Radian Research, Inc.

Model 505
UTEC Transformer Analyzer

Operations Manual

RADIAN

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CAUTION
READ THIS NOTE

The operation and application of the Model 505 Transformer Analyzer requires experience and training in the skills of electric service and meter testing. The information in this manual is designed to supplement existing knowledge and experience already attained and practiced by test technicians and is <u>not meant to be a tutorial in meter and service testing</u>. Test technicians should not attempt to operate this equipment without first gaining the basic knowledge of meter and service testing and the application of meter and service testing equipment from a certified training course.

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Model 505

The calibration factors are supplied in a report shipped with every new unit.

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INTRODUCTION

The **MODEL 505 Transformer Analyzer** is designed for testing current transformers (CT) and potential transformers (PT) without interruption of the customer's service. This instrument measures CT admittance, CT ratio, CT primary-to-secondary phase angle and the voltage, current and phase angle of the service. With the 'Burden CT/PT Option', it determines the CT secondary burden capability, the regulation of the PT and its secondary burden capability and provides for CT core demagnetization.

The Model 505 Transformer Analyzer incorporates the Model 500 CT Admittance Tester technology and an electronic burden tester into one small, lightweight, battery or line powered instrument.

The admittance section provides the capability of testing a CT with or without secondary current flow. It displays the admittance value of the CT loop which can be recorded and used as a reference value on future tests. Shorted turns, circuit shunts, minor deterioration in CT performance, defective watthour meter current coils, defective test switches, shunting of primary, partial by pass of primary current and high resistance connections are all easily detected from the admittance value.

The CT Ratio section provides for measuring the CT ratio as an 'Actual' ratio or a 'Best Fit' ratio. If the CT/PT Burden option is installed, ratios can be measured with and without burden applied. In addition, the phase angle between the primary and secondary is measured.

The CT/PT Burden section is optional. This option can be retrofitted but the instrument must be returned to the factory for installation. The instrument reads and displays the actual CT secondary loop current and when the selected burden is added, displays the new CT secondary loop current. Burdens may be selected individually or run in a sequence. Because the Model 505 is computer based, sampling techniques are used to time freeze comparative readings of CT secondary loop currents for more accurate and less interpretive measurements. The CT secondary loop current is sampled prior to and after the burden has been added and the % of change in current after the burden is added is displayed. This measurement technique eliminates the uncertainty of burden testing in services where continuous current changes are present. It reduces the interpretative requirements of the user since the reduction of CT secondary loop current due to the addition of the selected burden is displayed as a % of the original current. This new measurement method can respond to CT secondary loop currents as low as 0.2 amperes.

Data collected may be saved. Up to 13 site test records can be stored and downloaded to software provided for viewing and exporting the saved test results. Saved data may also be recalled for viewing from the 505.

The **Model 505 Transformer Analyzer** is the ultimate answer to in service CT and PT Testing!

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SPECIFICATIONS:

POWER

Service Connection:

80 - 530 VAC, 60 Hz (600 VAC Maximum) 50 Hz units also available. Units must be calibrated to the working (line) frequency they measure.

Battery Operation:

`C' size NiCad battery pack. Built in battery charging circuit provided. The battery discharge time will vary depending on operating point, temperature, and battery condition. Maximum storage time for a fully charged battery is about 3 months. Charge time is 10 – 18 hours. A low battery is indicated by a series of "beeps" about 10 seconds apart. At each "beep", a low battery symbol is displayed at the end of the last display line for 2 seconds.

Battery Saver:

The Model 505 is provided with a battery saver circuit designed to turn the instrument OFF approximately 10 minutes after turning ON. The display back light turns OFF approximately 2 minutes after turning ON.

MEASUREMENT RANGE

Service Parameters:

Voltage: 10 – 530 volts AC, 60 Hz
Current: 0.1 – 25 amperes AC, 60 Hz
Phase Angle: 0 to 360

Admittance:

Test Frequency: 1575 Hz
Ranges: 1-10 mS and 10-100 mS (autoranging)

CT Burden:

Burdens may be added individually or in a sequence.

CT Current: 0.1 – 25 Amperes
Burdens: 0.1, 0.2, 0.5, 1.0, 2.0, 4.0 and 8.0 Ohms

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CT Ratio:

The ratio between CT primary and CT secondary is displayed. Primary current is measured using optional CT clip-on probes.

Primary Current: 10 – 3000 amperes, 60 Hz
Secondary Current: 0.1 – 25 amperes, 60 Hz
CT Clip-on Probe Scales: 1 mV/A, 2 mV/A, 5 mV/A, 10 mV/A, 100 mV/A and 1000 mV/A.
Maximum CT Clip-on Probe Input Voltage: 3 VAC

PT Burden:

PT burdens may be added individually or in a sequence.

Voltage: 10 – 140 volts, 60 Hz
Burden: 25 VA, 50 VA, 75 VA, 100 VA, 125 VA, 150 VA and 175 VA.

MAXIMUM MEASUREMENT INPUTS

CT Primary Current – 3000 AAC (using external CT probe)
CT Secondary Current – 25 AAC
PT Primary Voltage – 600 VAC
PT Secondary Voltage – 135 VAC

DISPLAY

The instrument display is a 4 line by 40 character LCD with 5/32" high characters. A back light is provided which is turned ON from a front panel switch. A battery saver circuit is provided to automatically turn the back light OFF 2 minutes after turning ON.

Resolution:

Admittance: 10 – 100 mS, 0.1 mS
1 – 10 mS, 0.01 mS
Voltage: 10 – 530 Volts, 0.1 V
Current:
Primary: 10 – 3000 Amperes, 0.1 A
Secondary: 0.1 – 25 Amperes, 0.01 A
Phase Angle: 0 - 360 , 0.1
Ratio:
Actual: 999.99:5, 0.01
Best Fit: 999:5, 1

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TEST METHOD

Admittance:

Injects a small audio sine wave signal into the CT secondary loop and measures the induced current at the audio frequency to determine admittance value. For a more detailed description, refer to the Admittance section of this manual. Admittance values from 0 – 100 mS (milli-Siemens) are displayed.

Burden:

Inserts a known precision resistor element in series with the CT secondary loop. The resistor is inserted for 1 second during which current samples are taken.

MEASUREMENT ACCURACY

Admittance Mode: 0 - 100 mS,   5% F.S. The presence or absence of AC current in the CT primary is unlikely to affect the admittance readings by more than   1.5% of F.S. value.

Current: 1% F.S.

Burden Mode: Current measurement only 0.1 to 25.0 Amperes   1% F.S.
Tolerance of internal resistive elements   5%

Current measurement with burden added: 0.1 to 25 Amperes   2% F.S.

OPERATION TEMPERATURE

The electronics and LCD of the Model 505 has an operating range of 0 to +50 C. The instrument has a storage temperature of -20 to +70 C. Humidity 10% - 95% non-condensing (@35 C).

SIZE

10 inches (25.4 cm) long X 7.5 inches (19 cm) wide X 8.5 inches (21.6 cm) high

WEIGHT

Model 505 without CT/PT Burden Option: 13 lbs (5.9 kg)
Model 505-01 with CT/PT Burden Option: 16 lbs (7.3 kg)
Model 103 Clip-on CT current probe: 5.4 ounces (153 g)
Model 411 Clip-on CT 0-600A current probe: 15 oz (440g)
Model 521 Clip-on CT 1-150/1500A current probe: 17 oz (480g)
Model LW2000-15 Clip-on CT 1-2000A current probe and case: 13 lbs. (5.9 kg)

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Model LW2000-16 Clip-on CT 1-2000A current probe and case: 13 lbs. (5.9 kg)
Model i2000 Rope CT 2-200/2000A 24 inch current probe: 15 oz (420g)
Model RR3035-24 Rope CT 1-30/300/3000A 24 inch current probe: 7 oz
Model RR3035-36 Rope CT 1-30/300/3000A 36 inch current probe: 9 oz
Model RR3035-48 Rope CT 1-30/300/3000A 48 inch current probe: 12 oz
Model HV-216 Hot Stick, 16.9 feet extended: 5 lbs
Model 505-02 Current Cable with Superior TSP: 1 lb. (0.45 kg)
Model 505-03 Current Cable with Westinghouse TSP: 1 lb. (0.45 kg)

PANEL

Aluminum, covered with polycarbonate for durability and appearance.

ENCLOSURE

Black ABS material. This material offers high resistance to impact, thermal shock, moisture, weather, and corrosion. The lid is removable.

WARRANTY

Two year limited warranty

OPERATION INSTRUCTIONS

One manual provided with instrument on distribution CD. Manual also available from Help in the Report Viewer software or available from www.radianresearch.com

OPTIONS

The Model 505 is provided with a Voltage Test Lead. The Current Test Lead and CT clip-on probes are optional because a variety of models exist.

CT/PT Burden Tests: 3 lbs (1.36 Kg)
Model 103 Clip-on CT current probe: 5.4 ounces (153 g)
Model 411 Clip-on CT 0-600A current probe: 15 ounces (440g)
Model 521 Clip-on CT 1-150/1500A current probe: 17 ounces (480g)
Model LW2000-15 Clip-on CT 1-2000A current probe and case: 13 lbs (5.9 kg)
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Model i2000 Rope CT 2-200/2000A 24 inch current probe: 15 oz (420g)
Model RR3035-24 Rope CT 1-30/300/3000A 24 inch current probe: 7 oz
Model RR3035-36 Rope CT 1-30/300/3000A 36 inch current probe: 9 oz
Model RR3035-48 Rope CT 1-30/300/3000A 48 inch current probe: 12 oz
Model HV-216 Hot Stick, 16.9 feet extended: 5 lb (2.2 kg)
Model 505-02 Current Cable with Superior TSP: 1 lb (453g)

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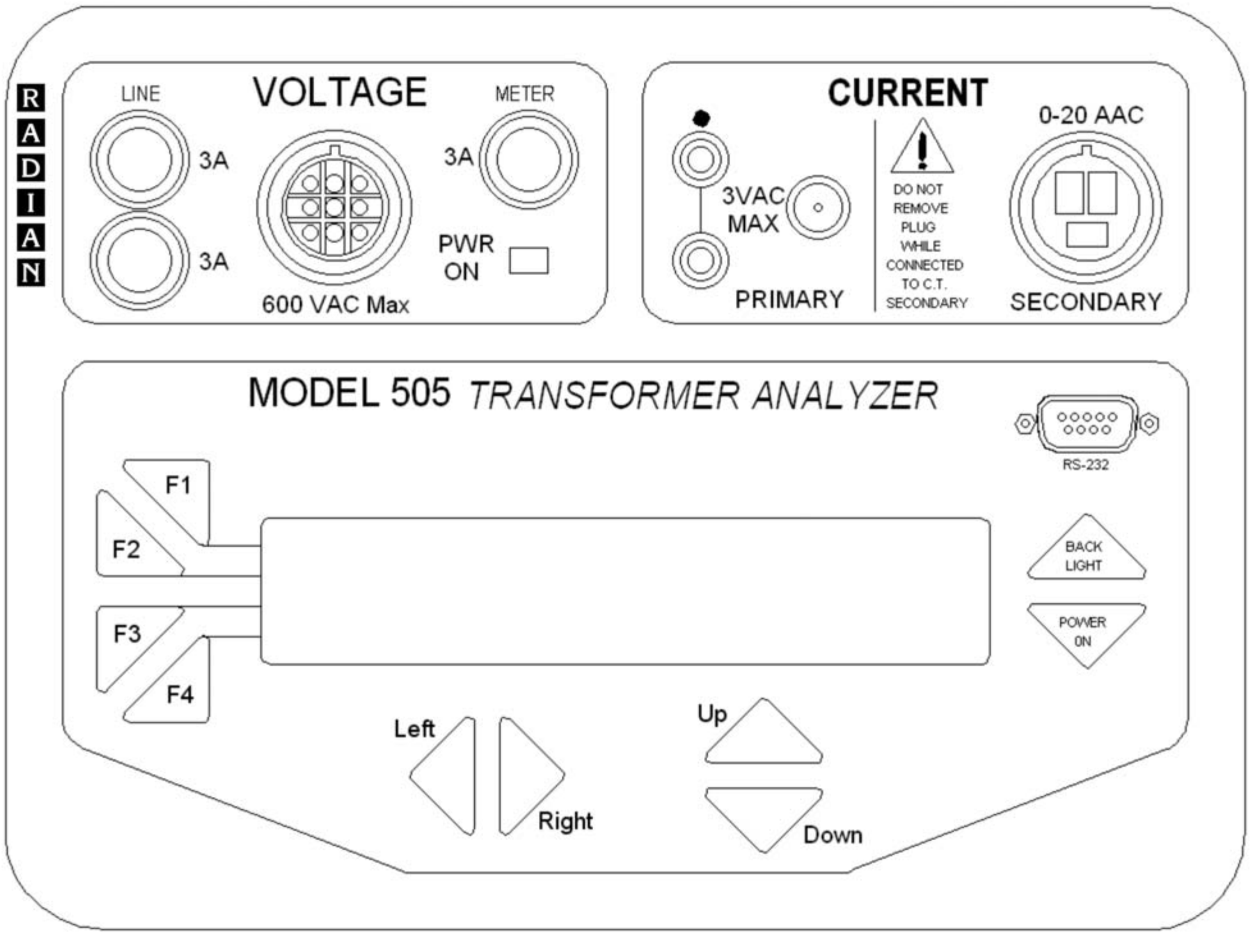
Model 505-03 Current Cable with Westinghouse TSP: 1 lb (453g)

FRONT PANEL CONTROLS

The Model 505 front panel is shown below. The panel is divided into function areas indicated by a gray area outlined with a black border. The 505 has three such areas Voltage, Current and Display.



VOLTAGE FUNCTIONS

The Voltage function area is located in the top left corner of the panel. This area contains the plug for the Voltage Test Cable, fuses and power ON lamp.

Voltage Test Cable

The Voltage Test Cable is supplied with the instrument. It is constructed of very flexible silicone insulated wire covered with a tight weave nylon loom for additional protection. It is 7½ feet long and is terminated with test clips on one end and a keyed plug on the other. To insert the Voltage Test Cable, line up the plug keys and twist the ring clockwise until it locks. Never install the Voltage Test Cable with it connected to the service voltage. This will cause damage to the connector pins.

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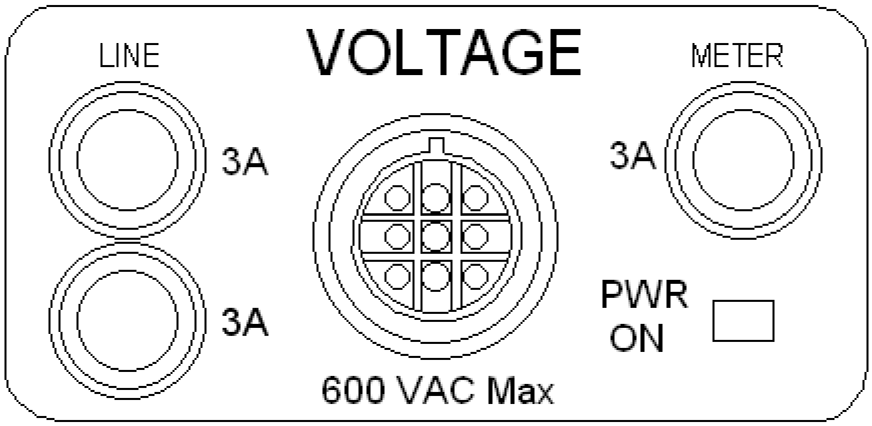
WARNING!!! CONNECT THE VOLTAGE TEST CABLE TO THE FRONT PANEL PLUG BEFORE WIRING TEST CLIPS TO THE SERVICE. FAILURE TO OBSERVE THIS REQUIREMENT WILL CAUSE PERMANENT DAMAGE TO THE CONNECTORS.



Line Fuses

The Model 505 is provided with two LINE fuses on the front panel. The fuses are 3 ampere fast blow, 3AG size. In addition to the front panel fuses, there is an internal set of fuses to protect the instrument power supply. These fuses are 1 ampere fast blow, 3AG size and are located inside the instrument on the side panel that contains the battery. Do not replace any of these fuses with any other type or size of fuse. Some early production units of the Model 505 showed 1 ampere fuse size on the panel overlay. Units showing a 1 ampere fuse requirement on the panel overlay may be replaced with a 3 ampere fast blow, 3AG size if excessive fuse blowing occurs.

Meter Fuse

The Model 505 is provided with a METER fuse on the front panel. This fuse is in series with the Voltage Test Lead with the yellow insulating boot and marked METER. The fuse is a 3 ampere fast blow, 3AG size. Do not replace this fuse with any other type or size of fuse. Some early production units of the Model 505 showed 1 ampere fuse size on the panel overlay. Units showing a 1 ampere fuse requirement on the panel overlay may be replaced with a 3 ampere fast blow, 3AG size if excessive fuse blow occurs.

Power ON

The Model 505 is provided with a power ON indicator. The red LED lamp will illuminate anytime the instrument is powered by line voltage. This lamp will be ON even if the 505 has not been turned ON using the front panel switch.

Input Voltages

The service input voltage is from 80 to 530 V (600 V is the maximum). The PT Secondary input voltage is from 10 to 135 V (140 V is the maximum). Some early production units of the Model 505 showed 0 to 600 V on the panel overlay. Units marked 0 – 600 VAC, have the same voltage ranges and maximums as stated above.

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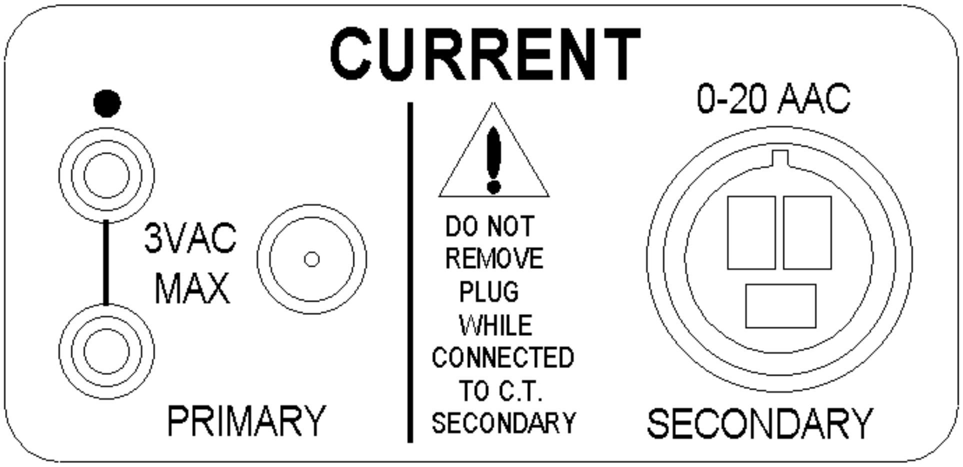
CURRENT FUNCTIONS

The Current function area is located in the top right corner of the panel. This area contains the plug for the Current Test Cable and plugs for connecting the CT clip-on probes. This area is divided into two sections, PRIMARY and SECONDARY.



Primary Current

The Model 505 is provided with two plugs for connecting CT clip-on probes to measure primary current. One set are safety banana plugs and the other a standard BNC connector. These connectors are wired in parallel. Therefore only one connector may be used at a time. Several different types of CT clip-on probes can be used with the Model 505. The mV output per ampere value of the CT clip-on probe can be programmed in the CT Ratio test mode. The maximum voltage input is 3 volts.

Secondary Current

The Model 505 is provided with one keyed plug for connecting the Current Test Cable. There are many Current Test Cable options to choose from. They are constructed of very flexible silicone insulated wire covered with a tight weave nylon loom for additional protection. They are 7½ feet long and terminated with Test Switch Safety Plugs on one end and a keyed plug on the other. To insert the Current Test Cable, line up the plug keys and twist the ring clockwise until it locks. Never install or remove the Current Test Cable with it connected to the CT secondary. This will cause a potentially lethal situation to the operator and may damage the connector pins.

WARNING!! NEVER INSTALL OR REMOVE THE CURRENT TEST CABLE WITH IT CONNECTED TO THE CT SECONDARY. THIS WILL CAUSE A POTENTIALLY LETHAL SITUATION TO THE OPERATOR AND MAY DAMAGE THE CONNECTOR PINS.

The maximum current input is 25 amperes.

DISPLAY FUNCTIONS

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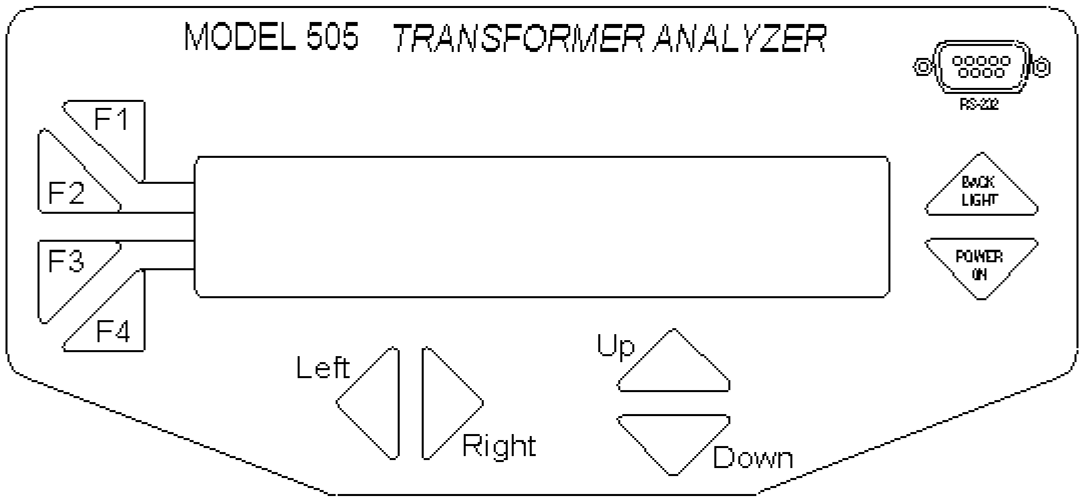
The display area of the panel occupies the bottom 2/3 of the panel. It contains the Power On, Back Light, Function, Left (◄), Right (►), Up (▲) and Down (▼) buttons together with the LED display and RS-232 output connector.



Power ON Button

The *Power ON* button is located to the right of the display and is so labeled. To turn ON the Model 505, push and hold this button for 2 seconds. The display back light will come on and the Model 505 will start “Searching for installed components” mode. When the search is complete, the back light will go OFF. If no button is pushed for 10 minutes the Model 505 is provided with a battery saver feature that automatically turns the unit OFF. Should the instrument time out before the measurements are complete, simply turn it ON and continue testing. Using the finger nail or other sharp items to push the buttons will damage the button. The button key pad is an overlay and should the buttons become damaged, the entire front panel overlay must be replaced.

Back Light Button

The *Back Light* button is located to the right of the display and is so labeled. To turn ON the display back light, push and hold this button for 1 second. The Model 505 is provided with a battery saver feature that automatically turns the back light OFF after 2 minutes of operation. Should the back light time out before the measurements are complete, simply turn it ON again and continue testing.

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Function Select Buttons

The 4 *Function Select* buttons are located on the left side of the display. When the display is ON, the selectable functions will be displayed to the right of each button. To select a function, push and hold the function button for 1 second. Never use anything except the fleshy part of the finger to push these buttons. These function buttons will be referred to as F1, F2, F3 and F4 throughout this manual.

Left and Right Buttons

The *Left* (◄) and *Right* (►) buttons are located at the bottom and left of center of the display. These buttons are used to move the programming cursor (_ or ^) to the left and right on the display. To move the cursor to the left, push the ◄ button. To move the cursor to the right, push the ► button.

Up and Down Buttons

The *Up* (▲) and *Down* (▼) buttons are located at the bottom and right of center of the display. These buttons are used to move data through the display screen. To move the data up, push the ▲ button. To move the data down, push the ▼ button.

LCD Display

The Model 505 is provided with a 4 line by 40 character LCD display which is located in the center of the display area. All instrument programming and measurement data is displayed here. The display is provided with a back light that can be turned ON by selecting the Back Light button to the right of the display. The Model 505 is provided with a battery saver feature that automatically turns the back light OFF after 2 minutes of operation. Should the back light time out before the measurements are complete, simply turn it ON again and continue testing.

RS-232 Plug

The Model 505 is provided with a RS-232 plug for downloading the saved test data via an external computer connection. This plug was not functional in early units but can be upgraded. For older units needing upgrade, contact Radian Research and request upgrade number A0505099R00. Units needing upgrading must be returned to the factory.

Report Viewer software is provided with the Model 505 for retrieving the saved data and for viewing, printing and exporting the data.

OPERATION FROM SERVICE VOLTAGE

The Model 505 may be operated from a service voltage from 80 to 530 VAC, 60 Hz. The Voltage Test Cable must be inserted in the Voltage Plug of the unit. The two wires labeled *Aux Power* are connected to the service. Either phase-to-phase or phase-to-neutral connections may be used as long as the voltage does not exceed a maximum of 600 VAC. When the *Aux Power* leads are connected to a power source, the Power ON lamp will be lit and the internal battery pack will be charging. The instrument is provided with an automatic turn OFF that occurs at about 10 minutes after the Power On button is depressed. If the Model 505 turns OFF prior to completing the test, simply restart by depressing the ON pushbutton. The Voltage Test Cable is provided with a 3 conductor connector for the *Aux Power* input. A 120VAC line cord and a service connection cable with test clips are provided for selecting field versus shop power. When operating the 505 in the shop, plug in the 120VAC line cord to a duplex wall outlet. When operating the 505 in the field, plug in the service connection cable and connect the test clips as described in the test procedure section.

OPERATION FROM INTERNAL BATTERY PACK

The Model 505 may be operated from the internal battery pack. This is most useful for field test applications. The instrument is provided with an automatic turn OFF that occurs about 10 minutes after the Power ON pushbutton is depressed. This feature prevents unnecessary battery drain.

The Model 505 is powered from eight (8) 2000 mAhr NiCad batteries assembled into pack form. The instrument has a built-in charging circuit that will charge the battery pack whenever the *Aux Power* leads are connected to the service or the 120VAC line cord is plugged into a duplex wall outlet.

The unit will operated continuously from 3 to 5 hours at full charge depending on functions in use and temperature. Because in normal operation the unit is not used in a continuous mode the batteries will last much longer. In fact, it is projected that with normal use (testing 15 minutes out of each hour or 2 hours daily) the Model 505 will require charging every two days. These are conservative estimates as the battery will be charging whenever the *Aux Power* leads are connected to the service.

NiCad batteries have a self discharging characteristic of 1% of their capacity per day even if they are not being used. Therefore, if the Model 505 batteries were fully charged but placed in storage without use, the batteries would be flat in about 3 months as a result of the self discharge characteristic.

Charging the Batteries

To charge the batteries, connect the *Aux Power* leads to a service voltage from 80 - 530 VAC, 60 Hz. or plug the 120VAC line cord into a duplex wall outlet. Internal battery will take between 10 to 18 hours to charge depending on the temperature and condition of the batteries.

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CT TESTING SAFETY

THE TEST PROCEDURES OUTLINED IN THIS SECTION ARE NOT INTENDED TO REPLACE THE TEST PROCEDURES YOUR COMPANY HAS ESTABLISHED - INSTEAD, THEY ARE INTENDED TO EMPHASIZE SAFE TESTING TECHNIQUES AND THE CORRECT APPLICATION OF THE MODEL 505. IF THE PROCEDURES GIVEN HERE DO NOT AGREE WITH YOUR COMPANY'S PROCEDURES, CHECK WITH YOUR SUPERVISOR BEFORE CONTINUING!

Testing current transformers while they are in service can be a dangerous operation if certain safety procedures are not followed. The secondary loop of a current transformer must NEVER BE OPENED when service current is present in the primary. When there is current in the primary, and the secondary of a current transformer is open circuited, the voltage across the secondary can rise to hundreds and even thousands of volts, creating an extremely dangerous situation. The open CT secondary voltage magnitude varies with CT design and primary current flow. See Table 1 below for typical open CT secondary voltages.

TABLE 1 – Typical Voltages for Open Circuit CT Secondary

Transformer Type	Current Rating	Crest Voltage at % of Primary Current			Rating Factor (RF)
		50%	100%	@RF	
Miniature Window	200:5	140	205	280	2.0
	400:5	175	280	395	2.0
Intermediate Window	200:5	140	200	420	3.0
	400:5	190	305	760	4.0
	600:5	395	540	950	2.0
	800:5	550	865	1525	2.0
Wound	5 - 600:5	1100	1500	2750	2.0

The high voltage that is present on the open secondary of an energized current transformer generates two great hazards. The first hazard is **ELECTRICAL SHOCK TO TESTING PERSONNEL**. The second hazard is **THE BREAKDOWN OF THE CURRENT TRANSFORMER INSULATION**. Both hazards can be avoided provided that the secondary of the current transformer is never opened.

The safest current transformer installations for testing are those that have a Test Switch as part of the secondary loop. A Test Switch is a device that will facilitate inserting instrumentation in the current transformer secondary loop without the danger of opening the circuit. On installations that contain Test Switches, test leads terminated with a test switch safety test probe should be used for the Model 505. This provides a "make-before-break" connection to prevent accidental opening of the current transformer secondary loop.

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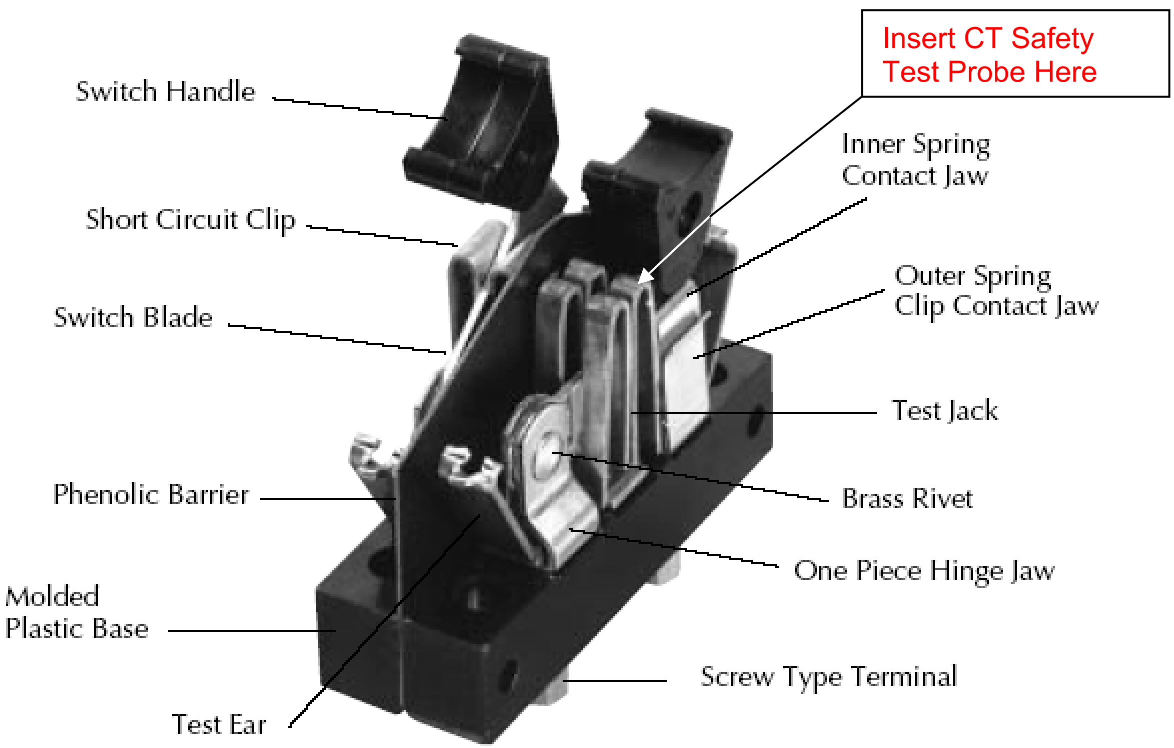
CT Safety Test Probes

This CT safety test probe is made by Superior and is ½" across. This probe fits most CT test switches but will not fit mini-CT test switches used in sub-station panels.

This CT safety test probe is made by Westinghouse and is about 3/8" across. This probe fits most CT test switches and mini-CT test switches. It is not as rugged as the Superior and is easily damaged.



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This is an example of a typical 10 pole Safety Test Switch. The 3 knife switches on the left are the voltage phases A, B and C. The 4th from the left is the neutral connection for the voltage. The 6 knife switches for the current phases A, B and C are on the right.

There are 3 sets of 2 switches each for the current phases (see above picture). The 5th switch from the left is the shunting switch which shorts the A phase (typically) CT secondary and opens the A phase current loop to the electricity meter. The 6th switch from the left is bridged by the Safety Test Probe connector. When open, the Safety Test Switch probe can be inserted in series with the CT secondary circuit. Always shunt the CT (raise switch 5 for phase A, switch 7 and 9 for B and C phase) before inserting the Safety Test Probe.

On installations that do not have a Test Switch included in the current transformer secondary loop, **THE SECONDARY TERMINALS OF THE CURRENT TRANSFORMER MUST BE SHORTED** before the loop is opened for inserting the Model 505 and once again shorted when removing the Model 505. Radian Research does not recommend the use of the Model 505 on services that do not have installed Test Switches.

In addition to using the correct equipment, appropriate safety dress such as safety glasses, insulated gloves, fire retardant pants and long sleeve shirts should be worn.

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INSTRUMENT OPERATION

The **MODEL 505 Transformer Analyzer** is designed for testing current transformers (CT) and potential transformers (PT) without interruption of the customer's service. This instrument measures CT admittance, CT ratio, CT primary-to-secondary phase angle and the voltage, current and phase angle of the service. With the *Burden CT/PT Option,* it determines the CT secondary burden capability the regulation of the PT and its secondary burden capability and provides for CT core demagnetization.

The Model 505 should be used with CT secondary test leads terminated in a test switch safety probe which is easily and safely inserted into the CT secondary loop via the test switch safety plug in the test switch. If installations are to be tested that are not fitted with test switches, **extreme care must be exercised when inserting the Model 505 in the CT secondary loop not to open the CT secondary**. Opening the CT secondary loop can result in extremely high voltage levels which can cause harm to the CT, devices in the CT secondary loop, the Model 505, and most importantly the operating personnel. See Table 1 above for typical voltage magnitudes of open CT secondary.

> WARNING!! DO NOT OPEN THE CT SECONDARY LOOP!
> OPENING THE CT SECONDARY MAY CAUSE DAMAGE TO
> THE MODEL 505 AND/OR OPERATING PERSONNEL.

The Model 505 consists of four different test methods conveniently packaged so that only one test hook-up need be made to use any device.

One test method measures the admittance of the CT secondary loop and can be used with or without service current flowing in the CT secondary loop. Another test method (optional) uses the burden support capability of the CT secondary loop as a measure for evaluating the CT's performance. This test method requires service current of at least 0.1 amperes to be flowing in the CT secondary loop. Another test method uses the primary to secondary ratio of the CT as a measure for evaluating the CT's performance. This test method requires service current flowing in the CT secondary loop of at least 0.1 amperes. The last test method (optional) addresses the PT in the metering service. This test method uses the burden support capability of the PT secondary as a measure for evaluating the PT's performance. Each of these methods is discussed in detail in the following pages.

CONNECTING THE MODEL 505 TO THE SERVICE

Connection to Services having test switches –

The safety procedures discussed in TESTING SAFETY should be followed when performing tests. If the connection is in a substation or switch yard, refer to the Appendix topic 'Protection of Electronic Equipment used in Substation Yards for Testing'.

1. Install the plug of the Test Voltage Cable into the front panel plug of the Model 505.

2. Position all of the current by-pass knife switches in the by-pass position and open all but the neutral voltage knife switches of the test switch.

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3. Connect the wire with the Green Insulation Boot marked ***Earth Ground*** to the earth ground of the service. When using the line cord, the ground pin of the line cord is connected to the earth ground wire.

4. Connect the two wires labeled ***Aux Power*** to the service voltage not to exceed 600 VAC. Make these connections on the service side of the test switch. The Power ON lamp will illuminate when this connection is made, the display is still OFF. If the connection is in a substation or switch yard, refer to the Appendix topic 'Protection of Electronic Equipment Used In Substation Yards For Testing'.

5. Connect the wire with the Red Insulation Boot marked ***Voltage ±*** to the polarity (HOT) side of the 'A phase' voltage. Make this connection on the service side of the test switch.

6. Connect the wire with the Black Insulation Boot marked ***Voltage*** to the return side of the 'A phase' voltage. Make this connection on the service side of the test switch.

7. Connect the wire with the Yellow Insulation Boot marked ***Meter*** to the polarity (HOT) side of the 'A phase' voltage coil of the meter. Make this connection on the meter side of the test switch.

   WARNING!! DO NOT CONNECT THE WIRE WITH THE YELLOW INSULATED BOOT MARKED *METER* TO THE SERVICE NEUTRAL. A SHORT WILL OCCUR WHEN THE PT BURDEN TEST IS PERFORMED WHICH WILL BLOW THE PANEL METER FUSE AND MAY DAMAGE THE INTERNAL RELAY.

   IF THIS WIRE IS NOT CONNECTED, THE 'METER ON/OFF' SELECTION MUST BE SET TO 'METER OFF'. REFER TO TOPIC PT BURDEN TESTING FOR INFORMATION ON HOW TO SET THE 'METER OFF'.

8. Install the plug of the Current Test Cable into the front panel plug of the Model 505.

9. Plug the Safety Test Switch Probe into the 'A phase' current safety plug jack with the red side toward the meter side of the test switch.

10. Connect the primary current clip-on CT probe to the correct plugs on the 505 front panel. (The probe should be calibrated to the 505 circuits for maximum accuracy)

11. Clip the CT probe around the primary wires for the 'A phase' CT. Be sure clip-on is attached in the right orientation to establish the correct polarity.

12. The 505 is now ready to test 'A phase' CT and PT and measure voltage, current and phase angle. When test are complete, save the data – see test instructions.

13. Repeat steps 5, 6, 7, 9 and 11 for testing 'B phase' and 'C phase'.

14. When tests are complete, turn the 505 OFF with the front panel switch. Disconnect the ***Voltage ±***, ***Voltage*** and ***Meter*** wires followed by the ***Aux Power***. Next unplug the Test Switch Safety Probe and finally remove the ***Earth Ground***.

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15. When all the test cables are removed from the Test Switch, restore the Test Switch knife switches to the service position, install the cover and seal.

WARNING!! DO NOT OPEN THE CT SECONDARY LOOP! OPENING THE CT SECONDARY MAY CAUSE DAMAGE TO THE MODEL 505 AND/OR ELECTRICAL SHOCK TO OPERATING PERSONNEL.

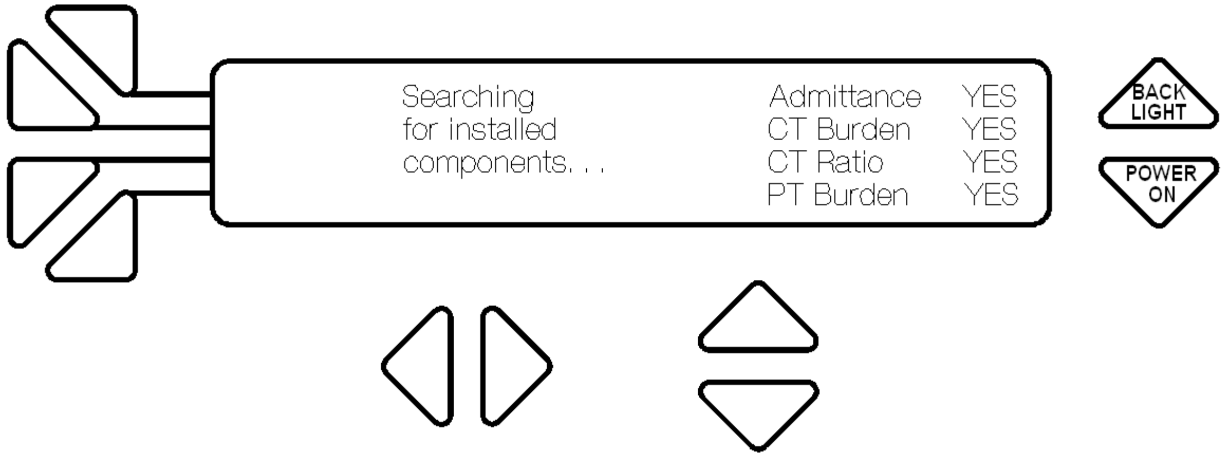
Connecting to Services without Test Switches –

Radian Research does not recommend the use of the Model 505 or any other CT testing device or phase angle meter on a socket base service that does not have Test Switches without the use of a *Safety Test Fixture*. If the meter is the bottom connected type and is wired direct to the service, a Test Switch must be installed for testing.

Turning ON the Model 505 –

After the test cables are connected as outlined previously, the Model 505 is ready to test. Turn ON the instrument by press and holding the ***Power ON*** button for 2 seconds. Never use anything except the fleshy part of the finger to push this button. Using the finger nail or other sharp items to push the button will damage the button. The button key pad is an overlay and should the buttons become damaged, the entire front panel overlay must be replaced.

The Model 505 is programmed to search for the testing components when it first turns ON. The following screen will be displayed at turn ON.



The back light also comes ON during the search. This display indicates that the instrument has the CT/PT Burden Option installed. NO would appear where the YES is now if this option was not installed. This display times out and the following screen is displayed.

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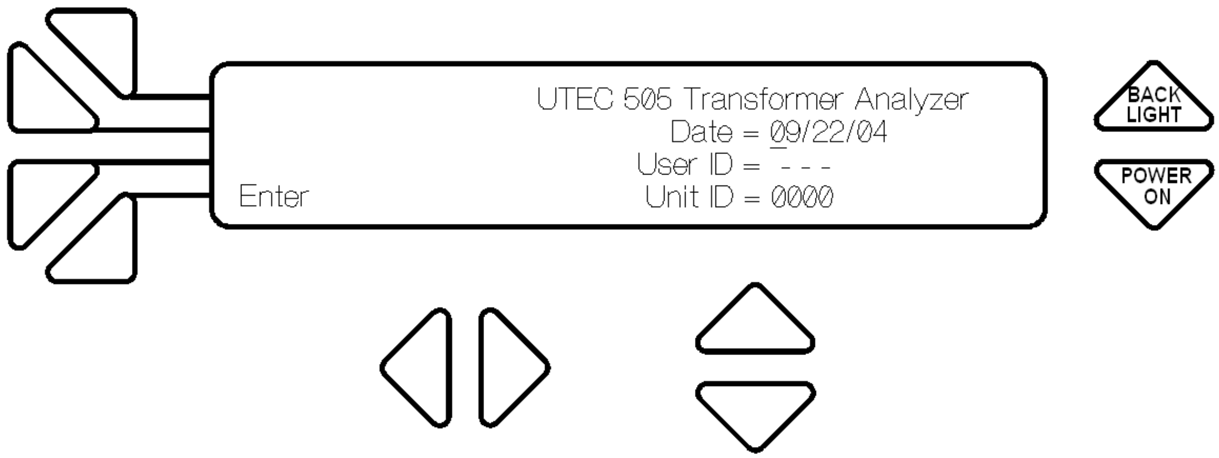
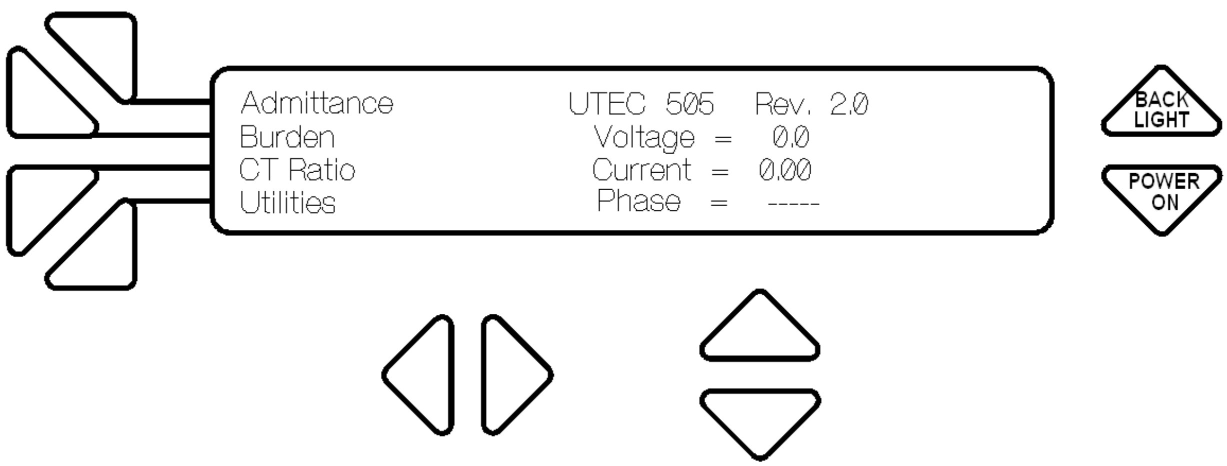


Enter the date using the ◄ ► buttons to move the cursor and the ▲▼ buttons to scroll through the characters. Pushing the ▲ button once will move the number from 0 to 1. Holding down the ▲ button will automatically run the number up to 9 – release the button when the desired number is attained. When the correct character is displayed, move to the next position and repeat the scroll. When the date is entered, select *Enter* by selecting the F4 button and the following screen will display.



SERVICE PARAMETER TESTING

From the Main Menu, the existing voltage, current and phase angle can be observed for the 'voltage and current phase' to which the 505 is connected. The phase angle shown is between the voltage and current being measured and reads directly in degrees. The 0° reference is the +X axis line of quadrant 1 and the rotation is counter-clockwise (CCW).

Service parameters cannot be tested if operated only on battery power, as the Test Voltage cable will not be installed and connected to the service.

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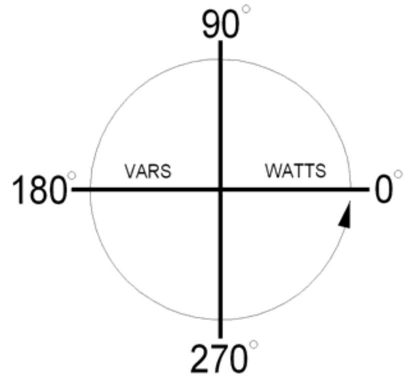
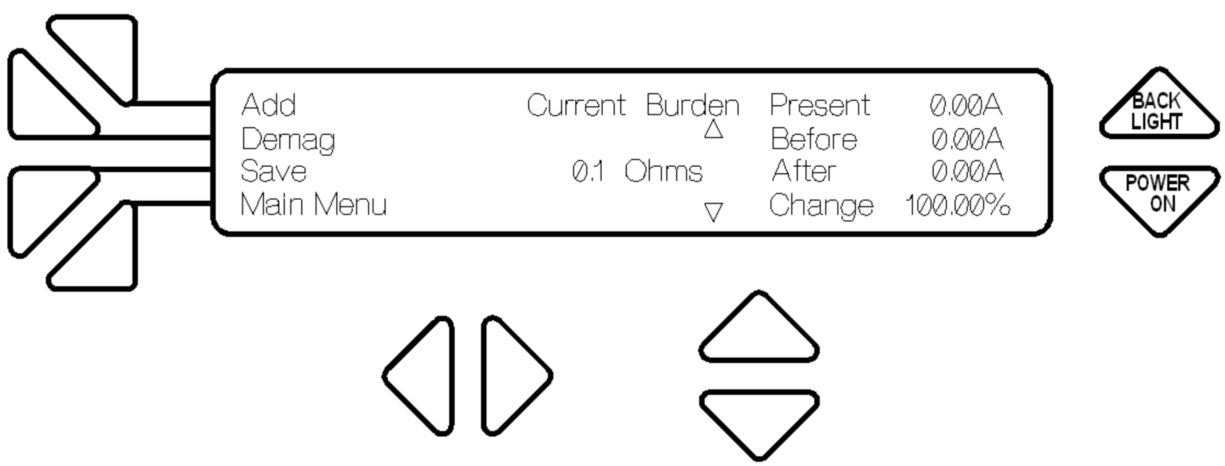


CT Demagnetization

CT's should be demagnetized after testing whenever possible. This can be done easily if the CT has sufficient current in the secondary loop by using the Demag function that is available from the CT Burden screen. This function applies a series of resistances in a smooth fashion from 0.1 ohm to 8 ohms and back down to 0.1 ohm again to the CT secondary loop. This high applied burden should drive the CT into saturation and demagnetize the core. To be most effective enough secondary current must be present to cause a significant (65% – 75%) reduction of current in the secondary loop as burden is added. For safety reasons the 505 is limited to a maximum burden of 8 ohms. This maximum resistance and the available secondary current define the limit the 505 has for this function. Use the CT burden test with 8 ohms to verify that a significant secondary current drop occurs to determine if this function will be effective. Operating the Demag function with insufficient secondary current will not be detrimental to the CT, but will have limited results. **Extreme care should be exercised when demagnetizing CT cores as the voltage developed across the CT terminals will approach and may reach the secondary terminal voltage.** See Table 1 in the section on CT Testing Safety for typical voltage values.

To demagnetize a CT, choose ***Burden*** from the main screen by selecting the F2 function button to its left. Choose ***CT Burden*** from the next screen by selecting F1, and the following screen will display.



From this screen choose ***Demag*** by selecting the F2 button and the automatic demagnetization sequence will begin. A sequence of relay clicks about every second for about 7 seconds will be heard during the demag cycle and the following screen will be displayed.

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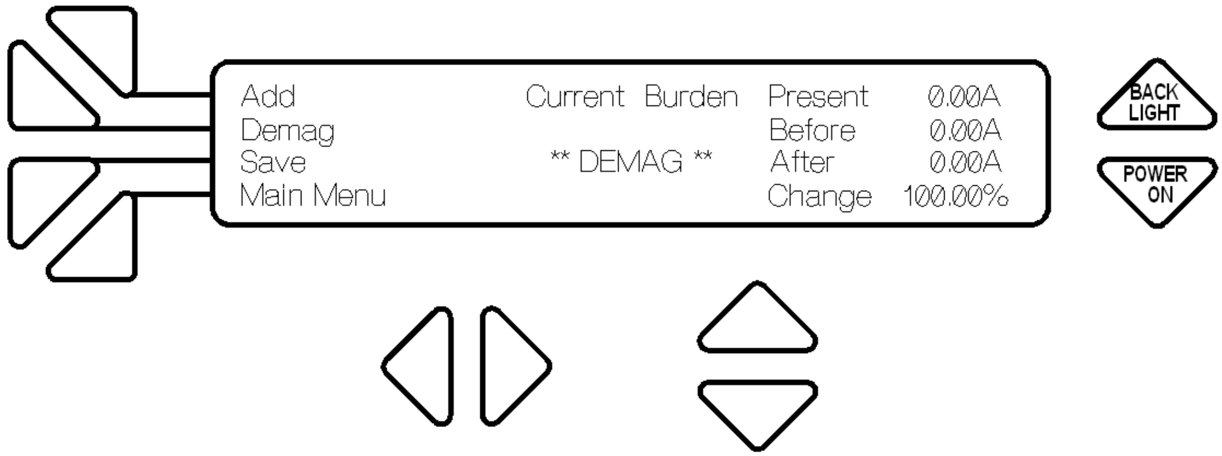

When the sequence is complete, return to the ***Main Menu*** by selecting F4.

ADMITTANCE TESTING

Measurement Principle

The Model 505 Transformer Analyzer checks for abnormal admittance by injecting an Audio Frequency (AF) into the secondary line of the in service CT, and determines the circuit admittance. Any AF signal between 1 kHz and 2 kHz would probably be satisfactory. The Model 505 uses an AF of 1575Hz to avoid the probability of any multiple harmonic of 50 or 60Hz being present in the system, and possibly causing a false signal in the AF detecting circuitry.

Metering accuracy current transformers have very small errors (less than 0.3%) when operated within the specified current and burden ratings. Therefore, it is known that the circuit admittance of any particular CT installation is very nearly constant throughout the normal operating range, unless a fault condition develops. If the admittance measurement shows a deviation from normal while in service, it is likely that the CT will have: (1) an internal short (usually a shorted turn); (2) an abnormal internal or external resistance (such as a high resistance joint); or (3) possibly the CT is operating under abnormal conditions (such as D.C. in the primary). Serious faults are immediately obvious due to an abnormally high admittance reading, normally at least 1.5 times the normal reading. CTs with a wrong ratio, such as wired to the wrong tap, will have readings substantially different than normal readings.

The best way to establish the "normal" reading is to record measurements taken during installation and at subsequent test intervals. Admittance values depend on core design, burden rating, ratio, rating factor, etc., but changes due to non-fault conditions (such as temperature, operating point, etc.) are small in comparison to the change caused by fault conditions. If measurements were not taken during installing, because service CTs are usually tested in groups, a high admittance reading obtained on one CT in the group strongly implies that a fault condition does exist. If all readings in the group are high, it could be caused by a capacitive load on both sides of the CT, high system noise, or the presence of a D.C. signal in the primary circuit.

Theoretical Considerations

Errors of a CT are readily defined in terms of circuit parameters by reference to an equivalent circuit for a simplified CT having a 1:1 turns ratio. In the simple case under consideration, CT

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errors are proportional to the total secondary resistance and to the relevant component of the magnetizing admittance.

In the case of modern metering CTs of interest, the conductance changes with current to a minor degree only, hence, as a first approximation it may be assumed to be constant. A change in the errors after installation may be caused by any of the following factors:

1) Appearance of a fault admittance caused either by an internal fault, usually short-circuited turns or a shunt that has not been opened, or by a less likely external fault, e.g. leakage across CT terminals.
2) Abnormal change in the secondary circuit resistance, e.g. due to a high resistance joint. A change in conductance will take place when the CT is forced to operate at a secondary voltage exceeding the knee voltage.
3) Change in magnetizing admittance due to the CT operating under abnormal conditions, e.g. in the presence of a DC component in the primary current.

The metering manuals prescribe in-situ testing by the "added burden" method, based on producing an increase in current error when secondary burden is increased by additional resistance selected to ensure operation below the knee voltage in case of a sound CT. The resultant change in current error in the case of a fault CT will exceed the expected change if the CT operates above the knee voltage. This method is insensitive and difficult to use in the case of fluctuating loads, since the change in error is monitored as a reduction in the secondary current. It may be expected that only large errors (probably exceeding 2%) will be positively identified.

Certain improvements in the above method are possible and have been tried, but the sensitivity achieved falls far short of that considered necessary to detect the presence of a fault in a class 0.5 metering CT, in an incipient stage, before it develops into a more serious condition. It is based on the experimentally established principle that the magnetizing admittance of a sound CT, measured at a frequency substantially higher than the working frequency (50 or 60 Hz), is directly related to the 50 or 60 Hz conductance. (The Model 505 must be calibrated to measure either 50 or 60 Hz. One Model 505 cannot measure accurately both working frequencies. The same applies to the CT probes used with the Model 505).

Consequently, admittance measured using a test frequency signal superimposed onto the 50 or 60 Hz working current can be used to judge the condition of a CT, i.e. the change in its current error, if any.

To get the transformer action of the CT to begin to operate, a small amount of magnetizing current, $\mathbf{I_M}$, is needed. With this small current flow $\mathbf{I_M}$ there is associated a corresponding voltage $\mathbf{E_M}$. The 'magnetizing admittance' is the ratio of $\mathbf{I_M / E_M}$; correspondingly, the 'magnetizing impedance' is the ratio of $\mathbf{E_M / I_M}$. The power necessary to energize the core of a CT with its connected burdens so that the core is dynamic and ready for primary to secondary transfer is the product $\mathbf{I_M \times E_M}$.

The Model 505 measures the admittance presented to the test leads. This impedance value includes the following:

Impedance of all meters and instruments in the CT secondary circuit.
Impedance of the secondary wiring (both phase and common).
Impedance of the test switch connections.
Impedance of all terminal block connections.
Magnetizing admittance of the CT.

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Impedance of the power system on the primary side of the CT as reflected to the secondary side of the CT by the turns ratio squared.
The impedance of any parallel paths if the CT secondary circuit is improperly grounded at more than one point.

Though impedance and admittance are both mentioned in the above list, the Model 505 measures and displays the admittance of all of the quantities.

The impedance of the power system on the primary side of the CT is very low. When this impedance is reflected to the secondary side of the CT by the turns ratio squared it becomes an even lower number. The power system admittance (inverse of the impedance) is thus very, very high when viewed from the CT secondary circuit.

When reflected to the secondary side of the CT the admittance of the power system is in series with the magnetizing admittance of the CT and hence in series with all the admittances of the CT secondary circuit.

The combined admittance of the series is the product of the two admittances divided by the sum of the two admittances. As a result the overall admittance of a series of admittances is thus no greater than the smallest admittance in the string. For CT circuits the magnetizing admittance of the CT is supposed to be the smallest admittance of the string and will thus substantially determine the overall admittance of the circuit being measured. The power system admittance is very, very high when viewed from the secondary side and so the admittance of the power system essentially falls out of the measurement and not affect the measurement of the Model 505.

The Model 505 measures the admittance of all loops that result from an improper multiple grounding of the CT secondary circuit and this will affect the reading and can render the reading useless, even misleading.

CT and PT secondary circuits must be grounded at one point, and they should not be grounded at more than one point. A multiple grounded CT secondary circuit presents problems:
Metering accuracy (registration) can be changed;
Metering equipment can be damaged by stray currents; and,
Admittance testing is compromised.

If the CT secondary circuit is grounded at more than one point then the admittance measured by the Model 505 includes the admittances of the various parallel paths. The admittances of these parallel paths may change from time to time (summer, fall, winter, spring; damp, dry, frozen, wet, etc.). Thus the multiple grounds can result in a misleading reading. To eliminate this problem check the CT circuit for multiple grounds and remove all but one of the ground connections before performing admittance tests.

When examining the CT secondary circuit for multiple grounds look for both intentional (purposefully installed) and inadvertent (accidental, loose wire, something touching the CT secondary circuit, etc.) grounds.

SAFETY NOTE: The CT secondary circuit must remain grounded at one point at all times, else, by leakage current and by winding to winding capacitance in the CTs the secondary circuit will acquire a charge and drift up in voltage toward the primary voltage. At some voltage level it may flash over to ground.

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Sensitivity

The sensitivity of the instrument is sufficient to detect a 0.1% change in current error; the corresponding change in instrument reading may be expected to exceed 20% of the relevant range value.

Operation of the Model 505 is extremely simple: after connections to the metering test switch have been made, the CT secondary loop admittance values are read from the LCD display.

Technical Description

Circuit Arrangement –

The circuit consists of a pair of coupling transformers, an audio frequency source feeding the injection circuit and providing reference frequency for the phase-locked loop, an audio frequency detection circuit switched to read either the injection voltage or the resultant current.

The tuned injection transformer and the inductive shunt are wound as identical transformers on ferrite cores. The secondary winding of the injection transformer and the primary winding to the shunt carry the 50 or 60 Hz CT loop current as well as the much smaller audio frequency injection currents. Both transformers are therefore designed to work on the linear portion of their magnetizing characteristic up the highest allowable 50 or 60 Hz current. Furthermore, the transformer is tuned only as close to the resonance as is needed to give reasonably efficient coupling to the CT under test and to produce a visibly satisfactory sine wave output from the near square wave supplied by the power amplifier.

Test Criteria –

The Admittance Test method is most valuable when the past history of the CT under test is known, i.e. the normal audio frequency admittance value has been recorded previously (before installation, during initial tests and during subsequent checks). In such situations the CT is considered to pass the test when the measured admittance does not exceed the previous established value by more than 50% + 0.6 mS.

If no previous data is available, the difference between the measured value and the average value displayed on the LCD should not exceed the fault admittance given. The above tolerances may appear to be large, but it should be remembered that possible variations in Magnetizing Admittance due to a number of factors discussed previously must be absorbed. Furthermore, the risk of removing a sound CT from service on suspicion of a minor fault is not justified. The minimum, average and maximum admittance values collected historically are displayed on the LCD display. Each user should establish these values based on the actual installations encountered in their own distribution system. Since the Model 505 measures a combination of primary and secondary admittance, deviations from the recorded data should be expected as a result in variations of installation procedure, wire sizes and run lengths, and equipment in the secondary loop. When the measured admittance exceeds the expected limits either the CT under test is faulty or an apparent fault situation exists.

As the CT's are tested in polyphase groups of either 3 or 2, a high admittance reading obtained for one CT in a group implies strongly an actual fault condition, where as high readings in all phases may be caused by an apparent fault condition.

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Apparent Fault Conditions–

Various fault conditions that may create the appearance of a fault, i.e. high admittance reading despite soundness of CT. Examples of such conditions are as follows.

1. A condition of high reflected admittance arises only when a capacitive load is present on both sides of the CT under test - an infrequent condition, easily recognized from the known system data. In a typical case a capacitive bank at the substation, used for power factor improvement of an industrial customer, created a capacitive load for the CT of another customer with predominantly fluorescent lighting load.

2. A condition of high system noise, i.e. presence of harmonics close to the injection test frequency, has become more prevalent during the last decade due to the increase of electronically controlled loads.

3. An apparent fault due to the presence of a DC component in practical installations. However, in view of the ever increasing distribution pollution, the possibility of such a situation occurring is very likely. When the presence of DC is suspected it can be verified by means of a special clip-on ammeter capable of measuring small amounts of DC in the presence of large AC components.

4. A special case of an apparent fault condition occurs when a multi-ratio CT has been connected on an incorrect ratio. Should this happen, the admittance measured will prove the "fault" readily, as the admittance changes by a factor exceeding 2.

Actual Faults –

Faults due to the appearance of a shunt admittance, particularly those caused by internal breakdown, are by far the most common. In the majority of cases recorded the resultant error was large, from -5% to -80%. Actual location of such fully developed internal faults can be pinpointed by investigation of the hot spot created - this technique has been used successfully on a number of occasions.

However, in several cases the fault was of an intermittent nature, caused by external pressure on the CT body, and of much lower magnitude. The most interesting case was a switchgear H.V. CT found to have measured admittance of 20 mS, equivalent to a current error of -0.3%. The fault admittance was increasing slowly, reaching 36 mS some 8 months later when the installation was shut down and the CT replaced. A fault caused by external shunt admittance was found in a 22 kV CT in which the spark-over device developed sufficient leakage to cause a change in current error of nearly -5%.

The more important case of a fault caused by high series resistance due to a bad joint (internal or external) is usually readily detected, because such faults deteriorate to a degree sufficient to cause operation above the knee voltage; a complete failure due to burnout may follow. A typical fault of this nature caused intermittent CT operation, up to the extreme of open-circuit (measured admittance = 0). Inspection after removal traced the fault to an unsoldered joint at the secondary winding termination.

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Affects of CTs With Wound Primaries -

Because of the transformer action of the CT, the impedance (admittance) of the primary circuit appears in series with impedance (admittance) of the secondary circuit. The primary impedance is reflected to the secondary by the square of the turns ratio. If the turns ratio is 100:1, 1/10,000th of the primary impedance would be reflected to the secondary.

The Model 505 was designed for use on window and bar type CTs, that is, CTs with 1 turn primaries. In this configuration,

> the impedance of the primary winding of the CT as seen from the secondary circuit is small (only one turn); that is,
> the admittance contribution of the primary winding of the CT as seen from the secondary circuit is low (this because of the square of the turns ratio transfer);
> the total admittance then is essentially determined by the secondary admittance value; and so,
> the admittance that the Model 505 measures is essentially the ‘magnetizing admittance’ of the secondary circuit.

When the CT has a wound primary, that is, the CT has multiple turns on the primary,

> the impedance of the primary winding of the CT as seen from the secondary circuit is higher than for the ‘one turn’ case above; that is,
> the admittance contribution of the primary winding of the CT as seen from the secondary circuit is high (this because of the square of the turns ratio transfer);
> the total admittance is the sum of the primary and secondary admittance contributions; and so,
> the total impedance that the Model 505 measures is high, therefore, the admittance is very low, which is near or effectively zero milli-Siemens.

When testing CTs with multiple turns on the primary, expect to see the admittance value on the Model 505 at near zero. However, if the CT has shorted turns then the Model 505 will display a non zero admittance value, which is an indication that the CT is suspect. This is due to the primary winding impedance, not so much the power system impedance.

CTs with multiple turns on the primary can be better admittance tested if the primary is opened, that is, one terminal of the primary of the CT is disconnected from the power system. In this configuration there is no transformer action between the primary and the secondary of the CT and so the impedance (admittance) of the CT is not reflected into the secondary circuit. Note that in this configuration the primary of the CT is opened, which is okay, yet the secondary of the CT remains shorted through the CT secondary circuit.

Even though the primary is open, the admittance may still be zero or very near to zero. The admittance that the Model 505 is measuring is the magnetizing admittance of the CT core. This magnetizing requirement remains almost constant with or without a primary connected. The open primary impedance will not be a factor in the admittance readings.

Concerning the impedance of the power system (the combined impedance of the power system and the customer’s load):

> The impedance of the power system on the primary side of the CT is small; and so,
> the power system impedance as seen from the CT secondary circuit is even smaller (reduced by the turns ratio squared); that is,

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the admittance contribution of the power system as seen from the CT secondary circuit is very high;
the total admittance is essentially determined by the lowest admittance value; and so,
the admittance that the Model 505 measures is essentially the magnetizing admittance of the secondary circuit.

The admittance measured by the Model 505 is a value associated with the magnetizing admittance requirements of the core of the CT influenced by the connected burdens and impedances of the primary and secondary of the CT. The Model 505 is not effectively measuring the power systems admittance, for the reasons cited. It is actually the impedance of the primary CT winding that most influences the admittance reading of the Model 505, although the power system impedance influences this to some small degree

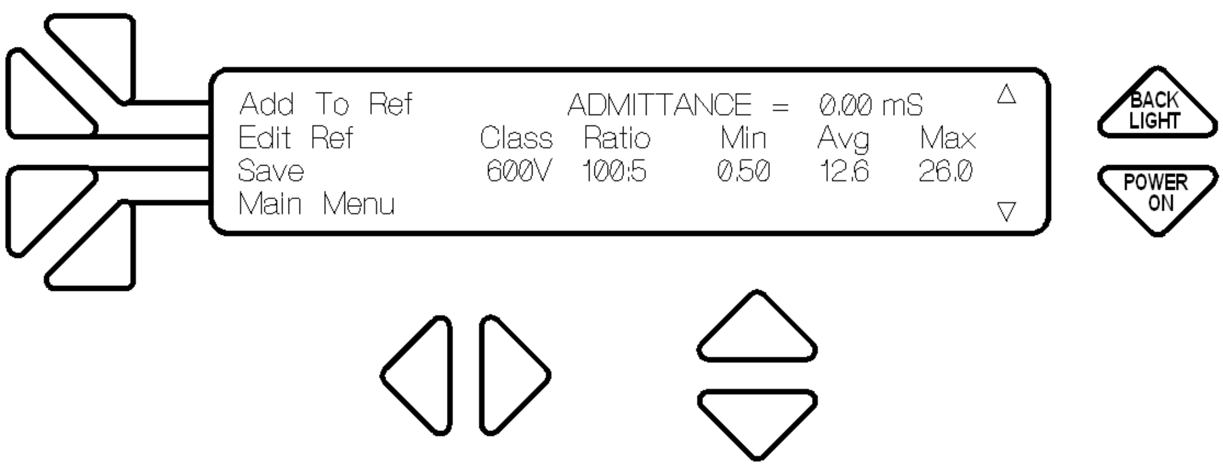
Harmonics Affects On Admittance Testing -

Be alert for the presence of excessive harmonics in the CT secondary circuit that come from the primary side of the CT. Such harmonics may cause erratic, alternating, or misleading admittance readings.

Generally, if you average the highest and lowest admittance readings, the result will be the true admittance value of the CT. Record the lowest and highest values if alternating readings are present. Also record the frequency of the change of readings there maybe harmonics present causing the alternating readings. This frequency of the data display is a function of the sample rate of the Model 505, but the change between successive reading pairs (high and low) would indicate if the data is in a drift or alternating mode.

Admittance Test Procedure

After the test cables are connected as outlined previously, the 505 turned ON and the CT demagnetized following the procedure outlined in the topic CT Demagnetization, choose ***Admittance*** by depressing the F1 function button to its left in the main screen. The following screen will be displayed.



Using the ◄ ► and ▲▼ buttons, select the Class and Ratio of CT transformer to be tested. The Minimum, Average and Maximum Admittance values for this Class and Ratio of CT will be displayed together with the current Admittance reading. The Minimum, Average and Maximum Admittance values are historical average values based on past measurements for this Class

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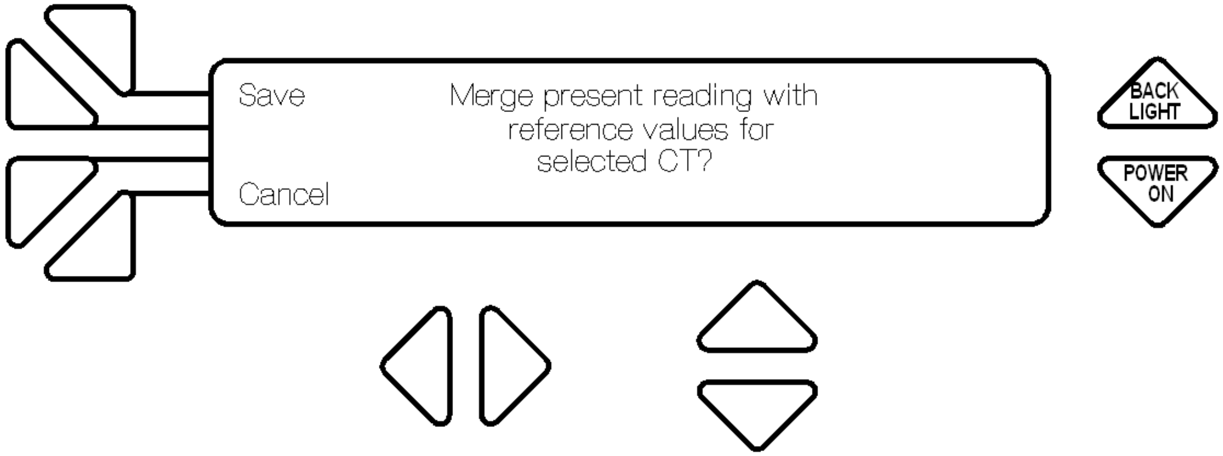
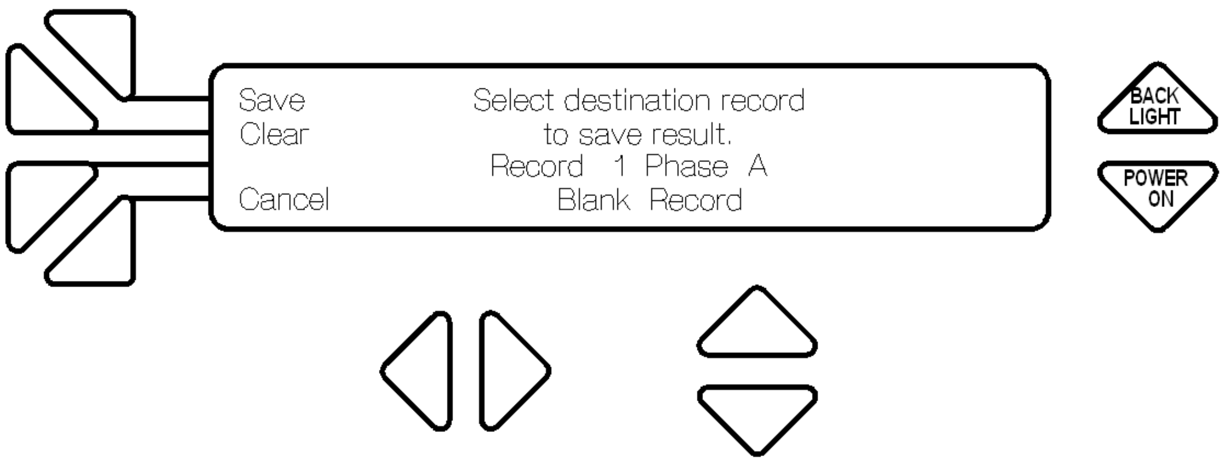
and Ratio of CT. If you want to include the current admittance reading with the other previous readings, push F1 button to select ***Add To Ref***. The following screen will be displayed.



Push F1 button to ***Save*** the admittance reading or F4 to ***Cancel*** the save. The 505 will save the last 9999 readings and present the lowest reading for the Minimum, the average of all values for the Average and highest reading for the Maximum. These values are presented for the user to make better decisions about the current admittance reading. When the reading is saved, the display reverts back to the admittance display.

To save the admittance data to a record, push F1 button to ***Save*** and the following screen will be displayed.



The screen is advising that the admittance test result will be saved to Record 1 Phase A and the name of the record is 'Blank Record'. See the section Utilities, to learn how to set up and view records. If Record 1 Phase A is not the right record, use the ▲▼ buttons to select Record 1 Phase B, Record 1 Phase C, Record 2 Phase A, etc. If data already exist in Record 1 Phase A and it is desired to enter the new data, push the F2 button to ***Clear*** the record followed by F1 button to ***Save*** the new data.

Move the current test switch probe to the next current phase and repeat the process choosing Record 1 Phase B and C to save the test data. When all phases have been tested, press F4 to return to the ***Main Menu***.

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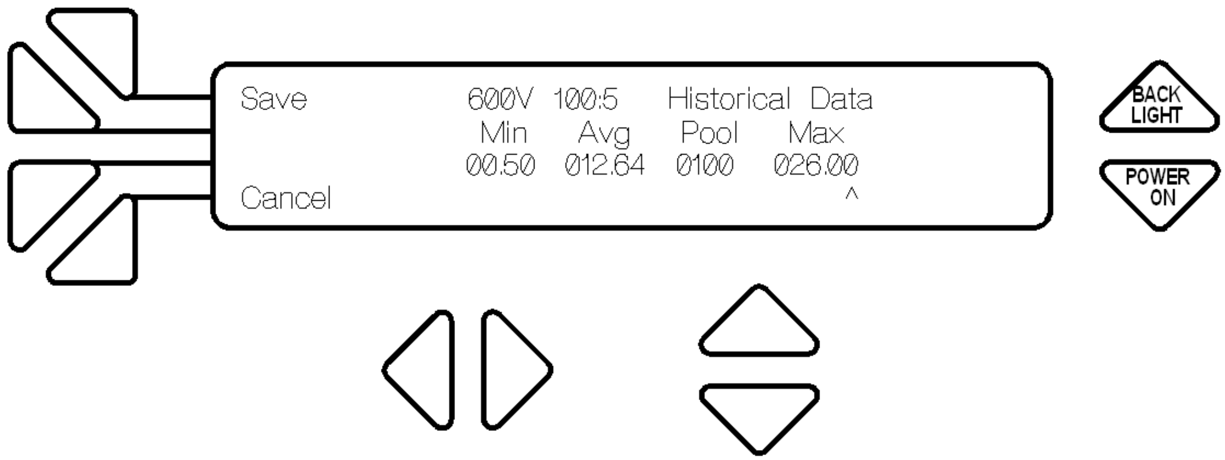
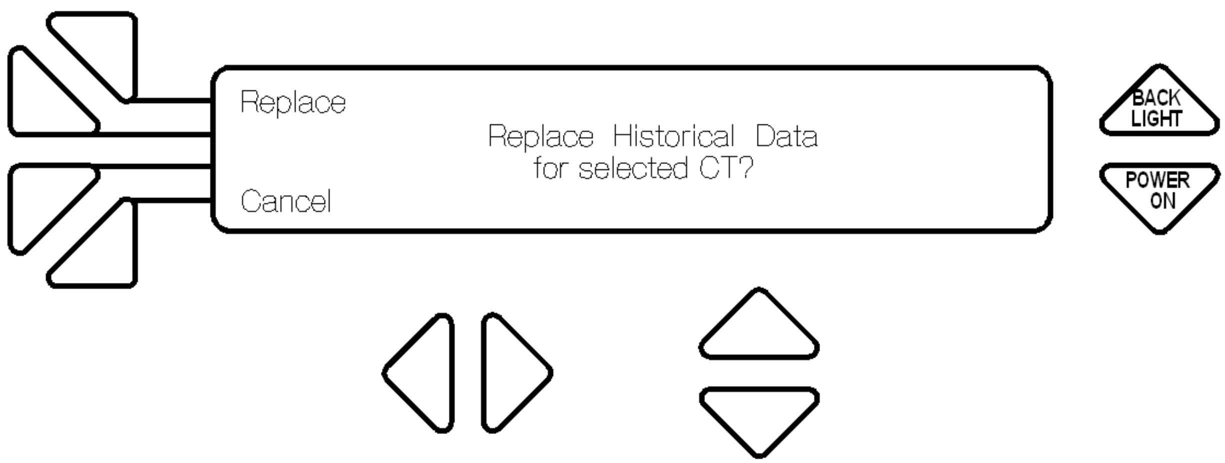
Editing Historical Data –

The historical admittance data may be edited. To edit push F2 from the admittance display above and select ***Edit Ref***. The following display will present the Minimum, Average, Pool, and Maximum data for editing. Editing is performed using the ◄ ► buttons to position the cursor (^) under the number to be edited and then using the ▲▼ buttons to select the number. Press the ▲ button once will move the number from 0 to 1. Holding down the ▲ button will automatically run the number up to 9 – release the button when the desired number is attained. The Pool number is the number of records that have been saved. In the sample display to follow, there have been 100 records saved to date. This is the default value set in the Initiation of the Admittance tables.



When editing is complete push F1 to ***Save*** and the following screen will display.



Push F1 to ***Replace*** (Save) the historical data with the edited values or ***Cancel*** (F4) to abort the edited values and keep the historical data.

As the Pool value approaches 9999 records, a message will be displayed indicating that the memory is about full for that class and ratio of CT. When this message appears, select ***Edit Ref*** and change the Pool value only to read 2000. The Minimum, Average and Maximum values should not be edited. Since the Minimum, Average and Maximum values are the historical result of 9,999 data points, setting the value to 2000 will let the collection of data continue with the next added data point affecting the historical value by only 1/2000.

CT BURDEN TESTING

Measurement Principle –

Current transformers are designed to supply a known current, dictated by the turns ratio, into a known burden and maintain a stated accuracy. The principle of a CT Burden Tester is to challenge the capability of the CT to deliver a current into a known burden.

Theoretical Considerations –

The challenge is presented in the form of a known ohmic resistance value that is added in series with the CT secondary loop. The total burden of the CT secondary loop is made up of the watthour meter current coils, the mounting device, test switch, connection resistances, and the length and size of the loop wiring. Therefore, each CT has a secondary burden when installed in a metering circuit. Assuming that the meter engineer has properly sized the CT to match the loop burden, the CT will provide metering currents according to its accuracy class rating. Should additional burden be added that exceeds the design burden capability of the CT, the transformer will not be able to supply the same level of current to the increased burden and the net result is a drop in CT secondary loop current.

The amount of this current drop is dependent on a number of factors and is not absolutely definable. The operating current level of the CT secondary loop is a major factor. CT's operating at very low currents can support several times the burden rating because at low currents the flux density of the core is very low leaving a lot of head room for additional flux before saturation. Therefore, performing burden test at very low CT secondary loop current levels is not very accurate or conclusive. The Model 505 will operate at very low current levels (0.1A) but caution should be used in the interpretation of the test results at these low currents. The most accurate and revealing burden tests are performed at the full rated secondary current. At the upper end of the current range, additional burden quickly pushes the CT out of its operating range and causes dramatic drops in output current.

Another factor affecting the CT burden capability is the 'Rating Factor'. Transformers with high rating factors can support additional burden than that given on the name plate for the nominal 5 ampere rating. Therefore, the same interpretative caution as with low secondary currents must be exercised in these cases.

It can readily be seen that it would be impossible to provide a chart of test expectations for CT's because of all the variables affecting the test. Therefore, it is left to the user to determine acceptable test levels relative to the specific application, selection of CT, and circuit designs of the utility.

Technical Description –

The Model 505 provides two methods of performing the burden test. The first method allows the user to add a selected burden to the CT secondary and observe the Present, Before Burden, After Burden currents together with the Percent (%) of change between Before and After Burden currents.

The second method allows the user to add a complete sequence of burdens to the CT secondary. The sequence consists of 0.1, 0.2, 0.5, 1, 2, 4 and 8 ohms automatically applied for

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1 second. The display provides for the recall of test values for each burden by pressing the ▲▼ buttons.

Highest Test Burden For CTs -

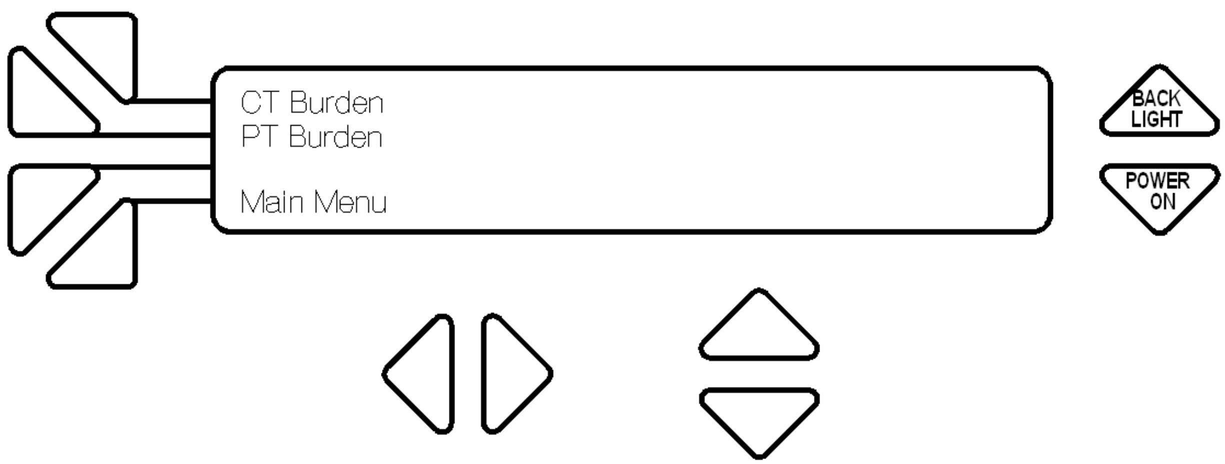
It is suggested when burden testing CTs, that the highest burden placed on the CT be one step larger than the rating for the CT being tested times the rating factor. For example, if the maximum burden capability of the CT is 0.5 Ohms, and the rating factor = 1 then the largest burden to be placed on the CT during testing would be 1 Ohm (0.5 x 1 = 0.5) Next highest burden value is 1 ohm).

Placing too large a burden on the CT could saturate the CT. Subsequent testing may give misleading results, unless the CT is demagnetized before the next test.

Long term accuracy of the CT is probably not affected by any minor magnetization of the CT since normal load and system voltage changes will most likely demagnetize the CT over time. If the CT core magnetization is the result of a direct or nearby lighting hit, the residual magnetism will most likely not be demagnetized through normal use and will require demagnetization using one of the approved methods. Approved methods include using the demagnetization feature of the Model 505, and the demagnetization methods described in the <u>Handbook For Electricity Metering</u>.

Test Procedure – Single Burden Value –

After the test cables are connected as outlined previously choose ***Burden*** by depressing the F2 function button to its left in the Main Menu. The following screen will be displayed.



Push F1 to select ***CT Burden*** and the following screen will display.

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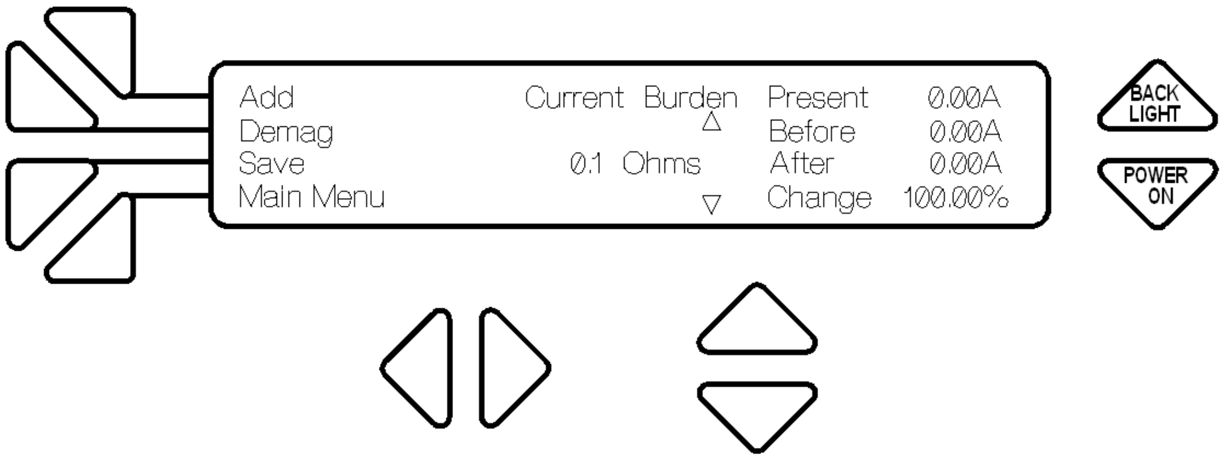
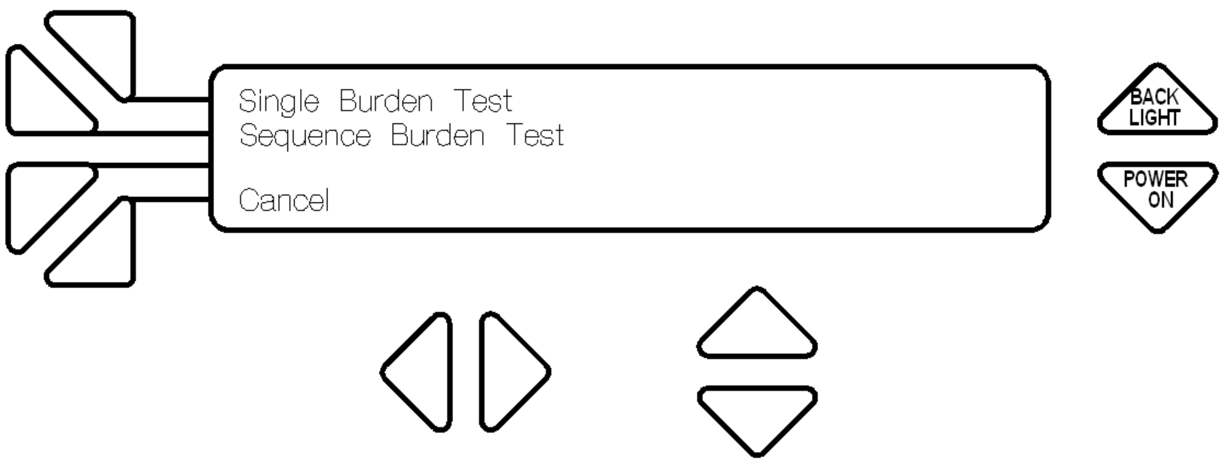
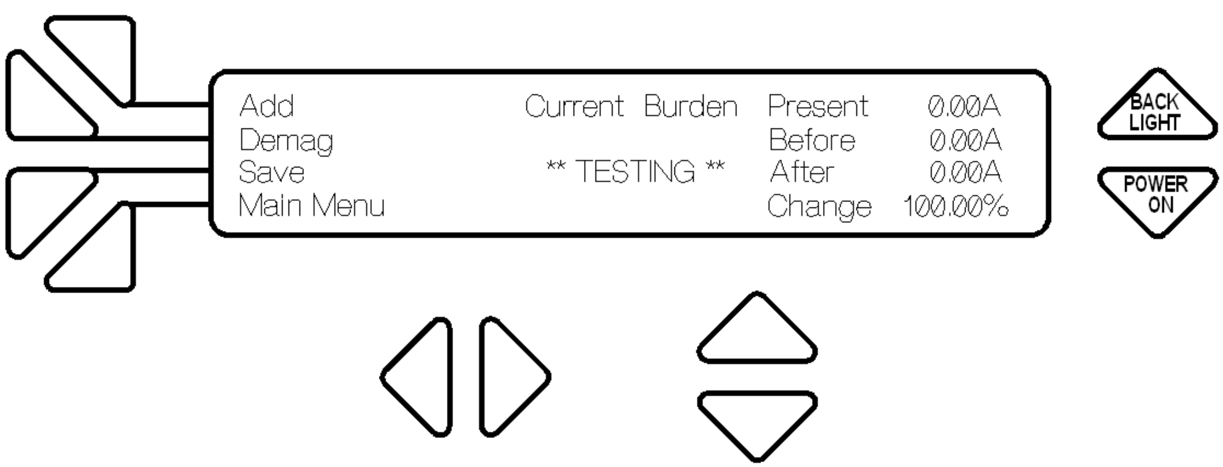


Select the ***Burden*** value to be added by using the ▲▼ buttons. To add a burden push F1 to the left of ***Add*** on the display. The following screen will display.



Select ***Single Burden Test*** by selecting the F1 button, the sound of a relay clicking is heard, the display says **TESTING** and the Before, After and Change values are displayed when the test completes.



The Before value is the CT secondary loop current just before the burden was applied, the After value is the CT secondary loop current after the burden was applied and the Change is the % of current change between the Before and After CT secondary loop currents. It is left to the user to determine acceptable % of change levels relative to the specific application, selection of CT, and circuit designs of the utility.

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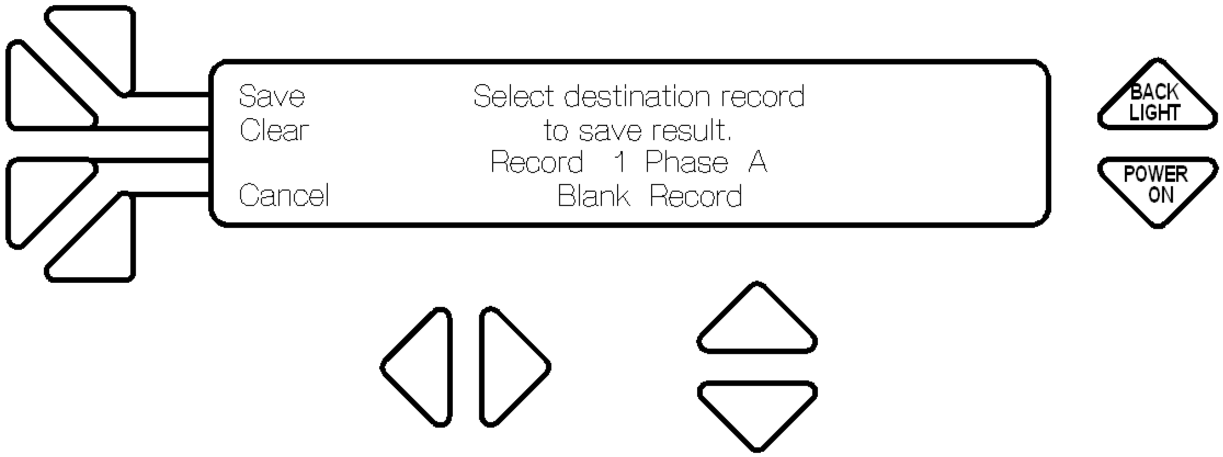
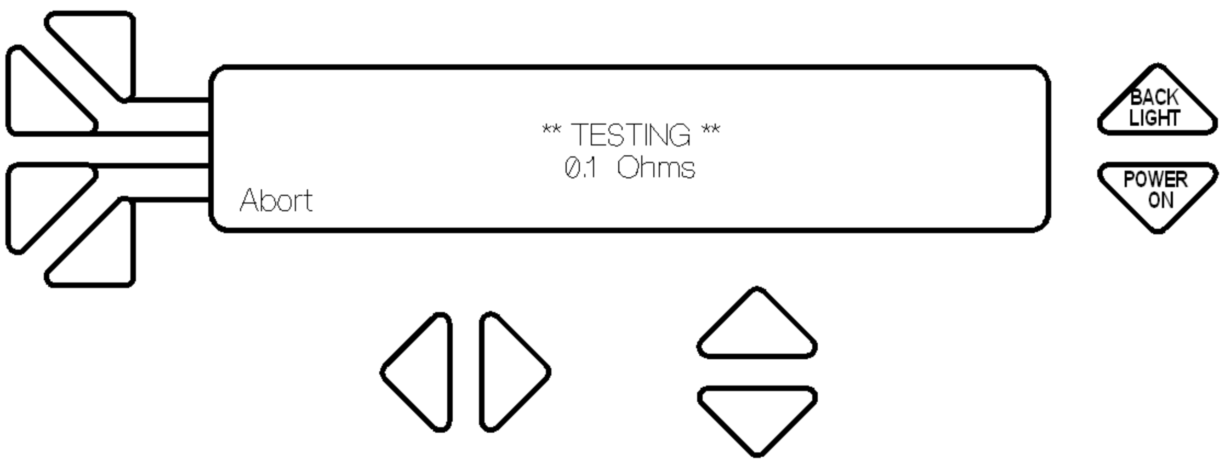
To ***Save*** the test data, push the F1 button and the following screen will display.



Select the destination record by pushing the ▲▼ buttons and push F1 button to ***Save*** the test results to the record and return to the screen above. Press F2 to ***Clear*** any previous test results in the record. Press F4 to ***Cancel*** the save and return to the CT Burden menu screen.

Test Procedure – Sequence Burden Values –

From the display above, choose ***Sequence Burden Test*** by selecting the F2 function button to its left. The following screen will be displayed and a sequence of relays will click every second for about 7 seconds. The value being tested will display on the screen. The burden values are 0.1, 0.2, 0.5, 1, 2, 4 and 8 ohms.



When the burden sequence is complete, the following screen is displayed.

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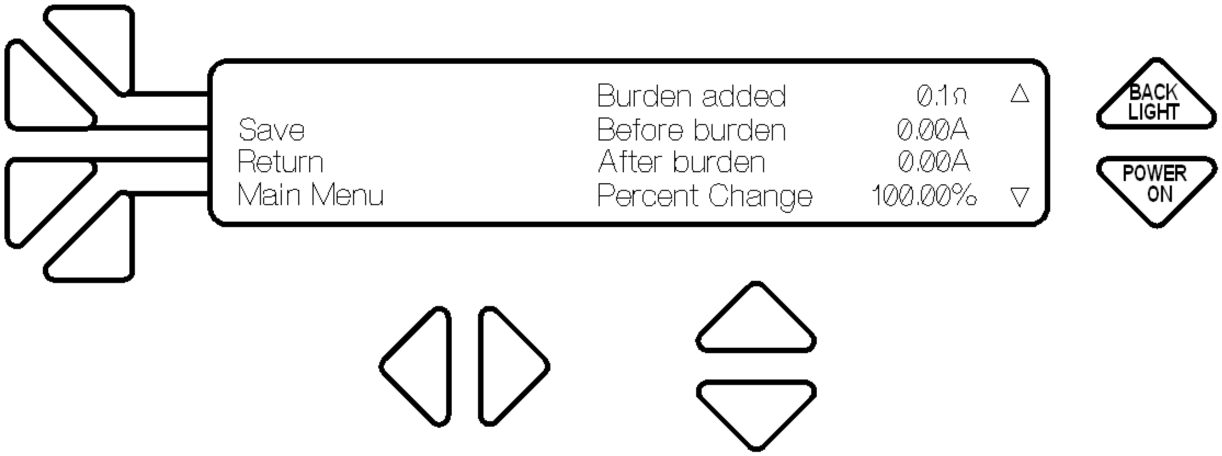
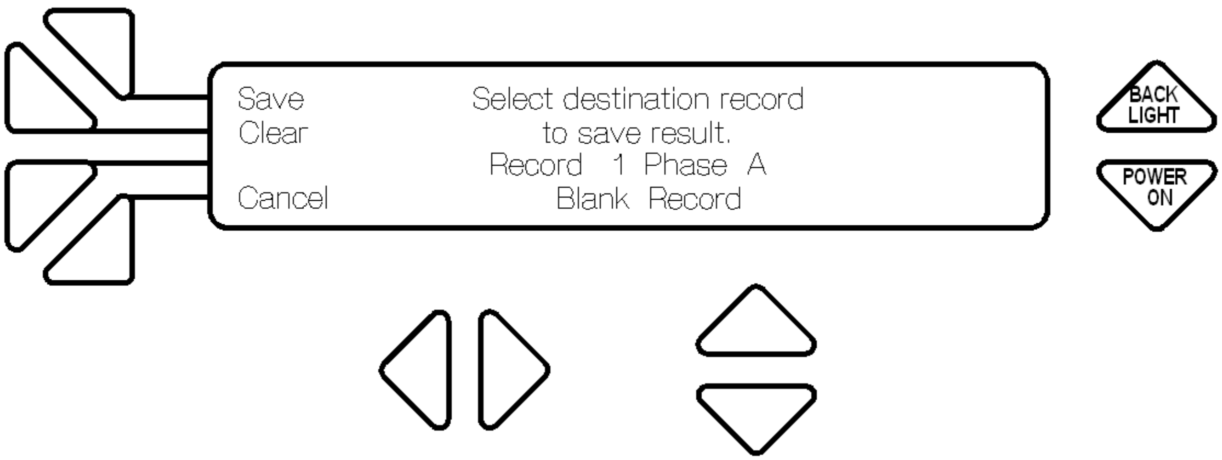


Test data for the various burdens can be viewed by using the ▲▼ buttons. To save the data, select the Burden Added value to be saved using the ▲▼ buttons and push F2 button to ***Save***. and the following screen will display. To ***Return*** to the CT Burden menu without saving the data, push the F3 button. To return to the ***Main Menu***, push the F4 button.



Select the destination record by pushing the ▲▼ buttons and push F1 button to ***Save*** the test results to the record and return to the screen above to select another Burden Value to be saved, etc., until all of the Burden Values are saved. Press F2 to ***Clear*** any previous test results in the record. Press F4 to ***Cancel*** the save and return to the CT Burden menu screen.

CT RATIO TESTING

Measurement Principle –

The Model 505 determines the CT ratio by measuring the primary and secondary currents and performing a calculation. The secondary value is always presumed to be either 1 or 5 amperes and the Primary ratio is calculated on this basis. (The 1 or 5 ampere secondary calculation is selected in the ***Options*** menu of the CT Ratio screen.) Therefore, all ratios will be displayed as XXX:1 or XXX:5. The 505 calculates CT ratio in two ways. Actual Ratio which is the actual calculation of primary to secondary current and may result in 398.76:5, for example, when a 400:5 CT is tested. The other is Best Fit Ratio. This is the integer ratio that is the nearest to the Actual Ratio. In the example the Best Fit Ratio would be 400:5. A selected burden may be added to the ratio test in either mode if desired.

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Theoretical Considerations –

The Model 505 determines the primary CT ratio by using a clip-on CT probe. These probes are subject to large errors under certain circumstances. Care must be taken when using these clip-on CT probes. Twisting the clamping jaws of the probe, snapping the jaws together, misalignment of the jaws or the jaws not closing completely together all degrade the accuracy of the clip-on CT. Do not leave the jaws open for a long period of time, this may cause residual magnetism in the CT core material, thereby offsetting measurements. These inaccuracies must be considered when analyzing the 505 data.

The Model 505 primary current clamp input is calibrated at the factory. Primary current probes used with the 505 can have improved accuracy by using calibration factors for the probe combined with the factory calibration for this input. This process is useful occasionally but many current probes, particularly the “Rope” clamps and “Fork” clamps are not repeatable enough to rely on this being beneficial. See the accuracy map in the Appendix for more information about conductor placement in the fork opening. To implement a correction for a particular clamp, multiply the slope of the best fit line that includes 0 amps for the clamp by the Primary I gains from the calibration table and enter the result in the calibration table

A current transformers core is easily magnetized. This could occur in service from a lighting strike, the CT having had an open secondary at one time, being over burdened or from uninstalled CTs being stored without shunts on the secondary terminals. Magnetized cores will result in CT ratio errors. If ratio measurements show significant error (>2%) with at least 20% rated secondary current, try demagnetizing the CT and retest.. If the ratio improves the CT was likely magnetized and its performance was compromised in a manner that would result in measurement losses. See the section on Demagnetization for details on the 505’s capability for this purpose.

Since the measured CT Ratio is determined from primary and secondary current values, successive measurements will provide slightly different ratios. For better accuracy, several ratios should be measured and then averaged.

Actual Ratio

Modern day metering current transformers have an accuracy class of 0.3% at 100% full load current and at the minimum operating range of 10% full load current the transformers accuracy degrades to 0.6%. A relay class current transformer with an accuracy class of 0.5% at 100% full load will nearly generate two times the error in measurements. Any ratio measurement below the 10% accuracy rating of the current transformer is not recommended. The Actual Ratio is determined by measuring the CT primary current using a clip-on current probe and comparing it to the CT secondary loop current measured by an in series current meter. It is important that the polarity of the clip-on current probe be observed when clipping it on the primary wire (requires all primary wires). This value is commonly referred to as the *True Ratio,* which is defined as the ratio of the RMS primary current to the RMS secondary current under specified conditions.

Best Fit Ratio

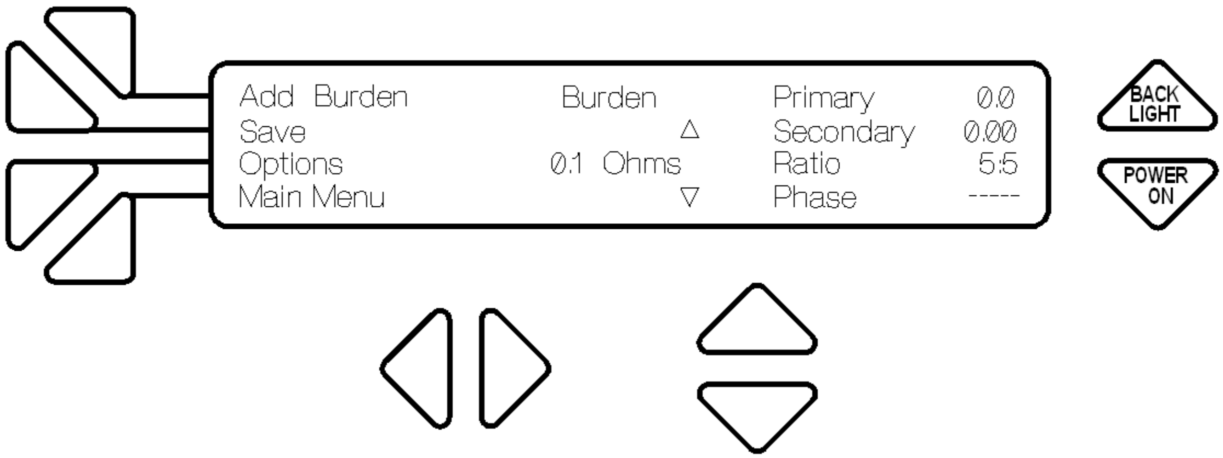
The Best Fit Ratio is the nearest integer ratio to the Actual or True Ratio calculation. The Best Fit Ratio is commonly referred to as the *Marked Ratio* or *Name Plate Ratio,* which is defined as the ratio of the rated primary value to the rated secondary value as stated on the nameplate of the CT.

Burden Added Ratio

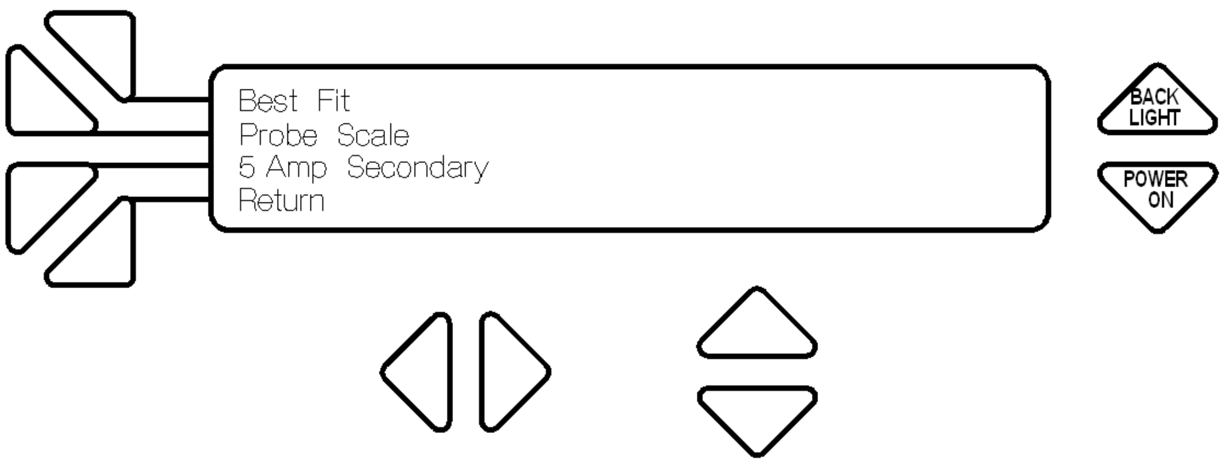
If a CT has an internal problem, it sometimes shows up best when the secondary burden is high. The Model 505 allows the user to add a burden of choice to the CT while the CT Ratio is being measured. This provides data for comparison of the CT ratio with and without additional burden.

Test Procedure –

Choose ***CT Ratio*** by depressing the F3 function button to its left in the Main Menu. The following screen will be displayed.



Select ***Options*** by selecting F3 and the following screen displays.



Pushing F1 will select the CT Ratio display to be either ***Best Fit*** or ***Actual***. Selecting F3 will select for the CT Ratio to be calculated using a 5 amp or 1 amp secondary. Selecting F2, ***Probe Scale***, will display the following screen.

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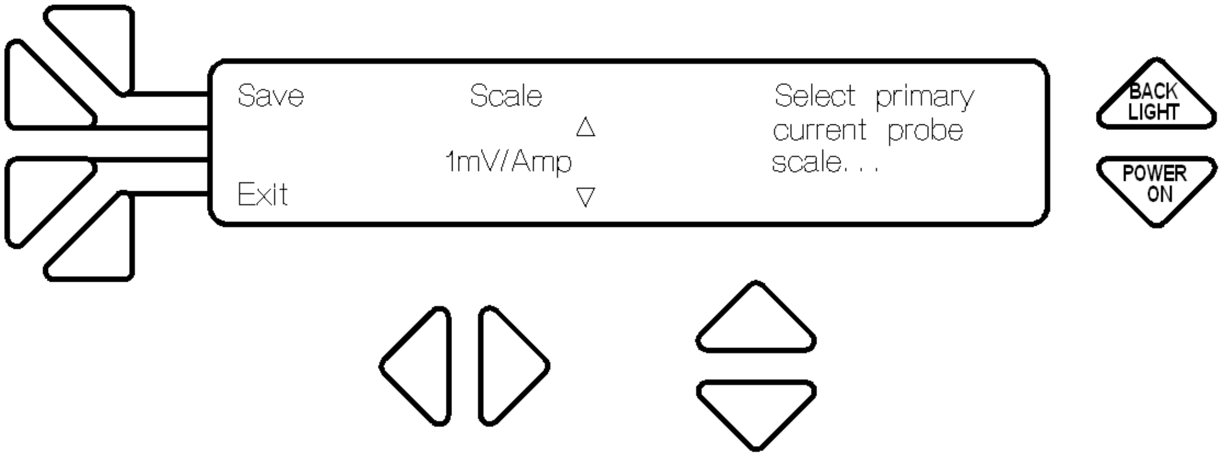
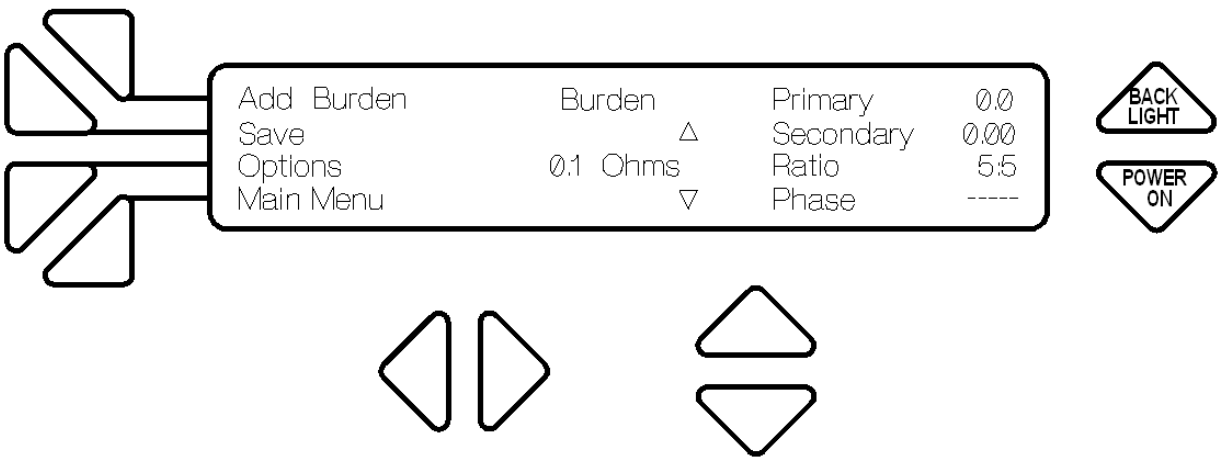


Using the ▲▼ buttons, select the output analog of the CT probe being used to measure the primary current. This should be the one that is calibrated to the 505 measurement circuits. Values are 1 mV/A, 2 mV/A, 5 mV/A, 10 mV/A, 100 mV/A and 1000 mV/A. No matter what scale is use, the Model 505 will only measure up to 3 volts on the input. For example, a 0-10 ampere clip-on that has an output of 1 mV/mA would output 10 volts when measuring 10 amperes. The 505 will measure and display up to 3 volts. Therefore, this probe can only be used to measure currents from 0 – 3 amperes when used with the Model 505. When the correct scale value is selected, push F1 to ***Save*** the data and return to the Options menu. The scale selection is only necessary when the CT probe is changed from one device to another. Push F4 to ***Exit*** to the Options menu and make no changes.

When all the Options are selected, push the F4 button to ***Return*** to the Ratio menu screen.



This screen displays that a burden value of 0.1 ohm is selected and will display the Primary, Secondary, Ratio and Phase difference between primary and secondary. Push F1 to ***Add Burden*** that is selected. The measured values will change displaying the new values with the burden added to the CT secondary loop. To change the burden value, use the ▲▼ buttons. The ratio will display calculated as selected in the Options menu – Actual or Best Fit.

To test the CT ratio with a burden added, first select the burden value using the ▲▼ buttons and push F1 to the left of ***Add Burden***. The following screen will be displayed.

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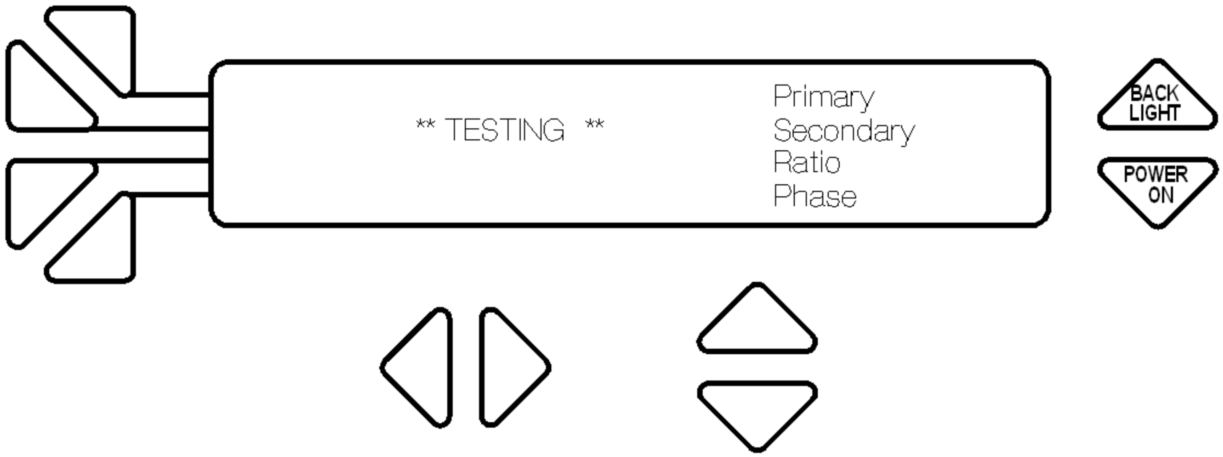
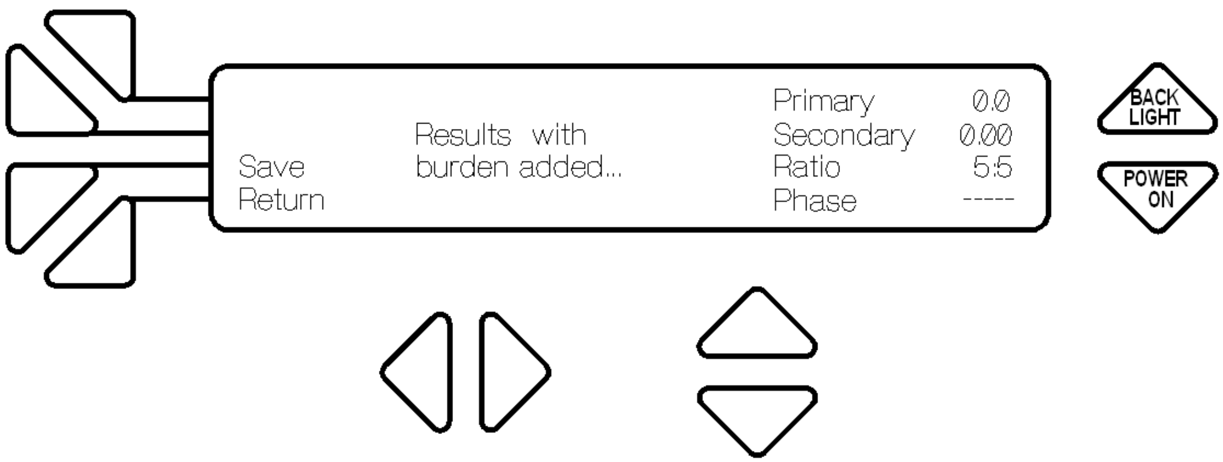


Followed by this screen



Push F3 to ***Save*** to display the following screen. Push F4 to ***Return*** to the CT Ratio screen without saving the data. The following screen will display when the ***Save*** button is selected.

Select the destination record by pushing the ▲▼ buttons and push F1 button to ***Save*** the test results to the record. Press F2 to ***Clear*** any previous test results in the record. Press F4 to ***Cancel*** the save and return to the CT Ratio screen.

Press F4, ***Main Menu*** on the CT Ratio screen to return to the main menu.

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PT BURDEN TESTING

Measurement Principle –

Voltage transformers are designed to supply a known voltage under a defined VA load, dictated by the turns ratio, into a known burden and maintain a stated accuracy. The principle of the PT Burden Tester is to challenge the capability of the PT to maintain the secondary voltage while delivering current into a known VA burden.

Theoretical Considerations –

The challenge is presented in the form of a known ohmic resistance value that is added in series with the PT secondary loop. The total burden of the PT secondary loop is made up of the watthour meter voltage coils, meter/AMI power supply circuit board, other circuit boards (Ethernet, modem, RS232, IEEE, mod-bus, etc.), junction boxes, transducers, the mounting device, test switch, connection resistances, and the length and size of the loop wiring. Therefore, each PT has a secondary burden when installed in a metering circuit. Assuming the meter installation is designed to your construction specifications the PT will provide metering voltages according to its accuracy class rating. Should additional burden be added that exceeds the design burden capability of the PT, the transformer will not be able to supply the same level of voltage and the net result is a drop in PT secondary voltage.

The amount of this voltage drop is dependent on a number of factors and is not absolutely definable. It would be impossible to provide a chart of test expectations for PT's because of all the variables affecting the test. Therefore, it is left to the user to determine acceptable test levels relative to the specific application, selection of PT, and circuit designs of the utility.

Technical Description –

The Model 505 provides two methods of performing the PT burden test. The first method allows the user to add a selected burden to the PT secondary and observe the Present, Before Burden, After Burden voltages together with the Percent (%) of change between Before and After Burden voltages.

The second method allows the user to add a complete sequence of burdens to the PT secondary. The sequence consists of 25, 50, 75, 100, 125, 150 and 175 VA automatically applied for about 1 second. The display allows the recall of test values for each burden buy pushing the ▲▼ buttons.

Both of the PT Burden test can be performed with and without the meter voltage coil attached to the PT secondary.

Test Procedure – Single Burden Value –

After the test cables are connected as outlined previously and the 505 turned ON, choose ***Burden*** by depressing the F2 function button to its left in the Main Menu screen. The following screen will be displayed.

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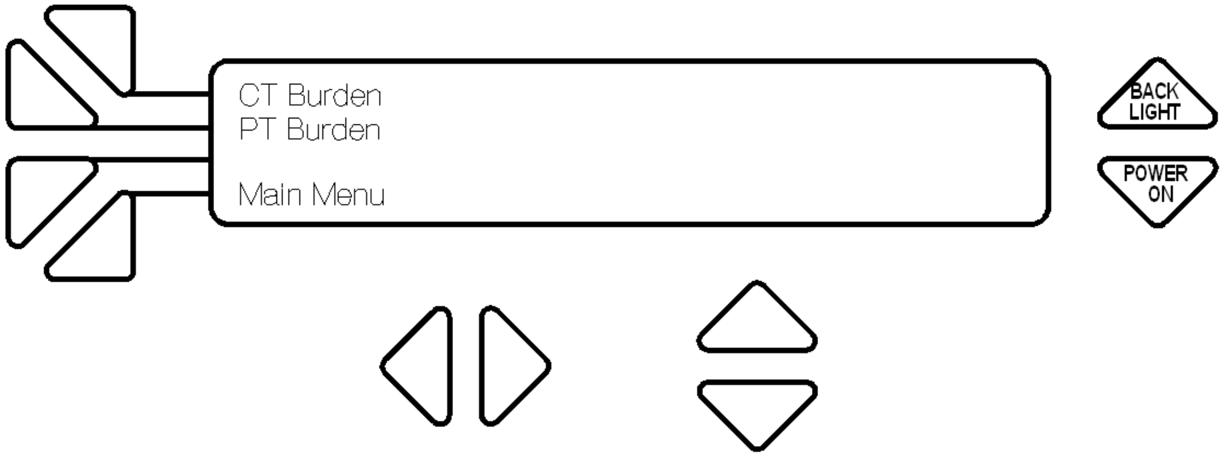
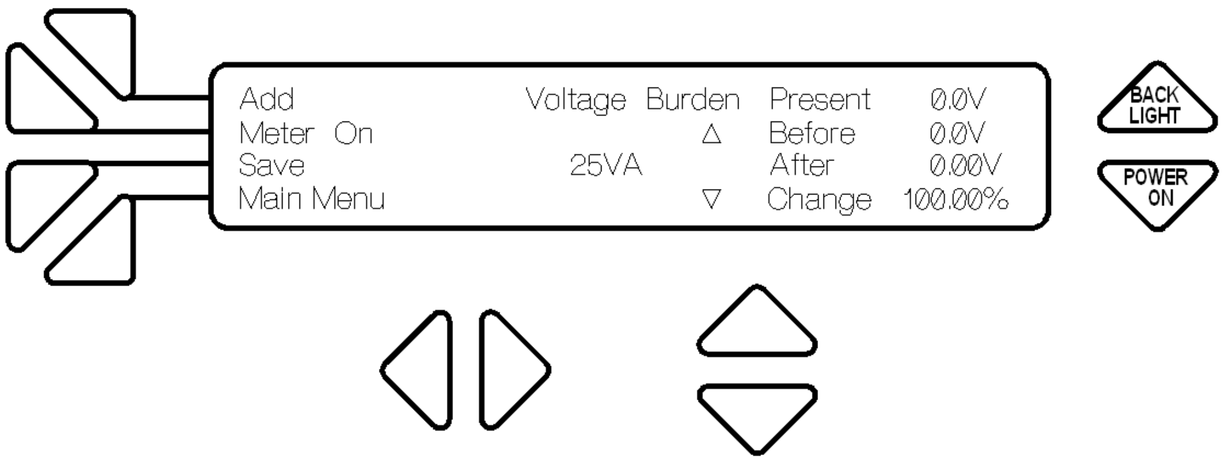
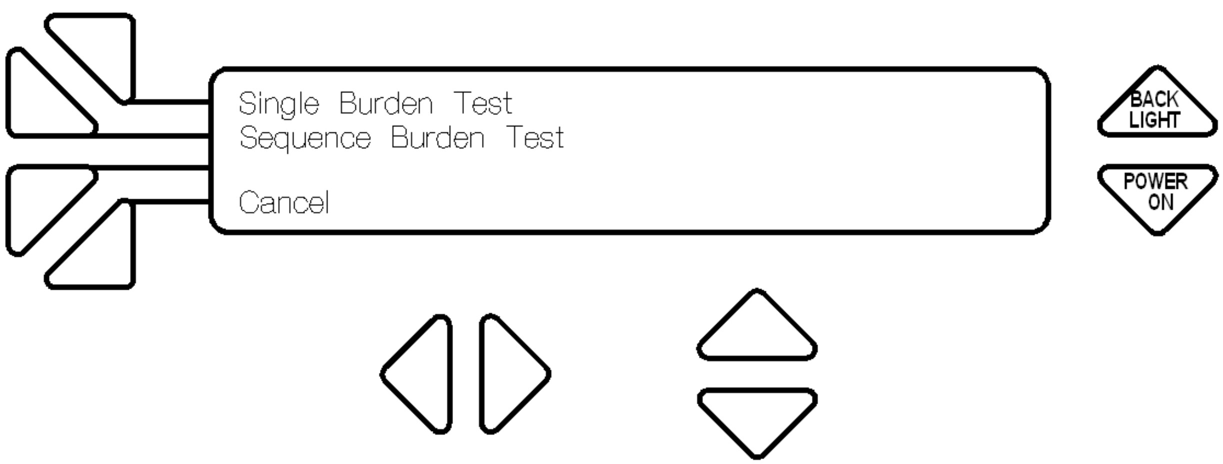


Push F2 to select ***PT Burden*** and the following screen will display.



Select the Voltage Burden value to be added by using the ▲▼ buttons. To add the burden push F1 to the left of ***Add*** and the following screen will display.



Push the F1 button ***Single Burden Test*** to add the selected burden. When the F1 button is pushed, the sound of a relay clicking is heard, the following screen is displayed showing that the 505 is **TESTING**.

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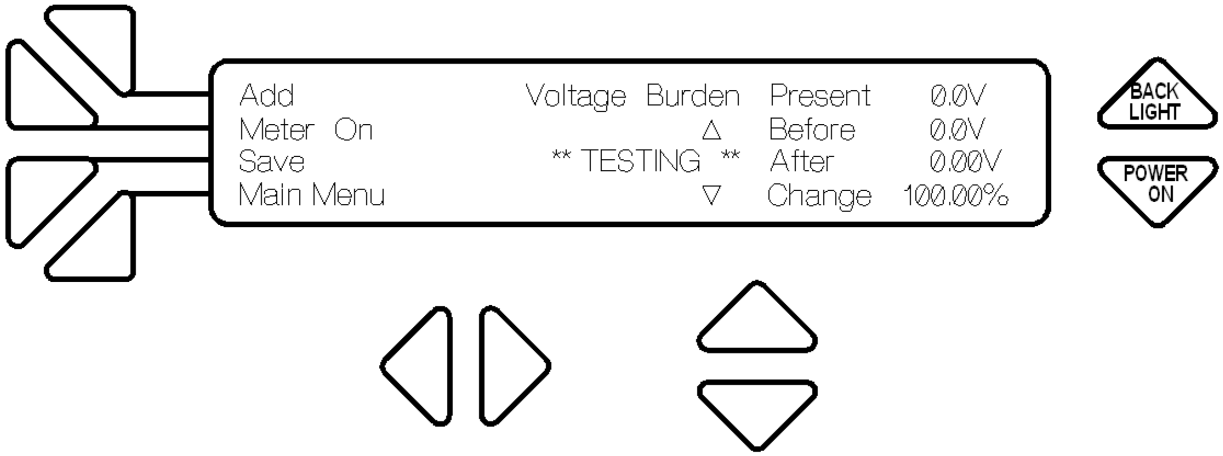
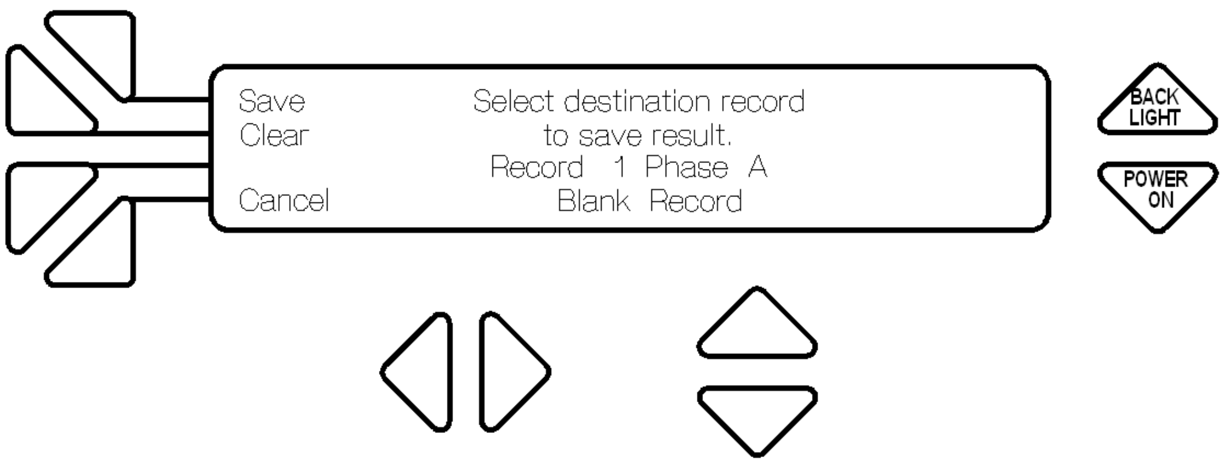


When the test is complete, the Before, After and Change values are displayed. The Before value is the PT secondary voltage just before the burden was applied, the After value is the PT secondary voltage after the burden was applied and the Change is the % of voltage change between the Before and After PT secondary voltages. It is left to the user to determine acceptable % of change levels relative to the specific application, selection of PT, and circuit designs of the utility.

Push F3 to ***Save*** the data and the following screen will display.



Select the destination record by pushing the ▲▼ buttons and push F1 button to ***Save*** the test results to the record. Press F2 to ***Clear*** any previous test results in the record. Press F4 to ***Cancel*** the save and return to the PT Burden menu screen.

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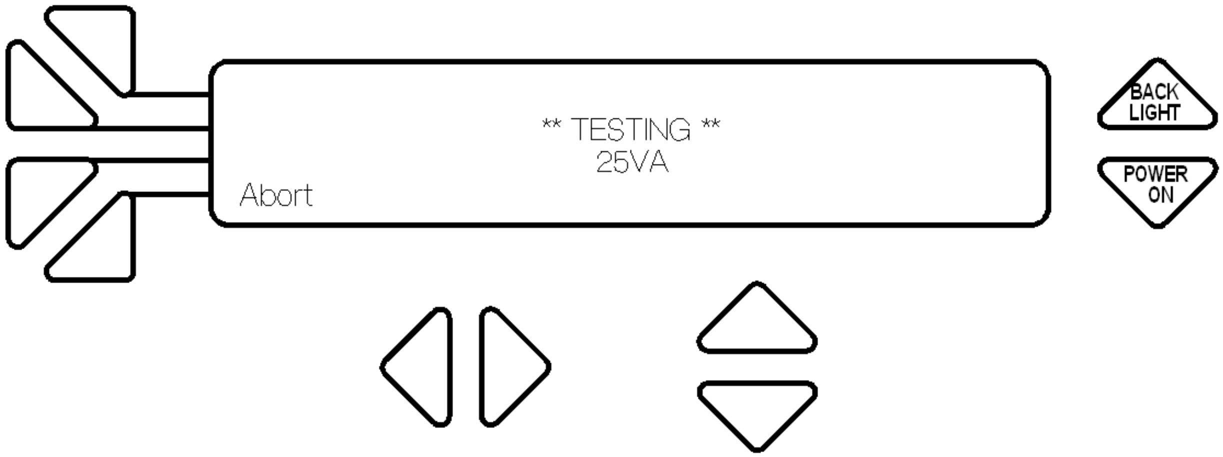
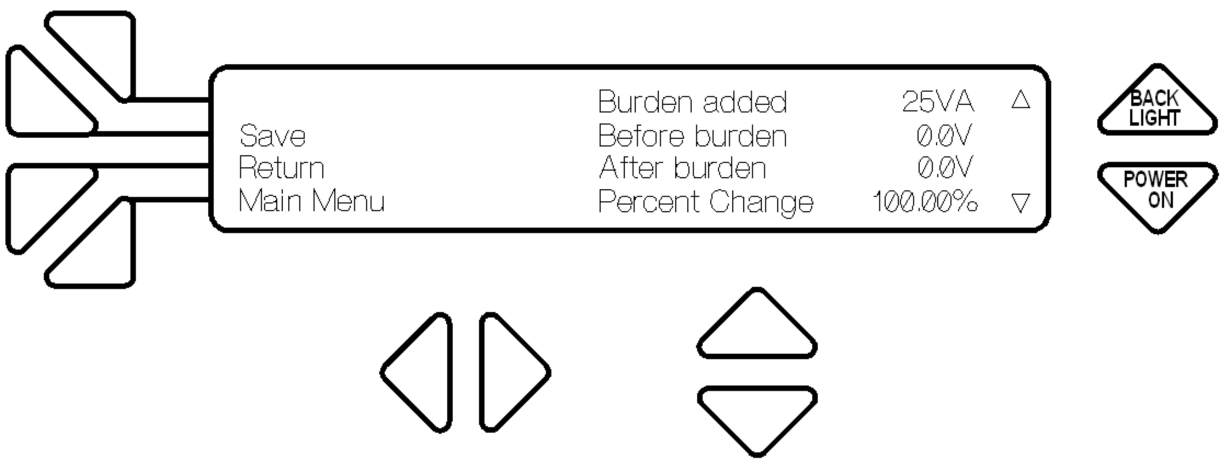
Test Procedure – Sequence Burden Values –

From the Add Burden screen, choose Sequence ***Burden Test*** by depressing the F2 function button to its left.



During the test, the screen above will display and a sequence of relays will click every second for about 6 seconds. The value being tested will display on the screen. The burden values are 25, 50, 75, 100, 125, 150 and 175 VA. Push F4 to ***Abort*** (stop) the test and return to the PT Burden menu screen.

When the test is complete, the following screen will display.



Test data for the various burdens can be viewed by using the ▲▼ buttons. To save the data, select the Burden Added value to be saved using the ▲▼ buttons and push F2 button to ***Save*** and the following screen will display. To ***Return*** to the PT Burden menu without saving the data, push the F3 button. To return to the ***Main Menu***, push the F4 button.

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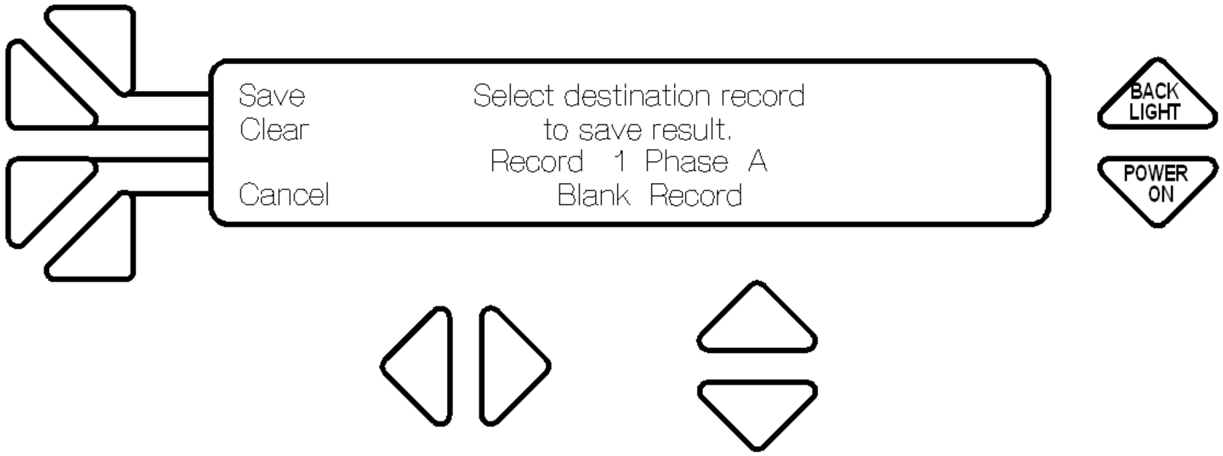

Select the destination record by pushing the ▲▼ buttons and push F1 button to ***Save*** the test results to the record and return to the screen above to select another Burden Value to be saved, etc., until all of the Burden Values are saved. Press F2 to ***Clear*** any previous test results in the record. Press F4 to ***Cancel*** the save and return to the PT Burden menu screen.

PT Burden Testing Meter ON/OFF –

Both of the above PT Burden test can be performed with and without the meter voltage coil attached to the PT secondary. Selecting F2 to the left of ***Meter ON*** will switch it to ***Meter OFF*** and disconnect the meter voltage coils from the secondary of the PT. Selecting F2 again will switch to ***Meter ON*** and reconnect the meter voltage coils to the PT secondary. Differences in regulation of the PT secondary can then be observed.

> **WARNING!!** When the Meter ON/OFF is positioned to the Meter ON setting, there is voltage present on the test clip of the Yellow booted wire marked “Meter”. Do not touch this test clip with bare hands or let it contact service or earth ground. Electrical shock or damage to the equipment may result. A fuse on the instrument panel will provide some protection to the instrument under fault conditions.

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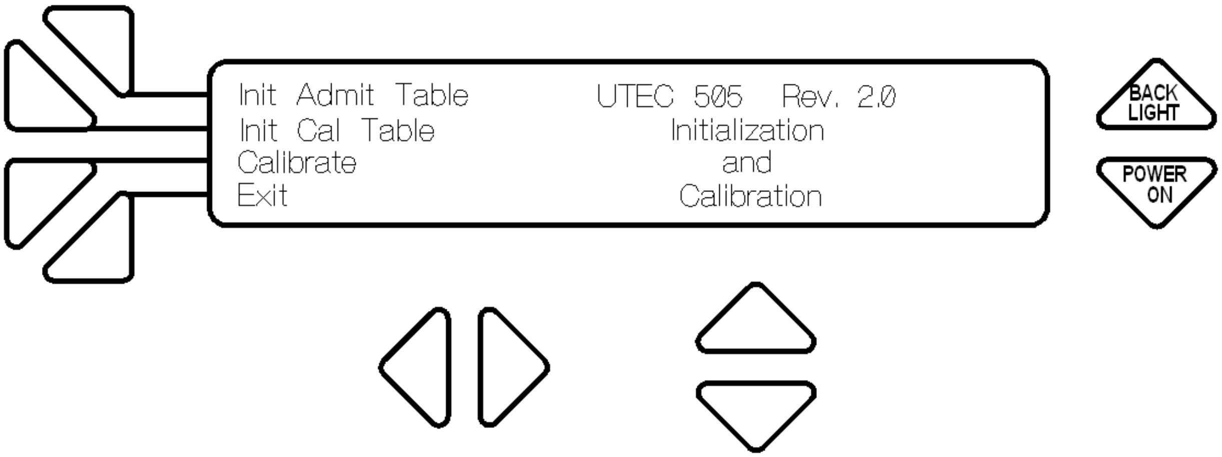
CALIBRATION

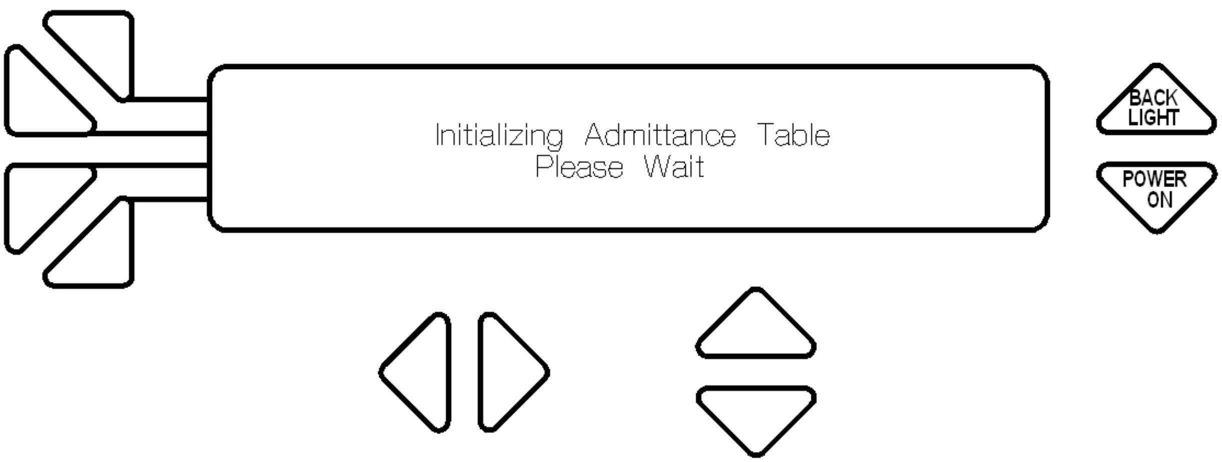
The Model 505 software is provided with calibration factors for the various measured quantities to eliminate the need for adjustment devices such as potentiometers. The calibration display is accessed by holding down both the ◄ ► buttons and turning ON the unit. This will display the following screen.



INITIALIZE ADMITTANCE TABLE

Selecting F1 to the left of the ***Int Admt Table*** on the screen will load the factory default values into the admittance table. As it comes from the factory, values are entered for each class and ratio with a Pool value of 0100. Do not push this button if you have been saving the admittance values of your tests. If this button is pushed it will eliminate your test results and put in the default values. When the Pool value reaches 9999, a message will be displayed. While in the Admittance Edit screen, reset the pool value to 2000. Do not change the historical values in the *Minimum, Average* and *Maximum* data areas.

Selecting F1 will display the following screen while the Admittance Table is being reset to factory defaults.



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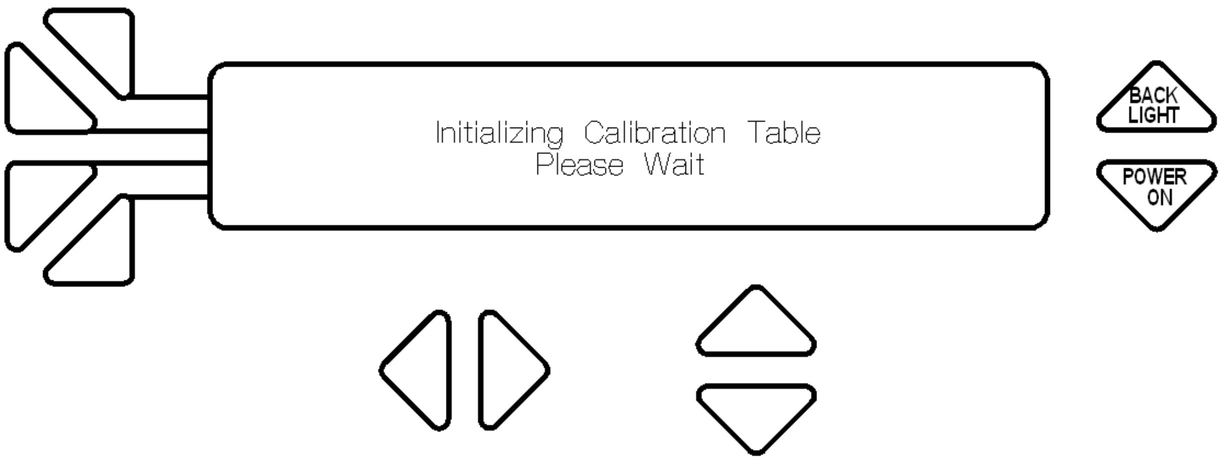
INITIALIZE CALIBRATION TABLE

Selecting F2 to the left of the ***Int Cal Table*** on the display will load the factory default correction values into the calibration table. Do not push this button unless new calibration values are being entered. The factory default values are all 1.0000 and 0.00. Selecting the ***Init Cal Table*** button, will make the Model 505 be out of calibration.

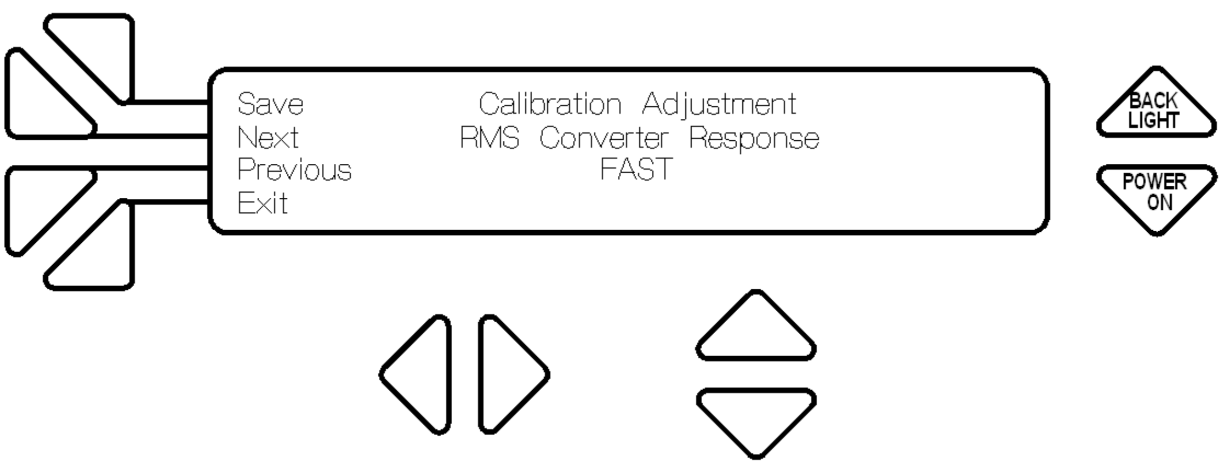
Selecting F2 will display the following screen while the Calibration Table is being reset to factory defaults.



If the ***Int Cal*** *Table* button is accidentally pushed, the original factory calibration values that were shipped with the instrument must be re-entered in the ***Calibrate*** (F3) screen or a new calibration must be made and entered in the ***Calibrate*** screen. If the original calibration information is unavailable, call Radian Research to request a copy.

CALIBRATE

Selecting F3 to the left of ***Calibrate*** will show the following display.



The RMS Converter Response can be set from SLOW, MED and FAST. SLOW is the longest sample time and produces the most accurate readings. The settling time can be shortened at the expense of accuracy in the measurements. The factory default setting for the RMS Converter Response is FAST. Press F1, ***Save*** after making any changes in the Calibrate screen.

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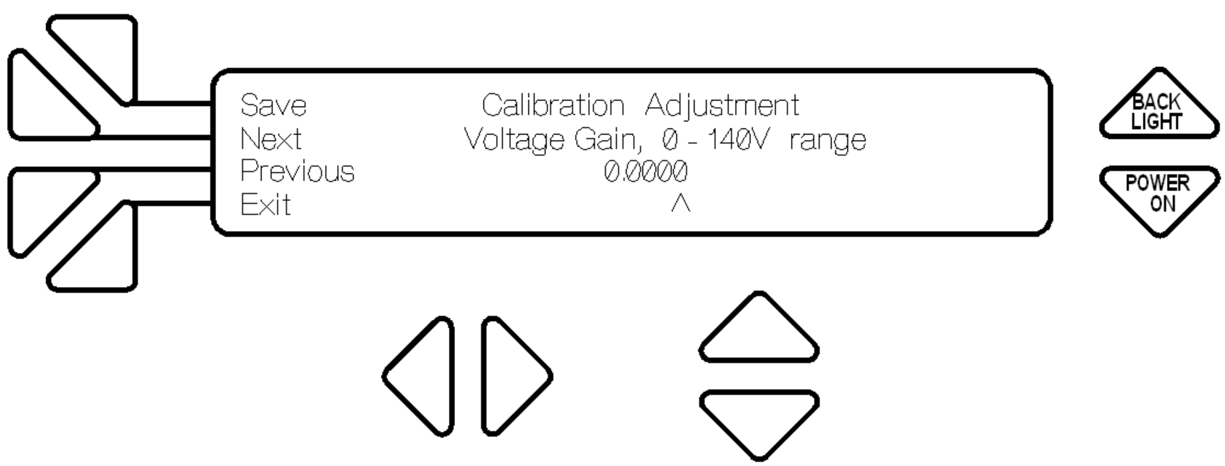
Other calibrations are as follows:

Operating Frequency (50 or 60 Hz)
Voltage Gain, 0-140 V range (Multiplier ±0.0000)
Voltage Gain, 140-600 V range (Multiplier ±0.0000)
Secondary I Gain, 0-2 A range (Multiplier ±0.0000)
Secondary I Gain, 2-20 A range (Multiplier ±0.0000)
Primary I Gain, 0-0.2 V range (Multiplier ±0.0000)
Primary I Gain, 0.2-3 V range (Multiplier ±0.0000)
Admittance Offset, 0-1 mS range (±00.00mS)
Admittance Gain, 0-1 mS range (Multiplier ±0.0000)
Admittance Poly, 0-1 mS range (Multiplier ±0.0000)
Admittance Offset 0-10 mS range (±00.00 mS)
Admittance Gain, 0-10 mS range (Multiplier ±0.0000)
Admittance Poly, 0-10 mS range (Multiplier ±0.0000)
Admittance Offset, 10-100 mS range (±00.00 mS)
Admittance Gain, 10-100 mS range (Multiplier ±0.0000)
Admittance Poly, 10-100 mS range (Multiplier ±0.0000)
Phase Offset, Voltage to Sec (±00.00 degrees)
Phase Offset, Pri to Sec (±00.00 degrees)
Voltage Burden Dwell Time (0.0000 seconds)
Current Burden Dwell Time (0.0000 seconds)

To enter the calibration numbers, position the cursor (^) using the ◄ ► buttons and the ▲▼ buttons to select the number. Pushing the ▲ button once will move the number from 0 to 1. Holding down the ▲ button will automatically run the number up to 9 – release the button when the desired number is attained. An example of a calibration display is shown below.



The calibration factors as shipped from the factory are included on a data sheet sent separately. The Appendix shows the blank calibration factors form.

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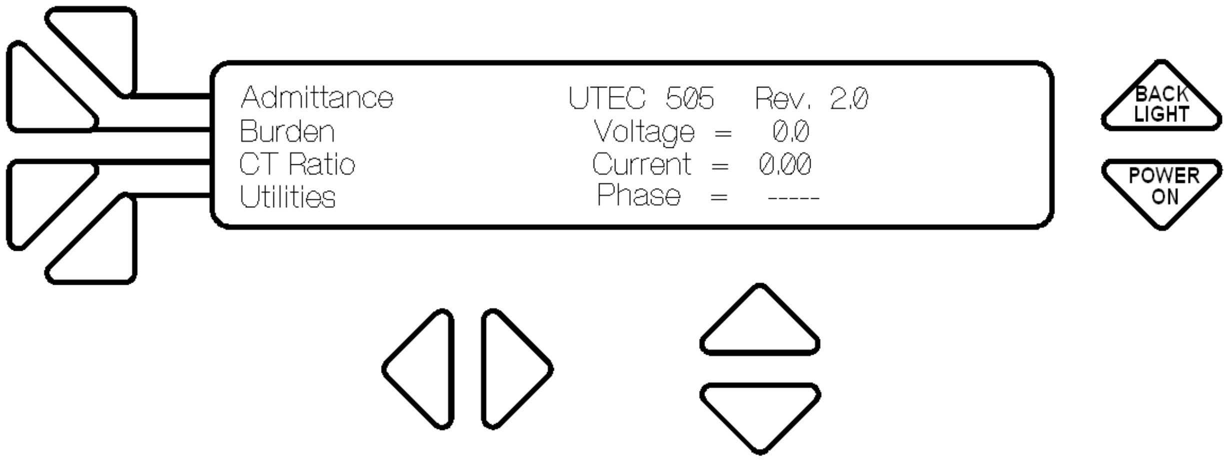
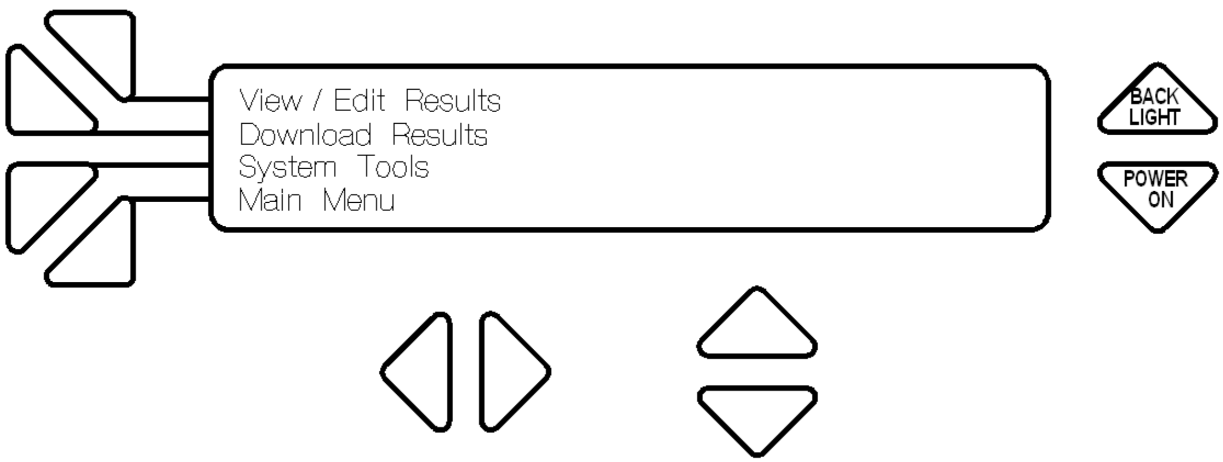
UTILITIES

Utility functions are provided for viewing, editing and downloading test results and setting some system parameters.



To access the ***Utilities***, push the F4 button on the main menu and the following screen will display.



The test results can be viewed and edited. Push F1 to the left of ***View/Edit Results*** and the following screen will display.

VIEW RECORD RESULTS

To view the test record results, select the record using the ▲▼ buttons. When the record is selected, use the ◄ ► buttons to scroll through the record data.

To clear a selected result from the selected record (Phase A of record 1 noted in the upper right hand corner of screen. The record number is 1 and the phase is A – 1A) push F2, ***Clear Result***. To clear the complete selected record, push F3, ***Clear Record***. This will clear all of the data in the selected record (record 1 – Demo Record). To ***Return*** to the Utilities main menu, push F4.

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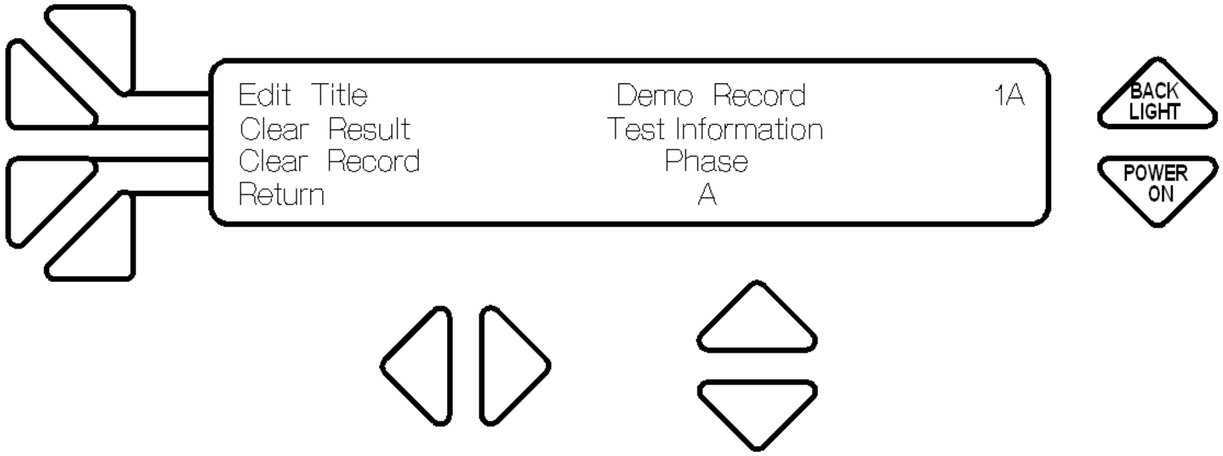
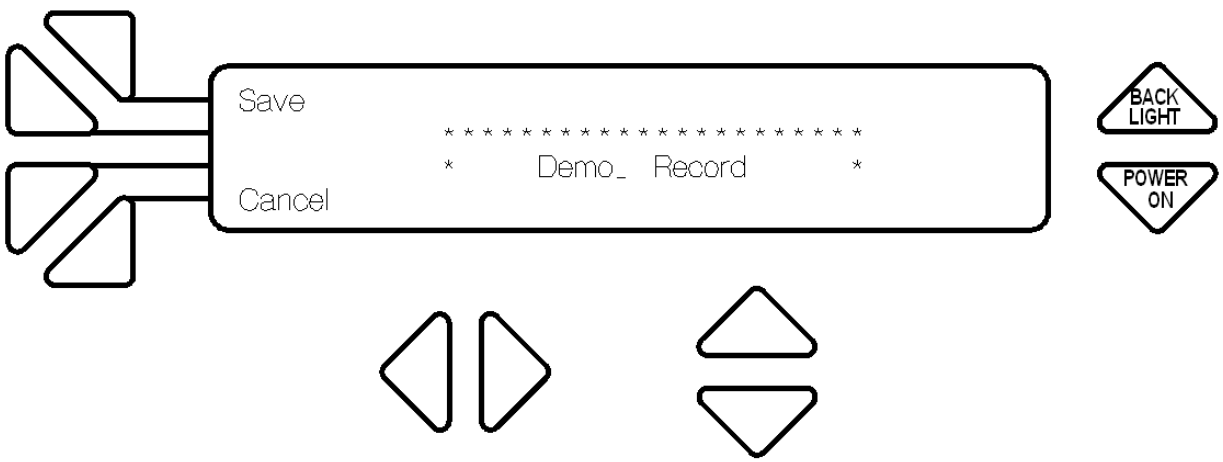


EDIT TITLE

To edit the title of the selected record (Demo Record), push ***Edit Title*** (F1) and the following screen will display.



Position the cursor (_) using the ◄ ► buttons and the ▲▼ buttons to select the number. Pushing the ▲ button once will move the number from 0 to Z. Holding down the ▲ button will automatically run the characters up – release the button when the desired character is attained. Move the cursor to the next position and repeat the character selection. When the title is edited, push F1 to ***Save*** and return to the View/Edit Results menu screen.

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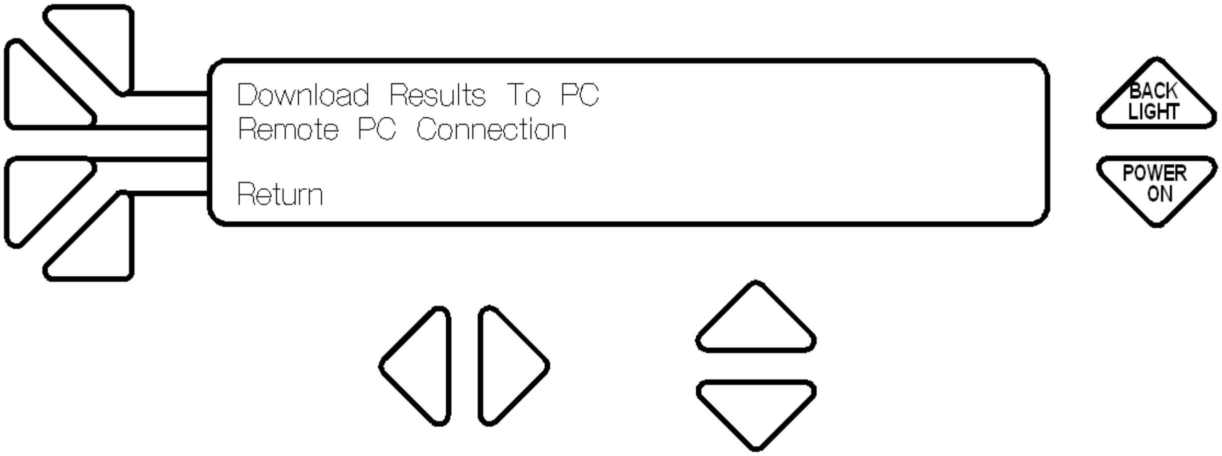
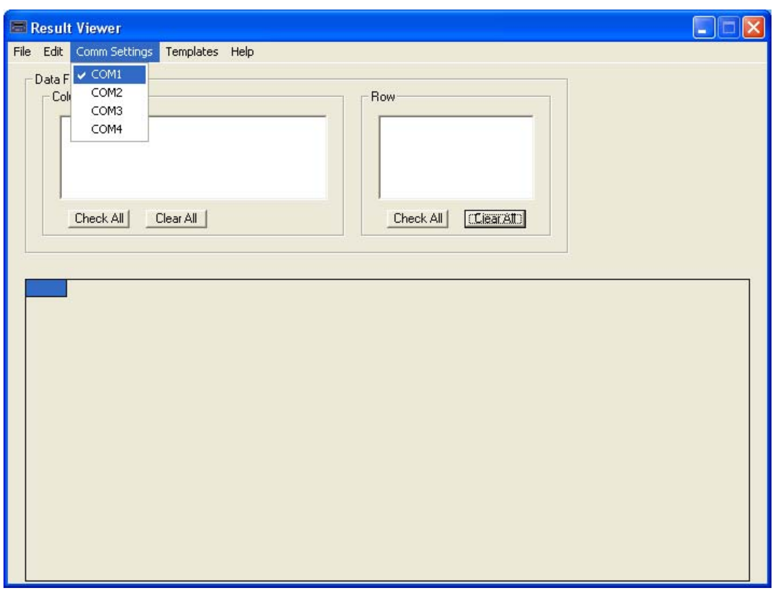
DOWNLOAD TEST RESULTS

From the Utilities main menu, select F2, ***Download Results*** and the following screen will display.

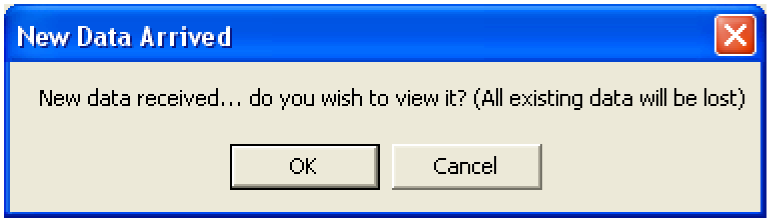


Connect the 9 pin RS-232 cable between the Model 505 panel plug and a selected COM port on the PC loaded with the Results Viewer software. Start the Results Viewer software and select the COM port to which the RS-232 cable is attached. Select the 'Com Settings' tool bar button and choose the COM port from the drop down list.

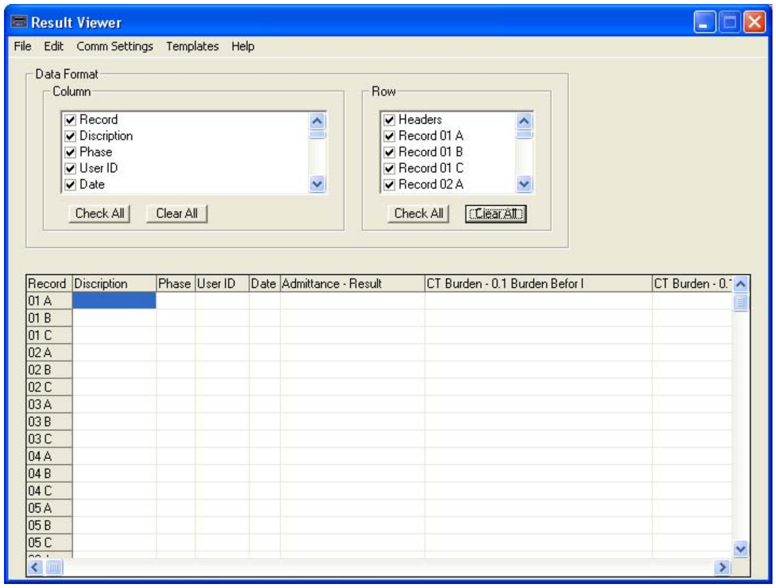


With the RS-232 cable connected and the correct COM port selected, push F1, ***Download Results To PC*** to begin the download.

When the download completes, the following screen will be displayed.



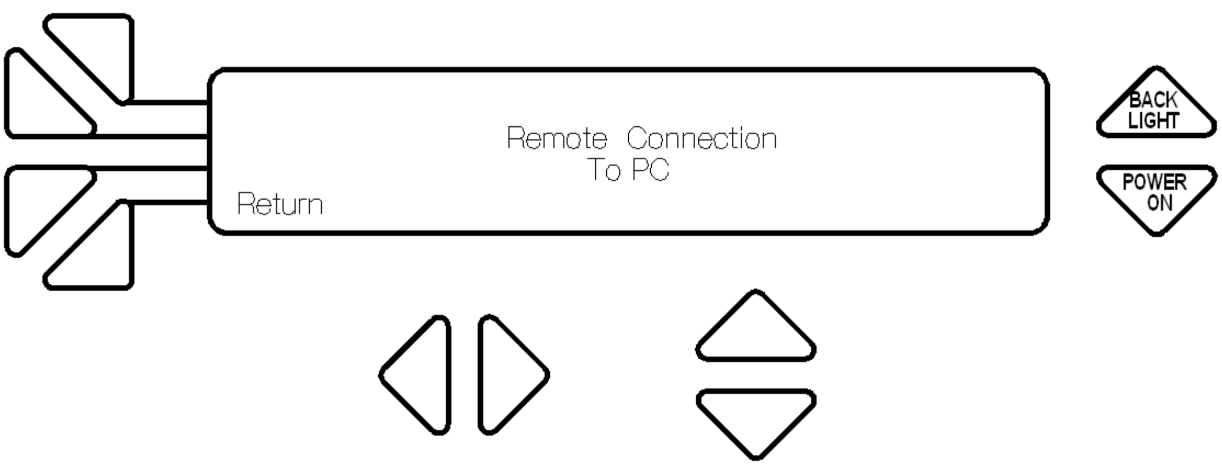
Left click the OK button to enter the records into the Results Viewer.



Read the 'Viewer Help' in the drop down list under the Help tool bar button for more details on the operation of the Results Viewer software.

REMOTE PC CONNECTION

Push F2, ***Remote PC Connection*** and the following screen will display.



This function is not part of the normal use of the Model 505. It is provided for downloading updates to the internal ROM of the Model 505 to facilitate future upgrades.

Pushing F4, ***Return*** will turn OFF the Model 505 to force a reboot of the microprocessor.

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MAINTENANCE

FRONT PANEL OVERLAY

The front panel overlay is made from polycarbonate (Lexan) material and contains pressure sensitive key switches. The labels are silk screened on the back side of the overlay which protects them from normal wear. The overlay may be cleaned using Windex or 409 cleaner. Do not use harsh chemicals which may cloud or etch the surface. The window for the display should be carefully cleaned without pressing it down.

TEST CABLES

The voltage and current test cables should be inspected for wear, broken or frayed wires and loose connections each time the instrument is used. Replace any defective components before connecting to service. On occasion, the plastic ring around the cable connector may crack if over tightened. These rings are replaceable and available from RADIAN RESEARCH.

> **WARNING!!** Do not test using Test Cables with worn, broken or frayed wires. Doing so may cause electrical shock to operating personnel and/or damage to the instrument.

BURDEN RESISTORS

It is mandatory that the burden resistors are continuous and are not OPEN. They should be tested before each use if possible. They can be tested by setting the Dwell Time in the Calibration screen to 1.9000 seconds, connecting an ohm meter across the current test cable, selecting the CT or PT Burden Test and selecting a Sequence. As the unit sequences through the various values, the ohm value should be read on the attached ohm meter. If one of the resistors is open, the ohm meter will read infinity ( ). After testing, be sure to set the Dwell Time back to 0.8000 seconds for both the Voltage and Current relays. Failure to set the Dwell Time to 0.8000 seconds could result in burned out burden resistors and a possible open CT secondary which can generate very high voltages.

WARNING!! Set dwell time to 0.8000 seconds before testing.

BATTERY REPLACEMENT

The Model 505 is designed with a replaceable 2000 mAH NiCad battery pack. Replace the battery pack only with RADIAN RESEARCH part # B0505209

The instrument must be removed from the carrying case for battery pack replacement. This is accomplished by removing the 8 screws through the aluminum rails on the case bottom and lifting the unit from the case. On the top side of the chassis (side next to the voltage and current cable plugs) there is a removable cover. Remove the 6 screws from the cover and set aside. The battery pack can now be viewed. Unplug the battery pack and remove it from the unit. The battery pack is held in place with 2 Velcro strips, one on each end, removing it will require a fair amount of force. Line up the new battery pack so the edges and ends do not touch the chassis and push in place. The Velcro strips should hold it tightly. Plug in the battery pack and replace the cover and screws. Reassemble chassis to case.

WARNING!! DO NOT ATTEMPT TO REPLACE BATTERIES WHILE UNIT IS CONNECTED TO THE SERVICE VOLTAGE

Dispose of old battery properly, do not put old battery in the trash.

LIMITED WARRANTY STATEMENT

Radian Research warrants each of our products to be free of defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or component which, within the warranty period, is proved to be defective upon examination. If warranty service is required contact Radian Research and request a Return Material Authorization (RMA) number. You will need to provide the model number and serial number as well as a detailed description of the problem.

SERVICE

Warranty Service –

NOTE: REMOVING THE WARRANTY SEAL WITHOUT FIRST OBTAINING PERMISSION FROM THE FACTORY WILL VOID THE WARRANTY.

All warranty replacements must be authorized by the factory and all warranty returns require an "RMA" number (Return Material Authorization number). A separate number is required for each warranty claim. Items being returned for warranty repair must be shipped prepaid. Shipments should be made in the original packing to minimize the chance of damage in transit. Items should be shipped fully insured as Radian Research does not accept any liability for damage caused by improper packing or handling during shipment. Radian Research will prepay the regular shipping expenses of warranty repairs being returned after repair.

FOR WARRANTY REPAIR

1. Call the factory for an RMA number. This number must appear on the equipment, shipping label, purchase orders and payment.
2. Ship the unit in original packing to Radian Research as instructed when obtaining the RMA number

.

After Warranty Service –

After Warranty Service is basically the same as Warranty Service except that a purchase order or credit card is required to perform the service and the user pays the shipping costs both ways. Estimates of repair cost can be given if requested

FOR AFTER WARRANTY SERVICE

1. Call the factory for RMA number. This number must appear on the equipment shipping label, purchase orders and payments.

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2. Issue purchase order or credit card number and authorization to charge for repair. Bank card information required is billing address for the card, name on the card, card number and expiration date.
3. Ship unit in original packing, insured for replacement value to Radian Research as instructed when obtaining the RMA.

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CONTACTING RADIAN RESEARCH

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ACKNOWLEDGMENTS

The Admittance tester design is based on the principles given in the paper In-Situ Testing of Current Transformers without Interruption of the Supply, dated October 1980, by V.A. Muntz, Senior Test Engineer and P.G. Holmes, Engineer - Standards both of the State Electricity Commission of Victoria.

Portions of the text in this manual was contributed by Michael R. Hajny, Principal, Metering Engineering Inc., 725 Clearview Drive, Charleston, South Carolina, 29412-4545, USA, email michaelhajny@cs.com.

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APPENDIX

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CALIBRATION FACTORS

Model 505

Serial Number ______________________ Date of Shipment ___________________

Calibration corrections at shipment:

RMS Converter Response ______FAST_______

Operating Frequency ______50 or 60 Hz___

Voltage Gain, 0-140V range __________________

Voltage Gain, 140-600V range __________________

Secondary I Gain, 0-2A range __________________

Secondary I Gain, 2-20A range __________________

Primary I Gain, 0-0.2V range __________________

Primary I Gain, 0.2-3V range __________________

Admittance Offset 0-1 mS range __________________

Admittance Gain, 0-1 mS range __________________

Admittance Poly, 0-1 mS range __________________

Admittance Offset 0-10 mS range __________________

Admittance Gain, 0-10 mS range __________________

Admittance Poly, 0-10 mS range __________________

Admittance Offset 10-100 mS range __________________

Admittance Gain, 10-100 mS range __________________

Admittance Poly, 10-100 mS range __________________

Phase Offset, Voltage to Sec __________________

Phase Offset, Pri to Sec __________________

Voltage Burden Dwell Time ______0.8000______

Current Burden Dwell Time ______0.8000______

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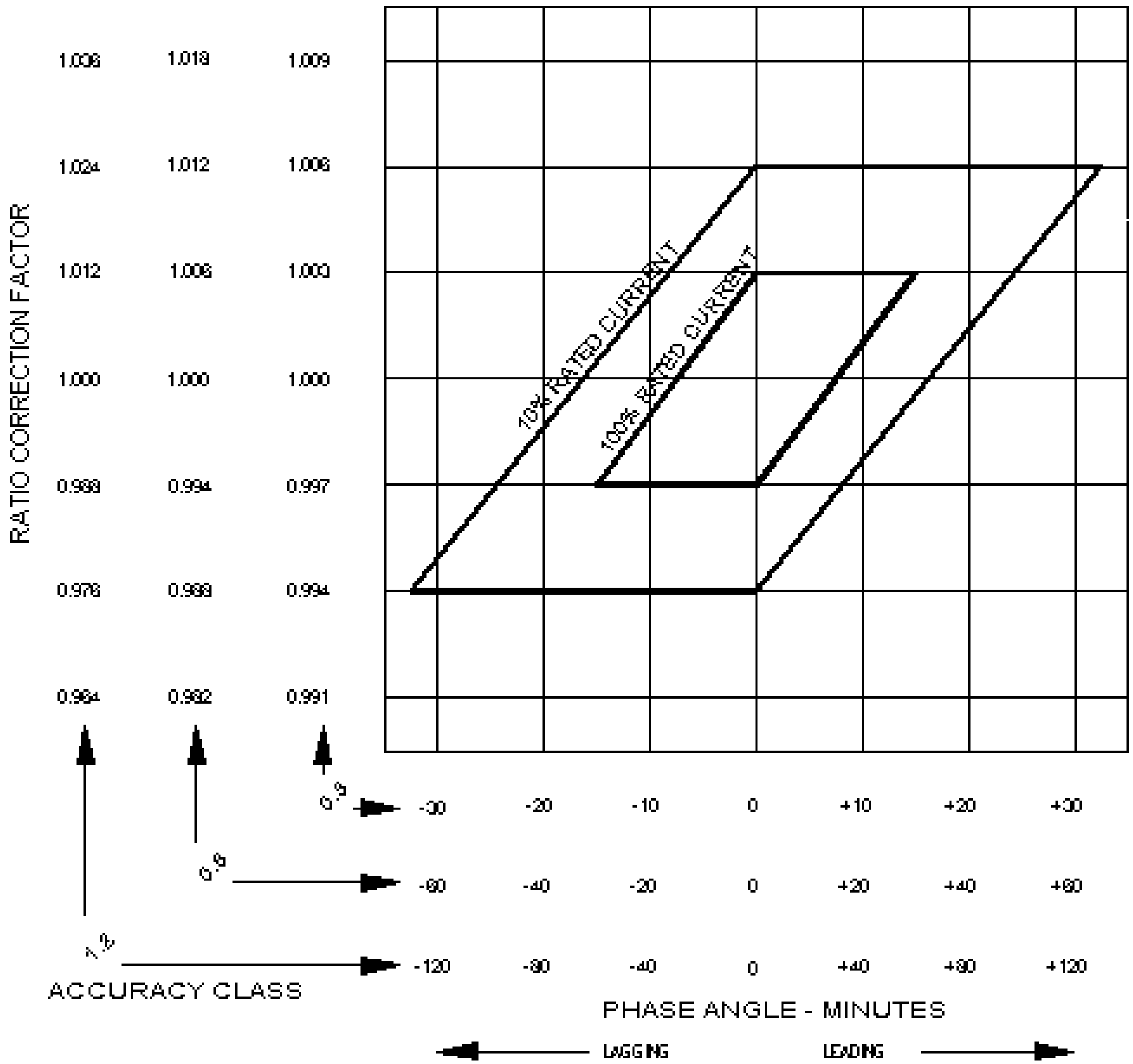
LIMITS OF ACCURACY CLASSES FOR CURRENT TRANSFORMERS

FOR METERING SERVICE



The accuracy requirements for 100% rated current also apply at the continuous-thermal-current rating of the transformer.

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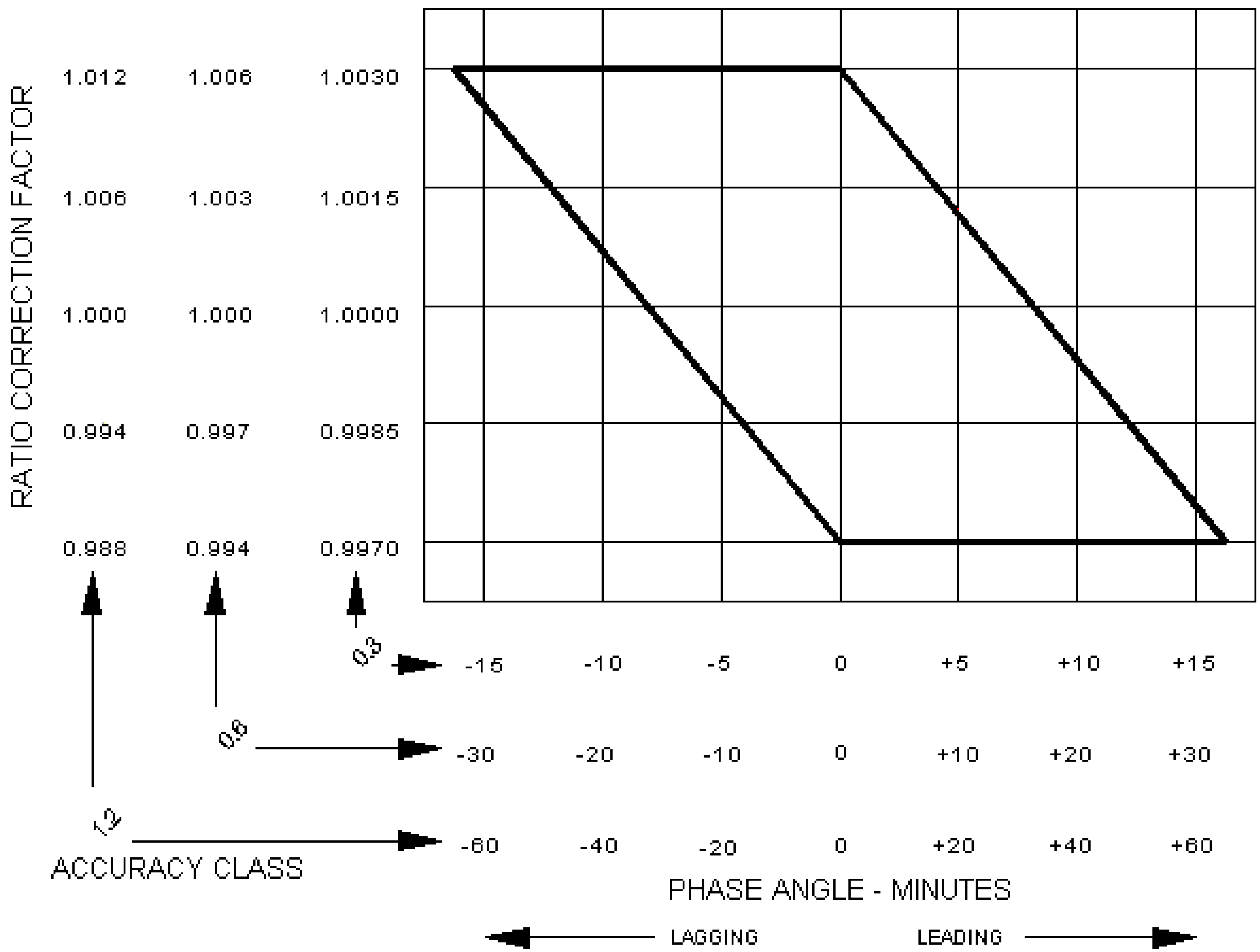
LIMITS OF ACCURACY CLASSES FOR VOLTAGE TRANSFORMERS

FOR METERING SERVICE



The transformer characteristics shall lie within the limits of the parallelogram for all voltages between 90% and 110% of rated voltage.

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GLOSSARY OF TERMS

Marked Ratio –

The ratio of the rated primary value to the rated secondary value as stated on the nameplate. This may also be called Best Fit Ratio and applies to Current and Voltage Transformers.

True Ratio –

The ratio of the rms primary value to the rms secondary value under specified conditions. This may also be called Actual Ratio. The secondary burden will affect the True Ratio which applies to Current and Voltage Transformers. In addition, the magnitude of the primary current will affect the True Ratio of a CT.

Accuracy Class –

Accuracy class defines an envelope of ratio accuracy and phase angle accuracy for defined burdens and applies to Current and Voltage Transformers.

Ratio Correction Factor –

The ratio of the True Ratio to the Marked Ratio applies to Current and Voltage Transformers.

Phase Angle –

The phase displacement between two measured Service parameters.

Transformer Correction Factor –

The ratio of True Watthours to the Measured Secondary Watthours, divided by the Marked Ratio.

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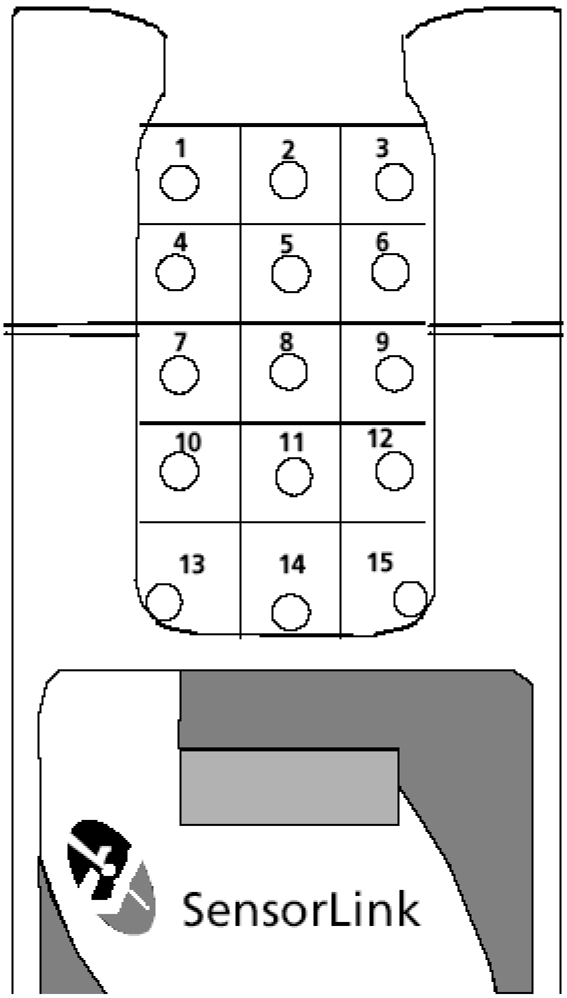
SENSORLINK ACCURACY MAP

Amp Sensor Accuracy Map



Ampstik Sensor Map
Unit: Ampstik Model 8-021
Conductor Used: ROME XLP Power Cable
Test: 60.0 Amps RMS SineWave

Date: 8/27/99

Grid Block	Ampstik Under Test Amps RMS	Calibration Standard Position 11 Amps RMS	Percent Error
1	63.0	60.0	-4.762
2	51.6	60.0	16.279
3	63.8	60.0	-5.956
4	60.0	60.0	0.000
5	59.3	60.0	1.180
6	60.2	60.0	-0.332
7	60.1	60.0	-0.166
8	60.1	60.0	-0.166
9	60.4	60.0	-0.662
10	60.0	60.0	0.000
11	60.0	60.0	0.000
12	60.1	60.0	-0.166
13	59.9	60.0	0.167
14	59.8	60.0	0.334
15	59.8	60.0	0.334

The above mapping of our Amp Sensor is a typical representation of the SensorLink patented amp sensor design. Actual mapping may vary slightly.

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PROTECTION OF ELECTRONIC EQUIPMENT USED IN SUBSTATION YARDS FOR TESTING

Situation

Electronic equipment is being operated in a substation yard, and the equipment is powered from a transformer located some distance away from the electronic equipment. The equipment could be test equipment, lap top computer, digital camera, cell phone, etc.

The source of the power is one of the auxiliary power transformers for the substation; in this case the power extension cord is often connected to a circuit breaker in the electrical service panel in the control building. Another source of the power could be one of the banks of PTs used for metering, relaying, instrumentation, and control; in this case the power extension cord is connected to the load side of the fuses for the PT.

The length of the extension cord is long, 75 feet (25 meters) or more.

Symptoms

From time to time some of the equipment is destroyed; that is, components inside a device are burned up, opened, or shorted.

Causes

Switching operations and lightening on the transmission and distribution system give rise to two phenomenon that damage the electronic equipment at the test site.

1. ‘Touch and step potential rise’ between (a) the grounded neutral of the power transformer and (b) the location where you have placed the equipment in the yard (the test site).

2. Transients coming down the long power extension cord.

Remedy

At the location where the test equipment is being used install an isolation power transformer. Preferably the isolation power transformer has a Faraday shield inside. The lead wire for this shield is bonded to earth ground at the test site. The primary and secondary voltages of the isolation transformer are chosen to match the source voltage (110 or 220 VAC), and the load voltages of the electronic devices (110 or 220 VAC). The VA capacity of the transformer needs to be large enough to handle the load of the electronic equipment.

The isolation power transformer must be a two winding transformer, not an autotransformer. Therefore, for safety and operational reasons the neutral of the secondary of the isolation transformer must be connected to earth ground at the test site.

Install two plug strips with surge arresters at the test site, one on each side of the isolation power transformer. The plug strips with surge arresters should be the kind that have MOVs connected line to ground, line to neutral and line to line. Both plug strips must be grounded at the test site.

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One of the plug strips with surge arresters will fault internally from time to time. The extent of the fault can range from the MOV being destroyed to the insides of the strip being burned and blackened. Most likely it will be the plug strip on the line supply side of the isolation transformer. This is evidence that there are touch and step potential rises and transients in the yard, and the transients are large and damaging. Do not be surprised when a plug strip does fail, and have a couple of the extra power strips handy for replacements. Plug strips with surge arresters are available at many local computer and electronics supply stores.

Use a twisted pair and shielded cable for the long power extension cord. Ground the shield of the extension cord at one end; for example, at the test site in the yard where the work is being performed. The shield at the other end must be folded back and covered with electrical tape to prevent a shock hazard to personnel and to prevent a flashover from the shield to earth at the ungrounded end.

Additional features include an indicating voltmeter, an indicating lamp, and a double pole molded case circuit breaker. The molded case circuit breaker is used for protection in the event that the plug strip's circuit breaker does not clear the fault. Also, the double pole molded case circuit breaker is used so that both the hot and the neutral lines from the power extension cord can be disconnected from the source simultaneously.

Additional Considerations

Operate the electronic equipment in accord with the manufacturer's suggested practices.

Comply with all of the utilities safety and operating requirements and procedures.

Following is a diagram of the proposed isolation transformer connection.

Acknowledgement

This protection method was designed by Michael R. Hajny, Principal, Metering Engineering Inc., 725 Charleston, South Carolina, 29412-4545, USA, for his work with the Electric Utility of the country of Georgia. Michael's email is michaelhajny@cs.com.

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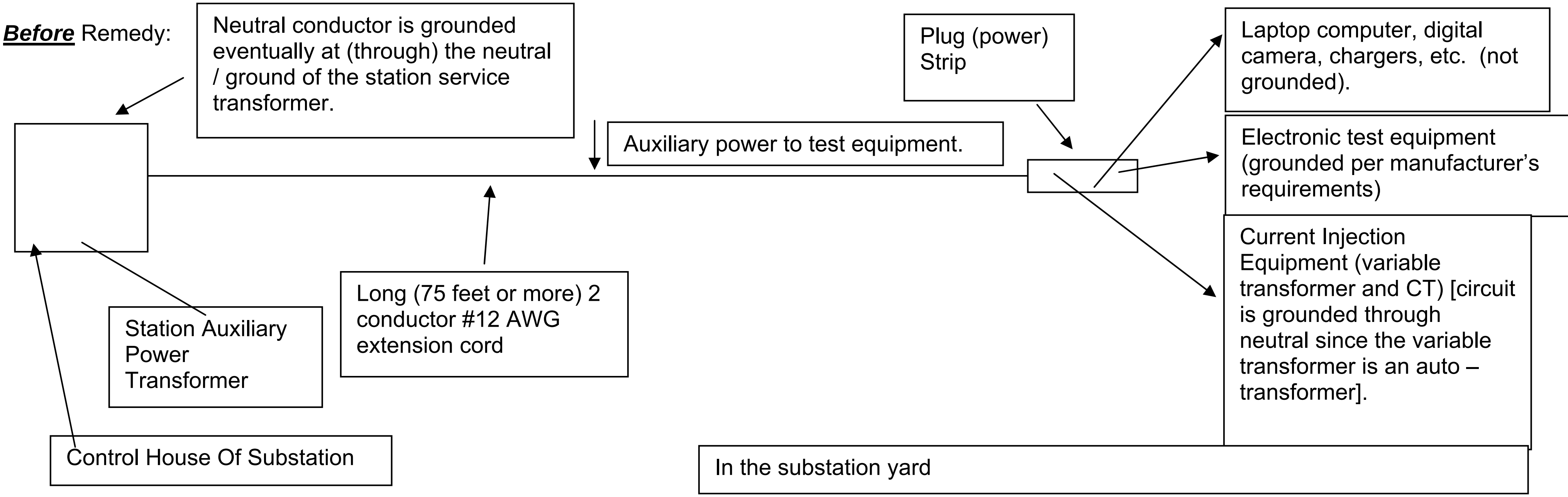

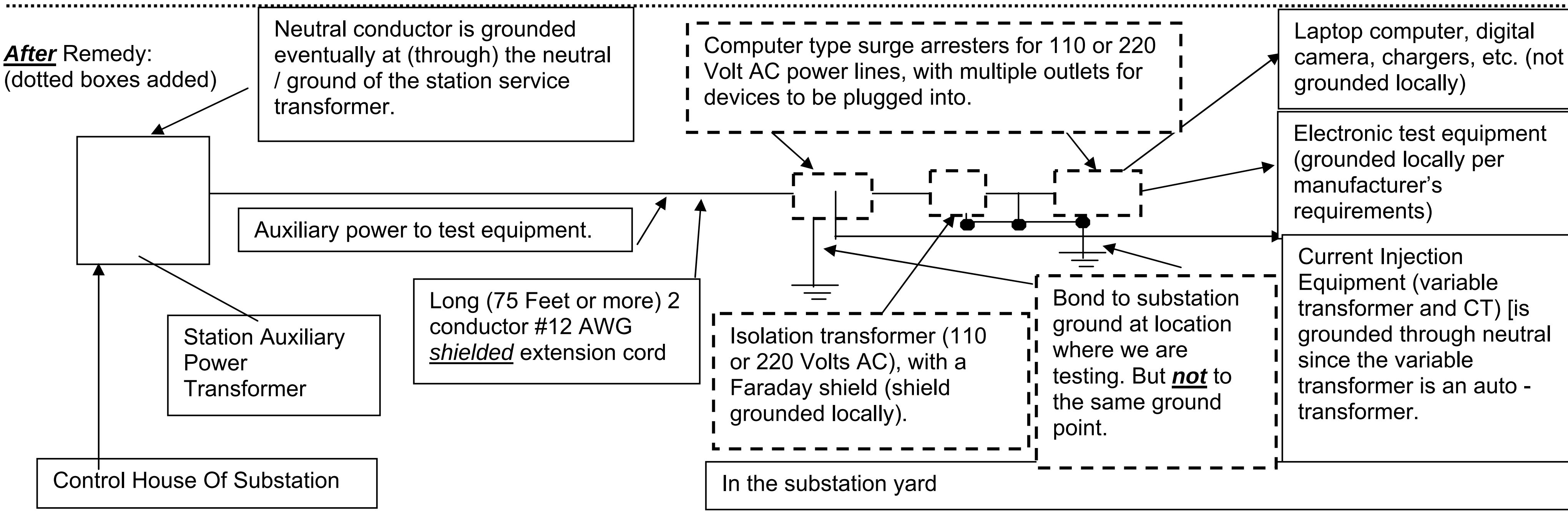

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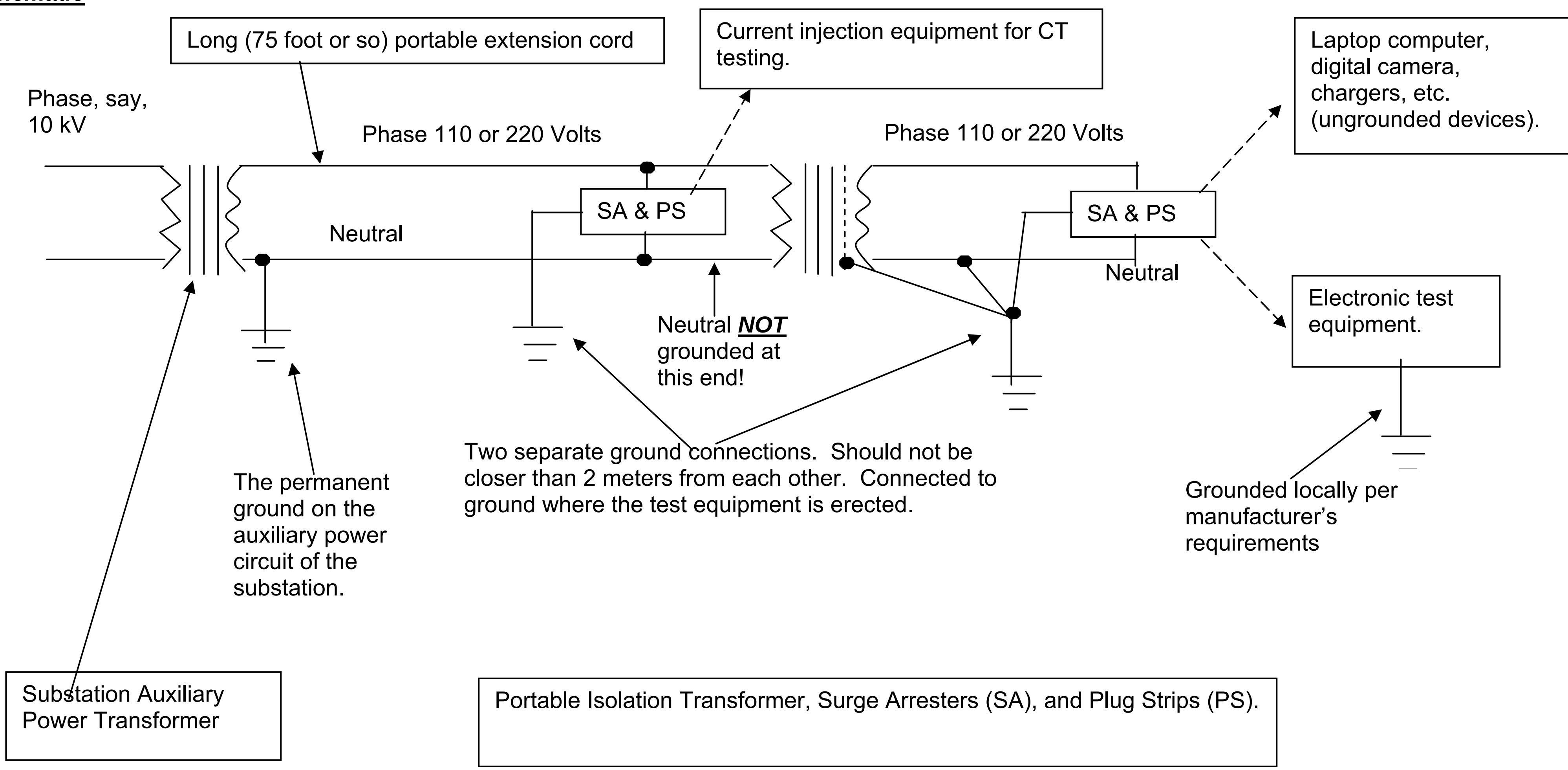
Schematic



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