

# ***12-mm Tape-and-Reel Component-Delivery System***

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## Contents

	<i>Title</i>	<i>Page</i>
<b>Abstract</b> .....		<b>1</b>
<b>Background</b> .....		<b>1</b>
<b>Summary of Component and Industry-Standard Information</b> .....		<b>2</b>
<b>Industry Trends Toward Standardization</b> .....		<b>3</b>
<b>Device Feeder Technology</b> .....		<b>3</b>
<b>Automated Board-Assembly Technology</b> .....		<b>4</b>
<b>Survey of Customer Experience</b> .....		<b>6</b>
<b>Conclusion</b> .....		<b>6</b>
<b>Acknowledgments</b> .....		<b>6</b>
<b>References</b> .....		<b>6</b>
<b>Glossary</b> .....		<b>7</b>

## List of Illustrations

<i>Figure</i>	<i>Title</i>	<i>Page</i>
1	Tape-and-Reel Packing .....	1
2	Carrier-Tape Dimensions .....	2
3	Typical Tape-and-Reel Configuration .....	3
4	Typical Tape-and-Reel Feeder Configuration .....	4
5	Carrier-Tape Flexing .....	4
6	16-mm and 12-mm Carrier-Tape Widths .....	5

## List of Tables

<i>Table</i>	<i>Title</i>	<i>Page</i>
1	Market Distribution of 8-/14-/16-Pin PW Package .....	2
2	PW-Package Outline Dimensions and Corresponding Industry Guidelines .....	2
3	Industry Shipping Configurations .....	3

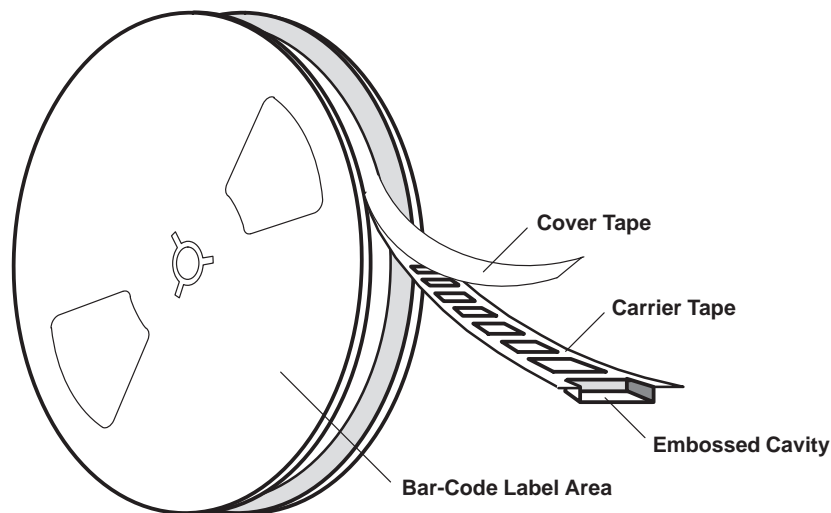


## Abstract

The design advances of component pick-and-place automated equipment for board assembly increasingly are pushing the margins of the tape-and-reel packing configurations. The continuing drive for faster assembly reduces the index time and tends to amplify the forces acting on the tape-and-reel component-delivery system. The magnified forces, when combined with a high carrier-tape width-to-component mass ratio, may cause component placement problems, reduced yield, and subsequent degradation of board-assembly manufacturing efficiency. Texas Instruments (TI™) has initiated an improved component-packing method for the 8-/14-/16-pin TSSOP PW packages to ensure that customer processes remain efficient. This application report describes the improved tape-and-reel configuration on a 12-mm carrier-tape width that performs better in end-user assembly operations and aligns more closely with modern industry standards.

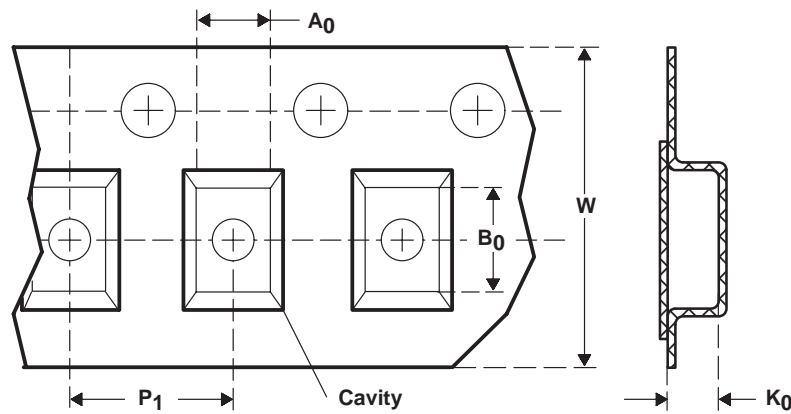
## Background

The tape-and-reel component-delivery system consists of a carrier tape and a cover tape sealed on the carrier tape (see Figure 1). This composite tape is wound onto a 330-mm-diameter reel. The reeled components are loaded on end-user assembly machines, and the components are indexed and removed from the carrier tape cavity as needed for the board-assembly operations. Multiple reels are loaded on the same machine to allow fully automated component placement during the board-assembly process.



**Figure 1. Tape-and-Reel Packing**

Tape-and-reel component-delivery systems are designed based on the component package dimensions: length, width, and height. The package dimensions determine the corresponding  $A_0$ ,  $B_0$ , and  $K_0$  dimensions of the carrier-tape cavity (see Figure 2). These basic dimensions influence the width ( $W$ ) and pitch ( $P_1$ ) of the carrier tape.



**Figure 2. Carrier-Tape Dimensions**

When the TSSOP PW 8-/14-/16-/20-/24-pin packages were initially released in TI-Japan, the tape-and-reel component-delivery system used the same width (16 mm) carrier tape for the entire device family. Initially, most of these products were used in the Japanese market. Over the years, as sales volume increased, the use of these devices outside Japan became more prevalent. Recent data indicates the market outside Japan is at parity with the internal Japanese market as shown in Table 1.

**Table 1. Market Distribution of 8-/14-/16-Pin PW Package (November 1997 Data)**

PINS	JAPAN (%)	ASIA/US/EUROPE (%)
8	10	90
14/16	57	43
Total	51	49

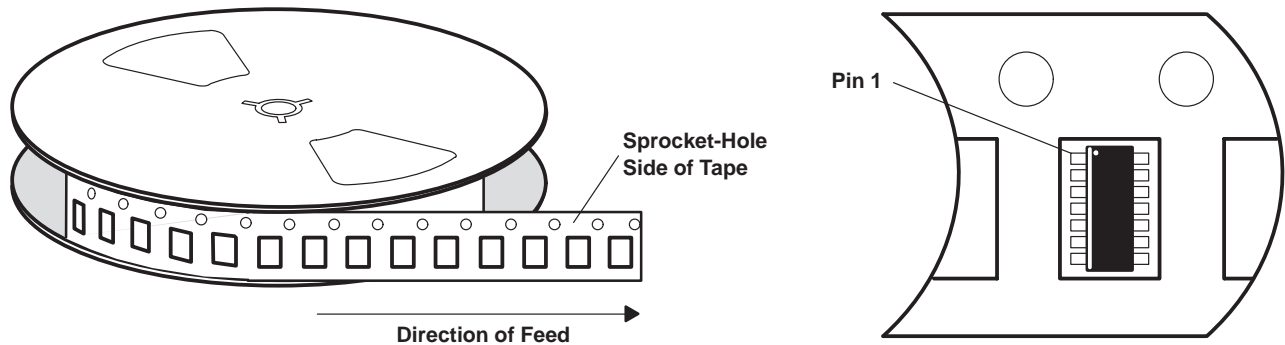
### Summary of Component and Industry-Standard Information

This application report pertains to the TI devices in the TSSOP 8-/14-/16-pin packages designated as PW. The package outline dimensions and tape-and-reel industry guidelines are in Table 2.

**Table 2. PW-Package Outline Dimensions and Corresponding Industry Guidelines**

PACKAGE	PINS	COMPONENT		CURRENT		JIS c0806	
		LENGTH (mm)	WIDTH (mm)	TAPE WIDTH (mm)	TAPE PITCH (mm)	TAPE WIDTH (mm)	TAPE PITCH (mm)
PW	8	3.00	6.40	16	8	8	4
	14	5.00	6.40	16	8	12	8
	16	5.00	6.40	16	8	12	8

The customer receives a 330-mm diameter reel containing 2000 components. The tape-and-reel configuration is shown in Figure 3.



**Figure 3. Typical Tape-and-Reel Configuration**

### Industry Trends Toward Standardization

Table 3 shows the tape widths and pocket pitch used by several semiconductor manufacturers for shipping their devices.

**Table 3. Industry Shipping Configurations**

COMPANY	TAPE WIDTH (mm)	POCKET PITCH (mm)
FSC	12	8
Hitachi	16	8
Motorola-Japan	12/16	8
Motorola-U.S.	12	8
Pericom	12	8
National-Japan	12/16	8
TI†	12	8
TI-Japan	16	8
Toshiba	16	8

† Beginning April 1, 1998, for all TI except Japan; TI-Japan began conversion on July 1, 1998.

### Device Feeder Technology

A tape feeder moves the cavity of the carrier tape into a fixed location for the component to be picked up by the vacuum head. Indexing the carrier tape, peeling the cover tape, and exposing the component for pick-up occur simultaneously. These actions cause rapid acceleration and deceleration of the component inside the carrier-tape cavity. These actions can cause low-mass components to tilt or be ejected from the cavity, making it impossible for the vacuum head to pick up the component. Figure 4 illustrates a typical feeder configuration.

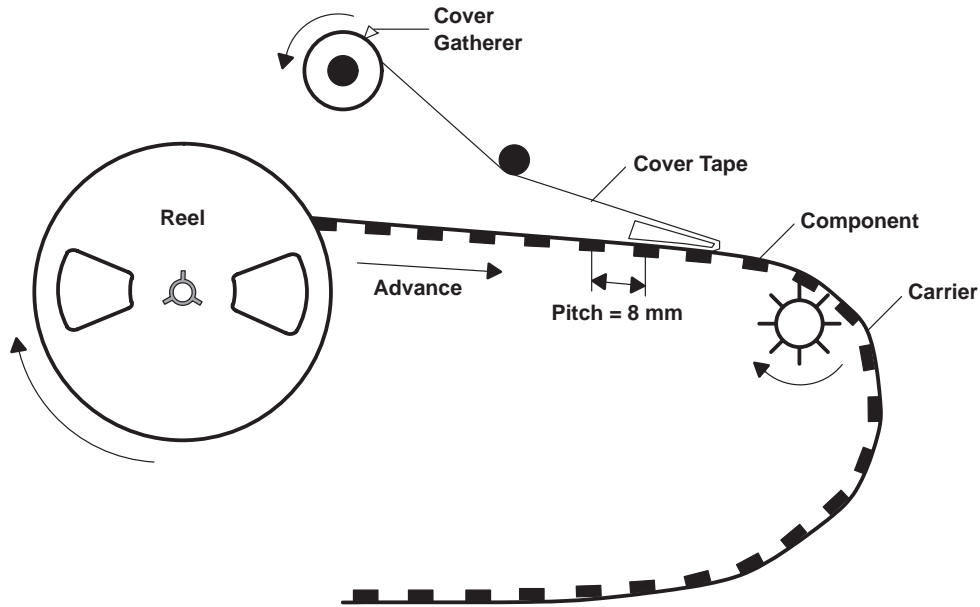


Figure 4. Typical Tape-and-Reel Feeder Configuration

### Automated Board-Assembly Technology

Carrier-tape feeder designs vary among manufacturers. In most cases, end users rely on the tape-and-reel component-delivery system to compensate for the multiple feeder designs.

Key elements to smooth transfer of the components from the carrier-tape cavity to the designated place on the board are the index time, cover-tape removal tension, design of the blade used to lift and route the cover tape away from the carrier tape, and the function and design of the feeder cavity cover (if used).

Low-mass components are more prone to bounce and jostle in reaction to flexural motions generated by the high-speed, rapid indexing of the feeder, and pick-and-place actions of the vacuum head on the carrier tape. The formed cavity of the carrier tape provides strength to the middle portion of the tape. The outer portions of the tape remain flat, which provides the area for vertical flexing. The flexing is illustrated in Figure 5.

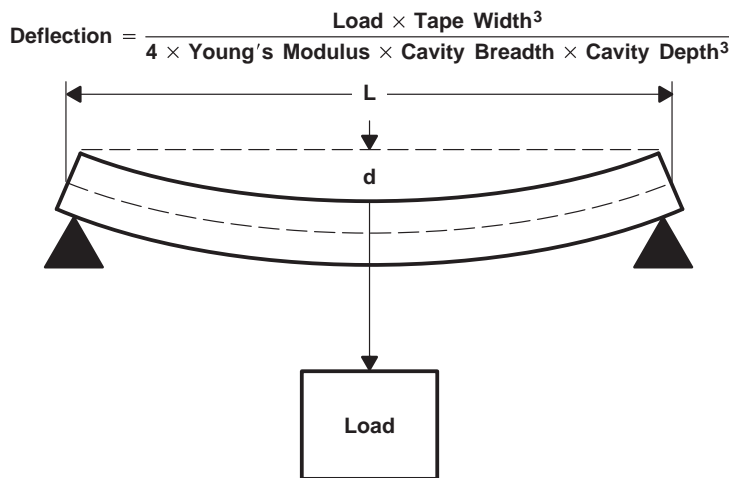
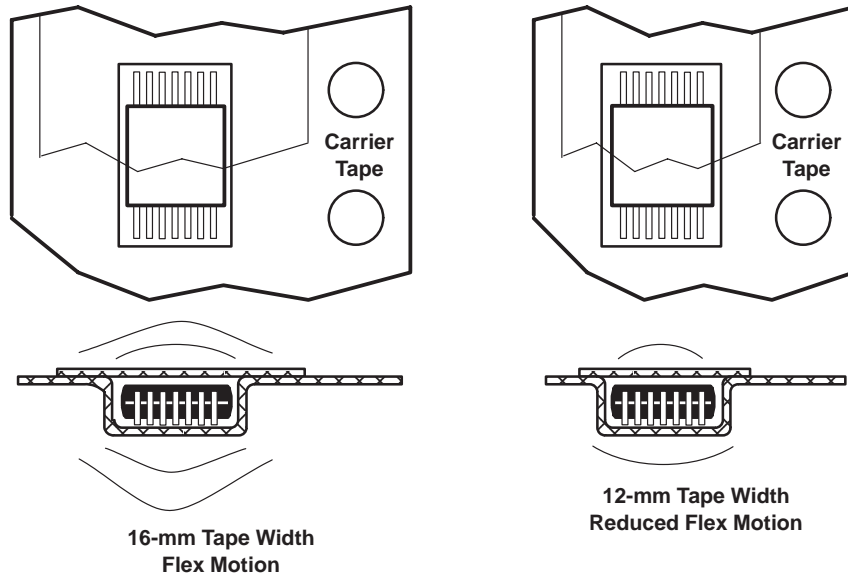


Figure 5. Carrier-Tape Flexing

The amplitude of the deflection is directly proportional to the cube of tape width. Reducing this value decreases the flexing potential. Figure 6 illustrates the improved performance that the reduced tape width provides.





**Figure 6. 16-mm and 12-mm Carrier-Tape Widths**

Assume that load, cavity breadth, cavity depth, and Young's modulus are identical for both tape widths. The carrier-tape deflection is directly proportional to the cube of the widths. Therefore, the reduction can be estimated to be 57.8%.

- For 16-mm tape, the calculations are:

Width	= 16 mm
Load (pick-up head)	= 0.01 N
Cavity breadth	= 3.8 mm
Cavity depth	= 1.6 mm
Young's modulus	= 0.5 N/mm <sup>2</sup>
Deflection	= $\frac{0.01 \times 16^3}{4 \times 0.5 \times 3.8 \times 1.6^3} = 1.312 \text{ mm}$

- For 12-mm tape, the calculations are:

Width	= 12 mm
Load (pick-up head)	= 0.01 N
Cavity breadth	= 3.8 mm
Cavity depth	= 1.6 mm
Young's modulus	= 0.5 N/mm <sup>2</sup>
Deflection	= $\frac{0.01 \times 12^3}{4 \times 0.5 \times 3.8 \times 1.6^3} = 0.555 \text{ mm}$

**NOTE:**

These values are assumptions, and are given for explanatory purposes only. Actual conditions vary, depending on material suppliers and assembly equipment manufacturers.

## Survey of Customer Experience

While limited data is available from customers receiving components in 12-mm tape, some customers receiving units in 16-mm tape widths reported that 35–40% of the components fell out of the tape. No issues related to this topic have been reported since converting to 12-mm tape.

A key customer recorded the process with a high-speed camera. Their analysis of the 16-mm tape configuration is summarized in the following paragraph:

*The tape is too wide and thus flexible. The feeder mechanism is allowing the part to be jostled in the pocket. As the tape is ratcheted and advanced (electrical solenoid), the device is jostled 'up' in the pocket and is being caught in the cover of the feeder mechanism so as to bind the part and bend the lead(s) during the normal advancing to the next pocket stop.*

Local feeder modifications could minimize this issue, but each time the device was set up for a new run, the above process was repeated.

## Conclusion

Using a narrower-width carrier tape reduces flexural forces applied to the component during the indexing action of the feeder, which leads to a more efficient board-assembly process for the end user.

Additionally, narrower-width carrier tape proportionally reduces the amount of raw materials consumed in the component-packing process. This reduction requires less space for inventory and reduces waste.

## Acknowledgments

The authors of this application report, Cles Troxtell and Bobby O'Donley, acknowledge the assistance of Mary Helmick and Edgar Zuniga.

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## Glossary

### C

- Carrier tape      Formed polystyrene semirigid tape used to contain individual components for sequential pick-and-place operations in automated board-assembly processes.
- Cover tape      Transparent PET material attached to the surface of the carrier tape to contain the individual component in the carrier-tape cavity during reeling, shipping, and unreeling of the tape-and-reel-packaged components.

### T

- Tape and reel      Method of packing components in a tape system and reeling specified lengths or quantities onto a reel for shipping, handling, and configuring for use in industry-standard automated board-assembly equipment.
- Tape feeder      Industry-standard feeder mechanism designed to accept the tape-and-reel-configured components and index the taped components for precise positioning to be picked up by the vacuum head used by the automated board-assembly equipment.