Detection of Failure Capacitor from Shunt Capacitor Bank by Current Sensing Method

Abhijit R Bendre [1], Sanket P Jarande[2], Sumit T Waghmare[3], Abhijit B Ithape[4], Jaydeep S Nigade[5]

Head of the Department, Department of Electrical Engineering [1]

Students, Department of Electrical Engineering [2,3,4,5]

Navsahyadri Group of Institutions, Pune, Maharashtra, India

Savitribai Phule Pune University, Pune

ABSTRACT

The To achieve more reliable grid, it is crucial for utilities to expedite the repair process of critical assets, including Shunt Capacitor Banks (SCBs). Exposure to sharp temperature variations, transient over voltages, aging and manufacturing defects can cause internal failures of capacitor elements. A new method using indicating quantity Superimposed Reactance (SR), is presented in this paper to locate capacitor elements failures in Shunt Capacitor Banks. The proposed quantity is estimated using available measurements to the unbalance protection function of SCBs numerical protective relays. The proposed SR adopts calibrating factors for fault location and can provide live report of the number of failed capacitor elements. The proposed method benefits are: Rapid identification of the SCBs failed elements for fuse less and internally fused designs, determining failure and faulted phase of single-wye connected banks, Ability to detect consecutive failures, even in the same or different phases due to self-tuning, Online reporting of elements failure for proactive maintenance planning. The developed method supports three different grounding arrangements, wye-ungrounded, wye grounded via a low ratio current transformer, and wye-grounded via a grounding capacitor at the SCB neutral point. Comprehensive simulation and fault-location analysis using PSCAD and MATLAB have verified the proposed algorithm performance. Advantages of the proposed method reports over conventional unbalance relaying alarms are also demonstrated using a relay test results comparison. Shunt capacitor bank in power transmission are essential in providing reactive power support and improvement of voltage profile at any required point within the grid system. The failure of shunt capacitor bank due to unbalance capacitance caused reactive power and voltage losses to the power transmission network.

Keywords - Shunt Capacitor Bank, Capacitor Failure Detection, Power System Protection, Reactive Power Consumption, Capacitor Bank Monitoring, Fault Detection System, Condition Monitoring .

2. INTRODUCTION

Capacitor units for high voltage power system applications incorporate different designs, this includes externally fused, internally fused, and fuse less technologies. Reliability and total life cycle cost issues have resulted in higher interest in the latter two designs for substation applications. Although internally fused and fuse less capacitor units have higher avail ability, they lack the advantage of having the outward external fuse to identify the failed units. With unbalance being a major occurrence, developing methods for determining the failed elements' phase is an Enhancement for Shunt Capacitor Banks (SCBs) numerical protection and control relays. This helps the crew by often Localizing the problem of fault location to a particular phase for repairing and preparing the bank faster for operation.In addition, a detailed event report would be useful for condition-based maintenance, and it would reduce unscheduled Outages of the SCBs. Fault location could be inherent within unbalance protection schemes based on the level of Selectivity they provide. Accordingly, except for configurations and protection methods that utilize per-phase Measurements it is challenging for common unbalance protection functions to incorporate fault location indication, Which is because of the less-than-ideal number of available measurements. In the area of fault location and online Monitoring of SCBs very little research work has been reported in the literature, particularly for the unbalance Protection methods intended for this paper. Present methods in the literature can be categorized into two types.

3. LITERATURE SURVEY

Shunt capacitor banks are critical power system assets that play a crucial part in Providing reactive power support, improving voltage profile, increasing system capacity, and Reducing system losses. Shunt capacitor banks are widely installed in the power system as they Are relatively inexpensive compared with alternatives. Shunt capacitor banks consists of many Single-phase capacitor units connected in series and parallel to meet the desired voltage and Reactive power ratings. Shunt capacitor banks are critical power system assets that play a crucial part in Providing reactive power support, improving voltage profile, increasing system capacity, and Reducing system losses. Shunt capacitor banks are widely installed in the power system as they Are relatively inexpensive compared with alternatives. Shunt capacitor banks consists of many Single-phase capacitor units connected in series and parallel to meet the desired voltage and Reactive power ratings. Shunt capacitor bank are used for power factor correction and voltage Support. Capacitor units for high voltage power system applications incorporate different designs, This includes externally fused, internally fused, and fuseless technologies. Reliability and total Life cycle cost issues have resulted in higher interest in the latter two designs for substation Applications. Although internally fused and fuseless capacitor units have higher availability, they Lack the advantage of having the outward external fuse to identify the failed units. With Unbalance being a major occurrence, developing methods for determining the failed elements' Phase is an enhancement for Shunt Capacitor Banks (SCBs) numerical protection and control Relays. This helps the crew by often localizing the problem of fault location to a particular phase For repairing and preparing the bank faster for operation.

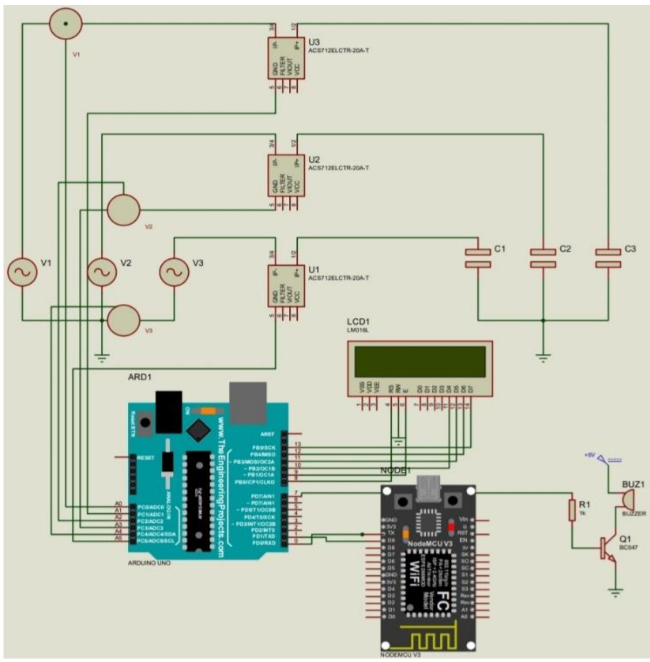
4. HARDWARE REQUIREMENT

- Current Sensor
- Voltage Sensor

- Lcd 16*2 display
- Arduino Uno
- Power Supply for circuit
- Node MCU
- Buzzer

5. METHODOLOGY

Circuit diagram



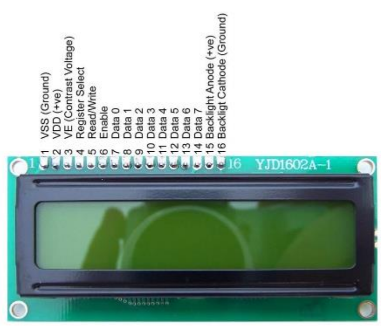
1.Current Sensor

For selection of the current sensor, the line current of the load is into Consideration. For hardware development, load rating is considered 4 A. The current sensor ACS 712 – 20A range Hall Effect CT can be selected for the Hardware development.

2.Voltage Sensor

The voltage rating of the load in three phase 4 wire system is 230V. Hence, the voltage sensor 440V/ 3.3V transformer sensor is selected for voltage sensing. The voltage sensor is chosen such that the maximum (peak) value of voltage applied to microcontroller does not exceed 5V. Thus, the voltage sensor ZMPT 101b is selected for the project work.

3.Display Unit



16×2 LCD Display connected to port PB (PB0–PB5). Displays system status, sensor readings, or alerts.

4. Arduino Uno

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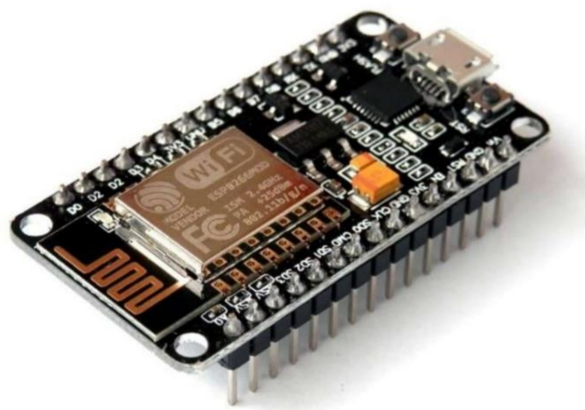
The Arduino Uno is a popular, open-source microcontroller board based on the ATmega328P, designed for beginners and electronics prototyping. It features 14 digital I/O pins (6 PWM), 6 analog inputs, a 16 MHz clock, and USB connectivity. It operates at 5V, can be Powered via USB or a 7-12V barrel jack, and is programmed using the C/C++ based Arduino IDE.

5.Node MCU



NodeMCU is an open-source, low-cost Wi-Fi enabled development board and firmware based on the ESP8266 SoC, specifically designed for IoT prototyping. It features a 32-bit Tensilica processor, built-in Wi-Fi, 4MB flash memory, and GPIO pins, often programmed using Arduino IDE or Lua. It enables rapid development of connected devices, smart home automation, and sensor nodes.

6.Buzzer

A buzzer or beeper is an audio signaling device that converts electrical signals into sound, typically in the 1 to 7 kHz range. Common in alarms, timers, and user-input confirmation (e.g., in electronics), they are powered by DC voltage. They primarily come in two types: piezoelectric (using a diaphragm) and magnetic (using a coil).

CONCLUSION

The capacitor failure has been detected successfully by current sensing technique. The System continuously monitors the capacitor current and compares it with a threshold limit To identify the capacitor failure. The comparison indicates that the system accurately detects capacitor failures in the Shunt capacitor bank. The hardware measurements align with the data logged and Displayed on the ThingSpeak platform, confirming the reliability of the IoT-based Monitoring system. This setup ensures that faults can be detected promptly, allowing for Timely maintenance and reduced downtime in the power distribution network. The IoT interface provides the global display to the end user thereby allowing monitoring Of the system from anywhere in the world. This technology is particularly useful for Remote monitoring of the system. With remote monitoring, the preventive maintenance and breakdown maintenance can be Provided on time and the downtime of the system can be reduced.

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