

Instruction Manual AVTM830280
for
Transformer Ohmmeter

Catalog No. 830280

High-Voltage Equipment
Read the entire manual before operating.

Aparato de Alto Voltaje
Antes de operar este producto lea este manual enteramente.

Megger.

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Megger.

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The information presented in this manual is believed to be adequate for the intended use of the product. If the product or its individual instruments are used for purposes other than those specified herein, confirmation of their validity and suitability must be obtained from Megger. Refer to the warranty information included in this instruction manual. Specifications are subject to change without notice.

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1. GENERAL INFORMATION

1.1 ABOUT THE TRANSFORMER OHMMETER

The **Megger**. Transformer Ohmmeter is a line-operated, field-portable instrument designed specifically to measure the dc resistance of all types of magnetic windings safely and accurately.

Its predominant use is the measurement of the dc resistance of all types of transformer windings within the defined ranges of current and resistance.

It can also test rotating machine windings and perform low-current resistance measurements on connections, contacts and control circuits.

Three features combine to make this instrument unique: dual measurement, load tap-changer testing and safety shutdown.

The dual set of potential inputs measure the resistance of the primary and secondary windings of a single- or three-phase transformer simultaneously. The dual reading characteristic will speed up the measurement when it is used to test windings on delta-delta connected windings on three-phase transformers.

Due to circulating currents induced when the test current is applied to the primary winding, this type of measurement is countered by the same current on the secondary winding. This action attenuates the circulating current and the reading time is improved tenfold.

The Transformer Ohmmeter is extremely useful when testing the windings and contact resistance on tap-changers with make-before-break contacts and voltage regulators.

The internal shutdown circuit will be triggered by a voltage kickback of a few microseconds if the tap-changer contacts are opened when the tap-changer circuit is operated through all of the tap positions.

This action will check for pitted or misaligned contacts as the instrument will shut down if either condition occurs.

Users are protected by the shutdown circuit safety feature: any inadvertent disconnection of a test lead or loss of power to the instrument will safely discharge the energy stored in the test sample.

The Transformer Ohmmeter's wide resistance range (1 micro-ohm to 1999 ohms) gives the optimum resolution for even the lowest winding resistance tested.

1.2 FEATURES

- Direct digital reading saves time, no balancing is required.
- Built-in discharge circuit safely discharges the specimen when test is completed, if lead accidentally disconnects or if power is lost.
- Electromechanical safety indicator gives a visual indication of a charged or discharged specimen, even if power to the instrument is lost.
- Two independent measuring channels allow simultaneous testing of primary and secondary windings or measurement of two phases at a time.
- The sensitive surge detection circuitry monitors the contact operation of on-load tap-changers for the proper make-before-break sequence. If an open circuit condition exists, the instrument shuts down immediately.
- High-accuracy, four-terminal bridge: no lead compensation required.
- Electronically generated and regulated current supply overcomes high-inductance transformers quickly, allowing fast measurements to be taken. Display of measurement occurs only after test current stabilizes.
- Wide resistance range is suitable for testing a wide variety of transformers.
- Lightweight and portable, the Transformer Ohmmeter is ideal for use in shop or substation environments.
- Overtemperature protection provides automatic current shutdown and LED indication to prevent instrument damage.
- Instrument and accessories come in a foam-lined transport case.

1.3 UPON RECEIPT OF PRODUCT

Check the equipment received against the packing list to ensure that all materials are present. Notify Megger of any shortage (tel: 610-676-8500).

Examine the instrument for damage received in transit. If you find damage, file a claim with the carrier at once. Also notify Megger or its nearest authorized sales representative, and describe the damage in detail.

1.4 UNPACKING AND INSPECTION

Prior to shipment, this instrument was electrically tested and mechanically inspected and found to meet specifications and be free of mechanical defects.

After unpacking the instrument, visually inspect the instrument and accessories for damage. If evidence of damage is present YOU must contact the carrier who transported the unit and file a claim in writing. The shipping container and packing material should be retained for inspection by the carrier's agent. Electrical operation per Section 3 should be checked as soon as possible after shipment.

1.5 SAFETY FIRST

Be sure to read the safety information in Section 2 thoroughly and observe all safety precautions and recommendations. **Safety is the responsibility of the user.**

1.6 HOW TO USE THIS MANUAL

Typographic conventions

- Figures and tables are numbered in sequence by section
- Numbered lists show procedural steps
- Bullets list items and options
- Warnings, Cautions and Notes
 - *Warnings* alert you to conditions that are potentially hazardous to people
 - *Cautions* alert you to possible damage to equipment
 - *Notes* provide important explanation or assistance



WARNING

DO NOT DISCONNECT LEADS BEFORE INDICATOR (7) IS OFF (BLACK)!!!



CAUTION

It should be carefully noted that the jumper in Figure 3 be connected to opposite polarities of transformer in order to achieve correct results.

NOTE

For larger transformers, the resistance display (14) should be observed and resistance readings taken when the reading stabilizes. The drift in the indicated resistance reading is due to the inductance of the transformer. For small transformers the drift lasts for only a few seconds; for single-phase high voltage transformers (500 kV), the drift may last for a fraction of a minute; for large delta connected transformers the drift may last longer as a result of circulating current.

e.g. 345MVA, 500kV single-phase transformer requires approximately 2 minutes for the display to settle.

1.6 PREPARATION FOR USE

THIS INSTRUMENT IS DESIGNED TO OPERATE WITH HIGHLY INDUCTIVE TRANSFORMERS. ANY BREAK IN CONNECTION WHILE D.C. CURRENT IS FLOWING MAY RESULT IN HIGH VOLTAGE FLASHOVER. It is highly recommended that the operator familiarize himself with the controls and functions detailed in Section 3 prior to use. ALL SAFETY PROCEDURE AND PRECAUTIONS MUST BE FOLLOWED WHEN OPERATING ON LINES WITH LETHAL VOLTAGES OF HIGH CAPACITY.

1.7 LINE SUPPLY VOLTAGE

This instrument is shipped from the factory for operation on a 115 volt, 60Hz line. To prevent damage to the instrument, select the proper line voltage on the front panel selector before connection to a line supply.

1.8 REPACKING AND SHIPMENT

To insure proper shipment of this instrument, it is recommended that the original shipping case be retained. If being returned for calibration or service, please attach a card to the instrument specifying the owner, model and serial number and service required.

1.9 SPECIFICATIONS

The detailed specifications for the model are given below.

Input Power:	120/240 V, 50/60Hz, 350 VA		
Measurement Principle:	Electronic Thompson-type circuit		
Current Supply Principle:	Electronically generated and regulated		
Test Current:	Switch selectable		
Ranges:	5 mA, 50 mA, 500 mA, 5 A (dc)		
Open Circuit Test Voltage:	30 V dc		
Rating:	Continuous use on all ranges		
Indication:	Mechanical indicator (indication of current flow even when instrument turned off or unplugged). Output current displayed on display "A"(in %).		
Over Temperature Protection:	Automatic current shutdown with L.E.D. indication of over temperature condition for 5A range.		
Resistance Measurements:			
Inputs:	Two isolated high impedance inputs, each with separate range control and protection provided for flashover caused by inductive kickback		
Ranges (ohms):			
	Nominal	Resolution	Maximum Display
	2m	0.001m	1.999m
	20m	0.01m	19.99m
	200m	0.1m	199.9m
	2	0.001	1.999
	20	0.01	19.99
	200	0.1	199.9
	2000	1.0	1999
Accuracy:	$\pm 0.5\%$ reading, $\pm 0.5\%$ full scale (when current has stabilized).		

Overrange: Indicated by leading number 1 displayed with all other digits blanked.

Operation:

Environmental: Operating: 32 to 104° F (0 to 40°C) RH to 80%
Storage: -40 to 149° F (-40 to +65°C)

Temperature Coefficients: $\pm 0.05\%$ of applicable accuracy specification per °C of resistance range.

Displays: Two high-temperature, 0.7 in. (18 mm), liquid crystal 3 1/2-digit displays showing 1999 at full scale. Update rate is approximately three times per second.

Physical: Instrument and accessories supplied with portable foam lined carrying case. Case has hinged opening from above with a lockable latch.

Sizes: Instrument: 11 H x 16 W x 10.5 D in.
280 H x 406 W x 267 D mm
Case: 13 H x 20 W x 21 D in.
330 H x 508 W x 533 D mm

Weight: Instrument: Net 40 lb (18 kg)
Shipping: 75 lb (34 kg)

1.10 ACCESSORIES FURNISHED

Each instrument is supplied complete with:

- Two sets of potential leads, 33 ft (10 m)
- One set of current leads, 33 ft (10 m)
- One shorting lead, 9.9 ft (3 m)
- Universal bushing adapters (set of 4)
- AC power cord
- One operating and instruction manual
- One transport case

1.11 CHANGES

Please note that this instrument is subject to continuous development and improvement. This instrument may therefore incorporate minor changes in detail from the information contained herein.

1.12 WARRANTY

Megger warrants this instrument sold by us or our authorized agents, to be free from defects in material and workmanship for a period of 12 months from date of shipment. During the warranty period, Megger will, at our option, repair or replace the Instrument or part thereof which proves to be defective providing:

- (1) The Instrument is returned properly packed and transportation prepaid with prior authorization from us or our appointed agent,
- (2) The Instrument has not been altered, modified or repaired by unauthorized personnel and,
- (3) That our examination discloses to our satisfaction that any improper operation or failure was the result of defective material or workmanship and was not the result of improper use, negligence or accident, exceeding environmental limits, or connecting the instrument to incompatible equipment.

This warranty is exclusive and is given and accepted in lieu of all other warranties, express or implied, and constitutes fulfillment of all our liabilities to the purchaser. Megger specifically disclaims the implied warranties of merchantability and fitness for a specific purpose. We assume no liability, in any event, for consequential damages, for anticipated or lost profits, for personal injury due to use or accident, for incidental damages or loss of time or other losses incurred by the purchaser or any third party in connection with instruments covered by this warranty or otherwise.

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2. SAFETY

2.1 Introduction

Megger has designed the Transformer Ohmmeter and the recommended operating procedures with careful attention to safety. It performs formal safety reviews of the initial design and any subsequent changes to all new Megger products. The safety review covers areas over and above those included in applicable IEC and ANSI standards.

Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment or to foresee every possible hazard. You are therefore urged not only to follow the safety rules in this manual, but also to consider carefully all safety aspects of the test before proceeding. **Safety is the responsibility of the user.**

The design of this equipment follows safety specifications IEC 1010-1 and ANSI/ISA 582.01 and meets the requirements for Class I, Installation Category II equipment.

Megger recommends that a qualified operator attend the system at all times while it is in operation. Only qualified service personnel should replace components or make internal adjustments.

2.2 General Safety Precautions

The equipment and the cable to which the Transformer Ohmmeter connects are sources of high-voltage electrical energy. Observe the following safety precautions:

- Observe all safety warnings on the equipment. They identify areas of immediate hazard that could result in injury or death.
- Use this equipment only for the purposes described in this manual.
- Treat all terminals of high-voltage power equipment as potential electric shock hazards.
- Use all practical safety precautions to prevent contact with energized parts of the equipment and related circuits.
- Use suitable barriers, barricades, or warnings to keep persons not directly involved with the work away from test activities.
- Never connect the test equipment to energized cables.
- Do not connect to energized equipment or use in an explosive atmosphere.
- Use the grounding and connection procedures recommended in this manual.
- Observe strictly the warning and caution notices used throughout this manual (see ‘How to Use This Manual’ on page 3).

2.3 SAFETY IN USING THE TRANSFORMER OHMMETER

Safety is the responsibility of the user.

When applying current to a transformer with very high inductance, care should always be taken not to remove current leads while current is still flowing. This causes an extremely high voltage to develop across the point where current is broken. With correct conditions, this voltage may even be lethal to the operator breaking the current path.

The Megger Transformer Ohmmeter has built-in safety protection. This safety feature is present in the form of an alternate route through either of the potential leads.

Example: If a current lead is disconnected while current is flowing through the transformer, the current will flow through the alternate path of the potential lead without damage to instrument or electrical shock to operator.

WARNING



It is very important, therefore, not to connect potential leads on top of or to close to current leads. In this way, if one lead falls off the transformer, the other lead will automatically follow.

WARNING



The Transformer Ohmmeter is protected in the event of both potential and current lead falling off at the same time. This does not mean, however, that the operator will not feel the high voltage that will be developed (if he is standing near the area where the lead disconnects).

3. OPERATING INSTRUCTIONS

3.1 PANEL CONTROLS AND OPERATING FUNCTIONS

This section details and describes the operating functions of the Transformer Ohmmeter. Refer to Figure 1.

1. Power ON.

Flipping this switch upwards will activate the instrument. With current control (4) in the center position, ready LED (5) will illuminate 15 seconds after the instrument is turned on.

2. Line Input Socket.

This international line socket also contains the line fuse and a spare fuse.

3. Line Voltage Selector.

The instrument is configured at the factory for 115 volt operation. Failure to select the correct line voltage could result in damage to the instrument.

4. Current Control.

This switch is used to initiate current flow from the instrument (up) and to activate a process whereby the device under test is discharged (down).

5. Ready L.E.D.

This L.E.D. must be illuminated to initiate a given test. This indicator will be inactive under the following conditions

- the test has been initiated
- the test specimen is undergoing discharge
- the surrounding electrical interference exceeds the instruments suppression capability

6. Over Temperature L.E.D.

This L.E.D. illuminates when the instruments internal components have exceeded their thermal capacity. This condition typically occurs after extended operation on the 5A range. A period of approximately 20 minutes is required before the instrument will again operate.

7. Current Indicator.

This mechanical device indicates the presence of current flow through the output terminals (9) and/or excitation voltage. This process operates independently of the power line voltage because current may be flowing in the test leads after the instrument has been turned off.

8. Potential Input "A".

Connected across a transformer winding, this input measures the winding voltage drop and displays the related resistance value on display "A" (15).

9. Current Output.

Connected across a transformer winding, this output supplies a selected D.C. current through the winding.

10. Potential Input "B".

Connected across a transformer winding, this input measures the winding voltage drop and displays the related resistance value on display "B" (16).

11. Current Selector.

This switch allows selection of the test current which will be supplied to the transformer windings via output terminals (9). It also changes resistance ranges, increasing resolution with an increase in the test current range.

12. Range Selector "A".

This switch changes the resistance range for potential input "A".

13. Range Selector "B".

This switch changes the resistance range for potential input "B".

14. Display Selector.

This switch selects the value to be monitored on display "A". (Either percent of the test current or the load resistance).

15. Display "A".

Value displayed is either the resistance related to potential input "A" (8) or percent of the test current output (9).

16. Display "B".

Value displayed is resistance related to potential input "B" (10).

17. Resistance Range Table.

This table shows the maximum allowable resistance for the combination of current selector (11) and range selector (12 or 13).

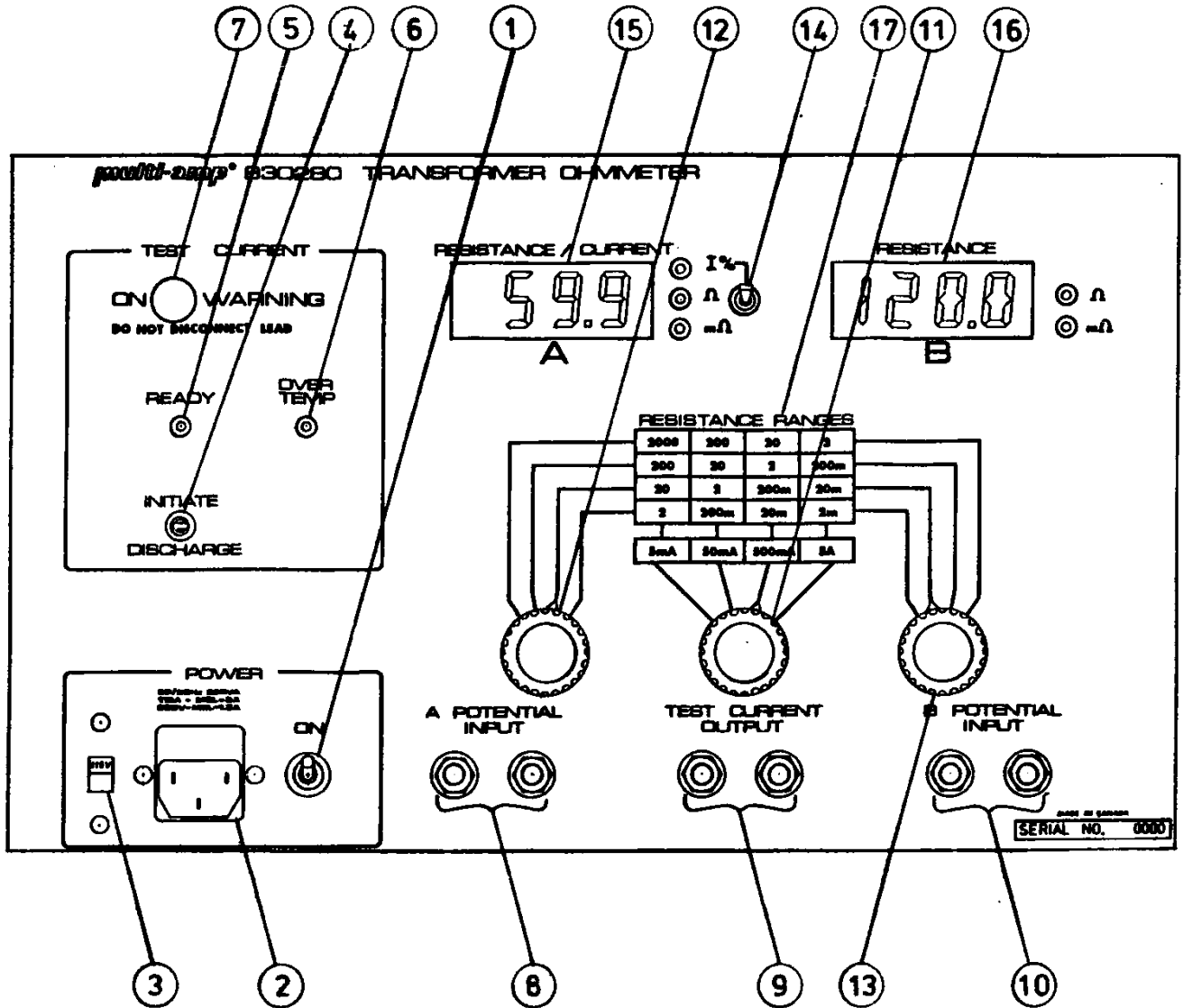


FIGURE 1: PANEL CONTROLS AND OPERATING FUNCTIONS

3.2 PRINCIPLE OF OPERATION

The Megger Transformer Ohmmeter measures the resistance of a transformer winding by:

1. Applying a D.C. current through the transformer winding and an internal standard current shunt.
2. Measuring the D.C. voltages across the winding and the shunt.
3. Comparing the two voltages and displaying their ratio as resistance.

This method neglects lead resistance because it is independent of current. All readings are direct and therefore no multiplication factor need be applied when changing current ranges.

When testing transformers having large inductance, the D.C. current source must be extremely stable. This is seen in the formula for the D.C. voltage across an inductor:

$$V \text{ D.C.} = I \times R + L \, dI/dt$$

Where,

$V \text{ D.C.} =$ D.C. voltage across transformer winding.

$I =$ D.C. current through transformer winding.

$R =$ Resistance of the Tx winding.

$L =$ Inductance of Tx winding.

$dI/dt =$ Changing value of current (ripple) (Equals "0" for steady D.C.).

For optimum operation, the Transformer Ohmmeter resistance displays will only stay on with test current larger than 55% of set current range. If current does not reach the required 55%, resistance display will not show any value.

3.3 GENERAL OPERATING INSTRUCTIONS & INSTRUMENT SELF-CHECK (see Figure 1).

1. Connect line cord to instrument and plug into power socket (ensure that line voltage selector (3) is set to correct voltage).
2. Set the following:
 - a. Current Control (4): Middle position.
 - b. Display Selector (14): Up position.
 - c. Range Selector "A" (12): Left most position.
 - d. Range Selector "B" (13): Right most position.
 - e. Current Selector (11): 5mA.
3. Short current output (9); Short potential input "A" (8).
4. Turn power switch (1) "ON". "Ready" L.E.D. (5) should illuminate.
5. Push current control switch (4) up to initiate current flow. Release when current indicator (7) comes on.
6. Observe display "A". Indication should show an increasing number with "%" L.E.D. illuminated.
7. Reading should settle. This value has no effect on accuracy of resistance readings.
8. Switch display selector (14) down.
9. Indication should be "000" and ohms L.E.D. illuminated.
10. Set momentary current control (4) "down". Current should discharge and current flow indicator (7) should turn off.
11. If desired, set current selector (11) to another current and proceed with steps 3 to 11.

ALTERNATE

1. For step 3 above; place a standard current shunt or standard resistor (of known value, less than 2,000 ohms) between current output (9). Place potential input "A" (8) across inside of current shunt.
2. Following steps 1 to 11 above (with the exception of step 3), the value of the standard shunt should be read on display "A".

WARNING



When testing a transformer or regulator, make sure that a good ground is placed on the test specimen as shown on all connection diagrams.

3.4 PROCEDURE FOR SINGLE PHASE TRANSFORMER TESTING

This procedure describes only the basic connections and control settings for a single phase, two winding transformer. Following this description will be connections and any special notes for three phase transformers. Different types and sizes will vary the settling time of the test current and hence vary the time required to obtain readings. Because all input and output terminals are totally isolated on the Transformer Ohmmeter, no grounds need be removed from the transformer under test.

See Section 3.1 for explanation and location of controls.

3.4.1 SINGLE WINDING TEST

See Figure 2 for connection to the test transformer.

PROCEDURE:

1. Connect line cord to unit and plug into 120V socket.
2. Set the following conditions:
 - a. Display Selector (14): up position.
 - b. Range Selector "A" (12): left most position.
 - c. Range Selector "B" (13): right most position.
 - d. Current Selector (11): to desired test current (guide by resistance table on face plate).
3. Connect current output (9) to test specimen winding. See Figure 2.
4. Connect "B" potential input (10) to test specimen winding. Do not clip potential leads on to the current leads, since this will add contact resistance to the measurement. Potential leads should always be placed inside (between) current leads. See Figure 2.
5. Turn power switch (1) "ON". "READY" L.E.D. (5) should illuminate.
6. Push current control switch (4) up to initiate current flow. Release when current indicator (7) comes ON.
7. Display "A" (15) indicates current output (in %). As output current approaches steady value, display "B" (16) comes on and indicates resistance of specimen.

NOTE

For larger transformers, the resistance display (14) should be observed and resistance readings taken when the reading stabilizes. The drift in the indicated resistance reading is due to the inductance of the transformer. For small transformers the drift lasts for only a few seconds; for single phase high voltage transformers (500 kV), the drift may last for a fraction of a minute; for large delta connected transformers the drift may last longer as a result of circulating current.

e.g. 345MVA, 500kV single phase transformer requires approximately 2 minutes for the display to settle.

8. The range switch "B" (13) may require re-setting to a more suitable resistance range.
9. When measurement is complete, push the current control switch (4) down to terminate measurement and discharge current. Discharge is complete when current indicator (7) is off (black).



WARNING

DO NOT DISCONNECT LEADS BEFORE INDICATOR (7) IS OFF (BLACK)!!!

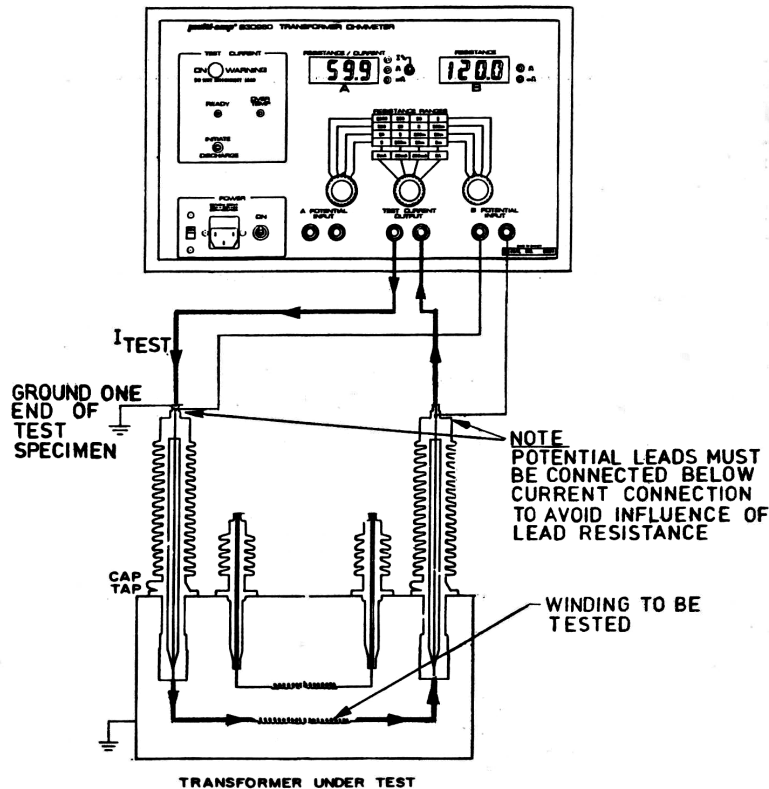


FIGURE 2: SINGLE WINDING MEASUREMENT

3.4.2 DUAL WINDING TEST

This procedure described below is for testing both windings (high and low) on a single phase transformer.

See Figure 3 for connection to test transformer.



CAUTION

It should be carefully noted that the jumper in Figure 3 be connected to opposite polarities of transformer in order to achieve correct results.

PROCEDURE:

1. Connect line cord to unit and plug into line socket.
2. Set the following conditions:
 - a. Display Selector (14): down position.
 - b. Range Selector "A" (12): left most position.
 - c. Range Selector "B" (13): right most position.
 - d. Current Selector (11): to desired test current. Best results will be at highest current (guide by resistance table on face plate).
3. Connect current output (9) to test specimen winding. See Figure 3.
4. Connect "A" potential input (8) to H1 and H2 terminals of test transformer. Potential leads should be placed inside current lead and shorting jumper.
5. Connect "B" potential input (10) to X1 and X2 terminals of test transformer. Potential leads should be placed inside current lead and shorting jumper.
6. Turn power Switch (1) "ON". "READY" L.E.D. (5) should illuminate.
7. Push current control switch (4) up to initiate flow. Release when current indicator (7) comes on.
8. Observe display "A". Indication should show an increasing value with "%" L.E.D. illuminated.
9. When reading settles indication will automatically switch to "ohm" indication and display resistance of H1 - H2 winding.
10. Display "B" will now indicate resistance of X1 - X2 winding.
11. To obtain best resolution for both display A and B, adjust range selectors (12 and 13).

- When measurement is complete, push the momentary current control switch (4) down to terminate measurement and discharge current. Discharge is complete when current indicator (7) is OFF (black).



WARNING

DO NOT DISCONNECT LEADS BEFORE INDICATOR (7) IS OFF (BLACK)!!!

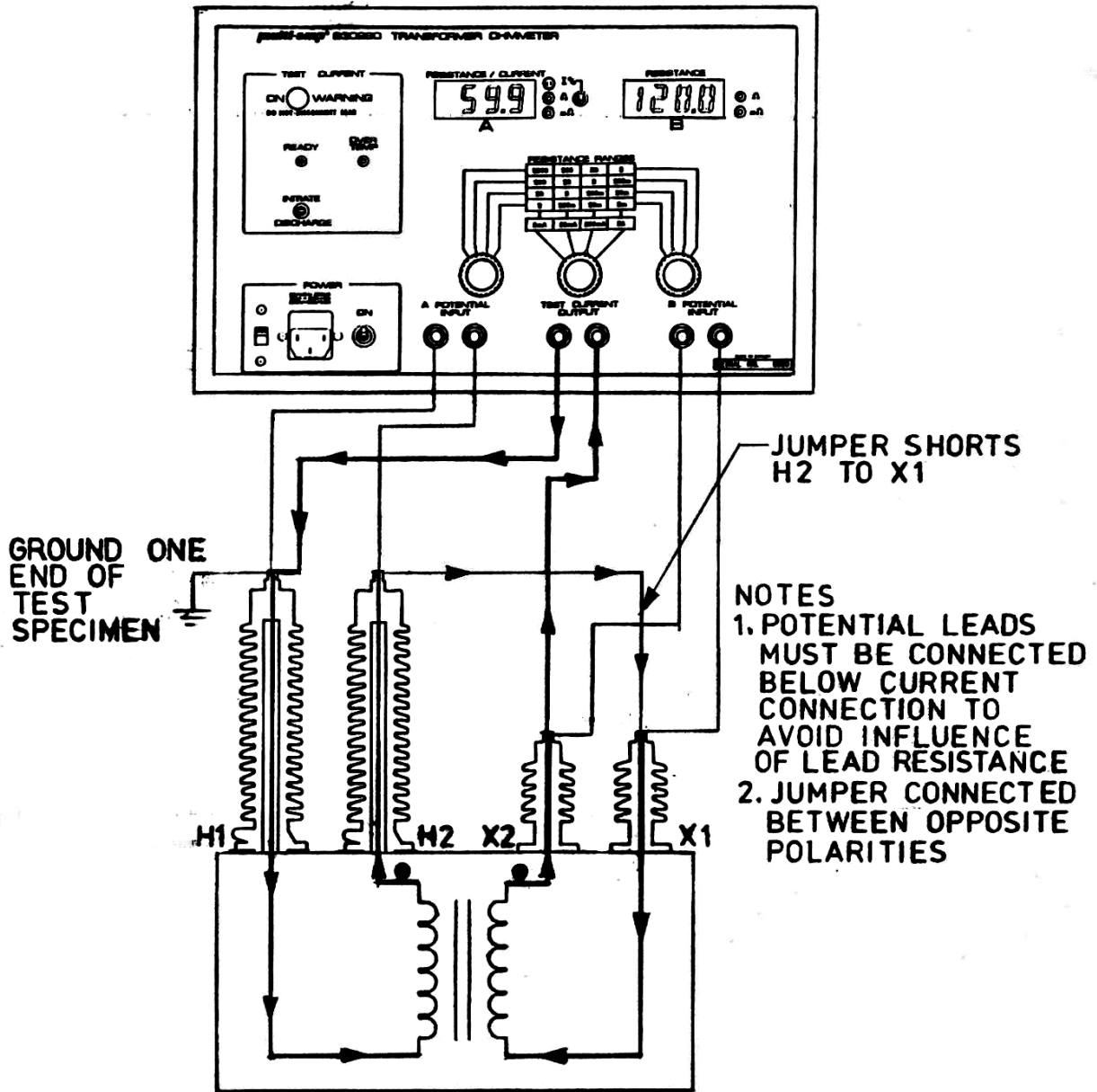


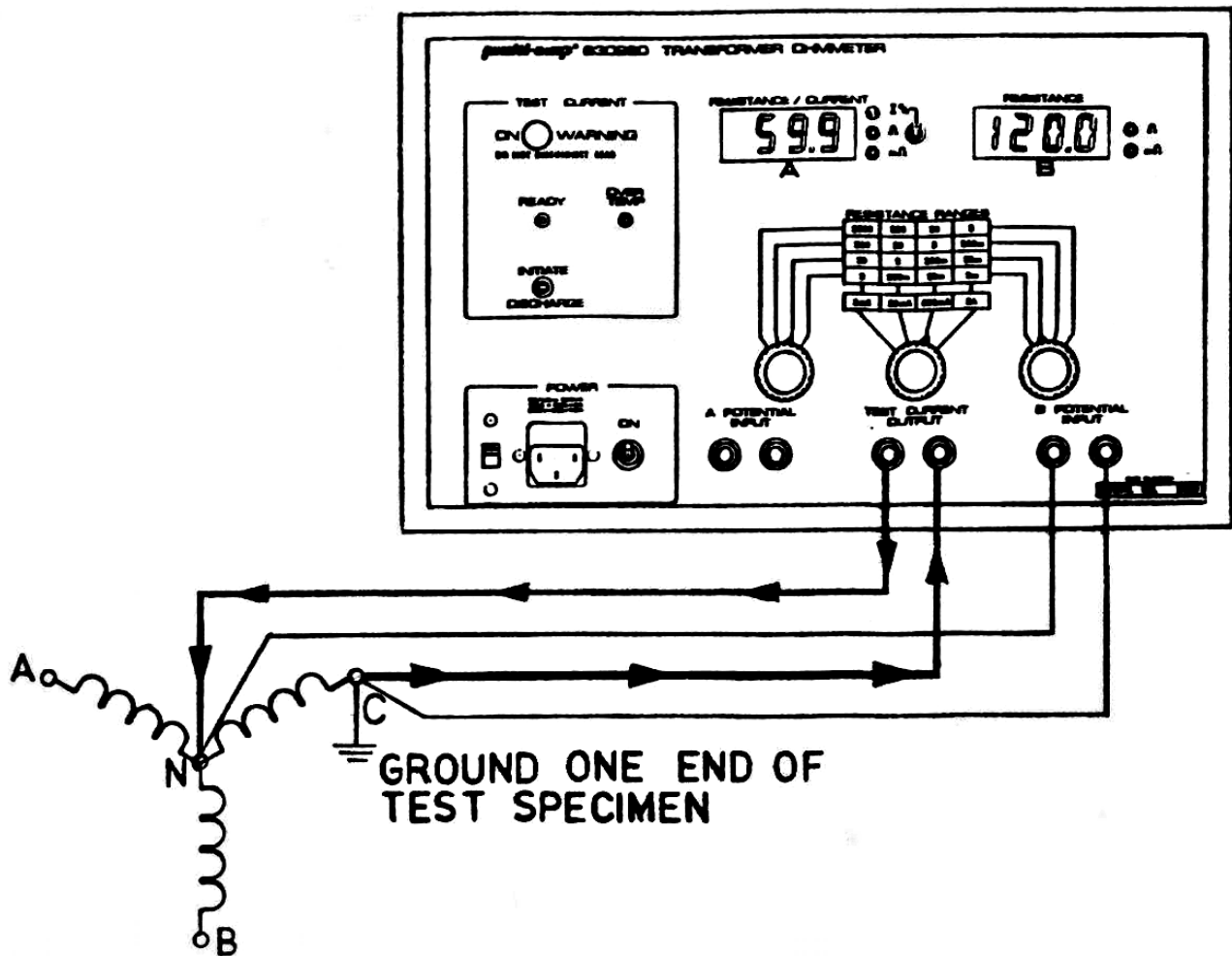
FIGURE 3: DUAL WINDING TEST

3.5 PROCEDURE FOR THREE PHASE TRANSFORMER TESTING

The following section details connections to be made on three phase transformers. These connections detail the different methods to be used in order to obtain the best results. The measurements taken will be for one winding at a time. The following connection diagrams (Figures 4 to 7), therefore, are to be used in conjunction with procedure "3.4.1 Single Winding Test". This procedure is to be used when performing three phase transformer testing. The only changes will be placement of leads.

PROCEDURE:

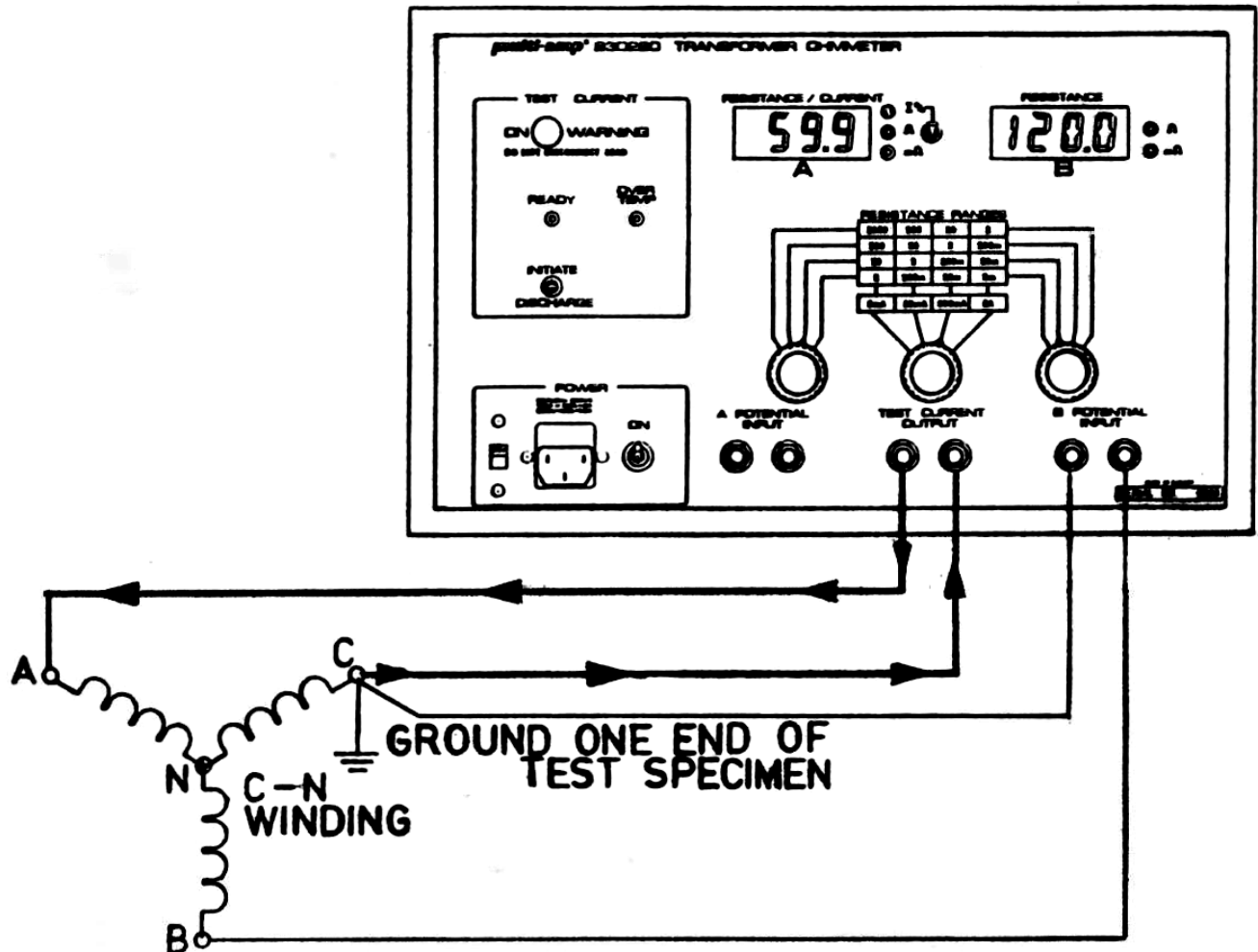
1. THREE PHASE WYE CONFIGURED WINDING WITH NEUTRAL



READING OBTAINED IS DIRECT, RESISTANCE OF C-N WINDING

FIGURE 4

2. THREE PHASE WYE CONFIGURED WINDING, NO NEUTRAL BROUGHT OUT



READING OBTAINED IS DIRECT, RESISTANCE OF C-N WINDING

FIGURE 5

3. THREE PHASE, DELTA CONFIGURED WINDING

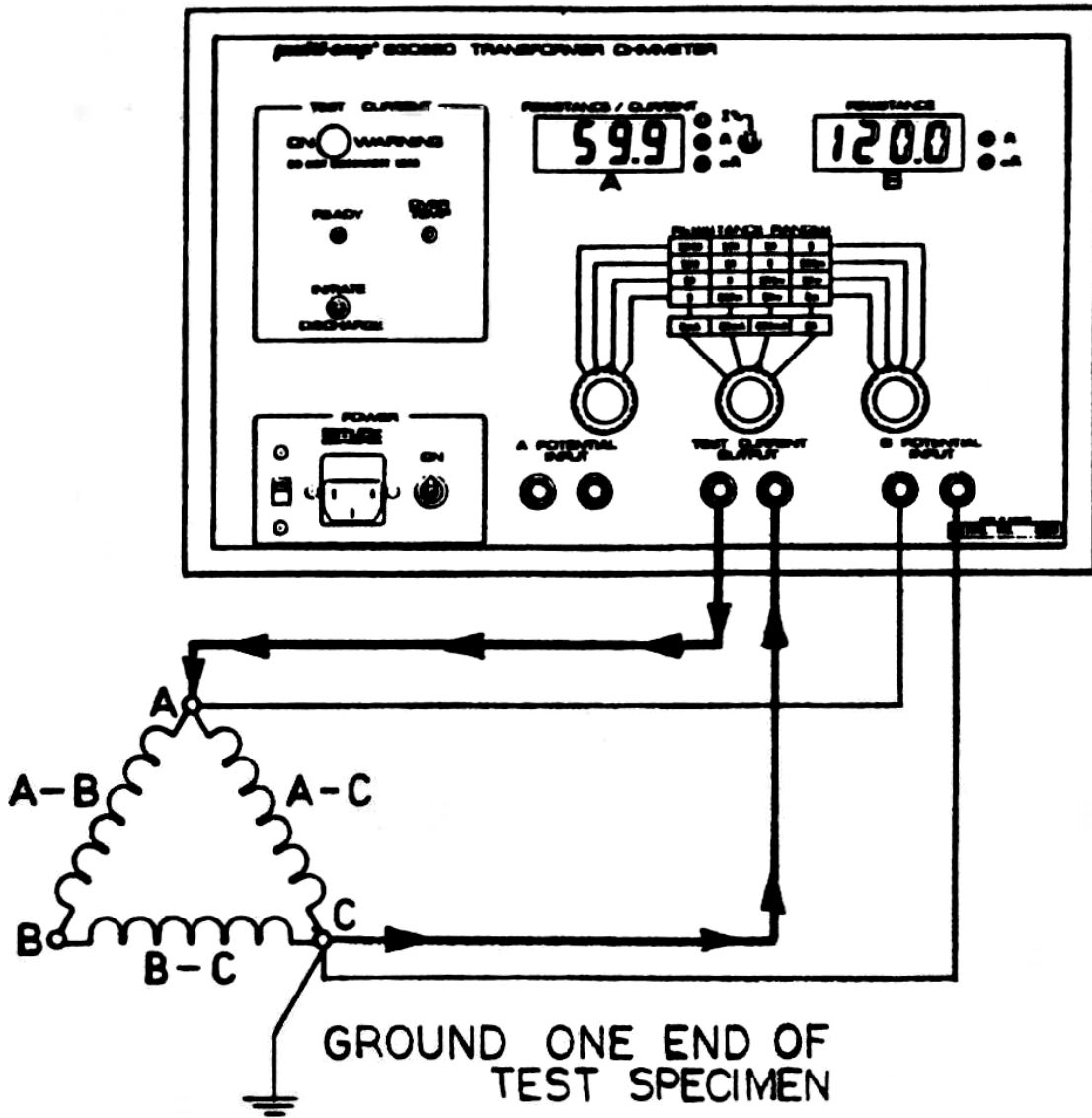


FIGURE 6

Assuming resistance of all three windings are equal.

Resistance of winding a-c = reading obtained x 1.5

Two other windings are parallel to winding to be measured (a-b + b-c)

To measure winding a-b, place current and potential leads to a phase and b phase bushings

Winding resistance a-b = reading obtained x 1.5

For absolute method, see section 3.5.1

3.5.1 TESTING DELTA-DELTA CONFIGURED WINDINGS

Although Delta-Delta transformers are not very common, they are present for various requirements. The testing of a Delta-Delta for winding resistance is usually a very time consuming procedure. This is because the two windings resemble two closed loop inductors. When energy is brought into the inductors, this energy (in the form of D.C. current) continually circulates within each winding. The correct balance time can take up to 30 minutes, which far exceeds the time restriction of many tests.

The method for testing this configuration quickly requires that both the high side and low side be connected in series with the Transformer Ohmmeter's current source (see Figure 7). By having the two windings in opposite polarity, the internal circulating currents settle very quickly to obtain a balance, and discharge with the same speed. Test time, for example, is reduced from 14 minutes to 30 seconds on a 300k VA Delta-Delta transformer. Even if only one side of the transformer needs to be tested, connecting both high and low windings in series will speed the test up considerably.

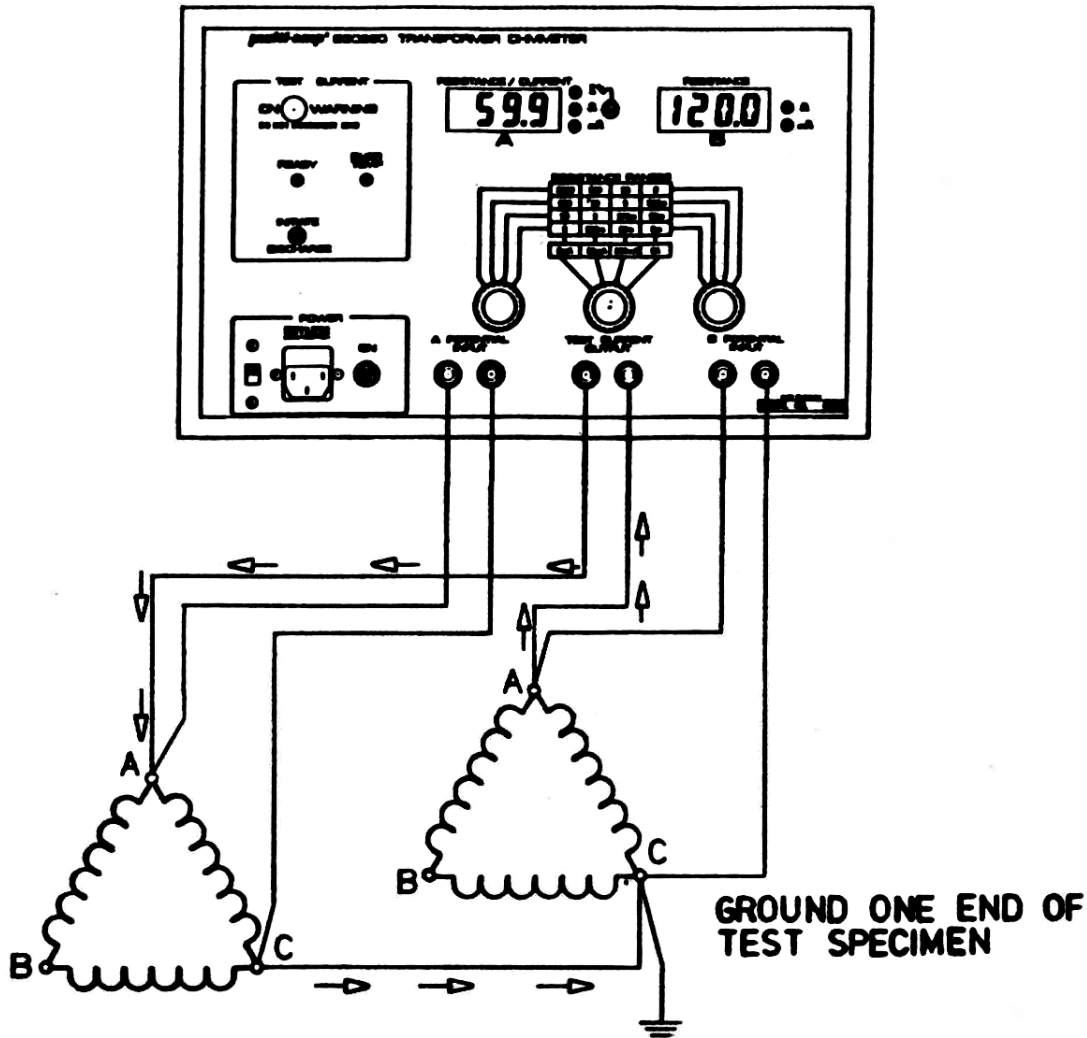


FIGURE 7

3.5.2 CALCULATION OF DELTA WINDING RESISTANCE

In the electrical power industry we find a lot of equipment that is connected in delta. An ordinary ohmmeter, when measuring a delta connected set of resistances, measures one resistance shunted by the other two series connected resistances. Calculating the value of the resistances is easy when they are equal, since the measured value can be multiplied by 1.5. When the resistances are not equal, one must solve three simultaneous equations in order to find the resistance values. This can be rather involved and time consuming.

The purpose of this technical note is to present a method of calculating the resistance values of a delta-connected network using the Megger 830280 Ohmmeter. The calculation is simple and can be easily done on a four function electronic calculator.

Measuring Procedure.

The complete measuring procedure involves two different connections for each of the three phases that are measured. The procedure gives three resistance values and six ratios that are used to calculate the individual, delta connected, resistors. The connections and readings to be taken are shown on the appended drawings.

The results of the measurement and calculations are entered in the table shown below to a network as defined thus:

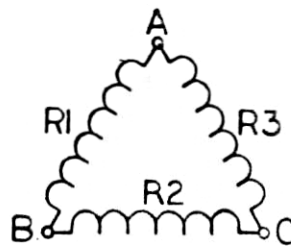


FIGURE 8- TYPICAL 3 PHASE DELTA NETWORK

Values of steps 1-9 are obtained by referring to the preceding pages.

Phase	Resistance	Ratio	Inverse Ratio
A - B	Step i	Step ii	Step iii
B - C	Step iv	Step v	Step vi
C - A	Step vii	Step viii	Step ix

The values of the resistances are calculated from the following equations:

$$\text{Equation 1} \quad R1 = i \times \frac{1 + v + ix}{v + ix}$$

$$\text{Equation 2} \quad R2 = iv \times \frac{1 + viii + iii}{viii + iii}$$

$$\text{Equation 3} \quad R3 = vii \times \frac{1 + ii + vi}{ii + vii}$$

The lower case roman numeral values refer to the numerical values obtained in the appropriate step of the measuring procedures (see table on previous page).

Example: Assuming a delta network as shown below,

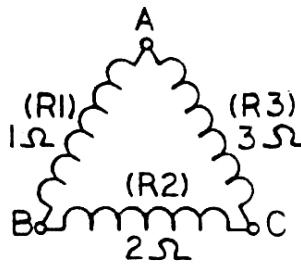


FIGURE 9

The results of the nine steps of the measurement procedure (follow on the preceding pages) should result in the following table:

Phase	Resistance	Ratio	Inverse Ratio
A - B	(i) 0.833	(ii) 0.666	(iii) 1.500
B - C	(iv) 1.333	(v) 3.000	(vi) 0.333
C - A	(vii) 1.500	(viii) 0.500	(ix) 2.000

Using equations 1, 2 and 3 from above, we arrive at the following values:

R1 = 1 ohm; R2 = 2 ohms; R3 = 3 ohms.

Conclusion

A procedure that allows the individual resistance values of delta-connected equipment to be easily calculated has been presented. Although the method, with certain modifications, is applicable to most ohmmeters, it is especially applicable when using the Megger 830280 Transformer Ohmmeter for testing delta connected transformers.

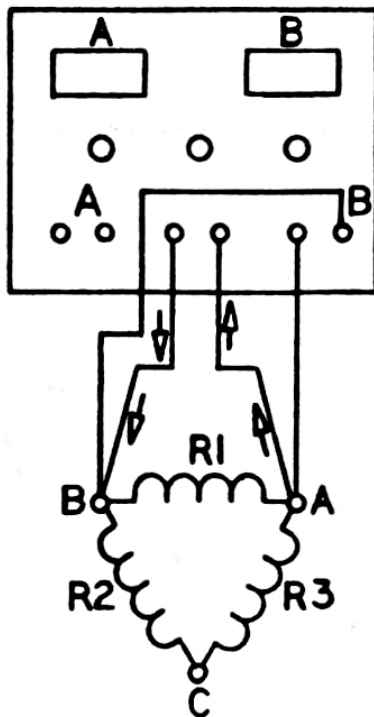


FIGURE 10

Step i

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record R A-B on meter "B".

$$\text{Step i} = R \text{ A-B}$$

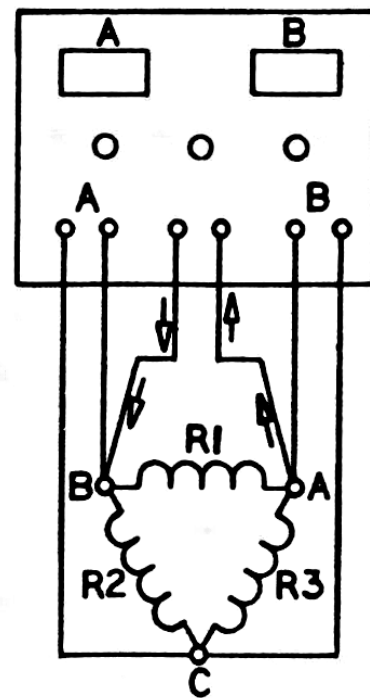


FIGURE 11

Step ii

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record:
 - a. Meter "A";
 - b. Meter "B".

$$\text{Step ii} = \frac{\text{Meter "A"}}{\text{Meter "B"}}$$

Step iii

1. Using procedure of Step ii,

$$\text{Step ii} = \frac{\text{Meter "B"}}{\text{Meter "A"}}$$

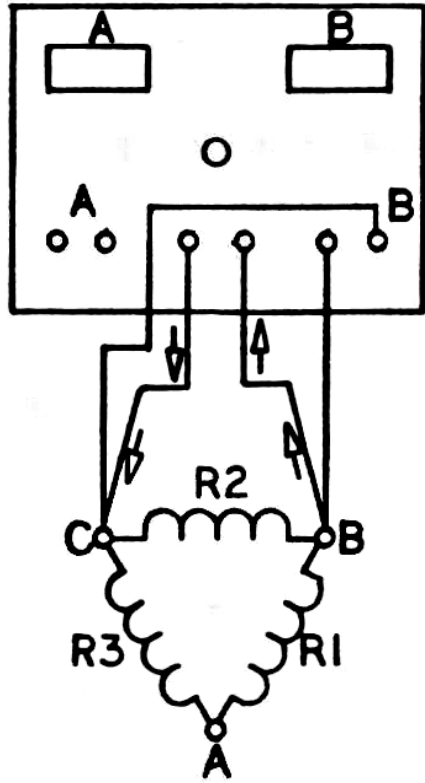


FIGURE 12

Step iv

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record R B-C on meter "C".

Step iv = R B-C

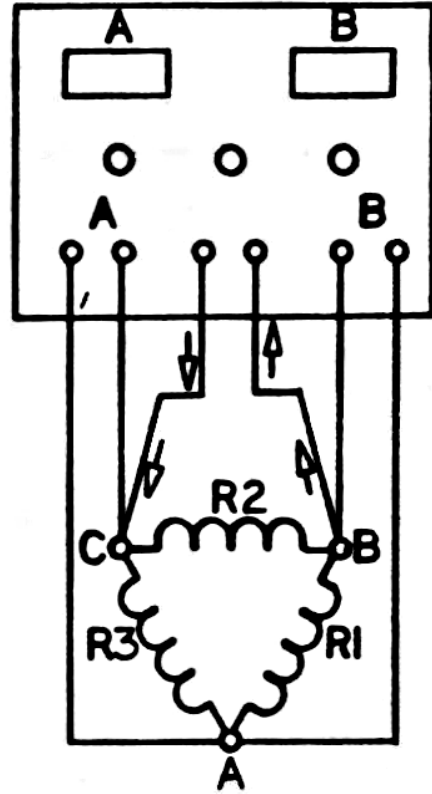


FIGURE 13

Step v

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record:
 - a. Meter "A"
 - b. Meter "B".

Step v = $\frac{\text{Meter "A"}}{\text{Meter "B"}}$

Step vi

1. Using procedure of Step v,

Step vi = $\frac{\text{Meter "B"}}{\text{Meter "A"}}$

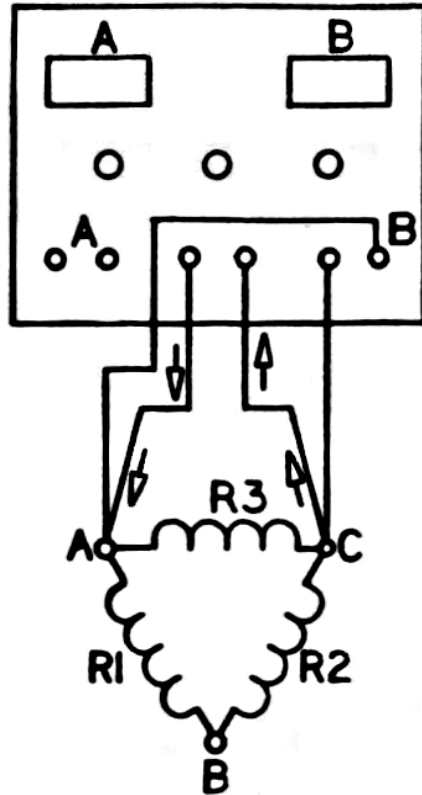


FIGURE 14

Step vii

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record R A-C on meter "B".

Step vii = R A-C

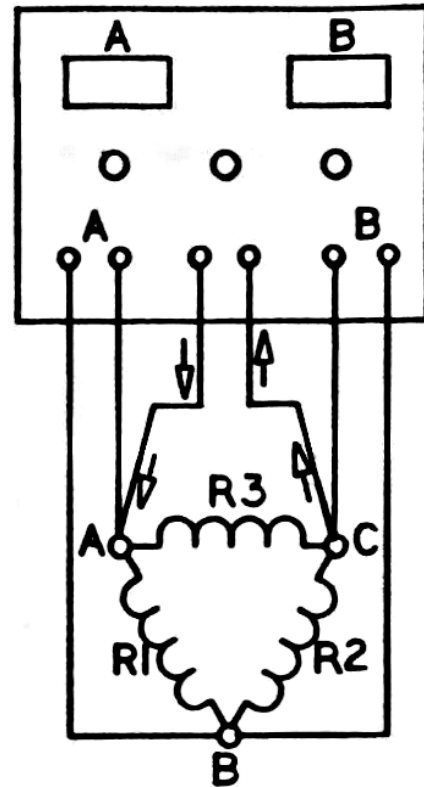


FIGURE 15

Step viii

1. Connect transformer as shown.
2. Following test procedures of instruction manual, record:
 - a. Meter "A";
 - b. Meter "B".

Step viii = $\frac{\text{Meter "A"}}{\text{Meter "B"}}$

Step ix

Using procedure of Step viii,

Step ix = $\frac{\text{Meter "B"}}{\text{Meter "A"}}$

3.6 TESTING TRANSFORMERS WITH TAP CHANGERS

Many transformers used today have taps built into them. These taps allow ratio to be increased or decreased by fractions of a percent. Any of the ratio changes involve a mechanical movement of a contact from one position to another. It is this contact that need to be checked by way of its resistance.

The contact may go bad for a number of reasons.

1. Misaligned when manufactured causing insufficient surface contact. Full load current overheats contact surface causing it to burn.
2. Current passing through contact exceeds full load rating.
3. Tap changing operation not "Make before break" creating internal arcing of contact surface.
4. An off-load tap changer is switched while on load. Contact surface becomes pitted and uneven.

Tap changers are divided into two types; On-load and Off-load. The "On-load" tap changer allows selection of ratio change while the transformer is in service. This would mean the ratio of a transformer can be changed while power (current) is still passing through it. The most common example of this type of "On-load" tap changer is a "Voltage Regulator".

The Transformer Ohmmeter is ideally suited to test on-load tap changers because the instrument can be left ON while changing from tap to tap. This allows the operator to take measurements very quickly without discharging, then re-charging the transformer for every tap. The Transformer Ohmmeter will re-balance after every tap change. If the tap is defective (open) or if there is even a fraction of time (1 m.s.) where circuit is open, the Transformer Ohmmeter will automatically go into its discharge cycle. This gives the operator a clear indication of a possible fault within the tap changer. For this OPEN condition, no damage will be done to the transformer by the Transformer Ohmmeter's D.C. current.

The second type of tap changer is the "Off-load". This is not as common as On-load because in order to change taps, the transformer has to be taken out of service or at least disconnected from the load. This type of tap changer may typically go bad faster than an On-load because of inadvertent changing of taps while still in service. The Transformer Ohmmeter will test this transformer, but it must be discharged between tap changes. If the Transformer Ohmmeter is not discharged of test current between tap changes, the instrument will automatically discharge upon sensing a break in the current path. Because of its low 5A, 30V D.C. current, no real damage will be done to the tap surface contact by the Transformer Ohmmeter when switching of tap changer occurs.

When actually testing tap changers, follow procedure of the transformer under test while keeping this section in mind.

3.7 TESTING VOLTAGE REGULATORS

This procedure describes the basic connections to a single phase regulator. The main test for a regulator is the evaluation of the condition of the tap positions. Because there are a large number of taps (typical 32), this test would normally take a very long time. With the Megger Transformer Ohmmeter, this test time is drastically reduced because the instrument will stay on while changing tap positions. This means charge and discharge cycles are virtually eliminated.

All regulators have internal bridging reactors. It is because of these reactors that balance time for the Transformer Ohmmeter will vary. On odd position taps, balance time will be longer than even positions. This is due to circulating current generated when on odd positions and is shown below:

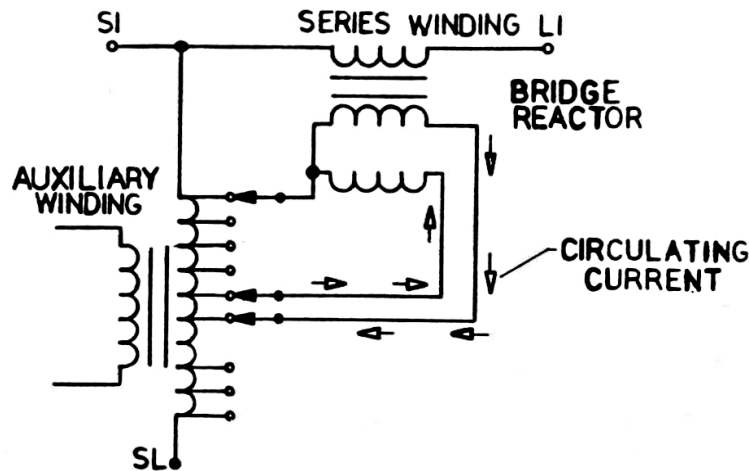


FIGURE 16: ODD POSITION TAP

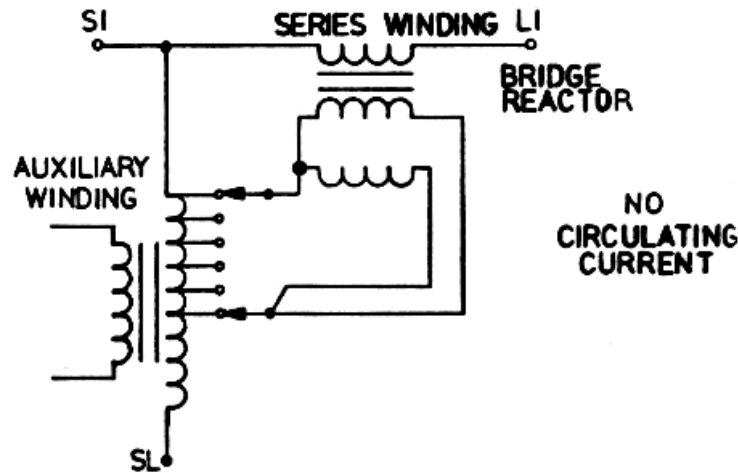


FIGURE 17: EVEN POSITION TAP

See Figure 18 for connection to the voltage regulator.

PROCEDURE

1. Connect line cord to unit and plug into 120V socket.
2. Set the following conditions:
 - a. Display Selector (14): up position.
 - b. Range Selector "A" (12): left most position.
 - c. Range Selector "B" (13): right most position.
 - d. Current Selector (11): 5A nominal (guide by resistance table on face plate).
3. Connect current output (9) to test specimen winding.
4. Connect "B" potential input (10) to test specimen winding. Do not clip potential leads on to the current leads, since this will add contact resistance to the measurement. Potential leads should always be placed inside (between) current leads. See Figure 18.
5. Turn power switch (1) "ON". "READY" L.E.D. (5) should illuminate.
6. Push current control switch (4) up to initiate current flow. Release when current indicator (7) comes ON.
7. Display "A" (15) indicates current output (in %). As output current approaches steady value, display "B" (16) comes on and indicates resistance of specimen.
8. The range switch "B" (11) may require re-setting to a more suitable resistance range.
9. When measurement is complete, push the current control switch (4) down to terminate measurement and discharge current. Discharge is complete when current indicator (7) is off (black).

CAUTION



Current selector (11) should be at highest acceptable current in order to obtain best results.

WARNING



DO NOT DISCONNECT LEADS BEFORE INDICATOR (7) IS OFF (BLACK)!!!

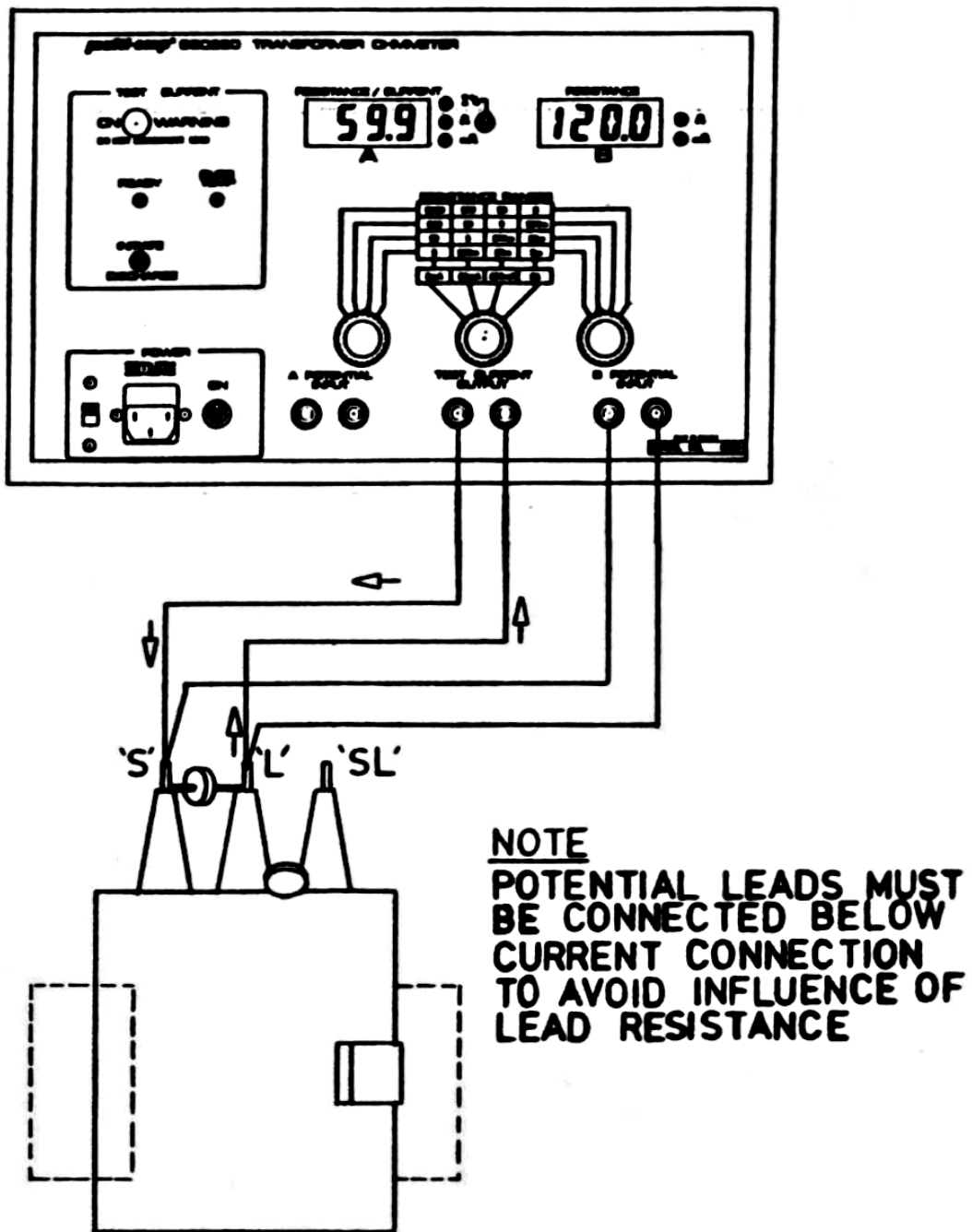


FIGURE 18: CONNECTION TO A REGULATOR

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4. SERVICE AND MAINTENANCE

4.1 DESCRIPTION

Megger maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists.

When contacting our service department, complete information concerning the trouble and any steps taken in attempting repair should be given. The catalog number and serial number of the instrument should also be specified. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Repair Department.

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