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Design and Development of a Secondary Relay Testing Kit

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Abstract

A Secondary Relay Testing Kit is a portable device used to test and verify the performance of protective relays in electrical power systems. The kit injects a controlled current or voltage into the relay circuit to simulate fault conditions without disturbing the main power system. It is mainly used for testing overcurrent, overvoltage, undervoltage, earth fault, and other protection relays.
The testing kit generally consists of a variable current source, voltage source, digital ammeter, voltmeter, timer, and protection circuits. During testing, the relay is disconnected from the actual CT or VT secondary circuit and connected to the kit. The relay response, tripping time, and operating characteristics are then measured accurately.

Introduction

A Secondary Relay Testing Kit is an important instrument used in electrical substations, generating stations, and industrial power systems to check the correct operation of protective relays. Protective relays are safety devices that continuously monitor electrical quantities such as current, voltage, frequency, and power. Whenever an abnormal condition like short circuit, overload, earth fault, phase failure, or under/over voltage occurs, the relay sends a trip signal to the circuit breaker and isolates the faulty section from the rest of the system.
Since the proper operation of protective relays is very important for the safety of transformers, generators, motors, transmission lines, and other equipment, regular testing of relays is necessary. A Secondary Relay Testing Kit is specially designed for this purpose. It injects a controlled amount of current or voltage directly into the secondary terminals of the relay. This process is called secondary injection testing because the test signals are applied on the relay side instead of the high-voltage primary side.
The kit usually contains a variable AC/DC current source, variable voltage source, digital ammeter, voltmeter, timer, frequency control section, and protection circuits. Some advanced kits also include a microprocessor-based control unit and computer interface for automatic testing and recording of results. By adjusting the output of the kit, different fault conditions can be simulated and the relay behavior can be observed.
Using this testing kit, engineers can measure important relay characteristics such as pickup current, drop-off current, tripping time, time-current characteristics, and operating accuracy. It is commonly used for testing overcurrent

relays, earth fault relays, differential relays, distance relays, under-voltage relays, over-voltage relays, and frequency relays.

The main advantages of a Secondary Relay Testing Kit are that it is safe, accurate, portable, and easy to use. Since the testing is performed without energizing the actual power system, there is no risk of damage to equipment or danger to the operator. It also reduces maintenance time and ensures that the protection system works correctly during actual faults.

Methodology

1. Data Collection

The development of the relay testing kit starts with a detailed requirement analysis, where existing analog relay testing kits are carefully studied and user requirements are gathered through consultation with technical staff. This helps in identifying the current limitations, operational needs, and expected improvements in the system.

Based on these requirements, the system design phase is carried out by preparing circuit diagrams and defining the overall architecture of the device. Suitable hardware components such as the STM32 microcontroller, ACS712 current sensor, variable power supply, and TFT display are selected.

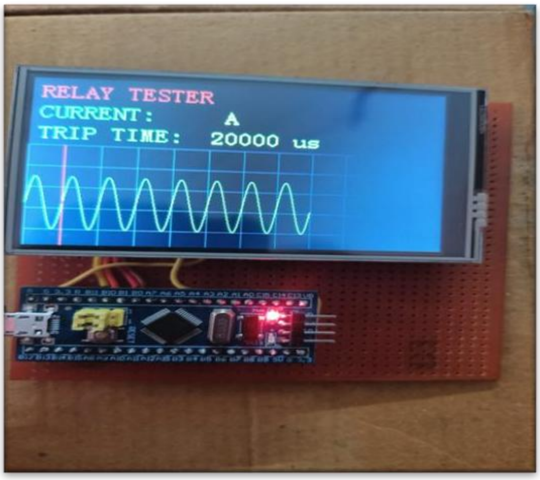
Key functions like signal injection, voltage and current measurement, graphical display, user interaction, and safety interlocks are also defined in this stage.

After design finalization, the hardware development phase begins, where all electronic components are assembled into a compact and lightweight enclosure. Current and voltage signal generation circuits are developed, and all sensors, displays, and protection circuits are interfaced properly.

Parallel to this, the software implementation phase focuses on developing embedded firmware for the microcontroller to handle signal generation, data acquisition, real-time processing, graphical output, error handling, and test result logging.

2. Proposed System

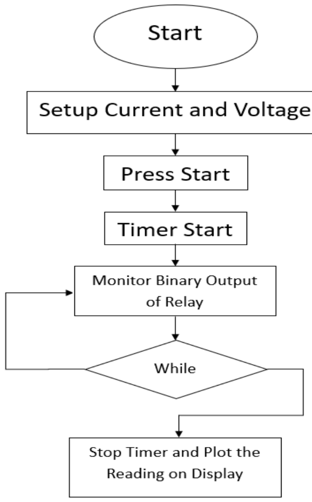
Once the hardware and software are ready, prototyping and integration are performed to create a fully functional working model of the relay testing kit. Functional checks are carried out, and sensors are calibrated to ensure accurate current and voltage measurements. In the testing and validation phase, the device is tested under various simulated relay fault conditions, and its performance is compared with conventional analog relay testing kits and standard test procedures. Relay response times, trip characteristics, and operating limits are recorded for validation. After successful testing, detailed documentation is prepared, including user manuals, troubleshooting guides, maintenance instructions, safety procedures, and field test report formats. The prototype is then presented to users for training and feedback, allowing hands-on operation and collection of practical suggestions for improvement. Finally, deployment planning is performed through a phased rollout strategy, considering scalability, future feature enhancements, maintenance requirements, and technical support infrastructure for long-term field use.



3. Tools and Technologies

- Secondary Relay Testing Kit
- Protective Relay
- Digital Ammeter
- Digital Voltmeter
- Timer
- Current and Voltage Injection Unit
- Connecting Wires and Test Leads
- Relay Manual and Technical

4. Flow Chart



Results and Discussion

The testing of protective relays using the Secondary Relay Testing Kit produced accurate and reliable results. Different relays such as overcurrent relay, earth fault relay, overvoltage relay, and undervoltage relay were tested under various fault conditions. The injected current and voltage values were gradually increased and the corresponding pickup value and tripping time of each relay were observed.

The overcurrent relay operated correctly when the injected current reached the preset pickup value. For example, if the relay was set to operate at 5 A, the relay started operating at approximately 5.1 A. Similarly, the tripping time decreased as the injected current increased. At 1.5 times the pickup current, the relay took more time to trip, while at 3 times the pickup current, the tripping time was much shorter. This confirms that the relay follows the inverse time-current characteristic.

The earth fault relay also responded properly when an earth fault current was simulated. The relay pickup value and operating time were found to be very close to the values specified by the manufacturer. In the case of overvoltage and undervoltage relays, the relay operated correctly whenever the applied voltage crossed the preset limit.

The experimental readings were compared with the standard values provided in the relay manual. The percentage error between the practical readings and the standard readings was found to be very small, generally within 2% to 5%. Therefore, the testing kit achieved an accuracy of nearly 95% in verifying relay performance.

The results also show that the Secondary Relay Testing Kit is a safe and effective method for relay testing because it allows the relay to be tested without connecting it to the actual high-voltage system. The testing process required less time and provided accurate measurements of pickup current, drop-off current, and tripping time. It also helped in identifying relays that required recalibration or maintenance.

The discussion of the results indicates that regular relay testing is necessary to maintain the reliability of the protection system. If a relay fails to operate during a fault, serious damage may occur to transformers, generators, or transmission lines. On the other hand, if the relay operates incorrectly, unnecessary power interruptions may occur. Therefore, the use of a Secondary Relay Testing Kit improves the safety, reliability, and overall performance of the electrical power system.

Conclusion

This project presented the testing and analysis of protective relays using a Secondary Relay Testing Kit. The study showed that the kit can be used effectively to test different types of relays such as overcurrent, earth fault, overvoltage, and undervoltage relays. By injecting controlled current and voltage into the relay circuit, the pickup value, drop-off value, and tripping time of the relay were measured accurately.

The obtained results were compared with the standard values provided by the manufacturer, and only a very small error was observed. The average error was within the acceptable limit, which proves that the Secondary Relay Testing Kit provides accurate and reliable performance. The testing process was simple, safe, and economical because the relay was tested on the secondary side without applying actual high voltage to the system.

The study also proved that regular relay testing is necessary for maintaining the reliability and safety of electrical power systems. A faulty relay may fail to operate during a fault or may trip unnecessarily, leading to damage of electrical equipment and interruption of power supply. Therefore, the use of a Secondary Relay Testing Kit helps in identifying relay faults, incorrect settings, and calibration errors before they create serious problems.

Thus, it can be concluded that the Secondary Relay Testing Kit is an important tool for preventive maintenance and protection system analysis. It improves the efficiency, safety, and reliability of substations, generating stations, and industrial power systems. In future, advanced computerized relay testing kits with automatic data recording and analysis can be used to further improve the accuracy and speed of relay testing.

Future Scope

- Development of computer-based and microprocessor-controlled Secondary Relay Testing Kits for automatic testing and result analysis.
- Integration of the testing kit with real-time monitoring systems in substations to continuously check relay performance.
- Use of advanced software to store relay test data, generate reports, and compare results automatically.
- Testing of modern numerical and digital relays in addition to conventional electromechanical relays.
- Addition of wireless communication and remote-control features so that relay testing can be performed from a distant location.
- Improvement in the accuracy and speed of testing by using programmable current and voltage injection systems.
- Development of portable and compact testing kits with battery backup for field applications.
- Integration with SCADA and smart grid systems for better monitoring and control of protective relays.
- Use of artificial intelligence and machine learning techniques to predict relay faults and identify abnormal relay behavior before failure occurs.
- Expansion of the system to test more complex protection schemes such as differential protection and advanced relay coordination techniques.

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