DSTAR Newsletter
Volume 1, August 2013

DISTRIBUTION SYSTEMS TESTING, APPLICATION, AND RESEARCH

Inside this issue…

Upcoming DSTAR and related events

DSTAR Annual Meeting & Training Session	10/8/13-10/10/13, Atlanta, GA
GE Digital Energy's Americas Software Summit	02/10/14-02/14/14, Orlando, FL

DSTAR: 25 Years and Going Strong

North American electric utilities are faced with a unique set of challenges in the current operating environment. They are under increasing pressure to design "smarter" systems and improve operational efficiency, even as the integrity of their physical infrastructure declines and resources become more constrained. In order to meet these challenges, today's distribution engineers must be equipped with the knowledge and tools that will help them do the job more effectively.

For more than a quarter century, DSTAR (Distribution Systems Testing, Application, and Research), a consortium of electric distribution utilities and utility organizations in North America, has worked with GE Energy Consulting to collaboratively sponsor near-team, pragmatic distribution research & development (R&D), which can be applied readily to everyday system design, operation, and maintenance activities. See www.dstar.org

Evolution

Throughout its 25-plus years of existence, DSTAR has sponsored or executed more than 90 separate projects for more than 30 utilities and utility organizations. The scope of the R&D activities encompasses just about every facet of distribution engineering, including equipment applications, system protection, reliability, power quality, and operational efficiency.

Over time, DSTAR has evolved with the needs of the industry. Initial work focused on equipment testing and produced groundbreaking work like DSTAR's ferroresonance guidelines for padmounts, and fault energy guidelines for transformer enclosures, which are still used today.

The 90's saw DSTAR produce many practical engineering software tools – more than 15 separate applications to help with everyday engineering tasks, such as calculating cable pulling tension, cable electrical parameters and guying tension, to more extensive analyses like evaluating transformer ownership costs and system economics.

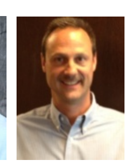
In recent years, driven by the changing needs of its dynamic membership, DSTAR has been instrumental in providing thought leadership to distribution utilities in the form of white papers, industry perspectives, and critical analysis of technology. Recent work on the impact of distributed energy resources, strategies for improving utility energy efficiency, and the changing nature of loads has provided valuable guidance for members as they navigate the uncertain path toward grid modernization and efficiency goals.

What the Future Holds

The future of DSTAR continues to be bright, molded by direct and intimate member control. Over the past 10 years, the consortium has moved progressively from a testing focus to developing engineering software and white papers, and critically evaluating technology. We are also adding a training component to help our members address the widening knowledge gap in the industry. The challenge facing the consortium is to remain relevant, following the industry trend, while not eroding the core "volts and amps" competencies that have made DSTAR successful during the last 25-plus years. DSTAR began with a pressing distribution problem, and pressing problems remain today. As long as DSTAR holds true to its mission statement, **"Pragmatic Distribution Research and Development for Today's Competitive Utility Environment,"** it will continue to find new challenges to tackle for the next 25 years and beyond.

Lavelle Freeman – DSTAR Program Manager, GE

Jim Weiss – DSTAR Chair, Ameren



DSTAR – An Organization for Myth Busters

"The 'Impact of Photovoltaic (PV) Generation on Distribution Systems' report from DSTAR (Project 13-9) was very detailed and comprehensive. This is the type of deliverable from DSTAR that can be beneficial to us. If you read this entire report, you would pretty much understand the PV issue."

Robert E. Hawthorne

Distribution Engineering Services Manager

Southern Company

Over the course of a 40-year career at a large investor owned utility, I have heard the following answer "That's the way we have always done it" to various engineering design questions that I have asked of our Engineering Support Experts. Basically they don't know the answers and they really don't want to take the time to investigate the problem.

So I turned to outside professional organizations for the answers. There are many to choose from and after a quick survey of these organizations, I discovered DSTAR could provide answers to these so called "myths" for my company.

There are several "myths" in the industry that I have wondered if they were "Fact" or "Fiction". The engineering answers to these questions are critical to making intelligent and timely decisions that affect the design of the distribution system of the future.

The first "myth" dealt with tracking down the elusive ferroresonance problem every time a fuse blows on a line feeding a closed wye delta transformer bank. I asked several experts within the company and really did not hear what sounded like a plausible answer. So the question was posed to DSTAR and they delivered a report with an explanation of not only what causes the ferroresonance, neutral shift condition, but it also included several options to manage the problem. But the real underlying "myth" that was busted was the suggestion to increase the sizes of transformers on grounded, open-delta transformer banks. The report encouraged the use of larger transformers in these banks. This would eliminate the "neutral shift" condition and would ultimately reduce our transformer cost to the customer. So our company revised its transformer practices for the 120/240 3-phase voltage and we started banking larger transformers in the open-wye delta configuration.

The second "myth" dealt with the need to install a companion current-limiting fuse on every 25KV and 35KV distribution transformer. Every time a current-limiting fuse blows it requires a large truck roll and two linemen. Even though these voltages cover 15% of our customer base, it still costs us money, time and effort to replace these fuses. So again the question was asked to DSTAR. They did comprehensive surveys of other utility practices; thorough technical literature search using internet and company libraries; and used the vast experience of the GE representatives to deliver a report that turned this "myth" into "Fact". So we continue to use these companion current limiting fuses and have solid answers to the field when they ask the "WHY" question.

The last "myth" that is being researched is the placement of arresters on distribution transformers. Some utilities install the arrester on the source side of the transformer's fuse and others place it next to the transformer. For as long as I can remember, my utility places the arrester on the source of the cutout. Why? "It's the way we have always done it". So DSTAR has taken on a project to determine the best location of the arrester. This project has just launched and hopefully by spring of 2014, I will be able to have good engineering reasons to either keep or relocate our transformer's arrester.

These are just three of the many projects DSTAR has undertaken and completed. Utilities need timely answers to their design questions. We need a research body where other like-minded utilities can pool their resources and an engineering staff that can direct and deliver reports, software, and white paper discussions. So the answer to the DSTAR "myth"…"FACT"!

Robert M. Cheney – DSTAR Secretary, Southern Company

Program 14 Update

P14-4: Surge Protection of Electronically-Controlled Devices Installed in Distribution Systems

Introduction

Utilities have installed many intelligent electronic devices (IEDs) to enable safe, reliable, and efficient operation of the distribution system. These IEDs include recloser controls, capacitor controls, and voltage regulators with electronic (microprocessor-based) components. The number of these devices has increased substantially due to smart grid initiatives and stimulus funding to the point where they have become critical to the operation of the distribution system. Therefore, it is very important that electronic controls are properly installed on both overhead and underground systems.

In recent years, many of these electronic controls have failed, often due to power surges and overvoltage events. These failures have created concerns about the practice and standardization of: grounding, arrester placement, and location of the control power transformer (CPT).

Attempts to study these control failures are documented in "Lightning Protection of Distribution Capacitor Controllers" by F.D. Crudele, et al.[1], "Application Guide for the Automation of Distribution Feeder Capacitors" by EPRI Solutions[2] and "Lightning protection of Distribution Lines" by T.E. McDermott, et al.[3]

Despite these attempts, there is still uncertainty within the utility industry relative to best practices, while manufacturers only provide limited information, if any, relative to grounding and surge protection of their control devices.

GE Energy Consulting is leading the effort on Project 14-4 (Surge Protection of Electronically-Controlled Devices Installed in Distribution Systems) on behalf of DSTAR members to simulate various prototypical pole installations that will be used as the basis for developing practical guidelines on how to better protect the electronically controlled equipment installed in their distribution systems from power surges. Guidelines will be developed from transient simulations performed on pole installation configurations as provided by the DSTAR membership.

Simulations and Results

Figure 1 displays a typical connection diagram used in this project. This diagram assumes the control power transformer (CPT) and capacitor controller are installed on the same pole. The solid lines represent fixed connections whereas the dotted lines represent other possible connections which can have a significant impact on the magnitude of surges at the controller equipment.

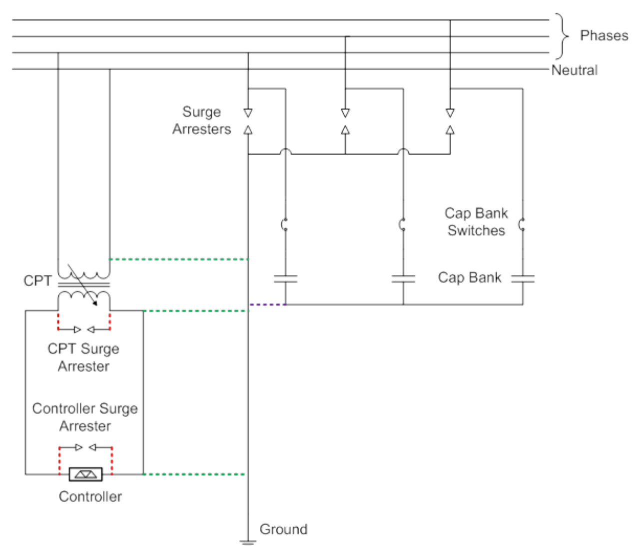


Figure 1: Connection diagram.

Arresters protect the power equipment from high voltages initiated by lightning surges but arrester practices differ within the industry. In order to study various combinations of arrester placement, the following cases were studied and analyzed in this project.

1. No arrester.
2. Arrester at transformer (CPT) secondary only.
3. Arrester at controller terminals only.
4. Arrester at transformer (CPT) secondary and controller terminals.

Continued on next page

P14 - Surge Protection of Electronically-Controlled Devices Installed in Distribution Systems

Continued from previous page

The Alternate Transient Program (ATP) was used to model and simulate the transient performance of the circuit. The lightning waveform displayed in Figure 2 was applied to one phase and the resultant voltages were measured at various locations along the pole. A lightning surge current raises the potential of all the nodes. Various factors such as lead length, transformer (CPT) grounding, stray capacitance, controller grounding, etc. determine the surge voltages at different nodes of the circuit.

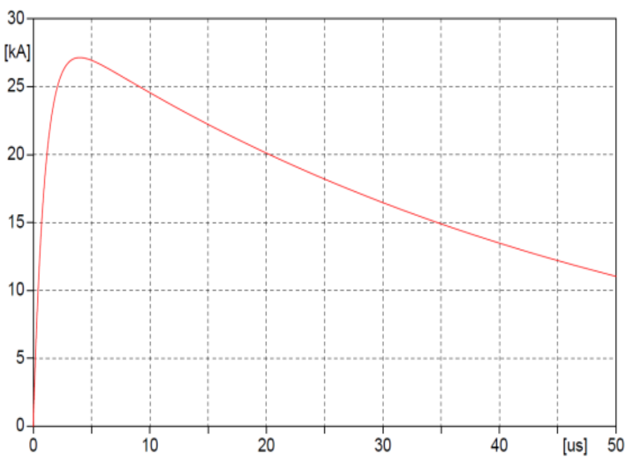


Figure 3: Lightning waveform from ATP Simulation.

Figure 3 displays the voltage across the controller terminals for a particular case when:

- One secondary terminal of the CPT secondary is connected to the ground lead.
- Arrester is connected across CPT secondary.
- One terminal of the controller is connected to the ground lead.

The voltage across the controller terminals is on the order of 70 kV peak which is sufficient to create a flashover or failure at the controller.

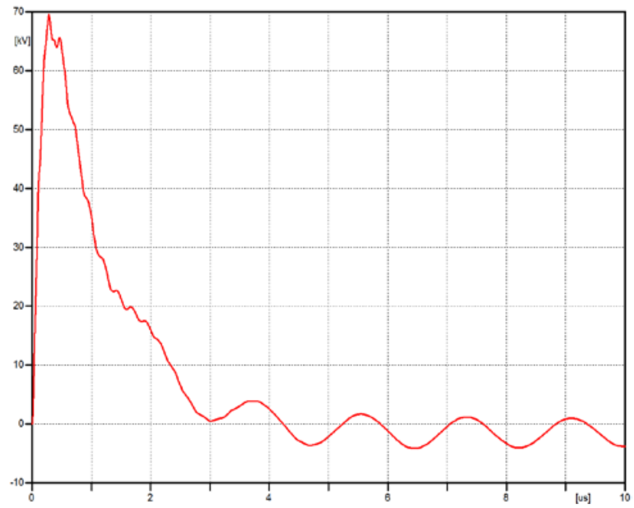


Figure 2. Voltage across controller terminals.

Current Status

Most of the simulations have been completed and additional data from a 1 kVA CPT needs to be obtained before completion of the investigation.

Once completed, guidelines for improved protection of electronic controls will be developed and presented in the final project report.

[1] Crudele, F. D.; Sutherland, P.E.; Short, T.A., "Lightning Protection of Distribution Capacitor Controllers," *IEEE PES Transmission and Distribution Conference and Exhibition*, vol., no., pp.459-464, May 2006.
[2] "Application Guide for the Automation of Distribution Feeder Capacitors," *EPRI Solutions Inc.*, Dec 2005.
[3] McDermott, T.E.; Short, T.A.; Anderson, J.G., "Lightning protection of distribution lines," *IEEE Transactions on Power Delivery*, vol.9, no.1, pp.138-152, Jan 1994.

John P. Skliutas – Senior Technical Advisor, DSTAR, GE

Suresh Gautam – Technical Advisor, DSTAR, GE

Current projects in program 14:

14-1 thru 14-3: Administrative Projects
14-4: Surge Protection of Electronically-Controlled Devices Installed in Distribution Systems
14-5: Cable Pulling Assistant Software Enhancement
14-6: Best Practices for Integration of Utility Communications
14-7: Survey of Best Practices for Copper Theft Deterrence
14-8: Motor Problems Resolution and Avoidance – Update CRN Publication

For additional information on our current projects, please visit: http://www.dstar.org/research/program/14

PROJECT SPOTLIGHT

Padmounted Transformer Tank Fault Withstand Capabilities

An objective of transformer fuse coordination is protection against violent failure of the transformer tank. While protection against high-impedance, low-current internal faults can be obtained from pressure relief devices, these devices offer no protection against the sudden application of pressure resulting from low-impedance, high-current faults. Unlike pole top transformers for which the standards provide a fault withstand test, based on cover retention, the present standards do not address the withstand capability of padmounted transformers to high- current internal faults.

DSTAR conducted research to determine the fault energy withstand capabilities of single-phase and three-phase padmounted transformers. In brief, the conclusions of this project were:

- The weak points of the padmounted transformers tested were accessory components, such as bushings and bayonet fuse holders, as well as covers on units with hand holes. Catastrophic failure of the tanks, such as gross weld splitting, was not observed in these tests for the fault duties applied.
- The failure threshold appears to be related to the ratio of fault energy to the air space volume above the oil in the transformer tank. A failure criterion of $40\ J/in^3$ has been identified by this research for padmounted transformers with flat tank walls and no radiator fins.
- Padmounted transformers with radiator fins appear to have substantially less fault energy withstand, due to stresses applied on the welds joining the fins to the tank. This is due to the relative stiffness of the fin against outward force compared to the tank wall.
- Fault energy is the product of the I^2t times an effective arc resistance, and the arc resistance is a nonlinear function of the arc current. For the 3" open arc used in this testing, a conservative estimate of arc resistance is:

$$R_{eff} = 0.5 \times \left(I_{crest(kA)}\right)^{-0.75}$$

Based on the above conclusions, definitive tank withstand guidelines have been created for padmount transformers without radiator fins. These guidelines are in the form of maximum current and time-current curves which can be used for overcurrent protective device coordination.

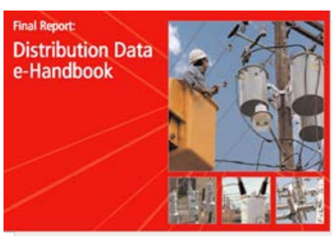
Featured White Paper Executive Summaries

1. Distributed Generation Impact
2. Ferroresonance Guidelines for Modern Transformer Application

www.DSTAR.org

Or upon request via Matt.Lecar@ge.com or T 415.391.7996 x3011

DSTAR e-HANDBOOK



Features include:

- **Hyperlinked navigation**
- **Simple calculation sheets**
- **Strong search capability**
- **Portable PDF format**
- **Nominal R&D investment per utility**

FOR MORE INFORMATION

Please visit our web site at
www.DSTAR.org

Contact

Lavelle Freeman, Program Manager
lavelle.freeman@ge.com
T 518.385.3335

Jim Weiss, DSTAR Chairman
Ameren
jweiss@ameren.com
T 314.554.3319

Emerging Trends

Revenue Protection Analytics Using AMI Data – Benchmarking Best Practices

A new project proposal that's currently under review by DSTAR concerns the value of AMI data in improving utility revenue protection practices. One of the promised benefits of Advanced Metering Infrastructure (AMI) deployment is the ability to detect and deter many traditional forms of meter tampering and electricity theft that have long plagued electro-mechanical meter use in the utility industry, improving revenue protection and recovery for the utility. From a physical standpoint, modern digital meters are less prone to mechanical trickery, such as the introduction of foreign material "under the glass" to slow the movement of gears and interfere with accurate metrology. However, the increased use of digital electronics may open the door to new modes of theft – such as "denial of service" attacks on the AMI communications or disruption of digital metrology (for example, there are anecdotal reports of meter hacks involving powerful permanent magnets placed around the meter).

A significant opportunity afforded by the AMI is the collection and archiving of large volumes of interval data, which allows for software-based analytics – either directly within the utility's enterprise systems or over web-based "cloud" services – to look for suspicious or abnormal patterns in the data that may be associated with meter tampering and electricity theft. These patterns could include, for example, sudden or intermittent deviations from historical usage for a given customer, or unexplained correlations within the non-technical losses, as measured by the delta between a substation meter and the aggregate metered load of customer end-points on a given distribution circuit. Through "last gasp" notification of meter-level outages, some AMI systems are able to document momentary interruptions of service that may in some cases be associated with diversions including specific meter or meter panel bypass theft modes.

Taken together, these features lead us to believe that AMI can make a significant contribution to improving utility revenue protection. The objective of this proposal is to quantify how strong this contribution can be and to understand the impact on the overall AMI business case, attributable to improved theft prevention, fraud detection and revenue recovery.

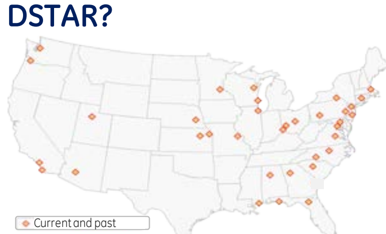
Matt Lecar
Operations Lead,
DSTAR, GE

WHAT IS DSTAR?

Distribution Systems Testing, Application, and Research (DSTAR) is a consortium of electric utilities, facilitated by General Electric International, Inc.'s Energy Consulting Department, sharing the results of distribution research. During its 25+ years of existence, DSTAR has focused on providing its member utilities with results that are directly applicable to everyday distribution design, operation, and maintenance.

DSTAR offers utilities a cost-effective and responsive means of addressing urgent problems that require near-term solutions. By cooperatively funding research with other utilities, each member utility substantially leverages its investment.

WHO IS DSTAR?



Ameren
American Public Power Association/DEED
Duke Energy
National Rural Electric Cooperative Association/CRN
Pacificorp
South Carolina Electric & Gas
Southern Company
We Energies
Wisconsin Public Service