

Automotive 750 V, 500 A Dual Side Cooling Half-Bridge Power Module

VE-Trac™ Dual NVG500A75L4DSF2

Product Description

The NVG500A75L4DSF2 is part of VE-Trac Dual family of power modules with dual side cooling and compact footprints for Hybrid (HEV) and Electric Vehicle (EV) traction inverter application.

The module consists of two narrow mesa Field Stop (FS4) IGBTs in a half-bridge configuration. The chipset utilizes the new narrow mesa IGBT technology in providing high current density and robust short circuit protection with higher blocking voltage to deliver outstanding performance in EV traction applications.

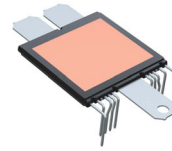
Liquid cooling heatsink reference design, loss models and CAD models are available to support customers in inverter designs.

Features

- Dual-Side Cooling
- Integrated Chip Level Temperature and Current Sensor
- $T_{vj\ max} = 175^{\circ}C$ for Continuous Operation
- Low Stray Inductance
- Low Conduction and Switching Losses
- Automotive Grade
- 4.2 kV Isolated DBC Substrate
- AEC Qualified and PPAP Capable
- This Device is Pb-Free and is RoHS Compliant

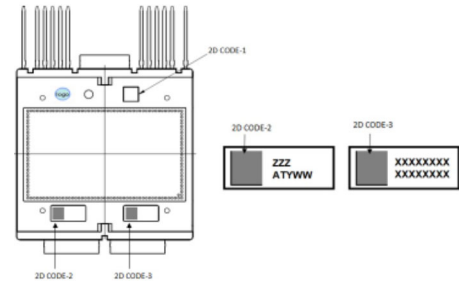
Typical Applications

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

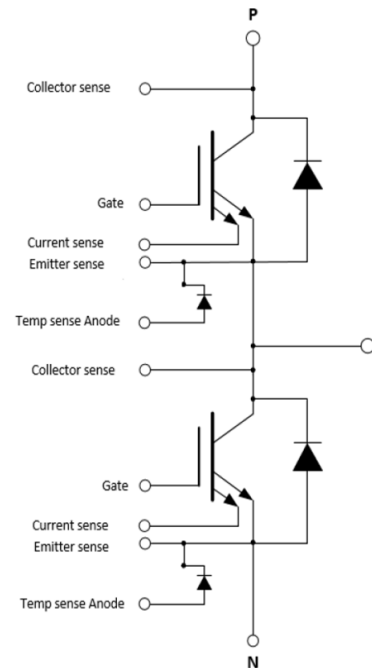


AHPM13-CGA MODULE
 CASE MODHR

MARKING DIAGRAM



ZZZ = Assembly Lot Code
 AT = Assembly & Test Location
 Y = Year
 WW = Work Week
 XXXX = Specific Device Code



ORDERING INFORMATION

See detailed ordering and shipping information on page 10 of this data sheet.

VE-Trac™ Dual NVG500A75L4DSF2

PIN DESCRIPTION

| Pin # | Pin | Pin Function 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 GATE | High Side Gate | |
| 6 | H/S EMITTER SENSE | High Side Emitter Sense | |
| 7 | H/S TEMP SENSE (ANODE) | High Side Temp sense Diode Anode | |
| 8 | ~ | Phase Output | |
| 9 | L/S CURRENT SENSE | Low Side Current Sense | |
| 10 | L/S EMITTER SENSE | Low Side Emitter Sense | |
| 11 | L/S GATE | Low Side Gate | |
| 12 | L/S TEMP SENSE (ANODE) | Low Side Temp sense Diode Anode | |
| 13 | L/S COLLECTOR SENSE | Low Side Collector Sense | |

DBC Substrate

Al₂O₃ isolated substrate, basic isolation, and copper on both sides.

Lead Frame

Copper with Tin electro-plating.

Flammability Information

All materials present in the power module meet UL flammability rating class 94V-0.

MODULE CHARACTERISTICS

| Symbol | Parameter | Rating | Unit | | |
|----------------------|---|------------|------------|------------|----|
| T _{vj} | Continuous Operating Junction Temperature Range | -40 to 175 | °C | | |
| T _{STG} | Storage Temperature range | -40 to 125 | °C | | |
| V _{ISO} | Isolation Voltage, AC, f = 50 Hz, t = 1 s | 4200 | V | | |
| CTI | Comparative Tracking Index | >600 | - | | |
| | | Min | Typ | Max | |
| Creepage | Pin/Terminal to Pin/Terminal (closest location) | 5.0 | - | - | mm |
| Clearance | Pin/Terminal to Pin/Terminal (closest location) | 2.9 | - | - | mm |
| L _{sCE} | Stray Inductance | - | 8 | - | nH |
| R _{CC'+EE'} | Module Lead Resistance, Terminals - Chip | - | 0.15 | - | mΩ |
| G | Module Weight | - | 75 | - | g |
| M | M4 Screws for Module Terminals | - | - | 2.2 | Nm |

VE-Trac™ Dual NVG500A75L4DSF2

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

| Symbol | Parameter | Rating | Unit |
|--------|-----------|--------|------|
|--------|-----------|--------|------|

IGBT

| | | | |
|--------------------|---|------|---|
| V _{CES} | Collector to Emitter Voltage | 750 | V |
| V _{GES} | Gate to Emitter Voltage | ±20 | V |
| I _{CN} | Implemented Collector Current | 500 | A |
| I _{C nom} | Continuous DC Collector Current, T _{vjmax} = 175°C, T _F = 65°C, Ref. Heatsink | 410 | A |
| I _{CRM} | Pulsed Collector Current @ V _{GE} = 15 V, t _p = 1 ms | 1000 | A |

DIODE

| | | | |
|------------------------|--|---------------|------------------|
| V _{RRM} | Repetitive Peak Reverse Voltage | 750 | V |
| I _{FN} | Implemented Forward Current | 500 | A |
| I _F | Continuous Forward Current, T _{vjmax} = 175°C, T _F = 65°C, Ref. Heatsink | 350 | A |
| I _{FRM} | Repetitive Peak Forward Current, t _p = 1 ms | 1000 | A |
| I ² t value | V _R = 0 V, t _p = 10 ms, T _{VJ} = 150°C T _{VJ} = 175°C | 10000 9000 | A ² s |

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.

THERMAL CHARACTERISTICS

| Symbol | Parameter | Min | Typ | Max | Unit |
|---------------------------|--|-----|-------|------|------|
| IGBT.R _{th,J-C} | Effective R _{th} , Junction to Case | – | 0.06 | 0.08 | °C/W |
| IGBT.R _{th,J-F} | Effective R _{th} , Junction to Fluid, λ _{TIM} = 6 W/m-K, F = 660 N 10 L/min, 65°C, 50/50 EGW, Ref. Heatsink | – | 0.164 | – | °C/W |
| Diode.R _{th,J-C} | Effective R _{th} , Junction to Case | – | 0.11 | 0.14 | °C/W |
| Diode.R _{th,J-F} | Effective R _{th} , Junction to Fluid, λ _{TIM} = 6 W/m-K, F = 660 N 10 L/min, 65°C, 50/50 EGW, Ref. Heatsink | – | 0.224 | – | °C/W |

VE-Trac™ Dual NVG500A75L4DSF2

CHARACTERISTICS OF IGBT ($T_{vj} = 25^{\circ}\text{C}$, unless otherwise specified)

| Parameters | | Conditions | Min | Typ | Max | unit | |
|-------------|--|--|--------------------------------|------|-----------|---------------|----|
| V_{CESAT} | Collector to Emitter Saturation Voltage | $V_{GE} = 15\text{ V}, I_C = 400\text{ A},$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 1.32 | 1.45 | V |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 1.37 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 1.39 | – | |
| | | $V_{GE} = 15\text{ V}, I_C = 500\text{ A},$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 1.39 | – | |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 1.51 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 1.55 | – | |
| I_{CES} | Collector to Emitter Leakage Current | $V_{GE} = 0, V_{CE} = 750\text{ V}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | – | 1 | mA |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 8 | – | |
| I_{GES} | Gate – Emitter Leakage Current | $V_{CE} = 0, V_{GE} = \pm 20\text{ V}$ | – | – | ± 400 | nA | |
| V_{th} | Threshold Voltage | $V_{CE} = V_{GE}, I_C = 500\text{ mA}$ | 4.5 | 5.6 | 6.5 | V | |
| Q_G | Total Gate Charge | $V_{GE} = -8\text{ to }15\text{ V}, V_{CE} = 400\text{ V},$ $I_C = 400\text{ A}$ | – | 0.96 | – | μC | |
| R_{Gint} | Internal Gate Resistance | | – | 2 | – | Ω | |
| C_{ies} | Input Capacitance | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 36 | – | nF | |
| C_{oes} | Output Capacitance | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 0.7 | – | nF | |
| C_{res} | Reverse Transfer Capacitance | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 0.09 | – | nF | |
| $T_{d.on}$ | Turn On Delay, Inductive Load | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.on} = 3.9\ \Omega$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 168 | – | ns |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 192 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 197 | – | |
| T_r | Rise Time, Inductive Load | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.on} = 3.9\ \Omega$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 67 | – | ns |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 82 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 86 | – | |
| $T_{d.off}$ | Turn Off Delay, Inductive Load | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.off} = 15\ \Omega$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 801 | – | ns |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 872 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 884 | – | |
| T_f | Fall Time, Inductive Load | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.off} = 15\ \Omega$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 112 | – | ns |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 165 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 196 | – | |
| E_{ON} | Turn-On Switching Loss (Including Diode Reverse Recovery Loss) | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.on} = 3.9\ \Omega$ $L_s = 25\text{ nH}$ $di/dt (T_{vj} = 25^{\circ}\text{C}) = 5.04\text{ A/ns}$ $di/dt (T_{vj} = 175^{\circ}\text{C}) = 4.15\text{ A/ns}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 10.49 | – | mJ |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 16.20 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 17.84 | – | |
| E_{OFF} | Turn-Off Switching Loss | $I_C = 400\text{ A}, V_{CE} = 400\text{ V}$ $V_{GE} = +15/-8\text{ V}$ $R_{g.off} = 15\ \Omega$ $L_s = 25\text{ nH}$ $dv/dt (T_{vj}=25^{\circ}\text{C}) = 3.0\text{ V/ns}$ $dv/dt (T_{vj}=175^{\circ}\text{C}) = 2.24\text{ V/ns}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 14.52 | – | mJ |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 23.31 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 23.88 | – | |
| E_{sc} | Minimum Short Circuit Energy Withstand | $V_{GE} \leq 15\text{ V}, V_{CE} = 400\text{ V}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 3.0 | – | J |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | 3.0 | – | – | |

VE-Trac™ Dual NVG500A75L4DSF2

CHARACTERISTICS OF INVERSE DIODE ($T_{vj} = 25^{\circ}\text{C}$, unless otherwise specified)

| Parameters | | Conditions | Min | Typ | Max | unit | |
|------------|-------------------------------|--|--------------------------------|-----|-------|------|---------------|
| V_F | Diode Forward Voltage | $V_{GE} = 0\text{ V}, I_C = 400\text{ A},$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 1.47 | 1.62 | V |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 1.44 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 1.42 | – | |
| | | $V_{GE} = 0\text{ V}, I_C = 500\text{ A},$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 1.55 | – | |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 1.54 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 1.53 | – | |
| E_{rr} | Reverse Recovery Energy | $V_R = 400\text{ V}, I_F = 400\text{ A},$ $R_{GON} = 3.9\ \Omega,$ $-di/dt = 3.61\text{ A/ns (175}^{\circ}\text{C)}$ $V_{GE} = -8\text{ V}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 1.16 | – | mJ |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 4.12 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 4.81 | – | |
| | | | | – | – | – | |
| Q_{RR} | Recovered Charge | $V_R = 400\text{ V}, I_F = 400\text{ A},$ $R_{GON} = 3.9\ \Omega,$ $-di/dt = 3.61\text{ A/ns (175}^{\circ}\text{C)}$ $V_{GE} = -8\text{ V}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 10.69 | – | μC |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 23.14 | – | |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 25.80 | – | |
| | | | | – | – | – | |
| I_{rr} | Peak Reverse Recovery Current | $V_R = 400\text{ V}, I_F = 400\text{ A},$ $R_{GON} = 3.9\ \Omega,$ $-di/dt = 3.61\text{ A/ns (175}^{\circ}\text{C)}$ $V_{GE} = -8\text{ V}$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 219 | – | A |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 272 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 276 | – | |
| | | | | – | – | – | |

SENSOR CHARACTERISTICS ($T_{vj} = 25^{\circ}\text{C}$, unless otherwise specified)

| Parameters | | Conditions | Min | Typ | Max | unit | |
|-------------|-------------------|-----------------------------|--------------------------------|-----|-------|------|----|
| T_{sense} | Temperature Sense | $I_F = 200\ \mu\text{A},$ | $T_{vj} = 25^{\circ}\text{C}$ | – | 2.165 | – | V |
| | | | $T_{vj} = 150^{\circ}\text{C}$ | – | 1.308 | – | |
| | | | $T_{vj} = 175^{\circ}\text{C}$ | – | 1.130 | – | |
| I_{sense} | Current Sense | $R_{shunt} = 0.56\ \Omega,$ | $I_C = 1000\text{ A}$ | – | 53 | – | mV |
| | | | $I_C = 500\text{ A}$ | – | 30 | – | |
| | | | $I_C = 100\text{ A}$ | – | 10 | – | |

VE-Trac™ Dual NVG500A75L4DSF2

TYPICAL CHARACTERISTICS

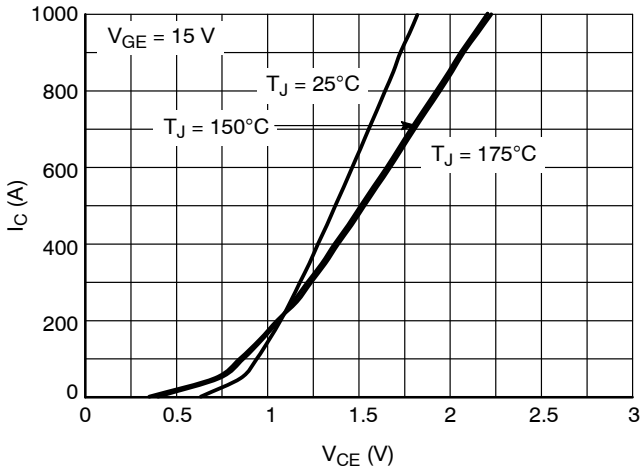


Figure 1. IGBT Output Characteristic

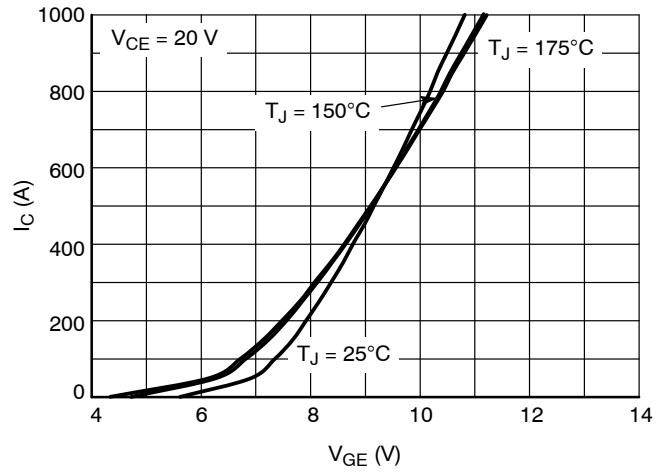


Figure 2. IGBT Transfer Characteristic

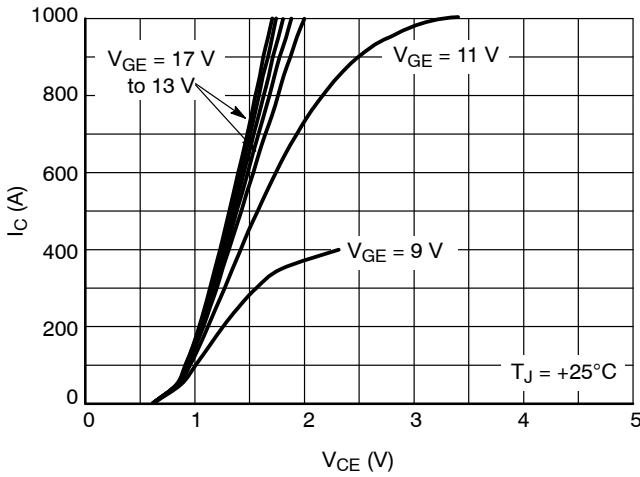


Figure 3. IGBT Output Characteristic, +25°C

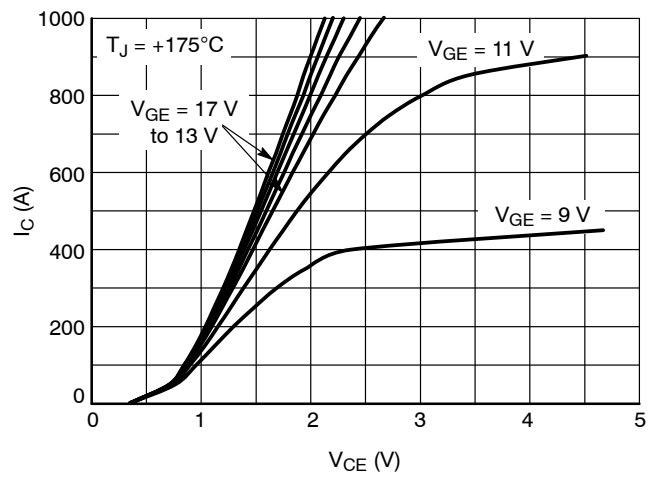


Figure 4. IGBT Output Characteristic, +175°C

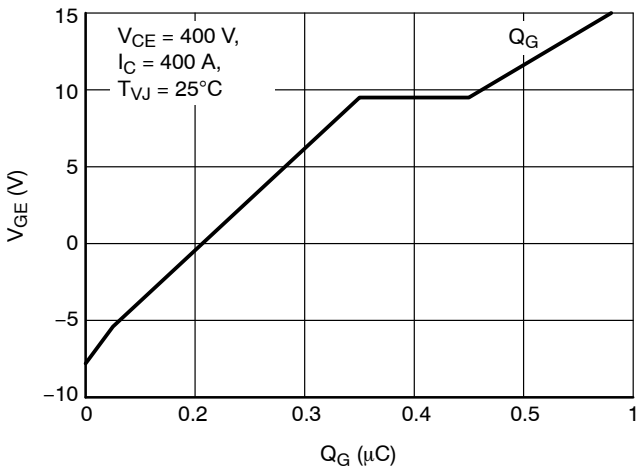


Figure 5. Gate Charge Characteristics

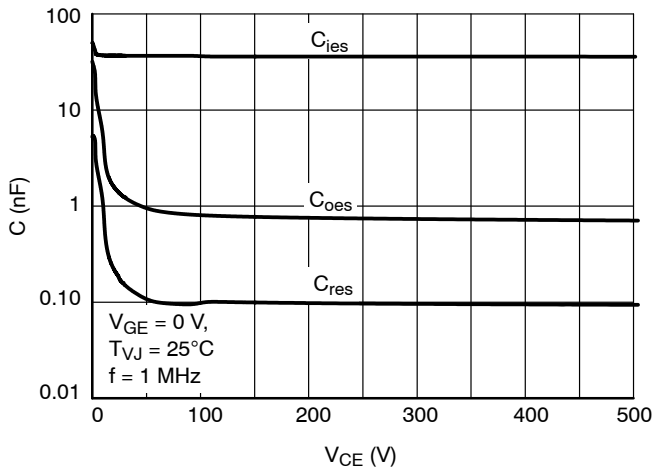


Figure 6. Capacitance Characteristics

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TYPICAL CHARACTERISTICS

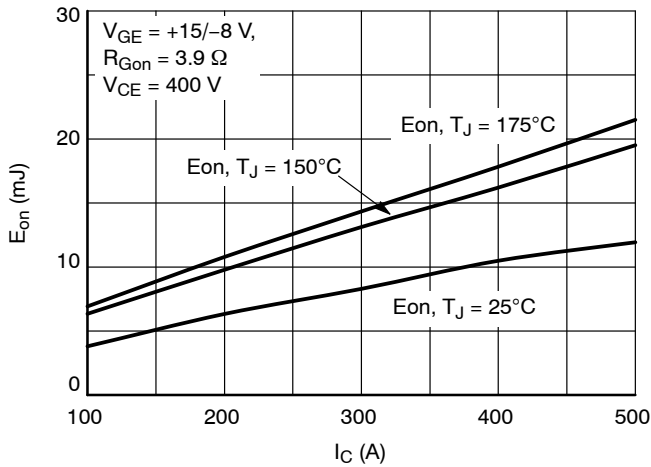


Figure 7. E_{on} vs. I_C

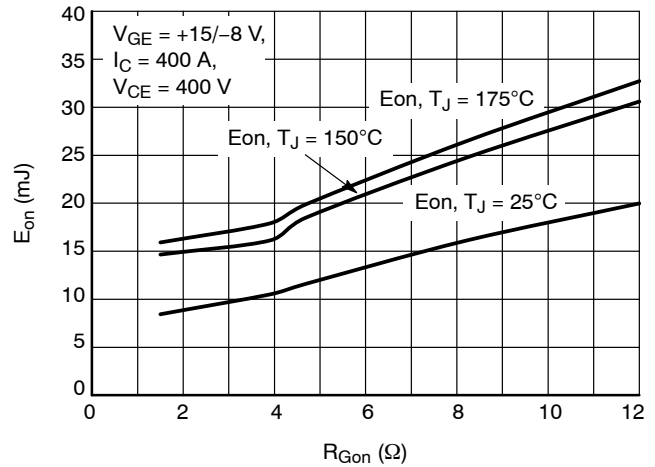


Figure 8. E_{on} vs. R_{Gon}

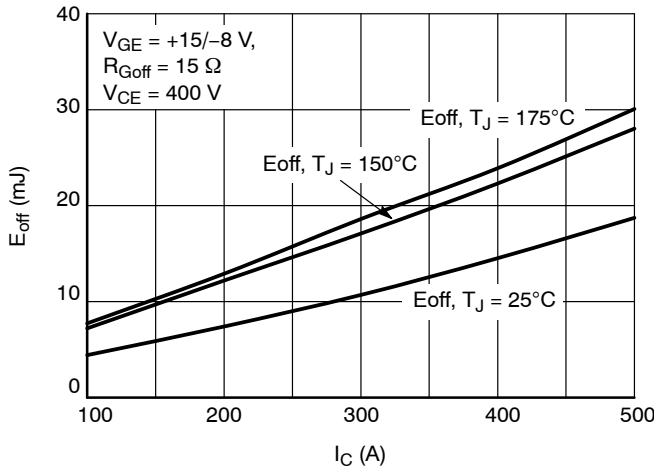


Figure 9. E_{off} vs. I_C

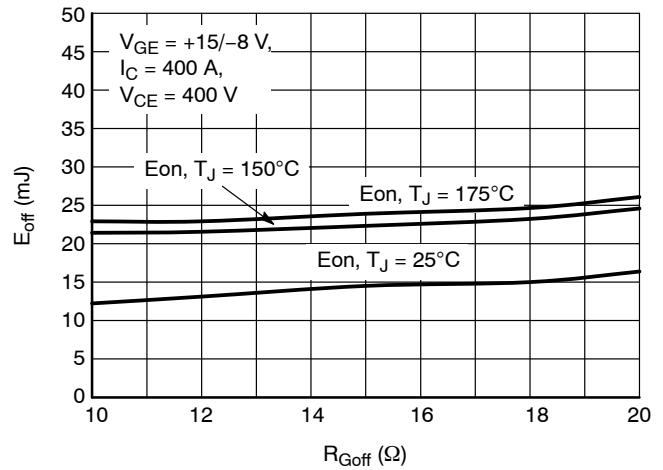


Figure 10. E_{off} vs. R_{Goff}

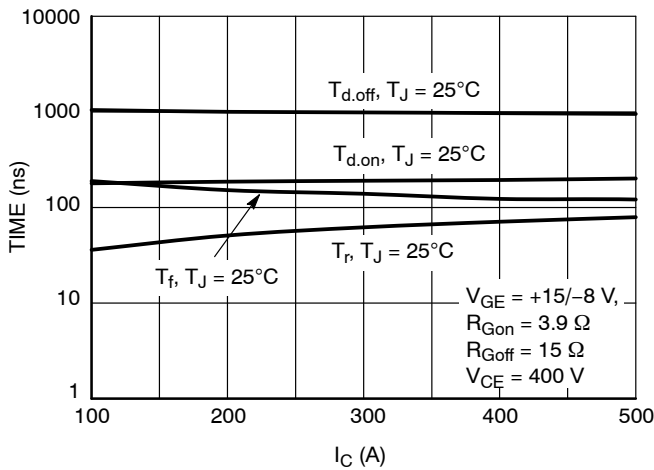


Figure 11. IGBT Switching Times vs. I_C , $T_{J} = 25^\circ\text{C}$

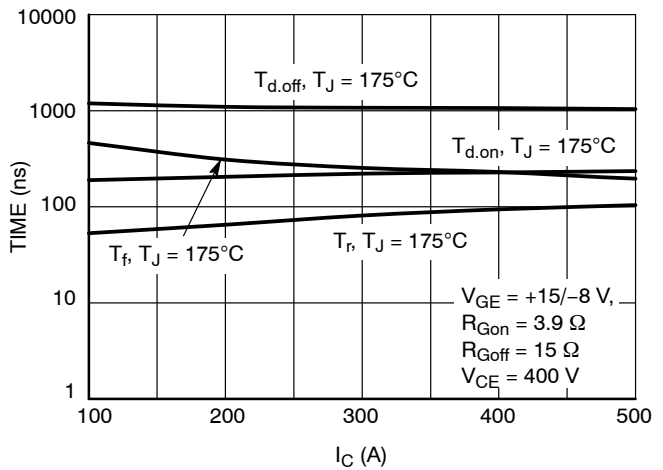


Figure 12. IGBT Switching Times vs. I_C , $T_{J} = 175^\circ\text{C}$

VE-Trac™ Dual NVG500A75L4DSF2

TYPICAL CHARACTERISTICS

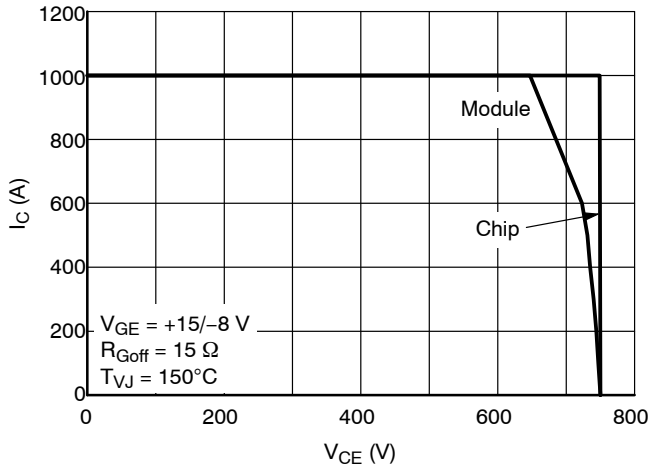


Figure 13. Reverse Bias Safe Operating Area

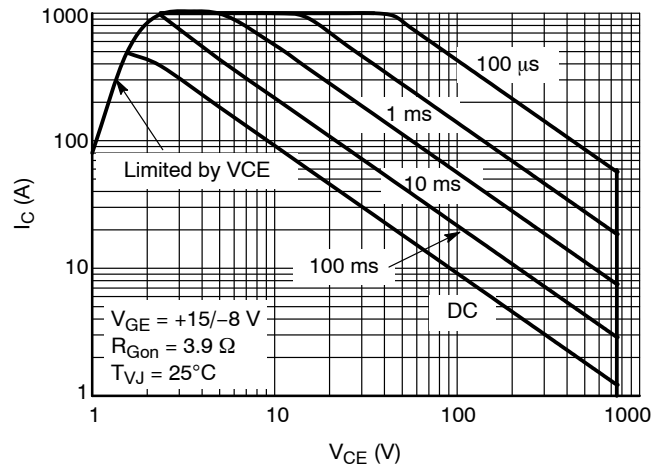


Figure 14. Forward Bias Safe Operating Area

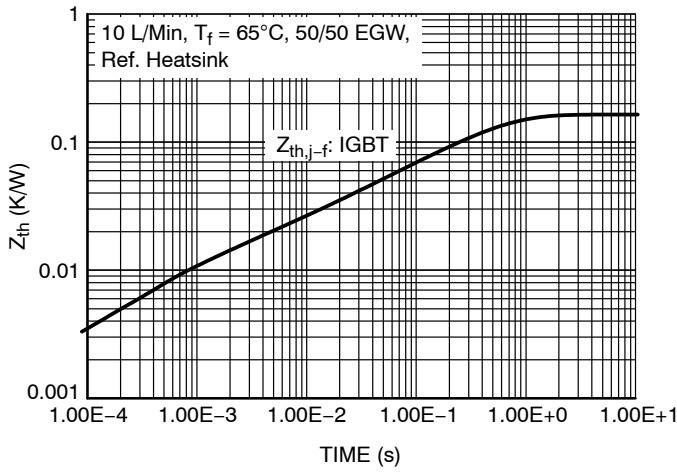


Figure 15. IGBT Transient Thermal Impedance

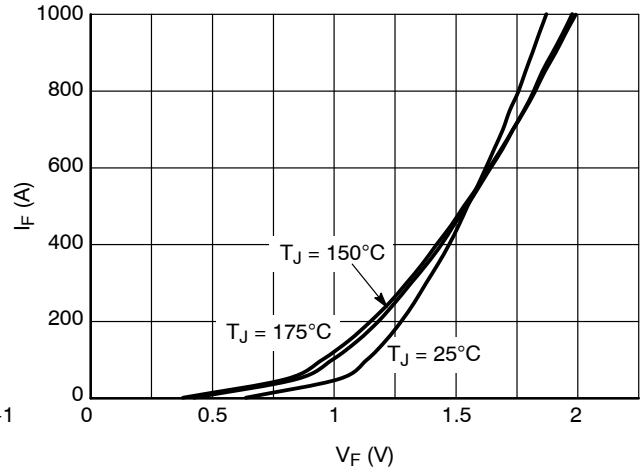


Figure 16. Diode Forward Characteristic

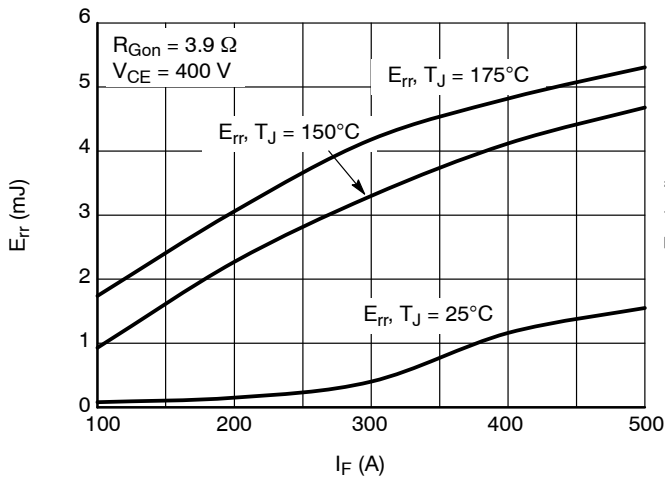


Figure 17. Diode Switching Losses vs. I_F

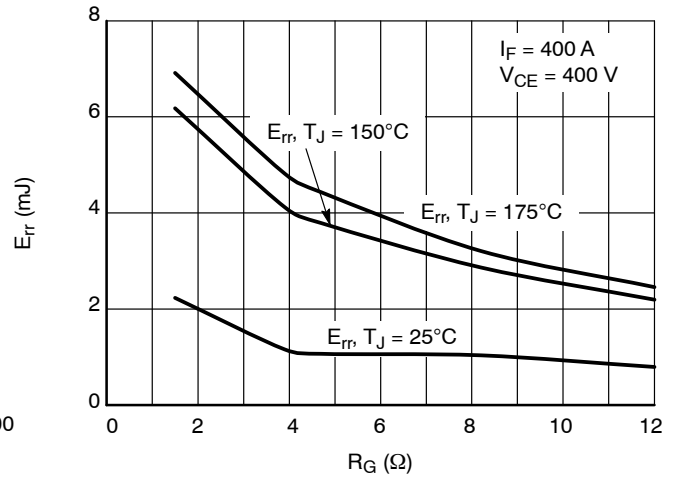


Figure 18. Diode Switching Losses vs. R_{Gon}

TYPICAL CHARACTERISTICS

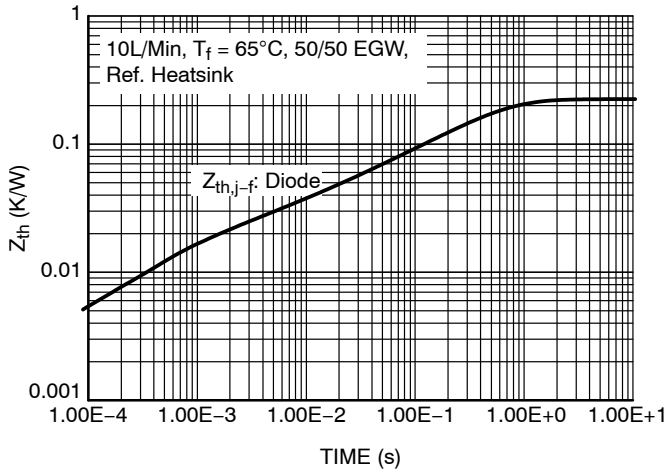


Figure 19. Diode Transient Thermal Impedance

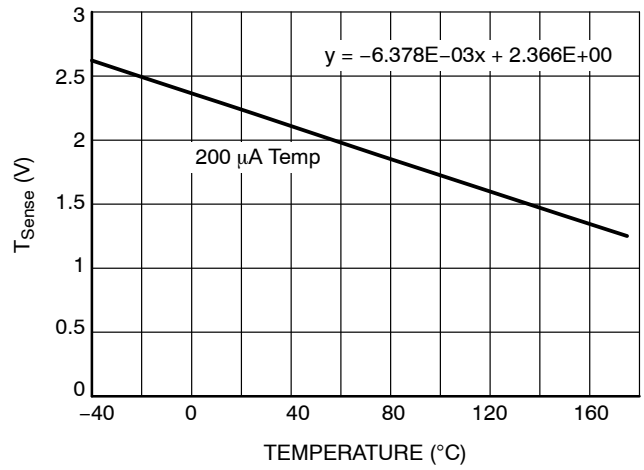


Figure 20. Temperature Sensor Characteristic

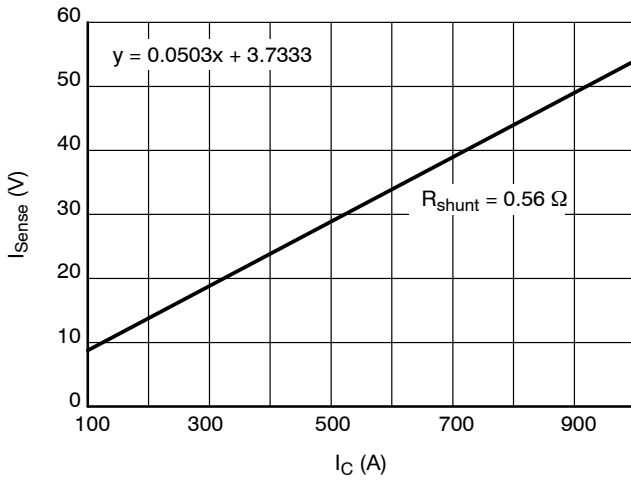


Figure 21. Current Sensor Characteristic

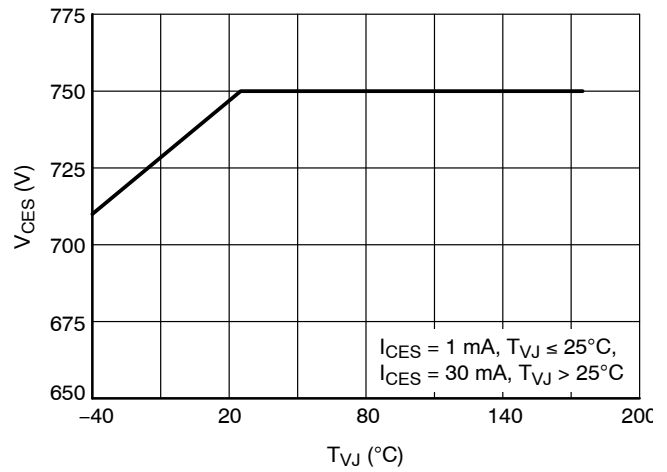


Figure 22. Maximum Allowed V_{CE}

General Note: These are preliminary values measured from a small number of DV units. Values will be updated based on higher quantity of PV measurements.

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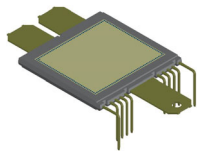
ORDERING INFORMATION

| Part Number | Package | Shipping |
|-----------------|---|----------------------------|
| NVG500A75L4DSF2 | AHPM13-CGA Module Case MODHR (Pb-Free) | 36 Units / 2x Blister Tray |

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MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

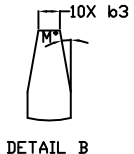
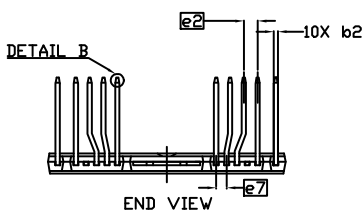


AHPM13-CGA MODULE

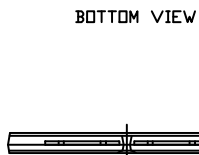
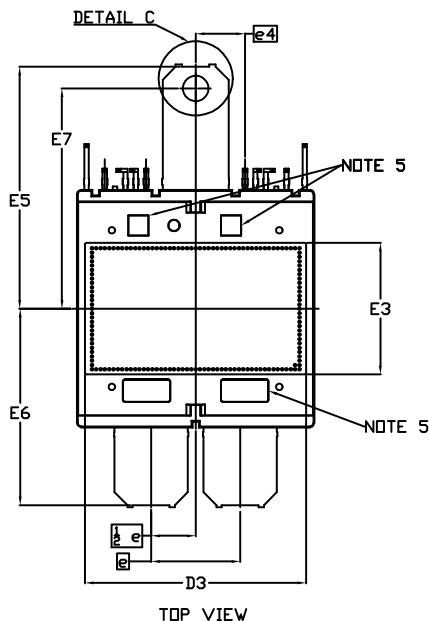
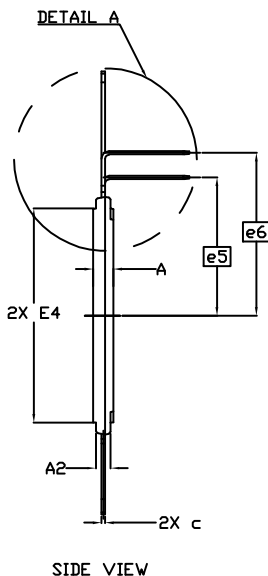
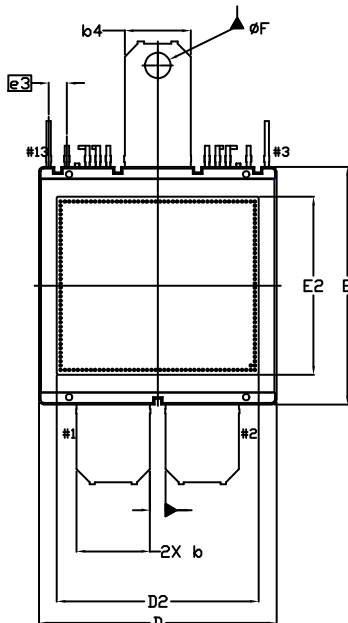
CASE MODHR

ISSUE B

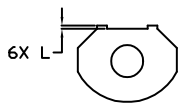
DATE 19 MAY 2023



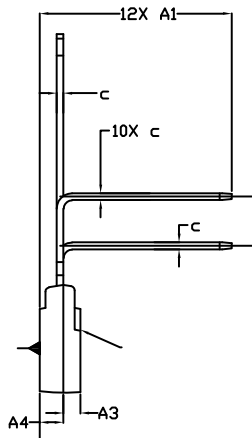
- NOTES:
1. DIMENSIONING AND TOLERANCING PER. ASME Y14.5M, 2009.
 2. CONTROLLING DIMENSION: MILLIMETERS
 3. DIMENSIONS D & E DO NOT INCLUDE MOLD PROTRUSIONS
 4. DIMENSIONS b,b1,b2 DO NOT INCLUDE DAMBAR REMAIN.
 5. MARKING AREA.
 6. ALTERNATE PACKAGE DIMENSIONING OPTION AVAILABLE IN DDC# 08ADN34464H



END VIEW



DETAIL C



DETAIL A

| DIM | MILLIMETERS | | |
|-----|-------------|-------|-------|
| | MIN. | NOM. | MAX. |
| A | 4.65 | 4.70 | 4.75 |
| A1 | 21.55 | 22.25 | 22.95 |
| A2 | 3.20 | 3.40 | 3.60 |
| A3 | 1.95 REF | | |
| A4 | 2.75 REF | | |
| b | 16.70 | 17.00 | 17.30 |
| b2 | 0.90 | 1.00 | 1.10 |
| b3 | 0.50 REF | | |
| b4 | 15.20 | 15.30 | 15.40 |
| c | 0.70 | 0.80 | 0.90 |
| D | 54.80 | 55.00 | 55.20 |
| D2 | 45.80 | 46.80 | 47.80 |
| D3 | 50.50 | 51.20 | 51.90 |
| E | 54.80 | 55.00 | 55.20 |
| E2 | 40.20 | 41.20 | 42.20 |

| DIM | MILLIMETERS | | |
|-----|-------------|-------|-------|
| | MIN. | NOM. | MAX. |
| E3 | 29.80 | 30.50 | 31.20 |
| E4 | 49.40 | 49.60 | 49.80 |
| E5 | 55.65 | 56.00 | 56.35 |
| E6 | 45.15 | 45.50 | 45.85 |
| E7 | 50.75 | 51.00 | 51.25 |
| e | 20.60 BSC | | |
| e2 | 3.20 BSC | | |
| e3 | 4.20 BSC | | |
| e4 | 11.45 BSC | | |
| e5 | 32.00 BSC | | |
| e6 | 37.70 BSC | | |
| e7 | 2.40 BSC | | |
| F | 5.90 | 6.00 | 6.10 |
| L | 0.50 REF | | |
| M* | 10* REF | | |

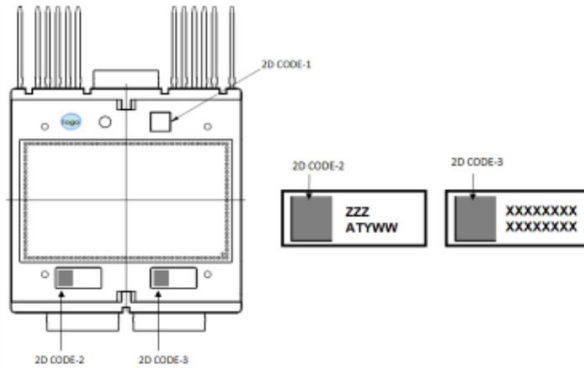
| | | |
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| DESCRIPTION: | AHPM13-CGA MODULE | PAGE 1 OF 2 |

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**AHPM13-CGA MODULE
CASE MODHR
ISSUE B**

DATE 19 MAY 2023

**GENERIC
MARKING DIAGRAM***



ZZZ = Assembly Lot Code
 AT = Assembly & Test Location
 Y = Year
 WW = Work Week
 XXXX = Specific Device Code

*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: | AHPM13-CGA MODULE | PAGE 2 OF 2 |

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