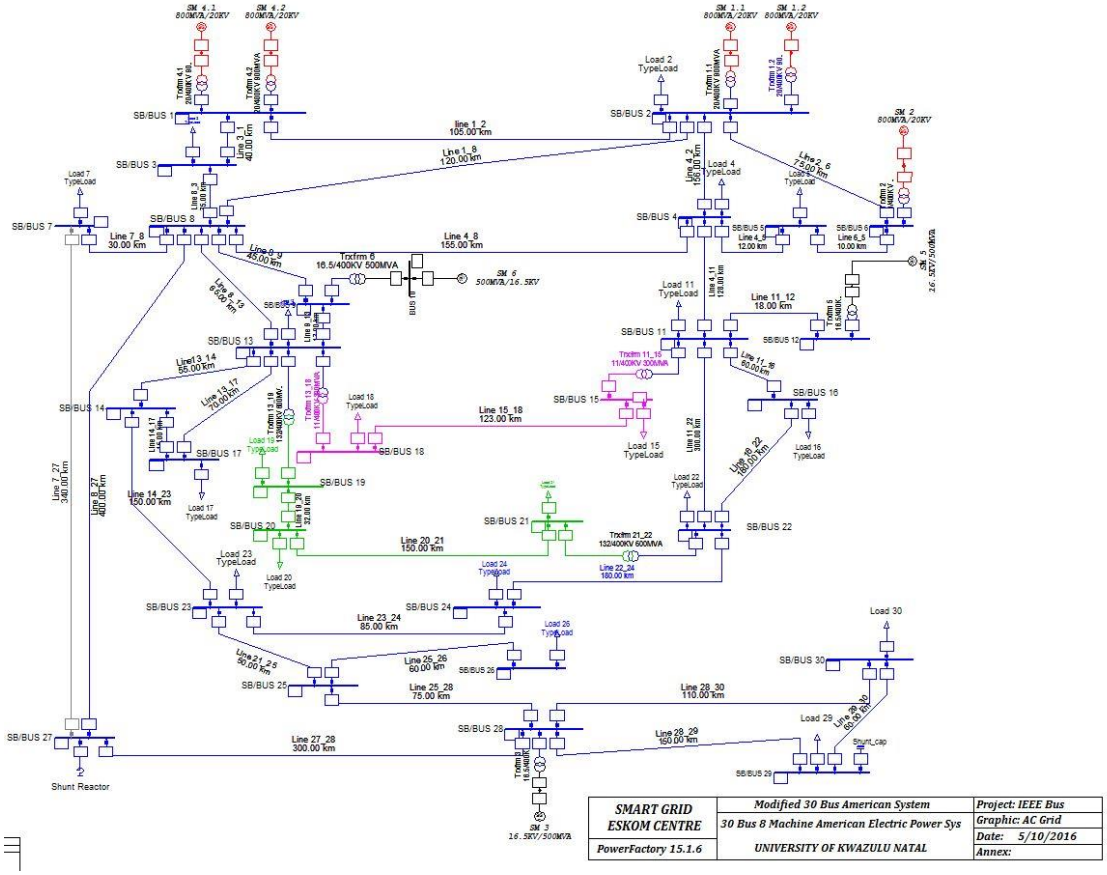
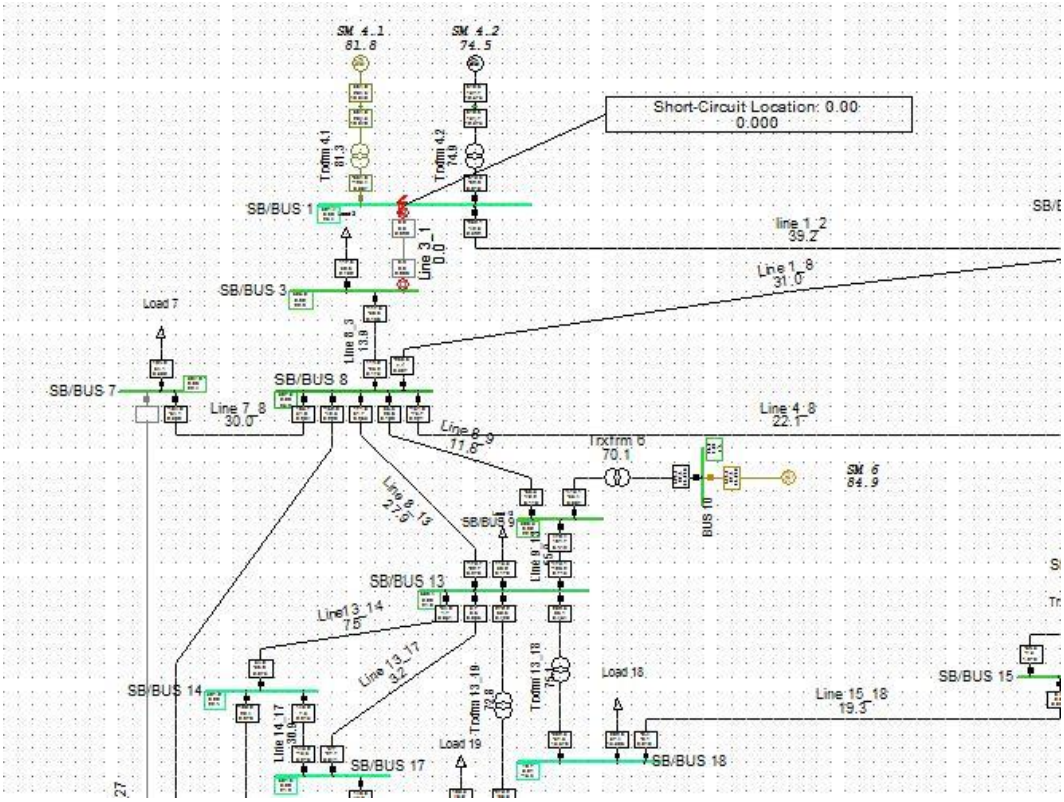
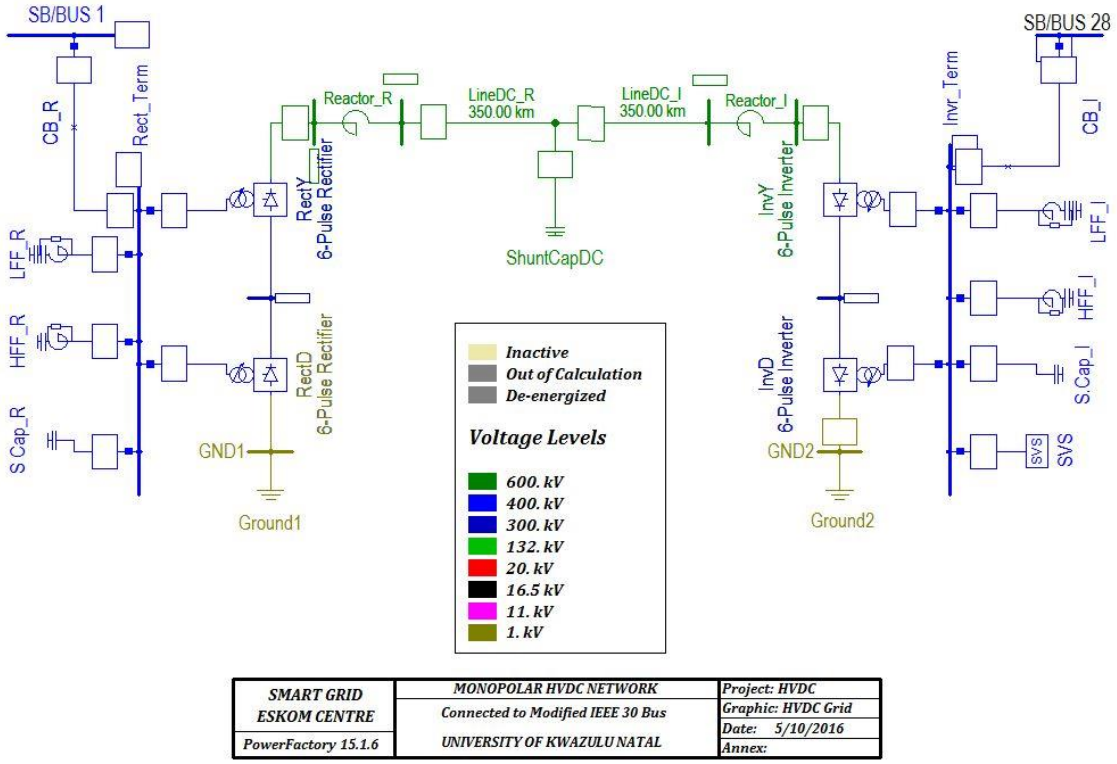
IEEE 30-bus system DATA.



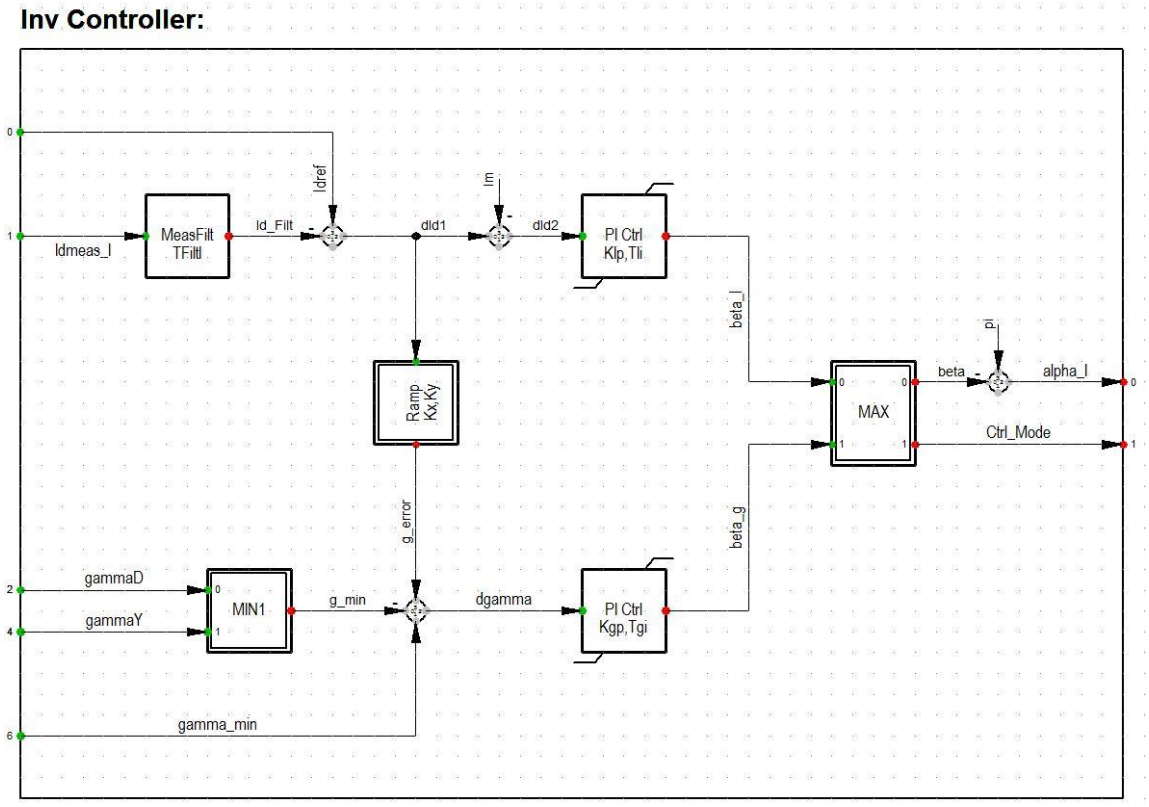


During 3-phase short circuits faults



600kV monopolar HVDC line diagram on DigSILENT

600kV Monopolar HVDC Data



Inverter control block

- **DigSILENT simulation language for Inverter control block**

inc(xg)=pi()-alpha_I

inc(xI)=bI_max

inc(gamma_min)=select(gammaD>gammaY,gammaY,gammaD)

inc(Idref)=Idmeas_I

inc(xFiltI)=1

inc0(gammaD)=99999.

inc0(gammaY)=99999.

vardef(gamma_min)='rad';'Minimum Extinction Angle'

vardef(Kgp)='p.u.';'Proportional Gain Gamma Controller'

vardef(Tgi)='s';'Integral Time Constant Gamma Controller'

vardef(alpha_g_max)='rad';'Maximum Firing Angle (Gamma Ctrl)'

vardef(alpha_g_min)='rad';'Minimum Firing Angle (Gamma Ctrl)'

vardef(KIp)='p.u.';'Proportional Gain Current Controller'

vardef(TIi)='s';'Integral Time Constant Current Controller'

vardef(alpha_I_max)='rad';'Maximum Firing Angle (Id Ctrl)'

vardef(alpha_I_min)='rad';'Minimum Firing Angle (Id Ctrl)'

vardef(Imargin)='p.u.';'Current Margin'

vardef(Kx)='p.u.';'x-Edge of Ramp Function'

vardef(Ky)='p.u.';'y-Edge of Ramp Function'

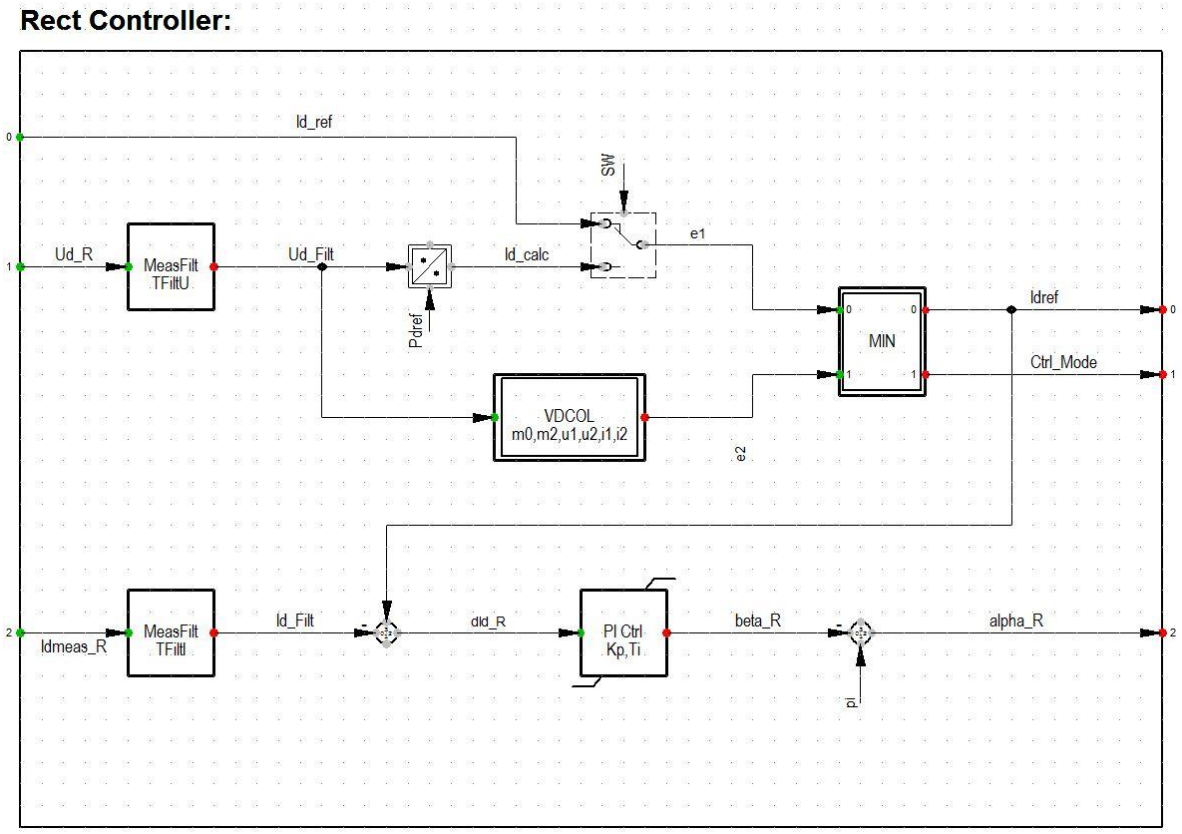
vardef(TFiltI)='s';'Filter Time Constant of Id-Measurement'

Inverter control Block parameters

Controller Signals	Inverter Control
Kgp Proportional Gain Gamma Controller (p.u.)	0.1
Tg Integral Time Constant Gamma Controller (s)	0.01
Kip Proportional Gain Current Controller (p.u.)	0.1
Tii Integral Time Constant Current Controller (s)	0.01
Imargin Current Margin (p.u.)	0.1
TFiltI Filter Time Constant of Id-Measurement (s)	0.0012
Kx x-Edge of Ramp Function (p.u.)	0.1
Ky y-Edge of Ramp Function (p.u.)	0.3
alpha_g_min Minimum Firing Angle Gamma Ctrl (rad)	90
alpha_I_min Minimum Firing Angle Id Ctrl rad	70
alpha_g_max Maximum Firing Angle Gamma Ctrl (rad)	150

alpha_I_max Maximum Firing Angle Id Ctrl (rad)	150

Rect Controller:



Rectifier control block diagram

- **DigSILENT simulaton language for Rectifier control block**

inc(xi)=pi()-alpha_R

inc(Id_ref)=Idmeas_R

inc(xFiltU)=1

inc(xFiltI)=1

inc0(Ud_R)=1

inc0(Idref)=Idmeas_R

vardef(Kp)='p.u.';'Proportional Gain'

vardef(Ti)='s';'Integral Time Constant'

vardef(alpha_max)='rad';'Maximum Firing Angle'

vardef(alpha_min)='rad';'Minimum Firing Angle'

vardef(Pd)='p.u.';'DC Power Setpoint'

vardef(P_I)='ON/OFF';'Current/Power Control, Pd=1/Id=0'

vardef(TFiltU)='s';'Filter Time Constant Ud-Measurement'

vardef(TFiltI)='s';'Filter Time Constant Id-Measurement'

alpha_deg = alpha_R/pi()*180

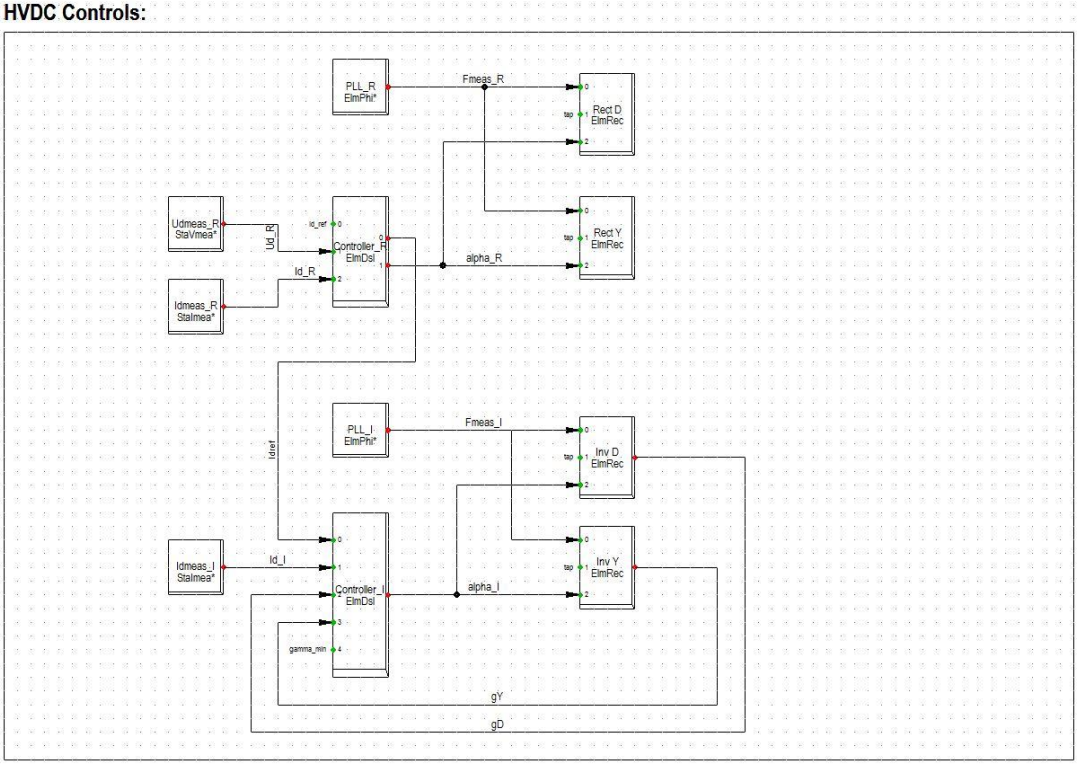
beta_deg = beta_R/pi()*180

Idref_kV = Idref*2

Rectifier control block parameters

Controller Signals	Rectifier Control
Kp Proportional Gain (p.u.)	1.1
Ti Integral Time Constant (s)	0.01
P_I Current/Power Control, Pd=1/Id=0 (ON/OFF)	0
Pd DC Power Setpoint p.u	1.1
TFiltU Filter Time Constant Ud-Measurement (s)	0.03
TFiltI Filter Time Constant Id-Measurement (s)	0.0013
m0	0
m2	1
u1	0.4
u2	0.8
i1	0.55
i2	0.9
alpha_min Minimum Firing Angle (rad)	5
alpha_max Maximum Firing Angle (rad)	150

HVDC Controls:



Overall composite model for monopolar HVDC scheme

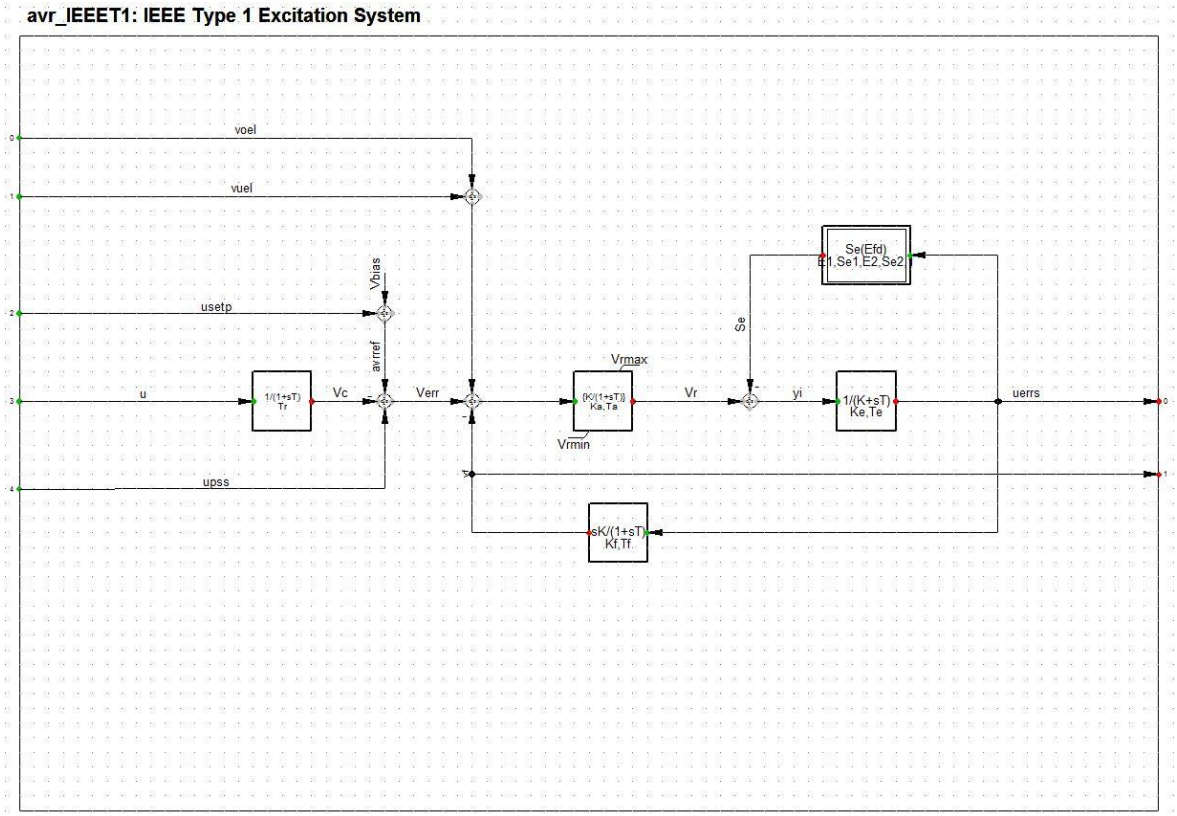
HVDC line parameters

Line Name	length (km)	I rated kA	Nom. V. (kV)	R' 20^{0}C Ω/km	x'	L'	R 80^{0}C Ω/km
LineDC_R	350	2.8	600	0.01	0.1	0.31831	0.012418
LineDC_I	350	2.8	600	0.01	0.1	0.31831	0.012418

HVAC line parameters

Line Name	Length (km)	I kA	Nom. V. (kV)	R' 20^{0}C Ω/km	x'	L'	B'	C'
line 1_2	105	1	400	0.0452	0.3	0.95493	4.426979	0.014092
Line13_14	55	1	400	0.057	0.3	0.95493	4.181989	0.013312
Line 9_13	17	1.3	400	0.1243	0.3	0.95493	3.5162	0.011192
Line 8_9	45	1	400	0.0169	0.3	0.95493	3.932318	0.012517
Line 8_3	75	1.3	400	0.057	0.3	0.95493	5.409538	0.017219
Line 8_27	400	1	400	0.0581	0.3	0.95493	2.937006	0.009349
Line 8_13	65	1	400	0.057	0.3	0.95493	2.49671	0.007947
Line 7_8	30	1	400	0.0936	0.3	0.95493	3.120888	0.009934
Line 7_27	340	1	400	0.0192	0.3	0.95493	3.99342	0.012711
Line 6_5	10	1.2	400	0.1	0.3	0.95493	5.201479	0.016557
Line 4_8	155	1	400	0.034	0.3	0.95493	5.201479	0.016557
Line 4_5	12	1	400	0.0231	0.3	0.95493	2.559128	0.008146
Line 4_2	156	1	400	0.0243	0.3	0.95493	3.8699	0.012318
Line 4_11	128	1	400	0.0243	0.3	0.95493	3.8699	0.012318
Line 3_1	40	1.4	400	0.011	0.3	0.95493	4.181989	0.013312
Line 2_6	75	1	400	0.057	0.3	0.95493	4.406173	0.014025
Line 29_30	60	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 28_30	110	1.3	400	0.0243	0.3	0.95493	2.60074	0.008278
Line 28_29	150	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 27_28	300	1	400	0.0181	0.3	0.95493	5.617597	0.017881
Line 25_28	75	1.3	400	0.057	0.3	0.95493	2.517516	0.008014
Line 25_26	60	1.3	400	0.057	0.3	0.95493	2.517516	0.008014
Line 23_24	85	1	400	0.057	0.3	0.95493	3.120888	0.009934
Line 22_24	180	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 21_25	50	1.5	400	0.057	0.3	0.95493	2.49671	0.007947
Line 20_21	150	1	132	0.0231	0.3	0.95493	4.614233	0.014688
Line 1_8	120	1.3	400	0.0192	0.3	0.95493	4.161183	0.013245
Line 19_20	32	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 16_22	180	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 15_18	123	0.1	11	0.0747	0.3	0.95493	4.452466	0.014173
Line 14_23	150	1.2	400	0.1243	0.3	0.95493	3.517516	0.011197
Line 14_17	15	0.7	400	0.0231	0.3	0.95493	3.745065	0.011921
Line 13_17	70	1.3	400	0.057	0.3	0.95493	2.517516	0.008014
Line 11_22	300	1	400	0.0581	0.3	0.95493	2.937006	0.009349
Line 11_16	60	0.7	400	0.0231	0.3	0.95493	3.745065	0.011921
Line 11_12	18	1	400	0.057	0.3	0.95493	3.120888	0.009934

- **Synchronous Machine Controller Data**



Avr_IEEET1- IEEE type 1 excitation system

- **DigSILENT simulation language for Avr_IEEET1- IEEE type 1 excitation system**

inc(upss) = 0

inc(vuel) = 0

inc(voel) = 0

!inc(usetp) = xa/Ka+u

inc(usetp) = u

inc(Vbias) = xa/Ka-(vuel+voel)

inc(xr) = u

inc(xe) = uerrs

inc(xf) = uerrs

inc(xa) = xe*Ke1+Se

inc(Y_max)=select(Vrmax<=0,select(Ke>0,(Se2+Ke)*E2,(Se2)*E2),Vrmax)

inc(Y_min)=select(Vrmax<=0,-Y_max,Vrmin)

inc(Ke1)=select(Ke=0,Y_max/uerrs/10-Se,Ke)

inc(vf) = 0.0

vardef(Tr) ='s';'Measurement Delay'

vardef(Ka) ='pu';'Controller Gain'

vardef(Ta) ='s';'Controller Time Constant'

vardef(Vrmax) ='pu';'Controller Output Maximum'

vardef(Vrmin) ='pu';'Controller Output Minimum'

vardef(Ke) ='pu';'Exciter Constant'

vardef(Te) ='s';'Exciter Time Constant'

vardef(Kf) ='pu';'Stabilization Path Gain'

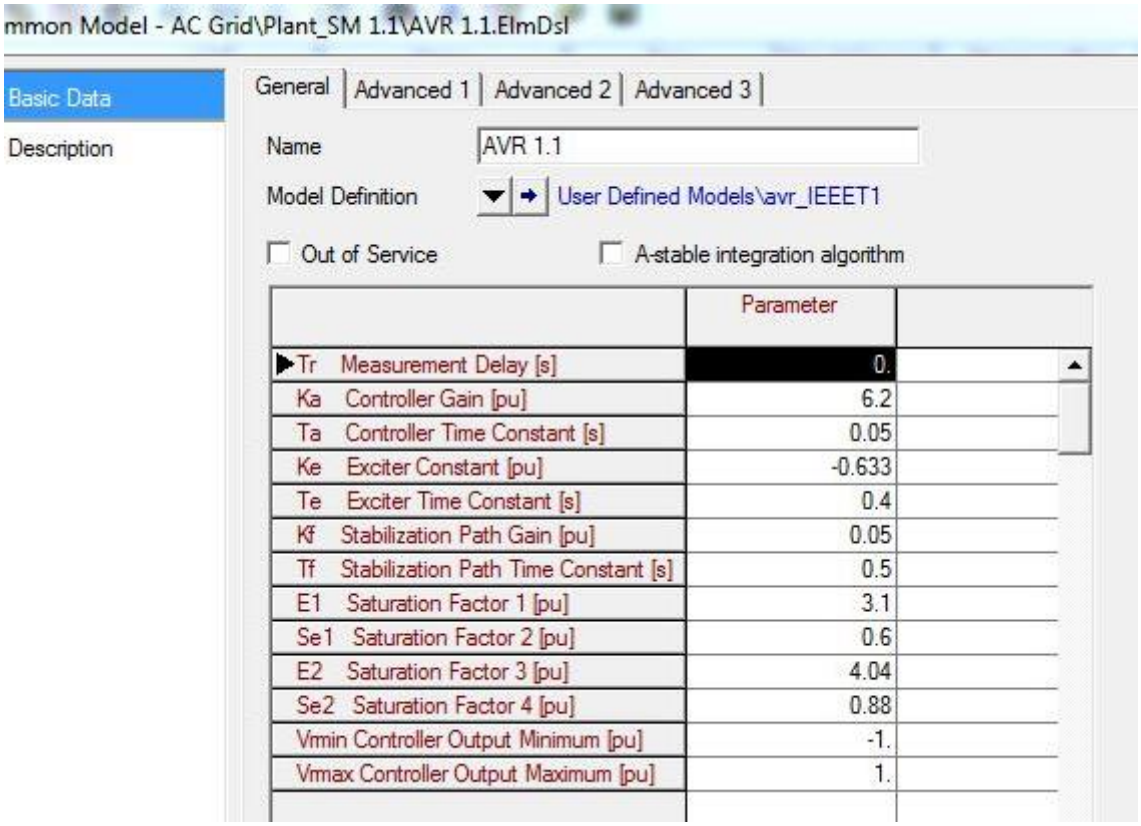
vardef(Tf) ='s';'Stabilization Path Time Constant'

vardef(E1) ='pu';'Saturation Factor 1'

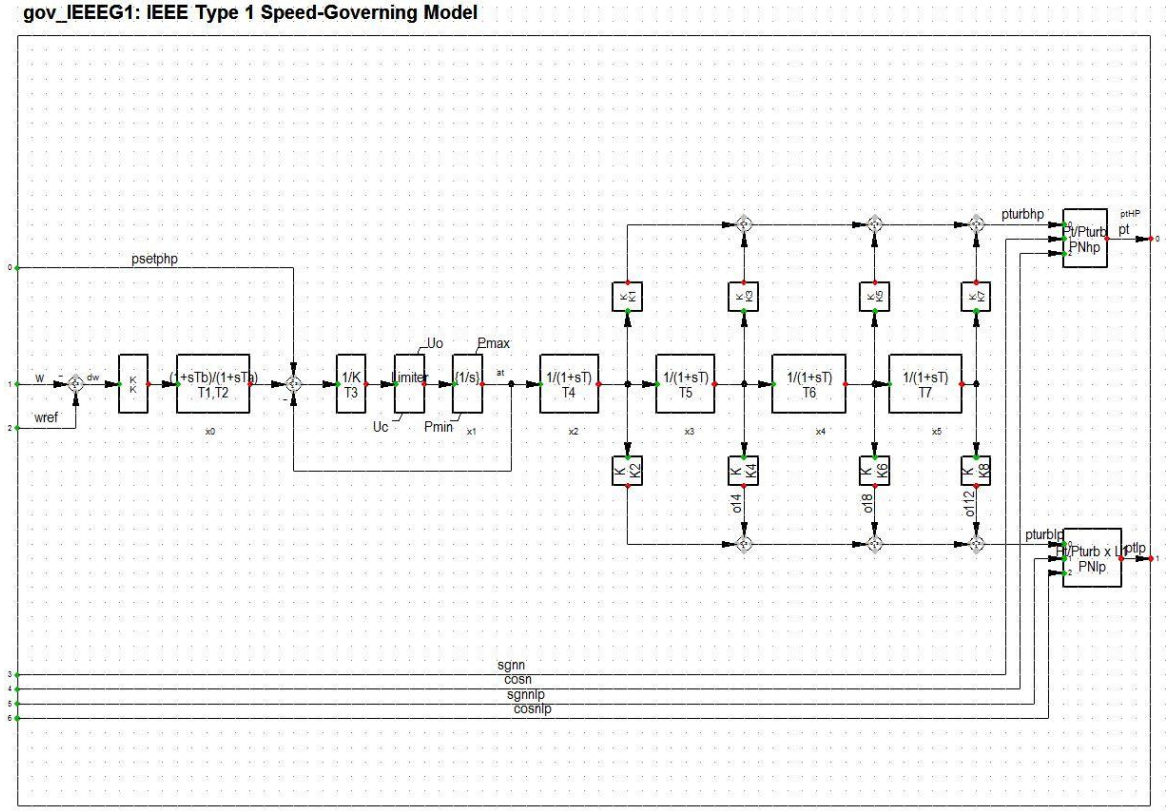
vardef(E2) ='pu';'Saturation Factor 3'

vardef(Se1) ='pu';'Saturation Factor 2'

vardef(Se2) ='pu';'Saturation Factor 4'



Avr_IEEET1- IEEE type 1 excitation system Parameters



Gov_IEEEGI – IEEE type 1 speed governing model

- **DigSILENT simulation language for Gov_IEEEGI – IEEE type 1 speed governing model**

inc(Plp) =select(PNlp>0.0,ptlp*sgnnlp*cosnlp/PNlp,ptlp)

inc(Php) =select(PNhp>0.0,pt*sgnn*cosn/PNhp,pt)

inc(L1) = select(K2+K4+K6+K8 > 0.00001,(Plp)/ ((Php)*(K2+K4+K6+K8) / (K1+K3+K5+K7)),0.0)

inc(x0) =0.0

inc(wref) =w

inc(psetphp)=pturbhp/(K1+K3+K5+K7)

inc(x1) =psetphp

inc(x2) =psetphp

inc(x3) =psetphp

inc(x4) =psetphp

inc(x5) =psetphp

inc0(ptlp) =0.0

inc0(cosnlp)=1.0

inc0(sgnnlp)=1.0

vardef(K) ='p.u.';'Controller Gain'

vardef(T1) ='s';'Governor Time Constant'

vardef(T2) ='s';'Governor Derivative Time Constant'

vardef(T3) ='s';'Servo Time Constant'

vardef(Uo) ='p.u./s';'Valve Opening Time'

vardef(Uc) ='p.u./s';'Valve Closing Time'

vardef(Pmax)='p.u.';'Maximum Gate Limit'

vardef(Pmin)='p.u.';'Minimum Gate Limit'

vardef(T4) ='s';'High Pressure Turbine Time Constant'

vardef(K1) ='p.u.';'High Pressure Turbine Factor'

vardef(K2) ='p.u.';'High Pressure Turbine Factor'

vardef(T5) ='s';'Intermediate Pressure Turbine Time Constant'

vardef(K3) ='p.u.';'Intermediate Pressure Turbine Factor'

vardef(K4) ='p.u.';'Intermediate Pressure Turbine Factor'

vardef(T6) ='s';'Medium Pressure Turbine Time Constant'

vardef(K5) ='p.u.';'Medium Pressure Turbine Factor'

vardef(K6) ='p.u.';'Medium Pressure Turbine Factor'

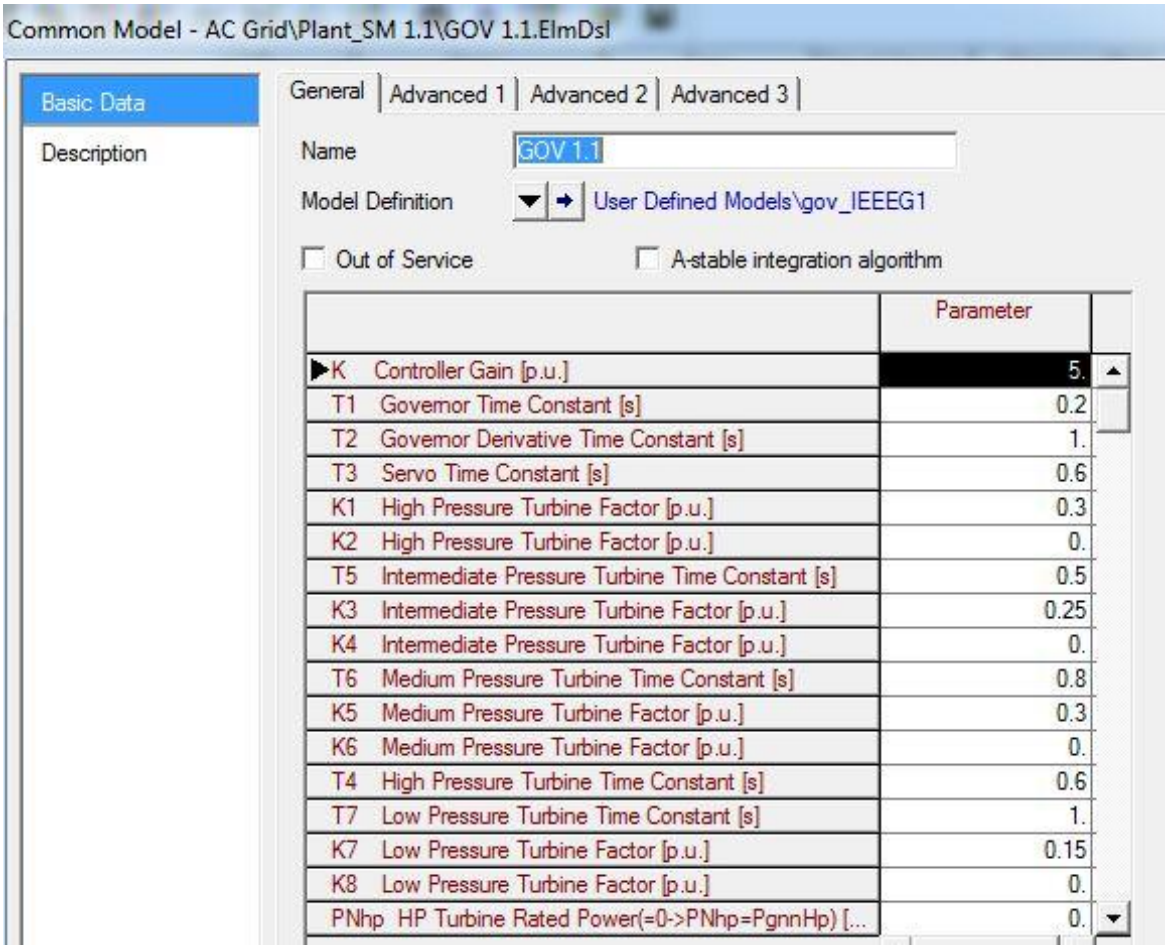
vardef(T7) ='s';'Low Pressure Turbine Time Constant'

vardef(K7) ='p.u.';'Low Pressure Turbine Factor'

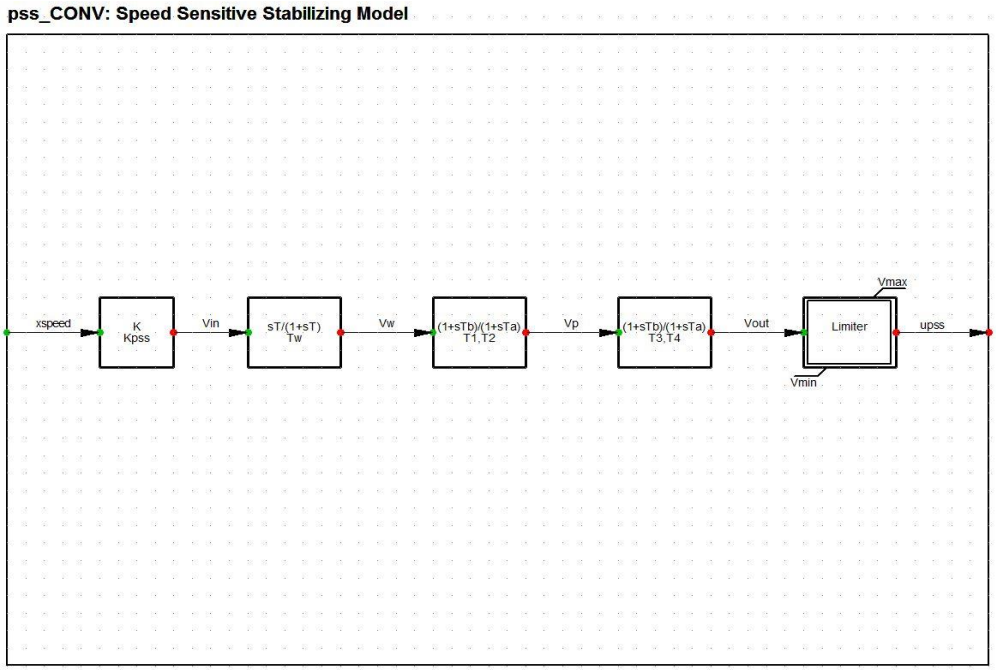
vardef(K8) ='p.u.';'Low Pressure Turbine Factor'

vardef(PNhp) ='MW';'HP Turbine Rated Power(=0->PNhp=PgnnHp)'

vardef(PNlp) ='MW';'LP Turbine Rated Power(=0->PNlp=Pgnnlp)'



Gov_IEEEGI – IEEE type 1 speed governing model parameters



PSS_CONV – speed sensitive stabilizing model

- **DigSILENT simulation language for PSS_CONV – speed sensitive stabilizing model**

inc(xw) =xspeed*Kpss

inc(x2) =0

inc(x3) =0

inc(upss) =0

vardef(Kpss) ='pu';'Stabilizer Gain'

vardef(Tw) ='s';'Washout integrate time constant'

vardef(T1) ='s';'First Lead/Lag derivative time constant'

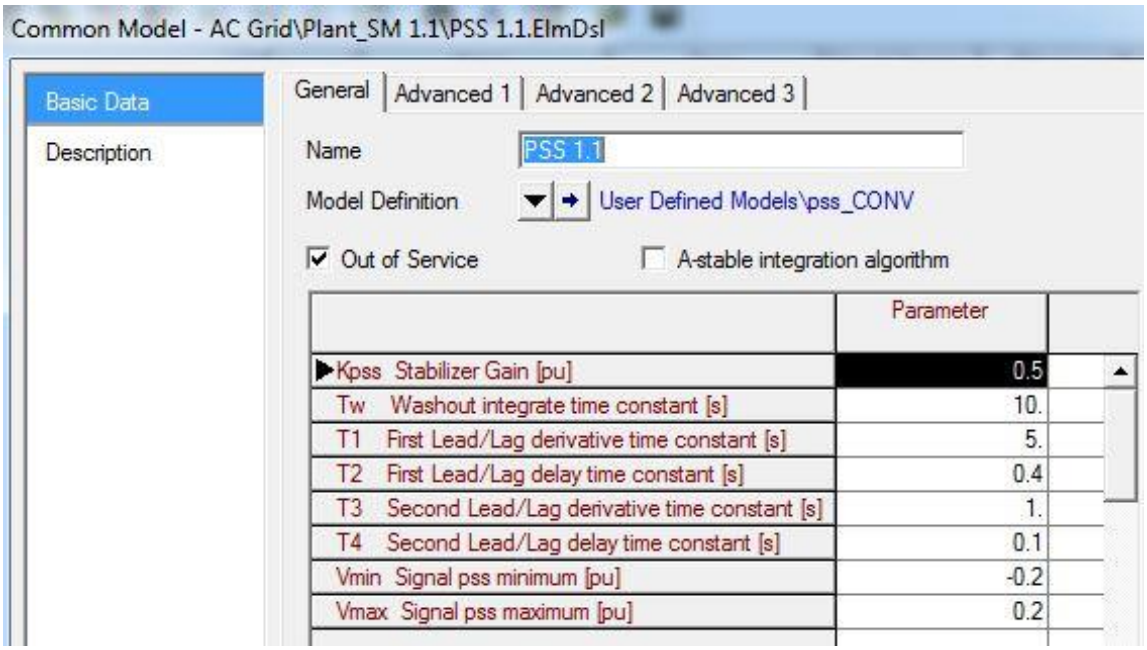
vardef(T2) ='s';'First Lead/Lag delay time constant'

vardef(T3) ='s';'Second Lead/Lag derivative time constant'

vardef(T4) ='s';'Second Lead/Lag delay time constant'

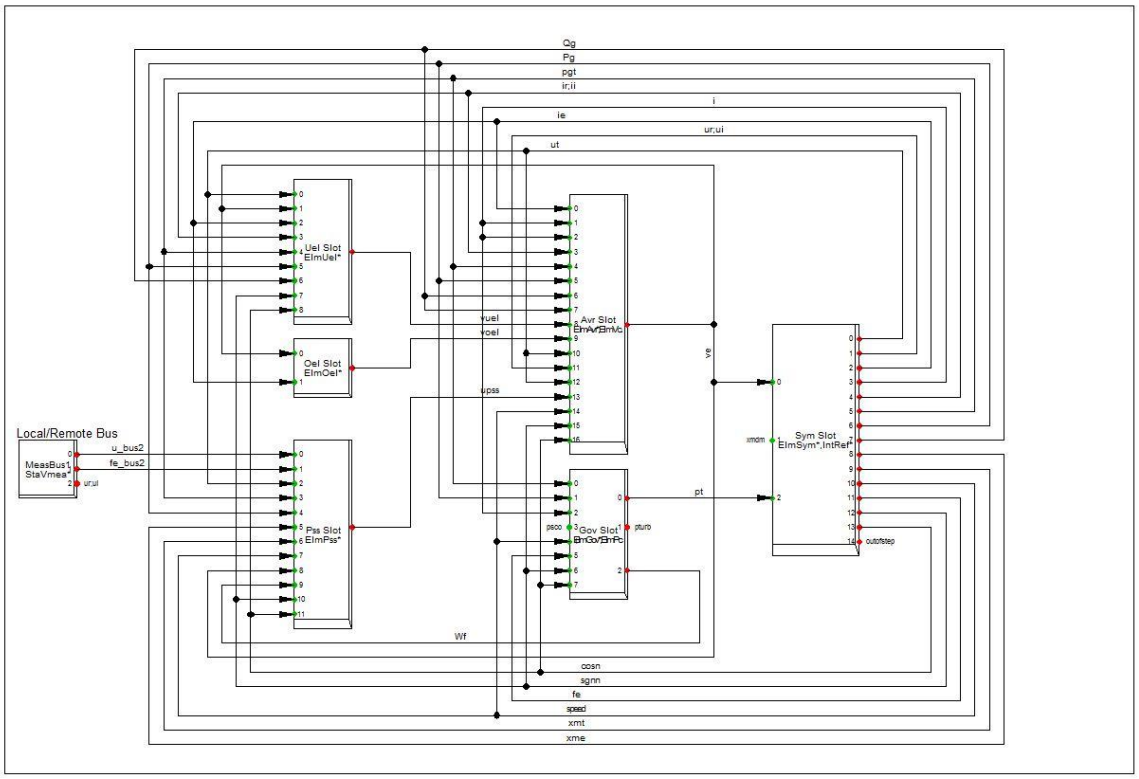
vardef(Vmax) ='pu';'Signal pss maximum'

vardef(Vmin) ='pu';'Signal pss minimum'



PSS_CONV – speed sensitive stabilizing model parameters

SYM Frame_no droop: Synchronous Machine Signal Interconnections



Synchronous machine signal interconnect on DigSILENT

Synchronous machine data

Machine Name	App. power MVA	Nom. V kV	power factor	P (MW)	Q Mvar	Vset p.u.	power factor
SM 1.1	850	20	0.9	700	5	1	0.9999744
SM 1.2	850	20	0.9	700.5651	0	0.99	1
SM 2	850	20	0.9	319.7674	0	1	1
SM 3	500	16.5	0.85	406.9767	0	1.03	1
SM 4.1	850	20	0.9	720.6294	5	1	0.9999759
SM 4.2	850	20	0.9	720.3079	0	1	1
SM 5	500	16.5	0.85	387.5969	0	1.01	1
SM 6	500	16.5	0.89	385.6589	5	1.01	0.999916

Synchronous machine type

SM Type	H_Sgn (s)	xl p.u	xd p.u.	xq p.u.	Td' (s)	Tq' (s)	Td'' (s)	Tq'' (s)	xd' p.u.	xq' p.u.	xd'' p.u.	xq'' p.u.	x0 p.u
SM 1.1	3	0.3	2.2	2.2	2.1	0.28	0.02	0.008	0.6	0.8	0.4	0.4	0.1
SM 1.2	3	0.3	2.2	2.2	2.1	0.28	0.02	0.008	0.6	0.8	0.4	0.4	0.1
SM 2	3	0.3	2.2	2.2	2.1	0.28	0.02	0.008	0.6	0.8	0.4	0.4	0.1
SM 3	4	0.1	2	2	1	1	0.05	0.05	0.3	0.3	0.2	0.2	0.1
SM 4.1	3	0.3	2.2	2.2	2.1	0.28	0.02	0.008	0.6	0.8	0.4	0.4	0.1
SM 4.2	3	0.3	2.2	2.2	2.1	0.28	0.02	0.008	0.6	0.8	0.4	0.4	0.1
SM 5	4	0.1	2	2	1	1	0.05	0.05	0.3	0.3	0.2	0.2	0.1
SM 6	4	0.15	1.3	2	1	1	0.05	0.05	0.3	0.3	0.2	0.2	0.18

Transformer parameters

Transformer Name	MVA Rating	LV kV	HV kV	shc volt (%)	x1 (p.u.)	x0 (p.u.)	vector group	uk (%)
Trxfrm 1.1	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 1.2	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 11_15	400	400	11	12.6	0.126	0.126	YNd1	12.6
Trxfrm 13_18	400	400	11	12.6	0.126	0.126	YNd1	12.6
Trxfrm 13_19	400	400	132	11.82	0.1182	0.1182	YNyn0	11.82
Trxfrm 2	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 21_22	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 3	600	400	16.5	14.88	0.1488	0.1488	YNd1	14.88
Trxfrm 4.1	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 4.2	850	400	20	14.44	0.1444	0.1444	YNd1	14.44
Trxfrm 5	600	400	16.5	14.88	0.1488	0.1488	YNd1	14.88
Trxfrm 6	600	400	16.5	14.88	0.1488	0.1488	YNd1	14.88

Transformer tap changers parameter

Transformer Name	tap changers					
	tap side	add. Volt/tap	phase of du (deg)	neutral tap	min tap	max tap
Trxfrm 1.1	HV	1.25	180	0	-5	5
Trxfrm 1.2	HV	1.25	180	0	-5	5
Trxfrm 11_15	HV	1.25	180	0	-5	5
Trxfrm 13_18	HV	1.25	180	0	-5	5
Trxfrm 13_19	HV	1.1	180	0	-3	3
Trxfrm 2	HV	1.25	180	0	-5	5
Trxfrm 21_22	HV	1.25	180	0	-5	5
Trxfrm 3	HV	1.1	180	0	-4	4
Trxfrm 4.1	HV	1.25	180	0	-5	5
Trxfrm 4.2	HV	1.25	180	0	-5	5
Trxfrm 5	HV	1.1	180	0	-4	4
Trxfrm 6	HV	1.1	180	0	-4	4