

# MOSFET – N-Channel, SuperFET®

600 V, 20 A, 190 mΩ

FCP20N60, FCPF20N60

## Description

SuperFET MOSFET is onsemi's first generation of high voltage super-junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low onresistance 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.

## Features

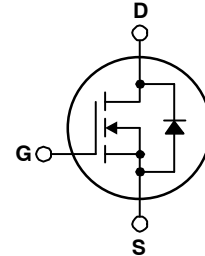
- 650 V @  $T_J = 150^\circ\text{C}$
- Typ.  $R_{DS(on)} = 150\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 75\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 165\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

## Applications

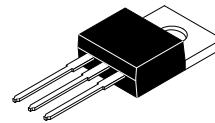
- Solar Inverter
- AC – DC Power Supply

| $V_{DS}$ | $R_{DS(on)} \text{ MAX}$ | $I_D \text{ MAX}$ |
|----------|--------------------------|-------------------|
| 600 V    | 190 mΩ @ 10 V            | 20 A*             |

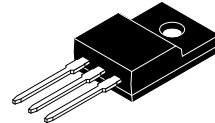
\*Drain current limited by maximum junction temperature.



N-CHANNEL MOSFET

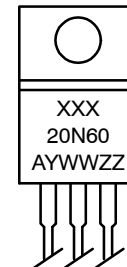


TO-220-3LD  
CASE 340AT



TO-220 Fullpack, 3-Lead  
/ TO-220F-3SG  
CASE 221AT

## MARKING DIAGRAM



XXX20N60 = Device Code (XXX = FCP, FCPF)  
A = Assembly Location  
YWW = Date Code (Year & Week)  
ZZ = Assembly Lot

## ORDERING INFORMATION

| Device    | Package | Shipping          |
|-----------|---------|-------------------|
| FCP20N60  | TO-220  | 1000 Units / Tube |
| FCPF20N60 | TO-220F | 1000 Units / Tube |

## FCP20N60, FCPF20N60

### MOSFET MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

| Symbol         | Parameter                                                               |                                         | FCP20N60        | FCPF20N60 | Unit                |
|----------------|-------------------------------------------------------------------------|-----------------------------------------|-----------------|-----------|---------------------|
| $V_{DS}$       | Drain-Source Voltage                                                    |                                         | 600             |           | V                   |
| $I_D$          | Drain Current                                                           | - Continuous, $T_C = 25^\circ\text{C}$  | 20              | 20*       | A                   |
|                |                                                                         | - Continuous, $T_C = 100^\circ\text{C}$ | 12.5            | 12.5*     |                     |
|                |                                                                         | - Pulsed (Note 1)                       | 60              | 60*       |                     |
| $I_{DM}$       |                                                                         |                                         |                 |           |                     |
| $V_{GS}$       | Drain-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                                                       | $T_C = 25^\circ\text{C}$                | 208             | 39        | W                   |
|                |                                                                         | -Derate above $= 25^\circ\text{C}$      | 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             |           | $^\circ\text{C}$    |

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.

\*Drain current limited by maximum junction temperature.

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  $T_J = 25^\circ\text{C}$ .

### THERMAL CHARACTERISTICS

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

# FCP20N60, FCPF20N60

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted)

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

### OFF CHARACTERISTICS

|                                      |                                           |                                                                        |     |     |      |      |
|--------------------------------------|-------------------------------------------|------------------------------------------------------------------------|-----|-----|------|------|
| BV <sub>DSS</sub>                    | Drain to Source Breakdown Voltage         | I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 25°C  | 600 | –   | –    | V    |
|                                      |                                           | I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 150°C | –   | 650 | –    | V    |
| $\frac{\Delta BV_{DSS}}{\Delta T_J}$ | Breakdown Voltage Temperature Coefficient | I <sub>D</sub> = 250 μA, referenced to 25°C                            | –   | 0.6 | –    | V/°C |
| BV <sub>DS</sub>                     | Drain–Source Avalanche Breakdown Voltage  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 20 A                           | –   | 700 | –    | V    |
| I <sub>DSS</sub>                     | Zero Gate Voltage Drain Current           | V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V                         | –   | –   | 1    | μA   |
|                                      |                                           | V <sub>DS</sub> = 480 V, T <sub>C</sub> = 125°C                        | –   | –   | 10   |      |
| I <sub>GSS</sub>                     | Gate to Body Leakage Current              | V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V                         | –   | –   | ±100 | μA   |

### ON CHARACTERISTICS

|                     |                                      |                                                             |     |      |      |   |
|---------------------|--------------------------------------|-------------------------------------------------------------|-----|------|------|---|
| V <sub>GS(th)</sub> | Gate Threshold Voltage               | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 250 μA | 3.0 | –    | 5.0  | V |
| R <sub>DS(on)</sub> | Static Drain to Source On Resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 10 A               | –   | 0.15 | 0.19 | Ω |
| g <sub>FS</sub>     | Forward Transconductance             | V <sub>DS</sub> = 40 V, I <sub>D</sub> = 10 A               | –   | 17   | –    | S |

### DYNAMIC CHARACTERISTICS

|                        |                               |                                                                                       |   |      |      |    |
|------------------------|-------------------------------|---------------------------------------------------------------------------------------|---|------|------|----|
| C <sub>iss</sub>       | Input Capacitance             | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V, f = 1 MHz                              | – | 2370 | 3080 | pF |
| C <sub>oss</sub>       | Output Capacitance            |                                                                                       | – | 1280 | 1665 | pF |
| C <sub>rss</sub>       | Reverse Transfer Capacitance  |                                                                                       | – | 95   | –    | pF |
| C <sub>oss</sub>       | Output Capacitance            | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, f = 1 MHz                             | – | 65   | 85   | pF |
| C <sub>oss(eff.)</sub> | Effective Output Capacitance  | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = 400 V, V <sub>GS</sub> = 0 V                 | – | 165  | –    | pF |
| Q <sub>g(tot)</sub>    | Total Gate Charge at 10 V     | V <sub>DS</sub> = 480 V, I <sub>D</sub> = 20 A,<br>V <sub>GS</sub> = 10 V<br>(Note 4) | – | 75   | 98   | nC |
| Q <sub>gs</sub>        | Gate to Source Gate Charge    |                                                                                       | – | 13.5 | 18   | nC |
| Q <sub>gd</sub>        | Gate to Drain “Miller” Charge |                                                                                       | – | 36   | –    | nC |

### SWITCHING CHARACTERISTICS

|                     |                     |                                                                                                           |   |     |     |    |
|---------------------|---------------------|-----------------------------------------------------------------------------------------------------------|---|-----|-----|----|
| t <sub>d(on)</sub>  | Turn–On Delay Time  | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 20 A,<br>V <sub>GS</sub> = 10 V, R <sub>G</sub> = 25 Ω (Note 4) | – | 62  | 135 | ns |
| t <sub>r</sub>      | Turn–On Rise Time   |                                                                                                           | – | 140 | 290 | ns |
| t <sub>d(off)</sub> | Turn–Off Delay Time |                                                                                                           | – | 230 | 470 | ns |
| t <sub>f</sub>      | 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,<br>dI <sub>F</sub> /dt = 100 A/μs | – | 530  | –   | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  |                                                                                  | – | 10.5 | –   | μC |

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.

4. Essentially independent of operating temperature typical characteristics.

TYPICAL PERFORMANCE CHARACTERISTICS

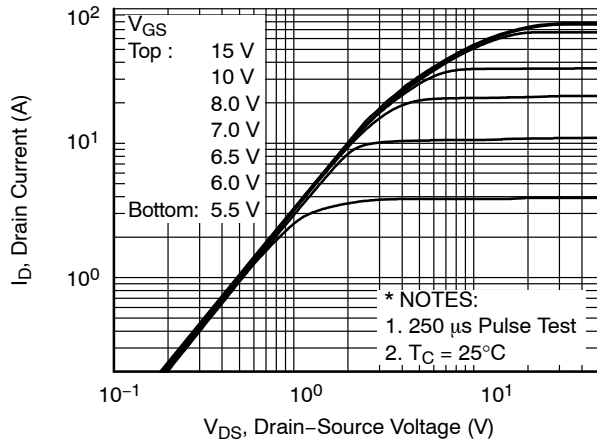


Figure 1. On-Region Characteristics

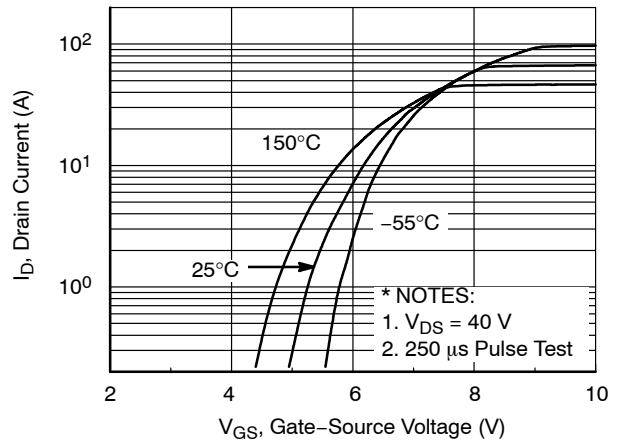


Figure 2. Transfer Characteristics

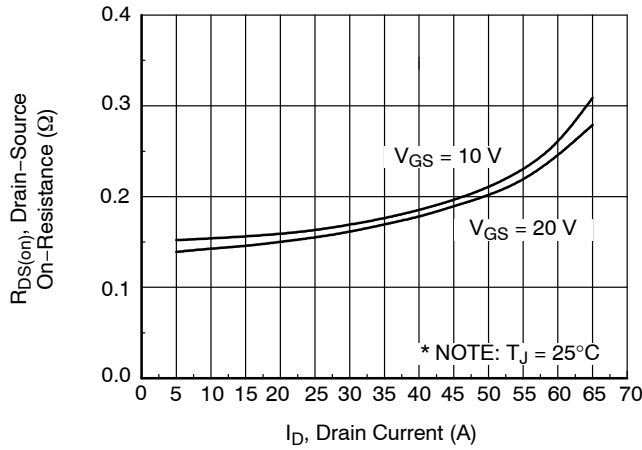


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

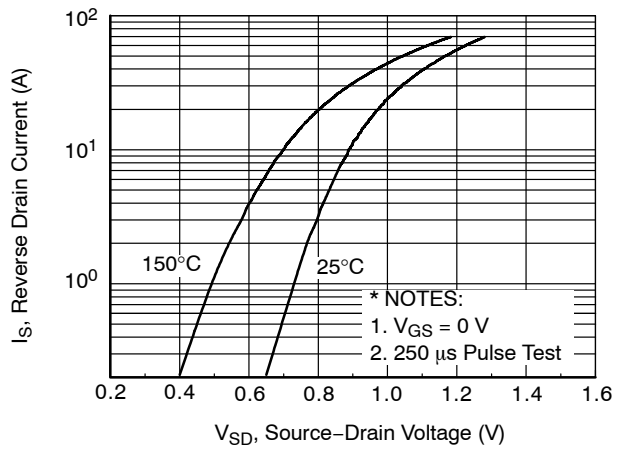


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

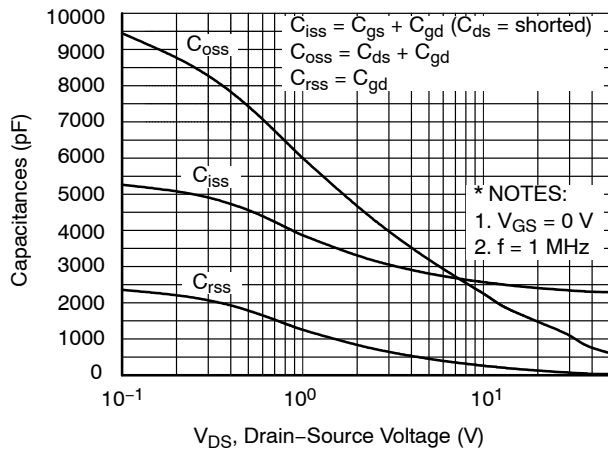


Figure 5. Capacitance Characteristics

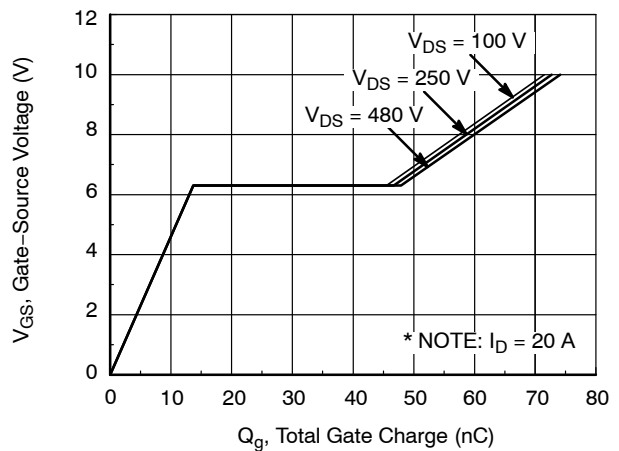
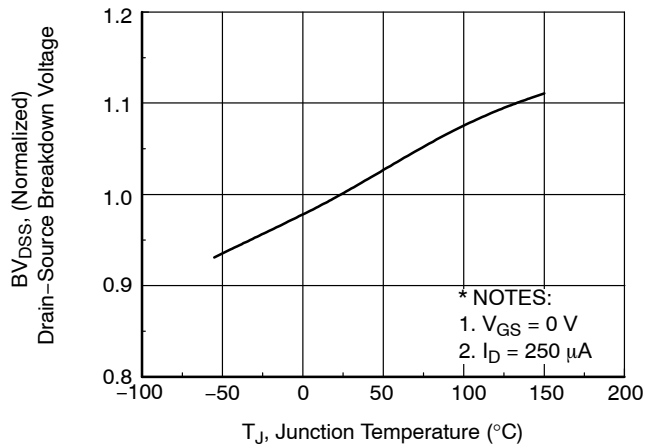


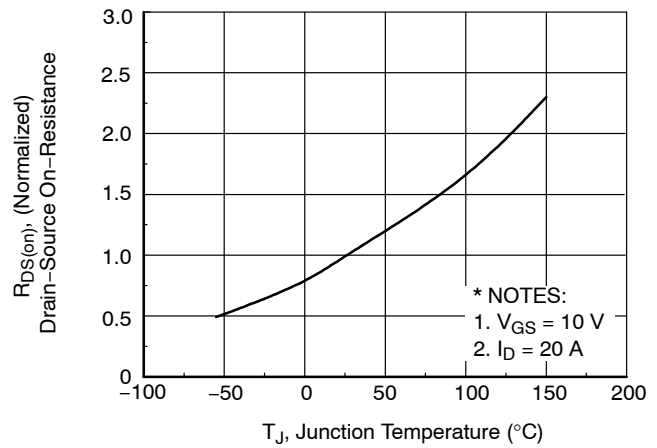
Figure 6. Gate Charge Characteristics

# FCP20N60, FCPF20N60

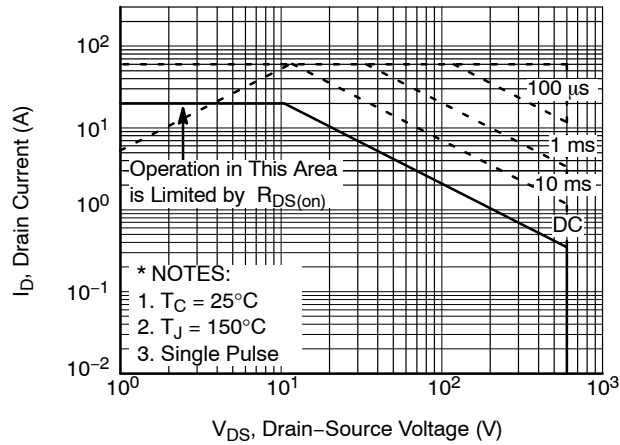
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



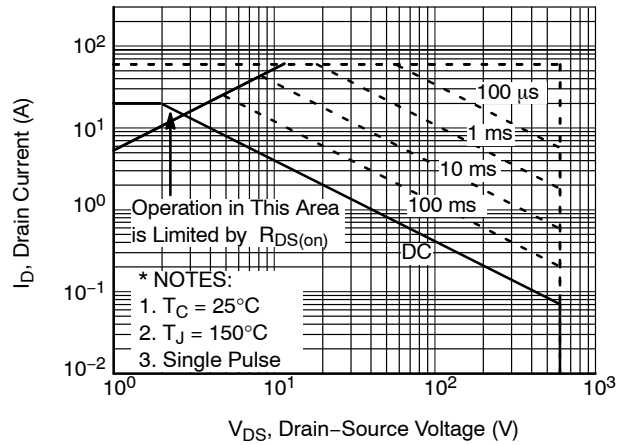
**Figure 7. Breakdown Voltage Variation vs. Temperature**



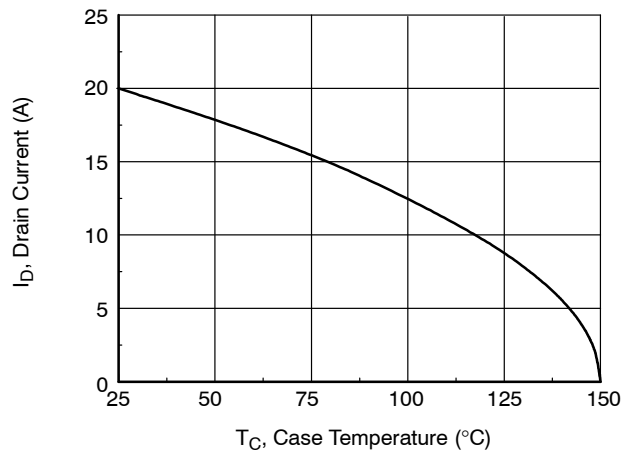
**Figure 8. On-Resistance Variation vs. Temperature**



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



**Figure 10. Maximum Safe Operating Area for FCPF20N60**



**Figure 11. Maximum Drain Current vs. Case Temperature**

# FCP20N60, FCPF20N60

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

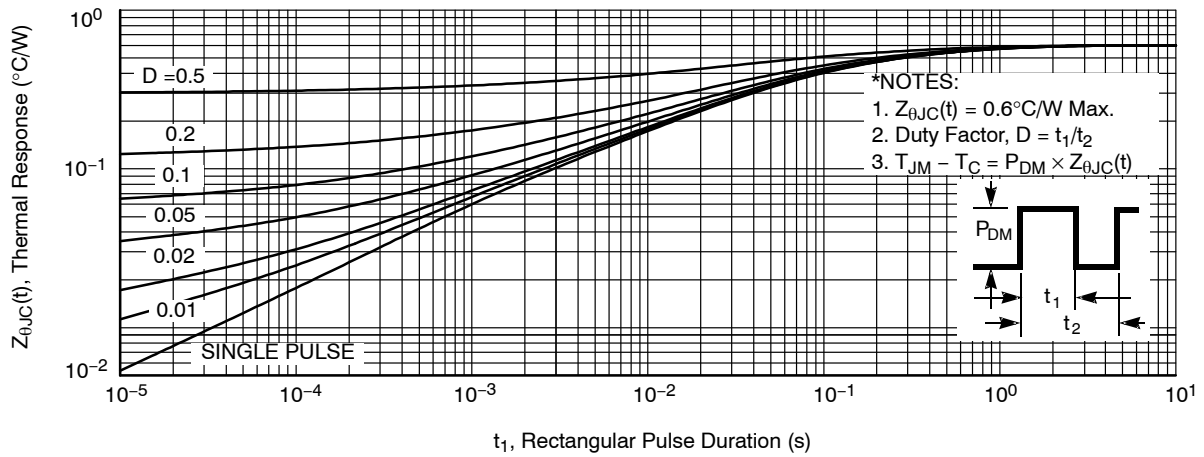


Figure 12. Transient Thermal Response Curve for FCP20N60

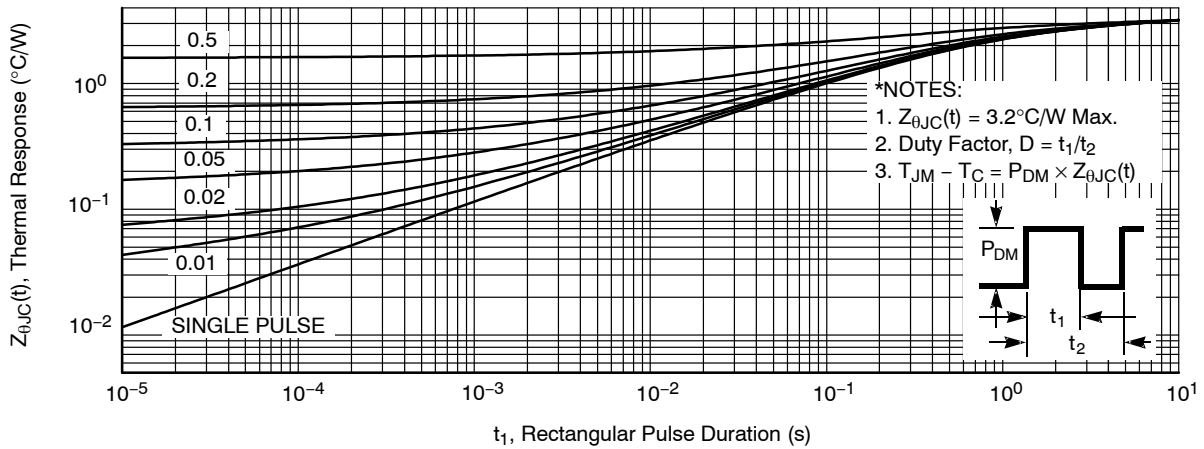


Figure 13. Transient Thermal Response Curve for FCPF20N60

## FCP20N60, FCPF20N60

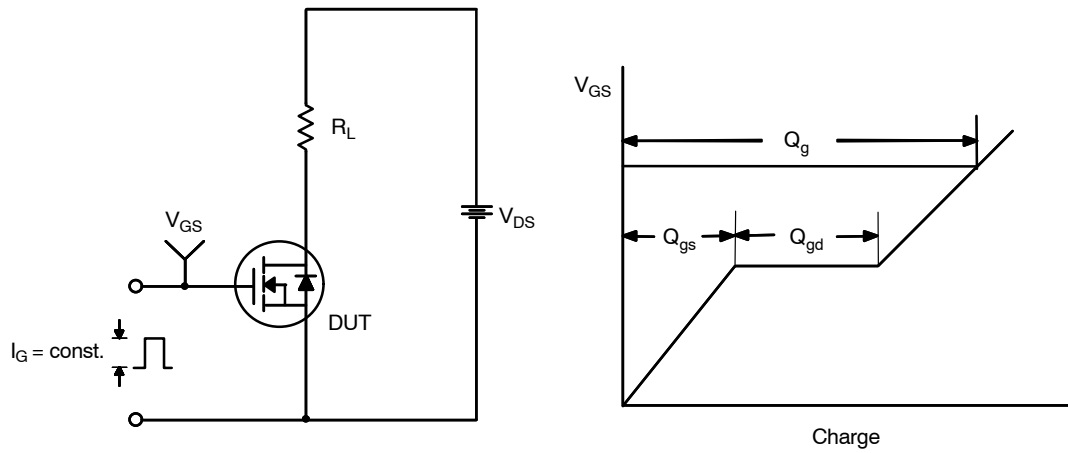


Figure 14. Gate Charge Test Circuit & Waveform

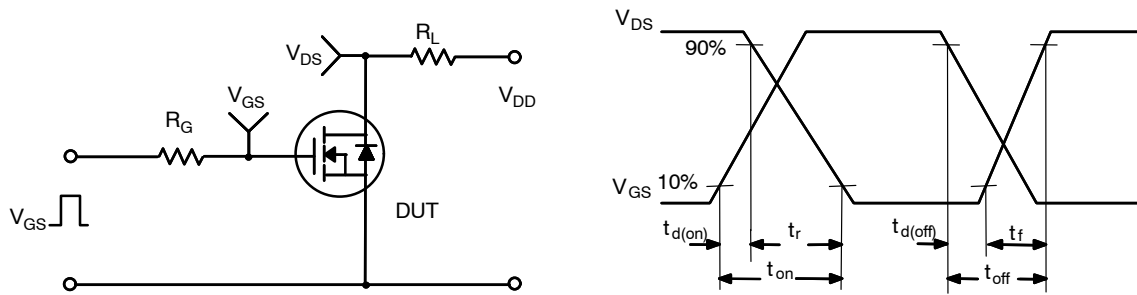


Figure 15. Resistive Switching Test Circuit & Waveforms

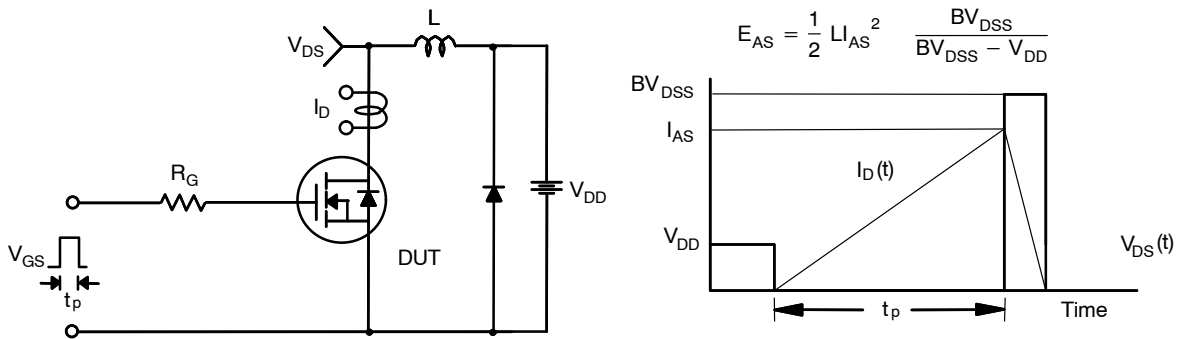
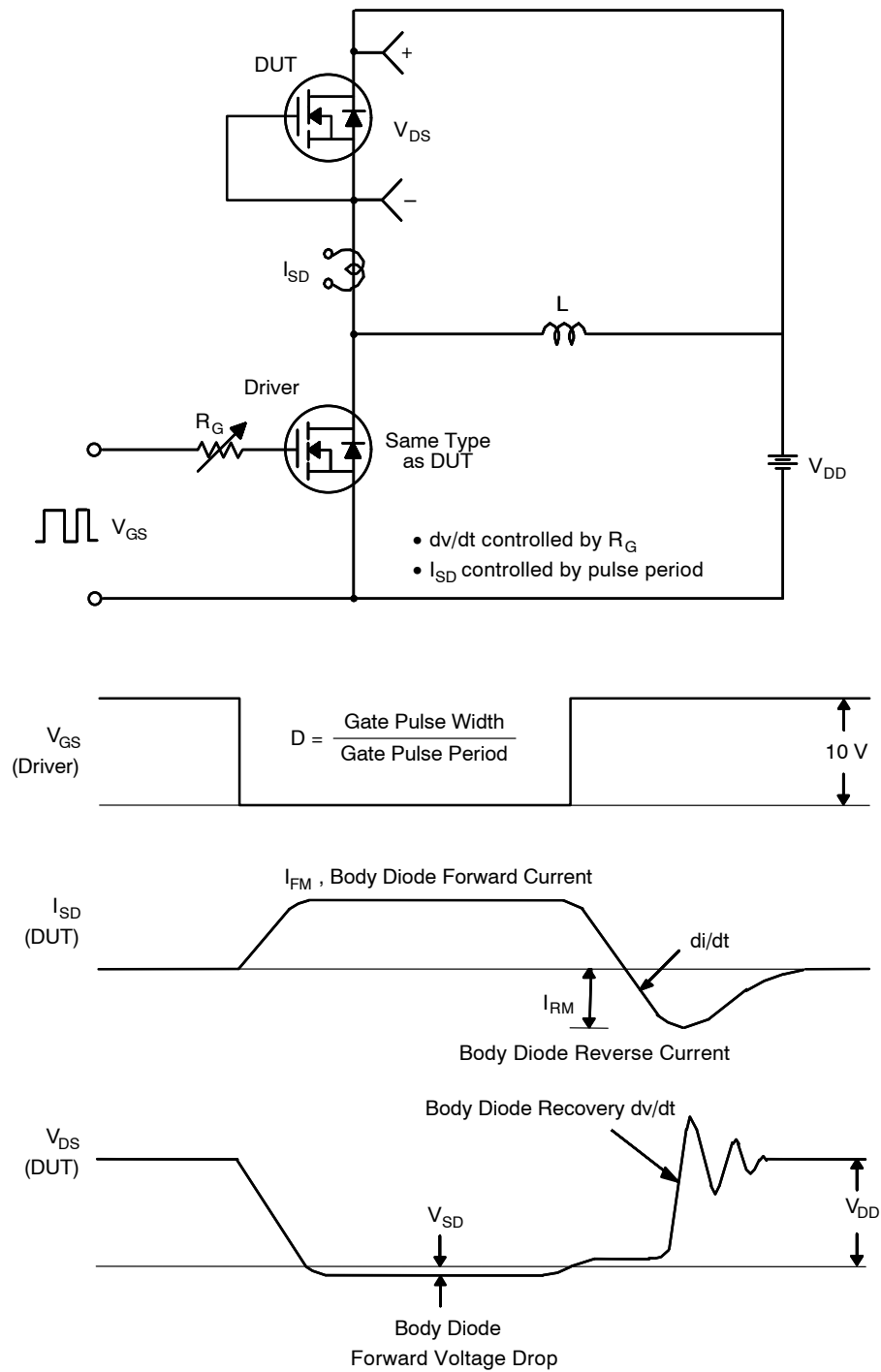


Figure 16. Unclamped Inductive Switching Test Circuit & Waveforms

## FCP20N60, FCPF20N60

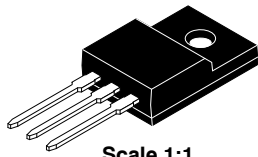


**Figure 17. Peak Diode Recovery  $dv/dt$  Test Circuit & Waveforms**

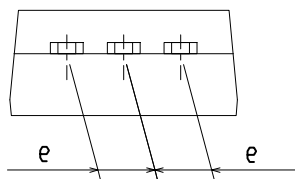
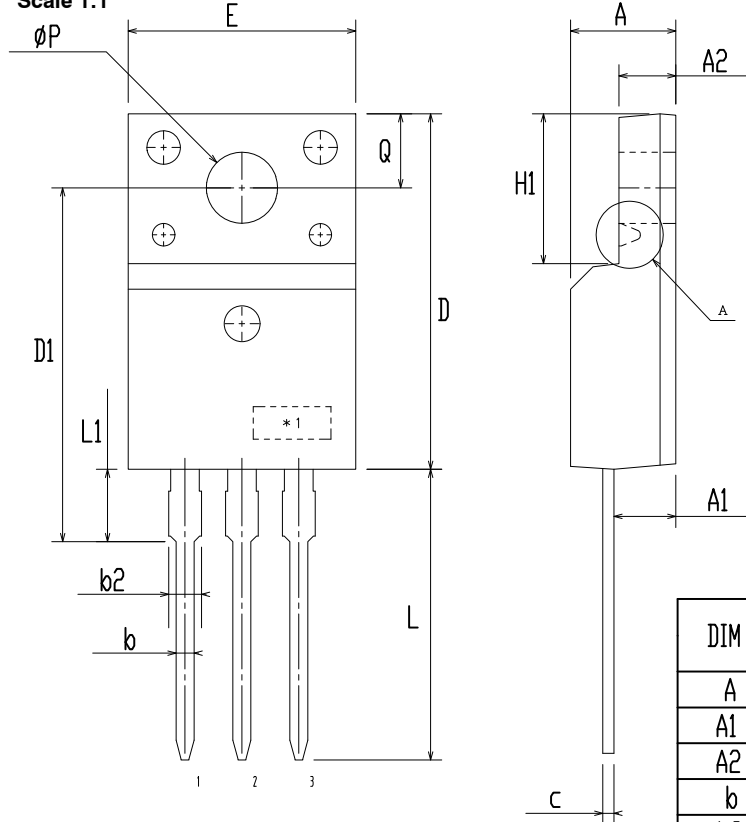


**TO-220 Fullpack, 3-Lead / TO-220F-3SG**  
**CASE 221AT**  
**ISSUE B**

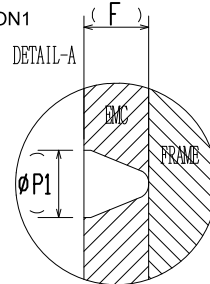
DATE 19 JAN 2021



Scale 1:1



OPTION1



| DIM  | MILLIMETERS |       |       |
|------|-------------|-------|-------|
|      | MIN         | NOM   | MAX   |
| A    | 4.50        | 4.70  | 4.90  |
| A1   | 2.56        | 2.76  | 2.96  |
| A2   | 2.34        | 2.54  | 2.74  |
| b    | 0.70        | 0.80  | 0.90  |
| b2   | ~           | ~     | 1.47  |
| c    | 0.45        | 0.50  | 0.60  |
| D    | 15.67       | 15.87 | 16.07 |
| D1   | 15.60       | 15.80 | 16.00 |
| E    | 9.96        | 10.16 | 10.36 |
| e    | 2.34        | 2.54  | 2.74  |
| F    | ~           | 0.84  | ~     |
| H1   | 6.48        | 6.68  | 6.88  |
| L    | 12.78       | 12.98 | 13.18 |
| L1   | 3.03        | 3.23  | 3.43  |
| Ø P  | 2.98        | 3.18  | 3.38  |
| Ø P1 | ~           | 1.00  | ~     |
| Q    | 3.20        | 3.30  | 3.40  |

**NOTES:**

A. DIMENSION AND TOLERANCE AS ASME Y14.5-2009

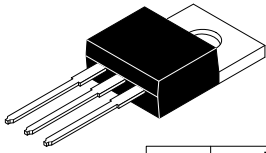
B. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUCTIONS.

C. OPTION 1 - WITH SUPPORT PIN HOLE

OPTION 2 - NO SUPPORT PIN HOLE

|                         |                                              |                                                                                                                                                                                     |
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| <b>DESCRIPTION:</b>     | <b>TO-220 FULLPACK, 3-LEAD / TO-220F-3SG</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

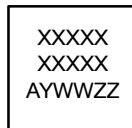
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**TO-220-3LD**  
**CASE 340AT**  
**ISSUE B**

DATE 08 AUG 2022

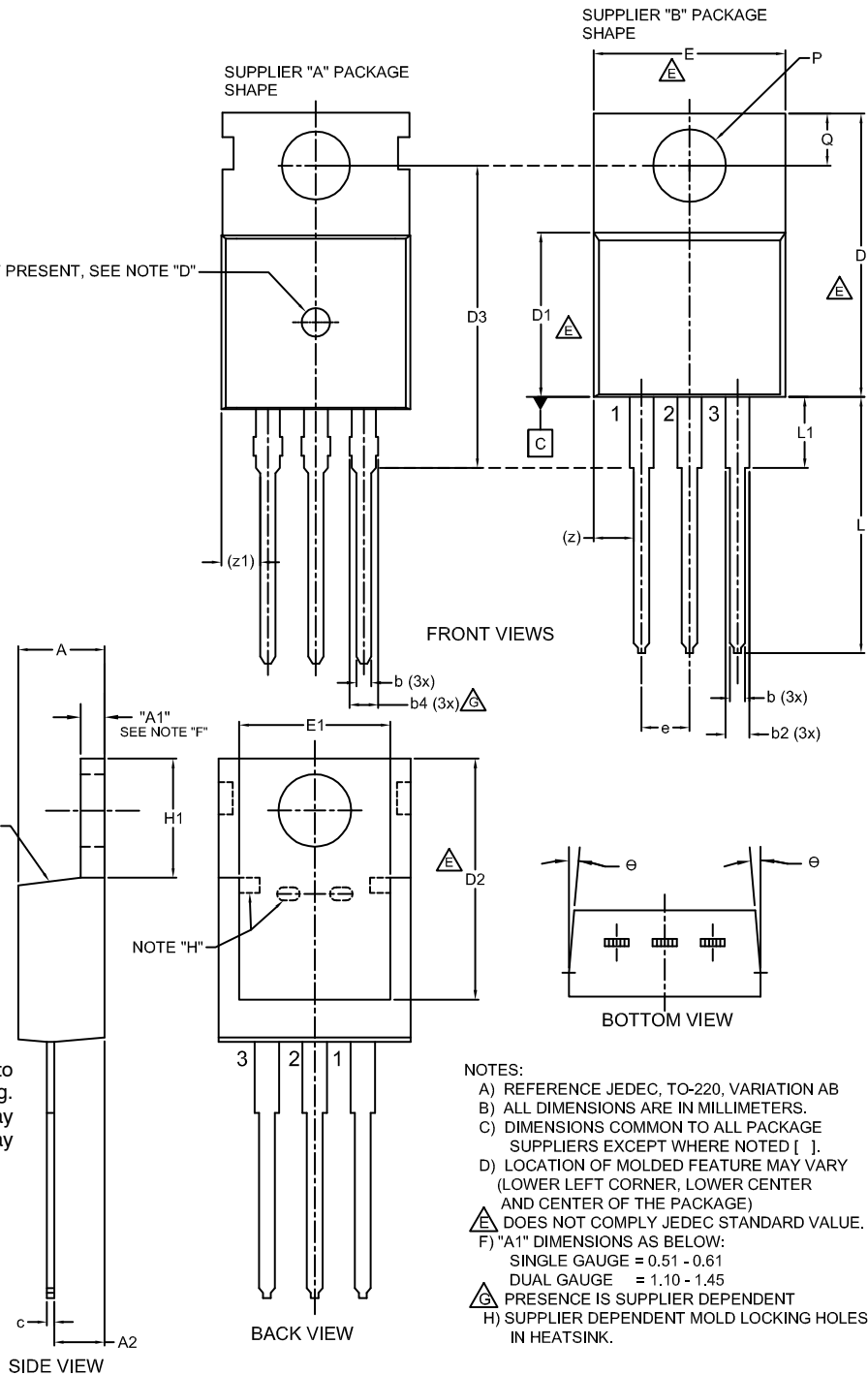
| DIM | MILLIMETERS  |      |       |
|-----|--------------|------|-------|
|     | MIN.         | NOM. | MAX.  |
| A   | 4.00         | --   | 4.70  |
| A1  | SEE NOTE "F" |      |       |
| A2  | 2.10         | --   | 2.85  |
| b   | 0.55         | --   | 1.00  |
| b2  | 1.10         | --   | 1.62  |
| b4  | 1.42         | --   | 1.62  |
| c   | 0.36         | --   | 0.60  |
| D   | 13.90        | --   | 16.30 |
| D1  | 8.13         | --   | 9.40  |
| D2  | 11.50        | --   | 14.30 |
| D3  | 15.42        | --   | 16.51 |
| E   | 9.65         | --   | 10.67 |
| E1  | 7.59         | --   | 8.65  |
| e   | 2.40         | --   | 2.67  |
| H1  | 6.06         | --   | 6.69  |
| L   | 12.70        | --   | 14.04 |
| L1  | 2.70         | --   | 4.10  |
| P   | 3.50         | --   | 4.00  |
| Q   | 2.50         | --   | 3.40  |
| z   | 2.13 REF     |      |       |
| z1  | 2.06 REF     |      |       |
| θ   | 3°           | --   | 5°    |

IF PRESENT, SEE NOTE "D"

**GENERIC**  
**MARKING DIAGRAM\***


XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Code

\*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.



|                         |                    |                                                                                                                                                                                     |
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| <b>DESCRIPTION:</b>     | <b>TO-220-3LD</b>  | <b>PAGE 1 OF 1</b>                                                                                                                                                                  |

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