International IOR Rectifier

DIGITAL AUDIO MOSFET

IRF6665PbF
IRF6665TRPbF

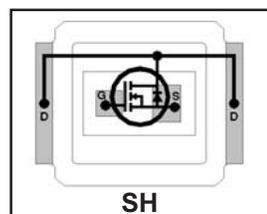| Key Parameters		
V_{DS}	100	V
$R_{DS(on)}$ typ. @ V_{GS} = 10V	53	mΩ
Q_g typ.	8.7	nC
$R_{G(int)}$ typ.	1.9	Ω

Features

- Latest MOSFET Silicon technology
- Key parameters optimized for Class-D audio amplifier applications
- Low $R_{DS(on)}$ for improved efficiency
- Low Q_g for better THD and improved efficiency
- Low Q_{rr} for better THD and lower EMI
- Low package stray inductance for reduced ringing and lower EMI
- Can deliver up to 100W per channel into 8Ω with no heatsink ⑩
- Dual sided cooling compatible
- Compatible with existing surface mount technologies
- RoHS compliant containing no lead or bromide
- Lead-Free (Qualified up to 260°C Reflow)

SH

DirectFET™ ISOMETRIC

Applicable DirectFET Outline and Substrate Outline (see p. 6, 7 for details)

SQ	SX	ST	**SH**	MQ	MX	MT	MN			

Description

This Digital Audio MOSFET is specifically designed for Class-D audio amplifier applications. This MOSFET utilizes the latest processing techniques to achieve low on-resistance per silicon area. Furthermore, gate charge, body-diode reverse recovery and internal gate resistance are optimized to improve key Class-D audio amplifier performance factors such as efficiency, THD, and EMI.

The IRF6665PbF device utilizes DirectFET™ packaging technology. DirectFET™ packaging technology offers lower parasitic inductance and resistance when compared to conventional wirebonded SOIC packaging. Lower inductance improves EMI performance by reducing the voltage ringing that accompanies fast current transients. The DirectFET™ package is compatible with existing layout geometries used in power applications, PCB assembly equipment and vapor phase, infra-red or convection soldering techniques, when application note AN-1035 is followed regarding the manufacturing method and processes. The DirectFET™ package also allows dual sided cooling to maximize thermal transfer in power systems, improving thermal resistance and power dissipation. These features combine to make this MOSFET a highly efficient, robust and reliable device for Class-D audio amplifier applications.

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{DS}	Drain-to-Source Voltage	100	V
V_{GS}	Gate-to-Source Voltage	± 20	
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V	19	
I_D @ T_A = 25°C	Continuous Drain Current, V_{GS} @ 10V	4.2	A
I_D @ T_A = 70°C	Continuous Drain Current, V_{GS} @ 10V	3.4	
I_{DM}	Pulsed Drain Current ①	34	
P_D @T_C = 25°C	Maximum Power Dissipation	42	W
P_D @T_A = 25°C	Power Dissipation ③	2.2	
P_D @T_A = 70°C	Power Dissipation ③	1.4	
	Linear Derating Factor	0.017	W/°C
T_J	Operating Junction and	-40 to + 150	°C
T_{STG}	Storage Temperature Range		

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient ③⑨	——	58	°C/W
$R_{\theta JA}$	Junction-to-Ambient ⑥⑨	12.5	——	
$R_{\theta JA}$	Junction-to-Ambient ⑦⑨	20	——	
$R_{\theta JC}$	Junction-to-Case ⑧⑨	——	3.0	
$R_{\theta J\text{-}PCB}$	Junction-to-PCB Mounted	1.4	——	

Notes ①   through ⑩ 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	100	——	——	V	V$_{GS}$ = 0V, I$_D$ = 250µA
ΔV$_{(BR)DSS}$/ΔT$_J$	Breakdown Voltage Temp. Coefficient	——	0.12	——	V/°C	Reference to 25°C, I$_D$ = 1mA
R$_{DS(on)}$	Static Drain-to-Source On-Resistance	——	53	62	mΩ	V$_{GS}$ = 10V, I$_D$ = 5.0A ④
V$_{GS(th)}$	Gate Threshold Voltage	3.0	——	5.0	V	V$_{DS}$ = V$_{GS}$, I$_D$ = 250µA
I$_{DSS}$	Drain-to-Source Leakage Current	——		20	µA	V$_{DS}$ = 100V, V$_{GS}$ = 0V
		——		250		V$_{DS}$ = 80V, 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	——	1.9	2.9	Ω	

Dynamic @ T$_J$ = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
gfs	Forward Transconductance	6.6	——	——	S	V$_{DS}$ = 10V, I$_D$ = 5.0A
Q$_g$	Total Gate Charge	——	8.4	13		V$_{DS}$ = 50V
Q$_{gs1}$	Pre-Vth Gate-to-Source Charge	——	2.2	——		V$_{GS}$ = 10V
Q$_{gs2}$	Post-Vth Gate-to-Source Charge	——	0.64	——		I$_D$ = 5.0A
Q$_{gd}$	Gate-to-Drain Charge	——	2.8	——	nC	See Fig. 6 and 17
Q$_{godr}$	Gate Charge Overdrive	——	2.8	——		
Q$_{sw}$	Switch Charge (Q$_{gs2}$ + Q$_{gd}$)	——	3.4	——		
t$_{d(on)}$	Turn-On Delay Time	——	7.4	——		V$_{DD}$ = 50V
t$_r$	Rise Time	——	2.8	——		I$_D$ = 5.0A
t$_{d(off)}$	Turn-Off Delay Time	——	14	——	ns	R$_G$ = 6.0Ω
t$_f$	Fall Time	——	4.3	——		V$_{GS}$ = 10V ④
C$_{iss}$	Input Capacitance	——	530	——		V$_{GS}$ = 0V
C$_{oss}$	Output Capacitance	——	110	——		V$_{DS}$ = 25V
C$_{rss}$	Reverse Transfer Capacitance	——	29	——	pF	f = 1.0MHz
C$_{oss}$	Output Capacitance	——	510	——		V$_{GS}$ = 0V, V$_{DS}$ = 1.0V, f = 1.0MHz
C$_{oss}$	Output Capacitance	——	67	——		V$_{GS}$ = 0V, V$_{DS}$ = 80V, f = 1.0MHz
C$_{oss}$ eff.	Effective Output Capacitance	——	130	——		V$_{GS}$ = 0V, V$_{DS}$ = 0V to 80V ⑤

Avalanche Characteristics

	Parameter	Typ.	Max.	Units
E$_{AS}$	Single Pulse Avalanche Energy②	——	11	mJ
I$_{AR}$	Avalanche Current ①	——	5.0	A

Diode Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I$_S$	Continuous Source Current (Body Diode)	——	——	38	A	MOSFET symbol showing the integral reverse p-n junction diode.
I$_{SM}$	Pulsed Source Current (Body Diode) ①	——	——	34		
V$_{SD}$	Diode Forward Voltage	——	——	1.3	V	T$_J$ = 25°C, I$_S$ = 5.0A, V$_{GS}$ = 0V ④
t$_{rr}$	Reverse Recovery Time	——	31	——	ns	T$_J$ = 25°C, I$_F$ = 5.0A, V$_{DD}$ = 25V
Q$_{rr}$	Reverse Recovery Charge	——	37	——	nC	di/dt = 100A/µs ④
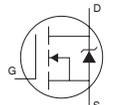
Notes:

① Repetitive rating; pulse width limited by
   max. junction temperature.

② Starting T$_J$ = 25°C, L = 0.89mH, R$_G$ = 25Ω, I$_{AS}$ = 5.0A.

③ Surface mounted on 1 in. square Cu board.

④ Pulse width ≤ 400µs; duty cycle ≤ 2%.

⑤ C$_{oss}$ eff. 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 Used double sided cooling , mounting pad.

⑦ Mounted on minimum footprint full size board with
   metalized back and with small clip heatsink.

⑧ T$_C$ measured with thermal couple mounted to top
   (Drain) of part.

⑨ R$_\theta$ is measured at T$_J$ of approximately 90°C.

⑩ Based on testing done using a typical device & evaluation board
   at Vbus=±45V, f$_{SW}$=400KHz, and T$_A$=25°C. The delta case
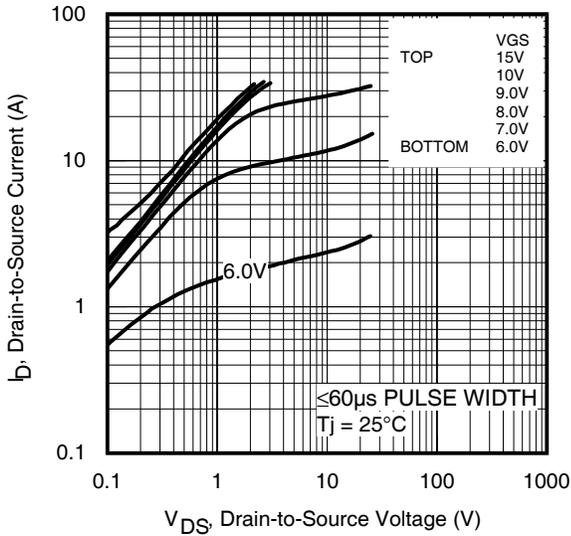   temperature ΔT$_C$ is 55°C.

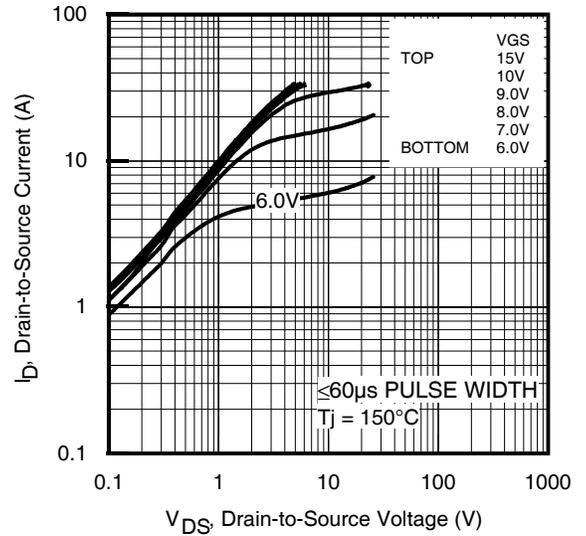**Fig 1.** Typical Output Characteristics

Graph legend: TOP / BOTTOM, VGS 15V, 10V, 9.0V, 8.0V, 7.0V, 6.0V. ≤60µs PULSE WIDTH, Tj = 25°C. Axes: I_D, Drain-to-Source Current (A) vs V_{DS}, Drain-to-Source Voltage (V).

Fig 2. Typical Output Characteristics

Graph legend: TOP / BOTTOM, VGS 15V, 10V, 9.0V, 8.0V, 7.0V, 6.0V. ≤60µs PULSE WIDTH, Tj = 150°C. Axes: I_D, Drain-to-Source Current (A) vs V_{DS}, Drain-to-Source Voltage (V).
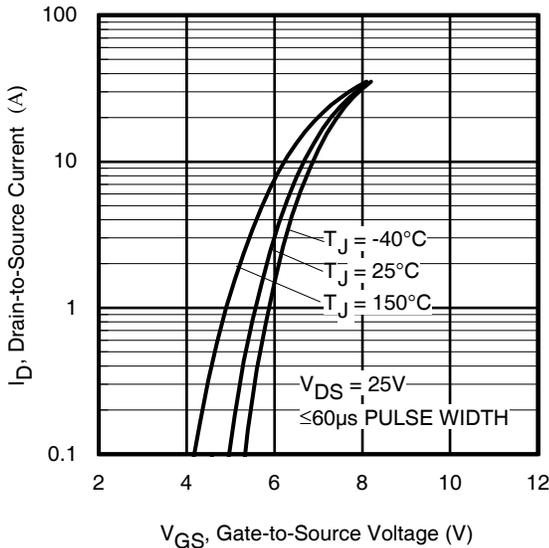
Fig 3. Typical Transfer Characteristics

Curves: $T_J = -40°C$, $T_J = 25°C$, $T_J = 150°C$. $V_{DS} = 25V$, ≤60µs PULSE WIDTH. Axes: I_D, Drain-to-Source Current (A) vs V_{GS}, Gate-to-Source Voltage (V).
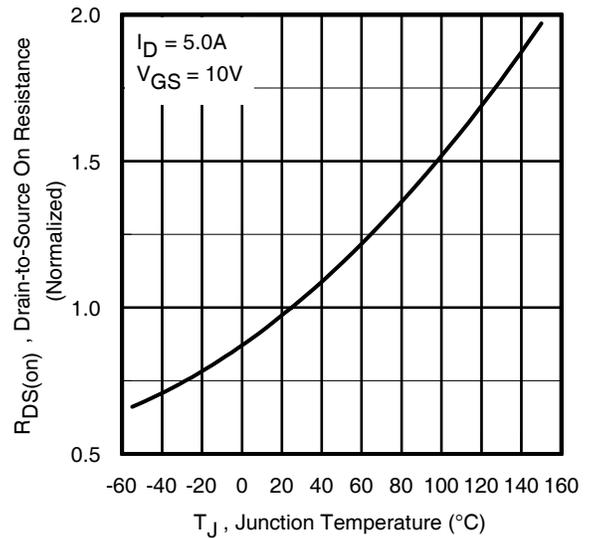
Fig 4. Normalized On-Resistance vs. Temperature

$I_D = 5.0A$, $V_{GS} = 10V$. Axes: $R_{DS(on)}$, Drain-to-Source On Resistance (Normalized) vs T_J, Junction Temperature (°C).
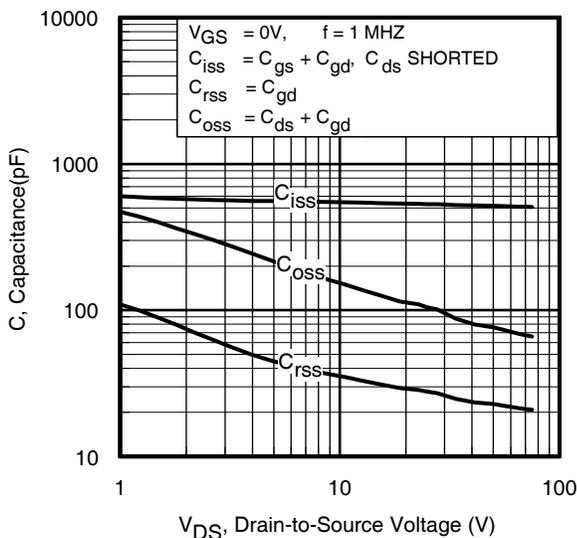
Fig 5. Typical Capacitance vs. Drain-to-Source Voltage

$V_{GS} = 0V$, f = 1 MHZ
$C_{iss} = C_{gs} + C_{gd}$, C_{ds} SHORTED
$C_{rss} = C_{gd}$
$C_{oss} = C_{ds} + C_{gd}$
Curves: C_{iss}, C_{oss}, C_{rss}. Axes: C, Capacitance(pF) vs V_{DS}, Drain-to-Source Voltage (V).
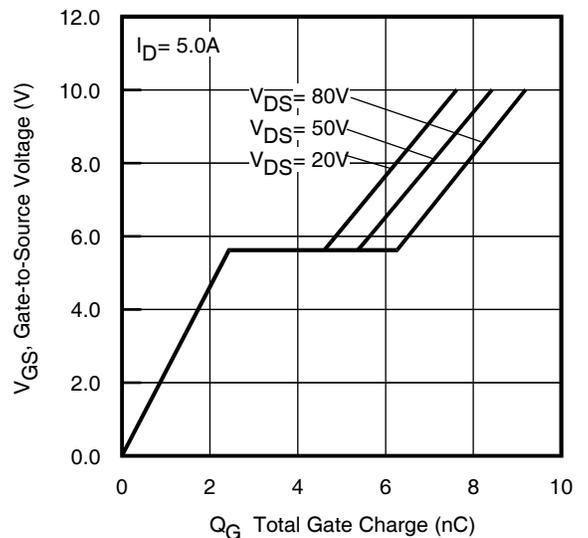
Fig 6. Typical Gate Charge vs. Gate-to-Source Voltage

$I_D = 5.0A$. Curves: $V_{DS} = 80V$, $V_{DS} = 50V$, $V_{DS} = 20V$. Axes: V_{GS}, Gate-to-Source Voltage (V) vs Q_G Total Gate Charge (nC).

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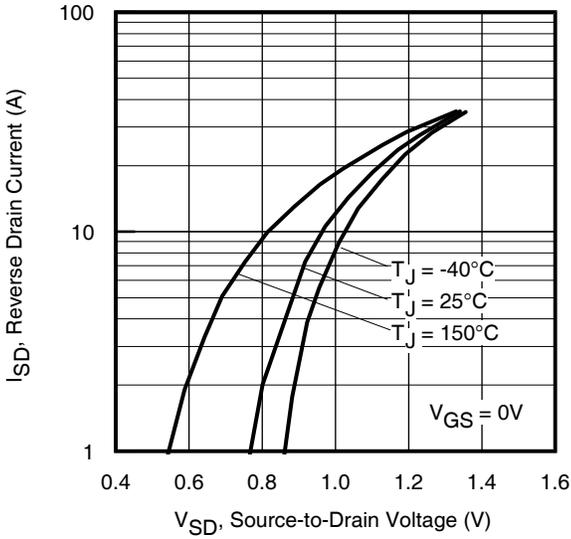
Fig 7. Typical Source-Drain Diode Forward Voltage
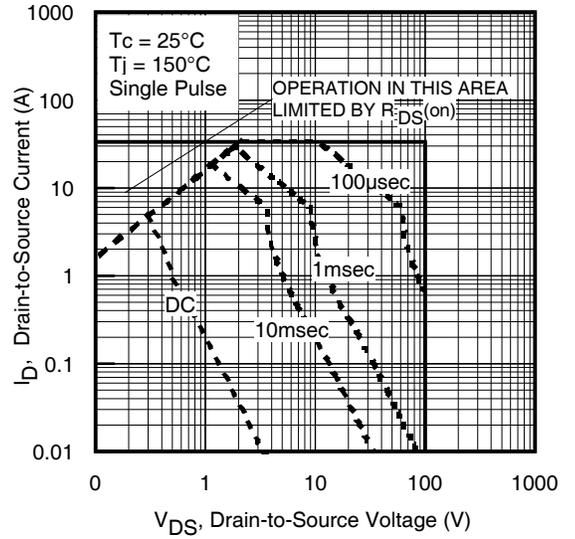
Fig 8. Maximum Safe Operating Area
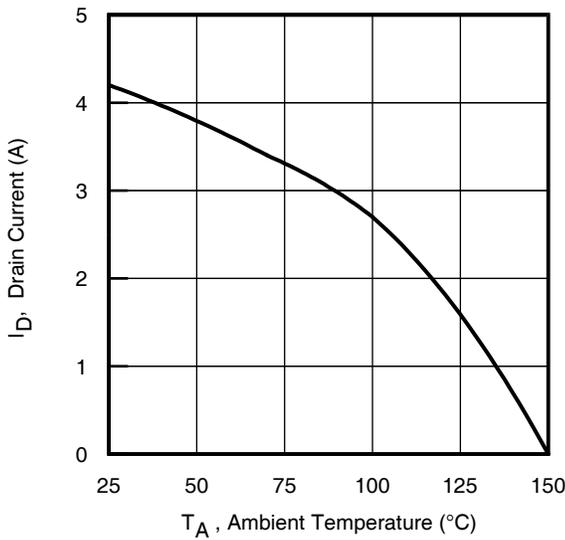
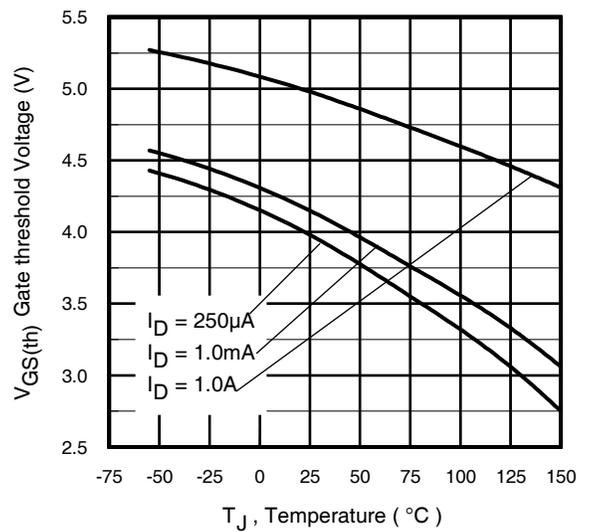**Fig 9.** Maximum Drain Current vs. Ambient Temperature
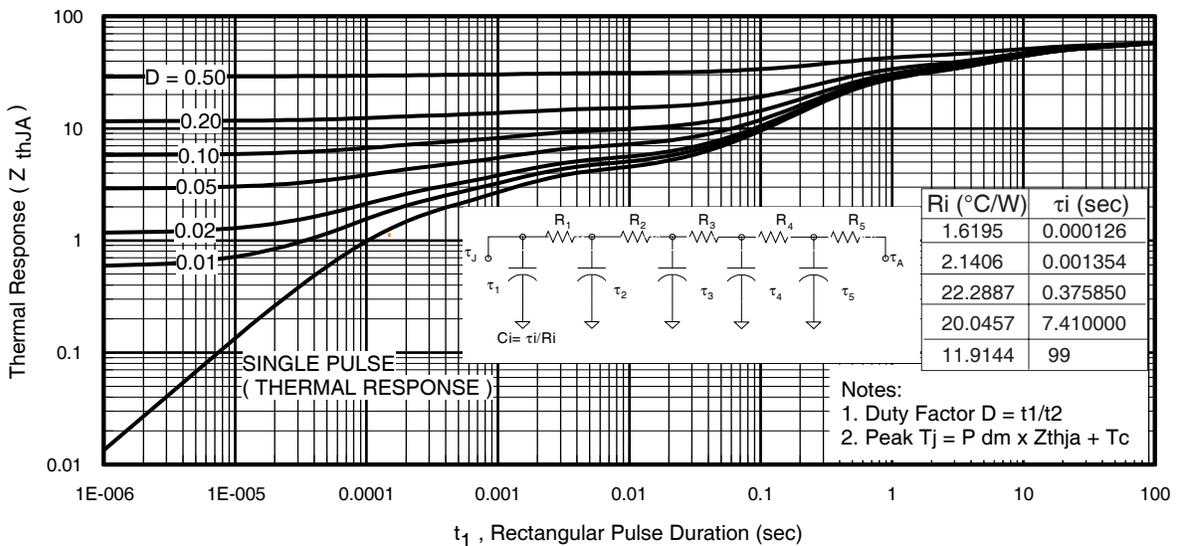
Fig 10. Threshold Voltage vs. Temperature

Ri (°C/W)	τi (sec)
1.6195	0.000126
2.1406	0.001354
22.2887	0.375850
20.0457	7.410000
11.9144	99

Notes:
1. Duty Factor D = t1/t2
2. Peak Tj = P dm x Zthja + Tc

Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Ambient ③

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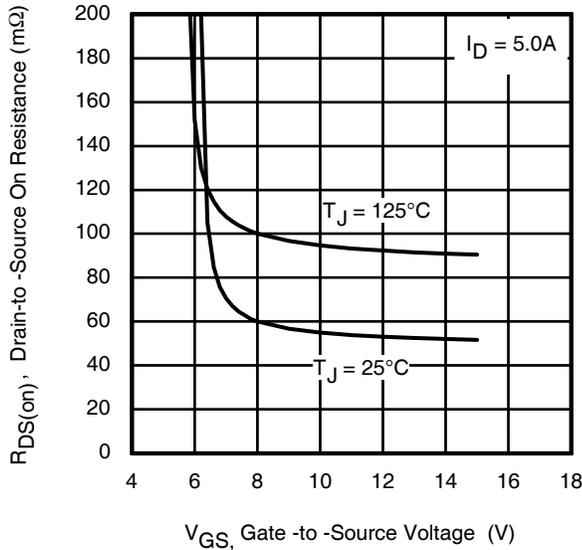
Fig 12. On-Resistance vs. Gate Voltage
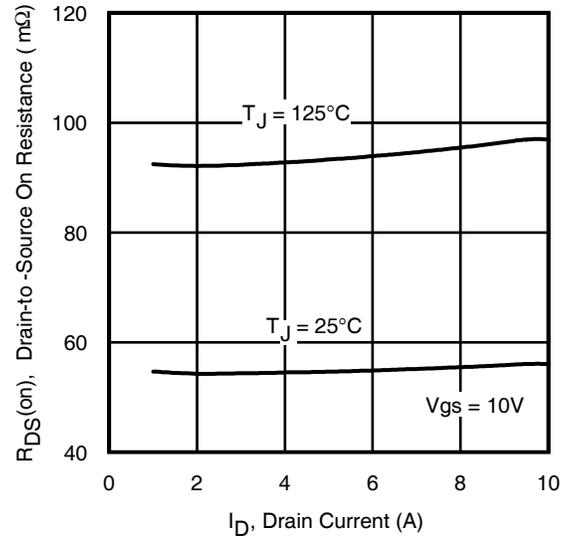
Fig 13. On-Resistance vs. Drain Current
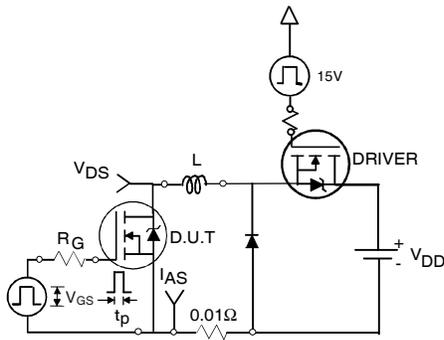
Fig 15a. Unclamped Inductive Test Circuit
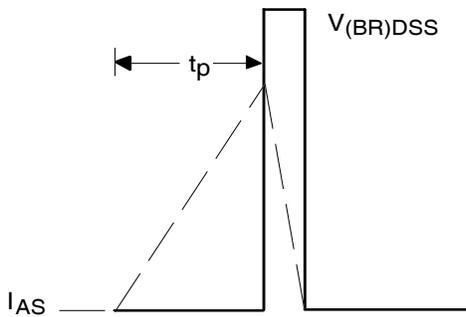
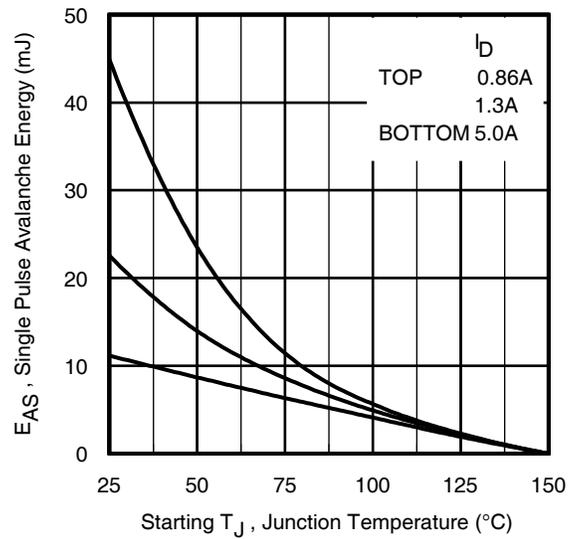**Fig 15b.** Unclamped Inductive Waveforms

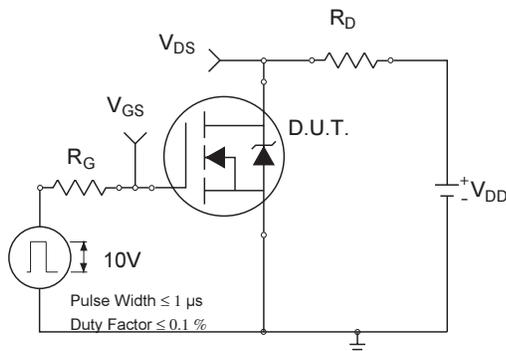**Fig 14.** Maximum Avalanche Energy vs. Drain Current
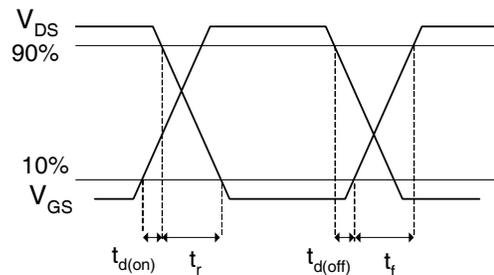
Fig 16a. Switching Time Test Circuit

Fig 16b. Switching Time Waveforms

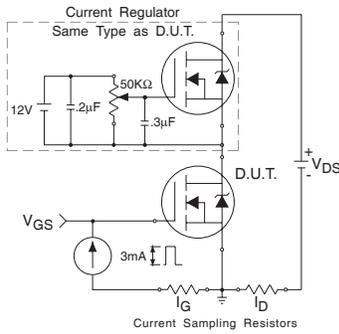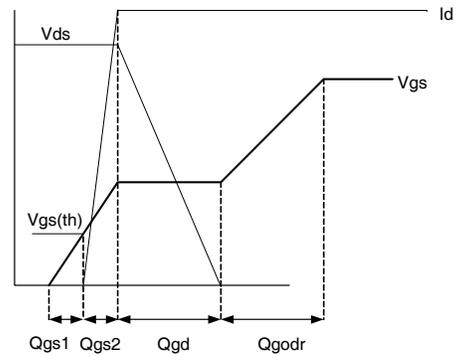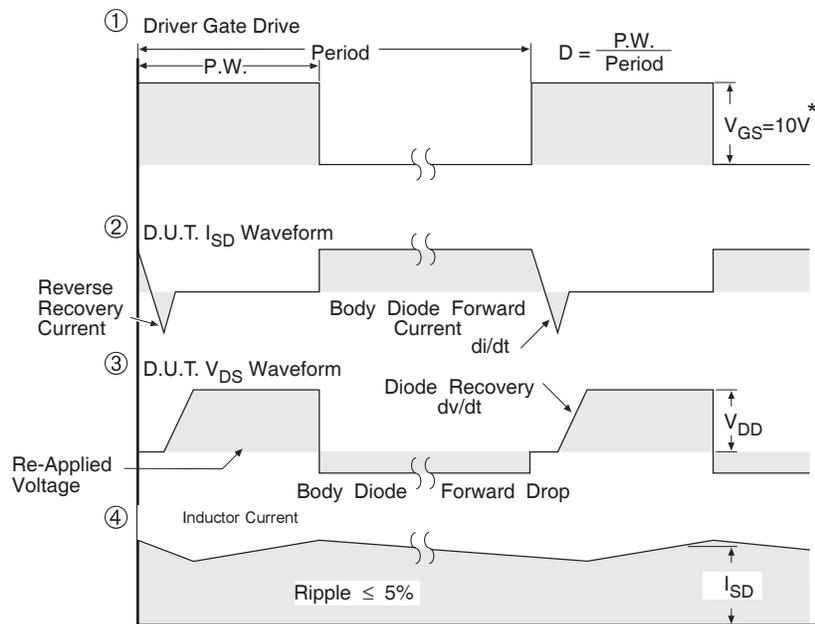**Fig 17a.** Gate Charge Test Circuit

Fig 17b. Gate Charge Waveform

Circuit Layout Considerations
- Low Stray Inductance
- Ground Plane
- Low Leakage Inductance Current Transformer

- di/dt controlled by R_G
- Driver same type as D.U.T.
- I_{SD} controlled by Duty Factor "D"
- D.U.T. - Device Under Test

V_{DD}

① Driver Gate Drive

$D = \dfrac{P.W.}{Period}$

$V_{GS}=10V$ *

② D.U.T. I_{SD} Waveform

Reverse Recovery Current

Body Diode Forward Current

di/dt

③ D.U.T. V_{DS} Waveform

Diode Recovery dv/dt

V_{DD}

Re-Applied Voltage

Body Diode Forward Drop

④ Inductor Current

Ripple ≤ 5%

I_{SD}

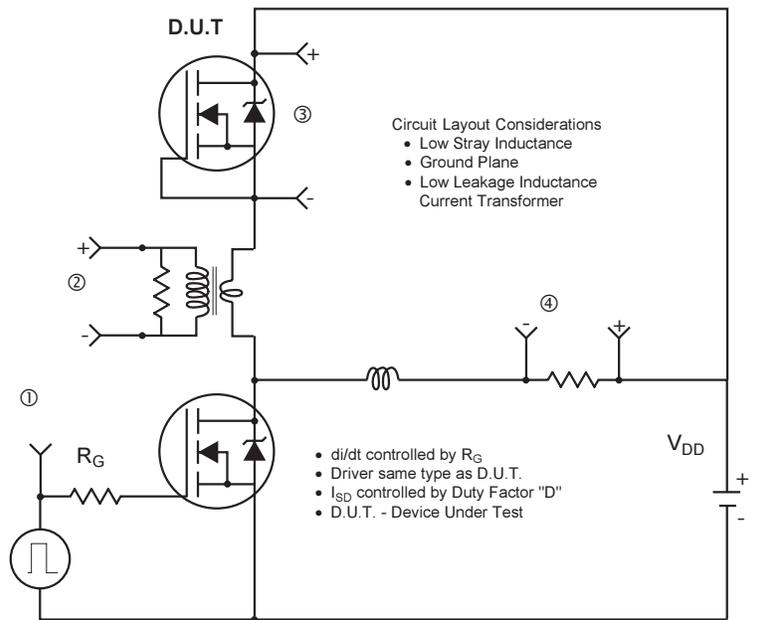* V_{GS} = 5V for Logic Level Devices

Fig 18. Diode Reverse Recovery Test Circuit for N-Channel HEXFET® Power MOSFETs

International IOR Rectifier

DirectFET™ Substrate and PCB Layout, SH Outline (Small Size Can, H-Designation).

Please see DirectFET application note AN-1035 for all details regarding PCB assembly using DirectFET. This includes all recommendations for stencil and substrate designs.

G = GATE
D = DRAIN
S = SOURCE
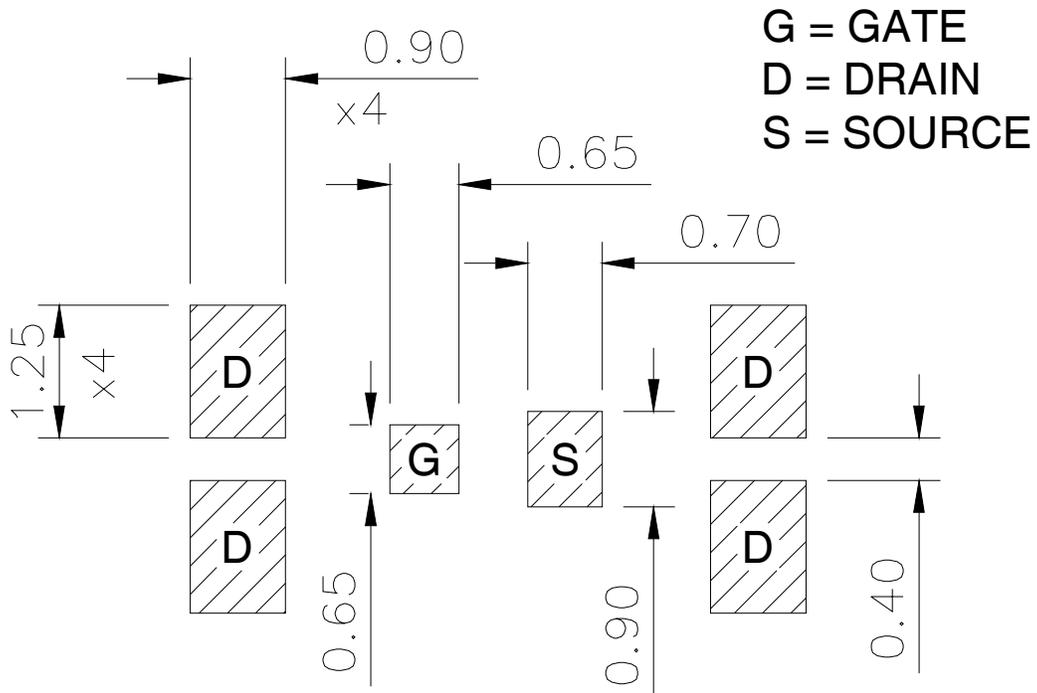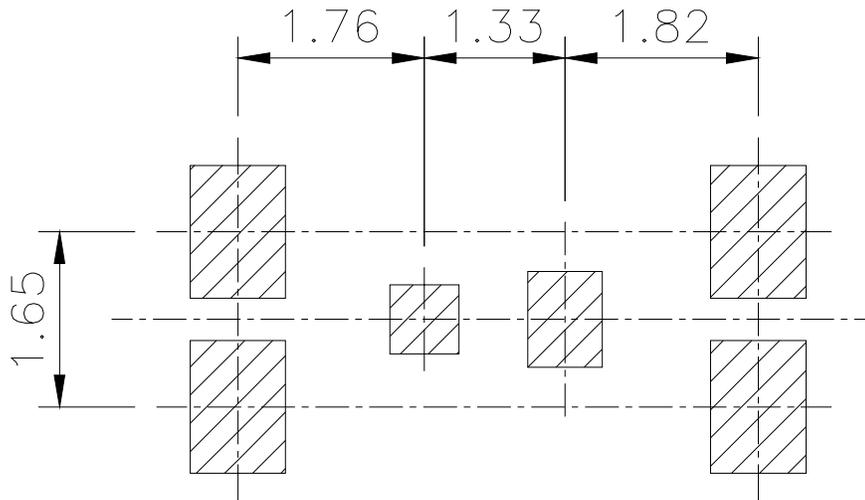
IRF6665PbF

DirectFET™ Outline Dimension, SH Outline
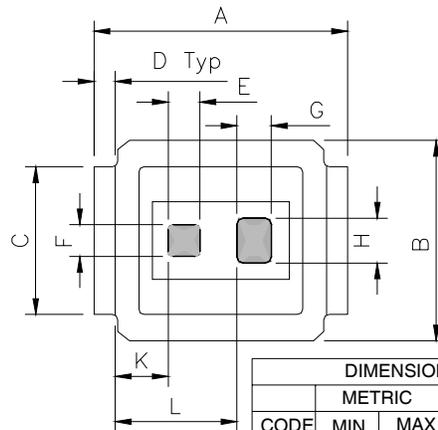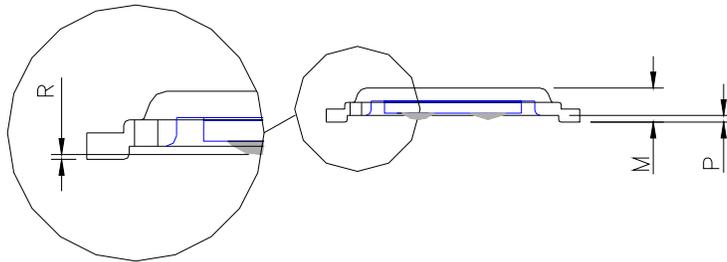## (Small Size Can, H-Designation).

Please see DirectFET application note AN-1035 for all details regarding PCB assembly using DirectFET. This includes all recommendations for stencil and substrate designs.
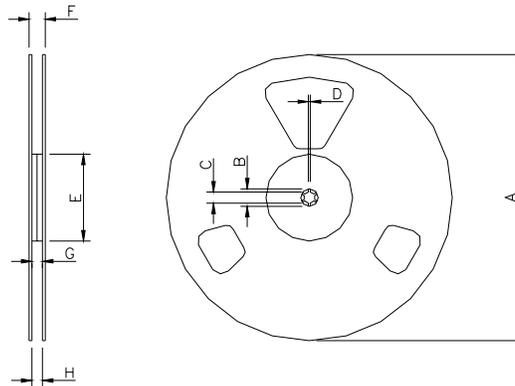

DIMENSIONS				
CODE	METRIC		IMPERIAL	
	MIN	MAX	MIN	MAX
A	4.75	4.85	0.187	0.191
B	3.70	3.95	0.146	0.156
C	2.75	2.85	0.108	0.112
D	0.35	0.45	0.014	0.018
E	0.58	0.62	0.023	0.024
F	0.58	0.62	0.023	0.024
G	0.63	0.67	0.025	0.026
H	0.83	0.87	0.033	0.034
K	0.99	1.03	0.039	0.041
L	2.29	2.33	0.090	0.092
M	0.616	0.676	0.0235	0.0274
R	0.020	0.080	0.0008	0.0031
P	0.08	0.17	0.003	0.007

DirectFET™ Part Marking

GATE MARKING

LOGO

PART NUMBER

BATCH NUMBER
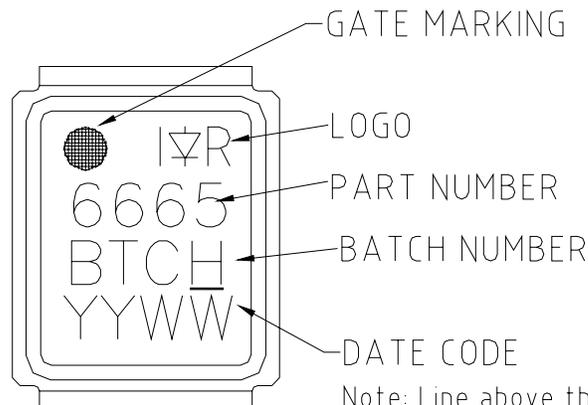
DATE CODE

Note: Line above the last character of the date-code indicates "Lead-Free".

DirectFET™ Tape & Reel Dimension (Showing component orientation).

NOTE: Controlling dimensions in mm
Std reel quantity is 4800 parts. (ordered as IRF6665TRPBF). For 1000 parts on 7"
reel, order   IRF6665TR1PBF

REEL DIMENSIONS							
STANDARD OPTION **(QTY 4800)**				TR1 OPTION **(QTY 1000)**			
	METRIC		IMPERIAL		METRIC		IMPERIAL	
CODE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
A	330.0	N.C	12.992	N.C	177.77	N.C	6.9	N.C
B	20.2	N.C	0.795	N.C	19.06	N.C	0.75	N.C
C	12.8	13.2	0.504	0.520	13.5	12.8	0.53	0.50
D	1.5	N.C	0.059	N.C	1.5	N.C	0.059	N.C
E	100.0	N.C	3.937	N.C	58.72	N.C	2.31	N.C
F	N.C	18.4	N.C	0.724	N.C	13.50	N.C	0.53
G	12.4	14.4	0.488	0.567	11.9	12.01	0.47	N.C
H	11.9	15.4	0.469	0.606	11.9	12.01	0.47	N.C

Loaded Tape Feed Direction
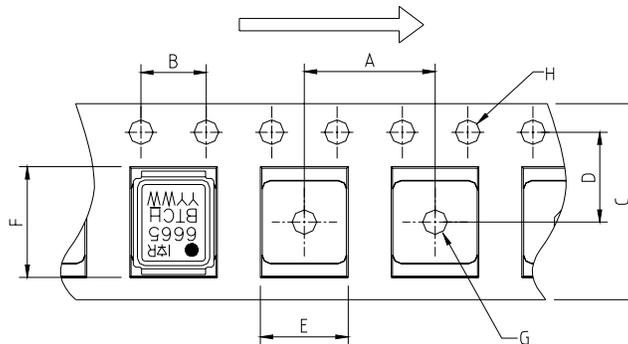
DIMENSIONS				
	METRIC		IMPERIAL	
CODE	MIN	MAX	MIN	MAX
A	7.90	8.10	0.311	0.319
B	3.90	4.10	0.154	0.161
C	11.90	12.30	0.469	0.484
D	5.45	5.55	0.215	0.219
E	4.00	4.20	0.158	0.165
F	5.00	5.20	0.197	0.205
G	1.50	N.C	0.059	N.C
H	1.50	1.60	0.059	0.063

Data and specifications subject to change without notice.
This product has been designed and qualified for the Consumer market.
Qualification Standards can be found on IR's Web site.

International IOR Rectifier

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

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