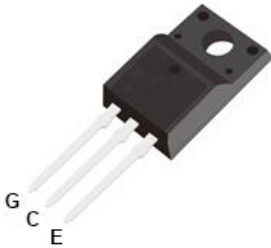
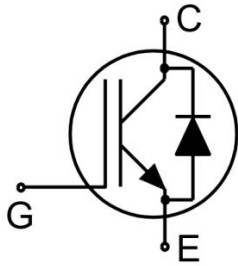


## 1. Descriptions

**TO-220F**

**Schematic Diagram**


## Key Performance Parameters

| Parameters                          | Value | Unit |
|-------------------------------------|-------|------|
| $V_{CE}$                            | 650   | V    |
| $I_C, T_J=100^\circ\text{C}$        | 15    | A    |
| $V_{CE(sat)}, T_J=25^\circ\text{C}$ | 1.7   | V    |

## Features

- 6 $\mu\text{s}$  of Short-circuit Withstand Time.
- Trench FS Technology Offering.
- Very Low  $V_{CE(sat)}$ .
- Positive Temperature Coefficient in  $V_{CE(sat)}$ .
- Very Tight Parameter Distribution.
- High Ruggedness, Temperature Stable Behavior.
- Maximum Junction Temperature:  $T_J=175^\circ\text{C}$ .

## Applications

- Motor Control.
- Sewing Machines.
- Home Appliances.
- Fan, Pump, Vacuum Cleaner.
- Other Hard Switching Applications.

| Type/Ordering Code | Package | Marking | Related Links  |
|--------------------|---------|---------|----------------|
| CKA15N65L1         | TO-220F | 15N65L1 | See Appendix A |

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## 2. Maximum Ratings

at  $T_J = 25^\circ\text{C}$ , unless otherwise specified

**Table 1. Absolute Maximum Ratings**

| Symbol         | Parameter                                                                                | Values               | Unit             | Test Condition                                                                                                               |
|----------------|------------------------------------------------------------------------------------------|----------------------|------------------|------------------------------------------------------------------------------------------------------------------------------|
| $V_{CES}$      | Collector-Emitter Voltage                                                                | 650                  | V                | $V_{GS}=0V$                                                                                                                  |
| $V_{GES}$      | Gate-Emitter Voltage<br>Transient Gate-Emitter Voltage ( $t_p \leq 10\mu s, D < 0.010$ ) | $\pm 20$<br>$\pm 30$ | V                |                                                                                                                              |
| $I_C$          | Collector Current                                                                        | 30<br>15             | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                                                            |
| $I_{C, pulse}$ | Pulsed Collector Current, $t_p$ Limited by $T_{Jmax}$                                    | 45                   | A                |                                                                                                                              |
| $I_F$          | Diode Continuous Forward Current                                                         | 30<br>15             | A                | $T_C=25^\circ\text{C}$<br>$T_C=100^\circ\text{C}$                                                                            |
| $I_{FM}$       | Diode Maximum Forward Current                                                            | 45                   | A                |                                                                                                                              |
| $P_D$          | Power Dissipation                                                                        | 136                  | W                | $T_C=25^\circ\text{C}$                                                                                                       |
|                |                                                                                          | 68                   | W                | $T_C=100^\circ\text{C}$                                                                                                      |
| $T_J, T_{stg}$ | Operating Junction and Storage Temperature Range                                         | -55~175              | $^\circ\text{C}$ |                                                                                                                              |
| $t_{sc}$       | Short Circuit Withstand Time                                                             | 6                    | us               | $V_{GE}=15.0V, V_{CC} \leq 400V$ ,<br>Allowed Number of Short<br>Circuits < 1000 Time Between<br>Short Circuits: $\geq 1.0s$ |

## 3. Thermal Characteristics

**Table 2. Thermal Characteristics**

| Symbol      | Parameter                                      | Values |      |      | Unit               | Test Condition         |
|-------------|------------------------------------------------|--------|------|------|--------------------|------------------------|
|             |                                                | Min.   | Typ. | Max. |                    |                        |
| $R_{thJC}$  | Thermal Resistance, Junction to Case for IGBT  |        |      | 1.10 | $^\circ\text{C/W}$ | $T_C=25^\circ\text{C}$ |
| $R_{thJCD}$ | Thermal Resistance, Junction to Case for Diode |        |      | 1.7  | $^\circ\text{C/W}$ | $T_C=25^\circ\text{C}$ |
| $R_{thJA}$  | Thermal Resistance, Junction to Ambient        |        |      | 78   | $^\circ\text{C/W}$ | $T_C=25^\circ\text{C}$ |

## 4. Electrical Characteristics

at  $T_J = 25^\circ\text{C}$ , unless otherwise specified

**Table 3. Static Characteristics**

| Symbol        | Parameter                                                                                              | Values |      |           | Unit | Test Condition                                                                  |
|---------------|--------------------------------------------------------------------------------------------------------|--------|------|-----------|------|---------------------------------------------------------------------------------|
|               |                                                                                                        | Min.   | Typ. | Max.      |      |                                                                                 |
| $V_{(BR)CES}$ | Collector-Emitter Breakdown Voltage                                                                    | 650    |      |           | V    | $V_{GE}=0V, I_{CE}=1mA$                                                         |
| $I_{CES}$     | Collector-Emitter Leakage Current                                                                      |        |      | 5         | uA   | $V_{GE}=0V, V_{CE}=650V$                                                        |
| $I_{GES}$     | Gate to Emitter Leakage Current                                                                        |        |      | $\pm 250$ | nA   | $V_{GE}=\pm 20V, V_{CE}=0V$                                                     |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage                                                                   |        | 1.7  | 2.4       | V    | $V_{GE}=15V, I_C=15A, T_J=25^\circ\text{C}$                                     |
|               |                                                                                                        |        | 2    |           | V    | $V_{GE}=15V, I_C=15A, T_J=125^\circ\text{C}$                                    |
|               |                                                                                                        |        | 2.2  |           | V    | $V_{GE}=15V, I_C=15A, T_J=175^\circ\text{C}$                                    |
| $V_{GE(th)}$  | Gate Threshold Voltage                                                                                 | 5.5    | 6.8  | 7.5       | V    | $I_C=1mA, V_{CE}=V_{GE}$                                                        |
| $I_{C(SC)}$   | Short Circuit Collector Current Max.1000<br>Short Circuits Time Between Short<br>Circuits: $\geq 1.0s$ |        | 40   |           | A    | $V_{GE}=15V, V_{CC}\leq 400V,$<br>$t_{SC}\leq 6\mu s, T_J\leq 25^\circ\text{C}$ |

**Table 4. Dynamic Characteristics**

| Symbol    | Parameter                    | Values |      |      | Unit | Test Condition                     |
|-----------|------------------------------|--------|------|------|------|------------------------------------|
|           |                              | Min.   | Typ. | Max. |      |                                    |
| $C_{ies}$ | Input Capacitance            |        | 1050 |      | pF   | $V_{GE}=0V, V_{CE}=25V, f=1MHz$    |
| $C_{oes}$ | Output Capacitance           |        | 30   |      | pF   | $V_{GE}=0V, V_{CE}=25V, f=1MHz$    |
| $C_{res}$ | Reverse Transfer Capacitance |        | 22   |      | pF   | $V_{GE}=0V, V_{CE}=25V, f=1MHz$    |
| $Q_g$     | Total Gate Charge            |        | 53   |      | nC   | $V_{CC}=480V, I_C=15A, V_{GE}=15V$ |
| $Q_{ge}$  | Gate to Emitter Charge       |        | 9    |      | nC   |                                    |
| $Q_{gc}$  | Gate to Collector Charge     |        | 33   |      | nC   |                                    |
| $Q_{gth}$ | Gate Threshold Charge        |        | 6    |      | nC   |                                    |

**Table 5. Switching Characteristics**

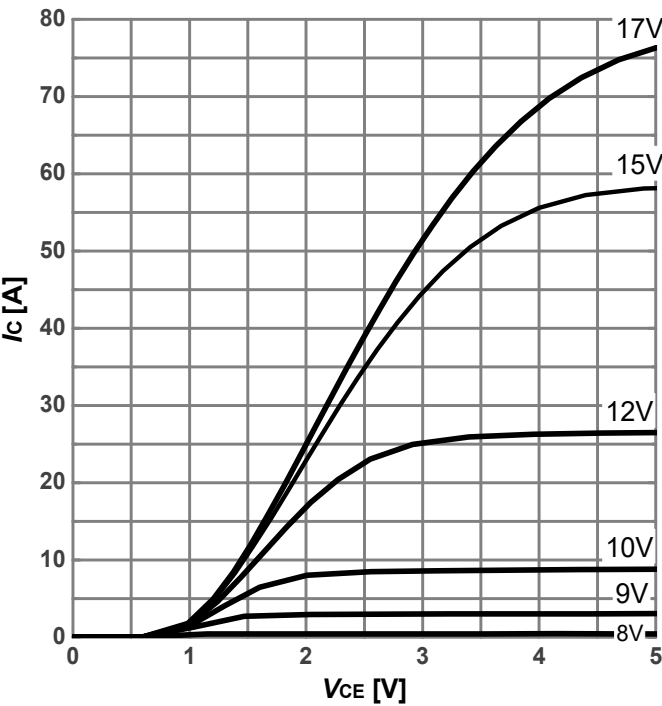
| Symbol       | Parameter               | Values |      |      | Unit | Test Condition                                                                        |
|--------------|-------------------------|--------|------|------|------|---------------------------------------------------------------------------------------|
|              |                         | Min.   | Typ. | Max. |      |                                                                                       |
| $t_{d(on)}$  | Turn-on Delay Time      |        | 39   |      | ns   | $V_{CE}=400V, I_C=15A, V_{GE}=15V,$<br>$R_G=39\Omega, T_J=25^\circ C$ Inductive Load  |
| $t_r$        | Rise Time               |        | 79   |      | ns   |                                                                                       |
| $t_{d(off)}$ | Turn-off Delay Time     |        | 115  |      | ns   |                                                                                       |
| $t_f$        | Fall Time               |        | 110  |      | ns   |                                                                                       |
| $E_{on}$     | Turn-On Switching Loss  |        | 0.6  |      | mJ   |                                                                                       |
| $E_{off}$    | Turn-Off Switching Loss |        | 0.3  |      | mJ   |                                                                                       |
| $E_{ts}$     | Total Switching Loss    |        | 0.9  |      | mJ   | $V_{CE}=400V, I_C=15A, V_{GE}=15V,$<br>$R_G=39\Omega, T_J=175^\circ C$ Inductive Load |
| $t_{d(on)}$  | Turn-on Delay Time      |        | 37   |      | ns   |                                                                                       |
| $t_r$        | Rise Time               |        | 82   |      | ns   |                                                                                       |
| $t_{d(off)}$ | Turn-off Delay Time     |        | 128  |      | ns   |                                                                                       |
| $t_f$        | Fall Time               |        | 160  |      | ns   |                                                                                       |
| $E_{on}$     | Turn-On Switching Loss  |        | 0.6  |      | mJ   |                                                                                       |
| $E_{off}$    | Turn-Off Switching Loss |        | 0.4  |      | mJ   |                                                                                       |
| $E_{ts}$     | Total Switching Loss    |        | 1.0  |      | mJ   |                                                                                       |

**Table 6. Reverse Diode Characteristics**

| Symbol    | Parameter                     | Values |      |      | Unit | Test Condition                               |
|-----------|-------------------------------|--------|------|------|------|----------------------------------------------|
|           |                               | Min.   | Typ. | Max. |      |                                              |
| $V_{FM}$  | Diode Forward Voltage         |        | 2.1  | 2.5  | V    | $V_{GE}=0V, I_F=15A, T_J=25^\circ C$         |
|           |                               |        | 1.8  |      | V    | $V_{GE}=0V, I_F=15A, T_J=125^\circ C$        |
|           |                               |        | 1.7  |      | V    | $V_{GE}=0V, I_F=15A, T_J=175^\circ C$        |
| $t_{rr}$  | Reverse Recovery Time         |        | 42   |      | ns   | $I_F=15A, di/dt=200A/\mu s, T_J=25^\circ C$  |
| $Q_{rr}$  | Reverse Recovery Charge       |        | 45   |      | uC   | $I_F=15A, di/dt=200A/\mu s, T_J=25^\circ C$  |
| $I_{rrm}$ | Peak Reverse Recovery Current |        | 2    |      | A    | $I_F=15A, di/dt=200A/\mu s, T_J=25^\circ C$  |
| $t_{rr}$  | Reverse Recovery Time         |        | 262  |      | ns   | $I_F=15A, di/dt=200A/\mu s, T_J=175^\circ C$ |
| $Q_{rr}$  | Reverse Recovery Charge       |        | 497  |      | uC   | $I_F=15A, di/dt=200A/\mu s, T_J=175^\circ C$ |
| $I_{rrm}$ | Peak Reverse Recovery Current |        | 5    |      | A    | $I_F=15A, di/dt=200A/\mu s, T_J=175^\circ C$ |

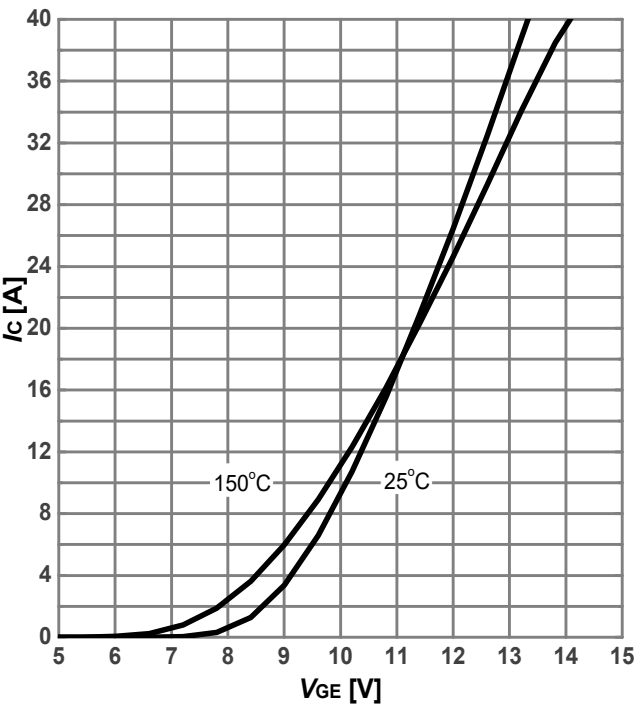
5. Electrical Characteristics Diagrams

Diagram 1: Typ. Output Characteristics



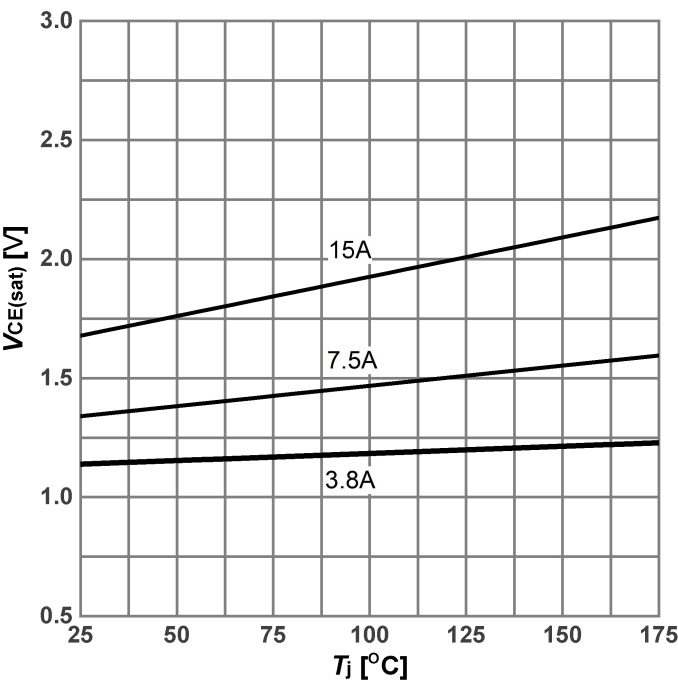
$I_C=f(V_{CE}); T_J=25^{\circ}\text{C}; \text{parameter: } V_{GE}$

Diagram 2: Typ. Transfer Characteristics



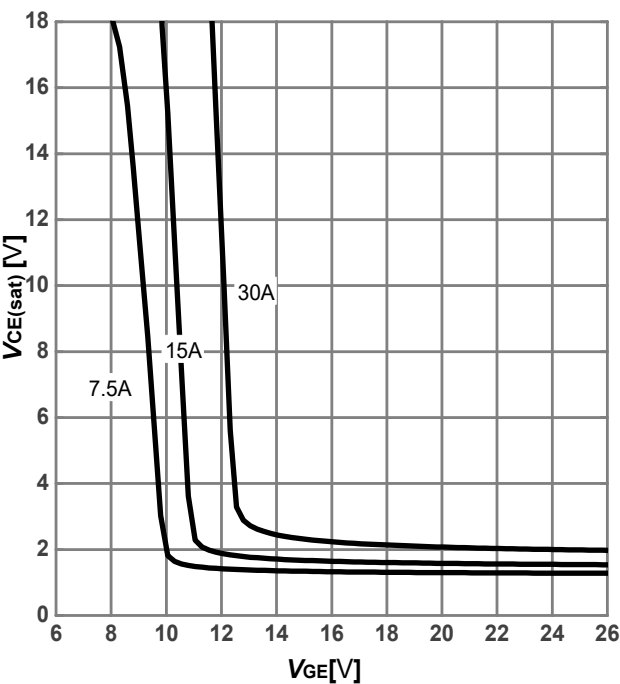
$I_C=f(V_{GE}); V_{CE}=20\text{V}; \text{parameter: } T_J$

Diagram 3:  $V_{CE(sat)}$  vs. Case Temperature



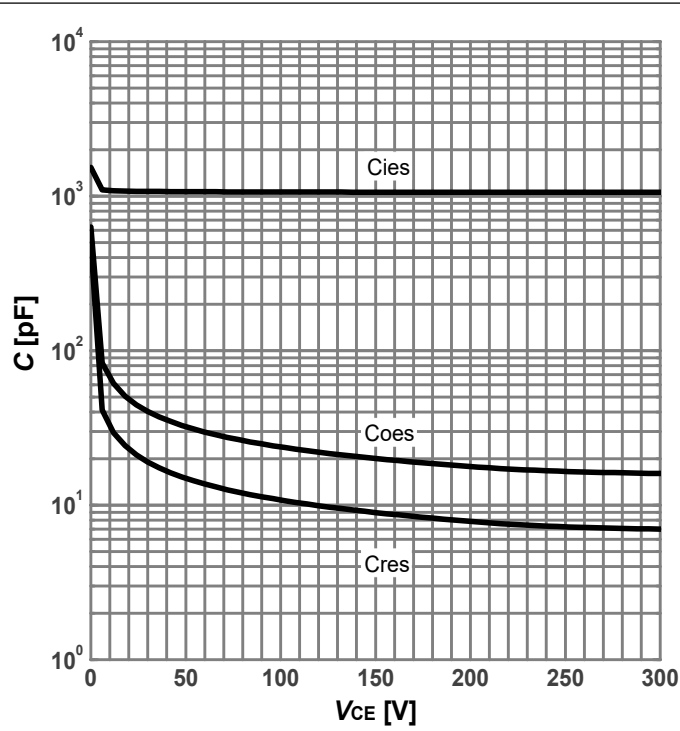
$V_{CE(sat)}=f(T_J); V_{GE}=15\text{V}; \text{parameter: } I_C$

Diagram 4: Saturation Voltage vs.  $V_{GE}$



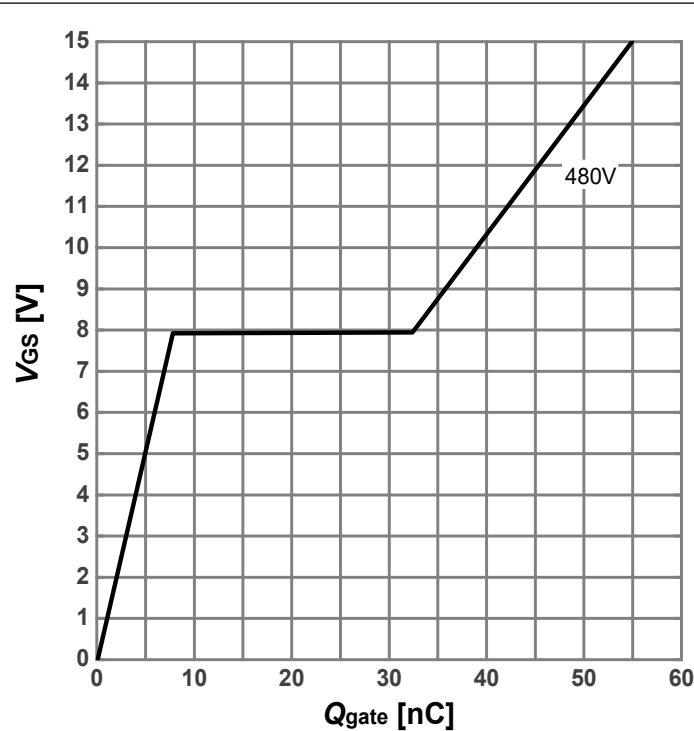
$V_{CE(sat)}=f(V_{GE}); \text{parameter: } I_C$

Diagram 5: Typ. Capacitances



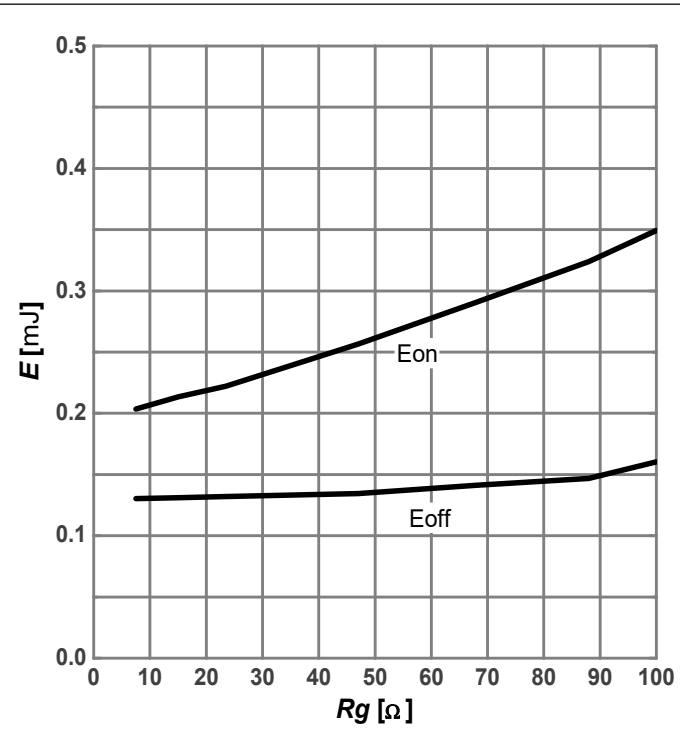
$C=f(V_{CE}); V_{GE}=0V; f=1MHz$

Diagram 6: Typ. Gate Charge



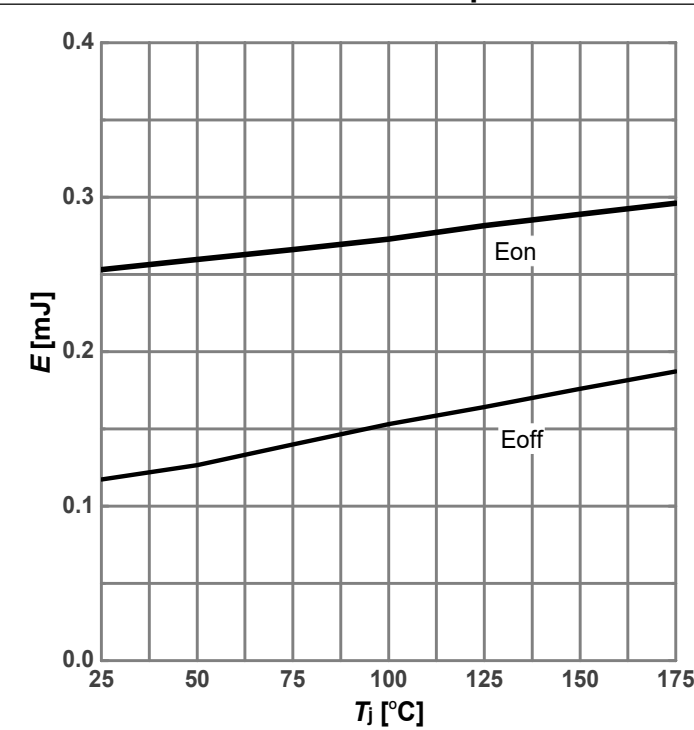
$V_{GE}=f(Q_{gate}); I_C=15A$  pulsed;  $V_{CC}=480V$

Diagram 7: Typical Switching Energy Losses As a Function of Gate Resistor



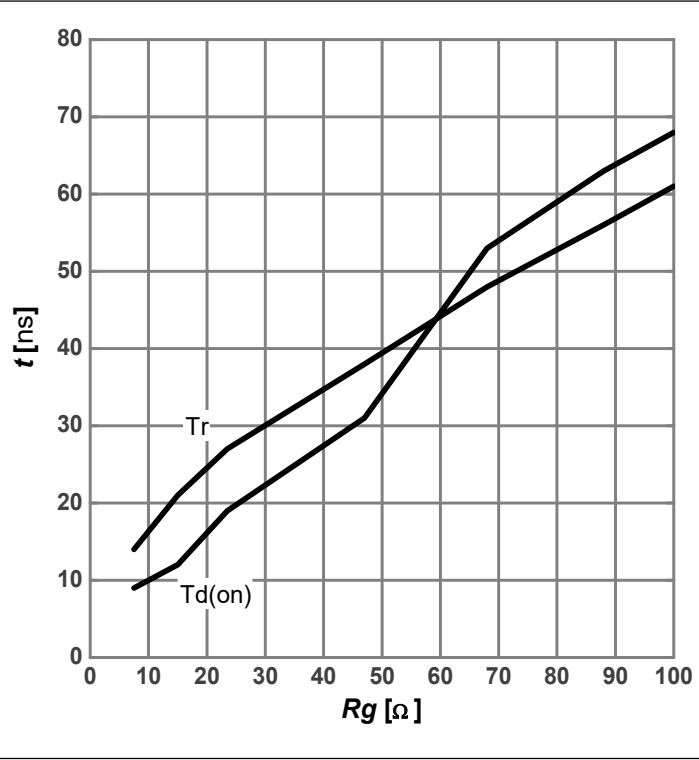
$E=f(R_G); V_{CE}=400V; V_{GE}=15V; I_C=7.5A; T_J=25^{\circ}C$

Diagram 8: Typical Switching Energy Losses As a Function of Junction Temperature



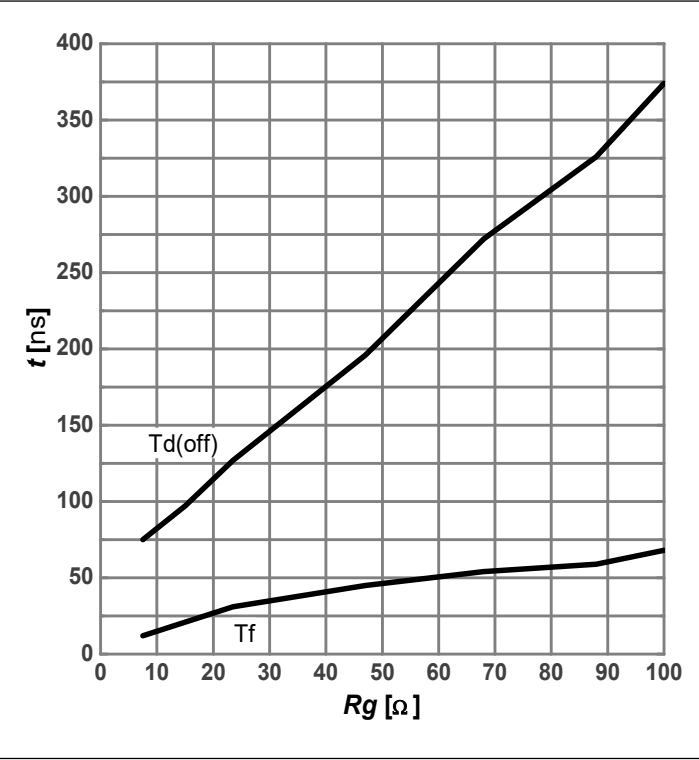
$E=f(T_J); V_{CE}=400V; V_{GE}=15V; I_C=7.5A; R_G=40\Omega$

Diagram 9: Typical Switching Times As a Function of Gate Resistor



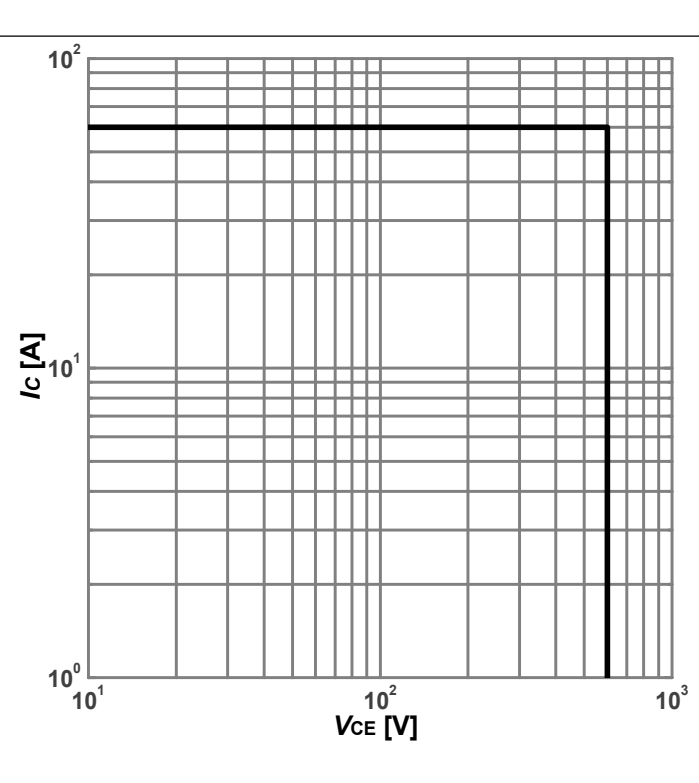
$t = f(R_G); V_{CE}=400V; V_{GE}=15V; I_C=7.5A$

Diagram 10: Typical Switching Times As a Function of Gate Resistor



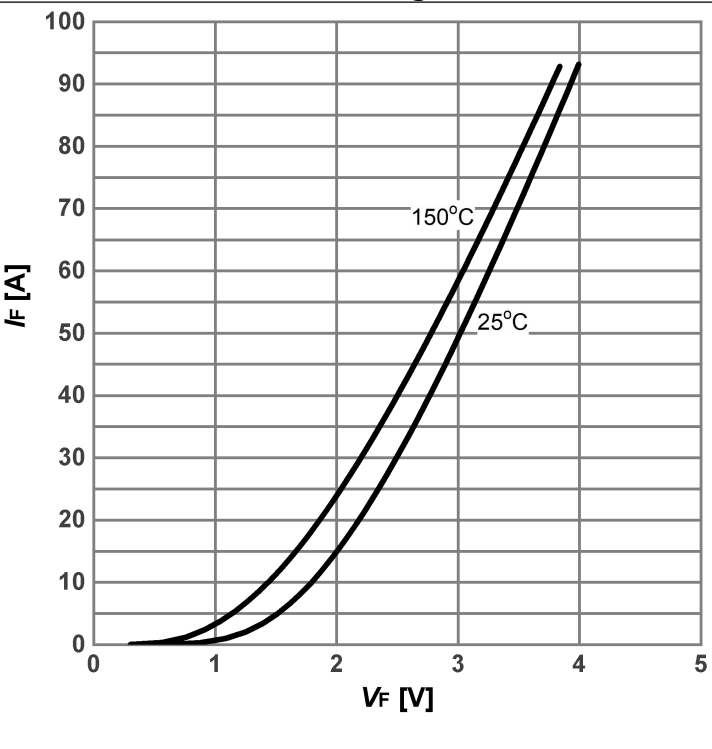
$t = f(R_G); V_{CE}=400V; V_{GE}=15V; I_C=7.5A$

Diagram 11: Reverse Bias SOA



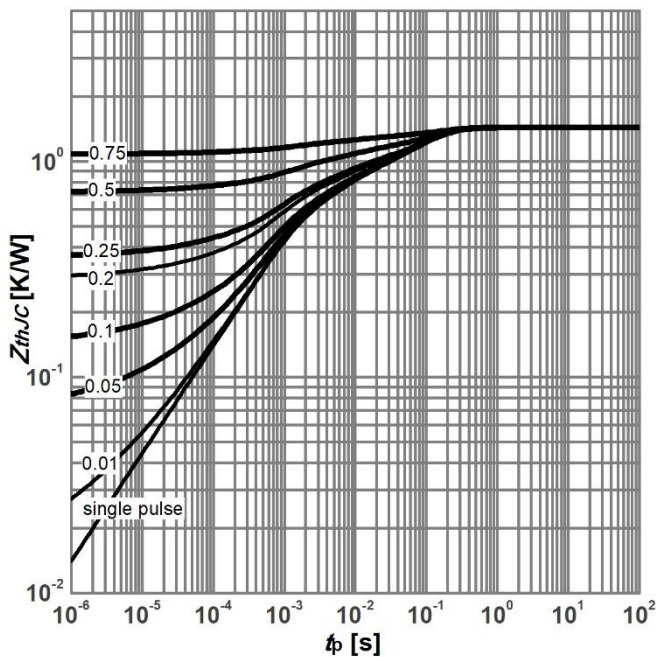
$I_C=f(V_{CE}); T_J=25^{\circ}C;$

Diagram 12: Typical diode forward current as A function of forward voltage



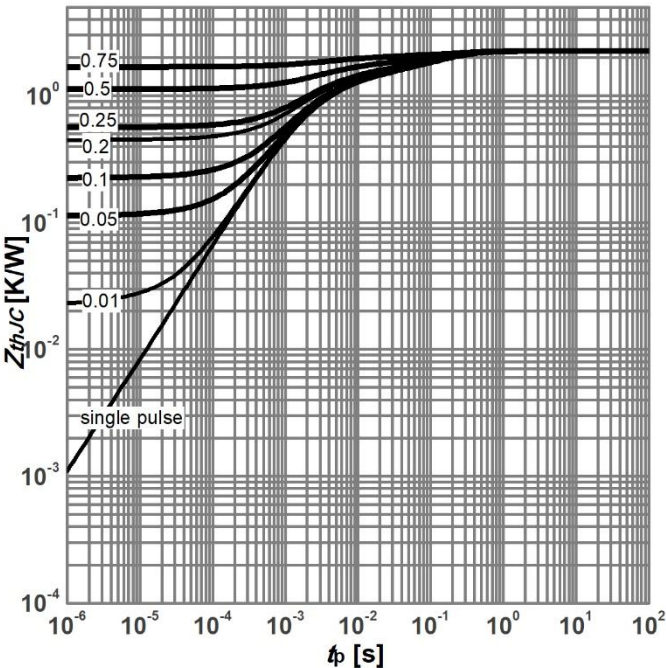
$I_F=f(V_F); \text{parameter: } T_J$

Diagram 13: Max. IGBT transient thermal impedance



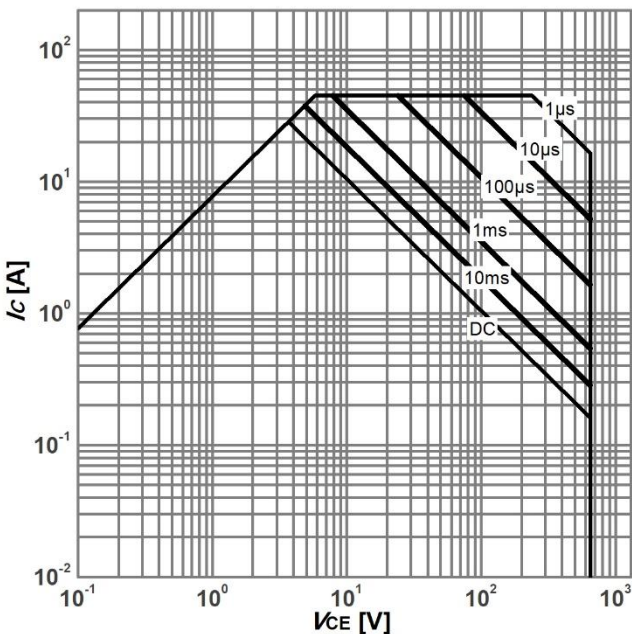
$Z_{thJC}=f(t_p)$ ; parameter:  $D= t_p/T$

Diagram 14: Max. Diode transient thermal impedance



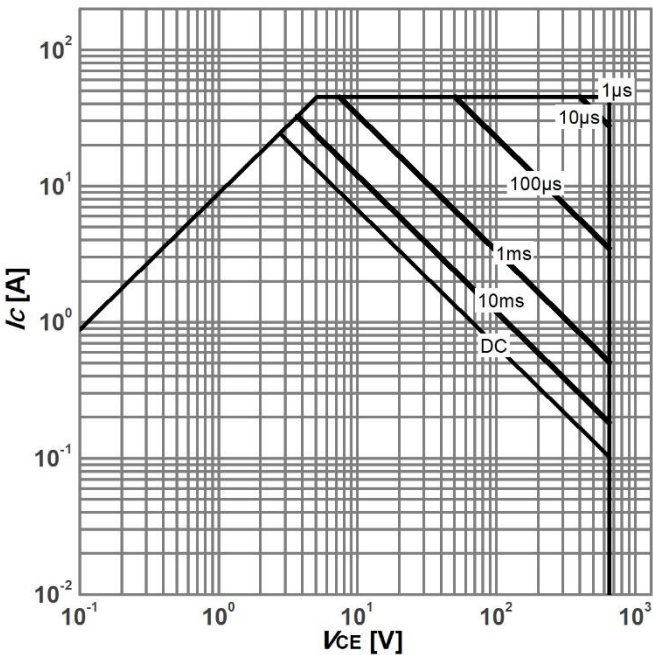
$Z_{thJC}=f(t_p)$ ; parameter:  $D= t_p/T$

Diagram 15: IGBT Safe operating area



$Z_{thJC}=f(t_p)$ ; parameter:  $D= t_p/T$

Diagram 16: Diode Safe operating area

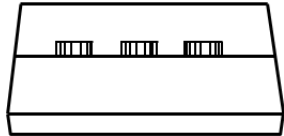
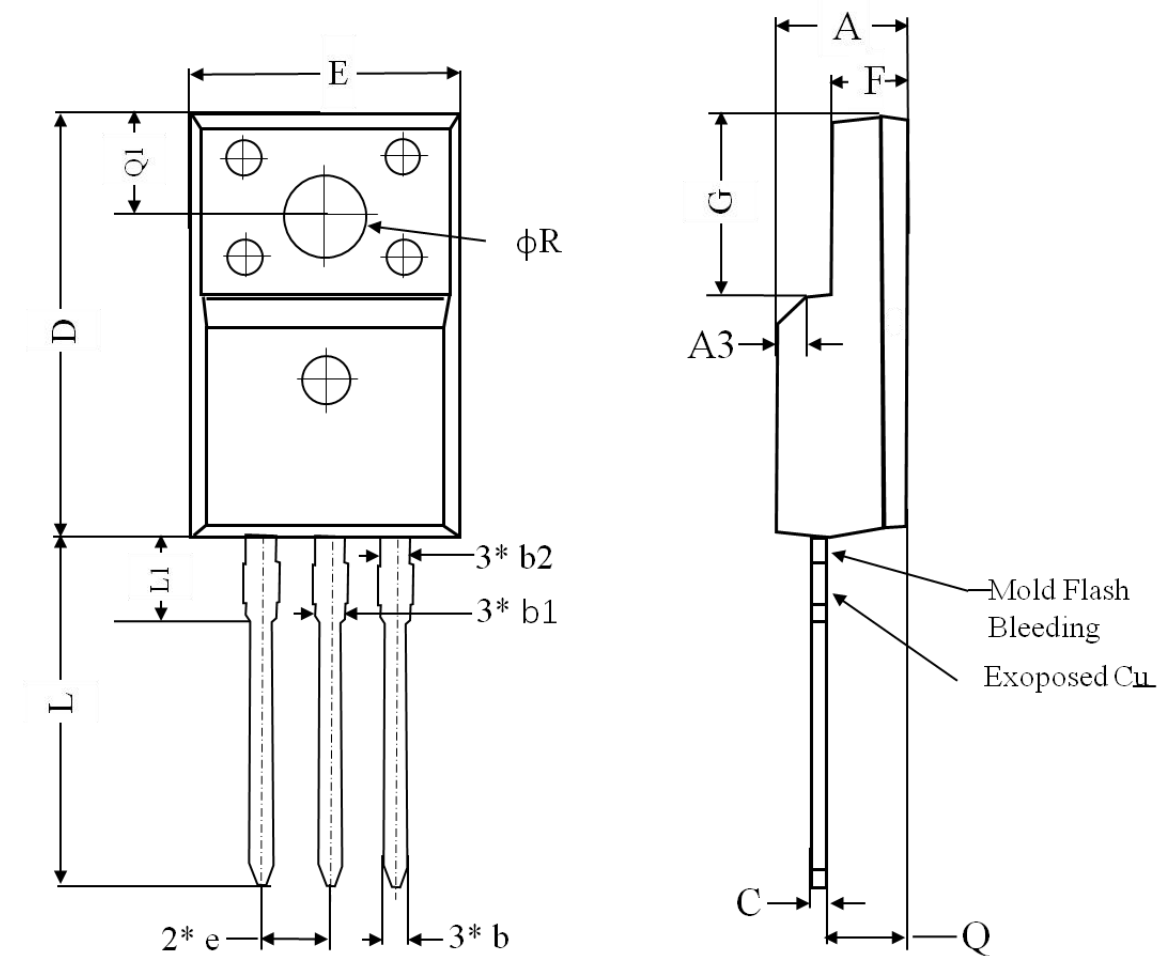


$Z_{thJC}=f(t_p)$ ; parameter:  $D= t_p/T$



7. Package Outlines

Figure 1 Outline TO-220F Dimensions in mm



- Note:
- 1. All Dimension Are In mm.
  - 2. Package Body Sizes Exclude Mold Flash And Burrs Mold Flash Should Be less Than 6 Mil.

| SYMBOL   | DIMENSIONS |       |       |
|----------|------------|-------|-------|
|          | Min.       | Nom.  | Max.  |
| A        | 4.60       | 4.70  | 4.80  |
| b        | 0.70       | 0.80  | 0.91  |
| b1       | 1.20       | 1.30  | 1.47  |
| b2       | 1.10       | 1.20  | 1.30  |
| C        | 0.45       | 0.50  | 0.63  |
| D        | 15.80      | 15.87 | 15.97 |
| e        | 2.54       |       |       |
| E        | 10.00      | 10.10 | 10.30 |
| F        | 2.44       | 2.54  | 2.64  |
| G        | 6.50       | 6.70  | 6.90  |
| L        | 12.90      | 13.10 | 13.30 |
| L1       | 3.13       | 3.23  | 3.33  |
| Q        | 2.65       | 2.75  | 2.85  |
| Q1       | 3.20       | 3.30  | 3.40  |
| $\Phi r$ | 3.08       | 3.18  | 3.28  |

## 8. Appendix

CoolSemi Webpage: [www.coolsemi.com](http://www.coolsemi.com).