

# ON Semiconductor

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ON Semiconductor®

## FDP038AN06A0 / FDI038AN06A0

### N-Channel PowerTrench® MOSFET

60 V, 80 A, 3.8 mΩ

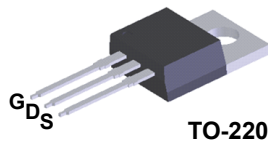
#### Features

- $R_{DS(on)} = 3.5 \text{ m}\Omega$  (Typ.) @  $V_{GS} = 10 \text{ V}$ ,  $I_D = 80 \text{ A}$
- $Q_{G(tot)} = 96 \text{ nC}$  (Typ.) @  $V_{GS} = 10 \text{ V}$
- Low Miller Charge
- Low  $Q_{rr}$  Body Diode
- UIS Capability (Single Pulse and Repetitive Pulse)

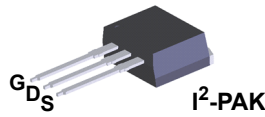
Formerly developmental type 82584

#### Applications

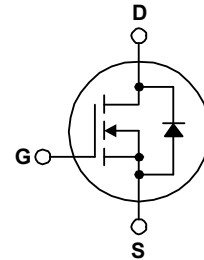
- Synchronous Rectification for ATX / Server / Telecom PSU
- Battery Protection Circuit
- Motor drives and Uninterruptible Power Supplies



TO-220



I²-PAK



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

Symbol	Parameter	FDP038AN06A0 FDI038AN06A0	Unit
$V_{DSS}$	Drain to Source Voltage	60	V
$V_{GS}$	Gate to Source Voltage	$\pm 20$	V
$I_D$	Drain Current		
	Continuous ( $T_C < 151^\circ\text{C}$ , $V_{GS} = 10\text{V}$ )	80	A
	Continuous ( $T_{amb} = 25^\circ\text{C}$ , $V_{GS} = 10\text{V}$ , with $R_{\theta JA} = 62^\circ\text{C/W}$ )	17	A
	Pulsed	Figure 4	A
$E_{AS}$	Single Pulse Avalanche Energy (Note 1)	625	mJ
$P_D$	Power dissipation	310	W
	Derate above $25^\circ\text{C}$	2.07	W/ $^\circ\text{C}$
$T_J, T_{STG}$	Operating and Storage Temperature	-55 to 175	$^\circ\text{C}$

#### Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance, Junction to Case, Max.	0.48	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient, Max. (Note 2)	62	$^\circ\text{C/W}$

## Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FDP038AN06A0	FDP038AN06A0	TO-220	Tube	N/A	50 units
FDI038AN06A0	FDI038AN06A0	I <sup>2</sup> -PAK	Tube	N/A	50 units

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
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### Off Characteristics

$B_{VDSS}$	Drain to Source Breakdown Voltage	$I_D = 250\mu\text{A}, V_{GS} = 0\text{V}$	60	-	-	V
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 50\text{V}$ $V_{GS} = 0\text{V}$ $T_C = 150^\circ\text{C}$	-	-	1	$\mu\text{A}$
$I_{GSS}$	Gate to Source Leakage Current	$V_{GS} = \pm 20\text{V}$	-	-	$\pm 100$	nA

### On Characteristics

$V_{GS(TH)}$	Gate to Source Threshold Voltage	$V_{GS} = V_{DS}, I_D = 250\mu\text{A}$	2	-	4	V
$r_{DS(ON)}$	Drain to Source On Resistance	$I_D = 80\text{A}, V_{GS} = 10\text{V}$	-	0.0035	0.0038	$\Omega$
		$I_D = 40\text{A}, V_{GS} = 6\text{V}$	-	0.0049	0.0074	
		$I_D = 80\text{A}, V_{GS} = 10\text{V},$ $T_J = 175^\circ\text{C}$	-	0.0071	0.0078	

### Dynamic Characteristics

$C_{ISS}$	Input Capacitance	$V_{DS} = 25\text{V}, V_{GS} = 0\text{V},$ $f = 1\text{MHz}$	-	6400	-	pF	
$C_{OSS}$	Output Capacitance		-	1123	-	pF	
$C_{RSS}$	Reverse Transfer Capacitance		-	367	-	pF	
$Q_{g(TOT)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V to } 10\text{V}$	$V_{DD} = 30\text{V}$ $I_D = 80\text{A}$ $I_g = 1.0\text{mA}$	96	124	nC	
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V to } 2\text{V}$		-	12	15	nC
$Q_{gs}$	Gate to Source Gate Charge			-	26	-	nC
$Q_{gs2}$	Gate Charge Threshold to Plateau			-	15	-	nC
$Q_{gd}$	Gate to Drain "Miller" Charge			-	27	-	nC

### Switching Characteristics ( $V_{GS} = 10\text{V}$ )

$t_{ON}$	Turn-On Time	$V_{DD} = 30\text{V}, I_D = 80\text{A}$ $V_{GS} = 10\text{V}, R_{GS} = 2.4\Omega$	-	-	175	ns
$t_{d(ON)}$	Turn-On Delay Time		-	17	-	ns
$t_r$	Rise Time		-	144	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	34	-	ns
$t_f$	Fall Time		-	60	-	ns
$t_{OFF}$	Turn-Off Time		-	-	115	ns

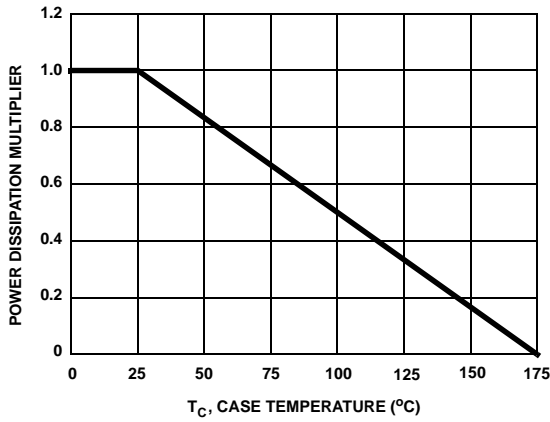
### Drain-Source Diode Characteristics

$V_{SD}$	Source to Drain Diode Voltage	$I_{SD} = 80\text{A}$	-	-	1.25	V
		$I_{SD} = 40\text{A}$	-	-	1.0	V
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 75\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	38	ns
$Q_{RR}$	Reverse Recovered Charge	$I_{SD} = 75\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	39	nC

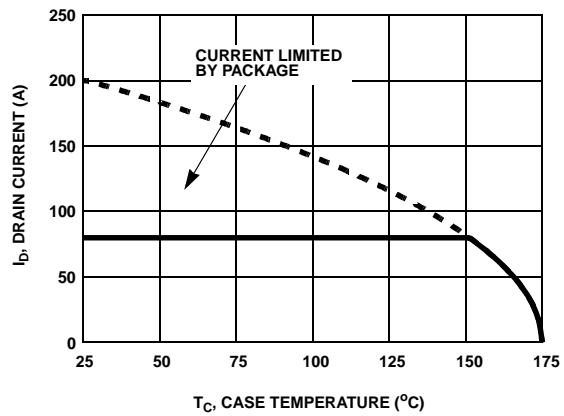
#### Notes:

- Starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.25\text{mH}$ ,  $I_{AS} = 70\text{A}$ .
- Pulse Width = 100s

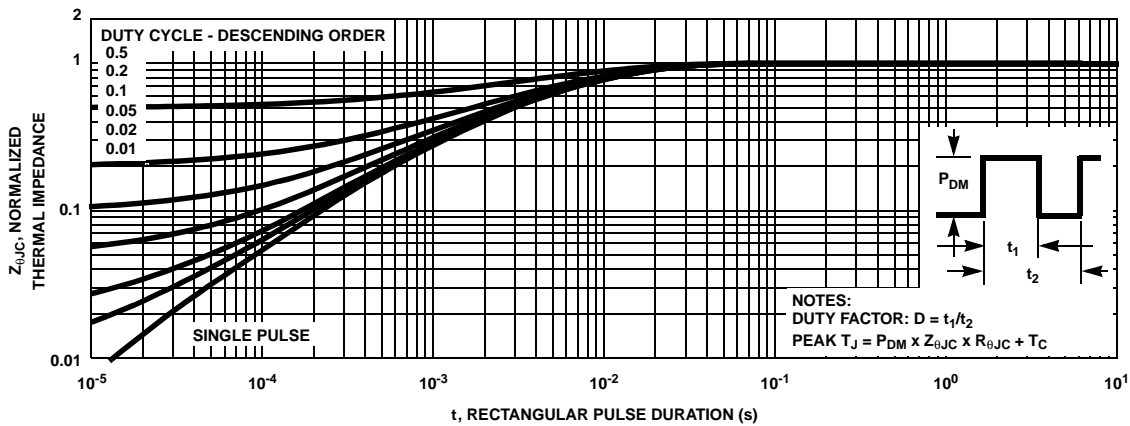
**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted



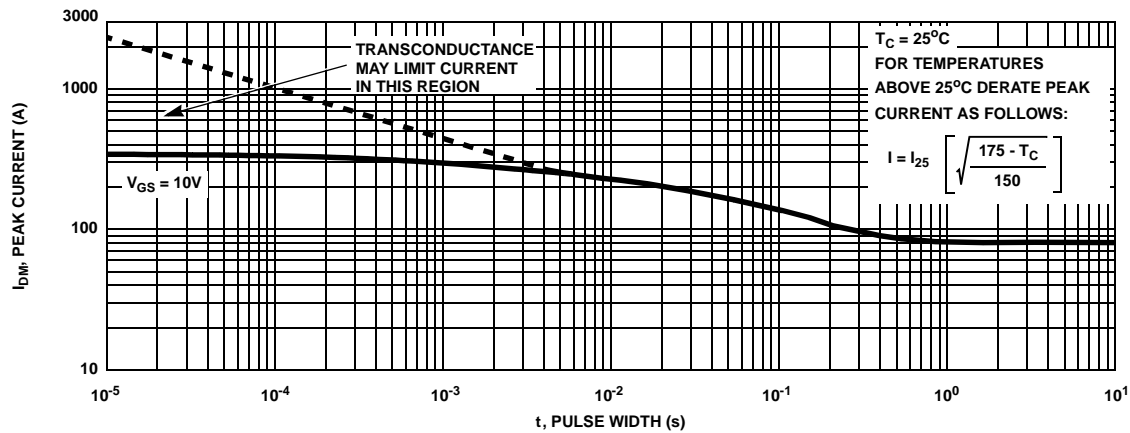
**Figure 1. Normalized Power Dissipation vs Ambient Temperature**



**Figure 2. Maximum Continuous Drain Current vs Case Temperature**

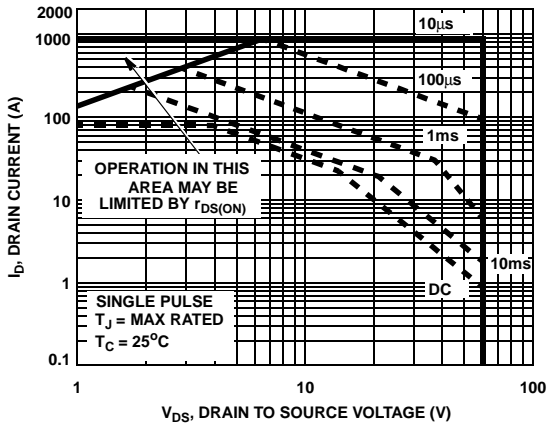


**Figure 3. Normalized Maximum Transient Thermal Impedance**

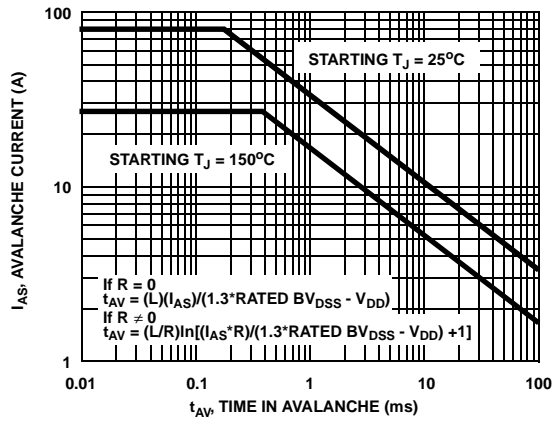


**Figure 4. Peak Current Capability**

**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted

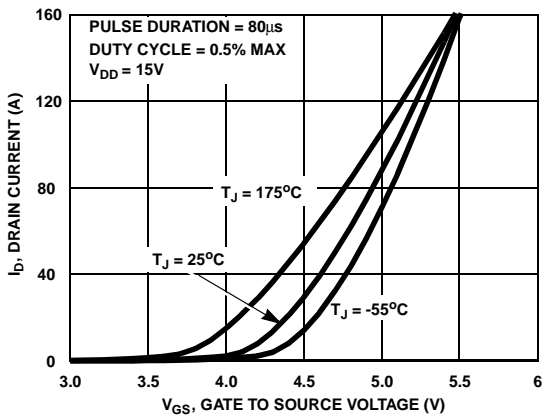


**Figure 5. Forward Bias Safe Operating Area**

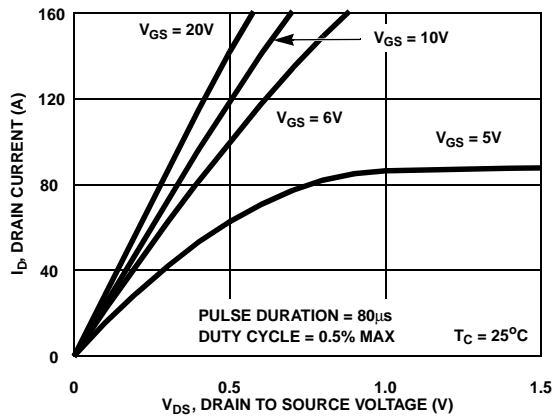


NOTE: Refer to ON Semiconductor Application Notes AN7514 and AN7515

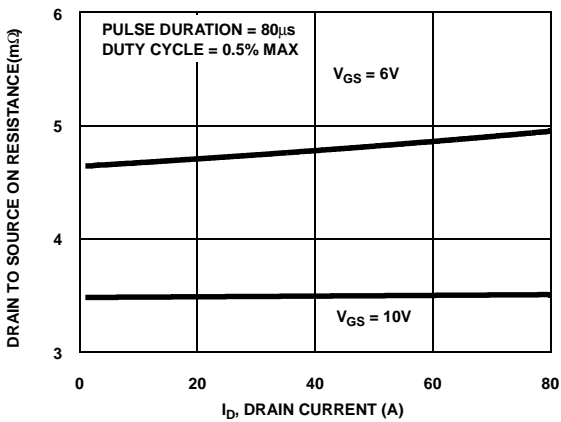
**Figure 6. Unclamped Inductive Switching Capability**



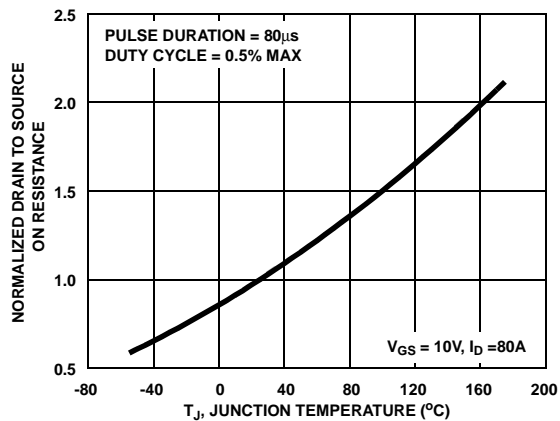
**Figure 7. Transfer Characteristics**



**Figure 8. Saturation Characteristics**

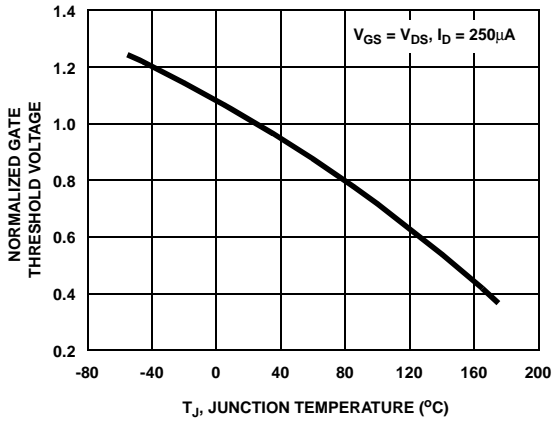


**Figure 9. Drain to Source On Resistance vs Drain Current**

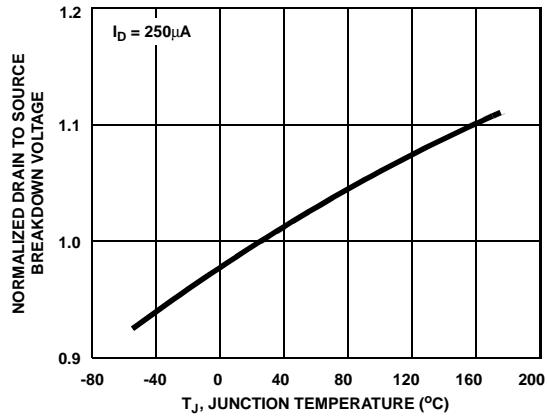


**Figure 10. Normalized Drain to Source On Resistance vs Junction Temperature**

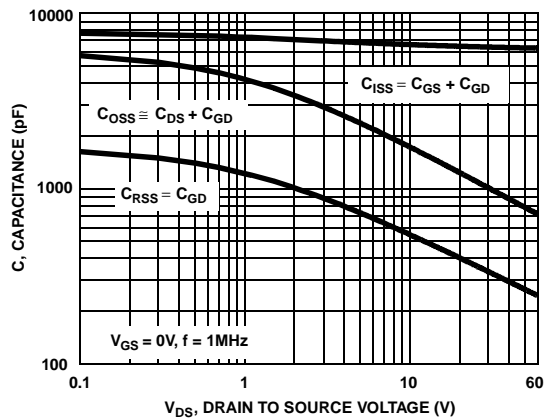
**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted



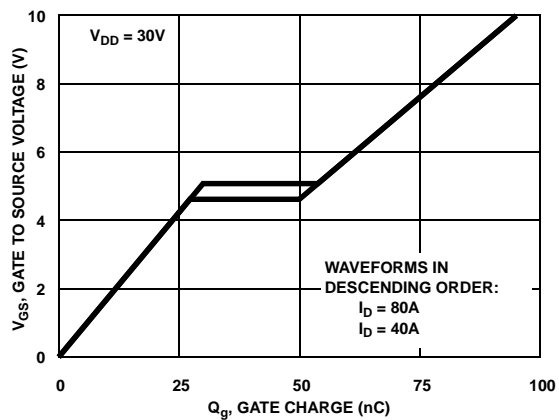
**Figure 11. Normalized Gate Threshold Voltage vs Junction Temperature**



**Figure 12. Normalized Drain to Source Breakdown Voltage vs Junction Temperature**



**Figure 13. Capacitance vs Drain to Source Voltage**



**Figure 14. Gate Charge Waveforms for Constant Gate Current**

### Test Circuits and Waveforms

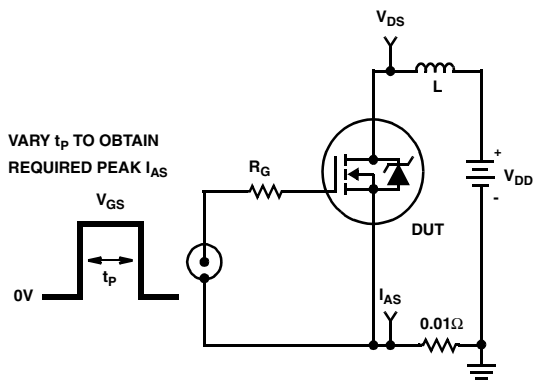


Figure 15. Unclamped Energy Test Circuit

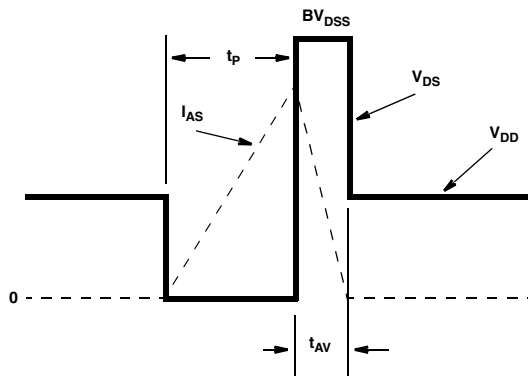


Figure 16. Unclamped Energy Waveforms

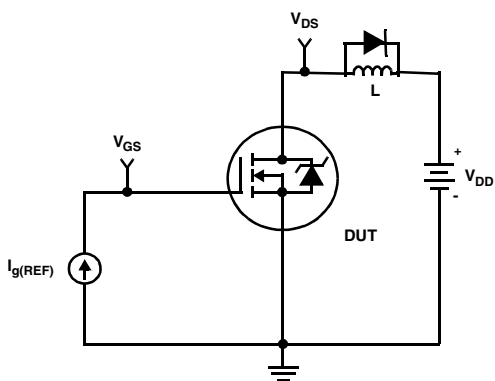


Figure 17. Gate Charge Test Circuit

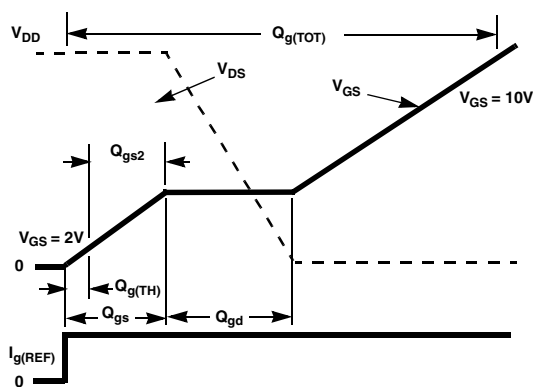


Figure 18. Gate Charge Waveforms

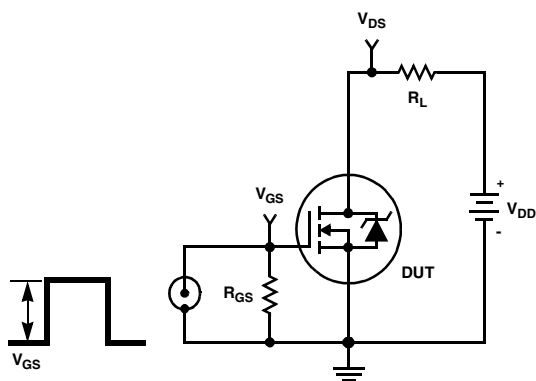


Figure 19. Switching Time Test Circuit

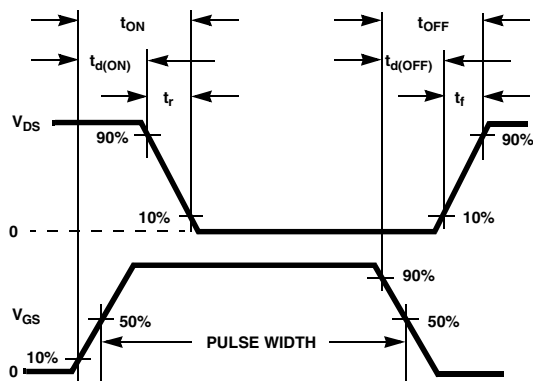


Figure 20. Switching Time Waveforms





# SABER Electrical Model

rev July 4, 2002  
 template FDP038AN06A0 n2,n1,n3 = m\_temp  
 electrical n2,n1,n3  
 number m\_temp=25

```
{
var i iscl
dp..model dbodymod = (isl=2.4e-11,nl=1.04,rs=1.65e-3,trs1=2.7e-3,trs2=2e-7,cjo=4.35e-9,m=5.4e-1,tt=1e-9,xti=3.9)
dp..model dbreakmod = (rs=1.5e-1,trs1=1e-3,trs2=-8.9e-6)
dp..model dplcapmod = (cjo=1.7e-9,isl=10e-30,nl=10,m=0.47)
m..model mmedmod = (type=_n,vto=3.3,kp=9,is=1e-30,tox=1)
m..model mstrongmod = (type=_n,vto=4.00,kp=275,is=1e-30,tox=1)
m..model mweakmod = (type=_n,vto=2.72,kp=0.03,is=1e-30,tox=1,rs=0.1)
sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-4,voff=-1.5)
sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-1.5,voff=-4)
sw_vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-1,voff=0.5)
sw_vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=0.5,voff=-1)
c.ca n12 n8 = 1.5e-9
c.cb n15 n14 = 1.5e-9
c.cin n6 n8 = 6.1e-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 = 69.3
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

```
l.lgate n1 n9 = 4.81e-9
l.l drain n2 n5 = 1.0e-9
l.l source n3 n7 = 4.63e-9
```

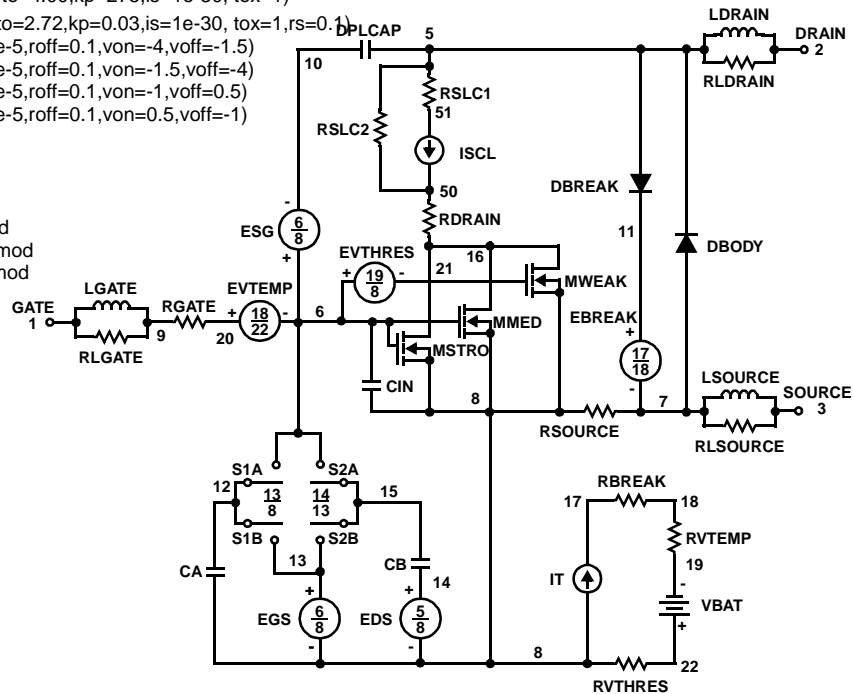
```
res.rlgate n1 n9 = 48.1
res.rldrain n2 n5 = 10
res.rlsource n3 n7 = 46.3
```

```
m.mmed n16 n6 n8 n8 = model=mmedmod, temp=m_temp, l=1u, w=1u
m.mstrong n16 n6 n8 n8 = model=mstrongmod, temp=m_temp, l=1u, w=1u
m.mweak n16 n21 n8 n8 = model=mweakmod, temp=m_temp, l=1u, w=1u
```

```
res.rbreak n17 n18 = 1, tc1=9e-4,tc2=-9e-7
res.rdrain n50 n16 = 1e-4, tc1=4e-2,tc2=3e-4
res.rgate n9 n20 = 1.36
res.rslc1 n5 n51 = 1e-6, tc1=1e-3,tc2=1e-5
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 2.8e-3, tc1=5e-3,tc2=1e-6
res.rvthres n22 n8 = 1, tc1=-6.7e-3,tc2=-1.5e-5
res.rvtemp n18 n19 = 1, tc1=-2.5e-3,tc2=1e-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))*1e6/250)** 10)
}
```



### SPICE Thermal Model

REV 23 July 4, 2002

FDP038AN06A0T

CTHERM1 TH 6 6.45e-3  
 CTHERM2 6 5 3e-2  
 CTHERM3 5 4 1.4e-2  
 CTHERM4 4 3 1.65e-2  
 CTHERM5 3 2 4.85e-2  
 CTHERM6 2 TL 1e-1

RTHERM1 TH 6 3.24e-3  
 RTHERM2 6 5 8.08e-3  
 RTHERM3 5 4 2.28e-2  
 RTHERM4 4 3 1e-1  
 RTHERM5 3 2 1.1e-1  
 RTHERM6 2 TL 1.4e-1

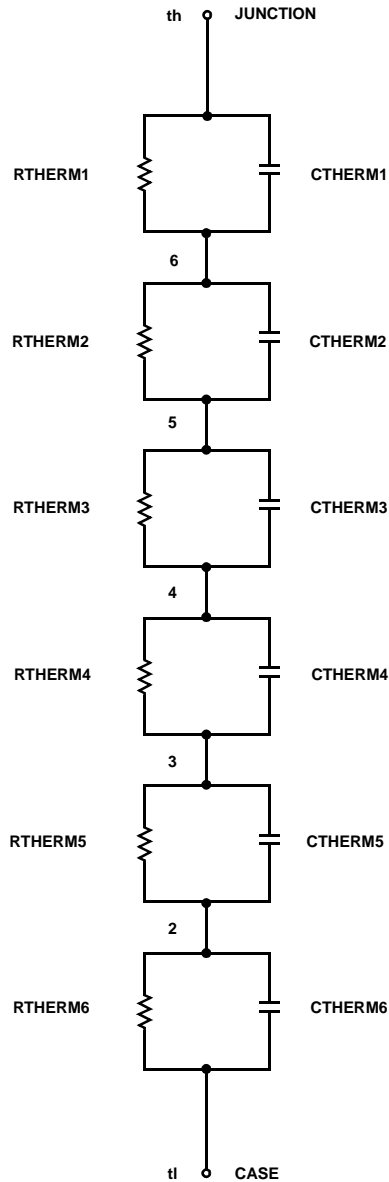
### SABER Thermal Model

SABER thermal model FDP035AN06A0T

template thermal\_model th tl  
 thermal\_c th, tl

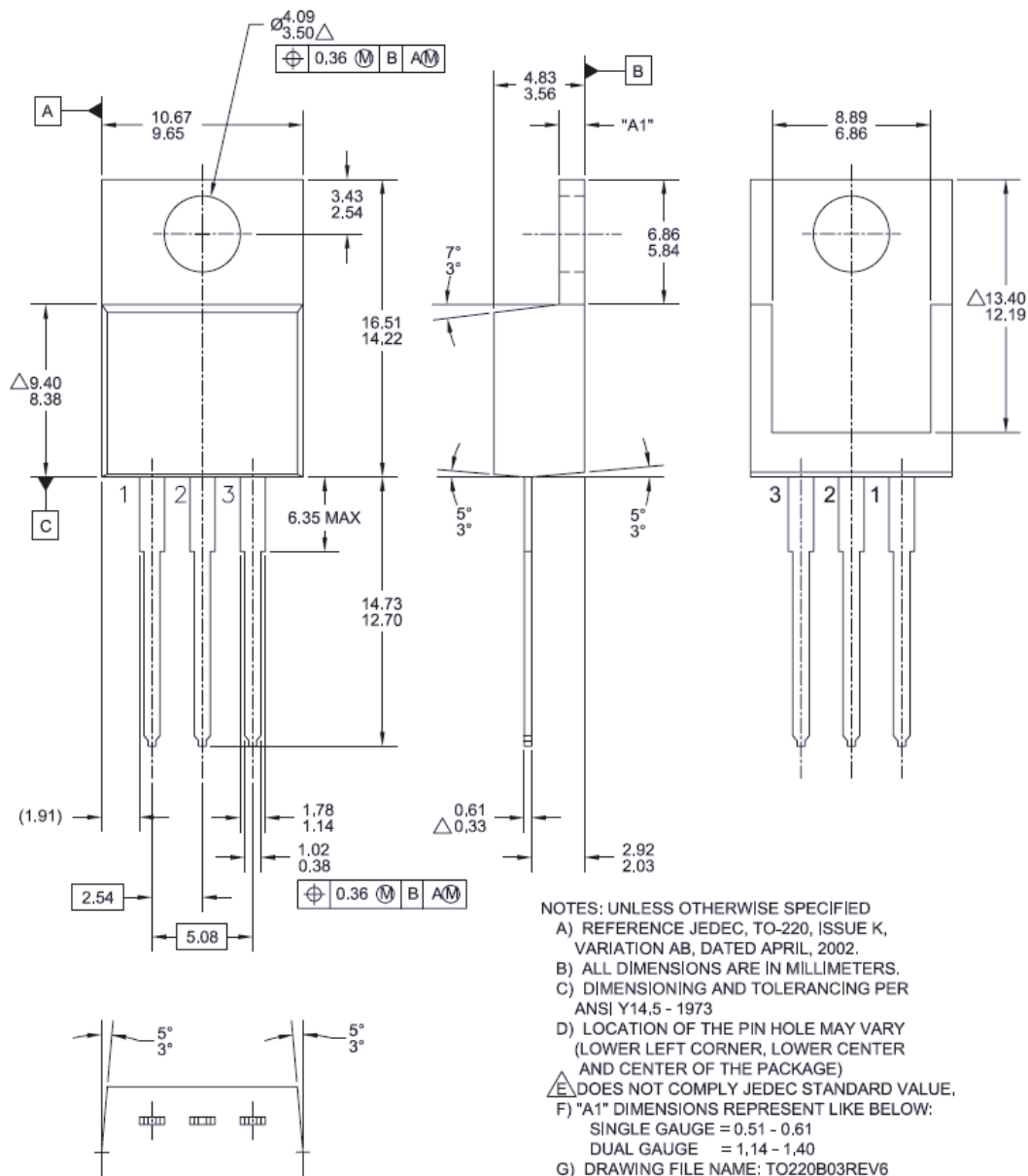
```
{
    ctherm.ctherm1 th 6 =6.45e-3
    ctherm.ctherm2 6 5 =3e-2
    ctherm.ctherm3 5 4 =1.4e-2
    ctherm.ctherm4 4 3 =1.65e-2
    ctherm.ctherm5 3 2 =4.85e-2
    ctherm.ctherm6 2 tl =1e-1
```

```
rtherm.rtherm1 th 6 =3.24e-3
rtherm.rtherm2 6 5 =8.08e-3
rtherm.rtherm3 5 4 =2.28e-2
rtherm.rtherm4 4 3 =1e-1
rtherm.rtherm5 3 2 =1.1e-1
rtherm.rtherm6 2 tl =1.4e-1
}
```



## Mechanical Dimensions

### TO-220 3L



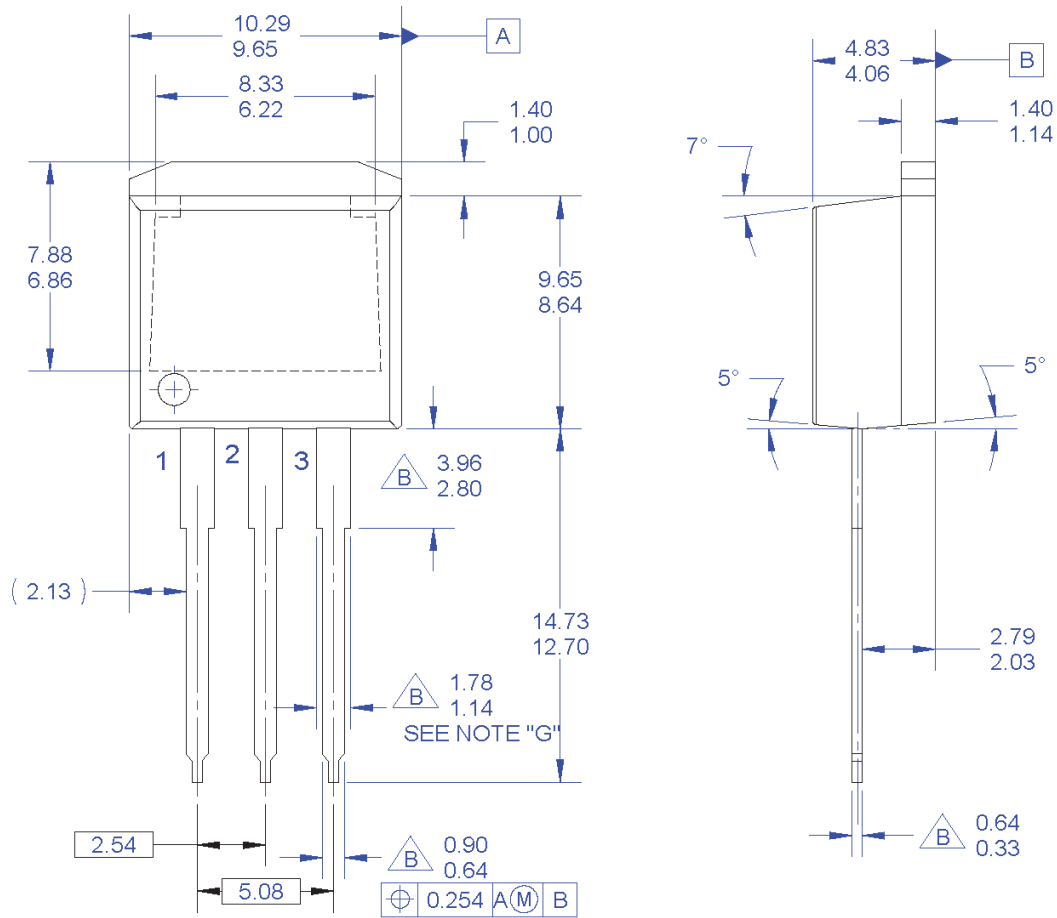
**Figure 21. TO-220, Molded, 3Lead, Jedec Variation AB**

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Dimension in Millimeters

## Mechanical Dimensions

### TO-262 3L (I<sup>2</sup>PAK)



#### NOTES:

- A. EXCEPT WHERE NOTED CONFORMS TO TO262 JEDEC VARIATION AA.
- $\triangle B$  DOES NOT COMPLY JEDEC 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 ANSI Y14.5-1994.
- F. LOCATION OF PIN HOLE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF PACKAGE)
- G. MAXIMUM WIDTH FOR F102 DEVICE = 1.35 MAX.
- H. DRAWING FILE NAME: TO262A03REV5

**Figure 22. 3LD, TO262, Jedec Variation AA (I<sup>2</sup>PAK)**

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Dimension in Millimeters

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