



## 4-20mA Current-Loop Transmitter

### FEATURES

- LOW QUIESCENT CURRENT: 130 $\mu$ A
- 5V REGULATOR FOR EXTERNAL CIRCUITS
- LOW SPAN ERROR: 0.05%
- LOW NONLINEARITY ERROR: 0.003%
- WIDE-LOOP SUPPLY RANGE: 7.5V to 40V
- MSOP-8 AND DFN-8 PACKAGES

### APPLICATIONS

- TWO-WIRE, 4-20mA CURRENT LOOP TRANSMITTER
- SMART TRANSMITTER
- INDUSTRIAL PROCESS CONTROL
- TEST SYSTEMS
- CURRENT AMPLIFIER
- VOLTAGE-TO-CURRENT AMPLIFIER

### DESCRIPTION

The XTR117 is a precision current output converter designed to transmit analog 4-20mA signals over an industry-standard current loop. It provides accurate current scaling and output current limit functions.

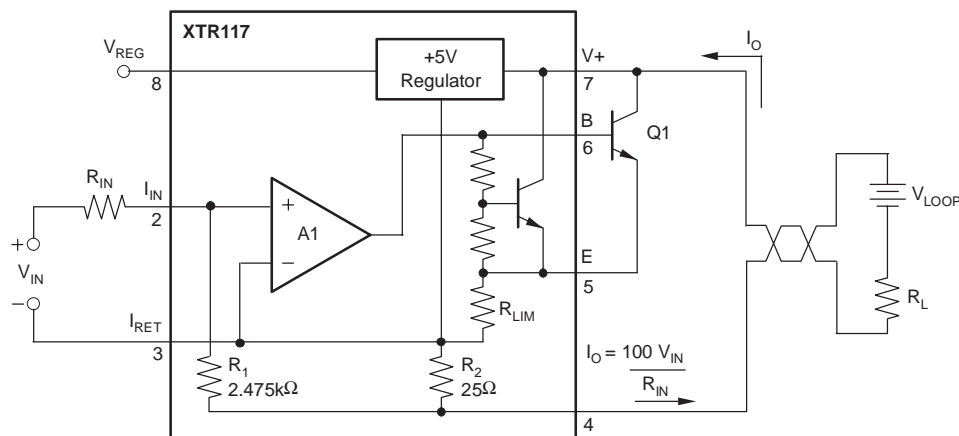
The on-chip voltage regulator (5V) can be used to power external circuitry. A current return pin ( $I_{RET}$ ) senses any current used in external circuitry to assure an accurate control of the output current.

The XTR117 is a fundamental building block of smart sensors using 4-20mA current transmission. The XTR117 is specified for operation over the extended industrial temperature range,  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### RELATED 4-20mA PRODUCTS

XTR115	5V regulator output and 2.5V reference output
XTR116	5V regulator output and 4.096V reference output

NOTE: For 4-20mA complete bridge and RTO conditioner solutions, see the XTR product family website at [www.ti.com](http://www.ti.com).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

**ABSOLUTE MAXIMUM RATINGS(1)**

Power Supply, V+ (referenced to I <sub>O</sub> pin)	+50V
Input Voltage, (referenced to I <sub>RET</sub> pin)	0V to V+
Output Current Limit	Continuous
V <sub>REG</sub> , Short-Circuit	Continuous
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-55°C to +125°C
Junction Temperature	+165°C
ESD Rating (Human Body Model)	2000V
(Charged Device Model)	1000V

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

**ELECTROSTATIC DISCHARGE SENSITIVITY**



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.

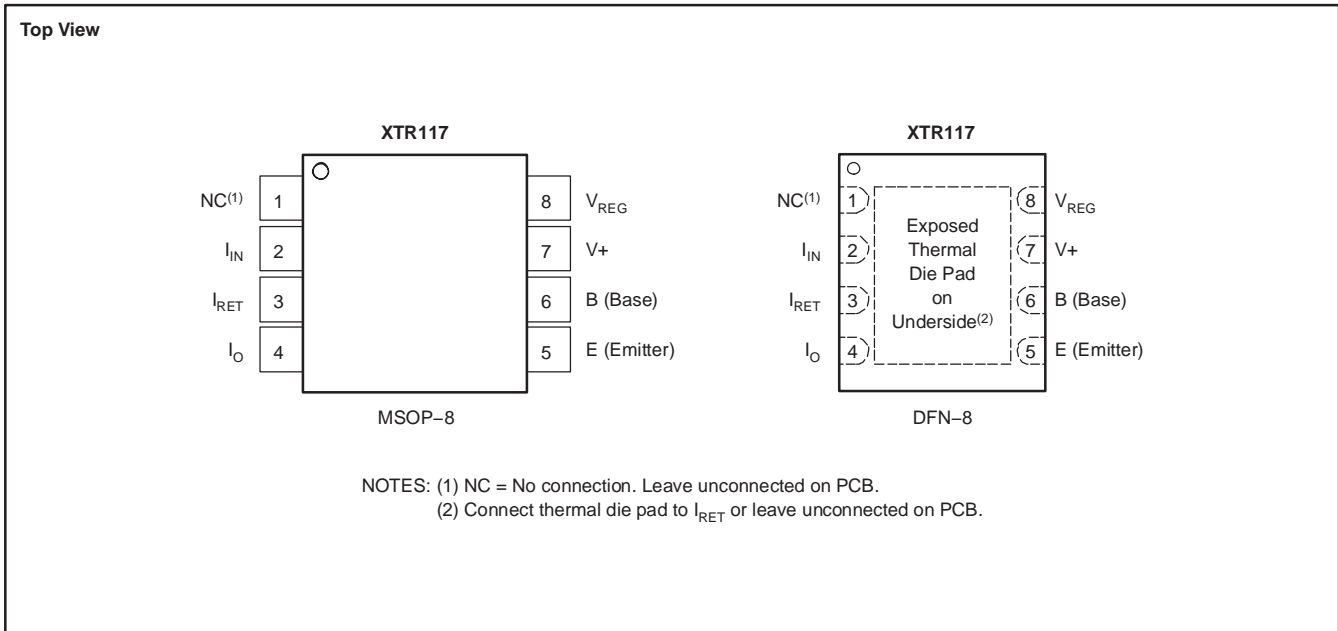
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**PACKAGE/ORDERING INFORMATION(1)**

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
XTR117	MSOP-8	DGK	BOZ
XTR117	DFN-8	DRB	BOY

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

**PIN ASSIGNMENTS**



**ELECTRICAL CHARACTERISTICS: V+ = +24V**
**Boldface** limits apply over the temperature range,  $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

 All specifications at  $T_A = +25^{\circ}\text{C}$ ,  $V_+ = 24\text{V}$ ,  $R_{IN} = 20\text{k}\Omega$ , and TIP29C external transistor, unless otherwise noted.

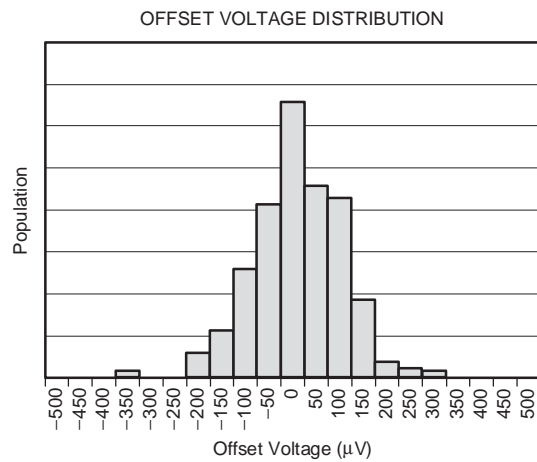
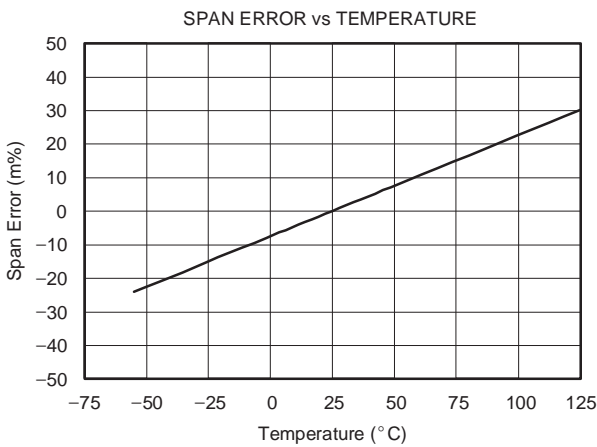
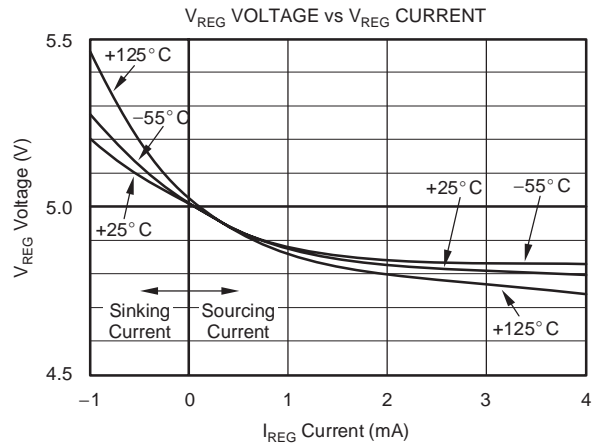
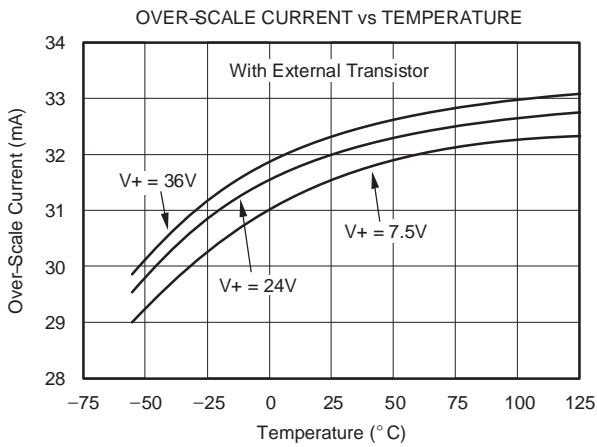
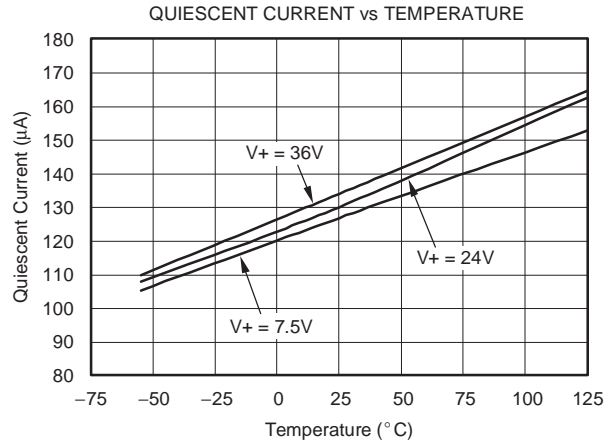
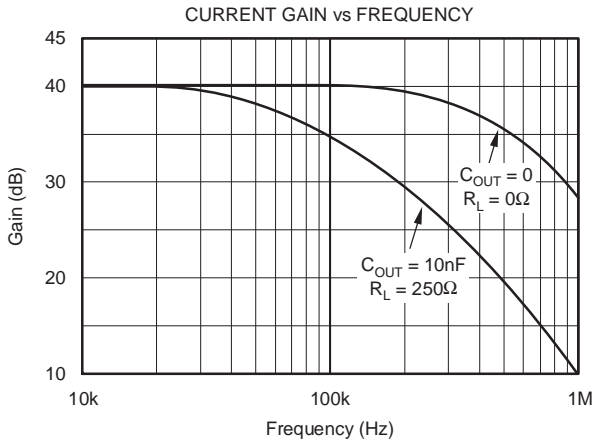
PARAMETER	CONDITION	XTR117			UNITS
		MIN	TYP	MAX	
<b>OUTPUT</b>					
Output Current Equation	$I_O$		$I_O = I_{IN} \times 100$		
Output Current, Linear Range		0.20		25	mA
Over-Scale Limit	$I_{LIM}$		32		mA
Under-Scale Limit	$I_{MIN}$		0.13	0.20	mA
	$I_{REG} = 0$				
<b>SPAN</b>					
Span (Current Gain)	S		100		A/A
Error(1)			$\pm 0.05$	$\pm 0.4$	%
<b>vs Temperature</b>			$\pm 3$	$\pm 20$	ppm/ $^{\circ}\text{C}$
Nonlinearity			$\pm 0.003$	$\pm 0.02$	%
	$I_O = 200\mu\text{A}$ to $25\text{mA}$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ $I_O = 200\mu\text{A}$ to $25\text{mA}$				
<b>INPUT</b>					
Offset Voltage (Op Amp)	$V_{OS}$		$\pm 100$	$\pm 500$	$\mu\text{V}$
<b>vs Temperature</b>			$\pm 0.7$	$\pm 6$	$\mu\text{V}/^{\circ}\text{C}$
vs Supply Voltage, V+			+0.1	+2	$\mu\text{V}/\text{V}$
Bias Current	$I_B$		-35		nA
<b>vs Temperature</b>			<b>150</b>		<b>pA/<math>^{\circ}\text{C}</math></b>
Noise: 0.1Hz to 10Hz	$e_n$		0.6		$\mu\text{V}_{PP}$
	$I_{IN} = 40\mu\text{A}$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ $V_+ = 7.5\text{V}$ to $40\text{V}$				
<b>DYNAMIC RESPONSE</b>					
Small-Signal Bandwidth			380		kHz
Slew Rate	$C_{LOOP} = 0$ , $R_L = 0$		3.2		mA/ $\mu\text{s}$
<b>VREG<sup>(2)</sup></b>					
Voltage			5		V
Voltage Accuracy			$\pm 0.05$	$\pm 0.1$	V
<b>vs Temperature</b>			$\pm 0.1$		<b>mV/<math>^{\circ}\text{C}</math></b>
vs Supply Voltage, V+			1		mV/V
vs Output Current			See Typical Characteristics		
Short-Circuit Current			12		mA
	$I_{REG} = 0$ $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ $V_+ = 7.5\text{V}$ to $40\text{V}$				
<b>POWER SUPPLY</b>					
Specified Voltage Range	V+		+24		V
Operating Voltage Range		+7.5		+40	V
Quiescent Current	$I_Q$		130	200	$\mu\text{A}$
<b>Over Temperature</b>				<b>250</b>	<b><math>\mu\text{A}</math></b>
	$T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$				
<b>TEMPERATURE RANGE</b>					
Specified Range		-40		+125	$^{\circ}\text{C}$
Operating Range		-55		+125	$^{\circ}\text{C}$
Storage Range		-55		+150	$^{\circ}\text{C}$
Thermal Resistance	$\theta_{JA}$				$^{\circ}\text{C}/\text{W}$
MSOP			150		$^{\circ}\text{C}/\text{W}$
DFN			53		$^{\circ}\text{C}/\text{W}$

 (1) Does not include initial error or temperature coefficient of  $R_{IN}$ .

 (2) Voltage measured with respect to  $I_{RET}$  pin.

**TYPICAL CHARACTERISTICS:  $V_+ = +2.7V$  to  $+5.5V$**

At  $T_A = +25^\circ C$ ,  $V_+ = 24V$ ,  $R_{IN} = 20k\Omega$ , and TIP29C external transistor, unless otherwise noted.



## APPLICATIONS INFORMATION

### BASIC OPERATION

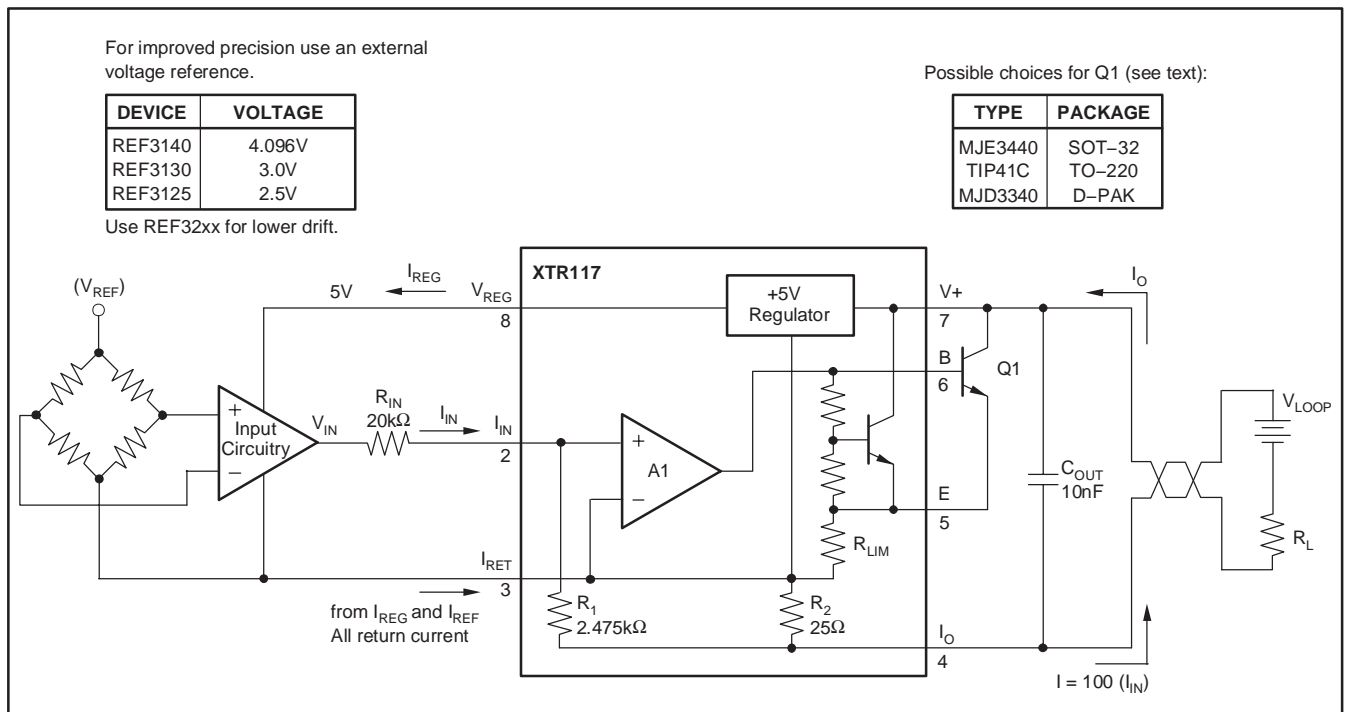
The XTR117 is a precision current output converter designed to transmit analog 4-20mA signals over an industry-standard current loop. Figure 1 shows basic circuit connections with representative simplified input circuitry. The XTR117 is a two-wire current transmitter. Its input current (pin 2) controls the output current. A portion of the output current flows into the V+ power supply, pin 7. The remaining current flows in Q<sub>1</sub>. External input circuitry connected to the XTR117 can be powered from V<sub>REG</sub>. Current drawn from these terminals must be returned to I<sub>RET</sub>, pin 3. The I<sub>RET</sub> pin is a *local ground* for input circuitry driving the XTR117.

The XTR117 is a current-input device with a gain of 100. A current flowing into pin 2 produces I<sub>O</sub> = 100 x I<sub>IN</sub>. The input voltage at the I<sub>IN</sub> pin is zero (referred to the I<sub>RET</sub> pin). A voltage input is converted to an input current with an external input resistor, R<sub>IN</sub>, as shown in Figure 1. Typical full-scale input voltages range from 1V and upward. Full-scale inputs greater than 0.5V are recommend to minimize the effects of offset voltage and drift of A1.

### EXTERNAL TRANSISTOR

The external transistor, Q<sub>1</sub>, conducts the majority of the full-scale output current. Power dissipation in this transistor can approach 0.8W with high loop voltage (40V) and 20mA output current. The XTR117 is designed to use an external transistor to avoid on-chip, thermal-induced errors. Heat produced by Q<sub>1</sub> will still cause ambient temperature changes that can influence the XTR117 performance. To minimize these effects, locate Q<sub>1</sub> away from sensitive analog circuitry, including XTR117. Mount Q<sub>1</sub> so that heat is conducted to the outside of the transducer housing.

The XTR117 is designed to use virtually any NPN transistor with sufficient voltage, current and power rating. Case style and thermal mounting considerations often influence the choice for any given application. Several possible choices are listed in Figure 1. A MOSFET transistor will not improve the accuracy of the XTR117 and is not recommended.



**Figure 1. Basic Circuit Connections**

### MINIMUM OUTPUT CURRENT

The quiescent current of the XTR117 (typically 130 $\mu$ A) is the lower limit of its output current. Zero input current ( $I_{IN} = 0$ ) will produce an  $I_O$  equal to the quiescent current. Output current will not begin to increase until  $I_{IN} > I_Q/100$ . Current drawn from  $V_{REG}$  will be added to this minimum output current. Up to 3.8mA is available to power external circuitry while still allowing the output current to go below 4mA.

### OFFSETTING THE INPUT

A low-scale output of 4mA is produced by creating a 40 $\mu$ A input current. This input current can be created with the proper value resistor from an external reference voltage ( $V_{REF}$ ) as shown in Figure 2.  $V_{REG}$  can be used as shown in Figure 2 but will not have the temperature stability of a high quality reference such as the REF3125.

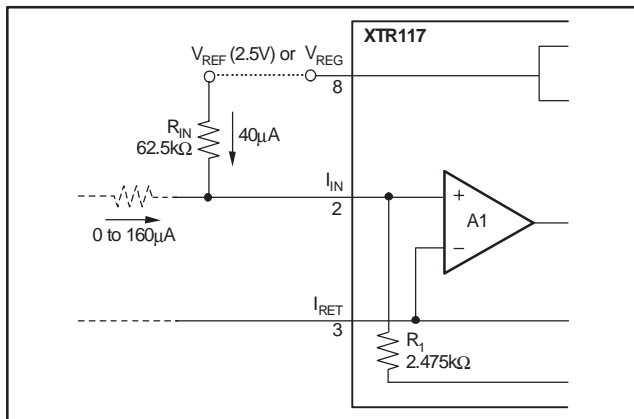


Figure 2. Creating Low-Scale Offset

### MAXIMUM OUTPUT CURRENT

The XTR117 provides accurate, linear output up to 25mA. Internal circuitry limits the output current to approximately 32mA to protect the transmitter and loop power/measurement circuitry.

It is possible to extend the output current range of the XTR117 by connecting an external resistor from pin 3 to pin 5, to change the current limit value. Since all output current must flow through internal resistors, it is possible to cause internal damage with excessive current. Output currents greater than 45mA may cause permanent damage.

### REVERSE-VOLTAGE PROTECTION

The XTR117 low compliance voltage rating (minimum operating voltage) of 7.5V permits the use of various voltage protection methods without compromising operating range. Figure 3 shows a diode bridge circuit which allows normal operation even when the voltage connection lines are reversed. The bridge causes a two diode drop (approximately 1.4V) loss in loop supply voltage. This voltage drop results in a compliance voltage of approximately 9V—satisfactory for most applications. A diode can be inserted in series with the loop supply voltage and the V+ pin to protect against reverse output connection lines with only a 0.7V loss in loop supply voltage.

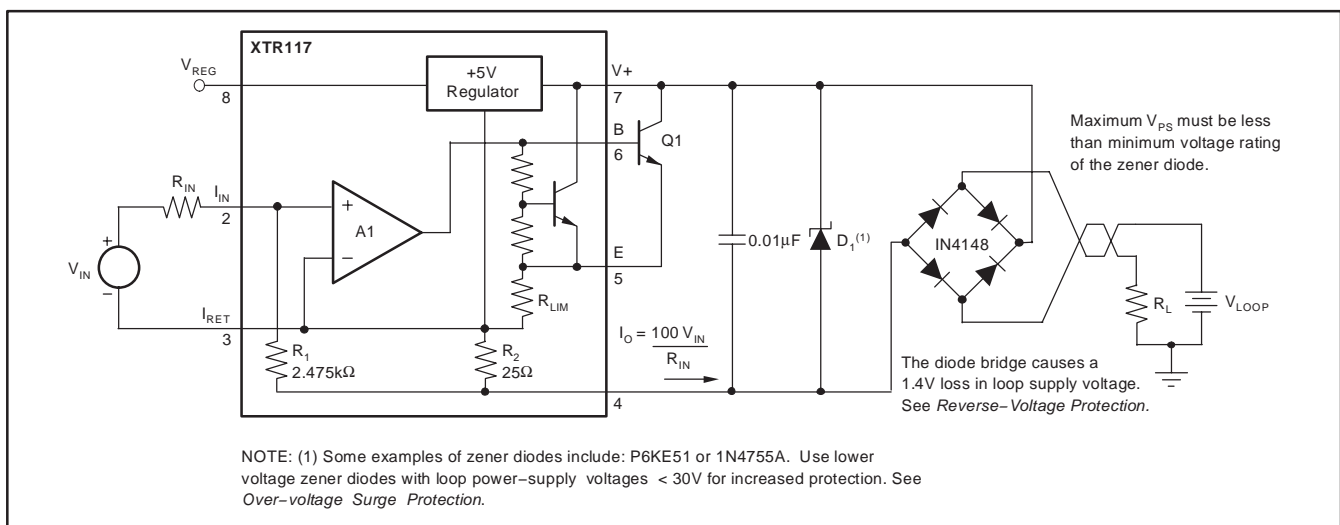


Figure 3. Reverse Voltage Operation and Over-Voltage Surge Protection

## OVER-VOLTAGE SURGE PROTECTION

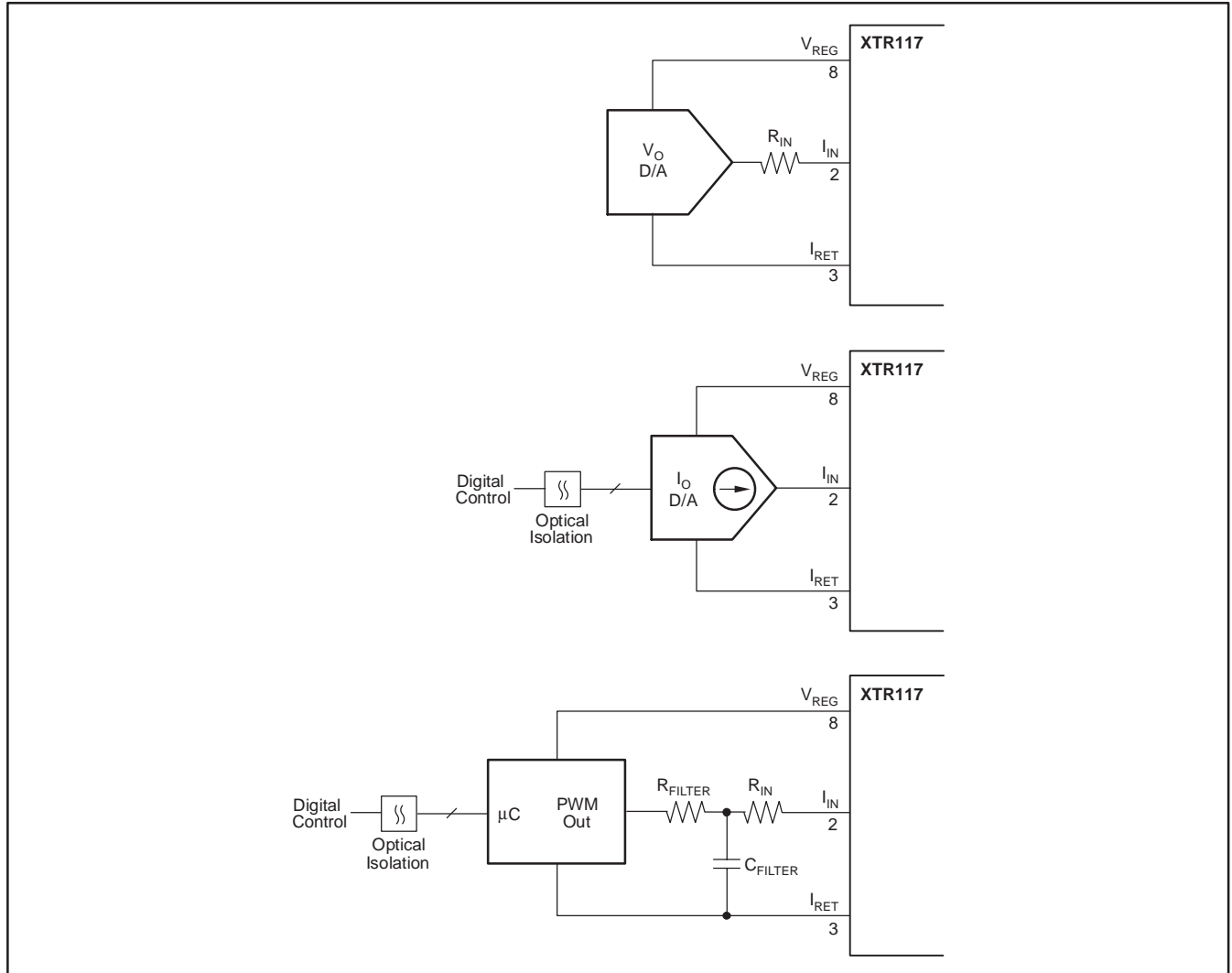
Remote connections to current transmitters can sometimes be subjected to voltage surges. It is prudent to limit the maximum surge voltage applied to the XTR117 to as low as practical. Various zener diode and surge clamping diodes are specially designed for this purpose. Select a clamp diode with as low a voltage rating as possible for best protection. Absolute maximum power-supply rating on the XTR117 is specified at +50V. Keep overvoltages and transients below +50V to ensure reliable operation when the supply returns to normal (7.5V to 40V).

Most surge protection zener diodes have a diode characteristic in the forward direction that will conduct excessive current, possibly damaging receiving-side circuitry if the loop connections are reversed. If a surge

protection diode is used, a series diode or diode bridge should be used for protection against reversed connections.

## RADIO FREQUENCY INTERFERENCE

The long wire lengths of current loops invite radio frequency (RF) interference. RF interference can be rectified by the input circuitry of the XTR117 or preceding circuitry. This effect generally appears as an unstable output current that varies with the position of loop supply or input wiring. Interference may also enter at the input terminals. For integrated transmitter assemblies with short connections to the sensor, the interference more likely comes from the current loop connections.



**Figure 4. Digital Control Methods**

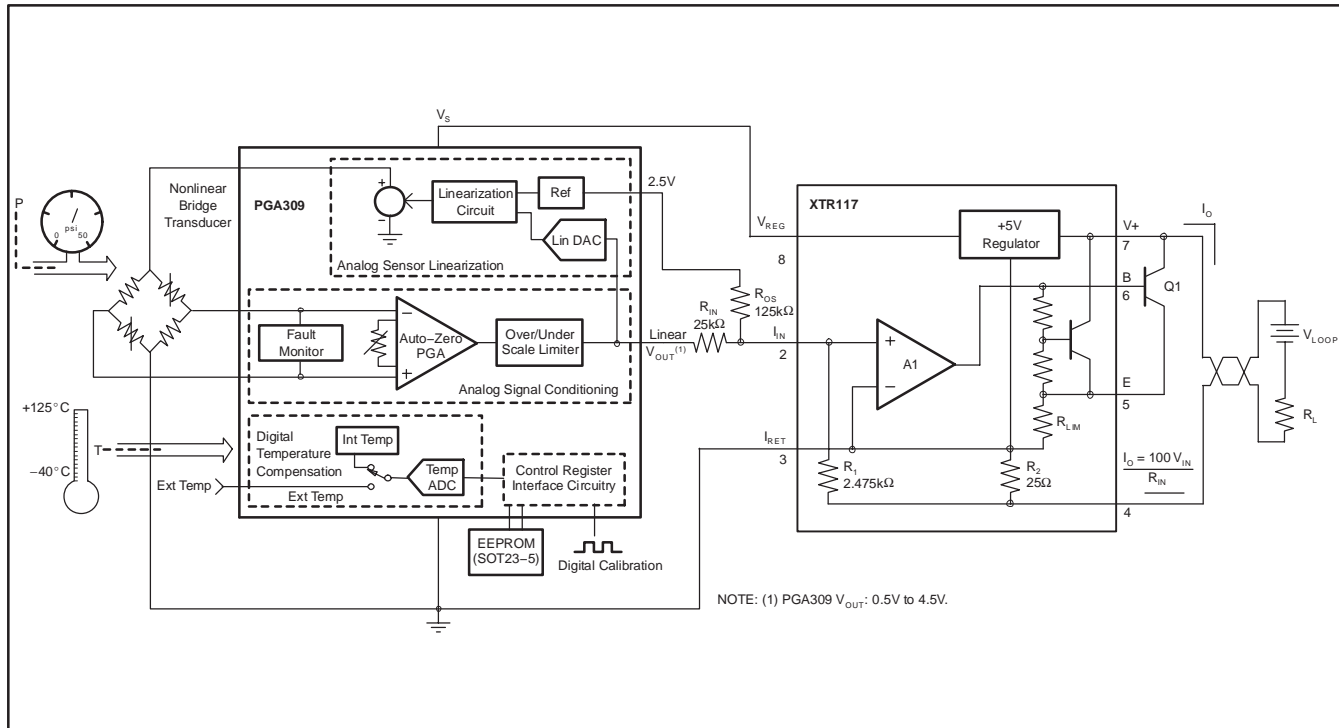


Figure 5. Complete 4-20mA Pressure Transducer Solution with PGA309 and XTR117

## DFN PACKAGE

The XTR117 is offered in a DFN-8 package (also known as SON). The DFN is a QFN package with lead contacts on only two sides of the bottom of the package. This leadless package maximizes board space and enhances thermal and electrical characteristics through an exposed pad.

DFN packages are physically small, have a smaller routing area, improved thermal performance, and improved electrical parasitics. Additionally, the absence of external leads eliminates bent-lead issues.

The DFN package can be easily mounted using standard printed circuit board (PCB) assembly techniques. See Application Note, *QFN/SON PCB Attachment* (SLUA271) and Application Report, *Quad Flatpack No-Lead Logic Packages* (SCBA017), both available for download at [www.ti.com](http://www.ti.com).

**The exposed leadframe die pad on the bottom of the package should be connected to  $I_{RET}$  or left unconnected.**

## LAYOUT GUIDELINES

The exposed leadframe die pad on the DFN package should be soldered to a thermal pad on the PCB. A mechanical drawing showing an example layout is attached at the end of this data sheet. Refinements to this layout may be required based on assembly process requirements. Mechanical drawings located at the end of this data sheet list the physical dimensions for the package and pad. The five holes in the landing pattern are optional, and are intended for use with thermal vias that connect the leadframe die pad to the heatsink area on the PCB.

Soldering the exposed pad significantly improves board-level reliability during temperature cycling, key push, package shear, and similar board-level tests. Even with applications that have low power dissipation, the exposed pad must be soldered to the PCB to provide structural integrity and long-term stability.



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
XTR117AIDGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDGKRG4	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDGKT	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDGKTG4	ACTIVE	MSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDRBR	ACTIVE	SON	DRB	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDRBRG4	ACTIVE	SON	DRB	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDRBT	ACTIVE	SON	DRB	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
XTR117AIDRBTG4	ACTIVE	SON	DRB	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

<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> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

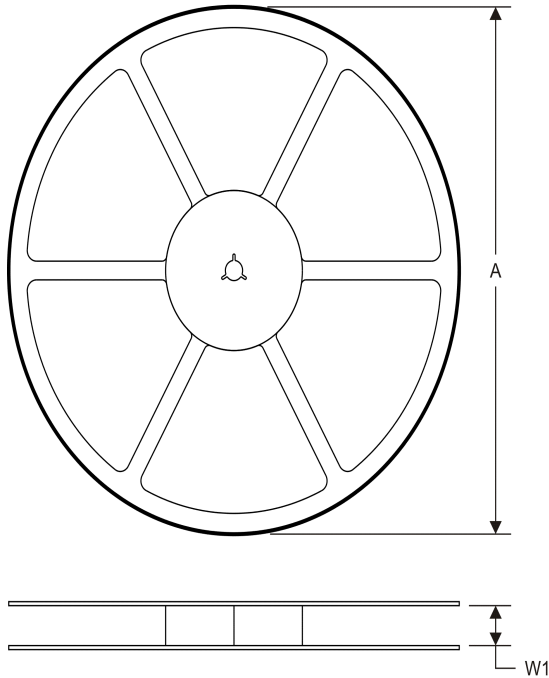
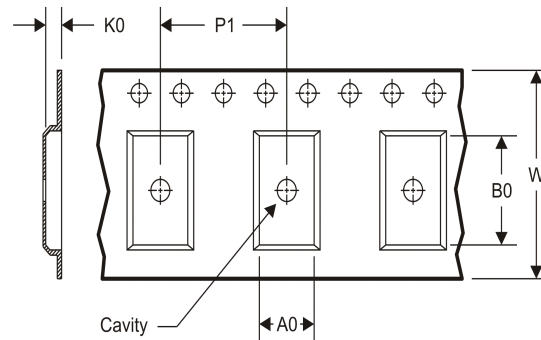
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

**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.

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.

**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

**TAPE AND REEL INFORMATION**

\*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
XTR117AIDGKR	MSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
XTR117AIDGKT	MSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
XTR117AIDRBR	SON	DRB	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
XTR117AIDRBT	SON	DRB	8	250	180.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

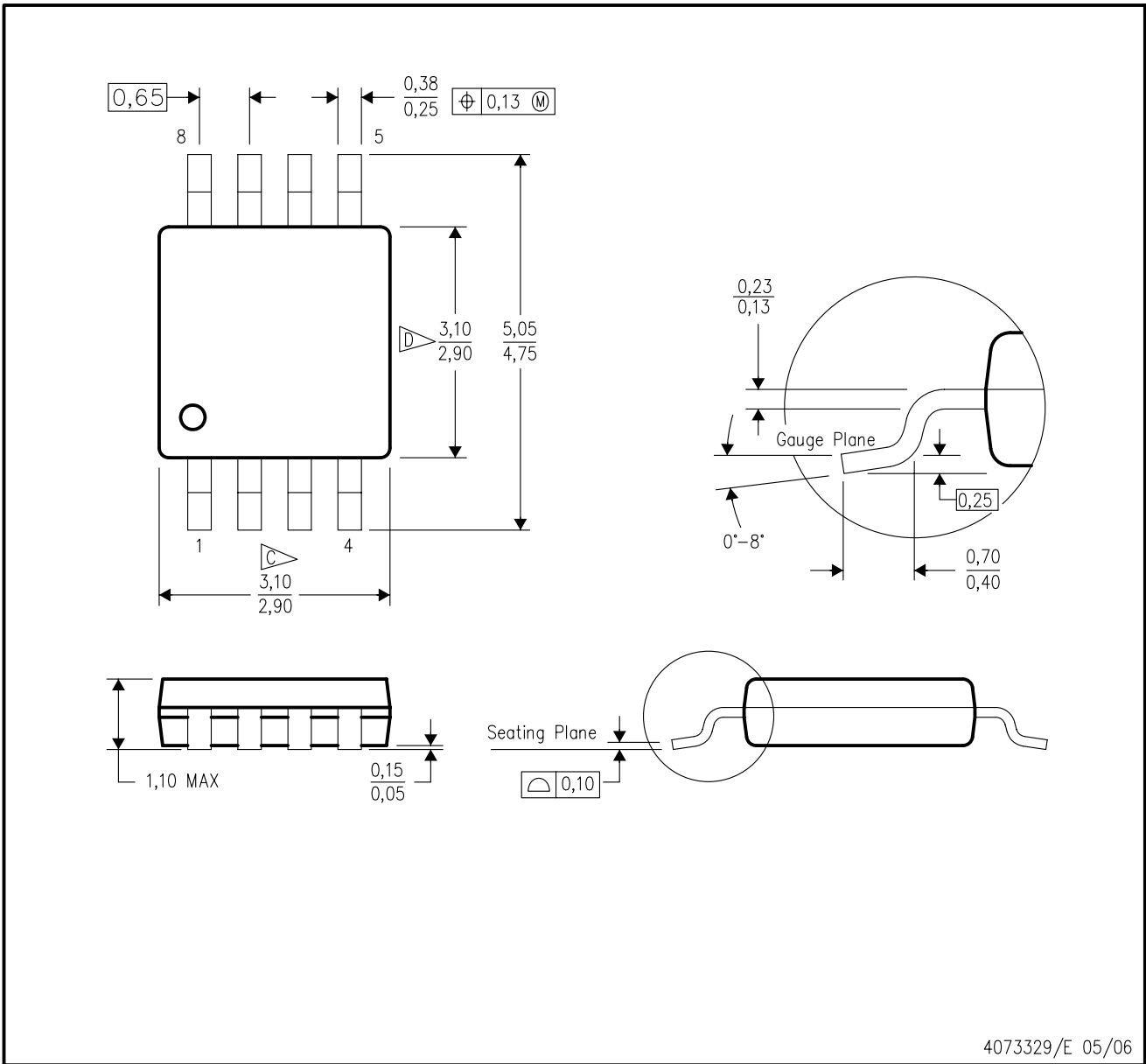
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
XTR117AIDGKR	MSOP	DGK	8	2500	346.0	346.0	29.0
XTR117AIDGKT	MSOP	DGK	8	250	210.0	185.0	35.0
XTR117AIDRBR	SON	DRB	8	3000	346.0	346.0	29.0
XTR117AIDRBT	SON	DRB	8	250	210.0	185.0	35.0

DGK (S-PDSO-G8)

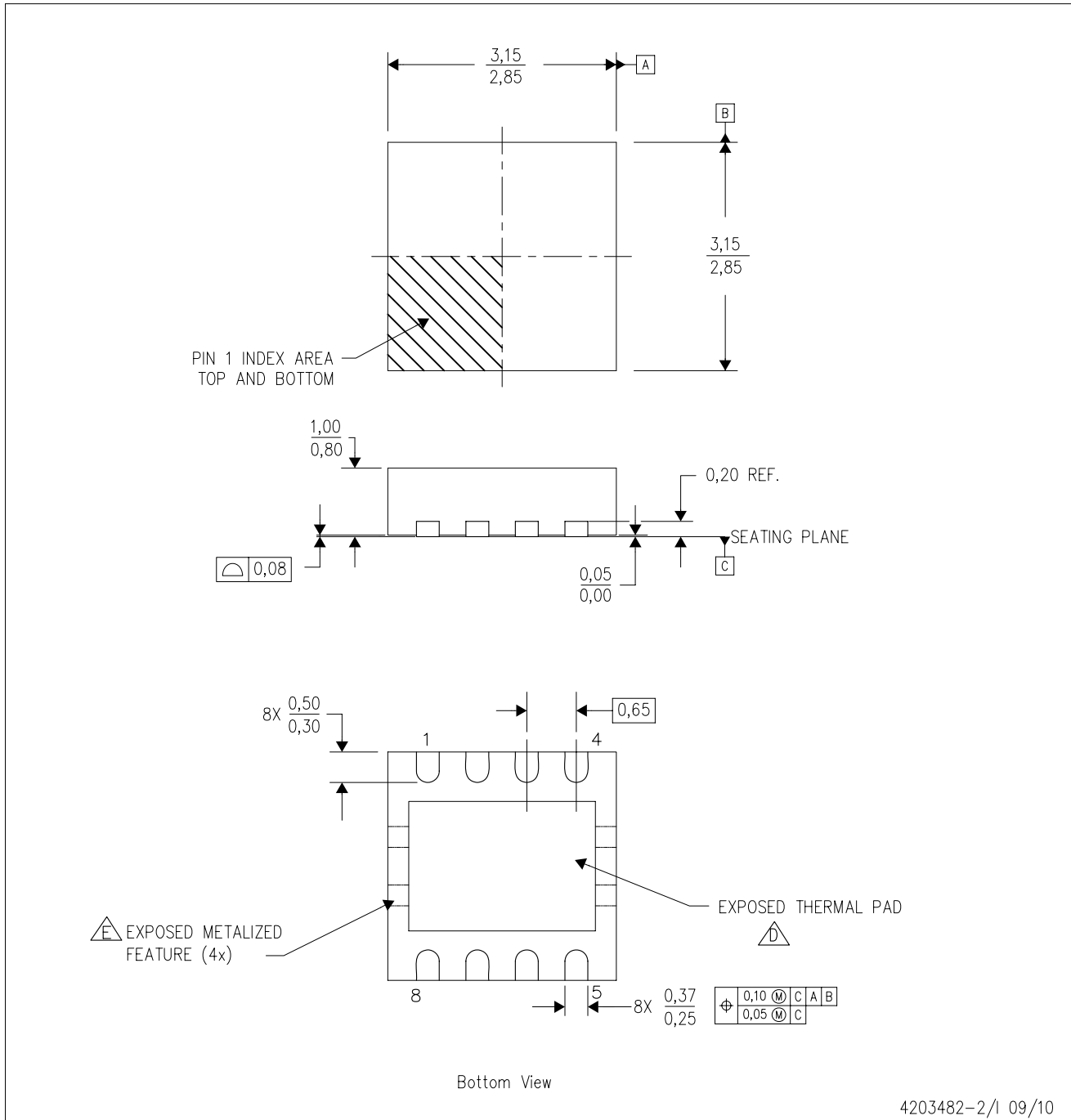
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
  - E. Falls within JEDEC MO-187 variation AA, except interlead flash.

DRB (S-PVSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



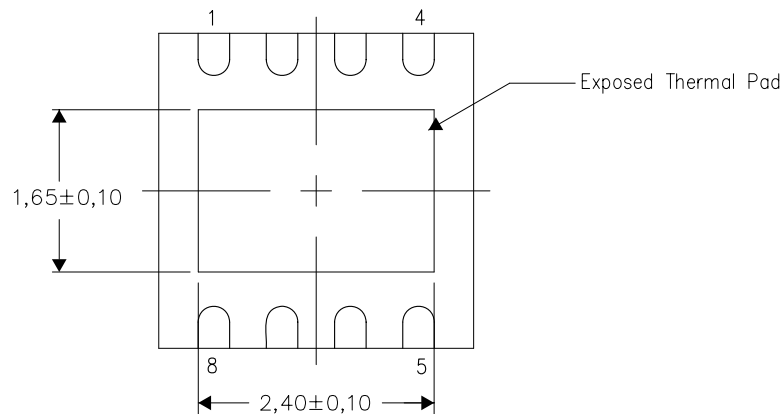
- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Small Outline No-Lead (SON) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

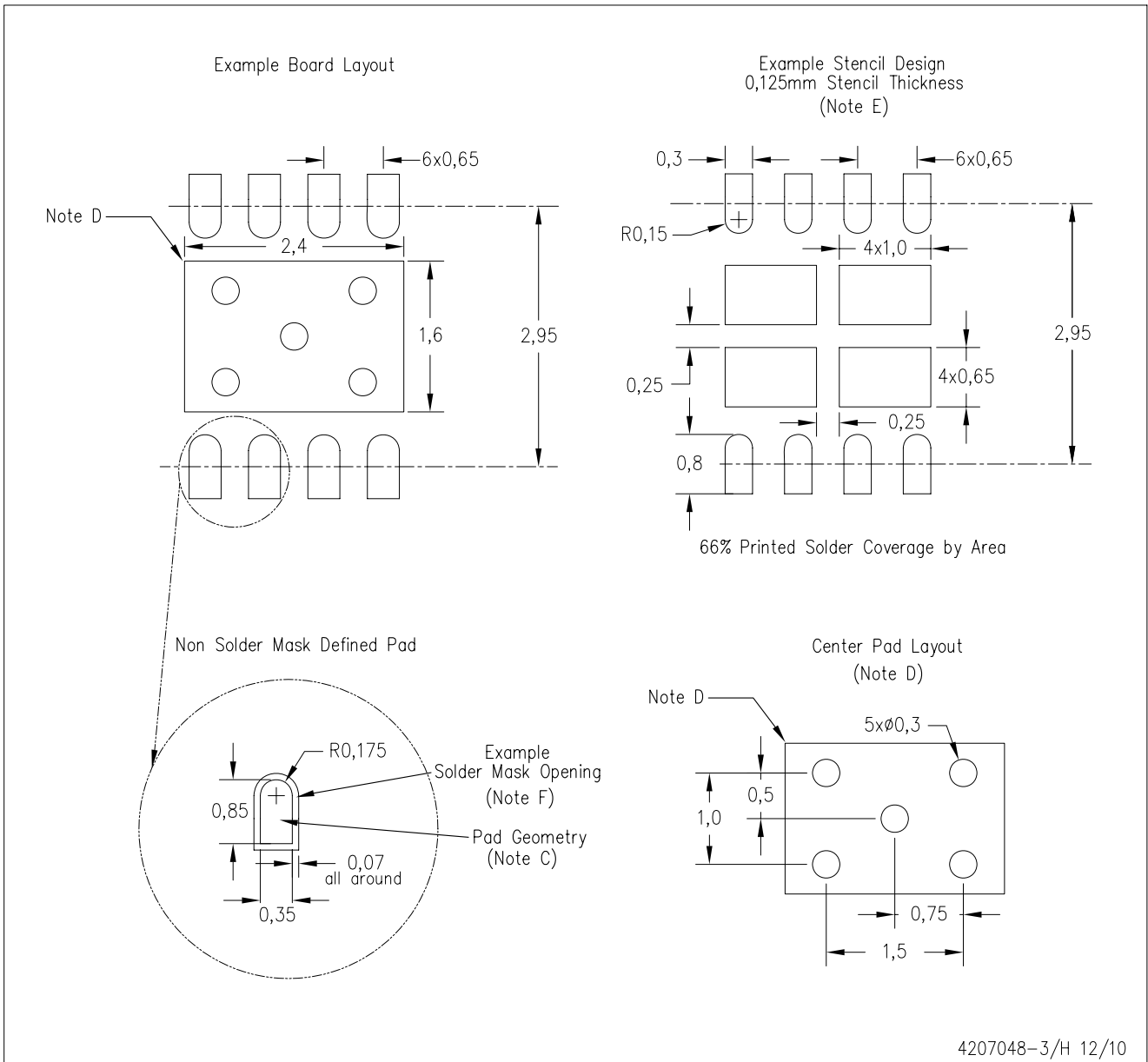
Exposed Thermal Pad Dimensions

4206340-3/L 12/10

NOTE: A. All linear dimensions are in millimeters

DRB (S-PVSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - Customers should contact their board fabrication site for solder mask tolerances.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2012, Texas Instruments Incorporated