

# MTP50P03HDLG

## Power MOSFET

### 50 Amps, 30 Volts, Logic Level P-Channel TO-220

This Power MOSFET is designed to withstand high energy in the avalanche and commutation modes. The energy efficient design also offers a drain-to-source diode with a fast recovery time. Designed for low voltage, high speed switching applications in power supplies, converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating areas are critical and offer additional safety margin against unexpected voltage transients.

#### Features

- Avalanche Energy Specified
- Source-to-Drain Diode Recovery Time Comparable to a Discrete Fast Recovery Diode
- Diode is Characterized for Use in Bridge Circuits
- $I_{DSS}$  and  $V_{DS(on)}$  Specified at Elevated Temperature
- These are Pb-Free Devices\*

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

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	30	Vdc
Drain-Gate Voltage ( $R_{GS} = 1.0\text{ M}\Omega$ )	$V_{DGR}$	30	Vdc
Gate-Source Voltage – Continuous – Non-Repetitive ( $t_p \leq 10\text{ ms}$ )	$V_{GS}$ $V_{GSM}$	$\pm 15$ $\pm 20$	Vdc Vpk
Drain Current – Continuous – Continuous @ $100^\circ\text{C}$ – Single Pulse ( $t_p \leq 10\text{ }\mu\text{s}$ )	$I_D$ $I_D$ $I_{DM}$	50 31 150	Adc Adc Apk
Total Power Dissipation Derate above $25^\circ\text{C}$	$P_D$	125 1.0	W W/ $^\circ\text{C}$
Operating and Storage Temperature Range	$T_J, T_{stg}$	$-55$ to $150$	$^\circ\text{C}$
Single Pulse Drain-to-Source Avalanche Energy – Starting $T_J = 25^\circ\text{C}$ ( $V_{DD} = 25\text{ Vdc}$ , $V_{GS} = 5.0\text{ Vdc}$ , Peak $I_L = 50\text{ Apk}$ , $L = 1.0\text{ mH}$ , $R_G = 25\text{ }\Omega$ )	$E_{AS}$	1250	mJ
Thermal Resistance, Junction-to-Case Junction-to-Ambient, when mounted with the minimum recommended pad size	$R_{\theta JC}$ $R_{\theta JA}$	1.0 62.5	$^\circ\text{C/W}$
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 10 seconds	$T_L$	260	$^\circ\text{C}$

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.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

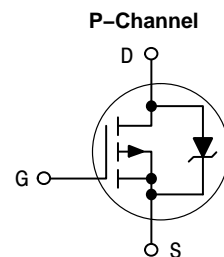


ON Semiconductor®

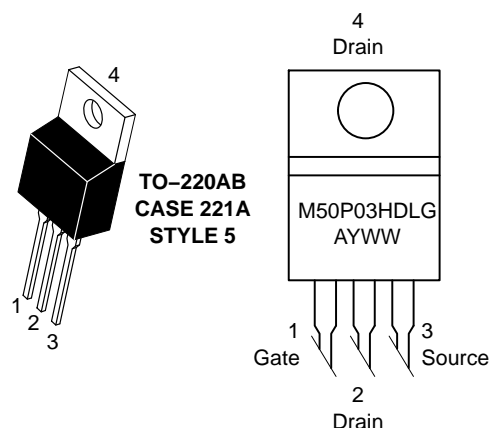
[www.onsemi.com](http://www.onsemi.com)

50 AMPERES, 30 VOLTS

$R_{DS(on)} = 25\text{ m}\Omega$



#### MARKING DIAGRAM & PIN ASSIGNMENT



M50P03HDL = Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

#### ORDERING INFORMATION

Device	Package	Shipping
MTP50P03HDLG	TO-220AB (Pb-Free)	50 Units/Rail

# MTP50P03HDLG

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

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Drain-to-Source Breakdown Voltage (V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc) Temperature Coefficient (Positive)	V <sub>(BR)DSS</sub>	30 –	– 26	– –	Vdc mV/°C	
Zero Gate Voltage Drain Current (V <sub>DS</sub> = 30 Vdc, V <sub>GS</sub> = 0 Vdc) (V <sub>DS</sub> = 30 Vdc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 125°C)	I <sub>DSS</sub>	– –	– –	1.0 10	μAdc	
Gate-Body Leakage Current (V <sub>GS</sub> = ± 15 Vdc, V <sub>DS</sub> = 0 Vdc)	I <sub>GSS</sub>	–	–	100	nAdc	
ON CHARACTERISTICS (Note 1)						
Gate Threshold Voltage (V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μAdc) Threshold Temperature Coefficient (Negative)	V <sub>GS(th)</sub>	1.0 –	1.5 4.0	2.0 –	Vdc mV/°C	
Static Drain-to-Source On-Resistance (V <sub>GS</sub> = 5.0 Vdc, I <sub>D</sub> = 25 Adc)	R <sub>DS(on)</sub>	–	0.020	0.025	Ω	
Drain-to-Source On-Voltage (V <sub>GS</sub> = 10 Vdc) (I <sub>D</sub> = 50 Adc) (I <sub>D</sub> = 25 Adc, T <sub>J</sub> = 125°C)	V <sub>DS(on)</sub>	– –	0.83 –	1.5 1.3	Vdc	
Forward Transconductance (V <sub>DS</sub> = 5.0 Vdc, I <sub>D</sub> = 25 Adc)	g <sub>FS</sub>	15	20	–	mhos	
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V <sub>DS</sub> = 25 Vdc, V <sub>GS</sub> = 0 Vdc, f = 1.0 MHz)	C <sub>iss</sub>	–	3500	4900	pF
Output Capacitance		C <sub>oss</sub>	–	1550	2170	
Transfer Capacitance		C <sub>rss</sub>	–	550	770	
SWITCHING CHARACTERISTICS (Note 2)						
Turn-On Delay Time	(V <sub>DD</sub> = 15 Vdc, I <sub>D</sub> = 50 Adc, V <sub>GS</sub> = 5.0 Vdc, R <sub>G</sub> = 2.3 Ω)	t <sub>d(on)</sub>	–	22	30	ns
Rise Time		t <sub>r</sub>	–	340	466	
Turn-Off Delay Time		t <sub>d(off)</sub>	–	90	117	
Fall Time		t <sub>f</sub>	–	218	300	
Gate Charge (See Figure 8)	(V <sub>DS</sub> = 24 Vdc, I <sub>D</sub> = 50 Adc, V <sub>GS</sub> = 5.0 Vdc)	Q <sub>T</sub>	–	74	100	nC
		Q <sub>1</sub>	–	13.6	–	
		Q <sub>2</sub>	–	44.8	–	
		Q <sub>3</sub>	–	35	–	
SOURCE-DRAIN DIODE CHARACTERISTICS						
Forward On-Voltage	(I <sub>S</sub> = 50 Adc, V <sub>GS</sub> = 0 Vdc) (I <sub>S</sub> = 50 Adc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 125°C)	V <sub>SD</sub>	– –	2.39 1.84	3.0 –	Vdc
Reverse Recovery Time (See Figure 15)	(I <sub>S</sub> = 50 Adc, V <sub>GS</sub> = 0 Vdc, dI <sub>S</sub> /dt = 100 A/μs)	t <sub>rr</sub>	–	106	–	ns
		t <sub>a</sub>	–	58	–	
		t <sub>b</sub>	–	48	–	
Reverse Recovery Stored Charge		Q <sub>RR</sub>	–	0.246	–	μC
INTERNAL PACKAGE INDUCTANCE						
Internal Drain Inductance (Measured from contact screw on tab to center of die) (Measured from the drain lead 0.25" from package to center of die)	L <sub>D</sub>	– –	3.5 4.5	– –	nH	
Internal Source Inductance (Measured from the source lead 0.25" from package to source bond pad)	L <sub>S</sub>	–	7.5	–	nH	

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
2. Switching characteristics are independent of operating junction temperature.
3. Reflects typical values.  $C_{pk} = \left| \frac{\text{Max limit} - \text{Typ}}{3 \times \text{SIGMA}} \right|$

TYPICAL ELECTRICAL CHARACTERISTICS

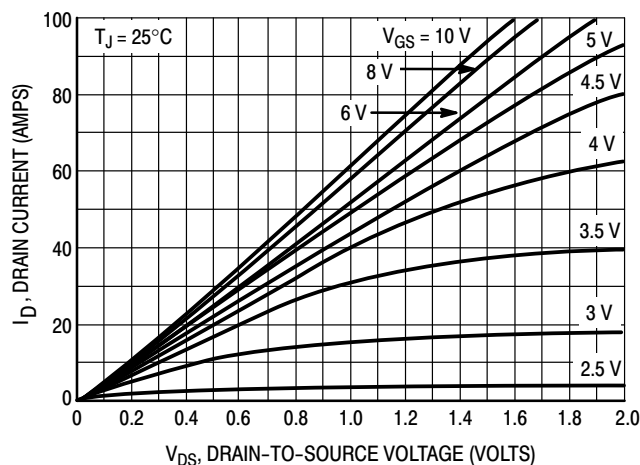


Figure 1. On-Region Characteristics

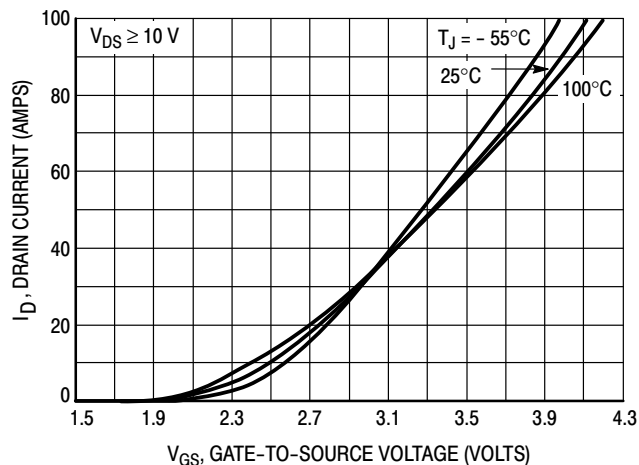


Figure 2. Transfer Characteristics

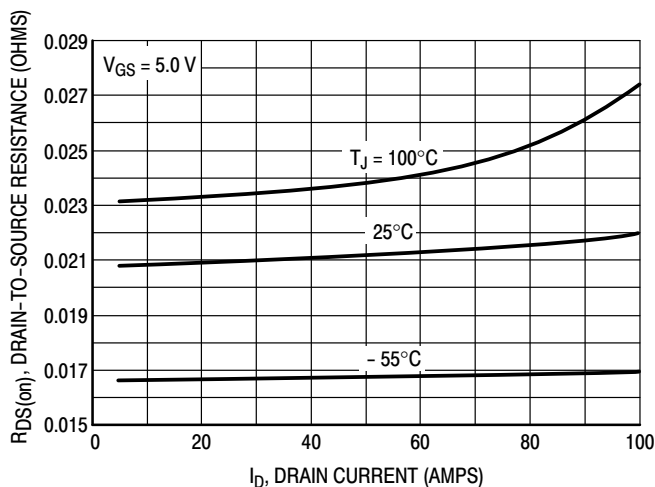


Figure 3. On-Resistance versus Drain Current and Temperature

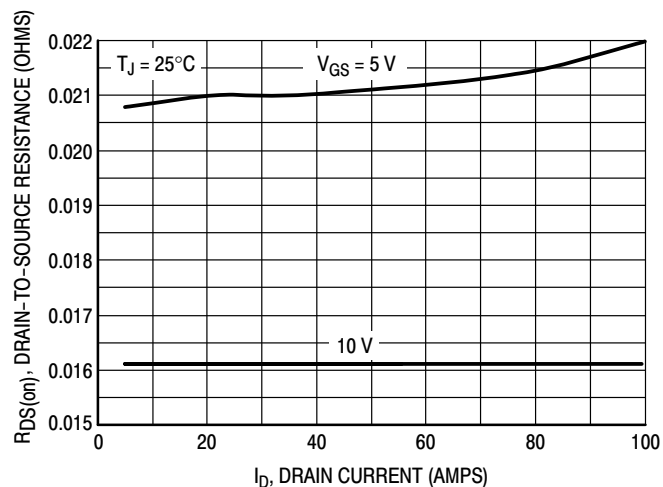


Figure 4. On-Resistance versus Drain Current and Gate Voltage

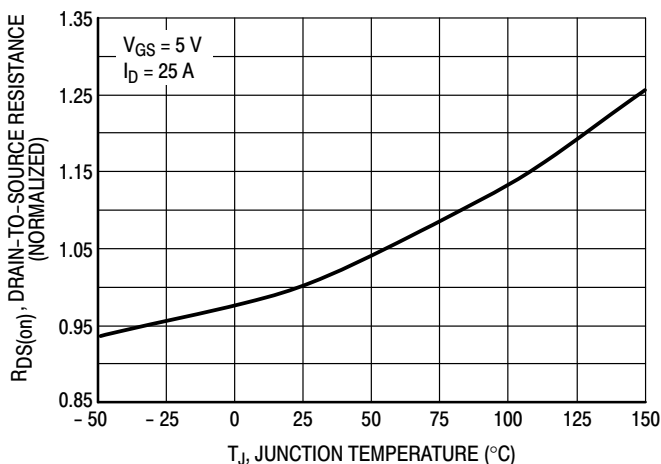


Figure 5. On-Resistance Variation with Temperature

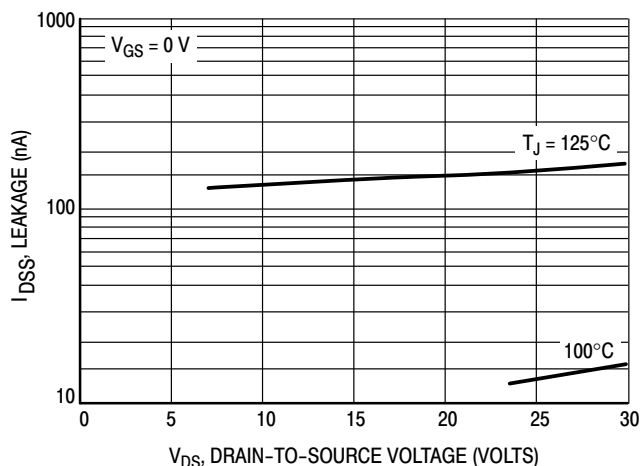


Figure 6. Drain-To-Source Leakage Current versus Voltage

## 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 ( $\Delta t$ ) 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,  $V_{GSP}$ . 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  $L di/dt$ , 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.

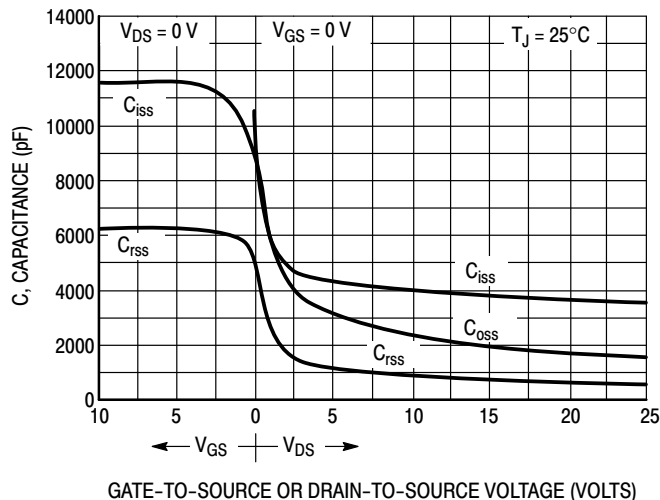


Figure 7. Capacitance Variation

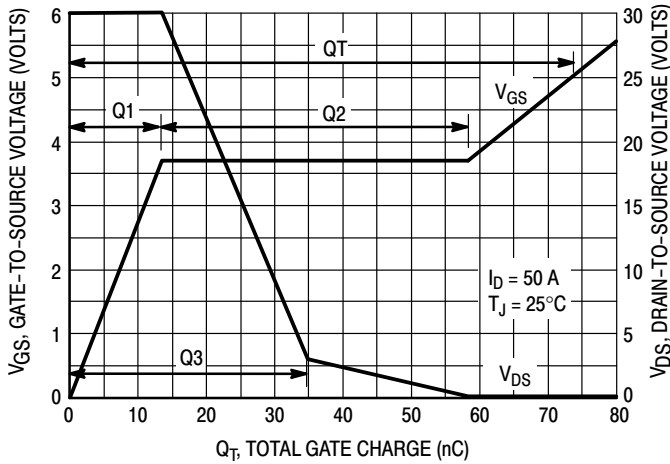


Figure 8. Gate-To-Source and Drain-To-Source Voltage versus Total Charge

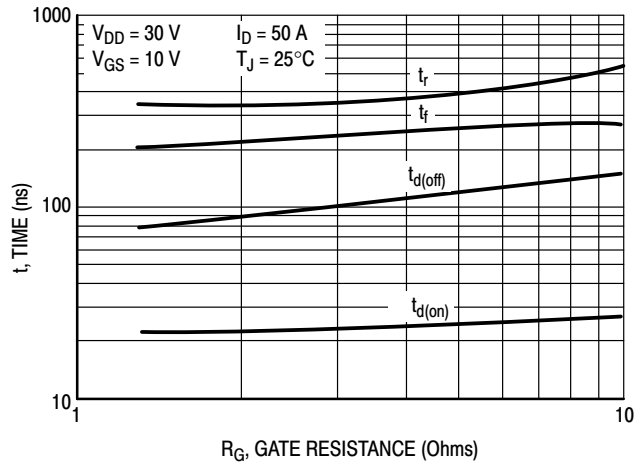


Figure 9. Resistive Switching Time Variation versus Gate Resistance

### DRAIN-TO-SOURCE DIODE CHARACTERISTICS

The switching characteristics of a MOSFET body diode are very important in systems using it as a freewheeling or commutating diode. Of particular interest are the reverse recovery characteristics which play a major role in determining switching losses, radiated noise, EMI and RFI.

System switching losses are largely due to the nature of the body diode itself. The body diode is a minority carrier device, therefore it has a finite reverse recovery time,  $t_{rr}$ , due to the storage of minority carrier charge,  $Q_{RR}$ , as shown in the typical reverse recovery wave form of Figure 12. It is this stored charge that, when cleared from the diode, passes through a potential and defines an energy loss. Obviously, repeatedly forcing the diode through reverse recovery further increases switching losses. Therefore, one would like a diode with short  $t_{rr}$  and low  $Q_{RR}$  specifications to minimize these losses.

The abruptness of diode reverse recovery effects the amount of radiated noise, voltage spikes, and current ringing. The mechanisms at work are finite irremovable circuit parasitic inductances and capacitances acted upon by

high  $di/dt$ s. The diode's negative  $di/dt$  during  $t_a$  is directly controlled by the device clearing the stored charge. However, the positive  $di/dt$  during  $t_b$  is an uncontrollable diode characteristic and is usually the culprit that induces current ringing. Therefore, when comparing diodes, the ratio of  $t_b/t_a$  serves as a good indicator of recovery abruptness and thus gives a comparative estimate of probable noise generated. A ratio of 1 is considered ideal and values less than 0.5 are considered snappy.

Compared to ON Semiconductor standard cell density low voltage MOSFETs, high cell density MOSFET diodes are faster (shorter  $t_{rr}$ ), have less stored charge and a softer reverse recovery characteristic. The softness advantage of the high cell density diode means they can be forced through reverse recovery at a higher  $di/dt$  than a standard cell MOSFET diode without increasing the current ringing or the noise generated. In addition, power dissipation incurred from switching the diode will be less due to the shorter recovery time and lower switching losses.

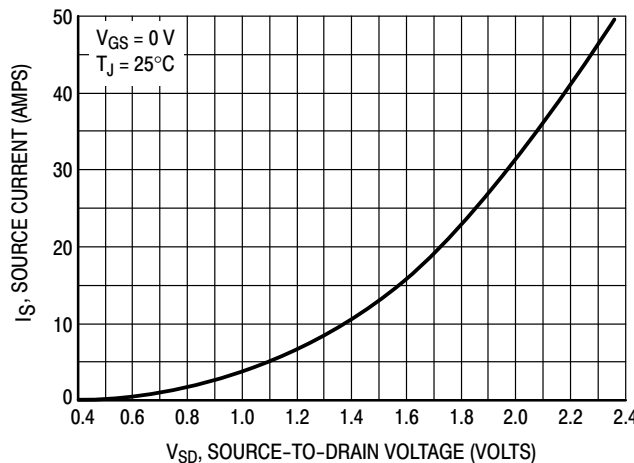


Figure 10. Diode Forward Voltage versus Current

## MTP50P03HDLG

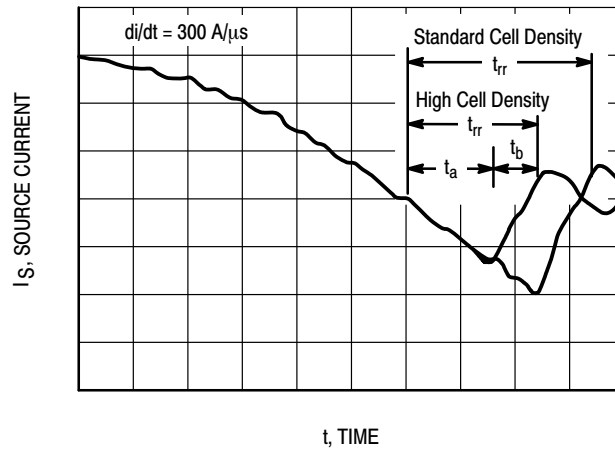


Figure 11. Reverse Recovery Time ( $t_{rr}$ )

## 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 that the transition time ( $t_r$ ,  $t_f$ ) does not exceed 10  $\mu$ s. In addition the total power averaged over a complete switching cycle must not exceed  $(T_{J(MAX)} - T_C)/(R_{\theta JC})$ .

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 must be 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 13). Maximum energy at currents below rated continuous  $I_D$  can safely be assumed to equal the values indicated.

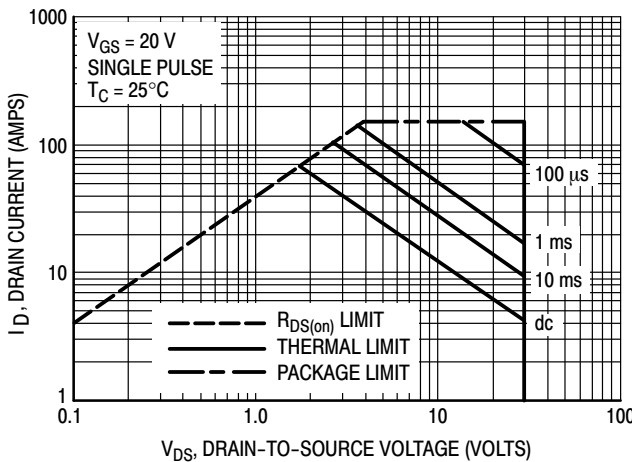


Figure 12. Maximum Rated Forward Biased Safe Operating Area

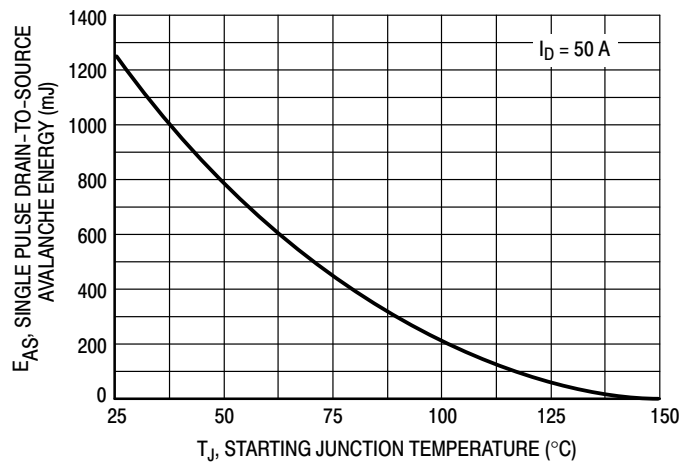


Figure 13. Maximum Avalanche Energy versus Starting Junction Temperature

# MTP50P03HDLG

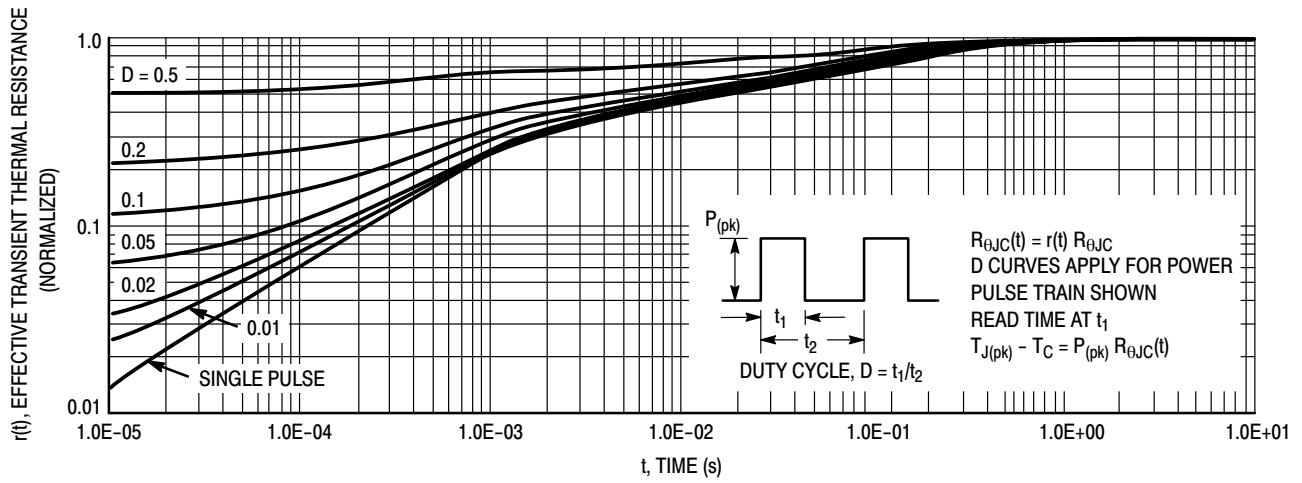


Figure 14. Thermal Response

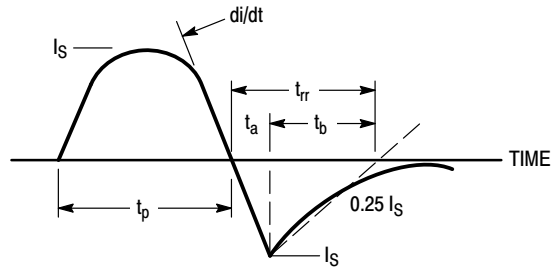
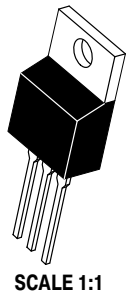


Figure 15. Diode Reverse Recovery Waveform

# MECHANICAL CASE OUTLINE

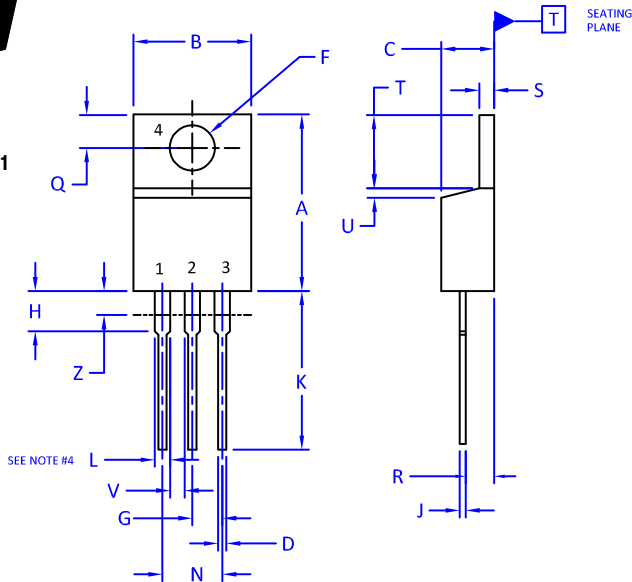
## PACKAGE DIMENSIONS

ON Semiconductor®



### TO-220 CASE 221A-09 ISSUE AJ

DATE 05 NOV 2019



#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 2009.
2. CONTROLLING DIMENSION: INCHES
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
4. MAX WIDTH FOR F102 DEVICE = 1.35MM

DIM	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.570	0.620	14.48	15.75
B	0.380	0.415	9.66	10.53
C	0.160	0.190	4.07	4.83
D	0.025	0.038	0.64	0.96
F	0.142	0.161	3.60	4.09
G	0.095	0.105	2.42	2.66
H	0.110	0.161	2.80	4.10
J	0.014	0.024	0.36	0.61
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.41
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	----	1.15	---
Z	----	0.080	---	2.04

#### STYLE 1:

- PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

#### STYLE 2:

- PIN 1. BASE  
2. EMITTER  
3. COLLECTOR  
4. EMITTER

#### STYLE 3:

- PIN 1. CATHODE  
2. ANODE  
3. GATE  
4. ANODE

#### STYLE 4:

- PIN 1. MAIN TERMINAL 1  
2. MAIN TERMINAL 2  
3. GATE  
4. MAIN TERMINAL 2

#### STYLE 5:

- PIN 1. GATE  
2. DRAIN  
3. SOURCE  
4. DRAIN

#### STYLE 6:

- PIN 1. ANODE  
2. CATHODE  
3. ANODE  
4. CATHODE

#### STYLE 7:

- PIN 1. CATHODE  
2. ANODE  
3. CATHODE  
4. ANODE

#### STYLE 8:

- PIN 1. CATHODE  
2. ANODE  
3. EXTERNAL TRIP/DELAY  
4. ANODE

#### STYLE 9:

- PIN 1. GATE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

#### STYLE 10:

- PIN 1. GATE  
2. SOURCE  
3. DRAIN  
4. SOURCE

#### STYLE 11:

- PIN 1. DRAIN  
2. SOURCE  
3. GATE  
4. SOURCE

#### STYLE 12:

- PIN 1. MAIN TERMINAL 1  
2. MAIN TERMINAL 2  
3. GATE  
4. NOT CONNECTED

DOCUMENT NUMBER: 98ASB42148B


Electronic versions are uncontrolled except when accessed directly from the Document Repository.  
Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.

DESCRIPTION: TO-220

PAGE 1 OF 1

ON Semiconductor and are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. ON Semiconductor does not convey any license under its patent rights nor the rights of others.



ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Email Requests to: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

ON Semiconductor Website: [www.onsemi.com](http://www.onsemi.com)

### TECHNICAL SUPPORT

North American Technical Support:

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative