

# AC Line Monitor Logic-Out Device

## MID400

### Description

The MID400 is an optically isolated AC line-to-logic interface device. It is packaged in an 8-lead plastic DIP. The AC line voltage is monitored by two back-to-back GaAs LED diodes in series with an external resistor. A high gain detector circuit senses the LED current and drives the output gate to a logic low condition.

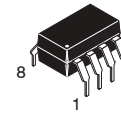
The MID400 has been designed solely for the use as an AC line monitor. It is recommended for use in any AC-to-DC control application where excellent optical isolation, solid state reliability, TTL compatibility, small size, low power, and low frequency operations are required.

### Features

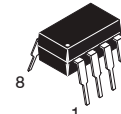
- Direct Operation from any Line Voltage with the Use of an External Resistor
- Externally Adjustable Time Delay
- Externally Adjustable AC Voltage Sensing Level
- Logic Level Compatibility
- Safety and Regulatory Approvals:
  - ♦ UL1577, 2,500 VAC<sub>RMS</sub> for 1 Minute
  - ♦ DIN-EN/IEC60747-5-5, 630 V Peak Working Insulation Voltage

### Applications

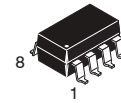
- Monitoring of the AC/DC “Line-down” Condition
- “Closed-loop” Interface between Electromechanical Elements such as Solenoids, Relay Contacts, Small Motors, and Microprocessors
- Time Delay Isolation Switch



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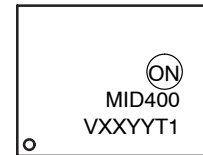


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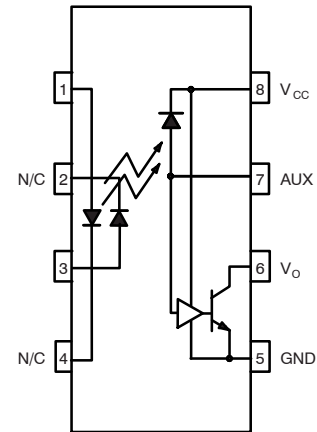
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### MARKING DIAGRAM



- MID400 = Specific Device Code  
 V = DIN EN/IEC60747-5-5 Option (only appears on component ordered with this option)  
 XX = Two-Digit Year Code, e.g., “06”  
 YY = Digit Work Week, Ranging from “01” to “53”  
 T1 = Assembly Package Code

### FUNCTIONAL SCHEMATIC



### ORDERING INFORMATION

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

## MID400

**SAFETY AND INSULATION RATINGS** (As per DIN EN/IEC 60747-5-5, this optocoupler is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings shall be ensured by means of protective circuits.)

| Parameter   |                       | Characteristics |
|---|-----------------------|-----------------|
| Installation Classifications per DIN VDE 0110/1.89 Table 1, For Rated Mains Voltage | <150 V <sub>RMS</sub> | I-IV            |
|   | <300 V <sub>RMS</sub> | I-IV            |
| Climatic Classification   |                       | 55/100/21       |
| Pollution Degree (DIN VDE 0110/1.89)  |                       | 2               |
| Comparative Tracking Index  |                       | 175             |

| Symbol                | Parameter  | Value            | Unit              |
|-----------------------|--|------------------|-------------------|
| V <sub>PR</sub>       | Input-to-Output Test Voltage, Method A, V <sub>IORM</sub> x 1.6 = V <sub>PR</sub> , Type and Sample Test with t <sub>m</sub> = 10 s, Partial Discharge < 5 pC  | 1008             | V <sub>peak</sub> |
|                       | Input-to-Output Test Voltage, Method B, V <sub>IORM</sub> x 1.875 = V <sub>PR</sub> , 100% Production Test with t <sub>m</sub> = 1 s, Partial Discharge < 5 pC | 1182             | V <sub>peak</sub> |
| V <sub>IORM</sub>     | Maximum Working Insulation Voltage   | 630              | V <sub>peak</sub> |
| V <sub>IOTM</sub>     | Highest Allowable Over-Voltage   | 6000             | V <sub>peak</sub> |
|                       | External Creepage  | ≥7               | mm                |
|                       | External Clearance   | ≥7               | mm                |
| DTI                   | Distance Through Insulation (Insulation Thickness)   | ≥0.4             | mm                |
| T <sub>S</sub>        | Case Temperature (Note 1)  | 150              | °C                |
| I <sub>S,INPUT</sub>  | Input Current (Note 1)   | 60               | mA                |
| P <sub>S,OUTPUT</sub> | Output Power (Note 1)  | 150              | mW                |
| R <sub>IO</sub>       | Insulation Resistance at T <sub>S</sub> , V <sub>IO</sub> = 500 V (Note 1)   | >10 <sup>9</sup> | Ω                 |

1. Safety limit values – maximum values allowed in the event of a failure.

### ABSOLUTE MAXIMUM RATINGS

| Symbol           | Parameter  | Value              | Unit  |
|------------------|--|--------------------|-------|
| T <sub>STG</sub> | Storage Temperature  | -55 to +125        | °C    |
| T <sub>OPR</sub> | Operating Temperature  | -40 to +85         | °C    |
| T <sub>J</sub>   | Junction Temperature   | -55 to +100        | °C    |
| T <sub>SOL</sub> | Lead Solder Temperature (Wave soldering only. See recommended reflow profile graph for SMD mounting) | 260 for 10 seconds | °C    |
| P <sub>D</sub>   | Total Device Power Dissipation @ T <sub>A</sub> = 25°C   | 115                | mW    |
|                  | Derate Above 70°C  | 4                  | mW/°C |

### EMITTER

|                         |   |     |       |
|-------------------------|---|-----|-------|
|                         | RMS Current                                   | 25  | mA    |
|                         | DC Current                                    | ±30 | mA    |
| P <sub>D(EMITTER)</sub> | LED Power Dissipation @ T <sub>A</sub> = 25°C | 45  | mW    |
|                         | Derate Above 70°C                             | 2   | mW/°C |

### DETECTOR

|                          |  |    |       |
|--------------------------|--|----|-------|
| I <sub>OL</sub>          | Low Level Output Current                           | 20 | mA    |
| V <sub>OH</sub>          | High Level Output Voltage                          | 7  | V     |
| V <sub>CC</sub>          | Supply Voltage                                     | 7  | V     |
| P <sub>D(DETECTOR)</sub> | Detector Power Dissipation @ T <sub>A</sub> = 25°C | 70 | mW    |
|                          | Derate Above 70°C                                  | 2  | mW/°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.

# MID400

## ELECTRICAL CHARACTERISTICS (0°C to 70°C Free Air Temperature unless otherwise specified)

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

### INDIVIDUAL COMPONENT CHARACTERISTICS

|                 |                                  |  |   |   |     |    |
|-----------------|----------------------------------|--|---|---|-----|----|
| <b>EMITTER</b>  |                                  |  |   |   |     |    |
| $V_F$           | Input Forward Voltage            | $I_{IN(DC)} = \pm 30 \text{ mA}$   | – | – | 1.5 | V  |
| <b>DETECTOR</b> |                                  |  |   |   |     |    |
| $I_{CCL}$       | Logic Low Output Supply Current  | $I_{IN(RMS)} = 4.0 \text{ mA}$ ,<br>$V_O = \text{Open}$ , $V_{CC} = 5.5 \text{ V}$ ,<br>$24 \text{ V} \leq V_{IN(ON\_RMS)} \leq 240 \text{ V}$ | – | – | 3.0 | mA |
| $I_{CCH}$       | Logic High Output Supply Current | $I_{IN(RMS)} = 0.15 \text{ mA}$ ,<br>$V_{CC} = 5.5 \text{ V}$ ,<br>$V_{IN(OFF\_RMS)} \geq 5.5 \text{ V}$                                       | – | – | 0.8 | mA |

### TRANSFER CHARACTERISTICS

|                           |                             |  |     |      |      |               |
|---------------------------|-----------------------------|--|-----|------|------|---------------|
| <b>DC CHARACTERISTICS</b> |                             |  |     |      |      |               |
| $V_{OL}$                  | Logic Low Output Current    | $I_{IN} = I_{IN(ON\_RMS)}$ , $I_O = 16 \text{ mA}$ ,<br>$V_{CC} = 4.5 \text{ V}$ ,<br>$24 \text{ V} \leq V_{IN(ON\_RMS)} \leq 240 \text{ V}$ | –   | 0.18 | 0.40 | V             |
| $I_{OH}$                  | Logic High Output Current   | $I_{IN(RMS)} = 0.15 \text{ mA}$ ,<br>$V_O = V_{CC} = 5.5 \text{ V}$ ,<br>$V_{IN(OFF\_RMS)} \geq 5.5 \text{ V}$                               | –   | 0.02 | 100  | $\mu\text{A}$ |
| $V_{IN(ON\_RMS)}$         | On-state RMS Input Voltage  | $I_O = 16 \text{ mA}$ ,<br>$V_O = 0.4 \text{ V}$ , $V_{CC} = 4.5 \text{ V}$ ,<br>$R_{IN} = 22 \text{ k}\Omega$                               | 90  | –    | –    | V             |
| $V_{IN(OFF\_RMS)}$        | Off-state RMS Input Voltage | $I_O \leq 100 \mu\text{A}$ ,<br>$V_O = V_{CC} = 5.5 \text{ V}$ ,<br>$R_{IN} = 22 \text{ k}\Omega$  | –   | –    | 5.5  | V             |
| $I_{IN(ON\_RMS)}$         | On-state RMS Input Current  | $I_O = 16 \text{ mA}$ ,<br>$V_O = 0.4 \text{ V}$ , $V_{CC} = 4.5 \text{ V}$ ,<br>$24 \text{ V} \leq V_{IN(ON\_RMS)} \leq 240 \text{ V}$      | 4.0 | –    | –    | mA            |
| $I_{IN(OFF\_RMS)}$        | Off-state RMS Input Current | $I_O \leq 100 \mu\text{A}$ ,<br>$V_O = V_{CC} = 5.5 \text{ V}$ ,<br>$V_{IN(OFF\_RMS)} \geq 5.5 \text{ V}$                                    | –   | –    | 0.15 | mA            |
| <b>AC CHARACTERISTICS</b> |                             |  |     |      |      |               |
| $t_{ON}$                  | Turn-On Time                | $I_{IN(RMS)} = 4.0 \text{ mA}$ , $I_O = 16 \text{ mA}$ ,<br>$V_{CC} = 4.5 \text{ V}$ , $R_{IN} = 22 \text{ k}\Omega$<br>(See figure 3)       | –   | 1.0  | –    | ms            |
| $t_{OFF}$                 | Turn-Off Time               |  | –   | 1.0  | –    | ms            |

### ISOLATION CHARACTERISTICS

|           |                                |  |           |   |   |                |
|-----------|--------------------------------|--|-----------|---|---|----------------|
| $V_{ISO}$ | Steady State Isolation Voltage | Relative Humidity $\leq 50\%$ ,<br>$I_{I-O} \leq 10 \mu\text{A}$ , 1 Minute, 60 Hz | 2,500     | – | – | $V_{AC_{RMS}}$ |
| $C_{ISO}$ | Isolation Capacitance          | $f = 1 \text{ MHz}$  | –         | – | 2 | pF             |
| $R_{ISO}$ | Isolation Resistance           | $V_{I-O} = 500 \text{ VDC}$  | $10^{11}$ | – | – | $\Omega$       |

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.

## APPLICATION INFORMATION

The input of the MID400 consists of two back-to-back LED diodes which will accept and convert alternating currents into light energy. An integrated photo diode-detector amplifier forms the output network. Optical coupling between input and output provides 2500 VAC<sub>RMS</sub> voltage isolation. A very high current transfer ratio (defined as the ratio of the DC output current and the DC input current) is achieved through the use of high gain amplifier. The detector amplifier circuitry operates from a 5 V DC supply and drives an open collector transistor output. The switching times are intentionally designed to be slow in order to enable the MID400, when used as an AC line monitor, to respond only to changes in input voltage exceeding many milliseconds. The short period of time during zero-crossing which occurs once every half cycle of the power line is completely ignored. To operate the MID400, always add a resistor, R<sub>IN</sub>, in series with the input (as shown in figure 2) to limit the current to the required value. The value of the resistor can be determined by the following equation:

$$R_{IN} = \frac{V_{IN} - V_F}{I_{IN}} \quad (\text{eq. 1})$$

Where,

V<sub>IN</sub> (RMS) is the input voltage.

V<sub>F</sub> is the forward voltage drop across the LED.

I<sub>IN</sub> (RMS) is the desired input current required to sustain a logic “O” on the output.

## PIN DESCRIPTION

| Pin Number | Pin Name                            | Description  |
|------------|-------------------------------------|--|
| 1, 3       | V <sub>IN1</sub> , V <sub>IN2</sub> | Input terminals  |
| 2, 4       | N/C                                 | No Connect   |
| 8          | V <sub>CC</sub>                     | Supply voltage, output circuit.  |
| 7          | AUX                                 | Auxiliary terminal.<br>Programmable capacitor input to adjust AC voltage sensing level and time delay. |
| 6          | V <sub>O</sub>                      | Output terminal; open collector.   |
| 5          | GND                                 | Circuit ground potential.  |

## SCHEMATIC DIAGRAM

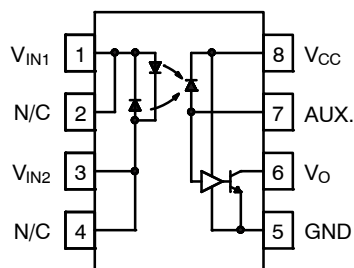


Figure 1. Schematic Diagram

## GLOSSARY

### Voltages

V<sub>IN (ON\_RMS)</sub>

*On-State RMS Input Voltage*

The RMS voltage at an input terminal for a specified input current with output conditions applied according to the product specification will cause the output switching element to be sustained in the on-state within one full cycle.

V<sub>IN (OFF\_RMS)</sub>

*Off-State RMS Input Voltage*

The RMS voltage at an input terminal for a specified input current with output conditions applied according to the product specification will cause the output switching element to be sustained in the off-state within one full cycle.

V<sub>OL</sub>

*Low-Level Output Voltage*

The voltage at an output terminal for a specific output current I<sub>OL</sub>, with input conditions applied according to the product specification will establish a low-level at the output.

V<sub>OH</sub>

*High-Level Output Voltage*

The voltage at an output terminal for a specific output current I<sub>OH</sub>, with input conditions applied according to the product specification will establish a high-level at the output.

V<sub>F</sub>

*LED Forward Voltage*

The voltage developed across the LED when input current I<sub>F</sub> is applied to the anode of the LED.

### Currents

I<sub>IN (ON\_RMS)</sub>

*On-State RMS Input Current*

The RMS current flowing into an input with output conditions applied according to the product specification will cause the output switching element to be sustained in the on-state within one full cycle.

I<sub>IN (OFF\_RMS)</sub>

*Off-state RMS Input Current*

The RMS current flowing into an input with output conditions applied according to the product specification will cause the output switching element to be sustained in the off-state within one full cycle.

I<sub>OH</sub>

*High-Level Output Current*

The current flowing into an output with input conditions applied according to the product specification will establish high-level at the output.

$I_{OL}$

*Low-Level Output Current*

The current flowing into an output with input conditions applied according to the product specification will establish low-level at the output.

$I_{CCL}$

*Supply Current, Output LOW*

The current flowing into the  $V_{CC}$  supply terminal of a circuit when the output is at a low-level voltage.

$I_{CCH}$

*Supply Current, Output HIGH*

The current flowing into the  $V_{CC}$  supply terminal of a circuit when the output is at a high-level voltage.

### Dynamic Characteristics

$t_{ON}$

*Turn-On Time*

The time between the specified reference points on the input and the output voltage waveforms with the output changing from the defined high-level to the defined low-level.

$t_{OFF}$

*Turn-Off Time*

The time between the specified reference points on the input and the output voltage waveforms with the output changing from the defined low-level to the defined high-level.

## TEST CIRCUITS



The diagram illustrates the timing characteristics of a 555 timer in astable mode. It shows three waveforms: the A-C INPUT (a sawtooth wave), the QV (output voltage), and the OUTPUT (a square wave). The output voltage QV is shown with levels  $V_{OH}$  and  $V_{OL}$ . The output pulse width is labeled  $t_{ON}$  and the off-time is labeled  $t_{OFF}$ . The duty cycle is indicated as 50% for the output pulse.

The diagram shows a 4-bit DAC circuit. It consists of a 74133 decoder and an 8-bit DAC. The 74133 decoder has four inputs: pin 1 (INPUT), pin 2 (N/C), pin 3 (2 INPUT with a 22 kΩ resistor), and pin 4 (N/C). The decoder has four outputs: VCC (pin 8), AUX. (pin 7), VOUT (pin 6), and GND (pin 5). The 8-bit DAC has four pins: pin 8 (VCC), pin 7 (AUX.), pin 6 (VOUT), and pin 5 (GND). A 300 Ω resistor (RL) is connected between VCC and VOUT. The output is shown as a square wave.

### Figure 3. MID400 Switching Time

TYPICAL PERFORMANCE CURVES

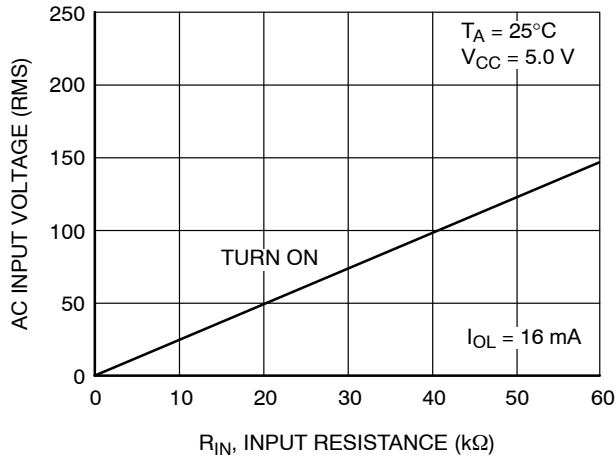


Figure 4. Input Voltage vs. Input Resistance

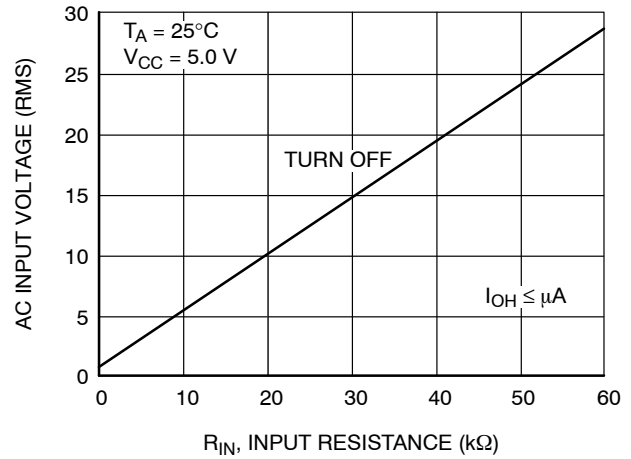


Figure 8. Input Voltage vs. Input Resistance

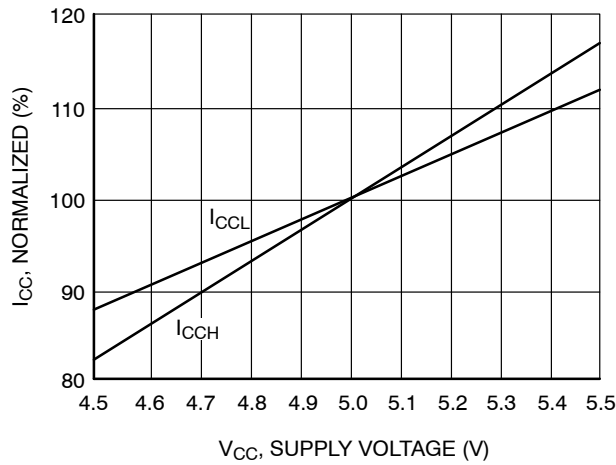


Figure 5. Supply Current vs. Supply Voltage

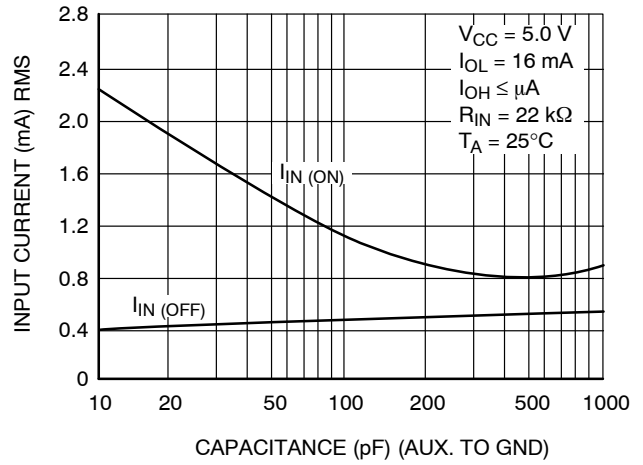


Figure 7. Input Current vs. Capacitance

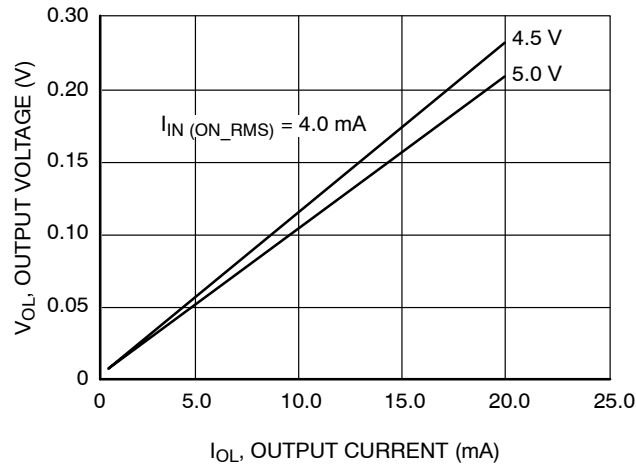
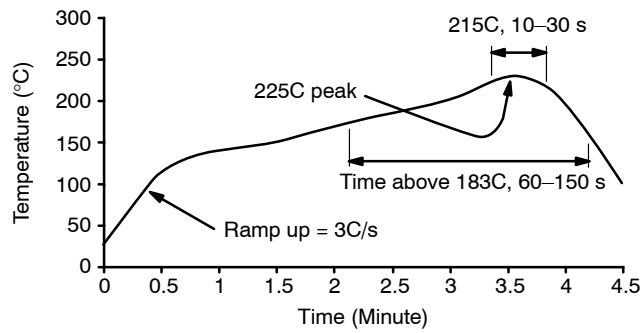


Figure 6. Output Voltage vs. Output Current

# MID400

## REFLOW PROFILE



- Peak reflow temperature: 225C (package surface temperature)
- Time of temperature higher than 183C for 60–150 seconds
- One time soldering reflow is recommended

**Figure 9. Reflow Profile**

## ORDERING INFORMATION

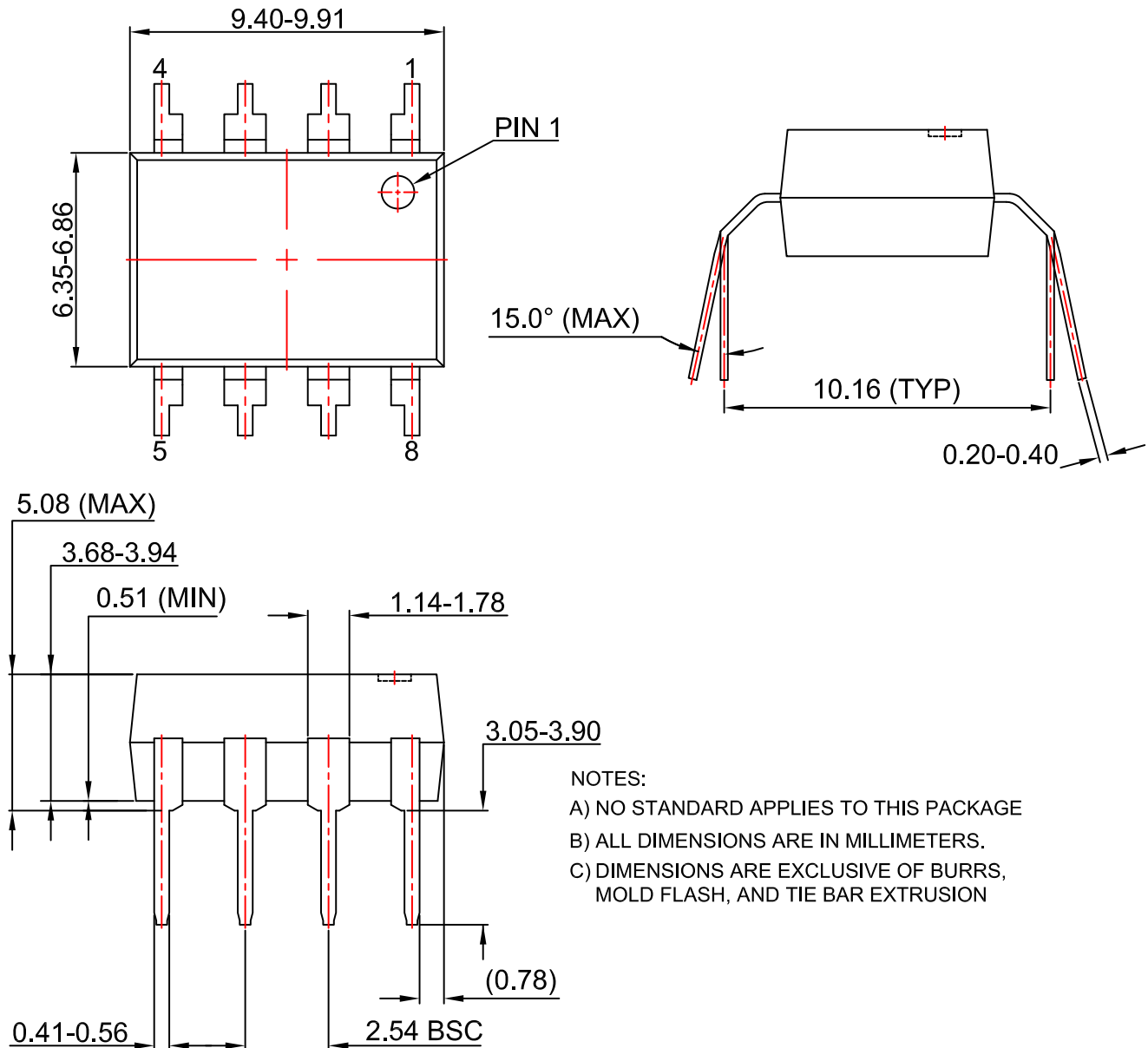
| Part Number | Package  | Shipping <sup>†</sup> |
|-------------|--|-----------------------|
| MID400      | DIP 8-Pin<br>(Pb-Free)   | 50 / Tube             |
| MID400S     | SMT 8-Pin (Lead Bend)<br>(Pb-Free)                                     | 50 / Tube             |
| MID400SD    | SMT 8-Pin (Lead Bend)<br>(Pb-Free)                                     | 1,000 / Tape and Reel |
| MID400V     | DIP 8-Pin, DIN EN/IEC 60747-5-5 Option<br>(Pb-Free)                    | 50 / Tube             |
| MID400SV    | SMT 8-Pin (Lead Bend), DIN EN/IEC 60747-5-5 Option<br>(Pb-Free)        | 50 / Tube             |
| MID400SDV   | SMT 8-Pin (Lead Bend), DIN EN/IEC 60747-5-5 Option<br>(Pb-Free)        | 1,000 / Tape and Reel |
| MID400WV    | DIP 8-Pin, 0.4" Lead Spacing, DIN EN/IEC 60747-5-5 Option<br>(Pb-Free) | 50 / Tube             |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



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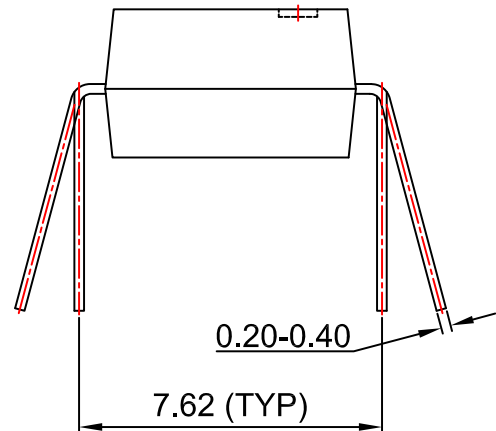
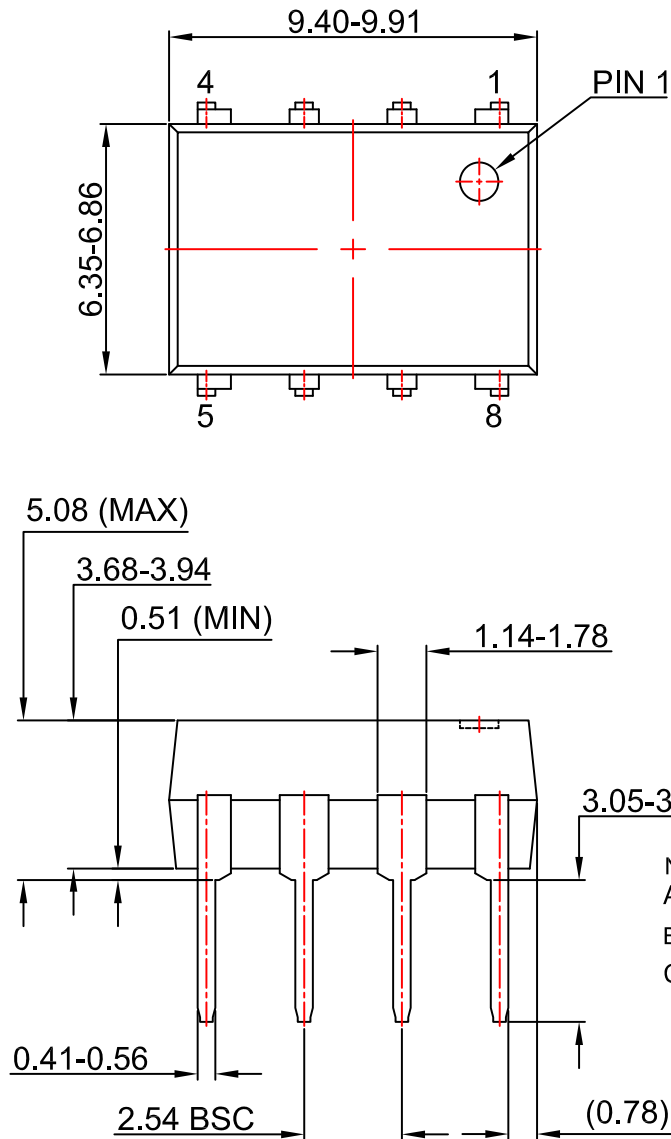


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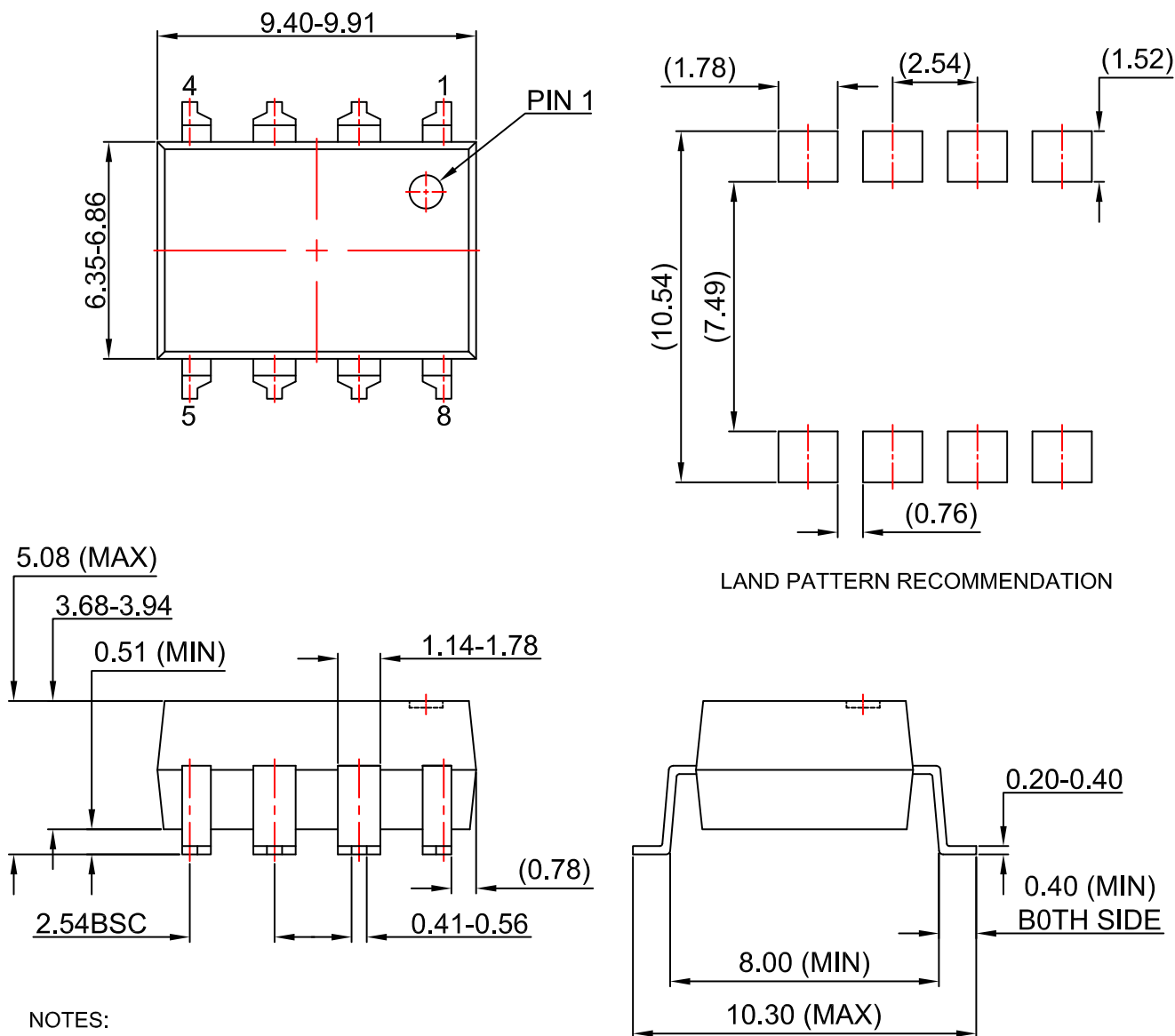
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