# Dynamic Analysis of Bare Printed Circuit Board under Impact

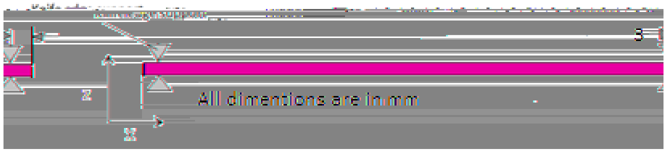


Figure 3 Square board with line-wedge support

We will also study the effect of the impulse duration. According to the Condition B in JESD22-B111, the input acceleration to the board is of half-sine shape, with 1500g peak and 0.5 ms duration, as shown in Figure 4. This impulse profile induces the board to vibrate in several cycles before the rest. We will propose a new impulse condition.

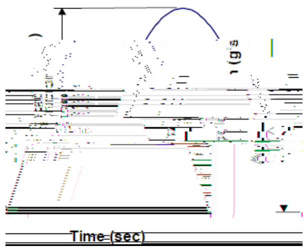


Figure 4 Impulse profile defined by JESD22-B111 drop test

**Experimental Validations of Finite Element Model**

The damping coefficient of the PCB used in the finite element analysis is calibrated through board strain history measurement. Figure 5 shows the overall comparison of entire strain history during impact, with a damping coefficient of 0.03. The damping coefficient is then used to predict the board dynamic behaviors under various conditions.

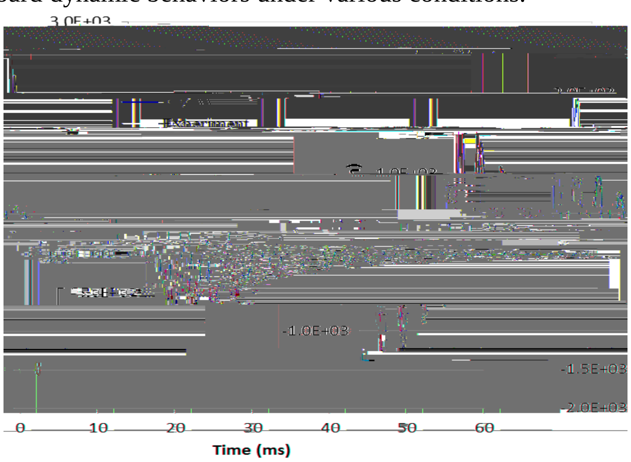


Figure 5 Comparison of bare board strain history

**Results of Fundamental Frequencies**

Table 1 gives the simulation results of the first four fundamental frequencies of the current JESD22-B111 bare board and the square-shape board with different dimensions. Three dimensions of the square board: 3”×3”, 4”×4”, an 5”×5”, respectively, are modeled. It can be seen,

1. The first fundamental frequency of the current JESD22-B111 bare board is around 231 Hz. Since the components attached to the board are relatively light and small (<15mm), the bare board frequency is very close the frequency with the components 212 Hz [9]. Therefore, the bard board frequency is a good representative value for the actual board with component attachment.
2. For the square-shape board, the first fundamental frequency ranges from 128 Hz to 393 Hz for screw-type support, and from 103 Hz to 287 Hz for wedge-type support, respectively The smaller the board is, the higher the frequency is. In addition, the wedge-type support gives lower frequency than the screw-type support. However, it will be shown later that the wedge-support board introduces larger board deformation (strain) under impact.
3. For the square-shape board, the second and third modes are symmetric with screw-type support. The bend mode shapes are shown in Figure 6.

Table 1 Fundamental frequency results

| Freq-uency (Hz) | JESD22 -B111 | Square shape |
|---|---|---|

downward, with the maximum bend strain at the center. However, in the two ends near screw supports, the board bends in the opposite direction, with the absolute strain value comparable to the one in the center. Please note this strain distribution is in the first peak mode during the first half of the period. In the second-half of the first period, the board center will bend upwards, while the region near screw support will bend downward. From these results, it can conclude that

1) Board strain near edge along Line 2 is comparable to the center strain, but in the different directions. This means that the components mounted near screws , e.g. group A defined JESD22-B111, may fail as quickly as those in the center (e.g. Group E and F) (for group numbers and labels, refer to the JESD22-B111 standard [1]).bco o2lir o2-389ts the b dper t

2) The strain near edge along Line 2 is significantly less than that in Line 1. This means that the components (e.g. Group C) may fail much slower.

3) The maximum strain at the center along Line 1 and Line 2 are very close. Therefore, Groups F and E will have similar failure rate.

4) The strain along L1 and L2 decreases as the distance from center increases. Thus, Group B or D would expect have less failure rate.

These findings are all in good agreement with previous analysis based on the actual board with component attachment [7-11, 16].

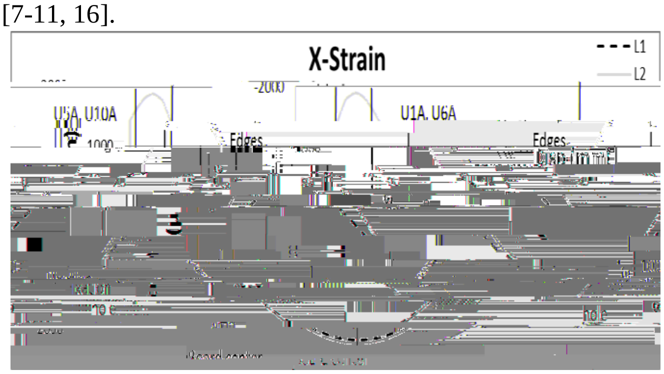


Figure 7 X-strain at Line 1 and Line 2 in the JESD22-B111 bare board

Figure 8 gives the y-strain distributions in Line 3 and Line 4, respectively. From this figure it clearly shows that the strain stays in a relatively flat value along the Line 3. But along Line 4, there are large strains at the two ends, but little strains at the center. These results again confirm the results mentioned above and correlate well with components results.

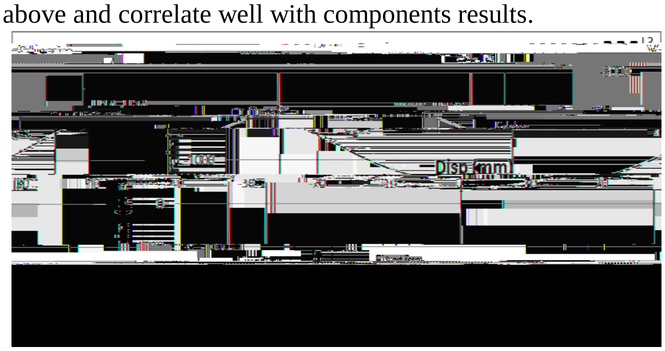

Figure 8 Y-strain Line 3 and Line 4 in the JESD22-B111 bare board

Figure 9 plots both maximum and minimum principal strain distributions in the diagonal direction along Line 5. It clearly shows the effect of screw support, where the absolute value of strain can be significantly higher than the center strain. When the board bends downward, solder joints will be in tensile state for the face-down component attachment [11]. This means that in the second half of the peak mode of the first period, the board will bend downward near screw region while the board center bends upward. Previous work showed that the corner components U1 (group A) will fail earlier than the center component if the component size is small [9]. The results from the bare board can give useful information without involving detailed FEA with components.all 4m5(o)-5(n)6(o)-7nl

while538-screwsuppkowidpoarx6(co)-rsfu52( )-62(W)-7eses52(3op)-5(o(al dpogen(er)--387(in)7(at )-3932the fac-5(ar)-5(d)4anents resul(t)-h([)-3(1)-5 almost same due to the zero shear strain along those lines. Excessive bend strain in the opposite direction to the center strain is observed for the square-shape board.

Based on the results from Figures 10 and 11, 12, Figure 13 plots the approximate region where the components might be placed (in yellow color), for the 3"x3" square-shape board. Outside this zone is possible that the effect of the reversed bending will occur. If multiple components are to be used, they cannot overlap each other, therefore, an inner circle can also be defined, as shown in Figure 13. From this analysis, the maximum component size must be less than 22mm for this board if multiple components are placed. The actual allowable component size will be even smaller to eliminate the interactions between adjacent components. If only one component is used and is placed in the center, the maximum size of the component can be very large.

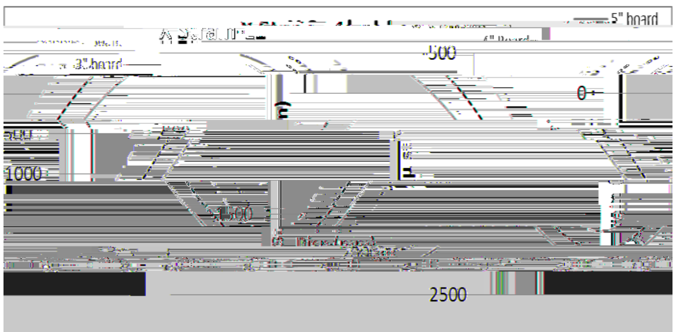

Figure 10 Line 1 X-strain (3x3, 4x4 and 5x5 boards)

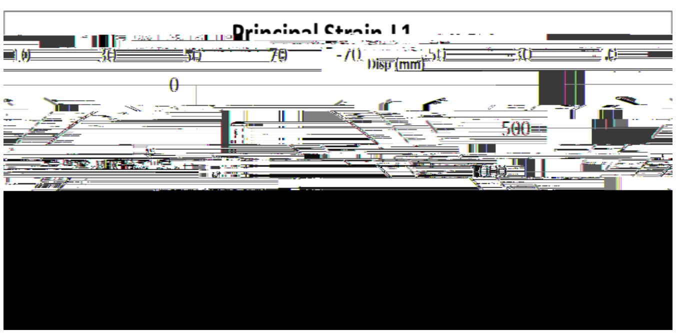

Figure 11 Line 1 Maximum and minimum principal strains (3x3, 4x4 and 5x5 boards)

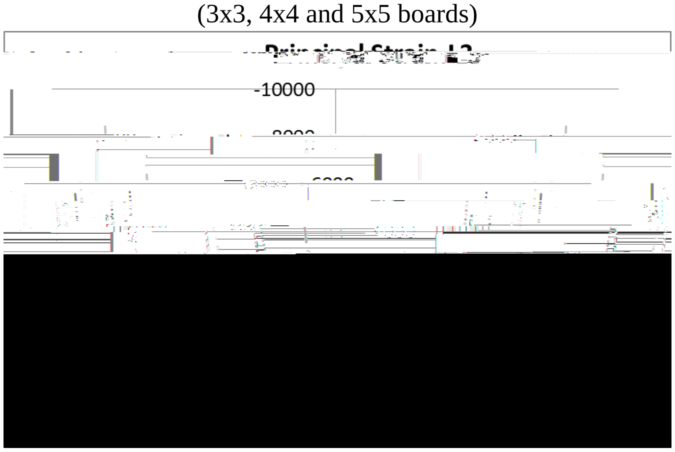

Figure 12: principal strains along L3

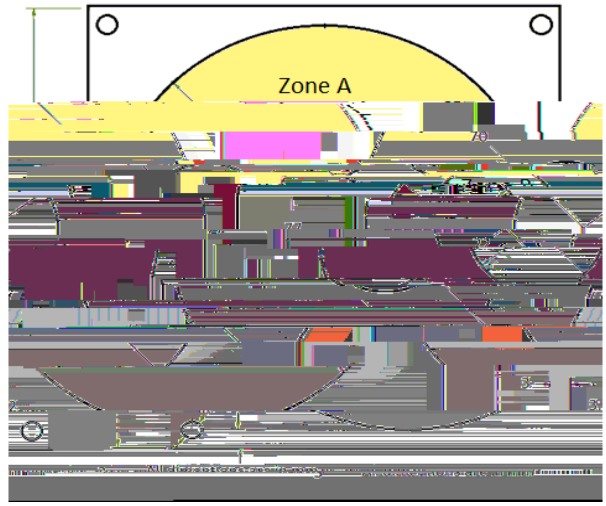


Figure 13 Allowable zone for components placement

**Effect of Boundary Conditions**

In the following section, the results from the square-shape

Figure 15 Line 2 Maximum and minimum principal strain for both BCs

Figure 16 plots principal strain distributions in the diagonal directions along Line 3. It clearly shows the difference between these two boundary conditions , on the edge region. For screw-type support the absolute value of strain can be significantly higher than the center strain (in the opposite direction). But line-wedge support does not cause the reversed bend at the edge.

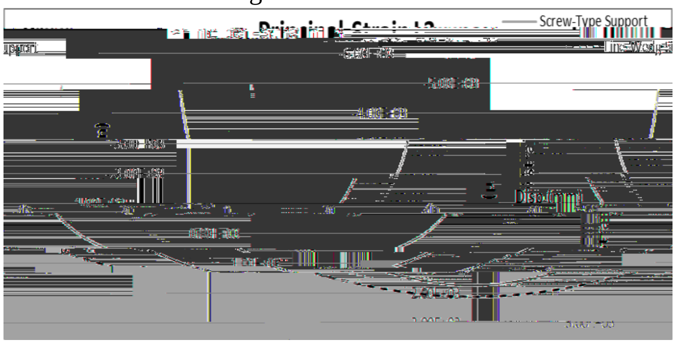


Figure 16 Line 3 Maximum and minimum principal strain for both BCs

**Effect of Impulse Duration**

Current JESD22-B111 drop test standard requires the impulse duration of 0.5ms. Under this condition, as seen in Figure 5, the board will vibrate several cycles before it comes to rest due to the damping effect. For a one degree-of-freedom model, the analytical solution is available for an -2(es )-372(5)-5 <</1 du cip0

9.