

# NUP4114 Series, SZNUP4114 Series

## Transient Voltage Suppressors

### ESD Protection Diodes with Low Clamping Voltage

The NUP4114 transient voltage suppressors are designed to protect high speed data lines from ESD. Ultra-low capacitance and high level of ESD protection make these devices well suited for use in USB 2.0 high speed applications.

#### Features

- Low Clamping Voltage
- Small Body Outline Dimensions on SC-88 Package:  
0.082" x 0.078" (2.10 mm x 1.25 mm)
- Low Body Height: 0.043" (1.10 mm)
- Stand-off Voltage: 5.5 V
- Low Leakage
- Response Time is Typically < 1.0 ns
- IEC61000-4-2 Level 4 ESD Protection
- These Devices are Pb-Free and are RoHS Compliant
- AEC-Q101 Qualified and PPAP Capable – SZNUP4114
- SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements

#### Typical Applications

- LVDS
- USB 2.0 High Speed Data Line and Power Line Protection
- Digital Video Interface (DVI) and HDMI
- Monitors and Flat Panel Displays
- High Speed Communication Line Protection
- Notebook Computers
- Gigabit Ethernet

#### MAXIMUM RATINGS (T<sub>J</sub> = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T <sub>J</sub>	-40 to +125	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C
Lead Solder Temperature – Maximum (10 Seconds)	T <sub>L</sub>	260	°C
IEC 61000-4-2 (ESD)	Contact Air	±8 ±15	kV

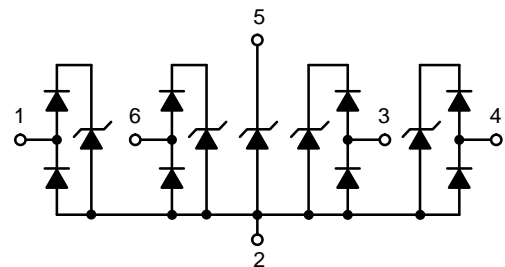
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

See Application Note AND8308/D for further description of survivability specs.



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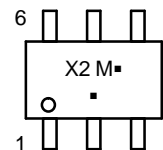
<http://onsemi.com>



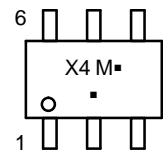
#### MARKING DIAGRAMS



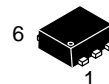
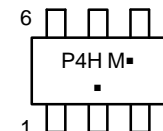
SC-88  
W1 SUFFIX  
CASE 419B



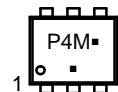
SC-88  
W1 SUFFIX  
CASE 419B



TSOP-6  
CASE 318G  
STYLE 12



SOT-563  
CASE 463A



XXX = Specific Device Code

M = Date Code

▪ = Pb-Free Package

(Note: Microdot may be in either location)

#### ORDERING INFORMATION

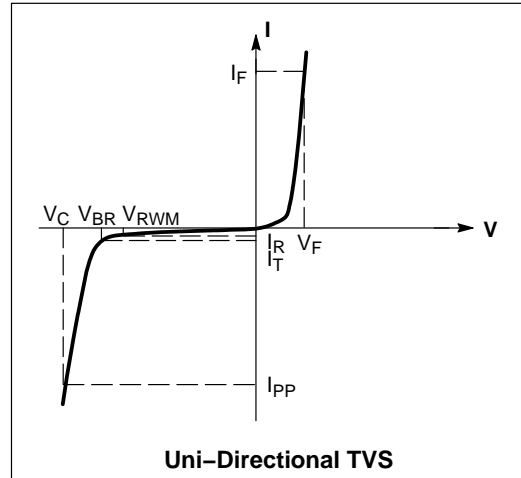
See detailed ordering and shipping information in the package dimensions section on page 4 of this data sheet.

# NUP4114 Series, SZNUP4114 Series

## ELECTRICAL CHARACTERISTICS

( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Symbol	Parameter
$I_{PP}$	Maximum Reverse Peak Pulse Current
$V_C$	Clamping Voltage @ $I_{PP}$
$V_{RWM}$	Working Peak Reverse Voltage
$I_R$	Maximum Reverse Leakage Current @ $V_{RWM}$
$V_{BR}$	Breakdown Voltage @ $I_T$
$I_T$	Test Current
$I_F$	Forward Current
$V_F$	Forward Voltage @ $I_F$
$P_{pk}$	Peak Power Dissipation
C	Capacitance @ $V_R = 0$ and $f = 1.0$ MHz



\*See Application Note AND8308/D for detailed explanations of datasheet parameters.

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reverse Working Voltage	$V_{RWM}$	(Note 1)			5.5	V
Breakdown Voltage	$V_{BR}$	$I_T = 1$ mA, (Note 2)	5.5			V
Reverse Leakage Current	$I_R$	$V_{RWM} = 5.5$ V			1.0	$\mu\text{A}$
Clamping Voltage	$V_C$	$I_{PP} = 5$ A (Note 3)			9.0	V
Clamping Voltage	$V_C$	$I_{PP} = 8$ A (Note 3)			10	V
Clamping Voltage	$V_C$	$I_{PP} = 1$ A (Note 4)		8.3	10	V
ESD Clamping Voltage	$V_C$	Per IEC61000-4-2 (Note 5)	See Figures 1 & 2			
Maximum Peak Pulse Current	$I_{PP}$	8x20 $\mu\text{s}$ Waveform (Note 3)			12	A
Junction Capacitance	$C_J$	$V_R = 0$ V, $f = 1$ MHz between I/O Pins and GND			0.6	pF
Junction Capacitance	$C_J$	$V_R = 0$ V, $f = 1$ MHz between I/O Pins			0.3	pF

1. TVS devices are normally selected according to the working peak reverse voltage ( $V_{RWM}$ ), which should be equal or greater than the DC or continuous peak operating voltage level.
2.  $V_{BR}$  is measured at pulse test current  $I_T$ .
3. Nonrepetitive current pulse (Pin 5 to Pin 2)
4. Nonrepetitive current pulse (I/O to GND).
5. For test procedure see Figures 3 and 4 and Application Note AND8307/D.
6. Include SZ-prefix devices where applicable.

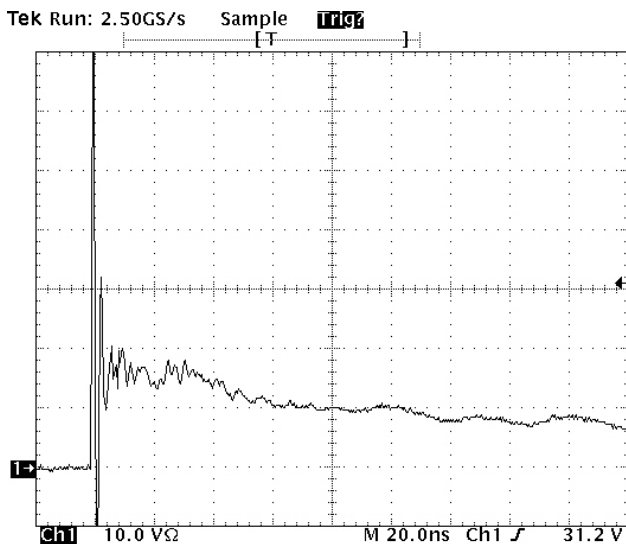


Figure 1. ESD Clamping Voltage Screenshot Positive 8 kV Contact per IEC61000-4-2

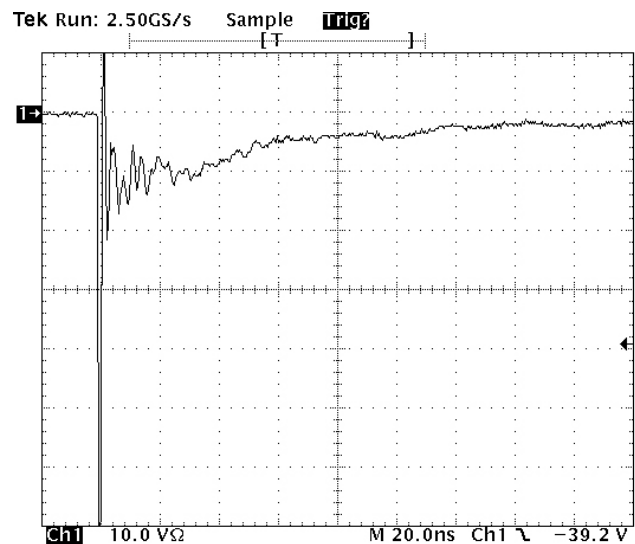


Figure 2. ESD Clamping Voltage Screenshot Negative 8 kV Contact per IEC61000-4-2

# NUP4114 Series, SZNUP4114 Series

## IEC 61000-4-2 Spec.

Level	Test Voltage (kV)	First Peak Current (A)	Current at 30 ns (A)	Current at 60 ns (A)
1	2	7.5	4	2
2	4	15	8	4
3	6	22.5	12	6
4	8	30	16	8



Figure 3. IEC61000-4-2 Spec

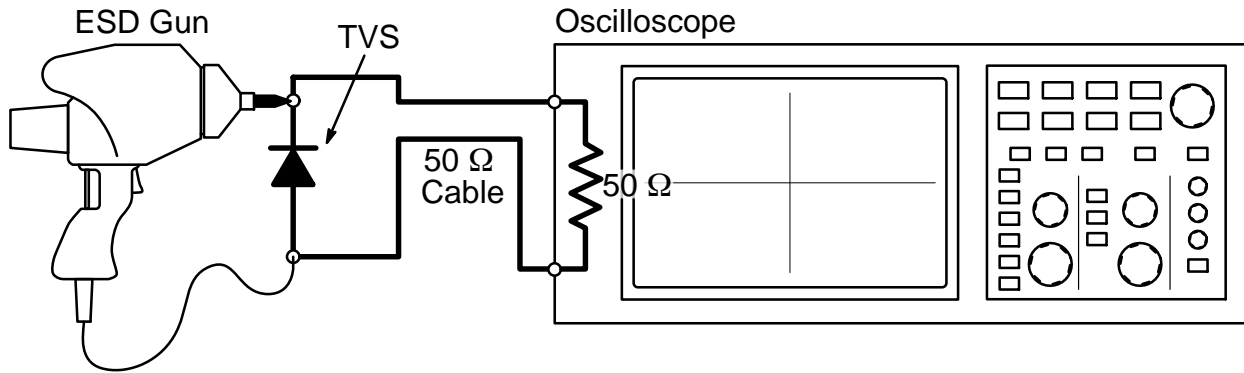


Figure 4. Diagram of ESD Test Setup

The following is taken from Application Note AND8308/D – Interpretation of Datasheet Parameters for ESD Devices.

### ESD Voltage Clamping

For sensitive circuit elements it is important to limit the voltage that an IC will be exposed to during an ESD event to as low a voltage as possible. The ESD clamping voltage is the voltage drop across the ESD protection diode during an ESD event per the IEC61000-4-2 waveform. Since the IEC61000-4-2 was written as a pass/fail spec for larger

systems such as cell phones or laptop computers it is not clearly defined in the spec how to specify a clamping voltage at the device level. ON Semiconductor has developed a way to examine the entire voltage waveform across the ESD protection diode over the time domain of an ESD pulse in the form of an oscilloscope screenshot, which can be found on the datasheets for all ESD protection diodes. For more information on how ON Semiconductor creates these screenshots and how to interpret them please refer to AND8307/D.

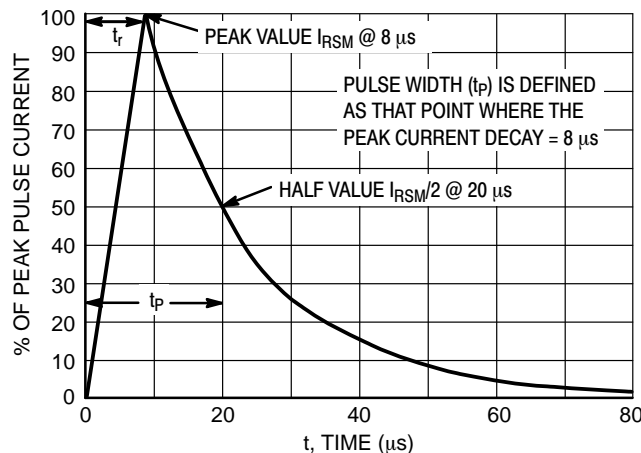
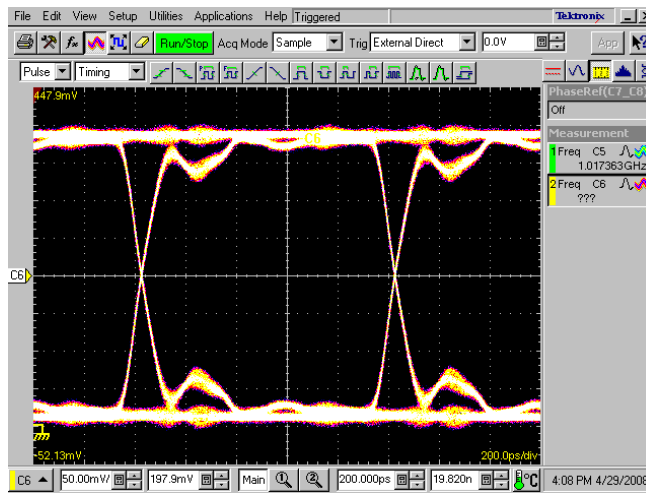


Figure 5. 8 X 20 μs Pulse Waveform

## NUP4114 Series, SZNUP4114 Series



**Figure 6. 500 MHz Data Pattern**

### ORDERING INFORMATION

Device	Marking	Package	Shipping <sup>†</sup>
NUP4114UCLW1T2G	X2	SC-88 (Pb-Free)	3000 / Tape & Reel
NUP4114UCW1T2G	X4	SC-88 (Pb-Free)	3000 / Tape & Reel
NUP4114UPXV6T1G	P4	SOT-563 (Pb-Free)	4000 / Tape & Reel
NUP4114HMR6T1G	P4H	TSOP-6 (Pb-Free)	3000 / Tape & Reel
SZNUP4114UCLW1T2G	X2	SC-88 (Pb-Free)	3000 / Tape & Reel
SZNUP4114HMR6T1G	P4H	TSOP-6 (Pb-Free)	3000 / Tape & Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# NUP4114 Series, SZNUP4114 Series

## APPLICATIONS INFORMATION

The new NUP4114 is a low capacitance TVS diode array designed to protect sensitive electronics such as communications systems, computers, and computer peripherals against damage due to ESD events or transient overvoltage conditions. Because of its low capacitance, it can be used in high speed I/O data lines. The integrated design of the NUP4114 offers low capacitance steering diodes and a TVS diode integrated in a single package (TSOP-6). If a transient condition occurs, the steering diodes will drive the transient to the positive rail of the power supply or to ground. The TVS device protects the power line against overvoltage conditions to avoid damage to the power supply and any downstream components.

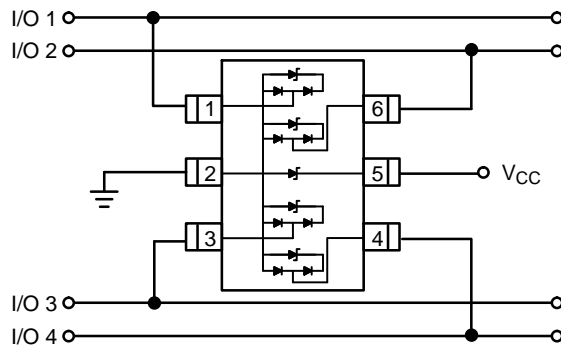
### NUP4114 Configuration Options

The NUP4114 is able to protect up to four data lines against transient overvoltage conditions by driving them to a fixed reference point for clamping purposes. The steering diodes will be forward biased whenever the voltage on the protected line exceeds the reference voltage ( $V_f$  or  $V_{CC} + V_f$ ). The diodes will force the transient current to bypass the sensitive circuit.

Data lines are connected at pins 1, 3, 4 and 6. The negative reference is connected at pin 2. This pin must be connected directly to ground by using a ground plane to minimize the PCB's ground inductance. It is very important to reduce the PCB trace lengths as much as possible to minimize parasitic inductances.

#### Option 1

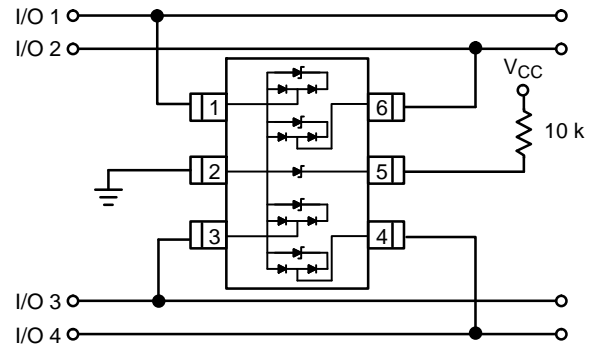
Protection of four data lines and the power supply using  $V_{CC}$  as reference.



For this configuration, connect pin 5 directly to the positive supply rail ( $V_{CC}$ ), the data lines are referenced to the supply voltage. The internal TVS diode prevents overvoltage on the supply rail. Biasing of the steering diodes reduces their capacitance.

#### Option 2

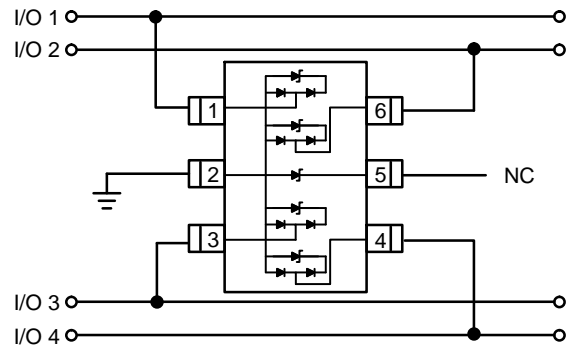
Protection of four data lines with bias and power supply isolation resistor.



The NUP4114 can be isolated from the power supply by connecting a series resistor between pin 5 and  $V_{CC}$ . A 10 kΩ resistor is recommended for this application. This will maintain a bias on the internal TVS and steering diodes, reducing their capacitance.

#### Option 3

Protection of four data lines using the internal TVS diode as reference.



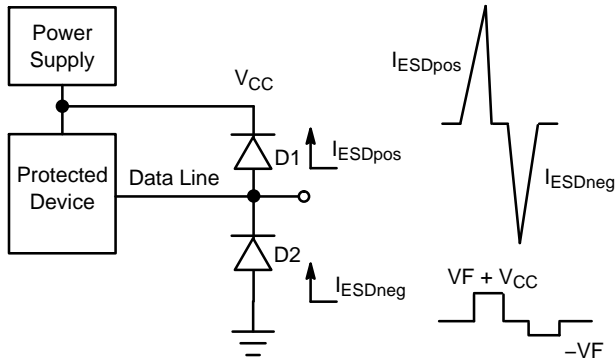
In applications lacking a positive supply reference or those cases in which a fully isolated power supply is required, the internal TVS can be used as the reference. For these applications, pin 5 is not connected. In this configuration, the steering diodes will conduct whenever the voltage on the protected line exceeds the working voltage of the TVS plus one diode drop ( $V_C = V_f + V_{TVS}$ ).

### ESD Protection of Power Supply Lines

When using diodes for data line protection, referencing to a supply rail provides advantages. Biasing the diodes reduces their capacitance and minimizes signal distortion.

## NUP4114 Series, SZNUP4114 Series

Implementing this topology with discrete devices does have disadvantages. This configuration is shown below:



Looking at the figure above, it can be seen that when a positive ESD condition occurs, diode D1 will be forward biased while diode D2 will be forward biased when a negative ESD condition occurs. For slower transient conditions, this system may be approximated as follows:

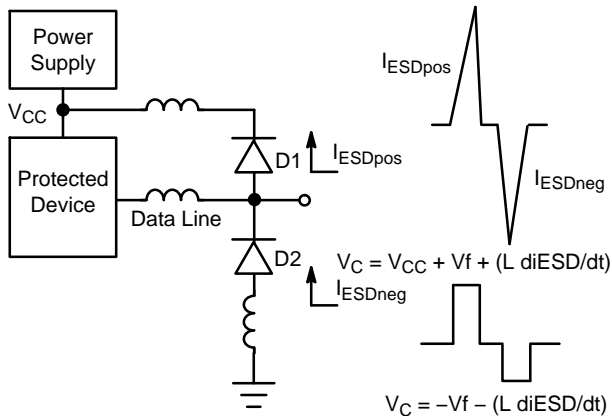
For positive pulse conditions:

$$V_c = V_{CC} + V_{fD1}$$

For negative pulse conditions:

$$V_c = -V_{fD2}$$

ESD events can have rise times on the order of some number of nanoseconds. Under these conditions, the effect of parasitic inductance must be considered. A pictorial representation of this is shown below.



An approximation of the clamping voltage for these fast transients would be:

For positive pulse conditions:

$$V_c = V_{CC} + V_f + (L \, di_{ESD}/dt)$$

For negative pulse conditions:

$$V_c = -V_f - (L \, di_{ESD}/dt)$$

As shown in the formulas, the clamping voltage ( $V_c$ ) not only depends on the  $V_f$  of the steering diodes but also on the  $L \, di_{ESD}/dt$  factor. A relatively small trace inductance can result in hundreds of volts appearing on the supply rail. This endangers both the power supply and anything attached to that rail. This highlights the importance of good board

layout. Taking care to minimize the effects of parasitic inductance will provide significant benefits in transient immunity.

Even with good board layout, some disadvantages are still present when discrete diodes are used to suppress ESD events across datalines and the supply rail. Discrete diodes with good transient power capability will have larger die and therefore higher capacitance. This capacitance becomes problematic as transmission frequencies increase. Reducing capacitance generally requires reducing die size. These small die will have higher forward voltage characteristics at typical ESD transient current levels. This voltage combined with the smaller die can result in device failure.

The ON Semiconductor NUP4114 was developed to overcome the disadvantages encountered when using discrete diodes for ESD protection. This device integrates a TVS diode within a network of steering diodes.

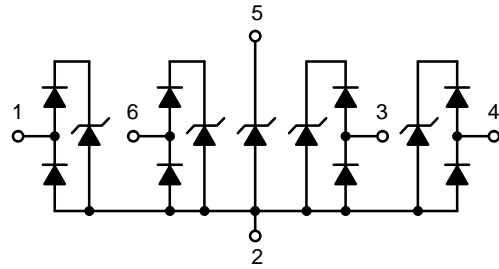
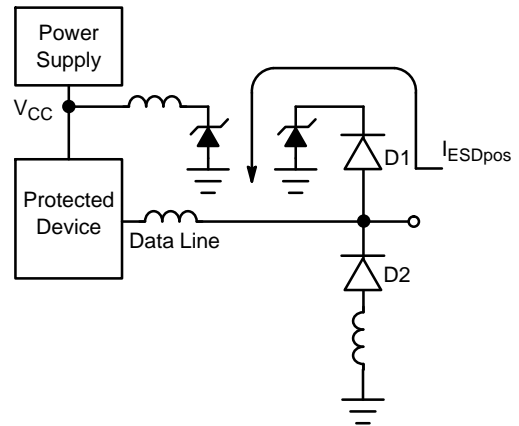


Figure 7. NUP4114 Equivalent Circuit

During an ESD condition, the ESD current will be driven to ground through the TVS diode as shown below.



The resulting clamping voltage on the protected IC will be:

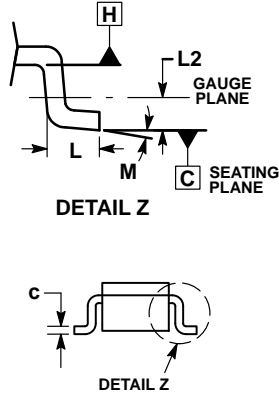
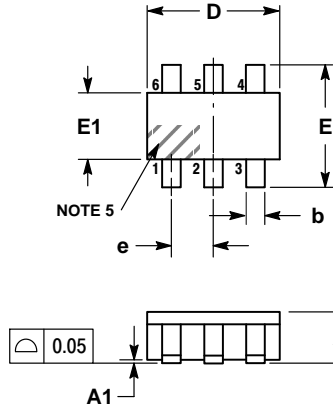
$$V_c = V_f + V_{TVS}$$

The clamping voltage of the TVS diode depends on the magnitude of the ESD current. The steering diodes are fast switching devices with unique forward voltage and low capacitance characteristics.

# NUP4114 Series, SZNUP4114 Series

## PACKAGE DIMENSIONS

### TSOP-6 CASE 318G-02 ISSUE U

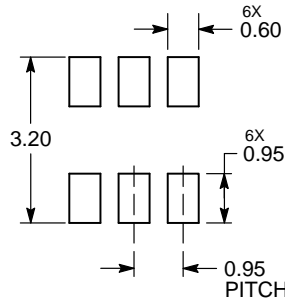


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSIONS D AND E1 ARE DETERMINED AT DATUM H.
5. PIN ONE INDICATOR MUST BE LOCATED IN THE INDICATED ZONE.

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	0.90	1.00	1.10
A1	0.01	0.06	0.10
b	0.25	0.38	0.50
c	0.10	0.18	0.26
D	2.90	3.00	3.10
E	2.50	2.75	3.00
E1	1.30	1.50	1.70
e	0.85	0.95	1.05
L	0.20	0.40	0.60
L2	0.25 BSC		
M	0°	-	10°

### RECOMMENDED SOLDERING FOOTPRINT\*



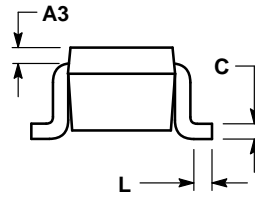
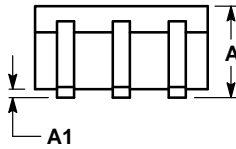
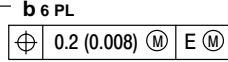
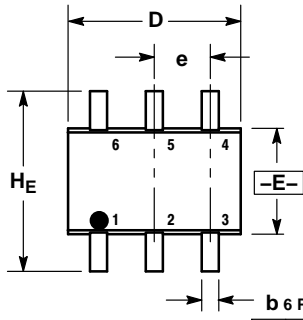
DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# NUP4114 Series, SZNUP4114 Series

## PACKAGE DIMENSIONS

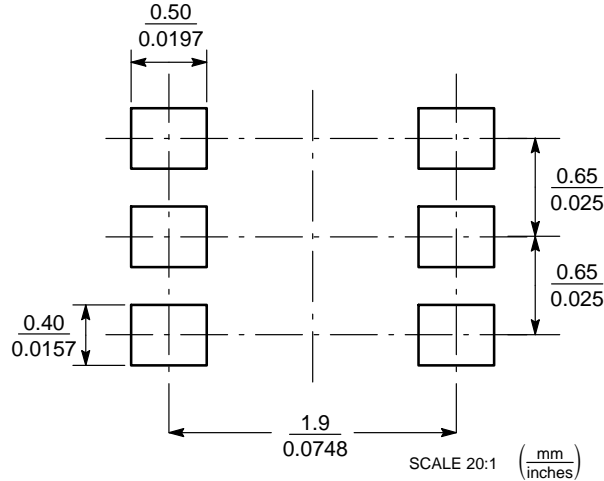
**SC-88/SC70-6/SOT-363**  
CASE 419B-02  
ISSUE W



- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.  
3. 419B-01 OBSOLETE, NEW STANDARD 419B-02.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.95	1.10	0.031	0.037	0.043
A1	0.00	0.05	0.10	0.000	0.002	0.004
A3	0.20 REF			0.008 REF		
b	0.10	0.21	0.30	0.004	0.008	0.012
C	0.10	0.14	0.25	0.004	0.005	0.010
D	1.80	2.00	2.20	0.070	0.078	0.086
E	1.15	1.25	1.35	0.045	0.049	0.053
e	0.65 BSC			0.026 BSC		
L	0.10	0.20	0.30	0.004	0.008	0.012
HE	2.00	2.10	2.20	0.078	0.082	0.086

### SOLDERING FOOTPRINT\*



**SC-88/SC70-6/SOT-363**

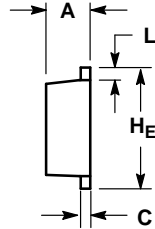
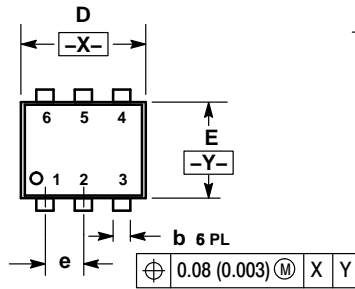
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# NUP4114 Series, SZNUP4114 Series

## PACKAGE DIMENSIONS

### SOT-563, 6 LEAD CASE 463A-01 ISSUE F

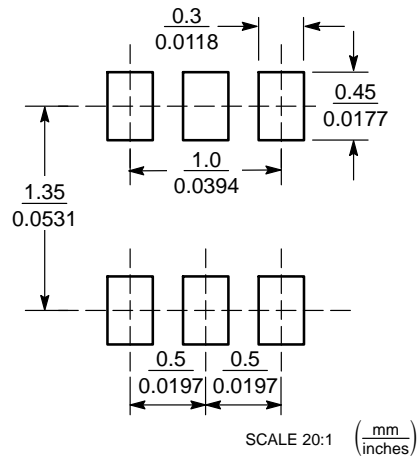


#### NOTES:


1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.50	0.55	0.60	0.020	0.021	0.023
b	0.17	0.22	0.27	0.007	0.009	0.011
C	0.08	0.12	0.18	0.003	0.005	0.007
D	1.50	1.60	1.70	0.059	0.062	0.066
E	1.10	1.20	1.30	0.043	0.047	0.051
e	0.5 BSC			0.02 BSC		
L	0.10	0.20	0.30	0.004	0.008	0.012
H <sub>E</sub>	1.50	1.60	1.70	0.059	0.062	0.066

### SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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