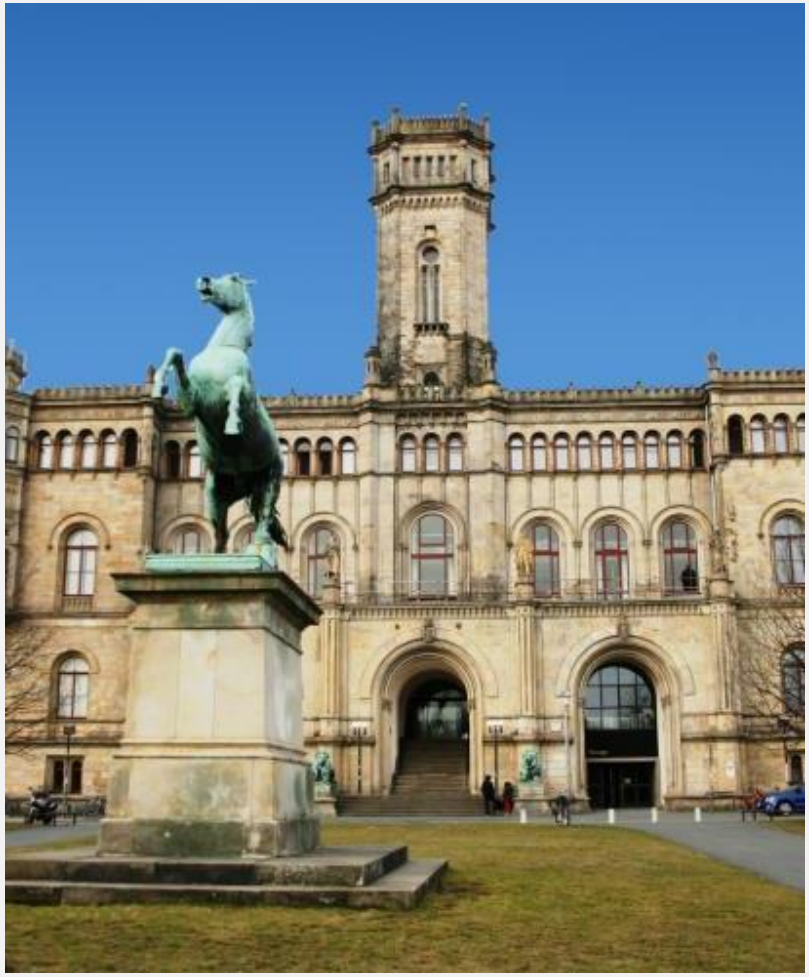
m+p international

Vibration Testing
Noise and Vibration Analysis
Data Acquisition
Test Stand Engineering

Some m+p Facts



Leibniz Universität Hannover

- Founded in 1980 as spin-off of the Institute of Mechanics at Leibniz Universität Hannover, Germany
- Long expertise and experience in vibration testing, structural analysis, process monitoring and test stand engineering
- Significant market share in key industries
- m+p international headquarters in Hannover
- Sales & support subsidiaries in Verona/New Jersey, Farnham/UK, Montesson/France and Beijing
- Representatives and agents worldwide

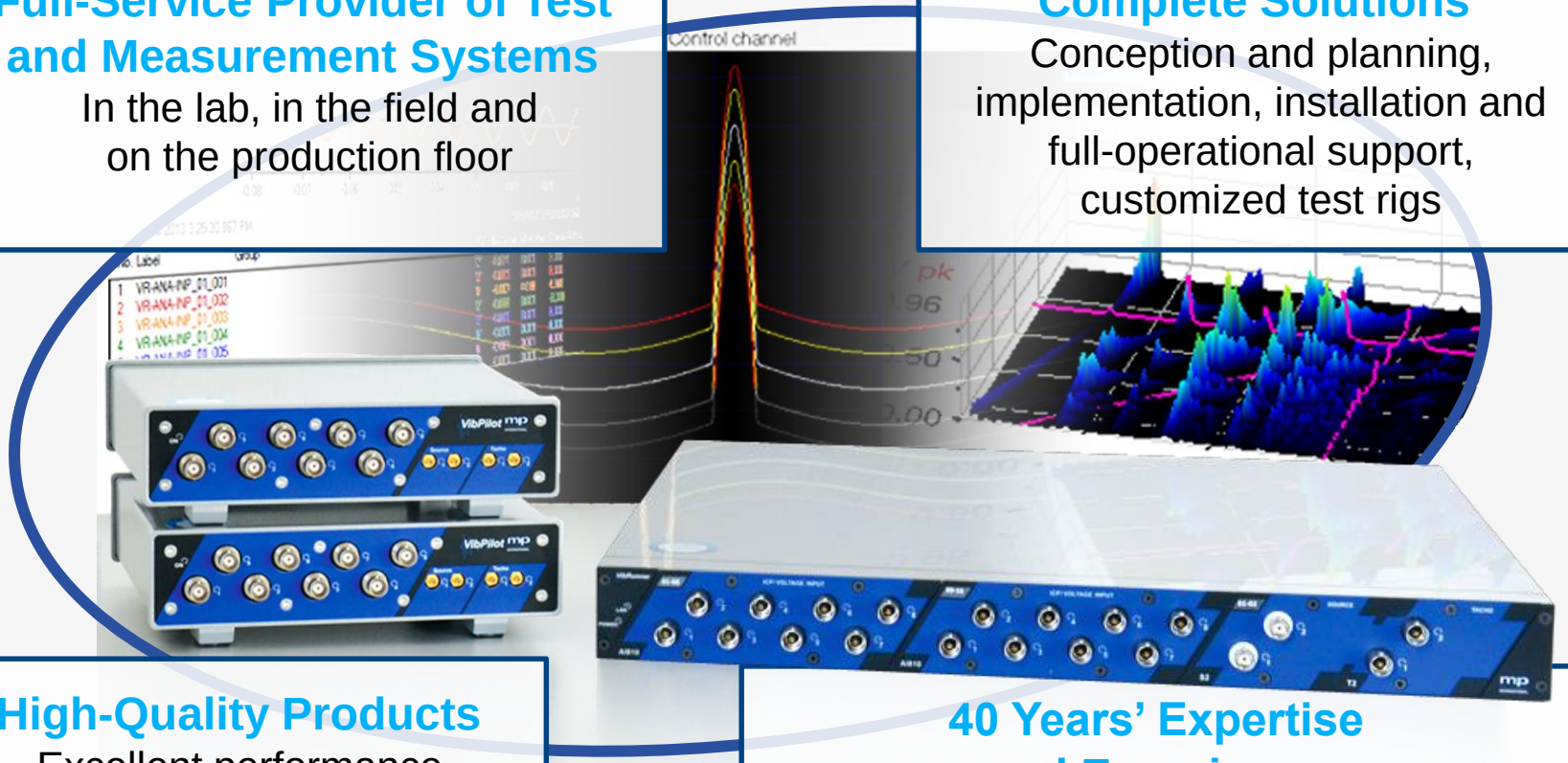
Why So Many Engineers Rely on m+p international

Full-Service Provider of Test and Measurement Systems

In the lab, in the field and on the production floor

Complete Solutions

Conception and planning, implementation, installation and full-operational support, customized test rigs



High-Quality Products

Excellent performance, reliability, stability, longevity and repeatable results

40 Years' Expertise and Experience

Experienced team of engineers, continuous research and development, state-of-the-art hardware and software tools

References in different Industries

Aerospace
Airbus
SSTL
NASA
THALES
RAL
Rolls-Royce

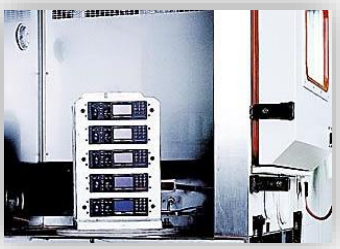
Automotive
Williams F1
Bentley
Aston Martin
Toyota
Volvo

Education
University of Surrey
University of Bath
Universita di Roma
Beijing University
Technische Universitat Berlin

Energy
Vestas
Alstom Nuclear Power
Siemens
Cummins Generators
Avalon Earth Sciences

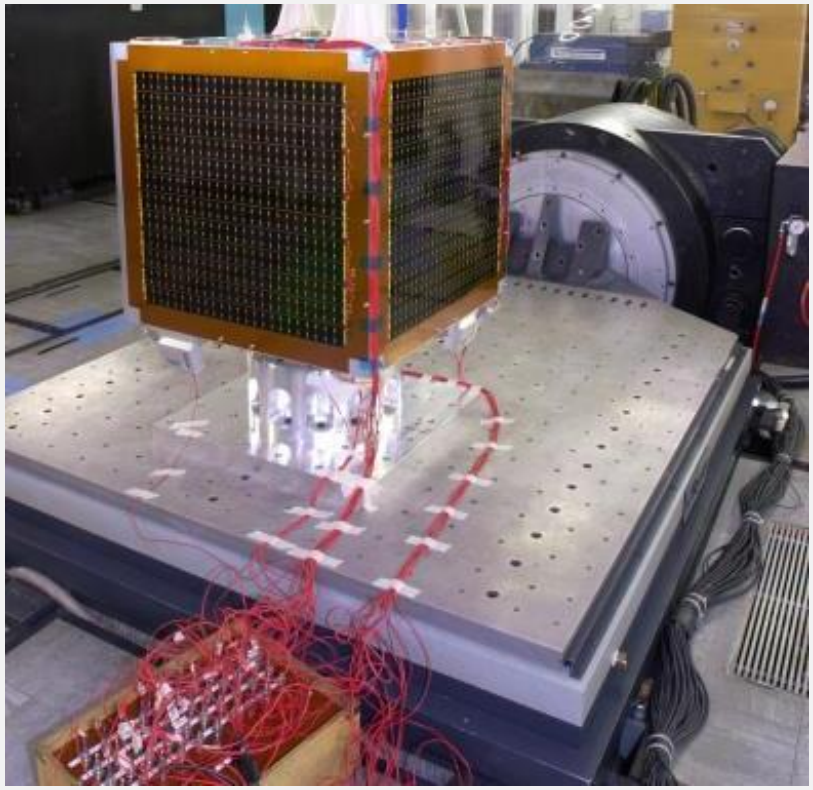
Test Houses
Eurofins VTT Finland
Intertek
Element Materials Technology
TUV SUD
Horiba MIRA

Defence
UK Atomic weapons establishment
BAE
Qinetiq
THALES
Bofors



Electronics
Texas Instruments
Philips
Hewlett Packard
Fujitsu
Amphenol

Vibration Testing



Satellite testing at Airbus Defence and Space, UK

- **m+p VibControl** products for sophisticated vibration testing from 4 to 512 channels
- Simple for production, advanced for development; standalone or networked
- All test standards supported from standard random testing to time domain replication, mixed mode testing and drop table capture, MIMO control
- Measurement hardware for all testing needs
- Acoustic control in reverberation chambers
- Supplier of complete test stands including shakers
- Technical leader in vibration and acoustic control applications

Noise and Vibration Analysis

In-car operation using m+p Analyzer and m+p VibPilot

- **m+p Analyzer** for noise and vibration testing applications
- Measurement, analysis and reporting in one package
- Import of 3rd party files
- NVH applications: real-time FFT, time history data acquisition, structural testing, modal analysis, impact testing, rotating machinery, acoustic analysis, environmental vibration testing
- Mobile, laboratory and network based
- Compatible with wide range of sensors and signals for future-proofing
- Standard hardware from ultra-portable frontends to high-channel count systems

Data Acquisition/Process Monitoring

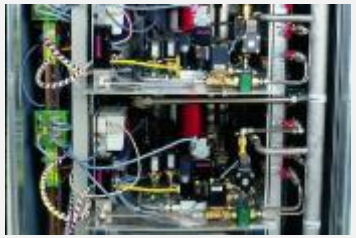
Structural testing of an airplane

- **m+p Coda**, the full-featured software platform for continuous data acquisition, signal analysis, real-time monitoring, visualization and documentation
- From tens to thousands of channels
- Mobile and stationary data acquisition, also standalone
- Applications: measurements (temperature, strain, pressure, force, fluid level, flow), testing (turbines, engines, pumps), evaluation (temperature/strain/stress distribution of mechanical structures)
- Intuitive GUI, client/server system, standardized data interfaces, SQL database-supported management, real-time limit checking and alarm monitoring
- Acquisition hardware: Ethernet, LXIbus, VXIbus, USB

Test Stand Engineering

Custom-Made Solutions for Functional Test Stands

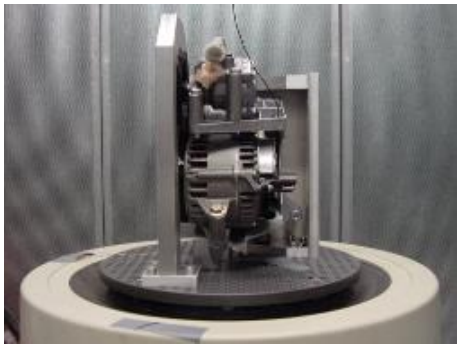
- High-frequency vibration test stand, Volkswagen
- Airbag electronics test system, Autoliv
- Vibration absorber test stand, Daimler
- Light bulb test stand, Volkswagen
- Carbon canister conditioning and test systems, IDIADA Automotive
- Antenna measuring range software, Airbus Defence and Space
- Data acquisition and monitoring at turbomachinery test facility, Siemens

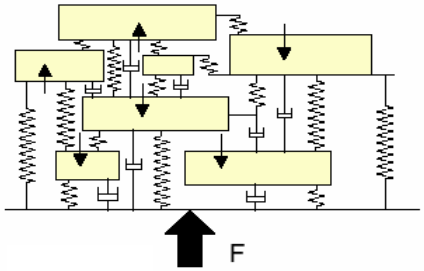


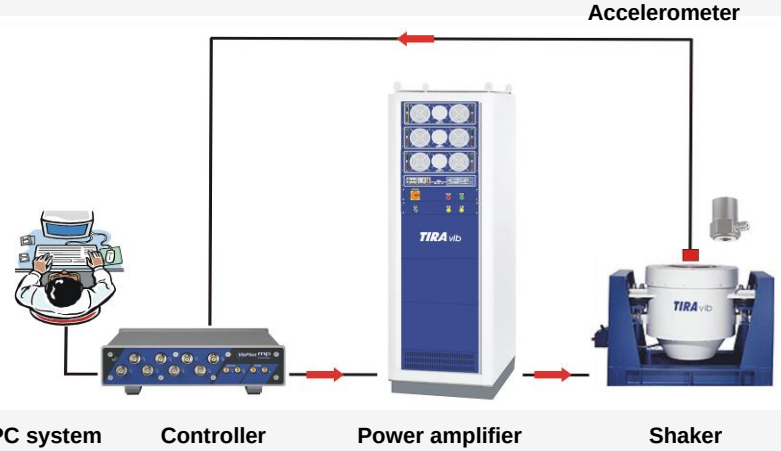
m+p VibControl Products

- Overview Closed-Loop Vibration Control
- Hardware: m+p VibPilot, m+p VibRunner and m+p VibMobile
- Software Features and Test Modes
- Applications
- Advanced - Time Data Recording (Throughput)
- Advanced – Notching/Force Limited Vibration Testing (FLVT)
- Advanced - Mixed Mode (SoR, RoR, SoRoR)
- Advanced – Multi-Sine
- Advanced - Acoustic Control for Reverberant Chambers and PWT
- Summary

m+p VibControl Products
Overview Closed-Loop Vibration Control

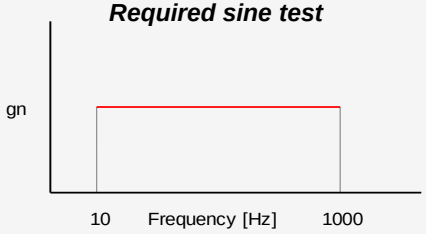




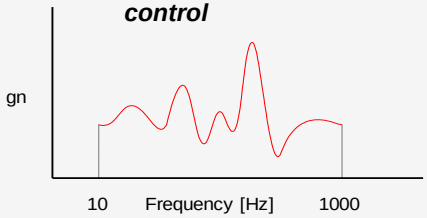


PC system Controller Power amplifier Shaker

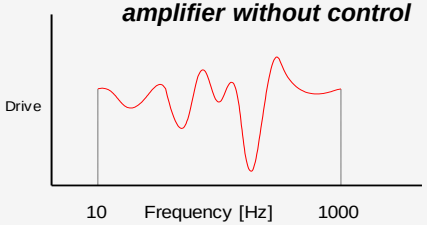
Required sine test



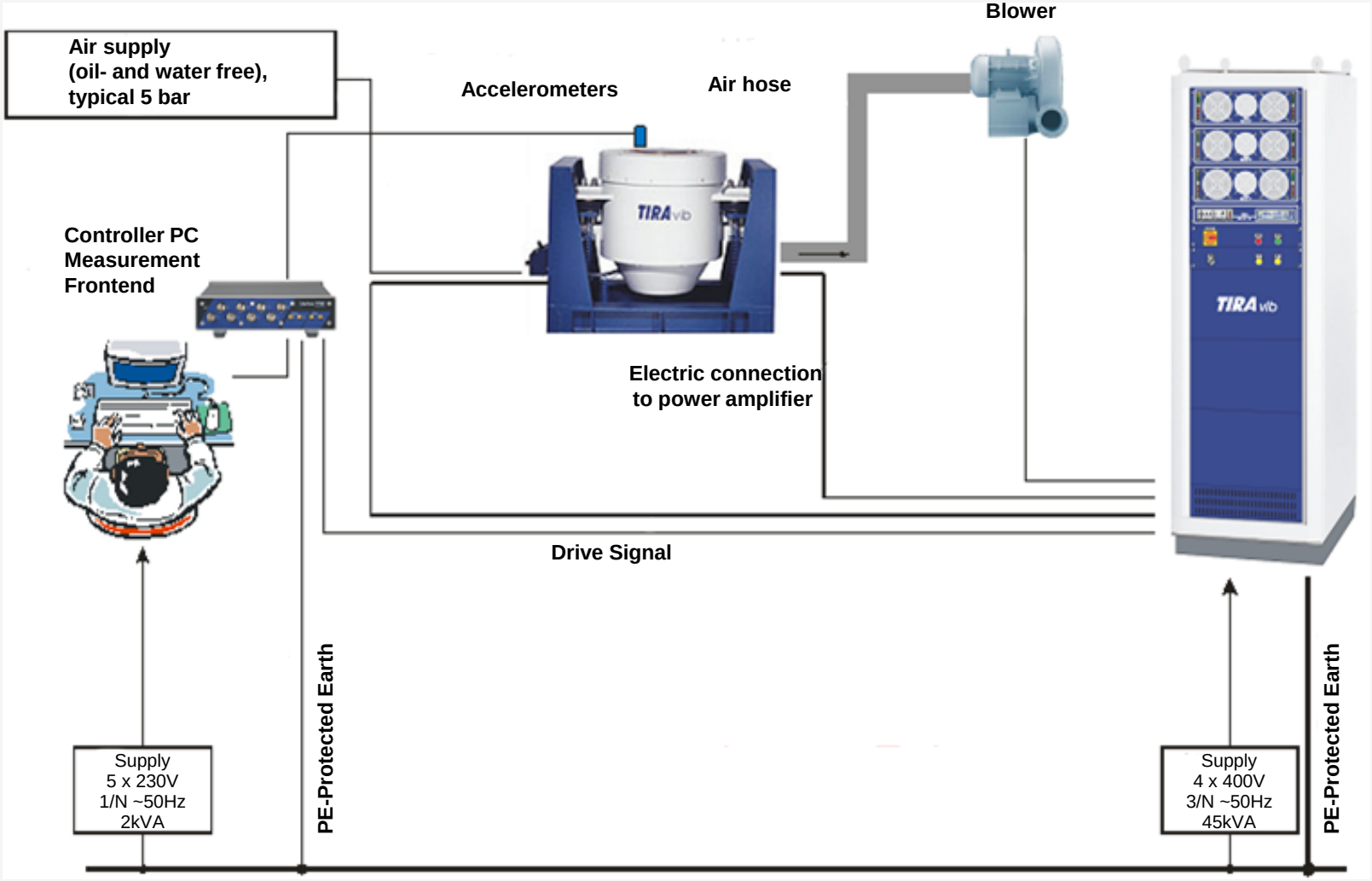
DUT response without control



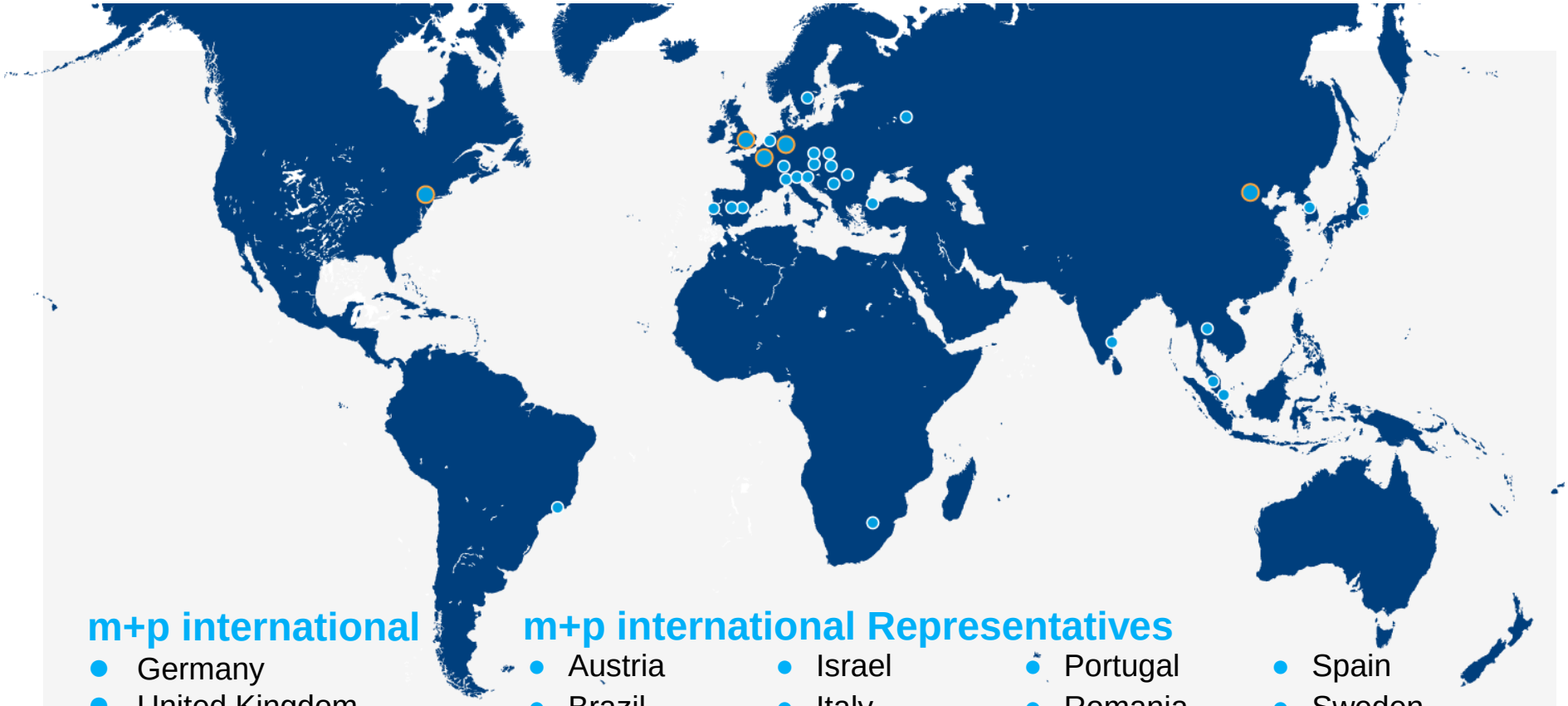
Drive signal to power amplifier without control



m+p VibControl Products
Overview Closed-Loop Vibration Control



m+p international Worldwide



m+p international

- Germany
- United Kingdom
- France
- United States
- China

m+p international Representatives

- Austria
- Brazil
- Canada
- Czech Republic
- Finland
- Hungary
- India
- Israel
- Italy
- Japan
- Korea
- Lithuania
- Malaysia
- Netherlands
- Norway
- Portugal
- Romania
- Russia
- Serbia
- Singapore
- Slovakia
- Slovenia
- South Africa
- Spain
- Sweden
- Switzerland
- Taiwan
- Thailand
- Turkey
- U. A. Emirates

Additional Information

Services and Support

- Regular software updates
- Hotline support
- Hardware warranty and repair
- On-site and return-to-bench calibration
- Rental
- Training classes

VIBRATION CONTROL

m+p VibControl

Powerful Shaker Controllers
for Low-Channel and
High-Channel Count Applications

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- Applications
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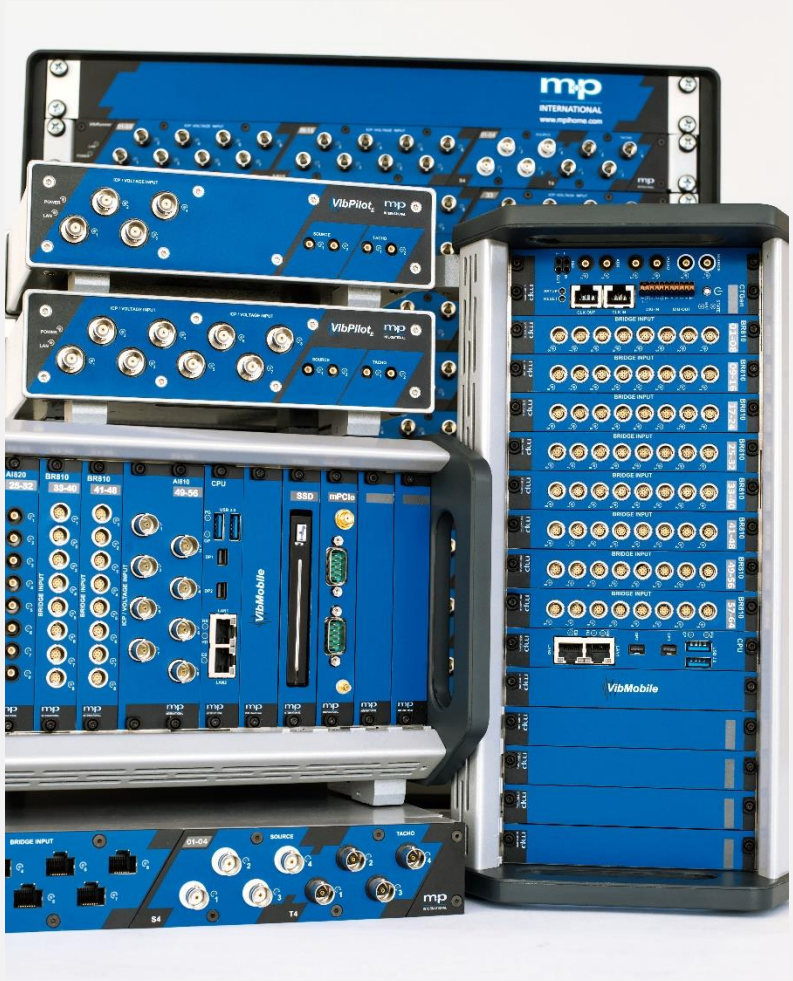
m+p VibControl Hardware



m+p Hardware Solutions

- **m+p VibPilot**
  4, 8, 12 or 16 channels,
  compact, rugged housing,
  USB and Ethernet interfaces
- **m+p VibRunner**
  high-channel count 8-512 channels,
  standalone or 19” rack mounting,
  high-speed 1 Gbit/s Ethernet interface
- **m+p VibMobile**
  up to 8 m+p I/O boards and
  4 CompactPCI® Serial boards,
  robust steel housing,
  high-speed Ethernet interface

m+p VibControl Hardware
m+p VibPilot

Compact Acquisition Hardware

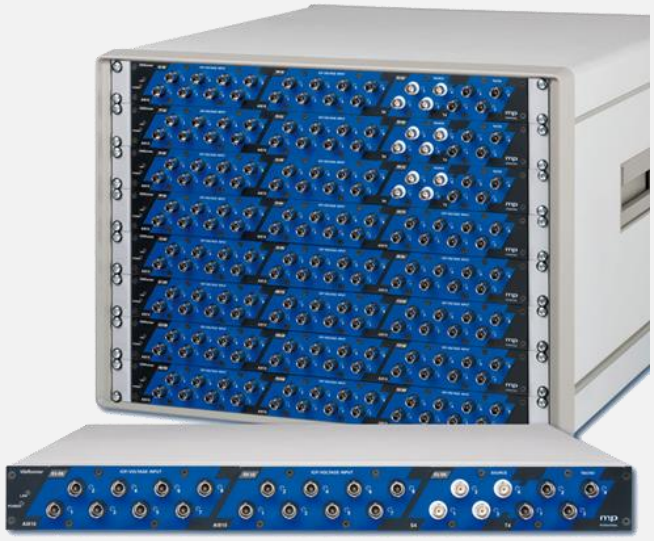
- All-in-one device for vibration testing, N+V analysis and data acquisition
  - → Supports m+p VibControl, m+p Analyzer and m+p Coda S/W
  - → Synchronisation of two m+p VibPilot frontends, hence hardware redundancy
- Input channels: 4, 8, 12 or 16
- Drive and COLA output
- Use on the bench and in the field
  - → For a multitude of industrial conditions
  - → AC/DC power flexibility
  - → Battery option
- Latest IC technology
  - → High-precision measurement
  - → Outstanding real-time performance

m+p VibControl Hardware
m+p VibPilot

Key Features

- 4 or 8 input channel per frontend
- Up to 16 input channels with clock sync
- AC/DC/ICP sensor conditioning with TEDS support
- 204.8 kHz simultaneous sampling, 24-bit A/D
- 2 sources, safety shutdown, 2 tacho inputs
- AC/DC supply, 20 W power consumption
- Compact, dust-proof, rugged housing
  - → Dimension (w x d x h): 211 x 190 x 53 mm
  - → Weight: 1.57 kg
  - → Fan-less, noise-free operation
- 8 digital inputs, 8 digital outputs
- USB and Ethernet host interfaces

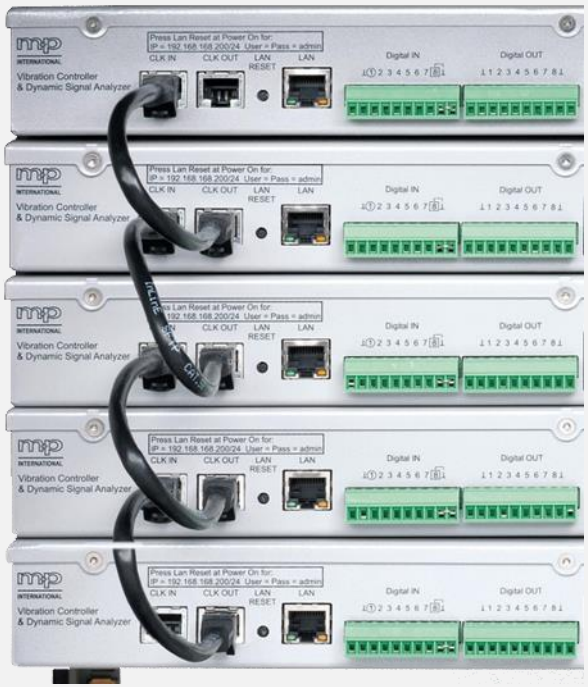
m+p VibControl Hardware
m+p VibRunner



High-Performance and Cost-Effective Acquisition Hardware

- Designed for the specific needs of dynamic measurements
  → Supports m+p VibControl, m+p Analyzer and m+p Coda S/W
- Up to 24 input channels per module
- Multiple sources and tacho inputs
- Bridge module for strain measurements
- 19“ mainframe: standalone or rack mounting
  → Flexible system configuration
- Multiple m+p VibRunner synchronization
  → Distributed daisy chain connection (to 100 m)
  → High-channel count measurements, expandable
  → Minimum transducer cabling
- 1 Gbit/s Ethernet interface, independent subnet
  → High data throughput, safe communication

m+p VibControl Hardware
m+p VibRunner



Synchronisation of five
m+p VibRunner frontends

Key Features

- Standalone or 19“ rack mounting, 1 U, 3 slots, BNC connectors
- Internal multi-range AC and external DC power supply
- Synchronization by means of daisy chain and master clock
- 1 Gbit/s Ethernet interface
- 8 - 24 analog input channels per m+p VibRunner, 24 bit, 204.8 kHz max. sampling rate
- True differential and single-ended user selection
- AC/DC/ICP sensor conditioning, TEDS support
- 2 - 12 floating source output channels per m+p VibRunner, safety shutdown
- 8 digital inputs and 8 digital outputs per m+p VibRunner
- Silent operation, temperature-controlled fan (can be turned off)

m+p VibControl Hardware
m+p VibRunner

Institute 511, First Launch Academy, Beijing

Key Features

- 2 x 19“ rack mounting, TOTAL 456 input channels, 8 output/DAC channels
- Applications:
  Sine & random data reduction with continuous throughput (**32.7 kHz/channel**)
  Modal analysis with modal shaker and impact excitation

m+p VibControl Hardware
m+p VibMobile

Mobile Multi-Channel Front-End

- Standalone or 19” rack mounting, ¾ 19” wide, 4U high
- Up to 8 m+p VibMobile boards totaling 64 channels and up to 4 freely selectable CompactPCI® Serial boards per mainfame
- Max. 204.8 kHz simultaneous sampling, max. 10 MHz with 3rd party CompactPCI® Serial board
- DSP powered real-time processing
- Ethernet interface, 1 Gbit/s transfer rate
- Robust steel housing
- Silent operation, temperature-controlled fan
- Strain gauge measurements

m+p VibControl Products

- Overview Closed-Loop Vibration Control
- Hardware: m+p VibPilot and m+p VibRunner
- **Software Features and Test Modes**
- Applications
- Advanced - Time Data Recording (Throughput)
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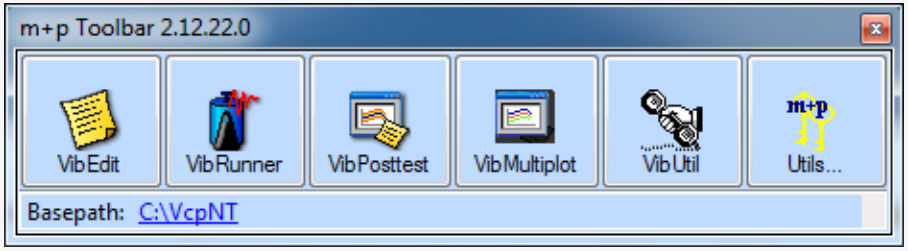
m+p VibControl Software

Key Features



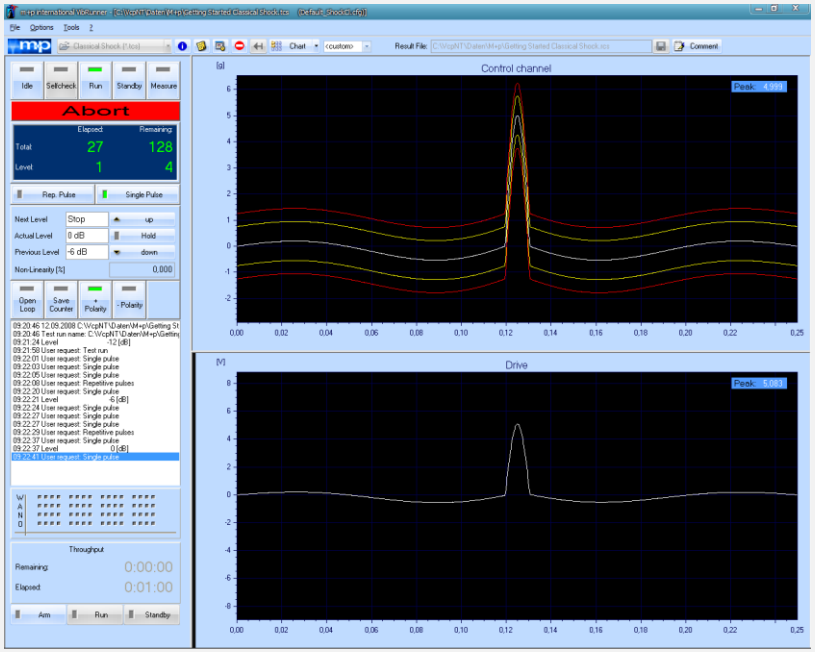
- **<u>True</u> multi-tasking system**
  Parallel use of test definition, test run and post-processing

- **Multi-language support**
  - → U/I and online manual in English, German, French, Chinese and Russian
  - → Define and run all tests in English, create reports and plots in any of the above languages

- **Easy-to-use, clear software concept**
  - → Test definitions with shaker feasibility check
  - → Test run with predefined layouts, 1-16 online displays, up to 64 traces/screen, online comparison of previous test runs, multi-monitor support
  - → Automated test reports in Word, data export: Word, Excel, UFF, ASCII
  - → Multiplot analysis of different test runs
  - → Analysis of test result after years with date/time stamp, restore original test definitions

- **Common m+p VibControl U/I across all m+p VibPilot, m+p VibRunner and m+p VibMobile front-ends**

m+p VibControl Software
Test Modes



Test Modes Fully Compliant with ISO, DIN, MIL-STD 810, etc.

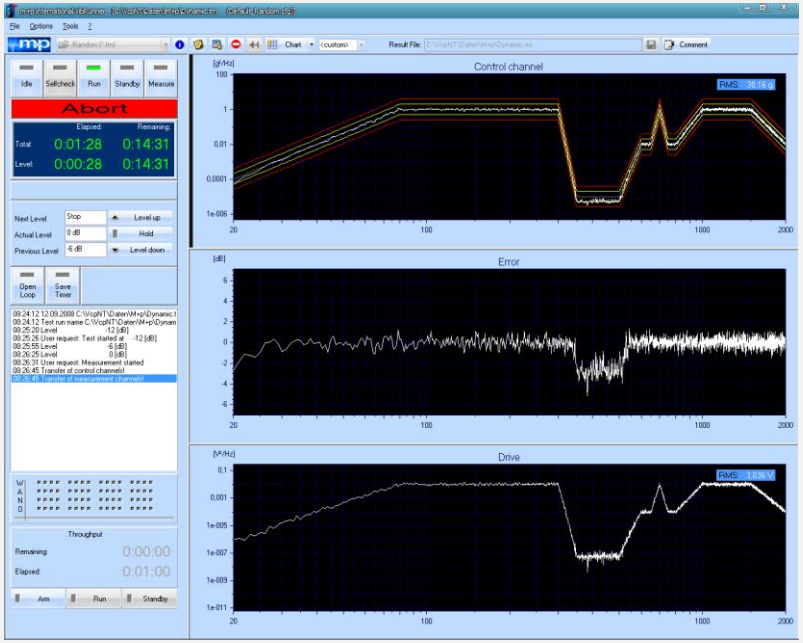
- Sine swept and stationary incl. notching/force limiting
- Multi-sine
- Sine resonance search, track & dwell
- Sine data reduction
- Random incl. notching/force limiting
- Random data reduction
- Classical shock
- External pulse
- Shock Response Spectrum (SRS)
- Transient capture with SRS calculation
- SoR, RoR, SoRoR
- Time domain replication (road load)
- Time history recording, throughput
- Multi-axis vibration control, MIMO

m+p VibControl Software
Test Modes

Sine

- **Sine swept and stationary with notching, force limiting (FVLT)**
  - → Frequency range: 20/40 kHz
  - → Control on acceleration, velocity, displacement and force
  - → Sine data incl. magnitude and phase to perform ODS analysis
- **Sine resonance search, track & dwell**
  - → Control criteria: fixed frequency, fixed phase, defined phase, auto phase, peak amplitude, high cycle fatigue
- **Sine data reduction**
  - → Track and online analysis of measured or tape recorded data with COLA signal 1 Vpk

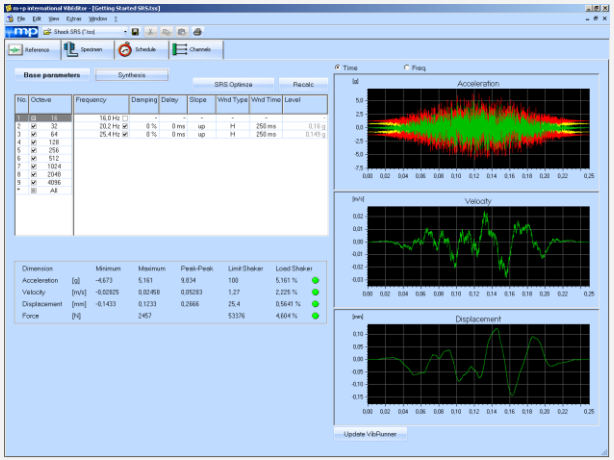
m+p VibControl Software
Test Modes



Random

- **Random incl. notching/force limiting**
  - → Frequency range: 12.8 kHz (standard)
  - → FFT resolution up to 25,600 lines
  - → Up to ten profiles per test setup
- **Random data reduction**
  - → Online analysis of random data

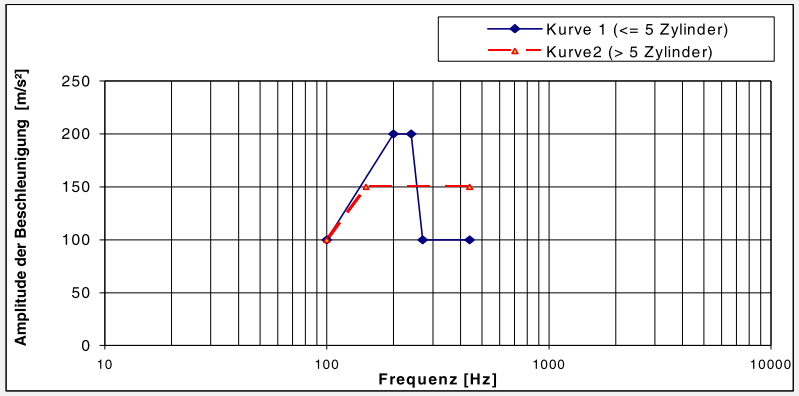
m+p VibControl Software
Test Modes



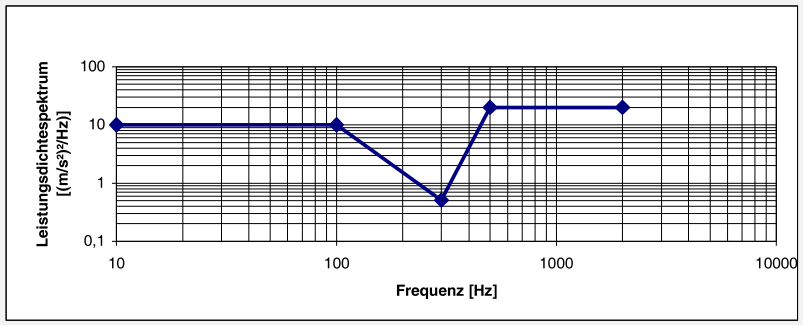
Shock

- **Classical shock**
  - → Half-sine, haversine, sawtooth, triangle, rectangle, trapezoid
  - → Auto-reverse of drive for positive and negative shocks
  - → Accelerometer negative sensitivity definition
- **External pulse**
  - → Synthesis of any pulse form
  - → Short transient history control up to 64 seconds
- **Shock Response Spectrum (SRS)**
  - → Frequency range: 20 kHz
  - → Octave analysis: 1/1 – 1/24
  - → Sine burst and sine beat with variable amplitudes
- **Transient capture with SRS calculation**
  - → For pyroshock (non-shaker) applications with high “g“ hammer/tap impact or other excitation
  - → Transient capture from drop shock machines, etc.

m+p VibControl Software
Test Modes



Sine vibration profile for engine components



Random vibration profile for engine components

VW 80101: SoR engine components

Mixed Test Modes

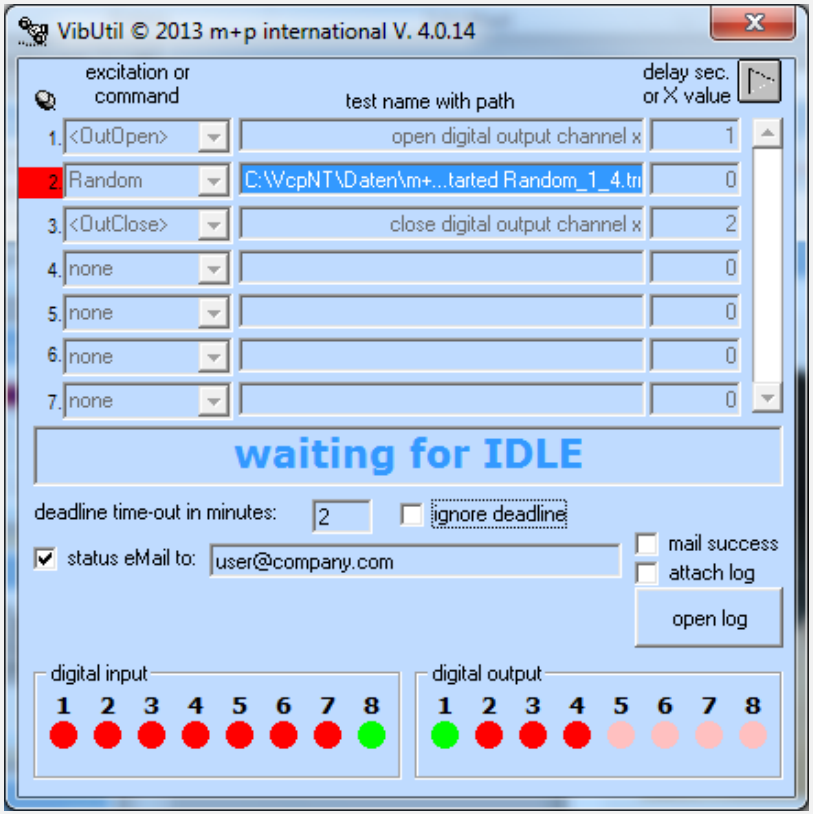
- **Sine-on-Random (SoR)**
  Independently sweeping or fixed sine tones are overlaid onto a random background
- **Random-on-Random (RoR)**
  Independently sweeping or fixed narrowband random signals are overlaid onto a random background
- **Sine-on-Random-on-Random (SoRoR)**
  Sine-on-random is combined with random-on-random

m+p VibControl Software
Test Modes

Unlimited Time Domain Replication

- Example: Road load simulation
- Create life cycles from different test runs
- Includes “Road Load Editor“ for kinematic shaker feasibility
  - → Resampling of test data
  - → Remove DC-offsets & overloads
  - → Increase/decrease levels
  - → Low- and high-pass filter
  - → Copy & paste sequences
- Create PSD from time domain data and import into random control

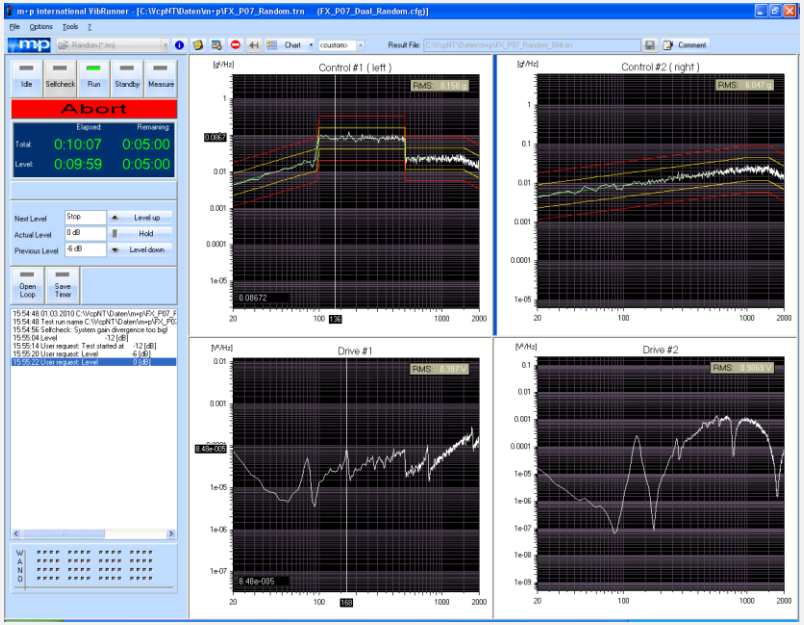
m+p VibControl Software
Chamber Interface



Advanced VibUtil

- Automation of vibration tests
- Automation of combined climatic and functional testing
- Test status report sent via email or via SMS
- Digital inputs and outputs interface to climatic/temperature chamber
- Switching off chamber, shaker's power amplifier during vibration test standby

m+p VibControl Software
Test Modes



Multi-Axis Vibration Control

- Sine, random, shock, time domain replication (x, y, z)
- Electrodynamic or hydraulic shakers
- Applications:
  - → Road load simulation
  - → Testing of large structures e.g. automobiles, aircraft, railroad cabins
  - → Earthquake simulation (IEEE 344)
  - → Transport simulation, e.g. portable PC's or automotive components
- m+p VibRunner hardware frontend

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m+p VibControl Applications
Multi-Axis Vibration Testing

German Aerospace Center (DLR), Göttingen:
Multi-axis vibration testing at the Institute for Aeroelasticity

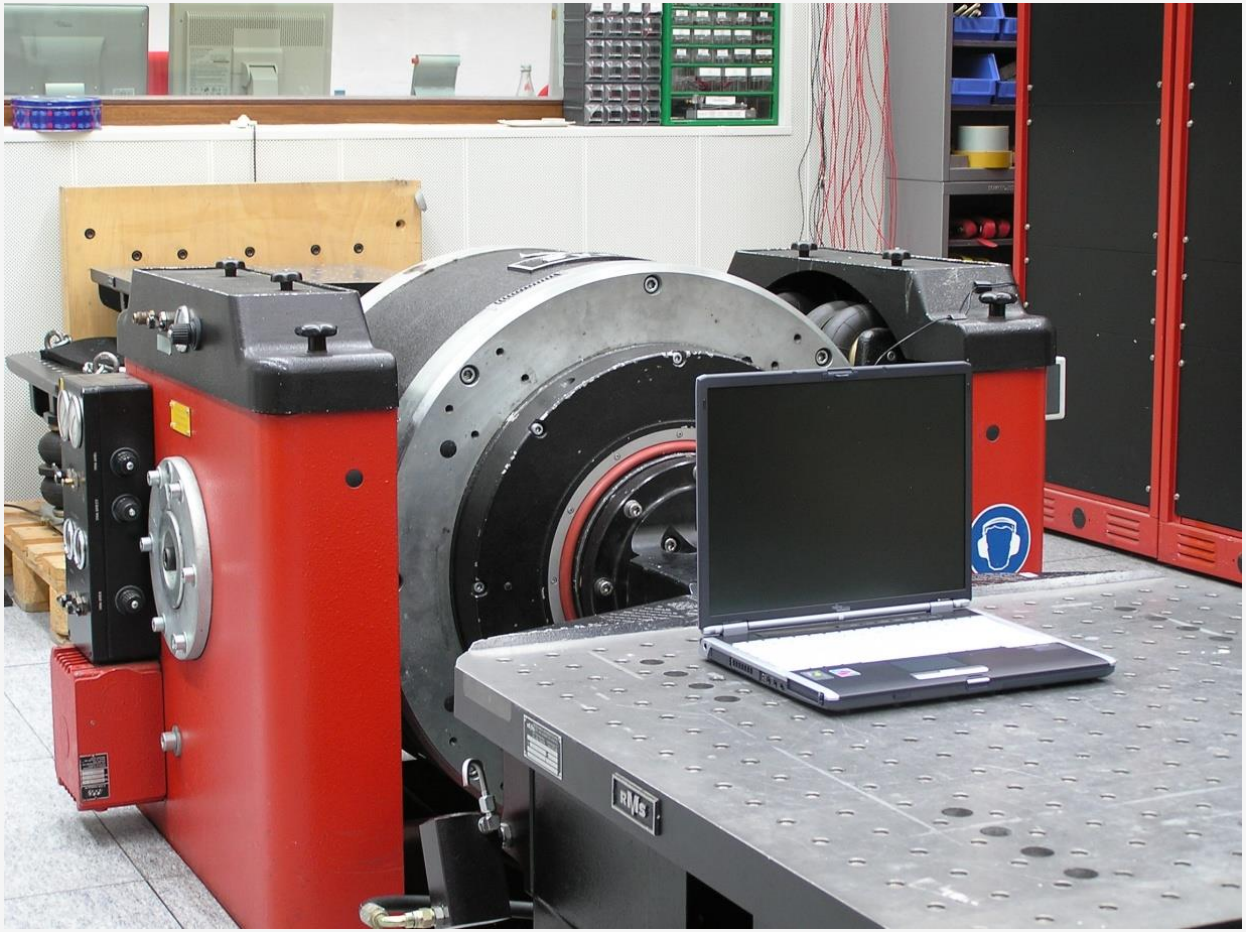
m+p VibControl Applications
Automotive

Porsche, Stuttgart/Germany:
Road load simulation

m+p VibControl Applications
Earthquake Simulation

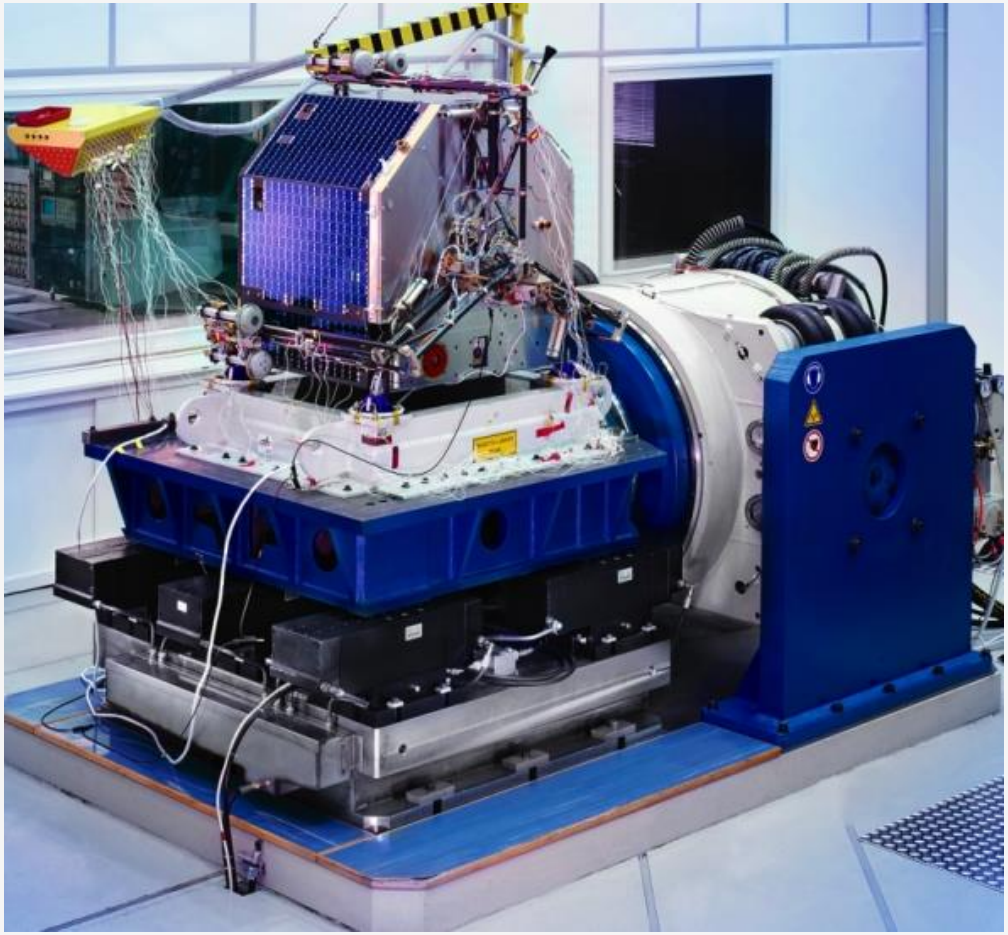
Lucent Technologies, New Jersey/USA:
SRS earthquake simulation

m+p VibControl Applications
Testing of Consumer Goods



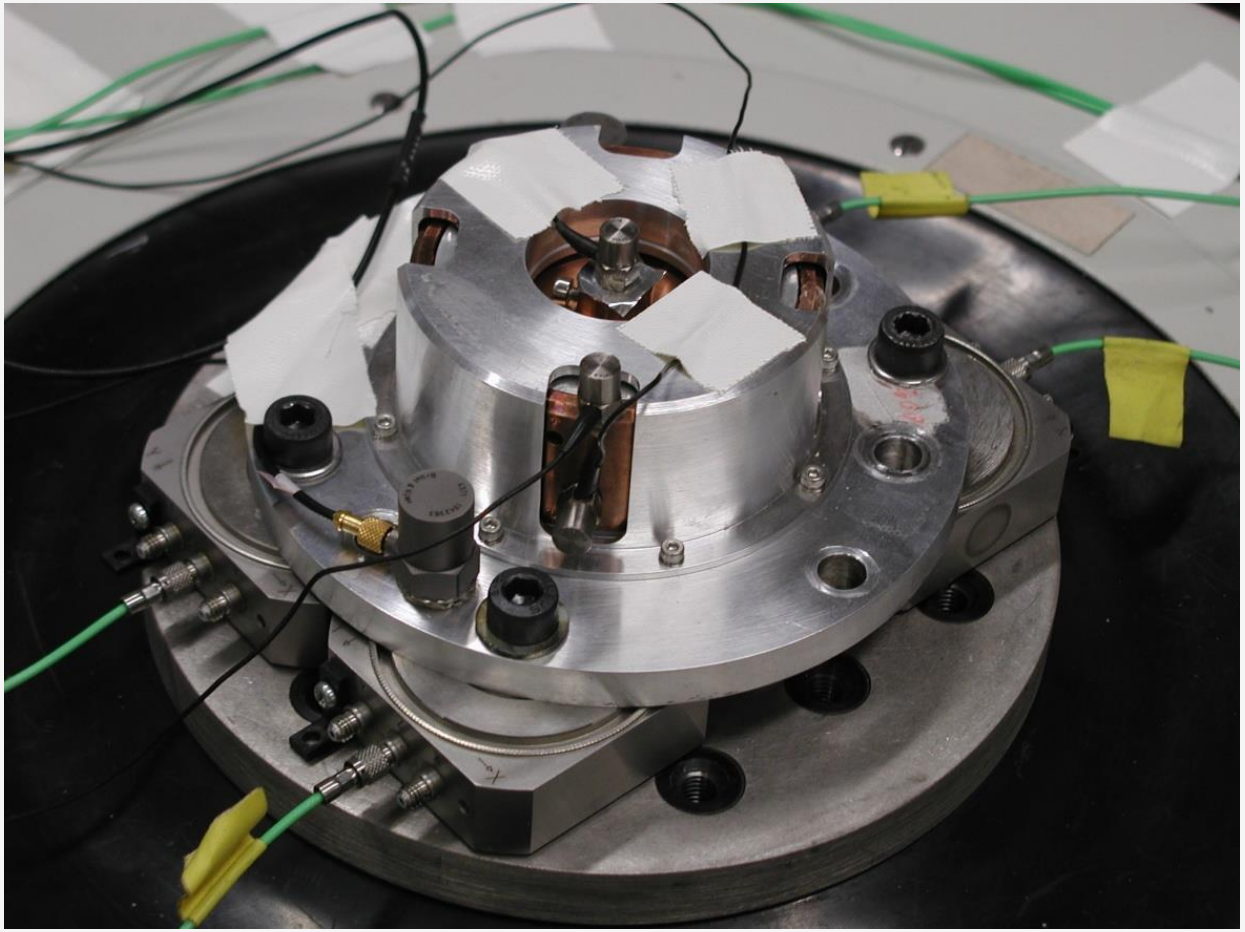
Fujitsu, Augsburg/Germany:
Vibration testing of a laptop

m+p VibControl Applications
Aerospace



IABG, Ottobrunn/Germany:
Vibration testing of Rosetta lander “Philae” 2004

m+p VibControl Applications
Force Limited Vibration Testing (FLVT)



Astro- und Feinwerktechnik, Berlin-Adlershof/Germany:
Sine and random tests using force limited vibration testing

m+p VibControl Applications
Customized Test Stands

Volkswagen, Wolfsburg/Germany:
High-frequency (2 kHz) test stand with preloaded static force for engine & transmission mounts in vehicles

m+p VibControl Products

- Overview Closed-Loop Vibration Control
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- Advanced – Notching/Force Limited Vibration Testing (FLVT)
- Advanced - Mixed Mode (SoR, RoR, SoRoR)
- Advanced – Multi-Sine
- Advanced - Acoustic Control for Reverberant Chambers and PWT
- Summary

m+p VibControl Software
Time Data Recording - Throughput

Features and Benefits Time Data Recording – Throughput

- Time domain data (acceleration, velocity, displacement, force vs. time) include all signal information from test start to test end
- Time domain data can be post-processed to get spectra in frequency domain (acceleration, velocity, displacement, force vs. frequency) at any time
- When damages occur or at test failures, time domain data provide answers in milliseconds to show what went wrong
- Time domain data can be replayed at any time for post-processing with different FFT settings, e.g. block size or filter, RMS, peak estimators in sine testing
- Time domain data can be given to customers for further post-processing

m+p VibControl Products
Vibration Control and Data Reduction

Typical Operation of Control and Data Reduction Systems

OPERATOR #1

Vibration Control System

- → Sine, Random, Shock Control
- → Control/Notch Channels
- → Measurement Channels

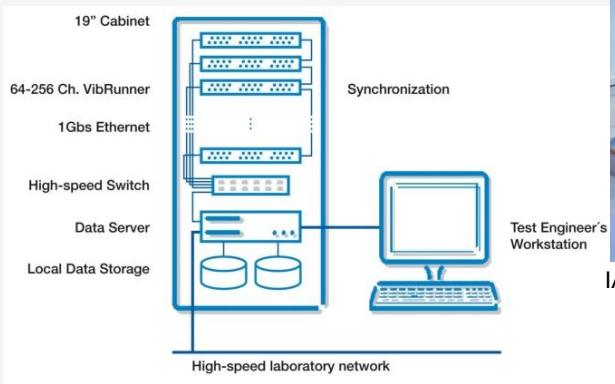
OPERATOR #2

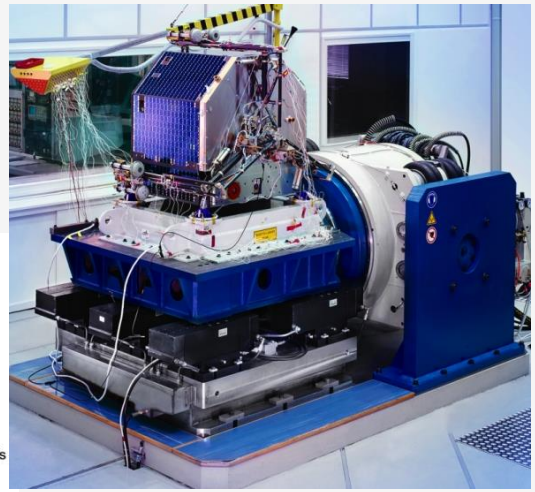
Vibration Data Reduction System

- → Sine, Random, Shock Data Reduction
- → Time Data Recording/Throughput
- → Post-Processing Throughput Data

Analog Inputs ~ 4 - 64

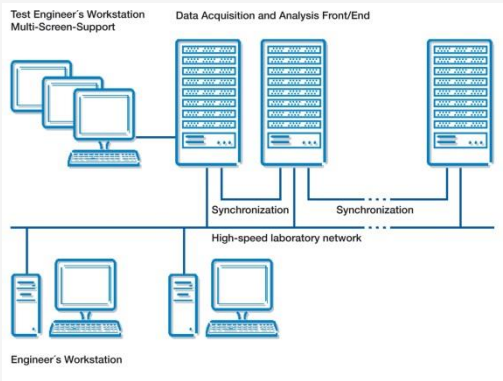
Drive





IABG, Ottobrunn/Germany: „Philae“ Rosetta lander

Analog Inputs ~ 32-256



COLA signal for
sine data reduction

m+p VibControl Products
Vibration Control and Data Reduction

Control System Replaces Data Reduction System Completely

OPERATOR #1

Vibration Control System

- → Sine, Random, Shock Control
- → Control/Notch Channels
- → Measurement Channels
- → Time Data Recording/Throughput parallel to Vibration Control

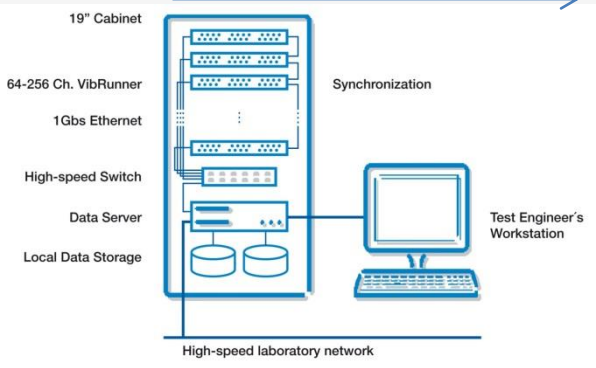
OPERATOR #2

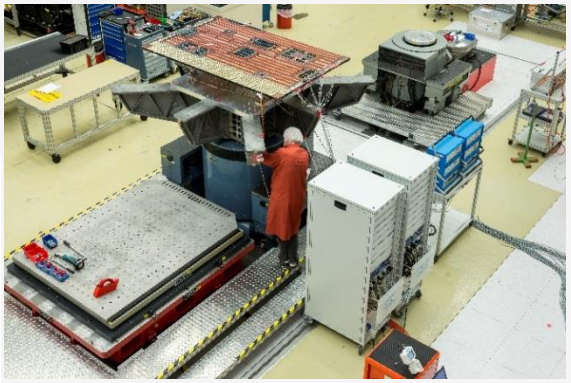
Vibration Data Reduction System

- → Sine, Random, Shock Data Reduction
- → Time Data Recording/Throughput
- → Post-Processing Throughput Data

Analog Inputs ~ 4 - 256

Drive

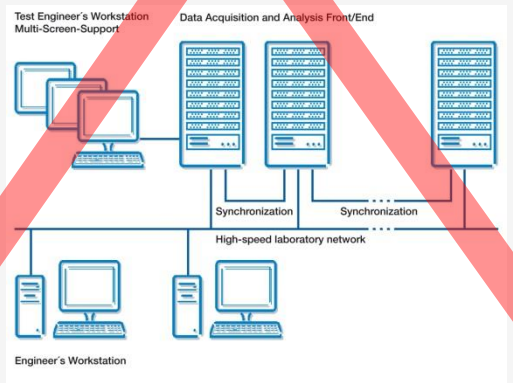




Airbus Defence und Space (Astrium), Ottobrunn/Germany

COLA signal for sine data reduction

Analog Inputs ~ 32-256

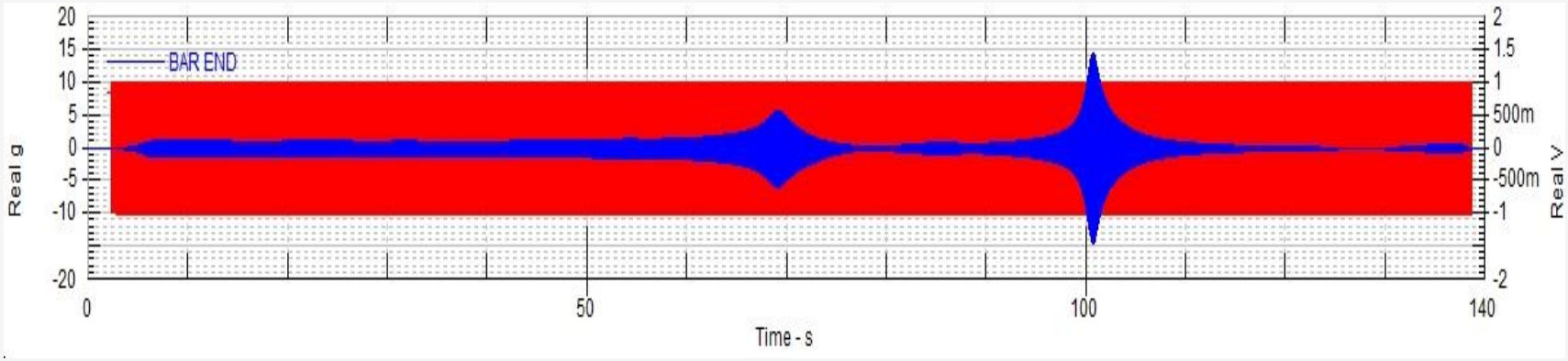


m+p VibControl Software Throughput

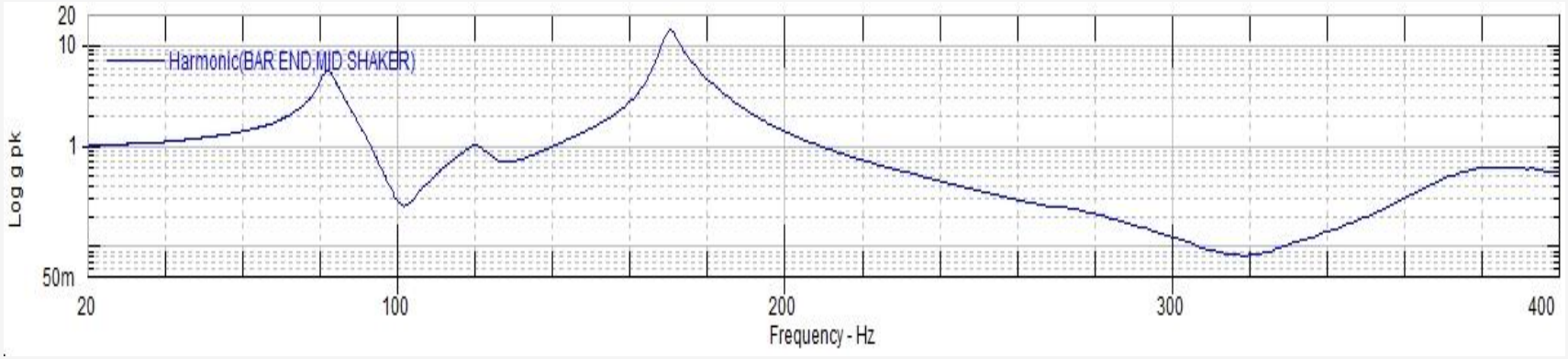
Continuous, Seamless Recording of Time Domain Data Using Just ONE Vibration Control System Offers a Number of Benefits such as:

- No additional hardware (data acquisition systems, tape recorder) required
- Avoiding errors, no synchronization with data acquisition system
- No double channel assignment, thus reduced cabling work
- Efficient operation – just one operator required
- m+p offers vibration control systems with 4 - 256 input channels

m+p VibControl Software
Throughput Sine - Time and Frequency Domain



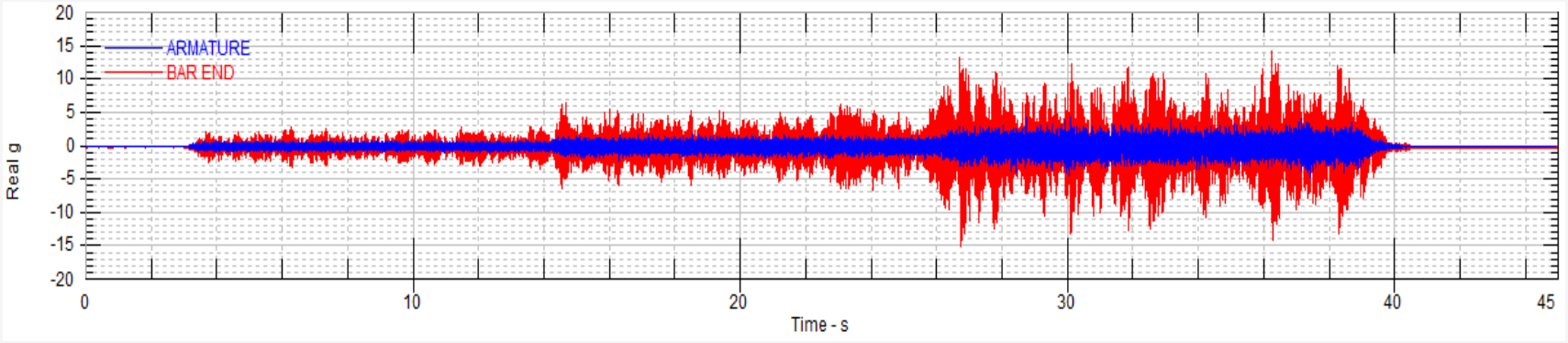
Sine test: Throughput File with Channel Response and COLA Signal

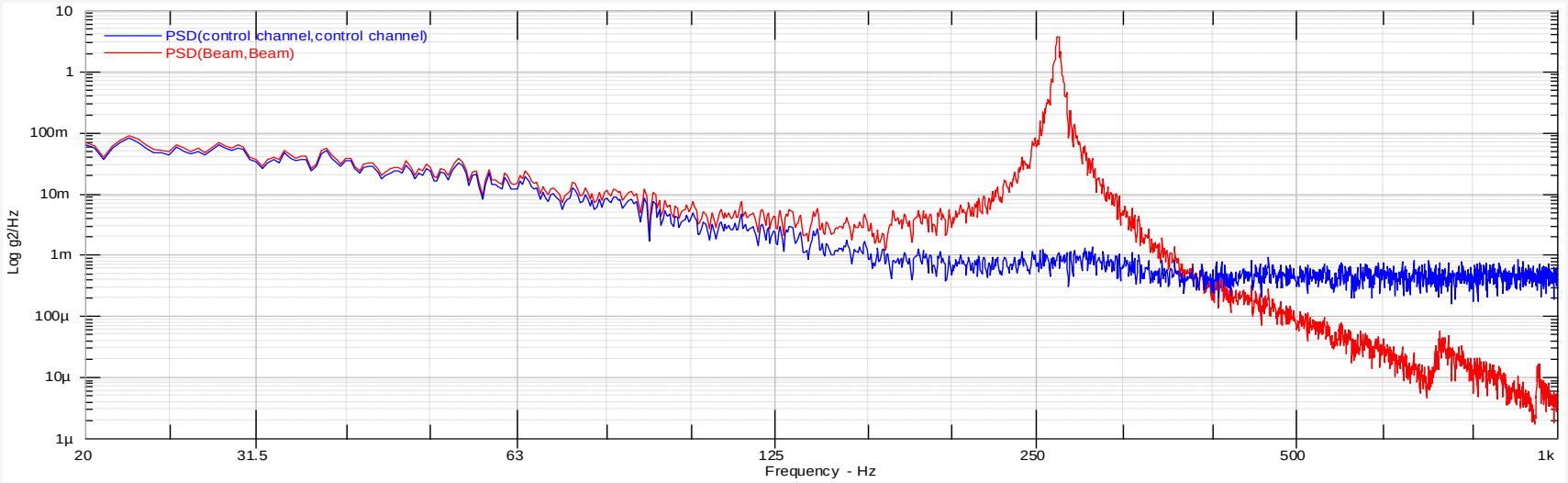


Sine Test: Channel Response

Throughput post-processing with m+p Analyzer

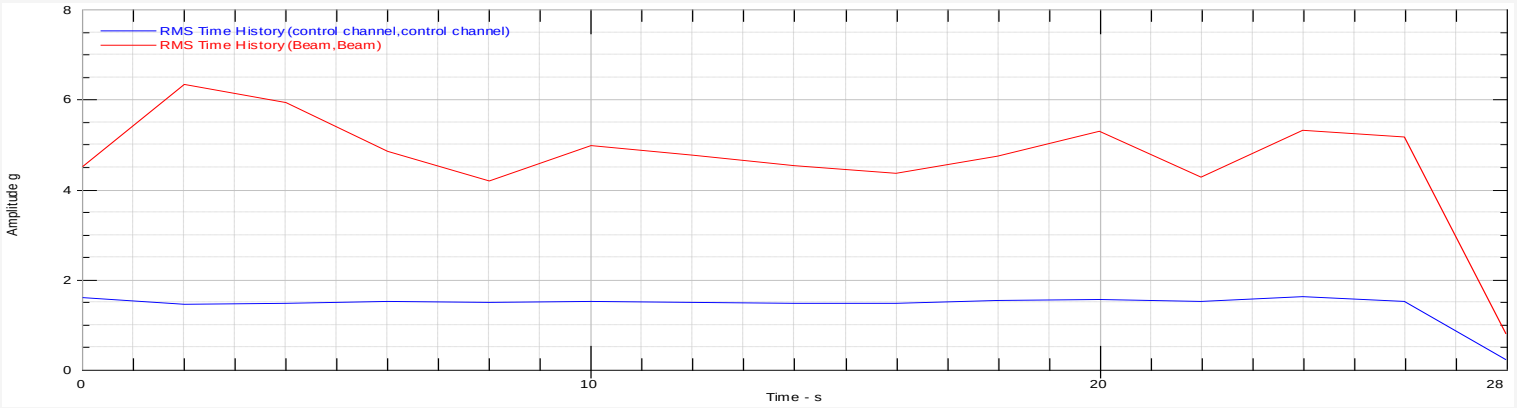
m+p VibControl Software Throughput Random - Time and Frequency Domain

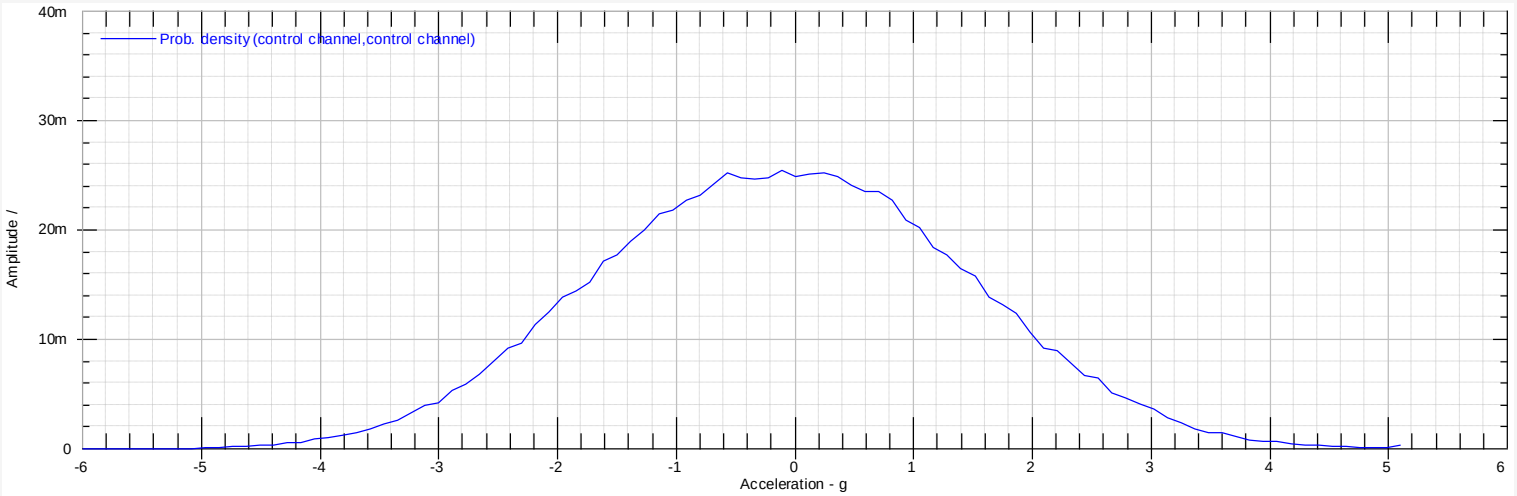




Throughput post-processing with m+p Analyzer

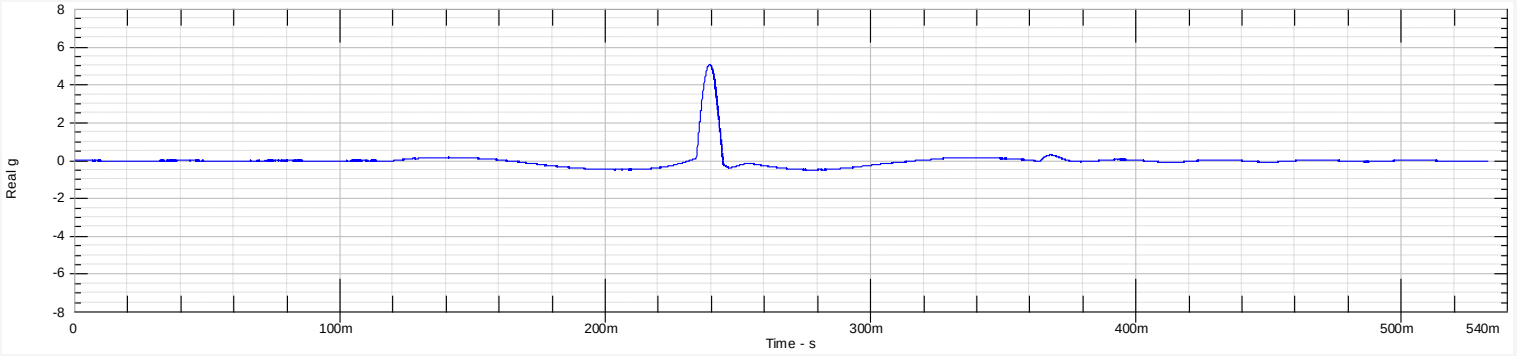
m+p VibControl Software
Throughput Random - RMS vs. Time

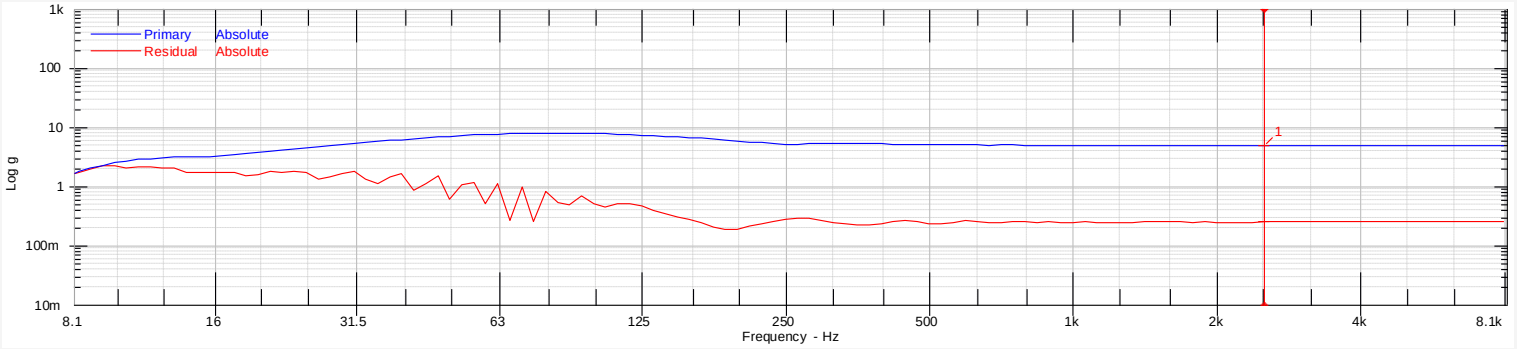




Throughput post-processing with m+p Analyzer
Kurtosian distribution

m+p VibControl Software
Throughput SRS Calculation with Half-Sine Excitation





Throughput post-processing with m+p Analyzer

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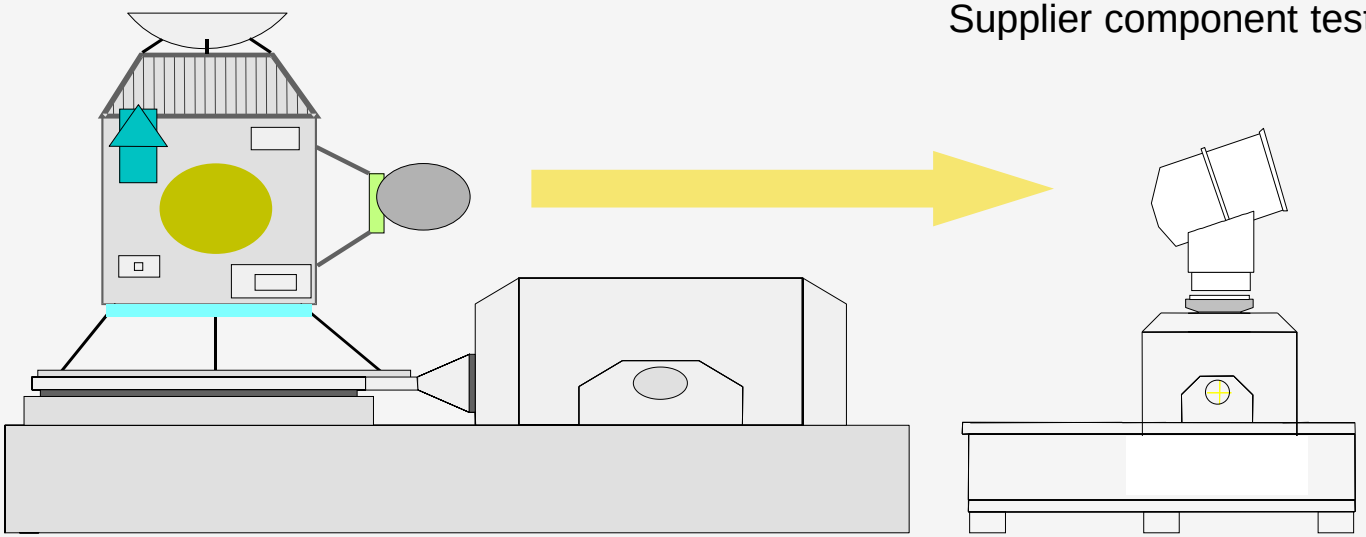
m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

Problem: Overtesting of Components

Complete system test

Supplier component test



Courtesy: Astro- und Feinwerktechnik, Berlin-Adlershof

m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

Method of FVLT

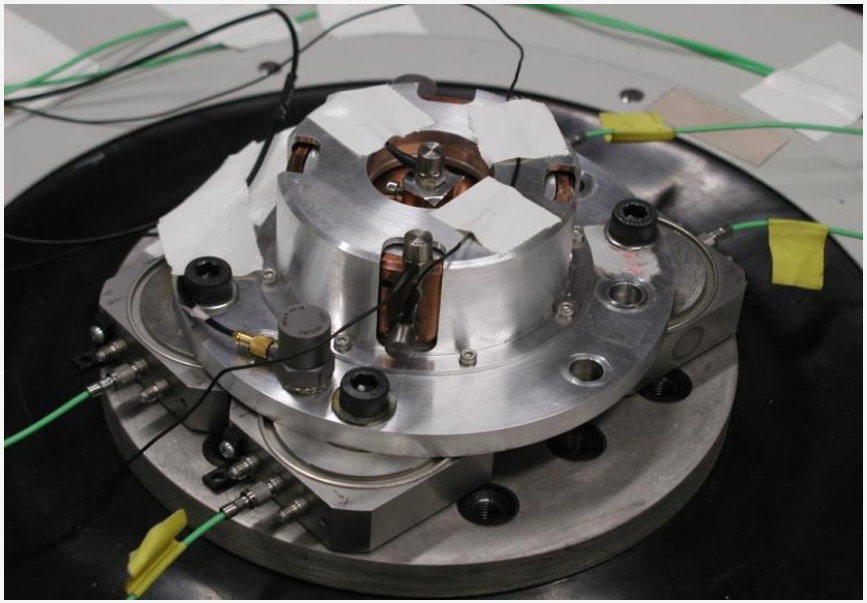
- Control on acceleration with limiting on forces as real test method to avoid component overtesting, hence R&D cost reduction
- FVLT considers impedance behaviour of shaker/fixture/specimen
- Required force limit definitions can be calculated or are available from FE calculations, real measurements or tests
- Development of method “Force Limited Vibration Testing“ by Dr. Terry D. Scharton NASA-JPL in early 1990‘s

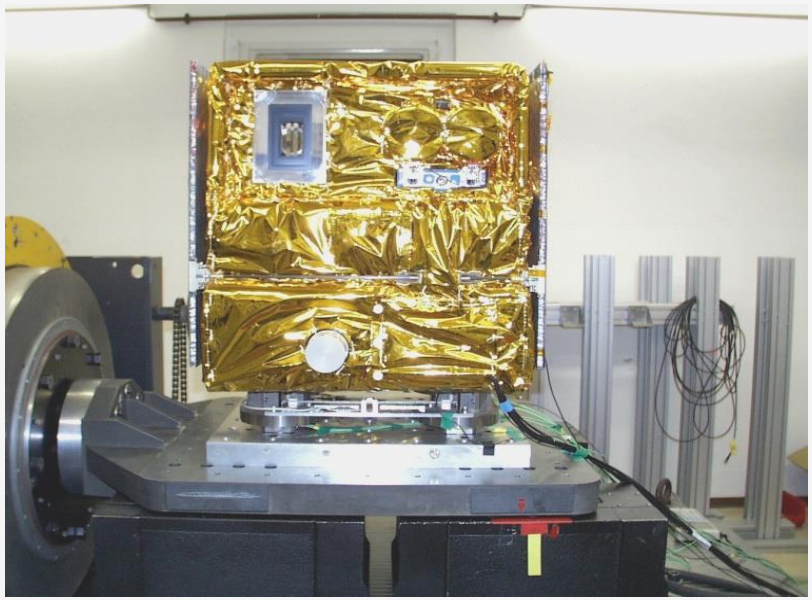
References

- NASA-HDBK-7004B, „Force Limited Vibration Testing“
- NASA Ref. Public. RP-1403, „Force Limited Vibration Testing Monograph“

m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

Vertical and Horizontal Shaker Test Setup with Sandwich Platform Control on Acceleration with Limiting on Force

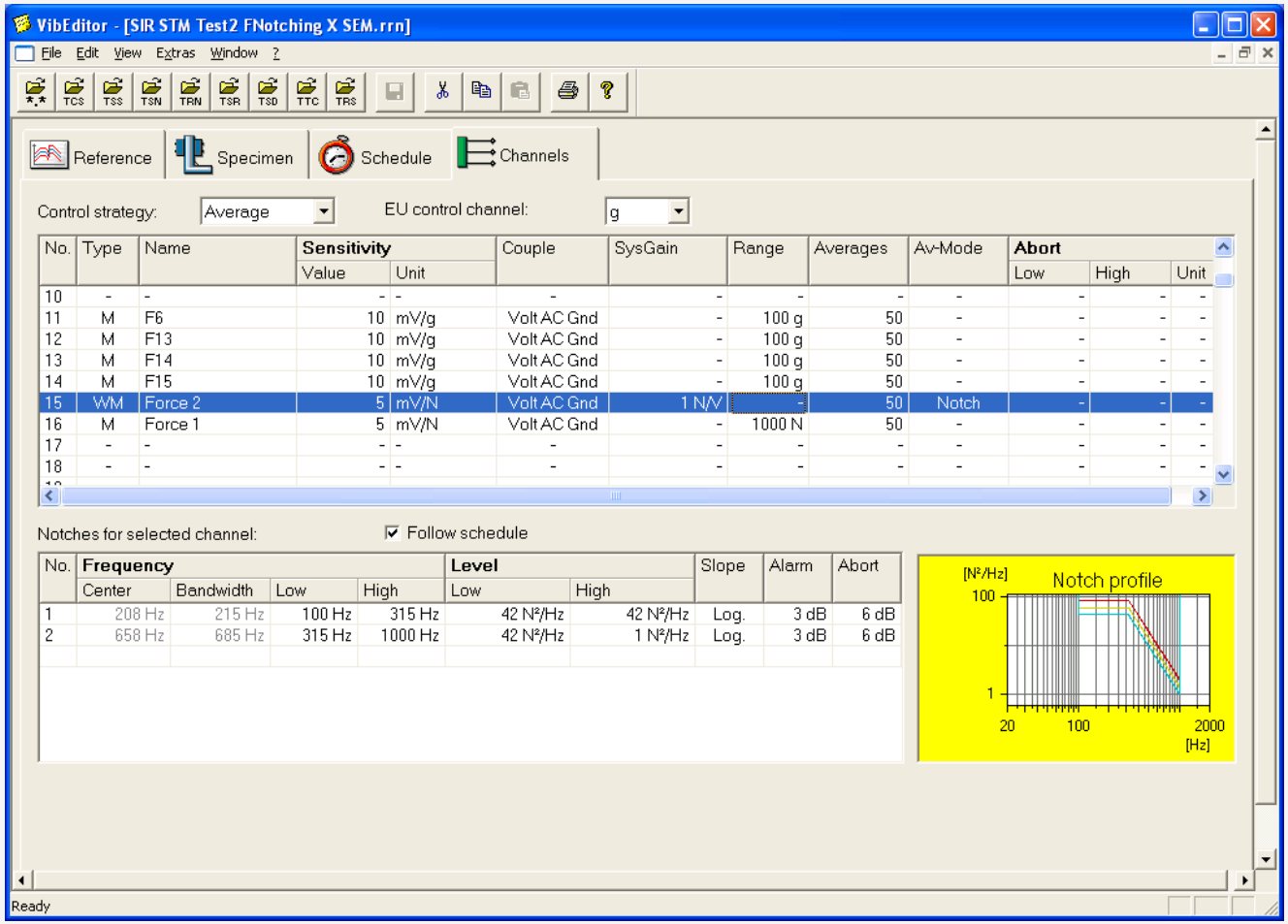




Courtesy: Astro- und Feinwerktechnik, Berlin-Adlershof

m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

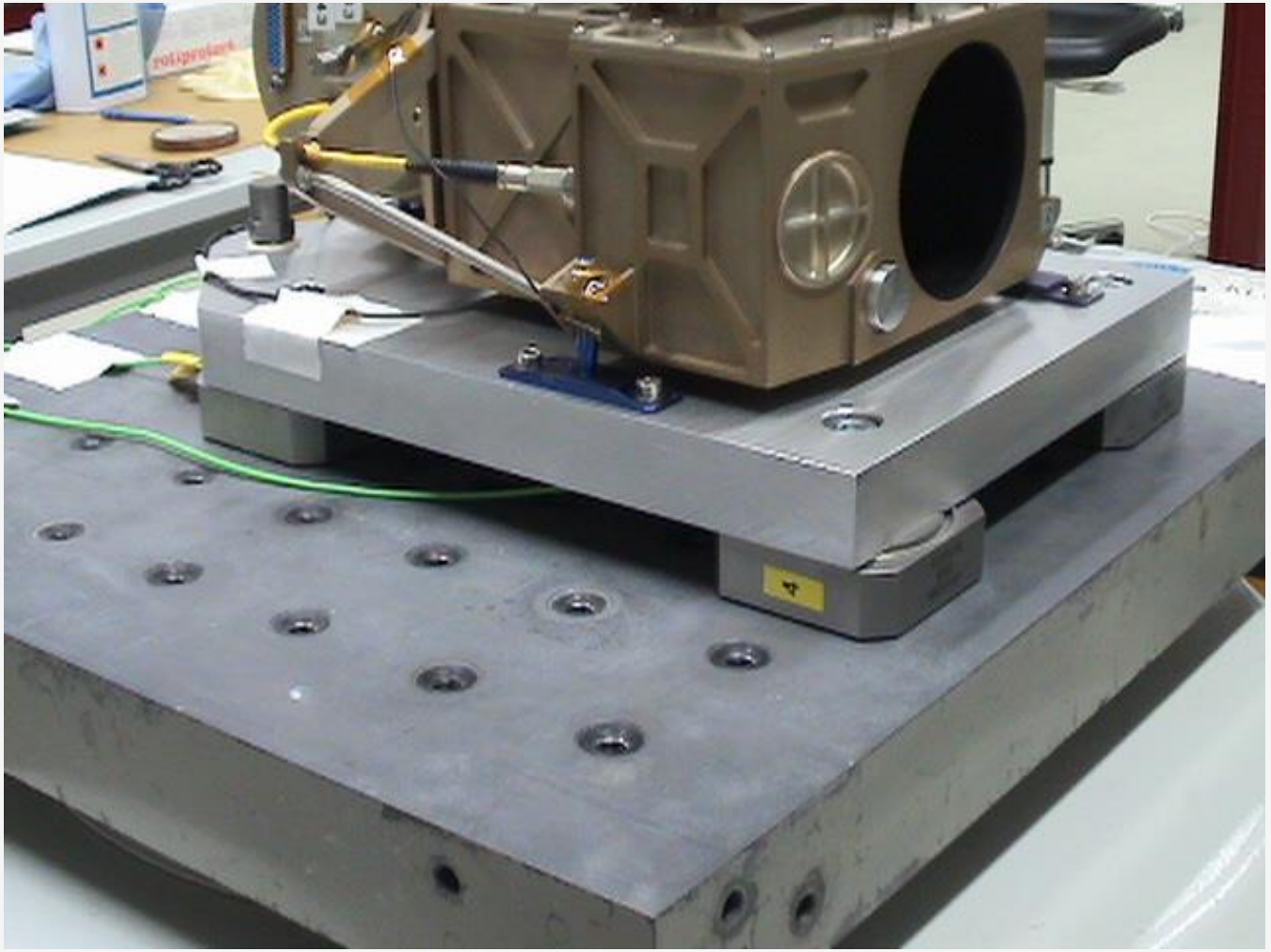
m+p VibControl Random Channel Definition FVLT with Notch Profile



No.	Type	Name	Sensitivity Value	Sensitivity Unit	Couple	SysGain	Range	Averages	Av-Mode	Abort Low	Abort High	Abort Unit
10	-	-	-	-	-	-	-	-	-	-	-	-
11	M	F6	10	mV/g	Volt AC Gnd	-	100 g	50	-	-	-	-
12	M	F13	10	mV/g	Volt AC Gnd	-	100 g	50	-	-	-	-
13	M	F14	10	mV/g	Volt AC Gnd	-	100 g	50	-	-	-	-
14	M	F15	10	mV/g	Volt AC Gnd	-	100 g	50	-	-	-	-
15	WM	Force 2	5	mV/N	Volt AC Gnd	1 N/V	-	50	Notch	-	-	-
16	M	Force 1	5	mV/N	Volt AC Gnd	-	1000 N	50	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-

No.	Frequency Center	Frequency Bandwidth	Frequency Low	Frequency High	Level Low	Level High	Slope	Alarm	Abort
1	208 Hz	215 Hz	100 Hz	315 Hz	42 N²/Hz	42 N²/Hz	Log.	3 dB	6 dB
2	658 Hz	685 Hz	315 Hz	1000 Hz	42 N²/Hz	1 N²/Hz	Log.	3 dB	6 dB

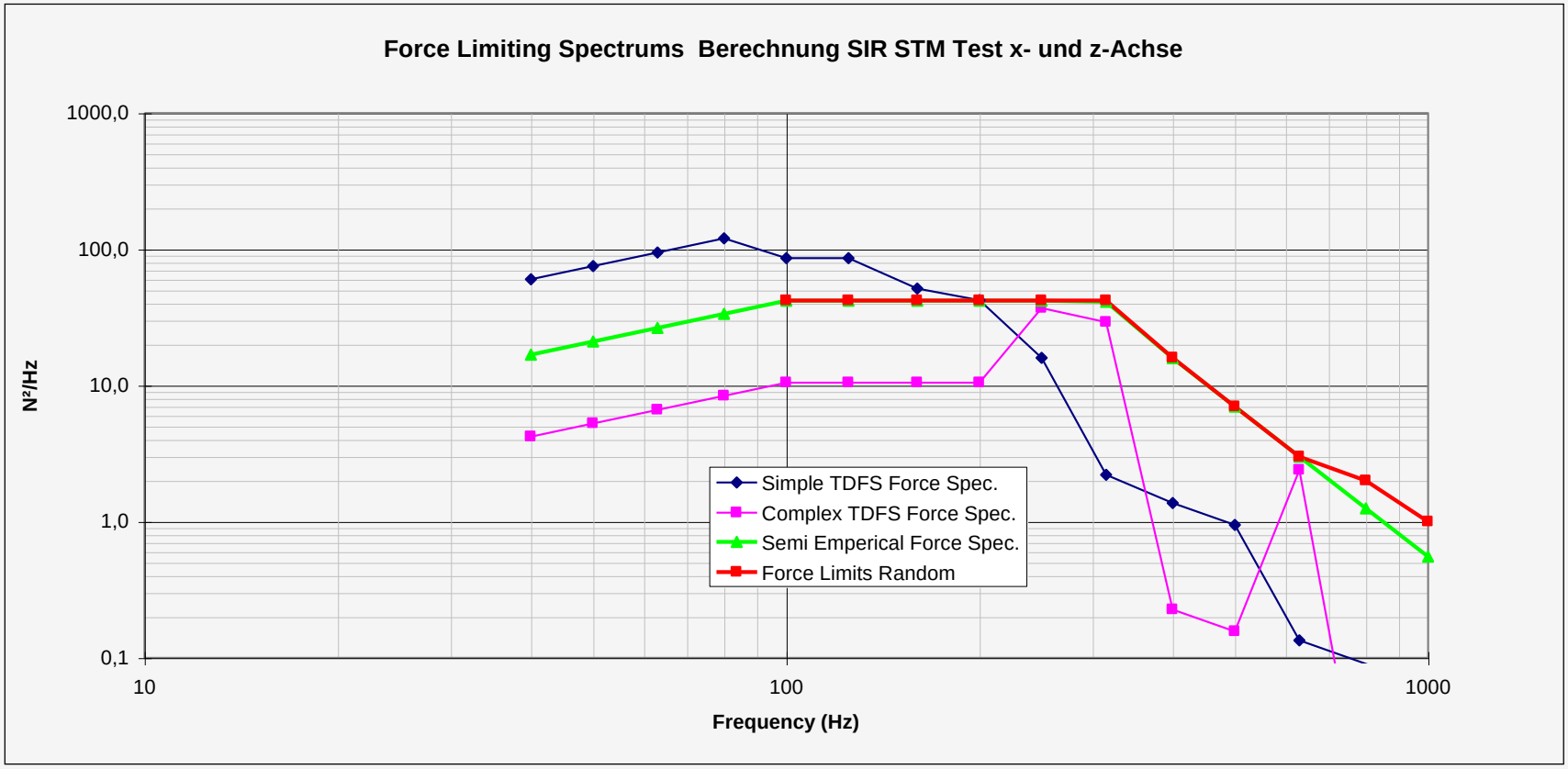
m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)



Courtesy: Astro- und Feinwerktechnik, Berlin-Adlershof

m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

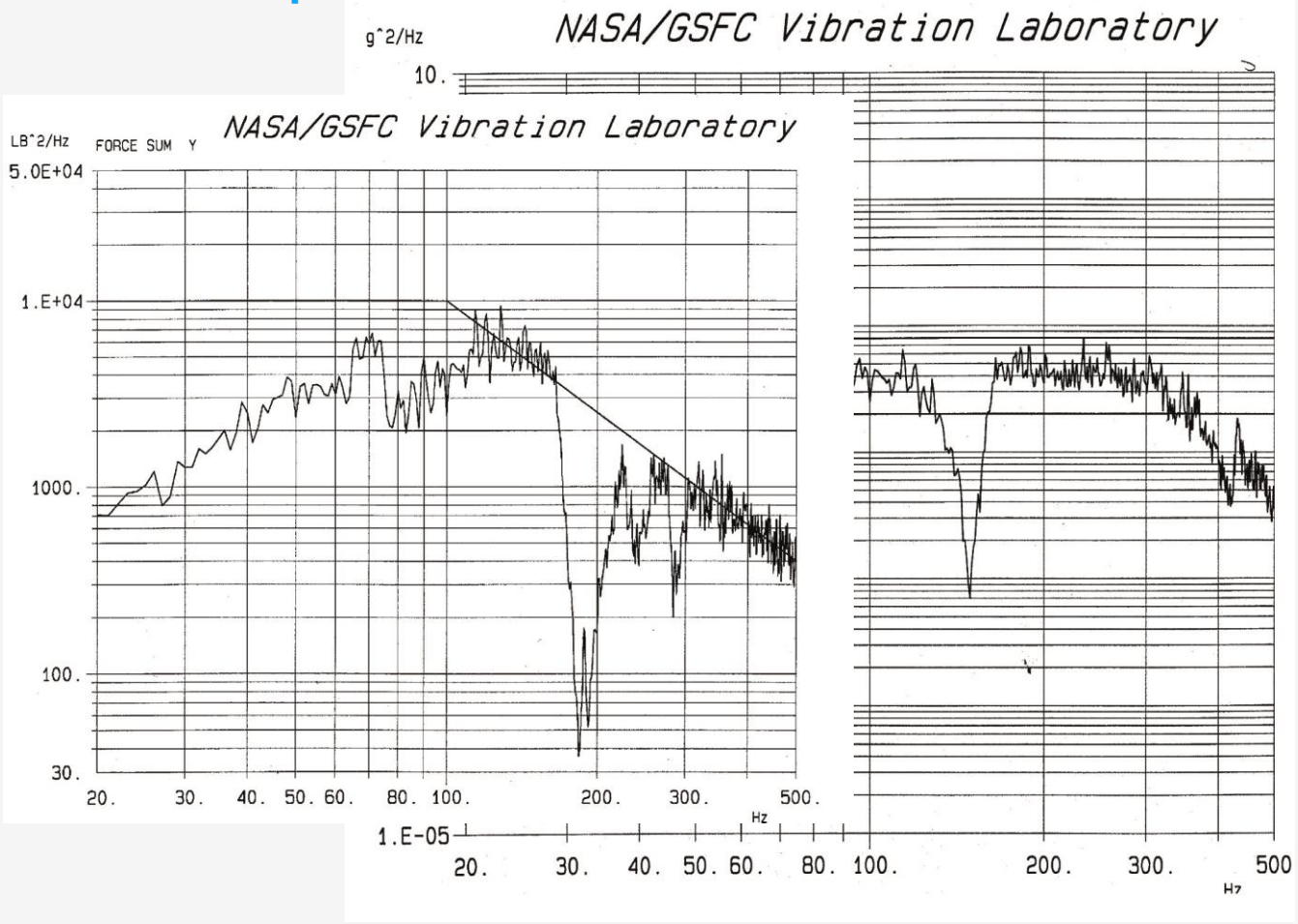
FVLT – Comparison of Different Force Limit Profile Methods in Random



Courtesy: Astro- und Feinwerktechnik, Berlin-Adlershof

m+p VibControl Software
Notching/Force Limited Vibration Testing (FLVT)

FVLT – Examples: Random Notch Influence on Force and Acceleration PSDs



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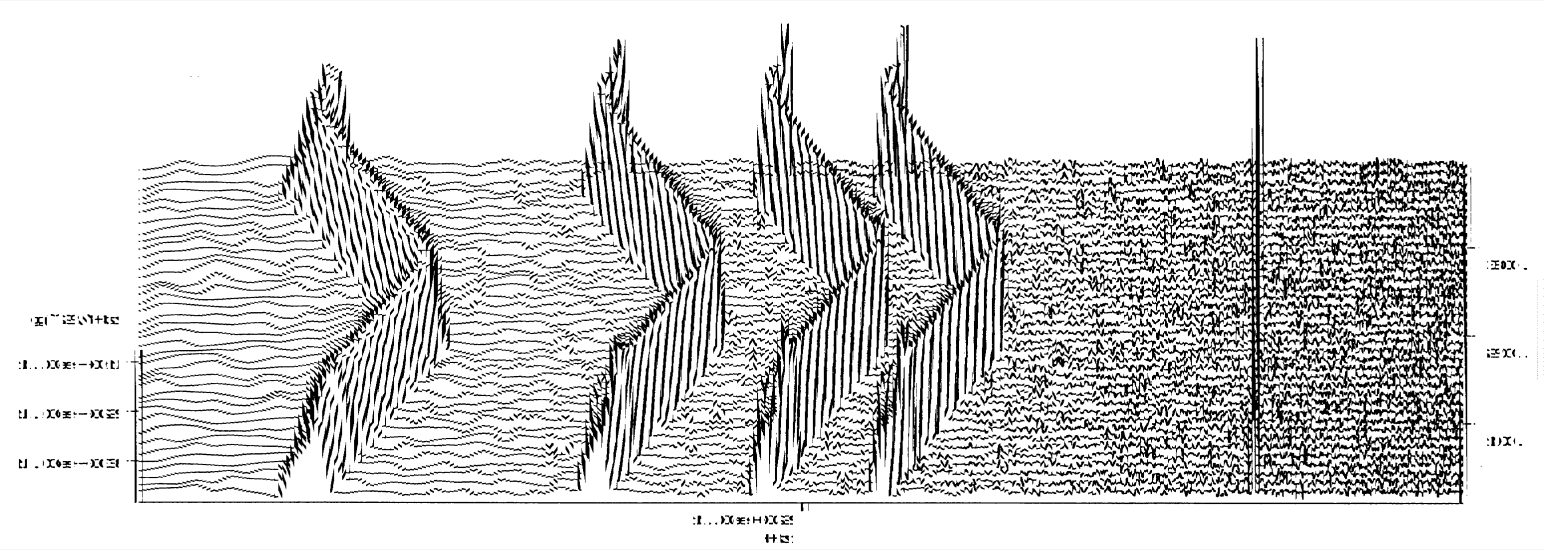
m+p VibControl Software
Mixed Mode SoR, RoR, SoRoR

Applications Sine-on-Random (SoR)

- Engine and gearbox components - automotive
- Helicopter components (SoR and SoRoR)
- Gunfire - defence

Applications Random-on-Random (RoR)

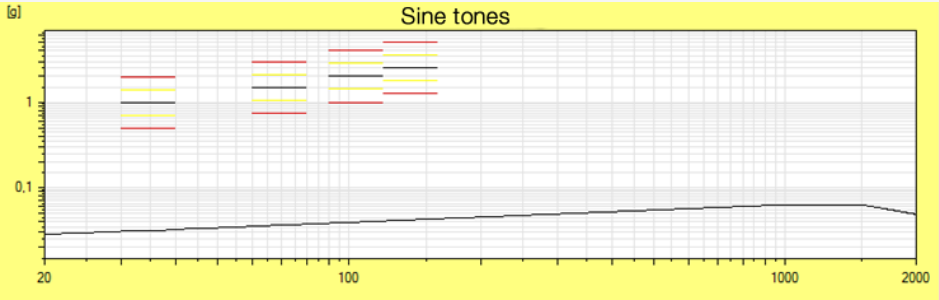
- Transport simulation for components, munitions in tanks, chainwheel vehicles

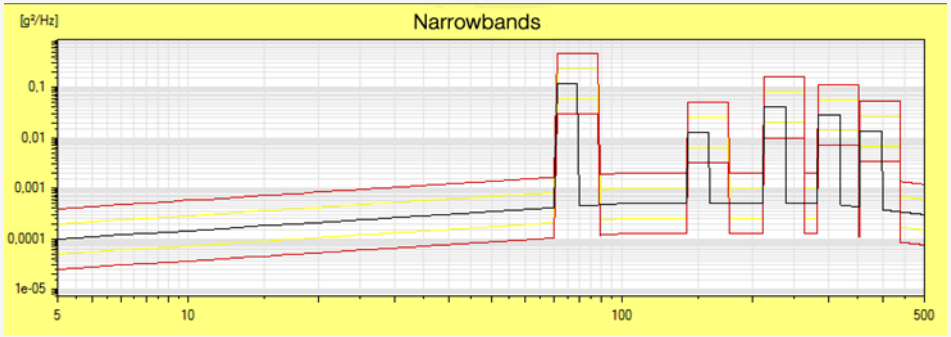


m+p VibControl Software
Mixed Mode SoR, RoR, SoRoR

Method

- One or several sine tones/narrowbands with/without profile are overlaid onto a broadband random
- Sine tones or narrowbands are sweeping or fixed
- Often harmonic frequencies up to 5th order
- Switch on/off sine components in gunfire applications





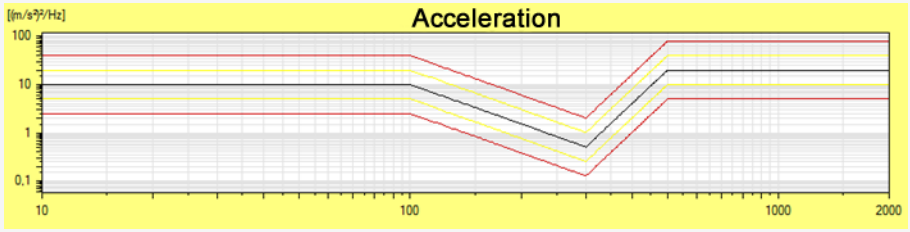
m+p VibControl Software
Mixed Mode SoR, RoR, SoRoR

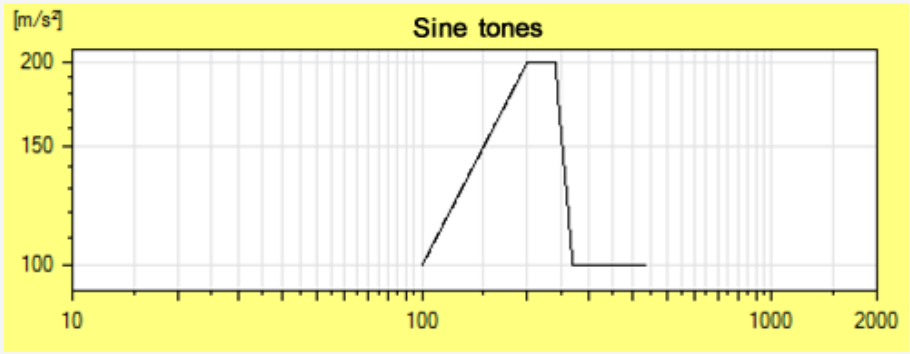
Spanfrequenz:	3200 Hz	Linienzahl:	1600
Frequenzauflösung:	2 Hz	Drivebegrenzung:	3

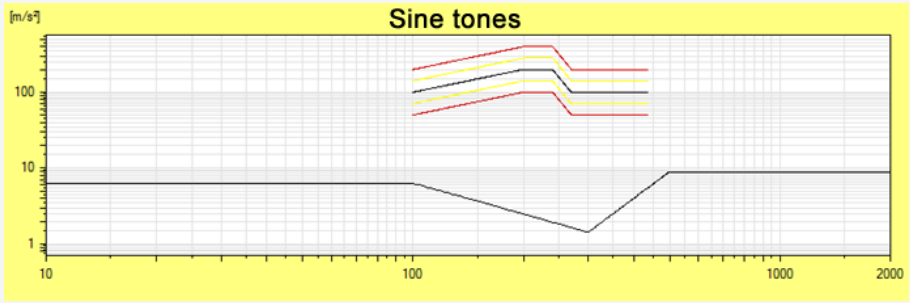
Nr.	Frequenz	Beschl.	Steigung	Warnung		Abbruch	
				Min.	Max.	Min.	Max.
1	10 Hz	10 (m/s²)²/Hz	Steigung	-3 dB	3 dB	-6 dB	12 dB
2	100 Hz	10 (m/s²)²/Hz	Steigung	-3 dB	3 dB	-6 dB	12 dB
3	300 Hz	0,51 (m/s²)²/Hz	Steigung	-3 dB	3 dB	-6 dB	12 dB
4	500 Hz	20 (m/s²)²/Hz	Steigung	-3 dB	3 dB	-6 dB	12 dB
5	2000 Hz	20 (m/s²)²/Hz	Steigung	-3 dB	3 dB	-6 dB	12 dB

Nr.	Frequenz			Sweep			Zeit			
	Unten	Oben	Start	Typ	Richtung	Rate	Dauer	Offset	Ein	Aus
1	100 Hz	440 Hz	100 Hz	Log.	pos.	1 Oct/min	128 s	0 s	30 s	0 s

Nr.	Frequenz	Beschl.	Geschw.	Weg	Steigung			Abbruch	
					Typ	Wert	Einheit	Min.	Max.
1	100 Hz	100 m/s²	0,159 m/s	0,253 mm	Auto Beschl.	0	dB/Okt	-6	6
2	200 Hz	200 m/s²	0,159 m/s	0,127 mm	Auto Beschl.	-2,50...	dB/Okt	-6	6
3	240 Hz	200 m/s²	0,133 m/s	0,088 mm	Auto Beschl.	0	dB/Okt	-6	6
4	270 Hz	100 m/s²	0,0589 m/s	0,0347 mm	Auto Beschl.	-3,52...	dB/Okt	-6	6
5	440 Hz	100 m/s²	0,0362 m/s	0,0131 mm	Auto Beschl.	0	dB/Okt	-6	6







VW 80101: SoR engine components

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m+p VibControl Software
Multi-Sine

Method

- A test method used in automotive to reduce sine testing time, hence cost reduction
- Multi-sine is similar to a standard sine test, but several sine tones are sweeping at the same time over a frequency interval with 1 Oct./min.
- Testing time is reduced by normal sine test time divided by no. of sine tones
- Method requires large shaker forces because acceleration of several sine tones sums up
- Development of method by German automotive companies Audi, BMW, Daimler, Porsche and Volkswagen in 2008

Reference

- AK-LH1, Arbeitskreis Lastenheft „Motoranbauteile“, November 2008

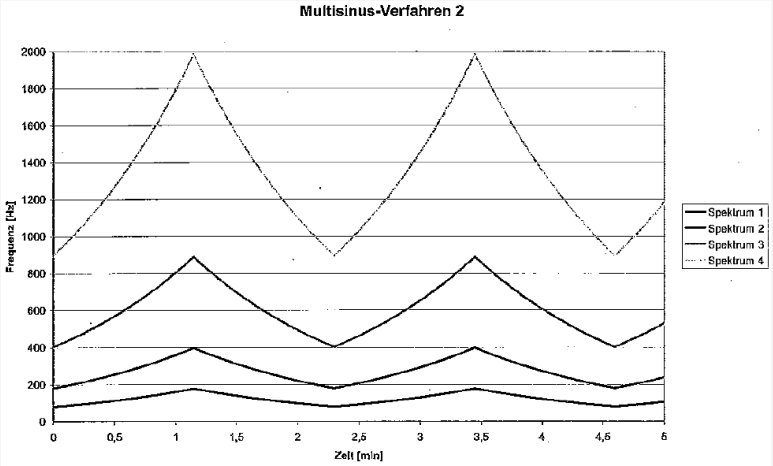
m+p VibControl Software
Multi-Sine

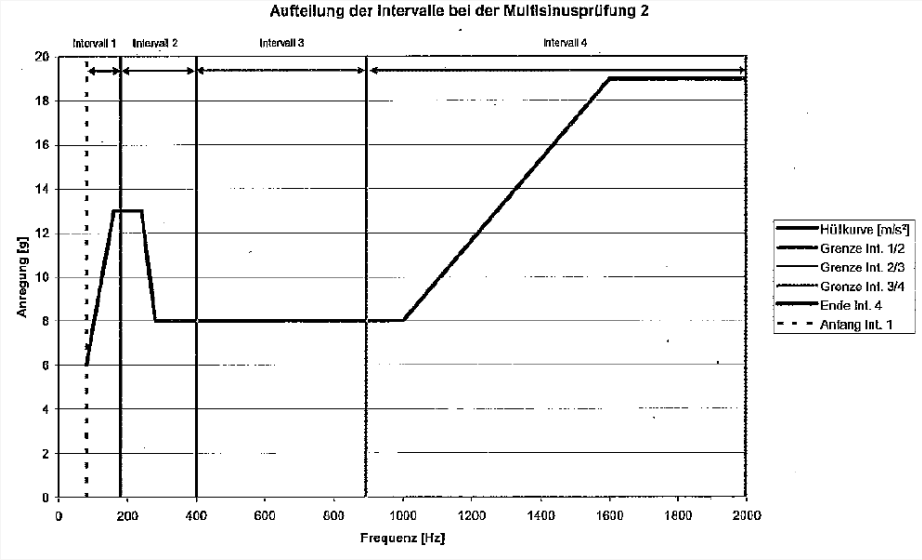
AK-LH1, Engine Components, November 2008

$$Intervallfaktor = \left(\frac{Max_Frequenz}{Min_Frequenz} \right)^{1/Zahl_der_Spektren}$$

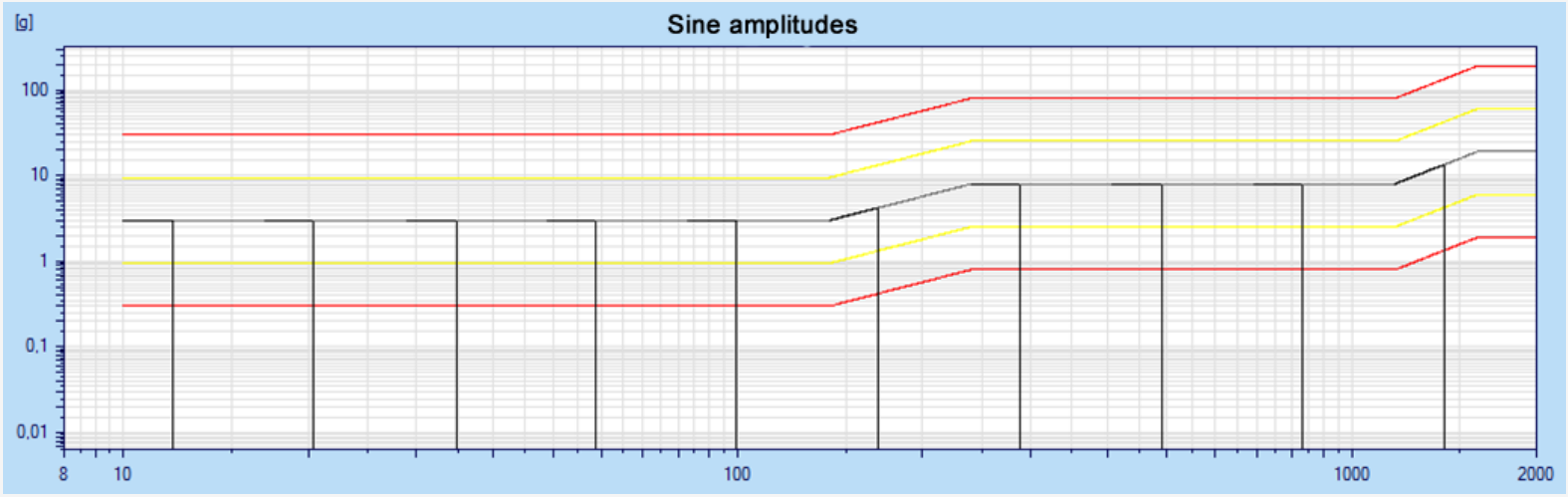
Beispiel: Es soll eine Prüfung zwischen 80 und 2000 Hz mit 4 Spektren stattfinden. Intervallfaktor ist $(2000/80)^{0,25} = 2{,}236$. Die vier Intervalle sind:

Beginn des Intervalls	Ende des Intervalls
80 Hz	179 Hz
179 Hz	400 Hz
400 Hz	894 Hz
894 Hz	2000 Hz





m+p VibControl Software
Multi-Sine



No.	Frequency			Sweep		
	lower	upper	Start	Type	Direction	Rate
1	10 Hz	17 Hz	10 Hz	Log.	pos.	1 Oct/min
2	17 Hz	29 Hz	17 Hz	Log.	pos.	1 Oct/min
3	29 Hz	49 Hz	29 Hz	Log.	pos.	1 Oct/min
4	49 Hz	83 Hz	49 Hz	Log.	pos.	1 Oct/min
5	83 Hz	141 Hz	83 Hz	Log.	pos.	1 Oct/min
6	141 Hz	240 Hz	141 Hz	Log.	pos.	1 Oct/min
7	240 Hz	408 Hz	240 Hz	Log.	pos.	1 Oct/min
8	408 Hz	693 Hz	408 Hz	Log.	pos.	1 Oct/min
9	693 Hz	1177 Hz	693 Hz	Log.	pos.	1 Oct/min
10	1177 Hz	2000 Hz	1177 Hz	Log.	pos.	1 Oct/min

Sweep rate 1 Oct./min, 10 intervals

m+p VibControl Products

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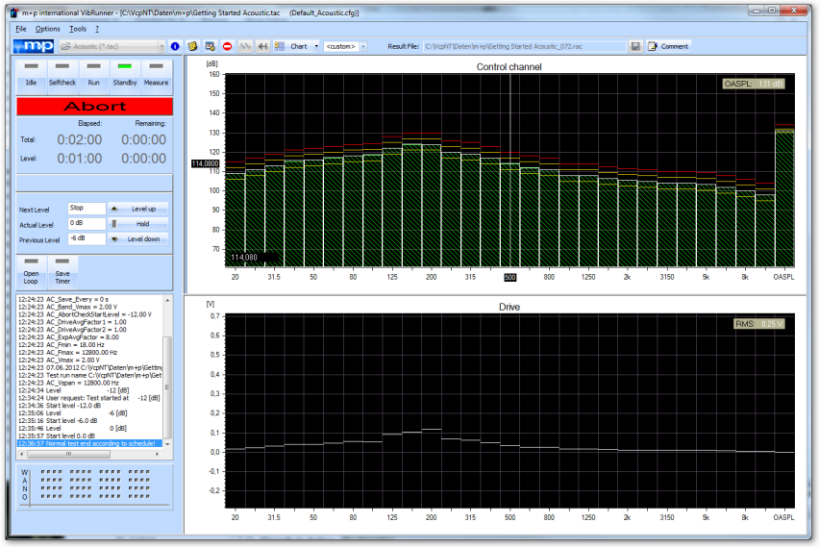
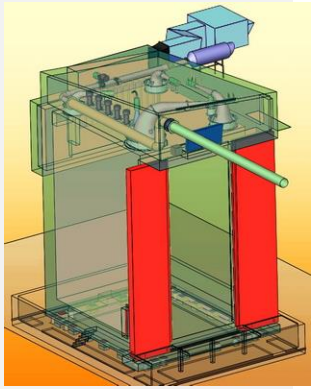
- Advanced – Notching/Force Limited Vibration Testing (FLVT)
- Advanced - Mixed Mode (SoR, RoR, SoRoR)
- Advanced – Multi-Sine
- **Advanced - Acoustic Control for Reverberant Chambers and PWT**
- Summary

m+p VibControl Products
Acoustic Control

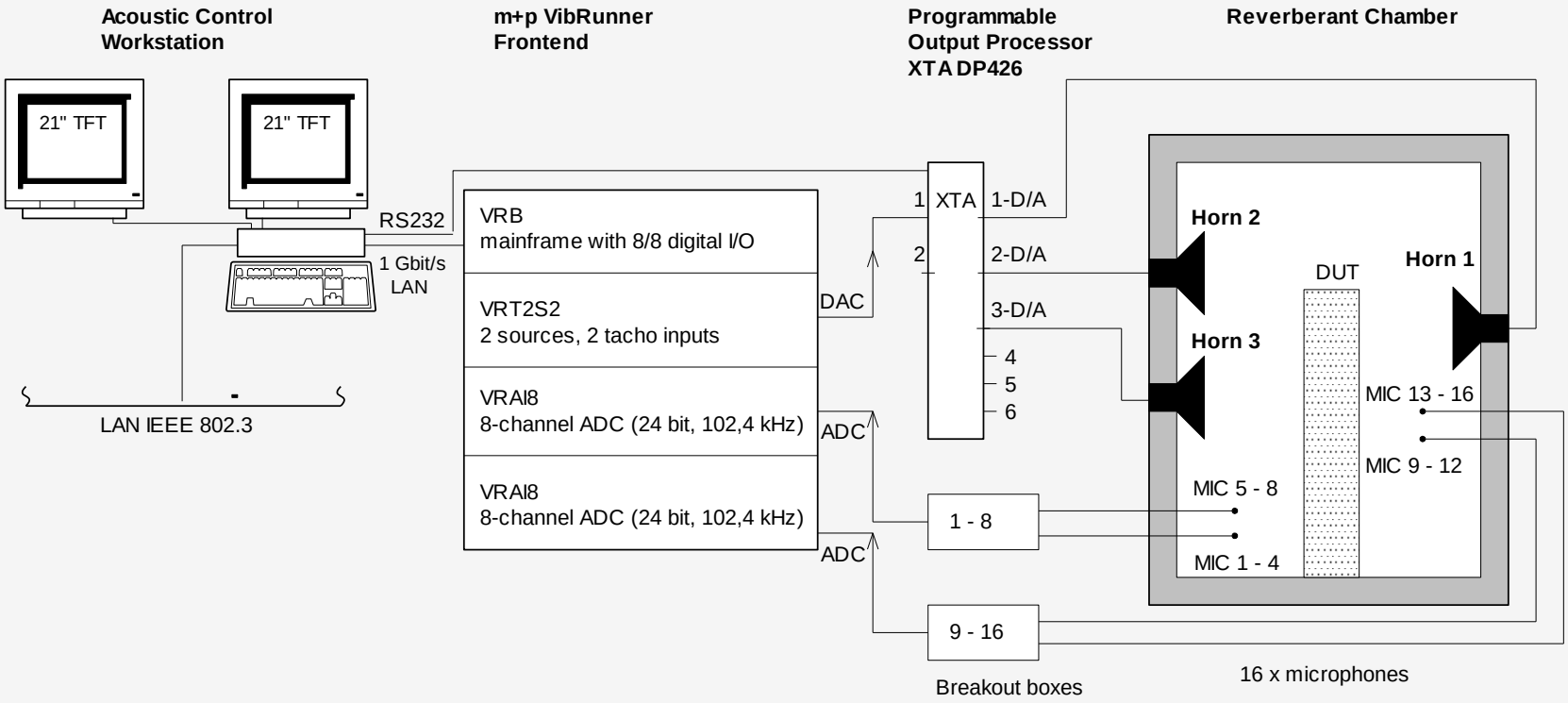




Acoustic Control for Reverberant Chambers and Progressive Wave Tubes (PWT)

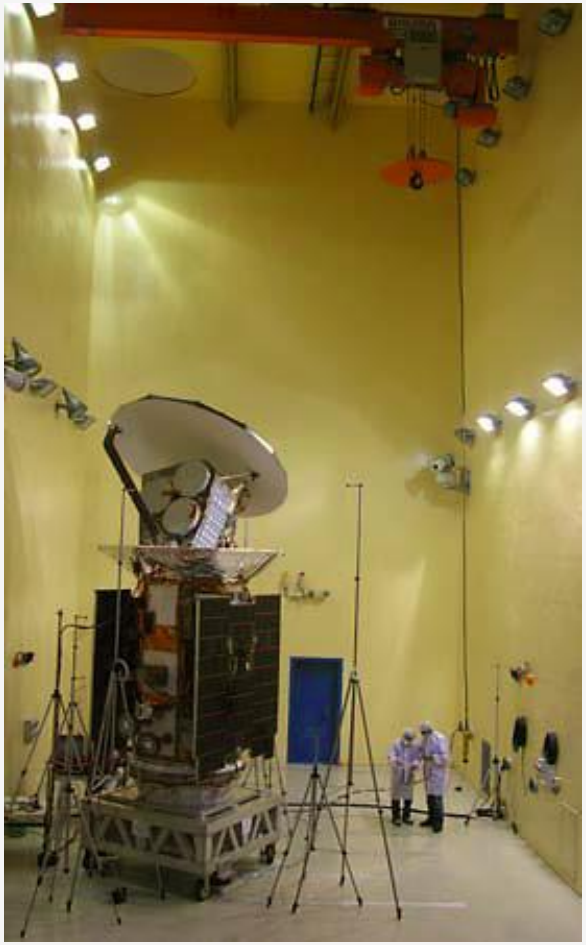
- Simulation of high-level noise in a reverberant chamber or Progressive Wave Tube (PWT)
- Control of reference octave band spectrum and overall sound pressure level (OASPL)
- 1/1 or 1/3 octave bands
- 40 (and more) microphones
- Frequency range 20 - 10,000 Hz with multi-horn control
- Time history recording
- Same measurement hardware and user interface as m+p VibControl shaker controller
  - → Acoustic control system can be easily configured as a vibration control system

m+p VibControl Products
Acoustic Control

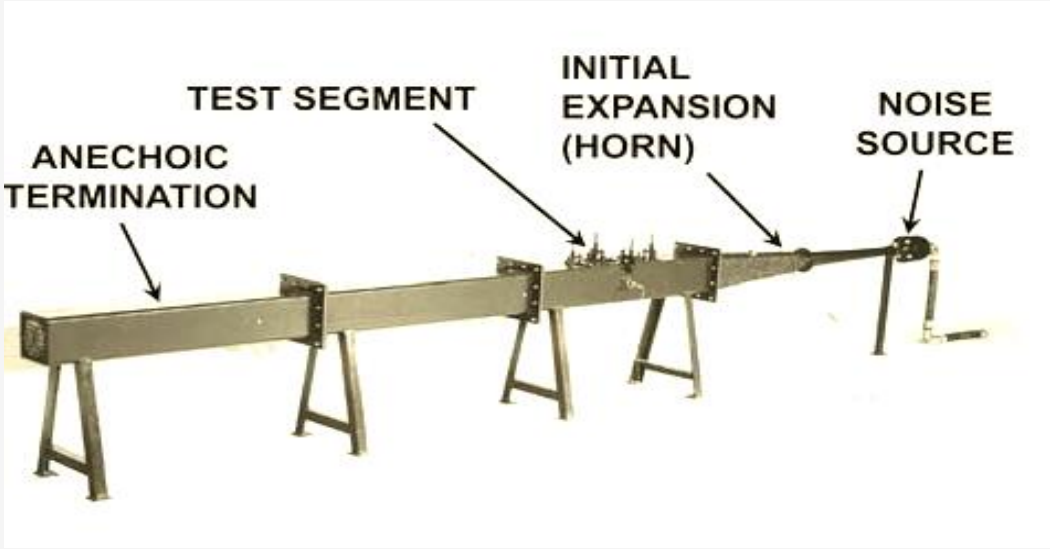


Acoustic control: typical configuration using 16 channels

m+p VibControl Products
Acoustic Control

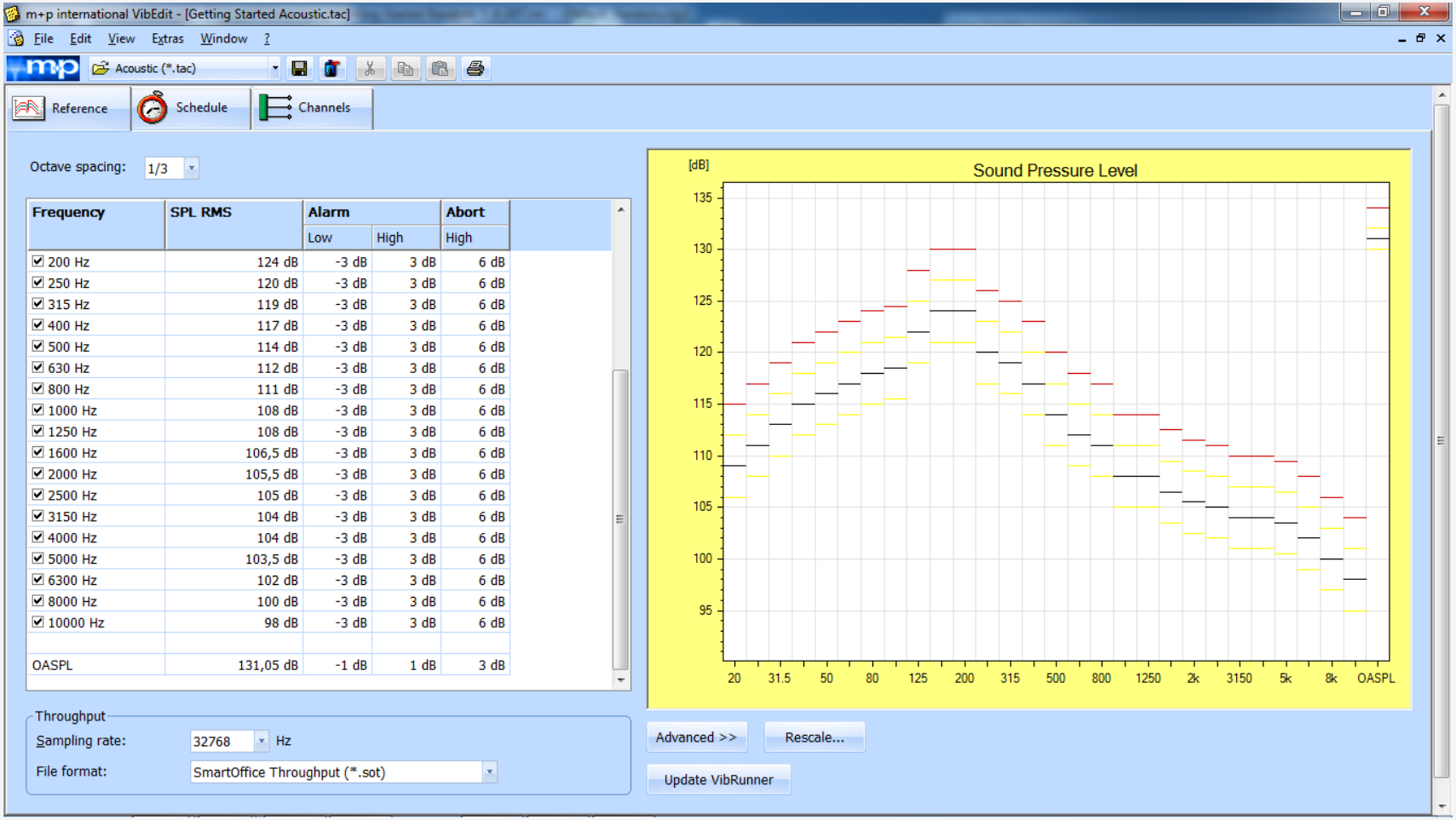


Reverberant chamber
INPE, São Jose dos Campos, Brazil



Progressive Wave Tube (PWT)

m+p VibControl Products
Acoustic Control



Acoustic control: typical configuration using 16 channels

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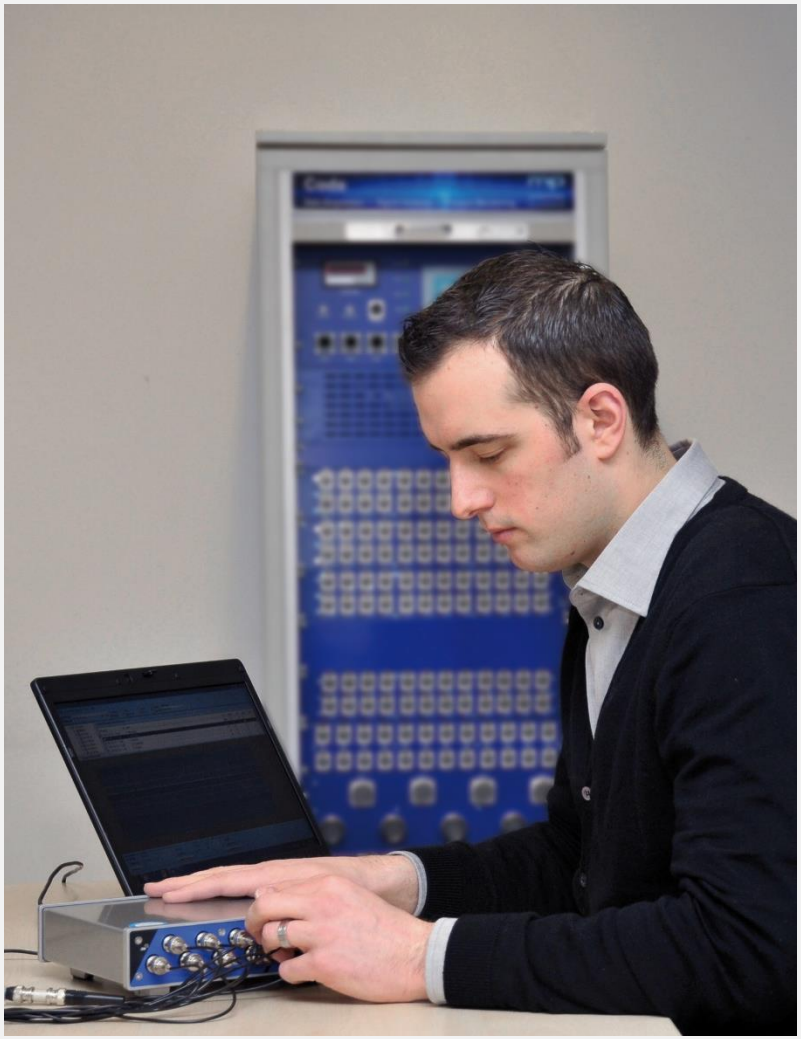
Why So Many Engineers Rely on m+p international



Full-Service Provider of Test and Measurement Systems for Use

- In the test laboratory
- On the production floor
- In the field

Complete Solutions

- Planning
- Implementation
- Installation
- Full-operational support

Our Strengths

- Expertise, excellent service & support from m+p international engineers
- State-of-the-art software and hardware tools
- 30 years of engineering experience

m+p VibControl Products
…for a Wide Variety of Test Requirements

Leading Environmental Test Laboratories Use Systems from m+p international

- Vibration control systems from 4 to 512 input channels
- True multi-tasking: test definition, test run and post-testing in parallel
- Simple for production, advanced for R&D
- Flexible measurement hardware specially developed for vibration control
- Future-proof software, regular updates
- Common user interface across all systems
- Complete vibration test stands including shakers, transducers, etc.
- Customized test stands
- Calibration service
- m+p is independent of shaker manufacturers
- 40 years of engineering experience and know-how