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Response of motor thermal overload relays and phase monitors to power quality events

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Abstract – **Laboratory tests were carried out on seven voltage monitoring relays to determine their operational characteristics. The objective was to gain an understanding of the impact of identical power quality events on different voltage monitors commonly installed on utilization equipment. The tests focused on typical monitors found on a local utility's customers' equipment including device models that have previously encountered power quality issues. A similar experiment was carried out on nine thermal overload relays that are widely used for motor protection. The results indicate that both the thermal overload and voltage monitoring relays are prone to erratic response and may be responsible for some nuisance trips observed on utilization equipment.**

Index Terms – Induction motors, voltage unbalance, single-phasing, relays, protection, phase monitor, thermal overload relay.

I. Introduction

Abnormal power quality events such as voltage unbalance and single-phasing are often encountered in plant operations. These events are known to affect operation of equipment including induction motors. In adverse circumstances, expensive equipment such as chillers and air compressors can be prematurely damaged if measures are not taken to protect them against some of these power quality events. Utilities advise their customers to protect their own equipment against power quality events. Depending on the installation and/or the equipment under consideration, the protective device can range from a fuse or fused contactor to sophisticated microprocessor based digital protective relays. For the protection of large and typically expensive motors, the use of numerical (or digital) protection relays is quite justified. The application of such multi-functional relays are described in [1] and [2]. The protection of small to medium and less critical motors is achieved with much cheaper devices such as phase monitors or thermal overload relays.

One of the most widely used motor protective devices - phase monitor relays, are marketed under various names such as phase protectors, phase monitors, voltage monitors, etc. The devices vary in price starting from a few tens of dollars to several hundreds. They also vary in functionality, and operate with different algorithms for calculating voltage unbalance.

Due to the differences in algorithms, the same power quality event can potentially trip some devices while other devices could be functional. On the other hand, some devices may not trip at all, in an event where trip is expected. Recently, several equipment fitted with these devices in a utility's distribution system experienced nuisance trips leading to calls to the utility. The utility dispatched engineers to affected sites to log voltage and current measurements over extended periods. In most cases, time was spent investigating elusive power quality events, which were probably due to false alarms from a protective device.

Consequently, a test program was initiated to evaluate the performance of a selected number of phase monitors. The focus was on typical phase monitors found on the utility's customer equipment including models that encountered power quality events in the past. The goal of the effort was to gain an understanding of the impact of identical power quality events on different phase monitors.

It was found that the devices exhibited different interpretation of voltage unbalance. In fact, most of the devices did not follow the industry definition of voltage unbalance. Due to inconsistent results obtained in the response characteristics of the phase monitors, the study was expanded to cover motor thermal overload relays. Thermal overload relays are typically mounted on contactors and are also used for motor protection. Nine overload relays from various manufacturers were procured and experimentally tested. The results indicate that both of these motor protective devices are prone to erratic response and may be responsible for nuisance trips on equipment.

This paper presents the findings of comparative experimental tests of phase monitors and thermal overload relays subjected to identical power quality events such as over/under voltage, voltage unbalance and single-phasing.

II. Phase monitors

Phase monitors are a cost effective means of protecting loads such as induction motors from potentially damaging effects during power quality events. The devices are able to detect over/under voltage, voltage unbalance, and loss of phase and phase reversal conditions. A typical phase monitor has three leads connected across the source and a pair of normally open and a normally closed contacts (some devices