# Product Specification

# PE4251

**UltraCMOS® SPDT RF Switch**
**10–4000 MHz, Absorptive**

## Features

- HaRP™ technology enhanced
- Low insertion loss: 0.60 dB @ 1000 MHz
- High isolation: 62 dB @ 1000 MHz
- P1dB typical: +30.5 dBm
- IIP3 typical: +59 dBm
- Fast switching time: 150 ns
- Flexible supply voltage: 3.3V ±10% or 5.0V ±10% supply (see *Table 3*)
- Excellent ESD protection: 4000V HBM
- No blocking capacitors required
- Single pin or complementary control inputs

## Product Description

The PE4251 is a HaRP™ technology-enhanced absorptive single pole double throw (SPDT) RF switch for use in general switching applications and mobile infrastructure. This device offers a flexible supply voltage of 3.3/5V, single-pin or complementary pin control inputs and 4 kV ESD tolerance. It presents a simple alternative solution to pin diode and mechanical relay switches.

Peregrine's HaRP™ technology enhancements deliver high linearity and exceptional performance. It is an innovative feature of the UltraCMOS® process, providing performance superior to GaAs with the economy and integration of conventional CMOS.

**Figure 1. Functional Diagram**

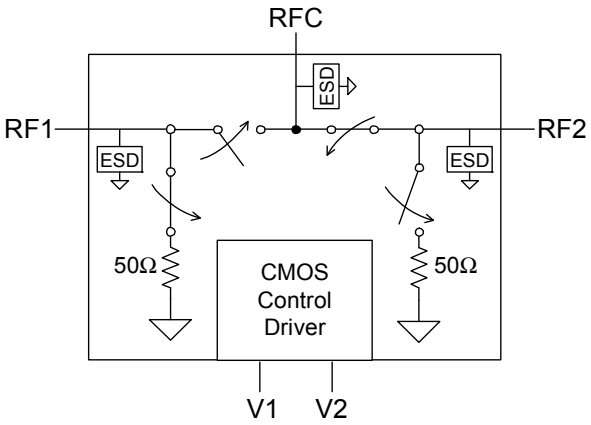



**Figure 2. Package Type**

**8-lead MSOP with exposed paddle**

**Table 1. Target Electrical Specifications Temp = +25 °C, $V_{DD}$ = 3.3V or 5.0V**

| Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operation frequency[1] | | 10 | | 4000 | MHz |
| Insertion loss (RF1/RF2) | 10 MHz | | 0.55 | 0.60 | dB |
| | 1000 MHz | | 0.60 | 0.70 | dB |
| | 2000 MHz | | 0.75 | 0.85 | dB |
| | 3000 MHz | | 0.75 | 0.90 | dB |
| | 4000 MHz | | 1.0 | | dB |
| Isolation (RFC to RF1/RF2) | 1000 MHz | 61 | 62 | | dB |
| | 2000 MHz | 51 | 53 | | dB |
| | 3000 MHz | 42 | 43 | | dB |
| | 4000 MHz | | 37 | | dB |
| Return loss | 1000 MHz | | 26 | | dB |
| | 2000 MHz | | 23 | | dB |
| | 3000 MHz | | 22 | | dB |
| | 4000 MHz | | 19 | | dB |
| Input 1dB compression[2] | 50–4000 MHz | | 30.5 | | dBm |
| Input IP3 | 50–4000 MHz, +18 dBm per tone, 5 MHz spacing | | 59 | | dBm |
| Switching time | 50% CTRL to 10/90% RF | | 150 | 300 | ns |

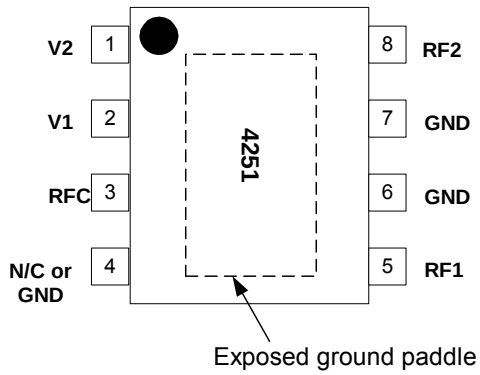
Notes: 1. Device linearity will begin to degrade below 10 MHz.
2. Absolute maximum rating of $P_{IN}$ = 27 dBm.

## Table 1A. Target Electrical Specifications Temp = +125 °C, $V_{DD}$ = 3.3V or 5.0V

| Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operation frequency | | 50 | | 4000 | MHz |
| Insertion loss (RF1/RF2) | 50 MHz | | 0.65 | | dB |
| | 1000 MHz | | 0.75 | | dB |
| | 2000 MHz | | 0.90 | | dB |
| | 3000 MHz | | 1.05 | | dB |
| | 4000 MHz | | 1.2 | | dB |
| Isolation (RFC to RF1/RF2) | 1000 MHz | | 62 | | dB |
| | 2000 MHz | | 52 | | dB |
| | 3000 MHz | | 43 | | dB |
| | 4000 MHz | | 36 | | dB |
| Return loss | 1000 MHz | | 24 | | dB |
| | 2000 MHz | | 23 | | dB |
| | 3000 MHz | | 19 | | dB |
| | 4000 MHz | | 18 | | dB |
| Input 1dB compression* | 50–4000 MHz | | 30.5 | | dBm |
| Input IP3 | 50–4000 MHz, +18 dBm per tone, 5 MHz spacing | | 57 | | dBm |
| Switching time | 50% CTRL to 10/90% RF | | 200 | | ns |

Note: * Absolute maximum rating of $P_{IN}$ = 22 dBm.

## Figure 3. Pin Configuration (Top View)




## Table 2. Pin Descriptions

| Pin # | Pin Name | Description |
|---|---|---|
| 1 | V2 | This pin supports two interface options: *Single-pin control mode*. A nominal 3-volt supply connection is required. *Complementary-pin control mode*. A complementary CMOS control signal to V1 is supplied to this pin. |
| 2 | V1 | Switch control input, CMOS logic level. |
| 3 | RFC | RF common port.* |
| 4 | N/C or GND | No connect or ground |
| 5 | RF1 | RF1 port.* |
| 6 | GND | Ground connection. Traces should be physically short and connected to ground plane for best performance. |
| 7 | GND | Ground connection. Traces should be physically short and connected to ground plane for best performance. |
| 8 | RF2 | RF2 port.* |
| Paddle | GND | Exposed ground paddle. Ground for proper device operation |

Note: * All RF pins must be DC blocked with an external series capacitor or held at 0 VDC.

## Table 3. Operating Ranges

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| $V_{DD}$ power supply voltage* | 3.0<br>4.5 | 3.3<br>5.0 | 3.6<br>5.5 | V<br>V |
| $I_{DD}$ power supply current<br>$V_{DD}$ = $V_{CNTL}$= 3.3V<br>$V_{DD}$ = $V_{CNTL}$= 5.0V | | <br>55<br>75 | <br>60<br>80 | <br>µA<br>µA |
| Control voltage high | 0.8 × $V_{DD}$ | | | V |
| Control voltage low | | | 0.2 × $V_{DD}$ | V |
| $P_{IN}$ RF input power (50Ω)<br>10 MHz–4 GHz, +85 °C<br>50 MHz–4 GHz, +125 °C | | | <br>27<br>22 | <br>dBm<br>dBm |
| $T_{OP}$ operating temperature range | –40 | +25 | +125 | °C |
| $T_{ST}$ storage temperature range | –65 | +25 | +150 | °C |

Note: * Customer must choose either 3.3V or 5.0V power supply range.

## Table 4. Absolute Maximum Ratings

| Symbol | Parameter/Condition | Min | Max | Unit |
|---|---|---|---|---|
| $V_{DD}$ | Power supply voltage | 3 | 5.5 | V |
| $V_I$ | Voltage on any control input | –0.3 | 5.5 | V |
| $T_{ST}$ | Storage temperature range | –65 | +150 | °C |
| $P_{IN}$ | RF input power (50Ω)<br>10 MHz–4 GHz, +85 °C<br>50 MHz–4 GHz, +125 °C | | <br>27<br>22 | <br>dBm<br>dBm |
| $V_{ESD}$ | ESD voltage, HBM<br>ESD voltage, MM (machine model) | | 4000<br>250 | V<br>V |

Note: 1. Human body model (MIL_STD 883 Method 3015).
2. Machine model (JEDEC JESD22-A115).

Exceeding absolute maximum ratings may cause permanent damage. Operation should be restricted to the limits in the Operating Ranges table. Operation between operating range maximum and absolute maximum for extended periods may reduce reliability.

### Latch-Up Immunity

Unlike conventional CMOS devices, UltraCMOS devices are immune to latch-up.

### Electrostatic Discharge (ESD) Precautions

When handling this UltraCMOS device, observe the same precautions that you would use with other ESD-sensitive devices. Although this device contains circuitry to protect it from damage due to ESD, precautions should be taken to avoid exceeding the specified rating.

### Switching Frequency

The PE4251 has a maximum 25 kHz switching rate.

### Moisture Sensitivity Level

The moisture sensitivity level rating for the PE4251 in the 8-lead MSOP package is MSL1.

**Table 5. Single-pin Control Logic Truth Table**

| Control Voltages | Signal Path |
|---|---|
| Pin 1 (V2) = $V_{DD}$<br>Pin 2 (V1) = High | RFC to RF1 |
| Pin 1 (V2) = $V_{DD}$<br>Pin 2 (V1) = Low | RFC to RF2 |

**Table 6. Complementary-pin Control Logic Truth Table**

| Control Voltages | Signal Path |
|---|---|
| Pin 1 (V2 ) = Low<br>Pin 2 (V1) = High | RFC to RF1 |
| Pin 1 (V2) = High<br>Pin 2 (V1) = Low | RFC to RF2 |

## Control Logic Input

The PE4251 is a versatile RF CMOS switch that supports two operating control modes: single-pin control mode and complementary-pin control mode.

*Single-pin control mode* enables the switch to operate with a single control pin (pin 2) supporting a +3.3 or 5.0-volt CMOS logic input, and requires a dedicated +3.3 or 5.0-volt power supply connection (pin 1). This mode of operation reduces the number of control lines required and simplifies the switch control interface typically derived from a CMOS µProcessor I/O port.

*Complementary-pin control mode* allows the switch to operate using complementary control pins V1 and V2 (pins 2 & 1), that can be directly driven by +3.3 or 5.0-volt CMOS logic or a suitable µProcessor I/O port. This enables the PE4251 to operate in positive control voltage mode within the PE4251 operating limits.

## Evaluation Kit

The SPDT switch evaluation kit board was designed to ease customer evaluation of the PE4251 SPDT switch. The RF common port is connected through a 50Ω transmission line to the bottom SMA connector, J3. Port 1 and Port 2 are connected through 50Ω transmission lines to two SMA connectors on either side of the board, J4 and J2. A through transmission line connects SMA connectors J5 and J6. This transmission line can be used to estimate the loss of the PCB over the environmental conditions being evaluated.

The board is constructed of a two metal layer FR4 material with a total thickness of 0.0322". The bottom layer provides ground for the RF transmission lines. The transmission lines were designed using a coplanar waveguide with ground plane model using a trace width of 0.033", trace gaps of 0.010", dielectric thickness of 0.028", copper thickness of 0.0021" and $\varepsilon_r$ of 4.3.

J1 provides a means for controlling the DC inputs to the device. The second-to-bottom lower right pin (J1–3) is connected to the device V1 input. The second-to-top upper right pin (J1–7) is connected to the device V2 input. Footprints for decoupling capacitors are provided on both V1 and V2 traces. It is the responsibility of the customer to determine proper supply decoupling for their design application. Removing these components from the evaluation board has not been shown to degrade RF performance.

**Figure 4. Evaluation Board Layouts**

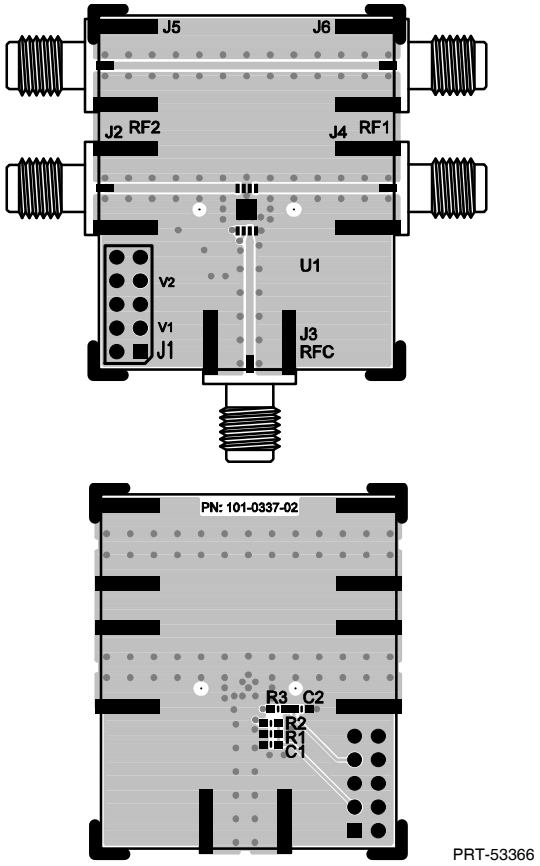
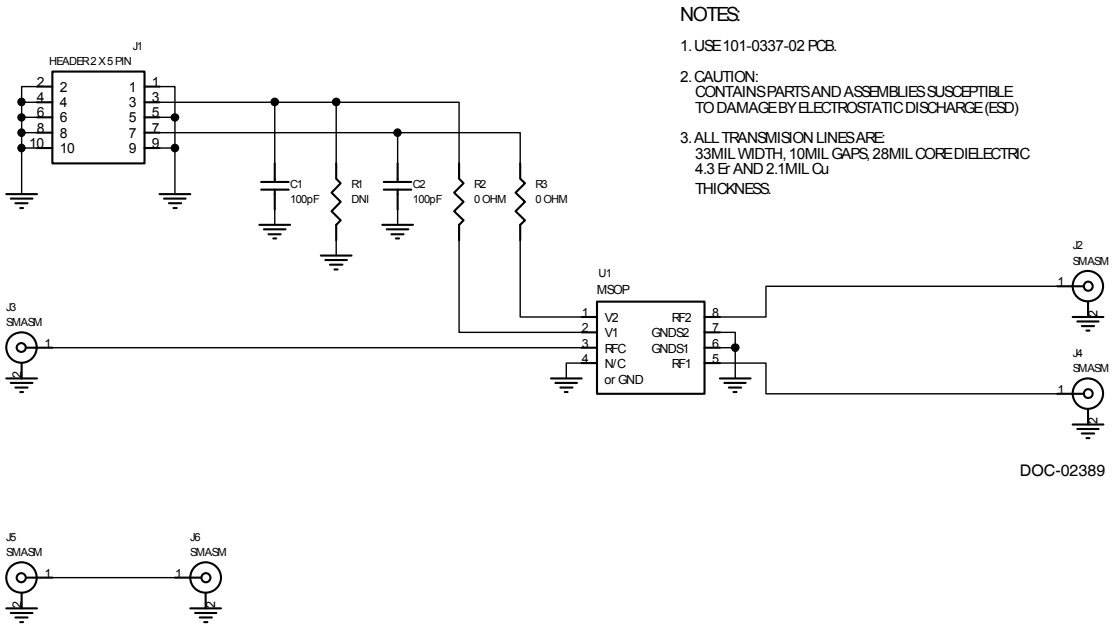
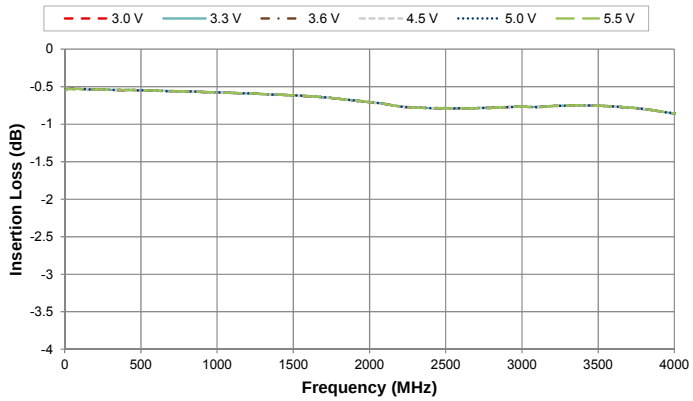


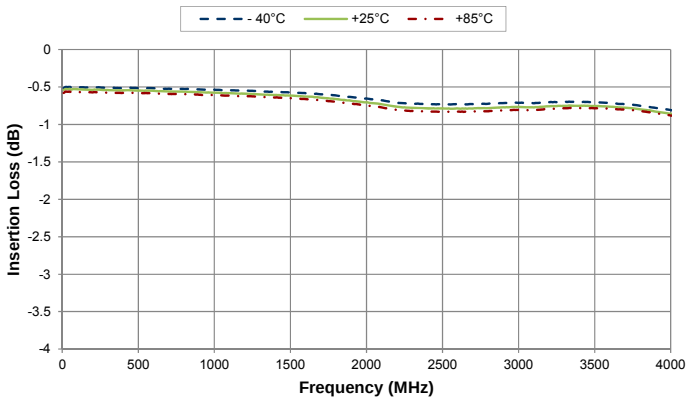

**Figure 5. Evaluation Board Schematic**



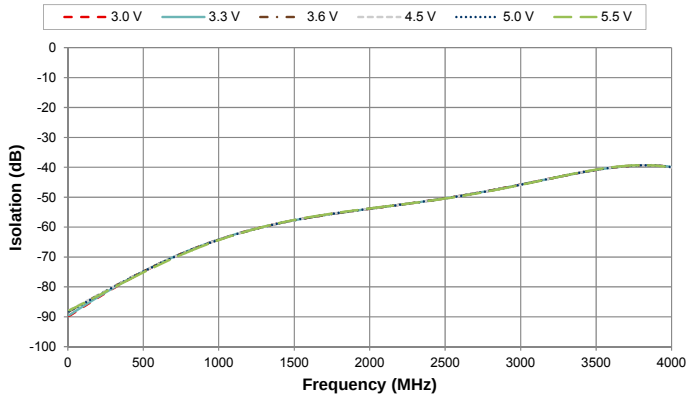
## Figure 6. Insertion Loss: RFC–RF @ +25 °C



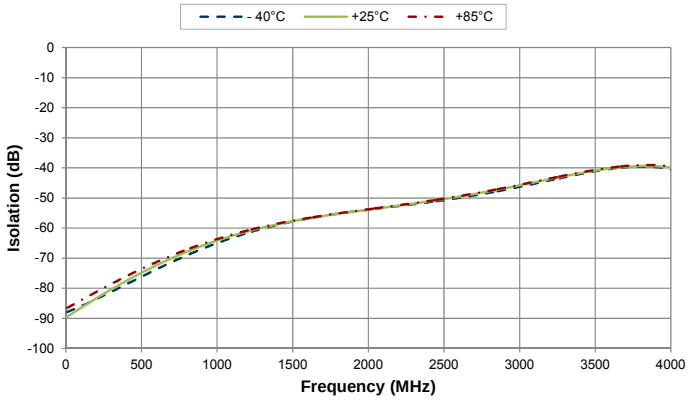

## Figure 7. Insertion Loss: RFC–RF @ 3.3V



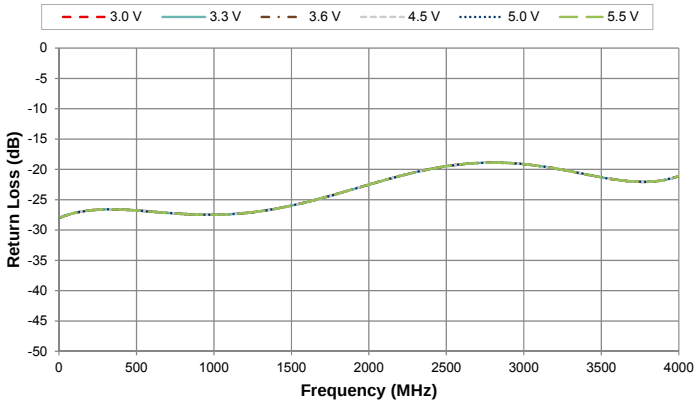

## Figure 8. Isolation: RFC–RF @ +25 °C




## Figure 9. Isolation: RFC–RF @ 3.3V



## Figure 10. Return Loss at Active Port @ +25 °C




## Figure 11. Return Loss at Active Port @ 3.3V

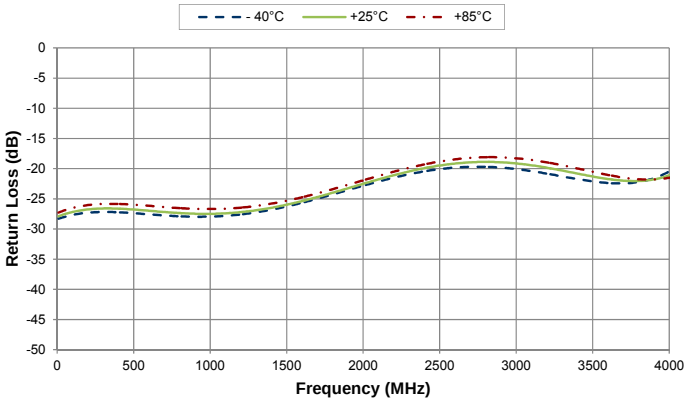


**Figure 12. Package Drawing**
8-lead MSOP

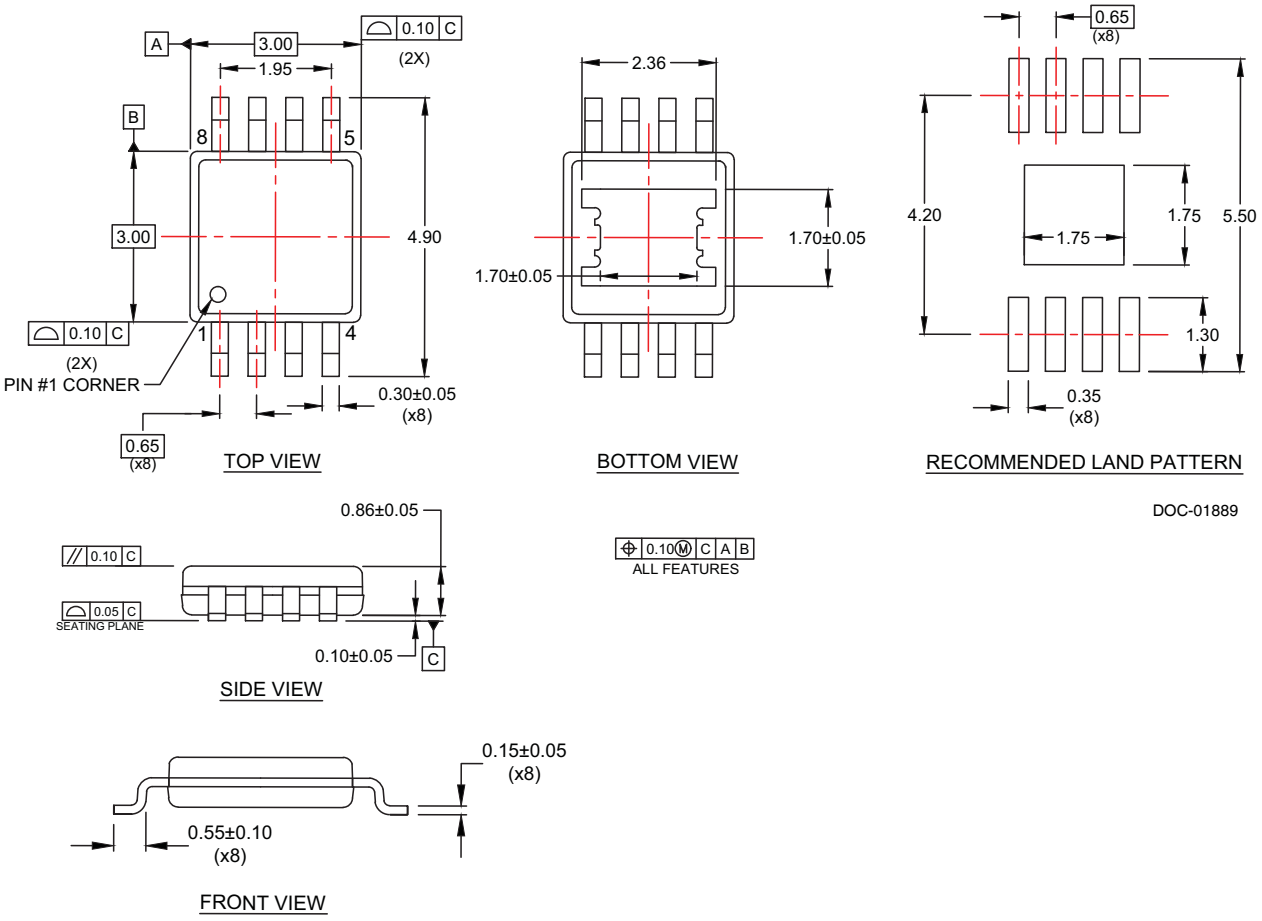
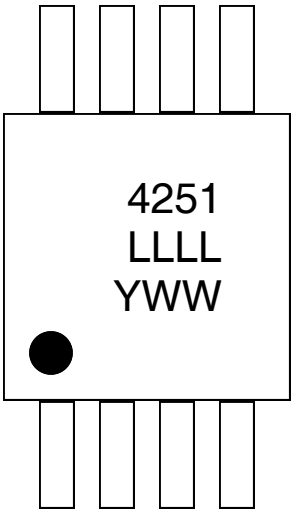
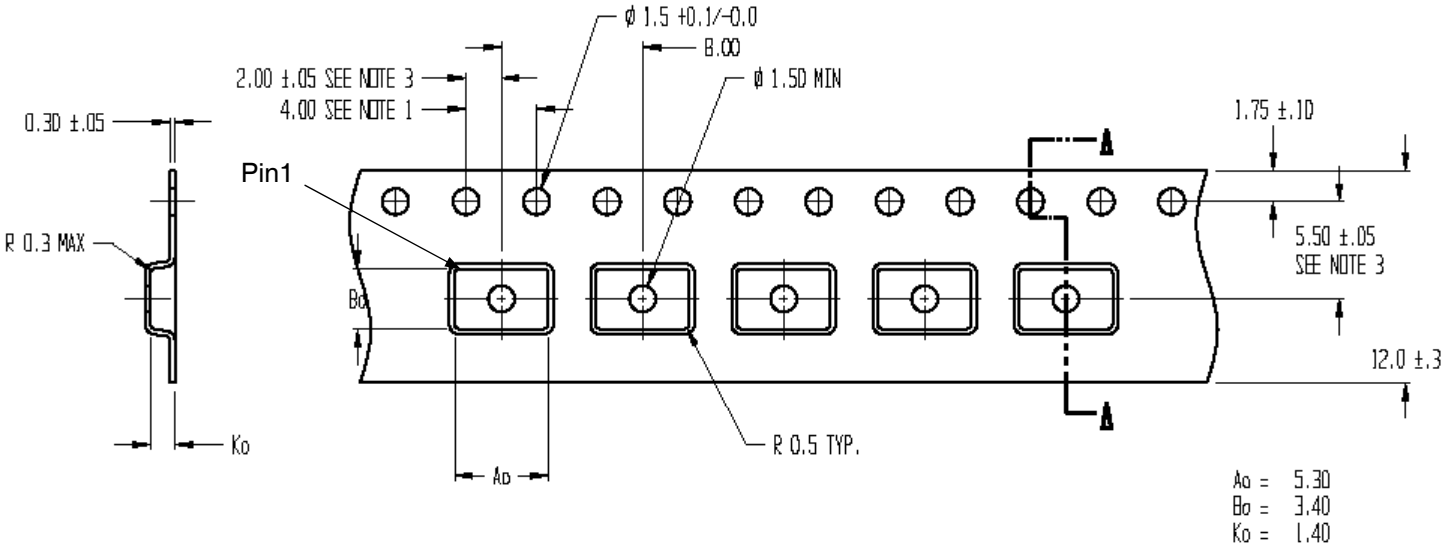


**Figure 13. Top Marking Specification**




AAAA: Product Number, last 4 digits, Exp.
LLLL: Last four digits of the Assembly lot number
YWW: Date Code, last digit of the year and work week

**Figure 14. Tape and Reel Specifications**
8-lead MSOP with exposed paddle




NOTES:
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.2
2. CAMBER IN COMPLIANCE WITH EIA 481
3. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE

## Table 7. Ordering Information

| Order Code | Description | Package | Shipping Method |
|---|---|---|---|
| EK4251-01 | PE4251 Evaluation kit | Evaluation kit | 1 / Box |
| PE4251MLI-Z | PE4251 SPDT RF switch | Green 8-lead MSOP, exposed paddle | 3000 units / T&R |

## Sales Contact and Information

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