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 the extensive power supply systems in total, 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), your provider of network consulting, network planning software and trainings on the Siemens T&D portfolio, is experienced in analyzing the fragments of information that are available for post-event analysis, in developing a clear picture of the real events and in 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 on the implications on both the failed equipment and on system operation.

The challenge

From the system perspective, equipment faults and failures in system operation do occur frequently. Many fault and failure events show a rather clear and simple pattern and do not require further investigations. But with other failures, the actual root causes, or even the observed events in system operation, are not easily comprehensible. Especially multiple faults may lead to disastrous consequences and very improbable operating sequences.

After such major disturbances there is either no, or very little, information available at all – or there is too much information, typically even with controversial pieces of information.

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 finally identify the root cause(s), the knowledge of different specialists has to be coordinated, e.g. on protection, insulation coordination, system dynamics, network operation, equipment of different vendors. Furthermore it is necessary to consider post failure conditions, events and operational procedures and to 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, by latest software tools for modeling steady state, electromagnetic transients and dynamic behavior of equipment and of systems, and by the vast experience of our engineers.

Based on the theoretical analyses, a draft hypothesis on the disturbance event is developed. By modeling the system in appropriate detail it is then possible to verify the root cause and also to 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.

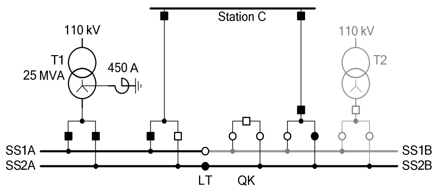

Figure 1: Substation configuration

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.

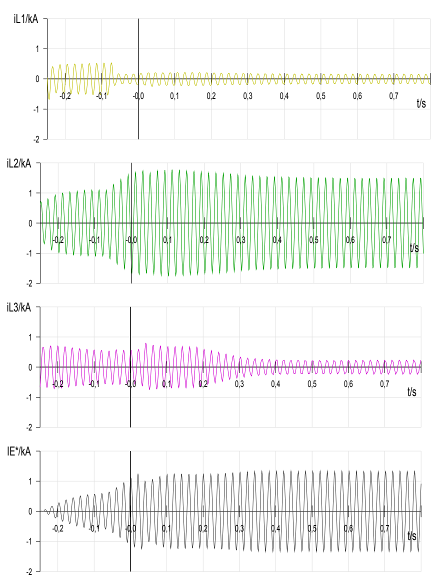

Figure 2: Phase and earth currents for single pole interruption

By modeling the system afterwards in a software tool it was possible to show that in networks with resonant earthing, single phase interruptions can lead to overcurrents 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 on the 6 kV auxiliary bus under start-up conditions. The distortion originated from the generator's start-up converter.

The simulation of the configuration with instantaneous values in PSS®NETOMAC 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 a very efficient, site specific solution. The installation of a series reactor resulted in reliable start-up in both the simulation and finally also in the real power plant.

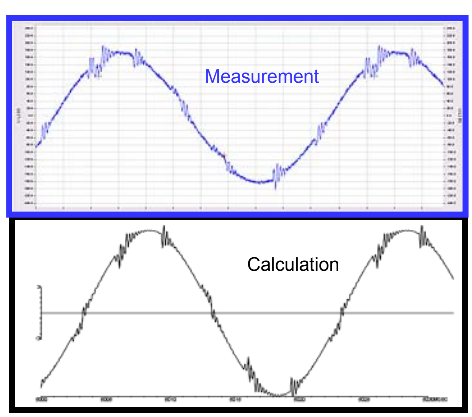

Figure 3: Simulated and measured voltage

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.

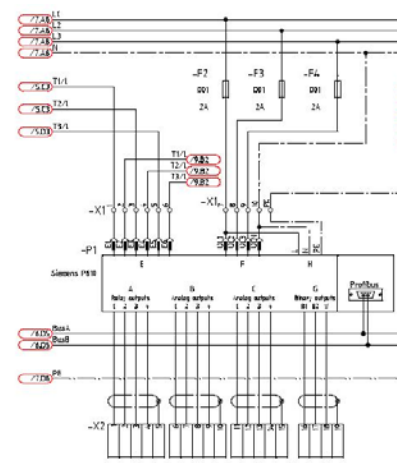

Figure 4: Secondary equipment configuration

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