

## SQ2337ES-T1\_BE3-VB Datasheet

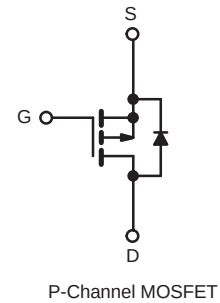
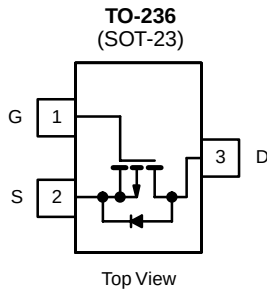
### P-Channel 60-V (D-S) MOSFET

#### PRODUCT SUMMARY

|                           |                         |      |
|---------------------------|-------------------------|------|
| $V_{DS}$ (V)              | - 60                    |      |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = -10\text{ V}$ | 0.05 |
| $Q_g$ (Max.) (nC)         | 12                      |      |
| $Q_{gs}$ (nC)             | 3.8                     |      |
| $Q_{gd}$ (nC)             | 5.1                     |      |
| Configuration             | Single                  |      |

#### FEATURES

- Isolated Package
- High Voltage Isolation = 2.5 kV<sub>RMS</sub> (t = 60 s; f = 60 Hz)
- Sink to Lead Creepage Distance = 4.8 mm
- P-Channel
- 175 °C Operating Temperature
- Dynamic dV/dt Rating
- Low Thermal Resistance
- Lead (Pb)-free Available



#### ABSOLUTE MAXIMUM RATINGS $T_C = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted

| PARAMETER                                        |                                    |                                     | SYMBOL         | LIMIT            | UNIT                  |
|--------------------------------------------------|------------------------------------|-------------------------------------|----------------|------------------|-----------------------|
| Drain-Source Voltage                             |                                    |                                     | $V_{DS}$       | - 60             | V                     |
| Gate-Source Voltage                              |                                    |                                     | $V_{GS}$       | $\pm 20$         |                       |
| Continuous Drain Current                         | $V_{GS}$ at - 10 V                 | $T_C = 25\text{ }^{\circ}\text{C}$  | $I_D$          | - 5.2            | A                     |
|                                                  |                                    | $T_C = 100\text{ }^{\circ}\text{C}$ |                | - 3.8            |                       |
| Pulsed Drain Current <sup>a</sup>                |                                    |                                     | $I_{DM}$       | - 21             |                       |
| Linear Derating Factor                           |                                    |                                     |                | 0.18             | W/ $^{\circ}\text{C}$ |
| Single Pulse Avalanche Energy <sup>b</sup>       |                                    |                                     | $E_{AS}$       | 120              | mJ                    |
| Repetitive Avalanche Current <sup>a</sup>        |                                    |                                     | $I_{AR}$       | - 5.2            | A                     |
| Repetitive Avalanche Energy <sup>a</sup>         |                                    |                                     | $E_{AR}$       | 2.7              | mJ                    |
| Maximum Power Dissipation                        | $T_C = 25\text{ }^{\circ}\text{C}$ |                                     | $P_D$          | 27               | W                     |
| Peak Diode Recovery $dV/dt^c$                    |                                    |                                     | $dV/dt$        | - 4.5            | V/ns                  |
| Operating Junction and Storage Temperature Range |                                    |                                     | $T_J, T_{stg}$ | - 55 to + 175    | $^{\circ}\text{C}$    |
| Soldering Recommendations (Peak Temperature)     |                                    | for 10 s                            |                | 300 <sup>d</sup> |                       |
| Mounting Torque                                  | 6-32 or M3 screw                   |                                     |                | 10               | lbf · in              |
|                                                  |                                    |                                     |                | 1.1              | N · m                 |

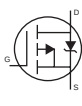
#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{PD} = -25\text{ V}$ , starting  $T_J = 25\text{ }^{\circ}\text{C}$ ,  $L = 5.0\text{ mH}$ ,  $R_G = 25\text{ }\Omega$ ,  $I_{AS} = -5.3\text{ A}$  (see fig. 12).
- $I_{SD} \leq -6.7\text{ A}$ ,  $dI/dt \leq 90\text{ A}/\mu\text{s}$ ,  $V_{PD} \leq V_{DS}$ ,  $T_J \leq 175\text{ }^{\circ}\text{C}$ .
- 1.6 mm from case.

**THERMAL RESISTANCE RATINGS**

| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 5.5  |      |

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

| PARAMETER                                 | SYMBOL                           | TEST CONDITIONS                                                                                                                                                 |                                                                                       | MIN.  | TYP.    | MAX.  | UNIT |
|-------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------|---------|-------|------|
| Static                                    |                                  |                                                                                                                                                                 |                                                                                       |       |         |       |      |
| Drain-Source Breakdown Voltage            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = - 250 μA                                                                                                                |                                                                                       | - 60  | -       | -     | V    |
| V <sub>DS</sub> Temperature Coefficient   | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = - 1 mA                                                                                                                     |                                                                                       | -     | - 0.060 | -     | V/°C |
| Gate-Source Threshold Voltage             | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = - 250 μA                                                                                                   |                                                                                       | - 1.0 | -       | - 2.5 | V    |
| Gate-Source Leakage                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V                                                                                                                                        |                                                                                       | -     | -       | ± 100 | nA   |
| Zero Gate Voltage Drain Current           | I <sub>DSS</sub>                 | V <sub>DS</sub> = - 60 V, V <sub>GS</sub> = 0 V                                                                                                                 |                                                                                       | -     | -       | - 100 | μA   |
|                                           |                                  | V <sub>DS</sub> = - 48 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 150 °C                                                                                        |                                                                                       | -     | -       | - 500 |      |
| Drain-Source On-State Resistance          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = - 10 V                                                                                                                                        | I <sub>D</sub> = - 3.2 A <sup>b</sup>                                                 | -     | 0.05    | -     | Ω    |
| Forward Transconductance                  | g <sub>fs</sub>                  | V <sub>DS</sub> = - 25 V, I <sub>D</sub> = - 3.2 A <sup>b</sup>                                                                                                 |                                                                                       | 1.6   | -       | -     | S    |
| Dynamic                                   |                                  |                                                                                                                                                                 |                                                                                       |       |         |       |      |
| Input Capacitance                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = - 25 V,<br>f = 1.0 MHz, see fig. 5                                                                                  |                                                                                       | -     | 270     | -     | pF   |
| Output Capacitance                        | C <sub>oss</sub>                 |                                                                                                                                                                 |                                                                                       | -     | 170     | -     |      |
| Reverse Transfer Capacitance              | C <sub>rss</sub>                 |                                                                                                                                                                 |                                                                                       | -     | 31      | -     |      |
| Drain to Sink Capacitance                 | C                                | f = 1.0 MHz                                                                                                                                                     |                                                                                       | -     | 12      | -     |      |
| Total Gate Charge                         | Q <sub>g</sub>                   | V <sub>GS</sub> = - 10 V                                                                                                                                        | I <sub>D</sub> = - 4.7 A, V <sub>DS</sub> = - 48 V,<br>see fig. 6 and 13 <sup>b</sup> | -     | -       | 12    | nC   |
| Gate-Source Charge                        | Q <sub>gs</sub>                  |                                                                                                                                                                 |                                                                                       | -     | -       | 3.8   |      |
| Gate-Drain Charge                         | Q <sub>gd</sub>                  |                                                                                                                                                                 |                                                                                       | -     | -       | 5.1   |      |
| Turn-On Delay Time                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = - 30 V, I <sub>D</sub> = - 4.7 A,<br>R <sub>G</sub> = 24 Ω, R <sub>D</sub> = 4.0 Ω,<br>see fig. 10 <sup>b</sup>                               |                                                                                       | -     | 11      | -     | ns   |
| Rise Time                                 | t <sub>r</sub>                   |                                                                                                                                                                 |                                                                                       | -     | 63      | -     |      |
| Turn-Off Delay Time                       | t <sub>d(off)</sub>              |                                                                                                                                                                 |                                                                                       | -     | 9.6     | -     |      |
| Fall Time                                 | t <sub>f</sub>                   |                                                                                                                                                                 |                                                                                       | -     | 31      | -     |      |
| Internal Drain Inductance                 | L <sub>D</sub>                   | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact  |                                                                                       | -     | 4.5     | -     | nH   |
| Internal Source Inductance                | L <sub>S</sub>                   |                                                                                                                                                                 |                                                                                       | -     | 7.5     | -     |      |
| Drain-Source Body Diode Characteristics   |                                  |                                                                                                                                                                 |                                                                                       |       |         |       |      |
| Continuous Source-Drain Diode Current     | I <sub>S</sub>                   | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode    |                                                                                       | -     | -       | - 5.2 | A    |
| Pulsed Diode Forward Current <sup>a</sup> | I <sub>SM</sub>                  |                                                                                                                                                                 |                                                                                       | -     | -       | - 21  |      |
| Body Diode Voltage                        | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = - 5.2 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                                                            |                                                                                       | -     | -       | - 5.5 | V    |
| Body Diode Reverse Recovery Time          | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = - 4.7 A, dI/dt = 100 A/μs <sup>b</sup>                                                                                 |                                                                                       | -     | 80      | 160   | ns   |
| Body Diode Reverse Recovery Charge        | Q <sub>rr</sub>                  |                                                                                                                                                                 |                                                                                       | -     | 0.096   | 0.19  | μC   |
| Forward Turn-On Time                      | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                                                               |                                                                                       |       |         |       |      |

**Notes**

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted

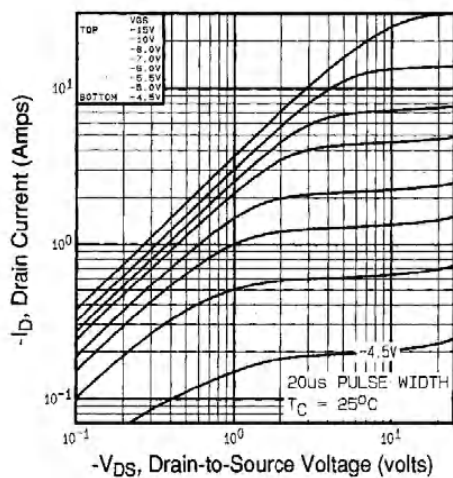


Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$

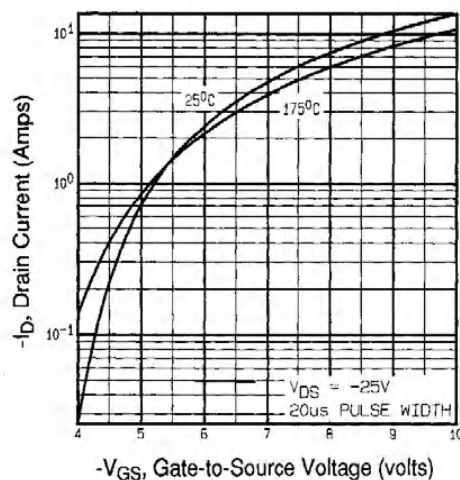


Fig. 3 - Typical Transfer Characteristics

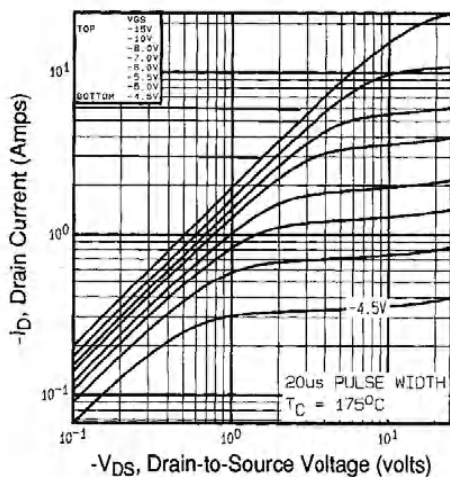


Fig. 2 - Typical Output Characteristics,  $T_C = 175^\circ\text{C}$

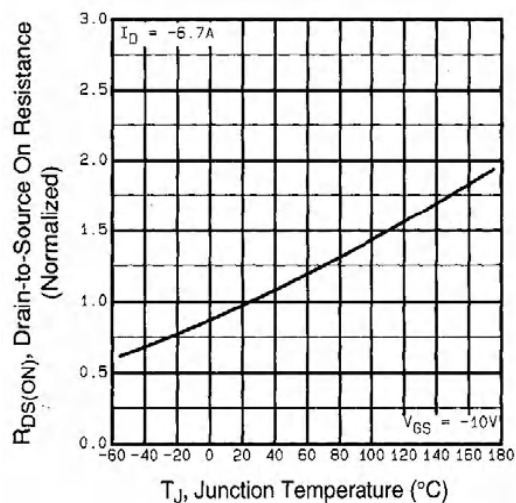


Fig. 4 - Normalized On-Resistance vs. Temperature

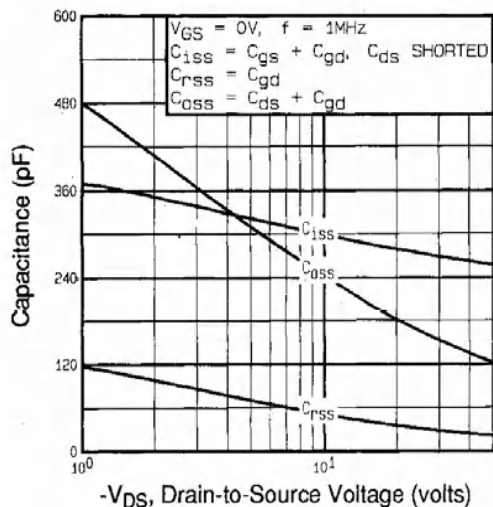


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

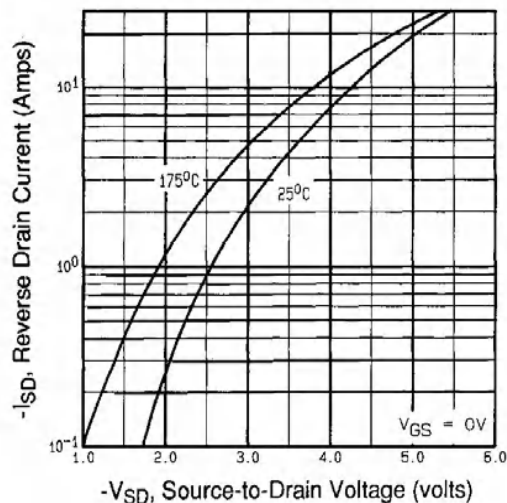


Fig. 7 - Typical Source-Drain Diode Forward Voltage

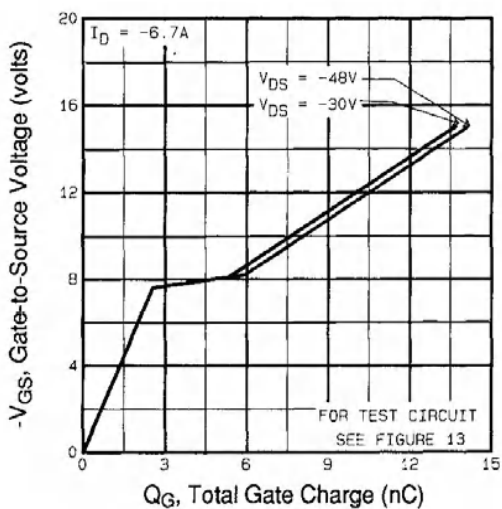


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

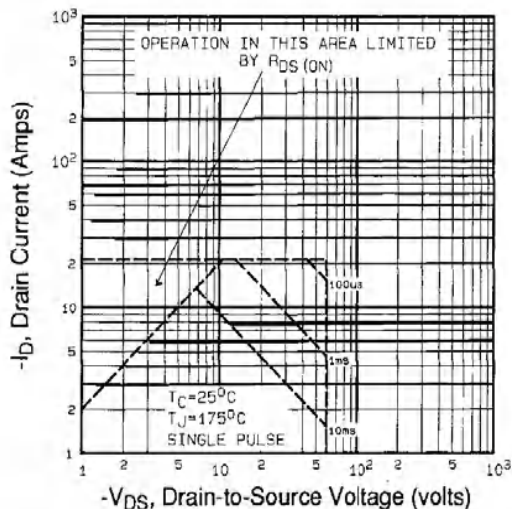


Fig. 8 - Maximum Safe Operating Area

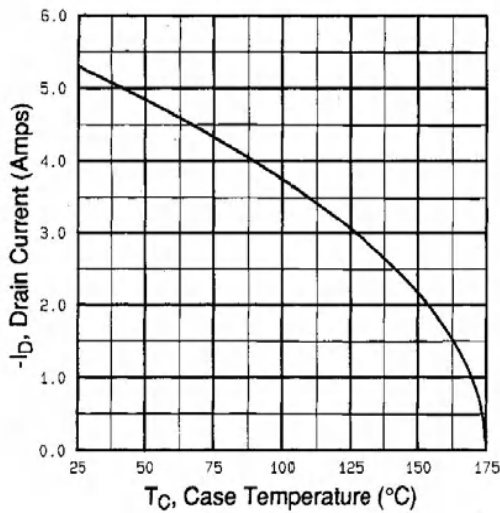


Fig. 9 - Maximum Drain Current vs. Case Temperature

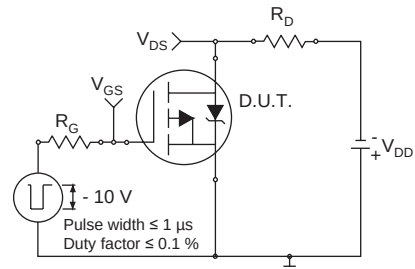


Fig. 10a - Switching Time Test Circuit

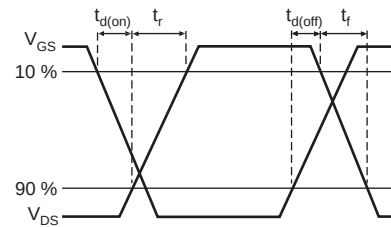


Fig. 10b - Switching Time Waveforms

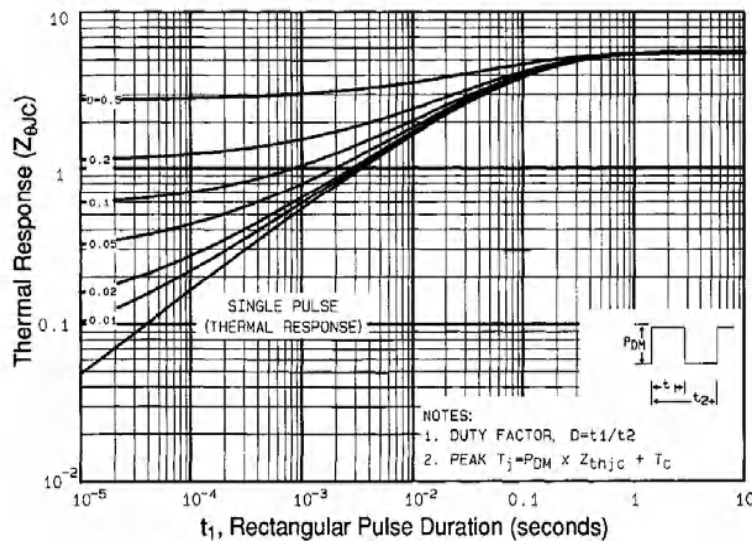


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

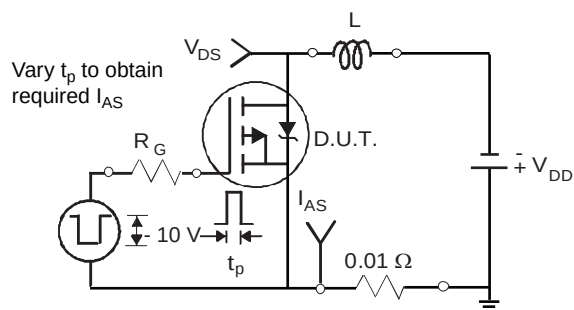


Fig. 12a - Unclamped Inductive Test Circuit

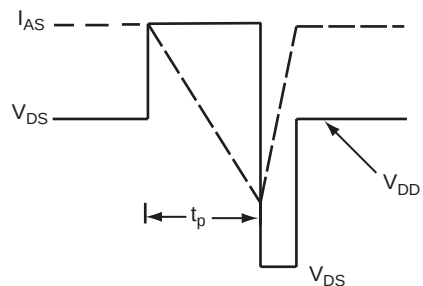
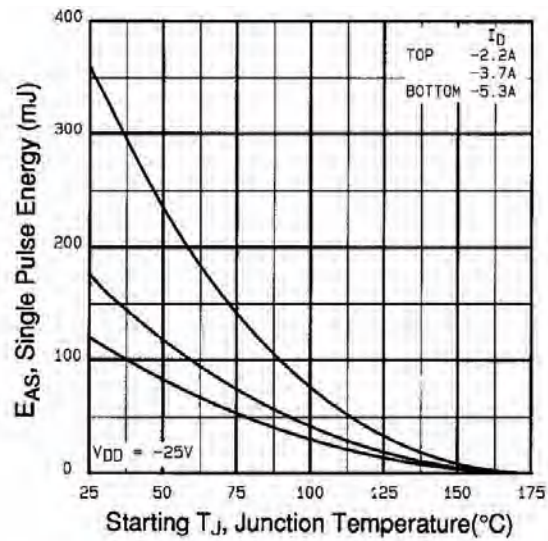
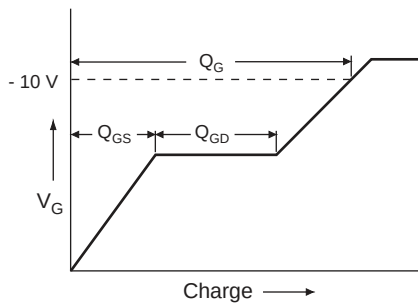


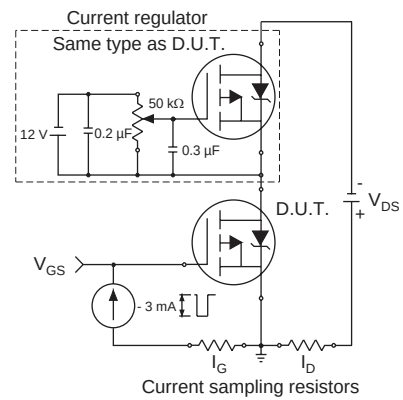
Fig. 12b - Unclamped Inductive Waveforms



**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**

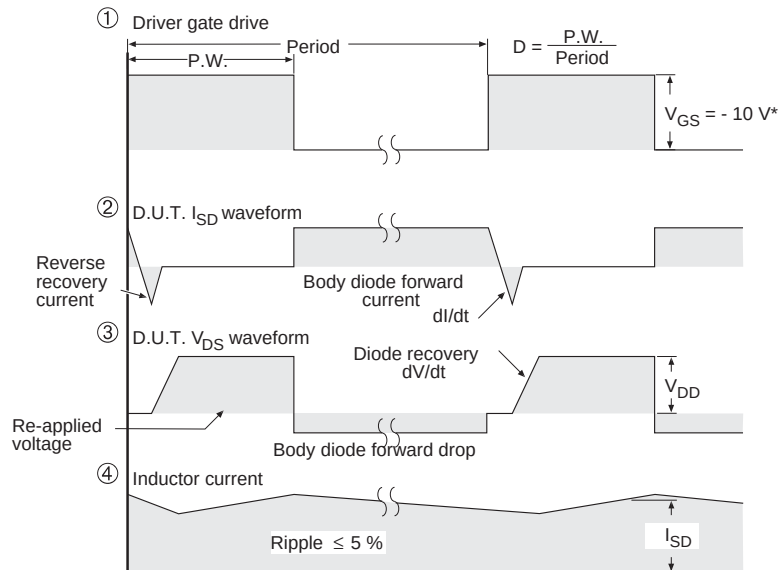
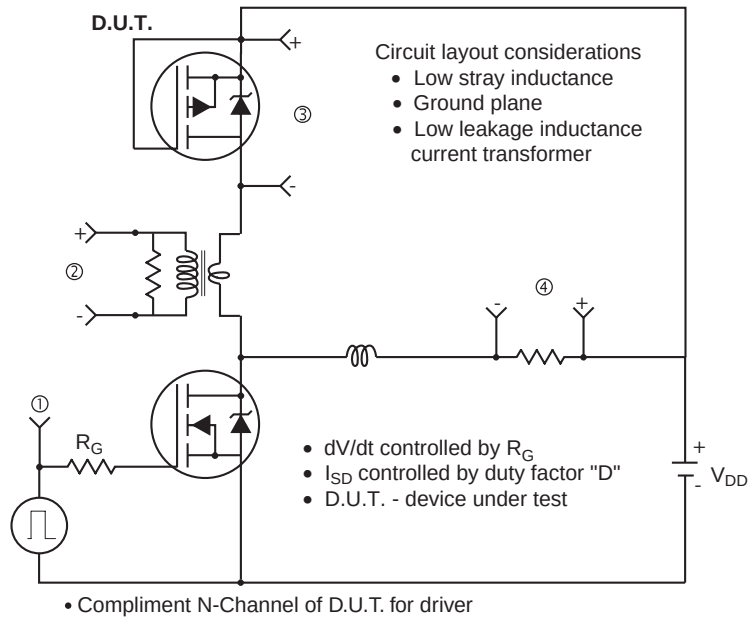


**Fig. 13a - Basic Gate Charge Waveform**



**Fig. 13b - Gate Charge Test Circuit**

### Peak Diode Recovery $dV/dt$ Test Circuit

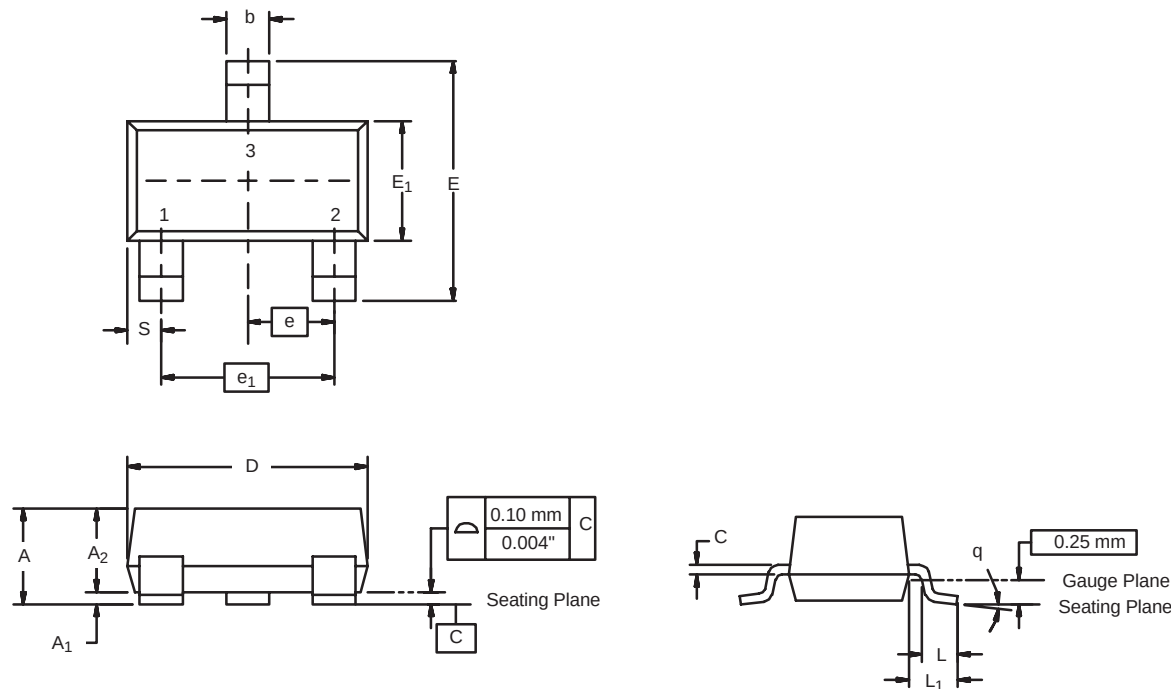


\*  $V_{GS} = -5 V$  for logic level and  $-3 V$  drive devices

**Fig. 14 - For P-Channel**



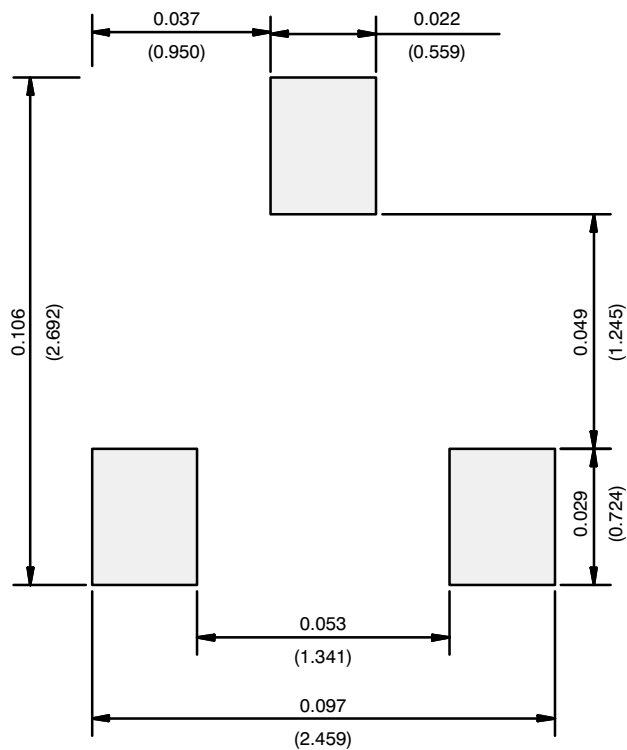
**SOT-23 (TO-236): 3-LEAD**



| 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<br>DWG: 5479 |             |      |            |       |



RECOMMENDED MINIMUM PADS FOR SOT-23



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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