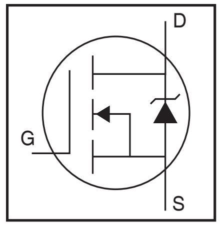
International
IOR Rectifier

PD - 97784

IRFR4510PbF
IRFU4510PbF

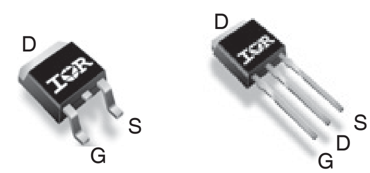
HEXFET® Power MOSFET

Applications
- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits



V_{DSS}		100V
$R_{DS(on)}$	typ.	11.1mΩ
	max.	13.9mΩ
I_D (Silicon Limited)		63A
I_D (Package Limited)		56A

Benefits
- Improved Gate, Avalanche and Dynamic dV/dt Ruggedness
- Fully Characterized Capacitance and Avalanche SOA
- Enhanced body diode dV/dt and dI/dt Capability
- Lead-Free



DPak
IRFR4510PbF

IPAK
IRFU4510PbF

G	D	S
Gate	Drain	Source

Absolute Maximum Ratings

Symbol	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, VGS @ 10V (Silicon Limited)	63	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V (Silicon Limited)	45	
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V (Package Limited)	56	
I_{DM}	Pulsed Drain Current ①	252	
P_D @T_C = 25°C	Maximum Power Dissipation	143	W
	Linear Derating Factor	0.95	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	

Avalanche Characteristics

$E_{AS\ (Thermally\ limited)}$	Single Pulse Avalanche Energy ②	127	mJ
I_{AR}	Avalanche Current ①	See Fig. 14, 15, 22a, 22b	A
E_{AR}	Repetitive Avalanche Energy ①		mJ

Thermal Resistance

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case ⑧	–––	1.05	°C/W
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑦	–––	50	
$R_{\theta JA}$	Junction-to-Ambient	–––	110	

ORDERING INFORMATION:
See detailed ordering and shipping information on the last page of this data sheet.

Notes ① through ⑧ are on page 11

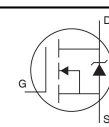
Static @ T_J = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	100	–––	–––	V	V_{GS} = 0V, I_D = 250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	–––	0.10	–––	V/°C	Reference to 25°C, I_D = 5mA ①
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	–––	11.1	13.9	mΩ	V_{GS} = 10V, I_D = 38A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	3.0	4.0	V	V_{DS} = V_{GS}, I_D = 100μA
I_{DSS}	Drain-to-Source Leakage Current	–––	–––	20	μA	V_{DS} = 100V, V_{GS} = 0V
		–––	–––	250		V_{DS} = 100V, 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
$R_{G(int)}$	Internal Gate Resistance	–––	0.61	–––	Ω	

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
gfs	Forward Transconductance	62	–––	–––	S	V_{DS} = 25V, I_D = 38A
Q_g	Total Gate Charge	–––	54	81	nC	I_D = 38A
Q_{gs}	Gate-to-Source Charge	–––	14	–––		V_{DS} = 50V
Q_{gd}	Gate-to-Drain ("Miller") Charge	–––	15	–––		V_{GS} = 10V ④
Q_{sync}	Total Gate Charge Sync. (Q_g - Q_{gd})	–––	39	–––		I_D = 38A, V_{DS} =0V, V_{GS} = 10V
$t_{d(on)}$	Turn-On Delay Time	–––	18	–––	ns	V_{DD} = 65V
t_r	Rise Time	–––	42	–––		I_D = 38A
$t_{d(off)}$	Turn-Off Delay Time	–––	42	–––		R_G = 7.5Ω
t_f	Fall Time	–––	34	–––		V_{GS} = 10V ④
C_{iss}	Input Capacitance	–––	3031	–––	pF	V_{GS} = 0V
C_{oss}	Output Capacitance	–––	213	–––		V_{DS} = 50V
C_{rss}	Reverse Transfer Capacitance	–––	104	–––		ƒ = 1.0MHz
C_{oss} eff. (ER)	Effective Output Capacitance (Energy Related)	–––	255	–––		V_{GS} = 0V, V_{DS} = 0V to 80V ⑥
C_{oss} eff. (TR)	Effective Output Capacitance (Time Related)	–––	478	–––		V_{GS} = 0V, V_{DS} = 0V to 80V ⑤

Diode Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions	
I_S	Continuous Source Current (Body Diode)	–––	–––	56	A	MOSFET symbol showing the integral reverse p-n junction diode. 	
I_{SM}	Pulsed Source Current (Body Diode) ①	–––	–––	252			
V_{SD}	Diode Forward Voltage	–––	–––	1.3	V	T_J = 25°C, I_S = 38A, V_{GS} = 0V ④	
dv/dt	Peak Diode Recovery	–––	7.0	–––	V/ns	T_J = 175°C, I_S = 38A, V_{DS} = 100V ③	
t_{rr}	Reverse Recovery Time	–––	34	–––	ns	T_J = 25°C	V_R = 86V
		–––	39	–––		T_J = 125°C	I_F = 38A
Q_{rr}	Reverse Recovery Charge	–––	47	–––	nC	T_J = 25°C	di/dt = 100A/μs ④
		–––	61	–––		T_J = 125°C	
I_{RRM}	Reverse Recovery Current	–––	2.4	–––	A	T_J = 25°C	
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD)					

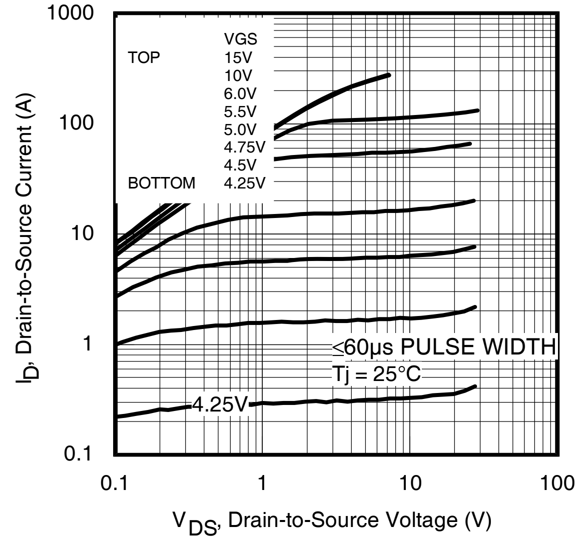


Fig 1. Typical Output Characteristics

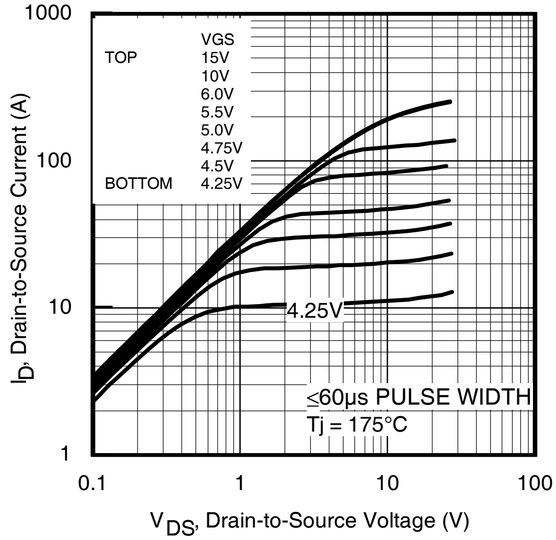


Fig 2. Typical Output Characteristics

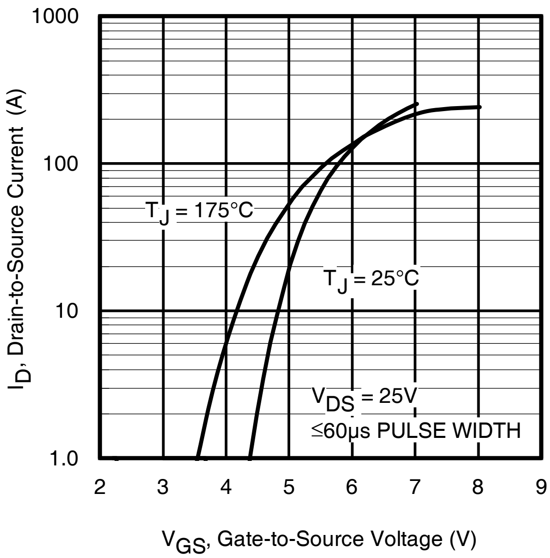


Fig 3. Typical Transfer Characteristics

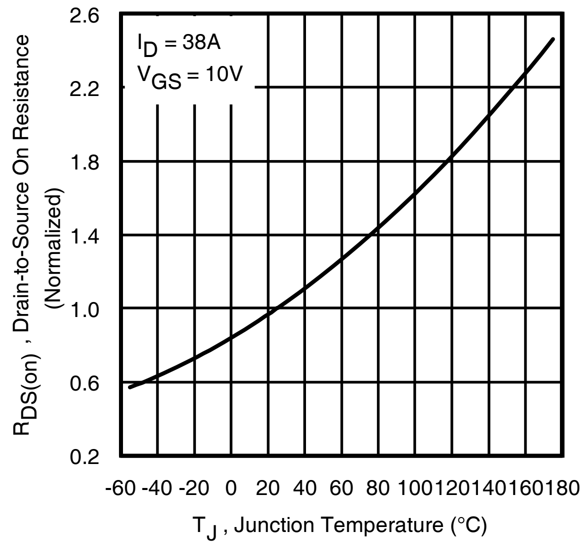


Fig 4. Normalized On-Resistance vs. Temperature

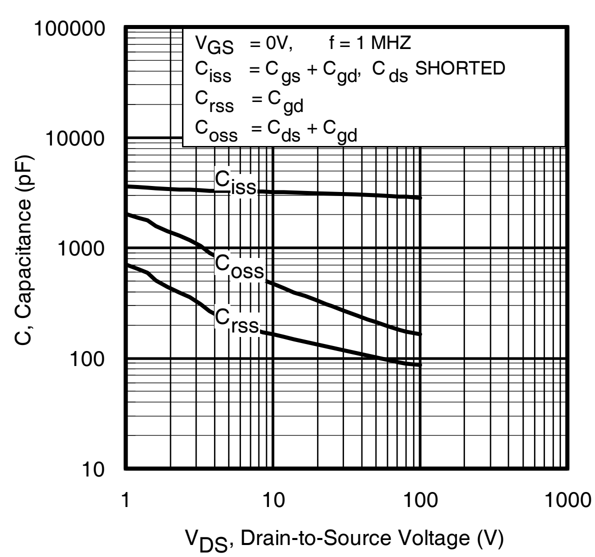


Fig 5. Typical Capacitance vs. Drain-to-Source Voltage

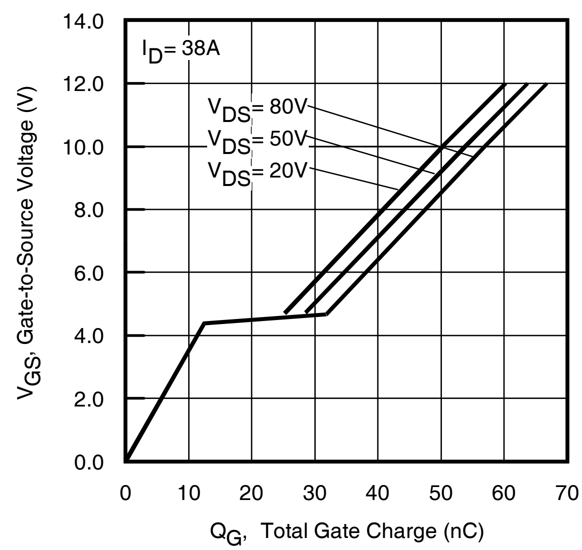


Fig 6. Typical Gate Charge vs. Gate-to-Source Voltage

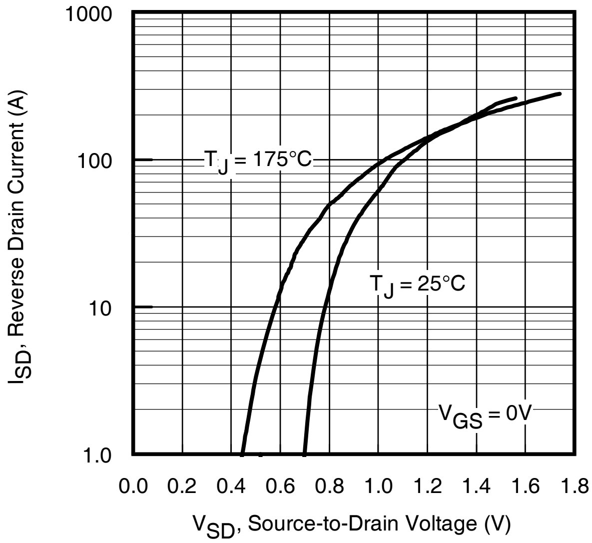


Fig 7. Typical Source-Drain Diode Forward Voltage

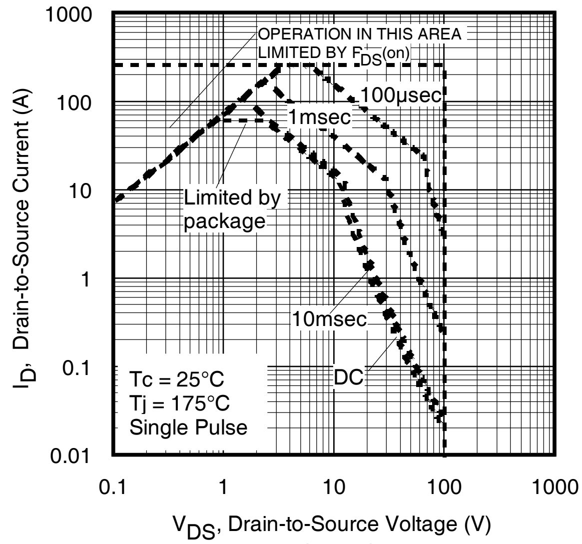


Fig 8. Maximum Safe Operating Area

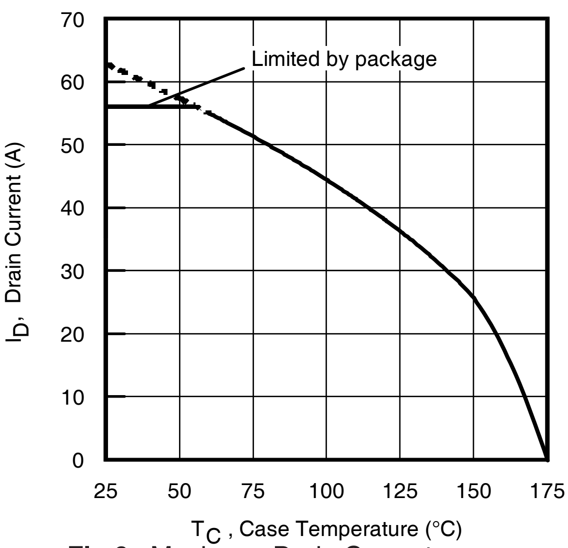


Fig 9. Maximum Drain Current vs. Case Temperature

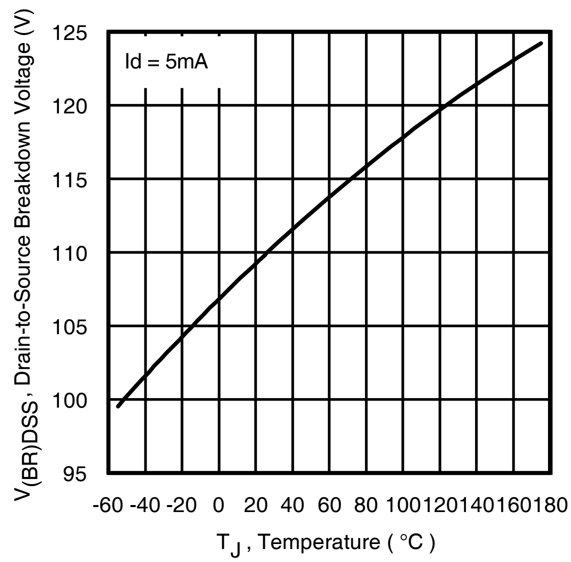


Fig 10. Drain-to-Source Breakdown Voltage

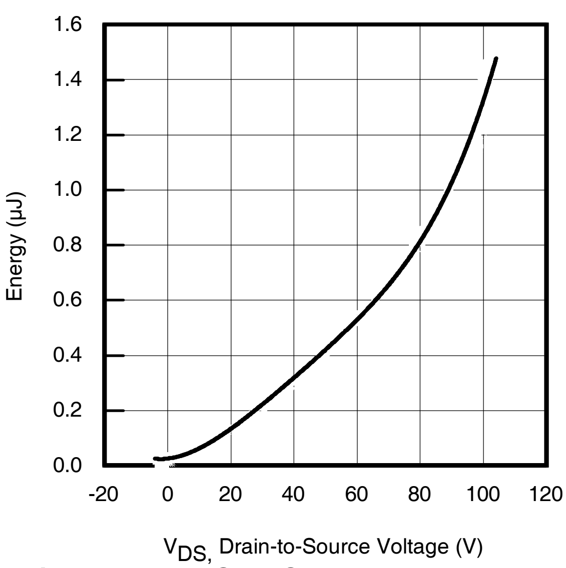


Fig 11. Typical C_{OSS} Stored Energy

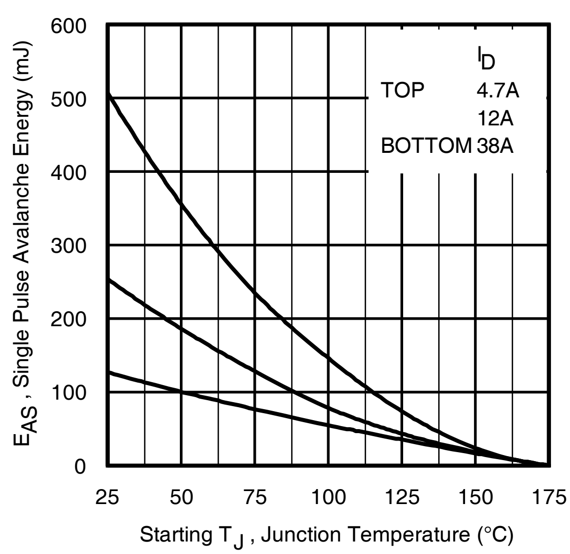


Fig 12. Maximum Avalanche Energy vs. DrainCurrent

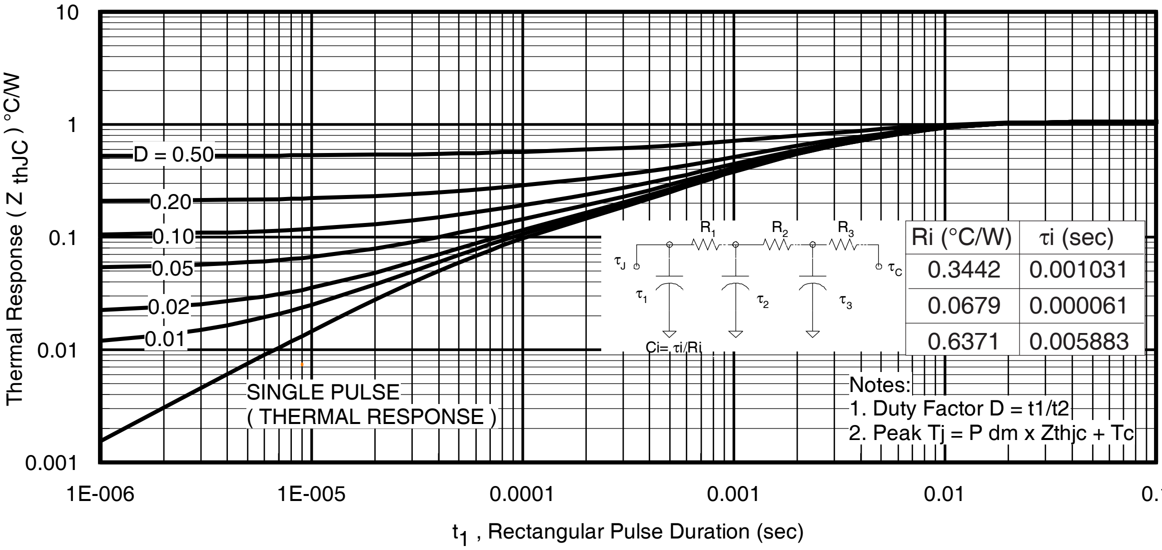


Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case

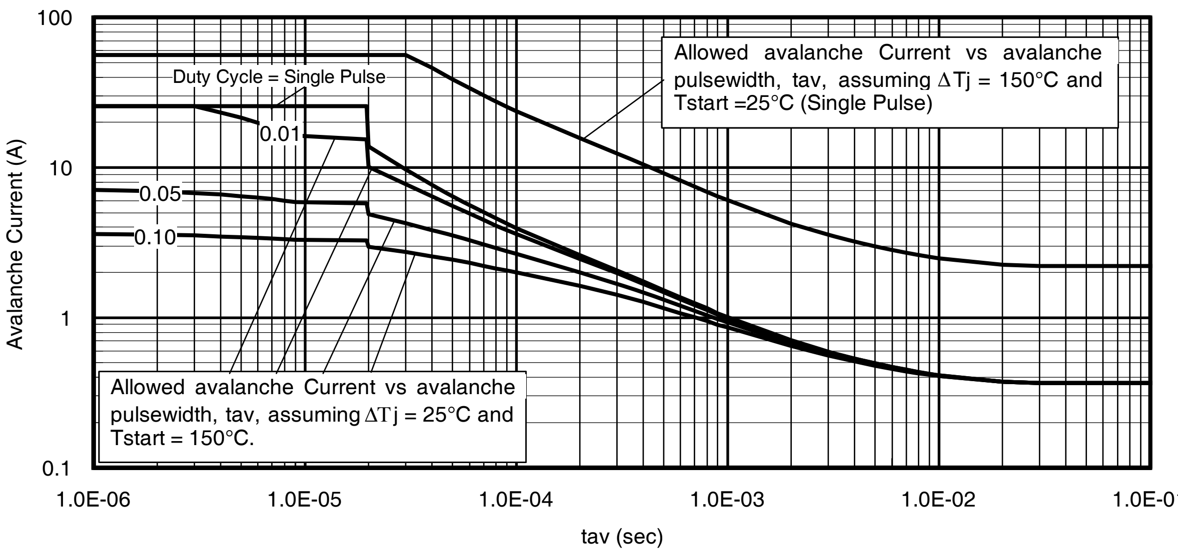


Fig 14. Typical Avalanche Current vs.Pulsewidth

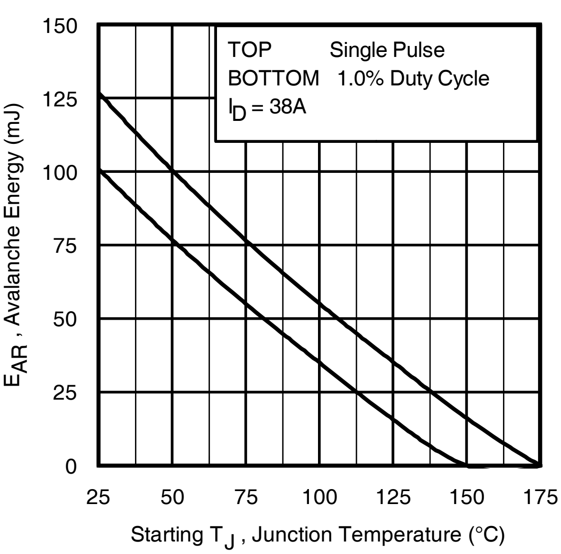


Fig 15. Maximum Avalanche Energy vs. Temperature

Notes on Repetitive Avalanche Curves , Figures 14, 15:
(For further info, see AN-1005 at www.irf.com)

1. Avalanche failures assumption:
   Purely a thermal phenomenon and failure occurs at a temperature far in excess of T_{jmax}. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as T_{jmax} is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 16a, 16b.
4. $P_{D\ (ave)}$ = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6. I_{av} = Allowable avalanche current.
7. ΔT = Allowable rise in junction temperature, not to exceed T_{jmax} (assumed as 25°C in Figure 14, 15).
   t_{av} = Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see Figures 13)

$$P_{D\ (ave)} = 1/2\ (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$
$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$
$$E_{AS\ (AR)} = P_{D\ (ave)} \cdot t_{av}$$

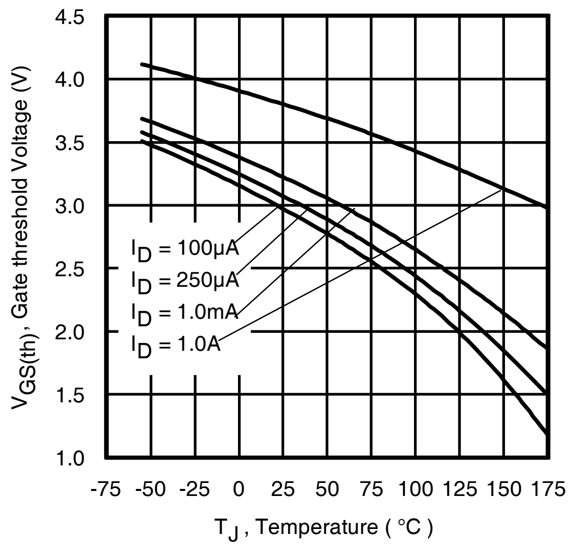


Fig 16. Threshold Voltage vs. Temperature

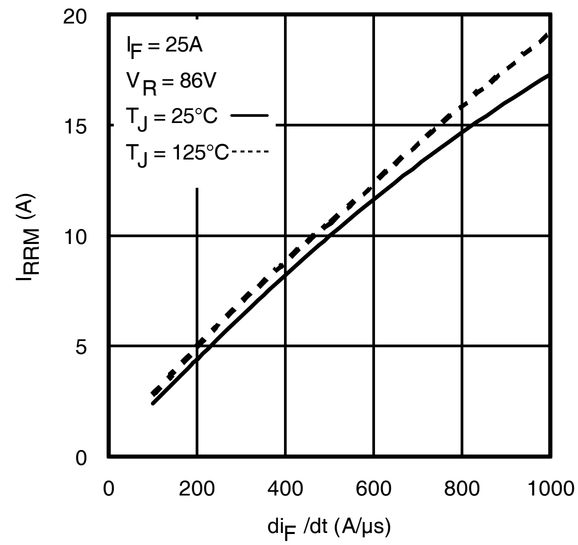


Fig. 17 - Typical Recovery Current vs. di_f/dt

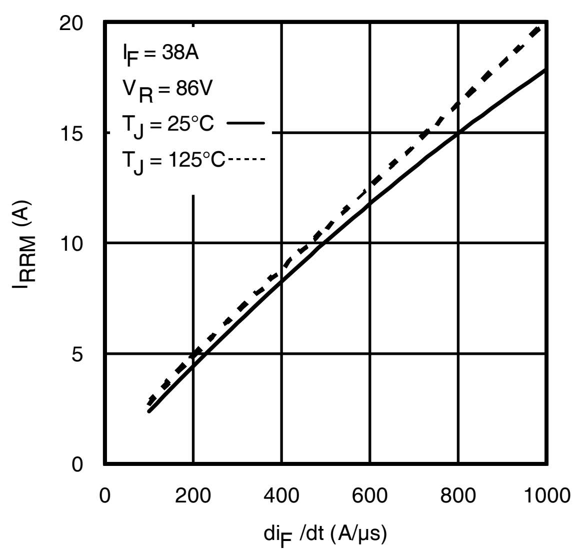


Fig. 18 - Typical Recovery Current vs. di_f/dt

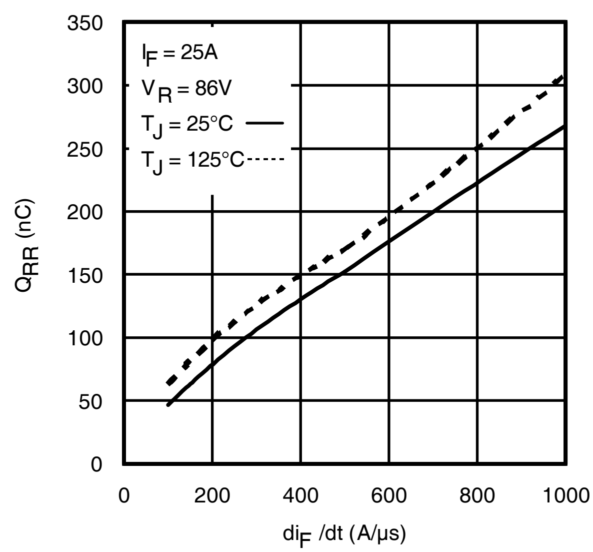


Fig. 19 - Typical Stored Charge vs. di_f/dt

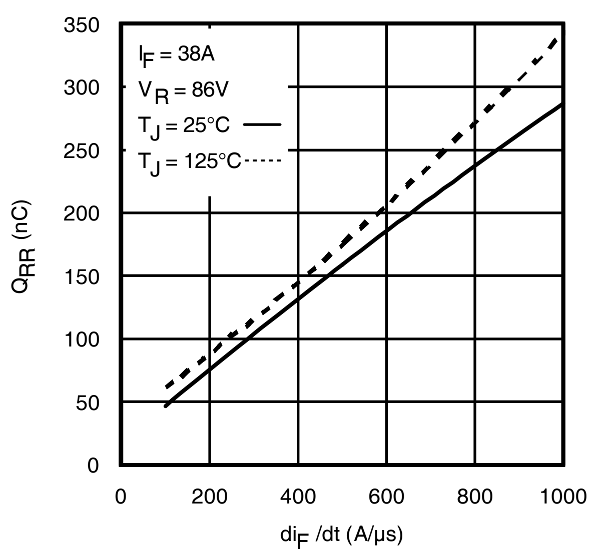


Fig. 20 - Typical Stored Charge vs. di_f/dt

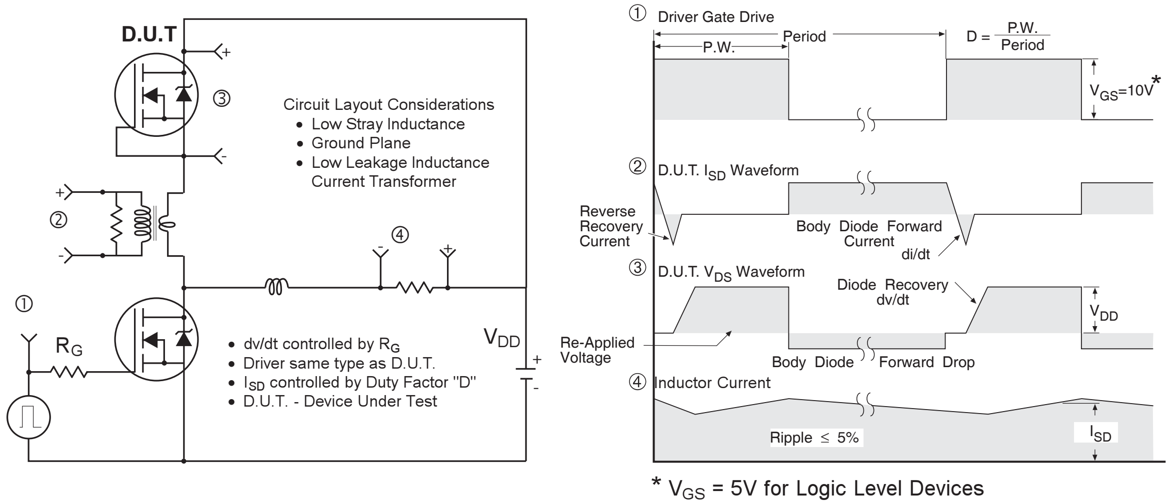


Fig 21. Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs

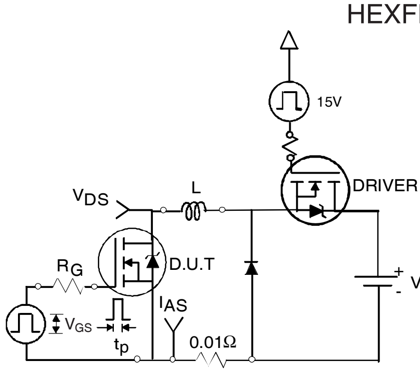


Fig 22a. Unclamped Inductive Test Circuit

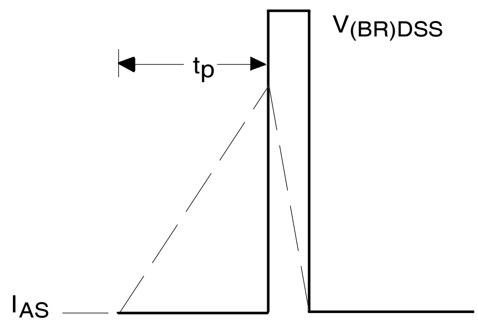


Fig 22b. Unclamped Inductive Waveforms

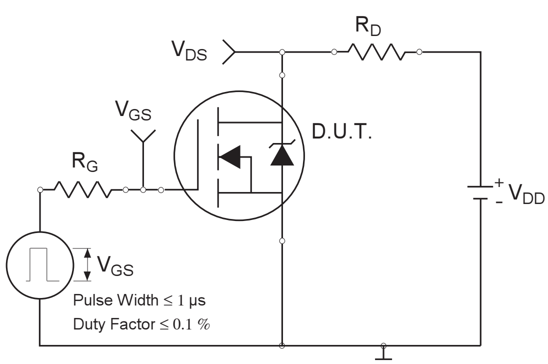


Fig 23a. Switching Time Test Circuit

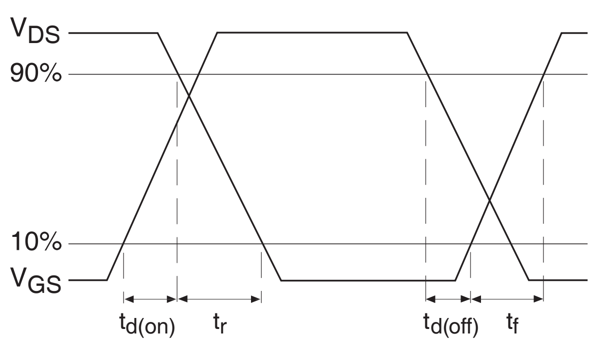


Fig 23b. Switching Time Waveforms

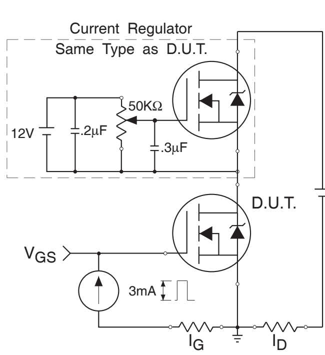


Fig 24a. Gate Charge Test Circuit

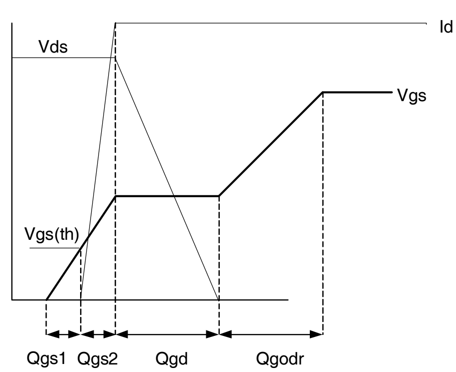
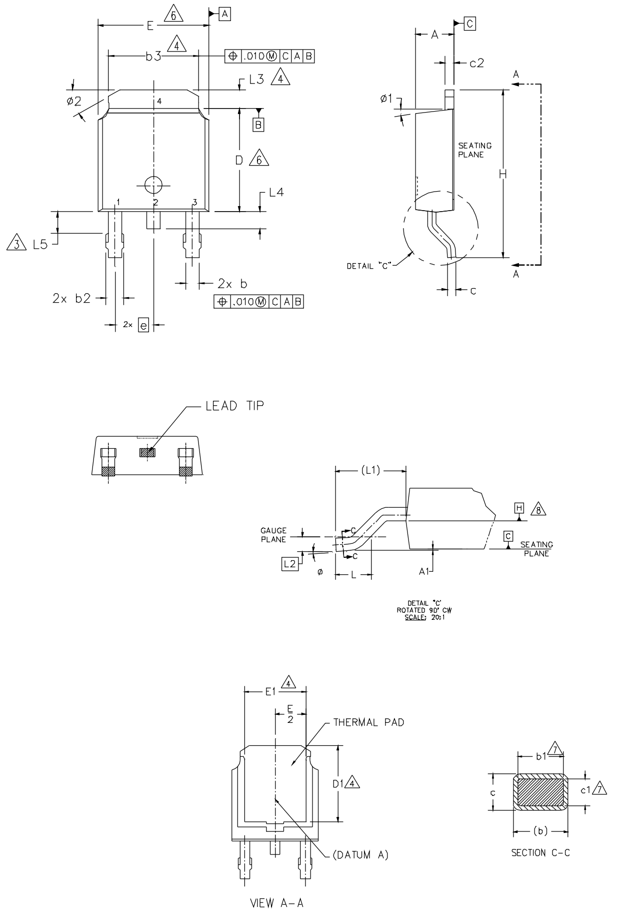


Fig 24b. Gate Charge Waveform

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 .005 [0.13] 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	0.65	0.79	.025	.031	7
b2	0.76	1.14	.030	.045	
b3	4.95	5.46	.195	.215	4
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	7
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	6
D1	5.21	–	.205	–	4
E	6.35	6.73	.250	.265	6
E1	4.32	–	.170	–	4
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	4
L4	–	1.02	–	.040	
L5	1.14	1.52	.045	.060	3
ø	0°	10°	0°	10°	
ø1	0°	15°	0°	15°	
ø2	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

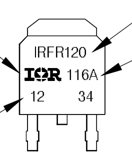
D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 1234
ASSEMBLED ON WW 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

INTERNATIONAL RECTIFIER LOGO



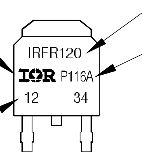
PART NUMBER

DATE CODE
YEAR 1 = 2001
WEEK 16
LINE A

ASSEMBLY LOT CODE

OR

INTERNATIONAL RECTIFIER LOGO



PART NUMBER

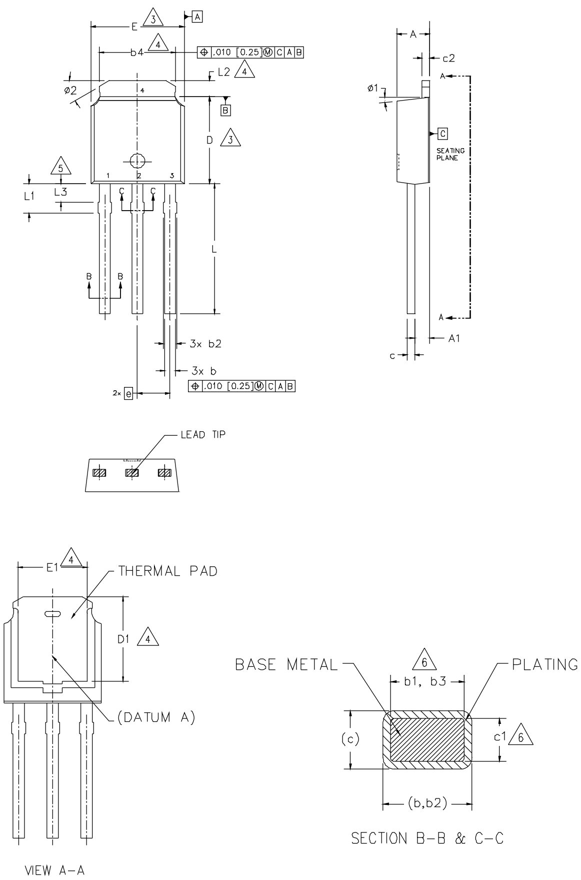
DATE CODE
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)
P̄ = DESIGNATES LEAD-FREE PRODUCT QUALIFIED TO THE CONSUMER LEVEL (OPTIONAL)
YEAR 1 = 2001
WEEK 16
A = ASSEMBLY SITE CODE

ASSEMBLY LOT CODE

Note: For the most current drawing please refer to IR website at http://www.irf.com/package/

I-Pak (TO-251AA) 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.– DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4.– THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.
5.– LEAD DIMENSION UNCONTROLLED IN L3.
6.– DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
7.– OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA (Date 06/02).
8.– CONTROLLING DIMENSION : INCHES.

SYMBOL	DIMENSIONS MILLIMETERS MIN.	MILLIMETERS MAX.	INCHES MIN.	INCHES MAX.	NOTES
A	2.18	2.39	.086	.094	
A1	0.89	1.14	.035	.045	
b	0.64	0.89	.025	.035	
b1	0.65	0.79	.025	.031	6
b2	0.76	1.14	.030	.045	
b3	0.76	1.04	.030	.041	6
b4	4.95	5.46	.195	.215	4
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	6
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	3
D1	5.21	–	.205	–	4
E	6.35	6.73	.250	.265	3
E1	4.32	–	.170	–	4
e	2.29 BSC		.090 BSC		
L	8.89	9.65	.350	.380	
L1	1.91	2.29	.045	.090	
L2	0.89	1.27	.035	.050	4
L3	1.14	1.52	.045	.060	5
ø1	0°	15°	0°	15°	
ø2	25°	35°	25°	35°	

LEAD ASSIGNMENTS

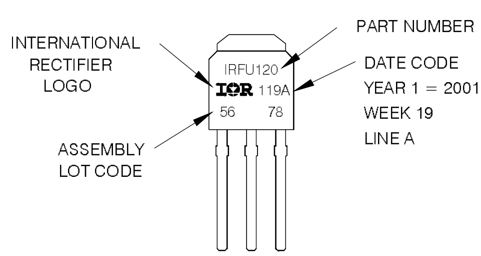
HEXFET

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

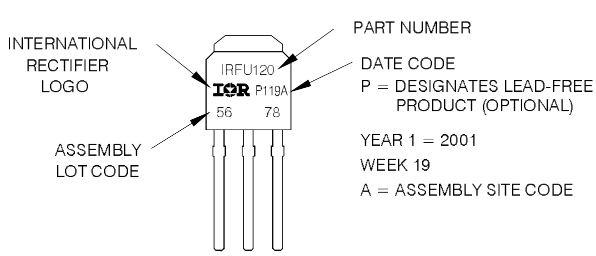
I-Pak (TO-251AA) Part Marking Information

EXAMPLE: THIS IS AN IRFU120
WITH ASSEMBLY
LOT CODE 5678
ASSEMBLED ON WW 19, 2001
IN THE ASSEMBLY LINE "A"

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



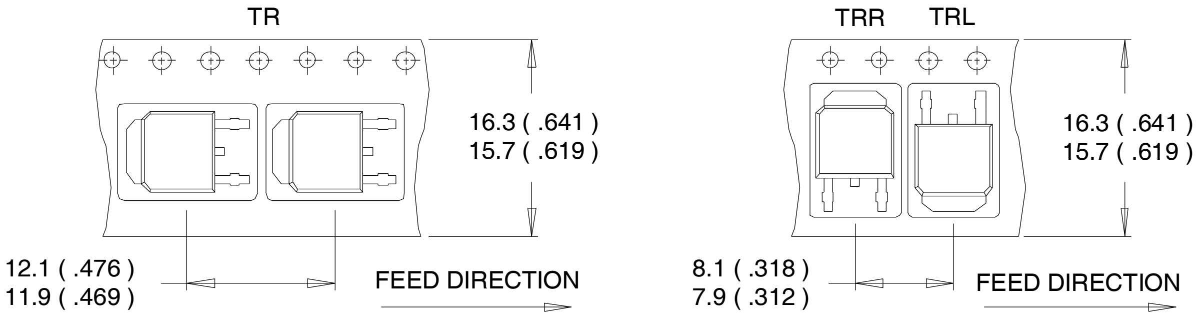
OR



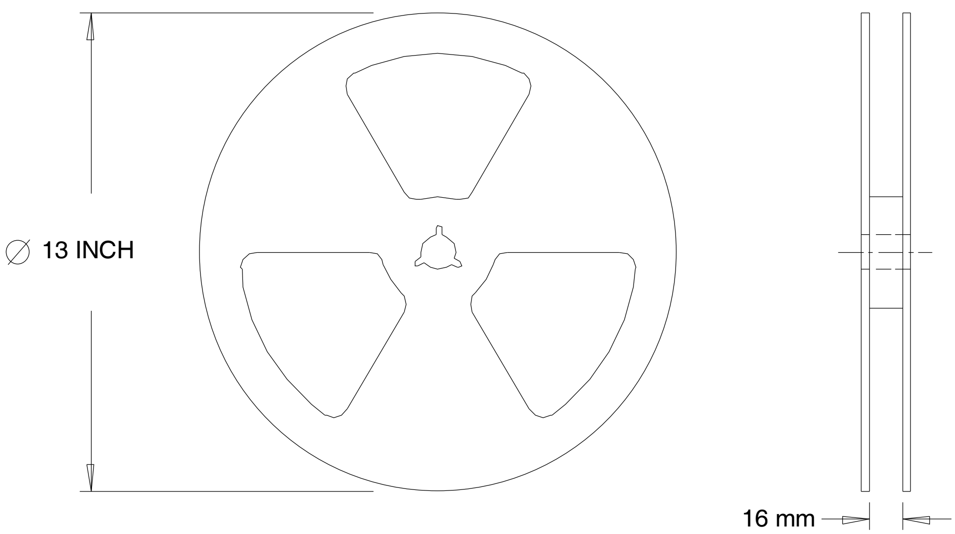
Note: For the most current drawing please refer to IR website at http://www.irf.com/package/

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 IR website at http://www.irf.com/package/

Orderable part number	Package Type	Standard Pack		Note
		Form	Quantity	
IRFR4510PbF	D-PAK	Tube/Bulk	75	
IRFR4510TRPbF	D-PAK	Tape and Reel	2000	
IRFU4510PbF	I-PAK	Tube/Bulk	75	

Qualification Information†

Qualification level	Industrial ††	
	(per JEDEC JESD47F††† guidelines)	
	Comments: This family of products has passed JEDEC's Industrial qualification. IR's Consumer qualification level is granted by extension of the higher Industrial level.	
Moisture Sensitivity Level	D-PAK	MSL1
		(per JEDEC J-STD-020D†††)
	I-PAK	Not applicable
RoHS Compliant	Yes	

† Qualification standards can be found at International Rectifier's web site http://www.irf.com/product-info/reliability
†† Higher qualification ratings may be available should the user have such requirements. Please contact your International Rectifier sales representative for further information: http://www.irf.com/whoto-call/salesrep/
††† Applicable version of JEDEC standard at the time of product release.

Notes:

① Repetitive rating; pulse width limited by max. junction temperature.
② Limited by T_{Jmax}, starting $T_J = 25°C$, L = 0.18mH $R_G = 50\Omega$, $I_{AS} = 38A$, $V_{GS} = 10V$. Part not recommended for use above this value.
③ $I_{SD} \leq 38A$, $di/dt \leq 2031A/\mu s$, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq 175°C$.
④ Pulse width ≤ 400µs; duty cycle ≤ 2%.
⑤ C_{oss} eff. (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}.
⑥ C_{oss} eff. (ER) is a fixed capacitance that gives the same energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS}.
⑦ When mounted on 1" square PCB (FR-4 or G-10 Material). For recom mended footprint and soldering techniques refer to application note #AN-994.
⑧ R_θ is measured at T_J approximately 90°C.

Data and specifications subject to change without notice

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