

# IRG4PH40UDPbF

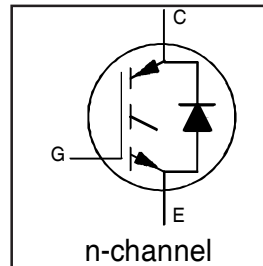
INSULATED GATE BIPOLAR TRANSISTOR WITH UltraFast CoPack IGBT  
ULTRAFAST SOFT RECOVERY DIODE

## Features

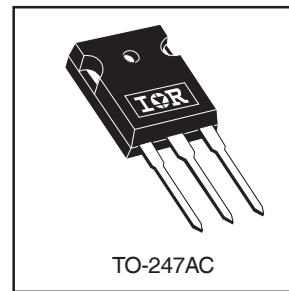
- UltraFast: Optimized for high operating frequencies up to 40 kHz in hard switching, >200 kHz in resonant mode
- New IGBT design provides tighter parameter distribution and higher efficiency than previous generations
- IGBT co-packaged with HEXFRED™ ultrafast, ultra-soft-recovery anti-parallel diodes for use in bridge configurations
- Industry standard TO-247AC package
- Lead-Free

## Benefits

- Higher switching frequency capability than competitive IGBTs
- Highest efficiency available
- HEXFRED diodes optimized for performance with IGBT's. Minimized recovery characteristics require less/no snubbing



$V_{CES} = 1200V$
$V_{CE(on)} \text{ typ.} = 2.43V$
@ $V_{GE} = 15V, I_C = 21A$



## Absolute Maximum Ratings

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Breakdown Voltage	1200	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	41	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	21	
$I_{CM}$	Pulsed Collector Current ①	82	
$I_{LM}$	Clamped Inductive Load Current ②	82	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	8.0	
$I_{FM}$	Diode Maximum Forward Current	130	
$V_{GE}$	Gate-to-Emitter Voltage	$\pm 20$	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	160	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	65	
$T_J$	Operating Junction and Storage Temperature Range	-55 to + 150	$^\circ C$
$T_{STG}$			
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

## Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	---	---	0.77	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	---	---	1.7	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	---	0.24	---	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	---	---	40	
Wt	Weight	---	6 (0.21)	---	g (oz)

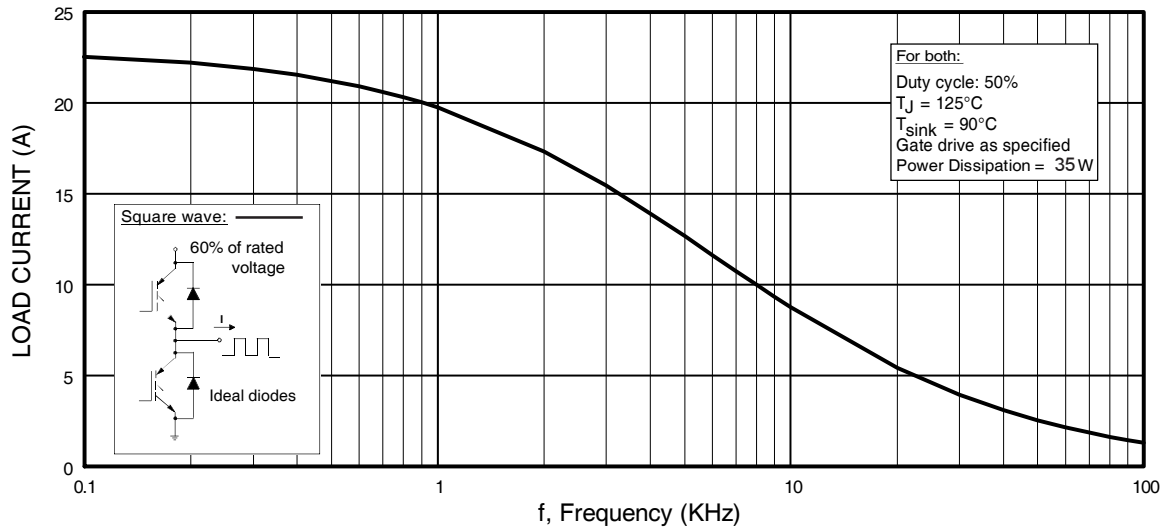
# IRG4PH40UDPbF

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

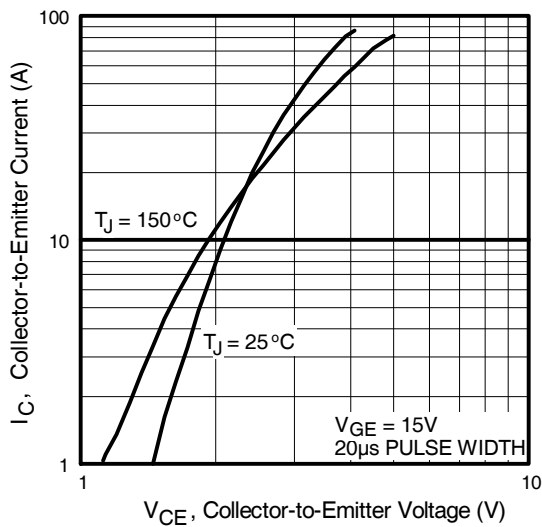
	Parameter	Min.	Typ.	Max.	Units	Conditions
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage <sup>③</sup>	1200	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.43	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1.0mA
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	—	2.43	3.1	V	I <sub>C</sub> = 21A I <sub>C</sub> = 41A I <sub>C</sub> = 21A, T <sub>J</sub> = 150°C V <sub>GE</sub> = 15V See Fig. 2, 5
		—	2.97	—		
		—	2.47	—		
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.0	—	6.0		V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA
ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Threshold Voltage	—	-11	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA
g <sub>fe</sub>	Forward Transconductance <sup>④</sup>	16	24	—	S	V <sub>CE</sub> = 100V, I <sub>C</sub> = 21A
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	—	250	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V
		—	—	5000		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> = 150°C
V <sub>FM</sub>	Diode Forward Voltage Drop	—	2.6	3.3	V	I <sub>C</sub> = 8.0A I <sub>C</sub> = 8.0A, T <sub>J</sub> = 125°C See Fig. 13
		—	2.4	3.1		
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ±20V

## Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

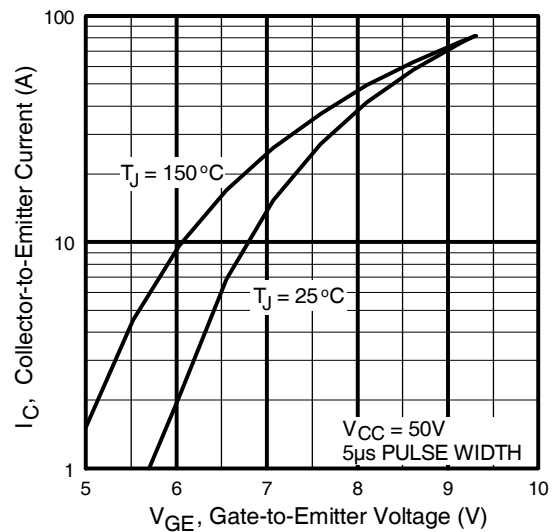
	Parameter	Min.	Typ.	Max.	Units	Conditions
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	86	130	nC	I <sub>C</sub> = 21A V <sub>CC</sub> = 400V V <sub>GE</sub> = 15V See Fig. 8
Q <sub>ge</sub>	Gate - Emitter Charge (turn-on)	—	13	20		
Q <sub>gc</sub>	Gate - Collector Charge (turn-on)	—	29	44		
t <sub>d(on)</sub>	Turn-On Delay Time	—	46	—	ns	T <sub>J</sub> = 25°C I <sub>C</sub> = 21A, V <sub>CC</sub> = 800V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω Energy losses include "tail" and diode reverse recovery. See Fig. 9, 10, 18
t <sub>r</sub>	Rise Time	—	35	—		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	97	150		
t <sub>f</sub>	Fall Time	—	240	360		
E <sub>on</sub>	Turn-On Switching Loss	—	1.80	—	mJ	T <sub>J</sub> = 150°C, See Fig. 11, 18 I <sub>C</sub> = 21A, V <sub>CC</sub> = 800V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω Energy losses include "tail" and diode reverse recovery.
E <sub>off</sub>	Turn-Off Switching Loss	—	1.93	—		
E <sub>ts</sub>	Total Switching Loss	—	3.73	4.6		
t <sub>d(on)</sub>	Turn-On Delay Time	—	42	—	ns	T <sub>J</sub> = 150°C, See Fig. 11, 18 I <sub>C</sub> = 21A, V <sub>CC</sub> = 800V V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω Energy losses include "tail" and diode reverse recovery.
t <sub>r</sub>	Rise Time	—	32	—		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	240	—		
t <sub>f</sub>	Fall Time	—	510	—		
E <sub>ts</sub>	Total Switching Loss	—	7.04	—	mJ	
L <sub>E</sub>	Internal Emitter Inductance	—	13	—	nH	Measured 5mm from package
C <sub>ies</sub>	Input Capacitance	—	1800	—	pF	V <sub>GE</sub> = 0V V <sub>CC</sub> = 30V f = 1.0MHz See Fig. 7
C <sub>oes</sub>	Output Capacitance	—	120	—		
C <sub>res</sub>	Reverse Transfer Capacitance	—	18	—		
t <sub>rr</sub>	Diode Reverse Recovery Time	—	63	95	ns	T <sub>J</sub> = 25°C See Fig. 14 T <sub>J</sub> = 125°C
		—	106	160		
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	4.5	8.0	A	T <sub>J</sub> = 25°C See Fig. 15 T <sub>J</sub> = 125°C
		—	6.2	11		
Q <sub>rr</sub>	Diode Reverse Recovery Charge	—	140	380	nC	T <sub>J</sub> = 25°C See Fig. 16 T <sub>J</sub> = 125°C
		—	335	880		
di <sub>(rec)</sub> /dt	Diode Peak Rate of Fall of Recovery During t <sub>b</sub>	—	133	—	A/μs	T <sub>J</sub> = 25°C See Fig. 17 T <sub>J</sub> = 125°C
		—	85	—		



**Fig. 1 - Typical Load Current vs. Frequency**  
 (Load Current =  $I_{\text{RMS}}$  of fundamental)

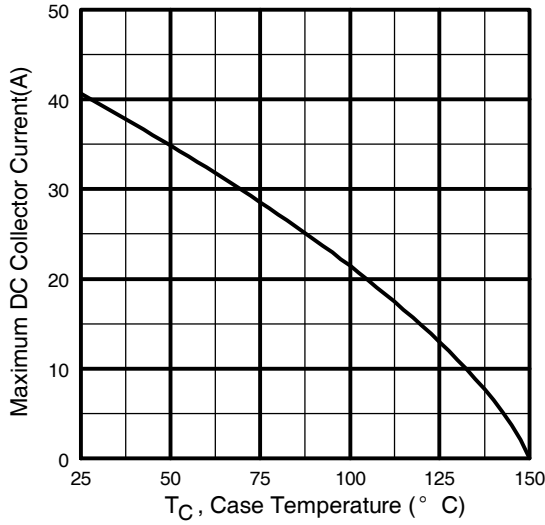


**Fig. 2 - Typical Output Characteristics**

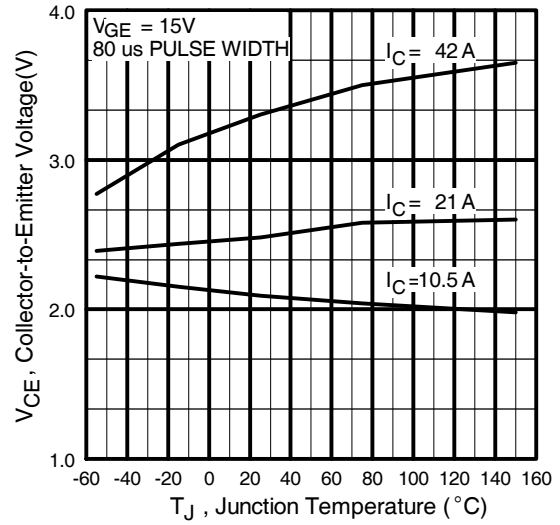


**Fig. 3 - Typical Transfer Characteristics**

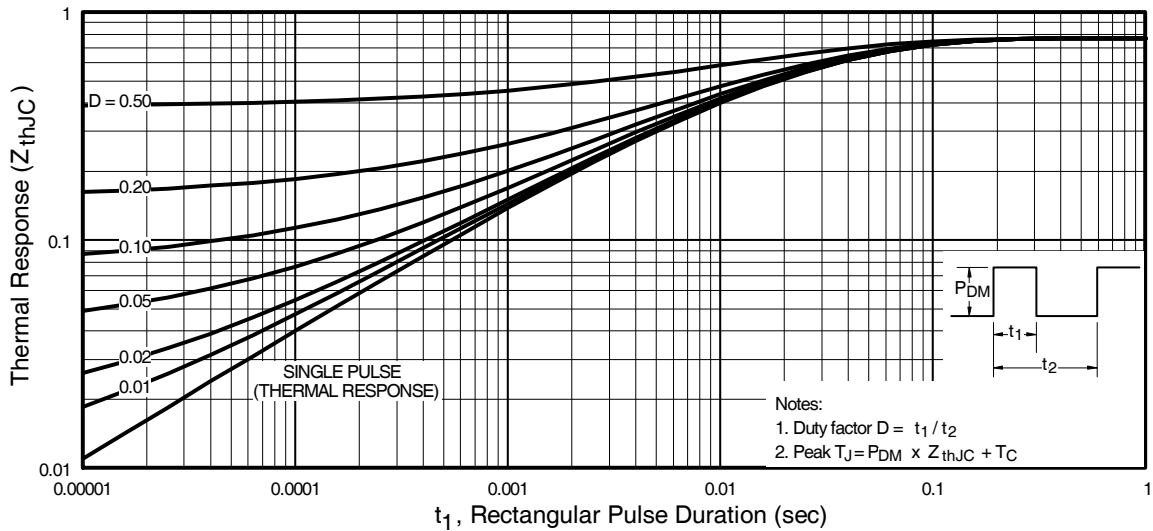
# IRG4PH40UDPbF



**Fig. 4 - Maximum Collector Current vs. Case Temperature**

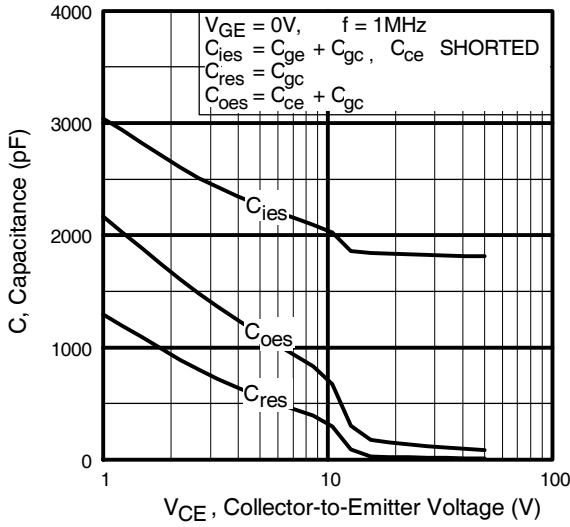


**Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature**

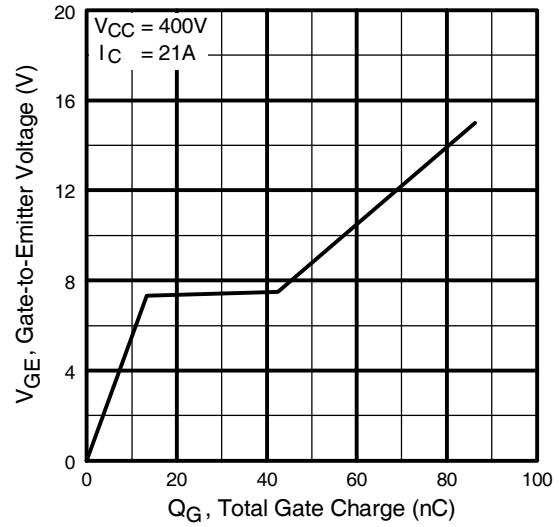


**Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**

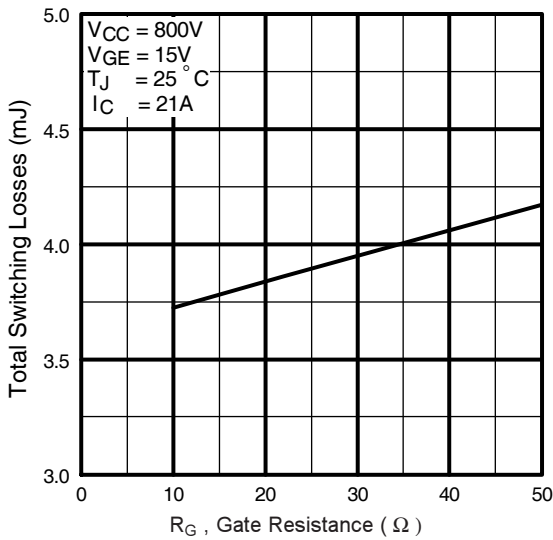
# IRG4PH40UDPbF



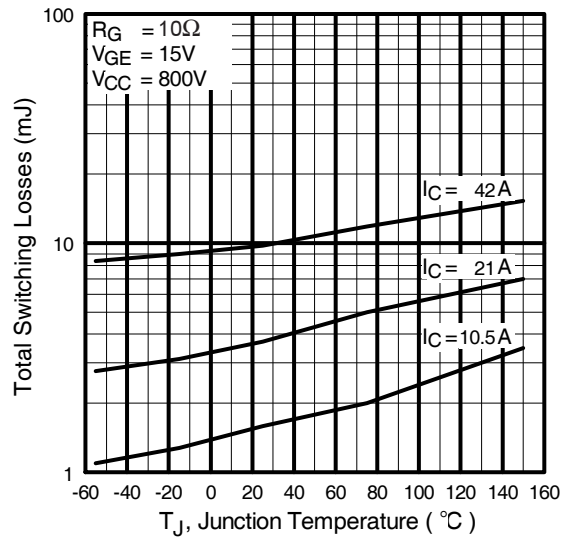
**Fig. 7 - Typical Capacitance vs. Collector-to-Emitter Voltage**



**Fig. 8 - Typical Gate Charge vs. Gate-to-Emitter Voltage**

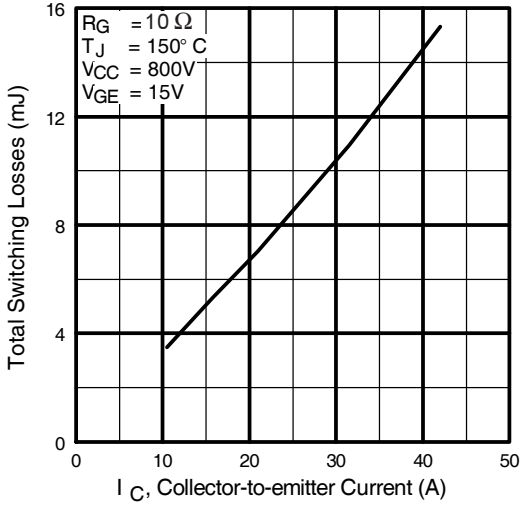


**Fig. 9 - Typical Switching Losses vs. Gate Resistance**

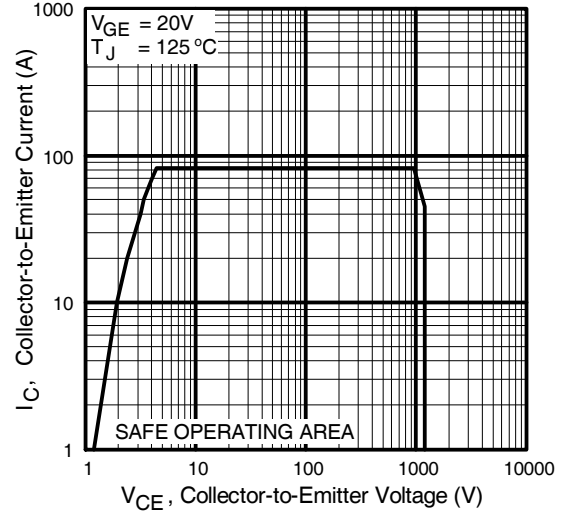


**Fig. 10 - Typical Switching Losses vs. Junction Temperature**

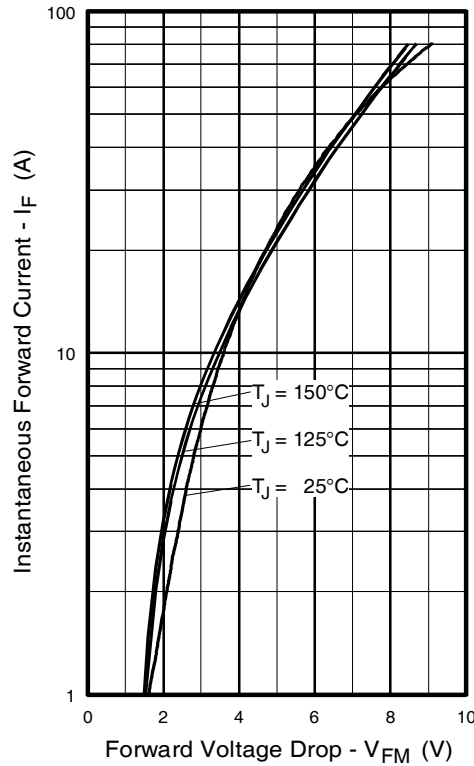
# IRG4PH40UDPbF



**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



**Fig. 12** - Turn-Off SOA



**Fig. 13** - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

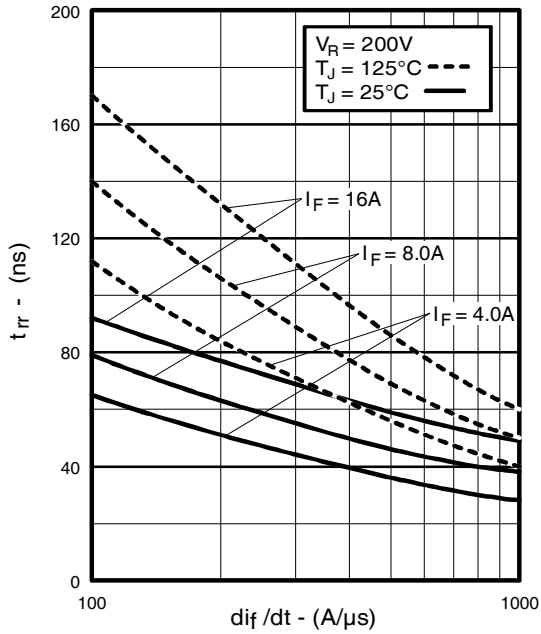


Fig. 14 - Typical Reverse Recovery vs.  $di_f/dt$

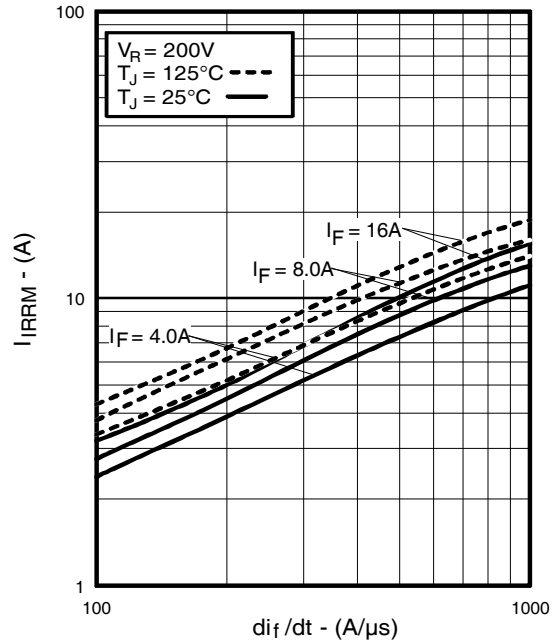


Fig. 15 - Typical Recovery Current vs.  $di_f/dt$

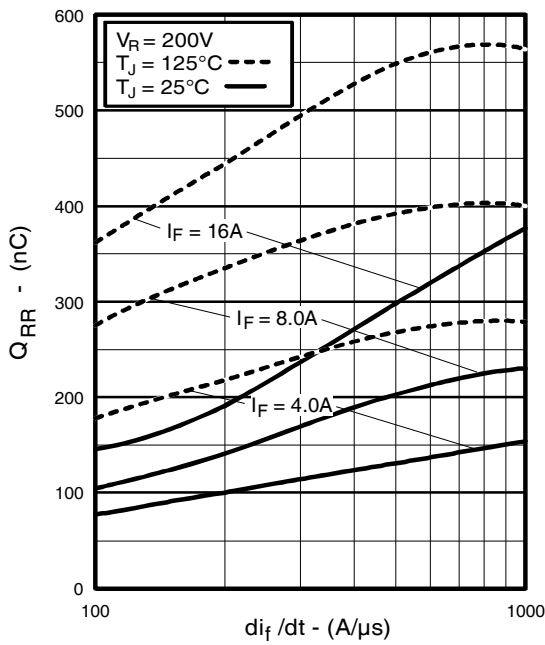


Fig. 16 - Typical Stored Charge vs.  $di_f/dt$

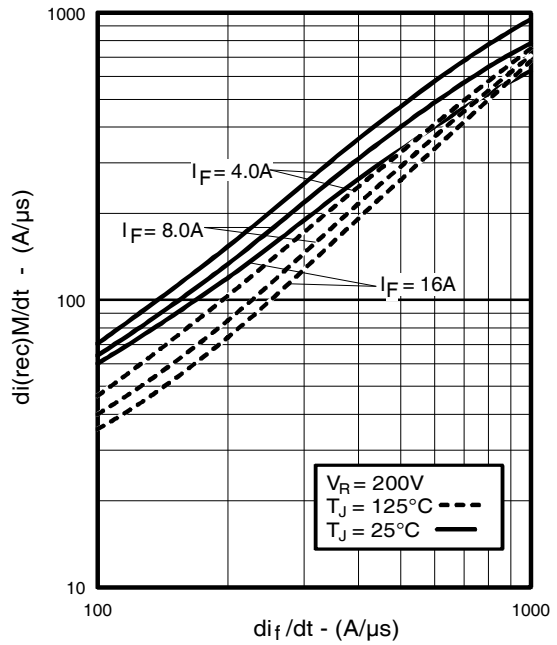
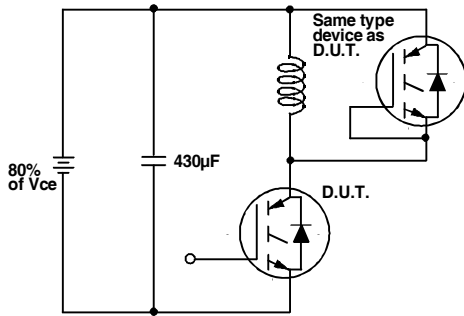
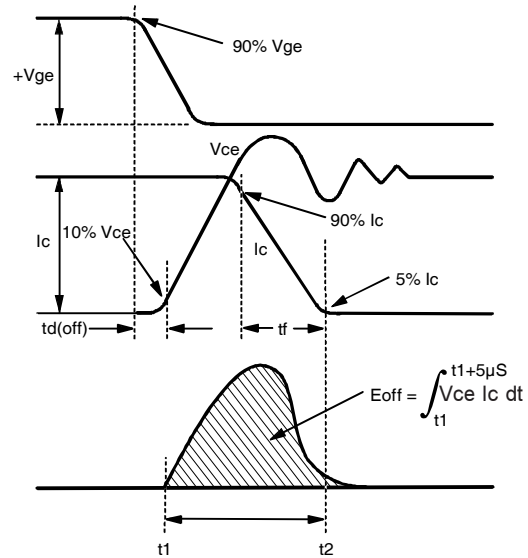


Fig. 17 - Typical  $di_{(rec)M}/dt$  vs.  $di_f/dt$

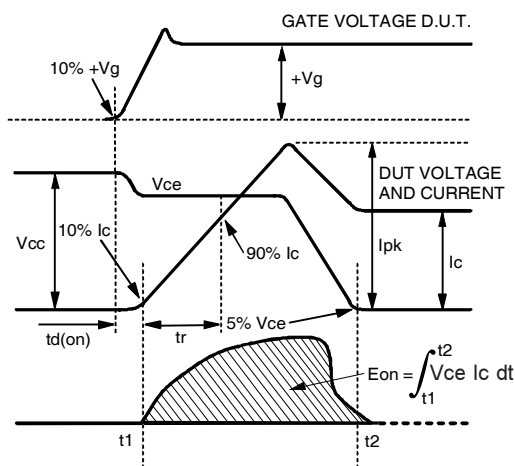
# IRG4PH40UDPbF



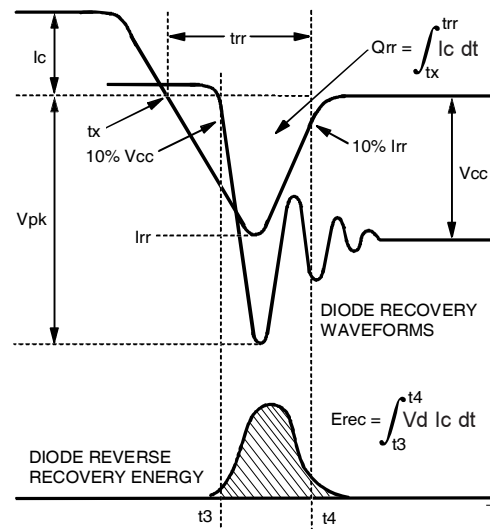
**Fig. 18a** - Test Circuit for Measurement of  $I_{LM}$ ,  $E_{on}$ ,  $E_{off}(\text{diode})$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$ ,  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$



**Fig. 18b** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{off}$ ,  $t_{d(off)}$ ,  $t_f$



**Fig. 18c** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{on}$ ,  $t_{d(on)}$ ,  $t_r$



**Fig. 18d** - Test Waveforms for Circuit of Fig. 18a, Defining  $E_{rec}$ ,  $t_{rr}$ ,  $Q_{rr}$ ,  $I_{rr}$



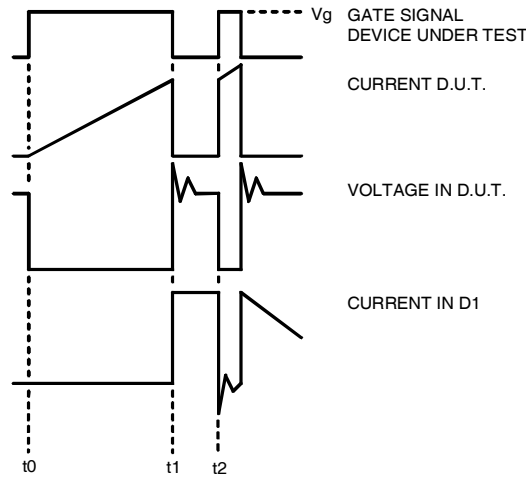


Figure 18e. Macro Waveforms for Figure 18a's Test Circuit

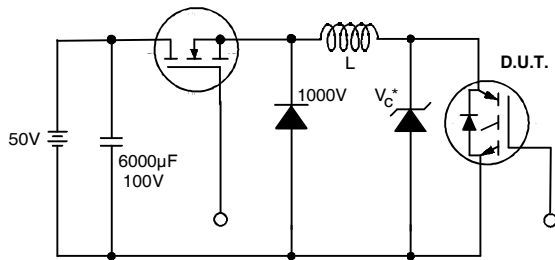


Figure 19. Clamped Inductive Load Test Circuit

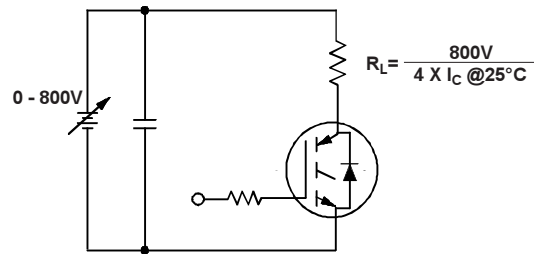


Figure 20. Pulsed Collector Current Test Circuit

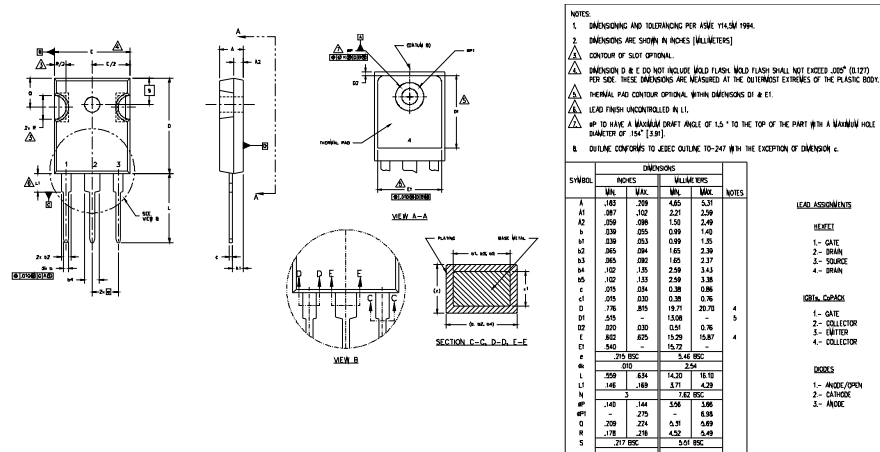
# IRG4PH40UDPbF

## Notes :

- ① Repetitive rating:  $V_{GE}=20V$ ; pulse width limited by maximum junction temperature (figure 20)
- ②  $V_{CC}=80\%(V_{CES})$ ,  $V_{GE}=20V$ ,  $L=10\mu H$ ,  $R_G=10\Omega$  (figure 19)
- ③ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ④ Pulse width  $5.0\mu s$ , single shot.

## TO-247AC Package Outline

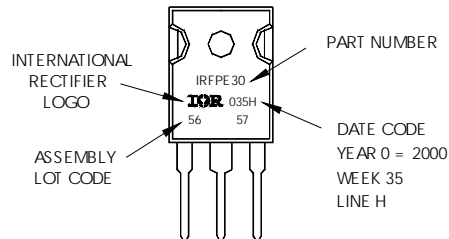
Dimensions are shown in millimeters (inches)



## TO-247AC Part Marking Information

EXAMPLE: THIS IS AN IRFP30  
WITH ASSEMBLY  
LOT CODE 5657  
ASSEMBLED ON WW 35, 2000  
IN THE ASSEMBLY LINE "H"

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



Data and specifications subject to change without notice.