# MD0101

## High-Voltage Protection T/R Switch with Clamp Diodes

### Features

- Up to ±100V Input Voltage Protection
- Low On-Resistance, 15Ω Typical
- Integrated Clamp Diodes
- Fast Switching Speed
- Four Electrically Isolated Channels
- No External Supplies Needed

### Applications

- Medical Ultrasound Imaging
- Non-Destructive Testing Applications
- Fast Resettable Fuses
- High-Side Switches
- Data Acquisition

### General Description

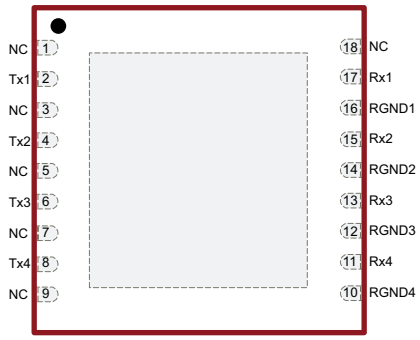
The MD0101 is a four-channel high-voltage current-limiting protection device. It is designed to protect a low-noise receiver from high-voltage transmit pulses in ultrasound applications and is commonly referred to as a T/R (transmit-and-receive) switch. Each channel has three terminals: TX, RX, and $R_{GND}$. The analog switch terminals are TX and RX. RX has integrated clamping diodes to $R_{GND}$ to protect the receiver against high voltages. The output voltages will be clamped by the anti-parallel diodes to RGND at about ±0.6V.

The MD0101 can be considered as a normally closed switch with a typical switch resistance of 15Ω, allowing small signals to pass. Once the voltage drop across the switch exceeds a nominal value of ±1V, the device turns off. In the OFF state, the MD0101 can withstand up to ±100V across its terminals. A small amount of current (200 µA, typically) is allowed to flow through.

The MD0101 is not limited to just ultrasound applications. It can also be used as resettable fuses to protect power lines, for output short-circuit protection, and for protection of data acquisition instruments. The MD0101 is available in an 18-lead, 5 x 5 mm DFN package.

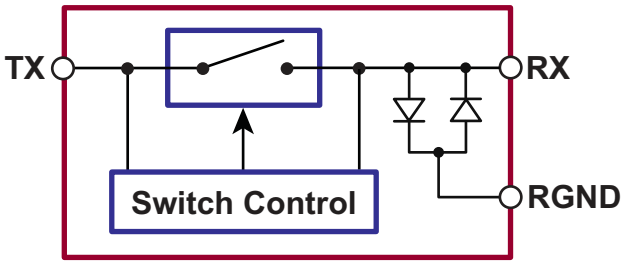
### Package Type

**18-lead DFN**
(Top view)

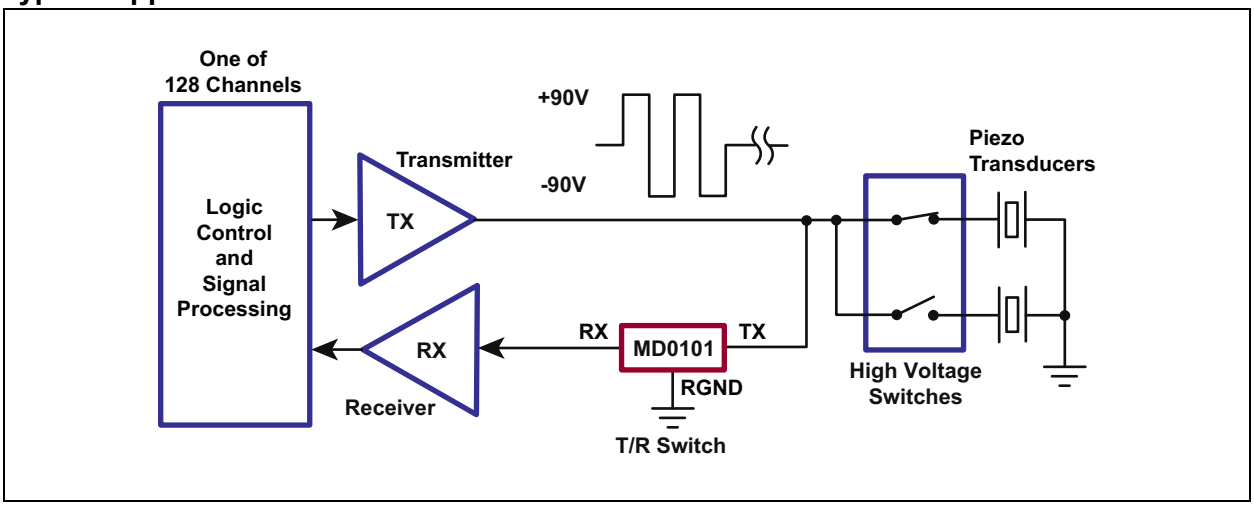



See Table 2-1 for pin information.

## Functional Block Diagram



## Typical Application Circuit



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

Differential Voltage, $V_{TX}$–$V_{RX}$ ..... 0V to +110V
Maximum Junction Temperature, $T_J$ ..... +125°C
Storage Temperature, $T_S$ ..... –65°C to +150°C
Power Dissipation:
18-lead DFN (**Note 1**) ..... 2.5W
ESD Rating (**Note 2**) ..... ESD sensitive

**† Notice:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

**Note 1:** Mounted on an FR4 board, 25 mm x 25 mm x 1.57 mm
**2:** Device is ESD sensitive. Handling precautions are recommended.

## DC ELECTRICAL CHARACTERISTICS

**Electrical Specifications:** $T_A$ = 25°C unless otherwise specified.

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Maximum Differential Input Voltage from TX to RX | $V_{TX-RX}$ | ±100 | — | — | V | $I_{TX–RX}$ = ±500 µA |
| Switch-On Resistance from TX to RX | $R_{SW}$ | — | 15 | — | Ω | $I_{TX–RX}$ = ±5 mA |
| $V_{TX-RX}$ Trip Point to Turn Off | $V_{TRIP}$ | — | ±1 | ±2 | V | |
| Switch Turn-Off Voltage | $V_{OFF}$ | — | ±2 | — | V | $I_{TX–RX}$ = ±1 mA |
| Switch-Off Current | $I_{A-B(OFF)}$ | — | ±200 | ±300 | µA | $V_{TX–RX}$ = ±100V |

## AC ELECTRICAL CHARACTERISTICS

**Electrical Specifications:** $T_A$ = 25°C unless otherwise specified.

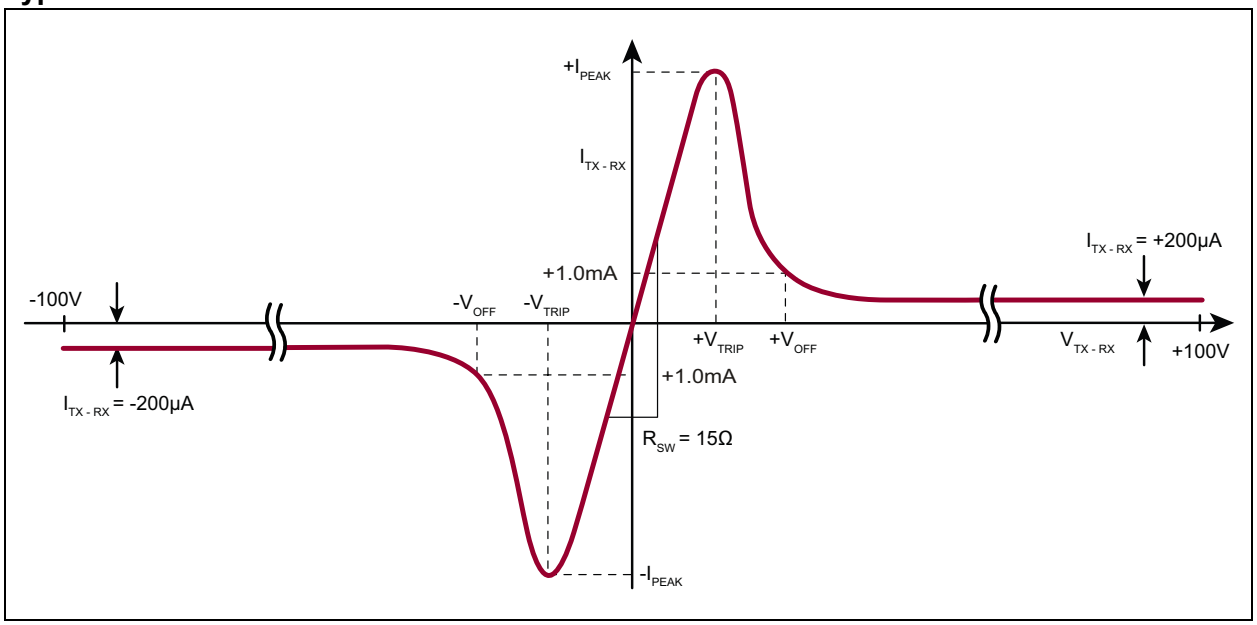
| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Peak Switching Current | $I_{PEAK}$ | — | ±60 | — | mA | |
| Turn-Off Time | $T_{OFF}$ | — | — | 20 | ns | |
| Turn-On Time | $T_{ON}$ | — | — | 20 | ns | |
| Switch-On Capacitance from TX to RX | $C_{TX(ON)}$ | — | 15 | — | pF | SW = ON |
| Switch-Off Capacitance from TX to RX | $C_{TX(OFF)}$ | — | 9 | — | pF | $V_{TX–RX}$ = 25V |
| Small Signal Bandwidth | BW | — | 100 | — | MHz | $R_{LOAD}$ = 50Ω |
| Diode Forward Voltage Drop | $V_{RX}$ | — | ±1.6 | — | V | $I_{RX}$ = ±200 mA, $R_{GND}$ = 0V, TX = Open |
| RX Capacitance to RGND | CD | — | 20 | — | pF | $R_{GND}$ = 0V, TX = Open |

## TEMPERATURE SPECIFICATIONS

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| **TEMPERATURE RANGE** | | | | | | |
| Operating Junction Temperature | $T_J$ | –40 | — | +125 | °C | |
| Storage Temperature | $T_S$ | –65 | — | +150 | °C | |
| **PACKAGE THERMAL RESISTANCE** | | | | | | |
| 18-lead DFN | $\theta_{JA}$ | — | 40 | — | °C/W | **Note 1** |

**Note 1:** 1 oz. 4-layer 3” x 4” PCB with thermal pad and thermal via array

## Typical I-V Characteristics



## 2.0 PIN DESCRIPTION

Functional descriptions for the pins are listed in Table 2-1. See **Package Type** for the location of pins.

**TABLE 2-1: PIN FUNCTION TABLE**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | NC | No internal connection |
| 2 | TX1 | Transmitter side of Transmit/Receive Switch 1 |
| 3 | NC | No internal connection |
| 4 | TX2 | Transmitter side of Transmit/Receive Switch 2 |
| 5 | NC | No internal connection |
| 6 | TX3 | Transmitter side of Transmit/Receive Switch 3 |
| 7 | NC | No internal connection |
| 8 | TX4 | Transmitter side of Transmit/Receive Switch 4 |
| 9 | NC | No internal connection |
| 10 | RGND4 | Clamp diode ground for Transmit/Receive Switch 4 |
| 11 | RX4 | Receiver side for Transmit/Receive Switch 4 |
| 12 | RGND3 | Clamp diode ground for Transmit/Receive Switch 3 |
| 13 | RX3 | Receiver side for Transmit/Receive Switch 3 |
| 14 | RGND2 | Clamp diode ground for Transmit/Receive Switch 2 |
| 15 | RX2 | Receiver side for Transmit/Receive Switch 2 |
| 16 | RGND1 | Clamp diode ground for Transmit/Receive Switch 1 |
| 17 | RX1 | Receiver side for Transmit/Receive Switch 1 |
| 18 | NC | No internal connection |
| Center Tab | | Connect to ground |

## 3.0 DETAILED DESCRIPTION

The MD0101 can be considered a normally closed switch controlled by a control circuit. (See **Functional Block Diagram**.) The control circuit monitors the voltage drop across Terminals TX and RX. If the voltage difference is greater than ±1V, the T/R switch opens. Once in the Open state, there is a small amount of current flowing through the T/R switch (200 µA) to detect if the high voltage is still present. The T/R switch does not close until the voltage across Terminals TX and RX drops below ±2V. Connecting the RGND to ground allows the initial peak current (about 60 mA) to flow to GND through the switch and the clamp diodes. The clamp diode I-V Curve is shown in Figure 3-8. If external diodes are used, the RGND pin can be connected to the corresponding RX pin or left floating. The external diodes can then be connected between RX and GND.

### 3.1 On Resistance

When the voltage across Terminals TX and RX is within ±2V, the switch is in Receive mode and the $R_{ON}$ is typically 15Ω. Once the voltage across Terminals TX and RX is greater than ±2V, the switch changes to Transmit mode and prevents high-voltage pulses from passing through to the receiver.

### 3.2 Switch Capacitance

The typical switch-on capacitance, $CSW_{(ON)}$, is 21 pF. This is measured from TX to RX when the switch is turned on.

The switch-off capacitance is a function of the voltage across the T/R switch. The $C_{TX(OFF)}$ is about 11 pF to 6.5 pF for 10V to 90V of transmit voltage. Refer to Figure 3-1 for the C–V curve of $C_{TX(OFF)}$.

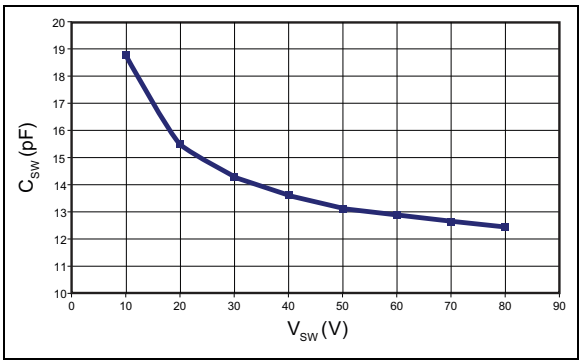



***FIGURE 3-1:*** *$C_{TX-RX}$ vs. $V_{TX-RX}$.*

### 3.3 $T_{ON}$ and $T_{OFF}$ Time

The $T_{ON}$ and $T_{OFF}$ of MD0101 are less than 20 ns, which provides a quick transition between Transmit and Receive modes. $T_{ON}$ and $T_{OFF}$ times are proportional to the rise and fall times of the transmit pulses. Setups used to measure $T_{OFF}$ and $T_{ON}$ are illustrated in Figure 3-2 and Figure 3-5, respectively.

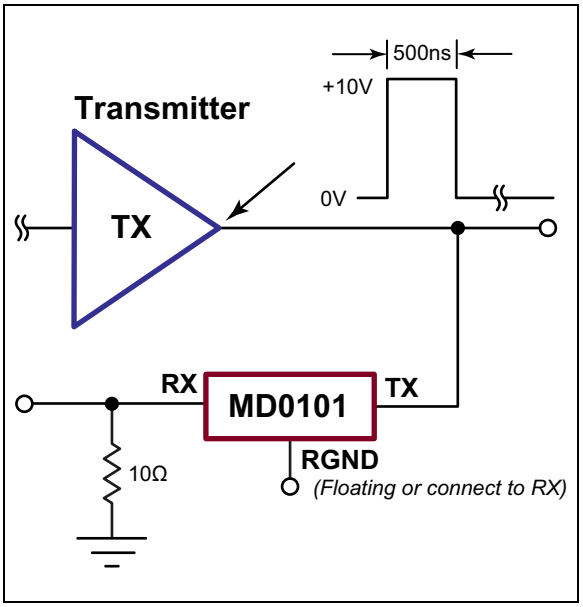



***FIGURE 3-2:*** *Test Setup for $T_{OFF}$.*

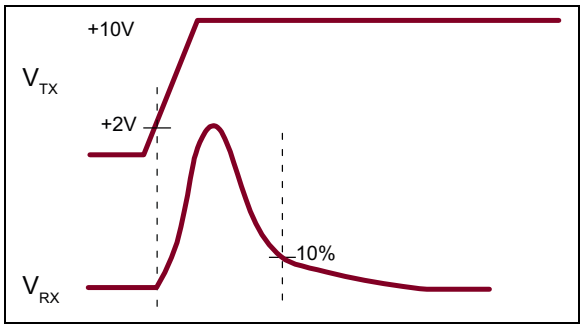



***FIGURE 3-3:*** *$T_{OFF}$ Timing Diagram.*

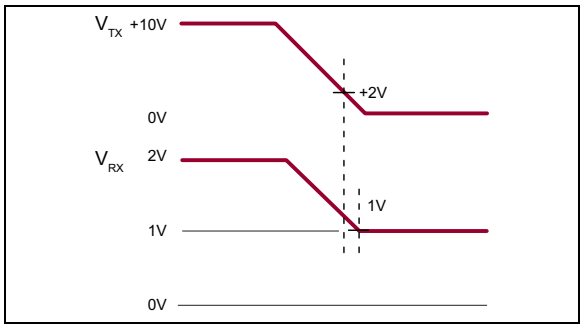



***FIGURE 3-6:*** *$T_{ON}$ Timing Diagram.*

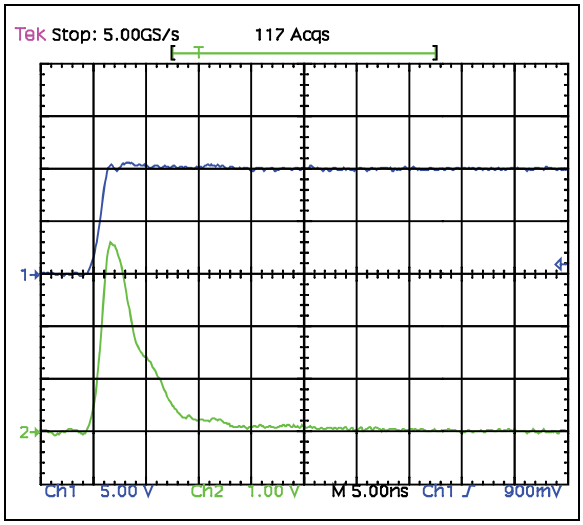



***FIGURE 3-4:*** *$T_{OFF}$ at $V_{TX}$ = 10V.*

Figure 3-4 shows the actual waveform and measurement of the $T_{OFF}$. $T_{OFF}$ is measured from 2V of the $V_{TX}$ to 10% of the $V_{RX}$.

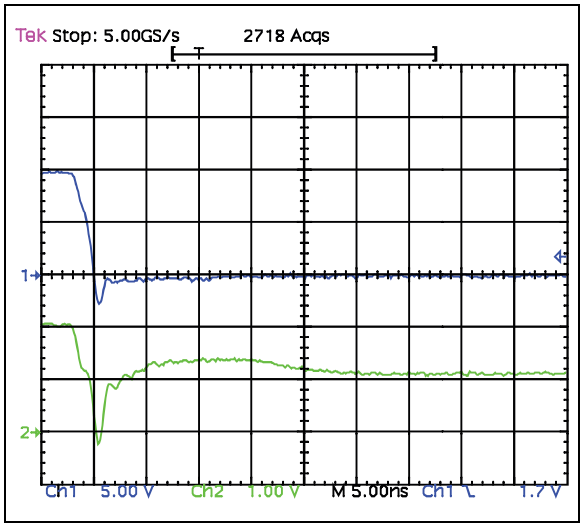



***FIGURE 3-7:*** *$T_{ON}$ at $V_{TX}$ = 10V.*

Figure 3-7 illustrates the actual waveform and measurement of the $T_{ON}$. The $T_{ON}$ is measured from 2V of the $V_{TX}$ to 1V of the $V_{RX}$.

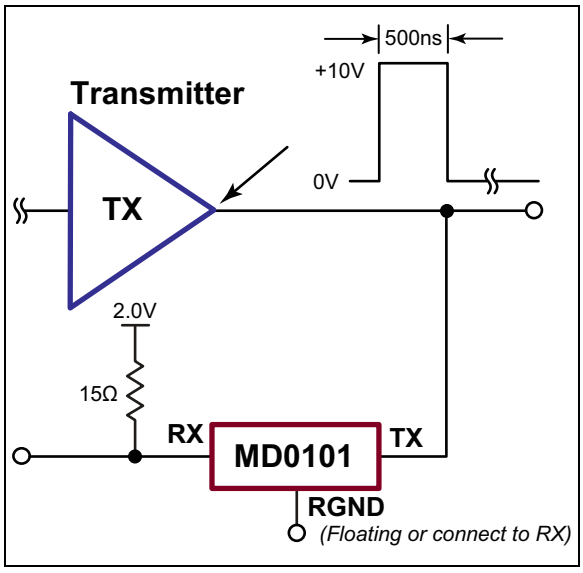



***FIGURE 3-5:*** *Test Setup for $T_{ON}$.*

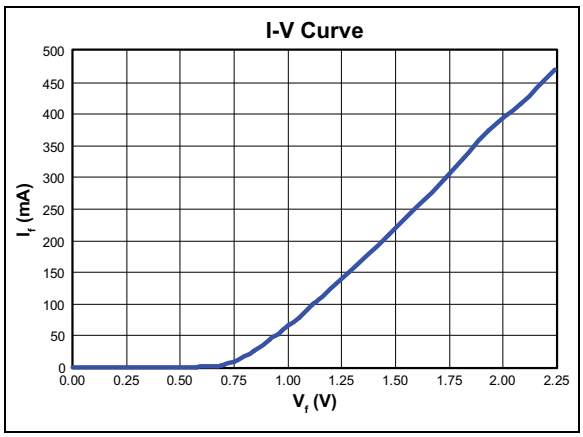
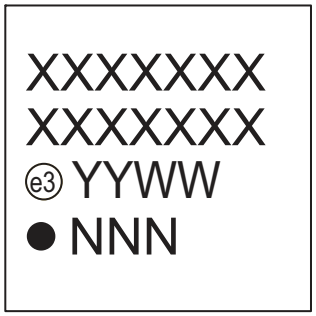



***FIGURE 3-8:*** *RX Clamp Diodes to RGND.*

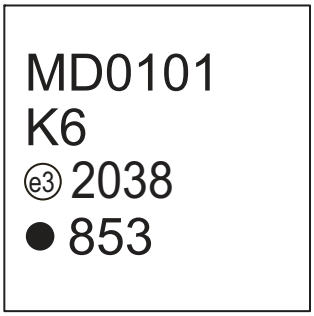
## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information

18-lead DFN




Example

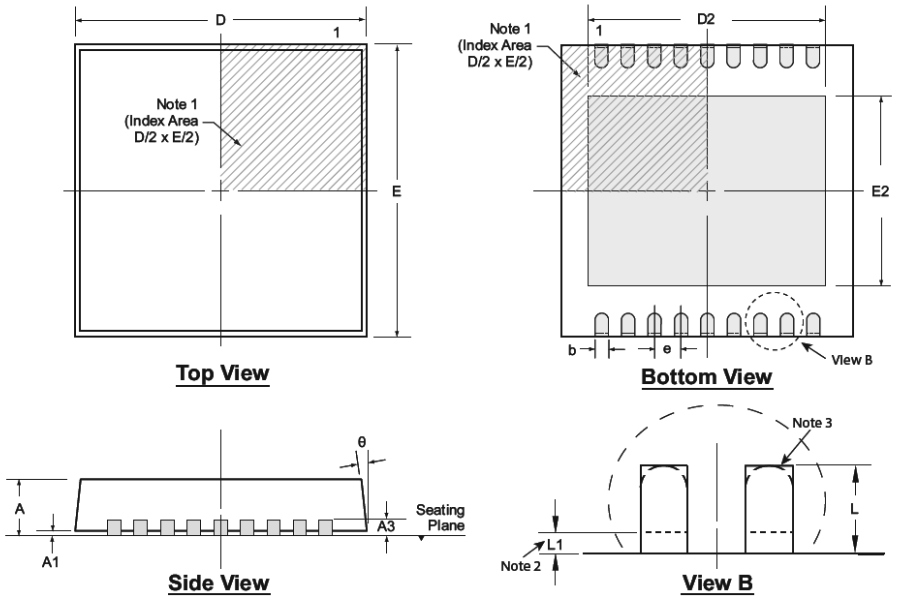



| | | |
|---|---|---|
| **Legend:** | XX...X | Product Code or Customer-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week ‘01’) |
| | NNN | Alphanumeric traceability code |
| | (e3) | Pb-free JEDEC® designator for Matte Tin (Sn) |
| | * | This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package. |

**Note**: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

## 18-Lead DFN Package Outline (K6)

***5.00x5.00mm body, 1.00mm height (max), 0.50mm pitch***




Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

***Notes:***

1. *A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.*
2. *Depending on the method of manufacturing, a maximum of 0.15mm pullback (L1) may be present.*
3. *The inner tip of the lead may be either rounded or square.*

| Symbol | | A | A1 | A3 | b | D | D2 | E | E2 | e | L | L1 | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimension (mm) | MIN | 0.80 | 0.00 | 0.20 REF | 0.18 | 4.85* | 4.20† | 4.85* | 3.50† | 0.50 BSC | 0.30† | 0.00* | 0° |
| | NOM | 0.90 | 0.02 | | 0.25 | 5.00 | 4.35† | 5.00 | 3.65† | | 0.40† | - | - |
| | MAX | 1.00 | 0.05 | | 0.30 | 5.15* | 4.45† | 5.15* | 3.75† | | 0.50† | 0.15 | 14° |

*JEDEC Registration MO-229, Variation VJJD-2, Issue C, Aug 2003.*
** This dimension is not specified in the JEDEC drawing.*
*† This dimension differs from the JEDEC drawing.*
***Drawings not to scale.***

**NOTES:**

# APPENDIX A: REVISION HISTORY

## Revision A (May 2020)

- Converted Supertex Doc# DSFP-MD0101 to Microchip DS20005916A
- Changed the package marking format
- Removed the 18-lead DFN (5 x 5) K6 M932 package type
- Made minor text changes throughout the document

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

| PART NO. | XX | - | X | - | X |
|---|---|---|---|---|---|
| Device | Package Options | | Environmental | | Media Type |

| | | | |
|---|---|---|---|
| Device: | MD0101 | = | High-Voltage Protection T/R Switch with Clamp Diodes |
| Package: | K6 | = | 18-lead DFN |
| Environmental: | G | = | Lead (Pb)-free/RoHS-compliant Package |
| Media Type: | (blank) | = | 490/Tray for a K6 Package |

**Example:**

a) MD0101K6-G: High-Voltage Protection T/R Switch with Clamp Diodes, 18-lead DFN, 490/Tray

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