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Network Operations Subcommittee

SCTE STANDARD

SCTE 205 2022

Outside Plant Power Recommended Preventive Maintenance Operational Practice

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Document Types and Tags

Document Type: Operational Practice

Document Tags:

☐ Test or Measurement	☐ Checklist	☐ Facility
☐ Architecture or Framework	☐ Metric	☒ Access Network
☒ Procedure, Process or Method	☐ Cloud	☐ Customer Premises

Document Release History

Release	Date
SCTE 205 2014	*08/11/2014*
SCTE 205 2022	*12/19/2022*

Note: Standards that are released multiple times in the same year use: a, b, c, etc. to indicate normative balloted updates and/or r1, r2, r3, etc. to indicate editorial changes to a released document after the year.

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1. Introduction

1.1. Executive Summary

This document is intended to deliver the information needed for a cable operator to properly maintain outside plant powering systems including the power supply, batteries, cable assemblies, and management and monitoring devices, while also providing a template to deliver comprehensive maintenance information back to management. With new cable network architectures such as distributed access architectures (DAA), outside plant powering becomes even more critical, because the slightest power interruption can cause an extended customer affecting outage.

1.2. Scope

The intent of this document is to serve as a reference for cable technical personnel on how to do a proper preventive maintenance visit on outside plant cable power systems. As reliability expectations increase, the powering sub-systems of today's cable networks must be depended on for near-perfect operation. The procedures in this document will help guide the reader through proper maintenance guidelines for power systems, including power supplies, batteries, transponders and enclosures, resulting in optimal system performance and reducing outages and unnecessary truck rolls.

1.3. Benefits

The procedures in this document will help to ensure that personnel performing outside plant power supply and powering maintenance correctly perform the task and record relevant information to help management in future power decisions. With new HFC architectures like DAA affected by the slightest powering issue, these routine tests become all the more critical, and must be performed correctly to ensure that maintenance does not create any powering impacts. The operator should see improved performance of their network powering system as well as complete documentation to better assess future decisions.

1.4. Intended Audience

The intended audience for this document includes cable system managers, supervisors, power supply maintenance departments, those in charge of recording and records, service technicians, and others who might be interested in proper maintenance of outside plant powering.

1.5. Areas for Further Investigation or to be Added in Future Versions

DAA powering architecture and centralized powering considerations could be investigated further in a future revision.

2. Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this document. The editions indicated were valid at the time of subcommittee approval. All documents are subject to revision and, while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

No normative references are applicable

2.2. Standards from Other Organizations

No normative references are applicable.

2.3. Published Materials

No normative references are applicable.

3. Informative References

3.1. SCTE References

No informative references are applicable.

3.2. Standards from Other Organizations

[OSHA 29 CFR 1926.441] Safety and Health Regulations for Construction; Batteries and battery charging.

3.3. Published Materials

Manufacturer-specific battery, power supply, cabinet and transponder manuals

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
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deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

AC	alternating current
ATS	automatic transfer switch
AWG	American Wire Gauge
°C	degree Celsius
DAA	distributed access architecture
°F	degree Fahrenheit
GPS	Global Positioning System
i.e.	id est (that is)
IM	inverter module
IP	Internet Protocol
LAP	lightning arrestor protector
LED	light emitting diode
MAC	media access control
MSO	multiple system operator
mV	millivolt
NEC	National Electrical Code
NESC	National Electrical Safety Code
OSP	outside plant
PIM	protective interface module
PM	preventive maintenance
PS	power supply
PTS	precision temperature sensor
RF	radio frequency
RMS	root mean square
RTS	remote temperature sensor
RX	1) receive; 2) receiver
SCTE	Society of Cable Telecommunications Engineers
SPI	service power inserter or interface
TMPR	tamper
TX	1) transmit; 2) transmitter
UPS	uninterruptible power supply
V	volt (or volts)
VAC	voltage (or volts) alternating current
VDC	voltage (or volts) direct current
XPDR	transponder

5.2. Definitions

alternating current (AC)	An electric current that periodically reverses direction and whose instantaneous magnitude varies continuously over time. Examples include extremely low frequency AC from a household electrical outlet (50 Hz or 60 Hz), as well as RF signals. See also *current*.
capacitor	An electronic component that exhibits capacitance, that is, the ability to store electrical energy in an electrostatic field. In cable TV standby

	power supplies, a capacitor is connected to a transformer to support ferrroresonant operation, which regulates the transformer's output voltage.
circuit breaker	A component used to protect an electrical circuit or device from an over-current condition. A magnetic or thermal switch in the circuit breaker automatically interrupts the flow of electricity when the current exceeds the circuit breaker's rated value. See also *fuse*.
current	The flow of charged particles per unit of time. Ampere is a measure of electrical current, and 1 ampere equals 1 coulomb of charge flowing past a given point in 1 second. Coulomb is a unit of measure of electrically charged particles, where 1 coulomb equals 6.242 x 10^{18} electrons. An analogy for current is the volume of water flowing through a garden hose, such as 1 gallon of water per second.
direct current (DC)	An electric current that is unidirectional. An example includes the output of a battery. See also *current*.
digital voltmeter (DVM)	An electronic instrument that is capable of measuring voltage, and sometimes also current and resistance. A digital voltmeter uses digital circuits and includes a digital display. Sometimes referred to as a digital multimeter (DMM).
enclosure	A housing, cabinet, pedestal or other protective covering for electronic or electrical components or equipment.
fuse	A component used to protect an electrical or electronic circuit or device from an over-current condition. When an over-current condition occurs, a wire or other conductor in the fuse melts and stops the flow of current.
ground	1) A conductive connection between an electrical or electronic circuit and earth. 2) A common-point connection in an electrical or electronic circuit providing a common reference potential (e.g., chassis).
inverter	A device or circuit that converts direct current electricity to alternating current electricity. Cable TV standby power supplies use an inverter to change the output of a set of rechargeable batteries into AC when there is a utility power outage.
jumper	A wire, cable, printed circuit board trace, or other conductor interconnecting two components or circuits.
light emitting diode (LED)	A semiconductor component that emits photons (light) when an electrical current flows across its P-N junction.
load	An electrical device or component connected to a power source.
module	One of several standardized units or components that function together in a chassis.
overvoltage	Any steady state (several seconds or longer) voltage in excess of the normal or rated operating voltage of a device or circuit.
power distribution unit	An interface between a power source such as a UPS and critical loads. The power distribution unit routes power from the UPS and distributes it to the various critical loads on separate circuits.
power supply	A device that produces electricity for use by electrical or electronic equipment, or that converts the electricity from the utility mains to a form suitable for use by electronic equipment.

state of charge	The available capacity of a battery expressed as a percentage of its rated capacity.
transfer switch	A mechanical or electronic switch that connects one or more power sensitive loads to one of several possible power sources, ensuring that the transition between the sources is smooth.
uninterruptible power supply (UPS)	A backup power source that maintains uninterrupted operation of one or more critical loads in the event of commercial power failure. A typical UPS uses a combination of batteries, inverter, and other components to provide backup power.
volt (E or V)	A derived unit for electric potential (or electromotive force), where 1 volt is the potential difference between two points on a conductor (wire) carrying 1 ampere of current when the power dissipated between the points is 1 watt. Analogous to water pressure in a garden hose. Note: Electromotive force is the force of electrical attraction between two points of different charge potential.

6. Safety Equipment

Only qualified personnel should service a power system. It is recommended to adhere to the following safety precautions when working on a power system. Safety training and the use of safety equipment is required before proceeding with this procedure.

- Verify the voltage requirements of the equipment to be protected, the AC input voltage to the power supply and the output voltage of the system.
- Ensure the utility service panel is equipped with a properly rated circuit breaker.
- Always use proper lifting techniques when handling system equipment.
- Even if AC voltage is not present at the input, voltage may still be present at the output.
- The battery string contains dangerous levels of stored energy. In the event of a short-circuit batteries can present a risk of electrical shock, fires and burns from high current.
- After disconnecting a battery cable, always tape or otherwise insulate the free end to prevent accidental contact/ short circuit with other battery terminals or metal cabinet parts.
- Do not allow battery wires to contact the enclosure chassis. Shorting battery wires can result in a fire or possible explosion.
- Always wear eye protection, rubber gloves, and a protective vest when working near batteries. To avoid battery contact, remove all metallic objects from your person.
- Use tools with insulated handles; do not rest any tools on top of batteries.
- Prior to handling any batteries or other equipment within the enclosure, touch a grounded metal object to dissipate any static charge that may have developed on your body.
- Use special caution when connecting or adjusting battery cabling. An improperly or unconnected battery cable can make contact with an unintended surface that can result in arcing, fire, or a possible explosion.
- OSHA 29 CFR 1926.411 states that face shields, aprons and rubber gloves be provided for workers handling acids or batteries.
- Additional safety equipment includes: hard hat, harness (for overhead applications), traffic cones and protected-toe safety boots

7. Recommended Tools and Equipment

Prior to beginning maintenance, ensure that all recommended tools and equipment, including safety equipment, is available and functional. The following is a list of the recommended equipment:

- True RMS digital voltmeter
- Foreign voltage detector
- Conductance meter
- Infrared temperature sensor and or thermal imager with temperature display
- Socket wrenches, insulated
- Box end wrenches, insulated
- Torque wrenches calibrated in units of pound·inch (lb·in).
- Rubber gloves
- Full face shield
- Safety glasses
- Plastic apron
- Hard hat
- Portable eyewash
- Spill kit, including sodium bicarbonate solution
- Fire extinguisher
- Anti-corrosive compound
- Paper towels and/or rags
- Plastic soft bristle brush
- Spare battery terminal hardware and cables

8. Frequency of performing HFC OSP Power Supply Maintenance.

It is recommended that each power supply location be visited at least once a year for preventive maintenance. Some companies may opt to increase or decrease frequency of visits depending on company policy and network requirements.

9. Proceedure – Physical Inspection of the System

9.1. Inspection of the cabinet

Upon arrival, the technician will do a visual inspection of the cabinet at the site location. This will consist of an inspection of the door, latches, hinges, lights and other indicators, and overall condition of the system.

1. Inspect power supply cabinet security and condition.
2. Inspect cabinet for integrity (securely mounted, service meter and conduit integrity, etc.)
3. Inspect cabinet for unwanted critters (i.e., rodents, poisonous spiders, poisonous snakes, fire ants, etc.)
4. Do a visual inspection for any sign of corrosion.
5. Verify the cabinet door opens and closes properly.
6. Check all locks and hinges for proper operation and lubricate if necessary.
7. Determine if the battery tray is operating properly by verifying it slides in and out without sticking.

8. If there is brush surrounding the enclosure, remove any overgrowth.
9. Identify if enclosure is located in a designated flood plain.
10. For overhead applications, note the distance from the bottom of the power supply to the ground

9.2. Pad Undermining

1. For ground-level applications, inspect the soil surrounding the enclosure. Verify that the soil has not eroded away from the enclosure causing the cabinet to lean.
2. Report.

9.3. Inspection of indicator lamps

1. Locate any installed indicator lamps and verify indicators are functioning correctly.
2. Replace defective lamps.

9.4. Ground Integrity

1. Inspect the ground rod and ensure it complies and meets NEC, NESC or local authority having jurisdiction.
2. Inspect the ground wire cable clamps and enclosure ground lug and make sure the connection is secure.
3. Verify the ground/bond wire is #6 AWG at a minimum.
4. Verify tight connections at both ends of the ground/bond wire. Appropriate bolts or clamps should be used and all bonds should be clean and free of corrosion.

9.5. Surge Suppression/SPI Alt Box

1. Inspect the surge suppressor and replace if needed. If the LED indicator is not illuminated for the LAP, it will need to be replaced.
2. Verify the SPI is tight, along with the coaxial connection, ensuring that the power supply and sheath of coax is grounded. Make sure the alt box is not loose and is secured properly to the coax cable at the back of the cabinet.
3. Visually inspect the SPI/alt box wires to verify they are in good working condition with the Anderson connectors (if used in the power supply).
4. Burnt or melted wires or connectors are an indication of bad wires, connectors, or excessive current caused by another problem.
5. Connectors may show signs of discoloration. This is an indication that they need to be replaced.

9.6. Inspect all Wiring and Power Supply

1. Inspect the breakers and receptacles and verify they are functioning properly.
2. Inspect breaker to ensure proper size for power supply, and if it is a single pole breaker, the breaker must be of a high magnetic type.
3. Examine the AC output on both sides of the receptacle. Replace if cracked.
4. Do not test the power supply standby functionality until after the batteries have been tested. Verify the battery breaker is in working condition and the unit will go into standby mode.
5. Verify the display on the inverter module is functioning. Replace the inverter module if it does not appear.
6. Visually inspect the battery cables for secure connections and any evidence of corrosion.
7. Record any active alarms.

9.7. Remove all Dirt, Dust and Debris from the Cabinet

1. To clean the enclosure, it is recommended to use a vacuum, leaf blower or damp rag.
2. Check the enclosure vent screens. If dirty clean, if damaged repair/replace.
3. Once the cabinet inspection is complete, proceed to check the batteries and cables.

10. Battery Maintenance Procedure

As part of a comprehensive preventive maintenance program, a technician must verify that all system batteries are operating correctly. When performing service and maintenance on batteries, always follow recommended safety practices and wear personal protective equipment. In order to most effectively track battery performance, it is important to test the batteries in consistent environmental conditions; however, this is not always possible when performing maintenance on actively-deployed systems. It is recommended to perform battery maintenance checks when the ambient temperature is between 32 °F (0 °C) and 100 °F (38 °C). It is recommended to follow each of the steps listed below to ensure batteries have been tested properly.

10.1. Battery Visual Inspection

1. Verify the batteries that make up a single string are of the same make and model. Any string consisting of a mixture of makes or models should be completely replaced.
2. Verify battery date codes do not exceed agreed upon age.
3. Physically inspect the batteries. The technician should look for leaking, cracking, swelling, discoloration and/or excessive terminal corrosion. Suspect batteries should be removed immediately by switching off the battery breaker, disconnecting the battery and removing it from the enclosure. Any battery suspected of leaking should be placed in a plastic bag, the bag tied close, and then placed in a second bag. The bagged battery should then be placed into a cardboard box for safe transport to the designated battery collection location. The same double-bag procedure should be used for all contaminated cleaning rags at the end of the shift. Batteries should be transported in their shipping cartons or with the terminals protected to prevent short circuits.
   NOTE: Always consult your company's hazardous spill containment and disposal procedures as they pertain to removing lead-acid batteries.
4. Using baking soda and water, clean any corrosion or excessive dirt from the battery itself and the battery tray. Suspect corroded surfaces may be considered neutralized when the bubbling and/or foaming of the baking soda stops.
5. If the corrosion is confined to the battery terminal itself (battery is not suspected of leaking), a plastic bristle brush and/or Scotch-Brite™-style pad may be required to remove corrosion from the battery terminals and battery cables. It is recommended to replace any hardware or cables where the corrosion has pitted or removed significant amounts of the cable lug plating.
6. Inspect battery terminals for proper hardware stack – note that the main battery cable should be next to the battery terminal itself, and that locking hardware is present. Verify the battery terminal hardware is torqued to proper specification.
7. Slide batteries apart to maximize space between batteries ensuring proper air circulation. A ½” (13 mm) of space is recommended, however, a minimum of a ¼” (7 mm) space is required.
8. Verify the RTS (remote temperature sensor) or PTS (precision temperature sensor) is properly installed to provide the power supply with the battery temperature for proper temperature compensation for the battery charger. Refer to the power supply manual for the proper installation procedure.

9. After battery testing is complete and if batteries are deemed good and serviceable, treat the battery posts with corrosion inhibitor.

10.2. Power Supply Charger Evaluation

1. Verify the correct battery model, number of strings and/or battery capacity was selected in the power supply settings via the front panel display.
2. Ensure power supply is in “Float” charger mode.
3. With the battery breaker on, measure the string voltage at the main positive and negative terminals of the battery string. Log the string voltage on maintenance report.
4. If the power supply charger is equipped with temperature compensation, note battery temperature from the power supply display and log this temperature on maintenance report.
5. Ensure float charge voltage for the string is within +/- 0.3 mV DC of the temperature compensated charger voltage.
6. Example: For a 36 VDC/ 3 battery string system
   Nominal charger voltage at 77 ºF (25 ºC) = 40.5 VDC
   Temperature compensation = .005 VDC per degree C per cell.
   Battery temperature = 59 °F (15 °C) at time of inspection.
   Nominal charger voltage calculation 25 ºC to 15 ºC= 10 degrees*(.005*18 cells) = 0.9 VDC + 40.5 VDC = 41.4 VDC charge voltage

10.3. Battery Test Evaluation Using Float Voltage

It is recommended to perform battery maintenance checks when the ambient temperature is between 32 ºF (0 ºC) and 100 ºF (38 °C).

1. With the battery breaker on and after confirming the power supply charger is in float mode and outputting the proper charge voltage above, measure and log each individual battery’s float voltage within the string.
2. Battery float voltage readings are temperature dependent. Use the information contained in Table 1 to determine suspect batteries.
3. Turn off battery breaker prior to replacing batteries. Do not perform self-test on known bad batteries.
4. Although float voltage evaluation is a good indication of a battery approaching end-of-life, further evaluation of the battery via conductance and self-test is required to determine if replacement is required. Proceed to step 11.4.

Table 1 – Battery Evaluation Criteria

Temperature	Battery OK	Battery Suspect	Replacement Candidate
32 °F / 0 °C	>13.6 VDC	≤13.6 VDC	<13.0 VDC
54.5 °F / 12.5 °C	>13.4 VDC	≤13.4 VDC	<12.8 VDC
77 °F / 25 °C	>13.1 VDC	≤13.1 VDC	<12.5 VDC
88.5 °F / 31.5 °C	>13.0 VDC	≤13.0 VDC	<12.4 VDC
100 °F / 38 °C	>12.8 VDC	≤12.8 VDC	<12.2 VDC

10.4. Battery Test Evaluation Using Conductance Reading

Conductance values are expressed with siemens (mhos) values. These values are directly affected by temperature. As a general rule of thumb, for every 2 ºF (1.11 ºC) drop in temperature below 77 °F (25 °C), the siemens reading should be adjusted up by 0.7%.

1. Turn the battery breaker off.
2. Allow the batteries to sit idle for one minute to stabilize.
3. Following the conductance meter manufacturer's instructions, perform a conductance test on each battery (using Midtronics meter or similar). Log the voltage and conductance readings in the maintenance log. Measure and record the battery temperature in the maintenance log. Apply the temperature compensation calculation to the measured values and record in the maintenance log. It is recommended to replace a battery when conductance readings are 40% of the initial or published value for a new battery.
4. Example: Battery temperature: 67 °F (19.4 °C), Measured conductance value: 880 siemens
5. Compensated Reading: (1+(((77-67)/2)*0.007))*880 = 911 siemens
6. Assuming that a battery has an initial (or new published value) siemens reading of 1000 mhos, follow the guidelines suggested below:
    - For readings below 400 mhos, replace the battery.
    - For readings between 400-800 mhos, it is considered a marginal reading and it requires a 10-minute self-test as outlined in the next section.

10.5. Battery Test Evaluation using Power Supply Self-Test

1. Initiate a 10-minute self-test via the front panel display of the power supply if this feature is supported.
2. Record the readings of the individual battery voltages in the 9th minute of the self-test. (It is important to measure all of the individual battery voltages before the self-test completes to ensure you get an accurate voltage reading while under load and before entering a charging state.)
3. If any battery voltage falls below 10.8 VDC, then that battery should be replaced if it is less than two years old. If it is greater than two years old then the string replacement is recommended. Refer to the next section for possible redeployment procedures of potentially good batteries.

a. Note: If there is more than 0.3 volt difference between batteries, take appropriate action (typically replace the affected battery or string of batteries).

10.6. Battery Redeployment Procedure using 24-hour Open Circuit Voltage Test (performed in the warehouse on batteries removed from the field but under consideration for redeployment)

Battery strings that fail the self-test may have batteries that are still healthy enough for redeployment. “Good batteries” can be redeployed if they are grouped with other “good batteries” of the same make and model with like date codes, voltages and conductance readings when redeployed. Batteries should be redeployed within 60 days of removal.

1. After returning batteries to the warehouse, recharge at 14.40 VDC for 12 hours.
2. Remove from charger and let stand open circuit for 24 hours. Measure the battery voltages and log. Any battery measuring below 12.60 VDC should be recycled.
3. Any battery above 12.6 VDC is a candidate for redeployment..

11. Power Supply Standby

11.1. Checking the Inverter Module

1. Turn off the battery breaker, pull the inverter module, and inspect and clean the electrical connections.
2. Using the handle, reseat the inverter module to test the capacitor.
- If the capacitor has dried out, the display will not appear.
- If the display no longer functions, replace the inverter module.
- Return a defective inverter module to be repaired.
3. Place the power supply into a self-test.
4. After successful completion of a self-test, place the unit into standby by shutting off the AC circuit breaker to ensure the unit is still operating correctly.
   CAUTION: Be prepared to restore power immediately if the unit does not go into standby. Otherwise, an outage may occur.
5. After a successful transfer into standby, turn the AC circuit breaker back on and ensure the unit transfers back to line mode properly.
6. If the standby test fails, first troubleshoot the batteries, then the inverter module and repair accordingly.

11.2. Replacing Inverter Module Procedures

It is recommended to refer to the power supply manufacturer's guide for details pertaining to inverter replacement. The following serves as an example:

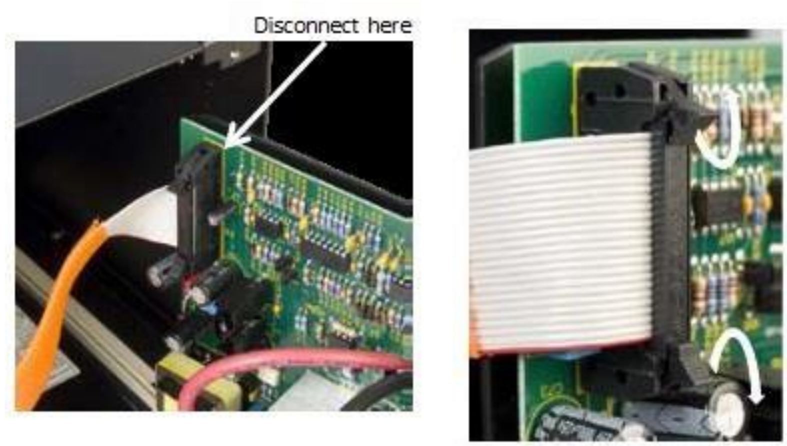

Figure 1 - Depending on the power supply make/model, some inverter modules may be tethered to the power supply with a ribbon cable that must be disconnected when removing the inverter module

Removal Procedure

1. Turn off the battery breaker.
2. Disconnect the battery input and temperature probe cables from the inverter module and the TMPR and XPDR cables from the communication module.
3. Loosen the thumbscrews.
4. Grasp the handle on the right side of the inverter module. Pull firmly to release the module from the inverter connector. Gently slide the module assembly straight out until the inverter module ribbon cable connector is accessible. Move the retaining clips apart and the ribbon cable will come free from the connector.

Installation Procedure

1. Reconnect the inverter module ribbon cable (some PS makes/models may not have a ribbon cable) to the inverter module circuit board by seating the cable into the connector (the locking tabs will automatically engage). Engage the sheet metal in the upper and lower guides and slide the inverter module back onto the connector. It is important that the sheet metal is properly seated in the card guides and fully inserted into the housing.
2. Tighten the thumbscrews.
3. Verify the battery breaker is off. Reconnect the battery input, temperature probe cables, TMPR and XPDR cables. Then turn the battery breaker on.

12. Communications/Transponder Evaluation

1. Review transponder web page to verify communications and RF levels. Verify TX/RX levels are communicating via the IP address with your laptop. Troubleshoot accordingly.
2. Repair/replace aerial drops to the tap at the top of the pole. If the tap is not located at the top of the pole, record the tap location.
3. Note location of any missing or defective underground drops.
4. Inspect the ground block and install one if needed. The ground block must be grounded to the cabinet.
5. Inspect the transponder RF surge protector if one is installed for proper grounding and any signs of degradation.
6. Check the status monitoring transponder and any associated adapter boards and/or wiring harness.
7. Assure RF levels are optimal into the transponder.

13. Alarms

In the event of a failure, an alarm may appear. For some power supplies, the active alarm screen displays the active alarms and how to correct the alarm condition. Table 2 provides example alarms and corrective actions.

Table 2 – Example Alarms and Corrective Actions

Active Alarm or Abnormal Condition	Probable Causes	Corrective Action
Self-Test Fail	36 Volt battery string below 33.0 VDC 48 Volt battery string below 44.0 VDC Alarm during a self-test Inverter failure has occurred Line isolation alarm	1. Check/correct other alarms 2. Ensure correct AC Input voltage is present 3. Check battery circuit breaker 4. Check battery fuse, if installed 5. Check battery condition and voltage 6. In the event that a self-test alarm condition was already present, re-run the self-test to clear the alarm. 7. Change the inverter module 8. Replace the power supply
Config Error	Configuration switch Settings incorrect Power distribution board failure	1. Check the configuration switch and jumper settings on the power distribution board. Match the requirements of the power supply. 2. Verify the configuration settings on display (press UP and ENTER simultaneously), match the application and configuration switch settings on the power distribution board. 3. Check transformer output tap setting to verify the inverter module voltage matches the transformer module voltage and voltage shown on the label of the inverter module. 4. Check for corrosion on the power distribution board. 5. Verify power distribution board, inverter module ribbon cable and connectors are properly connected. 6. Turn all power off, wait 10 seconds, turn all power back on. 7. Change inverter module 8. Replace power supply
Tap Fuse Fail	Open ATS fuse ATS damage Power distribution board damage	1. Check/replace fuse on ATS 2. Check for damaged contacts on the ATS board relay. 3. Check the configuration switch settings on the power distribution board matches those required by the power supply. 4. Check that the configuration settings on the display (press UP and ENTER simultaneously) matches the configuration switch settings on the power distribution board. 5. Turn all power off, wait 10 seconds, turn all power back on. 6. Replace the power supply

Output Overvoltage Reading	Configuration error Failure of metering circuit on power distribution board Failure of transformer	1. Check output voltage and compare to display reading. 2. Check the configuration switch settings on the power distribution board match those required for the power supply. 3. Check that configuration settings on the display (press UP and ENTER simultaneously) match the configuration switch settings on the power distribution board. 4.Check output taps from transformer 5.Change the inverter module 6.Replace the power supply
Output Overload	The output is overloaded or shorted.	1. Output Short Circuit 2. Check Output Current
Line Isolation Alarm	Failure of input relay	1. Open the battery circuit breaker 2. Pull out and re-seat the inverter module 3. Turn the battery circuit breaker back on 4. Run a self-test (Press DOWN and ENTER simultaneously) 5. If the alarm is still present, replace the power supply.
Output Failure Alarm	Battery end of discharge during line input fail Configuration settings incorrect Output overloaded Output in short circuit	1. Check for AC input voltage present 2. Check output current on the display. If output current is >100% of rating, correct overload conditions. 3. Measure the output voltage and compare to the display output voltage. 4. Check output taps from the transformer 5. Check the configuration switch settings on the power distribution board match those required for the power supply. 6. Check that configuration settings on the display (press UP and ENTER simultaneously) match the configuration switch settings on the power distribution board. 7. Open the battery circuit breaker 8. Pull out and re-seat the inverter module 9. Turn the battery circuit breaker on 10. Replace the power supply

Battery Temp Probe Alarm	Temperature sensor failure or inverter board failure	1. Check battery voltage and compare to display and battery voltage 2. Check for correct battery capacity on set-up menu 3. Check for AC input voltage present 4. Open the battery circuit breaker 5. Pull out the inverter module 6. Verify the inverter module is securely connected 7. Re-seat the inverter module 8. Turn of battery circuit breaker back on 9. Replace the inverter module
Low Batt Volts	Bad batteries or 36 volt battery string below 33.0 VDC or 48 volt battery string below 44.0 VDC Inverter module not seated AC input fail Inverter module failure	1. Check battery voltage and compare to displayed battery voltage. 2. Check for correct battery capacity on set-up menu 3. Check for AC input voltage present 4. Open the battery circuit breaker 5. Pull out the inverter module 6. Verify the inverter module is securely connected 7. Re-seat the inverter module 8. Turn the battery circuit breaker on 9. Replace the inverter module
High Batt Volts	36 volt battery string above 45.0 VDC 48 volt battery string above 60.0 VDC	1.Check charger settings
No Batteries	Detected the absence of batteries (alarm inactive when battery capacity set to 0)	1. Check battery breaker 2. Check connections 3. Check battery fuse
Batt Temp Probe	Remote temp sensor (RTS) failed or is not connected	1. Check connections 2. Check sensors
Input Failure	Utility AC input has failed	1. Input failure 2. Circuit breaker input 3. Input connections 4. Check 120/240 jumpers
N+1 In Use	Output of Cable UPS has failed. Load has been transferred to N+1 unit	1. Check output fuse 2. Check output connections
N+1 Fault	Input voltage was expected on N+1 unit; none detected	1. Verify wiring 2. Check N+1 output
Output 1 Tripped	Output 1 hardware protection mode engaged (only active with optional PIM installed)	1. Over current 2. Check settings

14. Documentation

As part of the standard outside plant preventive maintenance procedure, it is recommended that the technician collect vital network information on system elements. It is necessary to complete a preventive maintenance certification report, either manually or electronically. An example PM certification report is included in the Appendix.

Collected system information should include the following:

- System/Site Name: MSO, Region, Power Supply Number and Node Information
- Site Location: Physical Address and GPS Coordinates
- Battery Information: Battery Make, Model, Date Code, and Conductance Readings
- Power Supply Information: Make, Model, Date Code, Serial Number
- Transponder Information: MAC Address, IP Address, Transmit and Receive Levels
- Enclosure Information: Model, General Condition and Accessories
- System Information: Output VAC, AC Input Voltage, AC Input Current Draw, Total Run Days, Power Supply Events, Self-Test Duration

15. Appearance And Completion

15.1. Dress the Wires – All wires should be routed in an orderly manner.

- Ensure all wires are not at irregular angles that are likely to cause a kink.
- Ensure all wires will not be pinched in the door or battery tray.

15.2. Tie-wrap all wires neatly.

- Coil all slack together and ensure the battery trap will pull out freely.
- Ensure that all equipment is accessible and free of clutter.

15.3. Ensure equipment is secure and cabinet is locked before departing.

APPENDIX A: Sample Preventive Maintenance Certification Report

PM CERTIFICATION REPORT

INSTALL | MAINTAIN | REPAIR | VALIDATE

Site Data — Site ID:

Latitude		Longitude		Date		Time		Transformer #	
Hub		City		State / Province		Zip Code			
Region		System		Node		Country			
Project ID		Street(s)		Address Notes		Pole #			
Business Service		Output VAC		120V Or 240V?		Powering A Node			
Utility Company		Utility Account #		Utility Meter #					

Transponder Data

CM MAC Address		SNR		CER		Logic Card		Transmit Power		Receive Power	
CM IP Address		Transponder Type		Firmware Version		T3 Timeouts		T4 Timeouts			

SNMP TRAPS

Trap 1		Trap 2		Trap 3		Trap 4	
MIB 1		MIB 2		MIB 3		MIB 4	

UPSTREAM

Frequency		Modulation		Lock		Channel ID		Symbol Rate	

DOWNSTREAM

Frequency		Modulation		Lock		Channel ID		Symbol Rate	

Power Supply #1 Data

Make-Model		Date Code (MMYY)		Refurb Date (MMYY)		PIM /DOC Installed	
Firmware Version		Total Run Days		Controller Card		Serial Number	
Self-Test Duration (min)		Self-Test Interval (days)		Retry Limit		Retry Delay (Seconds)	
Event Log Cleared		Number Of Events		Events Time		Inverter Test Performed	
AC Input Voltage (VAC)		Output Voltage (VAC)		Output Current 1 (A)		Output Current 2 (A)	

Battery Data

Self-Test Verified		Self-Test Start Time		Self-Test Finish Time		Battery Temperature (°F / °C)	/

Battery #	Battery Manufacturer	Date Code (MMYY)	ID #	Voltage No Load (VDC)	Voltage Under Load (VDC) After 9 Minute Self-Test	BS Conductance (mhos) Meter Reading	BS Conductance (mhos) Corrected 77°F
A1							
A2							
A3							
A4							
Battery Separator Present			String A Total	0.0	0.0		String A Fused
B1							
B2							
B3							
B4							
Battery Separator Present			String B Total				String B Fused

CHARGER INFO

Charger Mode		Current (A)		Accept (V/C)		Current Limit (A)	
Float (V/C)		Temp Comp (mV/C/°C)					

PM CERTIFICATION REPORT

INSTALL | MAINTAIN | REPAIR | VALIDATE

Site Data — Site ID:

Latitude		Longitude		Date		Time		Transformer #	
Hub		City		State / Province		Zip Code			
Region		System		Node		Country			
Project ID		Street(s)		Address Notes		Pole #			
Business Service		Output VAC		120V Or 240V?		Powering A Node			
Utility Company		Utility Account #		Utility Meter #					

Transponder Data

CM MAC Address		SNR		CER		Logic Card		Transmit Power		Receive Power	
CM IP Address		Transponder Type		Firmware Version		T3 Timeouts		T4 Timeouts			

SNMP TRAPS

Trap 1		Trap 2		Trap 3		Trap 4	
MIB 1		MIB 2		MIB 3		MIB 4	

UPSTREAM

Frequency		Modulation		Lock		Channel ID		Symbol Rate	

DOWNSTREAM

Frequency		Modulation		Lock		Channel ID		Symbol Rate	

Power Supply #1 Data

Make-Model		Date Code (MMYY)		Refurb Date (MMYY)		PIM /DOC Installed	
Firmware Version		Total Run Days		Controller Card		Serial Number	
Self-Test Duration (min)		Self-Test Interval (days)		Retry Limit		Retry Delay (Seconds)	
Event Log Cleared		Number Of Events		Events Time		Inverter Test Performed	
AC Input Voltage (VAC)		Output Voltage (VAC)		Output Current 1 (A)		Output Current 2 (A)	

Battery Data

Self-Test Verified		Self-Test Start Time		Self-Test Finish Time		Battery Temperature (°F / °C)	

Battery #	Battery Manufacturer	Date Code (MMYY)	ID #	Voltage No Load (VDC)	Voltage Under Load (VDC) After 9 Minute Self-Test	BS Conductance (mhos) Meter Reading	BS Conductance (mhos) Corrected 77°F
A1							
A2							
A3							
A4							
Battery Separator Present			**String A Total**	0.0	0.0		String A Fused
B1							
B2							
B3							
B4							
Battery Separator Present			**String B Total**				String B Fused

CHARGER INFO

Charger Mode		Current (A)		Accept (V/C)		Current Limit (A)	
Float (V/C)		Temp Comp (mV/C/°C)					

PM CERTIFICATION REPORT

INSTALL | MAINTAIN | REPAIR | VALIDATE

As-Found Local Power Supply Alarms

Alarm	Major/ Minor	Cleared On Site

Exceptions

Exceptions

Inspection

Enclosure Exterior Maintenance Checklist

Item To Check	Yes/No	Item To Check	Yes/No	Item To Check	Yes/No
Check For Pad Undermining		Clean Dust/Dirt From Enclosure Inside		Enclosure Hardware Tightened	
ACI Installed & Functioning		LRI Installed & Functioning		Enclosure Snow Shield	
Generator Accessibility		PS Co-Locate With Node		Control Switch Installed	
Co-Locate With Vault		U-Guard On Ground Wire		PS Metered	
Lock Present		Security Bar Present			

Enclosure Make-Model		Enclosure Condition		Enclosure Depth (cm)	
Internal Breaker		Service Entrance		Receptacle Type	
Dual Utility Switch Present		UG Or Aerial		Total Battery Capacity	

Interior Systems Maintenance Checklist

Item To Check	Yes/No	Item To Check	Yes/No	Item To Check	Yes/No
Check Wire Harness And Connectors		Clean And NO-OX Batteries		Site Grounded Properly	
Tamper Installed And Functioning		AC TVSS Installed And Functioning		Battery Balance Installed And Functioning	
Battery Hardware Properly Tightened		Coax TVSS Present		Battery Temperature Probe Present	

Pad Value		Cable Sim Value		Ground Current (mA)	
Tap Installed		Drop Installed		Generator Cord Present	

Battery Heater Mat Types & Quantities

Mat Type	Quantity	Mat Type	Quantity

Work Items Performed On Site

Work Item	Quantity	Part Number(s)

Technician Info

Open Items For Repeat Visit							
Initial X-Tractor & Form Time (minutes)				Additional Form Time (minutes)			
PM Service Technician							
Last Name		First Name		Contact #		Technician #	