Part Size and Part Rotation in Carrier Tape

A Guide for Understanding the Relationship

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Understanding the rotational limits of part control related to part to pocket clearance

As parts get smaller and smaller, it becomes much more difficult to minimize the part rotation due to the higher percentage the tolerance makes up of both the part size and pocket size. Even a part with ±0.02mm tolerance and a pocket with ±0.03mm tolerance will have a minimum part to maximum pocket clearance of 0.10mm.

Part fit for rectangular devices is based on the corners hitting the side wall, and can be computed using the diagonal length of the part relative to the length and width of the pocket. See Figures 1-4

The device rotation is generally constrained by the walls of the longest edge of the pocket and device if the clearances are the same. The calculations are based on the following definitions

- $A$ is device length in x direction
- $B$ is device length in y direction
- $A_o$ is pocket size in x direction
- $B_o$ is pocket size in y direction
- $D$ is the length of the diagonal from corner to corner on the device
- $\theta_1$ is the standard angle of the device when sitting square to the pocket.
- $\theta_{2A}$ and $\theta_{2B}$ are the angles of the device constrained by the pocket, calculated using both $A_o$ and $B_o$ direction constraints
- $\theta$ is the maximum angle that the device moves from its standard position = $\theta_1 - \theta_2$

The calculations are as follows:

$D = \sqrt{A^2 + B^2}$

$\theta_1 = \tan^{-1}(B/A)$

$\theta_{2A} = \theta_1 - \left(\cos^{-1}\frac{A_o}{D}\right)$

$\theta_{2B} = \left(\sin^{-1}\frac{B_o}{D}\right) - \theta_1$
Maximum Rotation $\theta = \text{Min} (\theta_{2A}, \theta_{2B})$

The part diagonal length $D = \sqrt{A^2 + B^2}$

When centered in the tape, the standard angle of the diagonal is $\tan^{-1}(B/A) = \theta_1$ as shown in Figure 4.

![Figure 1](image)

When rotated so that the corners are constrained by the longest wall, the new angle $\theta_2$ can be computed because we know the diagonal distance $D$ and we now know the constrained distance $A_o$.

$\theta_2 = [\theta_1 - \cos^{-1}(A_o/D)]$ or $[\sin^{-1}(B_o/D) - \theta_1]$ depending on the constraining wall as shown in Figure 2 and 3.

![Figure 2](image)

Rotated Angle $A_o$ Contained

Rotated Angle $B_o$ Contained
θ is the minimum of \( \theta_2A \) and \( \theta_2B \) and represents the maximum rotation angle that the device can move. By using maximum pocket dimensions and minimum device dimensions, we can determine the maximum rotation of the device in the pocket as shown in Figure 4.
An example is shown below in Figure 5 and Table 1 using a minimum pocket size of $A_0 = 20$ min, $B_0 = 25$ min, and maximum device size of $A = 17^\circ$ max, and $B = 22^\circ$ max.

![Figure 5](image)

**Table 1**

<table>
<thead>
<tr>
<th>Inputs (mm)</th>
<th>Computations (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{\text{Max}}$</td>
<td>17</td>
</tr>
<tr>
<td>$B_{\text{Max}}$</td>
<td>22</td>
</tr>
<tr>
<td>$A_0_{\text{Min}}$</td>
<td>20</td>
</tr>
<tr>
<td>$B_0_{\text{Min}}$</td>
<td>25</td>
</tr>
<tr>
<td>$D$</td>
<td></td>
</tr>
<tr>
<td>$\theta_1$</td>
<td></td>
</tr>
<tr>
<td>$\theta_{2A}$</td>
<td></td>
</tr>
<tr>
<td>$\theta_{2B}$</td>
<td></td>
</tr>
<tr>
<td>$\theta$ (Min of $\theta_{2A}$ and $\theta_{2B}$)</td>
<td></td>
</tr>
</tbody>
</table>
