SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 19EE605 PROTECTION AND SWITCHGEAR

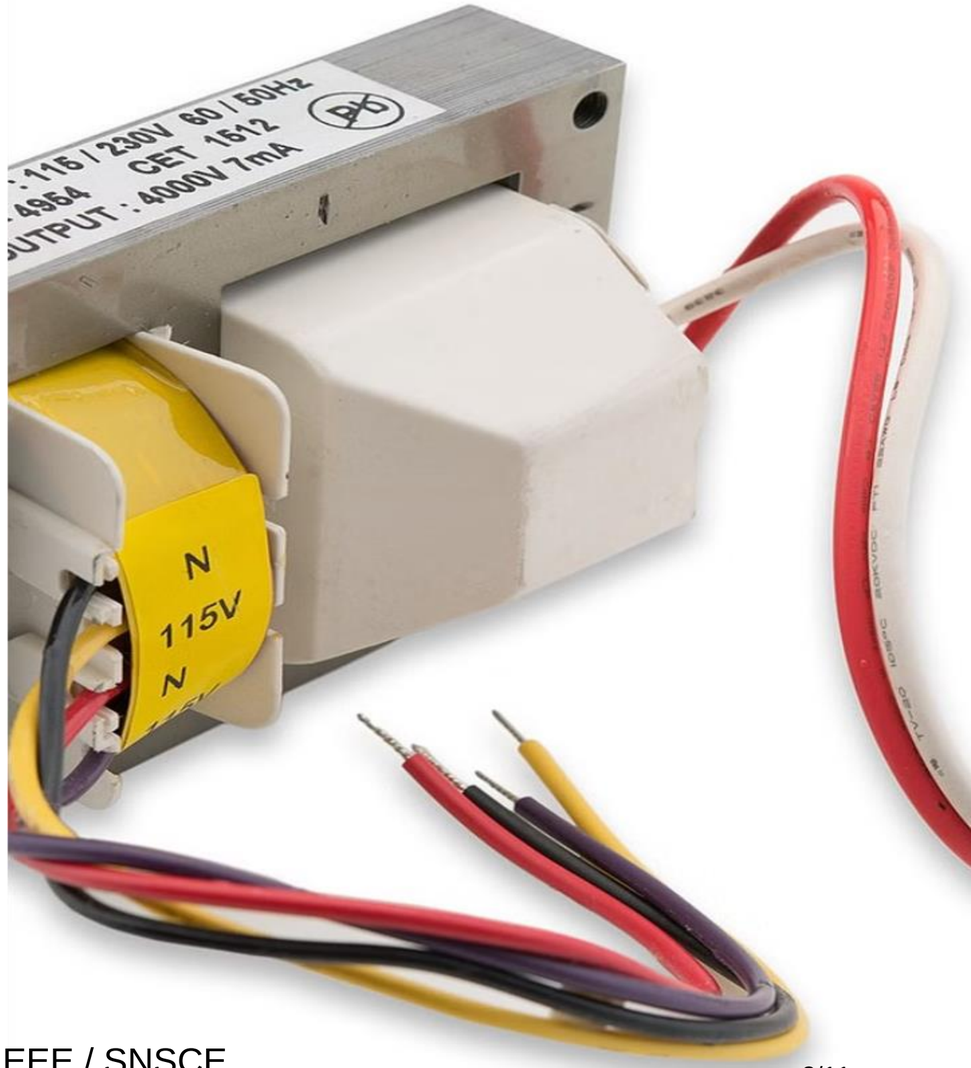
III YEAR /VI SEMESTER

Unit 4- STATIC RELAYS AND NUMERICAL PROTECTION

Topic: Transformer Differential Protection

Transformer Differential Protection

Transformer differential protection is a critical safeguard for power transformers, ensuring their reliable operation and protecting them from internal faults. This advanced protection scheme monitors the current flowing into and out of the transformer, quickly identifying and isolating any abnormal conditions that could damage the valuable asset. By constantly analyzing the differential current, the system can rapidly detect even minor faults, minimizing the risk of catastrophic failures and maximizing transformer uptime.



Key Components of Differential Protection

Current Transformers (CTs)

Differential protection relies on precision current transformers installed on the primary and secondary sides of the transformer. These CTs accurately measure the current flowing into and out of the transformer, providing the data needed for the protection scheme to operate.

Differential Relay

The heart of the differential protection system is the differential relay, which continuously compares the currents measured by the CTs. When an internal fault occurs, causing an imbalance between the input and output currents, the relay will rapidly detect the fault and issue a trip signal to isolate the transformer.

Wiring & Connections

Proper wiring and connections between the CTs, differential relay, and transformer terminals are critical to ensure accurate current measurements and reliable protection. Careful design and installation are necessary to avoid any potential sources of error or mismatch in the protection scheme.

Operating Principles of Differential Protection

Normal Operation

During normal operation, the currents flowing into and out of the transformer are equal, resulting in a zero differential current. The differential relay simply monitors this balanced condition and does not issue any trip signals.

External Fault

For faults occurring outside the transformer's protected zone, the differential current will remain balanced, and the relay will not trip. This ensures that the transformer is not unnecessarily isolated for external system disturbances, improving the overall reliability of the power network.

1

2

3

Internal Fault

When an internal fault occurs within the transformer, such as a winding short-circuit, the currents measured by the CTs will no longer be equal. This imbalance in the differential current will be detected by the relay, which will then trip the circuit breakers to isolate the faulty transformer.

Differential Protection Advantages

1 Highly Sensitive

Differential protection can detect even small internal faults, providing rapid and reliable isolation of the transformer to prevent further damage and minimize service interruptions.

2 Selective Operation

The scheme is selective, tripping only for faults within the transformer's protected zone and allowing the rest of the power system to remain in service during external disturbances.

3 Increased Reliability

By quickly isolating internal faults, differential protection helps ensure the long-term reliability and availability of power transformers, critical assets in the electrical grid.

4 Improved Safety

Rapid fault detection and isolation provided by differential protection can help mitigate the risks of transformer failures, enhancing the overall safety of the power system and its personnel.

Differential Protection Challenges

CT Saturation

During high-current external faults, the current transformers can become saturated, potentially compromising the accuracy of the differential current measurement and causing undesirable relay operation.

Tap Changer Influence

The differential protection scheme must be able to compensate for the current changes caused by the transformer's on-load tap changer, ensuring reliable operation across the full range of tap positions.

Inrush Currents

When a transformer is energized, it can experience high inrush currents that could potentially be misinterpreted as an internal fault by the differential relay, leading to unnecessary tripping.

Commissioning & Maintenance

Proper commissioning and regular maintenance of the differential protection system, including CT testing and relay calibration, are critical to ensure its continued reliable operation over the transformer's lifetime.

Advanced Differential Protection Schemes

Restraint

Restraint-type differential protection algorithms can help overcome the challenges of CT saturation and inrush currents, improving the overall dependability and security of the protection scheme.

Harmonic Restraint

Harmonic restraint techniques analyze the harmonic content of the differential current to distinguish between internal faults and magnetizing inrush conditions, preventing unnecessary tripping.

Percentage Differential

Percentage differential protection provides a more flexible and adaptive tripping characteristic, adjusting the relay's sensitivity based on the magnitude of the differential current to improve performance under varying operating conditions.

Bias Differential

Bias differential protection introduces a biasing signal that varies with the transformer's load current, further enhancing the relay's ability to distinguish between internal faults and other transient events.

Modern Trends in Differential Protection

1

Microprocessor-based Relays

The advent of microprocessor-based digital relays has enabled more advanced and sophisticated differential protection algorithms, providing increased flexibility, accuracy, and diagnostic capabilities.

2

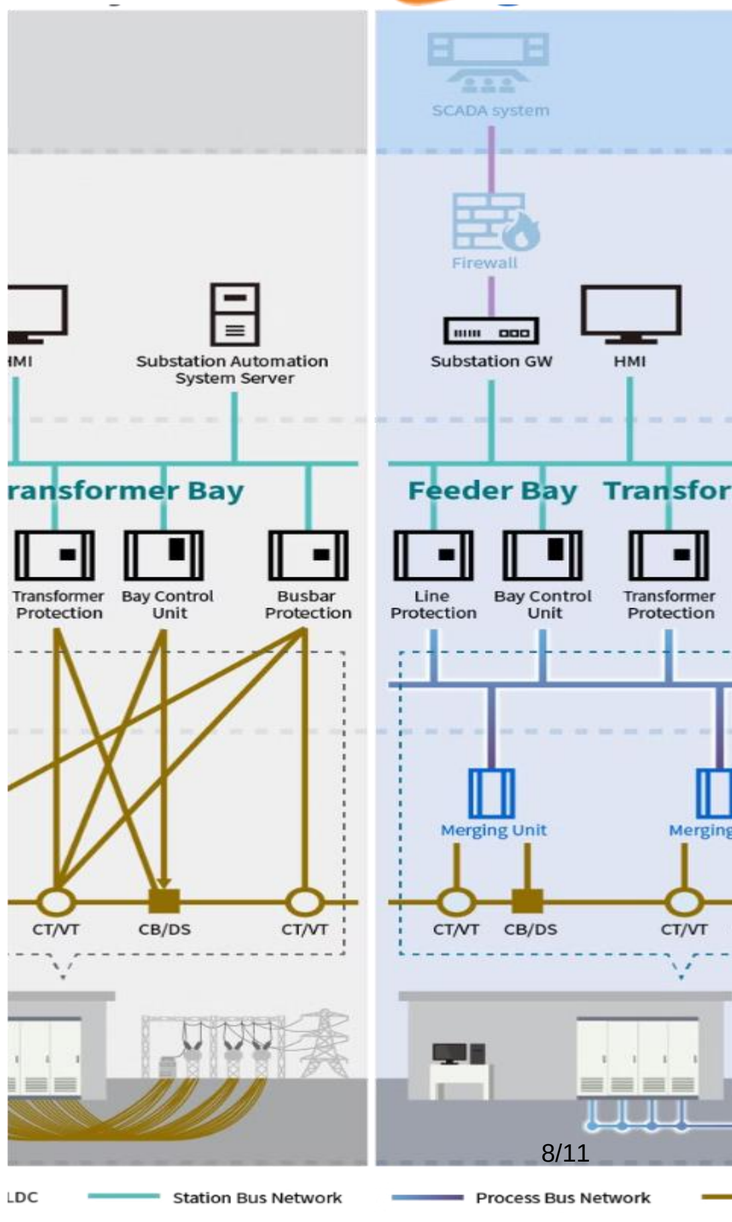
IEC 61850 Integration

The integration of differential protection schemes with the IEC 61850 substation automation standard allows for seamless communication and data exchange, improving overall system integration and monitoring.

3

Condition Monitoring

Advanced differential protection systems can now incorporate condition monitoring functionalities, providing valuable insights into the transformer's health and potential issues, enabling predictive maintenance strategies.



Ensuring Reliable Transformer Protection

1 Proper Design & Installation

Careful design and installation of the differential protection scheme, including accurate CT sizing, wiring, and connections, are crucial for ensuring its reliable and effective operation.

2 Regular Testing & Maintenance

Periodic testing and maintenance of the differential protection system, such as CT testing, relay calibration, and scheme verification, are essential to maintain the system's performance over the transformer's lifetime.

3 Continuous Monitoring

Implementing continuous monitoring and diagnostic capabilities within the differential protection system can help identify any issues or degradation, allowing for proactive maintenance and minimizing the risk of unexpected failures.

Assessment

1. Any transformer needs to be protected from _____

a) transformer faults

b) faults occurring on the transformer connected systems

c) faults within and on system.

d) other faults

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2. Paithankar Y G, Bhide S R, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt Ltd., New Delhi, 2nd Edition, 2014.

3. Badriram, Vishwakarma B.H, “Power System Protection and Switchgear”, New Age International Pvt Ltd Publishers, 2nd Edition 2017.

Thank You