

# NGTB40N120S3WG

## IGBT - Ultra Field Stop

This Insulated Gate Bipolar Transistor (IGBT) features a robust and cost effective Ultra Field Stop Trench construction, and provides superior performance in demanding switching applications, offering low switching losses. The IGBT is well suited for applications that require fast switching IGBT with low  $V_F$  diodes, e.g. phase-shifted full bridge, etc. Incorporated into the device is a free wheeling diode with a low forward voltage.

### Features

- Extremely Efficient Trench with Field Stop Technology
- $T_{Jmax} = 175^{\circ}C$
- Low  $V_F$  Reverse Diode
- Optimized for High Speed Switching
- These are Pb-Free Devices

### Typical Applications

- Welding
- Uninterruptible Power Inverter Supplies (UPS)
- Motor Control

### ABSOLUTE MAXIMUM RATINGS

| Rating                                                                                           | Symbol    | Value                | Unit        |
|--------------------------------------------------------------------------------------------------|-----------|----------------------|-------------|
| Collector-emitter voltage                                                                        | $V_{CES}$ | 1200                 | V           |
| Collector current<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                             | $I_C$     | 160<br>40            | A           |
| Pulsed collector current, $T_{pulse}$ limited by $T_{Jmax}$                                      | $I_{CM}$  | 160                  | A           |
| Diode forward current<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                         | $I_F$     | 160<br>40            | A           |
| Diode pulsed current, $T_{pulse}$ limited by $T_{Jmax}$                                          | $I_{FM}$  | 160                  | A           |
| Gate-emitter voltage<br>Transient gate-emitter voltage<br>( $T_{pulse} = 5 \mu s$ , $D < 0.10$ ) | $V_{GE}$  | $\pm 20$<br>$\pm 30$ | V           |
| Power Dissipation<br>@ $T_c = 25^{\circ}C$<br>@ $T_c = 100^{\circ}C$                             | $P_D$     | 454<br>227           | W           |
| Operating junction temperature range                                                             | $T_J$     | $-55$ to $+175$      | $^{\circ}C$ |
| Storage temperature range                                                                        | $T_{stg}$ | $-55$ to $+175$      | $^{\circ}C$ |
| Lead temperature for soldering, 1/8" from case for 10 seconds                                    | $T_{SLD}$ | 260                  | $^{\circ}C$ |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.



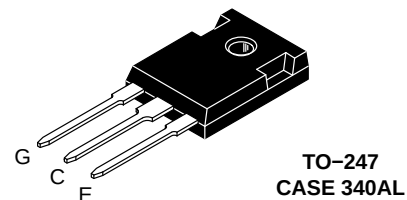
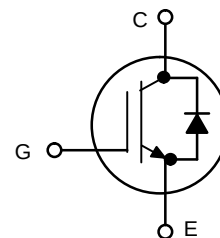
ON Semiconductor®

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40 A, 1200 V

$V_{CEsat} = 1.7 V$

$E_{off} = 1.1 mJ$



### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

| Device         | Package          | Shipping        |
|----------------|------------------|-----------------|
| NGTB40N120S3WG | TO-247 (Pb-Free) | 30 Units / Rail |

# NGTB40N120S3WG

## THERMAL CHARACTERISTICS

| Rating                                         | Symbol          | Value | Unit                 |
|------------------------------------------------|-----------------|-------|----------------------|
| Thermal resistance junction-to-case, for IGBT  | $R_{\theta JC}$ | 0.34  | $^{\circ}\text{C/W}$ |
| Thermal resistance junction-to-case, for Diode | $R_{\theta JC}$ | 0.5   | $^{\circ}\text{C/W}$ |
| Thermal resistance junction-to-ambient         | $R_{\theta JA}$ | 40    | $^{\circ}\text{C/W}$ |

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^{\circ}\text{C}$ unless otherwise specified)

| Parameter | Test Conditions | Symbol | Min | Typ | Max | Unit |
|-----------|-----------------|--------|-----|-----|-----|------|
|-----------|-----------------|--------|-----|-----|-----|------|

### STATIC CHARACTERISTIC

|                                                                   |                                                                                                                           |               |        |            |           |    |
|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------|--------|------------|-----------|----|
| Collector-emitter breakdown voltage, gate-emitter short-circuited | $V_{GE} = 0\text{ V}, I_C = 500\text{ }\mu\text{A}$                                                                       | $V_{(BR)CES}$ | 1200   | –          | –         | V  |
| Collector-emitter saturation voltage                              | $V_{GE} = 15\text{ V}, I_C = 40\text{ A}$<br>$V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 175^{\circ}\text{C}$         | $V_{CEsat}$   | –<br>– | 1.7<br>2.3 | 1.95<br>– | V  |
| Gate-emitter threshold voltage                                    | $V_{GE} = V_{CE}, I_C = 400\text{ }\mu\text{A}$                                                                           | $V_{GE(th)}$  | 4.5    | 5.5        | 6.5       | V  |
| Collector-emitter cut-off current, gate-emitter short-circuited   | $V_{GE} = 0\text{ V}, V_{CE} = 1200\text{ V}$<br>$V_{GE} = 0\text{ V}, V_{CE} = 1200\text{ V}, T_J = 175^{\circ}\text{C}$ | $I_{CES}$     | –<br>– | –<br>0.5   | 0.4<br>–  | mA |
| Gate leakage current, collector-emitter short-circuited           | $V_{GE} = 20\text{ V}, V_{CE} = 0\text{ V}$                                                                               | $I_{GES}$     | –      | –          | 200       | nA |

|                              |                                                                  |           |   |      |   |    |
|------------------------------|------------------------------------------------------------------|-----------|---|------|---|----|
| Input capacitance            | $V_{CE} = 20\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$    | $C_{ies}$ | – | 4912 | – | pF |
| Output capacitance           |                                                                  | $C_{oes}$ | – | 140  | – |    |
| Reverse transfer capacitance |                                                                  | $C_{res}$ | – | 80   | – |    |
| Gate charge total            | $V_{CE} = 600\text{ V}, I_C = 40\text{ A}, V_{GE} = 15\text{ V}$ | $Q_g$     | – | 212  | – | nC |
| Gate to emitter charge       |                                                                  | $Q_{ge}$  | – | 43   | – |    |
| Gate to collector charge     |                                                                  | $Q_{gc}$  | – | 102  | – |    |

### SWITCHING CHARACTERISTIC, INDUCTIVE LOAD

|                         |                                                                                                                                 |              |   |     |   |    |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------|---|-----|---|----|
| Turn-on delay time      | $T_J = 25^{\circ}\text{C}$<br>$V_{CC} = 600\text{ V}, I_C = 40\text{ A}$<br>$R_g = 10\text{ }\Omega$<br>$V_{GE} = 15\text{ V}$  | $t_{d(on)}$  | – | 12  | – | ns |
| Rise time               |                                                                                                                                 | $t_r$        | – | 25  | – |    |
| Turn-off delay time     |                                                                                                                                 | $t_{d(off)}$ | – | 145 | – |    |
| Fall time               |                                                                                                                                 | $t_f$        | – | 107 | – |    |
| Turn-on switching loss  |                                                                                                                                 | $E_{on}$     | – | 2.2 | – | mJ |
| Turn-off switching loss |                                                                                                                                 | $E_{off}$    | – | 1.1 | – |    |
| Total switching loss    |                                                                                                                                 | $E_{ts}$     | – | 3.3 | – |    |
| Turn-on delay time      | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 600\text{ V}, I_C = 40\text{ A}$<br>$R_g = 10\text{ }\Omega$<br>$V_{GE} = 15\text{ V}$ | $t_{d(on)}$  | – | 13  | – | ns |
| Rise time               |                                                                                                                                 | $t_r$        | – | 24  | – |    |
| Turn-off delay time     |                                                                                                                                 | $t_{d(off)}$ | – | 153 | – |    |
| Fall time               |                                                                                                                                 | $t_f$        | – | 173 | – |    |
| Turn-on switching loss  |                                                                                                                                 | $E_{on}$     | – | 2.8 | – | mJ |
| Turn-off switching loss |                                                                                                                                 | $E_{off}$    | – | 1.6 | – |    |
| Total switching loss    |                                                                                                                                 | $E_{ts}$     | – | 4.4 | – |    |

### DIODE CHARACTERISTIC

|                                                                  |                                                                                                                 |               |        |             |          |                        |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------|--------|-------------|----------|------------------------|
| Forward voltage                                                  | $V_{GE} = 0\text{ V}, I_F = 40\text{ A}$<br>$V_{GE} = 0\text{ V}, I_F = 40\text{ A}, T_J = 175^{\circ}\text{C}$ | $V_F$         | –<br>– | 2.0<br>2.55 | 2.6<br>– | V                      |
| Reverse recovery time                                            | $T_J = 25^{\circ}\text{C}$<br>$I_F = 40\text{ A}, V_R = 400\text{ V}$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$   | $t_{rr}$      | –      | 163         | –        | ns                     |
| Reverse recovery charge                                          |                                                                                                                 | $Q_{rr}$      | –      | 2.9         | –        | $\mu\text{C}$          |
| Reverse recovery current                                         |                                                                                                                 | $I_{rrm}$     | –      | 30          | –        | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                 | $dl_{rrm}/dt$ | –      | 137         | –        | $\text{A}/\mu\text{s}$ |

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## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise specified)

| Parameter                                                        | Test Conditions                                                                                                 | Symbol        | Min | Typ | Max | Unit                   |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------|-----|-----|-----|------------------------|
| <b>DIODE CHARACTERISTIC</b>                                      |                                                                                                                 |               |     |     |     |                        |
| Reverse recovery time                                            | $T_J = 175^\circ\text{C}$<br>$I_F = 40\text{ A}$ , $V_R = 400\text{ V}$<br>$di_F/dt = 500\text{ A}/\mu\text{s}$ | $t_{rr}$      | –   | 250 | –   | ns                     |
| Reverse recovery charge                                          |                                                                                                                 | $Q_{rr}$      | –   | 5.3 | –   | $\mu\text{C}$          |
| Reverse recovery current                                         |                                                                                                                 | $I_{rrm}$     | –   | 40  | –   | A                      |
| Diode peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                 | $dl_{rrm}/dt$ | –   | 482 | –   | $\text{A}/\mu\text{s}$ |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL CHARACTERISTICS

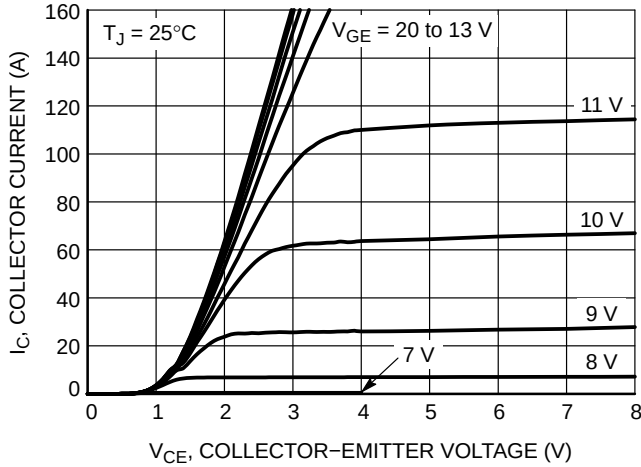


Figure 1. Output Characteristics

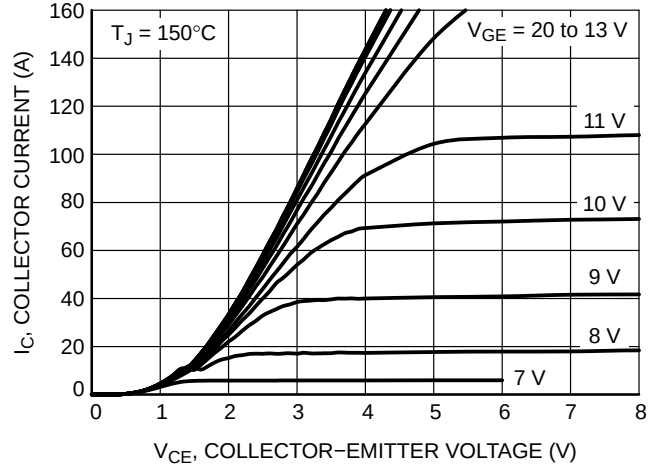


Figure 2. Output Characteristics

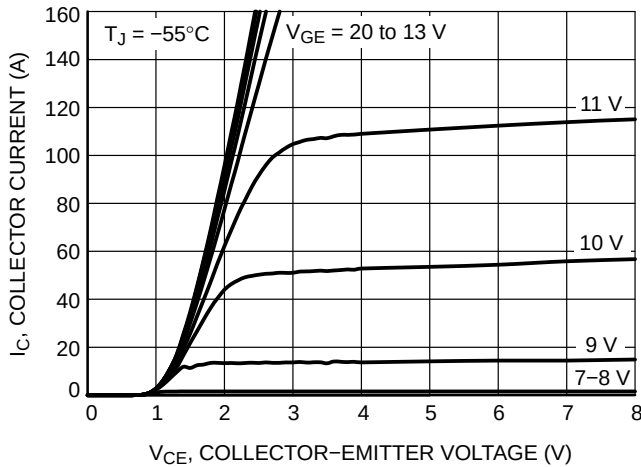


Figure 3. Output Characteristics

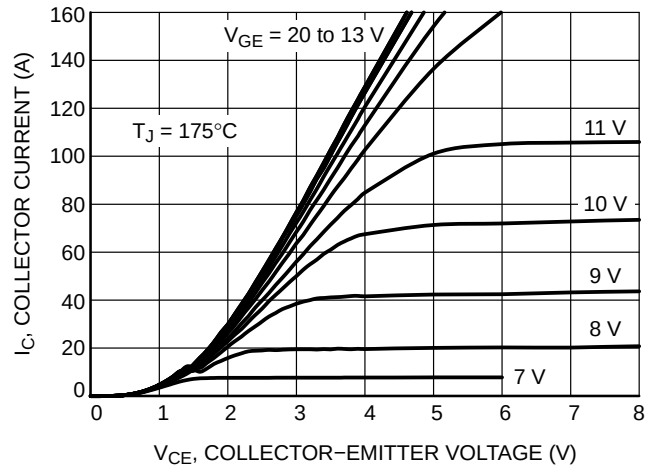


Figure 4. Output Characteristics

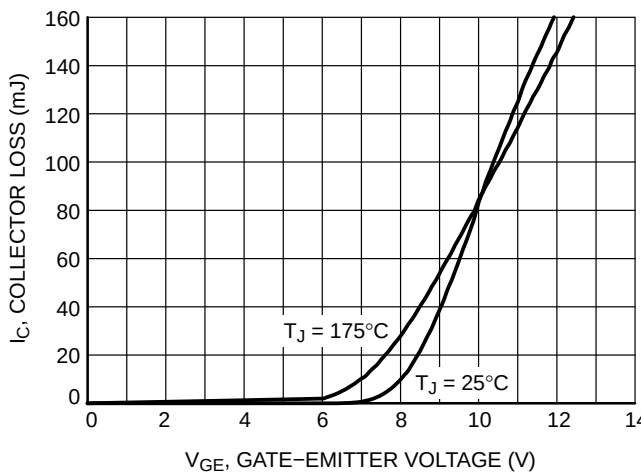


Figure 5. Typical Transfer Characteristics

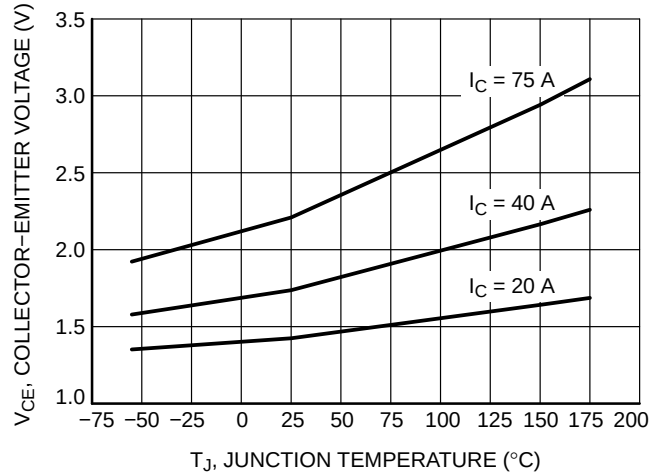


Figure 6.  $V_{CE(sat)}$  vs.  $T_J$

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## TYPICAL CHARACTERISTICS

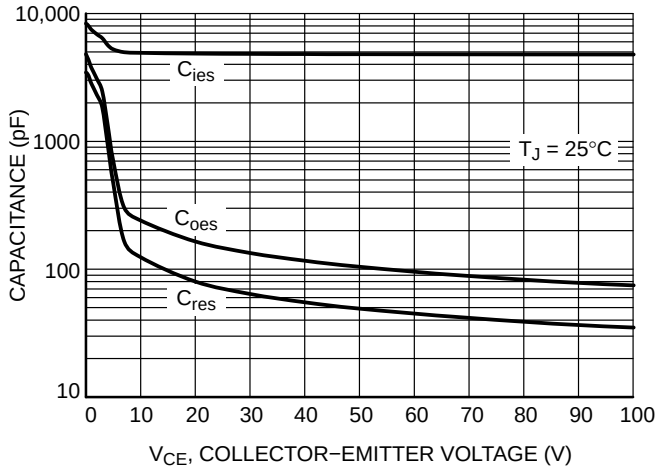


Figure 7. Typical Capacitance

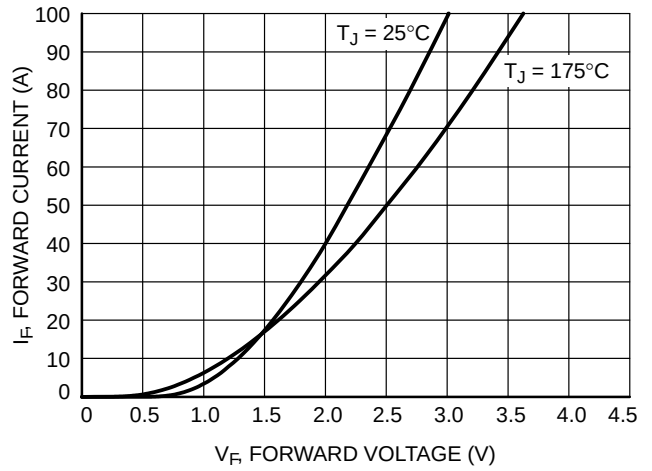


Figure 8. Diode Forward Characteristics

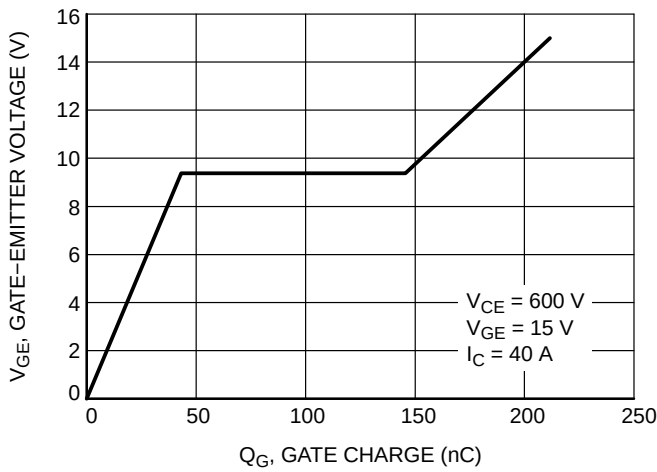


Figure 9. Typical Gate Charge

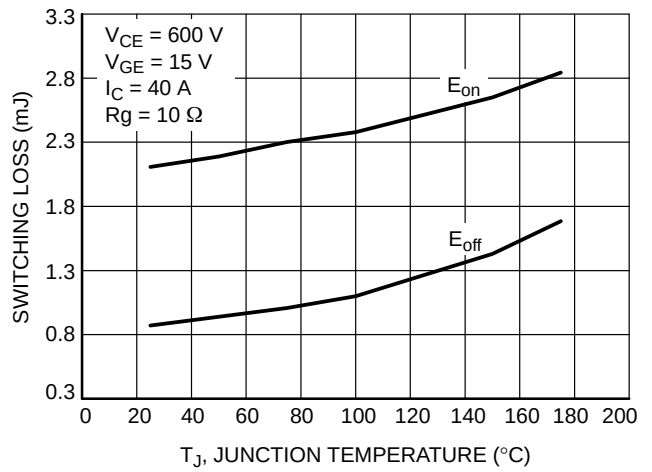


Figure 10. Switching Loss vs. Temperature

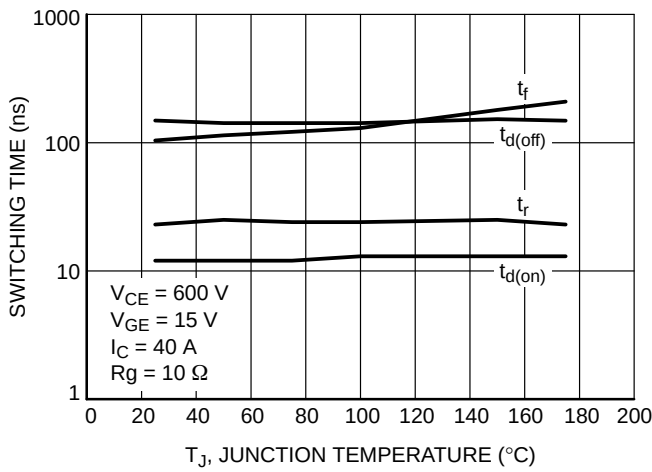


Figure 11. Switching Loss vs. Temperature

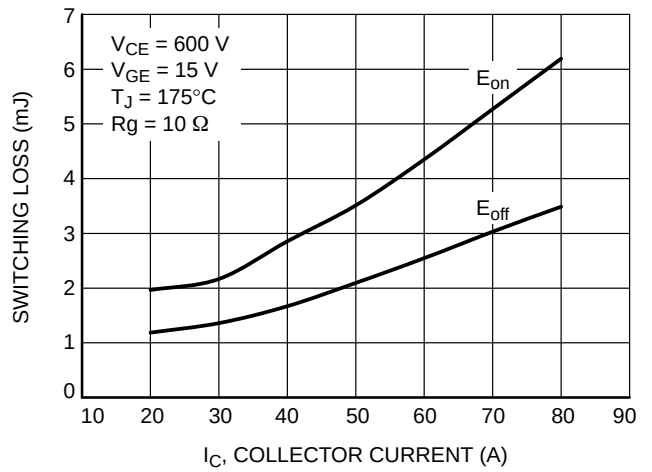


Figure 12. Switching Loss vs.  $I_C$

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## TYPICAL CHARACTERISTICS

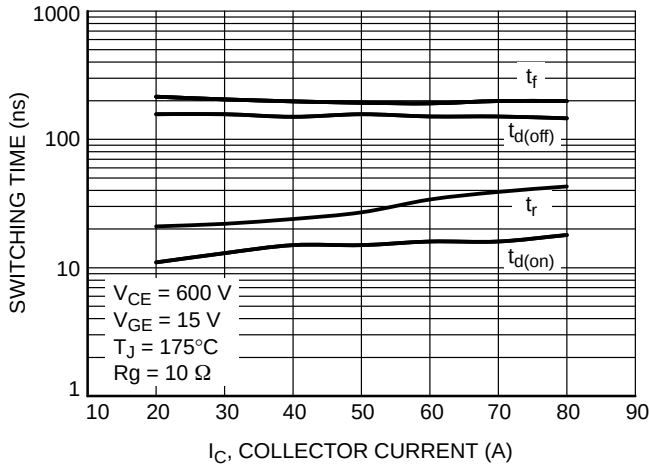


Figure 13. Switching Time vs.  $I_C$

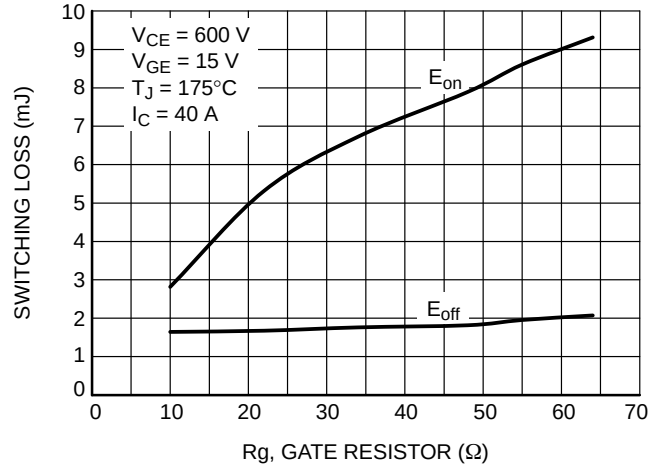


Figure 14. Switching Loss vs.  $R_G$

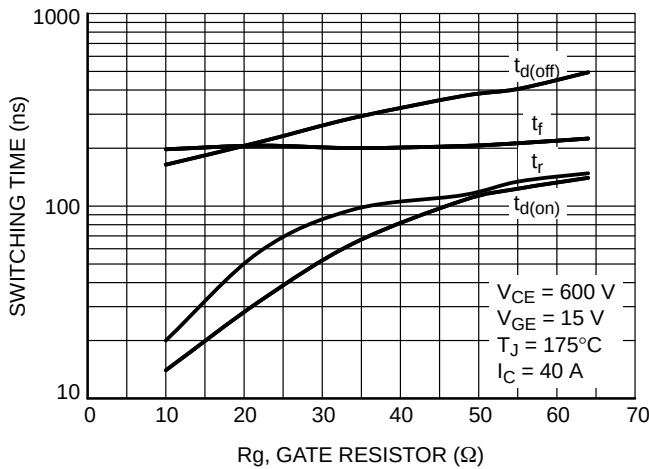


Figure 15. Switching Time vs.  $R_G$

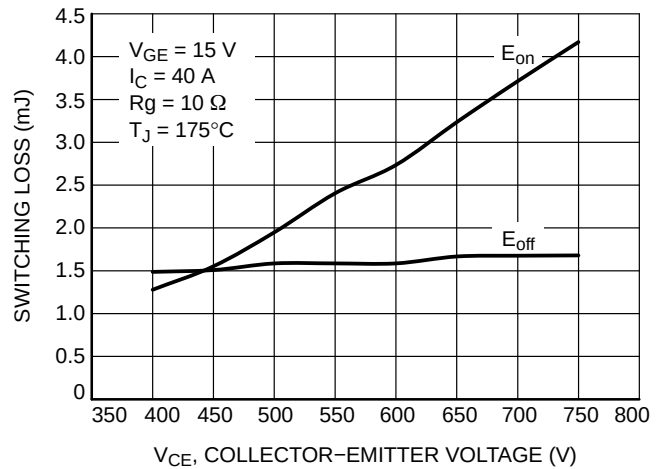


Figure 16. Switching Loss vs.  $V_{CE}$

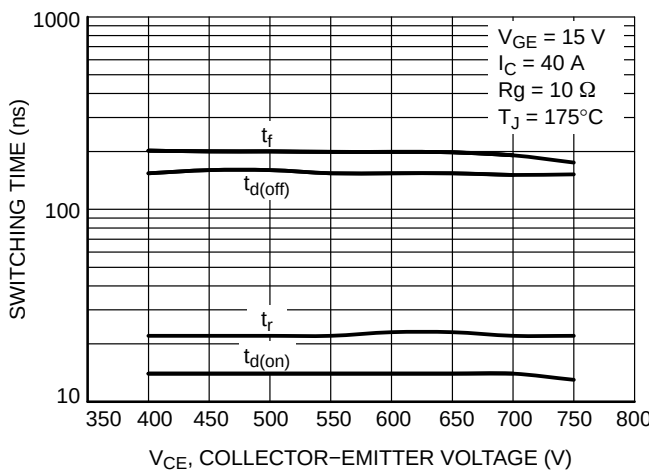


Figure 17. Switching Time vs.  $V_{CE}$

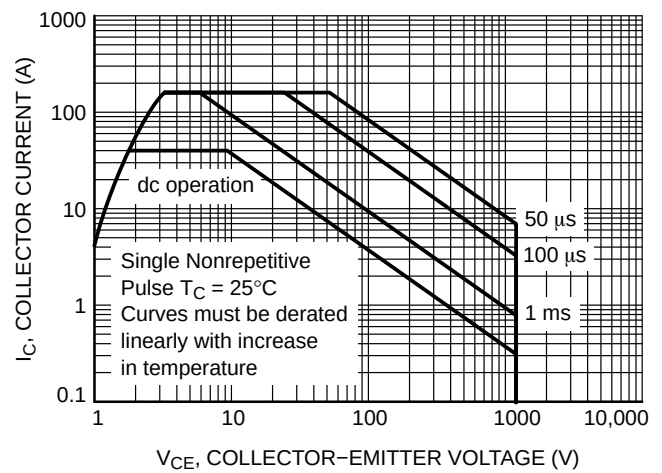


Figure 18. Safe Operating Area

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## TYPICAL CHARACTERISTICS

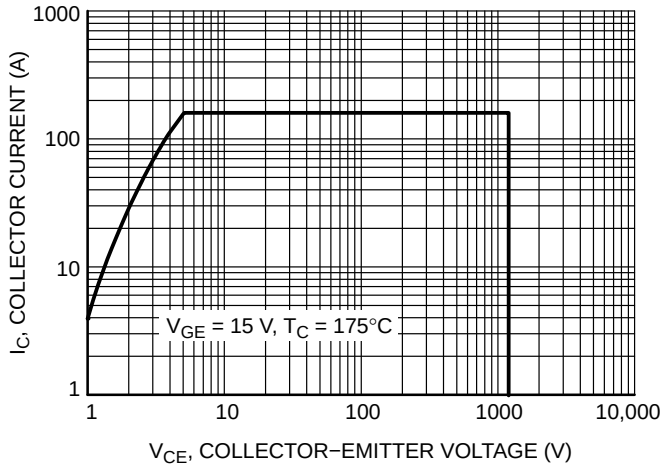


Figure 19. Reverse Bias Safe Operating Area

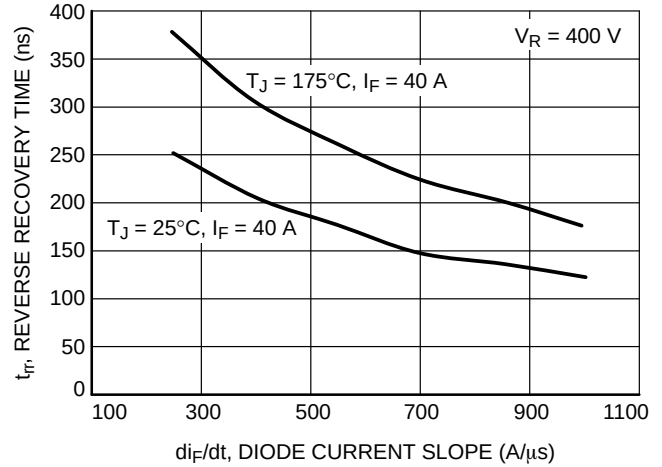


Figure 20.  $t_{rr}$  vs.  $di_F/dt$

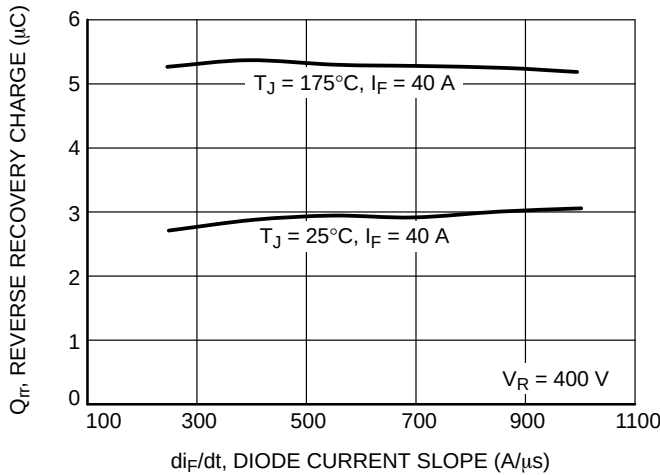


Figure 21.  $Q_{rr}$  vs.  $di_F/dt$

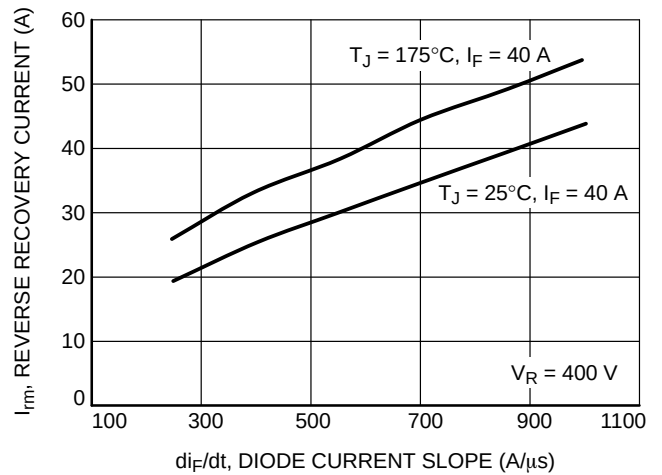


Figure 22.  $I_{rm}$  vs.  $di_F/dt$

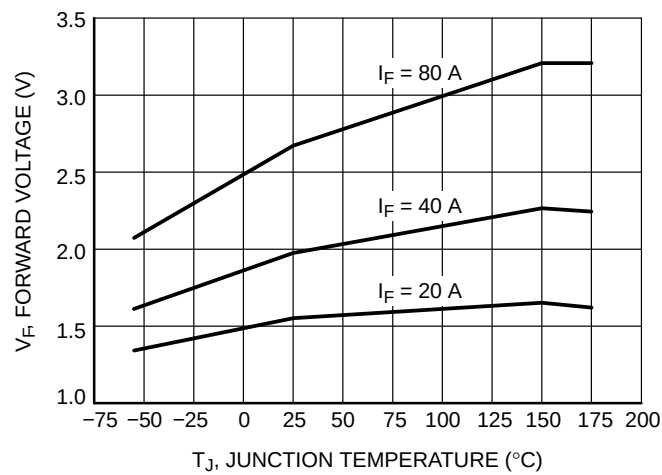
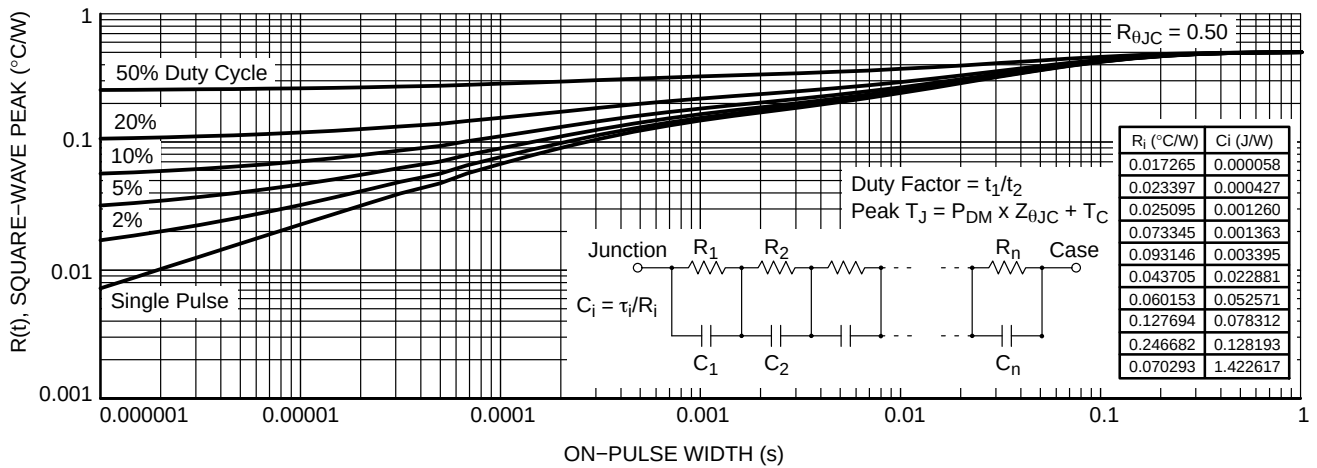
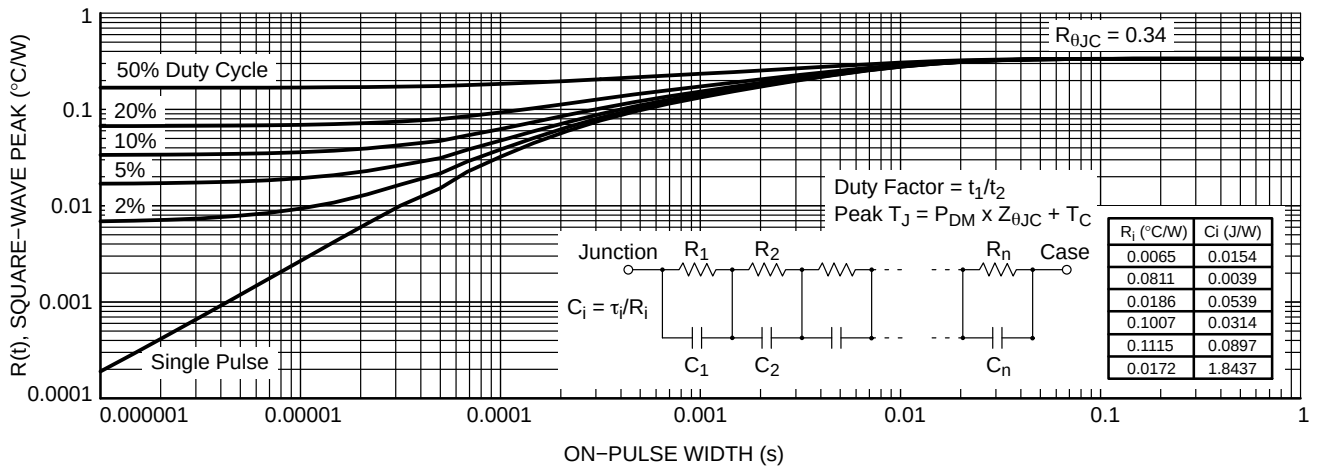
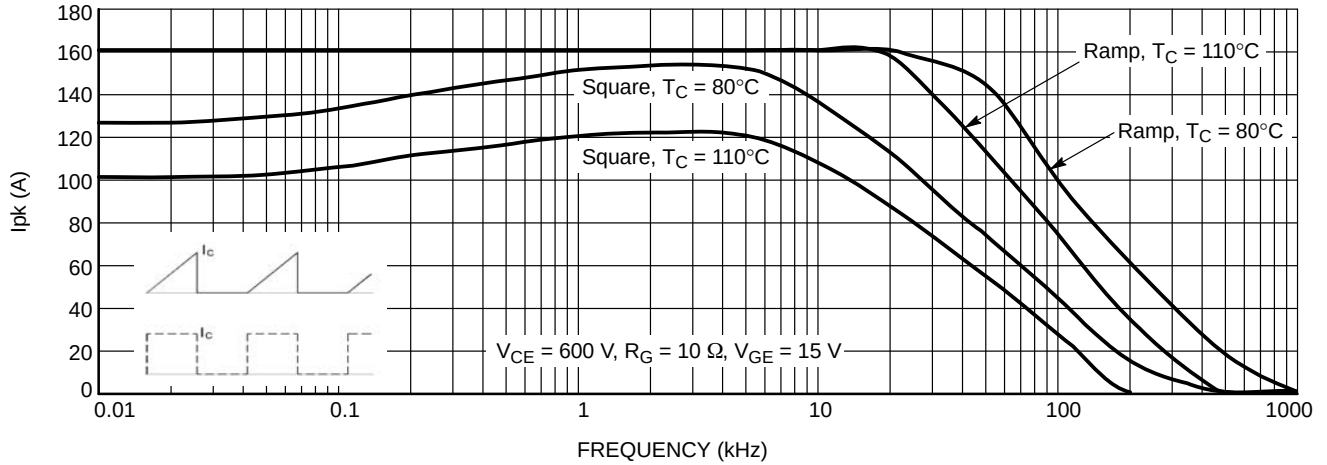


Figure 23.  $V_F$  vs.  $T_J$

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## TYPICAL CHARACTERISTICS





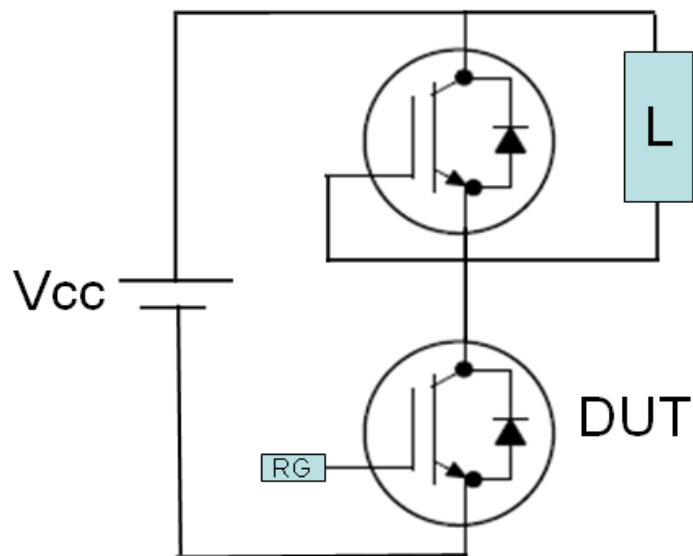


Figure 27. Test Circuit for Switching Characteristics

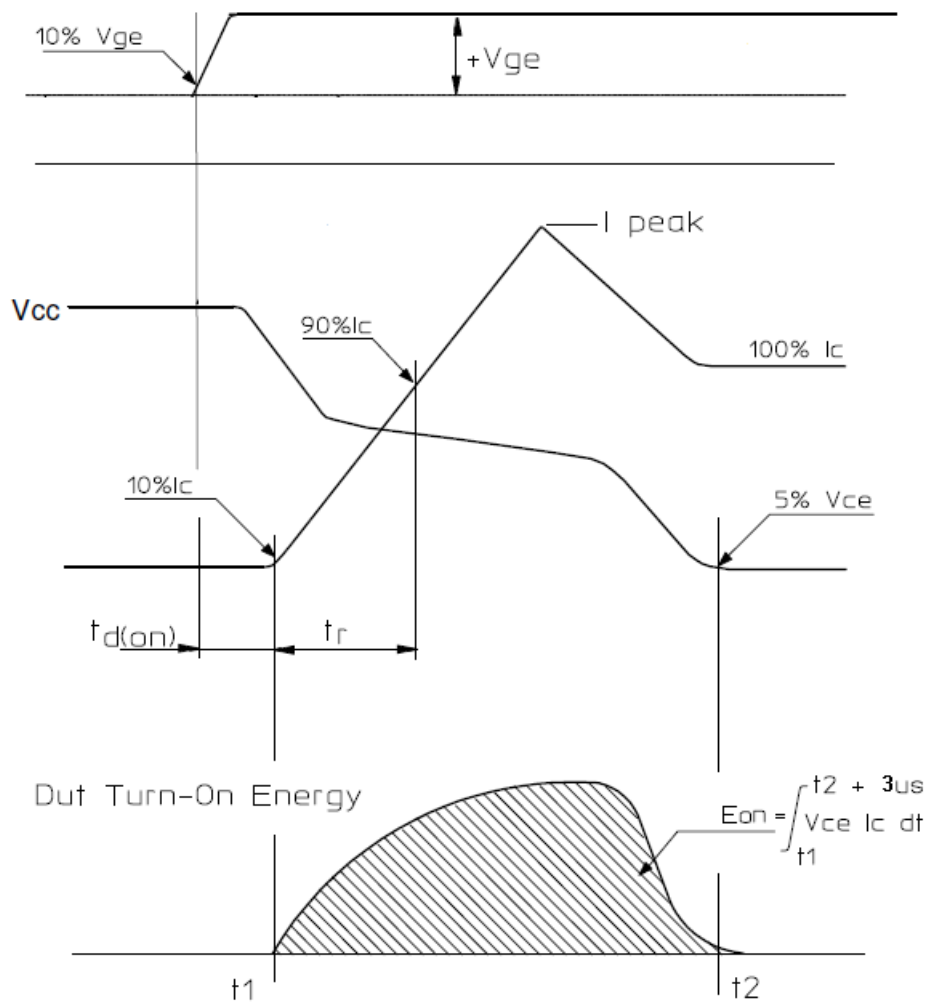


Figure 28. Definition of Turn On Waveform

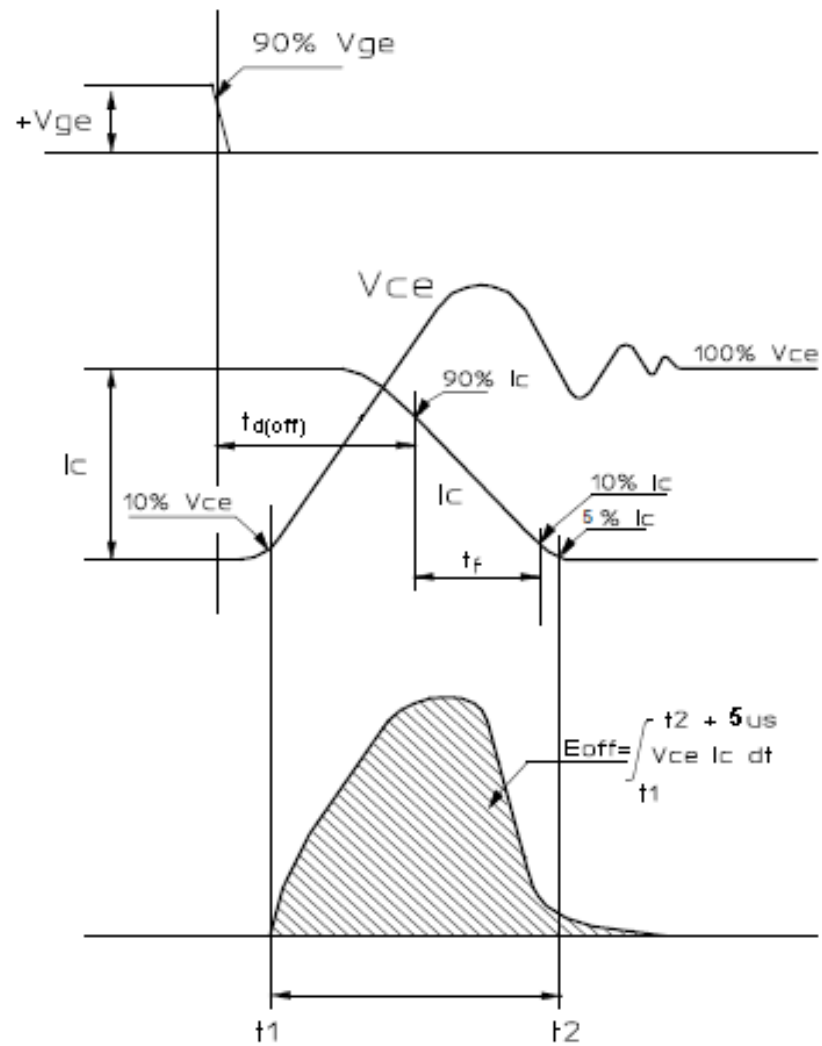
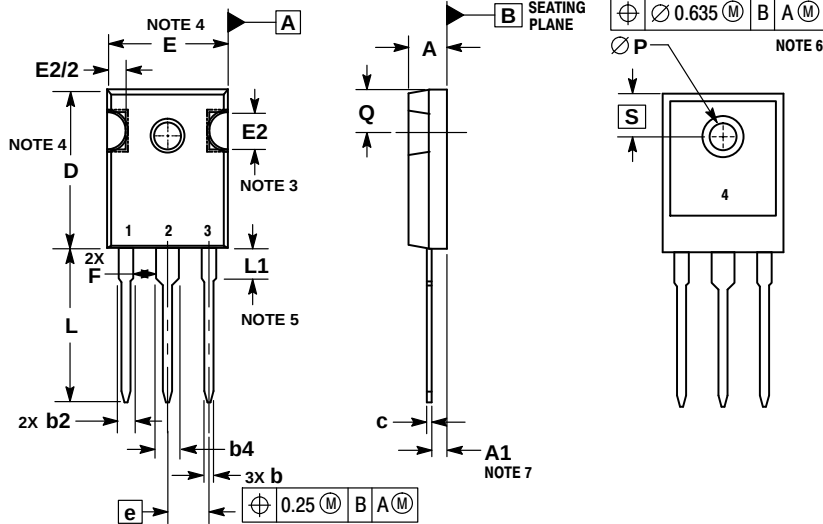


Figure 29. Definition of Turn Off Waveform

# NGTB40N120S3WG

## PACKAGE DIMENSIONS

### TO-247 CASE 340AL ISSUE D



#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. SLOT REQUIRED, NOTCH MAY BE ROUNDED.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.13 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREME OF THE PLASTIC BODY.
5. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.
6. ØP SHALL HAVE A MAXIMUM DRAFT ANGLE OF 1.5° TO THE TOP OF THE PART WITH A MAXIMUM DIAMETER OF 3.91.
7. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.

| DIM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 4.70        | 5.30  |
| A1  | 2.20        | 2.60  |
| b   | 1.07        | 1.33  |
| b2  | 1.65        | 2.35  |
| b4  | 2.60        | 3.40  |
| c   | 0.45        | 0.68  |
| D   | 20.80       | 21.34 |
| E   | 15.50       | 16.25 |
| E2  | 4.32        | 5.49  |
| e   | 5.45 BSC    |       |
| F   | 2.655       | ---   |
| L   | 19.80       | 20.80 |
| L1  | 3.81        | 4.32  |
| P   | 3.55        | 3.65  |
| Q   | 5.40        | 6.20  |
| S   | 6.15 BSC    |       |

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