# Automotive 1200 V, 450 A Dual Side Cooling Half-Bridge Power Module VE-Trac™ Dual NVG450A120L5DSC

**AHPM15−CEA**
**CASE 100DD**

## Product Description

The NVG450A120L5DSC is a member of the VE−Trac Dual power module family with dual side cooling and compact footprints for Hybrid (HEV) and Electric Vehicle (EV) traction inverter application.

The module consists of two latest 1200 V Ultra Field Stop (UFS) IGBTs in a half−bridge configuration. The chipset utilizes the proven Trench Ultra Field Stop IGBT technology in providing high current density while offering robust short circuit protection and increased blocking voltage. Additionally, UFS IGBT and copacked soft diode deliver a low power loss operation and soft switching simultaneously, which helps to improve overall system efficiency in HEV/EV traction applications.

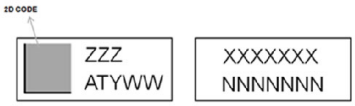
## Features

- Dual−Side Cooling
- Integrated Chip Level Temperature & Current Sensor
- $T_{vj\ max}$ = 175°C
- Low Stray Inductance
- Low Conduction and Switching Losses
- Automotive Grade
- 4.2 kV Isolated DBC Substrate
- This is a Pb−Free Device

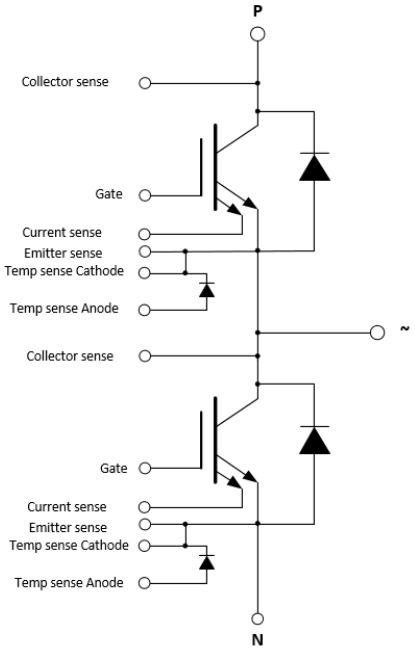
## Typical Applications

- Hybrid and Electric Vehicle Traction Inverter
- High Power DC−DC Converter

## MARKING DIAGRAM



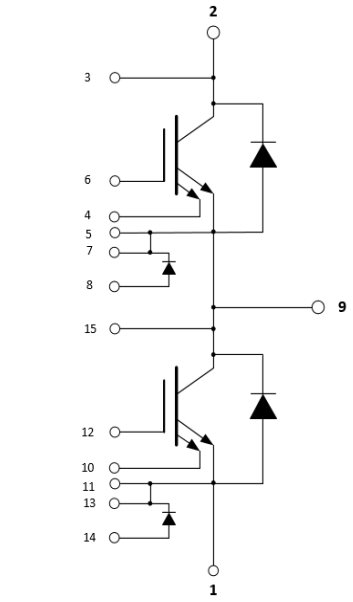

ZZZ = Assembly Lot Code
AT = Assembly & Test Site Code
Y = Year
WW = Work Week
XXXX = Specific Device Code
NNN = Serial Number




## ORDERING INFORMATION

See detailed ordering and shipping information on page 9 of this data sheet.

## PIN DESCRIPTION

| Pin No. | Pin | Description | Pin Arrangement |
|---|---|---|---|
| 1 | N | Low Side Emitter |  |
| 2 | P | High Side Collector | |
| 3 | H/S COLLECTOR SENSE | High Side Collector Sense | |
| 4 | H/S CURRENT SENSE | High Side Current Sense | |
| 5 | H/S EMITTER SENSE | High Side Emitter Sense | |
| 6 | H/S GATE | High Side Gate | |
| 7 | H/S TEMP SENSE (CATHODE) | High Side Temp sense Diode Cathode | |
| 8 | H/S TEMP SENSE (ANODE) | High Side Temp sense Diode Anode | |
| 9 | ~ | Phase Output | |
| 10 | L/S CURRENT SENSE | Low Side Current Sense | |
| 11 | L/S EMITTER SENSE | Low Side Emitter Sense | |
| 12 | L/S GATE | Low Side Gate | |
| 13 | L/S TEMP SENSE (CATHODE) | Low Side Temp sense Diode Cathode | |
| 14 | L/S TEMP SENSE (ANODE) | Low Side Temp sense Diode Anode | |
| 15 | L/S COLLECTOR SENSE | Low Side Collector Sense | |



### DBC Substrate

$Al_2O_3$ isolated substrate, basic isolation, and copper on both sides

### Lead frame

Copper, with tin electro−plating

### Flammability Information

All Power Module packaging materials meet UL flammability rating class 94V−0

## MODULE CHARACTERISTICS

| Symbol | Parameter | Min. | Typ. | Rating / Max. | Unit |
|---|---|---|---|---|---|
| $T_{vj}$ | Continuous Operating Junction Temperature Range | | | −40 to 150 | °C |
| $T_{vj.op}$ | Continuous Operating Junction Temperature Under Switching Conditions | | | −40 to 175 | °C |
| $T_{STG}$ | Storage Temperature Range | | | −40 to 125 | °C |
| $V_{ISO}$ | Isolation Voltage, DC, t = 1 s | | | 4200 | V |
| Creepage | Terminal to Heatsink<br>Terminal to Terminal | | | 6.0 | mm |
| Clearance | Terminal to Heatsink<br>Terminal to Terminal | | | 3.2 | mm |
| CTI | Comparative Tracking Index | | | >600 | |
| | | **Min.** | **Typ.** | **Max.** | |
| $L_{sCE}$ | Stray Inductance | – | – | 8 | nH |
| $R_{CC'+EE'}$ | Module Lead Resistance, Terminals − Chip | – | – | 0.15 | mΩ |
| G | Module Weight | – | – | 72 | g |
| M | M4 Screws for Module Terminals | – | – | 2.2 | Nm |

**ABSOLUTE MAXIMUM RATINGS** ($T_{vj}$ = 25°C, unless otherwise specified)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| **IGBT** | | | |
| $V_{CES}$ | Collector to Emitter Voltage | 1200 | V |
| $V_{GES}$ | Gate to Emitter Voltage | −15/+20 | V |
| $V_{GES\ transient}$ | Gate to Emitter Voltage, Limits under switching conditions | ±20 | V |
| $I_{CN}$ | Implemented Collector Current | 450 | A |
| $I_{C\ nom}$ | Continuous DC Collector Current, Tvjmax = 175°C, $T_F$ = 65°C, Ref. Heatsink | 410 (Note 1) | A |
| $I_{CRM}$ | Pulsed Collector Current @ VGE = 15 V, tp = 1 ms | 900 | A |
| **DIODE** | | | |
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 1200 | V |
| $I_{FN}$ | Implemented Forward Current | 450 | A |
| $I_F$ | Continuous Forward Current, Tvjmax = 175°C, $T_F$ = 65°C, Ref. Heatsink | 360 (Note 1) | A |
| $I_{FRM}$ | Repetitive Peak Forward Current, $t_p$ = 1 ms | 900 | A |
| $I^2t$ value | $V_R$ = 0 V, $t_p$ = 10 ms, $Tv_J$ = 150°C<br>$T_{VJ}$ = 175°C | 14400<br>12960 | $A^2s$ |

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.

1. Verified by characterization, not test.

**THERMAL CHARACTERISTICS** (Verified by characterization, not test)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| IGBT.$R_{th,J-C}$ | Effective Rth, Junction to Case (Note 2) | – | 0.06 | 0.08 | °C/W |
| IGBT.$R_{th,J-F}$ | Effective Rth, Junction to Fluid, $\lambda_{TIM}$ = 6 W/m−K, F = 660 N 10 L/min, 65°C, 50/50 EGW, Ref. Heatsink | – | 0.15 | – | °C/W |
| Diode.$R_{th,J-C}$ | Effective Rth, Junction to Case (Note 2) | – | 0.08 | 0.10 | °C/W |
| Diode.$R_{th,J-F}$ | Effective Rth, Junction to Fluid, $\lambda_{TIM}$ = 6 W/m−K, F = 660 N 10 L/min, 65°C, 50/50 EGW, Ref. Heatsink | – | 0.21 | – | °C/W |

2. For the measurement point of case temperature (Tc), DBC discoloration, picker circle print is allowed, please refer to the VE−Trac Dual assembly guide for additional details about acceptable DBC surface finish.

**CHARACTERISTICS OF IGBT** (Tvj = 25°C, unless otherwise specified)

| Parameters | | Conditions | | Min | Typ | Max | unit |
|---|---|---|---|---|---|---|---|
| $V_{CESAT}$ | Collector to Emitter Saturation Voltage (Terminal) | $V_{GE}$ = 15 V, $I_C$ = 300 A, | $T_{vj}$ = 25°C | – | 1.38 | 1.6 | V |
| | | | $T_{vj}$ = 150°C | – | 1.50 | – | |
| | | | $T_{vj}$ = 175°C | – | 1.53 | – | |
| | | $V_{GE}$ = 15 V, $I_C$ = 450 A, | $T_{vj}$ = 25°C | – | 1.59 | – | |
| | | | $T_{vj}$ = 150°C | – | 1.82 | – | |
| | | | $T_{vj}$ = 175°C | – | 1.87 | – | |
| $I_{CES}$ | Collector to Emitter Leakage Current | $V_{GE}$ = 0 V, $V_{CE}$ = 1200 V | $T_{vj}$ = 25°C | – | – | 1 | mA |
| | | | $T_{vj}$ = 175°C | – | 7 | – | |
| $I_{GES}$ | Gate − Emitter Leakage Current | $V_{CE}$ = 0 V, $V_{GE}$ = +20 V/−15 V | | – | – | ±400 | nA |
| $V_{th}$ | Threshold Voltage | $V_{CE}$ = $V_{GE}$ , $I_C$ = 500 mA | | 5.8 | 6.8 | 7.6 | V |
| $Q_G$ | Total Gate Charge | $V_{GE}$ = −8 to 15 V, $V_{CE}$ = 600 V | | – | 1.45 | – | μC |
| $R_{Gint}$ | Internal Gate Resistance | | | – | 0 | – | Ω |
| $C_{ies}$ | Input Capacitance | $V_{CE}$ = 30 V, $V_{GE}$ = 0 V, f = 1 MHz | | – | 61 | – | nF |
| $C_{oes}$ | Output Capacitance | $V_{CE}$ = 30 V, $V_{GE}$ = 0 V, f = 1 MHz | | – | 1.5 | – | nF |
| $C_{res}$ | Reverse Transfer Capacitance | $V_{CE}$ = 30 V, $V_{GE}$ = 0 V, f = 1 MHz | | – | 0.7 | – | nF |
| $T_{d.on}$ | Turn On Delay, Inductive Load | $I_C$ = 300 A, $V_{CE}$ = 600 V<br>$V_{GE}$ = +15/−8 V<br>Rg.on = 3 Ω | $T_{vj}$ = 25°C | – | 128 | – | ns |
| | | | $T_{vj}$ = 150°C | – | 121 | – | |
| | | | $T_{vj}$ = 175°C | – | 118 | – | |
| $T_r$ | Rise Time, Inductive Load | $I_C$ = 300 A, $V_{CE}$=600 V<br>$V_{GE}$ = +15/−8 V<br>Rg.on = 3 Ω | $T_{vj}$ = 25°C | – | 59 | – | ns |
| | | | $T_{vj}$ = 150°C | – | 66 | – | |
| | | | $T_{vj}$ = 175°C | – | 68 | – | |
| $T_{d.off}$ | Turn Off Delay, Inductive Load | $I_C$ = 300 A, $V_{CE}$ = 600 V<br>$V_{GE}$ = +15/−8 V<br>Rg.off = 5 Ω | $T_{vj}$ = 25°C | – | 1070 | – | ns |
| | | | $T_{vj}$ = 150°C | – | 1132 | – | |
| | | | $T_{vj}$ = 175°C | – | 1157 | – | |
| $T_f$ | Fall Time, Inductive Load | $I_C$ = 300 A, $V_{CE}$=600 V<br>$V_{GE}$ = +15/−8 V<br>Rg.off = 5 Ω | $T_{vj}$ = 25°C | – | 103 | – | ns |
| | | | $T_{vj}$ = 150°C | – | 250 | – | |
| | | | $T_{vj}$ = 175°C | – | 281 | – | |
| $E_{ON}$ | Turn−On Switching Loss (Including Diode Reverse Recovery Loss) | $I_C$ = 300 A, $V_{CE}$ = 600 V<br>$V_{GE}$ = +15/−8 V<br>Rg.on = 3 Ω<br>Ls = 25 nH<br>di/dt ($T_{vj}$=25°C) = 4.06 A/ns<br>di/dt ($T_{vj}$=175°C) = 3.95 A/ns | $T_{vj}$ = 25°C | – | 18 | – | mJ |
| | | | $T_{vj}$ = 150°C | – | 28 | – | |
| | | | $T_{vj}$ = 175°C | – | 30 | – | |
| $E_{OFF}$ | Turn−Off Switching Loss | $I_C$=300A, $V_{CE}$=600 V<br>$V_{GE}$=+15/−8 V<br>Rg.off=5 Ω<br>Ls=25 nH<br>dv/dt ($T_{vj}$=25°C) = 4.15 V/ns<br>dv/dt ($T_{vj}$=175°C) = 3.21 V/ns | $T_{vj}$ = 25°C | – | 19 | – | mJ |
| | | | $T_{vj}$ = 150°C | – | 34 | – | |
| | | | $T_{vj}$ = 175°C | – | 37 | – | |
| Esc | Minimum Short Circuit Energy Withstand | $V_{GE}$ = 15 V, $V_{CC}$ = 600 V | | | | | J |
| | | $T_{vj}$ = 25°C | | 16 | – | – | |
| | | $T_{vj}$ = 175°C | | 8.8 | – | – | |

**CHARACTERISTICS OF INVERSE DIODE** (Tvj = 25°C, unless otherwise specified)

| Parameters | | Conditions | | Min | Typ | Max | unit |
|---|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage (Terminal) | $V_{GE}$ = 0 V, $I_C$ = 300 A, | $T_{vj}$ = 25°C | – | 1.58 | 1.82 | V |
| | | | $T_{vj}$ = 150°C | – | 1.56 | – | |
| | | | $T_{vj}$ = 175°C | – | 1.54 | – | |
| | | $V_{GE}$ = 0 V, $I_C$ = 450 A, | $T_{vj}$ = 25°C | – | 1.80 | – | |
| | | | $T_{vj}$ = 150°C | – | 1.81 | – | |
| | | | $T_{vj}$ = 175°C | – | 1.78 | – | |
| $E_{rr}$ | Reverse Recovery Energy | $V_R$ = 600 V, $I_F$ = 300 A, $R_{GON}$ = 3 Ω, −di/dt = 3.95 A/ns (175°C) $V_{GE}$ = −8 V | $T_{vj}$ = 25°C | – | 10 | – | mJ |
| | | | $T_{vj}$ = 150°C | – | 22 | – | |
| | | | $T_{vj}$ = 175°C | – | 24 | – | |
| $Q_{RR}$ | Recovered Charge | $V_R$ = 600 V, $I_F$ = 300 A, $R_{GON}$ = 3 Ω, −di/dt = 3.95 A/ns (175°C) $V_{GE}$ = −8 V | $T_{vj}$ = 25°C | – | 25 | – | μC |
| | | | $T_{vj}$ = 150°C | – | 53 | – | |
| | | | $T_{vj}$ = 175°C | – | 59 | – | |
| Irr | Peak Reverse Recovery Current | $V_R$ = 600 V, $I_F$ = 300 A, $R_{GON}$ = 3 Ω, −di/dt = 3.95 A/ns (175°C) $V_{GE}$ = −8 V | $T_{vj}$ = 25°C | – | 250 | – | A |
| | | | $T_{vj}$ = 150°C | – | 332 | – | |
| | | | $T_{vj}$ = 175°C | – | 343 | – | |

**SENSOR CHARACTERISTICS** (Tvj = 25°C, unless otherwise specified)

| Parameters | | Conditions | | Min | Typ | Max | unit |
|---|---|---|---|---|---|---|---|
| $T_{sense}$ | Temperature Sense | $I_F$ = 250 μA, | $T_{vj}$ = −40°C | – | 3.40 | – | V |
| | | | $T_{vj}$ = 25°C | 2.95 (Note 3) | 3.01 | 3.086 (Note 3) | |
| | | | $T_{vj}$ = 150°C | – | 2.27 | – | |
| | | | $T_{vj}$ = 175°C | – | 2.08 | – | |
| $I_{sense}$ | Current Sense | $R_{shunt}$ = 10 Ω, | $I_C$ = 600 A | – | 392 | – | mV |
| | | | $I_C$ = 300 A | – | 254 | – | |
| | | | $I_C$ = 200 A | – | 209 | – | |
| | | $R_{shunt}$ = 20 Ω, | $I_C$ = 600 A | – | 566 | – | |
| | | | $I_C$ = 300 A | – | 377 | – | |
| | | | $I_C$ = 200 A | – | 314 | – | |

3. Measured at final test.

## TYPICAL CHARACTERISTICS

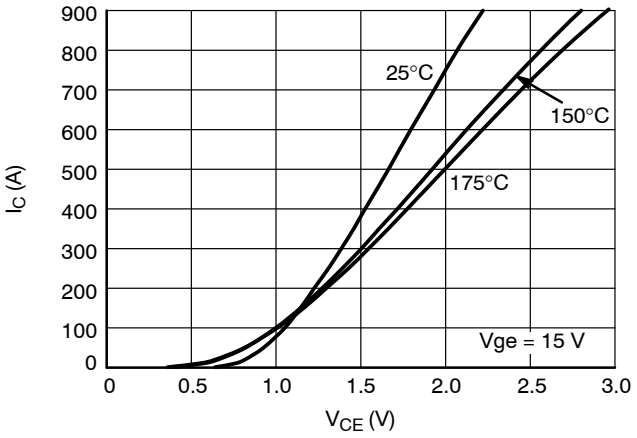



**Figure 1. IGBT Output Characteristic**

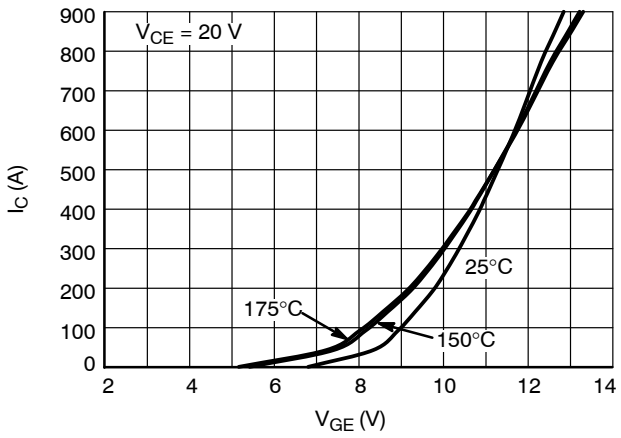



**Figure 2. IGBT Transfer Characteristic**

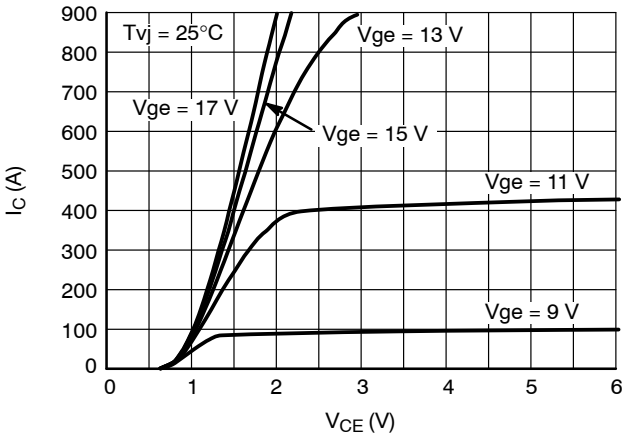



**Figure 3. IGBT Output Characteristic**

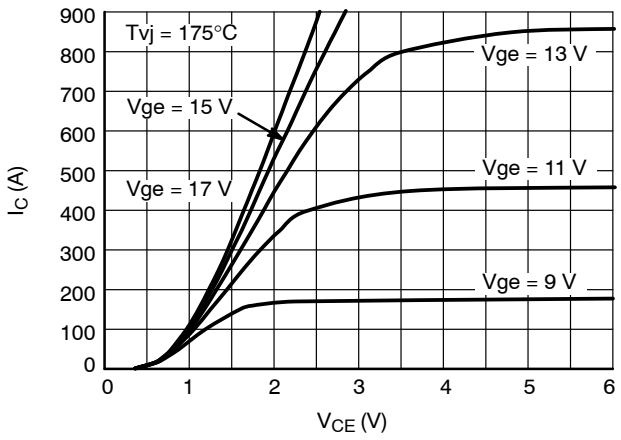



**Figure 4. IGBT Output Characteristic**

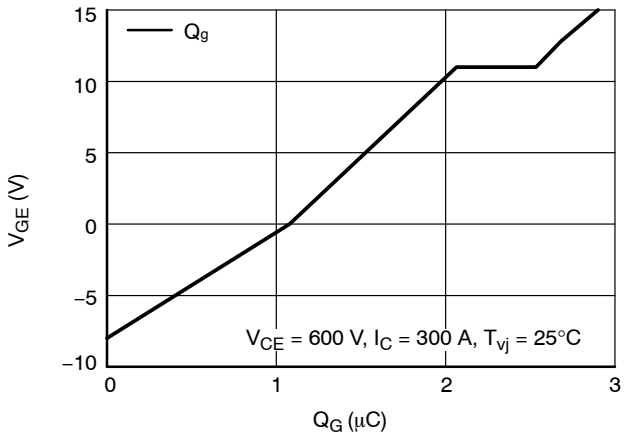



**Figure 5. Gate Charge Characteristic**

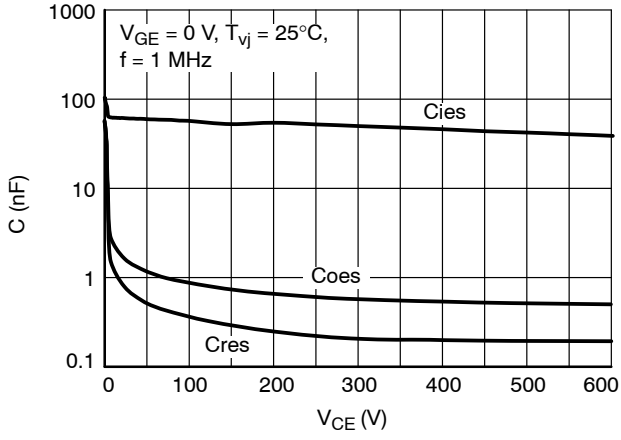



**Figure 6. Capacitance Characteristic**

## TYPICAL CHARACTERISTICS

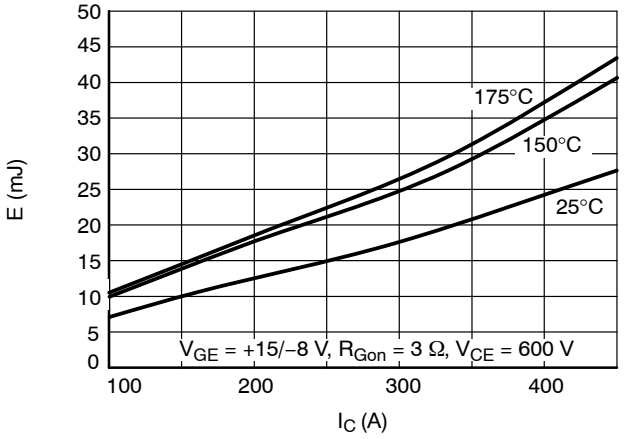



**Figure 7. IGBT Turn−on Losses vs. $I_C$**

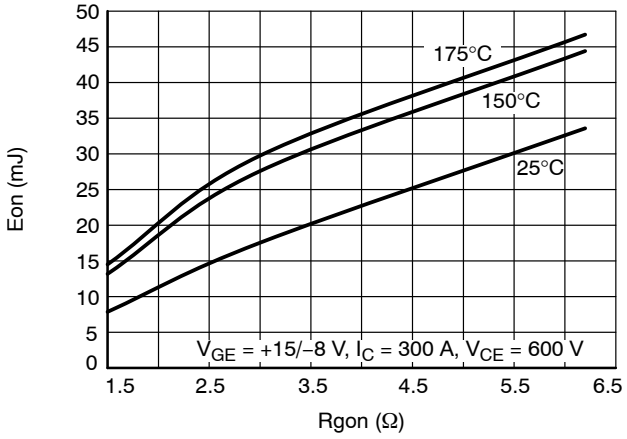



**Figure 8. IGBT Turn−on Losses vs. Rgon**

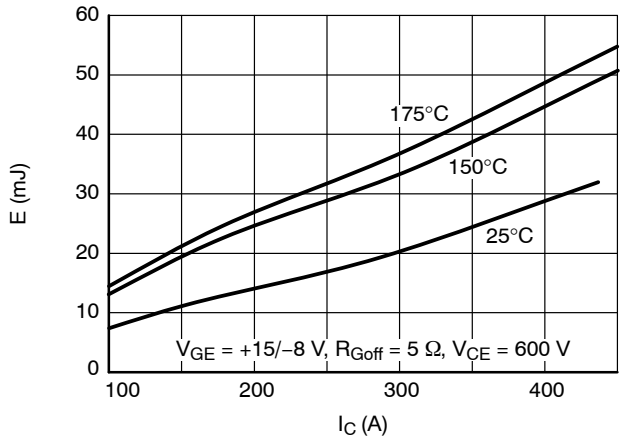



**Figure 9. IGBT Turn−off Losses vs. $I_C$**

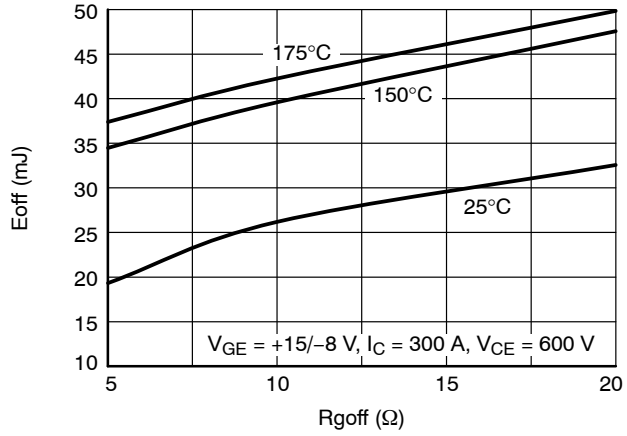



**Figure 10. IGBT Turn−off Losses vs. Rgoff**

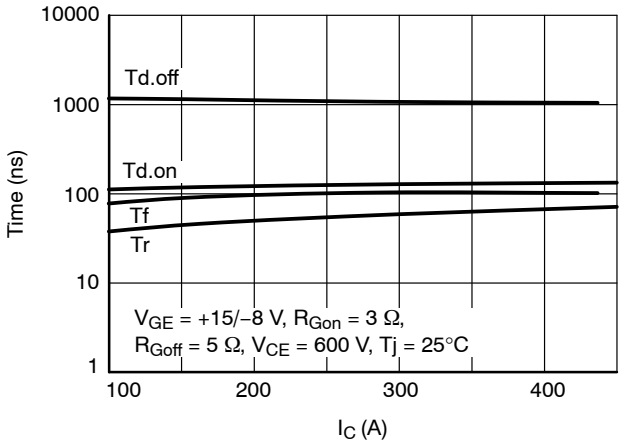



**Figure 11. IGBT Switching Times vs. $I_C$, $T_{vj}$ = 25°C**

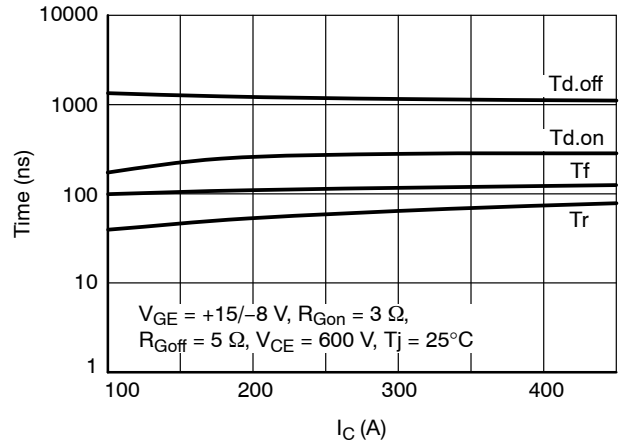



**Figure 12. IGBT Switching Times vs. $I_C$, $T_{vj}$ = 175°C**

## TYPICAL CHARACTERISTICS

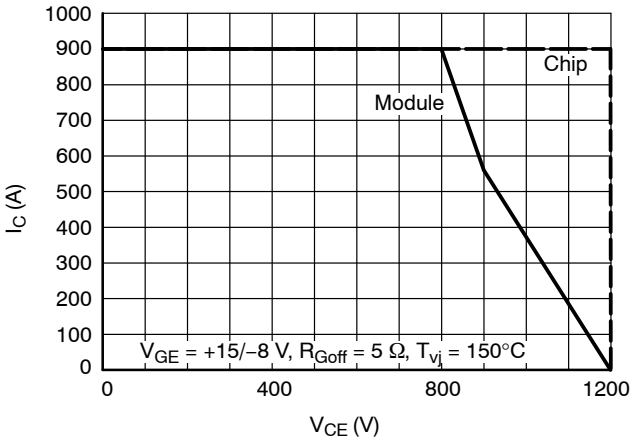



**Figure 13. Reverse Bias Safe Operating Area**

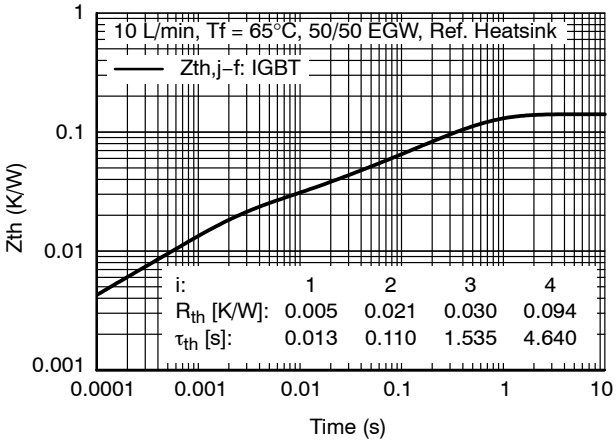



**Figure 14. IGBT Transient Thermal Impedance**

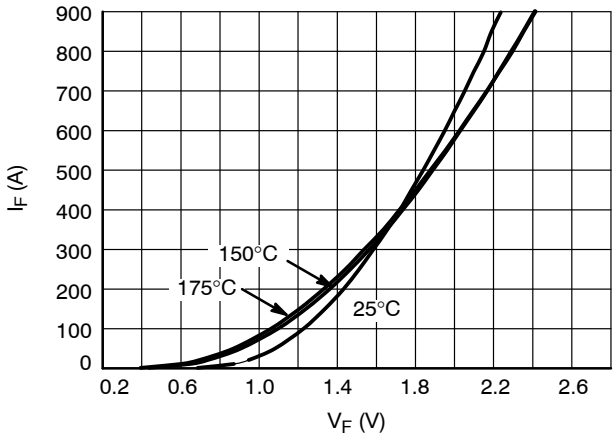



**Figure 15. Diode Forward Characteristics**

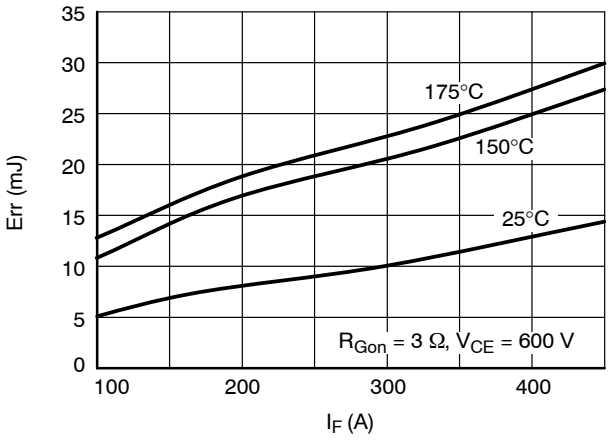



**Figure 16. Diode Switching Losses vs. $I_F$**

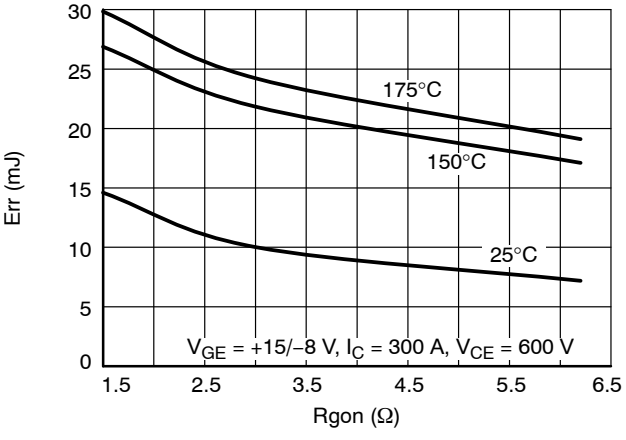



**Figure 17. Diode Reverse Recovery Losses vs. Rgon**

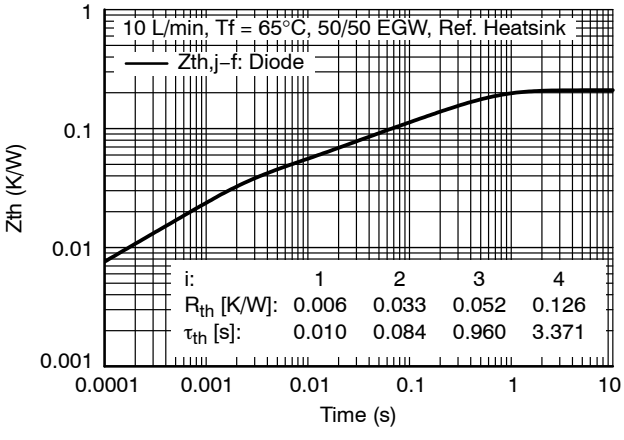



**Figure 18. Diode Transient Thermal Impedance**

## TYPICAL CHARACTERISTICS

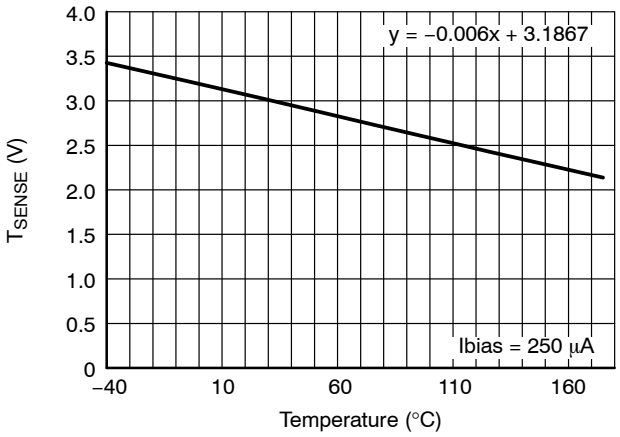



**Figure 19. Temperature Sensor Characteristics**

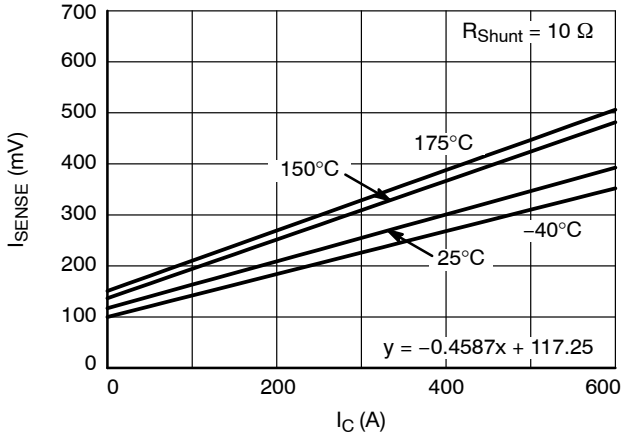



**Figure 20. Current Sensor Characteristics**

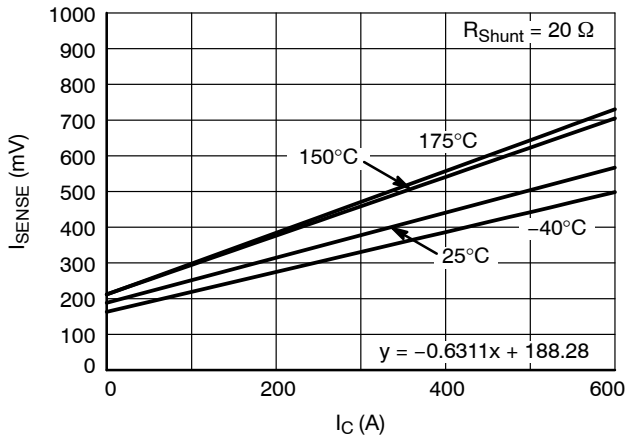
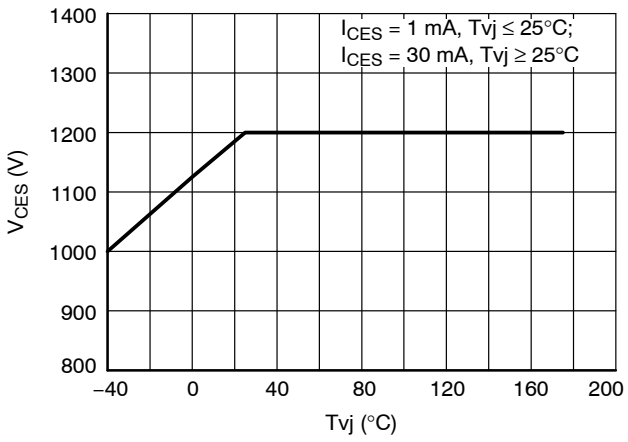



**Figure 21. Current Sensor Characteristics**




Verified by characterization/design,not by test.

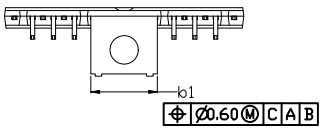
**Figure 22. Maximum Allowed Vce**

### ORDERING INFORMATION

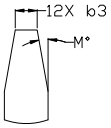
| Device | Device Marking | Package | Shipping |
|---|---|---|---|
| NVG450A120L5DSC | N412DSC | AHPM15−CEA<br>(Pb−Free) | 6 Unit / Tube |

**AHPM15−CEA**
CASE 100DD
ISSUE A

DATE 09 OCT 2019



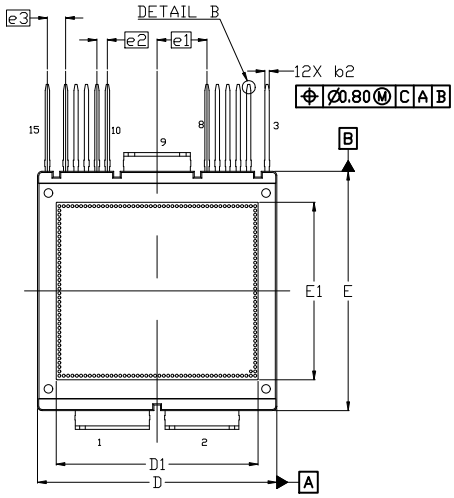

END VIEW



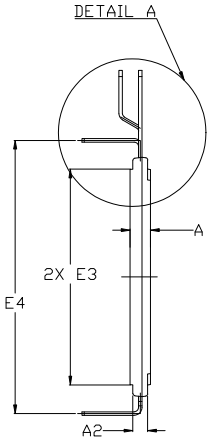

DETAIL B

NOTES:

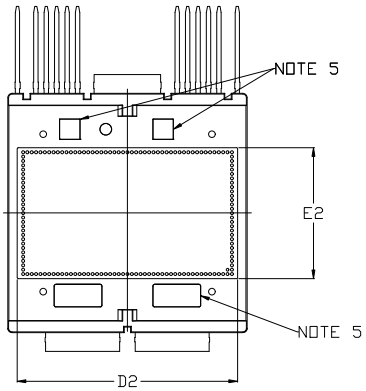
1. DIMENSIONING AND TOLERANCING PER. ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS D & E DO NOT INCLUDE MOLD PROTRUSIONS
4. DIMENSIONS b,b1,b2 DO NOT INCLUDE DAMBAR REMAIN.
5. MARKING AREA.



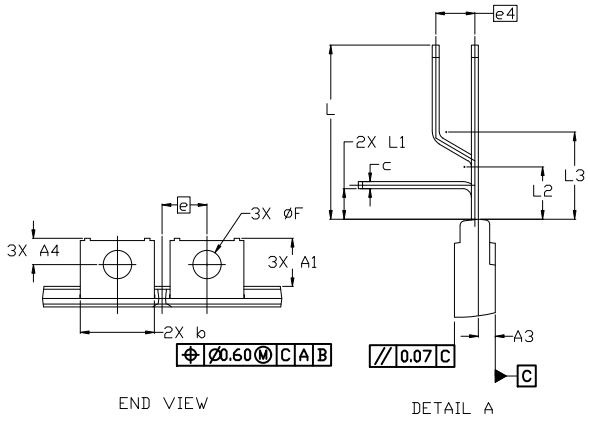

TOP VIEW




SIDE VIEW




BOTTOM VIEW



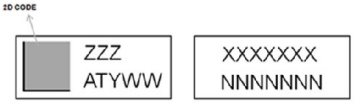

END VIEW

DETAIL A

| DIM | MILLIMETERS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX. |
| A | 4.65 | 4.70 | 4.75 |
| A1 | 10.75 | 11.05 | 11.35 |
| A2 | 3.20 | 3.40 | 3.60 |
| A3 | 1.60 | 1.95 | 2.30 |
| A4 | 5.70 | 6.00 | 6.30 |
| b | 16.90 | 17.00 | 17.10 |
| b1 | 15.20 | 15.30 | 15.40 |
| b2 | 0.90 | 1.00 | 1.10 |
| b3 | 0.50 REF | | |
| c | 0.70 | 0.80 | 0.90 |
| D | 54.80 | 55.00 | 55.20 |
| D1 | 46.10 | 46.40 | 46.70 |
| D2 | 50.40 | 50.70 | 51.00 |

| DIM | MILLIMETERS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX. |
| E | 54.80 | 55.00 | 55.20 |
| E1 | 40.50 | 40.80 | 41.10 |
| E2 | 29.80 | 30.10 | 30.40 |
| E3 | 49.40 | 49.60 | 49.80 |
| E4 | 61.60 | 62.00 | 62.40 |
| e | 10.30 BSC | | |
| e1 | 11.45 BSC | | |
| e2 | 2.40 BSC | | |
| e3 | 4.20 BSC | | |
| F | 6.45 | 6.50 | 6.55 |
| L | 19.60 | 20.00 | 20.40 |
| L1 | 3.10 | 3.50 | 3.90 |
| L2 | 5.70 | 6.00 | 6.30 |
| L3 | 9.70 | 10.00 | 10.30 |
| M | 10° REF | | |

### GENERIC MARKING DIAGRAM*




ZZZ = Assembly Lot Code
AT = Assembly & Test Site Code
Y = Year
WW = Work Week
XXXX = Specific Device Code
NNN = Serial Number

*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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| **DESCRIPTION:** | **AHPM15−CEA** | **PAGE 1 OF 1** |

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