Meeting minutes of the IEEE PES 'Lightning Performance of Overhead Lines' Working Group

Tuesday, July 29, 2014
8:12 AM
Chair: Emanuel Petrache
Vice-Chair: Jens Schoene

The IEEE PES Working Group 'Lightning Performance of Overhead Lines met in a single session at the IEEE PES General meeting in Washington, D.C. on Tuesday, July 29, 2014 with 18 participants. Working group chair Emanuel Petrache opened the session at 8:10am. All attendees briefly introduce themselves and Emanuel introduces the working group members with presentations scheduled for this session. The presenters are Tom Short with EPRI, Jonathan Woodworth with ArresterWorks, and Tom McDermott with the University of Pittsburgh.

Tom Short's presentation is on the IEEE Flash and OpenETran software application tools. Some characteristics features and facts of the two programs that Tom highlighted in his presentation are listed below:

- IEEE Flash doesn't handle arresters (not a transient program).
- OpenETran is a transient program. Does not have electrogeometric model (i.e., which conductor stroke terminates on)
- Tom McDermott updated OpenETran
- Tom Short created web interface
- OpenETran
    - can model arresters.
    - can model insulators and flashovers.
    - can model unequal tower spacing.
    - is a simple program, cannot handle three conductor - four conductor transitions
    - has the advantage of speed.
    - is easy to learn.
    - is tailored to lightning analysis. E.g., build-in model for grounding resistance, insulator model.
    - does not have model for coronal coupling (corona increases voltages, decreases flashover threshold). Tom McDermott looked at it. Presumably too difficult to implement.
- The footing resistances is usually the most uncertain parameter when modeling scenarios in OpenETran.
- IEEE Flash can model corona coupling, but uses a relatively simple model.
- Unsure if the corona model is time dependent? If not, run case to know peak voltages and re-run it with corona implemented in the coupling matrix. Later during the session, Tom McDermott explains that corona is modeled in a two-stage calculation.

Jonathan Woodworth's presentation is on an Excel spreadsheet interface for the OpenETran program. Jonathan's interface is essentially a front end on top of the OpenETran interface.
The interface is targeted for users that do not have a background in lightning. Can answer questions, such as how many arresters does line need and where to place them by employing pre-build line configurations. Currently only works for vertical construction. The idea is to create a number (maybe 12) of pre-build line configurations and the user picks the one that is closest to the configuration of interest

Jonathan demonstrate the interface during his presentation the key features are summarized below:

- Excel spreadsheet for model input parameters
- Excel spreadsheet hat four areas
    - Area A: Program/File locations, plot
    - Area B: Line information, simulation parameters (time step, stop time)
    - Area C: Tower configuration
    - Area D: Surge location and characteristics, Equipment on line (insulators, arresters, ground, meter)
- Significance of Beta input parameter
    - Beta large => tower surge impedance would determine flashover threshold
    - Beta small => footing resistance determines flashover threshold
- No build-in counterpoise model

A question that came up during Jonathan's presentation was, for a three wire system with no neutral, where to connect ground? No paired conductors to connect ground to. Later in the session, Tom McDermott answers this question (see below).

During Jonathan's presentation, Luis Marti (HydroOne) pointed out that his company used a different program. This program creates cost vs. performance graphs. At what point does more money does not buy me a significant performance increase (curve flattens)? It automatically choses best configuration (arresters on bottom phase of each pole, arresters on each phase every third pole, etc.) and is sufficient for planning engineers.
Bill Chisholm notes that OpenETran gets one level deeper and tells you why a particular performance is best. Also, the consequences of flashover in distribution systems are more complex compared to transmission, where the outcome of the simulation is only 'flashover' or 'no flashover'. Luis Marti's presentation that shows simulation results of their optimization program is attached to these minutes.

After the discussion, Jonathan continues his presentation by giving an example for the use of this OpenETran interface."

- The example shows arrester currents, insulator voltage, ground currents, margin to flashover (0%=>flashover)
- No arrester => flashover on middle phase
- Put arrester on middle phase => no flashover
- Increase current to 100 kA => flashover on bottom phase on every tower
- Gives you charge on arrester.
- Meaning of critical current somewhat hazy.
- No electrogeometric data.

After Jonathan's presentation, Tom Short shows the interface of OpenETran and notes the following points:

- Incorporated simplified electrogeometric model
- Electrogeometric model not rigorously checked. Percent flashover should be fine, but flashover densities needs checking.
- Tom McDermott has more complex electrogeometric model.
- Input Tables: Case, Parameters, Conductors, Insulators, Arresters, Grounds, Meters, Advanced
- Cases from IEEE 1410
- Critical current is main output, which translates to flashover probability.
- Effect of inductance in grounding? Increase inductance => critical current increases
- Does double impulse using advanced feature (text input) => can do first/subsequent stroke

- Other apps that use OpenETran
    - Lightning protection and underground cable: Can use open-point arrester and scout arrester
    - Traveling waves

Tom Short notes that OpenETran cannot easily differentiate between first and subsequent strokes. The analyst can do two runs with different waveform characteristics to account for both first and subsequent strokes. Jonathan is not sure if this indeed the case noting that there is a build-in two stroke feature. After looking into this, they found that OpenETran can do first-subsequent stroke sequences using the advanced double impulse feature, but this requires text input.

Tom McDermott's presentation is about the electrogeometric model that IEEE Flash has implemented. Additional details on this model can be found at www.meltran.com/egm/
The model uses some simplifying assumptions such as assuming that the channel geometry is vertical. The model output is a semicircle around each phase wire plus horizontal line representing ground. Shield wire and ground line green, phase wires red, if red wire sticking out => line can get struck. If red wire sticks out, change/add shield wires or add arresters to phases that stick out.
Tom McDermott notes the following aspects:

- Ground slope can be modeled.
- Can add house, house can bring strike closer to the line => induced effects, which can be an issue for distribution lines.
- Fast browser necessary, Chrome, Firefox, IE10; IE9 too slow (http://html5test.com/)
- How to get probabilities of line being hit? Can be derived from exposed area, ground flash density using simple formulas
- Log normal good distribution to use for footing resistance
- Corona model? Changes surge impedance. Two-stage calculation. Non-linear.
- Changing footing inductance as analog to changing tower inductance.
- Counterpoise can be simulated by changing inductance.
- Tom McDermott addresses the question raised earlier by Jonathan regarding a line w/o grounded wire (no neutral, no ground wire)
    - Phase to phase insulators
    - no place for arresters
    - Cannot model ground resistance on arresters connect phase to zero (1 to 0, 2 to 0, 3 to 0; i.e., put a ground where the arrester is)
    - Don't need ground as ground resistance is not important
    - If desirable, ground resistance could be "faked" by lead impedance of arresters
    - Two adjacent towers, one with large ground impedance, another with low ground impedance. Strike at large-resistance tower elevates potential, no current into ground; Potential difference relative to low-resistance tower, important to have phase-to-phase insulators
- OpenETran is in C
- Can be commercialized (just have to put the source)

The remaining discussion and informative items are listed below:

- EPRI did study to compare results with LDN with their calculations and got very good correlation. Luis did similar study and found poor correlation. Differences due to cloud-to-ground and cloud-to-cloud identification?
- IEEE 1410, no action required
- IEEE 1243
    - Status not known

- John McDaniel may have taken out part
- Needs updated/additions (e.g., add comprehensive section on line arresters)
- Separate meeting required to discuss updates

The meeting was sojourned at 12:00pm.