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July 2015

# FGA4060ADF 600 V, 40 A Field Stop Trench IGBT

## Features

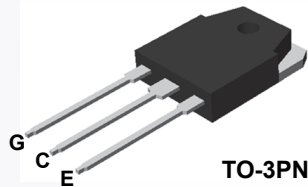
- Maximum Junction Temperature :  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.8\text{ V(Typ.)} @ I_C = 40\text{ A}$
- 100% of the Parts Tested for  $I_{LM}(1)$
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- RoHS Compliant

## General Description

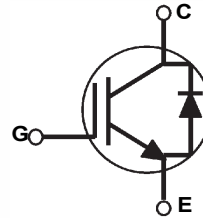
This ADF IGBT series adopted Field Stop Trench 3rd generation IGBT which offer extreme low  $V_{ce(sat)}$  and much faster switching characteristics for outstanding efficiency. And this kind of technology is fully optimized to variety PFC (Power Factor Correction) topology ; Single boost, Multi channel interleaved etc with over 20KHz switching performance. TO3P package provide Super Low thermal resistance for much wider SOA for system stability.

## Applications

- PFC topology for Home appliance : Single Boost , Multi channel Interleaved etc.



TO-3PN



## Absolute Maximum Ratings $T_C = 25^{\circ}\text{C}$ unless otherwise noted

| Symbol      | Description   | FGA4060ADF  | Unit               |
|-------------|---|-------------|--------------------|
| $V_{CES}$   | Collector to Emitter Voltage  | 600         | V                  |
| $V_{GES}$   | Gate to Emitter Voltage   | $\pm 20$    | V                  |
|             | Transient Gate to Emitter Voltage                                       | $\pm 30$    | V                  |
| $I_C$       | Collector Current @ $T_C = 25^{\circ}\text{C}$                          | 80          | A                  |
|             | Collector Current @ $T_C = 100^{\circ}\text{C}$                         | 40          | A                  |
| $I_{LM}(1)$ | Pulsed Collector Current @ $T_C = 25^{\circ}\text{C}$                   | 120         | A                  |
| $I_{CM}(2)$ | Pulsed Collector Current  | 120         | A                  |
| $I_F(3)$    | Diode Forward Current @ $T_C = 25^{\circ}\text{C}$                      | 3           | A                  |
|             | Diode Forward Current @ $T_C = 100^{\circ}\text{C}$                     | 1.5         | A                  |
| $I_{FM}(2)$ | Pulsed Diode Maximum Forward Current                                    | 6           | A                  |
| $P_D$       | Maximum Power Dissipation @ $T_C = 25^{\circ}\text{C}$                  | 238         | W                  |
|             | Maximum Power Dissipation @ $T_C = 100^{\circ}\text{C}$                 | 119         | W                  |
| $T_J$       | Operating Junction Temperature  | -55 to +175 | $^{\circ}\text{C}$ |
| $T_{stg}$   | Storage Temperature Range   | -55 to +175 | $^{\circ}\text{C}$ |
| $T_L$       | Maximum Lead Temp. for soldering Purposes, 1/8" from case for 5 seconds | 300         | $^{\circ}\text{C}$ |

### Notes:

1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 120\text{ A}$ ,  $R_G = 120\ \Omega$ , Inductive Load.
2. Repetitive rating: Pulse width limited by max. junction temperature.
3. The purpose of diode is protection for negative voltage.

## Thermal Characteristics

| Symbol                        | Parameter                                     | FGA4060ADF | Unit                        |
|-------------------------------|---|------------|-----------------------------|
| $R_{\theta JC}(IGBT)$         | Thermal Resistance, Junction to Case, Max.    | 0.63       | $^{\circ}\text{C}/\text{W}$ |
| $R_{\theta JC}(\text{Diode})$ | Thermal Resistance, Junction to Case, Max.    | 5          | $^{\circ}\text{C}/\text{W}$ |
| $R_{\theta JA}$               | Thermal Resistance, Junction to Ambient, Max. | 40         | $^{\circ}\text{C}/\text{W}$ |

## Package Marking and Ordering Information

| Part Number | Top Mark   | Package | Packing Method | Reel Size | Tape Width | Qty per Tube |
|-------------|------------|---------|----------------|-----------|------------|--------------|
| FGA4060ADF  | FGA4060ADF | TO-3PN  | Tube           | -         | -          | 30           |

## Electrical Characteristics of the IGBT $T_C = 25^{\circ}\text{C}$ unless otherwise noted

| Symbol                           | Parameter                                    | Test Conditions  | Min. | Typ. | Max.      | Unit                        |
|----------------------------------|--|--|------|------|-----------|-----------------------------|
| <b>Off Characteristics</b>       |  |  |      |      |           |                             |
| $BV_{CES}$                       | Collector to Emitter Breakdown Voltage       | $V_{GE} = 0\text{V}, I_C = 1\text{mA}$   | 600  | -    | -         | V                           |
| $\Delta BV_{CES} / \Delta T_J$   | Temperature Coefficient of Breakdown Voltage | $I_C = 1\text{mA}$ , Reference to $25^{\circ}\text{C}$   | -    | 0.6  | -         | $\text{V}/^{\circ}\text{C}$ |
| $I_{CES}$                        | Collector Cut-Off Current                    | $V_{CE} = V_{CES}, V_{GE} = 0\text{V}$   | -    | -    | 250       | $\mu\text{A}$               |
| $I_{GES}$                        | G-E Leakage Current                          | $V_{GE} = V_{GES}, V_{CE} = 0\text{V}$   | -    | -    | $\pm 400$ | nA                          |
| <b>On Characteristics</b>        |  |  |      |      |           |                             |
| $V_{GE(th)}$                     | G-E Threshold Voltage                        | $I_C = 40\text{mA}, V_{CE} = V_{GE}$   | 4.1  | 5.6  | 7.6       | V                           |
| $V_{CE(sat)}$                    | Collector to Emitter Saturation Voltage      | $I_C = 40\text{A}, V_{GE} = 15\text{V}$  | -    | 1.8  | 2.3       | V                           |
|                                  |  | $I_C = 40\text{A}, V_{GE} = 15\text{V}, T_C = 175^{\circ}\text{C}$   | -    | 2.31 | -         | V                           |
| <b>Dynamic Characteristics</b>   |  |  |      |      |           |                             |
| $C_{ies}$                        | Input Capacitance                            | $V_{CE} = 30\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$   | -    | 1525 | -         | pF                          |
| $C_{oes}$                        | Output Capacitance                           |  | -    | 60   | -         | pF                          |
| $C_{res}$                        | Reverse Transfer Capacitance                 |  | -    | 20   | -         | pF                          |
| <b>Switching Characteristics</b> |  |  |      |      |           |                             |
| $t_{d(on)}$                      | Turn-On Delay Time                           | $V_{CC} = 400\text{V}, I_C = 40\text{A}, R_G = 6\ \Omega, V_{GE} = 15\text{V}, \text{Inductive Load}, T_C = 25^{\circ}\text{C}$  | -    | 16.8 | -         | ns                          |
| $t_r$                            | Rise Time                                    |  | -    | 34.4 | -         | ns                          |
| $t_{d(off)}$                     | Turn-Off Delay Time                          |  | -    | 54.4 | -         | ns                          |
| $t_f$                            | Fall Time                                    |  | -    | 10   | -         | ns                          |
| $E_{on}$                         | Turn-On Switching Loss                       |  | -    | 1.37 | -         | mJ                          |
| $E_{off}$                        | Turn-Off Switching Loss                      |  | -    | 0.25 | -         | mJ                          |
| $E_{ts}$                         | Total Switching Loss                         |  | -    | 1.62 | -         | mJ                          |
| $t_{d(on)}$                      | Turn-On Delay Time                           | $V_{CC} = 400\text{V}, I_C = 40\text{A}, R_G = 6\ \Omega, V_{GE} = 15\text{V}, \text{Inductive Load}, T_C = 175^{\circ}\text{C}$ | -    | 16   | -         | ns                          |
| $t_r$                            | Rise Time                                    |  | -    | 35.2 | -         | ns                          |
| $t_{d(off)}$                     | Turn-Off Delay Time                          |  | -    | 57.6 | -         | ns                          |
| $t_f$                            | Fall Time                                    |  | -    | 12.8 | -         | ns                          |
| $E_{on}$                         | Turn-On Switching Loss                       |  | -    | 1.89 | -         | mJ                          |
| $E_{off}$                        | Turn-Off Switching Loss                      |  | -    | 0.47 | -         | mJ                          |
| $E_{ts}$                         | Total Switching Loss                         |  | -    | 2.36 | -         | mJ                          |

**Electrical Characteristics of the IGBT** (Continued)

| Symbol   | Parameter                | Test Conditions   | Min. | Typ. | Max | Unit |
|----------|--------------------------|---|------|------|-----|------|
| $Q_g$    | Total Gate Charge        | $V_{CE} = 400\text{ V}$ , $I_C = 40\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$ | -    | 55.5 | -   | nC   |
| $Q_{ge}$ | Gate to Emitter Charge   |   | -    | 9.8  | -   | nC   |
| $Q_{gc}$ | Gate to Collector Charge |   | -    | 21   | -   | nC   |

**Electrical Characteristics of the Diode**  $T_C = 25^\circ\text{C}$  unless otherwise noted

| Symbol    | Parameter                     | Test Conditions   | Min.                      | Typ. | Max  | Unit |               |
|-----------|-------------------------------|---|---------------------------|------|------|------|---------------|
| $V_{FM}$  | Diode Forward Voltage         | $I_F = 3\text{ A}$  | $T_C = 25^\circ\text{C}$  | -    | 1.6  | 2.3  | V             |
|           |                               |   | $T_C = 175^\circ\text{C}$ | -    | 1.4  | -    |               |
| $E_{rec}$ | Reverse Recovery Energy       | $I_F = 3\text{ A}$ , $dI_F/dt = 200\text{ A}/\mu\text{s}$ | $T_C = 175^\circ\text{C}$ | -    | 29.7 | -    | $\mu\text{J}$ |
| $t_{rr}$  | Diode Reverse Recovery Time   |   | $T_C = 25^\circ\text{C}$  | -    | 26   | -    | ns            |
|           |                               |   | $T_C = 175^\circ\text{C}$ | -    | 153  | -    |               |
| $Q_{rr}$  | Diode Reverse Recovery Charge |   | $T_C = 25^\circ\text{C}$  | -    | 35   | -    | nC            |
|           |                               | $T_C = 175^\circ\text{C}$                                 | -                         | 305  | -    |      |               |

## Typical Performance Characteristics

Figure 1. Typical Output Characteristics

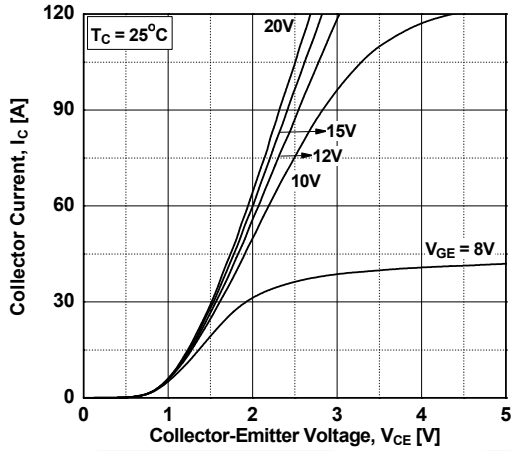


Figure 2. Typical Output Characteristics

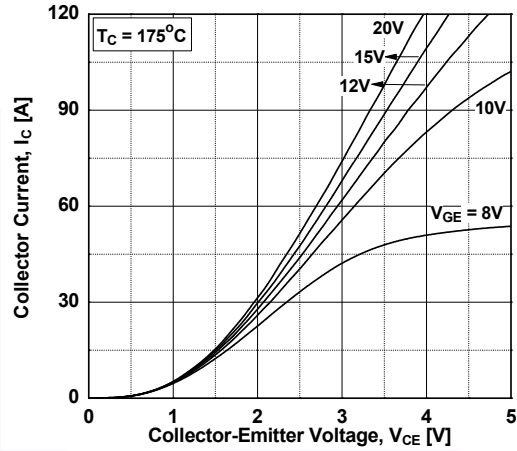


Figure 3. Typical Saturation Voltage Characteristics

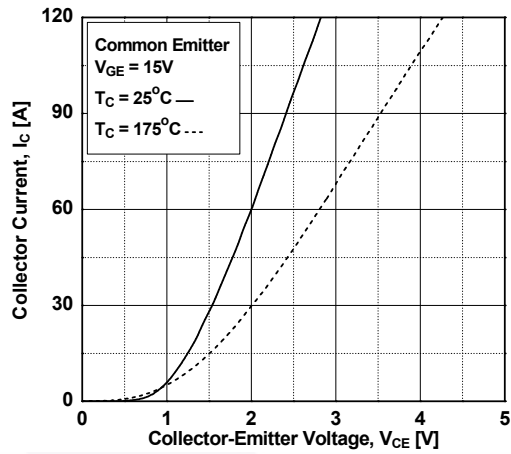


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

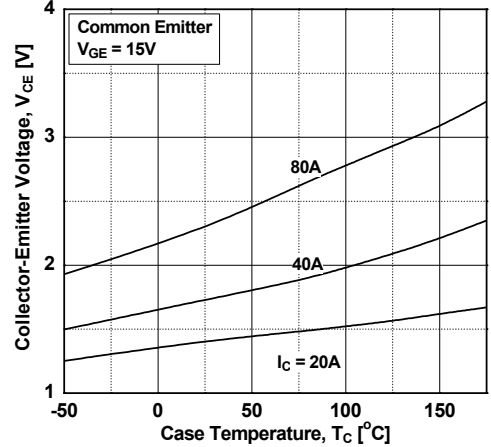


Figure 5. Saturation Voltage vs. Vge

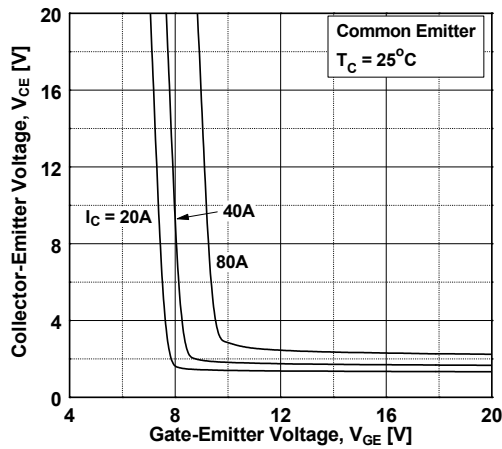
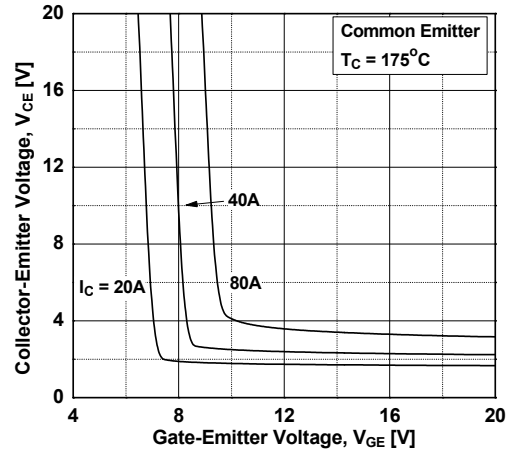


Figure 6. Saturation Voltage vs. Vge



## Typical Performance Characteristics

Figure 7. Capacitance Characteristics

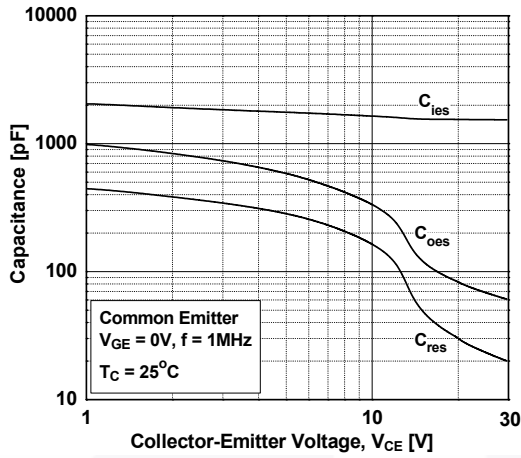


Figure 8. Gate charge Characteristics

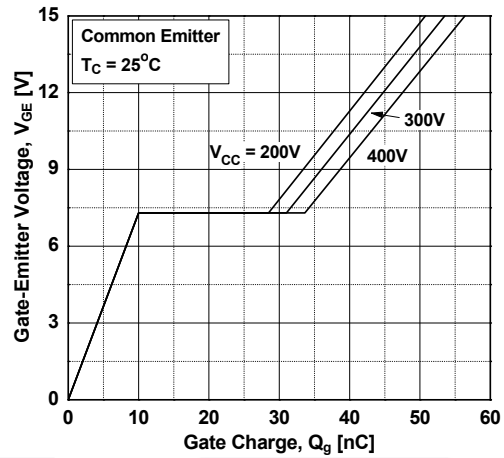


Figure 9. Turn-on Characteristics vs. Gate Resistance

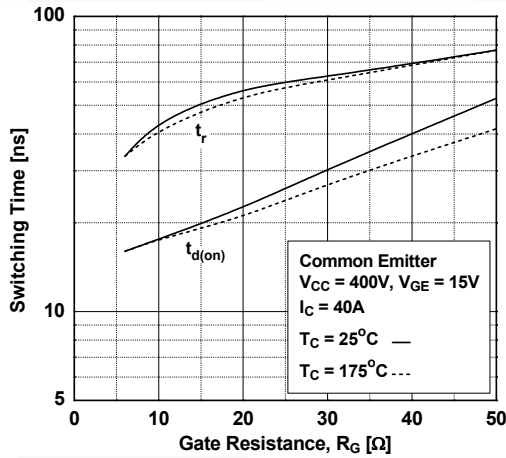


Figure 10. Turn-off Characteristics vs. Gate Resistance

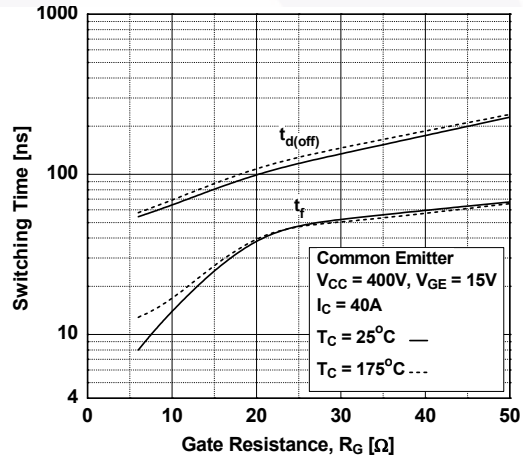


Figure 11. Switching Loss vs. Gate Resistance

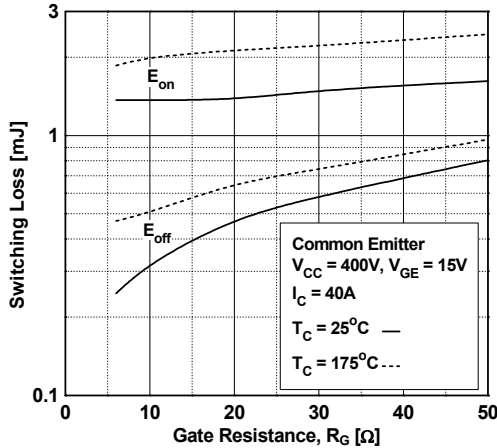
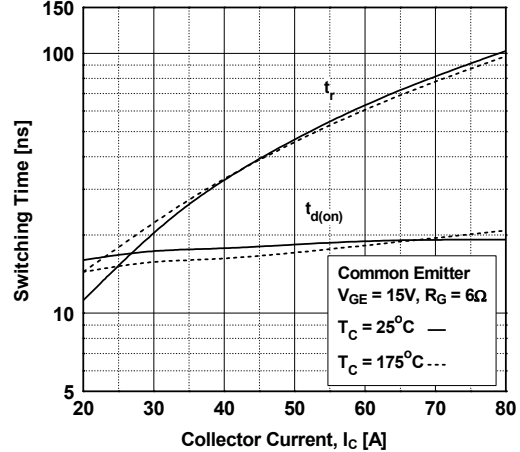
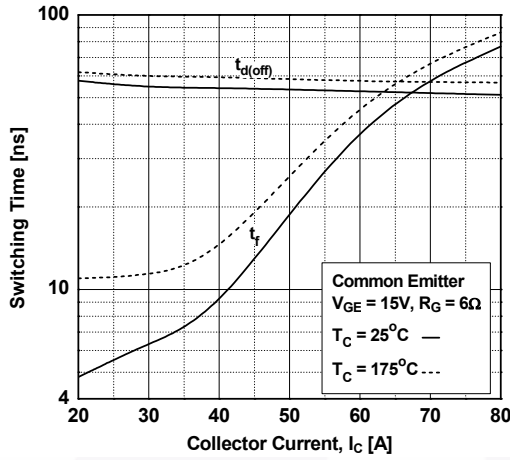


Figure 12. Turn-on Characteristics vs. Collector Current

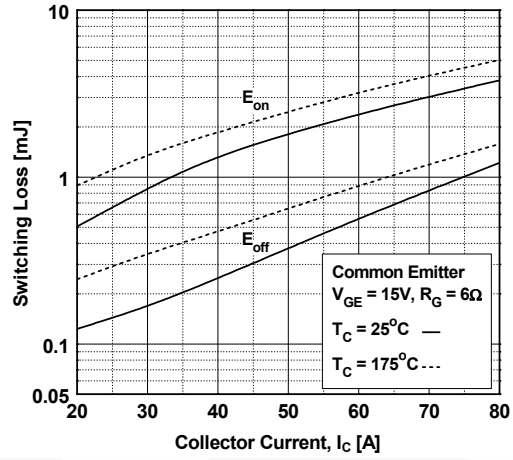


## Typical Performance Characteristics

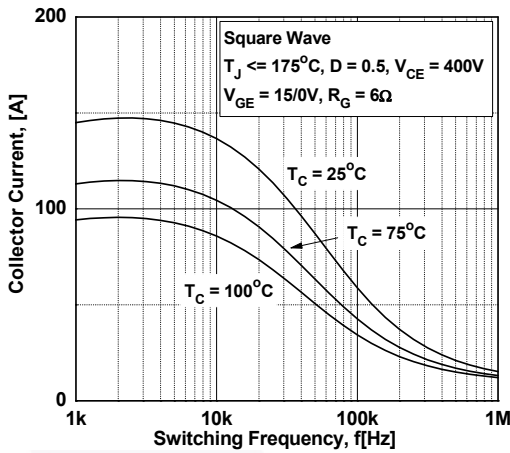
**Figure 13. Turn-off Characteristics vs. Collector Current**



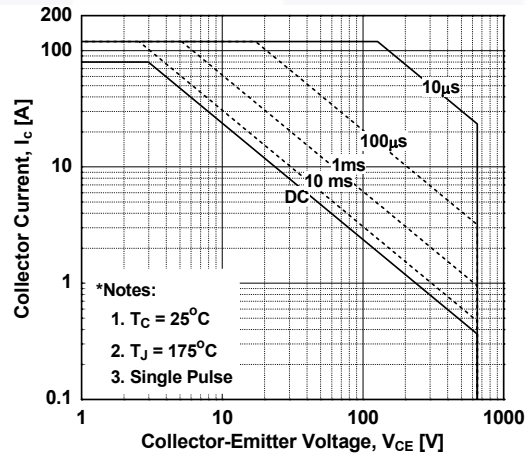
**Figure 14. Switching Loss vs. Collector Current**



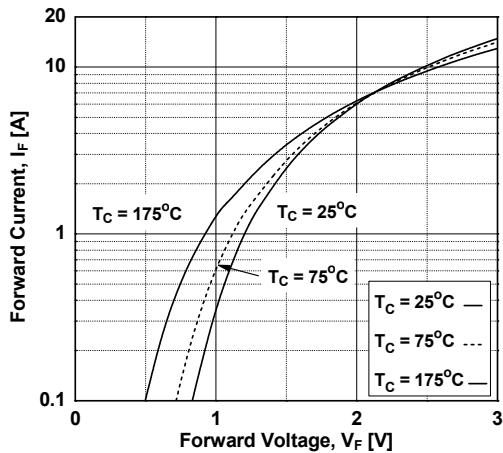
**Figure 15. Load Current Vs. Frequency**



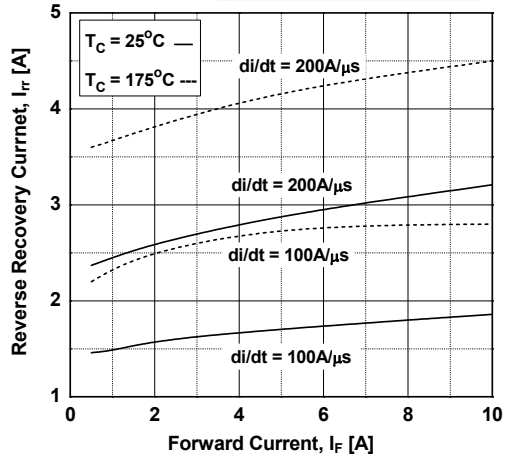
**Figure 16. SOA Characteristics**



**Figure 17. Forward Characteristics**



**Figure 18. Reverse Recovery Current**



## Typical Performance Characteristics

Figure 19. Reverse Recovery Time

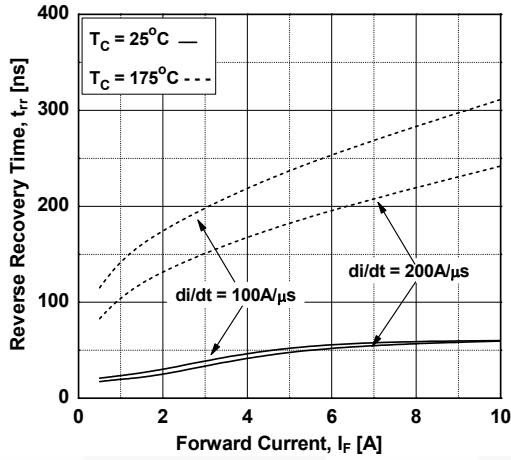


Figure 20. Stored Charge

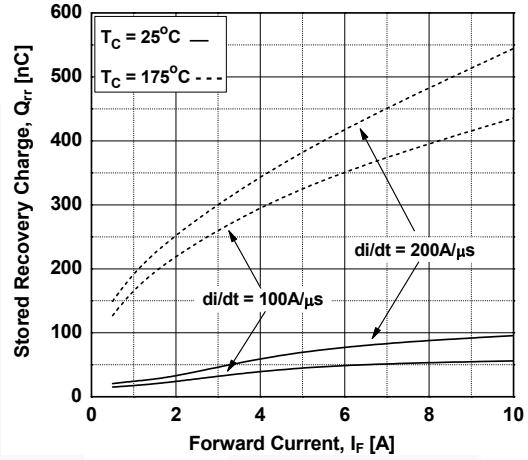


Figure 21. Transient Thermal Impedance of IGBT

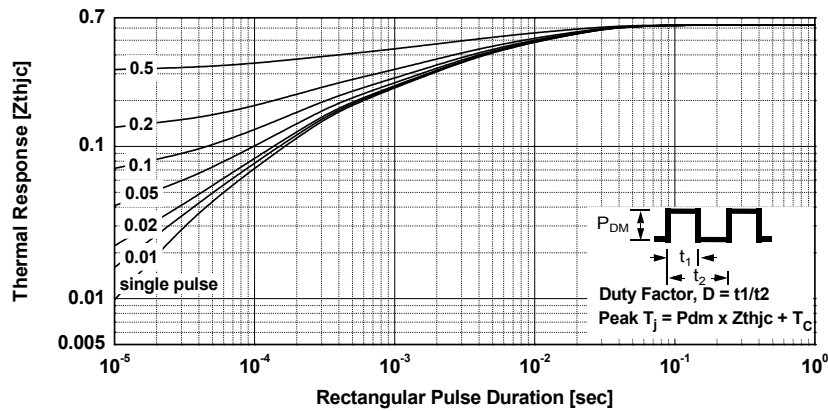
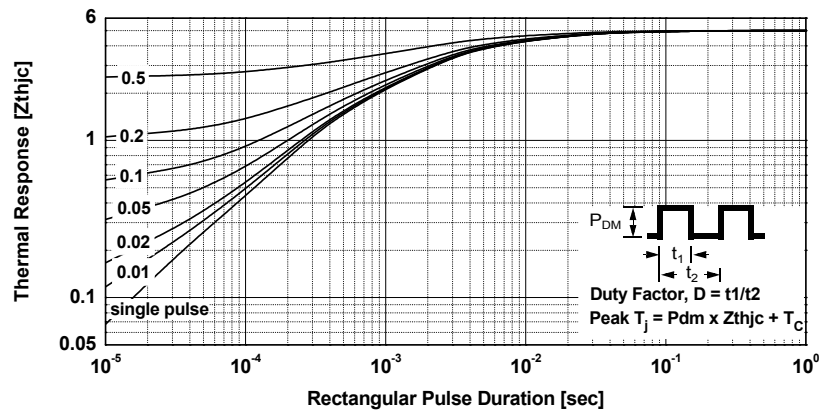


Figure 22. Transient Thermal Impedance of Diode







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