

# Volt-VAr management solutions For smart grid distribution automation applications

# Volt-VAR management solutions

## Increased efficiency through optimization

Today, utilities experience unprecedented power delivery challenges. An aging grid infrastructure coupled with satisfying increasing consumer demand, meeting stringent regulations, avoiding peak-time cost penalties, and integrating alternative energy sources into the grid are all factors utilities must consider to improve power delivery and reliability.

To ensure the grid is optimized, grid intelligence is required from more data collection points from feeder locations beyond the substation. Advanced software, smart IEDs, high accuracy sensors and instrument transformers, along with communications infrastructure are critical technologies that provide comprehensive visibility of distribution load and voltage conditions enabling intelligent decision making to optimize the grid. Utilities benefit from increased reliability and efficiency by decreasing energy costs, protecting revenue, avoiding costly regulatory penalties, and boosting customer satisfaction.

Voltage and VAR Optimization (VVO) is a key smart grid application. VVO refers to the optimization of reactive power and

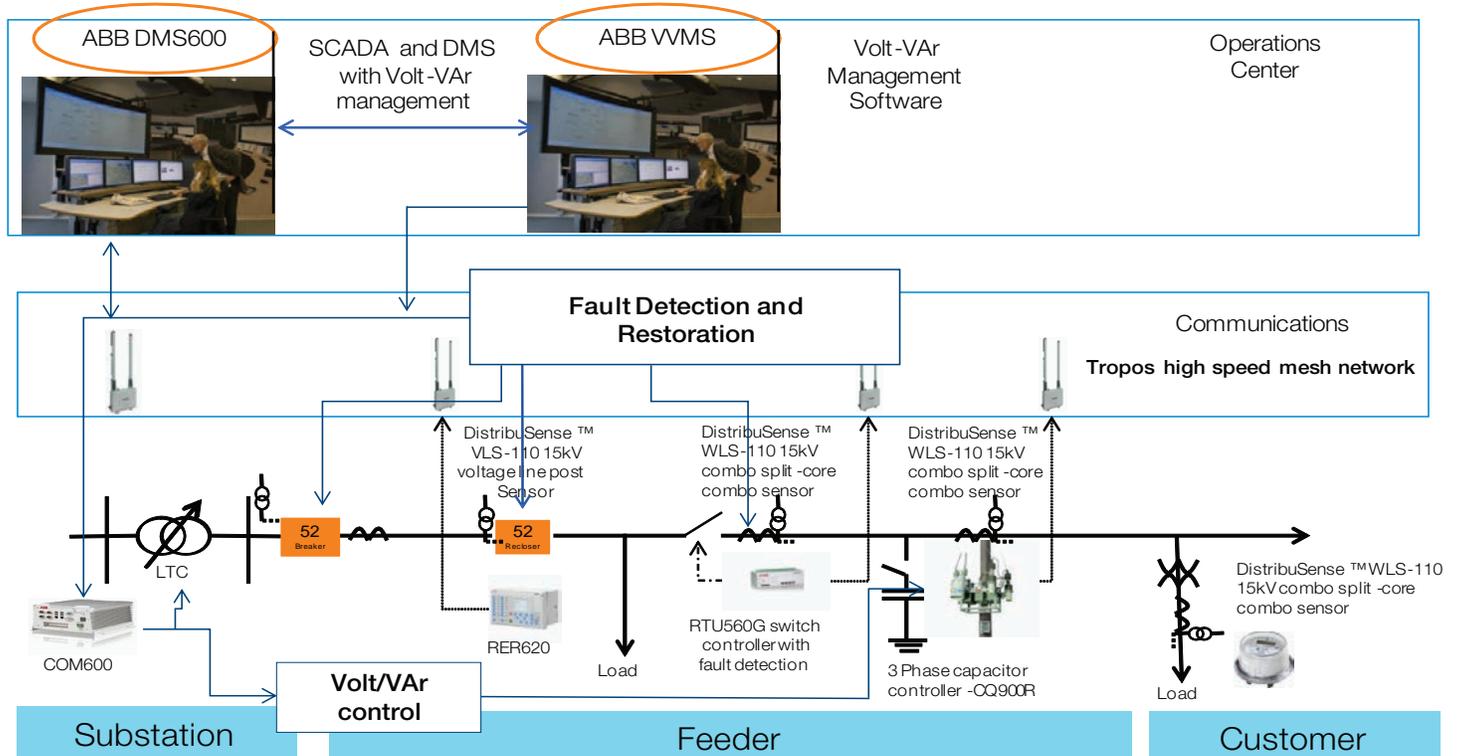
voltage regulation resources on the distribution system for the purpose of power factor correction, voltage correction, conservation voltage reduction, or loss reduction.

Optimized VAR flow improves power factor and can result in substantial savings in cost of energy and infrastructure utilization. Optimized voltage improves power quality by preventing over-under voltage conditions and achieving a flatter voltage profile along circuits. Conservation voltage reduction (CVR) is an advanced strategy that reduces real power demand by lowering customer voltages within approved limits.

### Savings

Savings in excess of \$4-\$6 million annually have been reported by medium to large utilities managing 2000-3000 switched capacitors. Improved power factor reduces the cost of energy needed to produce a given customer revenue and releases infrastructure capacity making it possible to defer or to better control substation and feeder construction projects.

ABB offers two Volt-VAR management systems: Volt-VAR Management Software (VVMS) and DMS600 Volt-VAR Control (VVC)



Volt-VAR solution architecture

# Volt-VAr Management Software (VVMS)

## Utility grade software for smart grid distribution automation

### Centralized distribution automation software

VVMS optimizes circuit VAR flow and circuit voltages. It is mature, utility-grade, automation software that is proven in 24x7 use by major utilities across the U.S. It leverages over 15 years of capacitor control experience provided by Radio Control Central Stations (RCCS). This solution is scalable and appropriate for both small and very large utilities. VVMS is a system of closed-loop voltage and VAR control. It continually samples loads and voltages along feeder circuits and when appropriate switches compensating devices; such as capacitors, regulators and LTC's, to improve power factor, improve power quality and reduce demand via automated conservation voltage reduction.

VVMS can operate as a "stand-alone" Volt-VAr control solution or it can be functionally integrated with a SCADA or DMS system. VVMS is interoperable with many models of SCADA, DMS, control hardware, and communications infrastructures. This approach offers three unique benefits for utility customers:

- Freedom to use the most appropriate hardware and communications products
- Short lead time to deployment
- Protection of investments in capitalized infrastructure

A key feature of VVMS is its comprehensive web based GUI. Using the GUI, authorized users can view the system's well organized, real time Volt-VAr application displays and reports. Engineers and crews can view status of substation, feeders, capacitors and voltage devices, set control constraints, and

operate switches manually. Capacitor switch states, loads, voltages, and circuit "VAR Loss Performance" statistics are conveniently at their fingertips.

### Deployment speed

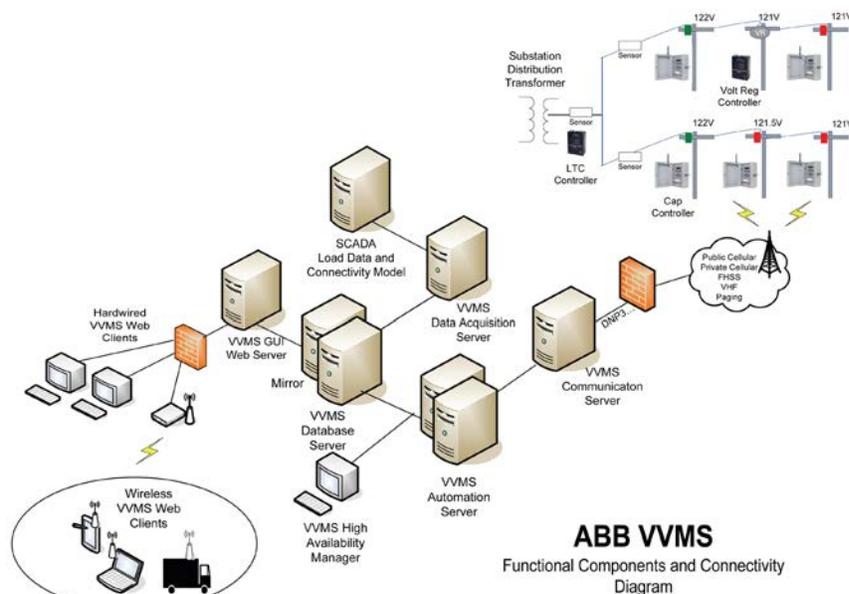
VVMS can begin delivering savings right away. Depending on your distribution automation and communication choices, VVMS can be operational in as little as a month. We work with your technology staff (IT, SCADA, and communications) and with a cap controller vendor that you select to configure VVMS compatibly within your organization's distribution automation plan.

VVMS acquires load, voltage and connectivity data from SCADA, Pi Historian, two-way DNP3 devices as well as from AMI metering, GIS/OMS and other relevant resources. We work with your team to determine the optimal integration.

Utility crews have found VVMS contributes to rapid deployments. Cap crews at CenterPoint Energy, Houston, for example, recently installed 5000 capacitor controllers at the remarkable rate of 30 caps per day. This rate was accomplished inclusive of inspecting and rehabbing existing capacitor assets and installing new capacitor banks.

### Hardware interoperability

VVMS automation may be used with cap controllers and voltage control hardware (LTC's and VR's) from all major hardware suppliers.



# Volt-VAR Management Software (VVMS)

## Features and benefits

### Communications alternatives

ABB's VVMS interoperates with many types of networking technologies for two-way or one-way monitoring and controlling of capacitors, transformer LTCs and voltage regulators. Utilities may choose to concurrently utilize any combination of these technologies for accessibility to remote equipment in all locations.

### Web ready

VVMS facilities are conveniently accessible to authorized viewers from anywhere using an internet browser. Our web client provides comprehensive design and operating capabilities with easy to follow real-time graphic display of stations, feeders, LTC and cap conditions (see figures 1-3). It incorporates our intuitively powerful "Reactive Report Generator" that sorts historic and real time information to your specifications and delivers it on-line or downloaded to your own computer.

### Operation with paging and VHF radio systems

VVMS uses SNPP protocol to communicate directly with paging servers and commercial paging services equipped to send Flex or other pager protocols. VVMS has considerable experience with VHF radio systems. We consult your radio shop to understand your FCC license provisions, transmitter configuration and assess their suitability for use with VVMS.

By supporting both legacy one-way technologies and newer two-way capabilities simultaneously, the ABB VVMS enables utilities to migrate to the new technologies at their own pace while managing only one Volt-VAR system.

### Connectivity model management

The "asset update" can automatically build and maintain your VVMS application database from your utility's equipment records (Asset Management System) and then automatically adjust to connectivity reconfigurations from your GIS/OMS data source.

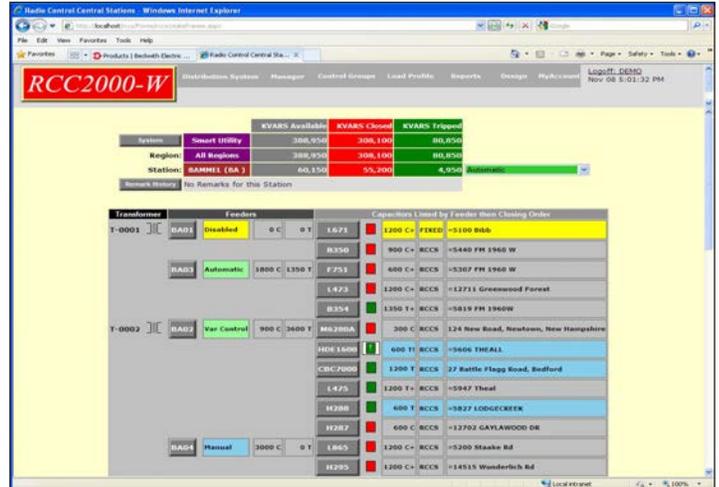


Figure 1 VVMS substation screen depicting LTC, feeder and capacitor association

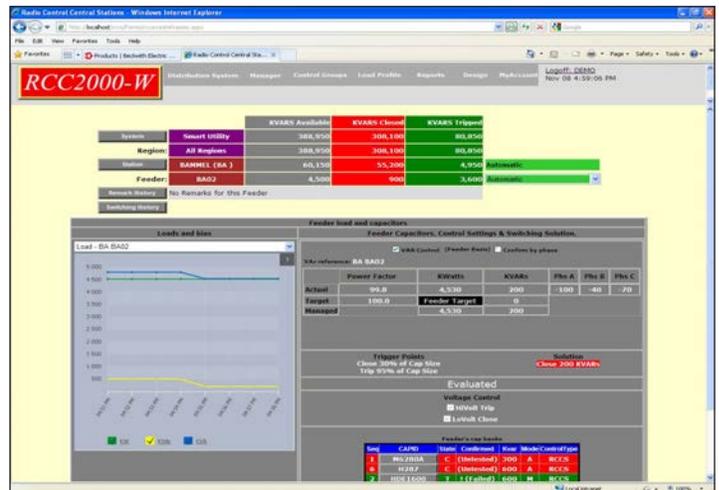


Figure 2 VVMS feeder screen showing target vs. actual power factor



Figure 3 VVMS capacitor screen



# DMS600 Volt-VAr control (VVC) system SCADA strength distribution automation

DMS600 is a distribution management system (DMS), extending traditional SCADA capabilities with geographically based network views and advanced distribution management. DMS600 integrates static information stored in the network database with real-time process data.

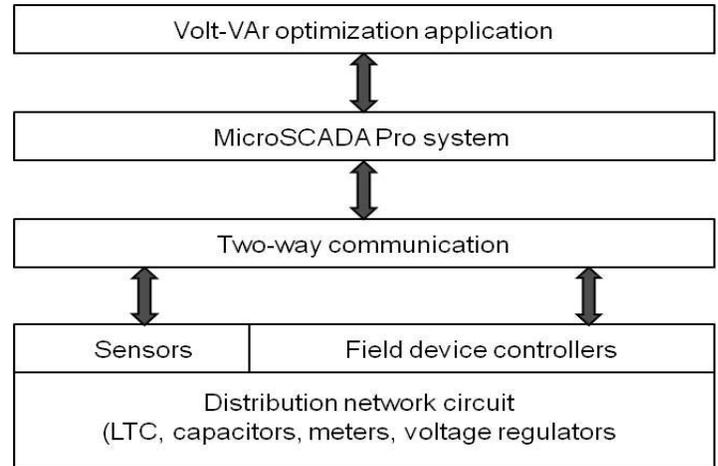
DMS600 provides tools for comprehensive network topology management using standard GIS models. It also provides real-time status data, connectivity analysis and distribution topology representation via feeder coloring. In addition to local access, operators can have remote access to the system through the use of Remote Desktop.

## Volt-VAr optimization (VVO)

The DMS600 Volt-VAr control system provides full SCADA system functionality, ensuring the optimal solution with remote automatic or manual control of the capacitor banks and tap positions on the voltage regulators. The VVO application can be enabled/disabled locally through the HMI, remotely through SCADA or based on a schedule and/or pre-configured system conditions. Once configured, the system can run automatically.

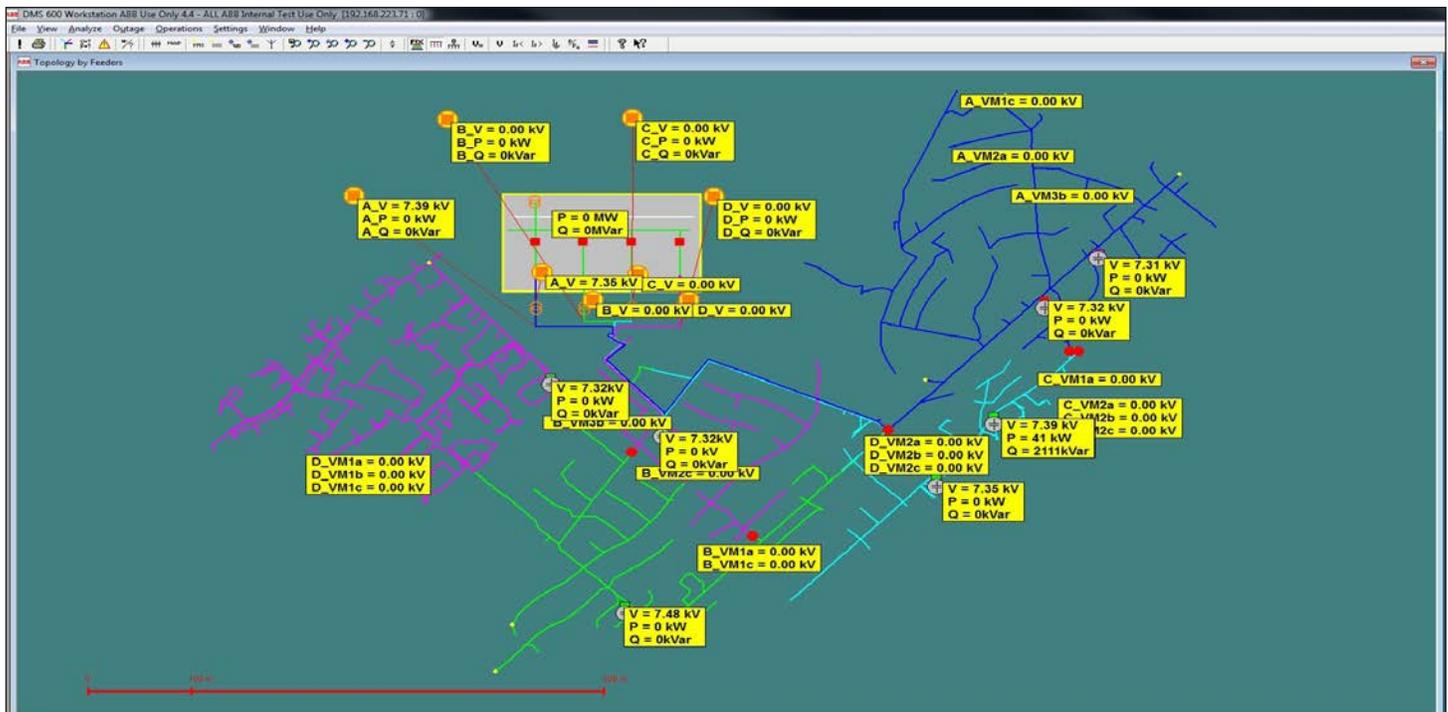
The VVO application uses system information from the DMS600 database and the configured thresholds to determine the optimal capacitor bank and voltage regulator configuration. The

application does not require a full DMS model to run, instead it uses the measured values reported through SCADA and the configured setpoints to determine the optimal solution.



Volt-VAr optimization data flow

The Volt-VAr control system solution incorporates both hardware and software. The above image illustrates the data flow between the field deployed sources (IEDs, meters, capacitor controllers, regulator controllers) and the centralized control and optimization software.



Network view of the distribution system

### Robust, real-time reporting

DMS600 supports extensive operational and measurement reporting, enabling fast and efficient reporting of operational statistics and outages to utility management and external parties, such as authorities and media.

**Measurement reports** that present currents, voltages and active and reactive power in both numerical and graphical formats. The reports can contain, for instance, five-minute or hourly average values.

**Energy reports** in both numerical and graphical formats containing active and reactive energy data with yearly, monthly, weekly, daily and hourly statistics based on three-minute average values.

**Customized reports** are easily produced using the flexible historian that can store all process data for long periods and refine the data into meaningful information. This gives a clear view of the situation in the primary process and enables optimized utilization of the power and primary equipment. Reports and statistics are easily produced. The information is visualized in the form of various graphs, trends and numerical reports. The numerical reports can embed Microsoft Excel which provides commonly known tools for further data refinement.

You can also open standardized control dialogs directly from the geographical view to make the necessary control actions safely with pre-defined interlocking. Tools for managing protection and control IEDs, and uploading disturbance recordings, can be activated from the SCADA system to make changes such as parameter settings, or to evaluate disturbances at the substation level.

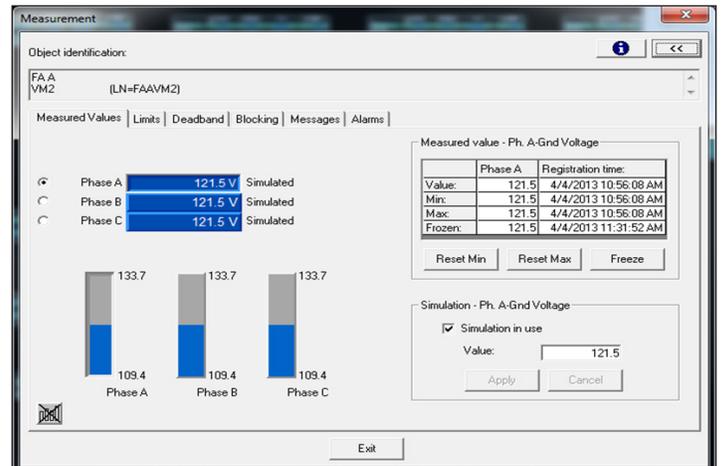
**Alarm, events and trend** views can be customized, sorted and filtered to meet the operators specific information needs enabling them to take the correct actions:

The alarm list displays the summary of the current alarm status of the supervised network, including information on alarm causes. The alarms can be classified, sorted and filtered easily. Alarms can also be defined as summary alarms, for example alarms from a certain location or alarms having a similar functional background. Summary alarms can be additionally used in other summary alarms.

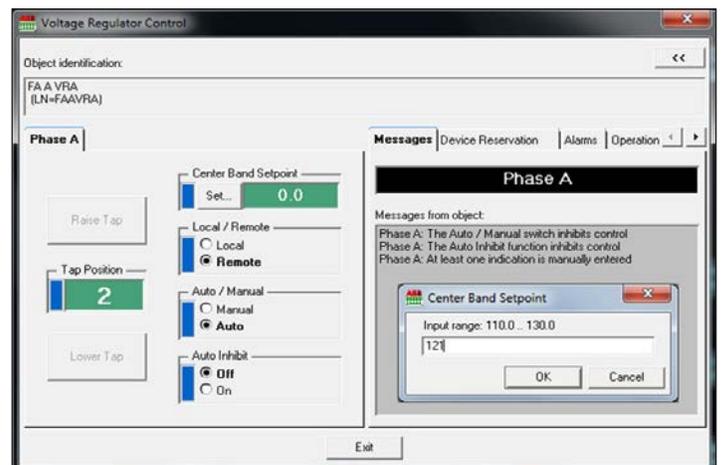
Event list supports the operator in making the right decisions and verifying that the actions taken have been successfully performed. You can also receive information about operations and

activities carried out by other operators at different hierarchical levels. An operator can also add comments about events and locate the object that generated an event on the geographical map.

The trends display shows measured values as graphs or numerical tables. They can be easily created by pre-defining parameters such as measurements, time period and sampling frequency. The freely defined trends can be saved as pre-configured trends enabling you to quickly open a certain trend picture. You can use them to analyze the root cause of a disturbance, or to make decisions on primary equipment maintenance or replacement.



Measurement report sample



Custom report sample

# Volt-VAr management solutions

## Supporting hardware - Capacitors

Utilities are now applying smart grid distribution automation technologies to their capacitor bank assets on their feeders to increase system efficiency and lower maintenance and operating costs. ABB capacitors offer a conservative design with long term reliability and the lowest field failure rate in the industry.

### Power capacitors

These banks provide an economical way to apply capacitors to a distribution feeder system to provide voltage support, lower system losses, release system capacity and eliminate power factor penalties. They are factory pre-wired and assembled, ready for installation.

### Available options:

- In-line aluminum or galvanized steel rack vacuum or oil switches
- Normal and heavy duty design capacitors
- Junction box
- Switching controller – local and remote comms 900 mhz radio or modem
- Line and neutral current sensors
- Wildlife guards
- Insulated conductor
- Control power transformer - 1 or 3 KVA
- Distribution class arresters
- Fused cutout
- Current limiting reactors

### Qpole

The ABB 'Qpole' pole mounted capacitor system is an economical solution for shunt reactive compensation on overhead distribution networks. The Qpole is suitable for use in networks up to 34.5kV grounded.

### Benefits:

- Power factor correction close to customer loads
- Voltage stability
- Increased network capacity
- Cost saving through lower losses

The Qpole is available as a fixed or switched system depending on the network profile. Fixed banks are for systems with relatively constant VAr loading, while switched banks are more suited for systems with variable VAr loading.

The fixed and switched system utilizes ABB single phase capacitors arranged in grounded Y, ungrounded Y or delta configurations.

The switched system utilizes the complete range of ABB components including capacitors, vacuum switches and VAr controller. Optional ABB equipment including potential transformers, current sensors, surge arresters and fuse cutouts are also available.

The Qpole is a factory pre-wired assembly with a welded aluminum rack, suitable for pole mounting. All high voltage wiring has insulated tubing and outdoor bushing terminals are provided with bird guards for increased safety and reliability.

The Qpole is unique in that it offers customers a complete 'one stop shop' solution which has all the major components manufactured by ABB. Each component is manufactured to a relevant international standard (IEEE-18, CSA, IEC, etc.).

Customers have peace of mind knowing that the Qpole has been manufactured to the highest quality and environmental standards with ISO9001 and ISO 14001 certified facilities.



QPole capacitor system

# Volt-VAr management solutions

## Supporting hardware - Switches and controls



Capacitor vacuum switch

### PS Vacuum Switch

The PS vacuum switch is a solid dielectric vacuum switch suitable for use in distribution systems up to 38kV ungrounded (and 66kV grounded). The switch has been specifically designed and tested in accordance with ANSI C37.66 for heavy-duty operation in capacitor-switching applications for the harshest climatic conditions.

### Benefits:

- Vacuum technology
- Superior HCEP solid dielectric insulator technology
- Magnetic actuator leads to few moving parts
- Maintenance free
- 50,000+ CO operations ensure long life
- Stainless steel 304 housing for normal and coastal locations
- ANSI C2 restrike rating
- Lightweight for easy handling

### Types:

- PS15 rated 15.5 KV, 200 or 400 amps
- PS17 rated 17.5 KV, 400 amps
- PS25 rated 25KV, 200 amps
- PS36 rated 38 KV, 300 amps, 3 phase

### CQ900 Smart Controller with 2-way communications

ABB's CQ900, the next generation in smart controllers, is designed specifically for capacitor applications and advanced volt-VAr management applications. It features an extensive range of control modes including remote, automatic and manual control. The automatic mode includes VAr, time, temperature, current and/or voltage control, as well as

combinations of these. In addition, the CQ900 includes measurement and monitoring capabilities and useful features such as a 10,000 event data log for easy analysis and troubleshooting.

New 3 phase monitoring provides three phase voltage and current measurements for centralized volt-VAr management and smart grid applications.

The CQ900 is now equipped with communication via the RS232 and Ethernet interfaces which can be used with a wide range of radio or modem devices. The main communication protocol is DNP3.0 with IEC 61850 to follow. The enclosure is designed to allow standard modems to be installed and powered from within.

### Introducing ABB CapLink

The CQ900 has a secure wireless feature allowing local control, interrogation and programming from a linesman's vehicle, providing added safety and comfort for operators.

Other desirable features included on the controller are flash upgradable capability, a neutral current sensing option and test plugs, as well as a large, four-line LCD screen. The user-friendly interface and sizeable keypad allows for easy operation at any time of the day.

A durable 304 stainless steel enclosure provides added protection for even the harshest weather conditions, while the internal circuitry is protected by heavy duty surge protection. The unit is fully FCC (Part 15, class B) and ROHS component compliant.

The ABB CQ900 smart controller is an easy-to-use, feature-packed controller designed to offer customers true value through smarter management of their electrical systems and reliable integration with Smart Grid systems.



CQ900R Smart Controller

# Volt-VAR management solutions

## Supporting hardware - Sensors

The DistribuSense current and voltage sensor product family enables increased feeder intelligence and drives timely decision-making for Volt-VAR Control (VVC) and Conservation Voltage Reduction (CVR) applications. Utilities benefit from executing these applications by earning financial incentives and decreasing energy costs through demand reduction, loss mitigation, and asset optimization. Accurate and reliable sensors such as the VLS-110 and WLS-110 are the key components enhancing distribution grid visibility to realize these benefits.

### VLS-110 voltage sensor

The VLS-110 sensor implements proven resistive voltage divider technology for distribution grid voltage measurements. This provides the secondary voltage directly proportional to the primary line-ground voltage with high linearity and accuracy. Standard distribution voltage ratios are available to provide the connecting device with a 120 V output.

The VLS-110 is bolt-mounted and lightweight for installation ease and portability. The voltage clamp at the top of the sensor is connected by tapping to the primary conductor. A built-in connector and secondary shielded cable attach the sensor to the voltage monitoring device. For independent voltage sensing at the end of feeder or between capacitor bank installations, the VLS-110 ensures voltage levels meet expectations.

### WLS-110 combination sensor

ABB's latest in outdoor sensing technology, the DistribuSense WLS-110 sensor combines the VLS-110 voltage monitoring with state of the art, precision cut split-core current transformer technology. Installed live to support the primary conductor, the WLS-110 outputs a reliable, high accuracy current signal to measure during normal and fault current conditions for power quality analytics.

The swing bolt design allows for easy opening and closing of the sensor top and the core is protected by a water-tight EPDM gasket to prevent moisture intrusion and weather exposure. In addition, the sensor is cast in HCEP (hydrophobic cycloaliphatic epoxy) to maintain superior performance throughout its extended life.

Light enough to install on the existing cross-arm of the same pole with the QPole Capacitor Bank and connect to the CQ900R 3 Phase Controller, the WLS-110 completes the fully integrated ABB Volt/VAR control solution to improve grid efficiency and performance.



DistribuSense current and voltage sensors

# Tropos wireless communication system

## Supporting infrastructure

Smart grids require an industry standards-based wireless IP broadband network that creates a solid foundation upon which multiple demanding, mission-critical applications can be deployed.

The Tropos product line includes outdoor, mobile and indoor mesh routers; the patented Tropos Mesh OS built from the ground-up to meet the challenges of mission critical outdoor network deployments; directional radio systems for point-to-point and point-to-multipoint communications; and a carrier-class centralized management and control system. Using these building blocks, Tropos systems are used to construct the most resilient, scalable, high performance, and secure networks for utilities, municipalities, mining and industrial customers.

### Features and Benefits:

#### Software

- Decentralized architecture optimizes throughput in real-time and ensures scalability
- Dynamic selection of optimal end-to-end path delivers the highest performance
- Network performance and capacity maximized by automatic optimization of power and rate on per-connection and per-packet basis
- Comprehensive management system streamlines deployment, optimization, maintenance, and control of large, outdoor networks

#### Platform

- Ruggedized and weatherized to operate in hostile environments
- Open-standards-based 802.11a/b/g/n radios optimized for outdoor use
- Supports the industry's widest array of power input options
- Ideal for providing source PoE to collocated devices
- Mobile routers enable field workforce applications

#### Tropos Mesh Routers

- Tropos mesh routers build highly resilient wireless networks with high capacity for aggregating multiple, mission critical applications covering broad geographic areas.
- All Tropos mesh routers run Tropos Mesh OS. Tropos Mesh OS leverages each router's on-board intelligence to minimize network congestion and adapt on a real-time, packet-by-packet scale. This distributed approach optimizes performance and throughput by minimizing control traffic, delivers a highly scalable solution, and helps provide a quality user experience for network clients.
- Tropos Mesh OS is the key to delivering high throughput and scalability. It is the industry's only mesh routing software that dynamically selects end-to-end paths through the mesh based on maximizing client-server throughput and minimizing latency.

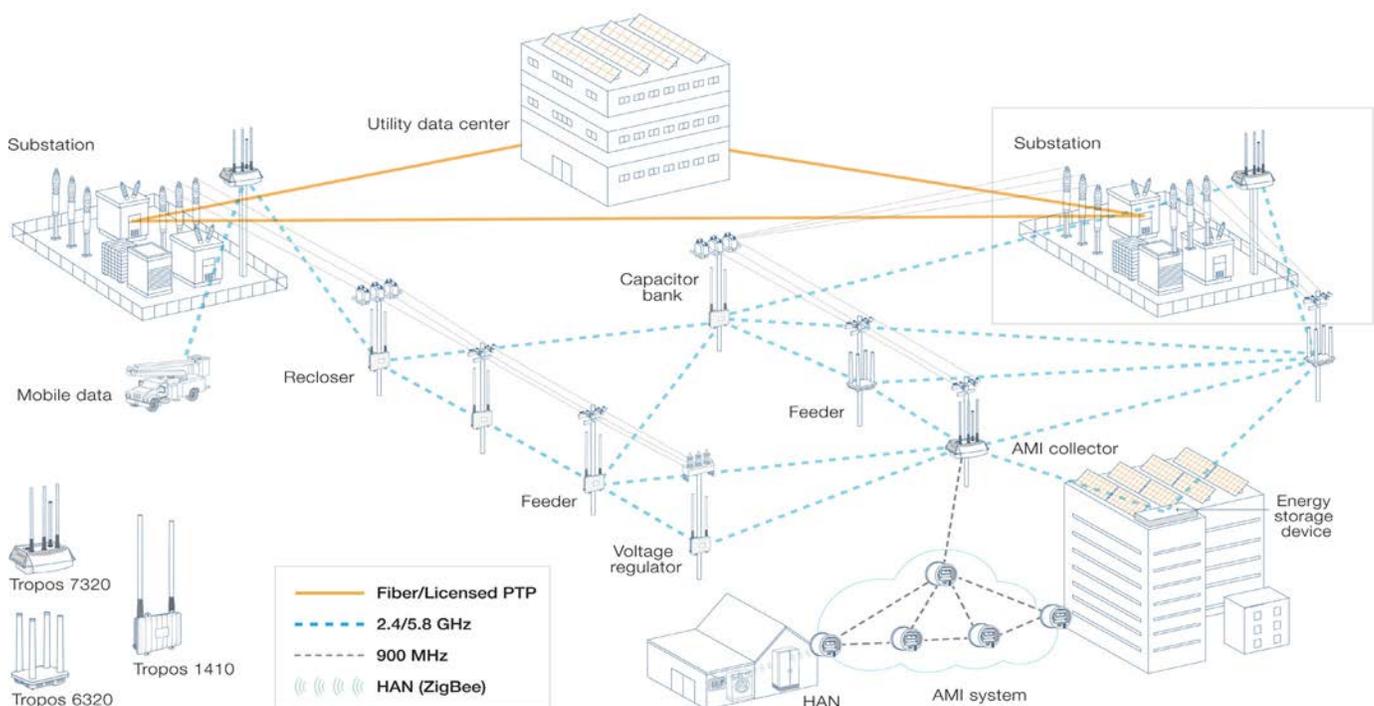


ABB Tropos wireless communication system architecture

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