



The perfect training tool for Wind Energy Technology from Power Generation to Operation & Maintenance



### Perfect Hands-on Training Tool for Wind Turbine Technician & Training Programs

Wind Energy is the fastest growing renewable form of energy source in the world. To maximize the benefits from this technology, engineering students and technicians must be educated with the science and operational methodologies of wind turbines. SpectraQuest's Wind Turbine Simulator (WTS) has been designed to teach/learn the fundamental principles of wind technology from power generation to energy operation and maintanence. This turnkey system provides an ideal platform for teaching the detailed concepts of how to generate electricity from the wind, workings of electro-mechanical mechanisms, wind turbine control systems, nature of aerodynamic forces, data acquistion, sensors & instrumentation, along with condition monitoring & diagnostics. The innovative design allows the WTS to be used with and without the presence of wind such as in laboratory settings. The system features three blade horizontal-axis turbine hub, nacelle with planetary and parallel shaft gearbox, three independently actuated blades with ability to control the pitch, yaw control mechanism, a vertical tower, and a complete control console. The integrated package comes with a hands-on experimentation device, curriculum along with a full set of instrumentation to expedite learning. This turnkey system can be used for teaching multiple courses in wind turbine technology.



#### Noteworthy Features & Benefits:

- All inclusive turnkey platform for teaching the fundamental principles from power generation to operation & maintenance
- An ideal package for enhancing an existing program or developing a new Wind Energy Technology program
- Fully integrated system with step-by-step instructions for experimentation and curriculum applicable to teaching several courses
- Planetary and parallel shaft gearbox designed for teaching condition monitoring and diagnostics
- Robust, modular, and easy to configure for a variety of experiments
- Can be operated with and without wind such as in laboratory settings
- Realistic system consisting of a nacelle, turbine hub, planetary and parallel shaft gearbox, three independently actuated blades, a vertical tower, wind speed/direction sensors, a control console and power measurement system

## **Smart Design Makes the WTS Versatile and Easy to Use**

The WTS is robust and designed to perform a variety of experiments to optimize the benefits on your investment. Modular design allows the user to configure WTS in many different ways. This feature enables instructors to use the same system in several courses for hands-on demonstrations to optimize student learning experience. The smart design of the WTS permits students to conduct controlled experiments first by varing one parameter at a time and changing several components simultaneously to mimic the reality. This approach is essential for explaining certain hard to understand underlying principles governing a bigger idea. The WTS system greatly suceed in this task because it is robust and each component is machined to a close tolerance.

The WTS is comprehensive and is applicable in teaching several courses. It permits the illustration of the principle of conversion of mechanical energy to electricity; how to store energy using a battery and a charging device; perform maintenance tasks, teach assembly and inspection procedures; perform data acquisition and condition monitoring; instruct complex instrumentation such as slip ring and transducers; and learn turbine control system. Several theoretical concepts are also computer simulated to expedite learning. The effects of various paraments such as number, length and type of blades, wind speed, etc. on the efficiency of power generation can be easily demonstrated.

The WTS system is an integrated all-in-one package. It is supplied with a detailed operations and curriculum manuals including step-by-step procedures and videos to perform various experiments. The WTS package is integrable with an existing program and/or to develop a new wind energy technology series of courses. It is also a perfect tool for learning assembly, safety issues, and maintenance procedures in a controlled environment. This unique integrated approach is based on SpectraQuest's talented staff and many years of experience designing complex test stands and world class machinery fault simulation devices which are used in over fifty countries for doing cutting edge research, developing new technologies/products, and for educational purposes.

### Key Experiments and Applications:

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- Perform controlled experiments to learn the effects of various components on electric power production and the performance of a wind turbine
- Measure voltage & current to compute power and develop characteristics curves as a function of wind speed, direction, turbulence and blade geometry/orientation
- Conduct aerodynamics experiments to study the effects of blade design, air speed and direction, blade angle of attack, etc on power production
- Measure the vibration signature of drive train components and turbine bearings for condition monitoring and diagnostics
- Perform assembly/removal operations to enhance maintenance and repair skills on electromechanical components of a wind turbine
- Learn to install and use different transducers such as accelerometers, wind speed sensor, wind vane, slip rings, gears, bearings, motors, generators, etc.
- Perform tests with PC based blade pitch and yaw control system to learn their effects on power production and develop automatic controls for power optimization
- Measure blade lift and drag forces, drive shaft torque, and the tower tilt forces as a function wind speed/direction, blade pitch angle, and other parameters
- Teach concepts of energy storage, DC to AC conversion, and series-parallel combination of generator output for distribution of produced power.

## The Best Tool Available for Learning Wind Turbine Condition Monitoring & Diagnostics

One of the major technological challenges of generating electricity from the wind is the reliability and maintenance cost of the drive train components such as bearings and gears. Conditionbased predictive maintenance (PdM) has proven to be the most reliable, cost-effective technique for monitoring and diagnosing machinery faults before they irreversibly damage your machinery, and cause breakdowns. Spectra Quest's Wind Turbine Simulator is an innovative tool you can use to train students on condition monitoring technology. Students can learn to recognize the signatures of common faults of bearings and gears by performing controlled experiments with seeded faults in bearings and gears supplied by SpectraQuest. Having trained vibration analysts on staff offers companies a high degree of confidence in their operating efficiency.

### The Most Versatile Tool to Maximize Your Benefits

The WTS 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 and other complications. The most comprehensive device of its kind on the market, the WTS is useful for a broad range of applications for wind energy education. It is an effective tool for training beginning maintenance professionals and offering experienced technicians a way to upgrade their job skills and improve performance.

SpectraQuest is dedicated to providing a complete package including course curriculum for the applications of the WTS in teaching several courses. We provide detailed instructions for performing each experiments along with theory and application notes. Often Power Point slides are also made available to assist teachers. The device is small enough for laboratory experimentation, but it is sufficiently robust to emulate a real world utility scale wind turbine. The WTS system is fully modular and it can be acquired in several configurations depending upon your requirements and budget. New option kits can be added at a future date without any fear of your existing unit becoming obsolete. We continue to develop new applications and associated hardware/software and experimental option kits with full backward compatibility and upgrades in mind.

## **Configurations and Application Specific Option Kits**

### **Basic Wind Turbine Simulator**

The WTS provides a basic setup to teach the fundamental principles of wind turbine technology. The basic system is provided with tools to introduce the fundamental operation of a wind turbine from energy production and control to some aspects of maintenance and condition monitoring. The user can perform many controlled experiments to clarify important concepts. However, additional Option Kits are needed to perform more advanced tests to gain in-depth understanding of the under lying principles.

#### Basic WTS Configuration (WT-BASE)

- Precision Machined Nacelle with a single stage planetary and parallel shaft gearbox
- Robust, modular three blade horizontal axis turbine hub
- Three 4' long durable, reinforced fiberglass, high efficiency blades
- Three permanent magnet DC Generators to produce up to 100W power
- Multiple slip ring system for signal transmittance from each blade pitch module and generators
- Two section tower with mountings for cables and instrumentation
- Cables with quick disconnect for easy handling
- Rigid foundation and hardware for mounting a variety of sensors
- Generator and bearings with capabilities to install bearing faults
- Brackets and attachments for field upgrades and installation of option kits
- Course Curriculum
- Comprehensive operations manual

#### Pitch Control Module

- Three independently actuated blade angle adjustment using a separate motorized mechanism for each blade
- Multiple slip ring system for signal communications
- **Yaw Control Module**
- Fully functional yaw control with motorized gearing system

#### **Control Console**

 Consists of two voltmeters, ammeter, resistive speed and load controllers, individual motor controllers for each blade pitch and yaw control, USB based eight channel data acquisition interface, tachometer for blade speed display

#### Software

- User friendly software for calculation and display of voltage, current and power characteristics and graph
- Pitch and yaw control software
- Data acquisition software
- Blade rotational speed

### Power Generation/Conversion Module

Power generation/conversion module allows learning power management using different generator combinations. The unit can accomodate upto six DC generators and the power produced by them can be combined. It also demonstrates DC-AC power conversion and storage of produced power for later use using a battery and charger. An inverter is used to generate AC power from the DC power produced by the WTS.

#### Power Generation/Conversion Module (WT-PGCM)

- Demonstrate the concepts of circuit combinations, power conversion and storage methods.
- This module includes three extra DC generators to increase the power production, DC-AC Inverter, Battery and charge controller

### Wind Measurement Control System

This module is designed to teach students more in-depth concepts of control systems used in modern wind turbines. The porwer generated is a direct function of the wind speed and direction. Since wind speed and directions are subject to change without prior notice, it is important to have a system that will adjust the pitch angles of blade and re-orient the nacelle in the direction of wind to extract the maximum energy. Students can gain a deeper understanding of this process by using this Option Kit.

#### Wind Measurement Control System (WT-MCS)

- Learn the concepts of wind measurements and optimization of power produced
- Study the concepts of basic feedback control systems
- Includes wind speed (anemometer) and direction (wind vane) sensors along with mounting hardware and signal conditioners
- Interactive feedback control software to optimize power production

### **Blades Module**

The geometry of a blade has a significant effect on the amount of energy extracted from the wind. The purpose of this module is to provide students learn aerodynamics issues associated with a blade profile and the angle of attack of the wind.

#### Blades Module (WT-BM)

- Study and compare the performance of different blade geometry profiles
- Learn the effects of different blade angles of attack on tip speed ratio and power output
- This module includes two sets of four blades with different geometry

### Hubs Module

Wind turbine manufacturers have experimented with different number of blades to maximize the power. This module enables the user to perform experiments with different numbers of blades and learn their effects on the power generation.

#### Hubs Module (WT-HM)

- Evaluate the effects and benefits of different blade count configurations on aerodynamics efficiency, reliability and power production
- This module includes 2 or 4 blade hub with axle, one extra blade and one additional bearing

### Wind Generator Module

The WTS is designed to generate power with or without wind. But, operating it without wind provides incomplete learning experience to students. Certain key experiments such as the effects on wind speed and directions cannot be demonstrated without wind. To address such issues, SpectraQuest has developed an adequate capacity wind generator that can be accommodated and used in the lab environment to produce enough power for different studies.

#### Wind Generator Module (WT-WGM)

 Produce and simulate wind flow inside the laboratory setting in order to operate and test the wind turbine simulator

Includes High efficiency 25000 CFM (cubic feet per minute) Axial Fan Blower, 4' x 5.5' circular duct with securely mounted fan and motor/drive system, specially designed Honey Comb type structure for straightening wind swirling and to create a laminar flow pattern, 3 HP 1 phase 6 pole motor with variable frequency drive to run the fan at different speeds and easy re-locatable rigid support structure for positioning duct in-line with turbine hub

### **Condition Monitoring and Diagnostics Instrumentation System**

One of the important tasks of the wind power industry is to reduce the maintenance costs and improve the reliability of drive train components, bearings and gearbox. The WTS along with SpectraQuest's data acquisition and software is an ideal tool for teaching turbine diagnostics and condition monitoring.

Condition Monitoring and Diagnostics Instrumentation System (WT-CMDS)

Provides a complete turnkey solution with low-cost portable data acquisition with PC, analysis software, proprietary condition monitoring software and sensors.

Collect real time data and perform analysis and monitoring

This module includes one 8 channel 5Khz portable USB data acquisition (8 channels at 5KHz freq. range or 2 channels at 20 KHz freq. range), Data acquisition and analysis software, Condition Monitoring Software, Dell PC with 20" Monitor(Intel Dual Core processor, 2 GB DDR RAM, 160 GB HD) and four accelerometers.

### **Defective Gears and Bearings Kit**

This kit provides intentionally damaged bearings and gears to learn condition monitoring and fault diagnosis. Students can install bearings and gears with known faults, one at a time, and learn to recognize their vibration signatures. After gaining enough experience they can introduce multiple faults at a time and enhance their skills to diagnose a problem with accuracy and confidence.

#### Defective Gears and Bearings Kit (WT-DGB)

- Study the effect of damaged gears and bearings in the drive train of a wind turbine
- Measure and compare vibration signatures between baseline and typical bearing & gear defects
- The kit consists of one set of four faulted bearings: one inner race defect, one outer race defect, one ball defect, and one combination defects

The kit consists of one gear with chipped tooth defect, one gear with missing tooth, and one gear with surface wear defects

### Modules for Measurement of Aerodynamic forces and Torque

It is important to understand the aerodynamic principles associated with power generation. Our innovative design of transducers allows students to measure the aerodynamic forces acting on blades and the tower foundation. This information can be used while designing structures and foundation. We also provide a transducer for measuring toque applied to the gearbox of the WTS.

#### Blade Lift and Drag forces Measurement System (WT-LDFM)

- Investigate the effect of lift and drag forces on turbine blades
- Includes two strain gage bridges mounted on a strut for individually measuring lift and drag forces
- of a blade along with its signal conditioner with analogue outputs
- Uses slip rings for signal transmission from both strain gages

#### Tower Tilt Force/Moment Measurement System (WT-TTFM)

- Investigate the effect of tilt force/moment on turbine tower
- Includes two Strain Gage bridges mounted on the tower base for individually measuring two directional tower tilt forces
- Signal conditioner for powering strain gages and analogue outputs

#### Turbine Drive Shaft Torque Measurement System (WT-TTM)

- Study torque variation through full rotation cycle
- Measure the torque on the turbine drive shaft to relate power and torque coefficients
- One strain gage bridge mounted on a strut for measuring torque on turbine main drive shaft
- Signal conditioner for powering strain gages and analogue outputs
- Slip rings for signal transmission of strain gages

## **High Value Combination Packages**

The WTS is available in various packages providing you with all the components necessary for a turnkey training system:

**Package 1:** Base WTS plus kits for enhanced power generation, control studies along with wind generator **Package 2C:** Base WTS plus kits for enhanced power generation, control studies, condition monitoring and

diagnostics along with wind generator **Package 2F:** Base WTS plus kits for enhanced power generation, control, force and torque measurement studies

**Package 2F:** Base WTS plus kits for enhanced power generation, control, force and torque measurement studies along with wind generator

**Package 3:** Base WTS plus kits for enhanced power generation, control, force and torque measurement studies, condition monitoring and diagnostics along with wind generator

Option kit		PKG 1	PKG 2C	PKG 2F	PKG 3
Power Generation/Conversion Module	WT-PGCM	x	х	x	x
Wind Measurement & Control System	WT-MCS	x	х	x	x
Blades Module	WT-BM	x	х	x	x
Hubs Module	WT-HM	x	х	x	x
Wind Generator Module	WT-WGM	x	х	x	x
Defective Gears and Bearing Kit	WT-DGB		х		x
Condition Monitoring and Diagnostics Instrumentation Module	WT-CMDS		x		x
Blade Lift and Drag Forces Measurement System	WT-LDFS			x	x
Tower Tilt Force/Moment Measurement System	WT-TTM			x	x
Turbine Drive Shaft Torque Measurement System	WT-TTM			x	x

## **Specifications**

Electrical	
Tachometer	Built-in tachometer with LCD display and one pulse per revolution analog TTL output for DAQ purposes
Voltage	24 VDC for control console
Power Generated	Up to 300W
Mechanical	
Gearbox	1 stage planetary gearbox and parallel shaft gearbox
Wind Turbine blade	3 blades, 8 feet span, fiber glass
RPM range (blades)	0 to 300 rpm variable speed
Physical	
Weight	Approximately 225 lb
Dimensions	L=44" (112cm), W=96" (243cm), H=120" (305cm)

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