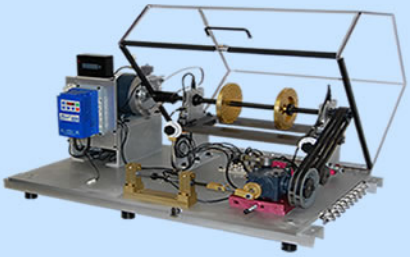
SQi SpectraQuest, Inc.

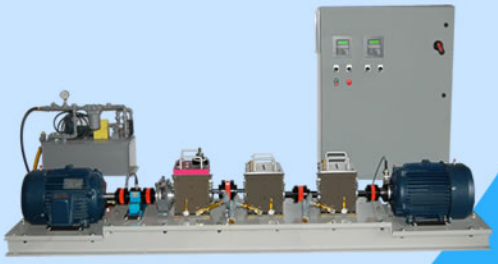
- Wind Energy



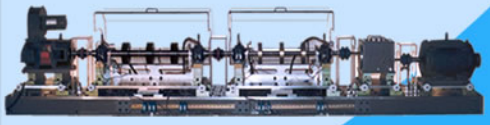
- Machinery Fault Simulators

- Vibration Analysis Hardware/Software

- Vibration, Kinematics & Dynamics Trainers



- DriveTrain Diagnostics/Prognostics



- Custom Designed Test Rigs

8201 Hermitage Road, Richmond, VA 23228
Tel: 804-261-3300, Fax: 804-261-3303
www.spectraquest.com, info@spectraquest.com

SpectraQuest Product Guide

SpectraQuest is a leading developer and manufacturer of products for enhancing reliability of rotating and reciprocating machinery. These products are ideal platform for research and education in machine fault diagnosis/prognosis, teaching dynamics and vibration courses, and wind turbine drivetrain studies. The distinguishing feature of SpectraQuest is a wide variety of Machinery Fault Simulators and Custom Designed Test Rigs which are sold in over forty five countries around the world. Our product line is classified in the following categories:

- Wind Energy
- Machinery Fault Simulator Series
- Vibration Analysis Hardware/Software
- Vibration, Kinematics & Dynamics Trainers
- DriveTrain Diagnostics/Prognostics Systems
- Custom Designed Test Rigs

➢ Wind Energy

Premature failure of bearings and gearbox of a wind turbine is a serious concern and is a fertile area of research. SpectraQuest offers test rigs for diagnostics and prognostics studies of complete drivetrain. Our simulators combined with data acquisition and analysis system provide the perfect turnkey research platform for researchers and practicing engineers.

Wind Turbine Simulator (WTS)

SpectraQuest's Wind Turbine Simulator (WTS) has been designed to teach/learn the fundamental principles of the wind turbine technology from power generation to the operation. The device provides an ideal platform for teaching the fundamental principles of how to generate electricity from wind energy and how to store it. The WTS is also an ideal tool for teaching wind turbine control system, instrumentation, and operation & maintenance procedures. The innovative design allows for the WTS to be used with and without the presence of wind such as in laboratory settings. This integrated package includes a hands-on experimentation device, curriculum, sensors and data acquisition and software along with a full set of instrumentation to expedite learning. The system consist of three independently actuated blades with ability to control the pitch, a 360 degrees turning yaw control mechanism, a nacelle, a turbine hub, a vertical tower, and complete control system. The WTS along with SpectraQuest's data acquisition and software is an ideal tool for teaching condition monitoring.

The WTS is robust and versatile designed to perform a variety of experiments to optimize benefits on your investment. It can be used to demonstrate several concepts and perform different experiments to optimize the electric power generation from the wind energy. The effects of various parameters such as number, length and type of blades, wind speed, etc. on the efficiency of power generation can be determined easily. The system gives a hands-on experience to students and can be integrated with a standard curriculum. It comes with a training book to assist with

exercises and learning. Sensors for wind speed and direction are provided so that the nacelle yaw and the pitch angles of each blade can be altered to optimize the power. The unit can be operated with and without wind. The unit is equipped to install several dc generators and the power produced by them can be combined. An inverter is used to generate AC power. WTS is also a perfect tool for learning how to assemble, safety issues, and maintenance procedures in a controlled environment.

Wind Turbine Drivetrain Diagnostics Simulator (WTDS)

SpectraQuest's Wind Turbine Drivetrain Diagnostics Simulator (WTDS) has been designed to simulate wind turbine drivetrains for research and educational purposes. The drivetrain consists of a 1 or 2 stage planetary gearbox with gear ratio upto 27:1, a 2 stage parallel shaft gearbox with rolling bearings, a radial bearing loader, and a programmable magnetic brake. This simulator also includes a tower, three blades with programatically controllable variable pitch system, with an option of direct coupled system to connect blades to gearbox brake-end or chain driven system to connect blades. All elements of the WTDS have been designed to maximize the number of drivetrain configurations to investigate gearbox dynamics and acoustic behavior, health monitoring, vibration based diagnostic techniques, lubricant conditioning or wear particle analysis.

The device is robust to handle heady fluctuating loads and spacious enough for easy gear placement, setup, and installation of monitoring devices. The two-stage parallel shaft gearbox can be configured as to reduce or increase the gear ratio. The planetary gear train, sun, planet and ring gears, the carrier, and bearings are all easily accessible. The common gear faults like surface wear, crack tooth, chipped tooth and missing tooth can be demonstrated on either spur gears or helical gears. Rolling element bearing faults like inner race, outer race, ball damage can also be incorporated. Adjustable clearance to study backlash is possible: increasing the amount of backlash is without major consequence (other than increased noise and rotational play), and reducing backlash can result in binding and/or excessive operating temperatures. Drivetrain misalignment can also be introduced intentionally in the WTDS. Any of these faults can be added to the drivetrain one at a time, or simultaneously to study fault interactions. Both torsional and radial loadings can be applied to study damage signature or propagation in gears and/or bearings: the torsional load is applied via a 3 HP variable frequency AC drive with a programmable, user-defined speed profiles; and the radial load is applied to a shaft in the parallel gearbox. With the programmable magnetic brake, rapid load fluctuation can be applied to simulate real life loading conditions experienced by wind turbines. The WTDS can be easily extended to perform prognostics studies using a larger drive and a robust loading system.

➢ Machinery Fault Simulator Series

Machinery fault simulators are test platforms for training and research in rotor dynamics, rotating machinery fault diagnostics, condition monitoring, and preventive maintenance. Spectra Quest offers a variety of simulators so that the costumers can select a model to fit their requirements. Robust, modular design allows the users to easily introduce controlled and calibrated faults and reconfigure the simulator for different studies. Some of the features and applications of a typical simulator are as follows:

SpectraQuest Product Guide

Features:

- Simple methods for introducing controlled, calibrated faults
- Study the vibration spectra of common faults and learn fault signatures
- Bench top machines for hands-on training and sharpening skills
- Learn machine fault diagnosis techniques, machine condition monitoring, and PdM
- Training manuals with exercises for individually paced study
- Simultaneous reciprocating and rotating mechanisms.
- Learn resonance, variable speed, gearbox, and belt drive diagnostics.
- Learn to determine vibration transmission path and perform root-cause analysis.
- Study correlation among vibration, motor current, and noise spectra.
- Model rotor dynamics and its effects on fault signatures.
- Validate balancing procedures above and below the first critical resonance.

Over forty application specific option kits are available for in-depth studies

Applications:

- Balance training
- Shaft alignment training
- Alignment system assessment
- Coupling studies
- Bearing faults and load effects
- Cocked rotor
- Eccentric rotor
- Resonance studies
- Sleeve bearing studies
- Belt drive performance
- Mechanical rub
- Gearbox fault studies
- Reciprocating mechanism studies
- Foundation studies
- Signal processing techniques
- Variable speed/load effects
- Motor current analysis
- Rotor dynamics
- Operating deflection shape and modal analysis
- Optimize sensor mounting
- Sensor types (accelerometer, proximity probes, etc.)
- Vibration training
- Analyst certification
- Customized test bed for rotor dynamics studies and demonstrations

Machinery Fault Simulator (MFS)

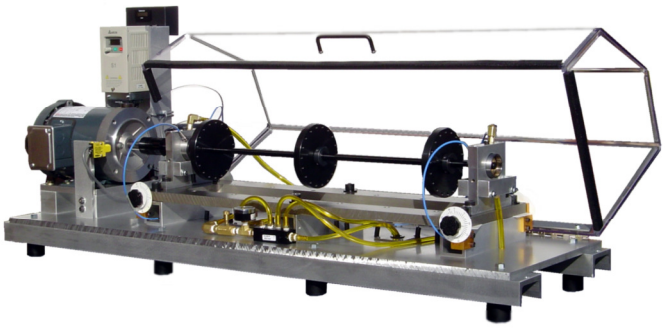
The MFS is an innovative tool to study the signatures of common machinery faults without compromising production schedule or profits. The bench-top system has a spacious modular design featuring versatility, operational simplicity, and robustness. Each component is machined to high tolerances so it can be operated without conflicting vibration. Then, various faults can be introduced either individually or jointly in a totally controlled environment, making the MFS the best tool available for learning machinery diagnosis.

The MFS is our most popular product which is designed to be both versatile and easy to operate. The simulator is constructed with a larger base plate, split bracket bearing housing, a sliding shaft, rotors with split collar ends, couplings, pulleys, a multiple belt tensioning and gearbox mounting mechanism, and reciprocating system; all of which are designed to be easily removed and replaced between various experiments. The MFS comes in four different models, from basic to most comprehensive to match your interests.

Machinery Fault Simulator Lite (MFS- LT)

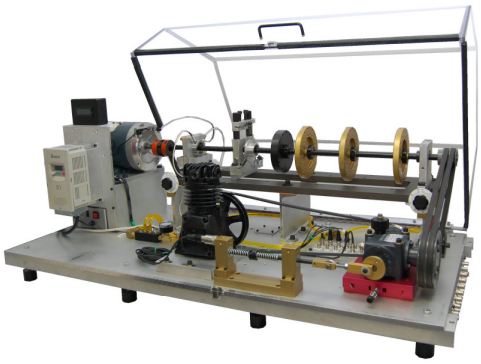
Precision machined basic simulator, providing the same features and benefits as the MFS, except gearbox, belt drive and reciprocating mechanism. Most of the MFS applications and option kits can be used with the MFS-Lite. The MFS-Lite is a portable, robust trainer used to teach vibration signatures of rotating machinery.

Machinery Fault and Rotor Dynamics Simulator (MFS-RDS)



The MFS-RDS is an innovative tool to study the dynamic behavior for rotor supported by oil lubricated journal bearings, as well as other common machinery faults, such as balancing and resonance study. An oil pump is provided with the simulator to drive the lubrication fluid. In addition, it provides different bearing clearance and size selection, and controllable lubrication oil pressure for rotor dynamics, whirl and whip phenomena. The MFS-RDS fitted with a resonance kit is the perfect tool to gain practical experience in rotating machinery critical speed and learn resonance mitigation methods. With different number of rotor disks installed at various locations on the main shaft, resonances up to the third mode can be excited. Oil whirl and whip, the important instability phenomena associated with rotors supported fluid film bearings, can be studied with the MFS-RDS.

MFS Magnum (MFS-MG)



The MFS Magnum is an innovative upgrade of the MFS. An oil lubricating system allows you to configure the machine using either fluid-film bearings or rolling element bearings. The extended shaft length provides more space for overhung rotors, and is more suitable for studies in resonance and fluid-induced instability issues. The magnum combines all the capabilities of the MFS and the MFS-RDS, making it the most comprehensive simulator that we offer.

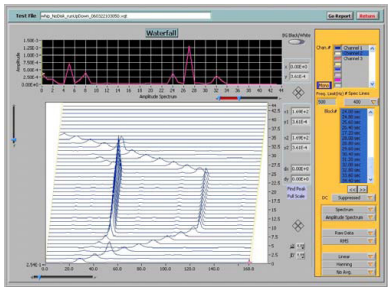
Bearing Balancing Simulator (BBS)

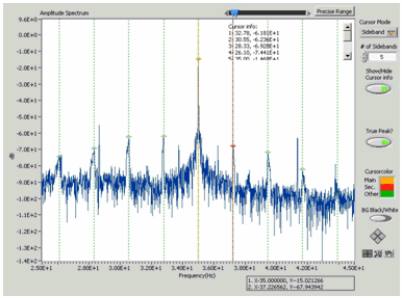
The Bearing/Balancing Simulator (BBS) is specifically designed for studying bearing faults and balancing under controlled conditions. The BBS provides a cost effective setup for performing experiments and learning vibration signatures of common unbalance and bearings malfunctions. It is an ideal device for learning balancing of rotors in a controlled lab environment. SpectraQuest also provides a balncing package consisting BBS, balancing practicle text book, user friendly balancing software, data acquistion system for learning and field applications.

SpectraQuest Product Guide

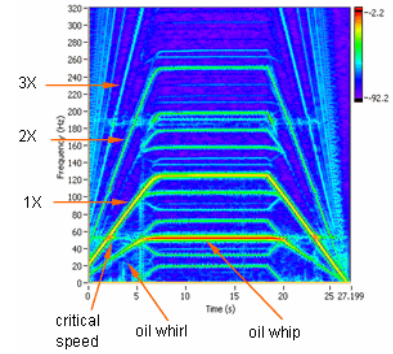
➢ Vibration Analysis Harware & Software

SpectraQuest has developed software and hardware for engineers, researchers, and student to perfect their machinery vibration and diagnosis skills. Our flagship data acquisition and analysis software, called **VibraQuest**, is an integrated solution package for diagnosing rotating/reciprocating machinery malfunctions, structural dynamics analysis and acoustical analysis. This novel software includes proprietary advanced signal processing algorithms specially designed for diagnosing faults in drivetrain components such as gearbox, bearings and rotor cracks. It integrates with XLRotor and MEScope to solve noise and vibration problems, from experimental design to the final correction. VibraQuest software comes in two variants: Lite and Pro. VibraQuest Lite provides all the functions for basic data acquisition and analysis, whereas VibraQuest Pro adds impulse data acquisition and additional, more advanced data analysis functions.





Twice slip frequency sidebands of a motor with broken rotor bars, mapped on the motor current spectrum



Noteworthy Benefits and Features:

- Powerful signal processing and data presentations of time waveform, FFT spectrum, and frequency response function, Polar, Bode, Nyquist, orbit and waterfall plots and more.
- Interactive cursors with auto updating and determining exact spectral peak values.
- Extensive data statistics useful for fault monitoring
- Ability for data comparison between different files or channels for trending and root cause analysis
- Simple project management, including experimental design with over thirty built-in templates to organize and document testing.
- User defined project and test templates for repetitive experiments.
- Capability to incorporate user-defined non-linear sensor behavior.
- Impulse and hammer test data acquisition.
- Octave analysis, 1 to 1/24 octave, linear, A, B, C weighting.
- Advanced Analysis: Digital filtering for signal separation and noise reduction, Induction Motor and Machinery fault diagnosis using envelope, cepstrum, demodulation, time-frequency and wavelet analysis techniques.

Data Acquisition Systems

SpectraQuest offers a wide range of data acquisition systems: 4 channels to 32 channels, low cost or high accuracy, portable or stationary. Combined with our VibraQuest data acquisition and analysis software, you can have a DAQ complete turnkey solution from one location.

DAQ Hardware Available

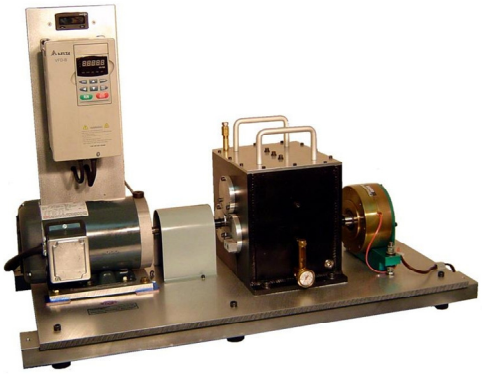
- 4 Channel Portable USB
  - 24 bits ADC, 51.2 Ksamples/sec, 20KHz frequency range
- 8 Channel 5kHz Low Cost Portable USB
  - 16 bits ADC, 8 channels at 5KHz or 2 channels at 20kHz

- 8 Channel Portable Compact SpectraPad
  - 16 bits ADC, 256Ksamples/sec, 60KHz frequency range
- 8-32 Channel Portable SpectraPad
  - 24 bits ADC, 102.4Ksamples/sec, 45KHz frequency range
- 8 or 16 Channel Desktop DAQ
  - 24 bits ADC, 102.4Ksamples/sec, 45KHz frequency range

Drivetrain Diagnostics/Prognostics Systems

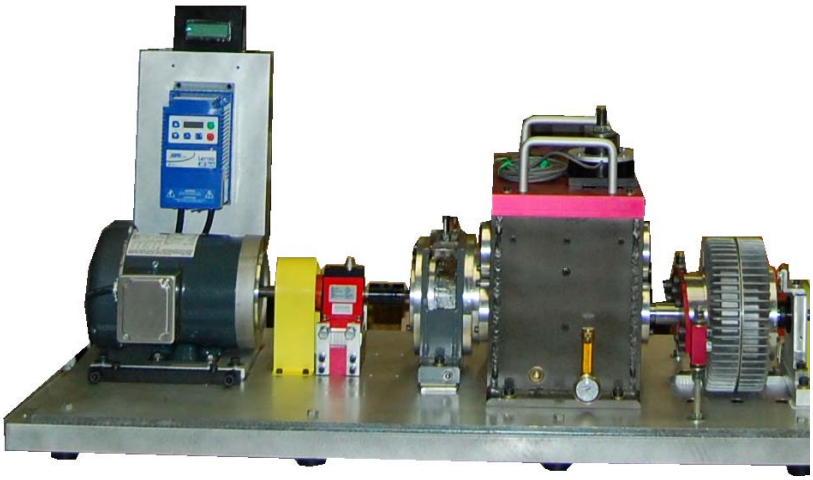
SpectraQuest offers several models to perform research on diagnostics and prognostics of gearboxes and bearing of a drivetrain. The simulators are robust to handle heady loads and spacious enough for easy gear placement, setup, and installation of monitoring devices.

Gearbox Dynamics Simulator (GDS)



SpectraQuest's Gearbox Dynamics Simulator (GDS) has been specifically designed to simulate industrial gearbox for experimental and educational purposes. The gearbox consists of a 2 stage parallel shaft gearbox with rolling bearings, and a magnetic brake. All elements of the GDS have been designed to investigate gearbox dynamics and acoustic behavior, health monitoring, vibration based diagnostic techniques, lubricant conditioning or wear particle analysis. It is robust enough to handle heady loads and spacious enough for easy gear placement, setup, and installation of monitoring devices. The two-stage parallel shaft gearbox can be configured as to reduce or increase the gear ratio.

Drivetrain Diagnostics Simulator (DDS)



While the GDS is focused on the of gearbox dynamics, the Drivetrain Diagnostics Simulator (DDS) goes further to research a complete drivetrain. The drivetrain consists of a 1 or 2 stage planetary gearbox, a 2 stage parallel shaft gearbox with rolling or sleeve bearings, a bearing loader, and a programmable heavy duty magnetic brake. The planetary gear train, sun, planet and ring gears, the carrier, and bearings are all easily accessible. The gear faults like surface wear, crack tooth, chipped tooth and missing tooth can be demonstrated on either spur gears or helical gears. Rolling element bearing faults like inner race, outer race, ball damage can also be incorporated. Drivetrain misalignment can also be introduced intentionally in the DDS. Any of these faults can be added to the drivetrain one at a time, or simultaneously to study fault interactions. Both torsional and radial loadings can be applied to study damage signature or propagation in gears and/or bearings.

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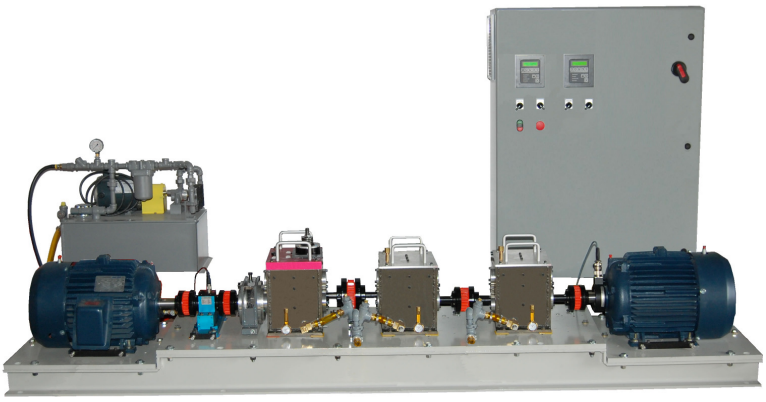
Drivetrain Prognostics Simulator (DPS)

SpectraQuest's Drivetrain Prognostics Simulator (DPS) has been specifically designed to simulate industrial drivetrains for diagnostics and prognostics research. The DPS drivetrain consists of a two-stage planetary test gearbox and a two-stage parallel shaft test gearbox with rolling or sleeve bearings. It is drive by a 10 HP variable speed motor; while another 10 HP motor is used to provide torsional loading to study gear failure evolution. Bearing and gears of load gearboxes are designed to absorb several times the applied load. In order to provide heavy torsional loading to test gearboxes two speed increasing load gearboxes. This innovative configuration enables accelerated gear wear without increasing the size of load motor. The DC buses of both motor drives are connected together thereby reducing power consumption and the heat generation. A heavy radial load can be applied to the bearings of test gearbox for bearing wear study.

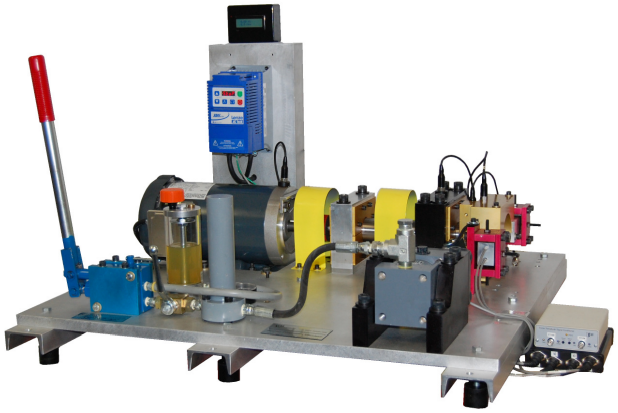


All elements of the DPS have been designed to maximize the number of drivetrain configurations to investigate gearbox dynamics and acoustic behavior, health monitoring, and vibration based diagnostic and prognostics techniques. It is robust enough to handle heady loads and spacious enough for easy gear placement, setup, and installation of monitoring devices. The effect faults like surface wear, crack tooth, chipped tooth and missing tooth can be demonstrated and induced on either spur gears or helical gears. Rolling element bearing faults like inner race, outer race, and ball damage can also be incorporated. Adjustable clearance to study backlash is possible: increasing the amount of backlash is without major consequence, and reducing backlash can result in binding and/or excessive operating temperatures. Drivetrain misalignment can also be introduced intentionally in the DPS. Any of these faults can be added to the drivetrain one at a time, or simultaneously to study fault interactions. With the programmable load drive, load fluctuations can be applied to simulate real life loading conditions.

Gearbox Prognostics Simulator (GPS)

Gearbox Prognostics Simulator (GPS) has been specifically designed to simulate industrial gearbox for diagnostics and prognostics research. The GPS gearbox consists of a two-stage parallel shaft test gearbox with rolling or sleeve bearings, which can be configured with a gear ratio from 1 to 6. The gearbox can be submitted to a torque large enough to induce wear and damage in the gears. All elements of the GPS have been designed to maximize the number of gearbox configurations to investigate gearbox dynamics and acoustic behavior, health monitoring, and vibration based diagnostic and prognostics techniques. A heavy duty gearbox and a 10 HP motor which acts as a generator are used to load gears of test gearbox.

Bearing Prognostics Simulator (BPS)



SpectraQuest's innovative Bearing Prognostics Simulator (BPS) is designed for conducting a fundamental research in bearing wear and in modeling bearing damage evolution process. An outstanding feature of the BPS is the inclusion of SpectraQuest's proprietary transducers for measuring bearing friction torque and transverse and axial loads applied to the bearing. The BPS can also be driven with a stepper motor in three software selectable modes: constant rotational speed, purely oscillatory motion, and oscillatory excitation superimposed on rotation. Experiments can be performed on rolling element bearing, pressurized fluid lubricated bearings, and the grease lubricated bearings. The friction torque and the load transducers provide unique data, previously not available, for understanding bearing prognostics signature and modeling bearing failure mechanisms. The BPS provides an opportunity to develop a predictive model of bearing remaining life based on routine condition monitoring measurement. The torque transducer is sensitive enough to measure the small frictional torque bearing resistance under several thousand pounds of transverse/axial load. The BPS can also be obtained with fluid film lubricated support bearings for minimizing extraneous noise. A higher rotational speed and loading versions are also available.

➢ Vibration Fundamentals Training System (VFT)

The Vibration Fundamentals Training System (alias VFT) is a turn-key integrated educational package for teaching/learning the fundamental principles of mechanical vibration as well as engineering mechanics. It provides both a comprehensive hands-on experimental device and an instrumentation package for performing laboratory exercises to enhance student understanding of vibration theory. The VFT clearly brings classical theory to life by providing a convenient mean to validate predictions and to demonstrate the influence of parameter changes on system response visually. Students can perform virtual experiments using the vibration simulation software and then verify the results with actual experiments thereby reinforcing the learning of difficult principles.

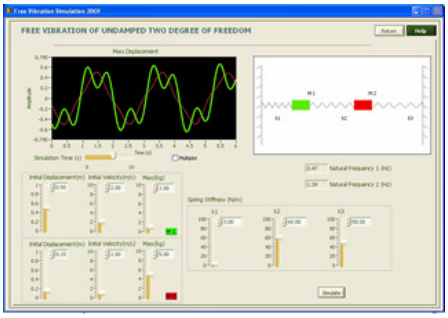
Highlights:

- Fully integrated turn-key package consisting of comprehensive experimental device, data acquisition instrumentation, analysis software, transducers, course curriculum, exercise book, and simulation software for virtual experimentation
- Robust, user friendly, modular, and compact bench-top device for performing controlled experiments
- Experimental setup for single and two-degrees of freedom spring-mass system (with and without damping), torsional vibration, and tuned-mass-damper
- Full experimental setup for beams with different boundary conditions, material, geometry, and length to understand effects on natural frequency and mode shapes
- User friendly software with pre-defined experiments integrated with data acquisition and data analysis

SpectraQuest Product Guide

It is an ideal tool for mechanical vibration courses both at under graduate and graduate levels. The VFT experimental hardware consists of four study modules:

(a) The **spring-mass-damper module** is the perfect tool for doing single and two DOF experiments, with and without viscous damping, with free or forced excitation.



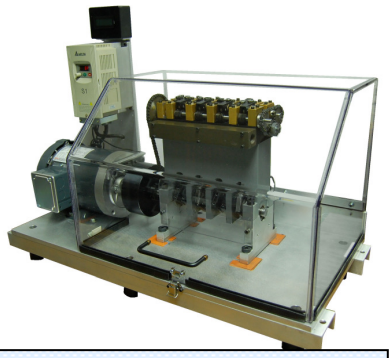
(b) The **torsional vibration module** can be configured as one and two degrees of freedom systems for free and forced vibration experiments with and without damping.

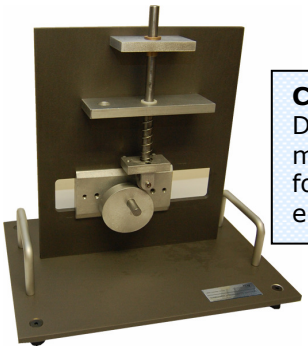
(c) The **vibration control module** is an ideal platform to learn passive vibration control by altering excitation frequency, change resonance frequency by modifying modal mass and/or stiffness, and add damping to bring vibration levels to acceptable values. Students can also design tuned-mass damper to absorb vibration in a spring-mass system or on beam a beam using a leaf spring with sliding masses.

(d) The **beam vibration module** allows to study natural frequencies, mode shapes, and damping in beams of different materials such as steel, aluminum, and plastic. The beam length is fully adjustable and can be configured with various boundary conditions.

➢ Kinematics & Dynamics of Machines Training System (KDT)

SpectraQuest offers a series of devices to enhance learning of kinematics and dynamics principles of a typical machine. Each apparatus is designed to visually illustrate sometimes elusive concepts to expedite learning. We also offer a set of instrumentations including sensors, data acquisition hardware, analysis and simulation software, and training manual to go along with applicable product. The devices are grouped as Kinematics and Dynamics according to the applications and associated demonstration.





Cam Apparatus
Designed to teach the cam follower motion. It also provides excellent tool for learning the influence of eccentricity on pressure angle.

4/6-cylinder Internal Combustion Engine Simulator
Designed to simulate the mechanical working of an internal combustion engine. Students can learn balancing, timing of input/exhaust valves, and instrumentation.

Geneva Mechanism
Designed to teach how a continuous rotational motion can be converted to a sequence of an intermittent motion and dwell periods.

Universal Joint
Demonstrate how rotational motion can be transmitted from one shaft to another for different angles of intersection of shaft.

Quick Return Mechanism
Demonstrate how a slider crank quick return mechanism works. Demonstrate how different time ratio of forward and return stroke can be achieved.

Kinematics

- Slider Crank Mechanism
- Four Bar Chain Mechanism
- Scotch Yoke Mechanism
- Hooke's/Universal Joint Demonstrator
- Quick Return Mechanisms
- Ackermann Steering Demonstrator
- Cam/Follower Mechanism
- Gears and Gear Train Demonstrator

Dynamics

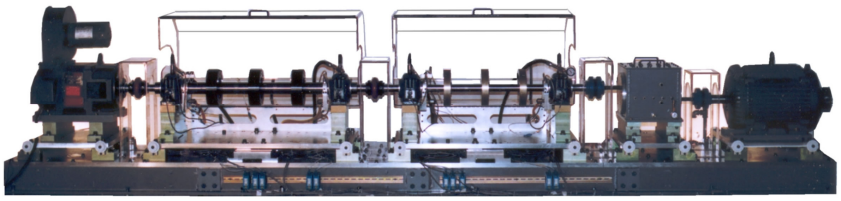
- Static and Dynamic Balancing Simulator
- Balance of Reciprocating Masses Simulator
- Centrifugal Governor
- Gyroscope
- Centrifugal Force Demonstrator
- Coriolis Force Demonstrator
- Hydrodynamic bearing Simulator
- Flywheel Apparatus

➢ Custom Designed Test Rigs

SpectraQuest has a long experience in making custom machinery to meet our customers' exact needs. From small modifications to our standard simulators to complete custom designs weighting more than several tons, we will provide you with the test rig that you need for your research, development, or training requirements. If you can't find it, we will make it. Following are a few recent custom designed test rigs:

Drive-train/Gearbox Diagnostics/Prognostics Test Rig
This unit was designed to study and understand failures of specially designed gearbox.

Rotordynamics Research Test Rig
This test rig has been specifically designed to simulate different rotor dynamics phenomena for experimental and educational purposes.



Turbine Blade Crack Research Test Rig
This test machine is specifically designed to simulate turbine blade crack and other machinery faults.

SpectraQuest Product Guide

Condition-based predictive maintenance (PdM) is a reliable, cost-effective technique for monitoring and diagnosing machinery faults before they irreversibly damage your machinery and cause breakdowns that threaten to undermine product quality, delivery and overall customer service. The success of any PdM program ultimately depends on how accurately and easily the vibration spectra, waveforms and phase relationships can be analyzed and understood. SpectraQuest offers a variety of machinery defect simulation devices for research and training in this important field.

	SAT	BBS	MFS-LT	MFS-RDS	MFS	MFS-MG	GDS	DDS	WTDS	DPS	BPS	VFT	KDT
Balancing		✓	✓	✓	✓	✓							
Alignment	✓		✓	✓	✓	✓							
Resonance			✓	✓	✓	✓							
Bent Shaft		✓	✓	✓	✓	✓							
Rolling Element Bearing		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Sleeve Bearing		✓	✓	✓	✓	✓		✓		✓	✓		
Damped Rolling Bearing			✓	✓	✓	✓							
Fluid Film Bearing				✓		✓					✓		
Oil Whirl and Whip				✓		✓							
Rotor Dynamics				✓		✓							
Crack Shaft			✓	✓	✓	✓							
Fan			✓	✓	✓	✓							
Mechanical Rub			✓	✓	✓	✓							
Belt Drive					✓	✓							
Straight Cut Bevel Gearbox					✓	✓							
Reciprocating Mechanism					✓	✓							
Pump					✓	✓							
Reciprocating Compressor					✓	✓							
Motor Defects					✓	✓		✓					
PC Control		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Parallel Spur Gearbox							✓	✓	✓	✓			
Parallel Helical Gearbox							✓	✓	✓	✓			
Planetary Gearbox								✓	✓	✓			
Prognosis Capable										✓	✓		
Vibration Training												✓	
Kinematics and Dynamics													✓

Some items listed are available through optional kits.

Content of brochure is subject to change without any notice