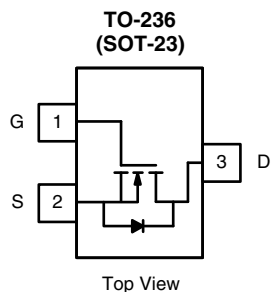


## N-Channel 60 V (D-S) MOSFET

### PRODUCT SUMMARY

$V_{DS}$ (V)	$R_{DS(on)}$ ( $\Omega$ )	$I_D$ (mA)
60	3 at $V_{GS} = 10$ V	240



Marking Code: 7E

Ordering Information: 2N7002E-T1-E3 (Lead (Pb)-free)  
2N7002E-T1-GE3 (Lead (Pb)-free and Halogen-free)

### FEATURES

- **Halogen-free According to IEC 61249-2-21 Definition**
- Low On-Resistance: 3  $\Omega$
- Low Threshold: 2 V (typ.)
- Low Input Capacitance: 25 pF
- Fast Switching Speed: 7.5 ns
- Low Input and Output Leakage
- Compliant to RoHS Directive 2002/95/EC



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
Available

### BENEFITS

- Low Offset Voltage
- Low-Voltage Operation
- Easily Driven Without Buffer
- High-Speed Circuits
- Low Error Voltage

### APPLICATIONS

- Direct Logic-Level Interface: TTL/CMOS
- Drivers: Relays, Solenoids, Lamps, Hammers, Display, Memories, Transistors, etc.
- Battery Operated Systems
- Solid-State Relays

### ABSOLUTE MAXIMUM RATINGS ( $T_A = 25$ °C, unless otherwise noted)

Parameter	Symbol	Limit	Unit
Drain-Source Voltage	$V_{DS}$	60	V
Gate-Source Voltage	$V_{GS}$	$\pm 20$	
Continuous Drain Current ( $T_J = 150$ °C)	$I_D$	240	mA
	$I_D$	190	
Pulsed Drain Current <sup>a</sup>	$I_{DM}$	1300	
Power Dissipation	$P_D$	0.35	W
	$P_D$	0.22	
Thermal Resistance, Junction-to-Ambient	$R_{thJA}$	357	°C/W
Operating Junction and Storage Temperature Range	$T_J, T_{stg}$	- 55 to 150	°C

Notes:

a. Pulse width limited by maximum junction temperature.

**SPECIFICATIONS** ( $T_A = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

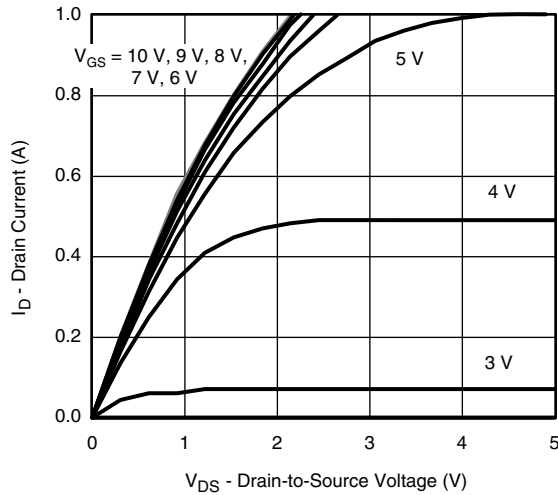
Parameter	Symbol	Test Conditions	Limits			Unit
			Min.	Typ. <sup>a</sup>	Max.	
Static						
Drain-Source Breakdown Voltage	V <sub>DS</sub>	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 μA	60	68		V
Gate-Threshold Voltage	V <sub>GS(th)</sub>	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA	1	2	2.5	
Gate-Body Leakage	I <sub>GSS</sub>	V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 15 V			± 10	nA
Zero Gate Voltage Drain Current	I <sub>DSS</sub>	V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V			1	μA
		V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V , T <sub>J</sub> = 125 °C			500	
On-State Drain Current <sup>b</sup>	I <sub>D(on)</sub>	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 7.5 V	800	1300		mA
		V <sub>GS</sub> = 4.5 V, V <sub>DS</sub> = 10 V	500	700		
Drain-Source On-Resistance <sup>b</sup>	R <sub>DS(on)</sub>	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 250 mA		1.2	3	Ω
		V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 200 mA		1.8	4	
Forward Transconductance <sup>b</sup>	g <sub>fs</sub>	V <sub>DS</sub> = 15 V, I <sub>D</sub> = 200 mA		600		mS
Diode Forward Voltage	V <sub>SD</sub>	I <sub>S</sub> = 200 mA, V <sub>GS</sub> = 0 V		0.85	1.2	V
Dynamic <sup>a</sup>						
Total Gate Charge	Q <sub>g</sub>	V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 4.5 V I <sub>D</sub> ≅ 250 mA		0.4	0.6	nC
Gate-Source Charge	Q <sub>gs</sub>			0.06		
Gate-Drain Charge	Q <sub>gd</sub>			0.06		
Input Capacitance	C <sub>iss</sub>	V <sub>DS</sub> = 5 V, V <sub>GS</sub> = 0 V, f = 1 MHz		21		pF
Output Capacitance	C <sub>oss</sub>			7		
Reverse Transfer Capacitance	C <sub>rss</sub>			2.5		
Switching <sup>a, c</sup>						
Turn-On Time	t <sub>d(on)</sub>	V <sub>DD</sub> = 10 V, R <sub>L</sub> = 40 Ω I <sub>D</sub> ≅ 250 mA, V <sub>GEN</sub> = 10 V, R <sub>g</sub> = 10 Ω		13	20	ns
Turn-Off Time	t <sub>d(off)</sub>			18	25	

Notes:

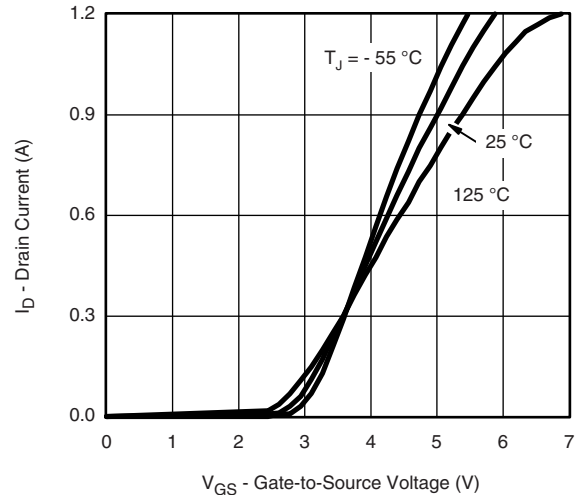
- a. For DESIGN AID ONLY, not subject to production testing.  
b. Pulse test: pulse width  $\leq 300\text{ }\mu\text{s}$  duty cycle  $\leq 2\%$ .  
c. Switching time is essentially independent of operating temperature.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

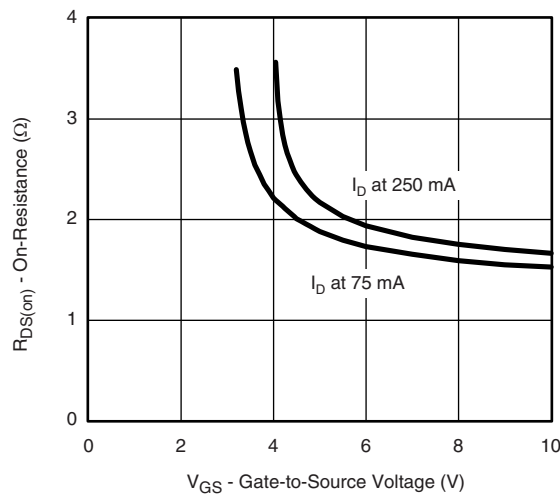
## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



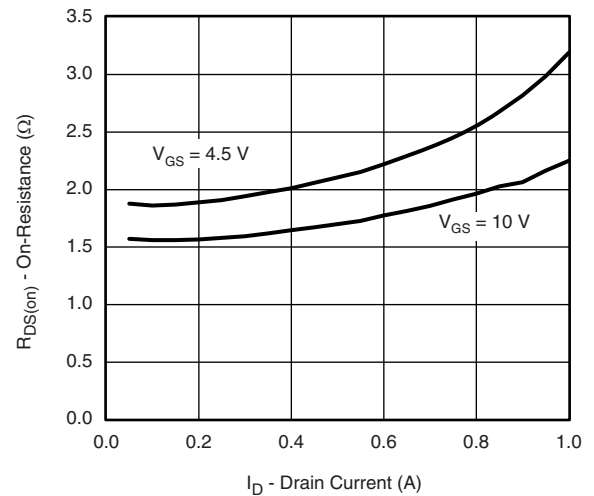
Output Characteristics



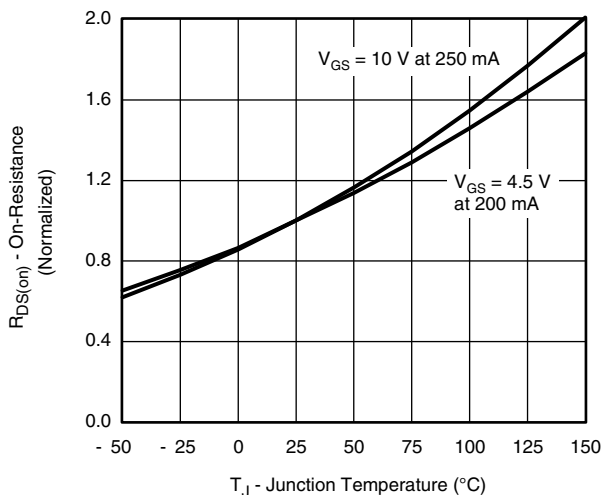
Transfer Characteristics



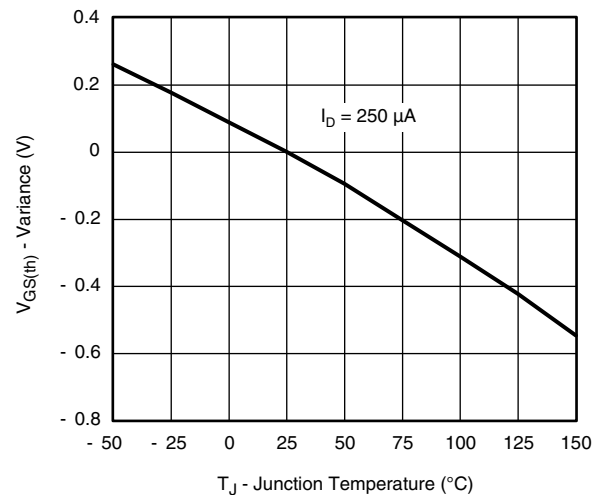
On-Resistance vs. Gate-Source Voltage



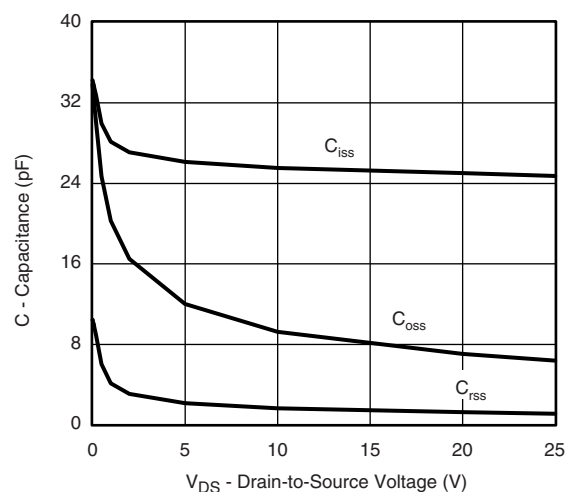
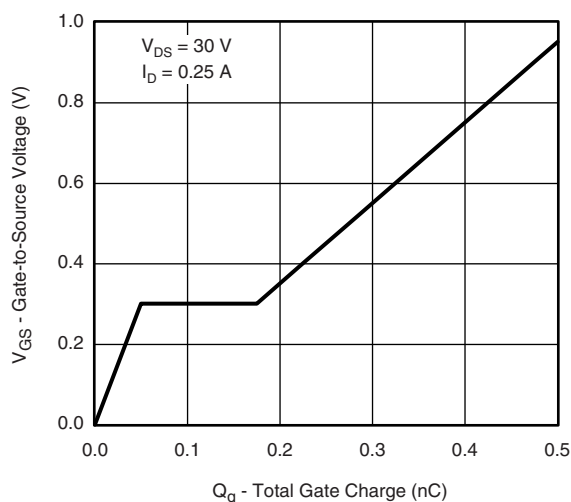
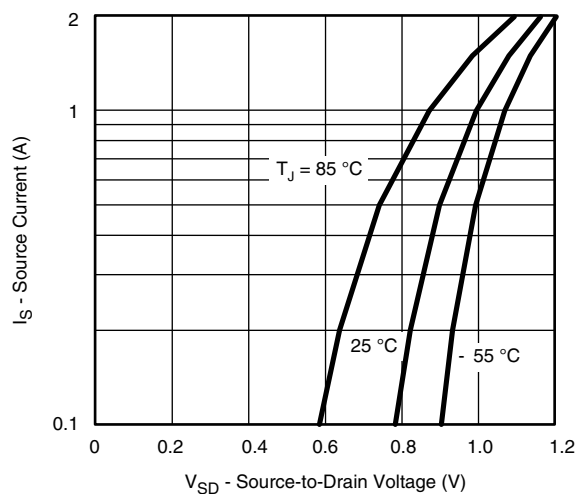
On-Resistance vs. Drain Current



On-Resistance vs. Junction Temperature

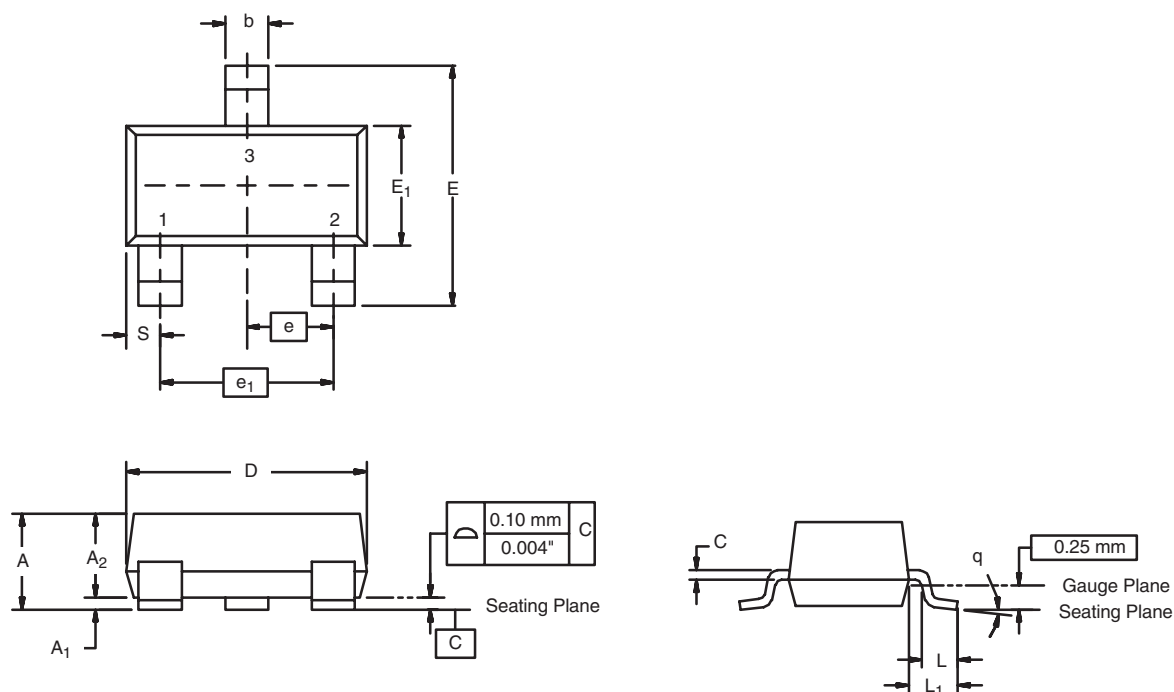


Threshold Voltage Variance Over Temperature

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)**Capacitance****Gate Charge****Source-Drain Diode Forward Voltage**

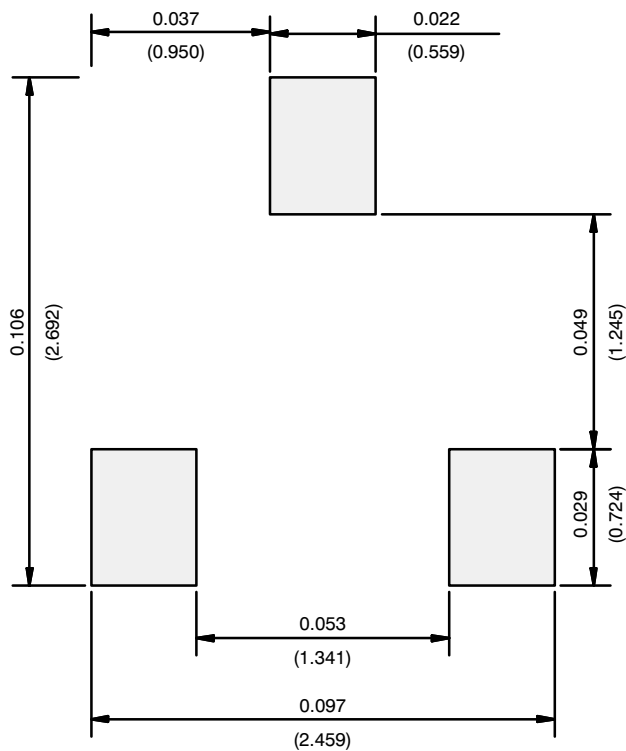
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## SOT-23 (TO-236): 3-LEAD



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	0.89	1.12	0.035	0.044
A <sub>1</sub>	0.01	0.10	0.0004	0.004
A <sub>2</sub>	0.88	1.02	0.0346	0.040
b	0.35	0.50	0.014	0.020
c	0.085	0.18	0.003	0.007
D	2.80	3.04	0.110	0.120
E	2.10	2.64	0.083	0.104
E <sub>1</sub>	1.20	1.40	0.047	0.055
e	0.95 BSC		0.0374 Ref	
e <sub>1</sub>	1.90 BSC		0.0748 Ref	
L	0.40	0.60	0.016	0.024
L <sub>1</sub>	0.64 Ref		0.025 Ref	
S	0.50 Ref		0.020 Ref	
q	3°	8°	3°	8°
ECN: S-03946-Rev. K, 09-Jul-01 DWG: 5479				

## RECOMMENDED MINIMUM PADS FOR SOT-23



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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