HEWLETT® PACKARD

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

Technical Data

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

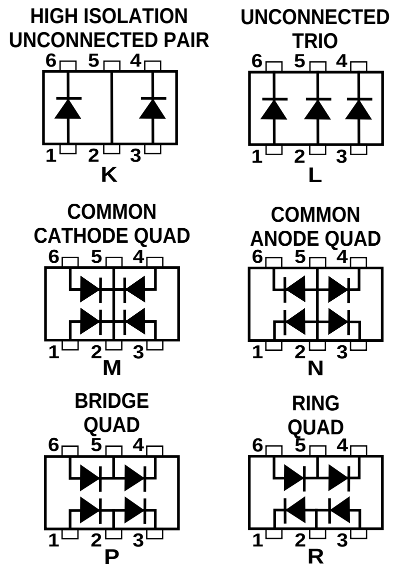
Features

- **Unique configurations in surface mount SOT-363 package**
  - increase flexibility
  - save board space
  - reduce cost
- **HSMS-28*x*K grounded center leads provide up to 10 dB higher isolation**
- **Matched diodes for consistent performance**
- **Better thermal conductivity for higher power dissipation**

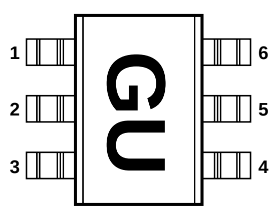
Applications

- HSMS-282*a* — good general purpose diode, specifically for:
  - DC biased detection at < 2.5 GHz
  - moderate voltage clipping and clamping
  - mixing applications < 3 GHz
- HSMS-280*a* — in high voltage clipping and clamping applications
- HSMS-281*a* — low 1/f @ 1 GHz mixing

Package Lead Code Identification (Top View)



Pin Connections and Package Marking



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

Description

These Schottky diodes are specifically intended for analog and digital applications, including DC biased detecting; mixing; switching; sampling; clipping and clamping; and wave shaping. This series offers a wide range of specifications and package configurations for design versatility. The benefit of this added flexibility translates into more board space and reduced cost.

Available in various package configurations, these families of diodes provide low cost solutions to a wide variety of design problems. Hewlett-Packard’s manufacturing techniques assure that when multiple diodes are mounted into a single SOT-363 package, they are taken from adjacent sites on the wafer, assuring the highest possible degree of match.

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)
280K	AK	K	High Isolation Unconnected Pair	70	400	1.0 15	200 50	2.0	35
280L	AL	L	Unconnected Trio					2.0	35
280M	H	M	Common Cathode Quad						
280N	N	N	Common Anode Quad						
280P	AP	P	Bridge Quad						
280R	O	R	Ring Quad						
281K	BK	K	High Isolation Unconnected Pair	20	400	1.0 35	200 15	1.2	15
281L	BL	L	Unconnected Trio						
282K	CK	K	High Isolation Unconnected Pair	15	340	0.7 30	100 1	1.0	12
282L	CL	L	Unconnected Trio						
282M	HH	M	Common Cathode Quad						
282N	NN	N	Common Anode Quad						
282P	CP	P	Bridge Quad						
282R	OO	R	Ring Quad						
Test Conditions				I_R = 10 µA	I_F = 1 mA[3]			V_F = 0 V 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-282*a* which is measured at 20 mA.
2. Package marking code is laser marked.
3. ΔV_F for diodes in trios and quads is 15.0 mV maximum at 1.0 mA.
4. ΔC_{TO} for diodes in trios and quads is 0.2 pF maximum.

Absolute Maximum Ratings, T_C= 25ºC

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
θ_{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.

ESD WARNING:
Handling Precautions Should Be Taken To Avoid Static Discharge.

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

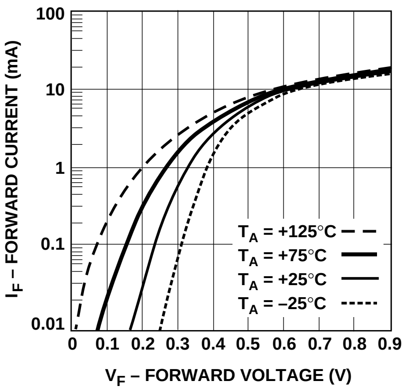


Figure 1. Forward Current vs. Forward Voltage at Temperatures—HSMS-280*a* Series.

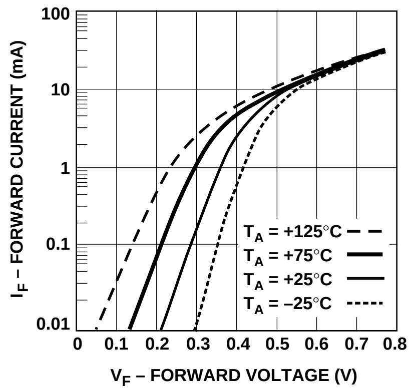


Figure 2. Forward Current vs. Forward Voltage at Temperatures—HSMS-281*a* Series.

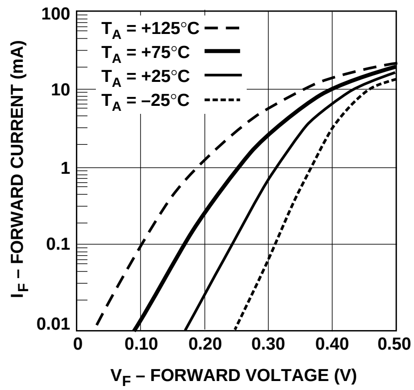


Figure 3. Forward Current vs. Forward Voltage at Temperatures—HSMS-282*a* Series.

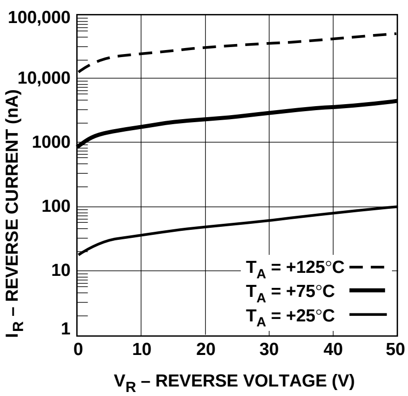


Figure 4. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-280*a* Series.

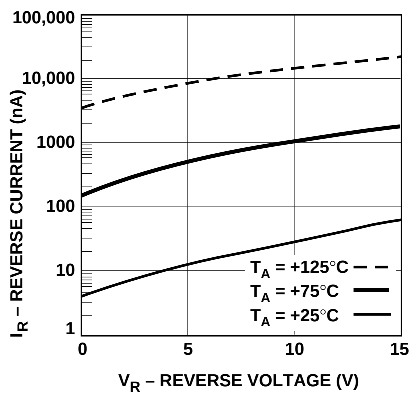


Figure 5. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-281*a* Series.

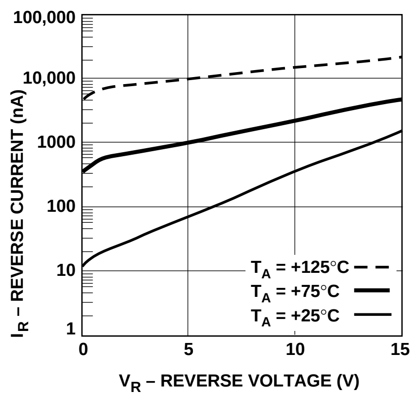


Figure 6. Reverse Current vs. Reverse Voltage at Temperatures—HSMS-282*a* Series.

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

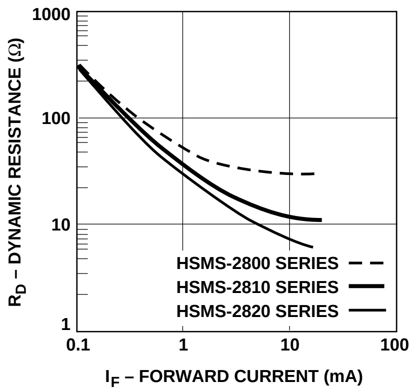


Figure 7. Dynamic Resistance vs. Forward Current.

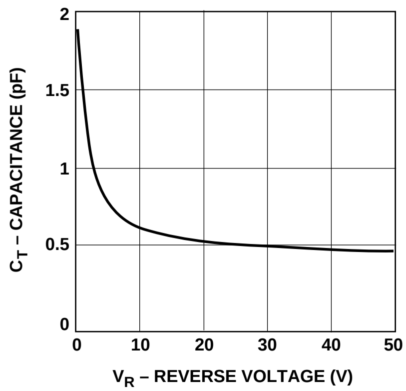


Figure 8. Total Capacitance vs. Reverse Voltage—HSMS-280*a* Series.

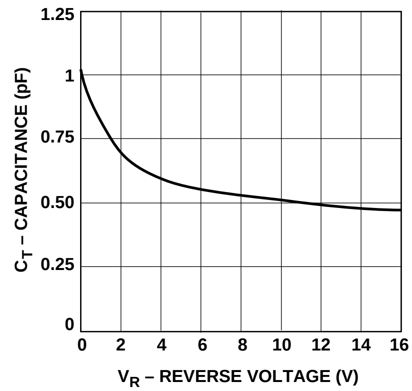


Figure 9. Total Capacitance vs. Reverse Voltage—HSMS-281*a* Series.

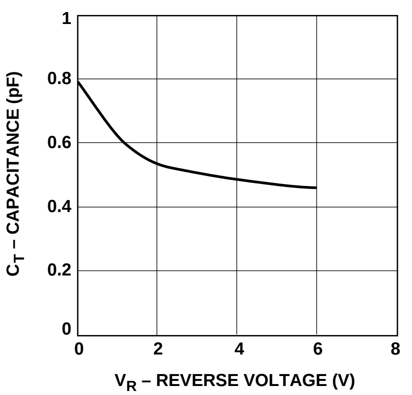


Figure 10. Total Capacitance vs. Reverse Voltage—HSMS-282*a* Series.

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-282*a* family use the same diode chip, and the same is true of the HSMS-281*a* and HSMS-280*a* 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-280*a* 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-282*a* family, with a lower value of series resistance, will offer higher current carrying capacity and better performance. The HSMS-281*a* family is a hybrid Schottky (as is the HSMS-280*a*), offering lower 1/f or flicker noise than the HSMS-282*a* family.

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

Six Lead Applications

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

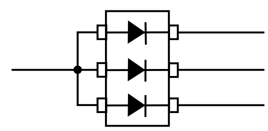


Figure 11. SP3T Switch.

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.

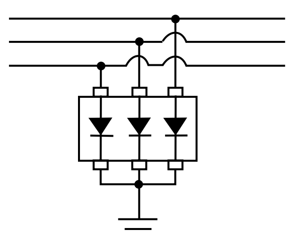


Figure 12. Clamping Three Lines.

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

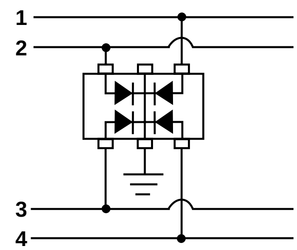


Figure 13. Clamping Four Lines.

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

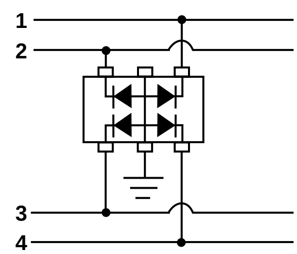


Figure 14. Clamping Four Lines.

The HSMS-28*x*P 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).

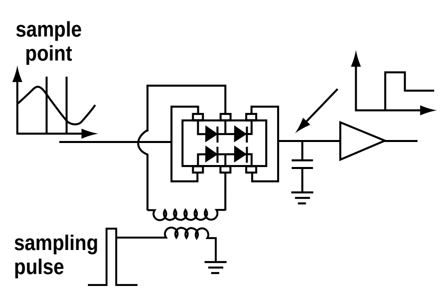


Figure 15. Sampling Circuit.

Table 1. Typical SPICE Parameters.

Parameter	Units	HSMS-280*a*	HSMS-281*a*	HSMS-282*a*
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 E-8	4.8 E-9	2.2 E-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.

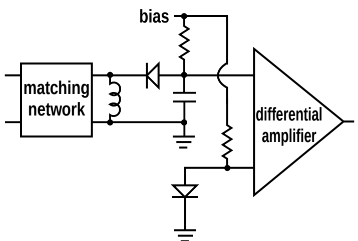


Figure 16. Differential Detector.

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 SOT-143 HSMS-2825 as shown in Figure 17.

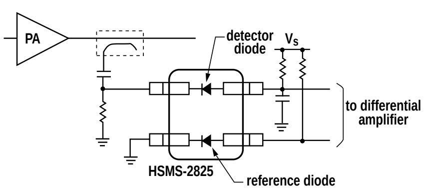


Figure 17. Conventional Differential Detector.

In high power differential detectors, RF coupling from the detector diode to the reference diode produces a rectified voltage in the latter, resulting in errors.

Isolation between the two diodes can be obtained by using the HSMS-282K diode with leads 2 and 5 grounded. The difference between this product and the conventional HSMS-2825 can be seen in Figure 18.

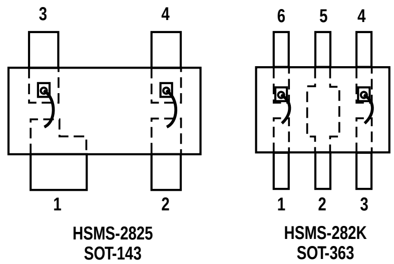


Figure 18. Comparing Two Diode Pairs.

The HSMS-282K, with leads 2 and 5 grounded, offers isolation from RF coupling between the diodes. This product is used in a differential detector as shown in Figure 19.

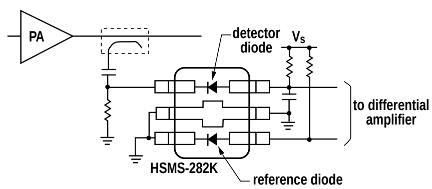


Figure 19. High Isolation Differential Detector.

In order to achieve the maximum isolation, the designer must take care to minimize the distance from leads 2 and 5 and their respective ground via holes. In addition, the ground strip will isolate the input RF and reference lines, as shown in Figure 20.

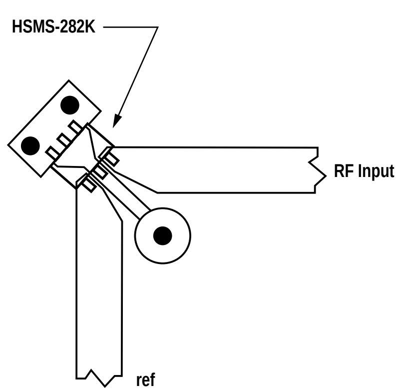


Figure 20. Diode Mounting, HSMS-282K.

Tests were run on the HSMS-282K and the conventional HSMS-2825 pair, with the results shown in Figure 21.

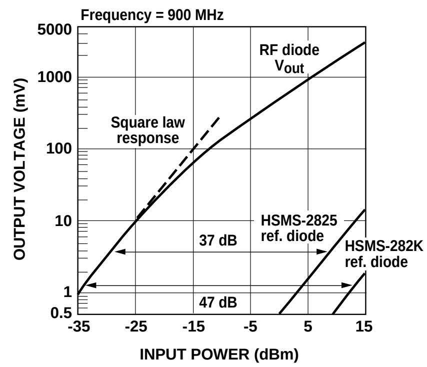


Figure 21. Comparing HSMS-282K with HSMS-2825.

The line marked “RF diode, V_{out}” is the transfer curve for the detector diode—both the HSMS-2825 and the HSMS-282K exhibited the same output voltage. The data were taken over the 50 dB dynamic range shown. To the right is the output voltage (transfer) curve for the reference diode of the HSMS-2825, showing 37 dB of isolation. To the right of that is the output voltage due to RF leakage for the reference diode of the HSMS-282K, demonstrating 10 dB higher isolation than the conventional part.

Such differential detector circuits generally use single diode detectors, either series or shunt mounted diodes. 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 22.

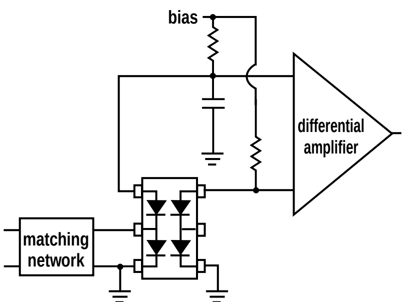


Figure 22. Differential Voltage Doubler, HSMS-282P.

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

The HSMS-28*x*R is an open ring quad, useful in double balanced mixers as shown in Figure 23. As was the case with the bridge product, the quad is closed using external connections.

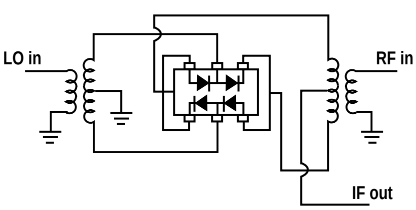


Figure 23. Double Balanced Mixer.

The advantage of an open ring quad can be seen in Figure 24, where two HSMS-28*x*R products are used to make an eight diode double balanced mixer having very low distortion.

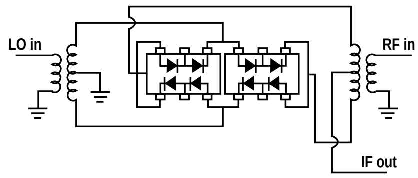


Figure 24. Low Distortion Mixer.

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 continuous 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:

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

Equation (1).

where

T_j = junction temperature

T_a = diode case temperature

θ_{jc} = thermal resistance

$V_f I_f$ = DC power dissipated

P_{RF} = RF power dissipated

Note that θ_{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:

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

Equation (3).

where

n = ideality factor

T = temperature in °K

R_s = diode series resistance

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 25 (dimensions are in inches). This layout provides ample allowance for package placement by automated assembly equipment without adding parasitics that could impair the performance.

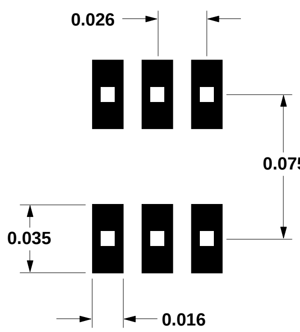


Figure 25. PCB Pad Layout (dimensions in inches).

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 26. 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.

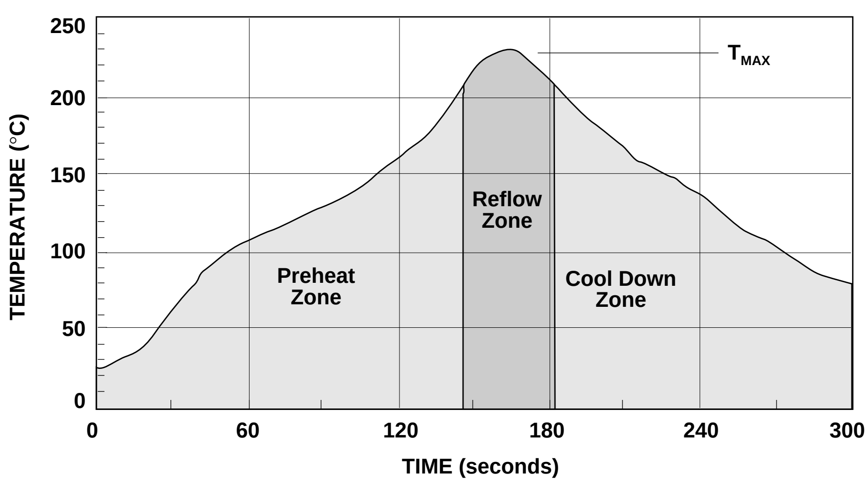
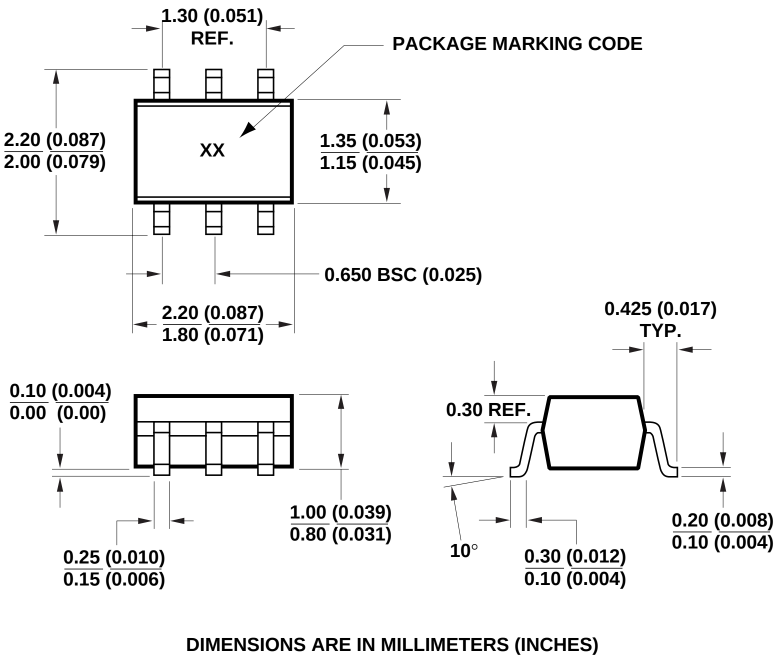


Figure 26. Surface Mount Assembly Profile.

Package Dimensions

Outline SOT-363 (SC-70 6 Lead)



Part Number Ordering Information

Part Number	No. of Devices	Container
HSMS-28*xa*-TR2*	10000	13" Reel
HSMS-28*xa*-TR1*	3000	7" Reel
HSMS-28*xa*-BLK*	100	antistatic bag

* where *x* = 0, 1 or 2

a = K, L, M, N, P or R for HSMS-280*a*, HSMS-282*a*

K or L for HSMS-281*a*

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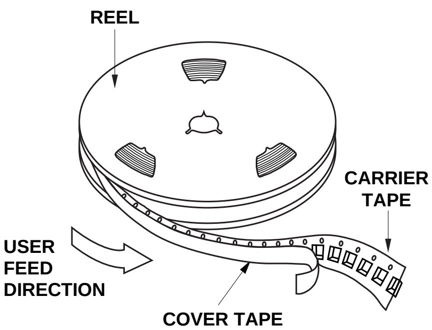
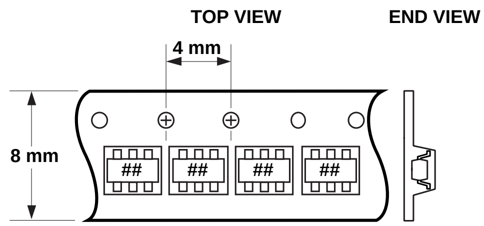
Device Orientation

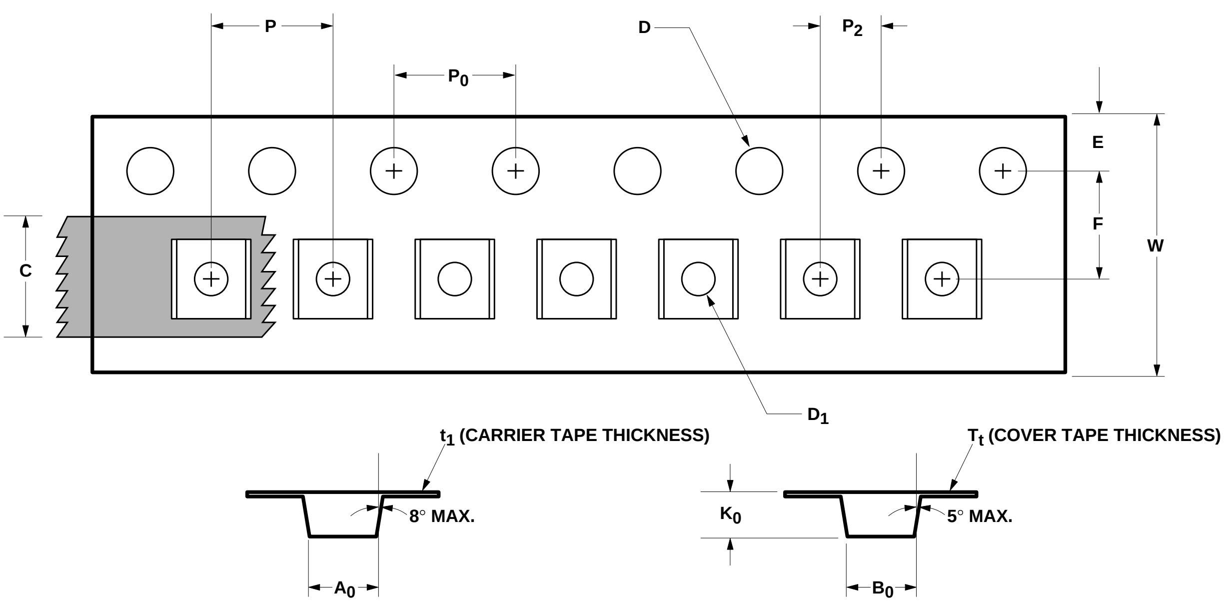




Note: "##" represents Package Marking Code. Package marking is right side up with carrier tape perforations at top. Conforms to Electronic Industries RS-481, "Taping of Surface Mounted Components for Automated Placement." Standard Quantity is 3,000 Devices per Reel.

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

www.hp.com/go/rf

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Japan: (81 3) 3335-8152

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Data subject to change.

Obsoletes 5966-2049E

5968-2356E (12/98)