2N7002

N-Channel Enhancement-Mode Vertical DMOS FET

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.)

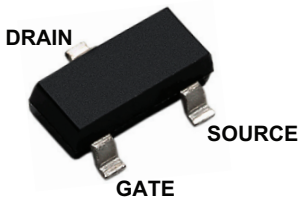
General Description

The 2N7002 is a low-threshold, Enhancement-mode (normally-off) transistor that 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 SOT-23
(Top view)



See Table 3-1 for pin information.

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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Drain-to-Source Voltage ..... BV_{DSS}
Drain-to-Gate Voltage ..... BV_{DGS}
Gate-to-Source Voltage ..... ±30V
Operating Ambient Temperature, T_A ..... –55°C to +150°C
Storage Temperature, T_S ..... –55°C to +150°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°C unless otherwise specified. (**Note 1**)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Drain-to-Source Breakdown Voltage	BV_{DSS}	60	—	—	V	V_{GS} = 0V, I_D = 10 µA
Gate Threshold Voltage	$V_{GS(th)}$	1	—	2.5	V	V_{GS} = V_{DS}, I_D = 250 µA
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	–5.5	mV/°C	V_{GS} = V_{DS}, I_D = 250 µA (**Note 2**)
Gate Body Leakage Current	I_{GSS}	—	—	±100	nA	V_{GS} = ±20V, V_{DS} = 0V
Zero-Gate Voltage Drain Current	I_{DSS}	—	—	1	µA	V_{GS} = 0V, V_{DS} = Maximum Rating
		—	—	500		V_{GS} = 0V, V_{DS} = 0.8 Maximum Rating, T_A = 125°C (**Note 2**)
On-State Drain Current	$I_{D(ON)}$	500	—	—	mA	V_{GS} = 10V, V_{DS} = 25V
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	—	7.5	Ω	V_{GS} = 5V, I_D = 50 mA
		—	—	7.5		V_{GS} = 10V, I_D = 500 mA
Change in $R_{DS(ON)}$ with Temperature	$\Delta_{RDS(ON)}$	—	—	1	%/°C	V_{GS} = 10V, I_D = 500 mA (**Note 2**)

Note 1: All DC parameters are 100% tested at 25°C unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle)

2: Specification is obtained by characterization and is not 100% tested.

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AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: T_A = 25°C unless otherwise specified. (Note 2)						
Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
Forward Transconductance	G_{FS}	80	—	—	mmho	V_{DS} = 25V, I_D = 500 mA
Input Capacitance	C_{ISS}	—	—	50	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1 MHz
Common Source Output Capacitance	C_{OSS}	—	—	25		
Reverse Transfer Capacitance	C_{RSS}	—	—	5		
Turn-On Time	$t_{(ON)}$	—	—	20	ns	V_{DD} = 30V, I_D = 200 mA, R_{GEN} = 25Ω
Turn-Off Time	$t_{(OFF)}$	—	—	20		
DIODE PARAMETER (Note 2)						
Diode Forward Voltage Drop	V_{SD}	—	1.2	—	V	V_{GS} = 0V, I_{SD} = 200 mA (Note 1)
Reverse Recovery Time	t_{rr}	—	400	—	ns	V_{GS} = 0V, I_{SD} = 800 mA

Note 1: All DC parameters are 100% tested at 25°C unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle)

2: Specification is obtained by characterization and is not 100% tested.

TEMPERATURE SPECIFICATIONS

Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
TEMPERATURE RANGE						
Operating Ambient Temperature	T_A	–55	—	+150	°C	
Storage Temperature	T_S	–55	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
3-lead SOT-23	θ_{JA}	—	203	—	°C/W	

THERMAL CHARACTERISTICS

Package	**I_D (Note 1) (Continuous) (mA)**	**I_D (Pulsed) (mA)**	**Power Dissipation at T_A = 25°C (W)**	**I_{DR} (Note 1) (mA)**	**I_{DRM} (mA)**
3-lead SOT-23	115	800	0.36	115	800

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

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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.

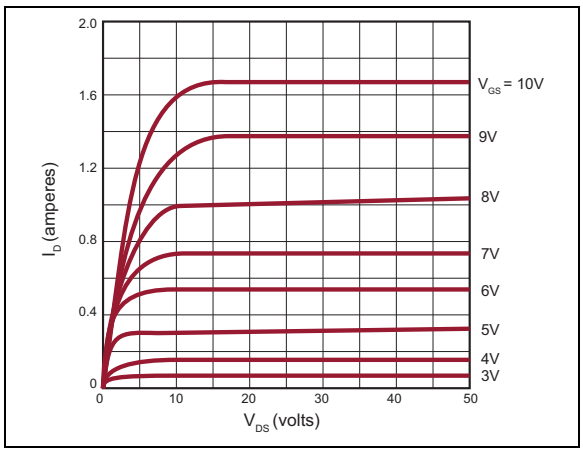

FIGURE 2-1: *Output Characteristics.*

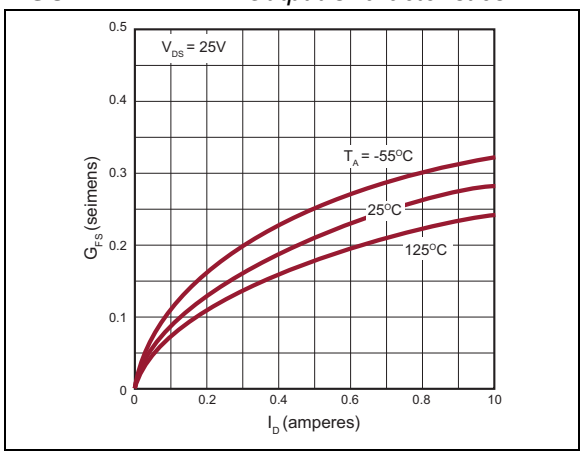

FIGURE 2-2: *Transconductance vs. Drain Current.*

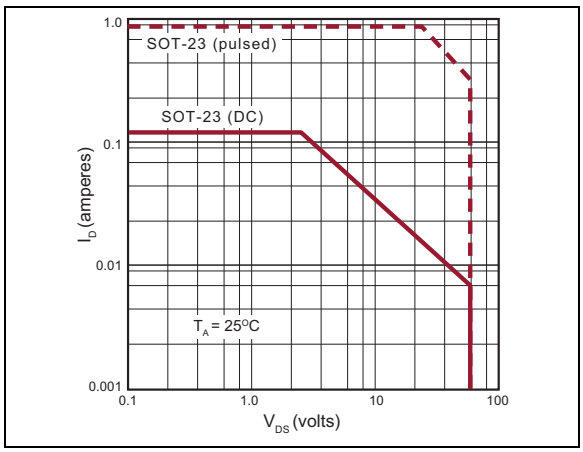

FIGURE 2-3: *Maximum Rated Safe Operating Area.*

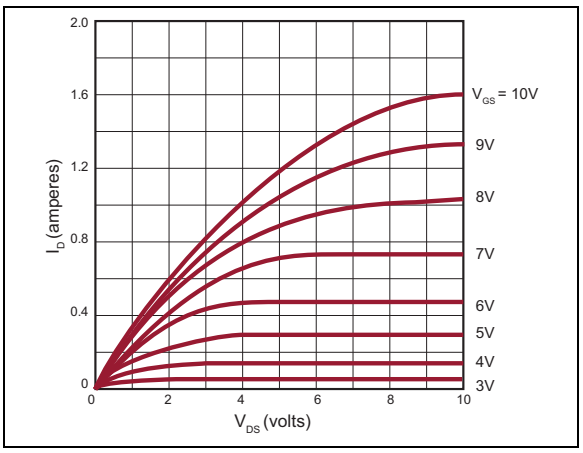

FIGURE 2-4: *Saturation Characteristics.*

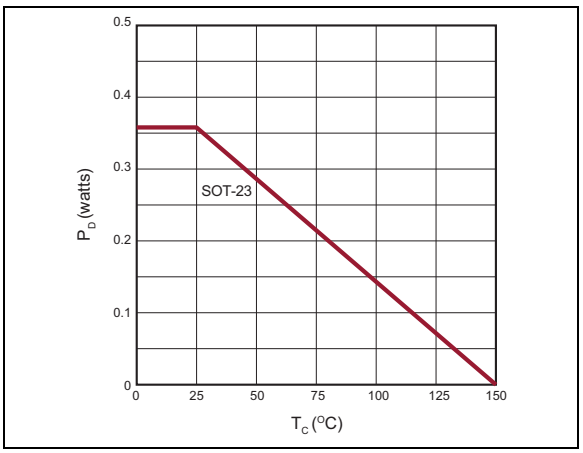

FIGURE 2-5: *Power Dissipation vs. Case Temperature.*

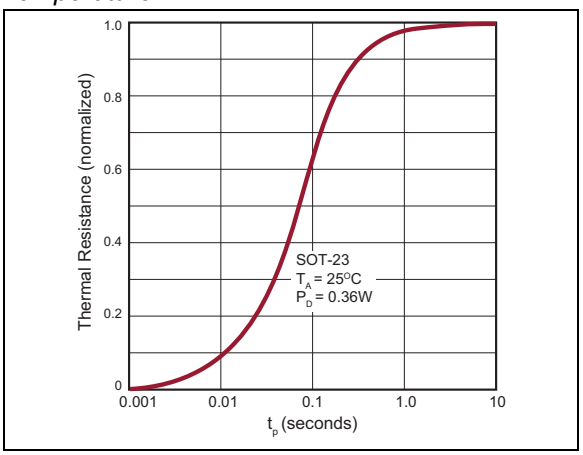

FIGURE 2-6: *Thermal Response Characteristics.*

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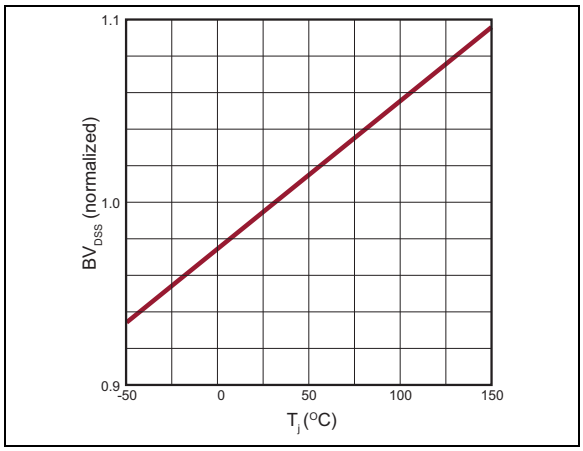

FIGURE 2-7: *BV_{DSS} Variation with Temperature.*

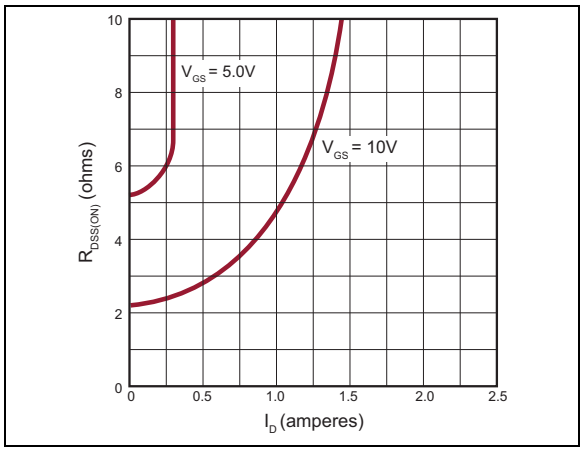

FIGURE 2-10: *On-Resistance vs. Drain Current.*

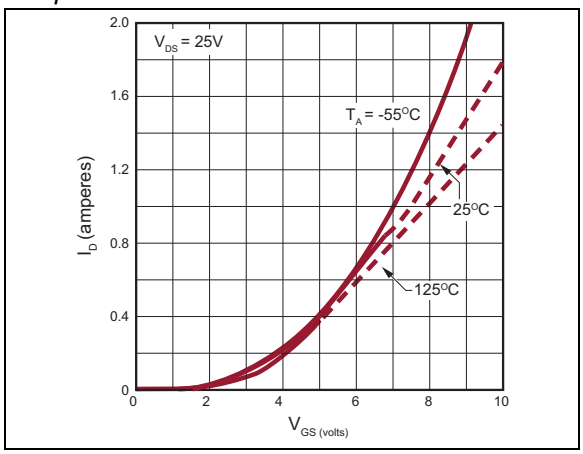

FIGURE 2-8: *Transfer Characteristics.*

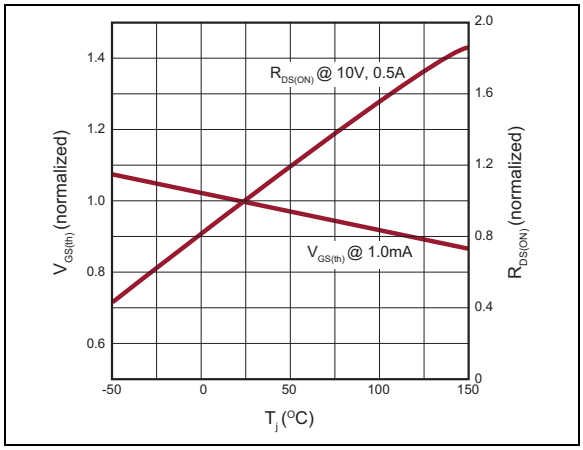

FIGURE 2-11: *$V_{GS(th)}$ and $R_{DS(ON)}$ Variation with Temperature.*

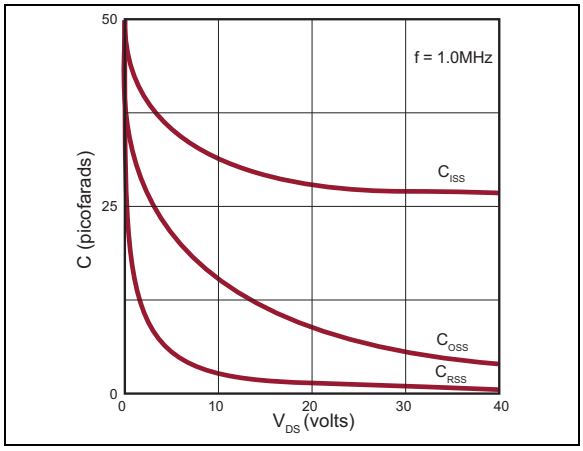

FIGURE 2-9: *Capacitance vs. Drain-to-Source Voltage.*

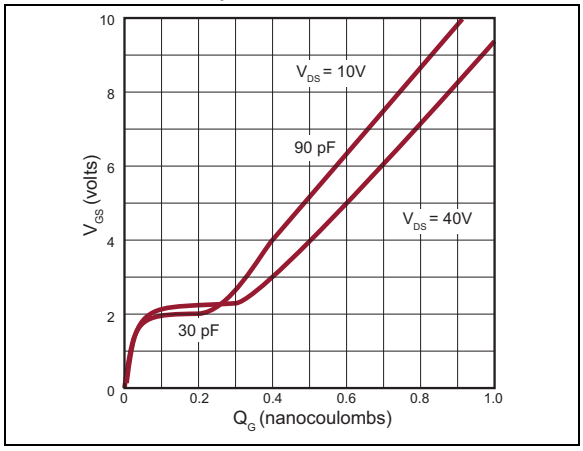

FIGURE 2-12: *Gate Drive Dynamic Characteristics.*

3.0 PIN DESCRIPTION

Table 3-1 shows the description of pins in 2N7002. Refer to **Package Type** for the location of pins.

TABLE 3-1: PIN FUNCTION TABLE

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

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4.0 FUNCTIONAL DESCRIPTION

Figure 4-1 illustrates the switching waveforms and test circuit for 2N7002.

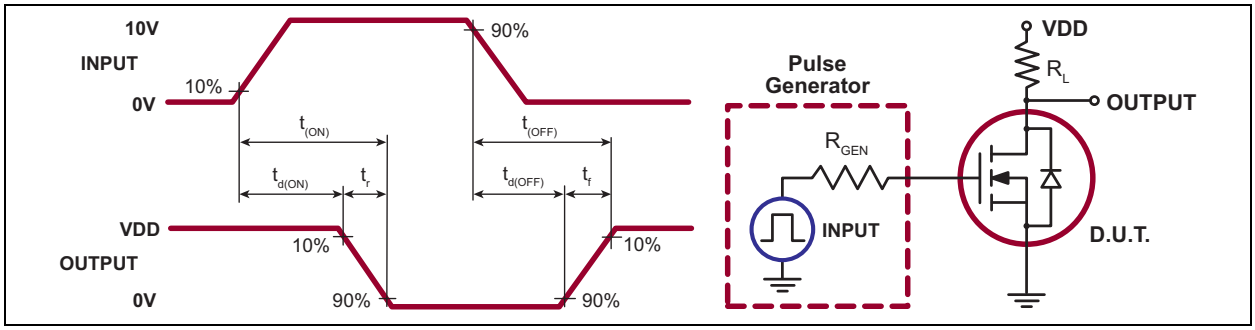


FIGURE 4-1: *Switching Waveforms and Test Circuit.*

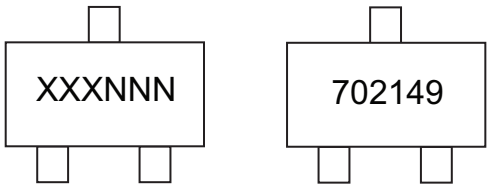
TABLE 4-1: PRODUCT SUMMARY

BV_{DSS}/BV_{DGS} (V)	$R_{DS(ON)}$ (Maximum) (Ω)	$I_{D(ON)}$ (Minimum) (mA)
60	7.5	500

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

3-lead SOT-23 Example



Legend:	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.

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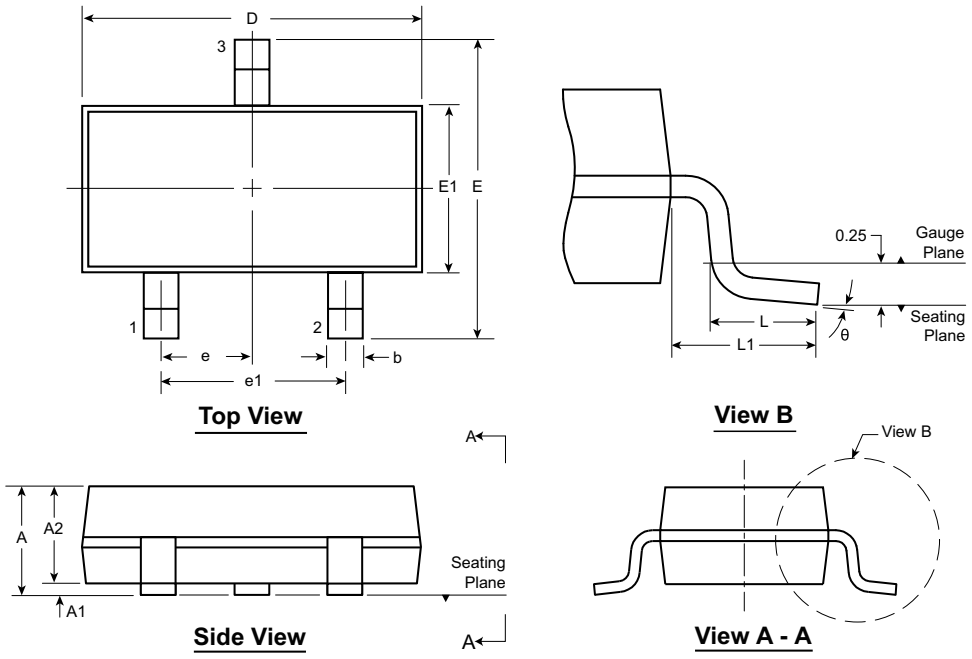
3-Lead TO-236AB (SOT-23) Package Outline (K1/T)

2.90x1.30mm body, 1.12mm height (max), 1.90mm pitch



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

Symbol		A	A1	A2	b	D	E	E1	e	e1	L	L1	θ
Dimension (mm)	MIN	0.89	0.01	0.88	0.30	2.80	2.10	1.20	0.95 BSC	1.90 BSC	0.20†	0.54 REF	0°
	NOM	-	-	0.95	-	2.90	-	1.30			0.50		-
	MAX	1.12	0.10	1.02	0.50	3.04	2.64	1.40			0.60		8°

JEDEC Registration TO-236, Variation AB, Issue H, Jan. 1999.
† This dimension differs from the JEDEC drawing.
Drawings not to scale.

NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (September 2018)

- Converted Supertex Doc# DSFP-2N7002 to Microchip DS20005797A
- Changed the package marking format
- Added some sections to comply with standard Microchip Technology documentation format
- Made minor text changes throughout the document

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Device:	2N7002	=	N-Channel Enhancement-Mode Vertical DMOS FET
Package:	(blank)	=	3-lead SOT-23
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	3000/Reel for an SOT-23 Package

Example:

a) 2N7002-G: N-Channel Enhancement-Mode Vertical DMOS FET, 3-lead SOT-23, 3000/Reel

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