U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office
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# Rotor Installed Corona Mapping of Stator Windings within Large Diameter Hydro Generators

**Research Bulletin**
**S&T Project 19078**

## Mission Issue

Increase diagnostic capabilities in rotating machines while increasing efficiencies and safety and decreasing costs and burden.


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## Problem

Rotating machines are large, complex, expensive assets, and Reclamation has more than 200 in its fleet for hydropower generation and pumping. Part of operating these assets involves continually monitoring their condition. Machine condition is then used to plan maintenance, repair, or replacement of the asset in an efficient and cost-effective manner. One valuable metric for machine condition is partial discharge (PD) activity within the high-voltage insulation system.

In practice, there are two types of PD monitoring systems and equipment: continuous online monitoring, and corona probe testing. While continuous online monitoring has very high temporal resolution, it suffers from poor spatial resolution and cannot locate specific problems within the machine. While corona probe testing has very high spatial resolution, it suffers from poor temporal resolution and cannot trend PD activity over the asset's lifetime. No known present technology allows for both high-temporal resolution for trending, and high-spatial resolution for problem localization throughout the entire insulation system.

## Solution

We developed a method of PD measurement which provides high spatial resolution while also allowing for more frequent trending than traditional corona probe testing would. This new method utilizes near-field communication (NFC) antennas, like those found in smart phones and other consumer electronics. Such antennas can be placed on the rotor to measure PD across the air gap of the machine while it rotates. The increased spatial resolution results from the antenna being exposed to every slot within the machine during rotation. This method is also very cost effective to carry out, which means it can be carried out much more often than corona probe testing can. This increased frequency of testing capability would allow for trending of PD activity throughout the life of the asset, detecting when significant deterioration of the insulation system is occurring.

*"I discovered that NFC antennas, which are typically used in smart phones and consumer electronics, are also able to detect partial discharge across a small air gap. After that, this application was a natural extension of that discovery."*

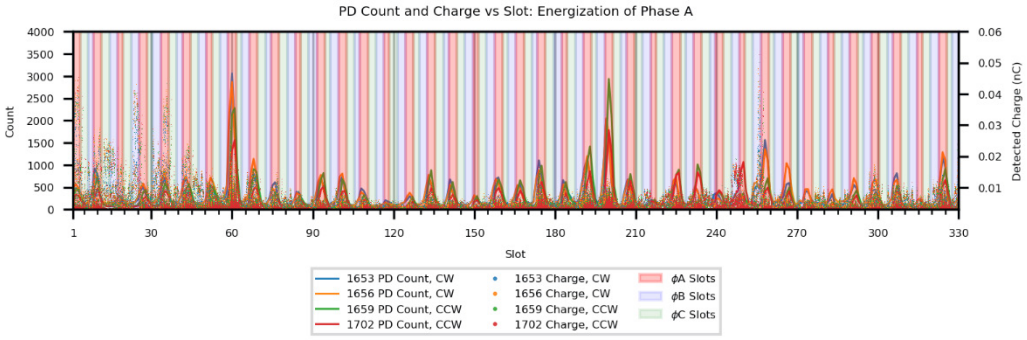
Jacob Lapenna
Principal Investigator, EE
Bureau of Reclamation

## More Information

https://www.usbr.gov/research/projects/detail.cfm?id=19078

## Application and Results

An NFC antenna was attached to a rotor pole face of Mount Elbert Unit 1. The rotor was then rotated clockwise (CW) and counterclockwise (CCW) to place the NFC antenna in front of each of the 330 stator slots while recording offline PD activity along with data correlated to the antenna's position. Post processing was then performed to extract the antenna's position throughout the test and allocate PD event count and detected antenna charge magnitude (nC) to each slot position based on time of detection. The below plot shows the results for Phase A of the stator winding at an applied 60 Hz line-to-ground voltage of 8.66 kV. In this plot, the Phase A coil groups are highlighted with a red background. Obtaining similar peaks of significance for CW and CCW rotation, as well as only detecting high frequency counts of PD events at Phase A coil groups, affirms the measurement abilities of the invented method and prototype. Trending of this data would be needed to determine if the peaks at specific coil groups are of any consequence.




## Future Plans

Reclamation's Economics Analysis Group has estimated a savings across our fleet of 100 to 200 million dollars over 30 years pending wide scale adoption of this invented methodology. However, the prototype that resulted from this research is a complex system of various commercially available test equipment, specialized sensors, networking equipment, laptops, and custom written software. Extensive specialized knowledge is required to use this prototype, which increases barriers toward full-scale adoption. To decrease these barriers to adoption, ongoing research is being carried out to streamline this prototype. The end goal of this endeavor is to have a more robust, easy-to-use system that can be deployed by a more diverse range of personnel across engineering disciplines and crafts. With more frequent deployment, more data will be collected, allowing further comparison of the invented method to traditional monitoring methods. At the same time, information sharing is underway with companies that provide commercial PD monitoring equipment to gauge commercial interest in this method of measurement.