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Power Electronics Module – Gun Launch

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RDAR-MEF-E

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- ## Goals:
  - Determine the strain and deflection induced on power electronics board locations under prescribed loads to determine if the capacitors on the power electronics boards are at risk of mechanical failure.

- ## Scope
  - Model: Power Electronics Module was modeled. Selected only major structural parts of the module. Small electronics parts (chips) were not modeled in this phase. Projectile mass and center of gravity were matched by adding two mass simulants, one in front and the other behind of Power Electronic Module.
  - Abaqus Explicit 6.13-1, dynamic analysis with axial acceleration, balloting and angular velocity applied load.
  - Evaluate: strains and deflections of the power electronics boards during the gun launch event.

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- General Purpose Finite Element Software: Abaqus Explicit 6.13-1
- Analysis: dynamic, non-liner materials, non-linear geometry
- Analysis time: 0.012 seconds
- Full model
- Parts: Imported from CAD. All parts modeled as deformable.
- Elements: 8-node brick elements, reduced integration, hourglass control.
- Materials: Elastic, Elastic-Plastic, Crushable Foam and Hyperelastic Arruda-Boyce models
- Loads: Preload none
- Boundary: Axial Acceleration, Balloting and Angular Velocity applied on Fuse Housing
- Initial Conditions: No initial conditions
- Friction: Assumed friction 0.3
- Assumed failure criteria per discussion[5] with Center for Advanced Life Cycle Engineering (CALCE) University of Maryland:
  - >0.001 strain – capacitor failure possible
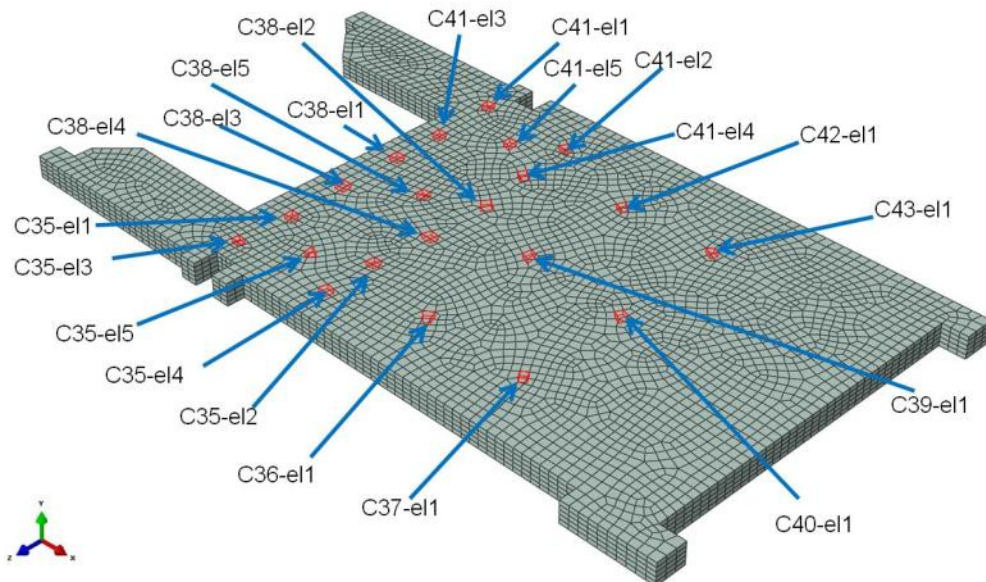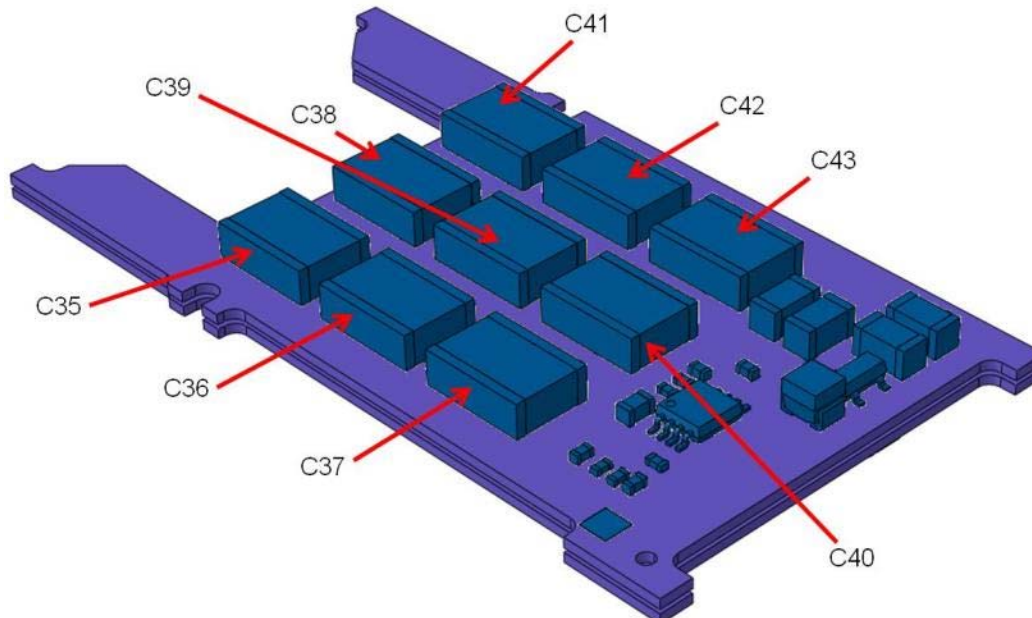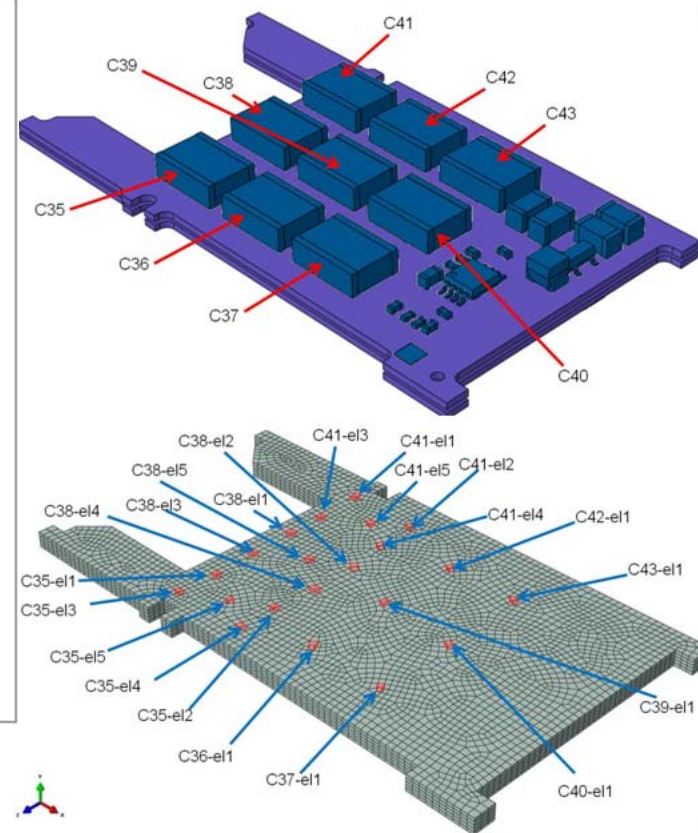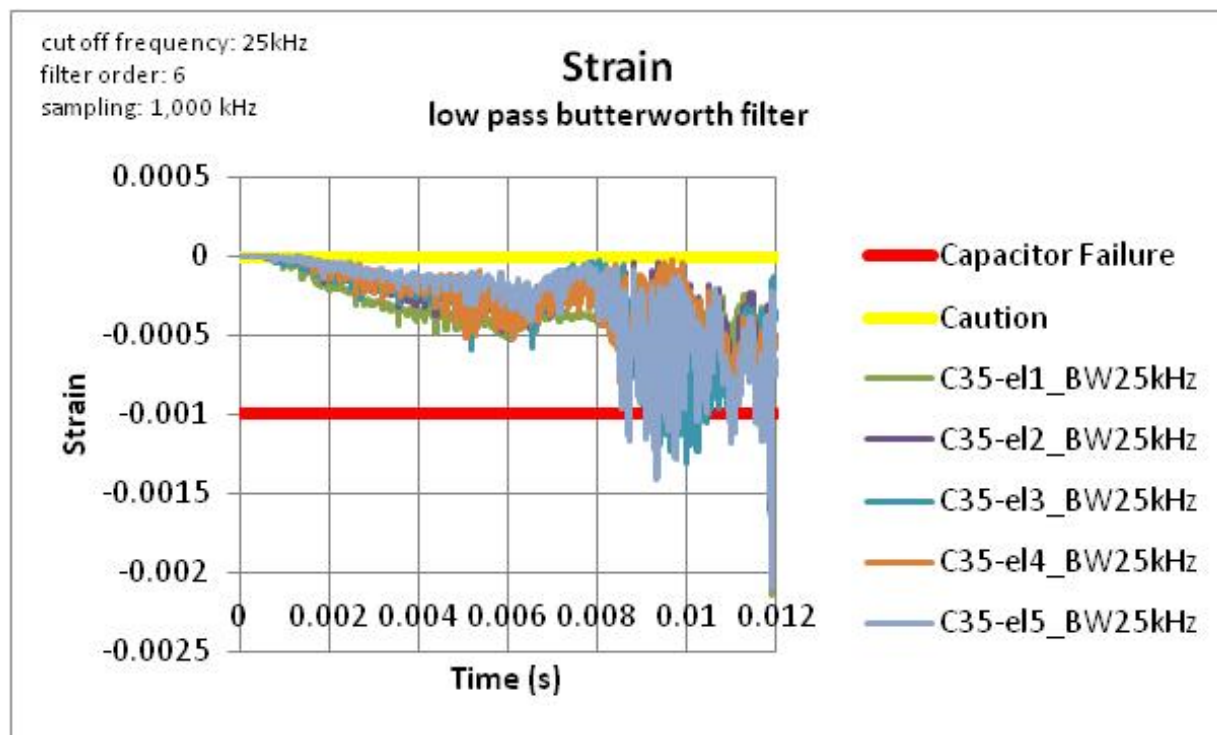 - >0.0000010 and <0.001 strain – caution area

– Possible Errors

- Geometry was defeatured. Nonstructural mass was added to defeatured parts to preserve the real mass of the assembly.

- "Boards" were modeled without chips, as result we have boards that are less stiff than boards with chips. Elastic material model was used for "Boards", the elastic modulus was from 3 point bend/flex testing done via DMA (Dynamic Mechanical Analysis).

- The prediction was based on strain of the "Board 4". Actual capacitors of interest were not modeled. Strain and stresses of the capacitors could be significantly different based on material properties and interaction of the capacitors, solder and conformal coating.

- General contact with coefficient of friction 0.3 for all contact. Slipping effects, temperature and pressure dependences were ignored.

- Assumed good adhesion between potting and parts in contact with potting. Adhesion is modeled as tie constraints.

- Threaded connections were not modeled, instead contacting surfaces were tied.

- Model was run using ambient material properties.

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Capacitors of interest C35 to C43 were not modeled. Instead, elements of the board were selected as indicated in red color on bottom picture. Capacitors C35, C38 and C41 were represented with 5 elements of the board. The rest of the capacitors were represented with one element.
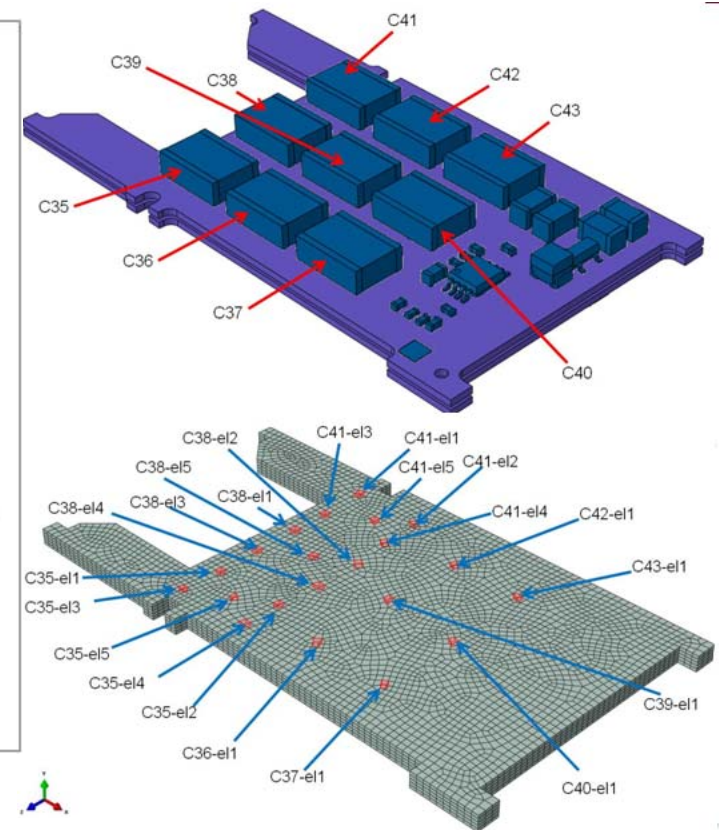
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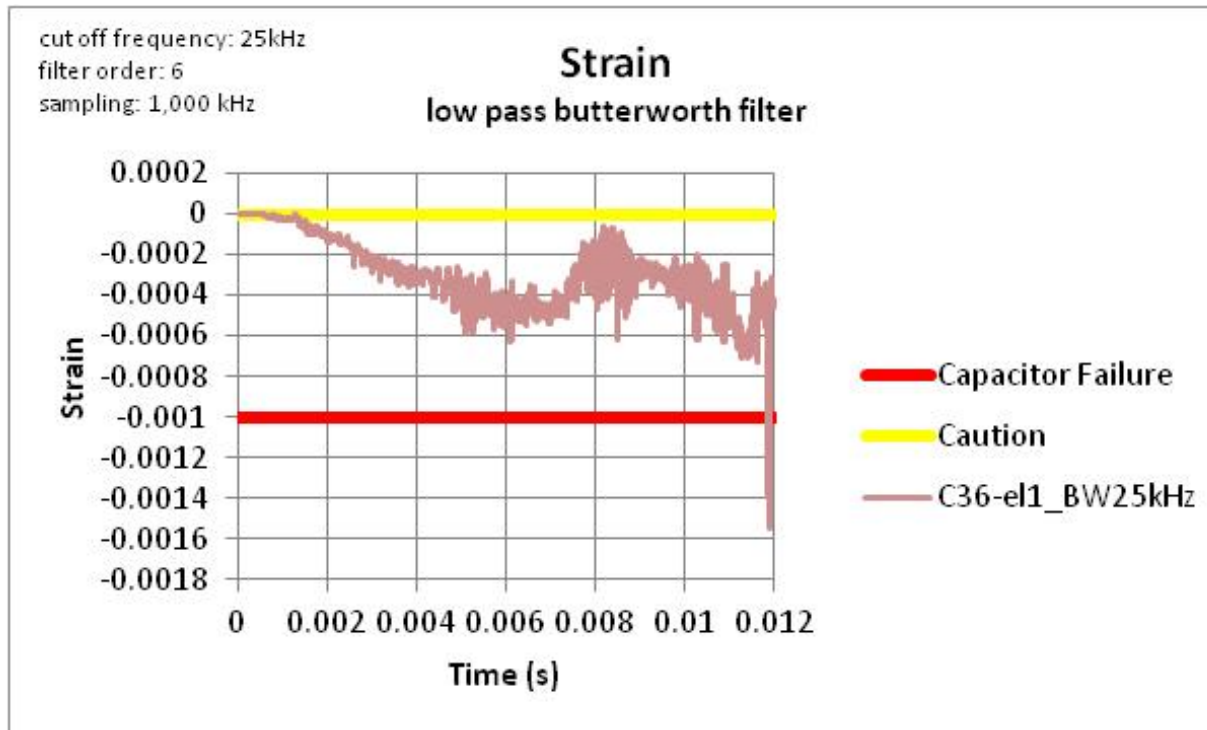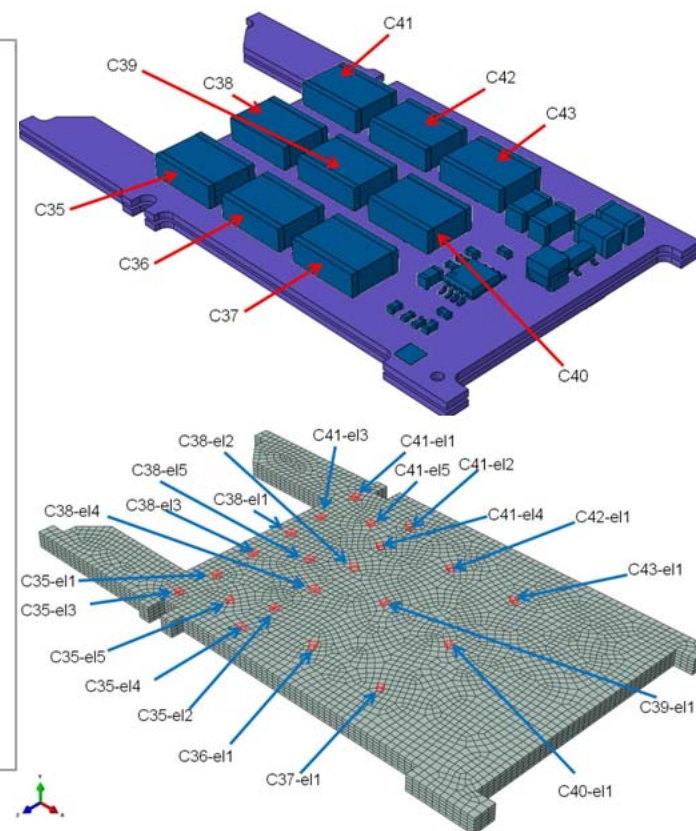*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*

Assumed failure criteria per Center for Advanced Life Cycle Engineering (CALCE)
University of Maryland is:
if strain is > 0.001   - capacitor failure possible
if strain is > 0.000010 and < 0.001 - caution area
Yellow line is at 0.000010 strain and red line is at 0.001 strain
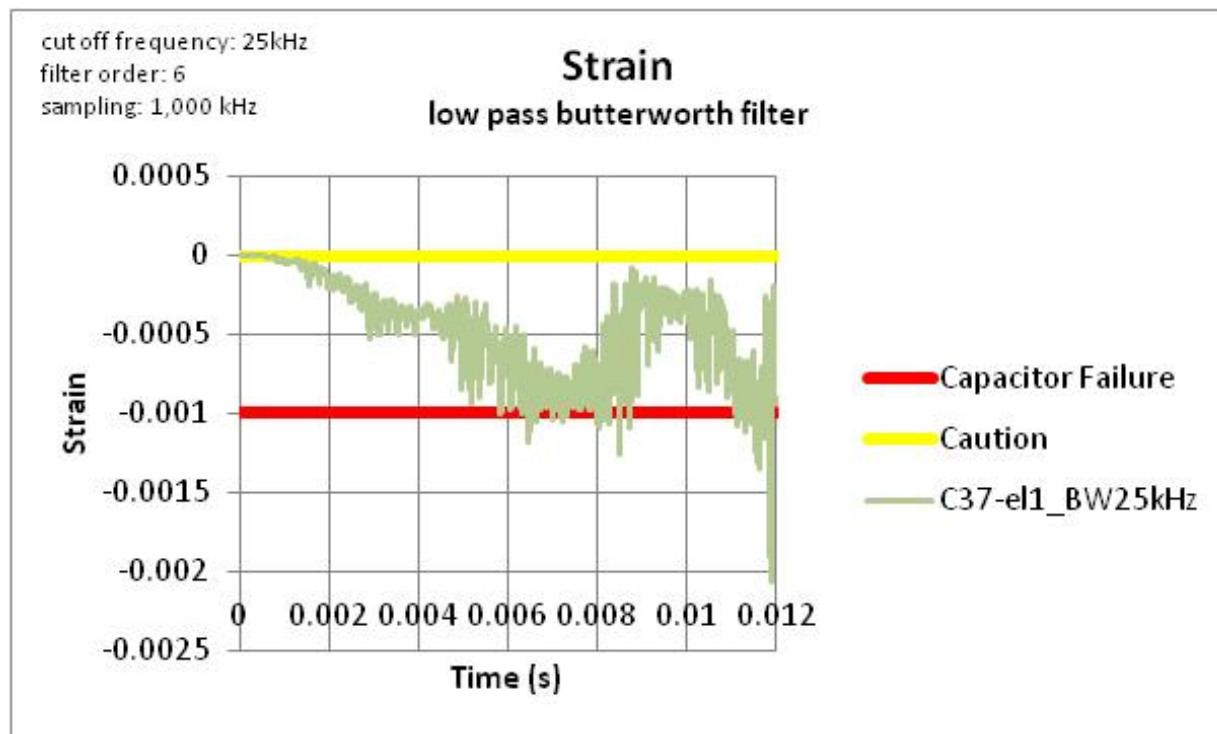
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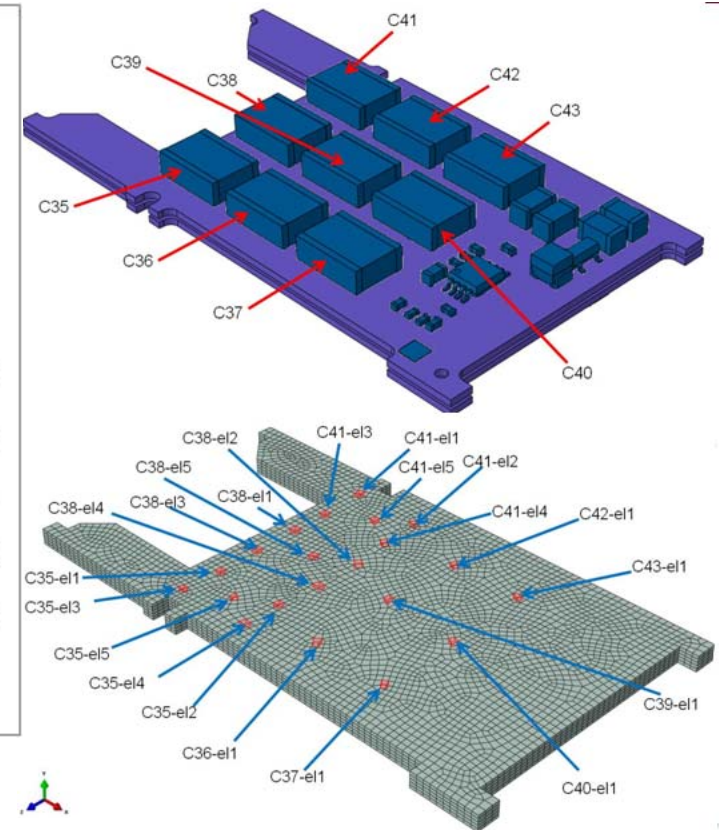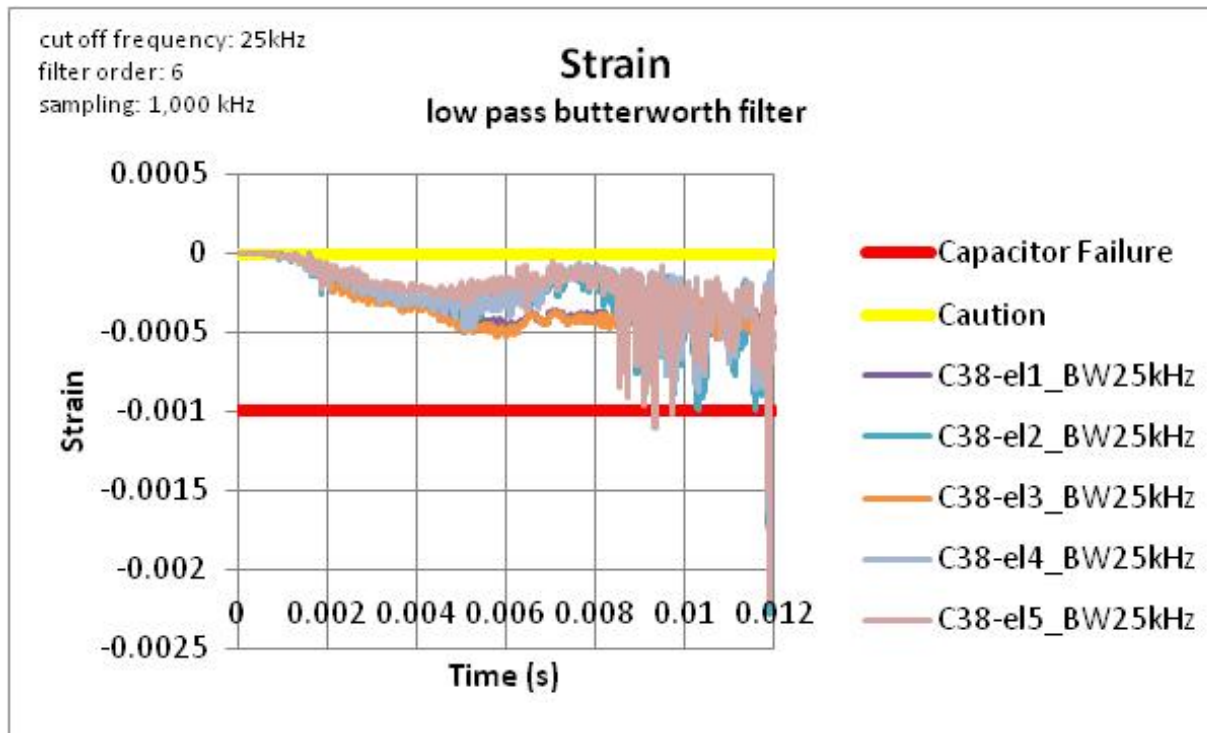
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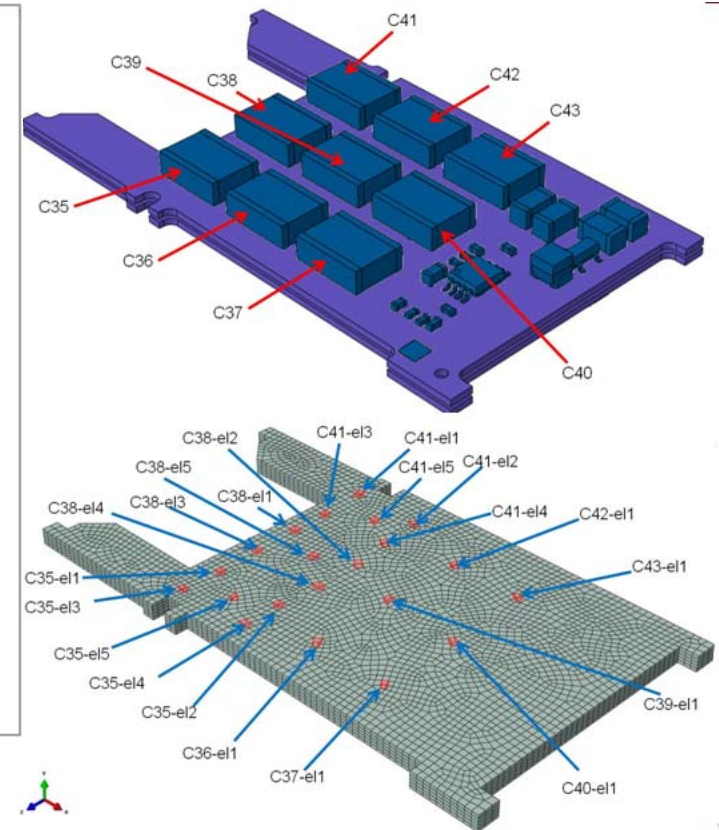
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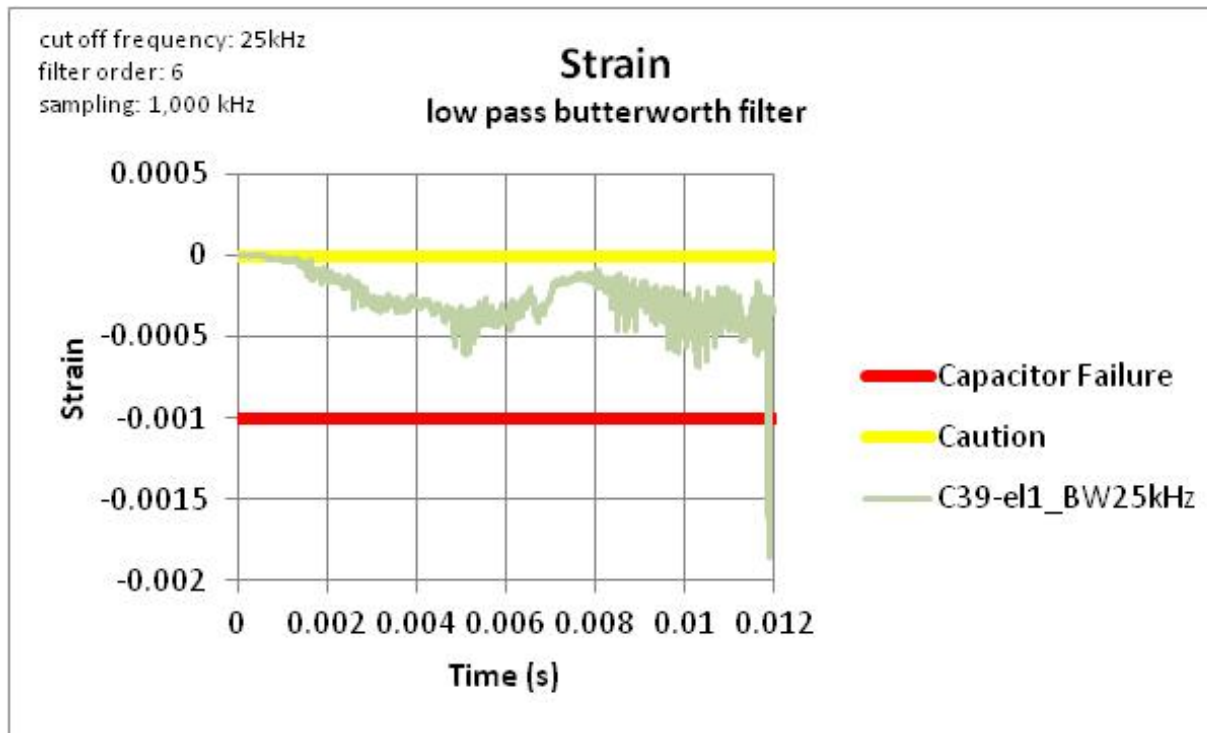
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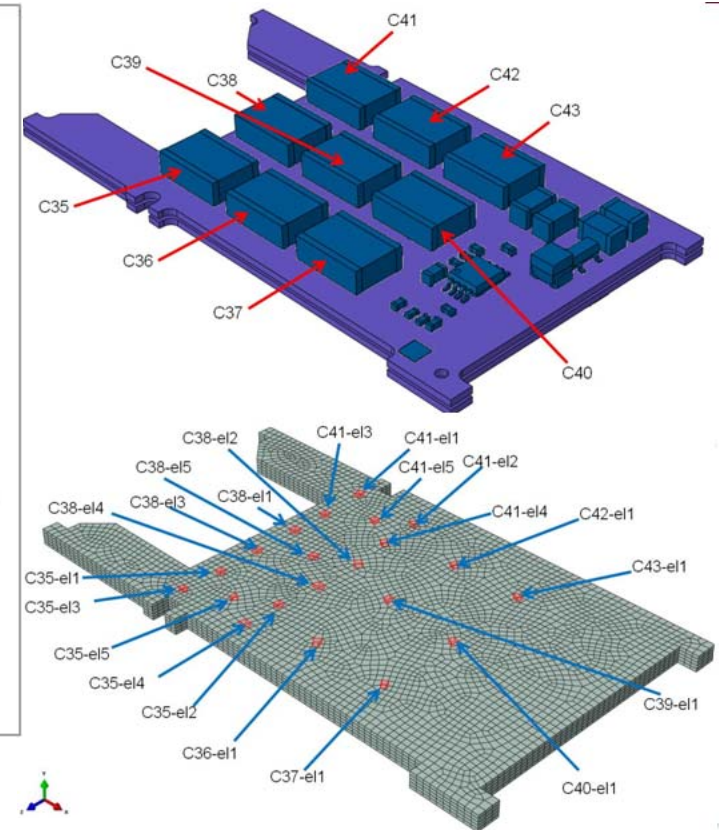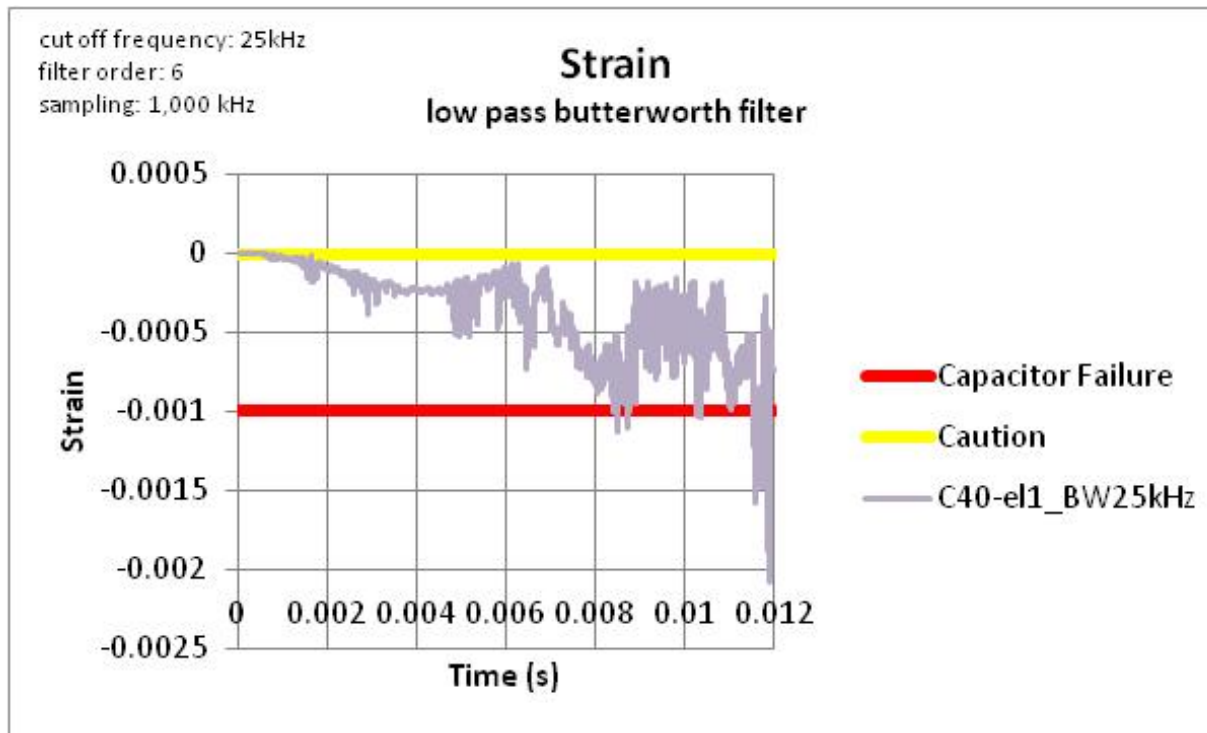
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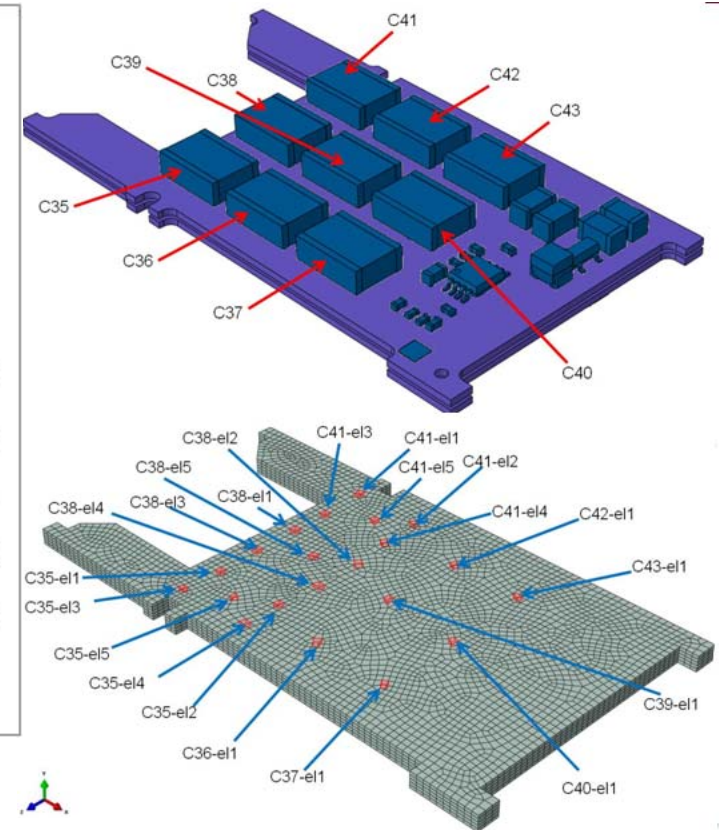
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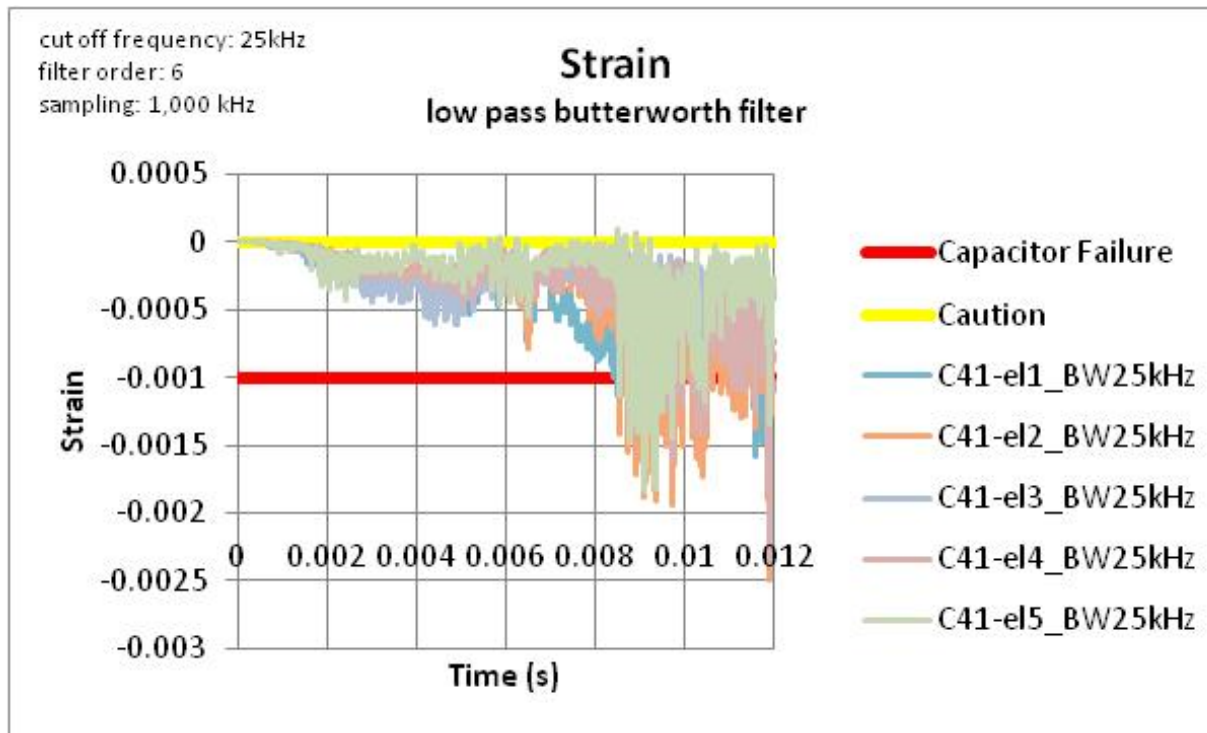
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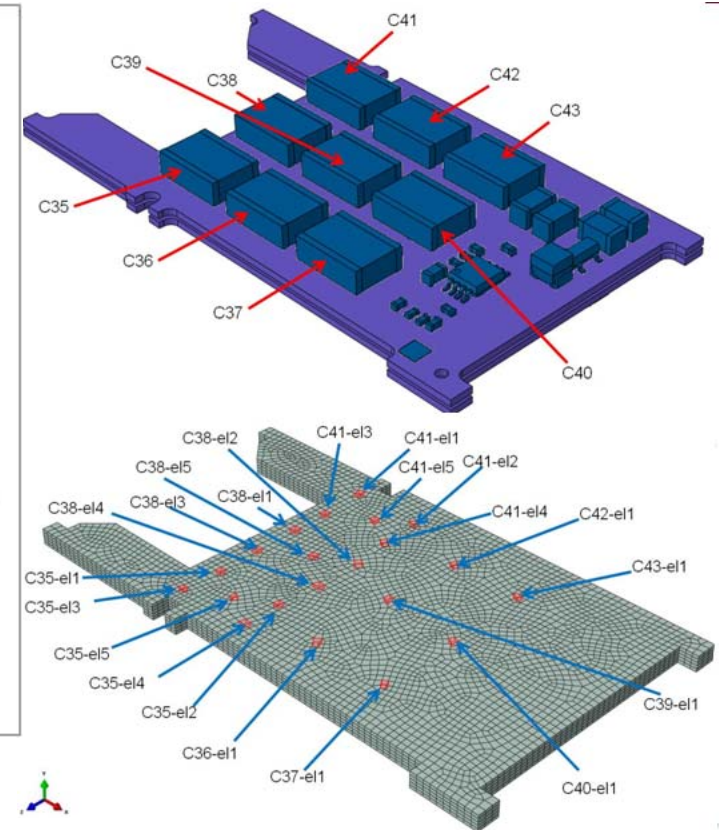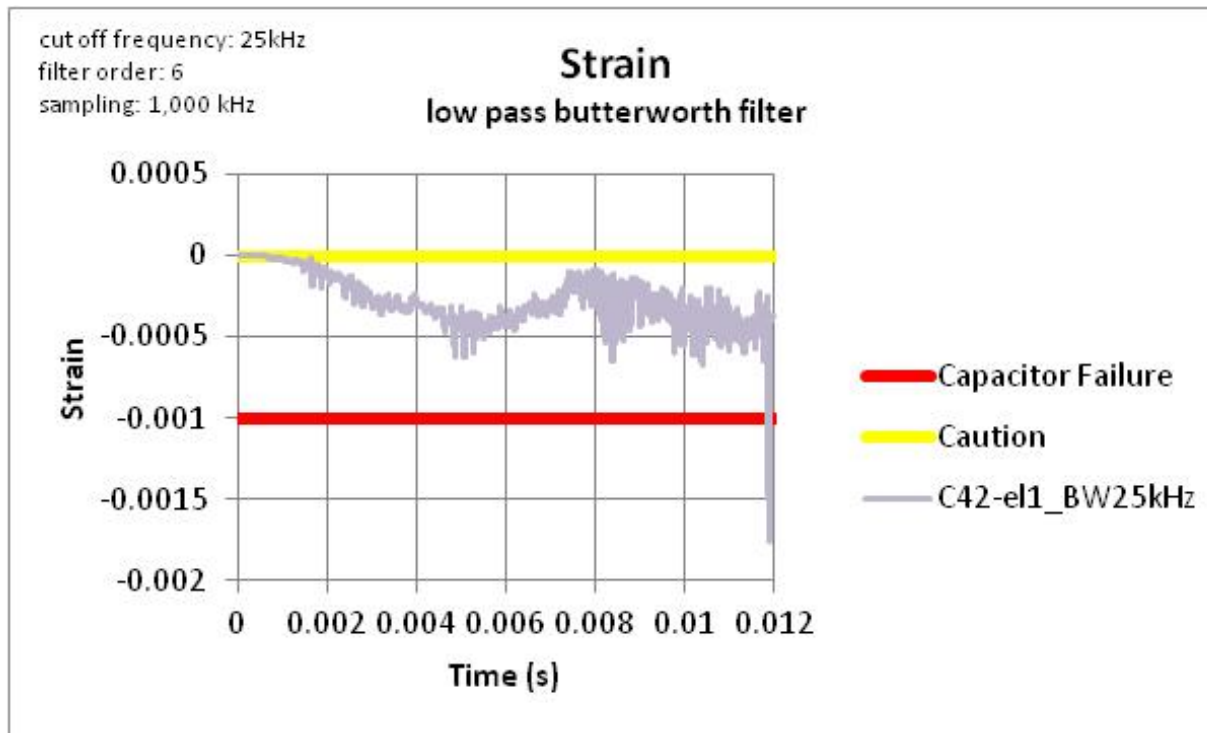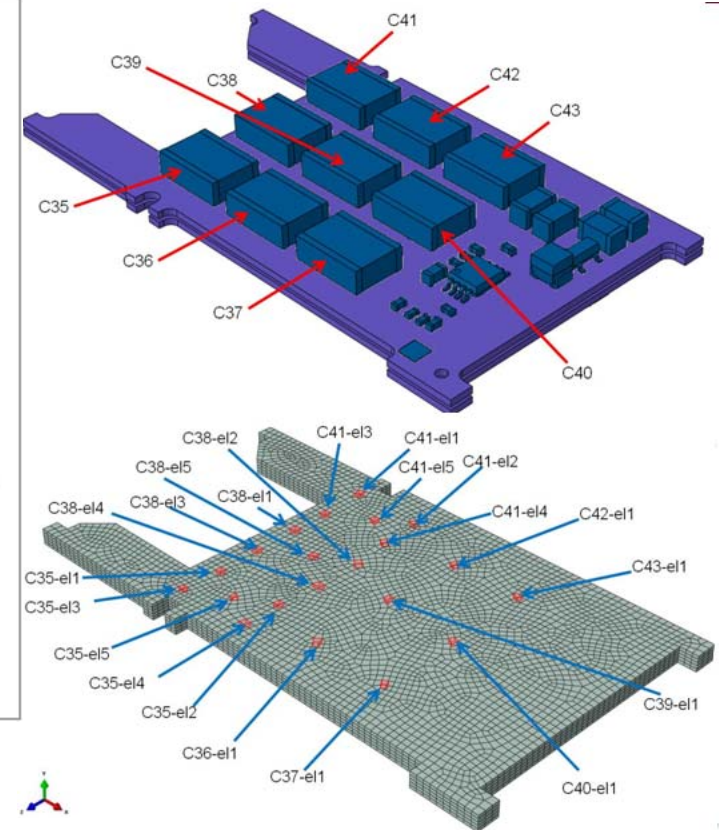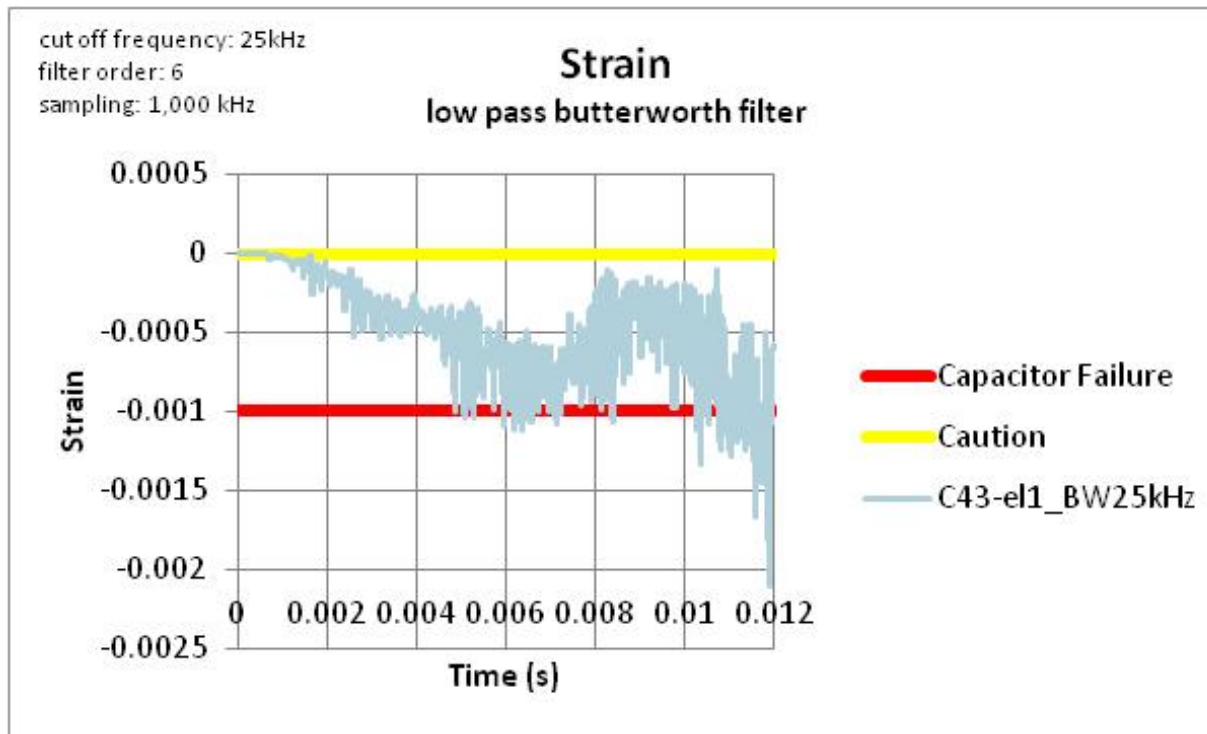
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Conclusion:

• Predicted strain in "Board 4" was shown in charts. The first row of three capacitors C35, C38 and C41 were represented by 5 elements on the board. The remaining six capacitors were represented by one element each on the "Board 4". Data acquisition sampling rate was at 1,000 kHz during FEA analyses. Data was filtered using low pass Butterworth filter, 25 kHz cut of frequency and filter order 6.

• Assumed failure criteria per discussion[5] with Center for Advanced Life Cycle Engineering (CALCE) University of Maryland was used. It was visible that all capacitors were in caution range of strain with some experiencing strain higher than critical failure strain. The worst case was found in C35, C38 and C41 the first row three capacitors .

• Capacitors C41 and C35 see 3 milliseconds of the strains that exceeded failure criteria strains. This is clear indication that those two capacitors represent an increased risk of catastrophic failure.

• This prediction was based on strain of the board. Actual capacitors were not modeled. Strain and stresses of the capacitors could be significantly different based on material properties and interaction of capacitors, solder and conformal coating. It would be a more reliable way to predict strain in capacitors of interest if capacitors, solder and conformal coating were modeled.

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1. Abaqus Inc., (2013), "Abaqus User Manual V6.13"

2. Handbook of Electronic Package Design, Michael Pecht, 1991 Marcel Dekker, Inc.

3. Ballistics Theory and Design of Guns and Ammunition, Donald E. Carlucci, Sidney S. Jacobson

4. Machinery's Handbook, twenty seven edition, 2004 Industrial Press Inc.

5. Telephone conversation with Michael Azarian and Abhijit Dasgupta, Center for Advanced Life Cycle Engineering, University of Maryland, April 03, 2014.

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