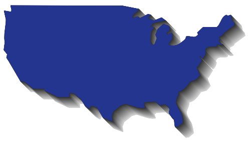
Unified power flow control at AEP

Utility
American Electric Power



UNITED STATES

Transparent FACTORY™ Open for Business

The existing installation

As one of the largest investor-owned utilities in the U.S., American Electric Power, a global energy company, provides energy to three million customers in Indiana, Kentucky, Michigan, Ohio, Tennessee, Virginia and West Virginia. AEP operates 37 coal and hydro plants and one nuclear plant with a total capacity of over 23.8 million kilowatts. The AEP transmission system consists of 22,000 miles of high-voltage lines, including 2,022 miles of 765 kV lines. A utility covering such an extensive territory faces numerous challenges,

UPFC series transformer

especially the control of real-time power flow through the entire grid. AEP in conjunction with Westinghouse developed a Wide Area Network (WAN) Unified Power Flow Control System (UPFC) to maximize utilization of the existing power lines and defer new line construction. The system includes the automation of seven substations using Modicon® PLCs and Ethernet-MMS communications protocol between the substations and AEP's Area Dispatch Center.

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The objective

AEP established clear objectives for the development of the new UPFC system:

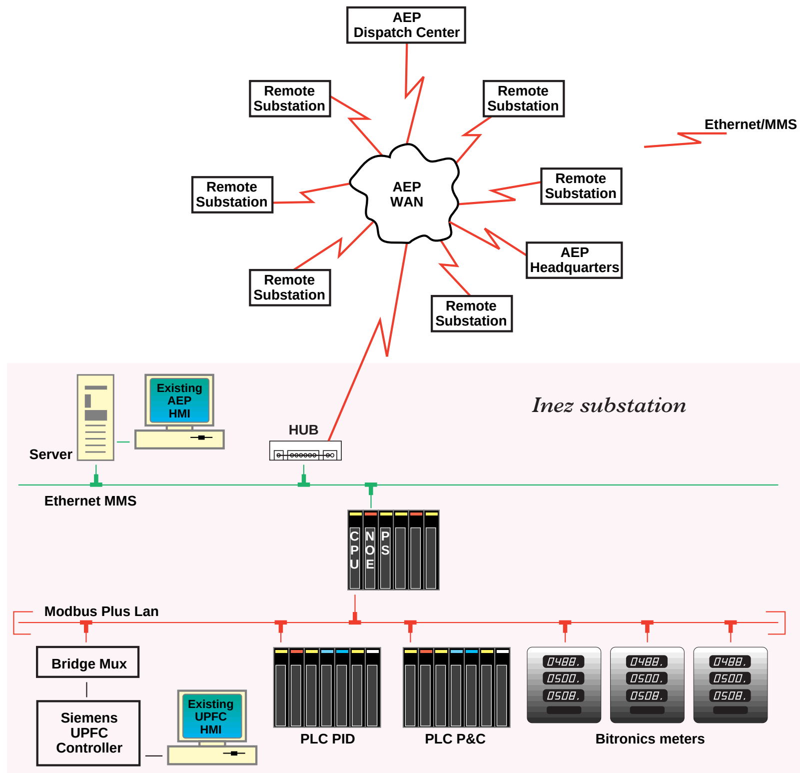
1. A solution based on a hardware platform with off-the-shelf components, easy to integrate and widely supported.
2. A solution providing user friendly software configuration tools.
3. An OPEN communications solution using Ehternet-MMS communications protocol between substation, and substations to areas dispatch center.
4. High speed control network strategy within the substations.
5. Ease of integration of third party devices.

The solution

AEP's original intent was to develop a PC based solution with "C" programs to perform the appropriate control algorithms. After some investigation, however, AEP determined that a PC-based solution would be a challenge to develop, implement, support, and ultimately, very costly. The alternate solution was to utilize PLC-based technology, allowing the development of the application using off-the-shelf hardware modules and software tools. Modicon TSX Quantum PLCs were chosen up front because the Quantum family offers the most extensive list of 125 VDC, utility-hardened modules, Quantum-supported Ethernet-MMS; and, Modicon Concept™ configuration software provides the most extensive list of software editors to program the PLCs.

The complete system includes seven regional substations and one Area Dispatch Center (AEP's headquarter). All nodes of the system communicate via Ethernet-MMS WAN. All substations have the same LAN configuration and architecture except for INEZ substation, which has, in addition to the local LAN, the UPFC controller and associated MMI.

The dual LAN architecture was developed by AEP in conjunction with EPRI. The Modbus Plus LAN was selected for high-speed deterministic control of the circuit breakers within the substations, and also executes the commands generated by the UPFC controller. The Ethernet-MMS was developed in the context of an EPRI initiative to demonstrate the powerful capabilities of MMS as a communications environment for utility applications.



The UPFC application is a state-of-the-art application in the utility industry. The system was developed to regulate 138KV-bus voltage and six-shunt capacitors located at INEZ substation in Kentucky, and three of the other seven substations. For the first time, both real and reactive power can be accurately set and independently controlled by the UPFC. The system can shed load and/or boost system voltage if needed using the PLCs and Bitronics meters located in seven substations in three different states. INEZ acts as the master station in the UPFC scheme for the all other six others. The remote stations monitor the power and capacitor status and execute commands as determined by the UPFC master.

AEP acted as systems integrator in this project. The overall design of the substation architecture and development of the applications using off-the-shelf PLC and software allowed AEP engineering staff to share the systems configuration tasks, hence optimizing time and money. One engineer was involved in the structured text math portion, one configured the HMI screens, and another wrote the station control algorithms using ladder logic, allowing them to make a tight commissioning time line.

Customer benefits

The development of the UPFC using a PLC-based system in conjunction with MMS/ICCP protocol resulted in the following benefits for AEP:

- Optimal utilization of existing power lines.
- Deferal of new line construction.
- Capital and maintenance cost reduction.
- System responds to deregulated Export/Import/Wheeling of power.
- Development of a base system within the substation with a clear migration path to further enhance functionalities and future applications.
- Off-the-shelf, globally-supported components with low maintenance cost.

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