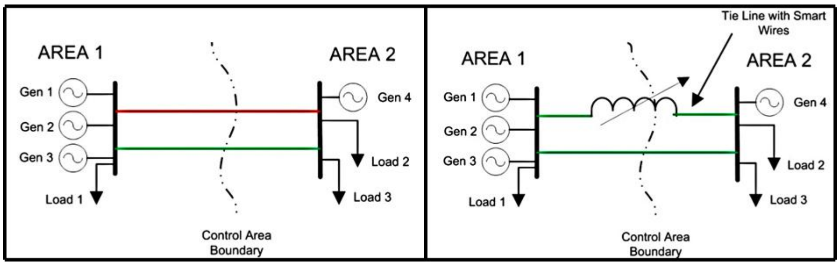
Smart Control of Power Lines – Converting Overhead Lines to Smart Wires

Recent technological advances create new, cost effective methods for dynamic power flow control on transmission and distribution systems. The PowerLine Guardians ("PLG") are devices mounted directly on the conductors themselves. The PLGs draw the power they require to operate directly from the conductor, and are capable of injecting approximately 50µH of inductance on command. PLGs are installed in series along the length of a line and may be switched on sequentially to provide the required level of impedance at any time.

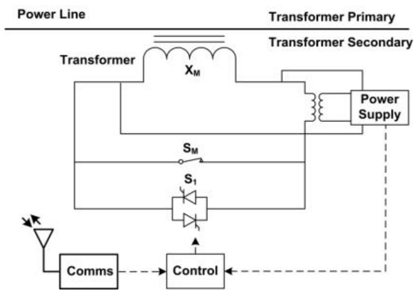
The PowerLine Guardian (formerly named Distributed Series Reactor) was developed at Georgia Tech in the US and is being marketed by Smart Wire Grid, Inc., a US corporation based in Oakland, California.

The following simple example demonstrates the use of PLGs. In the diagram, power flows from Area 1 to Area 2 through two lines. The upper line has lower impedance, and thus becomes overloaded as power seeks to flow through that line in preference to the other (left part of the diagram). By installing PLGs on the upper line, impedance can be increased, balancing out power flows on the two lines (right part of the diagram) thus utilizing the total available transmission capacity.



The PLG system is comprised of two components. A hardware component, the PLG device itself, which can change impedance on the overhead line, and a software component, which monitors the fleet of installed PLGs and is capable of controlling them remotely to control power flows.

The PLG is a transformer that uses the conductor as its primary turn. It is controlled by a switch which, when opened, allows magnetic inductance to be injected into the conductor. PLGs can be programmed to begin injecting at a pre-determined level of current or conductor temperature, or be controlled remotely which can not only allow more repaid changes in line impedance when required, but also allow more sophisticated control over the installed fleet of devices on the network as well as real time line monitoring.



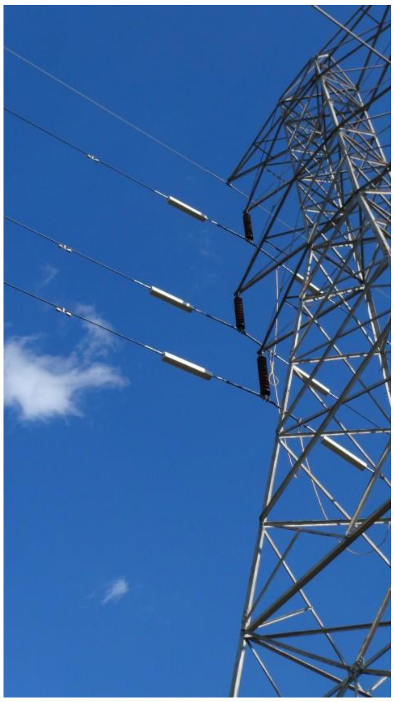
The diagram below shows the PLG communications system. PLGs (in blue) control the power flows on the lines. Super PLGs (in red) also control power flows, as well as controlling the PLGs, with each Super PLG controlling around ten PLGs. Super PLGs also have backhaul communications capabilities that allow them to communicate with the System Manager, normally located in the Energy Management Center and basically a server rack in the utility's computer system.

Advanced forms of the Flow Director are under development and will integrate with the EMS allowing automatic control of PLGs from the EMS. Communications can be configured to suit the requirements of the utility client.

In addition to controlling PLGs, the communications capabilities allow PLGs to provide real time data on the lines including: line current, conductor temperature, frequency, sag and blowout angles, PLG status and PLG set point. Fault indication provides information of where a fault occurred (between which two PLGs). Other optional capabilities include conductor vibration and geomagnetic induced current detection.

The PLG system offers a viable, cost effective solution for a number of applications, including:

- Reliability of the grid - during N-0, N-1 and N-2 conditions and under other regulatory loading requirements
- Congestion/Uplift – improving the economic dispatch generation driven by grid constraints and improving the integration of variable dispatch renewable energy
- Increase Available Transmission Capacity (ATC) on the grid
- Remedial Action Scheme/Special Protection Scheme (RAS/SPS) simplification – reducing the number of steps or tripping/mitigation required to meet N-1 and N-2 conditions
- Phase balancing – rebalancing the impedance of the conductors on un-transposed transmission lines
- Maintenance Support and construction schedule support – reduces the potential for overload on adjacent facilities during maintenance and construction
- Circular/inadvertent/unscheduled flow mitigation
- Grid optimisation – optimisation of dispatch of transmission as well as generation



Installation of PLGs is a straightforward process and crews installing PLGs for the first time have achieved installation times of seven minutes per unit. Installation of PLGs takes considerably less time than alternatives, such as the reconductoring of a line, and at a lower cost. Energized installation is under development and is expected to be available later this year.

PLGs have been installed by leading utilities in USA. They are operating successfully on overhead lines at 161kV and at 115kV in Tennessee and in Atlanta since October 2012 and March 2013, respectively (see Photos above). Deployment of a further overhead line upgrade is scheduled for April 2014.

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