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SEMICONDUCTOR



ESD



TVS



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MOV



GDT



PLED

## PT2470-MS

Product specification

## GENERAL DESCRIPTION

The PT2470-MS devices are a brushed-DC motor driver for printers, appliances, industrial equipment, and other small machines. Two logic inputs control the H-bridge driver, which consists of four N-channel MOSFETs that can control motors bi-directionally with up to 3.6-A peak current. The inputs can be pulse width modulated (PWM) to control motor speed, using a choice of current-decay modes. Setting both inputs slow enter a low-power sleep mode.

The PT2470-MS devices feature integrated current regulation, based on the analog input VREF and the voltage on the ISEN pin, which is proportional to motor current through an external sense resistor. The ability to limit current to a known level can significantly reduce the system power requirements and bulk capacitance needed to maintain stable voltage, especially for motor startup and stall conditions.

The devices are fully protected from faults and short circuits, including UVLO, OCP, and TSD.

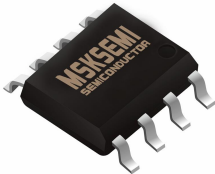

## FEATURES

- H-Bridge Motor Driver  
Drives One DC Motor, One Winding of a Stepper Motor, or Other Loads
- Wide 6.5V to 40V Operating Voltage
- 3.6-A Peak Current Drive
- PWM Control Interface
- Integrated Current Regulation
- Low-Power Sleep Mode
- VM under voltage Lockout (UVLO)
- Overcurrent Protection (OCP)  
- Retry after OCP: PT2470-MS
- Thermal Shutdown (TSD)
- Automatic Fault Recovery
- ESOP8 Small Package and Footprint

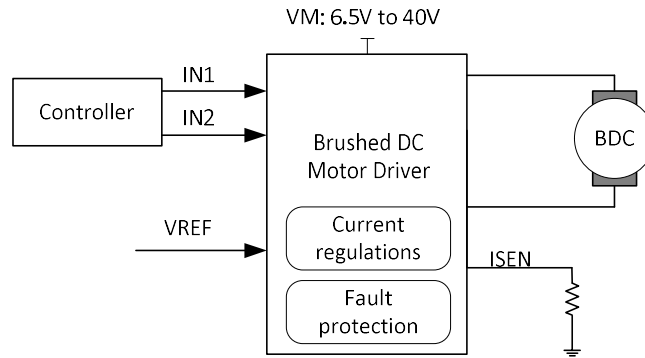
## APPLICATIONS

- Printers
- Appliances
- Industrial Equipment
- Other Mechatronics Applications

## PACKAGE/ORDER INFORMATION

| Part Number | Package |   | Marking  | QTY  |
|-------------|---------|---|--|------|
| PT2470-MS   | ESOP8   |  |  | 4000 |

**TYPICAL APPLICATON**

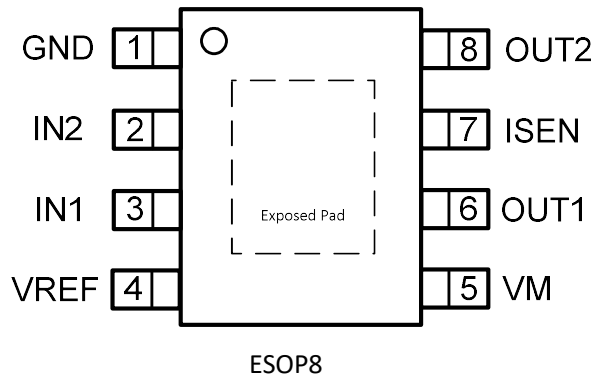


**Figure 1. Basic Application Circuit**

**ABSOLUTE MAXIMUM RATINGS** (Note 1)

| Parameter                                      | Value |        | Unit |
|--|-------|--------|------|
|  | Min   | Max    |      |
| Power supply voltage (VM)                      | -0.3  | 45     | V    |
| Logic input voltage (IN1, IN2)                 | -0.3  | 6      | V    |
| Reference input pin voltage (VREF)             | -0.3  | 6      | V    |
| Continuous phase node pin voltage (OUT1, OUT2) | -0.7  | VM+0.7 | V    |
| Current sense input pin voltage (ISEN)         | -0.5  | 1      | V    |
| Output current (100% duty cycle)               | 0     | 3.5    | A    |
| Operating junction temperature (Note 2)        | -40   | 150    | °C   |
| Storage temperature                            | -65   | 150    | °C   |

**PACKAGE/ORDER INFORMATION**



## PIN FUNCTIONS

| Pin | Name | Function  |
|-----|------|---|
| 1   | GND  | Logic ground. Connect to board ground   |
| 2   | IN2  | Logic inputs. Controls the H-bridge output. Has 100K $\Omega$ internal pulldowns.   |
| 3   | IN1  | Logic inputs. Controls the H-bridge output. Has 100K $\Omega$ internal pulldowns.   |
| 4   | VREF | Analog input. Apply a voltage between 0.3V to 5 V.  |
| 5   | VM   | 6.5V to 40V power supply. Connect a 0.1 $\mu$ F bypass capacitor to ground, as well as sufficient bulk capacitance, rated for the VM voltage.   |
| 6   | OUT1 | H-bridge output. Connect directly to the motor or other inductive load.   |
| 7   | ISEN | High-current ground path. If using current regulation, connect ISEN to a resistor (low-value, high-power-rating) to ground. If not using current regulation, connect ISEN directly to ground. |
| 8   | OUT2 | H-bridge output. Connect directly to the motor or other inductive load.   |

## ESD RATING

| Items            | Description                   | Value      | Unit |
|------------------|-------------------------------|------------|------|
| V <sub>ESD</sub> | Human Body Model for all pins | $\pm$ 2000 | V    |

JEDEC specification JS-001

## RECOMMENDED OPERATING CONDITIONS

| Items          | Description                          | Min | Max | Unit         |
|----------------|--------------------------------------|-----|-----|--------------|
| VM             | Power supply voltage range           | 6.5 | 40  | V            |
| T <sub>J</sub> | Operating Junction Temperature Range | -40 | 125 | $^{\circ}$ C |

**ELECTRICAL CHARACTERISTICS** (Note 3)

 T<sub>A</sub> = 25°C, over recommended operating conditions unless otherwise noted.)

| PARAMETER                                | SYMBOL                   | TEST CONDITIONS                                 | MIN | TYP | MAX  | UNIT |
|--|--------------------------|---|-----|-----|------|------|
| <b>POWER SUPPLY (VM)</b>                 |                          |   |     |     |      |      |
| VM operating voltage                     | VM                       |   | 6.5 |     | 40   | V    |
| VM operating supply current              | I <sub>VM</sub>          | VM = 24V  |     | 2   | 10   | mA   |
| VM sleep current                         | I <sub>VM_SLEEP</sub>    | VM = 24V  |     |     | 15   | μA   |
| Turn-on time (Note 4)                    | t <sub>ON</sub>          | VM > VUVLO with IN1 or IN2 high                 |     | 45  |      | μs   |
| <b>LOGIC-LEVEL INPUTS (IN1, IN2)</b>     |                          |   |     |     |      |      |
| Input logic low voltage                  | V <sub>IL</sub>          |   |     |     | 0.5  | V    |
| Input logic high voltage                 | V <sub>IH</sub>          |   | 2   |     |      | V    |
| Input logic hysteresis                   | V <sub>HYS</sub>         |   |     | 0.2 |      | V    |
| Input logic low current                  | I <sub>IL</sub>          | VIN = 0V  | -1  |     | 1    | μA   |
| Input logic high current                 | I <sub>IH</sub>          | VIN = 3.3V                                      |     | 33  |      | μA   |
| Pulldown resistance                      | R <sub>PD</sub>          | to GND  |     | 100 |      | kΩ   |
| Propagation delay                        | t <sub>PD</sub>          | Inx H to OUTx H change                          |     | 0.2 |      | μs   |
|  |                          | Inx L to OUTx L change                          |     | 1.0 |      | μs   |
| Time to sleep                            | t <sub>sleep</sub>       | Inputs low to sleep                             |     | 1.2 | 2.0  | ms   |
| <b>MOTOR DRIVER OUTPUTS (OUT1, OUT2)</b> |                          |   |     |     |      |      |
| High-side FET on resistance              | R <sub>DS(ON)_High</sub> | VM = 24 V, I = 1A,<br>f <sub>PWM</sub> = 25 kHz |     | 260 | 300  | mΩ   |
| Low-side FET on resistance               | R <sub>DS(ON)_Low</sub>  | VM = 24 V, I = 1A,<br>f <sub>PWM</sub> = 25kHz  |     | 260 | 300  | mΩ   |
| Output dead time                         | t <sub>DEAD</sub>        |   |     | 200 |      | ns   |
| <b>CURRENT REGULATION</b>                |                          |   |     |     |      |      |
| ISEN gain                                | A <sub>V</sub>           | VREF = 2.5V                                     | 9.4 | 10  | 10.4 | V/V  |
| PWM off-time                             | t <sub>OFF</sub>         |   |     | 30  |      | μs   |
| PWM blanking time                        | t <sub>BLANK</sub>       |   |     | 3.2 |      | μs   |
| <b>PROTECTION CIRCUITS</b>               |                          |   |     |     |      |      |
| VM undervoltage lockout                  | V <sub>UVLO_fall</sub>   | VM falls until UVLO triggers                    |     | 5.8 |      | V    |
|  | V <sub>UVLO_rise</sub>   | VM rises until operation recovers               |     | 6.0 |      | V    |
| VM undervoltage hysteresis               | V <sub>UV,_HYS</sub>     | Rising to falling threshold                     |     | 200 |      | mV   |
| Overcurrent protection trip level        | I <sub>OCP</sub>         |   |     | 4.2 |      | A    |
| Overcurrent deglitch time                | t <sub>OCP</sub>         |   |     | 2.5 |      | μs   |
| Overcurrent retry time                   | t <sub>RETRY</sub>       |   |     | 4   |      | ms   |

## ELECTRICAL CHARACTERISTICS (Continued)

| PARAMETER                    | SYMBOL           | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------|------------------|-----------------|-----|-----|-----|------|
| Thermal shutdown temperature | T <sub>SD</sub>  |                 |     | 170 |     | °C   |
| Thermal shutdown hysteresis  | T <sub>HYS</sub> |                 |     | 40  |     | °C   |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** T<sub>J</sub> is calculated from the ambient temperature T<sub>A</sub> and power dissipation P<sub>D</sub> according to the following formula: T<sub>J</sub> = T<sub>A</sub> + (P<sub>D</sub>) x (250°C/W).

**Note 3:** 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

**Note 4:** t<sub>ON</sub> applies when the device initially powers up, and when it exits sleep mode.

## OPERATION

### Overview

The PT2470-MS devices are optimized 8-pin devices for driving brushed DC motors with 6.5V to 40 V and up to 3.6-A peak current. The integrated current regulation restricts motor current to a predefined maximum. Two logic inputs control the H-bridge driver, which consists of four N-channel MOSFETs that have a typical R<sub>DS(ON)</sub> of 0.52Ω (including one high-side and one low-side FET). A single-power input, VM, serves as both device power and the motor winding bias voltage. The integrated charge pump of the device boosts VM internally and fully enhances the high-side FETs. Motor speed can be controlled with pulse-width modulation, at frequencies between 0 to 100 kHz. The devices have an integrated sleep mode that is entered by bringing both inputs low. An assortment of protection features prevents the device from being damaged if a system fault occurs.

### Bridge Control

The PT2470-MS output consists of four N-channel MOSFETs that are designed to drive high current. These outputs are controlled by the two logic inputs IN1 and IN2 as listed in Table 1.

**Table 1. H-Bridge Control**

| IN1 | IN2 | OUT1   | OUT2   | DESCRIPTION  |
|-----|-----|--------|--------|--|
| 0   | 0   | High-Z | High-Z | Coast; H-bridge disabled to High-Z (sleep entered after 1.2ms) |
| 0   | 1   | L      | H      | Reverse (Current OUT2 → OUT1)                                  |
| 1   | 0   | H      | L      | Forward (Current OUT1 → OUT2)                                  |
| 1   | 1   | L      | L      | Brake; low-side slow decay                                     |

The inputs can be set to static voltages for 100% duty cycle drive, or they can be pulse-width modulated (PWM) for variable motor speed. When using PWM, switching between driving and braking typically works best. For example, to drive a motor forward with 50% of the maximum RPM, IN1 = 1 and IN2 = 0 during the driving period, and IN1 = 1 and IN2 = 1 during the other period. Alternatively, the coast mode (IN1 = 0, IN2 = 0) for fast current decay is also available. The input pins can be powered before VM is applied.

### Sleep Mode

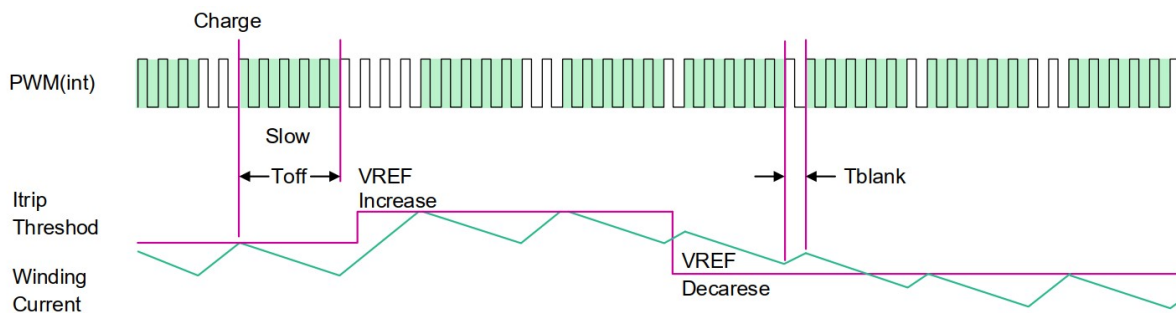
When the IN1 and IN2 pins are both low for time  $t_{SLEEP}$  (typically 1.2 ms), the PT2470-MS device enters a low-power sleep mode, where the outputs remain High-Z and the device uses  $I_{VMSLEEP}$  ( $\mu A$ ) of current. If the device is powered up while both inputs are low, it immediately enters sleep mode. After the IN1 or IN2 pins are high for at least 5  $\mu s$ , the device is operational 45  $\mu s$  ( $t_{ON}$ ) later.

### Current Regulation

In PT2470-MS, motor peak current can be limited by the analog reference input VREF and the resistance of external sense resistor on the ISEN pin according to the below equation:

$$I_{TRIP} (A) = \frac{VREF (V)}{A_V \times R_{ISEN} (\Omega)} = \frac{VREF (V)}{10 \times R_{ISEN} (\Omega)}$$

For example, if  $VREF = 2.0V$  and a  $R_{ISEN} = 0.2\Omega$ , the PWM current regulation mechanism will limit motor current to 1.0A no matter how much load is applied. When ITRIP is reached, the H-bridge enforces the inductor current into slow decay path by enabling both low-side FETs, and it does this for a fixed off time,  $T_{OFF}$  (typically 30 $\mu s$ ).



After  $T_{off}$  time passes, the H-bridge output is re-enabled according to the logic states of two inputs, IN1 and IN2, and motor winding current is charging until reaching another ITRIP event, this charge time is heavily depends on the VM voltage, the back-EMF of the motor, and the inductance of the motor.

### VM under voltage Lockout (UVLO)

If at any time the voltage on the VM pin falls below the under voltage lockout threshold voltage, all FETs in the H-bridge will be disabled. Operation resumes when VM rises above the UVLO threshold.

### Overcurrent Protection (OCP)

If the output current exceeds the OCP threshold, IOCP, for longer than  $t_{OCP}$ , all FETs in the H-bridge are disabled.

As to PT2470-MS, after a duration of  $t_{RETRY}$ , the H-bridge is re-enabled according to the state of the INx pins. If the overcurrent fault is still present, the cycle repeats; otherwise normal device operation resumes.

### **Thermal Shutdown (TSD)**

If the die temperature exceeds safe limits, all FETs in the H-bridge are disabled. After the die temperature has fallen to a safe level, operation automatically resumes.

### **Device Functional Modes**

The PT2470-MS devices can be used in multiple ways to drive a brushed DC motor.

#### **PWM With Current Regulation**

This scheme uses all of the capabilities of the device. The  $I_{TRIP}$  current is set above the normal operating current, and high enough to achieve an adequate spin-up time, but low enough to constrain current to a desired level. Motor speed is controlled by the duty cycle of one of the inputs, while the other input is static. Brake or slow decay is typically used during the off-time.

#### **PWM Without Current Regulation**

If current regulation is not required, the ISEN pin should be directly connected to the PCB ground plane. The VREF voltage must still be 0.3V to 5 V, and larger voltages provide greater noise margin. This mode provides the highest-possible peak current which is up to 3.6 A for a few hundred milliseconds (depending on PCB characteristics and the ambient temperature). If current exceeds 3.6 A, the device might reach overcurrent protection (OCP) or over temperature shutdown (TSD). If that happens, the device disables and protects itself for about 4ms ( $t_{RETRY}$ ) and then resumes normal operation.

#### **Static Inputs with Current Regulation**

The IN1 and IN2 pins can be set high and low for 100% duty cycle drive, and  $I_{TRIP}$  can be used to control the current of the motor, speed, and torque capability.

#### **VM Control**

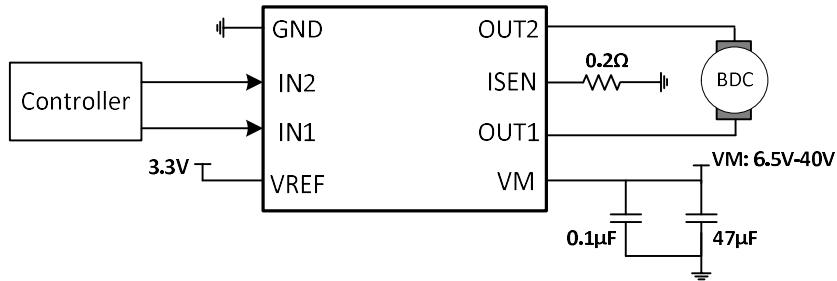
In some systems, varying VM as a means of changing motor speed is desirable.



## APPLICATION INFORMATION

### Application information

The PT2470-MS devices are typically used to drive one brushed DC motor as below:



### Block Diagram

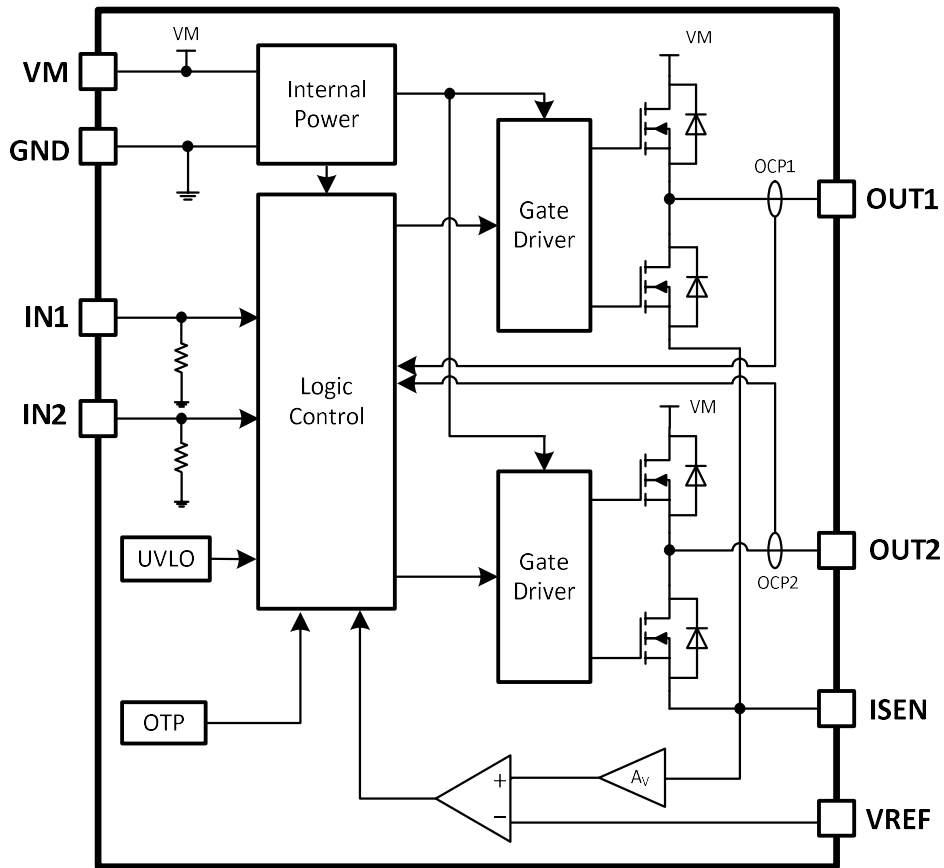
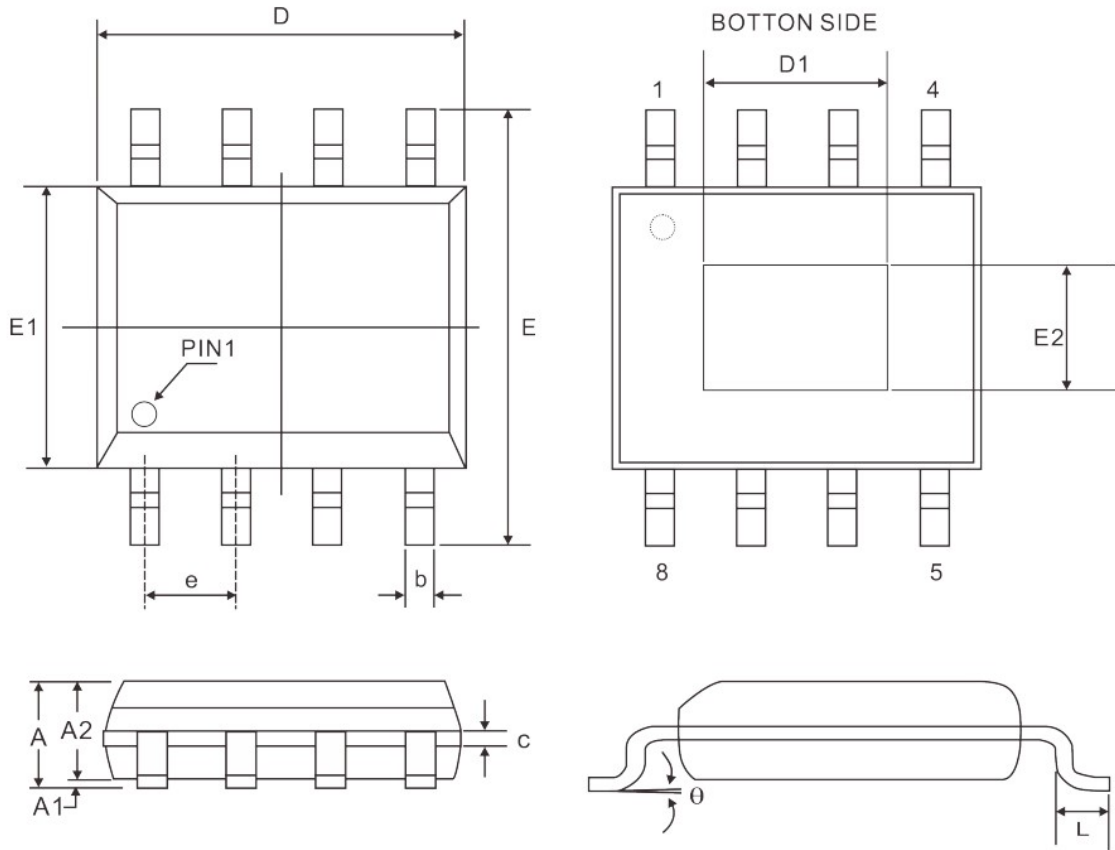


Figure 2. PT2470-MS Block Diagram

**PACKAGE INFORMATION**

**ESOP8**



| Symbol   | Dimensions(mm) |      |      |
|----------|----------------|------|------|
|          | Min.           | Nom. | Max. |
| A        | -              | -    | 1.70 |
| A1       | 0.00           | -    | 0.15 |
| A2       | 1.25           | -    | -    |
| b        | 0.31           | -    | 0.51 |
| c        | 0.10           | -    | 0.25 |
| e        | 1.27 BSC       |      |      |
| D        | 4.90 BSC       |      |      |
| D1       | 2.81           | -    | 3.30 |
| E        | 6.00 BSC       |      |      |
| E1       | 3.90 BSC       |      |      |
| E2       | 2.05           | -    | 2.41 |
| L        | 0.40           | 0.60 | 1.27 |
| $\theta$ | 0°             | -    | 8°   |

Notes: Refer to JEDEC MS-012 BA

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