Pyrotechnic Shock Modeling

Team Website: eng.fsu.edu/me/senior_design/2015/team15/

Project and Definition

Need Statement:

"The current shock testing method is insufficient in the amount of resources expended per test."

Project Objective:

Design an adaptable test apparatus and method in order to explore and tabulate the measured effects of varying test parameters on SRS curve generation

Pyrotechnic shocks generate high levels of acceleration at high frequencies. The industry standard in characterizing these shocks uses Shock Response Spectrums (SRS) to evaluate potential damage to electronic components near the shock origin.

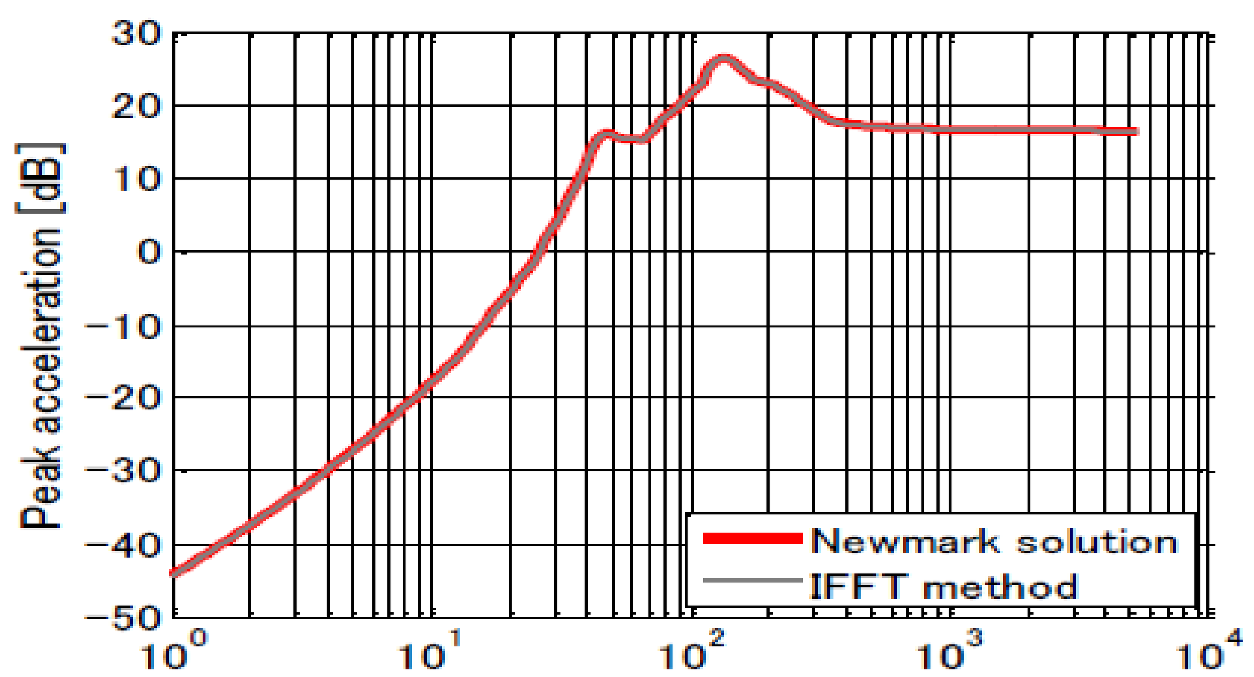


Figure 1 – Example SRS curve, logarithmic scale

Constraints and Considerations

These are sponsor and team identified project constraints:

- Proven consistency in shock generation
- Reliable release mechanism
- Acceleration data acquisition covering expected force ranges
- Software conversion of raw data to usable SRS curves (MATLAB)
- Adjustable fixture parameters
- Model simulations
- Test measurements database
- Remain on budget ($4000)

Figure 2 – A piezoresistive accelerometer

Experimental Methods

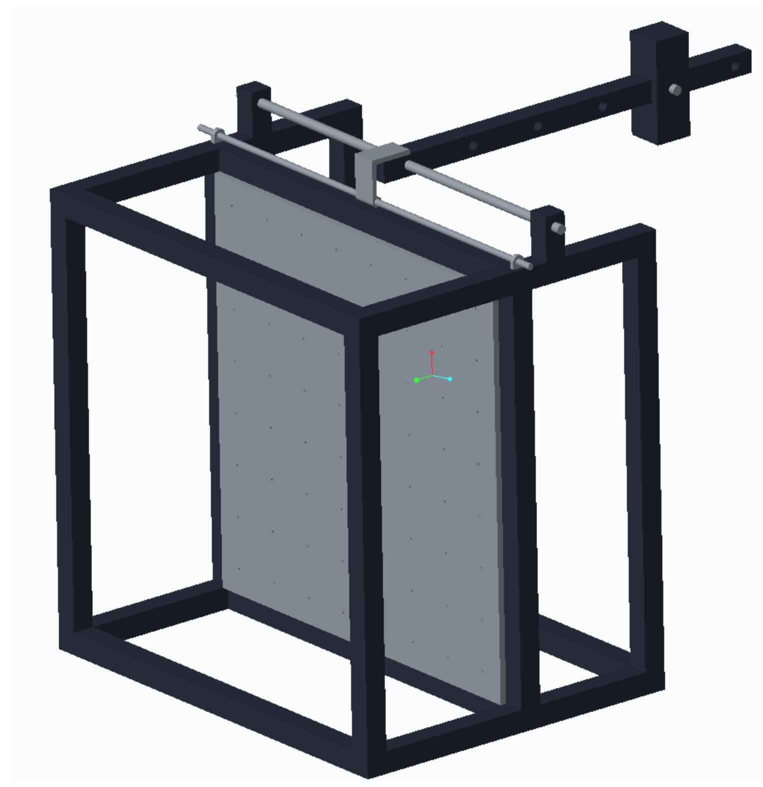


Figure 3 – Solid CAD model of shock test apparatus

Final design configuration allows test variability for parameters such as:

- Impact location
- Hammer shape
- Fixture boundary conditions
- Dampening and mass

Figure 3 shows the test rig. The dark blue components are made from different steels, the test fixture plate is made from Aluminum 6061

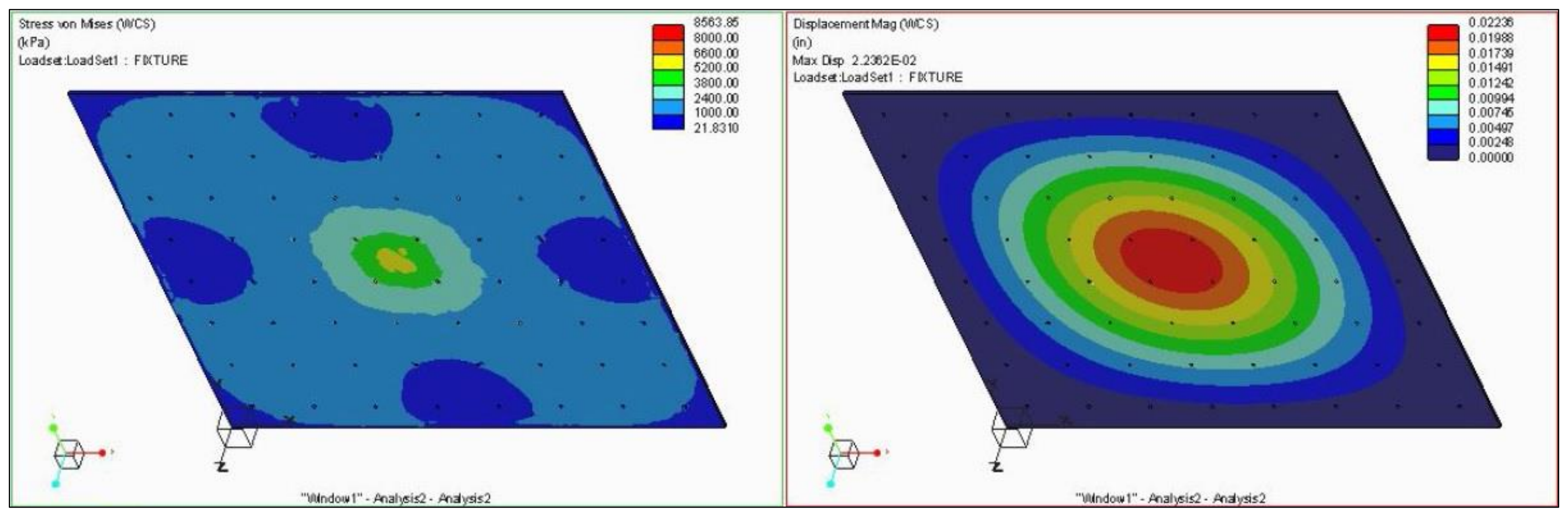


Figure 4 – Stress and displacement simulations

For a simple pendulum system, we are interested in the force generated.

Newton's 2nd law

Fx = -mgsin(θ)

Small angle approximation: sin(θ) ≈ θ.

Fx = ma = -mg(θ)

Here, the dependant variable θ is not linear.

Therefore, the solution to this equation is a 2nd order ODE:

$$\frac{d^2}{dt^2}(\theta) + \frac{g\theta}{L} = 0$$

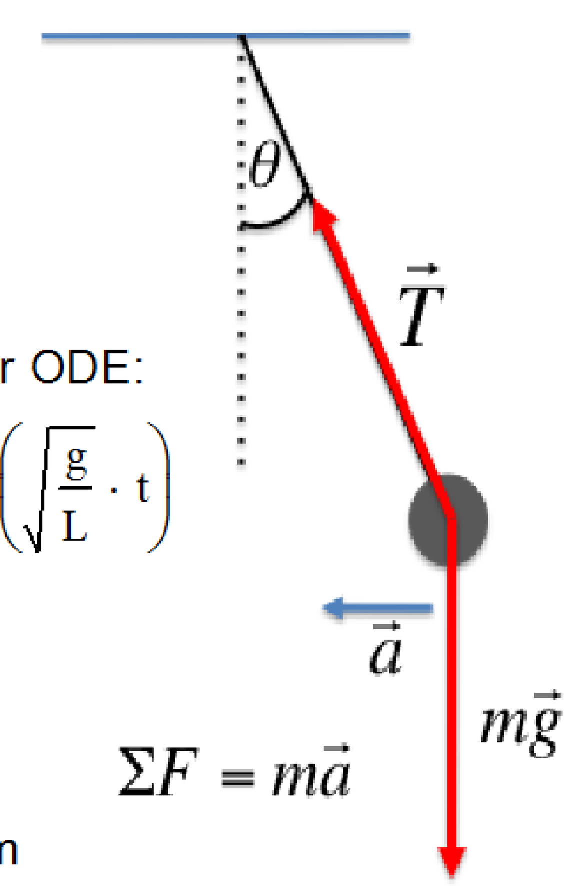
The solution is

$$\theta = \theta_{max} \cdot \sin\left(\sqrt{\frac{g}{L}} \cdot t\right)$$

The time dependant solution is:

$$Fx = mg\sin\left(\theta_{max} \cdot \sin\left(\sqrt{\frac{g}{L}} \cdot t\right)\right)$$

Where θ_{max} is the angle the hammer is dropped from



Analytical Methods

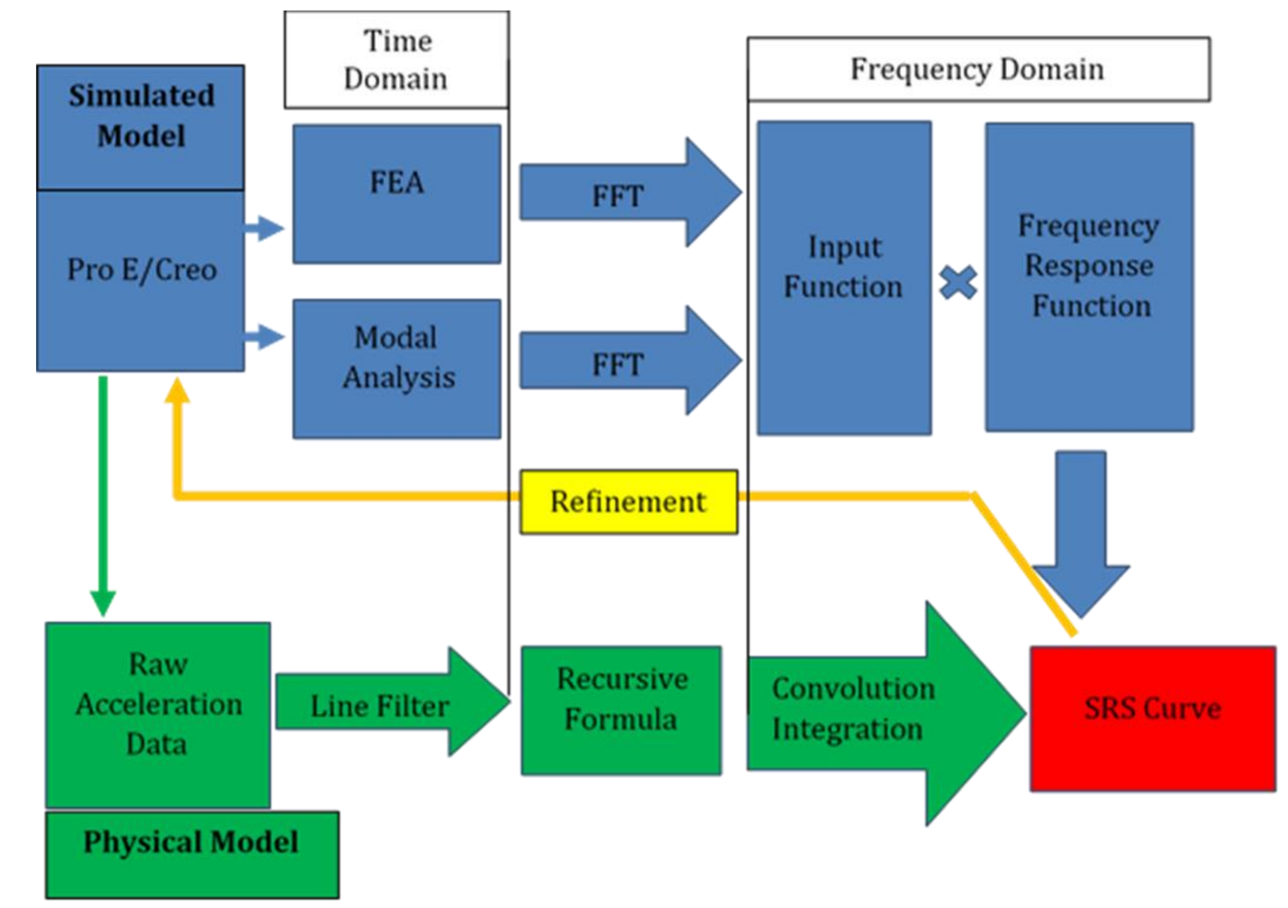


Figure 5 – Data flow for shock testing to SRS curve generation

The analytical models serve to help refine experimental techniques without having to perform excessive and repetitive testing. This allows a "guess and check" testing method to tabulate variable correlations.

Future Work

Challenges in the spring semester will include learning efficient use of the DAQ system and computer modeling, as well as building the test rig with emphasis on consistent results.

Our plan for testing methods will be:

Step 1) Evaluate the test plate alone

Step 2) Determine viable testing parameters through modeling

Step 3) Systematically isolate test variables

Step 4) Analyze resulting SRS curves

Step 5) Tabulate results

Step 6) Refine test method

Step 7) Confirm results with computer models

Our test location will be the low speed wind tunnel facility in the AME building. This is due to noise considerations, as well as access to available hardware and data acquisition systems.

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