

1.0 PURPOSE

This test procedure is used by the Electrical Safety Division to evaluate ground wire monitor systems and their remotely located peripheral parts for acceptance and extensions of acceptance.

2.0 SCOPE

This STP applies to all ground wire monitor systems and their remotely located peripheral parts as required by the provisions of the Title 30, Code of Federal Regulations, Sections 18.47(d)(2), 75.902, 75.803, 77.902 and 77.803.

3.0 REFERENCES

- 3.1 ACRI2003, Design and Performance Criteria for Acceptance of Ground Wire Monitor Systems
- 3.2 IEEE Standard Number 18, Part 5

4.0 DEFINITIONS

- 4.1. Broken or Open Grounding Conductor - greater than or equal to 50 ohms inserted into the ground wire (conductor) for continuity type ground wire monitor systems.
- 4.2. Continuity Ground Wire Monitor - an instrument, apparatus or system that continuously monitors the continuity of a grounding conductor regardless of the existence of parallel paths, and initiates a tripping signal when the grounding conductor's continuity is broken.
- 4.3. Dropout Resistance - a quantity of resistance that, when placed into the monitored circuit, causes a ground wire monitor to initiate a tripping function.
- 4.4. Failsafe - the failure of any component other than welded relay contacts shall not negate the ability of a ground wire monitor system to perform its intended function unless the ground wire monitor system is designed to initiate a tripping function when such failure occurs.
- 4.5. Failsafe Ground Check Circuit - an MSHA accepted ground wire monitor system which is installed according to the manufacturer's instructions and specifications and has met all applicable requirements specified in ACRI2003, "Design and Performance Criteria for Acceptance of Ground

Wire Monitor Systems" and ASTP2135, "Standard Test Procedure For Acceptance of Ground Wire Monitor Systems".

- 4.6. Hazardous Condition - a condition that can place personnel in contact with potentially harmful voltages. This condition can be the result of any single component failure internal to the ground wire monitor or the failure of its remotely located parts.
- 4.7. Impedance Ground Wire Monitor - an instrument, apparatus, or system that measures the impedance or resistance of a designated pilot and ground wire circuit and then initiates a tripping signal when the impedance or resistance exceeds an amount necessary to produce a 40-volt (for low and medium voltage systems and all permissible equipment) or a 100-volt (for high voltage systems) potential external to the neutral grounding resistor during grounded phase conditions. Note that all permissible equipment applications are limited to a maximum 40-volt potential per 30 CFR 18.50(b).
- 4.8. Parallel Path - an electrically conductive path between pieces of equipment, which is parallel to and in addition to the ground conductor.
- 4.9. Shunt - a device used to exclusively develop a voltage drop for signaling purposes and that has a known resistance or impedance.

5.0 TEST EQUIPMENT

Test equipment is identified in each test procedure.

6.0 TEST SAMPLES

NOTE:

(1) Unless stated otherwise in the test information, nominal voltage in the manufacturer's specifications will be used as the input control voltage to the monitor.

(2) Unless stated otherwise, only ground wire monitors with front panel controls provided specifically for calibration purposes will be calibrated when calibration is specified.

7.0 PROCEDURES

- 7.1. Manufacturers should verify that the ground wire monitor system submitted for acceptance performs satisfactorily according to the tests

outlined in this procedure. A description of the test setups used and test data sheets should be submitted with the application.

- 7.2. MSHA will evaluate submitted test documentation and will accept the results from the manufacturer with only random test verification. Thorough testing by the manufacturer can significantly reduce MSHA's fees for conducting tests. In addition, the manufacturer's testing awareness can improve design and the ability to address field problems.
- 7.3. The test sequence generally follows that listed. However, the sequence of testing has no direct effect on acceptance or rejection and may be changed to accommodate efficiency. The important aspect is to assure that all tests applying to a specific ground wire monitor system are performed.
- 7.4. The ground wire monitor system and associated documentation will be reviewed and a list of tests required will be developed during MSHA's fee estimate. The manufacturer will be informed of the tests which will be conducted by MSHA.
- 7.5. One production type ground wire monitor system shall be utilized for the complete series of tests except the failsafe test, which shall utilize the "breadboard" unit.
- 7.6. Deviations from these test procedures must be approved in advance by MSHA and provide equally informative results.
- 7.7. All voltages and currents are RMS values unless otherwise stated.
- 7.8. For test purposes a parallel path is a wire connected between the frame/chassis at the ground wire monitor system origination point and the system termination point which has a resistance equal to the resistance of the ground wire.
- 7.9. Characteristics Test:

The purpose of the characteristics test is to establish references about certain measurements for later comparisons. These comparisons will assist in determining whether critical components have failed during subsequent testing and whether the ground wire monitor system is performing within acceptable manufacturing tolerance. It also provides the investigator with a basic knowledge of the ground wire monitor system's operation

Results of this test are recorded on the Monitor Characteristics Record Form and the Time Delay Test Record Form.

7.9.1. The equipment required to perform the test is:

7.9.1.1. A power supply to provide power to the ground wire monitor.

7.9.1.2. Two 0.33 ohm, 50W, 1% resistors.

7.9.1.3. Three 0.25 ohm, 50W, 1% resistors.

7.9.1.4. One 50 ohm, 50W, 1% resistor.

7.9.1.5. One normally closed, SPST switch, 2A, 120V.

7.9.1.6. One ten-turn, 10 ohm, variable resistor (potentiometer).

7.9.1.7. One 1.3 ohm, 50W, 1% resistor.

7.9.1.8. A meter for measuring elapsed time from 0 - 0.5 seconds with an accuracy of plus/minus ten microseconds.

7.9.1.9. Oscilloscope with the capability of measuring frequencies of 20,000 hertz and voltages of 10 millivolts peak-to-peak.

7.9.1.10. Kelvin Bridge.

7.9.1.11. Volt-ohmmeter (multimeter).

7.9.1.12. One SPDT, center off, 2A, 120V AC switch.

7.9.1.13. One SPST 2A, 120V, AC switches.

7.9.1.14. One counter.

7.9.2. Test Procedure:

NOTE: The monitor is permitted 15 minutes to reach operating temperature before tests are performed.

7.9.2.1. Install and calibrate the ground wire monitor system in accordance with the manufacturer's specifications and instructions in a test circuit that is electrically equivalent to the test circuit shown in Figure 1.

- 7.9.2.2. Install a parallel path in the test circuit. If the monitor is an impedance or resistance type monitor the parallel path is not installed.
- 7.9.2.3. Increase the input voltage to the monitor from zero volts until the monitor's tripping relay "picks up".
- 7.9.2.4. Use a volt meter to measure the monitor's input voltage.
- 7.9.2.5. Record this value as the "pick up" voltage with a parallel path.
- 7.9.2.6. Reduce the input voltage to zero.
- 7.9.2.7. Remove the parallel path and repeat steps 7.9.2.3 and 7.9.2.4 of this test. Omit steps 7.9.2.7 and 7.9.2.8 for impedance monitors.
- 7.9.2.8. Record this value as the pickup voltage without a parallel path.
- 7.9.2.9. Adjust the monitor's input voltage to that specified by the manufacturer.
- 7.9.2.10. Reduce the input voltage until the monitor's tripping relay just "drops out". If the monitor relay trips before 80% voltage is reached, stop testing. The ground wire monitor system fails.
- 7.9.2.11. Measure the voltage at this point and record this value as the "drop out" voltage without a parallel path.
- 7.9.2.12. Adjust the monitor's input voltage to that specified by the manufacturer.
- 7.9.2.13. Install a parallel path in the test circuit and repeat steps 7.9.2.10, 7.9.2.11, and 7.9.2.12 of this test, except that the voltage recorded will be with a parallel path. Omit this step for impedance monitors.
- 7.9.2.14. Install the ten-turn 100 ohm potentiometer in the ground wire with the potentiometer adjusted to zero resistance. If the monitor is an impedance monitor, proceed to step 7.9.2.24.
- 7.9.2.15. Install a parallel path in the test circuit.
- 7.9.2.16. Slowly increase the resistance of the potentiometer until the tripping relay just trips.

- 7.9.2.17. Remove the potentiometer from the ground wire and measure its resistance with the ohmmeter.
- 7.9.2.18. Record this value as the dropout resistance with a parallel path.
- 7.9.2.19. Adjust the 100 ohm ten-turn potentiometer maximum value.
- 7.9.2.20. Reinstall the potentiometer in the ground wire.
- 7.9.2.21. Slowly decrease the potentiometer resistance until the tripping relay just picks up.
- 7.9.2.22. Remove the potentiometer from the ground wire and measure its resistance with the ohmmeter.
- 7.9.2.23. Record this value as the pick up resistance with a parallel path.
- 7.9.2.24. Remove the parallel path.
- 7.9.2.25. Repeat steps 7.9.2.14, 7.9.2.16, 7.9.2.17, 7.9.2.18, 7.9.2.19, 7.9.2.20, 7.9.2.21, 7.9.2.22 and 7.9.2.23 of this test, except that the values recorded in steps 7.9.2.18 and 7.9.2.23 of this test are recorded as values without a parallel path.
- 7.9.2.26. Reconnect the ground wire and parallel path. Omit the parallel path on impedance monitors.
- 7.9.2.27. Install the time elapse meter to measure the time period between inserting 50 ohms (the calibrated resistance plus 12% for impedance monitors) into the ground wire and the instant the tripping relay de-energizes (see Figure 1).
- 7.9.2.28. Measure the time period between inserting the resistance and the instant the tripping relay de-energizes (see Figure 1) to obtain ten measurements.
- 7.9.2.29. Average the ten measurements and enter the information as the time delay with a parallel path.
- 7.9.2.30. Remove the parallel path and repeat steps 7.9.2.28 and 7.9.2.29 to obtain the monitor's time delay without a parallel path. If the monitor is an impedance monitor proceed to step 7.9.2.32.

- 7.9.2.31. Record this value as the time delay without a parallel path.
- 7.9.2.32. Remove the time delay test circuit and repeat step 7.9.2.1 of this test.
- 7.9.2.33. Measure the amplitude and shape of the monitor's output waveform across the 0.33 ohm ground wire resistor through three complete cycles. Record this as the potentiometer frequency.
- 7.9.2.34. Disconnect the monitor from the test circuit and measure the amplitude and shape of the monitor's open circuit output waveform through three complete cycles. Record this value as the open circuit voltage.
- 7.9.2.35. Install a 0.10 ohm resistor across the monitor's output terminals and measure the amplitude and shape of the monitor's output waveform through three complete cycles. Record this information as the monitor's short circuit current.
- 7.9.2.36. Repeat step 7.9.2.1 of this test.
- 7.9.2.37. Install a counter circuit on the monitor's tripping relay contacts.
- 7.9.2.38. Adjust the input voltage of the monitor to 115% nominal. If the monitor relay trips or component failure occurs, stop the test. The ground wire monitor system fails.
- 7.9.2.39. Ensure that the monitor will trip when 50 ohms (the calibrated resistance plus 12% for impedance monitors) is inserted into the ground wire.
- 7.9.2.40. Allow the monitor to remain energized for eight hours.
- 7.9.2.41. Record any trip indicated on the counter during the eight hour period.
- 7.9.2.42. Adjust the input voltage of the monitor to 80% nominal.
- 7.9.2.43. Allow the monitor to remain energized for one minute.
- 7.9.2.44. Record any trips indicated during the one minute interval.
- 7.9.3. Pass Fail Criteria: When tested in accordance with the procedure outline in 7.1.2, the monitor shall:
- 7.9.3.1. Have a "pickup" resistance greater than 40% of the dropout resistance.

- 7.9.3.2. Have a “dropout” resistance less than or equal to 50 ohms for continuity monitors.
- 7.9.3.3. Not have a “dropout” resistance greater than the amount necessary to cause a 40 volt drop in the grounding circuit external to the neutral grounding resistor under grounded phase conditions (i.e., 1.7 ohms for a 25 ampere system) for impedance monitors.
- 7.9.3.4. Not have a time delay greater than 250 milliseconds or less than 150 milliseconds.
- 7.9.3.5. Not have an open circuit monitoring voltage greater than 40 volts.
- 7.9.3.6. Not have a short circuit monitoring current greater than 2 amperes.
- 7.9.3.7. Not have a monitoring current less than 50 milliamperes.
- 7.9.3.8. Not experience the failure of any components.
- 7.9.3.9. Not trip in steps 7.9.2.40 or 7.9.2.43.

7.10. Calibration Adjustment Test

- 7.10.1. The purpose of the test is to assure that continuity ground wire monitors cannot be calibrated for trip values greater than 50 ohms in the ground wire and that impedance ground wire monitors will not remain energized on circuits exceeding 15 ohms.
- 7.10.2. Results of this test are recorded on the Calibration Adjustment Test Record Form.
- 7.10.3. The equipment required to perform the test is:
 - 7.10.3.1. A power supply to provide power to the monitor.
 - 7.10.3.2. Two 0.33 ohm, 50W, 1% resistors.
 - 7.10.3.3. Three 0.25 ohm, 50W, 1% resistors.
 - 7.10.3.4. One 1.3 ohm, 50W, 1% resistor.
 - 7.10.3.5. One ten-turn 100 ohm variable resistor (Potentiometer).
 - 7.10.3.6. One volt-ohmmeter.

7.10.3.7. One normally closed push button switch, 120V, 2A.

7.10.4. Test Procedure

Note: Ground wire monitor systems that are designed to operate as pilot wire or pilot-wireless shall be tested in both configurations.

7.10.4.1. Install and calibrate the ground wire monitor system in accordance with the manufacturer's instructions and specifications in a test circuit similar to Figure 1. Do not install a parallel path.

7.10.4.2. Adjust the calibration dial, knob, or potentiometer of the monitor to the maximum position. This applies to internal and external calibration adjustments.

7.10.4.3. Open the switch across the 100 ohm ten-turn potentiometer and increase the resistance of the potentiometer from zero until the monitor's tripping relay just trips.

7.10.4.4. Remove the potentiometer from the test circuit. Measure and record its resistance on the Calibration Adjustment Test Record Form.

7.10.4.5. Reinstall the potentiometer in the test circuit.

7.10.4.6. Adjust the calibration dial, knob, or potentiometer of the monitor to the minimum position. This applies to internal and external adjustments.

7.10.4.7. Repeat steps 7.10.4.3 and 7.10.4.4 of this test.

7.10.4.8. For continuity monitors install a parallel path and repeat steps 7.10.4.1 through 7.10.4.7.

7.10.5. Pass/Fail Criteria: When tested in accordance with 7.10.4, the resistance of the potentiometer measured in steps 7.10.4.4, 7.10.4.7 and 7.10.4.8 of this test shall not exceed 50 ohms for continuity monitors and 15 ohms for impedance monitors.

7.11. Accelerated Life Test

7.11.1. The purpose of the test is to determine if elevated temperatures for extended periods of time will induce component failure which affects the failsafe performance of the monitor.

7.11.2. Results of this test are recorded on the Accelerated Life Test Record Form.

7.11.3. The equipment required to perform the test is:

7.11.3.1. Temperature chamber capable of sustaining a test temperature of $85^{\circ} \pm 1^{\circ}\text{C}$.

7.11.3.2. All of the equipment required for the characteristics test.

7.11.3.3. Two electronic counters.

7.11.3.4. One 0-15 minute electronic timer with an on/off output.

7.11.4. Test Procedure

Note: If the monitor is designed to operate with phase coupler filters and pilot wire filters, then this test shall be performed once on each configuration.

7.11.4.1. Install and calibrate the monitor in accordance with the manufacturer's specifications and instructions in the temperature chamber (see Figure 2).

7.11.4.2. Arrange a timing circuit that will automatically insert the 50 ohms (the calibrated resistance plus 12% for impedance monitors) into the ground wire 1000 times in 96 hours. Adjust the timing circuit to time-in and time-out the 50 ohm resistor for 1000 counts of approximately equal time periods for 96 hours.

7.11.4.3. Arrange two counters to automatically record the number of times the resistance is inserted and the number of times the ground wire monitor tripping relay trips in response.

7.11.4.4. Connect the timing circuit and counter circuit to the monitor circuit in accordance with Figure 3.

7.11.4.5. Adjust the input voltage of the monitor to 115% nominal and energize the power supply.

7.11.4.6. Turn the temperature chamber on and adjust the temperature for at least 85°C . The rate of temperature rise may be limited to not more than 15°C per 30 minutes.

- 7.11.4.7. Allow the temperature to stabilize at a minimum of 85⁰C for 30 minutes.
- 7.11.4.8. Maintain the chamber temperature at a minimum of 85⁰C for 24 hours.
- 7.11.4.9. Adjust the monitor input voltage to nominal and start the timing sequence to operate for 96 hours.
- 7.11.4.10. Reduce the temperature of the test chamber to room temperature. Allow the monitor to stabilize for 30 minutes and perform the characteristics test.
- 7.11.4.11. Compare the values recorded in step 7.11.4.10 with the values recorded in the initial characteristics test.
- 7.11.5. Pass/Fail Criteria: If the dropout resistance exceeds 50 ohms (the calibrated resistance plus 12% for impedance monitors); the values recorded in step 7.11.4.10 vary by more than 10% from the initial characteristics test values; the monitor trip indicator shows more than a 0.5% count discrepancy for the 96 hour period; or any component of the ground wire monitor system fails, the ground wire monitor system fails the test.

7.12. Temperature Variation Test

- 7.12.1. The purpose of the test is to assure that ground wire monitor systems maintain their calibration during temperature variations of -26⁰C to 60⁰C.
- 7.12.2. Results of this test are recorded on the Temperature Variation Test Record Form.
- 7.12.3. The equipment required to perform the test is:
- 7.12.3.1. Temperature chamber(s) with a capability of sustaining test temperatures of -26⁰C to + 60⁰C \pm 1⁰C.
- 7.12.3.2. A power supply to supply power to the monitor.
- 7.12.3.3. Kelvin Bridge.
- 7.12.3.4. Potentiometer, 0-100 ohm, ten-turn.
- 7.12.3.5. Switch, DPDT, 2A 120V.
- 7.12.3.6. Two 0.33 ohm, 50W, 1% resistors.

7.12.3.7. Three 0.25 ohm, 50W, 1% resistors.

7.12.3.8. One 1.3 ohm, 50W, resistor.

7.12.4. Test Procedure

Note: If the monitor is designed for use with phase coupler filters and pilot wire filters, then this test shall be performed once on each configuration. Each configuration must have its own set of test record forms.

7.12.4.1. Install the monitor in accordance with the manufacturer's instructions and specifications in the temperature chamber at room temperature (see Figure 3) and calibrate the monitor in accordance with manufacturer's instructions.

7.12.4.2. Adjust the temperature of the temperature chamber to $+ 22^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and perform steps 7.9.2.14 through 7.9.2.26 of the characteristics test.

7.12.4.3. Reduce the chamber temperature at the rate of 15°C per 30 minute period from $+ 22^{\circ}\text{C}$ until $- 26^{\circ}\text{C} \pm 1^{\circ}\text{C}$ temperature is obtained. Allow 30 minutes for temperature stabilization.

7.12.4.4. Perform steps 14 through 26 of the characteristics test. Record results.

7.12.4.5. Increase the chamber temperature at the rate of 15°C per 30 minute period until $+ 60^{\circ}\text{C} \pm 1^{\circ}\text{C}$ is obtained. Allow 30 minutes for temperature stabilization.

7.12.4.6. Perform steps 7.9.2.14 through 7.9.2.26 of the characteristics test. Record results.

7.12.4.7. Reduce the chamber temperature at the rate of 15°C per 30 minute period from 60°C until room temperature is obtained.

7.12.4.8. Allow 30 minutes for temperature stabilization and perform steps 7.9.2.14 through 7.9.2.26 of the characteristics test. Record results.

7.12.5. Pass/Fail Criteria: When tested in accordance with 7.12.4, the values measured in steps 7.12.4. 2, 7.12.4.4, 7.12.4.6, and 7.12.4.8 shall not vary by more than $\pm 10\%$ of the values measured during the initial characteristics test. In no case shall the dropout resistance exceed 50 ohms for continuity monitors or 15 ohms for impedance monitors. The failure of any

component of the ground wire monitor system also constitutes failure of the test.

7.13. Failsafe Test

7.13.1. The purpose of this test is to determine if the ground wire monitor is failsafe.

7.13.1.1. Results of this test are recorded on the Failsafe Test Record Form.

7.13.2. The equipment necessary to perform the failsafe test is:

7.13.2.1. A power supply to provide power to the monitor.

7.13.2.2. A wire, #18 gauge approximately 12 inches in length with spring clips at each end.

7.13.2.3. Two 0.33 ohm, 50W, 1% resistors.

7.13.2.4. Three 0.25 ohm, 50W, 1% resistors.

7.13.2.5. One 1.3 ohm, 50W, 1% resistor.

7.13.2.6. One 50 ohm, 50W, 1% resistor.

7.13.2.7. One 0-15 ohm, 50W, potentiometer.

7.13.2.8. One soldering iron, select wattage in accordance with the circuitry involved.

7.13.2.9. Two SPST switches, 2A, 120V.

7.13.3. Test Procedure

7.13.3.1. Install and calibrate the ground wire monitor system utilizing the "breadboarded" unit in accordance with the manufacturer's specifications and instructions in a test circuit as shown in Figure 1. Each component shall be tested with and without a parallel path.

7.13.3.2. Record results of this test on the Failsafe Test Record Form.

7.13.3.3. Use the 50 ohm test position for continuity monitors and the calibrated resistance plus 12% position for impedance monitors.

- 7.13.3.4. Inductors, transformers, resistors (except resistors used as shunts), relay coils and lamps shall be individually failed in the open-circuit mode.
- 7.13.3.5. Semiconductor devices, surge suppression devices, and capacitors shall be individually failed in both the open-circuit and short-circuit modes.
- 7.13.3.6. Integrated circuits shall be individually failed in both the open-circuit and short-circuit modes in accordance with their design and application.
- 7.13.3.7. All component tests are performed with the ground wire monitor system operating at manufacturers' specifications. If the tripping relay does not trip the instant the test is performed, insert 50 ohms into the ground wire of continuity monitors or the calibrated test resistance plus 12% is inserted into the pilot wire of impedance monitors.

7.13.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.13.3, the ground wire monitor system shall:

- 7.13.4.1. Initiate a tripping function immediately, or
- 7.13.4.2. Initiate a tripping function when 50 ohms is inserted into the ground wire of continuity monitors, or
- 7.13.4.3. Initiate a tripping function when the calibrated dropout resistance plus 12% is inserted into the pilot wire of impedance or resistance monitors.

7.14. Shunt Test

7.14.1. The purpose of the test is to determine if a resistor used as a shunt internal to the ground wire monitor may be exempt from testing during the failsafe test.

7.14.1.1. Results of this test are recorded on the Shunt Test Record Form.

7.14.2. The equipment required to perform the shunt test is:

7.14.2.1. A power supply of adequate power and frequency to deliver the voltage and current required for the test.

7.14.2.2. Resistors and/or reactors for current limiting the power supply.

7.14.2.3. Time elapse meter.

7.14.2.4. Kelvin Bridge.

7.14.2.5. Oscilloscope.

7.14.2.6. A timing relay.

7.14.2.7. One AC contactor.

7.14.3. Test Procedure

7.14.3.1. Prior to performing the shunt test, measure and record the nominal amplitude and shape of the shunt's waveform through three complete cycles to obtain the shunt's voltage, current and signal frequency and record the results.

7.14.3.2. Use a sample shunt provided for testing and measure and record the resistance.

7.14.3.3. Calibrate a power supply to deliver an output frequency equal to the shunt frequency.

7.14.3.4. Arrange the shunt in a series circuit with the power supply (see Figure 4) and calibrate the circuit to deliver 10 times the shunt's nominal current through the shunt for one minute.

7.14.3.5. De-energize the circuit for 30 seconds.

7.14.3.6. Repeat the test to obtain a total of 3 tests.

7.14.3.7. Remove the shunt from the test circuit and allow the shunt to cool to approximate room temperature for approximately 30 minutes.

7.14.3.8. Measure the resistance of the shunt with the Kelvin Bridge and record the results.

7.14.3.9. Calculate the difference between the resistance recorded in step 7.14.3.2 and the resistance recorded in step 7.14.3.9 and record the results.

7.14.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.14.3, the difference in resistance of the shunt measured in steps 7.14.3.2 and 7.14.3.9 of this test shall not be greater than $\pm 5\%$ of the resistance measured in step 7.14.3.2 of this test.

7.15. Energized Relay Test

7.15.1. The purpose of this test is to assure that ground wire monitor system tripping relays are energized under normal operating conditions.

7.15.1.1. Results of this test are recorded on the Energized Relay Test Record Form.

7.15.2. The equipment required to perform the test is:

7.15.2.1. A mine duty circuit breaker with a 120 VAC undervoltage release.

7.15.2.2. Approximately one foot of number 18 AWG wire with spring clips on each end for use as a jumper during testing.

7.15.2.3. A power supply to provide power to the monitor.

7.15.2.4. Two 0.33 ohm, 50W, 1% resistors.

7.15.2.5. Three 0.25 ohm, 50W, 1% resistors.

7.15.2.6. One 1.3 ohm, 50W, 1% resistor.

7.15.2.7. One normally closed and one normally open SPST, 2A, 120V switch.

7.15.3. Test Procedure

7.15.3.1. Install and calibrate the monitor in accordance with the manufacturer's specifications and instructions in a test circuit that is electrically equivalent to the test circuit shown in Figure 1.

7.15.3.2. Connect the normally open contacts of the monitor in series with the circuit breaker's undervoltage release and a power supply providing power to the under voltage release.

7.15.3.3. Close the circuit breaker. (No power leads to breaker required).

7.15.3.4. Use the 18 AWG jumper and short the ground wire monitor tripping relay coil.

7.15.3.5. Record whether or not the circuit breaker tripped in step 7.15.3.4.

7.15.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.15.3, the mine duty circuit breaker shall trip when the monitor tripping relay coil is shorted. Failure occurs if the mine duty circuit breaker does not trip.

7.16. Stray DC Current Test

7.16.1. The purpose of the test is to determine if ground wire monitor systems will operate properly in the presence of stray DC currents.

7.16.1.1. Results of this test are recorded on the Stray DC Current Test Record Form.

7.16.2. The equipment required to perform the test is:

7.16.2.1. A variable, 3-Phase, 60 hertz power supply.

7.16.2.2. A 3-Phase, full wave rectifier.

7.16.2.3. A variable tap, 25 ohm, 3.5 kilowatt resistor.

7.16.2.4. DC ammeters capable of measuring test currents of 0.5, 1.0, 1.5, 2.0, 2.5, 5.0 and 10.0 amperes at approximately the mid-range point of the scale in each section of the test.

7.16.2.5. Three 0.25 ohm, 50W, 1% resistors.

7.16.2.6. Two 0.33 ohm, 1000W, 10% resistors.

7.16.2.7. A 10 amp, 120V, SPST switch.

7.16.2.8. One 1.3 ohm, 50W, 1% resistor.

7.16.2.9. One 50 ohm, 50W, 1% resistor.

7.16.2.10. One 0-15 ohm, 50W potentiometer.

7.16.3. Test Procedure

7.16.3.1. Install and calibrate the monitor in accordance with the manufacturer's specifications and instructions in a test circuit that is electrically equivalent to the test circuit shown in Figure 5. Use the 50 ohm test position for continuity monitors and the calibrated resistance plus 12% position for impedance monitors.

7.16.3.2. Connect the 3-Phase rectified power supply into the circuit.

NOTE: Whenever the test procedure calls for replacing the ammeter, the power must be turned off and then restarted after the ammeter is installed.

- 7.16.3.3. Install a DC ammeter capable of measuring 0.5 amperes current at approximately the mid-range point of the scale into the ground wire of the monitored circuit.
- 7.16.3.4. Set the DC current to 0.5 amperes.
- 7.16.3.5. Open switch S1 and reclose after approximately one second.
- 7.16.3.6. Repeat step 7.16.3.5 two more times.
- 7.16.3.7. Replace the ammeter and set the DC current to 1.0 amperes.
- 7.16.3.8. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.9. Replace the ammeter and set the DC current to 1.5 amperes.
- 7.16.3.10. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.11. Replace the ammeter and set the DC current to 2.0 amperes.
- 7.16.3.12. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.13. Replace the ammeter and set the DC current to 2.5 amperes.
- 7.16.3.14. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.15. Replace the ammeter and set the DC current to 5.0 amperes.
- 7.16.3.16. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.17. Replace the ammeter and set the DC current to 10.0 amperes.
- 7.16.3.18. Repeat step 7.16.3.5 of this test three times.
- 7.16.3.19. Reverse the polarity of the DC source and repeat steps 7.16.3.4 through 7.16.3.18.
- 7.16.3.20. De-energize and disconnect the 3-Phase rectified power supply from the monitored circuit.
- 7.16.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.16.3, the monitor shall trip only when 50 ohms is inserted into the grounding conductor for continuity monitors or when the

calibrated resistance plus 12% is inserted into the grounding conductor of impedance monitors.

7.17. Induced 60 Hz Voltage Test

7.17.1. The purpose of the test is to assure that pilot wire ground wire monitor systems can operate properly in the presence of induced voltages.

7.17.1.1. Results of this test are recorded on the Induced 60 Hz Voltage Test Record Form.

7.17.2. The equipment required to perform the test is:

7.17.2.1. A power supply for providing power to the monitor.

7.17.2.2. A 1000 VA, 120V, isolation transformer.

7.17.2.3. One push button, 120V, 10A.

7.17.2.4. One 120V, 15A, AC contactor.

7.17.2.5. One 15A, 120V, variable transformer.

7.17.2.6. One 500 watt, 0.33 ohm resistor.

7.17.2.7. One 500 watt, 1.33 ohm resistor.

7.17.2.8. One 1000 watt, 10 ohm, variable resistor.

7.17.2.9. One 0-100V voltmeter.

7.17.2.10. One 50 ohm, 500W, resistor.

7.17.2.11. One 0-15 ohm, 500W potentiometer.

7.17.2.12. One transformer suitable for the parameters of the test.

7.17.3. Test Procedure

7.17.3.1. Using the 0.33 ohm ground wire resistor, and the 1.33 ohm pilot wire resistor, install the monitor in accordance with the manufacturer's instructions and specifications in the pilot wire configuration in accordance with Figure 6. Use the 50 ohm test position for continuity

monitors and the calibrated resistance plus 12% position for impedance monitors.

7.17.3.2. Connect the test circuit into the ground wire and increase the variable transformer setting until the voltage at the pilot/ground wire terminals of the monitor measures 50 VAC.

7.17.3.3. De-energize and energize the test circuit, two seconds on and two seconds off, for a total of five times and record whether the monitor relay tripped.

7.17.3.4. Reverse the polarity of the test circuit and repeat step 7.17.3.3 of this test.

7.17.3.5. Disconnect the test circuit and reconnect the ground wire.

7.17.3.6. Insert the 50 ohm resistor in the ground wire for continuity monitors or the calibrated resistance plus 12% for impedance monitors and record the results.

7.17.4. Pass/Fail Criteria: When tested in accordance with 7.17.3, the monitor may trip during step 7.17.3.3 or step 7.17.3.4 of this test, but not in both steps, and only if a polarity switch is incorporated into the monitor. If the monitor does not incorporate a polarity switch, then no trips are allowed in steps 7.17.3.3 or 7.17.3.4 of this test. All monitors shall trip in step 7.17.3.6 of this test.

7.18. Series Operation Test

7.18.1. The purpose of this test is to assure that ground wire monitor systems monitoring series circuits will not interfere with the operation of each other.

7.18.1.1. Results of this test are recorded on the Series Operation Test Record Form.

7.18.2. The equipment required to perform the test is:

7.18.2.1. Two ground wire monitor systems complete with any remotely located devices.

7.18.2.2. A power supply to provide power to the monitors.

7.18.2.3. Four 0.33 ohm, 50W, 1% resistors.

7.18.2.4. Six 0.25 ohm, 50W, 1% resistors.

7.18.2.5. Two 50 ohm, 50W, 1% resistors.

7.18.2.6. Three normally closed, and three normally open SPST switches, 2A, 120V.

7.18.2.7. Two 1.3 ohm, 50W, 1% resistors.

7.18.2.8. One 0-15 ohm, 50W potentiometer.

7.18.2.9. One SPDT, center off, 2A, 120V switch.

7.18.3. Test Procedure

7.18.3.1. Install and calibrate two monitors in accordance with the manufacturer's specifications and instructions in a test circuit that is electrically equivalent to the test circuit shown in Figure 7. Use the 50 ohm test position for continuity monitors and the 15 ohm position for impedance monitors. With the parallel path switch open, open switch (S1) in ground wire A.

7.18.3.2. Close the switch (S1).

7.18.3.3. With parallel path switches open, open switch (S1) in ground wire B.

7.18.3.4. Close the switch (S1) opened in step 7.18.3.3.

7.18.3.5. Close the PP1 (Parallel Path =1) switch and repeat steps 7.18.3.1 through 7.18.3.4.

7.18.3.6. Open the PP1 switch and close the PP2 switch. Repeat steps 7.18.3.1 through 7.18.3.4.

7.18.3.7. Open the PP2 switch and close the PP3 switch. Repeat steps 7.18.3.1 through 7.18.3.4.

7.18.3.8. Open the PP3 switch and close the PP2 and PP1 switches. Repeat steps 7.18.3.1 through 7.18.3.4.

7.18.3.9. Open the PP2 switch and close PP3 switch. Repeat steps 7.18.3.1 through 7.18.3.4.

7.18.3.10. Open PP 1 switch and close PP2 switch. Repeat steps 7.18.3.1 through 7.18.3.4.

7.18.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.18.3, monitor A shall only trip every time step 7.18.3.1 is conducted. Monitor B shall only trip every time step 7.18.3.3 is conducted.

7.19. Parallel Path Operation Test

7.19.1. The purpose of the test is to assure that monitors monitoring parallel circuits will not interfere with the operation of each other.

7.19.1.1. Results of this test are recorded on the Parallel Path Operation Test Record Form.

7.19.2. The equipment required to perform the test is:

7.19.2.1. Six ground wire monitor systems complete with any remotely located devices, etc.

7.19.2.2. A power supply to provide power to the monitors.

7.19.2.3. Twelve 0.33 ohm, 50W, 1% resistors.

7.19.2.4. Eighteen 0.25 ohm, 50W, 1% resistors.

7.19.2.5. Six 50 ohm, 50W, 1% resistors.

7.19.2.6. Six 1.33 ohm, 50W, 1% resistors.

7.19.2.7. Eighteen SPST switches 2A, 120V.

7.19.2.8. Six SPDT, center off, 2A, 120V switch.

7.19.2.9. Six 0-15 ohm, 50W potentiometers.

7.19.3. Test Procedure

7.19.3.1. Install and calibrate six ground wire monitor systems in accordance with the manufacturer's specifications and instructions in a test circuit that is electrically equivalent to the test circuit shown in Figure 8, Figure 9 or Figure 10. If the monitors are designed to operate in either pilot wire or pilot-wireless configurations, then three test setups shall be evaluated. These test setups shall be six monitors installed as pilot wire

monitors, six monitors installed as pilot-wireless monitors and three monitors each installed as pilot-wireless and pilot wire monitors.

- 7.19.3.2. Make sure that all parallel path switches are open.
 - 7.19.3.3. Open the (S1) switch in the ground wire of each monitor one at a time. Close the switch before proceeding to the next switch. Record whether the tripping relay tripped for each monitor each time a switch was opened for monitors A, B, C, D, E and F. Record the results each time a switch is operated.
 - 7.19.3.4. Close all parallel path switches.
 - 7.19.3.5. Repeat step 7.19.3.3 of this test.
 - 7.19.3.6. Open parallel path switches PP1, 2, 3, 4, 5 and 6.
 - 7.19.3.7. Repeat step 7.19.3.3 of this test.
 - 7.19.3.8. Close parallel path switches PP1, 2, 3, 4, 5 and 6 and open switches PP7, 8, 9, 10, 11 and 12.
 - 7.19.3.9. Repeat step 7.19.3.3 of this test.
 - 7.19.3.10. Repeat steps 7.19.3.1 through 7.19.3.9 of this test with the simulated circuit breakers in Figure 9 or 10 in the closed position.
- 7.19.4. Pass/Fail Criteria: When tested in accordance with the procedures outlined in 7.19.3, monitors A, B, C, D, E and F tripping relays must open when the switch S1 in the ground wire is opened during steps 7.19.3.3, 7.19.3.5, 7.19.3.7 and 7.19.3.9 of this test. The monitor tripping relays must open only when their corresponding ground wire switches are opened. Tripping relay operation other than that listed is failure of the test.

7.20. Pilot Wire Device Test

- 7.20.1. The purpose of the test is to assure that devices connected in series with the pilot wire have a 60 hertz impedance less than or equal to 10 ohms and that the impedance of the device will not change when subjected to 25 amperes of 60 hertz current.
 - 7.20.1.1. Results of this test are recorded on the Pilot Wire Device Test Record Form.

7.20.2. The equipment required to perform the test is:

7.20.2.1. A single phase AC power supply capable of delivering 25 amperes of current at 577 volts for 2.5 seconds.

7.20.2.2. A variable tap current limiting resistor with wattage selected appropriately for 25 amperes.

7.20.2.3. A 0-50 ampere AC ammeter.

7.20.2.4. Push button momentary switch, 2A, 120V.

7.20.2.5. AC contactor 25A, 600V.

7.20.2.6. A 2.5 second timing apparatus with automatically controlled auxiliary contacts rated at 2A, 120V.

7.20.2.7. Isolated power supply for supplying power to the timing apparatus.

7.20.2.8. Instrument capable of measuring the 60 Hz impedance of the device under test.

7.20.3. Test Procedure

7.20.3.1. Measure and record the 60 hertz impedance of the pilot wire device.

7.20.3.2. Use the equipment listed in 7.20.2 and arrange a test circuit similar to Figure 11.

7.20.3.3. Adjust the test circuit to supply 577 volts and 25 amperes to the device for 2.5 seconds.

7.20.3.4. Apply 25 amperes at 577 volts to the device for 2.5 seconds.

7.20.3.5. Allow the pilot wire device to cool for 10 minutes.

7.20.3.6. Repeat step 7.20.3.4.

7.20.3.7. Repeat step 7.20.3.5.

7.20.3.8. Repeat step 7.20.3.4.

7.20.3.9. Permit the device to cool for 30 minutes and measure and record the 60 hertz impedance of the pilot wire device.

7.20.4. Pass/Fail Criteria: The pilot wire device fails if the 60 hertz impedance exceeds 10 ohms. The device also fails if the 60 hertz impedance varies by more than $\pm 5\%$ of the value measured in 7.20.3.1.

7.21. Optional Pilot Wire Device Test

Note: If the pilot wire device passed test 7.20, do not perform this test.

7.21.1. The purpose of the test is to determine if a monitor can independently clear a phase-to-pilot wire fault in less than 200 milliseconds when the 60 hertz impedance of a device connected in series with the pilot wire exceeds 10 ohms.

7.21.1.1. Results of this test are recorded on the Optional Pilot Wire Device Test Record Form.

7.21.2. The equipment required to perform the test is:

7.21.2.1. An AC power supply capable of supplying 25 amperes for one minute.

7.21.2.2. A variable tap current limiting resistor rated for 25 amperes.

7.21.2.3. A 600V, 25 Ampere, AC contactor.

7.21.2.4. Momentary push button switch, 2A, 120V.

7.21.2.5. A 0 to 50 ampere, AC ammeter.

7.21.2.6. One 0.33 ohm, 250W, 1% resistor.

7.21.2.7. One 0.25 ohm, 250W, 1% resistor.

7.21.2.8. Instrumentation capable of measuring and recording a 20 millisecond time span with an accuracy of \pm two microseconds.

7.21.2.9. Instrument capable of measuring the 60 Hz impedance of the pilot wire device.

7.21.3. Test Procedure

7.21.3.1. Measure and record the 60 hertz impedance of the pilot wire device.

- 7.21.3.2. Install and calibrate a monitor in the pilot wire configuration in accordance with the manufacturer's specifications and instructions in accordance with Figure 12.
- 7.21.3.3. Calibrate the test circuit to deliver 25 amperes at 577 volts through the pilot wire device.
- 7.21.3.4. Connect the test circuit to the monitor circuit in accordance with Figure 12.
- 7.21.3.5. Energize the test circuit for one minute.
- 7.21.3.6. If the monitor de-energizes the test circuit in 200 milliseconds or less, repeat the test two more times. Allow approximately one minute between tests. Record results.
- 7.21.3.7. If the monitor does not de-energize the test circuit in 200 milliseconds or less, stop the test. Record results.
- 7.21.3.8. Measure and record the 60 hertz impedance of the pilot wire device.
- 7.21.4. Pass/Fail Criteria When tested in accordance with the procedures outlined in 7.21.3, the monitor shall de-energize the test circuit in 200 milliseconds or less and the 60 hertz impedance of the pilot wire device shall not change by more than $\pm 5\%$ due to the test current and voltage.

7.22. Hypot Test

Note: The ground wire monitor is not connected to any test circuit during this test.

- 7.22.1. The purpose of the test is to assure that monitors provide separation between the ground wire terminal and the monitor case.
 - 7.22.1.1. Results of this test are recorded on the Hypot Test Record Form.
- 7.22.2. The equipment required to perform the test is:
 - 7.22.2.1. One 3KV, 60 hertz, AC power supply.
 - 7.22.2.2. Two test leads insulated for the voltage of the test.
- 7.22.3. Test Procedure

- 7.22.3.1. Attach one test lead to the ground wire terminal and one test lead to monitor case.
- 7.22.3.2. Increase the voltage gradually to 3KV while observing the current meter on the power supply. If the current meter exceeds 0.1mA stop the test. Record results.
- 7.22.3.3. Attach one test lead to the pilot wire terminal and one test lead to monitor case.
- 7.22.3.4. Repeat step 7.22.3.2.
- 7.22.3.5. Attach one test lead to one side of the control voltage and one test lead to the ground wire terminal.
- 7.22.3.6. Repeat step 7.22.3.2.
- 7.22.3.7. Attach one test lead to the other side of the control voltage and one test lead to the ground wire terminal.
- 7.22.3.8. Repeat step 7.22.3.2.
- 7.22.3.9. Attach one test lead to one side of the control voltage and one test lead to the pilot terminal.
- 7.22.3.10. Repeat step 7.22.3.2.
- 7.22.3.11. Attach one test lead to the other side of the control voltage and one test lead to the pilot terminal.
- 7.22.3.12. Repeat step 7.22.3.2.
- 7.22.3.13. Attach one test lead to the monitor's normally closed trip relay contacts and one test lead to the ground terminal.
- 7.22.3.14. Repeat step 7.22.3.2.
- 7.22.3.15. Attach one test lead to the monitor's normally open trip relay contacts and one test lead to the ground terminal.
- 7.22.3.16. Repeat step 7.22.3.2.
- 7.22.3.17. Attach one test lead to the monitor's trip relay common terminal(s) and one test lead to the ground terminal.

7.22.3.18. Repeat step 7.22.3.2.

7.22.4. Pass/Fail Criteria: When tested in accordance with 7.22.3, the current meter shall not read more than 0.1 milliamperes.

7.23. 300-Volt Fault Test

7.23.1. The purpose of the test is to assure that monitors are not affected by phase-to-ground faults.

7.23.1.1. Results of this test are recorded on the 300-Volt Fault Test Record Form.

7.23.2. The equipment required to perform the test is:

7.23.2.1. One 300-volt, AC, 25 ampere power supply.

7.23.2.2. One 600-volt, AC, 25 ampere contactor.

7.23.2.3. One 0 to 0.5 second timing relay with output contacts.

7.23.2.4. One 0.33 ohm, 500W, 1% resistor.

7.23.2.5. Three 0.25 ohm, 1000W, 1% resistors.

7.23.2.6. One 1.3 ohm, 500W, 1% resistor.

7.23.2.7. One momentary push button, 2 amps, 120 volts.

7.23.2.8. One mine duty circuit breaker, 600 volts, 20A.

7.23.2.9. Instrumentation capable of measuring and recording 250 milliseconds time span with an accuracy of \pm two milliseconds.

7.23.2.10. A SPST, 2A, 120V switch.

7.23.2.11. One 0 – 100 ohm, ten turn potentiometer.

7.23.2.12. One 50 ohm, 50W, 1% resistor.

7.23.3. Test Procedure

7.23.3.1. Install and calibrate the monitor in accordance with the manufacturer's specifications and instructions.

7.23.3.2. Arrange a test circuit similar to Figure 13.

7.23.3.3. Calibrate the test circuit to remain energized for 250 milliseconds.

7.23.3.4. Insert the test circuit into the ground wire in accordance with Figure 13.

7.23.3.5. Energize the test circuit and initiate the test. Record results.

7.23.3.6. Wait one minute.

7.23.3.7. Initiate the test. Record results.

7.23.3.8. Repeat steps 7.23.3.6 and 7.23.3.7 of this test.

7.23.3.9. Remove the test circuit from the ground wire and install the ground wire portion of the test circuit shown in Figure 1.

7.23.3.10. Make the appropriate selection of 50 ohms or the dropout resistance plus 12% and open switch S1. Record results.

7.23.4. Pass/Fail Criteria: When tested in accordance with 7.23.3, the monitor shall pick up in step 7.23.3.9 and dropout in step 7.23.3.10.

7.24. Cable Length Test

7.24.1. The purpose of the test is to assure that pilot-wireless monitors will monitor at least 1000 feet of cable, which is applicable to the mining environment, and to determine what length of cable the monitor will monitor up to a maximum of 5000 feet.

7.24.2. Results of this test are recorded on the Cable Length Test Record Form

7.24.3. The equipment required to perform the test is:

7.24.3.1. A power supply for supplying power to the monitor.

7.24.3.2. Capacitance values as follows:

7.24.3.2.1. LENGTH (ft.) CAPACITANCE (microfarads)

500	0.10
1000	0.20
1500	0.30
2000	0.41
2500	0.51
3000	0.60

3500	0.71
4000	0.82
4500	0.92
5000	1.00

7.24.4. Test Procedure

7.24.4.1. Install and calibrate the monitor in accordance with the manufacturer's specifications and instructions on simulated cable lengths of 500 feet each until the maximum length of 5000 feet is achieved.

7.24.4.2. The simulated cable lengths shall be constructed in accordance with Figure 14.

7.24.4.3. The ground wire shall be opened (physically opened as opposed to the normal 50 ohm open) at the end of each simulated section to verify that the monitor will trip.

7.24.4.4. Record whether the monitor tripped when the ground wire was opened after the addition of each 500 foot length of cable. When the monitor fails to trip after an additional 500 foot length is added, or 5000 feet is reached, stop the test.

7.24.5. Pass/Fail Criteria: When tested in accordance with 7.24.3, the monitor's tripping relay shall trip when the ground wire is opened for the 500 and 1000 foot lengths.

7.24.6. Voltage Discharge Test

7.24.6.1. The purpose of the test is to assure that the impressed voltage on phase coupler filter capacitors discharges to 50 volts or less in one minute or less.

7.24.6.2. Results of this test are recorded on the Voltage Discharge Test Record Form.

7.24.7. The equipment required to perform the test is:

7.24.7.1. A single phase, 60 hertz voltage power supply (or DC) capable of providing the voltage necessary for the capacitor under test.

7.24.7.2. A time elapse meter capable of recording the exponential decay of the capacitor voltage that will decay to 50 volts or less in one minute or less.

7.24.7.3. One circuit breaker for interrupting the capacitor voltage.

7.24.7.4. A voltmeter capable of measuring the capacitor test voltages.

7.24.8. Test Procedure

7.24.8.1. Install the phase coupler in accordance with Figure 15.

7.24.8.2. Adjust the voltage of the power supply to the capacitor's nominal voltage or 1000VAC RMS, whichever is greater.

7.24.8.3. Energize the voltage supply for 5 minutes.

7.24.8.4. Initiate the time elapse meter and disconnect the voltage supply by opening switch S1.

7.24.8.5. Allow the voltage to discharge for 1.5 minutes or until the voltage reaches 40 volts.

7.24.8.6. Calculate the time when the voltage discharged to 50 volts. Record results.

7.24.8.7. Repeat steps 7.24.8.1 through 7.24.8.6 of this test for each leg of the phase coupler.

7.24.8.8. Review the certification letter from the capacitor manufacturer.

7.24.9. Pass/Fail Criteria: When tested in accordance with 7.24.7, the voltage on each leg of the phase coupler must discharge to 50 volts or less in one minute or less. The certification letter must state that the capacitors meet the requirements of IEEE Standard Number 18, Part 5, excluding paragraph 5.4 (Voltage and Reactive Power Rating) and shall be subject to the limitations of paragraph 5.2.3 to maximum continuous voltage of 2400 VAC total RMS voltage. All capacitor RMS voltage ratings shall not be less than 1000VAC and shall equal or exceed the nominal voltage of the system in which the capacitors are to be installed.

7.25. Transient Test

7.25.1. The purpose of the transient test is to assure that ground wire monitor systems have adequate transient suppression.

7.25.1.1. Results of this test are recorded on the Transient Test Record Form.

7.25.2. The equipment required to perform the test is:

7.25.2.1. High power pulse generator capable of producing a pulse of 3KV for 50 nanoseconds to 500 microseconds. It should be capable of variable voltage and current selection and a power output of no less than 400 watts.

7.25.3. Test Procedure

Note: If a manufacturer provides transient suppression protection, this test may be waived.

7.25.3.1. Set up ground wire monitor system according to the operating instructions provided by the manufacturer (See Figure 1).

7.25.3.2. Set up the pulse generator making connections to the ground wire monitor's input voltage terminals.

7.25.3.3. Apply a transient pulse which is 10 times the nominal input voltage with a pulse width of 10 microseconds. The pulse source impedance will not be less than 50 ohms. Record results.

7.25.3.4. Repeat step 7.25.3.3 for a total of 20 pulses within a time range of 50 to 60 seconds.

7.25.3.5. Record any trips in step 7.25.3.3 and 7.25.3.4 as a monitor failure.

7.25.3.6. Set up the pulse generator making connections between one input voltage terminal and ground wire terminal.

7.25.3.7. Apply 20 transient pulses of 2,400 volts with a pulse width of 10 microseconds in 50 to 60 seconds. The pulse source impedance will not be less than 50 ohms. Record results.

7.25.3.8. Record any trips as a monitor failure.

7.25.3.9. Repeat steps 7.25.3.7 and 7.25.3.8, using the other input voltage terminal and the ground wire terminal.

7.25.3.10. Set up the pulse generator making connections between one input voltage terminal and the monitor case.

7.25.3.11. Repeat steps 7.25.3.7 and 7.25.3.8.

7.25.3.12. Repeat steps 7.25.3.7 and 7.25.3.8 using the other input voltage terminal and the ground wire terminal.

7.25.4. Pass/Fail Criteria: Failure of any component part of the monitor or monitor tripping constitutes failure of this test.

8.0 TEST DATA

Test Data information is defined in each test sequence.

9.0 PASS/FAIL CRITERIA

Pass / Fail Criteria information is defined in each test sequence.

File No. _____ PAR No. _____ Data Sheet No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

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MONITOR CHARACTERISTICS RECORD FORM

MONITOR TRADE NAME: _____

MODEL NO _____

RELAYS REQUESTED: Manufacturer Part No. _____

MONITOR TYPE: Continuity Resistance/Impedance

**Initial Parameters - Unit will be installed as per manufacturer specifications
& instructions in accordance with Figure 1.**

MODE INSTALLED: PILOT WIRE: _____ PILOT WIRELESS: _____

NOMINAL INPUT VOLTAGE: _____ VAC _____ VDC

WITHOUT PARALLEL PATH

PICKUP VOLTAGE: _____

DROPOUT VOLTAGE: _____

DROPOUT RESISTANCE: _____

PICKUP RESISTANCE: _____

TIME DELAY (MILLISECONDS): _____

MONITOR FREQUENCY: _____

OPEN CIRCUIT VOLTAGE: _____

SHORT CIRCUIT CURRENT: _____

WITH PARALLEL PATH

PICKUP VOLTAGE: _____

DROPOUT VOLTAGE: _____

DROPOUT RESISTANCE: _____

PICKUP RESISTANCE: _____

TIME DELAY (MILLISECONDS): _____

MONITOR FREQUENCY: _____

OPEN CIRCUIT VOLTAGE: _____

SHORT CIRCUIT CURRENT: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. ____ of ____ Investigator _____
Test Results: _____ Pass Fail

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MONITOR CHARACTERISTICS RECORD FORM

1. Connect the GWM tripping relay in series with an electro-mechanical counter and 120 V power supply.
2. Adjust monitor input voltage to 115% of nominal voltage.
3. Allow monitor to remain energized for eight (8) hours. Did monitor relay trip in the eight hour period? Yes ____ No ____
4. Adjust monitor input voltage to 80% of nominal voltage.
5. Allow monitor to remain energized for one (1) minute. Did monitor relay trip in the one minute period? Yes ____ No ____

NOTES/SPECIAL INFORMATION: _____

RECOMMENDATIONS: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. ____ of ____ Investigator _____
Test Results: _____ Pass Fail

TIME DELAY TEST RECORD FORM

RELAY MANUFACTURER: _____

MANUFACTURER'S PART NUMBER: _____

APPLICANT'S PART NUMBER: _____

MODE INSTALLED:

PILOT WIRE: _____ PILOT WIRELESS: _____

With Parallel Path

Without Parallel Path

1. _____ Milliseconds
2. _____ Milliseconds
3. _____ Milliseconds
4. _____ Milliseconds
5. _____ Milliseconds
6. _____ Milliseconds
7. _____ Milliseconds
8. _____ Milliseconds
9. _____ Milliseconds
10. _____ Milliseconds

1. _____ Milliseconds
2. _____ Milliseconds
3. _____ Milliseconds
4. _____ Milliseconds
5. _____ Milliseconds
6. _____ Milliseconds
7. _____ Milliseconds
8. _____ Milliseconds
9. _____ Milliseconds
10. _____ Milliseconds

Average Time Delay
_____ Milliseconds

Average Time Delay
_____ Milliseconds

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: _____ Pass Fail

CALIBRATION ADJUSTMENT TEST RECORD FORM

MODE INSTALLED: PILOT WIRE: _____ PILOT WIRELESS: _____

		RELAY TRIP	
		Yes	No
1.	Adjust calibration to maximum.	_____	_____
2.	Increase potentiometer to relay drop out.	_____	_____
3.	Measure and record resistance at relay drop out.	_____	_____ ohms
4.	Adjust calibration to minimum.	_____	_____
5.	Increase potentiometer to relay drop out.	_____	_____
6.	Measure and record resistance at relay drop out.	_____	_____ ohms

NOTE: Resistance must not exceed 50 ohms for continuity monitors
or 15 ohms for impedance monitors.

File No. _____ PAR No. _____ Data Sheet No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. ____ of ____ Investigator _____
Test Results: _____ Pass Fail

ACCELERATED LIFE TEST RECORD FORM

115% Nominal Line Voltage at a Temperature of 85°C (185°F) for 24 hours

TIME IN: _____ TIME OUT: _____

CONCLUSIONS AND/OR

RECOMMENDATIONS: _____

Adjust line voltage to nominal with temperature @ 85°C. Start timing circuit to operate for 96 hours.

DATE IN: _____ DATE OUT: _____

No. of Trips Required: _____ No. of Monitor Trips: _____

CONCLUSIONS AND/OR

RECOMMENDATIONS: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. _____ of _____ Investigator _____

Test Results: _____ Pass Fail

TEMPERATURE VARIATION TEST RECORD FORM

All monitors tested will be allowed to stabilize for at least 30 minutes at the specified temperature before testing the pickup and dropout resistances (all temperature changes may occur at a rate of not more than 15°C per 30 minute time period if necessary.)

DROPOUT	PICKUP	DROPOUT	PICKUP
Resistance	Resistance	Resistance	Resistance
With PP	With PP	Without PP	Without PP

Calibrated at 22°C	_____	_____	_____
Dropped to -26°C	_____	_____	_____
Raised to +60°C	_____	_____	_____
Dropped to +22°C	_____	_____	_____

CONCLUSIONS AND/OR

RECOMMENDATIONS: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

“Continuation Sheet ____ of ____ Sheets”

FAILURE MODE													
	COMPONENT OPENED						COMPONENT SHORTED						
	Monitor Tripping Relay Operated						Monitor Tripping Relay Operated						
Component	Instantly		50 ohms inserted in Ground Wire		Calib. D.O. Resistance		Instantly		50 ohms inserted in Ground Wire		Calib. D.O. Resistance		
	WPP	WOPP	WPP	WOPP	WPP	WOPP	WPP	WOPP	WPP	WOPP	WPP	WOPP	

WPP=With Parallel Path

WOPP=Without Parallel Path

Note: When needed make additional copies of this form.

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. ____ of ____ Investigator _____
Test Results: _____ Pass Fail

SHUNT TEST RECORD FORM

1. Shunt resistance _____ ohms @ 72°F.
2. Frequency of shunt current _____ .
3. Nominal shunt current _____ amps x 10 = _____ test amps.
4. Connect test circuit, see Figure 6.
5. Energize test circuit for one minute.
6. De-energize the test circuit for 30 seconds.
7. Repeat test to obtain a total of 3 tests.
8. Allow shunt to cool to room temperature, but not more than approximately 30 minutes; measured resistance of shunt _____ ohms.
9. Resistance from step 1 _____ ohms.
10. Difference in resistance values measured in step 8 and step 9 must be less than 5%.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. ____ of ____ Investigator _____
Test Results: _____ Pass Fail

ENERGIZED RELAY TEST RECORD FORM

1. Install and calibrate (calibrate only GWMs with external front panel controls specific for calibration purposes) the monitor according to manufacturers specifications.
2. Connect the normally open (N.O.) contacts of the monitor's tripping relay into a UV relay circuit on a mine duty circuit breaker and energize the UV circuit.
3. Close the mine circuit breaker.
4. With jumper wire, short the relay coil.
5. Breaker tripped _____ yes _____ no.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

STRAY D.C. CURRENT TEST RECORD FORM

For each ½ amp increment from 0 to 2.5 amps, then to 5.0 amps, then to 10 amps, the D.C. power must be inserted four times and during the time the D.C. power is on, resistor “R” is to be inserted in the ground wire. The state of the tripping relay is to be observed and recorded for each condition.

R = 50 Ω resistor for continuity monitors or calibrated drop-out resistance for impedance monitors.

D.C. Amp	State of Tripping Relay	D	R	R	D	D	R	R	D	D	R	R	D	D	R	R	D
		C	Ω	Ω	C	C	Ω	Ω	C	C	Ω	Ω	C	C	Ω	Ω	C
		O	I	U	O	O	I	U	O	O	I	U	O	O	I	U	O
		N	N	T	F	N	N	T	F	N	N	T	F	N	N	T	F
0.5	Close Open																
1.0	Close Open																
1.5	Close Open																
2.0	Close Open																
2.5	Close Open																
5.0	Close Open																
10.0	Close Open																

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

Page 1 of 2

INDUCED 60 HZ VOLTAGE TEST RECORD FORM

Install monitor in accordance with the manufacturer's instructions in a pilot-wire configuration. See Figure 7.

Does monitor have a polarity reversing switch? Yes No

Voltmeter reading _____ volts.

		Monitor Tripping Relay	
		Close	Open
1.	Test circuit "on"	_____	_____
2.	Test circuit "off"	_____	_____
3.	Test circuit "on"	_____	_____
4.	Test circuit "off"	_____	_____
5.	Test circuit "on"	_____	_____
6.	Test circuit "off"	_____	_____
7.	Test circuit "on"	_____	_____
8.	Test circuit "off"	_____	_____
9.	Test circuit "on"	_____	_____
10.	Test circuit "off"	_____	_____

If monitor has polarity reversing switch, reverse switch.

11.	Test circuit "on"	_____	_____
12.	Test circuit "off"	_____	_____
13.	Test circuit "on"	_____	_____
14.	Test circuit "off"	_____	_____
15.	Test circuit "on"	_____	_____
16.	Test circuit "off"	_____	_____
17.	Test circuit "on"	_____	_____
18.	Test circuit "off"	_____	_____
19.	Test circuit "on"	_____	_____
20.	Test circuit "off"	_____	_____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. _____ of _____ Investigator _____

Test Results: _____ Pass Fail

Page 2 of 2

INDUCED 60 HZ VOLTAGE TEST RECORD FORM

After test re-check monitor for proper operation.

	Monitor Tripping Relay	
	Close	Open
21. Insert 50 Ω in ground wire of continuity monitor.	_____	_____
22. Insert calibrated D.O. resistance in ground wire of impedance monitor.	_____	_____

Note: Do **not** recalibrate the monitor to perform this test.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. _____ of _____ Investigator _____

Test Results: Pass Fail

SERIES OPERATION TEST RECORD FORM

Refer to Figure 7 for wiring connections										
				Monitor		Monitor A		Monitor B		
				A	B	Trip		Trip		
Test	PP1	PP2	PP3	S1	S2	Yes	No	Yes	No	
1.	O	O	O	O	C					
2.	O	O	O	C	O					
3.	C	O	O	O	C					
4.	C	O	O	C	O					
5.	O	C	O	O	C					
6.	O	C	O	C	O					
7.	O	O	C	O	C					
8.	O	O	C	C	O					
9.	C	C	O	O	C					
10.	C	C	O	C	O					
11.	O	C	C	O	C					
12.	O	C	C	C	O					
13.	C	O	C	O	C					
14.	C	O	C	C	O					
15.	C	C	C	O	O					
16.	C	C	C	C	O					

Legend:
 O=Open, C=Close
 PP1=Parallel Path #1

Record Monitor Tripping
 Relay Function in last
 Four columns

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. _____ of _____ Investigator _____

Test Results: Pass Fail

PARALLEL PATH OPERATION TEST RECORD FORM
See Figures 8, 9, and 10 for connection diagram.

Parallel Path													Relay A Trip		Relay B Trip		Relay C Trip		Relay D Trip		Relay E Trip		Relay F Trip							
	1	2	3	4	5	6	7	8	9	10	11	12	A S 1	Yes	No	B S1	Yes	No	C S 1	Yes	No	D S 1	Yes	No	E S 1	Yes	No	F S 1	Yes	No
1.	O	O	O	O	O	O	O	O	O	O	O	O	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			O			X			X		
													X			X			X			X			O			X		
													X			X			X			X			O			X		
2.	X	X	X	X	X	X	X	X	X	X	X	X	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			X			O			X		
													X			X			X			X			X			O		

X = Closed O = Open

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

PARALLEL PATH OPERATION TEST RECORD FORM

Parallel Path													Relay A Trip		Relay B Trip		Relay C Trip		Relay D Trip		Relay E Trip		Relay F Trip							
	1	2	3	4	5	6	7	8	9	10	11	12	A S 1	Yes	No	B S1	Yes	No	C S 1	Yes	No	D S 1	Yes	No	E S 1	Yes	No	F S 1	Yes	No
3.	O	O	O	O	O	O	X	X	X	X	X	X	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			O			X			X		
													X			X			X			X			X			O		
													X			X			X			X			X			X		
4.	X	X	X	X	X	X	O	O	O	O	O	O	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			X			X			O		
													X			X			X			X			X			X		
													X			X			X			X			X			O		

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

PARALLEL PATH OPERATION TEST RECORD FORM

NOTE: Test must be repeated with simulated circuit breakers shown on Figures 9 and 10 in closed position.

Parallel Path													Relay A Trip		Relay B Trip		Relay C Trip		Relay D Trip		Relay E Trip		Relay F Trip							
	1	2	3	4	5	6	7	8	9	10	11	12	A S 1	Yes	No	B S1	Yes	No	C S 1	Yes	No	D S 1	Yes	No	E S 1	Yes	No	F S 1	Yes	No
1.	O	O	O	O	O	O	O	O	O	O	O	O	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			O			X			X		
													X			X			X			X			O			X		
													X			X			X			X			X			O		
2.	X	X	X	X	X	X	X	X	X	X	X	X	O			X			X			X			X			X		
													X			O			X			X			X			X		
													X			X			O			X			X			X		
													X			X			X			X			O			X		
													X			X			X			X			X			O		

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. _____ of _____ Investigator _____

Test Results: Pass Fail

PARALLEL PATH OPERATION TEST RECORD FORM

Parallel Path													Relay A Trip		Relay B Trip		Relay C Trip		Relay D Trip		Relay E Trip		Relay F Trip													
	1	2	3	4	5	6	7	8	9	10	11	12	A S 1	Yes	No	B S1	Yes	No	C S 1	Yes	No	D S 1	Yes	No	E S 1	Yes	No	F S 1	Yes	No						
3.	O	O	O	O	O	O	X	X	X	X	X	X	O			X			X			X			X			X			X			X		
													X			O			X			X			X			X			X			X		
													X			X			O			X			X			X			X			X		
													X			X			X			X			X			O			X			X		
													X			X			X			X			X			X			O			X		
4.	X	X	X	X	X	X	O	O	O	O	O	O	O			X			X			X			X			X			X			X		
													X			O			X			X			X			X			X			X		
													X			X			O			X			X			X			X			X		
													X			X			X			X			X			O			X			X		
													X			X			X			X			X			X			O			X		

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

PILOT WIRE DEVICE TEST RECORD FORM

1. Measure impedance of device at 60 HZ _____ ohms.
2. Connect test circuit - (See Figure No. 11).
3. Adjust timer for 2.5 seconds.
4. Energize test circuit for 2.5 seconds.
5. Allow device to cool for approximately 10 minutes.
6. Energize test circuit for 2.5 seconds.
7. Allow device to cool for approximately 10 minutes.
8. Energize test circuit for 2.5 seconds.
9. Measure impedance of device at 60 HZ _____ ohms.
10. Difference between the values measured step 1 and step 7 must be less than 5% and the total resistance of the device cannot exceed 10 ohms at any time.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

OPTIONAL PILOT WIRE DEVICE TEST RECORD FORM

1. Measure 60 HZ impedance of device _____ ohms.
2. Connect test circuit - (See Figure No. 12).
3. Calibrate test circuit to give 25 amp at 577 volts.
4. Energize test circuit. Time for monitor to trip = _____ milliseconds.
5. Allow device to cool for approximately one minute.
6. Energize test circuit. Time for monitor to trip = _____ milliseconds.
7. Allow device to cool for approximately one minute.
8. Energize test circuit. Time for monitor to trip = _____ milliseconds.
9. Time must be less than 200 milliseconds.
10. Measure 60 HZ impedance _____ ohms.
11. Impedance must not change more than 5%.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

HYPOT TEST RECORD FORM

1. Test lead to ground terminal, other lead to case.
2. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
3. Test lead to pilot wire terminal, other lead to case.
4. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
5. Test lead to monitor control voltage terminal, other lead to ground terminal.
6. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
7. Test lead to monitor control voltage terminal, other lead to pilot wire terminal.
8. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
9. Test lead to monitor N.C. trip relay current, other lead to ground terminal.
10. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
11. Test lead to monitor N.O. trip relay contact, other lead to ground terminal.
12. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
13. Test lead to monitor trip relay common terminal, other lead to ground terminal.
14. Energize power supply, increase voltage to 3KV; leakage current _____ milliamps.
15. In all tests ammeter indication cannot exceed 0.1 milliamps.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

300 VOLT FAULT TEST RECORD FORM

1. Connect monitor according to manufacturer's specifications. (See Figure No. 13)
2. Calibrate test circuit time to energize test circuit for 250 milliseconds _____ .
3. Connect test circuit to monitor, energize monitor.
4. Energize test circuit (for 250 MS).
5. Wait one approximately minute.
6. Energize test circuit (for 250 MS).
7. Disconnect test circuit from monitor.
8. Connect ground wire to monitor; relay trip? Yes No
9. For continuity monitor insert 50 Ω in ground wire; relay trip? Yes No
10. For impedance monitor insert calibrated D.O. resistance in ground wire; relay trip? Yes No

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____

Company _____

Date _____ STP No. _____

Test Sheet No. ____ of ____ Investigator _____

Test Results: Pass Fail

CABLE LENGTH TEST RECORD FORM

	Tripping Relay Status					
	Normal Operation			Open Ground Wire		
	Relay Energized			Relay Trip		
	Yes	No	No	Yes	No	No
Cable Length						
500 FT						
1000 FT						
1500 FT						
2000 FT						
2500FT						
3000 FT						
3500 FT						
4000 FT						
4500 FT						
5000 FT						

Comments: _____

EXAMPLE #1,

2500FT	X			X		
3000 FT	X					X

Monitor capability = 2500 FT

EXAMPLE #2,

4500 FT	X			X		
5000 FT			X			

Monitor capability = 4500 FT

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

VOLTAGE DISCHARGE TEST RECORD FORM

See Figure 15 for typical test circuit.

1. Connect supply voltage to one phase coupler capacitor and common.
2. Connect time elapse meter to same leads.
3. Energize test circuit - - leave "on" for five (5) minutes to fully charge the capacitor.
4. De-energize test circuit starting the time elapse at same time.
5. Allow capacitor to discharge for 1-1/2 minutes.
6. Record voltage _____ after 1-1/2 minutes.
7. Record time when 50 volts is reached; _____ minutes _____ seconds.
NOTE: Capacitor must discharge to 50 volts or less in one minute or less.
8. Repeat test for each leg of capacitor.

Comments: _____

Data Sheet No. _____

File No. _____ PAR No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

Page 1 of 2

TRANSIENT TEST RECORD FORM

Transient suppression protection is _____ is not _____ provided for this monitor.

Note: If it is not provided, this test shall be conducted.

1. Set up ground wire monitor (GWM) in accordance with the manufacturers instructions.
2. Set up pulse generator to produce a transient pulse 10 times the monitor nominal input voltage with a pulse width of 10 microseconds.
3. Connect pulse generator to monitor input voltage terminals.
4. Energize monitor.
5. Energize pulse generator.
6. Apply 20 pulses within one minute.
7. Record any trips as a failure _____ .
8. Disconnect pulse generator.
9. Adjust pulse generator to produce a transient pulse of 2400 volts with a pulse width of 10 microseconds.
10. Connect the pulse generator between the monitor input voltage terminal and the monitor ground wire.
11. Energize the pulse generator and monitor.
12. Apply 20 pulses over a one minute period.
13. Record any trips as a failure _____ .
14. De-energize both pulse generator and monitor.
15. Re-connect pulse generator leads between the other monitor input voltage terminal and the monitor ground wire.
16. Energize both pulse generator and monitor.
17. Apply 20 pulses (2400 V) over a one minute period.

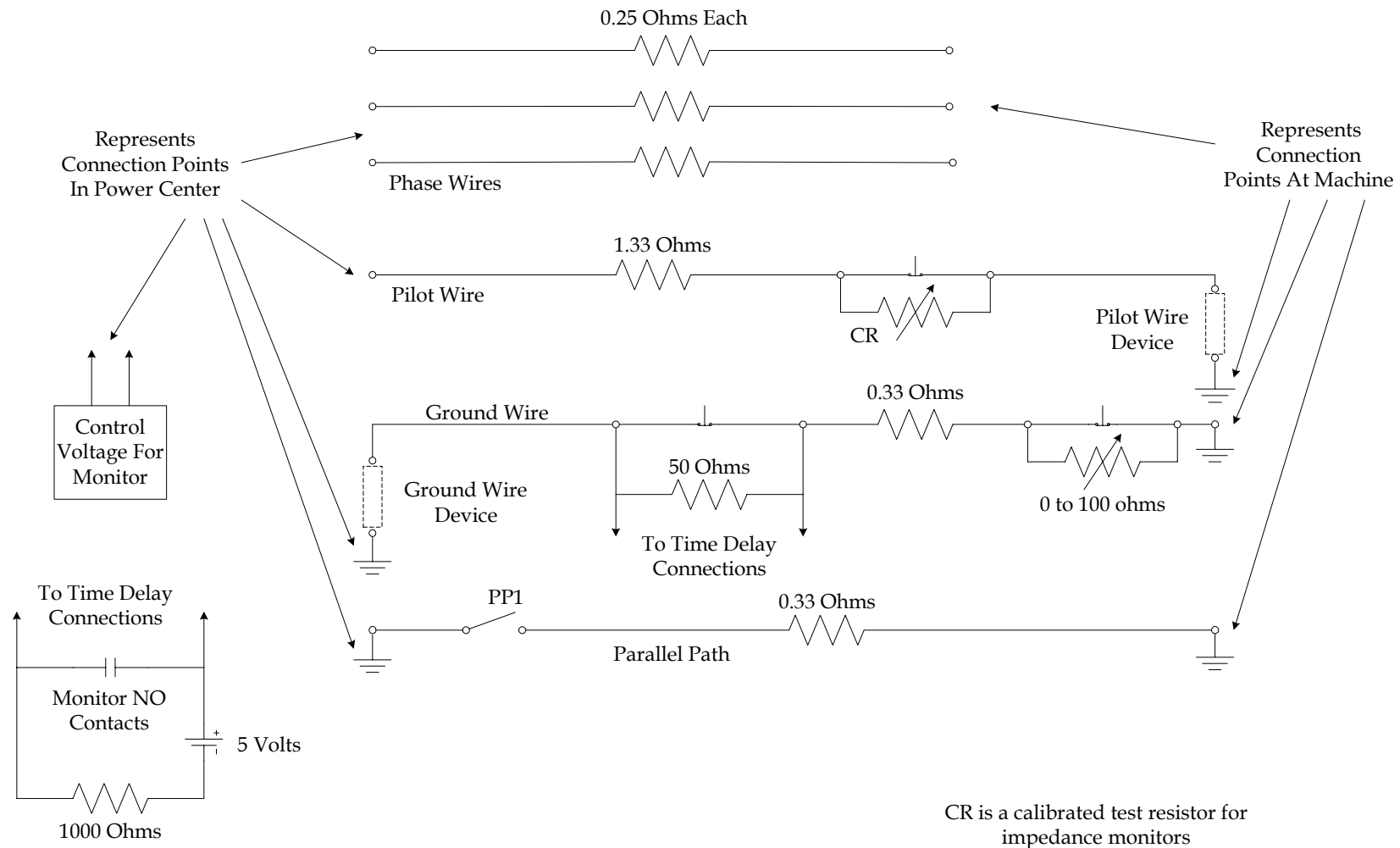
File No. _____ PAR No. _____ Data Sheet No. _____
Company _____
Date _____ STP No. _____
Test Sheet No. _____ of _____ Investigator _____
Test Results: _____ Pass Fail

Page 2 of 2

TRANSIENT TEST RECORD FORM

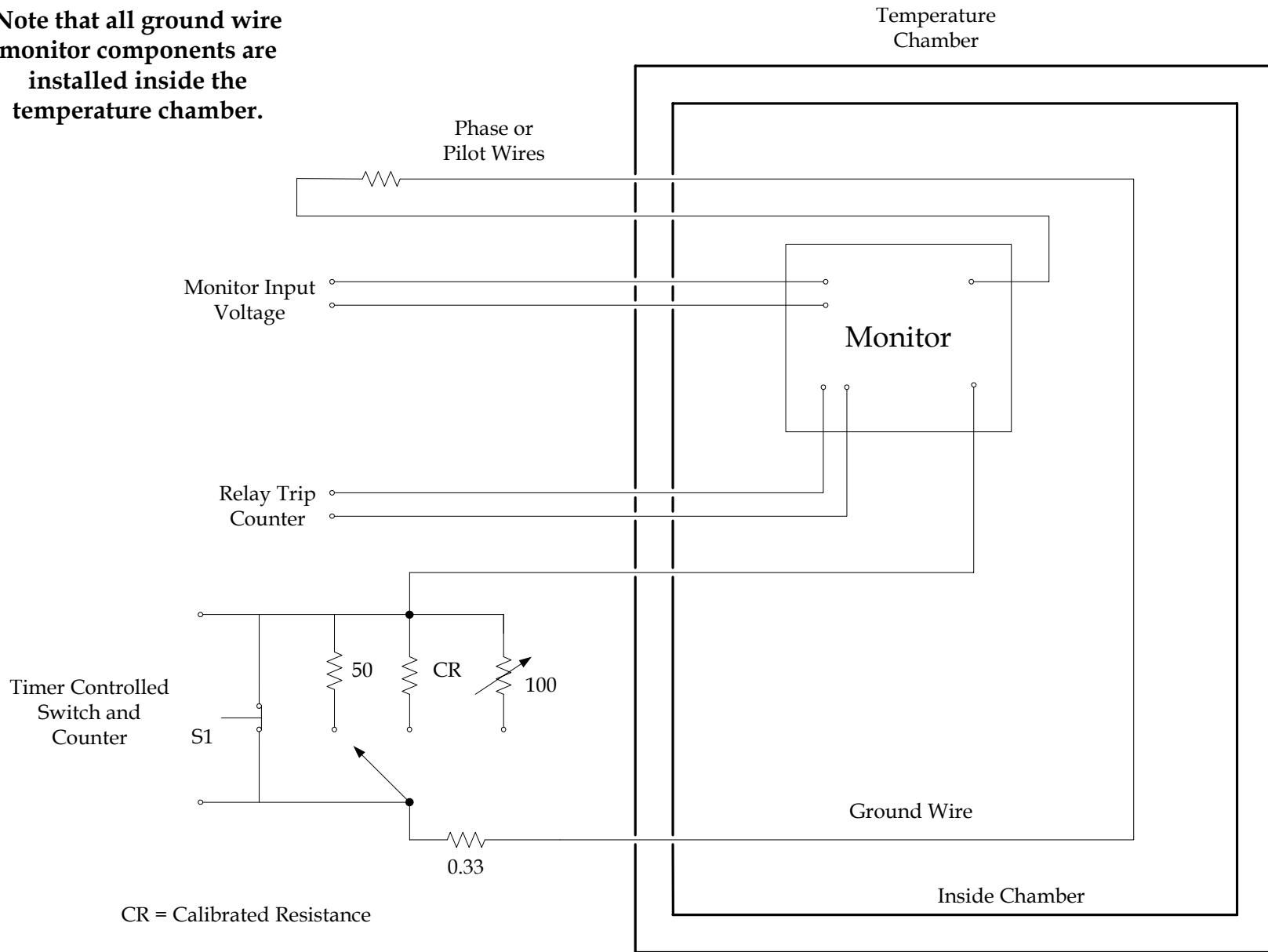
18. Record any trips as a failure.
19. De-energize both pulse generator and monitor.
20. Re-connect pulse generator leads between one monitor input voltage terminal and the monitor case.
21. Energize both pulse generator and monitor.
22. Apply 20 pulses (2400 V) over a one minute period.
23. Record any trips as a failure _____.
24. De-energize both pulse generator and monitor.
25. Re-connect pulse generator leads between the other monitor input terminal and the monitor ground wire.
26. Energize both pulse generator and monitor.
27. Apply 20 pulses (2400 V) over a one minute period.
28. Record any trips as a failure _____.
29. Record any component failure _____.

Comments: _____



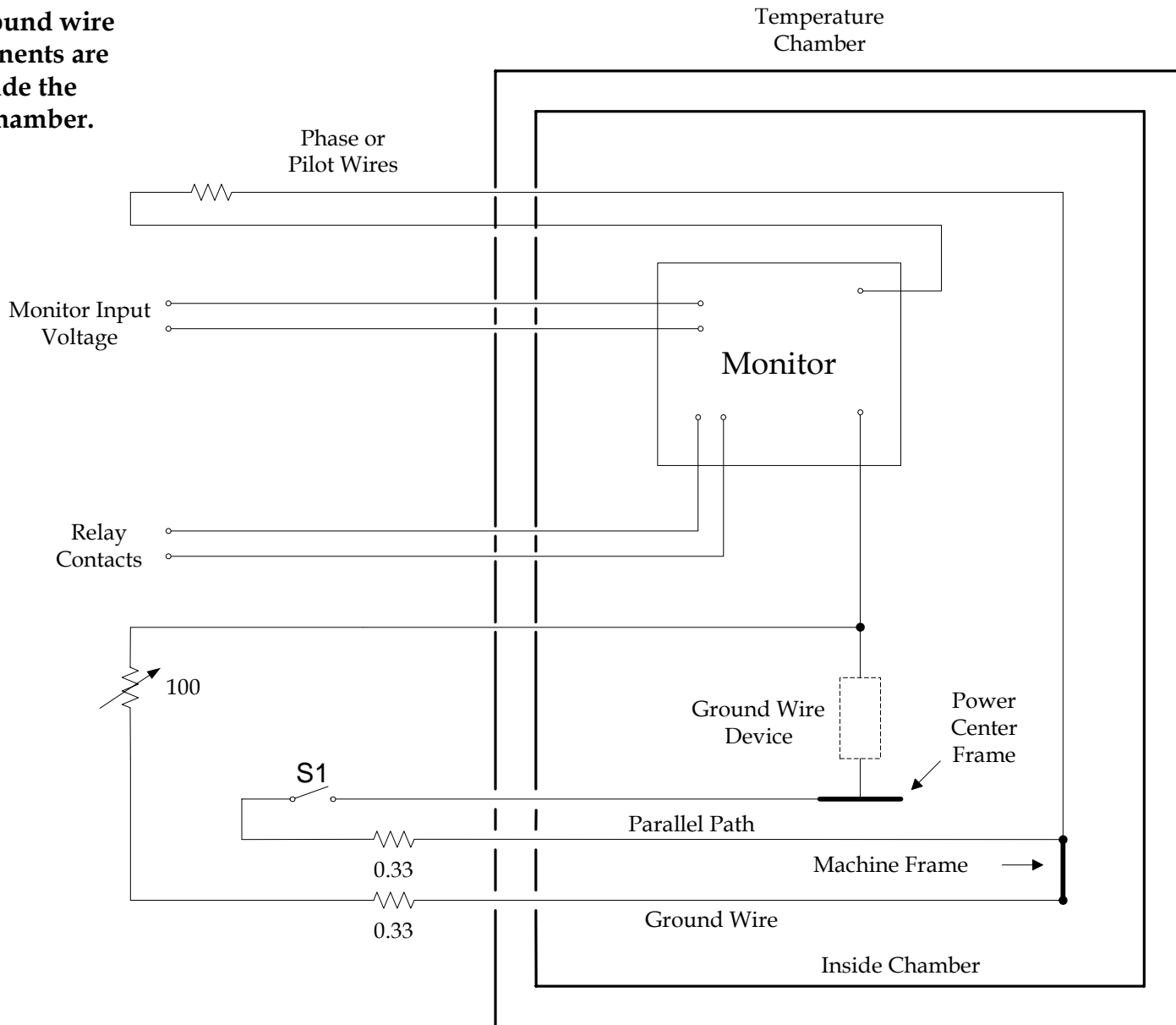
**Laboratory Test Schematic
Figure 1**

Note that all ground wire monitor components are installed inside the temperature chamber.

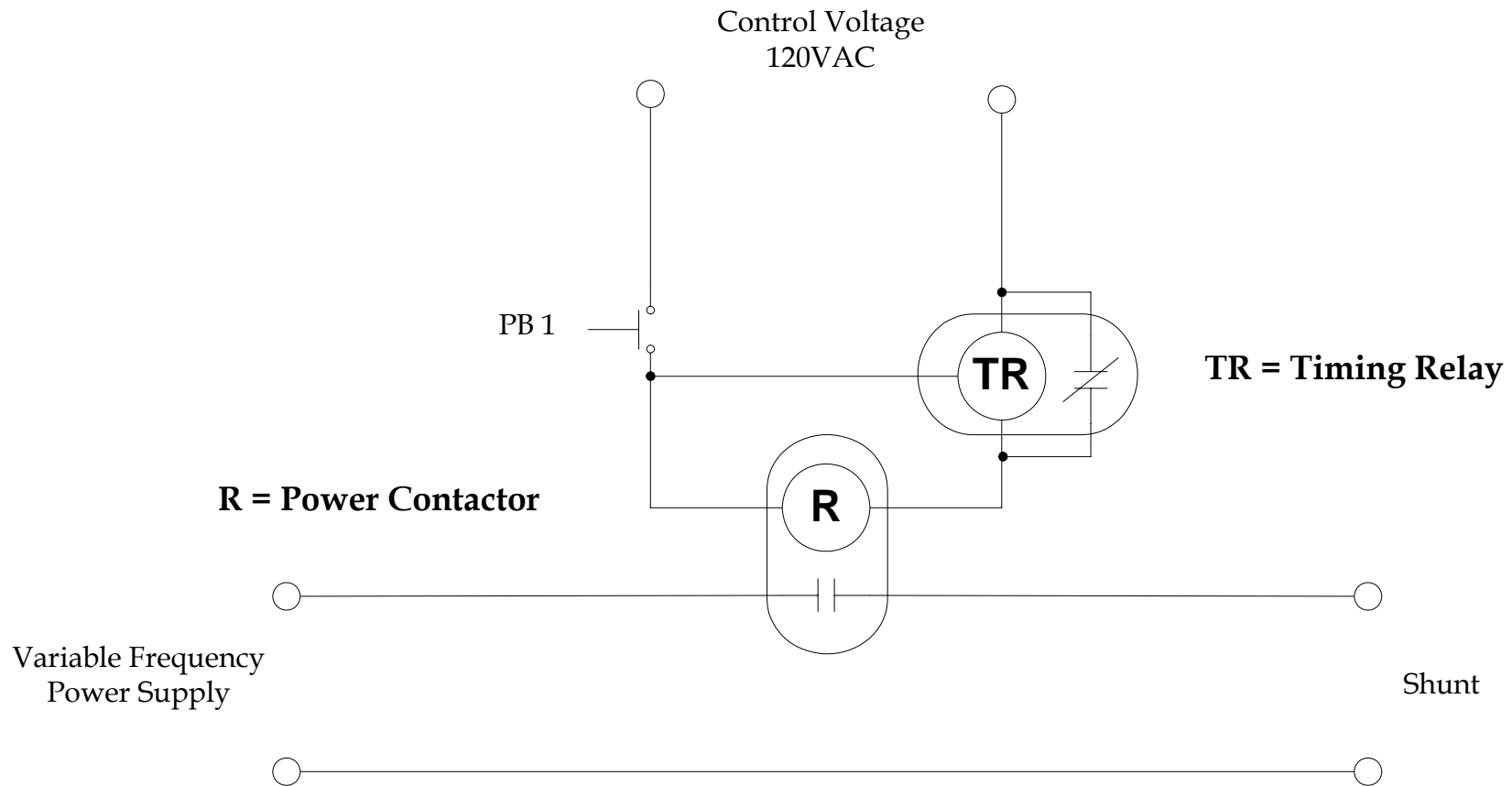


**Accelerated Life Test Schematic
Figure 2**

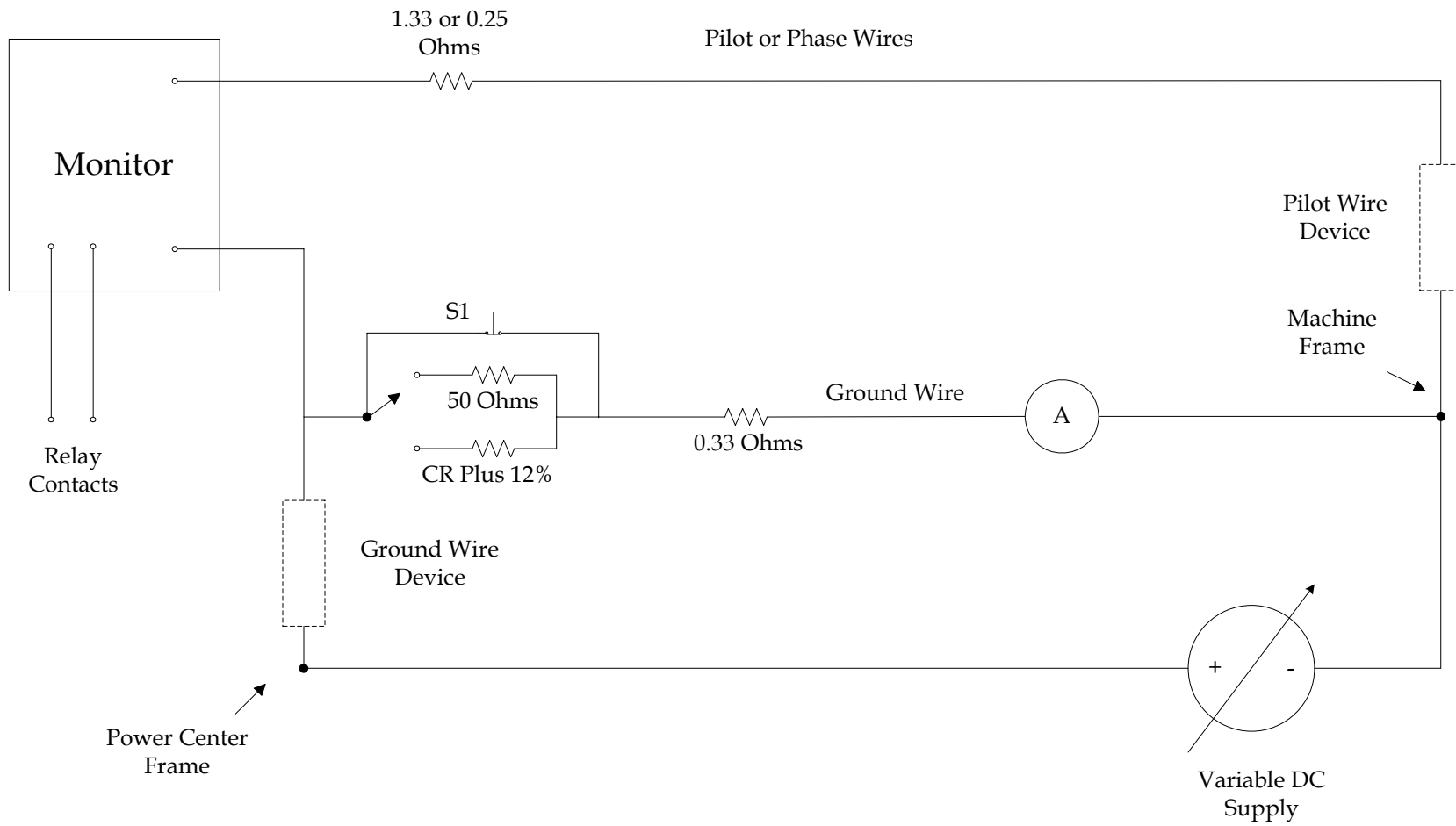
Note that all ground wire monitor components are installed inside the temperature chamber.



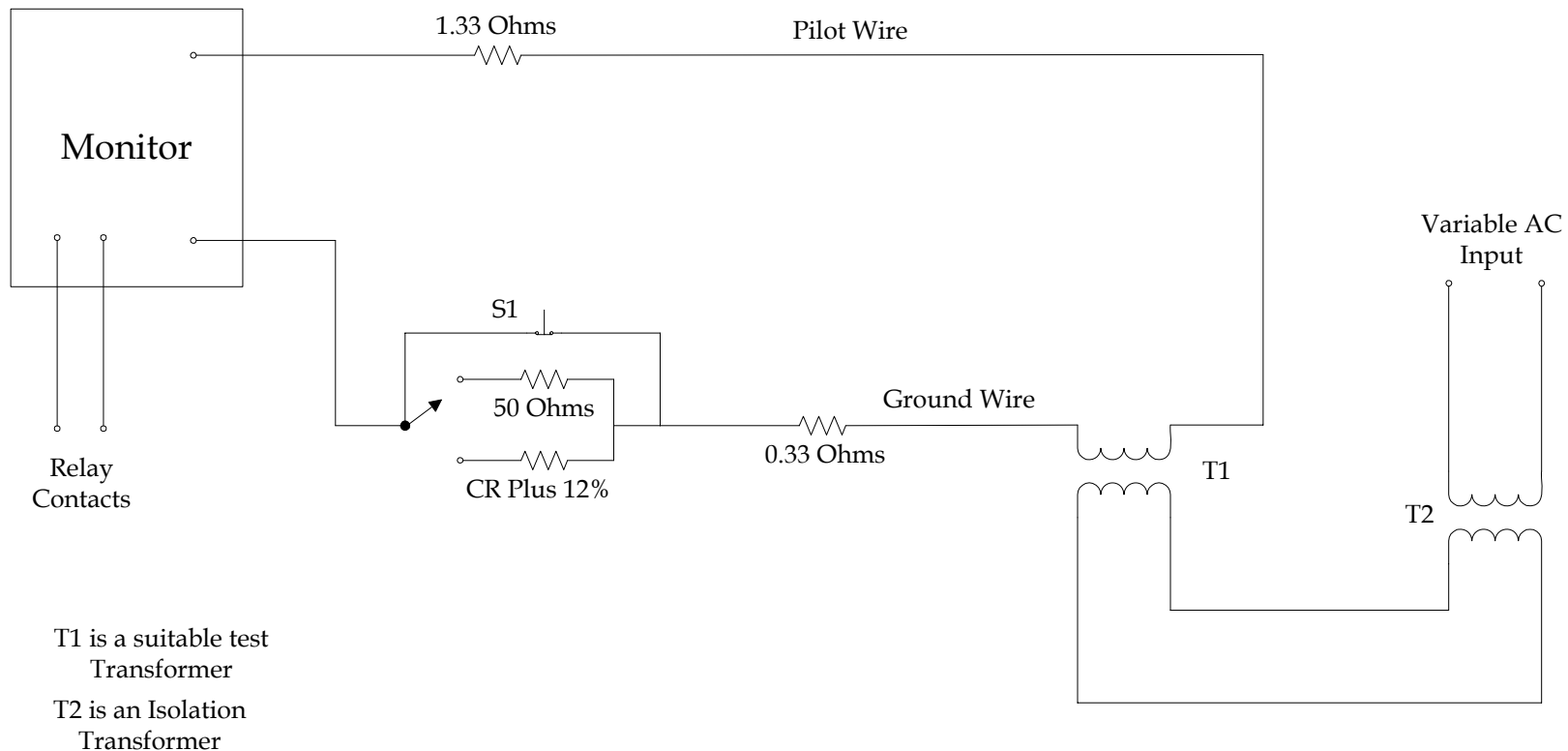
Temperature Variation Test Schematic
Figure 3



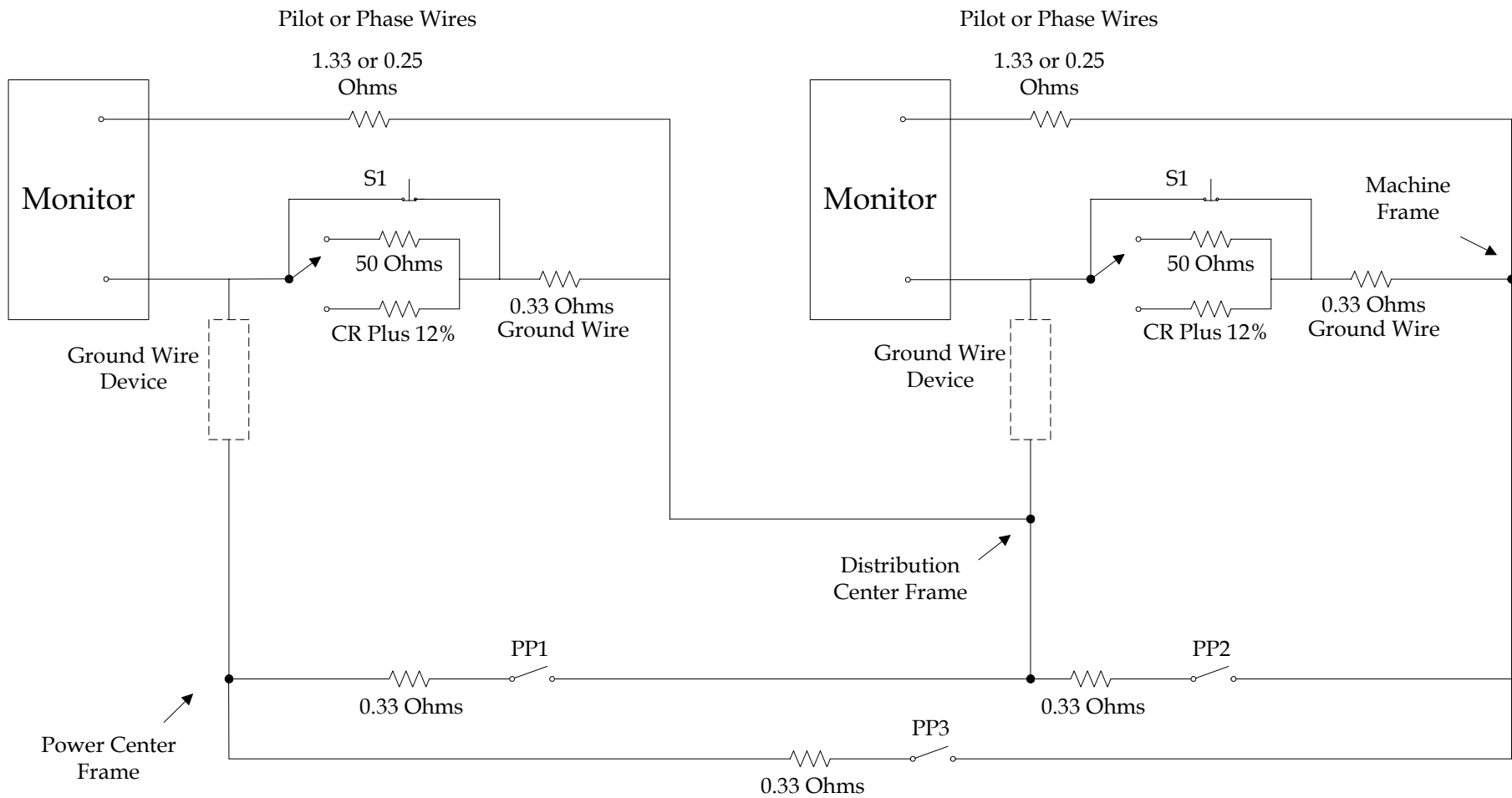
**Shunt Schematic
Figure 4**



**Stray DC Schematic
Figure 5**

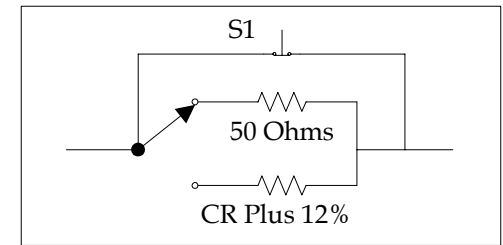
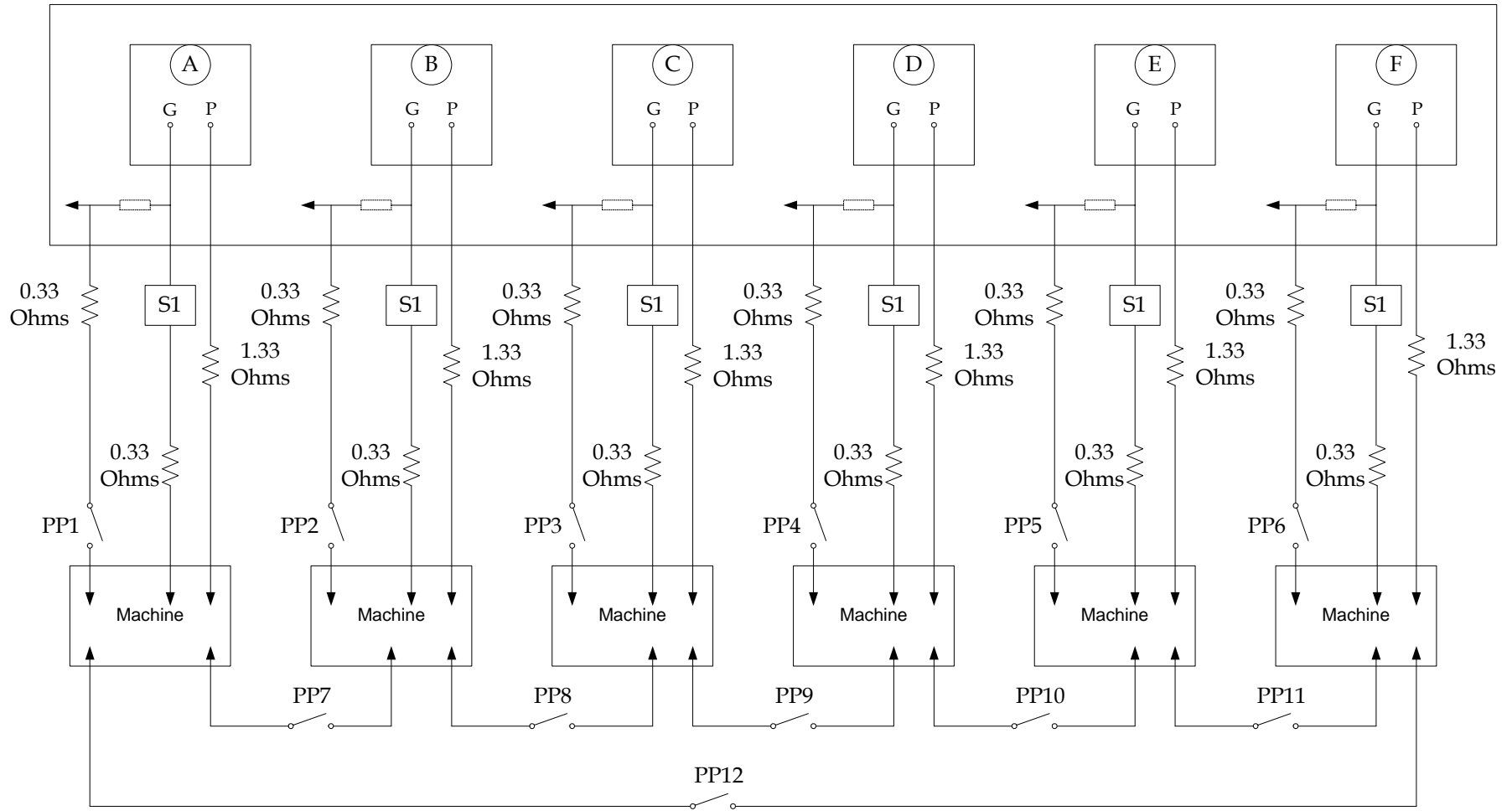


**Induced 60 Hertz Schematic
Figure 6**



Series Operation Schematic
Figure 7

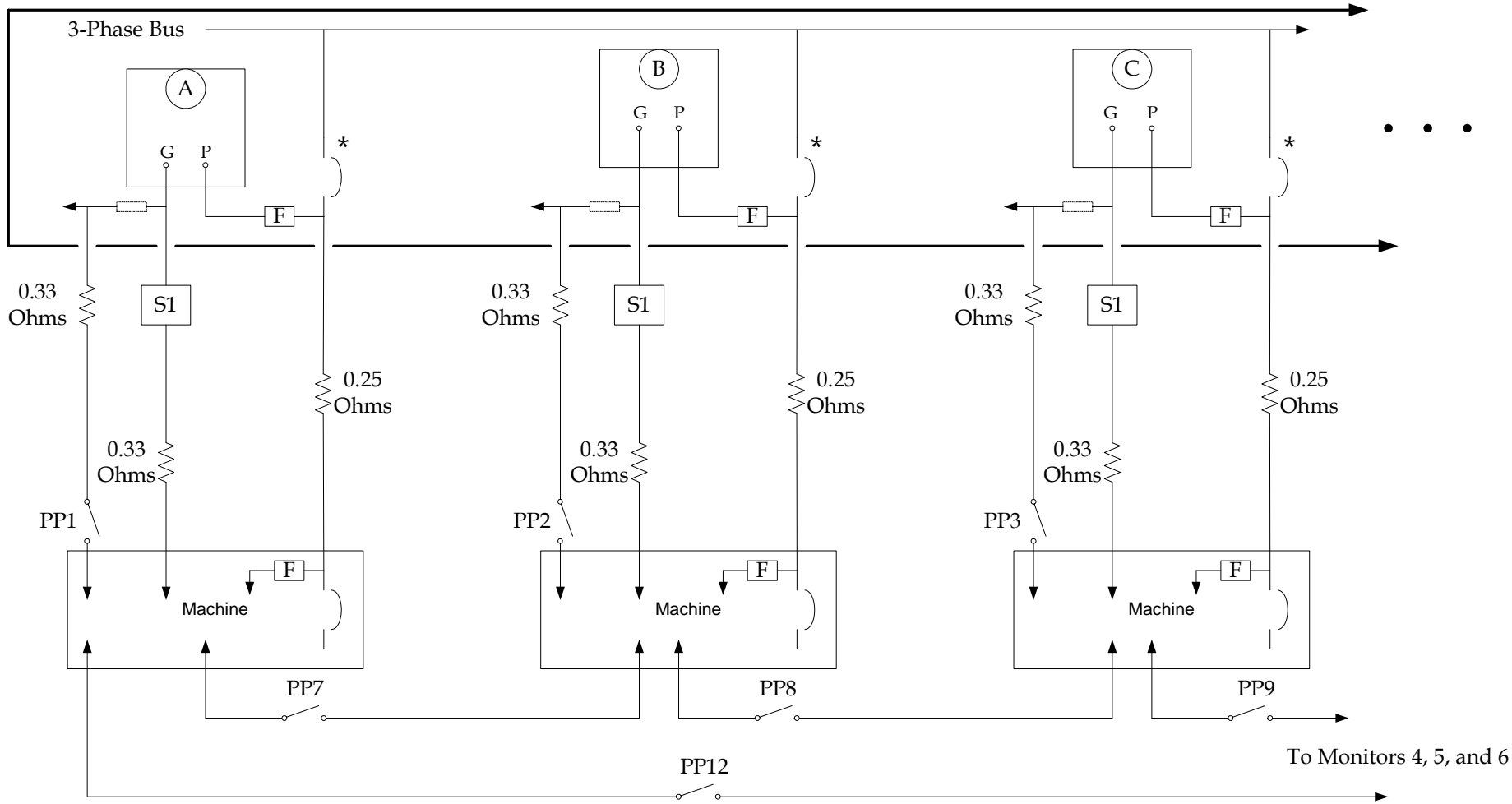
Power Center With Pilot Wire Monitors



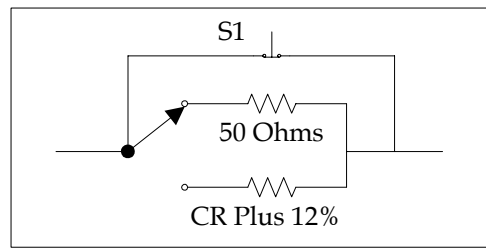
Ground Wire Switch S1

Parallel Operation Test Schematic
Figure 8

Power Center With 3 of 6 Pilot Wireless Monitors



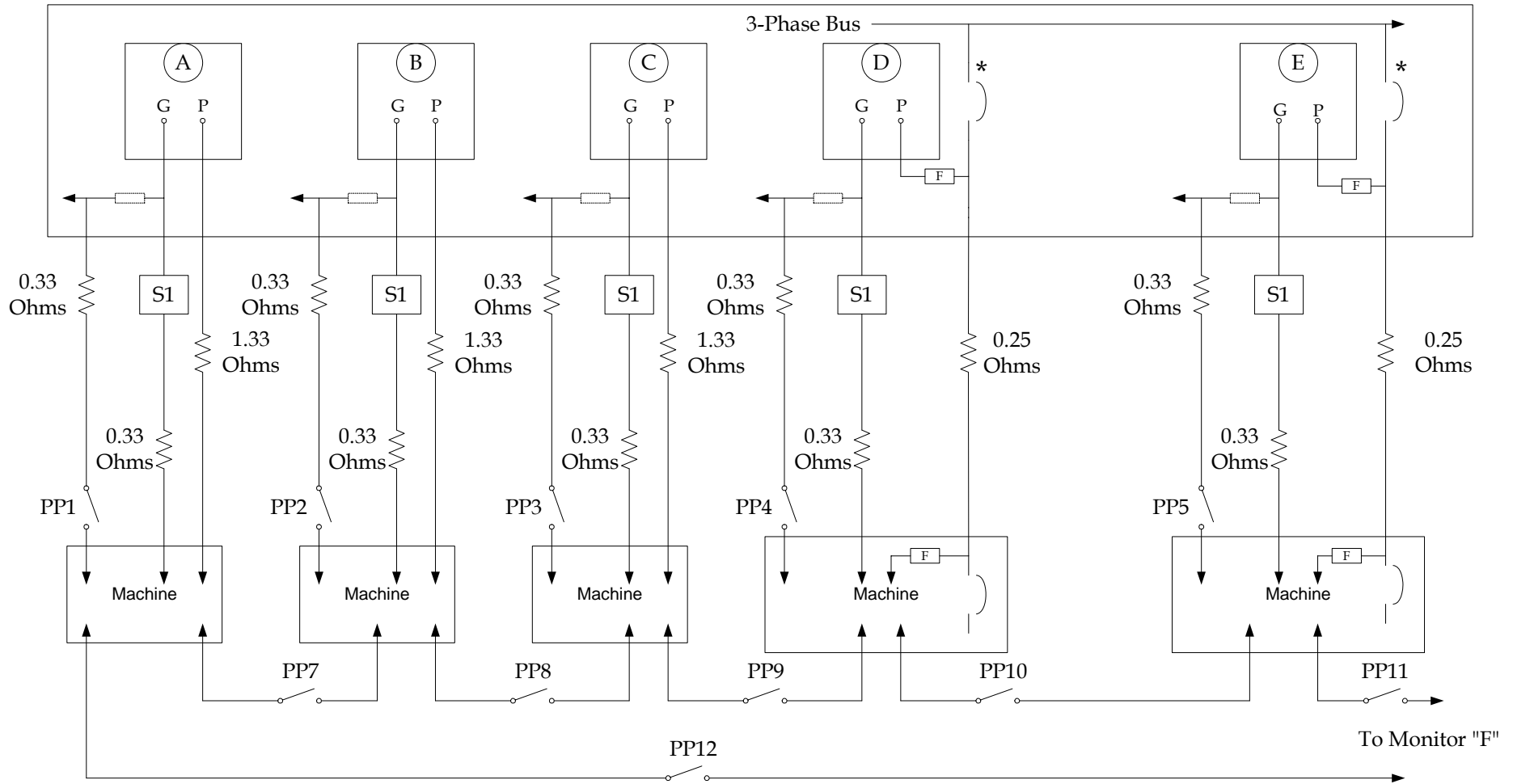
*Only One Phase Conductor Shown For Simplicity



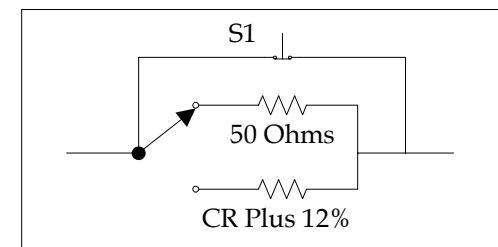
Ground Wire Switch S1

Parallel Operation Test Schematic
Figure 9

Power Center With 3 Pilot Wire Monitors and 2 of 3 Pilot Wireless Monitors

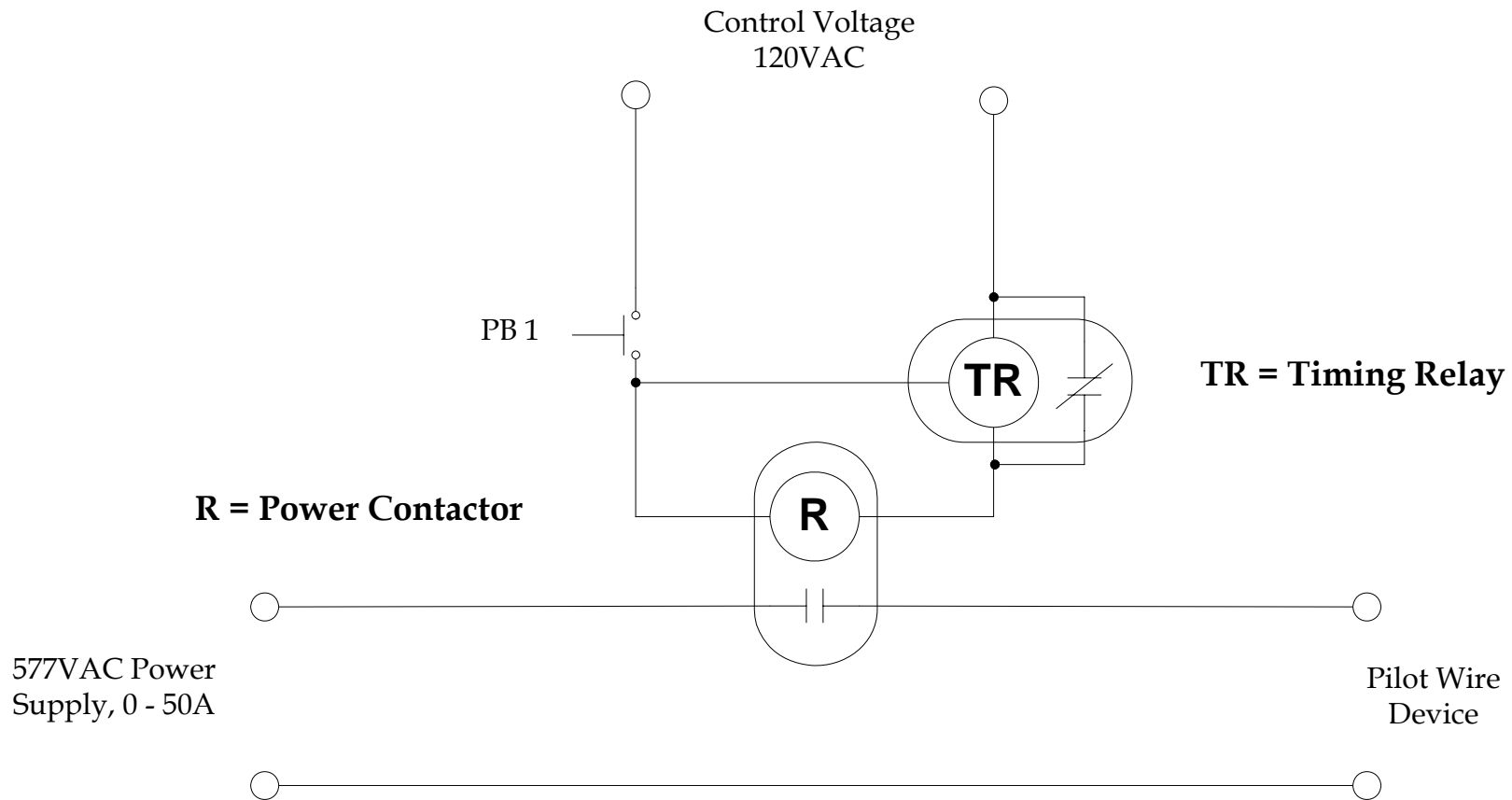


* Only One Phase Conductor Shown For Simplicity

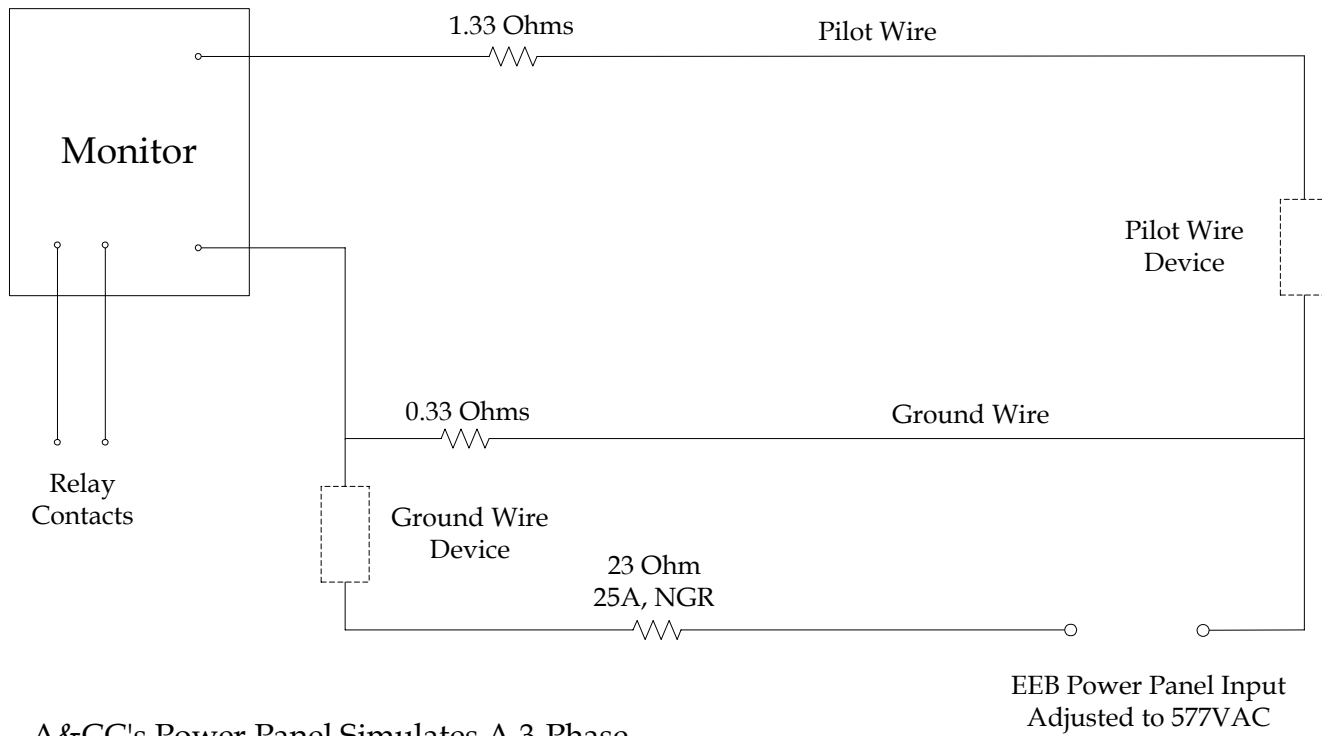


Ground Wire Switch S1

Parallel Operation Test Schematic Figure 10

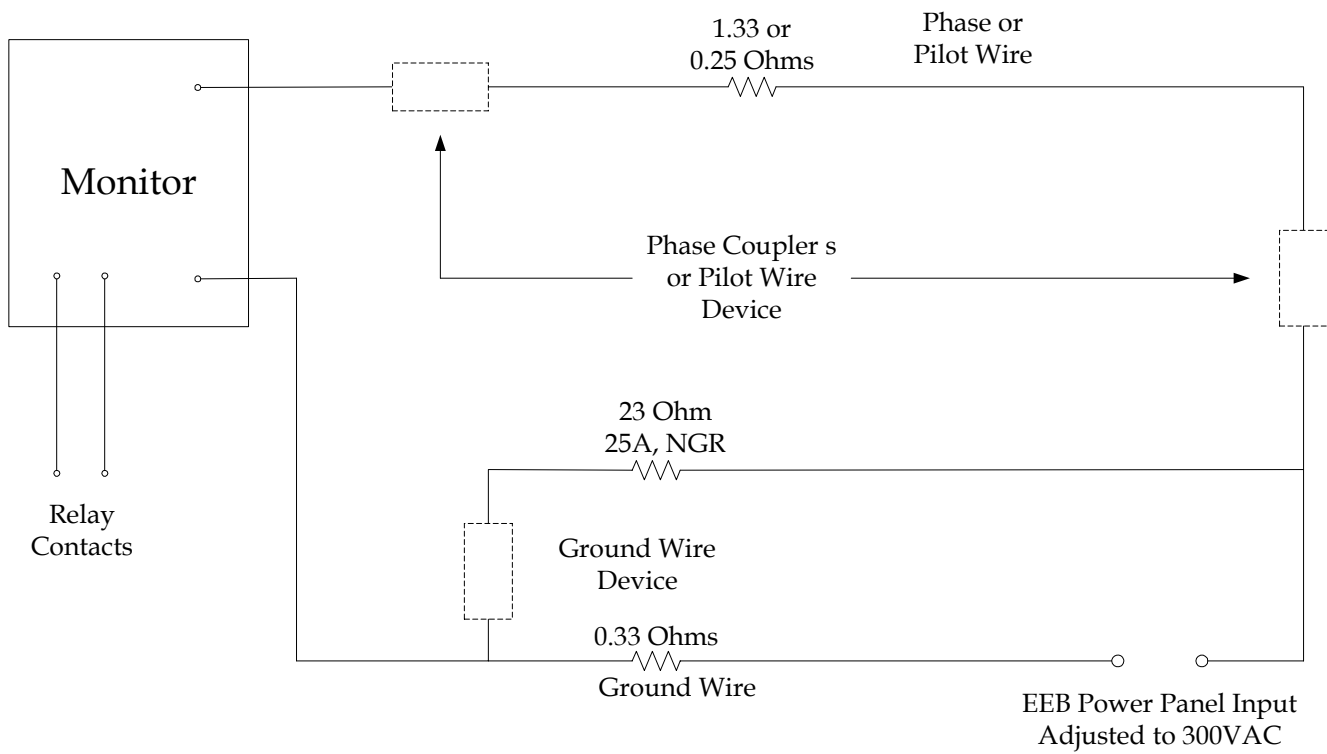


**Pilot Wire Device Test Schematic
Figure 11**



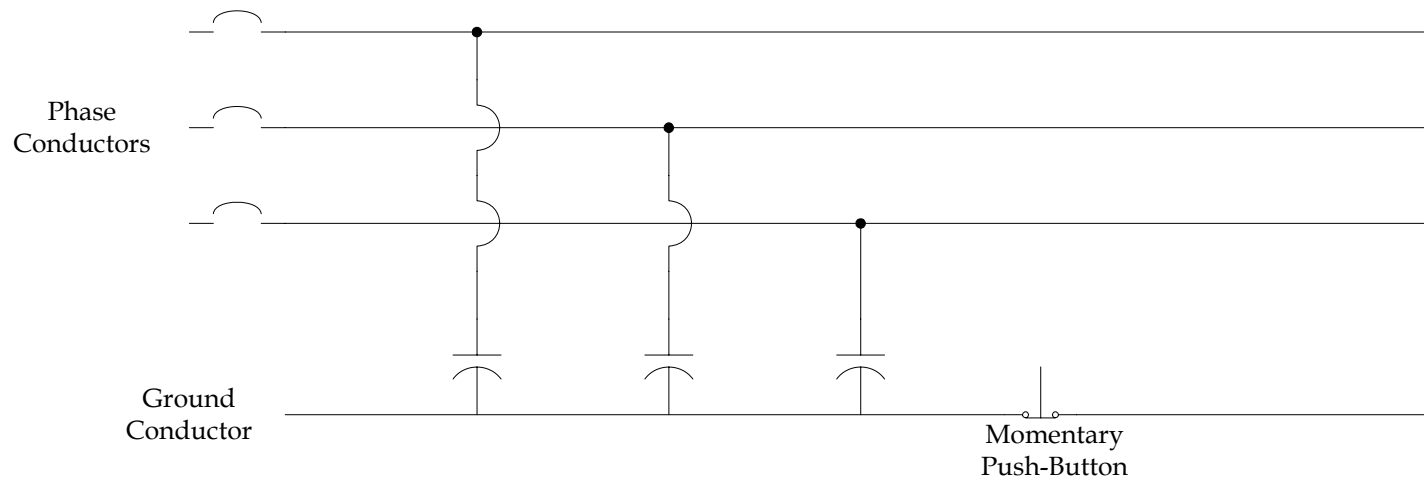
A&CC's Power Panel Simulates A 3-Phase
Underground Section Power Center

**Optional Pilot Wire Device Test Schematic
Figure 12**

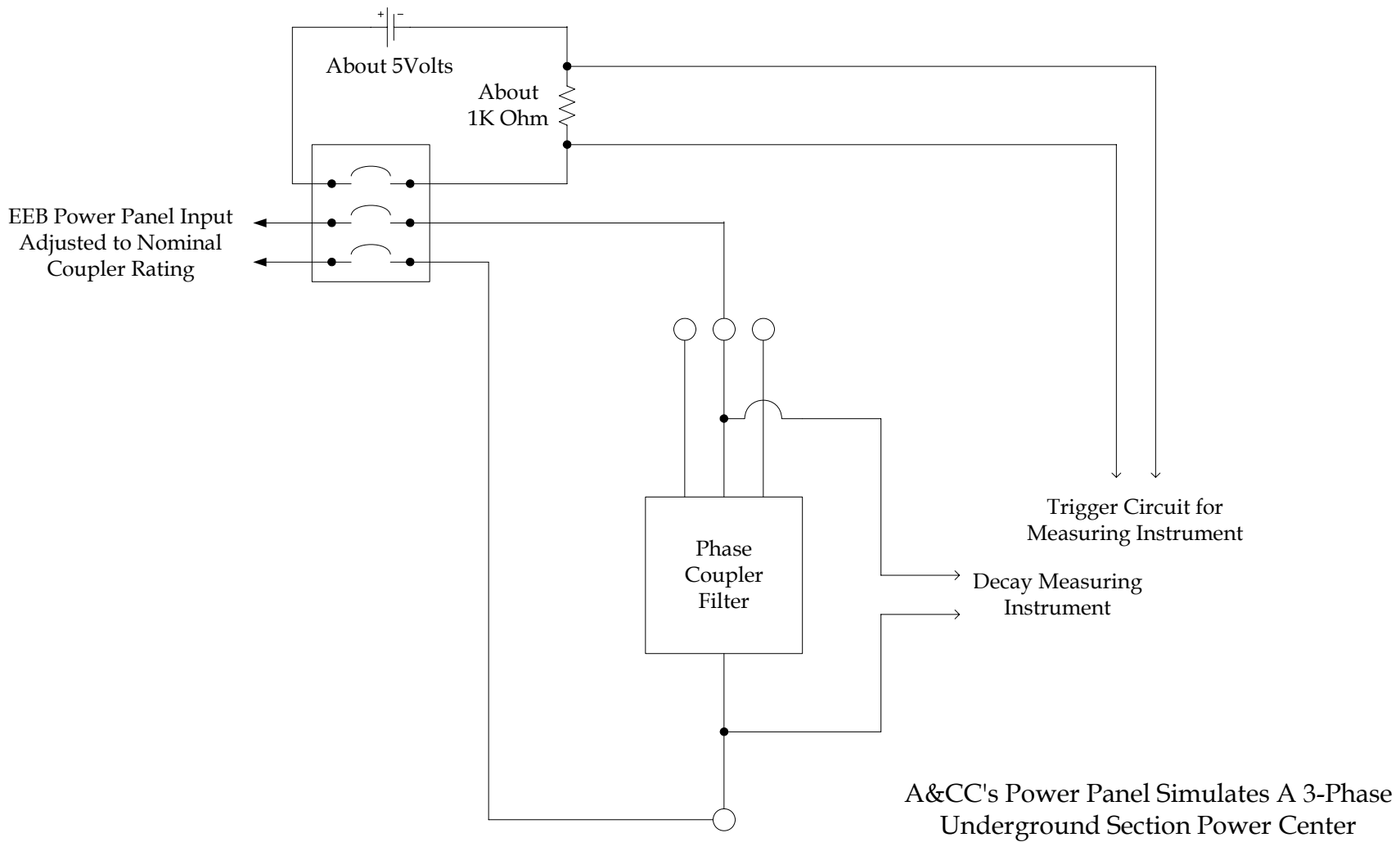


A&CC's Power Panel Simulates A 3-Phase
Underground Section Power Center

**300Volt Fault Test Schematic
Figure 13**



Cable Length Test Schematic
Figure 14



**Phase Coupler Filter Capacitor Discharge Test Schematic
Figure 15**