



ON Semiconductor®

# 2N7000 / 2N7002 / NDS7002A N-Channel Enhancement Mode Field Effect Transistor

## Features

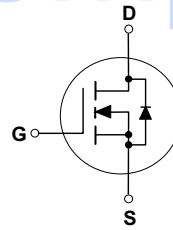
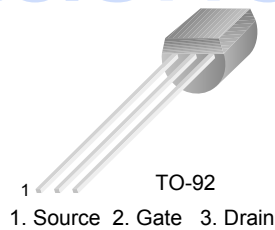
- High Density Cell Design for Low  $R_{DS(ON)}$
- Voltage Controlled Small Signal Switch
- Rugged and Reliable
- High Saturation Current Capability

## Description

These N-channel enhancement mode field effect transistors are produced using ON Semiconductor's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while providing rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400 mA DC and can deliver pulsed currents up to 2 A. These products are particularly suited for low-voltage, low-current applications, such as small servo motor control, power MOSFET gate drivers, and other switching applications.

2N7000 / 2N7002 / NDS7002A — N-Channel Enhancement Mode Field Effect Transistor

# Datasheet.Company



## Ordering Information

Part Number	Marking	Package	Packing Method	Min Order Qty / Immediate Pack Qty
2N7000	2N7000	TO-92 3L	Bulk	10000 / 1000
2N7000-D74Z	2N7000	TO-92 3L	Ammo	2000 / 2000
2N7000-D75Z	2N7000	TO-92 3L	Tape and Reel	2000 / 2000
2N7000-D26Z	2N7000	TO-92 3L	Tape and Reel	2000 / 2000
2N7002	702	SOT-23 3L	Tape and Reel	3000 / 3000
NDS7002A	712	SOT-23 3L	Tape and Reel	3000 / 3000

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at  $T_C = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Value			Unit
		2N7000	2N7002	NDS7002A	
$V_{DSS}$	Drain-to-Source Voltage	60			V
$V_{DGR}$	Drain-Gate Voltage ( $R_{GS} \leq 1\text{ M}\Omega$ )	60			V
$V_{GSS}$	Gate-Source Voltage - Continuous	$\pm 20$			V
	Gate-Source Voltage - Non Repetitive ( $t_p < 50\ \mu\text{s}$ )	$\pm 40$			
$I_D$	Maximum Drain Current - Continuous	200	115	280	mA
	Maximum Drain Current - Pulsed	500	800	1500	
$P_D$	Maximum Power Dissipation Derated above $25^\circ\text{C}$	400	200	300	mW
		3.2	1.6	2.4	$\text{mW}/^\circ\text{C}$
$T_J, T_{STG}$	Operating and Storage Temperature Range	-55 to 150		-65 to 150	$^\circ\text{C}$
$T_L$	Maximum Lead Temperature for Soldering Purposes, 1/16-inch from Case for 10 Seconds	300			$^\circ\text{C}$

## Thermal Characteristics

Values are at  $T_C = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Value			Unit
		2N7000	2N7002	NDS7002A	
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	312.5	625	417	$^\circ\text{C}/\text{W}$

## Electrical Characteristics

Values are at  $T_C = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Unit
<b>Off Characteristics</b>							
$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0\text{ V}, I_D = 10\ \mu\text{A}$	All	60			V
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 48\text{ V}, V_{GS} = 0\text{ V}$	2N7000			1	$\mu\text{A}$
		$V_{DS} = 48\text{ V}, V_{GS} = 0\text{ V}, T_C = 125^\circ\text{C}$				1	mA
		$V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$	2N7002 NDS7002A			1	$\mu\text{A}$
		$V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}, T_C = 125^\circ\text{C}$				0.5	mA
$I_{GSSF}$	Gate - Body Leakage, Forward	$V_{GS} = 15\text{ V}, V_{DS} = 0\text{ V}$	2N7000			10	nA
		$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$	2N7002 NDS7002A			100	nA
$I_{GSSR}$	Gate - Body Leakage, Reverse	$V_{GS} = -15\text{ V}, V_{DS} = 0\text{ V}$	2N7000			-10	nA
		$V_{GS} = -20\text{ V}, V_{DS} = 0\text{ V}$	2N7002 NDS7002A			-100	nA

**Electrical Characteristics** (Continued)

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Unit
<b>On Characteristics</b>							
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 1 \text{ mA}$	2N7000	0.8	2.1	3	V
		$V_{DS} = V_{GS}, I_D = 250 \mu\text{A}$	2N7002 NDS7002A	1	2.1	2.5	
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	2N7000		1.2	5	$\Omega$
		$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 125^\circ\text{C}$			1.9	9	
		$V_{GS} = 4.5 \text{ V}, I_D = 75 \text{ mA}$			1.8	5.3	
		$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	2N7002		1.2	7.5	
		$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 100^\circ\text{C}$			1.7	13.5	
		$V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}$			1.7	7.5	
		$V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}, T_C = 100^\circ\text{C}$			2.4	13.5	
		$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	NDS7002A		1.2	2	
		$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}, T_C = 125^\circ\text{C}$			2	3.5	
		$V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}$			1.7	3	
		$V_{GS} = 5 \text{ V}, I_D = 50 \text{ mA}, T_C = 125^\circ\text{C}$			2.8	5	
		$V_{DS(ON)}$	Drain-Source On-Voltage	$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	2N7000		
$V_{GS} = 4.5 \text{ V}, I_D = 75 \text{ mA}$				0.14		0.4	
$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	2N7002				0.6	3.75	
$V_{GS} = 5.0 \text{ V}, I_D = 50 \text{ mA}$					0.09	1.5	
$V_{GS} = 10 \text{ V}, I_D = 500 \text{ mA}$	NDS7002A				0.6	1	
$V_{GS} = 5.0 \text{ V}, I_D = 50 \text{ mA}$					0.09	0.15	
$I_{D(ON)}$	On-State Drain Current	$V_{GS} = 4.5 \text{ V}, V_{DS} = 10 \text{ V}$	2N7000	75	600		mA
		$V_{GS} = 10 \text{ V}, V_{DS} \geq 2 V_{DS(on)}$	2N7002	500	2700		
		$V_{GS} = 10 \text{ V}, V_{DS} \geq 2 V_{DS(on)}$	NDS7002A	500	2700		
$g_{FS}$	Forward Transconductance	$V_{DS} = 10 \text{ V}, I_D = 200 \text{ mA}$	2N7000	100	320		mS
		$V_{DS} \geq 2V_{DS(ON)}, I_D = 200 \text{ mA}$	2N7002	80	320		
		$V_{DS} \geq 2V_{DS(ON)}, I_D = 200 \text{ mA}$	NDS7002A	80	320		

### Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Unit
<b>Dynamic Characteristics</b>							
$C_{iss}$	Input Capacitance	$V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V},$ $f = 1.0\text{ MHz}$	All		20	50	pF
$C_{oss}$	Output Capacitance		All		11	25	
$C_{rss}$	Reverse Transfer Capacitance		All		4	5	
$t_{on}$	Turn-On Time	$V_{DD} = 15\text{ V}, R_L = 25\ \Omega,$ $I_D = 500\text{ mA}, V_{GS} = 10\text{ V},$ $R_{GEN} = 25\ \Omega$	2N7000			10	ns
		$V_{DD} = 30\text{ V}, R_L = 150\ \Omega,$ $I_D = 200\text{ mA}, V_{GS} = 10\text{ V},$ $R_{GEN} = 25\ \Omega$	2N7002 NDS7002A			20	
$t_{off}$	Turn-Off Time	$V_{DD} = 15\text{ V}, R_L = 25\ \Omega,$ $I_D = 500\text{ mA}, V_{GS} = 10\text{ V},$ $R_{GEN} = 25\ \Omega$	2N7000			10	ns
		$V_{DD} = 30\text{ V}, R_L = 150\ \Omega,$ $I_D = 200\text{ mA}, V_{GS} = 10\text{ V},$ $R_{GEN} = 25\ \Omega$	2N7002 NDS7002A			20	
<b>Drain-Source Diode Characteristics and Maximum Ratings</b>							
$I_S$	Maximum Continuous Drain-Source Diode Forward Current		2N7002			115	mA
			NDS7002A			280	
$I_{SM}$	Maximum Pulsed Drain-Source Diode Forward Current		2N7002			0.8	A
			NDS7002A			1.5	
$V_{SD}$	Drain-Source Diode Forward Voltage	$V_{GS} = 0\text{ V},$ $I_S = 115\text{ mA}^{(1)}$	2N7002		0.88	1.5	V
		$V_{GS} = 0\text{ V},$ $I_S = 400\text{ mA}^{(1)}$	NDS7002A		0.88	1.2	

**Note:**

1. Pulse test : Pulse Width  $\leq 300\ \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

# Typical Performance Characteristics

2N7000 / 2N7002 / NDS7002A

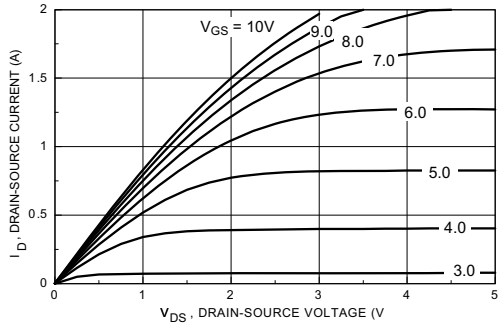


Figure 1. On-Region Characteristics

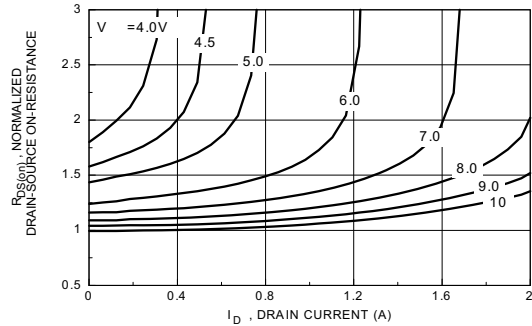


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

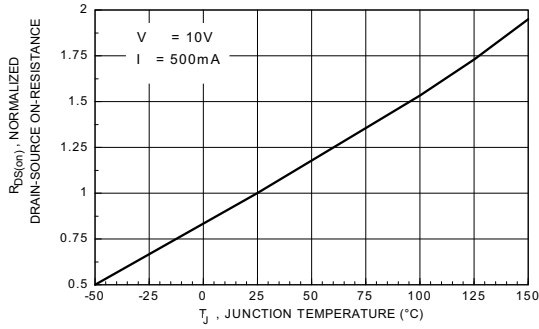


Figure 3. On-Resistance Variation with Temperature

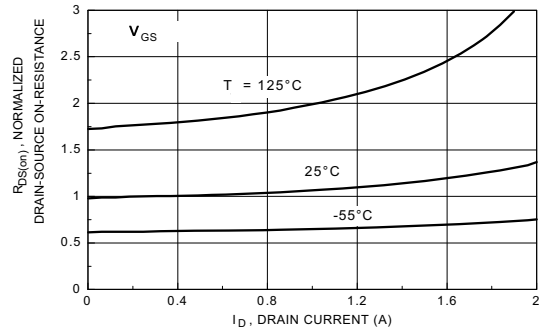


Figure 4. On-Resistance Variation with Drain Current and Temperature

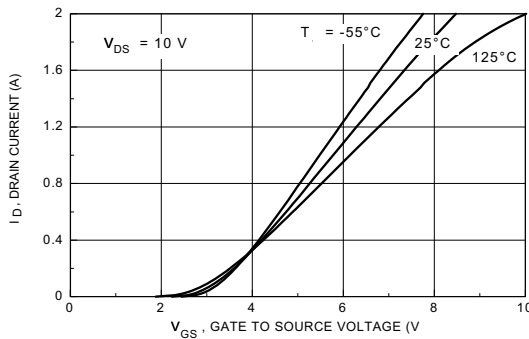


Figure 5. Transfer Characteristics

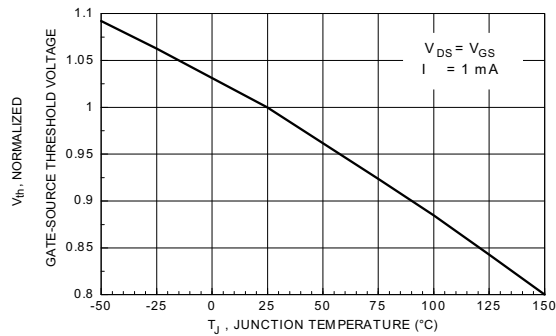
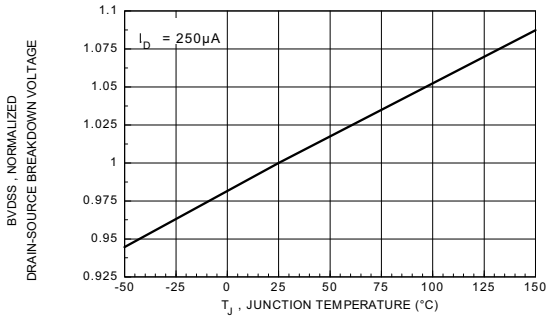


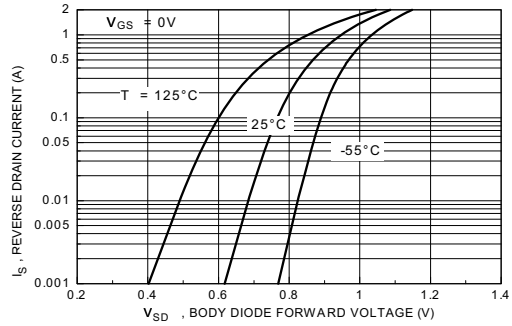
Figure 6. Gate Threshold Variation with Temperature

## Typical Performance Characteristics (Continued)

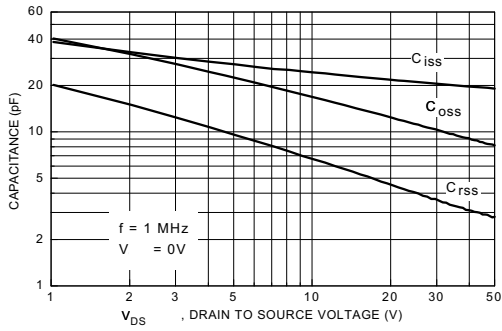
### 2N7000 / 2N7002 / NDS7002A



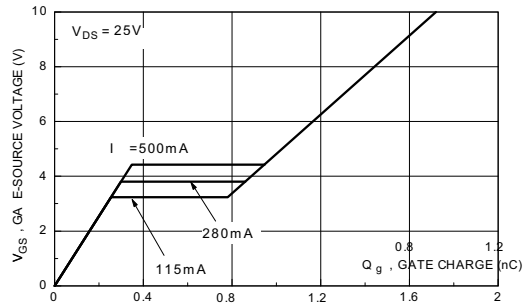
**Figure 7. Breakdown Voltage Variation with Temperature**



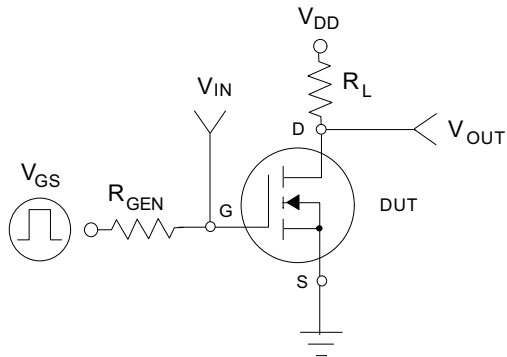
**Figure 8. Body Diode Forward Voltage Variation with Temperature**



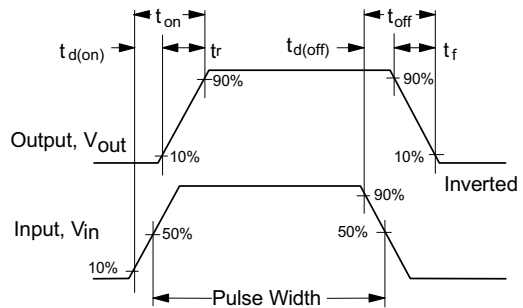
**Figure 9. Capacitance Characteristics**



**Figure 10. Gate Charge Characteristics**



**Figure 11. Switching Test Circuit**



**Figure 12. Switching Waveforms**

Typical Performance Characteristics (Continued)

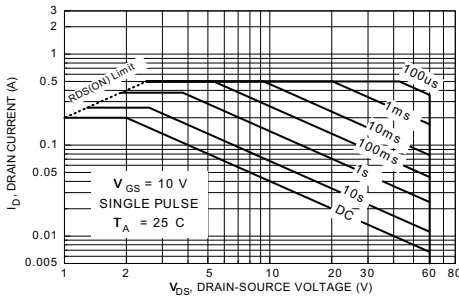


Figure 13. 2N7000 Maximum Safe Operating Area

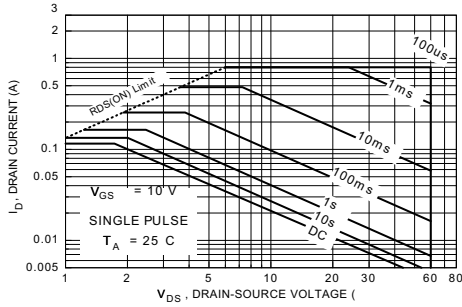


Figure 14. 2N7002 Maximum Safe Operating Area

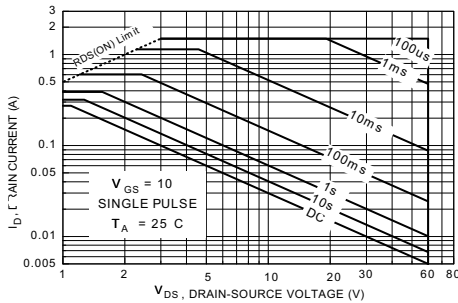


Figure 15. NDS7000A Maximum Safe Operating Area

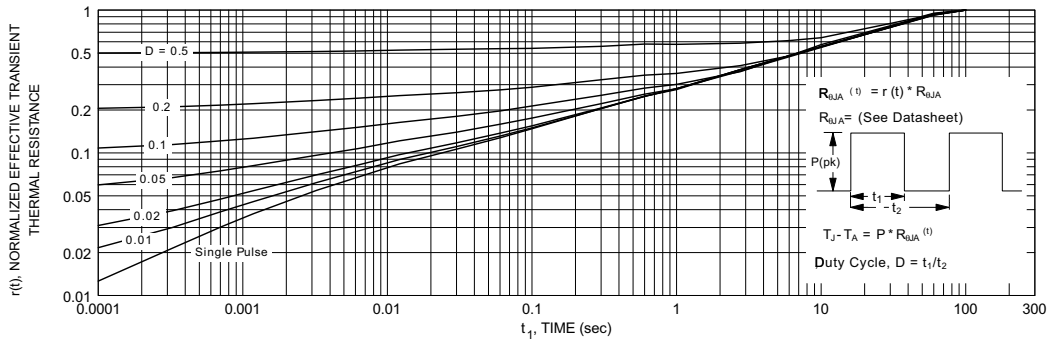


Figure 16. TO-92, 2N7000 Transient Thermal Response Curve

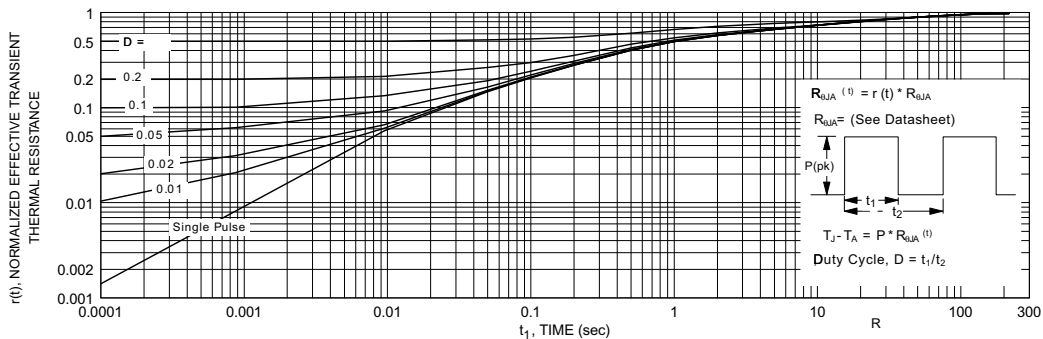


Figure 17. SOT-23, 2N7002 / NDS7002A Transient Thermal Response Curve

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