POWER TRANSMISSION AND DISTRIBUTION
DL GTU102-S

Introduction:

Today, the public electric power is supplied almost exclusively using three-phase systems with a frequency of 50 or 60 Hz, depending on the country. The major advantage of AC three-phase over DC power systems 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 providing them with two different levels of voltage depending on the application needs.

The major components of electric power transmission and distribution systems are:

- Transformers: step up transformers increase the generated voltage to values suitable for high voltage transmission systems, isolation transformers are used to exchange power between networks, and step down transformers decrease the voltages to medium voltage level and further down to low voltage to be distributed to the consumer.
- Transmission lines: 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. 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.

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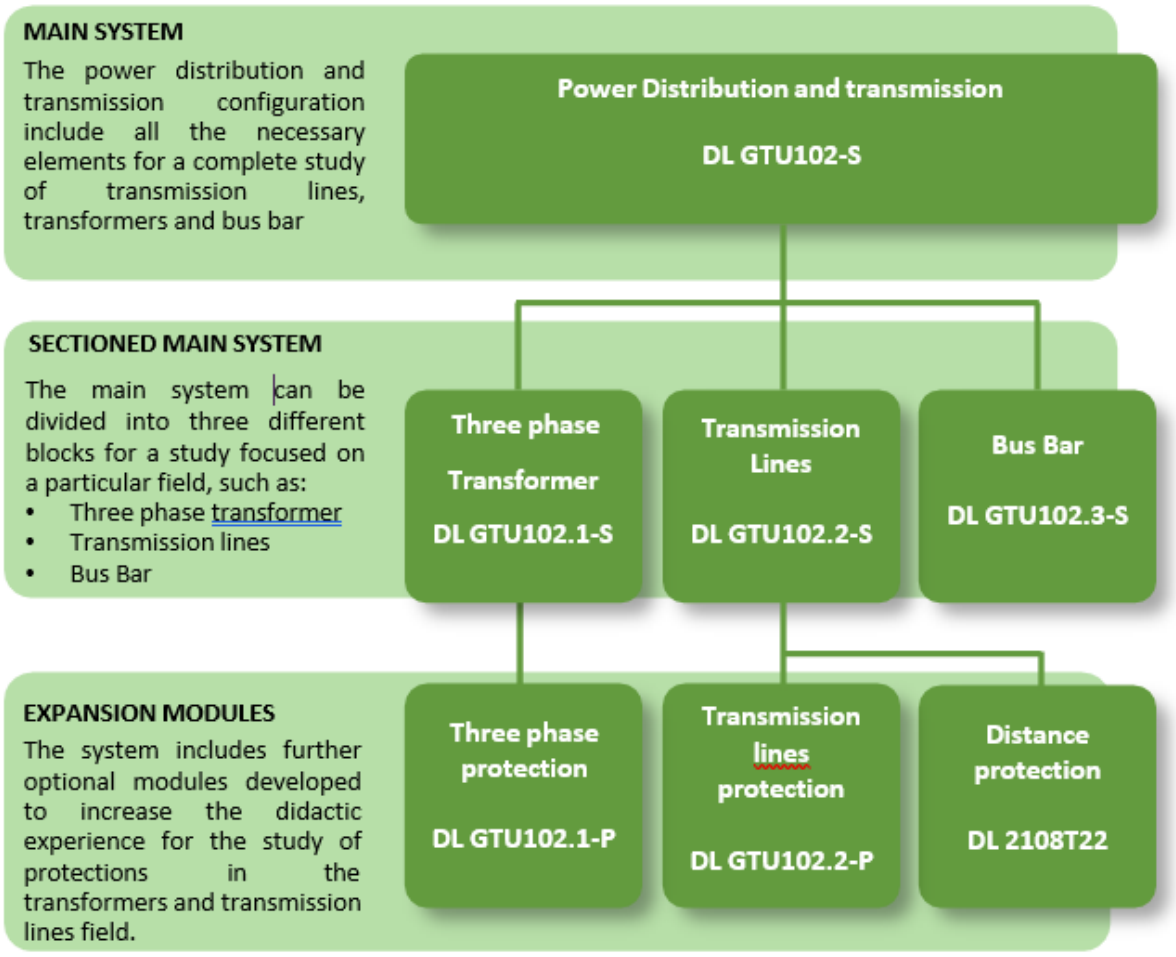
- Busbars, disconnectors and power circuit breakers: they are the main components found in a switching station used for power distribution.

To evaluate the optimum network configuration complex calculations have to be carried out.

Laboratory description

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. Our system, composed of a modular configuration, allows the student to identify immediately the main components. Three-phase transformers, transmission lines and bus bar are the main subjects of study. The entire lab can be divided in three different configurations, related to the three subjects of study, to perform a didactic experience focused on that specific field.

The graph below consists of a block diagram, which clarifies the system division, subjects of study and expansions.



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ELECTRICAL POWER ENGINEERING

Experiments:

DL GTU102-S - Power Distribution and transmission

DL GTU102.1-S - Three-phase transformers

- Transformer vector group.
- Transformer no load performance.
- Transformer short-circuit performance and equivalent circuit.
- Load performance.
- Zero impedance.
- Asymmetrical load.
- Autotransformer.
- Parallel operation.

DL GTU102.2-S - Transmission lines

Studies on three-phase transmission lines

- No-load performance, Ferranti effect.
- Matched load performance.
- Three-phase symmetrical short-circuits.
- Resistive-inductive load.
- Resistive-capacitive load.
- Zero-phase impedance.
- Parallel compensation for a resistive-inductive load.
- Series compensation for a resistive-inductive load.
- Three-phase asymmetric short-circuit.

Parallel and series connection of transmission lines

- Series connection of two lines.
- Parallel connection of two lines.

Transmission line with earth-fault compensation

- Earth fault on a line with an isolated star point.
- Petersen suppression coil.

DL GTU102.3-S – Bus bar

Three-pole double busbar systems

- Basic double busbar system.
- Double busbar system with load.
- Busbar coupling.

Network topologies

- Radial network.
- Meshed network (DL GTU102.2-P is required).

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Expansion:

Adding optional modules to the configurations (DL GTU102-S or DL GTU102.1-S and DL GTU102.2-S), the available list of experiments and system capabilities are expanded.

DL GTU102.1-P Transformer protection

- *Parameter configuration, fault simulation, relay response measurement and oscillograph recording for the following protections:*
  - Time overcurrent protection
  - Transformer differential protection

DL GTU102.2-P Transmission line protection

- *Parameter configuration, fault simulation, relay response measurement and oscillograph recording for the following protections:*
  - Inverse time overcurrent protection
  - Earth-fault protection
  - Undervoltage and overvoltage protection
  - Unbalanced load protection
  - Directional power protection
  - Protection of parallel connected lines

DL 2108T22 Distance protection

- *Parameter configuration, fault simulation, relay response measurement and recording for the following protections:*
  - Overcurrent protection
  - Overvoltage protection
  - Undervoltage protection
  - Unbalanced load protection
  - Distance protection

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List of modules

DL GTU102-S

DL 1013T1MR	Motorized variable three-phase power supply	1
DL 1080TT	Three-phase transformer	2
DL 2109T29	Three-phase power meter	2
DL 1017R	Resistive load	1
DL 1017L	Inductive load	1
DL 1017C	Capacitive load	1
DL 2108T02	Power circuit breaker	4
DL 2109D51	Digital Vector group meter	1
DL 2109D30	Digital Power meter	1
DL 7901TT	Overhead line model	2
DL 7901TTS	Overhead line model 110Km	1
DL 2108T03	Line capacitor	2
DL 2108T04	Petersen Coil	1
DL 2108T02/2	Double busbar with two disconnectors	3
DL 2102AL	Three-phase supply unit	1
DL HUBRS485F	Communication MODBUS	1
DL 2600TTI	Three-phase isolation transformer	1
DL SCADA-256	SCADA Software with capacity limited to 256 tags	1
DL PCGRID	All-in-One Computer	1
TLGTU102.T	Cables	1
DL 1196	Holder for leads	1
DL T12090_SK	120x90 working bench	2
DL T06090	60x90 working bench	2
DL A120-3M	Frame with three levels, basic version	2
DL SP-A120-LED	Upper base with LED strip, for DL A120-3M	2

Expansion modules

DL GTU102.1-P

DL 2108T21	Differential transformer relay	1
DL 2109T22	Three-phase current transformer	2
DL T06090	60x90 working bench	1

DL GTU102.2-P

DL 2108T13	Inverse time overcurrent relay	1
DL 2108T18	Earth-fault relay	1
DL 2108T23	Feeder manager relay	1

DL 2108T22

DL 2108T22	Distance protection relay	1

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DL 1017L	Inductive load	1
DL 1017C	Capacitive load	1
DL 2108T02	Power circuit breaker	1
DL 2109D51	Digital Vector group meter	1
DL HUBRS485F	Communication MODBUS	1
DL 2600TTI	Three-phase isolation transformer	1
DL SCADA-256	SCADA Software with capacity limited to 256 tags	1
DL PCGRID	All-in-One Computer	1
TLGTU102.X	Cables	1
DL 1196	Holder for leads	1
DL T12090_SK	120x90 working bench	1
DL T06090	60x90 working bench	1
DL A120-3M	Frame with three levels, basic version	1
DL SP-A120-LED	Upper base with LED strip, for DL A120-3M	1

Expansion modules

DL GTU102.1-P

DL 2108T21	Differential transformer relay	1
DL 2109T22	Three-phase current transformer	2

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DL 2109T29	Three-phase power meter	2
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DL 2109D30	Digital Power meter	1
DL 7901TT	Overhead line model	2
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DL SCADA-256	SCADA Software with capacity limited to 256 tags	1
DL PCGRID	All-in-One Computer	1
TLGTU102.X	Cables	1
DL 1196	Holder for leads	1
DL T12090_SK	120x90 working bench	2
DL A120-3M	Frame with three levels, basic version	2
DL SP-A120-LED	Upper base with LED strip, for DL A120-3M	2

Expansion modules

DL GTU102.2-P

DL 2108T13	Inverse time overcurrent relay	1
DL 2108T18	Earth-fault relay	1
DL 2108T23	Feeder manager relay	1

DL 2108T22

DL 2108T22	Distance protection relay	1

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List of modules

DL GTU102.3-S

DL 1080TT	Three-phase transformer	1
DL 2109T29	Three-phase power meter	2
DL 1017R	Resistive load	1
DL 2108T02	Power circuit breaker	4
DL 7901TT	Overhead line model	1
DL 2108T02/2	Double busbar with two disconnectors	3
DL 2109D30	Digital Power meter	1
DL 2109D51	Digital Vector group meter	1
DL 2102AL	Three-phase supply unit	1
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