The damping ratio can be obtained from time-domain peak to peak analysis of the decaying impact response. An FFT is first performed to establish frequencies of interest in the system. A cut-off frequency is established, and any noise or signal outside the region of interest is attenuated.

The logarithmic decrement, , is calculated by taking the natural logarithm of the ratio of successive peak amplitudes, , cycles apart.

Diagram

Description automatically generated

Figure 2 - Decaying vibration of linear visco-elastic system

To calculate the logarithmic decrement more accurately, this can be calculated for every successive peak and averaged. Repeating this using different peak separations () allows an average value for the system to be obtained. The following relationships allow the damping ratio, *ζ*, damping, *c*, and natural frequency, *ωn*, to be obtained.

Chart

Description automatically generated

Figure 10 - Free vibration response in the vertical direction

The logarithmic decrement was then calculated for each successive peak with different peak separations. These measurements started at the sixth peak to allow transient effects to reduce. The damping ratio (*ζ*) for each *δ* was calculated using the following relationship and an average of those values was taken.

Table 4 - Logarithmic decrement values

|  |  |
| --- | --- |
| **N** | **ζ** |
| **6** | 0.207 |
| **7** | 0.201 |
| **8** | 0.200 |
| **9** | 0.210 |
| **…** | **…** |
| **24** | 0.185 |
| **Average** | 0.195 |

The damped natural frequency can then be found using the decay by first calculating the oscillation period, . The following relationships allow the damping ratio, *ζ*, and natural frequency, *ωn*, damping, *c,* and stiffness, , to be obtained.