

## P-Channel Enhancement-Mode Vertical DMOS FET

### Features

- -2.4V Maximum Low Threshold
- High Input Impedance
- 60 pF 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

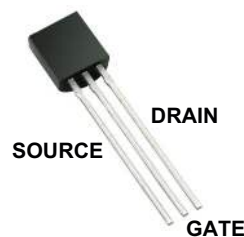
### General Description

The TP2535 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 Type

**3-lead TO-92**  
(Top view)



See [Table 3-1](#) for pin information.

# TP2535

## 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	$BV_{DSS}$	-350	—	—	V	$V_{GS} = 0V, I_D = -2\text{ mA}$
Gate Threshold Voltage	$V_{GS(th)}$	-1	—	-2.4	V	$V_{GS} = V_{DS}, I_D = -1\text{ mA}$
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	4.8	mV/ $^{\circ}C$	$V_{GS} = V_{DS}, I_D = -1\text{ mA}$ (Note 1)
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	$V_{DS} = 0.8 \text{ Maximum rating},$ $V_{GS} = 0V, T_A = 125^{\circ}C$ (Note 1)
On-State Drain Current	$I_{D(ON)}$	-0.2	-0.3	—	A	$V_{GS} = -4.5V, V_{DS} = -25V$
		-0.4	-1.1	—	A	$V_{GS} = -10V, V_{DS} = -25V$
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	20	30	$\Omega$	$V_{GS} = -4.5V, I_D = -100\text{ mA}$
		—	19	25	$\Omega$	$V_{GS} = -10V, I_D = -100\text{ mA}$
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	0.75	%/ $^{\circ}C$	$V_{GS} = -10V, I_D = -100\text{ mA}$ (Note 1)

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

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Forward Transconductance	$G_{FS}$	100	175	—	mmho	$V_{DS} = -25\text{V}$ , $I_D = -100\text{ mA}$
Input Capacitance	$C_{ISS}$	—	60	125	pF	$V_{GS} = 0\text{V}$ , $V_{DS} = -25\text{V}$ , $f = 1\text{ MHz}$
Common-Source Output Capacitance	$C_{OSS}$	—	20	70	pF	
Reverse Transfer Capacitance	$C_{RSS}$	—	10	25	pF	
Turn-On Delay Time	$t_{d(ON)}$	—	—	10	ns	$V_{DD} = -25\text{V}$ , $I_D = -0.4\text{A}$ , $R_{GEN} = 25\Omega$
Rise Time	$t_r$	—	—	10	ns	
Turn-Off Delay Time	$t_{d(OFF)}$	—	—	20	ns	
Fall Time	$t_f$	—	—	13	ns	

### DIODE PARAMETER

Diode Forward Voltage Drop	$V_{SD}$	—	—	-1.8	V	$V_{GS} = 0\text{V}$ , $I_{SD} = -100\text{ mA}$ (Note 1)
Reverse Recovery Time	$t_{rr}$	—	300	—	ns	$V_{GS} = 0\text{V}$ , $I_{SD} = -100\text{ mA}$

**Note 1:** Unless otherwise stated, all DC parameters are 100% tested at  $25^\circ\text{C}$ . 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-92	$\theta_{JA}$	—	132	—	$^\circ\text{C/W}$	

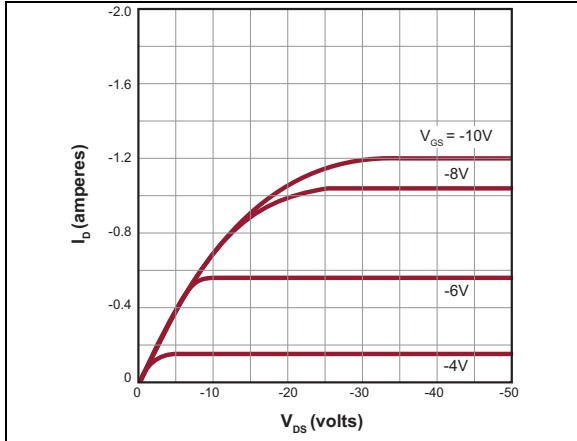
## THERMAL CHARACTERISTICS

Package	$I_D$ (Note 1) (Continuous) (mA)	$I_D$ (Pulsed) (mA)	Power Dissipation at $T_A = 25^\circ\text{C}$ (W)	$I_{DR}$ (Note 1) (mA)	$I_{DRM}$ (mA)
3-lead TO-92	-86	-600	0.74	-86	-600

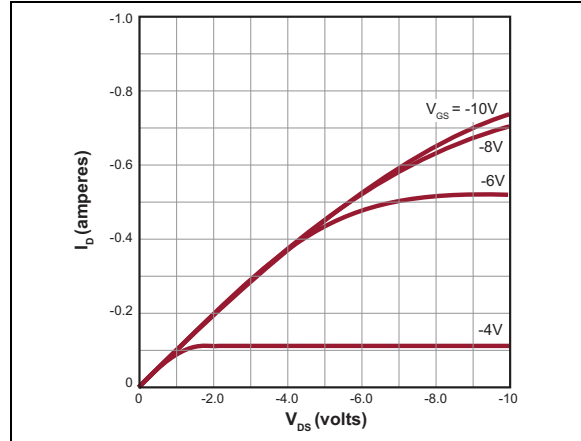
**Note 1:**  $I_D$  (continuous) is limited by maximum rated  $T_J$ .

## 2.0 TYPICAL PERFORMANCE CURVES

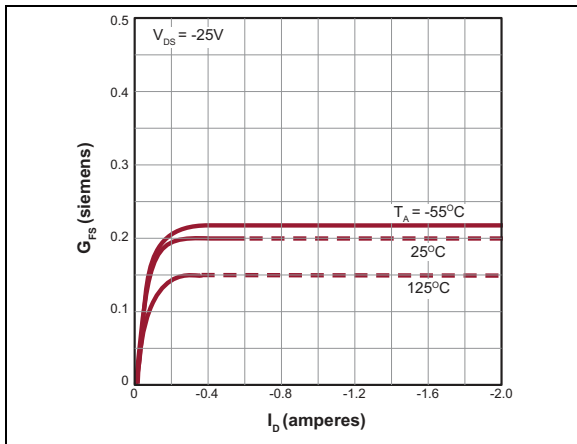
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be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



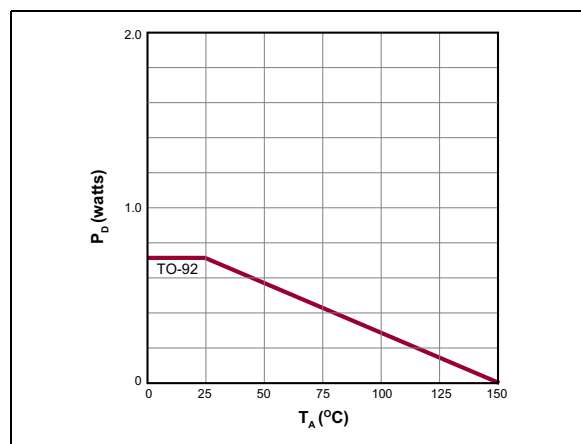
**FIGURE 2-1:** Output Characteristics.



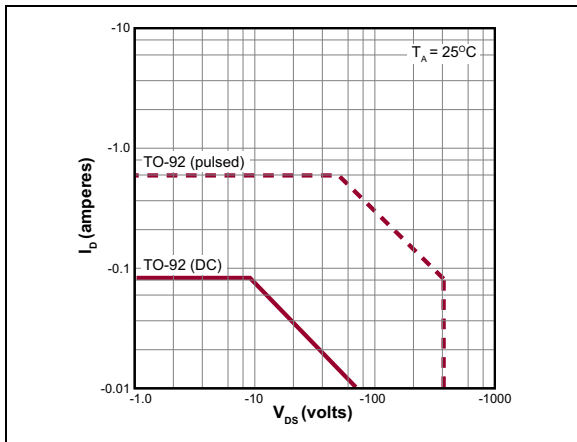
**FIGURE 2-4:** Saturation Characteristics.



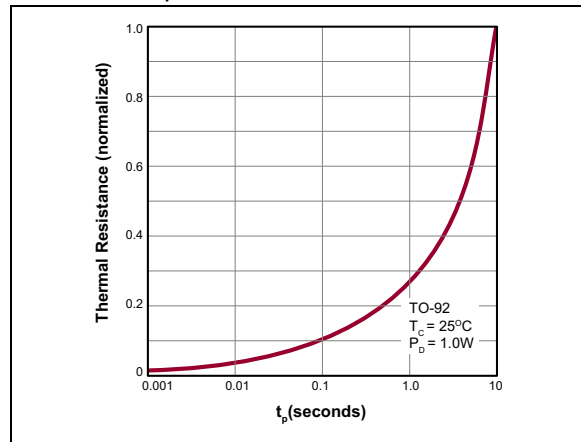
**FIGURE 2-2:** Transconductance vs. Drain Current.



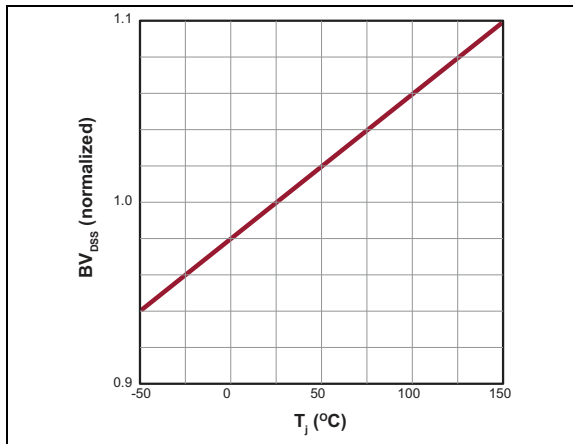
**FIGURE 2-5:** Power Dissipation vs. Ambient Temperature.



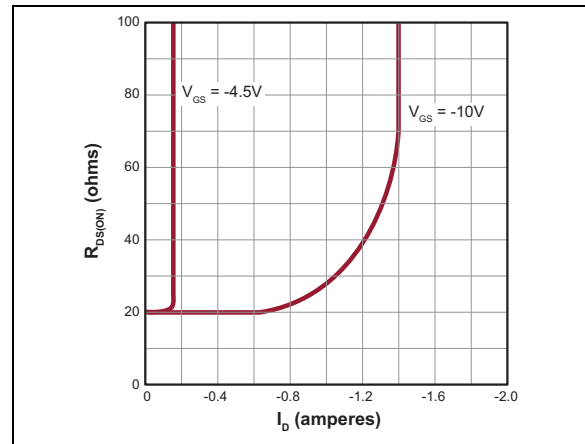
**FIGURE 2-3:** Maximum Rated Safe Operating Area.



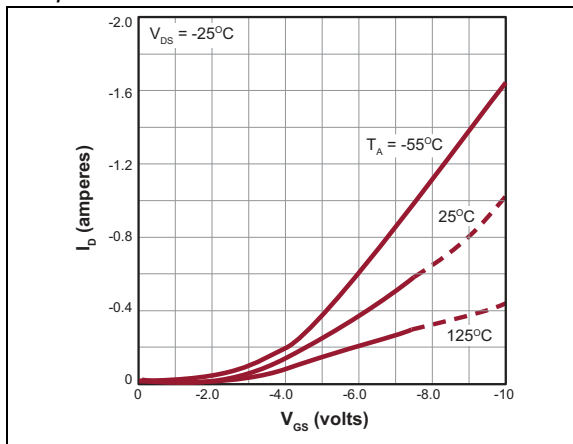
**FIGURE 2-6:** Thermal Response Characteristics.



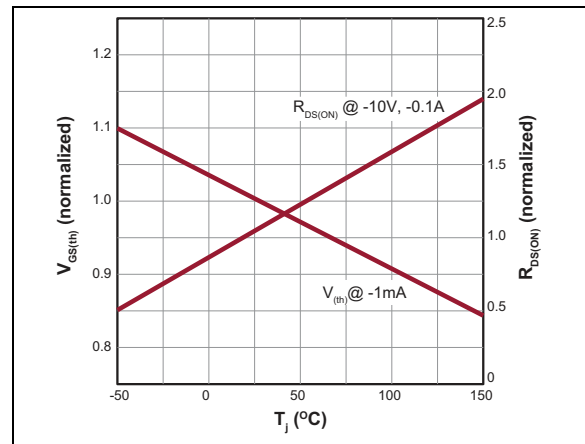
**FIGURE 2-7:**  $BV_{DSS}$  Variation with Temperature.



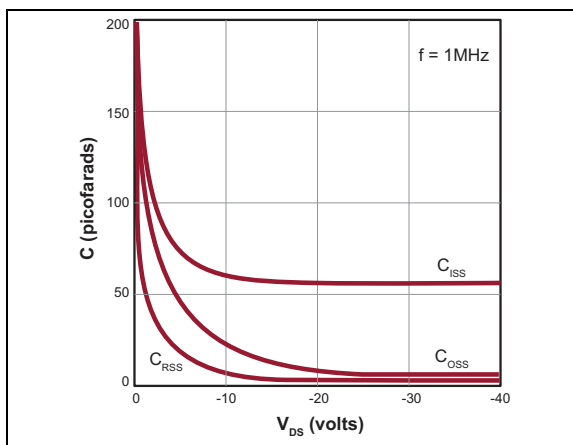
**FIGURE 2-10:** On-Resistance vs. Drain Current.



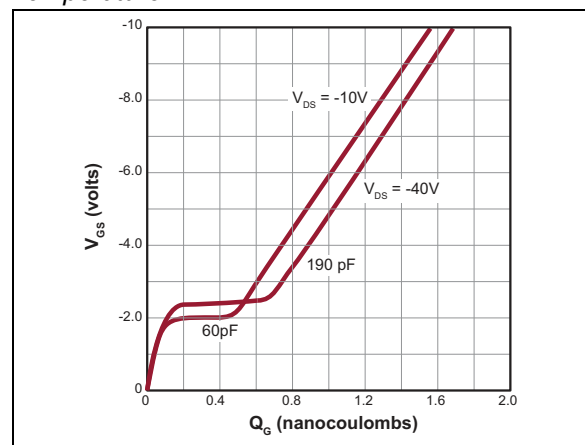
**FIGURE 2-8:** Transfer Characteristics.



**FIGURE 2-11:**  $V_{(th)}$  and  $R_{DS}$  Variation with Temperature.



**FIGURE 2-9:** Capacitance vs. Drain-to-Source Voltage.



**FIGURE 2-12:** Gate Drive Dynamic Characteristics.

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## 3.0 PIN DESCRIPTION

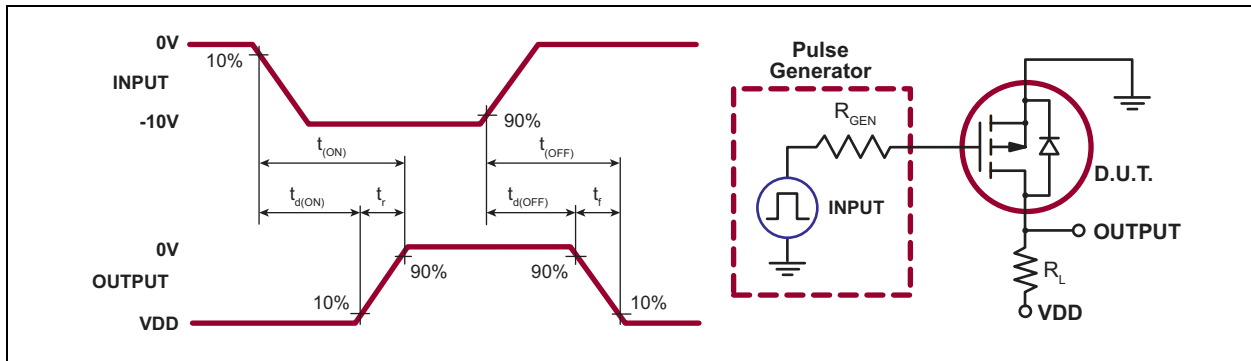
The details on the pins of TP2535 TO-92 package are listed in [Table 3-1](#). Refer to [Package Type](#) for the location of pins.

**TABLE 3-1: 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 the TP2535.



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

**TABLE 4-1: PRODUCT SUMMARY**

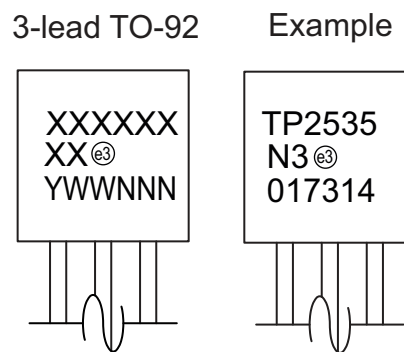
$BV_{DSS}/BV_{DGS}$ (V)	$R_{DS(ON)}$ (Maximum) ( $\Omega$ )	$V_{GS(TH)}$ (Maximum) (V)	$I_{D(ON)}$ (Minimum) (A)
-350	25	-0.4	-2.4

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## 5.0 PACKAGE MARKING INFORMATION

### 5.1 Package Marking Information

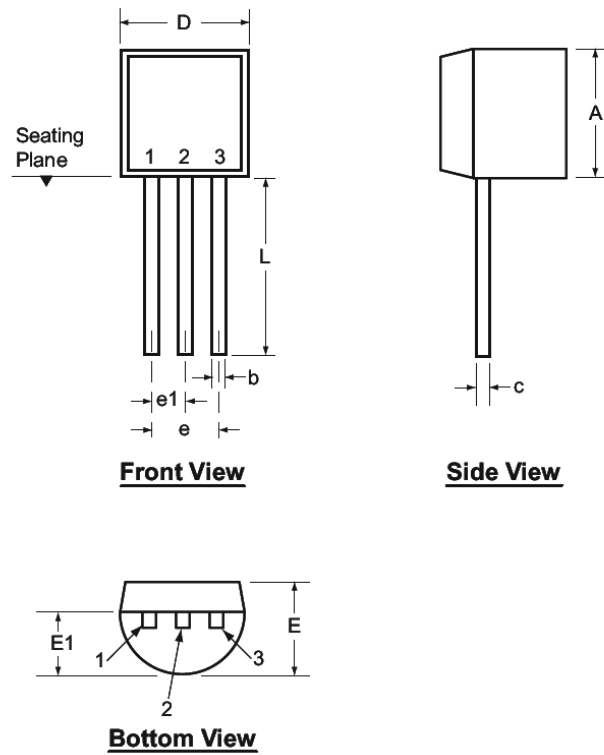


<b>Legend:</b>	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC <sup>®</sup> designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

**Note:** 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-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 (June 2020)

- Converted Supertex Doc# DSFP-TP2535 to Microchip DS20005971A
- Added a pin function table
- Changed the package marking format
- Removed the 3-Lead TO-92 N3 P003, P005, P013, and P014 media types
- Made minor text changes throughout the document

# TP2535

## 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:	TP2535	=	P-Channel Enhancement-Mode Vertical DMOS FET		
Package:	N3	=	3-lead TO-92		
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package		
Media Type:	(blank)	=	1000/Bag for an N3 Package		

**Example:**

a) TP2535N3-G: P-Channel Enhancement-Mode, Vertical DMOS FET, 3-lead TO-92, 1000/Bag

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