

## Description

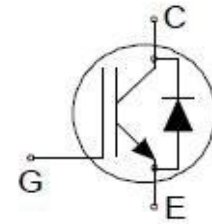
FGH40N60SMD is obtained by advanced Trench Field Stop (FS) technology which is characteristic with low  $V_{CE(sat)}$ , optimized switching performance and low gate charge  $Q_g$ . The IGBT is suitable device for welding, UPS, and high switching frequency applications.

## General Features

- ① 600V Breakdown Voltage
- ② Fast Switching
- ③ Low  $V_{CE(sat)}$ , typ=1.55V@ $I_C=40A$
- ④ Positive temperature coefficient
- ⑤ Fast recovery anti-parallel diode
- ⑥ RoHS product

## Application

- ① Welding converters
- ② UPS
- ③ Boost Chopper
- ④ Air condition



Schematic diagram



TO-247

## Package Marking And Ordering Information:

| Ordering Codes | Package | Product Code | Packing |
|----------------|---------|--------------|---------|
| FGH40N60SMD    | TO-247  | FGH40N60SMD  | Tube    |

## Absolute Maximum Ratings:

| Symbol              | Parameter                                                                                                                                                                  | Values          | Units       |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------|
| $V_{CES}$           | Collector-Emitter Voltage                                                                                                                                                  | 600             | V           |
| $I_C$               | Collector Current @ $T_C=25^{\circ}C$                                                                                                                                      | 80              | A           |
|                     | Collector Current @ $T_C=100^{\circ}C$                                                                                                                                     | 40              | A           |
| $I_{CM}$            | Pulsed Collector Current, tp limited by $T_{Jmax}$                                                                                                                         | 160             | A           |
| $I_F$               | Diode Continuous Forward Current @ $T_C=25^{\circ}C$                                                                                                                       | 40              | A           |
|                     | Diode Continuous Forward Current @ $T_C=100^{\circ}C$                                                                                                                      | 20              | A           |
| $I_{FM}$            | Diode Maximum Forward Current, limited by $T_{Jmax}$                                                                                                                       | 80              | A           |
| $V_{GES}$           | Gate-Emitter Voltage                                                                                                                                                       | $\pm 30$        | V           |
| $t_{SC}$            | Short circuit withstand time $V_{GE}=15V$ , $V_{CC}\leq 400V$ , Allowed number of short circuits<1000, Times between short circuits: $\geq 1.0s$ , $T_J \leq 175^{\circ}C$ | 3.0             | $\mu s$     |
| $P_D$               | Power Dissipation @ $T_C=25^{\circ}C$                                                                                                                                      | 298             | W           |
| $T_{Jmax}, T_{stg}$ | Operating Junction and Storage Temperature Range                                                                                                                           | 175, -55 to 175 | $^{\circ}C$ |
| $T_L$               | Maximum Temperature for Soldering                                                                                                                                          | 260             | $^{\circ}C$ |

## Thermal characteristics

| Symbol          | Parameter                | Values | Units                       |
|-----------------|--------------------------|--------|-----------------------------|
| $R_{\theta JC}$ | Junction-to-Case (IGBT)  | 0.5    | $^{\circ}\text{C}/\text{W}$ |
| $R_{\theta JC}$ | Junction-to-Case (Diode) | 0.8    | $^{\circ}\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Junction-to-Ambient      | 40     | $^{\circ}\text{C}/\text{W}$ |

## Electrical Characteristics (at $T_c = 25^{\circ}\text{C}$ , unless otherwise specified)

| Symbol        | Parameter                            | Test Conditions                                                                                                           | Values         |                      |                  | Units         |
|---------------|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|------------------|---------------|
|               |                                      |                                                                                                                           | Min.           | Typ.                 | Max.             |               |
| $V_{CES}$     | Collector-Emitter Breakdown Voltage  | $V_{GE}=0\text{V}$ ,<br>$I_C=250\mu\text{A}$                                                                              | 600            | --                   | --               | V             |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $V_G=15\text{V}$ , $I_C=40\text{A}$<br>$T_J=25^{\circ}\text{C}$<br>$T_J=125^{\circ}\text{C}$<br>$T_J=175^{\circ}\text{C}$ | --<br>--<br>-- | 1.55<br>1.80<br>1.90 | 1.95<br>--<br>-- | V             |
| $V_{GE(TH)}$  | Gate Threshold Voltage               | $V_{CE}=V_{GE}$ , $I_C=1\text{mA}$                                                                                        | 4.8            | 5.5                  | 6.2              | V             |
| $V_F$         | Diode Forward Voltage                | $I_F=20\text{A}$<br>$T_J=25^{\circ}\text{C}$<br>$T_J=125^{\circ}\text{C}$<br>$T_J=175^{\circ}\text{C}$                    | --<br>--<br>-- | 2.20<br>1.80<br>1.52 | 2.80<br>--<br>-- | V             |
| $V_F$         | Diode Forward Voltage                | $I_F=40\text{A}$<br>$T_J=25^{\circ}\text{C}$<br>$T_J=125^{\circ}\text{C}$<br>$T_J=175^{\circ}\text{C}$                    | --<br>--<br>-- | 2.60<br>2.25<br>1.95 | 3.20<br>--<br>-- | V             |
| $I_{CES}$     | Collector-Emitter Leakage Current    | $V_{CE}=650\text{V}$ , $V_{GE}=0\text{V}$                                                                                 | --             | --                   | 4                | $\mu\text{A}$ |
| $I_{GES(F)}$  | Gate-Emitter Forward Leakage Current | $V_{GE}=+30\text{V}$                                                                                                      | --             | --                   | 200              | nA            |
| $I_{GES(R)}$  | Gate-Emitter Reverse Leakage Current | $V_{GE}=-30\text{V}$                                                                                                      | --             | --                   | -200             | nA            |

Pulse width  $t_p \leq 300\mu\text{s}$ ,  $\delta \leq 2\%$ 

## Dynamic Characteristics

| Symbol      | Parameter                                                                                                       | Test Conditions                                                                                                    | Values |      |      | Units |
|-------------|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|--------|------|------|-------|
|             |                                                                                                                 |                                                                                                                    | Min.   | Typ. | Max. |       |
| $C_{iss}$   | Input Capacitance                                                                                               | $V_{GE}=0\text{V}$<br>$V_{CE}=25\text{V}$<br>$f=1.0\text{MHz}$                                                     | --     | 2225 | --   | pF    |
| $C_{oss}$   | Output Capacitance                                                                                              |                                                                                                                    | --     | 90   | --   |       |
| $C_{rss}$   | Reverse Transfer Capacitance                                                                                    |                                                                                                                    | --     | 27   | --   |       |
| $Q_G$       | Gate charge                                                                                                     | $V_{CC}=520\text{V}$<br>$I_{CE}=20\text{A}$<br>$V_{GE}=15\text{V}$                                                 | --     | 110  | --   | nC    |
| $Q_{GE}$    | Gate-emitter charge                                                                                             |                                                                                                                    | --     | 52   | --   |       |
| $Q_{GC}$    | Gate-collector charge                                                                                           |                                                                                                                    | --     | 23   | --   |       |
| $I_{C(SC)}$ | Short circuit collector current<br>Max.1000 short circuits,<br>Times between short circuits: $\geq 1.0\text{s}$ | $V_{GE}=15.0\text{V}$ , $V_{CC} \leq 400\text{V}$ ,<br>$t_{SC} \leq 3\mu\text{s}$ , $T_J \leq 175^{\circ}\text{C}$ |        | 320  |      | A     |

### IGBT Switching Characteristics(at $T_J=25^{\circ}\text{C}$ )

| Symbol       | Parameter               | Test Conditions                                                                                                                          | Values |      |      | Units |
|--------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------|------|------|-------|
|              |                         |                                                                                                                                          | Min.   | Typ. | Max. |       |
| $t_{d(on)}$  | Turn-on Delay Time      | $I_C = 40\text{A}$<br>$V_{CE} = 400\text{V}$<br>$V_{GE} = 15\text{V}$<br>$R_G = 5\Omega$<br>$T_J = 25^{\circ}\text{C}$<br>Inductive Load | --     | 19   | --   | ns    |
| $t_r$        | Rise Time               |                                                                                                                                          | --     | 35   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time     |                                                                                                                                          | --     | 90   | --   |       |
| $t_f$        | Fall Time               |                                                                                                                                          | --     | 26   | --   |       |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                                                          | --     | 0.60 | --   | mJ    |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                                                          | --     | 0.38 | --   |       |
| $E_{ts}$     | Total Switching Loss    |                                                                                                                                          | --     | 0.98 | --   |       |

### IGBT Switching Characteristics(at $T_J=175^{\circ}\text{C}$ )

| Symbol       | Parameter               | Test Conditions                                                                                                                           | Values |      |      | Units |
|--------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------|------|------|-------|
|              |                         |                                                                                                                                           | Min.   | Typ. | Max. |       |
| $t_{d(on)}$  | Turn-on Delay Time      | $I_C = 40\text{A}$<br>$V_{CE} = 400\text{V}$<br>$V_{GE} = 15\text{V}$<br>$R_G = 5\Omega$<br>$T_J = 175^{\circ}\text{C}$<br>Inductive Load | --     | 17   | --   | ns    |
| $t_r$        | Rise Time               |                                                                                                                                           | --     | 32   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time     |                                                                                                                                           | --     | 142  | --   |       |
| $t_f$        | Fall Time               |                                                                                                                                           | --     | 36   | --   |       |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                                                           | --     | 0.8  | --   | mJ    |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                                                           | --     | 0.65 | --   |       |
| $E_{ts}$     | Total Switching Loss    |                                                                                                                                           | --     | 1.45 | --   |       |

### Diode Characteristics(at $T_J=25^{\circ}\text{C}$ )

| Symbol    | Parameter                | Test Conditions                                                                           | Values |      |      | Units |
|-----------|--------------------------|-------------------------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                                           | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 20\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 25^{\circ}\text{C}$ | --     | 97   | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                           | --     | 109  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                           | --     | 1.8  | --   | A     |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 40\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 25^{\circ}\text{C}$ | --     | 127  | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                           | --     | 326  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                           | --     | 4.8  | --   | A     |

## Diode Characteristics(at $T_J=175^{\circ}\text{C}$ )

| Symbol    | Parameter                | Test Conditions                                                                      | Values |      |      | Units |
|-----------|--------------------------|--------------------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                                      | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F=20\text{A}$ ,<br>$di/dt=200\text{A}/\mu\text{s}$ ,<br>$T_J=175^{\circ}\text{C}$ | --     | 147  | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                      | --     | 742  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                      | --     | 7.8  | --   | A     |
| $T_{rr}$  | Reverse Recovery Time    | $I_F=40\text{A}$ ,<br>$di/dt=200\text{A}/\mu\text{s}$ ,<br>$T_J=175^{\circ}\text{C}$ | --     | 158  | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                      | --     | 870  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                      | --     | 9    | --   | A     |

## Characteristics Curves

Figure 1. Forward Bias Safe Operating Area for TO247

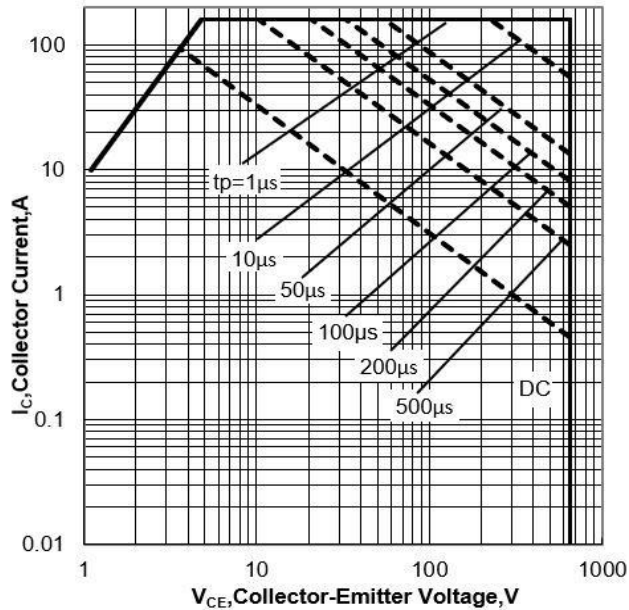


Figure 2. Power Dissipation vs Case Temperature for TO247

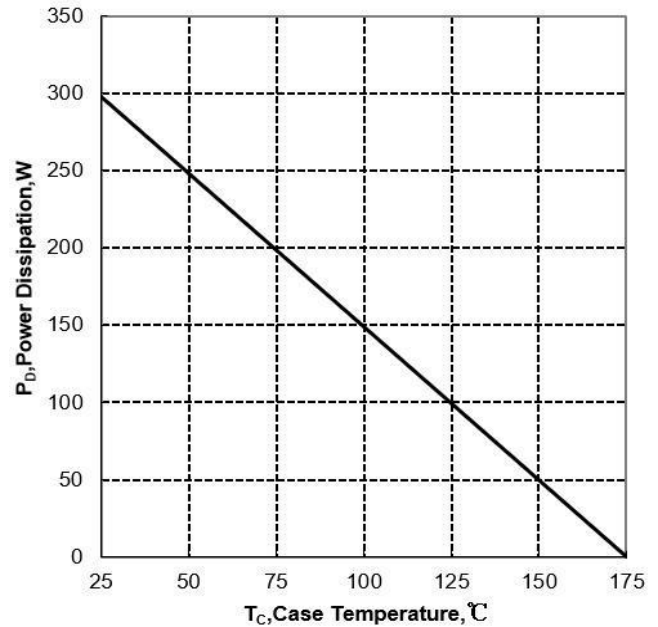


Figure 3. Collector Current vs Case Temperature

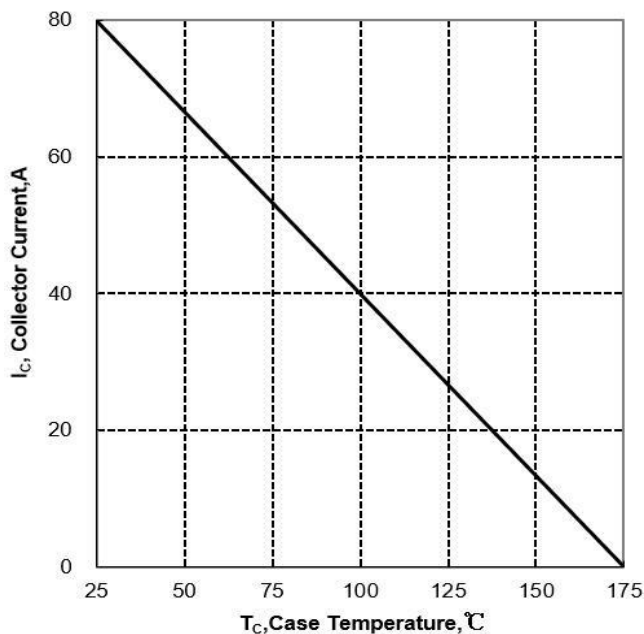


Figure 4. Typical Transfer Characteristics

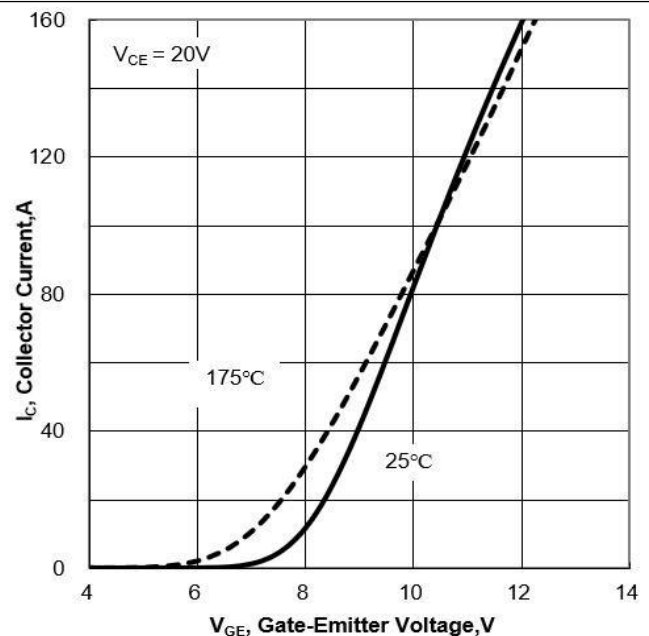


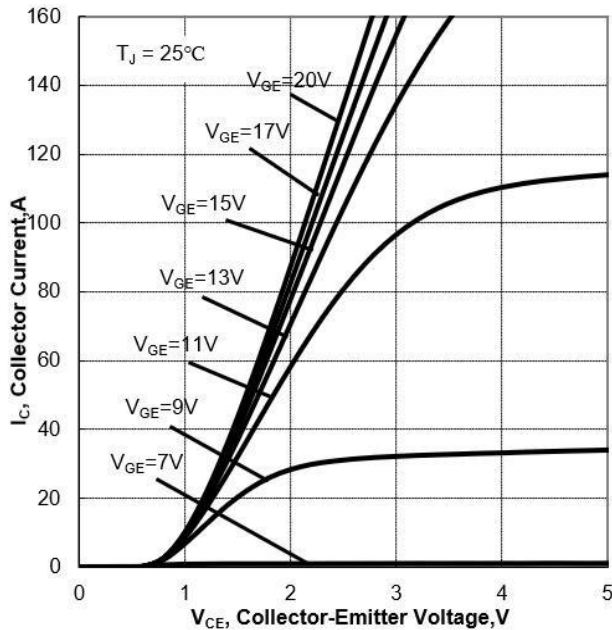
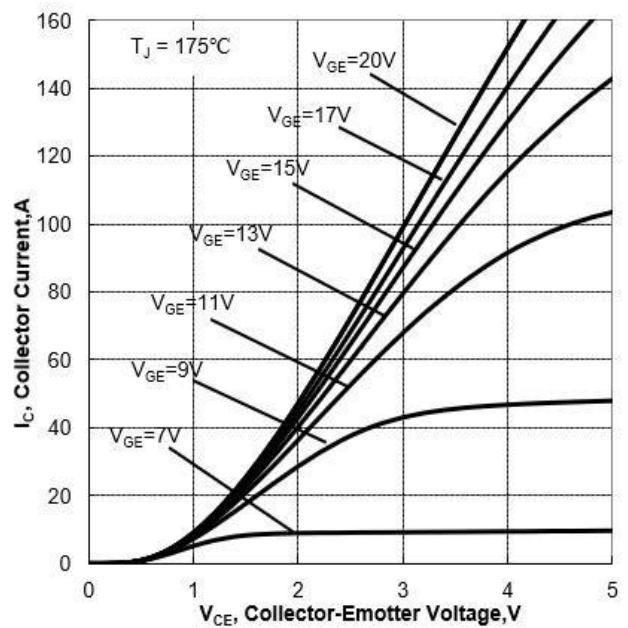
Figure 5. Typical Output Characteristics ( $T_J=25^{\circ}\text{C}$ )

Figure 6. Typical Output Characteristics ( $T_J=175^{\circ}\text{C}$ )


Figure 7. Typical Collector-Emitter Saturation Voltage vs Junction Temperature

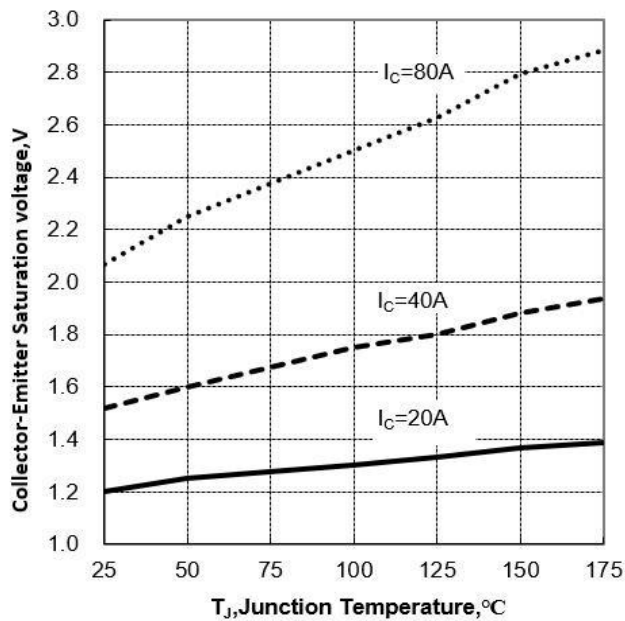


Figure 8. Typical Gate-Emitter Threshold Voltage vs Junction Temperature

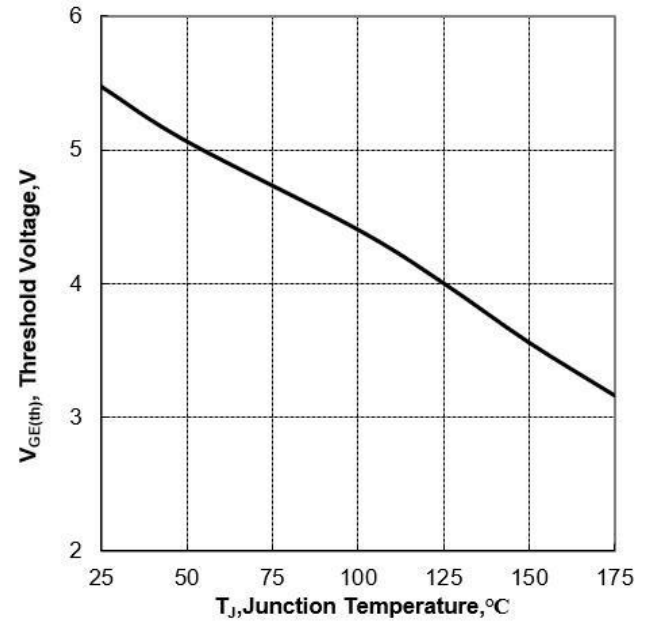


Figure 9. Typical Switching Times vs Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )

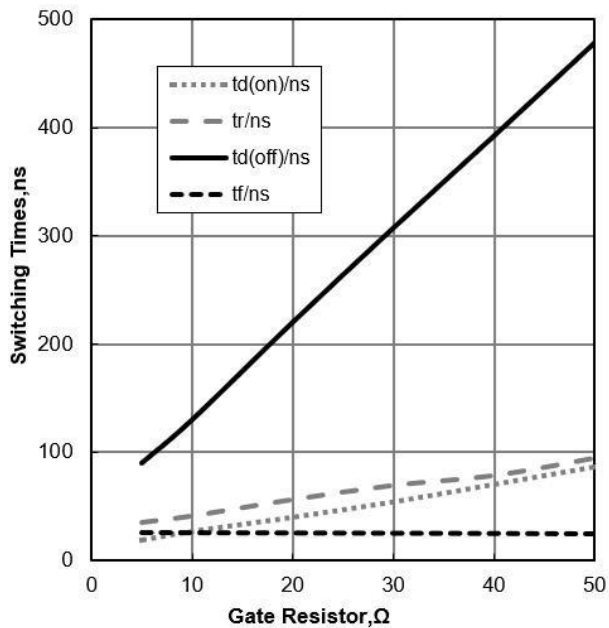


Figure 10. Typical Switching Energy vs Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )

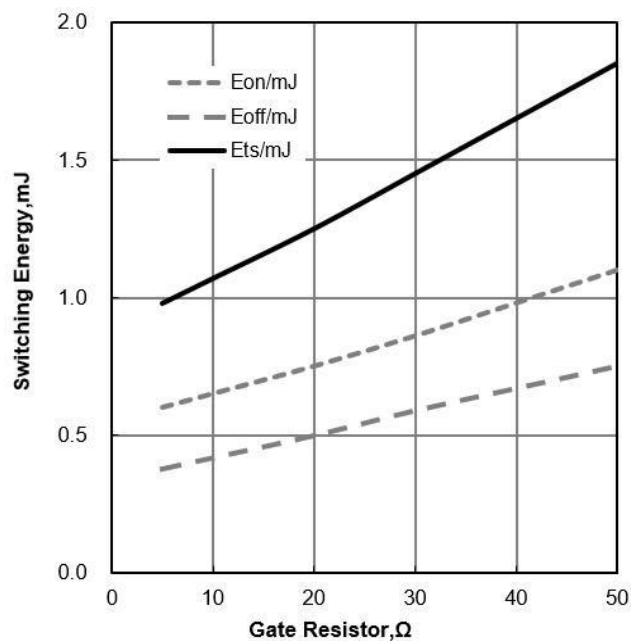


Figure 11. Typical Switching Times vs Junction Temperature ( $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )

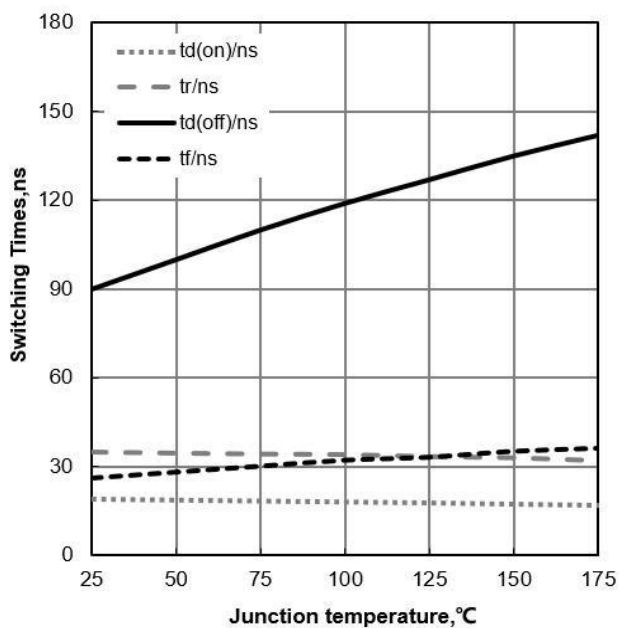
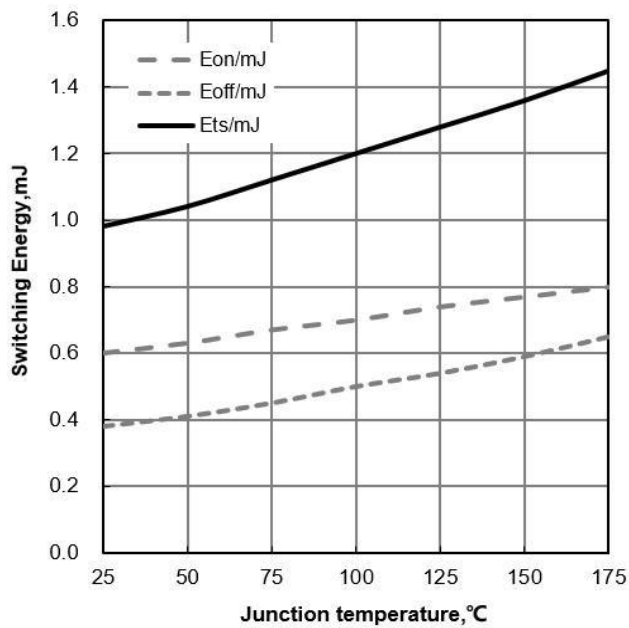
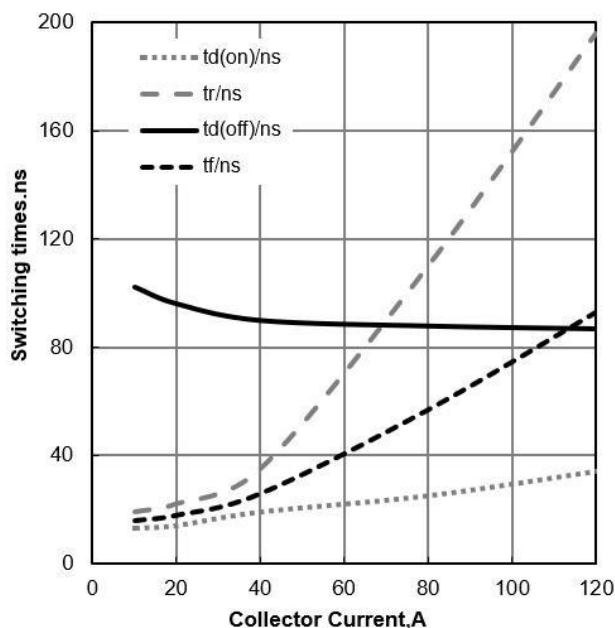


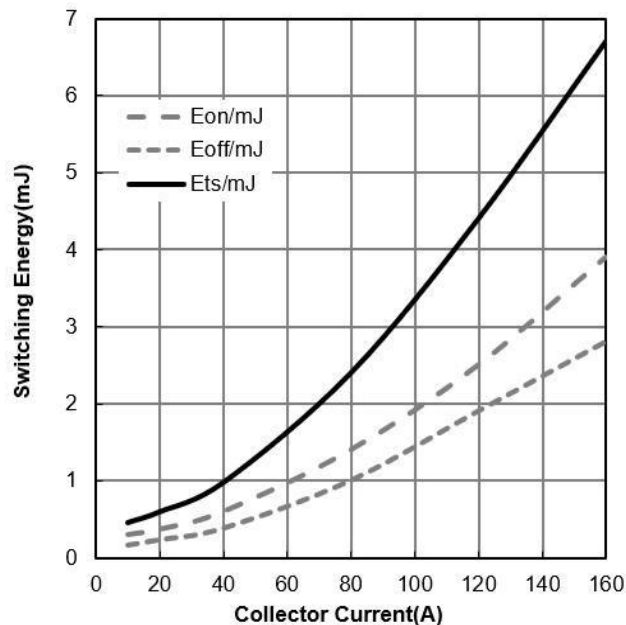
Figure 12. Typical Switching Energy vs Junction Temperature ( $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )



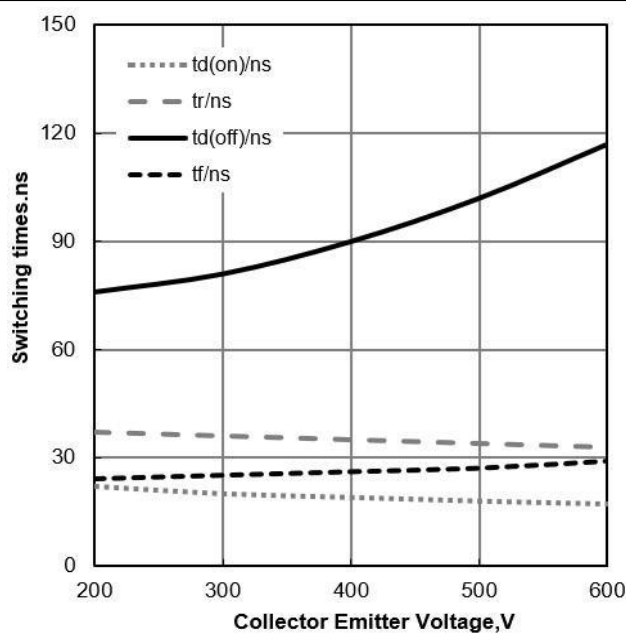
**Figure 13. Typical Switching Times vs Collector Current**  
( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ )



**Figure 14. Typical Switching Energy vs Collector Current**  
( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ )



**Figure 15. Typical Switching Times vs VCE**  
( $T_J=25^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )



**Figure 16. Typical Switching Energy vs VCE**  
( $T_J=25^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=40\text{A}$ )

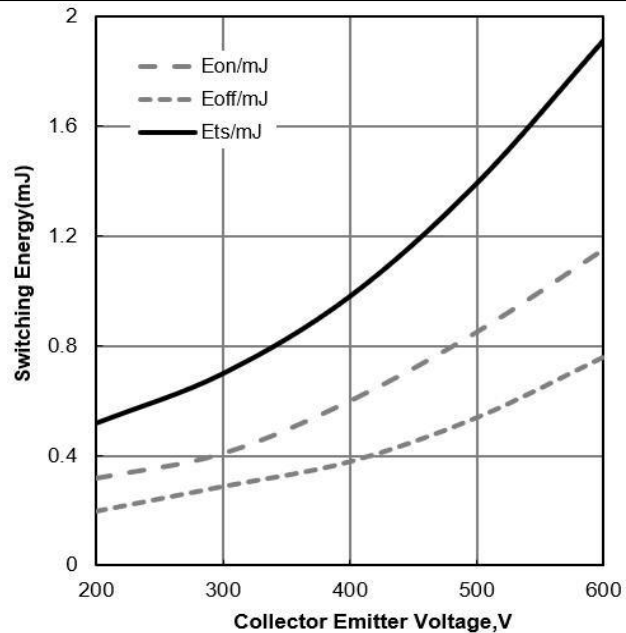


Figure 17. Typical Gate Charge

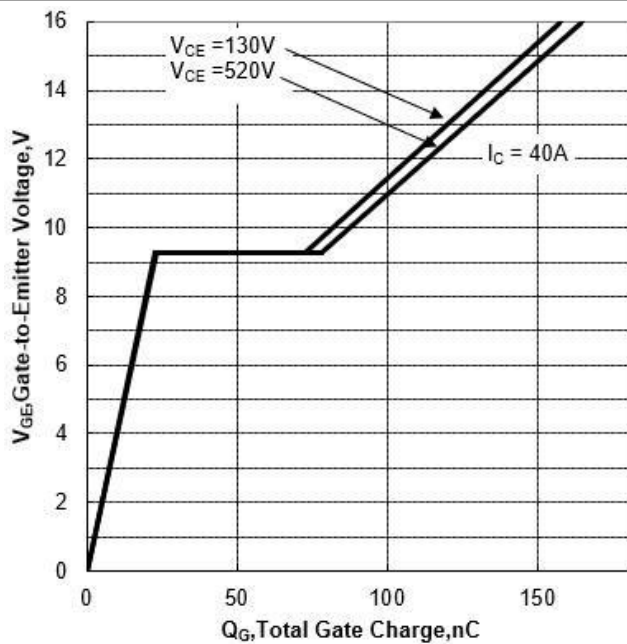


Figure 18. Typical Capacitance vs Collector-Emitter Voltage

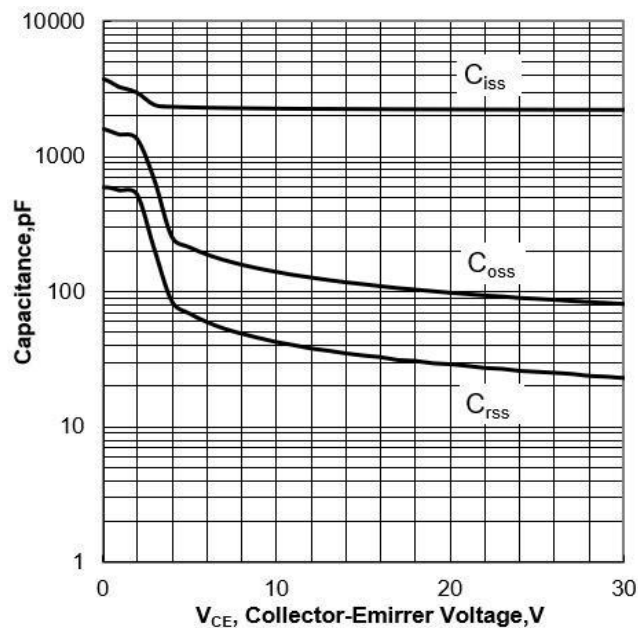


Figure 19. IGBT Transient Thermal Impedance vs Pulse Width(TO247)

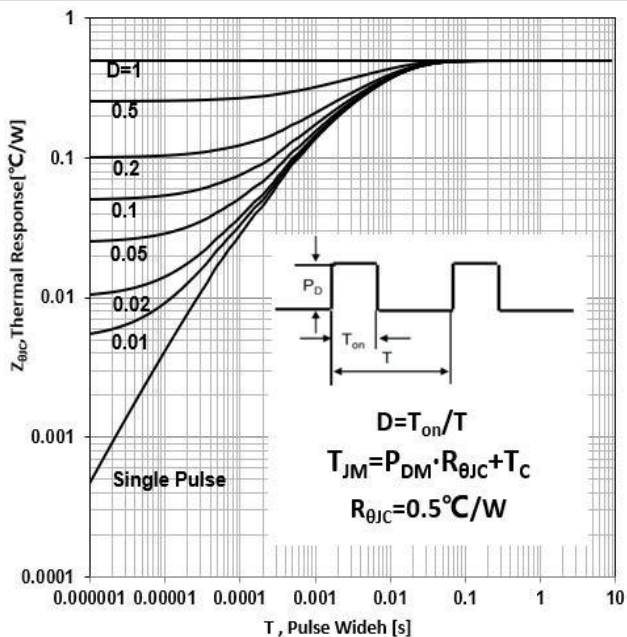
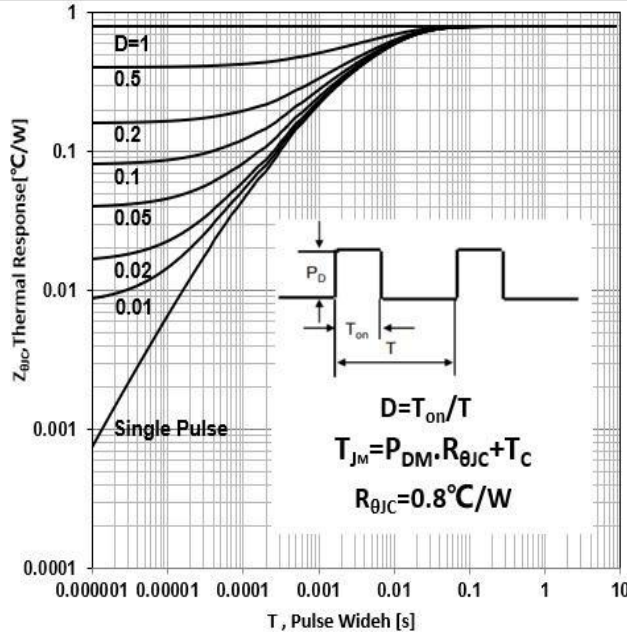
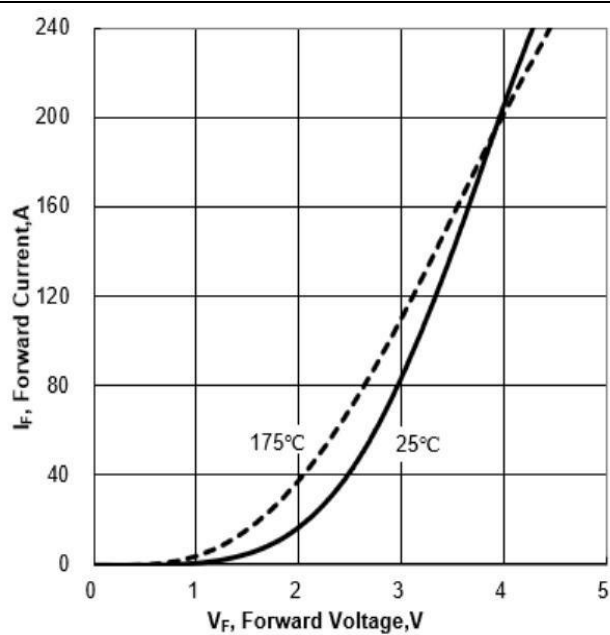


Figure 20. Diode Transient Thermal Impedance vs Pulse Width(TO247)



**Figure 21. Typical Diode Forward Current vs Forward Voltage**



## Test Circuit and Waveform

Figure 22. Inductive Switching Test Circuit

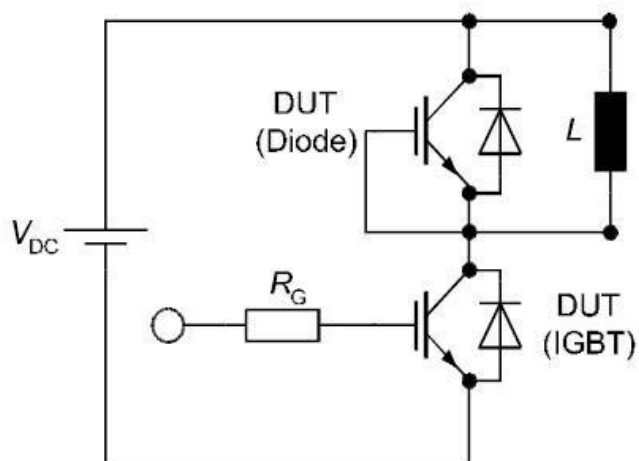


Figure 23. Definition of switching times

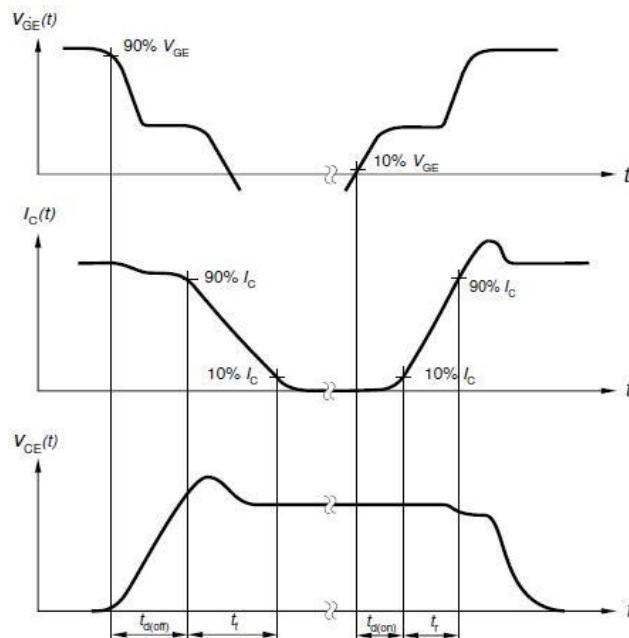


Figure 24. Definition of switching losses

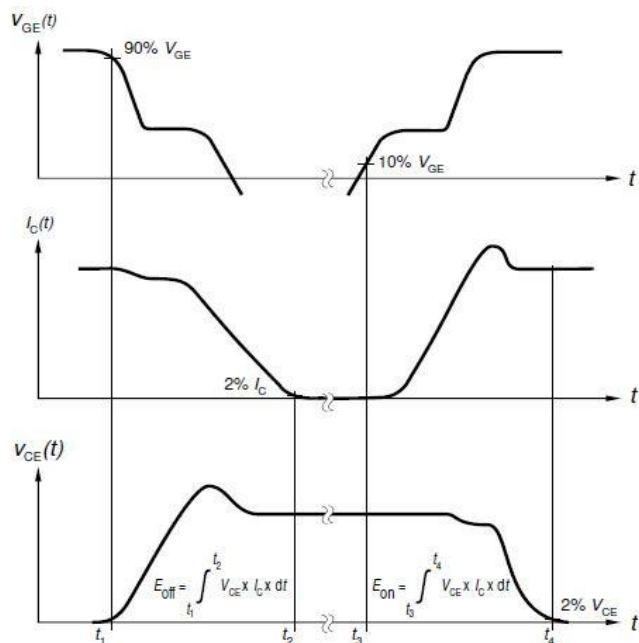
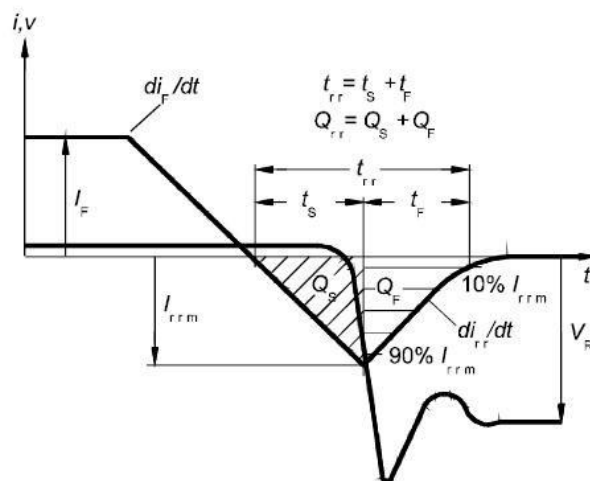
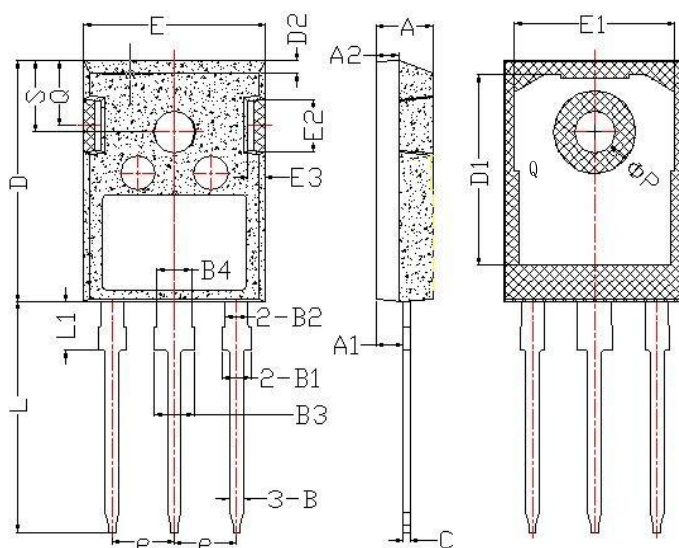


Figure 25. Definition of diode switching characteristics



## Package Description



| Items | Values (mm) |       |
|-------|-------------|-------|
|       | MIN         | MAX   |
| A     | 4.90        | 5.16  |
| A1    | 2.27        | 2.53  |
| A2    | 1.85        | 2.11  |
| B     | 1.07        | 1.33  |
| B1    | 1.90        | 2.41  |
| B2    | 1.75        | 2.15  |
| B3    | 2.87        | 3.38  |
| B4    | 2.87        | 3.13  |
| C     | 0.55        | 0.68  |
| D     | 20.82       | 21.10 |
| D1    | 16.25       | 17.65 |
| D2    | 1.05        | 1.35  |
| E     | 15.70       | 16.03 |
| E1    | 13.10       | 14.15 |
| E2    | 3.68        | 5.10  |
| E3    | 1.68        | 2.60  |
| e     | 5.44        |       |
| L     | 19.80       | 20.31 |
| L1    | 4.17        | 4.47  |
| ΦP    | 3.50        | 3.70  |
| Q     | 5.49        | 6.00  |
| S     | 6.04        | 6.30  |

TO-247 Package



迈诺斯科技

**FGH40N60SMD**

**NOTE:**

1. Exceeding the maximum ratings of the device in performance may cause damage to the device, even the permanent failure, which may affect the dependability of the machine. Please do not exceed the absolute maximum ratings of the device when circuit designing.
2. When installing the heat sink, please pay attention to the torsional moment and the smoothness of the heat sink.
3. MOSFETs is the device which is sensitive to the static electricity, it is necessary to protect the device from being damaged by the static electricity when using it.
4. Shenzhen Minos reserves the right to make changes in this specification sheet and is subject to change without prior notice.

**CONTACT:**

**深圳市迈诺斯科技有限公司（总部）**

地址：深圳市福田区华富街道田面社区深南中路4026号田面城市大厦22B-22C

邮编：518025

电话：0755-83273777