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ME 747

Lab 4

PART 1: POTENTIOMETER ACCELEROMETER

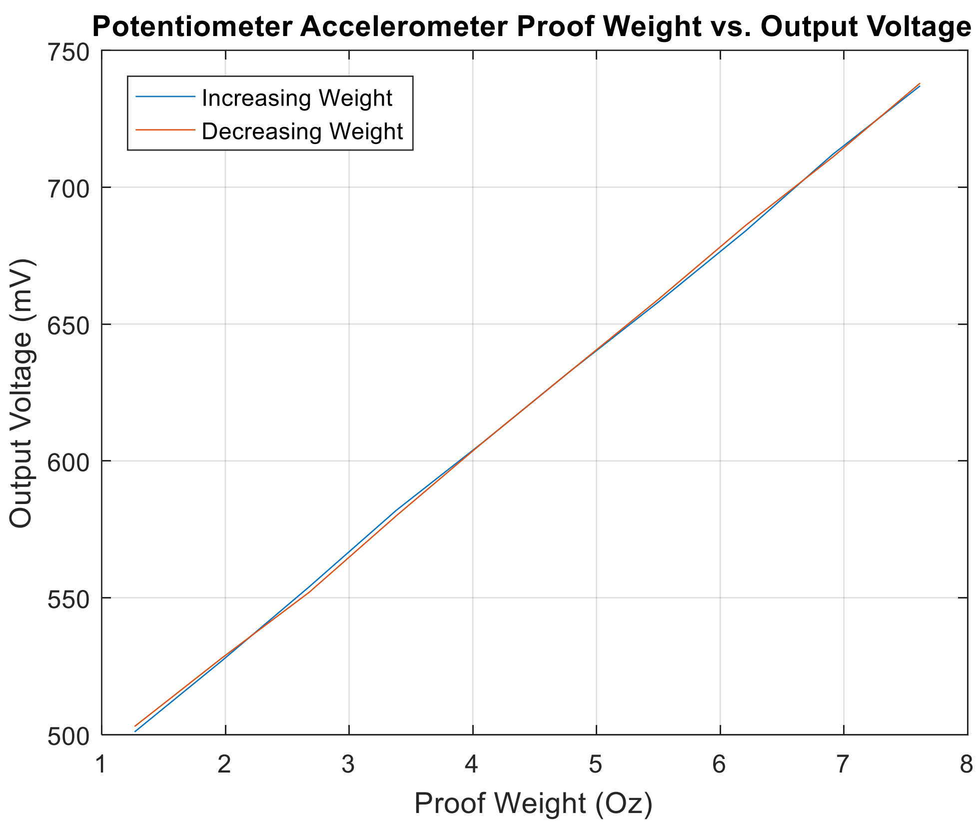

Figure 1

Figure 1 shows the calibration plot of the potentiometer accelerometer. Proof weights were added whilst output voltage was recorded, the results are linear. Measurement noise is about equal to hysteresis error for this unit. The sensitivity of this sensor was found to be .0372 V/Oz. For computations, the mean value of the increasing and decreasing weights was used.

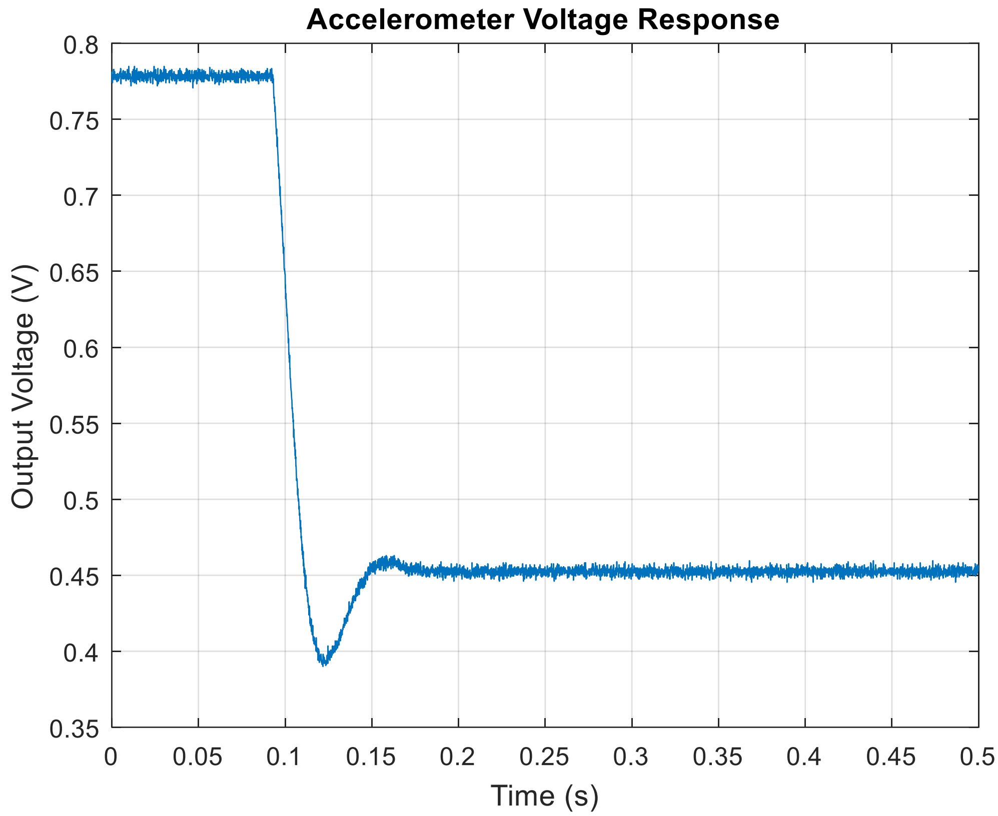

Figure 2

Figure 2 shows the change in accelerometer voltage with respect to time in response to a perturbation. The system is second order with the following parameters:

- Spring Constant: 69.5 Oz/in
- Natural Frequency: 126.8 rad/s
- Effective Mass: .00320 Slugs
- Damping Ratio: .57

The sensitivity of the accelerometer was found to be: .0001606 V*s^2/in. The maximum acceleration this instrument can theoretically measure is 4,845 in/s^2, which is roughly 12.5 Gs. The bode plot of the output in voltage for an acceleration input is shown in Figure 3 on the next page. Sinusoidal inputs at frequencies above 10^2 radians per second will suffer severe attenuation, and should not be measured with this instrument.

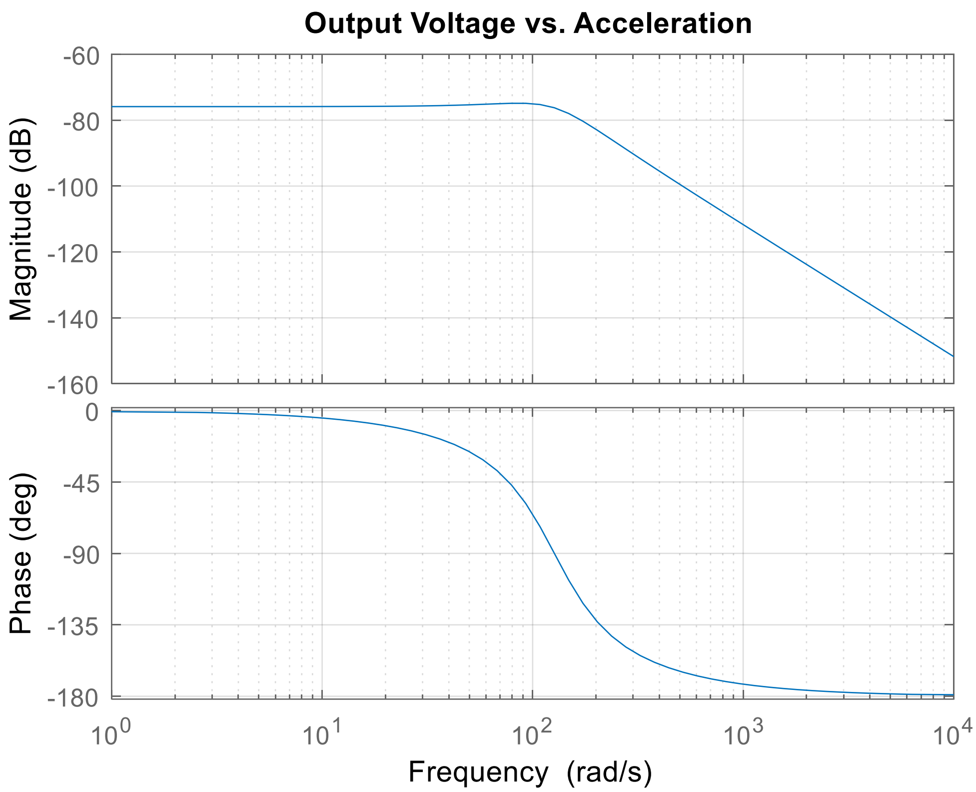

Figure 4

PIEZOELECTRIC FORCE SENSOR

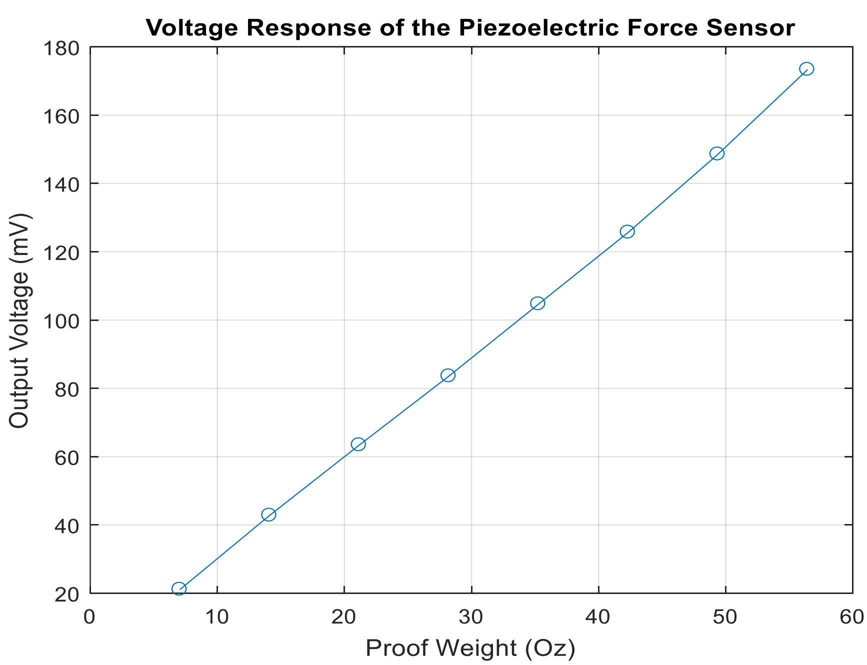

Figure 3

Figure 4 on the previous page shows the calibration curve of the piezoelectric force sensor. The sensitivity of this sensor was found to be: .0030 V/Oz. The full scale error percentage was 1.67%.

The decay time constant was calculated to be 10.6 seconds. This sensor would not be a good choice for measuring steady state forces, as steady state typically implies that a measurement must be held for longer than a few seconds. A ten second time constant implies that only a fraction of a second yields an accurate measurement (i.e. within a few percent). If the time constant was several orders of magnitude larger, this sensor would be a better choice for steady state measurements.

The natural frequency of the system/structure was calculated to be 10,406 rad/s, making this system vulnerable to vibrations in the immediate 1.66 kHz range. These frequencies should be avoided, as they will cause the system to resonate. This sensor is still a better choice for high frequencies compared to the potentiometer accelerometer.

IMPULSE LOADING AND VIBRATION

The parameters for the foam mass system are listed below:

- Spring constant: 81.7 lb/in
- Natural Frequency: 125.6 rad/s
- Damping Ratio: .2284
- Damping Coefficient: .2971 lb*s/in

Governing Differential Equation:

$$F(t) = \frac{\frac{1}{k}}{\frac{1}{\omega_n^2} + \frac{2\xi}{\omega_n} + 1}$$

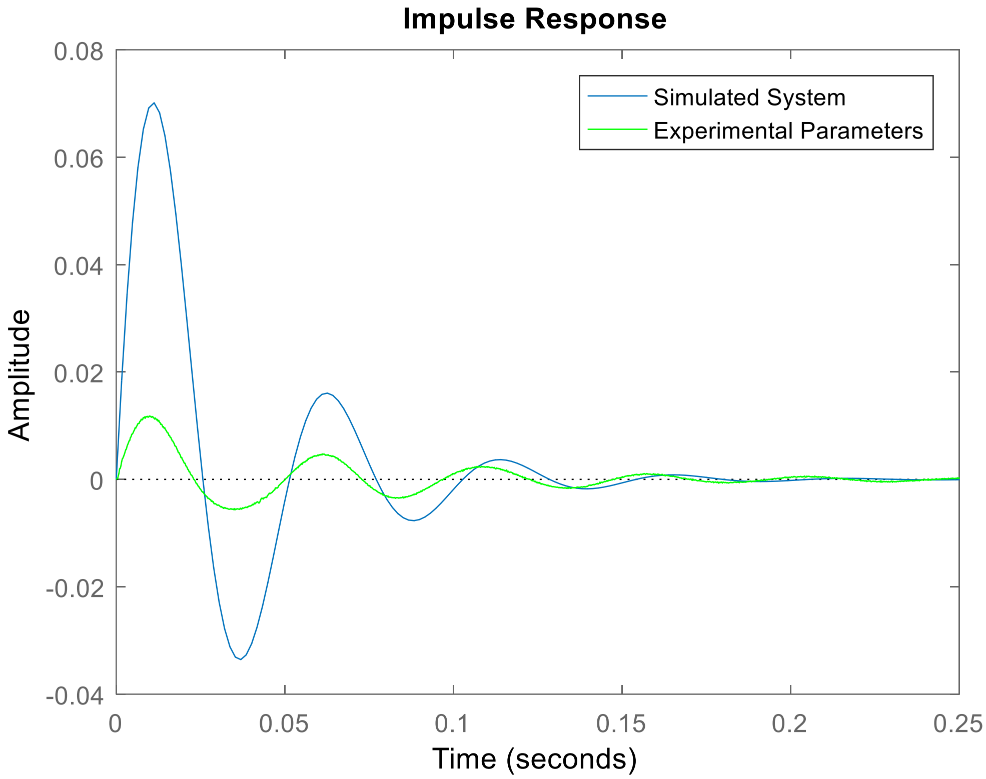

Figure 5

Figure 5 shows a plot of the simulated and experimental impulse responses. The peaks on the experimental curve tended to be shifted more to the left compared to the simulated value. The differences in amplitude can be ignored, and is a factor of adjusting system gain to make both curves fit nicely on the same figure. Aside from the minor skew, the simulated and experimental systems match fairly well. It is noted that it is impossible to replicate an impulse waveform in real life, because there is always a duration of time that will pass as the sensor is struck with an object – true impulse exerts a force over an infinitesimally small duration of time.

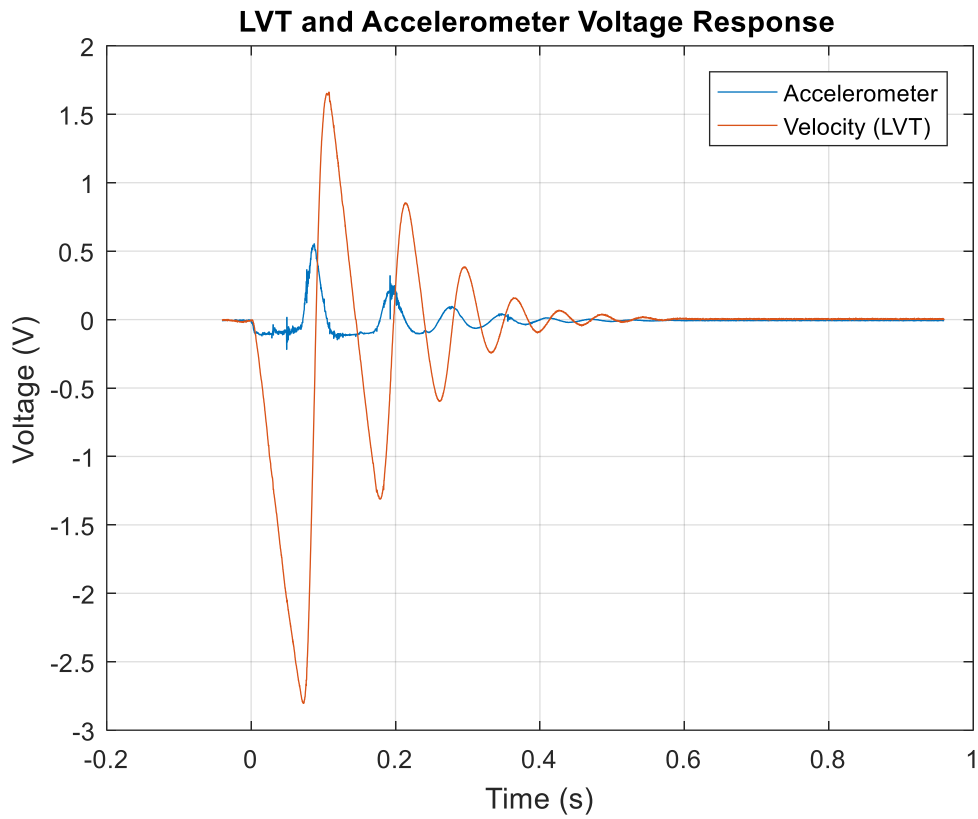

Figure 6

Figure 6 shows both the LVT and accelerometer voltage output for the duration of time where a weight was dropped onto a foam pad. The sensitivity of the accelerometer was calculated to be: .0002813 V*s^2/in, the sensitivity of the LVT was calculated to be .1181 V*s/in.

Figure 7 on the next page shows the raw results of integrated accelerometer data. The integration removed a lot of the noise from the signal, however there is a clear linear skew in the upwards direction. This was corrected for, and a secondary figure (Figure 8) shows the corrected results. The integrated signal is nearly the same, however it is flipped about the X-axis – this is caused by the gain of the inverting amplifier being -1. The issue of skew occur in the second lab as well.

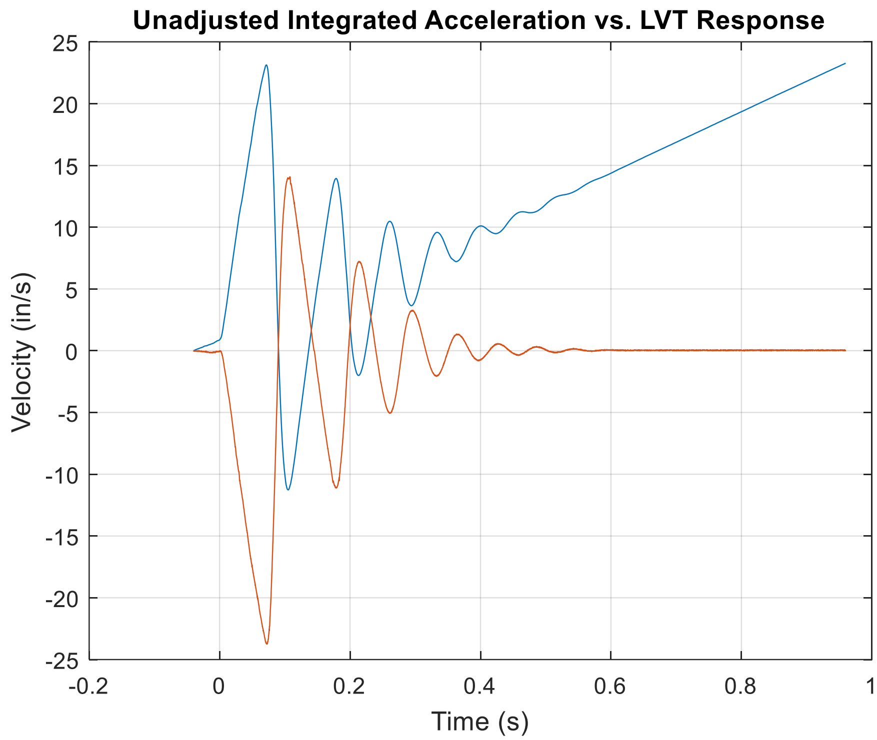

Figure 7

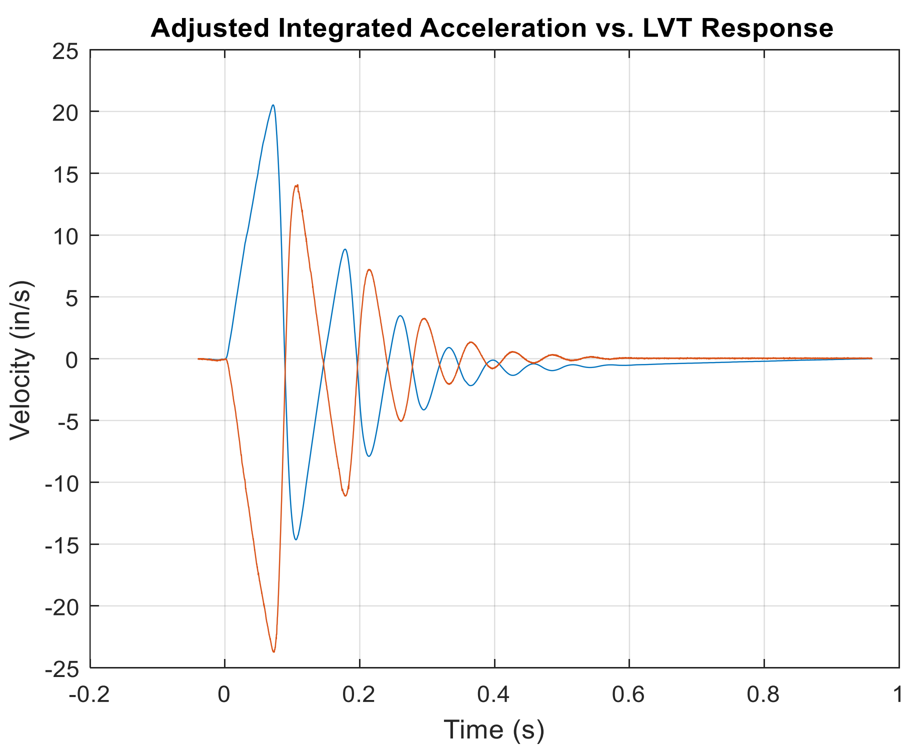

Figure 8

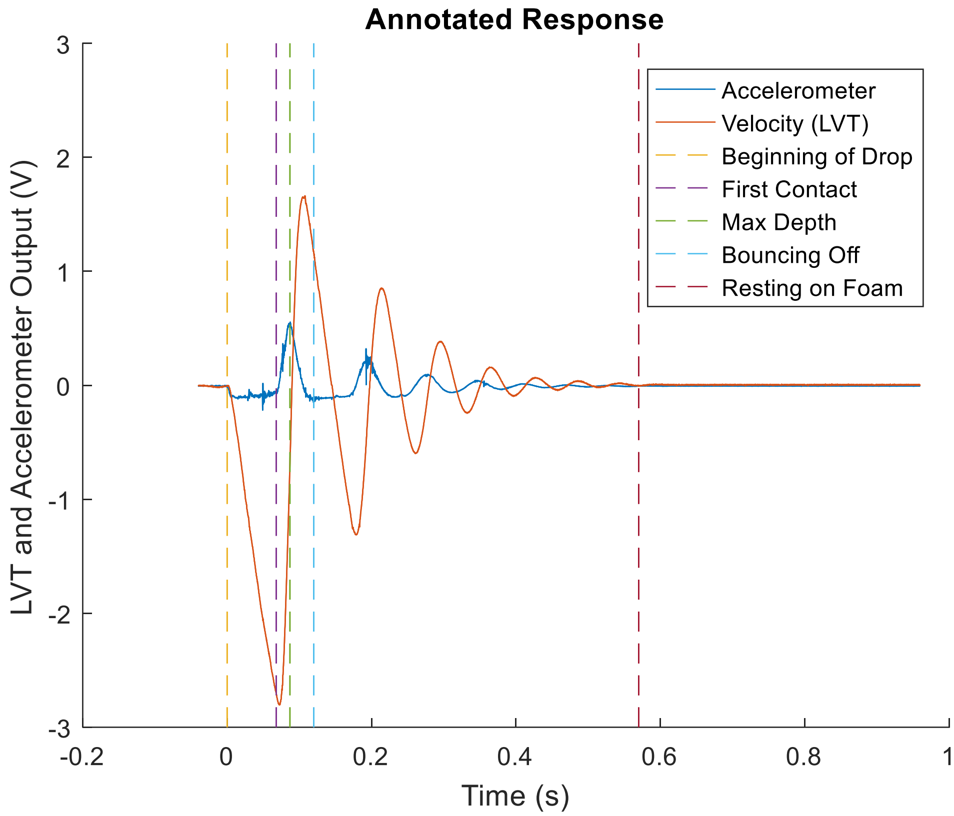

Figure 9

Figure 9 shows the voltage response from Figure 6, annotated to show what is going on at important points in time in the foam mass system. The vertical lines and corresponding legend entries show times of interest.

The maximum velocity of the core was calculated to be: 23.7 in/s.

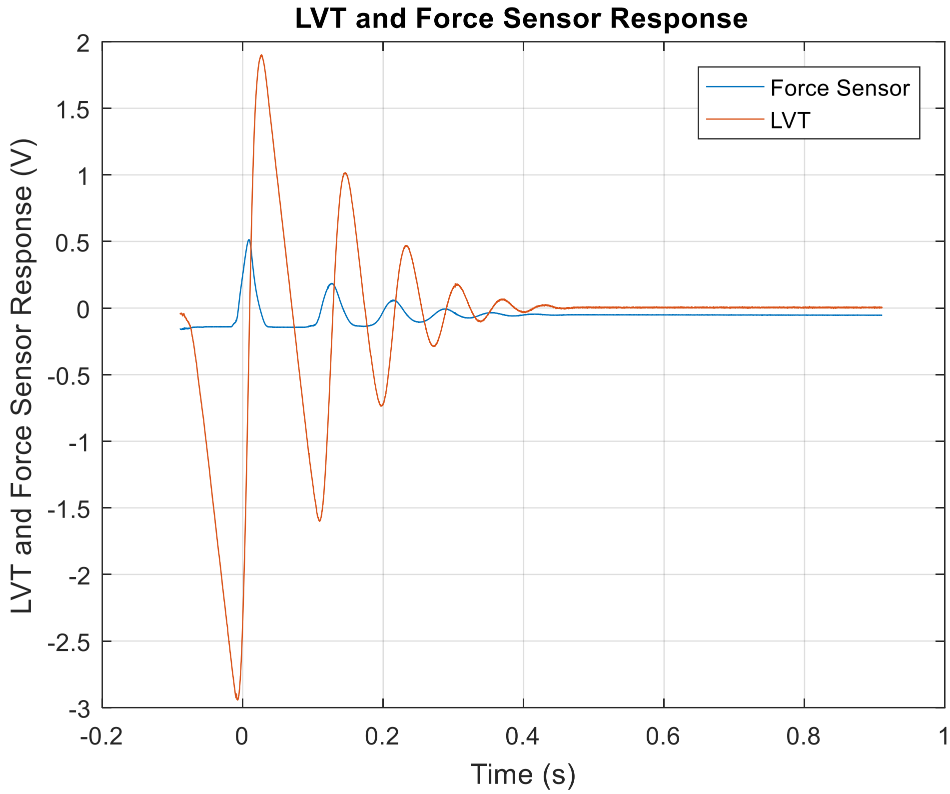

Figure 10

Figure 10 shows the output of a force sensor and LVT with respect to time. Note that when force rises from zero, the LVT shows a peak on the other side of the X-axis. The force on the foam at maximum core velocity was calculated to be .216 lbs. The steady state force between the foam and the core was found to be .2129 lbs. The total mass of the core with attached sensors was calculated to be .0066 slugs.