

Three Phase Inverter Automotive Power MOSFET Module

NXV04V120DB1

Features

- Three-Phase Inverter Bridge for Variable Speed Motor Drive
- RC Snubber for Low EMI
- Current Sensing and Temperature Sensing
- Electrically Isolated DBC Substrate for Low Thermal Resistance
- Compact Design for Low Total Module Resistance
- Module Serialization for Full Traceability
- AEC Qualified – AQG324
- PPAP Capable
- This Device is Pb-free, RoHS and UL94-V0 Compliant

Applications

- 12 V Motor Control
- Electric and Electro-Hydraulic Power Steering
- Electric Water Pump, Oil Pump and Fan

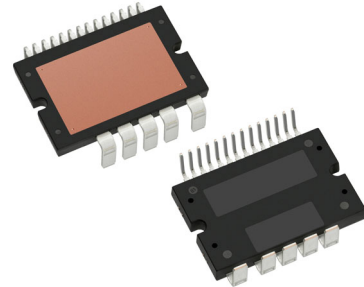
Benefits

- Enable Design of Small, Efficient and Reliable System for Reduced Vehicle Fuel Consumption and CO₂ Emission
- Simplified Vehicle Assembly
- Enable Low Thermal Resistance to Junction-to-Heat Sink by Direct Mounting via Thermal Interface Material between Module Case and Heat Sink



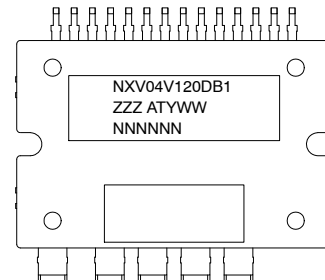
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19LD, APM, PDD STD
CASE MODCD

MARKING DIAGRAM



NXV04V120DB1 = Specific Device Code
ZZZ = Lot ID
AT = Assembly & Test Location
Y = Year
WW = Work Week
NNN = Serial Number

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

NXV04V120DB1

PACKAGE MARKING AND ORDERING INFORMATION

| Part Number | Package | Pb-Free and RoHS Compliant | Operating Temperature Range | Packing Method |
|--------------|-----------|----------------------------|-----------------------------|----------------|
| NXV04V120DB1 | APM19-CBC | Yes | -40 ~ 150°C | Tube |

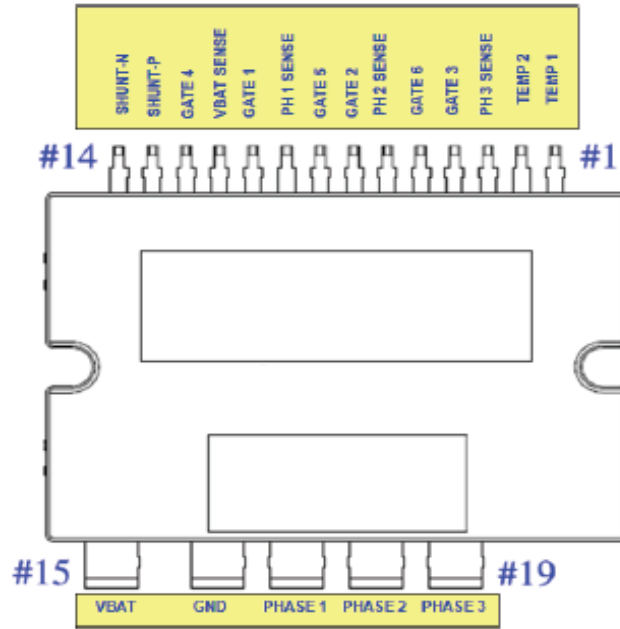


Figure 1. Pin Configuration

PIN DESCRIPTION

| Pin Number | Pin Name | Pin Description |
|------------|---------------|---|
| 1 | TEMP 1 | NTC Thermistor Terminal 1 |
| 2 | TEMP 2 | NTC Thermistor Terminal 2 |
| 3 | PHASE 3 SENSE | Source of Q3 and Drain of Q6 |
| 4 | GATE 3 | Gate of Q3, high side Phase 3 MOSFET |
| 5 | GATE 6 | Gate of Q6, low side Phase 3 MOSFET |
| 6 | PHASE 2 SENSE | Source of Q2 and Drain of Q5 |
| 7 | GATE 2 | Gate of Q2, high side Phase 2 MOSFET |
| 8 | GATE 5 | Gate of Q5, low side Phase 2 MOSFET |
| 9 | PHASE 1 SENSE | Source of Q1 and Drain of Q4 |
| 10 | GATE 1 | Gate of Q2, high side Phase 1 MOSFET |
| 11 | VBAT SENSE | Sense pin for battery voltage and Drain of high side MOSFETs |
| 12 | GATE 4 | Gate of Q4, low side Phase 1 MOSFET |
| 13 | SHUNT P | Positive CSR sense pin and source connection for low side MOSFETs |
| 14 | SHUNT N | Negative CSR sense pin and sense pin for battery return |
| 15 | VBAT | Battery voltage power lead |
| 16 | GND | Battery return power lead |
| 17 | PHASE 1 | Phase 1 power lead |
| 18 | PHASE 2 | Phase 2 power lead |
| 19 | PHASE 3 | Phase 3 power lead |

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Schematic Diagram

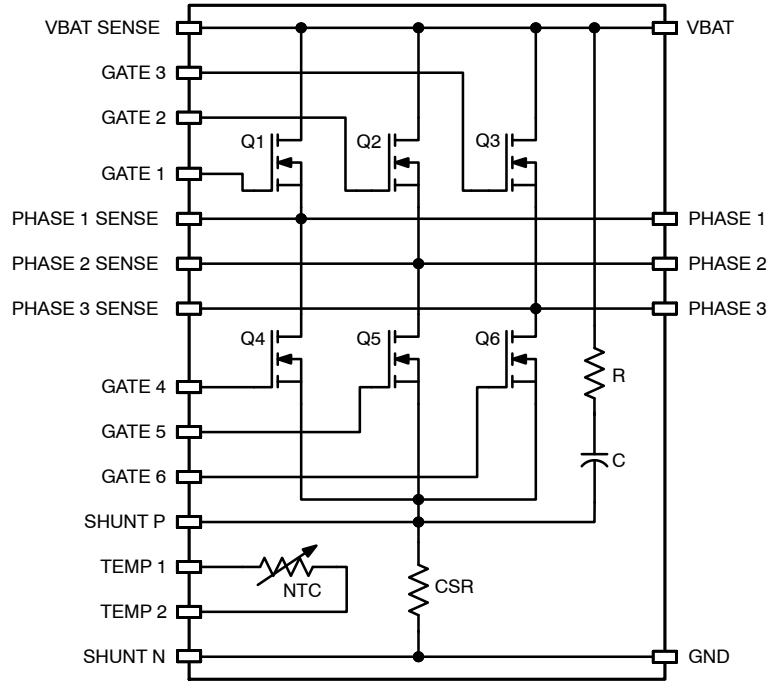


Figure 2. Schematic

Flammability Information

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

Solder

Solder used is a lead free SnAgCu alloy.

Compliance to RoHS Directives

The power module is 100% lead free and RoHS compliant 2000/53/C directive.

ABSOLUTE MAXIMUM RATINGS ($T_J = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Max | Unit |
|--------------|--|----------|------------------|
| V_{DS} | Drain-to-Source Voltage | 40 | V |
| V_{GS} | Gate-to-Source Voltage | ± 20 | V |
| I_D | Drain Current Continuous ($T_C = 25^\circ\text{C}$, $T_J = 175^\circ\text{C}$) (Note 1) | 160 | A |
| E_{AS} | Single Pulse Avalanche Energy (Note 2) | 340 | mJ |
| $T_{J(max)}$ | Maximum Junction Temperature | 175 | $^\circ\text{C}$ |
| T_{STG} | Storage Temperature Range | 150 | $^\circ\text{C}$ |
| V_{ISO} | Isolation Voltage | 2500 | V_{rms} |

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. Defined by design, not subject to production testing. The value is the result of the calculation, Min (package limit max current, Silicon limit max current) where the silicon limit current is calculated based on the maximum value which is not to exceed $T_J = 175^\circ\text{C}$ on maximum thermal limitation and on resistance.
2. Starting $T_J = 25^\circ\text{C}$, $L = 0.47\text{ mH}$, $I_{AS} = 50\text{ A}$, $V_{DD} = 40\text{ V}$ during inductor charging and $V_{DD} = 0\text{ V}$ during time in avalanche.

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THERMAL CHARACTERISTICS

| Symbol | Parameter | Min | Typ | Max | Unit |
|-----------------|---|-----|-----|-----|------|
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case (Note 3) | - | - | 1.2 | K/W |

3. Test method compliant with MIL-STD-883-1012.1, case temperature measured below the package at the chip center. Cosmetic oxidation and discolor on the DBC surface is allowed.

MODULE SPECIFIC CHARACTERISTICS ($T_J = 25^\circ\text{C}$ unless otherwise noted)

| Parameters | Test Conditions | Symbol | Min | Typ | Max | Unit |
|--|--|-----------------|------|------|-------|------------------|
| Drain-to-Source Breakdown Voltage | $I_D = 250 \mu\text{A}$, $V_{GS} = 0 \text{ V}$ | B_{VDSS} | 40 | - | - | V |
| Drain-to-Source Leakage Current | $V_{DS} = 40 \text{ V}$, $V_{GS} = 0 \text{ V}$ | I_{DSS} | - | - | 1 | μA |
| Gate-to-Source Leakage Current | $V_{GS} = \pm 20 \text{ V}$ | I_{GSS} | -100 | - | +100 | nA |
| Gate-to-Source Threshold Voltage | $V_{GS} = V_{DS}$, $I_D = 250 \mu\text{A}$ | $V_{GS(th)}$ | 2.0 | - | 4.0 | V |
| Body Diode Forward Voltage of MOSFET | $I_S = 80 \text{ A}$, $V_{GS} = 0 \text{ V}$ | V_{SD} | - | - | 0.955 | V |
| Drain-to-Source On Resistance, Q1 | $I_D = 80 \text{ A}$, $V_{GS} = 10 \text{ V}$ (Note 4) | $R_{DS(ON)Q1}$ | - | 0.85 | 1.1 | $\text{m}\Omega$ |
| Drain-to-Source On Resistance, Q2 | | $R_{DS(ON)Q2}$ | - | 0.9 | 1.1 | $\text{m}\Omega$ |
| Drain-to-Source On Resistance, Q3 | | $R_{DS(ON)Q3}$ | - | 1 | 1.2 | $\text{m}\Omega$ |
| Drain-to-Source On Resistance, Q4 | | $R_{DS(ON)Q4}$ | - | 1.1 | 1.3 | $\text{m}\Omega$ |
| Drain-to-Source On Resistance, Q5 | | $R_{DS(ON)Q5}$ | - | 1.3 | 1.5 | $\text{m}\Omega$ |
| Drain-to-Source On Resistance, Q6 | | $R_{DS(ON)Q6}$ | - | 1.6 | 1.9 | $\text{m}\Omega$ |
| VBAT to PHASE 1 | $I_D = 80 \text{ A}$, $V_{GS} = 10 \text{ V}$ | $R_{DS(ON)MQ1}$ | - | 1.7 | 2 | $\text{m}\Omega$ |
| VBAT to PHASE 2 | | $R_{DS(ON)MQ2}$ | - | 1.8 | 2 | $\text{m}\Omega$ |
| VBAT to PHASE 3 | | $R_{DS(ON)MQ3}$ | - | 1.9 | 2.1 | $\text{m}\Omega$ |
| PHASE1 to GND | | $R_{DS(ON)MQ4}$ | - | 1.9 | 2.2 | $\text{m}\Omega$ |
| PHASE2 to GND | | $R_{DS(ON)MQ5}$ | - | 2.1 | 2.4 | $\text{m}\Omega$ |
| PHASE3 to GND | | $R_{DS(ON)MQ6}$ | - | 2.4 | 2.7 | $\text{m}\Omega$ |
| Total Loop Resistance B+ \geq Phase \geq GND | $I_D = 80 \text{ A}$, $V_{GS} = 10 \text{ V}$ | | - | 4.15 | 4.8 | $\text{m}\Omega$ |

4. All MOSFETs have same size and on resistance. However, the different values listed due to the different access points available inside the module for on resistance measurement. Q1 has the shortest measurement path in the layout, in this reason, on resistance of Q1 can be used for simple power loss calculation.

COMPONENTS

| Symbol | Spec | Quantity | Size |
|--------------------------|--------------------------------|----------|----------------------|
| RESISTOR | 1.0 Ω | 1 | 142 \times 55 mil |
| CAPACITOR | 100 V, 0.022 μF | 1 | 79 \times 49 mil |
| CURRENT SENSING RESISTOR | 0.5 $\text{m}\Omega$ | 1 | 250 \times 120 mil |
| NTC | B57342V5103H060, 10 k Ω | 1 | 63 \times 32 mil |

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ELECTRICAL CHARACTERISTICS

(T_J = 25°C unless otherwise noted, Reference typical characteristics of FDBL9406–F085, TOLL)

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

DYNAMIC CHARACTERISTICS

| | | | | | | |
|---------------------|-------------------------------|--|---|------|-----|----|
| C _{iss} | Input Capacitance | V _{DS} = 25 V, V _{GS} = 0 V, f = 1 MHz | – | 7735 | – | pF |
| C _{oss} | Output Capacitance | | – | 2160 | – | pF |
| C _{rss} | Reverse Transfer Capacitance | | – | 129 | – | pF |
| R _g | Gate Resistance | f = 1 MHz | – | 2.5 | – | Ω |
| Q _{g(ToT)} | Total Gate Charge | V _{GS} = 0 to 10 V | – | 90 | 112 | nC |
| Q _{g(th)} | Threshold Gate Charge | V _{GS} = 0 to 2 V | – | 13.5 | 18 | nC |
| Q _{gs} | Gate-to-Source Gate Charge | V _{DD} = 32 V, I _D = 80 A | – | 43 | – | nC |
| Q _{gd} | Gate-to-Drain "Miller" Charge | | – | 10 | – | nC |

SWITCHING CHARACTERISTICS

| | | | | | | |
|---------------------|---------------------|--|---|----|-----|----|
| t _{on} | Turn-On Time | V _{DD} = 20 V, I _D = 80 A, V _{GS} = 10 V, R _{GEN} = 6 Ω | – | – | 102 | ns |
| t _{d(on)} | Turn-On Delay Time | | – | 33 | – | ns |
| t _r | Turn-On Rise Time | | – | 40 | – | ns |
| t _{d(off)} | Turn-Off Delay Time | | – | 47 | – | ns |
| t _f | Turn-Off Fall Time | | – | 23 | – | ns |
| t _{off} | Turn-Off Time | | – | – | 91 | ns |

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

(Graphs are generated using the die assembled in discrete package for reference purposes only. Datasheet of FDBL9406-F085 is available in the web)

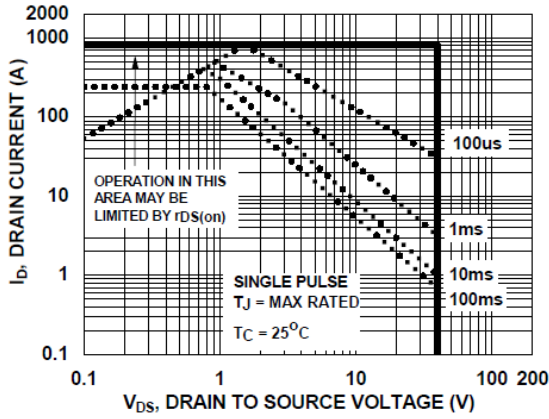
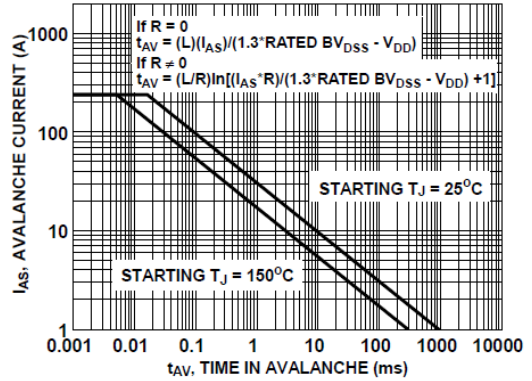


Figure 3. Forward Bias Safe Operating Area



NOTE: Refer to ON Semiconductor Application Notes AN7514 and AN7515

Figure 4. Unclamped Inductive Switching Capability

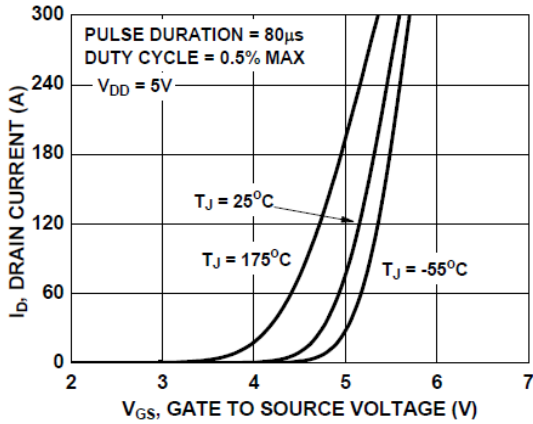


Figure 5. Transfer Characteristics

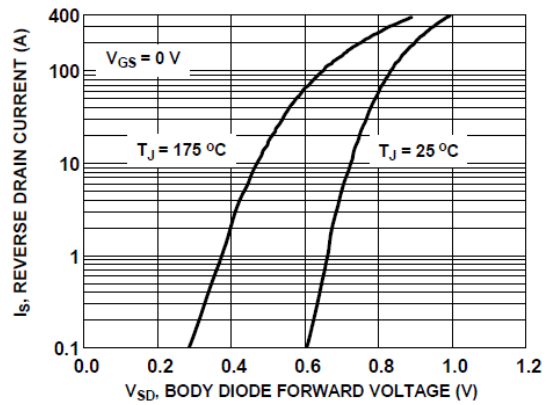


Figure 6. Forward Diode Characteristics

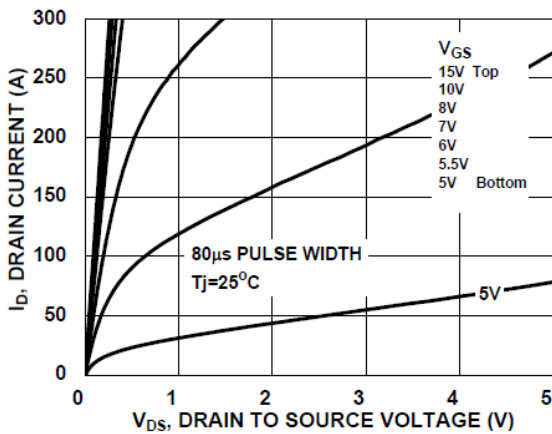


Figure 7. Saturation Characteristics

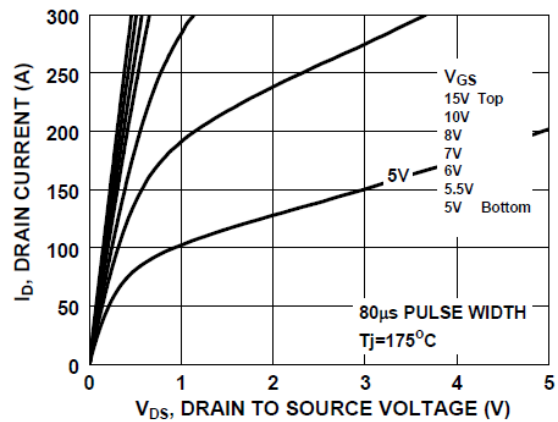


Figure 8. Saturation Characteristics

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TYPICAL CHARACTERISTICS (continued)

(Graphs are generated using the die assembled in discrete package for reference purposes only. Datasheet of FDBL9406-F085 is available in the web)

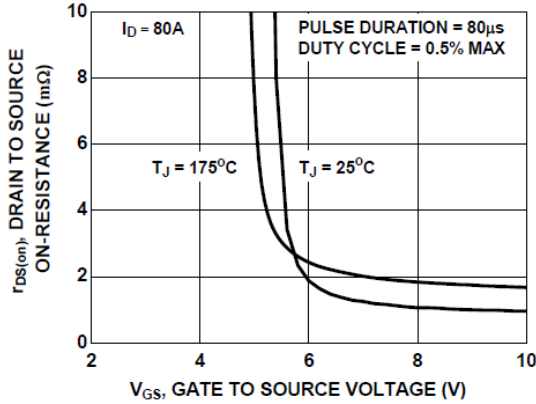


Figure 9. $R_{DS(on)}$ vs. Gate Voltage

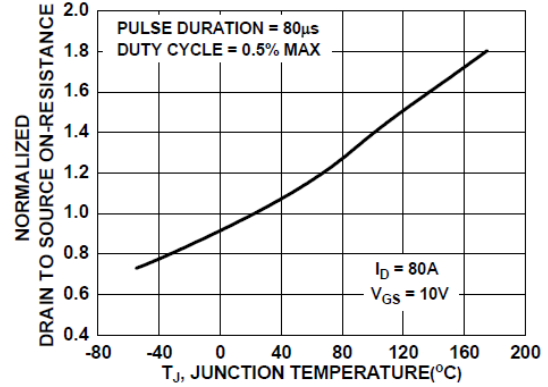


Figure 10. Normalized $R_{DS(on)}$ vs. Junction Temperature

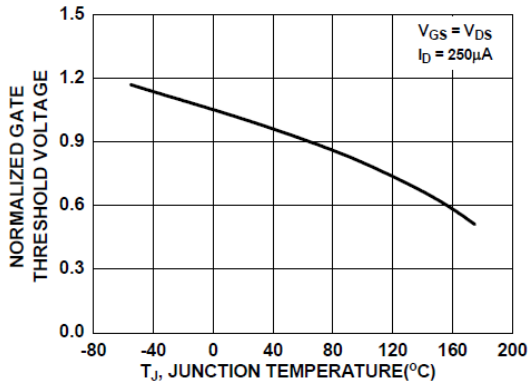


Figure 11. Normalized Gate Threshold Voltage vs. Temperature

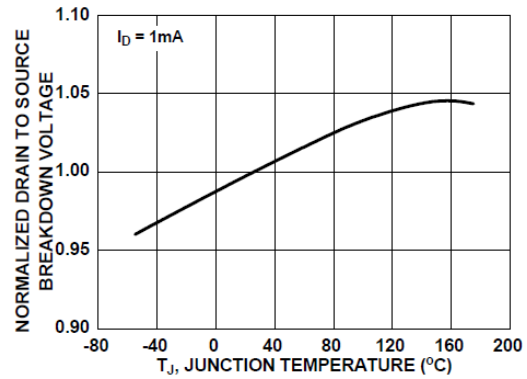


Figure 12. Normalized Drain-to-Source Breakdown Voltage vs. Junction Temperature

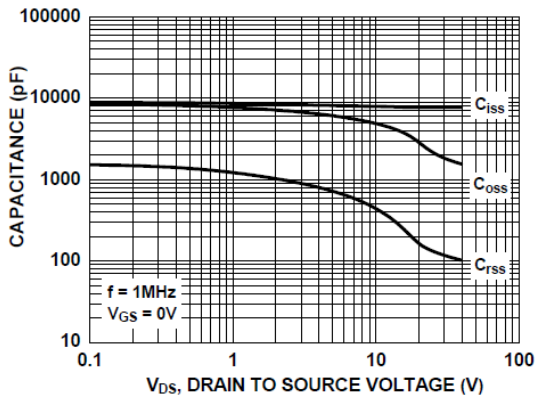


Figure 13. Capacitance vs. Drain-to-Source Voltage

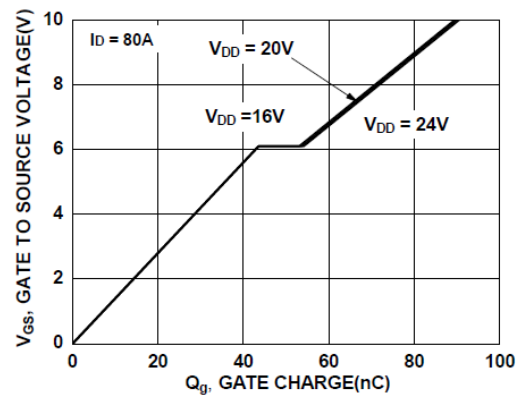
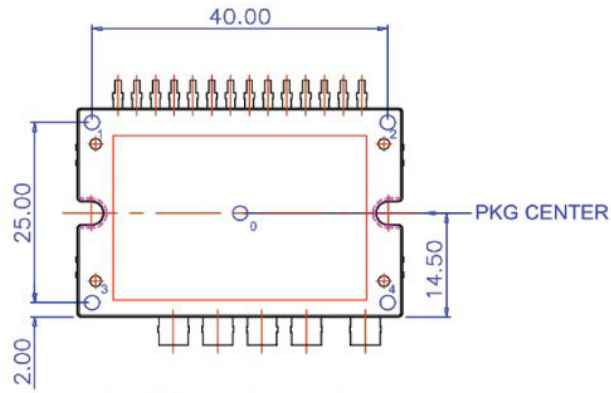


Figure 14. Gate Charge vs. Gate-to-Source Voltage

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FLATNESS: MAX. 150um

-. MEASURING AT INDICATING POINTS
1, 2, 3, AND 4 (BASED ON "0")

Figure 15. Flatness Measurement Position

MECHANICAL CHARACTERISTICS AND RATINGS

| Parameter | Test Conditions | Min. | Typ. | Max. | Units |
|-----------------|---|------|------|------|-------|
| Device Flatness | Refer to the package dimensions | 0 | - | 150 | um |
| Mounting Torque | Mounting screw: M3, recommended 0.7 N•m | 0.4 | - | 0.8 | N•m |
| Weight | | - | 20 | - | g |

MECHANICAL CASE OUTLINE

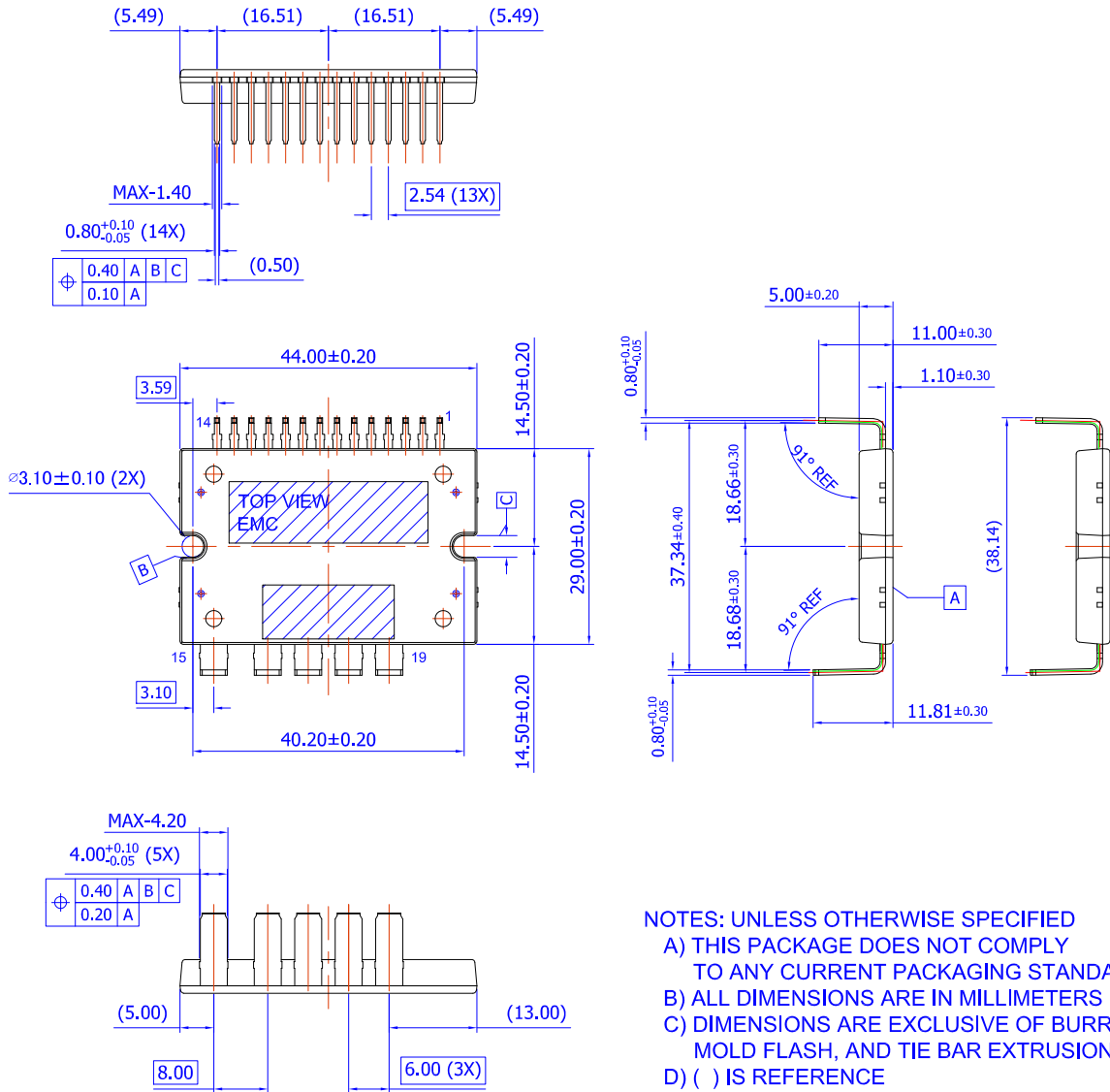
PACKAGE DIMENSIONS

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