

# Automotive Gate Driver IC, High and Low Side 600 V, 4.5 A

## FAN7191-F085, FAD7191

### Description

The FAN7191 / FAD7191 is a monolithic high- and low-side gate-driver IC, which can drive high speed MOSFETs and IGBTs that operate up to +600 V. It has a buffered output stage with all NMOS transistors designed for high pulse driving capability and minimum cross-conduction.

ON Semiconductor's high-voltage process and common-mode noise canceling technique provide stable operation of high-drivers under high dV/dt noise circumstances. An advanced level-shift circuit allows high-side gate driver operation up to  $V_S = -9.8$  V (typical) for  $V_{BS} = 15$  V.

The UVLO circuit prevents malfunction when  $V_{DD}$  and  $V_{BS}$  are lower than the specified threshold voltage.

The high current and low output voltage drop features make this device suitable for controlling direct injection actuators and for use in many automotive DC-DC converter and motor control applications.

### Features

- Floating Channel for Bootstrap Operation to +600 V
- 4.5 A Sourcing and 4.5 A Sinking Current Driving Capability
- Common-Mode dV/dt Noise Cancelling Circuit
- Built-in Under-Voltage Lockout for Both Channels
- Matched Propagation Delay for Both Channels
- 3.3 V and 5 V Input Logic Compatible
- Output In-phase with Input
- Enable Pin (For 14-SOP Package Only)
- 14-SOP with Separate Signal and Power Ground for Enhanced Noise Immunity
- 14-SOP with Increased Clearance for High Voltage Applications
- Automotive Applications, AEC Qualified and PPAP Capable
- These Devices are Pb-Free and are RoHS Compliant

### Applications

- Electric and Hybrid Electric Vehicles
- 48 V Mild Hybrid Vehicles
- Automotive High Voltage DC-DC converters
- Motor Control (Fans, Pumps, Compressors)
- Advanced Fuel Injection Systems
- Starter/Alternator
- Electric Power Steering
- MOSFET and IGBT Driver Applications

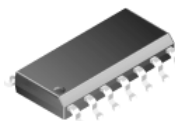


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SOIC8  
CASE 751EB



SOIC14  
CASE 751EF

### ORDERING INFORMATION

| Part Number    | Package        | Shipping           |
|----------------|----------------|--------------------|
| FAN7191MX-F085 | 8-SOP (751EB)  | 2500 / Tape & Reel |
| FAD7191M1X     | 14-SOP (751EF) | 2500 / Tape & Reel |

Typical Application Circuit

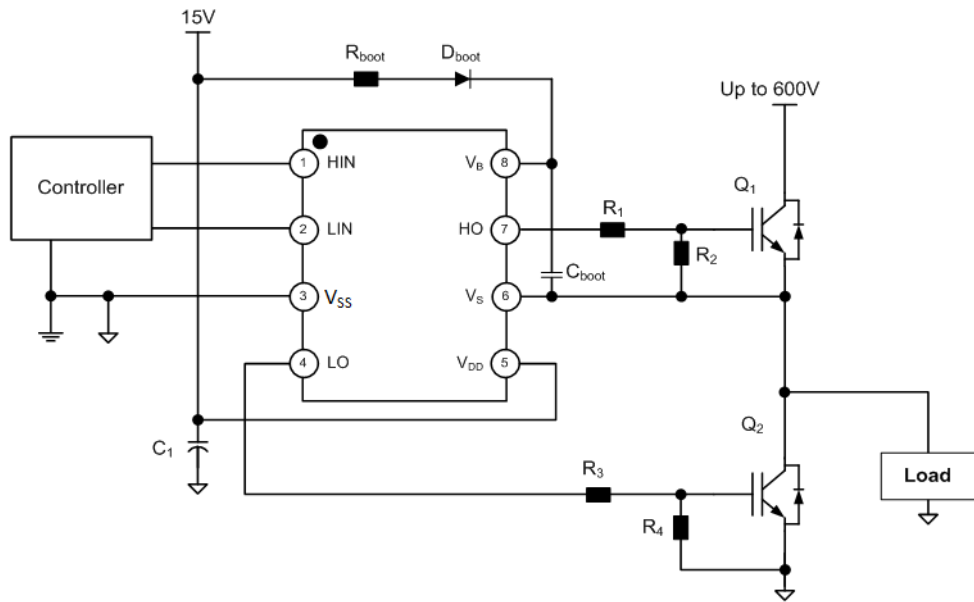


Figure 1. Half-Bridge Application Circuit (8-SOP)

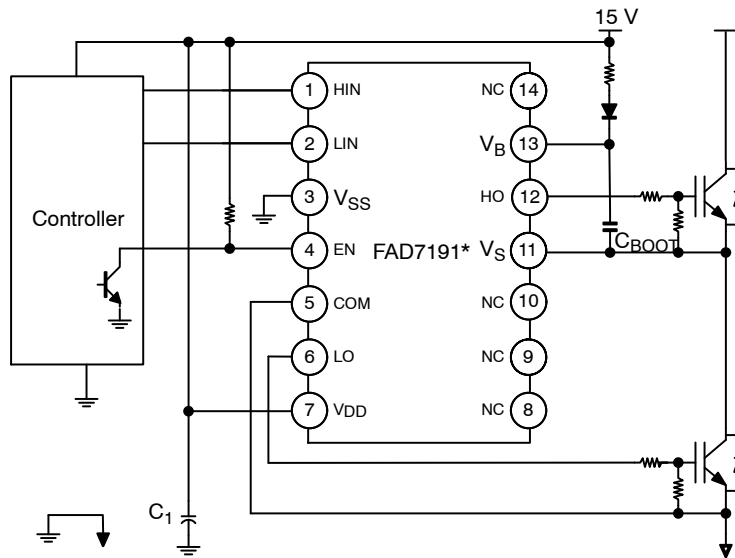


Figure 2. Half-Bridge Application Circuit (14-SOP)

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## INTERNAL BLOCK DIAGRAM



Figure 3. Functional Block Diagram (8-SOP)

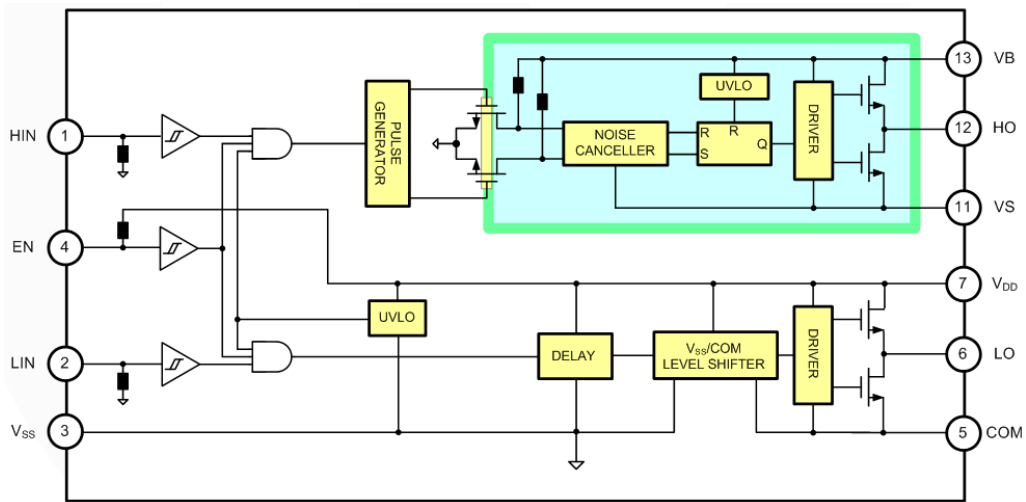


Figure 4. Functional Block Diagram (14-SOP)

# FAN7191–F085, FAD7191

## Pin Assignment

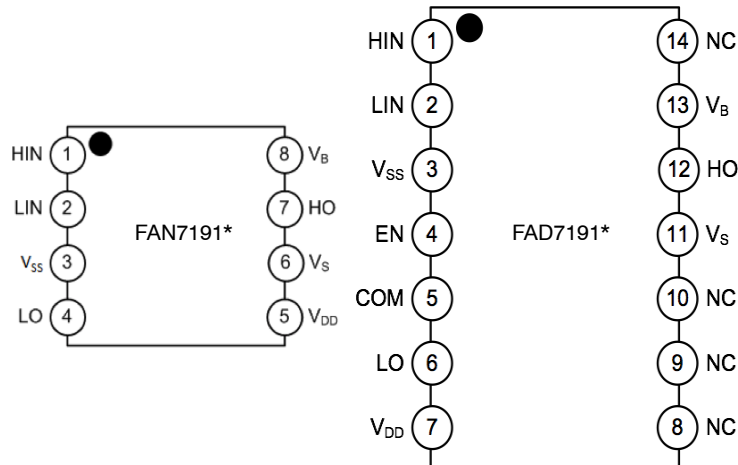


Figure 5. Pin Assignments (Top View)

Table 1. PIN DEFINITIONS

| 8-Pin | 14-Pin       | Name            | Description                                     |
|-------|--------------|-----------------|---|
| 1     | 1            | HIN             | Logic Input for High-Side Gate Driver Output    |
| 2     | 2            | LIN             | Logic Input for Low-Side Gate Driver Output     |
| 3     | 3            | V <sub>SS</sub> | Logic Ground, Power ground for 8-SOP            |
|       | 4            | EN              | Enable Input (Internal Pull Up)                 |
|       | 5            | COM             | Power Ground for 14-SOP, Low-side Driver Return |
| 4     | 6            | LO              | Low-Side Driver Output                          |
| 5     | 7            | V <sub>DD</sub> | Low-Side and Logic Power Supply Voltage         |
| 6     | 11           | V <sub>S</sub>  | High-Side Floating Supply Return                |
| 7     | 12           | HO              | High-Side Driver Output                         |
| 8     | 13           | V <sub>B</sub>  | High-Side Floating Supply                       |
|       | 8, 9, 10, 14 | NC              | No Connect                                      |

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**Table 2. ABSOLUTE MAXIMUM RATINGS**

( $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ , unless otherwise specified.  $V_B$ ,  $V_{DD}$  and  $V_{IN}$  are referenced to  $V_{SS}$ )

| Symbol                       | Parameter                                     |                                   | Min.           | Max.           | Unit                        |
|------------------------------|---|-----------------------------------|----------------|----------------|-----------------------------|
| $V_S$                        | High-side offset voltage $V_S$                |                                   | $V_B - 25$     | $V_B + 0.3$    | V                           |
| $V_B$                        | High-side floating supply voltage $V_B$       |                                   | -0.3           | 625            | V                           |
| $V_{HO}$                     | High-side floating output voltage             |                                   | $V_S - 0.3$    | $V_B + 0.3$    | V                           |
| $V_{DD}$                     | Low-side and logic-fixed supply voltage       |                                   | -0.3           | 25             | V                           |
| COM                          | Power Ground (14-SOP)                         |                                   | $V_{DD} - 25$  | $V_{DD} + 0.3$ | V                           |
| $V_{IN}$                     | Logic Input voltage (HIN, LIN, EN)            |                                   | -0.3           | $V_{DD} + 0.3$ | V                           |
| $V_{LO}$                     | Low-Side Output Voltage LO (8-SOP)            |                                   | $V_{SS} - 0.3$ | $V_{DD} + 0.3$ | V                           |
|                              | Low-Side Output Voltage LO (14-SOP)           |                                   | COM - 0.3      | $V_{DD} + 0.3$ | V                           |
| $T_{\text{pulse}}$ (Note 4)  | Minimum Pulse Width                           |                                   | 80             |                | ns                          |
| $dV_S/dt$                    | Allowable offset voltage slew rate            |                                   |                | 50             | V/ns                        |
| $P_D$<br>(Note 1, 2, 3)      | Power Dissipation, $T_A = 25^{\circ}\text{C}$ |                                   | 8-SOP          | 0.625          | W                           |
|                              |   |                                   | 14-SOP         | 0.80           | W                           |
| $\theta_{JA}$<br>(Note 1, 2) | Thermal Resistance, junction-to-ambient       |                                   | 8-SOP          | 200            | $^{\circ}\text{C}/\text{W}$ |
|                              |   |                                   | 14-SOP         | 156            | $^{\circ}\text{C}/\text{W}$ |
| $T_J$                        | Junction temperature                          |                                   |                | +150           | $^{\circ}\text{C}$          |
| $T_S$                        | Storage temperature                           |                                   | -55            | +150           | $^{\circ}\text{C}$          |
| ESD                          | Electrostatic Discharge Capability            | Human Body Model, JESD22-A114     | 8-SOP          | 2500           | V                           |
|                              |   |                                   | 14-SOP         | 2000           |                             |
|                              |   | Charged Device Model, JESD22-C101 |                | 2000           |                             |

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. Mounted on  $76.2 \times 114.3 \times 1.6$  mm PCB (FR-4 glass epoxy material).
2. Refer to the following standards: JESD51-2: Integral circuits thermal test method environmental conditions – natural convection. JESD51-3: Low effective thermal conductivity test board for leaded surface mount packages.
3.  $P_D$  is the power that raises  $T_J$  to  $150^{\circ}\text{C}$  for  $T_A = 25^{\circ}\text{C}$ .  $P_D$  to be derated at higher ambient temperature.
4. Minimum input pulse width that guarantee to produce an output pulse. Valid for turn on and turn off pulse width.

**Table 3. RECOMMENDED OPERATING CONDITIONS** ( $V_S$ ,  $V_{DD}$  and  $V_{IN}$  are referenced to  $V_{SS}$ )

| Symbol   | Parameter                                | Min.          | Max.       | Unit               |
|----------|--|---------------|------------|--------------------|
| $V_B$    | High-side floating supply voltage        | $V_S + 10$    | $V_S + 22$ | V                  |
| $V_S$    | High-side Floating Supply Offset Voltage | $6 - V_{BS}$  | 600        | V                  |
| $V_{HO}$ | High-side Output Voltage                 | $V_S$         | $V_B$      | V                  |
| $V_{DD}$ | Low-side and Logic Supply voltage        | 10            | 22         | V                  |
| $V_{LO}$ | Low-side output voltage (8-SOP)          | 0             | $V_{DD}$   | V                  |
|          | Low-side output voltage (14-SOP)         | COM           | $V_{DD}$   | V                  |
| $V_{IN}$ | Logic input voltage (HIN, LIN, EN)       | 0             | $V_{DD}$   | V                  |
| COM      | Power Ground (14-SOP)                    | $V_{DD} - 22$ | $V_{DD}$   | V                  |
| $T_A$    | Ambient Temperature                      | -40           | +125       | $^{\circ}\text{C}$ |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

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**Table 4. ELECTRICAL CHARACTERISTICS**

( $V_{BIAS}$  ( $V_{DD}$ ,  $V_{BS}$ ) = 15.0 V,  $V_S = V_{SS} = \text{COM}$ ,  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$ , unless otherwise specified. The  $V_{IL}$ ,  $V_{IH}$  and  $I_{IN}$  parameters are referenced to  $V_{SS}$  and are applicable to the respective input signals HIN and LIN. The  $V_O$  and  $I_O$  parameters are referenced to COM (or  $V_{SS}$  in case of 8–SOP).  $V_S$  and COM ( $V_{SS}$  for 8–SOP) are applicable to the respective outputs HO and LO)

| Symbol  | Characteristic  | Condition  | Min. | Typ. | Max. | Unit             |
|---|---|--|------|------|------|------------------|
| <b>POWER SUPPLY SECTION (<math>V_{DD}</math> AND <math>V_{BS}</math>)</b> |   |  |      |      |      |                  |
| $V_{DDUV+}$<br>$V_{BSUV+}$  | $V_{DD}$ and $V_{BS}$ Supply Under-Voltage Positive-going Threshold   |  | 7.8  | 8.8  | 9.8  | V                |
| $V_{DDUV-}$<br>$V_{BSUV-}$  | $V_{DD}$ and $V_{BS}$ Supply Under-Voltage Negative Going Threshold   |  | 7.2  | 8.3  | 9.1  |                  |
| $V_{DDHYS}$   | $V_{DD}$ supply under-voltage lockout hysteresis                      |  |      | 0.5  |      |                  |
| $I_{LK}$  | Offset Supply Leakage Current   | $V_B = V_S = 600\text{ V}$   |      |      | 50   | $\mu\text{A}$    |
| $I_{QBS}$   | Quiescent $V_{BS}$ Supply Current                                     | $V_{IN} = 0\text{ V}$ or $5\text{ V}$                                    |      | 45   | 110  |                  |
| $I_{QDD}$   | Quiescent $V_{DD}$ Supply Current                                     | $V_{IN} = 0\text{ V}$ or $5\text{ V}$                                    |      | 75   | 150  |                  |
| $I_{PBS}$   | Operating $V_{BS}$ Supply Current                                     | $f_{IN} = 20\text{ kHz}$ , RMS value<br>(See Figure 26)                  |      | 400  | 800  | $\mu\text{A}$    |
| $I_{PDD}$   | Operating $V_{DD}$ Supply Current                                     | $f_{IN} = 20\text{ kHz}$ , RMS value<br>(See Figure 26)                  |      | 400  | 800  |                  |
| <b>LOGIC INPUT SECTION (HIN, LIN, EN)</b>                                 |   |  |      |      |      |                  |
| $V_{IH}$  | Logic “1” Input Voltage   |  | 2.5  |      |      | V                |
| $V_{IL}$  | Logic “0” Input Voltage   |  |      |      | 1.2  |                  |
| $I_{IN+}$   | Logic “1” Input Bias Current (HIN/LIN)                                | $V_{IN} = 5\text{ V}$  |      | 25   | 50   | $\mu\text{A}$    |
| $I_{IN-}$   | Logic “0” Input Bias Current (HIN/LIN)                                | $V_{IN} = 0\text{ V}$  |      | 1.0  | 2.0  |                  |
| $I_{EN+}$   | Enable High Input Bias Current  | $EN = 5\text{ V}$  | -100 | -50  | -10  |                  |
| $I_{EN-}$   | Enable Low Input Bias Current   | $EN = 0\text{ V}$  | -140 | -75  | -20  |                  |
| $R_{IN}$  | Input Pull-down Resistance  |  | 100  | 200  |      | $\text{k}\Omega$ |
| <b>GATE DRIVER OUTPUT SECTION (HO, LO)</b>                                |   |  |      |      |      |                  |
| $V_{OH}$  | High-level Output Voltage, $V_{BIAS}-V_O$                             | No Load  |      |      | 1.35 | V                |
| $V_{OL}$  | Low-level Output Voltage, $V_O$                                       | No Load  |      |      | 35   | mV               |
| $I_{O+}$<br>(Note 5)  | Output HIGH, Short-circuit Pulsed Current                             | $V_O = 0\text{ V}$ , $V_{IN} = 5\text{ V}$ with<br>$PW < 10\mu\text{s}$  | 3.5  | 4.5  |      | A                |
| $I_{O-}$<br>(Note 5)  | Output LOW Short-circuit Pulsed Current                               | $V_O = 15\text{ V}$ , $V_{IN} = 0\text{ V}$ with<br>$PW < 10\mu\text{s}$ | 3.5  | 4.5  |      |                  |
| $V_S$   | Allowable Negative $V_S$ Pin Voltage for HIN Signal Propagation to HO | $V_{BS} = 15\text{ V}$   |      | -9.8 | -9.0 | V                |
| COM- $V_{SS}$<br>(Note 5)   | Allowable COM- $V_{SS}$ ground offset                                 | 14-SOP, $V_{DD} = 15\text{ V}$ ,<br>$V_{SS} = 0\text{ V}$                | -7.0 |      |      | V                |

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.

5. Parameters guaranteed by design.

# FAN7191–F085, FAD7191

**Table 5. DYNAMIC ELECTRICAL CHARACTERISTICS**

( $V_{BIAS}$  ( $V_{DD}$ ,  $V_{BS}$ ) = 15.0 V,  $V_S = V_{SS} = COM = 0$  V,  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $C_{LOAD} = 1000$  pF unless otherwise specified)

| Symbol    | Characteristic             | Condition   | Min. | Typ. | Max. | Unit |
|-----------|----------------------------|-------------|------|------|------|------|
| $t_{on}$  | Turn-on Propagation Delay  | $V_S = 0$ V |      | 140  | 200  | ns   |
| $t_{off}$ | Turn-off Propagation Delay | $V_S = 0$ V |      | 140  | 200  | ns   |
| MT        | Delay Matching             |             |      |      | 55   | ns   |
| $t_r$     | Turn-on Rise Time          |             |      | 25   | 50   | ns   |
| $t_f$     | Turn-off Fall Time         |             |      | 25   | 50   | ns   |

Typical Characteristics

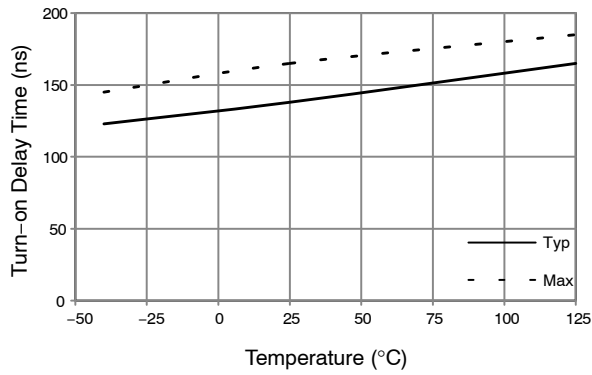


Figure 6. Turn-on Propagation Delay vs. Temperature

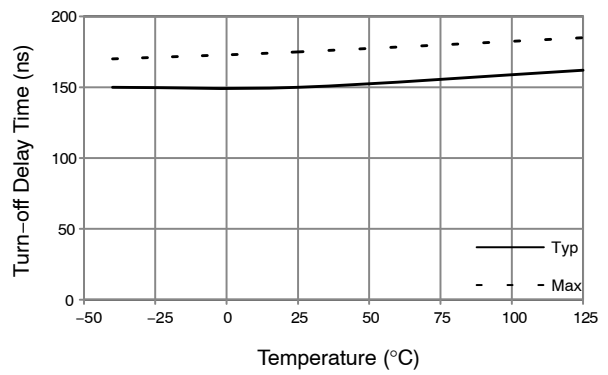


Figure 7. Turn-off Propagation Delay vs. Temperature

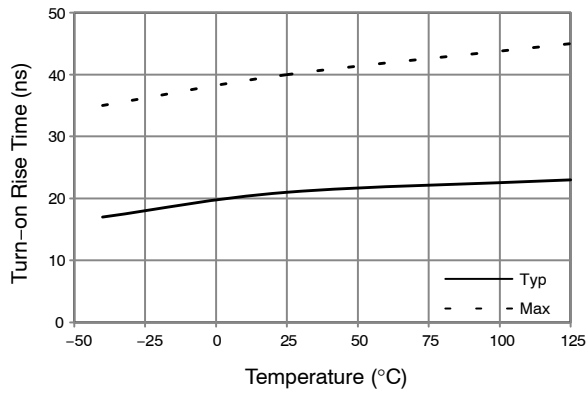


Figure 8. Turn-on Rise Time vs. Temperature

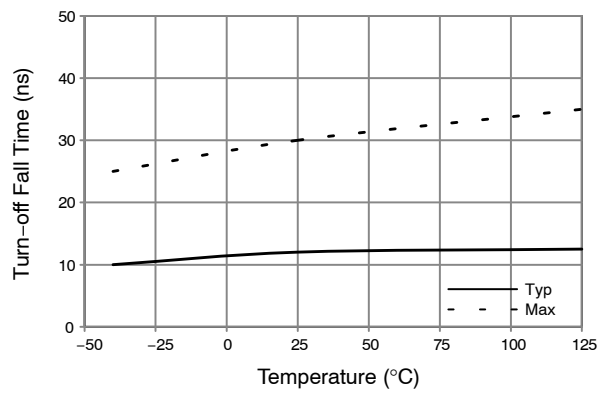


Figure 9. Turn-off Fall Time vs. Temperature

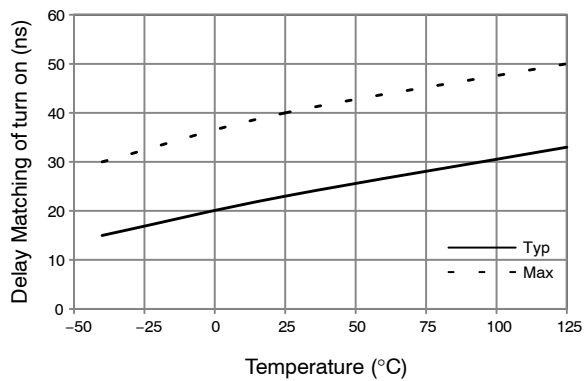


Figure 10. Turn-on Delay Matching vs. Temperature

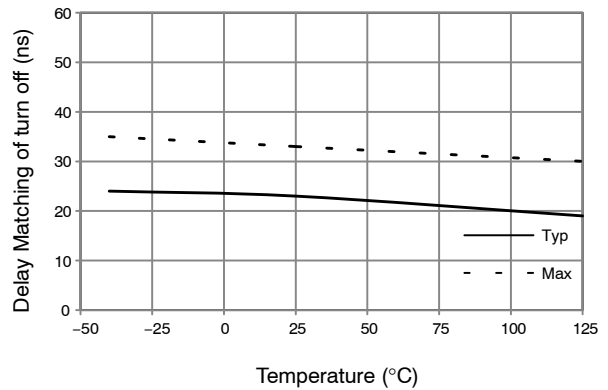


Figure 11. Turn-off Delay Matching vs. Temperature



Typical Characteristics (continued)

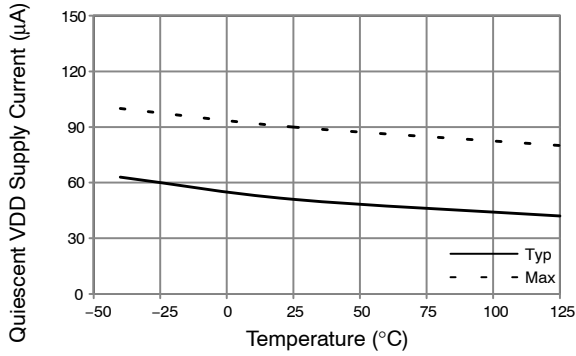


Figure 12. Quiescent  $V_{DD}$  Supply Current vs. Temperature

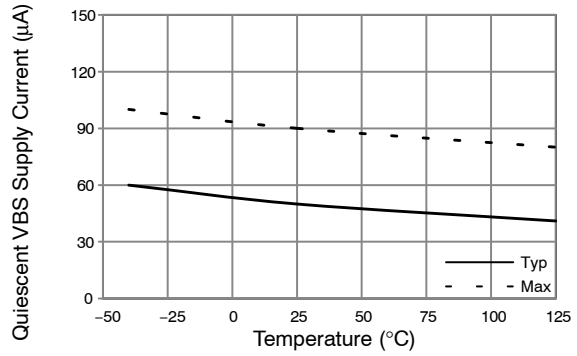


Figure 13. Quiescent  $V_{BS}$  Supply Current vs. Temperature

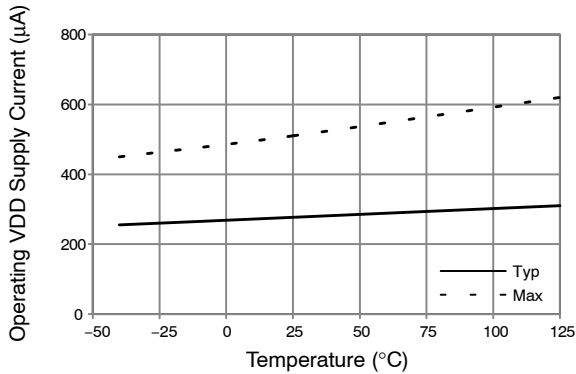


Figure 14. Operating  $V_{DD}$  Supply Current vs. Temperature

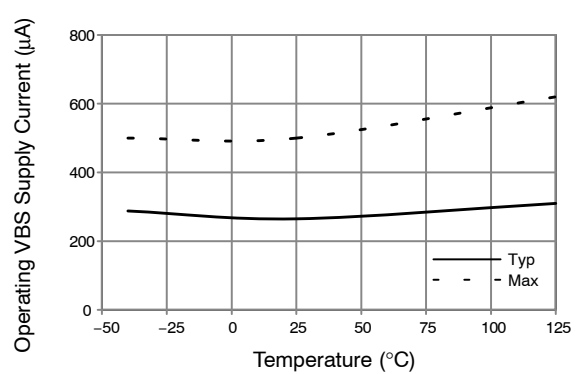


Figure 15. Operating  $V_{BS}$  Supply Current vs. Temperature

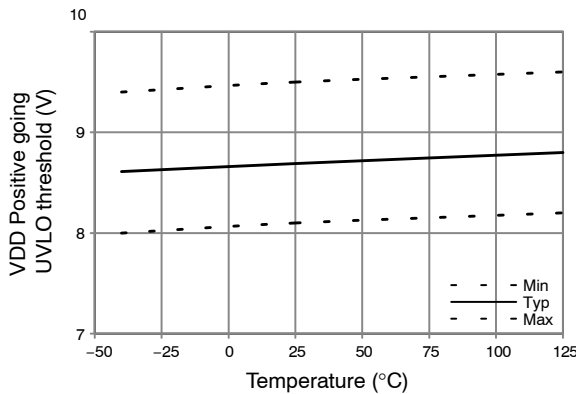


Figure 16.  $V_{DD}$  UVLO+ vs. Temperature

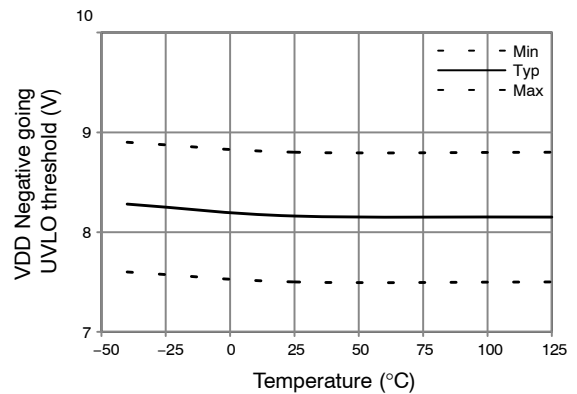


Figure 17.  $V_{DD}$  UVLO- vs. Temperature

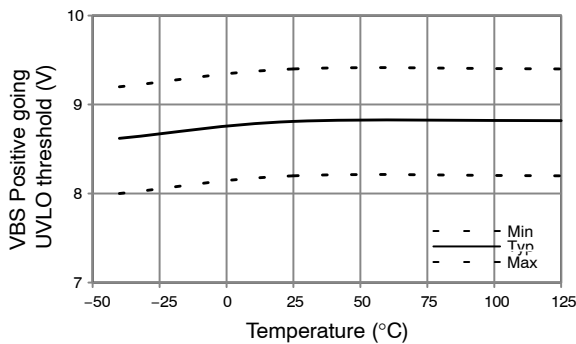


Figure 18.  $V_{BS}$  UVLO+ vs. Temperature

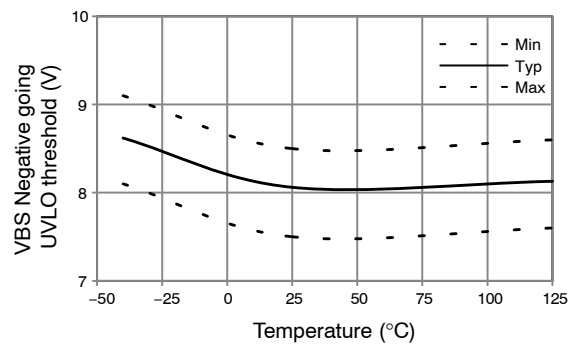


Figure 19.  $V_{BS}$  UVLO- vs. Temperature

Typical Characteristics (continued)

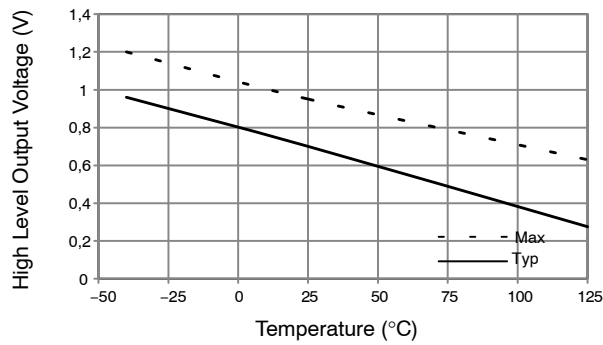


Figure 20. High-Level Output Voltage vs. Temperature

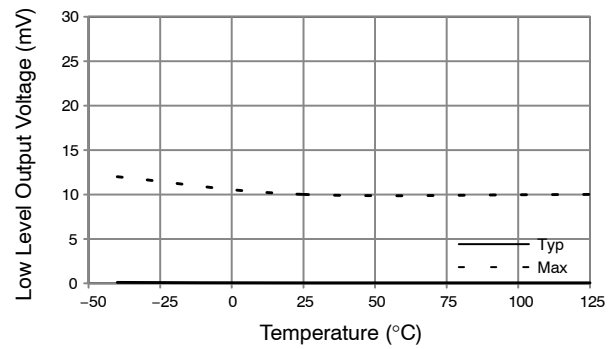


Figure 21. Low-Level Output Voltage vs. Temperature

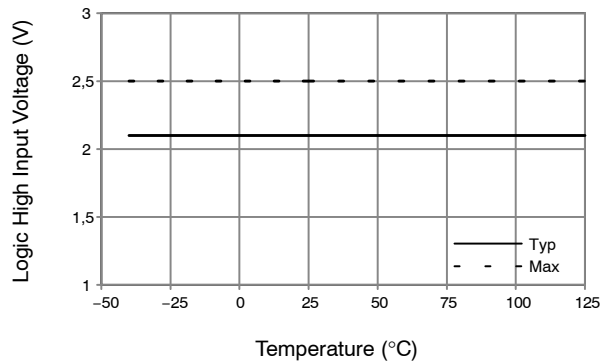


Figure 22. Logic High Input Voltage vs. Temperature

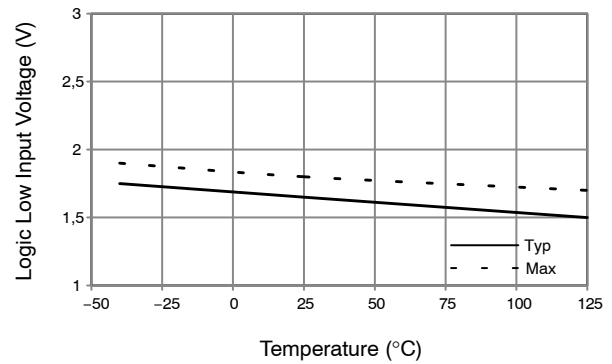


Figure 23. Logic Low Input Voltage vs. Temperature

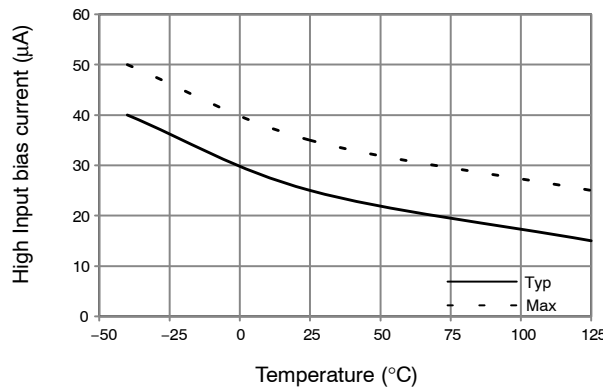


Figure 24. Logic "1" Input Bias Current vs. Temperature

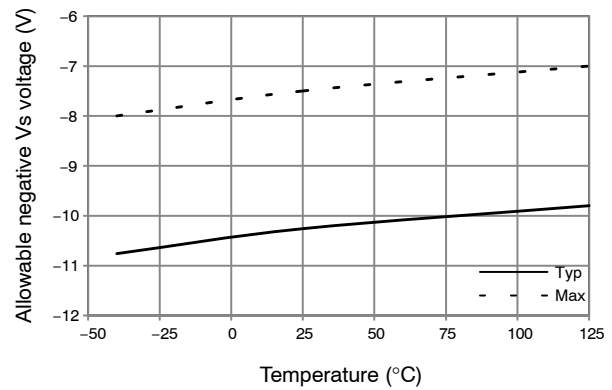


Figure 25. Allowable Negative VS Voltage vs. Temperature

Switching Time Definitions

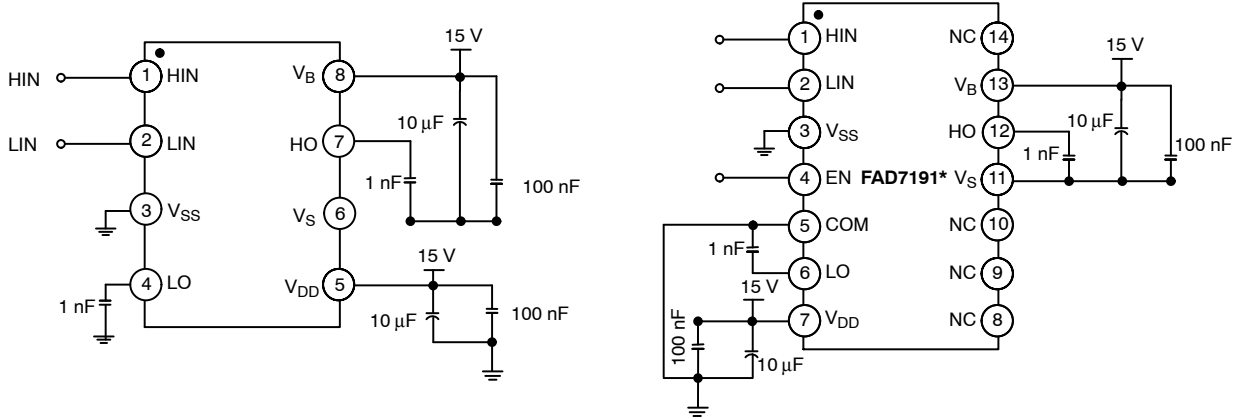


Figure 26. Switching Time Test Circuit

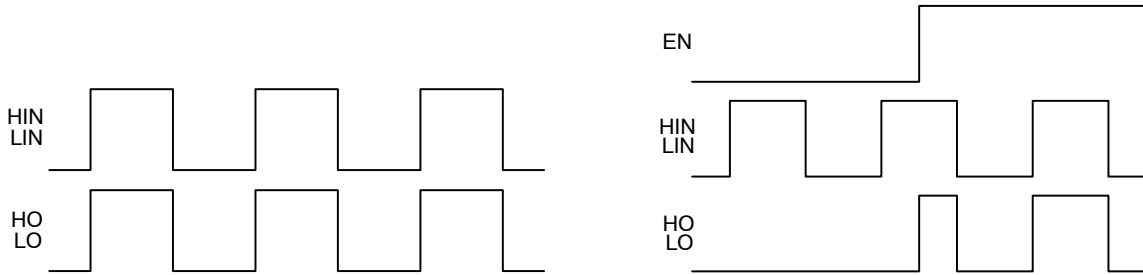


Figure 27. Input / Output Timing Diagram

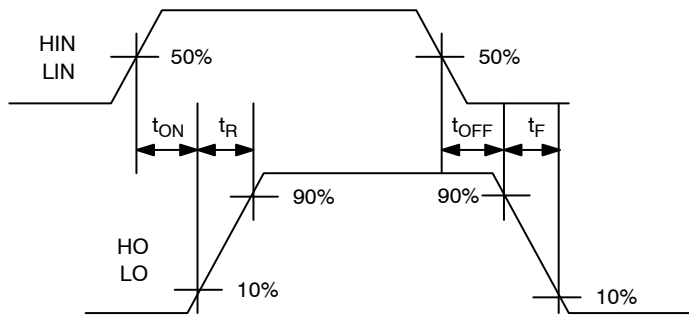


Figure 28. Switching Time Waveform Definitions

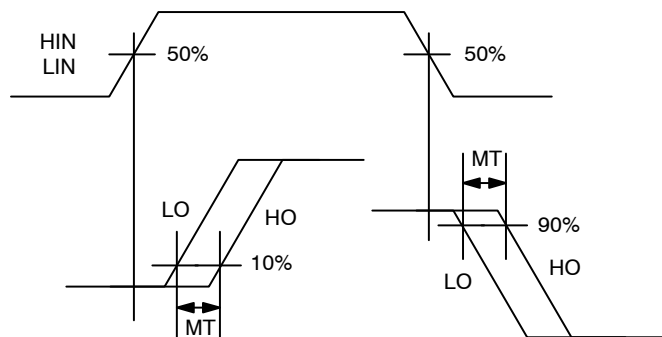


Figure 29. Delay Matching Waveform Definition

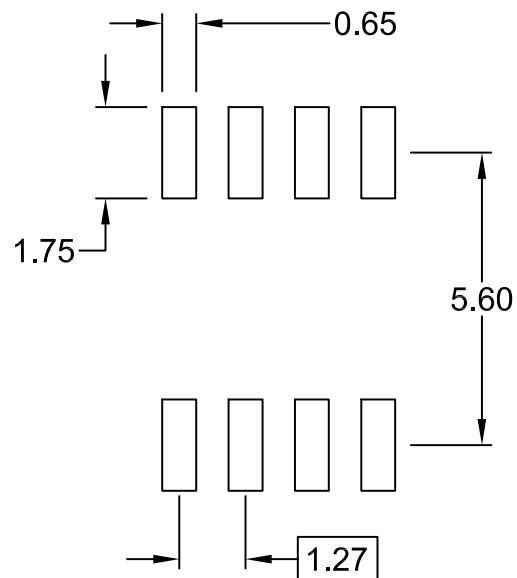
**MECHANICAL CASE OUTLINE**  
**PACKAGE DIMENSIONS**

ON Semiconductor®



**SOIC8**  
**CASE 751EB**  
**ISSUE A**

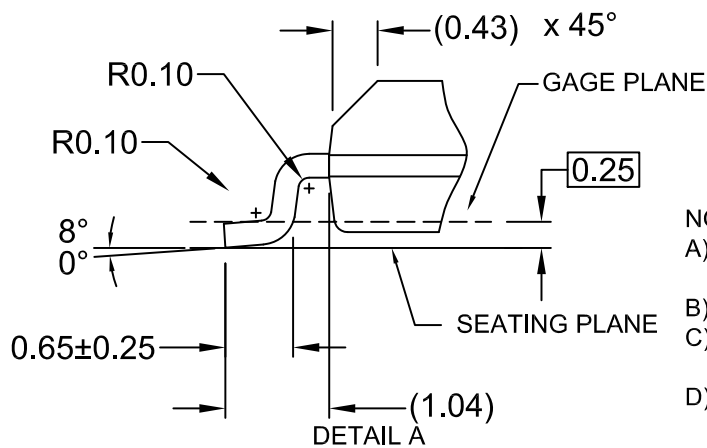
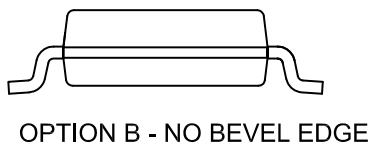
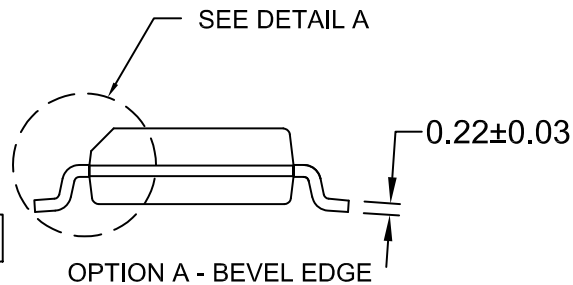
DATE 24 AUG 2017



⊕ 0.25 (M) C B A



⌒ 0.10



**DETAIL A**  
 SCALE: 2:1

**NOTES:**

- A) THIS PACKAGE CONFORMS TO JEDEC MS-012, VARIATION AA.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS DO NOT INCLUDE MOLD FLASH OR BURRS.
- D) LANDPATTERN STANDARD: SOIC127P600X175-8M

|                         |                    |  |
|-------------------------|--------------------|--|
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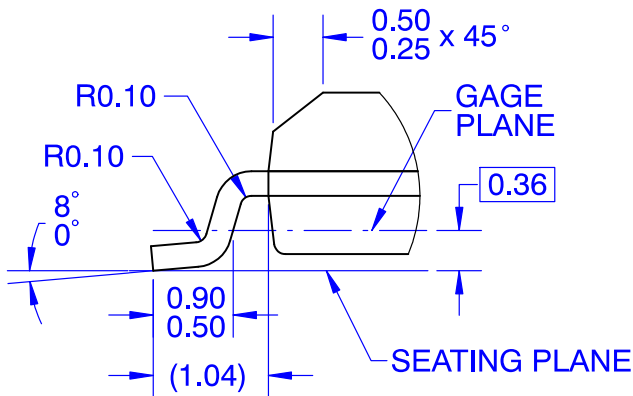
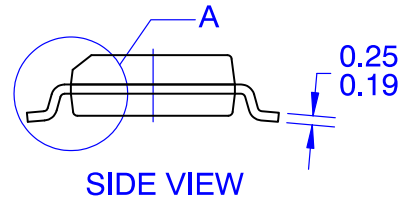
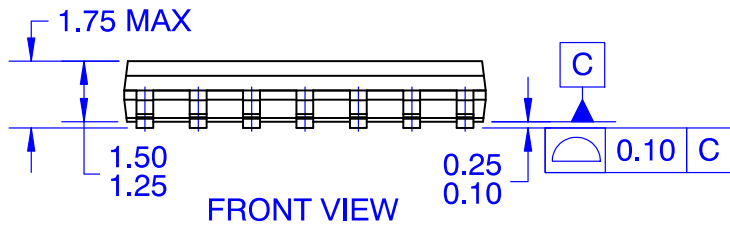
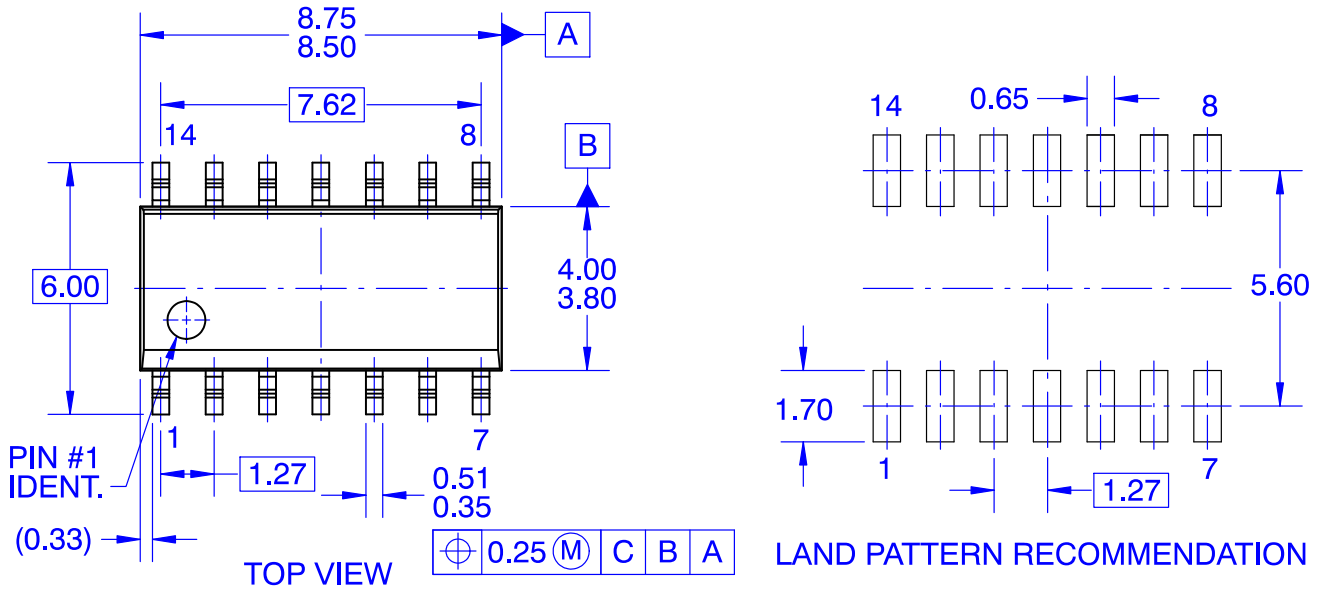
**MECHANICAL CASE OUTLINE**  
**PACKAGE DIMENSIONS**

ON Semiconductor®



**SOIC14**  
**CASE 751EF**  
**ISSUE O**

DATE 30 SEP 2016



**DETAIL A**  
**SCALE 16 : 1**

**NOTES:**

- A. CONFORMS TO JEDEC MS-012, VARIATION AB, ISSUE C
- B. ALL DIMENSIONS ARE IN MILLIMETERS
- C. DIMENSIONS DO NOT INCLUDE MOLD FLASH OR BURRS
- D. LAND PATTERN STANDARD: SOIC127P600X145-14M
- E. CONFORMS TO ASME Y14.5M, 2009

|                         |                    |  |
|-------------------------|--------------------|--|
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