The nonlinear vibration absorber is not effective in reducing transient vibrations.

Damped mass-spring system \((m_i, k_i, c_i)\) at a certain location \(\nu_i\) = local attachment of an extra element to the main system.

- **Reduce vibrations of main system**

The beating phenomenon is the basic idea behind the nonlinear absorber.

**Linear case**

Intensive energy exchange

- **How to avoid the return of energy?**
- **Damping is not the solution**
- **Instead use strong nonlinearity**

**Nonlinear case**

For a certain energy level, there is an energy exchange (beating).

- **For a nonlinear system: frequency depends on energy**
- **Damping decreases energy**
- **Frequency changes**
- **Energy sink**

The nonlinear absorber reduces transient vibrations much faster than the linear absorber.

**Main system**

\[ \begin{align*}
\ddot{x}_1 + c_1(x_1 - \dot{x}_2) + \frac{4}{3}(x_1 - x_2)^3 &= 0 \\
\ddot{x}_2 - c_2(x_2 - \dot{x}_1) + \frac{4}{3}(x_2 - x_1)^3 &= 0
\end{align*} \]

**Nonlinear absorber**

\[ \begin{align*}
\dot{\ddot{x}}_1 + c_1\dot{x}_1 &+ \frac{4}{3}(x_1 - x_1)^3 = 0 \\
\dot{\ddot{x}}_2 - c_2\dot{x}_2 &+ \frac{4}{3}(x_2 - x_2)^3 = 0
\end{align*} \]

**BUT...**

- Highly discontinuous !!!

The frequency energy plot helps to understand the important phenomena.

**Nonlinear normal modes**

Wavelet transform

Averaging theory can be used to analyze the nonlinear absorber in an approximate way.

**Example of averaging**

\[ \begin{align*}
\dot{x} &= -\alpha x^2 t \\
x(t) &= \exp\left(-\frac{\alpha}{2} t^2 \right) \sin(2t)
\end{align*} \]

\[ \langle x(t) \rangle = \frac{1}{2\pi} \int_{-\infty}^{\infty} x(t) \, dt \]

\[ \langle x(t) \rangle = -\frac{\alpha}{2} \int_{-\infty}^{\infty} t \sin^2 \pi t \, dt \]

\[ \approx -\frac{\alpha^2}{4} \]

**Nonlinear 2DOF system**

- **Energy (big scale)**
- **Energy (small scale)**

**Two solutions**

- **Averaged solution**

How to describe all this?

E-mail: Frits.Petit@ugent.be

Frits Petit, Mia Locuufier & Dirk Aeyels

Systems Research Group, Ghent University,
Department of Electrical Energy, Systems and Automation
Technologiepark 914, 9052 Zwijnaarde