Dynamics of industrial systems

Ability to cope with faults of external power systems

At a glance

In order to prevent power supply outages, the dynamic performance of a system needs to be observed. Industrial networks, which generate their own energy, are especially vulnerable to system instabilities. An individual solution must be developed and adapted to the needs of your industrial network in order to increase the stability of the system and thus avoid system outages.

Siemens Power Technologies International (Siemens PTI) can assist in the following:

- detecting the causes for power supply faults
- providing state-of-the-art simulation tools from the PSS® product suite to model system performances and identify possible solutions
- implementing the changes which will increase the stability of the industrial network

The challenge

Decoupling

Power plants and industrial plants that produce their own energy are capable, to a limited extent, of surviving serious faults in the external power system. Large frequency dips or longer periods of undervoltage, as a result of short circuits, for example, in the external system, can cause the internal power supply system to break down.

In addition to the steady-state behavior, various dynamic responses need to be considered in order to ensure reliable and safe system performance. The following are the main disturbances and faults that occur during operation.

Connecting transformers to the system

The connection of transformers may cause significant voltage problems due to the inrush current which occurs during switching. The system can be protected by taking different measures, such as voltage reduction, a gradual increase of voltage, or switching of salient poles according to the transformer flow.

Motor start-up

If large motors are connected to the system, it is important to examine whether the system is capable of ensuring the start-up of these motors. Asynchronous motors during start-up time require the reactive power of the external system, as well as of the generators. The system voltage has to stay sufficiently high.

For synchronous motors, it is important to determine if the machine is pulled up to speed or accelerated, asynchronously via the damper cage, and when and how the excitation is switched in.

Our solution

A power system fault can be detected by means of suitable indicators. These indicators can be current, voltage, power, phase, frequency or frequency gradient. Simulations can be used to model all power system faults and to determine the response of the plant in terms of stability, voltage recovery and frequency. This makes it possible to derive parameters for protecting the plant with regard to size and time, so that the stability of the generators and voltage recovery are ensured when there is a transition to isolated operation.

The dynamic response of the loads and generators, as well as the control response of the voltage regulators and turbines, must be considered for a safe transition to isolated operation. The results obtained are used to set the disconnecting devices and also considered for other protection settings, e.g. undervoltage protection.

As for a transformer connection, a suitable measure to overcome the transformer inrush must be defined. This could be acceleration through generator voltage, reduction of system voltage, or controlled switching, for instance.

For motor start-up, any of the following methods can be applied: direct start, reactor start, starter transformer, motor-starter or starting converter.

Special case: Isolated networks
Many industrial plants are operated as isolated networks (oil platforms, LNG-plants, ore mines, etc.). If an industrial plant is operated with separate energy supply, a variety of dynamic performances need to be considered in addition to the above mentioned switching operations.

The outage of a generator is the most critical fault and must be compensated with the reserve of the other machines or by load shedding. In this case the operating conditions and technically realizable possibilities need to be synchronized to ensure a continuous and reliable operation. The generator reserve can also be dependent on the process (required steam, possibility of using additional furnaces). Load shedding can be activated by signal as reaction to a generator outage or by frequency reduction, depending on whether fast frequency stabilization is required. Generator outages not only lead to a lack in active power, but in reactive power, which, among others, can cause the voltage to collapse.

Additionally, the demand for reactive power can be critical after short circuits, since motors or groups of motors have to accelerate again and therefore have a higher demand for reactive power at longer fault times, which cannot be supplied by the generators in the isolated network.

In large plants, large drive units are often installed. The outage of a drive or a chain of drives can lead to extensive unloading, resulting in high and dangerous overvoltages.

The system should be coordinated and the measures adjusted (reserve, disconnection of generators, protection, disconnection of loads, etc.). Due to their size, isolated networks react more critically to dynamic performances than networks which are connected to an external system.

Application example

Figure 1 shows the behavior of an industrial network operating close to the stability limit (rotor angle of approx. 180°) after a three-phase short circuit of 230 ms. At 240 ms, the system would become unstable. This information is important for setting the protective devices.

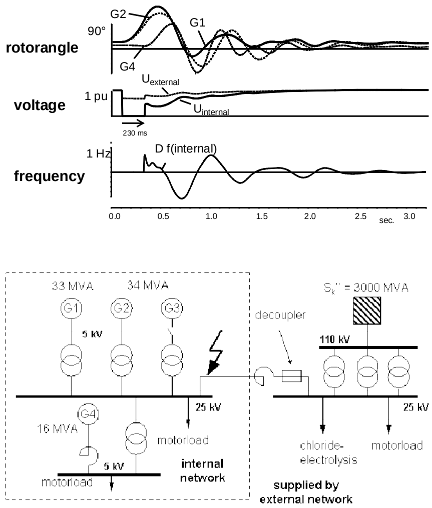

Figure 1: Generator stability

The example in Figure 2 shows a petrochemical plant with a desired voltage recovery after a 110 ms three-phase fault and the incapability of the system to handle a 150 ms short circuit. This information can be used for undervoltage trips of groups of motors for system backup.

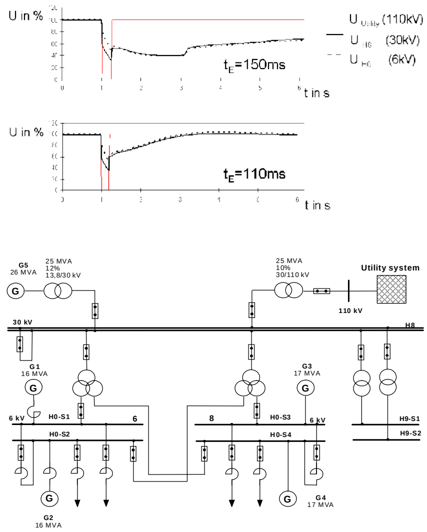

Figure 2: Voltage recovery after short circuit in 110 kV system for 150 / 110 ms

Published by
Siemens AG 2017

Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact:
power-technologies.energy@siemens.com

AL=N, ECCN=EAR99