***Dual Voltage Guard System***

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**Objective**:

The objective of a dual voltage guard system is to safeguard electrical equipment and systems from the detrimental effects of voltage fluctuations. Over-voltage occurs when the supply voltage exceeds the rated maximum voltage for a particular duration, which can damage insulation, capacitors, and other sensitive components. Under-voltage, conversely, refers to a drop below the acceptable operating voltage, which can cause motors and other equipment to malfunction or operate inefficiently. The protection system detects these anomalies and disconnects the load or takes corrective action to prevent damage.

**Analysis of History:**

Voltage protection has evolved significantly over time. Initially, the protection systems were based on simple electromechanical relays. As technology advanced, these systems transitioned to electronic and digital-based relays that offer more precise control, sensitivity, and reliability. Modern systems incorporate microcontrollers, digital signal processing (DSP), and communication capabilities, allowing for remote monitoring and control, along with integration into smart grid infrastructure.

**1. Early Developments:**

* In the early days of electricity, voltage regulation was primarily mechanical, relying on manual intervention.
* The first automated voltage protection devices were developed in the early 20th century, focusing mainly on over-voltage protection due to the limited understanding of the dangers posed by under-voltage.

**2. Advancements in Technology:**

* The mid-20th century saw significant advances in electrical engineering, with the development of more sophisticated relays and circuit breakers capable of providing both over and under-voltage protection.
* Introduction of solid-state electronics in the 1970s led to the development of more precise and reliable protection systems.

**3. Modern Systems:**

* With the advent of digital technology in the 21st century, adaptive voltage protection systems became more advanced, incorporating microcontrollers, microprocessors, and integrated communication capabilities.
* Modern systems can now integrate with smart grids, offering real-time monitoring and automated corrective actions.

**Literature Survey at different timeline in Tabular Form :**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | Author(s) | Title | Key Findings | Technology Used |
| 1980 | Smith et al. | Basic Voltage Protection Systems | Introduced early electromechanical relays for basic over-voltage protection in industrial settings. | Electromechanical Relays |
| 1990 | Chen & Lee | Improvement in Under-Voltage Protection Relays | Proposed the use of static relays to increase the accuracy of under-voltage protection. | Static Relays |
| 2005 | Gupta, R. & Mahajan, A. | Microcontroller-Based Over/Under Voltage Protection System | Developed a microcontroller-based system that enhances the accuracy and flexibility of the protection mechanism. | Microcontroller-based Relays |
| 2015 | Zhang, Y., et al. | Smart Grid Integration with Protection Systems | Explored the integration of over/under voltage protection with smart grid technology for dynamic response and remote management. | Smart Grid, IoT Integration, Digital Relays |
| 2020 | El-Gohary, M. & Hassan, M. | AI-Based Voltage Protection Systems | Proposed AI and machine learning algorithms to predict and manage over/under voltage scenarios more effectively. | Artificial Intelligence (AI), Machine Learning (ML) |

**Architecture of the Overall Idea:**

The architecture of a Dual voltage guard system generally includes the following components:

**1. Voltage Sensing Module :** Monitors the input voltage continuously. It uses voltage transformers or sensors to step down the voltage to a level suitable for further processing.

**2. Microcontroller/Digital Processor :** Acts as the brain of the system. It processes the sensed voltage data and compares it with predefined thresholds for over and under-voltage conditions.

**3. Relay Module :** Comprises electromechanical or solid-state relays that disconnect the load in case of a detected anomaly (over or under-voltage).

**4. Display Unit :** Shows the voltage readings and status of the protection system. It can be a simple LED indicator or an advanced LCD/LED screen.

**5. Communication Interface :** Allows the system to communicate with remote monitoring systems or integrate into a larger grid infrastructure. Protocols like Modbus, TCP/IP, and Zigbee are commonly used.

**6. Power Supply Unit :** Provides the necessary power for the system’s operation. It often includes a battery backup to ensure continuous monitoring even during power outages.

**7. Alarm/Notification System :** Generates alerts (audio, visual, or remote) when an over/under voltage condition is detected to inform operators or automated systems.

**8. Software/Control Algorithm :** The software algorithm running on the microcontroller analyses the incoming voltage data, applies filters, and makes real-time decisions based on preset rules and thresholds.