# onsemi

# **MOSFET** – N-Channel, POWERTRENCH<sup>®</sup>

## 150 V, 37 A, 36 m $\Omega$

## FDP2552, FDB2552

## Features

- $R_{DS(on)} = 32 \text{ m}\Omega$  (Typ.),  $V_{GS} = 10 \text{ V}$ ,  $I_D = 16 \text{ A}$
- $Q_g(tot) = 39 \text{ nC} (Typ.), V_{GS} = 10 \text{ V}$
- Low Miller Charge
- Low Q<sub>RR</sub> Body Diode
- UIS Capability (Single Pulse and Repetitive Pulse)
- These Devices are Pb-Free, Halide Free and are RoHS Compliant

## Applications

- DC/DC Converters and Off-line UPS
- Distributed Power Architectures and VRMs
- Primary Switch for 24 V and 48 V Systems
- High Voltage Synchronous Rectifier

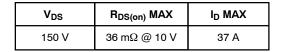
### MOSFET MAXIMUM RATINGS (T<sub>C</sub> = 25°C, unless otherwise noted)

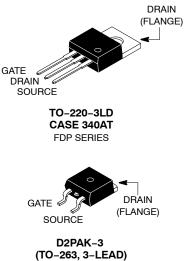
| Symbol                            | Parameter  | Ratings                   | Unit |
|-----------------------------------|--|---------------------------|------|
| V <sub>DSS</sub>                  | Drain to Source Voltage  | 150                       | V    |
| V <sub>GS</sub>                   | Gate to Source Voltage   | ±20                       | V    |
| ID                                | $ \begin{array}{l} \text{Drain Current} \\ \text{Continuous } (T_{C} = 25^{\circ}\text{C},  \text{V}_{GS} = 10  \text{V}) \\ \text{Continuous } (T_{C} = 100^{\circ}\text{C},  \text{V}_{GS} = 10  \text{V}) \\ \text{Continuous } (T_{amb} = 25^{\circ}\text{C},  \text{V}_{GS} = 10  \text{V}, \\ \text{with } R_{\theta JA} = 43^{\circ}\text{C}/\text{W}) \\ \text{Pulsed} \end{array} $ | 37<br>26<br>5<br>Figure 4 | A    |
| E <sub>AS</sub>                   | Single Pulse Avalanche Energy (Note 1)   | 390                       | mJ   |
| PD                                | Power Dissipation  | 150                       | W    |
|                                   | Derate above 25°C  | 1.0                       | W/°C |
| T <sub>J</sub> , T <sub>STG</sub> | Operating and Storage Temperature  | -55 to 175                | °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.

## THERMAL CHARACTERISTICS

| Symbol          | Parameter  | Ratings | Unit |
|-----------------|--|---------|------|
| $R_{\theta JC}$ | Thermal Resistance Junction to Case TO-220, TO-263                               | 1.0     | °C/W |
| $R_{	hetaJA}$   | Thermal Resistance Junction to Ambient TO-220, TO-263 (Note 2)                   | 62      |      |
| $R_{	hetaJA}$   | Thermal Resistance Junction to Ambient TO-263, 1 in <sup>2</sup> Copper Pad Area | 43      |      |





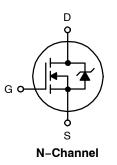
CASE 418AJ FDB SERIES

## MARKING DIAGRAM



&Z = Assembly Plant Code &3

- = 3-Digit Date Code
- &K = 2-Digits Lot Run Traceability Code
- FDx2552 = Device Code (x = P, B)



## **ORDERING INFORMATION**

See detailed ordering and shipping information on page 12 of this data sheet.

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## **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = $25^{\circ}$ C unless otherwise noted)

| Symbol            | Parameter                         | Test Condition                                    | Min | Тур | Max  | Unit |
|-------------------|-----------------------------------|---|-----|-----|------|------|
| OFF CHAR          | OFF CHARACTERISTICS               |   |     |     |      |      |
| B <sub>VDSS</sub> | Drain to Source Breakdown Voltage | $I_D = 250 \ \mu A, \ V_{GS} = 0 \ V$             | 150 | -   | _    | V    |
| I <sub>DSS</sub>  | Zero Gate Voltage Drain Current   | $V_{DS}$ = 120 V, $V_{GS}$ = 0 V                  | -   | -   | 1    | μΑ   |
|                   |                                   | $V_{DS}$ = 120 V, $V_{GS}$ = 0 V, $T_{C}$ = 150°C | -   | -   | 250  |      |
| I <sub>GSS</sub>  | Gate to Source Leakage Current    | $V_{GS} = \pm 20 \text{ V}$                       | -   | -   | ±100 | nA   |

#### **ON CHARACTERISTICS**

| V <sub>GS(TH)</sub> | Gate to Source Threshold Voltage | $V_{GS}$ = $V_{DS}$ , $I_D$ = 250 $\mu$ A           | 2 | -     | 4     | V |
|---------------------|----------------------------------|---|---|-------|-------|---|
| R <sub>DS(on)</sub> | Drain to Source On Resistance    | $I_D = 16 \text{ A}, \text{ V}_{GS} = 10 \text{ V}$ | - | 0.032 | 0.036 | Ω |
|                     |                                  | $I_{D} = 8 \text{ A}, V_{GS} = 6 \text{ V}$         | - | 0.036 | 0.054 |   |
|                     |                                  | $I_D$ = 16 A, $V_{GS}$ = 10 V, $T_J$ = 175°C        | - | 0.084 | 0.097 |   |

#### DYNAMIC CHARACTERISTICS

| C <sub>ISS</sub>    | Input Capacitance                | $V_{DS}$ = 25 V, $V_{GS}$ = 0 V, f = 1 MHz                                | - | 2800 | -   | pF |
|---------------------|----------------------------------|---|---|------|-----|----|
| C <sub>OSS</sub>    | Output Capacitance               |   | - | 285  | -   | pF |
| C <sub>RSS</sub>    | Reverse Transfer Capacitance     |   | - | 55   | -   | pF |
| Q <sub>g(TOT)</sub> | Total Gate Charge at 10 V        | $V_{GS}$ = 0 V to 10 V, $V_{DD}$ = 75 V, $I_{D}$ = 16 A, $I_{g}$ = 1.0 mA | - | 39   | 51  | nC |
| Q <sub>g(TH)</sub>  | Threshold Gate Charge            | $V_{GS}$ = 0 V to 2 V, $V_{DD}$ = 75 V, $I_{D}$ = 16 A, $I_{g}$ = 1.0 mA  | - | 5.2  | 6.8 | nC |
| Q <sub>gs</sub>     | Gate to Source Gate Charge       | $V_{DD}$ = 75 V, $I_D$ = 16 A, $I_g$ = 1.0 mA                             | - | 13.5 | -   | nC |
| Q <sub>gs2</sub>    | Gate Charge Threshold to Plateau |   | - | 8.4  | -   | nC |
| Q <sub>gd</sub>     | Gate to Drain "Miller" Charge    |   | - | 8.3  | -   | nC |

#### SWITCHING CHARACTERISTICS (V<sub>GS</sub> = 10 V)

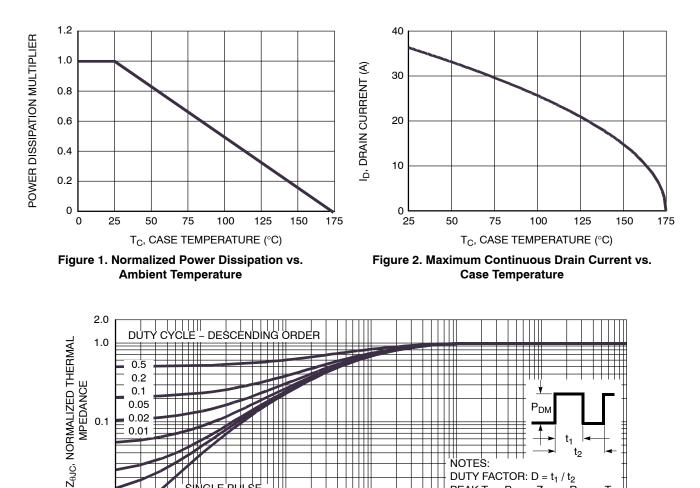
| t <sub>ON</sub>     | Turn-On Time        | $V_{DD}$ = 75 V, $I_{D}$ = 16 A, $V_{GS}$ = 10 V, $R_{GS}$ = 8.2 $\Omega$ | - | -  | 62 | ns |
|---------------------|---------------------|---|---|----|----|----|
| t <sub>d(ON)</sub>  | Turn-On Delay Time  | $n_{GS} = 0.2 S_2$  | - | 12 | -  | ns |
| t <sub>r</sub>      | Rise Time           |   | - | 29 | -  | ns |
| t <sub>d(OFF)</sub> | Turn-Off Delay Time |   | - | 36 | -  | ns |
| t <sub>f</sub>      | Fall Time           |   | - | 29 | -  | ns |
| t <sub>OFF</sub>    | Turn–Off Time       |   | - | -  | 97 | ns |

#### **DRAIN-SOURCE CHARACTERISTICS**

| V <sub>SD</sub> | Source to Drain Diode Voltage | I <sub>SD</sub> = 16 A                                  |   | - | 1.25 | V  |
|-----------------|-------------------------------|---|---|---|------|----|
|                 |                               | I <sub>SD</sub> = 8 A                                   | - | - | 1.0  | V  |
| t <sub>rr</sub> | Reverse Recovery Time         | I <sub>SD</sub> = 16 A, dI <sub>SD</sub> /dt = 100 A/μs | - | - | 90   | ns |
| Q <sub>RR</sub> | Reverse Recovery Charge       | $I_{SD}$ = 16 A, dI <sub>SD</sub> /dt = 100 A/µs        | - | - | 242  | nC |

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. 1. Starting  $T_J = 25^{\circ}$ C, L = 7.8 mH,  $I_{AS} = 10$  A. 2. Pulse Width = 100 s.

Typical Characteristics (T<sub>C</sub>=  $25^{\circ}$ C, unless otherwise noted)



t1 t<sub>2</sub>

10<sup>1</sup>

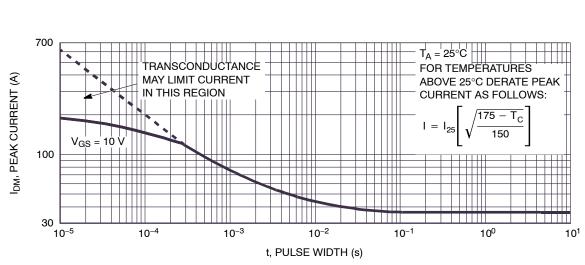
NOTES:

10-1

DUTY FACTOR:  $D = t_1 / t_2$ 

 $PEAK T_{J} = P_{DM} \times Z_{\theta JC} \times R_{\theta JC} + T_{C}$ 

100



10-2

t, RECTANGULAR PULSE DURATION (s)

Figure 3. Normalized Maximum Transient Thermal Impedance

ŚINGLE PULŚE

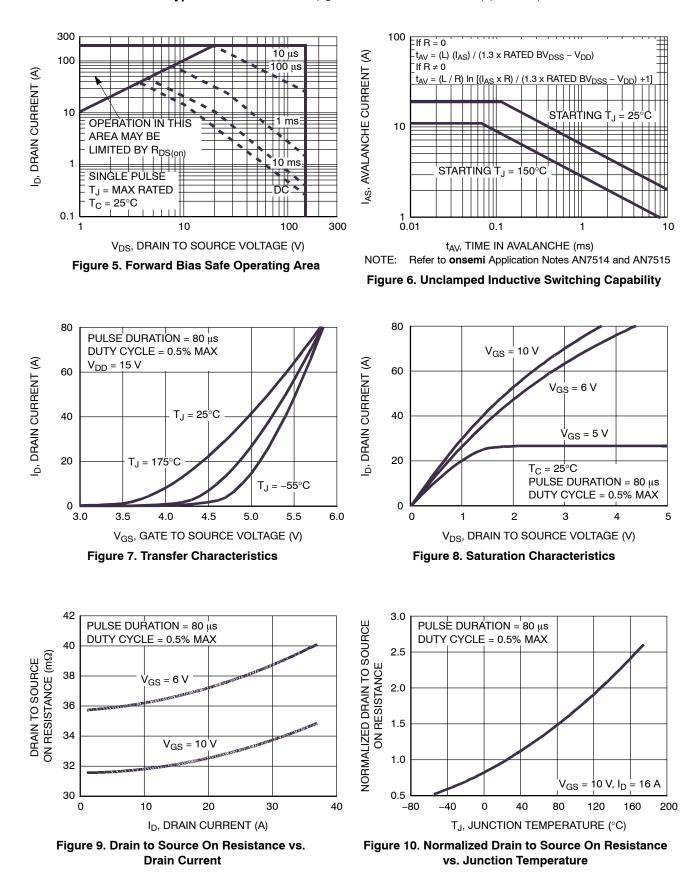
10<sup>-3</sup>

10-4

0.01 10-5

Figure 4. Peak Current Capability

**Typical Characteristics** ( $T_C = 25^{\circ}C$ , unless otherwise noted) (continued)





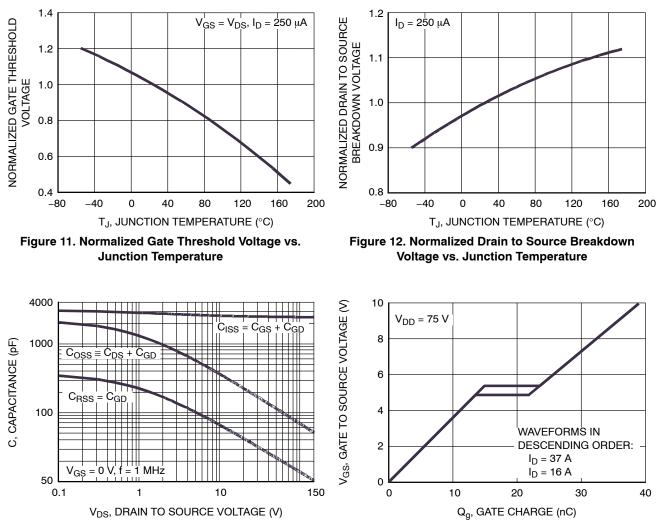


Figure 13. Capacitance vs. Drain to Source Voltage

Figure 14. Gate Charge Waveforms for Constant Gate Currents

## **Test Circuits and Waveforms**

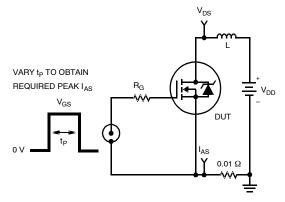


Figure 15. Unclamped Energy Test Circuit

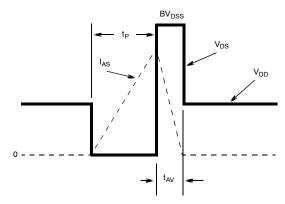


Figure 16. Unclamped Energy Waveforms

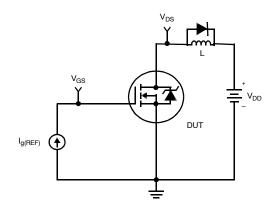


Figure 17. Gate Charge Test Circuit

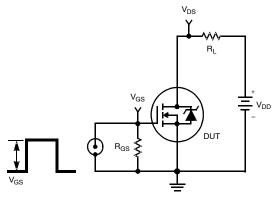


Figure 19. Switching Time Test Circuit

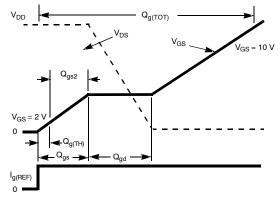


Figure 18. Gate Charge Waveforms

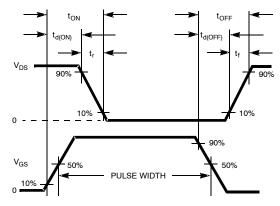


Figure 20. Switching Time Waveforms

#### Thermal Resistance vs. Mounting Pad Area

The maximum rated junction temperature,  $T_{JM}$ , and the thermal resistance of the heat dissipating path determines the maximum allowable device power dissipation,  $P_{DM}$ , in an application. Therefore the application's ambient temperature,  $T_A$  (°C), and thermal resistance  $R_{\theta JA}$  (°C/W) must be reviewed to ensure that  $T_{JM}$  is never exceeded. Equation 1 mathematically represents the relationship and serves as the basis for establishing the rating of the part.

$$P_{DM} = \frac{\left(T_{JM} - T_{A}\right)}{R_{\theta JA}}$$
 (eq. 1)

In using surface mount devices such as the TO-263 package, the environment in which it is applied will have a significant influence on the part's current and maximum power dissipation ratings. Precise determination of  $P_{DM}$  is complex and influenced by many factors:

- 1. Mounting pad area onto which the device is attached and whether there is copper on one side or both sides of the board.
- 2. The number of copper layers and the thickness of the board.
- 3. The use of external heat sinks.
- 4. The use of thermal vias.
- 5. Air flow and board orientation.
- 6. For non steady state applications, the pulse width, the duty cycle and the transient thermal response of the part, the board and the environment they are in.

**onsemi** provides thermal information to assist the designer's preliminary application evaluation. Figure 21 defines the  $R_{0JA}$  for the device as a function of the top copper (component side) area. This is for a horizontally positioned FR-4 board with 1 oz copper after 1000 seconds of steady state power with no air flow. This graph provides the necessary information for calculation of the steady state junction temperature or power dissipation. Pulse applications

can be evaluated using the **onsemi** device Spice thermal model or manually utilizing the normalized maximum transient thermal impedance curve.

Thermal resistances corresponding to other copper areas can be obtained from Figure 21 or by calculation using Equation 2 or 3. Equation 2 is used for copper area defined in inches square and Equation 3 is for area in centimeters square. The area, in square inches or square centimeters is the top copper area including the gate and source pads.

$$R_{\theta JA} = 26.51 + \frac{19.84}{(0.262 + Area)}$$
 (eq. 2)

Area in Inches Squared

$$R_{\theta JA} = 26.51 + \frac{128}{(1.69 + Area)}$$
 (eq. 3)

Area in Centimeters Squared

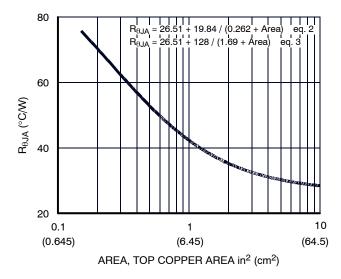


Figure 21. Thermal Resistance vs. Mounting Pad Area

### **PSPICE Electrical Model**

ESLC 51 50 VALUE={(V(5,51)/ABS(V(5,51)))\*(PWR(V(5,51)/(1e-6\*75),3))}

.MODEL DbodyMOD D (IS=2.6E-11 N=1.09 RS=2.6e-3 TRS1=3.0e-3 TRS2=1.5e-6 + CJO=1.9e-9 M=0.62 TT=5.1e-8 XTI=4.2) .MODEL DbreakMOD D (RS=0.3 TRS1=3.0e-3 TRS2=-8.9e-6) .MODEL DplcapMOD D (CJO=5.7e-10 IS=1.0e-30 N=10 M=0.58)

```
.MODEL MmedMOD NMOS (VTO=3.5 KP=6 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=1.04)
.MODEL MstroMOD NMOS (VTO=4.15 KP=80 IS=1e-30 N=10 TOX=1 L=1u W=1u)
.MODEL MweakMOD NMOS (VTO=2.91 KP=0.03 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=10.4 RS=0.1)
```

.MODEL RbreakMOD RES (TC1=1.1e-3 TC2=-2e-6) .MODEL RdrainMOD RES (TC1=8.5e-3 TC2=2.5e-5) .MODEL RSLCMOD RES (TC1=3.4e-3 TC2=1.5e-6) .MODEL RsourceMOD RES (TC1=4.0e-3 TC2=1.0e-6) .MODEL RvthresMOD RES (TC1=-4.3e-3 TC2=-1.6e-5) .MODEL RvtempMOD RES (TC1=-4.1e-3 TC2=1.5e-6)

.MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-6.0 VOFF=-4.0) .MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-4.0 VOFF=-6.0) .MODEL S2AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-2 VOFF=-0.5) .MODEL S2BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-0.5 VOFF=-2)

## .ENDS

NOTE: Note: For further discussion of the PSPICE model, consult *A New PSPICE Sub-Circuit for the Power MOSFET Featuring Global Temperature Options*; IEEE Power Electronics Specialist Conference Records, 1991, written by William J. Hepp and C. Frank Wheatley.

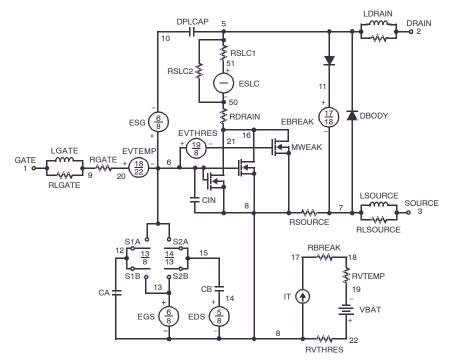


Figure 22.

## SABER Electrical Model

```
REV May 2002
template FDP2552 n2,n1,n3
electrical n2,n1,n3
{
var i iscl
dp..model dbodymod = (isl=2.6e-11,nl=1.09,rs=2.6e-3,trs1=3.0e-3,trs2=1.5e-6,cjo=1.9e-9,m=0.62,tt=5.1e-8,xti=4.2)
dp..model dbreakmod = (rs=0.3, trs1=3.0e-3, trs2=-8.9e-6)
dp..model dplcapmod = (cjo=5.7e-10,isl=10.0e-30,nl=10,m=0.58)
m..model mmedmod = (type= n,vto=3.5,kp=6,is=1e-30,tox=1)
m..model mstrongmod = (type= n,vto=4.15,kp=80,is=1e-30,tox=1)
m..model mweakmod = (type= n,vto=2.91,kp=0.03,is=1e-30,tox=1,rs=0.1)
sw vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-6.0,voff=-4.0)
sw vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-4.0,voff=-6.0)
sw vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-2,voff=-0.5)
sw vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=-0.5,voff=-2)
c.ca n12 n8 = 1e-9
c.cb n15 n14 = 1e-9
c.cin n6 n8 = 2.65e-9
dp.dbody n7 n5 = model = dbodymod
dp.dbreak n5 n11 = model=dbreakmod
dp.dplcap n10 n5 = model=dplcapmod
spe.ebreak n11 n7 n17 n18 = 178
spe.eds n14 n8 n5 n8 = 1
spe.egs n13 n8 n6 n8 = 1
spe.esg n6 n10 n6 n8 = 1
spe.evthres n6 n21 n19 n8 = 1
spe.evtemp n20 n6 n18 n22 = 1
i.it n8 n17 = 1
1.1gate n1 n9 = 7.15e-9
1.1 drain n2 n5 = 1.0 e-9
1.1source n3 n7 = 2.3e-9
res.rlgate n1 n9 = 71.5
res.rldrain n2 n5 = 10
res.rlsource n3 n7 = 23
m.mmed n16 n6 n8 n8 = model=mmedmod, l=1u, w=1u
m.mstrong n16 n6 n8 n8 = model=mstrongmod, l=1u, w=1u
m.mweak n16 n21 n8 n8 = model=mweakmod, l=1u, w=1u
res.rbreak n17 n18 = 1, tc1=1.1e-3,tc2=-2e-6
res.rdrain n50 n16 = 2.5e-2, tc1=8.5e-3,tc2=2.5e-5
res.rgate n9 n20 = 1.04
res.rslc1 n5 n51 = 1.0e-6, tc1=3.4e-3,tc2=1.5e-6
res.rslc2 n5 n50 = 1.0e3
res.rsource n8 n7 = 4.6e-3, tc1=4.0e-3,tc2=1.0e-6
res.rvthres n22 n8 = 1, tc1 = -4.3e - 3, tc2 = -1.6e - 5
res.rvtemp n18 n19 = 1, tc1=-4.1e-3,tc2=1.5e-6
```

```
sw_vcsp.s1a n6 n12 n13 n8 = model=s1amod
sw_vcsp.s1b n13 n12 n13 n8 = model=s1bmod
sw_vcsp.s2a n6 n15 n14 n13 = model=s2amod
sw_vcsp.s2b n13 n15 n14 n13 = model=s2bmod
```

```
v.vbat n22 n19 = dc=1
equations {
 i (n51->n50) +=iscl
 iscl: v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51)))))*((abs(v(n5,n51)*1e6/75))** 3))
 }
}
```

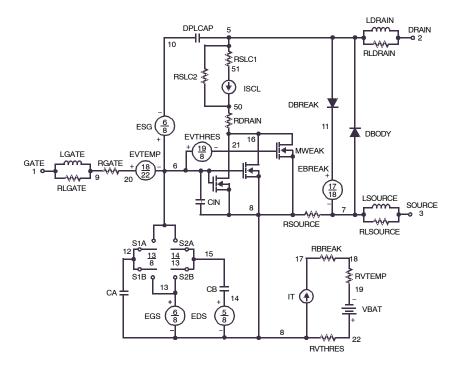


Figure 23.

## SPICE THERMAL MODEL

REV 23 May 2002

#### FDP2552T

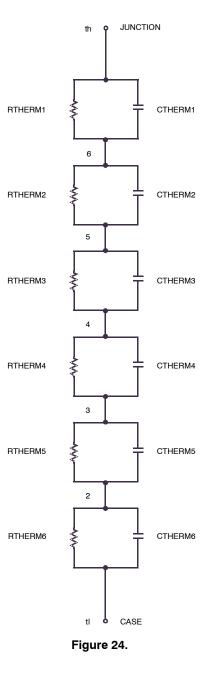
CTHERM1 TH 6 1e-2 CTHERM2 6 5 1.5e-2 CTHERM3 5 4 2e-2 CTHERM4 4 3 2.1e-2 CTHERM5 3 2 2.2e-2 CTHERM6 2 TL 9e-2

RTHERM1 TH 6 2.7e-2 RTHERM2 6 5 2.8e-2 RTHERM3 5 4 7.8e-2 RTHERM4 4 3 9e-2 RTHERM5 3 2 2.7e-1 RTHERM6 2 TL 2.87e-1

## SABER THERMAL MODEL

SABER thermal model FDP2552T template thermal\_model th tl thermal c th, tl { ctherm.ctherm1 th 6 = 1e-2ctherm.ctherm2 6 5 = 1.5e-2ctherm.ctherm3 5 4 = 2e-2ctherm.ctherm4 4 3 = 2.1e-2ctherm.ctherm5 3 2 = 2.2e-2ctherm.ctherm6 2 tl =9e-2rtherm.rtherm1 th 6 = 2.7e - 2rtherm.rtherm2 6 5 = 2.8e-2rtherm.rtherm354 = 7.8e - 2rtherm.rtherm4 4 3 = 9e-2rtherm.rtherm5 3 2 = 2.7e-1 rtherm.rtherm6 2 tl =2.87e-1

}



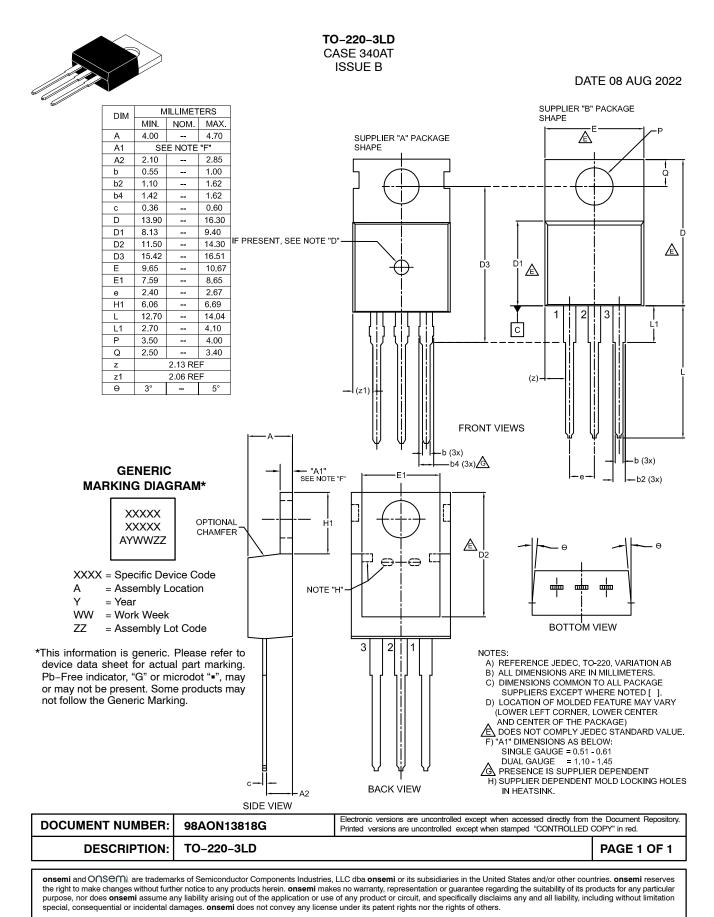
### PACKAGE MARKING AND ORDERING INFORMATION

| Device  | Device Marking | Package                                  | Reel Size | Tape Width | Quantity <sup>†</sup>   |
|---------|----------------|--|-----------|------------|-------------------------|
| FDB2552 | FDB2552        | TO-263, 3-LEAD<br>(Pb-Free, Halide Free) | 330 mm    | 24 mm      | 800 Units / Tape & Reel |
| FDP2552 | FDP2552        | TO-220-3LD<br>(Pb-Free, Halide Free)     | Tube      | N/A        | 8000 Units / Tube       |

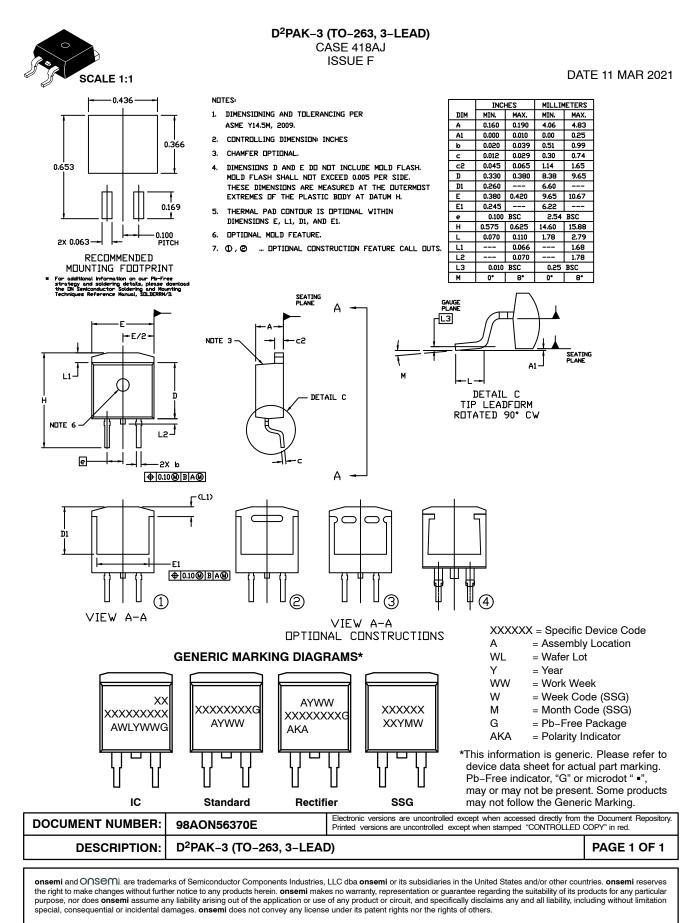
+For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, <u>BRD8011/D</u>.

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