FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEE4403

POWER SYSTEMS

project

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Abstract

This project aims to take knowledge about power simulator this program is used to implement high voltage systems it shows all the necessary data (transmission impedance, bus voltage, power losses, and the Y bus matrix) it helps to analyze the circuit and see the fault currents and voltage impacts and detect the condition of the system when the load is changed

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Production

Question1: calculate per unit impedances for all transmission lines

calculating per-unit impedances

$$Z_{PU}=\frac{Z_{actual}}{Z_{base}}\ ,\ Y_{PU}=\frac{Y_{actual}}{Y_{base}}$$

$$Z_{base}=\frac{V_{rated}^2}{S_{base}}=\frac{230^2}{100}=529$$

$$Y_{base}=\frac{1}{Z_{base}}\quad 1.890*10^{\wedge -3}$$

the calculator impedance of the power word simulator was used to calculate the parameter of the transmission line in the up

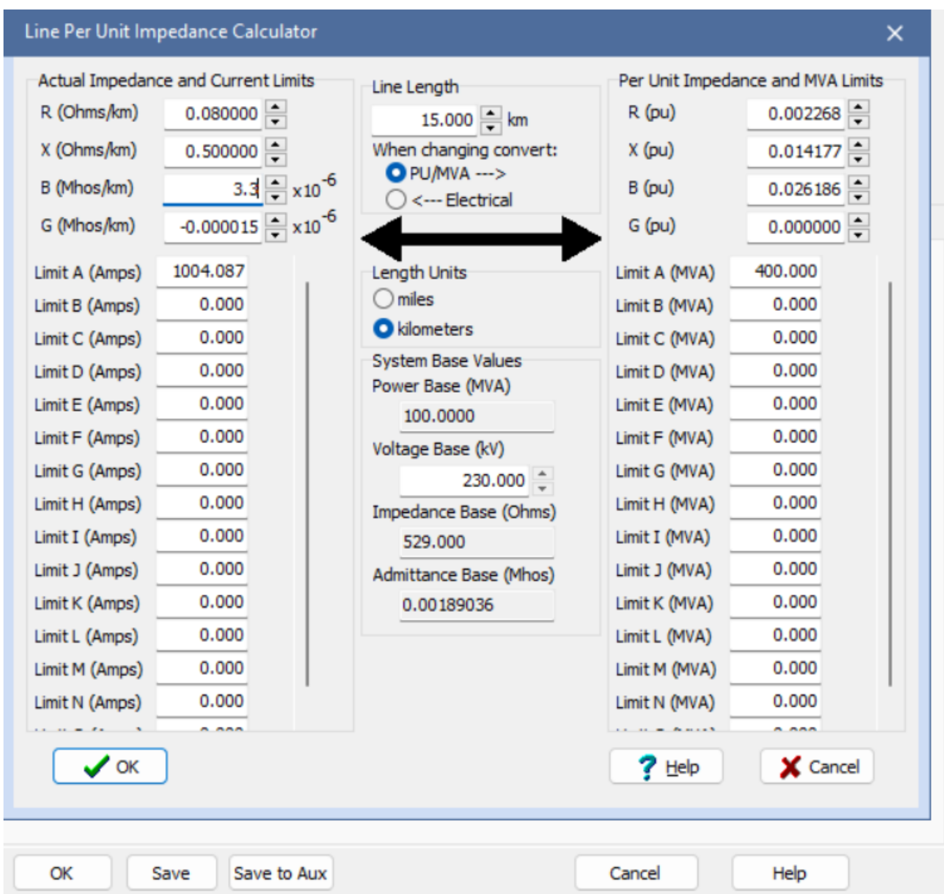

Figure 1: power word parameter calculator

lines parameter

$$\boldsymbol{Z_{pu}} = \frac{Z_{\text{Actual}}}{Z_{\text{base}}} = \left(\frac{0.08+j0.5}{529}\right)*28=0.04233+j0.026459$$

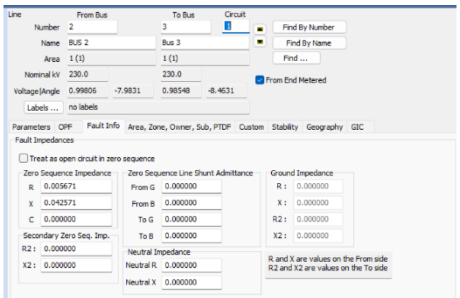

Figure 2:L1 parameter

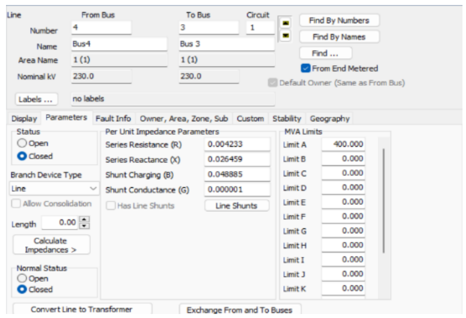

Figure 4:L2 parameter

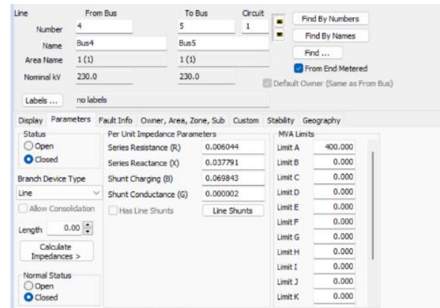

Figure 3:L3 parameter

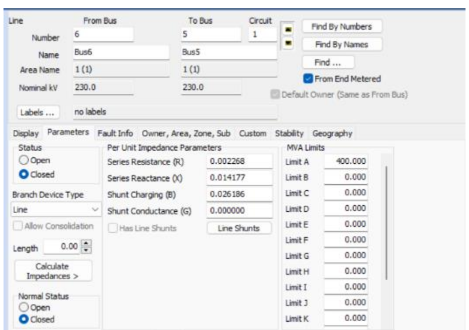

Figure 6:L4 parameter

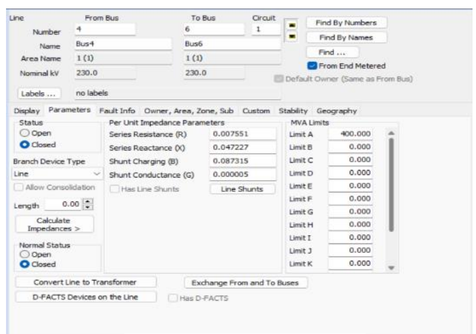

Figure 5:L5 parameter

This table can be found from case >>>> branch input

Table 1:Transmtion line parameters Table

	To Number	To Name ▲	Circuit	Status	Branch Device Type	Xfrmr	R	X	B	Lim MVA A
1	3	Bus 3	1	Closed	Line	NO	0.00423	0.02646	0.04888	400.0
2	3	Bus 3	1	Closed	Line	NO	0.00227	0.01418	0.02619	400.0
3	1	Bus1	1	Closed	Transformer	YES	0.00000	0.10000	0.00000	200.0
4	5	Bus5	1	Closed	Line	NO	0.00227	0.01418	0.02619	400.0
5	5	Bus5	1	Closed	Line	NO	0.00604	0.03779	0.06984	400.0
6	6	Bus6	1	Closed	Line	NO	0.00755	0.04723	0.08732	400.0
7	7	Bus7	1	Closed	Transformer	YES	0.00000	0.10000	0.00000	200.0

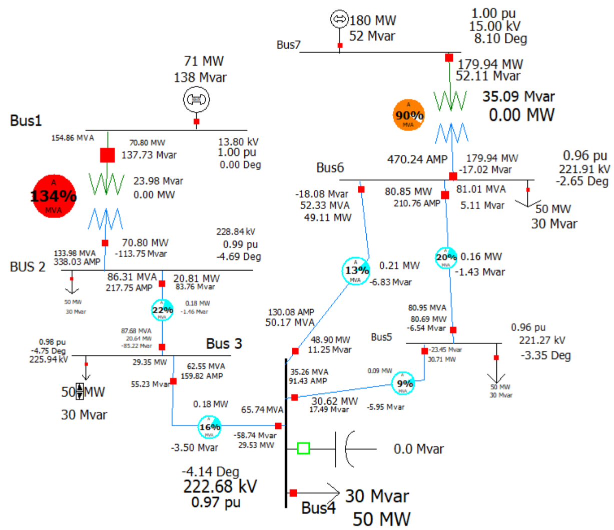

Figure 7:system as the required data

As noted transformer one is fully loaded since the total loaded power 250 MW and 150 MVar and the generation power is equal to 250.8 MW and 189Mvar so this surplus will affect the complex power that is on the slack bus is higher than the rated value on the transformer so the transformer will be full loaded so the value of the complex power of the transformer was changed to 200MVar

Question 2-part a

One-line diagram with data

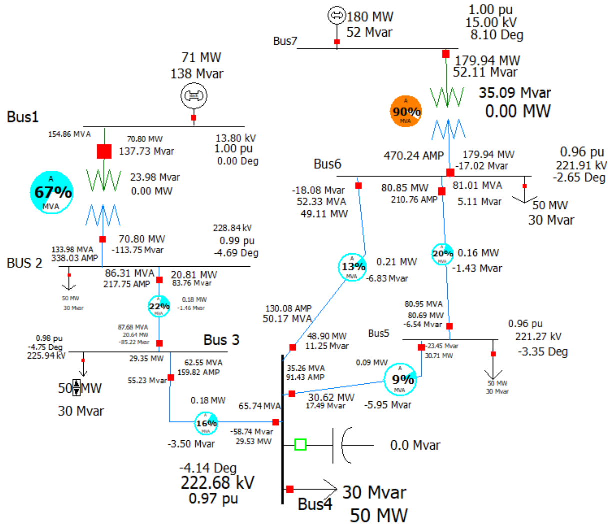

Figure 8:system structure

running the system

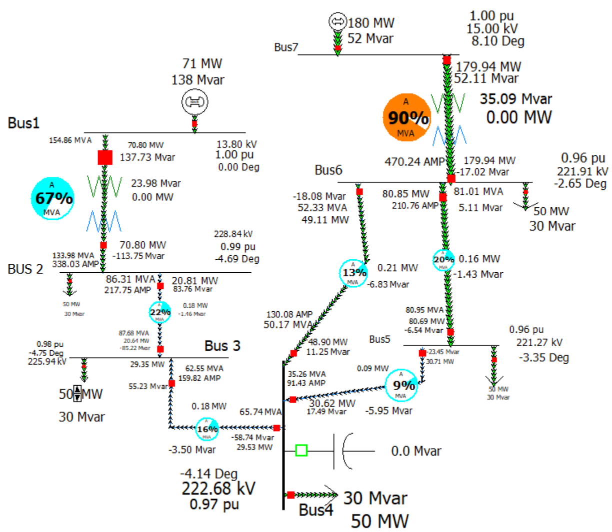

Figure 9:running the system

Question 2-part b

Total load, total generation power, and total losses this data can be seen from the case summary:

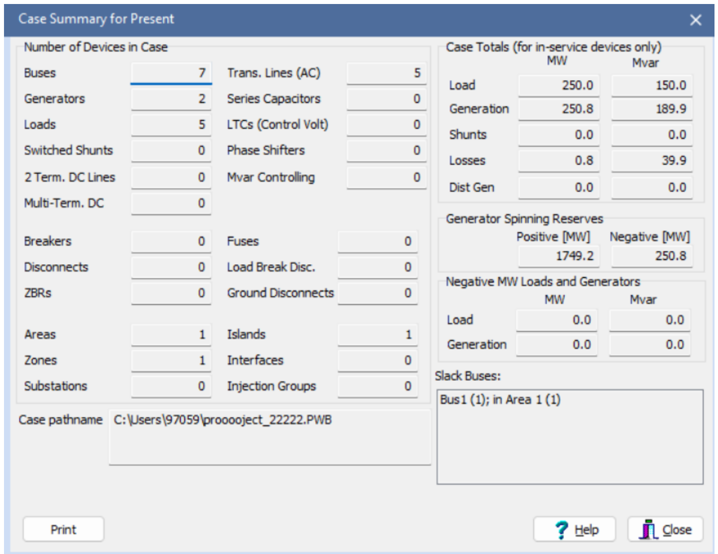

Figure 10:Total load, power and losses

Question 2-part c

The y bus matrix can be found from solution detail (Y bus matrix)

the table of Y bus matrix can be found from >>>solution detail >>> Y bus matrix

Table 2:Y Bus Matrix

	Number	Name	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5	Bus 6	Bus 7
1	1	Bus1	0.00 - j10.00	-0.00 + j8.70					
2	2	BUS 2	-0.00 + j8.70	11.00 - j76.32	-11.00 + j68.78				
3	3	Bus 3		-11.00 + j68.78	16.90 - j105.59	-5.90 + j36.85			
4	4	Bus4			-5.90 + j36.85	13.32 - j83.20	-4.13 + j25.80	-3.30 + j20.65	
5	5	Bus5				-4.13 + j25.80	15.13 - j94.53	-11.00 + j68.78	
6	6	Bus6				-3.30 + j20.65	-11.00 + j68.78	14.30 - j99.37	-0.00 + j10.00
7	7	Bus7						-0.00 + j10.00	0.00 - j10.00

Question 2 -part d

Table 3:Busess data

	Number	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW	Gen Mvar	Switched Shunts Mvar	Act G Shunt MW	Act B Shunt Mvar	Area Num	Zone Num
1	1	Bus1	1	13.80	1.00000	13.800	0.00			70.82	137.77		0.00	0.00	1	1
2	2	BUS 2	1	230.00	0.99490	228.827	-4.70	50.00	30.00				0.00	0.00	1	1
3	3	Bus 3	1	230.00	0.98230	225.930	-4.76	50.00	30.00				0.00	0.00	1	1
4	4	Bus4	1	230.00	0.96811	222.666	-4.14	50.00	30.00				0.00	0.00	1	1
5	5	Bus5	1	230.00	0.96201	221.262	-3.35	50.00	30.00				0.00	0.00	1	1
6	6	Bus6	1	230.00	0.96477	221.897	-2.65	50.00	30.00				0.00	0.00	1	1
7	7	Bus7	1	15.00	1.00000	15.000	8.10			180.00	52.17		0.00	0.00	1	1

Question 2-part e

Table 4:Branches state

Branches State | Buses | DC Lines | Branches Input | Ybus

Records Geo Set Columns f(x) Options

Filter Advanced Branch Find... Remove Quick Filter

	From Number	From Name	To Number	To Name	Circuit	Status	Branch Device Type	Xfrmr	MW From	Mvar From	MVA From	Lim MVA	% of MVA Limit (Max)	MW Loss	Mvar Loss
1	2	BUS 2	1	Bus1	1	Closed	Transforme	YES	-70.8	-113.8	134.0	200.0	77.5	0.00	24.00
2	2	BUS 2	3	Bus 3	1	Closed	Line	NO	20.8	83.8	86.3	400.0	21.9	0.18	-1.46
3	4	Bus4	3	Bus 3	1	Closed	Line	NO	29.5	-58.7	65.7	400.0	16.4	0.18	-3.50
4	4	Bus4	5	Bus5	1	Closed	Line	NO	-30.6	17.5	35.3	400.0	9.7	0.09	-5.95
5	4	Bus4	6	Bus6	1	Closed	Line	NO	-48.9	11.2	50.2	400.0	13.1	0.21	-6.83
6	6	Bus6	5	Bus5	1	Closed	Line	NO	80.9	5.1	81.0	400.0	20.3	0.16	-1.43
7	6	Bus6	7	Bus7	1	Closed	Transforme	YES	-180.0	-17.0	180.8	200.0	93.7	0.00	35.12

The direction of the power value is determined by the power angle, transitioning from a higher power angle to a lower one. The current value in a transmission line varies due to differences in line length, with Zpu being influenced by this length. Moreover, an increase in the transmission line's length leads to greater losses, as Z rises in proportion to the length, resulting in a reduction of current within the line. The power in the line is influenced by the power angle, with power flow remaining stable for $\delta<90\circ$ and becoming unstable for $\delta>90$. This simulation offers the voltage and angle for each bus, in addition to the quantity of power (both real power in MW and reactive power in MVar) utilized at every bus. It likewise illustrates how much power is lost within the system, both real and reactive, as well as the current that flows through the transmission lines and transformers.

Question 3 Fully loaded Transformer

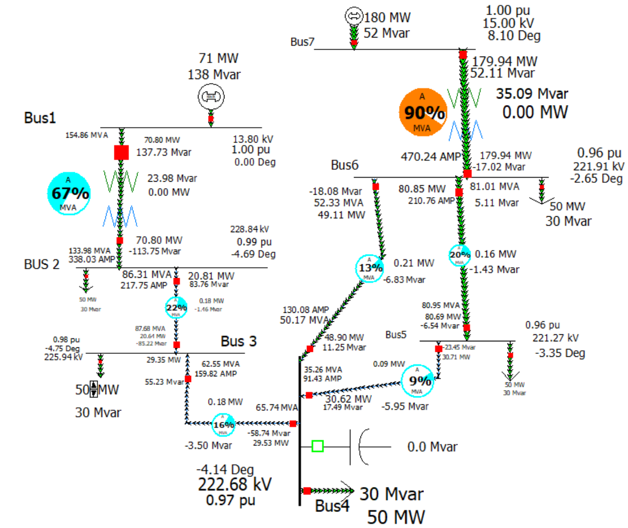

Figure 11: System before increasing the load

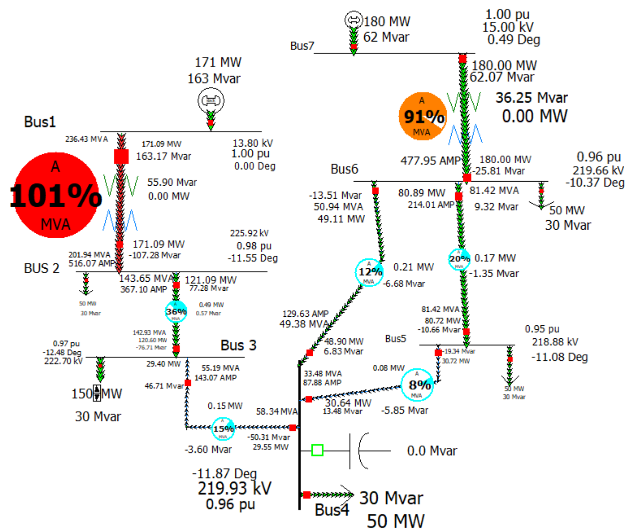

Figure 12:system when the transformer T1 overloaded

The value that makes the T1 full loaded is 150MW

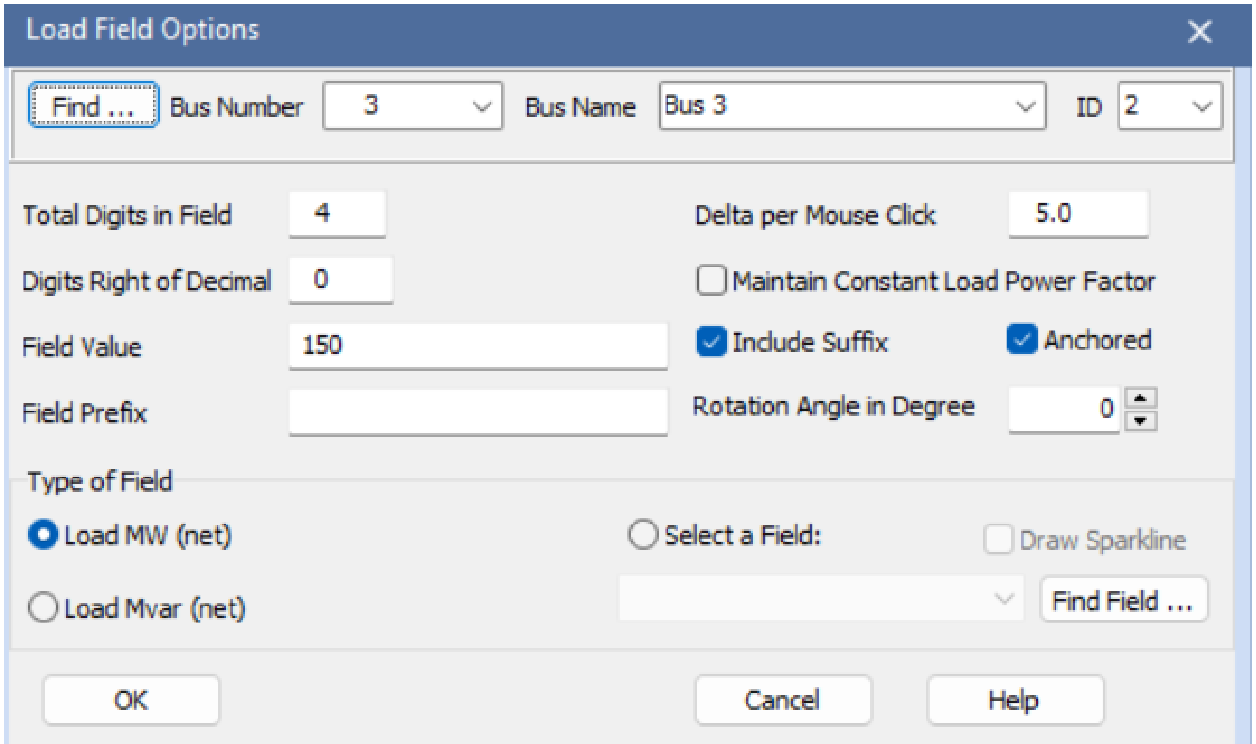

Figure 13: the value of the load on Bus 3 when T1 is fully loaded

When the load at Bus 3 rises to 150 MW, the voltage at Bus 3 along with other buses drops due to the increased current. Transmission lines and transformers near Bus 3 can handle more load, increasing power losses and the risk of overload. Generators must supply additional power, which may put a strain on the system. Without a reactive power supply, voltage stability may be compromised. as losses increase, overall system efficiency decreases

Question 4 shunt capacitor

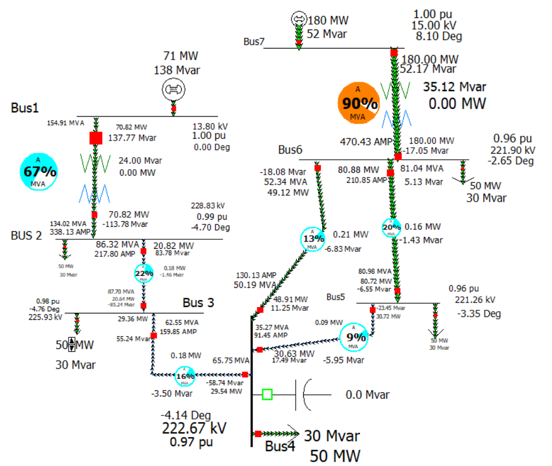

Figure 14:before the capacitor

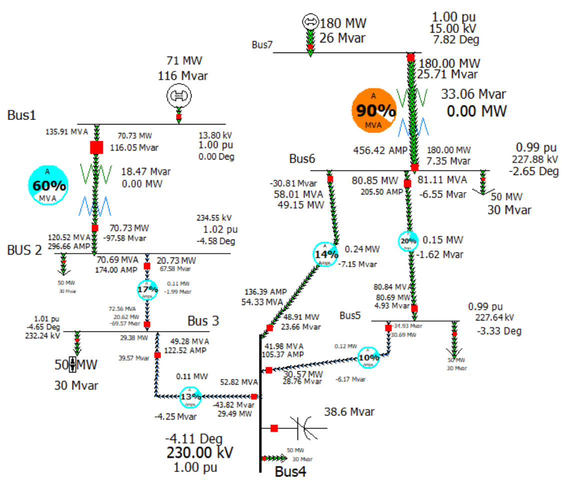

Figure 15: after adding the capacitor

$$C = \frac{Qc}{V^2 w} = \frac{38.6*10^{\wedge}6}{(230k)^2\,(2*pi*50)} = 2.323\mu\text{F}$$

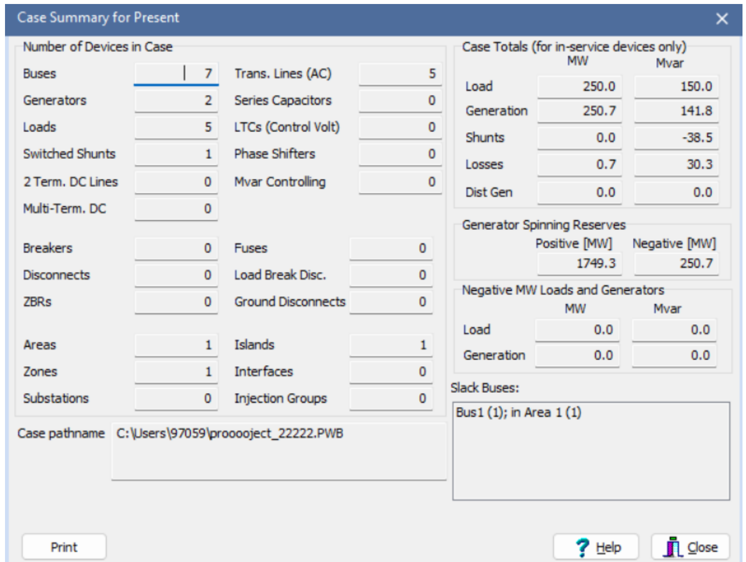

Figure 16:total load generator and loses when shunt =35Mvar

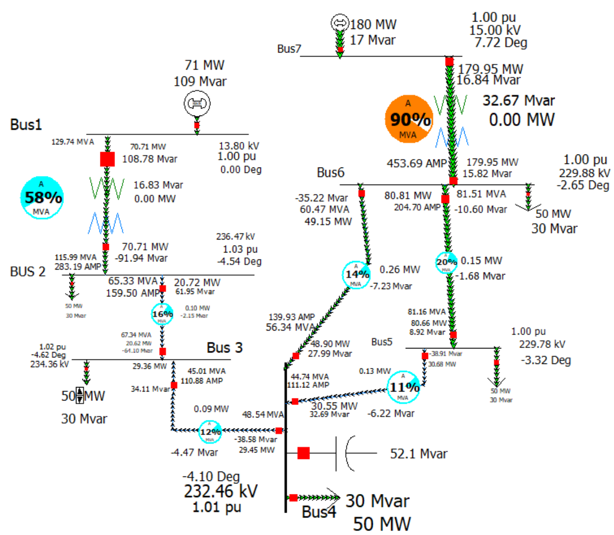

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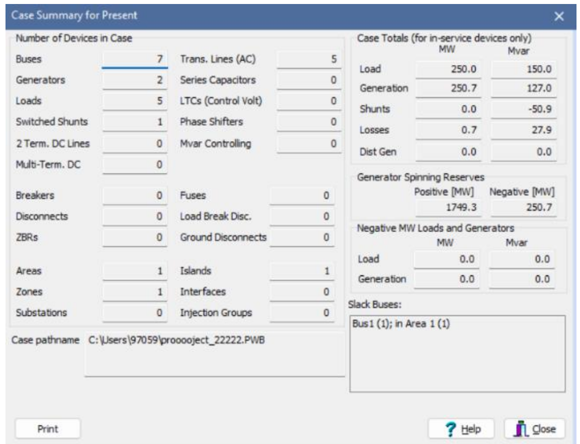
Figure 17:after increase the value of the capacitor to51Mvar

$$C = \frac{Qc}{V^2 w} = \frac{52.1*10^{\wedge}6}{(230k)^2\,(2*pi*50)} = 3.13\mu\text{F}$$


Case Summary for Present

Number of Devices in Case

Buses	7	Trans. Lines (AC)	5
Generators	2	Series Capacitors	0
Loads	5	LTCs (Control Volt)	0
Switched Shunts	1	Phase Shifters	0
2 Term. DC Lines	0	Mvar Controlling	0
Multi-Term. DC	0		
Breakers	0	Fuses	0
Disconnects	0	Load Break Disc.	0
ZBRs	0	Ground Disconnects	0
Areas	1	Islands	1
Zones	1	Interfaces	0
Substations	0	Injection Groups	0

Case pathname C:\Users\97059\proooject_22222.PWB

Case Totals (for in-service devices only)

	MW	Mvar
Load	250.0	150.0
Generation	250.7	127.0
Shunts	0.0	-50.9
Losses	0.7	27.9
Dist Gen	0.0	0.0

Generator Spinning Reserves

Positive [MW]	Negative [MW]
1749.3	250.7

Negative MW Loads and Generators

	MW	Mvar
Load	0.0	0.0
Generation	0.0	0.0

Slack Buses:

Bus1 (1); in Area 1 (1)

Print Help Close

Figure 18:total load generator and loses when the shunt =51MVR

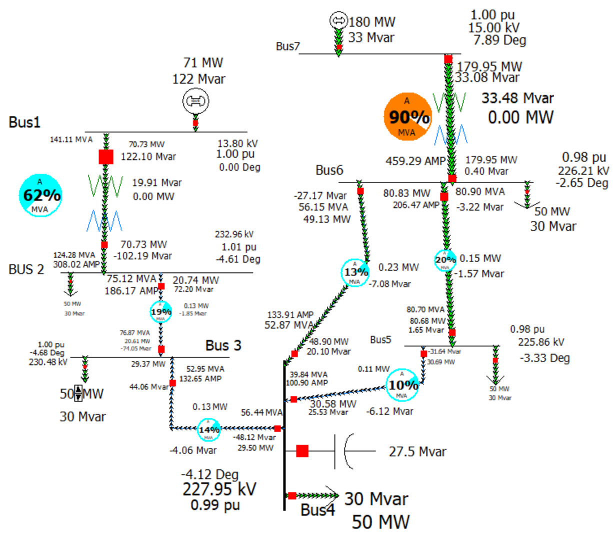


Figure 19:System with shunt =28Mvar

$$C = \frac{Qc}{V^2 w} = \frac{27.5*10^6}{(230k)^2\,(2*pi*50)} = 1.6\mu\text{F}$$

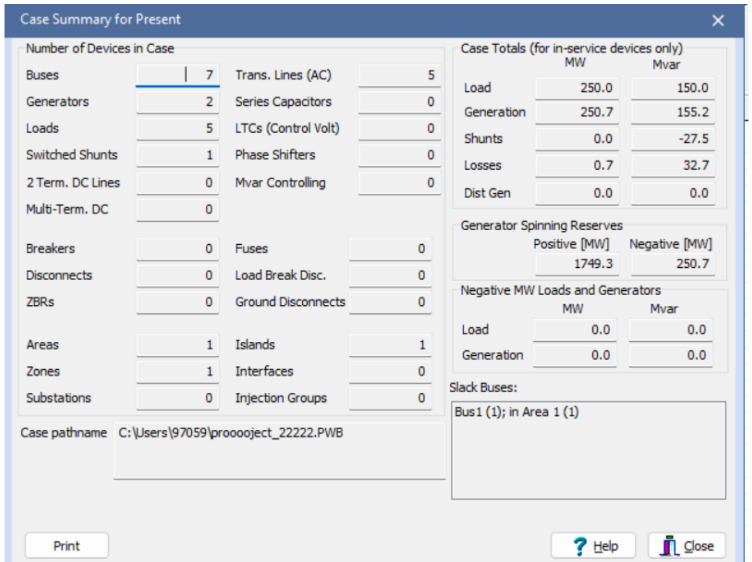


Figure 20:total load when shunt =28Mvar

The capacitor enhanced voltage stability, reduced losses, and improved system performance since the value of Mvar increases in the bus the total reactive power in the network decreases before adding the shunt the value of the reactive power in line two was -58.74Mvar after adding the capacitor it decreases to -43.82Mvar it also help to make the system more stable the required shunt capacitance to make the voltage in bus 4 equal 1 pu is 38Mvar and if the value of the shunt capacitance increases the losses of the system will decrease and the system becomes more stable

Question 5 Fault

to calculate the parameter zo in pu

$$Z_{OPU}=\frac{Z_{O\ Actual}}{Z_{base}} = \frac{0.2+j1.5}{529} * 18 = 0.01058+j0.079338$$

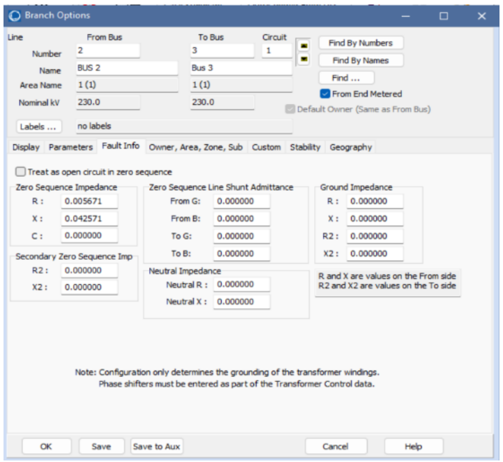


Figure 25:Transmission 1 line fault parameter

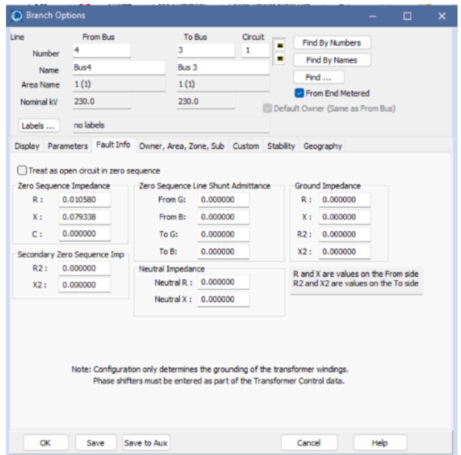


Figure 24:Transmission 2 line fault parameter

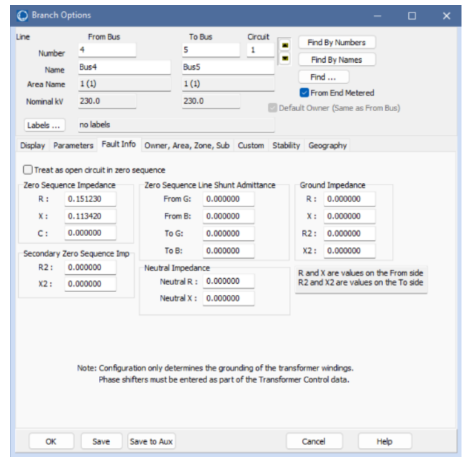


Figure 21::Transmission 3 line fault parameter

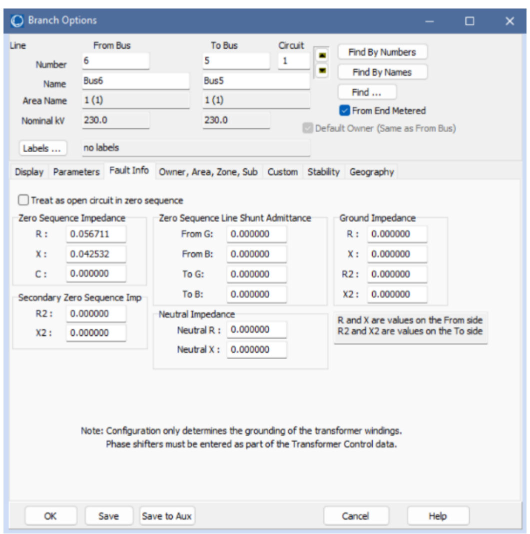


Figure 23:Transmission 4 line fault parameter

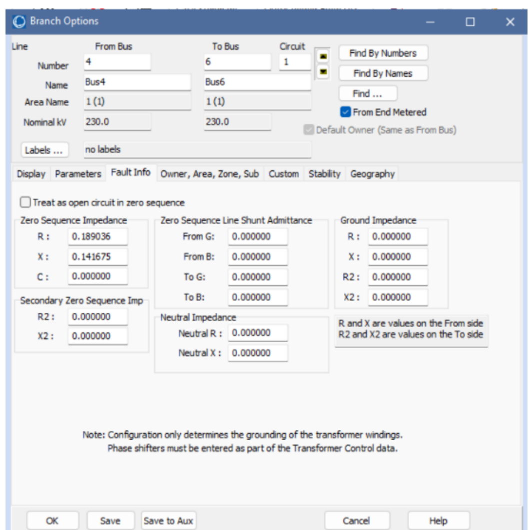


Figure 22:Transmission 5 line fault parameter

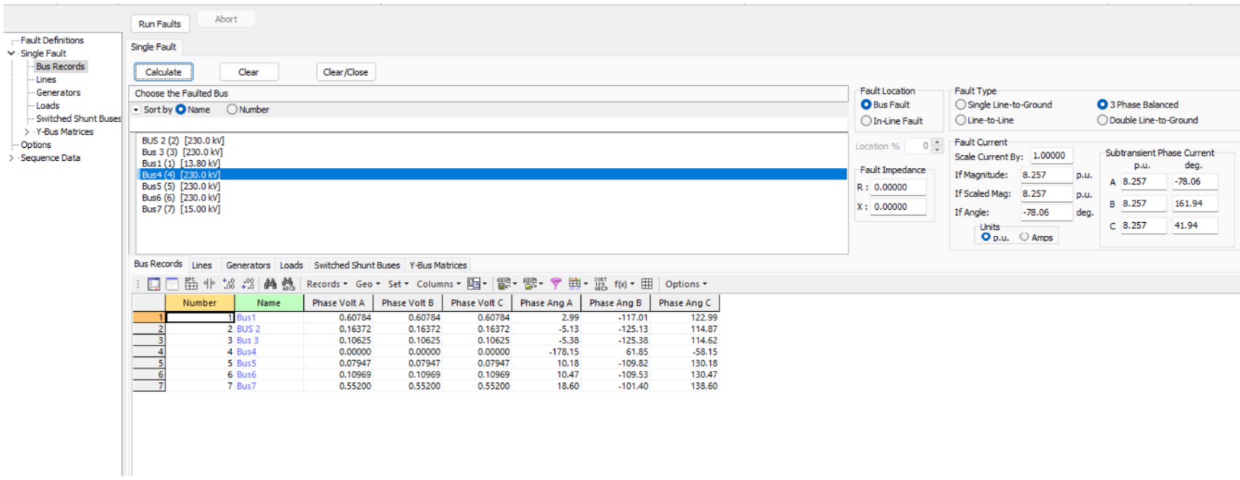


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Figure 26: fault at bus4

A three-phase balanced fault is applied to multiple buses in the system, resulting in the highest fault current magnitude at bus 4 where the voltage at it becomes 0 and the current 8.257 with angle-78.06 this test helps to take the worst case that can happen to the system and take the necessary transmission line cable and protection that should be used to avoid the current born

Conclusion

The knowledge of the power word simulator was taken, where the system was built, designed, and analyzed using the power word, the Y Bus matrix, power flow, losses, and voltages on buses were determined, and the T1 was set to be fully loaded, and the value of the load that makes it full loaded 150MW and a shunt capacitor was added to bus 4 to see the effect of the shunt capacitance, where it helps the system to be more stable and reduces the losses, a three-phase fault was made on bus 4 and the value of current was determined and the results of the fault on the system was seen and analyzed