CHAPTER FIVE

Conclusion and Recommendations

5-1: Conclusion

The objective of this thesis was to carry out extensive studies to Atbara - Portsudan transmission line and explore the impacts of using SVC, series compensation using TCSC (With variable compensation degree), or going to a traditional solution which is changing transmission line to a new configuration. All these solutions are investigated and put it in comparison to each other's to explore the best option to achieve based on following criteria's:

- ✓ Reduce transmission loss.
- ✓ Secure transmission.
- ✓ Continuity of supply.
- ✓ Enhance voltage regulation.
- ✓ Suitable to carry expected future load.
- ✓ Economic solution.

From the results presented in chapter four the best option for enhancing transmission line performance of ATB-POR transmission line is re-configuration of existing design (1*480mm^2, ACSR, r=0.076Ω/km, x_L=0.403Ω/km, c=9.02nF/km) to a common 220kV design (2*240mm^2, ACSR, r=0.067Ω/km, x_L=0.302Ω/km, c=13.06nF/km). Inclusion of FACT devices in ATB-POR transmission line increase the line carry-ability and improve the voltage profile at receiving end in Portsudan. SVC and TCSC must be included in the line as alternative solution for reconfiguration of the

line. Also, the uses of new trend of distributed generation are effective option for enhancement of the line. A generation station can be built in Portsudan to supplies the load instead of heavy using ATB-POR transmission line.

5-2: Recommendations

In the following, some recommendations are given for future research in this area:

- Over-all investigation of Sudan National Grid using the new generation of FACTS (SSSC, UPFC and IPFC).
- Develop a new optimization methods to specify transmission line require to improving of using FACTS devices accompanied by contingency analysis.
- Develop an intelligent control schemes to adjust accurate degree of compensation.

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Appendix (A)

System Data

A.1 *Generators data:*

Power station	***Machine Name***	***Rated App. Power (MVA)***	***Rated Voltage (kV)***	***Power factor (pu)***
GARI 1	GAR GT01	41.3	11	0.9
	GAR GT02	41.3	11	0.9
	GAR ST01	41.3	11	0.9
	GAR GT03	41.3	11	0.9
	GAR GT04	41.3	11	0.9
	GAR ST02	41.3	11	0.9
GARI 2	GAR GT05	41.3	11	0.9
	GAR GT06	41.3	11	0.9
	GAR GT07	41.3	11	0.9
	GAR GT08	41.3	11	0.9
	GAR ST03	41.3	11	0.9
	GAR ST04	41.3	11	0.9
GARI 4	GAR ST05	70	11	0.9
	GAR ST06	70	11	0.9
KHARTOUM NORTH	KHN ST06	137.5	13.8	0.85
	KHN ST05	137.5	13.8	0.85
	KHN ST04	75	11	0.9
	KHN ST03	75	11	0.9
	KHN ST02	41.25	11	0.9
	KHN ST01	41.25	11	0.9
	KHNG GT01	30	11	0.85
	KHNG GT02	30	11	0.85
	KHNG GT03	30	11	0.85
	KHNG GT04	30	11	0.85
	KHNG GT05	30	11	0.85
	KHNG GT06	30	11	0.85
MERWE	MWP HT01	140	13.8	0.9
	MWP HT02	140	13.8	0.9

	MWP HT03	140	13.8	0.9
	MWP HT04	140	13.8	0.9
	MWP HT05	140	13.8	0.9
	MWP HT06	140	13.8	0.9
	MWP HT07	140	13.8	0.9
	MWP HT08	140	13.8	0.9
	MWP HT09	140	13.8	0.9
	MWP HT10	140	13.8	0.9
ROSIERIS	ROS HT01	44.5	11	0.9
	ROS HT02	44.5	11	0.9
	ROS HT03	44.5	11	0.9
	ROS HT04	43	11	0.9
	ROS HT05	43	11	0.9
	ROS HT06	43	11	0.9
	ROS HT07	43	11	0.9
SENNAR	SNP HT01	9.4	11	0.8
	SNPHT02	9.4	11	0.8
KOSTI	KOSTI ST01	147.059	11	0.9
	KOSTI ST02	147.059	11	0.9
	KOSTI ST03	147.059	11	0.9
	KOSTI ST04	147.059	11	0.9

***A.2** Off-Peak Load:*

Substation	***Name***	***P (MW)***	***Q (MVAr)***
AFRA	AFR11-TR01	4.5	1.8
	AFR11-TR02	4.6	1.3
	AFR33-TR01	7	4
	AFR33-TR02	7	4.5
AROMA	ARM33-TR01	1.7	0
	ARM33-TR02	0	0
ATBARA	ATB33-TR01	26.5	11
	ATB33-TR02	54.3	17.9
BAGAIR	BAG11-TR01	4	3.6
	BAG11-TR02	3.3	2.4
	BAG33-TR01	11.6	7.7
	BAG33-TR02	6	1.3

BANAT	BNT11-TR01	7.7	15.7
	BNT11-TR02	9.1	19.2
	BNT33-TR01	19.8	43.3
	BNT33-TR02	12.6	8.3
BASAIR	BSH	0.1	2
DEBBA	DEB33-TR01	4	3
	DEB33-TR02	15.2	5
DONGOLA	DON33-TR01	12.6	6
	DON33-TR02	9	5
FAO	FAO	9	2
FAROUG	FAR11-TR01	6	3.1
	FAR11-TR02	6	3
	FAR33-TR01	11.8	3.9
	FAR33-TR02	11.9	4
FREE ZONE	FRZ33-TR02	10	0.3
GIAD	GAD33-TR01	0.7	-0.1
	GAD33-TR02	4	2
GAMOEIA	GAM33-TR01	16.2	9.2
	GAM33-TR02	0	0
KHARTOUM REFINERY	GAR33-TR07	2.2	0.6
GADARIF	GDF33-TR01	7	3.9
	GDF33-TR2	6.5	0
	O GDF	5.2	0
GENAID	GND11-TR01	0	0
	GND11-TR02	15.6	7.7
	GND33-TR01	0	0
	GND33-TR02	10.5	5
GIRBA	GRB33-TR01	3.3	1.4
	GRB33-TR02	0	0
	KILO3	3.4	4.5
	NHLF	0	0
HAG ABDALLAH	HAG11-TR01	0	0
	HAG33-TR01	5	3
HASAHISA	HAS11-TR01	4.5	3.4
	HAS11-TR03	0	0

	HAS33-TR01	4.9	2.9
	HAS33-TR03	0	0
HALFA	HLF33-TR01	5.5	2.8
	HLF33-TR02	5.6	1.4
HAWATA	HWT33-TR01	0	0
	HWT33-TR02	0.6	0
IED BABIKER	IBA11-TR04	5.3	4.8
	IBA11-TR05	5.6	3.9
	IBA33-TR04	19	13
	IBA33-TR05	12	3
IZBA	IZB33-TR01	19.9	7
	IZB33-TR02	34.7	9.3
IZERGAB	IZG11-TR01	6.8	5
	IZG11-TR02	0	0
	IZG11-TR04	9	6
	IZG33-TR01	20	11
	IZG33-TR02	10.6	4.9
	IZG33-TR04	26.3	16.1
JABAL AWLIA	JAS33-TR01	21.8	10.1
KHARTOUM EAST	KHE11-TR01	0.7	0.2
	KHE11-TR02	3.5	2
	KHE33-TR01	37.2	15.5
	KHE33-TR02	37.9	11.7
KILO X	KLX11-TR01	2.4	1.4
	KLX11-TR02	3.9	1.8
	KLX33-TR01	6.3	0.4
	KLX33-TR02	13.8	7.8
KASALA	KSL33-TR01	6.8	2.5
	KSL33-TR02	7.1	3.1
KUKU	KUK33-TR01	13.1	6.3
	KUK33-TR02	12.4	6.3
	KUK33-TR03	0	0
LOCAL MARKET	LOM11-TR01	3.9	2.3
	LOM11-TR02	2.3	1.37
	LOM33-TR01	3.6	2
	LOM33-TR02	41.9	22.4

MANAGIL	Managil	25.7	15
MARINGAN	MAR11-TR03	0	0
	MAR11-TR04	6.2	6.8
	MAR11-TR05	1.6	1.2
	MAR33-TR03	27.3	14.7
	MAR33-TR04	24	13
	MAR33-TR05	3	1.9
MAHDIA	MHD11-TR02	4.8	1.2
	MHD11-TR03	3	1.9
	MHD33-TR02	12.5	7.1
	MHD33-TR03	7.4	4.5
	MHD33-TR04	30.6	20.7
	MHD33-TR05	18	12.2
MINA SHARIF	MINA	8.1	0.3
MASKOUR	MSH33-TR03	11.5	4.9
	MSH33-TR04	0	0
MUGRAN	MUG11-TR01	3.2	1
	MUG11-TR03	4.7	2.3
	MUG33-TR01	5.3	0
	MUG33-TR03	16.9	3
MERWE TOWN	MWT33-TR01	6.9	2
	MWT33-TR02	5	3
NEW HASAHISA	NHS33-TR03	8.6	4.9
	NHS33-TR04	12.6	5.9
OBIED	OBD33-TR01	9.1	0.6
	OBD33-TR02	11.6	3.3
OMDURMAN	OMD11-TR01	6.9	4.6
	OMD11-TR02	0.3	0
	OMD11-TR03	4.3	2.7
	OMD33-TR01	23.8	11.3
	OMD33-TR02	5.7	2.3
	OMD33-TR03	21.4	14.1
PORTSUDAN	POR33-TR03	26	6.2
	POR33-TR04	25.9	6.3
RABAK	RBK33-TR03	24.9	8.5
	RBK33-TR04	33.8	12.1

RANK	RNK33-TR01	0	0
	RNK33-TR02	0.3	0.1
ROSIERS	ROS33-TR05	2.6	0.6
	ROS33-TR06	6	1.7
SHAGARA	SHG11-TR01	8.33	5.16
	SHG11-TR02	6.29	3.28
	SHG33-TR01	27.1	9.1
	SHG33-TR02	26.74	13.23
	SHG33-TR03	0	0
	SHG33-TR04	7	2.5
SHOWAK	SHK33-TR01	0	0
	SHK33-TR02	2.4	0.4
SHANDI	SHN33-TR01	12.7	3.4
	SHN33-TR02	12.8	5.2
SINGA	SNG33-TR01	3.2	2.3
	SNG33-TR02	7.63	2.07
SENNAR JUNCTION	SNJ-TR04	10.22	5.54
	SNJ33-TR02	7.7	2.3
TANDALTI	TND33-TR01	0	0
	TND33-TR02	0.9	0.6
UMRAWABA	UMR33-TR01	4.3	2
WAWA	WAW33-TR01	0	0
	WAW33-TR02	0.3	0.1
WADI HALFA	WHL33-TR01	0	0
	WHL33-TR02	1.4	0.7

A.3 *Peak load:*

Substation	***Name***	***P (MW)***	***Q (MVAr)***
AFRA	AFR11-TR01	8	2
	AFR11-TR02	8	2
	AFR33-TR01	25	10.5
	AFR33-TR02	24.4	10.3
AROMA	ARM33-TR01	1.07	1.25
	ARM33-TR02	1.07	1.25
ATBARA	ATB33-TR01	41	21
	ATB33-TR02	81.2	40.5

BAGAIR	BAG11-TR01	6.8	6.9
	BAG11-TR02	12.8	0.8
	BAG33-TR01	20.5	12.4
	BAG33-TR02	2.2	2.1
BANAT	BNT11-TR01	8.77	5.63
	BNT11-TR02	14.25	8.54
	BNT33-TR01	22.6	13.2
	BNT33-TR02	35.85	20.81
BASAIR	BSH	5	2
DEBBA	DEB33-TR01	13	6
	DEB33-TR02	22	10
DONGOLA	DON33-TR01	29	16
	DON33-TR02	19	12
FAO	FAO	7	2
FAROUG	FAR11-TR01	15.2	6.2
	FAR11-TR02	15.1	6
	FAR33-TR01	22.1	8.2
	FAR33-TR02	22.2	8.3
FREE ZONE	FRZ33-TR02	19.4	8.7
GIAD	GAD33-TR01	7.3	9.3
	GAD33-TR02	14.2	17.4
GAMOEIA	GAM33-TR01	13.9	6.2
	GAM33-TR02	10.55	5.5
KHARTOUM REFINERY	GAR33-TR07	1.7	1.1
GADARIF	GDF33-TR01	12.1	6.3
	GDF33-TR2	8.4	1.4
	O GDF	11	5
GENAID	GND11-TR01	10.6	4.87
	GND11-TR02	10.18	5.1
	GND33-TR01	16	7.1
	GND33-TR02	4.9	2.1
GIRBA	GRB33-TR01	5.4	2.1
	GRB33-TR02	0	0
	KILO3	15.4	7.2
	NHLF	0	0

HAG ABDALLAH	HAG11-TR01	10.8	4.3
	HAG33-TR01	0	0
HASAHISA	HAS11-TR01	6.6	3.6
	HAS11-TR03	0	0
	HAS33-TR01	7.4	4.4
	HAS33-TR03	0	0
HALFA	HLF33-TR01	8.79	5.36
	HLF33-TR02	9.86	4.72
HAWATA	HWT33-TR01	0	0
	HWT33-TR02	2.8	1.8
IED BABIKER	IBA11-TR04	9.1	7.1
	IBA11-TR05	4.1	2.5
	IBA33-TR04	30	22
	IBA33-TR05	24	10
IZBA	IZB33-TR01	42.6	13.9
	IZB33-TR02	49.7	24.1
IZERGAB	IZG11-TR01	9.4	6.1
	IZG11-TR02	0	0
	IZG11-TR04	8.7	6.1
	IZG33-TR01	41.9	26.9
	IZG33-TR02	15.9	8.2
	IZG33-TR04	39.1	26.9
JABAL AWLIA	JAS33-TR01	38.5	14.6
KHARTOUM EAST	KHE11-TR01	1.2	0.3
	KHE11-TR02	5.6	2.1
	KHE33-TR01	71	30.3
	KHE33-TR02	72.3	24.9
KILO X	KLX11-TR01	3.8	1.8
	KLX11-TR02	8.7	3.7
	KLX33-TR01	11.3	7.1
	KLX33-TR02	10.9	5.3
KASALA	KSL33-TR01	11.58	6.22
	KSL33-TR02	13.94	8.36
KUKU	KUK33-TR01	18.1	6.7
	KUK33-TR02	19.4	9.8
	KUK33-TR03	22.1	5.3

LOCAL MARKET	LOM11-TR01	7.2	9.1
	LOM11-TR02	5.8	4.3
	LOM33-TR01	45.5	17.9
	LOM33-TR02	37.6	16.1
MANAGIL	Managil	36	20
MARINGAN	MAR11-TR03	14.4	7.5
	MAR11-TR04	11.3	9
	MAR11-TR05	0	0
	MAR33-TR03	24	14
	MAR33-TR04	23	13
	MAR33-TR05	9.6	6.1
MAHDIA	MHD11-TR02	3.8	2
	MHD11-TR03	3.8	2
	MHD33-TR02	13.1	4.5
	MHD33-TR03	13	4.5
	MHD33-TR04	35.8	14.3
	MHD33-TR05	30.7	18.8
MINA SHARIF	MINA	15	4
MASKOUR	MSH33-TR03	9.4	7.9
	MSH33-TR04	0	0
MUGRAN	MUG11-TR01	8.2	2.3
	MUG11-TR03	8.3	3.6
	MUG33-TR01	40	19.4
	MUG33-TR03	34.1	11
MERWE TOWN	MWT33-TR01	20	9
	MWT33-TR02	14	8
NEW HASAHISA	NHS33-TR03	12.86	8.15
	NHS33-TR04	19.3	10.5
OBIED	OBD33-TR01	18.9	4.7
	OBD33-TR02	18.3	5.7
OMDURMAN	OMD11-TR01	4.4	6.7
	OMD11-TR02	9.2	8.4
	OMD11-TR03	6.7	7.6
	OMD33-TR01	41.8	19.2
	OMD33-TR02	13.7	6.2
	OMD33-TR03	42.9	21.7

PORTSUDAN	POR33-TR03	39	10
	POR33-TR04	38	10
RABAK	RBK33-TR03	31.6	10.9
	RBK33-TR04	36.2	14.1
RANK	RNK33-TR01	0	0
	RNK33-TR02	0.75	0.25
ROSIERS	ROS33-TR05	14.5	8.1
	ROS33-TR06	11.8	3
SHAGARA	SHG11-TR01	7	6
	SHG11-TR02	11	5.66
	SHG33-TR01	35.3	20
	SHG33-TR02	31.4	23.54
	SHG33-TR03	0	0
	SHG33-TR04	17.6	8.8
SHOWAK	SHK33-TR01	0	0
	SHK33-TR02	1.5	0
SHANDI	SHN33-TR01	17.6	7.2
	SHN33-TR02	28.1	13.4
SINGA	SNG33-TR01	11	4
	SNG33-TR02	3.4	1.4
SENNAR JUNCTION	SNJ-TR04	14.2	7.8
	SNJ33-TR02	10.5	3
TANDALTI	TND33-TR01	0	0
	TND33-TR02	1.7	1.2
UMRAWABA	UMR33-TR01	7.4	3.4
WAWA	WAW33-TR01	0	0
	WAW33-TR02	1.34	0.67
WADI HALFA	WHL33-TR01	0	0
	WHL33-TR02	3.62	1.45

***A.4** Transmission line data:*

Name	***Length (km)***	***Nominal Voltage (kV)***	***Resistance (Ω/km)***	***Reactance (Ω/km)***	***Capacitance (μF/km)***	***Susceptance (μS/km)***
AFR-FAR-1	4.5	110	0.067	0.269	0.013	4.084
AFR-FAR-2	4.5	110	0.067	0.269	0.013	4.084
ARM-KSL-1	43.87	220	0.067	0.302	0.01306	4.103
ARM-KSL-2	43.87	220	0.067	0.302	0.01306	4.103
ATB-POR	448.92	220	0.076	0.403	0.00902	2.834
BNT-OMD-1	5.9	110	0.067	0.269	0.01306	4.103
BNT-OMD-2	5.9	110	0.067	0.269	0.01306	4.103
DEB-DON	139.38	220	0.076	0.403	0.00902	2.834
DON-WAW-1	166	220	0.067	0.302	0.01306	4.103
DON-WAW-2	166	220	0.067	0.302	0.01306	4.103
FRZ-SHN-1	115	220	0.067	0.302	0.01306	4.103
FRZ-SHN-2	115	220	0.067	0.302	0.01306	4.103
GAD-NHS	80.7	110	0.348	0.421	0.0086	2.702
GAD-NHS-1	80.7	220	0.067	0.302	0.01306	4.103
GAD-NHS-2	80.7	220	0.067	0.302	0.01306	4.103
GAM-BNT-1	16.5	110	0.067	0.269	0.01306	4.103
GAM-BNT-2	16.5	110	0.067	0.269	0.01306	4.103
GAR-FRZ-1	5	220	0.067	0.302	0.01306	4.103
GAR-FRZ-2	5	220	0.067	0.302	0.01306	4.103
GAR-IBA-1	60	220	0.067	0.302	0.01306	4.103
GAR-IBA-2	60	220	0.067	0.302	0.01306	4.103
GDF-FAO	153	110	0.348	0.421	0.0086	2.702
GDF-HWT-1	110	220	0.067	0.302	0.01306	4.103
GDF-HWT-2	110	220	0.067	0.302	0.01306	4.103
GDF-SHK-1	75.12	220	0.067	0.302	0.01306	4.103
GDF-SHK-2	75.12	220	0.067	0.302	0.01306	4.103
GIAD-BAG	3	110	0.348	0.421	0.0086	2.702
GND-NHS-1	15	110	0.067	0.302	0.01306	4.103
GND-NHS-2	15	110	0.067	0.302	0.01306	4.103
GRB-HLF-1	48.87	220	0.067	0.302	0.01306	4.103
GRB-HLF-2	48.87	220	0.067	0.302	0.01306	4.103

GRB-SHK-1	62.54	220	0.067	0.302	0.01306	4.103
GRB-SHK-2	62.54	220	0.067	0.302	0.01306	4.103
HWT-SNG-1	90	220	0.067	0.302	0.01306	4.103
HWT-SNG-2	90	220	0.067	0.302	0.01306	4.103
IBA-IZB-1	11	110	0.067	0.269	0.01306	4.103
IBA-IZB-2	11	110	0.067	0.269	0.01306	4.103
IBA-KHN-1	12	110	0.067	0.269	0.01306	4.103
IBA-KHN-2	12	110	0.067	0.269	0.01306	4.103
IBA-KLX-1	14	220	0.067	0.302	0.01306	4.103
IBA-KLX-2	14	220	0.067	0.302	0.01306	4.103
JAS-GAD-1	36	220	0.067	0.302	0.01306	4.103
JAS-GAD-2	36	220	0.067	0.302	0.01306	4.103
JAS-GAM-1	37	220	0.067	0.302	0.01306	4.103
JAS-GAM-2	37	220	0.067	0.302	0.01306	4.103
JAS-MSH-1	100	220	0.067	0.302	0.01306	4.103
JAS-MSH-2	100	220	0.067	0.302	0.01306	4.103
JAS-SHG-1	39	110	0.067	0.269	0.013	4.084
JAS-SHG-2	39	110	0.067	0.269	0.013	4.084
KBA-FRZ-1	34	220	0.067	0.302	0.01306	4.103
KBA-FRZ-2	34	220	0.067	0.302	0.01306	4.103
KBA-IBA-1	30	220	0.067	0.302	0.01306	4.103
KBA-IBA-2	30	220	0.067	0.302	0.01306	4.103
KHN-IZG-1	12	110	0.067	0.269	0.01306	4.103
KHN-IZG-2	12	110	0.067	0.269	0.01306	4.103
KHN-KUK-1	4.5	110	0.0384	0.302	0.0095	2.985
KHN-KUK-2	4.5	110	0.0384	0.302	0.0095	2.985
KLX-AFR-1	9.5	110	0.067	0.269	0.013	4.084
KLX-AFR-2	9.5	110	0.067	0.269	0.013	4.084
KLX-BAG	28	110	0.348	0.421	0.0086	2.702
KLX-GAD-1	43	220	0.076	0.403	0.00902	2.834
KLX-GAD-2	43	220	0.076	0.403	0.00902	2.834
KLX-LOM-1	3	110	0.067	0.269	0.01306	4.103
KLX-LOM-2	3	110	0.067	0.269	0.01306	4.103
KSL-GRB-1	74.5	220	0.067	0.302	0.01306	4.103
KSL-GRB-2	74.5	220	0.067	0.302	0.01306	4.103

KUK-KHE-1	3.2	110	0.067	0.269	0.01306	4.103
KUK-KHE-2	3.2	110	0.067	0.269	0.01306	4.103
KUK-KLX-1	14.6	110	0.087	0.379	0.0095	2.985
KUK-KLX-2	14.6	110	0.087	0.379	0.0095	2.985
MAR-FAO	71	110	0.348	0.421	0.0086	2.702
MAR-HAG	35	110	0.348	0.421	0.0086	2.702
MAR-HAS	55	110	0.348	0.421	0.0086	2.702
MAR-NHS-1	60.3	220	0.076	0.403	0.00902	2.834
MAR-NHS-2	60.3	220	0.076	0.403	0.00902	2.834
MHD-IZG-1	8	110	0.067	0.269	0.01306	4.103
MHD-IZG-2	8	110	0.067	0.269	0.01306	4.103
MHD-OMD-1	9.3	110	0.067	0.269	0.01306	4.103
MHD-OMD-2	9.3	110	0.067	0.269	0.01306	4.103
MRK-GAM-1	37	220	0.067	0.302	0.01306	4.103
MRK-GAM-2	37	220	0.067	0.302	0.01306	4.103
MRK-KAB	36.8	500	0.028	0.276	0.013083	4.11
MRK-MHD-1	21	220	0.067	0.302	0.01306	4.103
MRK-MHD-2	21	220	0.067	0.302	0.01306	4.103
MSH-RBK-1	100	220	0.067	0.302	0.01306	4.103
MSH-RBK-2	100	220	0.067	0.302	0.01306	4.103
MUG-BNT-1	3.8	110	0.067	0.269	0.01306	4.103
MUG-BNT-2	3.8	110	0.067	0.269	0.01306	4.103
MUG-SHG-1	11	110	0.067	0.269	0.01306	4.103
MUG-SHG-2	11	110	0.067	0.269	0.01306	4.103
MWP-ATB	236.7	500	0.028	0.276	0.013083	4.11
MWP-DON	34.55	220	0.076	0.403	0.00902	2.834
MWP-MRK-1	346	500	0.028	0.276	0.013083	4.11
MWP-MRK-2	346	500	0.028	0.276	0.013083	4.11
MWP-MWT	34.55	220	0.076	0.403	0.00902	2.834
MWT-DEB	139.3	220	0.076	0.403	0.00902	2.834
NHS-HAS	6	110	0.348	0.421	0.0086	2.702
RBK-RNK-1	172.8	220	0.067	0.302	0.01306	4.103
RBK-RNK-2	163	220	0.067	0.302	0.01306	4.103
RBK-TND-1	84	220	0.067	0.302	0.01306	4.103
RBK-TND-2	84	220	0.067	0.302	0.01306	4.103

ROS-RNK-1	172.8	220	0.067	0.302	0.01306	4.103
ROS-RNK-2	172.8	220	0.067	0.302	0.01306	4.103
ROS-SNG-1	178	220	0.076	0.403	0.00902	2.834
ROS-SNG-2	178	220	0.076	0.403	0.00902	2.834
SHG-LOM-1	7.8	110	0.067	0.269	0.01306	4.103
SHG-LOM-2	7.8	110	0.067	0.269	0.01306	4.103
SHN-ATB-1	140	220	0.067	0.302	0.01306	4.103
SHN-ATB-2	140	220	0.067	0.302	0.01306	4.103
SNG-SNJ-1	50	220	0.076	0.403	0.00902	2.834
SNG-SNJ-2	50	220	0.076	0.403	0.00902	2.834
SNJ-MAR-1	84	220	0.076	0.403	0.00902	2.834
SNJ-MAR-2	84	220	0.076	0.403	0.00902	2.834
SNP-HAG	60	110	0.348	0.421	0.0086	2.702
SNP-SNJ	10	110	0.348	0.421	0.0086	2.702
TND-UMR-1	78.3	220	0.067	0.302	0.01306	4.103
TND-UMR-2	78.3	220	0.067	0.302	0.01306	4.103
UMR-OBD-1	126	220	0.067	0.302	0.01306	4.103
UMR-OBD-2	126	220	0.067	0.302	0.01306	4.103
WAW-WHL-1	205	220	0.067	0.302	0.01306	4.103
WAW-WHL-2	205	220	0.067	0.302	0.01306	4.103

***A.5** Bus data:*

Bus Name	***Type***	***V. Level (kV)***	***F (Hz)***	V_{min} ***(%)***	V_{max} ***(%)***
MWP500-1	Busbar	500	50	95%	105%
MWP500-2	Busbar	500	50	95%	105%
KBA500-1	Busbar	500	50	95%	105%
KBA500-2	Busbar	500	50	95%	105%
MRK500-1	Busbar	500	50	95%	105%
MRK500-2	Busbar	500	50	95%	105%
ATB500-1	Busbar	500	50	95%	105%
ATB500-2	Busbar	500	50	95%	105%
WAW220-1	Busbar	220	50	95%	105%
WAW220-2	Busbar	220	50	95%	105%
WHL220-1	Busbar	220	50	95%	105%

WHL220-2	Busbar	220	50	95%	105%
GDF220-1	Busbar	220	50	95%	105%
GDF220-2	Busbar	220	50	95%	105%
SHK220-1	Busbar	220	50	95%	105%
SHK220-2	Busbar	220	50	95%	105%
TND220-1	Busbar	220	50	95%	105%
TND220-2	Busbar	220	50	95%	105%
UMR220-1	Busbar	220	50	95%	105%
UMR220-2	Busbar	220	50	95%	105%
HLF220-1	Busbar	220	50	95%	105%
HLF220-2	Busbar	220	50	95%	105%
OBD220-1	Busbar	220	50	95%	105%
OBD220-2	Busbar	220	50	95%	105%
MWP220-1	Busbar	220	50	95%	105%
MWP220-2	Busbar	220	50	95%	105%
DON220	Busbar	220	50	95%	105%
DEB220	Busbar	220	50	95%	105%
MWT220	Busbar	220	50	95%	105%
KLX220	Busbar	220	50	95%	105%
GAD220-1	Busbar	220	50	95%	105%
GAD220-2	Busbar	220	50	95%	105%
IBA220-1	Busbar	220	50	95%	105%
IBA220-2	Busbar	220	50	95%	105%
GAM 220-1	Busbar	220	50	95%	105%
GAM 220-2	Busbar	220	50	95%	105%
MHD220-1	Busbar	220	50	95%	105%
MHD220-2	Busbar	220	50	95%	105%
JAS220-1	Busbar	220	50	95%	105%
JAS220-2	Busbar	220	50	95%	105%
KBA220-1	Busbar	220	50	95%	105%
KBA220-2	Busbar	220	50	95%	105%
MRK220-1	Busbar	220	50	95%	105%
MRK220-2	Busbar	220	50	95%	105%
GAR220-1	Busbar	220	50	95%	105%
GAR220-2	Busbar	220	50	95%	105%
FRZ 220-1	Busbar	220	50	95%	105%

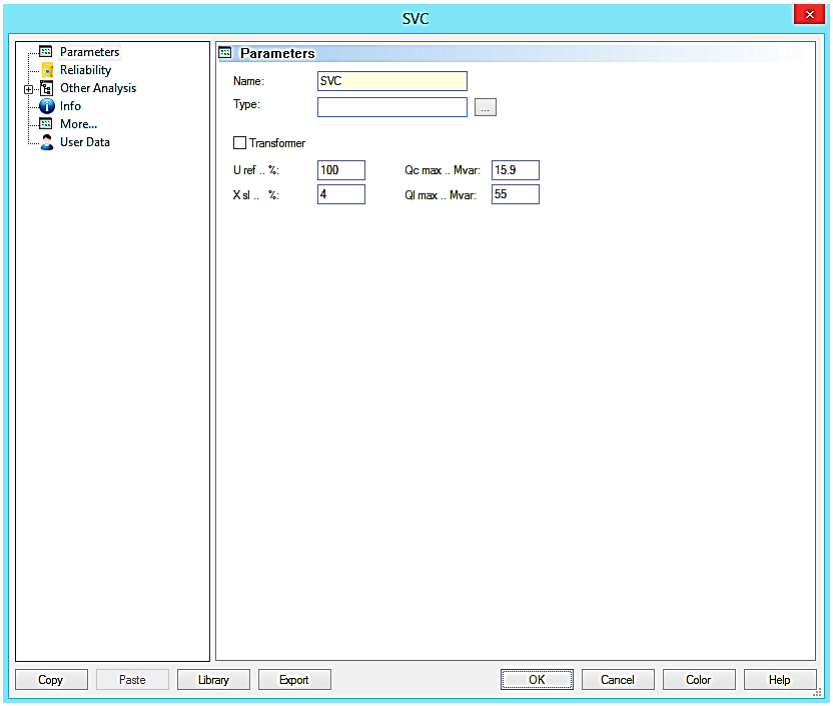
FRZ 220-2	Busbar	220	50	95%	105%
ATB220-1	Busbar	220	50	95%	105%
ATB220-2	Busbar	220	50	95%	105%
POR220-1	Busbar	220	50	95%	105%
POR220-2	Busbar	220	50	95%	105%
SHN 220-1	Busbar	220	50	95%	105%
SHN 220-2	Busbar	220	50	95%	105%
ROS220-1	Busbar	220	50	95%	105%
ROS220-2	Busbar	220	50	95%	105%
SNG220-1	Busbar	220	50	95%	105%
SNG220-2	Busbar	220	50	95%	105%
SNJ220	Busbar	220	50	95%	105%
RNK220-1	Busbar	220	50	95%	105%
RNK220-2	Busbar	220	50	95%	105%
HWT220-1	Busbar	220	50	95%	105%
HWT220-2	Busbar	220	50	95%	105%
GRB220-1	Busbar	220	50	95%	105%
GRB220-2	Busbar	220	50	95%	105%
MSH220-1	Busbar	220	50	95%	105%
MSH220-2	Busbar	220	50	95%	105%
RBK220-1	Busbar	220	50	95%	105%
RBK220-2	Busbar	220	50	95%	105%
MAR220	Busbar	220	50	95%	105%
NHS220-1	Busbar	220	50	95%	105%
NHS220-2	Busbar	220	50	95%	105%
KSL220-1	Busbar	220	50	95%	105%
KSL220-2	Busbar	220	50	95%	105%
ARM220-1	Busbar	220	50	95%	105%
ARM220-2	Busbar	220	50	95%	105%
KLX110-1	Busbar	110	50	93%	107%
KLX110-2	Busbar	110	50	93%	107%
KUK110-1	Busbar	110	50	93%	107%
KUK110-2	Busbar	110	50	93%	107%
KHN110-1	Busbar	110	50	93%	107%
KHN110-2	Busbar	110	50	93%	107%
IBA110-1	Busbar	110	50	93%	107%

IBA110-2	Busbar	110	50	93%	107%
KHE110-1	Busbar	110	50	93%	107%
KHE110-2	Busbar	110	50	93%	107%
IZG110-1	Busbar	110	50	93%	107%
IZG110-2	Busbar	110	50	93%	107%
LOM110-1	Busbar	110	50	93%	107%
LOM110-2	Busbar	110	50	93%	107%
IZB110-1	Busbar	110	50	93%	107%
IZB110-2	Busbar	110	50	93%	107%
MHD110-1	Busbar	110	50	93%	107%
MHD110-2	Busbar	110	50	93%	107%
OMD 110-1	Busbar	110	50	93%	107%
OMD 110-2	Busbar	110	50	93%	107%
MUG110-1	Busbar	110	50	93%	107%
MUG110-2	Busbar	110	50	93%	107%
SHG110-1	Busbar	110	50	93%	107%
SHG110-2	Busbar	110	50	93%	107%
GAD110	Busbar	110	50	93%	107%
AFR110-1	Busbar	110	50	93%	107%
AFR110-2	Busbar	110	50	93%	107%
BAG110	Busbar	110	50	93%	107%
GAM 110-1	Busbar	110	50	93%	107%
GAM 110-2	Busbar	110	50	93%	107%
BNT110-1	Busbar	110	50	93%	107%
BNT110-2	Busbar	110	50	93%	107%
FAR110-1	Busbar	110	50	93%	107%
FAR110-2	Busbar	110	50	93%	107%
JAS110-1	Busbar	110	50	93%	107%
JAS110-2	Busbar	110	50	93%	107%
POR110-1	Busbar	110	50	93%	107%
POR110-2	Busbar	110	50	93%	107%
NHS110-1	Busbar	110	50	93%	107%
NHS110-2	Busbar	110	50	93%	107%
GND110-1	Busbar	110	50	93%	107%
GND110-2	Busbar	110	50	93%	107%
MAR110	Busbar	110	50	93%	107%

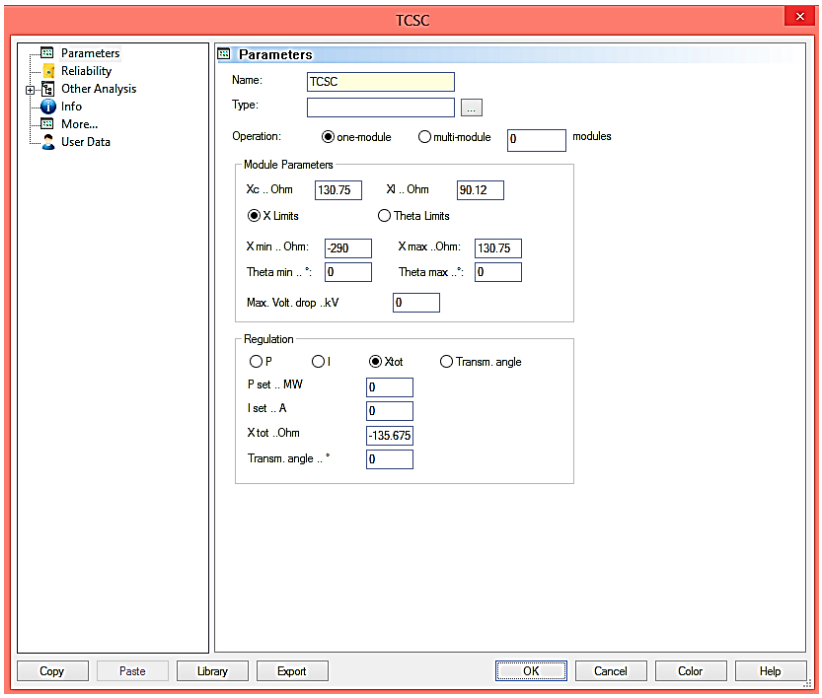
HAS110	Busbar	110	50	93%	107%
HAG110	Busbar	110	50	93%	107%
SNJ110	Busbar	110	50	93%	107%
SNP110	Busbar	110	50	93%	107%
RBK110-1	Busbar	110	50	93%	107%
RBK110-2	Busbar	110	50	93%	107%
MSH110-1	Busbar	110	50	93%	107%
MSK 110-2	Busbar	110	50	93%	107%
SNG 110-2	Busbar	110	50	93%	107%
SNG 110-1	Busbar	110	50	93%	107%
HWT 110 -2	Busbar	110	50	93%	107%
HWT 110 -1	Busbar	110	50	93%	107%
FAO110	Busbar	110	50	93%	107%
GDF110	Busbar	110	50	93%	107%
GRB 66 -1	Busbar	66	50	93%	107%
GRB 66 -2	Busbar	66	50	93%	107%

Appendix (B)

FACT's Parameter



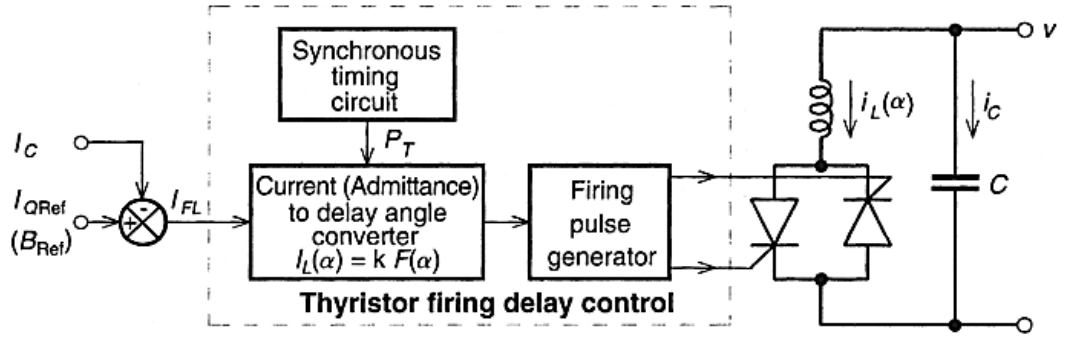
Portsudan SVC parameters.



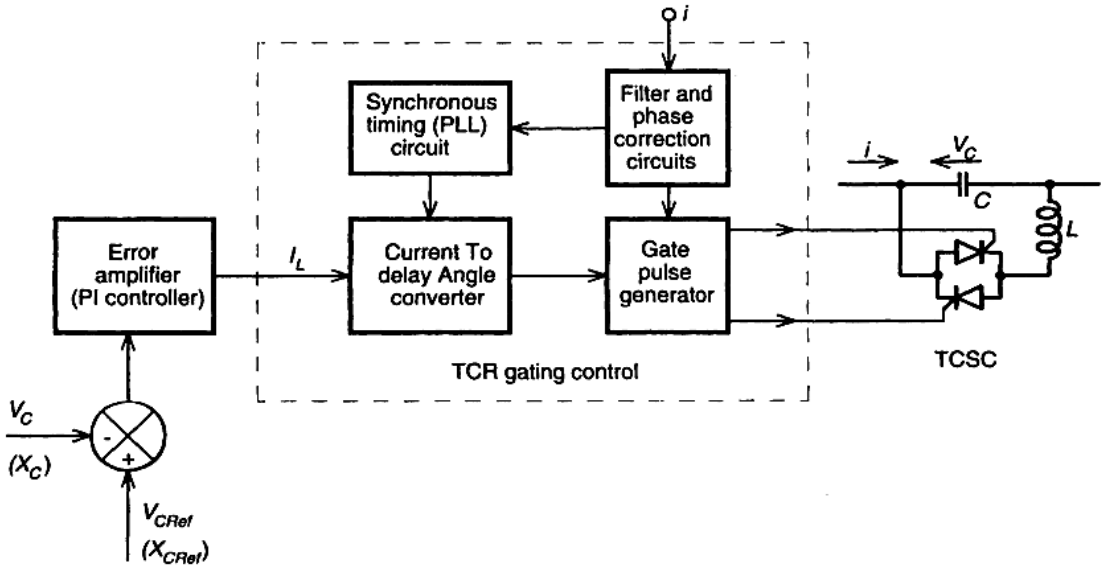
TCSC parameters

Appendix (C)

Control Circuits



A functional control scheme for the FC-TCR type static var compensator.



A functional control scheme for the TCSC based on the synchronization to the fundamental component of the line current.