Disturbance investigation

Analysis of unplanned events in system and equipment operation

At a glance

Statistics show that faults on individual equipment are very rare events – nevertheless, in extensive power supply systems, faults do occur frequently. Systems and equipment are typically designed to withstand certain disturbance events. However, as soon as mechanical, thermal or electrical stresses exceed equipment ratings or the actual condition of equipment, such disturbance events cause equipment faults and can lead to failures in system operation.

Siemens Power Technologies International (Siemens PTI) is experienced in analyzing the fragments of information that are available for post-event analysis, developing a clear picture of the real events and proposing suitable mitigation measures. Our disturbance investigation reports will deliver:

- an independent expert view on the events,
- clear documentation of the available data,
- detailed information on the basic physical concepts and implications on both the failed equipment and system operation.

The challenge

From the system perspective, equipment faults and failures in system operation occur frequently. Many fault and failure events show a rather clear and simple pattern and do not require further investigations. With other failures, the actual root causes, or the observed events in system operation, are not easily understood. This especially holds for multiple faults, which may lead to disastrous consequences and improbable operating sequences.

It is essential to investigate the subject from an independent point of view. Network operators tend to blame the performance of the equipment, while manufacturers often presume that the operational environment was exceeding the specified capabilities.

In order to analyze the event and to identify the root cause(s), the knowledge of different specialists, for instance in system protection, insulation coordination, system dynamics, network operation, or in the equipment of different vendors has to be combined. Furthermore, it is necessary to consider post failure conditions, events and operational procedures, and cross check official statements.

Our solution

The first step in a thorough disturbance investigation process is to clearly define which data is relevant, where and how to acquire this information, how missing information may be approximated and to cross check the various statements. Data verification may include site visits, interviews, analysis of reference events, and measurements on-site or in a laboratory.

It may also be necessary to discuss the events with non-technical parties, such as insurance companies, legal departments, regulators, other consultants or manufacturers.

The analysis is backed and supported by state-of-the-art, calibrated measuring devices, the latest software tools for modeling steady state, electromagnetic transients and dynamic behavior of equipment and systems, and by the vast experience of our engineers.

Based on the theoretical analyses, a draft hypothesis of the disturbance event is developed. By modeling the system in appropriate detail, it is then possible to verify the root cause and validate proposed mitigation measures. Finally, the report is delivered, and the results are presented to the involved parties.

Application examples

Unexpected transformer trip
During a switching operation in a 20 kV substation the feeding 110/20 kV transformer was tripped by overcurrent protection.

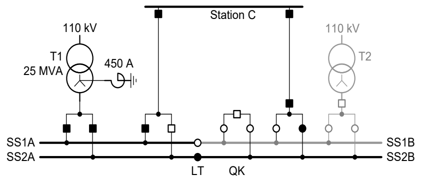

Figure 1: Substation configuration

The on-site inspection revealed that the isolator of the bus coupler had closed only two contacts. The task was to verify that the interruption of a single pole could cause an overcurrent trip of the feeding transformer. This was achieved in a first step by analyzing the situation in symmetrical components.

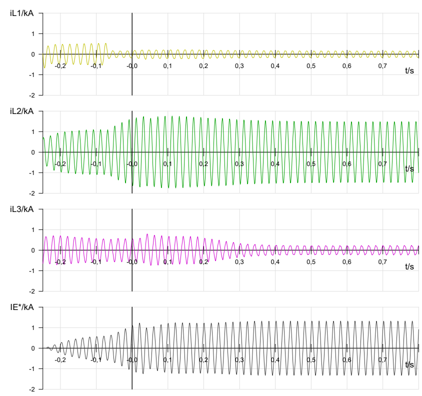

Figure 2: Phase and earth currents for single pole interruption

By modeling the system afterwards in a software tool, it was possible to show that in networks with resonant earthing / grounding, single phase interruptions can lead to over-currents and even overvoltages. The result of the analysis was the basis to propose improved protection settings to eliminate such failures in future.

Start-up failure of a power station
The trip of a low voltage drive resulted in an unsuccessful start-up process of a power station. Measurements showed a high level of voltage distortion under start-up conditions of the 6kV auxiliary bus. The distortion originated from the generator's start-up converter. Simulation of the configuration with instantaneous values in PSS®SINCAL resulted in similar diagrams as shown in the measurements of the disturbance. This underlines the high quality of the model for the converter drive. The simulation was then used to investigate mitigation options.

In addition to the well-known, but expensive solutions such as filter circuits, it was possible to present an efficient, site specific solution. The installation of a series reactor resulted in reliable start-up in both the simulation and the real power plant.

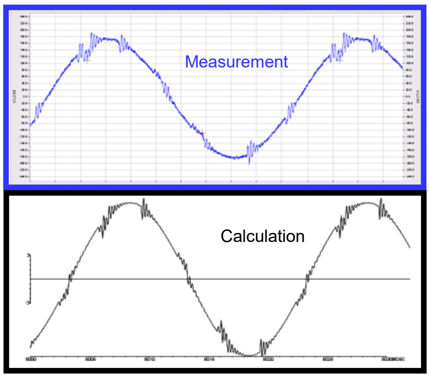

Figure 3: Simulated and measured voltage

Blackout of an industrial complex
A trip signal of a bus bar differential protection caused a costly blackout of a liquid natural gas (LNG) plant, as all busses of a double bus bar system were affected.

The analysis on-site revealed that the switchgear was composed of two sections from different vendors and the protection concept was a third-party engineering work.

By analyzing the fault records and local measurements, it was possible to reveal that the delay time of a single auxiliary contact started a crucial sequence of subsequent events. Defining a set of improved settings eliminated the cause of such failure events.

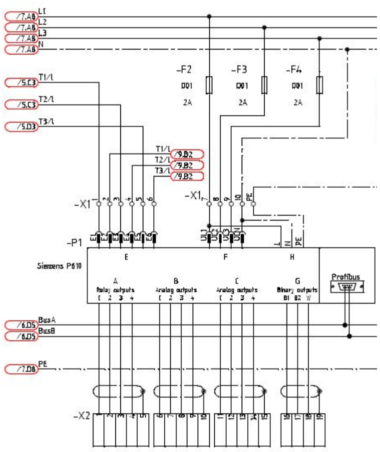

Figure 4: Secondary equipment configuration

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