APPENDICES A

Power distribution system modeling with DIgSILENT PowerFactory

A.1 DIgSILENT PowerFactory program

DIgSILENT PowerFactory or PowerFactory program is a program used to create the model. To analyses power supply system, all models can be created in the form of pictures or writing. The program writing in the form of a Text File also has the ability to analysis power supply system. A wide variety of power flow analysis, problem analysis and short circuit. The Analysis of protection systems, power loss analysis system analysis and reliability. A system for using DIgSILENT PowerFactory program in this thesis will be used the program to Version 15.1 in DIgSILENT PowerFactory [14] modelling and analysis of the issue.

A.1.1 The structure of the program PowerFactory

The structure of the program, there are several PowerFactory sections on this topic will be discussed. The specific structure of the highlights includes a data management structure for the various electrical systems. It created and stored in the program window's components PowerFactory Main Window.

1) The management structure of data in the program PowerFactory

The information management program will be located in the Data window PowerFactory. Manager, which shows the folder structure to store data in a Database as shown in Figure A.1.

1.1 Main Library Folder contains the Types and Models of various standards programs PowerFactory.

1.2 System Folder contains the o bject used within the PowerFactory which, if you want to update in the User must Log on Edit. Only Administrator's Account

and what should be done under the guidance from DIgSILENT customer support because it will affect the operation of the program.

1.3 User Account Folders contains a folder of the Project and Setting. Normal User-defined according to various examples is the Aksacksy User.

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| | System | 12/6/2006 9:53:10 P | Administrator | 1 |
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Figure A.1 Shows the Data Window Manager the data storage structure

2) The various components of the Main Window.

Components of the Main window, the Window contain the 10 key components as shown in Figure A.2.

2.1 Title Bar is the bar shows the name and Version of the program.

2.2 Menu Bar is the main command bar of the program.

2.3 A Main Tool Bar button is used instead of the main Menu Bar in command, which can be activated immediately.

2.4 Drawing Tool Bar buttons that are used to create the device, an electrical system in a different model.

2.5 Data Manager Window is a window that displays a Data structure to store all of the data.

2.6 Context Menu is the window that is displayed when you rightclick the folder in the Object Data Manager.

2.7 Output Window is a window that displays the results of calculations or display Error.

2.8 Output Tool Bar is the Tool Bar which works attributed to the Output Window.

2.9 Workspace is the area that is used to create the Single Line

Diagram.

2.10 Status Bar displays the status on the workpiece that is Active.



A.1.2 Modelling a system test 4 buses

Test system for model 4 bus to make it as a model system to test. IEEE standards information to create it as a reference by IEEE Bus Feeder 4 Test Cases [12].

1) Creating a node or a bus (Creating Terminal)

Clicking on the bus — (Terminal) or node • (Point Terminal) on the Drawing Toolbar on the right side, then placed in the Workspace by

moving areas. Mouse to where you want to create the node, or a bus, then left click 1 time to paste. Equipment (create a vertical bus, right-click, and then select the Clockwise or Counter Clockwise Rotate) bus as shown in Figure A.3. To cancel create the Drawing mode, the device, press and hold the Esc or right-click 1 time, then it will be able to choose a different image to create the device.

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Figure A.3 Create the Drawing the bus on the Workspace

Input data bus can do so by double-clicking the bus appears Dialog Box of a loud bus as shown in Figure A.4. Each window of analysis will provide different input. In this case study, data input as shown in Table A.1.

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| Load Flow | Name IBUS A | | |
|------------------------------|--|---|-------------|
| VDE /IEC Sheet Cir | Terr Lal | | |
| | | | Cancel |
| Complete Short-Cire | Area | | Jump to |
| ANSI Short-Circuit | | | Cubicles |
| IEC 61363 | Out of Service | | |
| DC Short-Circuit | System Type AC | ✓ Usage Busbar | - |
| BMS-Simulation | Phase Technology ABC-N | | _ |
| EMT-Simulation | Nominal Voltage | _ | |
| Harmonics/Power | Quality Line-Line 12.47 | kV | |
| Protection | Line-Ground 7.19955 | 8 kV | |
| Optimal Power Flow | N | | |
| Reliability | Earthed | | |
| Generation Adequa | асу | | |
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| | Figure A.4 The | e input data bus or node | |
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| | Figure A.4 The Table A. | e input data bus or node 1 Data on that bus | |
| Jame | Figure A.4 The Table A. Phase Technology | e input data bus or node 1 Data on that bus Line to Line Voltage | Voltage Typ |
| Jame | Figure A.4 The Table A. Phase Technology | e input data bus or node 1 Data on that bus Line to Line Voltage | Voltage Typ |
| Jame US_A | Figure A.4 The Table A.1 Phase Technology ABC-N | e input data bus or node 1 Data on that bus Line to Line Voltage 12.47 kV | Voltage Typ |
| Jame US_A | Figure A.4 The Table A. Phase Technology ABC-N | e input data bus or node 1 Data on that bus Line to Line Voltage 12.47 kV | Voltage Typ |
| Jame US_A US_B | Figure A.4 The Table A. Phase Technology ABC-N ABC-N | e input data bus or node 1 Data on that bus Line to Line Voltage 12.47 kV 12.47 kV | Voltage Typ |
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| Name US_A US_B US_C | Figure A.4 The Table A. Phase Technology ABC-N ABC-N ABC | e input data bus or node 1 Data on that bus Line to Line Voltage 12.47 kV 12.47 kV 4.16 kV | Voltage Typ |
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2) To build the transmission line (Line)

Select a device line r_1 (Line) from the Drawing Toolbar on the right side, then placed in the Workspace area by clicking on one of the bus first and then come. Click on another bus that you want to connect to the transmission line will be the link between the two, such as a bus. Create a link between the bus line 1 and 2 by selecting the line from the Drawing Toolbar and then click on the bus 1 first and then click on the bus 2 as shown in Figure A.5.

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Figure A.5 Create the building transmission line

Input data transmissions made by double-clicking on a line will appear on the Dialog Box on the line as shown in Figure A.6. Then the input data of the transmission line as shown in Table A.2.

| | 5 | | 1 1-1 | N/ | ~ 11 | | |
|-----------------------------|--|---------------------------------------|-------|---|----------------|------|--------|
| Line - Grid\Line_A-B.ElmLne | | | | | | ? | × |
| Basic Data | Name | Line_A-B | | | | C | Ж |
| Load Flow | Туре | ▼ → | | | | Ca | ncel |
| VDE/IEC Short-Circuit | Terminal i | ▼ → Grid\BUS_A\Cub_1 | | BUS_A | | | |
| Complete Short-Circuit | Terminal j | ▼ → Grid\BUS_B\Cub_1 | | BUS_B | | Figu | ire >> |
| ANSI Short-Circuit | Zone | Terminal i 🔹 🔹 | • | | | Jump | o to |
| IEC 61363 | Area | Teminal i 💌 🔹 | • | | | | |
| DC Short-Circuit | Out of Service | | | | | | |
| RMS-Simulation | Number of | | | Resulting Values | | | |
| EMT-Simulation | parallel Lines | 1 | | Rated Current (act.) | 0. kA | | |
| Harmonics/Power Quality | Parameters | | | Pos. Seq. Impedance, 21 Pos. Seq. Impedance, Angle | 0. deg | | |
| Optimal Power Flow | Thermal Rating | ▼ + | | Pos. Seq. Resistance, R1 | 0. Ohm | | |
| Reliability | Length of Line | 0.6096 km | | Zero Seq. Resistance, R0 | 0. Ohm | | |
| Generation Adequacy | Derating Factor | 1. | | Zero Seq. Reactance, X0 Farth-Fault Current Ice | 0. Ohm 0. A | | |
| Tie Open Point Opt. | Laying | Ground | | Earth Factor, Magnitude | | | |
| Cable Sizing | | | | Earth Factor, Angle | | | |
| Description | Line Model C Lumped Para Distributed P Sections/I | ameter (PI) arameter Line Loads | | | | | |

Figure A.6 The input data of transmission line

| Name | Terminal Con | nect to BUS | Type of Line | Length (km) |
|----------|--------------|-------------|---------------|-------------|
| | Ι | j | | 5 () |
| Line A-B | А | В | Line A-B Type | 0.6096 |
| Line C-D | С | D | Line C-D Type | 0.762 |

Table A.2 Data on the transmission line

Then determine the type of transmission line for the case study, this will create a kind of new Type Tower cables by selecting New Project Type => Tower Type as shown in Figure A.7.

| | 11/ 1 | | | | |
|-----------------------------|---|-------------------------------------|-------|---|-----------|
| Line - Grid\Line_A-B.ElmLne | • | | | | ? × |
| Basic Data | Name | Line_A-B | | | ок |
| Load Flow | Туре | | | | Cancel |
| VDE/IEC Short-Circuit | Terminal i | Select Global Type | | BUS_A | |
| Complete Short-Circuit | Terminal j | Select Project Type | > | BUS_B | Figure >> |
| ANSI Short-Circuit | Zone | New Project Type | > | Line Type (TypLne) | Jump to |
| IEC 61363 | Area | Paste Type | | Tower Type (TypTow) | |
| DC Short-Circuit | Out of Service | Remove Type | | Tower Geometry Type (TypGeo) | |
| RMS-Simulation | Number of | | | Cable Definition (TypCabsys) | |
| EMT-Simulation | parallel Lines | 1 | | Rated Current (act.) 0. kA Pos Sea Impedance 71 0. Ohm | |
| Harmonics/Power Quality | Parameters | | | Pos. Seq. Impedance, Angle 0. deg | |
| Optimal Power Flow | Thermal Rating | ▼ → | | Pos. Seq. Resistance, R1 0. Ohm Pos. Seq. Reactance, X1 0. Ohm | |
| Reliability | Length of Line | 0.6096 km | | Zero Seq. Resistance, R0 0. Ohm | |
| Generation Adequacy | Derating Factor | 1. | | Zero Seq. Reactance, X0 0. Ohm Earth-Fault Current, Ice 0. A | |
| Tie Open Point Opt. | Laying | Ground | | Earth Factor, Magnitude | |
| Cable Sizing | | | | Earth Factor, Angle | |
| Description | Line Model C Lumped Para C Distributed Pa Sections/L | meter (PI) srameter ine Loads | | | |
| | Figure A. | 7 The input da | ata c | of transmission line | e d |

A Dialog Box will appear in the input data of transmission line. Tower

model Type, as shown in Figure A.8.

| Tower Type - Equipment Typ | e Library\Line_A-B Tower Type.Ty | rpTow * | ? × |
|----------------------------|-----------------------------------|-------------------------------------|-----------|
| Basic Data | General Geometry | | ОК |
| Load Flow | Name | Line_A-B Tower Type | Cancel |
| VDE/IEC Short-Circuit | Nominal Frequency | 50. Hz | |
| Complete Short-Circuit | Number of Earth Wires | 1 * | Calculate |
| ANSI Short-Circuit | Number of Line Circuits | 1 Transposition none | |
| IEC 61363 | Input Mode | | |
| DC Short-Circuit | Geometrical Parameter | Earth Conductivity 100. | |
| RMS-Simulation | C Electrical Parameter | | |
| EMT-Simulation | Types of Earth Conductors: | | |
| Harmonics/Power Quality | | Conductor Types TwoCon | |
| Optimal Power Flow | Earth Conductor 1 | | |
| Reliability | | | |
| Generation Adequacy | | | |
| Description | | | |
| | Conductor Types of Line Circuits: | Types Num. of Phases Transposition | |
| | TypCo | | |
| | | 3. | |
| | | | |
| | | | |
| | | | |
| | • | | |
| | | | |
| | | 1 ma | 11 |
| Figu | e A 8 To create | a data transmission of a Tower Type | _ |
| 11501 | e mo no ereau | a data transmission of a rower ryp | |

To choose a Mode Input Electrical Parameter and then creating the replica of the phase line by double-clicking on a space in the first column of the first row. Type of Conductor Line Circuits as shown in Figure A.9.

| | | | | | 111. |
|----------------------------|--|---------------------|---------------|----------|-----------|
| Tower Type - Equipment Typ | e Library\Line_A-B Tower Type.Typ | Tow * | | | ? × |
| Basic Data | General Geometry | | | | ОК |
| Load Flow | Name | Line_A-B Tower Type | | | Cancel |
| VDE/IEC Short-Circuit | Nominal Frequency | 50. Hz | | | |
| Complete Short-Circuit | Number of Earth Wires | 1 📫 | | | Lalculate |
| ANSI Short-Circuit | Number of Line Circuits | 1 📫 | | | |
| IEC 61363 | Input Mode | | | | |
| DC Short-Circuit | C Geometrical Parameter | | | | |
| RMS-Simulation | Electrical Parameter | | | | |
| EMT-Simulation | | | | | |
| Harmonics/Power Quality | | | | | |
| Optimal Power Flow | | | | | |
| Reliability | | | | | |
| Generation Adequacy | | | | | |
| Description | Conductor Tunco of Line Circuite: | | | | |
| | Conductor Types of Elife Circuits. | pes Num. of Phases | Transposition | | |
| | ►Circuit 1 | 3. | | • | |
| | | | | | |
| | <u> </u> | | | <u>▼</u> | |
| 1 | | | | | |

Figure A.9 Setting conductors of the phase line

Appears next to the Data Manager for the select or create the Guide, click on the Menu Bar, 👔 as shown in Figure A.10, to make the line a new phase.

| Please Select 'Conductor Type' - Library\Equipment Type Library : | ? × |
|--|------------------------|
| Image: Study Cases Image: | OK Cancel Filter |
| Ln 1 0 object(s) of 1 0 object(s) selected | /// |

Figure A.10 Modelling conductors of the phase line.

A Dialog Box window appears, as shown in Figure A.11 for data input as conductor. Phase wiring for in this case study, the data input as shown in Table A.3, when input data is finished, press OK.

| onductor Type - Equipmer | nt Type Library\Phase_12.47_kV | .TypCon | | | ? × |
|--------------------------|---------------------------------------|-------------|--------|---|--------|
| Basic Data 📥 | Name | Phase_12.47 | _kV | | ОК |
| Load Flow | Nominal Voltage | 12.47 | kV | | Cancel |
| VDE/IEC Short-Circuit | Nominal Current | 0.53 | kA | | |
| Complete Short-Circuit | Number of Subconductors | 1 ÷ | | | |
| ANSI Short-Circuit | | | | | |
| IEC 61363 | Conductor Model | | | | |
| DC Short-Circuit | Solid Conductor Tubular Conductor | | | | |
| RMS-Simulation | | | | | |
| EMT-Simulation | (Sub-)Conductor | | _ | ⇒ | |
| Harmonics/Power Quality | DC-Resistance (20?C) | 0.1901448 | Ohm/km | | |
| Optimal Power Flow | GMR (Equivalent Radius) | 7.43712 | mm | | |
| Reliability | Outer Diameter | 18.3134 | mm | | |
| Generation Adequacy | | | | | |
| Description | Skin effect | | | | |

Figure A.11 To input data, a leading cable system test phase 4 buses

| | Nomi | nal | DC Resistance | GMR | Outer Diameter |
|------------------|-----------------|--------------|----------------|----------|-------------------|
| Name | Voltage (kV) | Current (kA) | (20C) (Ohm/km) | (mm) | (mm) |
| Phase_12.47_kV | 12.47 | 0.53 | 0.190139585 | 7.43712 | 18.3134 |
| Neutral_12.47 kV | 12.47 | 0.34 | 0.36786180326 | 2.481072 | 14.3002 |
| Phase_4.16 kV | 4.16 | 0.53 | 0.190139585 | 7.43712 | 18.3134 |

Table A.3 Data transmission line conductor

Then came a Load Flow Resistance and Reactance values for input of

the transmission line and then input the values as shown in Table A.4, as shown in Figure 23.21

1 ~ She

A.12.

| lasic Data | Impedances | Admittances | | | | | ОК |
|-----------------------|-------------|-----------------|-----------|-----------|--------------|----------|----------|
| oad Flow | | | | | | → | Cancel |
| DE/IEC Short-Circuit | Matrix of F | Resistances R_i | [Ohm/km]: | | | | |
| omplete Short-Circuit | | 1 | 2 | 3 | • | | Calculat |
| NCI Sheet Course | 2 | 0.0966703 | 0.2901722 | 0.0979555 | | | |
| Not onon-circuit | 3 | 0.09512069 | 0.0979555 | 0.286934 | | | |
| | | | | | | | |
| C Short-Circuit | | | | | | | |
| MS-Simulation | | | | | | | |
| MT-Simulation | | | | | • | | |
| amonics/Power Quality | | | | | • | | |
| ntinual Danuar Danu | Matrix of F | Reactances X_ij | [Ohm/km]: | | | | |
| pumai Fower Flow | | 1 | 2 | 3 | | | |
| eliability | | 0.6705416 | 0.3121856 | 0.2397339 | ^ | | |
| ieneration Adequacy | 2 | 0.3121836 | 0.6519041 | 0.6624669 | | | |
| escription | | 0.2337333 | 0.2037033 | 0.0024003 | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | • | | |
| | | | | 1 | • | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Figure A.12 Input Resistance and Reactance values of line test system 4 bus

| Table A.4 The Resistance and Reactance data of | f transmission line |
|--|---------------------|
|--|---------------------|

| Name | e | Matrix of R | esistances R_i | j (Ohm/km) | Matrix of R | eactance X_i | j (Ohm/km) |
|--------|----|-------------|----------------|------------|-------------|--------------|------------|
| of Lin | es | 1 | 2 | 3 | 1 | 2 | 3 |
| Lino | 1 | 0.284482 | 0.0966703 | 0.09512069 | 0.6705416 | 0.3121856 | 0.2397339 |
| A-B | 2 | 0.0966703 | 0.2901722 | 0.0979555 | 0.3121856 | 0.6519041 | 0.2637839 |
| | 3 | 0.09512069 | 0.0979555 | 0.286934 | 0.2397339 | 0.2637839 | 0.6624669 |

| Name | e | Matrix of R | esistances R_i | j (Ohm/km) | Matrix of R | eactance X_i | j (Ohm/km) |
|---------|----|-------------|----------------|------------|-------------|--------------|------------|
| of Line | es | 1 | 2 | 3 | 1 | 2 | 3 |
| Line | 1 | 0.2485279 | 0.0579578 | 0.05795723 | 0.8794718 | 0.5304363 | 0.452805 |
| C-D | 2 | 0.0579578 | 0.2485279 | 0.05795761 | 0.5304363 | 0.8794718 | 0.4861183 |
| | 3 | 0.05795723 | 0.05795761 | 0.2485279 | 0.452805 | 0.4861183 | 0.8794718 |

Table A.4 The Resistance and Reactance data of transmission line (Continued)

Then, back to the Basic window, select the Data Input Mode is a Geometrical Parameter, then it will make the modelling of conductor neutral by double Click on the gap in the first row of the first column of Type Earth Conductor as shown in Figure A.13.

| | NI JUN VAI | |
|----------------------------|---|-----------|
| Tower Type - Equipment Typ | pe Library\Line_A-B Type.TypTow * | ? × |
| Basic Data | General Geometry | ОК |
| Load Flow | Name Line_A-B Type | Cancel |
| VDE/IEC Short-Circuit | Nominal Frequency 50. Hz | |
| Complete Short-Circuit | Number of Earth Wires | Calculate |
| ANSI Short-Circuit | Number of Line Circuits 1 Transposition none | |
| IEC 61363 | Input Mode | |
| DC Short-Circuit | Geometrical Parameter Earth Conductivity 100. uS/cm | |
| RMS-Simulation | C Electrical Parameter | |
| EMT-Simulation | Types of Earth Conductors: | |
| Harmonics/Power Quality | Conductor Types TwnCon | |
| Optimal Power Flow | Eath Conductor 1 | |
| Reliability | | |
| Generation Adequacy | | |
| Description | | |
| | Conductor Types Num. of Phases Transposition | |
| | TypCon ▶Circuit 1 Phase 12.47 kV 3. | |
| | | |
| | | |
| | | |
| | | |
| | | |
| Copy | right [®] by Chiang Mai Univers | sity |
| Ei | gure A 13 Modelling line conductor of the Neutral | 1 |
| ATT | gure A.15 Wodening the conductor of the Neutral | e d |

Data appears next to the Data Manager for the select or create the leading neutral, click. (2) On the Menu Bar to create a new line neutral, guide will appear. Window, Dialog Box, for data input line neutral, for in this case study, the data input as shown in Table A.5, as shown in Figure A.14 when the input data is finished, press OK.

| onductor Type - Equipmen | t Type Library\Neutral_12.47 k | :V.TypCon | | ? > |
|--------------------------|--------------------------------|------------------|---|--------|
| Basic Data 🔺 | Name | Neutral_12.47 kV | | ок |
| Load Flow | Nominal Voltage | 12.27 kV | | Cancel |
| VDE/IEC Short-Circuit | Nominal Current | 0.34 kA | | |
| Complete Short-Circuit | Number of Subconductors | 1 🕂 | | |
| ANSI Short-Circuit | | | | |
| IEC 61363 | Conductor Model | | | |
| DC Short-Circuit | Solid Conductor | | | |
| RMS-Simulation | U Tubular Conductor | | | |
| EMT-Simulation | (Sub-)Conductor | | • | |
| Harmonics/Power Quality | DC-Resistance (20?C) | 0.3678618 Ohm/km | | |
| Optimal Power Flow | GMR (Equivalent Radius) | 2.481072 mm | | |
| Reliability | Outer Diameter | 14.3002 mm | | |
| Generation Adequacy | | | | |
| Description | ✓ Skin effect | | | |
| - | | | | |
| | | | | |

Figure A.14 Data input of line neutral for test system 4 bus

Then, click on the symbol to define the values of the transmission line Pole Configuration, as shown in Figure A.15 and then input the values in Pole Configuration case study, this input value is Pole Configuration as shown in Table A.5, as shown in Figure A.16.

| asic Data | General Geometry | | ОК |
|----------------------|-----------------------------------|-----------------------------------|----------|
| ad Flow | Name | Line_A-B Type | Cancel |
| DE/IEC Short-Circuit | Nominal Frequency | 50. Hz | |
| mplete Short-Circuit | Number of Earth Wires | 1 * | Calculat |
| ISI Short-Circuit | Number of Line Circuits | 1 Transposition none 💌 | |
| C 61363 | Input Mode | | |
| C Short-Circuit | Geometrical Parameter | Earth Conductivity 100. | |
| MS-Simulation | C Electrical Parameter | | |
| MT-Simulation | Types of Earth Conductors: | | |
| monics/Power Quality | | Conductor Types | |
| timal Power Flow | Earth Conductor 1 Neutral_12 | 147 kV | |
| liability | | | |
| eneration Adequacy | | | |
| escription | | ۶. | |
| | Conductor Types of Line Circuits: | Num of Discours Transcowing | |
| | TypCon | ypes Num. or Phases Transposition | |
| | Circuit 1 Phase_12.47_kV | 3. | |
| | | | |
| | | | |
| | | | |

Figure A.15 The input of Pole Configuration value

| Nome | Coordinat Conduc | e of Earth ctor [m] | | Coordi | nate of L | ine Circu | its [m] | |
|-------------|---------------------|------------------------|--------|--------|-----------|-----------|---------|--------|
| Iname | Х | Y | | Х | | | Y | |
| | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| Line A-B | 0.1524 | 7.3152 | 1.0668 | 0.3048 | 1.0668 | 8.5344 | 8.5344 | 8.5344 |
| Line C-D | - | | 1.0668 | 0.3048 | 1.0668 | 8.5344 | 8.5344 | 8.5344 |

Table A.5 The data pole configuration



Figure A.16 The input Pole Configuration for test system 4 bus

When the value data input Pole Configuration, click on the symbol shown in Figure A.17 will be returned to the window for input data Basic Data again, as shown in Figure A.18, do as shown in Table A.6 data inputs.

| | LI NI ADT | | | | | | | | | 2 | ~ |
|---------------------------|-------------------------|----------------|-------------|--------|--------|--------|----------|---|------|----------|----------|
| Tower Type - Equipment Ty | pe Library\Line_A-B_lyp | e. Typ Tow ^ | | | | | | | | ? | × |
| Basic Data | General Geometry | | | | | | | | | ОК | |
| Load Flow | Coordinate of Earth C | onductors [m]: | | | | | | | | Cancel | . 1 |
| VDE/IEC Short-Circuit | Farth Conductor 1 | X 0 1524 | Y 7 3152 | | | | | | | | <u> </u> |
| Complete Short-Circuit | | 0.1024 | 7.0102 | | | | | | | Calculat | te |
| ANSI Short-Circuit | | | | | | | | | | | |
| IEC 61363 | | | | | | | - | | | | |
| DC Short-Circuit | | • | | | | | | | | | |
| RMS-Simulation | Coordinate of Line Cir | cuits [m]: | | | | | | | | | |
| EMT-Simulation | X1 | X2 | X3 | Y1 | Y2 | Y3 | | | | | |
| Harmonics/Power Quality | Circuit 1 -1.0688 | -0.3048 | 1.0688 | 8.5344 | 8.5344 | 8.5344 | ^ | | | | |
| Optimal Power Flow | | | | | | | | | | | |
| Reliability | | | | | | | | | | | |
| Generation Adequacy | | | | | | | | | | | |
| Description | | | | | | | | | | | |
| | | | | | | | | | | | |
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| | 11 I. | | 1 | | | | | 1 | 1.11 | - | |

Figure A.17 The window Basic Data to input data, the type of transmission line Kust 1 205

ι.

| Tower Type - Equipment Type Library\Line_A-B Type.TypTow | ? × |
|---|-----------------|
| Basic Data General Geometry | ОК |
| Load Flow Name Line_A-B Type | Cancel |
| VDE/IEC Short-Circuit Nominal Frequency 60. Hz | |
| Complete Short-Circuit Number of Earth Wires 1 | Calculate |
| ANSI Short-Circuit Number of Line Circuits 1 🕂 Transposition none 💌 | |
| IEC 61363 | |
| DC Short-Circuit © Geometrical Parameter Earth Conductivity 100. uS/cm | |
| RMS-Simulation | |
| EMT-Simulation Types of Earth Conductors: | |
| Hamonics/Power Quality Conductor Types TypCon | |
| Optimal Power Flow | |
| Reliability \aksacksy\IEEE 4 Bus Test Feeder Cases\Library\Equipment Type Library\Neutral_12.47 | [·] kV |
| Generation Adequacy | |
| Description | |
| Conductor Types Num. of Phases Transposition | |
| TypCon Circuit 1 Phase 12.47 kV 3. | |
| | |
| | |
| | |
| | |
| | |

Figure A.18 Window of Basic Data to input data, the type of transmission line

| | Nun | nber | Co | onductor Typ | bes | Nominal |
|------------------|----------------|------------------|-------------------|---------------------|-------------------|---------|
| Name | Earth Wires | Line Circuits | Phases | Neutral | NUM. of Phases | (Hz) |
| Line A-B Type | 1 | 1 | Phase 12.47 kV | Neutral 12.47 kV | 3 | 60 |
| Line C-D Type | 0 | 1 | Phase 4.16 kV | - | 3 | 60 |

Table A.6 Type of data transmission

When building a transmission line A-B successfully, creating a cable line C-D, using the same methods to create the cable line A-B.

3) To create the transformers

To create a transformer made by selected symbols \ominus transformers. On the Drawing Toolbar Placed in the Workspace area, click Mouse at any bus. One of the first, and then come and click on the bus to make a connection to the transformer model. As shown in Figure A.19 then the input data transformer by Double click that Dialog Box will contain a transformer of transformer appears. Then create the type of transformer. By selecting the check box, Type-a New Project => Type, as shown in Figure A.20.



Figure A.19 To create the transformers

| Basic Data | General Grour | iding/Neutral Conductor | | ОК |
|-------------------------|----------------|--------------------------|---------------------------|-----------|
| Load Flow | Name | 2-Winding Transformer | | Cancel |
| VDE/IEC Short-Circuit | Туре | ➡ → | | |
| Complete Short-Circuit | HV-Side | Select Global Type | BUS_B | Figure >> |
| ANSI Short-Circuit | LV-Side | Select Project Type | BUS_C | Jump to |
| IEC 61363 | Zone | New Project Type | | |
| DC Short-Circuit | Area | Paste Type | | |
| RMS-Simulation | Out of Serv | Remove Type | - | |
| EMT-Simulation | Number of - | | Flip Connections | |
| Harmonics/Power Quality | parallel Trans | formers 1 | | |
| Protection | Thermal Rating | ▼ → | | |
| Optimal Power Flow | Rating Factor | 1. F | Rated Power (act.) 0. MVA | |
| State Estimation | Auto Trans | fomer | | |
| Reliability | Supplied Eler | nents | | |
| Generation Adequacy | | Mark Elements in Graphic | Edit Elements | |
| Tie Open Point Opt | | | | |
| no open i one ope. | - | | | |
| Description | - | | | |
| Description | | | | |
| Description | _ | | | |
| Description | | | | |
| Description | | | | |

Dialog Box will appear for the data input of the transformer. For the transformers in case studies, this Technology is a Three Phase Transformer which means. A three-phase transformer and then click on the Positive Sequence Impedance check box is selected in Resistance and Reactance p.u. in p.u. as shown in Figure A.21, then press OK, and configure other parameters the Table A.7 will get parameter values, as shown in Figure A.22 and when the configuration parameters until you hit OK.

| | | INGINE | 2-winding transformer type | | | |
|-------------|-------------------|---------------------------|---|----------------------------|--------|--------|
| Load Flow | | Technology | Three Phase Transformer | • | | Cancel |
| VDE/IEC S | hort-Circuit | Rated Power | 1. MVA | | | |
| Complete S | hort-Circuit | Nominal Frequency | 50. Hz | | | |
| ANSI Short | -Circuit | Rated Voltage | | Vector Group | | |
| IEC 61363 | | HV-Side | 6. kV | HV-Side YN 💌 | | |
| DC Short-C | ircuit | LV-Side | 6. kV | LV-Side YN 💌 | | |
| RMS-Simula | ation | - Positive Sequence Imper | lance | Internal Delta Winding | | |
| EMT-Simula | ation | Reactance x1 | 0.03 p.u. | Phase Shift 0. | *30deg | |
| Harmonics/ | /Power Quali Sett | ings 2-Winding Transform | er\Input Options\Settings 2- | Winding Transformer.OptTyp | ? × | |
| Protection | | os Segu Representation | - Input | | ОК | |
| Optimal Pov | wer Flow | ero Serui Representation | C Short-Circuit Voltage uk and | Copper Losses | | |
| Reliability | 6 | ero dega. Representation | C Short-Circuit Voltage uk and | SHC-Voltage Re(uk) | Cancel | |
| Generation | Adequacy | | C Short-Circuit Voltage uk and | X/R Ratio | | |
| Description | | | Reactance in p.u. and Resis | ance in p.u. | | |
| Dobonption | | | | | | |

Figure A.21 Select Reactance in p u and Resistance in p u

| Rated | Rated Vol | ltage (kV) | Positive S Impedar | Sequence ice (p u) | Vector | Nominal | |
|----------------|-----------------|----------------|-----------------------|-----------------------|-----------------|----------------|-------------------|
| Power (MVA) | High Voltage | Low Voltage | Resistance | Reactance | High Voltage | Low Voltage | Frequency (Hz) |
| | Side | Side | r1 | x1 | Side | Side | |
| 6 | 12.47 | 4.16 | 0.01 | 0.06 | YN | D | 60 |

Table A.7 Data of transformers

| -Winding Transformer Type | - Equipment Type Library\12. | 47/4.16 kV.Ty | pTr2 | | | | ? | |
|---------------------------|------------------------------|---------------|---------------|--------------|------|--------|----|------|
| Basic Data | Name | 12.47/4.16 | κV | | | | (| ЭК |
| Load Flow | Technology | Three Phase | e Transformer | • | | | Ca | ncel |
| VDE/IEC Short-Circuit | Rated Power | 6. | MVA | _ | | | | |
| Complete Short-Circuit | Nominal Frequency | 60. | Hz | | | | | |
| ANSI Short-Circuit | Rated Voltage | , | | Vector Group | | | | |
| IEC 61363 | HV-Side | 12.47 | kV | HV-Side | YN 💌 | | | |
| DC Short-Circuit | LV-Side | 4.16 | kV | LV-Side | D 💌 | | | |
| RMS-Simulation | Positive Sequence Impedan | ce - | | | | | | |
| EMT-Simulation | Reactance x1 | 0.06 | ● | Phase Shift | 0. | *30deg | | |
| Harmonics/Power Quality | Resistance r1 | 0.01 | p.u. | Name | YNd0 | | | |
| Protection | | 1 | | | | | | |
| Optimal Power Flow | Zero Sequence Impedance | | | | | ⇒ | | |
| Reliability | Short-Circuit Voltage uk0 | 3. | - % | | | | | |
| Generation Adequacy | SHC-Voltage (Re(uk0)) uk0r | 0. | % | | | | | |
| Description | | | | | | | | |
| Description | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Figure A.22 Input data of the transformer

4) To create supply

To create supply (External Grid) is by clicking to select the device on the Drawing window supply Toolbar, then select the desired bus connection. Such a device would be a model as shown in Figure A.23 supply in this case studies. To make a connection to the supply into the bus at 1, and then double-click the device supply. The Dialog Box has been created will appear as shown in Figure A.24. Then go to the window, Load Flow. As shown in Figure A.25, and define the Type as SL Bus, which refers to the. Slack Bus Voltage in this case study will define the Set point is equal to 1 when the input parameter values window p.u. Load Flow and the VDE/IEC.Short-Circuit as shown in Figure A.26 and then configure a Power Short-Circuit Short-Circuit Power Sk max and "Ik" min. in the study assigned Short-Circuit Current max Ik ", which equal to 100 MVA and Short-Circuit Power Sk" min. Equal to 100 MVA, then press OK.

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| | Figure A 22 To prosto supply | |
| | Figure A.25 To create suppry | |
| -35 | the Protection Latter | |
| External Grid - Grid\External G | Grid.ElmXnet | ? × · |
| Basic Data | General Grounding/Neutral Conductor | ОК |
| Load Flow | Name External Grid | Cancel |
| VDE/IEC Short-Circuit | Terminal | |
| Complete Short-Circuit | Zone 🔸 | |
| ANCI Chart Circuit | | Figure >> |
| ANSI SHOR-GICUL | Area 📥 (Parameter Name: cpZone) | Figure >> Jump to |
| IEC 61363 | Area (Parameter Name: cpZone) | Figure >> Jump to |
| IEC 61363 DC Short-Circuit | Area (Parameter Name: cpZone) | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation | Area | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation | Area (Parameter Name: cpZone) | Figure >> |
| IEC 61363 DC Short-Grout RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Flow | Area (Parameter Name: cpZone) | Figure >> |
| IEC 61363 DC Short-Grout RMS-Simulation EMT-Simulation Hamonics/Power Quality Optimal Power Row Reliability | Area <u>(Parameter Name: cpZone)</u> Out of Service | Figure >> |
| IEC 61363 DC Short-Grouit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Flow Reliability Generation Adequacy | Area (Parameter Name: cpZone) | Figure >> |
| IEC 61363 DC Short-Grouit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Flow Reliability Generation Adequacy Description | Area | Figure >> |
| IEC 61363 DC Short-Grouit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area → (Parameter Name: cpZone) → Out of Service - | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area → (Parameter Name: cpZone) Out of Service | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation Harmonica/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area (Parameter Name: cpZone) | Figure >> |
| IEC 61363 DC Short-Circuit RMS-Simulation EMT-Simulation Hamonica/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area (Parameter Name: cpZone) | Figure >> Jump to |
| IEC 6163 IC Shot-Grout RMS-Simulation EMT-Simulation Hamonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area (Parameter Name: cpZone) | Figure >> Jump to |
| IEC 6163 IC Shot-Circuit RMS-Simulation EMT-Simulation Harmonics/Power Quality Optimal Power Row Reliability Generation Adequacy Description | Area (Parameter Name: cpZone) | Figure >> Jump to |

Figure A.24 Input Data Basic of Supply

| E | xternal Grid - Grid\External Grid.ElmXnet * | ? × |
|----|---|---|
| ſ | Basic Data Bus Type | ОК |
| | Load Row Setopirt logal | |
| | VDE/IEC Short-Circuit | Cancel |
| | Complete Short-Circuit Angle 0. deg | Figure >> |
| | ANSI Short-Circuit Voltage Setpoint 1. p.u. | Jump to |
| | IFC 61363 Reference Busbar ▼ ↓ | |
| | DC Shot-Grouit | |
| lŀ | RMS-Simulation | |
| | FMT-Simulation | |
| | | |
| | Control Rower Rower Operational Limits | |
| | Reliability Min 0000 Mune Caption Easter (ein) 100 % | |
| | Generation Adenuacy Mare Gooling Factor (min.) 100. % | |
| ŀ | Description | |
| | Desciption | |
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| | 6 6 1 3 | |
| | Figure A 25 Input data Load Flow of supply | |
| | Figure A.25 Input data Load Flow of supply | |
| | Figure A.25 Input data Load Flow of supply | |
| E | Figure A.25 Input data Load Flow of supply | 7 X |
| E | Figure A.25 Input data Load Flow of supply | ? × |
| E | Kternal Grid - Grid/External Grid.ElmXnet Basic Data Max. Values Shot Cricel Reuror String | ? × |
| E | Aternal Grid - Grid/External Grid.ElmXnet | ? × OK Cancel |
| E | Kernal Grid - Grid/External Grid.ElmXnet Basic Data Load Row VDE/IEC Short-Circuit | ? X OK Cancel Figure >> |
| E | Resc Data Max. Values Short-Circuit Short-Circuit Current Ik'max VDE/IEC: Short-Circuit Max. Values Short-Circuit Short-Circuit Current Ik'max Complete Short-Circuit Image Internation (max) Load Row Image Internation (max) VDE/IEC: Short-Circuit Image Internation (max) Complete Short-Circuit Image Internation (max) Image Internation (max) Image Internation (max) Image Internation (max) Image Internation (max) Image Internation (max) Image Internation (max) | ? × OK Cancel Figure >> |
| E | Active Max. Values Short-Circuit Short-Circuit Current Ik/max Complete Short-Circuit Max. Values Min. Values Short-Circuit Current Ik/max | ? × OK Cancel Figure >> Jump to |
| E | Basic Data Max. Values Load Row Short-Grout VDE/IEC Short-Grout Max. Values Complete Short-Grout Max. Values Max. Values MVA Short-Grout Max. Values Max. Values MVA Short-Grout Model (max) Model Short-Grout Model (max) Max. Values MVA Short-Grout MVA More Crout MVA More Crout MVA Model Short-Grout MVA Max. Values MVA Short-Grout MVA Model Short-Grout MVA Model Short-Grout Model (max) Model (max) Model (max) Model (max) Model (max) <td>? × OK Cancel Figure >> Jump to</td> | ? × OK Cancel Figure >> Jump to |
| E | Basic Data Max. Values Load Row Short-Grout Curcuit VDE/EC Short-Grout Max. 0056665 Complete Short-Grout Impedance Ratio Min. Values Min. Values Short-Grout Impedance Ratio Cost Gasa 0.56665 C. Short-Grout 0.56665 D. Short-Grout 0.56665 D. Short-Grout 0.56665 | ? X OK Cancel Figure >> Jump to |
| E | Basic Data Max. Values Load Row Short-Grout Curcent Ik/max VDE/IEC Short-Grout Max. 00.68618 Complete Short-Grout Impedance Ratio ANSI Short-Grout Impedance Ratio Z2/21 max. 0.56665 X0/X1 max. 0.5 R0/X0 max. 0.56618 | ? X OK Cancel Figure >> Jump to |
| E | Basic Data Load Row Max. Values VDE/EC Short-Circuit Complete Short-Circuit ANSI Short-Circuit EC 61363 DC Short-Circuit RMS-Simulation Max. Values RMS-Simulation EMT-Simulation VDE/EC Short-Circuit Short-Circuit Power Sk'max MVA Short-Circuit Power Sk'max | ? × OK Cancel Figure >> Jump to |
| E | Basic Data Laad Row Max. Values Max. Values Max. Values VDE/IES Nont-Grout Complete Short-Grout EC 61363 EC Short-Grout EC 61363 ES Short-Grout EMS-Simulation EMT-Simulation Hamonics/Power Quality Max. Values Max. Values Max. Values Max. Values 0.68618 MVA Stot-Grout Current Ik max. Values Max. Values Max. Values Max. Values 0.68618 MVA Stot-Grout Current Ik max. Values Max. Values Max. Values Max. Values 0.56665 Max. Values Max. Values Max. Values Max. Values Max. Values 0.56665 Max. Values Max. Values Max. Values Max. Values Max. Values 0.56665 Max. Values Max. | ? X OK Cancel Figure >> Jump to |
| E | Baic Data Impedance Ratio Lead Row Short-Circuit Power Sk*max VDE/IcS Noot-Circuit Max. Values Short-Circuit Max. Values Inc. Gata Impedance Ratio 22 Short-Circuit 0.56665 Complete Short-Circuit 0.56665 Ext Simulation 0.566618 Eministion Impedance Ratio Hamonics/Power Quality 0.68618 Optimal Power Flow 0.1 | ? X OK Cancel Figure >> Jump to |
| | Baic Data Image: Short-Great Complete Short-Great Sort-Great MS-Smudation Image: Discore Ratio EXT-Smudation Image: Discore Ratio EMT-Smudation Fix-Smudation Min-Smudation Fix-Smudation Mamorice/Power Ratio Discore Ratio Extramadation Discore Ratio <tr< td=""><td>? X OK Cancel Figure >> Jump to</td></tr<> | ? X OK Cancel Figure >> Jump to |
| E | Account of a constraint of a co | ? X OK Cancel Figure >> Jump to |
| | Baic Data Load Row VDE/EC Short Circuit Short Circuit RMS-Smulation EMS-Smulation Hamonics/Power Quality Optimal Power Row Relability Relability <td>? X OK Cancel Figure >> Jump to</td> | ? X OK Cancel Figure >> Jump to |
| | Image: Space Ac25 Input data Load Flow of supply Image: Space Ac25 Input data Load Flow of supply Image: Space Ac26 Information Space Ac20 Image: Space Ac26 Information Space Ac20 Image: Space Ac20 | ? X OK Cancel Figure >> Jump to |
| | sectors Sectors <td< th=""><th>? × OK Cancel Figure >> Jump to</th></td<> | ? × OK Cancel Figure >> Jump to |
| E | scalar Nava Nava Nava Nava <td>? × OK Cancel Figure >> Jump to</td> | ? × OK Cancel Figure >> Jump to |
| E | scalar | ? X OK Cancel Figure >> Jump to |
| | screate of a constrained o | ? X OK Cancel Figure >> Jump to |
| E | secretor Secretor Name Name <td>? X OK Cancel Figure >> Jump to</td> | ? X OK Cancel Figure >> Jump to |
| | scalar | ? X OK Cancel Figure >> Jump to |
| | Signe A.25 Input data Load Flow of supply state State <td>? X OK Cancel Figure >> Jump to</td> | ? X OK Cancel Figure >> Jump to |
| | | ? × OK Cancel Figure >> Jump to |

Figure A.26 Input data Short-Circuit of Supply

5) To create load

Creating the load (Load General) 🔄 start to build by selecting the model of your load on the Drawing Toolbar, and then select the bus that you want to connect to a replica. In this case study will make a connection where data input 4 bus

makes your load by. Double-click the load will be a replica of the load, as shown in Figure A.27 will appear. Dialog Box of the load, then creates the type of load. By selecting the Project Type New-Type => General Load Type, as shown in Figure A.28. A Dialog Box will appear, determine the type of Technology, as shown in Figure A.29, 3PH-D then press OK.



Figure A.27 Modeling of the load

1a

| General Load - Grid\General | Load.ElmLod | | | | ? × |
|-----------------------------|-------------|---------------------|---|---------------------------|-----------|
| Basic Data | Name Ge | neral Load | | | ОК |
| Load Flow | Туре 💌 | ➡ | | | Cancel |
| VDE/IEC Short-Circuit | Terminal | Select Global Type | 1 | BUS_D | |
| Complete Short-Circuit | Zone | Select Project Type | > | | Figure >> |
| ANSI Short-Circuit | Area | New Project Type | > | General Load Type (TypLod |) Jump to |
| IEC 61363 | Out of : | Paste Type | | Complex Load (TypLodind) | |
| DC Short-Circuit | Technolog | Remove Type | | | |
| RMS-Simulation | Consider | Load Transformer | | | |
| EMT-Simulation | | | | | |
| Harmonics/Power Quality | | | | | |
| Optimal Power Flow | | | | | |
| State Estimation | L | | | | |
| Reliability | | | | | |
| Generation Adequacy | | | | | |
| Description | | | | | |
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Figure A.28 Input data of the load

| General Load Type - Equipm | ent Type Library\General Load Type(1).TypLod * | ? × |
|----------------------------|--|--------|
| Basic Data | Name General Load Type | ОК |
| Load Flow | , | Cancel |
| VDE/IEC Short-Circuit | System Type AC 💌 | |
| Complete Short-Circuit | Technology 3PH-'D' | |
| ANSI Short-Circuit | | |
| IEC 61363 | | |
| DC Short-Circuit | | |
| RMS-Simulation | | |
| EMT-Simulation | | |
| Harmonics/Power Quality | | |
| Optimal Power Flow | | |
| Reliability | | |
| Generation Adequacy | | |
| Description | | |
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| | Munuly V | |
| | | 11 |
| L CR | Figure A.29 Select the type of load | |
| Carlo | | 11 |

Then go to the window, Load Flow, make the data input as shown in Table A.8. Because the system test 4 test system is used for transformer tests. So, a very large load size, therefore, to test the transformer in case of overload. When analyzing health system. Parties may need to reduce the size of the load. In this case it drops just 50 percent of the reloading of all defined spaces direct Scaling Factor equal to 0.5 shown at in Figure A.30.

| | Sagni | Та | able A.8 Da | ta of load | าเรีย | ิ่งให | 1 |
|----------------|-------------------------|-------------------------|-----------------------------|-------------------------|-----------------------------|-------------------------|-----------------------------|
| | Balanced/Un balanced | Pha | ise A | Pha | ise B | Phase C | |
| Input Model | | Active Power (MW) | Reactive Power (Mvar) | Active Power (MW) | Reactive Power (Mvar) | Active Power (MW) | Reactive Power (Mvar) |
| Default | Balanced | 1.8 | 0.8717 | 1.8 | 0.8717 | 1.8 | 0.8717 |
| Default | Unbalanced | 1.275 | 0.79017 | 1.8 | 0.87178 | 2.375 | 0.78052 |

144

| Basic Data | General Advanced | | | | ОК |
|-------------------------|--------------------|------------|----------------------|---------------|---------|
| Load Flow | Input Mode | Defau | t | | Cance |
| VDE/IEC Short-Circuit | Balanced/Unbalance | d Unbala | anced 👻 | | |
| Complete Short-Circuit | Operating Point | 1 | | Actual Values | Figure |
| ANSI Short-Circuit | Active Power | 5.45 | MW | 2.725 MW | Jump to |
| IEC 61363 | Reactive Power | 2.44247 | Mvar | 1.221235 Mvar | |
| DC Short-Circuit | Voltage | 1. | p.u. | | |
| RMS-Simulation | Scaling Factor | 0.5 | _ | 0.5 | |
| EMT-Simulation | Adjusted by Loa | ad Scaling | Zone Scaling Factor: | 1. | |
| Harmonics/Power Quality | Phase 1 | | | Actual Values | |
| Optimal Power Flow | Active Power | 1.275 | MW | 0.6375 MW | |
| State Estimation | Reactive Power | 0.79017 | Mvar | 0.395085 Mvar | |
| Reliability | | 7 | | | |
| Generation Adequacy | Phase 2 | 1.0 | MM | Actual Values | |
| Description | - Active Power | 0.07170 | Mar | 0.3 MW | |
| | Reactive Power | JU.87178 | Mvar | 0.43589 Mvar | |
| | Phase 3 | | | Actual Values | |
| | Active Power | 2.375 | MW | 1.1875 MW | |
| | Reactive Power | 0.78052 | Mvar | 0.39026 Mvar | |

When finished, the system will be tested the system 4 bus, as shown in

Figure A.31.



Figure A.31 Circuit tested the system 4 bus

A.2 To create the replica of the relay

A.2.1 Selecting the use relay.

Selecting the use, a relay which has a step is used, as shown in Figure A.32.



2) The maximum load flow analysis, then adjusts the flow starts, set higher than the maximum load current 2 x.

3) Analysis, find the minimum short-circuit current by making an analysis, three-phase short circuit current at the position the installation end of relay, and then adjusts the flow setting, work during the minimum short circuit current.

4) Analysis, find the maximum short-circuit current by making an analysis, three-phase short circuit current at the position the load end of the cable, and then adjusts the flow setting, work during the maximum short circuit current.

A.2.2 To create the replica of the relay

To create the replica, the relay will be built on the grounds of origin, transmission line, right-click the area of the source line and then choose New Devices=> Relay Model. As in the picture Dialog Box in Figure A.33 window appears, as shown in Figure A.34.



Figure A.33 To create the replica of the relay.

| Relay Model - Grid\BUS_A\Cu | b_1\Relay Model.ElmRelay ? | × |
|-----------------------------|---|----|
| Basic Data | Category: OK | |
| Current/Voltage Transformer | Name Relay Model Cance | |
| Max./Min. Fault Currents | Relay Type 💌 🔸 | |
| Description | Application Main Protection Device Number | ts |
| | Location Reference Busbar Grid\BUS_A Remote End Grid\Line_A-B Grid\BUS_B (Parameter Name: cn_rembus) Out of Service Slot Definition: | |
| | | |
| 2752 | | |

Figure A.34 Dialog box for data input relays

Then select the type of relay by clicking the Select Project Type-Relay => Type, as shown in Figure A.35 and then press OK.

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| Relay Model - Grid\BUS_A\Cu | b_1\Relay Model.E | ImRelay | ? × |
|-----------------------------|-------------------|-----------------------------|----------|
| Basic Data | Category: | | ок |
| Current/Voltage Transformer | Name | Relay Model | Cancel |
| Max./Min. Fault Currents | Relay Type | ★ | |
| Description | Application | Select Global Type mber 1 🕂 | Contents |
| | | Select Project Type | |
| | Reference | New Project Type | |
| | Busbar | Paste Type | |
| | Remote End | Remove Type | |
| | Connected Brar | nch 🔸 Grid\Line_A-B | |
| | = | | |
| | Out of Service | e | |
| | Slot Definition: | Net Flements | |
| | Re | I*,Elm*,Sta*,IntRef | |
| | 2 | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | ,• | |
| | Slot Upda | ate | |
| 1902 | 1 | 90.51 190 | 21 |

Figure A.35 Selecting the type of relay

Data Manager Window appears for the selected type of the relay. For a case study, this will select the Inverse Time Overcurrent relay from the Main Library of the Program by clicking on the Library-> Relays-Overcurrent Relays => General Electric-IAC >=> 60Hz => Series-Long-Time Inverse => IAC66B51A => as shown in Figure A.36.

|) 🔁 🏷 🕺 🖻 🖬 🛍 🗹 🏶 🛞 | ø | 60° ¥ | ž 🏤 📶 🛤 | ; 🖬 | | ОК |
|------------------------------|---|-------|-----------|----------------------|-----------------------|---------------|
| IÚÚÍ Generic IÚÚÍ Relays | | | Name | Туре | Object modified O | Cancel |
| Directional Relays | | Ē | IAC66A51A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P 🔺 | Cancer |
| Distance Relays | | | IAC66A52A | Toc Ph & Earth | 12/6/2006 9:53:25 P | Global Type |
| Covercurrent Relays | | | IAC66A53A | Toc Ph & Earth | 12/6/2006 9:53:25 P | Giobal Type |
| DID ABB/Westinghouse | | | IAC66B51A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | Project Type |
| | | | IAC66B52A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | 110/000 17/20 |
| | | | IAC66B53A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| | | | IAC66B54A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| | | F | IAC66B55A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| TIT Extremely Inverse | | | IAC66B56A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| 1 TII Inverse | | | IAC66B57A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| 🕀 📶 Long Time Inverse | | | IAC66C51A | Toc + loc Ph & Earth | 12/6/2006 9:53:25 P | |
| | | | IAC66C52A | Toc + loc Ph & Farth | 12/6/2006 9:53:25 P | |
| Tery Inverse | | | LACCCCE2A | Tee Lee Die 8 Feetle | 12/0/2000 0-52-25 0 | |

Figure A.36 Selecting the type of relay from the Library

Then it will be created by clicking the Create CT current transformer, as shown in Figure A.37.

| Relay Model - Grid\BUS_A\Cu | b_1\Relay Model.E | ImRelay * | ? × |
|-----------------------------|-------------------|-----------------------------------|----------|
| Basic Data | Category: | Overcurrent | ОК |
| Current/Voltage Transformer | Name | Relay Model | Canad |
| Max./Min. Fault Currents | Relay Type | ▼ → z\Long Time Inverse\IAC66B51A | Caricer |
| Description | Application | Main Protection Device Number | Contents |
| | | | |
| | Location | | |
| | Reference | ▼ ◆ … | |
| | Busbar | ➡ Grid\BUS_A | |
| | Remote End | ➡ Grid\BUS_B | |
| | Connected Brar | nch → Grid\Line A-B | |
| | | | |
| | Out of Service | 3 | |
| | Slot Definition: | | |
| | | Net Elements | |
| | Ct 20 /2-10 | Rel",Elm",Sta",IntRef | |
| | Meas 3ph/310 | Meas 3ph/310 | |
| | Toc | ✓ Toc | |
| | loc | ✓ loc | |
| | Toc Earth | V Toc Earth | |
| | Logic Ph | | |
| | Logic Earth | ✓ Logic Earth | |
| | | ▼ | |
| | | | |
| | Slot Upda | te Create CT | |
| | | | |

Figure A.37 To select of current transformer

Dialog box window appears for the input data, current transformer, then

select it by clicking on the current transformer. Type-Select Project Type => as shown in

Figure A.38.

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| Basic Data | Name Cu | rrent Transformer | OK |
|-----------------|-------------|----------------------------|------|
| Additional Data | Туре | → | Canc |
| Description | Out of Serv | Select Global Type | |
| | Cubicle | Select Project Type | |
| | Location | New Project Type | |
| | Busbar | Paste Type | |
| | Branch | Remove Type | |
| | Orientation | | |
| | Primary | Secondary | |
| | Тар | 1. 💌 A Tap 1. 💌 A | |
| | Set | Connection Y - | |
| | Ratio: 1 | A/1A Complete Ratio: 1A/1A | |
| | No. Phases | 3 Phase Rotation a-b-c | |
| | | | |
| | | | |
| 177 / | | | |

Data Manager for window appears, select the type of current transformer for this case study will select type current transformer CT 120-1000/1A from the Main Library of the. Program by clicking on the Library => Relays => CTs-120 CT-1000/1A => shown in Figure A.39.

YA.

| Please Select 'Current Transformer Type' - \Library\ | Relays\CTs : | | | ~ | ? | × |
|--|--------------|--|------|---|-------------|-----|
| 🗈 🕞 🏷 🕺 🖻 🖬 🛍 🗹 🎙 | 🖕 🛞 💁 6 | w 💀 🏤 🖽 🛤 🖻 | ; 🖬 | | ОК | _ |
| DID Library DID Characteristics DID Characteristics | | Name | Туре | Object modified O | Cancel | |
| LILLI Composite Model Frames LILLI Conductors LILLI General Composite Folder | | ф- СТ 120-1000/1А ф- СТ 120-1000/5А | | 12/6/2006 9:53:16 P | Global Typ | bes |
| DIDID Harmonics DIDID IEC Standard Cable DIDID Induction Machines | | | | | Project Typ | pes |
| IDI Induction Machines (old version) IDI Motor Driven Machines | | | | | | |
| DDD PV Panels DDD PV Panels DDD Relays Thin CTs | | | | | | |
| DID Fuses DID Generic | | | | | | |
| E DDD Relays | - | | | <u> </u> | | |
| Ln 1 2 object(s) of 2 1 object(s) se | lected | | | | | 1 |

Figure A.39 To select the type of current transformer from the Library

Then set the tap flows of current transformer for a case study, this will set up the primary-side current tap kept at 1000 A. Secondary and therefore 1A as shown in Figure A.40.

| Current Transformer - G | Grid\BUS_A\Cub | b_1\Current Transformer.StaCt * | ? × |
|--------------------------------|--|--|--------|
| Basic Data | Name | Current Transformer | ОК |
| Additional Data | Туре | ▼ → \Library\Relays\CTs\CT 120-1000/1A | Cancel |
| Additional Data Description | Type Out of Set Cubicle Location Busbar Branch Orientation Primary Tap Se Ratio: No. Phases | ✓ ↓ Library\Relays\CTs\CT 120-1000/1A rvice ✓ ✓ Grid\BUS_A ♦ Grid\Line_A-B -> Branch 1000. A 120. 300. 500. Connection Y 1000. Complete Ratio: 1000A/1A 3 Y Phase Rotation | Cancel |
| | | | |

Figure A.40 To settings tap current of current transformer

After creating the replica, the relay and current transformer, it will set the stream starts. And the value of the multiplier value is set at the time of the relay for convenience. User can settings the time current curve (TCC) graph Curve with a set by the source, right-click the area of the line creating the replica relay. Then choose Create Time-Overcurrent Plot (TOP) as shown in Figure A.41. TOP window appears as shown in Figure A.42.

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Figure A.42 Shows the TCC

Then double-click the graph area that resembles a curve Dialog box window appears. For a start, and the currents set up the multiplier relay timing type Inverse Overcurrent Relays. Dialog box without Shows that curves that make doubleclicking away it is a relay which type curves (number 51 is the Inverse Overcurrent Relays). And are used to protect phase or ground, as shown in Figure A.43.

| DIgSILENT PowerFactory 15.1 - [Graphic : Study Cases\Study Ca | ase\Graphics Board\Time-Overcurrent Plot] | | |
|---|--|---|---|
| File Edit View Insert Data Calculation Output To | ools Window Help | | |
| 🔄 😼 🏟 🟟 🗟 🕂 💈 💆 🗟 | | 🖻 🛛 🗢 🤮 🎇 🚔 🖃 🖿 | |
| P D 100% ▼ ∰ ₩ 월 ⊞ 21 100% ▼ ₩ | 🛍 🐟 🔒 🛄 💷 🐭 🔛 🗸 | 니 🗀 📫 🚦 📈 🛵 🖓 🛲 Default | - |
| | Time Overcurrent - Grid\BUS_A\Cub_1\Relay N Basic Data Tripping Times Blocking Description | Aodel\Toc.RelToc Jot ANSI Symbol: 51 Phase Current (1ph) 51 Tide: | ? X OK Cancel Relay Calculate |
| Grid Time-Overcurrent Plot | | | |
| | | | |

Figure A.43 Dialog box set a multiplier to adjust Inverse Overcurrent Relays type

If you double-click the graph area that resembles a straight-line Dialog box window appears. For setting the stream start relay-type Instantaneous Overcurrent. Dialog box without Relays will indicate whether the curves that make double-clicking away it is a relay which type curves (number 50 is the Instantaneous Overcurrent. Relays) and anti-phase or ground, as shown in Figure A.44.

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| DIgSILENT PowerFactory 15.1 - [Graphic : Study Case\Study Case\Graphics Board\Time-Overcurrent Plot] File Edit View Insert Data Calculation Output Tools Window Help | |
|---|--------------------------------------|
| <u> </u> | |
| Image: Second | ? × × OK ze Xancel Relay |
| Ln 1 2 object(s) of 2 1 object(s) selected | li |

Figure A.44 Dialog box for setting Instantaneous Overcurrent Relays type

In case of need to use the Inverse Type Overcurrent relays only one type, make a click in the Relay as shown in the picture Dialog box window appears of relay as shown in Figure A.45.

| | 121 | | |
|--|---|---|------------------------------------|
| Time Overcurrent - Grid\BU | JS_A\Cub_1\Relay M | odel\Toc.RelToc | ? × |
| Basic Data H Tripping Times N Blocking N Description T T C O C | EC Symbol: Measure Type: Name Type Out of Service Tripping Direction Characteristic Current Setting Time Dial | Ix ANSI Symbol: 51 Phase Current (1ph) Image: State | OK Cancel Relay Calculate |

Figure A.45 To access the Dialog box window of the relay

Then double-click on the Ioc in the Slot Definition, as shown in Figure A.46 Dialog box window appears of Instantaneous Overcurrent Relays.

| Relay Model - Grid\BUS_A\Cu | b_1\Relay Model.E | ImRelay | ? × |
|-----------------------------|---|--|----------|
| Basic Data | Category: | Overcurrent | ОК |
| Current/Voltage Transformer | Name | Relay Model | Cancel |
| Max./Min. Fault Currents | Relay Type | ▼ → z\Long Time Inverse\IAC66B51A | |
| Description | Application | Main Protection Device Number 1 | Contents |
| | Location Reference Busbar Remote End Connected Bran | ✓ + → Grid\BUS_A → Grid\BUS_B → Grid\Line_A-B | |
| | Out of Service | e | |
| | Slot Definition: | | |
| | | Net Elements Rel*,Elm*,Sta*,IntRef | |
| | Ct-3P/3xI0 | ✓ Current Transformer | |
| | Meas 3ph/310 | Meas 3ph/310 | |
| | Toc | | |
| | Noc | | |
| | Toc Earth | ✓ Toc Earth | |
| | loc Earth | Y loc Earth | |
| | Logic Fath | | |
| | Logic Earth | | |
| | | | |
| | | | |
| | Slot Upda | ite | |
| | | MAI | |

Figure A.46 Dialog box window of the Instantaneous Overcurrent Relays type

Make click on Out of Service as shown in Figure A.47 then click then OK change the double-clicking working Definition Earth in Ioc Slot, click the Out of Service. Similarly, and for the consideration in this case is only a short-circuit style phase (Phase Fault). So, do double-click in Toc Earth Slot Definition. Make click on Out of Service as well.

| Relay Model - Grid\BUS_A\Cu | ıb_1\Relay Model. | ElmRelay | | ? × |
|--|--|---|-----------------------------|--------------------------|
| Basic Data Current/Voltage Transformer Max./Min. Fault Currents Description | Category: Name Relay Type Application | Overcurrent Relay Model | C66B51A vice Number 1 + | OK Cancel Contents |
| | - Location | | | |
| Basic Data Tripping Times Blocking Description | IEC Symbol: Measure Type: Name Type I Out of Service Tripping Direction Pickup Current Total Time | ub_trkelay Model(loc.kelloc* l>> ANSI Symbol: 50 Phase Current (1ph) loc ie\60Hz\Long Time Inverse\L None 6. sec.A 6. p.u. 0.04 s | AC66B51A\loc 6000. pri.A | Cancel Relay |
| | Toc Earth loc Earth Logic Ph Logic Earth Slot Upc | Toc Earth Yoc Earth Yoc Earth Yoc Earth Yogic Ph Yogic Earth 4 A | | |

Figure A.47 Working out of Service with Instantaneous Overcurrent Relays type

Then adjusts the flow setting start relay, start relay without work is higher than the maximum load current coordinates. And relays must be active during the short circuit current and maximum flow. The minimum short circuit in the area of the scope of health. Parties of the relay, which maximum load current can be obtained from the analysis of power flow. By clicking on the symbols on the Main Tool Bar will appear the window Load Flow Calculation, **P** as shown in Figure A.48, select the set-up parameters that are used in the calculation. If the system is used as a load balancing load (Load Balanced), select the Calculation Method as an AC Load. Flow, Balanced, positive sequence, but if the system is used to load a load balancing (Unbalanced Load), select the Calculation Method as the Unbalanced Load Flow, AC, 3-phase (ABC), and then click the Execute button. To have the program calculate as configured.

| Basic Options Calculation Method Execute Active Power Control Advanced Options Calculation Method Cose Advanced Options C Load Flow, unbalanced, 3phase (ABC) Consider Availability Factors Cancel Outputs Code Flow (linear) Consider Availability Factors Cancel Load/Generation Scaling Automatic Tap Adjust of Transformers Cancel Low Voltage Analysis Consider Reactive Power Limits Consider Reactive Power Limits Consider Reactive Power Limits Scaling Factor Temperature Dependency: Line/Cable Resistances C | Load Flow Calculation - Study (| Cases\Study Case\Load Flow Calculation.ComLdf | ? × |
|--|--|---|-----------------------------------|
| | Load Flow Calculation - Study C Basic Options Active Power Control Advanced Options Iteration Control Outputs Load/Generation Scaling Low Voltage Analysis Advanced Simulation Options | Cases\Study Case\Load Flow Calculation.ComLdf Calculation Method AC Load Row, balanced, positive sequence AC Load Row, unbalanced, 3-phase (ABC) DC Load Row (linear) Consider Availability Factors Reactive Power Control Automatic Tap Adjust of Transformers Automatic Shunt Adjustment Consider Reactive Power Limits Consider Reactive Power Limits Scaling Factor Temperature Dependency: Line/Cable Resistances Cat 20?C Cat Maximum Operational Temperature Load Options Consider Voltage Dependency of Loads Feeder Load Scaling Consider Coincidence of Low-Voltage Loads Scaling Factor for Night Storage Heaters 100. % | ? × Execute Close Cancel |

Figure A.48 In the configuration window, Load Flow Calculation in order to analyze, find the maximum load current

Notice that the graph Curve if TCC during the relay, maximum load current, as shown in Figure A.49, adjust settings, stream relay starts up by double-clicking away. Graph line, then adjust the Current Setting to a higher value, as shown in Figure A.50.

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Figure A.49 The relay operates during the peak load currents

| | | 1 24 | |
|---|--|--|------------------------------------|
| Time Overcurrent - Gri | d\BUS_A\Cub_1\Relay | Model\Toc.RelToc * | ? × |
| Basic Data Tripping Times Blocking Description | IEC Symbol: Measure Type: Name Type Out of Service Tripping Direction Characteristic Current Setting Time Dial | Ix ANSI Symbol: 51 Phase Current (1ph) Toc Toc ie\60Hz\Long Time Inverse\IAC66B51A\Toc None ▼ IAC Long Time Inverse GES7004B ▼ IAC Long Time Inverse GES7004B ▼ 1.8 sec.A 1.8 p.u. 540. pri.A 0.6 0.8 1. 1.2 1.4 1.6 1.8 ■ | OK Cancel Relay Calculate |
| | | | |

Figure A.50 Configuring the current setting starts

When setting is complete, try to analyze the flow of electro. Again, if relay is not working during high load current. Curve graphs will be shown in Figure A.51.



Figure A.51 Relay is not working in the current maximum load after setting the current starts

For the minimum short-circuit current can be obtained from the analysis of short circuit if the current position is a bus node connected load ends. The cable sent by bus or position. The node is attached to the load area. It is outside the scope Pro. Parties of the relay by right-clicking the node or the bus. Select the Calculate => Short-Circuit, as shown in Figure A.52.

as shown in Figure A.52. **Add Burnon State Stat**

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| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Switch Off | ₽Ţ | 1 1 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Isolate (with Earthing) | | = 8] |
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| | | | | | | | | | | | | | | | | | | | | | | | | Contil | ngeno | :y Cor | npari | ion | | _ | Create Additional Result Box | | r y - |
| | | | | | | | | | | | | | | | | | | | | | | | | Reliab | ility A | ssessi | ment | | | | Create Text Laber | | |
| | | | | | | | | | | | | | | | | | | | | | | | | Optim | nal Po | wer R | estora | tion | | | Disconnect All | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 判響目 |
| | | | | | | | | | | | | | | | | | | | | | | | | Optim | nal RC | S Plac | emer | ıt | | | Cut | 9 🕀 🤇 | D (D) |
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| | | | | | | | | | | | | | | | | | | | | | | | | Voltar | ie san | table | | | | | Delete | + -(> ₌ | 5 C |
| | . · . | ÷., | 1 | | | - | | | | | | | - | | | | | | | | | | | Backh | one (| alcula | ation | | | | Delete Graphical Object only | | |
| ₹ | | | | Grie | 1/1 | îme- | Overc | urrent | Plot | / | | | | | | | | | | | | | | bucho | one e | - arcan | | | | _ | Shift to Layer > | | |
| | | | | | | | | | | | | | | | | | | | | | | | | Load | Flow S | Sensiti | vities | | | | Hide Result Boxes | 1 - P | |
| | | | | | | | | | | | | | | | | | | | | | | | | Cable | Sizing | g | | | | | Define template | | 3 848 6 |
| | | | | | | | | | | | | | | | | | | | | | | | | Motor | r Start | ing | | | | | Change Symbol | | k A a |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Push to Back | | |
| Ī | | | ; | × 1 | E | 80 | - | | > | | | | | | | | | | | | Grid | Fre | eze | Orth | 0 | Snap | | X= | 198 | 266 \ | Edit Graphic Object | PM FF 4 Bue | Test Feede |
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Figure A.52 Analysis of short circuit, if the current position is a minimum bus node connected to the load line ends

Short-Circuit Calculation window appears, set the Calculate a Min. Short-Circuit Currents, which refers to the analysis if the minimum short-circuits current, then click on Execute As shown in the Figure A.53.

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| Short-Circuit Calculatio | on - Study Cases\Study Case\Short-Circuit Calculation.ComShc * | ? × |
|--------------------------|---|----------|
| Basic Options | Method IEC 60909 Published 2001 | Execute |
| Advanced Options | Fault Type 3-Phase Short-Circuit | Close |
| Verification | Calculate Min. Short-Circuit Currents | Creat |
| | Max. Voltage Tolerance for LV-Systems 6 🗸 | Cancei |
| | Short-Circuit Duration | Contents |
| | Break Time 0.1 s Used Break Time global 💌 | |
| | Fault Clearing Time (Ith) 1. s | |
| | Fault Impedance | |
| | Enhanced Fault Impedance Definition | |
| | Resistance, Rf 0. Ohm | |
| | Reactance, Xf 0. Ohm | |
| | Fault Location | |
| | At User Selection | |
| | User Selection | |
| | Show Output | |
| | Command Study Cases\Study Case\Output of Results | |
| | Shows Fault Locations with Feeders | |
| | Short-Circuit at Branch/Line | |
| | Fault Distance from Length of line: 0.6096 km | |
| | Terminal i: etwork Data\Grid\BUS_A Absolute: 0. km G Terminal i: etwork Data\Grid\BUS_B | |
| | C Terminal J: etwork Data \Gind \BUS_B Relative: 0. % | |
| | | |
| I | | |
| | | |

Figure A.53 In the configuration window to Short-Circuit Calculation. For analysis find the maximum short circuit current

Notice that the graph Curve if TCC relay does not work in the minimum short-circuit current, as shown in Figure A.54, adjust settings, stream relay starts up by double. Click on the graph line, then make adjustments to higher Current Setting as shown in Figure A.55, when tuning is complete, try to do the analysis. Find the short circuit current again. If the relay is working on the maximum short circuit current. The graph will be shown in Figure A.56.



DIgSILENT PowerFactory 15.1 - [Graphic : Study Cases\Study Case\Graphics Board\Time-Overcurrent Plot] I File Edit View Insert Data Calculation Output Tools Window Help

Figure A.54 Relay will not working during short circuit current low Nr 11 4 / 1

| Time Overcurrent - Grid\BUS_A\Cub_1\Relay Model\Toc.RelToc * ? X | | | |
|--|--|---|------------------------------------|
| Basic Data Tripping Times Blocking Description | IEC Symbol: Measure Type: Name Type Out of Service Tripping Direction Characteristic Current Setting Time Dial | Ix ANSI Symbol: 51 Phase Current (1ph) Toc Toc ie\60Hz\Long Time Inverse\IAC66B51A\Toc None ▼ IAC Long Time Inverse GES7004B ▼ I.2 sec.A 1.2 p.u. 360. pri.A 0.6 0.8 1.2 1.2 1.2 I.2 Image: Sec.A 1.2 p.u. 360. pri.A | OK Cancel Relay Calculate |

Figure A.55 Setting the current starts



Figure A.56 The relay will be work during the relay of current low, after setting the current setting starts

When setting relay in the circuit minimum, analyze, find the short circuit current Max. Maximum flow was mostly short circuit can be obtained from the. Short circuit current for transmission line position area to create a source replica relay to remove them. By right-clicking the line creating the replica relay to remove them. Select the Calculate => Short-Circuit, as shown in Figure A.57.

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Figure A.57 Analysis area, find the maximum short-circuit current source of transmission line

Short-Circuit Calculation window appears, set the Calculate a Max. Short-Circuit Currents, which refers to the analysis, finding the maximum short-circuit current assigned relative 0 to 100%, which means for Short circuit current at the beginning of the line area, and then click Execute, as shown in Figure A.58.

10

| Short-Circuit Calculation | n - Study Cases\Study Case\Short-Circuit Calculation.ComShc * | ? × |
|---------------------------|---|----------|
| Basic Options | Method IEC 60909 Published 2001 | Execute |
| Advanced Options | Fault Type 3-Phase Short-Circuit | Close |
| Verification | Calculate Max. Short-Circuit Currents | Cancel |
| | Max. Voltage Tolerance for LV-Systems 6 💌 % | |
| | Short-Circuit Duration | Contents |
| | Break Time 0.1 s Used Break Time global 💌 | |
| | Fault Clearing Time (Ith) 1. s | |
| | Fault Impedance | |
| | | |
| | Resistance, Rf 0. Ohm | |
| | Reactance, Xf 0. Ohm | |
| | Fault Location | |
| | At User Selection | |
| | User Selection Grid\Line_A-B | |
| | Show Output | |
| | Command Study Cases\Study Case\Output of Results | |
| | Shows Fault Locations with Feeders | |
| | Short-Circuit at Branch/Line | |
| | Fault Distance from Length of line: 0.6096 km | |
| | Terminal i: etwork Data\Grid\BUS_A Absolute: 0. km | |
| | C Terminal j: etwork Data \Gnd \BUS_B Relative: 0. % | |
| | | |
| | | |
| | | |

Figure A.58 In the configuration window to Short-Circuit Calculation.For analysis find the maximum short circuit current

Notice that the graph TCC Curve if the relay works in the maximum circuit shown in Figure A.59 then it is not necessary to adjust the flow setting start relay. If relay is not working at the maximum short-circuit current range, adjust the set flow relay starts up. But it must not exceed the minimum short-circuit current range.



Figure A.59 Relay will be work the during the short circuit current max

A case study for this test system bus 4, adjust the relay as shown in Table A.9.

| Table A.7 Data of setting the relay | | | | |
|-------------------------------------|------------|------------|----------------------------|------------------------|
| Relay Name | Relay Type | Curve Name | Current Setting (sec.A) | ^e Time Dial |
| Relay Model | IAC66B51A | Toc | 0.5 | 5 |

Table A.9 Data of setting the relay

A.3 Modelling of contingency analysis

A.3.1 Contingency analysis

In general terms, an emergency analysis can be defined an evaluation of the electrical systems and security levels as shown in Figure A.60.



Contingency definition is selected by passing the condition, according to the following as creation of contingencies and network component as shown in Figure A.61.

| Image: Second and the second and th | 0 × _ = = × |
|--|---------------------------------|
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| Contingency Definition | •□○司 ☆ ^ • |
| Image: Second Part Part Part Part Part Part Part Part | ₽ ■₽₽₽ ≈ |
| Outage Level Contents IF in Cases Contents IF in Cases Contents In A cases Add In A cases of mutually coupled lines/cables Add Network Components Sign of the system IF Lines/cables If the system If Unes/cables If the system IF Lines/cables If Series Reactors IF Generators Sign of the system If Generators Sign of the system | 5 () = @• @ & @ () © @ A |
| Network Components Create Cases for Whole system ・ ビロールscholles マ Series Capacitors マ Transformen マ Series Reactors ロ Generators ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ | ∱©⊈® |
| Image: Construction of the second | ** ∂ ¢ ↑ ↓ + ₪ |
| | ■ ■ ■ 2 ② ② ↓ = |
| PoweFactory 151.7 ProveFactory 1 | □ A → 4 ∩ ₪ |

Figure A.61 Contingency definition

After, click on the symbols on the Main Tool Bar will appear the window Contingency definition, as shown in Figure A.61, select the set-up parameters that are used in the calculation. If the system is used as N-1 Cases, select the Calculation Method as Generate Contingency Cases for Analysis, Create Cases for whole system, Lines/Cables, and then click the Execute button. To have the program calculate as configured.

2) Contingency analysis

A contingency analysis can be defined as the evaluation of the. The level of security of the power system .Contingency analysis generally involves Analysis of abnormal system condition is a major problem both in planning by calculation method and limits for recording as shown in Figure A.62.



Figure A.62 Contingency analysis

After, click on the symbols is on the Main Tool Bar will appear the window Contingency analysis, as shown in Figure A.62, select the set-up parameters that are used in the calculation. If the system is used calculation method as alternating current (AC) Load Flow, direct current (DC) Load Flow, and DC Load Flow+ AC Load Flow for Critical Cases, select the Calculation Method as AC Load Flow, select the Show button for add cases, and then click the Execute button. To have the program calculate max loading of line as shown in Figure A.63.



Figure A.63 The program calculate max loading of line



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APPENDICES B

DIgSILENT Programming Language (DPL) function

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B.1 DPL Command (Script)

B.1.1 Script DPL of contingency analysis

- 1. object o_con,o_Lines,o_conN;
- 2. set set_Lines;
- 3. int iCol,iRow;
- 4. double a,b,min,max,dValue;
- 5. string sName;
- 6. EchoOff ();
- 7. ClearOutput();
- 8. xlStart();

9. xlSetVisible(1);

- 10. xlNewWorkbook();
- 11. o_conN=GetCaseObject('ComNmink');
 - 12. o_con=GetCaseObject('ComSimoutage');
 - 13. o_con:loadmax=LoadingMax;
 - 14. o_con:vlmin=LowerVoltage;
 - 15. o_con:vlmax=UpperVoltage;
 - 16. o_con:vmax_step=StepVoltage;

- 17. o_con.Execute();
- 18. set_Lines = SEL.GetAll('ElmLne');
- 19. set_Lines.SortToVar(0,'c:maxLoading');
- 20. iRow=5;
- 21. iCol=6;
- 22. sName='Name of Line';

23. xlSetValue(iCol,iRow,sName);

- 24. iRow=5;
- 25. iCol=7;
- 26. sName='Overloading (N-1)(%)';
- 27. xlSetValue(iCol,iRow,sName);
- 28. iRow=6;
- 29. for(o_Lines=set_Lines.First();o_Lines;o_Lines=set_Lines.Next()){

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%6f

- 30. printf('Contingency of %s%%',o_Lines:loc_name,o_Lines:c:maxLoading);
- 31. iCol=6;
 - 32. sName=o_Lines:loc_name;
 - 33. xlSetValue(iCol,iRow,sName);
 - 34. iCol=iCol+1;
 - 35. dValue=o_Lines:c:maxLoading;
 - 36. xlSetValue(iCol,iRow,dValue);
 - 37. iRow=iRow+1;

- 38. }
- 39. iRow=5;
- 40. iCol=8;
- 41. sName='I (kA)';
- 42. xlSetValue(iCol,iRow,sName);
- 43. iRow=6;
- 44. for(o_Lines=set_Lines.First();o_Lines;o_Lines=set_Lines.Next()){

ามยนต

- 45. printf('Contingency of %s %6f %%',o_Lines:loc_name,o_Lines:c:Imax);
- 46. dValue=o_Lines:c:Imax;
- 47. xlSetValue(iCol,iRow,dValue);
- 48. iRow=iRow+1;
- 49.
- 50. xlTerminate();
- 51. EchoOn ();

52. TD_zone_1.Execute();
53. TD_zone_2.Execute();
54. TD_zone_3.Execute();

- 55. TD_zone_4.Execute();
- 56. TD_zone_5.Execute();
- 57. TD_zone_6.Execute();
- 58. TD_zone_7.Execute();

- 59. TD_zone_8.Execute();
- 60. TD_zone_9.Execute();

B.1.2 Script DPL of coordination time (3 phase and 1 phase fault)

- **♦** TD_zone_1, 2, 3, 4, 5, 6, 7, 8, and 9.
- 1. set SCom, Sbus, srelay, SRelay, SRelayCont;
- object
 OCom,Obus,OSC,ORelayMain,ORelay_Br,ORelay_Bus,ORelay_BB;
- 3. object OToc_set,Obusa,Obusb,OLdf;
- 4. double Fault,DRuT,DRuT_old;
- 5. int I, IRelay, INRelay, Name, Ih;
- 6. string Value;
- 7. ClearOutput();
- 8. !!!!!!Point short circuit at the bus!!!!!!!
- 9. Sbus= SetBus_Zone1.GetAll('ElmTerm');
- 10. I = Sbus.Count();

11. if (I=0) { UN1910101010101010101

12. Info('No busbars or terminals selected : nothing to do');

13. exit(); rights reserved

- 14. }
- 15. !!!!!!!!!Max Short circuit!!!!!!!!!!
- 16. Obus= Sbus.First();
- 17. OSC = GetCaseObject('ComShc');

- 18. EchoOff();
- 19. OSC:iopt_shc = '3psc';
- 20. OSC:iopt_mde=1;
- 21. OSC:iopt_cur = 0;
- 22. OSC:iopt_allbus = 0;
- 23. OSC:shcobj = Obus ;
- 24. OSC.Execute();
- 25. Fault = Obus:m:Ikss;
- 26. printf('Fault current at end of Protection Zone = %f kA',Fault);

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21024 23

- 27. 111111111111111111Relay!!!!!!!!!!!!!!!
- 28. SRelay=SetRelays_Zone.GetAll('ElmRelay');
- 29. IRelay = SRelay.Count();
- 30. OCom=GetActiveProject();
- 31. SCom=OCom.GetContents('TD_zone');
- 32. OCom=SCom.FirstFilt('TD_zone');
- 33. for (INRelay=0;INRelay<IRelay;INRelay=INRelay+1){
- 34. OCom.GetVal(Value,'IntExpr',INRelay);
- 35. sscanf(Value,'%d',Name);
- 36. printf('% f',Name);
- 37. }
- 38. I=0;
- 39. for (INRelay=0;INRelay<IRelay;INRelay=INRelay+1){

| 40. | OCom.GetVal(Value,'IntName',INRelay); |
|-----|--|
| 41. | ORelayMain = SRelay.FirstFilt(Value); |
| 42. | <pre>printf('%s',ORelayMain:loc_name);</pre> |
| 43. | !!!!!!!!!!!!!!!Relay trip time!!!!!!!!!!!! |
| 44. | SRelayCont = ORelayMain.GetContents(); |
| 45. | ORelay_Br = ORelayMain:cbranch ; |
| 46. | ORelay_BB = ORelayMain:cn_bus ; |
| 47. | Ih = ORelay_Br.VarExists ('r:bus1:r:cpRelays:0:c:yout'); |
| 48. | if(lh = 1) |
| 49. | |
| 50. | DRuT = ORelay_Br:r:bus1:r:cpRelays:0:c:yout; |
| 51. | EL MARAS |
| 52. | if(Ih = 0) |
| 53. | { AIAI UNIVERS |
| 54. | DRuT = ORelay_Br:r:bus2:r:cpRelays:0:c:yout; |
| 55. | |
| 56. | if(Ih=1){ |
| 57. | Obusa=ORelay_Br.GetNode(0); |
| 58. | Obusb=ORelay_Br.GetNode(1); |
| 59. | if(ORelay_BB=Obusa){ |
| 60. | DRuT = ORelay_Br:r:bus1:r:cpRelays:0:c:yout; |
| 61. | } |

- 62. if(ORelay_BB=Obusb){
- 63. DRuT = ORelay_Br:r:bus2:r:cpRelays:0:c:yout ;
- 64. }
- 65. }
- 66. printf('%s','Operating Time of Relay');
- 67. printf('%f s',DRuT) ;
- 68. printf('%s',' ');
- 69. if(I>0){
- 70. if(DRuT>DRuT_old*0.9){
- 71. while(DRuT>DRuT_old*0.9){
- 72. if(I=2){
- 73. break;

}

- 74.
- 75. OToc_set = SRelayCont.FirstFilt('51PL');
- 76. OToc_set:Tpset = OToc_set:Tpset 0.01;
 77. OLdf = GetCaseObject('ComLdf');
 78. OLdf:iopt_net = 0;

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- 79. ResetCalculation();
- 80. EchoOff();
- 81. OLdf.Execute();
- 82. OSC.Execute();

- 84. Ih = ORelay_Br.VarExists ('r:bus1:r:cpRelays:0:c:yout');
- 85. if(Ih = 1)
- 86. {
- 87. DRuT = ORelay_Br:r:bus1:r:cpRelays:0:c:yout ;
- 88. }
- 89. if(Ih = 0)
- 90. {
- 91. DRuT = ORelay_Br:r:bus2:r:cpRelays:0:c:yout ;

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- 92.
- 93. if(Ih=1){

} (a

- 94. Obusa=ORelay_Br.GetNode(0);
- 95. Obusb=ORelay_Br.GetNode(1);
- 96. if(ORelay_BB=Obusa){
- 97. DRuT = ORelay_Br:r:bus1:r:cpRelays:0:c:yout ;
- 98.
- 99. if(ORelay_BB=Obusb){
- 100. DRuT = ORelay_Br:r:bus2:r:cpRelays:0:c:yout ;
- 101. }
- 102. }
- 103. printf('%s','New Operating Time of Relay');
- 104. printf('%f s',DRuT);
- 105. printf('%s','>>>>>>');



- 107. break;
- 108. }
- 109. }
- 110. }
- 111. }
- 112. DRuT_old = DRuT;
- 113. I=I+1;
- 114. }
- 115. ResetCalculation();

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CURRICULUM VITAE

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