SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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PREPARATORY COMMISSION

# Challenges and improvements to DC power systems at IMS waveform stations

C. Johannsen, S. Stefanova, P. Yao

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POSTER

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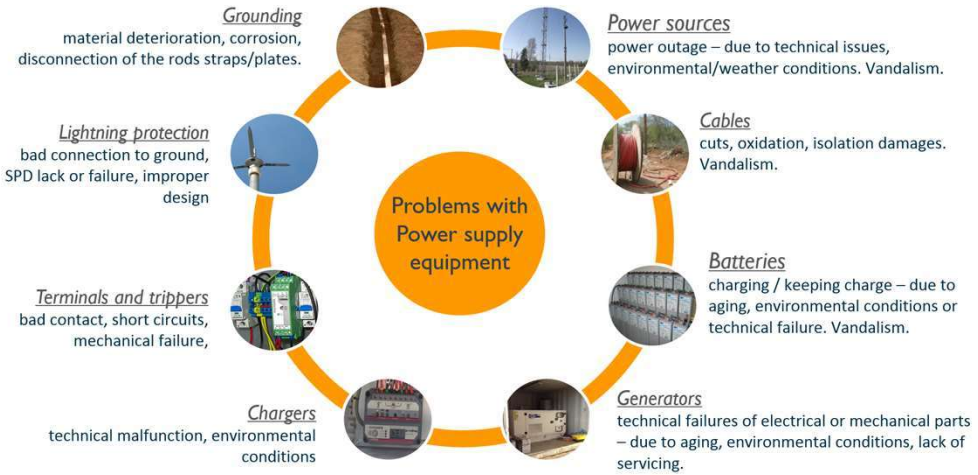
Most waveform stations in the IMS network are now 10-20 years old. Problems with power and communication systems often relate to cables, circuit breakers, connectors and/or surge protection becoming corroded or deteriorated to a point where good connections and functionality can be compromised.

Many stations are located near the sea, in high humidity and salty environments, which inevitably provokes corrosion over time, almost regardless of precautions during installation to protect the electrical installations. In addition, DC power installations are prone to create a constant ion flow that can create electrolysis and could damage metals in the installation.

Examples of corrosion has been observed on cables, connectors and surge protection devices and shows the importance of proper installation, timely inspection and periodic maintenance of the power and communication systems, to ensure sustainable operation and high data availability of IMS stations.

Installation methods to simplify inspection and maintenance can help the station operators during troubleshooting and to report power issues before they become problems.
This poster describes some of the power systems installed at IMS waveform stations and focusses on the operation and maintenance of these power systems.



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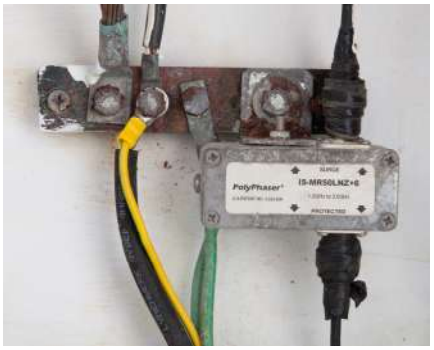
INTRODUCTION



Groundbar after 14 years in an ocean near vault.
Corrosion developed on the ground bar, bolts and wires.
Worst affected is the mounting bolts. The surge protector connection to the groundbar is rusty and the protection functionality is questionable.

Many of IMS waveform stations have site installations with independent DC power systems (photovoltaic, wind turbine or other similar power production units) combined with a battery backup bank.
As many stations are now more than 10 years old, degradation issues in the power installations have started to show its presence.

The issues mainly relates to corrosion, conditions of surge protectors and issues of cables and wires. The observed issues are not something that occurs immediately but takes years to develop and therefore requires regular inspection and maintenance to be discovered and repaired in due time before failures happens.

It has also been observed that troubleshooting, repairs and partial upgrades can lead to poor and incorrect or incomplete installations, especially if the correct planning or materials are not followed or available at the time of installation.

Circuit breaker box not installed properly because the right materials not available at the time of installation. Many of the wires used are not rated for the maximal current and lugs are missing.
A rodent had build a nest in the box, creating a fire hazard. The box and wires were later replaced.

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## Observed Issues

Examples of cable isolation failures due to missing strain releif and grommets when passing cables trough a steel enclosure.
Sun, heat and small movements creates the broken insulation, leaving the copper exposed, corroded and creates both an electrical hazard as well as a fire hazard!

Corrosion can be anodic, cathodic or galvanic with the latter being the most dominant at IMS waveform DC stations. Avoiding corrosion completely at remote sites is almost impossible over years of time. Routine inspections and maintenance is crucial to keep a station site continuously sending data.

Corrosion is often most dominant seen on ground bars. Galvanic corrosion happens when combining different metals in the ground wire system. A good large ground wire system has plenty of exposed cable area to chemically connect with any substance in the soil and ground around the site.

Corrosion is also seen in cables, where copper turns black or green which is a clear sign of oxidized copper. This is not necessary a problem in the short term as corroded copper conducts as well as a non-corroded. However when the wire is moved, it will break easily or result in poor connection. This problem is much more severe on copper plated aluminum wires which use should be avoided.

In case of flooded vaults, electrolysis reaction causes severe and fast material corrosion as soon as the water creates a conducting path between power terminals.

Two examples of flooded electrical enclosures showing fast corrosion due to electrolysis reaction, when the water reaches power terminals.
The copper and other metals becomes electrodes that deteriorates very fast due to electron and ion-movement.

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## Observed Issues

Power and communication enclosure before and after a maintenance upgrade. The installation was simplified due to advances and standardization of equipment, eliminating the need for port servers and a power converter. All status diodes are facing outward to the user for easier inspection and maintenance. The excess cables in the bottom of the enclosure were left mounted to avoid open holes.

Poor electrical connections lead to resistance which then leads to heat production resulting in melted wires and eventually disconnection.

This has been seen mostly on the power production side of power systems (photovoltaic panels or similar) where the voltage and current are highest in the power systems. However it can happen at all points in a power system.

Proper connection terminals, wire termination and strain relief is essential to prevent such issues over years of station operation as well as regular inspection and maintenance is essential to discover such issues before they turn into lack of power of damaging fire.

Examples of melted and corroded power wires due to poor electrical connections. The top picture shows a poorly connected wire from a photovoltaic panel which generated heat that melted the wire insulation and caused corrosion.
The bottom picture shows a melted wire in a power panel box.

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Solutions

The picture shows a large power station for 4 remote sites after a partial upgrade.
The upgrade was made without proper wires and materials available, leaving the installation messy and impossible to touch without high risk of damaging connections or equipment.
This also poses a safety hazard to the personnel.

For long term sustainable operation of any IMS station it is important to use correct materials and installation methods. If this is not possible due to unforeseen constraints (logistics, time etc.), follow-up corrections must be carried out for long term sustainable operation.

When planning installation or upgrades, use as simple as possible installation setup for easier future maintenance, troubleshooting and repairs. Combined with proper sparing of on-site equipment, repairs can restore data flow in a timely manner.

Designing power systems with modular equipment (DIN rail or similar systems) and proper installation and termination of wires, makes it easier to keep an overview of the system.
Form-Fit-Function replacement of equal modular system spares guarantees keeping the systems intact and accessible.

Same power station after a complete maintenance repair.
Except the charge controllers, everything is DIN rail mounted in sealed enclosures.
All wires, circuit breakers and surge protection have been replaced.
The station operator can now inspect, maintain and troubleshoot the power systems without the risk of equipment damage or personnel risk.

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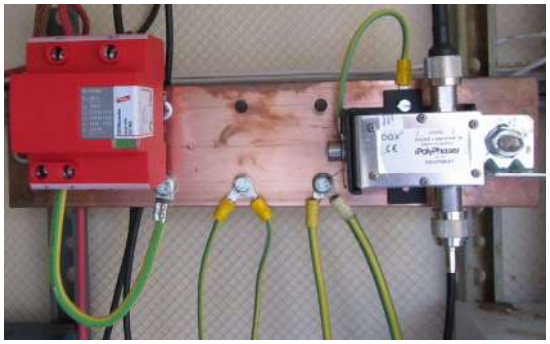
Solutions

The picture shows an old grounding bar with a power surge protection and a GPS surge protection unit.
Both surge protectors are more than 10 years old and corroded.
The wires connected to the power surge protector has not been terminated and also has corrosion.
Both surge protectors were replaced and upgraded to modern types of surge protection.

For remote sites with independent DC power systems and vault installation, corrosion over years of time in almost unavoidable.

Proper maintenance inspection is necessary to identify corrosion, poor connections and degraded cables or connections in due time to plan for repairs and replacement to keep the station in an operation condition.
It is important to inspect for poor connections and hidden corrosion.

Using surge protection devices with fault indicators and easy replacement modules makes it easy for the station operator to keep the surge protection intact and functional at any time.



The picture shows a cleaned copper ground bar with new bolts and modern surge protection.
Note the ground wire installed on the GPS surge protector in order to ensure a proper ground connection.
Also note the green indicator on the power surge protector. The indicator changes to red if a large power surge is suppressed. This can be noted and the module can be replaced.

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## CONCLUSIONS

For stations with remote sites where exposure to water, humidity and temperature fluctuations are unavoidable, correct installation and proper maintenance inspection is crucial for long term sustainable operation.

Troubleshooting and changes without proper spares, tools and wires often leads to messy installations which can be impossible to inspect and maintain afterwards.

Making sure the installation type is a simple as possible needed for a given station, makes it easier to maintain and keep the overview of components in the power system.

Proper wires, termination, grommets and strain relief is essential for avoiding poor wire connections and cable damage.

Keeping all components mounted with the same modular system (DIN rail or similar), simplifies the overview of the installed components and it makes it simple to replace components when needed.

New types of surge protection with indicators and replacement modules enables timely replacement of surge protection, keeping the sites well protected from power surges over years of life time.