Power Transmission and Distribution

The major advantage of ac and three-phase technology over dc technology is that the electrical power is generated economically in large power stations relatively far from the end users, transported at high voltage over long distances with very little power loss and finally made available to the consumers the way they need it.

This is possible only by using transformers. In fact, they are suitable for stepping up the voltage of the generator to values which are suitable for high voltage systems, for power exchanging between networks, for stepping down the voltages to the medium voltage level and then for feeding the power into the low voltage network.

In this laboratory a three-winding transformer is investigated. It consists of three individual poles with different connection possibilities on the primary side and variable secondary voltage. The third winding (tertiary winding) is designed as the delta stabilizing winding needed for asymmetrical loads.

Overhead power lines are mainly used to transmit electrical energy from the power stations to the consumers. However, in densely populated areas the power can only be supplied via cables.

Both means of transmission, overhead lines and cables, are included in the general term “line”.

Today, the public supply of power takes place almost exclusively by means of three-phase current with frequency of 50 or 60 Hz, depending upon the Country. Due to the phase shift of the three currents in a three-phase system, a rotating field is created which is ideal for use by consumers. Furthermore, another advantage of three-phase systems is that they provide the consumers with two different levels of voltage, so that he can use his equipment in the best economical way.

In this laboratory a three-phase model of an overhead power transmission line (with a simulated length of 360 km long, a simulated voltage of 380 kV and a simulated current of 1000 A) is used, with a scale factor of 1:1000.

The performance characteristics of the line are investigated under various load conditions. Circuit configurations are then connected for the demonstration of various neutral point connections in three-phase mains systems. Asymmetrical short-circuits are also simulated.

Questions regarding reactive power compensation are finally addressed. But, transmission networks require a great number of lines and transformers as well as switchgears and substations.

Of course, because of the importance of electrical power, special attention is paid to guaranteeing the smooth operation of all the transmission devices.

Various voltage levels are used for transmitting power; the levels are determined by the amount of power and the distance; the higher the transmission voltages, the lower the currents as well as the transmission losses. However, it must also be considered that network investment costs increase with the voltage.

To evaluate the optimum network configuration heavy calculations have to be carried out. In this laboratory the basic circuits of power engineering, series and parallel connections of operating equipment (lines, transformers) as well as circuits involving the conversion of delta connections to star connections and vice versa, are analyzed.

Also busbars, disconnectors, power circuit breakers, voltage and current transformers are studied; these, in fact, are among the most important components of a switching station.

Three-phase transformer - GTU102.1

- determination of the vector group of the three-phase transformer
- determination of the voltage transformation ratio of the transformer operating at no-load
- determination of the current transformation ratio of the transformer operating with short-circuit
- determination of the equivalent circuit quantities based on the consumed active and reactive power
- measurement of the effect of the load type and magnitude on the performance of the secondary voltage
- determination of the efficiency of the transformer
- investigation of the zero-impedance of the three-phase transformer with various connection modes
- examination of the load capacity of the secondary side using a single-phase load with different connection modes on the primary side
- determination of the influence of a delta stabilizing winding
- demonstration of the possibility of utilizing a three-phase transformer in economy connection (autotransformer)

ELECTRICAL POWER ENGINEERING

Overhead line model - GTU102.2

- measurement of the voltages in no-load operation
- concept of operating capacitance
- line model with increased operating capacitance
- measurement of current and voltage relationship of an over-head line in matched-load operation; interpretation of the terms: characteristic wave impedance, lagging and leading operation, efficiency and transmission losses
- measurement and interpretation of the current and voltage ratios of a transmission line during a three-phase short-circuit
- measurement and interpretation of the current and voltage ratios of a transmission line with mixed ohmic-inductive and pure inductive loads
- measurement and interpretation of the current and voltage ratios of a transmission line with mixed ohmic-capacitive and pure capacitive loads
- investigation on the performance of a transmission line with isolated neutral point connection in the case of a fault to earth
- measurement of the earth-fault current and the voltage rise of the faulty phases
- determination of the inductance of an earth-fault neutralizer for the overhead line model
- investigation on the performance of a transmission line with a fault and comparison of the current values with those determined during earth-fault with isolated neutral point system
- measurement of the fault currents of asymmetrical short-circuits and comparison of the results with those for a three-phase fault
- investigation on the effect of parallel compensation on the voltage stability at the load and the transmission losses of the line
- investigation on the effect of series compensation on the voltage stability at the load
- use of measurement techniques to determine the zero-phase sequence impedance of the overhead line model and comparison of this value with the theoretical one

Series and parallel connection of HV lines - GTU102.3

- measurement of the voltage distribution in the series connection of two lines without operating capacitances
- measurement of the voltage distribution in the series connection of two lines with operating capacitances
- measurement of the voltage distribution in the parallel connection of two lines without operating capacitances
- measurement of the voltage distribution in the parallel connection of two lines with operating capacitances

Busbar systems - GTU102.4

- operation of a switching station with two busbars and different voltages
- busbar transfer with interruption of the power supply to the consumer
- busbar coupling and bus transfer without interruption of the power supply to the consumer
- switching sequence for disconnectors and power circuit breakers

		GTU102.1	GTU102.2	GTU102.3	GTU102.4	TOTAL
Variable three-phase power supply	DL 1013T1	1	1	1		1
Line model	DL 7901TT		1	2	1	2
Three-phase transformer	DL 1080TT	1	1	1	1	1
Resistive load	DL 1017R	1	1	1	1	1
Inductive load	DL 1017L	1	1	1		1
Capacitive load	DL 1017C	1	1			1
Three-phase power supply	DL 2108TAL-SW		1		1	1
Power circuit breaker	DL 2108T02		1	1	4	4
Double busbar with two disconnectors	DL 2108T02/2				1	1
Double busbar with four disconnectors	DL 2108T02/4				1	1
Line capacitor	DL 2108T03		2			2
Petersen coil	DL 2108T04		1			1
Moving coil ammeter (100-500-1000mA)	DL 2109T1A	1	1			1
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5	2	3	3	3	3
Moving iron voltmeter (600V)	DL 2109T1PV		2		2	2
Moving iron voltmeter (125-250-500V)	DL 2109T3PV	2		3		3
Power meter	DL 2109T26	2	1			2
Power factor meter	DL 2109T27		1			1
Connecting leads	DL 1155GTU	1	1	1	1	1
Table	DL 1001-1	1	1	1	1	1
Frame	DL 2100-3M	2	2	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1	1	1
For Countries with 3-phase mains different from 380V:						
Three-phase transformer	DL 2100TT	1	1	1	1	1