

Self-Healing Methods in Smart Grids

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Abstract—Today's power systems are based on Tesla's design principles developed in the 1880s and have evolved over time to become the present state. Although communication technology is developing very fast, the development of power systems has not been able to keep up with it. Because the structure of the power system used is often far behind and is unable to meet the needs of the 21st century. With the rapid development of today's technology, it has become possible to make the electricity network better by utilizing the computer and network technologies in the electricity networks. Thus, the electricity networks will provide a safe and uninterrupted energy to the consumers by providing bi-directional information and electricity flow. The grids that can do this are called smart grids. One of the most important features of smart grids is; in the event of a possible interruption or failure, continue to improve the self-healing energy flow. The main goal in self-healing is; to be effective against network breakdowns and at the same time to take security against network breakdowns. To be able to achieve this, the smart grid needs to do the following:

- a) Quick and accurate detection of mains faults.
- b) Redistribution of network resources to protect the system from harmful effects.
- c) To ensure continuity of service in any positive or negative situation.
- d) The service is the most reduced of the self-renewal period.

Various solutions have been proposed for the self-healing of the transmission network. This solution is recommended: optimal voltage control with genetic algorithm base, unified power flow controller (UPFC) and islanding process.

Several solutions have been proposed for the self-healing of the distribution network. This solution is recommended: a new smart distribution grid based on the propulsion system, ant colony algorithm, a new multi-stakeholder control system (MACS) for intelligent distribution networks, fault location, isolation and service restoration (FLISR). Some methods have been developed to provide transient stability when self-healing is performed in the smart grids. These methods include; staking is the real-time monitoring and load-balancing method of the network using the phaser unit (PMU) following the generator rotor angles. In this study, the self-healing methods mentioned above are explained in detail in smart grids.

Keywords— *Smart grids, self-healing methods*

I. INTRODUCTION

Electricity networks, which have been working almost the same since Tesla, have become unable to meet the needs of the 21st century. It is inevitable to use information technologies in electrical energy generation, transmission and distribution technologies in order for the networks to respond adequately to today's needs and provide uninterrupted energy. A sustainable, safe and efficient energy can be obtained by providing real-time two-way information flow at every stage from the generation to consumption of energy. In recent years, the electricity sector has been facing important challenges such as energy demand, commercial losses and power supply quality [1]. In order to overcome these difficulties, energy must be delivered to the consumer in a safe, sustainable and quality manner [2].

In addition; Although power demands were large, the rate of network growth remained slow. The electricity consumption rate is expected to double the current consumption rate in the next decade [3]. Thus, using electrical energy efficiently and reliably; is

critical. This situation creates the need for independent electricity grid operation that makes hardware and software planning throughout the electricity grid. As a result, while achieving effective electrical power operation, the grid response to faults must be improved [4]. Smart grids must be used to improve this and provide sustainable energy to consumers. Smart grid technologies can be defined as self-healing systems that reduce workforce and aim for sustainable, reliable and quality energy to all consumers, find solutions to problems in an existing system quickly [5]. Although conventional power lines have unidirectional power flow, smart grid; It provides two-way information and electricity flow by placing various hardware and software on the network.

Smart grids are one of the most important evolutionary developments in energy management systems, as they enable integrated systems, including decentralized energy systems, large-scale renewable energy use, significant improvements in demand-side management, and sustainable energy [6]. The basic components that make up the smart grid are shown in Figure 1.

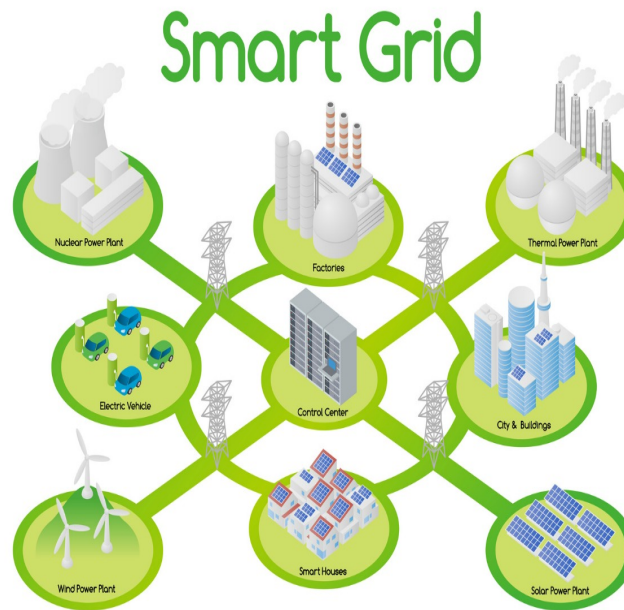


Fig 1. Smart Grid Basic Components

The purpose of this study; to explain the self-healing functions, applications and developments of the smart grid. The tools used for self-healing (eg. communication technologies, software agents and measurements) in the smart grid, transient inertia, and how the network will heal itself in cyber-attack situations were investigated.

II. SELF-HEALING NETWORK APPLICATIONS AND FUNCTIONS

According to Ghosh et al. [7], the self-healing function is the ability to automatically distinguish whether a system is working properly or not, and the ability to apply the necessary settings to maintain its normal operating state. Thus, the intended goals of self-healing systems can be summarized as shown in Figure 2. The main purpose in self-healing; to be effective against network failures and at the same time to secure the network against fault propagation.

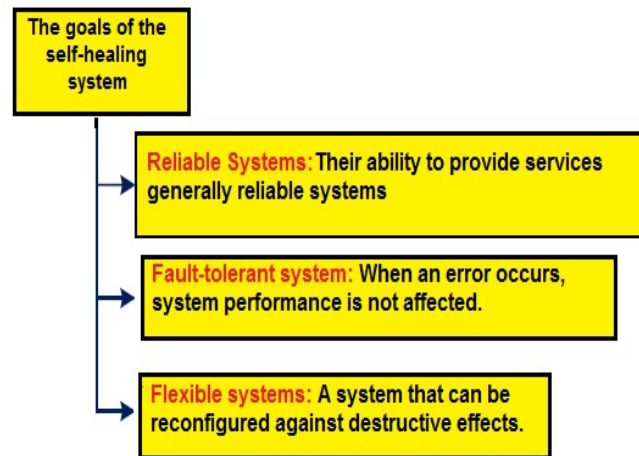


Fig 2. Self-Healing System Goals

2.1. Self-Healing Transmission Network

To monitor the performance of transmission lines, breakers and transformers in an intelligent transmission network; Advanced sensors, signal processors and communication networks must be installed in the entire transmission network. Thus, transmission line parameters are determined and observed continuously. Various solutions have been suggested for the transmission network to heal itself. One of these solution suggestions is the genetic algorithm-based optimal tension control. When checking the tension, fast and high quality solutions can be obtained by inserting the previously occurring facts in the system into the genetic learning algorithm.

In [8], the authors propose a self-healing method for the smart grid using a combined power flow controller (UPFC) and obtaining a continuous power flow under grid faults. In this method, to apply the control algorithm, the reverse current network is applied instead of the iteration algorithm, the node analysis method instead of the optimization method, and the power flow is rearranged.

In addition, the authors in [9]; When a disruptive effect comes to the network, they talked about an algorithm that makes islanding and heals itself. In [10]; An algorithm that monitors and detects overvoltage occurrences is mentioned. In order to achieve this, the self-improvement feature of the smart grid has been used and the transformation algorithm has been explained in detail.

2.2. Self-Healing Distribution Network

It is of great importance to establish a self-improvement system of the smart distribution network. For this, the authors in [11]; They proposed a new smart distribution grid self-healing method based on the traveling wave system. In this method, a fault is detected when the first measured moving wave is greater than the setting threshold. The fault distance is calculated exactly as a result of the least squares method. Then the system provides a smooth and uninterrupted energy by self-healing with the help of the proposed algorithm.

In [12]; An analytical method using the Markov method has been proposed to ensure electrical distribution system reliability. Thanks to this method, electrical power distribution network elements have been tested and proven on a real system by intelligently monitoring them and obtaining great economic benefits. In [13]; An ant colony algorithm has been proposed so that the distribution network can use its self-healing feature. Thanks to this algorithm, the system reacts faster to an adverse situation and finds a solution.

The authors in [14]; have proposed a new multi-item control system (MACS) for smart distribution networks. In this system, fuzzy control algorithms are used for the decision making mechanism. Thanks to this algorithm that can reconfigure the distributor network, voltage irregularities are eliminated and the operation of reactive power control devices can be controlled. Also in [15]; Fault location, isolation and service restoration (FLISR) program has been proposed in accordance with the latest technology standards in smart grids. With the help of this microcontroller based program, the fault location in the distribution network was determined and solution suggestions were presented.

2.3. Self-Healing Micro Grids

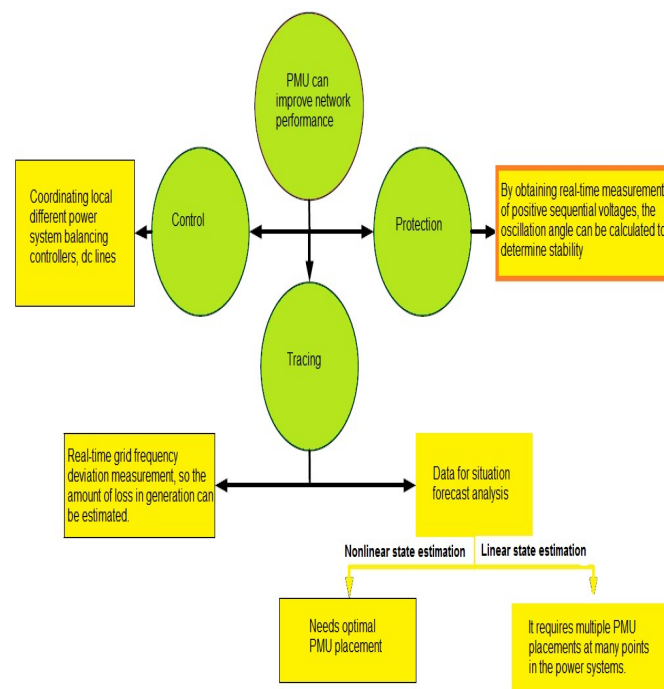
Micro grid plays an important role within the smart grid. Because the micro grid can be integrated into the grid, it can also feed the loads connected in island status. Generally, micro energy sources that generate electrical energy are named as follows: Solar panels, fuel cells and wind turbines. In normal operation, the micro grid is connected to the conventional power grid.

In [16], a method aiming to maximize the power flow time is mentioned, taking into account the availability of renewable resources and stored energy to create a micro-grid under island conditions. Disconnection from the electricity grid, distributed generations independently from the grid will continue to feed the loads connected to the micro grid. Integrating micro grids into the distribution grid is useful as it simplifies the implementation of many smart grid functions. Accordingly, overall system reliability and efficiency will increase and renewable energy can be integrated into the system. The authors in [17]; have presented a central protection strategy for medium voltage micro grids. A fault isolation method has been proposed that provides economical, fast and selective protection by using a minimum number of circuit breakers in case of a possible failure.

III. SYNCHRONIZED PHASE MEASUREMENT UNIT (PMU)

Synchronous phase measurement units (PMUs) were first introduced in the early 1980s and have been used in many applications in power systems since then. In large power systems, PMUs are used to get accurate and fast information in case of a possible power failure. The error rate of information obtained from PMUs is very low. In case of power failure; Thanks to the information received from the PMU, the interruption can be intervened quickly and safely. The PMU uses the frequency tracking step and estimates the fundamental period of the frequency before determining the phasor. PMU's main task; Determining which phase is faulty by distinguishing the fundamental components of the frequency

Synchronous PMU is a digital device that measures the phasor value in a time interval. In the time interval, the power system is referenced as multiples of its nominal frequency [18]. In large field measurements, several phasor values are required simultaneously; therefore, the time interval of the PMUs must be synchronized simultaneously. The block diagram shown in Figure 3 summarizes the applications of PMUs in electrical power systems.



IV. CONCLUSIONS

In this study, the self-healing ability of the smart grid; It is tried to be explained through transmission, distribution and micro networks. The role of PMU in electrical power systems has been tried to be explained. Thanks to the developments in power electronics converters and virtual network security, the self-improvement goals of the smart grid are being approached step by step.

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