

### 1. Description

SPS60N65 is obtained by advanced Trench Field Stop (T-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 Photovoltaic, UPS, Boost and high switching frequency applications.

#### KEY CHARACTERISTICS

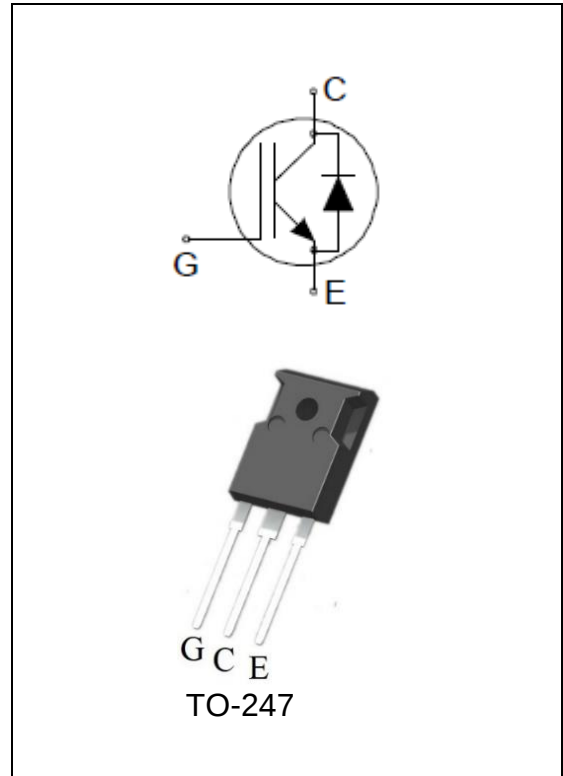
| Parameter         | Value | Unit |
|-------------------|-------|------|
| $V_{CES}$         | 650   | V    |
| $I_C$             | 75    | A    |
| $V_{CE(sat).typ}$ | 1.7   | V    |

#### FEATURES

- Fast Switching
- Low  $V_{CE(sat)}$
- Positive temperature coefficient
- Fast recovery anti-parallel diode
- RoHS product

#### APPLICATIONS

- Photovoltaic converters
- UPS
- Boost



## 2. ABSOLUTE RATINGS

| Symbol              | Parameter                                                                                                                                                                                                | Values            | Units              |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|
| $V_{CES}$           | Collector-Emitter Voltage                                                                                                                                                                                | 650               | V                  |
| $I_C$               | Collector Current @ $T_C=25^{\circ}\text{C}$                                                                                                                                                             | 150               | A                  |
|                     | Collector Current @ $T_C=100^{\circ}\text{C}$                                                                                                                                                            | 75                | A                  |
| $I_{CM}$            | Pulsed Collector Current, tp limited by $T_{Jmax}$                                                                                                                                                       | 300               | A                  |
| $I_F$               | Diode Continuous Forward Current @ $T_C=25^{\circ}\text{C}$                                                                                                                                              | 150               | A                  |
|                     | Diode Continuous Forward Current @ $T_C=100^{\circ}\text{C}$                                                                                                                                             | 75                | A                  |
| $I_{FM}$            | Diode Maximum Forward Current, limited by $T_{Jmax}$                                                                                                                                                     | 300               | A                  |
| $V_{GES}$           | Gate-Emitter Voltage                                                                                                                                                                                     | $\pm 30$          | V                  |
| $t_{SC}$            | Short circuit withstand time $V_{GE}=15\text{V}$ , $V_{CC}\leq 400\text{V}$ , Allowed number of short circuits < 1000, Times between short circuits: $\geq 1.0\text{s}$ , $T_J \leq 175^{\circ}\text{C}$ | 8.0               | $\mu\text{s}$      |
| $P_D$               | Power Dissipation @ $T_C=25^{\circ}\text{C}$                                                                                                                                                             | 468               | W                  |
| $T_{Jmax}, T_{stg}$ | Operating Junction and Storage Temperature Range                                                                                                                                                         | 175, $-55$ to 175 | $^{\circ}\text{C}$ |
| $T_L$               | Maximum Temperature for Soldering                                                                                                                                                                        | 260               | $^{\circ}\text{C}$ |

## 3. Thermal characteristics

| Symbol          | Parameter                | Values | Units                |
|-----------------|--------------------------|--------|----------------------|
| $R_{\theta JC}$ | Junction-to-Case (IGBT)  | 0.32   | $^{\circ}\text{C/W}$ |
| $R_{\theta JC}$ | Junction-to-Case (Diode) | 0.65   | $^{\circ}\text{C/W}$ |
| $R_{\theta JA}$ | Junction-to-Ambient      | 40     | $^{\circ}\text{C/W}$ |

## 4. Electrical Characteristics

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

### Static Characteristics

| Symbol        | Parameter                            | Test Conditions                                                     | Values |      |      | Units |
|---------------|--------------------------------------|---------------------------------------------------------------------|--------|------|------|-------|
|               |                                      |                                                                     | Min.   | Typ. | Max. |       |
| $V_{CES}$     | Collector-Emitter Breakdown Voltage  | $V_{GE} = 0\text{V}$ ,<br>$I_C = 250\mu\text{A}$                    | 650    | --   | --   | V     |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $V_{GE} = 15\text{V}, I_C = 75\text{A}$<br>$T_J=25^{\circ}\text{C}$ | --     | 1.70 | 2.10 | V     |
|               |                                      | $T_J=125^{\circ}\text{C}$                                           | --     | 2.10 | --   |       |
|               |                                      | $T_J=175^{\circ}\text{C}$                                           | --     | 2.20 | --   |       |

|                                                  |                                      |                                                                            |                |                      |                  |         |
|--------------------------------------------------|--------------------------------------|----------------------------------------------------------------------------|----------------|----------------------|------------------|---------|
| $V_{GE(TH)}$                                     | Gate Threshold Voltage               | $V_{CE} = V_{GE}, I_C = 1mA$                                               | 4.8            | 5.5                  | 6.2              | V       |
| $V_F$                                            | Diode Forward Voltage                | $I_F=40A$<br>$T_J=25^{\circ}C$<br>$T_J=125^{\circ}C$<br>$T_J=175^{\circ}C$ | --<br>--<br>-- | 1.90<br>1.50<br>1.30 | 2.50<br>--<br>-- | V       |
| $V_F$                                            | Diode Forward Voltage                | $I_F=75A$<br>$T_J=25^{\circ}C$<br>$T_J=125^{\circ}C$<br>$T_J=175^{\circ}C$ | --<br>--<br>-- | 2.25<br>1.90<br>1.75 | 2.85<br>--<br>-- | V       |
| $I_{CES}$                                        | Collector-Emitter Leakage Current    | $V_{CE} = 650V,$<br>$V_{GE} = 0V$                                          | --             | --                   | 4                | $\mu A$ |
| $I_{GES(F)}$                                     | Gate-Emitter Forward Leakage Current | $V_{GE} = +30V$                                                            | --             | --                   | 200              | nA      |
| $I_{GES(R)}$                                     | Gate-Emitter Reverse Leakage Current | $V_{GE} = -30V$                                                            | --             | --                   | -200             | nA      |
| Pulse width $t_p \leq 300\mu s, \delta \leq 2\%$ |                                      |                                                                            |                |                      |                  |         |

### Dynamic Characteristics

| Symbol      | Parameter                                                                                                   | Test Conditions                                                                  | Values |      |      | Units |
|-------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------|------|------|-------|
|             |                                                                                                             |                                                                                  | Min.   | Typ. | Max. |       |
| $C_{iss}$   | Input Capacitance                                                                                           | $V_{GE}=0V$<br>$V_{CE}=25V$<br>$f=1.0MHz$                                        | --     | 3930 | --   | pF    |
| $C_{oss}$   | Output Capacitance                                                                                          |                                                                                  | --     | 200  | --   |       |
| $C_{rss}$   | Reverse Transfer Capacitance                                                                                |                                                                                  | --     | 36   | --   |       |
| $Q_G$       | Gate charge                                                                                                 | $V_{CC}=520V$<br>$I_{CE}=75A$<br>$V_{GE}=15V$                                    | --     | 145  | --   | nC    |
| $Q_{GE}$    | Gate-emitter charge                                                                                         |                                                                                  | --     | 55   | --   |       |
| $Q_{GC}$    | Gate-collector charge                                                                                       |                                                                                  | --     | 38   | --   |       |
| $I_{C(SC)}$ | Short circuit collector current<br>Max.1000 short circuits,<br>Times between short circuits:<br>$\geq 1.0s$ | $V_{GE}=15.0V, V_{CC} \leq 400V,$<br>$t_{SC} \leq 8\mu s, T_J \leq 175^{\circ}C$ |        | 375  |      | A     |

### IGBT Switching Characteristics, at $T_J=25^{\circ}C$

| Symbol       | Parameter              | Test Conditions                                                                                            | Values |      |      | Units |
|--------------|------------------------|------------------------------------------------------------------------------------------------------------|--------|------|------|-------|
|              |                        |                                                                                                            | Min.   | Typ. | Max. |       |
| $t_{d(on)}$  | Turn-on Delay Time     | $I_C = 75A$<br>$V_{CE} = 400V$<br>$V_{GE} = 15V$<br>$R_G = 5\Omega$<br>$T_J=25^{\circ}C$<br>Inductive Load | --     | 32   | --   | ns    |
| $t_r$        | Rise Time              |                                                                                                            | --     | 74   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time    |                                                                                                            | --     | 114  | --   |       |
| $t_f$        | Fall Time              |                                                                                                            | --     | 73   | --   |       |
| $E_{on}$     | Turn-On Switching Loss |                                                                                                            | --     | 1.14 | --   | mJ    |

|           |                         |  |    |      |    |  |
|-----------|-------------------------|--|----|------|----|--|
| $E_{off}$ | Turn-Off Switching Loss |  | -- | 1.53 | -- |  |
| $E_{ts}$  | Total Switching Loss    |  | -- | 2.67 | -- |  |

### 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      | $I_C = 75\text{A}$<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 | --     | 32   | --   | ns    |
| $t_r$        | Rise Time               |                                                                                                                                           | --     | 75   | --   |       |
| $t_{d(off)}$ | Turn-Off Delay Time     |                                                                                                                                           | --     | 161  | --   |       |
| $t_f$        | Fall Time               |                                                                                                                                           | --     | 141  | --   |       |
| $E_{on}$     | Turn-On Switching Loss  |                                                                                                                                           | --     | 1.40 | --   | mJ    |
| $E_{off}$    | Turn-Off Switching Loss |                                                                                                                                           | --     | 1.85 | --   |       |
| $E_{ts}$     | Total Switching Loss    |                                                                                                                                           | --     | 3.25 | --   |       |

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

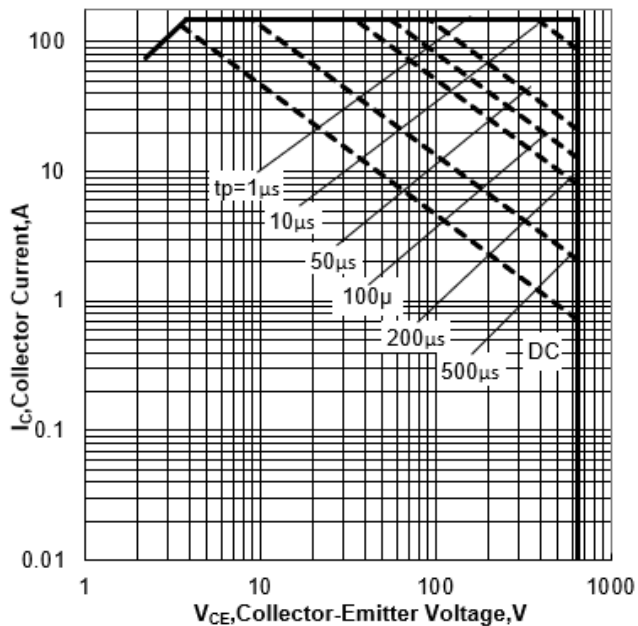
| Symbol    | Parameter                | Test Conditions                                                                           | Values |      |      | Units |
|-----------|--------------------------|-------------------------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                                           | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 40\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 25^{\circ}\text{C}$ | --     | 39   | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                           | --     | 126  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                           | --     | 3.5  | --   | A     |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 75\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 25^{\circ}\text{C}$ | --     | 46   | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                           | --     | 146  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                           | --     | 5.3  | --   | A     |

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

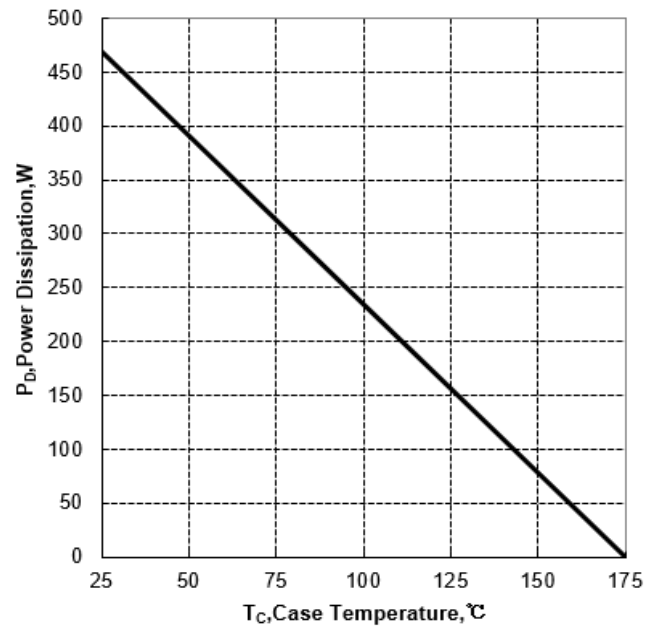
| Symbol    | Parameter                | Test Conditions                                                                            | Values |      |      | Units |
|-----------|--------------------------|--------------------------------------------------------------------------------------------|--------|------|------|-------|
|           |                          |                                                                                            | Min.   | Typ. | Max. |       |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 40\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 175^{\circ}\text{C}$ | --     | 216  | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                            | --     | 175  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                            | --     | 4.5  | --   | A     |
| $T_{rr}$  | Reverse Recovery Time    | $I_F = 75\text{A}$ ,<br>$di/dt = 200\text{A}/\mu\text{s}$ ,<br>$T_J = 175^{\circ}\text{C}$ | --     | 243  | --   | ns    |
| $Q_{rr}$  | Reverse Recovery Charge  |                                                                                            | --     | 210  | --   | nC    |
| $I_{rrm}$ | Reverse Recovery Current |                                                                                            | --     | 4.8  | --   | A     |

## 5. Characteristics Curves

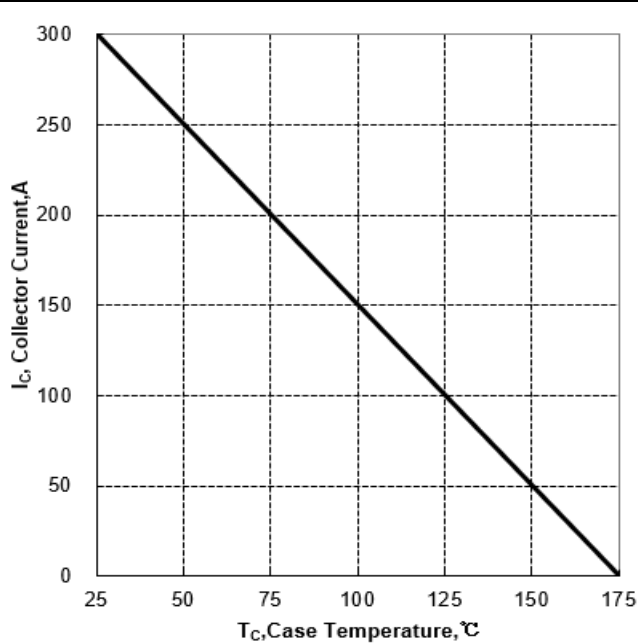
**Figure 1. Forward Bias Safe Operating Area for TO3PN/TO247**



**Figure 2. Power Dissipation vs Case Temperature for TO3PN/TO247**



**Figure 3. Collector Current vs Case Temperature**



**Figure 4. Typical Transfer Characteristics**

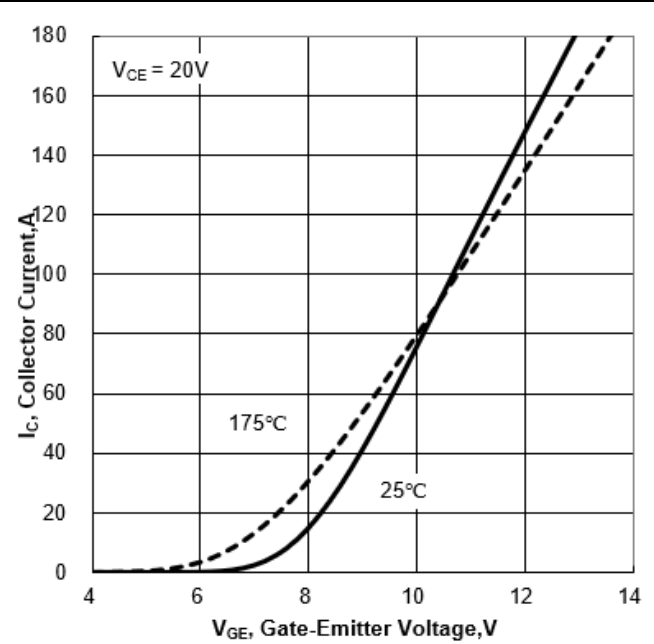


Figure 5. Typical Output Characteristics  
( $T_J=25^{\circ}\text{C}$ )

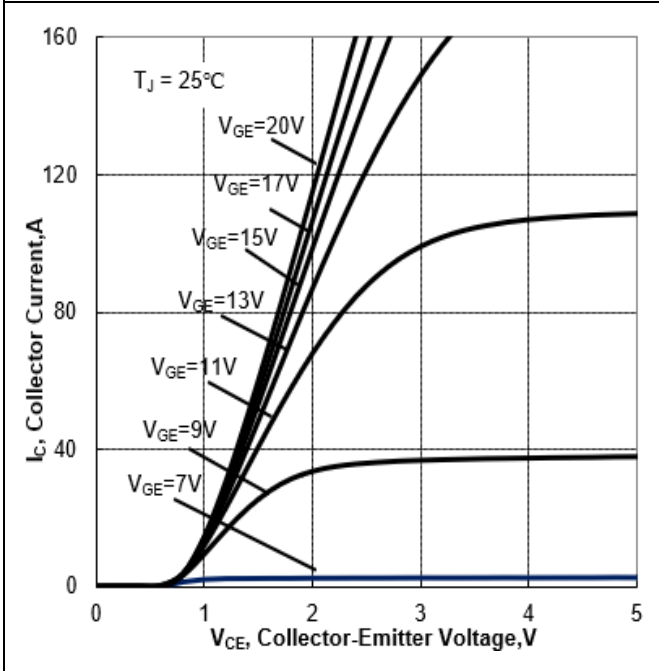


Figure 6. Typical Output Characteristics  
( $T_J=175^{\circ}\text{C}$ )

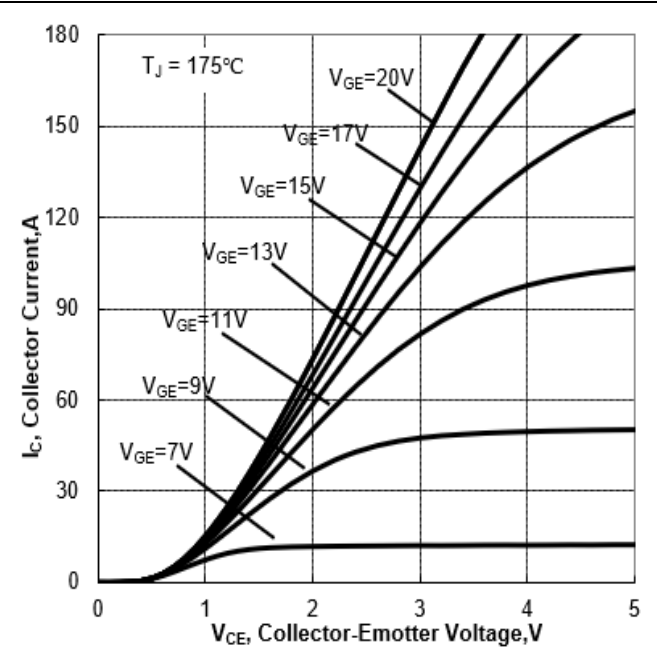


Figure 7. Typical Collector-Emitter Saturation  
Voltage vs Junction temperature

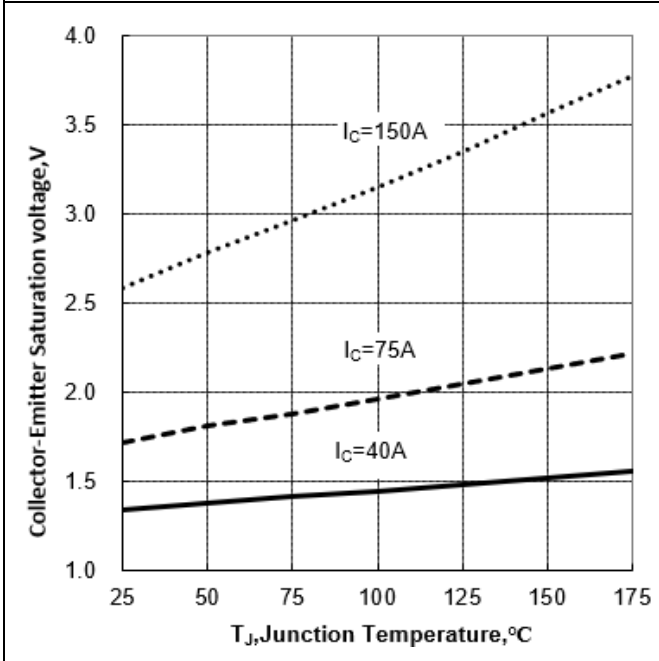
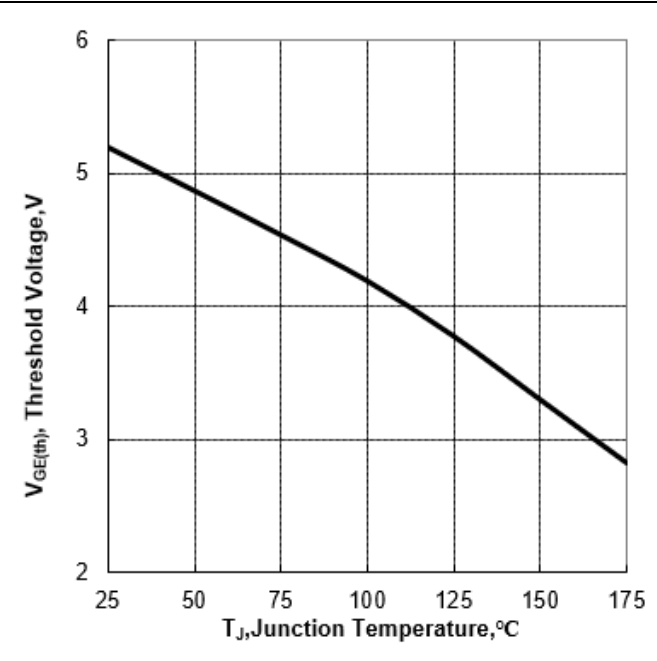
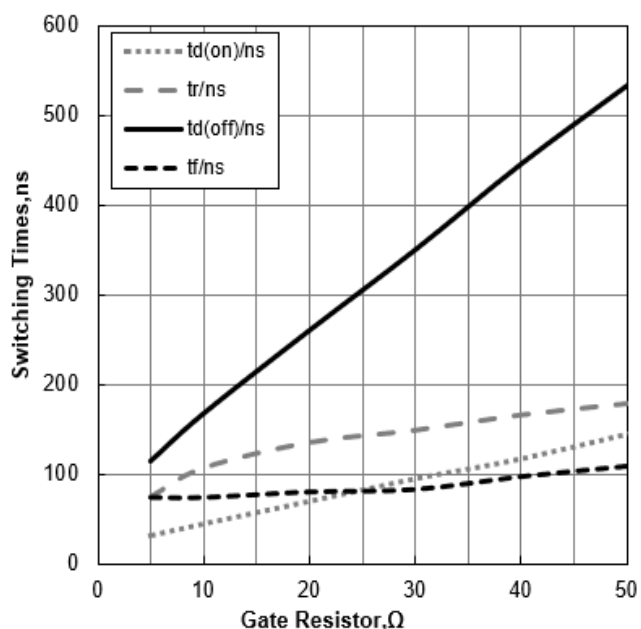


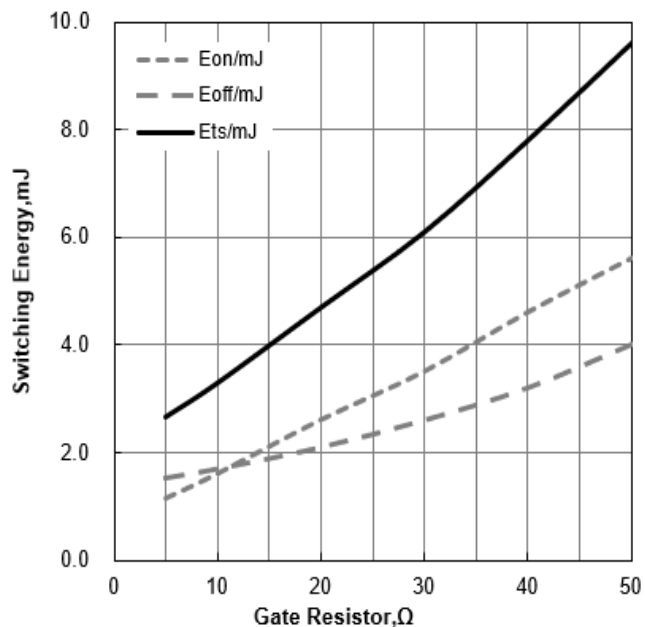
Figure 8. Threshold Voltage vs Junction  
Temperature



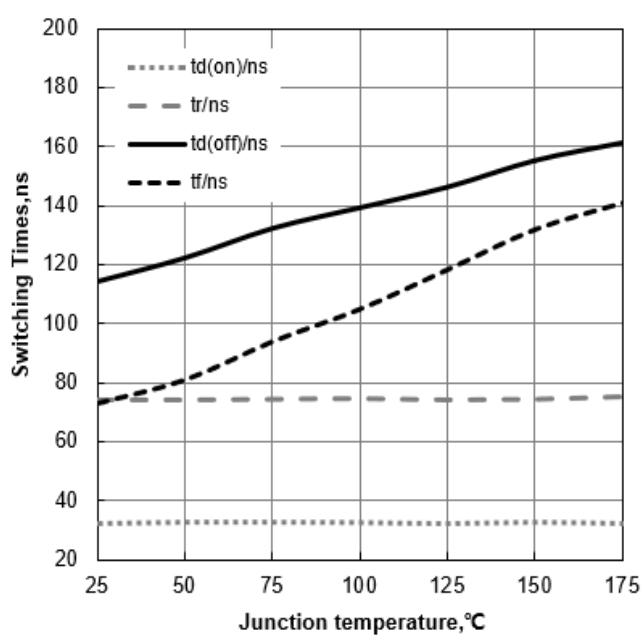
**Figure 9. Typical Switching Times vs Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**



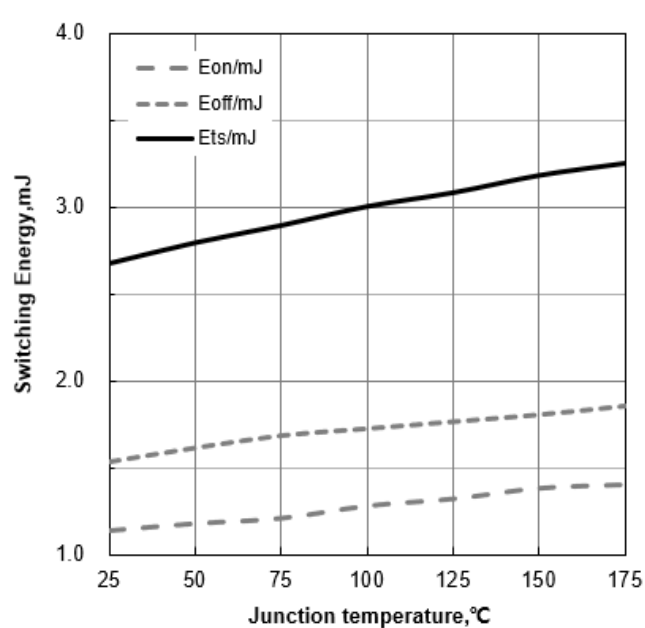
**Figure 10. Typical Switching Energy vs Gate Resistor ( $T_J=25^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**



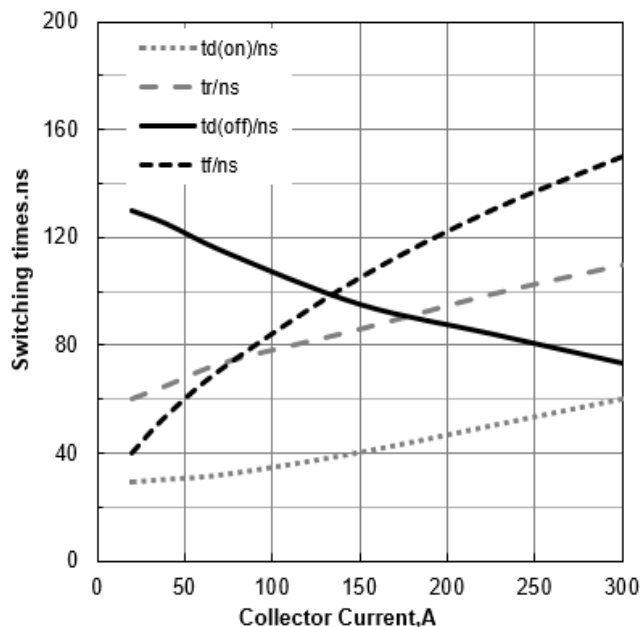
**Figure 11. Typical Switching Times vs Junction Temperature ( $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**



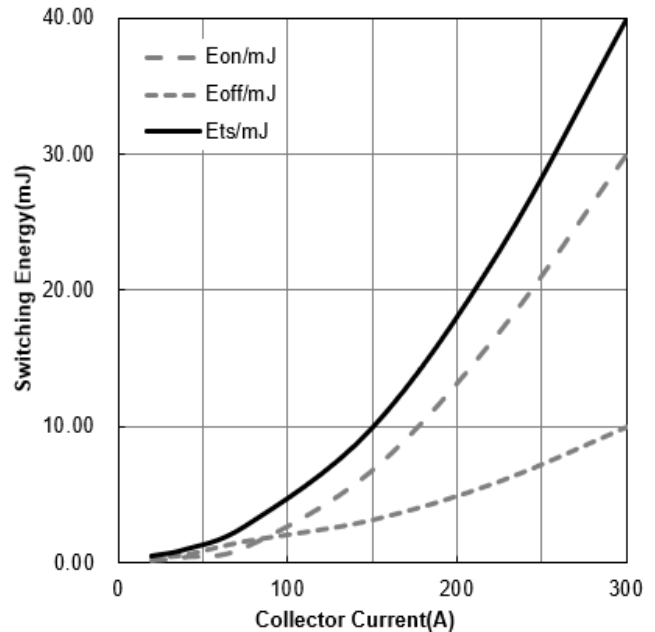
**Figure 12. Typical Switching Energy vs Junction Temperature ( $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**



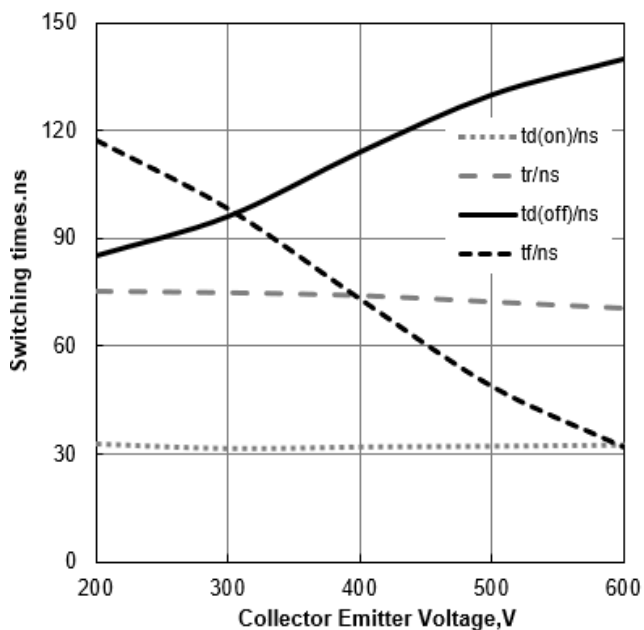
**Figure 13. Typical Switching Times vs Collector Current ( $T_J=25^\circ\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ )**



**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  $V_{CE}$  ( $T_J=25^\circ\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**



**Figure 16. Typical Switching Energy vs  $V_{CE}$  ( $T_J=25^\circ\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=75\text{A}$ )**

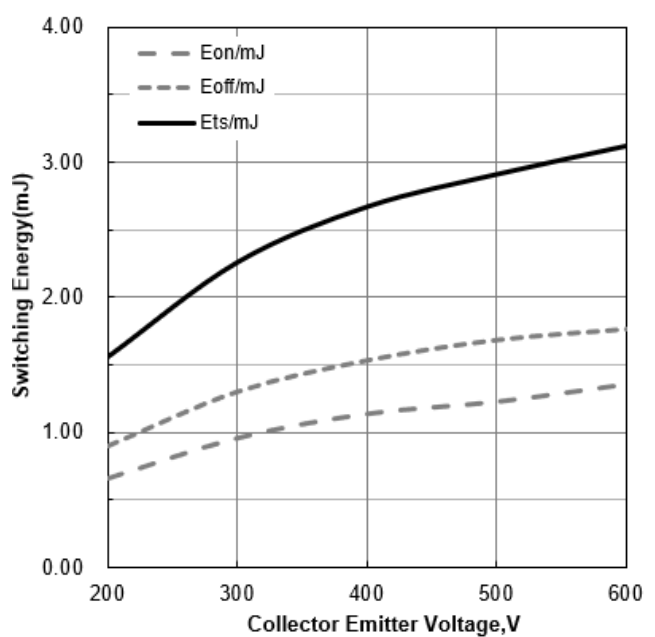


Figure 17. Typical Gate Charge

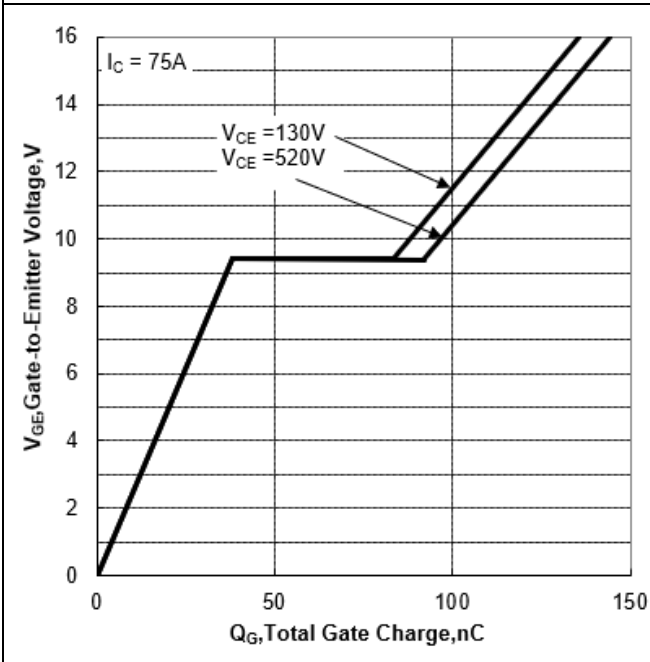


Figure 18. Typical Capacitance vs Collector-Emitter Voltage

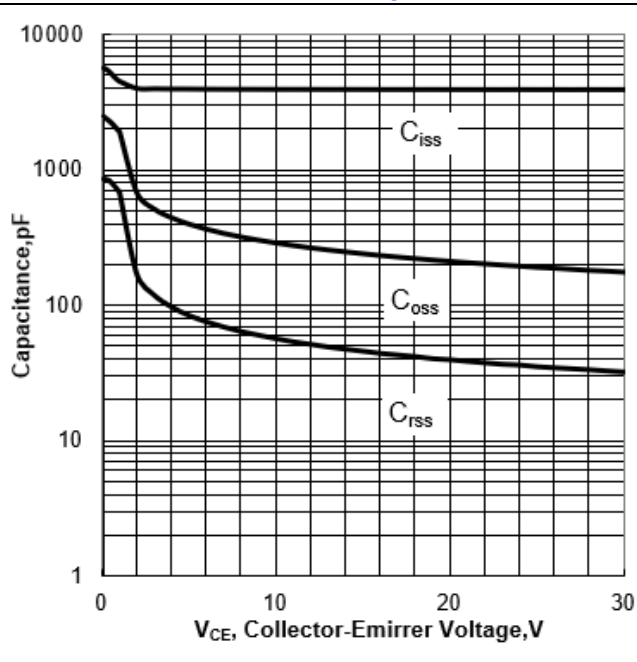


Figure 19. IGBT Transient Thermal Impedance vs Pulse Width (TO3PN/TO247)

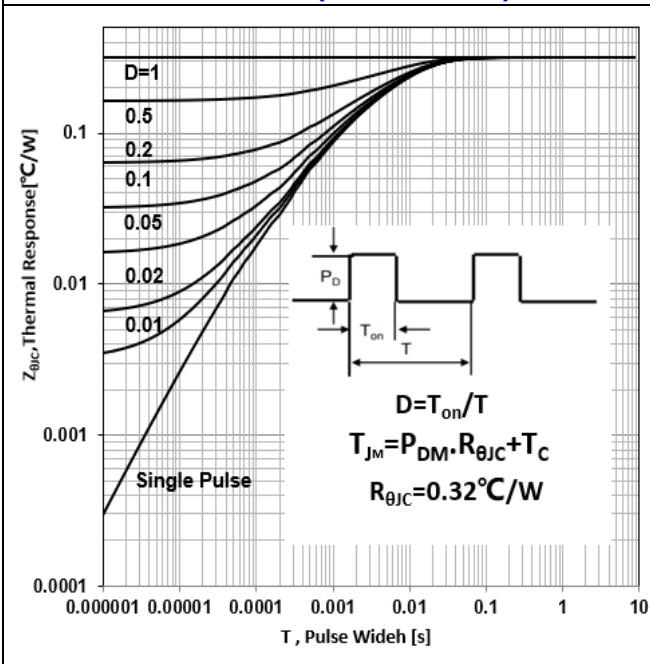


Figure 20. Diode Transient Thermal Impedance vs Pulse Width (TO3PN/TO247)

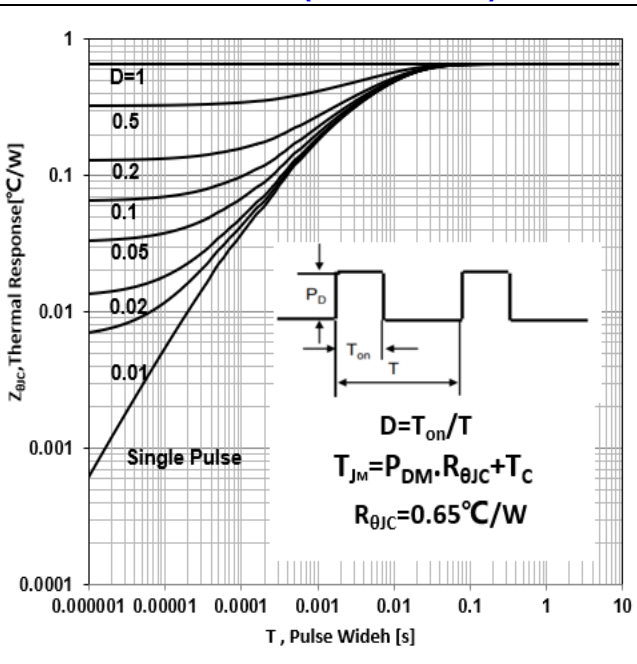
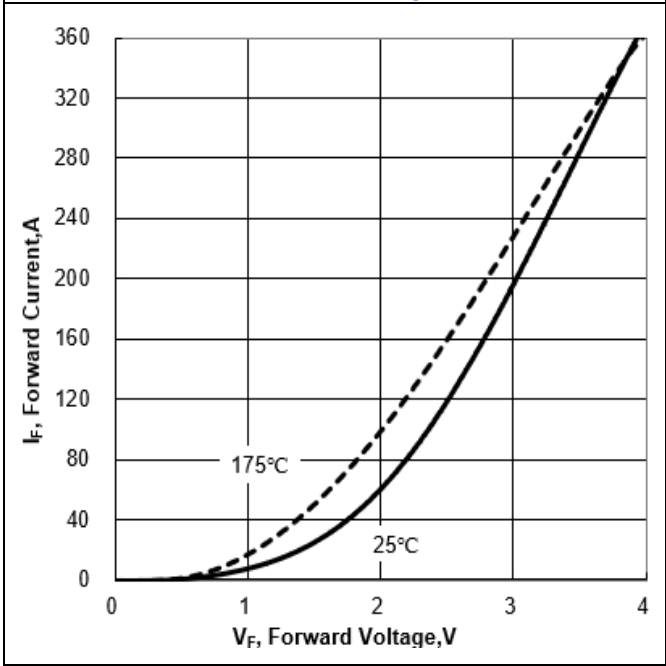


Figure 21. Typical Diode Forward Current vs Forward Voltage



### 6. Test Circuit and Waveform

Figure 22. Inductive Switching Test Circuit

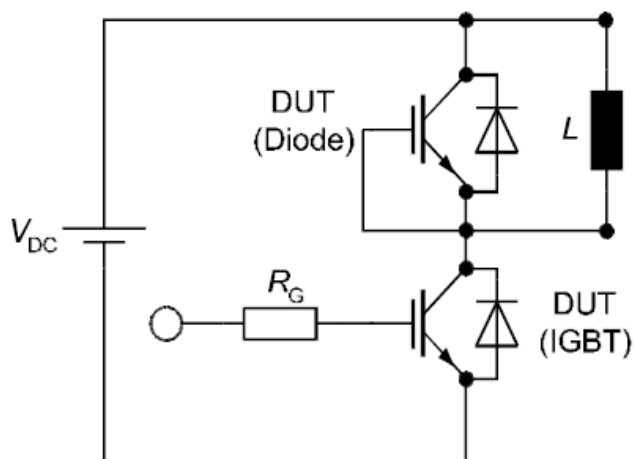


Figure 23. Definition of switching times

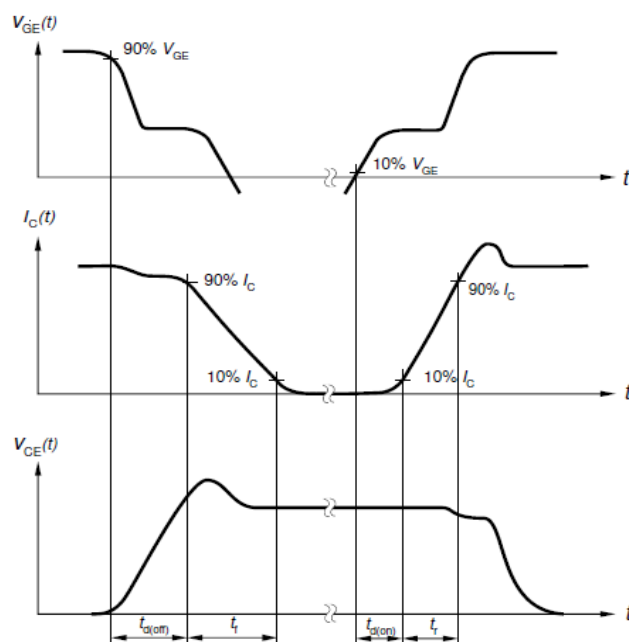


Figure 24. Definition of switching losses

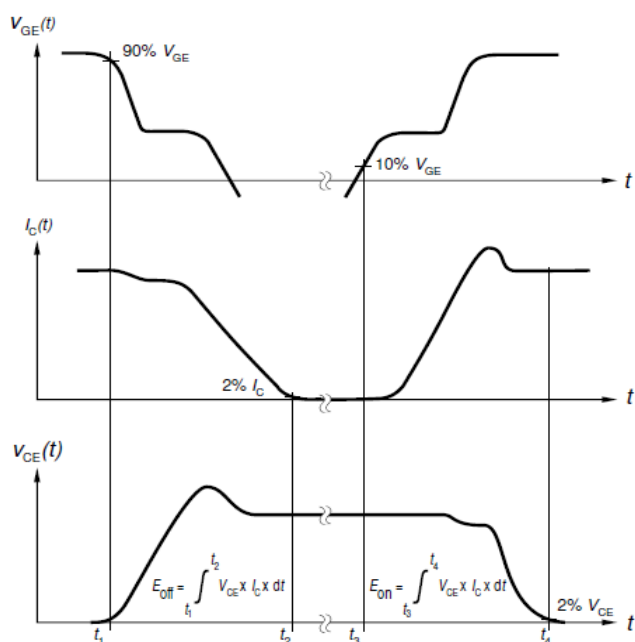
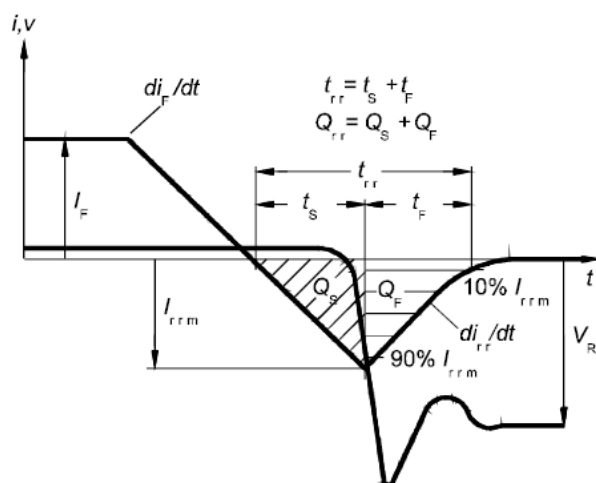
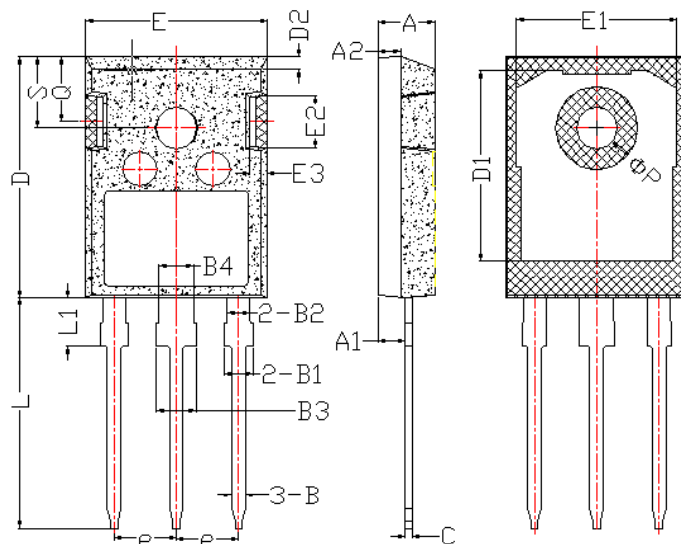


Figure 25. Definition of diode switching characteristics



## 7. Package Description



TO-247 Package

| 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  |