

## N-Channel Enhancement-Mode Vertical DMOS FET

### Features

- 2V Maximum Low Threshold
- High Input Impedance
- Low Input Capacitance
- Fast Switching Speeds
- Low On-Resistance
- Free from Secondary Breakdown
- Low Input and Output Leakage

### Applications

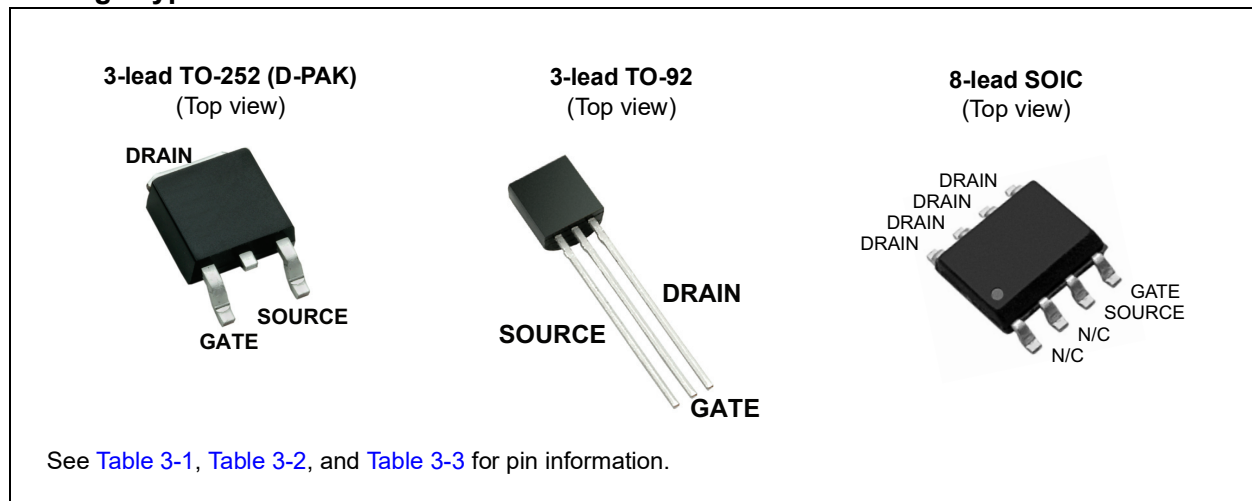
- Logic-Level Interfaces (Ideal for TTL and CMOS)
- Solid-State Relays
- Battery-Operated Systems
- Photovoltaic Drives
- Analog Switches
- General Purpose Line Drivers
- Telecommunication Switches

### General Description

The TN2640 low-threshold Enhancement-mode (normally-off) transistor uses a vertical DMOS structure and a well-proven silicon-gate manufacturing process. This combination produces a device with the power handling capabilities of bipolar transistors and the high input impedance and positive temperature coefficient inherent in MOS devices. Characteristic of all MOS structures, this device is free from thermal runaway and thermally induced secondary breakdown.

Microchip's vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where very low threshold voltage, high breakdown voltage, high input impedance, low input capacitance, and fast switching speeds are desired.

### Package Types



# TN2640

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

Drain-to-Source Voltage .....	$BV_{DSS}$
Drain-to-Gate Voltage .....	$BV_{DGS}$
Gate-to-Source Voltage.....	$\pm 20V$
Operating Ambient Temperature, $T_A$ .....	$-55^{\circ}C$ to $+150^{\circ}C$
Storage Temperature, $T_S$ .....	$-55^{\circ}C$ to $+150^{\circ}C$

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

### DC ELECTRICAL CHARACTERISTICS

**Electrical Specifications:**  $T_A = 25^{\circ}C$  unless otherwise specified. All DC parameters are 100% tested at  $25^{\circ}C$  unless otherwise stated. (Pulse test: 300  $\mu s$  pulse, 2% duty cycle)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Drain-to-Source Breakdown Voltage	$BV_{DSS}$	400	—	—	V	$V_{GS} = 0V, I_D = 1\text{ mA}$
Gate Threshold Voltage	$V_{GS(th)}$	0.8	—	2	V	$V_{GS} = V_{DS}, I_D = 2\text{ mA}$
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	-2.5	-4	mV/ $^{\circ}C$	$V_{GS} = V_{DS}, I_D = 2\text{ mA}$ ( <b>Note 1</b> )
Gate Body Leakage Current	$I_{GSS}$	—	—	100	nA	$V_{GS} = \pm 20V, V_{DS} = 0V$
Zero-Gate Voltage Drain Current	$I_{DSS}$	—	—	10	$\mu A$	$V_{GS} = 0V,$ $V_{DS} = \text{Maximum rating}$
		—	—	1	mA	$V_{DS} = 0.8 \text{ Maximum rating},$ $V_{GS} = 0V, T_A = 125^{\circ}C$ ( <b>Note 1</b> )
On-State Drain Current	$I_{D(ON)}$	1.5	3.5	—	A	$V_{GS} = 5V, V_{DS} = 25V$
		2	4	—	A	$V_{GS} = 10V, V_{DS} = 25V$
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	3.2	5	$\Omega$	$V_{GS} = 4.5V, I_D = 500\text{ mA}$
		—	3	5	$\Omega$	$V_{GS} = 10V, I_D = 500\text{ mA}$
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	0.75	%/ $^{\circ}C$	$V_{GS} = 10V, I_D = 500\text{ mA}$ ( <b>Note 1</b> )

**Note 1:** Specification is obtained by characterization and is not 100% tested.

## AC ELECTRICAL CHARACTERISTICS

**Electrical Specifications:**  $T_A = 25^\circ\text{C}$  unless otherwise specified. All AC parameters are not 100% sample tested.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Forward Transconductance	$G_{FS}$	200	330	—	mmho	$V_{DS} = 25\text{V}, I_D = 100\text{ mA}$
Input Capacitance	$C_{ISS}$	—	210	225	pF	$V_{GS} = 0\text{V}, V_{DS} = 25\text{V}, f = 1\text{ MHz}$
Common-Source Output Capacitance	$C_{OSS}$	—	30	50	pF	
Reverse Transfer Capacitance	$C_{RSS}$	—	8	15	pF	
Turn-On Delay Time	$t_{d(ON)}$	—	4	15	ns	
Rise Time	$t_r$	—	15	20	ns	$V_{DD} = 25\text{V}, I_D = 2\text{A}, R_{GEN} = 25\Omega$
Turn-Off Delay Time	$t_{d(OFF)}$	—	20	25	ns	
Fall Time	$t_f$	—	22	27	ns	
<b>DIODE PARAMETER</b>						
Diode Forward Voltage Drop	$V_{SD}$	—	—	0.9	V	$V_{GS} = 0\text{V}, I_{SD} = 200\text{ mA}$ (Note 1)
Reverse Recovery Time	$t_{rr}$	—	300	—	ns	$V_{GS} = 0\text{V}, I_{SD} = 1\text{A}$

**Note 1:** All DC parameters are 100% tested at  $25^\circ\text{C}$  unless otherwise stated.  
(Pulse test: 300  $\mu\text{s}$  pulse, 2% duty cycle)

## TEMPERATURE SPECIFICATIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
<b>TEMPERATURE RANGE</b>						
Operating Ambient Temperature	$T_A$	-55	—	+150	$^\circ\text{C}$	
Storage Temperature	$T_S$	-55	—	+150	$^\circ\text{C}$	
<b>PACKAGE THERMAL RESISTANCE</b>						
3-lead TO-252 (D-PAK)	$\theta_{JA}$	—	81	—	$^\circ\text{C/W}$	
8-lead SOIC	$\theta_{JA}$	—	101	—	$^\circ\text{C/W}$	
3-lead TO-92	$\theta_{JA}$	—	132	—	$^\circ\text{C/W}$	

## THERMAL CHARACTERISTICS

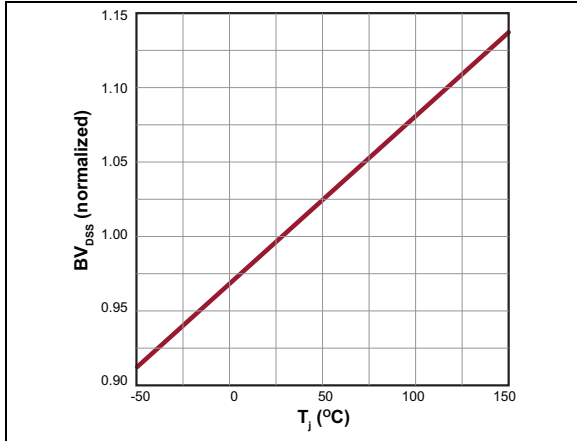
Package	$I_D$ (Note 1) (Continuous) (mA)	$I_D$ (Pulsed) (A)	Power Dissipation at $T_A = 25^\circ\text{C}$ (W)	$I_{DR}$ (Note 1) (mA)	$I_{DRM}$ (A)
3-lead TO-252 (D-PAK)	500	3	2.5 (Note 2)	500	3
8-lead SOIC	260	2	1.3 (Note 2)	260	2
3-lead TO-92	220	2	0.74	220	2

**Note 1:**  $I_D$  (continuous) is limited by maximum  $T_J$ .

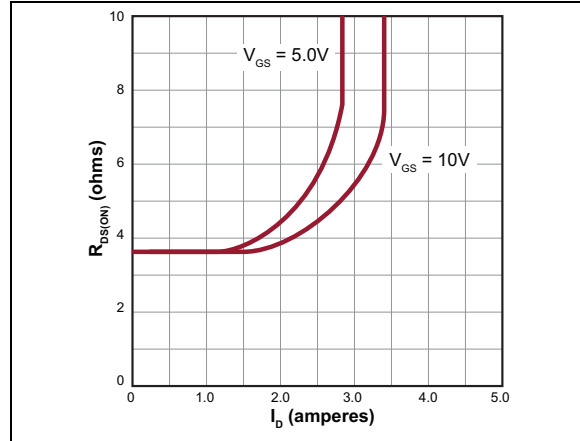
**2:** Mounted on an FR4 board, 25 mm x 25 mm x 1.57 mm

## 2.0 TYPICAL PERFORMANCE CURVES

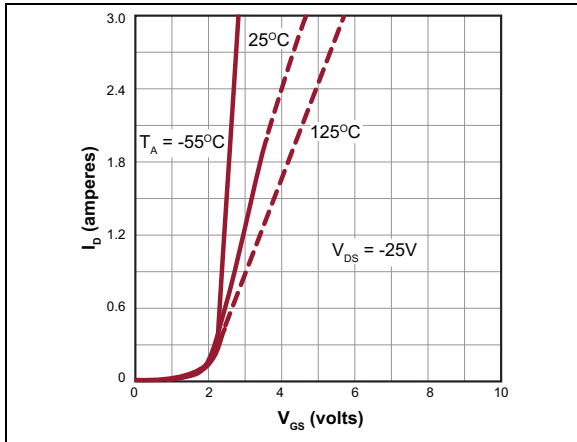
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g. outside specified power supply range) and therefore outside the warranted range.



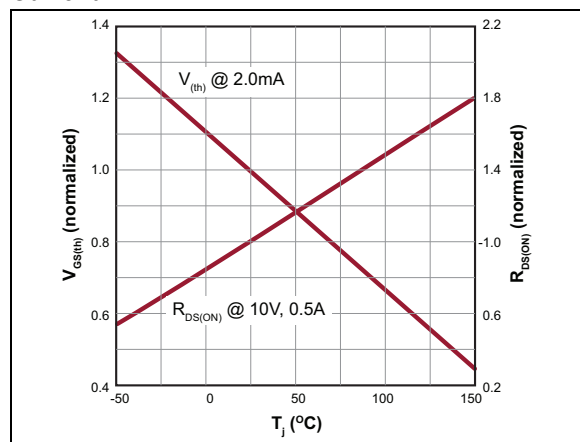
**FIGURE 2-1:**  $BV_{DSS}$  Variation with Temperature.



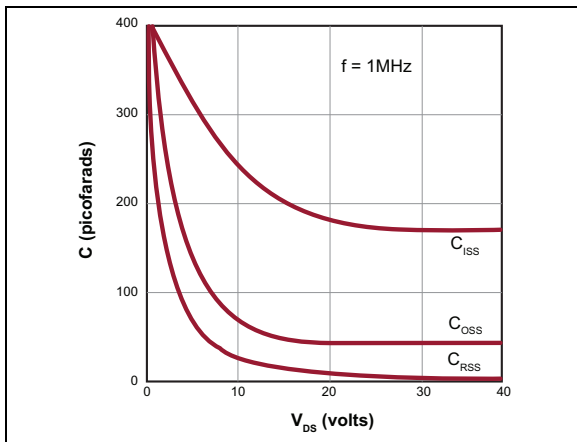
**FIGURE 2-4:** On-resistance vs. Drain Current.



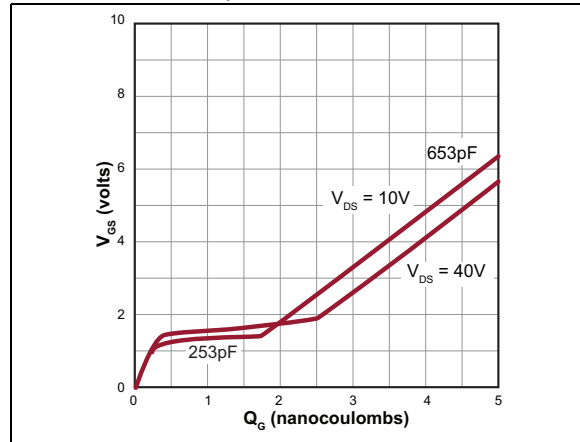
**FIGURE 2-2:** Transfer Characteristics.



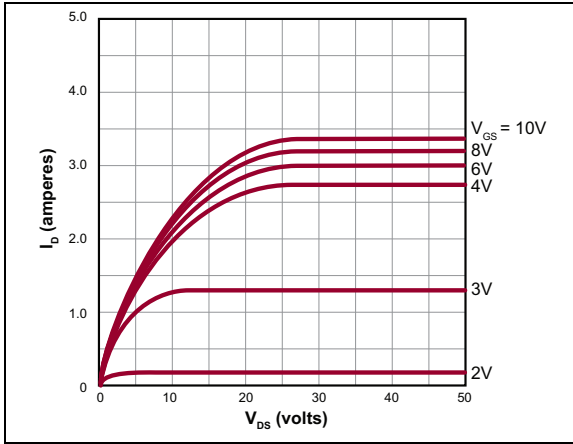
**FIGURE 2-5:**  $V_{GS(th)}$  and  $R_{DS(ON)}$  Variation with Temperature.



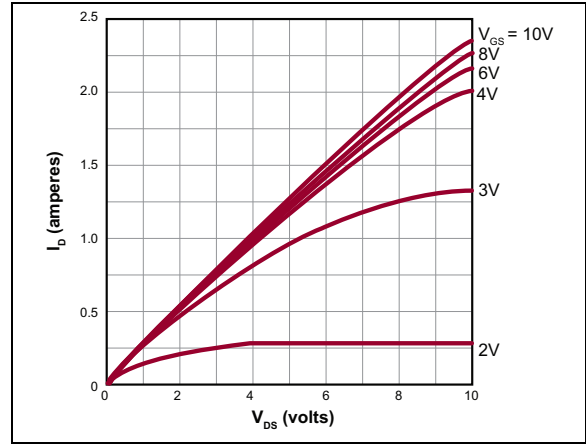
**FIGURE 2-3:** Capacitance vs. Drain-to-source Voltage.



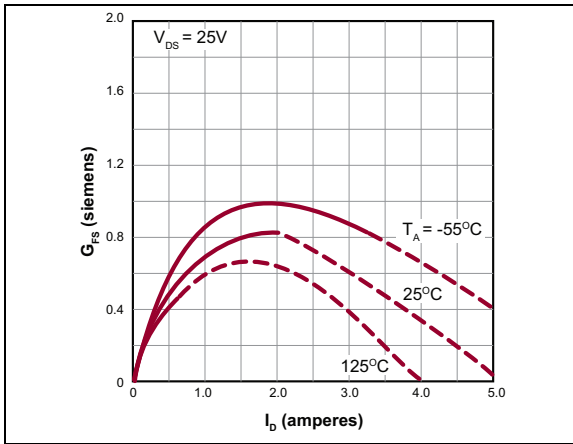
**FIGURE 2-6:** Gate Drive Dynamic Characteristics.



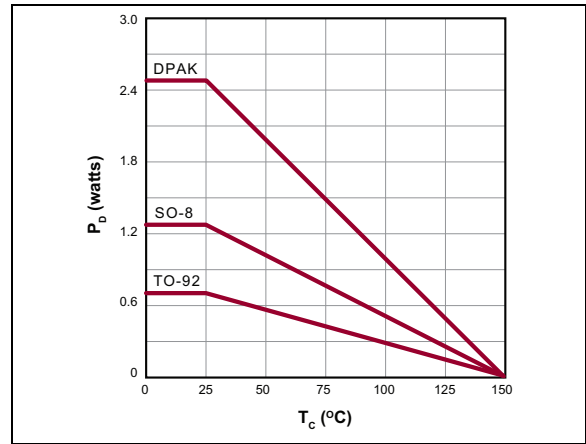
**FIGURE 2-7:** Output Characteristics.



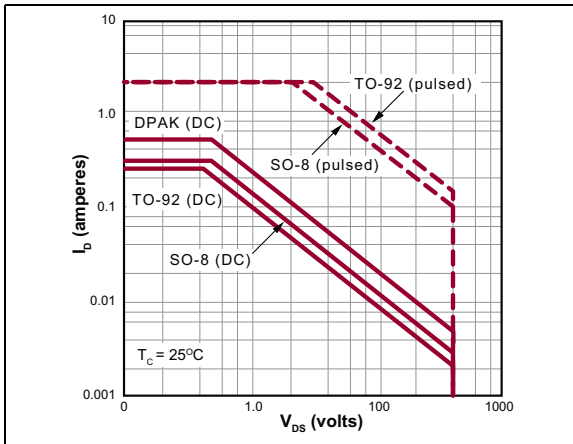
**FIGURE 2-10:** Saturation Characteristics.



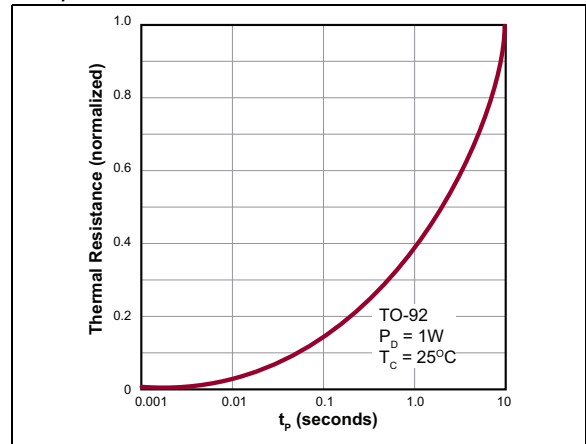
**FIGURE 2-8:** Transconductance vs. Drain Current.



**FIGURE 2-11:** Power Dissipation vs. Temperature.



**FIGURE 2-9:** Maximum Rated Safe Operating Area.



**FIGURE 2-12:** Thermal Response Characteristics.

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## 3.0 PIN DESCRIPTION

Table 3-1, Table 3-2, and Table 3-3 show the description of pins in TN2640. Refer to [Package Types](#) for the location of the pins.

**TABLE 3-1: 3-LEAD TO-252 (DPAK) PIN FUNCTION TABLE**

Pin Number	Pin Name	Description
1	Gate	Gate
3	Source	Source
4	Drain	Drain

**TABLE 3-2: 8-LEAD SOIC PIN FUNCTION TABLE**

Pin Number	Pin Name	Description
1	N/C	No connect
2	N/C	No connect
3	Source	Source
4	Gate	Gate
5	Drain	Drain
6	Drain	Drain
7	Drain	Drain
8	Drain	Drain

**TABLE 3-3: 3-LEAD TO-92 PIN FUNCTION TABLE**

Pin Number	Pin Name	Description
1	Source	Source
2	Gate	Gate
3	Drain	Drain

## 4.0 FUNCTIONAL DESCRIPTION

Figure 4-1 illustrates the switching waveforms and test circuit for TN2640.



**FIGURE 4-1:** Switching Waveforms and Test Circuit.

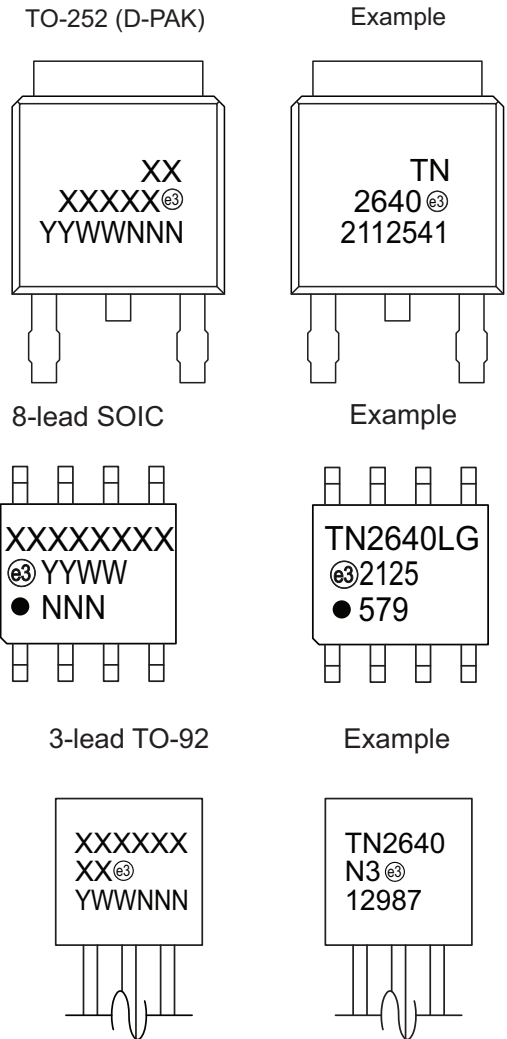
**TABLE 4-1: PRODUCT SUMMARY**

$BV_{DSS}/BV_{DGS}$ (V)	$R_{DS(ON)}$ (Maximum) ( $\Omega$ )	$I_{D(ON)}$ (Minimum) (A)	$V_{GS(th)}$ (Maximum) (V)
400	5	2	2

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## 5.0 PACKAGING INFORMATION

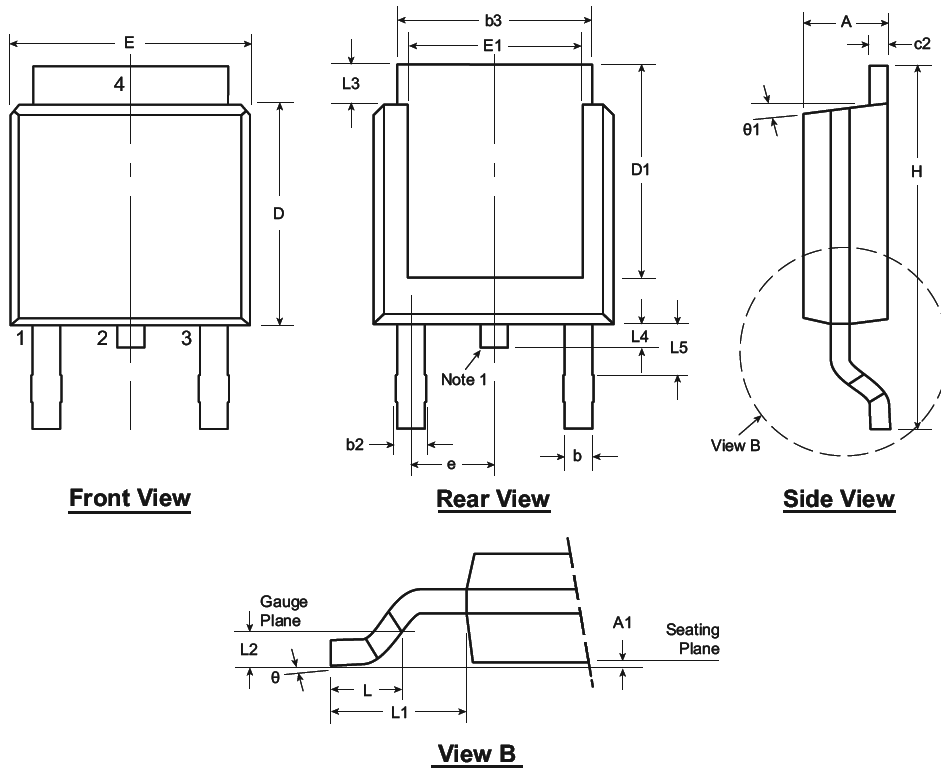
### 5.1 Package Marking Information



<b>Legend:</b>	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC <sup>®</sup> designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.
<b>Note:</b>	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.	



## 3-Lead TO-252 (D-PAK) Package Outline (K4)



Note: For the most current package drawings, see the Microchip Packaging Specification at [www.microchip.com/packaging](http://www.microchip.com/packaging).

**Note:**

1. Although 4 terminal locations are shown, only 3 are functional. Lead number 2 was removed.

Symbol	A	A1	b	b2	b3	c2	D	D1	E	E1	e	H	L	L1	L2	L3	L4	L5	$\theta$	$\theta_1$
Dimension (inches)	MIN	.086	.000*	.025	.030	.195	.018	.235	.205	.250	.170	.370	.055	.108 REF	.020 BSC	.035	.025*	.035†	0°	0°
	NOM	-	-	-	-	-	.240	-	-	-	.090 BSC	-	.060	.108 REF	.020 BSC	-	-	-	-	-
	MAX	.094	.005	.035	.045	.215	.035	.245	.217*	.265	.200*	.410	.070	.108 REF	.020 BSC	.050	.040	.060	10°	15°

JEDEC Registration TO-252, Variation AA, Issue E, June 2004.

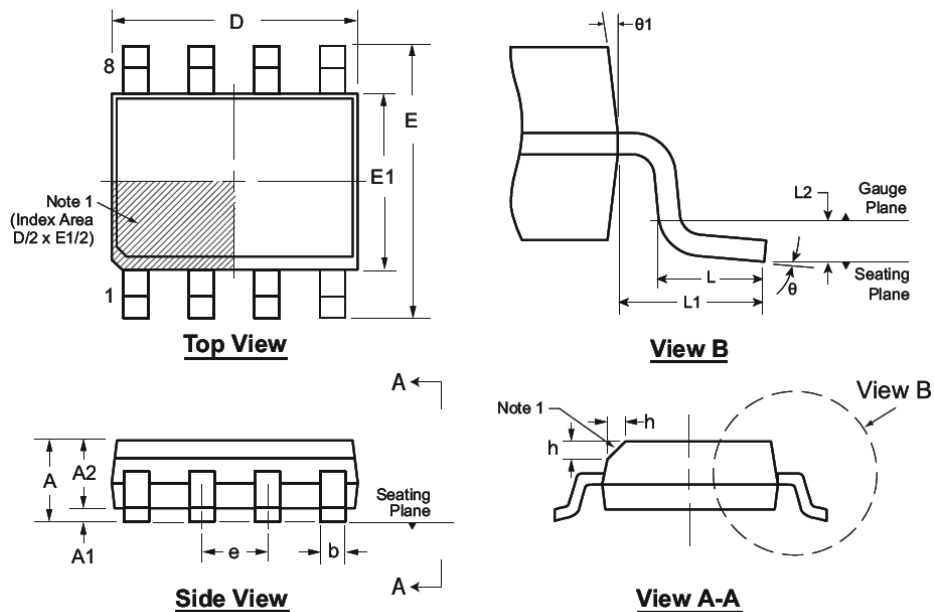
\* This dimension is not specified in the JEDEC drawing.

† This dimension differs from the JEDEC drawing.

Drawings not to scale.

## 8-Lead SOIC (Narrow Body) Package Outline (LG/TG)

4.90x3.90mm body, 1.75mm height (max), 1.27mm pitch



Note: For the most current package drawings, see the Microchip Packaging Specification at [www.microchip.com/packaging](http://www.microchip.com/packaging).

**Note:**

- This chamfer feature is optional. A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.

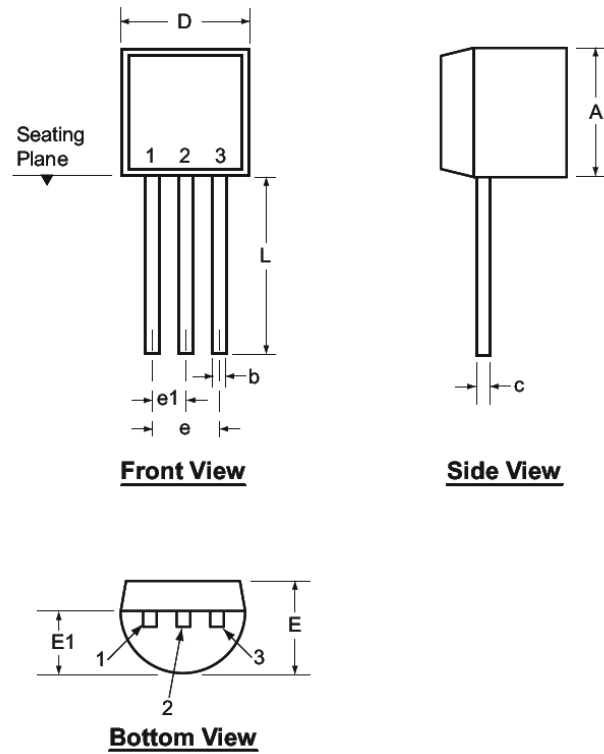
Symbol	A	A1	A2	b	D	E	E1	e	h	L	L1	L2	$\theta$	$\theta 1$				
Dimension (mm)	MIN	1.35*	0.10	1.25	0.31	4.80*	5.80*	3.80*	1.27 BSC	0.25	0.40	1.04 REF	0.25	BSC	0°	5°		
	NOM	-	-	-	-	4.90	6.00	3.90		-	-		-	-	-	-	-	-
	MAX	1.75	0.25	1.65*	0.51	5.00*	6.20*	4.00*		0.50	1.27		-	-	8°	15°		

JEDEC Registration MS-012, Variation AA, Issue E, Sept. 2005.

\* This dimension is not specified in the JEDEC drawing.

Drawings are not to scale.

## 3-Lead TO-92 Package Outline (L/LL/N3)



Note: For the most current package drawings, see the Microchip Packaging Specification at [www.microchip.com/packaging](http://www.microchip.com/packaging).

Symbol	A	b	c	D	E	E1	e	e1	L	
Dimensions (inches)	MIN	.170	.014 <sup>†</sup>	.014 <sup>†</sup>	.175	.125	.080	.095	.045	.500
	NOM	-	-	-	-	-	-	-	-	-
	MAX	.210	.022 <sup>†</sup>	.022 <sup>†</sup>	.205	.165	.105	.105	.055	.610*

JEDEC Registration TO-92.

\* This dimension is not specified in the JEDEC drawing.

† This dimension differs from the JEDEC drawing.

**Drawings not to scale.**

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision A (February 2021)

- Converted Supertex Doc# DSFP-TN2640 to Microchip DS20005795A
- Changed the package marking format
- Updated the quantity of the 8-lead SOIC from 2500/Reel to 3300/Reel to align it with the actual BQM
- Removed the TO-92 N3 P002, P003, P005, P013, and P015 media types to align package specifications with the actual BQM
- Made minor text changes throughout the document

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## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>PART NO.</u>		<u>XX</u>	-	<u>X</u>	-	<u>X</u>
Device	Package Options			Environmental		Media Type
Device:	TN2640	=		N-Channel Enhancement-Mode Vertical DMOS FET		
Packages:	K4	=		3-lead TO-252 (D-PAK)		
	LG	=		8-lead SOIC		
	N3	=		3-lead TO-92		
Environmental:	G	=		Lead (Pb)-free/RoHS-compliant Package		
Media Types:	(blank)	=		2000/Reel for a K4 Package		
		=		3300/Reel for an LG Package		
		=		1000/Bag for an N3 Package		

Examples:	
a) TN2640K4-G:	N-Channel Enhancement-Mode Vertical DMOS FET, 3-lead TO-252 (D-PAK), 2000/Reel
b) TN2640LG-G:	N-Channel Enhancement-Mode Vertical DMOS FET, 8-lead SOIC, 3300/Reel
c) TN2640N3-G:	N-Channel Enhancement-Mode Vertical DMOS FET, 3-lead TO-92, 1000/Bag

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