SM74611 Smart Bypass Diode

1 Features

- Maximum reverse voltage (V_R) of 30 V
- Operating forward current (I_F) of up to 15 A
- Low average forward voltage (26 mV at 8 A)
- Less power dissipation than Schottky diode
- Lower leakage current than Schottky diode
- Footprint and pin compatible with conventional D2PAK Schottky diode
- Operating range (Tj) of -40°C to 125°C

2 Applications

- Bypass Diodes for Photovoltaic Panels
- Bypass Diodes for Microinverter and Power Optimizer

3 Description

The SM74611 is a smart bypass diode used in photovoltaic applications. It serves the purpose of providing an alternate path for string current when parts of the panel are shaded during normal operation. Without bypass diodes, the shaded cells will exhibit a hot spot which is caused by excessive power dissipation in the reverse biased cells.

Currently, conventional P-N junction diodes or Schottky diodes are used to mitigate this issue. Unfortunately the forward voltage drop for these diodes is still considered high (~0.6 V for normal diodes and 0.4 V for Schottky). With 10 A of currents flowing through these diodes, the power dissipation can reach as high as 6 W. This in turn will raise the temperature inside the junction box where these diodes normally reside and reduce module reliability.

The advantage of the SM74611 is that it has a lower forward voltage drop than P-N junction and Schottky diodes. It has a typical average forward voltage drop of 26 mV at 8A of current. This translates into typical power dissipation of 208 mW, which is significantly lower than the 3.2 W of conventional Schottky diodes. The SM74611 is also footprint and pin compatible with conventional D2PAK Schottky diodes, making it a drop-in replacement in many applications.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SM74611	DDPAK/TO-263 (KTT) (3)	10.16 mm x 9.02 mm

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

Typical Application in a Junction Box

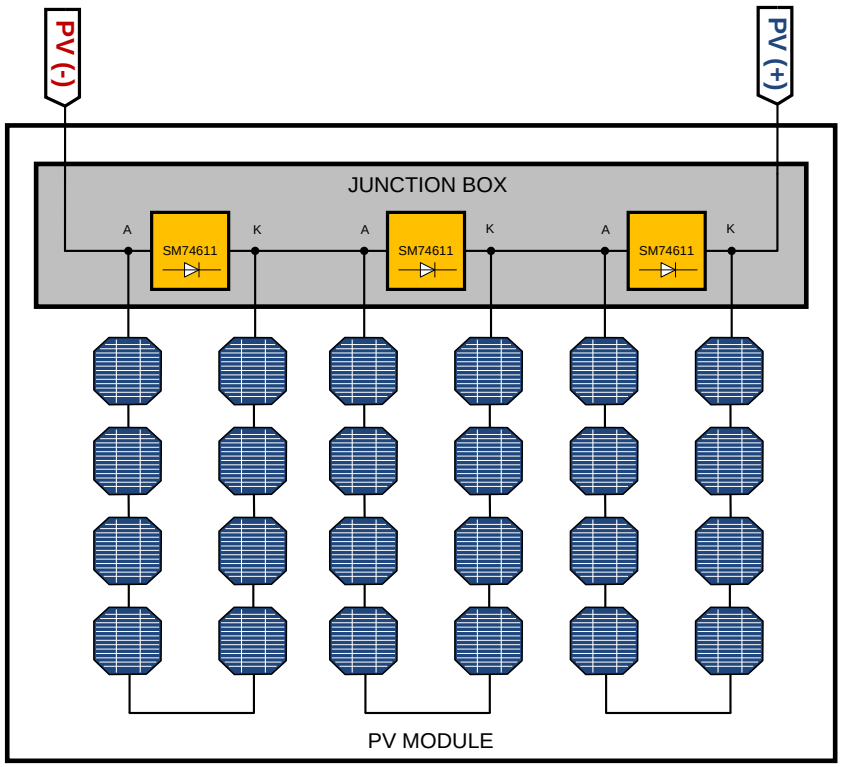


Table of Contents

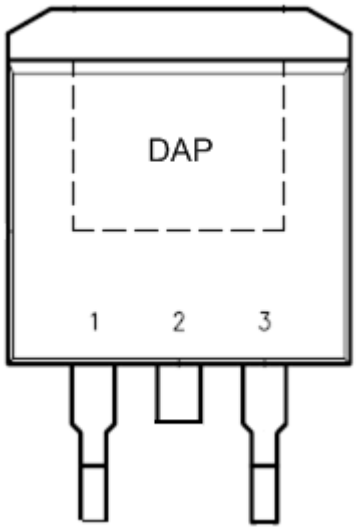
4 Revision History

Changes from Original (December 2012) to Revision A **Page**

- Added new junction temperature for t ≤ 1 hour ... 4
- Added Thermal Table ... 4
- Changed typical characteristic curves ... 5

5 Pin Configuration and Functions

DDPAK
3 Pin (KTT)
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
ANODE	1,3(1)	I	Connect both of these pins to the negative side of the PV cells
CATHODE	2,DAP(2)	O	Pin 2 and the DAP are shorted internally. Connect the DAP to the positive side of the PV cells

(1) Pin 1 and Pin 3 should be connected together for proper operation
(2) Package drawing at the end of datasheet is shown without Pin 2 being trimmed

6 Specifications

6.1 Absolute Maximum Ratings

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

	MIN	MAX	UNIT
Ambient Storage temperature, T_{stg}	-65	125	°C
DC Reverse Voltage		30	V
Forward Current		24	A
Junction Temperature, t ≤ 1 hour		135	°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) System must be thermally managed so as not to exceed maximum junction temperature

6.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±1000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±250	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±XXX V may actually have higher performance.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Pins listed as ±YYY V may actually have higher performance.

6.3 Recommended Operating Conditions (1)

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

		MIN	NOM	MAX	UNIT
DC Reverse Voltage				28	V
Junction Temperature Range (T_J)		-40		125	°C
Forward Current		0		15	A

(1) System must be thermally managed so as not to exceed maximum junction temperature

6.4 Thermal Information

THERMAL METRIC (1)		SM74611 DDPAK (KTT) 3 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	40.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	42.6	
$R_{\theta JB}$	Junction-to-board thermal resistance	23.0	
ψ_{JT}	Junction-to-top characterization parameter	9.8	
ψ_{JB}	Junction-to-board characterization parameter	22.0	
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.5	

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

6.5 Electrical Characteristics

	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
$I_{F(AVG)}$	Forward Current				8	15	A
$V_{F(AVG)}$	Forward Voltage	I_F = 8A	T_J = 25°C		26		mV

Electrical Characteristics (continued)

	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
P_D	Power Dissipation	I_F = 8A	T_J = 25°C		208		mW
			T_J = 125°C		450		
			-40°C to 125°C (1)			575	
		I_F = 15A	T_J = 25°C		695		
			T_J = 125°C		1389		
D	Duty Cycle	I_F = 8A	T_J = 25°C		99.5%		
			T_J = 125°C		96.0%		
I_R	Reverse Leakage Current	$V_{REVERSE}$ = 28V	T_J = 25°C		0.3		µA
			T_J = 125°C		3.3		

(1) Limits -40°C to 125°C apply over the entire junction temperature range for operation. Limits appearing in normal type apply for $T_A = T_J$ = 25°C.

6.6 Typical Characteristics

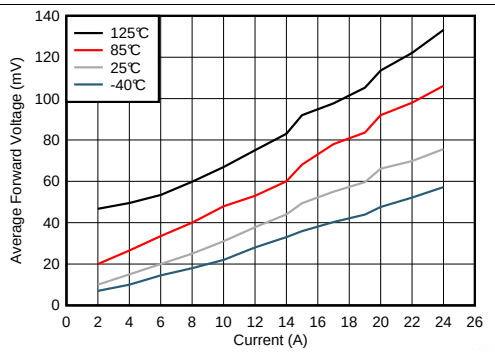


Figure 1. Average Forward Voltage (Anode to Cathode) Over Temperature

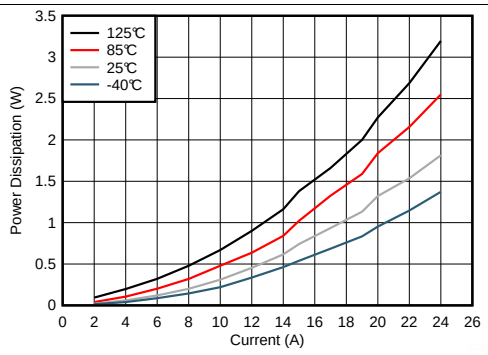


Figure 2. Power Dissipation Over Temperature

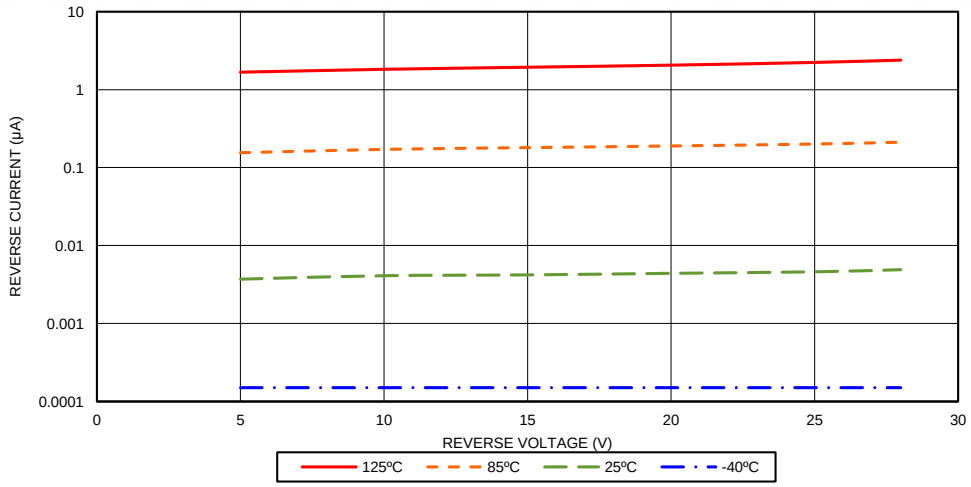


Figure 3. Reverse Current Over Temperature (Cathode to Anode)

7 Detailed Description

7.1 Overview

The SM74611 is designed for use as a bypass diode in photovoltaic modules. The SM74611 utilizes a charge pump to drive an N-channel FET to provide a resistive path for the bypass current to flow.

7.2 Functional Block Diagram

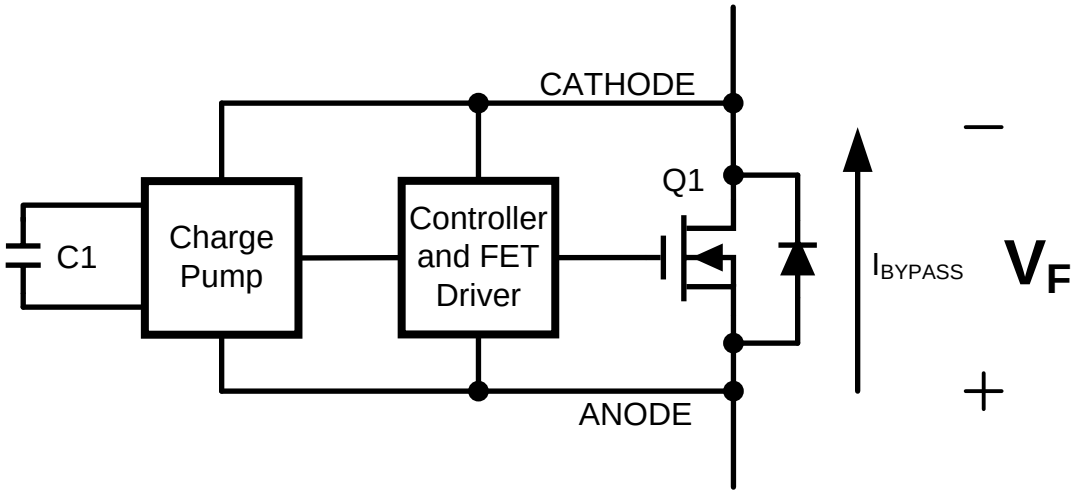


Figure 4. SM74611 Block Diagram

7.3 Feature Description

The operational description is described below. Please refer to Figure 4 and Figure 5.

From t_0 to t_1:

When cells in the solar panels are shaded, the FET Q1 is off and the bypass current will flow through the body diode of the FET as shown on Figure 4. This current will produce a voltage drop (V_F) across ANODE and CATHODE terminal of the bypass diode. During this time, the charge pump circuitry is active and charging capacitor C1 to a higher voltage.

At t_1:

Once the voltage on the capacitor reaches its predetermined voltage level, the charge pump is disabled and the capacitor voltage is used to drive the FET through the FET driver stage.

From t_1 to t_2 :

When the FET is active, it provides a low resistive path for the bypass current to flow thus minimizing the power dissipation across ANODE and CATHODE. Since the FET is active, the voltage across the ANODE and CATHODE is too low to operate the charge pump. During this time, the stored charge on C1 is used to supply the controller as well as drive the FET.

At t_2:

When the voltage on the capacitor C1 reaches its predetermined lower level, the FET driver shuts off the FET. The bypass current will then begin to flow through the body diode of the FET, causing the FET body diode voltage drop of approximately 0.6V to appear across ANODE and CATHODE. The charge pump circuitry is re-activated and begins charging the capacitor C1. This cycle repeats until the shade on the panel is removed and the string current begins to flow through the PV cells instead of the body diode of the FET.

The key factor to minimizing the power dissipation on the device is to keep the FET on at a high duty cycle. The average forward voltage drop will then be reduced to a much lower voltage than for a Schottky or regular P-N junction diode.

Feature Description (continued)

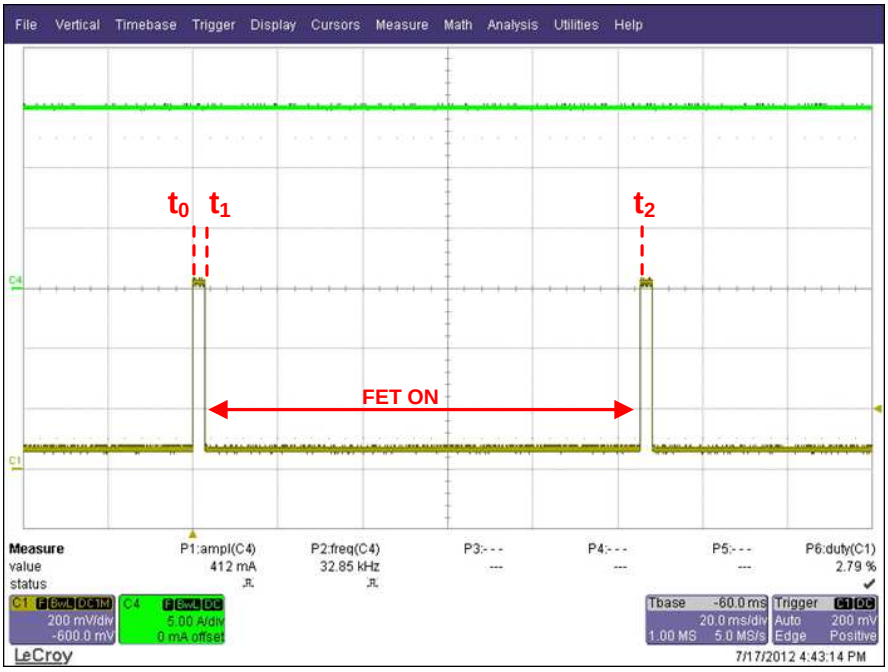


Figure 5. ANODE to CATHODE Voltage (Ch1) with I_{BYPASS} = 15A (Ch4) for SM74611 in Junction Box at 85˚C Ambient

8 Device and Documentation Support

8.1 Trademarks

All trademarks are the property of their respective owners.

8.2 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.

8.3 Glossary

SLYZ022 — *TI Glossary*.

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

9 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/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SM74611KTTR	ACTIVE	DDPAK/ TO-263	KTT	3	500	Pb-Free (RoHS Exempt)	CU SN	Level-3-245C-168 HR	-40 to 125	SM74611KTT	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) 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)

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

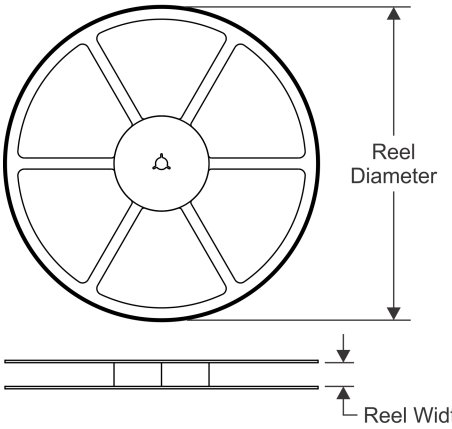
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

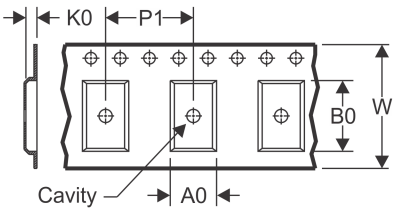
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

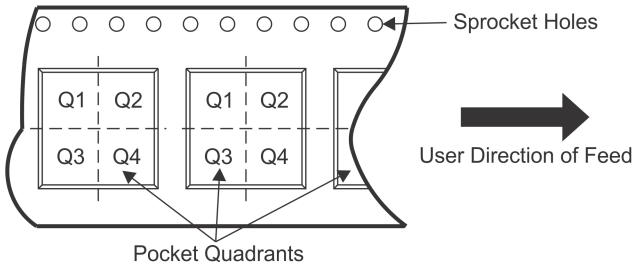


TAPE DIMENSIONS



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

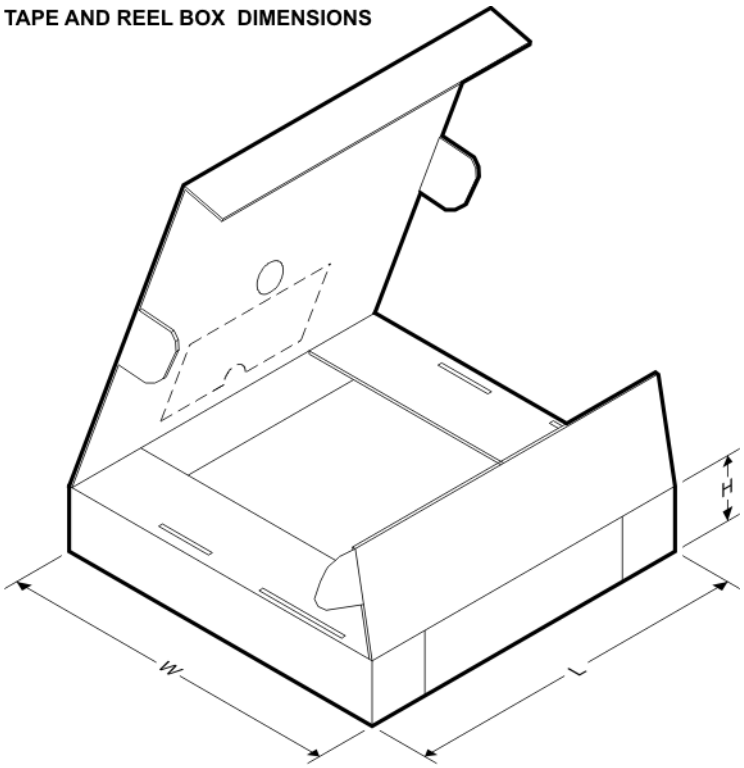
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SM74611KTTR	DDPAK/ TO-263	KTT	3	500	330.0	24.4	10.6	15.8	4.9	16.0	24.0	Q2

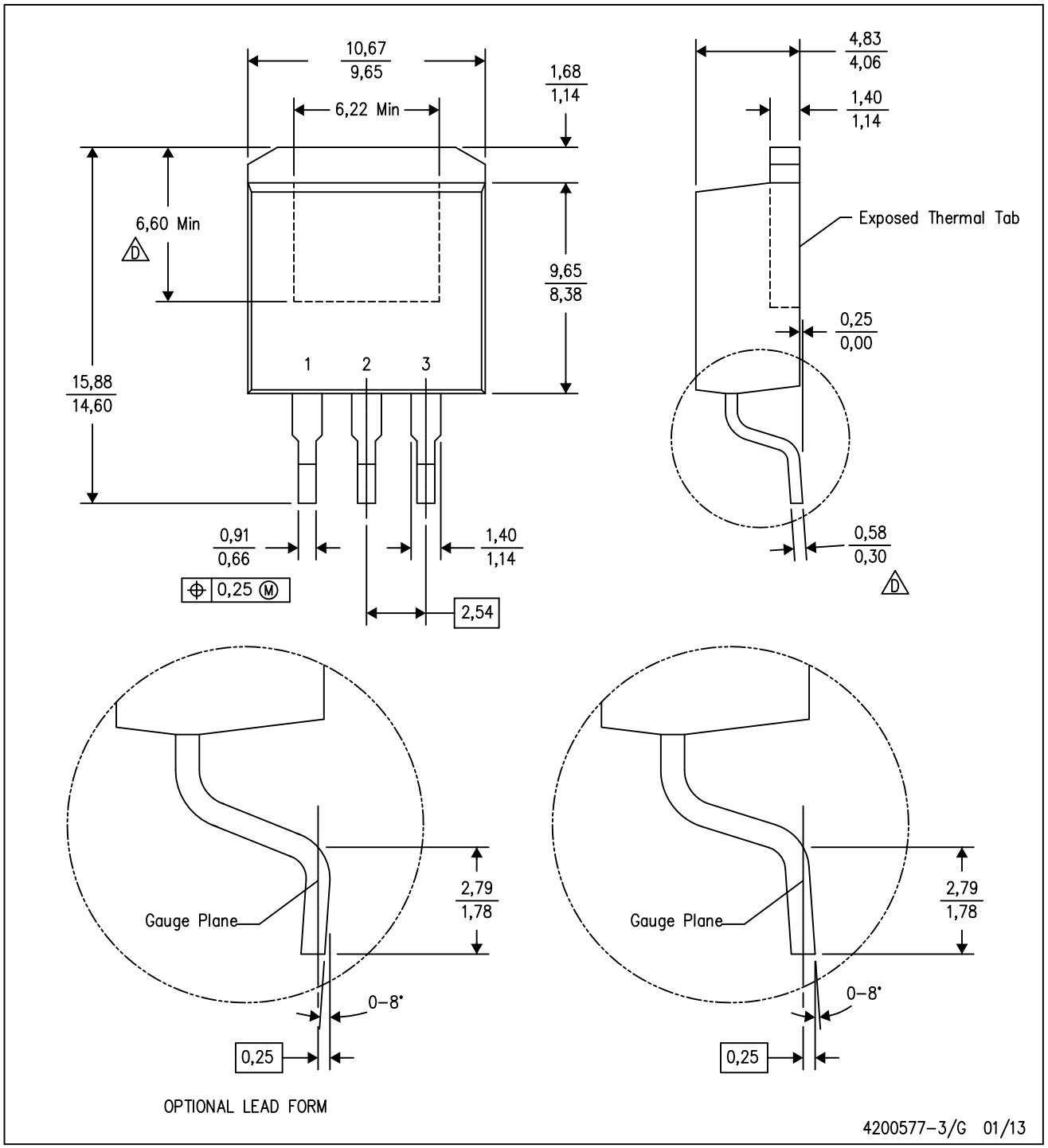
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SM74611KTTR	DDPAK/TO-263	KTT	3	500	340.0	340.0	38.0

KTT (R–PSFM–G3) PLASTIC FLANGE–MOUNT PACKAGE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash or protrusion not to exceed 0.005 (0,13) per side.
D. Falls within JEDEC TO–263 variation AA, except minimum lead thickness and minimum exposed pad length.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265