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# FGAF40N60UFD

## Ultrafast IGBT

### General Description

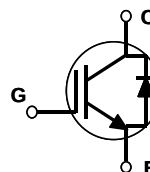
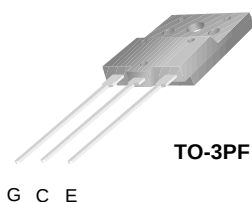
Fairchild's UFD series of Insulated Gate Bipolar Transistors (IGBTs) provides low conduction and switching losses. The UFD series is designed for applications such as motor control and general inverters where high speed switching is a required feature.

### Features

- High speed switching
- Low saturation voltage :  $V_{CE(sat)} = 2.3 \text{ V @ } I_C = 20\text{A}$
- High input impedance
- CO-PAK, IGBT with FRD :  $t_{rr} = 50\text{ns (typ.)}$

### Applications

AC & DC motor controls, general purpose inverters, robotics, and servo controls.



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

| Symbol      | Description                                                             | FGAF40N60UFD | Units            |
|-------------|-------------------------------------------------------------------------|--------------|------------------|
| $V_{CES}$   | Collector-Emitter Voltage                                               | 600          | V                |
| $V_{GES}$   | Gate-Emitter Voltage                                                    | $\pm 20$     | V                |
| $I_C$       | Collector Current @ $T_C = 25^\circ\text{C}$                            | 40           | A                |
|             | Collector Current @ $T_C = 100^\circ\text{C}$                           | 20           | A                |
| $I_{CM(1)}$ | Pulsed Collector Current                                                | 160          | A                |
| $I_F$       | Diode Continuous Forward Current @ $T_C = 100^\circ\text{C}$            | 15           | A                |
| $I_{FM}$    | Diode Maximum Forward Current                                           | 160          | A                |
| $P_D$       | Maximum Power Dissipation @ $T_C = 25^\circ\text{C}$                    | 100          | W                |
|             | Maximum Power Dissipation @ $T_C = 100^\circ\text{C}$                   | 40           | W                |
| $T_J$       | Operating Junction Temperature                                          | -55 to +150  | $^\circ\text{C}$ |
| $T_{stg}$   | Storage Temperature Range                                               | -55 to +150  | $^\circ\text{C}$ |
| $T_L$       | Maximum Lead Temp. for Soldering Purposes, 1/8" from Case for 5 Seconds | 300          | $^\circ\text{C}$ |

#### Notes :

(1) Repetitive rating : Pulse width limited by max. junction temperature

### Thermal Characteristics

| Symbol                        | Parameter                               | Typ. | Max. | Units              |
|-------------------------------|-----------------------------------------|------|------|--------------------|
| $R_{\theta JC}(\text{IGBT})$  | Thermal Resistance, Junction-to-Case    | --   | 1.2  | $^\circ\text{C/W}$ |
| $R_{\theta JC}(\text{DIODE})$ | Thermal Resistance, Junction-to-Case    | --   | 2.6  | $^\circ\text{C/W}$ |
| $R_{\theta JA}$               | Thermal Resistance, Junction-to-Ambient | --   | 40   | $^\circ\text{C/W}$ |

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

| Symbol                         | Parameter                                    | Test Conditions                 | Min. | Typ. | Max.      | Units        |
|--------------------------------|----------------------------------------------|---------------------------------|------|------|-----------|--------------|
| <b>Off Characteristics</b>     |                                              |                                 |      |      |           |              |
| $BV_{CES}$                     | Collector-Emitter Breakdown Voltage          | $V_{GE} = 0V, I_C = 250\mu A$   | 600  | --   | --        | V            |
| $\Delta BV_{CES} / \Delta T_J$ | Temperature Coefficient of Breakdown Voltage | $V_{GE} = 0V, I_C = 1mA$        | --   | 0.6  | --        | $V/^\circ C$ |
| $I_{CES}$                      | Collector Cut-Off Current                    | $V_{CE} = V_{CES}, V_{GE} = 0V$ | --   | --   | 250       | $\mu A$      |
| $I_{GES}$                      | G-E Leakage Current                          | $V_{GE} = V_{GES}, V_{CE} = 0V$ | --   | --   | $\pm 100$ | nA           |

**On Characteristics**

|               |                                         |                               |     |     |     |   |
|---------------|-----------------------------------------|-------------------------------|-----|-----|-----|---|
| $V_{GE(th)}$  | G-E Threshold Voltage                   | $I_C = 20mA, V_{CE} = V_{GE}$ | 3.5 | 5.1 | 6.5 | V |
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C = 20A, V_{GE} = 15V$     | --  | 2.3 | 3.0 | V |
|               |                                         | $I_C = 40A, V_{GE} = 15V$     | --  | 3.1 | --  | V |

**Dynamic Characteristics**

|           |                              |                                       |    |      |    |    |
|-----------|------------------------------|---------------------------------------|----|------|----|----|
| $C_{ies}$ | Input Capacitance            | $V_{CE} = 30V, V_{GE} = 0V, f = 1MHz$ | -- | 1075 | -- | pF |
| $C_{oes}$ | Output Capacitance           |                                       | -- | 170  | -- | pF |
| $C_{res}$ | Reverse Transfer Capacitance |                                       | -- | 50   | -- | pF |

**Switching Characteristics**

|              |                             |                                                                                                    |    |     |      |         |
|--------------|-----------------------------|----------------------------------------------------------------------------------------------------|----|-----|------|---------|
| $t_{d(on)}$  | Turn-On Delay Time          | $V_{CC} = 300V, I_C = 20A, R_G = 10\Omega, V_{GE} = 15V, \text{Inductive Load}, T_C = 25^\circ C$  | -- | 15  | --   | ns      |
| $t_r$        | Rise Time                   |                                                                                                    | -- | 30  | --   | ns      |
| $t_{d(off)}$ | Turn-Off Delay Time         |                                                                                                    | -- | 65  | 130  | ns      |
| $t_f$        | Fall Time                   |                                                                                                    | -- | 35  | 100  | ns      |
| $E_{on}$     | Turn-On Switching Loss      |                                                                                                    | -- | 470 | --   | $\mu J$ |
| $E_{off}$    | Turn-Off Switching Loss     | $V_{CC} = 300V, I_C = 20A, R_G = 10\Omega, V_{GE} = 15V, \text{Inductive Load}, T_C = 125^\circ C$ | -- | 130 | --   | $\mu J$ |
| $E_{ts}$     | Total Switching Loss        |                                                                                                    | -- | 600 | 1000 | $\mu J$ |
| $t_{d(on)}$  | Turn-On Delay Time          |                                                                                                    | -- | 30  | --   | ns      |
| $t_r$        | Rise Time                   |                                                                                                    | -- | 37  | --   | ns      |
| $t_{d(off)}$ | Turn-Off Delay Time         |                                                                                                    | -- | 110 | 200  | ns      |
| $t_f$        | Fall Time                   |                                                                                                    | -- | 80  | 250  | ns      |
| $E_{on}$     | Turn-On Switching Loss      | $V_{CE} = 300V, I_C = 20A, V_{GE} = 15V$                                                           | -- | 500 | --   | $\mu J$ |
| $E_{off}$    | Turn-Off Switching Loss     |                                                                                                    | -- | 310 | --   | $\mu J$ |
| $E_{ts}$     | Total Switching Loss        |                                                                                                    | -- | 810 | 1200 | $\mu J$ |
| $Q_g$        | Total Gate Charge           |                                                                                                    | -- | 77  | 150  | nC      |
| $Q_{ge}$     | Gate-Emitter Charge         |                                                                                                    | -- | 20  | 30   | nC      |
| $Q_{gc}$     | Gate-Collector Charge       |                                                                                                    | -- | 25  | 40   | nC      |
| $L_e$        | Internal Emitter Inductance | Measured 5mm from PKG                                                                              | -- | 14  | --   | nH      |

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

| Symbol          | Parameter                           | Test Conditions                          |                        | Min. | Typ. | Max. | Units |
|-----------------|-------------------------------------|------------------------------------------|------------------------|------|------|------|-------|
| V <sub>FM</sub> | Diode Forward Voltage               | I <sub>F</sub> = 15A                     | T <sub>C</sub> = 25°C  | --   | 1.4  | 1.7  | V     |
|                 |                                     |                                          | T <sub>C</sub> = 100°C | --   | 1.3  | --   |       |
| t <sub>rr</sub> | Diode Reverse Recovery Time         | I <sub>F</sub> = 15A,<br>di/dt = 200A/us | T <sub>C</sub> = 25°C  | --   | 50   | 95   | ns    |
|                 |                                     |                                          | T <sub>C</sub> = 100°C | --   | 74   | --   |       |
| I <sub>rr</sub> | Diode Peak Reverse Recovery Current |                                          | T <sub>C</sub> = 25°C  | --   | 4.5  | 6.0  | A     |
|                 |                                     |                                          | T <sub>C</sub> = 100°C | --   | 6.5  | --   |       |
| Q <sub>rr</sub> | Diode Reverse Recovery Charge       |                                          | T <sub>C</sub> = 25°C  | --   | 80   | 180  | nC    |
|                 |                                     |                                          | T <sub>C</sub> = 100°C | --   | 220  | --   |       |

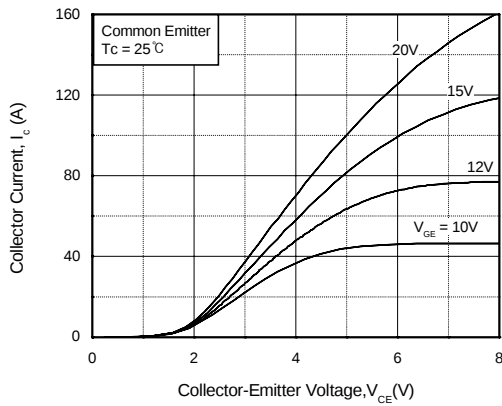


Fig 1. Typical Output Characteristics

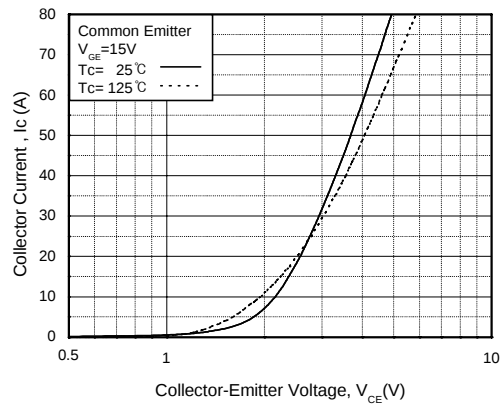


Fig 2. Typical Saturation Voltage Characteristics

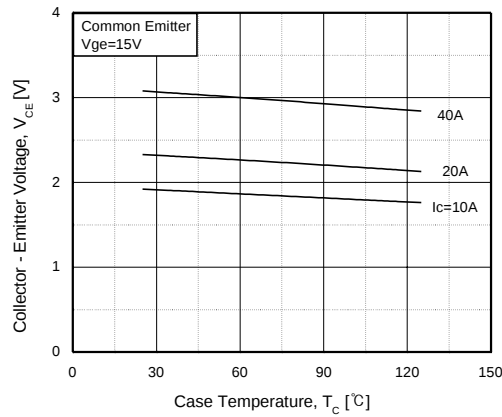


Fig 3. Saturation Voltage vs. Case Temperature at Variant Current Level

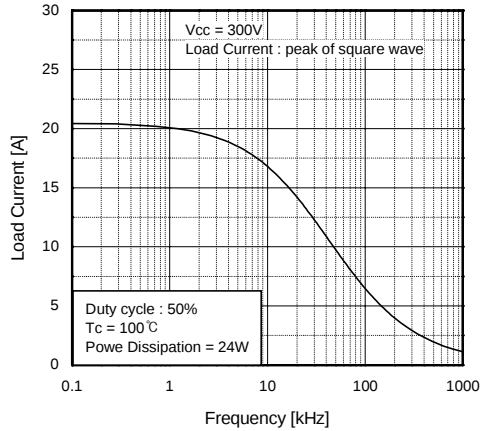


Fig 4. Load Current vs. Frequency

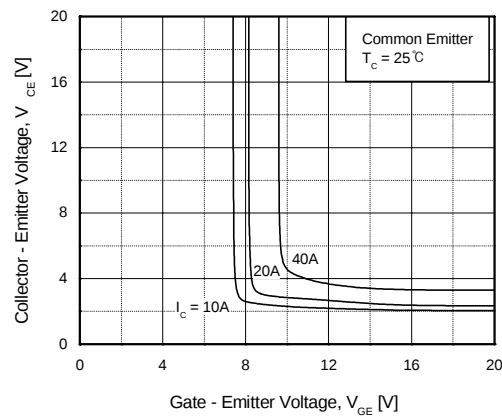


Fig 5. Saturation Voltage vs.  $V_{GE}$

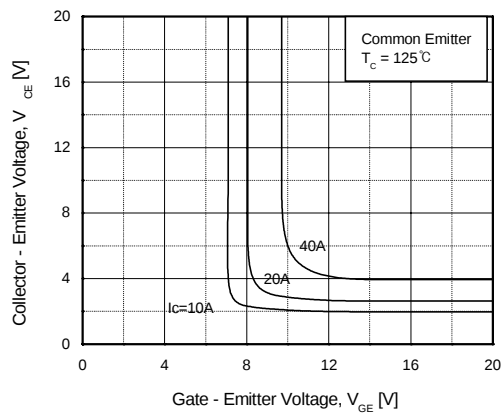


Fig 6. Saturation Voltage vs.  $V_{GE}$

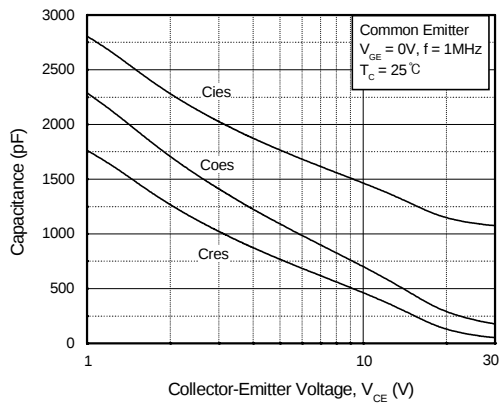


Fig 7. Capacitance Characteristics

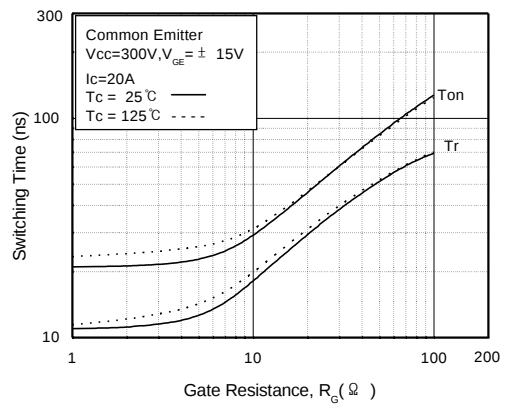


Fig 8. Turn-On Characteristics vs. Gate Resistance

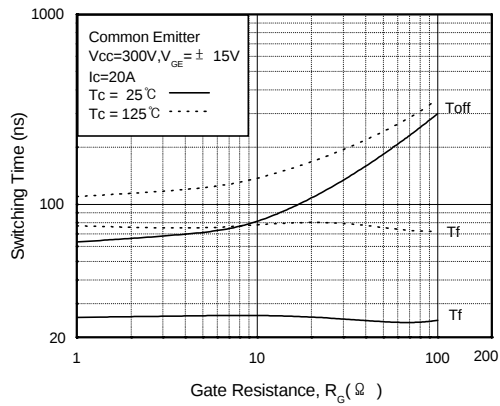


Fig 9. Turn-Off Characteristics vs. Gate Resistance

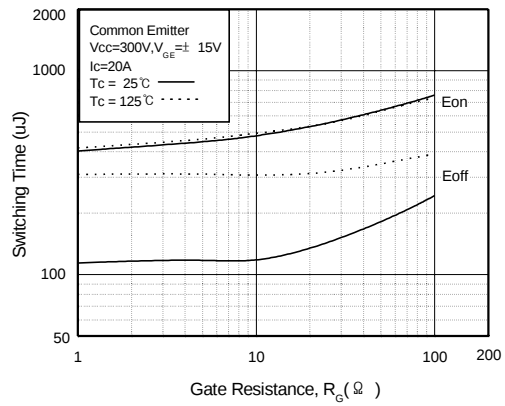


Fig 10. Switching Loss vs. Gate Resistance

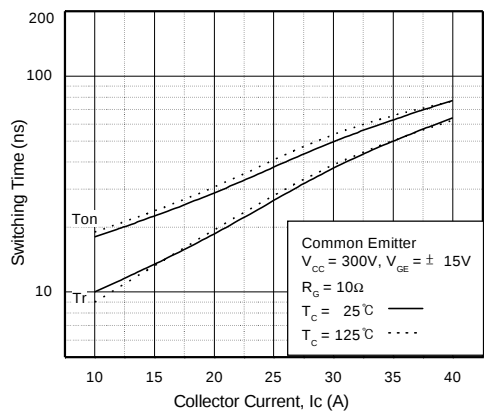


Fig 11. Turn-On Characteristics vs. Collector Current

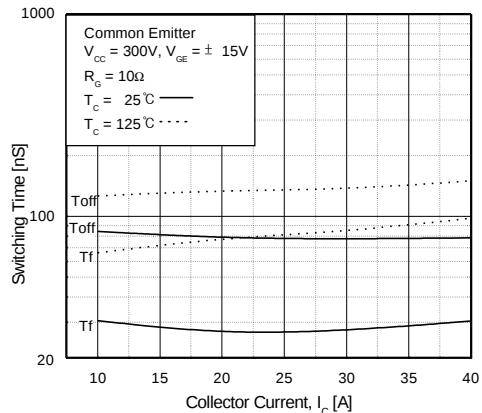


Fig 12. Turn-Off Characteristics vs. Collector Current

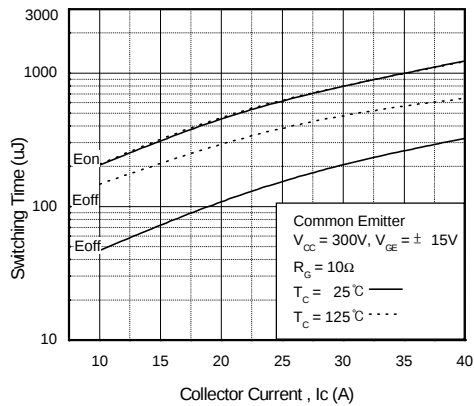


Fig 13. Switching Loss vs. Collector Current

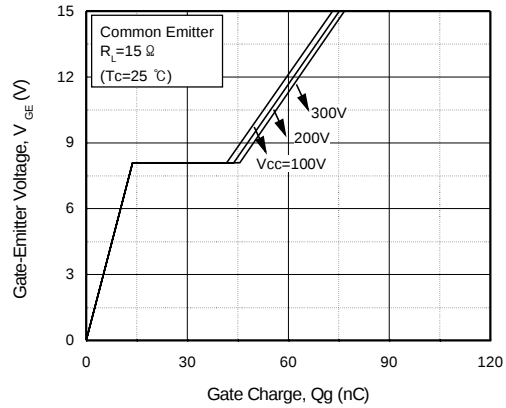


Fig 14. Gate Charge Characteristics

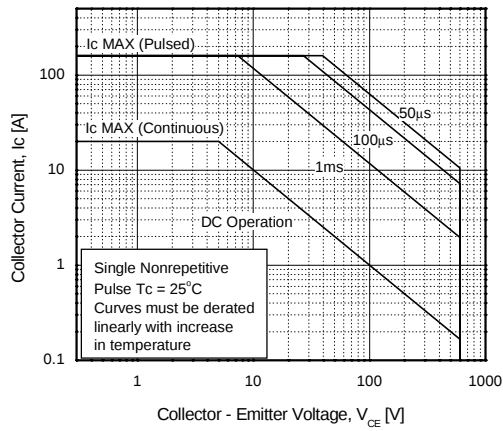


Fig 15. SOA Characteristics

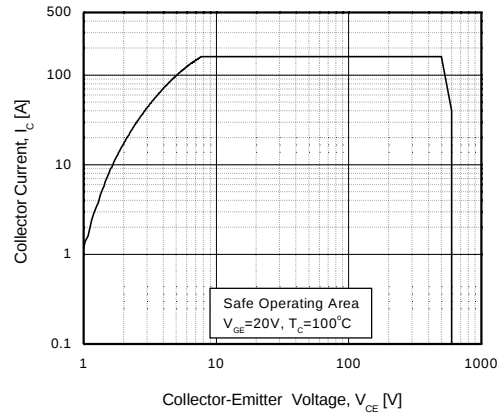


Fig 16. Turn-Off SOA Characteristics

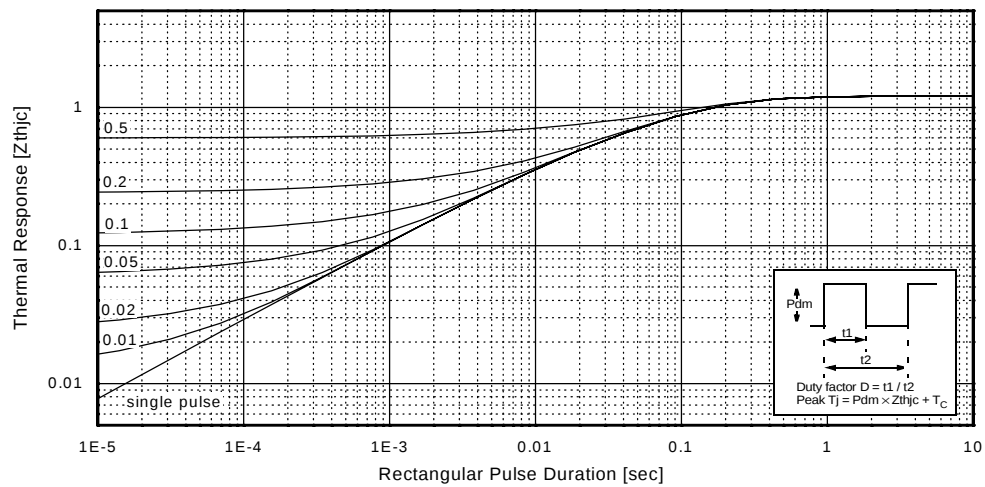


Fig 17. Transient Thermal Impedance of IGBT

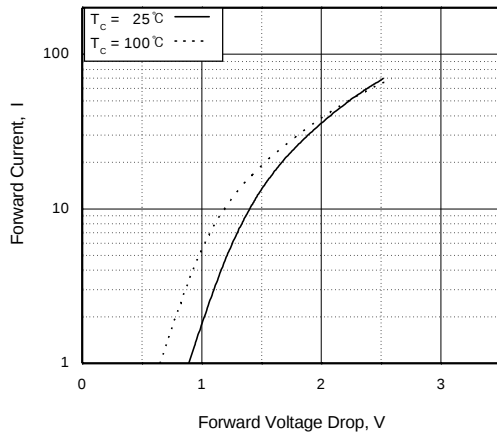


Fig 18. Forward Characteristics

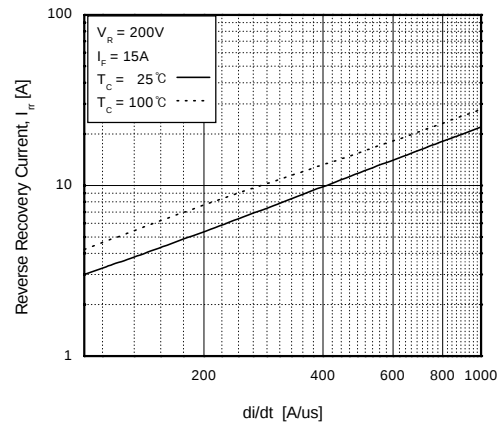


Fig 19. Reverse Recovery Current

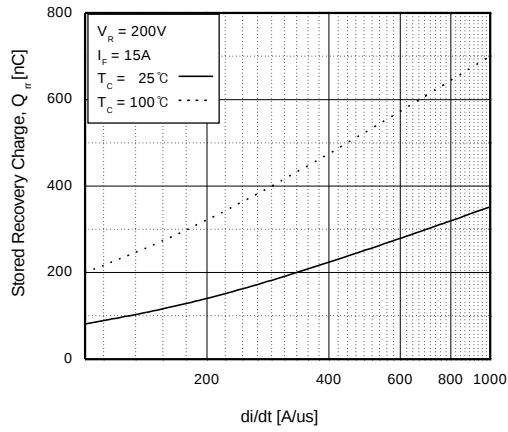


Fig 20. Stored Charge

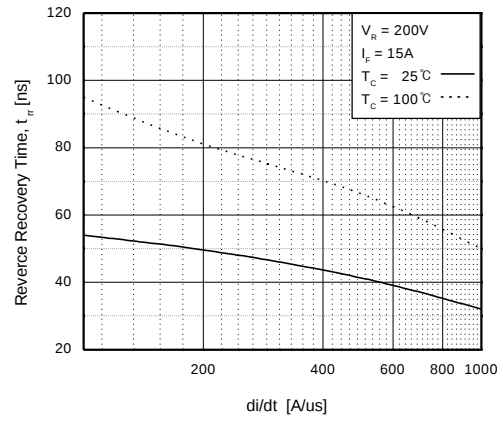


Fig 21. Reverse Recovery Time

**FGAF40N60UFD**

Technical drawing of a mechanical part, showing three views: front, side, and top. The drawing includes dimensions and tolerances.

**Front View Dimensions:**

- Overall width:  $15.50 \pm 0.20$
- Overall height:  $26.50 \pm 0.20$
- Top section height:  $4.50 \pm 0.20$
- Central hole diameter:  $\varnothing 3.60 \pm 0.20$
- Four side holes (diameter not specified)
- Bottom section height:  $2.50 \pm 0.20$
- Three vertical pins (diameter not specified)
- Pin spacing dimensions:  $2.00 \pm 0.20$ ,  $2.00 \pm 0.20$ ,  $4.00 \pm 0.20$
- Pin diameter:  $0.75^{+0.20}_{-0.10}$
- Material specification:  $5.45\text{TYP}$  [ $5.45 \pm 0.30$ ]

**Side View Dimensions:**

- Overall width:  $5.50 \pm 0.20$
- Overall height:  $23.00 \pm 0.20$
- Top section height:  $3.00 \pm 0.20$
- Chamfer angle:  $10^\circ$
- Chamfer width:  $0.85 \pm 0.03$
- Bottom section height:  $1.50 \pm 0.20$
- Pin diameter:  $2.00 \pm 0.20$
- Pin spacing:  $3.30 \pm 0.20$
- Material specification:  $0.90^{+0.20}_{-0.10}$

**Top View Dimensions:**

- Overall width:  $3.30 \pm 0.20$
- Overall height:  $5.50 \pm 0.20$
- Section height:  $2.00 \pm 0.20$

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FGAF40N60UFD Rev. A

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| The Power Franchise <sup>™</sup>                 |                                 | OPTOPLANAR <sup>™</sup>   | SMART START <sup>™</sup>        | VCX <sup>™</sup>            |
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