

Distribution Network Automation Design and Organization Scheme

Article Overview

A robust Distribution Network Automation (DNA) design integrates automated control, real-time monitoring, and communication infrastructure to optimize fault management, Volt/VAR control, and service restoration across primary and secondary substations.

Core Architecture

Distribution Network Automation relies on a hierarchical architecture connecting field devices, substations, and control centers. The main components include:

- o Primary Distribution Substations: Connect the transmission network to the distribution system, typically using air-insulated or gas-insulated switchgear for high-voltage (HV) and medium-voltage (MV) sides, sometimes in hybrid configurations for compact layouts and enhanced safety .
- o Secondary Substations: Serve as centralized nodes in Europe, Asia, and parts of South America, managing multiple feeders and enabling automated control of voltage and reactive power (Volt/VAR) and fault management .
- o Feeder Networks: Decentralized transformer-based distribution schemes common in North America and the Pacific Rim, where automation is applied along feeders to control switches, capacitors, and voltage regulators .

Automation Functions

Key automation functions include:

- o Fault Location, Isolation, and Service Restoration (FLISR): Automated detection and isolation of faults to minimize outage areas, using intelligent electronic devices (IEDs) and coordinated breaker operations .
- o Volt/VAR Optimization: Real-time adjustment of voltage and reactive power to improve efficiency and reduce losses.
- o Demand Response and Predictive Maintenance: Integration with smart meters and sensors to manage peak loads and schedule maintenance based on predictive analytics .
- o Quality of Service Monitoring: Tracking voltage sags, harmonics, and outages to maintain reliability and meet regulatory standards .

Communication Infrastructure

A reliable communication network is critical for DNA:

- o Neighborhood Area Network (NAN): Connects field devices and secondary substations using mesh

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networks or cellular gateways.

- o Wide Area Network (WAN): Provides backhaul communication to control centers.
- o Headend/Operations Centers: Centralized monitoring and control, integrating real-time data acquisition and decision-making algorithms . Protocols such as IEC 61850, DNP3, Modbus, RS232/RS485 are commonly used to ensure interoperability and secure data exchange between devices and control systems .

Automation Logic Design

Designing automation logic involves:

- o Model-Based or Automata-Based Approaches: Formal methods to define fault detection, isolation, and restoration sequences, ensuring correct coordination of protection devices .
- o Soft-PLC Implementation: Logic is deployed on programmable controllers within substations, enabling semi-automatic code generation and standardization across devices.
- o Selective Fault Isolation: Minimizes de-energized areas by placing protection devices strategically along feeders and substations .

Implementation Considerations

- o Scalability: The system should support expansion of feeders, substations, and distributed energy resources.
- o Reliability and Redundancy: Redundant communication paths and fail-safe mechanisms are essential for continuous operation.
- o Integration with Smart Grid: DNA should support distributed generation, energy storage, and advanced metering infrastructure (AMI) for real-time optimization .
- o Regulatory Compliance: Design must meet local standards for safety, reliability, and service quality, often measured by SAIFI and SAIDI indices .

Summary

A well-designed Distribution Network Automation scheme combines centralized and decentralized control, robust communication networks, and advanced automation logic to enhance reliability, efficiency, and service quality. By integrating FLISR, Volt/VAR optimization, predictive maintenance, and smart grid capabilities, utilities can achieve real-time operational optimization and minimize outage impacts across the distribution network .

The other parts of this paper are assigned to the areas of implementation the distributed automation system, technical

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This paper summarizes the development of distribution network automation in China, and analyses the shortcomings

Distribution automation is an important method to improve the reliability, quality and capacity of power supply, and helps to realize

In the conventional distribution network, systems designed for the control of individual constituents are autonomous

Opportunities for distribution automation, such as enhanced reliability, improved operational efficiency, enhanced data

Overall architecture of distribution network automation system (1) Main station composition and configuration The main station

These features enable Distribution Automation (DA) operations by coordinating field devices, specialized software, and dedicated

Flexible control of distribution systems, which can be used to enhance efficiency, reliability, and quality of electricity

Automatic network reconfiguration controllers respond quickly to permanent fault conditions and restore power to de

With the current increase of distributed generation in distribution networks, line congestions and PQ issues are

In view of this, on the basis of consulting and summarizing the current situation at home and abroad, this paper discusses the

Distribution systems analysis employs a set of techniques that allow engineers to simulate, analyse, and optimise power distribution

The handbook describes various power distribution system constructions and elements there-of, technical considerations, distribution

Implementing automation system in distribution networks needs a huge investment that usually cannot be funded

Distribution automation in case of DER should also include islanding (micro-grid) scheme as a part of distribution operations and

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Aiming to this purpose, distribution companies use supervision, monitoring, control, management and georeferencing

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