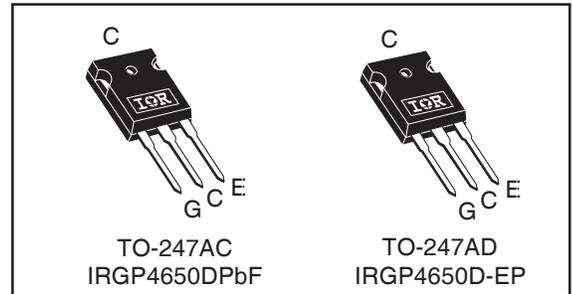
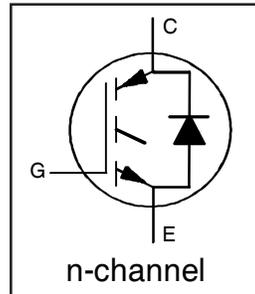


INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

| |
|--|
| $V_{CES} = 600V$ |
| $I_C = 50A, T_C = 100^\circ C$ |
| $t_{SC} \geq 5\mu s, T_{J(max)} = 175^\circ C$ |
| $V_{CE(on)} \text{ typ.} = 1.60V @ I_C = 35A$ |



| | | |
|----------|-----------|----------|
| G | C | E |
| Gate | Collector | Emitter |

Applications

- Industrial Motor Drive
- Inverters
- UPS
- Welding

| Features | Benefits |
|---|---|
| Low $V_{CE(ON)}$ and Switching Losses | High efficiency in a wide range of applications and switching frequencies |
| Square RBSOA and Maximum Junction Temperature $175^\circ C$ | Improved reliability due to rugged hard switching performance and higher power capability |
| Positive $V_{CE(ON)}$ Temperature Coefficient | Excellent current sharing in parallel operation |
| $5\mu s$ short circuit SOA | Enables short circuit protection scheme |
| Lead-Free, RoHS compliant | Environmentally friendly |

| Base part number | Package Type | Standard Pack | | Orderable part number |
|------------------|--------------|---------------|----------|-----------------------|
| | | Form | Quantity | |
| IRGP4650DPbF | TO-247AC | Tube | 25 | IRGP4650DPbF |
| IRGP4650D-EPbF | TO-247AD | Tube | 25 | IRGP4650D-EPbF |

Absolute Maximum Ratings

| Parameter | Max. | Units | |
|---|------------------------------------|------------|-----------------------------------|
| V_{CES} Collector-to-Emitter Voltage | 600 | V | |
| $I_C @ T_C = 25^\circ C$ Continuous Collector Current | 76 | A | |
| $I_C @ T_C = 100^\circ C$ Continuous Collector Current | 50 | | |
| I_{CM} Pulse Collector Current, $V_{GE} = 15V$ ② | 105 | | |
| I_{LM} Clamped Inductive Load Current, $V_{GE} = 20V$ ① | 140 | | |
| $I_F @ T_C = 25^\circ C$ Diode Continuous Forward Current | 76 | | |
| $I_F @ T_C = 100^\circ C$ Diode Continuous Forward Current | 50 | V | |
| I_{FM} Diode Maximum Forward Current | 140 | | |
| V_{GE} Continuous Gate-to-Emitter Voltage | ± 20 | | |
| | Transient Gate-to-Emitter Voltage | ± 30 | |
| $P_D @ T_C = 25^\circ C$ Maximum Power Dissipation | 268 | W | |
| $P_D @ T_C = 100^\circ C$ Maximum Power Dissipation | 134 | | |
| T_J Operating Junction and T_{STG} Storage Temperature Range | -55 to +175 | $^\circ C$ | |
| | Soldering Temperature, for 10 sec. | | 300 (0.063 in. (1.6mm) from case) |
| | Mounting Torque, 6-32 or M3 Screw | | 10 lbf-in (1.1 N·m) |

Thermal Resistance

| Parameter | Min. | Typ. | Max. | Units |
|--|------|------|------|--------------|
| $R_{\theta JC}$ (IGBT) Junction-to-Case (IGBT) ④ | — | — | 0.56 | $^\circ C/W$ |
| $R_{\theta JC}$ (Diode) Junction-to-Case (Diode) ④ | — | — | 1.0 | |
| $R_{\theta CS}$ Case-to-Sink (flat, greased surface) | — | 0.24 | — | |
| $R_{\theta JA}$ Junction-to-Ambient (typical socket mount) | — | — | 40 | |

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|--|---|------|------|------|-------|---|
| V _{(BR)CES} | Collector-to-Emitter Breakdown Voltage | 600 | — | — | V | V _{GE} = 0V, I _C = 100μA ③ |
| ΔV _{(BR)CES} /ΔT _J | Temperature Coeff. of Breakdown Voltage | — | 1.3 | — | mV/°C | V _{GE} = 0V, I _C = 1mA (25°C-175°C) |
| V _{CE(on)} | Collector-to-Emitter Saturation Voltage | — | 1.60 | 1.90 | V | I _C = 35A, V _{GE} = 15V, T _J = 25°C ② |
| | | — | 1.90 | — | | I _C = 35A, V _{GE} = 15V, T _J = 150°C ② |
| | | — | 2.00 | — | | I _C = 35A, V _{GE} = 15V, T _J = 175°C ② |
| V _{GE(th)} | Gate Threshold Voltage | 4.0 | — | 6.5 | V | V _{CE} = V _{GE} , I _C = 1.0mA |
| ΔV _{GE(th)} /ΔT _J | Threshold Voltage temp. coefficient | — | -18 | — | mV/°C | V _{CE} = V _{GE} , I _C = 1.0mA (25°C - 175°C) |
| g _{fe} | Forward Transconductance | — | 25 | — | S | V _{CE} = 50V, I _C = 35A, PW = 60μs |
| I _{CES} | Collector-to-Emitter Leakage Current | — | 1.0 | 70 | μA | V _{GE} = 0V, V _{CE} = 600V |
| | | — | 770 | — | | V _{GE} = 0V, V _{CE} = 600V, T _J = 175°C |
| V _{FM} | Diode Forward Voltage Drop | — | 2.0 | 3.0 | V | I _F = 35A |
| | | — | 1.4 | — | | I _F = 35A, T _J = 175°C |
| I _{GES} | Gate-to-Emitter Leakage Current | — | — | ±100 | nA | V _{GE} = ±20V |

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---------------------|--------------------------------------|-------------|------|------|---|--|
| Q _g | Total Gate Charge (turn-on) | — | 69 | 104 | nC | I _C = 35A |
| Q _{ge} | Gate-to-Emitter Charge (turn-on) | — | 18 | 27 | | V _{GE} = 15V |
| Q _{gc} | Gate-to-Collector Charge (turn-on) | — | 29 | 44 | | V _{CC} = 400V |
| E _{on} | Turn-On Switching Loss | — | 390 | 508 | μJ | I _C = 35A, V _{CC} = 400V, V _{GE} = 15V |
| E _{off} | Turn-Off Switching Loss | — | 632 | 753 | | R _G = 10Ω, L = 200μH, L _S = 150nH, T _J = 25°C |
| E _{total} | Total Switching Loss | — | 1022 | 1261 | | Energy losses include tail & diode reverse recovery |
| t _{d(on)} | Turn-On delay time | — | 46 | 56 | ns | I _C = 35A, V _{CC} = 400V, V _{GE} = 15V |
| t _r | Rise time | — | 33 | 42 | | R _G = 10Ω, L = 200μH, L _S = 150nH, T _J = 25°C |
| t _{d(off)} | Turn-Off delay time | — | 105 | 117 | | |
| t _f | Fall time | — | 44 | 54 | | |
| E _{on} | Turn-On Switching Loss | — | 1013 | — | | μJ |
| E _{off} | Turn-Off Switching Loss | — | 929 | — | R _G = 10Ω, L = 200μH, L _S = 150nH, T _J = 175°C | |
| E _{total} | Total Switching Loss | — | 1942 | — | Energy losses include tail & diode reverse recovery | |
| t _{d(on)} | Turn-On delay time | — | 43 | — | ns | I _C = 35A, V _{CC} = 400V, V _{GE} = 15V |
| t _r | Rise time | — | 35 | — | | R _G = 10Ω, L = 200μH, L _S = 150nH |
| t _{d(off)} | Turn-Off delay time | — | 127 | — | | T _J = 175°C |
| t _f | Fall time | — | 61 | — | | |
| C _{ies} | Input Capacitance | — | 2113 | — | pF | V _{GE} = 0V |
| C _{oes} | Output Capacitance | — | 197 | — | | V _{CC} = 30V |
| C _{res} | Reverse Transfer Capacitance | — | 65 | — | | f = 1.0Mhz |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | T _J = 175°C, I _C = 140A V _{CC} = 480V, V _p ≤ 600V R _G = 10Ω, V _{GE} = +20V to 0V |
| SCSOA | Short Circuit Safe Operating Area | 5 | — | — | μs | V _{CC} = 400V, V _p ≤ 600V R _G = 10Ω, V _{GE} = +15V to 0V |
| E _{rec} | Reverse Recovery Energy of the Diode | — | 304 | — | μJ | T _J = 175°C |
| t _{rr} | Diode Reverse Recovery Time | — | 120 | — | ns | V _{CC} = 400V, I _F = 35A |
| I _{rr} | Peak Reverse Recovery Current | — | 25 | — | A | V _{GE} = 15V, R _G = 10Ω, L = 210μH, L _S = 150nH |

Notes:

- ① V_{CC} = 80% (V_{CES}), V_{GE} = 20V, L = 19μH, R_G = 10Ω.
- ② Pulse width limited by max. junction temperature.
- ③ Refer to AN-1086 for guidelines for measuring V_{(BR)CES} safely.
- ④ R_θ is measured at T_J of approximately 90°C.

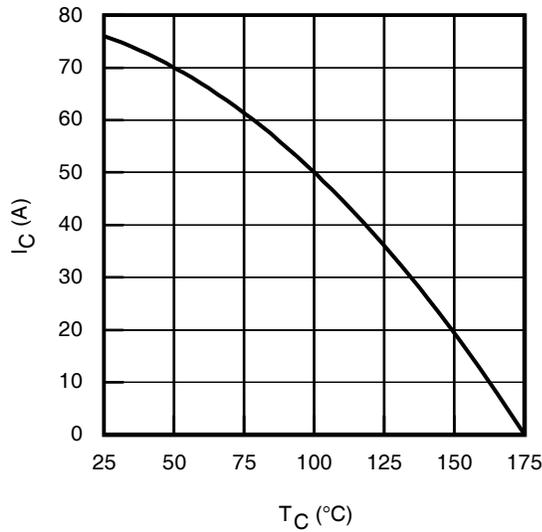


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

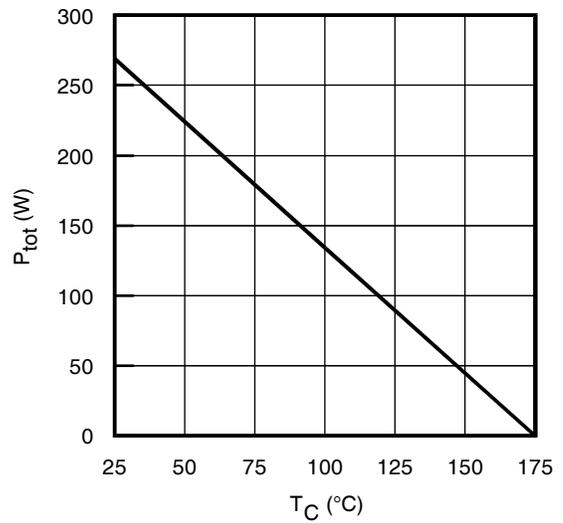


Fig. 2 - Power Dissipation vs. Case Temperature

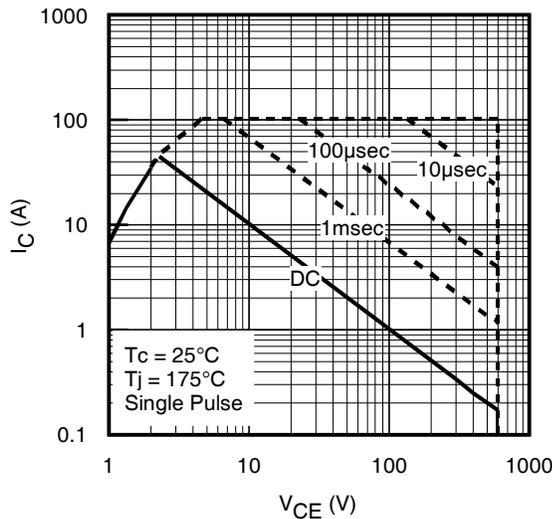


Fig. 3 - Forward SOA
 $T_C = 25^\circ\text{C}$, $T_J \leq 175^\circ\text{C}$; $V_{GE} = 15\text{V}$

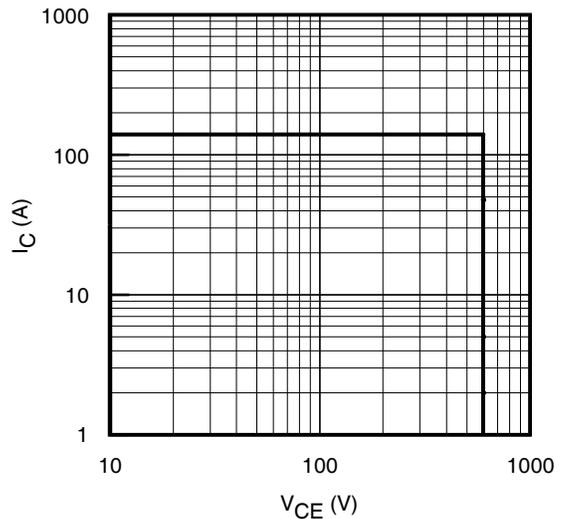


Fig. 4 - Reverse Bias SOA
 $T_J = 175^\circ\text{C}$; $V_{GE} = 20\text{V}$

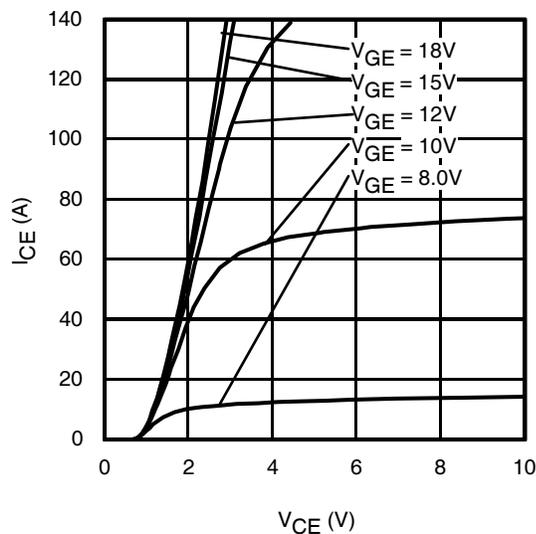


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p \leq 60\mu\text{s}$

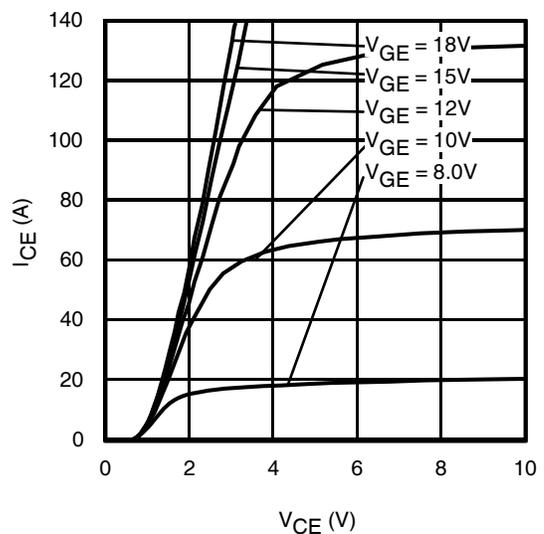


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p \leq 60\mu\text{s}$

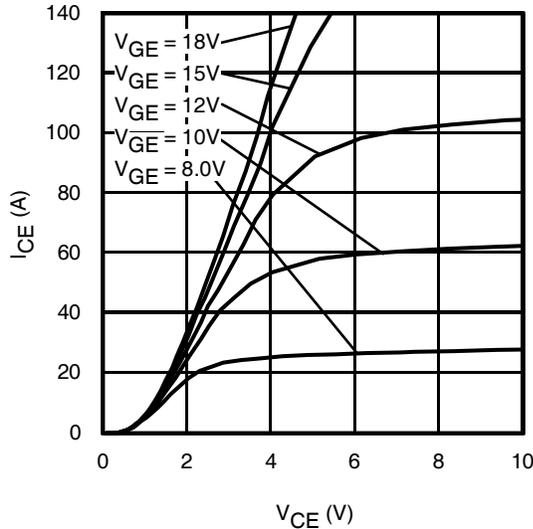


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = \leq 60\mu\text{s}$

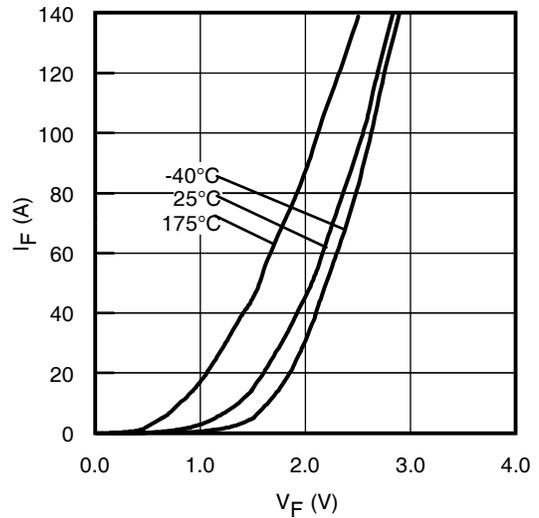


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

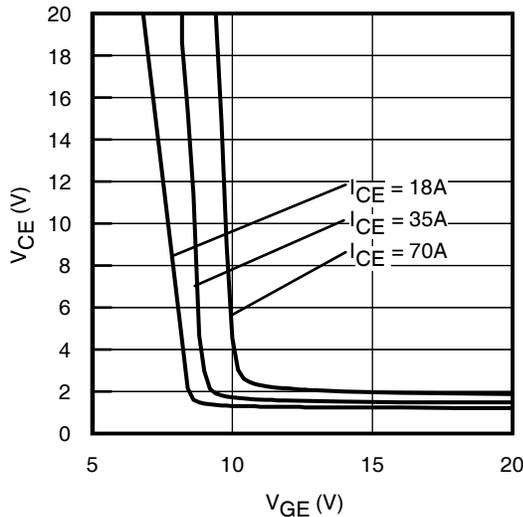


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

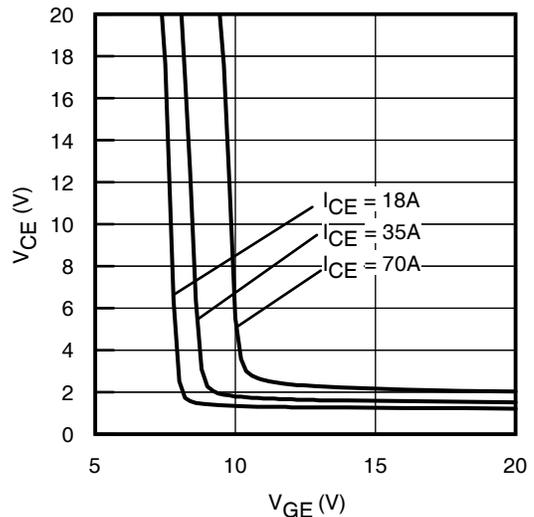


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

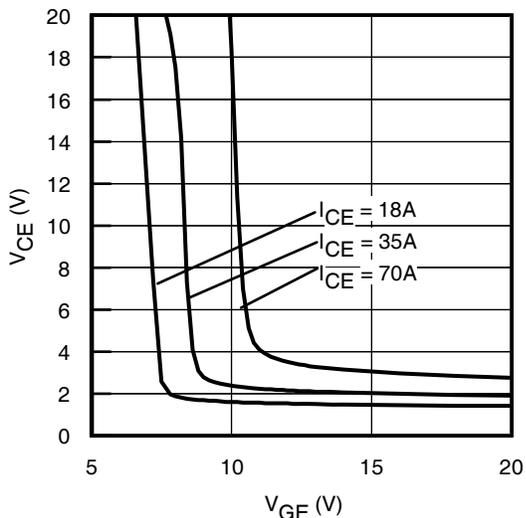


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

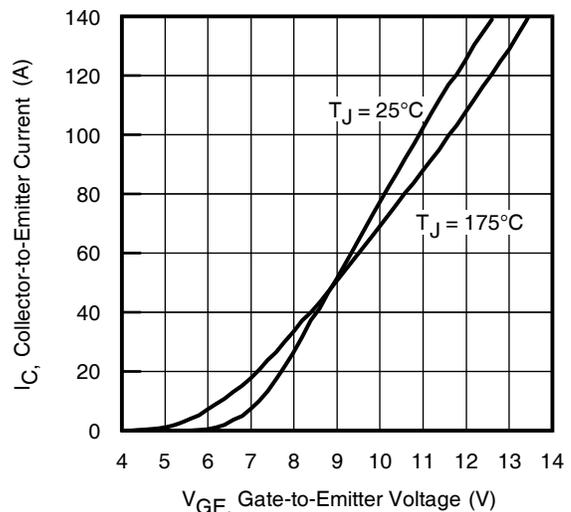
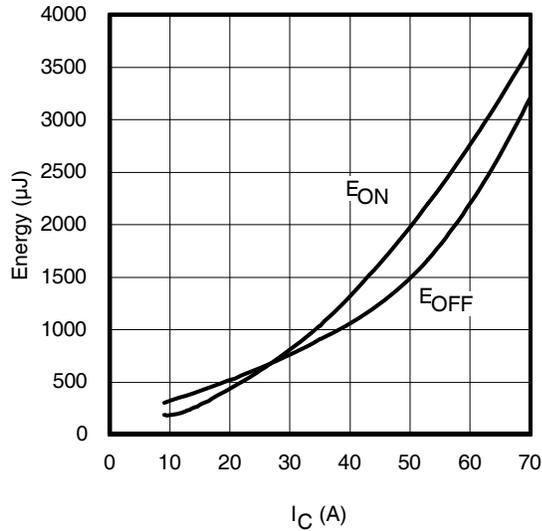
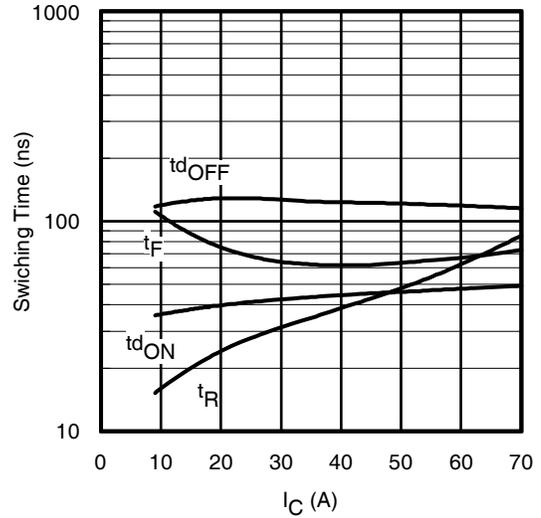
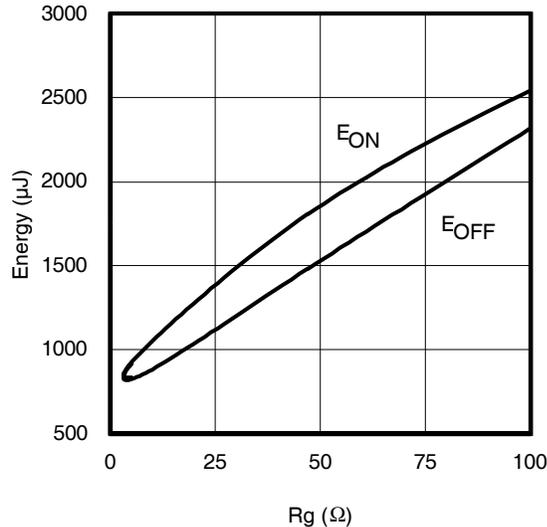
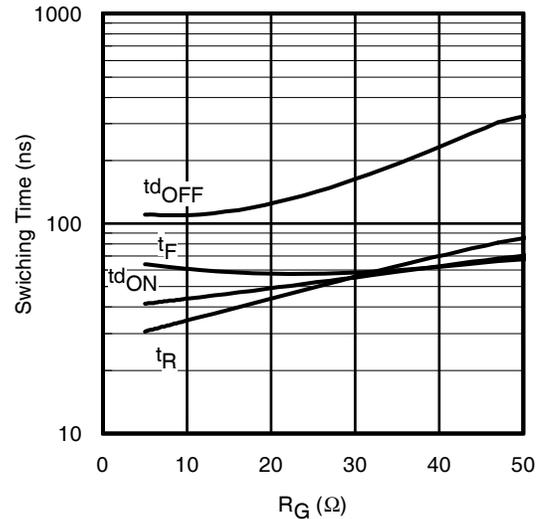
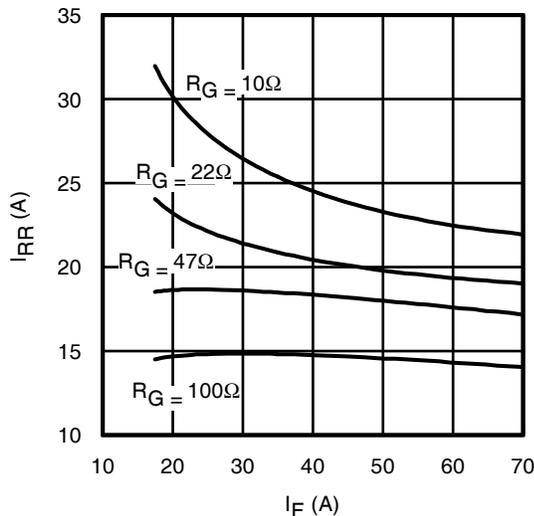
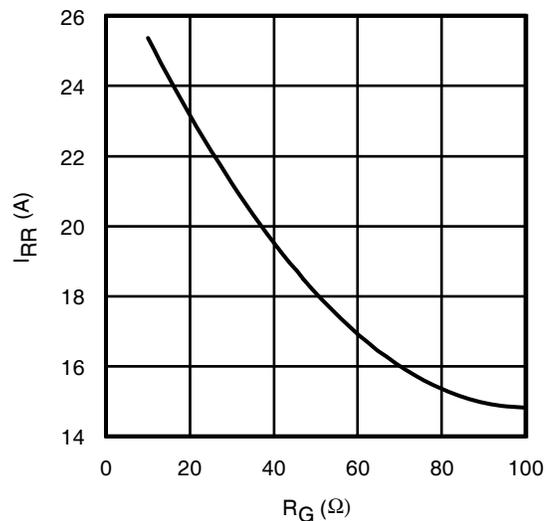


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 60\mu\text{s}$


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 175^\circ\text{C}; L = 200\mu\text{H}; V_{CE} = 400\text{V}, R_G = 10\Omega; V_{GE} = 15\text{V}$

Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 175^\circ\text{C}; L = 200\mu\text{H}; V_{CE} = 400\text{V}, R_G = 10\Omega; V_{GE} = 15\text{V}$

Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 175^\circ\text{C}; L = 210\mu\text{H}; V_{CE} = 400\text{V}, I_{CE} = 35\text{A}; V_{GE} = 15\text{V}$

Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 175^\circ\text{C}; L = 210\mu\text{H}; V_{CE} = 400\text{V}, I_{CE} = 35\text{A}; V_{GE} = 15\text{V}$

Fig. 17 - Typ. Diode I_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

Fig. 18 - Typ. Diode I_{RR} vs. R_G
 $T_J = 175^\circ\text{C}$

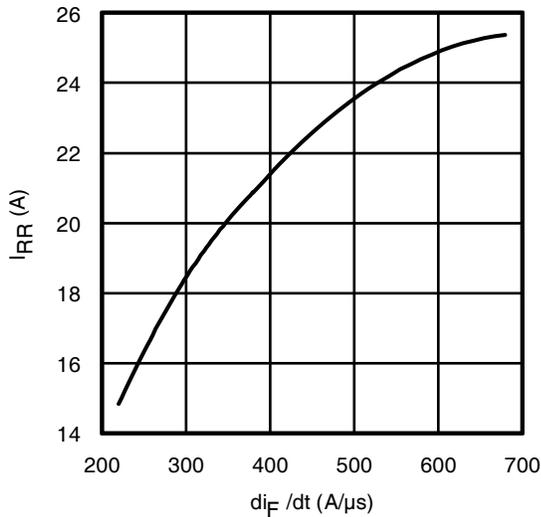


Fig. 19 - Typ. Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $I_F = 35A$; $T_J = 175^\circ C$

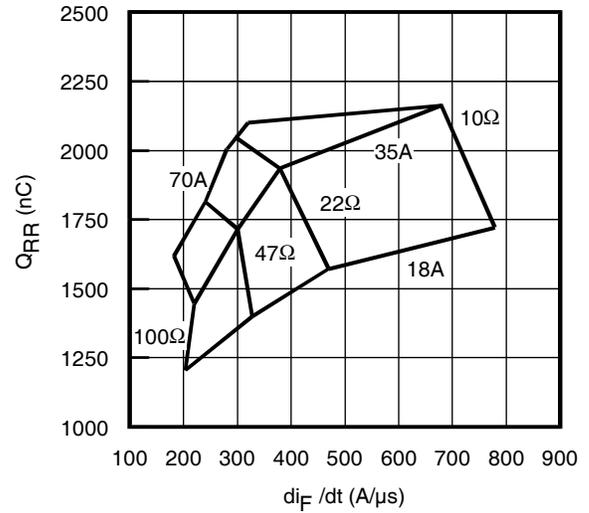


Fig. 20 - Typ. Diode Q_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 175^\circ C$

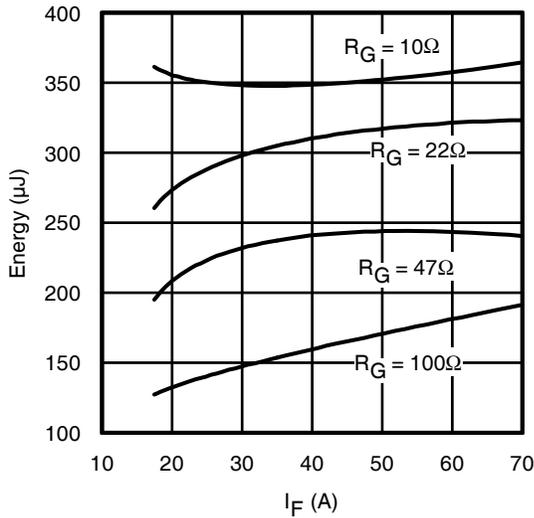


Fig. 21 - Typ. Diode E_{RR} vs. I_F
 $T_J = 175^\circ C$

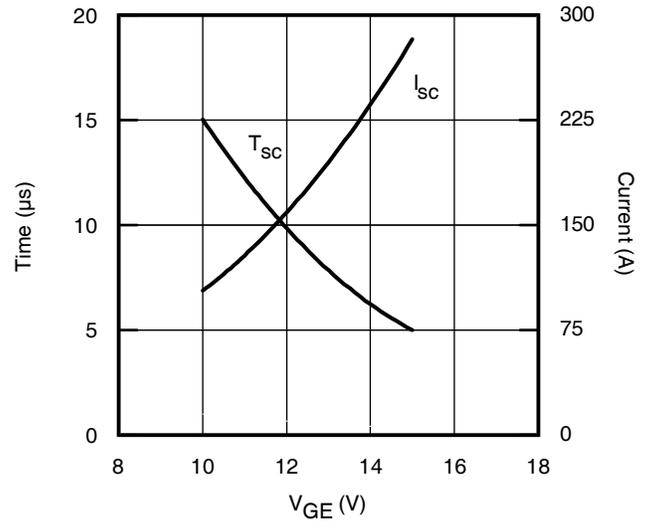


Fig. 22 - V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$; $T_C = 25^\circ C$

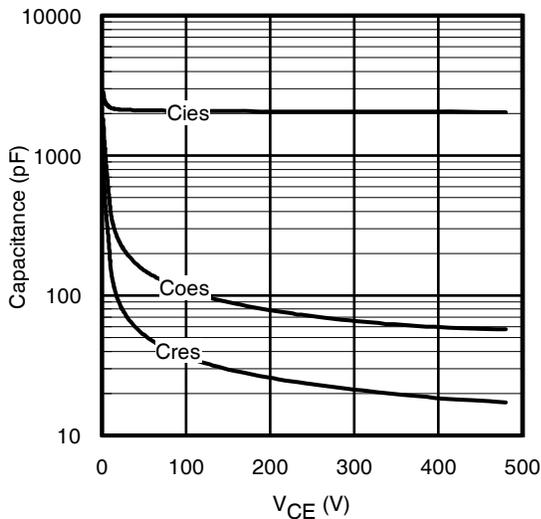


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

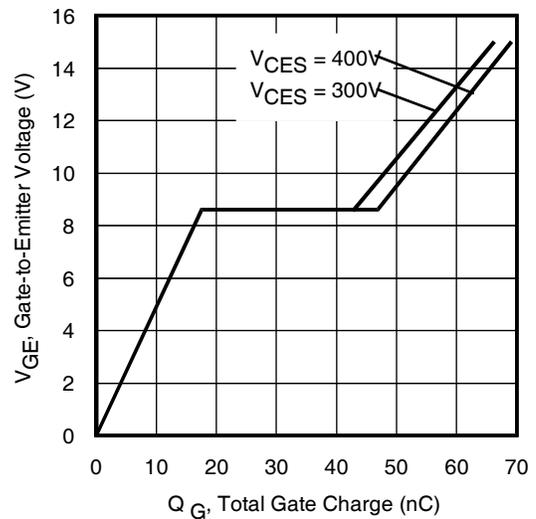
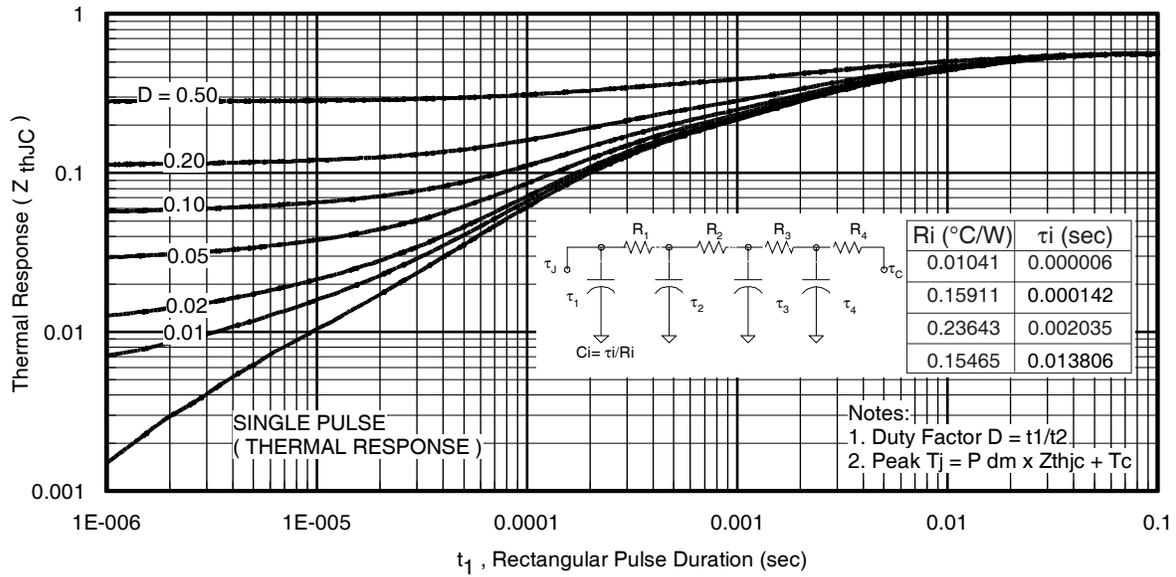
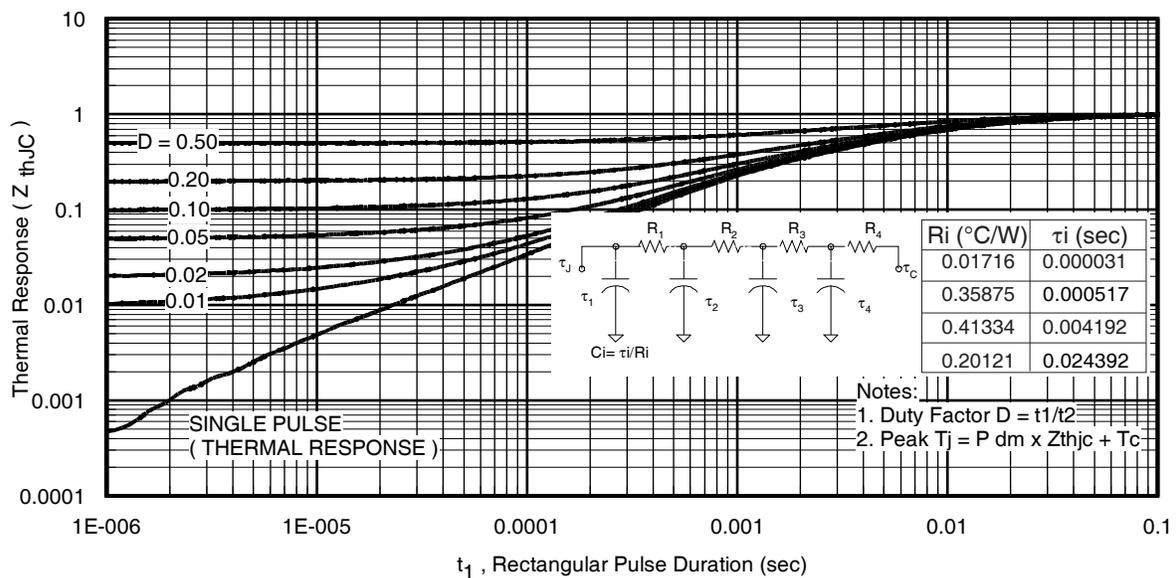


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 35A$; $L = 740\mu H$


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

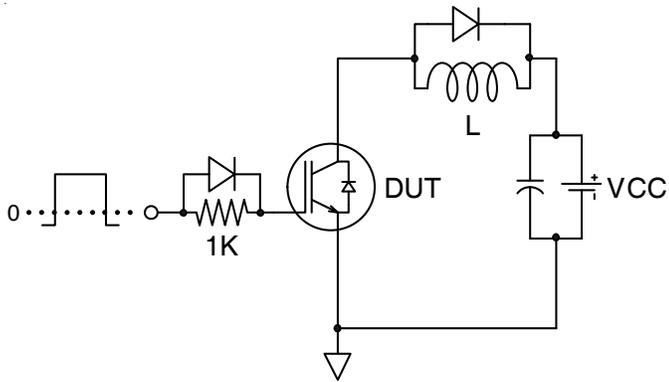


Fig.C.T.1 - Gate Charge Circuit (turn-off)

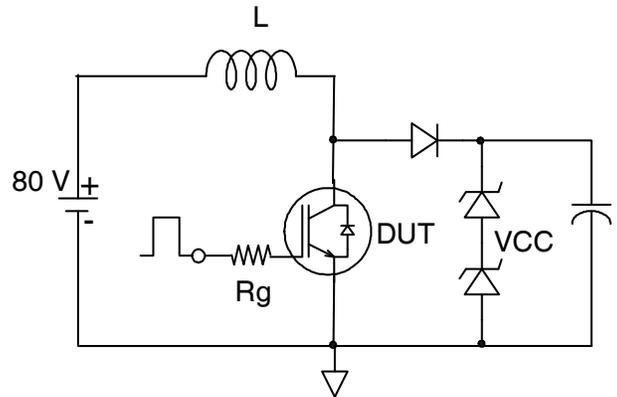


Fig.C.T.2 - RBSOA Circuit

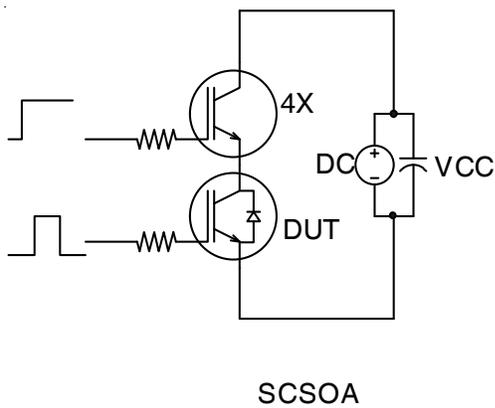


Fig.C.T.3 - S.C. SOA Circuit

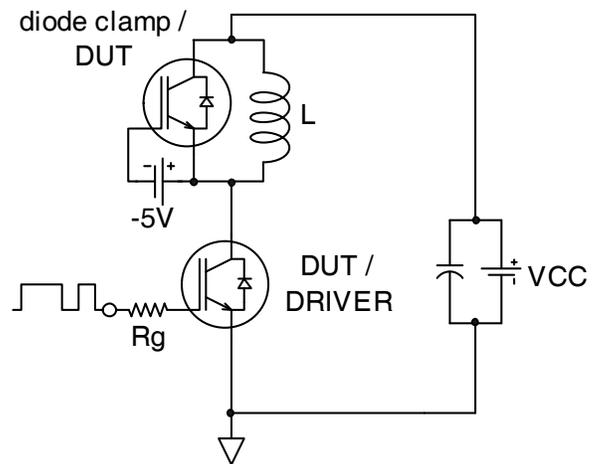


Fig.C.T.4 - Switching Loss Circuit

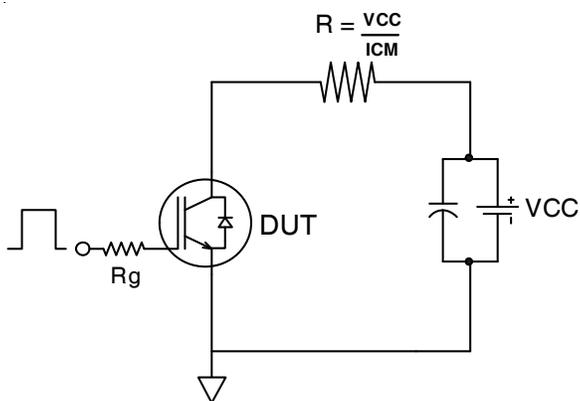


Fig.C.T.5 - Resistive Load Circuit

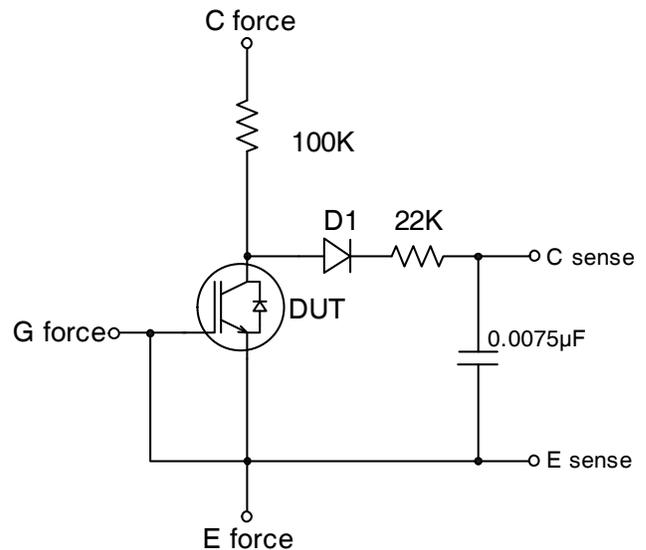


Fig.C.T.6 - BVCES Filter Circuit

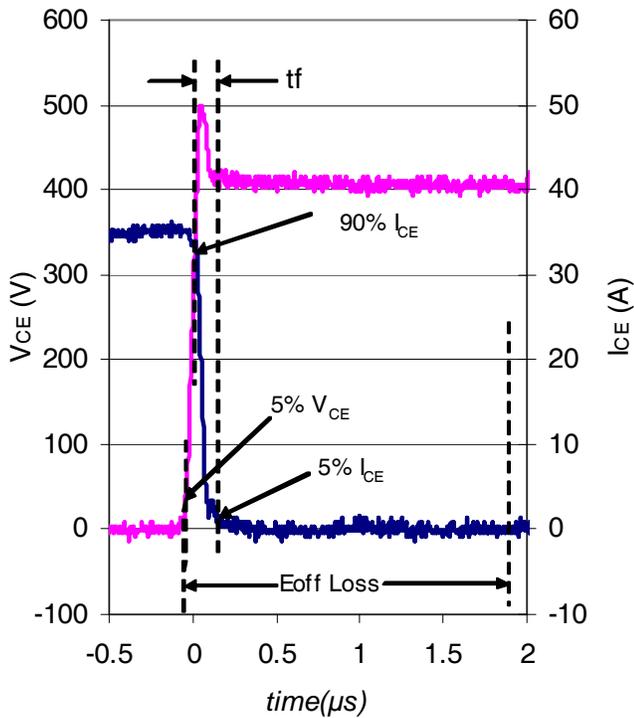


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

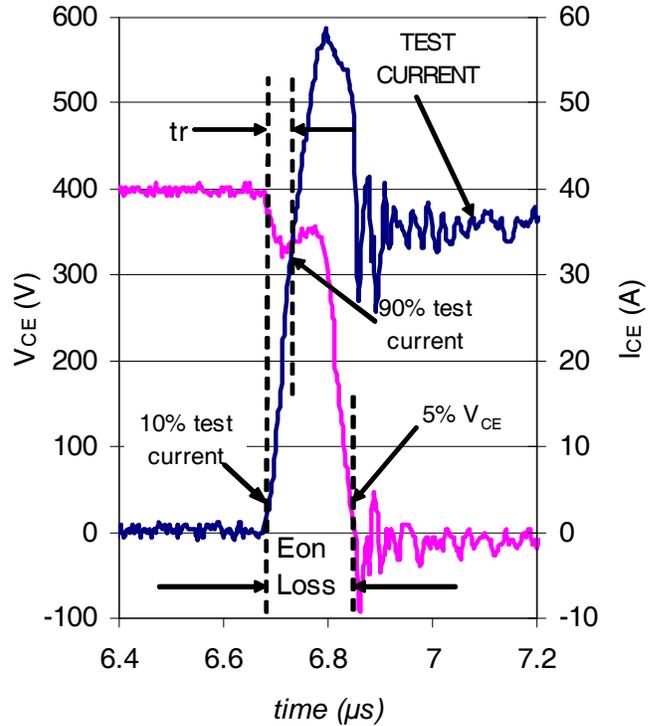


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

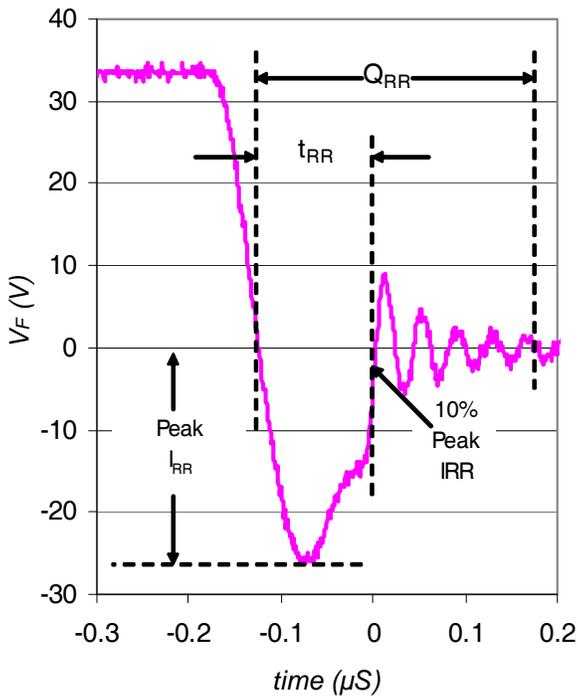


Fig. WF3 - Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

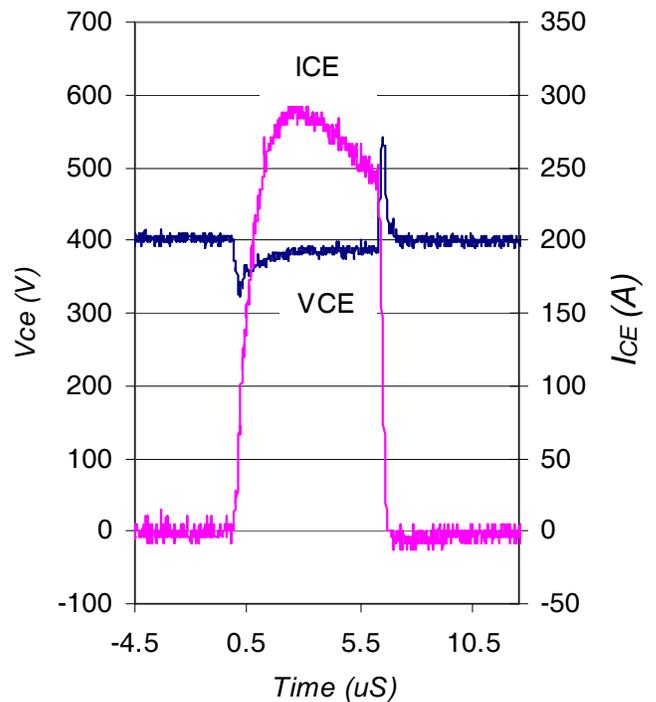
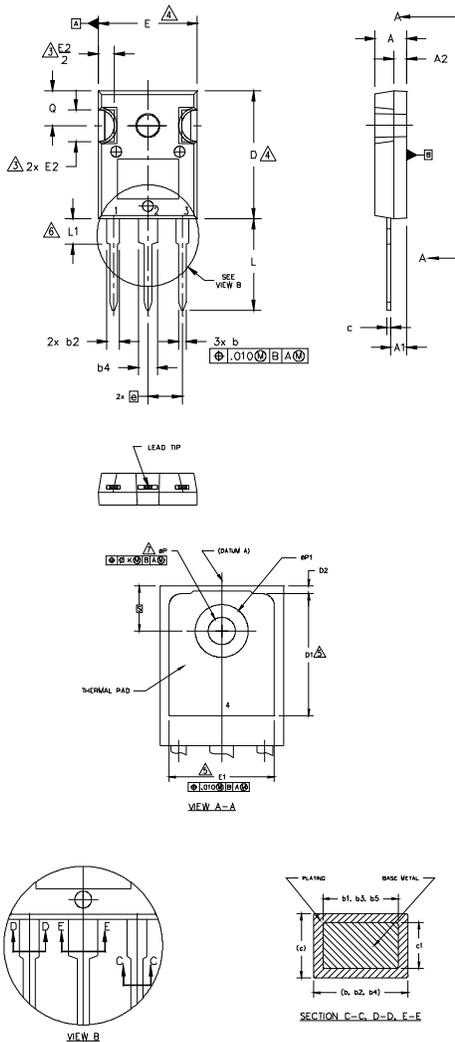


Fig. WF4 - Typ. S.C. Waveform
@ $T_J = 25^\circ\text{C}$ using Fig. CT.3

TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
4. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. ϕP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AC .

| SYMBOL | DIMENSIONS | | | | NOTES |
|-----------|------------|------|-------------|-------|-------|
| | INCHES | | MILLIMETERS | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | .183 | .209 | 4.65 | 5.31 | |
| A1 | .087 | .102 | 2.21 | 2.59 | |
| A2 | .059 | .098 | 1.50 | 2.49 | |
| b | .039 | .055 | 0.99 | 1.40 | |
| b1 | .039 | .053 | 0.99 | 1.35 | |
| b2 | .065 | .094 | 1.65 | 2.39 | |
| b3 | .065 | .092 | 1.65 | 2.34 | |
| b4 | .102 | .135 | 2.59 | 3.43 | |
| b5 | .102 | .133 | 2.59 | 3.38 | |
| c | .015 | .035 | 0.38 | 0.89 | |
| c1 | .015 | .033 | 0.38 | 0.84 | |
| D | .776 | .815 | 19.71 | 20.70 | 4 |
| D1 | .515 | - | 13.08 | - | 5 |
| D2 | .020 | .053 | 0.51 | 1.35 | |
| E | .602 | .625 | 15.29 | 15.87 | 4 |
| E1 | .530 | - | 13.46 | - | |
| E2 | .178 | .216 | 4.52 | 5.49 | |
| e | .215 BSC | | 5.46 BSC | | |
| ϕk | .010 | | 0.25 | | |
| L | .559 | .634 | 14.20 | 16.10 | |
| L1 | .146 | .169 | 3.71 | 4.29 | |
| ϕP | .140 | .144 | 3.56 | 3.66 | |
| $\phi P1$ | - | .291 | - | 7.39 | |
| Q | .209 | .224 | 5.31 | 5.69 | |
| S | .217 BSC | | 5.51 BSC | | |

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

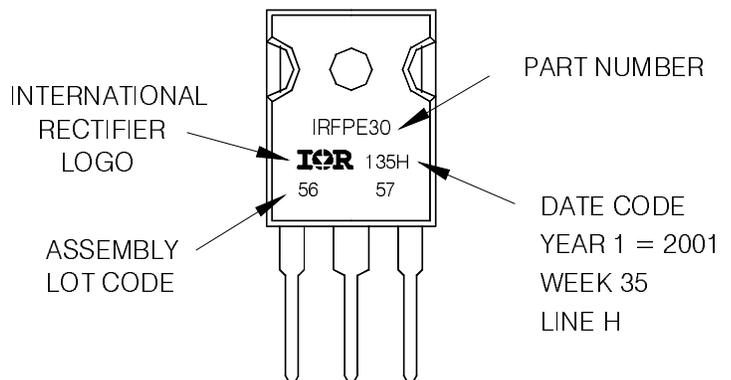
DIODES

- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

TO-247AC Part Marking Information

EXAMPLE: THIS IS AN IRFPE30
WITH ASSEMBLY
LOT CODE 5657
ASSEMBLED ON WW 35, 2001
IN THE ASSEMBLY LINE "H"

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

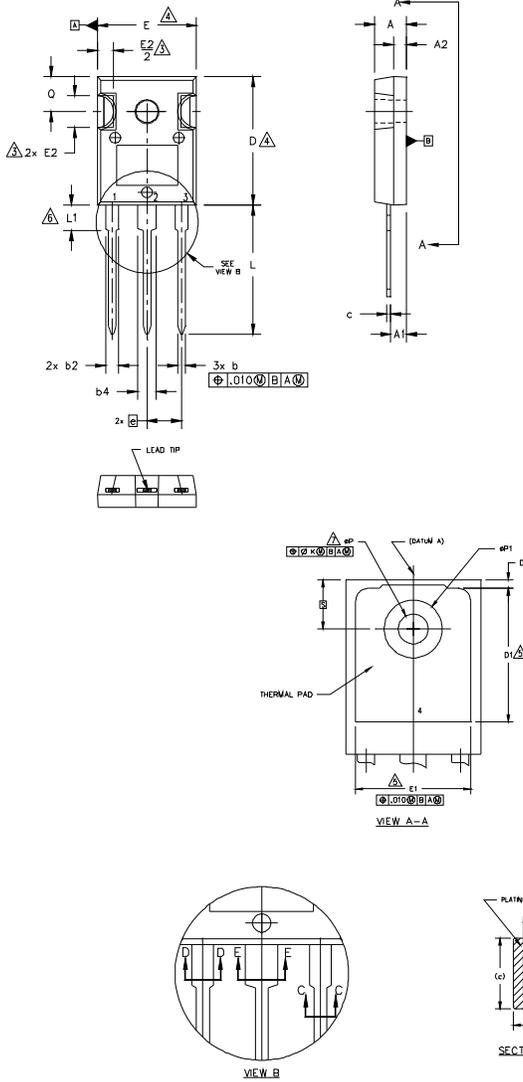


TO-247AC package is not recommended for Surface Mount Application.

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

TO-247AD Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
4. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. ØP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AD.

| SYMBOL | DIMENSIONS | | | | NOTES |
|--------|------------|------|-------------|-------|-------|
| | INCHES | | MILLIMETERS | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | .183 | .209 | 4.65 | 5.31 | |
| A1 | .087 | .102 | 2.21 | 2.59 | |
| A2 | .059 | .098 | 1.50 | 2.49 | |
| b | .039 | .055 | 0.99 | 1.40 | |
| b1 | .039 | .053 | 0.99 | 1.35 | |
| b2 | .065 | .094 | 1.65 | 2.39 | |
| b3 | .065 | .092 | 1.65 | 2.34 | |
| b4 | .102 | .135 | 2.59 | 3.43 | |
| b5 | .102 | .133 | 2.59 | 3.38 | |
| c | .015 | .035 | 0.38 | 0.89 | |
| c1 | .015 | .033 | 0.38 | 0.84 | |
| D | .776 | .815 | 19.71 | 20.70 | 4 |
| D1 | .515 | - | 13.08 | - | 5 |
| D2 | .020 | .053 | 0.51 | 1.35 | |
| E | .602 | .625 | 15.29 | 15.87 | 4 |
| E1 | .530 | - | 13.46 | - | |
| E2 | .178 | .216 | 4.52 | 5.49 | |
| e | .215 BSC | | 5.46 BSC | | |
| Øk | .010 | | 0.25 | | |
| L | .780 | .827 | 19.57 | 21.00 | |
| L1 | .146 | .169 | 3.71 | 4.29 | |
| ØP | .140 | .144 | 3.56 | 3.66 | |
| ØP1 | - | .291 | - | 7.39 | |
| Q | .209 | .224 | 5.31 | 5.69 | |
| S | .217 BSC | | 5.51 BSC | | |

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

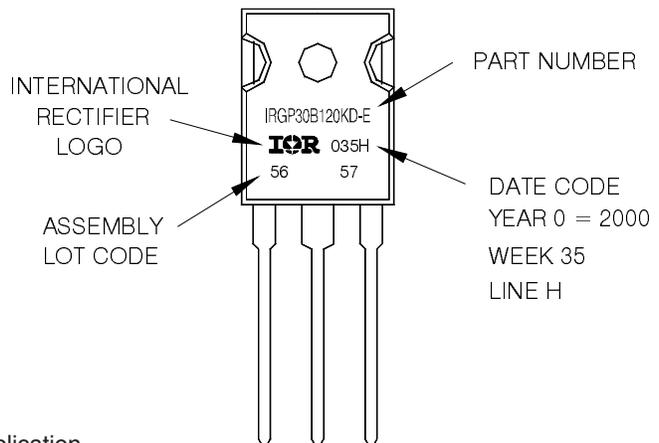
DIODES

- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

TO-247AD Part Marking Information

EXAMPLE: THIS IS AN IRGP30B120KD-E
WITH ASSEMBLY
LOT CODE 5657
ASSEMBLED ON WW 35, 2000
IN THE ASSEMBLY LINE "H"

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



TO-247AD package is not recommended for Surface Mount Application.

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

Qualification Information†

| | | |
|-----------------------------------|---|-----|
| Qualification Level | Industrial (per International Rectifier's internal guidelines) | |
| Moisture Sensitivity Level | TO-247AC | N/A |
| | TO-247AD | N/A |
| RoHS Compliant | Yes | |

† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/product-info/reliability>