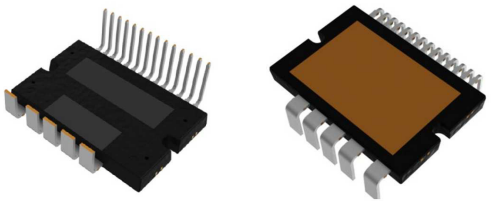
# 3-Phase Inverter Automotive Power Module

# FTCO3V455A1



APMCB−A19
CASE MODCG

## General Description

The FTCO3V455A1 is a 40 V low $R_{DS(ON)}$ automotive qualified power module featuring a 3−phase MOSFET inverter optimized for 12 V battery systems. It includes a precision shunt resistor for current sensing an NTC for temperature sensing and an RC snubber circuit.

The module utilizes **onsemi**'s trench MOSFET technology and it is designed to provide a very compact and high performance variable speed motor drive for applications like electric power steering, electro−hydraulic power steering, electric water pumps, electric oil pumps. The power module is 100% lead free, RoHS and UL compliant.

## Features

- 40 V − 150 A 3−phase Trench MOSFET Inverter Bridge
- 1% Precision Shunt Current Sensing
- Temperature Sensing
- DBC Substrate
- 100% Lead Free and RoHS Compliant with 2000/53/C Directive
- UL94V−0 Compliant
- Isolation Rating of 2500 V rms/min
- Mounting Through Screws
- Automotive Qualified

## Benefits

- Low Junction−sink Thermal Resistance
- Low Inverter Electrical Resistance
- High Current Handling
- Compact Motor Design
- Highly Integrated Compact Design
- Better EMC and Electrical Isolation
- Easy and Reliable Installation
- Improved Overall System Reliability

## Applications

- Electric and Electro−Hydraulic Power Steering
- Electric Water Pump
- Electric Oil Pump
- Electric Fan

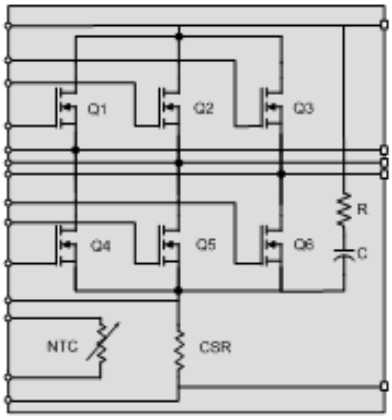
## Flammability Information

- All Materials Present in the Power Module Meet UL Flammability Rating Class 94 V−0 or Higher

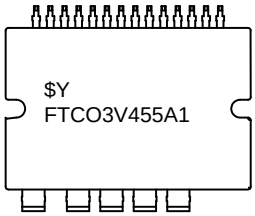
## Solder

- Solder Used is a Lead Free SnAgCu Alloy

## ELECTRICAL CONNECTION




## MARKING DIAGRAM




| | |
|---|---|
| $Y | = ON Semiconductor |
| FTCO3V455A1 | = Specific Device Code |

## ORDERING INFORMATION

See detailed ordering and shipping information on page 8 of this data sheet.

**ABSOLUTE MAXIMUM RATINGS** ($T_J$ = 25°C, Unless Otherwise Specified)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| $V_{DS}$(Q1~Q6) | Drain to Source Voltage | 40 | V |
| $V_{GS}$(Q1~Q6) | Gate to Source Voltage | ±20 | V |
| $I_D$(Q1~Q6) | Drain Current Continuous ($T_C$ = 25°C, $V_{GS}$ = 10 V) | 150 | A |
| $E_{AS}$(Q1~Q6) | Single Pulse Avalanche Energy (Note 1) | 947 | mJ |
| $P_D$ | Power Dissipation | 115 | W |
| $T_J$ | Maximum Junction Temperature | 175 | °C |
| $T_{STG}$ | Storage Temperature | 125 | °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.

**THERMAL RESISTANCE**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Rthjc<br>Thermal Resistance Junction to case, Single Inverter FET, chip center<br>(Note 2) | Q1 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| | Q2 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| | Q3 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| | Q4 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| | Q5 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| | Q6 Thermal Resistance J −C | − | 0.8 | 1.1 | °C/W |
| $T_J$ | Maximum Junction Temperature | − | | 175 | °C |
| $T_S$ | Operating Sink Temperature | −40 | | 120 | °C |
| $T_{STG}$ | Storage Temperature | −40 | | 125 | °C |

1. Starting $T_J$ = 25°C, $V_{DS}$ = 20 V, $I_{AS}$ = 64 A, L = 480 μH.
2. These values are based on Thermal simulations and PV level measurements.
   These values assume a single MOSFET is on, and the test condition for referenced temperature is “Chip Center”.
   This means that the DT is measured between the $T_J$ of each MOSFET and the temperature of the case located immediately under the center of the chip.

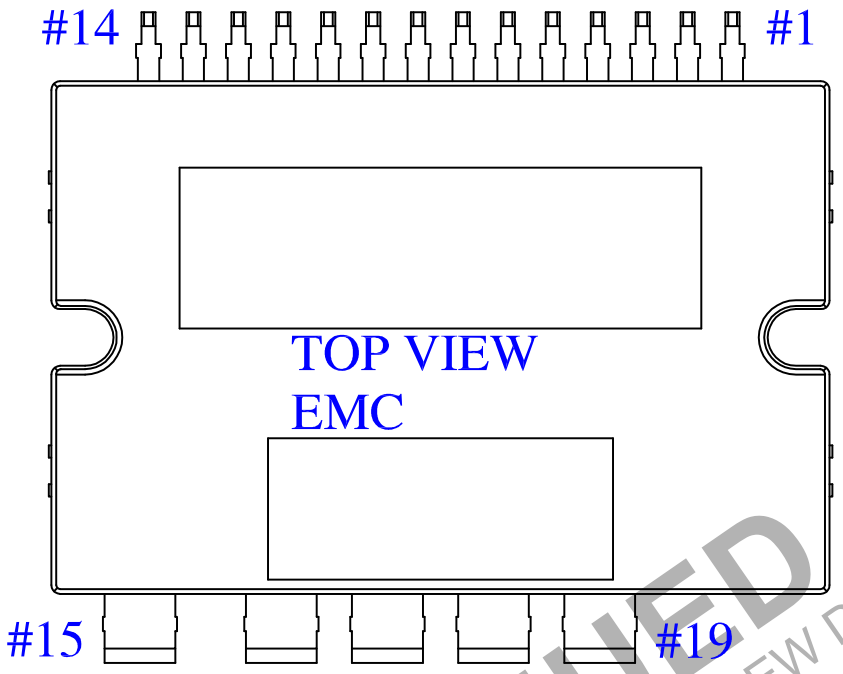



**Figure 1. Pin Configuration**



**PIN DESCRIPTION**

| Pin Number | Pin Name | Pin Descriptions |
|---|---|---|
| 1 | TEMP 1 | NTC Thermistor Terminal 1 |
| 2 | TEMP 2 | NTC Thermistor Terminal 2 |
| 3 | PHASE W SENSE | Source of HS W and Drain of LS W |
| 4 | GATE HS W | Gate of HS phase W MOSFET |
| 5 | GATE LS W | Gate of LS phase W MOSFET |
| 6 | PHASE V SENSE | Source of HS V and Drain of LS V |
| 7 | GATE HS V | Gate of HS phase V MOSFET |
| 8 | GATE LS V | Gate of LS phase V MOSFET |
| 9 | PHASE U SENSE | Source of HS U and Drain of LS U |
| 10 | GATE HS U | Gate of HS phase U MOSFET |
| 11 | VBAT SENSE | Drain of HS U, V and W MOSFET |
| 12 | GATE LS U | Gate of LS phase U MOSFET |
| 13 | SHUNT P | Source of LS U, V W MOSFETS / Shunt + |
| 14 | SHUNT N | Negative shunt terminal (shunt −) |
| 15 | VBAT | Positive battery terminal |
| 16 | GND | Negative battery terminal |
| 17 | PHASE U | Motor phase U |
| 18 | PHASE V | Motor phase V |
| 19 | PHASE W | Motor phase W |

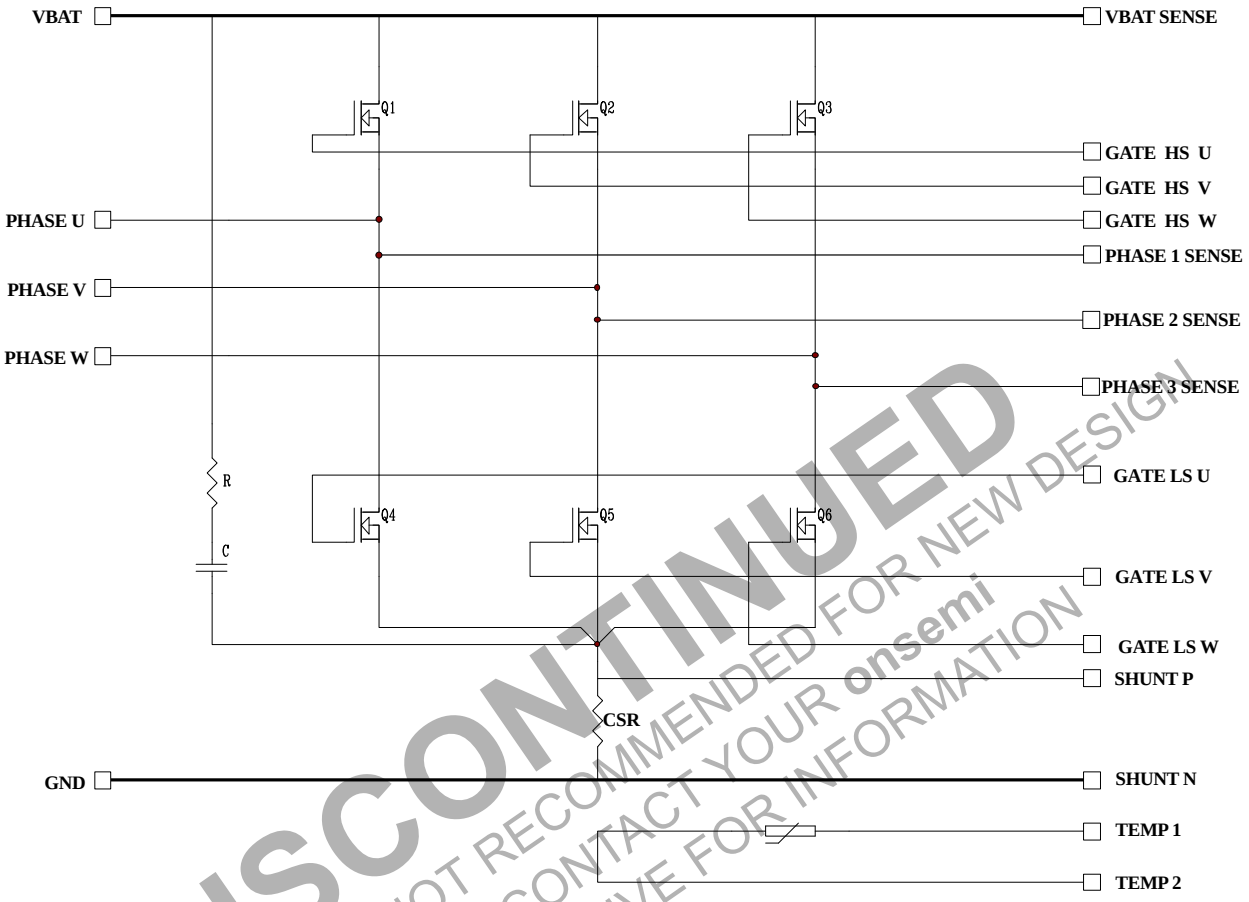





**Figure 2. Internal Equivalent Circuit**

**ELECTRICAL CHARACTERISTICS** ($T_J$ = 25°C, Unless Otherwise Specified)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $BV_{DSS}$ | D−S Breakdown Voltage (Inverter MOSFETs) | $V_{GS}$ = 0, $I_D$ = 250 μA | 40 | − | − | V |
| $V_{GS}$ | Gate to Source Voltage (Inverter MOSFETs) | | −20 | − | 20 | V |
| $V_{TH}$ | Threshold Voltage (Inverter MOSFETs) | $V_{GS}$ = $V_{DS}$, $I_D$ = 250 μA, $T_j$ = 25°C | 2.0 | 2.8 | 4.0 | V |
| $V_{SD}$ | MOSFET Body Diode Forward Voltage | $V_{GS}$ = 0 V, $I_S$ = 80 A, $T_j$ = 25°C | | 0.8 | 1.28 | V |
| $R_{DS(ON)Q1}$ | Inverter High Side MOSFETs Q1 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 1.15 | 1.66 | mΩ |
| $R_{DS(ON)Q2}$ | Inverter High Side MOSFETs Q2 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 1.22 | 1.73 | mΩ |
| $R_{DS(ON)Q3}$ | Inverter High Side MOSFETs Q3 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 1.31 | 1.82 | mΩ |
| $R_{DS(ON)Q4}$ | Inverter Low Side MOSFETs Q4 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ =25°C | − | 1.36 | 1.87 | mΩ |
| $R_{DS(ON)Q5}$ | Inverter Low Side MOSFETs Q5 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 1.57 | 2.08 | mΩ |
| $R_{DS(ON)Q6}$ | Inverter Low Side MOSFETs Q6 (See Note 3) | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 1.86 | 2.32 | mΩ |
| $I_{DSS}$ | Inverter MOSFETs (UH,UL,VH,VL,WH,WL) | $V_{GS}$ = 0 V, $V_{DS}$ = 32 V, $T_j$ = 25°C | − | − | 1.0 | μA |
| $I_{GSS}$ | Inverter MOSFETs Gate to Source Leakage Current | $V_{GS}$ = ±20 V | − | − | ±100 | nA |
| Total loop resistance VLINK(+) − V0 (−) | | $V_{GS}$ = 10 V, $I_D$ = 80 A, $T_j$ = 25°C | − | 4.69 | 5.5 | mΩ |

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.

3. All MOSFETs have same die size and $R_{DS(ON)}$. The different $R_{DS(ON)}$ values listed in the datasheet are due to the different access points available inside the module for $R_{DS(ON)}$ measurement. While the high side MOSFETs (Q1, Q2, Q3) have source sense wire bonds, the low side MOSFETs (Q4, Q5, Q6) do not have source sense wire bonds, thus resulting in higher $R_{DS(ON)}$ values.

**TEMPERATURE SENSE** (NTC Thermistor)

| Symbol | Test Conditions | Test Time | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Voltage | Current = 1 mA, Temperature = 25°C | T = 0.5 ms | 7.5 | − | 12 | V |

**CURRENT SENSE RESISTOR**

| Symbol | Test Conditions | Test Time | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Resistance | Current Sense resistor current = 80 A | T = 0.5 ms | 0.46 | − | 0.53 | mΩ |

## TYPICAL CHARACTERISTICS

(Generated using MOSFETs assembled in a TO263 package, for reference purposes only.)

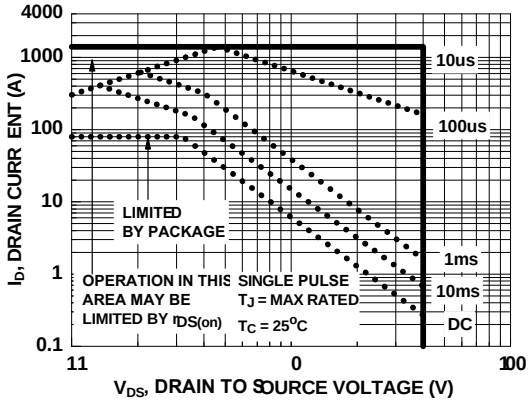
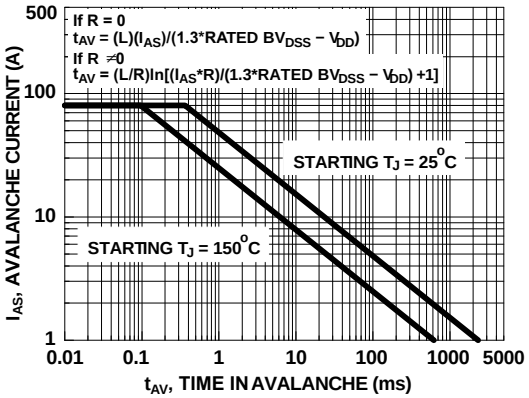



**Figure 3. Forward Bias Safe Operating Area**




NOTE: Refer to Application Notes AN7514 and AN7515

**Figure 4. Unclamped Inductive Switching Capability**

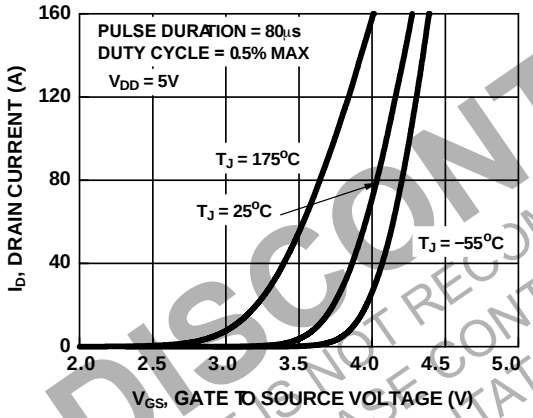



**Figure 5. Transfer Characteristics**

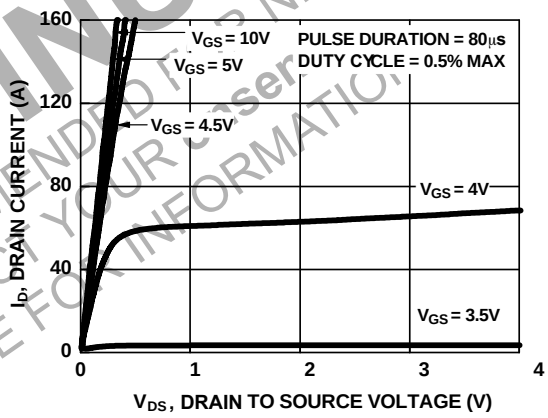



**Figure 6. Saturation Characteristics**



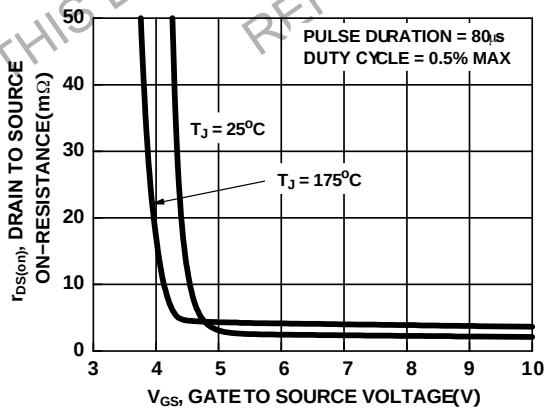



**Figure 7. Drain to Source On−Resistance Variation vs Gate to Source Voltage**

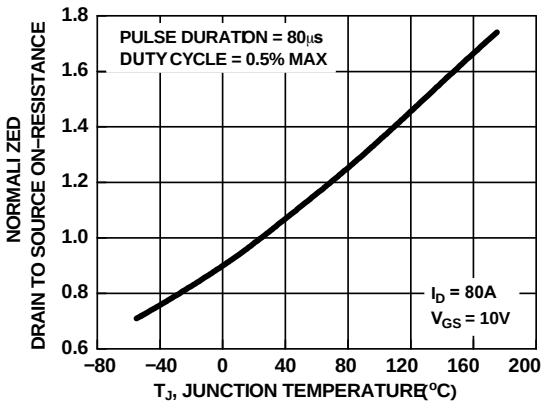



**Figure 8. Normalized Drain to Source On Resistance vs Junction Temperature**

## TYPICAL CHARACTERISTICS

(Generated using MOSFETs assembled in a TO263 package, for reference purposes only.)

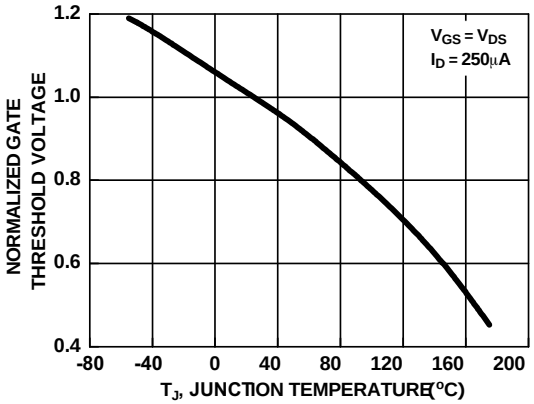



**Figure 9. Normalized Gate Threshold Voltage vs Junction Temperature**

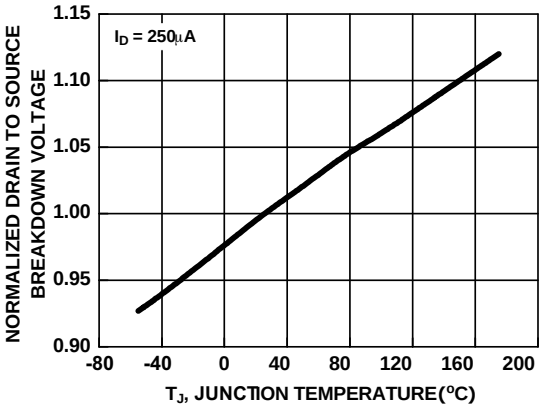



**Figure 10. Normalized Drain to Source Breakdown Voltage vs Junction Temperature**

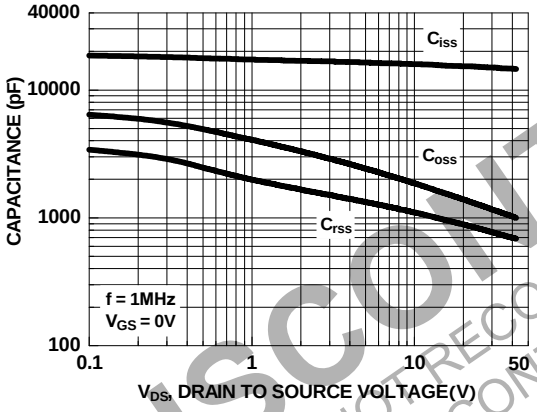



**Figure 11. Capacitance vs Drain to Source Voltage**

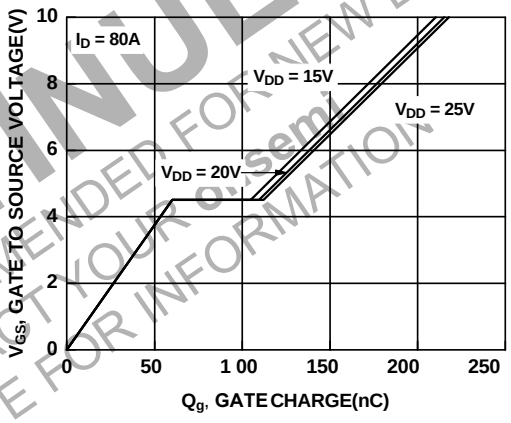



**Figure 12. Gate Charge vs Gate to Source Voltage**

## MECHANICAL CHARACTERISTICS AND RATINGS

| Parameter | Condition | Limits | | | Unit |
|---|---|---|---|---|---|
| | | Min | Typ | Max | |
| Device Flatness | Note Figure 13. | 0 | − | +200 | μm |
| Mounting Torque | Mounting Screw: − M3, Recommended 0.7 N.m | 0.6 | 0.7 | 0.8 | N.m |
| Weight | | − | 20 | − | g |

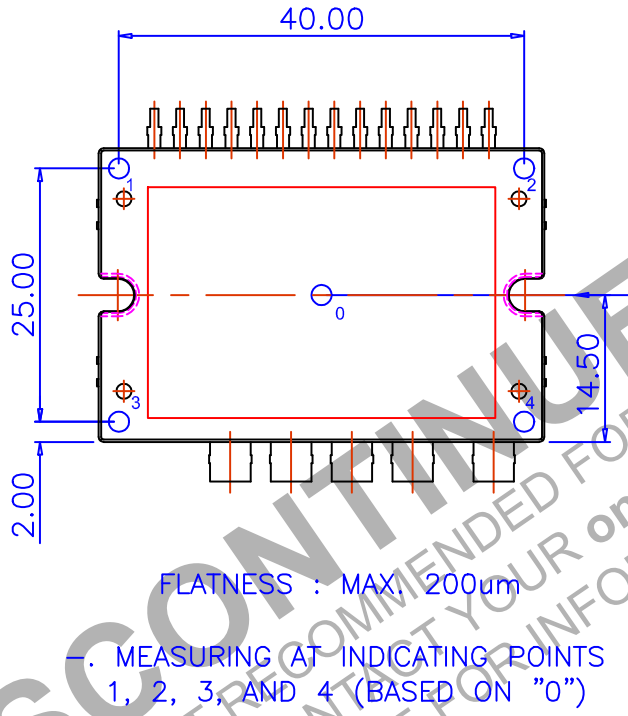



**Figure 13. Flatness Measurement Position**



## ORDERING INFORMATION

| Device Marking | MOSFET | Packing Type | Quantity |
|---|---|---|---|
| FTCO3V455A1 | PCF33478 | Tube | 11 |

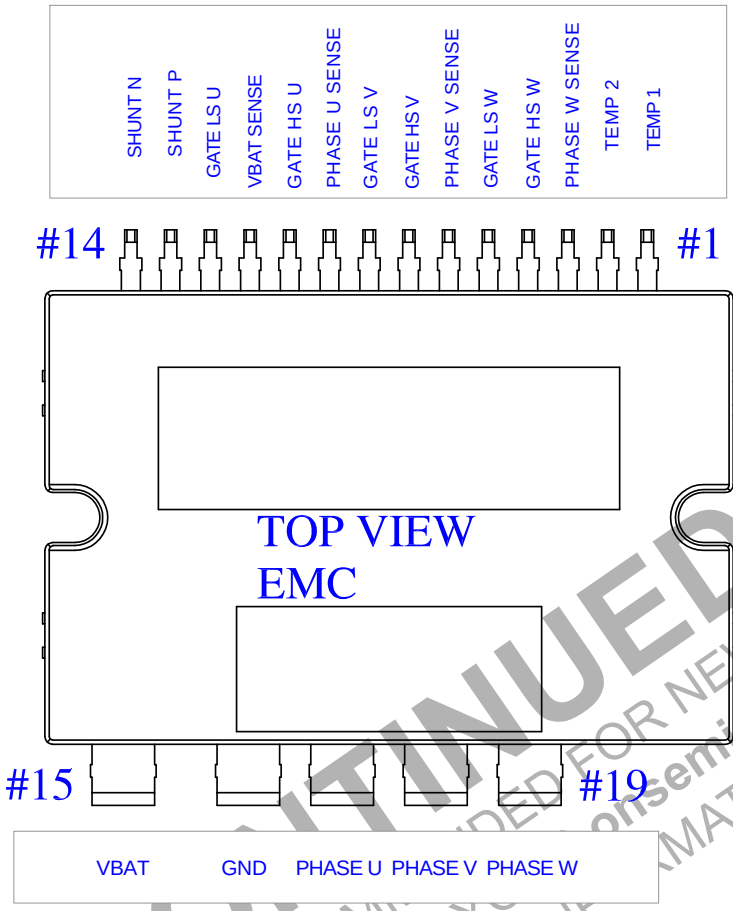



**Figure 14.**

**APMCB−A19 / 19LD, APM, PDD STD DBC, DIP TYPE**
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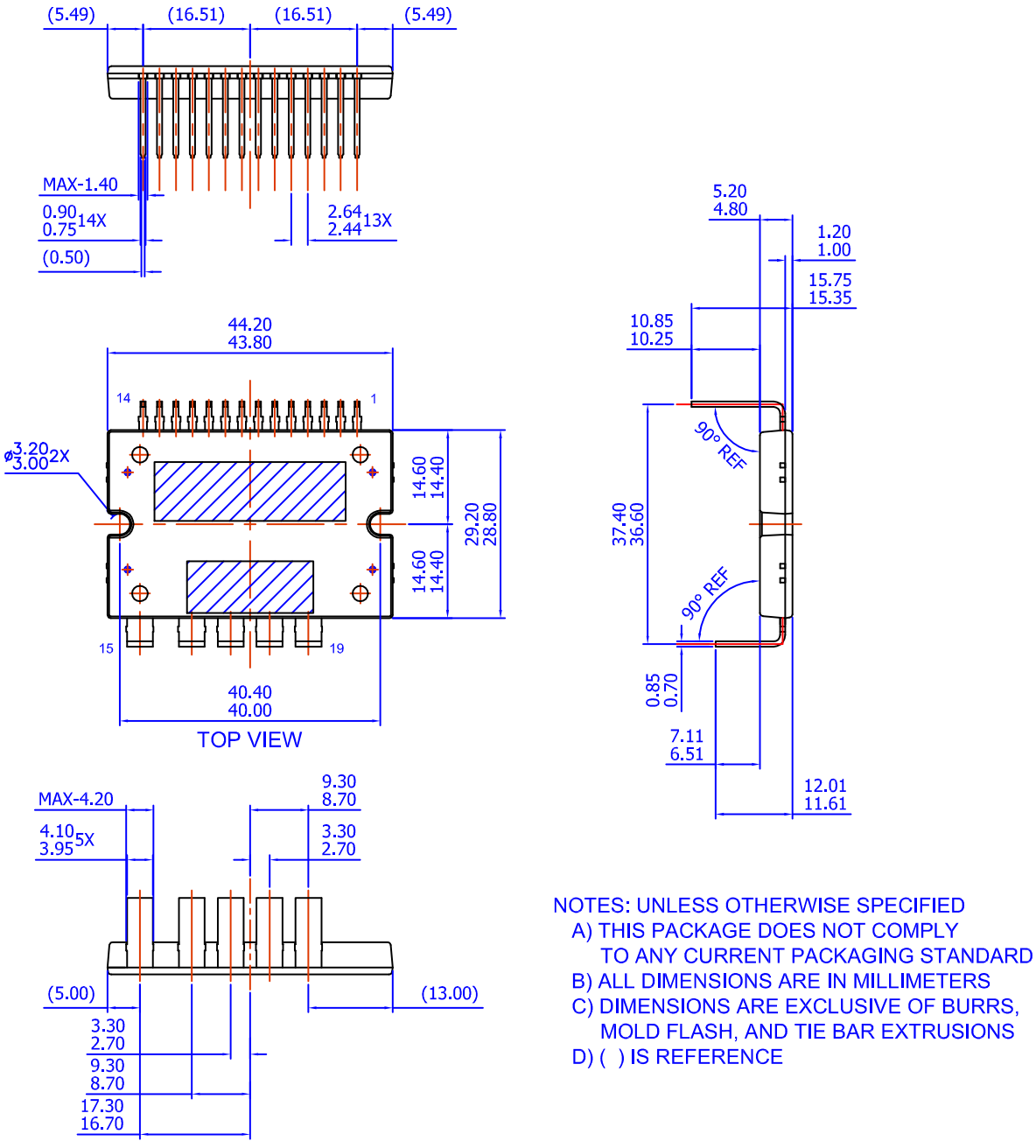


NOTES: UNLESS OTHERWISE SPECIFIED
A) THIS PACKAGE DOES NOT COMPLY TO ANY CURRENT PACKAGING STANDARD
B) ALL DIMENSIONS ARE IN MILLIMETERS
C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS
D) ( ) IS REFERENCE

| | | | |
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