



**INSTRUCTION BOOK**

**HIGH RESISTANCE  
NEUTRAL GROUNDING EQUIPMENT WITH  
TRACEABLE SIGNAL TO FAULT FOR  
2400/ OR 4160V WYE UNGROUNDED SYSTEMS**

**WARNING**

**FOLLOW THE SAFETY INSTRUCTIONS AND WARNINGS  
THROUGHOUT THIS BOOK. FAILURE TO DO SO  
CAN RESULT IN DAMAGE TO PROPERTY, PERSONAL INJURY, OR DEATH.**

**IN ADDITION TO THE MAINTENANCE AND PRECAUTIONS  
AS OUTLINED WITHIN, REFER TO ANSI Z244.1-1982 ENTITLED:  
LOCKOUT/TAGOUT OF ENERGY SOURCES MINIMUM SAFETY REQUIREMENTS**

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**These instructions may not cover all details or variations in equipment, nor provide for every possible contingency encountered. Should further information be desired or should problems arise which are not covered sufficiently, the matter should be referred to the POWERCON CORPORATION**

**WARNING  
IMPORTANT**

IT IS IMPERATIVE THAT YOU READ AND COMPLETELY UNDERSTAND THE WARNING LOCATED TO THE RIGHT OF THIS BLOCK, FAILURE TO DO SO CAN RESULT IN DAMAGE TO PROPERTY, PERSONAL INJURY OR DEATH



DO NOT REMOVE COVERS, OPEN DOORS, OR WORK ON EQUIPMENT UNLESS POWER HAS BEEN TURNED OFF AND ALL CIRCUITS DE-ENERGIZED AND DISCONNECTED. DISCONNECT, DE-ENERGIZE, LOCKOUT AND PROPERLY GROUND CIRCUIT(S) BEFORE WORKING ON THIS EQUIPMENT. USE PROPER SAFETY PRECAUTIONS WHEN WORKING ON THIS EQUIPMENT.

ALL SAFETY CODES, SAFETY STANDARDS, AND/OR REGULATIONS AS THEY MAY BE APPLIED TO THIS TYPE OF EQUIPMENT MUST BE STRICTLY ADHERED TO. BEFORE ANY ADJUSTMENTS, SERVICING, PARTS REPLACEMENT OR ANY OTHER ACT IS PERFORMED REQUIRING ANY PHYSICAL CONTACT WITH THE ELECTRICAL COMPONENTS OR WIRING OF THIS EQUIPMENT, THE POWER SUPPLY MUST BE DISCONNECTED.



IN ADDITION TO THE PERSONNEL PRECAUTIONS AS OUTLINED, REFER TO:

- Z244.1-1982 PERSONNEL PROTECTION LOCKOUT/TAGOUT OF ENERGY SOURCES MINIMUM SAFETY REQUIREMENTS
- ANSI/NFPA 70E-1988: ELECTRICAL SAFETY REQUIREMENTS FOR EMPLOYEE WORKPLACES
- ANSI/NFPA 70B-1988: ELECTRICAL EQUIPMENT MAINTENANCE



THE EQUIPMENT COVERED BY THIS INSTRUCTION BOOK MUST BE SELECTED FOR A SPECIFIC APPLICATIONS AND IT MUST BE INSTALLED, OPERATED, AND MAINTAINED BY QUALIFIED PERSONS WHO ARE THOROUGHLY TRAINED AND WHO UNDERSTAND ALL OF THE HAZARDS INVOLVED. As with any electrical apparatus, the thorough knowledge of the engineering safety, inspection, maintenance and repair techniques as well as being familiar with particular features of the apparatus involved is mandatory. THIS BOOK DOES NOT PROVIDE SUFFICIENT INSTRUCTIONS FOR INEXPERIENCED ELECTRICIANS OR UNQUALIFIED PERSONS TO DO ANY WORK REQUIRED INCLUDING THE HANDLING, INSTALLATION, TESTING, OPERATION, INSPECTION, MAINTENANCE, AND REPAIR.



BEFORE CHECKING OR MAINTENANCE OF SWITCHGEAR, AFTER IT HAS BEEN INSTALLED - THE FOLLOWING MUST BE OBSERVED: ONLY QUALIFIED PERSONS MAY OPERATE, INSPECT OR MAINTAIN POWER SWITCHGEAR. IN ADDITION TO THE PERSONNEL YOU MAY HAVE WHO ARE QUALIFIED, OTHERS MAY BE AVAILABLE FROM AN EXPERIENCED HIGH VOLTAGE CONTRACTOR OR THE UTILITY SERVICING THE INSTALLATION. IT IS THE RESPONSIBILITY OF THE PURCHASER, INSTALLER, OR ULTIMATE USER TO INSURE THAT THE WARNING SIGNS ARE NOT REMOVED AND TO MAKE SURE THAT ALL ACCESS DOORS, AND OPERATING HANDLES ARE SECURELY LOCKED WHEN THE GEAR IS LEFT UNATTENDED BY QUALIFIED PERSONS, EVEN MOMENTARILY.



SAFETY GROUNDING TO BE DONE ON DE-ENERGIZED EQUIPMENT ONLY.

Before energizing the equipment and prior to any testing it is recommended that all circuits be safely grounded. Prior to any grounding whether it be for any testing, inspection, or maintenance procedures, assure that all safety precautions are taken. It is further recommended that an appropriate properly operating glow tube instrument that lights up and warns the worker when held in any alternating current field, indicating the presence of voltage, be used prior to grounding.

PERSONNEL DOING SUCH WORK SHOULD WEAR LINEMAN'S PROTECTIVE EQUIPMENT IN ACCORDANCE WITH SUCH EQUIPMENT MANUFACTURER'S RECOMMENDATIONS INCLUDING BUT NOT LIMITED TO PROTECTIVE GLOVES, INSULATED SLEEVES, LINEMAN'S BLANKETS, INSULATED HELMETS, FACE AND EYE PROTECTION that will assist in preventing injury if for any reason the equipment is grounded to an energized circuit. Every precaution should be taken to prevent electrical grounding on an energized circuit. Suitable grounding clamp leads should be used and safety grounding techniques employed. ALL SUCH GROUNDS MUST BE REMOVED AFTER TESTING, INSPECTION, OR MAINTENANCE PRIOR TO ENERGIZING THE EQUIPMENT.

In as much as Powercon has no control over the use to which others may put this material, statements concerning uses of the materials described herein are not to be construed as suitable for these used unless proper technology in the usage, applications, and maintenance are strictly observed. For further information call or write the Powercon Corporation.



**LIMITED WARRANTY**

Powercon warrants that the equipment we deliver will be of the kind and quality described in the order or contract and will be free of defects in workmanship and material. Should any failure to conform to this warranty appear within one year after date of shipment, Powercon shall upon prompt notification thereof and substantiation that the equipment has been stored, installed, operated and maintained in accordance with Powercon recommendations and standard industry practice, correct such nonconformities, at its option, either by repairing any defective part or parts or by supplying a repaired or replacement part or parts F.O.B. factory. However, if Powercon has installed the equipment or furnished field engineering services with respect to its installation, and provided such installation has not been delayed by the Purchaser, said one year shall run from the completion of the installation. The total warranty period shall not exceed 18 months from the date of shipment in any case.

In no event shall Powercon be responsible for providing working access to the defect, including the removal, disassembly, replacement or reinstallation of any equipment material or structures to the extent necessary to permit Powercon to perform its warranty obligations, or transportation costs to and from the Powercon factory or repair facility. The conditions of any tests shall be mutually agreed upon and Powercon shall be notified of, and may be present at, all tests that may be made.

**THE WARRANTIES SET FORTH IN THIS PROVISION ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER STATUTORY, EXPRESS OR IMPLIED (INCLUDING ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE AND ALL WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE), EXCEPT OF TITLE AND AGAINST PATENT INFRINGEMENT.** The remedies provided above are the purchaser's sole remedies for any failure of Powercon to comply with its obligations. Correction of any nonconformity in the manner and for the period of time provided above shall constitute complete fulfillment of all the liabilities of Powercon whether the claims of the Purchaser are based in contract, in tort (including negligence) or otherwise with respect to or arising out of the equipment furnished hereunder.

**WARRANTY IMPLEMENTATIONS AND CONDITIONS**

On those occasions where service help is required, the Powercon Corporation should be notified at once through its Service Department. No charges or expenses should be incurred except as authorized by the Corporation in writing. Making unauthorized corrections or doing unauthorized work voids this Warranty and renders reimbursement impossible.

At times, the Powercon Corporation may request labor and/or material services from you. At our option we will provide competent supervision who will authorize such services by signing the Time Sheets of the people involved. No reimbursement can be made without signed Time Sheets.

The services rendered must be of the type and quality satisfactory to the Powercon Corporation, and we reserve the right to reject any and all such services.

The above in no way prejudices the right of the Powercon Corporation to correct, as stipulated in the Warranty, any problems that may occur in equipment manufactured by the Powercon Corporation.

## FOREWORD

The warranty associated with this equipment is fully described with its implementation on Page i. It should be emphasized that unless approved by the Powercon Corporation no modification, alteration, change or correction should be undertaken without such express authority provided in writing by an authorized Powercon representative.

This Instruction Book is furnished in "As is" condition. No warranties expressed or implied, including warranties of fitness for a particular purpose, or merchantability, or warranties arising from course of dealing or usage of trade are made regarding the information, recommendations, descriptions, and safety notations contained herein. In no way will Powercon be responsible to the user in contract, in tort (including negligence), strict liability or otherwise for any direct special, indirect, incidental, or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant, or power system, cost of capital, loss of profits or revenues, cost of replacement power, additional expenses in the use of existing power facilities, or claims against the user by its customer resulting from the use of information, recommendations, descriptions, and safety notations contained herein.

The information, recommendations, descriptions, and safety notations in this document are based on Powercon's experience and judgment in respect to all of the subject matter contained herein. This information must not be considered to be all inclusive or covering all contingencies.

### QUALIFIED PERSONNEL ONLY

#### **WARNING IMPORTANT**

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The equipment covered by this Instruction Book must be selected for a specific application and it must be installed, operated and maintained by qualified persons who are thoroughly trained and who understand all of the hazards involved. As with any electrical apparatus the thorough knowledge of the engineering safety, inspection, maintenance and repair techniques and familiarity with particular features of the apparatus involved is mandatory. This book does not provide sufficient instructions for inexperienced electricians or unqualified persons to do any work required including the handling, installation, testing, operation, inspection, maintenance, and repair. Refer to OSHA 29CFR Part 1910.399 for definition of "qualified person".

#### WARNING **SAFETY GROUNDING**

#### **TO BE DONE ON DE-ENERGIZED EQUIPMENT ONLY**

Before energizing the equipment and prior to any testing or maintenance it is recommended that all circuits be safely grounded. Prior to any grounding whether it be for any testing, inspection, or maintenance procedures, assure that all safety precautions are taken. It is further recommended that an appropriate properly operating glow tube instrument that lights up and warns the worker when held in any alternating current field, indicating the presence of voltage, be used prior to grounding

Personnel doing such work should wear lineman's protective equipment in accordance with such equipment manufacturer's recommendations including but not limited to protective gloves, insulated sleeves, lineman's blankets, insulated helmets, face and eye protection that will assist in preventing injury if for any reason the equipment is grounded to an energized circuit. Every precaution should be taken to prevent electrical grounding on an energized circuit. Suitable grounding clamp leads should be used and safety grounding techniques employed. All such grounds must be removed after testing, inspection, or maintenance prior to energizing the equipment.

The above in no way replaces the user's safety techniques or applicable safety codes, rules, or regulations.

#### **WARNING IMPORTANT**

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## THE HIGH-RESISTANCE GROUNDED NEUTRAL SYSTEM WITH TRACEABLE SIGNAL TO FAULT

The high-resistance ground neutral system with traceable signal to fault, is one in which a high-value resistor has been inserted in the neutral connection to ground to limit the resistor current under ground-fault conditions to a value not less than the total system charging current, resulting in a total ground fault current of approximately  $\sqrt{2}$  times the charging current.

This system is equipped with ground-fault indicators and a means of pulsing a traceable signal onto a grounded phase to aid in rapid location of system faults to ground while the system is energized.

### APPLICATION

Power Systems High Resistance Grounded Neutral Systems with tracing pulses is applied where:

1. Electric Power Service immediate interruption on first phase to ground fault is to be avoided.

This prevents disorderly shutdowns of equipment which may result in severe financial losses, production delays, or hazards due to immediate loss of electric power.

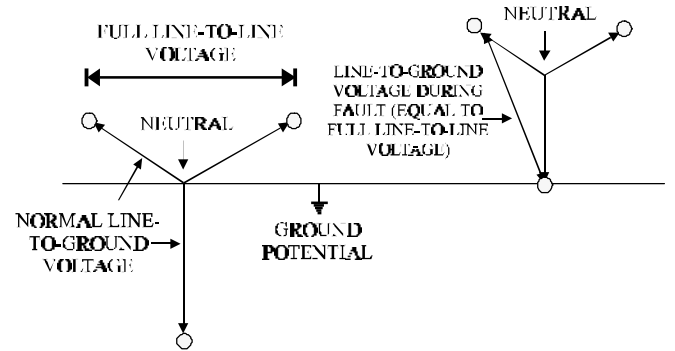
2. Transient Overvoltage Control on arcing ground faults protection will be obtained.
3. Minimization of Personnel Injuries from arc flash due to accidental line to ground faults.

The fundamental objectives in the use of of the high-resistance grounded neutral system with a fault-tracing pulses are several:

1. The avoidance of an immediate service interruption on the occasion of the first ground fault.

2. The minimizing of flash hazard to personnel arising from accidental ground faults in equipment.
3. A substantial reduction in the risk of equipment burndown arising from ground faults.
4. The ability to trace the location of a ground fault without de-energizing the system.
5. A reduction in voltage dip during ground faults, provided simultaneously ground faults on different phases are not encountered.

The facility of quickly locating grounds faults with the pulsing and tracing equipment on this system tends to lessen the probability of a second ground fault shutting down two circuits simultaneously.



(A) NO FAULT ON SYSTEM  
(NEUTRAL FLOATS AT  
GROUND POTENTIAL)

(B) SINGLE-LINE-TO-GROUND  
FAULT ON SYSTEM (ONE LINE  
AT GROUND POTENTIAL)

Figure 1. Effect on line-to-ground voltages of a single line-to-ground fault on an ungrounded-neutral system.

### FAULT LOCATING

The success of operating a high resistance grounded system relies heavily on a dependable method of searching out the ground fault location to allow the faulty system member to be removed with the least delay.

The two important innovations introduced in this equipment to take the uncertainty out of signal tracing include:

1. A repeating cyclic switching sequence by which the tracer current can be rhythmically switched to a slightly higher value. This give unique character to the tracer signal by which it can be distinguished frc- steady state background noise.
2. An extremely sensitive ground-faultcurrent sensor incorporating a split core CT by which extraneous noise will be ignored and only the current carrying member which passes through the window will be registered on the meter.

### SYSTEM CAPACITANCE CHARGING CURRENT

The maximum system capacitance charging current must be known before the high resistance grounding system panel resistor can be set for the correct ground current during a fault. If the maximum system charging current is not known, then one of the following tests may be used to determine this current depending on the system voltage and connection.

### TESTING FOR SYSTEM CAPACITANCE CHARGING CURRENT FOR 2400 & 4150 VOLT SYSTEMS

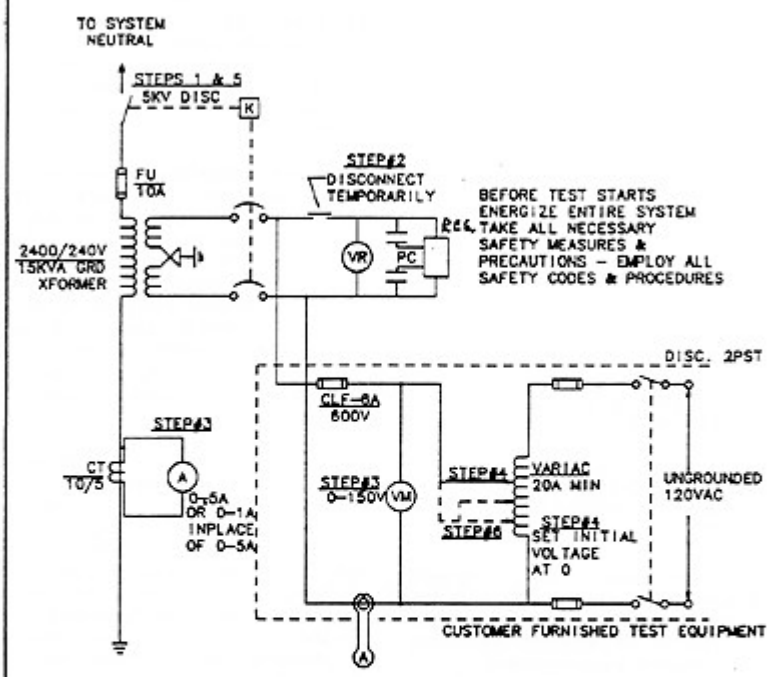
#### WARNING

**TESTING FOR CAPACITANCE CHARGING CURRENT REQUIRES THAT THE ENTIRE SYSTEM BE ENERGIZED; HENCE. TAKE ALL THE NECESSARY SAFETY MEASURES AND EMPLOY ALL SAFETY CODES AND PRACTICES.**

### TESTING PROCEDURE FOR 2400 & 4160 VOLT WYE SYSTEMS(Refer to Figure 2)

1. De-energize grounding equipment by opening main neutral disconnect switch. control power disconnect switch, and all other sources of power. Be sure no other ground is connected to system.
2. Disconnect or open circuit secondary resistor during test. Furnish a 5 amp current limiting fuse as shown in Figure 2 while testing for capacitance charging current.
3. Connect sensitive (0.5A or 1.0A full scale) ammeter in place of IOA panel ammeter during test. Connect 0-150 volt voltmeter across secondary of neutral transformer as shown.
4. Connect a variable voltage transformer to the secondary of this neutral transformer supplied in the pulsing ground equipment. Energize this transformer secondary with the variable voltage transformer. initially set at zero voltage. Energize variac from an ungrounded 100 volt 60 hertz source. Variable voltage transformer should be rated 20 amps minimum.
5. Re-energize the grounding equipment by closing main neutral disconnect switch.
6. With maximum operating load equipment connected on the system, gradually increase the voltage from zero to 50 volt maximum recording neutral displacement voltage and current at selected tests points until a linear variation of current with voltage is obtained.
7. Calculate system capacitance charging -current. IC at rated voltage by extrapolation as follows:

TITLE: TEST CONNECTIONS	S.O. SO#
X	
X	
CUST: X	P.O. PO#



TEST CONNECTIONS  
FIGURE #2

SUMMARY S-	DWN BY D.HAAB	POWERCON CORPORATION	DRAWING NO.
WD/NO. WO-	DATE 4/6/86	SEVERN MD. PLANT	W-

$$I_c = \frac{E}{\sqrt{3}} \times \frac{I_a}{NV} = \text{Amps System Charging Current}$$

Where:

E = Rated system voltage, line to line

V = Measured Test Voltage

N = Turns ratio of isolating transformer (Usually 10)  
(NV = System neutral voltage displacement)

$I_a$  = Measured ground current corresponding to NV

= (Ammeter reading times 2:1 CT ratio)

- B. Plot various test values to verify that linear relationship of current to voltage is being attained as system neutral is gradually displaced from ground potential.

### **DESCRIPTION OF BASIC EQUIPMENT FOR 2400V OR 41 60V WYE SYSTEMS**

(Refer to Figure 3)

During normal conditions, with no ground fault on the system, no current flows in the grounding transformer or resistor. When a ground fault occurs, the reflected impedance of the resistor limits the ground current.

The resulting voltage appearing across the secondary windings of the grounding transformer will be sensed by the voltage relay. Auxiliary contacts in the control, operated by the voltage relay are used for remote indication and annunciation.

A green indicating light on the equipment indicates that control voltage is available and that the system is normal. When a fault occurs, a red indicating light on the equipment will remain lighted until the ground fault

is removed. If no remote annunciator is available to notify the operator, an audible signal may be added to the equipment as an option. A rotating red signal beacon can be used in noisy or remote installations.

To trace the ground fault the operator then turns the selector switch to the "pulse" position. This initiates cycle timing alternately energizing and de-energizing a shorting contactor at the secondary resistor resulting in a rhythmic fluctuation in the magnitude of the ground current.

A current transformer and ammeter at the panel will allow the operator to determine the current fluctuations on the system. A portable hook on detector is then used to trace the fluctuations in ground current through the system to the point of fault. After the ground point has been located and removed from the system, the operator then resets the selector switch to de-energize the pulse cycle timing circuits, and depresses a reset button to reset indicating lights and annunciators.

Taps are provided on the secondary resistor to adjust the magnitude of the ground current, in the range of 2 to 7 amperes, depending on size of system, through the fault. This value should be set slightly higher than the system's natural zero sequence capacitance charging current, with a recommended increase of three amperes during pulsing. For example, if the system capacitance charging current is measured at 1.9 amps, the resistor taps should be set for approximately 2 amperes ground current, with a periodic increase during pulsing to 5 amperes. Most 2400 volt systems will have less than 4 amps charging current if no surge capacitors are used.

### **PORTABLE DETECTOR**

The ground current detector is a portable hook-on and includes the following special features:

- Multi-Range Switch.
- Large Window, suitable for conduits up to 5 inches nominal diameter.



- Removable Arm to facilitate use in limited spaces where conduits are closely adjacent.
- Shorting Switch to provide transient protection while detector is being positioned around conductors.
- Closed Magnetic Core to minimize effects of stray fields.
- For use on systems rated up to 4160 volts nominal. The handle is insulated making it suitable for use where cables are not in conduit. The instrument is given a dielectric test of 12,000 volts, between metal core and handle, during manufacturing.

### **RESISTOR**

Since ground current is limited by the resistor, the last section must never be shorted out by the shorting contactor during pulsing.

The resistor must be adjusted at installation so that the ground current with one ground fault is equal to or slightly greater than the maximum system capacitance charging current. (The value obtained with maximum connected load on the system). If maximum system capacitance charging current is not known, instructions will be furnished for measuring the actual value before placing the equipment in operation.

### **OPERATION OF EQUIPMENT**

The following instructions will appear on an engraved nameplate on the door:

#### **NORMAL OPERATION**

1. Leave switch on normal position.
2. Red light indicates ground fault on system.
3. Green light indicates normal condition and equipment energized.

### **GROUND DETECTION**

1. Turn switch to pulse position.
2. Trace pulsing ground current with portable detector.
3. Remove fault.
4. Return switch to normal position.
5. Press reset button to remove fault indication.

### **TEST**

1. Press test button to simulate ground fault, and operate.
2. Press reset button after test to return to normal.
3. Green light on.

### **LIST OF EQUIPMENT INCLUDED IN STANDARD 2400V AND 4160V WYE SYSTEM WITH NEUTRAL AVAILABLE**

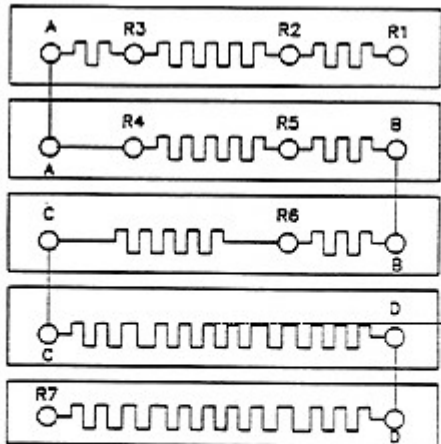
- (1) Primary Disconnect Switch. Single Phase, with an EJ-1 Current Limiting Fuse. Key Interlocked with a Circuit Breaker on the secondary of the Transformer.
- (1) Grounding Transformer. Dry-Type.
- (1) Neutral Current Transformer.
- (1) Voltage Relay.
- (1) Pulsing Contactor Set to produce approximately 40 current pulsations per minute.
- (1) Secondary Resistor.
- (1) Relay for Pulsing Contactor.
- (1) Holding Relay, with extra Interlocks for Remote Alarm.

- (1) Fused Control Power Disconnect Switch.
- (1) Neutral Ammeter.
- (1) "Ground Fault" Red Indicating Light.
- (1) "Normal" Green Indicating Light.
- (1) "Normal Pulse" Selector Switch.
- (1) "Reset" Pushbutton.
- (1) "Test" Pushbutton.
- (1) Instruction Plate on Door.
- (I) Portable Ground Current Detector with Carrying Case. (Optional).
- (X) Control Circuit Operates from Remote Source.
- (X) All Connections to Control and Annunciator Circuits Wired to Terminal Boards.



**TITLE:** CONNECTIONS FOR GROUNDING RESISTOR FOR 2400-4160V WYE UNGROUNDED SYSTEMS. **S.O.** 03-23312  
**CUSE:** P.O. PO#XXXXXXXXXX

SYSTEM I CAP	SECONDARY CONNECTION TO RESISTOR		AMPERES NORMAL		PULSE	
	NORMAL	PULSE	PR I .	SEC .	PR I .	SEC .
2.0A	10.5 OHMS CB2-R1 PCAT1-R7	5.23 OHMS PCT1-R3 PCT2-R7	2.3A	23A	4.6A	46A
3.0A	7.0 OHMS CB2-R2 PCAT1-R7	3.49 OHMS PCT1-R5 PCT2-R7	3.4A	34A	6.8A	68A
4.0A	5.23 OHMS CB2-R3 PCAT1-R7	3.49 OHMS PCT1-R5 PCT2-R7	4.6A	46A	6.8A	68A
5.0A	4.5 OHMS RB2-R3 JUMPER R4-R5 PCAT1-R7	3.49 OHMS PCT1-R6 PCAT1-R7	5.4A	54A	6.8A	68A



STEPS	OHMS
R1-R2	3.444
R2-R3	1.854
R3-R4	0.992
R4-R5	0.744
R5-R6	0.532
R6-R7	2.964
	10.530

RESISTOR BANK

SUMMARY S-	DWN BY Donna R.	POWERCON CORPORATION	DRAWING NO.
WD/NO. W-2330	DATE 05/06/86	SEVERN MD. PLANT	W-2330