Vibration Testing. Theory and Practice. 2nd Edition

Description: Vibration Testing: Theory and Practice, Second Edition is a step-by-step guide that shows how to obtain meaningful experimental results via the proper use of modern instrumentation, vibration exciters, and signal-processing equipment, with particular emphasis on how different types of signals are processed with a frequency analyzer. Thoroughly updated, this new edition covers all basic concepts and principles underlying dynamic testing, explains how current instruments and methods operate within the dynamic environment, and describes their behavior in a number of commonly encountered field and laboratory test situations.

Contents:

Chapter One: an Overview Of Vibration Testing.

1.1 Introduction.
1.2 Preliminary Considerations.
1.3 General Input/Output Relationships in the Frequency Domain.
1.4 Overview of Equipment Employed.
1.5 Summary.

Chapter Two: Dynamic Signal Analysis.

2.1 Introduction.
2.1.1 Signal Classification.
2.1.2 Temporal Mean Value.
2.1.3 Temporal Mean Square and Temporal Root Mean Square.
2.1.4 The Frequency Spectrum.
2.1.5 Analysis of a Single Sinusoid.
2.2 Phasor Representation of Periodic Functions.
2.2.1 The Phasor.
2.2.2 The Phasor and Real-Valued Sinusoids.
2.3 Periodic Time Histories.
2.3.1 Periodic Fourier Series.
2.3.2 The Mean, Mean Square, and Parseval’s Formula.
2.3.3 Analysis of a Square Wave.
2.4 Transient Signal Analysis.
2.4.1 Difference Between Periodic and Transient Frequency Analysis.
2.4.2 The Transient Fourier Transform.
2.4.3 Transient Mean, Mean Square, And Parseval's Formula.

2.5 Correlation Concepts - A Statistical Point of View.

2.6 Correlation Concepts - Periodic Time-Histories.

2.6.1 Cross-Correlation.

2.6.2 Auto-Correlation.

2.7 Correlation Concepts - Transient Time-Histories.

2.7.1 Cross-Correlation.

2.7.2 Auto-Correlation.

2.8 Correlation Concepts - Random Time Histories.

2.8.1 Auto-Correlation and Auto-Spectral Density.

2.8.3 Correlation and Spectral Densities of Multiple Random Processes.

2.8.4 Statistical Distributions.

2.9 Summary.

2.10 General References on Signal Analysis.

References.

Chapter Three: Vibration Concepts.

3.1 Introduction.

3.2 The Single DOF Model.

3.2.1 Equation of Motion.

3.2.2 Free Undamped Vibration.

3.2.3 Free Damped Vibration.

3.2.4 Structure Orientation and Natural Frequency.

3.3 Single Degree of Freedom Forced Response.

3.3.1 The Viscous Damping Case.

3.3.2 Common Frfs.

3.3.3 Damping Models in Forced Response.

3.3.4 The Structural Damping Response.

3.3.5 The Bode Diagram.

3.3.6 Real & Imaginary Plots and Nyquist Diagrams.

3.4 General Input-Output Model for Linear Systems.

3.4.1 The Frequency-Domain (Fourier Transform) Approach.

3.4.2 The Time-Domain Impulse Response Approach.
3.4.3 Receptance Frf Vs Impulse Response Function.
3.4.4 Random Input-Output Relationships.
3.4.5 Shock Response Spectra.
3.5 The Two Degree of Freedom Vibration Model.
  3.5.1 Equations of Motion.
  3.5.2 Undamped Natural Frequencies and Mode Shapes.
  3.5.3 Steady State Forced Vibration Response (Direct Method).
  3.5.4 Steady State Forced Response (Modal Method).
  3.5.5 Comparison of Direct and Modal Response FRFs.
3.6 The Second Order Continuous Vibration Model.
  3.6.1 The Fundamental Equation of Motion.
  3.6.2 Separation of Space and Time Variables.
  3.6.3 Orthogonality Conditions.
  3.6.4 The Modal Model and Forced Vibrations.
  3.6.5 The Generalized Excitation Force for Distributed Loads.
  3.6.6 Continuous Model FRFs.
3.7 Fourth Order Continuous Vibration System - The Beam.
  3.7.1 The Fundamental Equation of Motion.
  3.7.2 Natural Frequencies and Mode Shapes.
  3.7.3 Natural Frequencies and Boundary Conditions.
  3.7.4 The Modal Model.
  3.7.5 The Beam Under Tension.
3.8 Non-Linear Behavior.
  3.8.1 The Phase Plane.
  3.8.2 The Simple Pendulum.
  3.8.3 The Duffing Equation of Forced Vibration.
  3.8.4 The Van Der Pol Equation and Limit Cycles.
  3.8.5 The Mathieu Equation.
  3.8.6 Chaotic Vibration.
3.9 Summary.
References.
Chapter Four: Transducer Measurement Considerations.

4.1 Introduction.

4.2 Fixed Reference Transducers.

4.2.1 The Linear Variable Differential Transformer (LVDT).

4.2.2 The Laser Doppler Vibrometer (LDV).

4.3 Mechanical Model of Seismic Transducers - The Accelerometer.

4.3.1 The Basic Mechanical Model.

4.3.2 Gravity Forces And Acceleration Measurements.

4.4 Piezoelectric Sensor Characteristics.

4.4.1 Basic Circuits and Operational Amplifiers.

4.4.2 Charge Sensitivity Model.

4.4.3 The Charge Amplifier.

4.4.4 Built-In Voltage Followers.

4.4.5 The Overall Accelerometer FRF.

4.5 Combined Linear and Angular Accelerometers.

4.5.1 Using Multiple Accelerometers To Measure Combined.

4.5.2 The Combined Linear And Angular Accelerometer Transducer Response to Transient Inputs.

4.6 Transducer Response to Transient Inputs.

4.6.1 Mechanical Response.

4.6.2 Piezoelectric Circuit Response To Transient Signals.

4.6.3 Field Experience With Shock Loading.

4.7 Accelerometer Cross-Axis Sensitivity.

4.7.1 The Single Accelerometer Cross-Axis Sensitivity Model.

4.7.2 The Tri-Axial Accelerometer Cross-Axis Sensitivity Model.

4.7.3 Correcting Tri-Axial Acceleration Voltage Readings.

4.7.4 FRF Contamination and Its Removal.

4.7.5 Cross Axis Resonance.

4.8 The Force Transducer General Model.

4.8.1 General Electromechanical Model.

4.8.2 Force Transducer Attached to a Fixed Foundation.

4.8.3 The Force Transducer Attached to an Impulse Hammer.

4.8.4 The Force Transducer Used with Vibration Exciter and Structure.
4.8.5 The Impedance Head.

4.9 Correcting Frf Data For Force Transducer Mass Loading.

4.9.1 A Consistent Force Transducer Model.

4.9.2 Correcting Driving Point Accelerance FRF in Frequency Domain.

4.9.3 Correcting Transfer Accelerance FRFs in Frequency Domain.

4.9.4 Electronic Compensation Using Seismic Acceleration.

4.9.5 Errors Due To Hipp(O) Being Nonunity.

4.10 Calibration.

4.10.1 Accelerometer Calibration - Sinusoidal Excitation.

4.10.2 Accelerometer Calibration - Transient Excitation.

4.10.3 Force Transducer - Sinusoidal Excitation.

4.10.4 Force Transducer - Transient Excitation.

4.10.5 Effects of Bending Moments on Measured Forces.

4.11 Environmental Factors.

4.11.1 Base Strain.

4.11.2 Cable Noise.

4.11.3 Humidity and Dirt.

4.11.4 Mounting the Transducer.

4.11.5 Nuclear Radiation.

4.11.6 Temperature.

4.11.7 Transducer Mass.

4.11.8 Transverse Sensitivity.

4.12 Summary.

References.

Chapter Five: The Digital Frequency Analyzer.

5.1 Introduction.

5.2 Basic Processes of A Digital Frequency Analyzer.

5.2.1 The Time Sampling Process.

5.2.2 Time-Domain Multiplication and Frequency-Domain Convolution.

5.2.3 Sample Function Multiplication Gives Aliasing.

5.2.4 The Window Function Creates the Digital Filter Characteristics.
5.2.5 Filter Leakage.

5.3 Digital Analyzer Operating Principles.

5.3.1 Operating Block Diagram.

5.3.2 Internal Calculation Relationships.

5.3.3 Display Scaling.

5.4 Factors In The Application of a Single Channel Analyzer.

5.4.1 Filter Performance Characteristics.

5.4.2 Four Commonly Employed Window Functions.

5.4.3 Window Comparison for Use with Sinusoidal Signals.

5.4.4 Spectral Line Uncertainty.

5.4.5 Recommended Window Usage.

5.5 The Dual Channel Analyzer.

5.5.1 Ideal Input - Output Relationships.

5.5.2 Actual Input-Output Estimates for A Digital Analyzer.

5.5.3 Auto-Spectra and Cross-Spectra Averaging.

5.5.4 Some Reasons Coherence Is Less than Unity.

5.5.5 Operating Block Diagram.

5.6 The Effects of Signal Noise on Frf Measurements.

5.6.1 Noise in The Input Signal.

5.6.2 Noise in The Output Signal.

5.6.3 Noise in The Input And Output Signals.

5.6.4 More than One External Input.

5.7 Overlapping Signal Analysis to Reduce Analysis Time.

5.7.1 Overlapping And Ripple.

5.7.2 Effective Bandwidth Time Product And Measurement Uncertainty.

5.7.3 Real Time Analysis.

5.8 Zoom Analysis.

5.8.1 Zoom FFT Analysis Using The Heterodyning Method.

5.8.2 Long Time Record Zoom FFT Analysis.

5.8.3 Zoom Analysis With And Without Sample Tracking.

5.9 Scan Analysis, Scan Averaging, And More On Spectral Smearing.

5.9.1 Scan Analysis.
5.9.2 Scan Averaging and Resulting Frequency Spectra.
5.9.3 Scan Average Analysis of a Transient Signal.
5.9.4 More on Spectral Smearing.
5.10 Summary.
5.11 References.

Chapter Six: Vibration Excitation Mechanisms.
6.1 Introduction.
6.1.1 Static Excitation Schemes.
6.1.2 Dynamic Impulse Loading Schemes.
6.1.3 Controlled Dynamic Loading Schemes.
6.2 Mechanical Vibration Exciters.
6.2.1 The Direct-Drive Exciter Model.
6.2.2 The Direct-Drive Vibration Exciter Table.
6.2.3 The Direct-Drive Reaction Type Vibration Exciter.
6.2.4 The Rotating Unbalance Exciter.
6.2.5 Driving Torque Considerations.
6.3 Electrohydraulic Exciters.
6.3.1 Electrohydraulic System Components.
6.3.2 Application to Earthquake Simulator.
6.4.1 Exciter Support Dynamics.
6.4.2 Armature Dynamics.
6.4.3 Electro-Mechanical Coupling Relationships.
6.4.4 Power Amplifier Characteristics.
6.5 An Exciter System's Bare Table Characteristics.
6.5.1 The Electro-Dynamic Model.
6.5.2 Constant Current Mode Power Amplifier.
6.5.3 Voltage Mode Power Amplifier.
6.5.4 Comparison Of Bare Table Armature Responses.
6.6 Interaction Of An Exciter And A Grounded Single Dof Structure.
6.6.1 The Single DOF SUT and Electrodynamic Exciter Model.
6.6.2 The SUT's Accelerance Response.
6.6.3 The Force Transmitted To The Sut And Force Drop Out.
6.7 Interaction Of An Exciter And An Ungrounded Structure Under Test.
6.7.1 A General Dynamic Model Using Driving Point and Transfer Accelerance.
6.7.2 Ungrounded Test Structure and Exciter Accelerance Characteristics.
6.7.3 Test Responses for Current and Voltage Mode Power Amplifier Inputs.
6.8 Measuring an Exciters Actual Characteristics.
6.8.1 Theoretical Model.
6.8.2 Armature Impact Test Results with "stiff" and "Soft" Supporting System.
6.8.3 Armature Driven by a Second Exciter.
6.8.4 Armature's Rotational Degrees of Freedom.
6.8.5 Exciter Structure Interaction During Test.

References.

Chapter Seven: The Application Of Basic Concepts To Vibration Testing.

7.1 Introduction.
7.2 Sudden Release Or Step Relaxation Method.
7.2.1 Theoretical Modal Model.
7.2.2 Mid-Point Excitation and Response.
7.2.3 Resolving the Measurement Dilemma.
7.2.4 Results from an Actual Test.
7.3 Forced Response Of A Simply Supported Beam Mounted On An Exciter.
7.3.1 Modal Model of The Test Environment.
7.3.2 The Effect of Accelerometer Mass on Measurements.
7.3.3 The Limits for Modal Mass Correction to Natural Frequencies.
7.3.4 Added Mass at the Quarter Point.
7.4 Impulse Testing.
7.4.1 Impulse Requirements.
7.4.2 The Input Noise Problem.
7.4.3 The Output Leakage Problem.
7.4.4 Application of Impulse Testing to a Free-Free Beam.
7.5 Selecting Proper Windows for Impulse Testing.
7.5.1 Window Parameters.
7.5.2 Modeling the Data Process.
7.5.3 Truncation and Exponential Window Effects.
7.5.4 The Effects of the Input Transient Window.
7.5.5 A Second Example of An Impact Driving Point Accelerance Test Results.
7.5.6 Recommended Procedure for Setting Window Parameters.
7.6 Vibration Exciter Driving A Free-Free Beam With Point Loads.
7.6.1 Selecting the Excitation Signal.
7.6.2 Test Setup.
7.6.3 Theoretical Exciter Structure Interaction.
7.6.4 Comparison of Experimental and Theoretical Results.
7.7 Windowing Effects On Random Test Results.
7.7.1 A Model of Window Function Filter Leakage Characteristics.
7.7.2 Estimating FRF Errors Due to Leakage.
7.7.3 Theoretical Simulation of Leakage and its Effects.
7.7.4 Recommendations to Check For This Filter Error.
7.8 Low Frequency Damping Measurements Reveal Subtle Data Processing Problems.
7.8.1 The Test Set Up.
7.8.2 The Hardware Error.
7.8.3 A Software Problem.
7.8.4 Another Common Measurement Error Source.
7.9 A Linear Structure Becomes Non-Linear Due To Its Test Environment.
7.10 Summary.

References.

Chapter Eight: General Vibration Testing Model: From The Field To The Laboratory.

8.1 Introduction.
8.1.1 General Linear System Relationships.
8.1.2 Three Structures Involved in the Process.
8.2 A Two Point Input-Output Model Of Field And Laboratory Simulation Environments.
8.2.1 Notation Scheme.
8.2.2 The Field Environment.
8.2.3 Laboratory Environment.
8.2.4 Discussion of Elementary Results.

8.3 Laboratory Simulation Schemes Based On The Elementary Model.

8.3.1 Test Scenario ---1 - Matched Interface Motions and NO External Forces.

8.3.2 Test Scenario ---2 - Matched Interface Forces and No External Forces.

8.3.3 Test Scenario ---3 - Matched Test Item Motion and No External Forces.

8.3.4 Scenario ---4 - Matched Interface Motion with Field External Force but No Laboratory External Force.

8.3.5 Scenario ---5 - Matched Interface Forces with Field External Force but No Laboratory External Force.

8.3.6 Test Scenario ---6 - Matched Test Item Motion with Field External Force but No Laboratory External Force.

8.3.7 Summary of Six Possible Test Scenarios.

8.4 An Example Using A Two Dof Test Item And A Two DOF Vehicle.

8.4.1 Test Item And Vehicle Dynamic Characteristics.

8.4.2 Laboratory Test Setup Employed During Tests.

8.4.3 Field Simulation Results.

8.4.4 Laboratory Simulation.

8.4.5 Predicting Interface Forces and Accelerations From Bare Vehicle Interface Acceleration ASD Data.

8.4.6 Summary And Conclusions For This Simple Example.

8.5 The General Field Environment Model.

8.5.1 Frequency Domain Modeling.

8.5.2 Field Motions and Boundary Conditions.

8.6 The General Laboratory Environment Model.

8.7 Test Scenarios for Laboratory Simulations.

8.8 Summary.

Ordering:

Order Online - http://www.researchandmarkets.com/reports/2215286/

Order by Fax - using the form below

Order by Post - print the order form below and send to

Research and Markets,
Guinness Centre,
Taylors Lane,
Dublin 8,
Ireland.
Fax Order Form
To place an order via fax simply print this form, fill in the information below and fax the completed form to 646-607-1907 (from USA) or +353-1-481-1716 (from Rest of World). If you have any questions please visit http://www.researchandmarkets.com/contact/

Order Information
Please verify that the product information is correct.

Product Name: Vibration Testing. Theory and Practice. 2nd Edition
Web Address: http://www.researchandmarkets.com/reports/2215286/
Office Code: SCDVVBTX

Product Format
Please select the product format and quantity you require:

| Quantity | Hard Copy (Hard Back): USD 206 + USD 28 Shipping/Handling |

* Shipping/Handling is only charged once per order.

Contact Information
Please enter all the information below in BLOCK CAPITALS

<table>
<thead>
<tr>
<th>Title:</th>
<th>Mr ☐ Mrs ☐ Dr ☐ Miss ☐ Ms ☐ Prof ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Name:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Email Address: *</td>
<td>____________________________</td>
</tr>
<tr>
<td>Job Title:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Organisation:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Address:</td>
<td>____________________________</td>
</tr>
<tr>
<td>City:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Postal / Zip Code:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Country:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Phone Number:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Fax Number:</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

* Please refrain from using free email accounts when ordering (e.g. Yahoo, Hotmail, AOL)
Payment Information

Please indicate the payment method you would like to use by selecting the appropriate box.

☐ Pay by credit card: You will receive an email with a link to a secure webpage to enter your credit card details.

☐ Pay by check: Please post the check, accompanied by this form, to:

Research and Markets,
Guinness Center,
Taylors Lane,
Dublin 8,
Ireland.

☐ Pay by wire transfer: Please transfer funds to:

Account number 833 130 83
Sort code 98-53-30
Swift code ULSBIE2D
IBAN number IE78ULSB98533083313083
Bank Address Ulster Bank,
27-35 Main Street,
Blackrock,
Co. Dublin,
Ireland.

If you have a Marketing Code please enter it below:

Marketing Code: ____________________________

Please note that by ordering from Research and Markets you are agreeing to our Terms and Conditions at http://www.researchandmarkets.com/info/terms.asp

Please fax this form to:
(646) 607-1907 or (646) 964-6609 - From USA
+353-1-481-1716 or +353-1-653-1571 - From Rest of World