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June 2014

# FCP104N60

## N-Channel SuperFET® II MOSFET

600 V, 37 A, 104 mΩ

### Features

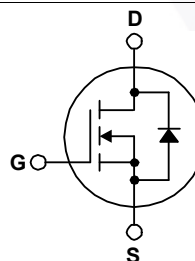
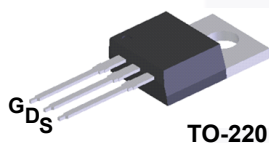
- 650 V @  $T_J = 150^\circ\text{C}$
- Typ.  $R_{DS(on)} = 96\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 63\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 280\text{ pF}$ )
- 100% Avalanche Tested
- RoHS Compliant

### Applications

- Telecom / Server Power Supplies
- Industrial Power Supplies

### Description

SuperFET® II MOSFET is Fairchild Semiconductor's brand-new high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on-resistance and lower gate charge performance. This advanced technology is tailored to minimize conduction loss, provide superior switching performance, and withstand extreme dv/dt rate and higher avalanche energy. Consequently, SuperFET II MOSFET is suitable for various AC/DC power conversion for system miniaturization and higher efficiency.



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

| Symbol         | Parameter                                                            | FCP104N60                                  | Unit             |
|----------------|----------------------------------------------------------------------|--------------------------------------------|------------------|
| $V_{DSS}$      | Drain to Source Voltage                                              | 600                                        | V                |
| $V_{GSS}$      | Gate to Source Voltage                                               | - DC                                       | $\pm 20$         |
|                |                                                                      | - AC ( $f > 1\text{ Hz}$ )                 | $\pm 30$         |
| $I_D$          | Drain Current                                                        | - Continuous ( $T_C = 25^\circ\text{C}$ )  | 37               |
|                |                                                                      | - Continuous ( $T_C = 100^\circ\text{C}$ ) | 24               |
| $I_{DM}$       | Drain Current                                                        | - Pulsed (Note 1)                          | 111              |
| $E_{AS}$       | Single Pulsed Avalanche Energy                                       | (Note 2)                                   | 809              |
| $I_{AR}$       | Avalanche Current                                                    | (Note 1)                                   | 6.8              |
| $E_{AR}$       | Repetitive Avalanche Energy                                          | (Note 1)                                   | 3.57             |
| dv/dt          | MOSFET dv/dt                                                         | 100                                        | V/ns             |
|                | Peak Diode Recovery dv/dt (Note 3)                                   | 20                                         |                  |
| $P_D$          | Power Dissipation                                                    | ( $T_C = 25^\circ\text{C}$ )               | 357              |
|                |                                                                      | - Derate Above $25^\circ\text{C}$          | 2.85             |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range                              | -55 to +150                                | $^\circ\text{C}$ |
| $T_L$          | Maximum Lead Temperature for Soldering, 1/8" from Case for 5 Seconds | 300                                        | $^\circ\text{C}$ |

### Thermal Characteristics

| Symbol          | Parameter                                     | FCP104N60 | Unit               |
|-----------------|-----------------------------------------------|-----------|--------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max.    | 0.35      | $^\circ\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max. | 40        |                    |

## Package Marking and Ordering Information

| Part Number | Top Mark  | Package | Packing Method | Reel Size | Tape Width | Quantity |
|-------------|-----------|---------|----------------|-----------|------------|----------|
| FCP104N60   | FCP104N60 | TO-220  | 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         | $V_{GS} = 0\text{ V}, I_D = 10\text{ mA}, T_J = 25^\circ\text{C}$     | 600 | -    | -         | V                  |
|                                |                                           | $V_{GS} = 0\text{ V}, I_D = 10\text{ mA}, T_J = 150^\circ\text{C}$    | 650 | -    | -         | V                  |
| $\Delta BV_{DSS} / \Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D = 10\text{ mA}$ , Referenced to $25^\circ\text{C}$               | -   | 0.67 | -         | $V/^\circ\text{C}$ |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current           | $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$                          | -   | -    | 1         | $\mu\text{A}$      |
|                                |                                           | $V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_C = 125^\circ\text{C}$ | -   | 1.98 | -         | $\mu\text{A}$      |
| $I_{GSS}$                      | Gate to Body Leakage Current              | $V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$                       | -   | -    | $\pm 100$ | nA                 |

### On Characteristics

|              |                                      |                                                 |     |    |     |            |
|--------------|--------------------------------------|-------------------------------------------------|-----|----|-----|------------|
| $V_{GS(th)}$ | Gate Threshold Voltage               | $V_{GS} = V_{DS}, I_D = 250\text{ }\mu\text{A}$ | 2.5 | -  | 3.5 | V          |
| $R_{DS(on)}$ | Static Drain to Source On Resistance | $V_{GS} = 10\text{ V}, I_D = 18.5\text{ A}$     | -   | 96 | 104 | m $\Omega$ |
| $g_{FS}$     | Forward Transconductance             | $V_{DS} = 20\text{ V}, I_D = 18.5\text{ A}$     | -   | 33 | -   | S          |

### Dynamic Characteristics

|                 |                               |                                                                                |   |      |      |          |
|-----------------|-------------------------------|--------------------------------------------------------------------------------|---|------|------|----------|
| $C_{iss}$       | Input Capacitance             | $V_{DS} = 380\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$                 | - | 3130 | 4165 | pF       |
| $C_{oss}$       | Output Capacitance            |                                                                                | - | 75   | 100  | pF       |
| $C_{rss}$       | Reverse Transfer Capacitance  |                                                                                | - | 3.66 | -    | pF       |
| $C_{oss(eff.)}$ | Effective Output Capacitance  | $V_{DS} = 0\text{ V to } 480\text{ V}, V_{GS} = 0\text{ V}$                    | - | 280  | -    | pF       |
| $Q_{g(tot)}$    | Total Gate Charge at 10V      | $V_{DS} = 380\text{ V}, I_D = 18.5\text{ A}, V_{GS} = 10\text{ V}$<br>(Note 4) | - | 63   | 82   | nC       |
| $Q_{gs}$        | Gate to Source Gate Charge    |                                                                                | - | 14   | -    | nC       |
| $Q_{gd}$        | Gate to Drain "Miller" Charge |                                                                                | - | 15   | -    | nC       |
| ESR             | Equivalent Series Resistance  | $f = 1\text{ MHz}$                                                             | - | 0.97 | -    | $\Omega$ |

### Switching Characteristics

|              |                     |                                                                                                         |   |     |     |    |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------|---|-----|-----|----|
| $t_{d(on)}$  | Turn-On Delay Time  | $V_{DD} = 380\text{ V}, I_D = 18.5\text{ A}, V_{GS} = 10\text{ V}, R_g = 4.7\text{ }\Omega$<br>(Note 4) | - | 26  | 62  | ns |
| $t_r$        | Turn-On Rise Time   |                                                                                                         | - | 18  | 46  | ns |
| $t_{d(off)}$ | Turn-Off Delay Time |                                                                                                         | - | 72  | 154 | ns |
| $t_f$        | Turn-Off Fall Time  |                                                                                                         | - | 3.3 | 17  | ns |

### Drain-Source Diode Characteristics

|                 |                                                          |                                                                                    |   |     |     |    |
|-----------------|----------------------------------------------------------|------------------------------------------------------------------------------------|---|-----|-----|----|
| I <sub>S</sub>  | Maximum Continuous Drain to Source Diode Forward Current |                                                                                    | - | -   | 37  | A  |
| I <sub>SM</sub> | Maximum Pulsed Drain to Source Diode Forward Current     |                                                                                    | - | -   | 114 | A  |
| V <sub>SD</sub> | Drain to Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 18.5 A                                    | - | -   | 1.2 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 18.5 A,<br>dI <sub>F</sub> /dt = 100 A/μs | - | 414 | -   | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  |                                                                                    | - | 8.8 | -   | μC |

#### Notes:

1. Repetitive rating: pulse width limited by maximum junction temperature.
2.  $I_{AS} = 6.8\text{ A}, R_G = 25\text{ }\Omega$ , Starting  $T_J = 25^\circ\text{C}$
3.  $I_{SD} \leq 18.5\text{ A}, di/dt \leq 200\text{ A}/\mu\text{s}, V_{DD} \leq 380\text{ V}$ , Starting  $T_J = 25^\circ\text{C}$
4. Essentially independent of operating temperature.

## Typical Performance Characteristics

Figure 1. On-Region Characteristics

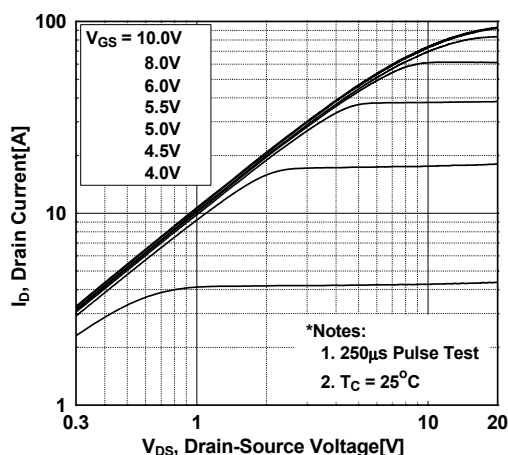


Figure 2. Transfer Characteristics

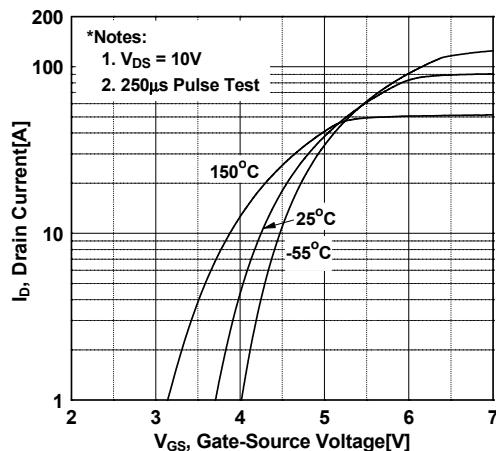


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

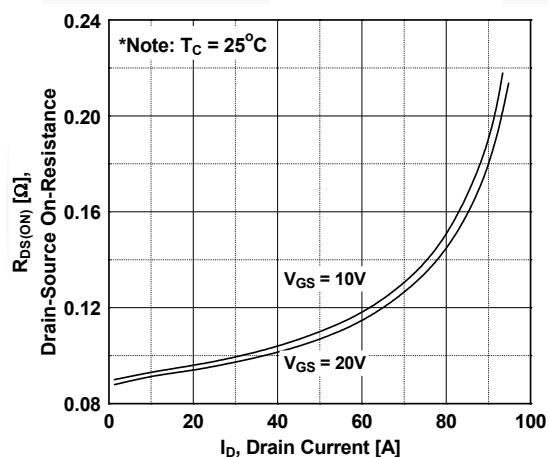


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

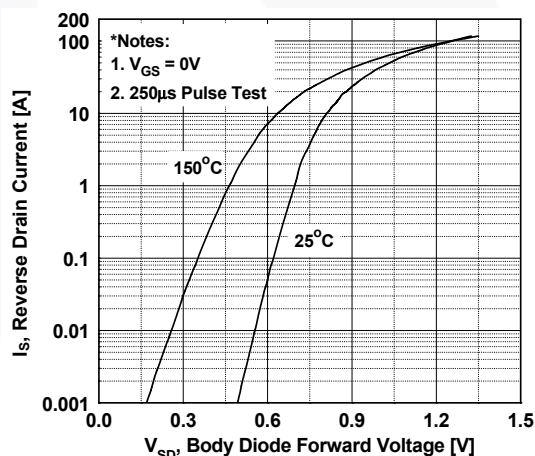


Figure 5. Capacitance Characteristics

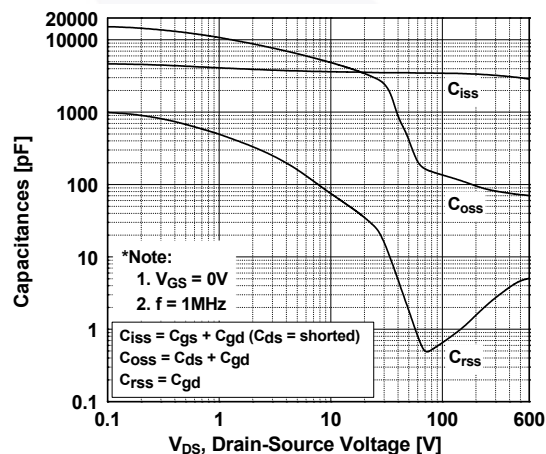
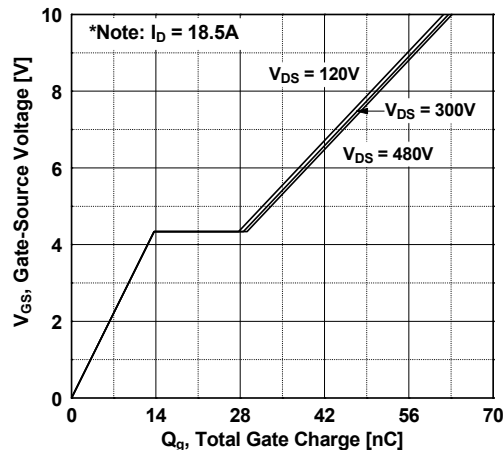


Figure 6. Gate Charge Characteristics



## Typical Performance Characteristics (Continued)

Figure 7. Breakdown Voltage Variation vs. Temperature

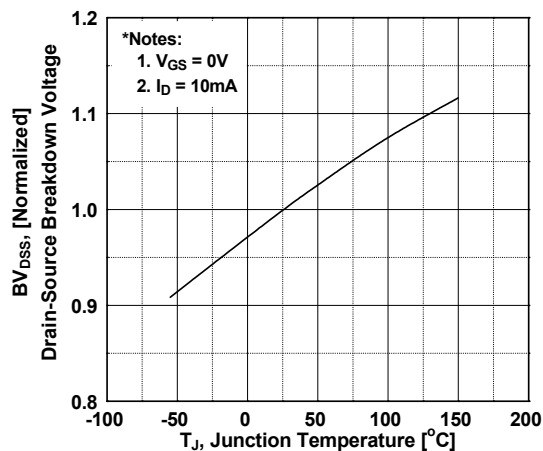


Figure 8. On-Resistance Variation vs. Temperature

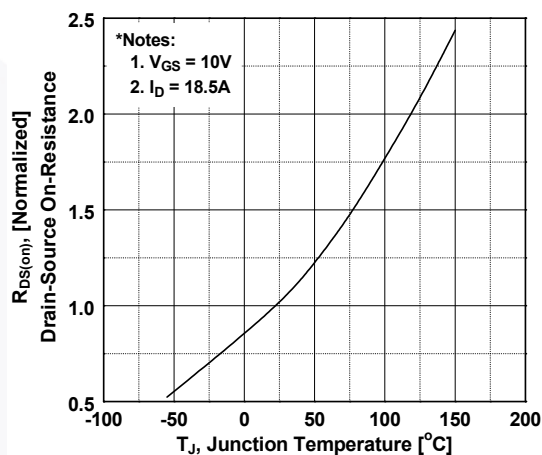


Figure 9. Maximum Safe Operating Area

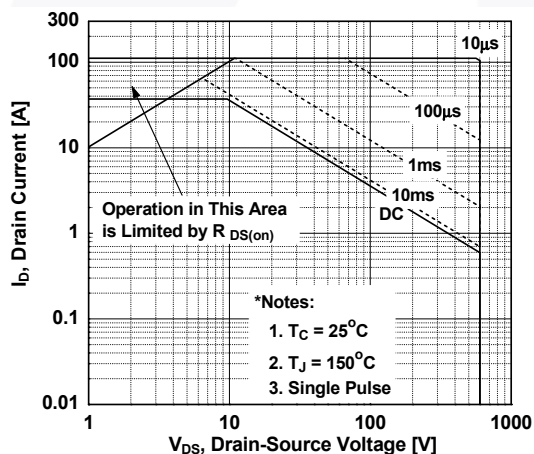


Figure 10. Maximum Drain Current vs. Case Temperature

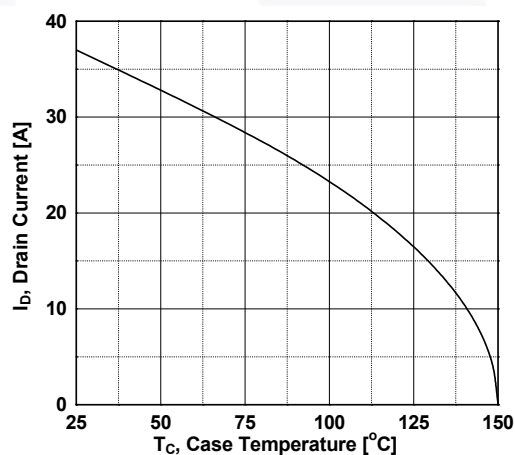
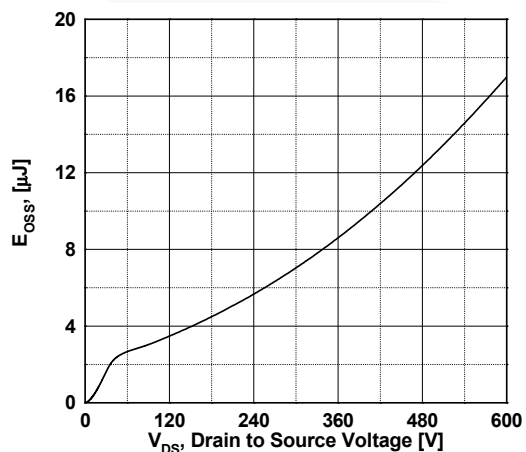


Figure 11. Eoss vs. Drain to Source Voltage



# Typical Characteristics (Continued)

Figure 12. Transient Thermal Response Curve

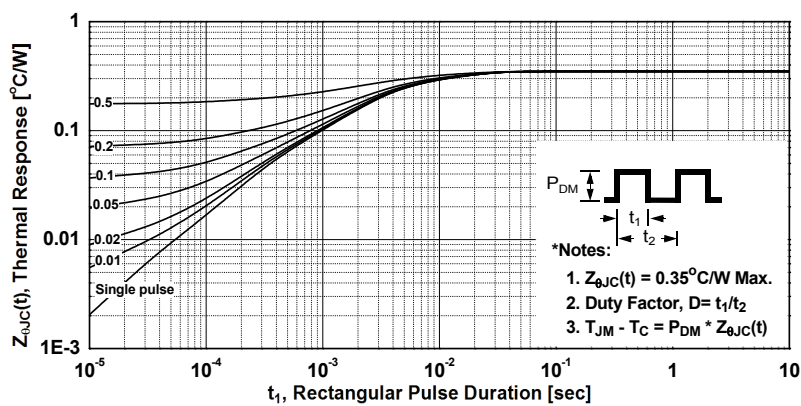


Figure 13. Gate Charge Test Circuit & Waveform

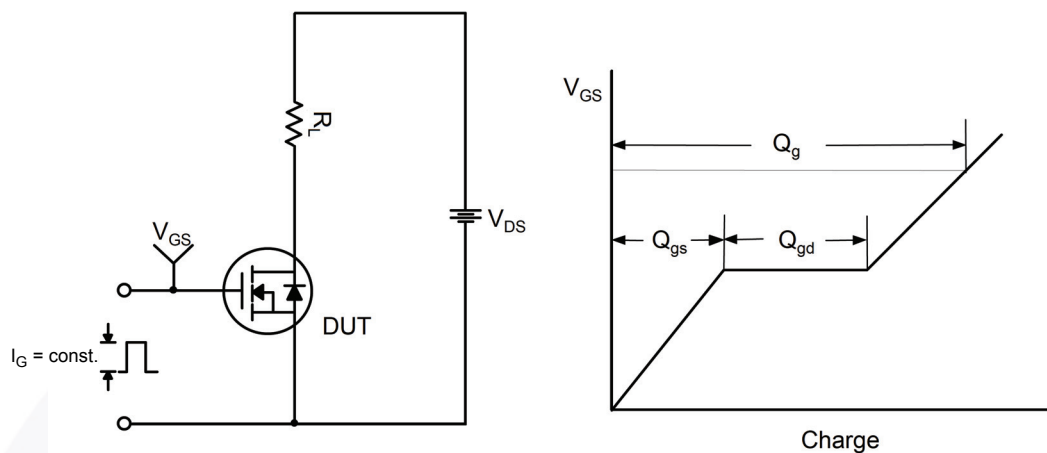


Figure 14. Resistive Switching Test Circuit & Waveforms

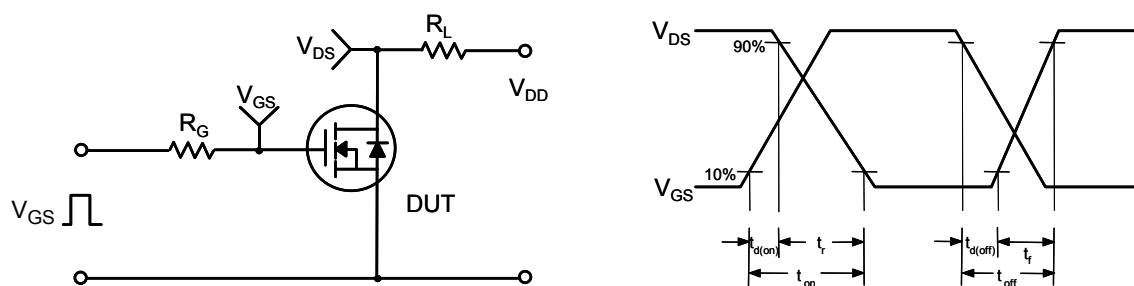


Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms

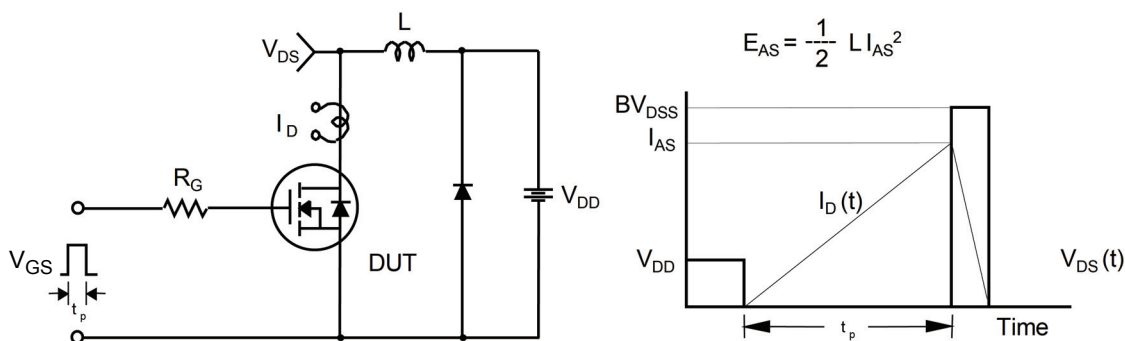
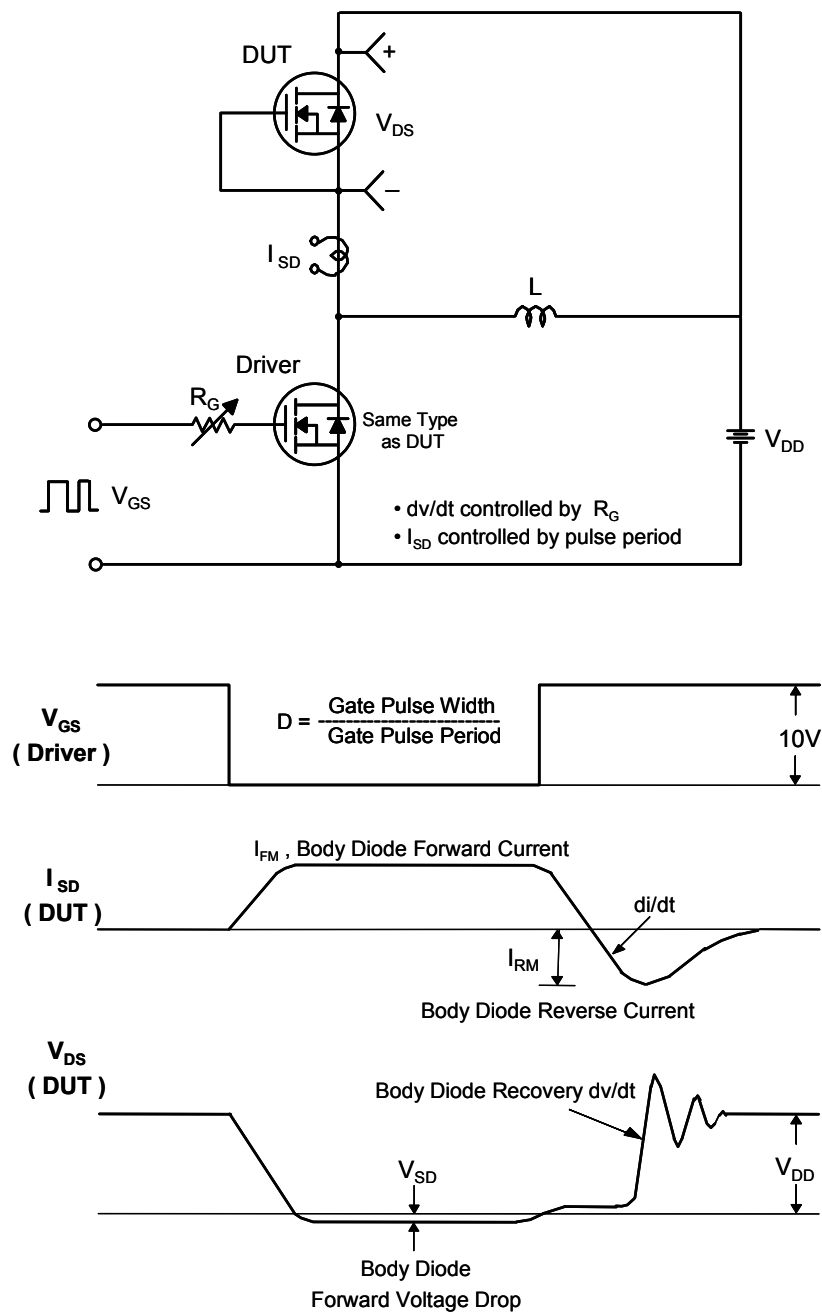
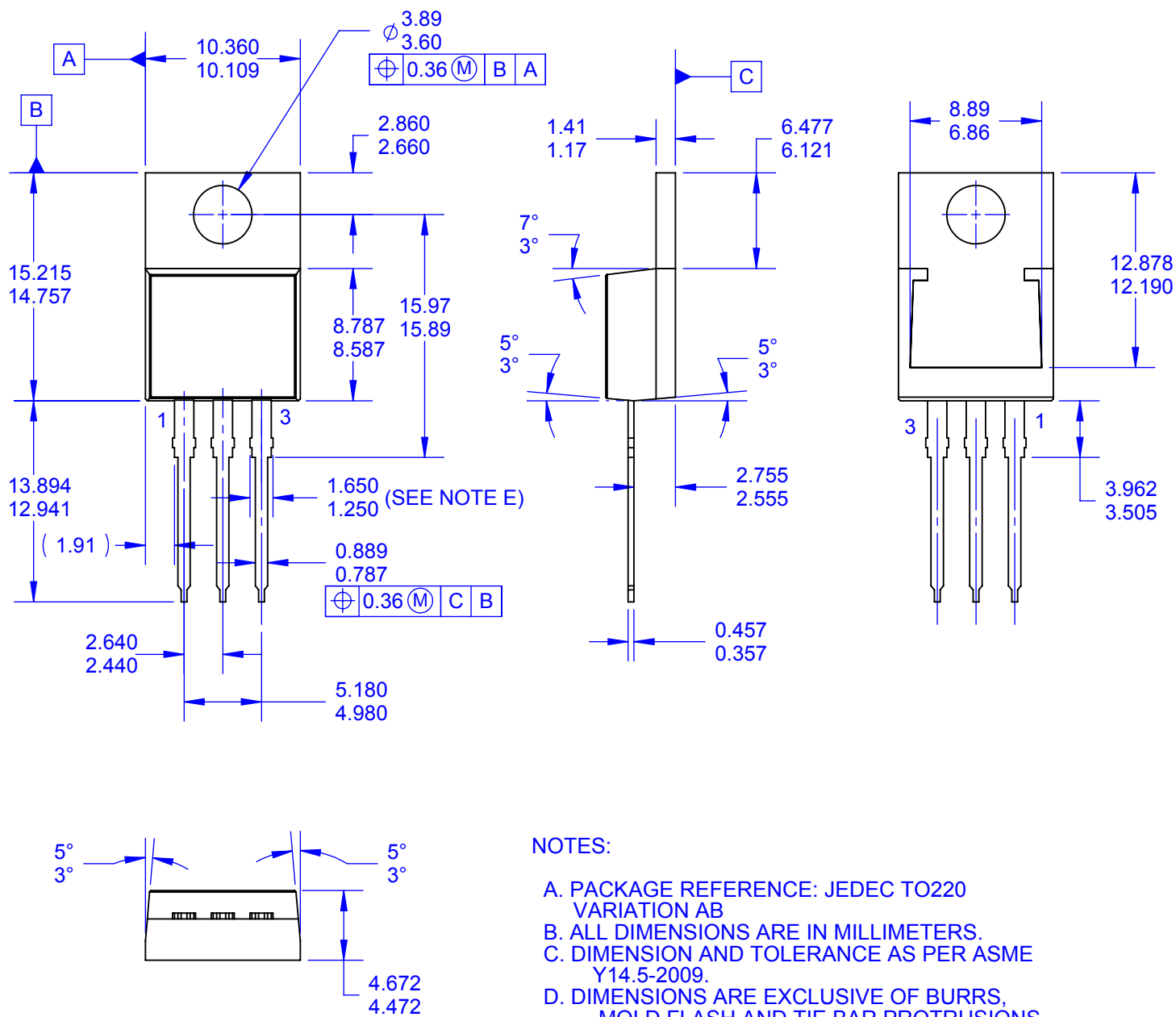


Figure 16. Peak Diode Recovery dv/dt Test Circuit & Waveforms





#### NOTES:

- PACKAGE REFERENCE: JEDEC TO220 VARIATION AB
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- DIMENSION AND TOLERANCE AS PER ASME Y14.5-2009.
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