

# BU323Z

## NPN Silicon Power Darlington

### High Voltage Autoprotected

The BU323Z is a planar, monolithic, high-voltage power Darlington with a built-in active zener clamping circuit. This device is specifically designed for unclamped, inductive applications such as Electronic Ignition, Switching Regulators and Motor Control, and exhibit the following main features:

#### Features

- Integrated High-Voltage Active Clamp
- Tight Clamping Voltage Window (350 V to 450 V) Guaranteed Over the  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  Temperature Range
- Clamping Energy Capability 100% Tested in a Live Ignition Circuit
- High DC Current Gain/Low Saturation Voltages Specified Over Full Temperature Range
- Design Guarantees Operation in SOA at All Times
- Offered in Plastic SOT-93/TO-218 Type or TO-220 Packages
- Pb-Free Packages are Available\*

#### MAXIMUM RATINGS

| Rating                                                                                             | Symbol                            | Max             | Unit                       |
|----------------------------------------------------------------------------------------------------|-----------------------------------|-----------------|----------------------------|
| Collector-Emitter Sustaining Voltage                                                               | $V_{\text{CEO}}$                  | 350             | Vdc                        |
| Collector-Emitter Voltage                                                                          | $V_{\text{EBO}}$                  | 6.0             | Vdc                        |
| Collector Current<br>– Continuous<br>– Peak                                                        | $I_{\text{C}}$<br>$I_{\text{CM}}$ | 10<br>20        | Adc                        |
| Base Current<br>– Continuous<br>– Peak                                                             | $I_{\text{B}}$<br>$I_{\text{BM}}$ | 3.0<br>6.0      | Adc                        |
| Total Power Dissipation @ $T_{\text{C}} = 25^{\circ}\text{C}$<br>Derate above $25^{\circ}\text{C}$ | $P_{\text{D}}$                    | 150<br>1.0      | W<br>W/ $^{\circ}\text{C}$ |
| Operating and Storage Junction Temperature Range                                                   | $T_{\text{J}}, T_{\text{stg}}$    | $-65$ to $+175$ | $^{\circ}\text{C}$         |

#### THERMAL CHARACTERISTICS

| Characteristic                                                                | Symbol                | Max | Unit                        |
|-------------------------------------------------------------------------------|-----------------------|-----|-----------------------------|
| Thermal Resistance, Junction-to-Case                                          | $R_{\theta\text{JC}}$ | 1.0 | $^{\circ}\text{C}/\text{W}$ |
| Maximum Lead Temperature for Soldering Purposes: 1/8" from Case for 5 Seconds | $T_{\text{L}}$        | 260 | $^{\circ}\text{C}$          |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

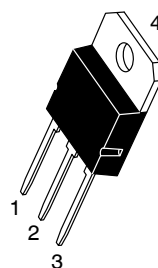
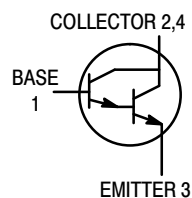
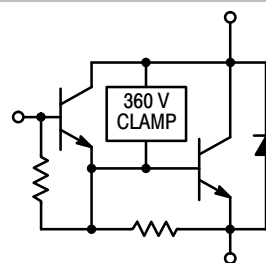
\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



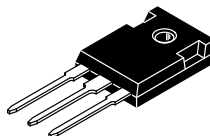
ON Semiconductor®

<http://onsemi.com>

### 10 AMPERE DARLINGTON AUTOPROTECTED 360 – 450 VOLTS CLAMP, 150 WATTS



SOT-93  
CASE 340D  
STYLE 1



TO-247  
CASE 340L  
STYLE 3

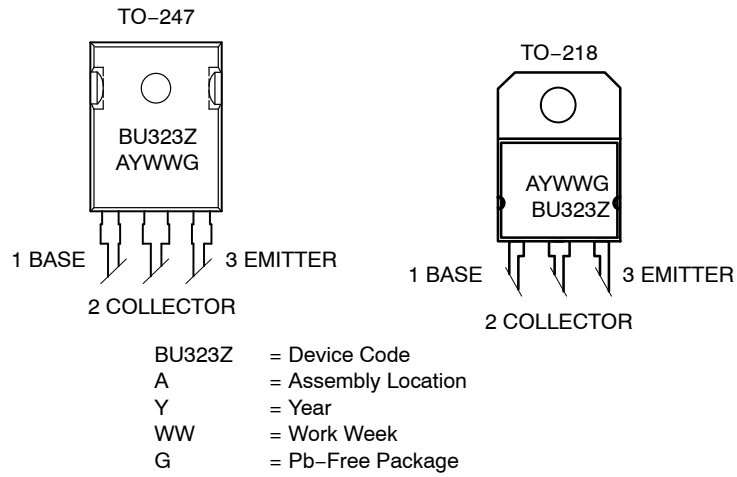
**NOTE: Effective June 2012 this device will be available only in the TO-247 package. Reference FPCN# 16827.**

#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

# BU323Z

## MARKING DIAGRAMS



## ORDERING INFORMATION

| Device Order Number | Package Type        | Shipping        |
|---------------------|---------------------|-----------------|
| BU323ZG             | TO-218<br>(Pb-Free) | 30 Units / Rail |
| BU323ZG             | TO-247<br>(Pb-Free) | 30 Units / Rail |

# BU323Z

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

### OFF CHARACTERISTICS (1)

|                                                                                                                      |             |     |   |     |                 |
|----------------------------------------------------------------------------------------------------------------------|-------------|-----|---|-----|-----------------|
| Collector–Emitter Clamping Voltage ( $I_C = 7.0\text{ A}$ )<br>( $T_C = -40^\circ\text{C}$ to $+125^\circ\text{C}$ ) | $V_{CLAMP}$ | 350 | – | 450 | Vdc             |
| Collector–Emitter Cutoff Current<br>( $V_{CE} = 200\text{ V}$ , $I_B = 0$ )                                          | $I_{CEO}$   | –   | – | 100 | $\mu\text{Adc}$ |
| Emitter–Base Leakage Current<br>( $V_{EB} = 6.0\text{ Vdc}$ , $I_C = 0$ )                                            | $I_{EBO}$   | –   | – | 50  | mAdc            |

### ON CHARACTERISTICS (1)

|                                                                                                                                                                                                                   |               |                  |                  |                                 |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------|------------------|---------------------------------|-----|
| Base–Emitter Saturation Voltage<br>( $I_C = 8.0\text{ Adc}$ , $I_B = 100\text{ mAdc}$ )<br>( $I_C = 10\text{ Adc}$ , $I_B = 0.25\text{ Adc}$ )                                                                    | $V_{BE(sat)}$ | –<br>–           | –<br>–           | 2.2<br>2.5                      | Vdc |
| Collector–Emitter Saturation Voltage<br>( $I_C = 7.0\text{ Adc}$ , $I_B = 70\text{ mAdc}$ )<br><br>( $I_C = 8.0\text{ Adc}$ , $I_B = 0.1\text{ Adc}$ )<br><br>( $I_C = 10\text{ Adc}$ , $I_B = 0.25\text{ Adc}$ ) | $V_{CE(sat)}$ | –<br>–<br>–<br>– | –<br>–<br>–<br>– | 1.6<br>1.8<br>1.8<br>2.1<br>1.7 | Vdc |
| Base–Emitter On Voltage<br>( $I_C = 5.0\text{ Adc}$ , $V_{CE} = 2.0\text{ Vdc}$ )<br>( $I_C = 8.0\text{ Adc}$ , $V_{CE} = 2.0\text{ Vdc}$ )                                                                       | $V_{BE(on)}$  | 1.1<br>1.3       | –<br>–           | 2.1<br>2.3                      | Vdc |
| Diode Forward Voltage Drop<br>( $I_F = 10\text{ Adc}$ )                                                                                                                                                           | $V_F$         | –                | –                | 2.5                             | Vdc |
| DC Current Gain<br>( $I_C = 6.5\text{ Adc}$ , $V_{CE} = 1.5\text{ Vdc}$ )<br>( $I_C = 5.0\text{ Adc}$ , $V_{CE} = 4.6\text{ Vdc}$ )                                                                               | $h_{FE}$      | 150<br>500       | –<br>–           | –<br>3400                       | –   |

### DYNAMIC CHARACTERISTICS

|                                                                                                        |          |   |   |     |     |
|--------------------------------------------------------------------------------------------------------|----------|---|---|-----|-----|
| Current Gain Bandwidth<br>( $I_C = 0.2\text{ Adc}$ , $V_{CE} = 10\text{ Vdc}$ , $f = 1.0\text{ MHz}$ ) | $f_T$    | – | – | 2.0 | MHz |
| Output Capacitance<br>( $V_{CB} = 10\text{ Vdc}$ , $I_E = 0$ , $f = 1.0\text{ MHz}$ )                  | $C_{ob}$ | – | – | 200 | pF  |
| Input Capacitance<br>( $V_{EB} = 6.0\text{ V}$ )                                                       | $C_{ib}$ | – | – | 550 | pF  |

### CLAMPING ENERGY (see notes)

|                                                                                                                                                            |             |     |   |   |    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|---|---|----|
| Repetitive Non–Destructive Energy Dissipated at turn–off:<br>( $I_C = 7.0\text{ A}$ , $L = 8.0\text{ mH}$ , $R_{BE} = 100\ \Omega$ ) (see Figures 2 and 4) | $W_{CLAMP}$ | 200 | – | – | mJ |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|---|---|----|

### SWITCHING CHARACTERISTICS: Inductive Load ( $L = 10\text{ mH}$ )

|                 |                                                                                                                                                 |          |   |     |    |               |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------|---|-----|----|---------------|
| Fall Time       | $(I_C = 6.5\text{ A}$ , $I_{B1} = 45\text{ mA}$ ,<br>$V_{BE(off)} = 0$ , $R_{BE(off)} = 0$ ,<br>$V_{CC} = 14\text{ V}$ , $V_Z = 300\text{ V}$ ) | $t_{fi}$ | – | 625 | –  | ns            |
| Storage Time    |                                                                                                                                                 | $t_{si}$ | – | 10  | 30 | $\mu\text{s}$ |
| Cross–over Time |                                                                                                                                                 | $t_c$    | – | 1.7 | –  | $\mu\text{s}$ |

1. Pulse Test: Pulse Width  $\leq 300\ \mu\text{s}$ , Duty Cycle = 2.0%.

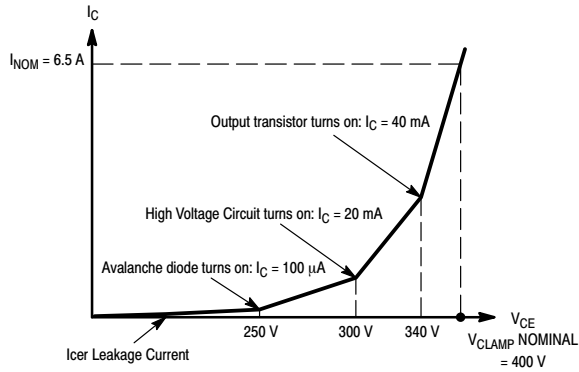


Figure 1.  $I_C = f(V_{CE})$  Curve Shape

By design, the BU323Z has a built-in avalanche diode and a special high voltage driving circuit. During an auto-protect cycle, the transistor is turned on again as soon as a voltage, determined by the zener threshold and the network, is reached. This prevents the transistor from going into a Reverse Bias Operating limit condition. Therefore, the device will have an extended safe operating area and will always appear to be in "FBSOA." Because of the built-in zener and associated network, the  $I_C = f(V_{CE})$  curve exhibits an unfamiliar shape compared to standard products as shown in Figure 1.

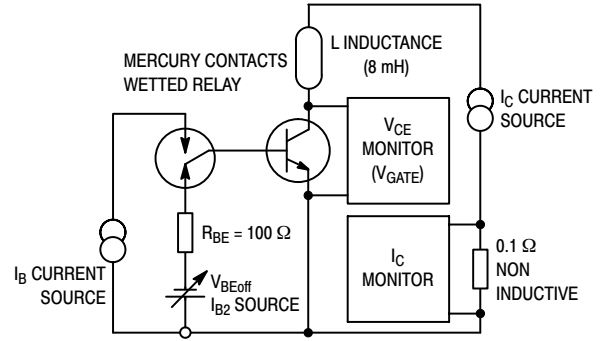


Figure 2. Basic Energy Test Circuit

The bias parameters,  $V_{CLAMP}$ ,  $I_{B1}$ ,  $V_{BE(off)}$ ,  $I_{B2}$ ,  $I_C$ , and the inductance, are applied according to the Device Under Test (DUT) specifications.  $V_{CE}$  and  $I_C$  are monitored by the test system while making sure the load line remains within the limits as described in Figure 4.

Note: All BU323Z ignition devices are 100% energy tested, per the test circuit and criteria described in Figures 2 and 4, to the minimum guaranteed repetitive energy, as specified in the device parameter section. The device can sustain this energy on a repetitive basis without degrading any of the specified electrical characteristics of the devices. The units under test are kept functional during the complete test sequence for the test conditions described:

$I_{C(peak)} = 7.0$  A,  $I_{CH} = 5.0$  A,  $I_{CL} = 100$  mA,  $I_B = 100$  mA,  $R_{BE} = 100$  Ω,  $V_{gate} = 280$  V,  $L = 8.0$  mH

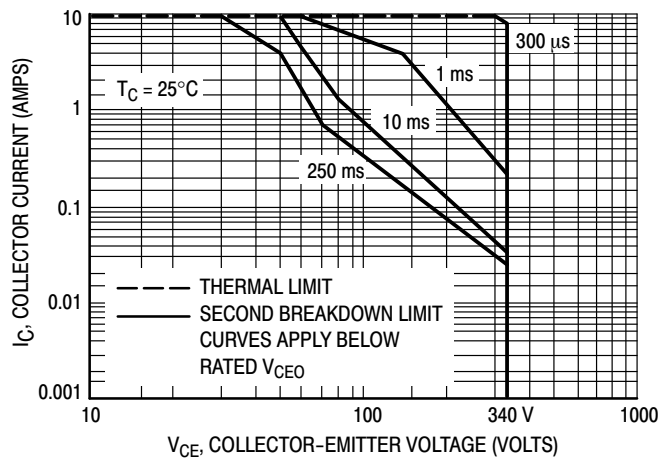
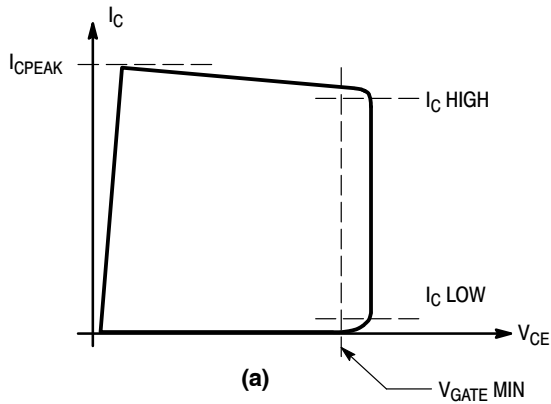
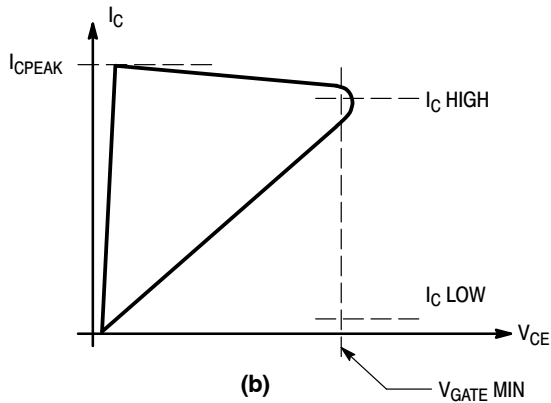


Figure 3. Forward Bias Safe Operating Area

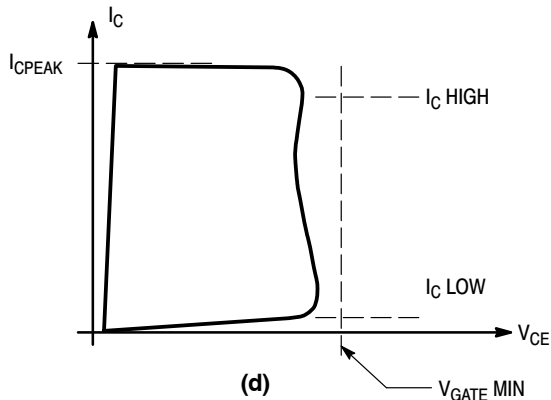
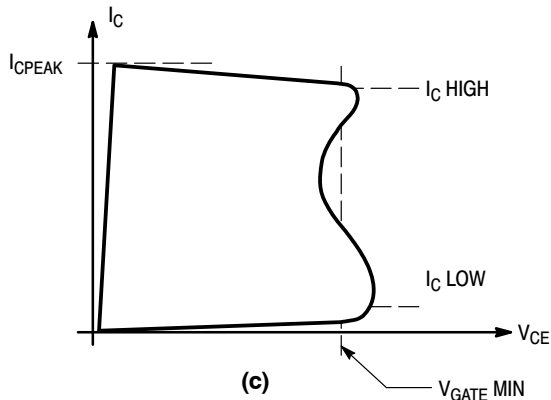


The shaded area represents the amount of energy the device can sustain, under given DC biases ( $I_C/I_B/V_{BE(off)}/R_{BE}$ ), without an external clamp; see the test schematic diagram, Figure 2.

The transistor **PASSES** the Energy test if, for the inductive load and  $I_{CPEAK}/I_B/V_{BE(off)}$  biases, the  $V_{CE}$  remains outside the shaded area and greater than the  $V_{GATE}$  minimum limit, Figure 4a.



The transistor **FAILS** if the  $V_{CE}$  is less than the  $V_{GATE}$  (minimum limit) at any point along the  $V_{CE}/I_C$  curve as shown on Figures 4b, and 4c. This assures that hot spots and uncontrolled avalanche are not being generated in the die, and the transistor is not damaged, thus enabling the sustained energy level required.



The transistor **FAILS** if its Collector/Emitter breakdown voltage is less than the  $V_{GATE}$  value, Figure 4d.

Figure 4. Energy Test Criteria for BU323Z

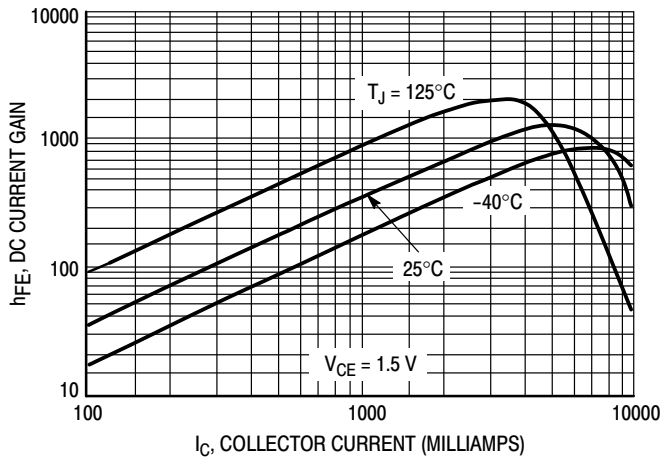


Figure 5. DC Current Gain

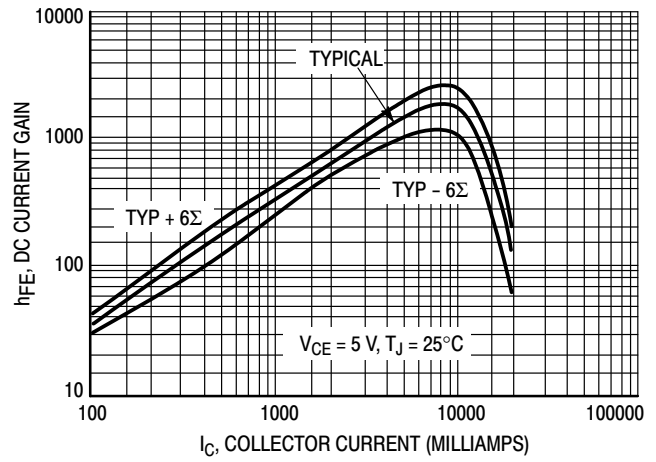


Figure 6. DC Current Gain

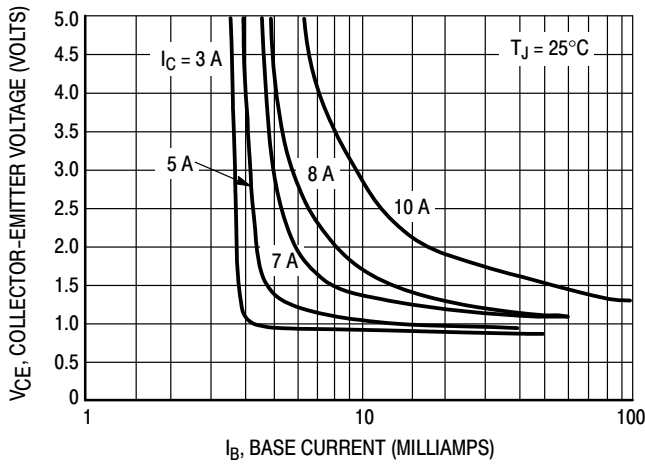


Figure 7. Collector Saturation Region

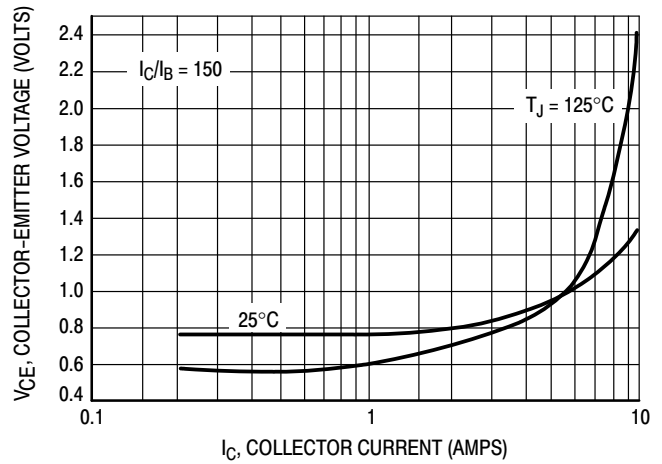


Figure 8. Collector-Emmitter Saturation Voltage

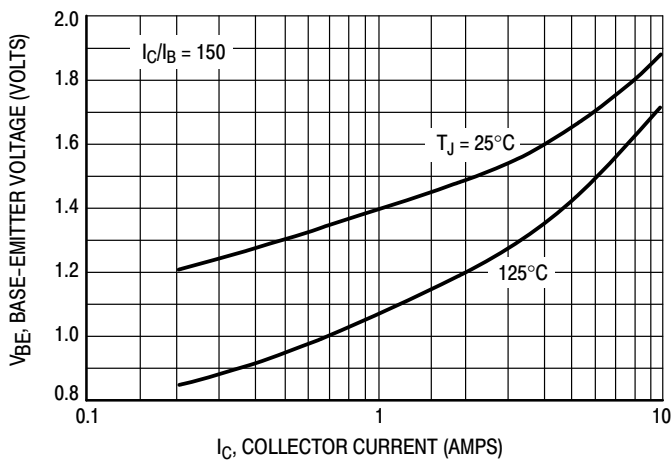


Figure 9. Base-Emmitter Saturation Voltage

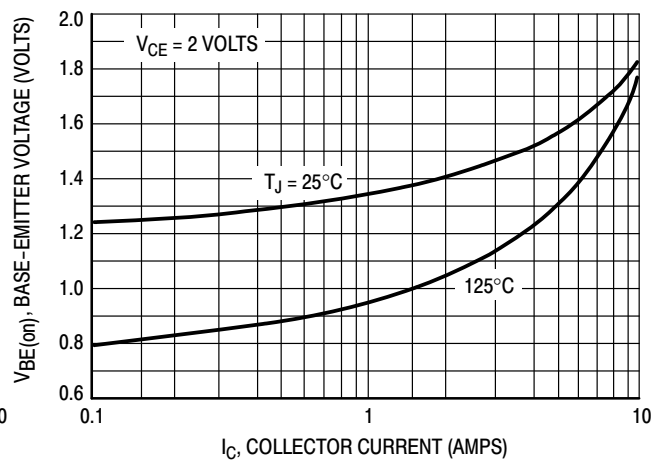


Figure 10. Base-Emmitter "ON" Voltages

# MECHANICAL CASE OUTLINE

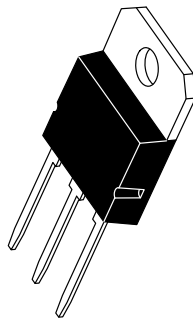
## PACKAGE DIMENSIONS

ON Semiconductor®

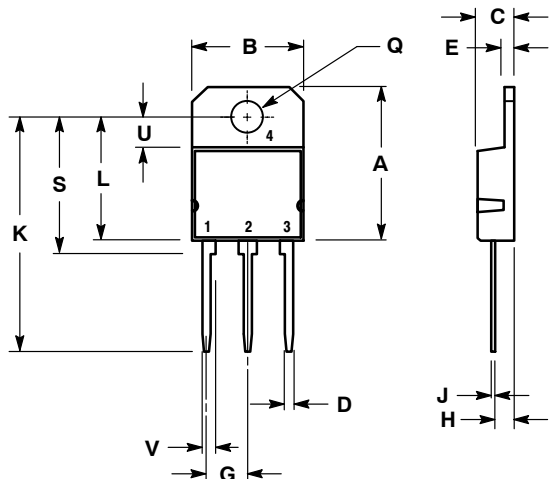


### SOT-93 (TO-218) CASE 340D-02 ISSUE E

DATE 01/03/2002



SCALE 1:1



STYLE 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

STYLE 2:  
PIN 1. ANODE  
2. CATHODE  
3. ANODE  
4. CATHODE

- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | ---         | 20.35 | ---       | 0.801 |
| B   | 14.70       | 15.20 | 0.579     | 0.598 |
| C   | 4.70        | 4.90  | 0.185     | 0.193 |
| D   | 1.10        | 1.30  | 0.043     | 0.051 |
| E   | 1.17        | 1.37  | 0.046     | 0.054 |
| G   | 5.40        | 5.55  | 0.213     | 0.219 |
| H   | 2.00        | 3.00  | 0.079     | 0.118 |
| J   | 0.50        | 0.78  | 0.020     | 0.031 |
| K   | 31.00 REF   |       | 1.220 REF |       |
| L   | ---         | 16.20 | ---       | 0.638 |
| Q   | 4.00        | 4.10  | 0.158     | 0.161 |
| S   | 17.80       | 18.20 | 0.701     | 0.717 |
| U   | 4.00 REF    |       | 0.157 REF |       |
| V   | 1.75 REF    |       | 0.069     |       |

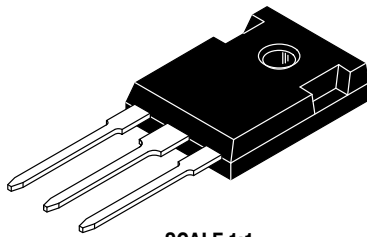
### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
xxxxx = Device Code

|                  |             |                                                                                                                                                                                     |
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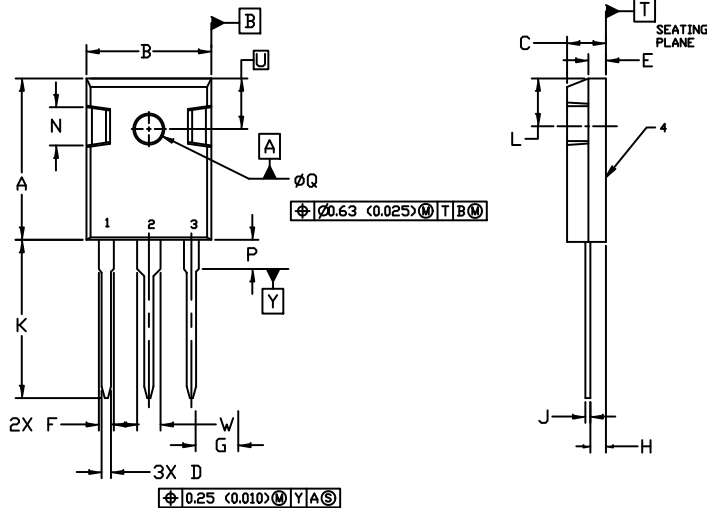
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TO-247  
CASE 340L  
ISSUE G

DATE 06 OCT 2021

SCALE 1:1

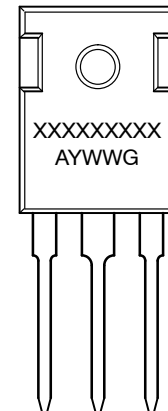


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER

|     | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
| DIM | MIN.        | MAX.  | MIN.      | MAX.  |
| A   | 20.32       | 21.08 | 0.800     | 0.830 |
| B   | 15.75       | 16.26 | 0.620     | 0.640 |
| C   | 4.70        | 5.30  | 0.185     | 0.209 |
| D   | 1.00        | 1.40  | 0.040     | 0.055 |
| E   | 1.90        | 2.60  | 0.075     | 0.102 |
| F   | 1.65        | 2.13  | 0.065     | 0.084 |
| G   | 5.45 BSC    |       | 0.215 BSC |       |
| H   | 1.50        | 2.49  | 0.059     | 0.098 |
| J   | 0.40        | 0.80  | 0.016     | 0.031 |
| K   | 19.81       | 20.83 | 0.780     | 0.820 |
| L   | 5.40        | 6.20  | 0.212     | 0.244 |
| N   | 4.32        | 5.49  | 0.170     | 0.216 |
| P   | ----        | 4.50  | ----      | 0.177 |
| Q   | 3.55        | 3.65  | 0.140     | 0.144 |
| U   | 6.15 BSC    |       | 0.242 BSC |       |
| W   | 2.87        | 3.12  | 0.113     | 0.123 |

GENERIC  
MARKING DIAGRAM\*



|                                                               |                                                                                           |                                                                       |                                                                       |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|
| STYLE 1:<br>PIN 1. GATE<br>2. DRAIN<br>3. SOURCE<br>4. DRAIN  | STYLE 2:<br>PIN 1. ANODE<br>2. CATHODE (S)<br>3. ANODE 2<br>4. CATHODE (S)                | STYLE 3:<br>PIN 1. BASE<br>2. COLLECTOR<br>3. EMITTER<br>4. COLLECTOR | STYLE 4:<br>PIN 1. GATE<br>2. COLLECTOR<br>3. EMITTER<br>4. COLLECTOR |
| STYLE 5:<br>PIN 1. CATHODE<br>2. ANODE<br>3. GATE<br>4. ANODE | STYLE 6:<br>PIN 1. MAIN TERMINAL 1<br>2. MAIN TERMINAL 2<br>3. GATE<br>4. MAIN TERMINAL 2 |                                                                       |                                                                       |

XXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

|                  |             |                                                                                                                                                                                  |
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