

AC Resonant Test Systems – Tank Type

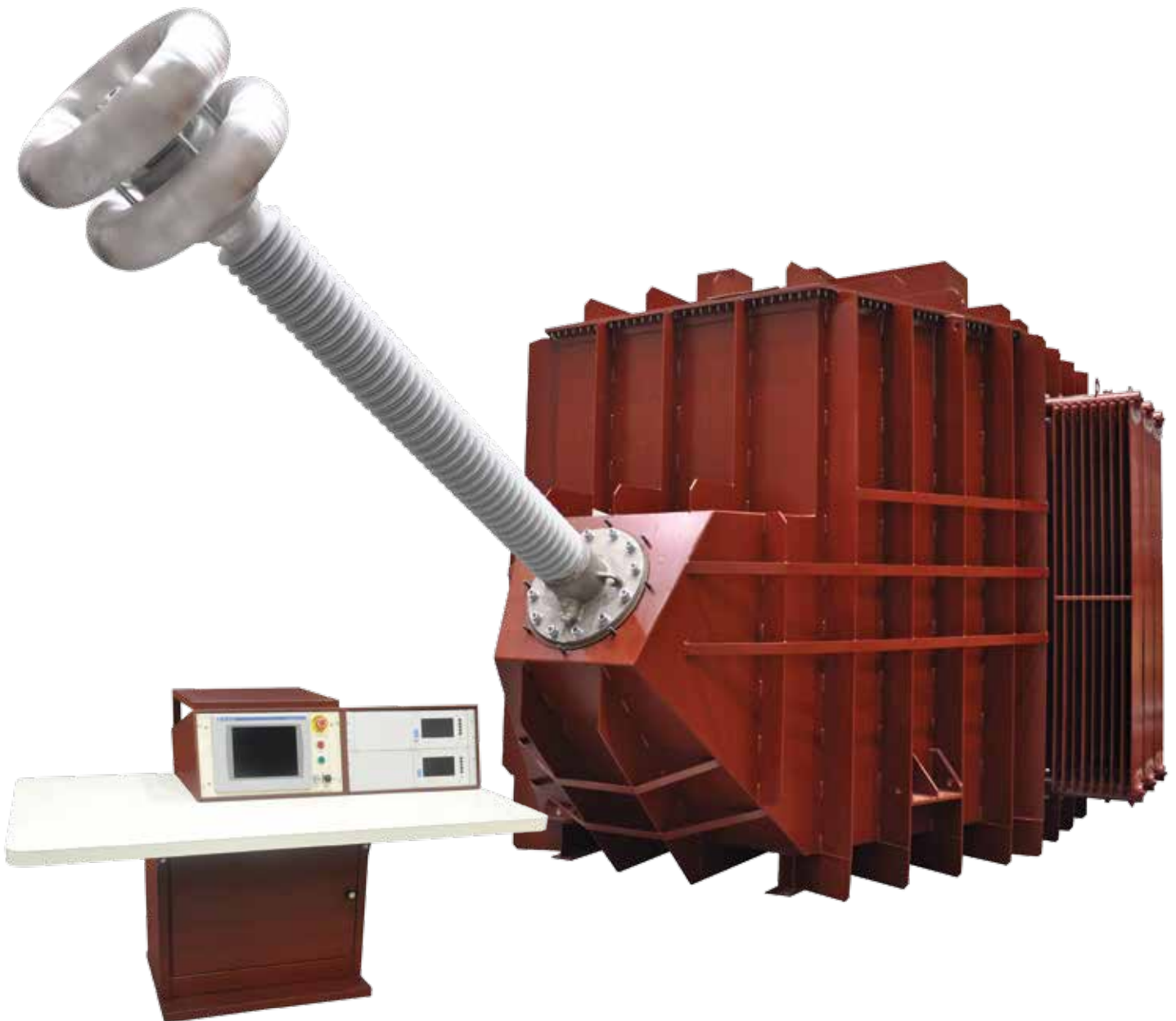
Up to 500 kV



Testing Applications

High power AC Resonant Test Systems are used where the load is largely capacitive with very low real power losses primarily for testing power cables.

- **Steel grounded "dead"** tank design is **potential free**
- Can operate in both **parallel** and **series** resonant **modes**
- Extended **tuning range** available via **multiple output voltage taps**



AC Resonant Test Systems

Phenix Technologies has supplied AC Resonant Test Systems and AC Dielectric Test Systems for over 40 years. As a worldwide leader in high voltage, high current, and high power testing applications, we have earned a reputation for producing high quality test systems and exceeding our customers' expectations. Phenix Technologies is ISO 9001:2008 compliant which ensures high quality standards are met through each step of the design and manufacturing process to give our customers a superior product with years of service. Our test systems function in compliance with IEC 60060-1, IEEE 4, and other recognized national and international industry testing standards.

Phenix Technologies produces several configurations of variable voltage, variable inductance AC Resonant Test Systems and offers options for additional testing capabilities. AC Resonant Test Systems measure dielectric performance of electrical equipment and insulating materials at all voltage levels. Additionally, these test systems are ideally suited to be paired with partial discharge measurement equipment and tangent delta (power factor) bridges. Phenix AC Resonant Test Systems are built for indoor or fair weather outdoor operation, but optionally may be designed to operate in adverse outdoor conditions.

Quality Construction Ensures Reliability

In addition to our quality standards, we conduct final pre-shipment tests at our facility where your representative can be present. Testing and operator training are available at this time or later once the test system is on-site. Supervision of on-site set-up, commissioning, and final operator training are available as options. Phenix Technologies' test systems are designed and built to provide years of reliable service. Rigorous factory testing before shipment ensures that the units function properly. Our standard tests include:

- Control and functionality test
- Ratio and polarity test (if equipped with exciter transformer)
- Resistance measurement
- Short circuit impedance test (if equipped with exciter transformer)
- No-load test
- Load test*
- Traceable meter calibration
- 110% overvoltage test at 2 minutes
- Flashover test
- Partial discharge test

* Heat Run Test and Full Load Tests are available for most systems; please check with your Phenix Sales Representative for further details.

Resonance Theory and Q

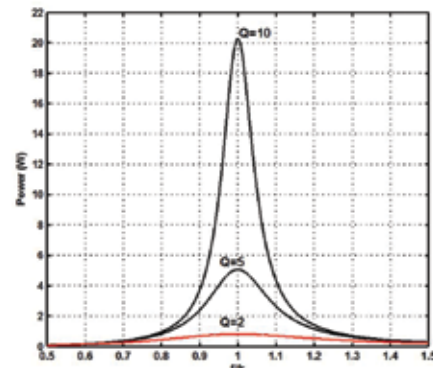
A resonant circuit consists of both capacitance (load) and inductance (test set). Resonance is defined as the condition that occurs when net inductive reactance equals the net capacitive reactance. Resonance is achieved when the energy absorbed at any instant is exactly equal to that released by another reactive element in the system. When the system has reached a state of resonance, it requires no further reactive power because it is self-sustaining. Only the real losses which primarily consist of $I^2 \cdot R$ winding losses and reactor core losses have to be supplied by the excitation winding.

When an R-L-C circuit is excited at its frequency, it may be characterized by the ratio of reactive power flow in the circuit to the real power input required to sustain stable (constant voltage) resonance. This ratio is known as the Quality Factor, or simply "Q", of the circuit. From general resonance theory, the Quality Factor is directly proportional to the maximum energy stored in the reactive elements of the circuit divided by the total energy lost per alternating voltage cycle. In a high voltage test circuit, the "Q" may be straightforwardly viewed as the ratio of Output Reactive Power [KVAR] to Input Real Power [kW]. Therefore in a high voltage resonant test circuit where $Q = 100$, the input power required by the test set is only approx. 1/100 (or 1%) of the reactive power required by the test object. This huge reduction in input power is the reason why resonant test systems are used almost exclusively when performing AC voltage tests on test objects having large capacitances.

Parallel or Series Resonant Mode

Choosing to operate in Parallel or Series mode depends upon the test object and the measurements to be conducted. A **series** resonant mode is best suited for sensitive partial discharge requirements that include some cables, HV transformers, bushings, and gas-insulated switchgear. Harmonics from the supply are better suppressed than in parallel mode.

The **parallel** resonant mode provides a more stable output voltage with test objects such as large generator windings or other specimens with corona losses. In parallel mode, the rate of rise is stable independent of the degree of tuning or Q of the circuit. Parallel mode also allows the test set to be energized to full voltage without a load. This is used to calibrate instrumentation and to check the partial discharge of the test equipment.



Advantages

Resonant Test Systems have several major advantages over conventional AC dielectric test sets including:

- Reduced input power requirements that save costs in installation and service
- Because the circuit utilizes a tuned circuit at the power frequency, a pure sine wave, without harmonics or distortion, appears across the test sample
- No power follow-up is required as a result of test failure
- When partial discharge measurements are required, the reduced input kVA requirements result in proportionately less expensive line filter systems
- Test equipment is reduced in both size and weight over conventional AC dielectric test sets

TANK TYPE Resonant Test Systems

- Can be electrically connected in parallel or series resonant mode
- Can be built with several output voltage taps to extend the tuning range
- May have the bushing installed in either vertical or angled configuration depending upon application

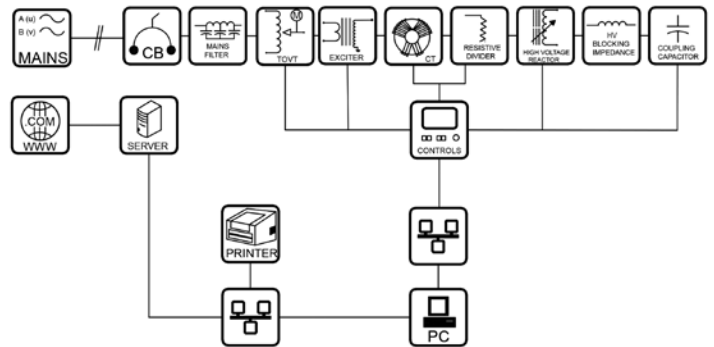
Safety and Design Features

Phenix Technologies designs in numerous safety features to protect personnel and equipment from potential injury, loss, or damage. To protect against flashovers or short circuits, our units have an adjustable electronic overload circuit. The circuit has a response time of less than 30 milli-seconds. The test systems have an input circuit breaker and backup overload protection. Additional safety features are included in our automated control software. All test sets include the following standard protection features:

- Main power circuit breaker
- Emergency stop switch with key lock
- Zero-start interlock
- Slow and fast acting overload protection
- Overvoltage and overcurrent controls
- External safety interlock provisions
- External warning circuit connections
- Overload circuit adjustable from 10% to 110% of rated current; includes indicator with reset

System Components

All Resonant Test Systems contain 5 main components: High Voltage Reactor, Power Regulator, Exciter Winding Transformer, High Voltage Divider, Controls.



High Voltage Reactor

Enclosed in a rugged steel tank, the variable core, oil-insulated reactor is adjusted until its inductive reactance is equal to the capacitive reactance of the test specimen. The copper windings are of layer type construction. The coils are mounted to the fixed part of the core to surround the two variable gaps. The vertical core uses a gear reducer and ball screw arrangement with heavy vertical supports to create a rigid structure with few moving parts. This design results in a considerable reduction in size and weight.

- Reactor core and coils are contained in an oil filled tank
- Motorized drive system is used to vary the air gap
- Designed to minimize inter-element capacitance
- Built to withstand harsh forces from severe flashover
- Over-temperature protection
- Minimal mechanical vibration reduces audible noise

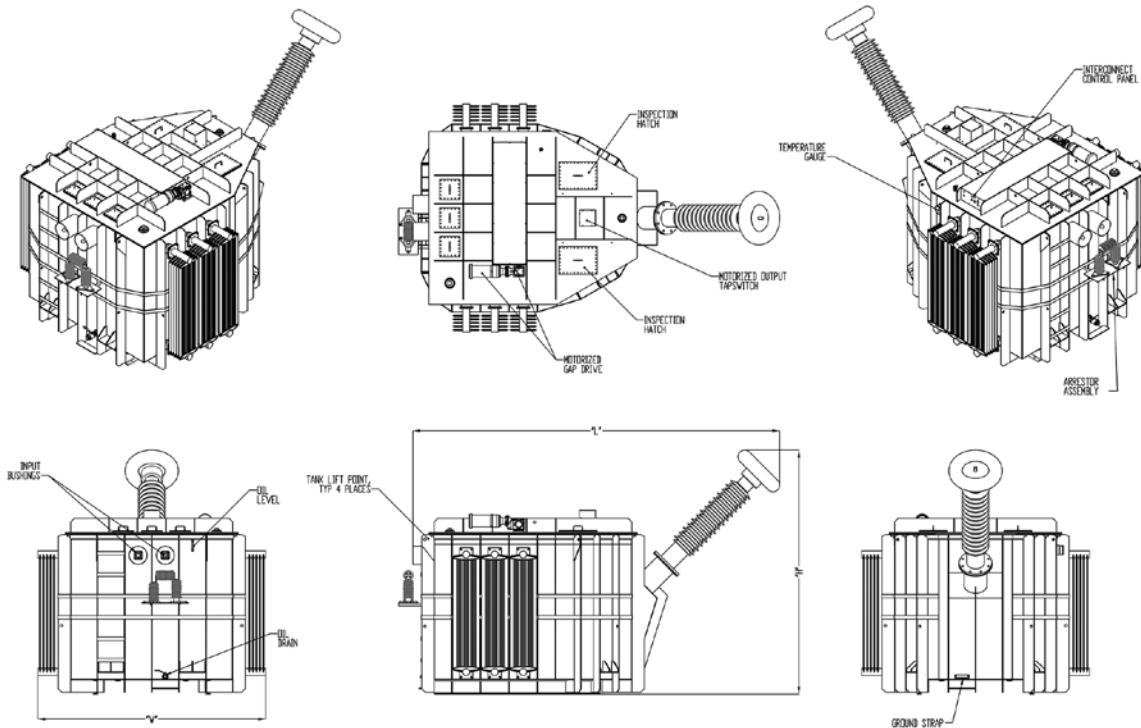
HV Tank Type Reactors up to 500 kV

(Sizes and weights are approximate for standard designs and may vary with custom orders)

Model	VOLTAGE				Max kVA	Length (m)	Width (m)	Height (m)	Weight (tons)
	Tap 1 (kV)	Tap 1 (kV)	Tap 1 (kV)	Tap 1 (kV)					
8TC250-5000	250 kV	150 kV	100 kV	Optional	5000	5.2	3.3	3.5	22.5
Load 50 Hz	255 nF	707 nF	1590 nF	N/A	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	210 nF	590 nF	1325 nF	N/A					
8TC350-7000	350 kV	230 kV	150 kV	100 kV	7000	6.9	3.1	3.3	28.5
Load 50 Hz	180 nF	420 nF	990 nF	2230 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	150 nF	350 nF	825 nF	1855 nF					
8TC350-11000	350 kV	230 kV	150 kV	100 kV*	11000	7.0	3.5	3.3	36.5
Load 50 Hz	285 nF	660 nF	1555 nF	2385 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	235 nF	550 nF	1295 nF	1990 nF					
8TC350-14000	350 kV	230 kV	150 kV*	100 kV*	14000	7.1	3.8	3.3	38.5
Load 50 Hz	365 nF	840 nF	1590 nF	2385 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	300 nF	700 nF	1325 nF	1990 nF					
8TC400-11000	400 kV	230 kV	150 kV	100 kV*	11000	7.5	3.5	3.5	38.5
Load 50 Hz	215 nF	660 nF	1555 nF	2385 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	180 nF	550 nF	1295 nF	1990 nF					
8TC400-14000	400 kV	230 kV	150 kV*	100 kV*	14000	7.5	3.5	3.5	40.5
Load 50 Hz	275 nF	840 nF	1590 nF	2385 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	230 nF	700 nF	1325 nF	1990 nF					
8TC500-11000	500 kV	350 kV	230 kV	150 kV	11000	9.5	5.0	5.5	67.0
Load 50 Hz	140 nF	285 nF	660 nF	1555 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	115 nF	235 nF	550 nF	1295 nF					
8TC500-14000	500 kV	350 kV	230 kV	150 kV*	14000	10.2	5.1	5.5	70.5
Load 50 Hz	175 nF	365 nF	840 nF	1590 nF	Duty Cycle 1 Hour On / 1 Hour Off, 6 Cycles per Day				
Load 60 Hz	145 nF	300 nF	700 nF	1325 nF					

* Current Limited Tap

** Load Indication does not include Divider Capacitances





Power Regulator

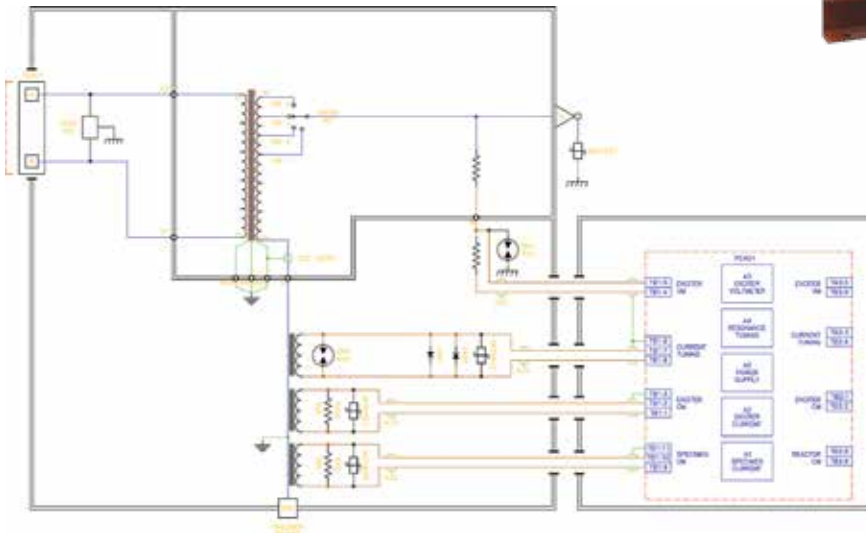
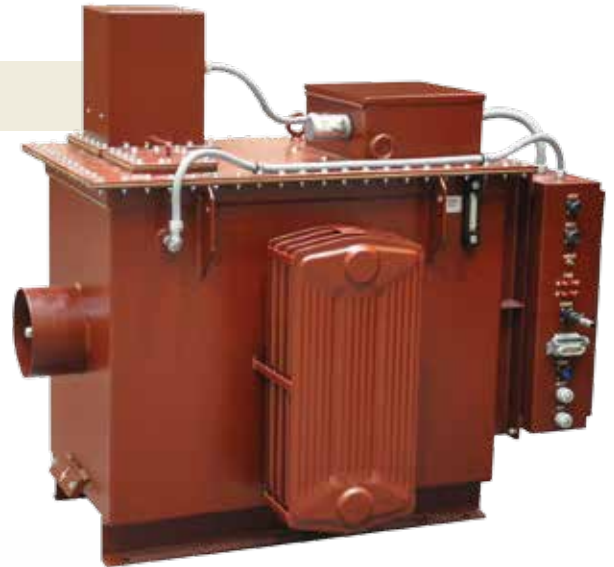
The regulator provides an adjustable input voltage to the exciter and controls the output voltage of the high voltage reactor from near zero to full voltage. The power regulator is designed and manufactured by Phenix Technologies and consists of variable auto transformers of either toroidal or column type construction depending upon the power rating of the unit.

- Housed in a rugged steel cabinet with provisions for moving by fork lift
- Forced air cooling with air filters
- Removable panels for easy service and maintenance
- System controls may be contained within the regulator cabinet or in a separate console

Exciter Transformer

The exciter section consists of a two-winding, single-phase transformer that supplies the power to the resonant circuit. The exciter steps up the output voltage level to the reactor.

- Located electrically between regulator and HV reactor
- Motorized high voltage switches for selecting taps
- Rugged, oil-filled enclosure
- Built with double-shielded isolation screen
- Contains lower voltage output taps that ease tuning to high Q loads



High Voltage Filters

High Power Tank Type Resonant Test Systems are typically equipped with high voltage filters which enables highly sensitive PD measurements. The filters are designed to use high quality low parasitic capacitance offering excellent high frequency blocking characteristics. Filter networks of one or more stages can be used to offer additional noise reduction. The filters are connected to the output of the Resonance Test Set and are electrically located between the reactor and the load / partial discharge coupling capacitor.



Shielded Enclosures

Cable testing typically requires a shielded enclosure. Phenix Technologies can provide a complete turn-key installation that includes shielded enclosures and other accessories, custom-designed to meet your requirements and factory floorplan with options to provide an optimal solution for your production requirements.



Water Terminations

Used to temporarily terminate shielded high voltage cables for testing. The application of high voltage to the cable requires a special process in order to eliminate partial discharge at the cable ends. The terminations are ideally suited to perform partial discharge (PD) measurements, impulse voltage testing, and tan delta (loss factor) measurements. The cable is prepared in the same way as for slip-on terminations; i.e., by stripping the cable to the outer semiconducting layer and removing the outer semiconducting layer.





800C Series Controls

The 800C series represent the latest development in computer-assisted controls. Our configuration creates ease in set-up and simplicity in testing. The test system features an industrial-grade color touch screen Human Machine Interface (HMI) and Ethernet port for automated control of your tests via a Personal Computer. Functions and metering included on the HMI display:

- Auto Ranging Output Voltmeter
- Auto Ranging Specimen Currentmeter
- Auto Ranging Excitation Voltage and Current Meters
- Meters include Bar Graphs that indicate percent of full scale
- Peak Memory Output Voltmeter (records maximum voltage applied to test specimen)
- Fault Memory Output Voltmeter (records voltage at which the specimen failed)
- Resonance Indicator (null type indicator for tuning the resonant circuit)
- Precise Automatic Tuning and Voltage Control (can also be manually controlled via touch screen)
- Dwell Timer (time elapsed while at test voltage level)
- Duration Timer (total test time for multi-level Automatic Sequence Tests)
- User Programmable Dwell Time and Test Voltage Level (Automatic Voltage Test)
- User Programmable Automatic Sequence Test
- Up to ten Test Profiles can be stored in the HMI (virtually unlimited number of profiles in a PC via Ethernet)
- User Programmable Over Voltage Set Point (turns voltage off immediately if level is reached)
- Message display that indicates system status and fault information
- Regulator and Reactor Gap Controls (motorized drives)
- Exciter and Reactor Tap Selectors (optional motorized high voltage tap switches)
- Variable Inductance (gap drive) and Voltage Regulator Speed Control

Also included are calibration and service modes. All adjustments needed for yearly recalibration are simply made by adjusting a few numbers in the software via the Human Machine Interface. The service mode assists and simplifies maintenance, and helps in the diagnosis of failed components in the rare cases that may be necessary.

800C Series Instrumentation

A high precision measuring system is designed to enable accurate measurement of voltages and currents. The metered information is displayed on the Human Machine Interface (HMI) display. The values displayed on the HMI are performed as a function of the Programmable Logic Controller (PLC). The following metering measurements are displayed:

Output Voltage is measured by means of peak responding circuitry and is displayed in its peak/ 2 value. Accuracy \pm (0.8% of reading + 0.2% of range to least significant digit (LSD))

Specimen Current is measured by means of true RMS conversion. Accuracy \pm (0.8% of reading + 0.2% of range to LSD)

Exciter Voltage is measured by means of peak responding circuitry and is displayed in its peak/ 2 value. Accuracy \pm 1% of Full Scale

Exciter Current is measured by means of true RMS conversion. Accuracy \pm (0.8% of reading + 0.2% of range to LSD)

Resonance is measured and displayed as a zero-center null type bar graph indicator

Duration and Dwell Timers. Time is displayed in an HOURS:MINUTES:SECONDS format from 0000:00:00 to 9999:59:59.

Peak Voltage Memory Meter. The maximum applied test voltage level is retained and displayed.

Fault Voltage Memory Meter. The applied test voltage level at the time of a specimen failure is retained and displayed.

Specialty test applications may be accommodated by options within our designs. Please consult one of Phenix Technologies Sales Representatives for further information.

Software

Phenix Technologies PC based software provides innovative features through a user friendly interface. The operator enters specific test parameters, or recalls previous test "recipes" for easy test duplication. Test results can be displayed, stored to a database, or printed.

Test Results

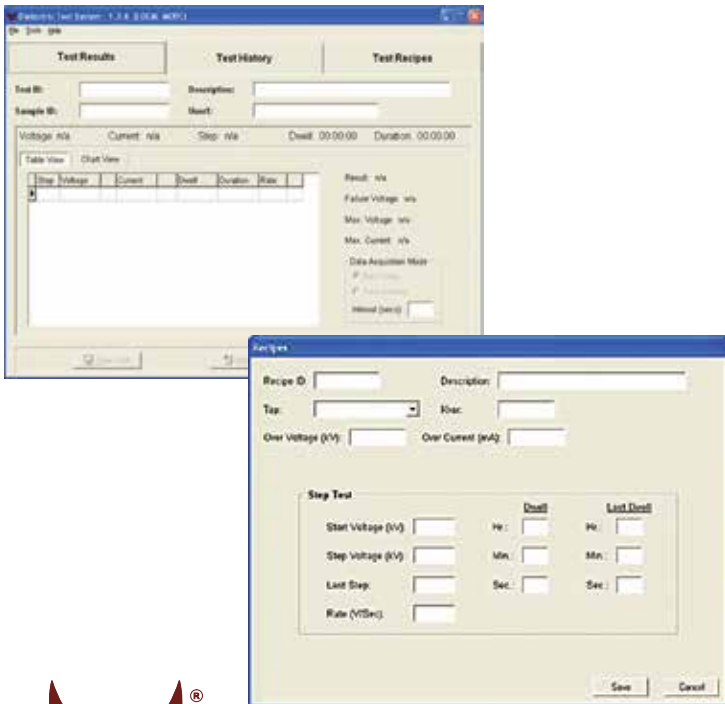
Test results can be viewed in table or chart format and show real-time voltages, current, step, dwell, and duration data. Report generating options allow for a concise or detailed print-out of data.

Test History

The software collects all saved test results in a database for easy recall and review. Search, sort, and printing of previous test results can be performed.

Test Profiles

Create new test profiles or "recipes" by selecting a custom test, cycle test, or step test and then choosing a tap value. A screen opens to enter test criteria desired, and the test profile is saved, and may be run or downloaded. Quickly recall previous profiles by test type, description, or ID value.



Cables

Phenix Technologies supplies interconnect cables 20 feet (6 m) from the High Voltage Reactor to the Exciter Transformer and from the Power Regulator to the Exciter Transformer. Power input cabling from mains and the cables required to the test specimen are the customer's responsibility.

Options

- Control Desk
- Casters and/or skid mounting for easier movement of larger system components
- Line Filters to reduce mains interference
- High Voltage Filters for sensitive PD measurements
- PD Detectors
- Tangent Delta Bridges
- Extended cable lengths
- On-site Training
- On-site Service and Calibration
- ISO 17025 Calibration

Warranty and After Sales Service

Phenix Technologies designs and builds AC Resonant Test Systems to provide years of efficient and dependable service. A long term warranty is included with every system. On-site periodic maintenance and calibration contracts, or extended warranties are available as options.

Phenix Technologies' Service Department is ready to assist our customers by answering inquiries or by dispatching technicians if serious issues arise. Our worldwide facilities provide locations that stock some critical parts or may offer assistance in troubleshooting if required. Commonly used spare parts are available from our factory inventory in Maryland (USA), and can be shipped worldwide, expedited delivery if necessary. We stand behind our products and the Service Department is available to assist in gaining full value from your equipment.



PHENIX
TECHNOLOGIES

WORLD HEADQUARTERS

Phenix Technologies, Inc.
75 Speicher Drive
Accident, MD 21520 USA
Ph: +1.301.746.8118
Fx: +1.301.895.5570
Info@phenixtech.com

BRANCH OFFICES

Phenix Systems AG
Riehenstrasse 62A, 4058 Basel, Switzerland
Ph: +41.61.383.2770, Info@phenixsystems.com

Phenix Asia

Zhong Cheng Rd, Sec 1, No 177, 2F, Taipei 11148 Taiwan
Ph: +886.2.2835.9738, Fx: +886.2.2835.9879, Info@phenixasia.com

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