PCIB-1031

INSTRUCTION BOOK

SYSTEM 2001

GROUNDING EQUIPMENT FOR FAULT LOCATION

W/ High Resistance Neutral Grounding

for use on

480 VOLT 3 PHASE 60HZ 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

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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 OT 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 AR 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.

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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 he 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.

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QUALIFIED PERSONNEL ONLY

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 perso".

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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.

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FIGURES

SAFETY

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.

INTRODUCTION

These instructions cover the description, operation and maintenance of the Powercon High Resistance Ground and Fault Location System used on 480V, 3 phase, 60 Hertz ungrounded power systems.

The purposes of this equipment are:

1. To ground the neutral of an "ungrounded" 3 phase power system, utilizing the "high resistance" method. This allows the system to operate as an "ungrounded" system but eliminates the danger of high transient overvoltage during certain types of ground faults.

2. To give an immediate warning when the first ground fault occurs.

3. To provide a method for quickly locating and removing the fault before another fault develops on another phase, thereby preventing circuit outages due to double line to ground faults.

APPLICATION

The major advantage of ungrounded electrical systems over grounded systems is their ability to provide continuous service with a ground fault on one phase. A single phase failure to ground does not cause high current to flow, because the current is limited by the capacitance of the other two phases, but the voltage to ground of the two other phases rises by 73%, stressing the insulation of cables and equipment connected to the system. It is common practice to run a faulted ungrounded system until it is convenient to shut it down for repairs.

The operation of a faulted ungrounded system, without proper protection against overvoltages, is dangerous because it may experience overvoltages of six times the nominal system voltage, in case of intermittent (arcing) ground faults. The occurrence of any overvoltage, overstressing the

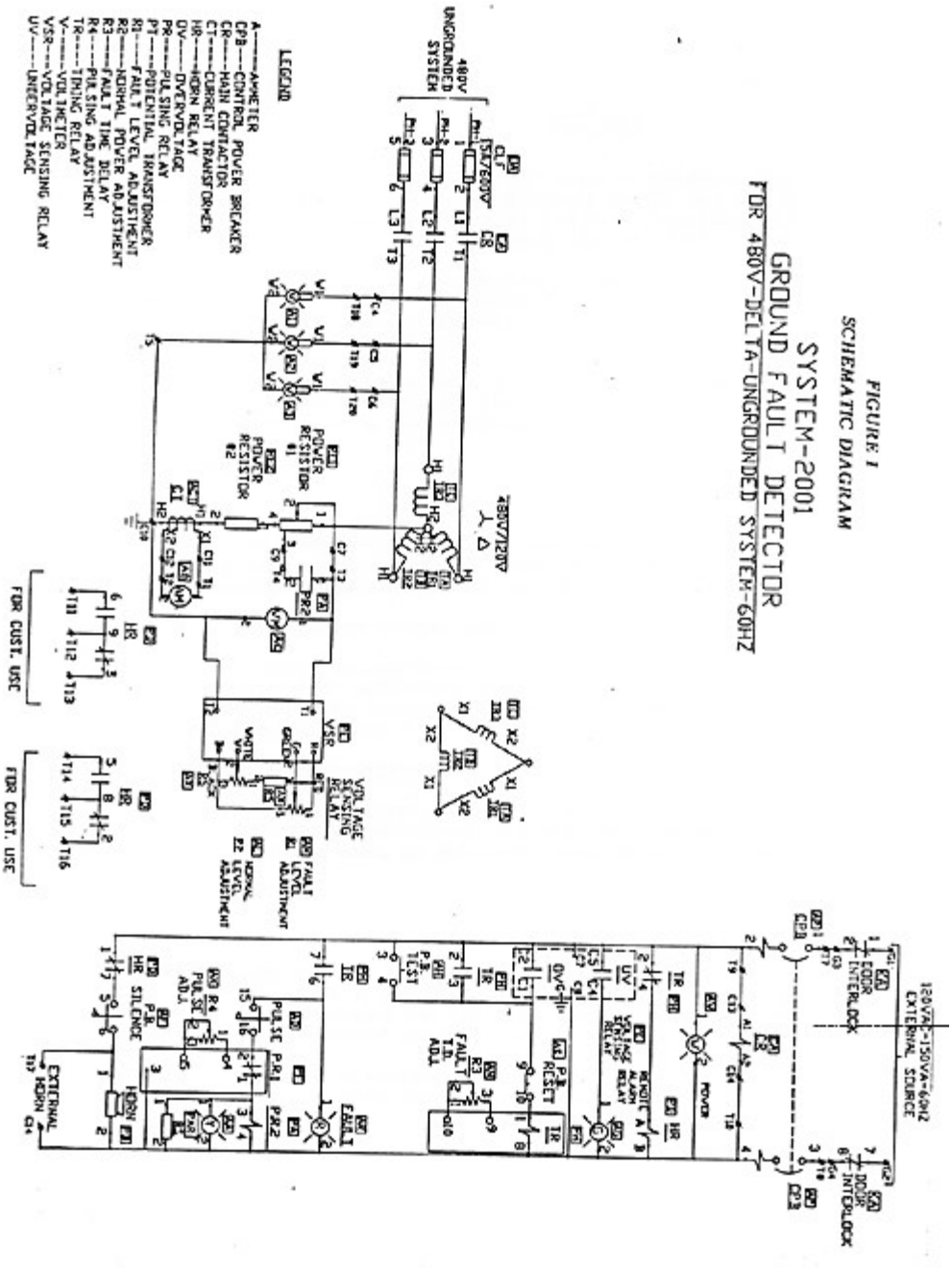
FIGURE 1

SCHEMATIC DIAGRAM

SYSTEM-2001

GROUND FAULT DETECTOR

FOR 480V-DELTA-UNGROUNDED SYSTEM-60HZ



2. ARTIFICIAL NEUTRALS

On delta connected systems, high resistance grounding can be applied through grounding transformers to form a neutral which can be grounded through a resistor.

Grounding transformers are wye/delta connected as shown in Figure 1. It provides a low impedance path for ground currents to flow, so that under line-to-ground fault conditions on the system the ground currents can flow from the neutral of the grounding transformer into the fault. Second, the impedance normal 3 phase current is high, so that when there is no fault on the system, only a small magnetizing current flows in the transformer windings.

Distribution transformers are either 3 phase or 3 single phase units, connected wye/delta used as grounding transformers. The wye connected primary is grounded through a current limiting resistor with the closed delta connected secondary to stabilize the neutral (Figure 1).

The per phase kva rating of the star/delta grounding transformer should be equal to rated Line-to-line voltage times rated neutral current for continuous duty.

The grounding resistors and the artificial neutrals shall be designed for continuous duty when the service continuity is prime concern.

It is to be noted that high resistance grounding, when properly applied, limits the self-generated system transient overvoltages to a proper value, but will not provide relief from overvoltages caused by physical contacts with higher voltage systems, resonance effects in series inductive-capacitive circuits and auto-transformer connections.

SYSTEM CAPACITANCE

The line-to-ground capacitance associated with system components determines the magnitude of zero sequence charging current. This value of current is required for proper selection of high resistance grounding equipment.

The capacitance to ground of transformers is negligible. The large spacings between the core and the windings and the shielding effects of the winding adjacent to the core limit the capacitance to ground minimum.

Overhead line and cable capacitance to ground can be large if considerable lengths are involved. Cable capacitance is many times greater than the capacitance of open line wire lines. Capacitance of cable, is dependent upon the conductor size, insulation and construction.

FAULT LOCATING

The operation of 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. This is accomplished by:

1. A repeating cyclic switching sequence by which the tracer current can be rhythmically switched to a slightly higher value. This gives unique character to the tracer signal by which it can be distinguished from steady state background noise.

2. An extremely sensitive ground fault current 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 upon the system voltage and connection.

TESTING FOR SYSTEM CAPACITANCE CHARGING CURRENT 480 VOLT WYE AND DELTA

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.

1. De-energize grounding equipment by opening panel disconnect switch or breaker. Be sure no other ground is connected to system.

2. Disconnect or open circuit the resistor during test, and insert a 6 amp, 600V current limiting fuse as shown in Figure 2.

3. Connect a Variable Voltage Auto Transformer rated five (5) amps or more between equipment and ground as shown. Initially set at zero volts.

4. Connect a voltmeter as shown.

5. Use portable signal detector if furnished to read ground current. (1-amp scale for most systems). Wire can be passed through detector window several times to produce greater sensitivity.

6. With maximum operating load equipment connected on system, re-energize the grounding equipment by closing primary disconnect switch.

7. Energize the variable voltage auto transformer from an ungrounded, 110V, 60 Cycle single phase test source.

8. With maximum operating load equipment connected on the system, bring the voltage up slowly, recording neutral displacement voltage and current at selected test points until a linear variation of current with voltage is obtained.

9. Calculate system capacitance charging current, Ic, at rated voltage by extrapolation as follows:

$$I_c = \frac{E}{\sqrt{3}} x \frac{I_a}{V} = \text{Amps system charging current}$$

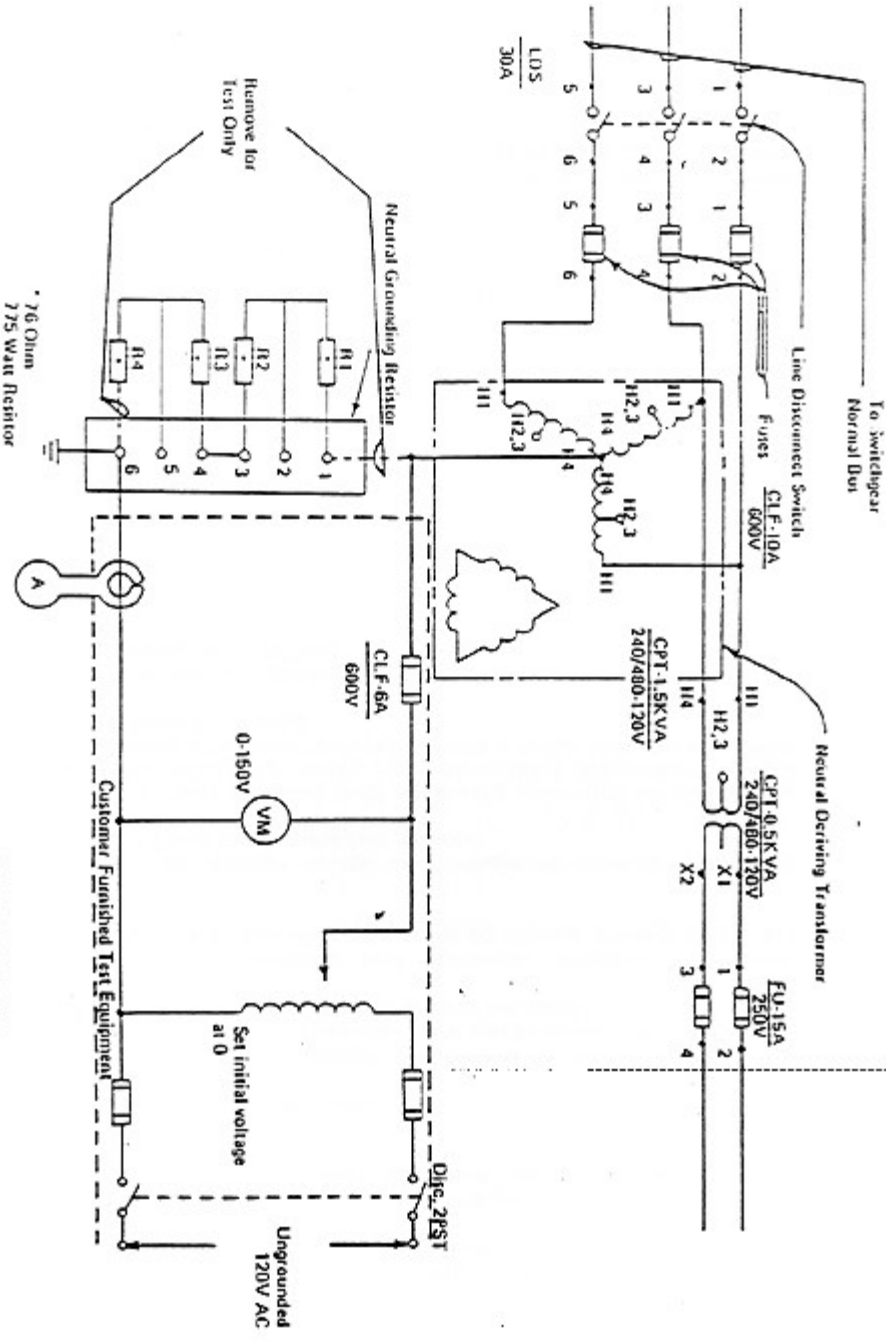
Where:

E = Rated system voltage, line to line (Usually 480V)

V = Measured test voltage. (Neutral displacement).

I_a = Measured ground current corresponding to V.

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



TEST CONNECTIONS

Figure 2

DESCRIPTION OF BASIC EQUIPMENT
FOR 480V SYSTEM

The System 2001 consists of four basic elements: a system neutral; grounding resistor, a fault detector and annunciation system, and fault tracer.

System Neutral

The "System 2001" may be used on a low voltage grounding wye system, where a neutral is already available. On delta systems the neutral is derived by using three wye/delta connected transformers.

Grounding Resistor

The ohmic value of the grounding resistor will determine how much ground fault current will flow. Required ohmic value of the resistor depends on the system capacitive charging current, which can be accurately determined only by measurement. Two resistors in series: fixed and adjustable, are provided with the System 2001, that can be appropriately connected and regulated to a proper setting after the system has been installed.

Fault Detector

A double setpoint voltage sensing relay (V.S.R.) and a voltmeter (V.M.) are connected across the grounding resistor. Voltmeter provides a visual indication of voltage presence, the V.S. R. detects a fault condition and provides a signal for further fault analysis within the System 2001.

Fault Tracing Device

The fault tracing device features the following:

Multi-range switch

Large window.

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.

SYSTEM 2001 ADJUSTMENTS

The system is provided with four adjustment potentiometers. Two of them allow the user to set the 'Normal" capacitive charging current and the "ground fault" levels to avoid false alarms. The third potentiometer adjusts the time delay. The fourth allows the user to vary the length of pulses (3 - 150 pulses per minute).

SYSTEM 2001 INDICATORS

The System 2001 is provided with seven indicating lights. The three white lights "Phase 1", "Phase 2", "Phase 3" indicate that the grounding system is connected to the power system. In the event of ground fault in any phase, the associated white light will turn off, or dim, clearly indicating which phase is exposed to ground.

The white "Power" light indicates that control voltage is present; in case of loss of control power source, this light will extinguish, and the main power contactor (CR) will disconnect the derived neutral, leaving the delta ungrounded.

The green "Normal" light indicates that no fault exists on the system.

The red "Fault" light comes on when a ground fault occurs.

WARNING

When both green "Normal" and red "Fault" lights come on, it means that either one or both setpoints are incorrect.

The amber "Pulse" light will operate with the pulsing frequency during the tracing fault procedure.

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.

DESCRIPTION OF OPERATION

When a ground fault occurs, the V.S.R. actuates the time delay relay (TR). An adjustable time delay is provided to prevent activation of alarm in case of transient faults. If the fault is still present after time delay relay times out, the TR relay picks up and seals in through its own contact and the "Reset" pushbutton. Contacts of the TR relay close to operate the red "Fault" light and the horn.

The white phase lights indicate which phase has faulted, by dimming or extinguishing.

GROUND FAULT TRACING PROCEDURE

To trace the ground fault the operator pushes the selector switch to the "pulse" position.

A current transformer and ammeter at the panel will allow the operator to determine the current fluctuations on the system.

Fault locating scheme employs a pulsing circuit to short a portion of the grounding resistor for an adjustable period of time (3 - 150 pulses per minute). with the pulser (PRl & PR2) in operation, a clamp-on ammeter is used to identify the location of the fault. The jaws of the clamp-on ammeter are large enough to fit around the conduit in the system. When the ammeter is placed around the feeder containing the fault, the meter needle will fluctuate with the pulsing frequency. Checks are then made along the feeder (moving away from the power source) until no indication is obtained on the instrument. This point is the location of the 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 resistor to adjust the magnitude of the ground current in the range of from 0.9 to 3.6A, depending on the size of the system, so that the current supplied by the resistor is a ground fault which will be slightly greater than the system's natural capacitance charging current.

The capacitance charging current of most 480 volt systems is below one ampere so that the resistor is usually set at 0.9 ampere with an increase to 3.6 amperes during pulsing.

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).

OPERATION OF EQUIPMENT

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.
4. Both lights indicate improper setting.

GROUND DETECTION

1. Alarm horn sounds.
2. Depress silence switch It latches.
3. Push switch to pulse position. It latches.
4. Trace pulsing ground current with portable detector.
5. Remove fault.
6. Return switch to normal position by depressing to release latch
7. Press reset button to remove fault indication.
8. Depress silence switch to reset horn.

TEST

1. Press test button to simulate control circuits. Red light on and system operates as Ground Detection system above.
2. Press reset button after test to return to normal
3. Green light on.

LIST OF EQUIPMENT INCLUDED IN STANDARD 480V DELTA SYSTEM

1 - Fused Disconnect, 3 Phase with Current Limiting Fuses

3 - Grounding Transformers, Dry Type

1 - Voltage Relay

1 - Pulsing Relay, set to produce approximately 40 current pulsations per minute adjustable for 6 - 150 pulses

1 - Neutral Grounding Resistor

1 - Alarm Relay, with extra interlocks for remote alarm

1 - Control Transformer (as required).

1 - "Ground Fault" Red Indicating Light

1 - "Normal" Green Indicating Light

3 - Phase Indicating Lights

1 - Pulse Indicating Light

1 - Reset Button to Return to Normal Operation

1 - Pulse Pushbutton

1 - Alarm Silence Pushbutton

1 - "Test" Pushbutton

1 - Instruction Plate on Cover

X- All connections to control circuits wired to terminal boards

1 - Voltmeter, 0 - 300 Volts

1 - Ammeter, 0 - 5A

1 - Current Transformer, 5/5A

1 - Control Power Circuit Breaker

1 - Internal Alarm Horn

TECHNICAL DATA

DIMENSIONS

Electronic Assembly	15"L x 10-114"H x 10-114"D
Power Resistor Assembly	30"L x 16"H x 15"D

WEIGHTS

Electronic Assembly	Approximately 8 Lbs.
Power Resistor Assembly	Approximately 70 Lbs.

POWER REQUIREMENTS:	120 VAC -+ 15% 47 - 63 Hz 25 Watt Max

ENVIRONMENTAL REQUIREMENTS

Ambient Temperature	-10 to +75 Degrees C
Relative Humidity	0% - 95% (Non-Condensing)
Surge Withstand Capability	Satisfies IEEE-1974 & ANSI C37.90A

VOLTAGES

Maximum Ground Fault System Voltage	Up to *500 VAC* Continuously
Ground Fault Voltage	*480V* to +15% - 100%
	0 to *320V*

ADJUSTMENTS

Fault Sensing Time Delay	*.6 to 60 Seconds*
Pulsing	3 to *150 Pules* Per Minute
Normal Level Adjustment	0 to *68V*
Fault Detection Adjustment	0 to *320 VAC*