IC Package Thermal Metrics* application report, SPRA953

11.2 Community Resources

The following links connect to TI community resources. Linked contents are 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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

E2E is a trademark of Texas Instruments.
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11.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

12 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 (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM57FEPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 150	LM57FE	Samples
LM57FEPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 150	LM57FE	Samples
LM57FQPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 125	LM57FQ	Samples
LM57FQPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 125	LM57FQ	Samples
LM57FSPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 160	LM57FS	Samples
LM57FSPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 160	LM57FS	Samples
LM57TEPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 150	LM57TE	Samples
LM57TEPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 150	LM57TE	Samples
LM57TQPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 125	LM57TQ	Samples
LM57TQPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 125	LM57TQ	Samples
LM57TSPWQ1	ACTIVE	TSSOP	PW	8	150	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 160	LM57TS	Samples
LM57TSPWRQ1	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-50 to 160	LM57TS	Samples

(1) 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.

(2) **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 (Cl) 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.

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

(4) 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.

(6) 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.

OTHER QUALIFIED VERSIONS OF LM57-Q1 :

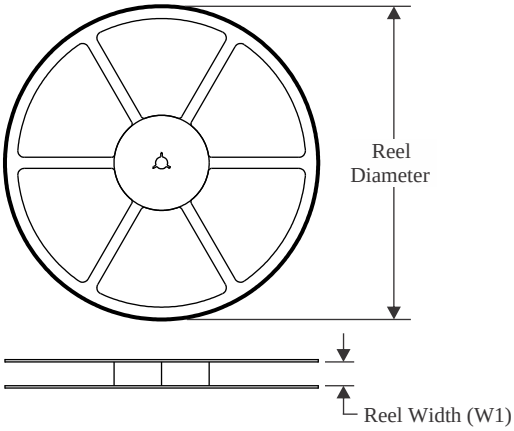
- Catalog: LM57

NOTE: Qualified Version Definitions:

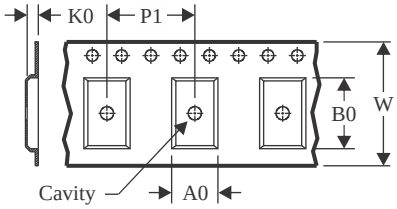
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

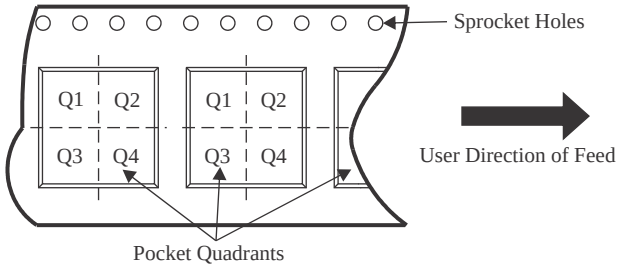


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

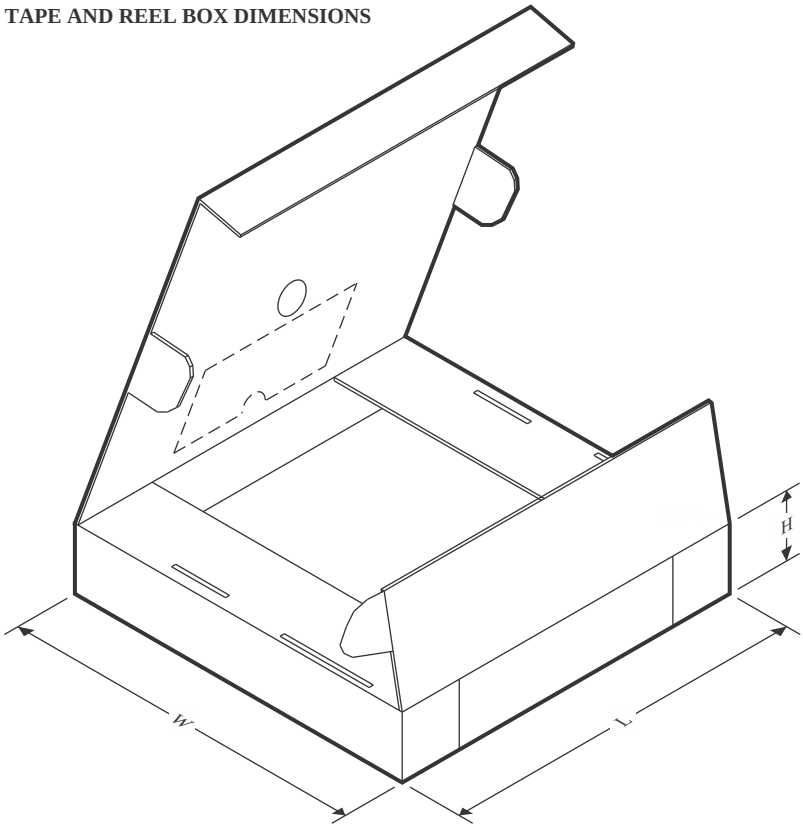
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

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
LM57FEPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM57FQPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM57FSPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM57TEPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM57TQPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM57TSPWRQ1	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

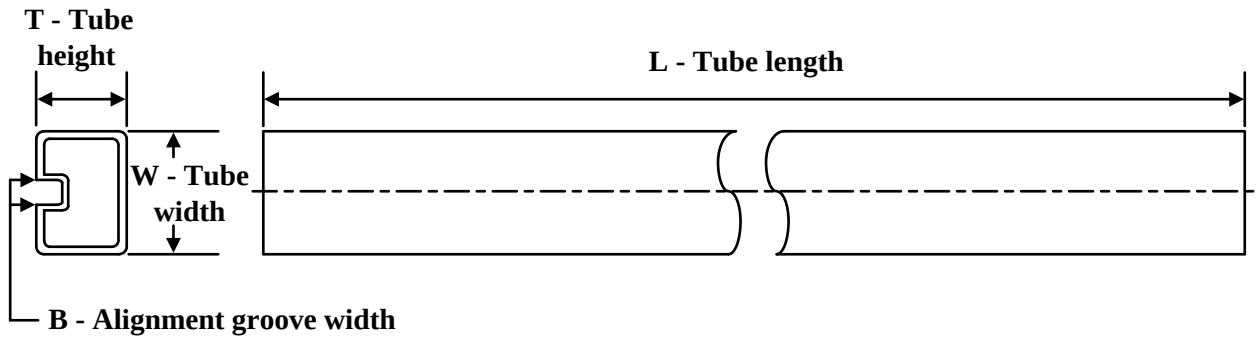
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM57FEPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0
LM57FQPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0
LM57FSPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0
LM57TEPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0
LM57TQPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0
LM57TSPWRQ1	TSSOP	PW	8	2000	356.0	356.0	35.0

TUBE



*All dimensions are nominal

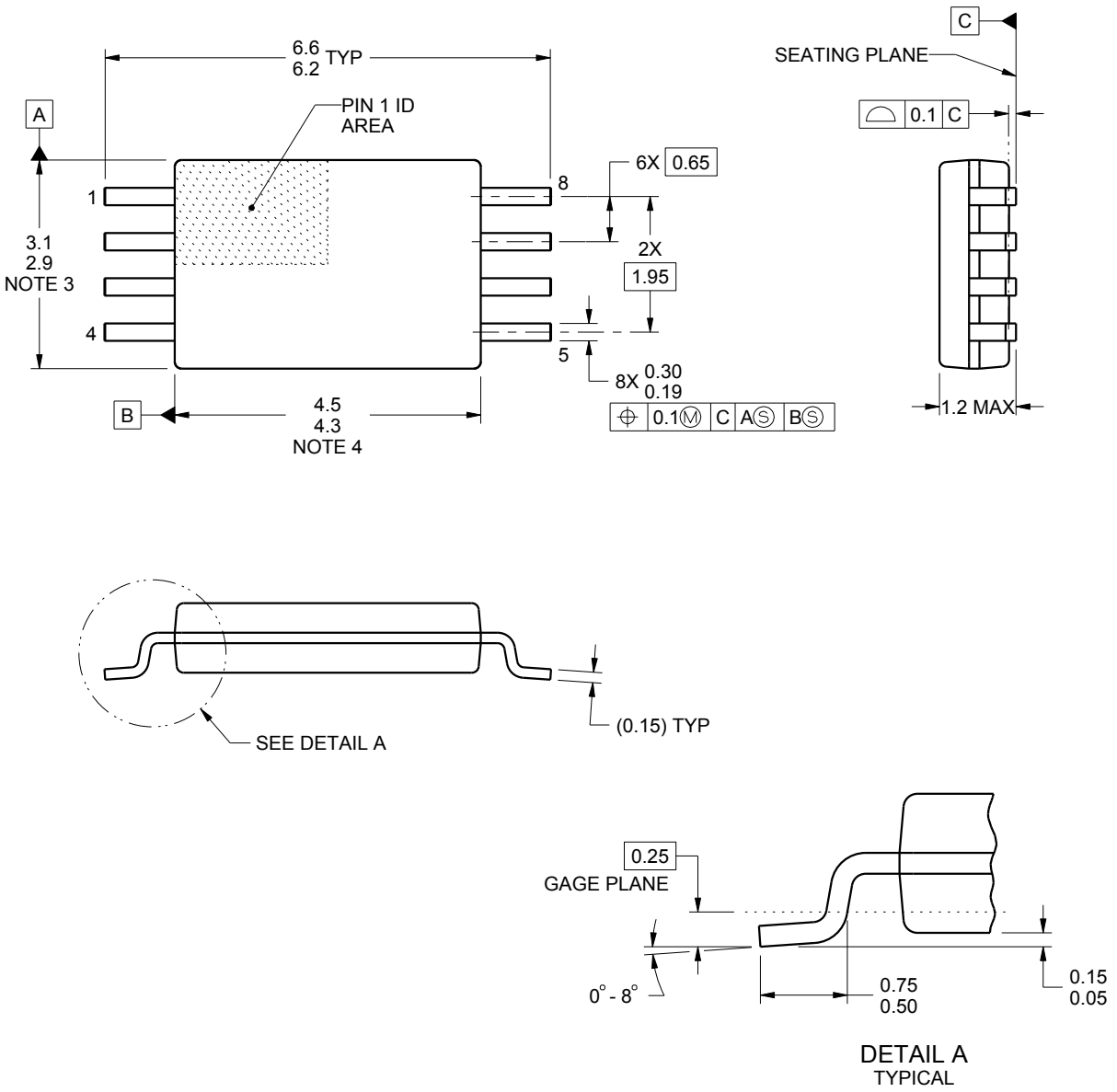
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM57FEPWQ1	PW	TSSOP	8	150	530	10.2	3600	3.5
LM57FQPWQ1	PW	TSSOP	8	150	530	10.2	3600	3.5
LM57FSPWQ1	PW	TSSOP	8	150	530	10.2	3600	3.5
LM57TEPWQ1	PW	TSSOP	8	150	508	8.5	3250	2.8
LM57TQPWQ1	PW	TSSOP	8	150	530	10.2	3600	3.5
LM57TSPWQ1	PW	TSSOP	8	150	508	8.5	3250	2.8

PACKAGE OUTLINE

PW0008A

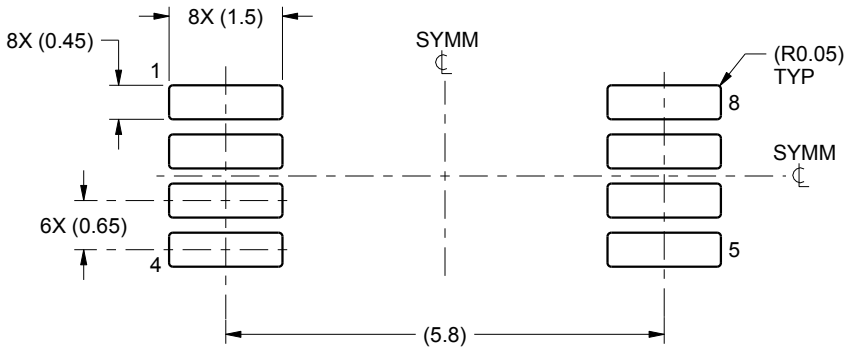
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

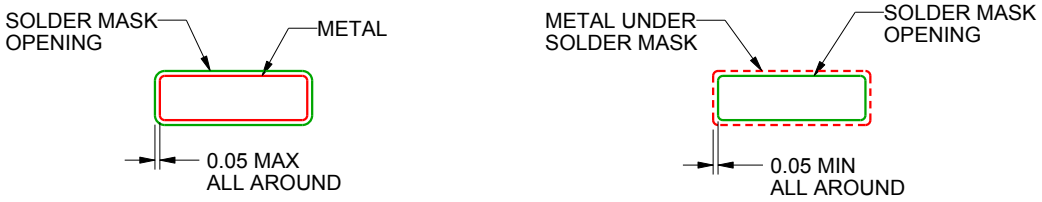


NOTES:

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.



LAND PATTERN EXAMPLE
SCALE:10X

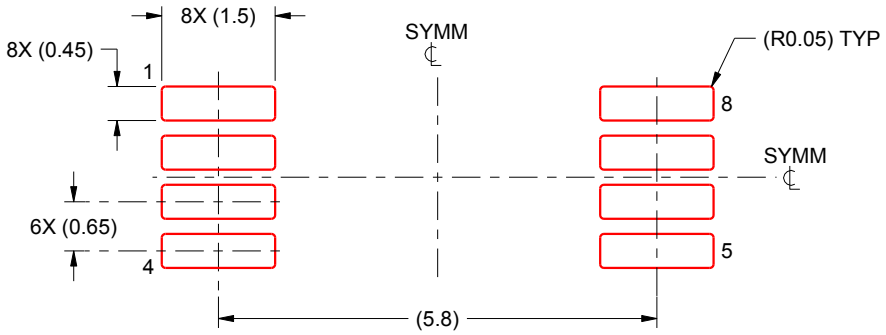


SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

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.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221848/A 02/2015

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.

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