Electrical Energy Production and Distribution

Location

Campus Offenburg, room B137

Profile and objectives

Increased requirements for operational safety and economic efficiency of the electrical energy supply have prompted the energy supply companies to have their power plants and high-voltage grids operated in interconnected operation.

One of the prerequisites for interconnected operation of three-phase networks is the synchronous operation of all generators. In case of errors (short circuit, load shedding, overload, etc.) the synchronism and thus the stability of the mains operation can be lost. Therefore, special requirements are placed on the stability of long transmission lines. In addition to the lectures EVE1 and EVE2, the "Model Power Plant" experiment is intended to familiarize students with these problems.

Through participation in the laboratory exercises and dealing with specific project tasks in the field of electrical energy engineering, students of the EP and EP-plus courses are to be enabled to consolidate and expand their basic knowledge acquired in various lectures on this topic. The aim is to put them in a position to work in the field of electrical energy technology, especially with electrical energy suppliers, if they have a corresponding interest after their bachelor's degree.

Scientific head of laboratory

Prof. Dr.-Ing. Sven Meier

Laboratory supervisor and laboratory assistant

Dipl.-Ing. (FH) Bernhard Schwarz

Test beds and equipment

1.1 Model power plant

The power plant is simulated by a diesel three-phase generator (nominal generator data: 230/400 V; 12.5 kVA; cosφ = 0.8). It is operated from a console.

The mechanically supplied power is adjusted by remote control of the engine's injection pump. A speed controller based on the centrifugal principle only permits speed changes within the control range when the generator is loaded and unloaded in isolated operation.

In emergency power mode, the generator is self-excited - in test mode, it is externally excited via the exciter replacement. Switching operations can be performed using the push-buttons located on the panel in the mimic diagram. The measurements are made via converters and measuring devices built into the console.

The transmission angle Θ is determined by illuminating an identification disc on the axis of the generator with a flash stroboscope.

The generator is roughly synchronized with the mains by manual connection after a comparison of voltage, phase sequence, phase position and frequency. Since the automatic synchronisation device is not in operation when the generator and mains are connected via the transmission line model, it is advisable to first establish the direct connection between the generator and the mains, to connect the long-distance line in parallel and then to disconnect the direct connection.

In contrast to the other tests, this test will initially only be conducted by the supervising student assistant or only under his/her direct instruction, since the generator set designed for the emergency power supply could not be equipped with all the safety interlocks desirable for a test operation.

Transmission line simulation

The 400 km long 220 kV overhead line is simulated in three phases by three π-links connected in series. A simple switchover to 1/3 of the cable length is possible.

Optionally, it can be fed into a rigid network and/or into a consumer. The rigid network is simulated by the university's low-voltage network.

Internships and Tutorials

1.2 Three-phase power grids

1.2.1 Symmetrical three-phase transmission

In the symmetrical three-phase current (DS) system, the sum of all phase currents at the neutral point is zero. Since the neutral conductor Mp remains currentless under symmetrical load, a single-phase operating circuit diagram (operating ESB) can be specified for the line in which Mp forms the return conductor; the return conductor now carrying current must be assumed to be impedance-free in order to achieve the same conditions as with a currentless return conductor with impedance. When designating the voltages, it must be noted that in single-phase operating ESB, phase voltages (= voltages conductor to neutral) are always used.

In the symmetrical DS system, these are calculated from the conductor voltages (= linked voltages) usually specified for DS networks by multiplying them by the factor 1/Ö3 When calculating power, the single-phase ESB delivers the power per phase, i.e. only 1/3 of the power of the entire D5 system.

The following applies to electrically short cables:

R » R'*l C » C'*l

L » L'*l G » G'*l

R', C', L' and G' sind die entsprechenden Leitungsbeläge. are the corresponding cable coverings. At f = 50 Hz and for the transmission lengths:

l < 200km for overhead power lines

l < 40km for cords

the above equations are a good approximation. With high operating voltages, losses can usually be neglected wher calculating currents and voltages (R' = O, G' = O).

1.2.2 Creating the Line Pointer Diagram

1.2.3 Demonstration of the static stability of the ideal three-phase current transmission

1.2.4 Grid regulaton

1.3 Model power plant and overhead line simulation

In the present experiment, various operating cases of a power plant feeding into a rigid grid via a 400 km long 220 kV overhead line are to be investigated at a model plant. The voltages and currents resulting from the operation of the model system are reduced by certain scale factors compared to those of the 220 kV system. However, since the phase angles are unchanged, the pointer diagrams are the same in both cases.

2.1 Grid feed

2.2 Recording of power curves

2.3 Recording of values for the construction of the remote transmission pointer diagram

2.4 Analysis of static stability

2.5 Recording of the mains curves