Base Shake — Random PSD
Solution Method with Verification & Limitations

1. Overview

This module simulates base-excited rigid-body motion using a four-corner spring–damper system subject to a random acceleration time history generated from a one-sided PSD input. The solver produces top center acceleration, corner spring reactions, and animation of the relative motion between the base and the mass.

2. Governing Equations

The rigid body has three degrees of freedom: vertical translation z, rotation θx, and rotation θy. An additional two DOF represent base displacement zb and velocity vb driven by the random acceleration input.

Each corner spring produces force $F_i = -(k_i * \delta_i + c_i * \dot{\delta}_i)$, where δ_i and $\dot{\delta}_i$ are the relative displacement and velocity between the top rigid body corner and the base. Summation of these four corner forces produces the net vertical force and pitch/roll moments. Base motion is governed by $m_{base} * \ddot{z}b = m_{base} * a_{base}(t) - \Sigma(F_i) - k_{ground}\, zb - c_{ground}\, \dot{z}b$.

See the base shake model.

3. Random PSD Time-History Generation

The user specifies a one-sided PSD S(f) in G^2/Hz. The code performs log–log interpolation between the tabulated points, constructs amplitudes $A_k = \sqrt{2\, S(f_k)\, \Delta f}$, assigns random phases, and synthesizes the signal by inverse Fourier summation. Optional Tukey tapering reduces spectral leakage.

4. Time Integration (RKF45)

The system of ODEs is integrated using an adaptive Fehlberg Runge–Kutta (RKF45) method with local error control. Adaptive step sizing captures both the high-frequency PSD content and the system's rigid-body modes.

5. Outputs

Outputs include: (1) top center acceleration (G), (2) corner spring forces, (3) maximum accelerations at center and corners, (4) animated visualization of rigid-body response, and (5) JSON/CSV export of all time histories.

6. Verification & Limitations

Rigid-body assumption: The top object is treated as a perfectly rigid mass. No panel bending modes or internal flexibility are included.

No nonlinear springs or impacts: Springs are linear in both stiffness and damping. Bottoming-out or separator limits are not modeled.

PSD interpolation accuracy: The PSD is log–log interpolated between user points. Poorly spaced points can distort intended shapes.

No frequency-domain solution: Only time-domain simulation is used; no transfer-function or modal-response PSD integration.

Base plate modeling is simplified: The base has a large lumped mass and linear ground spring approximation, not a full mounting system.

High-frequency fidelity limited by sample rate: PSD input above Nyquist frequency (fs/2) is discarded.