

March 1993

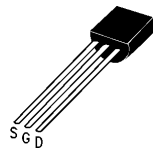
2N7000/2N7002/NDF7000A/NDS7002A N-Channel Enhancement Mode Field Effect Transistor

General Description

These n-channel enhancement mode field effect transistors are produced using National's very high cell density third generation DMOS technology. These products have been designed to minimize on-state resistance provide rugged and reliable performance and fast switching. They can be used, with a minimum of effort, in most applications requiring up to 400 mA DC and can deliver pulsed currents up to 2A. This product is particularly suited to low voltage, low current applications, such as small servo motor controls, power MOSFET gate drivers, and other switching applications.

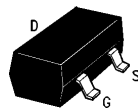
Features

- Efficient high density cell design approaching (3 million/in²)
- Voltage controlled small signal switch
- Rugged
- High saturation current
- Low R_{DS} (ON)



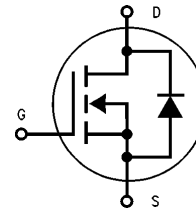
TO-92
7000 Series

TL/G/11378-1



TO-236 AB
(SOT-23)
7002 Series

TL/G/11378-2



TL/G/11378-3

Absolute Maximum Ratings

Symbol	Parameter	2N7000	2N7002	NDF7000A	NDS7002A	Units
V _{DSS}	Drain-Source Voltage	60				V
V _{DGR}	Drain-Gate Voltage (R _{GS} ≤ 1 MΩ)	60				V
V _{GSS}	Gate-Source Voltage	±40				V
I _D	Drain Current—Continuous	200	115	400	280	mA
	—Pulsed	500	800	2000	1500	mA
P _D	Total Power Dissipation @ T _A = 25°C	400	200	625	300	mW
	Derating above 25°C	3.2	1.6	5	2.4	mW/°C
T _J , T _{STG}	Operating and Storage Temperature Range	-55 to 150		-65 to 150		°C
T _L	Maximum Lead Temperature for Soldering Purposes, 1/16" from Case for 10 Seconds	300				°C

2N7000**Electrical Characteristics** $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OFF CHARACTERISTICS						
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 10 \mu A$	60			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 48V, V_{GS} = 0V$			1	μA
		$T_C = 125^\circ\text{C}$			1	mA
I_{GSSF}	Gate-Body Leakage, Forward	$V_{GS} = -15V, V_{DS} = 0V$			-10	nA
ON CHARACTERISTICS*						
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 1 \text{ mA}$	0.8	2.1	3	V
$r_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 0.5A$		1.2	5	Ω
		$T_C = 125^\circ\text{C}$		1.9	9	Ω
$V_{DS(ON)}$	Drain-Source On-Voltage	$V_{GS} = 10V, I_D = 0.5A$		0.6	2.5	V
		$V_{GS} = 4.5V, I_D = 75 \text{ mA}$		0.14	0.4	V
$I_{D(ON)}$	On-State Drain Current	$V_{GS} = 4.5V, V_{DS} = 10V$	75	600		mA
g_{FS}	Forward Transconductance	$V_{DS} = 10V, I_D = 200 \text{ mA}$	100	320		ms
DYNAMIC CHARACTERISTICS						
C_{iss}	Input Capacitance	$V_{DS} = 25V, V_{GS} = 0V, f = 1.0 \text{ MHz}$		20	60	pF
C_{oss}	Output Capacitance			11	25	pF
C_{rss}	Reverse Transfer Capacitance			4	5	pF
SWITCHING CHARACTERISTICS*						
t_{on}	Turn-On Time	$V_{DD} = 15V, I_D = 0.5V, V_{GS} = 10V,$ $R_G = 25\Omega, R_L = 25\Omega$			10	ns
t_{off}	Turn-Off Time				10	ns
BODY-DRAIN DIODE RATINGS						
I_S	Maximum Continuous Drain-Source Diode Forward Current				200	mA
I_{SM}^*	Maximum Pulsed Drain-Source Diode Forward Current				500	mA
V_{SD}^*	Drain-Source Diode Forward Voltage	$V_{GS} = 0V, I_S = 200 \text{ mA}$			1.5	V
THERMAL CHARACTERISTICS						
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient				312.5	$^\circ\text{C/W}$
$R_{\theta JC}$	Thermal Resistance, Junction to Case				40	$^\circ\text{C/W}$

*Pulse Test: Pulse Width $\leq 300 \mu s$, Duty Cycle $\leq 2.0\%$.

2N7002**Electrical Characteristics** $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OFF CHARACTERISTICS						
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 10 \mu A$	60			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 60V, V_{GS} = 0V$			1	μA
		$T_C = 125^\circ\text{C}$			500	μA
I_{GSSF}	Gate-Body Leakage, Forward	$V_{GS} = 20V$			100	nA
I_{GSSR}	Gate-Body Leakage, Reverse	$V_{GS} = -20V$			-100	nA
ON CHARACTERISTICS*						
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 250 \mu A$	1	2.1	2.5	V
$r_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 0.5A$		1.2	7.5	Ω
		$T_C = 125^\circ\text{C}$		2	13.5	Ω
		$V_{GS} = 5V, I_D = 50 \text{ mA}$		1.7	7.5	Ω
$V_{DS(ON)}$	Drain-Source On-Voltage	$V_{GS} = 10V, I_D = 0.5A$		0.6	3.75	V
		$V_{GS} = 5V, I_D = 50 \text{ mA}$		0.09	1.5	V
$I_{D(ON)}$	On-State Drain Current	$V_{GS} = 10V, V_{DS} \geq 2 V_{DS(ON)}$	500	2700		mA
g_{FS}	Forward Transconductance	$V_{DS} \geq 2 V_{DS(ON)}, I_D = 200 \text{ mA}$	80	320		ms
DYNAMIC CHARACTERISTICS						
C_{iss}	Input Capacitance	$V_{DS} = 25V, V_{GS} = 0V, f = 1.0 \text{ MHz}$		20	50	pF
C_{oss}	Output Capacitance			11	25	pF
C_{rss}	Reverse Transfer Capacitance			4	5	pF
SWITCHING CHARACTERISTICS*						
t_{ON}	Turn-On Time	$V_{DD} = 30V, I_D = 200 \text{ mA}, V_{GS} = 10V,$ $R_{GEN} = 25\Omega, R_L = 150\Omega$			20	ns
t_{OFF}	Turn-Off Time				20	ns
BODY-DRAIN DIODE RATINGS						
I_S	Maximum Continuous Drain-Source Diode Forward Current				115	mA
I_{SM}	Maximum Pulsed Drain-Source Diode Forward Current				800	mA
V_{SD}^*	Drain-Source Diode Forward Voltage	$V_{GS} = 0V, I_S = 115 \text{ mA}$			1.5	V
THERMAL CHARACTERISTICS						
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient				625	$^\circ\text{C/W}$

*Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

NDF7000A**Electrical Characteristics** $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OFF CHARACTERISTICS						
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 10 \mu A$	60			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 48V, V_{GS} = 0V$ $T_C = 125^\circ\text{C}$			1	μA
					1	mA
I_{GSSF}	Gate-Body Leakage, Forward	$V_{GS} = -15V$			-10	nA
ON CHARACTERISTICS*						
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 1 \text{ mA}$	0.8	2.1	3	V
$r_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 0.5A$ $T_C = 125^\circ\text{C}$		1.2	2	Ω
				2	3.5	Ω
$V_{DS(ON)}$	Drain-Source On-Voltage	$V_{GS} = 10V, I_D = 500 \text{ mA}$		0.6	1	V
		$V_{GS} = 4.5V, I_D = 75 \text{ mA}$		0.14	0.225	V
$I_{D(ON)}$	On-State Drain Current	$V_{GS} = 4.5V, V_{DS} \geq 2 V_{DS(ON)}$	400	600		mA
g_{FS}	Forward Transconductance	$V_{DS} \geq 2 V_{DS(ON)}, I_D = 200 \text{ mA}$	100	320		ms
DYNAMIC CHARACTERISTICS						
C_{iss}	Input Capacitance	$V_{DS} = 25V, V_{GS} = 0V, f = 1.0 \text{ MHz}$		20	60	pF
C_{oss}	Output Capacitance			11	25	pF
C_{rss}	Reverse Transfer Capacitance			4	5	pF
SWITCHING CHARACTERISTICS*						
t_{on}	Turn-On Time	$V_{DD} = 15V, I_D = 500 \text{ mA}, V_{GS} = 10V,$ $R_G = 25\Omega, R_L = 25\Omega$			10	ns
t_{off}	Turn-Off Time				10	ns
BODY-DRAIN DIODE RATINGS						
I_S	Maximum Continuous Drain-Source Diode Forward Current				400	mA
I_{SM}	Maximum Pulsed Drain-Source Diode Forward Current				2000	mA
V_{SD}^*	Drain-Source Diode Forward Voltage	$V_{GS} = 0V, I_S = 400 \text{ mA}$		0.88	1.2	V
THERMAL CHARACTERISTICS						
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient				200	$^\circ\text{C}/\text{W}$

*Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

NDS7002A

Electrical Characteristics $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OFF CHARACTERISTICS						
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 10 \mu A$	60			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 60V, V_{GS} = 0V$			1	μA
		$T_C = 125^\circ\text{C}$			500	μA
I_{GSSF}	Gate-Body Leakage, Forward	$V_{GS} = 20V$			100	nA
I_{GSSR}	Gate-Body Leakage, Reverse	$V_{GS} = -20V$			-100	nA
ON CHARACTERISTICS*						
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 250 \mu A$	1	2.1	2.5	V
$r_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 0.5A$		1.2	2	Ω
		$T_C = 125^\circ\text{C}$		2	3.5	Ω
		$V_{GS} = 5V, I_D = 50 mA$		1.7	3	Ω
		$T_C = 125^\circ\text{C}$		2.8	5	Ω
$V_{DS(ON)}$	Drain-Source On-Voltage	$V_{GS} = 10V, I_D = 500 mA$		0.6	1	V
		$V_{GS} = 5.0V, I_D = 50 mA$		0.09	0.15	V
$I_{D(ON)}$	On-State Drain Current	$V_{GS} = 10V, V_{DS} \geq 2 V_{DS(ON)}$	500	2700		mA
g_{FS}	Forward Transconductance	$V_{DS} \geq 2 V_{DS(ON)}, I_D = 200 mA$	80	320		ms
DYNAMIC CHARACTERISTICS						
C_{iss}	Input Capacitance	$V_{DS} = 25V, V_{GS} = 0V, f = 1.0 MHz$		20	50	pF
C_{oss}	Output Capacitance			11	25	pF
C_{rss}	Reverse Transfer Capacitance			4	5	pF
SWITCHING CHARACTERISTICS*						
t_{ON}	Turn-On Time	$V_{DD} = 30V, I_D = 200 mA, V_{GS} = 10V,$ $R_G = 25\Omega, R_L = 150\Omega$			20	ns
t_{OFF}	Turn-Off Time				20	ns
BODY-DRAIN DIODE RATINGS						
I_S	Maximum Continuous Drain-Source Diode Forward Current				280	mA
I_{SM}	Maximum Pulsed Drain-Source Diode Forward Current				1500	mA
V_{SD}^*	Drain-Source Diode Forward Voltage	$V_{GS} = 0V, I_S = 400 mA$		0.88	1.2	V
THERMAL CHARACTERISTICS						
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient				417	$^\circ\text{C}/\text{W}$

*Pulse Test: Pulse Width $\leq 300 \mu s$, Duty Cycle $\leq 2.0\%$.

Typical Electrical Characteristics

2N7000/2N7002/NDF7000A/NDS7002A

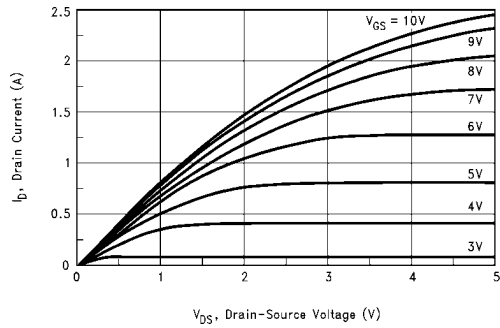


FIGURE 1. On-Region Characteristics

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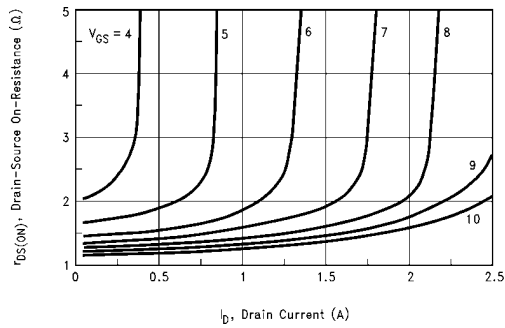


FIGURE 2. $r_{DS(ON)}$ Variation with Drain Current and Gate Voltage

TL/G/11378-5

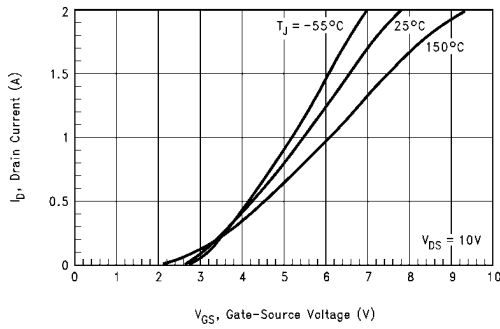


FIGURE 3. Transfer Characteristics

TL/G/11378-6

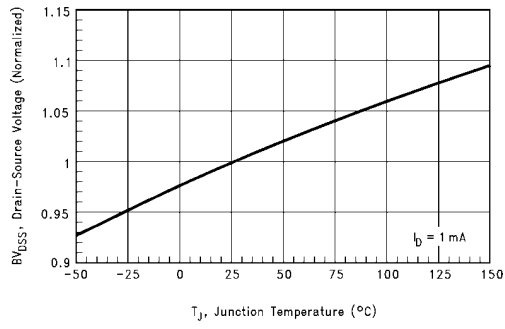


FIGURE 4. Breakdown Voltage Variation with Temperature

TL/G/11378-7

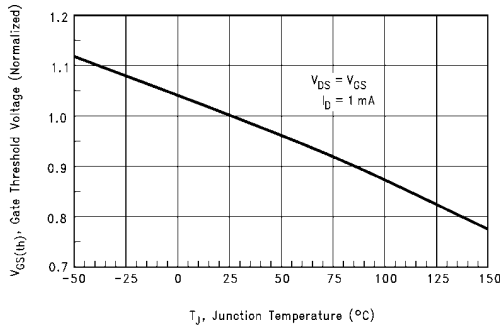


FIGURE 5. Gate Threshold Variation with Temperature

TL/G/11378-8

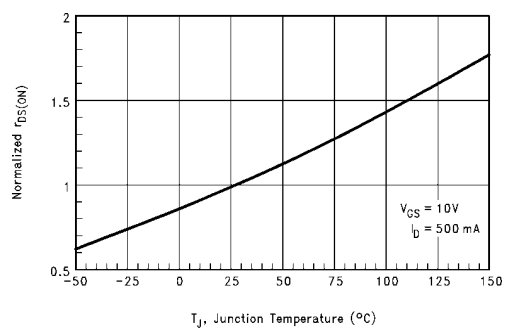


FIGURE 6. On-Resistance Variation with Temperature

TL/G/11378-9

Typical Electrical Characteristics (Continued)

2N7000/2N7002/NDF7000A/NDS7002A (Continued)

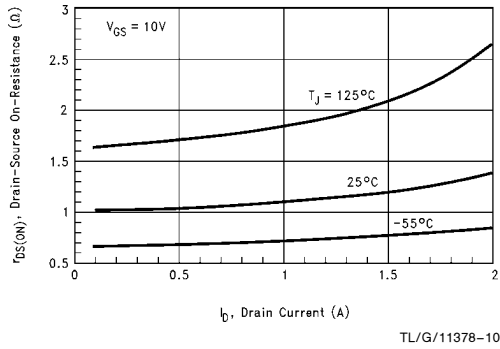


FIGURE 7. On-Resistance vs Drain Current

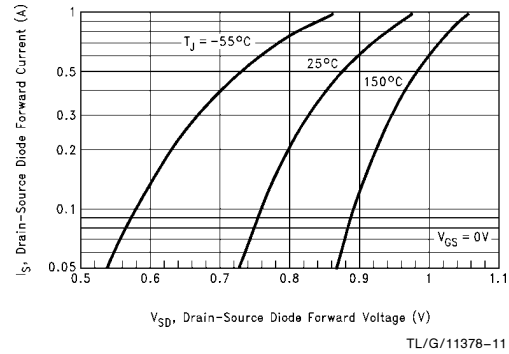


FIGURE 8. Body Diode Forward Voltage Variation with Current and Temperature

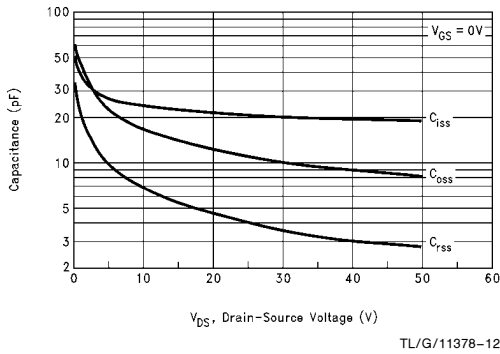


FIGURE 9. Capacitance vs Drain-Source Voltage

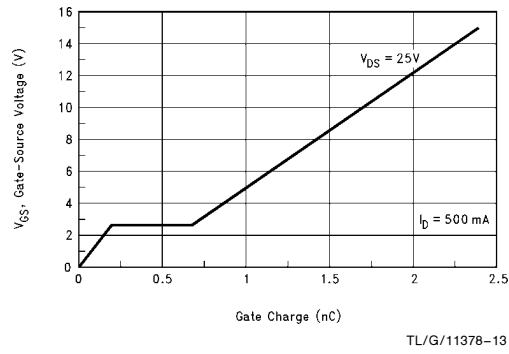


FIGURE 10. Gate Charge vs Gate-Source Voltage

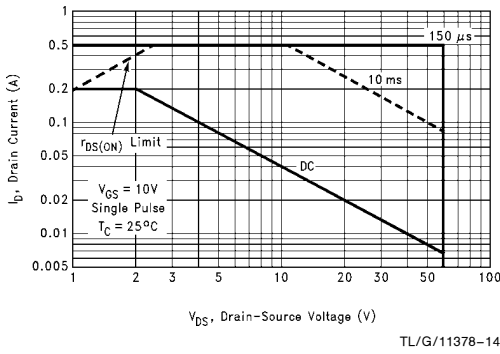


FIGURE 11. 2N7000 Safe Operating Area

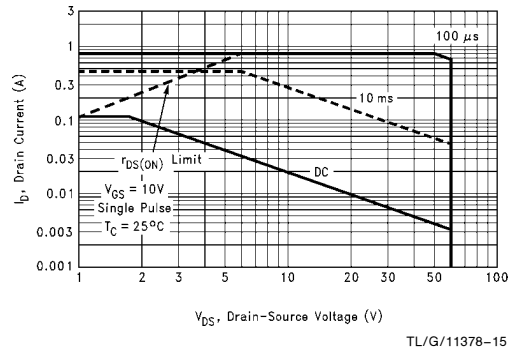
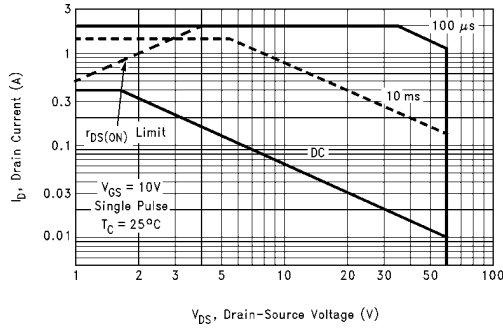


FIGURE 12. 2N7002 Safe Operating Area

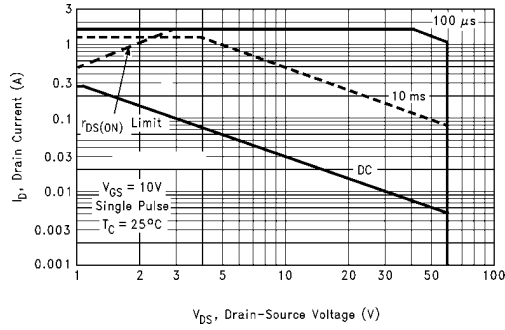
Typical Electrical Characteristics (Continued)

2N7000/2N7002/NDF7000A/NDS7002A (Continued)



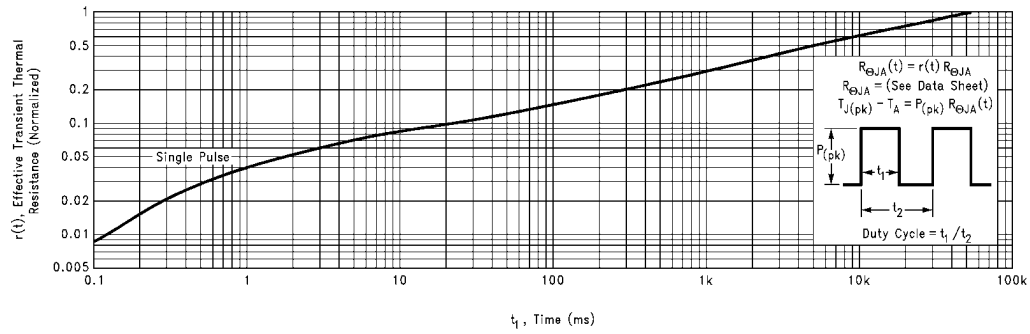
TL/G/11378-16

FIGURE 13. NDF7000A Safe Operating Area



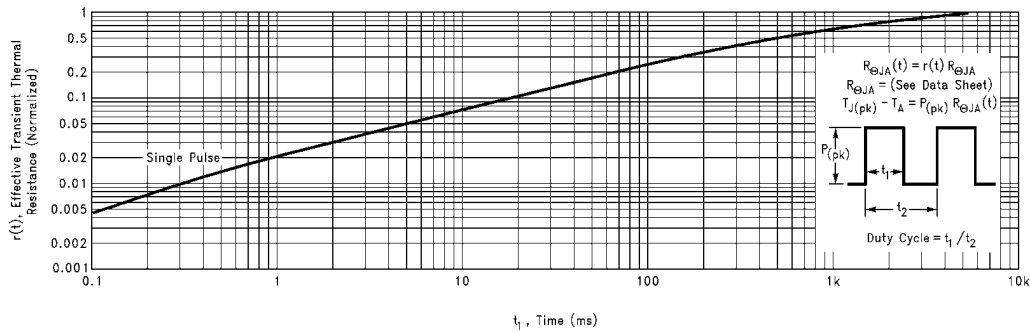
TL/G/11378-17

FIGURE 14. NDS7002A Safe Operating Area



TL/G/11378-18

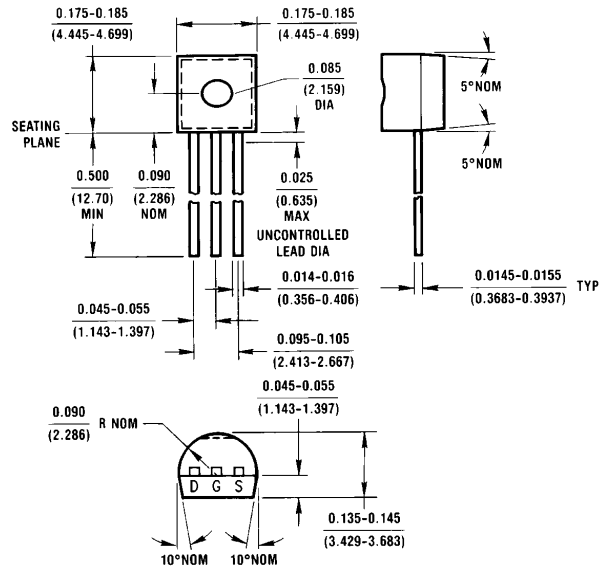
FIGURE 15. TO-92 Transient Thermal Response



TL/G/11378-19

FIGURE 16. SOT-23 Transient Thermal Response

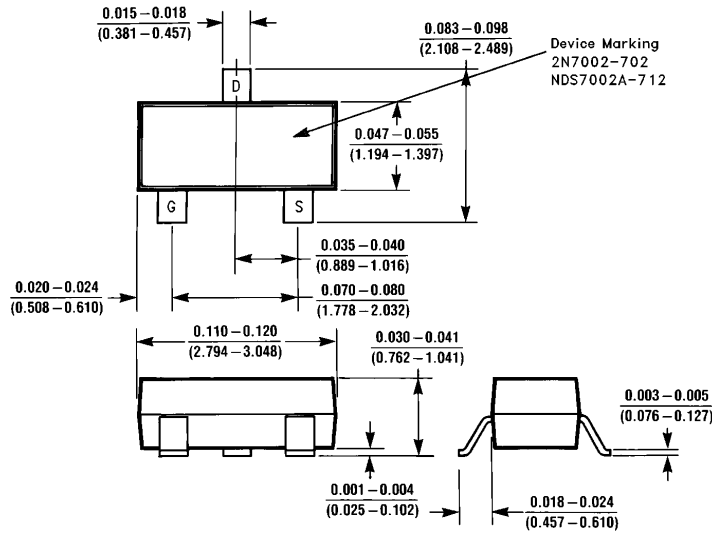
Physical Dimensions inches (millimeters)



TO-92

TL/G/11378-20

Physical Dimensions inches (millimeters) (Continued)



TL/G/11378-21

Note 1: Meets all JEDEC dimensional requirements for TO-236AB.

Note 2: Controlling dimension: millimeters.

Note 3: Available also in TO-236AA. Contact your local National Semiconductor representative for delivery and ordering information.

Note 4: Tape and reel is the standard packaging method for TO-236.

TO-236AB (SOT-23) (Notes 3, 4)

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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