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VIBROANALYTICS
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TECHNICAL DATASHEET

DIN 60068 Vibration Testing Software

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1. Overview

VibroAnalytics is a comprehensive software solution for vibration testing conforming to DIN 60068-2-6 standards. Developed by SADAP GmbH, it provides a complete workflow from initial background noise measurement through endurance testing with real-time compliance validation and F1 Telemetry-inspired visualization.

Analysis Framework

Each phase provides three complementary analysis tools:

Tool	Purpose	When to Use
Analysis Metrics	Visual inspection of 6 key plots per phase	Automatic after phase completion
Statistical Analysis	Quantitative assessment with DIN compliance	Manual, for detailed investigation
Waterfall Analysis	3D time-frequency evolution visualization	Manual, for transient/stability analysis

Data Flow Between Phases

Phase 1 (Initial Check) → Raw: background_data (acceleration)

Phase 2 (Low-Level Sweep) → Processed: force_data, displacement_data → FRF, coherence

Phase 3 (Resonance Search) → Results: modes[], fn, ζ, Q for each resonance

Phase 4 (Endurance Test) → Monitoring: freq_values[], amp_values[], coherence_values[]

2. Phase 1: Initial Check

Purpose: Verify background noise levels and measurement system quality before excitation. Detect fundamental issues that would invalidate subsequent analysis.

Data Source: Raw acceleration signal (background vibration)

2.1 Analysis Metrics (6 Plots)

Plot	Content	What to Look For
Acceleration Time Domain	a(t) waveform with RMS lines	Drift, transients, clipping, saturation
Signal Statistics	RMS, Peak, Crest Factor, Duration	Abnormal values indicating sensor issues
Power Spectral Density	PSD with DIN frequency range highlight	Noise floor level, unexpected peaks
DIN Requirements	Sample rate, duration, data points, RMS	All bars reaching 100% compliance
Amplitude Distribution	Histogram with mean ± σ markers	Gaussian-like distribution (healthy signal)
Signal Stationarity	Segment RMS over time ± 10% bounds	All points within ±10% of mean RMS

2.2 Statistical Analysis (5 Types)

Analysis Type	Metrics Computed	DIN Relevance
Signal Quality Assessment	SNR, dynamic range, noise floor, THD	DIN 60068 §5.3: Signal quality

Analysis Type	Metrics Computed	DIN Relevance
Distribution Analysis	Skewness, kurtosis, normality tests	Validates statistical assumptions
Stationarity Test	ADF test, KPSS test, trend analysis	DIN 60068 §5.2: Stationary signals
Coherence Preview	$\gamma^2(f)$, mean coherence, dropout %	DIN 60068 §6.4.2: $\gamma^2 \geq 0.95$
Cross-Correlation Analysis	Lag, correlation coefficient, sync error	DIN 60068 §5.4: Time alignment

2.3 Waterfall Analysis (3 Types)

View Type	3D Visualization	DIN Relevance
Magnitude	$\lvert H(f,t) \rvert$ 3D surface evolution	FRF temporal stability verification
Phase	$\phi(f,t)$ 3D phase surface	Phase consistency over time
Coherence	$\gamma^2(f,t)$ 3D coherence surface	DIN 60068 §6.4.2: γ^2 temporal stability

2.4 Phase 1 Summary

The Initial Check phase answers: "Is this measurement system ready for testing?"

Question	Analysis Tool	Pass Criteria
Is sample rate adequate?	DIN Requirements	$f_s \geq 5$ kHz
Is background noise low?	Signal Statistics	RMS < 0.1 g
Is the data stationary?	Stationarity + Waterfall	ADF $p < 0.05$, RMS CV < 10%
Is duration sufficient?	DIN Requirements	Duration ≥ 60 s
Are there enough samples?	DIN Requirements	Data points ≥ 300,000

3. Phase 2: Low-Level Sweep

Purpose: Perform full frequency sweep at low amplitude to characterize system transfer function and identify frequency response characteristics.

Data Source: Force signal F(t), Displacement signal X(t)

3.1 Analysis Metrics (6 Plots)

Plot	Content	What to Look For
FRF Magnitude	$|H(f)|$ in dB with peak markers	Resonance peaks, overall transfer function shape
Phase Response	$\phi(f)$ with 0°, ±90° reference lines	Phase transitions at resonances
Coherence Function	$\gamma^2(f)$ with DIN threshold (0.95)	Values above 0.95, poor coherence regions
Coherence Statistics	Mean, Min, Max, >95% percentage bars	All bars reaching 95% threshold
Bode Plot	Combined magnitude + phase (log scale)	System dynamics, resonance identification
Control Error	% deviation from unity gain, DIN 10% limit	Error below 10% across frequency range

3.2 Statistical Analysis (5 Types)

Analysis Type	Metrics Computed	Acceptance Criteria
Control Error	Mean error, Max error, points within limit	Mean ≤ 10%, Points within limit ≥ 90%
Coherence Statistics	Mean, Min, Std by frequency band	Mean ≥ 0.95, Min ≥ 0.90
Phase Response	Linearity R^2, discontinuities count	$R^2 \geq 0.80$, discontinuities ≤ 5
SNR Distribution	Mean SNR, Min SNR by band	Mean ≥ 40 dB, Min ≥ 20 dB
Cross-Axis Motion	Cross-axis to main-axis ratio	Ratio ≤ 50%

3.3 DIN 60068 Compliance Checks

Parameter	Requirement	Severity	Status
Mean Coherence	$\gamma^2 \geq 0.95$	CRITICAL	Pass/Fail
Frequency Range	5 - 2000 Hz minimum	CRITICAL	Pass/Fail
Resolution	$\Delta f \leq 1.0$ Hz	CRITICAL	Pass/Fail
SNR	≥ 40 dB	CRITICAL	Pass/Fail
Sweep Rate	1.0 ± 0.1 oct/min	WARNING	Info

4. Phase 3: Resonance Search

Purpose: Identify and validate resonance frequencies from sweep data. Apply strict DIN 60068 criteria to determine which modes are suitable for endurance testing.

Data Source: FRF from sweep phase (or new force/displacement data)

4.1 DIN 60068 Resonance Criteria

A mode is DIN-compliant only if ALL of the following are satisfied:

Parameter	Requirement	Physical Meaning
Q-Factor	Q ≥ 10	Sharp, well-defined resonance peak
Coherence	$\gamma^2 \geq 0.95$	Strong input-output correlation at mode
Damping Ratio	0.1% ≤ ζ ≤ 5%	Valid mechanical damping range
Frequency Range	5 Hz ≤ fn ≤ 2000 Hz	Within DIN test frequency band
Mode Separation	≥ 0.1 octaves	Modes must be distinguishable

4.2 Analysis Metrics (6 Plots)

Plot	Content	What to Look For
Resonance Frequencies	Bar chart of fn for each mode	Modes within 5-2000 Hz range
Q-Factor Analysis	Q values with DIN min (10) line	Green bars (Q ≥ 10) for compliant modes
Damping Ratio	ζ% with 0.1-5% valid band	Values within shaded valid region
Coherence at Resonance	γ^2 at each mode with 95% threshold	All bars above 95% threshold line
Mode Spacing	Octave spacing between adjacent modes	Spacing ≥ 0.1 octaves (DIN min)
DIN Compliance Summary	Horizontal bars: pass ratio per criterion	All criteria reaching 100%

4.3 Statistical Analysis (4 Types)

Analysis Type	Metrics Computed	DIN Relevance
Modal Parameters	fn, ζ, Q distributions, mode count	Mode count ≤ 5, valid parameter ranges
Mode Shapes	Mode separation analysis, clustering	Separation ≥ 0.1 octaves
Damping Analysis	ζ range, Q-factor correlation	ζ = 1/(2Q), range 0.1% - 5%
Q-Factor Statistics	Distribution, compliance ratio, outliers	All modes Q ≥ 10 for compliance

5. Phase 4: Endurance Test

Purpose: Long-duration stability test at selected resonance frequency. Monitor for degradation, frequency shift, and amplitude changes over the test duration.

Data Source: Continuous force/displacement monitoring at resonance frequency

5.1 DIN 60068 Stability Criteria

Parameter	Requirement	Formula	Unit
Frequency Shift	≤ ± 5%	$\Delta f/f_0 \times 100$	%
Amplitude Change	≤ ± 10%	$\Delta A/A_0 \times 100$ (LINEAR)	%
Coherence	≥ 0.95 maintained	$\gamma^2(t)$ throughout test	—
Test Duration	≥ 3600 seconds	Total test time	s

CRITICAL: Amplitude change is calculated in LINEAR domain (10% linear ≈ 0.83 dB), not in dB.

5.2 Two-Tier Compliance Assessment

Phase 4 implements a two-tier compliance system per DIN 60068-2-6 Section 5.7:

Level	DIN Standard	SADAP Enhanced
Frequency Shift	$\lvert \Delta f_r \rvert < 5\%$	$\lvert \Delta f_r \rvert < 0.5\%$
Amplitude Change	$\lvert \Delta X/X_0 \rvert < 10\%$	$\lvert \Delta X/X_0 \rvert < 3\%$
Duration	≥ 3,600 s	(same)
Coherence	$\gamma^2 \geq 0.95$	(same)

Interpretation:

Both Pass	Excellent — Exceptional stability, specimen suitable for service
DIN Only	Acceptable — Investigate friction interface per Section 5.7
DIN Fail	FAILED — Specimen requires re-testing or rejection

5.3 Analysis Metrics (6 Plots)

Plot	Content	What to Look For
Frequency Trend + CI	f(t) scatter + linear trend + 95% CI	Slope within ±5% band, narrow CI
Amplitude Trend + CI	A(t) % change + trend + DIN ±10% lines	Values within ±10% bounds
Environmental Effects	Detrended signal, thermal cycling detection	No thermal cycling detected (stable)
Degradation Trends	Normalized freq/amp degradation %	Low degradation class, TTF >> test time
Event Timeline	Discrete events (freq/amp) markers	Minimal events, no clustering
Correlation Matrix	Freq-Amp-Coh-Time heatmap	Low cross-correlations (independent)

5.4 Statistical Analysis (5 Types)

Analysis Type	Metrics Computed	DIN Relevance
Stability Analysis	Overall compliance summary, pass/fail	Aggregate DIN 60068 stability check
Frequency Stability	Max shift, drift rate, trend p-value	Shift ≤ 5%, drift ≤ 1%/hr
Amplitude Stability	Max change, drift rate, trend p-value	Change ≤ 10%, drift ≤ 2%/hr

Analysis Type	Metrics Computed	DIN Relevance
Degradation Analysis	Class (Low/Mod/High), rate, TTF estimate	Predict remaining useful life
Environmental Effects	Thermal cycling, parameter correlations	Detect external influences

5.5 Degradation Classification

Classification	Rate Threshold	Interpretation
Low	< 0.5%/hour	Excellent stability
Moderate	0.5% – 2.0%/hour	Monitor closely
High	> 2.0%/hour	Investigate cause

5.6 Discrete Event Detection

Sudden structural changes are detected between measurement segments:

Event Type	Threshold	Physical Interpretation
Frequency Event	> 3% change	Stiffness reduction → crack growth, joint loosening
Amplitude Event	> 5% change (linear)	Damping change → friction modification, material yield

Note: Frequency decrease indicates stiffness reduction; amplitude decrease indicates increased damping.

5.7 Cycle Count Calculation

Fatigue cycle count for S-N curve assessment: **N_cycles = duration_seconds × frequency_hz**

Example: 3600 s at 150 Hz = 540,000 cycles

6. Cross-Phase Relationships

6.1 Phase Dependency Chain

Each phase builds upon validated results from the previous phase:

Phase 1 (Initial Check) → Validates measurement system readiness

↓ (system validated)

Phase 2 (Low-Level Sweep) → Characterizes transfer function, validates coherence

↓ (FRF validated, $\gamma^2 \geq 0.95$)

Phase 3 (Resonance Search) → Identifies DIN-compliant modes for testing

↓ (≥1 compliant mode required)

Phase 4 (Endurance Test) → Monitors stability at selected resonance

6.2 Waterfall Analysis Connections

Phase	Primary Waterfall Check	Pass Criteria
1. Initial Check	Coherence surface $\gamma^2(f,t)$ stability	Uniform surface, no temporal drift
2. Low-Level Sweep	Magnitude $\|H(f,t)\|$ consistency	Stable resonance peaks over time
3. Resonance Search	Phase $\phi(f,t)$ at mode frequencies	Phase transitions consistent
4. Endurance Test	All three (Mag/Phase/Coh) stability	No degradation patterns visible

6.3 Cumulative Quality Assessment

If Phase 1...	Then Phase 2...	Then Phase 3...	Then Phase 4...
Low coherence	Poor FRF quality	Unreliable modes	Invalid test
Non-stationary	Invalid spectral	False resonances	Unstable baseline
Poor SNR	Noisy transfer fn	Scattered Q-factors	High uncertainty
✓ All pass	✓ Clean FRF	✓ Valid modes	✓ Reliable test

7. DIN 60068 Compliance Chain

Complete DIN 60068-2-6 compliance requires verification at each phase:

Phase 1: Initial Check

- Verify sample rate ≥ 5 kHz
- Verify background RMS < 0.1 g
- Stationarity confirmed (ADF $p < 0.05$)
- Duration ≥ 60 seconds

Phase 2: Low-Level Sweep

- Verify coherence $\gamma^2 \geq 0.95$ (mean)
- Frequency range covers 5 - 2000 Hz
- Resolution $\Delta f \leq 1.0$ Hz
- SNR ≥ 40 dB

Phase 3: Resonance Search

- At least 1 mode with Q ≥ 10
- Mode coherence $\gamma^2 \geq 0.95$
- Damping ratio 0.1% ≤ ζ ≤ 5%
- Mode separation ≥ 0.1 octaves

Phase 4: Endurance Test

- Frequency shift ≤ ±5%
- Amplitude change ≤ ±10% (LINEAR domain)
- Test duration ≥ 3600 seconds
- Coherence maintained ≥ 0.95

→ COMPLIANT: Full DIN 60068-2-6 measurement with phase-by-phase validation

8. Key Formulas Reference

Formula	Phase	Purpose
$H(f) = X(f) / F(f)$	2	Frequency Response Function
$\gamma^2(f) = \lvert Sxf \rvert^2 / (Sxx \cdot Sff)$	1, 2, 3	Coherence function
$SNR = 10 \cdot \log_{10}(\gamma^2 / (1 - \gamma^2))$	2	Signal-to-noise ratio from coherence
$Q = fn / \Delta f_3dB$	3	Quality factor (sharpness)
$\zeta = 1 / (2Q)$	3	Damping ratio
$\Delta f/f_0 \times 100 \leq 5\%$	4	Frequency shift limit
$\Delta A/A_0 \times 100 \leq 10\%$ (LINEAR)	4	Amplitude change limit
Octave spacing = $\log_2(f_2/f_1)$	3	Mode separation calculation
N_cycles = duration × frequency	4	Fatigue cycle count
Degradation Rate = max(trends) × 100	4	Material degradation [%/hour]

9. Data Requirements

Minimum data requirements per DIN 60068-2-6:

Parameter	Minimum	Recommended	Optimal
Sampling Rate	5 kHz	10 kHz	20+ kHz
Initial Check Duration	60 s	120 s	300 s
Frequency Resolution	≤ 1.0 Hz	≤ 0.5 Hz	≤ 0.25 Hz
Sweep Rate	1.0 oct/min	1.0 oct/min	0.5-1.0 oct/min
Coherence (mean)	0.95	0.97	0.99+
SNR	40 dB	50 dB	60+ dB
Endurance Duration	3600 s (1 hr)	7200 s (2 hr)	14400+ s (4+ hr)
Q-Factor (modes)	≥ 10	≥ 15	≥ 20

9.1 Supported Data Formats

- CSV files with Time(s) and signal columns (Force, Displacement, Acceleration)
- ORF recordings from CF-9200A FFT Analyzer (direct import with segmented recording support)
- Column headers: Time(s), Force(N), Displacement(mm), Acceleration(g)

10. Summary Tables

10.1 All Analyses by Phase

Phase	Metrics (6)	Statistical (4-5)	Waterfall (3)
1. Initial Check	Time, Stats, PSD, DIN Req, Distrib, Station	Signal, Distrib, Station, Coh, Cross-Corr	Mag, Phase, Coh
2. Low-Level Sweep	FRF, Phase, Coh, Coh Stats, Bode, Error	Ctrl Err, Coh Stats, Phase, SNR, Cross-Ax	Mag, Phase, Coh
3. Resonance Search	Freq, Q-Factor, Damp, Coh, Spacing, Compl	Modal, Shapes, Damping, Q-Stats	Mag, Phase, Coh
4. Endurance Test	Freq CI, Amp CI, Environ, Degrad, Events, Corr	Stability, Freq, Amp, Degrad, Environ	Mag, Phase, Coh

10.2 DIN 60068 Quick Reference

Phase	Critical Check	Key Metric	Pass Criteria
1. Initial	Background noise	RMS level	< 0.1 g
1. Initial	Stationarity	RMS CV%	< 10%
2. Sweep	Coherence	γ^2 mean	≥ 0.95
2. Sweep	Signal quality	SNR	≥ 40 dB
3. Resonance	Mode sharpness	Q-factor	≥ 10
3. Resonance	Mode validity	Damping ζ	0.1% - 5%
4. Endurance	Freq stability	Max shift	≤ ±5%
4. Endurance	Amp stability	Max change	≤ ±10%

Appendix A: Specimen-Specific Material Thresholds

Phase 4 endurance testing applies material-specific degradation thresholds to account for different failure mechanisms and expected behavior.

B.1 Foil Bearing Materials

Material	Excellent	Warning	Interpretation
Inconel X-750	< 0.5%/hr	> 2.0%/hr	Heat treatment verification
Inconel 718	< 0.4%/hr	> 1.5%/hr	Heat treatment verification
Other Superalloy	< 1.0%/hr	> 3.0%/hr	Heat treatment verification

Note: Foil bearing thresholds verify precipitation hardening state. Elevated rates indicate improper heat treatment.

B.2 Composite Structures

Material	Excellent	Warning	Interpretation
CFRP	< 0.2%/hr	> 1.0%/hr	Matrix damage (microcracking)
GFRP	< 0.3%/hr	> 1.5%/hr	Matrix damage (microcracking)
Sandwich (Foam Core)	< 0.4%/hr	> 1.5%/hr	Core shear, face delamination
Natural Fiber	< 0.5%/hr	> 2.0%/hr	Moisture-sensitive, matrix damage

B.3 Bonded Assemblies & Metals

Material	Excellent	Warning	Interpretation
Adhesive Joints	< 0.3%/hr	> 1.0%/hr	Interface failure, disbond growth
Steel	< 0.3%/hr	> 1.0%/hr	Fatigue crack growth, joint loosening
Aluminum	< 0.4%/hr	> 1.5%/hr	No fatigue limit — continuous monitoring

B.4 Polymer Components

Material	Excellent	Warning	Interpretation
Thermoplastic/Thermoset	< 1.0%/hr	> 3.0%/hr	Viscoelastic changes, crystallization
Elastomer	< 2.0%/hr	> 5.0%/hr	Mullins effect, molecular degradation

Note: Elastomers exhibit Mullins effect (stress softening) which may appear as degradation but is often reversible.

B.5 General/Custom Specimens

Classification	Default Threshold	Interpretation
Excellent	< 0.5%/hour	Structural stability maintained
Moderate	0.5% – 2.0%/hour	Monitor for developing issues
Warning	> 2.0%/hour	Investigate mechanical changes

Document prepared for SADAP GmbH vibration testing per DIN 60068-2-6:2007

Version 3.0 — Complete Technical Datasheet (All Four Phases)