Apr 2024

SemiHow
Know-How for Semiconductor

# HIS20N65T-SA

## 650V N-Channel Trench Field Stop IGBT

### Features

- Very Low $V_{CE(sat)}$
- Extremely low switching loss
- Excellent stability and uniformity
- Soft Fast Reverse Recovery Diode
- Short Circuit Withstand Time 5.0$\mu s$
- Maximum Junction temperature, $T_{J(max)}$=175℃

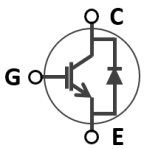
### Application

- Uninterruptible Power Supplies (UPS)
- Solar / Welding converters
- Motor drivers
- High frequency converters

### Key Parameters

| Parameter | Value | Unit |
|---|---|---|
| $V_{CES}$ | 650 | V |
| $I_C$ | 20 | A |
| $V_{CE(sat)}$ | 1.42 | V |
| $E_{tot}$ | 0.422 | mJ |

### Package & Internal Circuit

| TO-220F | SYMBOL |
|---|---|
|  |  |





### Absolute Maximum Ratings

$T_C$=25℃ unless otherwise specified

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 650 | V |
| $V_{GE}$ | Gate-Emitter Voltage | ±25 | V |
| | Transient Gate-Emitter Voltage, Tp ≤ 10us, D < 0.01 | ±30 | V |
| $I_C$ | Collector Current ( @ $T_C$ = 25 ℃ ) | 40 | A |
| | Collector Current ( @ $T_C$ = 100 ℃ ) | 20 | A |
| $I_{CM}$ | Pulsed Collector Current (Note. 1) | 60 | A |
| $I_F$ | Diode Continuous Forward Current ( @ $T_C$ = 100 ℃ ) | 20 | A |
| $I_{FM}$ | Diode Maximum Forward Current | 60 | A |
| $P_D$ | Power Dissipation ( @ $T_C$ = 25 ℃ ) | 47 | W |
| | Power Dissipation ( @ $T_C$ = 100 ℃ ) | 23 | W |
| $T_J$ | Maximum Operating Junction Temperature | 175 | ℃ |
| $T_{STG}$ | Storage Temperature Range | -55 to +175 | ℃ |

### Thermal Resistance Characteristics

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{\theta JC}$ | IGBT Thermal Resistance, Junction-to-Case, Max. | 3.3 | ℃/W |
| $R_{\theta JC}$ | Diode Thermal Resistance, Junction-to-Case, Max. | 5.0 | ℃/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient, Max. | 62.5 | ℃/W |

**Notes :** 1. Repetitive Rating, Pulse width limited by maximum junction temperature

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## Electrical Characteristics $T_J$=25°C unless otherwise specified

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Static Characteristics** | | | | | | |
| $BV_{CES}$ | Collector-Emitter Breakdown Voltage | $V_{GE}$ = 0 V, $I_C$ = 250 μA | 650 | - | - | V |
| $I_{CES}$ | Zero Gate Voltage Collector Current | $V_{CE}$ = 650 V, $V_{GE}$ = 0<br>$T_J$ = 25 ℃<br>$T_J$ = 175 ℃ | -<br>- | -<br>250 | 10<br>- | μA |
| $I_{GES}$ | Gate Leakage Current | $V_{GE}$ = ±25 V, $V_{CE}$ = 0 V | - | - | ±100 | nA |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 250 μA | 4.2 | 5.0 | 5.8 | V |
| $V_{CE(SAT)}$ | Collector-Emitter Saturation Voltage | $V_{GE}$ = 15 V, $I_C$ = 10 A,<br>$T_J$ = 25 ℃<br>$T_J$ = 175 ℃ | -<br>- | 1.15<br>1.17 | -<br>- | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 20 A,<br>$T_J$ = 25 ℃<br>$T_J$ = 150 ℃<br>$T_J$ = 175 ℃ | -<br>- | 1.42<br>1.58<br>1.60 | 1.80<br>-<br>- | |
| $V_{FEC}$ | Diode Forward Voltage | $V_{GE}$ = 0 V, $I_F$ = 10 A,<br>$T_J$ = 25 ℃<br>$T_J$ = 175 ℃ | -<br>- | 1.40<br>1.35 | -<br>- | V |
| | | $V_{GE}$ = 0 V, $I_F$ = 20 A,<br>$T_J$ = 25 ℃<br>$T_J$ = 175 ℃ | -<br>- | 1.70<br>1.75 | 2.30<br>- | |
| $g_{fs}$ | Transconductance | $V_{CE}$ = 15 V, $I_C$ = 20 A | - | 8.9 | - | S |
| **Dynamic Characteristics** | | | | | | |
| $C_{ies}$ | Input Capacitance | $V_{CE}$ = 25 V, $V_{GE}$ = 0 V,<br>f = 1.0 MHz | - | 1,390 | - | pF |
| $C_{oes}$ | Output Capacitance | | - | 55.4 | - | pF |
| $C_{res}$ | Reverse Transfer Capacitance | | - | 13.8 | - | pF |
| $Q_g$ | Total Gate Charge | $V_{CE}$ = 520 V, $I_C$ = 20 A,<br>$V_{GE}$ = 15 V | - | 44 | - | nC |
| $Q_{ge}$ | Gate Emitter Charge | | - | 12 | - | nC |
| $Q_{gc}$ | Gate Collector Charge | | - | 18 | - | nC |
| $t_{SC}$ | Short Circuit Withstand Time | $V_{CE}$ = 400 V, $V_{GE}$ = 15 V<br>$T_J$ = 100℃ | 5.0 | - | - | μs |

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## Electrical Characteristics $T_J$=25°C unless otherwise specified

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Switching Characteristics** | | | | | | |
| $t_{d(on)}$ | Turn-On Time | $V_{CE}$ = 400 V, $I_C$ = 20 A, $R_G$ = 10 Ω, $V_{GE}$ = 0 / 15 V $T_J$ = 25 ℃ (Note. 2) | - | 60 | - | ns |
| $t_r$ | Turn-On Rise Time | | - | 11 | - | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | - | 119 | - | ns |
| $t_f$ | Turn-Off Fall Time | | - | 36 | - | ns |
| $E_{on}$ | Turn-On Energy Loss | | - | 0.034 | - | mJ |
| $E_{off}$ | Turn-Off Energy Loss | | - | 0.388 | - | mJ |
| $E_{tot}$ | Total Energy Loss | | - | 0.422 | - | mJ |
| $t_{d(on)}$ | Turn-On Time | $V_{CE}$ = 400 V, $I_C$ = 20 A, $R_G$ = 10 Ω, $V_{GE}$ = 0 / 15 V $T_J$ = 150 ℃ (Note. 2) | - | 64 | - | ns |
| $t_r$ | Turn-On Rise Time | | - | 12 | - | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | - | 141 | - | ns |
| $t_f$ | Turn-Off Fall Time | | - | 48 | - | ns |
| $E_{on}$ | Turn-On Energy Loss | | - | 0.044 | - | mJ |
| $E_{off}$ | Turn-Off Energy Loss | | - | 0.485 | - | mJ |
| $E_{tot}$ | Total Energy Loss | | - | 0.529 | - | mJ |
| **Diode Reverse Recovery Characteristics** | | | | | | |
| $t_{rr}$ | Diode Reverse Recovery Time | $V_R$ = 400 V, $I_F$ = 20 A, di/dt = 1,000 A/μs | - | 60 | - | ns |
| $I_{rr}$ | Diode Reverse Recovery Current | | - | 13.8 | - | A |
| $Q_{rr}$ | Diode Reverse Recovery Charge | | - | 442 | - | nC |
| $t_{rr}$ | Diode Reverse Recovery Time | $V_R$ = 400 V, $I_F$ = 20 A, $T_J$ = 150 ℃ di/dt = 1,000 A/μs | - | 73 | - | ns |
| $I_{rr}$ | Diode Reverse Recovery Current | | - | 18.0 | - | A |
| $Q_{rr}$ | Diode Reverse Recovery Charge | | - | 780 | - | nC |

**Notes :** 2. Include tail current and diode reverse recovery.

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## IGBT Static Characteristics Figure.

Figure.1 Saturation Voltage characteristics ,Junction Temperature($T_J$) 25℃

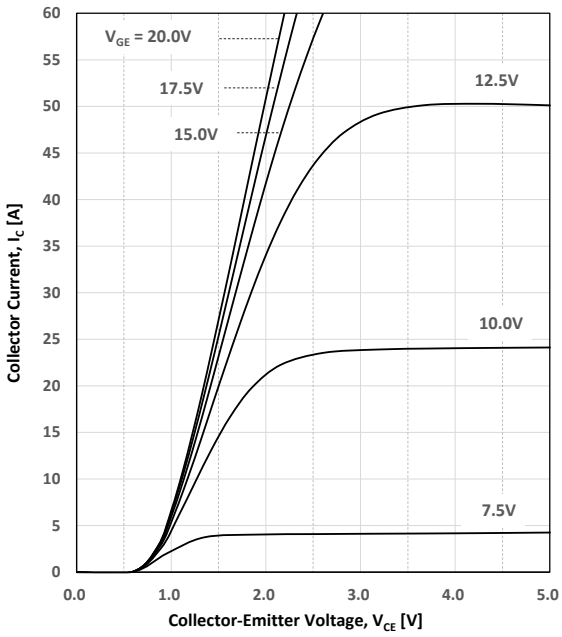


Figure.2 Saturation Voltage characteristics ,Junction Temperature($T_J$) 150℃

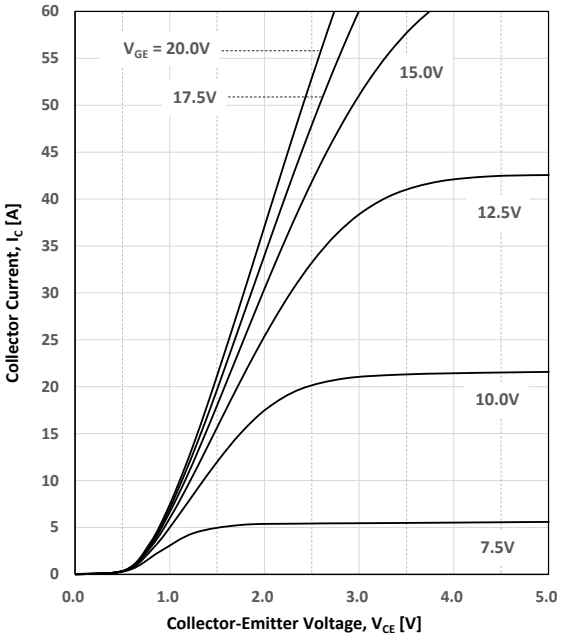


Figure.3 Saturation Voltage characteristics as Junction Temperature, $V_{GE}$=15V

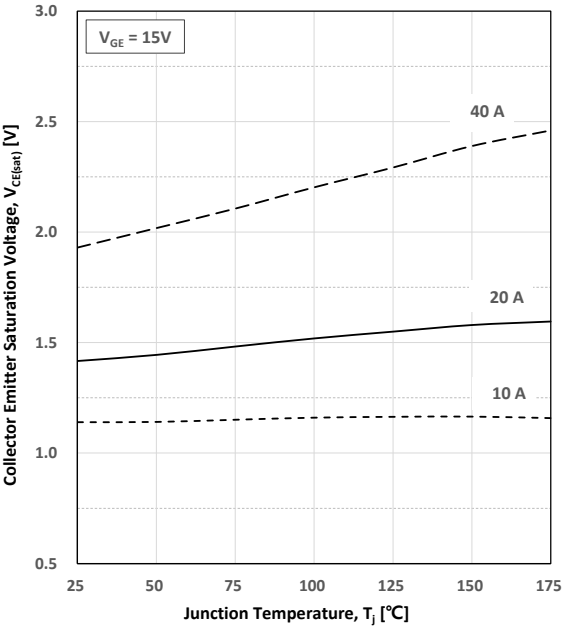


Figure.4 Transconductance characteristics as Junction Temperature

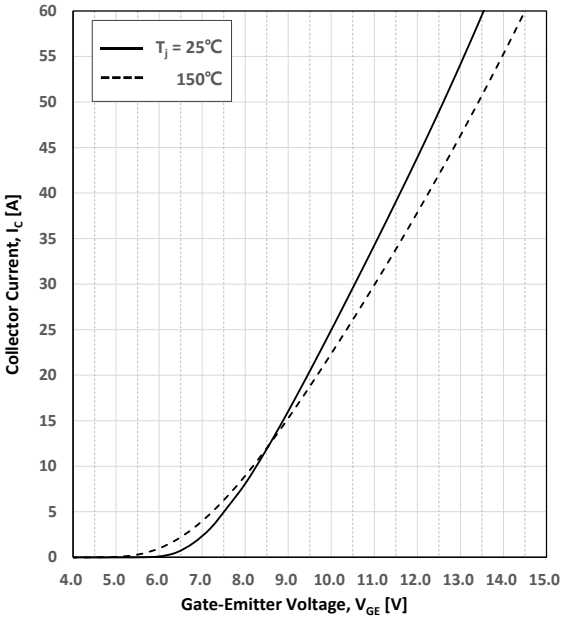


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Figure.5 Threshold Voltage characteristics as Junction Temperature

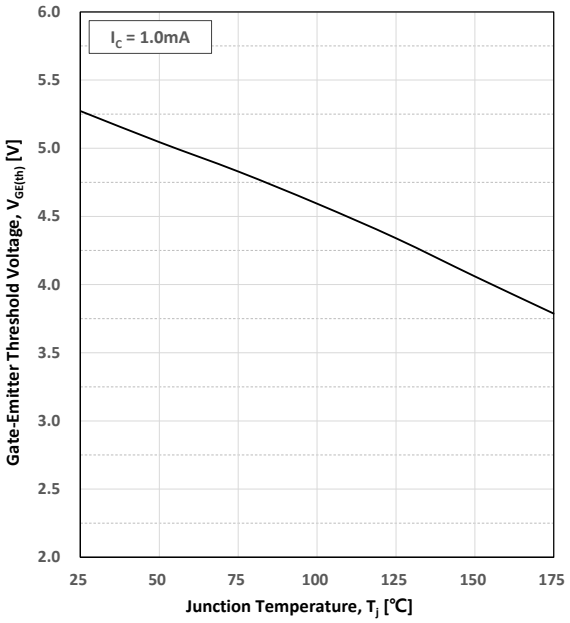
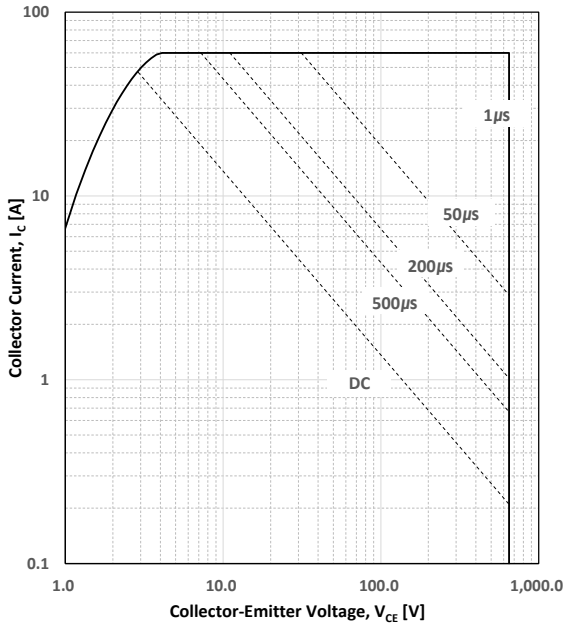



Figure.6 Forward Bias Safe Operating Area ($T_C$=25℃, $T_J$≤175℃, $V_{GE}$=15V, $t_p$=1μs, D=0)




## IGBT Dynamic Characteristics Figure.

Figure.7 Capacitance characteristics (f=1MHz)

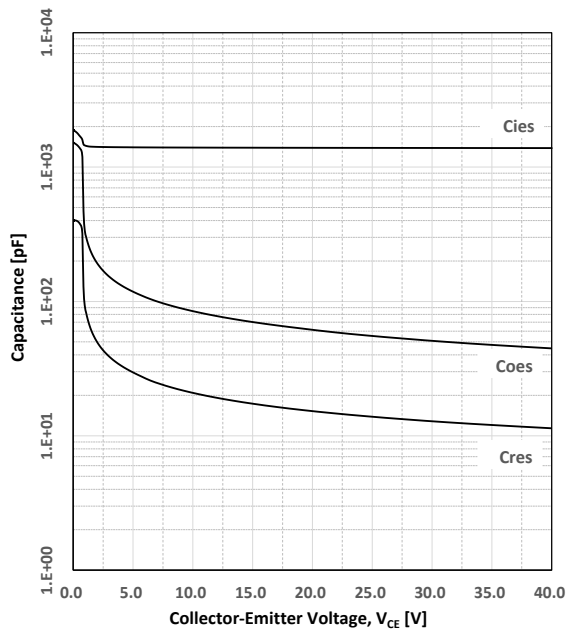
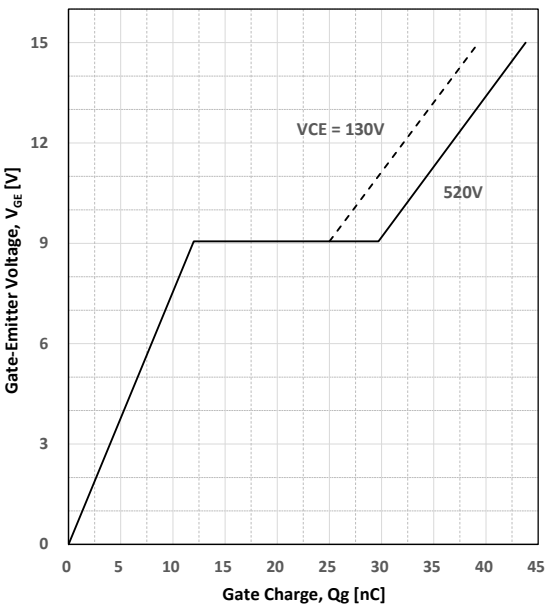



Figure.8 Gate Charge characteristics ($I_C$=20A)

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## IGBT Switching Characteristics Figure.

Figure.9 Switching Times as Gate Resistance
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, $T_J$=25℃)

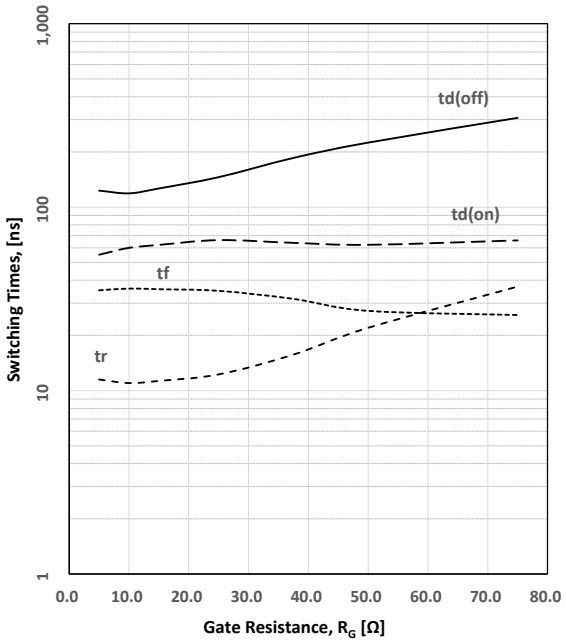


Figure.10 Switching Loss as Gate Resistance
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, $T_J$=25℃)

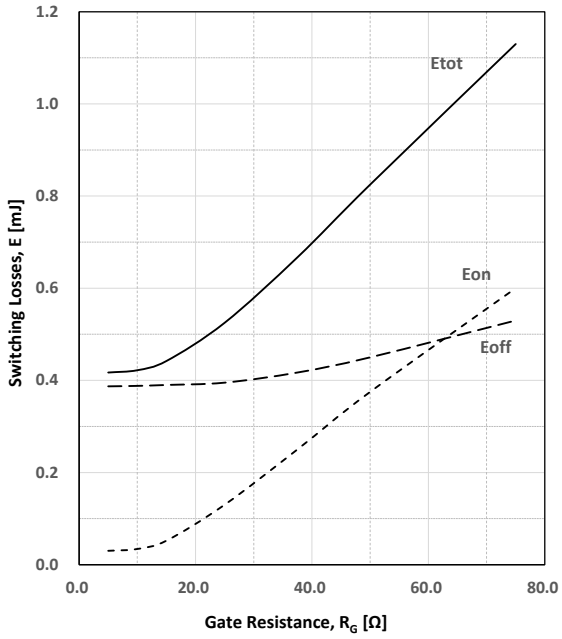


Figure.11 Switching Times as Collector Current
($V_{CE}$=400V, $V_{GE}$=15V, Rg=10Ω, $T_J$=25℃)

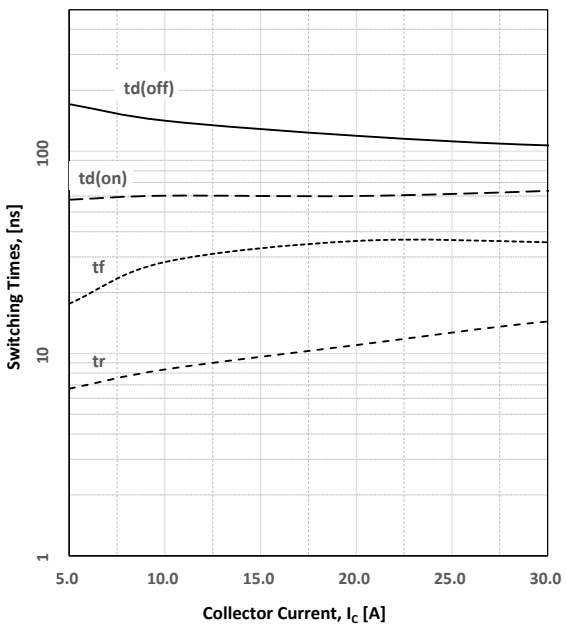


Figure.12 Switching Loss as Collector Current
($V_{CE}$=400V, $V_{GE}$=15V, Rg=10Ω, $T_J$=25℃)

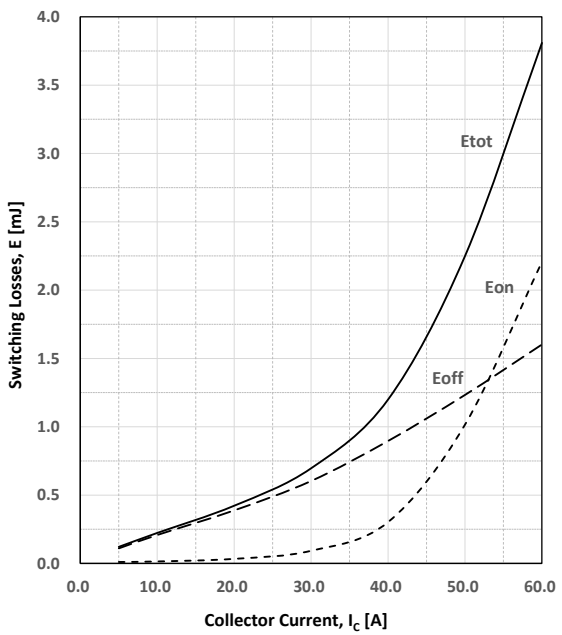


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Figure.13 Switching Times as Collector Voltage
($I_C$=20A, $V_{GE}$=15V, Rg=10Ω, $T_J$=25℃)

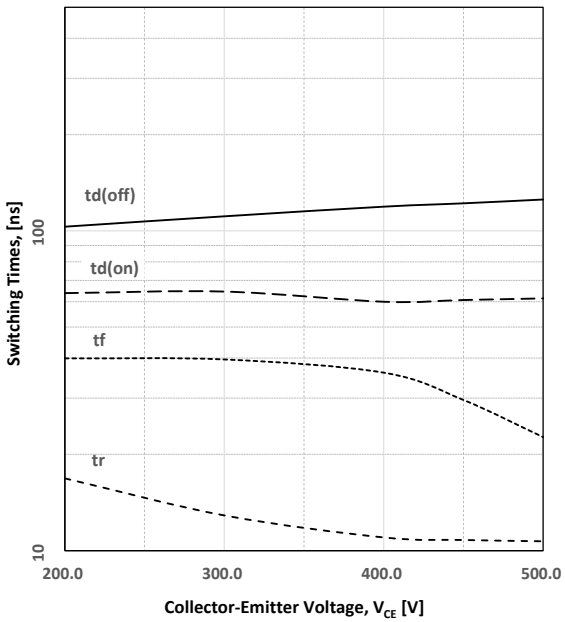


Figure.14 Switching Loss as Collector Voltage
($I_C$=20A, $V_{GE}$=15V, Rg=10Ω, $T_J$=25℃)

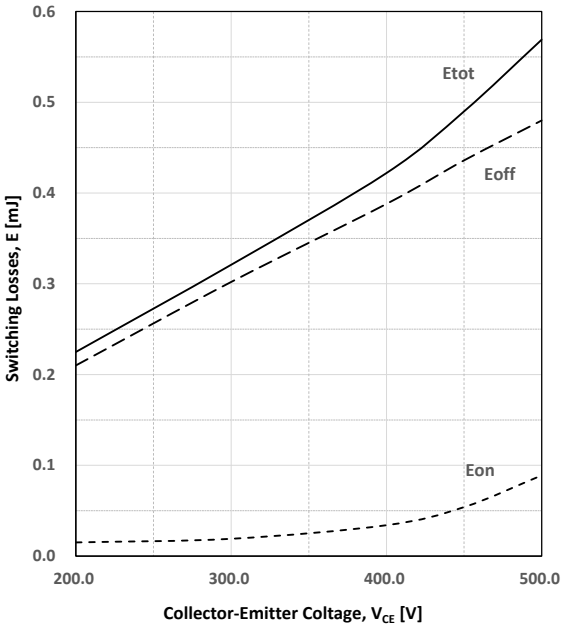


Figure.15 Switching Times as Gate Resistance
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, $T_J$=150℃)

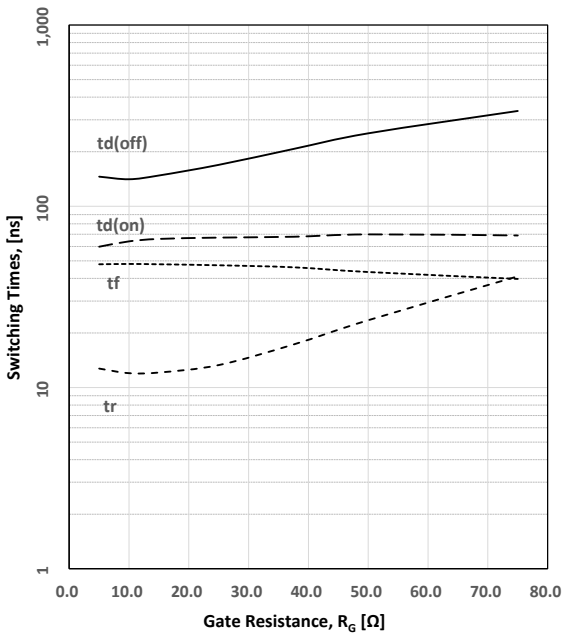


Figure.16 Switching Loss as Gate Resistance
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, $T_J$=150℃)

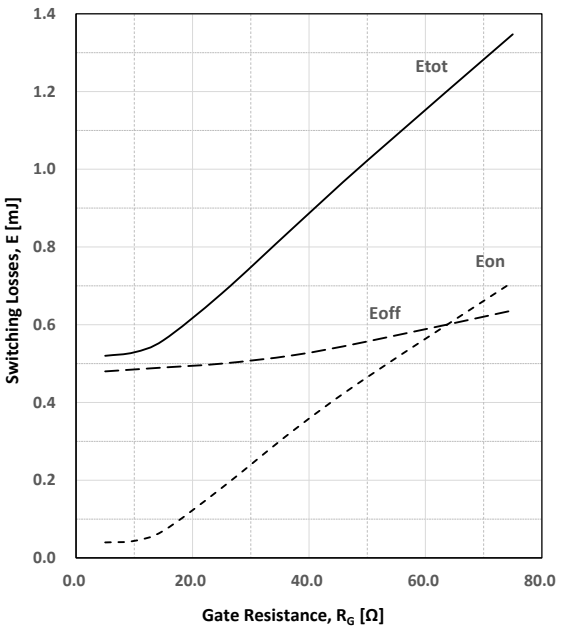


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Figure.17 Switching Times as Collector Current
($V_{CE}$=400V, $V_{GE}$=15V, Rg=10Ω, $T_J$=150℃)

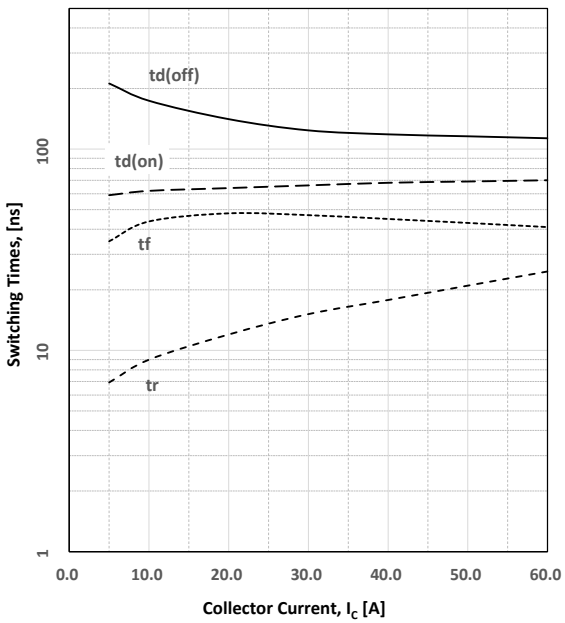



Figure.18 Switching Loss as Collector Current
($V_{CE}$=400V, $V_{GE}$=15V, Rg=10Ω, $T_J$=150℃)

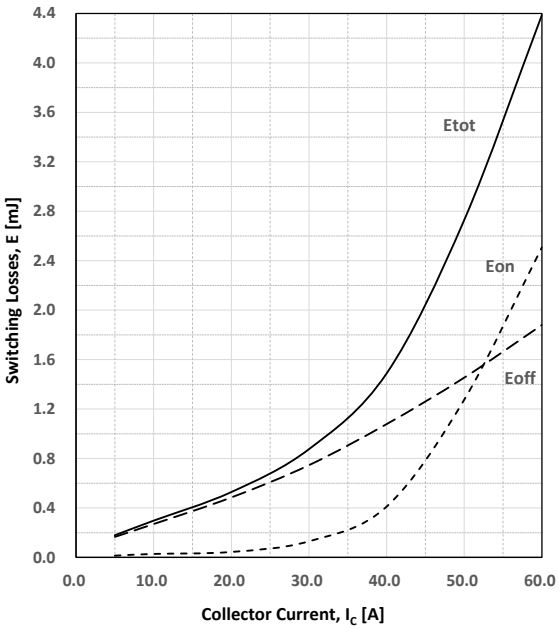



Figure.19 Switching Times as Collector Voltage
($I_C$=20A, $V_{GE}$=15V, Rg=10Ω, $T_J$=150℃)

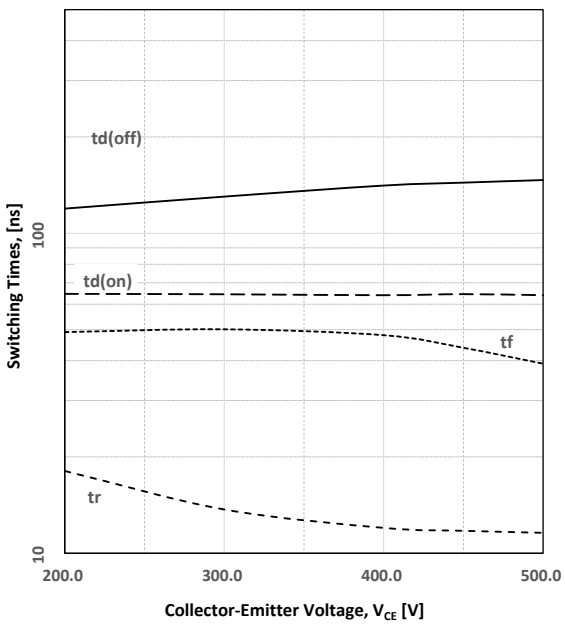



Figure.20 Switching Loss as Collector Voltage
($I_C$=20A, $V_{GE}$=15V, Rg=10Ω, $T_J$=150℃)

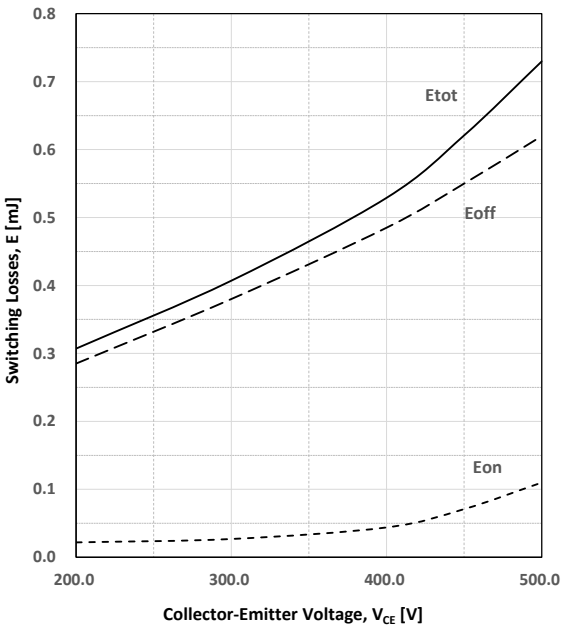


Figure.21 Switching Times as Junction Temp.
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, Rg=10Ω)

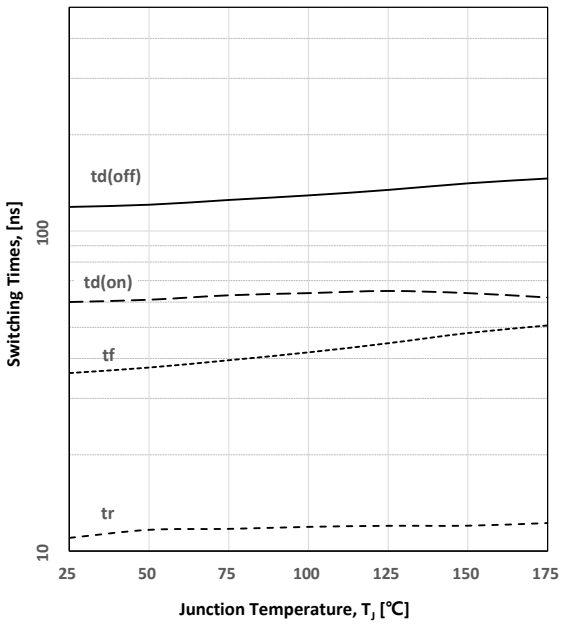
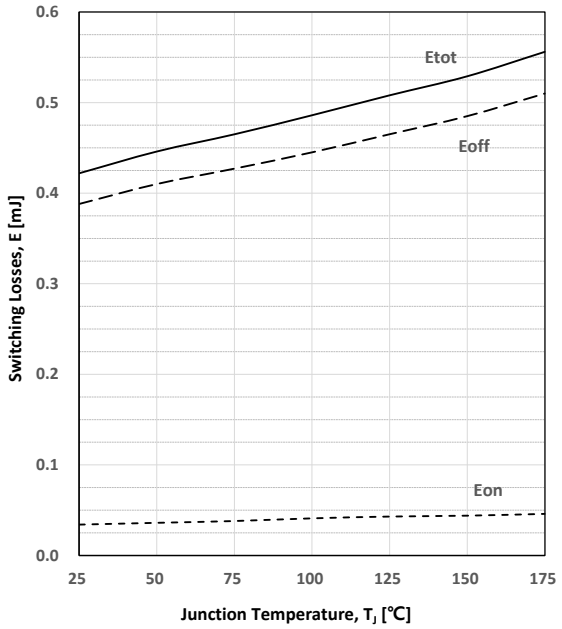
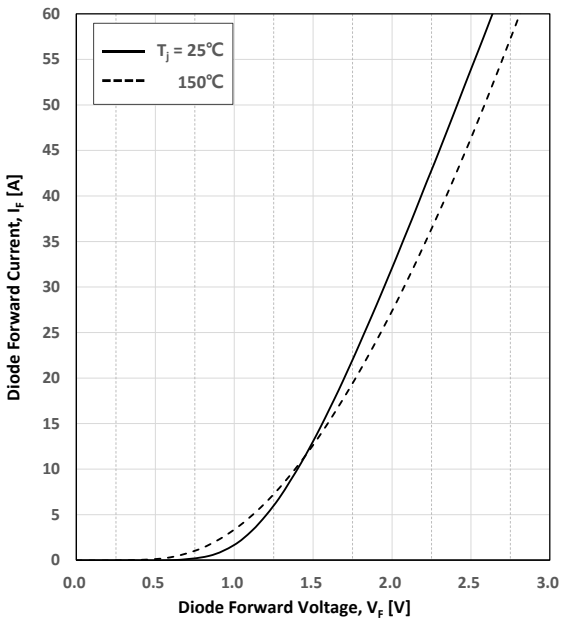


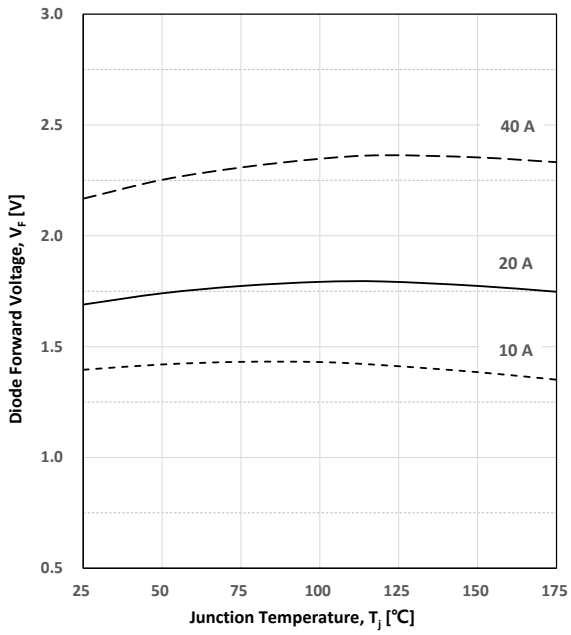

Figure.22 Switching Loss as Junction Temp.
($V_{CE}$=400V, $I_C$=20A, $V_{GE}$=15V, Rg=10Ω)




## Diode Static Characteristics Figure.

Figure.23 Diode Forward current characteristics as Junction Temperature and Forward current

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## Diode Reverse Recovery Characteristics Figure.

Figure.24 Reverse Recovery Current as di/dt ($V_R$=400V, $I_F$=20A)

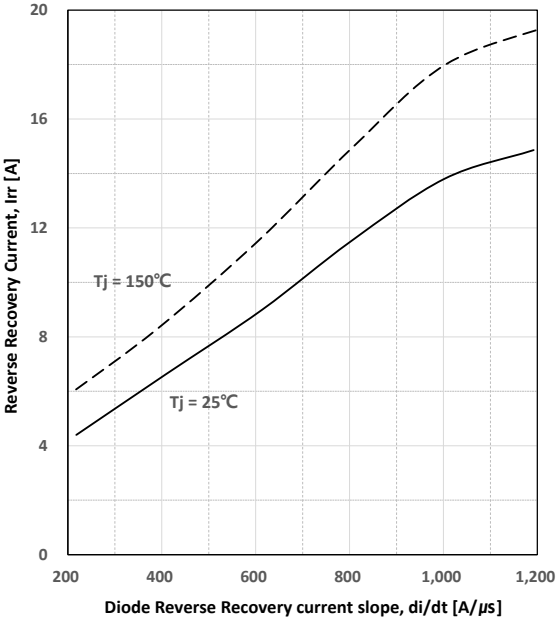



Figure.25 Reverse Recovery Time as di/dt ($V_R$=400V, $I_F$=20A)

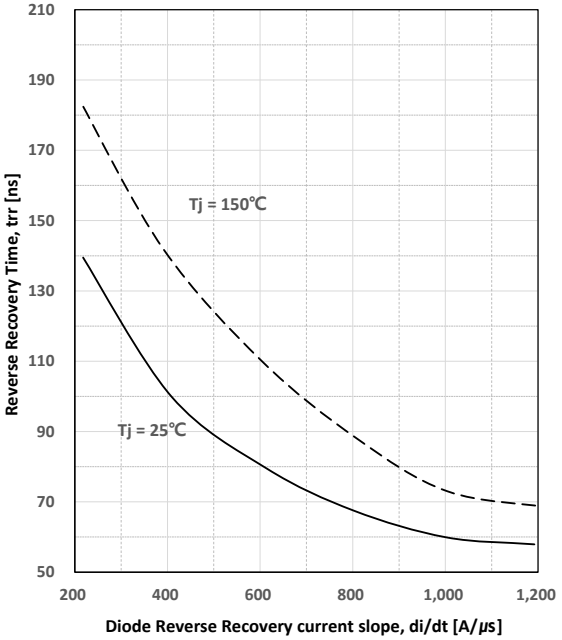
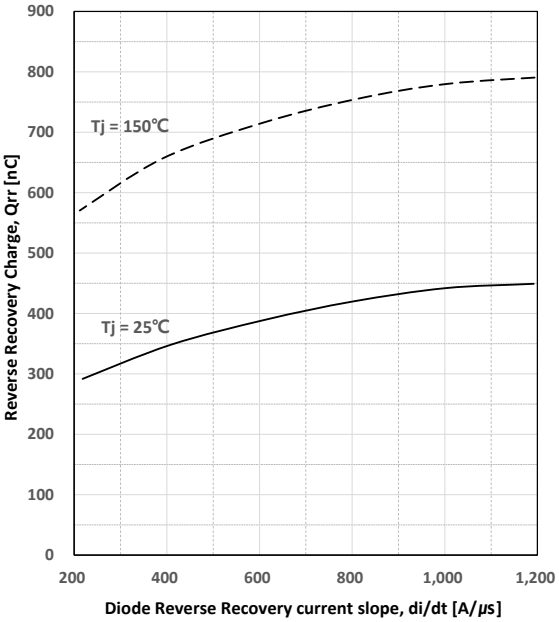
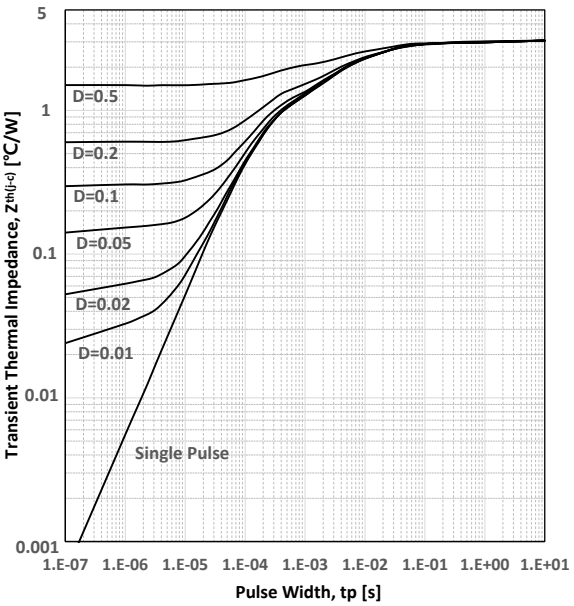



Figure.26 Reverse Recovery Charge as di/dt ($V_R$=400V, $I_F$=20A)

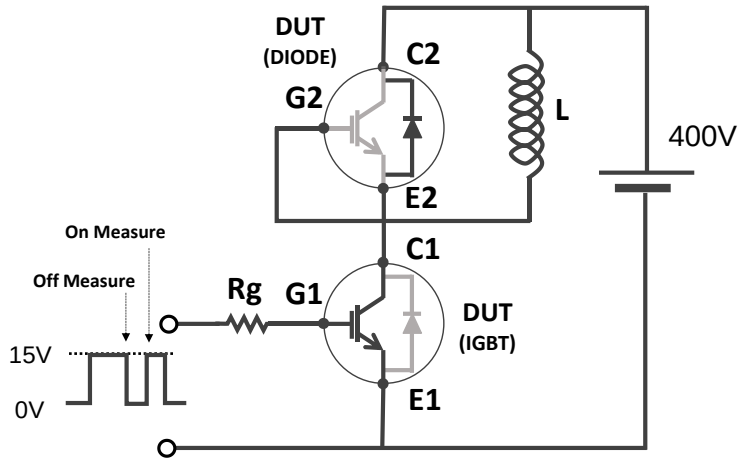



## Transient Thermal Impedance Figure.

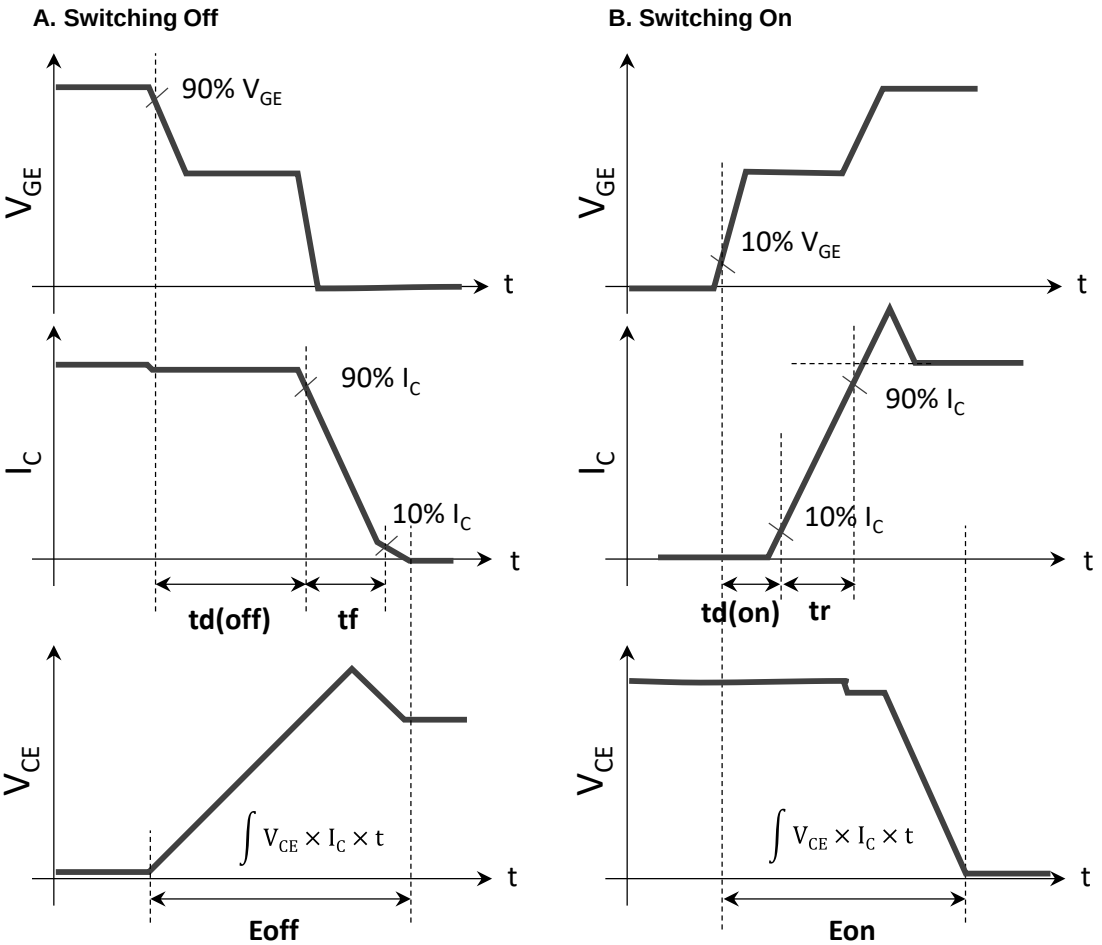
Figure.27 IGBT Transient Thermal Impedance



## Ref. 1) Switching Test Circuit




## Ref. 2) Definition of switching time and loss

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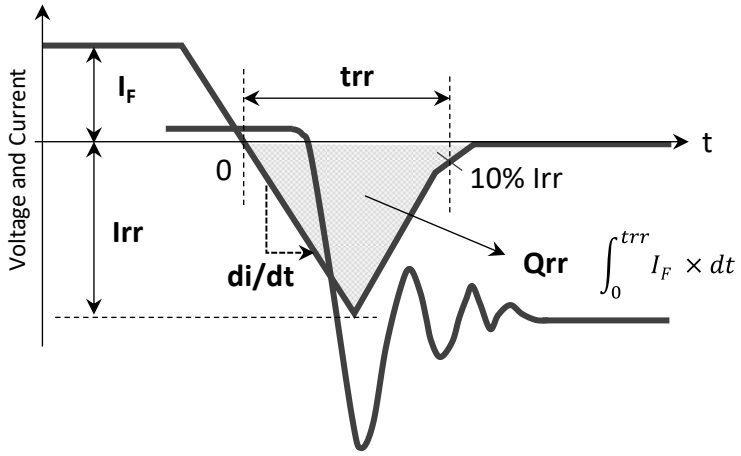
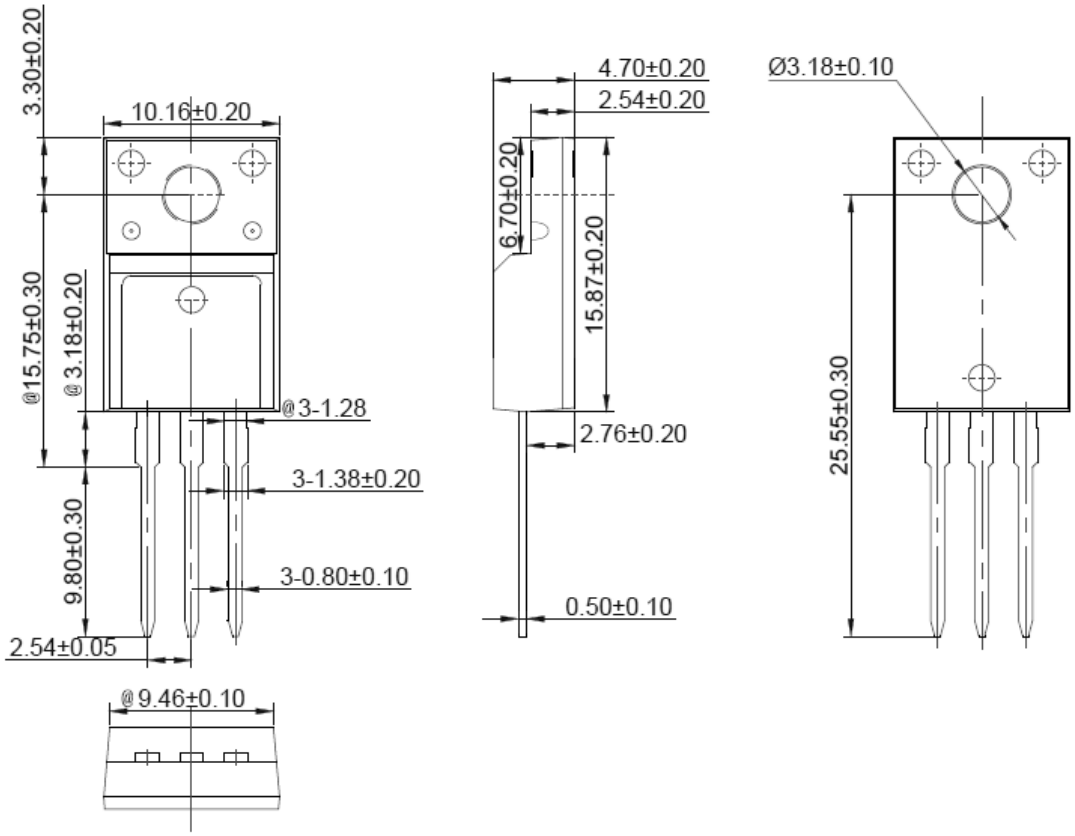
## Ref. 3) Definition of Diode switching time




## Package Dimension : TO-220F

**Unit : mm**

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