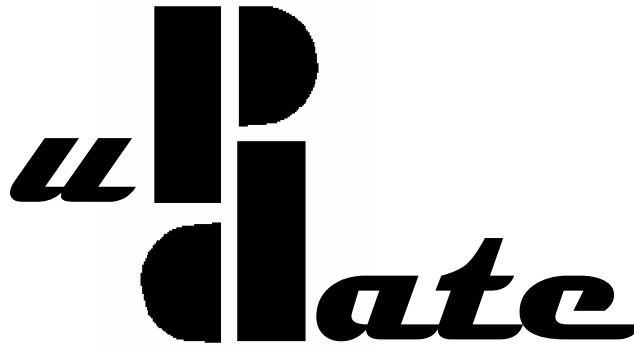


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## *Fall-of-Potential Method versus the Smart Ground Multimeter*

*By Richard Rush, Senior Test Engineer  
Hood-Patterson & Dewar, Inc.*

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The following discussion will describe the test methods for measuring the ground impedance of a substation ground grid; The Fall-of-Potential (FOP) method and the Smart Ground Meter (SGM). The FOP method has been used for years while the SGM method is the relatively “new kid on the block”.

### **Fall-of-Potential Method**

The FOP method is the most popular method of measuring the ground impedance of a substation ground grid. The FOP test method and probe arrangement is fully described in the IEEE Std. 81-1983 and Std. 81.2-1991. Please note in Std. 81-1983, page 10, Section 6.1 - Complexi-

ties:

“With the development and industrial growth adjacent to power substations, it becomes difficult to choose a suitable direction or locations for test probes to make a resistance test. Moreover, the connection of overhead ground wires, buried water pipes, cable sheaths, etc. all have the effect of physically distorting and enlarging the ground grid.

Ground impedance measurements should be made immediately after the ground grid has been installed to insure that there are no major omissions of the grounded components normally con-

*(Continued on page 2)*

## *Name Our Newsletter Contest Winner*

In the first issue of our P&D newsletter, we asked you to help us name our new newsletter. Congratulations to Lynn Timbrook, PE, at CHELCO in DeFuniak Springs, FL. Lynn suggested the name we selected; uDate, with P&D incorporated into the new logo. Very creative, Lynn. Thank you to everyone who submitted suggestions. Lynn will be receiving a \$25.00 gift certificate.



We want our newsletter to be useful to you. If you have any suggestion for future articles, questions or comments, please email them to [sales@pd-engineers.com](mailto:sales@pd-engineers.com) or via fax at 404-299-3542. We look forward to hearing from you. ❖

## *Fall-of-Potential vs. SGM* cont'd from page 1

*P&D is made up of three different departments: Electrical, Civil and Testing, known as Hood-Patterson & Dewar*

nected to the grid. Future installations of water pipes, rail, etc. will alter the readings. “

The FOP test procedure is based on the fact that the earth voltage potentials with respect to *remote earth* decrease the further one gets from the ground grid. If you get far enough from the ground grid, theoretically the voltage is zero which is referred to as *re-*

*mote earth*. For the FOP test to work correctly the current return probe must be positioned some distance beyond this zero voltage point, actually about 40% further, or else the voltage gradients around the current probe interact with the ground grid voltage gradients. On small, isolated ground grids practical experience has shown us that a properly placed current return

probe location will return accurate test results. However, this same practical experience has shown that as the ground grids get larger or are interconnected to other grounding sources the ability to accurately measure the ground grid or system impedance gets quite complex.

The recommended procedure for performing the

*(Continued on page 4)*

## *PDMap/GIS Developments*

Welcome from the GIS/mapping department. It has been an exciting few months. First, we are getting ready for our PDMap user meeting which will take place September 13-14. This year's meeting will be held at The Georgia Center for Continuing Education at the University of Georgia in Athens. All PDMap users should have received an invitation to this event. We would also welcome any of our clients who wish to see this powerful GIS system.

We are also excited about the release of ESRI AR-CGIS 9.0. This version of

software has given us the technology necessary to write our own products using the core ESRI software. Our latest offering is our map viewing product PDView. This product will enable our users to economically provide map viewing to the entire utility. Gibson EMC has agreed to install about 40 of these viewers at their utility. We will have much to say about map viewing at our user meeting.

Other exciting developments involve one of our new clients, Ocmulgee EMC. When we arrived at Ocmulgee we learned that

they had built a database that stored information from their Automated Meter Reading software (TWACS) and Customer Information System (SEDC). With this information in a centralized database we now will be able to “ping” an AMR meter and check for service. Should a meter fail to report we will be showing this potential outage on the map. We are very excited about this project and will update everyone on the development of this interface.

We would also like to welcome Canoochee EMC to

our growing PDMap client list. Canoochee has purchased our GIS product along with Milsoft's Dispatch outage program. Canoochee also is responsible for system maintenance at Hunter and Ft. Stewart military bases. We have converted these military installations and are looking at the possibility of providing GIS services to other military bases.

It is a great pleasure to work with all of you. Your involvement has proven crucial to the development of our GIS products. Again, thank you for all your support. ❖

## *P&D People*

This issue's focus on people will be on a new face at P&D. His name is Jerry Crawford. Jerry came to P&D as the new transmission line engineer in March of 2004. Jerry has over 20 years of experience in siting, permitting, survey oversight, right-of-way acquisition, designing and construction of high and extra high voltage transmission lines. Jerry has

designed in excess of 1500 miles of transmission during his career. In addition to transmission line design, Jerry has knowledge in the areas of Spill Prevention Countermeasures and Control (SPCC), foundation design, structural analysis and design.

Jerry comes to P&D from the Municipal Electric Authority of Georgia

(MEAG); he also has worked for Southwestern Public Service Company, New Century Services and American Electric, Steel Structures Group (now Thomas & Betts). Jerry has a B.S. in civil engineering with a structural option from New Mexico State University.

Jerry has been married to his wife, Cindy, for 19

years and has two children, ages 17 and 13.

Please feel free to contact Jerry anytime by phone at (404) 299-4665 or by email at [jcrawford@pd-engineers.com](mailto:jcrawford@pd-engineers.com). ❖

## *Infrared Your Control House*

Recently, we had a client who had a current transformer wire burn in a substation relay switchboard. The burned wire occurred in a substation that had been in service for several years, and it occurred on the back of a relay, where the wire was connected to a crimped terminal. Obviously, the crimp was bad and eventually burned. When this wire burned, it opened the current transformer (CT) circuit on the transformer differential relay, causing the transformer differential relay to operate.

If only, when the utility

regularly did an infrared survey of its system, they had surveyed the control house switchboard, this overheating terminal might have been found and repaired before it caused an outage. It is an excellent idea to do an infrared survey of the control house equipment: battery, charger, switchboard, etc., whenever the annual system infrared survey is done. Typically, the infrared survey is concerned with high voltage connections in the substation and heavily loaded lines, but the control house might be an excellent place to look as well! ❖

*Did you know...?*

*P&D is a Cooper Power Systems Certified Idea Developer. Many of our engineers have been through CPS training and are able to design workbench tools on ProView 4.0, CPS's newest software for their Form 6 recloser control and other protective relays*

FOP test on a large grounding system is to establish the current return probe location (6.5 times the maximum diagonal) and perform a series of voltage measurements, each measurement progressively further from the grid than the last, until the difference between several of the voltage readings are negligible. It should be noted that even under homogeneous soil conditions and no extended ground connections, a current probe spacing 50 times the maximum grounding system dimensions has an expected measurement accuracy of 98.5%.

Therefore, it should be concluded from all of the above listed conditions, warnings and problems noted in both Std. 81 and Std. 81.2 that the typical FOP test method utilizing the typical portable test equipment is not suitable for the measurement of ground impedance of large ground grids, and it is definitely not acceptable for interconnected grounding systems.

Due to the increased complexities of using the FOP method, it is obvious that most testing procedures have been lacking. While it is not empirically stated, a thorough review of the Standards reveals that the FOP method utilizing simplified, low powered, test equipment was intended for small, isolated ground grids smaller than 900 m<sup>2</sup>. The test procedures that worked 30 to 40 years ago on smaller, remote, isolated ground grids won't work in today's congested geography. This has resulted in ground tests that are being performed incorrectly per the present standards.

### SGM Method

The development of the SGM test method centered on all of the known inherent impedance measurement problems and test equipment limitations. The SGM test equipment has two primary components, a laptop computer running a Windows OS (98, NT, 2000, & XP) and the test unit itself. The many advanced features that the SGM offers over the typical Fall-of-Potential (FOP) test devices are listed below:

- Ground grid does not need to be isolated from other grounding sources
- Current is injected over a user selected frequency spectrum (example: 0 – 250 hertz, 0-500 Hz, up to 2,500 Hz)
- Selectable voltage source (250 or 500 volts)
- Amount of injected current is typically 100 times greater than most FOP test devices

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can inject (2 to 15 amps)

Ground potentials and their phase angles are measured at 6 discrete locations

Typically 10 current injections are performed for each individual test

Typically 140,000 data samples are collected

Voltage conductors and probes are calibrated for each test

Lead induced voltage is removed

The collected data and voltage probe performance is qualified

The data is corrected for noise and harmonics

The current return electrode does not have to be positioned as far from the ground under test (minimum of 2 times the grid diagonal)

In summary, the SGM method embraces many of the recommendations that are discussed in IEEE Std. 81.2-1991 and combines them into a convenient package that simplifies set up time and provides data assessment, statistical analysis, and data storage. The SGM provides additional test functions for performing touch and step voltage, soil resistivity, transfer voltage, and continuity tests. The SGM method adheres to the proper methods as outlined in the Standards while the typical test procedure performed by utilities and testing companies is a convenient short cut that yields a number that is not corrected for all of the conditions that one normally encounters with large, complex energized substation grounding systems.

*Note:* This article is condensed and may be seen in its entirety at [www.hoodpd.com/groundnews.pdf](http://www.hoodpd.com/groundnews.pdf). If you would like more information about the SGM or our testing services with the SGM, please contact [sales@pd-engineers.com](mailto:sales@pd-engineers.com). ❖