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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

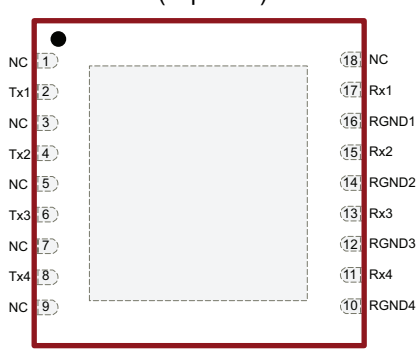
The MD0101 is a four-channel high-voltage current-limiting protection device. It is designed to protect a low-noise receiver from high-voltage transmit pulses in ultrasound applications and is commonly referred to as a T/R (transmit-and-receive) switch. Each channel has three terminals: TX, RX, and R_{GND}. 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

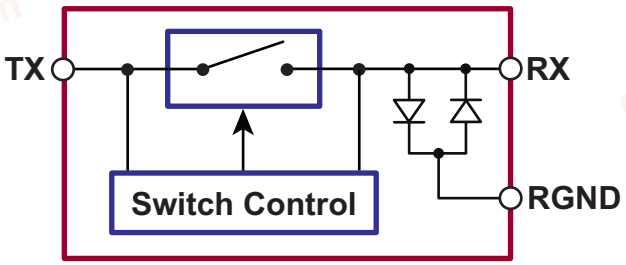
18-lead DFN
(Top view)



See Table 2-1 for pin information.

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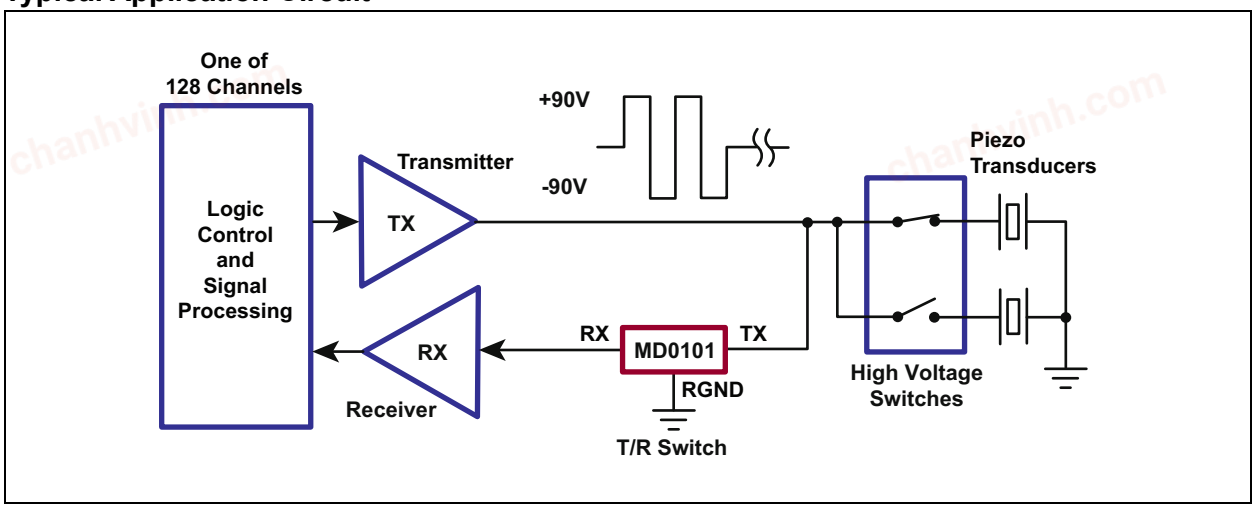
Functional Block Diagram



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Typical Application Circuit



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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

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TEMPERATURE SPECIFICATIONS

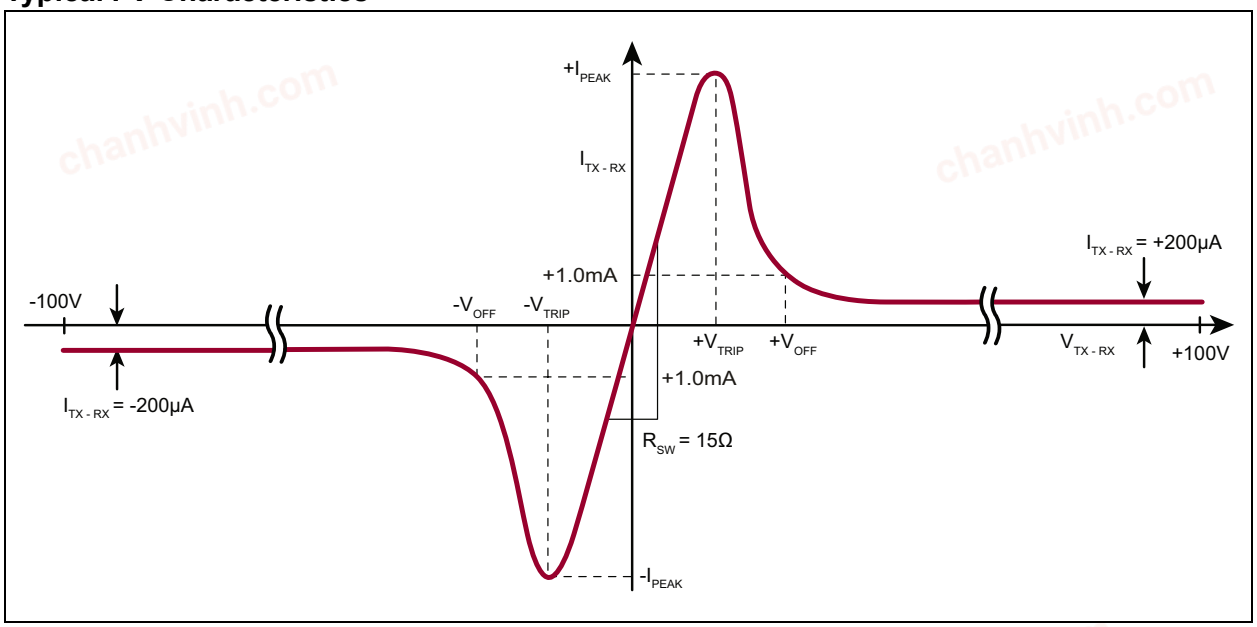
Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
TEMPERATURE RANGE						
Operating Junction Temperature	T_J	–40	—	+125	°C	
Storage Temperature	T_S	–65	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
18-lead DFN	θ_{JA}	—	40	—	°C/W	**Note 1**

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

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Typical I-V Characteristics



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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

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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 $C_{TX(OFF)}$.

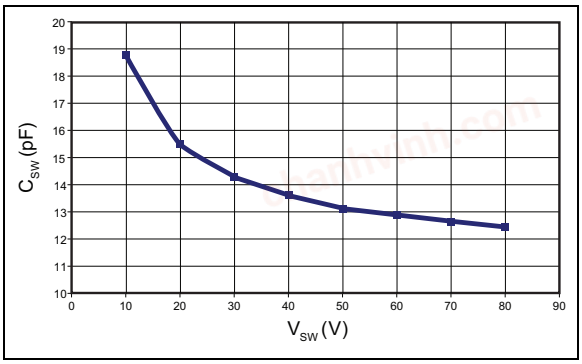


FIGURE 3-1: *C_{TX-RX} vs. V_{TX-RX}.*

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.

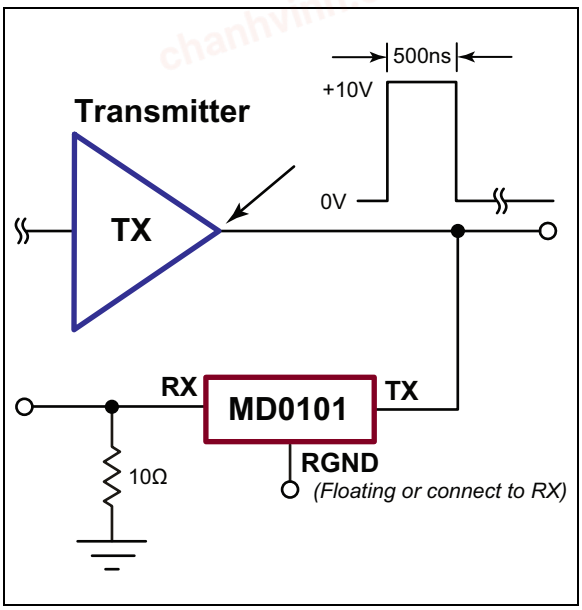


FIGURE 3-2: *Test Setup for T_{OFF}.*

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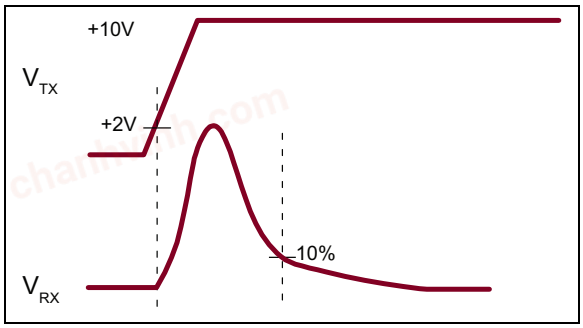


FIGURE 3-3: *T_{OFF} Timing Diagram.*

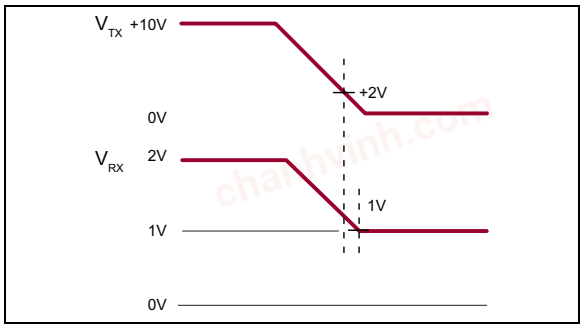


FIGURE 3-6: *T_{ON} Timing Diagram.*

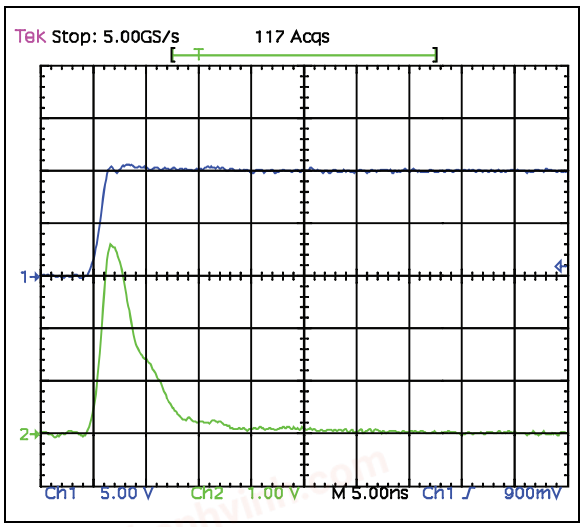


FIGURE 3-4: *T_{OFF} at V_{TX} = 10V.*

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}.

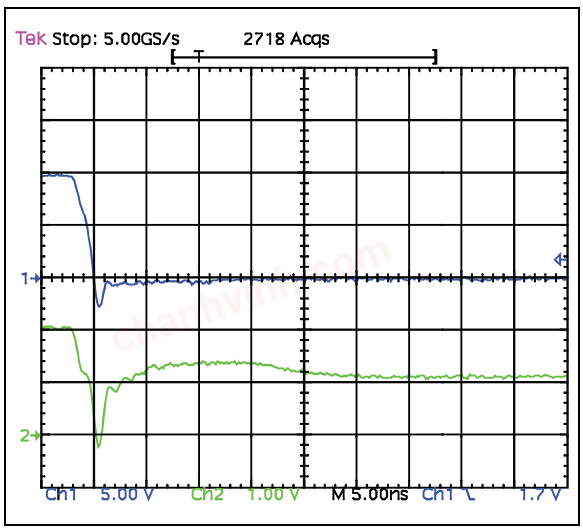


FIGURE 3-7: *T_{ON} at V_{TX} = 10V.*

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}.

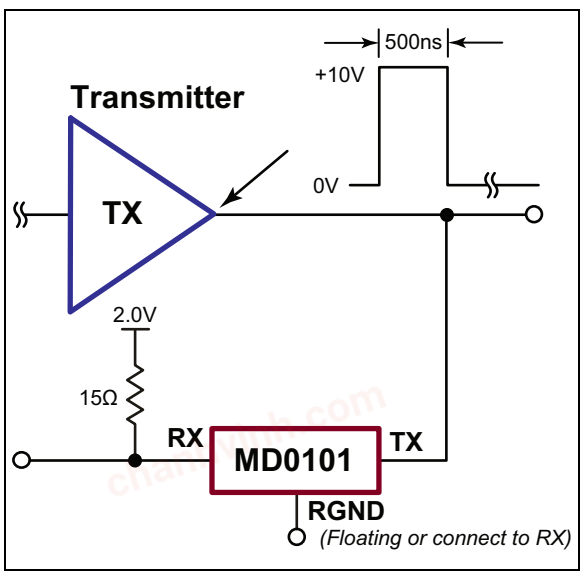


FIGURE 3-5: *Test Setup for T_{ON}.*

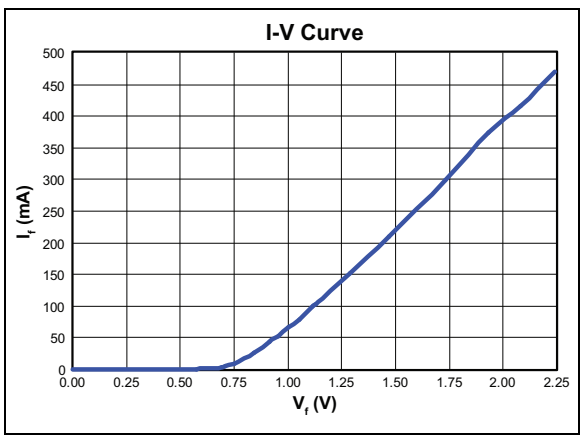


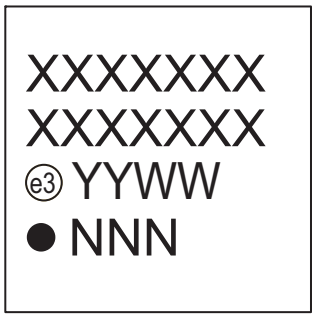
FIGURE 3-8: *RX Clamp Diodes to RGND.*

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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.

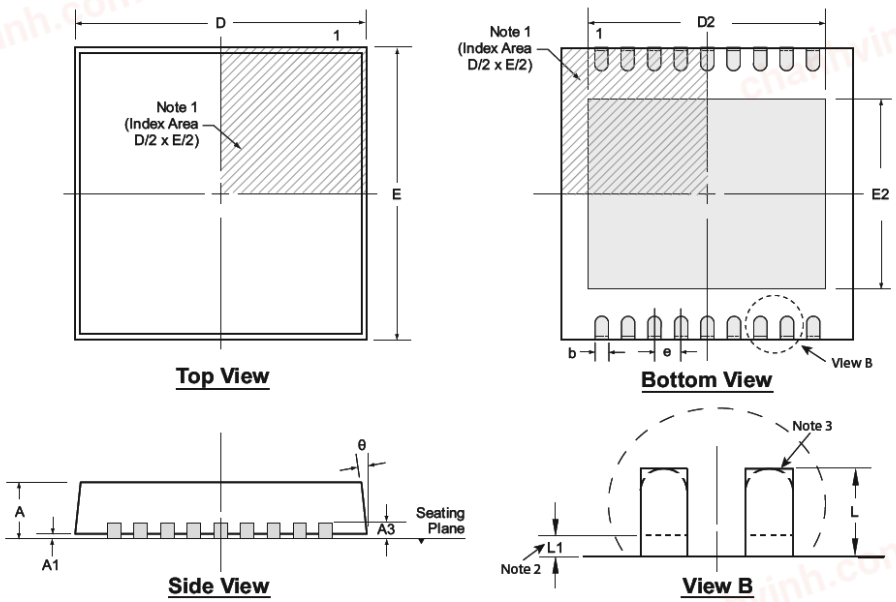
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

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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.

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NOTES:

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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

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MD0101

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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