

# Small Signal MOSFET

## 60 V, 310 mA, Single, N-Channel, SOT-23

### 2N7002E

#### Features

- Low  $R_{DS(on)}$
- Small Footprint Surface Mount Package
- Trench Technology
- S Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

#### Applications

- Low Side Load Switch
- Level Shift Circuits
- DC-DC Converter
- Portable Applications i.e. DSC, PDA, Cell Phone, etc.

#### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage	$V_{DS}$	60	V
Gate-to-Source Voltage	$V_{GS}$	$\pm 20$	V
Drain Current (Note 1) Steady State	$I_D$	$T_A = 25^\circ\text{C}$ 260	mA
		$T_A = 85^\circ\text{C}$ 190	
$t < 5$ s		$T_A = 25^\circ\text{C}$ 310 $T_A = 85^\circ\text{C}$ 220	
Power Dissipation (Note 1) Steady State $t < 5$ s	$P_D$	300 420	mW
Pulsed Drain Current ( $t_p = 10$ $\mu\text{s}$ )	$I_{DM}$	1.2	A
Operating Junction and Storage Temperature Range	$T_J, T_{STG}$	-55 to +150	$^\circ\text{C}$
Source Current (Body Diode)	$I_S$	300	mA
Lead Temperature for Soldering Purposes (1/8" from case for 10 s)	$T_L$	260	$^\circ\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

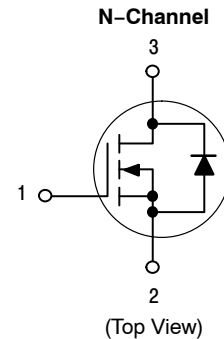
#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Junction-to-Ambient – Steady State (Note 1)	$R_{\theta JA}$	417	$^\circ\text{C/W}$
Junction-to-Ambient – $t \leq 5$ s (Note 1)	$R_{\theta JA}$	300	

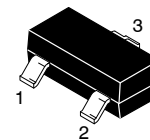
1. Surface-mounted on FR4 board using 1 in sq pad size (Cu area = 1.127 in sq [1 oz] including traces)

$V_{(BR)DSS}$	$R_{DS(on)}$ MAX	$I_D$ MAX (Note 1)
60 V	3.0 $\Omega$ @ 4.5 V	310 mA
	2.5 $\Omega$ @ 10 V	

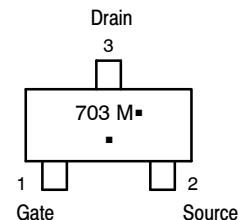
#### Simplified Schematic



#### MARKING DIAGRAM & PIN ASSIGNMENT



SOT-23  
CASE 318  
STYLE 21



703 = Device Code  
M = Date Code  
■ = Pb-Free Package  
(Note: Microdot may be in either location)

#### ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
2N7002ET1G, S2N7002ET1G	SOT-23 (Pb-Free)	3000 / Tape & Reel
2N7002ET7G, S2N7002ET7G	SOT-23 (Pb-Free)	3500 / Tape & Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## 2N7002E

### ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
<b>OFF CHARACTERISTICS</b>						
Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$	60			V
Drain-to-Source Breakdown Voltage Temperature Coefficient	$V_{(BR)DSS}/T_J$			75		mV/ $^\circ\text{C}$
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{GS} = 0\text{ V},$ $V_{DS} = 60\text{ V}$	$T_J = 25^\circ\text{C}$		1	$\mu\text{A}$
			$T_J = 125^\circ\text{C}$		500	
Gate-to-Source Leakage Current	$I_{GSS}$	$V_{DS} = 0\text{ V}, V_{GS} = \pm 20\text{ V}$			$\pm 100$	nA

### ON CHARACTERISTICS (Note 2)

Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 250\text{ }\mu\text{A}$	1.0		2.5	V
Negative Threshold Temperature Coefficient	$V_{GS(TH)}/T_J$			4.4		mV/ $^\circ\text{C}$
Drain-to-Source On Resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}, I_D = 240\text{ mA}$		0.86	2.5	$\Omega$
		$V_{GS} = 4.5\text{ V}, I_D = 50\text{ mA}$		1.1	3.0	
Forward Transconductance	$g_{FS}$	$V_{DS} = 5\text{ V}, I_D = 200\text{ mA}$		530		mS

### CHARGES AND CAPACITANCES

Input Capacitance	$C_{ISS}$	$V_{GS} = 0\text{ V}, f = 1\text{ MHz},$ $V_{DS} = 25\text{ V}$		26.7	40	pF
Output Capacitance	$C_{OSS}$			4.6		
Reverse Transfer Capacitance	$C_{RSS}$			2.9		
Total Gate Charge	$Q_{G(TOT)}$	$V_{GS} = 5\text{ V}, V_{DS} = 10\text{ V};$ $I_D = 240\text{ mA}$		0.81		nC
Threshold Gate Charge	$Q_{G(TH)}$			0.31		
Gate-to-Source Charge	$Q_{GS}$			0.48		
Gate-to-Drain Charge	$Q_{GD}$			0.08		

### SWITCHING CHARACTERISTICS, $V_{GS} = V$ (Note 3)

Turn-On Delay Time	$t_{d(ON)}$	$V_{GS} = 10\text{ V}, V_{DD} = 30\text{ V},$ $I_D = 200\text{ mA}, R_G = 10\text{ }\Omega$		1.7		ns
Rise Time	$t_r$			1.2		
Turn-Off Delay Time	$t_{d(OFF)}$			4.8		
Fall Time	$t_f$			3.6		

### DRAIN-SOURCE DIODE CHARACTERISTICS

Forward Diode Voltage	$V_{SD}$	$V_{GS} = 0\text{ V},$ $I_S = 200\text{ mA}$	$T_J = 25^\circ\text{C}$		0.79	1.2	V
			$T_J = 85^\circ\text{C}$		0.7		

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

2. Pulse Test: pulse width  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$

3. Switching characteristics are independent of operating junction temperatures

## TYPICAL CHARACTERISTICS

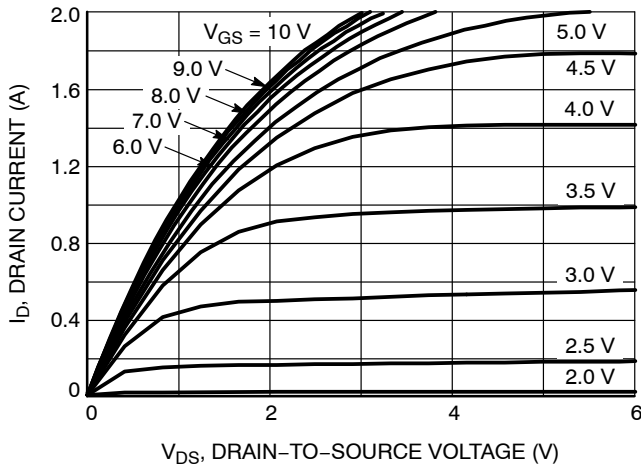


Figure 1. On-Region Characteristics

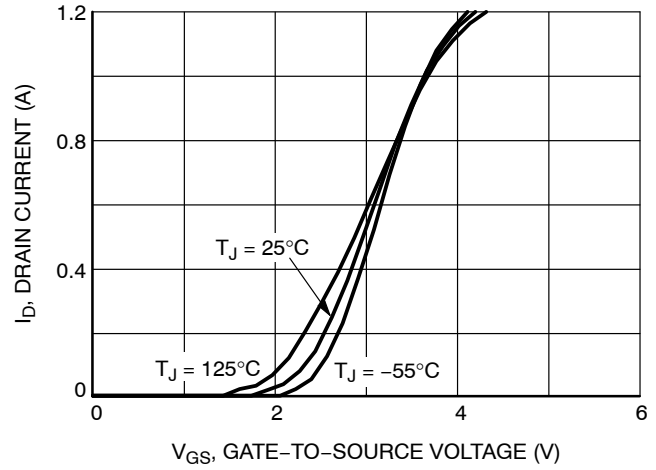


Figure 2. Transfer Characteristics

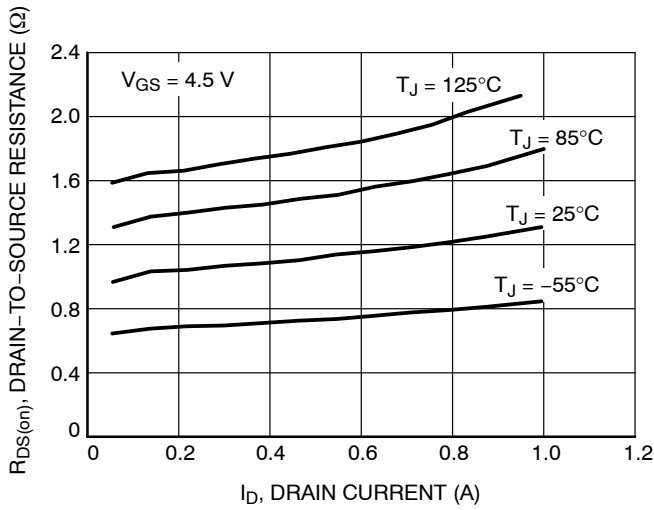


Figure 3. On-Resistance vs. Drain Current and Temperature

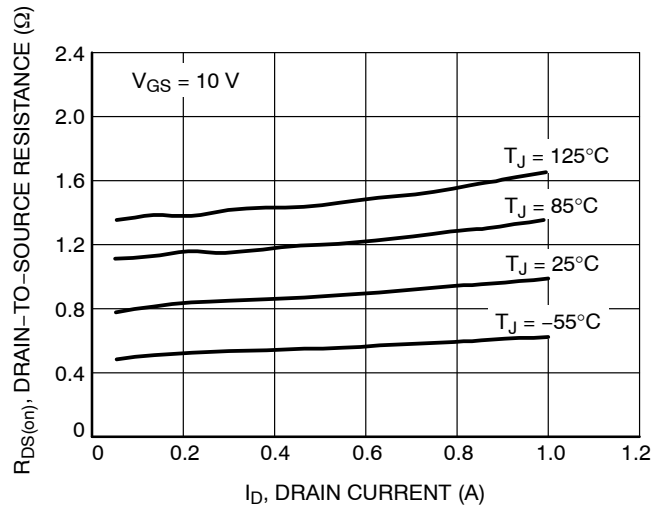


Figure 4. On-Resistance vs. Drain Current and Temperature

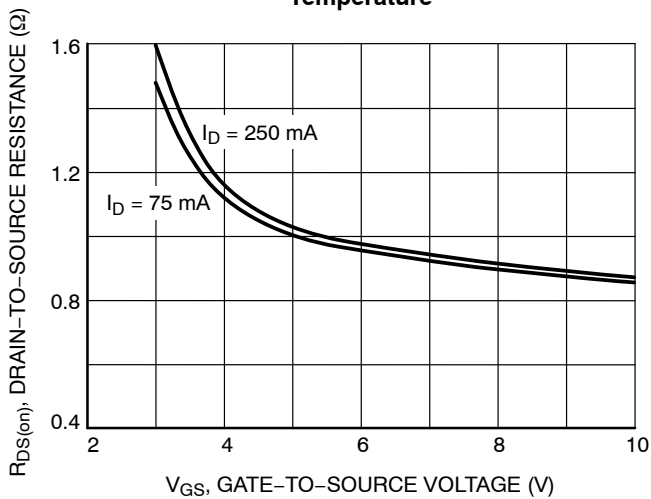


Figure 5. On-Resistance vs. Gate-to-Source Voltage

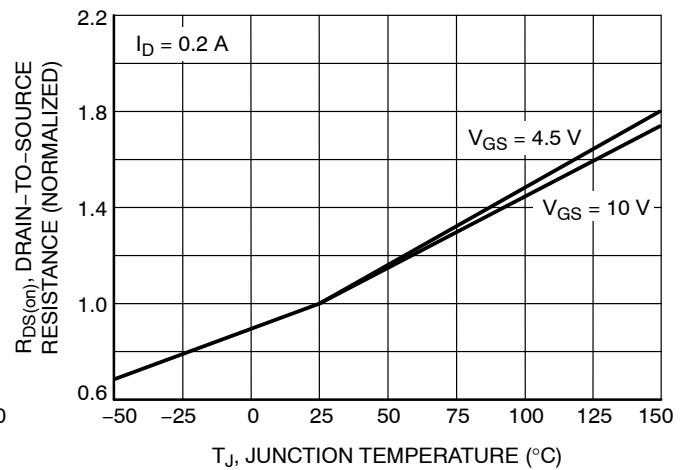


Figure 6. On-Resistance Variation with Temperature

TYPICAL CHARACTERISTICS

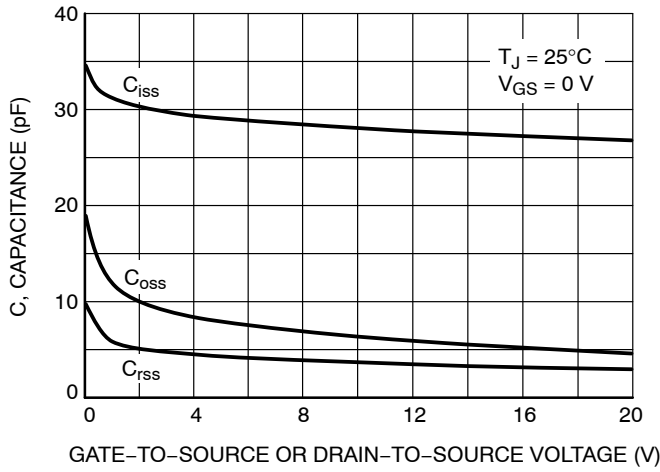


Figure 7. Capacitance Variation

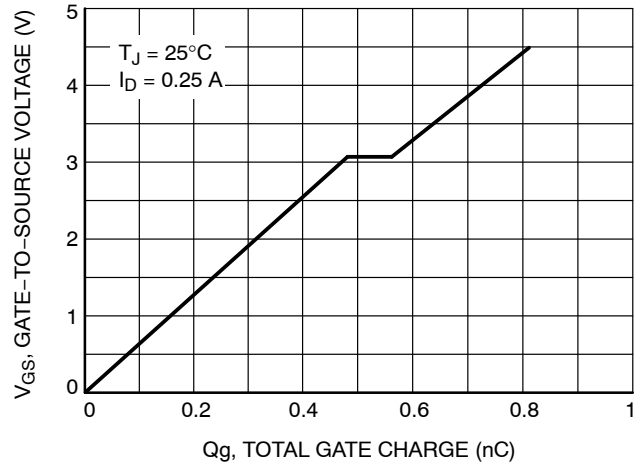


Figure 8. Gate-to-Source and Drain-to-Source Voltage vs. Total Charge

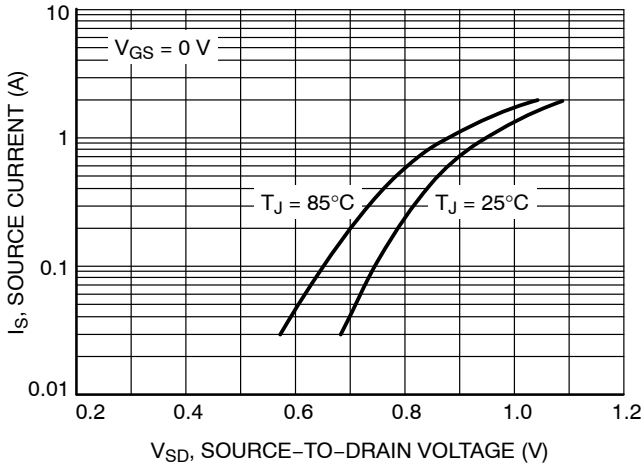


Figure 9. Diode Forward Voltage vs. Current

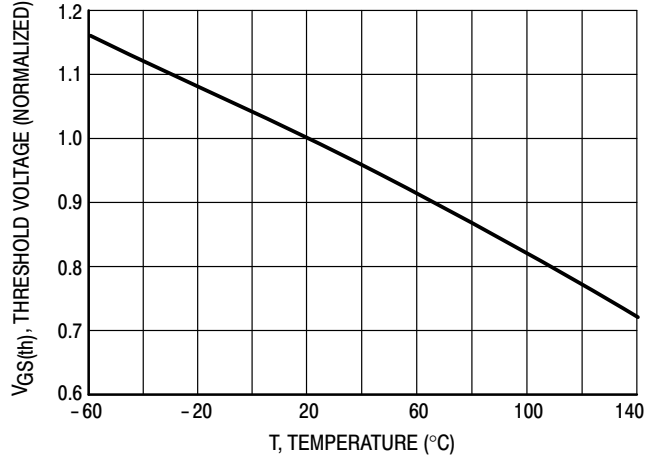


Figure 10. Temperature versus Gate Threshold Voltage

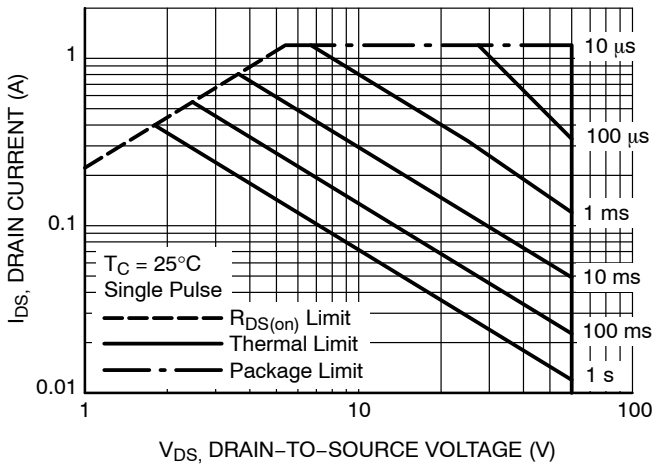


Figure 11. Safe Operating Area

## 2N7002E

### TYPICAL CHARACTERISTICS

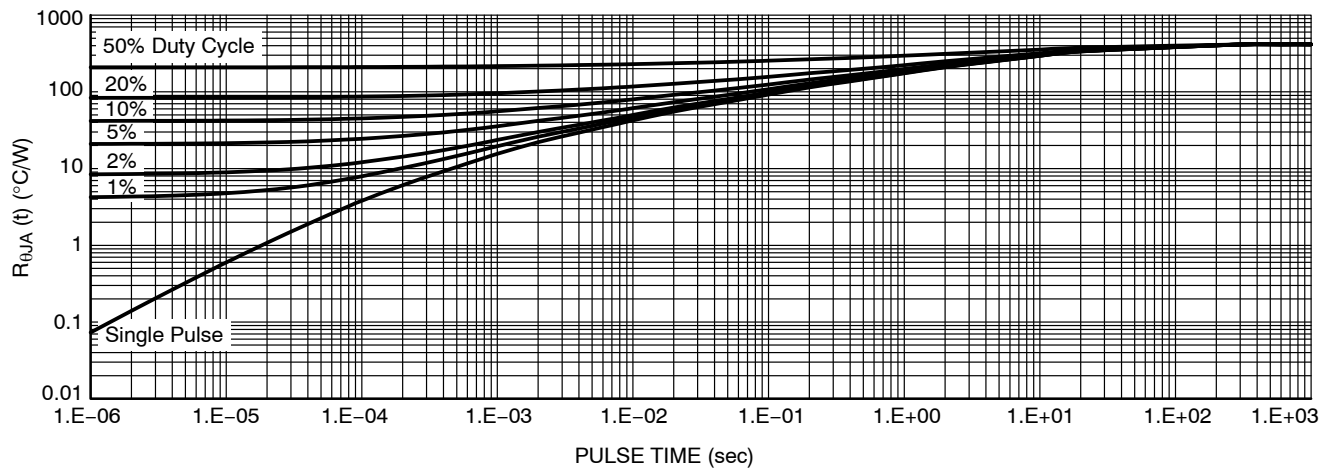
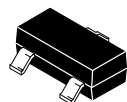


Figure 12. Thermal Impedance

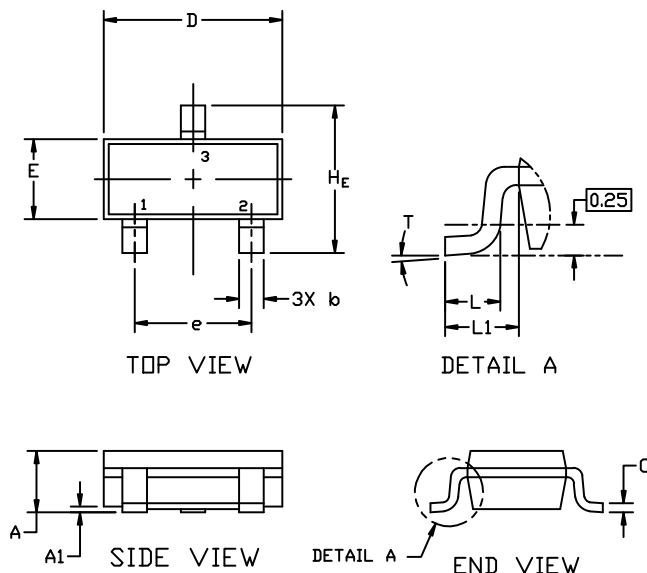
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



SCALE 4:1

**SOT-23 (TO-236)**  
CASE 318  
ISSUE AT

DATE 01 MAR 2023

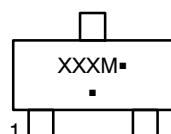


## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M,1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

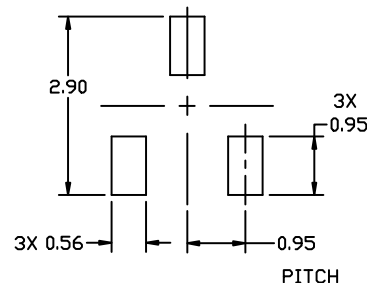
DIM	MILLIMETERS			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.89	1.00	1.11	0.035	0.039	0.044
A1	0.01	0.06	0.10	0.000	0.002	0.004
b	0.37	0.44	0.50	0.015	0.017	0.020
c	0.08	0.14	0.20	0.003	0.006	0.008
D	2.80	2.90	3.04	0.110	0.114	0.120
E	1.20	1.30	1.40	0.047	0.051	0.055
e	1.78	1.90	2.04	0.070	0.075	0.080
L	0.30	0.43	0.55	0.012	0.017	0.022
L1	0.35	0.54	0.69	0.014	0.021	0.027
H <sub>E</sub>	2.10	2.40	2.64	0.083	0.094	0.104
T	0°	---	10°	0°	---	10°

## GENERIC MARKING DIAGRAM\*



XXX = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.



## RECOMMENDED MOUNTING FOOTPRINT

\* For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## STYLES ON PAGE 2

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# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS



### SOT-23 (TO-236) CASE 318 ISSUE AT

DATE 01 MAR 2023

STYLE 1 THRU 5: CANCELLED	STYLE 6: PIN 1. BASE 2. EMITTER 3. COLLECTOR	STYLE 7: PIN 1. EMITTER 2. BASE 3. COLLECTOR	STYLE 8: PIN 1. ANODE 2. NO CONNECTION 3. CATHODE		
STYLE 9: PIN 1. ANODE 2. ANODE 3. CATHODE	STYLE 10: PIN 1. DRAIN 2. SOURCE 3. GATE	STYLE 11: PIN 1. ANODE 2. CATHODE 3. CATHODE-ANODE	STYLE 12: PIN 1. CATHODE 2. CATHODE 3. ANODE	STYLE 13: PIN 1. SOURCE 2. DRAIN 3. GATE	STYLE 14: PIN 1. CATHODE 2. GATE 3. ANODE
STYLE 15: PIN 1. GATE 2. CATHODE 3. ANODE	STYLE 16: PIN 1. ANODE 2. CATHODE 3. CATHODE	STYLE 17: PIN 1. NO CONNECTION 2. ANODE 3. CATHODE	STYLE 18: PIN 1. NO CONNECTION 2. CATHODE 3. ANODE	STYLE 19: PIN 1. CATHODE 2. ANODE 3. CATHODE-ANODE	STYLE 20: PIN 1. CATHODE 2. ANODE 3. GATE
STYLE 21: PIN 1. GATE 2. SOURCE 3. DRAIN	STYLE 22: PIN 1. RETURN 2. OUTPUT 3. INPUT	STYLE 23: PIN 1. ANODE 2. ANODE 3. CATHODE	STYLE 24: PIN 1. GATE 2. DRAIN 3. SOURCE	STYLE 25: PIN 1. ANODE 2. CATHODE 3. GATE	STYLE 26: PIN 1. CATHODE 2. ANODE 3. NO CONNECTION
STYLE 27: PIN 1. CATHODE 2. CATHODE 3. CATHODE	STYLE 28: PIN 1. ANODE 2. ANODE 3. ANODE				

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