

# FQD13N06L / FQU13N06L

## 60V LOGIC N-Channel MOSFET

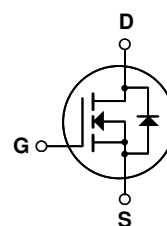
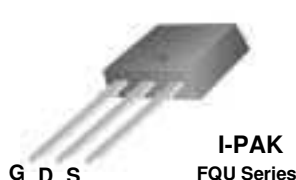
### General Description

These N-Channel enhancement mode power field effect transistors are produced using Fairchild's proprietary, planar stripe, DMOS technology.

This advanced technology has been especially tailored to minimize on-state resistance, provide superior switching performance, and withstand high energy pulse in the avalanche and commutation mode. These devices are well suited for low voltage applications such as automotive, DC/DC converters, and high efficiency switching for power management in portable and battery operated products.

### Features

- 11A, 60V,  $R_{DS(on)} = 0.115\Omega @ V_{GS} = 10V$
- Low gate charge ( typical 4.8 nC)
- Low  $C_{rss}$  ( typical 17 pF)
- Fast switching
- 100% avalanche tested
- Improved dv/dt capability
- 175°C maximum junction temperature rating
- RoHS Compliant



### Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ unless otherwise noted

| Symbol         | Parameter                                                                     | FQD13N06L / FQU13N06L | Units               |
|----------------|-------------------------------------------------------------------------------|-----------------------|---------------------|
| $V_{DSS}$      | Drain-Source Voltage                                                          | 60                    | V                   |
| $I_D$          | Drain Current - Continuous ( $T_C = 25^\circ\text{C}$ )                       | 11                    | A                   |
|                | - Continuous ( $T_C = 100^\circ\text{C}$ )                                    | 7                     | A                   |
| $I_{DM}$       | Drain Current - Pulsed (Note 1)                                               | 44                    | A                   |
| $V_{GSS}$      | Gate-Source Voltage                                                           | $\pm 20$              | V                   |
| $E_{AS}$       | Single Pulsed Avalanche Energy (Note 2)                                       | 90                    | mJ                  |
| $I_{AR}$       | Avalanche Current (Note 1)                                                    | 11                    | A                   |
| $E_{AR}$       | Repetitive Avalanche Energy (Note 1)                                          | 2.8                   | mJ                  |
| dv/dt          | Peak Diode Recovery dv/dt (Note 3)                                            | 7.0                   | V/ns                |
| $P_D$          | Power Dissipation ( $T_A = 25^\circ\text{C}$ ) *                              | 2.5                   | W                   |
|                | Power Dissipation ( $T_C = 25^\circ\text{C}$ )                                | 28                    | W                   |
|                | - Derate above $25^\circ\text{C}$                                             | 0.22                  | W/ $^\circ\text{C}$ |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range                                       | -55 to +150           | $^\circ\text{C}$    |
| $T_L$          | Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds | 300                   | $^\circ\text{C}$    |

### Thermal Characteristics

| Symbol          | Parameter                                 | Typ | Max | Units              |
|-----------------|-------------------------------------------|-----|-----|--------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case      | --  | 4.5 | $^\circ\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient * | --  | 50  | $^\circ\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient   | --  | 110 | $^\circ\text{C/W}$ |

\* When mounted on the minimum pad size recommended (PCB Mount)

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

| Symbol                         | Parameter                                 | Test Conditions                                                   | Min | Typ  | Max  | Units               |
|--------------------------------|-------------------------------------------|-------------------------------------------------------------------|-----|------|------|---------------------|
| <b>Off Characteristics</b>     |                                           |                                                                   |     |      |      |                     |
| $BV_{DSS}$                     | Drain-Source Breakdown Voltage            | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$               | 60  | --   | --   | V                   |
| $\Delta BV_{DSS} / \Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D = 250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$ | --  | 0.05 | --   | V/ $^\circ\text{C}$ |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current           | $V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$                       | --  | --   | 1    | $\mu\text{A}$       |
|                                |                                           | $V_{DS} = 48\text{ V}, T_C = 150^\circ\text{C}$                   | --  | --   | 10   | $\mu\text{A}$       |
| $I_{GSSF}$                     | Gate-Body Leakage Current, Forward        | $V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$                       | --  | --   | 100  | nA                  |
| $I_{GSSR}$                     | Gate-Body Leakage Current, Reverse        | $V_{GS} = -20\text{ V}, V_{DS} = 0\text{ V}$                      | --  | --   | -100 | nA                  |

**On Characteristics**

|              |                                   |                                                     |     |       |       |          |
|--------------|-----------------------------------|-----------------------------------------------------|-----|-------|-------|----------|
| $V_{GS(th)}$ | Gate Threshold Voltage            | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$     | 1.0 | --    | 2.5   | V        |
| $R_{DS(on)}$ | Static Drain-Source On-Resistance | $V_{GS} = 10\text{ V}, I_D = 5.5\text{ A}$          | --  | 0.092 | 0.115 | $\Omega$ |
|              |                                   | $V_{GS} = 5\text{ V}, I_D = 5.5\text{ A}$           | --  | 0.115 | 0.145 | $\Omega$ |
| $g_{FS}$     | Forward Transconductance          | $V_{DS} = 25\text{ V}, I_D = 5.5\text{ A}$ (Note 4) | --  | 6     | --    | S        |

**Dynamic Characteristics**

|           |                              |                                                                      |    |     |     |    |
|-----------|------------------------------|----------------------------------------------------------------------|----|-----|-----|----|
| $C_{iss}$ | Input Capacitance            | $V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V},$<br>$f = 1.0\text{ MHz}$ | -- | 270 | 350 | pF |
| $C_{oss}$ | Output Capacitance           |                                                                      | -- | 95  | 125 | pF |
| $C_{rss}$ | Reverse Transfer Capacitance |                                                                      | -- | 17  | 23  | pF |

**Switching Characteristics**

|              |                     |                                                                                            |    |     |     |    |
|--------------|---------------------|--------------------------------------------------------------------------------------------|----|-----|-----|----|
| $t_{d(on)}$  | Turn-On Delay Time  | $V_{DD} = 30\text{ V}, I_D = 6.8\text{ A},$<br>$R_G = 25\text{ }\Omega$<br><br>(Note 4, 5) | -- | 8   | 25  | ns |
| $t_r$        | Turn-On Rise Time   |                                                                                            | -- | 90  | 190 | ns |
| $t_{d(off)}$ | Turn-Off Delay Time |                                                                                            | -- | 20  | 50  | ns |
| $t_f$        | Turn-Off Fall Time  |                                                                                            | -- | 40  | 90  | ns |
| $Q_g$        | Total Gate Charge   | $V_{DS} = 48\text{ V}, I_D = 13.6\text{ A},$<br>$V_{GS} = 5\text{ V}$<br><br>(Note 4, 5)   | -- | 4.8 | 6.4 | nC |
| $Q_{gs}$     | Gate-Source Charge  |                                                                                            | -- | 1.6 | --  | nC |
| $Q_{gd}$     | Gate-Drain Charge   |                                                                                            | -- | 2.7 | --  | nC |

**Drain-Source Diode Characteristics and Maximum Ratings**

|                 |                                                       |                                                 |    |    |     |    |
|-----------------|-------------------------------------------------------|-------------------------------------------------|----|----|-----|----|
| I <sub>S</sub>  | Maximum Continuous Drain-Source Diode Forward Current |                                                 | -- | -- | 11  | A  |
| I <sub>SM</sub> | Maximum Pulsed Drain-Source Diode Forward Current     |                                                 | -- | -- | 44  | A  |
| V <sub>SD</sub> | Drain-Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 11 A    | -- | -- | 1.5 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                 | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 13.6 A, | -- | 45 | --  | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                               | dI <sub>F</sub> / dt = 100 A/μs (Note 4)        | -- | 45 | --  | nC |

**Notes:**

1. Repetitive Rating : Pulse width limited by maximum junction temperature
2.  $L = 870\text{ }\mu\text{H}$ ,  $I_{AS} = 11\text{ A}$ ,  $V_{DD} = 25\text{ V}$ ,  $R_G = 25\text{ }\Omega$ , Starting  $T_J = 25^\circ\text{C}$
3.  $I_{SD} \leq 13.6\text{ A}$ ,  $di/dt \leq 300\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , Starting  $T_J = 25^\circ\text{C}$
4. Pulse Test : Pulse width  $\leq 300\text{ }\mu\text{s}$ , Duty cycle  $\leq 2\%$
5. Essentially independent of operating temperature

## Typical Characteristics

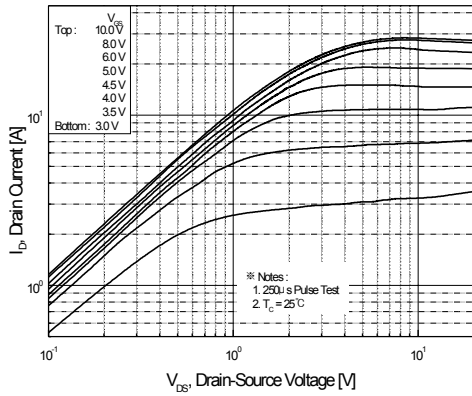


Figure 1. On-Region Characteristics

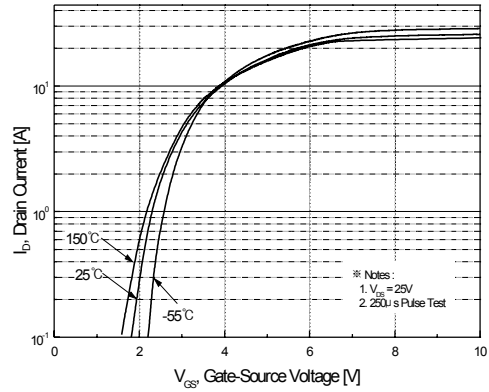


Figure 2. Transfer Characteristics

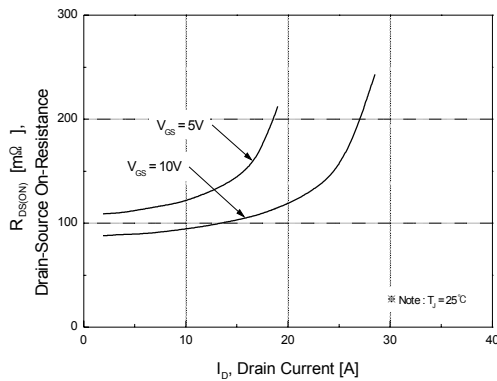


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

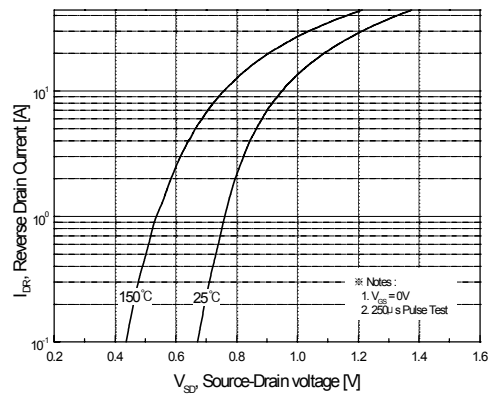


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

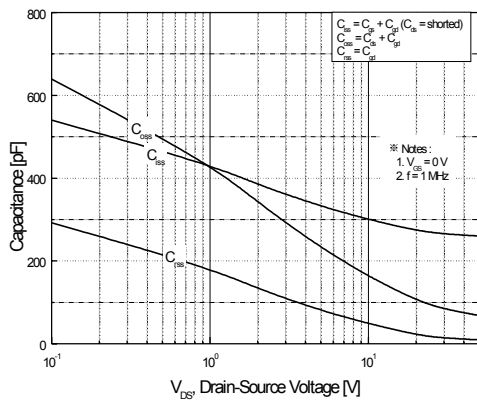


Figure 5. Capacitance Characteristics

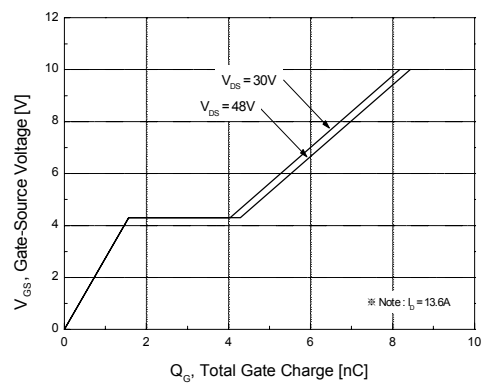
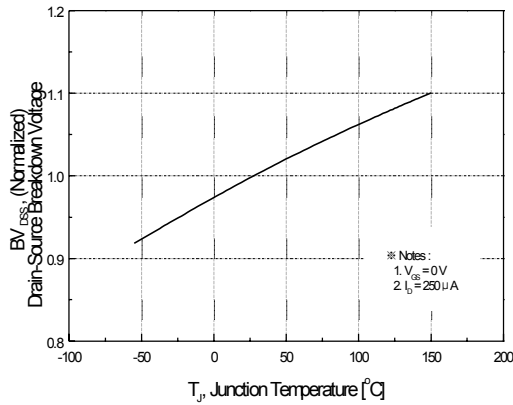
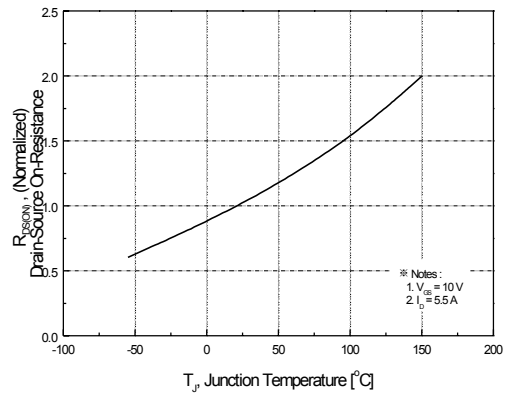


Figure 6. Gate Charge Characteristics

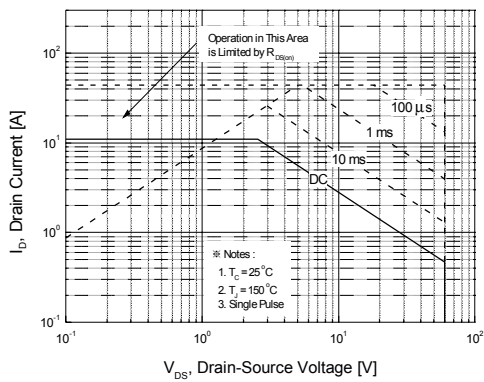
# Typical Characteristics (Continued)



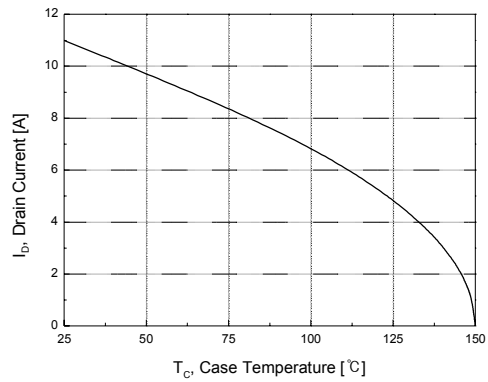
**Figure 7. Breakdown Voltage Variation vs. Temperature**



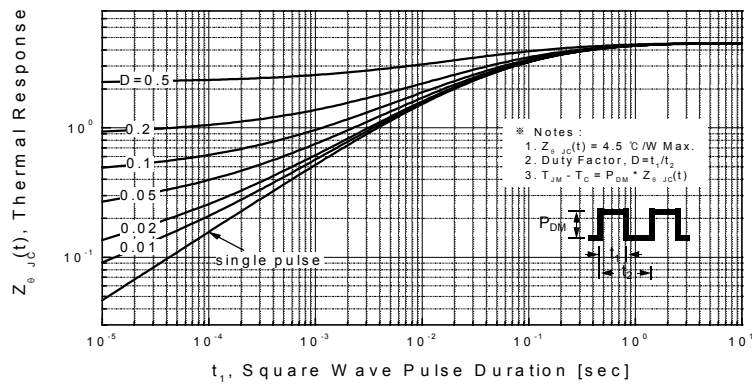
**Figure 8. On-Resistance Variation vs. Temperature**



**Figure 9. Maximum Safe Operating Area**

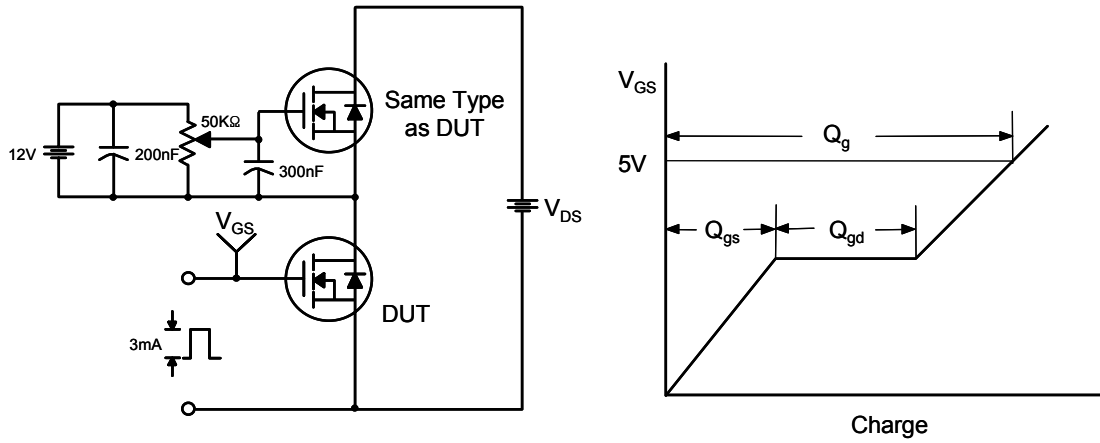


**Figure 10. Maximum Drain Current vs. Case Temperature**

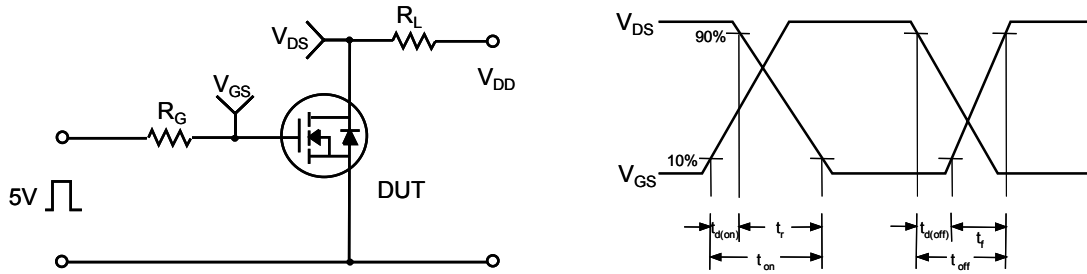


**Figure 11. Transient Thermal Response Curve**

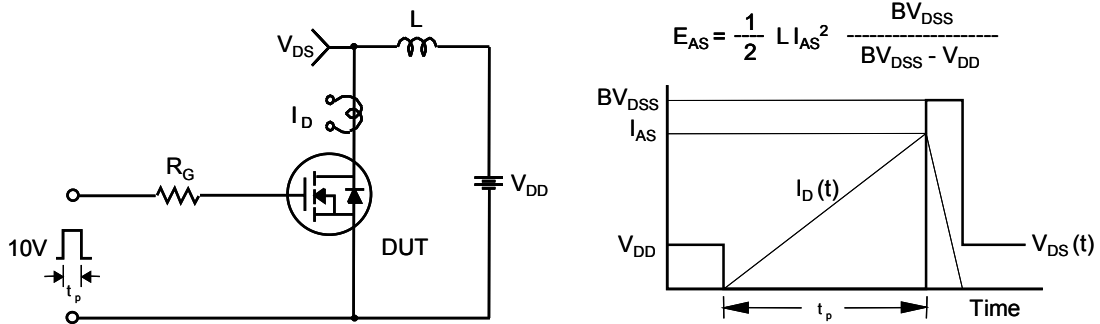
### Gate Charge Test Circuit & Waveform



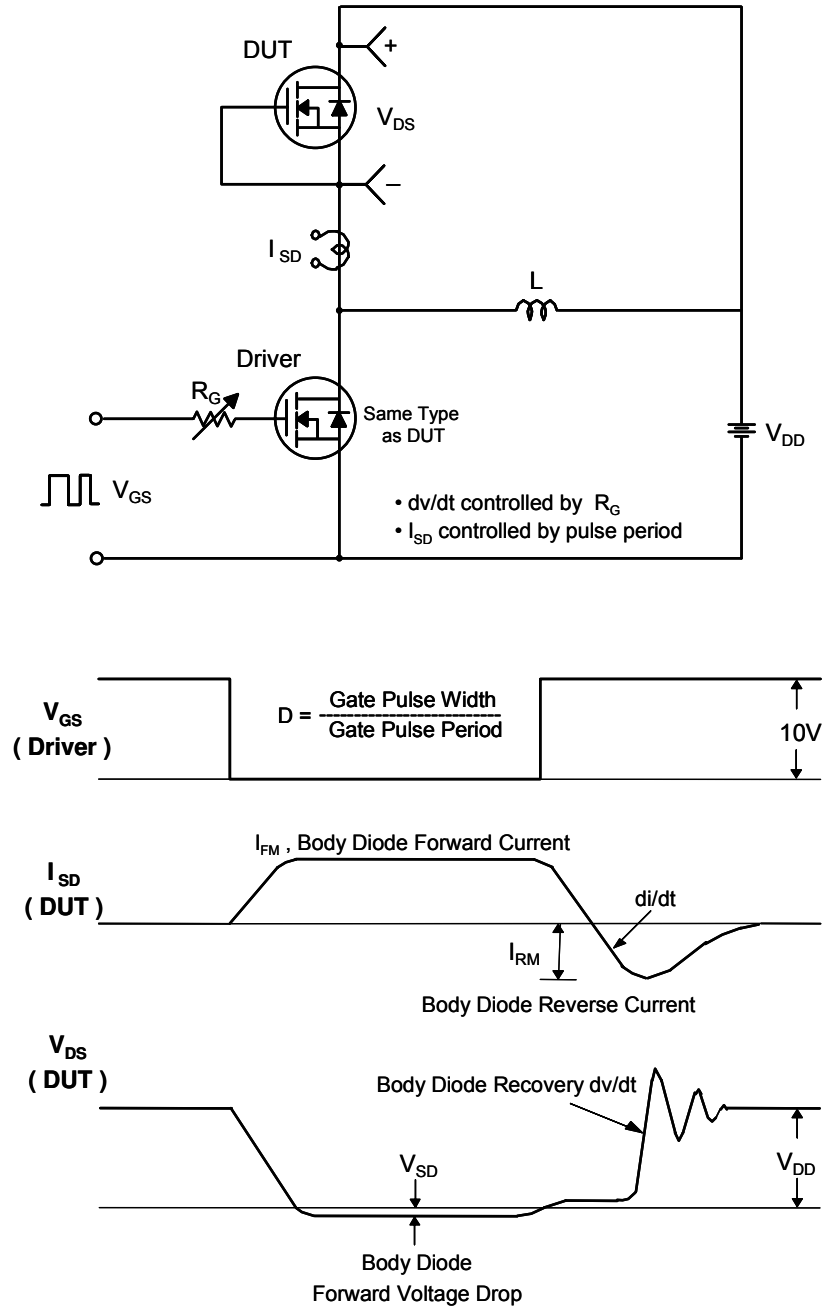
### Resistive Switching Test Circuit & Waveforms



### Unclamped Inductive Switching Test Circuit & Waveforms

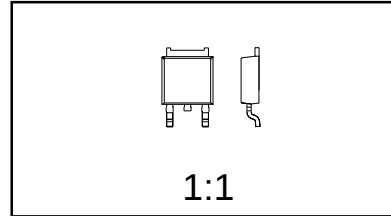
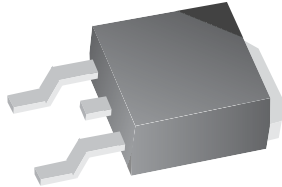


Peak Diode Recovery dv/dt Test Circuit & Waveforms



Package Dimensions

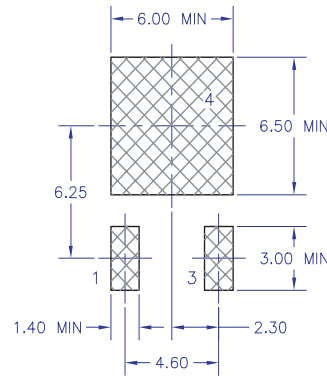
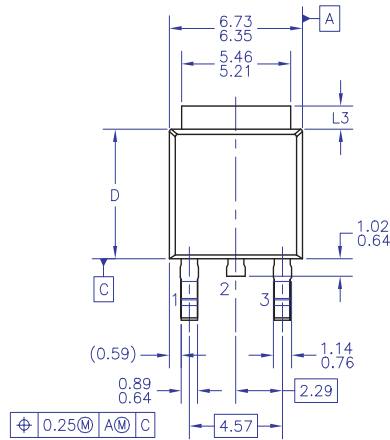
# TO-252 (DPAK) (FS PKG Code 36)



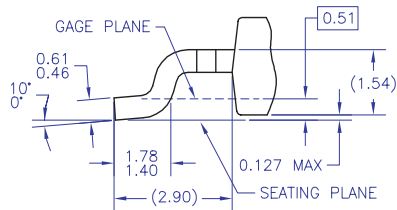
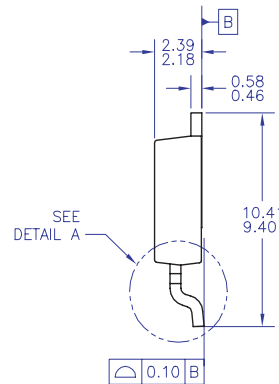
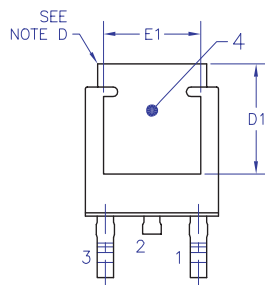
Scale 1:1 on letter size paper

Dimensions shown below are in:  
millimeters

Part Weight per unit (gram): 0.33



LAND PATTERN RECOMMENDATION



DETAIL A  
(ROTATED -90°)  
SCALE: 12X

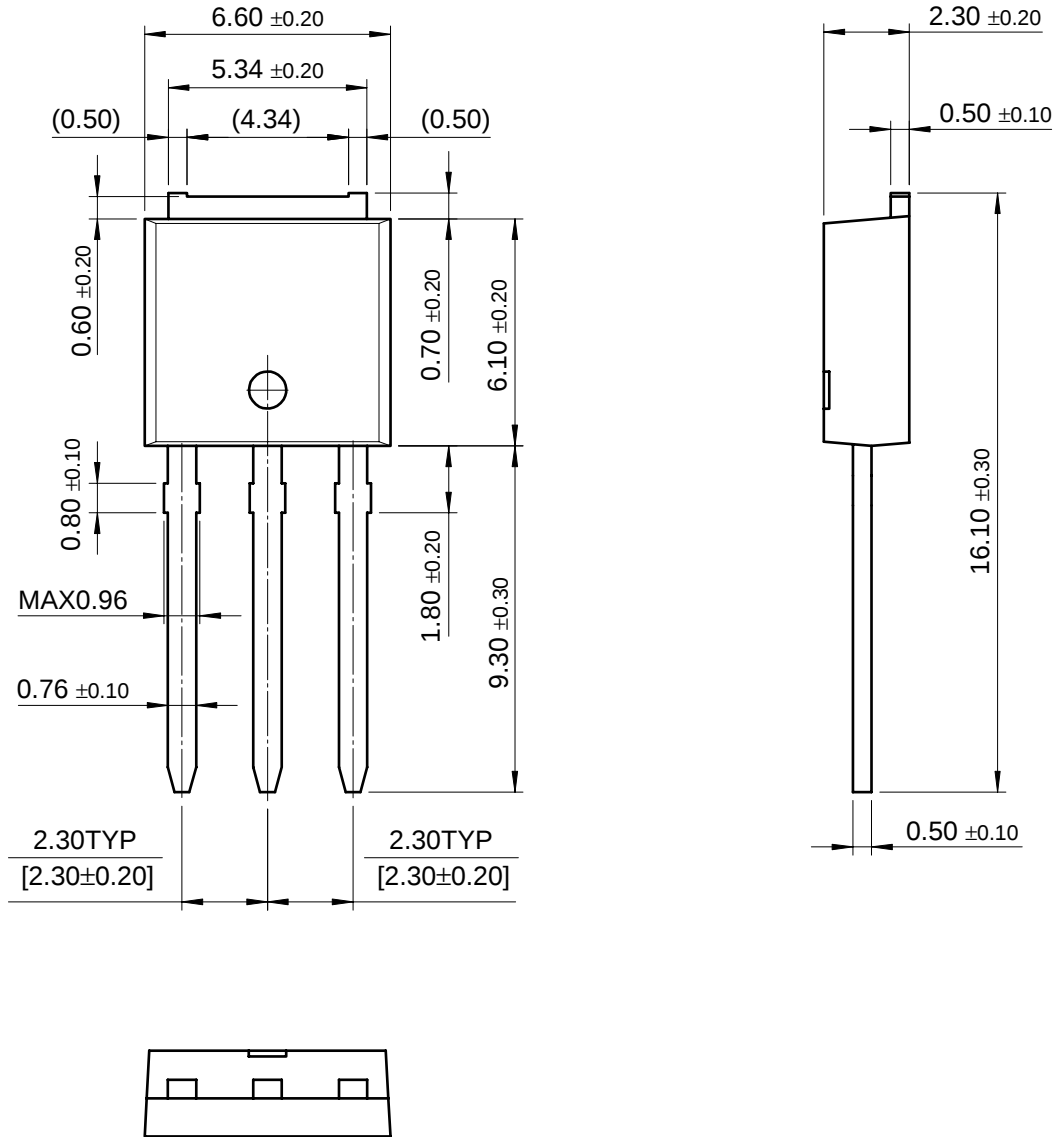
NOTES: UNLESS OTHERWISE SPECIFIED

- A) ALL DIMENSIONS ARE IN MILLIMETERS.
- B) THIS PACKAGE CONFORMS TO JEDEC, TO-252, ISSUE C, VARIATION AA & AB, DATED NOV. 1999.
- C) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
- D) HEAT SINK TOP EDGE COULD BE IN CHAMFERED CORNERS OR EDGE PROTRUSION.
- E) DIMENSIONS L3,D,E1&D1 TABLE:

|    | OPTION AA | OPTION AB |
|----|-----------|-----------|
| L3 | 0.89-1.27 | 1.52-2.03 |
| D  | 5.97-6.22 | 5.33-5.59 |
| E1 | 4.32 MIN  | 3.81 MIN  |
| D1 | 5.21 MIN  | 4.57 MIN  |

Package Dimensions (Continued)

IPAK



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|--------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advance Information      | Formative / In Design | Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.                                                                       |
| Preliminary              | First Production      | Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design. |
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