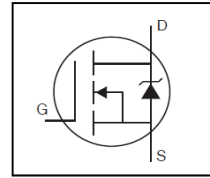


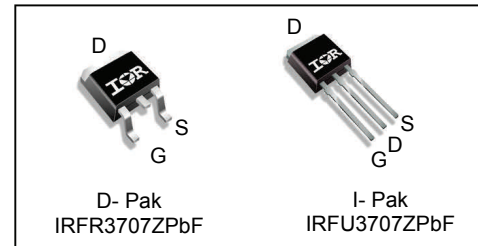
HEXFET® Power MOSFET

Applications

- High Frequency Synchronous Buck Converters for Computer Processor Power
- High Frequency Isolated DC-DC Converters with Synchronous Rectification for Telecom and Industrial Use



V_{DSS}	30V
R_{DS(on)} max	9.5mΩ
Q_g	9.6nC


Benefits

- Very Low R_{DS(on)} at 4.5V V_{GS}
- Ultra - Low Gate Impedance
- Fully Characterized Avalanche Voltage and Current
- Lead-Free

G	D	S
Gate	Drain	Source

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRFU3707ZPbF	I-Pak	Tube	75	IRFU3707ZPbF
IRFR3707ZPbF	D-Pak	Tube	75	IRFR3707ZPbF
		Tape and Reel Left	3000	IRFR3707ZTRLpBF

Absolute Maximum Ratings

Symbol	Parameter	Max.	Units
V _{DS}	Drain -to-Source Voltage	30	V
V _{GS}	Gate-to-Source Voltage	± 20	V
I _D @ T _C = 25°C	Continuous Drain Current, V _{GS} @ 10V	56 ^④	A
I _D @ T _C = 100°C	Continuous Drain Current, V _{GS} @ 10V	39 ^④	
I _{DM}	Pulsed Drain Current ^①	220	
P _D @ T _C = 25°C	Maximum Power Dissipation	50	W
P _D @ T _C = 100°C	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.33	W/°C
T _J	Operating Junction and	-55 to + 175	°C
T _{STG}	Storage Temperature Range		
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	

Thermal Resistance

Symbol	Parameter	Typ.	Max.	Units
R _{θJC}	Junction-to-Case	—	3.0	°C/W
R _{θJA}	Junction-to-Ambient (PCB Mount) ^⑤	—	50	
R _{θJA}	Junction-to-Ambient	—	110	

 Notes ^① through ^⑤ are on page 2.

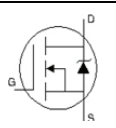
Static @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
V _{(BR)DSS}	Drain-to-Source Breakdown Voltage	30	—	—	V	V _{GS} = 0V, I _D = 250μA
ΔV _{(BR)DSS} /ΔT _J	Breakdown Voltage Temp. Coefficient	—	0.023	—	V/°C	Reference to 25°C, I _D = 1mA
R _{DS(on)}	Static Drain-to-Source On-Resistance	—	7.5	9.5	mΩ	V _{GS} = 10V, I _D = 15A ③
		—	10	12.5		V _{GS} = 4.5V, I _D = 12A ③
V _{GS(th)}	Gate Threshold Voltage	1.35	1.80	2.25	V	V _{DS} = V _{GS} , I _D = 25μA
ΔV _{GS(th)} /ΔT _J	Gate Threshold Voltage Temp. Coefficient	—	-5.0	—	mV/°C	
I _{DSS}	Drain-to-Source Leakage Current	—	—	1.0	μA	V _{DS} = 24V, V _{GS} = 0V
		—	—	150		V _{DS} = 24V, V _{GS} = 0V, T _J = 125°C
I _{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V _{GS} = 20V
	Gate-to-Source Reverse Leakage	—	—	-100		V _{GS} = -20V
g _{fs}	Forward Trans conductance	71	—	—	S	V _{DS} = 15V, I _D = 12A
Q _g	Total Gate Charge	—	9.6	14	nC	V _{DS} = 15V V _{GS} = 4.5V I _D = 12A See Fig. 16
Q _{gs1}	Pre-V _{th} Gate-to-Source Charge	—	2.6	—		
Q _{gs2}	Post-V _{th} Gate-to-Source Charge	—	0.90	—		
Q _{gd}	Gate-to-Drain Charge	—	3.5	—		
Q _{godr}	Gate Charge Overdrive	—	2.6	—		
Q _{sw}	Switch Charge (Q _{gs2} + Q _{gd})	—	4.4	—		
Q _{oss}	Output Charge	—	5.8	—	nC	V _{DS} = 15V, V _{GS} = 0V
t _{d(on)}	Turn-On Delay Time	—	8.0	—	ns	V _{DD} = 16V, V _{GS} = 4.5V ③ I _D = 12A Clamped Inductive Load
t _r	Rise Time	—	11	—		
t _{d(off)}	Turn-Off Delay Time	—	12	—		
t _f	Fall Time	—	3.3	—		
C _{iss}	Input Capacitance	—	1150	—	pF	V _{GS} = 0V V _{DS} = 15V f = 1.0MHz
C _{oss}	Output Capacitance	—	260	—		
C _{rss}	Reverse Transfer Capacitance	—	120	—		

Avalanche Characteristics

	Parameter	Max.	Units
E _{AS}	Single Pulse Avalanche Energy ②	42	mJ
I _{AR}	Avalanche Current ①	12	A
E _{AR}	Repetitive Avalanche Energy ①	5.0	mJ

Diode Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I _S	Continuous Source Current (Body Diode)	—	—	56④	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I _{SM}	Pulsed Source Current (Body Diode) ①	—	—	220		
V _{SD}	Diode Forward Voltage	—	—	1.0	V	T _J = 25°C, I _S = 12A, V _{GS} = 0V ③
t _{rr}	Reverse Recovery Time	—	25	38	ns	T _J = 25°C, I _F = 12A, V _{DS} = 15V
Q _{rr}	Reverse Recovery Charge	—	17	26	nC	di/dt = 100A/μs ③
t _{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L _S +L _D)				

Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature
- ② starting T_J = 25°C, L = 0.58mH, R_G = 25Ω, I_{AS} = 12A.
- ③ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ④ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 30A.
- ⑤ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.

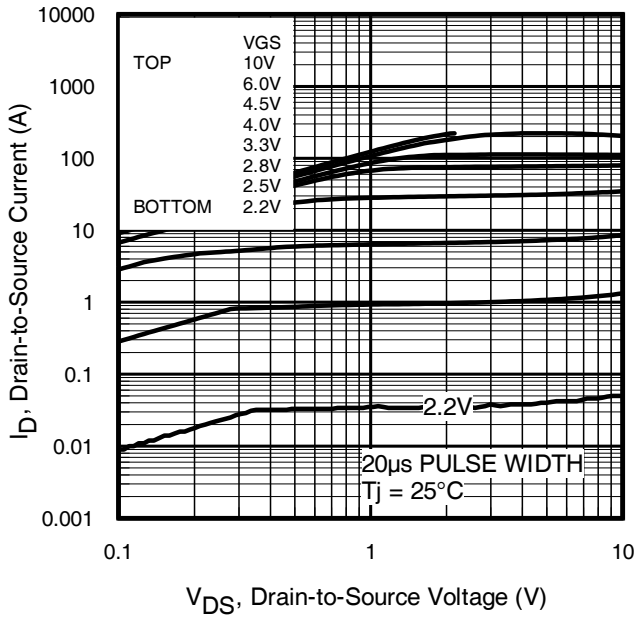


Fig. 1 Typical Output Characteristics

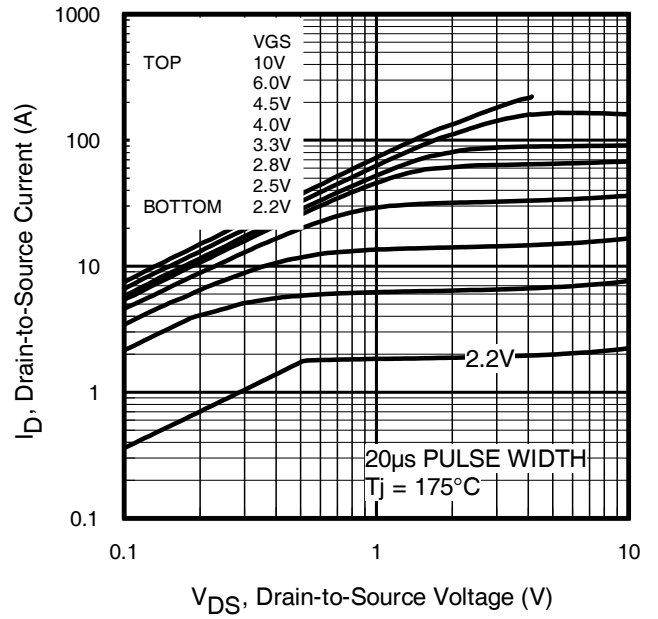


Fig. 2 Typical Output Characteristics

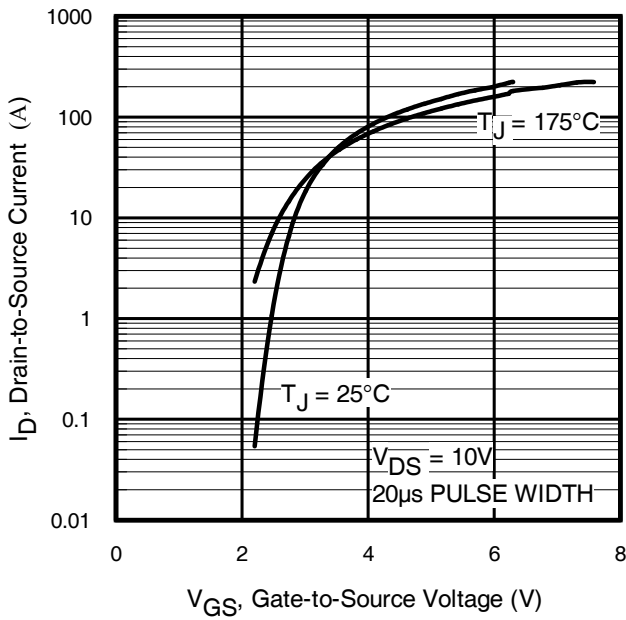


Fig. 3 Typical Transfer Characteristics

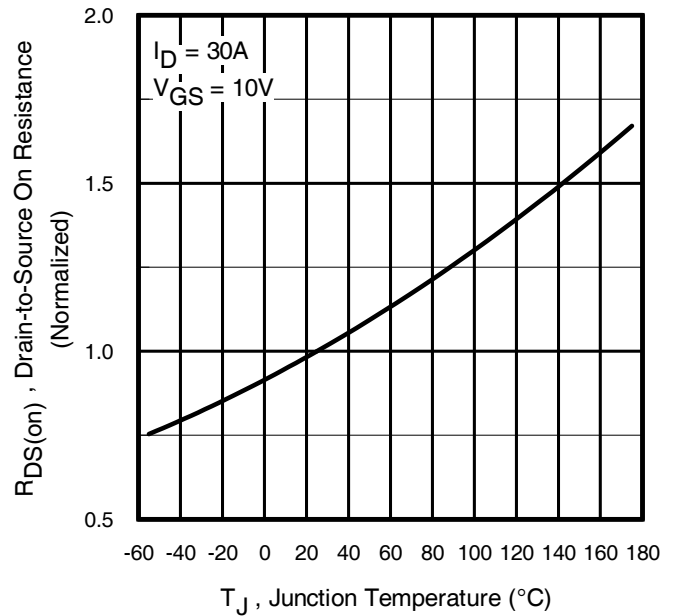


Fig. 4 Normalized On-Resistance vs. Temperature

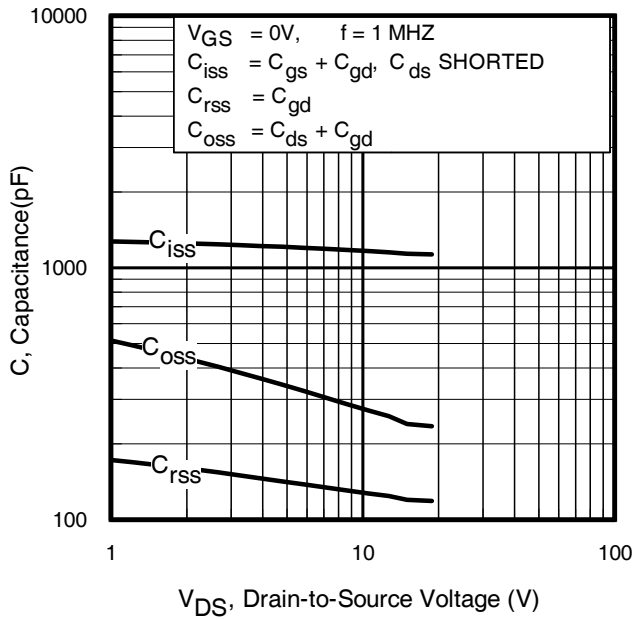


Fig 5. Typical Capacitance vs. Drain-to-Source Voltage

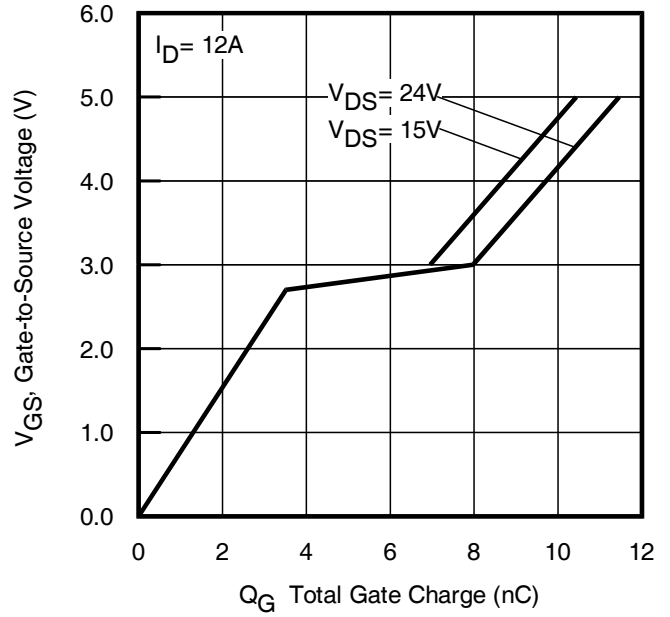


Fig 6. Typical Gate Charge vs. Gate-to-Source Voltage

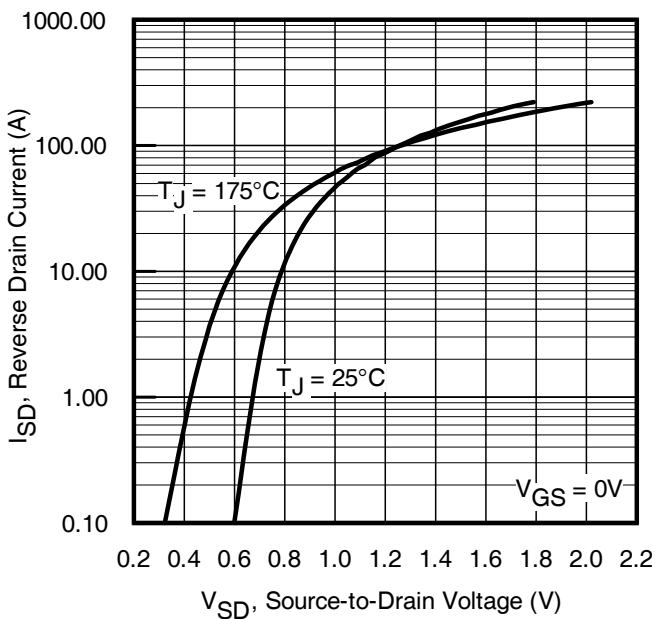


Fig 7. Typical Source-to-Drain Diode Forward Voltage

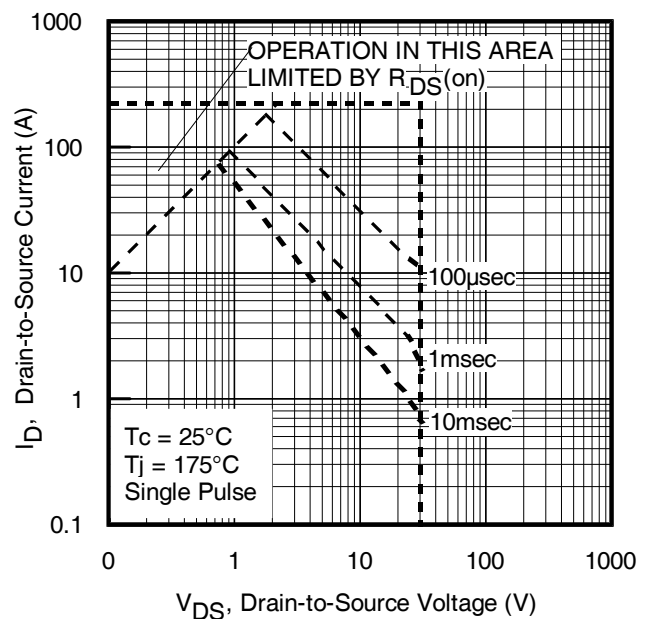


Fig 8. Maximum Safe Operating Area

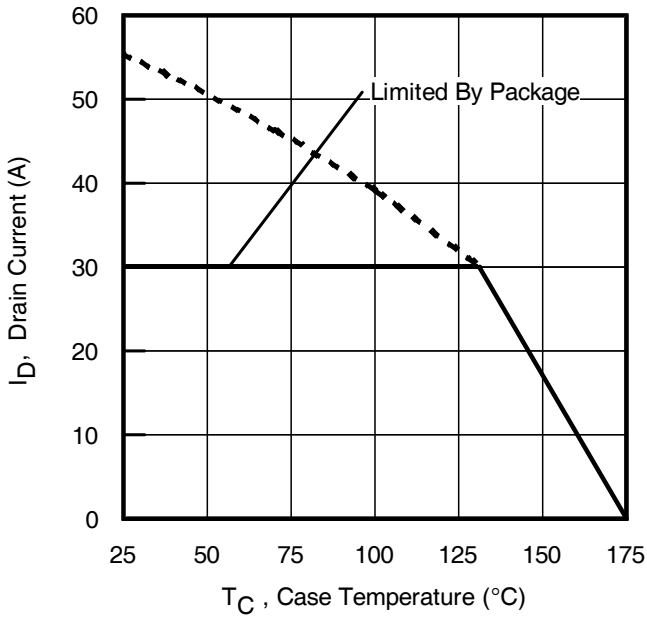


Fig 9. Maximum Drain Current vs. Case Temperature

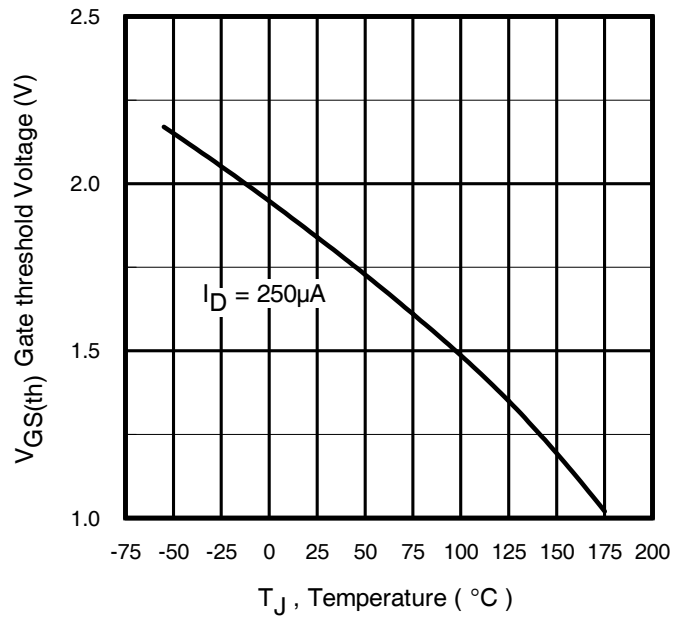


Fig 10. Threshold Voltage vs. Temperature

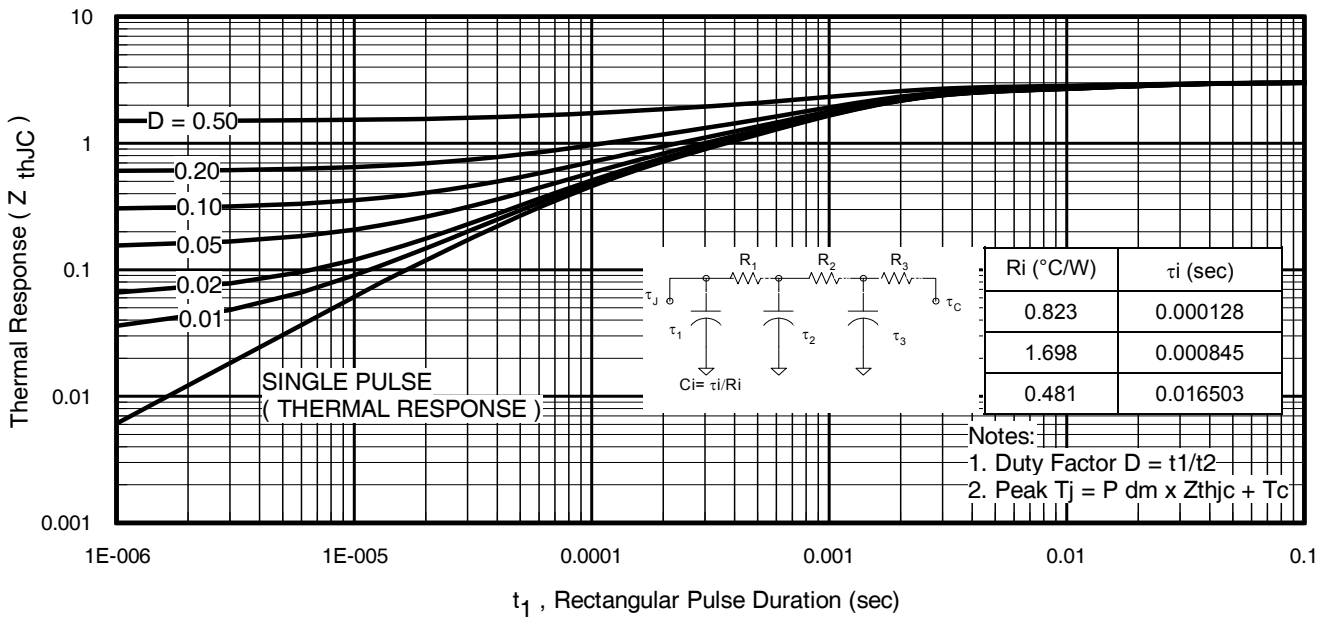


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

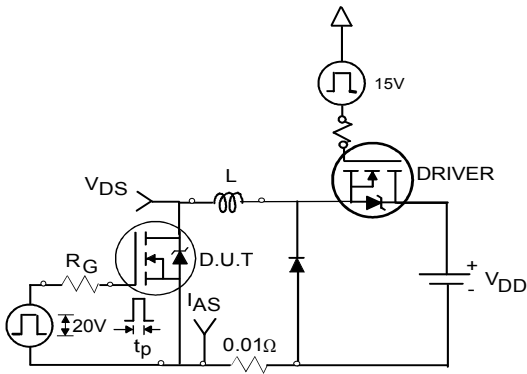


Fig 12a. Unclamped Inductive Test Circuit

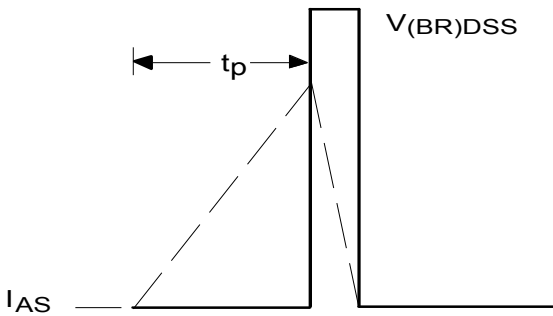


Fig 12b. Unclamped Inductive Waveforms

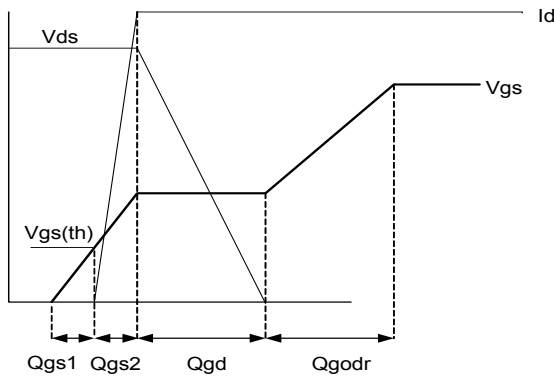


Fig 13a. Gate Charge Waveform

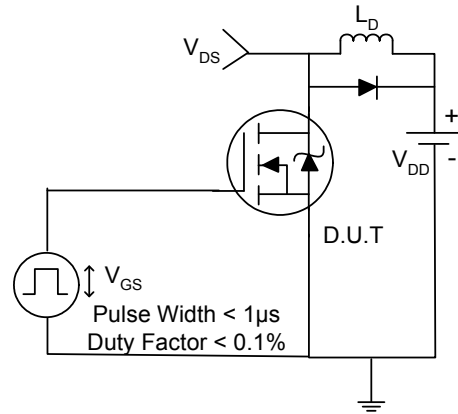


Fig 14a. Switching Time Test Circuit

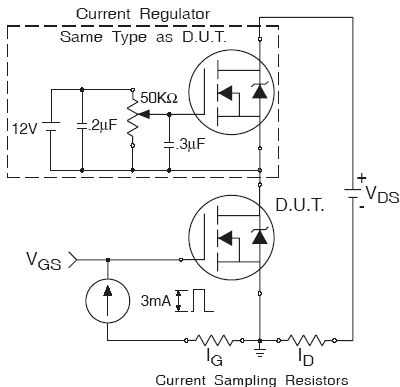


Fig 13b. Gate Charge Test Circuit

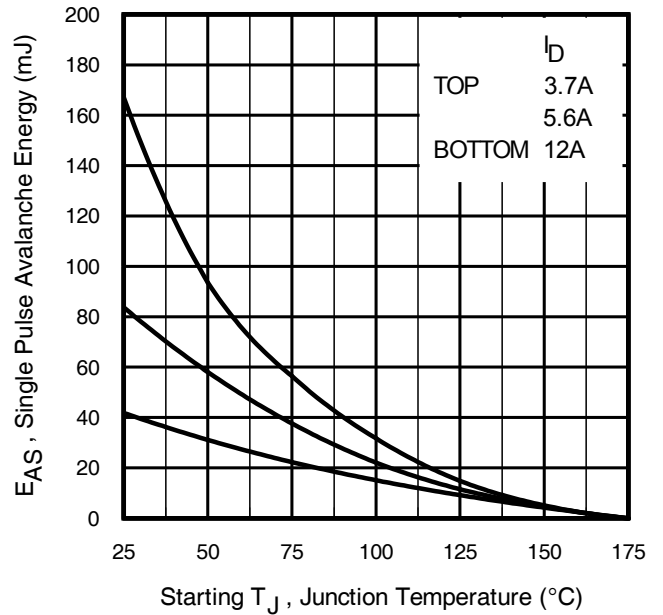


Fig 12c. Maximum Avalanche Energy vs. Drain Current

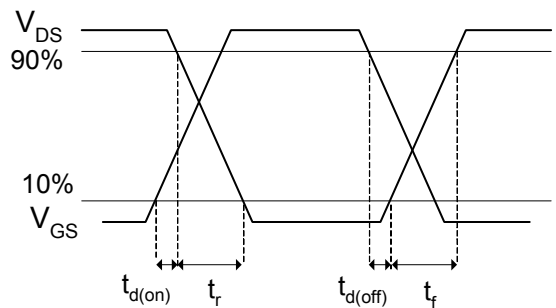
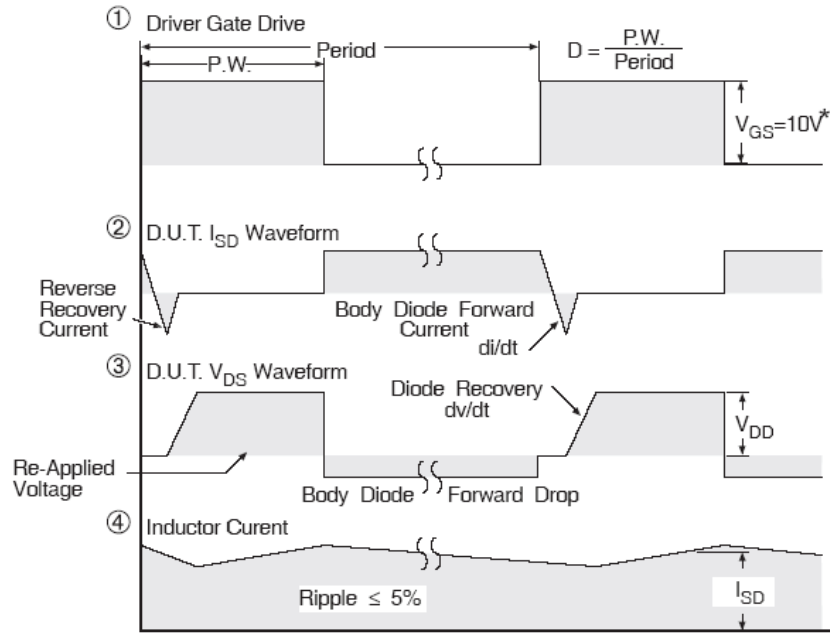
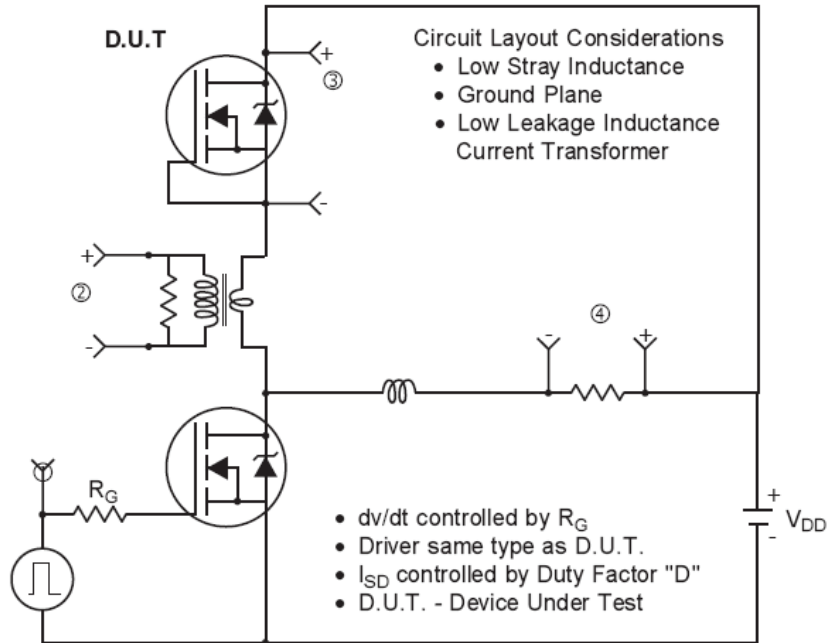


Fig 14b. Switching Time Waveforms

Peak Diode Recovery dv/dt Test Circuit



* $V_{GS} = 5V$ for Logic Level Devices

Fig 15. Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs

Power MOSFET Selection for Non-Isolated DC/DC Converters

Control FET

Special attention has been given to the power losses in the switching elements of the circuit - Q1 and Q2. Power losses in the high side switch Q1, also called the Control FET, are impacted by the $R_{ds(on)}$ of the MOSFET, but these conduction losses are only about one half of the total losses.

Power losses in the control switch Q1 are given by;

$$P_{loss} = P_{conduction} + P_{switching} + P_{drive} + P_{output}$$

This can be expanded and approximated by;

$$P_{loss} = (I_{rms}^2 \times R_{ds(on)}) + \left(I \times \frac{Q_{gd}}{i_g} \times V_{in} \times f \right) + \left(I \times \frac{Q_{gs2}}{i_g} \times V_{in} \times f \right) + (Q_g \times V_g \times f) + \left(\frac{Q_{oss}}{2} \times V_{in} \times f \right)$$

This simplified loss equation includes the terms Q_{gs2} and Q_{oss} which are new to Power MOSFET data sheets.

Q_{gs2} is a subelement of traditional gate-source charge that is included in all MOSFET data sheets. The importance of splitting this gate-source charge into two sub elements, Q_{gs1} and Q_{gs2} , can be seen from Fig 16.

Q_{gs2} indicates the charge that must be supplied by the gate driver between the time that the threshold voltage has been reached and the time the drain current rises to I_{dmax} at which time the drain voltage begins to change. Minimizing Q_{gs2} is a critical factor in reducing switching losses in Q1.

Q_{oss} is the charge that must be supplied to the output capacitance of the MOSFET during every switching cycle. Figure A shows how Q_{oss} is formed by the parallel combination of the voltage dependent (non-linear) capacitance's C_{ds} and C_{dg} when multiplied by the power supply input buss voltage.

Synchronous FET

The power loss equation for Q2 is approximated by;

$$P_{loss} = P_{conduction} + P_{drive} + P_{output}^*$$

$$P_{loss} = (I_{rms}^2 \times R_{ds(on)}) + (Q_g \times V_g \times f) + \left(\frac{Q_{oss}}{2} \times V_{in} \times f \right) + (Q_{rr} \times V_{in} \times f)$$

*dissipated primarily in Q1

For the synchronous MOSFET Q2, $R_{ds(on)}$ is an important characteristic; however, once again the importance of gate charge must not be overlooked since it impacts three critical areas. Under light load the MOSFET must still be turned on and off by the control I_c so the gate drive losses become much more significant. Secondly, the output charge Q_{oss} and reverse recovery charge Q_{rr} both generate losses that are transferred to Q1 and increase the dissipation in that device. Thirdly, gate charge will impact the MOSFETs' susceptibility to $C_{dv/dt}$ turn on.

The drain of Q2 is connected to the switching node of the converter and therefore sees transitions between ground and V_{in} . As Q1 turns on and off there is a rate of change of drain voltage dV/dt which is capacitive coupled to the gate of Q2 and can induce a voltage spike on the gate that is sufficient to turn the MOSFET on, resulting in shoot-through current. The ratio of Q_{gd}/Q_{gs1} must be minimized to reduce the potential for $C_{dv/dt}$ turn on.

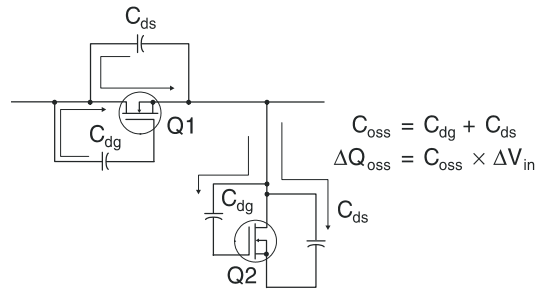
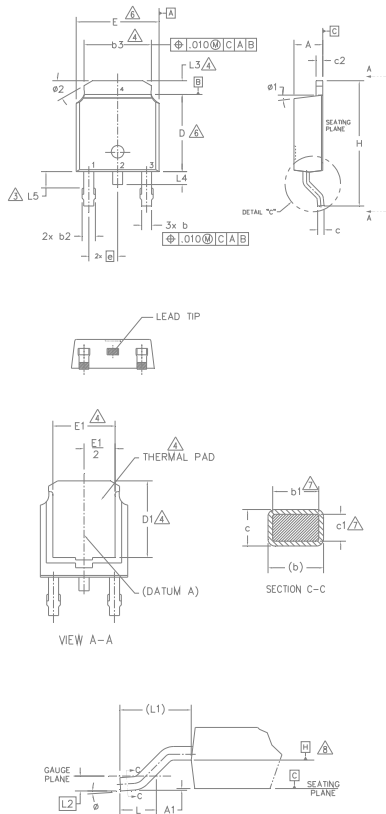


Figure A: Q_{oss} Characteristic

D-Pak (TO-252AA) Package Outline (Dimensions are shown in millimeters (inches))



- NOTES:
- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
 - 2.- DIMENSION ARE SHOWN IN INCHES [MILLIMETERS]
 - 3.- LEAD DIMENSION UNCONTROLLED IN L5.
 - 4.- DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
 - 5.- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
 - 6.- DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .006 [0.15] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
 - 7.- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
 - 8.- DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
 - 9.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1	-	0.13	-	.005	
b	0.64	0.89	.025	.035	
b1	0.64	0.79	.025	.031	
b2	0.76	1.14	.030	.045	
b3	4.95	5.46	.195	.215	
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	
D1	5.21	-	.205	-	
E	6.35	6.73	.250	.265	
E1	4.32	-	.170	-	
e	2.29 BSC		.090 BSC		
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	
L4	-	1.02	-	.040	
L5	1.14	1.52	.045	.060	
φ	0"	10"	0"	10"	
φ1	0"	15"	0"	15"	
φ2	25"	35"	25"	35"	

LEAD ASSIGNMENTS

HEXFET

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

IGBT & CoPAK

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

D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120 WITH ASSEMBLY LOT CODE 1234 ASSEMBLED ON VV 16, 2001 IN THE ASSEMBLY LINE "A"

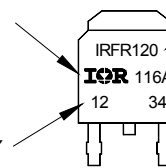
Note: "P" in assembly line position indicates "Lead-Free"

"P̄" in assembly line position indicates "Lead-Free" qualification to the consumer-level

OR

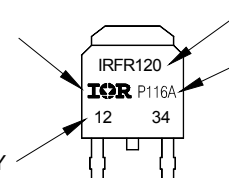
INTERNATIONAL RECTIFIER LOGO
ASSEMBLY LOT CODE

INTERNATIONAL RECTIFIER LOGO
ASSEMBLY LOT CODE



PART NUMBER
DATE CODE
YEAR 1 = 2001
WEEK 16
LINE A

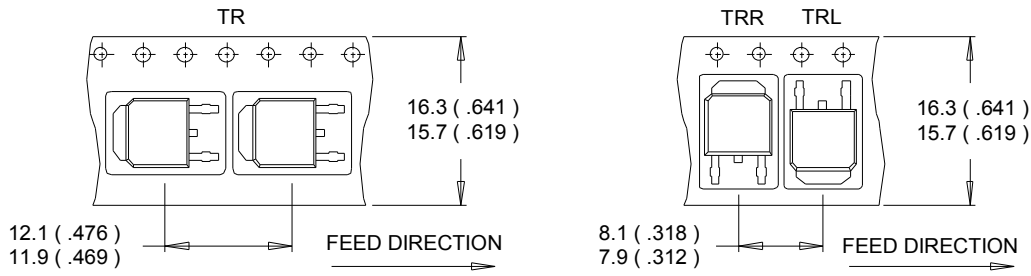
INTERNATIONAL RECTIFIER LOGO
ASSEMBLY LOT CODE



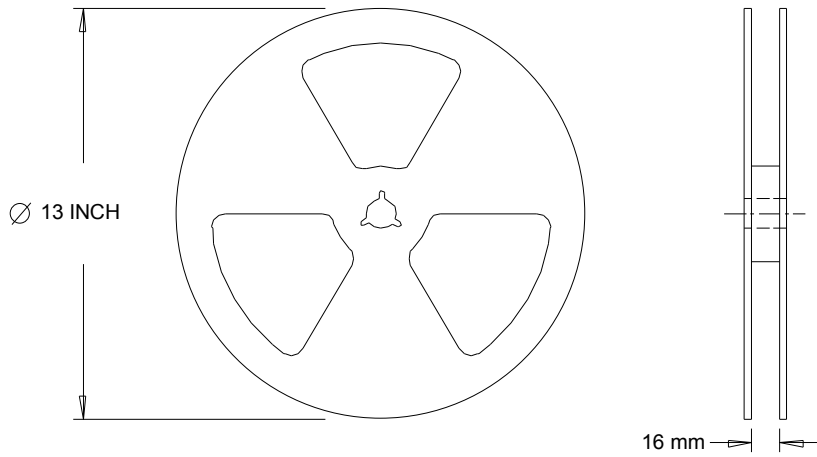
PART NUMBER
DATE CODE
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)
P̄ = DESIGNATES LEAD-FREE PRODUCT QUALIFIED TO THE CONSUMER LEVEL (OPTIONAL)
YEAR 1 = 2001
WEEK 16
A = ASSEMBLY SITE CODE

Note: For the most current drawing please refer to Infineon's web site www.infineon.com

D-Pak (TO-252AA) Tape & Reel Information Dimensions are shown in millimeters (inches)



- NOTES :
1. CONTROLLING DIMENSION : MILLIMETER.
 2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
 3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



- NOTES :
1. OUTLINE CONFORMS TO EIA-481.

Note: For the most current drawing please refer to Infineon's web site www.infineon.com

Qualification Information†

Qualification Level	Industrial (per JEDEC JESD47F) ††	
Moisture Sensitivity Level	D-Pak	MSL1 (per JEDEC J-STD-020D) ††
	I-Pak	
RoHS Compliant	Yes	

† Qualification standards can be found at Infineon’s web site www.infineon.com

†† Applicable version of JEDEC standard at the time of product release.

Revision History

Date	Comments
5/31/2016	<ul style="list-style-type: none"> Updated datasheet with corporate template. Added disclaimer on last page.

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