# MD0100

## Single/Dual-Channel High-Voltage Protection T/R Switch

### Features

- Up to ±100V Input Voltage Protection
- Low On-Resistance, 15Ω Typical
- Fast-Switching Speed
- Effective Simple Two-Terminal Device
- No External Supplies Needed

### Applications

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

### General Description

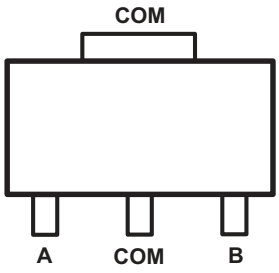
The MD0100 is a high-voltage, two-terminal, bi-directional, current-limiting protection device. The two terminals are interchangeable. It is designed to protect a low-noise receiver from high-voltage transmit pulses in ultrasound applications and is commonly referred to as a transmit-and-receive (T/R) switch.

The MD0100 can be considered as a normally closed switch with a typical switch resistance of 15Ω that allows small signals to pass. When the voltage drop across the two terminals exceeds a nominal value of ±2V, the device turns off. In the OFF state, the MD0100 can withstand up to ±100V across its terminals. A small amount of current (typically 200 µA) is allowed to flow through.

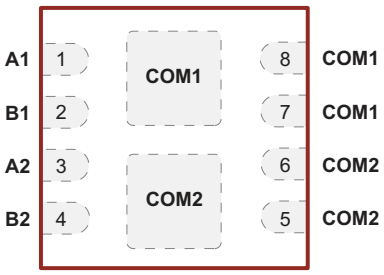
The applications for the MD0100 are not limited to just ultrasound. It can also be used as resettable fuses to protect power lines, output short-circuit protection and data acquisition. The MD0100 is available in an SOT-89 package as a single-channel device, as well as in a 4 mm x 4 mm 8-lead DFN package as a dual-channel device.

### Package Types

**3-lead SOT-89**
(Top view)

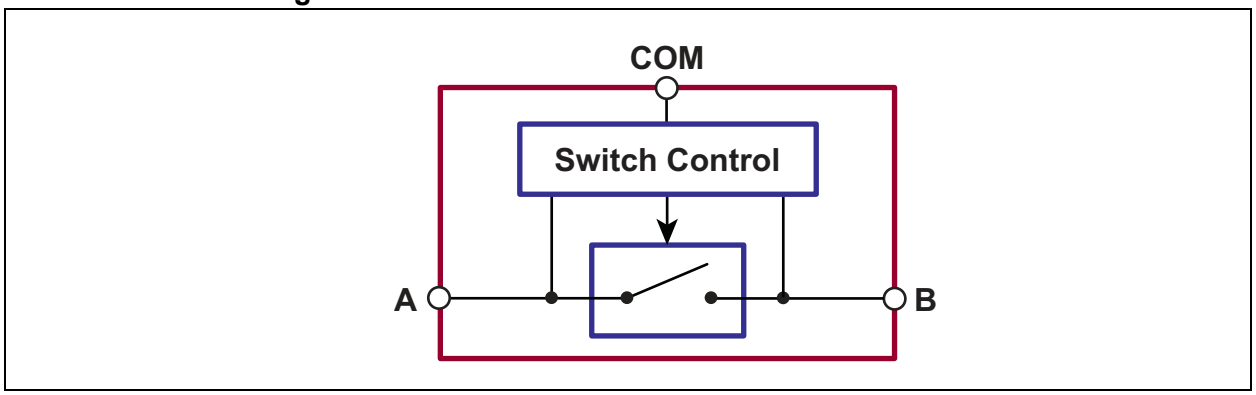



**8-lead DFN**
(Top view)

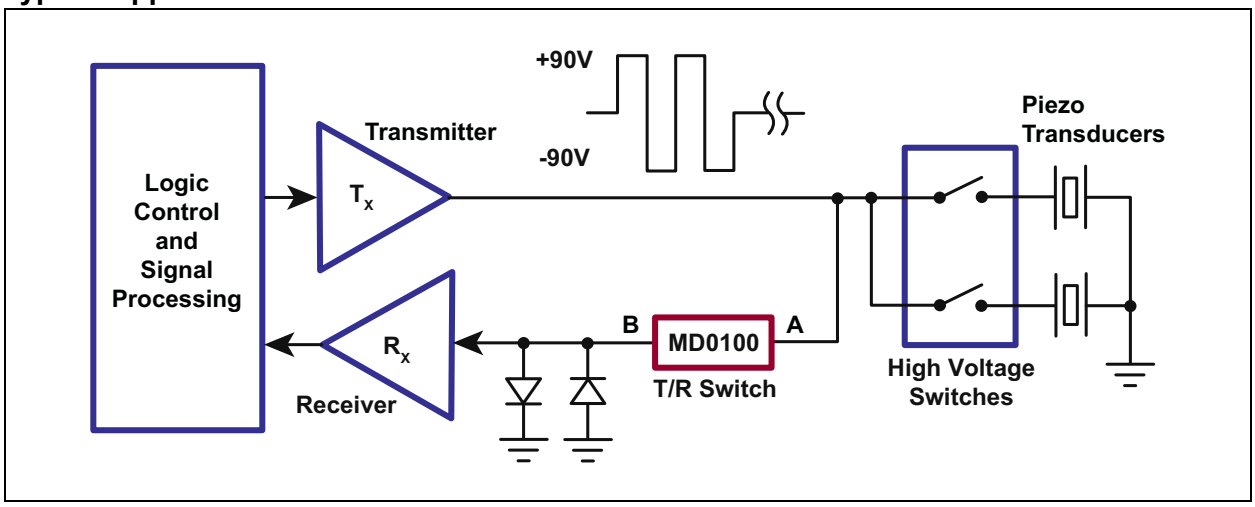



See Table 2-1 and Table 2-2 for pin information.

**Functional Block Diagram**



## Typical Application Circuit



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

Differential Voltage, $V_{A-B}$ ..... 0V to +110V
Maximum Junction Temperature, $T_J$ ..... +125°C
Storage Temperature, $T_S$ ..... –65°C to +150°C
Power Dissipation:
3-lead SOT-89 (**Note 1**, **Note 2**) ..... 1.6W
8-lead DFN (**Note 1**, **Note 2**) ..... 1.67W

**† 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:** The maximum power dissipation is per die. A package has two dies.

## DC ELECTRICAL CHARACTERISTICS

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

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

## AC ELECTRICAL CHARACTERISTICS

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

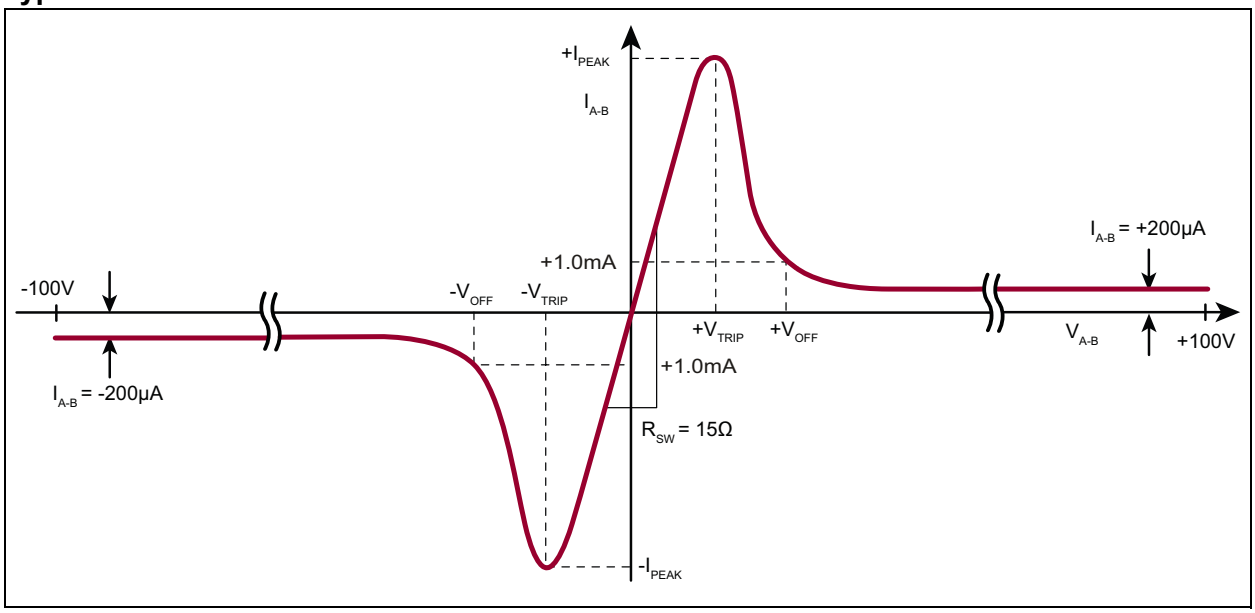
| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Peak Switching Current | $I_{PEAK}$ | — | ±60 | — | mA | See Figure 3-8. |
| Turn-Off Time | $T_{OFF}$ | — | — | 20 | ns | See Figure 3-2, Figure 3-3 and Figure 3-4. |
| Turn-On Time | $T_{ON}$ | — | — | 20 | ns | See Figure 3-5, Figure 3-6 and Figure 3-7. |
| Switch-On Capacitance from A to B | $C_{SW(ON)}$ | — | 21 | — | pF | SW = ON |
| Switch-Off Capacitance from A to B | $C_{SW(OFF)}$ | — | 15 | — | pF | $V_{SW}$ = 25V |
| Small Signal Bandwidth | BW | — | 100 | — | MHz | $R_{LOAD}$ = 50Ω |

## 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** | | | | | | |
| 3-lead SOT-89 | $\theta_{JA}$ | — | 133 | — | °C/W | **Note 1** |
| 8-lead DFN | $\theta_{JA}$ | — | 44 | — | °C/W | |

**Note 1:** 4-inch-x-4.5-inch JEDEC 2s2p PCB

## Typical I-V Characteristics



## 2.0 PIN DESCRIPTION

The functional descriptions for the pins of MD0100 are listed in Table 2-1 and Table 2-2. See **Package Types** for the location of pins.

**TABLE 2-1: 3-LEAD SOT-89 PIN FUNCTION TABLE**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | A | Switch Terminal A |
| 2 | COM | Do not connect. |
| 3 | B | Switch Terminal B |

**TABLE 2-2: 8-LEAD DFN PIN FUNCTION TABLE**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | A1 | Switch Terminal A1 |
| 2 | B1 | Switch Terminal B1 |
| 3 | A2 | Switch Terminal A2 |
| 4 | B2 | Switch Terminal B2 |
| 5, 6, and Heat Slug 2 | COM2 | Do not connect. |
| 7, 8, and Heat Slug 1 | COM1 | Do not connect. |

## 3.0 DETAILED DESCRIPTION

The MD0100 can be considered as a normally closed switch controlled by a built-in control circuit. (See **Functional Block Diagram**.) The switch control circuit monitors the voltage drop between Terminal A and Terminal B. If the voltage difference is greater than ±2V, the T/R switch will be opened. Once in the Open state, there is a small amount of current flowing through the T/R switch (200 uA) to detect if high voltage is still present. The T/R switch will not close until the voltage between Terminal A and Terminal B drops within ±2V. A pair of back-to-back diodes, from Terminal B (if it is connected to the receiver side) to ground is needed to complete the circuit and allow the peak current (about 60 mA) to flow through the switch. If the diodes are not present, there is no current path and the voltage drop across Terminal A and B will be less than ±2V. As a result, the switch will remain in the ON position.

The other purpose of the diodes is to clamp voltage spikes to ±0.7V during transmitting and receiving periods. Low-voltage diodes with low reverse recovery time and low junction capacitances (like BAV99T) should be used.

### 3.1 On Resistance

When the voltage between Terminal A and Terminal B is within ±2V, the switch is ON and the $R_{ON}$ is typically 15Ω. Once the voltage between Terminal A and Terminal B is greater than ±2V, the switch will be OFF and prevent high-voltage pulses from passing through to the receiver and damaging it.

The MD0100 does not require any power supply. There are only two active pins: the first connects to the transmitter side and the second connects to the receiver side.

### 3.2 Switch Capacitance

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

The switch-off capacitance is a function of the voltage across the T/R switch. The $C_{SW(OFF)}$ is about 12 pF to 19 pF for 10V to 100V of transmit voltage. Refer to Figure 3-1 for the C–V curve of $C_{SW(OFF)}$.

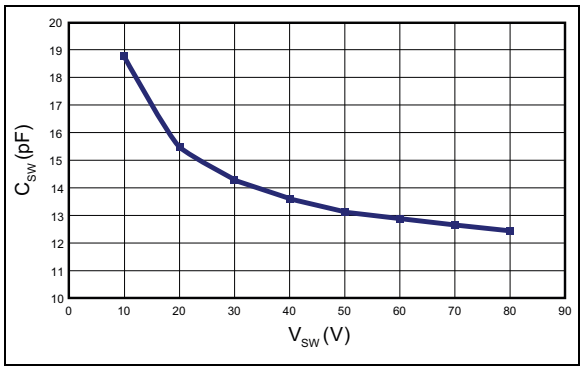



***FIGURE 3-1:*** *$C_{SW(OFF)}$ vs. $V_{SW}$.*

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

The $T_{ON}$ and $T_{OFF}$ of the MD0100 are less than 20 ns, which provides a quick transition between the Transmit and Receive modes. $T_{ON}$ and $T_{OFF}$ times are proportional to the rise and fall times of the transmit pulses. The $T_{OFF}$ and $T_{ON}$ setups are shown in Figure 3-2 and Figure 3-5, respectively.

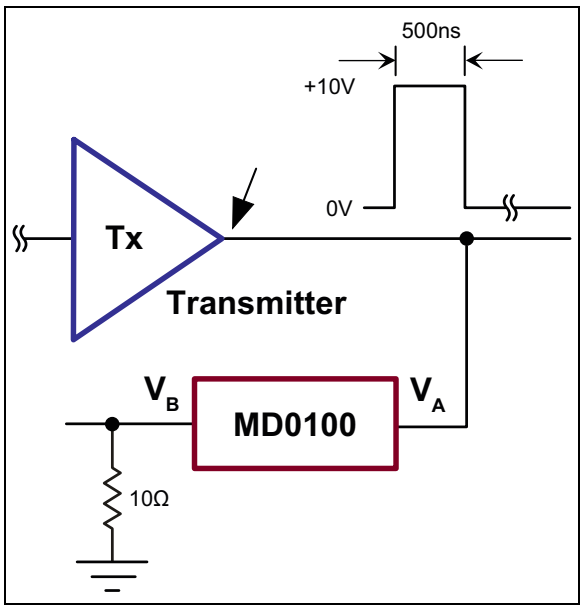



***FIGURE 3-2:*** *Test Setup for $T_{OFF}$.*

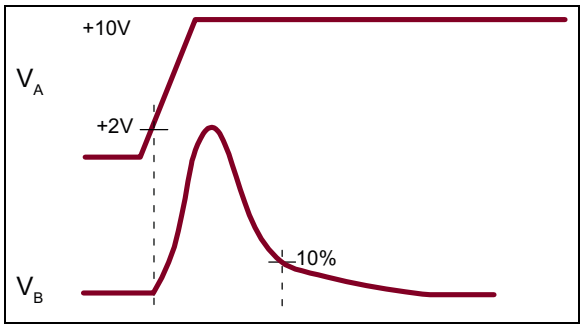



***FIGURE 3-3:*** *$T_{OFF}$ Timing Diagram.*

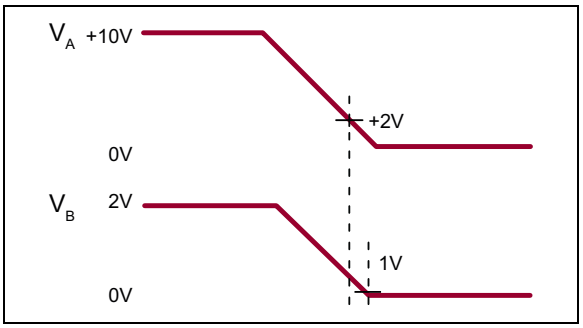



***FIGURE 3-6:*** *$T_{ON}$ Timing Diagram.*

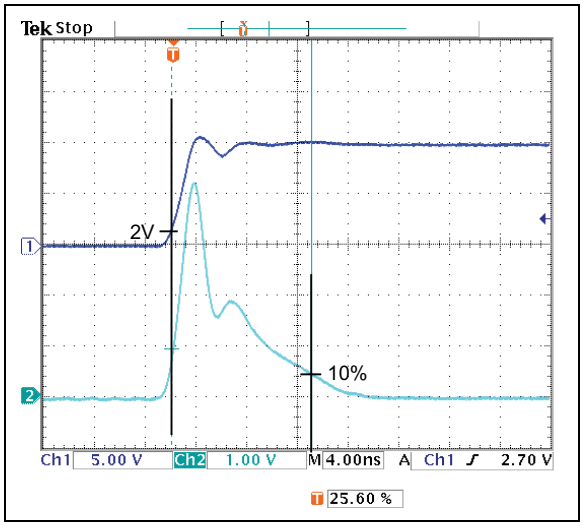



***FIGURE 3-4:*** *$T_{OFF}$ at $V_A$ = 10V.*

Figure 3-4 shows the actual waveform and measurement of $T_{OFF}$. $T_{OFF}$ is measured from 2V of $V_A$ to 10% of $V_B$. From the above waveform, $T_{OFF}$ is 11 ns.

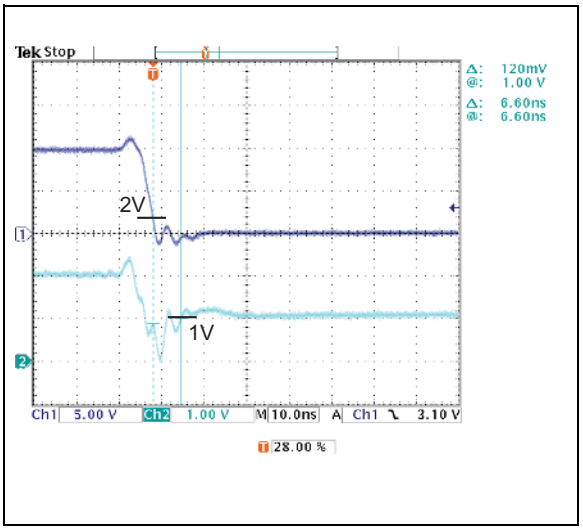



***FIGURE 3-7:*** *$T_{ON}$ at $V_A$ = 10V.*

Figure 3-7 illustrates the actual waveform and measurement of $T_{ON}$. $T_{ON}$ is measured from 2V of $V_A$ to 1V of $V_B$. From the above waveform, $T_{ON}$ is 6.6 ns.

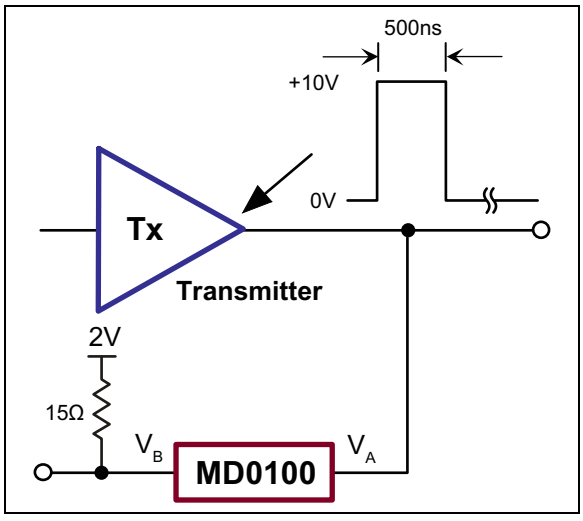



***FIGURE 3-5:*** *Test Setup for $T_{ON}$.*

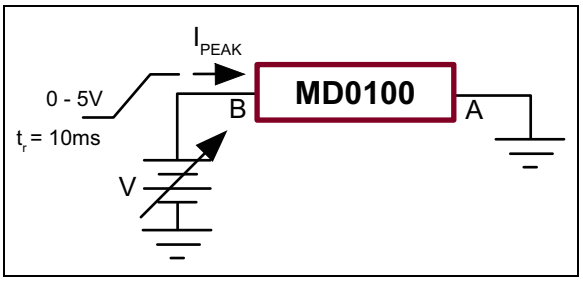



***FIGURE 3-8:*** *Test Setup for $I_{PEAK}$.*

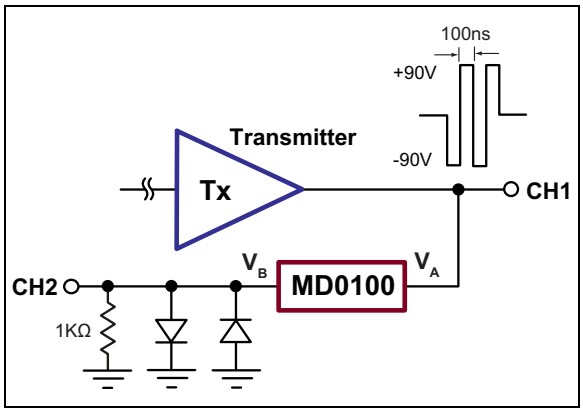



***FIGURE 3-9:*** *Test Setup for Waveforms in Figure 3-10 and Figure 3-11.*

Figure 3-10 shows the waveforms of $V_A$ and $V_B$ for the test circuit in Figure 3-9. There is a small bump of about 0.5V at the tail of the $V_B$ signal because the transmit signal falls into the ±2V range, and the MD0100 turns back on again. Figure 3-11 illustrates the same waveforms with both $V_A$ and $V_B$ shown with same voltage scale of 2V/div.

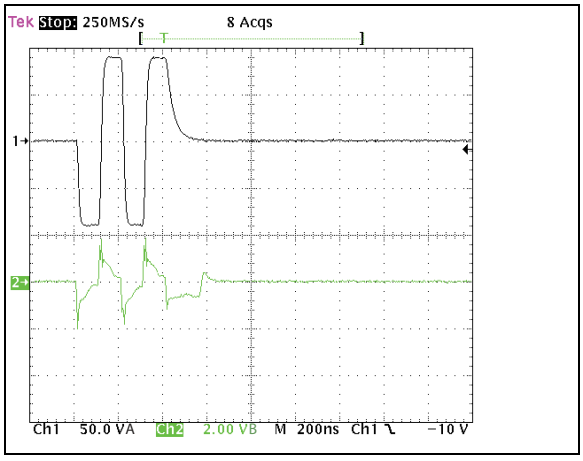



***FIGURE 3-10:*** *Typical Waveform A.*

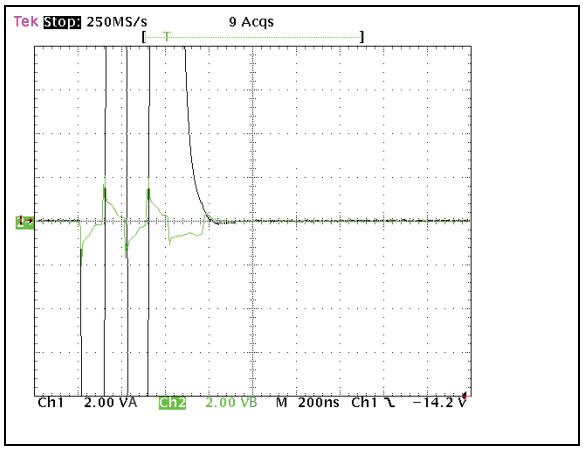
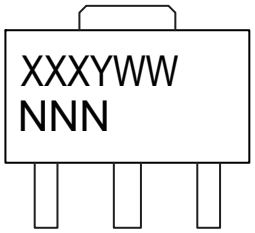



***FIGURE 3-11:*** *Typical Waveform B.*

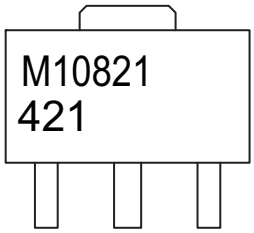
## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information

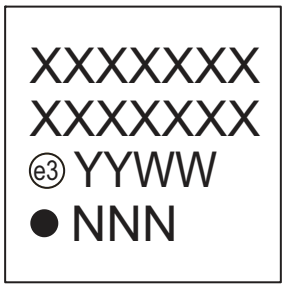
3-lead SOT-89



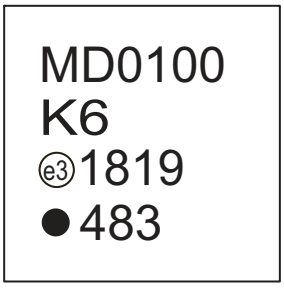

Example




8-lead DFN



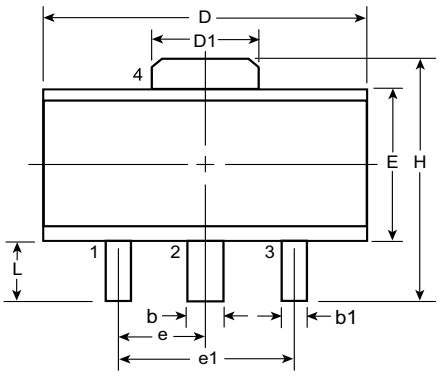

Example



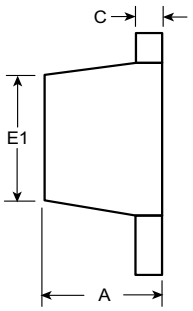

| | | |
|---|---|---|
| **Legend:** | XX...X | Product Code or Customer-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week ‘01’) |
| | NNN | Alphanumeric traceability code |
| | (e3) | 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.

## 3-Lead TO-243AA (SOT-89) Package Outline (N8)




**Top View**




**Side View**

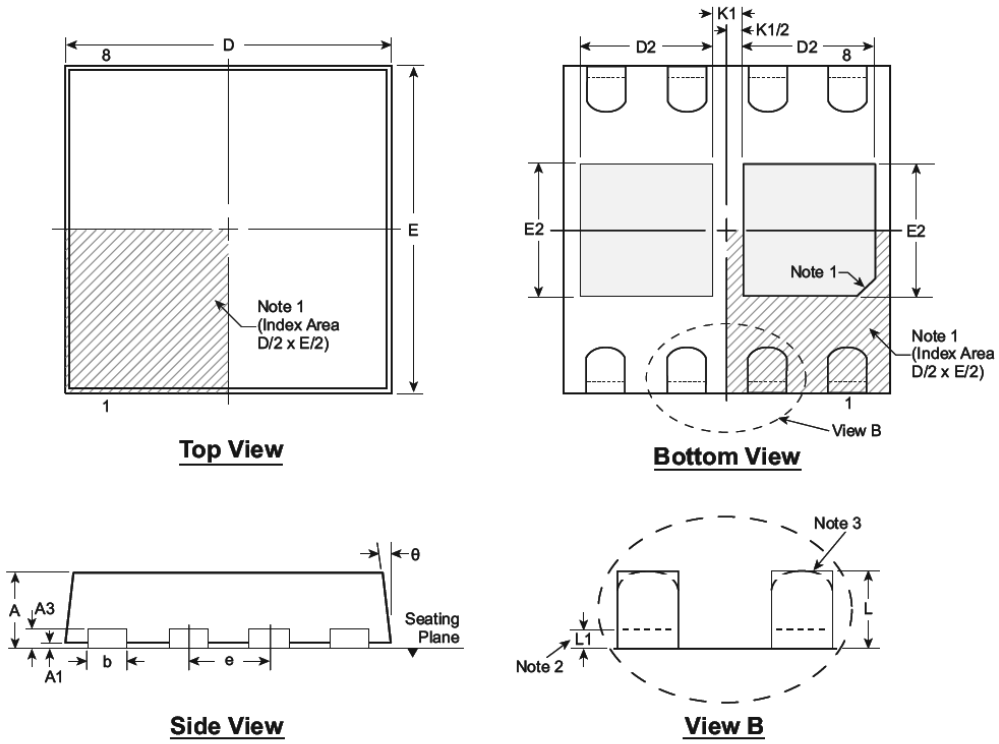
Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

| Symbol | | A | b | b1 | C | D | D1 | E | E1 | e | e1 | H | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimensions (mm) | MIN | 1.40 | 0.44 | 0.36 | 0.35 | 4.40 | 1.62 | 2.29 | 2.00† | 1.50 BSC | 3.00 BSC | 3.94 | 0.73† |
| | NOM | - | - | - | - | - | - | - | - | | | - | - |
| | MAX | 1.60 | 0.56 | 0.48 | 0.44 | 4.60 | 1.83 | 2.60 | 2.29 | | | 4.25 | 1.20 |

*JEDEC Registration TO-243, Variation AA, Issue C, July 1986.*
*† This dimension differs from the JEDEC drawing*
***Drawings not to scale.***

## 8-Lead DFN Package Outline (K6)

***4.00x4.00mm body, 1.00mm height (max), 1.00mm pitch (dual pad)***




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 | K1 | L | L1 | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimension (mm) | MIN | 0.80 | 0.00 | 0.20 REF | 0.25 | 3.90 | 1.35 | 3.90 | 1.35 | 1.00 BSC | 0.50 REF | 0.40 | 0.00 | 0° |
| | NOM | 0.90 | - | | 0.30 | 4.00 | 1.45 | 4.00 | 1.45 | | | 0.50 | - | - |
| | MAX | 1.00 | 0.05 | | 0.35 | 4.10 | 1.55 | 4.10 | 1.55 | | | 0.60 | 0.15 | 14° |

***Drawings not to scale***

# APPENDIX A: REVISION HISTORY

## Revision A (October 2018)

- Converted Supertex Doc# DSFP-MD0100 to Microchip DS20005738A
- Changed the power dissipation value of 8-lead DFN from “1.1W” to “1.67W”
- Changed Note 1 to “4-inch-x-4.5-inch JEDEC 2s2p PCB”
- Changed the package marking format
- Changed the quantity of the 8-lead DFN K6 package from 3000/Reel to 3300/Reel
- Changed the “3-lead TO-243AA (SOT-89)” package marking to “3-lead SOT-89”
- 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 |

| | | | |
|---|---|---|---|
| Devices: | MD0100 | = | Single-Channel High-Voltage Protection T/R Switch, Single Channel |
| | MD0100D | = | Dual-Channel High-Voltage Protection T/R Switch |
| Packages: | N8 | = | 3-lead SOT89 (for single channel only) |
| | K6 | = | 8-lead (4x4) VDFN (for dual channel only) |
| Environmental: | G | = | Lead (Pb)-free/RoHS-compliant Package |
| Media Type: | (blank) | = | 2000/Reel for an N8 Package |
| | (blank) | = | 3300/Reel for a K6 Package |

**Examples:**

a) MD0100N8-G: Single-Channel High-Voltage Protection T/R Switch, 3-lead SOT89, 2000/Reel

b) MD0100DK6G: Dual-Channel High-Voltage Protection T/R Switch, 8-lead (4x4) VDFN, 3300/Reel

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.



*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

**QUALITY MANAGEMENT SYSTEM**
**CERTIFIED BY DNV**
**═ ISO/TS 16949 ═**

**Trademarks**



ISBN: 978-1-5224-3685-0

# Worldwide Sales and Service


## AMERICAS

**Corporate Office**
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

**Atlanta**
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

**Austin, TX**
Tel: 512-257-3370

**Boston**
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

**Chicago**
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

**Dallas**
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

**Detroit**
Novi, MI
Tel: 248-848-4000

**Houston, TX**
Tel: 281-894-5983

**Indianapolis**
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

**Los Angeles**
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

**Raleigh, NC**
Tel: 919-844-7510

**New York, NY**
Tel: 631-435-6000

**San Jose, CA**
Tel: 408-735-9110
Tel: 408-436-4270

**Canada - Toronto**
Tel: 905-695-1980
Fax: 905-695-2078

## ASIA/PACIFIC

**Australia - Sydney**
Tel: 61-2-9868-6733

**China - Beijing**
Tel: 86-10-8569-7000

**China - Chengdu**
Tel: 86-28-8665-5511

**China - Chongqing**
Tel: 86-23-8980-9588

**China - Dongguan**
Tel: 86-769-8702-9880

**China - Guangzhou**
Tel: 86-20-8755-8029

**China - Hangzhou**
Tel: 86-571-8792-8115

**China - Hong Kong SAR**
Tel: 852-2943-5100

**China - Nanjing**
Tel: 86-25-8473-2460

**China - Qingdao**
Tel: 86-532-8502-7355

**China - Shanghai**
Tel: 86-21-3326-8000

**China - Shenyang**
Tel: 86-24-2334-2829

**China - Shenzhen**
Tel: 86-755-8864-2200

**China - Suzhou**
Tel: 86-186-6233-1526

**China - Wuhan**
Tel: 86-27-5980-5300

**China - Xian**
Tel: 86-29-8833-7252

**China - Xiamen**
Tel: 86-592-2388138

**China - Zhuhai**
Tel: 86-756-3210040

## ASIA/PACIFIC

**India - Bangalore**
Tel: 91-80-3090-4444

**India - New Delhi**
Tel: 91-11-4160-8631

**India - Pune**
Tel: 91-20-4121-0141

**Japan - Osaka**
Tel: 81-6-6152-7160

**Japan - Tokyo**
Tel: 81-3-6880- 3770

**Korea - Daegu**
Tel: 82-53-744-4301

**Korea - Seoul**
Tel: 82-2-554-7200

**Malaysia - Kuala Lumpur**
Tel: 60-3-7651-7906

**Malaysia - Penang**
Tel: 60-4-227-8870

**Philippines - Manila**
Tel: 63-2-634-9065

**Singapore**
Tel: 65-6334-8870

**Taiwan - Hsin Chu**
Tel: 886-3-577-8366

**Taiwan - Kaohsiung**
Tel: 886-7-213-7830

**Taiwan - Taipei**
Tel: 886-2-2508-8600

**Thailand - Bangkok**
Tel: 66-2-694-1351

**Vietnam - Ho Chi Minh**
Tel: 84-28-5448-2100

## EUROPE

**Austria - Wels**
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

**Denmark - Copenhagen**
Tel: 45-4450-2828
Fax: 45-4485-2829

**Finland - Espoo**
Tel: 358-9-4520-820

**France - Paris**
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

**Germany - Garching**
Tel: 49-8931-9700

**Germany - Haan**
Tel: 49-2129-3766400

**Germany - Heilbronn**
Tel: 49-7131-67-3636

**Germany - Karlsruhe**
Tel: 49-721-625370

**Germany - Munich**
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

**Germany - Rosenheim**
Tel: 49-8031-354-560

**Israel - Ra'anana**
Tel: 972-9-744-7705

**Italy - Milan**
Tel: 39-0331-742611
Fax: 39-0331-466781

**Italy - Padova**
Tel: 39-049-7625286

**Netherlands - Drunen**
Tel: 31-416-690399
Fax: 31-416-690340

**Norway - Trondheim**
Tel: 47-7288-4388

**Poland - Warsaw**
Tel: 48-22-3325737

**Romania - Bucharest**
Tel: 40-21-407-87-50

**Spain - Madrid**
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

**Sweden - Gothenberg**
Tel: 46-31-704-60-40

**Sweden - Stockholm**
Tel: 46-8-5090-4654

**UK - Wokingham**
Tel: 44-118-921-5800
Fax: 44-118-921-5820