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August 2014

# FCP20N60 / FCPF20N60

## N-Channel SuperFET<sup>®</sup> MOSFET

600 V, 20 A, 190 mΩ

### Features

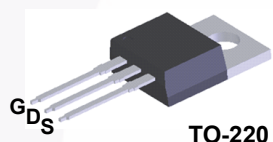
- 650V @  $T_J = 150^{\circ}\text{C}$
- Typ.  $R_{DS(on)} = 150\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 75\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 165\text{ pF}$ )
- 100% Avalanche Tested

### Applications

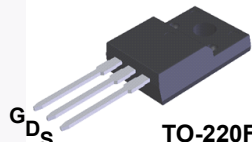
- Solar Inverter
- AC-DC Power Supply

### Description

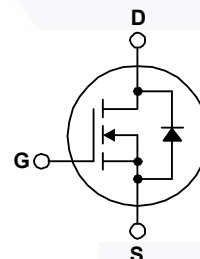
SuperFET<sup>®</sup> MOSFET is Fairchild Semiconductor's first generation of high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on-resistance and lower gate charge performance. This technology is tailored to minimize conduction loss, provide superior switching performance, dv/dt rate and higher avalanche energy. Consequently, SuperFET MOSFET is very suitable for the switching power applications such as PFC, server/telecom power, FPD TV power, ATX power and industrial power applications.



TO-220



TO-220F



### Absolute Maximum Ratings

| Symbol         | Parameter                                                                                                    | FCP20N60    | FCPF20N60 | Unit                  |
|----------------|--------------------------------------------------------------------------------------------------------------|-------------|-----------|-----------------------|
| $V_{DSS}$      | Drain-Source Voltage                                                                                         | 600         |           | V                     |
| $I_D$          | Drain Current<br>- Continuous ( $T_C = 25^{\circ}\text{C}$ )<br>- Continuous ( $T_C = 100^{\circ}\text{C}$ ) | 20          | 20*       | A                     |
|                |                                                                                                              | 12.5        | 12.5*     | A                     |
| $I_{DM}$       | Drain Current - Pulsed (Note 1)                                                                              | 60          | 60*       | A                     |
| $V_{GSS}$      | Gate-Source Voltage                                                                                          | $\pm 30$    |           | V                     |
| $E_{AS}$       | Single Pulsed Avalanche Energy (Note 2)                                                                      | 690         |           | mJ                    |
| $I_{AR}$       | Avalanche Current (Note 1)                                                                                   | 20          |           | A                     |
| $E_{AR}$       | Repetitive Avalanche Energy (Note 1)                                                                         | 20.8        |           | mJ                    |
| dv/dt          | Peak Diode Recovery dv/dt (Note 3)                                                                           | 4.5         |           | V/ns                  |
| $P_D$          | Power Dissipation ( $T_C = 25^{\circ}\text{C}$ )<br>- Derate Above $25^{\circ}\text{C}$                      | 208         | 39        | W                     |
|                |                                                                                                              | 1.67        | 0.3       | 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,<br>1/8" from Case for 5 Seconds                                      | 300         |           | $^{\circ}\text{C}$    |

\*Drain current limited by maximum junction temperature.

### Thermal Characteristics

| Symbol          | Parameter                               | FCP20N60 | FCPF20N60 | Unit                 |
|-----------------|-----------------------------------------|----------|-----------|----------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case    | 0.6      | 3.2       | $^{\circ}\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 62.5     | 62.5      | $^{\circ}\text{C/W}$ |

## Package Marking and Ordering Information

| Part Number | Top Mark  | Package | Packing Method | Reel Size | Tape Width | Quantity |
|-------------|-----------|---------|----------------|-----------|------------|----------|
| FCP20N60    | FCP20N60  | TO-220  | Tube           | N/A       | N/A        | 50 units |
| FCPF20N60   | FCPF20N60 | TO-220F | Tube           | N/A       | N/A        | 50 units |

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

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------|-----------------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|

### Off Characteristics

|                                |                                           |                                                                               |     |     |           |                     |
|--------------------------------|-------------------------------------------|-------------------------------------------------------------------------------|-----|-----|-----------|---------------------|
| $BV_{DSS}$                     | Drain to Source Breakdown Voltage         | $I_D = 250\ \mu\text{A}$ , $V_{GS} = 0\ \text{V}$ , $T_J = 25^\circ\text{C}$  | 600 | -   | -         | V                   |
|                                |                                           | $I_D = 250\ \mu\text{A}$ , $V_{GS} = 0\ \text{V}$ , $T_J = 150^\circ\text{C}$ | -   | 650 | -         | V                   |
| $\Delta BV_{DSS} / \Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D = 250\ \mu\text{A}$ , Referenced to $25^\circ\text{C}$                   | -   | 0.6 | -         | V/ $^\circ\text{C}$ |
| $BV_{DS}$                      | Drain-Source Avalanche Breakdown Voltage  | $V_{GS} = 0\ \text{V}$ , $I_D = 20\ \text{A}$                                 | -   | 700 | -         | V                   |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current           | $V_{DS} = 600\ \text{V}$ , $V_{GS} = 0\ \text{V}$                             | -   | -   | 1         | $\mu\text{A}$       |
|                                |                                           | $V_{DS} = 480\ \text{V}$ , $T_C = 125^\circ\text{C}$                          | -   | -   | 10        |                     |
| $I_{GSS}$                      | Gate to Body Leakage Current              | $V_{GS} = \pm 30\ \text{V}$ , $V_{DS} = 0\ \text{V}$                          | -   | -   | $\pm 100$ | nA                  |

### On Characteristics

|              |                                      |                                                |     |      |      |          |
|--------------|--------------------------------------|------------------------------------------------|-----|------|------|----------|
| $V_{GS(th)}$ | Gate Threshold Voltage               | $V_{GS} = V_{DS}$ , $I_D = 250\ \mu\text{A}$   | 3.0 | -    | 5.0  | V        |
| $R_{DS(on)}$ | Static Drain to Source On Resistance | $V_{GS} = 10\ \text{V}$ , $I_D = 10\ \text{A}$ | -   | 0.15 | 0.19 | $\Omega$ |
| $g_{FS}$     | Forward Transconductance             | $V_{DS} = 40\ \text{V}$ , $I_D = 10\ \text{A}$ | -   | 17   | -    | S        |

### Dynamic Characteristics

|                 |                               |                                                                                          |   |      |      |    |
|-----------------|-------------------------------|------------------------------------------------------------------------------------------|---|------|------|----|
| $C_{iss}$       | Input Capacitance             | $V_{DS} = 25\ \text{V}$ , $V_{GS} = 0\ \text{V}$ ,<br>$f = 1\ \text{MHz}$                | - | 2370 | 3080 | pF |
| $C_{oss}$       | Output Capacitance            |                                                                                          | - | 1280 | 1665 | pF |
| $C_{rss}$       | Reverse Transfer Capacitance  |                                                                                          | - | 95   | -    | pF |
| $C_{oss}$       | Output Capacitance            | $V_{DS} = 480\ \text{V}$ , $V_{GS} = 0\ \text{V}$ , $f = 1\ \text{MHz}$                  | - | 65   | 85   | pF |
| $C_{oss(eff.)}$ | Effective Output Capacitance  | $V_{DS} = 0\ \text{V}$ to $400\ \text{V}$ , $V_{GS} = 0\ \text{V}$                       | - | 165  | -    | pF |
| $Q_g$           | Total Gate Charge at 10V      | $V_{DS} = 480\ \text{V}$ , $I_D = 20\ \text{A}$ ,<br>$V_{GS} = 10\ \text{V}$<br>(Note 4) | - | 75   | 98   | nC |
| $Q_{gs}$        | Gate to Source Gate Charge    |                                                                                          | - | 13.5 | 18   | nC |
| $Q_{gd}$        | Gate to Drain "Miller" Charge |                                                                                          | - | 36   | -    | nC |

### Switching Characteristics

|              |                     |                                                                                                               |   |     |     |    |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------|---|-----|-----|----|
| $t_{d(on)}$  | Turn-On Delay Time  | $V_{DD} = 300\ \text{V}$ , $I_D = 20\ \text{A}$ ,<br>$V_{GS} = 10\ \text{V}$ , $R_G = 25\ \Omega$<br>(Note 4) | - | 62  | 135 | ns |
| $t_r$        | Turn-On Rise Time   |                                                                                                               | - | 140 | 290 | ns |
| $t_{d(off)}$ | Turn-Off Delay Time |                                                                                                               | - | 230 | 470 | ns |
| $t_f$        | Turn-Off Fall Time  |                                                                                                               | - | 65  | 140 | ns |

### Drain-Source Diode Characteristics

|                 |                                                          |                                                |   |      |     |    |
|-----------------|----------------------------------------------------------|------------------------------------------------|---|------|-----|----|
| I <sub>S</sub>  | Maximum Continuous Drain to Source Diode Forward Current |                                                | - | -    | 20  | A  |
| I <sub>SM</sub> | Maximum Pulsed Drain to Source Diode Forward Current     |                                                | - | -    | 60  | A  |
| V <sub>SD</sub> | Drain to Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 20 A  | - | -    | 1.4 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 20 A, | - | 530  | -   | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  | dI <sub>F</sub> /dt = 100 A/μs                 | - | 10.5 | -   | μC |

#### Notes:

- 1: Repetitive rating; pulse-width limited by maximum junction temperature.
- 2:  $I_{AS} = 10\ \text{A}$ ,  $V_{DD} = 50\ \text{V}$ ,  $R_G = 25\ \Omega$ , starting  $T_J = 25^\circ\text{C}$ .
- 3:  $I_{SD} \leq 20\ \text{A}$ ,  $di/dt \leq 200\ \text{A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , starting  $T_J = 25^\circ\text{C}$ .
- 4: Essentially independent of operating temperature typical characteristics.

## Typical Performance Characteristics

Figure 1. On-Region Characteristics

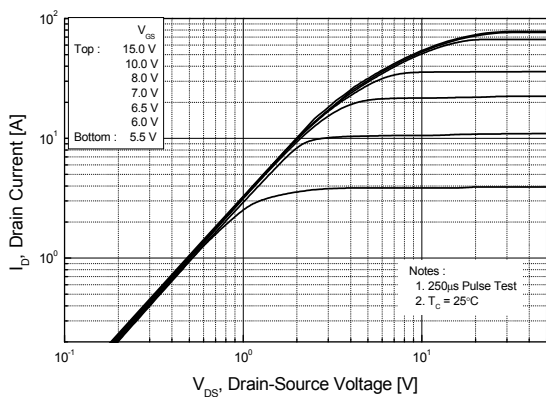


Figure 2. Transfer Characteristics

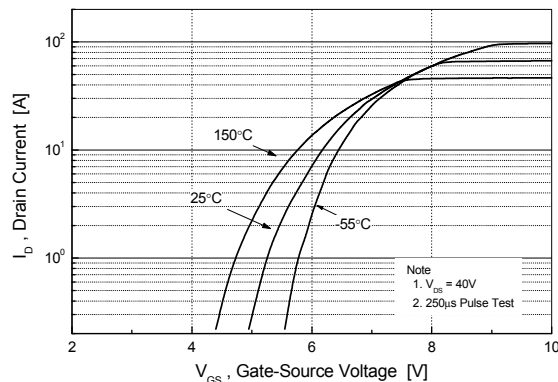


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

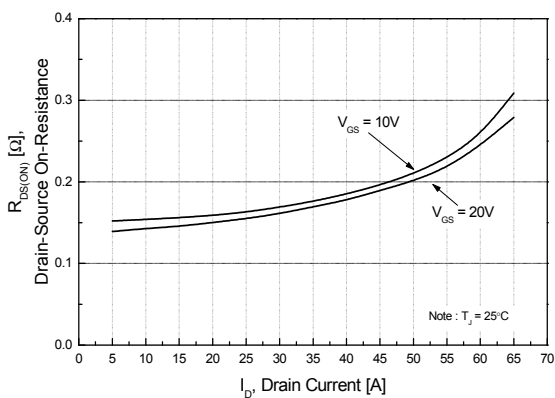


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

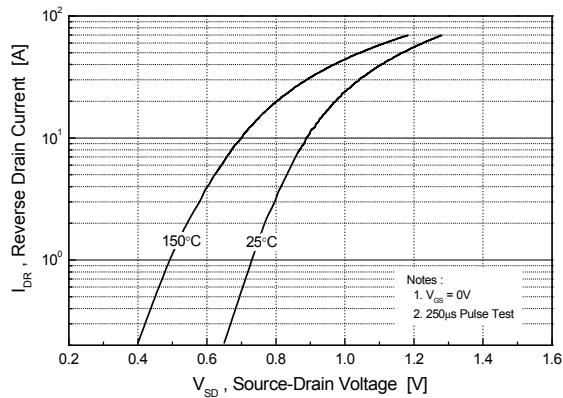


Figure 5. Capacitance Characteristics

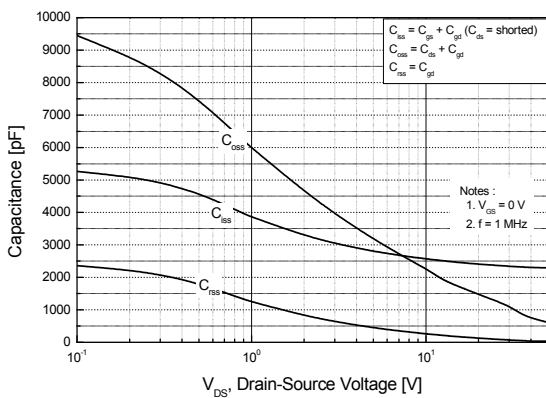
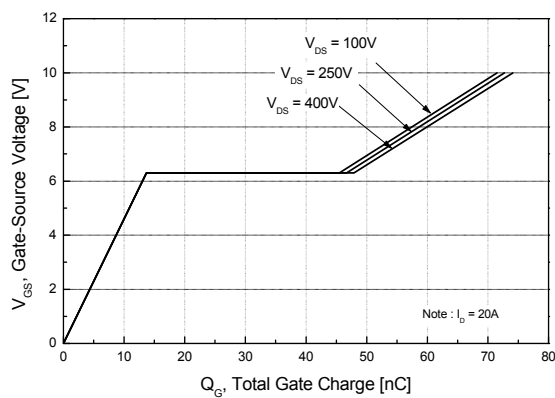
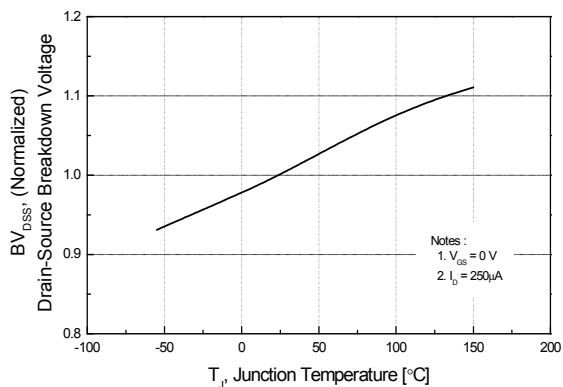


Figure 6. Gate Charge Characteristics

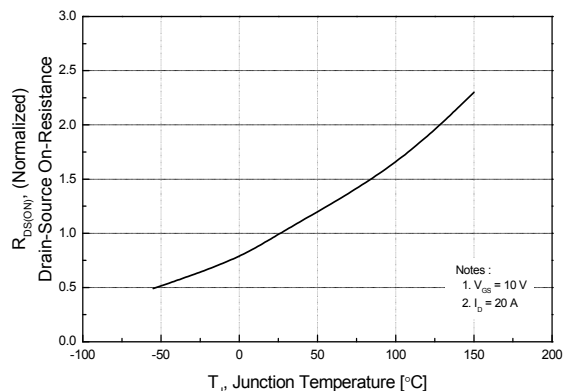


## Typical Performance Characteristics (Continued)

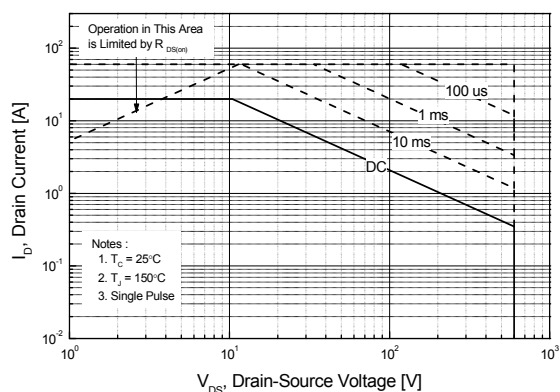
**Figure 7. Breakdown Voltage Variation vs. Temperature**



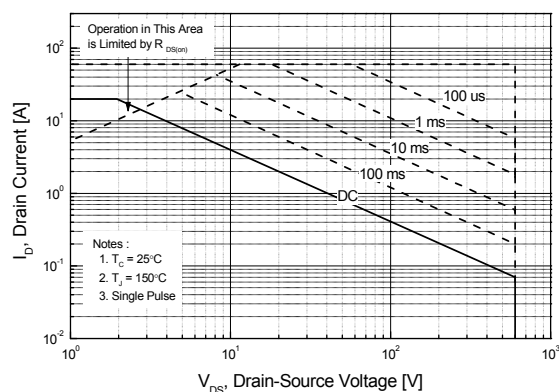
**Figure 8. On-Resistance Variation vs. Temperature**



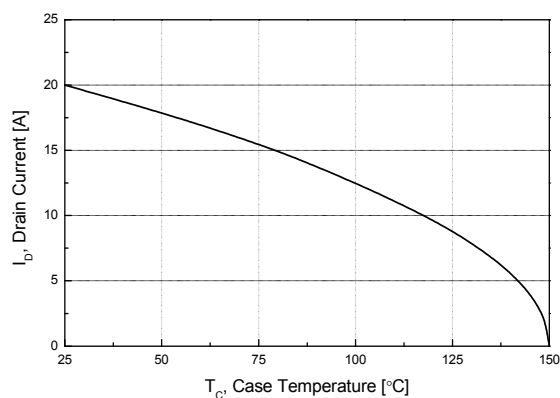
**Figure 9-1. Maximum Safe Operating Area for FCP20N60**



**Figure 9-2. Maximum Safe Operating Area for FCPF20N60**



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



# Typical Performance Characteristics (Continued)

Figure 11-1. Transient Thermal Response Curve for FCP20N60

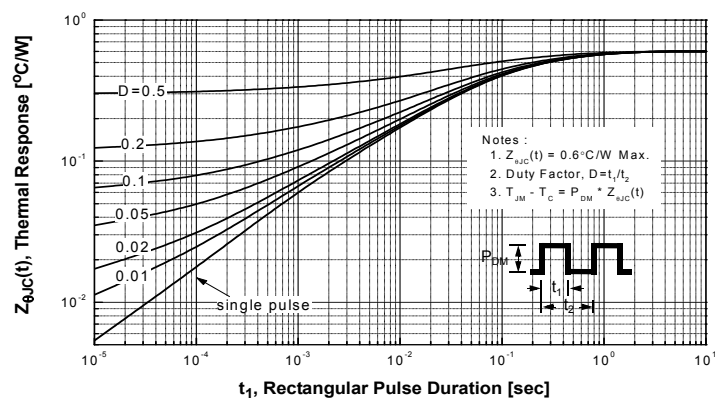
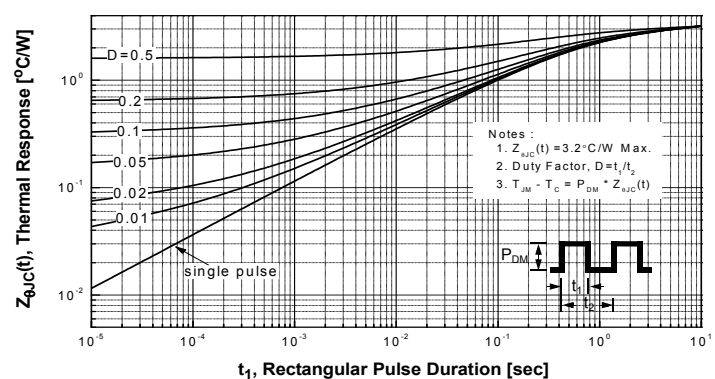


Figure 11-2. Transient Thermal Response Curve for FCPF20N60



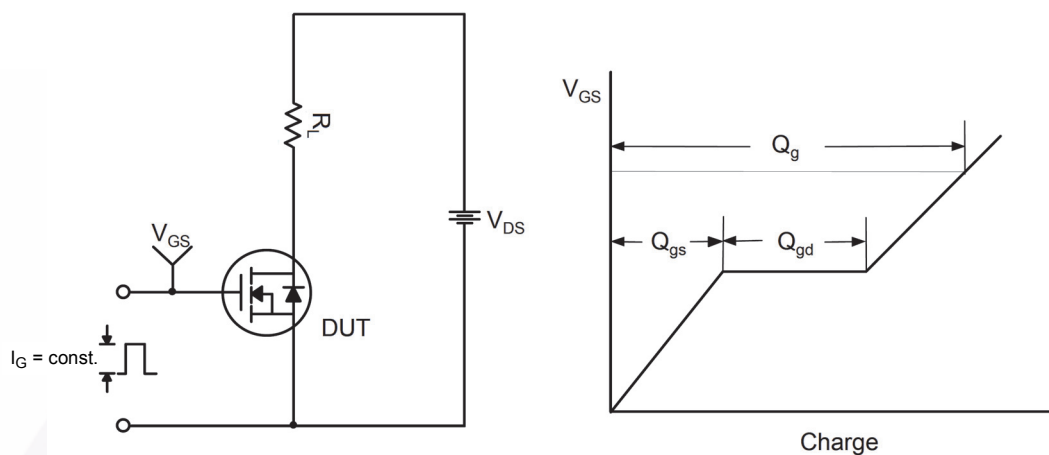


Figure 12. Gate Charge Test Circuit & Waveform

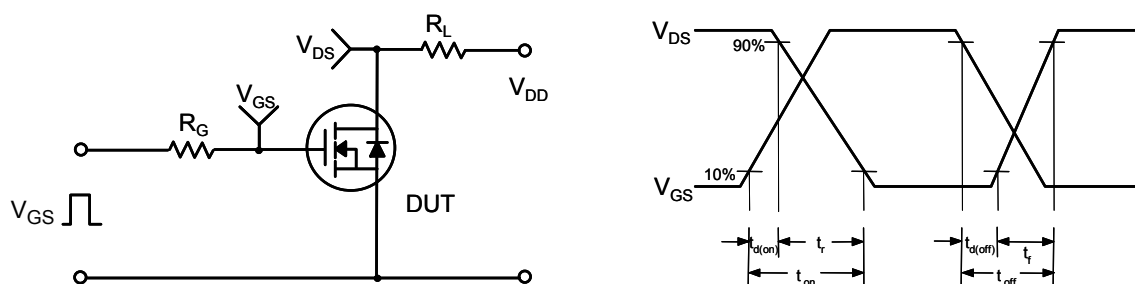


Figure 13. Resistive Switching Test Circuit & Waveforms

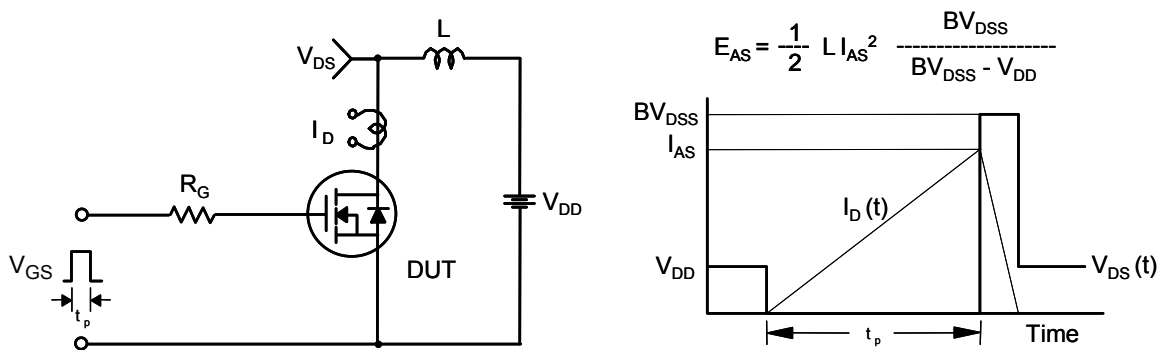


Figure 14. Unclamped Inductive Switching Test Circuit & Waveforms

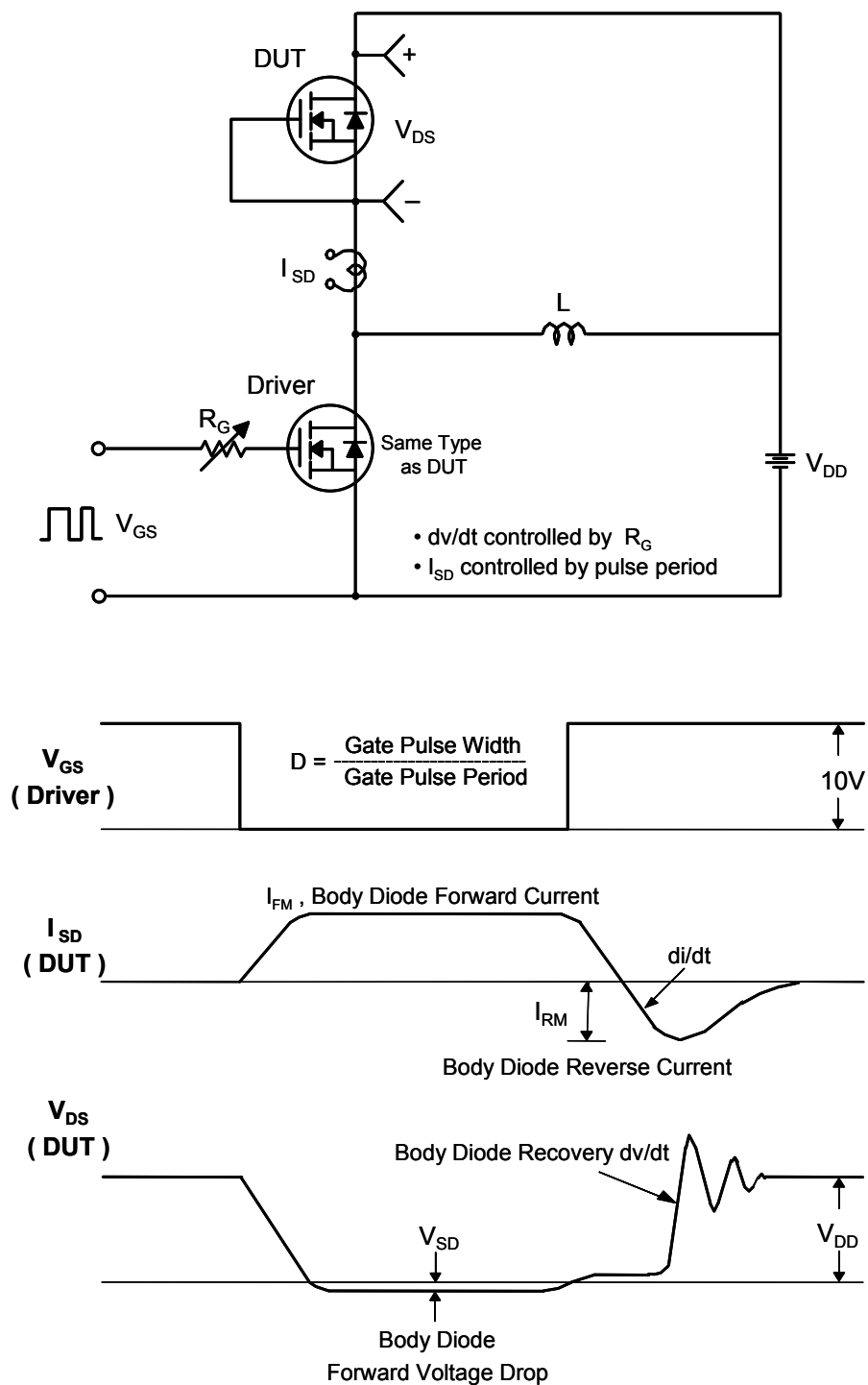
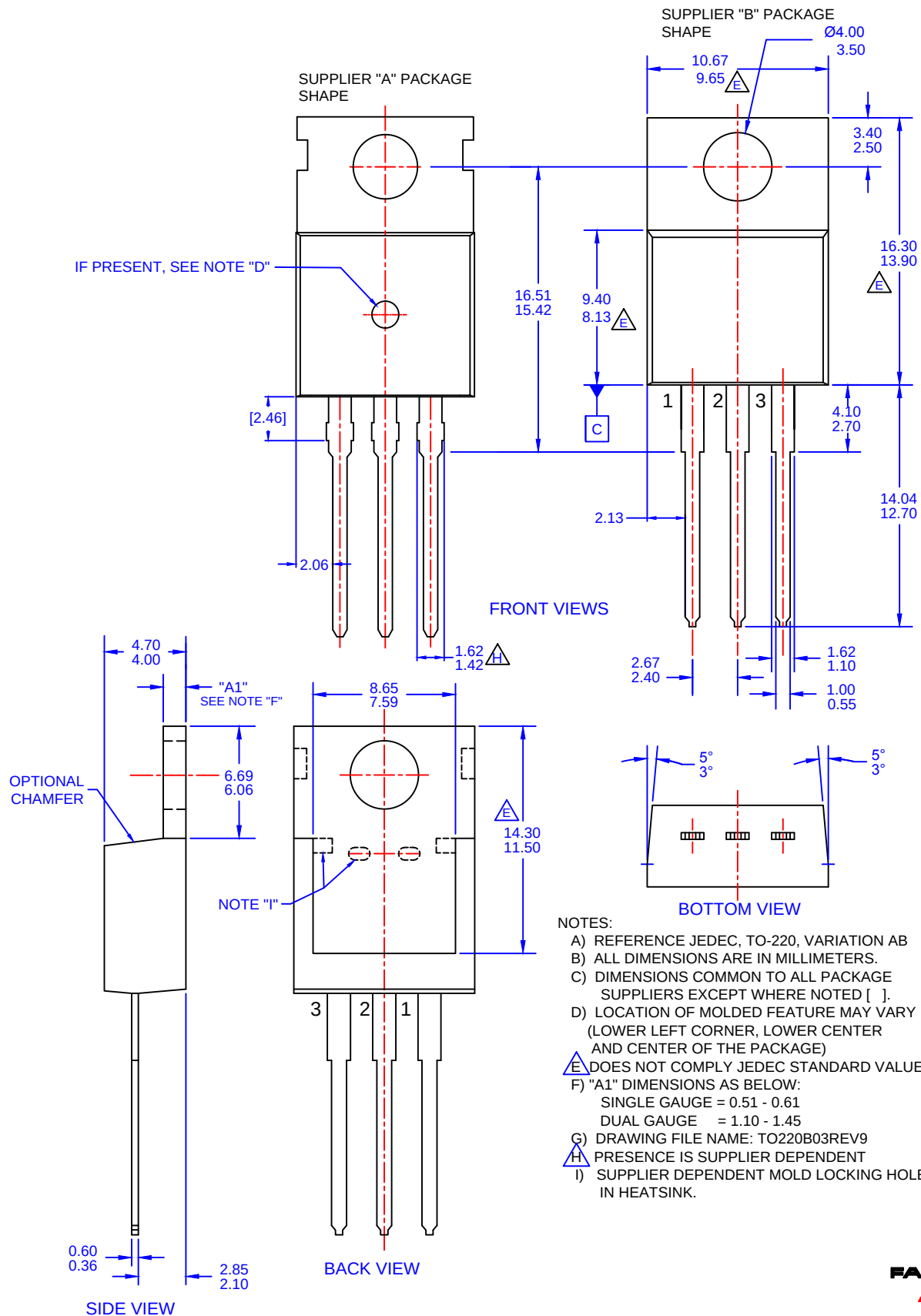


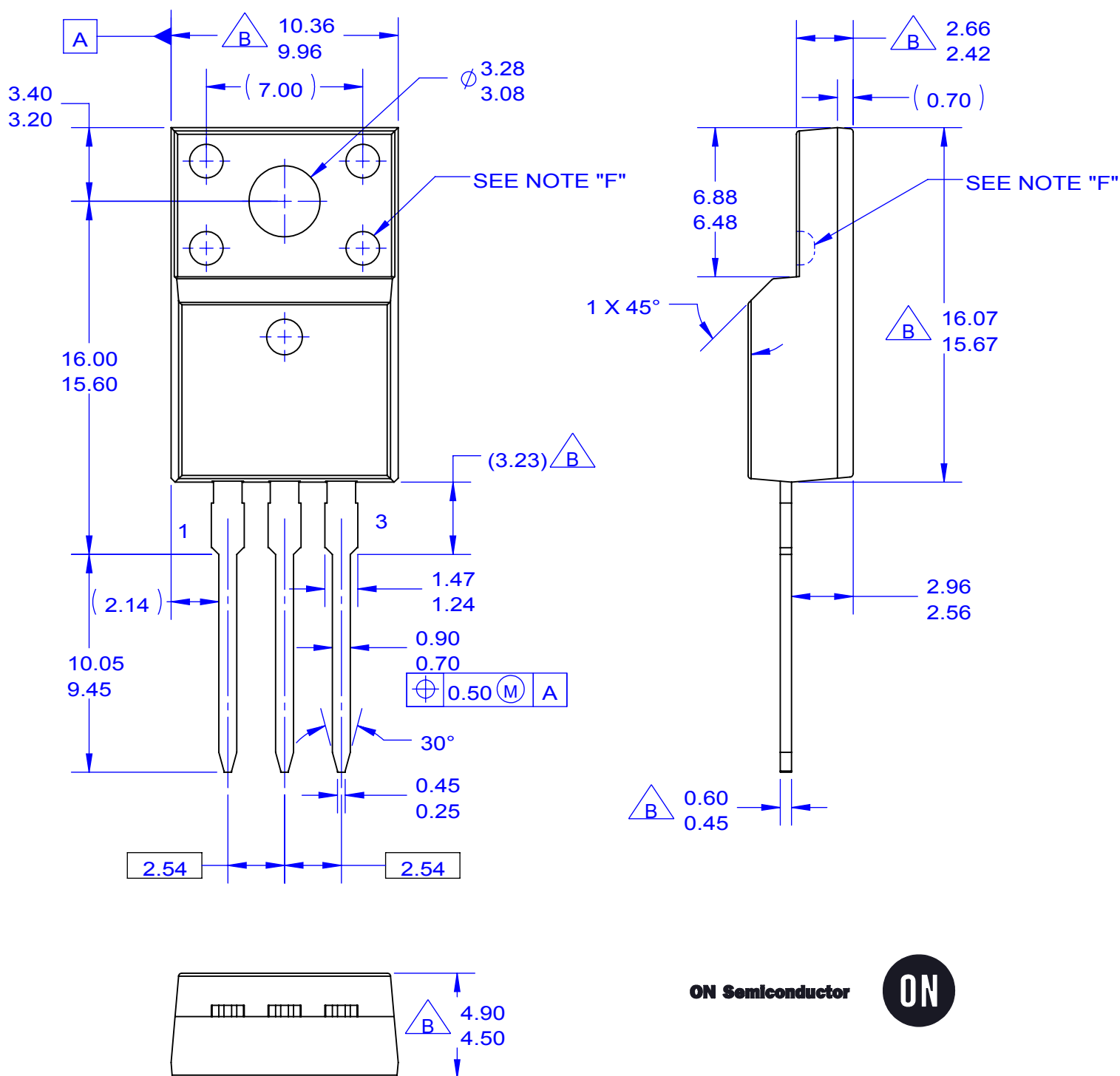
Figure 15. Peak Diode Recovery  $dv/dt$  Test Circuit & Waveforms





**NOTES:**

- A) REFERENCE JEDEC, TO-220, VARIATION AB
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS COMMON TO ALL PACKAGE SUPPLIERS EXCEPT WHERE NOTED [ ].
- D) LOCATION OF MOLDED FEATURE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)
- E) DOES NOT COMPLY JEDEC STANDARD VALUE.
- F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
- G) DRAWING FILE NAME: TO220B03REV9
- H) PRESENCE IS SUPPLIER DEPENDENT
- I) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.



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# NOTES:

- A. EXCEPT WHERE NOTED CONFORMS TO EIAJ SC91A.
- B. DOES NOT COMPLY EIAJ STD. VALUE.
- C. ALL DIMENSIONS ARE IN MILLIMETERS.
- D. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUSIONS.
- E. DIMENSION AND TOLERANCE AS PER ASME Y14.5-1994.
- F. OPTION 1 - WITH SUPPORT PIN HOLE.  
OPTION 2 - NO SUPPORT PIN HOLE.
- G. DRAWING FILE NAME: TO220M03REV5

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