

**MML4400 Series Datasheet**  
**RoHS-Compliant Fast Surface Mount MRI**  
**Protection Diodes**



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# 1 Revision History

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The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

## 1.1 Revision 1.0

Revision 1.0 was the first publication of this document.

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## 2 Product Overview

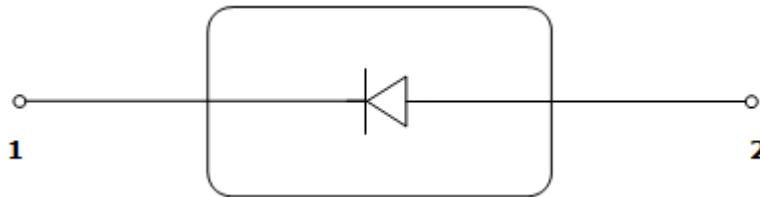
There are two principal applications for which the MML4400 series are intended.

The first is MRI receiver protection from high-RF energy fields, including long RF pulses and RF spike pulses present in most MRI machines. The MML4400 series acts as a passive protector (limiter) for the MRI receiver's low-noise amplifier (LNA). The diode assembly exhibits extremely low insertion loss, both in the on state (high power present) and the off state (receiver power present), so that the receiver's noise figure is not increased by the protector circuit.

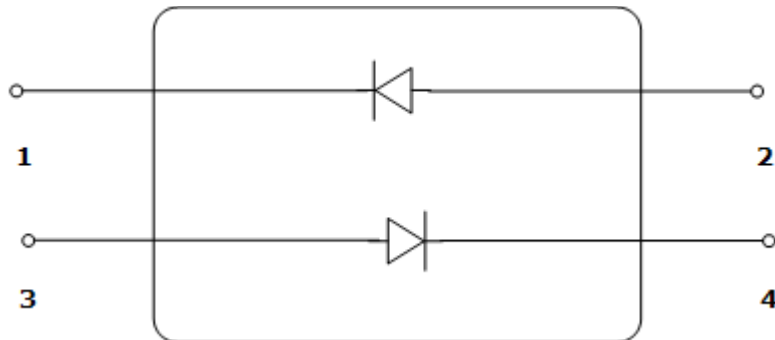
The second principal application is passive switching of surface-coil detuning and blocking circuits. In this case, the flow of the loop current during transmitter pulses turns on the diodes, without the use of a switch driver.

The following illustrations show the primary functional blocks of the MML4400 series devices.

**Figure 1 GM2 Package Option**



**Figure 2 GM3 Package Option**



### 2.1 Applications

The MML4400 series can be combined with a PIN diode (UM7201SM), and the combination can be used to implement a semi-active detune or block circuit design. The MML4400 series devices turn on the PIN diode (used for higher-power switching) during the  $\text{sinc}(x)$  sidelobes, before the main pulse of the transmitter waveform ( $\text{sinc}(x) = [\sin(x)]/x$ ) occurs.

This surface mount limiter meets RoHS requirements according to EU directives 2011/65/EC and 2002/95 EC.

#### 2.1.1 Benefits

The MML4400 series devices provide the following application benefits:

- MRI passive receiver protection

- MRI passive blocking circuits
- MRI passive detuning circuits
- MRI passive disable circuits

## 2.2 Key Features

The following are key features of the MML4400 series devices:

- Designed for MRI applications
- Anti-parallel (unconnected pairs) option available with GM3 package
- Low capacitance at 0 V bias: 1.5 pF maximum
- Low conductance at 0 V bias: 40  $\mu$ s maximum at F = 64 MHz
- Low magnetic construction surface mount package
- RoHS compliant and 260 °C reflow compatible
- Passivated chip
- Compatible with automatic insertion equipment



## 3 Electrical Specifications

### 3.1 Absolute Maximum Ratings

The following table shows the absolute maximum ratings at 25 °C unless otherwise specified.

**Table 1 Absolute Maximum Ratings**

| Rating  | Symbol    | Value      | Unit               |
|---|-----------|------------|--------------------|
| Maximum leakage current<br>(at 80% of minimum-rated $V_b$ ) | $I_R$     | 0.5        | $\mu\text{A}$      |
| Operating temperature                                       | $T_{OP}$  | -55 to 150 | $^{\circ}\text{C}$ |
| Storage temperature   | $T_{STG}$ | -65 to 150 | $^{\circ}\text{C}$ |
| ESD sensitivity (HBM)                                       |           | Class 1A   |                    |
| Moisture sensitivity level                                  |           | MSL 1      |                    |

### 3.2 Device Electrical Parameters

The following table shows the device electrical parameters at 25 °C. Specifications for the GM3 configurations are based on a single diode in anti-parallel topology.

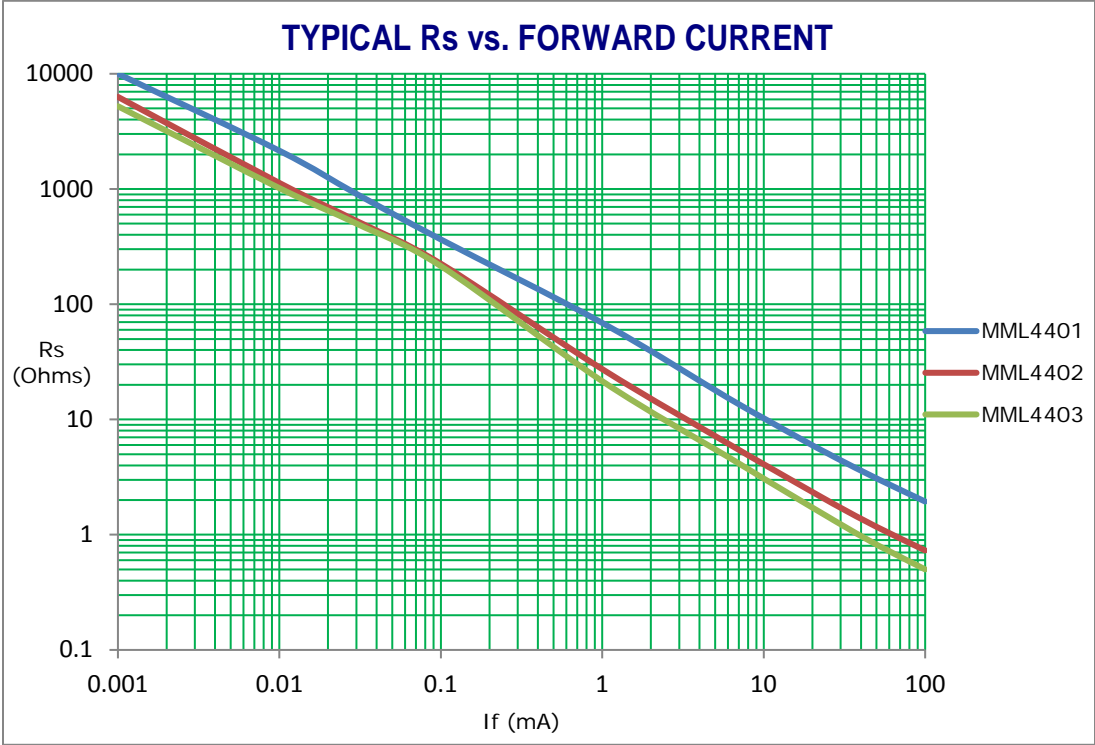
**Table 2 Device Electrical Parameters**

| Model Number | $V_b$<br>$I_R = 10 \mu\text{A}$<br>(Min) | $C_{T0}$<br>at 0 V<br>(Max) | $R_S$<br>at 100 mA<br>$f = 100 \text{ MHz}$<br>(Max) | $T_L$<br>(Typ) | Conductance<br>(G)<br>$V_r = 0 \text{ V}$<br>$F = 64 \text{ MHz}$<br>(Max) | $\theta_P$<br>Thermal<br>Resistance<br>(Max) |
|--------------|--|-----------------------------|--|----------------|--|--|
| MML4401-GM2  | 75 V                                     | 1.5 pF                      | 2.5 $\Omega$   | 10 ns          | 40 $\mu\text{s}$   | 20 $^{\circ}\text{C/W}$                      |
| MML4401-GM3  | 75 V                                     | 1.5 pF                      | 2.5 $\Omega$   | 10 ns          | 40 $\mu\text{s}$   | 20 $^{\circ}\text{C/W}$                      |
| MML4402-GM2  | 75 V                                     | 2.0 pF                      | 1.5 $\Omega$   | 20 ns          | 40 $\mu\text{s}$   | 20 $^{\circ}\text{C/W}$                      |
| MML4402-GM3  | 75 V                                     | 2.0 pF                      | 1.5 $\Omega$   | 20 ns          | 40 $\mu\text{s}$   | 20 $^{\circ}\text{C/W}$                      |
| MML4403-GM2  | 75 V                                     | 1.5 pF                      | 1.0 $\Omega$   | 30 ns          | 40 $\mu\text{s}$   | 30 $^{\circ}\text{C/W}$                      |
| MML4403-GM3  | 75 V                                     | 1.5 pF                      | 1.0 $\Omega$   | 30 ns          | 40 $\mu\text{s}$   | 30 $^{\circ}\text{C/W}$                      |

### 3.3 Typical $R_s$ Performance

The following graph shows the typical  $R_s$  performance of the MML4400 series devices, where  $f = 100$  MHz.

Figure 3 Typical  $R_s$  Performance

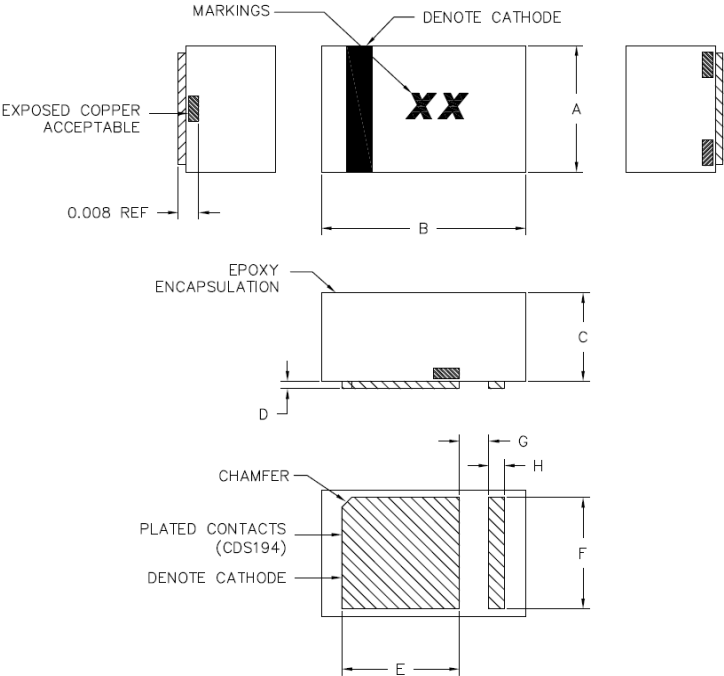


## 4 Package Outline

### 4.1 GM2 Package Outline

The following illustration shows the GM2 package outline of the MML4400 series devices.

Figure 4 GM2 Package Outline



The following table shows the GM2 package dimensions of the MML4400 series devices.

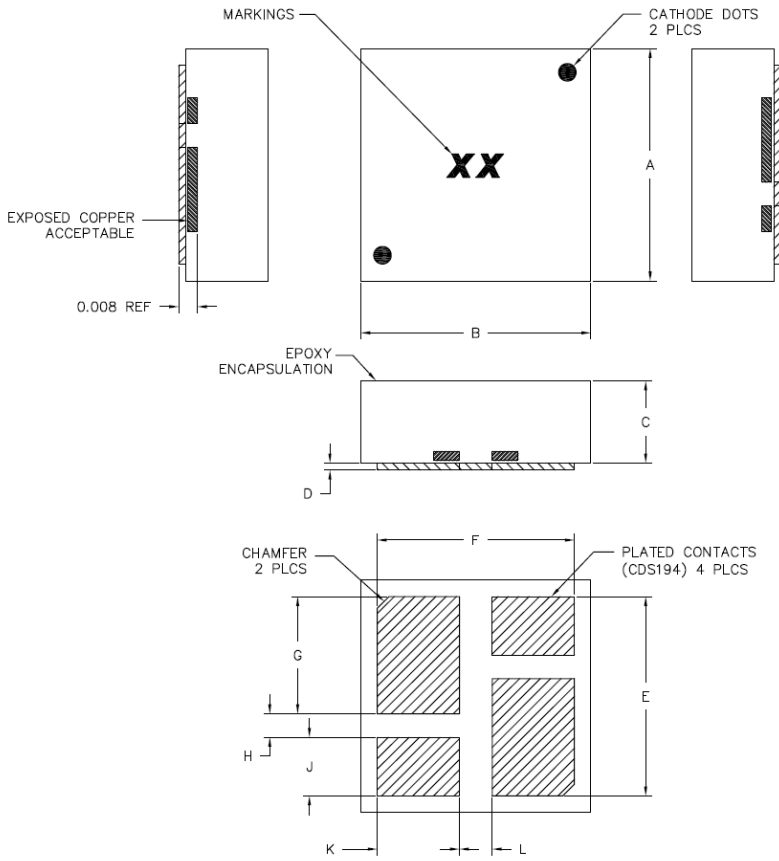
**Table 3 GM2 Package Dimensions**

| DIM | Inches |       |       | Millimeters |       |       |
|-----|--------|-------|-------|-------------|-------|-------|
|     | Min    | Typ   | Max   | Min         | Typ   | Max   |
| A   | 0.045  | 0.050 | 0.055 | 1.143       | 1.270 | 1.397 |
| B   | 0.075  | 0.080 | 0.085 | 1.905       | 2.032 | 2.159 |
| C   | 0.030  | 0.035 | 0.040 | 0.762       | 0.889 | 1.016 |
| D   |        |       | 0.003 |             |       | 0.076 |
| E   |        | 0.046 |       |             | 1.168 |       |
| F   |        | 0.044 |       |             | 1.118 |       |
| G   |        | 0.011 |       |             | 0.279 |       |
| H   |        | 0.006 |       |             | 0.152 |       |

### 4.2 GM3 Package Outline

The following illustration shows the GM3 package outline of the MML4400 series devices.

Figure 5 GM3 Package Outline



The following table shows the GM3 package dimensions of the MML4400 series devices.

**Table 4 GM3 Package Dimensions**

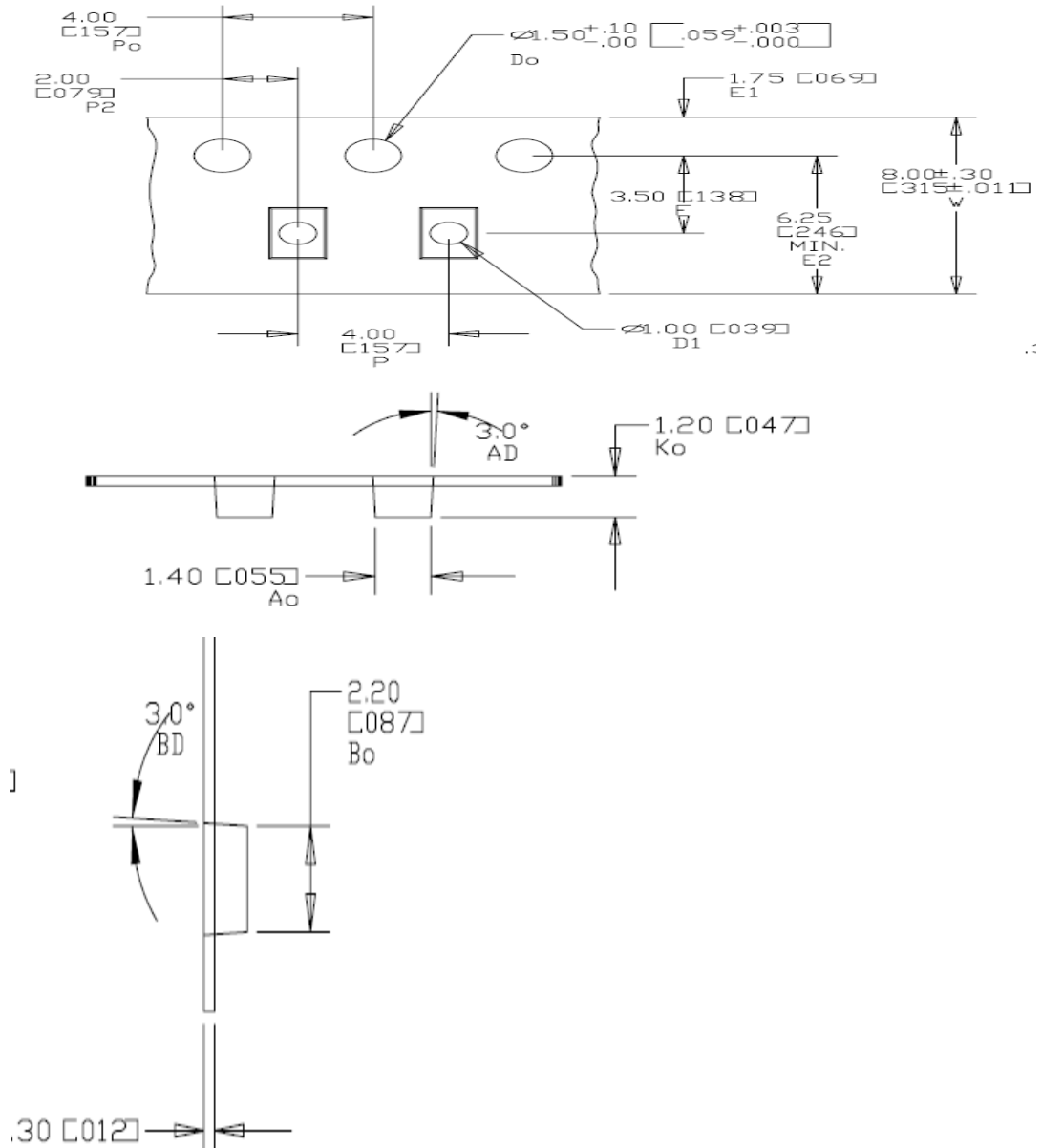
| DIM | Inches |        |       | Millimeters |       |       |
|-----|--------|--------|-------|-------------|-------|-------|
|     | Min    | Typ    | Max   | Min         | Typ   | Max   |
| A   | 0.094  | 0.099  | 0.104 | 2.388       | 2.515 | 2.642 |
| B   | 0.093  | 0.098  | 0.103 | 2.362       | 2.489 | 2.616 |
| C   | 0.030  | 0.035  | 0.040 | 0.762       | 0.889 | 1.016 |
| D   |        |        | 0.003 |             |       | 0.076 |
| E   |        | 0.085  |       |             | 2.159 |       |
| F   |        | 0.084  |       |             | 2.134 |       |
| G   |        | 0.050  |       |             | 1.270 |       |
| H   |        | 0.0120 |       |             | 0.254 |       |
| J   |        | 0.025  |       |             | 0.635 |       |
| K   |        | 0.035  |       |             | 0.889 |       |
| L   |        | 0.014  |       |             | 0.356 |       |

## 5 Tape-and-Reel Format

### 5.1 GM2 Tape-and-Reel Format

The following illustration shows the GM2 tape-and-reel format of the MML4400 series devices in inches and millimeters.

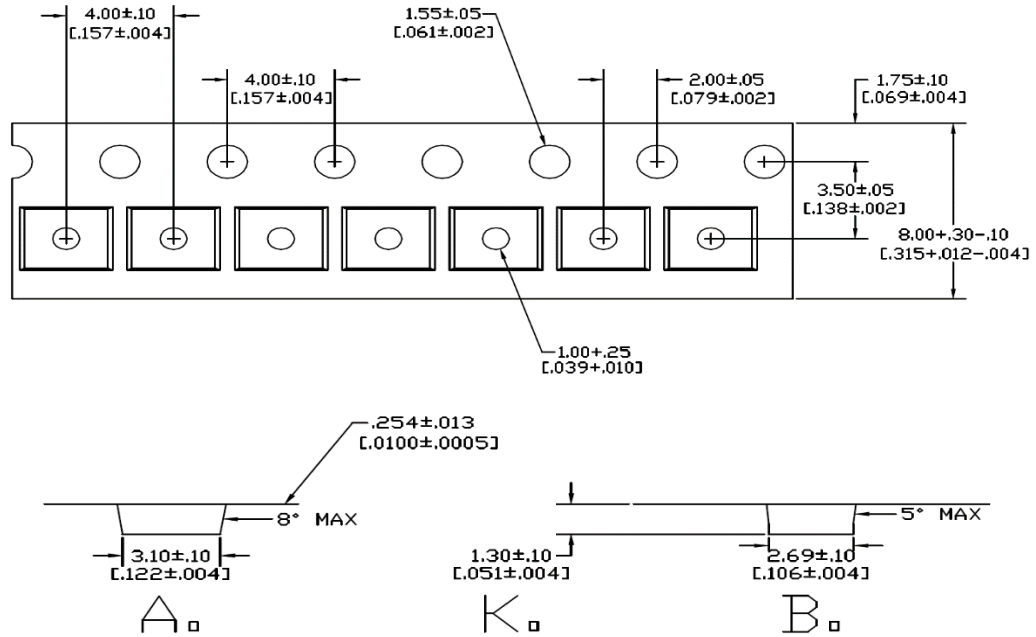
**Figure 6 GM2 Tape-and-Reel Format**



## 5.2 GM3 Tape-and-Reel Format

The following illustration shows the GM3 tape-and-reel format of the MML4400 series devices in inches and millimeters.

**Figure 7 GM3 Tape-and-Reel Format**





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## 6 Ordering Information

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The following table shows the ordering information for the MML4400 series devices.

**Table 5 Ordering Information**

| Part Number | Package |
|-------------|---------|
| MML4401-GM2 | GM2     |
| MML4401-GM3 | GM3     |
| MML4402-GM2 | GM2     |
| MML4402-GM3 | GM3     |
| MML4403-GM2 | GM2     |
| MML4403-GM3 | GM3     |

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