

### Features

- Low Insertion Loss and Noise Figure
- High Peak and Average Operating Power
- Various P1dB Compression Powers
- Au Doped Devices for Lower Recovery Time
- Non-Au doped devices for Lower Flat Leakage Power
- Proven Reliable, Silicon Nitride Passivation
- RoHS Compliant

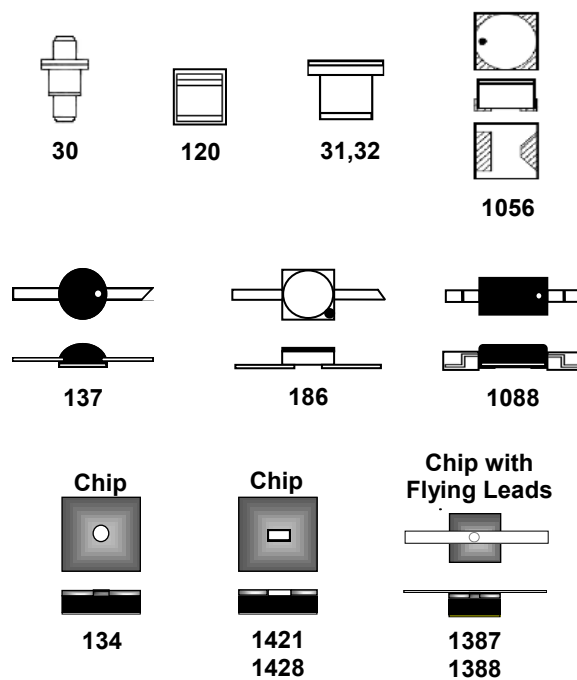
### Description

The MA4L and MADL Series are silicon PIN limiter diodes with small and medium I-region lengths which are specifically designed for high signal applications. The devices are designed to provide low insertion loss, at zero bias, as well as low flat leakage power with fast signal response/recovery times. Parts are available as discrete die or assembled into a variety of surface mount or ceramic pill packages. See the Available Case Style table for the specific ceramic package styles and their availability for individual part numbers.

### Applications

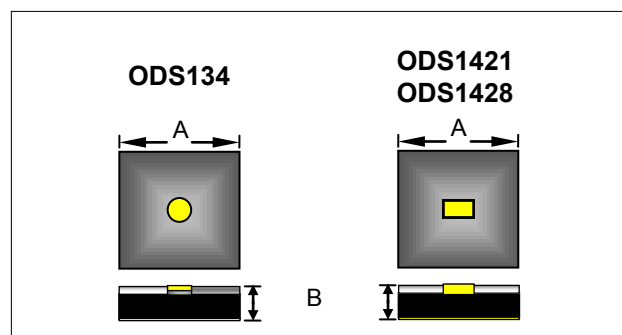
The MA4L and MADL Series of PIN limiter diodes are designed for use in passive limiter control circuits to protect sensitive receiver components such as low noise amplifiers (LNA), detectors, and mixers covering the 10 MHz to 18 GHz frequency range.

### Available Packages<sup>1</sup>



1. Packages not to size, dimensions can be found on the MACOM website.

### Chip Outlines<sup>2</sup>



| ODS             | Dimension   | mils              | mm           |
|-----------------|-------------|-------------------|--------------|
| 134, 1421, 1428 | A (squared) | 15 ±2             | 0.381 ±0.51  |
|                 | B           | 7 ±1 <sup>2</sup> | 0.178 ±0.025 |

2. For the MADL-000301-01340W, MADL-000301-13870G, MA4L401-134 and MADL-000401-13870G, "B" dimension, is 10 ±1 mils.

## Silicon Limiter Diodes

Rev. V24

Electrical Specifications:  $T_A = 25^\circ\text{C}$

### Gold Doped Die

| Part Number        | $V_B^3$<br>(10 $\mu\text{A}$ ) | $C_J$<br>@ 10 V <sup>4</sup><br>(1 MHz) |      | $C_J$<br>@ 0 V<br>(1 MHz) | $R_S$<br>@ 10 mA <sup>5</sup><br>(500 MHz) | Carrier<br>Lifetime <sup>5</sup><br>$I_F = +10\text{ mA}$<br>$I_R = -6\text{ mA}$ | I-Region<br>Thickness | Contact<br>Diameter | CW<br>Thermal<br>Resistance <sup>5</sup> |
|--------------------|--------------------------------|-----------------------------------------|------|---------------------------|--------------------------------------------|-----------------------------------------------------------------------------------|-----------------------|---------------------|------------------------------------------|
|                    | Min./Max.                      | Typ.                                    | Max. | Typ.                      | Max.                                       | Nominal Characteristics                                                           |                       |                     |                                          |
|                    | V                              | pF                                      | pF   | pF                        | Ohms                                       | ns                                                                                | $\mu\text{m}$         | mils                | $^\circ\text{C/W}$                       |
| MA4L011-134        | 15/35                          | 0.13                                    | 0.18 | 0.18                      | 2.10                                       | 10                                                                                | 2                     | 1.2                 | 35                                       |
| MA4L021-134        | 20/35                          | 0.11                                    | 0.16 | 0.20                      | 2.10                                       | 10                                                                                | 2                     | 1.2                 | 35                                       |
| MA4L022-134        | 20/35                          | 0.12                                    | 0.17 | 0.19                      | 2.00                                       | 10                                                                                | 2                     | 1.2                 | 35                                       |
| MA4L031-134        | 30/50                          | 0.14                                    | 0.20 | 0.21                      | 2.00                                       | 20                                                                                | 3                     | 1.4                 | 34                                       |
| MA4L032-134        | 30/50                          | 0.12                                    | 0.18 | 0.20                      | 2.50                                       | 15                                                                                | 3                     | 1.5                 | 34                                       |
| MA4L062-134        | 60/75                          | 0.08                                    | 0.11 | 0.15                      | 2.50                                       | 10                                                                                | 4                     | 1.5                 | 33                                       |
| MADL-011009-01340W | 20/35                          | 0.15                                    | 0.20 | 0.23                      | 1.50                                       | 10                                                                                | 2                     | 3.0                 | 35                                       |
| MADL-011010-01340W | 30/50                          | 0.15                                    | 0.21 | 0.24                      | 1.50                                       | 15                                                                                | 3                     | 3.0                 | 34                                       |
| MADL-011011-01340W | 60/75                          | 0.10                                    | 0.13 | 0.17                      | 2.30                                       | 10                                                                                | 4                     | 3.0                 | 33                                       |
| MADL-011021-14210G | 20/35                          | 0.18                                    | 0.23 | 0.24                      | 2.00                                       | 10                                                                                | 2                     | 2.6 x 5.8           | 35                                       |

### Non Gold Doped Die

| Part Number        | $V_B^3$<br>(10 $\mu\text{A}$ ) | $C_J$<br>@ 10 V <sup>4</sup><br>(1 MHz) |      | $C_J$<br>@ 0 V<br>(1 MHz) | $R_S$<br>@ 10 mA <sup>5</sup><br>(500 MHz) | Carrier<br>Lifetime <sup>5</sup><br>$I_F = +10\text{ mA}$<br>$I_R = -6\text{ mA}$ | I-Region<br>Thickness | Contact<br>Diameter | CW<br>Thermal<br>Resistance <sup>5</sup> |
|--------------------|--------------------------------|-----------------------------------------|------|---------------------------|--------------------------------------------|-----------------------------------------------------------------------------------|-----------------------|---------------------|------------------------------------------|
|                    | Min./Max.                      | Typ.                                    | Max. | Typ.                      | Max.                                       | Nominal Characteristics                                                           |                       |                     |                                          |
|                    | V                              | pF                                      | pF   | pF                        | Ohms                                       | ns                                                                                | $\mu\text{m}$         | mils                | $^\circ\text{C/W}$                       |
| MA4L101-134        | 100/175                        | 0.07                                    | 0.11 | 0.15                      | 2.00                                       | 90                                                                                | 13                    | 3.5                 | 25                                       |
| MA4L401-134        | 250/300                        | 0.19                                    | 0.22 | 0.25                      | 1.20                                       | 800                                                                               | 25                    | 4.5                 | 16                                       |
| MADL-000301-01340W | 200/300                        | 0.11                                    | 0.16 | 0.20                      | 1.50                                       | 200                                                                               | 20                    | 3.0                 | 39                                       |
| MADL-011052-14280W | 20/40                          | 0.16                                    | 0.19 | 0.21                      | 2.0                                        | 23                                                                                | 2                     | 2.6 x 5.8           | 36                                       |
| MADL-011054-01340W | 60/80                          | 0.11                                    | 0.15 | 0.16                      | 1.6                                        | 74                                                                                | 4                     | 1.1                 | 38                                       |

- Maximum breakdown voltage is sample tested and guaranteed by design. Exceeding this maximum  $V_B$  value may damage the device.
- Junction capacitance is measured at 1 MHz @ -10 V reverse voltage.  $C_{J10}$  @ 1 MHz represents the microwave  $C_J$  @ frequency >50 MHz at 0 V.
- Test performed with the chip bonded into a ceramic pill package. For thermal resistance package is mounted to an infinite heatsink. Chip only CW value is approximately  $2^\circ\text{C/W}$  lower.

## Silicon Limiter Diodes

Rev. V24

### Nominal High Signal Performance<sup>6</sup>:

Freq. = 9.4 GHz,  $T_A = 25^\circ\text{C}$ , Pulse Width = 1  $\mu\text{s}$ , Duty Cycle = 0.1%

### Gold Doped Die

| Part Number        | Incident Peak Power |                |                | Recovery Time          | Incident Peak Power | CW Input Power |
|--------------------|---------------------|----------------|----------------|------------------------|---------------------|----------------|
|                    | 1 dB Limiting       | 10 dB Limiting | 15 dB Limiting | 3 dB Peak Power = 50 W | Maximum             | Maximum        |
|                    | dBm                 |                |                | ns                     | Watts               | Watts          |
| MA4L011-134        | 7                   | 30             | 40             | 10                     | 80                  | 2              |
| MA4L021-134        | 8                   | 31             | 41             | 15                     | 90                  | 3              |
| MA4L022-134        | 8                   | 31             | 41             | 15                     | 90                  | 3              |
| MA4L031-134        | 10                  | 33             | 43             | 25                     | 125                 | 4              |
| MA4L032-134        | 11                  | 34             | 44             | 25                     | 125                 | 4              |
| MA4L062-134        | 15                  | 38             | 50             | 75                     | 200                 | 5              |
| MADL-011009-01340W | 8                   | 31             | 41             | 10                     | 90                  | 3              |
| MADL-011010-01340W | 11                  | 34             | 44             | 25                     | 125                 | 4              |
| MADL-011011-01340W | 15                  | 38             | 50             | 75                     | 200                 | 5              |
| MADL-011021-14210G | 8                   | 31             | 41             | 10                     | 90                  | 3              |

### Non Gold Doped Die

| Part Number        | Incident Peak Power |                |                | Recovery Time          | Incident Peak Power | CW Input Power |
|--------------------|---------------------|----------------|----------------|------------------------|---------------------|----------------|
|                    | 1 dB Limiting       | 10 dB Limiting | 15 dB Limiting | 3 dB Peak Power = 50 W | Maximum             | Maximum        |
|                    | dBm                 |                |                | ns                     | dBm                 | dBm            |
| MA4L101-134        | 20                  | 45             | 53             | 100                    | 54                  | 38.0           |
| MA4L401-134        | 30                  | 52             | 60             | 250                    | 60                  | 40.0           |
| MADL-000301-01340W | 23                  | 46             | 57             | 50                     | 57                  | 38.5           |
| MADL-011052-14280W | 7                   | 28             | 39             | 50                     | 50                  | 36.0           |
| MADL-011054-01340W | 13                  | 37             | 48             | 100                    | 53                  | 38.0           |

6. Measured in a single shunt diode (die) configuration attached directly to the gold plated RF ground of a 50  $\Omega$ , SMA connectorized, test fixture using 1 mil thick conductive silver epoxy. Chip anode contact is thermo-compression wire bonded using a 1 mil. diameter gold wire onto a 7.2 mil thick Rogers 5880 Duroid microstrip trace. A shunt coil provides the DC return.

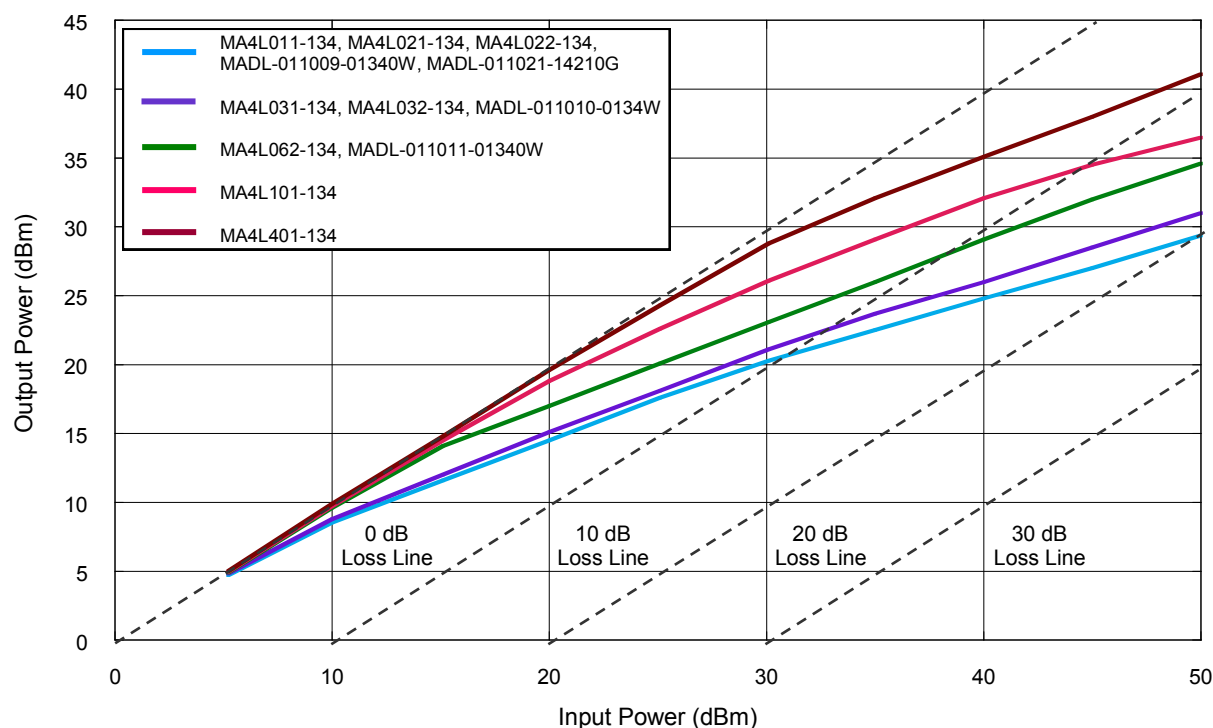
### Absolute Maximum Ratings<sup>7</sup> $T_A = +25^\circ\text{C}$

| Parameter                         | Absolute Maximum      |
|-----------------------------------|-----------------------|
| Forward Current                   | 100 mA                |
| RF Peak & CW Incident Power       | Per Performance Table |
| Junction Temperature <sup>8</sup> | +175°C                |
| Operating Temperature             | -55°C to +125°C       |
| Storage Temperature               | -55°C to +150°C       |
| Mounting Temperature              | +320°C for 10 sec.    |

7. Exceeding any one or combination of these limits may cause permanent damage to this device.

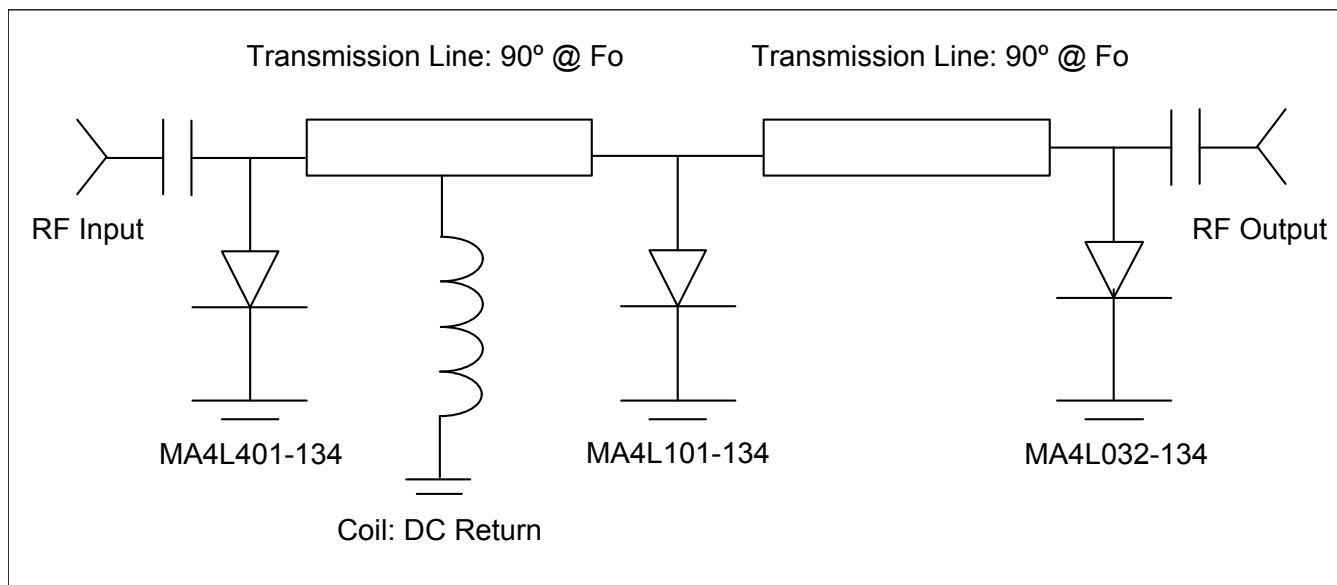
8. Maintaining diode junction  $\leq +175^\circ\text{C}$  will ensure MTBF  $> 1 \text{ E}+6$  hrs for silicon devices.

### Typical High Signal Peak Power Performance for a Single Shunt in a 50 $\Omega$ Circuit Frequency = 9.4 GHz, Pulse Width = 1 $\mu\text{s}$ , Duty Cycle = 0.1%

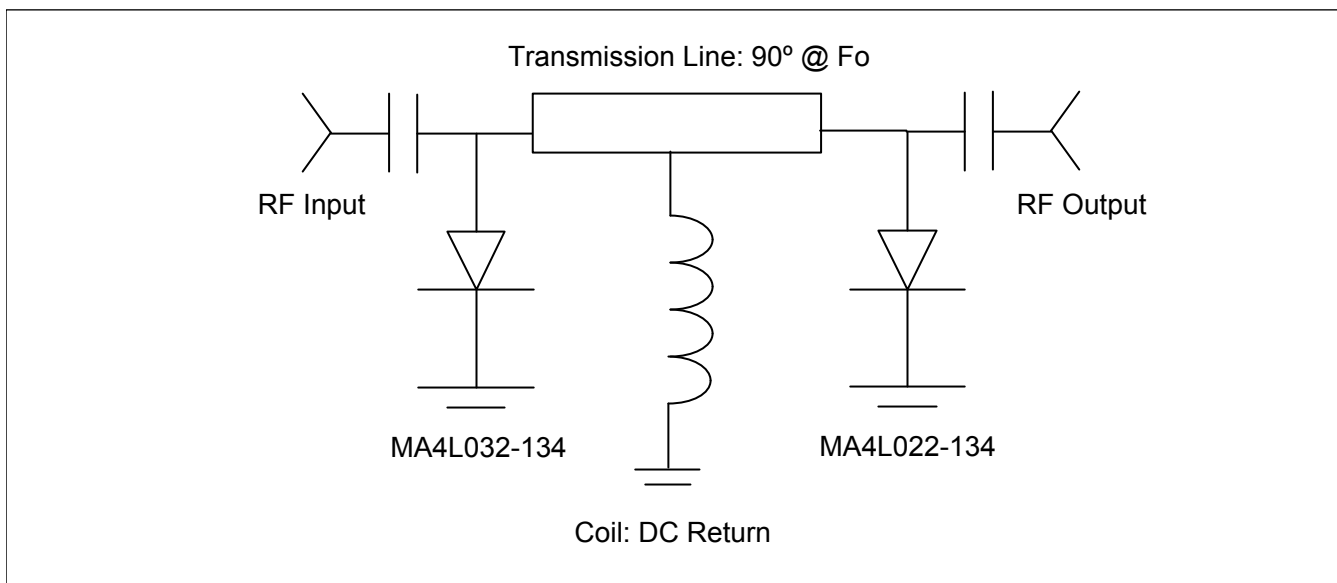


### Application Circuits

#### Typical 60 dBm Peak Power, 1 $\mu$ s P.W., 0.1% Duty Cycle, 20 dBm Flat Leakage Limiter Circuit



#### Typical 50 dBm Peak Power, 1 $\mu$ s P.W., 0.1% Duty Cycle, 20 dBm Flat Leakage Limiter Circuit



### Notes for Specification and Nominal High Signal Performance Tables:

**Maximum Series Resistance:**  $R_S$  is measured at 500 MHz in the ODS-30 package and is equivalent to the total diode resistance:  $R_S = R_J$  (Chip Junction Resistance) +  $R_O$  (Package Ohmic Resistance).

**Maximum High Signal Performance:** Test freq.= 9.4 GHz, RF pulse width = 1  $\mu$ s, Duty Cycle = 0.1%. Measured with a single shunt diode (die) attached directly to the gold plated RF housing ground with 1 mil thick conductive silver epoxy in a 50  $\Omega$ , SMA, connectorized test fixture. Chip anode contact is thermo-compression wire bonded using a 1 mil. diameter gold wire onto a 7.2 mil thick Rogers 5880 Duroid microstrip trace. A shunt coil provides the DC return and DC blocks are on the RF Input and Output.

**Maximum CW Incident Power:** Measured in a 50  $\Omega$ , SMA, connectorized housing @ 4 GHz utilizing a TWT amplifier and the same single diode assembly configuration as stated above.

### Die Handling and Mounting Information

**Handling:** All semiconductor chips should be handled with care in order to avoid damage or contamination from particulates, salts, and skin oils. For individual die, the use of plastic tipped tweezers or vacuum pick up tools is strongly recommended. Bulk handling should ensure that abrasion and mechanical shock are minimized.

**Die Attach:** The die have Ti-Pt-Au back and anode metal, with a final gold thickness of 1  $\mu$ m. Die can be mounted with a gold-tin, eutectic solder perform or conductive silver epoxy. The metal RF and DC ground plane mounting surface must be free of contamination and should have a surface flatness of  $< \pm 2$  mils.

- **Eutectic Die Attachment Using Hot Gas Die Bonder:** An 80/20, gold/tin eutectic solder perform is recommended with a work surface temperature of 255°C and a tool tip temperature of 220°C. When the hot gas is applied, the temperature at the tool tip should be approximately 290°C. The chip should not be exposed to a temperatures in excess of 320°C for more than 10 seconds.
- **Eutectic Die Attachment Using Reflow Oven:** Refer to Application Note M538, "Surface Mounting Instructions".
- **Epoxy Die Attachment:** A thin, controlled amount of electrically conductive silver epoxy should be applied, approximately 1-2 mils thick to minimize ohmic and thermal resistances. A small epoxy fillet should be visible around the outer perimeter of the chip after placement to ensure full area coverage. Cure the conductive silver epoxy per the manufacturer's schedule, typically 150°C for 1 hour.

**Wire Bonding:** The chip's top contact (anode) metallization layer is comprised of Ti/Pt/Au with a final gold thickness of 1  $\mu$ m. Thermo-compression wedge bonding using a 0.7 or 1 mil diameter gold wire is recommended. The heat stage temperature should be set to approximately 200°C with a tool tip temperature of 125°C and a force of 18 to 40 grams. Use of ultrasonic energy is not advised but if necessary should be adjusted to the minimum setting required to achieve a good bond. Excessive energy or force applied to the top contact will cause the metallization to dislodge and lift off. Automatic ball bonding may also be used.

See Application Note M541, "Bonding and Handling Procedures for Chip Diode Devices" for more detailed handling and assembly information.

### Part Numbering and Ordering Information

**When ordering :** Use the base part number followed by a dash plus the desired package style suffix or base part only as defined in Table I “Available Case Styles” below.

**For example:** The MA4L011 in the 186 style package becomes MA4L011-186 or for just the chip MA4L011-134.

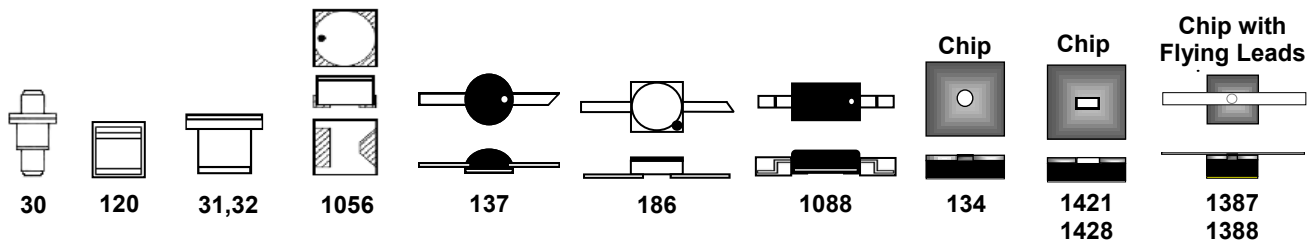
**Table I Available Case Styles**

| Base Part          | Available Package Styles <sup>9</sup>                                  |
|--------------------|------------------------------------------------------------------------|
| MA4L011            | 30, 31, 32, 134 (chip), 137,186, 1056, 1088                            |
| MA4L021            | 31, 120, 134 (chip), 1056                                              |
| MA4L022            | 30, 32, 120, 134 (chip), 137, 186, 1056                                |
| MA4L031            | 31, 134 (chip), 186, 1056                                              |
| MA4L032            | 31, 32, 134 (chip), 186, 1056                                          |
| MA4L062-134        | Base part (134 chip)                                                   |
| MA4L101            | 30, 134 (chip), 186                                                    |
| MA4L301            | Base Part (MADL-000301-01340W) 31, 1056                                |
| MA4L401            | 30, 31, 120,134 (chip), 1056, MADL-000401-01320G for die in Gel-pack   |
| MADL-000011-13880G | Base part (MA4L011-134 chip with flying leads)                         |
| MADL-000031-13880G | Base part (MA4L031-134 chip with flying leads)                         |
| MADL-000032-003000 | Base part (MA4L032 chip in 30 package)                                 |
| MADL-000062-105600 | Base part (MA4L062 chip in 1056 package)                               |
| MADL-000062-13880G | Base part (MA4L062-134 chip with flying leads)                         |
| MADL-000101-13880G | Base part (MA4L101-134 chip with flying leads)                         |
| MADL-000301-01340W | Base part (134 chip)                                                   |
| MADL-000301-13870G | Base part (MADL-000301-01340W chip with flying leads)                  |
| MADL-000401-13870G | Base part (MA4L401-134 chip with flying leads)                         |
| MADL-011009-01340W | Base part (134 chip)                                                   |
| MADL-011010-01340W | Base part (134 chip), In Waffle pack, MADL-011010-01340G for Gel pack  |
| MADL-011011-01340W | Base part (134 chip) In Waffle pack, MADL-011011-01340G for Gel pack   |
| MADL-011021-14210G | Chip with rectangular contact (MADL-011021-1421WR wafer on ring frame) |
| MADL-011052-14280W | Chip with rectangular contact                                          |
| MADL-011054-01340W | Base part (134 chip)                                                   |

9. See Table 2 Associated Package Parasitics.

**Table 2 Associated Package Parasitics**

| Package Style | Package Description                                 | Nominal                |                      |
|---------------|-----------------------------------------------------|------------------------|----------------------|
|               |                                                     | C <sub>PKG</sub><br>pF | L <sub>S</sub><br>nH |
| 30            | Ceramic Pill                                        | 0.18                   | 0.60                 |
| 31            | Ceramic Pill                                        | 0.18                   | 0.60                 |
| 32            | Ceramic Pill                                        | 0.30                   | 0.40                 |
| 120           | Ceramic Pill                                        | 0.13                   | 0.40                 |
| 134           | Chip                                                | —                      | —                    |
| 137           | Epoxy Encapsulated Ceramic Surface Mount with Leads | 0.14                   | 0.70                 |
| 186           | Ceramic Surface Mount with Leads                    | 0.15                   | 0.70                 |
| 1056          | Ceramic Surface Mount with Wrap Around Contacts     | 0.20                   | 0.70                 |
| 1088          | Epoxy Encapsulated Ceramic Surface Mount with Leads | 0.12                   | 0.70                 |
| 1387          | Chip with Flying Leads                              | —                      | —                    |
| 1388          | Chip with Flying Leads                              | —                      | —                    |
| 1421          | Chip with Rectangular Contact                       | —                      | —                    |
| 1428          | Chip with Rectangular Contact and BCB overlay       | —                      | —                    |



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