

# MOTOROLA SEMICONDUCTOR TECHNICAL DATA

## Designer's Data Sheet Power Field Effect Transistor N-Channel Enhancement-Mode Silicon Gate

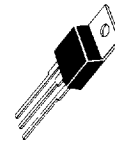
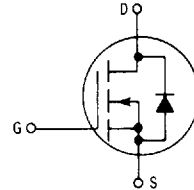
This TMOS Power FET is designed for high voltage, high speed power switching applications such as switching regulators, converters, solenoid and relay drivers.

- Silicon Gate for Fast Switching Speeds — Switching Times Specified at 100°C
- Designer's Data —  $I_{DSS}$ ,  $V_{DS(on)}$ ,  $V_{GS(th)}$  and SOA Specified at Elevated Temperature
- Rugged — SOA is Power Dissipation Limited
- Source-to-Drain Diode Characterized for Use With Inductive Loads



### MTP4N50

TMOS POWER FET  
4 AMPERES  
 $R_{DS(on)} = 1.5 \text{ OHMS}$   
500 VOLTS



CASE 221A-06  
TO-220AB

#### MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	500	Vdc
Drain-Gate Voltage ( $R_{GS} = 1 \text{ M}\Omega$ )	$V_{DGR}$	500	Vdc
Gate-Source Voltage — Continuous — Non-repetitive ( $t_p \leq 50 \mu\text{s}$ )	$V_{GS}$ $V_{GSM}$	$\pm 20$ $\pm 40$	Vdc Vpk
Drain Current Continuous Pulsed	$I_D$ $I_{DM}$	4 10	Adc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	75 0.6	Watts W/ $^\circ\text{C}$
Operating and Storage Temperature Range	$T_J, T_{stg}$	-65 to 150	$^\circ\text{C}$

#### THERMAL CHARACTERISTICS

Thermal Resistance Junction to Case Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	1.67 62.5	$^\circ\text{C}/\text{W}$
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds	$T_L$	260	$^\circ\text{C}$

Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

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

Characteristic	Symbol	Min	Max	Unit
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**OFF CHARACTERISTICS**

Drain-Source Breakdown Voltage ( $V_{GS} = 0, I_D = 0.25 \text{ mA}$ )	$V_{(BR)DSS}$	400	—	Vdc
Zero Gate Voltage Drain Current ( $V_{DS} = \text{Rated } V_{DSS}, V_{GS} = 0$ ) ( $V_{DS} = 0.8 \text{ Rated } V_{DSS}, V_{GS} = 0, T_J = 125^\circ\text{C}$ )	$I_{DSS}$	—	0.2 1	mAdc
Gate-Body Leakage Current, Forward ( $V_{GSF} = 20 \text{ Vdc}, V_{DS} = 0$ )	$I_{GSSF}$	—	100	nAdc
Gate-Body Leakage Current, Reverse ( $V_{GSR} = 20 \text{ Vdc}, V_{DS} = 0$ )	$I_{GSSR}$	—	100	nAdc

**ON CHARACTERISTICS\***

Gate Threshold Voltage ( $V_{DS} = V_{GS}, I_D = 1 \text{ mA}$ ) $T_J = 100^\circ\text{C}$	$V_{GS(th)}$	2 1.5	4.5 4	Vdc
Static Drain-Source On-Resistance ( $V_{GS} = 10 \text{ Vdc}, I_D = 2 \text{ Adc}$ )	$R_{DS(on)}$	—	1.5	Ohms
Drain-Source On-Voltage ( $V_{GS} = 10 \text{ V}$ ) ( $I_D = 4 \text{ Adc}$ ) ( $I_D = 2 \text{ Adc}, T_J = 100^\circ\text{C}$ )	$V_{DS(on)}$	—	7.5 6	Vdc
Forward Transconductance ( $V_{DS} = 15 \text{ V}, I_D = 2 \text{ A}$ )	$g_{FS}$	1.5	—	mhos

**DYNAMIC CHARACTERISTICS**

Input Capacitance	( $V_{DS} = 25 \text{ V}, V_{GS} = 0,$ $f = 1 \text{ MHz}$ ) See Figure 11	$C_{iss}$	—	1200	pF
Output Capacitance		$C_{oss}$	—	300	
Reverse Transfer Capacitance		$C_{rss}$	—	80	

**SWITCHING CHARACTERISTICS\*** ( $T_J = 100^\circ\text{C}$ )

Turn-On Delay Time	( $V_{DD} = 25 \text{ V}, I_D = 0.5 \text{ Rated } I_D$ $R_{gen} = 50 \text{ ohms}$ ) See Figures 9, 13 and 14	$t_{d(on)}$	—	50	ns
Rise Time		$t_r$	—	100	
Turn-Off Delay Time		$t_{d(off)}$	—	200	
Fall Time		$t_f$	—	100	
Total Gate Charge	( $V_{DS} = 0.8 \text{ Rated } V_{DSS},$ $I_D = \text{Rated } I_D, V_{GS} = 10 \text{ V}$ ) See Figure 12	$Q_g$	27 (Typ)	32	nC
Gate-Source Charge		$Q_{gs}$	17 (Typ)	—	
Gate-Drain Charge		$Q_{gd}$	10 (Typ)	—	

**SOURCE DRAIN DIODE CHARACTERISTICS\***

Forward On-Voltage	( $I_S = \text{Rated } I_D$ $V_{GS} = 0$ )	$V_{SD}$	1.1 (Typ)	1.4	Vdc
Forward Turn-On Time		$t_{on}$	Limited by stray inductance		
Reverse Recovery Time		$t_{rr}$	210 (Typ)	—	ns

**INTERNAL PACKAGE INDUCTANCE (TO-220)**

Internal Drain Inductance (Measured from the contact screw on tab to center of die) (Measured from the drain lead 0.25" from package to center of die)	$L_d$	3.5 (Typ) 4.5 (Typ)	—	nH
Internal Source Inductance (Measured from the source lead 0.25" from package to source bond pad.)	$L_s$	7.5 (Typ)	—	

\*Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

TYPICAL ELECTRICAL CHARACTERISTICS

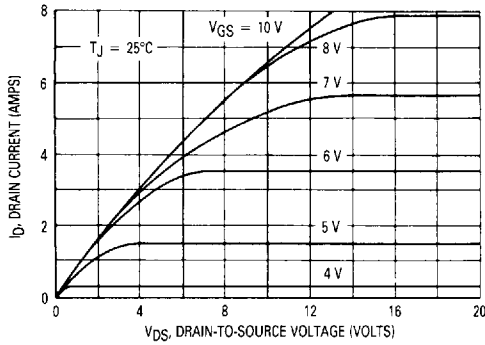


Figure 1. On-Region Characteristics

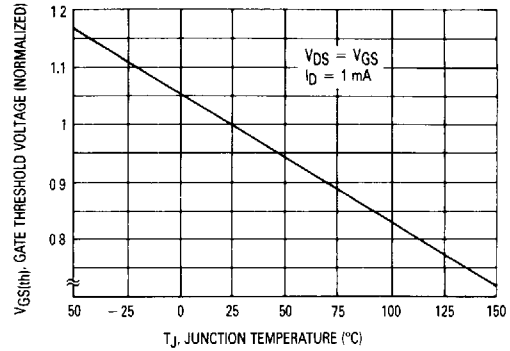


Figure 2. Gate-Threshold Voltage Variation With Temperature

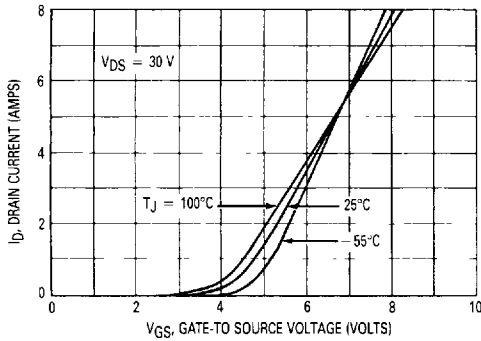


Figure 3. Transfer Characteristics

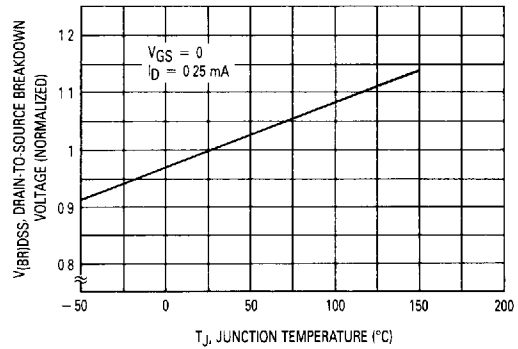


Figure 4. Breakdown Voltage Variation With Temperature

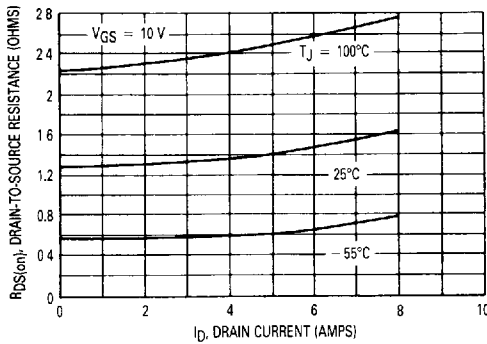


Figure 5. On-Resistance versus Drain Current

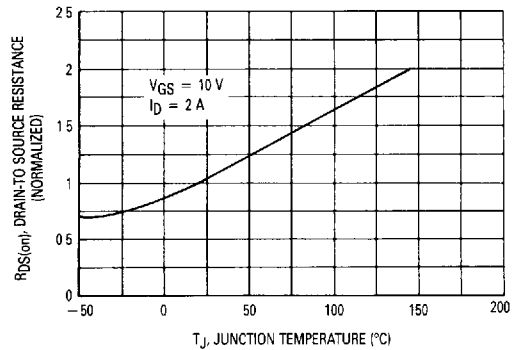


Figure 6. On-Resistance Variation With Temperature

SAFE OPERATING AREA INFORMATION

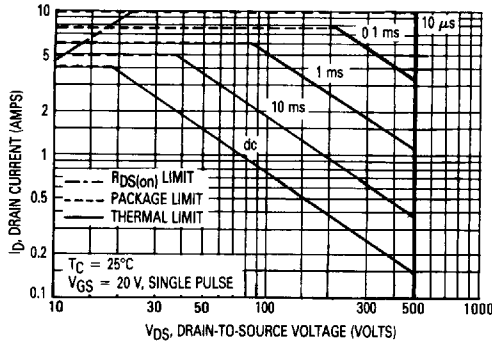


Figure 7. Maximum Rated Forward Biased Safe Operating Area

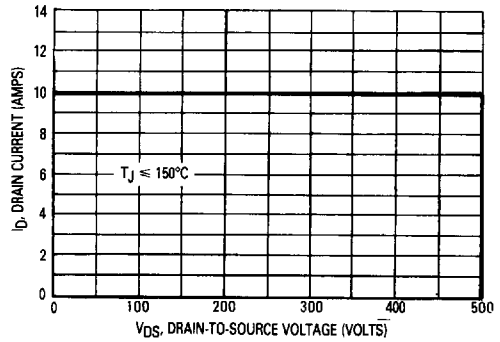


Figure 8. Maximum Rated Switching Safe Operating Area

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a case temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various case temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) of Figure 8 is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current,  $I_{DM}$  and the breakdown voltage,  $V_{(BR)DSS}$ . The switching SOA shown in Figure 8 is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

The power averaged over a complete switching cycle must be less than:

$$\frac{T_J(max) - T_C}{R_{\theta JC}}$$

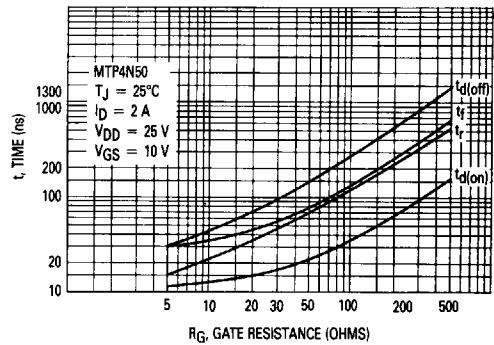


Figure 9. Resistive Switching Time Variation versus Gate Resistance

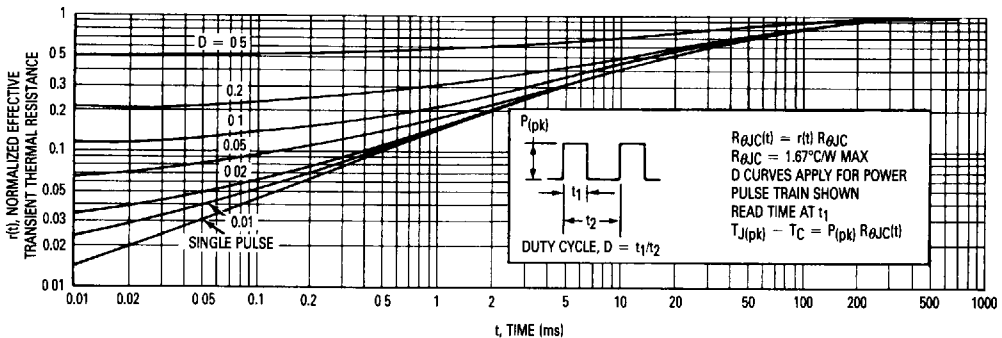


Figure 10. Thermal Response

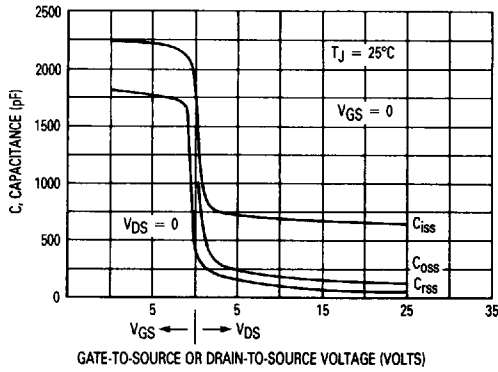


Figure 11. Capacitance Variation

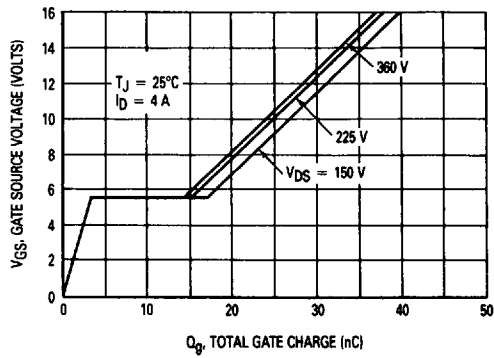


Figure 12. Gate Charge versus Gate-to-Source Voltage

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RESISTIVE SWITCHING

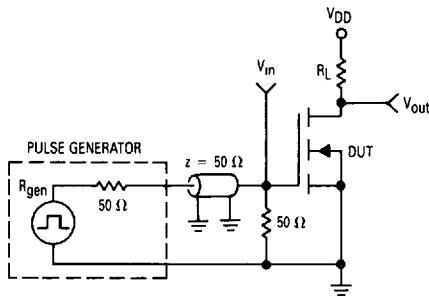


Figure 13. Switching Test Circuit

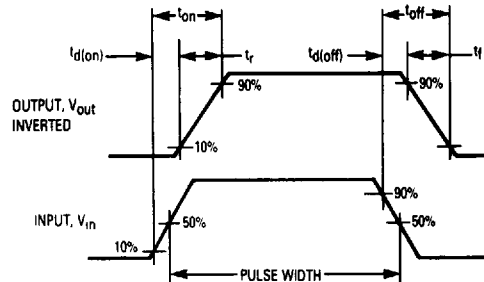


Figure 14. Switching Waveforms

PACKAGE OUTLINE DIMENSIONS AND FOOTPRINTS (continued)

SEATING PLANE -T-

STYLE 5  
PIN 1 GATE  
2 DRAIN  
3 SOURCE  
4 DRAIN

NOTES  
1 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M 1982  
2 CONTROLLING DIMENSION INCH  
3 DIM Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.48	15.75	0.570	0.620
B	9.66	10.28	0.380	0.405
C	4.07	4.82	0.160	0.190
D	0.64	0.88	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.42	2.66	0.095	0.105
H	2.80	3.93	0.110	0.155
J	0.46	0.64	0.018	0.025
K	12.70	14.27	0.500	0.562
L	1.15	1.52	0.045	0.060
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.15	1.39	0.045	0.055
T	5.97	6.47	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.15	—	0.045	—
Z	—	2.04	—	0.080

CASE 221A-06 (TO-220AB)

SEATING PLANE -T-

STYLE 1  
PIN 1 GATE  
2 DRAIN  
3 SOURCE

NOTES  
1 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M 1982  
2 CONTROLLING DIMENSION INCH  
3 221D 01 OBSOLETE, NEW STANDARD 221D 02

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.78	15.97	0.621	0.629
B	10.01	10.21	0.394	0.402
C	4.80	4.80	0.181	0.189
D	0.67	0.66	0.026	0.024
F	3.08	3.27	0.121	0.129
G	2.54 BSC	—	0.100 BSC	—
H	3.13	3.27	0.123	0.129
J	0.46	0.64	0.018	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.52	0.045	0.060
N	5.08 BSC	—	0.200 BSC	—
Q	3.21	3.40	0.126	0.134
R	2.72	2.81	0.107	0.111
S	2.44	2.64	0.096	0.104
U	6.58	6.78	0.259	0.267

0.25 (0.010) (M) B(M) Y

CASE 221D-02 (ISOLATED TO-220 TYPE)

SEATING PLANE -T-

STYLE 5  
PIN 1 GATE  
2 MIRROR  
3 DRAIN  
4 KELVIN  
5 SOURCE

NOTES  
1 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M 1982  
2 CONTROLLING DIMENSION INCH  
3 314B 01 AND 02 OBSOLETE, NEW STANDARD 314B 03  
STYLE 1 THRU 4 OBSOLETE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.528	15.570	0.572	0.613
B	9.906	10.541	0.390	0.415
C	4.318	4.572	0.170	0.180
D	0.635	0.965	0.025	0.038
E	1.169	1.397	0.046	0.055
F	21.590	23.749	0.850	0.936
G	1.702 BSC	—	0.067 BSC	—
H	3.800	5.080	0.149	0.200
J	0.381	0.535	0.015	0.025
K	22.860	27.940	0.900	1.100
L	8.052	8.398	0.317	0.370
N	7.674	8.800	0.310	0.346
Q	3.556	3.937	0.140	0.155
U	11.888	12.827	0.468	0.505
V	4.689	5.842	0.185	0.230
W	2.286	2.794	0.090	0.110

0.356 (0.014) (M) T Q (M)

CASE 314B-03 (5-PIN TO-220)

