# Designer's™ Data Sheet

# TMOS E-FET TM

# **Power Field Effect Transistor TO-247 with Isolated Mounting Hole**

# N-Channel Enhancement-Mode Silicon Gate

This advanced TMOS E-FET is designed to withstand high energy in the avalanche and commutation modes. The new 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.

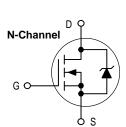
- Avalanche Energy Specified
- Source-to-Drain Diode Recovery Time Comparable to a Discrete Fast Recovery Diode
- · Diode is Characterized for Use in Bridge Circuits
- I<sub>DSS</sub> and V<sub>DS(on)</sub> Specified at Elevated Temperature
- Isolated Mounting Hole Reduces Mounting Hardware

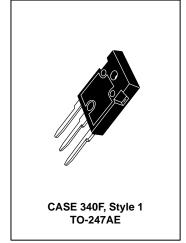




Motorola Preferred Device

TMOS POWER FET
33 AMPERES
100 VOLTS
RDS(on) = 0.06 OHM





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

Rating	Symbol	Value	Unit
Drain-Source Voltage	V <sub>DSS</sub>	100	Vdc
Drain-Gate Voltage ( $R_{GS} = 1.0 \text{ M}\Omega$ )	V <sub>DGR</sub>	100	Vdc
Gate-Source Voltage — Continuous — Non-Repetitive (t <sub>p</sub> ≤ 10 ms)	V <sub>GS</sub> V <sub>GSM</sub>	± 20 ± 40	Vdc Vpk
Drain Current — Continuous @ $25^{\circ}$ C — Continuous @ $100^{\circ}$ C — Single Pulse ( $t_p \le 10 \mu s$ )	I <sub>D</sub> I <sub>DM</sub>	33 20 99	Adc Apk
Total Power Dissipation @ T <sub>C</sub> = 25°C Derate above 25°C	P <sub>D</sub>	125 1.0	Watts W/°C
Operating and Storage Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	-55 to 150	°C
Single Pulse Drain-to-Source Avalanche Energy — Starting T <sub>J</sub> = $25^{\circ}$ C (V <sub>DD</sub> = $25$ Vdc, V <sub>GS</sub> = $10$ Vdc, I <sub>L</sub> = $33$ Apk, L = $1.000$ mH, R <sub>G</sub> = $25$ $\Omega$ )	EAS	545	mJ
Thermal Resistance — Junction to Case — Junction to Ambient	R <sub>θ</sub> JC R <sub>θ</sub> JA	1.0 40	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds	TL	260	°C

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

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Preferred devices are Motorola recommended choices for future use and best overall value.



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

Temperature Coefficient (Negative)	Ch	Symbol	Min	Тур	Max	Unit	
(V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μAdc)	OFF CHARACTERISTICS					•	•
Drain-Source Breakdown Voltage (V <sub>GS</sub> = 0 Vdc, lp = 250 μAde)	$(V_{DS} = V_{GS}, I_{D} = 250 \mu\text{Adc})$	V <sub>GS(th)</sub>	2.0 —	 7.0	4.0 —	Vdc mV/°C	
(V <sub>SS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc) Temperature Coefficient (Positive)  Zero Gate Voltage Drain Current (V <sub>DS</sub> = 100 Vdc, V <sub>SS</sub> = 0 Vdc, I <sub>D</sub> = 25°C)  Gate-Body Leakage Current (V <sub>GS</sub> = ± 20 Vdc, V <sub>DS</sub> = 0)  Brain-Source On-Voltage (V <sub>SS</sub> = 10 Vdc) (I <sub>D</sub> = 33 Adc) (I <sub>D</sub> = 16.5 Adc, I <sub>D</sub> = 25°C)  Input Capacitance  Output Capacitance  Output Capacitance  (V <sub>DS</sub> = 25 Vdc, V <sub>SS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 10.0 Vdc, I <sub></sub>	Static Drain-Source On-Resistance	R <sub>DS(on)</sub>	_	0.04	0.06	Ohm	
(V <sub>DS</sub> = 100 Vdc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = −25°C)  Gate-Body Leakage Current (V <sub>GS</sub> ± 20 Vdc, V <sub>DS</sub> = 0)  ON CHARACTERISTICS (1)  Drain-Source On-Voltage (V <sub>GS</sub> = 10 Vdc) (I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc) (I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc) (I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 34 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 34 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 Adc, V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 35 A	$(V_{GS} = 0 \text{ Vdc}, I_{D} = 250 \mu\text{Adc})$	V(BR)DSS	l			Vdc mV/°C	
ON CHARACTERISTICS (1)   Drain-Source On-Voltage (VGS = 10 Vdc)   (ID = 33 Adc, VGS = 10 Vdc)   (ID = 16.5 Adc, T <sub>J</sub> = -25°C)	$(V_{DS} = 100 \text{ Vdc}, V_{GS} = 0 \text{ Vdc})$	IDSS	_	_	1	μAdc	
Drain-Source On-Voltage (VGS = 10 Vdc) (ID = 13.5 Adc) (ID = 14.5 Adc)	Gate-Body Leakage Current (VGS	$_{S} = \pm 20 \text{ Vdc}, V_{DS} = 0)$	IGSS	_	_	100	nAdc
(I) = 33 Adc)         — 1.6         2.4           (I) = 16.5 Adc, T <sub>J</sub> = -25°C)         — 2.1           Forward Transconductance (V <sub>DS</sub> = 8.0 Vdc, I <sub>D</sub> = 16.5 Adc)         gFS         8.0         — 7         m           DYNAMIC CHARACTERISTICS           Input Capacitance         (V <sub>DS</sub> = 25 Vdc, V <sub>GS</sub> = 0 Vdc, f = 1.0 MHz)         Ciss         — 1830         2500           Output Capacitance         (V <sub>DS</sub> = 25 Vdc, V <sub>GS</sub> = 0 Vdc, f = 1.0 MHz)         Crss         — 559         1100           SWITCHING CHARACTERISTICS (2)           Turn-On Delay Time         (V <sub>DS</sub> = 50 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, R <sub>G</sub> = 9.1 Ω)         td(on)         — 18         40           Right Time         (V <sub>DS</sub> = 80 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc)         tf         — 164         330           Turn-Off Delay Time         (V <sub>DS</sub> = 80 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc)         QT         — 52         1110         — 110         — 12         — 22         — 32         — 22         — 32         — 22         — 32         — 22         — 32         — 22         — 32         — 22         — 32         — 20         — 20         — 20         — 20         — 20         — 20         — 20         — 20         — 20 <t< td=""><td>ON CHARACTERISTICS (1)</td><td></td><td></td><td></td><td>-</td><td></td><td></td></t<>	ON CHARACTERISTICS (1)				-		
DYNAMIC CHARACTERISTICS   Input Capacitance   (VDS = 25 Vdc, VGS = 0 Vdc, f = 1.0 MHz)   Ciss   -   1830   2500   Coss   -   678   1200   Crss   -   559   1100   Crss   -   164   330   Crss   -   164   Cr	$(I_D = 33 \text{ Adc})$	V <sub>DS(on)</sub>		1.6 —	1	Vdc	
Toput Capacitance	Forward Transconductance (VDS	= 8.0 Vdc, I <sub>D</sub> = 16.5 Adc)	9FS	8.0	_	_	mhos
Output Capacitance         (V <sub>DS</sub> = 25 Vdc, V <sub>GS</sub> = 0 Vdc, f = 1.0 MHz)         C <sub>OSS</sub> — 678         1200           Reverse Transfer Capacitance         C <sub>FSS</sub> — 559         1100           SWITCHING CHARACTERISTICS (2)           Turn-On Delay Time         (V <sub>DD</sub> = 50 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, R <sub>G</sub> = 9.1 Ω)         td(on)         — 18         40           Rise Time         (V <sub>DD</sub> = 50 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc, R <sub>G</sub> = 9.1 Ω)         td(off)         — 48         100           Fall Time         (V <sub>DS</sub> = 80 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, V <sub>GS</sub> = 10 Vdc)         Q <sub>T</sub> — 52         110           Gate Charge (See Figure 8)         (V <sub>DS</sub> = 80 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc)         Q <sub>1</sub> — 12         — 20           Q <sub>2</sub> — 32         — 24         — 32         — 32         — 32         — 32           SOURCE-DRAIN DIODE CHARACTERISTICS           Forward On-Voltage (1)         (I <sub>S</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 125°C)         VSD         — 1.0         2.0         — 2.0           Reverse Recovery Time (See Figure 14)         (I <sub>S</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, dI <sub>S</sub> /dt = 100 A/μs)         t <sub>1</sub> — 108         — 108         — 108         — 108         — 108         — 109         — 109         — 109         — 109         — 10	DYNAMIC CHARACTERISTICS						
Reverse Transfer Capacitance   f = 1.0 MHz    Coss   -     576   1200	Input Capacitance	05 )(1- )( 0.)(1-	C <sub>iss</sub>	_	1830	2500	pF
Reverse Transfer Capacitance   C <sub>rss</sub>   — 559   1100	Output Capacitance		C <sub>oss</sub>	_	678	1200	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Reverse Transfer Capacitance	,	C <sub>rss</sub>	_	559	1100	
Rise Time	SWITCHING CHARACTERISTICS	(2)					
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Turn-On Delay Time	1	<sup>t</sup> d(on)	_	18	40	ns
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Rise Time		t <sub>r</sub>	_	164	330	]
Cate Charge (See Figure 8)   (V <sub>DS</sub> = 80 Vdc, I <sub>D</sub> = 33 Adc, V <sub>GS</sub> = 10 Vdc)   Q <sub>1</sub>	Turn-Off Delay Time		<sup>t</sup> d(off)	_	48	100	]
$ (See \ Figure \ 8) \qquad (V_{DS} = 80 \ Vdc, \ I_{D} = 33 \ Adc, \ V_{GS} = 10 \ Vdc) \qquad \frac{Q_{1}}{Q_{2}} \qquad - \qquad 12 \qquad - \qquad \\ Q_{2} \qquad - \qquad 32 \qquad - \qquad \\ Q_{3} \qquad - \qquad 24 \qquad - \qquad \\ \\ SOURCE-DRAIN \ DIODE \ CHARACTERISTICS \\ \hline Forward \ On-Voltage \ (1) \qquad (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc) \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.044 \qquad - \qquad \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.08 \qquad - \qquad \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.08 \qquad - \qquad \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 \qquad 2.0 \\ (I_{S} = 33 \ Adc, \ V_{GS} = 0 \ Vdc, \ T_{J} = 125^{\circ}C) \qquad - \qquad 1.0 $	Fall Time		t <sub>f</sub>	_	83	170	
	•		QT	_	52	110	nC
SOURCE-DRAIN DIODE CHARACTERISTICS   Og 3	(See Figure 8)		Q <sub>1</sub>	_	12	_	-
Forward On-Voltage (1) $ \begin{pmatrix} (I_S = 33 \text{ Adc}, V_{GS} = 0 \text{ Vdc}) \\ (I_S = 33 \text{ Adc}, V_{GS} = 0 \text{ Vdc}, T_J = 125^{\circ}\text{C}) \end{pmatrix} \qquad \begin{pmatrix} V_{SD} \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} 1.0 \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} 2.0 \\ - \\ 0.98 \end{pmatrix} $ Reverse Recovery Time $ \begin{pmatrix} (I_S = 33 \text{ Adc}, V_{GS} = 0 \text{ Vdc}, \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ - \\ 0.98 \end{pmatrix} \qquad \begin{pmatrix} I_{TT} \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ $		V <sub>GS</sub> = 10 Vdc)	Q <sub>2</sub>	_	32	_	
Forward On-Voltage (1)			Q <sub>3</sub>	_	24	_	
$(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TJ = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TJ = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TJ = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $(IS = 33 \text{ Adc}, VGS = 0 \text{ Vdc}, TI = 125^{\circ}\text{C})$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text{ Add} = 100 \text{ A}/\mu \text{s}$ $Ta = 100 \text$		TERISTICS					
$ (I_S = 33 \text{ Adc, V}_{GS} = 0 \text{ Vdc, } \\ \text{dI}_S/\text{dt} = 100 \text{ A/}\mu\text{s}) $ $ t_0 \qquad t_$	Forward On-Voltage (1)	$(I_S = 33 \text{ Adc}, V_{GS} = 0 \text{ Vdc})$ $(I_S = 33 \text{ Adc}, V_{GS} = 0 \text{ Vdc}, T_J = 125^{\circ}\text{C})$	VSD	_ _		2.0 —	Vdc
$(IS = 33 \text{ Adc, } VGS = 0 \text{ Vdc,} \\ dIS/dt = 100 \text{ A}/\mu\text{s}) \\ \hline t_b & - & 36 & - \\ \hline Q_{RR} & - & 0.93 & - \\ \hline \textbf{INTERNAL PACKAGE INDUCTANCE} \\ \hline Internal Drain Inductance \\ (Measured from the drain lead 0.25" from package to center of die) \\ \hline Internal Source Inductance \\ \hline L_S & - & 13 & - \\ \hline \end{tabular}$		(I <sub>S</sub> = 33 Adc, V <sub>GS</sub> = 0 Vdc, dI <sub>S</sub> /dt = 100 A/μs)	t <sub>rr</sub>	_	144	_	ns
	(See Figure 14)		ta	_	108	_	
INTERNAL PACKAGE INDUCTANCE  Internal Drain Inductance (Measured from the drain lead 0.25" from package to center of die)  Internal Source Inductance			t <sub>b</sub>	_	36	_	
Internal Drain Inductance (Measured from the drain lead 0.25" from package to center of die)  Internal Source Inductance  LD  4.5  — 4.5  — 13 —	Reverse Recovery Stored Charge	Q <sub>RR</sub>	_	0.93		μC	
(Measured from the drain lead 0.25" from package to center of die)  Internal Source Inductance  L <sub>S</sub> - 13 -	INTERNAL PACKAGE INDUCTAN	CE					
			LD	_	4.5	_	nH
		LS	_	13	_	nH	

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

## TYPICAL ELECTRICAL CHARACTERISTICS

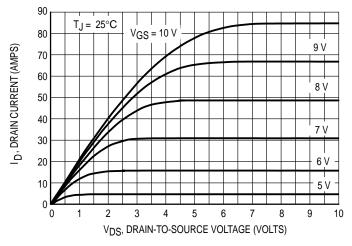


Figure 1. On-Region Characteristics

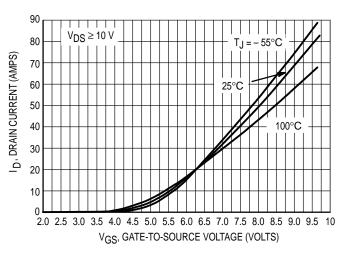


Figure 2. Transfer Characteristics

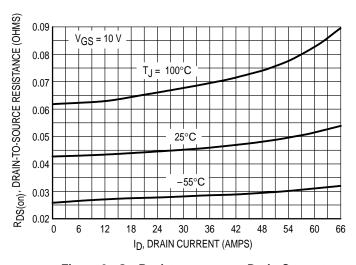


Figure 3. On-Resistance versus Drain Current and Temperature

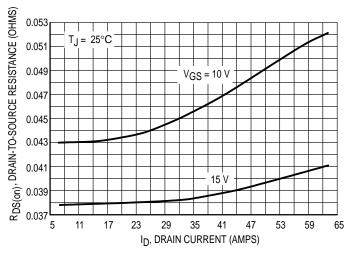


Figure 4. On-Resistance versus Drain Current and Gate Voltage

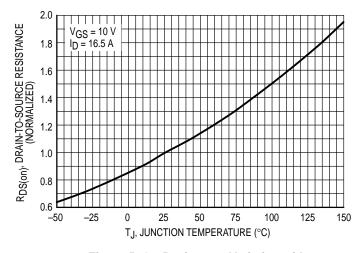


Figure 5. On-Resistance Variation with Temperature

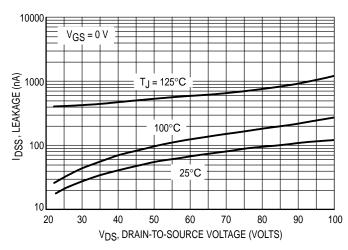


Figure 6. Drain-To-Source Leakage Current versus Voltage

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#### 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 (IG(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, VGS remains virtually constant at a level known as the plateau voltage, VSGP. Therefore, rise and fall times may be approximated by the following:

$$t_{\Gamma} = Q_2 \times R_G/(V_{GG} - V_{GSP})$$

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

where

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

RG = the gate drive resistance

and Q2 and VGSP 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:

$$t_{d(on)} = RG C_{iss} In [V_{GG}/(V_{GG} - V_{GSP})]$$

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

The capacitance  $(C_{iSS})$  is read from the capacitance curve at a voltage corresponding to the off-state condition when calculating td(on) and is read at a voltage corresponding to the on-state when calculating td(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.

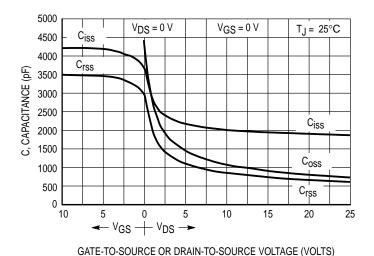
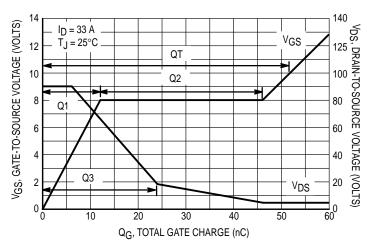


Figure 7. Capacitance Variation

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1000 VDD = 50 V ID = 33 A VGS = 10 V TJ = 25°C

tr

td(off)

10

RG, GATE RESISTANCE (OHMS)

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

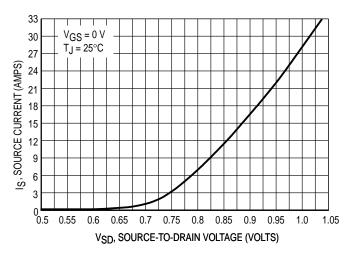


Figure 10. Diode Forward Voltage versus Current

## 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<sub>C</sub>) 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 (IDM) nor rated voltage (VDSS) is exceeded and the transition time (t<sub>r</sub>,t<sub>f</sub>) do not exceed 10  $\mu$ s. In addition the total power averaged over a complete switching cycle must not exceed (TJ(MAX) – TC)/(R $_{\theta}$ JC).

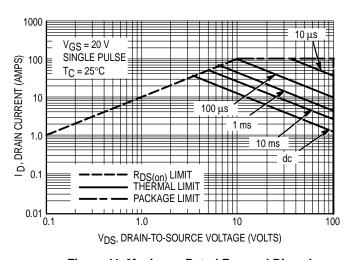
A Power MOSFET designated E-FET can be safely used in switching circuits with unclamped inductive loads. For

reliable operation, the stored energy from circuit inductance dissipated in the transistor while in avalanche must be less than the rated limit and 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<sub>DM</sub>), the energy rating is specified at rated continuous current (I<sub>D</sub>), 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<sub>D</sub> can safely be assumed to equal the values indicated.

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## **SAFE OPERATING AREA**



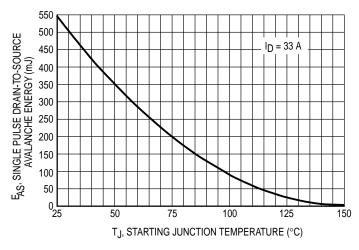


Figure 11. Maximum Rated Forward Biased Safe Operating Area

Figure 12. Maximum Avalanche Energy versus Starting Junction Temperature

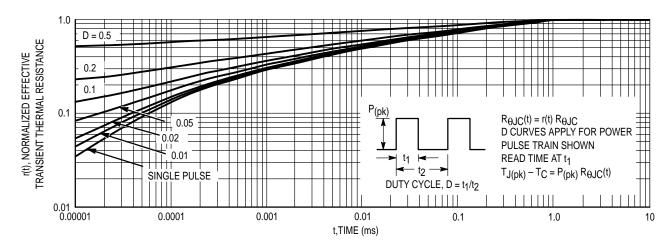


Figure 13. Thermal Response

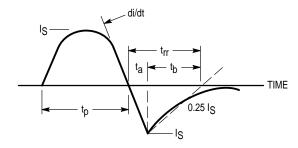
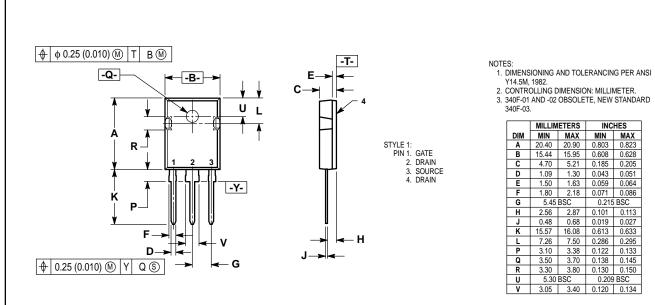


Figure 14. Diode Reverse Recovery Waveform

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# **PACKAGE DIMENSIONS**



	MILLIM	ETERS	INCHES	
DIM	MIN	MAX	MIN	MAX
Α	20.40	20.90	0.803	0.823
В	15.44	15.95	0.608	0.628
С	4.70	5.21	0.185	0.205
D	1.09	1.30	0.043	0.051
Е	1.50	1.63	0.059	0.064
F	1.80	2.18	0.071	0.086
G	5.45 BSC		0.215 BSC	
Н	2.56	2.87	0.101	0.113
J	0.48	0.68	0.019	0.027
K	15.57	16.08	0.613	0.633
L	7.26	7.50	0.286	0.295
Р	3.10	3.38	0.122	0.133
ď	3.50	3.70	0.138	0.145
R	3.30	3.80	0.130	0.150
כ	5.30 BSC 0.209 BSC		BSC	

**CASE 340F-03** 

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