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# Contact Interruptions due to Dynamic Load, e.g. Vibrations / Mechanical Shock

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Supporters:

# Connector Qualification – Dynamic Load (“Vibration”)

- Typical profiles and values according to OEM specifications
  - Sinusoidal sweep to detect mechanical resonances  
 *$a_{peak}=10m/s^2$ , frequency range 5~2000Hz*
  - Sinusoidal sweep for engine application (highest severity 4)  
 *$a_{peak}=100\sim 200m/s^2$ , frequency range 100~440Hz  
(maximum acceleration for  $f=200\dots 240Hz$ )*
  - Broadband noise for engine application (highest severity 4)  
 *$a_{rms}=181m/s^2$ , frequency range 10~2000Hz  
(maximum spectral density  $20(m/s^2)^2/Hz$  for  $f=500\dots 2000Hz$ )*
  - Continuous shocks for body (severity 2, not required for engine applications)  
 *$a_{peak}=30g$ , half sine, pulse width 6ms (corresponds to  $\approx 83Hz$  sine)*

→ Mechanical excitation frequencies are in the lower kHz range.

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# Qualification Criteria & Experiences

## Criteria according to standards:

- Continuous monitoring of contact resistance during tests
  - no interruption longer than 1 $\mu$ s
  - Interruption is defined as contact resistance > 7 $\Omega$
- Visual inspection (microscope) of contact surface after test
  - no damage of contact surface allowed (no “wear-through”)

## Experiences:

- Interruptions usually do not occur as a single event but as the begin of contact failure and permanent damage due to overload
- Contact surfaces are damaged in such cases

# Other Considerations & Assumptions

## 1 $\mu$ s Acquisition Time vs. Frequency Range:

- 1 $\mu$ s “sampling time interval” corresponds to 1MHz “sampling frequency”
  - acquisition bandwidth 0...500kHz (Nyquist-Shannon theorem)
  - corresponds to signal rise times up to 700ns ( $f_{-3dB}=500kHz$ )

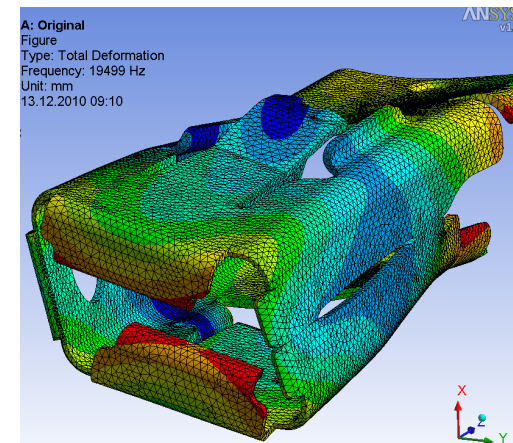
## Eigenmodes of Contact Systems:

- Analyses are done with regard to ultrasonic welding
  - first Eigenmodes of contact body typically in the region below 100kHz
  - mechanical movement due to excitation by direct coupling and high energy amplitude, e.g. us-welding

## Mechanical Excitation in the Application:

- No fast mechanical excitation (>700ns rise time) with high energy in real applications → “low pass” characteristic of mechanical systems

Example:  
Eigenmode analysis on contacts



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## Summary & Conclusion

- High energy vibration sources in cars operate at low frequencies (lower kHz range)
- Connector qualification for mechanical shock and vibration is done according OEM specification with defined load profiles
- Connector qualification requires demonstration of interrupt-free operation for these load profiles
- Acquisition time of  $1\mu\text{s}$  is short enough to detect interruptions caused by these mechanical load profiles
- High energy mechanical excitation for very high frequencies ( $>500\text{kHz}$ ) is unlikely due to the mechanical low pass characteristic of cable harnesses, connectors and car body

### Conclusions:

- Connector qualification demonstrates no interruption longer than  $1\mu\text{s}$ .
- Un-detected interruptions shorter than  $1\mu\text{s}$  are very unlikely.