

## 650V 50A Trench FS Gen.7 IGBT

### General Description

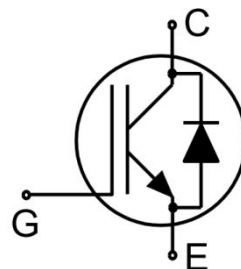
Using NCE's proprietary high density trench gate design and advanced FS (Field Stop) Gen.7 technology, the 650V Trench FS Gen.7 IGBT offers superior conduction and switching performances, and easy parallel operation;

### Features

- Trench Field Stop Gen.7 Technology Offering
- Low saturation voltage:  $V_{CEsat} = 1.50V(Typ.) @ I_C = 50 A$
- High speed switching, low switching losses
- Maximum junction temperature  $T_{vjmax} = 175^{\circ}C$
- Tighten parameter distribution
- High ruggedness, temperature stable behavior
- Pb-free lead plating, RoHS compliant
- AEC-Q101 qualified

### Application

- Inverters
- Motor drives
- Converter
- Automotive application



Schematic diagram

### Package Marking and Ordering Information

| Device       | Device Package | Device Marking |
|--------------|----------------|----------------|
| NCEA50ED65BT | TO-247-3L      | A50ED65BT      |



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

TO-247-3L

| Symbol      | Parameter                                                                                                                                                                  | Value       | Units       |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|
| $V_{CES}$   | Collector-Emitter Voltage                                                                                                                                                  | 650         | V           |
| $V_{GES}$   | Gate- Emitter Voltage                                                                                                                                                      | $\pm 30$    | V           |
| $I_C$       | Collector Current                                                                                                                                                          | 100         | A           |
|             | Collector Current @ $T_C = 100^{\circ}C$                                                                                                                                   | 50          | A           |
| $I_{Cpuls}$ | Pulsed Collector Current, $t_p$ limited by $T_{jmax}$                                                                                                                      | 150         | A           |
| -           | Turn off safe operating area, $V_{CE}=650V, T_J=175^{\circ}C$                                                                                                              | 150         | A           |
| $I_F$       | Diode Continuous Forward Current @ $T_C = 100^{\circ}C$                                                                                                                    | 50          | A           |
| $I_{FM}$    | Diode Maximum Forward Current                                                                                                                                              | 150         | A           |
| $P_D$       | Power Dissipation @ $T_C = 25^{\circ}C$                                                                                                                                    | 294         | W           |
|             | Power Dissipation @ $T_C = 100^{\circ}C$                                                                                                                                   | 147         | W           |
| $T_{stg}$   | Storage Temperature                                                                                                                                                        | -55 to +150 | $^{\circ}C$ |
| $T_{vj}$    | Operating junction temperature                                                                                                                                             | -40 to +175 | $^{\circ}C$ |
| $T_L$       | Maximum Temperature for Soldering                                                                                                                                          | 260         | $^{\circ}C$ |
| $t_{sc}$    | Short circuit withstand time $V_{GE}=15.0V, V_{CC} \leq 400V$ ,<br>Allowed number of short circuits<1000Time between<br>short circuits: $\geq 1.0s, T_J \leq 150^{\circ}C$ | 5           | us          |

## Thermal Characteristic

| Symbol          | Parameter                                      | Value | Units                |
|-----------------|------------------------------------------------|-------|----------------------|
| $R_{\theta JC}$ | Thermal Resistance, Junction to case for IGBT  | 0.50  | $^{\circ}\text{C/W}$ |
| $R_{\theta JC}$ | Thermal Resistance, Junction to case for Diode | 0.63  | $^{\circ}\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient        | 40    | $^{\circ}\text{C/W}$ |

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

| Symbol                    | Parameter                                                                                  | Conditions                                                                                               |                        | Value |      |      | Units |
|---------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------------|-------|------|------|-------|
|                           |                                                                                            |                                                                                                          |                        | Min.  | Typ. | Max. |       |
| Static Characteristics    |                                                                                            |                                                                                                          |                        |       |      |      |       |
| V <sub>(BR)CES</sub>      | Collector-Emitter Breakdown Voltage                                                        | V <sub>GE</sub> =0V, I <sub>CE</sub> =1mA                                                                |                        | 650   | --   | --   | V     |
| I <sub>CES</sub>          | Collector-Emitter Leakage Current                                                          | V <sub>GE</sub> =0V, V <sub>CE</sub> =650V                                                               |                        | --    | --   | 10   | uA    |
| I <sub>GES(F)</sub>       | Gate to Emitter Forward Leakage                                                            | V <sub>GE</sub> =+30V, V <sub>CE</sub> =0V                                                               |                        | --    | --   | 100  | nA    |
| I <sub>GES(R)</sub>       | Gate to Emitter Reverse Leakage                                                            | V <sub>GE</sub> =-30V, V <sub>CE</sub> =0V                                                               |                        | --    | --   | 100  | nA    |
| V <sub>CE(sat)</sub>      | Collector-Emitter Saturation Voltage                                                       | I <sub>C</sub> =25A                                                                                      | V <sub>GE</sub> =15V , | --    | 1.20 | --   | V     |
|                           |                                                                                            | I <sub>C</sub> =50A                                                                                      | T <sub>J</sub> =25°C   | --    | 1.50 | 2.00 | V     |
|                           |                                                                                            | I <sub>C</sub> =25A                                                                                      | V <sub>GE</sub> =15V , | --    | 1.30 | --   | V     |
|                           |                                                                                            | I <sub>C</sub> =50A                                                                                      | T <sub>J</sub> =175°C  | --    | 1.80 | --   | V     |
| V <sub>GE(th)</sub>       | Gate Threshold Voltage                                                                     | I <sub>C</sub> =1mA, V <sub>CE</sub> =V <sub>GE</sub>                                                    |                        | 4.5   | 5.25 | 6.0  | V     |
| Dynamic Characteristics   |                                                                                            |                                                                                                          |                        |       |      |      |       |
| C <sub>ies</sub>          | Input Capacitance                                                                          | V <sub>CE</sub> =25V, V <sub>GE</sub> =0V, f=1MHz                                                        |                        | 2400  | 3050 | 3700 | pF    |
| C <sub>oes</sub>          | Output Capacitance                                                                         |                                                                                                          |                        | --    | 105  | --   |       |
| C <sub>res</sub>          | Reverse Transfer Capacitance                                                               |                                                                                                          |                        | --    | 23   | --   |       |
| Q <sub>g</sub>            | Total Gate Charge                                                                          | V <sub>CC</sub> =480V, I <sub>C</sub> =50A, V <sub>GE</sub> =15V                                         |                        | --    | 106  | --   | nC    |
| Q <sub>ge</sub>           | Gate to Emitter Charge                                                                     |                                                                                                          |                        | --    | 35   | --   |       |
| Q <sub>gc</sub>           | Gate to Collector Charge                                                                   |                                                                                                          |                        | --    | 33   | --   |       |
| R <sub>g</sub>            | Internal Gate Resistance                                                                   | f=1MHz                                                                                                   |                        | --    | 0.5  | --   | Ω     |
| I <sub>C(SC)</sub>        | Short circuit collector current Max.1000 short circuits Time between short circuits: ≥1.0s | V <sub>GE</sub> =15V, V <sub>CC</sub> ≤400V, t <sub>sc</sub> ≤5us, T <sub>J</sub> ≤150°C                 |                        | --    | 230  | --   | A     |
| Switching Characteristics |                                                                                            |                                                                                                          |                        |       |      |      |       |
| t <sub>d(ON)</sub>        | Turn-on Delay Time                                                                         | V <sub>CC</sub> =400V, I <sub>C</sub> =50A, V <sub>GE</sub> =0/15V, R <sub>g</sub> =5.7Ω, Inductive Load |                        | --    | 51   | --   | ns    |
| t <sub>r</sub>            | Rise Time                                                                                  |                                                                                                          |                        | --    | 19   | --   |       |
| t <sub>d(OFF)</sub>       | Turn-Off Delay Time                                                                        |                                                                                                          |                        | --    | 149  | --   |       |
| t <sub>f</sub>            | Fall Time                                                                                  |                                                                                                          |                        | --    | 23   | --   |       |
| E <sub>on</sub>           | Turn-On Switching Loss                                                                     |                                                                                                          |                        | --    | 1.29 | --   | mJ    |
| E <sub>off</sub>          | Turn-Off Switching Loss                                                                    |                                                                                                          |                        | --    | 0.42 | --   |       |
| E <sub>ts</sub>           | Total Switching Loss                                                                       |                                                                                                          |                        | --    | 1.71 | --   |       |
| E <sub>on</sub>           | Turn-On Switching Loss                                                                     | V <sub>CC</sub> =400V, I <sub>C</sub> =50A,                                                              |                        | --    | 2.21 | --   | mJ    |
| E <sub>off</sub>          | Turn-Off Switching Loss                                                                    | V <sub>GE</sub> =0/15V, R <sub>g</sub> =5.7Ω,                                                            |                        | --    | 1.07 | --   |       |
| E <sub>ts</sub>           | Total Switching Loss                                                                       | Inductive Load, T <sub>J</sub> =175°C                                                                    |                        | --    | 3.28 | --   |       |

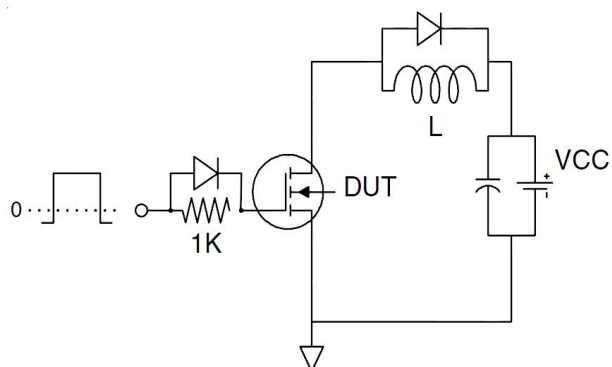
# Electrical Characteristics of the Diode (T<sub>c</sub>= 25°C unless otherwise specified)

| Symbol           | Parameter                           | Conditions                                                          | Rating |      |      | Units |
|------------------|-------------------------------------|---------------------------------------------------------------------|--------|------|------|-------|
|                  |                                     |                                                                     | Min.   | Typ. | Max. |       |
| V <sub>FM</sub>  | Diode Forward Voltage               | I <sub>F</sub> =50A                                                 |        |      |      |       |
|                  |                                     |                                                                     |        |      |      |       |
|                  |                                     | T <sub>j</sub> =25°C                                                | --     | 1.6  | 2.3  | V     |
|                  |                                     | T <sub>j</sub> =175°C                                               | --     | 1.4  | --   | V     |
| T <sub>rr</sub>  | Reverse Recovery Time               | I <sub>F</sub> =50A, R <sub>g</sub> =5.7Ω,<br>T <sub>j</sub> =25°C  | --     | 116  | --   | ns    |
| I <sub>RRM</sub> | Diode Peak Reverse Recovery Current |                                                                     | --     | 30   | --   | A     |
| Q <sub>rr</sub>  | Reverse Recovery Charge             |                                                                     | --     | 1.41 | --   | uC    |
| E <sub>rec</sub> | Reverse recovery energy             |                                                                     | --     | 0.22 | --   | mJ    |
| T <sub>rr</sub>  | Reverse Recovery Time               | I <sub>F</sub> =50A, R <sub>g</sub> =5.7Ω,<br>T <sub>j</sub> =175°C | --     | 175  | --   | ns    |
| I <sub>RRM</sub> | Diode Peak Reverse Recovery Current |                                                                     | --     | 48   | --   | A     |
| Q <sub>rr</sub>  | Reverse Recovery Charge             |                                                                     | --     | 3.45 | --   | uC    |
| E <sub>rec</sub> | Reverse recovery energy             |                                                                     | --     | 0.32 | --   | mJ    |

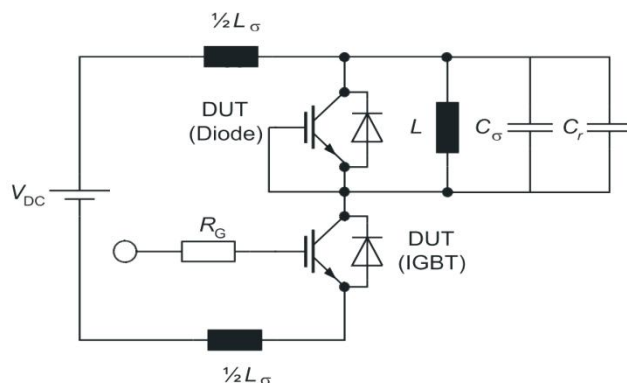
Note: For optimum lifetime and reliability, NCE recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

## Test Circuit

### 1) Gate Charge Test Circuit

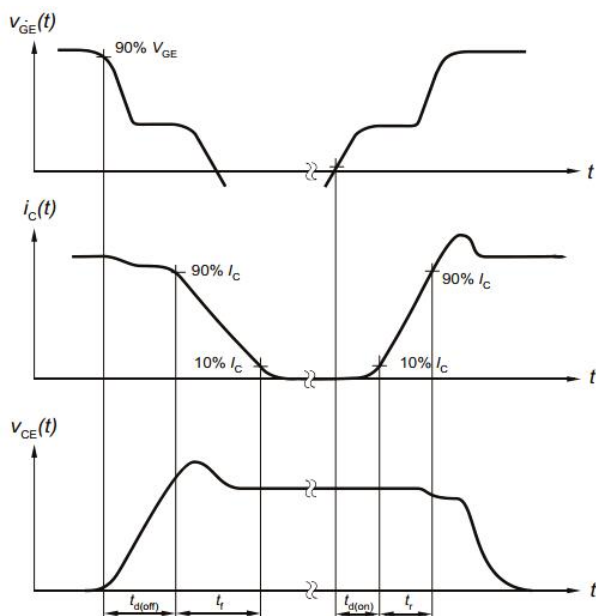


### 2) Switch Time Test Circuit

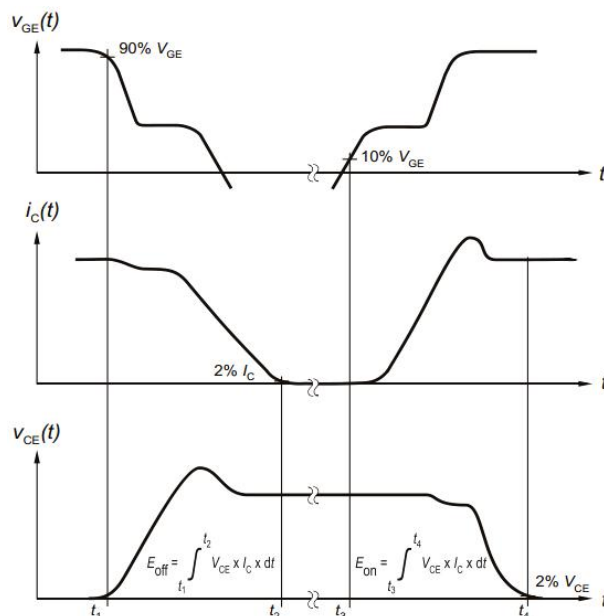


## Switching characteristics

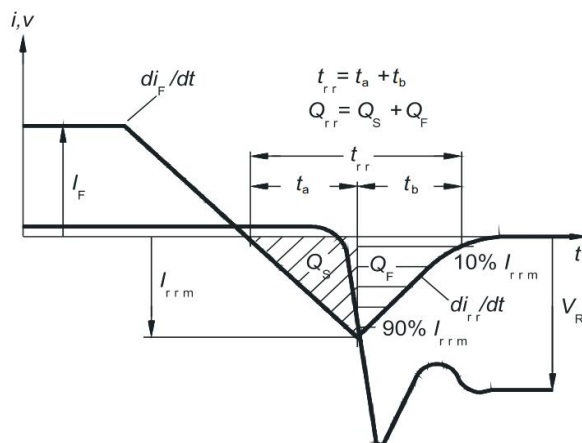
### 1) Definition of switching times



### 2) Definition of switching losses

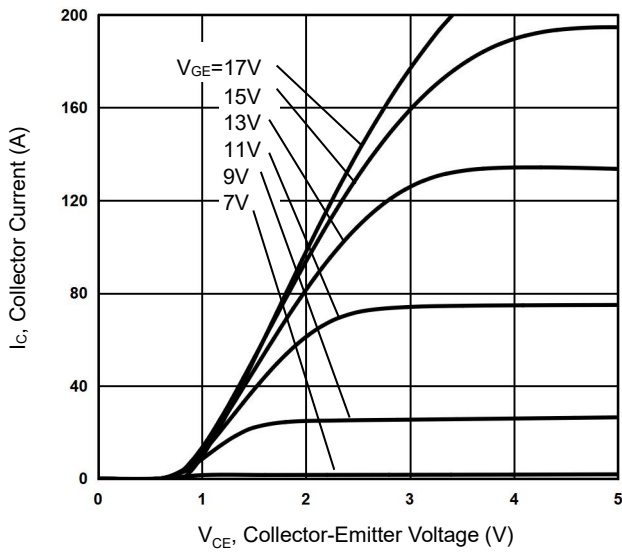


### 3) Definition of diode switching characteristics

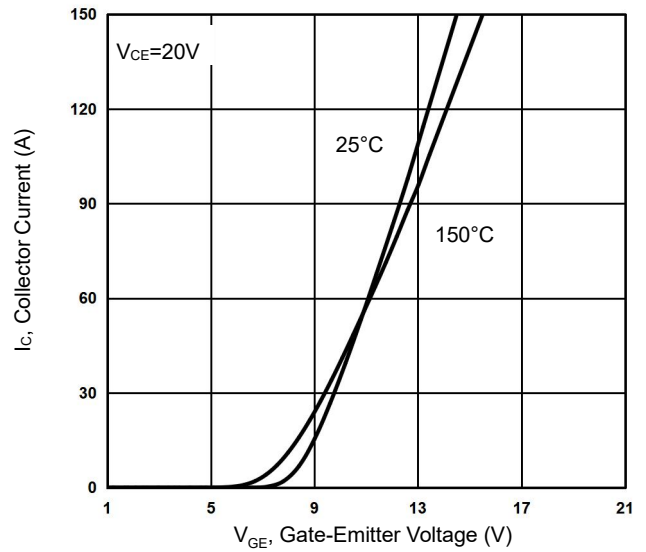


## Typical Electrical and Thermal Characteristics

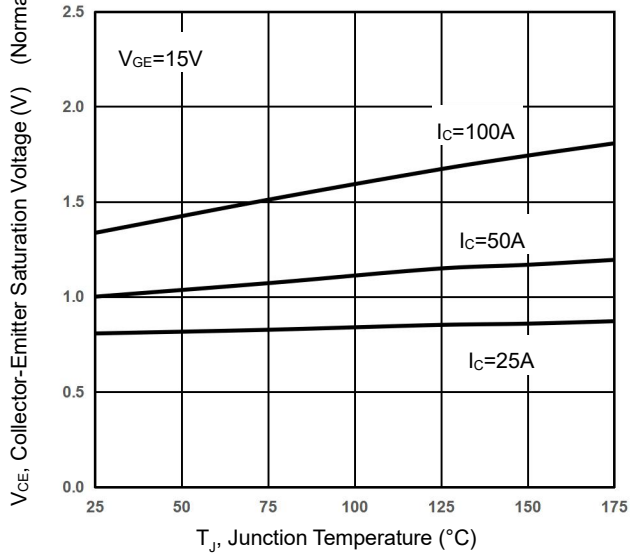
**Figure 1 Output Characteristics**



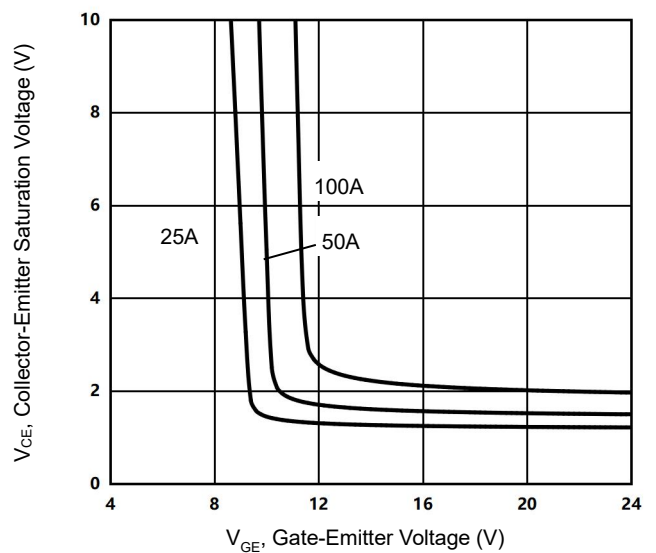
**Figure 2 Transfer Characteristics**



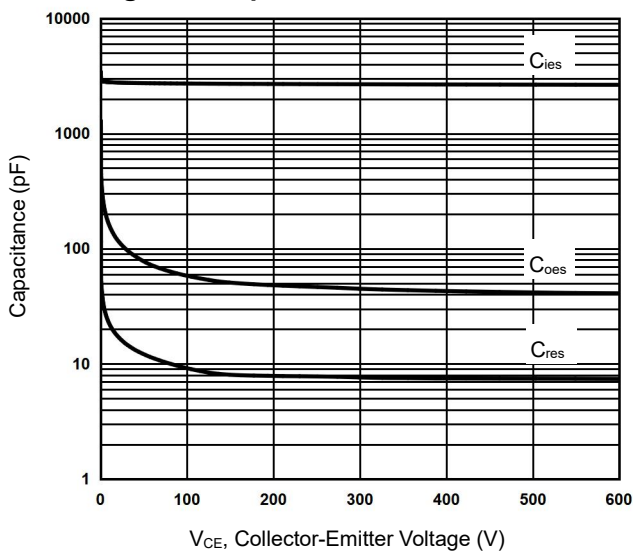
**Figure 3  $V_{CE(sat)}$  vs. Temperature**



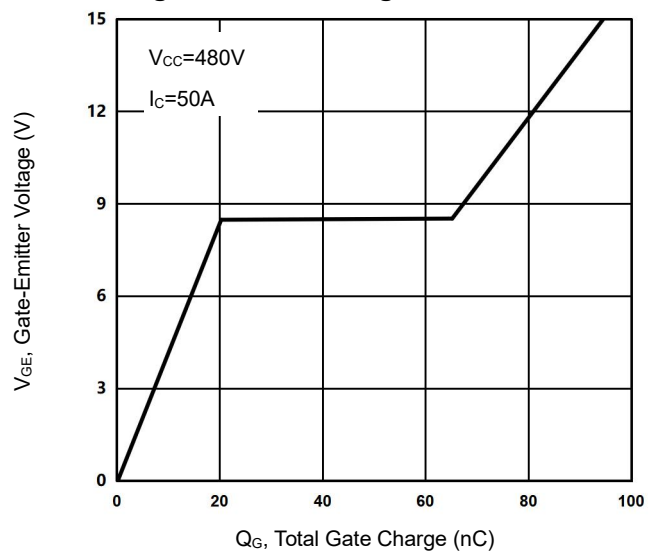
**Figure 4 Saturation Voltage vs.  $V_{GE}$**



**Figure 5 Capacitance Characteristics**

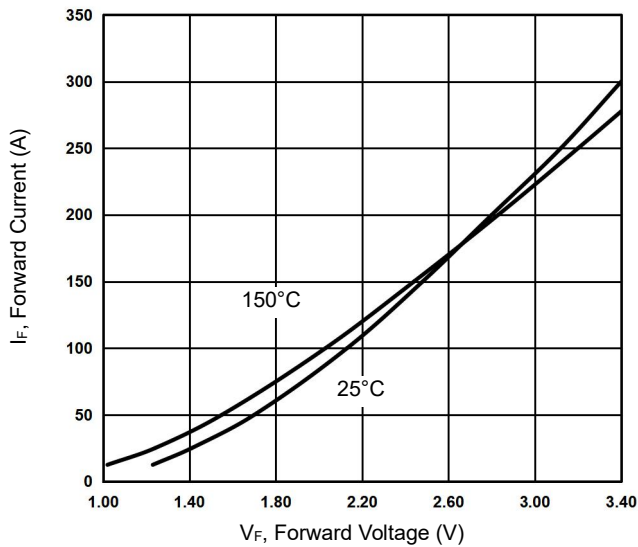


**Figure 6 Gate Charge Wave Form**

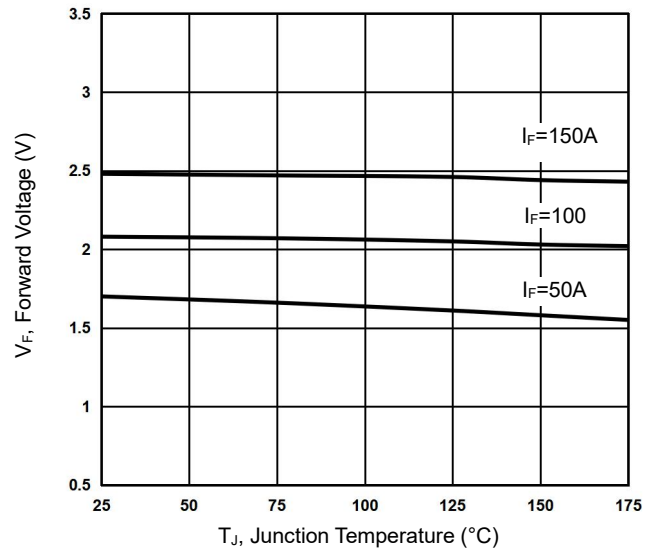


## Typical Electrical and Thermal Characteristics

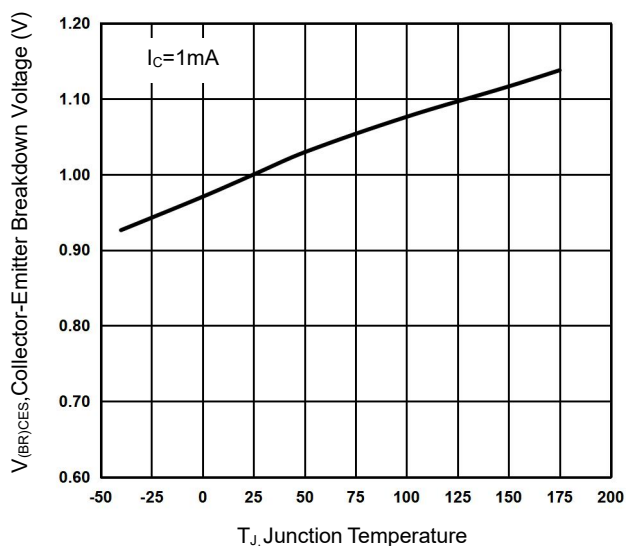
**Figure 7 Forward Characteristics**



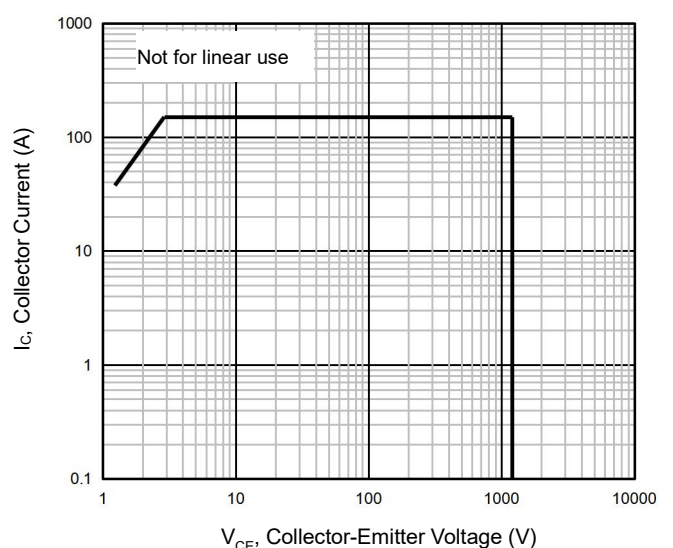
**Figure 8  $V_F$  vs. Temperature**



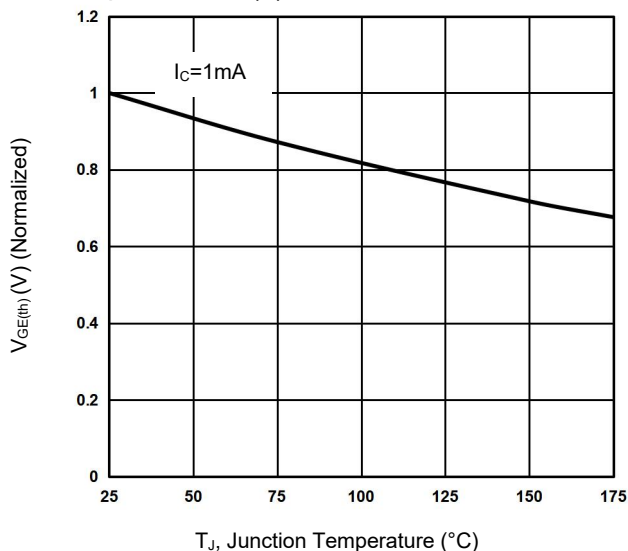
**Figure 9  $V_{(BR)CES}$  vs. Temperature**



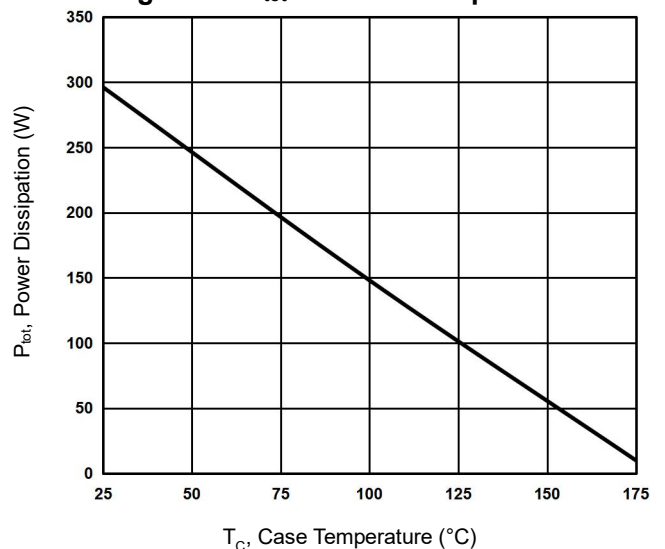
**Figure 10 Forward Bias Safe Operating Area**



**Figure 11  $V_{GE(th)}$  vs. Junction Temperature**



**Figure 12  $P_{tot}$  vs. Case Temperature**



## Typical Electrical and Thermal Characteristics

Figure 13 Switching Loss vs. Collector Current

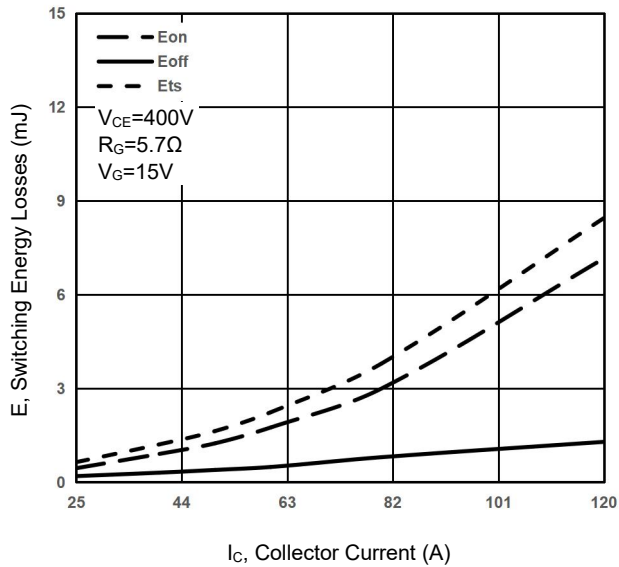


Figure 14 Switching Loss vs. Collector Current

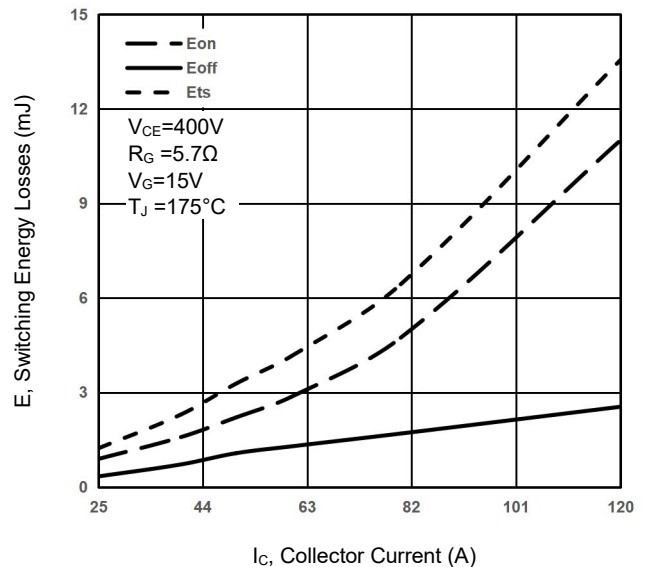


Figure 15 Switching Loss vs.  $R_G$

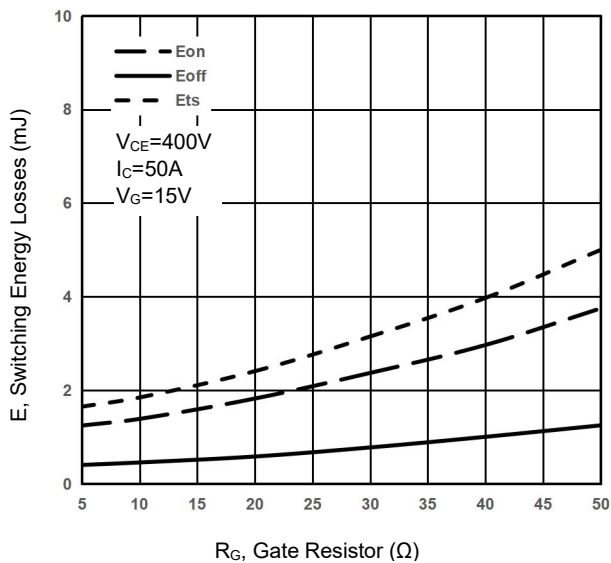


Figure 16 Switching Loss vs.  $R_G$

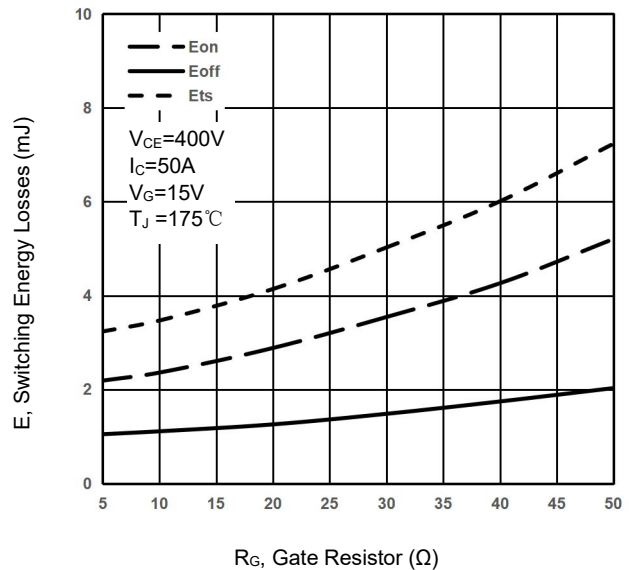
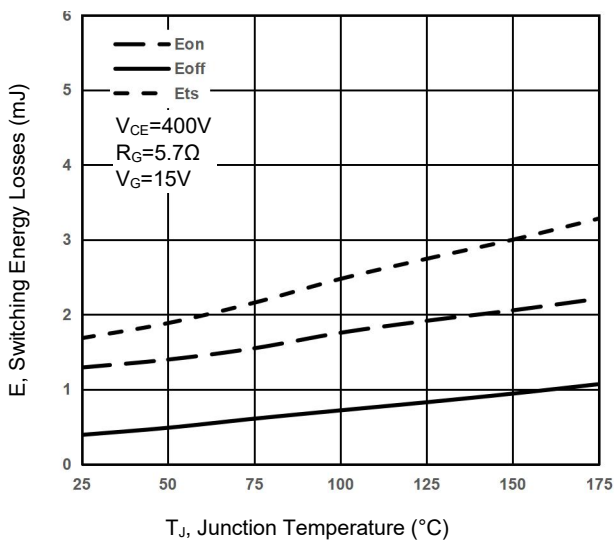
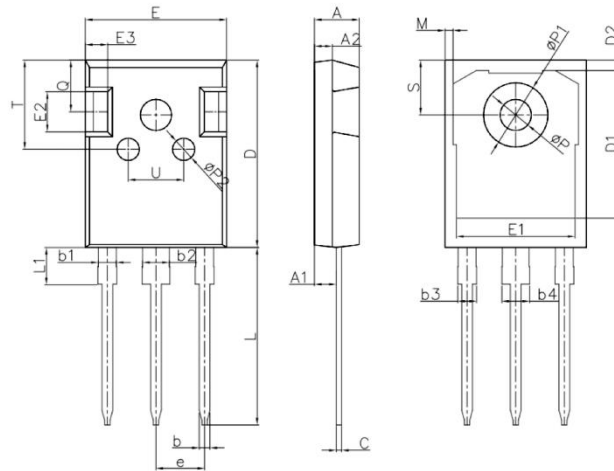


Figure 17 Switching Loss vs. Temperature

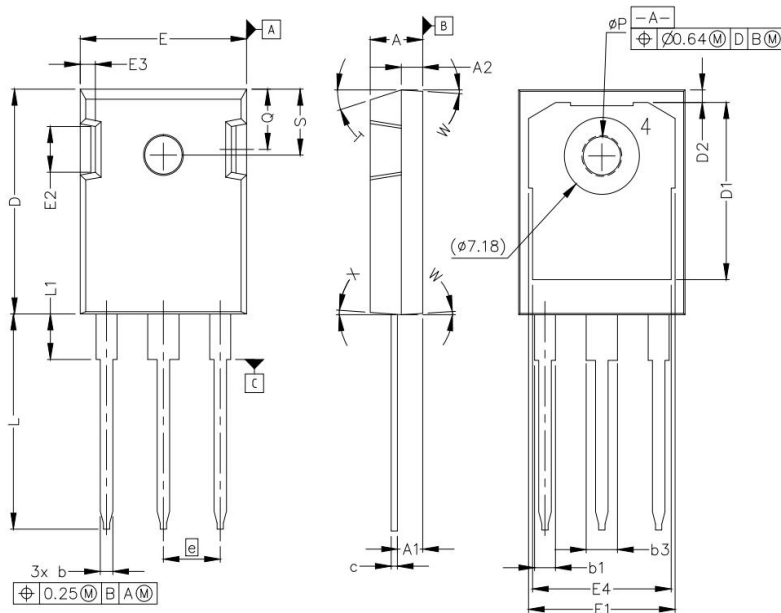


## TO-247-3L(E) Package Information



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |      |
|--------|---------------------------|-------|----------------------|------|
|        | Min.                      | Max.  | Min.                 | Max. |
| A      | 4.90                      | 5.10  | 0.19                 | 0.20 |
| A1     | 2.31                      | 2.51  | 0.09                 | 0.10 |
| A2     | 1.90                      | 2.10  | 0.07                 | 0.08 |
| b      | 1.16                      | 1.26  | 0.05                 | 0.06 |
| b1     | 1.96                      | 2.06  | 0.08                 | 0.09 |
| b2     | 2.96                      | 3.06  | 0.12                 | 0.13 |
| b3     | --                        | 2.25  | --                   | 0.09 |
| b4     | --                        | 3.25  | --                   | 0.13 |
| c      | 0.59                      | 0.66  | 0.02                 | 0.03 |
| D      | 20.90                     | 21.10 | 0.82                 | 0.83 |
| D1     | 16.25                     | 16.85 | 0.64                 | 0.66 |
| D2     | 1.05                      | 1.35  | 0.04                 | 0.05 |
| E      | 15.70                     | 15.90 | 0.62                 | 0.63 |
| E1     | 13.10                     | 13.50 | 0.52                 | 0.53 |
| E2     | 4.40                      | 4.60  | 0.17                 | 0.18 |
| E3     | 2.40                      | 2.60  | 0.09                 | 0.10 |
| e      | 5.436 BSC                 |       | 0.214 BSC            |      |
| L      | 19.80                     | 20.10 | 0.78                 | 0.79 |
| L1     | --                        | 4.30  | --                   | 0.17 |
| M      | 0.35                      | 0.95  | 0.01                 | 0.04 |
| P      | 3.40                      | 3.60  | 0.13                 | 0.14 |
| P1     | 7.00                      | 7.40  | 0.28                 | 0.29 |
| P2     | 2.40                      | 2.60  | 0.09                 | 0.10 |
| Q      | 5.60                      | 6.00  | 0.22                 | 0.24 |
| S      | 6.05                      | 6.25  | 0.24                 | 0.25 |
| T      | 9.80                      | 10.20 | 0.39                 | 0.40 |
| U      | 6.00                      | 6.40  | 0.24                 | 0.25 |

## TO-247-3L(B) Package Information



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |      |
|--------|---------------------------|-------|----------------------|------|
|        | Min.                      | Max.  | Min.                 | Max. |
| A      | 4.83                      | 5.21  | 0.19                 | 0.21 |
| A1     | 2.29                      | 2.54  | 0.09                 | 0.10 |
| A2     | 1.91                      | 2.16  | 0.08                 | 0.09 |
| b      | 1.07                      | 1.33  | 0.04                 | 0.05 |
| b1     | 1.91                      | 2.41  | 0.08                 | 0.10 |
| b3     | 2.87                      | 3.38  | 0.11                 | 0.13 |
| c      | 0.55                      | 0.68  | 0.02                 | 0.03 |
| D      | 20.80                     | 21.10 | 0.82                 | 0.83 |
| D1     | 16.25                     | 17.65 | 0.64                 | 0.70 |
| D2     | 0.95                      | 1.25  | 0.04                 | 0.05 |
| E      | 15.75                     | 16.13 | 0.62                 | 0.64 |
| E1     | 13.10                     | 14.15 | 0.52                 | 0.56 |
| E2     | 3.68                      | 5.10  | 0.15                 | 0.20 |
| E3     | 1.00                      | 1.90  | 0.04                 | 0.08 |
| E4     | 12.38                     | 13.43 | 0.49                 | 0.53 |
| e      | 5.44 BSC                  |       | 0.21 BSC             |      |
| L      | 19.81                     | 20.32 | 0.78                 | 0.80 |
| L1     | 4.10                      | 4.40  | 0.16                 | 0.17 |
| ØP     | 3.51                      | 3.65  | 0.14                 | 0.15 |
| Q      | 5.49                      | 6.00  | 0.22                 | 0.24 |
| S      | 6.04                      | 6.30  | 0.24                 | 0.25 |
| T      | 17.5° REF                 |       |                      |      |
| W      | 3.5° REF                  |       |                      |      |
| X      | 4° REF                    |       |                      |      |

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