



**AC CIRCUIT BREAKER TEST SET
OPERATOR'S MANUAL
Version 2.1**

MODEL HC-20C

SN

**Phenix Technologies
A Division of Doble Engineering
75 Speicher Drive
Accident, MD 21520**

Copyright © Phenix Technologies, Inc.

Rev 8/7/2017 jsh

HC-20C

Model Number

HC-20C

Serial Number

Customer

Customer's Purchase
Order Number

Manufacturing Date

TABLE OF CONTENTS

	<u>SECTION NUMBER</u>
DANGER / GENERAL SAFETY PRECAUTIONS	
SPECIFICATIONS	1
INTRODUCTION	2
SAFETY	3
INSTALLATION INSTRUCTIONS	4
POWER ON/OFF PROCEDURE	5
POWER SECTION DESCRIPTION	6
TESTING PROCEDURE	7
TROUBLESHOOTING	8
SERVICE AND MAINTENANCE	9
CALIBRATION OF CIRCUIT BREAKER TEST SETS	10
WinHC PC SOFTWARE	11
RETURNED MATERIAL	12
PARTS ORDERING INFORMATION	13
RECOMMENDED SPARE PARTS	14
PARTS LIST	15
ELECTRICAL SCHEMATICS	16
CUSTOMER COMMENTS / SUGGESTIONS	17

WARNING !!

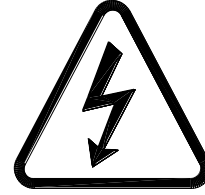
DANGER

Complete Grounding of this unit is necessary for the safe operation of this equipment. Disconnect inputs before ungrounding this equipment

GENERAL SAFETY PRECAUTIONS



CAUTION



HIGH VOLTAGE

This equipment is capable of providing POTENTIALLY LETHAL VOLTAGES! Improper operation or test practices may result in injury or death to the operator or surrounding personnel.

The operation of High Voltage test equipment should only be performed by personnel familiar with HIGH VOLTAGE testing and safety procedures. The operator of this equipment must be aware of all hazards associated with High Voltage testing. The operator is responsible for himself and others in close proximity of the testing area.

Some General Safety Practices for working with High Voltage Test Equipment have been listed below for your reference.

- Get familiar with your instrument before performing an actual test
- Know your work area, check that all circuits are de-energized and locked out.
- Never work alone; always work with another qualified worker.
- Mark off entire work area with barriers and warning tape.
- Make all personnel aware of your testing activities.
- Be aware of dangerous conditions that may arise from energizing a test specimen.
- Never modify test equipment, modifications to equipment could introduce an unknown hazard or hinder a designed-in safety feature.
- DO NOT operate damaged equipment. Remove power, and do not use the equipment until safe operation can be verified by service-trained personnel.

Phenix Technologies, Inc. assumes no liability for unsafe or improper use of test equipment.

SECTION 1: SPECIFICATIONS

Input: 240 / 480 VAC, 60 Hz, 150/75 AAC
400 VAC, 50 Hz, /50 AAC

(Note: The above current levels are based on the 30 minute duty cycle. To estimate the current draw on the facility power at different duty cycles, multiply the above currents by the ratio of the output currents. Ex.: An HC-75C will draw approximately 7.5 times the above current at the 1 second duty cycle.)

Output:

OUTPUT CURRENT SPECIFICATIONS (PARALLEL CONNECTION)				
DUTY CYCLE	1 Second ON / 2 Minutes OFF	1 Minute ON / 10 Minutes OFF	30 Minute ON / 30 Minutes OFF	Continuous
HC-12C	12,000 A	2,500 A	1,700 A	1,200 A
HC-20C	20,000 A	4,500 A	3,000 A	2,000 A
HC-40C	40,000 A	9,000 A	6,000 A	4,000 A
HC-75C	75,000 A	15,000 A	10,000 A	7,500 A

**Note: The HC-C Controller will impose a shutdown and a 5-minute off time if one of the above limits is exceeded.*

OUTPUT CURRENT SPECIFICATIONS (SERIES CONNECTION)				
DUTY CYCLE	1 Second ON / 2 Minutes OFF	1 Minute ON / 10 Minutes OFF	30 Minute ON / 30 Minutes OFF	Continuous
HC-12C	6,000 A	1,250 A	850 A	600 A
HC-20C	10,000 A	2,250 A	1,500 A	1,000 A
HC-40C	20,000 A	4,500 A	3,000 A	2,000 A
HC-75C	37,500 A	7,500 A	5,000 A	3,750 A

**Note: The HC-C Controller will impose a shutdown and a 5-minute off time if one of the above limits is exceeded.*

OUTPUT VOLTAGE SPECIFICATIONS (OPEN CIRCUIT)					
Connection / Frequency	Series / 60Hz	Parallel / 60Hz	Series / 50Hz	Parallel / 50Hz	Number of Taps
HC-12C	15 V	7.5 V	12.5 V	6.25 V	3
HC-20C	20 V	10 V	16.6V	8.3 V	4
HC-40C	24 V	12 V	20 V	10 V	6
HC-75C	32 V	16 V	26.6 V	13.3 V	8

**Note: Output voltage will vary with input. Values given are at nominal.*

SPECIFICATIONS

Instrumentation:

Currentmeter: Resolution: 0.1% of Full Scale
Ranges: 100/1000/10,000/100,000 Amps
Accuracy: 0.8% rdg + 0.3% range
 $\pm 5\%$ of Full Scale 0.02 – 0.10 Seconds

Timer: Resolution: 0.002 Seconds
0.120 Cycles
Ranges: 0 - 999.999 Seconds
0 - 99,999.990 Cycles

Test durations of less than 10 cycles

Timer Accuracy: ± 0.004 Seconds
 ± 0.250 Cycles

Test durations of greater than 10 cycles

Timer Accuracy: ± 0.010 Seconds
 ± 0.600 Cycles

SECTION 2: INTRODUCTION

Phenix Technologies' High Current Test Sets represent a new era of electrical testing technology. This design is based on time-proven concepts and the power offered by an embedded 32-bit microcomputer.

High reliability SCRs have been combined with a phase angle firing system to deliver precisely repeatable current pulses with minimal distortion.

The output is continuously variable over the entire range by means of tap selection and vernier adjustment. Utilizing a motorized vernier and programmable tap selector, the test set has both auto-jog and current-hold capabilities. These features can be controlled from the HC Controller User Interface Panel, or from a laptop computer plugged into the HC Controller's serial port.

The test set incorporates a standard measurement and control interface that is operated with special cards installed in an embedded computer system, under software control. The combination of automated hardware and a highly intelligent monitor/controller provides an extremely versatile test instrument capable of exceptional accuracy. This combination also allows for the manual control or remote computer control of the High Current Test Set.

SECTION 3: SAFETY

Several safeguards have been built into the Phenix Technologies high current test sets; however, these safeguards are only effective if safe work practices are also used. The test set and these procedures have been designed for use by knowledgeable electrical workers who have been properly trained in its use.

Please note the following:

1. The test set must be grounded before input power is connected.
2. All power must be disconnected before the test set is ungrounded.
3. The tests described here are to be used only on DE-ENERGIZED and isolated circuit breakers.
4. **WARNING:** High currents are generated during the tests and extreme caution must be used. **Follow all safety procedures.**
5. See section 4 for Installation Instructions.

SECTION 4: INSTALLATION INSTRUCTIONS

1. Position the test set in the desired position. For 2-cabinet units, place the regulator cabinet on top of the transformer cabinet.

The following procedure is only required for 2-cabinet units (HC-12C and HC-20C):

- a. Connect the interconnect ground cable from the regulator cabinet to the transformer cabinet.
- b. Connect the four interconnect power leads from the regulator cabinet to the transformer cabinet, connecting B1 to B1, B2 to B2,
- c. Connect the control interconnect cable from CON208 on the regulator cabinet to CON209 on the transformer cabinet.

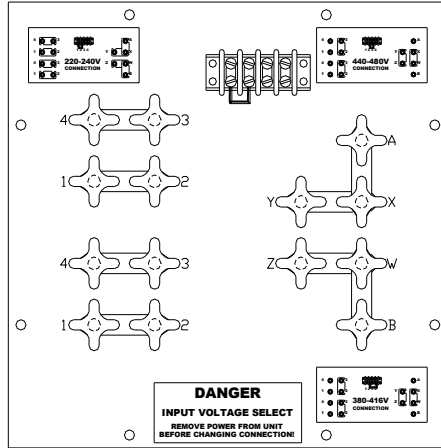
The following procedure is only required for models HC-12C, HC-20C, and HC-40C:

- d. Check the input power jumper configuration in both the Regulator and Transformer cabinet. It is *VERY* important that these are set correctly. See the tag on the inside panel of the unit and the following page.
2. Connect a #4 AWG ground cable from a good electrical ground to CON201 (green Cam-Lock connector). An additional ground stud is provided on the transformer cabinet for an optional connection of an external ground cable.
 3. Open the sliding cover over the controls. Place the control PC on the cover on top of the cabinet and connect the computer interconnect cable. Take special care not to pinch or damage the interconnect cable. Next, plug the PC into the provided outlet and position all wires and cables behind the computer to prevent catching or snagging during movement.
 4. Ensure that the main input circuit breaker (CB201), control power switch (SW201) and vernier circuit breaker (CB202) are all in the OFF position.
 5. Connect the input power cables to CON202 and CON203 (black Cam-Lock connectors), and then to the facility power. See the Specifications section for input ratings. Generally, cable sized thermally for the current listed in the specifications (30 minute duty) is sufficient.
 6. Perform the Power On Procedure as described on page 5-1.

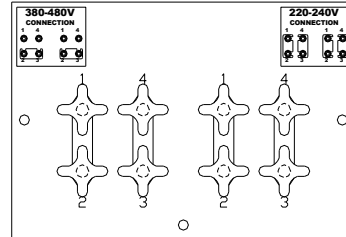
INSTALLATION INSTRUCTIONS

HC-12C, HC-20C, and HC40C INPUT POWER JUMPER CONFIGURATIONS:

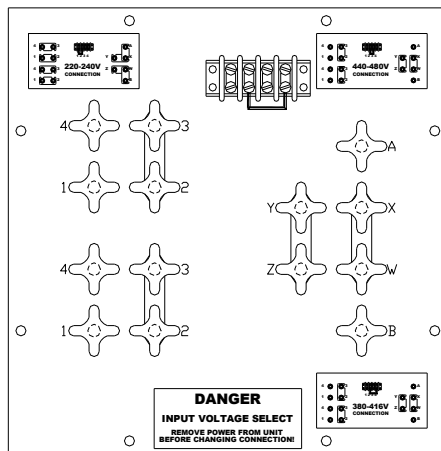
REGULATOR (TOP) CABINET 220-240V CONNECTION



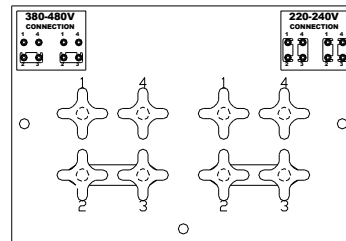
TRANSFORMER (BTM) CABINET 220-240V CONNECTION



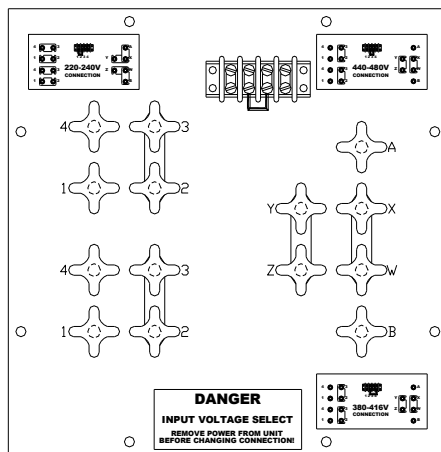
REGULATOR (TOP) CABINET 380-416V CONNECTION



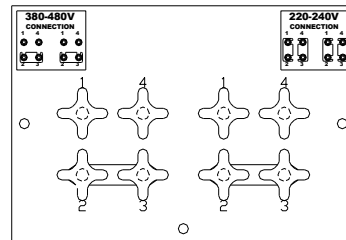
TRANSFORMER (BTM) CABINET 380-480V CONNECTION



REGULATOR (TOP) CABINET 440-480V CONNECTION



TRANSFORMER (BTM) CABINET 380-480V CONNECTION



SECTION 5: POWER ON PROCEDURE

1. Ensure proper connection of the test set and its components as described in the Installation Instructions, Section 4.
2. Ensure that CB201, CB202, and the CONTROL POWER switch (SW201) are in their OFF positions.
3. Energize the facility power distribution breaker. (Input Power lamp should illuminate.)
4. Turn the control power ON (SW201). The Control Power lamp should illuminate, and the HC Controller will automatically start the HC Operating Software.
5. Follow the outlined test procedure(s) in Section 7.

WARNING: To ensure safe operation, breaker CB201 should be opened prior to any connections being made to the output stabs on the test set. CB201 may then be closed after the connections are complete.

POWER OFF PROCEDURE

1. Ensure that the output is OFF.
2. Switch CB201 (main input circuit breaker) OFF.
3. Switch CB202 (vernier circuit breaker) OFF.
4. Switch the control power OFF (SW201).
5. De-energize the facility power distribution breaker.
6. Disconnect the test set as required.

WARNING: Connecting or disconnecting the controller with power applied may damage test set and/or controller.

SECTION 6: POWER SECTION DESCRIPTION

Fuses and Circuit Breakers

The single phase input power enters the regulator through CON202 and CON203 and is immediately connected to CB201. Circuit breaker CB201 protects the main power section and is equipped with an under-voltage release coil. The under-voltage release coil is wired so that if an interlock opens, the main circuit breaker will open and disable the power section.

Circuit breaker CB202 protects the output of the variable transformer, T202A/B, and the input to transformer Primary #1 of the main transformer T301.

Fuses F201 and F202 provide control power transformer protection. Fuse F203 protects the 120 V control circuits, and F204 protects the vernier motor controller.

Interlock Circuit

The interlock circuit is a safety mechanism that prevents the high power section from operating under unsafe conditions. The following conditions must exist to close the interlock:

1. Control power must be on.
2. The computer controller must be on, out of reset, and running the HC software. If the controller is displaying INTERLOCK or OVERTEMP, the interlock will not close.
3. CB202 must be in the ON position.
4. The Emergency Off mushroom switch must not be pressed. (Ensure that it is pulled out.)

After the interlock circuit is closed, the panel INTLK light will go out and allow the main circuit breaker CB201 to be reset.

Triggering

An SCR Trigger board, PCB201, turns the high current output ON when signaled by the HC Controller. The trigger board receives its command from the HC Controller via an I/O interface PC board, PCB202. The HC Controller precisely controls the phase angle and duration of the output waveform.

POWER SECTION DESCRIPTION

Taps and Variable Transformer

To achieve a variable output from minimum to maximum, a system of taps and a motorized variable transformer are employed. The tap selects the coarse range of the output, and the variable transformer controls the output from the 'top' of the previous tap to the maximum of the selected tap. The HC Controller controls all of the taps and the motorized variable transformer. This method makes possible the current hold and auto-jog functions.

A potentiometer is accessible on the front panel for varying the speed of the motorized variable transformer.

All transformers and regulators are equipped with several thermocouples and a thermistor to monitor and protect against an over-temperature condition. The output of the thermistor is fed back to the computer controller in order to constantly monitor the temperature. In addition to these safeguards, the SCR heatsink is forced-air cooled to provide lower operating temperature and a longer service life.

Metering

There is a precision current transformer employed in the high current section to measure the output current. This transformer is placed directly around the output bus.

Output Stabs

The stabs are designed to be versatile and facilitate connection to a large variety of circuit breakers. They are nickel plated for greater conductivity and a long service life.

The output stabs can be configured for parallel or series connection:

Parallel output connection is achieved by using the supplied stabs to short H1 to H2 for one output connection and L1 to L2 for the other output connection.

Series connection is achieved by shorting L1 to H2 and connecting the breaker to H1 and L2. A series connection link is available as an option.

Continuity

Located near the output stabs are the continuity binding posts. These posts can be connected to an unused pole of the breaker or an auxiliary contact. This allows the use of the Normally Closed or Normally Open test modes by the test set.

If the continuity connections cannot be used (i.e. a single-phase breaker), the set must be operated in the Current Latch mode.

CAUTION:

DO NOT CONNECT CONTINUITY TERMINALS TO ENERGIZED SOURCE.

DAMAGE TO CONTROLLER WILL OCCUR!

POWER SECTION DESCRIPTION

The following is a brief description of the various parts of the HC test set.

1	HC Controller	Performs all monitoring and control functions for the HC Test Set.
2	Input Power Indicator, LMP201	Indicates that Input Power is applied to the test set.
3	Control Power Switch, SW201	Applies 120-Volt AC Power to all of the controls in the test set.
4	Fuse, F201,202	Provides overload protection for the primary side of the control power transformer T201.
5	Fuse, F203	Provides overload protection for the secondary side of the control power transformer T201.
6	Fuse, F204	Provides overload protection for the vernier motor controller.
7	Variable Transformer Circuit Breaker, CB202	Provides overcurrent protection for the variable transformer output brushes. This circuit breaker must be energized for INTLK to be cleared.
8	Main Circuit Breaker, CB201	Applies Input Power to the transformers and relays. An under-voltage safety release is tied to the interlock circuit for safety purposes. If the interlock light is lit on the front panel, then the main circuit breaker cannot be turned on. If the interlock opens during the operation of the test set, the main circuit breaker will trip.
9	Emergency Off Button, SW202	De-energizes the output and the main circuit breaker. Control power will remain energized. Also part of the interlock circuit.
10	Control Power Indicator, LMP203	Indicates internal 120-Volts AC power has been energized.
11	Output On Indicator, LMP202	Indicates that the output of the HC test set is energized.
12	Interlock Open Indicator, LMP204	Indicates that the safety interlock is not reset. The main breaker cannot be turned on when this indicator is illuminated.
13	Chassis Ground Terminal	Connect to the facility ground with the Ground Cable (see #15)
14	Main Input Power Cables	Connect appropriate power to the test set.
15	Ground Cable	Connect between the Chassis Ground Terminal and the facility ground.
16	Output Stabs	Connection to the circuit breaker under test.
17	Continuity Binding Post	For use in contact mode, i.e. Normally Closed or Normally Open.
18	Regulator Speed Control	Controls the vernier speed.

SECTION 7: TESTING PROCEDURE

WARNING: *To ensure safe operation, breaker CB201 should be opened prior to any connections being made to the output stabs on the test set. CB201 may then be closed after the connections are complete.*

FACTORY SETTINGS

The following chart shows the factory settings. These are provided as a reference, as many of these will change with each test set-up.

MAX LIMITS	MAX AMPS	20000
	MAX SECONDS	OFF
	MAX CYCLES	OFF
TEST PARAMETERS	ON CYCLES	7
	OFF SECONDS	1
	HOLD AMPS	50
PHASE ANGLE	PHASE ANGLE	90

GENERAL SETTINGS

The following settings are the general limit settings of the high current test set. The limits set here are used as absolute limits that over-ride all other test settings, and therefore should be set high enough (or OFF) not to interfere with individual test settings or requirements.

- Click *Modify* under *Max Limits*: Set the maximum current allowed on the output of the test set. The default maximum setting is based on the 1 second rating of the specific model. This may be set to a lower value, if required, to limit the current that can be applied to a breaker during JOG to TRIP testing in case the breaker does not open at the expected value.
- Click *Modify* under *Max Limits*: Set the maximum amount of time the output can be energized. If set to Off, MAXIMUM SECONDS protection will be disabled.

CONNECTION NOTE

If using cables to connect the circuit breaker under test to the output stabs, twisting of the high current output and return cables together will reduce the impedance of the loop, which will increase the output capability of the set-up. Twisting the cables will also help to reduce noise on the current measurement.

SAVING RESULTS

After a test is performed and while test results are still displayed, click the *Save Result* button.

TESTING PROCEDURE

BASIC OPERATION

The following basic steps should be followed to test a circuit breaker after the POWER ON procedure in Section 5.

1. Ensure that the test set's main circuit breaker, CB201, is open.
2. Connect the breaker under test to the output of the test set. Ensure the output is configured correctly (either Parallel or Series connection) and that the WinHC connection setting matches the configuration. Also see *CONNECTION NOTE* on page 7-1.
3. If required, select the voltmeter sensing mode (INPUT, OUTPUT, or EXTERNAL) by clicking the *Voltmeter* radio button. The metering system is auto ranging. To see the current range, mouse-over the voltmeter display for 3 seconds.
4. Switch CB202 ON (if previously opened), then switch CB201 ON.
5. Ensure that Tap 1 is selected and the Vernier is at approximately 1%. Alternately, the Vernier and Tap may be set closer to their final positions, if known, to limit the time to reach a specific current level.
6. Click *Contact Mode* to select the method of breaker trip sense. Select either Normally Open (N.O.), Normally Closed (N.C.), or Current Latch Contact Mode. If using N.C. or N.O. sense, connect the continuity sense leads to an unused set of contacts on the breaker under test. *The N.O. and N.C. modes offer more reliable trip timing than Current Latch, and should be used whenever possible (i.e. multi-phase breakers).*
7. Click *Current Range* to select the appropriate current range. For best resolution, select the lowest appropriate range for the expected current. *The test set may auto-range up if the output current exceeds the selected range and Range Error will be indicated on the current meter. If this occurs, the test should be performed again to obtain a correct current measurement.*
8. Click *Test Mode* to select the desired mode of operation. The available test modes are as follows:
 - **NORMAL MODE** In this mode, the test technician controls all of the functions.
 - **MEMORY MODE** This mode retains the test results after the output is manually turned off (without the breaker tripping) to allow saving of the test results. It is used for tests that do not cause the breaker to trip, for example, performing a minimum pickup test, where the output is slowly increased until the minimum pickup indicator illuminates.
 - **JOG to TRIP** This mode is used for determining the instantaneous trip point of the circuit breaker under test.
 - **JOG to HOLD** This mode is used to reach a desired breaker holding current with minimal breaker stress.
 - **CURRENT HOLD** This mode is used to maintain a preset current value for a long period of time.
9. Click *Settings* in *Test Parameters* to access the test parameters. See the specific procedures for the different Test Modes on the next few pages.

TESTING PROCEDURE

NORMAL MODE

After performing the steps under *BASIC OPERATION*, follow the steps below to operate in Normal Mode.

1. The menu settings that affect operation during NORMAL mode depend upon whether the START button or JOG button is to be clicked to initiate the output.

START: Only the MAX AMPS, MAX DURATION, and MAX CYCLES settings affect the output level and duration. See GENERAL SETTINGS at the beginning of this section.

JOG: In addition to the general settings, the JOG / HOLD - ON CYCLES determine the output duration.

Click *Settings* in *Test Parameters*. Enter the number of cycles that the output will be energized. This should be long enough to get a good reading, but short enough to avoid overheating. Phenix Technologies recommends a value of 7 cycles.

2. Ensure that the breaker status indicator indicates that the Breaker is CLOSED.
3. Click either the START button or JOG button to initiate the test.
 - A. If the START button is clicked, the output will stay ON until either the operator clicks STOP, the circuit breaker trips, or the MAX DURATION or MAX CYCLES is reached. Use the Vernier and Tap controls to reach the desired output.
 - B. If the JOG button is pressed, the output will pulse ON for the ON CYCLES time. The current-meter will read the value of the current pulse, and the timer will read the duration in seconds or cycles, as selected by the Time radio buttons. Use the Vernier and Tap controls to reach the desired output. Clicking JOG again will initiate the output and record new data. The currentmeter and timer may be reset by clicking the RESET button.
4. Optional – click *Save Results*. Data is only displayed if the circuit breaker trips or if the JOG button was pressed.

MEMORY MODE

Similar to NORMAL Mode operation, except the data is retained when the output is turned off manually. Click RESET to clear the data.

TESTING PROCEDURE

JOG to TRIP MODE

After performing the steps under *BASIC OPERATION*, follow the steps below to perform the Jog to Trip function.

1. Click *Settings* in *Test Parameters*: Enter the number of cycles that the output will be energized. This should be long enough to get a good reading and at least twice the expected instantaneous trip time, but short enough to avoid overheating. Phenix Technologies recommends a value of 7 cycles. Be sure to click OK to record the setting.
2. Click *Settings* in *Test Parameters*: Enter the time period that the regulator will increase its output with the output of the test set de-energized. The OFF Seconds should be long enough to move the Vernier a reasonable amount, such as 1 to 2 seconds, but not so long that the current increment is too coarse. The setting of the Regulator Speed Control also must be adjusted in conjunction with the OFF SECONDS to prevent too much / too little travel during the OFF time.
3. Click *Settings* in *Test Parameters*: Set the maximum current allowed on the output of the test set. The default maximum setting is based on the 1 second rating of the specific model. If desired, the MAXIMUM AMPS may be set to a lower value to limit the current if the breaker does not trip at the expected value. Typically set at 20% higher than the expected trip current.
4. Ensure that the beaker status indicator indicates that the Breaker is CLOSED.
5. Click the START button to begin the test.
6. The test set will automatically increase the current until the breaker trips. Click the STOP button to stop the test at any time.
7. Optional – click *Save Results*.

TESTING PROCEDURE

JOG to HOLD MODE

After performing the steps under *BASIC OPERATION*, follow the steps below to perform the Jog to Hold function.

1. Click *Settings* in *Test Parameters*: Enter the desired output current set-point. This is the current that the test set will 'jog' to.
2. Click *Settings* in *Test Parameters*: Enter the number of cycles that the output will be energized. This should be long enough to get a good reading, but short enough to avoid overheating. Phenix Technologies recommends a value of 7 cycles.
3. Click *Settings* in *Test Parameters*: Enter the time period that the regulator will increase its output with the output of the test set de-energized. The OFF Seconds should be long enough to move the Vernier a reasonable amount, such as 1 to 2 seconds, but not so long that the current increment is too coarse. The setting of the Regulator Speed Control also must be adjusted in conjunction with the OFF SECONDS to prevent too much / too little travel during the OFF time.
4. Ensure that the breaker status indicator indicates that the Breaker is CLOSED.
5. Click the START button to begin the test.

Note: If the regulator speed is set too high, the test set may overshoot the set-point and will be constantly adjusting the variable transformer to try to obtain the set-point current. If this occurs, use the speed control to decrease the regulator speed until the variable transformer movement is acceptable.

If the desired current is obtained at a low Tap and Vernier position, it may be impossible to hold the set value accurately. Better results can be obtained by adding impedance (such as longer cables), to raise the Tap and Vernier settings.

6. The test set will automatically increase the current up to the HOLD AMPS setting. The output turns off when the HOLD AMPS setting is reached. Click the STOP button to stop the test at any time.

To continue with a long time test, perform the following:

7. Select either the CURRENT HOLD mode or the NORMAL mode by clicking the TEST MODE pull-down menu.
 - CURRENT HOLD mode will constantly adjust to hold the specified current. (Recommended)
 - NORMAL mode will not adjust the output, and the effects of heating and input line fluctuations will affect the output current. The operator must make any adjustments required to maintain current at the HOLD AMPS set-point.
8. Click the START button to energize the output. Click the STOP button to stop the test at any time.
9. The test set will hold the current until the breaker trips or the operator interrupts the test.
10. Optional – click *Save Results*.

TESTING PROCEDURE

CURRENT HOLD MODE

After performing the steps under *BASIC OPERATION*, follow the steps below to perform the Current Hold function. Although this continuous mode of operation is possible, the recommended method for reaching a HOLD current is to use the JOG to HOLD function.

1. Click *Settings* in *Test Parameters*: Enter the desired output current set point. This is the current that the test set will continuously increase to.
2. Ensure that the breaker status indicator indicates that the Breaker is CLOSED.
3. Click the START button to begin the test.

Note: If the regulator speed is set too high, the test set may overshoot the set point and will be constantly adjusting the variable transformer to try to obtain the set point current. If this occurs, use the speed control to decrease the regulator speed until the variable transformer movement is acceptable.

If the desired current is obtained at a low Tap and Vernier position, it may be impossible to hold the set value accurately. Better results can be obtained by adding impedance (such as longer cables), to raise the Tap and Vernier settings.

4. The test set will automatically increase the current up to the HOLD AMPS setting and remain ON until either the operator clicks STOP, the circuit breaker trips, or the MAX DURATION or MAX CYCLES is reached. Click the STOP button to stop the test at any time.

SECTION 8: TROUBLESHOOTING

If the unit is suspected to be malfunctioning, refer to the following guide for testing the unit and isolating the problem. Some minor repairs can be made in the field. Otherwise, call the factory for assistance.

WARNING: SOME TROUBLESHOOTING PROCEDURES REQUIRE OPENING THE TEST SET, WHICH HAS POTENTIALLY LETHAL VOLTAGES ON EXPOSED CONDUCTORS. ONLY FULLY EXPERIENCED TECHNICIANS SHOULD ATTEMPT TO PERFORM THESE PROCEDURES. IF YOU HAVE ANY DOUBTS, CONTACT THE PHENIX SERVICE DEPARTMENT FOR ASSISTANCE.

1. **Insufficient Output**

When the unit does not seem to yield sufficient current through a breaker, the problem could be one of the following:

- a. Insufficient power supply.
- b. Loose connection in unit.
- c. Incorrect controller range or output tap configuration setting.
- d. Poor connections or excessive contact resistance at the breaker. Check cable or stab connections.

2. **Cannot Energize Main Circuit Breaker**

- a. Main breaker can only be energized when the interlock is clear. Check the status on the controller.
- b. Remove power and inspect the under-voltage release mechanism for the main breaker.

3. **No Output Current When Initiated**

- a. Check to see that main circuit breaker is on.
- b. Verify that the breaker is reset and not in the trip position.
- c. Verify continuity of the breaker contacts.
- d. Check LED indicator on SCR trigger board. It should light when initiated.
- e. Check voltage out of SCR's when initiated.

SECTION 9: SERVICE AND MAINTENANCE

Periodic Maintenance

The following maintenance should be performed about once a year, unless otherwise indicated below, to ensure that the test set maintains proper output and operation. Units that are used and transported often should have shorter maintenance intervals.

1. Disconnect the unit from the input supply.
2. Open all panels on the unit. Using a vacuum cleaner, remove any dust and debris from the interior of the unit, including wiring and components. Use caution when cleaning printed circuit boards and small components.
3. Tighten all connections, especially those on transformers, contactors, and input and output connectors. Special attention should be given to tightening all connections in the high current section every six months or less. If the unit is transported often, this procedure should be performed more often.
4. Remove the front cover on the main circuit breaker and clean the main contacts. Replace the contacts if they are beyond repair.
5. Inspect the variable transformer brushes for wear. Replace if they appear worn.
6. Perform basic operational tests to determine proper operation.

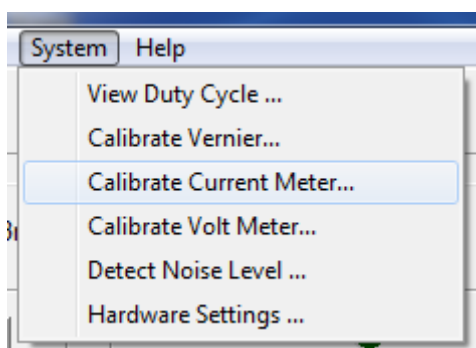
SECTION 10: CALIBRATION OF CIRCUIT BREAKER TEST SETS

Models HC-8C through HC-75C

Calibration of this HC must be performed with the laptop computer. The following items will be required to perform the calibration.

1. A laboratory “benchtop” multimeter
 - a. AC Voltage 0 – 480 with an overall accuracy of 0.3% or better.
 - b. AC Current from the output of your laboratory grade CT’s with trigger/memory and overall accuracy of 0.3% or better.
2. Laboratory grade CT’s capable of calibrating the 100, 1000 & 10000 amp ranges with an overall accuracy of 0.3% or better.
3. A variable voltage source 0 – 480 VAC to inject into your voltage metering circuit.

Start WinHC software from the laptop. Calibration will be explained in the order they appear in the drop down menu.

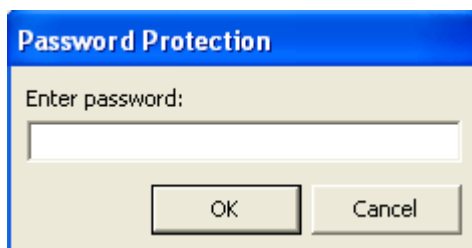


Calibrate Vernier:

This is a self calibrating function, when selected the variac will automatically run from limit to limit to adjust the systems 0% & 100% position sensors.

Calibrate Current Meter:

When selected you will get the following screen. Enter password 8118.



After password is entered, you will see the following screen.

CALIBRATION

Calibrate Current Meter

Calibration Procedure

1. Select the current Range.
2. Energize output and adjust current to 80% of full scale.
3. Enter the actual measured current and click Update.
4. Repeat for each current range.

Actual Current:

Cal Factors

100 A:

1K A:

10K A:

50K A:

100K A:

Before adjustment you should document the current Cal Factors for record keeping. Connect the standard CT with cables rated for the current you need to apply as if running a breaker.

NOTE: Make sure the top two plates and the bottom two plates are shorted. (Parallel Mode)
Use your Stabs or copper bars for this connection.

Raise the current to approximately 80% of range. Enter the value from your standard in the Actual Current field and press update. The Cal Factor will automatically update.

NOTE: For the higher ranges it is not necessary to be on to update. If you "jog" your current and capture your standard value, you can enter it and update between "jogs."

Repeat for other ranges.

NOTE: For the 100 kA range your standard will most likely be a much smaller value than your range. In this case you should calibrate near 100% of your standard's value. The standard should be at least 20% of range.

CALIBRATION

Calibrate Voltmeter

The voltmeter calibration functions the same as the current meter calibration.

Calibrate Volt Meter

Calibration Procedure

1. Select the voltage range.
2. Select External voltage input.
3. Inject calibration voltage.
4. Enter the actual measured voltage and click Update.
5. Repeat for each voltage range.

Range

- Range 1 (480 V)
- Range 2 (358 V)
- Range 3 (213 V)
- Range 4 (114 V)

Cal Factors

R1:

R2:

R3:

R4:

Actual Voltage:

Before adjustment you should document the current Cal Factors for record keeping.

For this calibration you will inject voltages into the banana jacks over the output panel. **(NOT CONTINUITY BINDING POSTS)**

Raise the voltage source to approximately 80% of range. Enter the value from your standard in the Actual Voltage field and press update. The Cal Factor will automatically update.

Repeat for other ranges.

CALIBRATION

Restore Calibration Factors:

It is recommended that documentation of the cal factors be maintained, in case the calibration factors become corrupt or if inadvertently changed and need to be restored. This can be done by going to the *Hardware Settings* screen.

Hardware Settings

Model No: HC-8

Frequency: 60 Hz

Has Volt Meter? YES

Show Raw Data

Scan Time (ms): 0

Current Range

Amps	Calibration
100 A:	0.0050
1K A:	0.0500
10K A:	0.5000
50K A:	2.5000
100K A:	5.0000

Voltage Range

Volts	Calibration
480 V:	0.0400
358 V:	0.0300
213 V:	0.0150
114 V:	0.0090

Vernier

Top: 6542

Bottom: 889

Allow output on with no error checks

OK Cancel

SECTION 11: WinHC PC Software

About WinHC

Welcome to WinHC, circuit breaker test system software developed by Phenix Technologies to control the Phenix Technologies high current test sets. WinHC provides advanced database and report generation capabilities, enabling you to save your circuit breaker test results in a database for future recall and report generation. WinHC also gives you complete remote control capability, allowing you to perform all tests from your computer.

Installation

If you have purchased a new circuit breaker test set, then WinHC will be pre-installed and tested on the accompanying notebook computer. No further software installation or setup is required. If you should ever need to re-install the software, here are the system requirements and the installation procedure.

Minimum System Requirements:

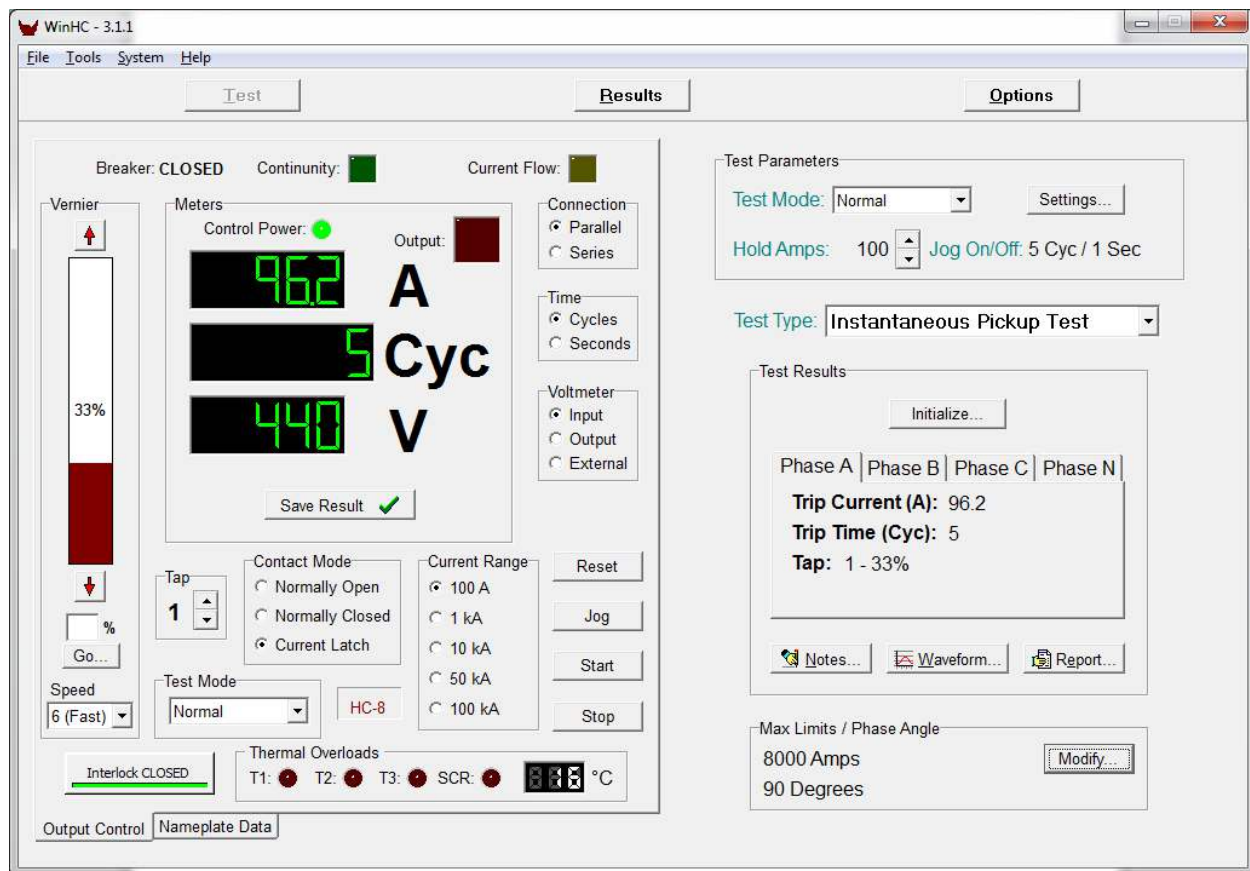
- Intel 2.0 Ghz compatible computer or greater
- 8 GB of system RAM
- 100 GB available hard disk space
- Microsoft Windows 7 / 10

Additional Hardware Requirements:

The computer must have one USB port available.

WinHC PC SOFTWARE

Using WinHC



WinHC main screen

Navigating WinHC is made easy by the navigation buttons. These buttons are always accessible and located on the heading bar of every screen. These buttons provide access to the major areas of WinHC: **Test**, **Results**, and **Options**.

Test: The starting point for all circuit breaker tests. Shows the nameplate data, test parameters and test results.

Results: Shows a list of your test history. From here you can generate test reports and view your history of tests.

Options: Contains your system configuration and customization.

Output Control

The output control screen allows you to completely control the individual functions of the high current test set: adjusting the vernier, selecting an output tap and current range, turning on the output, etc.

Vernier Control: The position of the vernier determines the level of the output voltage and current of the WinHC. Click the up/down arrows to change the position of the vernier, or enter a vernier position and click *Go...*

WinHC PC SOFTWARE

Tap: Selects the output tap. Higher taps produce a higher output voltage and therefore higher current.

Current Range: Selects the range on the current meter. Note: The current meter may auto-range upward when the current level exceeds the current range.

Start/Stop: Initiates and halts a test.

Jog: Pulses the output on, just long enough to collect an accurate RMS current reading, which is then displayed in the current meter window.

Reset: Aborts a test and resets the test results.

Meters: Displays the RMS output current, the trip timing, and the transformer temperature.

Save Result: Saves in the database the results of the latest breaker test, including the waveform.

Time: Selects the time base of the trip timer results, either seconds or cycles.

Test Mode: Selects the test mode of operation: Normal, Jog-To-Hold, Jog-To-Trip, Current Hold, or Memory.

Connection: The output connection mode, the default is Parallel for maximum output current.

Test Parameters

This window displays the current test parameters. Click the *Settings...* buttons to modify these parameters. Each test type title has a set of test parameters associated with it. When you select a different test type the test parameters, last used with that test type, will be recalled.

Max Limits

This window displays the present max duration and max current limits (if any exist). Click *Modify...* to change these parameters.

Initialize

The traditional method to position the output level is to use the Jog-To-Hold function. The Initialize function performs the exact same function as Jog-To-Hold but does it faster and more efficiently. Initialize is an automatic process, you do not need to pre-configure the output controls. The test mode, current range, etc. will all be controlled automatically.

Initialize works as follows: beginning near the bottom of tap 1, sample output pulses will be made at various points of each tap as the software determines the required tap and vernier position for the desired current. You **MUST NOT** enter a desired test current that is at or above the level where the breaker under test will trip. If the breaker trips during initialization, then the process will be aborted.

WinHC PC SOFTWARE



Performing a Circuit Breaker Test

The following is the step-by-step procedure for using WinHC to test a circuit breaker, save the results in the database and generate a test report.

1. On the Nameplate Data screen, click *New Job*.... Enter the Serial Number of the unit you are about to test then click *Ok* or use the pull-down menu to select a recently tested serial number.

NOTE: If a previous test result already exists for this circuit breaker, you will be given the option of creating a new test result, or of adding new results to the most recent test.

2. Enter the nameplate data for the circuit breaker you wish to test then click OK.

The Nameplate data screen is where you enter the circuit breaker nameplate, job, and location information. This data will appear on the test report. The serial number is the only required field.

Job No: Your internal job tracking number.

Make: The manufacturer of the circuit breaker. Select from the pull-down menu, or type it in.

Type: The type of the circuit breaker. Select from the pull-down menu, or type it in.

Rating (A): The continuous current rating of the circuit breaker.

Frame (A): The frame current rating of the circuit breaker.

Phase: Single or three-phase circuit breaker.

Technician: The name of the test technician.

Additional Info...: Click to open the additional information screen. This is optional nameplate and test data that may appear on the test report.

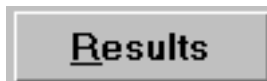
Use Tab to move through the fields or click the desired field to activate. Click OK when you're done.

3. The required test data has now been entered and you are ready to perform the circuit breaker test. Select the appropriate test type title for the test that you wish to perform. Select the phase of the circuit breaker that you wish to test.

Use the Output Control screen to perform the circuit breaker test. When the test is complete, click **Save Result** to save the test results. Click **Waveform...** to view the waveform of the output current.

WinHC PC SOFTWARE

4. Repeat step 3 for each phase and test level that you wish to test.
5. Click **Notes...** to add any test notes.
6. Click **Report...** to generate a test report.



Generating Reports

The WinHC software keeps a history of all circuit breaker and tests that have been performed. Here's the procedure for creating test reports of previous tests.

1. On the main screen, click the *Results* button. The Results screen will appear.
2. Select the order in which you want the results to appear by clicking a *Sort By...* item. This selection also determines which field is used by search.
3. Browse the results menu to find the test result you wish to print. The most recent test will already be highlighted. Or, to search for a specific result, click the search field and enter the search value.
NOTE: The search will be performed on the field selected by *Sort By...*
4. Click *Test Report...* to generate a report. You will be given the option of pre-viewing the report on screen or sending it directly to the printer.

WinHC PC SOFTWARE

Options

General Options

Use these options to configure your test report and other generic options. Access these options by clicking the Options button on the main screen, then click the *General* tab.

The screenshot shows the 'Setup' dialog box with the 'General' tab selected. The fields are as follows:

- Company: Phenix Technologies
- Header 1: Industrial Drive
- Header 2: Accident, MD. 21520
- Header 3: (301) 746-8118
- Logo File Name (.BMP):
- Data Path: C:\ProgramData\Phenix\HC\

The 'Report Options' section includes the following checked and unchecked items:

- Print Address in Header
- Print Test Notes
- Print Sign Off
- Print Resistance Measurements
- Print User Defined Fields (Group 1)
- Print User Defined Fields (Group 2)
- Send Directly To Printer

The General Options screen

Company, Header1, Header2, Header3: These fields determine what text will appear at the top of reports.

Report Options: These settings determine what “extras” will appear on test reports.

Serial Port: The serial port of your computer that you wish to use to communicate with the HC controller.

Data Path: This setting determines where the WinHC data files are located. For instance, you can change this setting to move your WinHC data to a network server. You are responsible for moving the data files, if you change this setting without moving the files, WinHC will create empty data files in the new location.

WinHC PC SOFTWARE

Labels

Setup

General | **Labels** | Lists | Tests | Custom

Nameplate Fields

Serial Number	Cubicle
Location	Designation

Resistance Measurements

1: Insulation Resistance (MegOhms)

2: Contact Resistance (MicroOhms)

3:

Phase

A: Phase A	C: Phase C
B: Phase B	N: Phase N

User Group 1

1: User 1	5: User 5
2: User 2	6: User 6
3: User 3	7: User 7
4: User 4	8: User 8

User Group 2

1: User 1	5: User 5
2: User 2	6: User 6
3: User 3	7: User 7
4: User 4	8: User 8

OK Cancel

The Labels Options Screen

The labels options screen contains the field labels for the optional circuit breaker nameplate fields. You may change any of these to suit your particular needs. These labels appear on the circuit breaker nameplate screen, under *Additional Info...*, and on test reports.

Lists

Setup

General | Labels | **Lists** | Tests | Custom

Manufacturer List

- SIEMENS
- SQUARE D

Breaker Type List

- WL
- NW 08 L
- NW 16 L
- NW 20 L
- NW 30 L

Technician List

- Sean
- D. Riley

OK Cancel

The Lists Options

WinHC PC SOFTWARE

Use these options to maintain standard circuit breaker type and circuit breaker manufacturer lists. Items in these lists will appear in pull-down menus, off of the circuit breaker type and make fields. You may edit these lists to match your specific needs.

Tests

The screenshot shows the 'Setup' dialog box with the 'Tests' tab selected. The dialog has four tabs: 'General', 'Labels', 'Lists', and 'Custom'. The 'Tests' tab contains a section titled 'Test Titles' with ten text input fields arranged in two columns. The first column contains Test 1 through Test 5, and the second column contains Test 6 through Test 10. The text in the fields is as follows:

Test Number	Test Title
Test 1:	Long Delay Pickup Test
Test 2:	Long Delay Timing Test
Test 3:	Short Delay Pickup Test
Test 4:	Short Delay Timing Test
Test 5:	Instantaneous Pickup Test
Test 6:	Ground Fault Pickup Test
Test 7:	Ground Fault Timing Test
Test 8:	
Test 9:	
Test 10:	

At the bottom right of the dialog are 'OK' and 'Cancel' buttons.

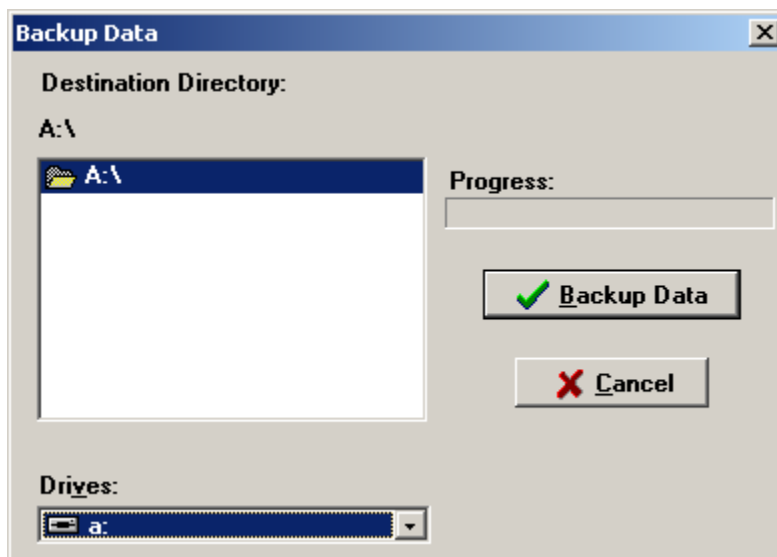
The Tests Options

Circuit breaker Test Titles: You may customize the test titles to match your individual testing procedures. Test Titles appear on the test screen and print on test reports.

WinHC PC SOFTWARE

Data Backup

WinHC data should be backed up on a regular basis. Hard disks do fail, you don't want to lose years of valuable data. We recommend that you maintain at least two separate backups. WinHC has backup and restore functions that make this an easy task.

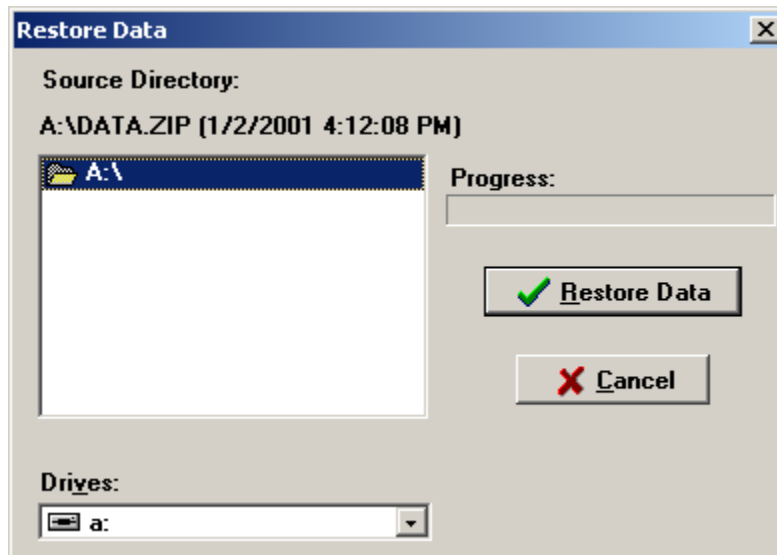


The Backup Data Screen

The backup data screen allows you to easily select a drive/directory as a destination for your data backup. Access this screen by selecting Tools and then Backup Data.... Select the drive/directory and Click *Backup Data* to begin the backup.

WinHC PC SOFTWARE

Data Recovery



The Restore Data Screen

Should something happen and you need to restore data from a backup, WinHC provides a similar function for restoring data. The restore data screen allows you to easily select a drive/directory as a source for your data recovery. Access this form by selecting Tools and then Restore Data.... Select the drive/directory and Click *Restore Data* to begin the data recovery.

SECTION 12: RETURNED MATERIAL

If for any reason it should become necessary to return this equipment to the factory, the Service Department of Phenix Technologies, Inc. must be given the following information:

Name Plate Information
Model Number
Serial Number
Reason for Return
Cause of Defect

If Phenix Technologies, Inc. deems return of the part appropriate, it will then issue an "Authorization for Return."

If return is not deemed advisable, other inspection arrangements will be made.

NOTE: Material received at this plant without the proper authorization shall be held as "Customer's Property" with no service until such time as the proper steps have been taken.

Your cooperation is requested in order to ensure prompt service.

SECTION 13: PARTS ORDERING INFORMATION

Replacement parts are available from Phenix Technologies, Inc.

Changes to Phenix Technologies' products are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest technical improvements developed in our Engineering Department. It is, therefore, important when ordering parts to include the serial number of the unit as well as the part number of the replacement part.

When your purchase order is received at our office, a representative of Phenix Technologies will contact you to confirm the current price of the part being ordered. If a part you order has been replaced with a new or improved part, an Applications Engineer will contact you concerning any change in part number.

Send orders for replacement parts to:

**Service Department
Phenix Technologies, Inc.
75 Speicher Drive
Accident, Maryland 21520**

**PH: 1 (301) 746-8118
FAX: 1 (301) 895-5570
E-mail: info@phenixtech.com**

SECTION 14: RECOMMENDED SPARE PARTS HC-20C

In order to maintain your set in full operating condition with a minimum of down time, the following spare parts should be kept on hand to avoid unnecessary phone calls, expensive modes of shipment, delays in repairs, etc. Pricing is available upon request.

Part Number	Description	Quantity
1603660	Fuse, 1/2A, 500 V	5
1603605	Fuse, 250 V, 5A	5
1603602	Fuse	5
1423260	Lamp, Neon, 125 VAC	1
1420145	Lamp, 28V	6
1606100	Movistor	3
1606108	Movistor	3

SECTION 15: HC-20C PARTS LIST

Qty	Phenix Part #	Item	Description
CONTROLLER (Part No. 9304593)			
4	1001402	CABLE 101-104	RIGHT ANGLE USB CABLE, 2'
3	1079908	CABLE 105-107	RIBBON CABLE
5	1152145	CABLE	37 PIN TO RIBBON
1	1152160	CABLE	40 PIN CONN
1	1152248	CON	3CKT
1	1152590	CON1	POWER INPUT MODULE
1	1152270	CON10	CON 6CKT
2	1152271	CON2	CON 6CKT
2	1152200	CON5	CON 2CKT
1	1152683	CON6	PLUG 2 POS
2	1152210	CON7	CON 10CKT
4	1152230	CON8-9	CON 12CKT
2	1001818	DAQ1-2	24 CH DIGITAL I/O BD
1	1001819	DAQ3	16 BIT MULTIFUNC
1	1603602	F101	FUSE
1	1001732	HC CBL	PVC CBL 10'
1	1077167	PWR	PWR CORD
2	1152623	J1	PLUG 3 POS
4	1151627	J3-4	PLUG 4 POS
2	1152668	J6	PLUG 10 POS
2	1152633	J7	PLUG 6 POS
1	1153973	J9	MOLEX RCPT
2	1153974	J9	MOLEX CONN FEM
1	1153910	LP1	MLX PLG
2	1153915	LP1	MOLEX F PIN
1	1153930	LP1	MLX RCPT
2	1153935	LP1	MLX M PIN
1	1420122	LP1	LED PANEL MNT
1	1001986	PC CBL	CABLE
1	1590158	PS101	PWR SUPPLY
1	1001391	USB	CONN PANEL MNT
1	1001395	USB	SEALING CAP
1	1001415	USB HUB	4 PORT USB HUB
1	31138901	PCB1389	HC INTERFACE BD
1	31139100	PCB1391	HC INTERCONNECT BD
REGULATOR AND HIGH CURRENT SECTION			
4	30120001	B1-B4 Cable	1 COND. POWER, 4AWG 34"
2	1356214	BP201,203	BINDING POST, BLK
2	1356215	BP202,204	BINDING POST, RED
1	1092590	C201	CAPACITOR
1	1099120	C202	CAPACITOR
1	30000022	CABLE 201	CONTROL CABLE W / CIRCULAR CONNECTORS
1	30030007	CABLE 202	INTERNAL RIBBON CABLE, 40 COND., 2FT.

HC-20C PARTS LIST

Qty	Phenix Part #	Item	Description
REGULATOR AND HIGH CURRENT SECTION (continued)			
1	1601052	CB201	CIRC BRKR, 2 POLE, 150A W / 24VDC UVR
1	1601504	CB202	CIRC BRKR, 2 POLE, 32A W / AUX. CONTACTS,
1	1601506	CB202 Aux.	AUXILIARY CONTACTS, #S500-H11
1	1152903	CON201	RECEPTACLE, FEMALE, GREEN
1	1152906	CON201	PLUG, GREEN
2	1152902	CON202, CON203	RECEPTACLE
2	1152910	CON202, CON203	PLUG
8	1153010	CON204-207, 210-213	TWECO, PANEL
24	1151174	CON208	CONTACT PINS, 24-20AWG, FEMALE
1	1150171	CON208	SERIES 1 CIRCULAR CONN, REV, 28-37
1	1150170	CON209	SERIES 1 CIRCULAR CONN, STD, 28-37
23	1151170	CON209	CONTACT PINS, 24-20AWG, MALE
1	1506560	CT201	COIL FOR CURRENT METER
6	1780025	D201-206	DIODE
2	1603667	F201, F202	FUSE
4	1603921	F201-202, F205-206	HPL-B FUSE HOLDER
2	1603605	F203,204	FUSE
1	1603920	F203	FUSE HOLDER, PANEL MOUNT
1	1603910	F204	FUSEHOLDER,
2	1603660	F205, F206	FUSE
1	2350125	FAN201	FAN
2	1705080	K201, K202	CONTACTOR, 3 POLE, 24V COIL
2	1705058	K203, K204	CONTACTOR, 4 POLE, 24V COIL
2	1705055	K203, K204	AUX. CONTACT BLOCK
2	1705082	K205, K206	CONTACTOR, 4 POLE, 24V COIL
2	1705056	K205, K206	AUX. CONTACT BLOCK
1	1701362	K207	RELAY
6	1701361	KS201-202,K211-214	RELAY
1	41000004	L201	CURRENT LIMIT CHOKE
1	1423260	LMP201	LAMP, NEON, 125V
1	1422150	LMP202	LENS, RED
3	1420145	LMP202- LMP204	LAMP, 28V
3	1423300	LMP202- LMP204	SOCKET
1	1422151	LMP203	LENS, GREEN
1	1422152	LMP204	LENS, YELLOW
1	1353048	Meter Leads	BATTERY CLIP, RED
1	1353050	Meter Leads	BATTERY CLIP, BLACK
1	1356213	Meter Leads	4mm PLUG, RED
1	1356212	Meter Leads	4mm PLUG, BLACK
1	1606150	MOV201	MOVISTOR
1	1606100	MOV202	MOVISTOR
6	1606108	MOV203-208	MOVISTOR
1	1606140	MOV213	MOVISTOR
40 Ft.	1073340	Output Lead	4/0, 600V CABLE (8 PIECES X 5 FT. LONG)
16	1352136	Output Lead	LUGS, BLU-025S2

HC-20C PARTS LIST

Qty	Phenix Part #	Item	Description
REGULATOR AND HIGH CURRENT SECTION (continued)			
1	31115600	PCB201	TRIGGER BOARD, PCB1156
1	31115520	PCB202	INPUT/OUTPUT BOARD, PCB1155B
1	31125210	PCB203	RMS-TO-DC CONVERTER, PCB1252
1	1590293	PS201	POWER SUPPLY, 24VDC
1	1590168	PS201	POWER SUPPLY, 24VDC
2	1714010	R201, R202	RESISTOR
1	1740201	R203	RESISTOR
1	1761055	R204	POTENTIOMETER
1	1769998	R205	POTENTIOMETER
1	1355315	R205	KNOB, 1"
1	1740300	R206	RESISTOR
1	1740150	R207	RESISTOR
1	1159922	RCP201	OUTLET, DUPLEX 120V, 15A, GFCI
1	1808215	SCR201, SCR202	RECTIFIER
1	1565226	SCRC201	SCR MOTOR CONTROLLER
1	1863360	SW201	SWITCH, 600VAC, 15A
1	1860900	SW202	SWITCH, MUSHROOM
1	1862905	SW202A	CONTACT BLOCK, NC
2	1866005	SW203, SW204	LIMIT SWITCH, ROLLER, 20A
1	3860025	T201	TRANSFORMER, CONTROL POWER, 500VA
1	1894415	T203	TRANSFORMER, 115/40V CT, 1A
1	1894438	T204	TRANSFORMER, 575/115 PT
1	1896016	T205	TRANSFORMER, CONTROL POWER, 50VA
1	38602190	T301	TRANSFORMER, IA1-2190
1	1482925	TH201	THERMOSTAT, 140°C
1	1482915	TH202	THERMOSTAT, 110°C
1	1482940	TH203	THERMOSTAT, 240°C
1	1763000	TH204	THERMISTOR 5K OHM
1	1482904	TH205	THERMAL SWITCH, 90-100 DEG. F
1	2960016		HC20 DUST COVER

SECTION 16: ELECTRICAL SCHEMATICS

HC Controller

	<u>Drawing Number</u>	<u>Description</u>
1.	9304593	HC-C Controller Electrical Schematic
2.	31138900	PCB 1389, HC Interface BD
3.	31139100	PCB1391, HC Interconnect BD

HC Regulator / Transformer Cabinet(s)

	<u>Drawing Number</u>	<u>Description</u>
1.	9304553	HC-20C Electrical Schematic
2.	31115520	PCB 1155B, HC I/O Interface Schematic
3.	31115600	PCB 1156, SCR Trigger Board
4.	31125210	PCB 1252A, RMS-to-DC Converter

