

# MOSFET – Power, N-Channel, SUPERFET III, Easy Drive

**650 V, 19 A, 165 mΩ**

**FCP165N65S3R0**

## Description

SUPERFET III MOSFET is onsemi'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.

Consequently, SUPERFET III MOSFET Easy drive series helps manage EMI issues and allows for easier design implementation.

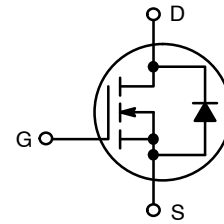
## Features

- 700 V @  $T_J = 150^\circ\text{C}$
- Typ.  $R_{DS(on)} = 140\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 39\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 341\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

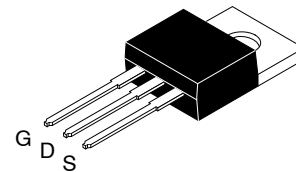
## Applications

- Computing / Display Power Supplies
- Telecom / Server Power Supplies
- Industrial Power Supplies
- Lighting / Charger / Adapter

| $V_{DSS}$ | $R_{DS(on)}\text{ MAX}$ | $I_D\text{ MAX}$ |
|-----------|-------------------------|------------------|
| 650 V     | 165 mΩ @ 10 V           | 19 A             |

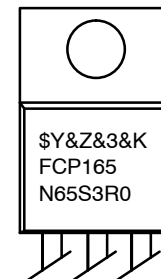


**N-Channel MOSFET**



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

## MARKING DIAGRAM



|               |                        |
|---------------|------------------------|
| \$Y           | = onsemi Logo          |
| &Z            | = Assembly Plant Code  |
| &3            | = Numeric Date Code    |
| &K            | = Lot Code             |
| FCP165N65S3R0 | = Specific Device Code |

## ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# FCP165N65S3R0

## ABSOLUTE MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ , Unless otherwise specified)

| Symbol         | Parameter                                                      |                                          | Value       | Unit                |
|----------------|----------------------------------------------------------------|------------------------------------------|-------------|---------------------|
| $V_{DSS}$      | Drain to Source Voltage                                        |                                          | 650         | V                   |
| $V_{GSS}$      | Gate to Source Voltage                                         | DC                                       | $\pm 30$    | V                   |
|                |                                                                | AC ( $f > 1\text{ Hz}$ )                 | $\pm 30$    | V                   |
| $I_D$          | Drain Current                                                  | Continuous ( $T_C = 25^\circ\text{C}$ )  | 19          | A                   |
|                |                                                                | Continuous ( $T_C = 100^\circ\text{C}$ ) | 12.3        |                     |
| $I_{DM}$       | Drain Current                                                  | Pulsed (Note 1)                          | 47.5        | A                   |
| $E_{AS}$       | Single Pulsed Avalanche Energy (Note 2)                        |                                          | 87          | mJ                  |
| $I_{AS}$       | Avalanche Current (Note 2)                                     |                                          | 2.7         | A                   |
| $E_{AR}$       | Repetitive Avalanche Energy (Note 1)                           |                                          | 1.54        | mJ                  |
| dv/dt          | MOSFET dv/dt                                                   |                                          | 100         | V/ns                |
|                | Peak Diode Recovery dv/dt (Note 3)                             |                                          | 20          |                     |
| $P_D$          | Power Dissipation                                              | ( $T_C = 25^\circ\text{C}$ )             | 154         | W                   |
|                |                                                                | Derate Above $25^\circ\text{C}$          | 1.23        | 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, 1/8" from Case for 5 s |                                          | 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.

1. Repetitive rating: pulse-width limited by maximum junction temperature.

2.  $I_{AS} = 2.7\text{ A}$ ,  $R_G = 25\ \Omega$ , starting  $T_J = 25^\circ\text{C}$ .

3.  $I_{SD} \leq 9.5\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq 400\text{ V}$ , starting  $T_J = 25^\circ\text{C}$ .

## THERMAL CHARACTERISTICS

| Symbol          | Parameter                                     | Value | Unit                      |
|-----------------|-----------------------------------------------|-------|---------------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max.    | 0.81  | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max. | 62.5  |                           |

## PACKAGE MARKING AND ORDERING INFORMATION

| Part Number   | Top Marking   | Package                                | Shipping        |
|---------------|---------------|----------------------------------------|-----------------|
| FCP165N65S3R0 | FCP165N65S3R0 | TO-220-3LD<br>(Pb-Free / Halogen Free) | 50 Units / Tube |

# FCP165N65S3R0

## ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

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

### OFF CHARACTERISTICS

|                                     |                                           |                                                                      |     |      |      |      |
|-------------------------------------|-------------------------------------------|----------------------------------------------------------------------|-----|------|------|------|
| BV <sub>DSS</sub>                   | Drain to Source Breakdown Voltage         | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 25°C  | 650 |      |      | V    |
|                                     |                                           | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 150°C | 700 |      |      | V    |
| ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temperature Coefficient | I <sub>D</sub> = 1 mA, Referenced to 25°C                            |     | 0.64 |      | V/°C |
| I <sub>DSS</sub>                    | Zero Gate Voltage Drain Current           | V <sub>DS</sub> = 650 V, V <sub>GS</sub> = 0 V                       |     |      | 1    | μA   |
|                                     |                                           | V <sub>DS</sub> = 520 V, T <sub>C</sub> = 125°C                      |     | 0.85 |      |      |
| I <sub>GSS</sub>                    | Gate to Body Leakage Current              | V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V                       |     |      | ±100 | nA   |

### ON CHARACTERISTICS

|                     |                                      |                                                              |     |     |     |    |
|---------------------|--------------------------------------|--------------------------------------------------------------|-----|-----|-----|----|
| V <sub>GS(th)</sub> | Gate Threshold Voltage               | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 0.44 mA | 2.5 |     | 4.5 | V  |
| R <sub>DS(on)</sub> | Static Drain to Source On Resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 9.5 A               |     | 140 | 165 | mΩ |
| g <sub>FS</sub>     | Forward Transconductance             | V <sub>DS</sub> = 20 V, I <sub>D</sub> = 9.5 A               |     | 12  |     | S  |

### DYNAMIC CHARACTERISTICS

|                        |                                   |                                                                                     |  |      |  |    |
|------------------------|-----------------------------------|-------------------------------------------------------------------------------------|--|------|--|----|
| C <sub>iss</sub>       | Input Capacitance                 | V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V, f = 1 MHz                           |  | 1500 |  | pF |
| C <sub>oss</sub>       | Output Capacitance                |                                                                                     |  | 35   |  | pF |
| C <sub>oss(eff.)</sub> | Effective Output Capacitance      | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                               |  | 341  |  | pF |
| C <sub>oss(er.)</sub>  | Energy Related Output Capacitance | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                               |  | 49   |  | pF |
| Q <sub>g(tot)</sub>    | Total Gate Charge at 10 V         | V <sub>DS</sub> = 400 V, I <sub>D</sub> = 9.5 A, V <sub>GS</sub> = 10 V<br>(Note 4) |  | 39   |  | nC |
| Q <sub>gs</sub>        | Gate to Source Gate Charge        |                                                                                     |  | 11   |  | nC |
| Q <sub>gd</sub>        | Gate to Drain "Miller" Charge     |                                                                                     |  | 16   |  | nC |
| ESR                    | Equivalent Series Resistance      | f = 1 MHz                                                                           |  | 0.5  |  | Ω  |

### SWITCHING CHARACTERISTICS

|                     |                     |                                                                                                                |  |    |  |    |
|---------------------|---------------------|----------------------------------------------------------------------------------------------------------------|--|----|--|----|
| t <sub>d(on)</sub>  | Turn-On Delay Time  | V <sub>DD</sub> = 400 V, I <sub>D</sub> = 9.5 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 4.7 Ω<br>(Note 4) |  | 17 |  | ns |
| t <sub>r</sub>      | Turn-On Rise Time   |                                                                                                                |  | 15 |  | ns |
| t <sub>d(off)</sub> | Turn-Off Delay Time |                                                                                                                |  | 44 |  | ns |
| t <sub>f</sub>      | Turn-Off Fall Time  |                                                                                                                |  | 5  |  | ns |

### SOURCE-DRAIN DIODE CHARACTERISTICS

|                 |                                                          |                                                                                     |  |      |    |
|-----------------|----------------------------------------------------------|-------------------------------------------------------------------------------------|--|------|----|
| I <sub>S</sub>  | Maximum Continuous Source to Drain Diode Forward Current |                                                                                     |  | 19   | A  |
| I <sub>SM</sub> | Maximum Pulsed Source to Drain Diode Forward Current     |                                                                                     |  | 47.5 | A  |
| V <sub>SD</sub> | Source to Drain Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 9.5 A                                      |  | 1.2  | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                    | V <sub>DD</sub> = 400 V, I <sub>SD</sub> = 9.5 A,<br>dI <sub>F</sub> /dt = 100 A/μs |  | 339  | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  |                                                                                     |  | 5.8  | 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

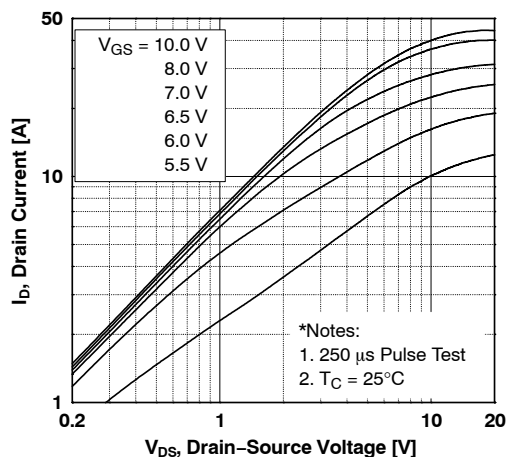


Figure 1. On-Region Characteristics

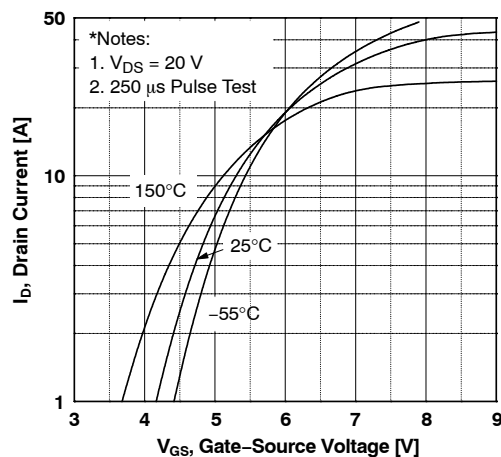


Figure 2. Transfer Characteristics

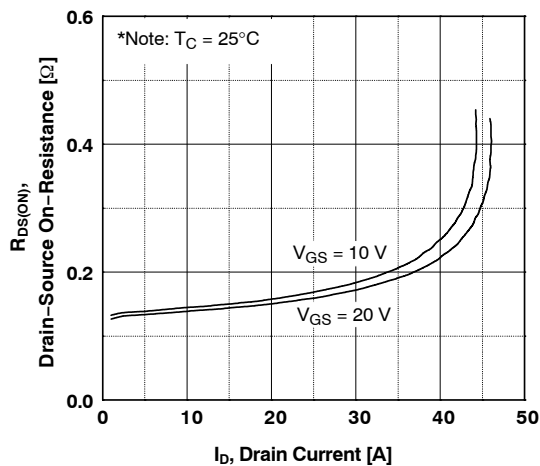


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

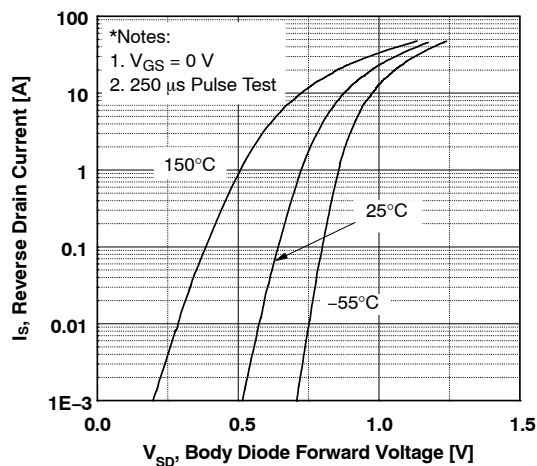


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

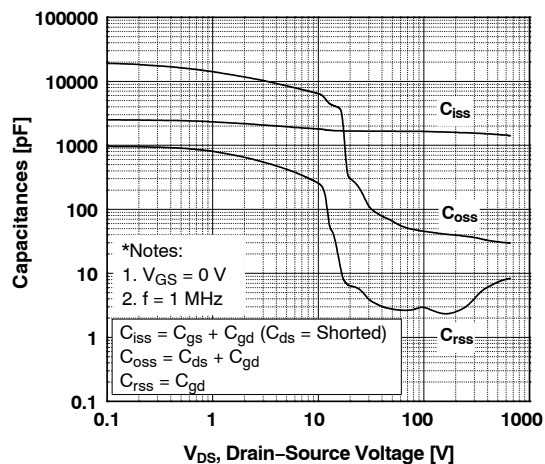


Figure 5. Capacitance Characteristics

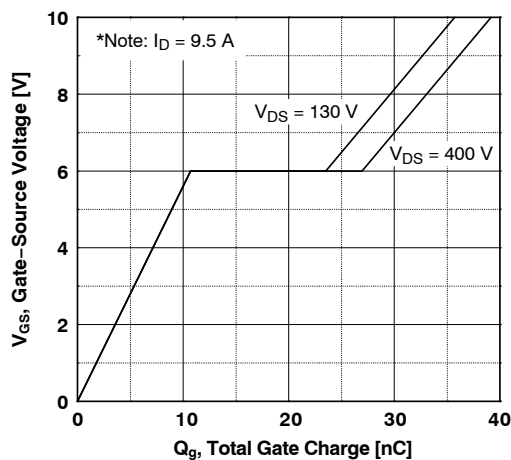


Figure 6. Gate Charge Characteristics

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

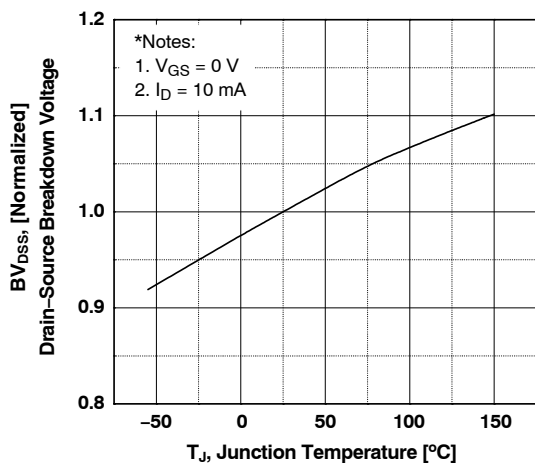


Figure 7. Breakdown Voltage Variation vs. Temperature

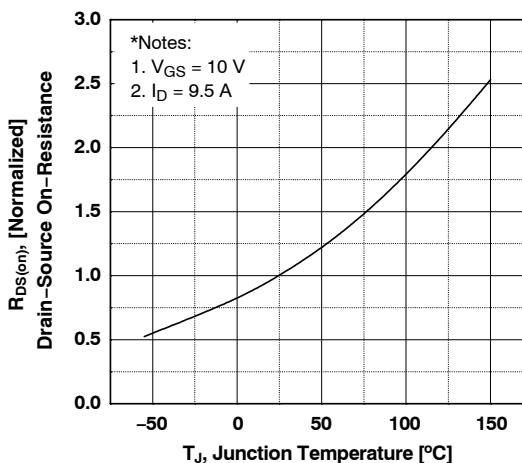


Figure 8. On-Resistance Variant vs. Temperature

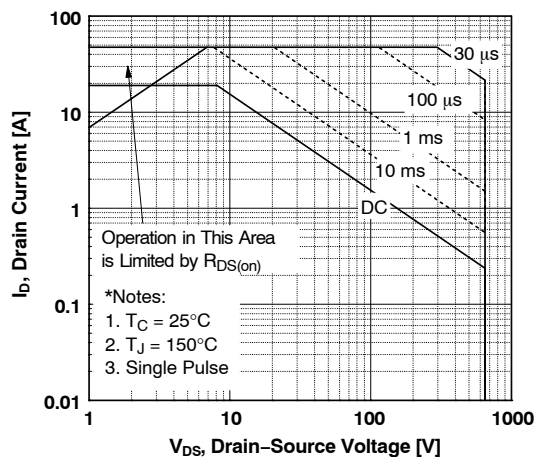


Figure 9. Maximum Safe Operation Area

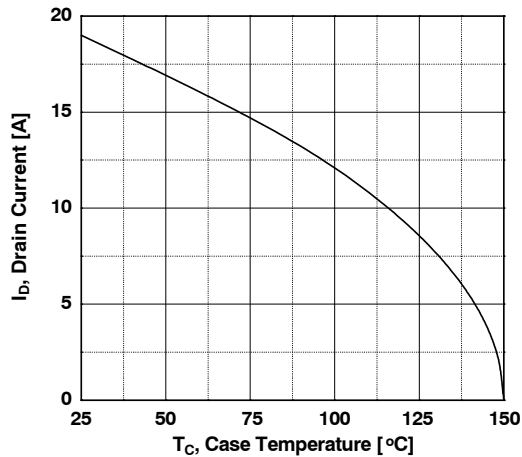
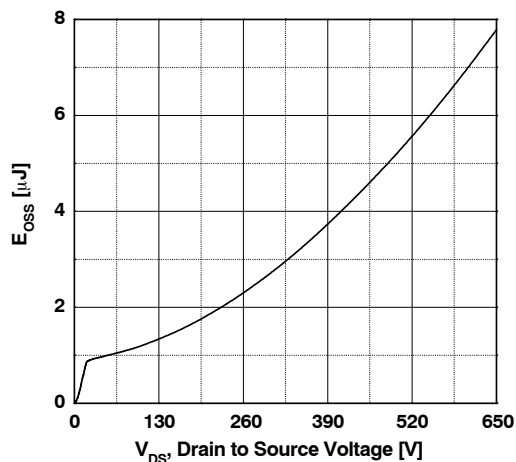


Figure 10. Maximum Drain Current vs. Case Temperature

Figure 11.  $E_{OSS}$  vs. Drain to Source Voltage

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

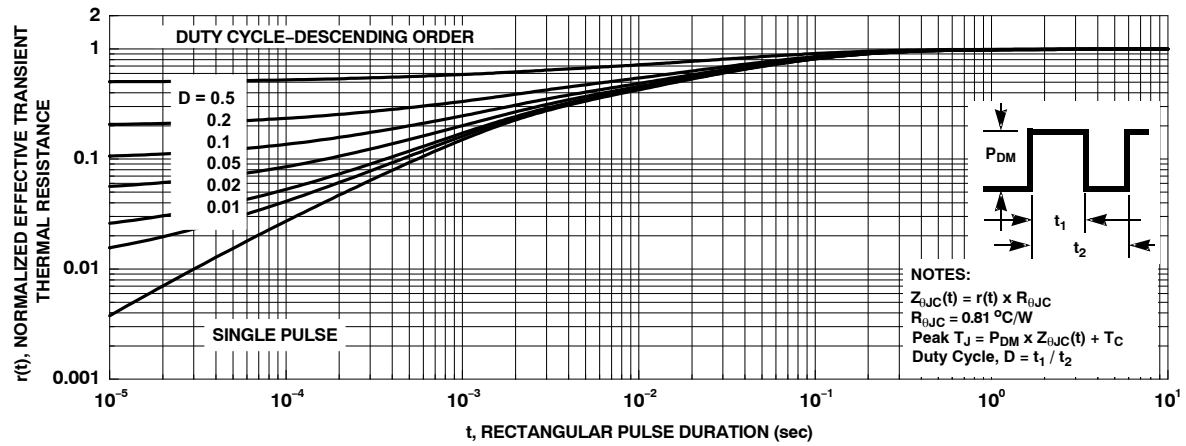


Figure 12. Transient Thermal Response Curve

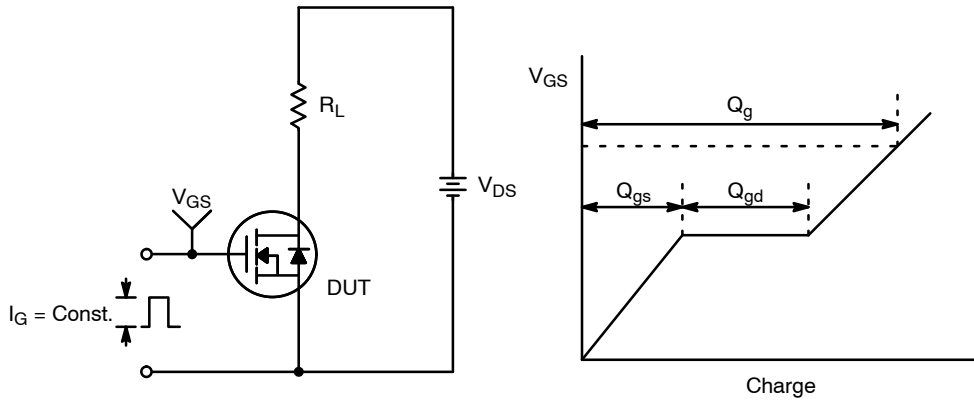


Figure 13. Gate Charge Test Circuit & Waveform

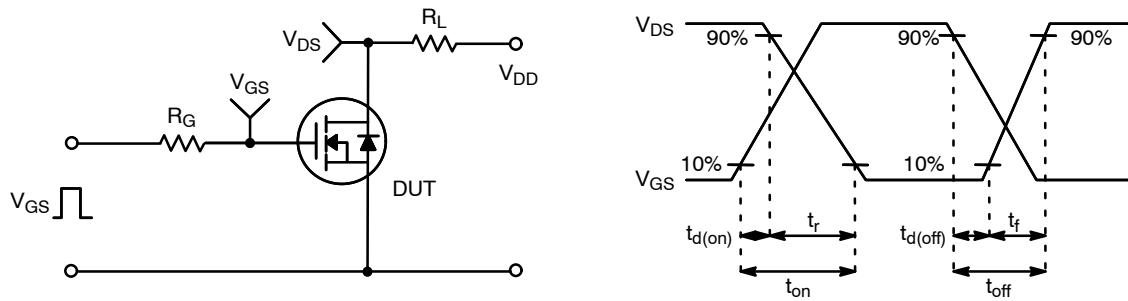


Figure 14. Resistive Switching Test Circuit & Waveforms

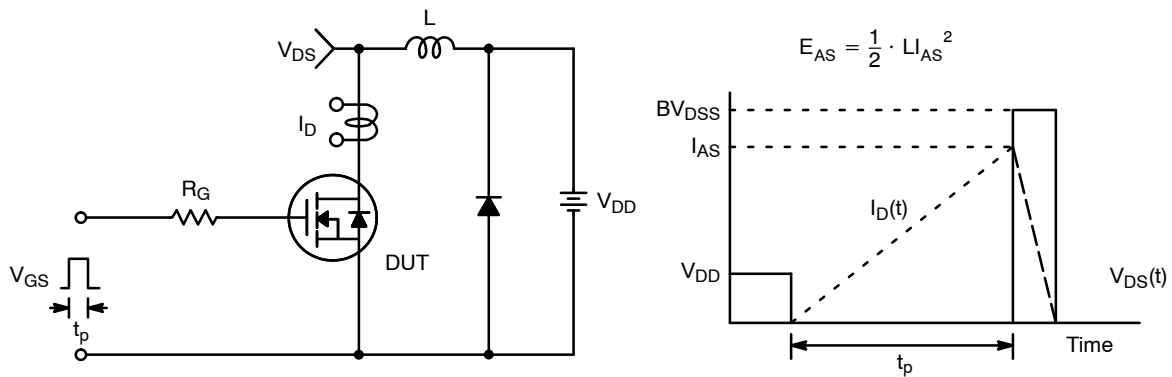
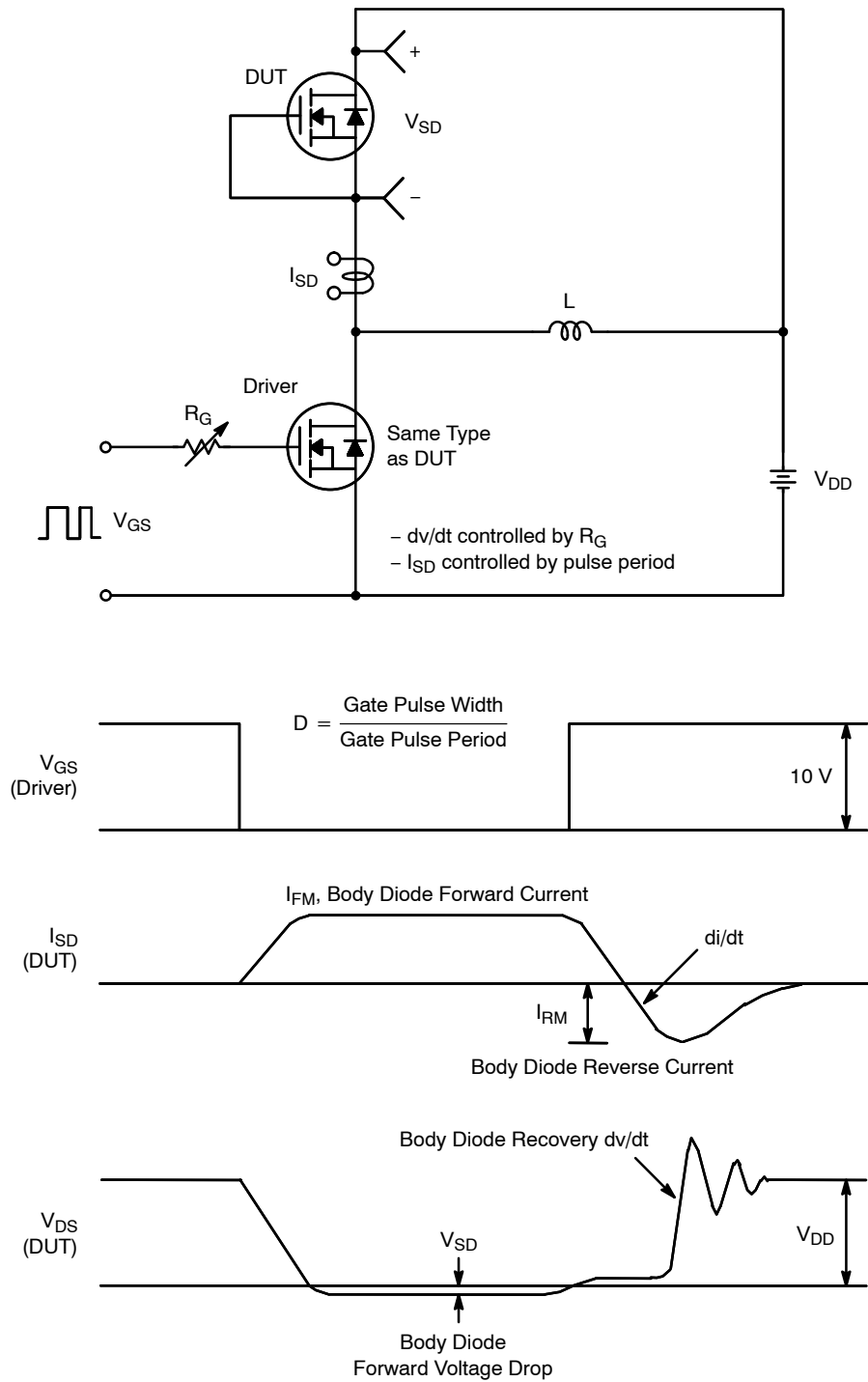
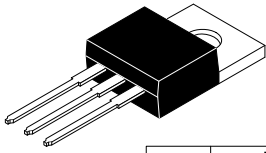


Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms

# FCP165N65S3R0



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



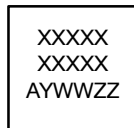
TO-220-3LD  
CASE 340AT  
ISSUE B

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°    |

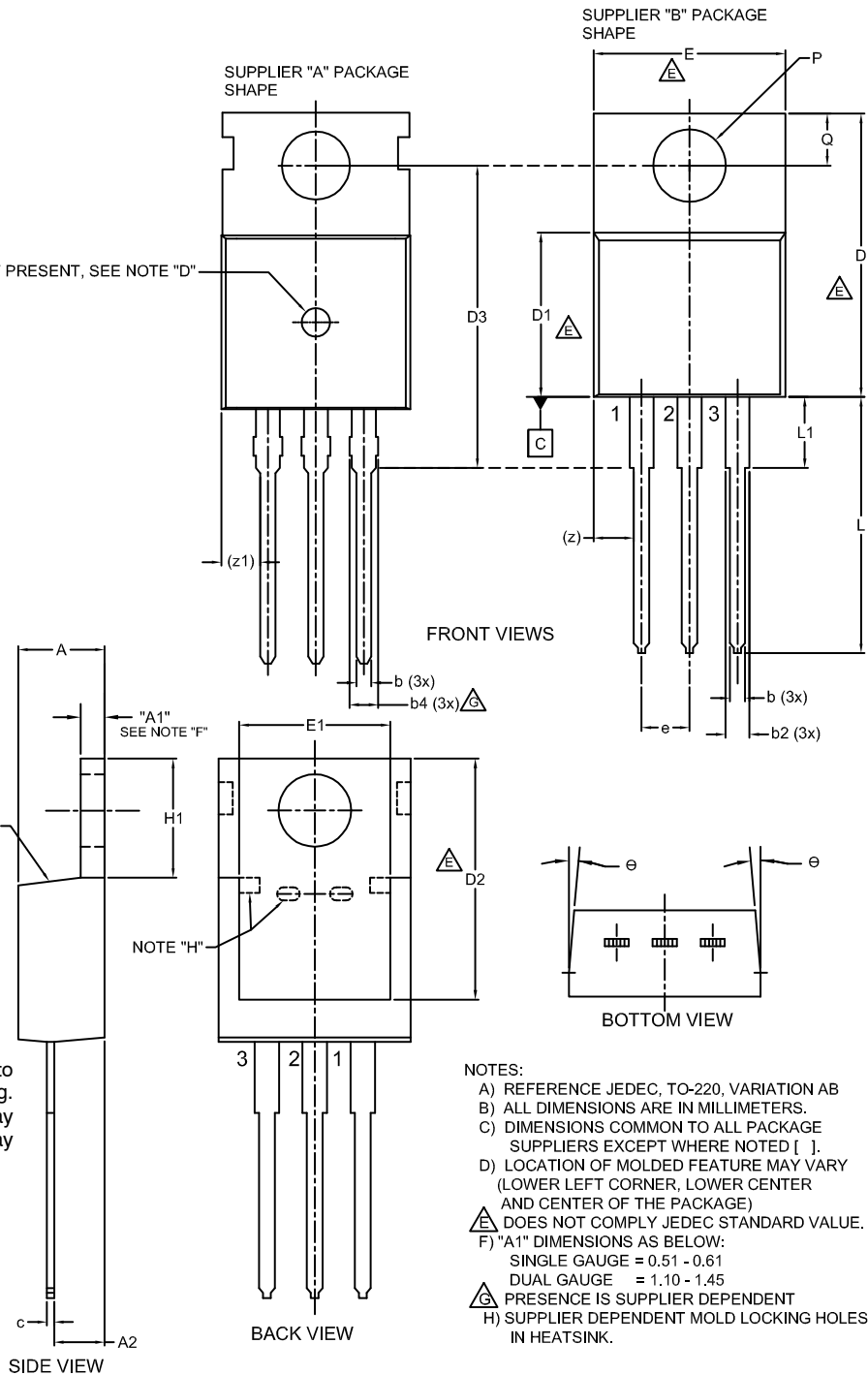
IF PRESENT, SEE NOTE "D"

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.



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)
- △ DOES NOT COMPLY JEDEC STANDARD VALUE.
- F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
- △ PRESENCE IS SUPPLIER DEPENDENT
- H) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

|                  |             |                                                                                                                                                                                     |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| DESCRIPTION:     | TO-220-3LD  | PAGE 1 OF 1                                                                                                                                                                         |

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