NTD3055L170

Power MOSFET

9.0 Amps, 60 Volts, Logic Level, N−Channel DPAK

Designed for low voltage, high speed switching applications in power supplies, converters and power motor controls and bridge circuits.

Features

- Pb−Free Packages are Available

Typical Applications

- Power Supplies
- Converters
- Power Motor Controls
- Bridge Circuits

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain−to−Source Voltage	V_{DSS}	60	Vdc
Drain−to−Gate Voltage (R_{GS} = 10 MΩ)	V_{DGR}	60	Vdc
Gate−to−Source Voltage – Continuous – Non−repetitive ($t_p \leq$ 10 ms)	 V_{GS} V_{GS}	 ±15 ±20	Vdc
Drain Current – Continuous @ T_A = 25°C – Continuous @ T_A = 100°C – Single Pulse ($t_p \leq$ 10 μs)	 I_D I_D I_{DM}	 9.0 3.0 27	Adc Apk
Total Power Dissipation @ T_A = 25°C Derate above 25°C Total Power Dissipation @ T_A = 25°C (Note 1) Total Power Dissipation @ T_A = 25°C (Note 2)	P_D	28.5 0.19 2.1 1.5	W W/°C W W
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 175	°C
Single Pulse Drain−to−Source Avalanche Energy – Starting T_J = 25°C (V_{DD} = 25 Vdc, V_{GS} = 5.0 Vdc, L = 1.0 mH, I_L(pk) = 7.75 A, V_{DS} = 60 Vdc)	E_{AS}	30	mJ
Thermal Resistance – Junction−to−Case – Junction−to−Ambient (Note 1) – Junction−to−Ambient (Note 2)	 $R_{\theta JC}$ $R_{\theta JA}$ $R_{\theta JA}$	 5.2 71.4 100	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8″ from case for 10 seconds	T_L	260	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.
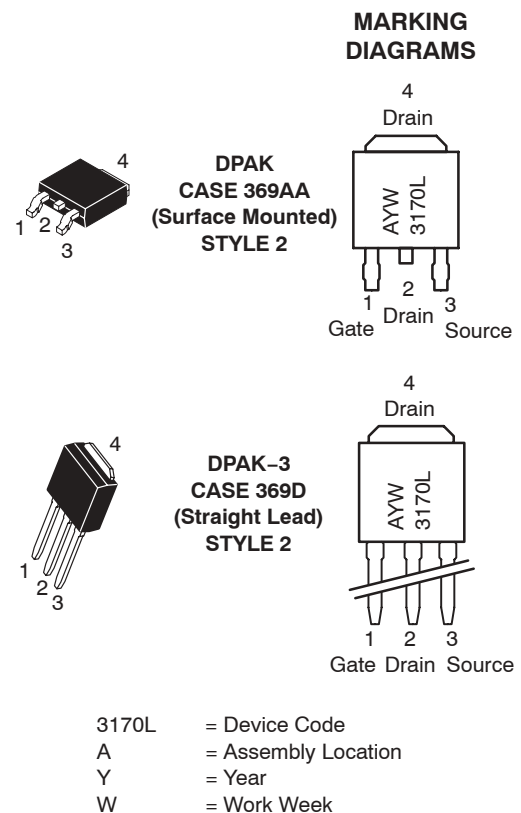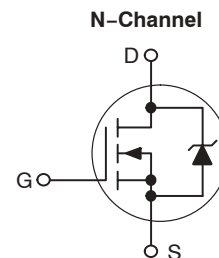
1. When surface mounted to an FR4 board using 0.5 sq in pad size.
2. When surface mounted to an FR4 board using minimum recommended pad size.

9.0 AMPERES, 60 VOLTS
$R_{DS(on)}$ = 170 mΩ

N−Channel

MARKING DIAGRAMS

DPAK
CASE 369AA
(Surface Mounted)
STYLE 2

AYW
3170L

4
Drain

1
Gate

2
Drain

3
Source

DPAK−3
CASE 369D
(Straight Lead)
STYLE 2

AYW
3170L

4
Drain

1
Gate

2
Drain

3
Source

3170L	= Device Code
A	= Assembly Location
Y	= Year
W	= Work Week

ORDERING INFORMATION

NTD3055L170

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain−to−Source Breakdown Voltage (Note 3)	$V_{(BR)DSS}$	60	–	–	Vdc
(V_{GS} = 0 Vdc, I_D = 250 μAdc)					
Temperature Coefficient (Positive)		–	53.6	–	mV/°C
Zero Gate Voltage Drain Current	I_{DSS}				μAdc
(V_{DS} = 60 Vdc, V_{GS} = 0 Vdc)		–	–	1.0	
(V_{DS} = 60 Vdc, V_{GS} = 0 Vdc, T_J = 150°C)		–	–	10	
Gate−Body Leakage Current (V_{GS} = ±15 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	–	–	±100	nAdc
ON CHARACTERISTICS (Note 3)					
Gate Threshold Voltage (Note 3)	$V_{GS(th)}$	1.0	1.7	2.0	Vdc
(V_{DS} = V_{GS}, I_D = 250 μAdc)					
Threshold Temperature Coefficient (Negative)		–	4.2	–	mV/°C
Static Drain−to−Source On−Resistance (Note 3)	$R_{DS(on)}$				mΩ
(V_{GS} = 5.0 Vdc, I_D = 4.5 Adc)		–	153	170	
Static Drain−to−Source On−Voltage (Note 3)	$V_{DS(on)}$				Vdc
(V_{GS} = 5.0 Vdc, I_D = 9.0 Adc)		–	1.8	2.1	
(V_{GS} = 5.0 Vdc, I_D = 4.5 Adc, T_J = 150°C)		–	1.3	–	
Forward Transconductance (Note 3) (V_{DS} = 8.0 Vdc, I_D = 6.0 Adc)	g_{FS}	–	7.3	–	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	C_{iss}	–	195	275	pF
Output Capacitance	C_{oss}	–	70	100	
Transfer Capacitance	C_{rss}	–	29	42	
SWITCHING CHARACTERISTICS (Note 4)					
Turn−On Delay Time	$t_{d(on)}$	–	9.7	20	ns
Rise Time	t_r	–	69	150	
Turn−Off Delay Time	$t_{d(off)}$	–	10	20	
Fall Time	t_f	–	38	80	
Gate Charge	Q_T	–	4.7	10	nC
	Q_1	–	1.4	–	
	Q_2	–	2.9	–	
SOURCE−DRAIN DIODE CHARACTERISTICS					
Forward On−Voltage (I_S = 9.0 Adc, V_{GS} = 0 Vdc) (Note 3)	V_{SD}	–	0.98	1.25	Vdc
(I_S = 9.0 Adc, V_{GS} = 0 Vdc, T_J = 150°C)		–	0.85	–	
Reverse Recovery Time	t_{rr}	–	29.8	–	ns
	t_a	–	17.6	–	
	t_b	–	12.2	–	
Reverse Recovery Stored Charge	Q_{RR}	–	0.031	–	μC

Dynamic characteristics conditions: (V_{DS} = 25 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)

Switching characteristics conditions: (V_{DD} = 30 Vdc, I_D = 9.0 Adc, V_{GS} = 5.0 Vdc, R_G = 9.1 Ω) (Note 3)

Gate charge conditions: (V_{DS} = 48 Vdc, I_D = 9.0 Adc, V_{GS} = 5.0 Vdc) (Note 3)

Reverse recovery conditions: (I_S = 9.0 Adc, V_{GS} = 0 Vdc, dI$_S$/dt = 100 A/μs) (Note 3)

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
4. Switching characteristics are independent of operating junction temperatures.

ORDERING INFORMATION

Device	Package	Shipping[†]
NTD3055L170	DPAK	75 Units/Rail
NTD3055L170G	DPAK (Pb−Free)	75 Units/Rail
NTD3055L170−1	DPAK−3	75 Units/Rail
NTD3055L170−1G	DPAK−3 (Pb−Free)	75 Units/Rail
NTD3055L170T4	DPAK	2500 Tape & Reel
NTD3055L170T4G	DPAK (Pb−Free)	2500 Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
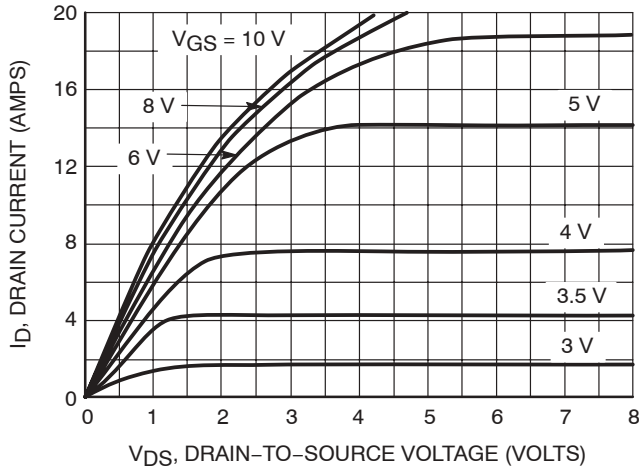
NTD3055L170

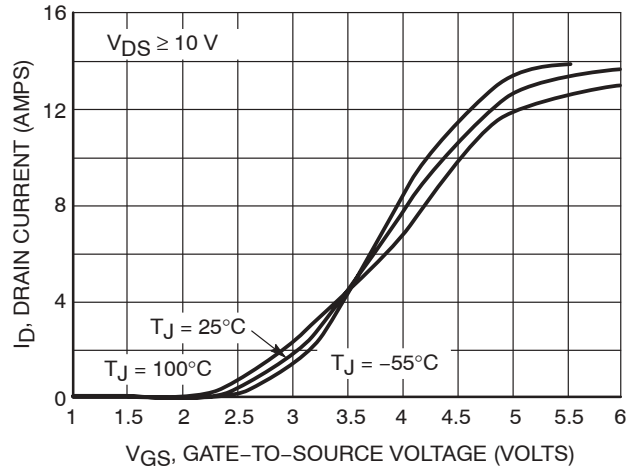Figure 1. On−Region Characteristics
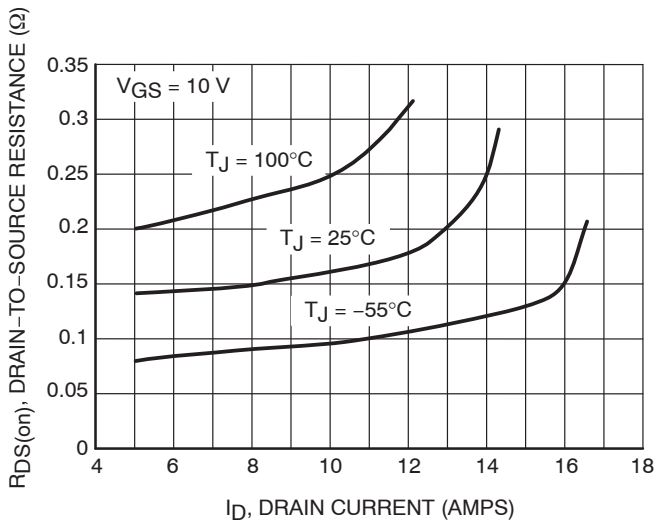

Figure 2. Transfer Characteristics

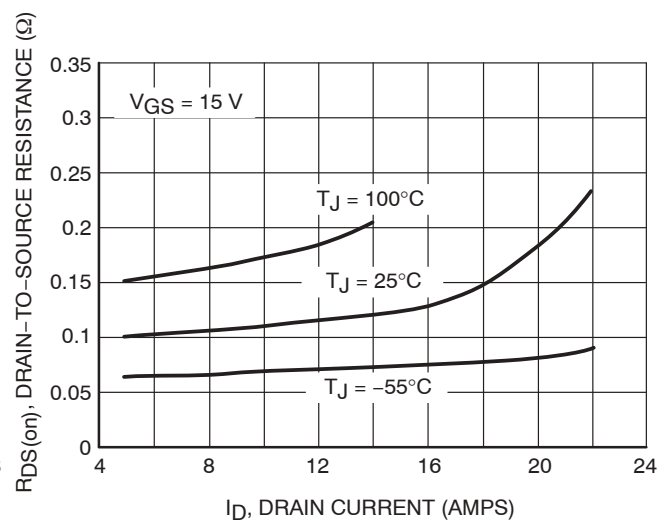Figure 3. On−Resistance versus
Gate−to−Source Voltage

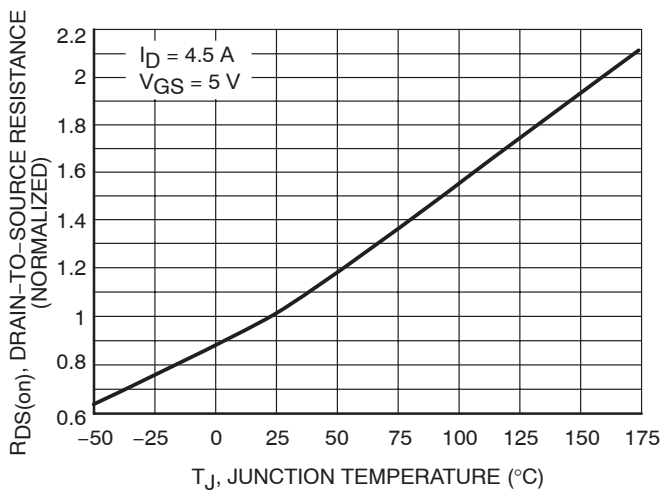Figure 4. On−Resistance versus Drain Current
and Gate Voltage

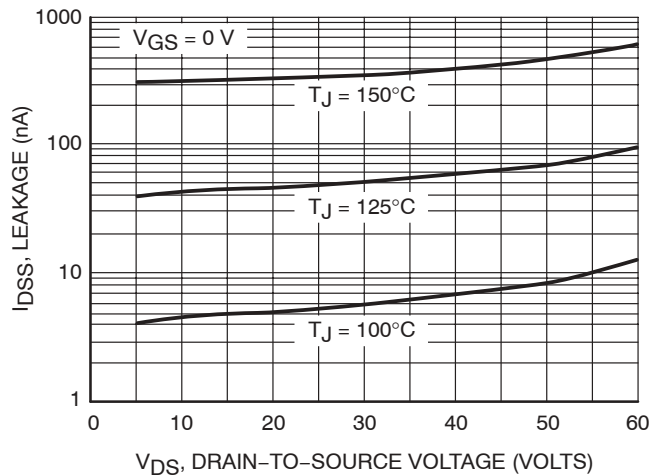Figure 5. On−Resistance Variation with
Temperature

Figure 6. Drain−to−Source Leakage Current
versus Voltage

POWER MOSFET SWITCHING

Switching behavior is most easily modeled and predicted by recognizing that the power MOSFET is charge controlled. The lengths of various switching intervals (Δt) are determined by how fast the FET input capacitance can be charged by current from the generator.

The published capacitance data is difficult to use for calculating rise and fall because drain−gate capacitance varies greatly with applied voltage. Accordingly, gate charge data is used. In most cases, a satisfactory estimate of average input current ($I_{G(AV)}$) can be made from a rudimentary analysis of the drive circuit so that

$t = Q/I_{G(AV)}$

During the rise and fall time interval when switching a resistive load, V_{GS} remains virtually constant at a level known as the plateau voltage, V_{SGP}. Therefore, rise and fall times may be approximated by the following:

$t_r = Q_2 \times R_G/(V_{GG} − V_{GSP})$

$t_f = Q_2 \times R_G/V_{GSP}$

where

V_{GG} = the gate drive voltage, which varies from zero to V_{GG}

R_G = the gate drive resistance

and Q_2 and V_{GSP} are read from the gate charge curve.

During the turn−on and turn−off delay times, gate current is not constant. The simplest calculation uses appropriate values from the capacitance curves in a standard equation for voltage change in an RC network. The equations are:

$t_{d(on)} = R_G\, C_{iss}\, \ln\, [V_{GG}/(V_{GG} − V_{GSP})]$

$t_{d(off)} = R_G\, C_{iss}\, \ln\, (V_{GG}/V_{GSP})$

The capacitance (C_{iss}) is read from the capacitance curve at a voltage corresponding to the off−state condition when calculating $t_{d(on)}$ and is read at a voltage corresponding to the on−state when calculating $t_{d(off)}$.

At high switching speeds, parasitic circuit elements complicate the analysis. The inductance of the MOSFET source lead, inside the package and in the circuit wiring which is common to both the drain and gate current paths, produces a voltage at the source which reduces the gate drive current. The voltage is determined by Ldi/dt, but since di/dt is a function of drain current, the mathematical solution is complex. The MOSFET output capacitance also complicates the mathematics. And finally, MOSFETs have finite internal gate resistance which effectively adds to the resistance of the driving source, but the internal resistance is difficult to measure and, consequently, is not specified.

The resistive switching time variation versus gate resistance (Figure 9) shows how typical switching performance is affected by the parasitic circuit elements. If the parasitics were not present, the slope of the curves would maintain a value of unity regardless of the switching speed. The circuit used to obtain the data is constructed to minimize common inductance in the drain and gate circuit loops and is believed readily achievable with board mounted components. Most power electronic loads are inductive; the data in the figure is taken with a resistive load, which approximates an optimally snubbed inductive load. Power MOSFETs may be safely operated into an inductive load; however, snubbing reduces switching losses.
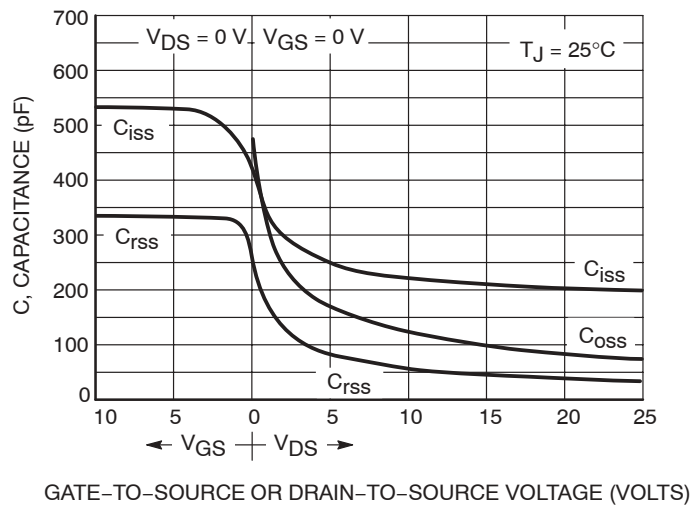
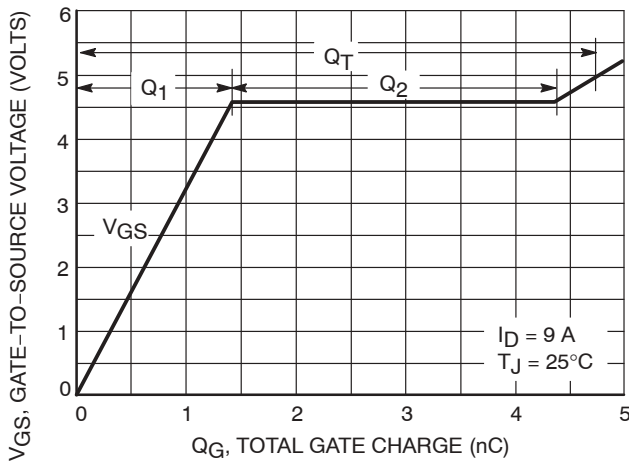

Figure 7. Capacitance Variation

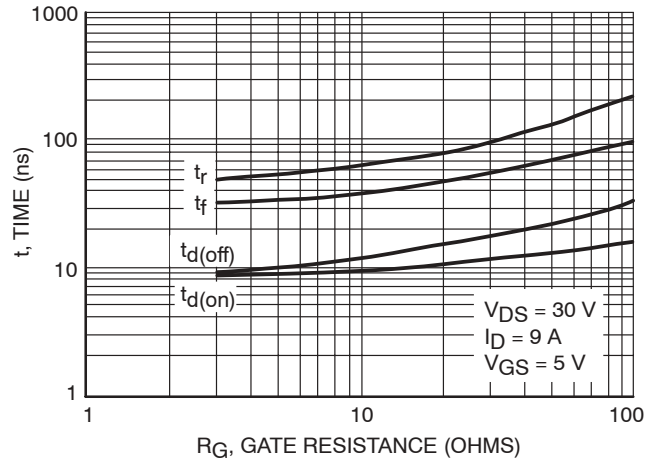Figure 8. Gate−To−Source and Drain−To−Source Voltage versus Total Charge

Figure 9. Resistive Switching Time Variation versus Gate Resistance
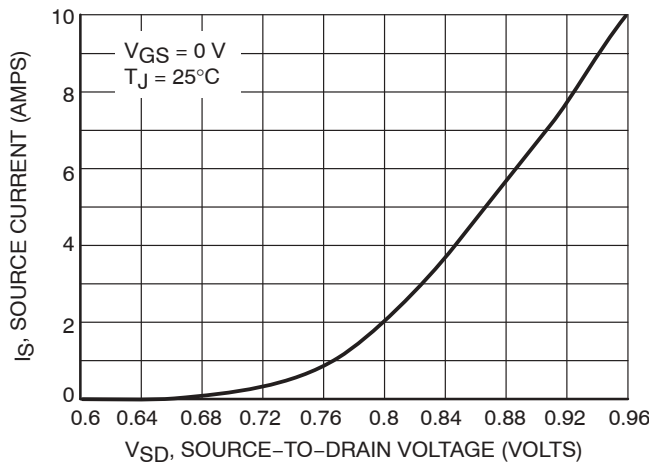
DRAIN−TO−SOURCE DIODE CHARACTERISTICS

Figure 10. Diode Forward Voltage versus Current

SAFE OPERATING AREA

The Forward Biased Safe Operating Area curves define the maximum simultaneous drain−to−source voltage and drain current that a transistor can handle safely when it is forward biased. Curves are based upon maximum peak junction temperature and a case temperature (T_C) of 25°C. Peak repetitive pulsed power limits are determined by using the thermal response data in conjunction with the procedures discussed in AN569, "Transient Thermal Resistance − General Data and Its Use."

Switching between the off−state and the on−state may traverse any load line provided neither rated peak current (I_{DM}) nor rated voltage (V_{DSS}) is exceeded and the transition time (t_r, t_f) do not exceed 10 μs. In addition the total power averaged over a complete switching cycle must not exceed ($T_{J(MAX)} − T_C)/(R_{θJC})$.

A Power MOSFET designated E−FET can be safely used in switching circuits with unclamped inductive loads. For reliable operation, the stored energy from circuit inductance dissipated in the transistor while in avalanche must be less than the rated limit and adjusted for operating conditions differing from those specified. Although industry practice is to rate in terms of energy, avalanche energy capability is not a constant. The energy rating decreases non−linearly with an increase of peak current in avalanche and peak junction temperature.

Although many E−FETs can withstand the stress of drain−to−source avalanche at currents up to rated pulsed current (I_{DM}), the energy rating is specified at rated continuous current (I_D), in accordance with industry custom. The energy rating must be derated for temperature as shown in the accompanying graph (Figure 12). Maximum energy at currents below rated continuous I_D can safely be assumed to equal the values indicated.
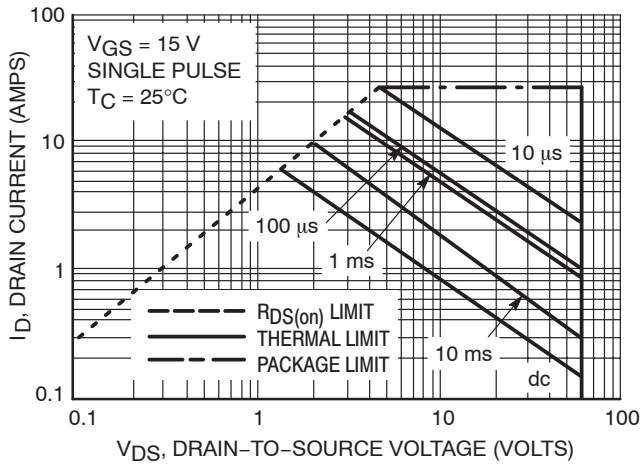
SAFE OPERATING AREA

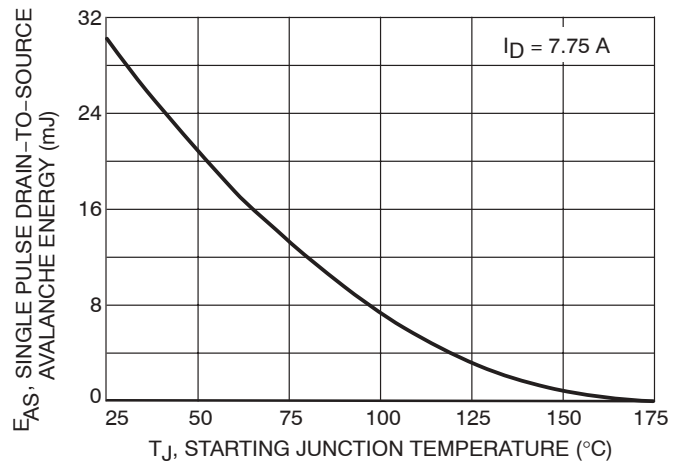**Figure 11. Maximum Rated Forward Biased Safe Operating Area**

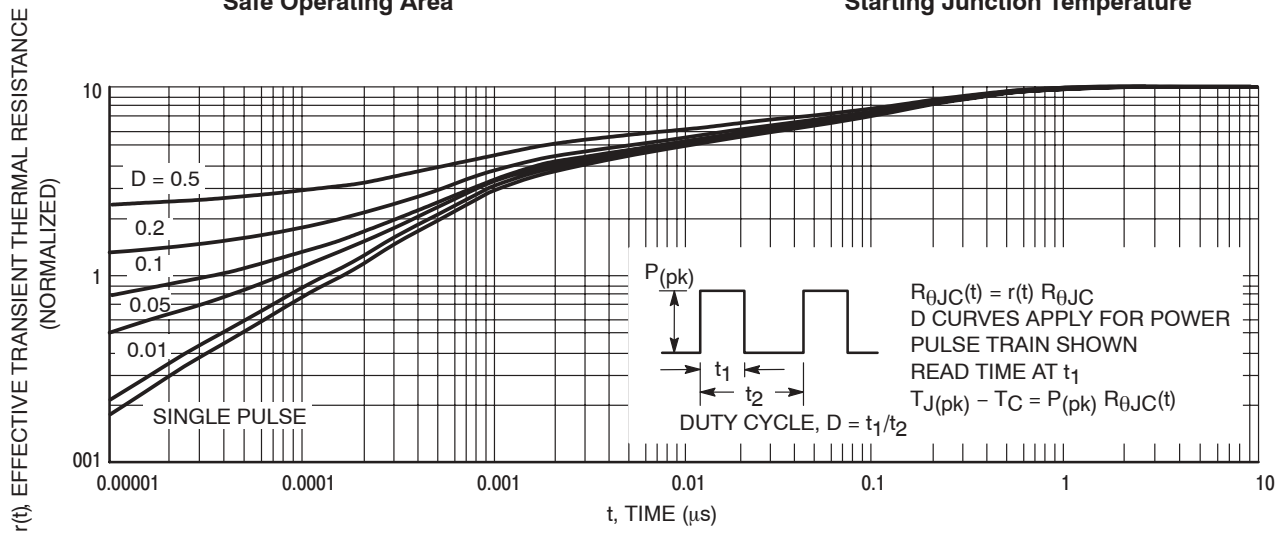**Figure 12. Maximum Avalanche Energy versus Starting Junction Temperature**

$$R_{\theta JC}(t) = r(t) R_{\theta JC}$$
D CURVES APPLY FOR POWER
PULSE TRAIN SHOWN
READ TIME AT t_1
$$T_{J(pk)} - T_C = P_{(pk)} R_{\theta JC}(t)$$
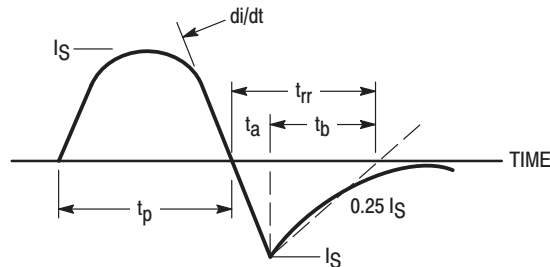
DUTY CYCLE, $D = t_1/t_2$

Figure 13. Thermal Response

Figure 14. Diode Reverse Recovery Waveform