DN2535

N-Channel Depletion-Mode Vertical DMOS FET

Features

- High Input Impedance
- Low Input Capacitance
- Fast Switching Speeds
- Low On-resistance
- Free from Secondary Breakdown
- Low Input and Output Leakage

Applications

- Normally-on Switches
- Solid-state Relays
- Converters
- Linear Amplifiers
- Constant-current Sources
- Power Supply Circuits
- Telecommunication Switches

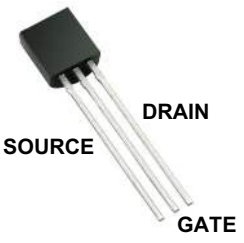
Description

The DN2535 is a low-threshold Depletion-mode (normally-on) transistor that uses an advanced 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, these devices are free from thermal runaway and thermally induced secondary breakdown.

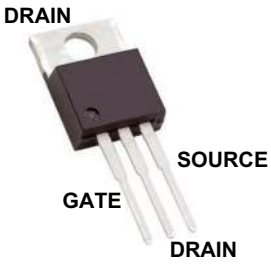
Microchip's vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where high breakdown voltage, high input impedance, low input capacitance, and fast switching speeds are desired.

Package Types

3-lead TO-92
(Top view)



3-lead TO-220
(Top view)



See Table 3-1 and Table 3-2 for pin information.

1.0 ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS†

Drain-to-Source Voltage ..... BV_{DSX}
Drain-to-Gate Voltage ..... BV_{DGX}
Gate-to-Source Voltage ..... ±20V
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 “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 listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: T_A = 25°C unless otherwise specified. All DC parameters are 100% tested at 25°C unless otherwise stated. Pulse test: 300 µs pulse, 2% duty cycle

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Drain-to-Source Breakdown Voltage	BV_{DSX}	350	—	—	V	V_{GS} = –5V, I_D = 100 µA
Gate-to-Source Off Voltage	$V_{GS(OFF)}$	–1.5	—	–3.5	V	V_{DS} = 25V, I_D = 10 µA
Change in $V_{GS(OFF)}$ with Temperature	$\Delta V_{GS(OFF)}$	—	—	–4.5	mV/°C	V_{DS} = 25V, I_D = 10 µA (**Note 1**)
Gate Body Leakage Current	I_{GSS}	—	—	100	nA	V_{GS} = ±20V, V_{DS} = 0V
Drain-to-Source Leakage Current	$I_{D(OFF)}$	—	—	10	µA	V_{DS} = Maximum rating, V_{GS} = –10V
		—	—	1	mA	V_{DS} = 0.8 Maximum rating, V_{GS} = –10V, T_A = 125°C (**Note 1**)
Saturated Drain-to-Source Current	I_{DSS}	150	—	—	mA	V_{GS} = 0V, V_{DS} = 25V
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	17	25	Ω	V_{GS} = 0V, I_D = 120 mA
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1.1	%/°C	V_{GS} = 0V, I_D = 120 mA (**Note 1**)

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

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: T_A = 25°C unless otherwise specified. Specification is obtained by characterization and is not 100% sample tested.						
Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
Forward Transconductance	G_{FS}	—	325	—	mmho	V_{DS} = 10V, I_D = 100 mA
Input Capacitance	C_{ISS}	—	200	300	pF	V_{GS} = –10V, V_{DS} = 25V, f = 1 MHz
Common-Source Output Capacitance	C_{OSS}	—	12	30	pF	
Reverse Transfer Capacitance	C_{RSS}	—	1	5	pF	
Turn-On Delay Time	$t_{d(ON)}$	—	—	10	ns	V_{DD} = 25V, I_D = 150 mA, R_{GEN} = 25Ω,
Rise Time	t_r	—	—	15	ns	
Turn-Off Delay Time	$t_{d(OFF)}$	—	—	15	ns	
Fall Time	t_f	—	—	20	ns	
DIODE PARAMETER						
Diode Forward Voltage Drop	V_{SD}	—	—	1.8	V	V_{GS} = –10V, I_{SD} = 120 mA (**Note 1**)
Reverse Recovery Time	t_{rr}	—	800	—	ns	V_{GS} = –10V, I_{SD} = 1A

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

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 TO-92	θ_{JA}	—	132	—	°C/W	
3-lead TO-220	θ_{JA}	—	29	—	°C/W	

THERMAL CHARACTERISTICS

Package	**I_D (Note 1) (Continuous) (mA)**	**I_D (Pulsed) (mA)**	**Power Dissipation at T_A = 25°C (Note 2) (W)**	**I_{DR} (Note 1) (mA)**	**I_{DRM} (mA)**
3-lead TO-92	120	500	1	120	500
3-lead TO-220	500	500	15	500	500

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.

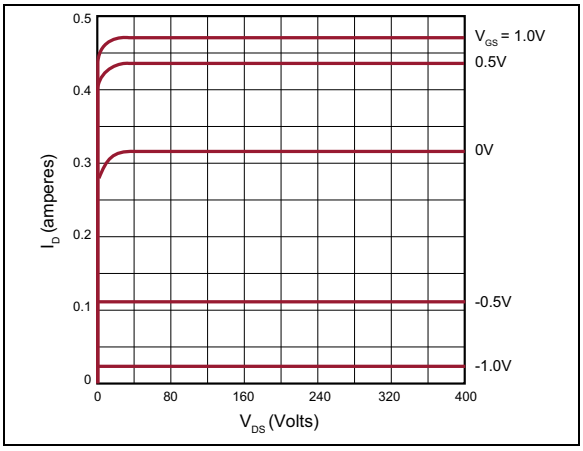


FIGURE 2-1: *Output Characteristics.*

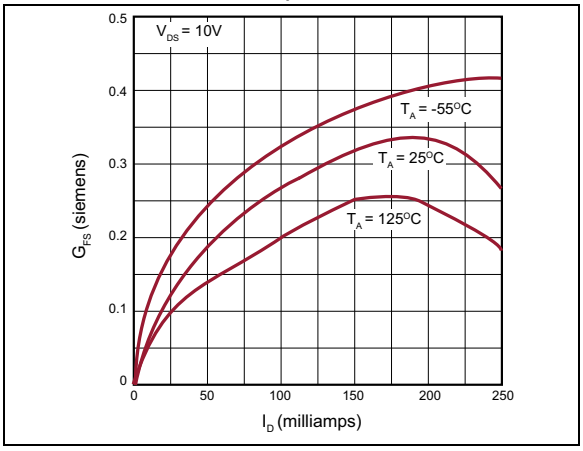


FIGURE 2-2: *Transconductance vs. Drain Current.*

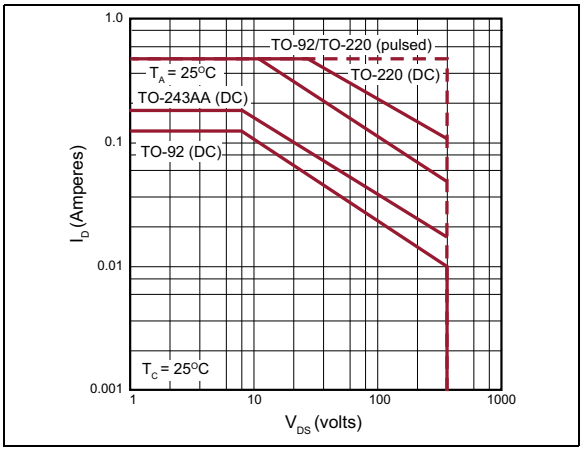


FIGURE 2-3: *Maximum Rated Safe Operating Area.*

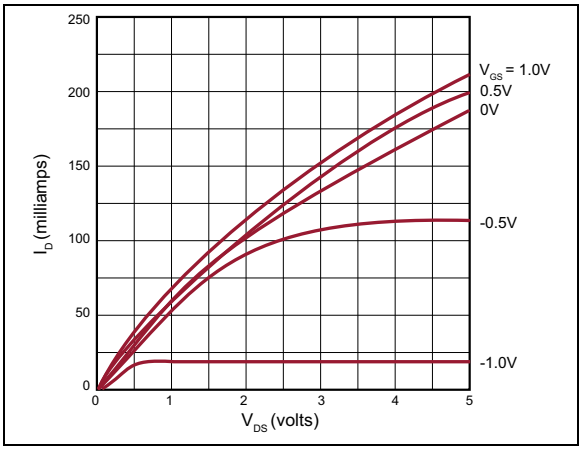


FIGURE 2-4: *Saturation Characteristics.*

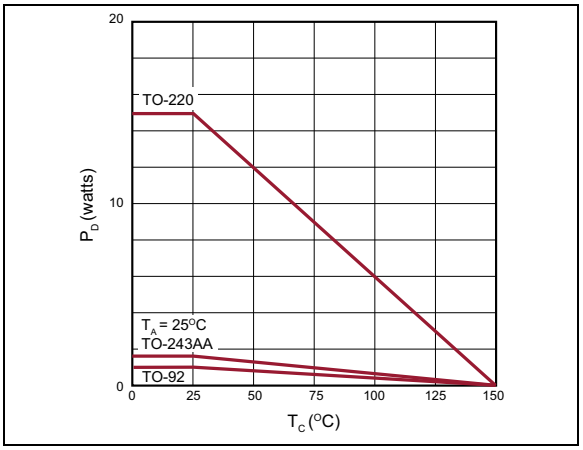


FIGURE 2-5: *Power Dissipation vs. Case Temperature.*

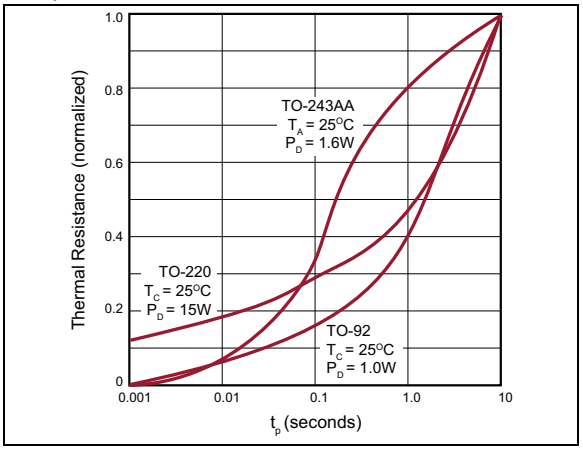


FIGURE 2-6: *Thermal Response Characteristics.*

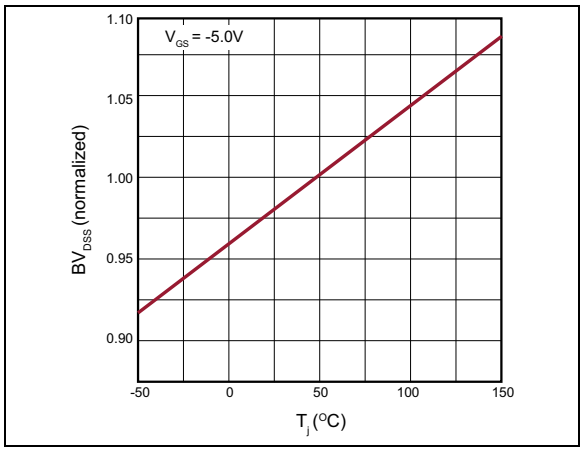


FIGURE 2-7: *BV_{DSV} Variation with Temperature.*

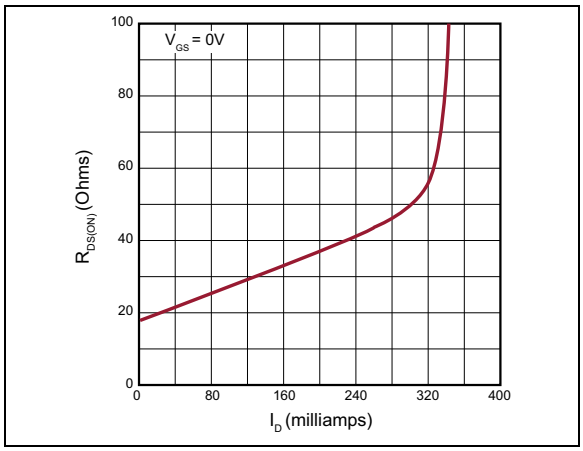


FIGURE 2-10: *On-Resistance vs. Drain Current.*

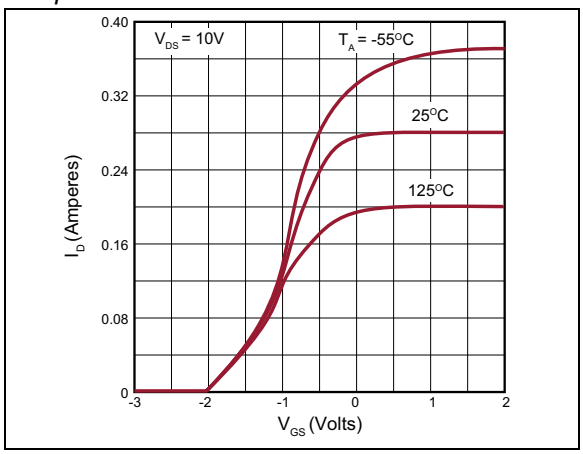


FIGURE 2-8: *Transfer Characteristics.*

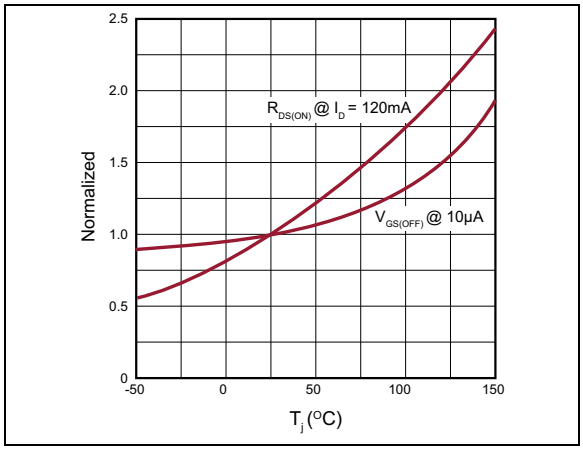


FIGURE 2-11: *$V_{GS(OFF)}$ and $R_{DS(ON)}$ with Temperature.*

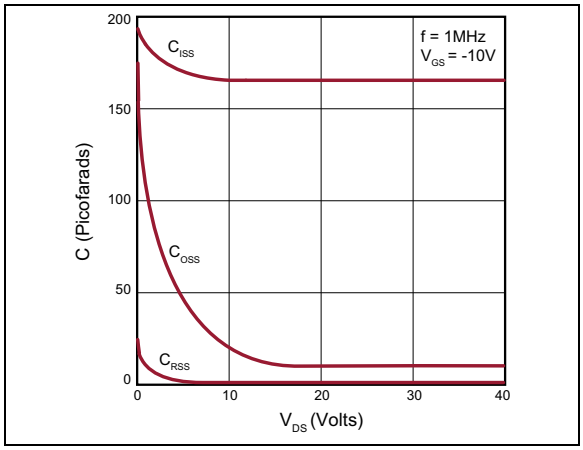


FIGURE 2-9: *Capacitance vs. Drain-to-Source Voltage.*

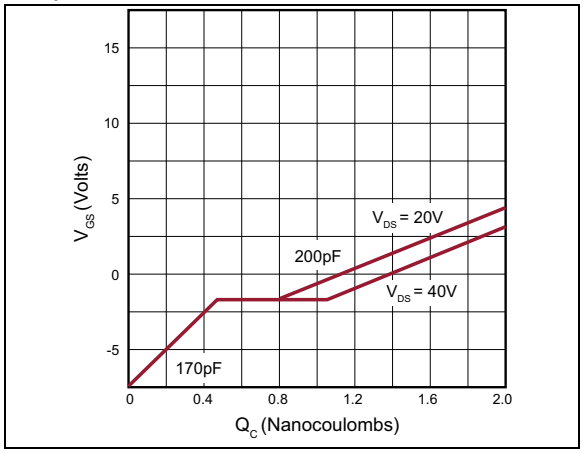


FIGURE 2-12: *Gate Drive Dynamic Characteristics.*

3.0 PIN DESCRIPTION

Table 3-1 and Table 3-2 show the description of pins in DN2535. Refer to **Package Types** 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

TABLE 3-2: 3-LEAD TO-220 FUNCTION TABLE

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

4.0 FUNCTIONAL DESCRIPTION

Figure 4-1 shows the switching waveforms and test circuit for DN2535.

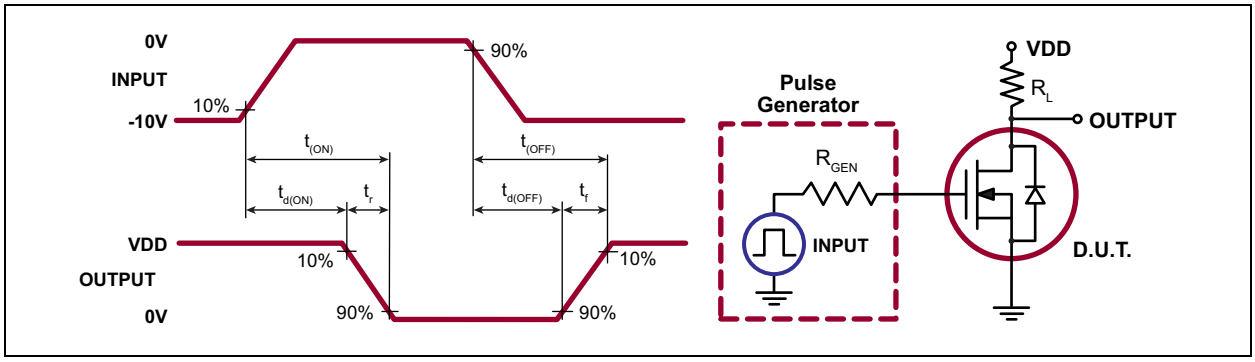


FIGURE 4-1: *Switching Waveforms and Test Circuit.*

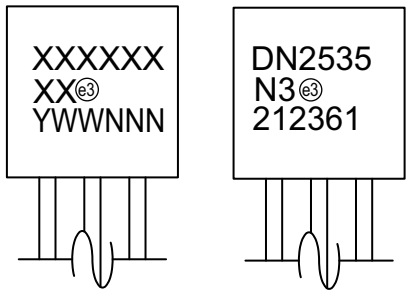
TABLE 4-1: PRODUCT SUMMARY

BV_{DSX}/BV_{DGX} (V)	$R_{DS(ON)}$ (Maximum) (Ω)	I_{DSS} (Minimum) (mA)
350	25	150

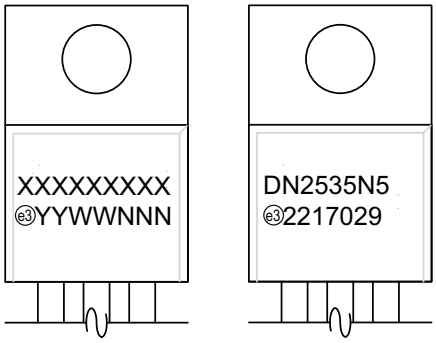
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

3-lead TO-92 Example



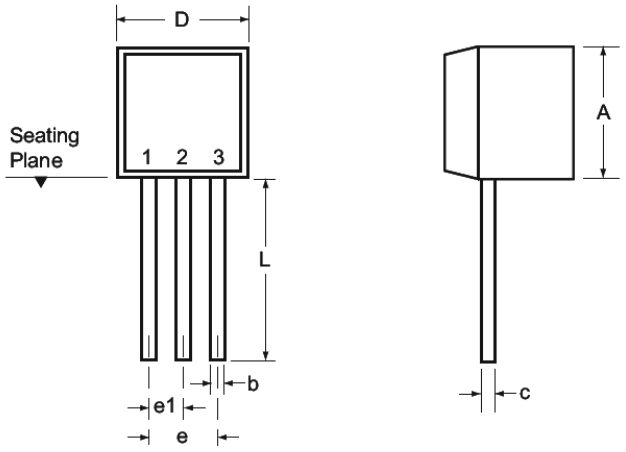
3-lead TO-220 Example



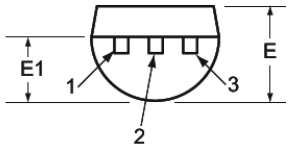
Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package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

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



Front View **Side View**



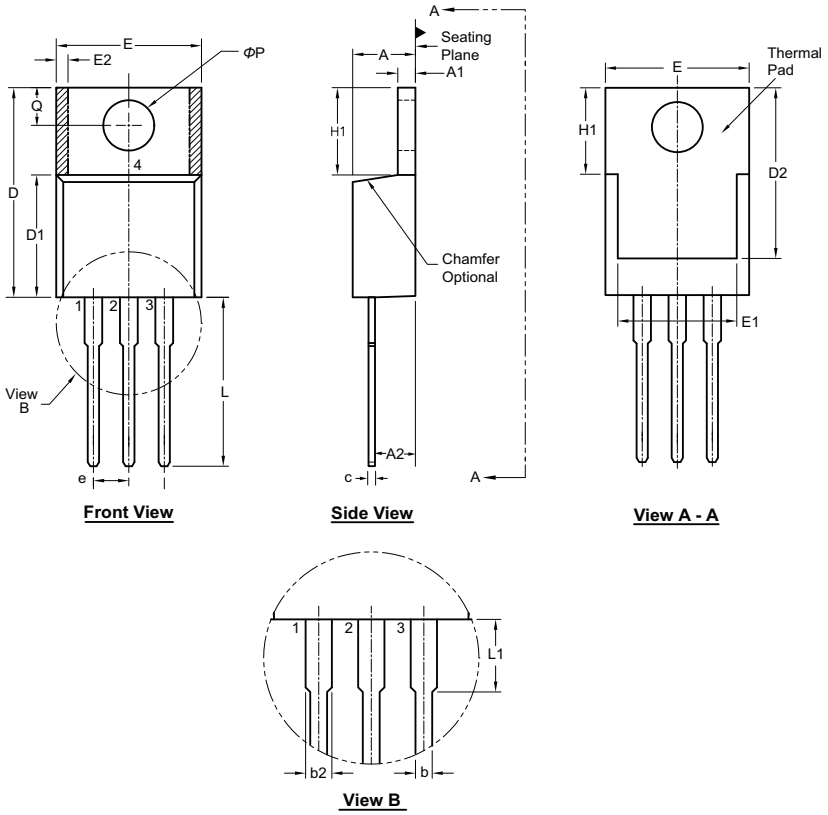
Bottom View

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

Symbol		A	b	c	D	E	E1	e	e1	L
Dimensions (inches)	MIN	.170	.014†	.014†	.175	.125	.080	.095	.045	.500
	NOM	-	-	-	-	-	-	-	-	-
	MAX	.210	.022†	.022†	.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.

3-Lead TO-220 Package Outline (N5)



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

Symbol		A	A1	A2	b	b2	c	D	D1	D2	E	E1	E2	e	H1	L	L1	Q	ΦP
Dimen-sion (inches)	MIN	.140	.020	.080	.015	.045	.012†	.560	.326†	.474†	.380	.270	0.20*	.100 BSC	.230	.500	.200*	.100	.139
	NOM	-	-	-	.027	.057	-	-	-	-	-	-	-		-	-	-	-	-
	MAX	.190	.055	.120†	.040	.070	.024	.650	.361†	.507	.420	.350	.030		.270	.580	.250	.135	.161

JEDEC Registration TO-220, Variation AB, Issue K, April 2002.
** This dimension is not specified in the JEDEC drawing.*
† This dimension differs from the JEDEC drawing.
Drawings not to scale.

APPENDIX A: REVISION HISTORY

Revision A (August 2022)

- Converted Doc# DSFP-DN2535 to Microchip DS20005541A
- Added some sections to comply with the standard Microchip format
- Changed the package marking format
- Removed the 3-lead TO-92 N3 P002, P005, and P014 media types to align packaging specifications with the actual BQM
- Made minor text changes throughout the document

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

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

Device:	DN2535	N-Channel Depletion-Mode Vertical DMOS FET
Packages:	N3	= 3-lead TO-92
	N5	= 3 lead TO-220
Environmental:	G	= Lead (Pb)-free/ROHS-compliant package
Media Types:	(blank)	= 1000/Bag for an N3 package
		= 50/Tube for an N5 package
	P003	= 2000/Reel for an N3 package
	P013	= 2000/Ammo Pack for an N3 package

Examples:

a) DN2535N3-G:	N-Channel Depletion-Mode, Vertical DMOS FET, 3-lead TO-92,1000/Bag
b) DN2535N3-G-P003	N-Channel Depletion-Mode, Vertical DMOS FET, 3-lead T0-92, 2000/Reel
c) DN2535N3-G-P013:	N-Channel Depletion-Mode, Vertical DMOS FET, 3-lead TO-92, 2000/Ammo Pack
d) DN2535N5-G:	N-Channel Depletion-Mode, Vertical DMOS FET, 3-lead TO-220, 50/Tube

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- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
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