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## N-Channel Enhancement-Mode Vertical DMOS FET

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### Features

- Free from Secondary Breakdown
- Low Power Drive Requirement
- Ease of Paralleling
- Low  $C_{ISS}$  and Fast Switching Speeds
- Excellent Thermal Stability
- Integral Source-Drain Diode
- High Input Impedance and High Gain

### Applications

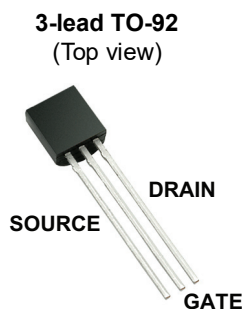
- Motor Controls
- Converters
- Amplifiers
- Switches
- Power Supply Circuits
- Drivers (Relays, Hammers, Solenoids, Lamps, Memories, Displays, Bipolar Transistors, etc.)

### General Description

The VN2224 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 for 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



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

## 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	$BV_{DSS}$	240	—	—	V	$V_{GS} = 0V, I_D = 5 mA$
Gate Threshold Voltage	$V_{GS(th)}$	1	—	3	V	$V_{GS} = V_{DS}, I_D = 5 mA$
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	-4	-5	mV/ $^{\circ}C$	$V_{GS} = V_{DS}, I_D = 5 mA$ <b>(Note 1)</b>
Gate Body Leakage Current	$I_{GSS}$	—	1	100	nA	$V_{GS} = \pm 20V, V_{DS} = 0V$
Zero-Gate Voltage Drain Current	$I_{DSS}$	—	—	50	$\mu A$	$V_{GS} = 0V,$ $V_{DS} = \text{Maximum rating}$
		—	—	5	mA	$V_{DS} = 0.8 \text{ Maximum rating},$ $V_{GS} = 0V, T_A = 125^{\circ}C$ <b>(Note 1)</b>
On-State Drain Current	$I_{D(ON)}$	2	—	—	A	$V_{GS} = 5V, V_{DS} = 25V$
		5	10	—	A	$V_{GS} = 10V, V_{DS} = 25V$
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	1	1.5	$\Omega$	$V_{GS} = 5V, I_D = 2A$
		—	0.9	1.25	$\Omega$	$V_{GS} = 10V, I_D = 2A$
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	1	1.4	%/ $^{\circ}C$	$V_{GS} = 10V, I_D = 2A$ <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	$G_{FS}$	1000	2200	—	mmho	$V_{DS} = 25\text{V}, I_D = 2\text{A}$
Input Capacitance	$C_{ISS}$	—	300	350	pF	$V_{GS} = 0\text{V},$ $V_{DS} = 25\text{V},$ $f = 1\text{ MHz}$
Common-Source Output Capacitance	$C_{OSS}$	—	85	150	pF	
Reverse Transfer Capacitance	$C_{RSS}$	—	20	35	pF	
Turn-On Delay Time	$t_{d(ON)}$	—	6	15	ns	$V_{DD} = 25\text{V},$ $I_D = 2\text{A},$ $R_{GEN} = 10\Omega$
Rise Time	$t_r$	—	16	25	ns	
Turn-Off Delay Time	$t_{d(OFF)}$	—	65	90	ns	
Fall Time	$t_f$	—	30	60	ns	
<b>DIODE PARAMETER</b>						
Diode Forward Voltage Drop	$V_{SD}$	—	0.8	1	V	$V_{GS} = 0\text{V}, I_{SD} = 100\text{ mA}$ (Note 1)
Reverse Recovery Time	$t_{rr}$	—	500	—	ns	$V_{GS} = 0\text{V}, I_{SD} = 1\text{A}$

**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	—	$^\circ\text{C/W}$	

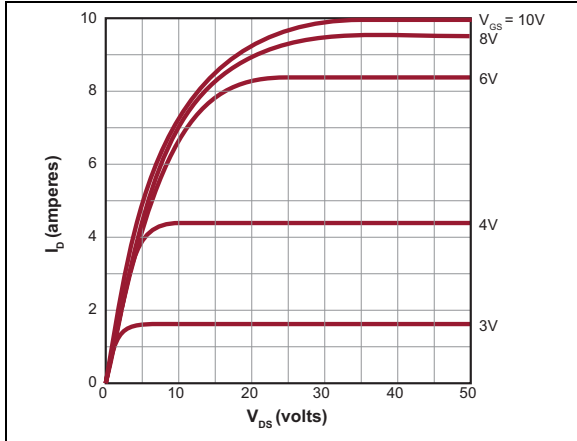
## THERMAL CHARACTERISTICS

Package	$I_D$ (Continuous) (mA) (Note 1)	$I_D$ (Pulsed) (A)	Power Dissipation at $T_A = 25^\circ\text{C}$ (W)	$I_{DR}$ (mA) (Note 1)	$I_{DRM}$ (A)
3-lead TO-92	540	5	1	540	5

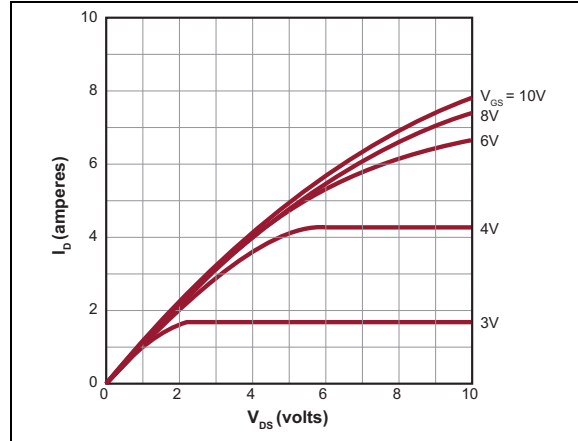
**Note 1:**  $I_D$  (continuous) is limited by maximum rated  $T_J$ .

## 2.0 TYPICAL PERFORMANCE CURVES

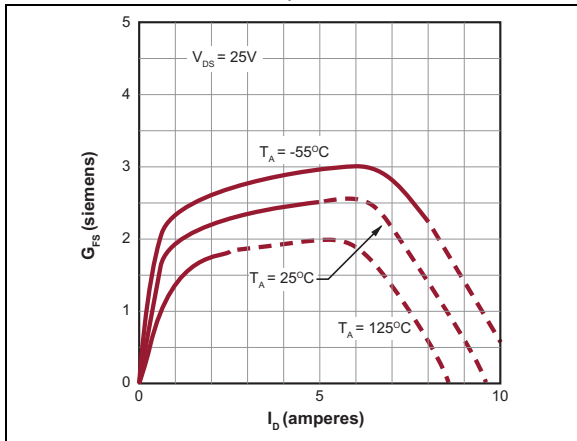
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be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



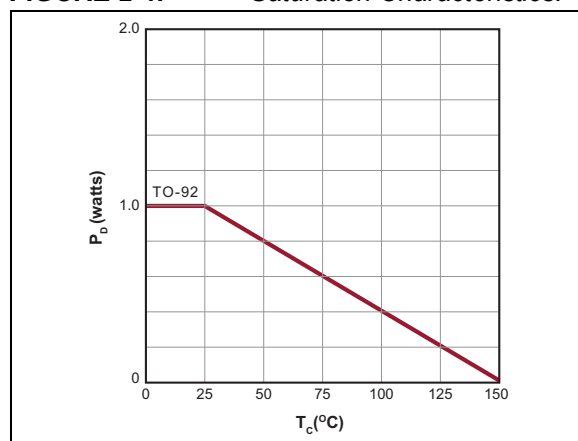
**FIGURE 2-1:** Output Characteristics.



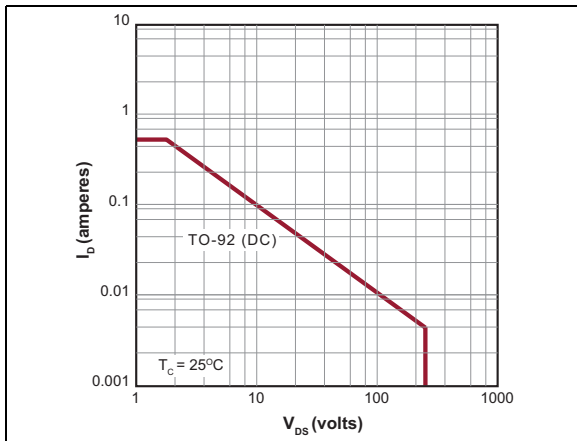
**FIGURE 2-4:** Saturation Characteristics.



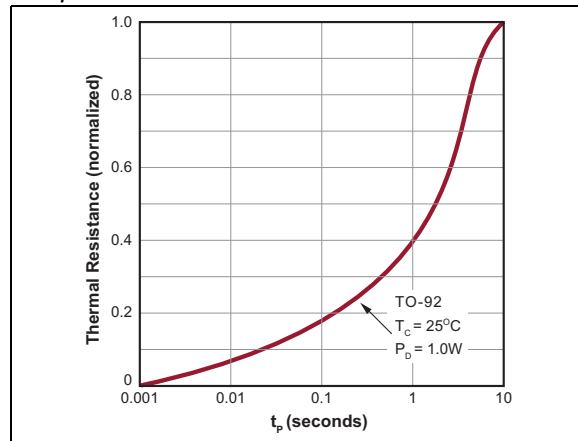
**FIGURE 2-2:** Transconductance vs. Drain Current.



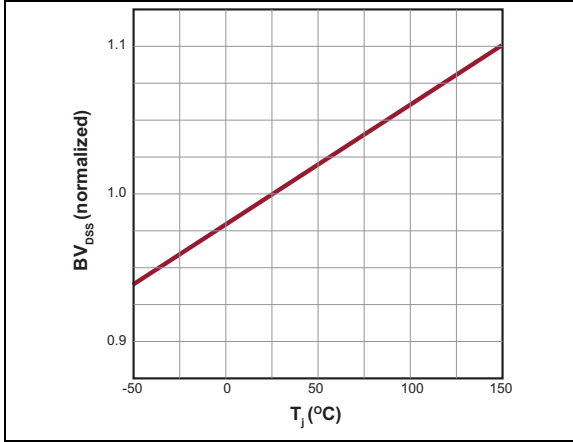
**FIGURE 2-5:** Power Dissipation vs. Case Temperature.



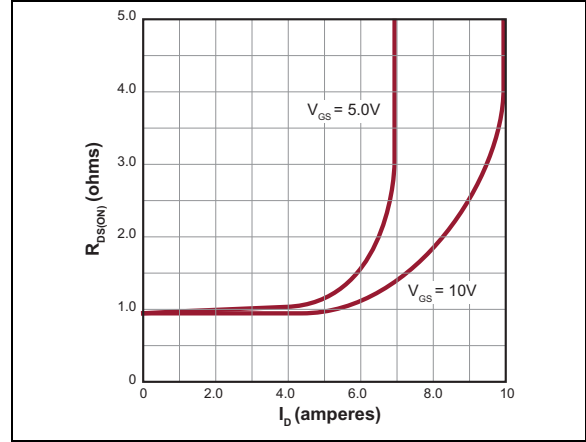
**FIGURE 2-3:** Maximum Rated Safe Operating Area.



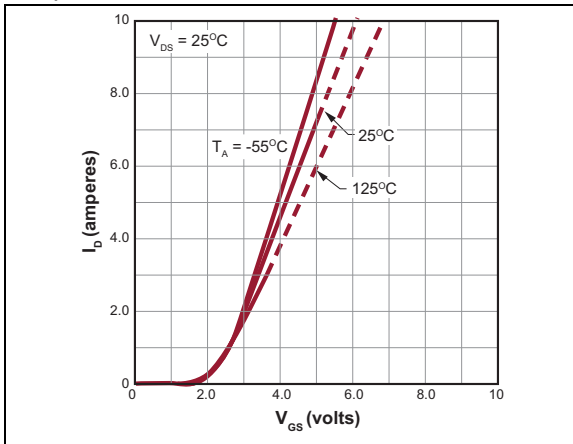
**FIGURE 2-6:** Thermal Response Characteristics.



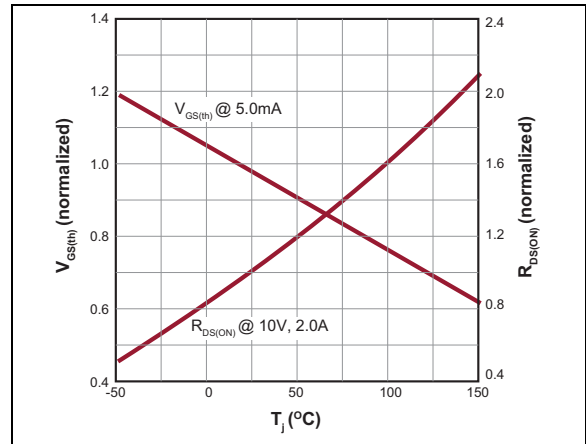
**FIGURE 2-7:**  $BV_{DSS}$  Variation with Temperature.



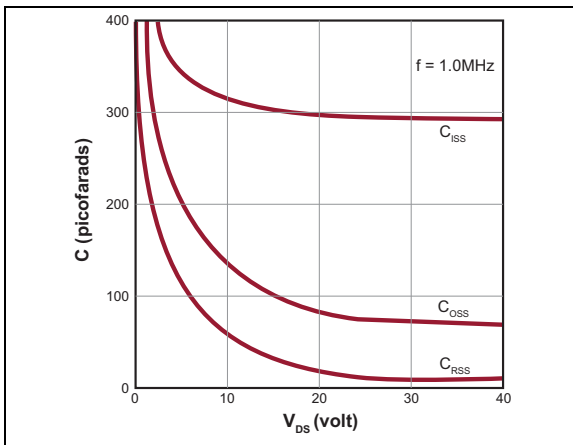
**FIGURE 2-10:** On-Resistance vs. Drain Current.



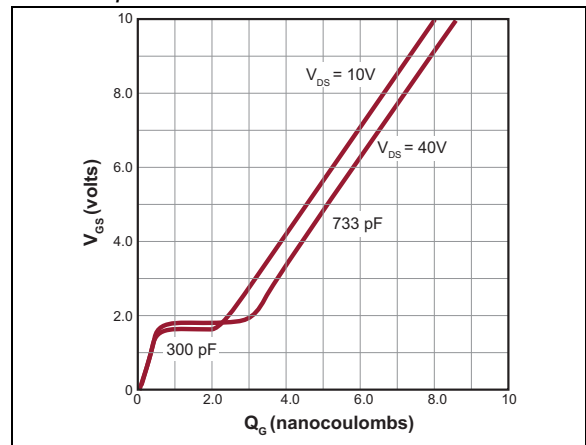
**FIGURE 2-8:** Transfer Characteristics.



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



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



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

# VN2224

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## 3.0 PIN DESCRIPTION

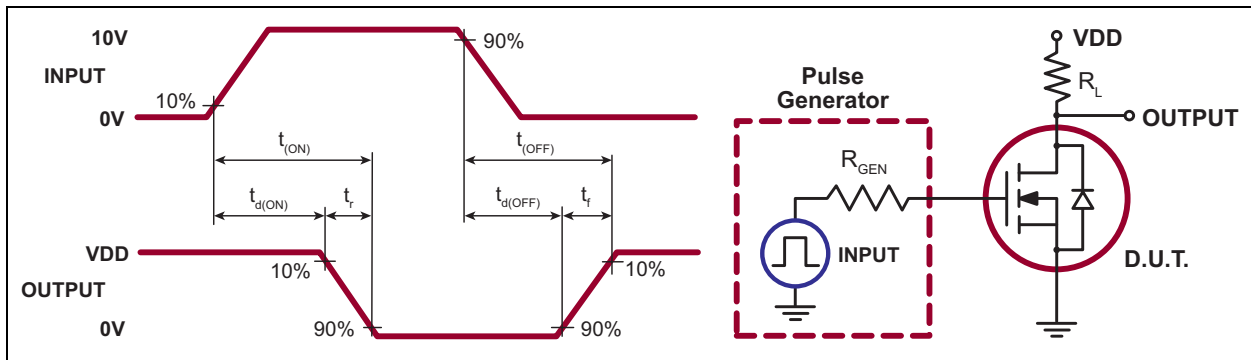
The details on the pins of VN2224 are listed on [Table 3-1](#). Refer to [Package Type](#) for the location of pins.

**TABLE 3-1: 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 VN2224.



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

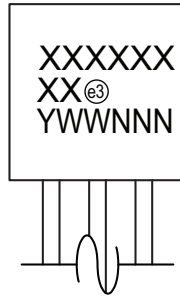
**TABLE 4-1: PRODUCT SUMMARY**

$BV_{DSS}/BV_{DGS}$ (V)	$R_{DS(ON)}$ (Maximum) ( $\Omega$ )	$I_{DSS}$ (Minimum) (A)
240	1.25	5

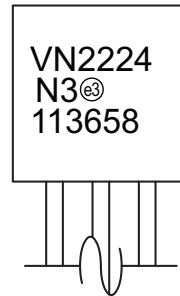
## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

3-lead TO-92



Example

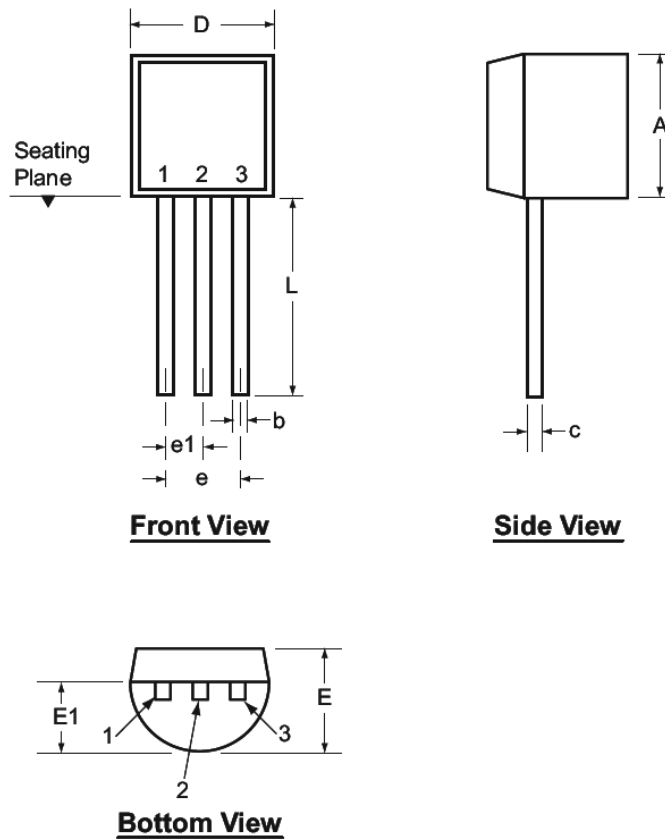


<b>Legend:</b>	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package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

# VN2224

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision A (March 2021)

- Converted Supertex Doc# DSFP-VN2224 to Microchip DS20005988A
- Added a pin function table
- Changed the package marking format
- Removed the 3-Lead TO-92 N3 P002, P003, P005, P013, and P014 media types to align packaging specifications with the actual BQM
- Made minor text changes throughout the document

# VN2224

## 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:	VN2224	=	N-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) VN2224N3-G: N-Channel Enhancement-Mode, Vertical DMOS FET, 3-lead TO-92, 1000/Bag

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