# Surface Mount RF Schottky Diodes in SOT-363 (SC-70, 6 Lead)

## Technical Data

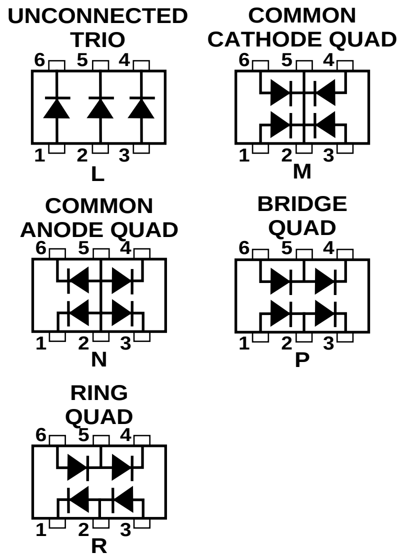
**HSMS-280L/M/N/P/R**
**HSMS-281L**
**HSMS-282L/M/N/P/R**

### Features

- **Surface Mount SOT-363 Package**
- **Low Turn-On Voltage (As Low as 0.34 V at 1 mA)**
- **Low FIT (Failure in Time) Rate***
- **Six-sigma Quality Level**
- **Single and Dual Versions**
- **Tape and Reel Options Available**

* For more information see the Surface Mount Schottky Reliability Data Sheet.

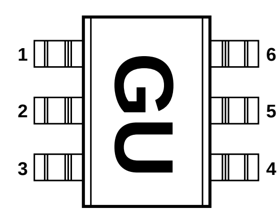
### Package Lead Code Identification (Top View)




### Description/Applications

These Schottky diodes are specifically designed for analog and digital applications requiring devices in SOT-363 surface mount packages. This series offers a wide range of specifications and package configurations to give the designer wide flexibility. Typical applications of these Schottky diodes are mixing, detecting, switching, sampling, clamping, and wave shaping.

### Pin Connections and Package Marking




**Notes:**
1. Package marking provides orientation and identification.
2. See “Electrical Specifications” for appropriate package marking.

### Absolute Maximum Ratings, $T_C = 25°C$

| Symbol | Parameter | Unit | Absolute Maximum[1] |
|---|---|---|---|
| $I_f$ | Forward Current (1µs Pulse) | Amp | 1 |
| $P_{IV}$ | Peak Inverse Voltage | V | Same as $V_{BR}$ |
| $T_J$ | Junction Temperature | °C | 150 |
| $T_{STG}$ | Storage Temperature | °C | -65 to 150 |
| $\theta_{jc}$ | Thermal Resistance[2] | °C/W | 140 |

**Notes:**
1. Operation in excess of any one of these conditions may result in permanent damage to the device.
2. $T_C$ = +25°C, where $T_C$ is defined to be the temperature at the package pins where contact is made to the circuit board.

## Electrical Specifications, $T_C$ = +25°C, Single Diode[1]

| Part Number HSMS- | Package Marking Code[2] | Lead Code | Configuration | Minimum Breakdown Voltage $V_{BR}$ (V) | Maximum Forward Voltage $V_F$ (mV) | Maximum Forward Voltage $V_F$ (V) @ $I_F$ (mA) | Maximum Reverse Leakage $I_R$ (nA) @ $V_R$ (V) | Maximum Capacitance $C_T$ (pF) | Typical Dynamic Resistance $R_D$ (Ω) |
|---|---|---|---|---|---|---|---|---|---|
| 280L<br>280M<br>280N<br>280P<br>280R | AL<br>H<br>N<br>AP<br>O | L<br>M<br>N<br>P<br>R | Unconnected Trio<br>Common Cathode Quad<br>Common Anode Quad<br>Bridge Quad<br>Ring Quad | 70 | 400 | 1.0 15 | 200 50 | 2.0 | 35 |
| 281L | BL | L | Unconnected Trio | 20 | 400 | 1.0 35 | 200 15 | 1.2 | 15 |
| 282L<br>282M<br>282N<br>282P<br>282R | CL<br>HH<br>NN<br>CP<br>OO | L<br>M<br>N<br>P<br>R | Unconnected Trio<br>Common Cathode Quad<br>Common Anode Quad<br>Bridge Quad<br>Ring Quad | 15 | 340 | 0.7 30 | 100 1 | 1.0 | 12 |
| Test Conditions | | | | $I_R$ = 10 µA | $I_F$ = 1 mA[3] | | | $V_F$ = 0 V<br>f = 1 MHz[4] | $I_F$ = 5 mA |

**Notes:**

1. Effective Carrier Lifetime (τ) for all these diodes is 100 ps maximum measured with Krakauer method at 5 mA, except HSMS-282X which is measured at 20 mA.
2. Package marking code is laser marked.
3. $\Delta V_F$ for diodes in trios and quads is 15.0 mV maximum at 1.0 mA.
4. $\Delta C_{TO}$ for diodes in trios and quads is 0.2 pF maximum.

## Typical Performance, $T_C$ = 25°C (unless otherwise noted), Single Diode

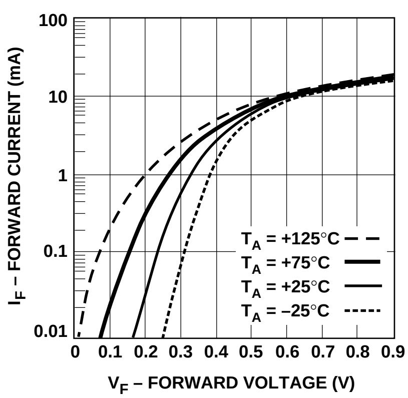



**Figure 1. Forward Current vs. Forward Voltage at Temperatures— HSMS-280A Series.**

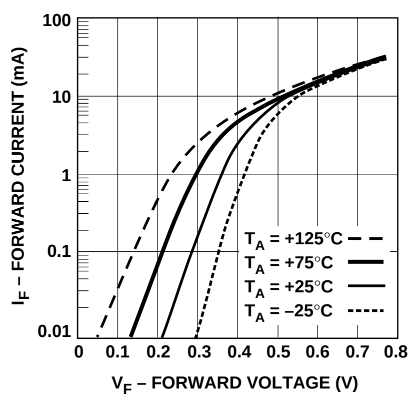



**Figure 2. Forward Current vs. Forward Voltage at Temperatures— HSMS-281L.**

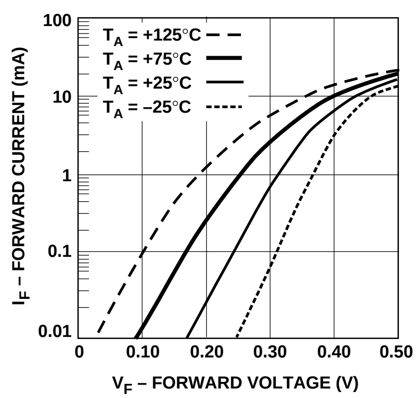



**Figure 3. Forward Current vs. Forward Voltage at Temperatures— HSMS-282A Series.**

## Typical Performance, $T_C$ = 25°C (unless otherwise noted), Single Diode, continued

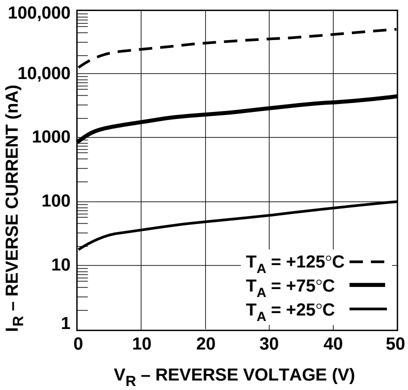



**Figure 4. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-280A Series.**

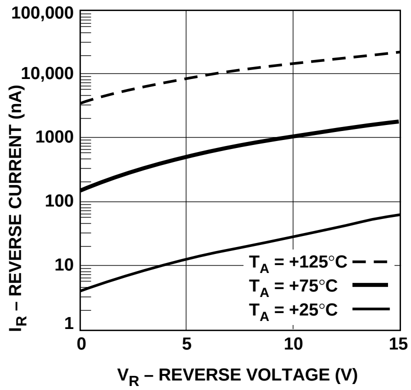



**Figure 5. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-281L.**

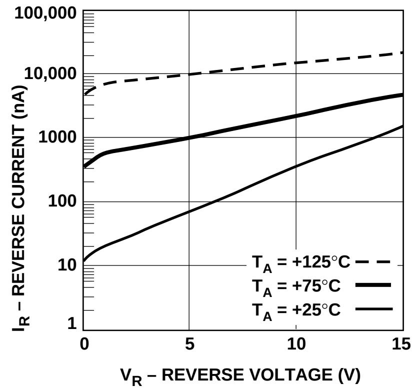



**Figure 6. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-282A Series.**

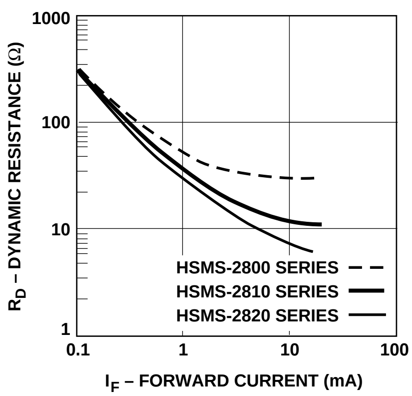



**Figure 7. Dynamic Resistance vs. Forward Current.**

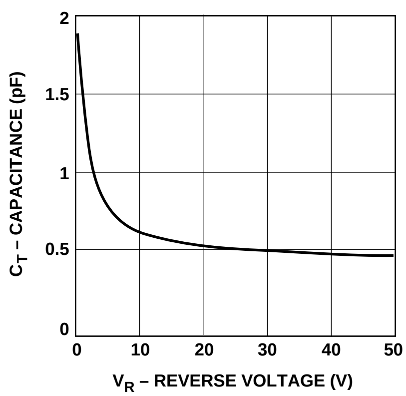



**Figure 8. Total Capacitance vs. Reverse Voltage—HSMS-280A Series.**

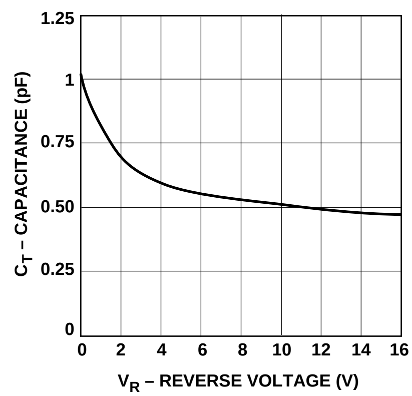



**Figure 9. Total Capacitance vs. Reverse Voltage—HSMS-281L.**

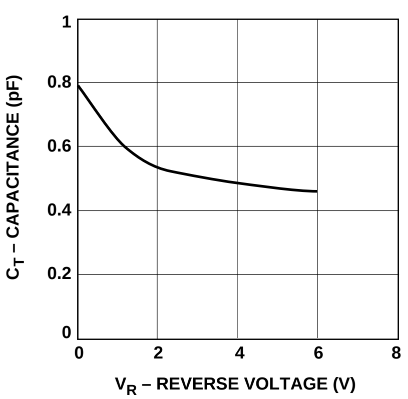



**Figure 10. Total Capacitance vs. Reverse Voltage—HSMS-282A Series.**

## Applications Information

**Introduction— Product Selection**

Hewlett-Packard's family of six-lead Schottky products provides unique solutions to many design problems.

The first step in choosing the right product is to select the diode type. All of the products in the HSMS-282A family use the same diode chip, and the same is true of the HSMS-281A and HSMS-280A families. Each family has a different set of characteristics which can be compared most easily by consulting the SPICE parameters in Table 1.

A review of these data shows that the HSMS-280A family has the highest breakdown voltage, but at the expense of a high value of series resistance ($R_S$). In applications which do not require high voltage the HSMS-282A family, with a lower value of series resistance, will offer higher current carrying capacity and better performance. The HSMS-281A family is a hybrid Schottky (as is the HSMS-280A), offering lower 1/f or flicker noise than the HSMS-282A family.

In general, the HSMS-282A family should be the designer's first choice, with the -280A family reserved for high voltage applications and the HSMS-281A family for low flicker noise applications.

**Six Lead Applications**

The HSMS-28xL is an unconnected trio of Schottky diodes. It can be used as a fast SP3T switch, as shown in Figure 11.

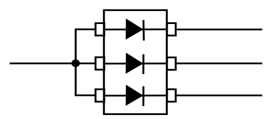


**Figure 11. SP3T Switch.**

The unconnected trio can also be used to clamp three data lines, as shown in Figure 12. Note that either polarity of clamping can be provided.

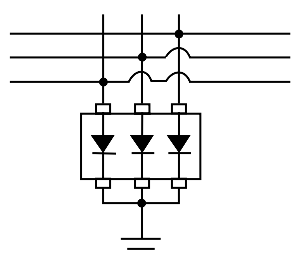


**Figure 12. Clamping Three Lines.**

The HSMS-28xM six lead product is designed to clamp four data lines to ground, protecting against positive noise spikes, as shown in Figure 13.

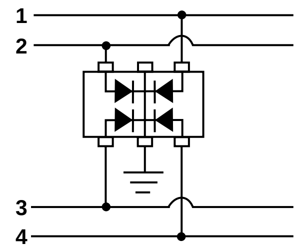



**Figure 13. Clamping Four Lines.**

Similarly, the HSMS-28xN common anode quad can be used to clamp four data lines against negative noise spikes, as shown in Figure 14.

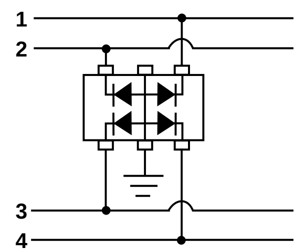



**Figure 14. Clamping Four Lines.**

The HSMS-28xP is open bridge quad is designed for sampling circuits, as shown in Figure 15. Note that the bridge is closed at opposite ends by external connections (a trace on the circuit board).

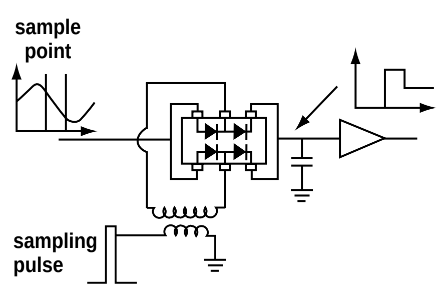



**Figure 15. Sampling Circuit.**

**Table 1. SPICE Parameters.**

| Parameter | Units | HSMS-280A | HSMS-281A | HSMS-282A |
|---|---|---|---|---|
| $B_V$ | V | 75 | 25 | 15 |
| $C_{J0}$ | pF | 1.6 | 1.1 | 0.7 |
| $E_G$ | eV | .69 | .69 | .69 |
| $I_{BV}$ | A | 10E-5 | 10E-5 | 10E-4 |
| $I_S$ | A | 3 x 10E-8 | 4.8 x 10E-9 | 2.2 x10E-8 |
| N | | 1.08 | 1.08 | 1.08 |
| $R_S$ | Ω | 30 | 10 | 6.0 |
| $P_B$ ($V_J$) | V | 0.65 | 0.65 | 0.65 |
| $P_T$ (XTI) | | 2 | 2 | 2 |
| M | | 0.5 | 0.5 | 0.5 |

The differential detector is often used to provide temperature compensation for a Schottky detector, as shown in Figure 16.

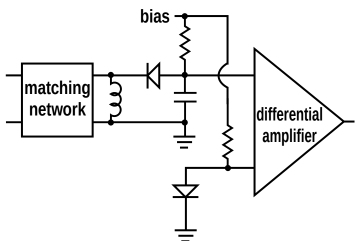



**Figure 16. Voltage Doubler.**

These circuits depend upon the use of two diodes having matched $V_f$ characteristics over all operating temperatures. This is best achieved by using two diodes in a single package, such as the HSMS-2825 in the SOT-143 package. However, such circuits generally use single diode detectors, either series or shunt mounted diode. The voltage doubler (HP Application Note 956-4) offers the advantage of twice the output voltage for a given input power. The two concepts can be combined into the differential voltage doubler, as shown in Figure 17.

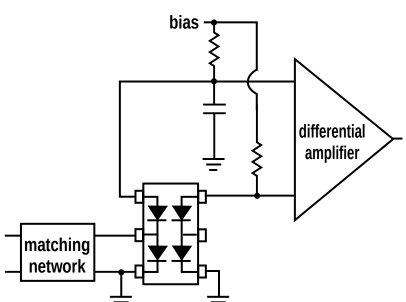



**Figure 17. Differential Voltage Doubler.**

Here, all four diodes are matched in their $V_f$ characteristics, because they came from adjacent sites on the wafer.

The HSMS-28xR is an open ring quad, useful in double balanced mixers as shown in Figure 18. As was the case with the bridge product, the quad is closed using external connections.

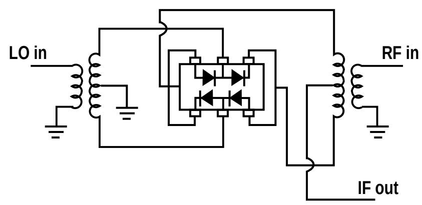



**Figure 18. Double Balanced Mixer.**

The advantage of an open ring quad can be seen in Figure 19, where two HSMS-28xR products are used to make an eight diode double balanced mixer having very low distortion.

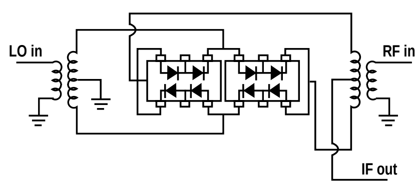



**Figure 19. Low Distortion Mixer.**

Other configurations of six lead Schottky products can be used to solve circuit design problems while saving space and cost.

**Thermal Considerations**

The obvious advantage of the SOT-363 over the SOT-143 is combination of smaller size and two extra leads. However, the copper leadframe in the SOT-363 has a thermal conductivity four times higher than the Alloy 42 leadframe of the SOT-143, which enables it to dissipate more power.

The maximum junction temperature for these three families of Schottky diodes is 150°C under all operating conditions. The following equation, equation (1), applies to the thermal analysis of diodes:

$$T_j = (V_f I_f + P_{RF})\,\theta_{jc} + T_a$$

where

$T_j$ = junction temperature
$T_a$ = diode case temperature
$\theta_{jc}$ = thermal resistance
$V_f I_f$ = DC power dissipated
$P_{RF}$ = RF power dissipated

**Equation (1).**

Note that $\theta_{jc}$, the thermal resistance from diode junction to the foot of the leads, is the sum of two component resistances,

$$\theta_{jc} = \theta_{pkg} + \theta_{chip}$$

**Equation (2).**

Package thermal resistance for the SOT-363 package is approximately 100°C/W, and the chip thermal resistance for these three families of diodes is approximately 40°C/W. The designer will have to add in the thermal resistance from diode case to ambient—a poor choice of circuit board material or heat sink design can make this number very high.

Equation (1) would be straightforward to solve but for the fact that diode forward voltage is a function of temperature as well as forward current. The equation, equation (3), for $V_f$ is:

$$I_f = I_S \left[ e^{\frac{11600\,(V_f - I_f R_s)}{nT}} - 1 \right]$$

where

n = ideality factor
T = temperature in °K
$R_s$ = diode series resistance

**Equation (3).**

and $I_S$ (diode saturation current) is given by

$$I_s = I_0 \left(\frac{T}{298}\right)^{\frac{2}{n}} e^{-4060\left(\frac{1}{T} - \frac{1}{298}\right)}$$

**Equation (4).**

Equations (1) and (3) are solved simultaneously to obtain the value of junction temperature for given values of diode case temperature, DC power dissipation and RF power dissipation.

## Assembly Instructions

### SOT-363 PCB Footprint

A recommended PCB pad layout for the miniature SOT-363 (SC-70, 6 lead) package is shown in Figure 20 (dimensions are in inches). This layout provides ample allowance for package placement by automated assembly equipment without adding parasitics that could impair the performance.

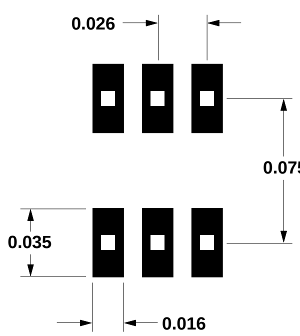



**Figure 20. PCB Pad Layout (dimensions in inches).**

### SMT Assembly

Reliable assembly of surface mount components is a complex process that involves many material, process, and equipment factors, including: method of heating (e.g., IR or vapor phase reflow, wave soldering, etc.) circuit board material, conductor thickness and pattern, type of solder alloy, and the thermal conductivity and thermal mass of components. Components with a low mass, such as the SOT-363 package, will reach solder reflow temperatures faster than those with a greater mass.

HP's SOT-363 diodes have been qualified to the time-temperature profile shown in Figure 21. This profile is representative of an IR reflow type of surface mount assembly process.

After ramping up from room temperature, the circuit board with components attached to it (held in place with solder paste) passes through one or more preheat zones. The preheat zones increase the temperature of the board and components to prevent thermal shock and begin evaporating solvents from the solder paste. The reflow zone briefly elevates the temperature sufficiently to produce a reflow of the solder.

The rates of change of temperature for the ramp-up and cool-down zones are chosen to be low enough to not cause deformation of the board or damage to components due to thermal shock. The maximum temperature in the reflow zone ($T_{MAX}$) should not exceed 235 °C.

These parameters are typical for a surface mount assembly process for HP SOT-363 diodes. As a general guideline, the circuit board and components should be exposed only to the minimum temperatures and times necessary to achieve a uniform reflow of solder.

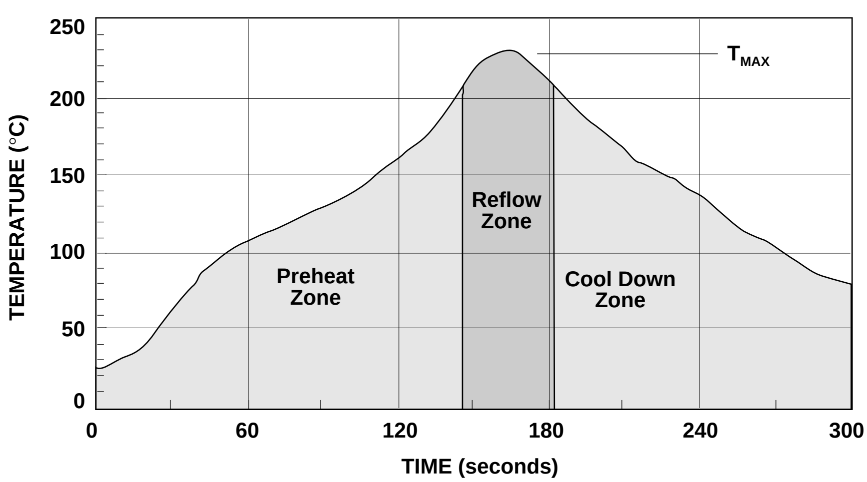
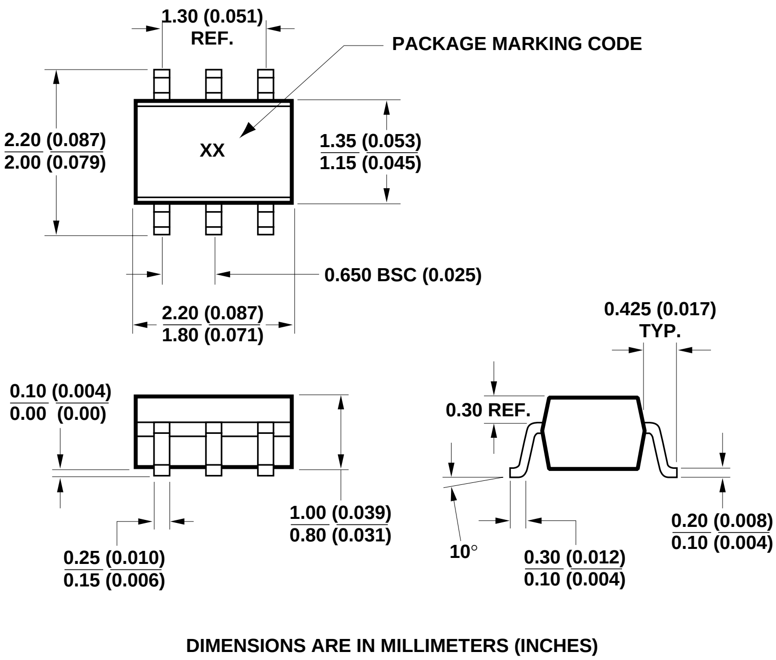



**Figure 21. Surface Mount Assembly Profile.**

## Package Dimensions

### Outline SOT-363 (SC-70 6 Lead)

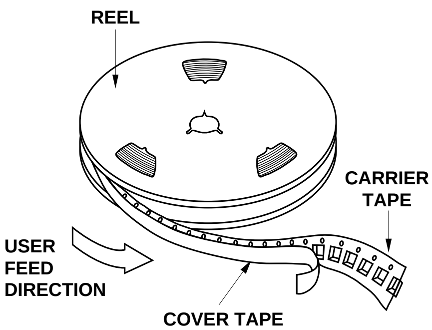


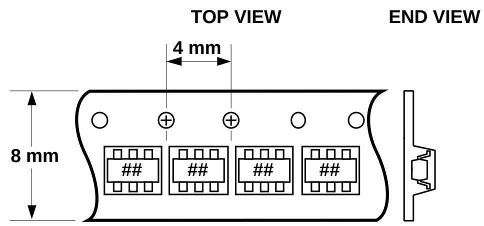

## Part Number Ordering Information

| Part Number | No. of Devices | Container |
|---|---|---|
| HSMS-28XA-TR1* | 3000 | 7" Reel |
| HSMS-28XA-BLK* | 100 | antistatic bag |
| HSMS-281L-TR1 | 3000 | 7" Reel |
| HSMS-281L-BLK | 100 | antistatic bag |

* where X = 0 or 2; A = L, M, N, P or R

# Device Orientation

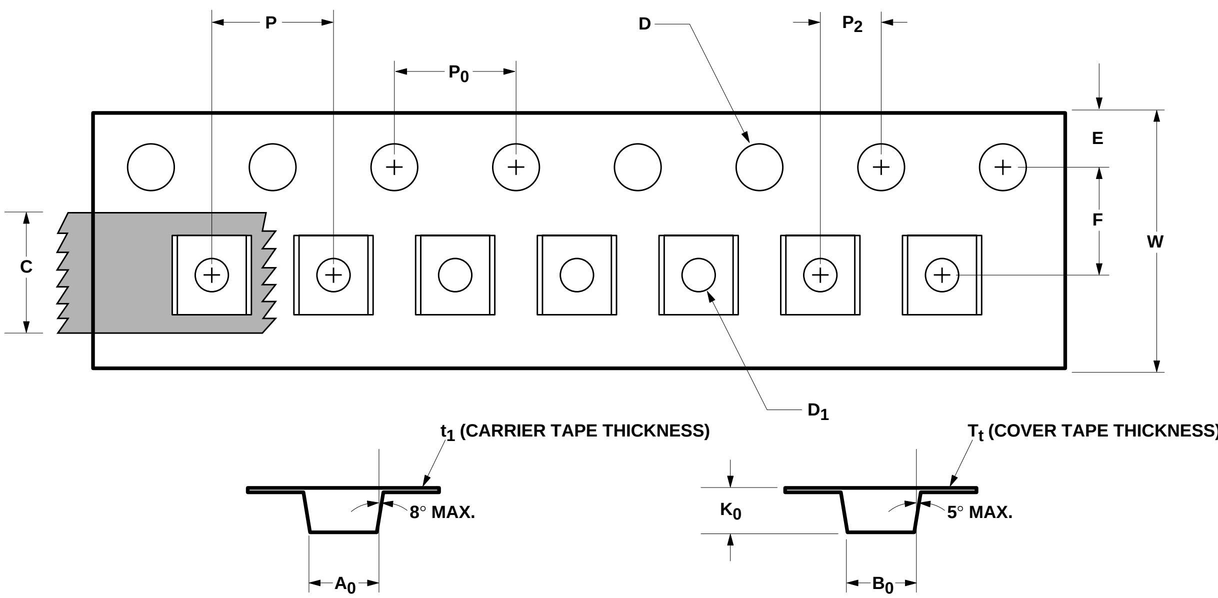



**Note: "##" represents Package Marking Code. Package marking is right side up with carrier tape perforations at top. Conforms to Electronic Industries RS-481, "Taping of Surface Mounted Components for Automated Placement." Standard Quantity is 3,000 Devices per Reel.**

# Tape Dimensions and Product Orientation

## For Outline SOT-363 (SC-70, 6 Lead)




| DESCRIPTION | | SYMBOL | SIZE (mm) | SIZE (INCHES) |
|---|---|---|---|---|
| CAVITY | LENGTH | $A_0$ | 2.24 ± 0.10 | 0.088 ± 0.004 |
| | WIDTH | $B_0$ | 2.34 ± 0.10 | 0.092 ± 0.004 |
| | DEPTH | $K_0$ | 1.22 ± 0.10 | 0.048 ± 0.004 |
| | PITCH | P | 4.00 ± 0.10 | 0.157 ± 0.004 |
| | BOTTOM HOLE DIAMETER | $D_1$ | 1.00 + 0.25 | 0.039 + 0.010 |
| PERFORATION | DIAMETER | D | 1.55 ± 0.05 | 0.061 ± 0.002 |
| | PITCH | $P_0$ | 4.00 ± 0.10 | 0.157 ± 0.004 |
| | POSITION | E | 1.75 ± 0.10 | 0.069 ± 0.004 |
| CARRIER TAPE | WIDTH | W | 8.00 ± 0.30 | 0.315 ± 0.012 |
| | THICKNESS | $t_1$ | 0.255 ± 0.013 | 0.010 ± 0.0005 |
| COVER TAPE | WIDTH | C | 5.4 ± 0.10 | 0.205 ± 0.004 |
| | TAPE THICKNESS | $T_t$ | 0.062 ± 0.001 | 0.0025 ± 0.00004 |
| DISTANCE | CAVITY TO PERFORATION (WIDTH DIRECTION) | F | 3.50 ± 0.05 | 0.138 ± 0.002 |
| | CAVITY TO PERFORATION (LENGTH DIRECTION) | $P_2$ | 2.00 ± 0.05 | 0.079 ± 0.002 |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**Japan:** (81 3) 3335-8152

**Europe:** Call your local HP sales office.


Data subject to change.



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