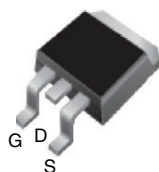


## EF Series Power MOSFET With Fast Body Diode

D<sup>2</sup>PAK (TO-263)


N-Channel MOSFET

### FEATURES

- 4<sup>th</sup> generation E series technology
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low effective capacitance ( $C_{o(er)}$ )
- Reduced switching and conduction losses
- Avalanche energy rated (UIS)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**

### APPLICATIONS

- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
  - High-intensity discharge (HID)
  - Fluorescent ballast lighting
- Industrial
  - Welding
  - Induction heating
  - Motor drives
  - Battery chargers
  - Solar (PV inverters)

### PRODUCT SUMMARY

$V_{DS}$ (V) at $T_J$ max.	650	
$R_{DS(on)}$ typ. ( $\Omega$ ) at 25 °C	$V_{GS} = 10$ V	0.168
$Q_g$ max. (nC)	32	
$Q_{gs}$ (nC)	7	
$Q_{gd}$ (nC)	7	
Configuration	Single	

### ORDERING INFORMATION

Package	D2PAK (TO-263)
Lead (Pb)-free and halogen-free	SIHB186N60EF-GE3

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted)

PARAMETER	SYMBOL	LIMIT	UNIT
Drain-source voltage	$V_{DS}$	600	V
Gate-source voltage	$V_{GS}$	$\pm 30$	
Continuous drain current ( $T_J = 150$ °C) <sup>e</sup>	$V_{GS}$ at 10 V	$T_C = 25$ °C	A
		$T_C = 100$ °C	
Pulsed drain current <sup>a</sup>	$I_{DM}$	43	
Linear derating factor		1.25	W/°C
Single pulse avalanche energy <sup>b</sup>	$E_{AS}$	24	mJ
Maximum power dissipation	$P_D$	156	W
Operating junction and storage temperature range	$T_J, T_{stg}$	-55 to +150	°C
Drain-source voltage slope	$dv/dt$	$T_J = 125$ °C	V/ns
Reverse diode $dv/dt$ <sup>d</sup>			
Soldering recommendations (peak temperature) <sup>c</sup>		For 10 s	°C
Mounting torque		M3 screw	Nm


#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DD} = 120$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 1.3$  A
- 1.6 mm from case
- $I_{SD} \leq I_D$ ,  $di/dt = 700$  A/ $\mu$ s, starting  $T_J = 25$  °C
- Limited by maximum junction temperature

**THERMAL RESISTANCE RATINGS**

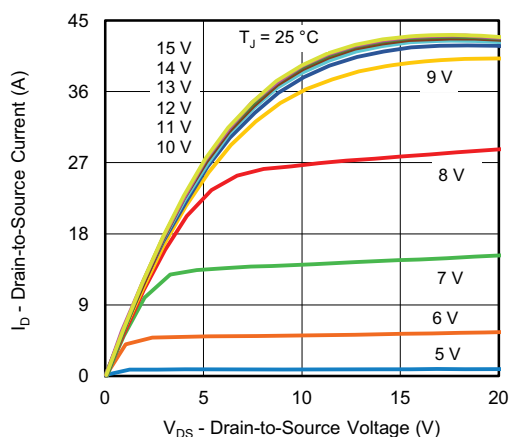
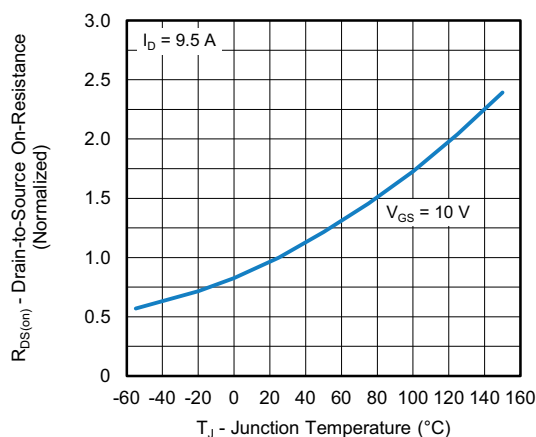
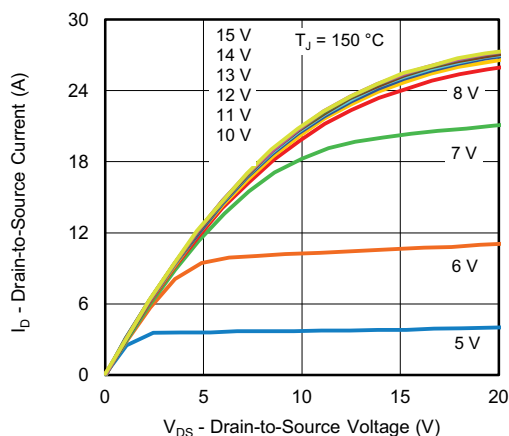
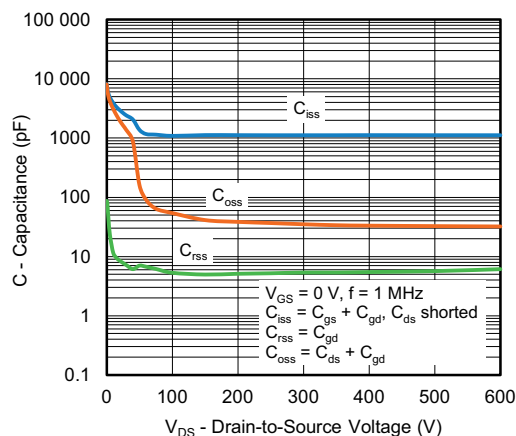
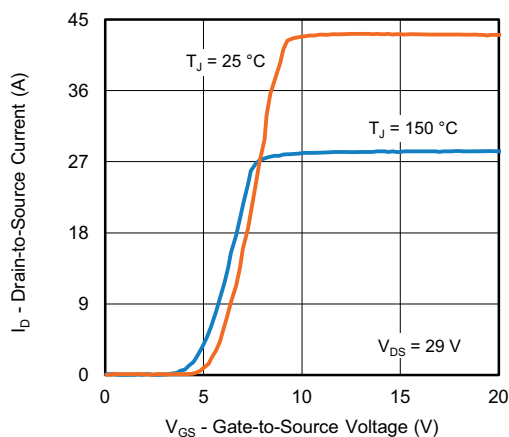
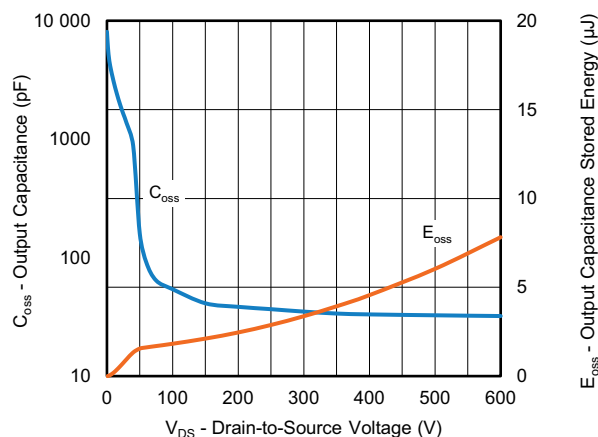
PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum junction-to-ambient	$R_{thJA}$	-	62	°C/W
Maximum junction-to-case (drain)	$R_{thJC}$	-	0.8	

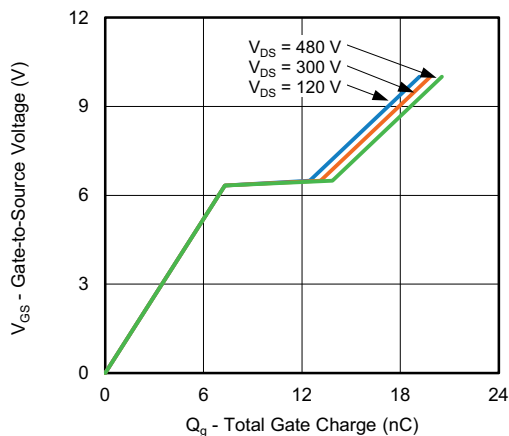
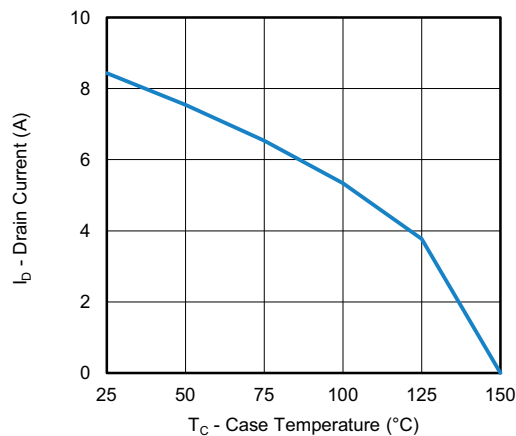
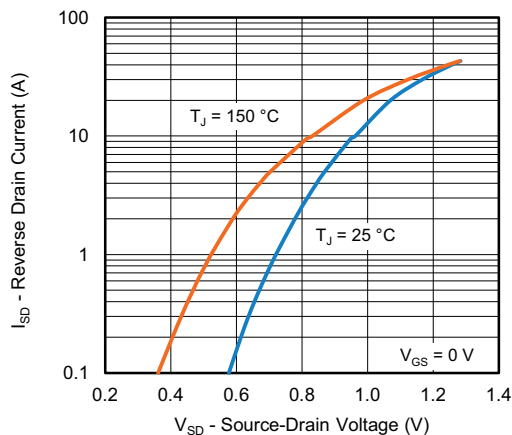
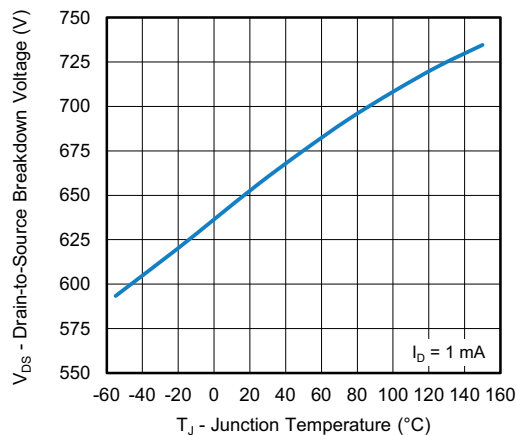
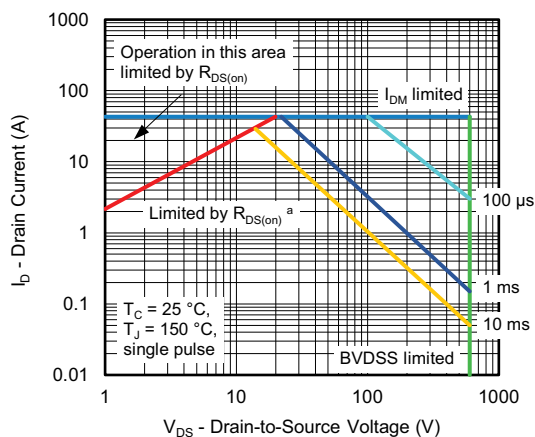
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Static							
Drain-source breakdown voltage	$V_{DS}$	$V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$		600	-	-	V
$V_{DS}$ temperature coefficient	$\Delta V_{DS}/T_J$	Reference to $25\text{ }^{\circ}\text{C}$ , $I_D = 1\text{ mA}$		-	0.69	-	V/ $^{\circ}\text{C}$
Gate-source threshold voltage (N)	$V_{GS(th)}$	$V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$		3.0	-	5.0	V
Gate-source leakage	$I_{GSS}$	$V_{GS} = \pm 20\text{ V}$		-	-	$\pm 100$	nA
		$V_{GS} = \pm 30\text{ V}$		-	-	$\pm 1$	$\mu\text{A}$
Zero gate voltage drain current	$I_{DSS}$	$V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$		-	-	1	$\mu\text{A}$
		$V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$		-	-	2	mA
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}$	$I_D = 9.5\text{ A}$	-	0.168	0.193	$\Omega$
Forward transconductance <sup>a</sup>	$g_{fs}$	$V_{DS} = 20\text{ V}$ , $I_D = 9.5\text{ A}$		-	5.4	-	S
Dynamic							
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{ V}$ , $V_{DS} = 100\text{ V}$ , $f = 1\text{ MHz}$		-	1081	-	pF
Output capacitance	$C_{oss}$			-	52	-	
Reverse transfer capacitance	$C_{rss}$			-	5	-	
Effective output capacitance, energy related <sup>a</sup>	$C_{o(er)}$	$V_{DS} = 0\text{ V to } 480\text{ V}$ , $V_{GS} = 0\text{ V}$		-	40	-	
Effective output capacitance, time related <sup>b</sup>	$C_{o(tr)}$			-	247	-	
Total gate charge	$Q_g$	$V_{GS} = 10\text{ V}$	$I_D = 9.5\text{ A}$ , $V_{DS} = 480\text{ V}$	-	21	32	nC
Gate-source charge	$Q_{gs}$			-	7	-	
Gate-drain charge	$Q_{gd}$			-	7	-	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 480\text{ V}$ , $I_D = 9.5\text{ A}$ , $V_{GS} = 10\text{ V}$ , $R_g = 9.1\text{ }\Omega$		-	14	28	ns
Rise time	$t_r$			-	23	46	
Turn-off delay time	$t_{d(off)}$			-	25	50	
Fall time	$t_f$			-	16	32	
Gate input resistance	$R_g$	$f = 1\text{ MHz}$ , open drain		0.3	0.7	1.4	$\Omega$
Drain-Source Body Diode Characteristics							
Continuous source-drain diode current	$I_S$	MOSFET symbol showing the integral reverse p - n junction diode 		-	-	18	A
Pulsed diode forward current	$I_{SM}$			-	-	43	
Diode forward voltage	$V_{SD}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 9.5\text{ A}$ , $V_{GS} = 0\text{ V}$		-	-	1.2	V
Reverse recovery time	$t_{rr}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = I_S = 9.5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 400\text{ V}$		-	111	222	ns
Reverse recovery charge	$Q_{rr}$			-	0.6	1.2	$\mu\text{C}$
Reverse recovery current	$I_{RRM}$			-	10	-	A

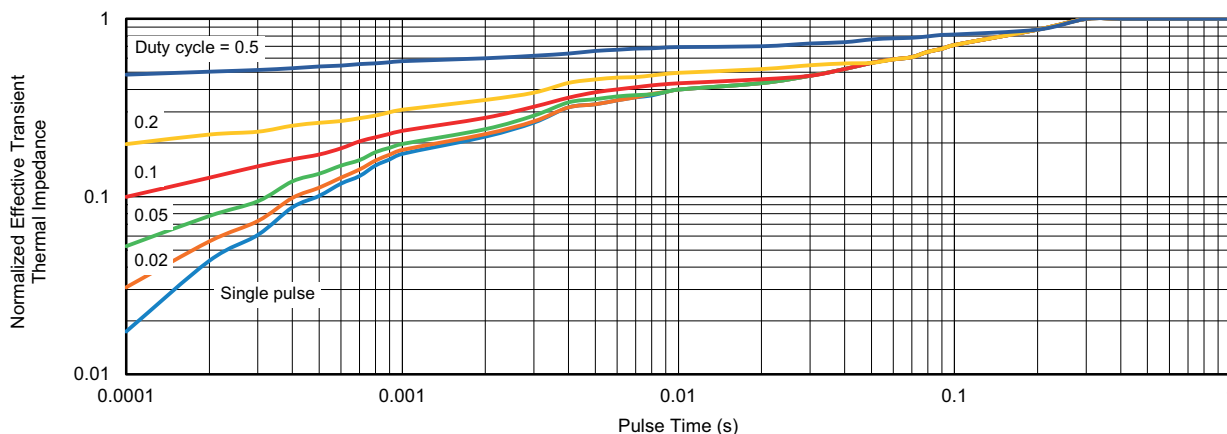
**Notes**

- a.  $C_{oss(er)}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$   
b.  $C_{oss(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$

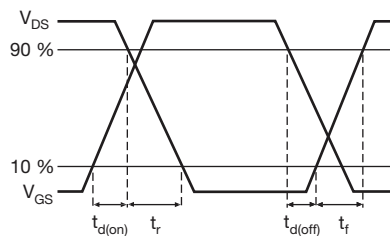
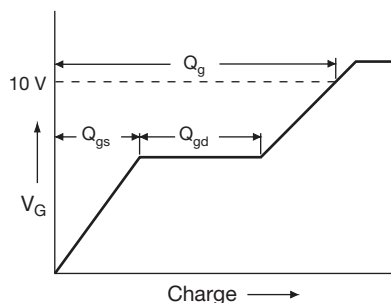
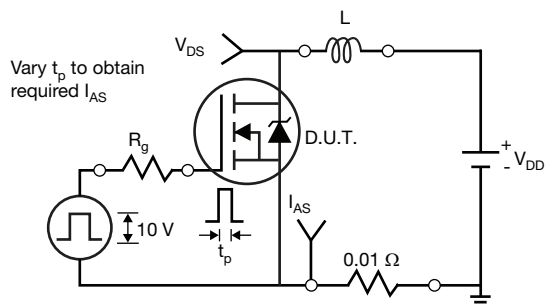
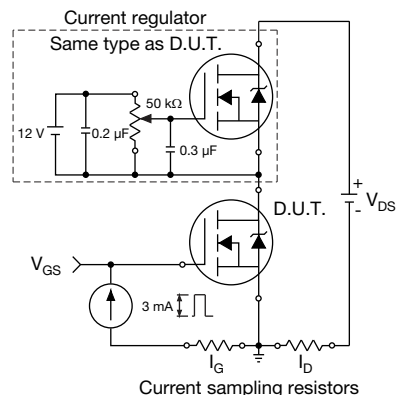
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Fig. 1 - Typical Output Characteristics**

**Fig. 4 - Normalized On-Resistance vs. Temperature**

**Fig. 2 - Typical Output Characteristics**

**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

**Fig. 3 - Typical Transfer Characteristics**

**Fig. 6 -  $C_{oss}$  and  $E_{oss}$  vs.  $V_{DS}$**


**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**

**Fig. 10 - Maximum Drain Current vs. Case Temperature**

**Fig. 8 - Typical Source-Drain Diode Forward Voltage**

**Fig. 11 - Temperature vs. Drain-to-Source Voltage**

**Fig. 9 - Maximum Safe Operating Area**
**Note**

a.  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified


**Fig. 12 - Normalized Transient Thermal Impedance, Junction-to-Case**

**Fig. 13 - Switching Time Test Circuit**

**Fig. 16 - Unclamped Inductive Waveforms**

**Fig. 14 - Switching Time Waveforms**

**Fig. 17 - Basic Gate Charge Waveform**

**Fig. 15 - Unclamped Inductive Test Circuit**

**Fig. 18 - Gate Charge Test Circuit**


**Fig. 19 - For N-Channel**

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### TO-263AB (HIGH VOLTAGE)



DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	4.06	4.83	0.160	0.190
A1	0.00	0.25	0.000	0.010
b	0.51	0.99	0.020	0.039
b1	0.51	0.89	0.020	0.035
b2	1.14	1.78	0.045	0.070
b3	1.14	1.73	0.045	0.068
c	0.38	0.74	0.015	0.029
c1	0.38	0.58	0.015	0.023
c2	1.14	1.65	0.045	0.065
D	8.38	9.65	0.330	0.380

DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
D1	6.86	-	0.270	-
E	9.65	10.67	0.380	0.420
E1	6.22	-	0.245	-
e	2.54 BSC		0.100 BSC	
H	14.61	15.88	0.575	0.625
L	1.78	2.79	0.070	0.110
L1	-	1.65	-	0.066
L2	-	1.78	-	0.070
L3	0.25 BSC		0.010 BSC	
L4	4.78	5.28	0.188	0.208

ECN: S-82110-Rev. A, 15-Sep-08  
DWG: 5970

#### Notes

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimensions are shown in millimeters (inches).
3. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.127 mm (0.005") per side. These dimensions are measured at the outmost extremes of the plastic body at datum A.
4. Thermal PAD contour optional within dimension E, L1, D1 and E1.
5. Dimension b1 and c1 apply to base metal only.
6. Datum A and B to be determined at datum plane H.
7. Outline conforms to JEDEC outline to TO-263AB.

**RECOMMENDED MINIMUM PADS FOR D<sup>2</sup>PAK: 3-Lead**



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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