White Paper

Improving Relay Settings Development Through Conventional and Intelligent Templates

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The North American Electric Reliability Corporation (NERC) State of Reliability Report in 2019 estimates that 30% of misoperations are due to incorrect settings, incorrect logic, or physical design errors. *Standardized templates* are an increasingly common approach being adopted by utilities to help reduce these errors in the relay settings development process. In this white paper, we outline template standardization, describe how it improves the process, and show remaining sources for errors when employing these conventional templates. Finally, we present *intelligent templates* and explain how they enable a more automated process that will further decrease human error, create an efficient peer review process, and ultimately, produce high quality settings. These improvements are possible because templates remove tedious, manual data-handling and also provide a well-defined framework for the process, freeing protection engineers to concentrate their efforts on the engineering activities that are the essence of relay settings development.

Standardized Templates

Many companies today do not have a standardized calculation sheet for relay settings. This lack of uniformity causes engineers to create their own ad-hoc templates, which rarely encompass the utility's entire philosophy. Consequently, every engineer interprets the philosophy differently, resulting in many conflicting variants created for the same project. These inconsistencies decrease the quality of the settings by causing confusion and uncertainty.

A common solution that companies have adopted to address these inconsistencies is a *standardized template* in the form of an Excel sheet, Mathcad file, or another similar tool. With standard templates, an experienced engineer can capture the entire set of calculations for the philosophy, leaving no room for misinterpretations. An example of an Excel standardized template is shown in Figure 1. Some of the advantages are as follows: (a) the process for calculating settings is systematized across the utility, (b) the templates will store variables and fault information used in the calculations, and (c) the templates provide a record of the setting creation activity which helps demonstrate compliance with NERC standards.

As shown in the sample sheet in Figure 1, the user inputs numbers from the short circuit software after manually simulating faults in the power system model. After inputting the required numbers, the Excel sheet or MathCad file will then calculate common settings such as positive sequence line impedance magnitude (Z1MAG). While the input data used in the calculations is now clearly documented, the manual transfer of this data by the engineer is a potential source of many errors. While the engineer repeatedly

Relay Setting Calculation Sheet

Relay Location:	0 ASH N	**Generated by Synchrogrid, LLC** 1101 University Drive East, Suite A-108 College Station, TX 77840 **Phone:** (713) 471-3429 **Email:** jperez@synchrogrid.com **Web:** www.synchrogrid.com	Date:	8/14/2019
Remote Location:	0 SYRATANK		By:	SG
Line Number:	28		Checked By:	JP
			Calc Sheet Version:	2/15/2019

GENERAL SYSTEM INFORMATION	
Nominal System Voltage (kV)	115
Base Ohms	12
CTR (/5)	10
PTR (/1)	50
Number of Second Lines	7
Number of Taps	8
Number of Distribution XFMRs	4
Number of Auto XFMRs	4

TRANSMISSION RELAY LOADABILITY	
- R1.1: Highest Seasonal Facility Rating (A)	**3.45**
PRC023 Margin (%)	151%
Loadability Limit	5
- R1.13: Line Equipment Limit (A)	**501**
PRC023 Margin (%)	115%
Loadability Limit	576
- Line Limit (A)	3
- Loadability Limit (A)	5

LINE IMPEDANCES			
- Primary Line		**- Second Line #1** **Name:**	
Positive Sequence Resistance (PU)	0.07106	Positive Sequence Resistance (PU)	0.2321
Positive Sequence Reactance (PU)	62.96621	Positive Sequence Reactance (PU)	45.56284
Zero Sequence Resistance (PU)	0.23278	Zero Sequence Resistance (PU)	0.32148
Zero Sequence Reactance (PU)	72.98956	Zero Sequence Reactance (PU)	59.2184
Line Length (miles)	0	Line Length (miles)	0

Figure 1: Standardized Template

refers to the short circuit program for information and then returns to the template to copy and paste, the likelihood of incorrect data transfer is high, especially with the frequent interruptions common in the workplace. Additionally, the number of calculations (e.g., impedances of multi-segment lines) and fault simulations called for by the philosophy may be overly burdensome to complete by hand. The result is a process in which challenges to reliability remain, and there are still potential misoperations due to avoidable errors and inaccuracies. These challenges are shown in Figure 2.

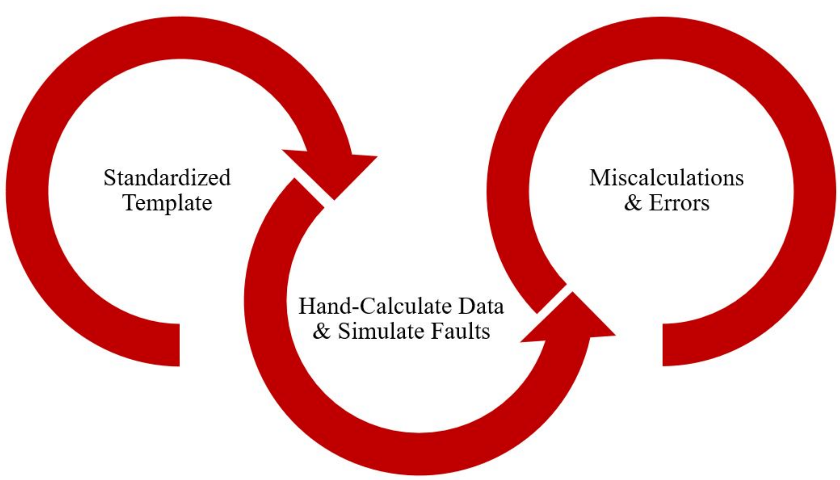

Figure 2: Remaining Challenges with Standardized Templates

To address these remaining challenges, many companies enforce a peer review process in an effort to catch setting calculation errors. Through this process, the settings engineer will send the finished, calculated template to another engineer who will then calculate all the settings a second time. This tedious process minimizes calculation errors but exhausts resources. In summary, while the adoption of *standardized templates* has improved the reliability significantly compared to having no uniform template at all, there are still some flaws inherent to this process.

Intelligent Templates

Given recent advancements in software automation technology, there is now a way to automate the process for calculating relay settings and easily comply with NERC PRC-027 Requirement 1 without the need for an Excel or Mathcad file. SARA (Setting Automation Relay Assistant) is an innovative application that uses an *intelligent settings template* for transmission line protection. By defining a set of equations and constructing fault study specifications, the engineer can create a settings template that fully represents the intent of the protection philosophy. Furthermore, the template can then be used in any line settings application. SARA will bidirectionally communicate with the short circuit program to automatically populate data the engineer previously had to manually gather and then copy and paste into standardized templates. All fault information and system characteristics (e.g., impedances) are computed automatically by algorithms customized to rapidly inspect the power system model.

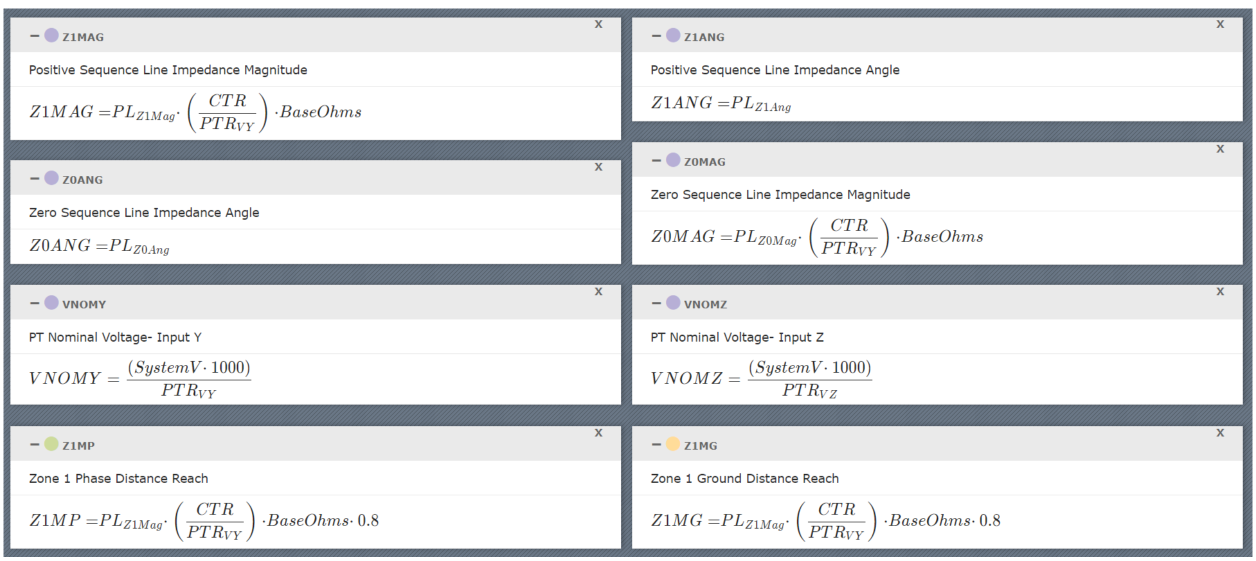

Figure 3: Portion of a SARA Intelligent Template

After the data is gathered, SARA displays the fault analysis and settings equations in a visually appealing layout (shown in Figure 3). After review, the new settings can be transferred automatically to the relay configuration file (e.g., RDB), avoiding another manual transfer of settings data. With this automation, the philosophy is uniformly applied to all line settings projects in the transmission system. This new automated process further reduces human error caused by the manual transfer of data from short circuit programs to spreadsheets and then to the target RDB, which is something conventional templates fail to do.

SARA also systematizes the peer-review process, allowing the reviewing engineer to fully visualize the exact setting equations and values together with fault computations. This new workflow reduces time spent revising data, allowing the engineer to keep better track of the process. Additionally, the engineer can evaluate any settings without having to apply all faults and equations a second time as was done while using a standardized template. Once all the data is confirmed and processed, the engineer can then simply convert it to an RDB file and/or export it to a report document. This process is summarized in Figure 4. With this automated process and template application, the efficiency of calculating settings increases as does the reliability of the data.

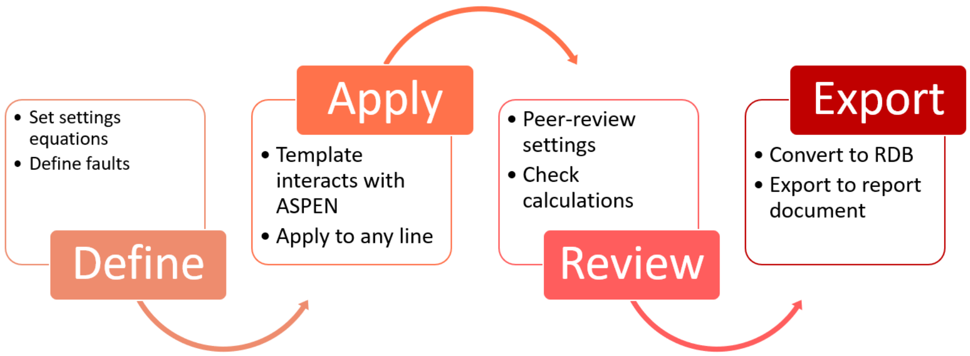

Figure 4: Steps to an Automated Process

Due to the various ways of calculating relay settings, there are many different types of settings templates and philosophies. When compared to existing methods that use spreadsheets or Mathcad programs, SARA provides a more advanced method for calculating settings and fulfilling NERC's PRC-027 Requirement 1. It also provides an automated way to uniformly standardize relay setting templates, eliminate errors from the manual data transfer, and perform complex calculations to define better settings. Furthermore, peer review processes and coordination studies can be completed in a fraction of the previous time required when using conventional templates. With this automated process and an intelligent settings template, the engineer can enjoy a simpler and more reliable system for calculating relay settings.

Why SynchroGrid

SynchroGrid offers innovative ways to calculate relay settings that enhance the quality and reliability of protection networks. By providing intelligent templates, SARA is able to bidirectionally communicate with short circuit programs, automate the calculations of settings, and export relay RDB files and reports, enabling engineers to produce sensitivity analyses and perform peer reviews in a fraction of the previous time. SARA not only dramatically improves the settings development process but also helps utilities maintain compliance with NERC standards.

References

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