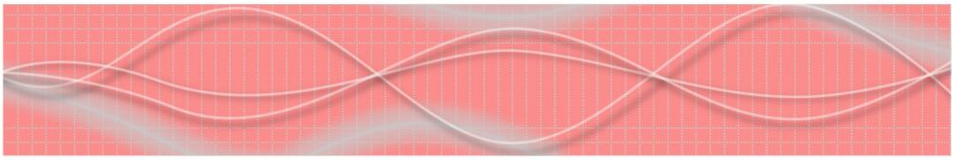
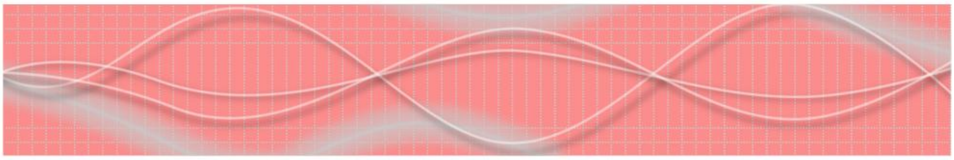
Professional Signal & Spectrum Analysis



WHITE PAPER

Shock Response Spectrum (SRS) for Transient Events

Quantifying damage potential of impacts, drops, and pyrotechnic shocks with SIGVIEW



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Overview

When a structure or device experiences a transient acceleration — a hammer impact, drop test, pyrotechnic separation event, or earthquake pulse — the conventional FFT gives only a limited view. A transient signal’s spectrum spreads its energy across a broad band and tells you nothing about how a specific resonant component would actually respond. The Shock Response Spectrum (SRS) answers exactly that question: for every conceivable natural frequency, how badly would a single-degree-of-freedom oscillator at that frequency be hammered by this shock? The SRS is the standard metric for shock specification in aerospace, defence, automotive, and consumer electronics qualification, and SIGVIEW computes it natively.

Background

What an SRS actually represents

Take an infinite family of single-degree-of-freedom (SDOF) mass-spring-damper systems, each with a different natural frequency f_n and the same damping ratio (typically 5 %, i.e. Q = 10). Subject each one to the recorded shock pulse and record its peak acceleration response. Plot those peak values against f_n. That plot is the SRS. The X-axis is natural frequency; the Y-axis is the peak acceleration any oscillator at that frequency would experience. An equipment specification of "30 g SRS at 100 Hz, Q = 10" means an SDOF system with f_n = 100 Hz subjected to the shock would peak at 30 g.

Why aerospace and defence rely on SRS

Two shocks with identical peak amplitudes and durations can damage equipment very differently if their frequency content differs. The SRS captures this directly. Qualification standards (MIL-STD-810, NASA-STD-7003, ECSS-E-ST-10-03C) specify shock environments as SRS profiles, and test labs reproduce them on shaker tables programmed to match the target SRS. Any new component must demonstrate it can survive the specified SRS at its mounting location, with margin.

SRS Variants

Variant	When to use
Maximax (positive peak)	Default for most aerospace / defence work. Reports the largest absolute peak of each oscillator’s response.
Primary (peak during pulse)	Used when the shock pulse itself is the concern (drop, impact). Ignores ring-down.
Residual (peak after pulse)	Used when ring-down causes the damage (pyrotechnic shocks on sensitive optics).
Pseudo-velocity (PVSS)	Damage-mechanism-relevant for ductile materials; integrates SRS over period.

Test Signal

A representative shock pulse is provided:

- `shock_pulse.wav` — 0.5 s, 10 000 Hz, mono. A half-sine acceleration pulse of 11 ms duration with a nominal 50 g peak, followed by structural ring-down at 250 Hz and 850 Hz. This is typical of a drop-table calibration shock.

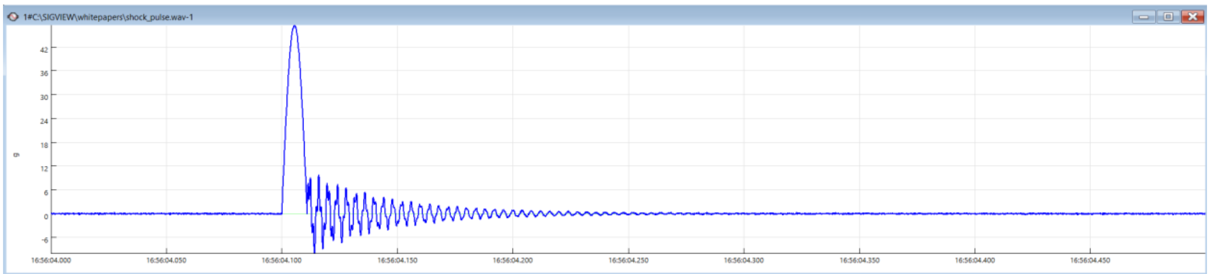
> **Recovering physical units:** If you perform data acquisition on your own, apply a corresponding calibration factor or simply scale the signal after data acquisition.

Real Measurement Setup

- **Accelerometer:** for high-g events, use a piezoelectric shock accelerometer (e.g. 5000 g range, 10 kHz to 50 kHz bandwidth). For low-amplitude long-duration pulses (drop tests of consumer electronics), a high-sensitivity MEMS device works.
- **Mounting:** must transmit the full event bandwidth. Stud-mount is best; epoxy is acceptable; wax or magnetic mounts are not, because they have a low resonance and clip high-frequency content.
- **Sample rate:** at least 10× the highest SRS frequency of interest. For aerospace pyrotechnic shocks specified to 10 kHz, sample at 100 kHz or higher.
- **Trigger:** use the rising edge of the accelerometer signal with a generous pre-trigger (10–20 % of total record length) to ensure the leading edge of the pulse is captured.

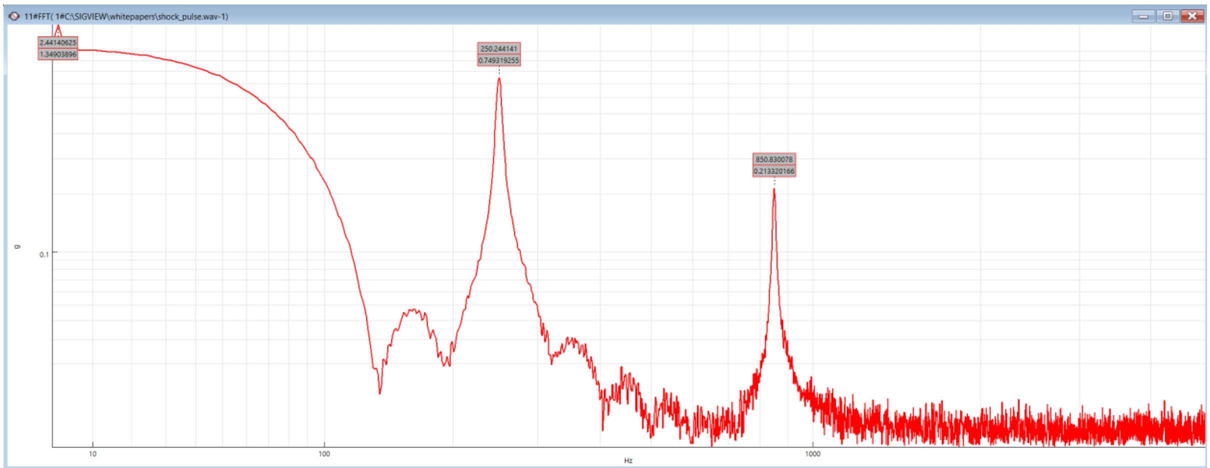
Procedure in SIGVIEW

1. **Load the signal.** Open `shock_pulse.wav` via `File / Open...` A time-domain window appears showing the half-sine pulse followed by ring-down.



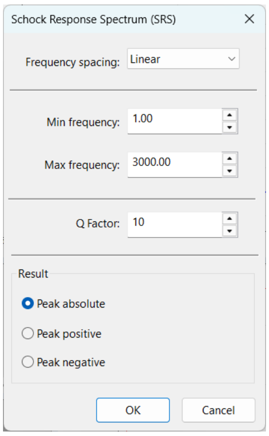
Time-domain window with the shock pulse. X-axis: 0–0.5 s. Y-axis: acceleration. A sharp half-sine bump rises at t = 0.10 s, peaks at ~50 g (or normalized equivalent), and decays in 11 ms. A short decaying ring-down at 250 Hz follows, fading after ~100 ms.

2. **Inspect the spectrum (optional sanity check).** Press `Ctrl+F` to compute the FFT. Note the smooth lobed shape characteristic of a half-sine pulse, with notches at multiples of 1/T (where T is the pulse duration), and prominence at the ring-down frequencies.



FFT magnitude of the shock pulse (log-log axis). X-axis: 0–5000 Hz. The classic sinc-like spectrum of a half-sine pulse is visible: a broad central lobe, the first null near 1/T = 90 Hz, then smaller lobes. Two narrow peaks rise above this envelope at 250 Hz and 850 Hz — the ring-down content.

3. **Compute the SRS.** With the time-domain window active, choose `Signal tools / Shock Response Spectrum (SRS)...` The SRS configuration dialog opens.



Frequency spacing: Linear

Min frequency: 1.00

Max frequency: 3000.00

Q Factor: 10

Result

● Peak absolute

○ Peak positive

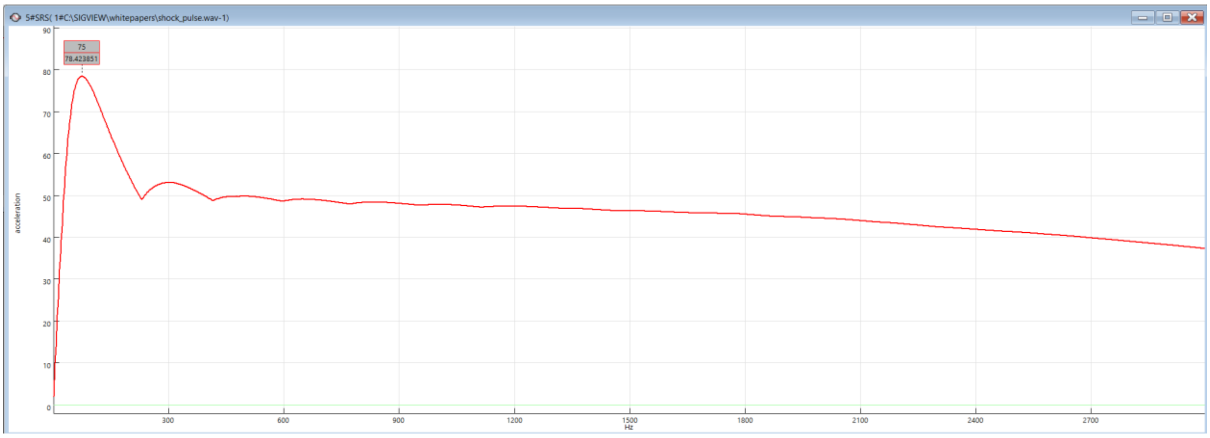
○ Peak negative

Shock Response Spectrum dialog. Visible parameters: frequency spacing (combo-box for 1/24, 1/12, 1/6, 1/3 octave, and Linear), Q-factor input (default 10, corresponding to 5 % damping), Minimum and Maximum frequency fields (defaults 10 Hz and 5000 Hz), and Peak detection method dropdown. An "OK" button initiates the calculation.

4. **Configure SRS parameters.** Recommended starting values:

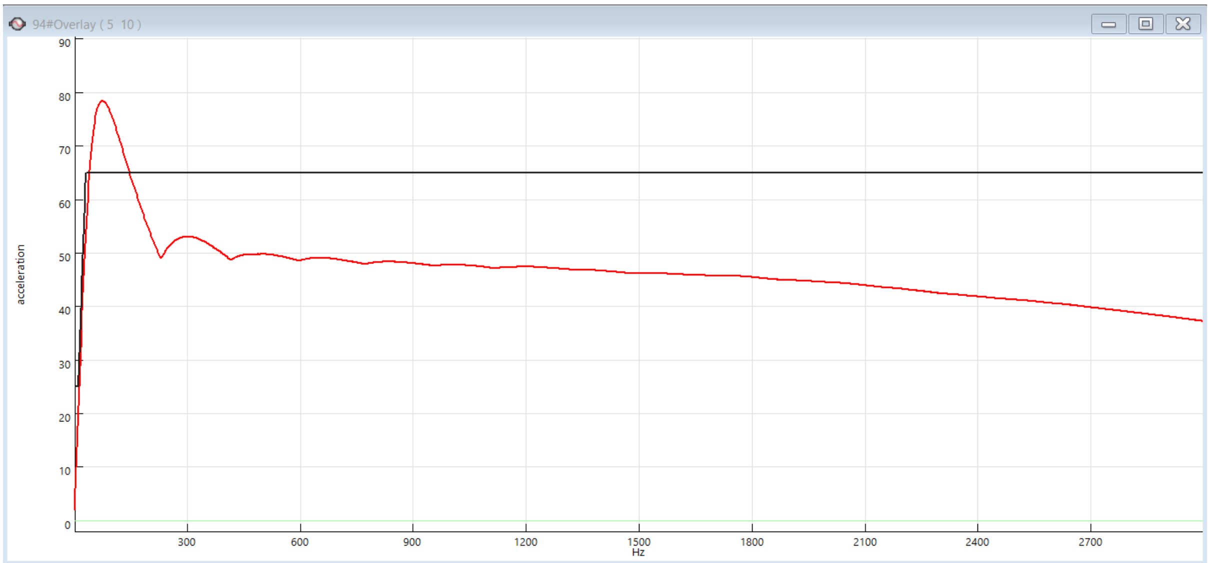
- **Frequency spacing:** Linear (works well for short signals – choose some of Octave options for faster computation time)
- **Q factor:** 10 (the industry-standard 5 % damping, used in MIL-STD-810).
- **Minimum frequency:** 10 Hz (or lower if your structure has very low modes).
- **Maximum frequency:** ~Nyquist / 2 to leave headroom (e.g. 3000 Hz when sampling at 10 kHz).
- Click OK. The SRS computation runs and a new SRS window opens.

5. **Inspect the SRS curve.** The X-axis is natural frequency (log-spaced). The Y-axis is peak acceleration. Use mouse cursors to read peak values at specific frequencies.



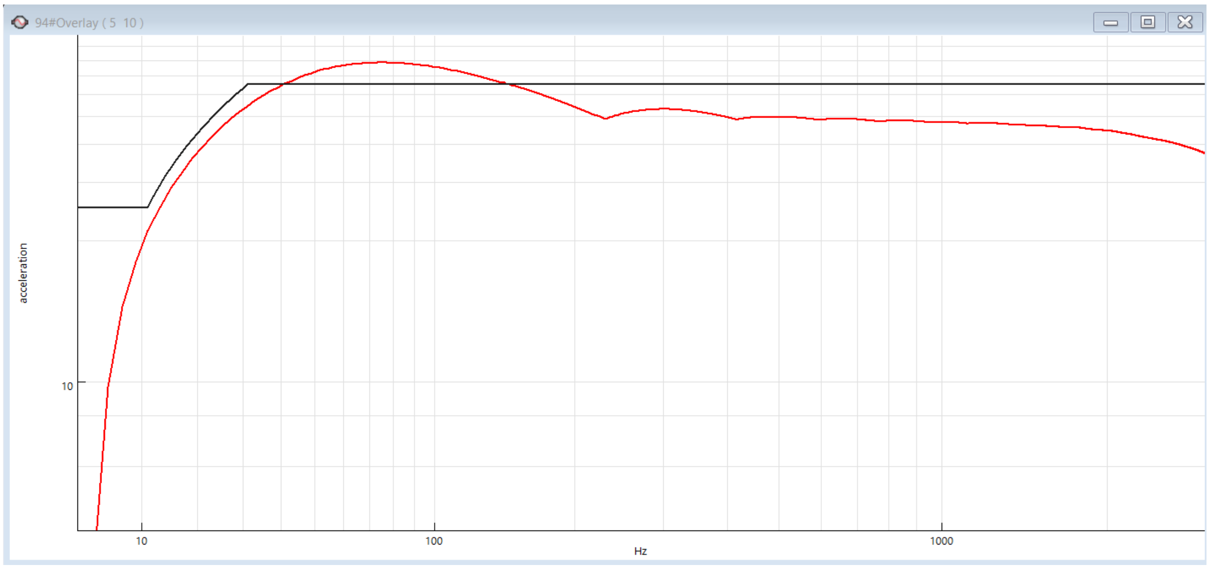
SRS plot window (log-log axis). X-axis: frequency from 10 Hz to 3000 Hz. Y-axis: peak acceleration. The curve rises steeply from low frequency, reaches a dominant peak of ~1.55× the input peak at roughly 70 Hz (this is the pulse-equivalent resonance, near 0.8/T where T is the half-sine duration), drops to a local minimum around 200–230 Hz, then shows a smaller lobe around 280–310 Hz caused by the 250 Hz ring-down content in the input. Above ~500 Hz the SRS approaches the input peak amplitude asymptotically — the static limit reached when the SDOF oscillator is much stiffer than the pulse.

6. **Compare against a specification (if applicable).** Open the qualification specification curve as a separate signal (CSV import via `File / ASCII/CSV files...` with the SIGVIEW ASCII / CSV loader). Use `Context menu / Overlay with>` to plot the measured SRS and the spec on the same axes. Any frequency where the measured SRS exceeds the spec indicates a margin failure.



Example of comparison between qualification specification curve (black) and the SRS curve (red). Any region where the red SRS rises above the black spec is a margin failure. In this demo signal the failure is centered around 70 Hz, spanning roughly 30–110 Hz at the SDOF natural frequency that resonates most strongly with the 11 ms pulse. Above ~110 Hz the SRS stays comfortably below the 65 plateau, including the small 290 Hz ring-down lobe.

7. **Switch to logarithmic Y-axis.** For aerospace work the SRS is conventionally plotted on log–log axes. Right-click in the SRS window, turn `Logarithmic X/Y-axis` on. Both axes are now logarithmic, matching MIL-STD-810 plot conventions.



SRS plot redrawn on log–log axes. The curve now appears as a slowly rising line that flattens above 100 Hz, making compliance with a typical "3 dB / octave roll-up below 100 Hz, flat above" specification curve easy to verify visually.

Damping Sensitivity Studies

SRS shape changes with the assumed damping. Q = 10 (5 % damping) is the default; higher Q values (less damping) produce sharper resonance peaks and higher peak g values. For sensitive equipment or unusual structural damping, repeat the SRS calculation with several Q values and compare. Multiple SRS windows can be overlaid using SIGVIEW's overlay feature to visualise damping sensitivity in one plot.

Saving Results

Export the SRS to ASCII / CSV for inclusion in test reports: select the SRS window and choose `File / Save signal as / ASCII/CSV files / Export signal as ASCII/CSV`. Each row contains frequency and peak acceleration. The resulting file imports directly into Excel, MATLAB, or any reporting pipeline.

Interpretation Cheat-Sheet

Pattern in the SRS	Implication
Smooth, broad peak around 1/T (T = pulse duration)	Pure pulse-driven response; no significant structural ring-down.
Narrow spike at a specific frequency	Structural mode being excited; that frequency component will damage components at this natural frequency.
Steep rise below 100 Hz	Long-duration content (slow drop, low-stiffness mounting); large displacement, low force.
Flat / rising profile above 1 kHz	High-frequency content (pyrotechnic-like); danger for stiff sensitive components (crystals, optics).
SRS exceeds spec at one frequency	Local margin violation; redesign mount or add isolator at that frequency.

Pattern in the SRS	Implication
SRS exceeds spec broadband	Source shock is too severe; problem is at the excitation, not the structure.

Common Pitfalls

- **Sampling rate too low:** clips the high-frequency content of the shock and underestimates SRS above f_s / 10. Always sample 10× the highest SRS frequency of interest.
- **Wrong mounting:** wax or magnetic mounts have a low resonance (often 5–10 kHz for magnets) that bandwidth-limits the accelerometer. Use stud mounting for SRS above 2 kHz.
- **Wrong Q:** if your spec uses Q = 50 (2 % damping) but you compute at Q = 10, you will systematically underestimate the peaks.
- **Comparing primary to maximax:** confirm both your measured and the spec curves use the same SRS variant.
- **Frequency range too narrow:** if the spec extends to 10 kHz but you computed only to 2 kHz, you cannot demonstrate compliance.

Summary

The Shock Response Spectrum quantifies how a transient excites every possible natural frequency, making it the right metric for aerospace, defence, and consumer-electronics shock qualification. SIGVIEW computes the SRS natively with configurable octave spacing, damping, and frequency range. Combined with overlays for specification compliance and CSV export for formal reports, SIGVIEW covers the full SRS workflow from raw acquisition to deliverable.