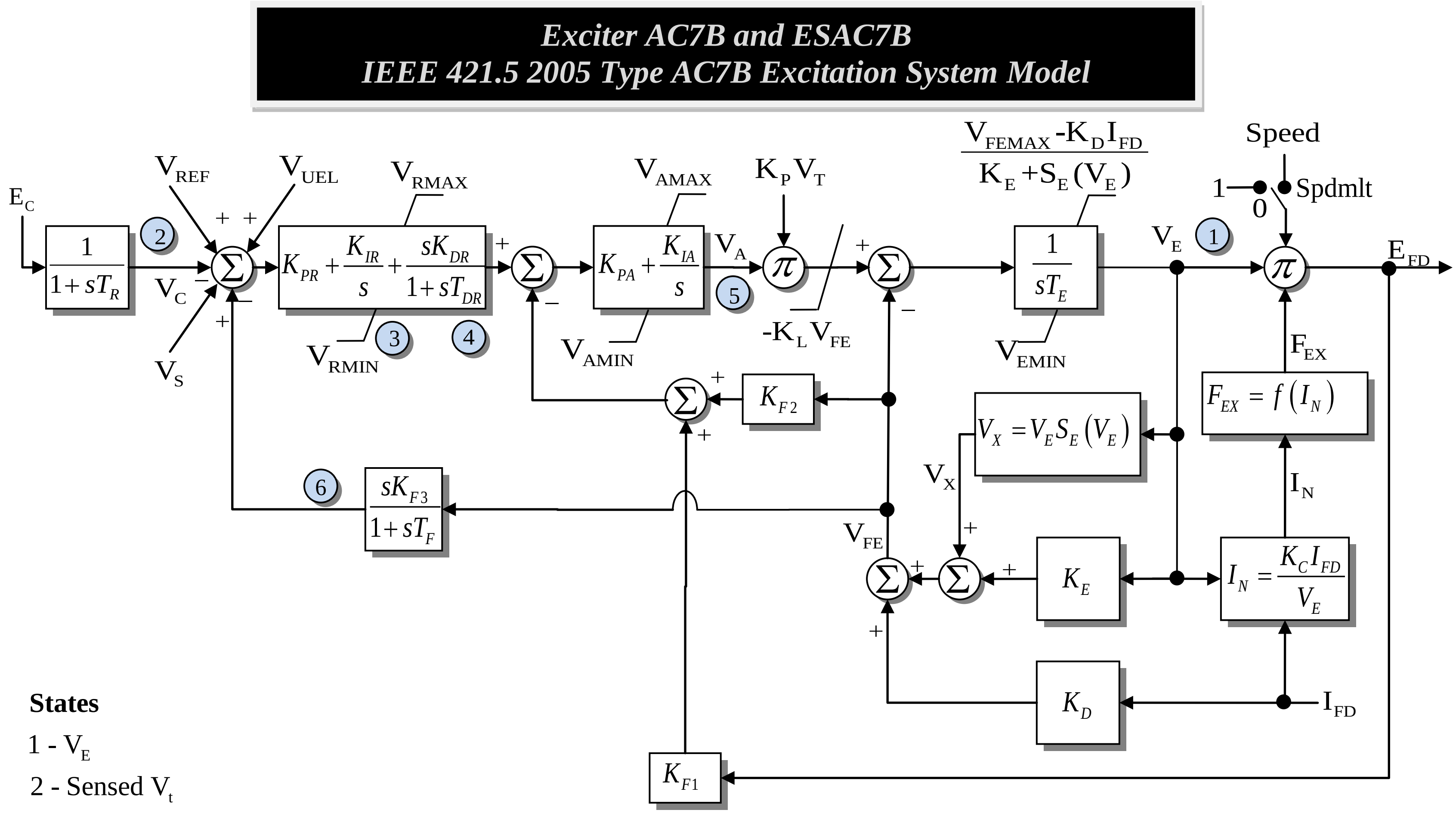
Exciter AC7B and ESAC7B



States

1 - V_E

2 - Sensed V_t

3 - K_{IR}

4 - K_{DR}

5 - V_A

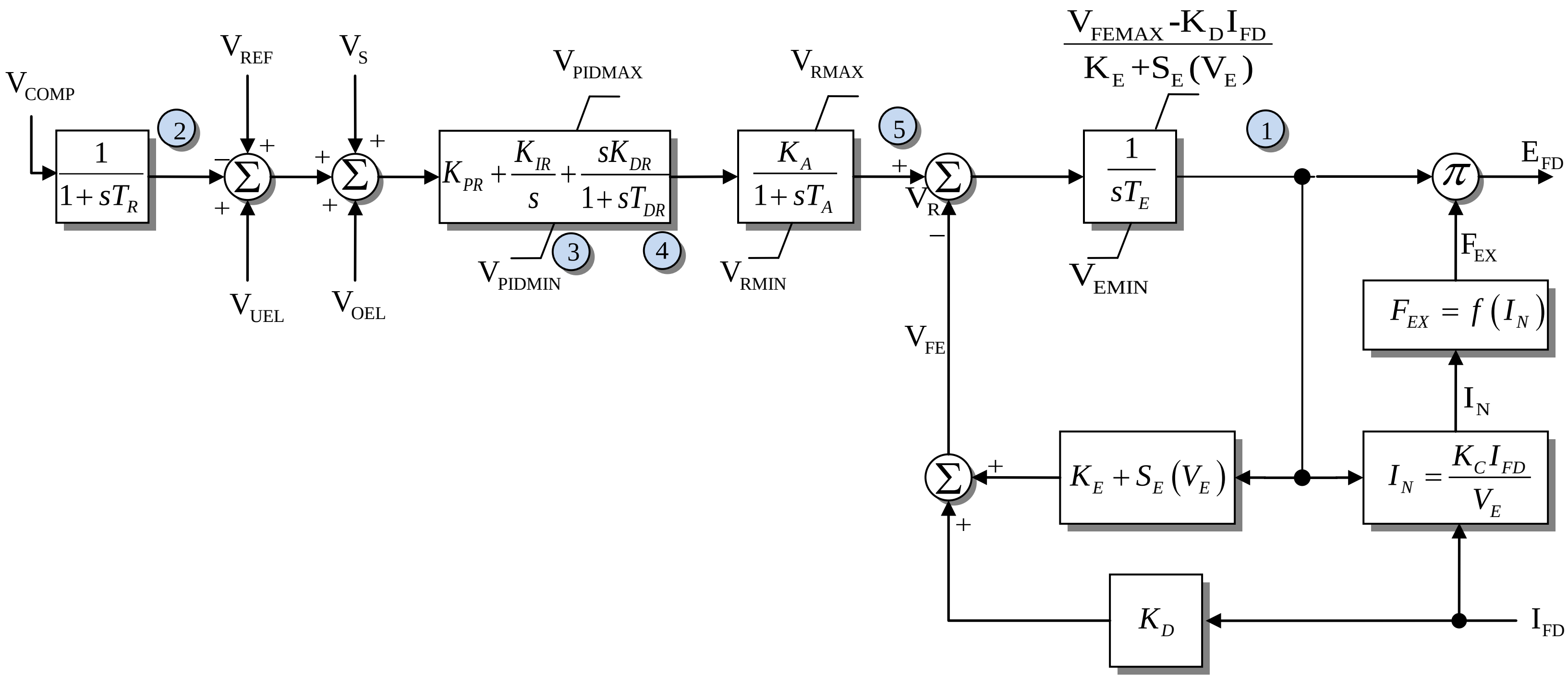
6 - Feedback

AC7B supported by PSSE

ESAC7B supported by PSLF with optional speed multiplier

Exciter AC8B

Exciter AC8B
IEEE 421.5 2005 AC8B Excitation System



States

1 - V_E

2 - Sensed V_t

3 - PID 1

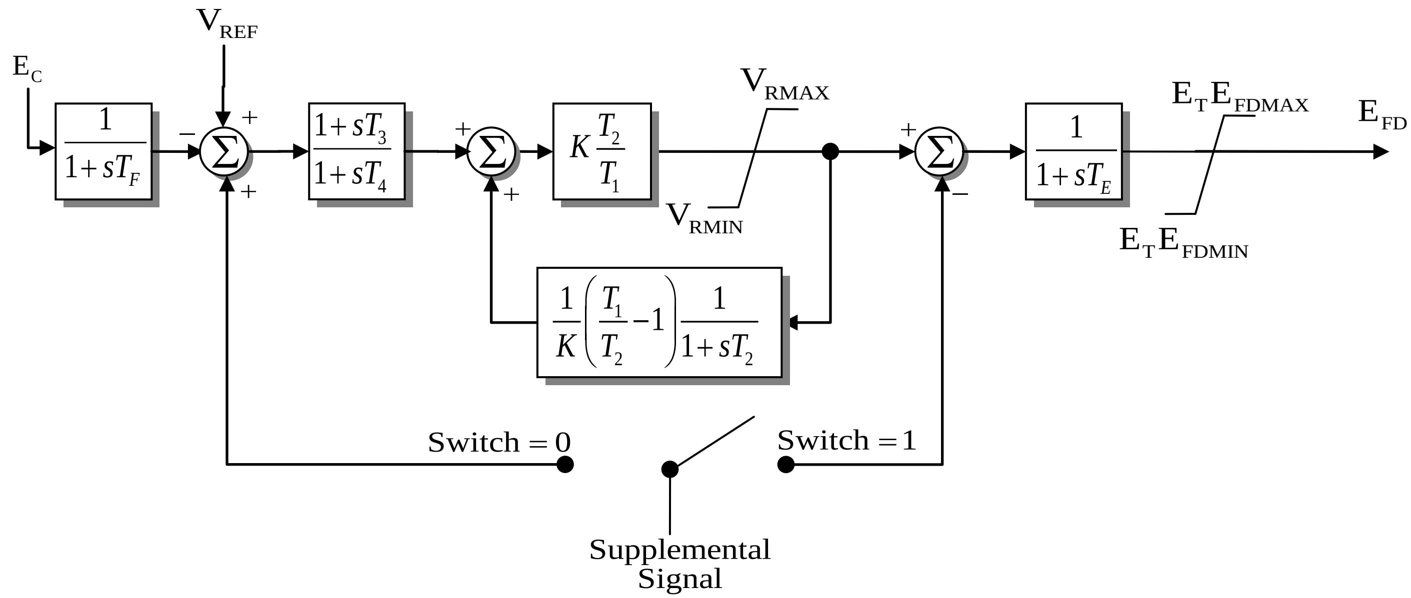
4 - PID 2

5 - V_R

Model supported by PSSE

Exciter BBSEX1

Exciter BBSEX1
Transformer-fed Excitation System

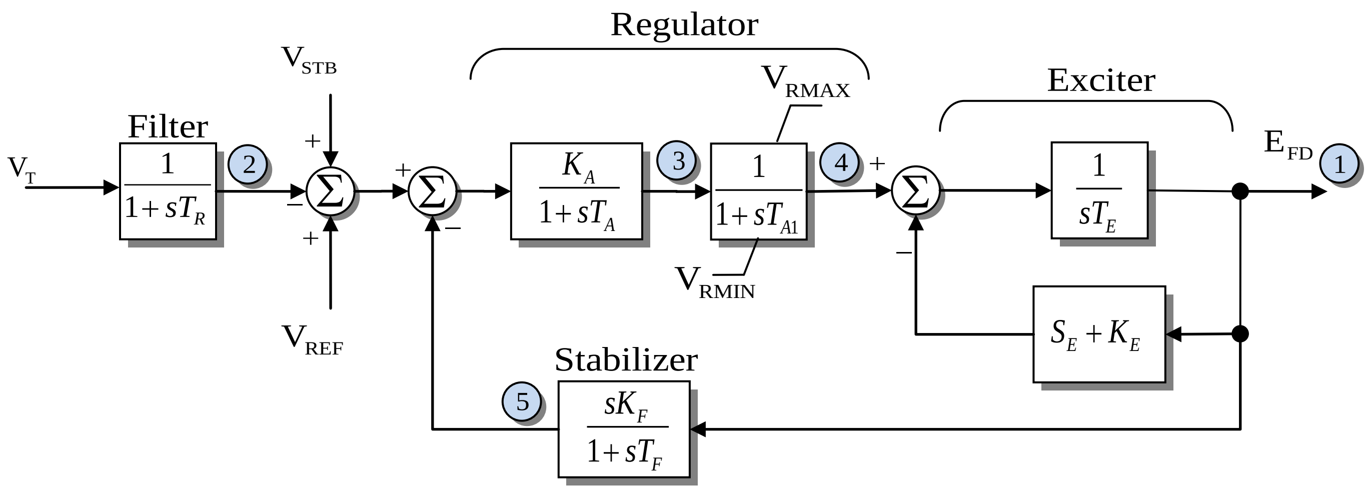


Model supported by PSSE

Very similar to the model EXBBC supported by PSLF

Exciter BPA_EA

Exciter BPA_EA
Continuously Acting DC Rotating Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

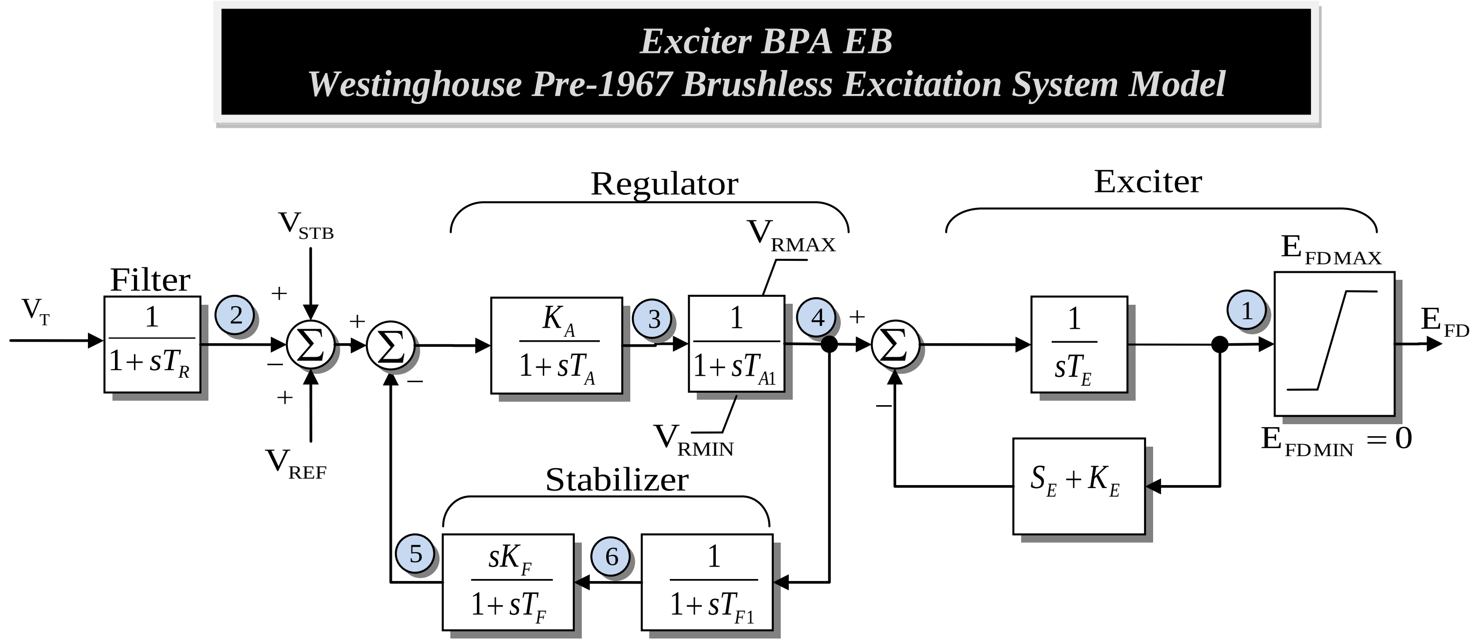
3 - V_R

4 - V_{R1}

5 - V_F

Model in the public domain, available from BPA

Exciter BPA EB



States

1 - E_{FD} before limit

2 - Sensed V_t

3 - V_R

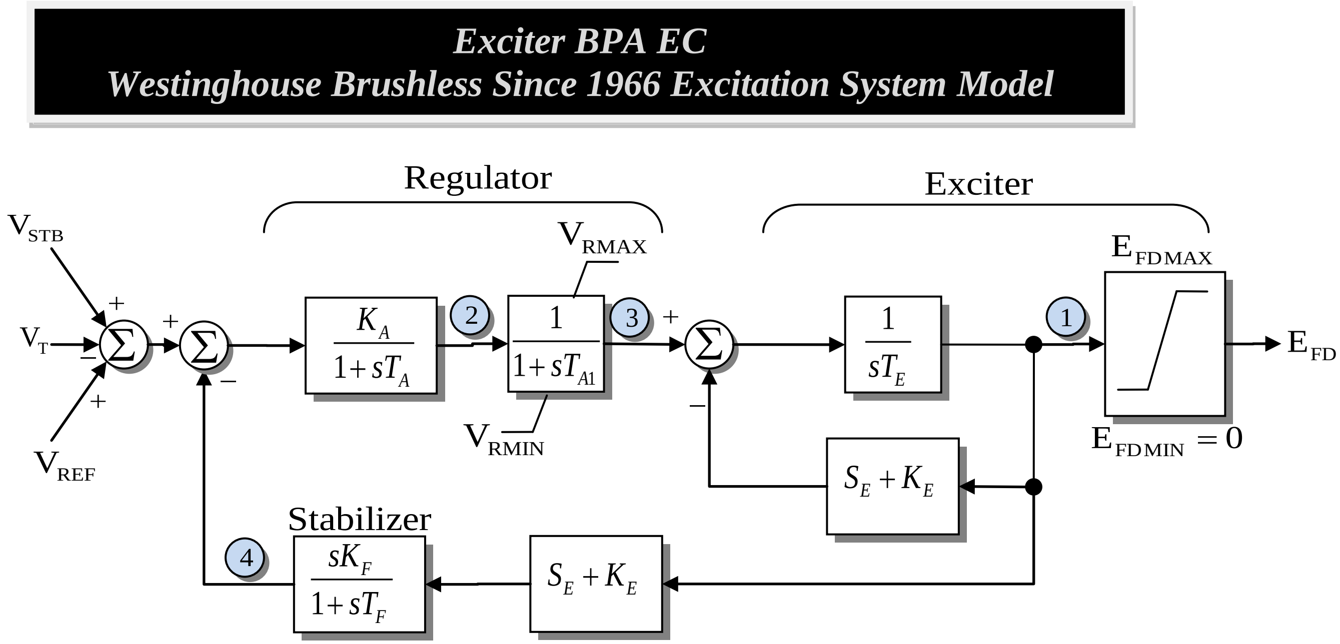
4 - V_{R1}

5 - V_F

6 - V_{F1}

Model in the public domain, available from BPA

Exciter BPA EC



States

1 - E_{FD} before limit

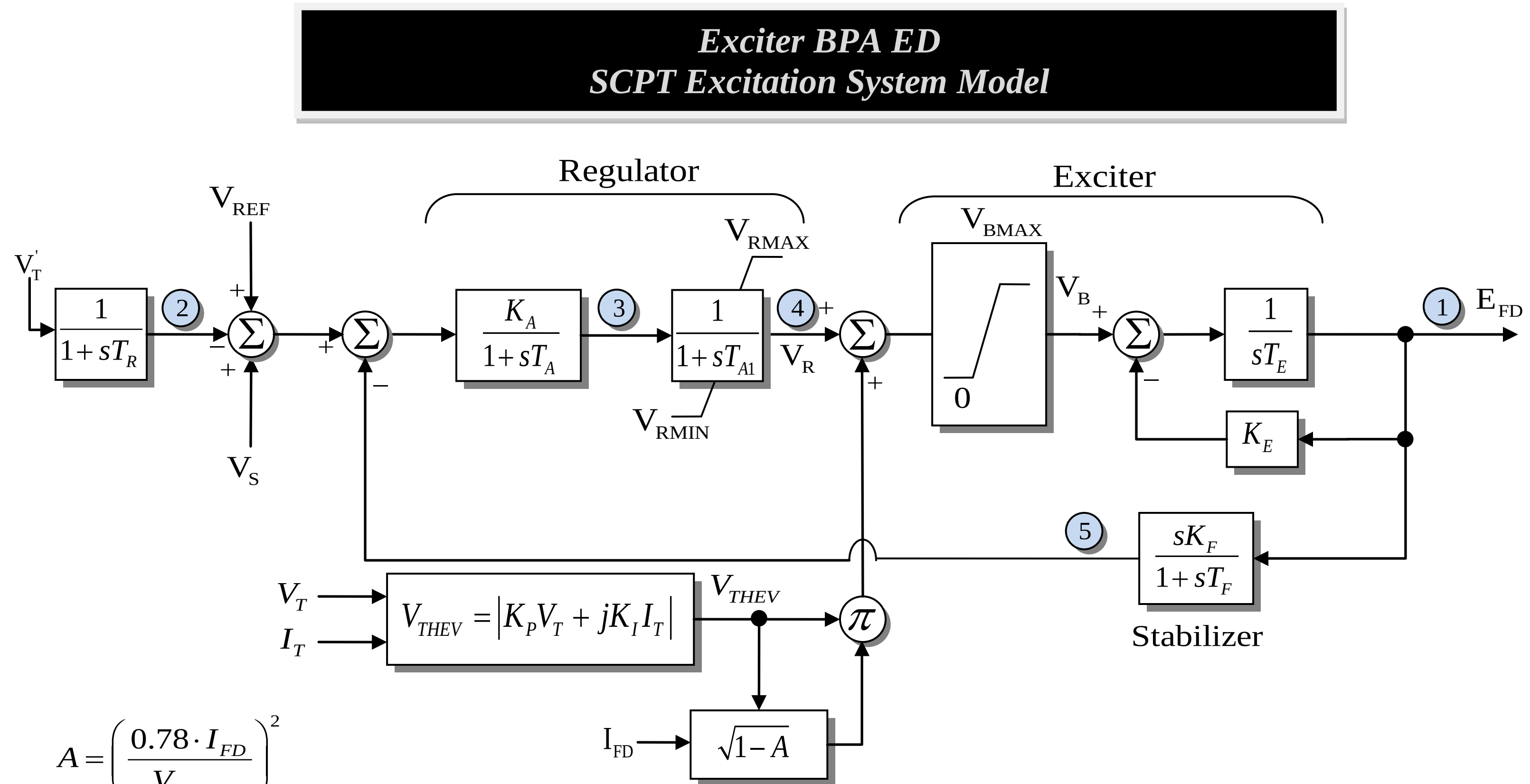
2 - V_R

3 - V_{R1}

4 - V_F

Model in the public domain, available from BPA

Exciter BPA ED



$$A = \left(\frac{0.78 \cdot I_{FD}}{V_{THEV}}\right)^2$$

If $A > 1$, $V_B = 0$

States

1 - EField

2 - Sensed V_t

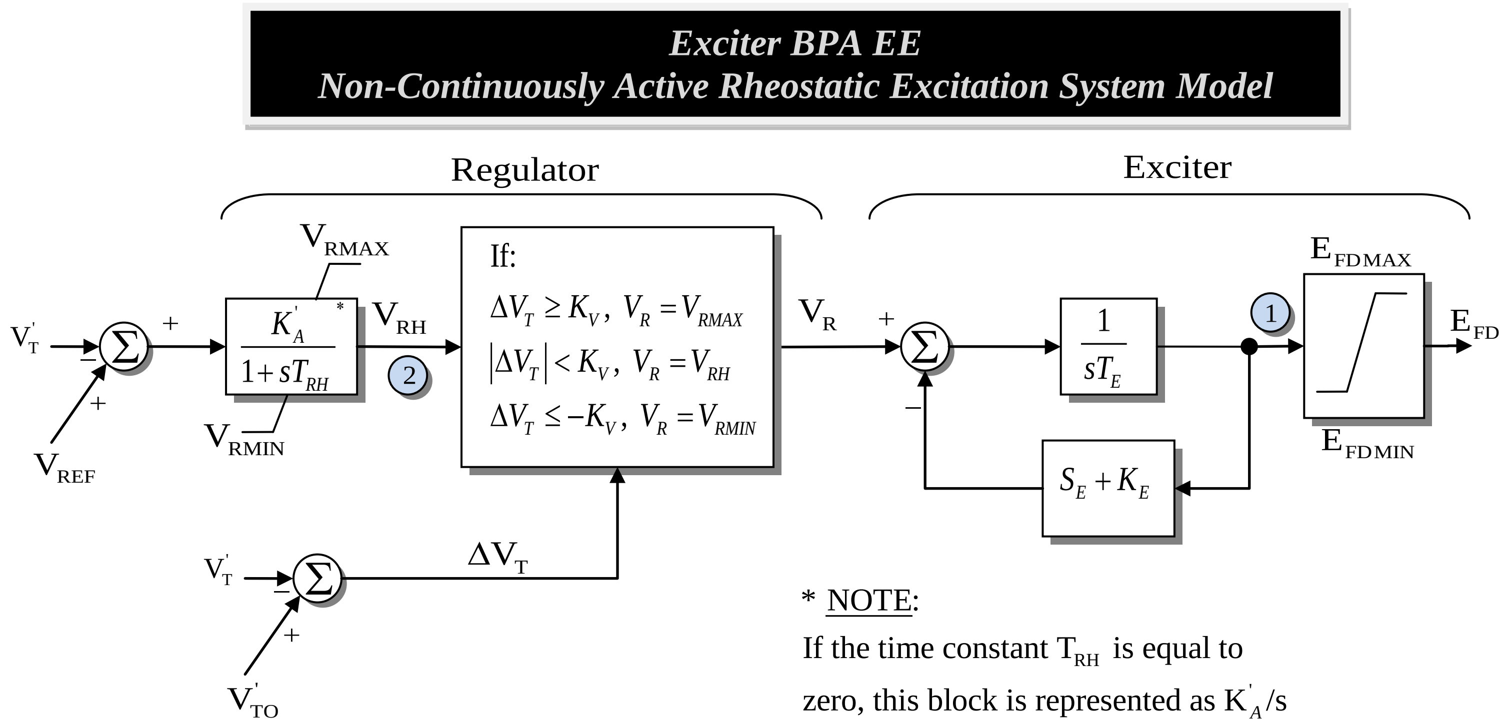
3 - V_A

4 - V_R

5 - Feedback

Model in the public domain, available from BPA

Exciter BPA EE



States

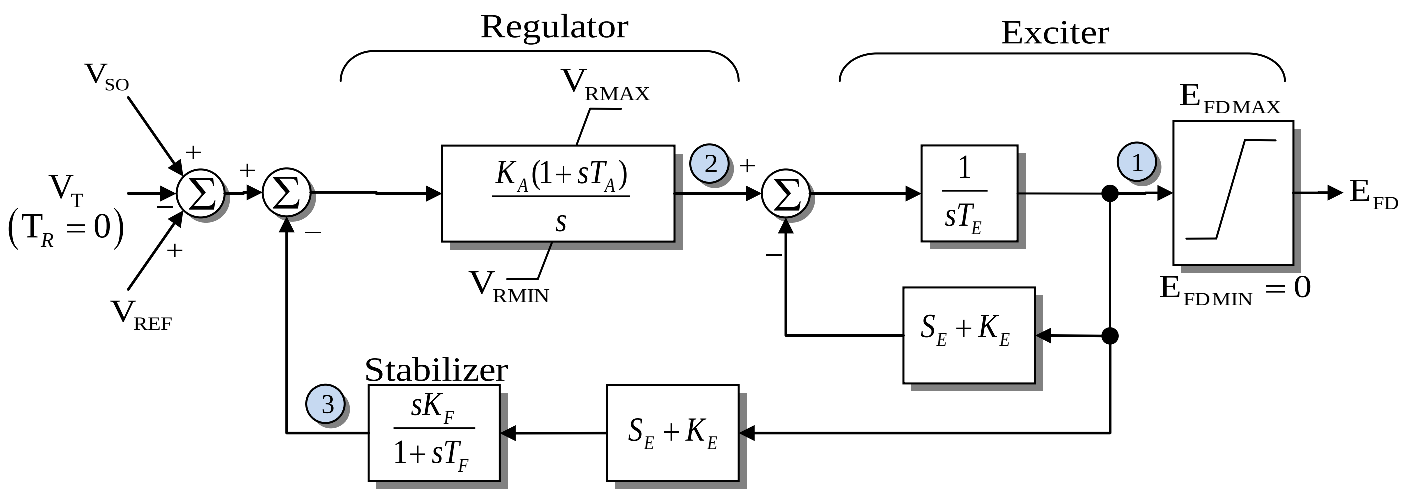
1 - EField before limit

2 - V_{RH}

Model in the public domain, available from BPA

Exciter BPA EF

Exciter BPA EF
Westinghouse Continuous Acting Brushless Rotating Alternator
Excitation System Model



States

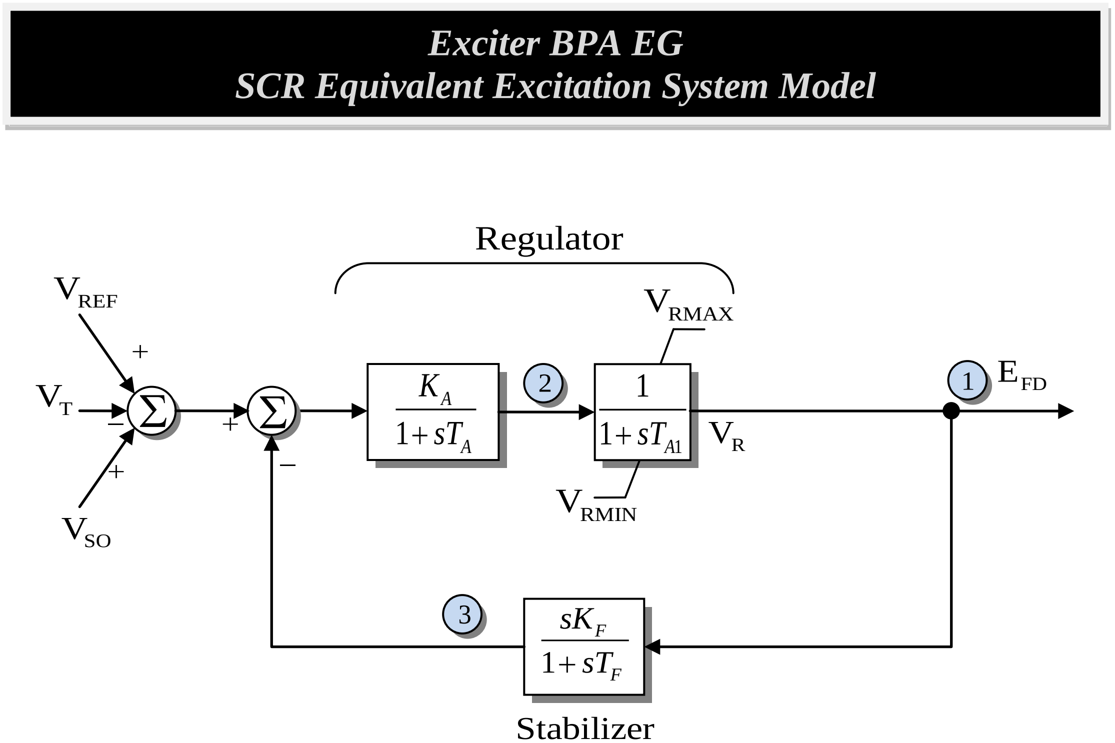
1 - EField before limit

2 - V_R

3 - V_F

Model in the public domain, available from BPA

Exciter BPA EG



States

1 - EField

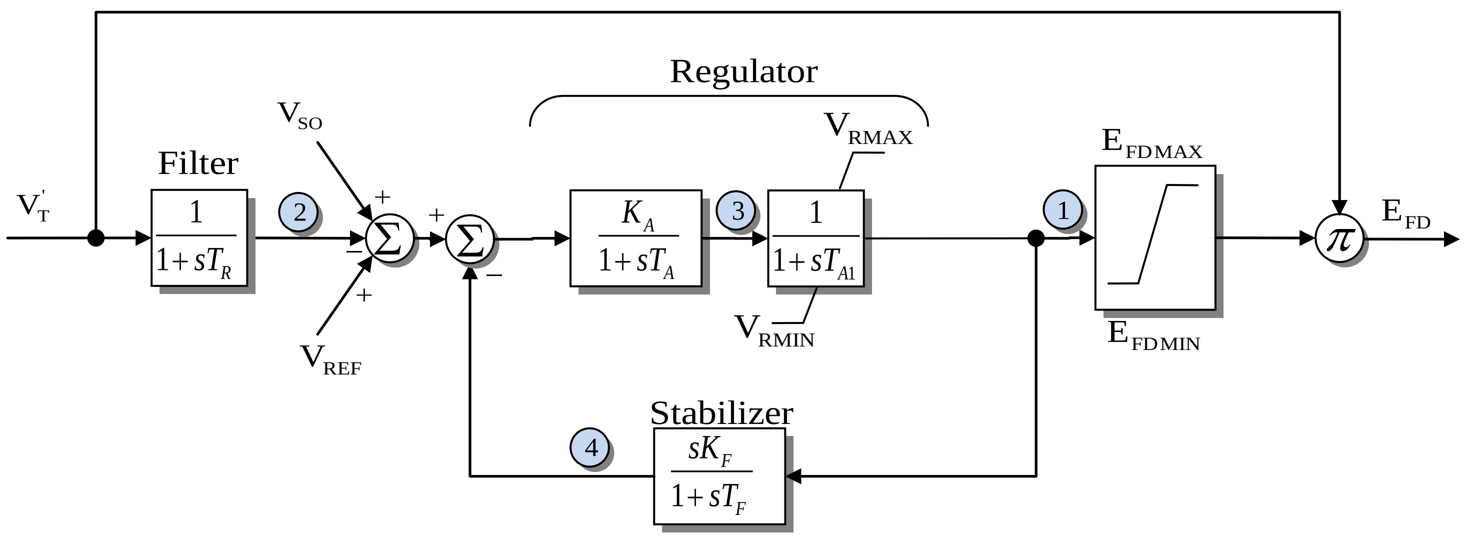
2 - V_A

3 - V_F

Model in the public domain, available from BPA

Exciter BPA EJ

Exciter BPA EJ
Westinghouse Static Grand Couple PP#3 Excitation System Model



States

1 - EField before limit

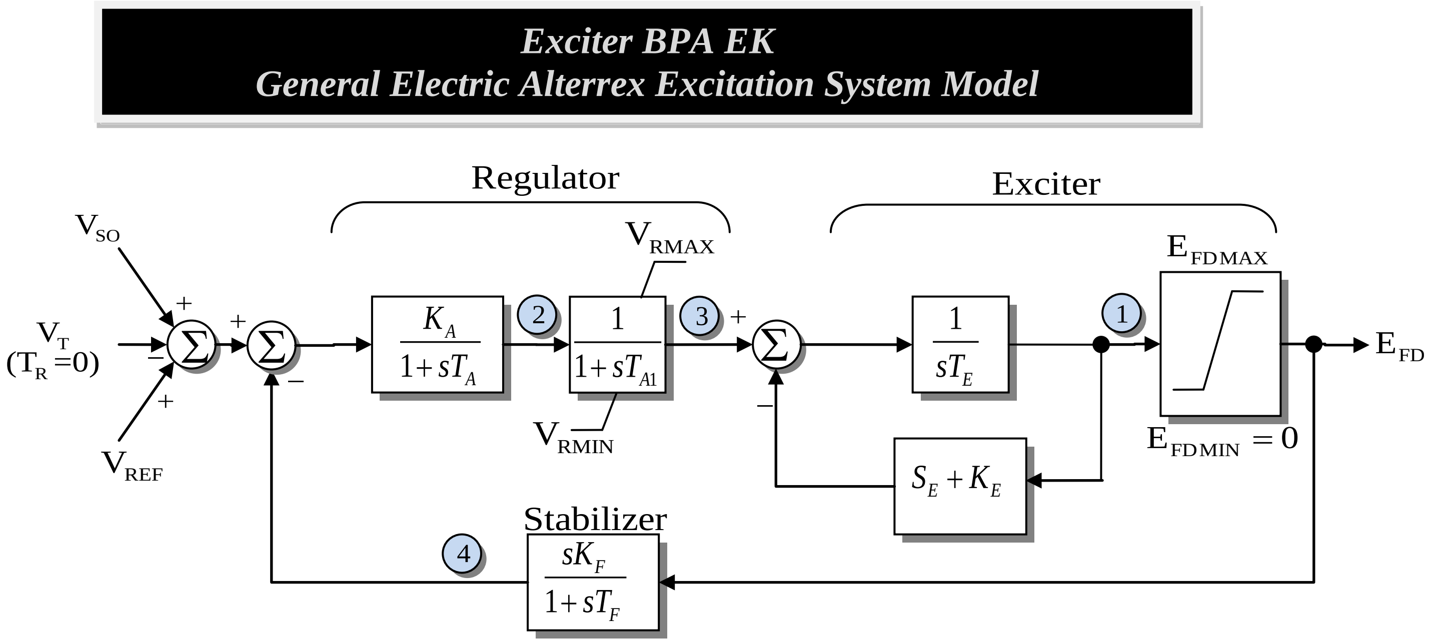
2 - Sensed V_t

3 - V_R

4 - V_F

Model in the public domain, available from BPA

Exciter BPA EK



States

1 - EField before limit

2 - V_R

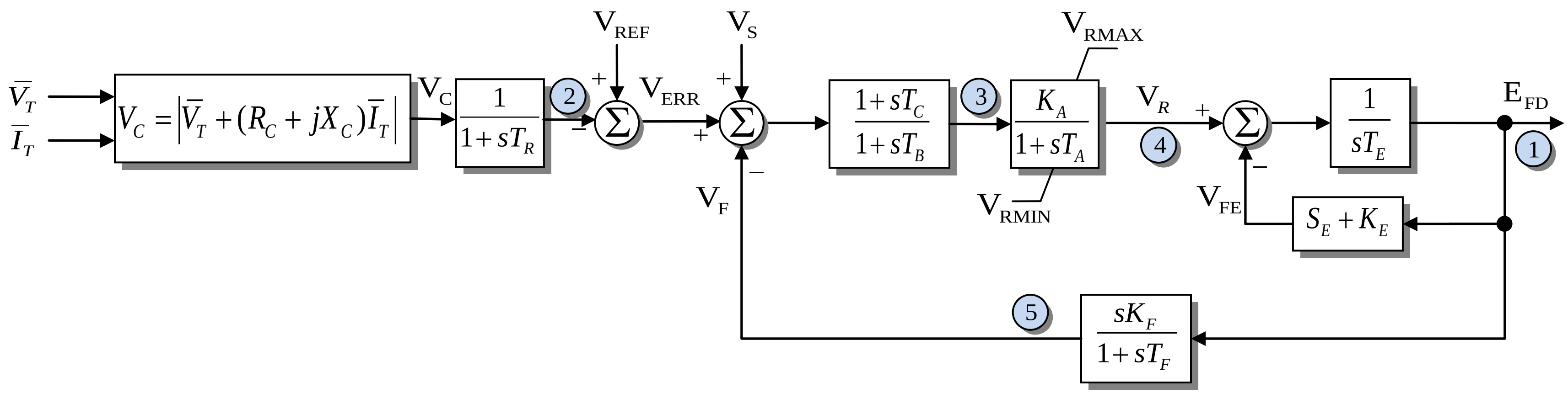
3 - V_{R1}

4 - V_F

Model in the public domain, available from BPA

Exciter BPA FA

Exciter BPA FA
WSCC Type A (DC1) Excitation System Model



States

1 - EField

2 - Sensed V_t

3 - V_B

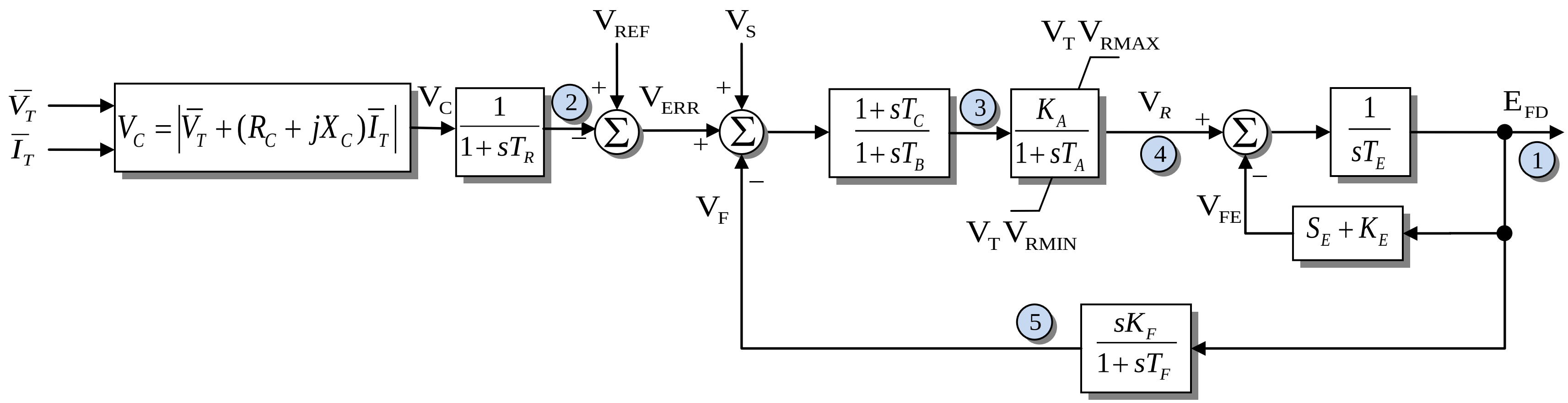
4 - V_R

5 - V_F

Model in the public domain, available from BPA

Exciter BPA FB

Exciter BPA FB
WSCC Type B (DC2) Excitation System Model



States

1 - EField

2 - Sensed V_t

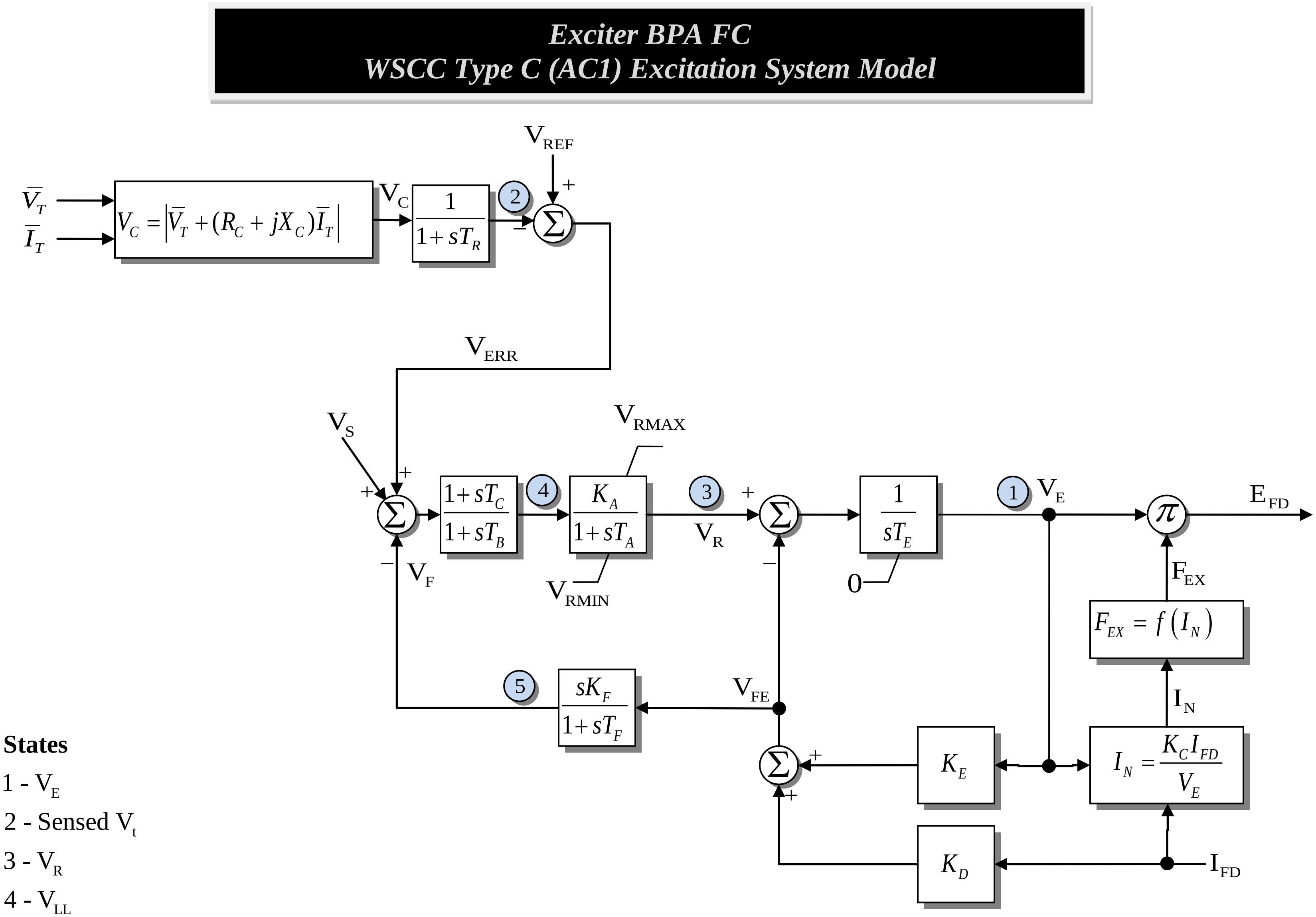
3 - V_B

4 - V_R

5 - V_F

Model in the public domain, available from BPA

Exciter BPA FC



States

1 - V_E

2 - Sensed V_t

3 - V_R

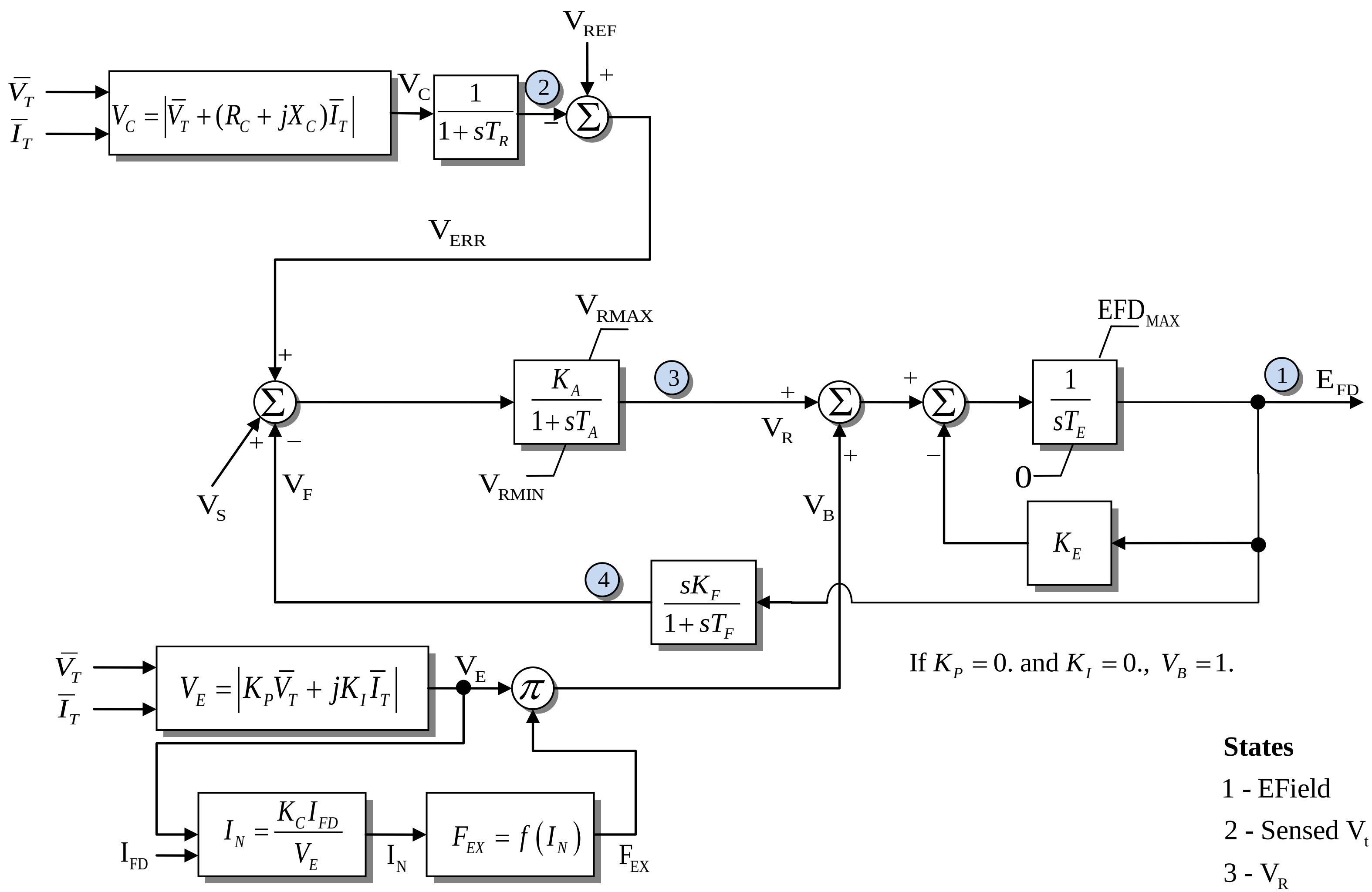
4 - V_{LL}

5 - V_F

Model in the public domain, available from BPA

Exciter BPA FD

Exciter BPA FD
WSCC Type D (ST2) Excitation System Model



If $K_P = 0.$ and $K_I = 0.$, $V_B = 1.$

States

1 - EField

2 - Sensed V_t

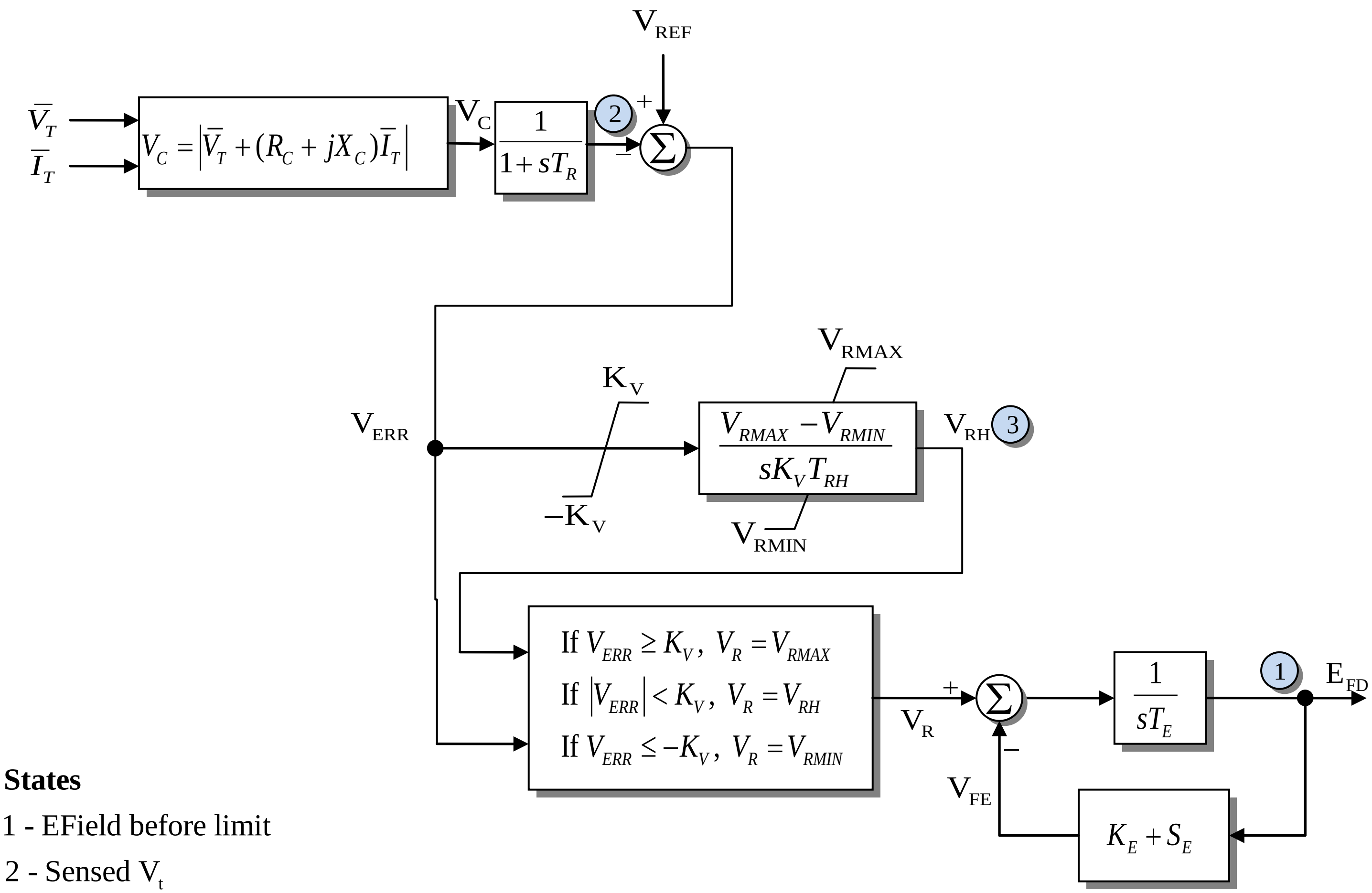
3 - V_R

4 - V_F

Model in the public domain, available from BPA

Exciter BPA FE

Exciter BPA FE
WSCC Type E (DC3) Excitation System Model



States

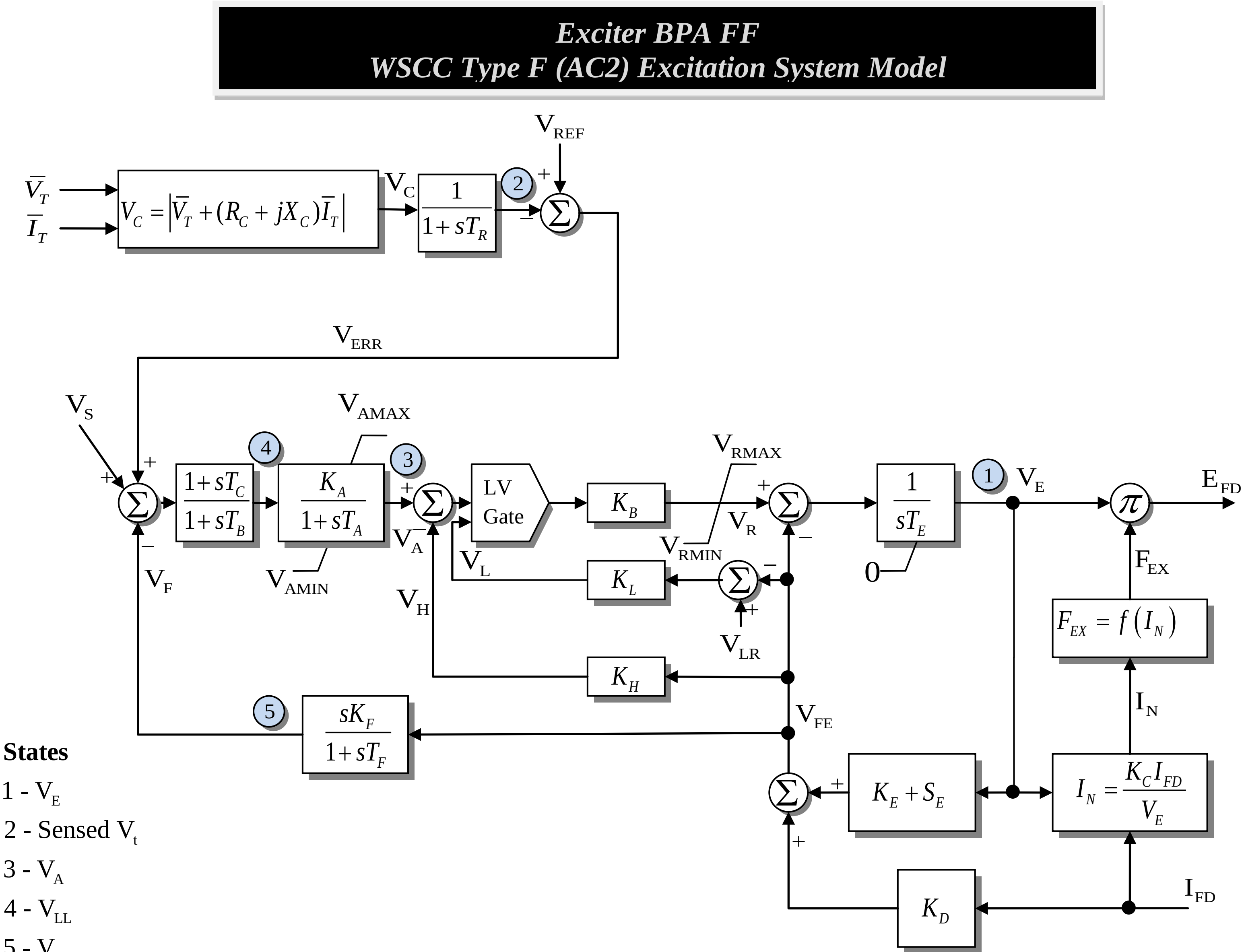
1 - EField before limit

2 - Sensed V_t

3 - V_{RH}

Model in the public domain, available from BPA

Exciter BPA FF



States

1 - V_E

2 - Sensed V_t

3 - V_A

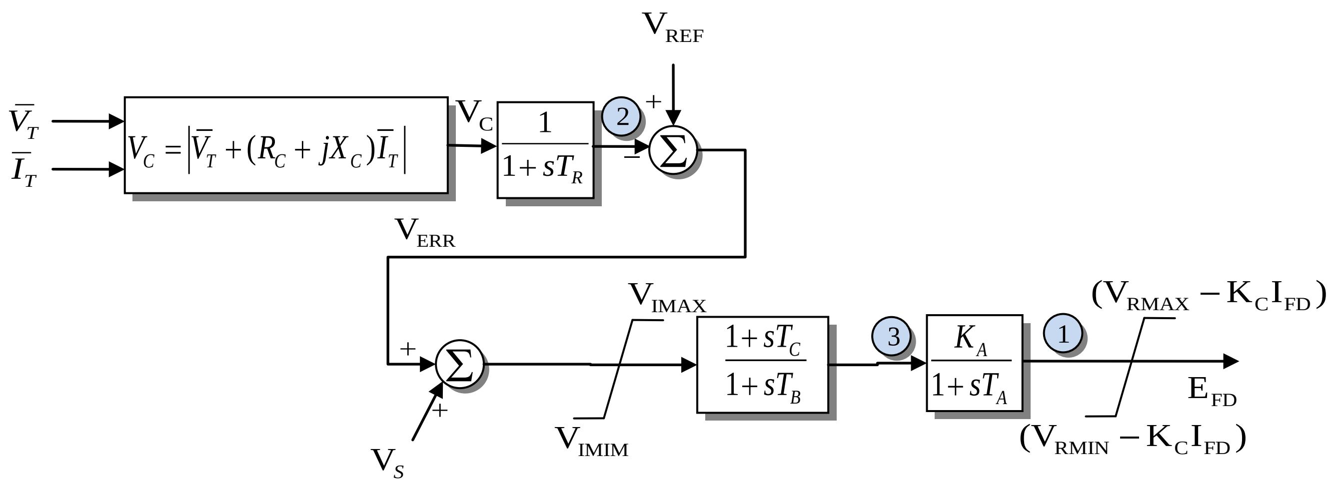
4 - V_{LL}

5 - V_F

Model in the public domain, available from BPA

Exciter BPA FG

Exciter BPA FG
WSCC Type G (AC4) Excitation System Model



States

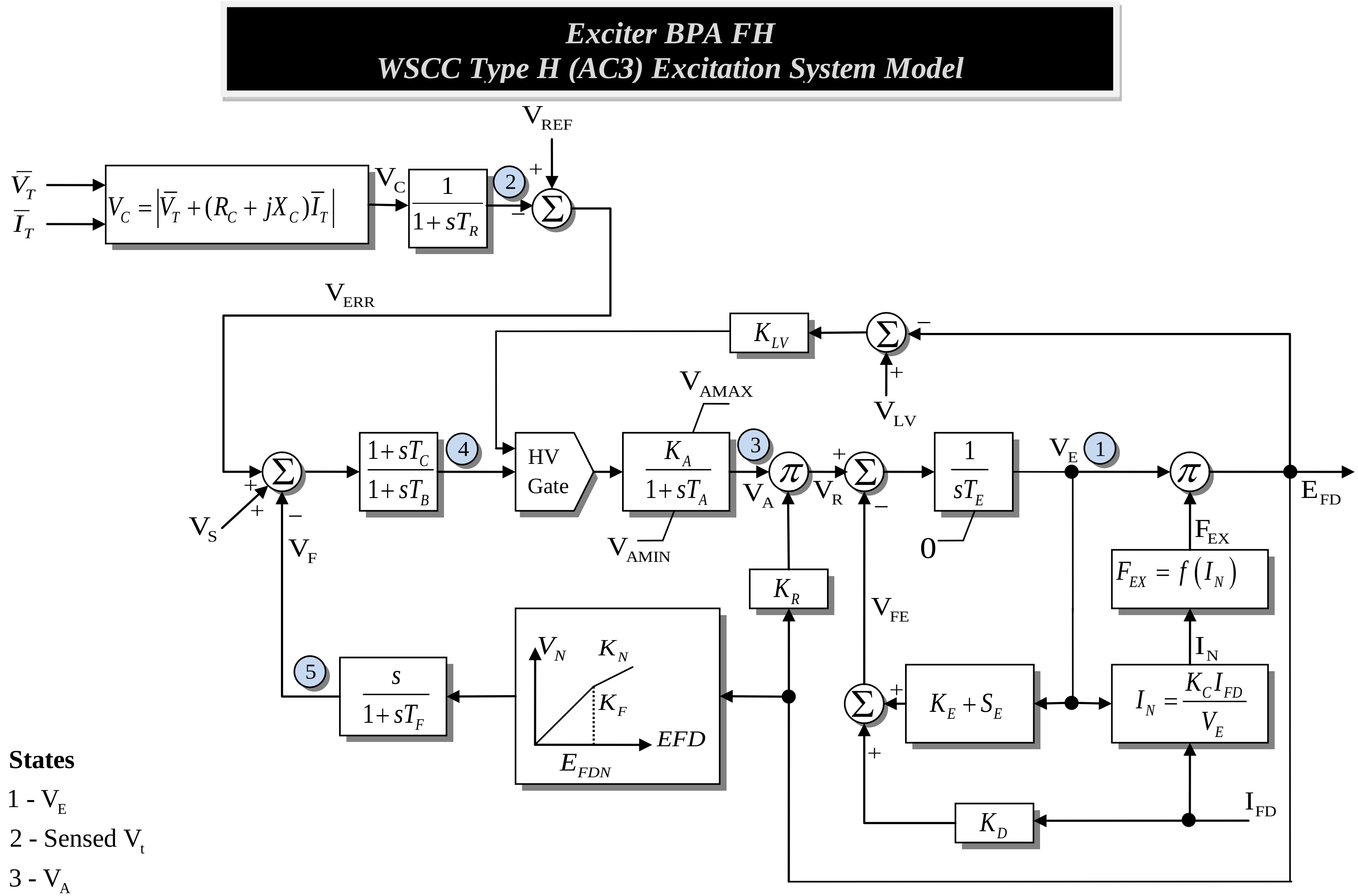
1 - EField before limit

2 - Sensed V_t

3 - V_{LL}

Model in the public domain, available from BPA

Exciter BPA FH



States

1 - V_E

2 - Sensed V_t

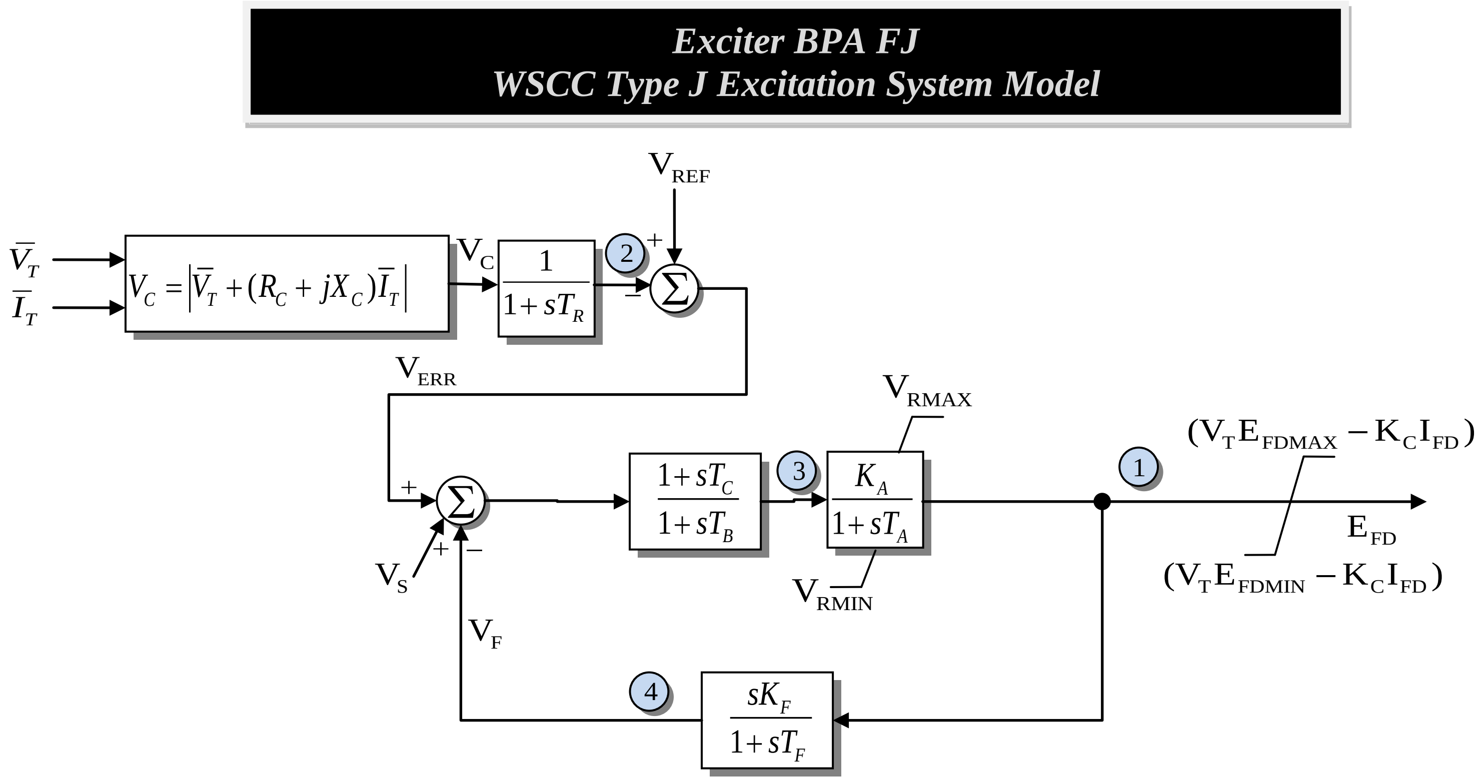
3 - V_A

4 - V_{LL}

5 - V_F

Model in the public domain, available from BPA

Exciter BPA FJ



States

1 - EField before limit

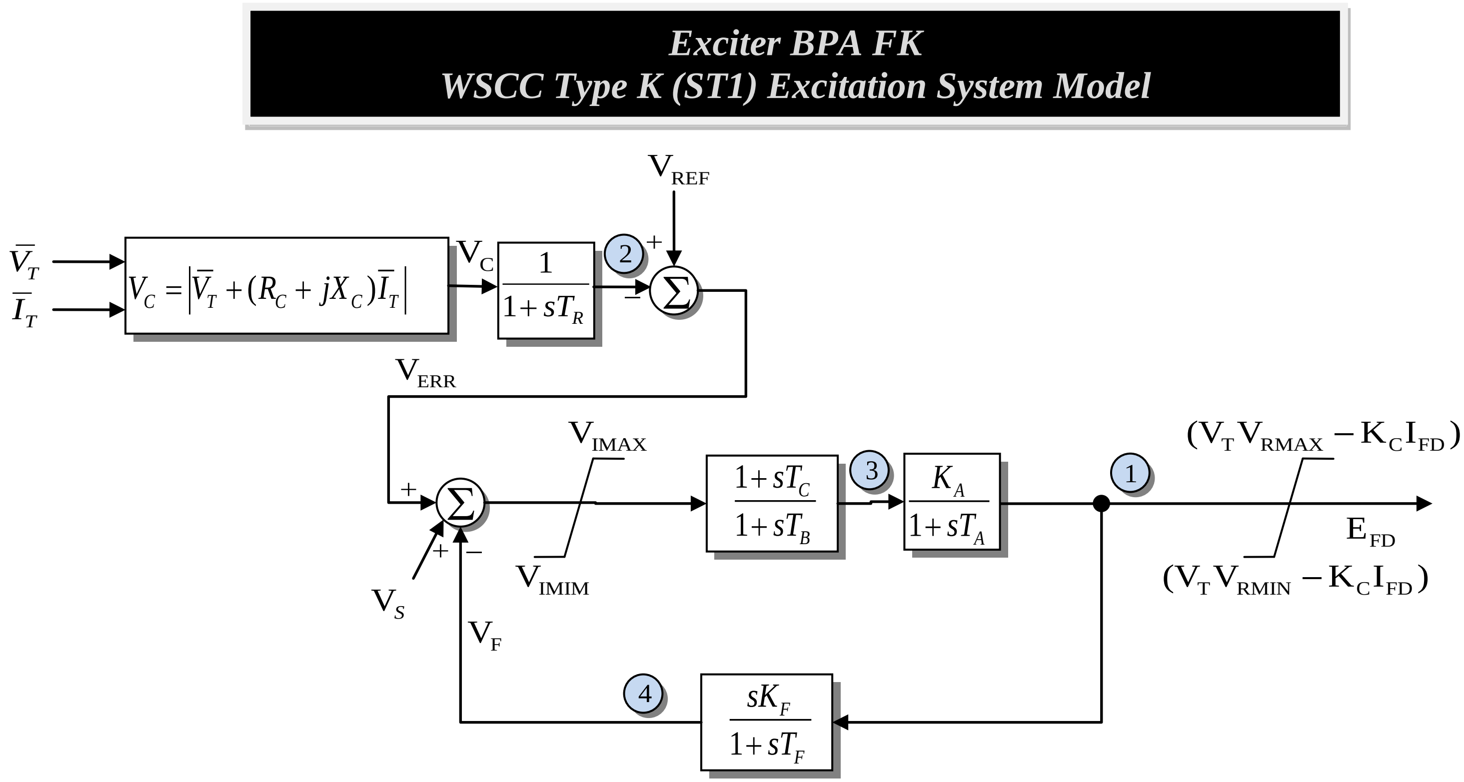
2 - Sensed V_t

3 - V_{LL}

4 - V_F

Model in the public domain, available from BPA

Exciter BPA FK



States

1 - EField before limit

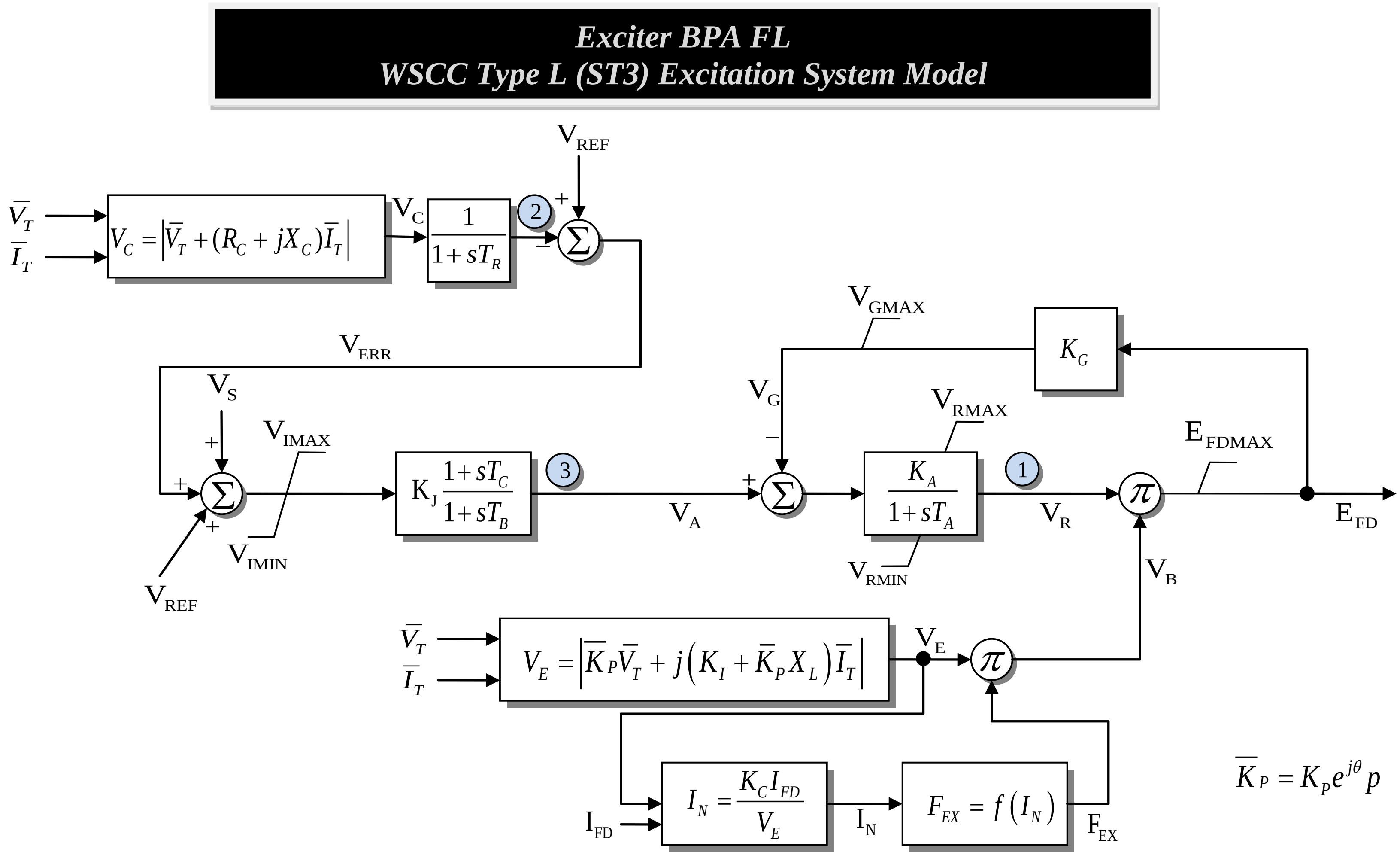
2 - Sensed V_t

3 - V_{LL}

4 - V_F

Model in the public domain, available from BPA

Exciter BPA FL



States

1 - V_M

2 - Sensed V_t

3 - V_{LL}

Model in the public domain, available from BPA

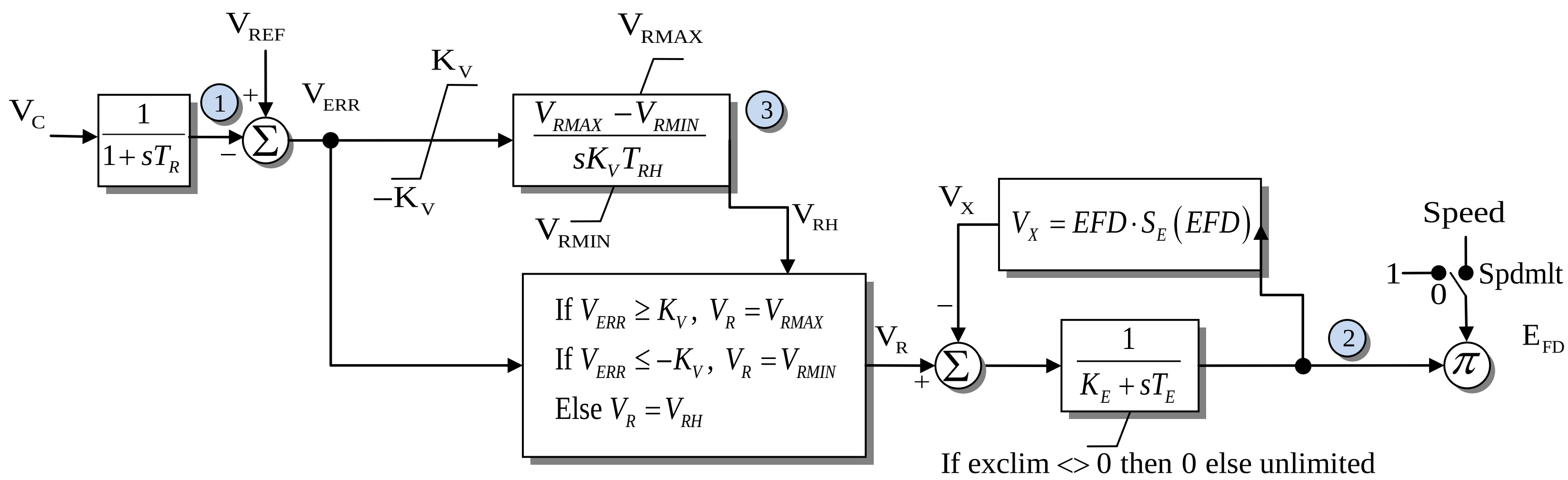
Exciter BPA FM through BPA FV

Exciter BPA FM through BPA FV

No block diagrams have been created

Exciter DC3A and ESDC3A

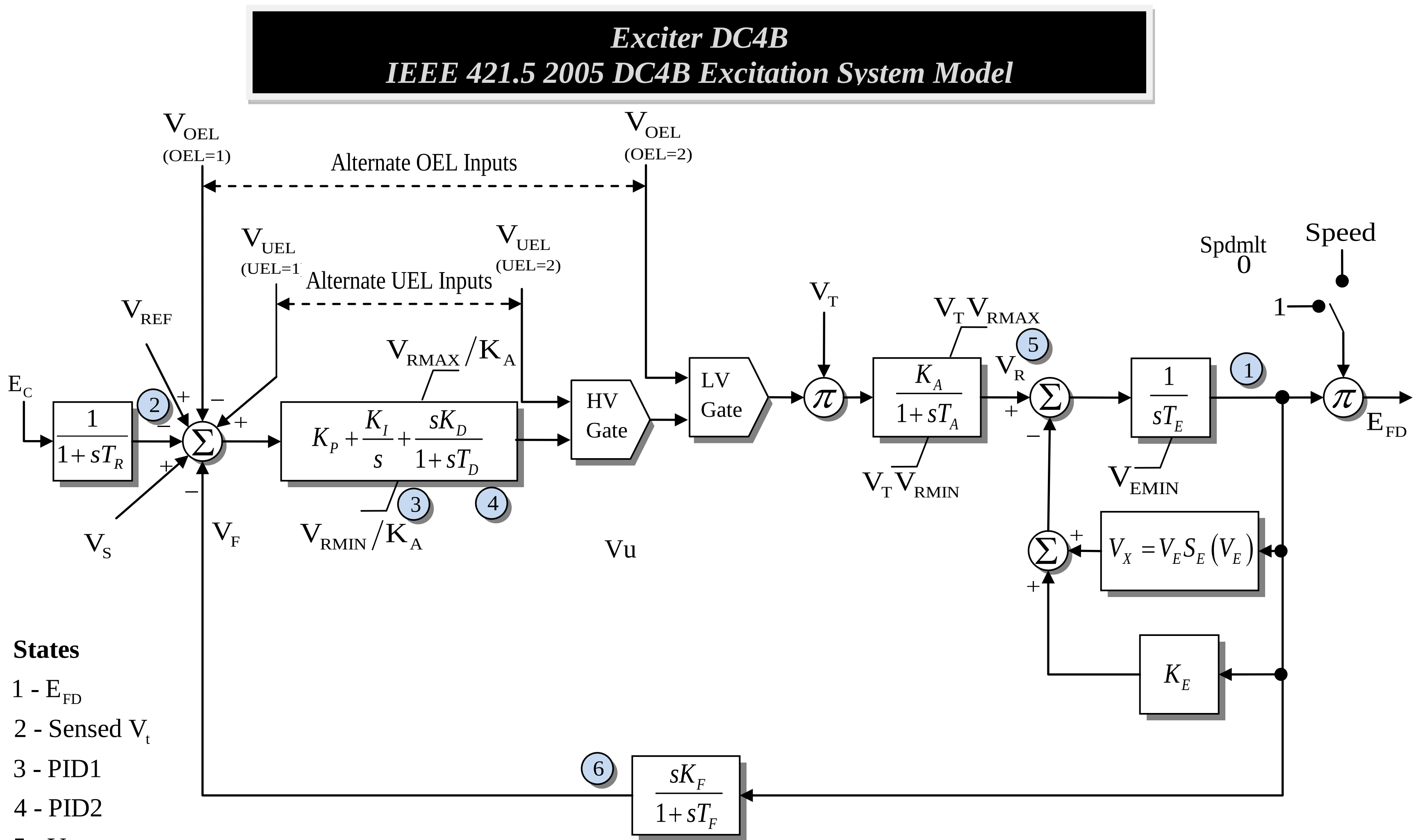
Exciter DC3A
IEEE 421.5 2005 DC3A Excitation System Model



States
1 - E_{FD}
2 – Sensed V_t
3 - V_{RH}

DC3A model supported by PSSE
ESDC3A model supported by PSLF

Exciter DC4B and ESDC4B



States

1 - E_{FD}

2 - Sensed V_t

3 - PID1

4 - PID2

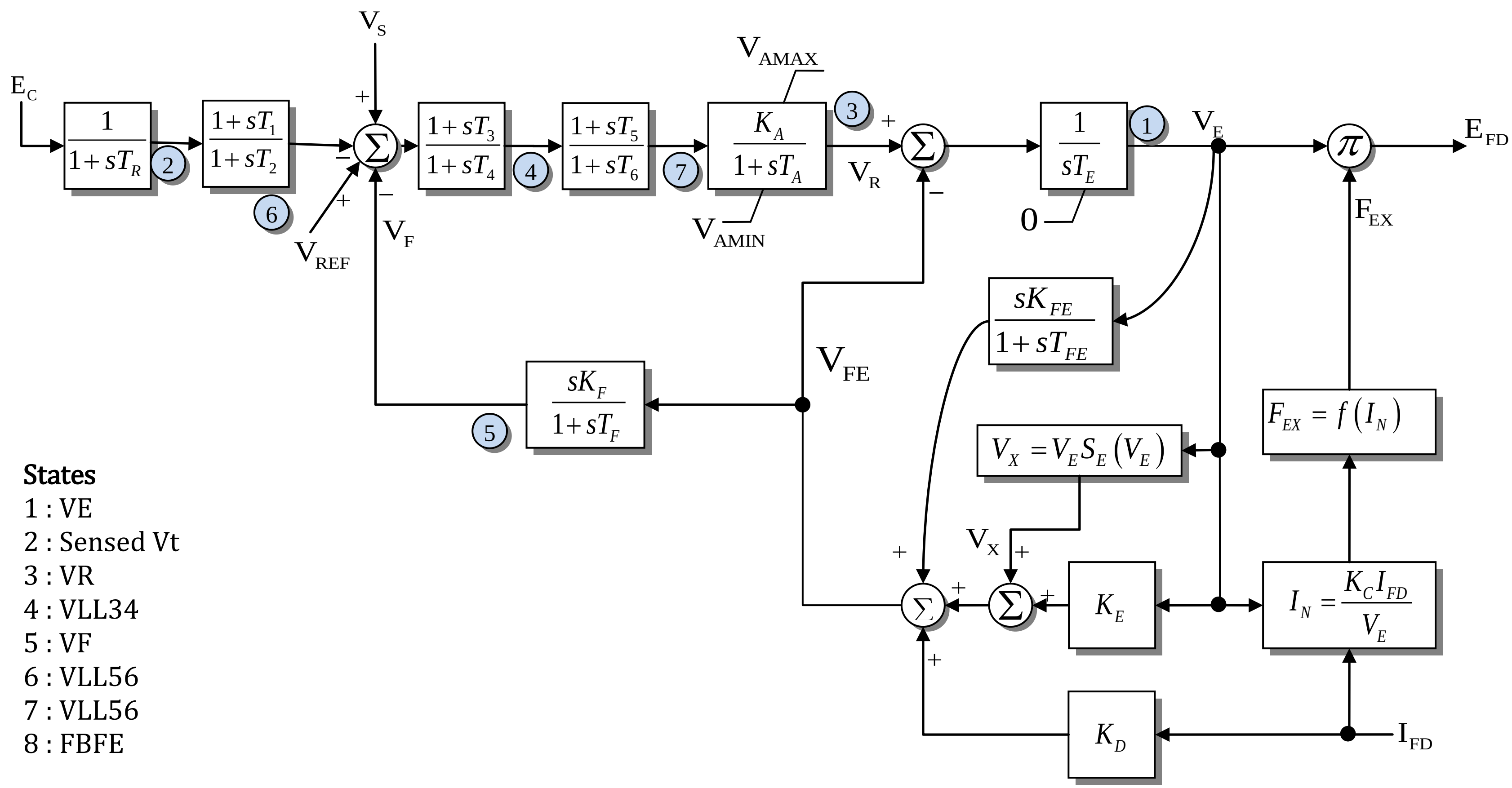
5 - V_R

6 - Feedback

DC4B model supported by PSSE
ESD4B model supported by PSLF

Exciter EMAC1T

Exciter EMAC1T
Modified IEEE Type AC1 Excitation System Model

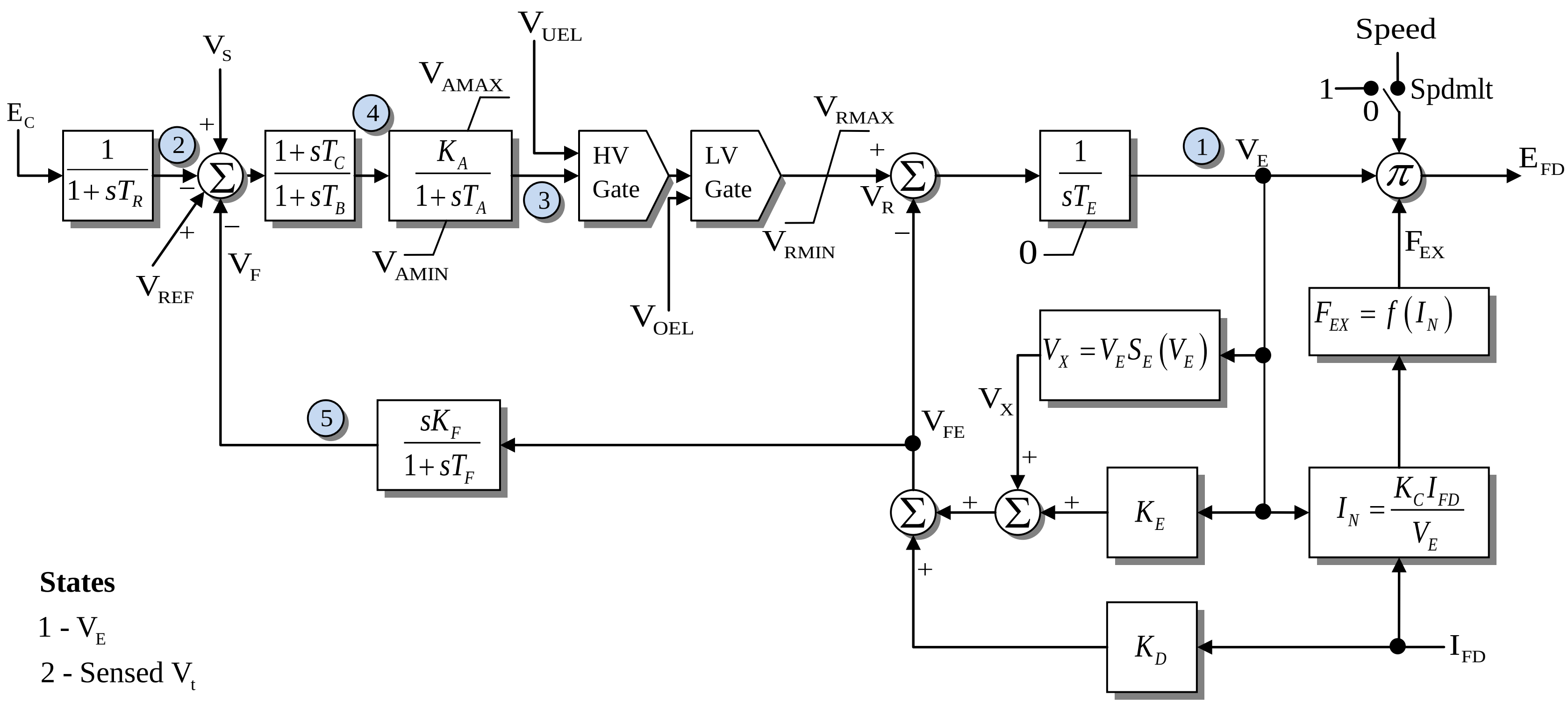


States
1 : VE
2 : Sensed Vt
3 : VR
4 : VLL34
5 : VF
6 : VLL56
7 : VLL56
8 : FBFE

Model supported by PSSE

Exciter ESAC1A

Exciter ESAC1A
IEEE Type AC1A Excitation System Model



States

1 - V_E

2 - Sensed V_t

3 - V_A

4 - V_{LL}

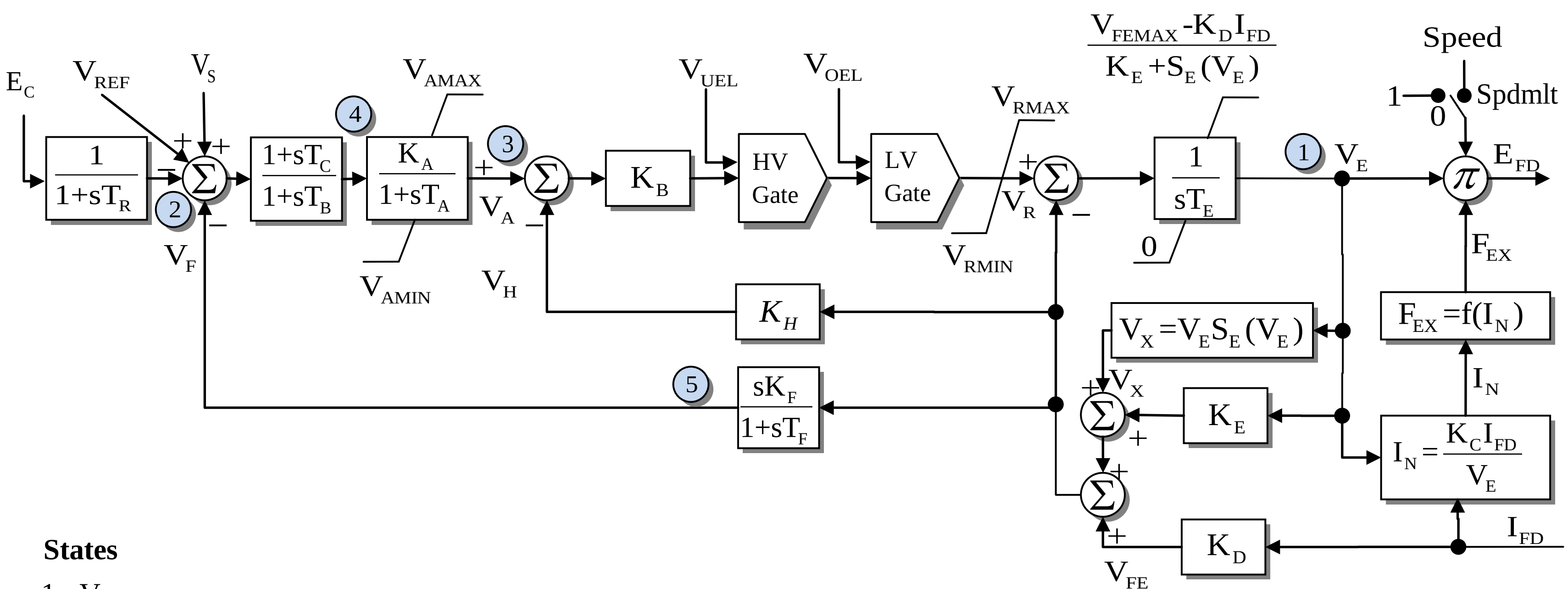
5 - V_F

Model supported by PSSE

Model supported by PSLF with optional speed multiplier

Exciter ESAC2A

Exciter ESAC2A
IEEE Type AC2A Excitation System Model



States

1 - V_E

2 - Sensed V_t

3 - V_A

4 - V_{LL}

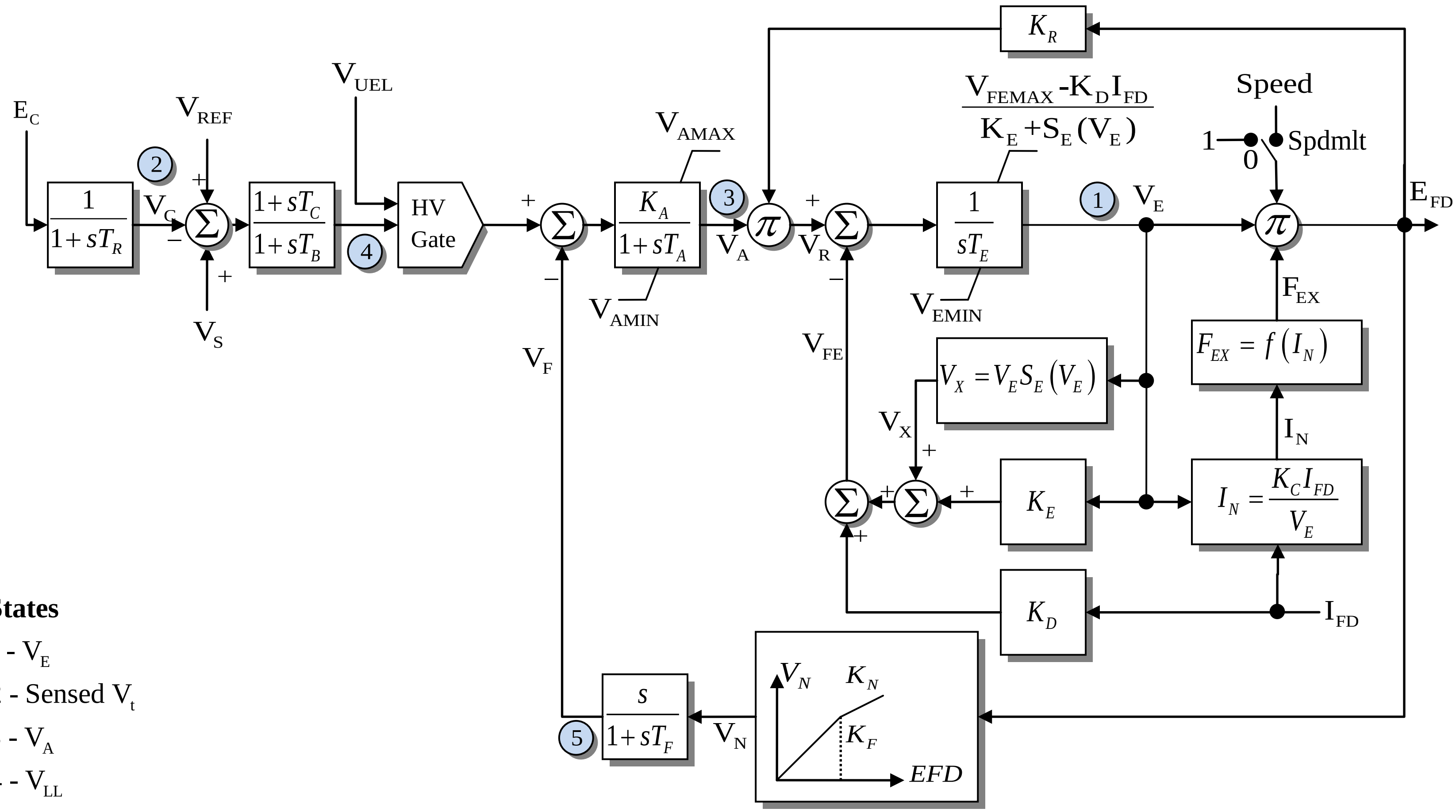
5 - V_F

Model supported by PSSE

Model supported by PSLF with optional speed multiplier

Exciter ESAC3A

Exciter ESAC3A
IEEE Type AC3A Excitation System Model



States

1 - V_E

2 - Sensed V_t

3 - V_A

4 - V_{LL}

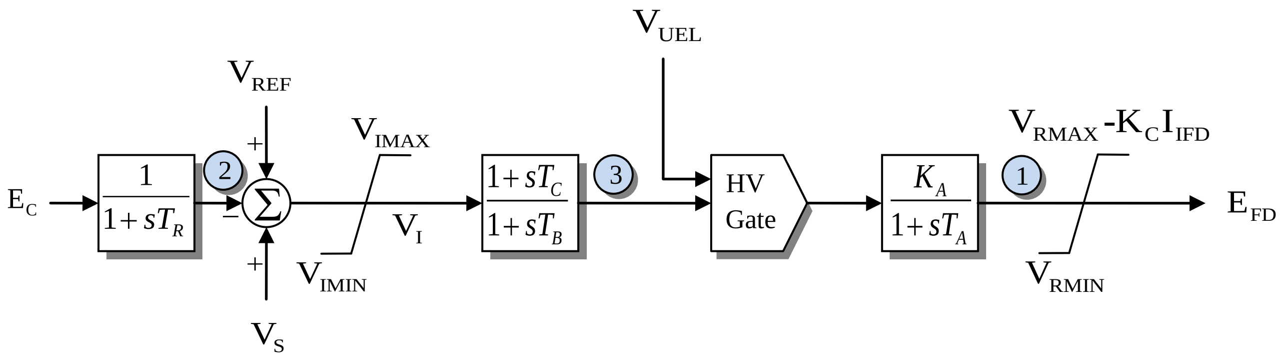
5 - V_F

Model supported by PSSE

Model supported by PSLF with optional speed multiplier

Exciter ESAC4A

Exciter ESAC4A
IEEE Type AC4A Excitation System Model



States

1 - EField before limit

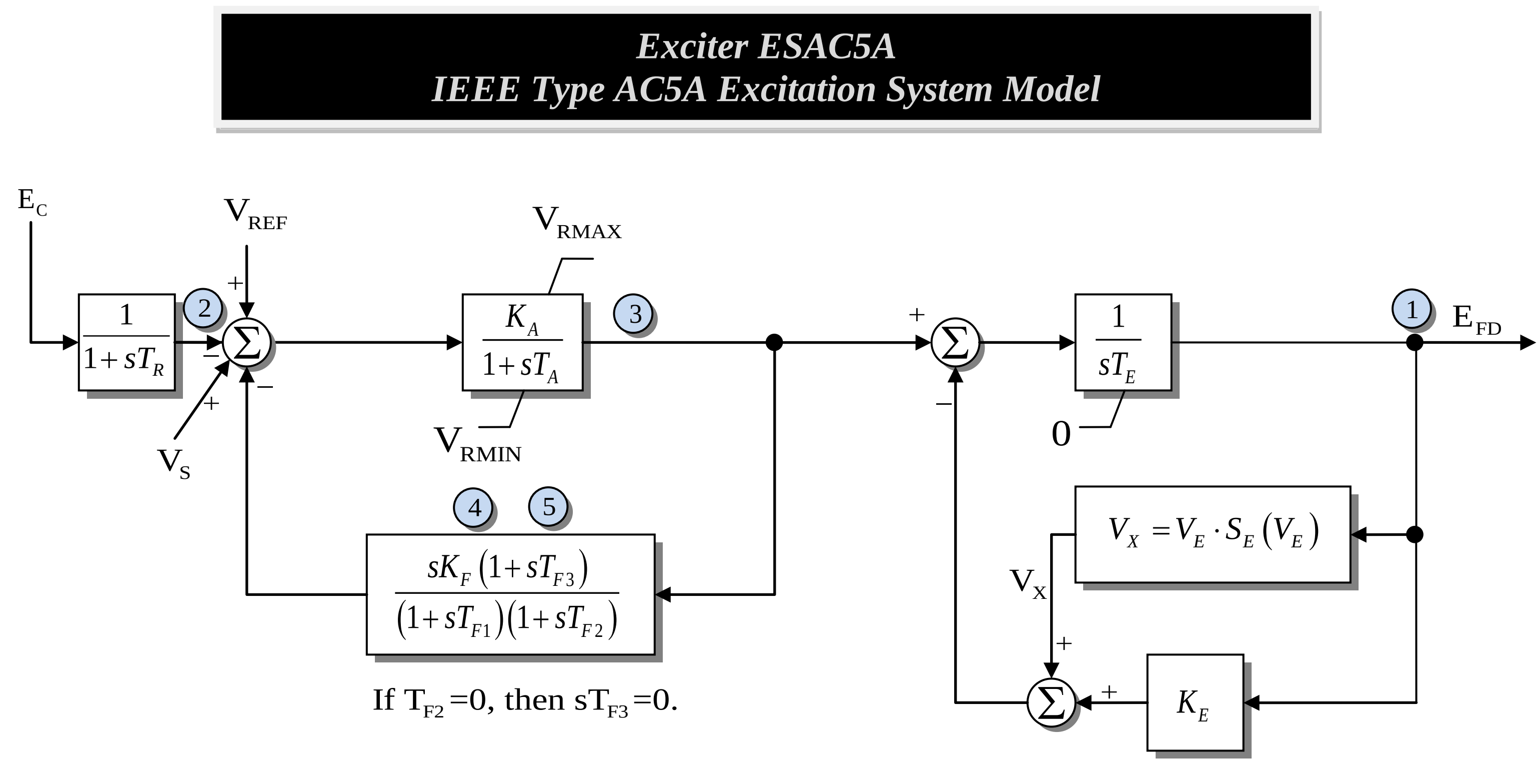
2 - Sensed V_t

3 - V_{LL}

Model supported by PSLF and PSSE

PSSE uses nonwindup limit on E_{FD}

Exciter ESAC5A



States

1 - EField

2 - Sensed V_t

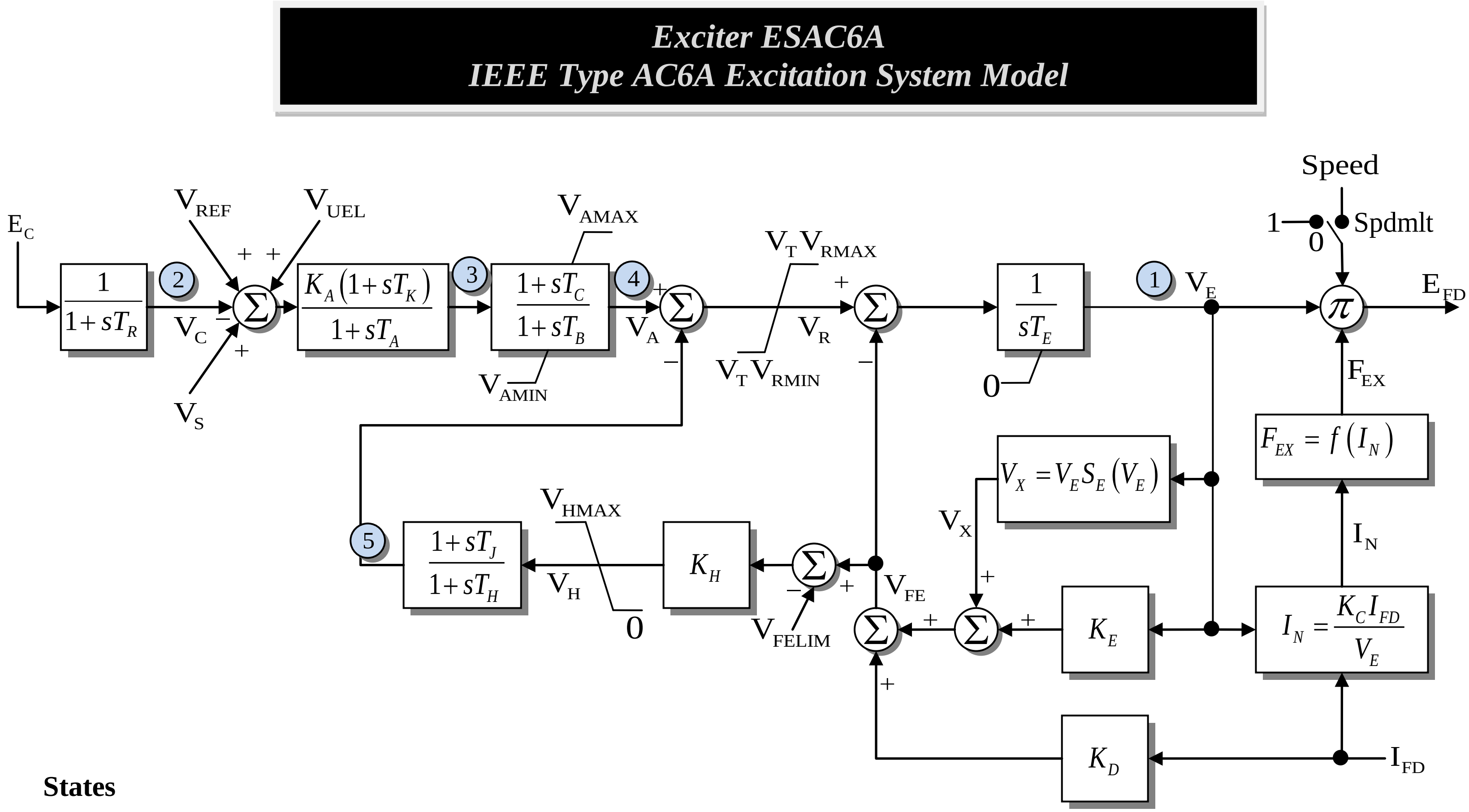
3 - V_R

4 - Feedback 1

5 - Feedback 2

Model supported by PSLF and PSSE

Exciter ESAC6A



States

1 - V_E

2 - Sensed V_t

3 - T_A Block

4 - V_{LL}

5 - V_F

Model supported by PSSE

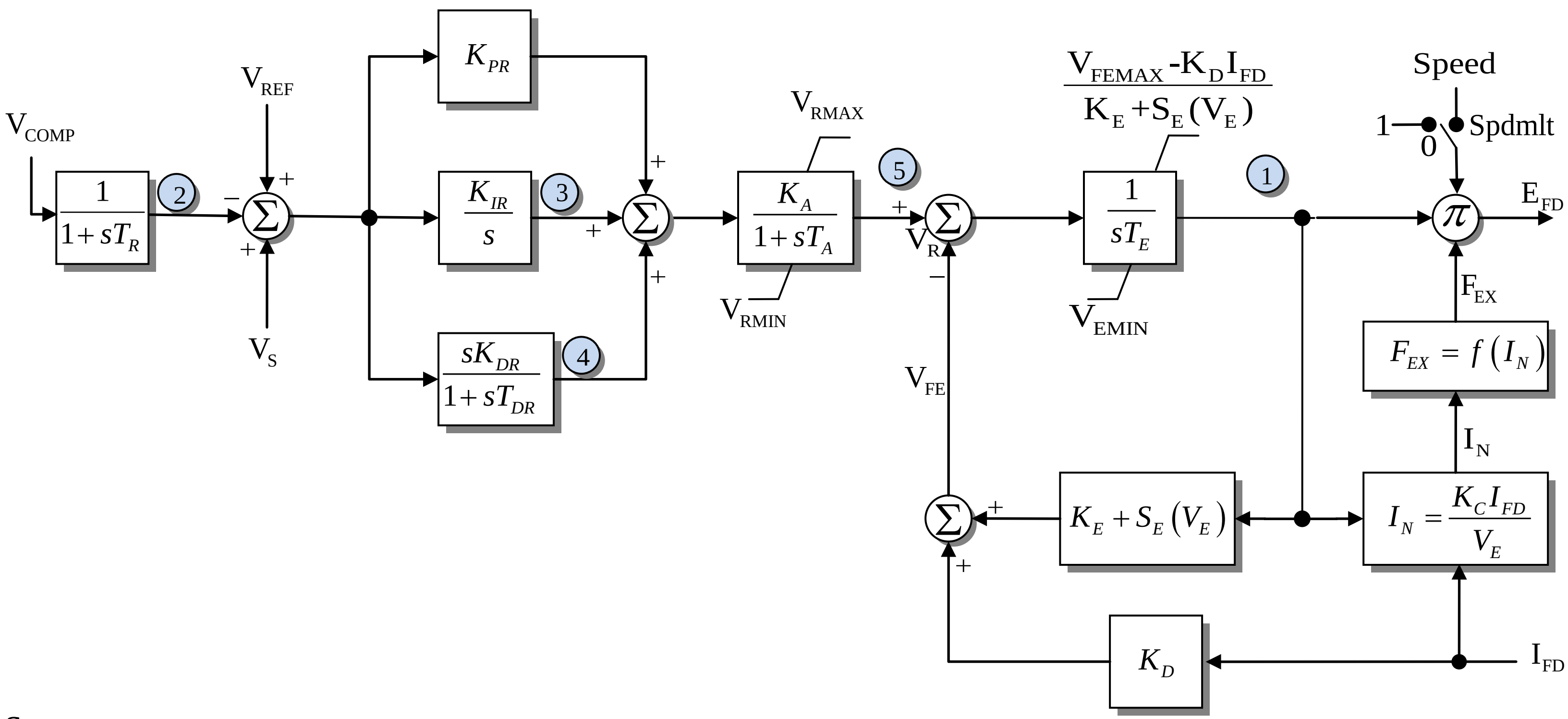
Model supported by PSLF with optional speed multiplier

Exciter ESAC7B and AC7B

ESAC7B is the same as AC7B. See AC7B documentation

Exciter ESAC8B_GE

Exciter ESAC8B_GE
IEEE Type AC8B with Added Speed Multiplier.



States

1 - V_E

2 - Sensed V_t

3 - PID 1

4 - PID 2

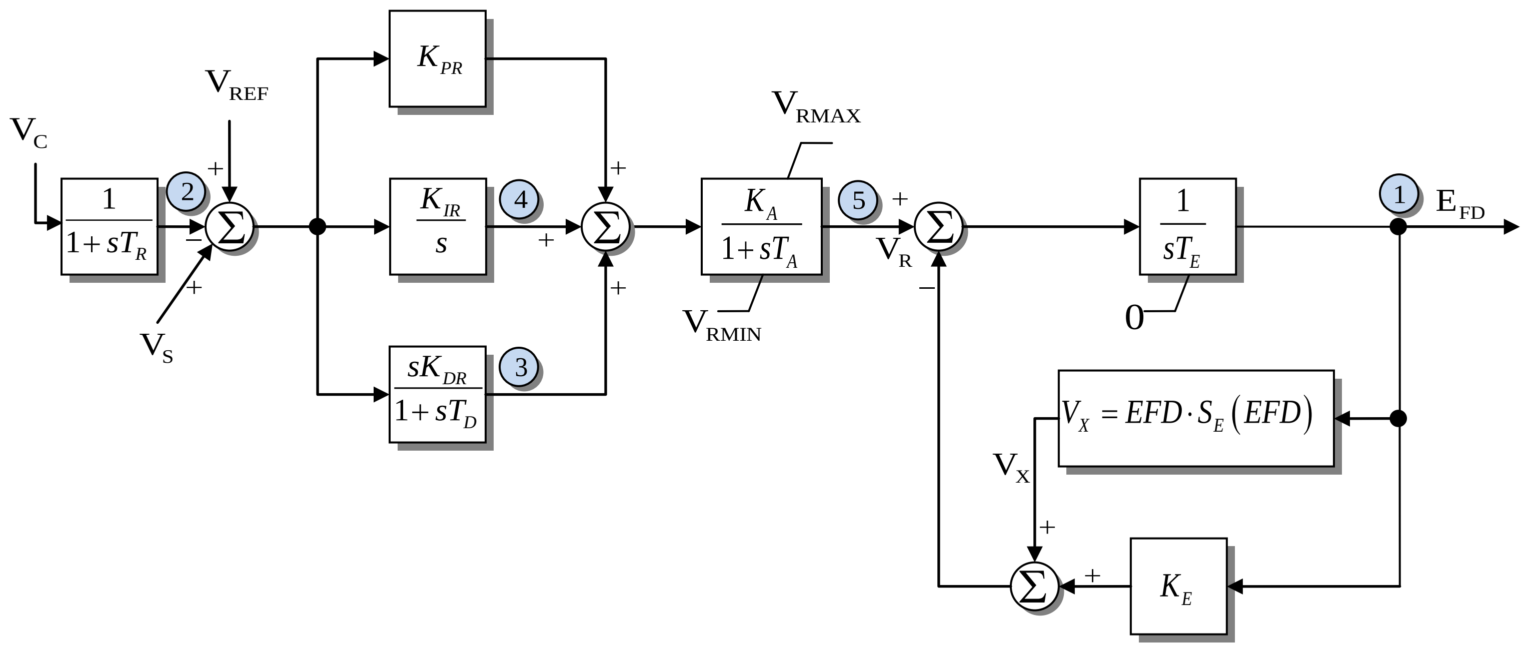
5 - V_R

Model supported by PSLF

If V_{TMULT} <> 0, $V_{RMAX} = V_T \bullet V_{RMAX}$ and $V_{RMIN} = V_T \bullet V_{RMIN}$

Exciter ESAC8B_PTI

Exciter ESAC8B_PTI
Basler DECS Model



States

1 - E_{FD}

2 - Sensed V_t

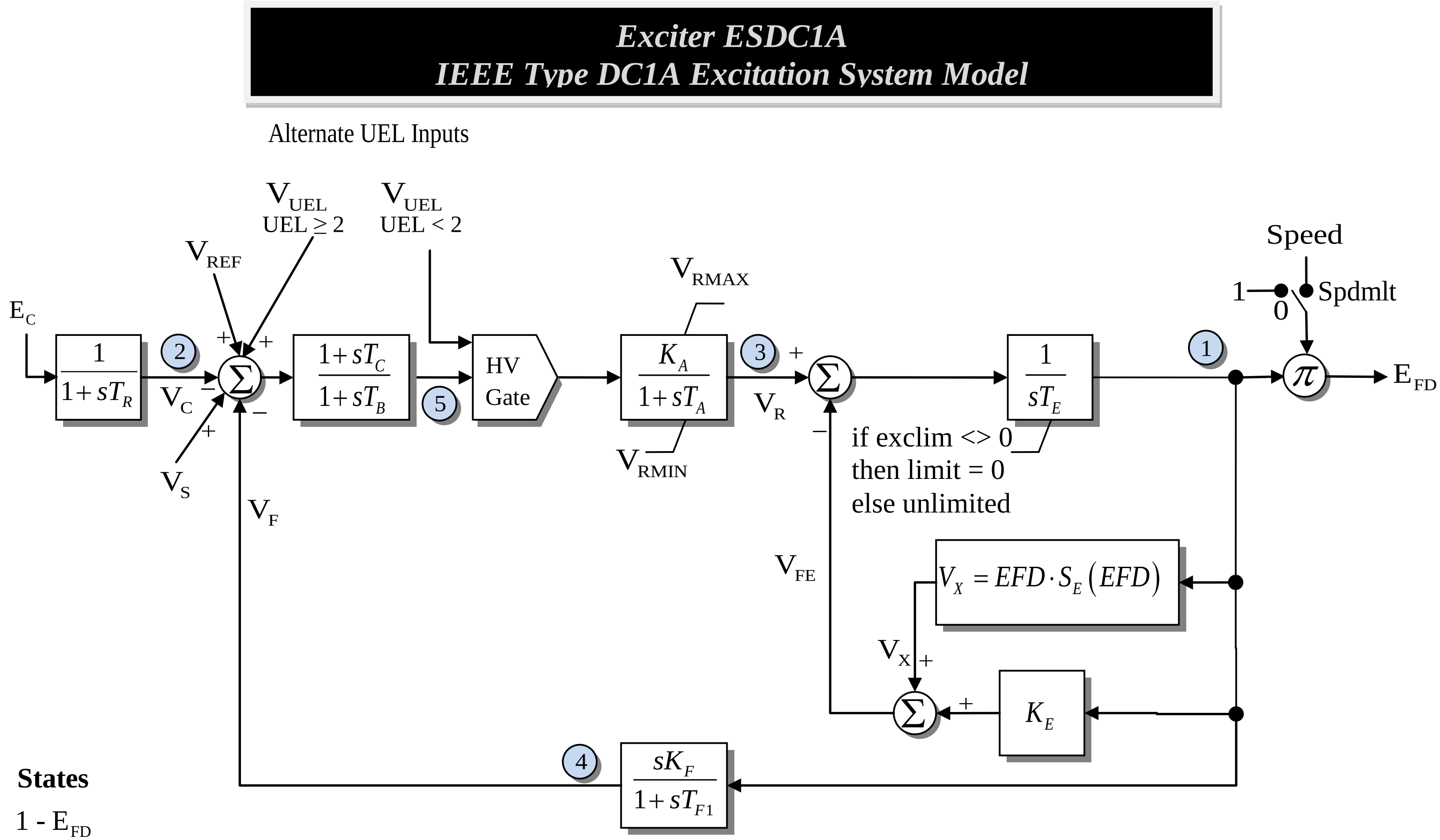
3 - Derivative Controller

4 - Integral Controller

5 - V_R

Model supported by PSSE

Exciter ESDC1A



States

1 - E_{FD}

2 - Sensed V_t

3 - V_R

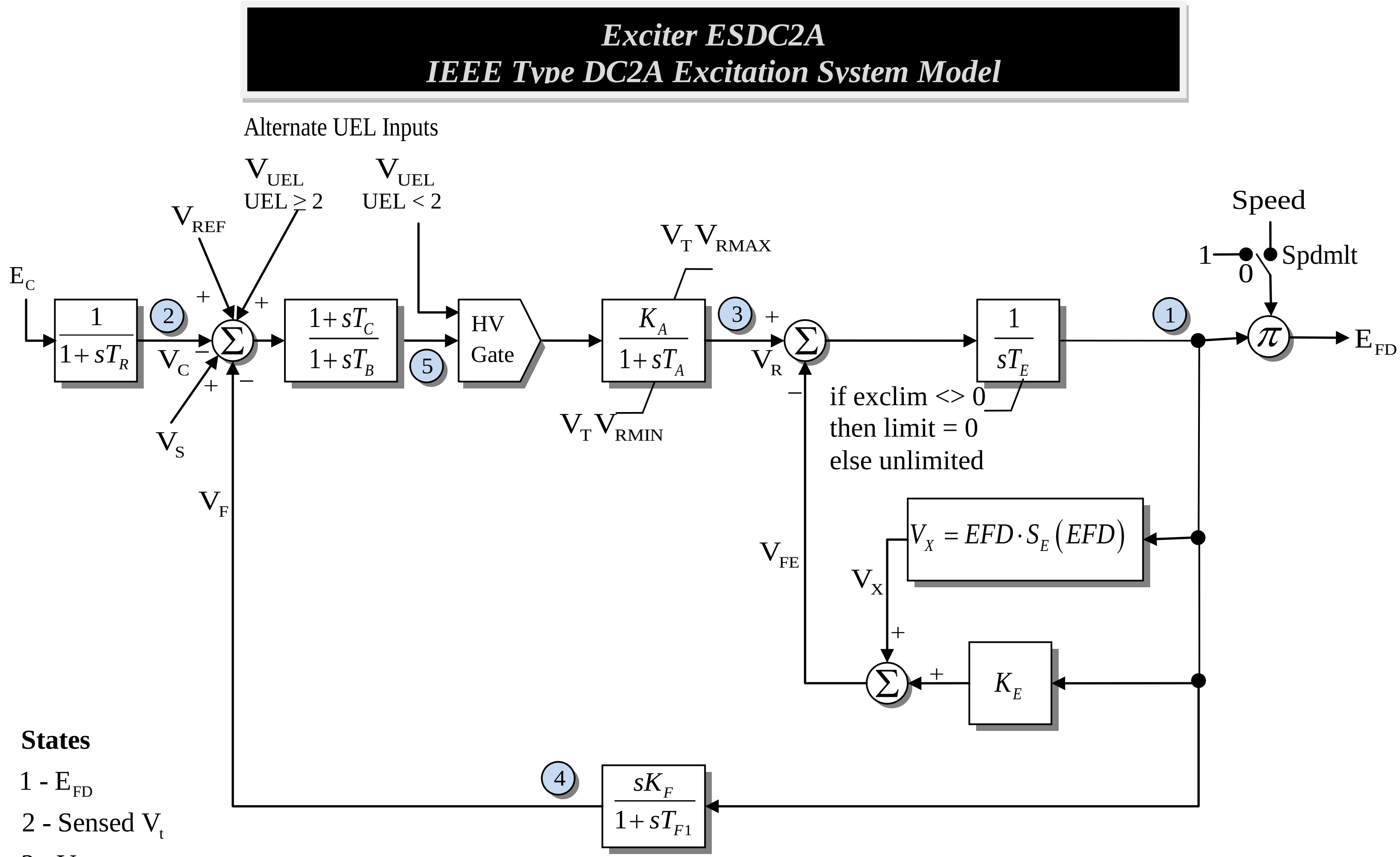
4 - V_F

5 - Lead-Lag

Model supported by PSSE but always assumes values of spdmlt = 0, UELin = 0, and exclim = 1

Model supported by PSLF

Exciter ESDC2A



States

1 - E_{FD}

2 - Sensed V_t

3 - V_R

4 - V_F

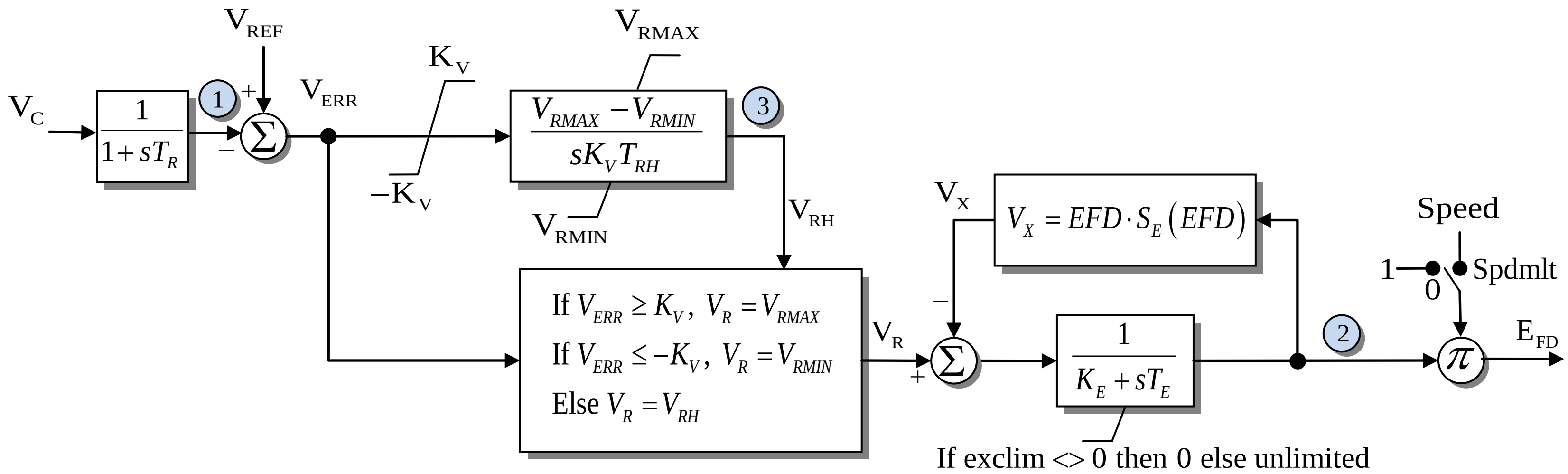
5 - Lead-Lag

Model supported by PSSE but always assumes values of spdmlt = 0, UELin = 0, and exclim = 1

Model supported by PSLF

Exciter ESDC3A

Exciter ESDC3A
IEEE Type DC3A with Added Speed Multiplier



States

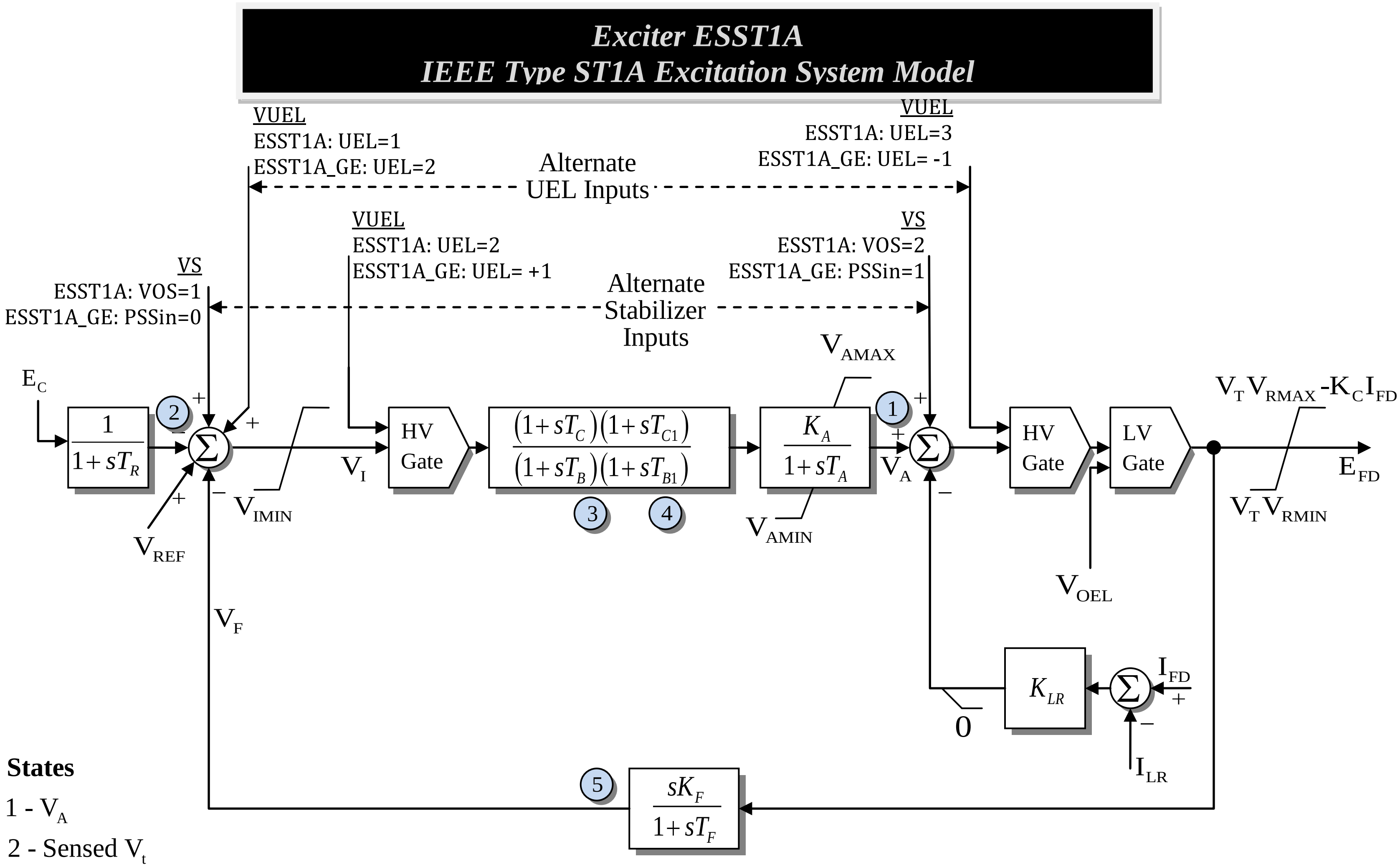
1 - EField

2 - Sensed V_t

3 - V_{RH}

Model supported by PSLF

Exciter ESST1A and ESST1A_GE



States

1 - V_A

2 - Sensed V_t

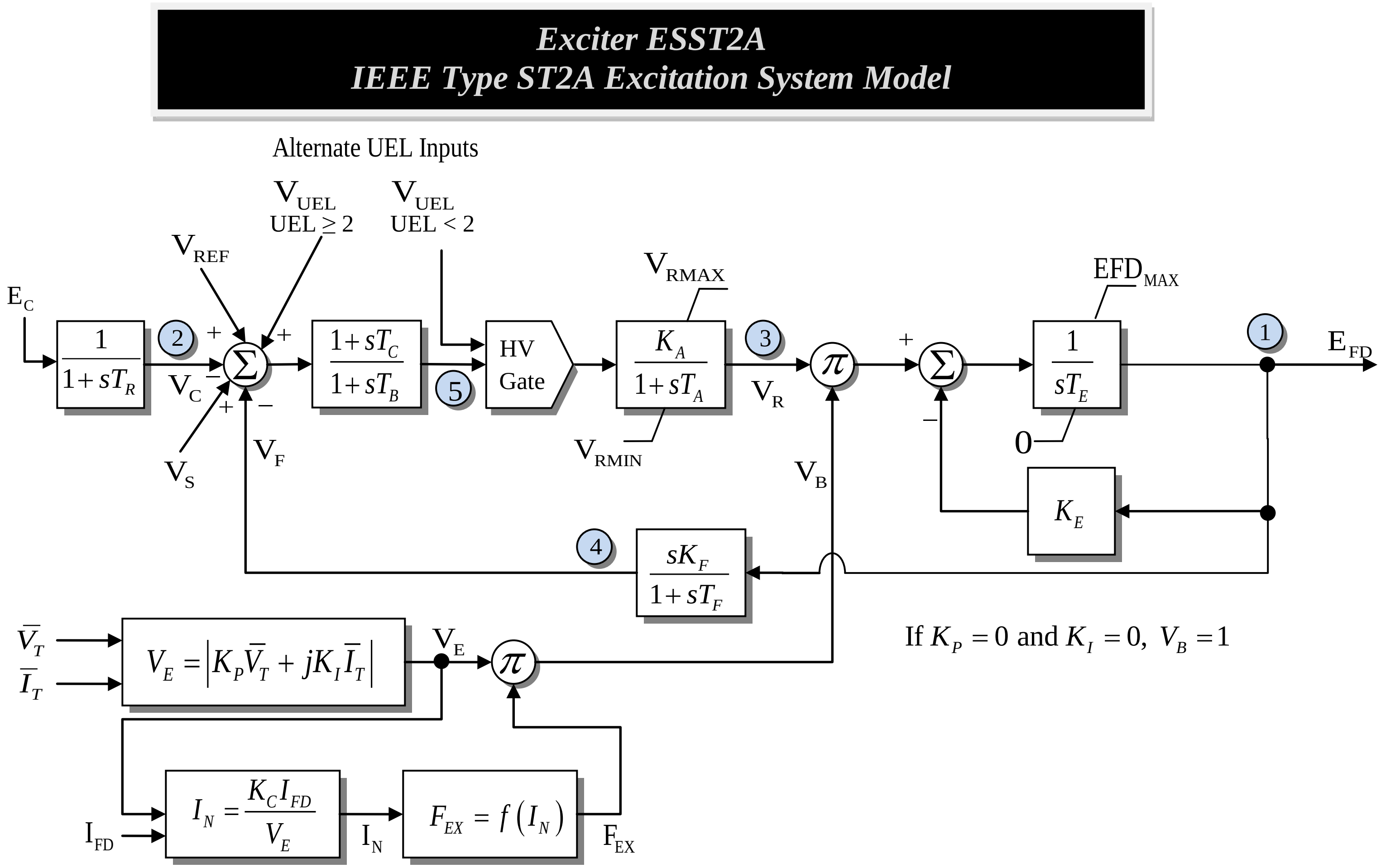
3 - LL

4 - LL1

5 - Feedback

Support in PSLF and PSSE. Different integer codes for VOS (or PSSin), and UEL codes

Exciter ESST2A



States

1 - E_{FD}

2 - Sensed V_t

3 - V_R

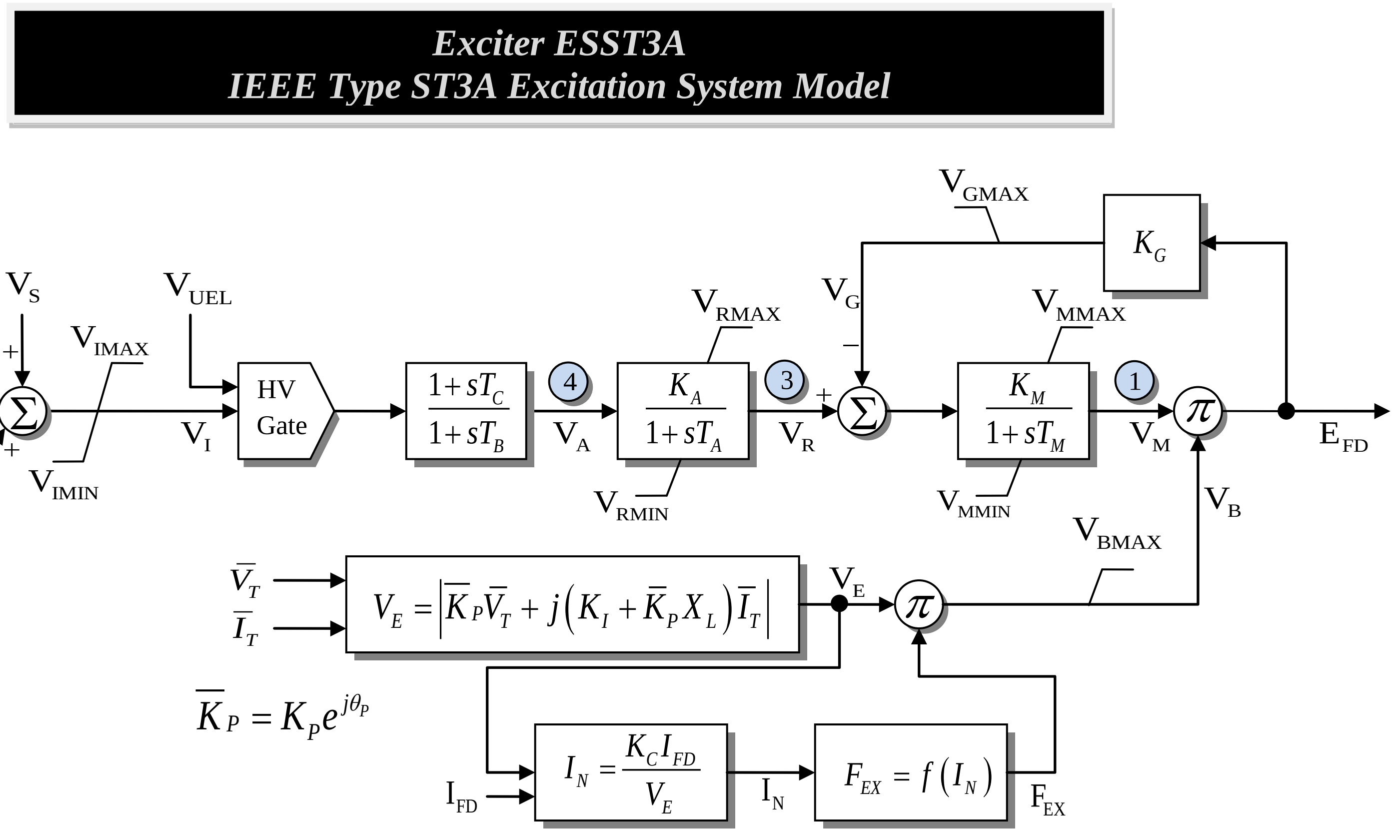
4 - V_F

5 - LL

Model supported by PSSE but always assumes values of UEL = 0, $T_C = 0$, and $T_B = 0$

Model supported by PSLF

Exciter ESST3A



States

1 - V_M

2 - Sensed V_t

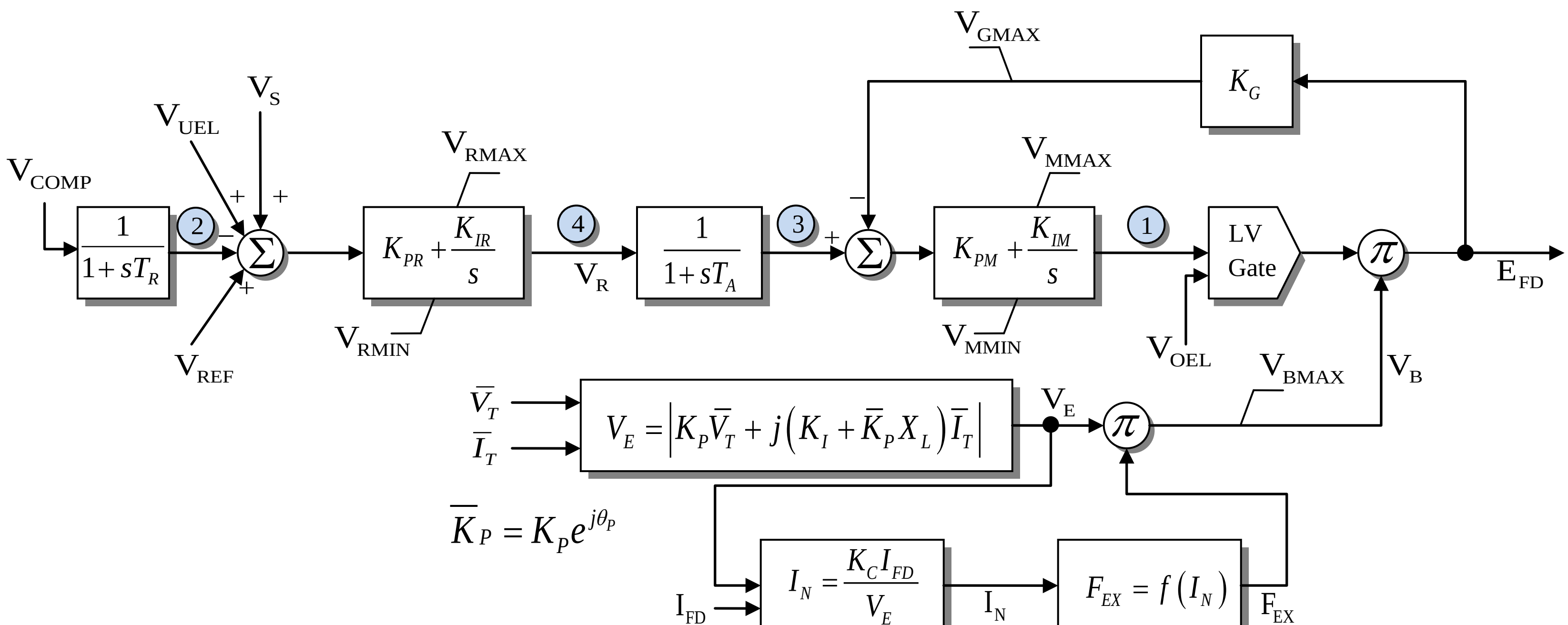
3 - V_R

4 - LL

Model supported by PSLF and PSSE

Exciter ESST4B

Exciter ESST4B
IEEE Type ST4B Potential- or Compound-Source Controlled-Rectifier Exciter Model



States

1 - V_M

2 - Sensed V_t

3 - V_A

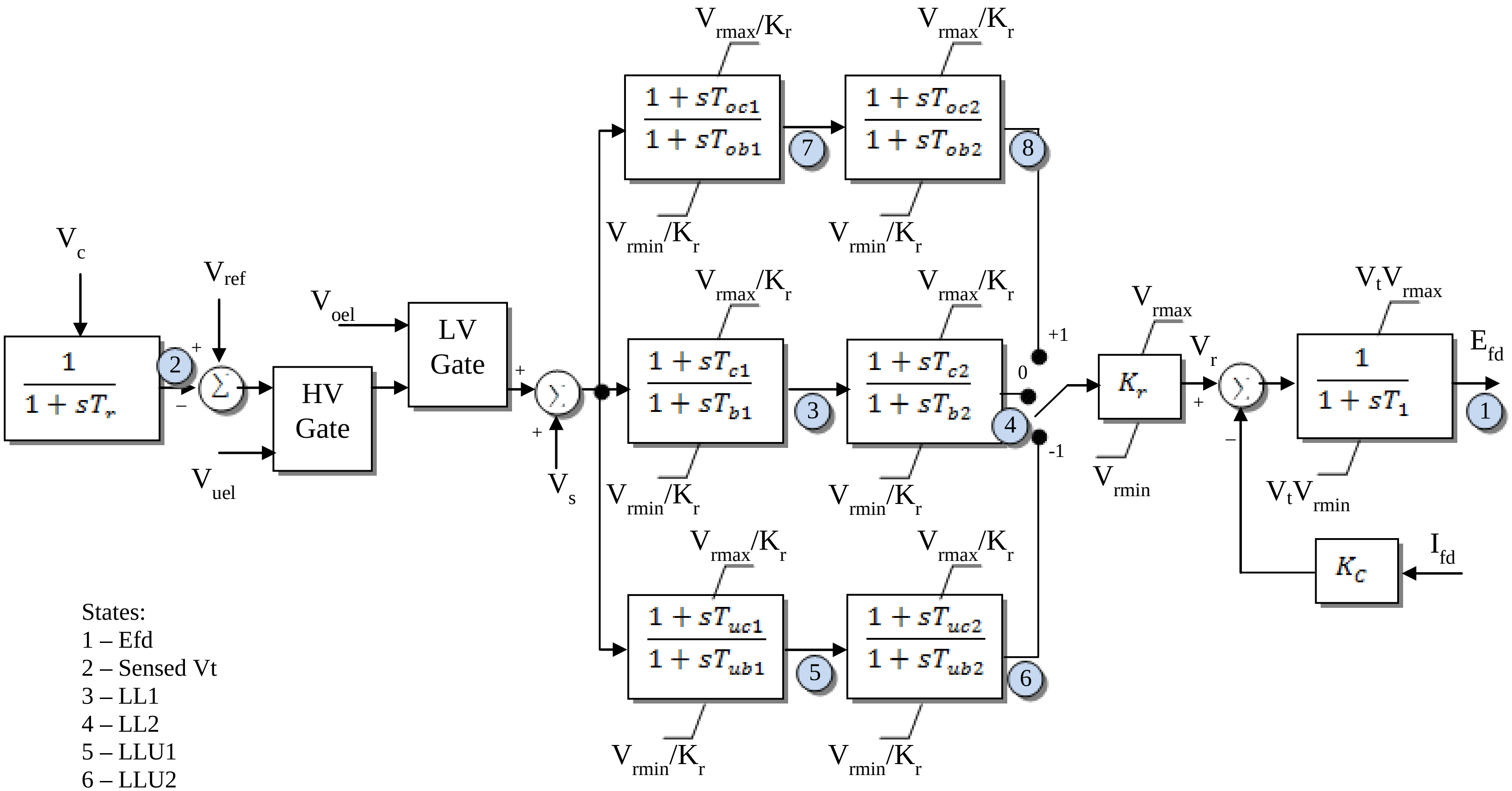
4 - V_R

Model supported by PSSE but assumes V_{GMAX} = infinite

Model supported by PSLF

Exciter ESST5B and ST5B

Exciter ESST5B and ST5B
IEEE (2005) Type ST5B Excitation System

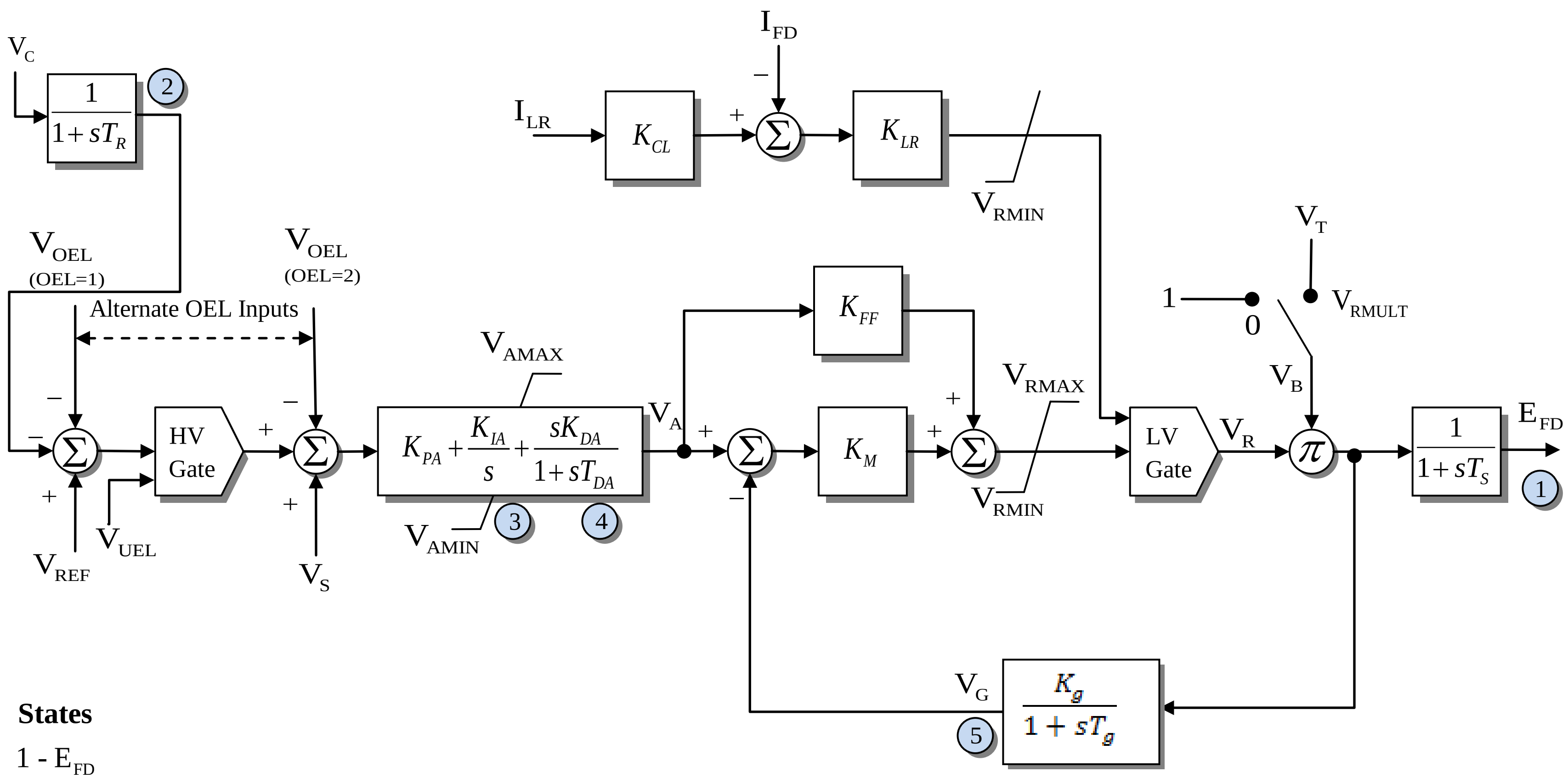


States:
1 – Efd
2 – Sensed Vt
3 – LL1
4 – LL2
5 – LLU1
6 – LLU2
7 – LLO1
8 – LLO2

Model supported by PSLF (ESST5B) and PSSE (ST5B)

Exciter ESST6B and ST6B

Exciter ESST6B
IEEE 421.5 2005 ST6B Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

3 - PID1

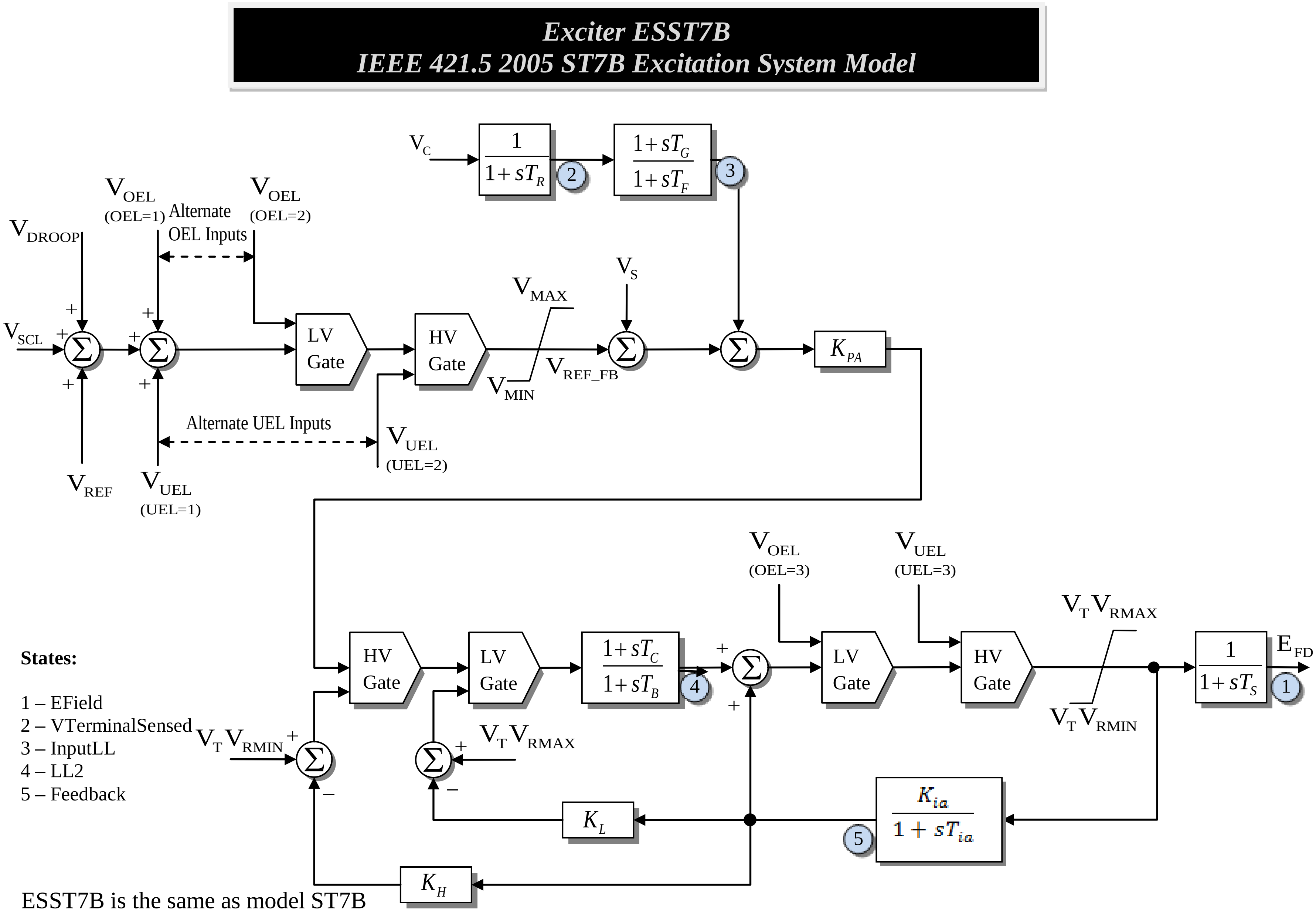
4 - PID2

5 - V_G

ESST6B is the same as model ST6B

ESST6B is a PSLF model and ST6B is a PSSE model

Exciter ESST7B and ST7B

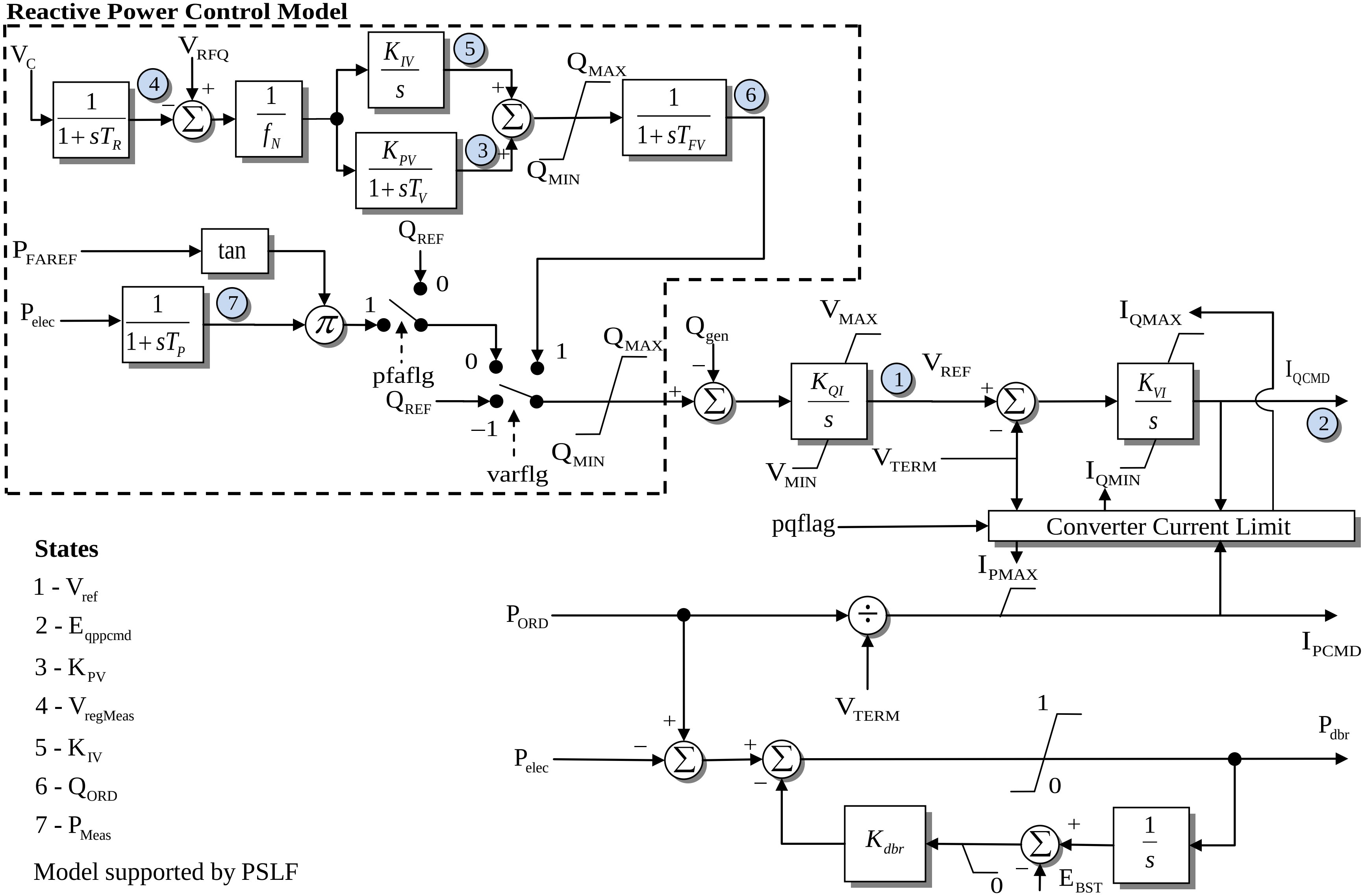


ESST7B is the same as model ST7B

ESST7B is a PSLF model and ST7B is a PSSE model

Exciter EWTGFC

Exciter EWTGFC
Excitation Control Model for Full Converter GE Wind-Turbine Generators



States

1 - V_{ref}

2 - E_{qppcmd}

3 - K_{PV}

4 - $V_{regMeas}$

5 - K_{IV}

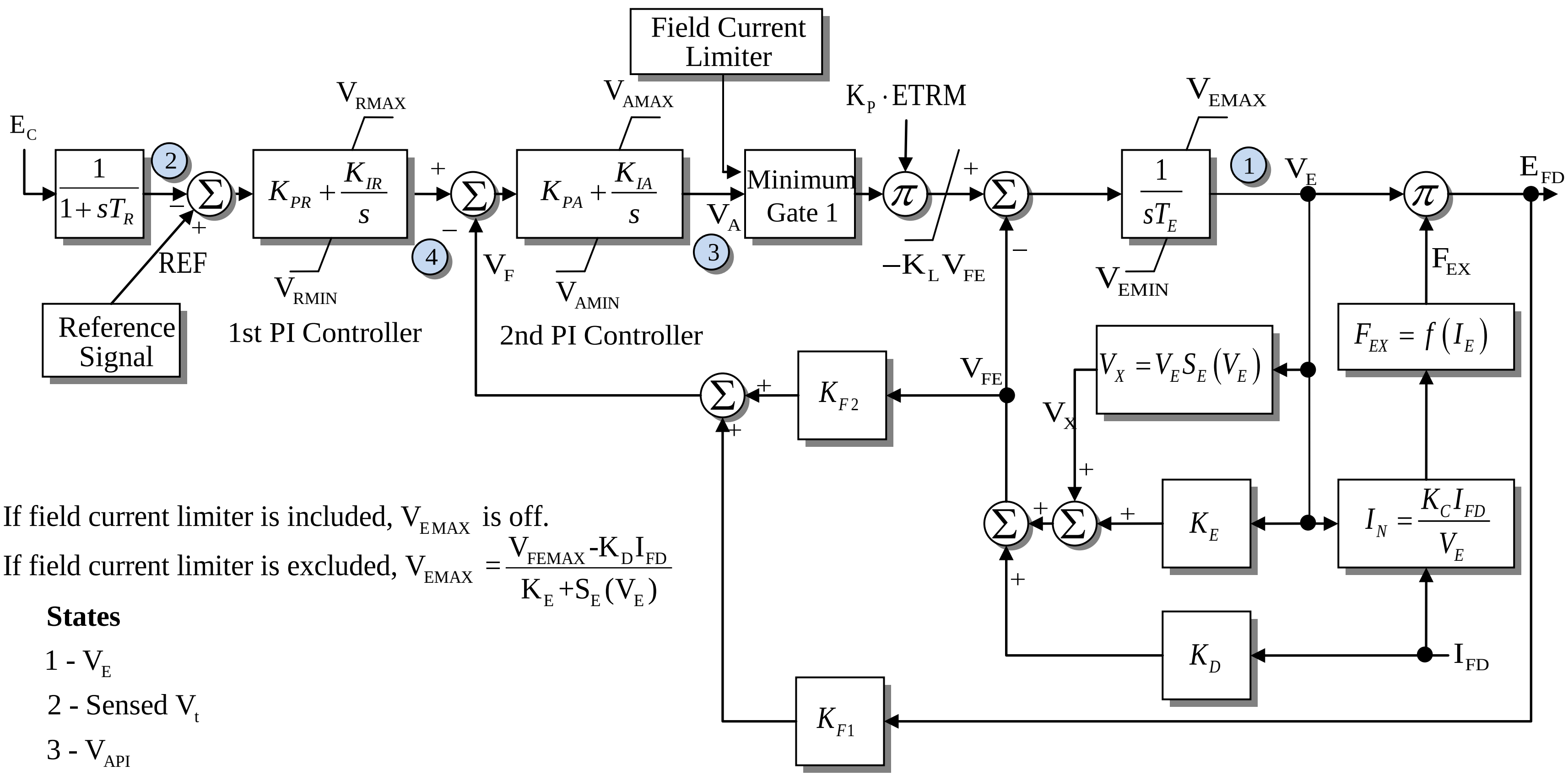
6 - Q_{ORD}

7 - P_{Meas}

Model supported by PSLF

Exciter EX2000

Exciter EX2000
IEEE Type AC7B Alternator-Rectifier Excitation System Model



If field current limiter is included, V_{EMAX} is off.

If field current limiter is excluded, $V_{EMAX} = \dfrac{V_{FEMAX} - K_D I_{FD}}{K_E + S_E(V_E)}$

States

1 - V_E

2 - Sensed V_t

3 - V_{API}

4 - V_{RPI}

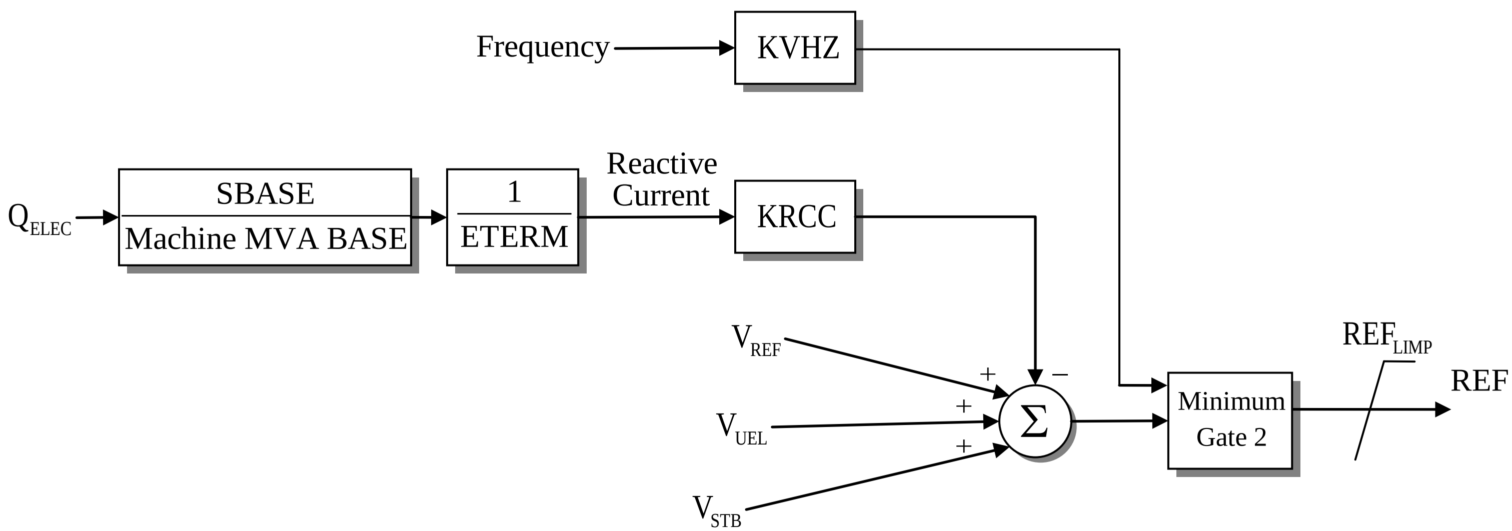
5 - LL

6 - IFD_{PI}

Model supported by PSSE

Exciter EX2000 REFERENCE SIGNAL MODEL

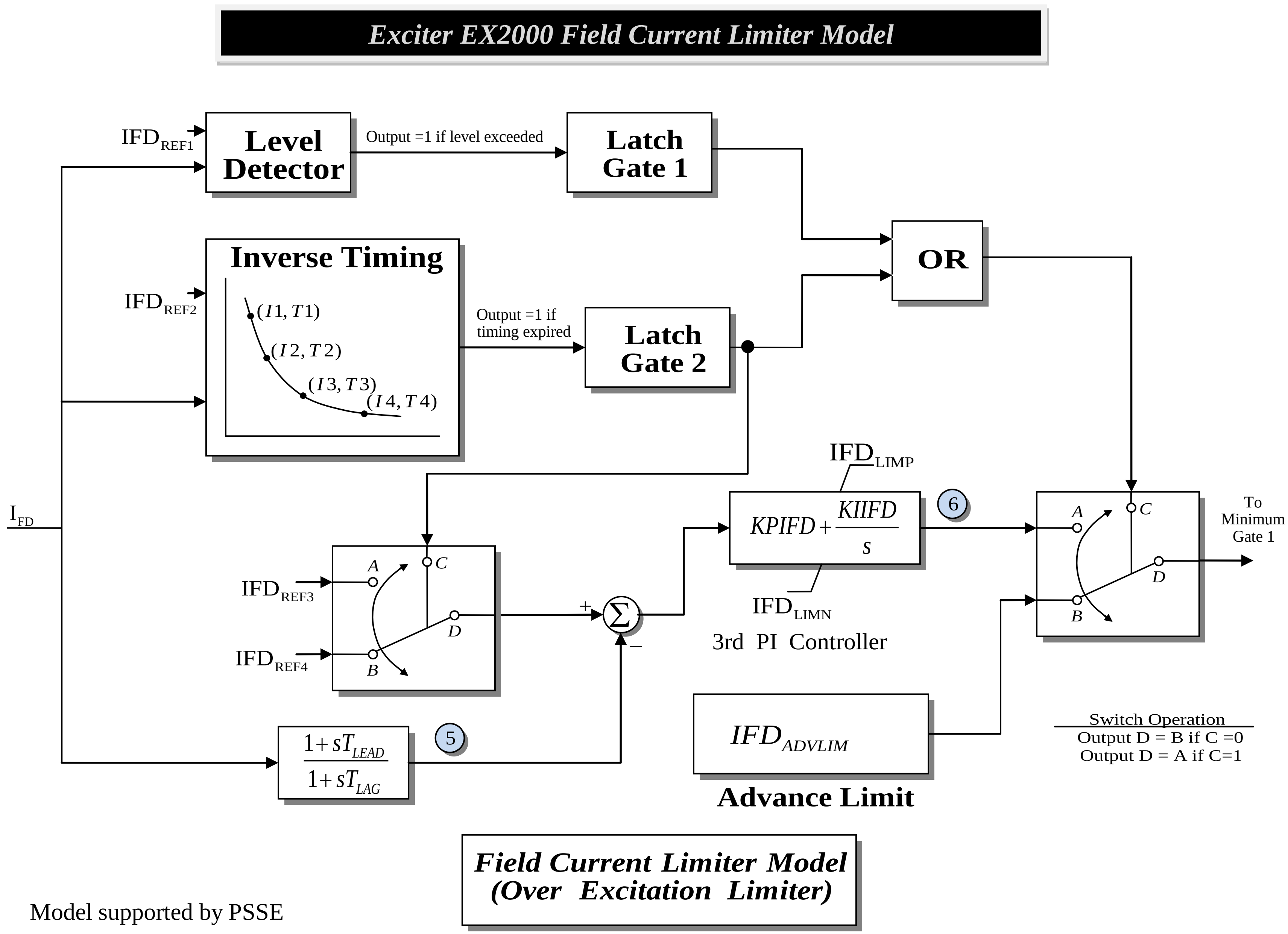
Exciter EX2000 Reference Signal Model



Reference Signal Model

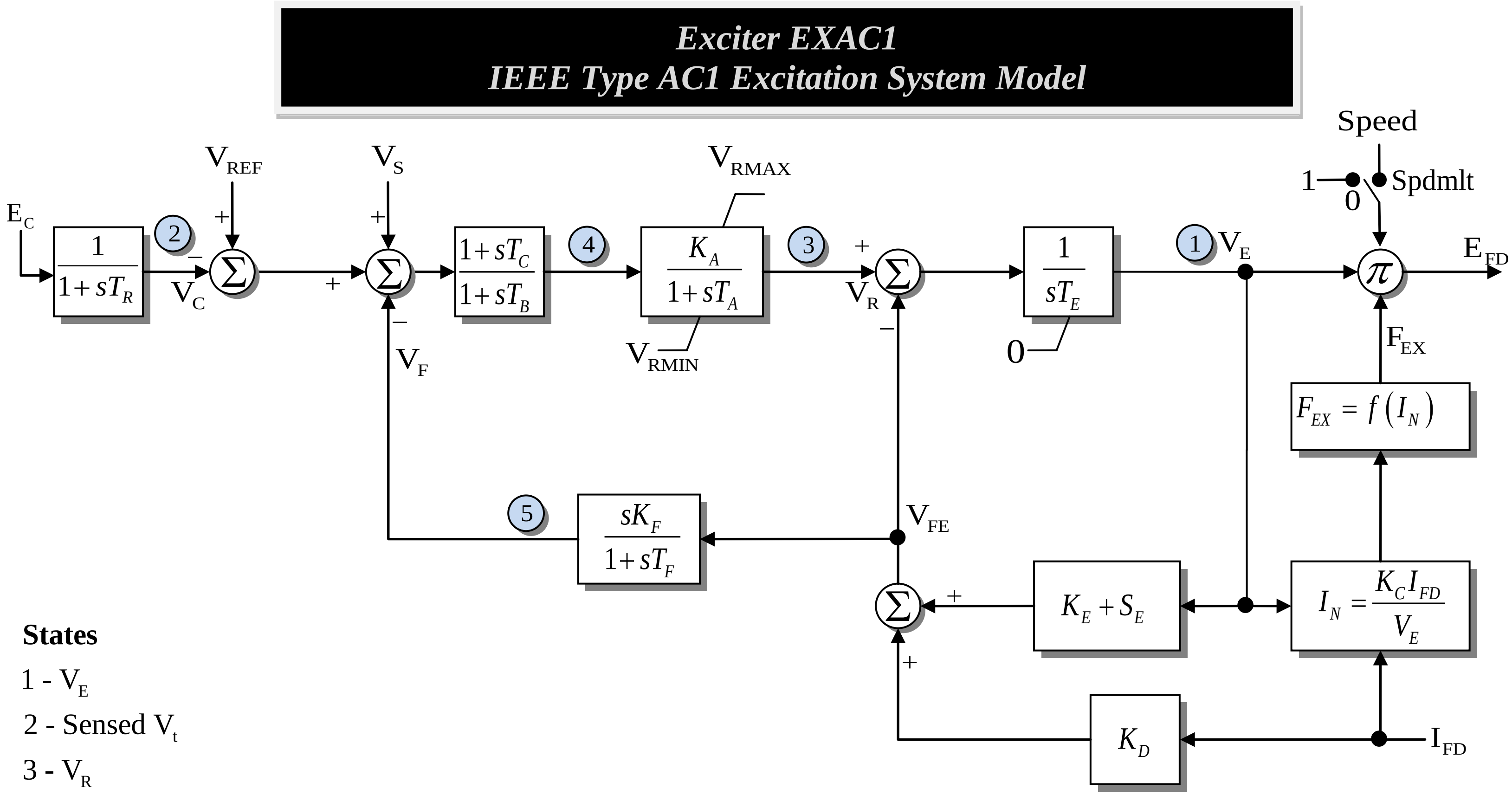
Model supported by PSSE

Exciter EX2000 FIELD CURRENT LIMITER MODEL



Model supported by PSSE

Exciter EXAC1



States

1 - V_E

2 - Sensed V_t

3 - V_R

4 - V_{LL}

5 - V_F

Model supported by PSSE but always assumes value of spdmlt = 0

Model supported by PSLF also uses V_{AMIN} and V_{AMAX}

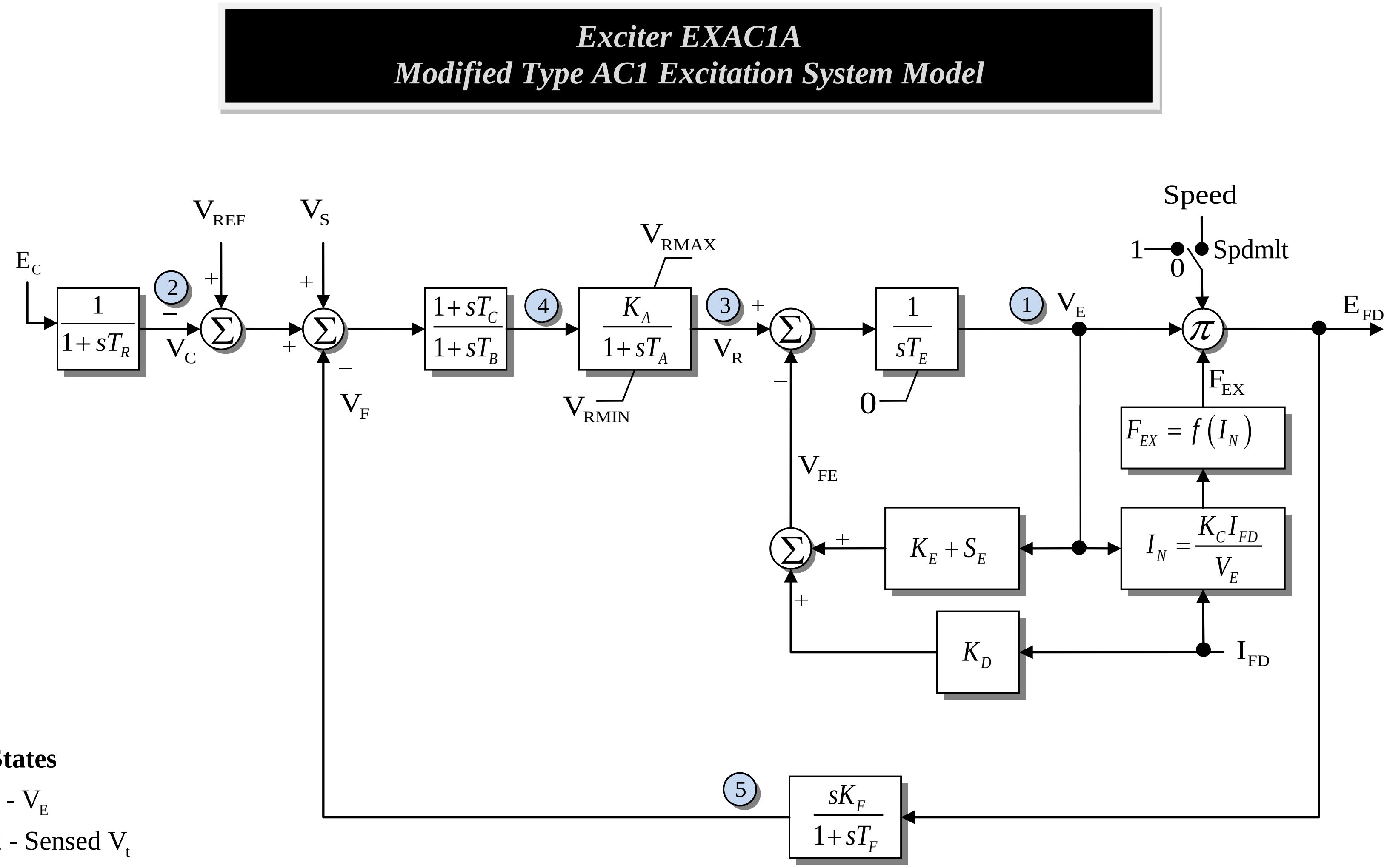
Simulator will narrow the limit range as appropriate when loading the DYD file

If $V_{AMIN} > V_{RMIN}$ then $V_{RMIN} = V_{AMIN}$

If $V_{AMAX} < V_{RMAX}$ then $V_{RMAX} = V_{AMAX}$

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter EXAC1A



States

1 - V_E

2 - Sensed V_t

3 - V_R

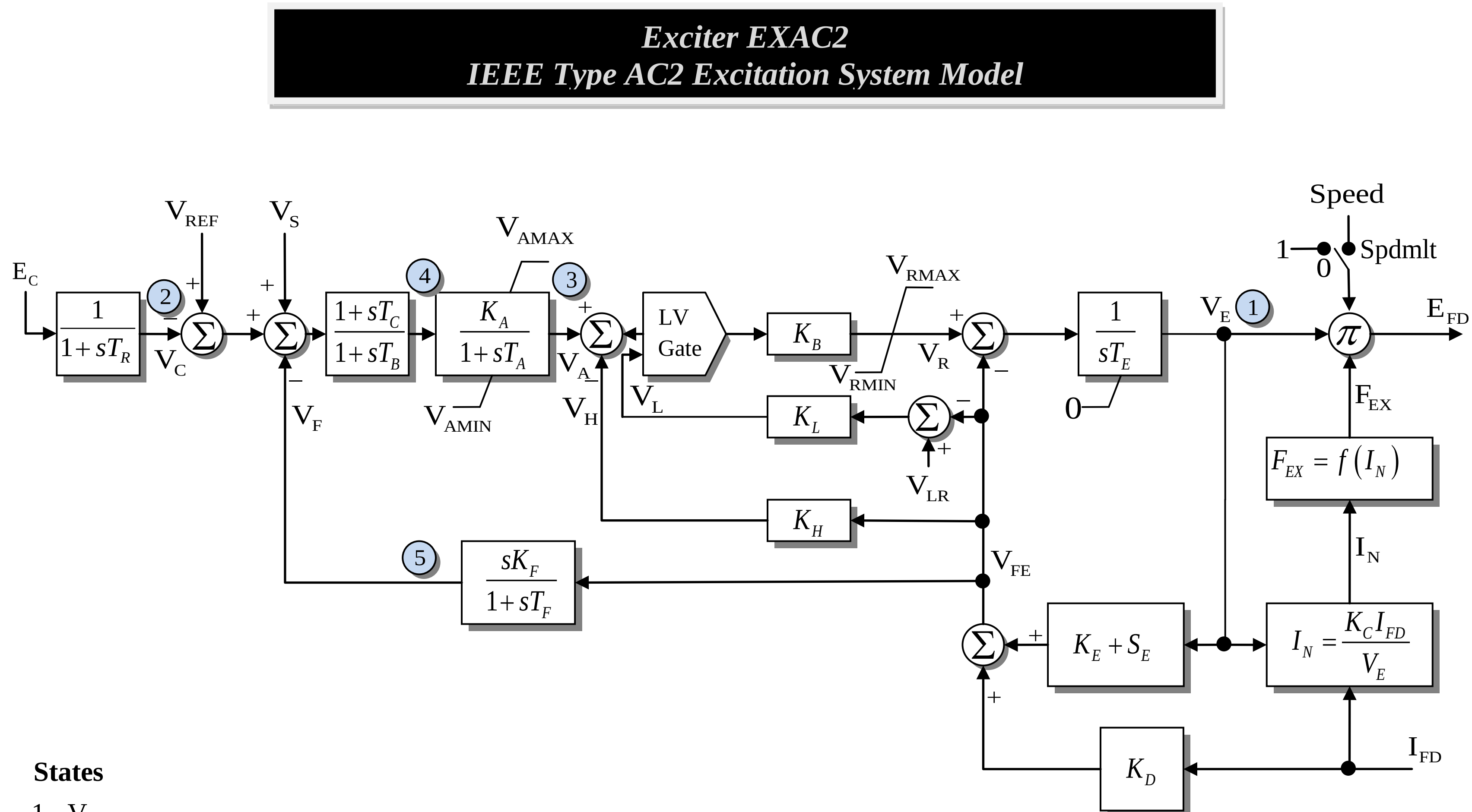
4 - V_{LL}

5 - V_F

Model supported by PSSE but always assumes value of spdmlt = 0

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter EXAC2



States

1 - V_E

2 - Sensed V_t

3 - V_A

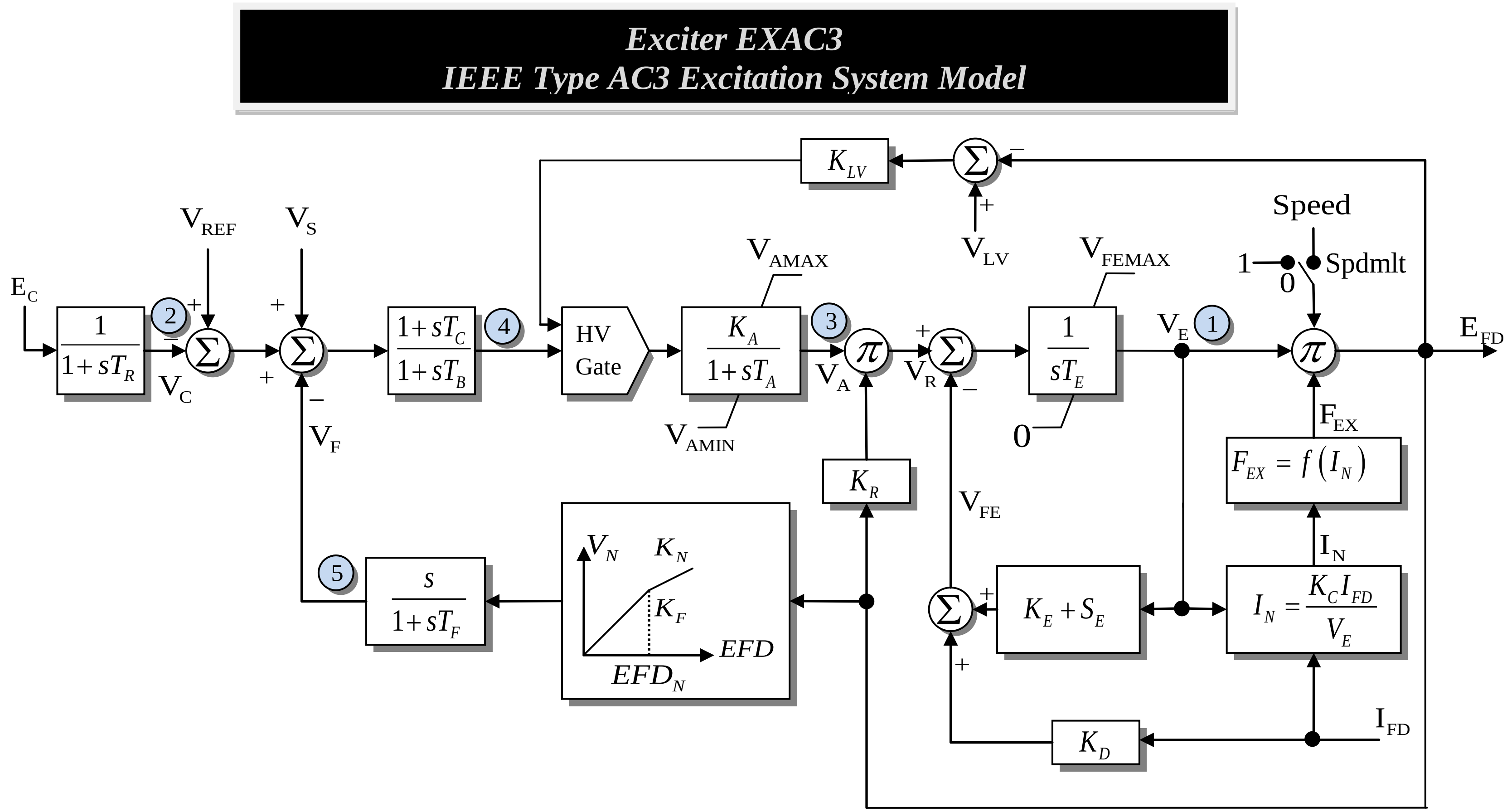
4 - V_{LL}

5 - V_F

Model supported by PSSE but always assumes value of spdmlt = 0

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter EXAC3



States

1 - V_E

2 - Sensed V_t

3 - V_A

4 - V_{LL}

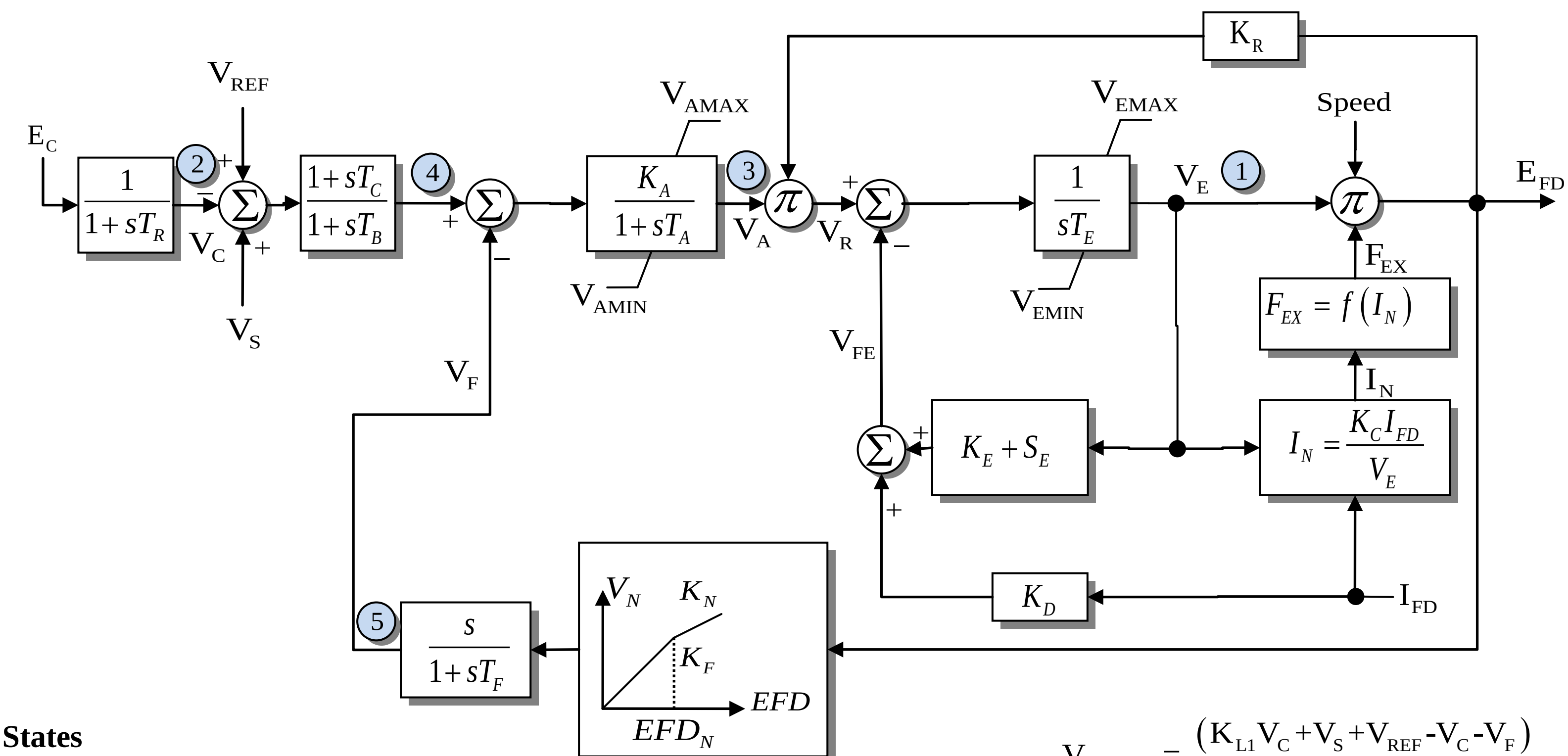
5 - V_F

Model supported by PSSE but always assumes values of $V_{FEMAX} = 9999$ and spdmlt = 0

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter EXAC3A

Exciter EXAC3A
IEEE Type AC3 Excitation System Model



States

1 - V_E

2 - Sensed V_t

3 - V_A

4 - V_{LL}

5 - V_F

Model supported by PSLF

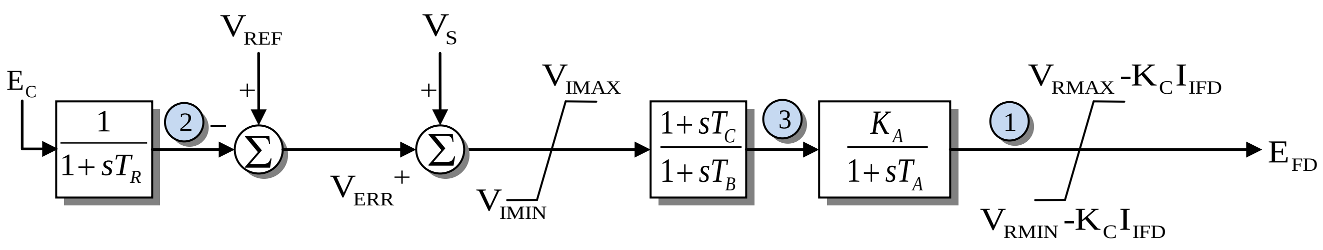
$$V_{FEMAX} = \frac{(K_{L1}V_C + V_S + V_{REF} - V_C - V_F)}{K_{FA}K_{L1}}$$

$$V_{EMAX} = \frac{(V_{FEMAX} - K_D I_{FD})}{S_E + K_E}$$

$$V_{EMIN} = \frac{V_{LV}}{F_{EX}}$$

Exciter EXAC4

Exciter EXAC4
IEEE Type AC4 Excitation System Model



States

1 - EField before limit

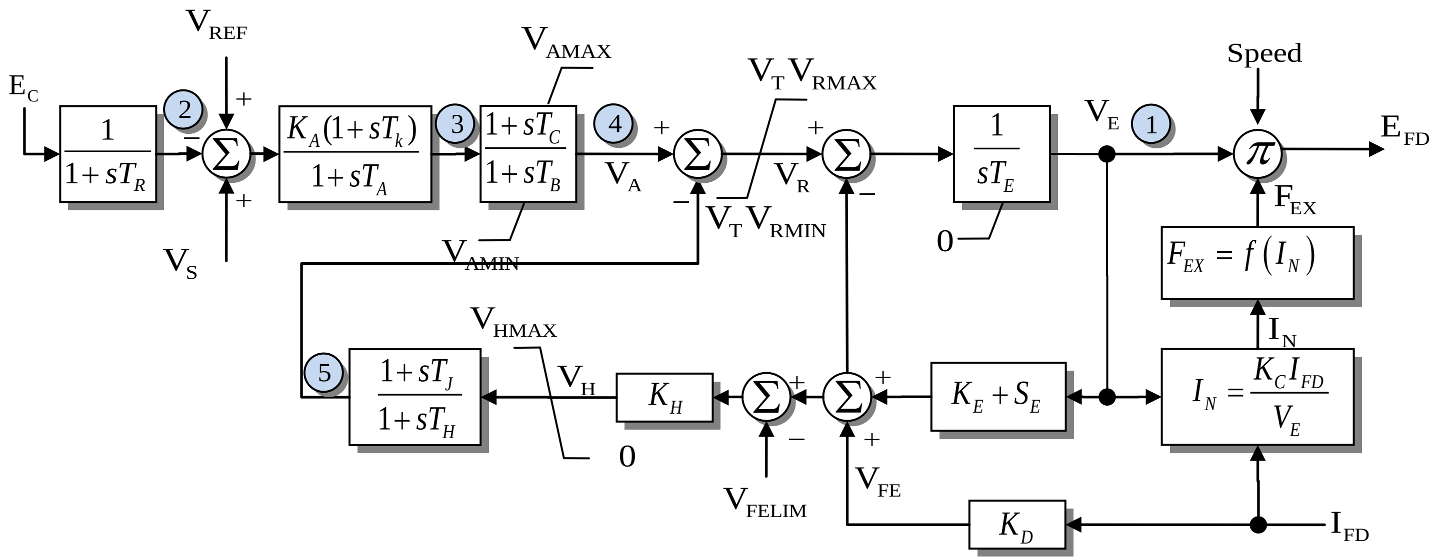
2 - Sensed V_t

3 - V_{LL}

Model supported by PSLF and PSSE

Exciter EXAC6A

Exciter EXAC6A
IEEE Type AC6A Excitation System Model



States

1 - V_E

2 - Sensed V_t

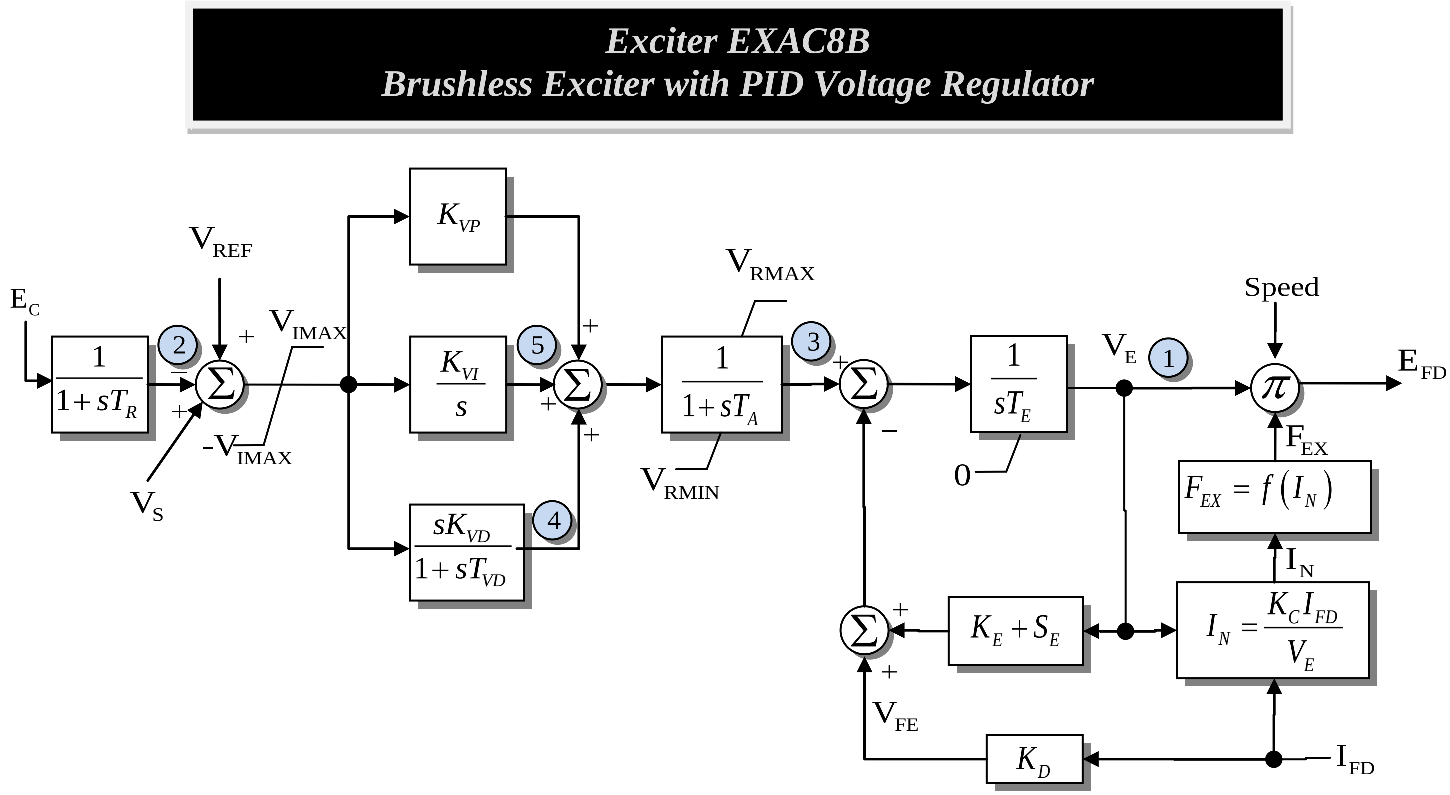
3 - T_A Block

4 - V_{LL}

5 - V_F

Model supported by PSLF

Exciter EXAC8B



States

1 - V_E

2 - Sensed V_t

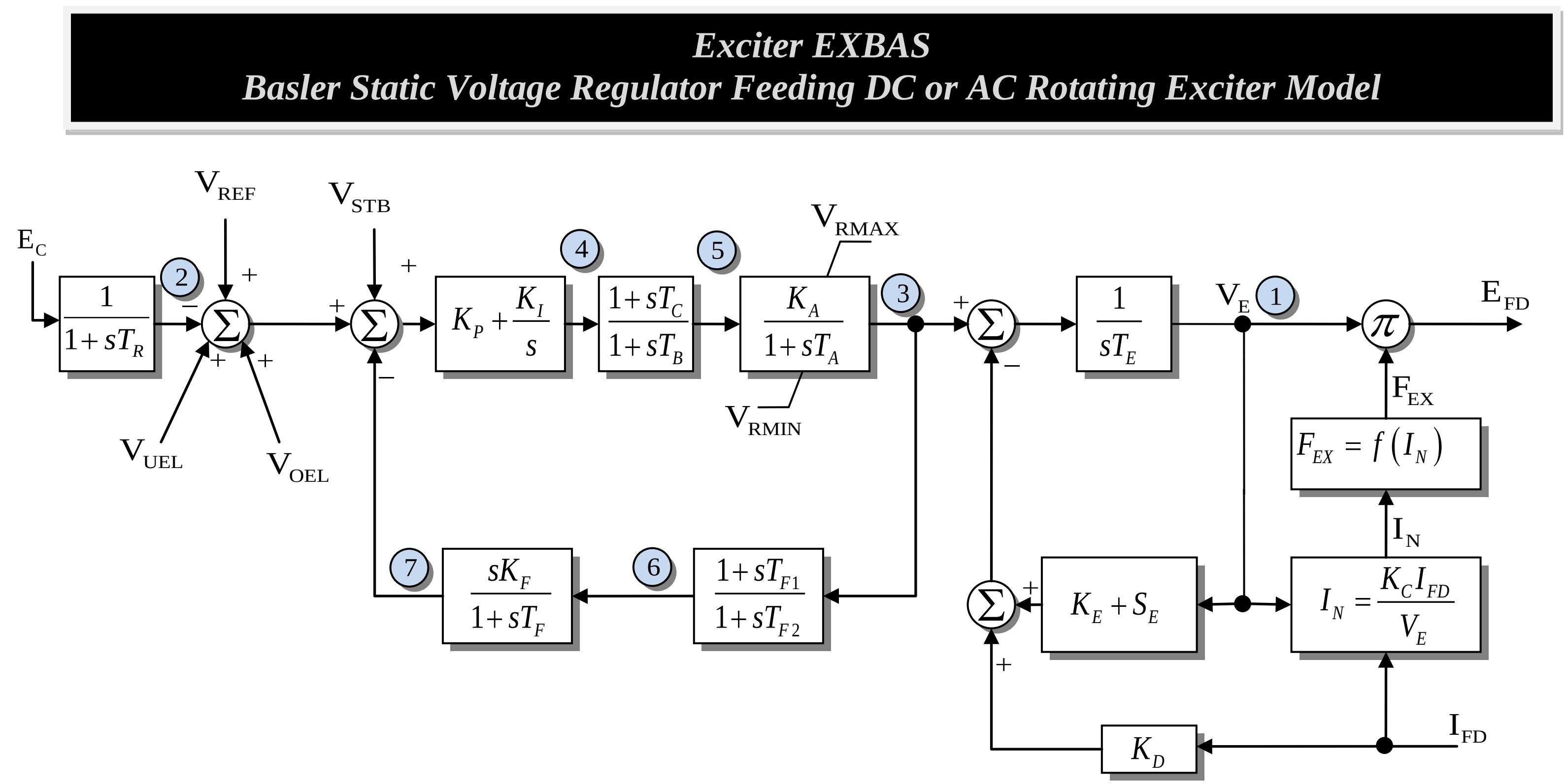
3 - V_R

4 - Derivative

5 - Integral

Model supported by PSLF

Exciter EXBAS



States

1 - V_E

2 - Sensed V_t

3 - V_R

4 - PI

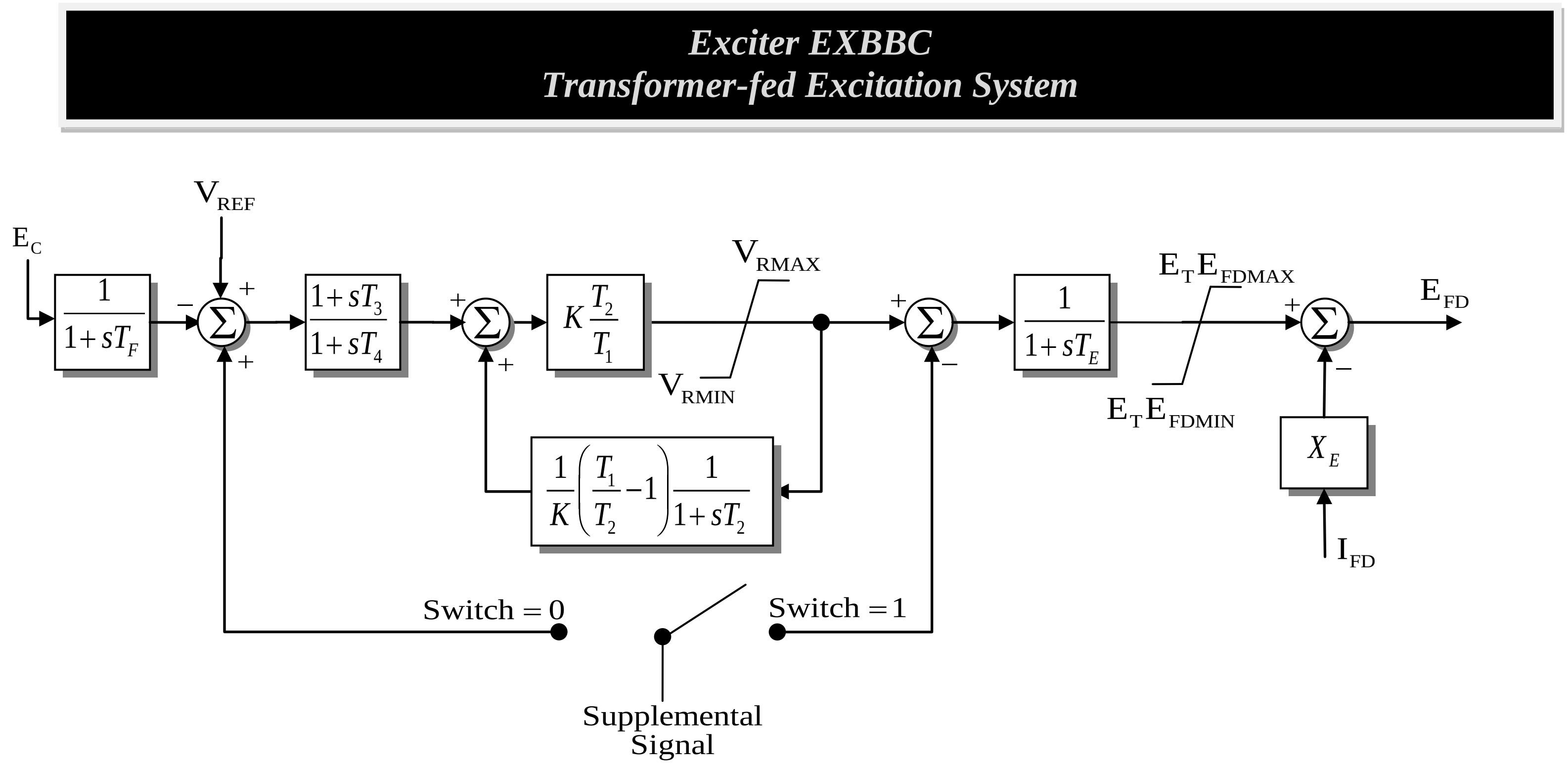
5 - LL

6 - Feedback LL

7 - Feedback

Model supported by PSSE

Exciter EXBBC

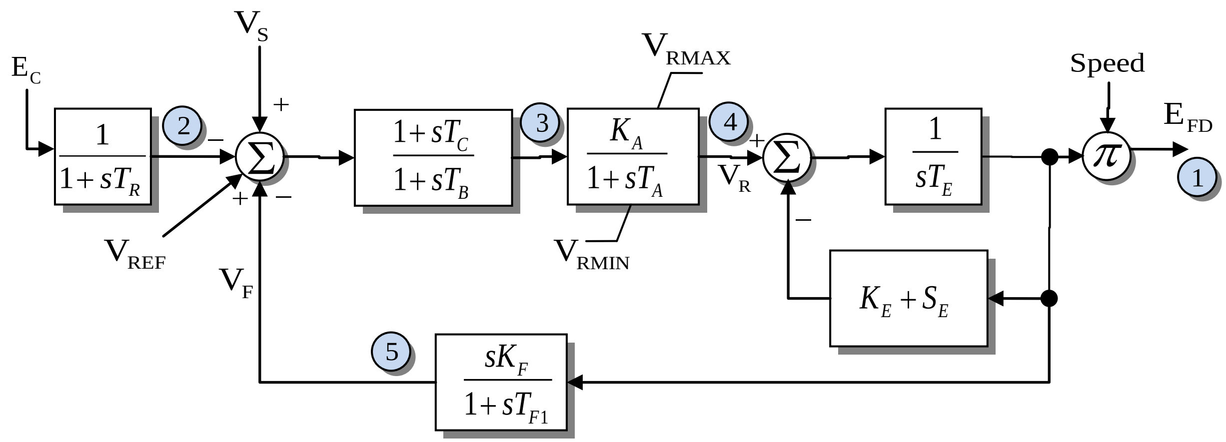


Very similar to the model BBSEX1 supported by PSSE

Model supported by PSLF

Exciter EXDC1

Exciter EXDC1
IEEE DC1 Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

3 - V_B

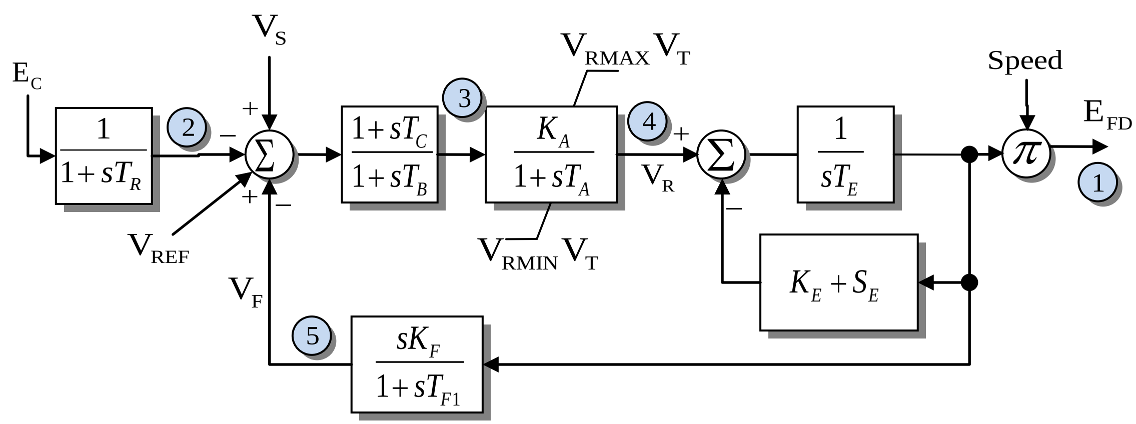
4 - V_R

5 - V_F

Model supported by PSLF

Exciter EXDC2A

Exciter EXDC2A
IEEE Type DC2 Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

3 - V_B

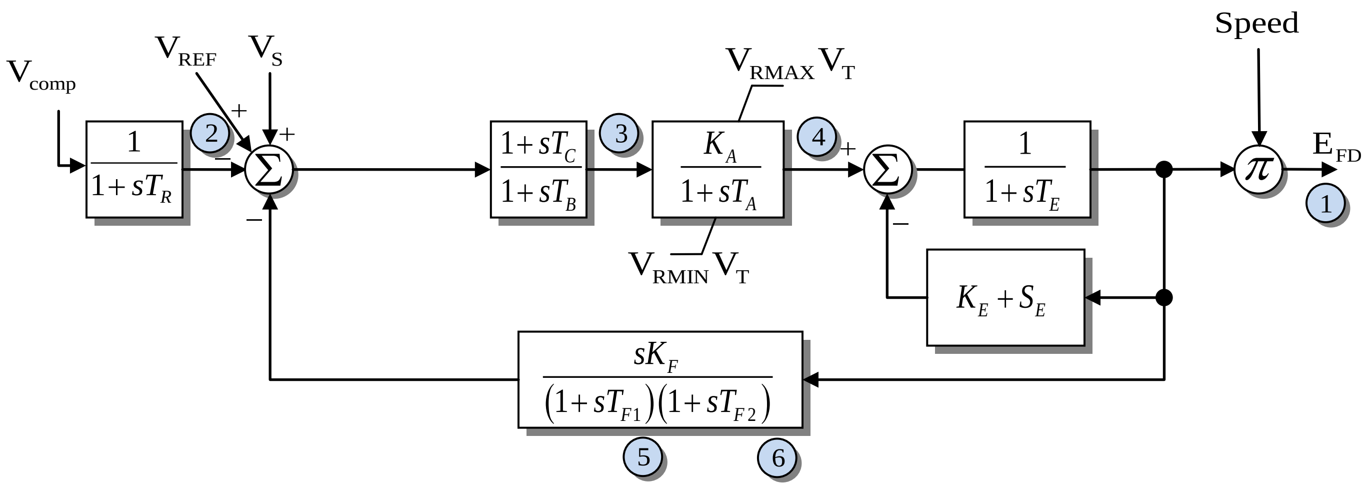
4 - V_R

5 - V_F

Model supported by PSLF

Exciter EXDC2_GE

Exciter EXDC2_GE
IEEE Type DC2 Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

3 - V_B

4 - V_R

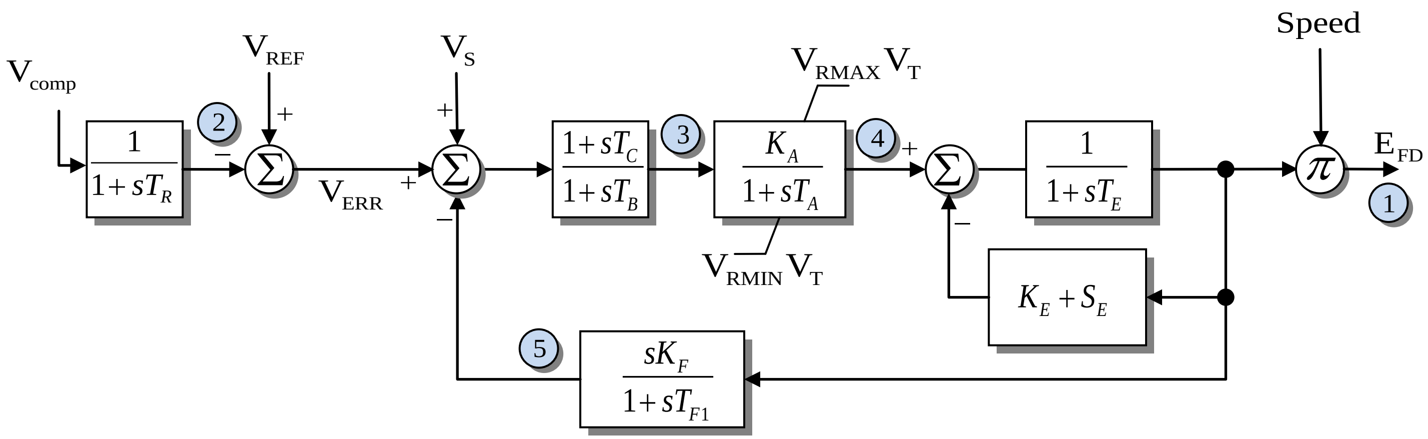
5 - V_{F1}

6 - V_{F2}

Model supported by PSLF

Exciter EXDC2_PTI

Exciter EXDC2_PTI
IEEE Type DC2 Excitation System Model



States

1 - E_{FD}

2 - Sensed V_t

3 - V_B

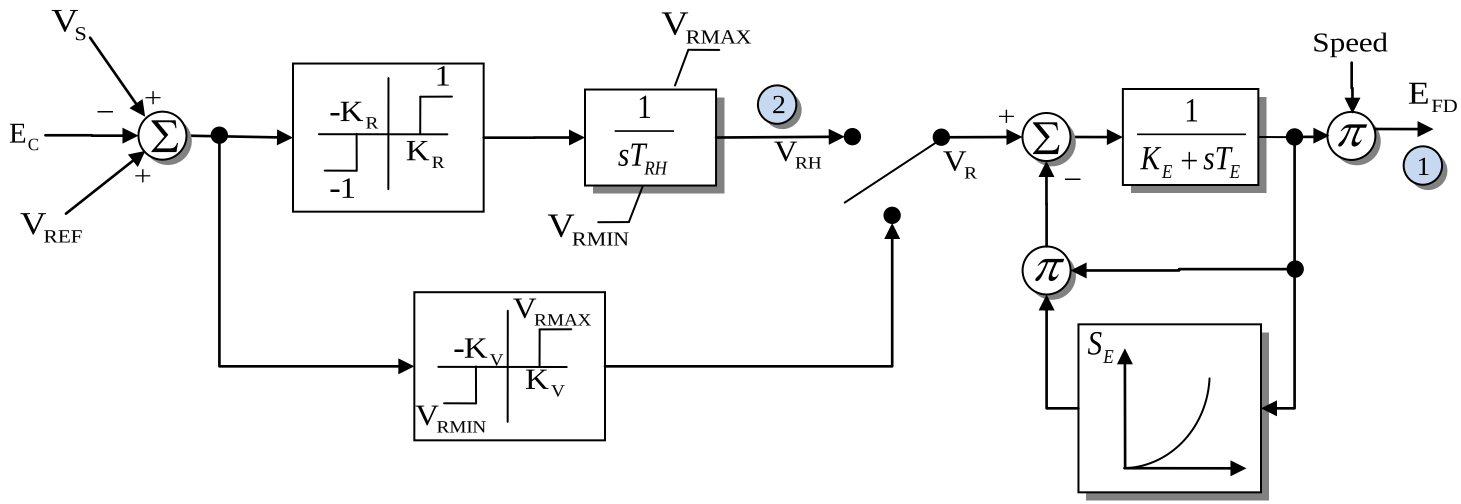
4 - V_R

5 - V_F

Model supported by PSEE

Exciter EXDC4

Exciter EXDC4
IEEE Type 4 Excitation System Model



States

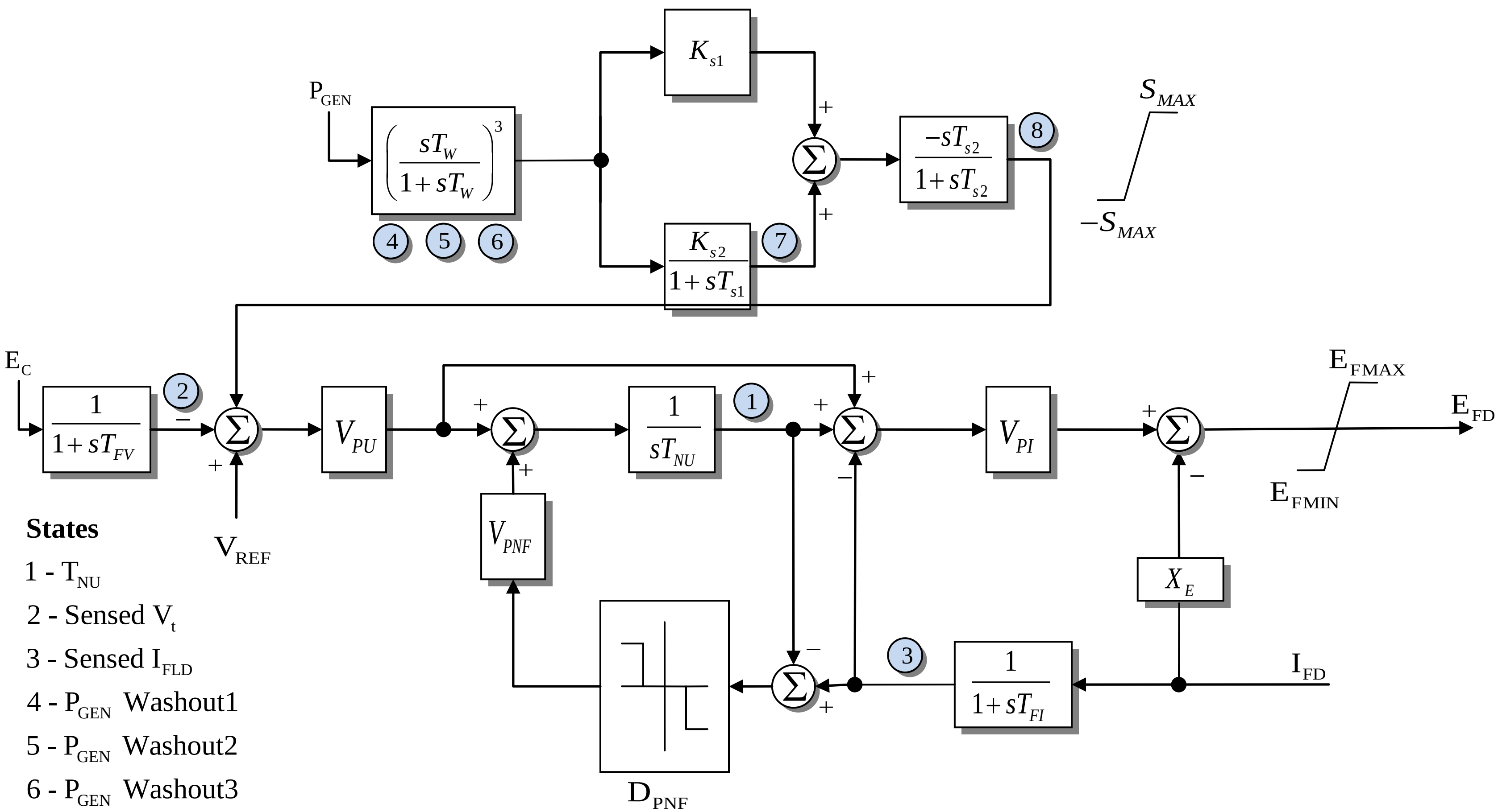
1 - E_{FD}

2 - V_{RH}

Model supported by PSLF

Exciter EXELI

Exciter EXELI
Static PI Transformer Fed Excitation System Model



States

1 - T_{NU}

2 - Sensed V_t

3 - Sensed I_{FLD}

4 - P_{GEN} Washout1

5 - P_{GEN} Washout2

6 - P_{GEN} Washout3

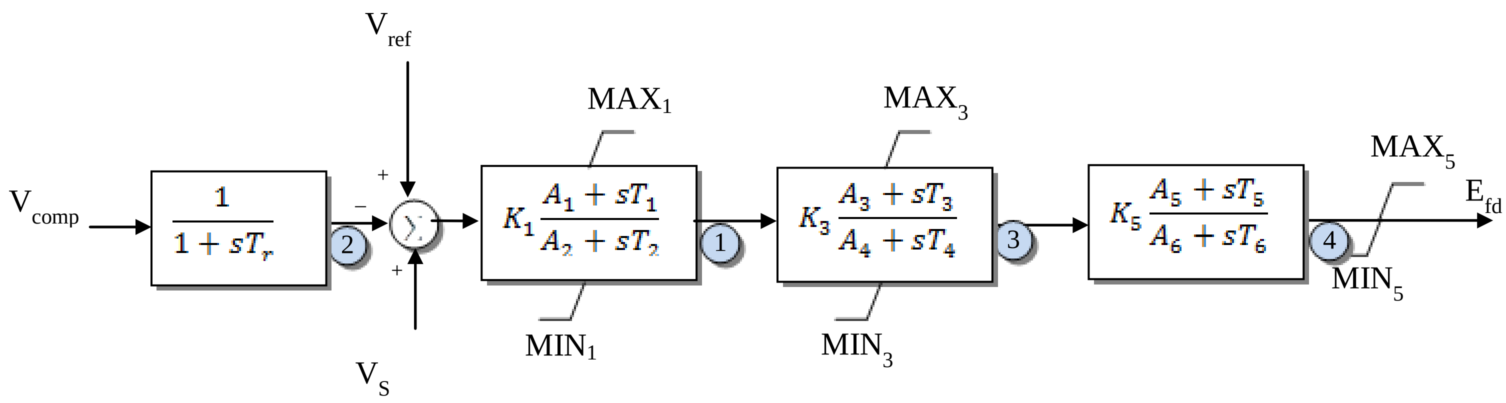
7 - Lag Stabilizer

8 - Washout Stabilizer

Model supported by PSLF and PSSE

Exciter EXIVO

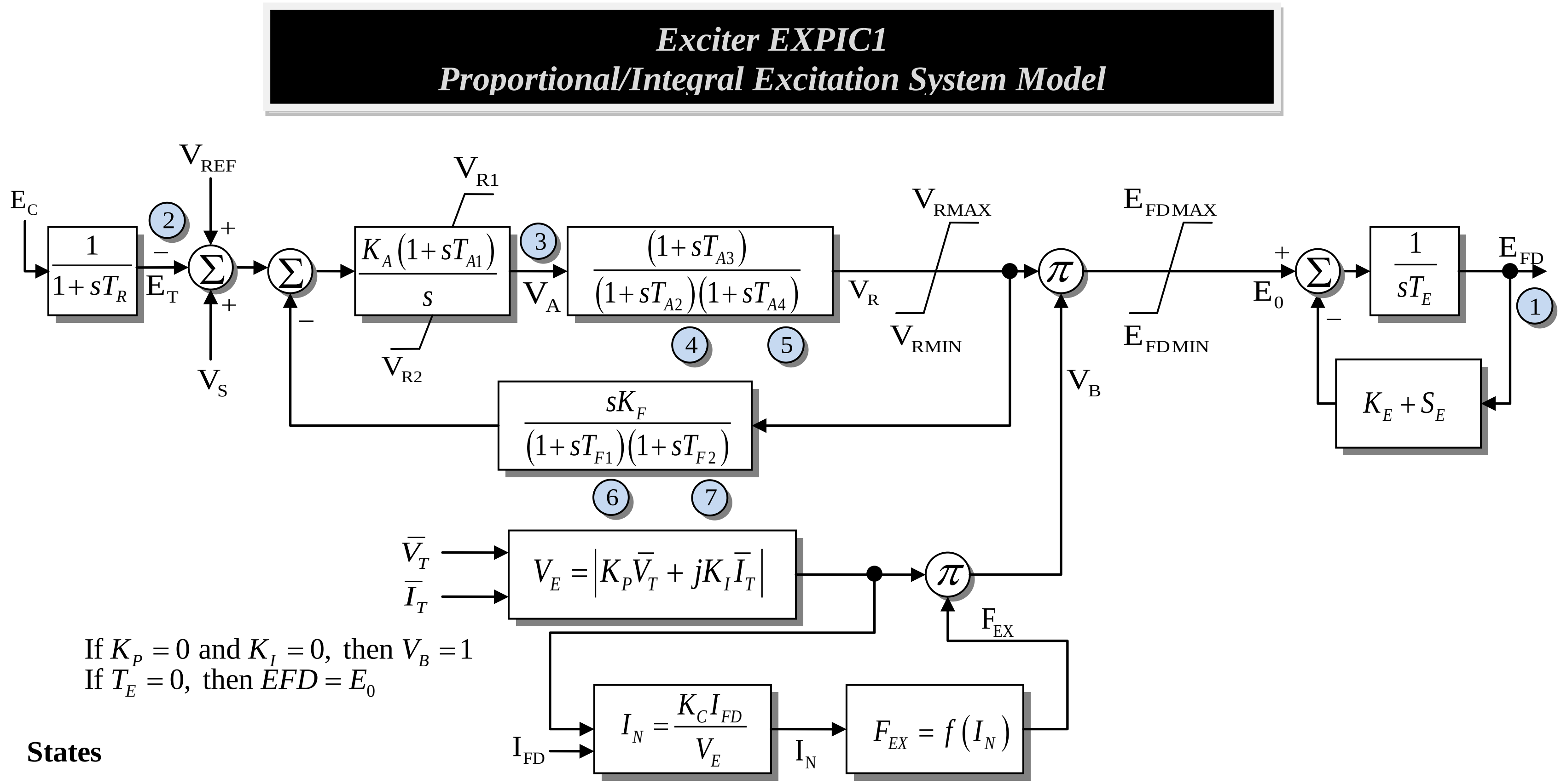
Exciter EXIVO
IVO Excitation Model



States:
1 – VLL12
2 – Sensed Vt
3 – VLL34
4 – VLL56

Model supported by PSLF

Exciter EXPIC1



If $K_P = 0$ and $K_I = 0$, then $V_B = 1$
If $T_E = 0$, then $EFD = E_0$

States

1 - E_{FD}

2 - Sensed V_t

3 - V_A

4 - V_{R1}

5 - V_R

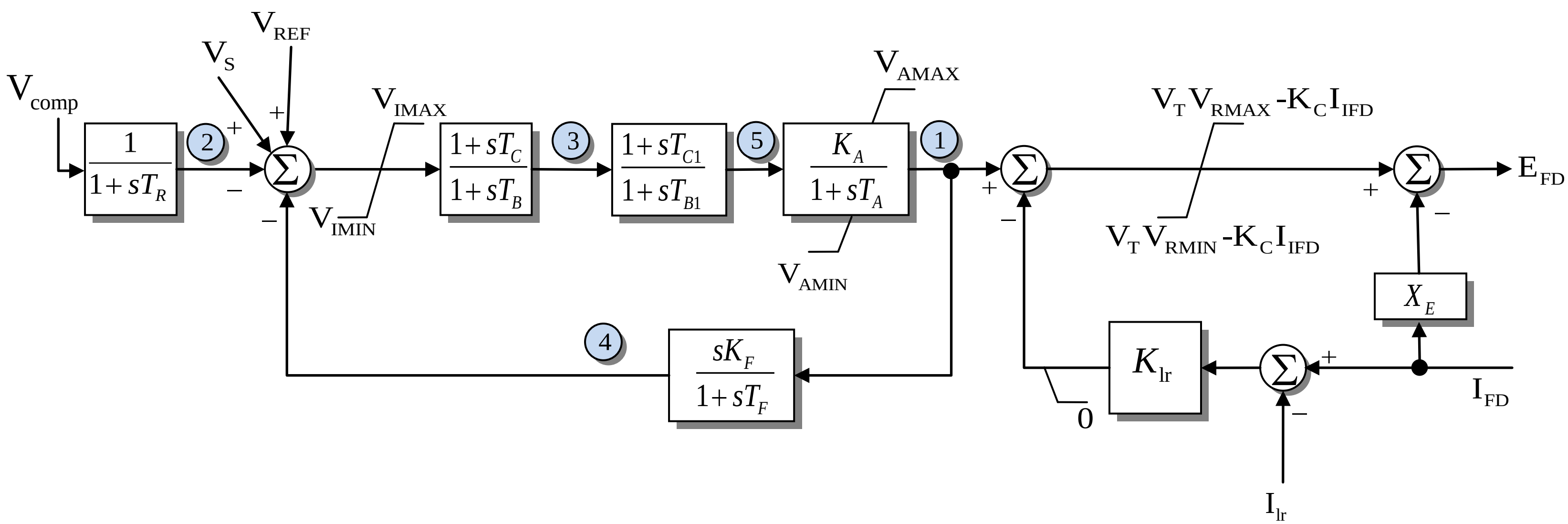
6 - V_{F1}

7 - V_F

Model supported by PSLF and PSSE

Exciter EXST1_GE

_Exciter EXST1_GE_
IEEE Type ST1 Excitation System Model



States

1 - V_A

2 - Sensed V_t

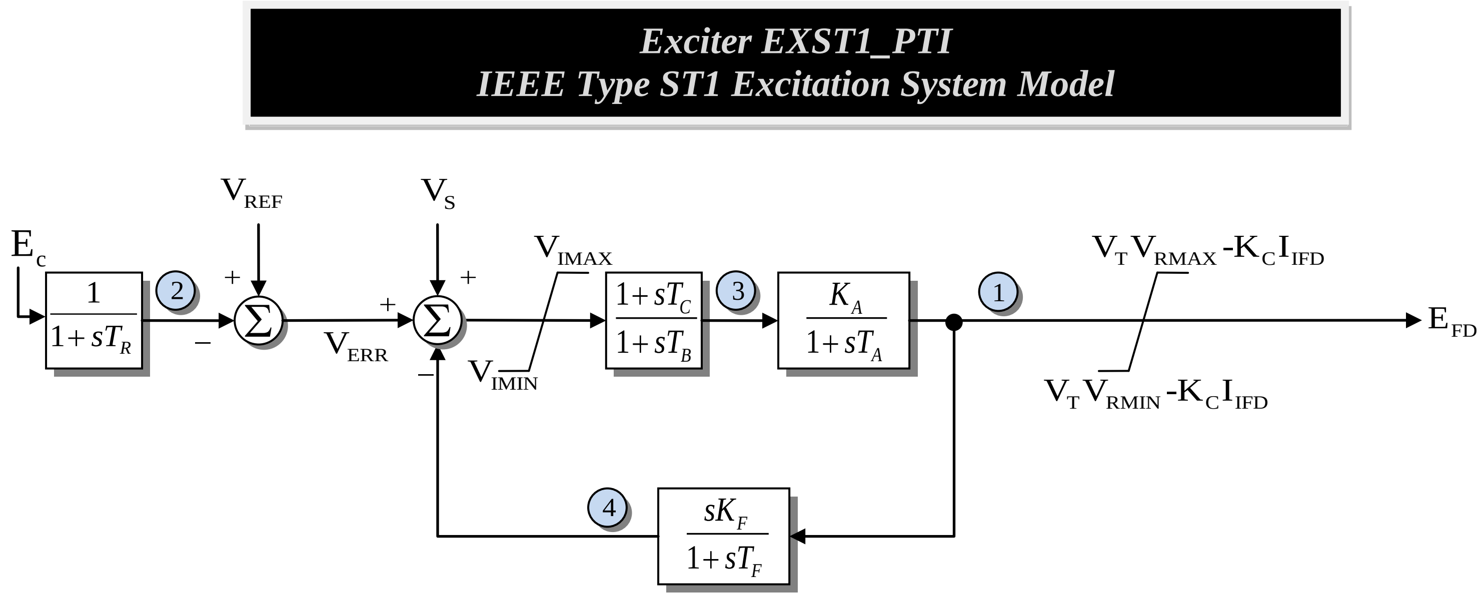
3 - V_{LL}

4 - V_F

5 - V_{LL1}

Model supported by PSLF

Exciter EXST1_PTI



States

1 - E_{FD} before limit

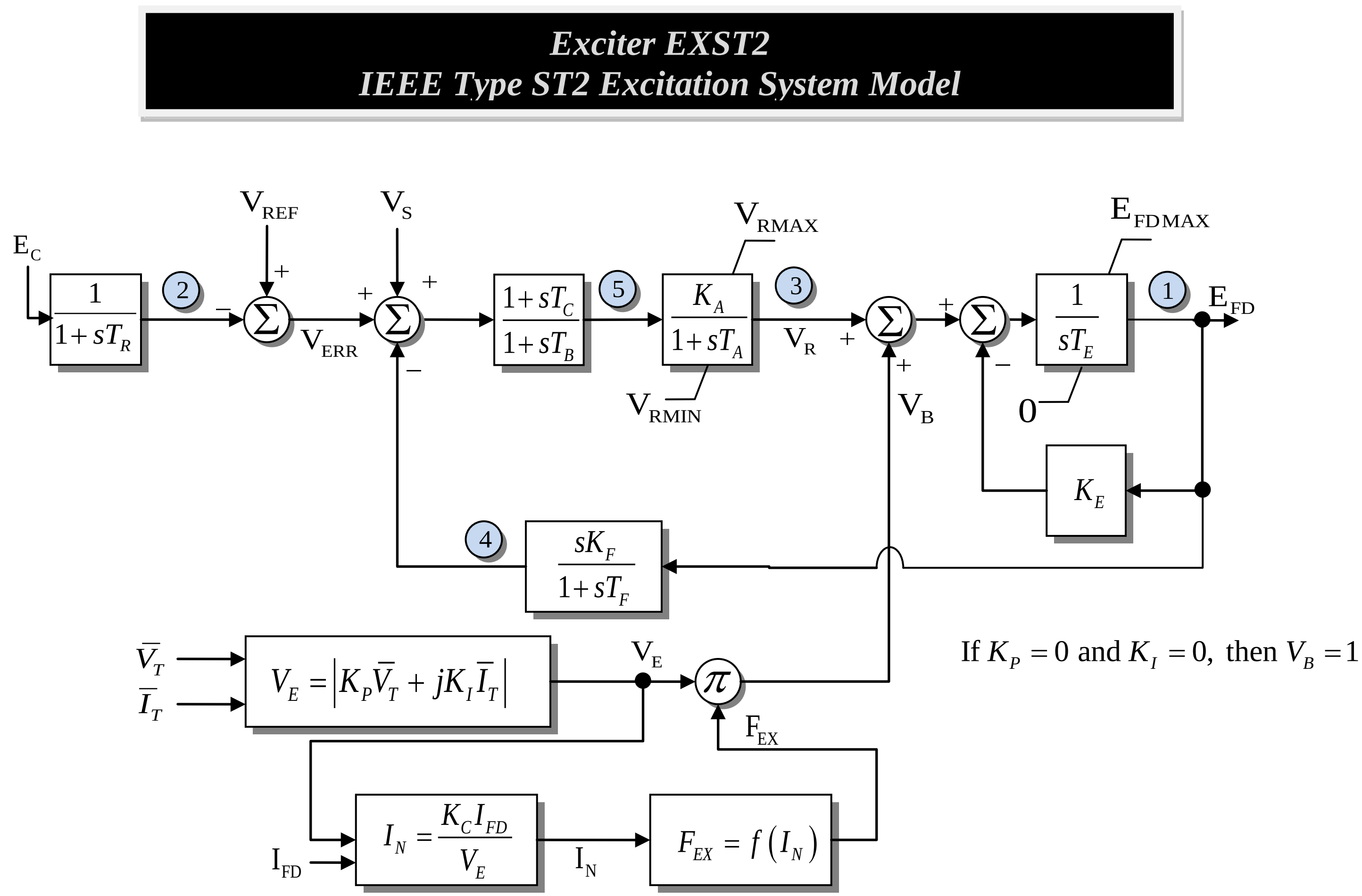
2 - Sensed V_t

3 - V_{LL}

4 - V_F

Model supported by PSSE

Exciter EXST2



States

1 - E_{FD}

2 - Sensed V_t

3 - V_R

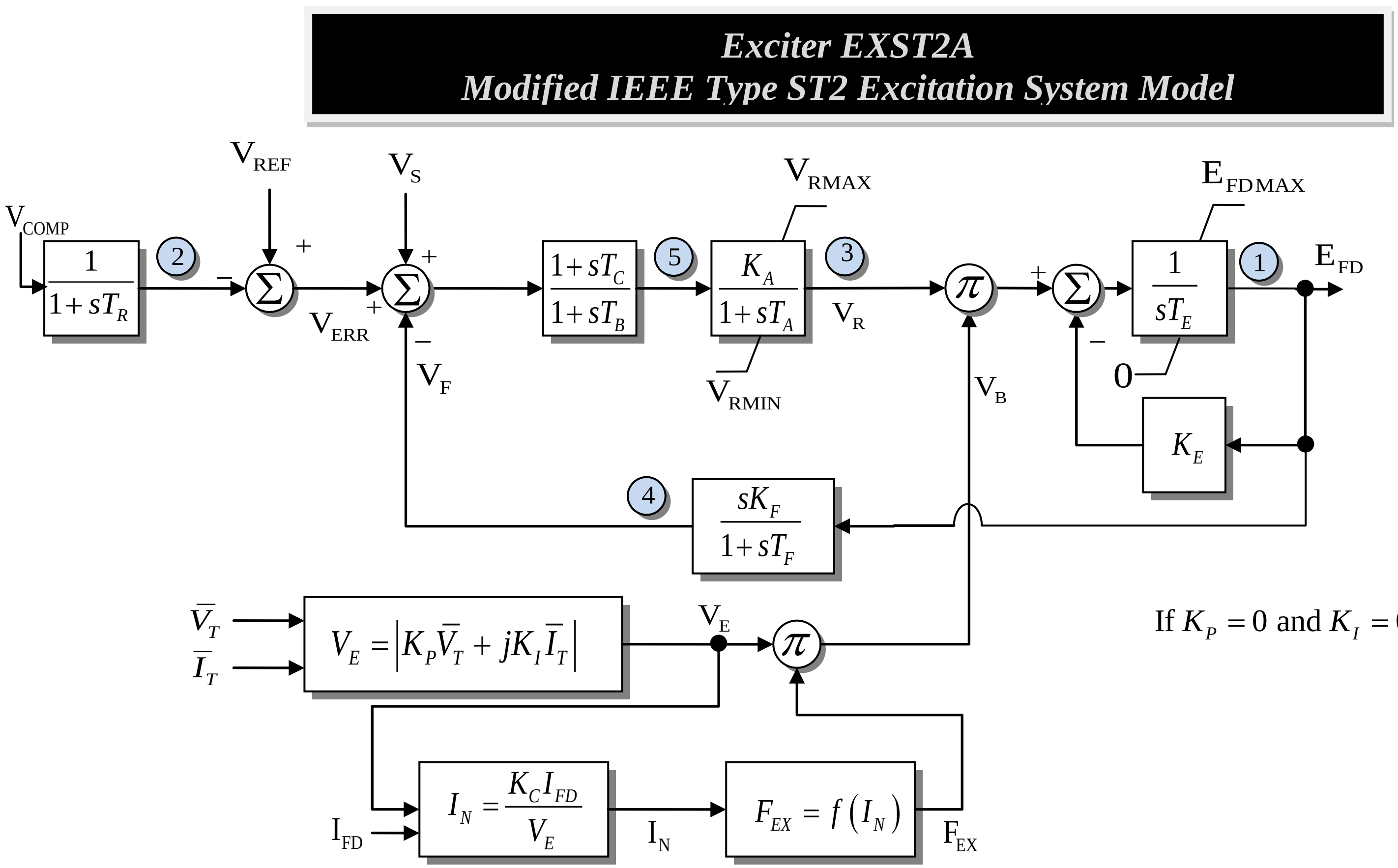
4 - V_F

5 - V_{LL}

Model supported by PSLF

Model supported by PSSE does not include T_B and T_C inputs

Exciter EXST2A



If $K_P = 0$ and $K_I = 0$, then $V_B = 1$

States

1 - E_{FD}

2 - Sensed V_t

3 - V_R

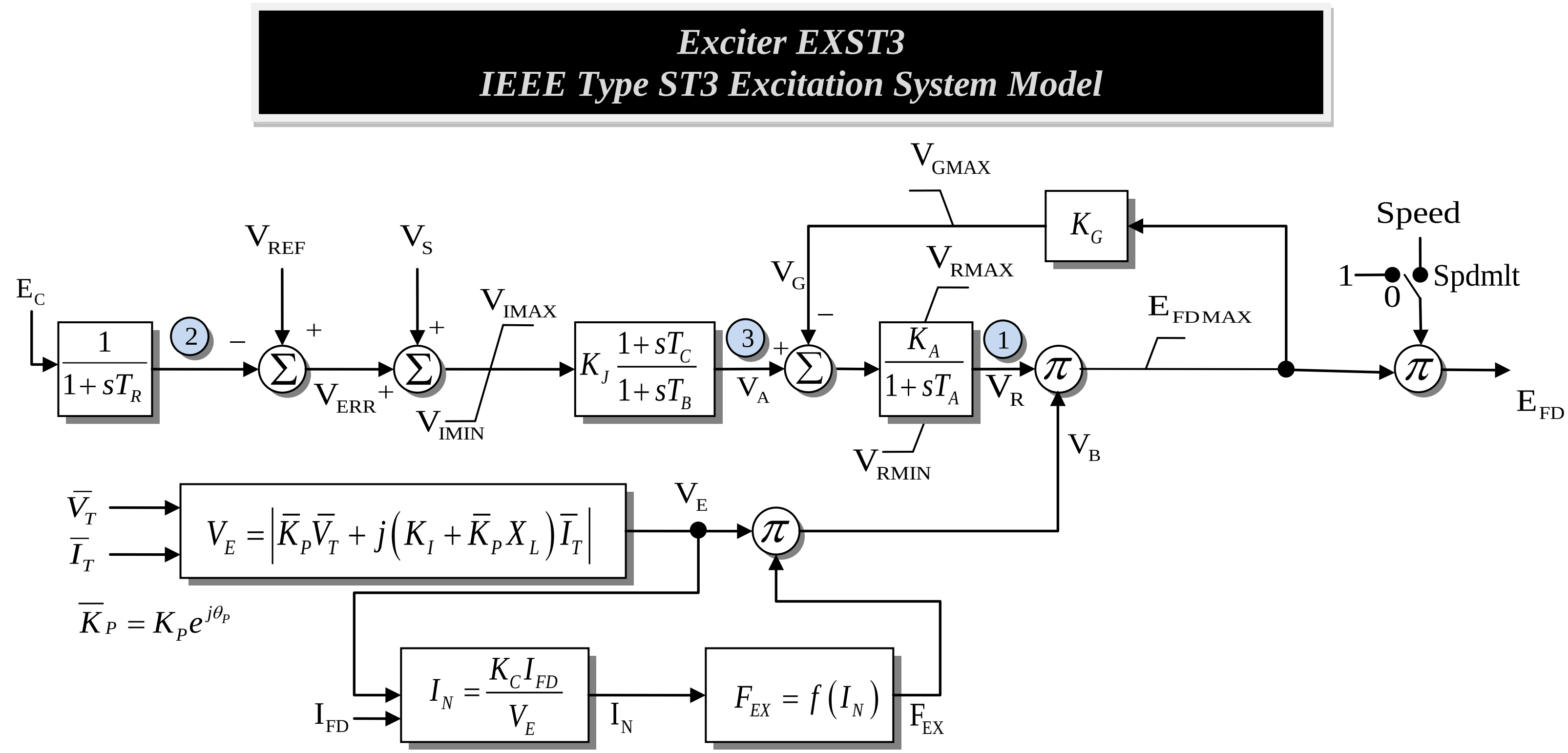
4 - V_F

5 - V_{LL}

Model supported by PSLF

Model supported by PSSE does not include T_B and T_C inputs

Exciter EXST3



States

1 - V_R

2 - Sensed V_t

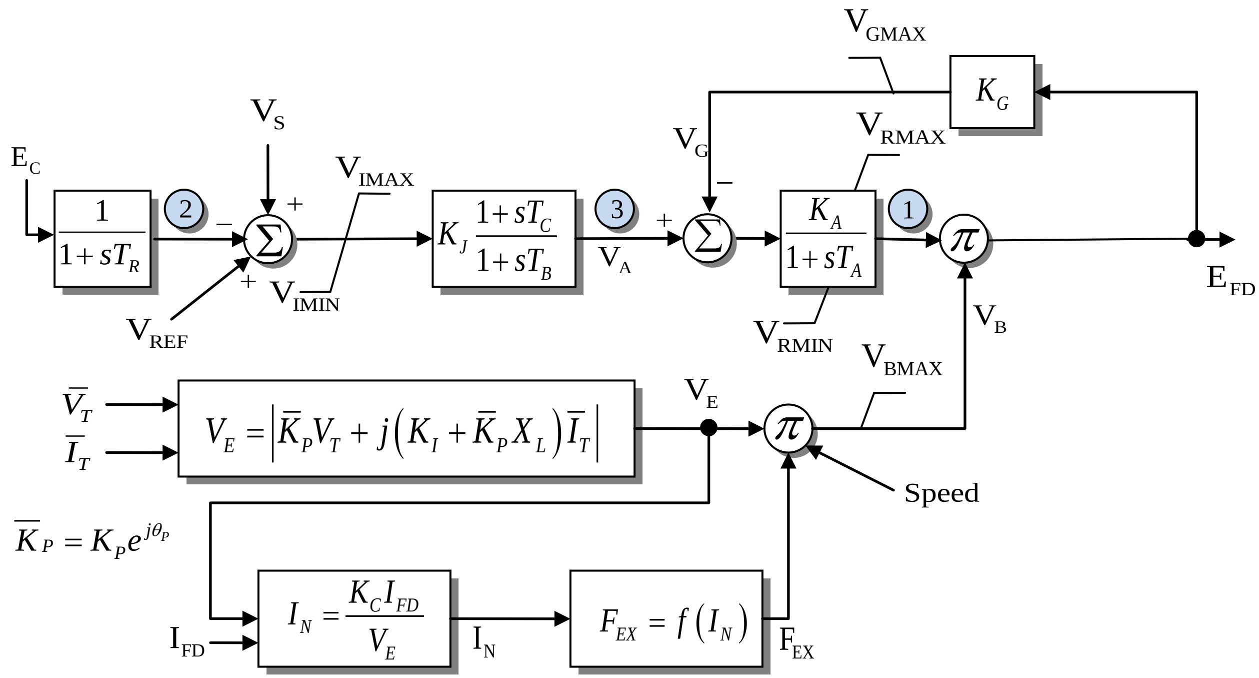
3 - LL

Model supported by PSSE but always assumes value of spdmlt = 0

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter EXST3A

Exciter EXST3A
IEEE Type ST3 Excitation System Model



States

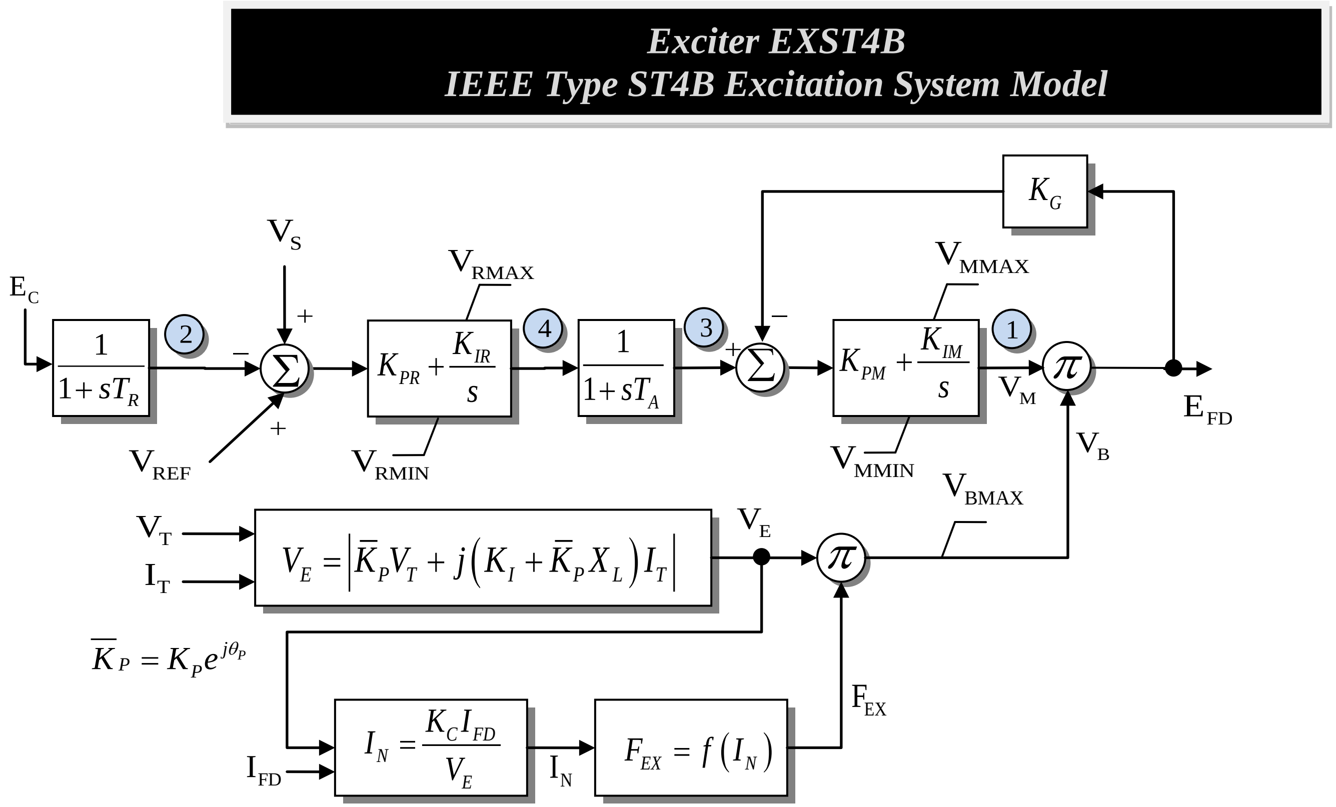
1 - V_R

2 - Sensed V_t

3 - LL

Model supported by PSLF

Exciter EXST4B



States

1 - V_{MInt}

2 - Sensed V_t

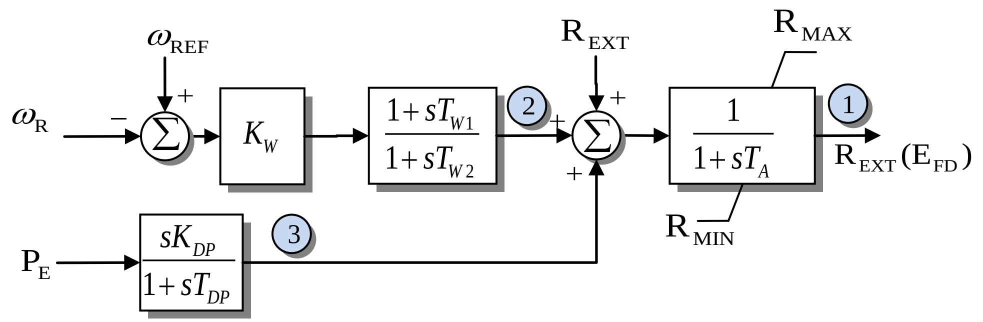
3 - V_A

4 - V_R

Model supported by PSLF

Exciter EXWTG1

Exciter EXWTG1
Excitation System Model for Wound-Rotor Induction Wind-Turbine Generators



States

1 - $R_{external}$

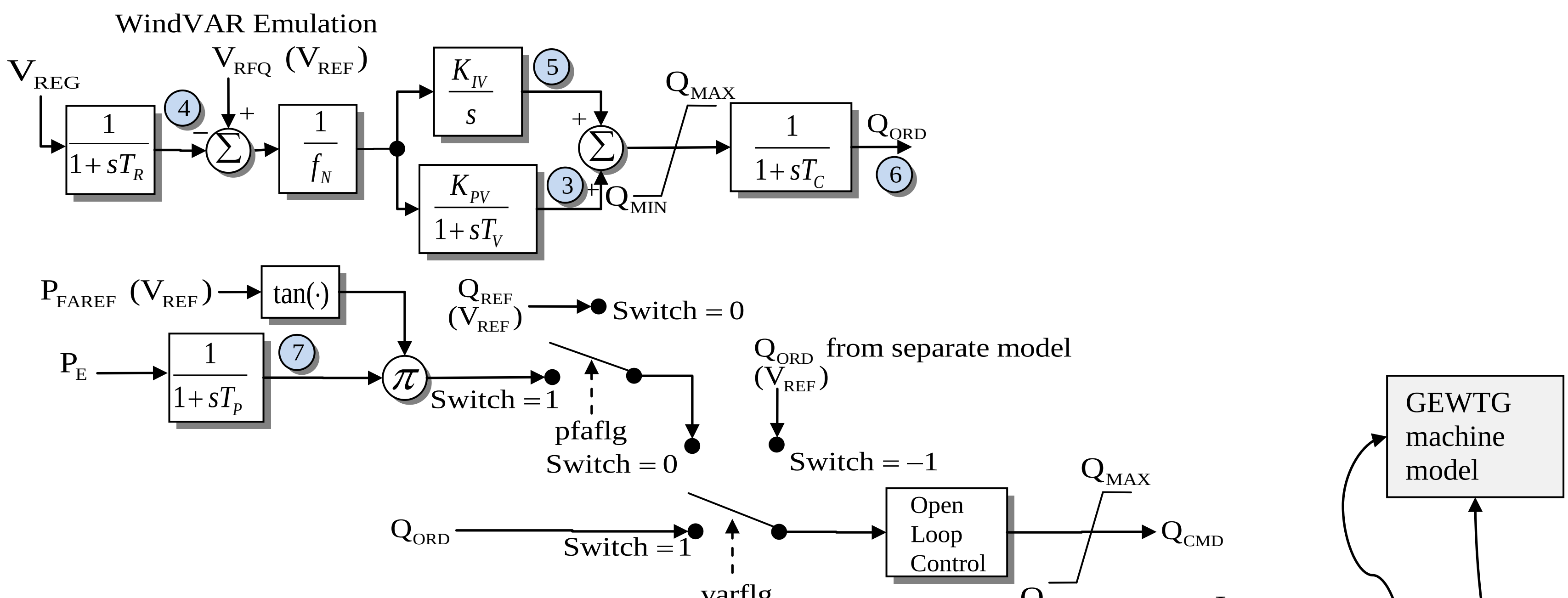
2 - SpeedReg

3 - Washout

Model supported by PSLF

Exciter EXWTGE

Exciter EXWTGE
Excitation System Model for GE Wind-Turbine Generators



States

1 - V_{ref}

2 - E''_{QCMD}

3 - K_{PV}

4 - $V_{regMeas}$

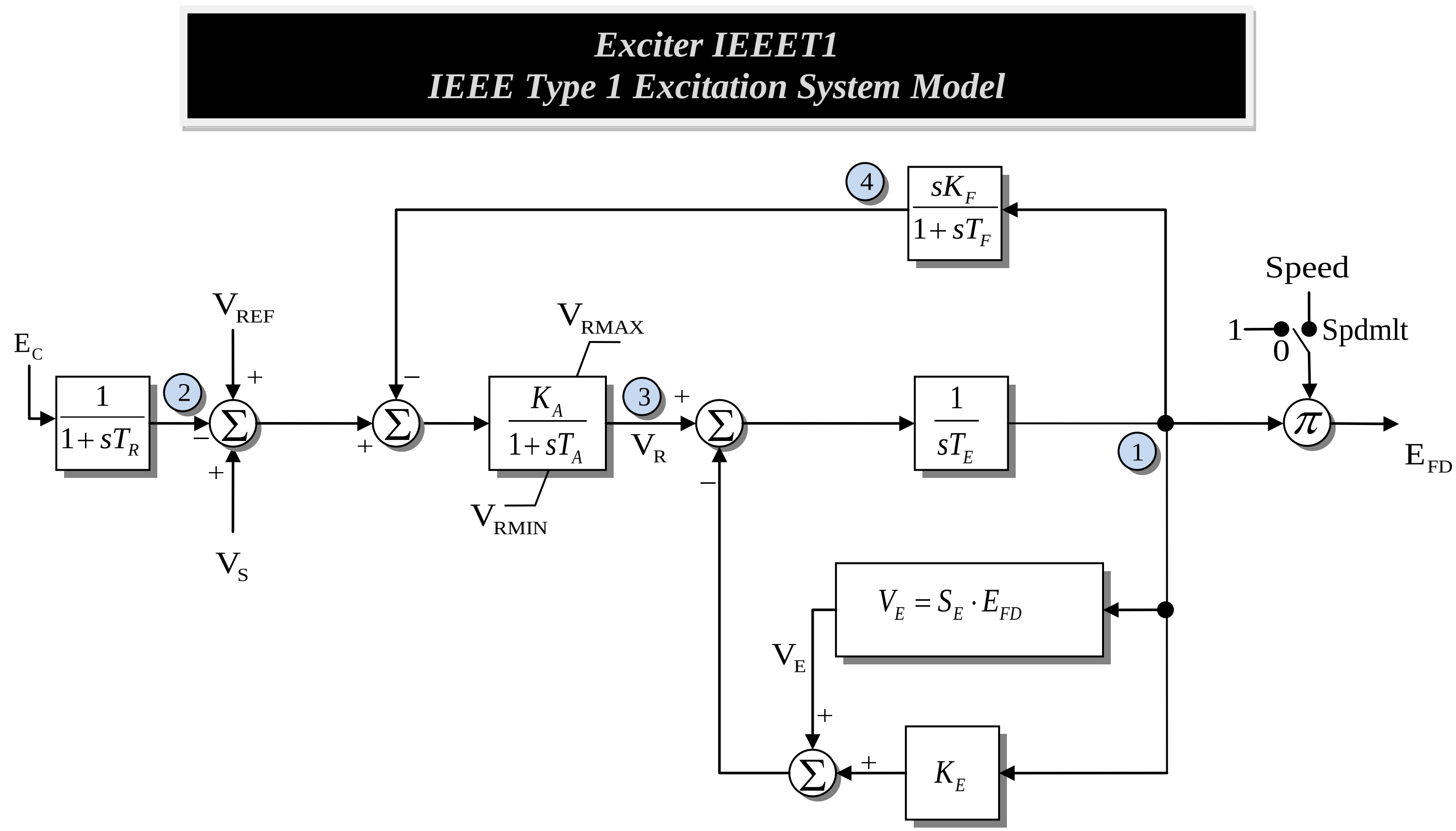
5 - K_{IV}

6 - Q_{ORD}

7 - P_{Meas}

Model supported by PSLF

Exciter IEEET1



States

1 - EField

2 - Sensed V_t

3 - V_R

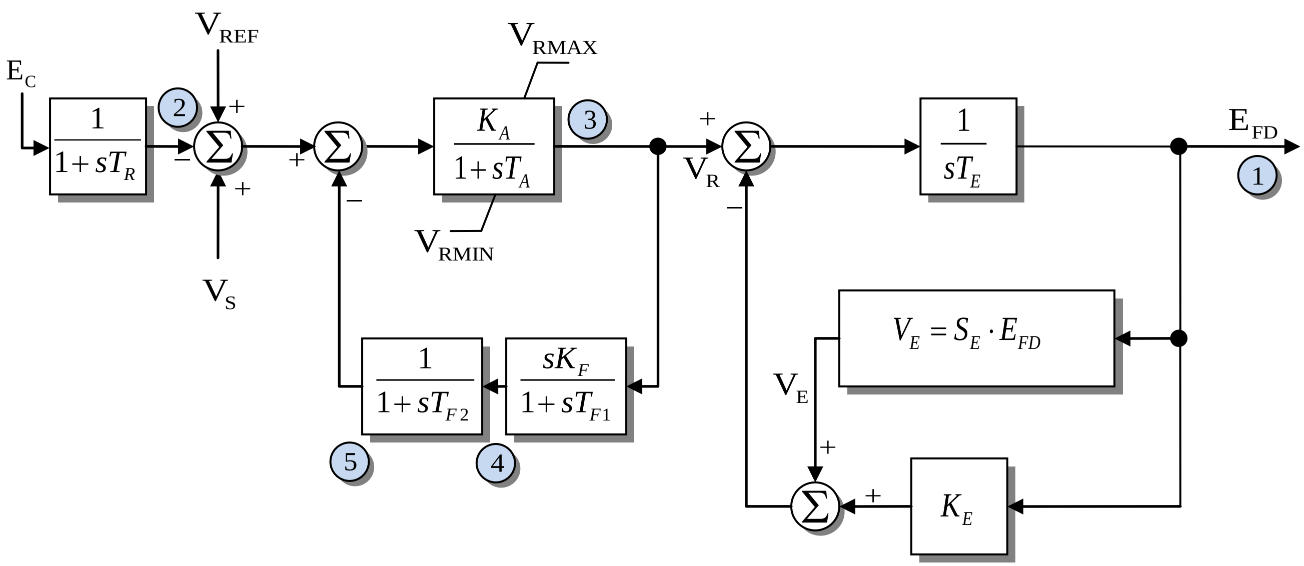
4 - V_F

Model supported by PSSE but always assumes value of spdmlt = 0

Model supported by PSLF but always assumes value of spdmlt = 1

Exciter IEEET2

Exciter IEEET2
IEEE Type 2 Excitation System Model



States

1 - EField

2 - Sensed V_t

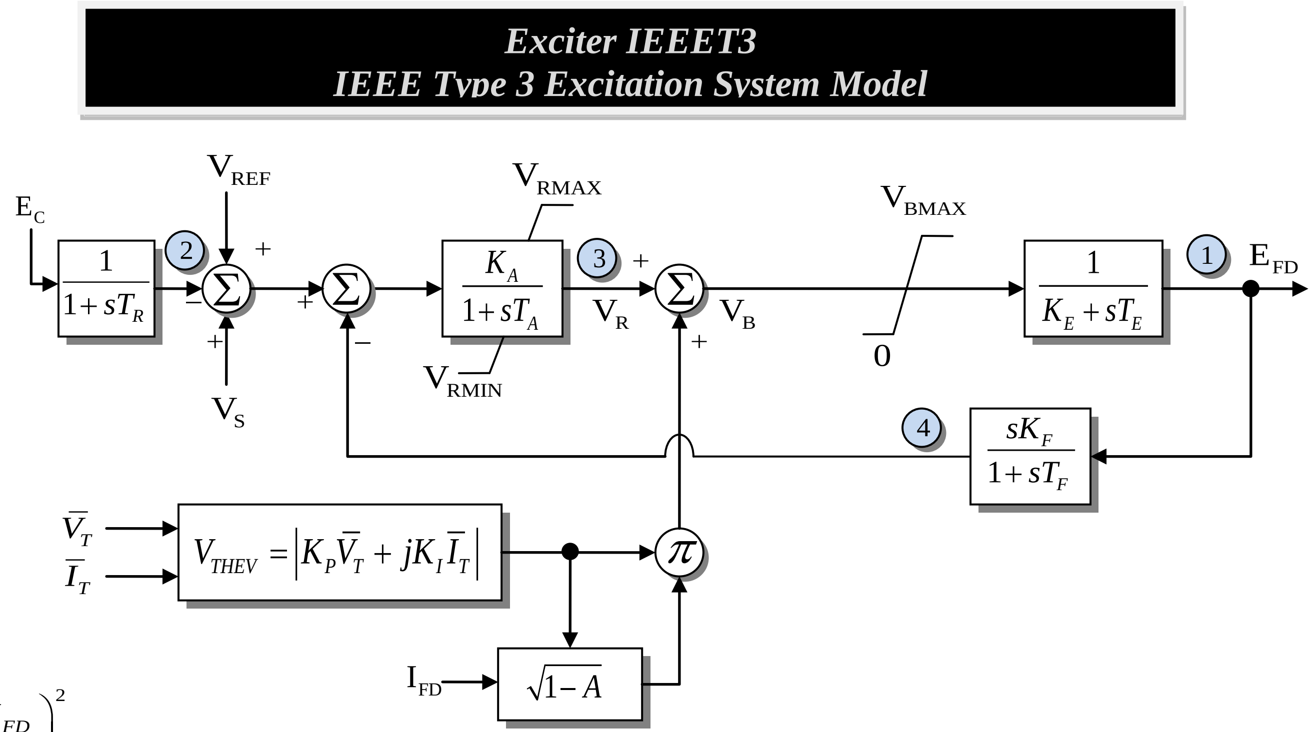
3 - V_R

4 - V_{F1}

5 - V_{F2}

Model supported by PSSE

Exciter IEEET3



$$A = \left(\frac{0.78 \cdot I_{FD}}{V_{THEV}}\right)^2$$

If $A > 1$, $V_B = 0$

States

1 - EField

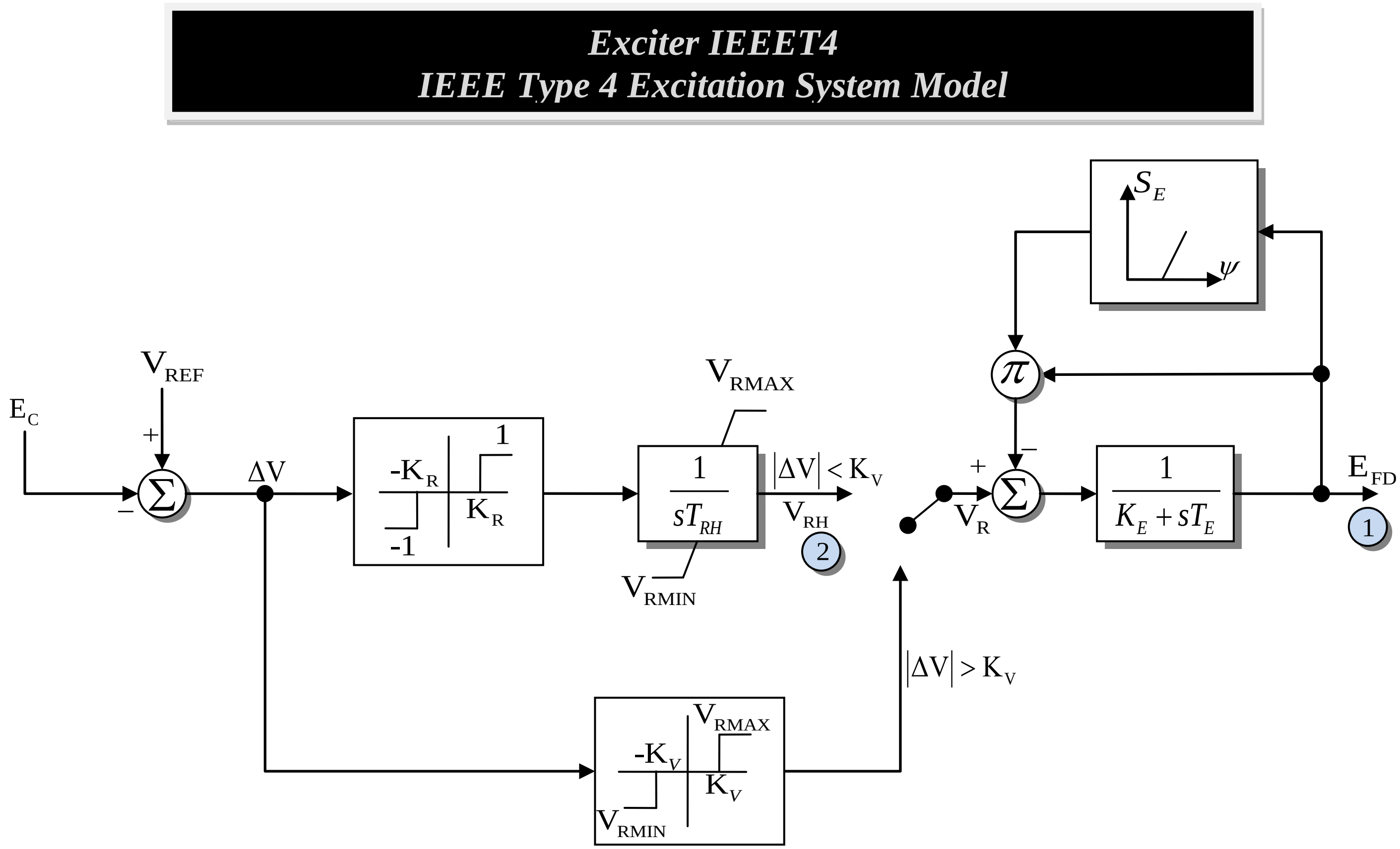
2 - Sensed V_t

3 - V_R

4 - V_F

Model supported by PSSE

Exciter IEEET4



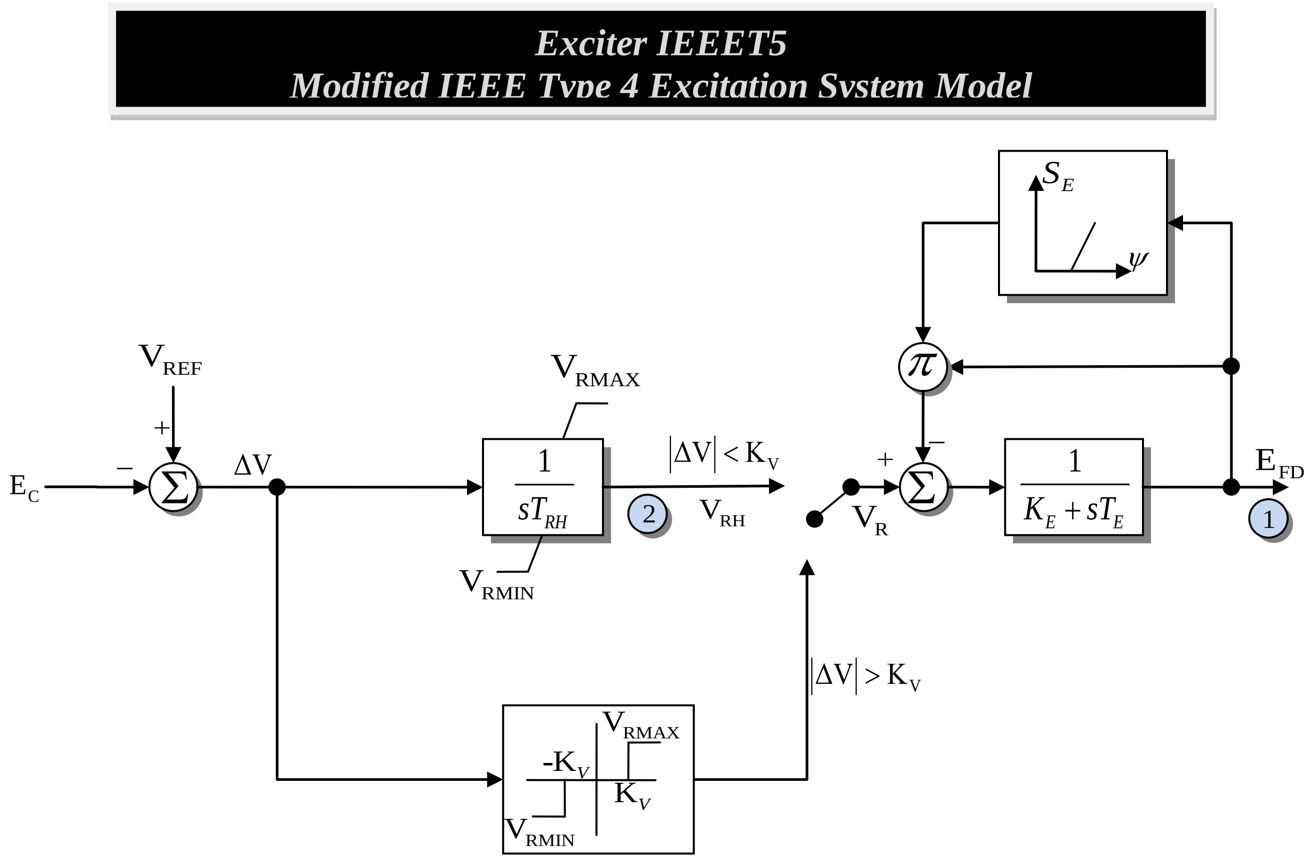
States

1 - EField

2 - V_{RH}

Model supported by PSSE

Exciter IEEET5



States

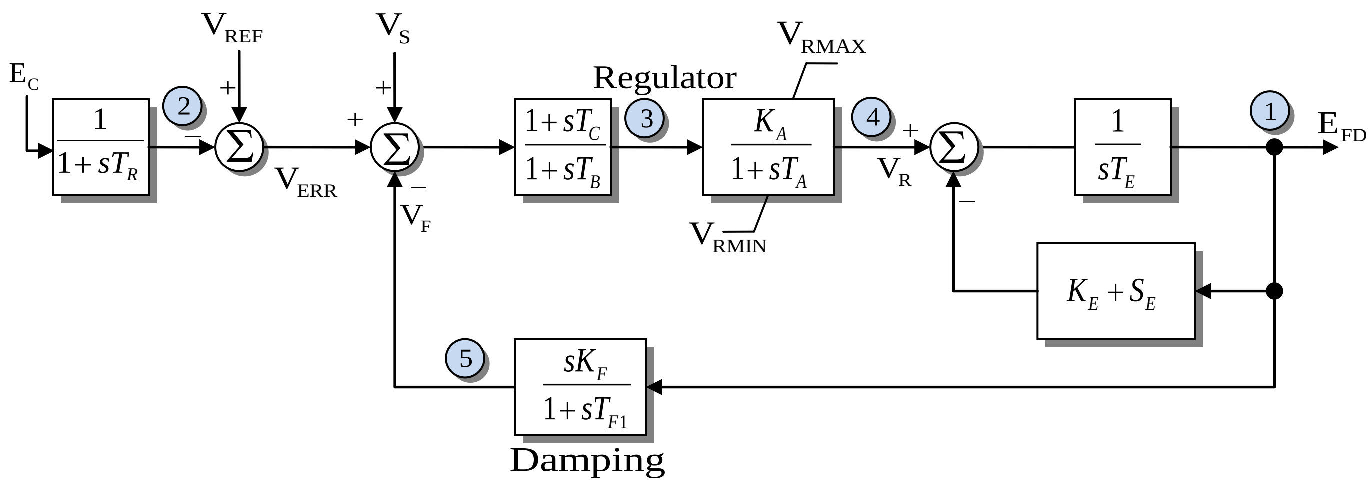
1 - EField

2 - V_{RH}

Model supported by PSSE

Exciter IEEEX1

Exciter IEEEX1
IEEE Type 1 Excitation System Model



States

1 - EField

2 - Sensed V_t

3 - V_B

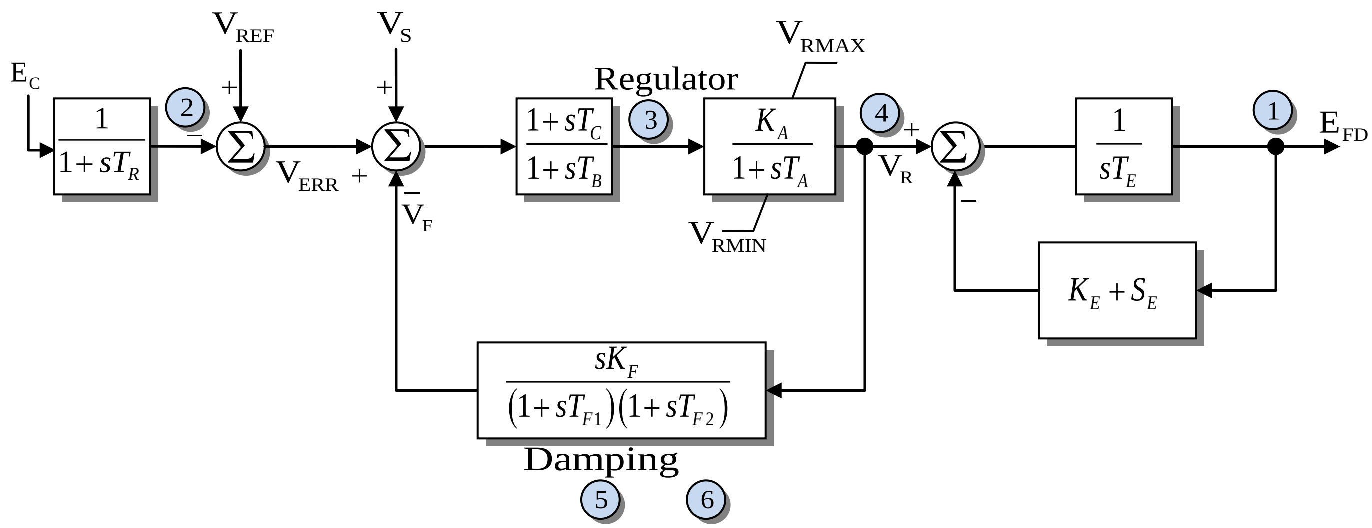
4 - V_R

5 - V_F

Model supported by PSSE

Exciter IEEEX2

Exciter IEEEX2
IEEE Type 2 Excitation System Model IEEEX2



States

1 - EField

2 - Sensed V_t

3 - LL

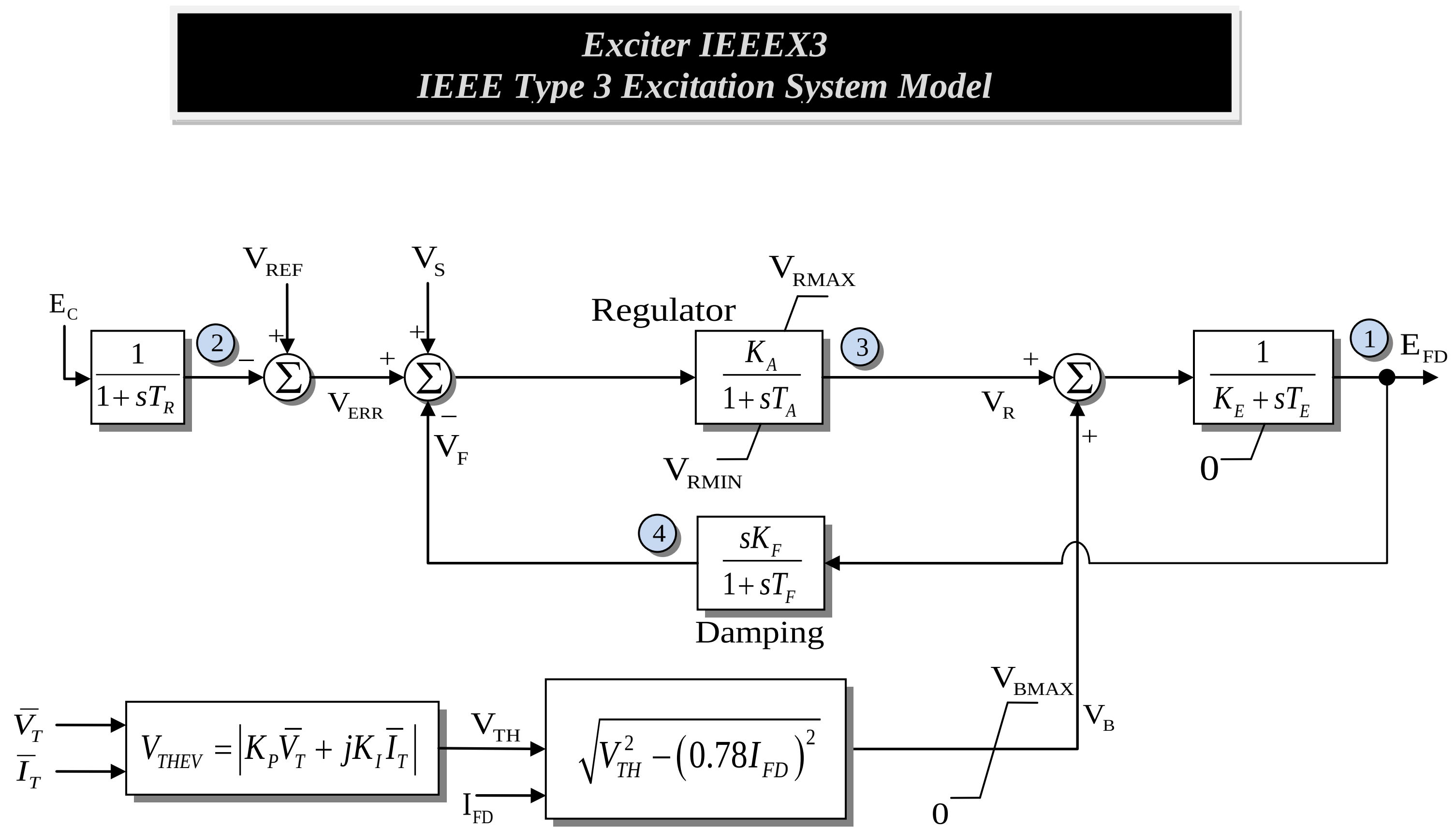
4 - V_R

5 - V_{F1}

6 - V_{F2}

Model supported by PSSE

Exciter IEEEX3



States

1 - EField

2 - Sensed V_t

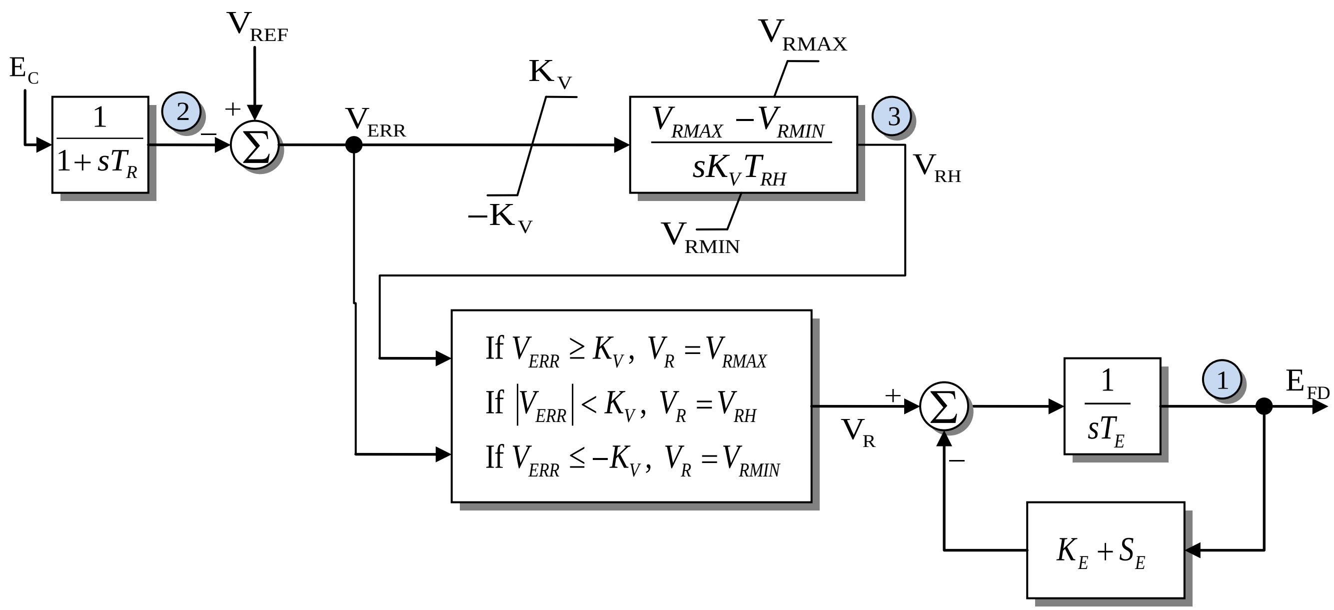
3 - V_R

4 - V_F

Model supported by PSSE

Exciter IEEEX4

Exciter IEEEX4
IEEE Type 4 Excitation System Model



States

1 - EField

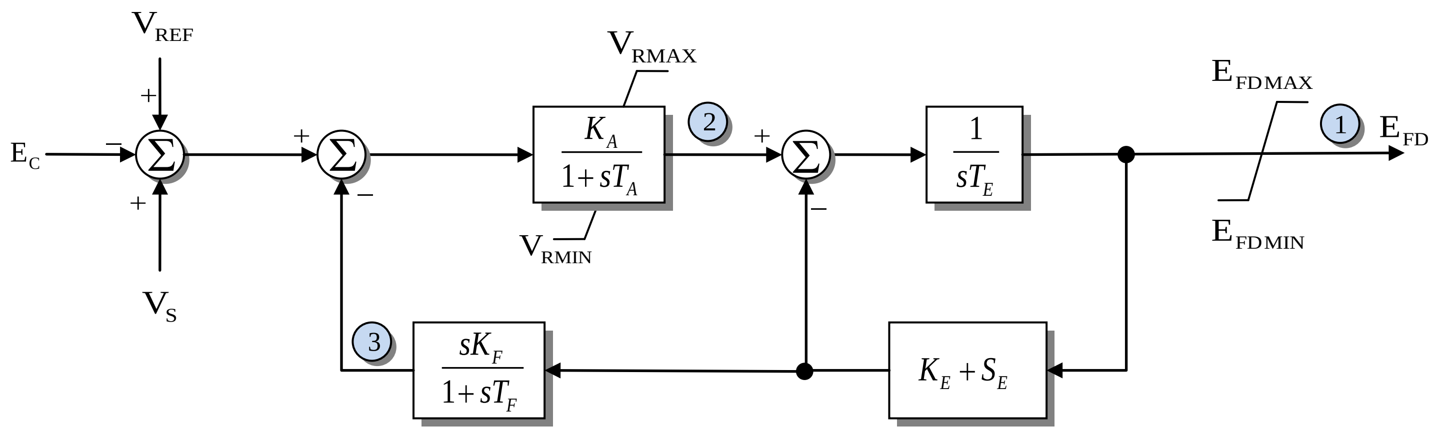
2 - Sensed V_t

3 - V_{RH}

Model supported by PSSE

Exciter IEET1A

Exciter IEET1A
Modified IEEE Type 1 Excitation System Model



States

1 - EField

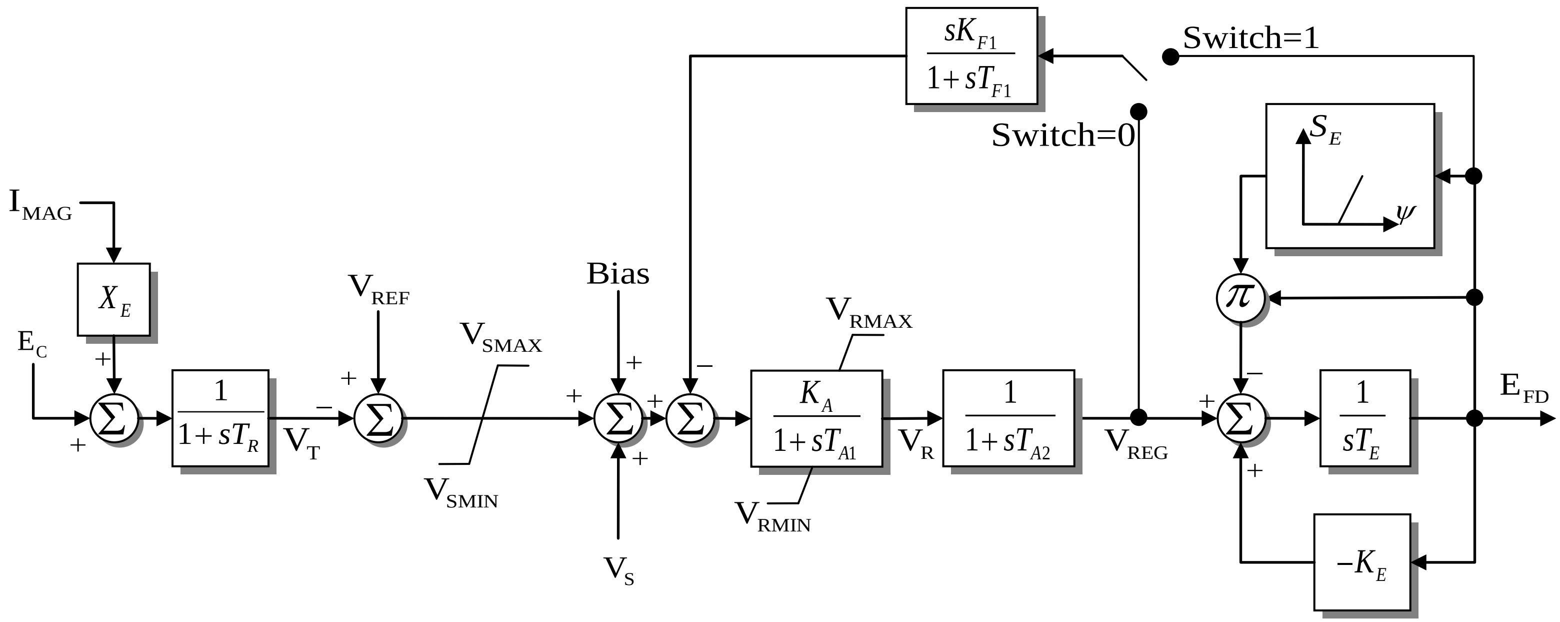
2 - V_R

3 - V_F

Model supported by PSSE

Exciter IEET1B

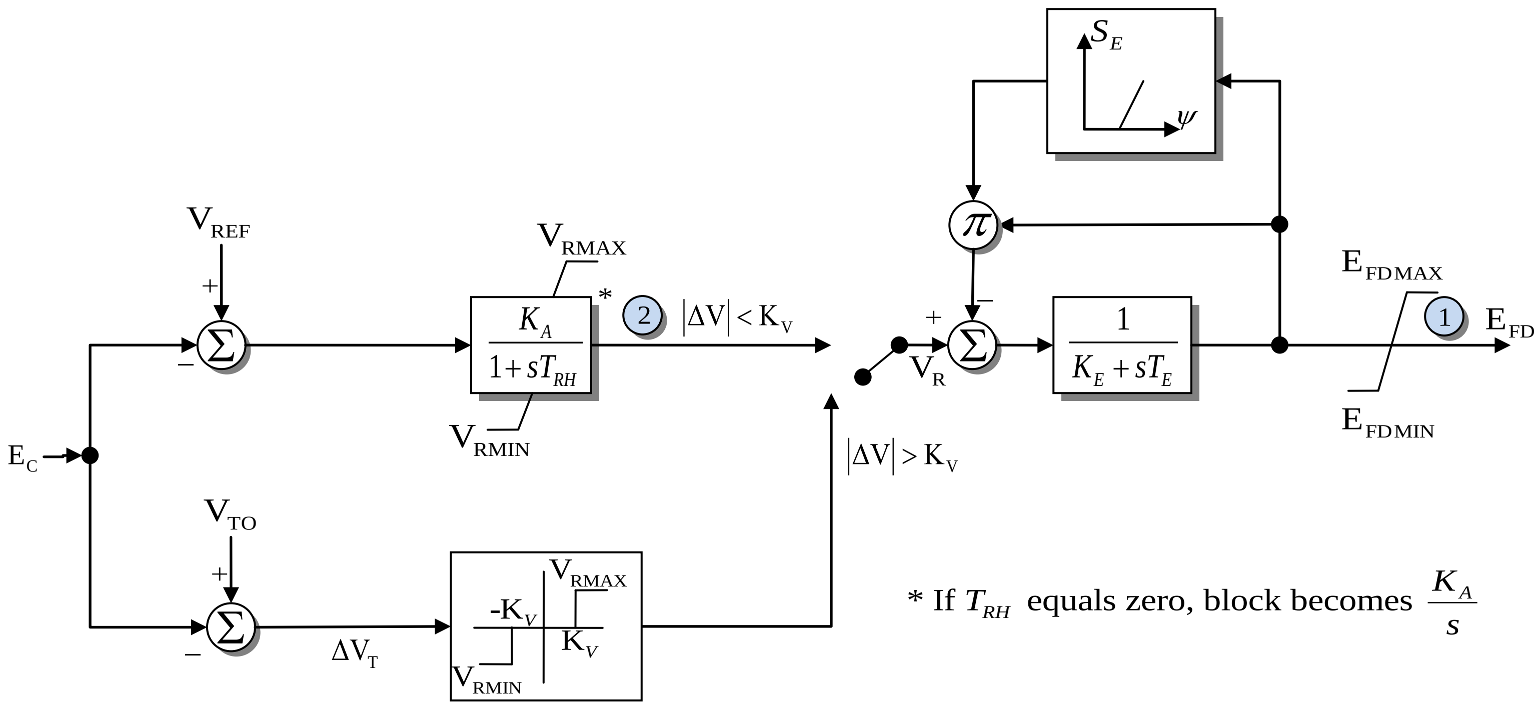
Exciter IEET1B
Modified IEEE Type 1 Excitation System Model



Model supported by PSSE but not implemented yet in Simulator

Exciter IEET5A

Exciter IEET5A
Modified IEEE Type 4 Excitation System Model



States

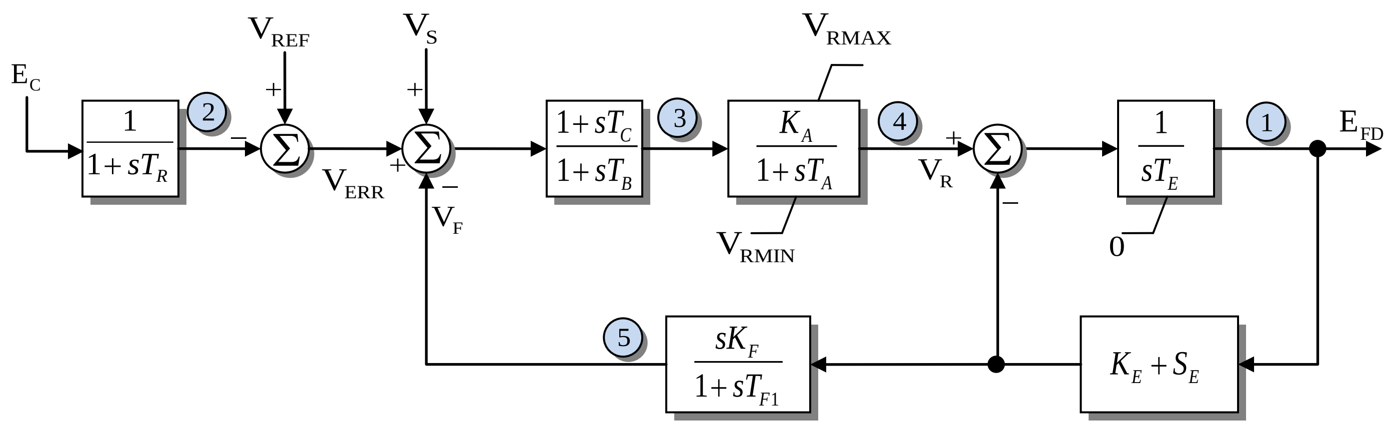
1 - EField

2 - V_{RH}

Model supported by PSSE

Exciter IEEX2A

Exciter IEEX2A
IEEE Type 2A Excitation System Model



States

1 - EField

2 - Sensed V_t

3 - V_B

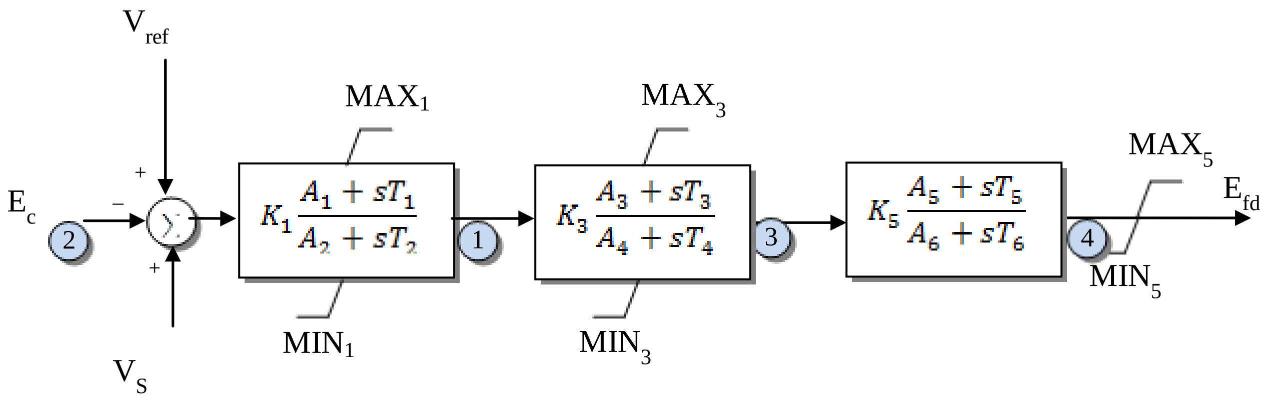
4 - V_R

5 - V_F

Model supported by PSSE

Exciter IVOEX

Exciter IVOEX
IVO Excitation Model

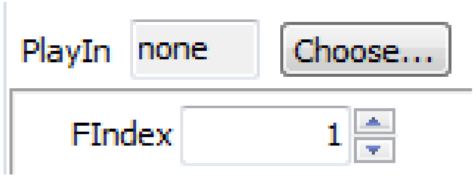


States:
1 – VLL12
2 – Sensed Vt
3 – VLL34
4 – VLL56

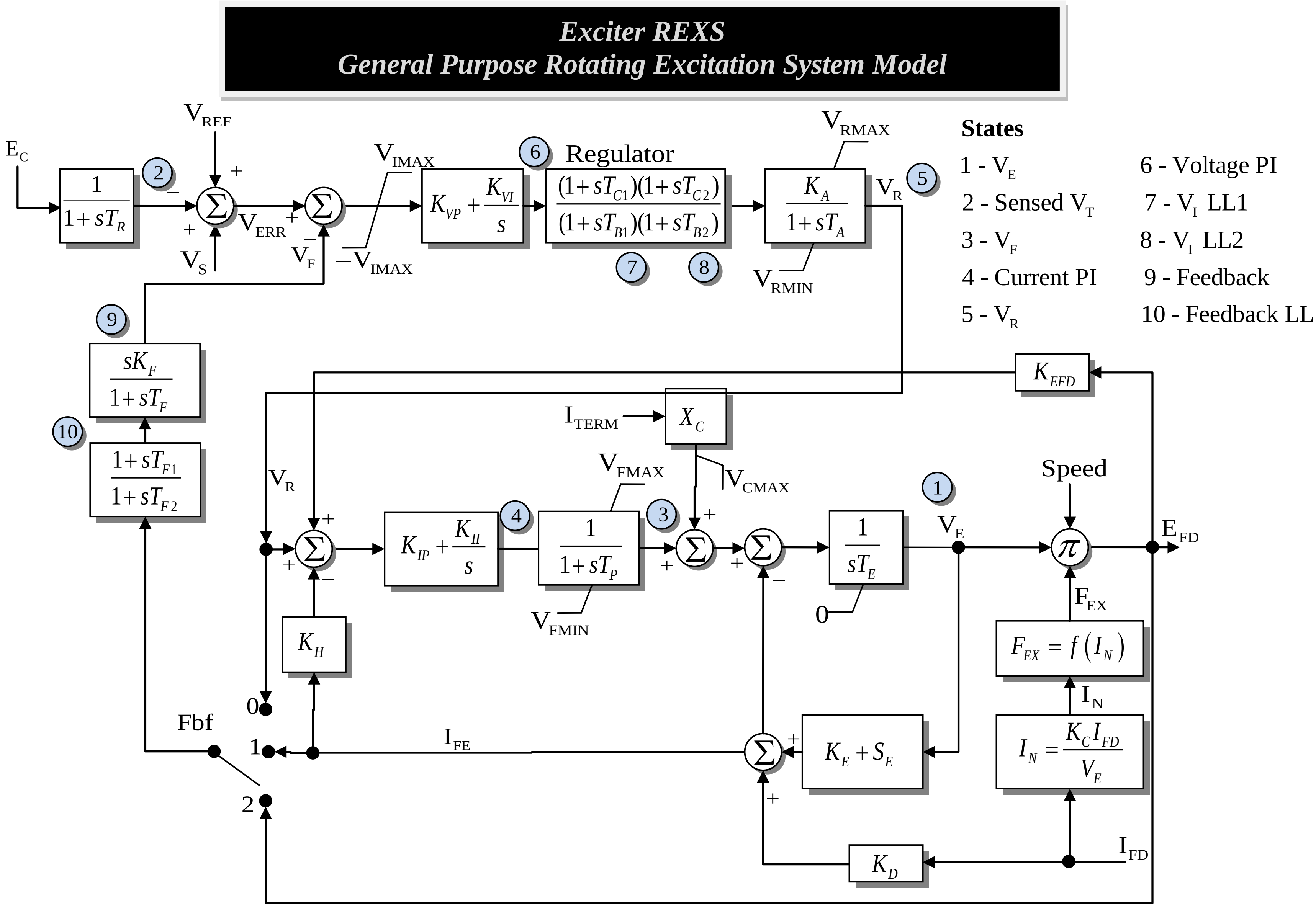
Model supported by PSSE

Exciter PLAYINEX

With the PLAYINEX model, specify the index (FIndex) of a specified PlayIn structure. That signal will then be played into the model as the field voltage during the simulation.

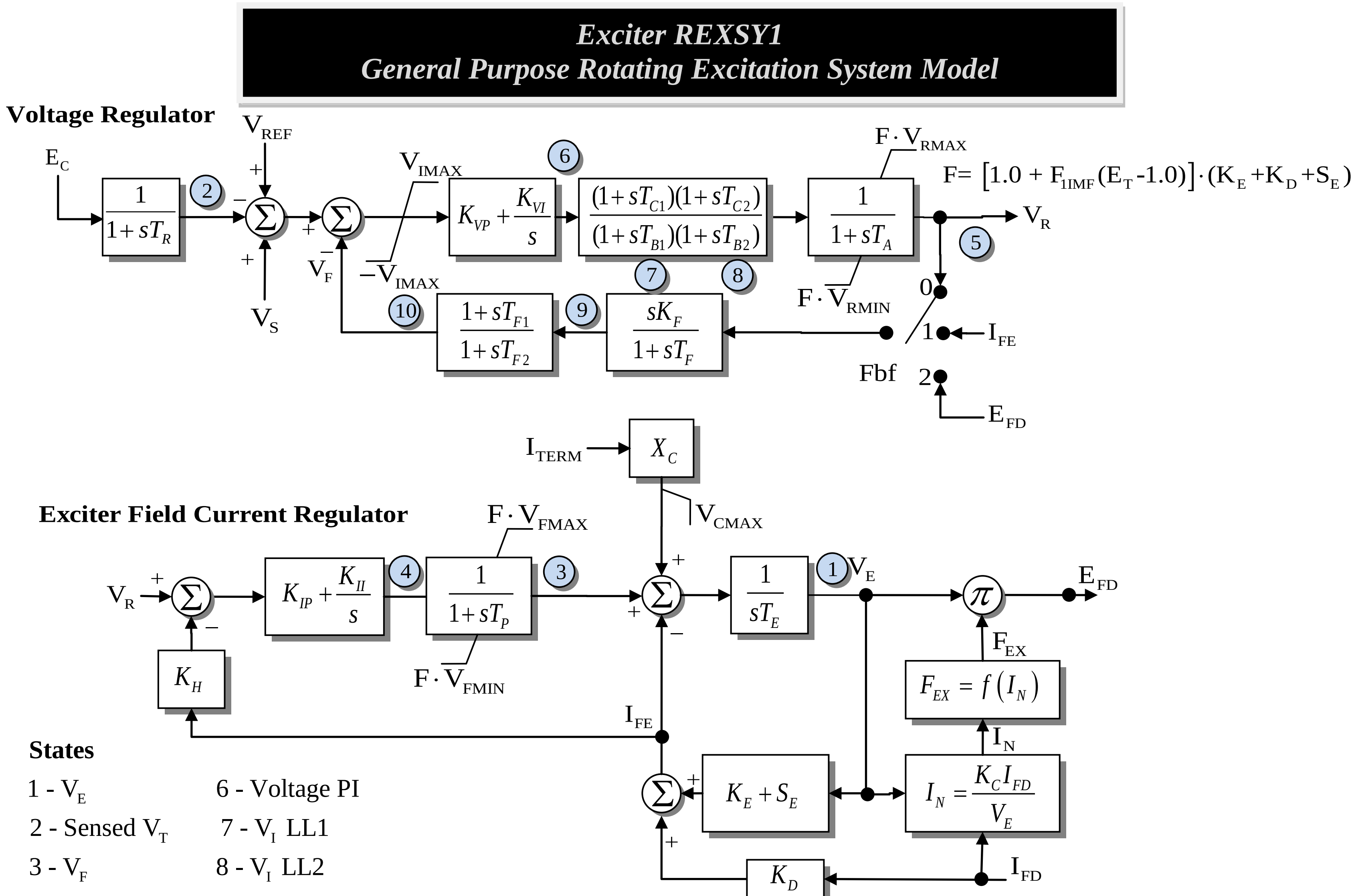


Exciter REXS



Model supported by PSLF. If flimf = 1 then multiply V_{RMIN}, V_{RMAX}, V_{FMIN}, and V_{FMAX} by V_{TERM}.

Exciter REXSY1

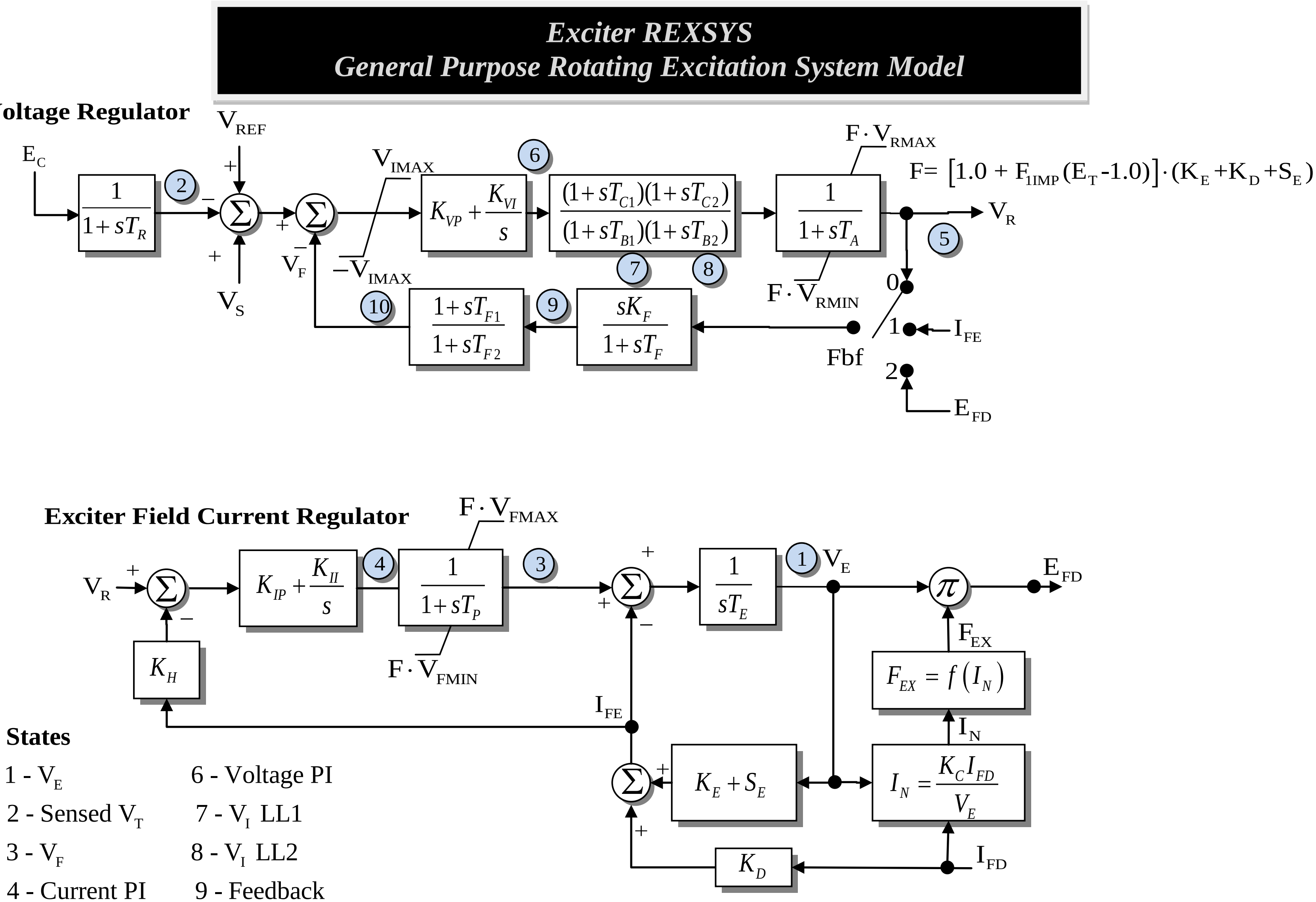


States

1 - V_E	6 - Voltage PI
2 - Sensed V_T	7 - V_I LL1
3 - V_F	8 - V_I LL2
4 - Current PI	9 - Feedback
5 - V_R	10 - Feedback LL

Model supported by PSSE

Exciter REXSYS

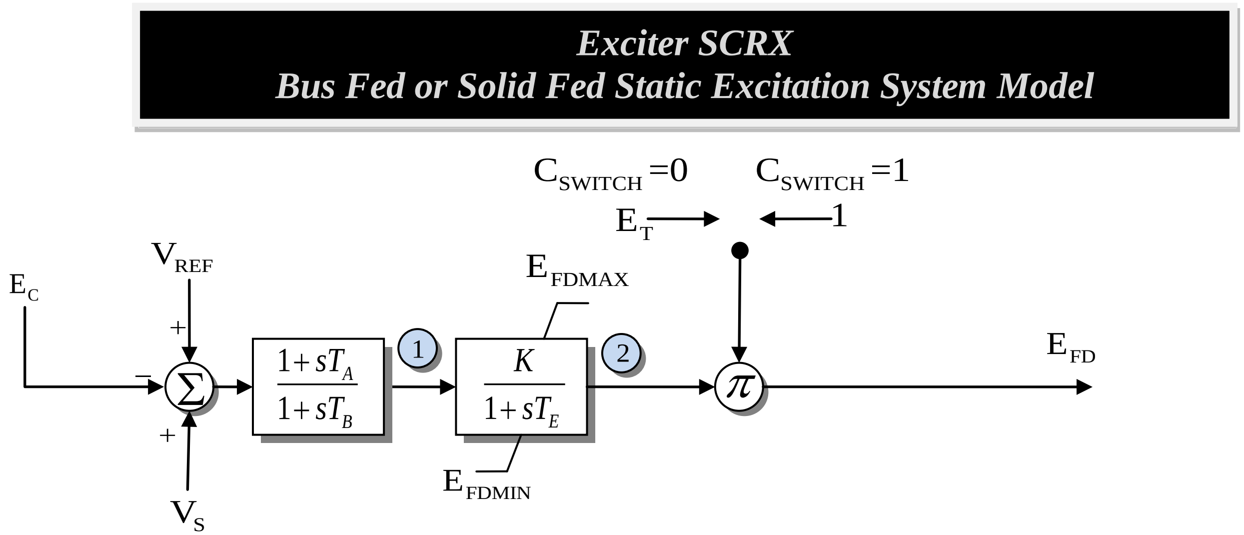


States

1 - V_E	6 - Voltage PI
2 - Sensed V_T	7 - V_I LL1
3 - V_F	8 - V_I LL2
4 - Current PI	9 - Feedback
5 - V_R	10 - Feedback LL

Model supported by PSSE

Exciter SCRX



States

1 - Lead-Lag

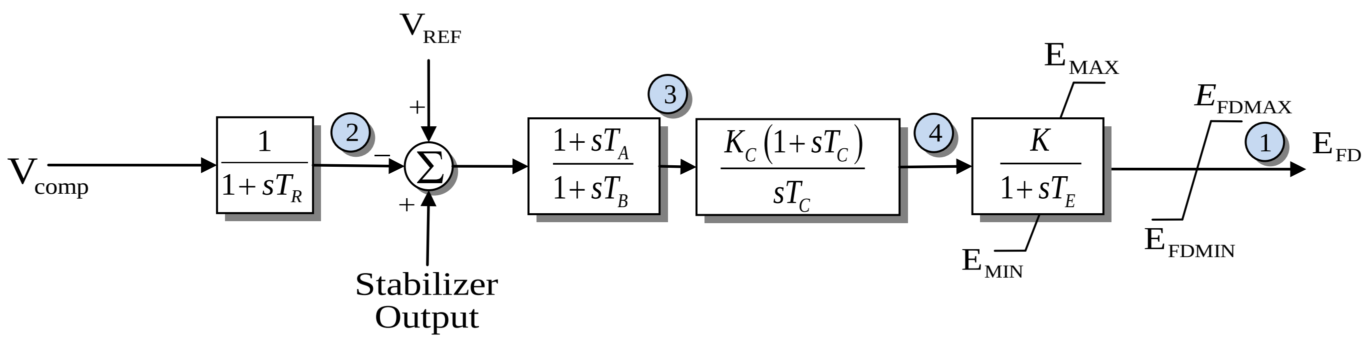
2 - V_E

Model supported by PSLF

Model supported by PSSE has $C_{SWITCH} = 1$

Exciter SEXS_GE

Exciter SEXS_GE
Simplified Excitation System Model



States

1 - EField

2 - Sensed V_t

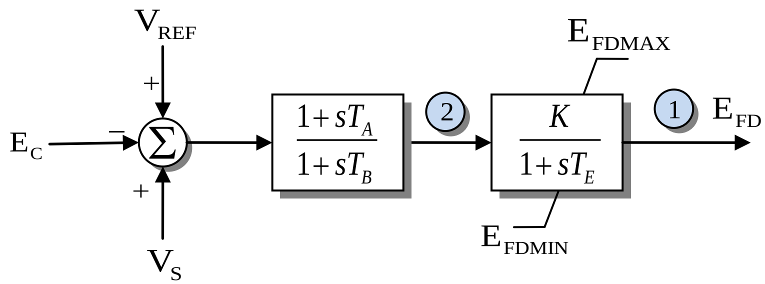
3 - LL

4 - PI

Model supported by PSLF

Exciter SEXS_PTI

Exciter SEXS_PTI
Simplified Excitation System Model



States

1 - EField

2 - LL

Model supported by PSSE

Exciter ST5B and ESST5B

ST5B is the same as ESST5B. See ESST5B documentation.

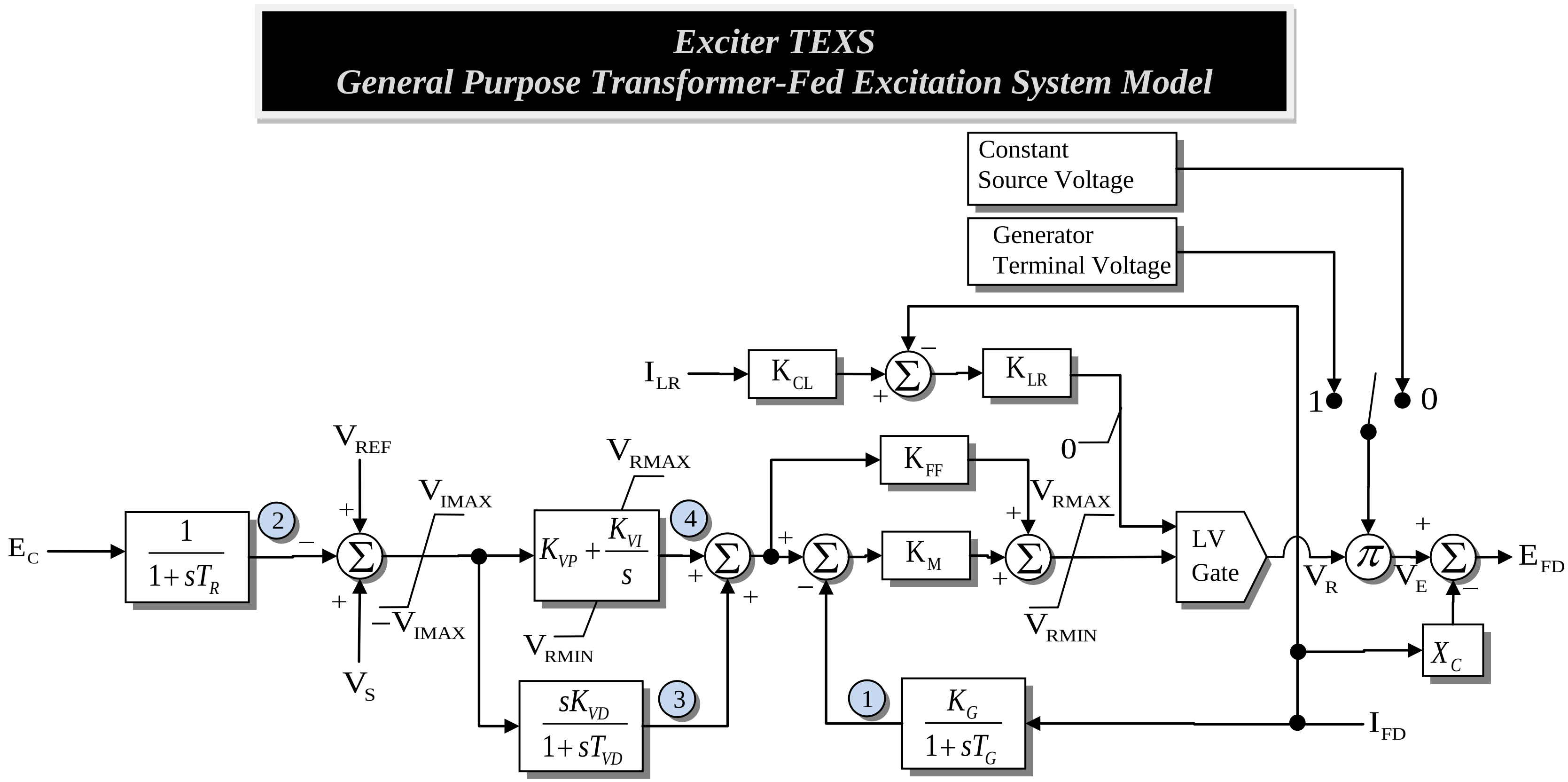
Exciter ST6B and ESST6B

ST6B is the same as ESST6B. See ESST6B documentation.

Exciter ST7B and ESST7B

ST7B is the same as ESST7B. See ESST7B documentation.

Exciter TEXS



States

1 - Feedback

2 - Sensed V_t

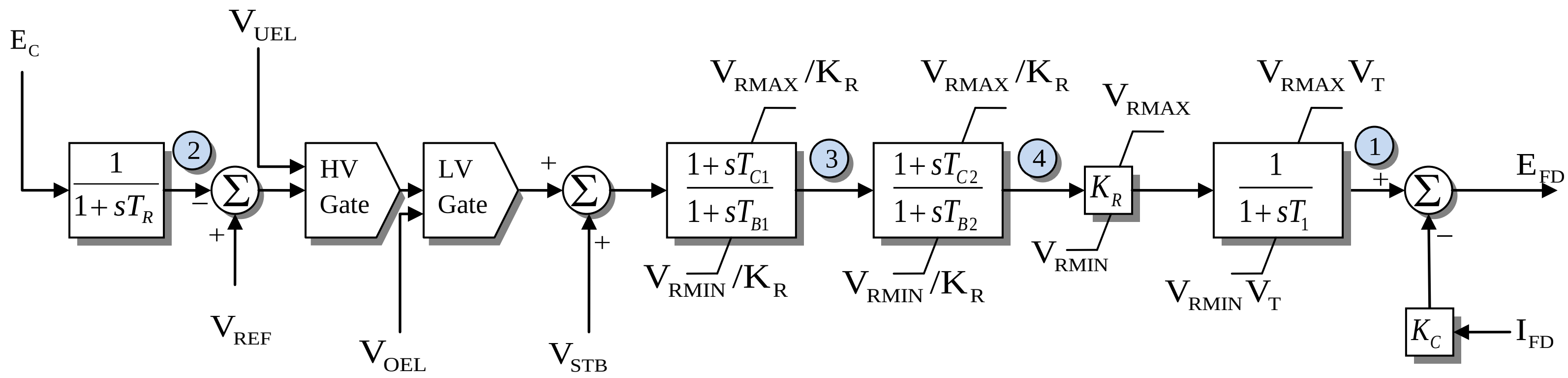
3 - Derivative Controller

4 - Integral Controller

Model supported by PSLF

Exciter URST5T

Exciter URST5T
IEEE Proposed Type ST5B Excitation System Model



States

1 - V_R

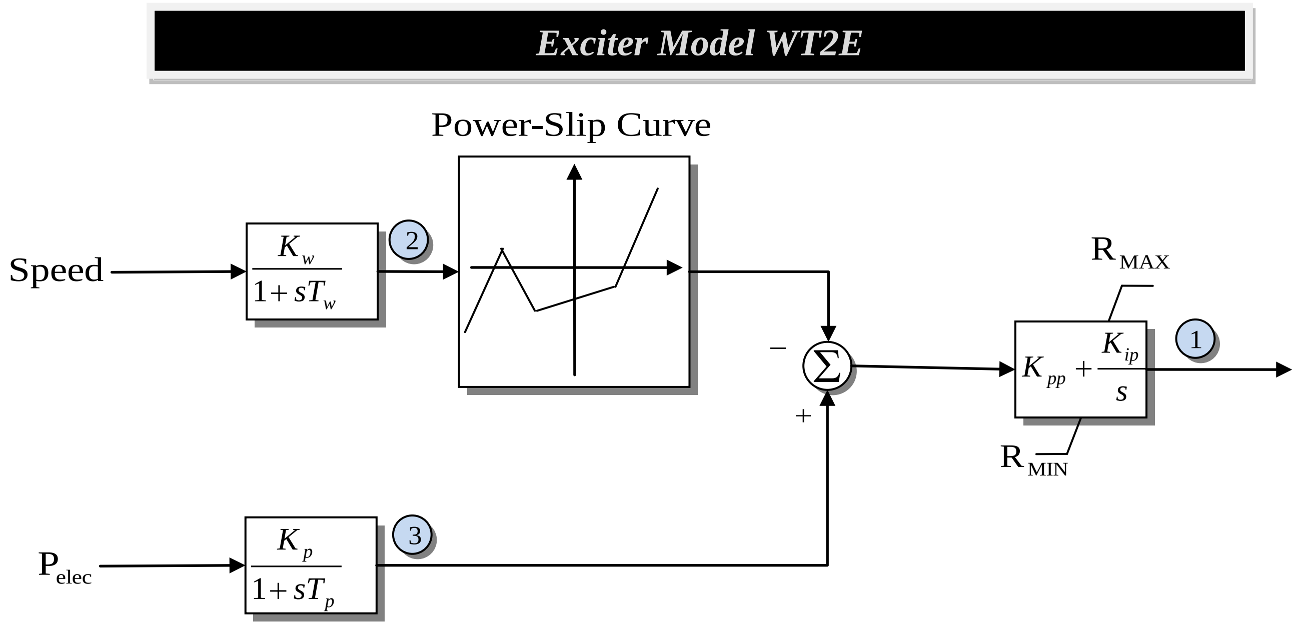
2 - Sensed V_t

3 - LL1

4 - LL2

Model supported by PSSE

Exciter WT2E

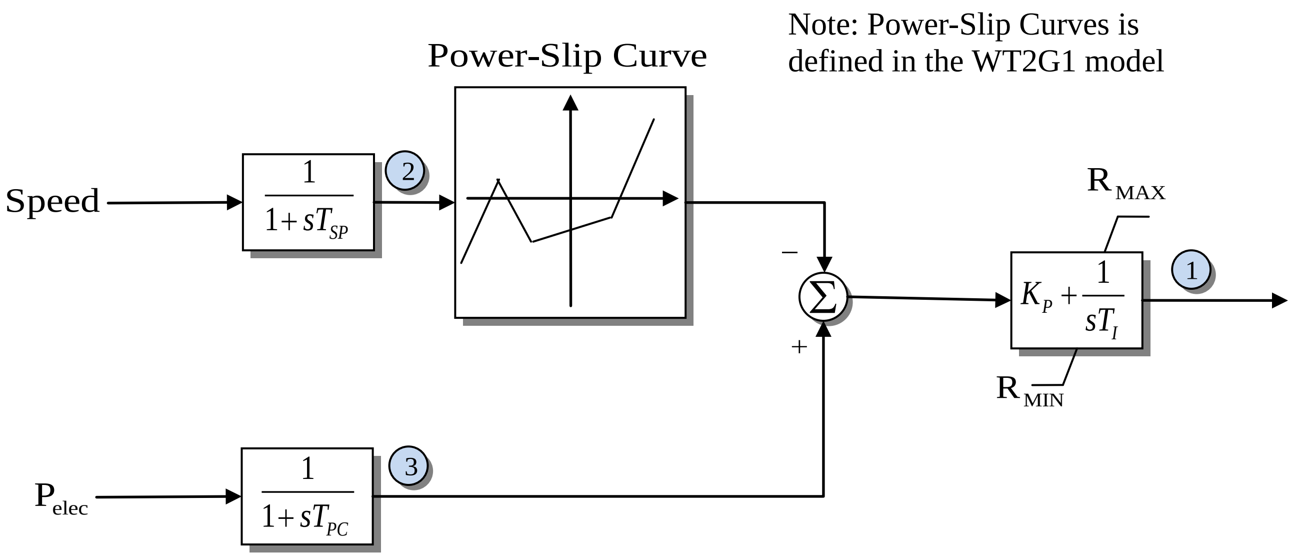


States:
1 – Rexternal
2 – Speed
3 – Pelec

Model supported by PSLF

Exciter WT2E1

Exciter WT2E1
Rotor Resistance Control Model for Type 2 Wind Generator



States

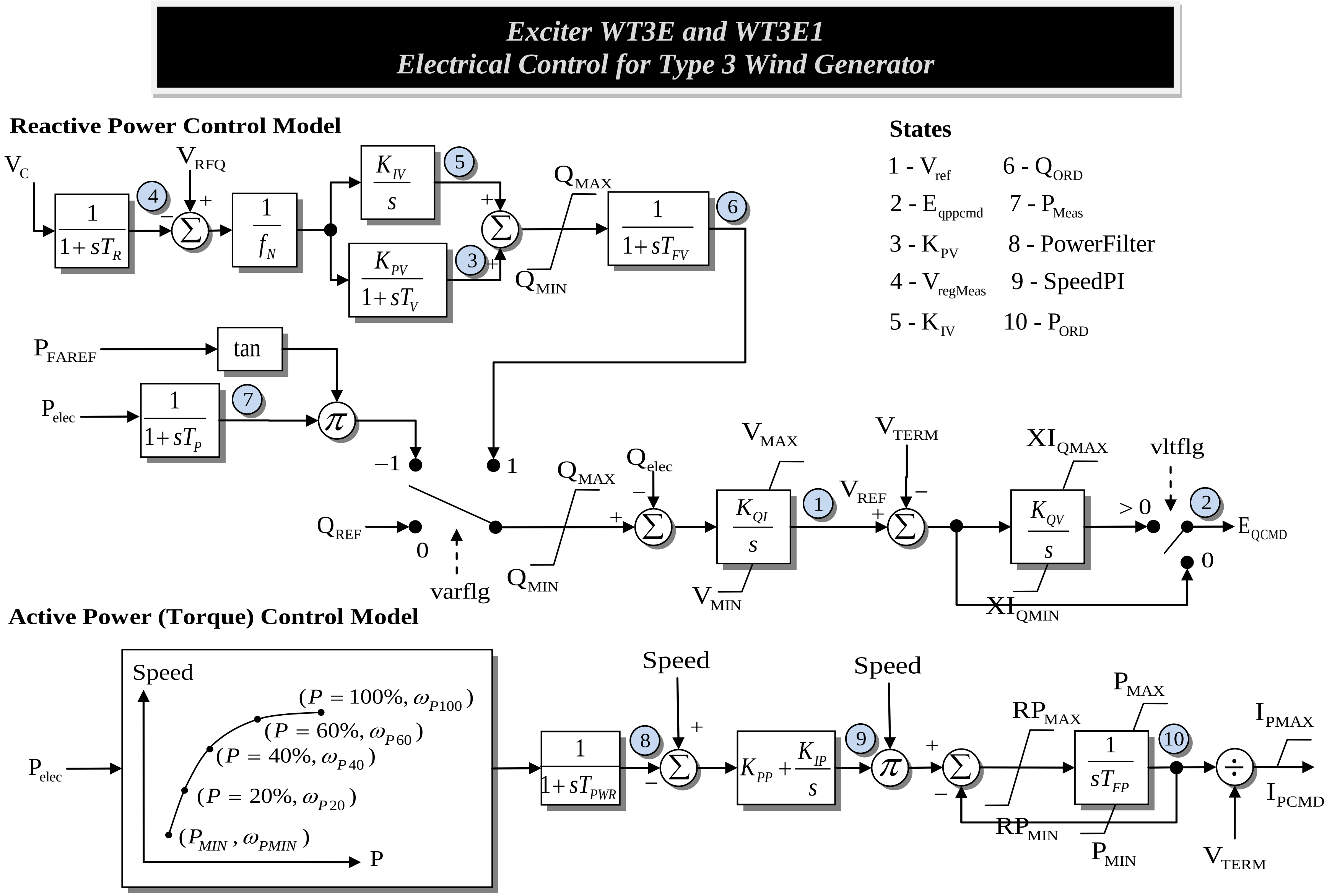
1 - $R_{external}$

2 - Speed

3 - P_{elec}

Model supported by PSSE

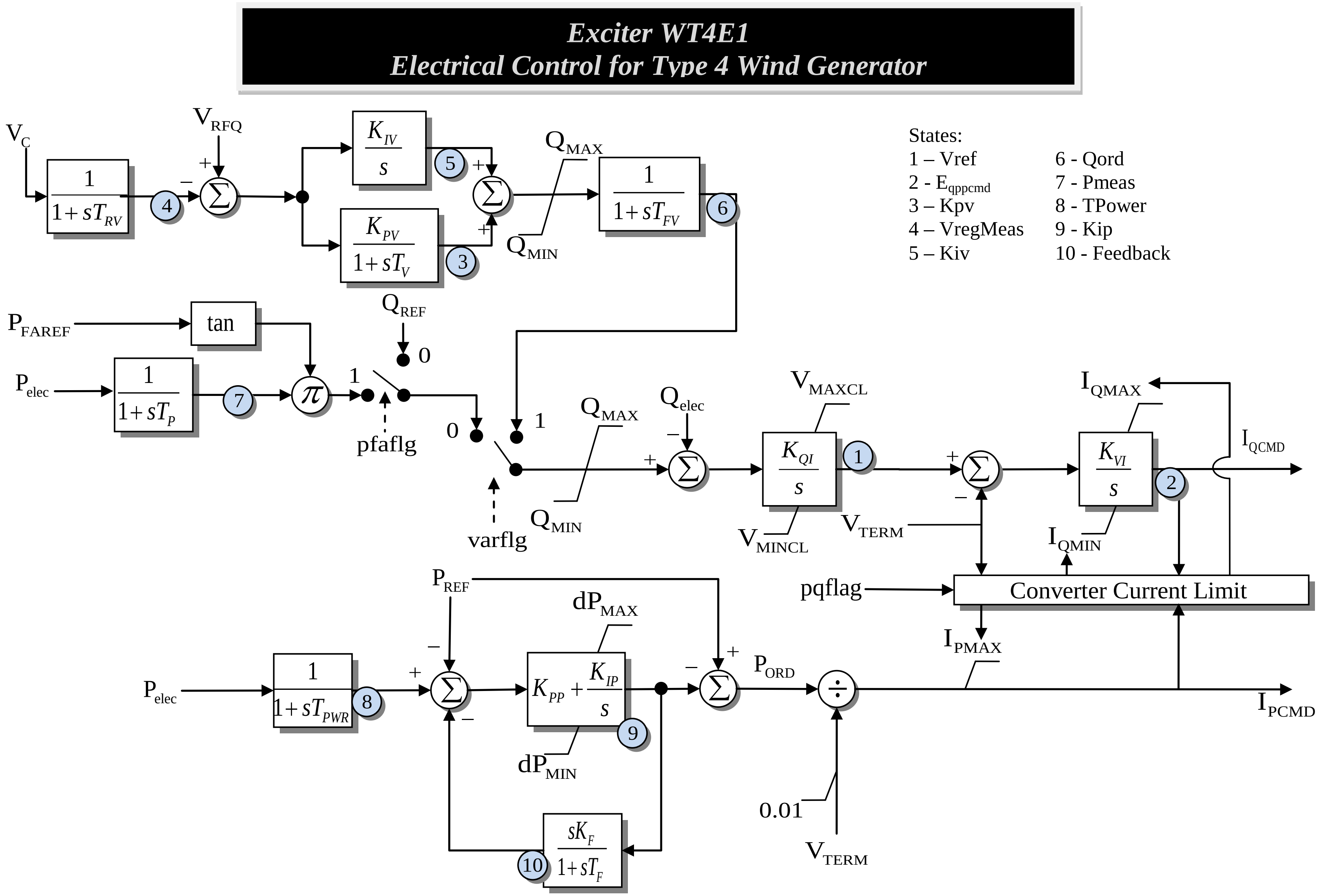
Exciter WT3E and WT3E1



WT3E supported by PSLF with $RP_{MAX} = P_{wrat}$ and $RP_{MIN} = -P_{wrat}$, $T_{FV} = T_C$

WT3E1 supported by PSSE uses vltflg to determine the limits on E_{QCMD}. When vltflg > 0 Simulator always uses XI_{QMAX} and XI_{QMIN}.

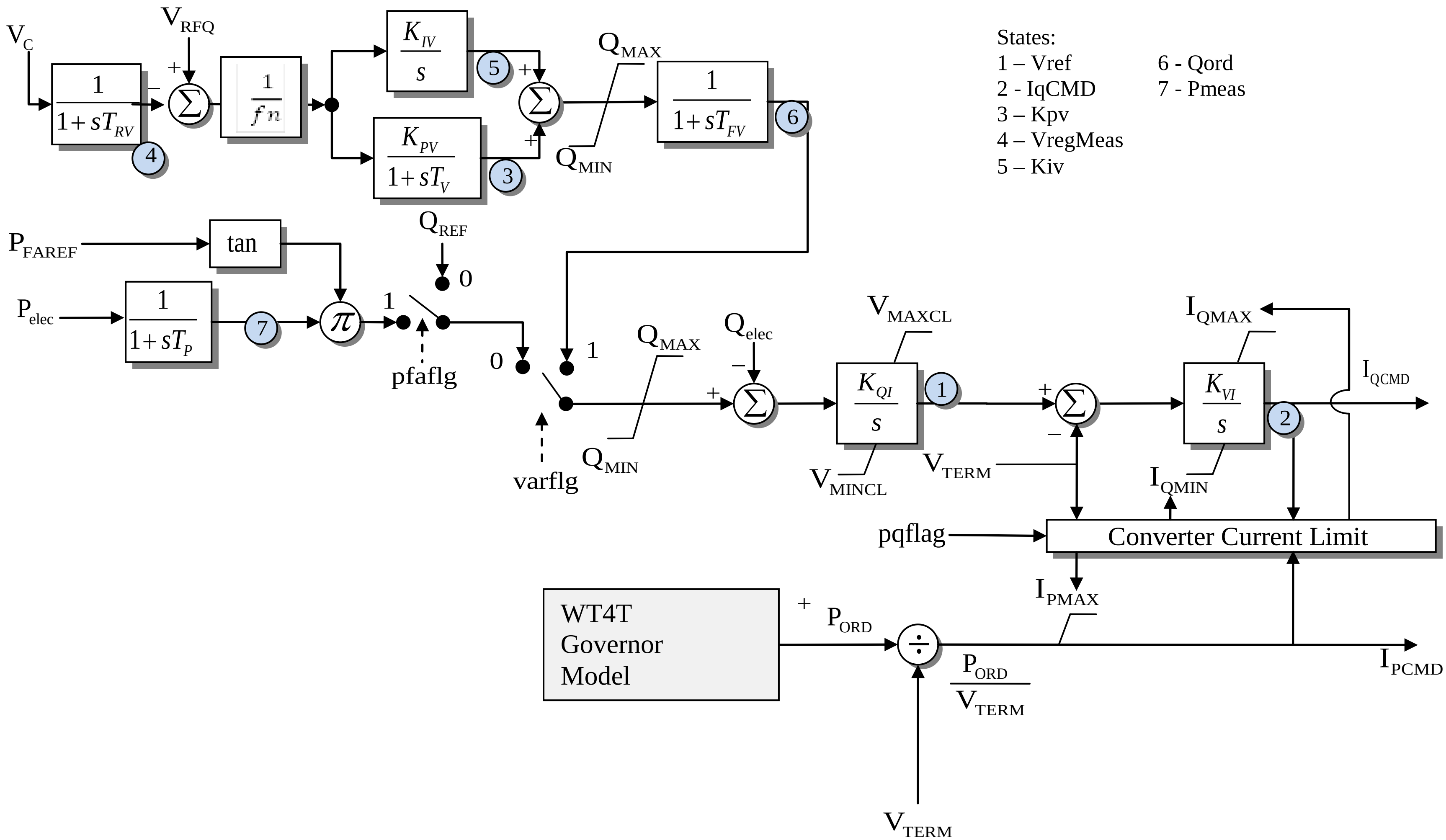
Exciter WT4E1



Model supported by PSSE

Exciter WT4E

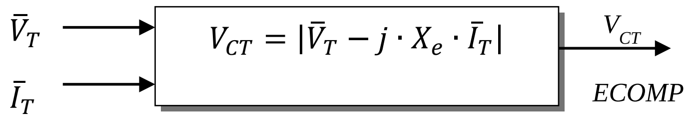
Exciter WT4E
Electrical Control for Full Converter Wind-turbine aenerators (FC WTG)



Model supported by PSLF

Generator Other Model COMP

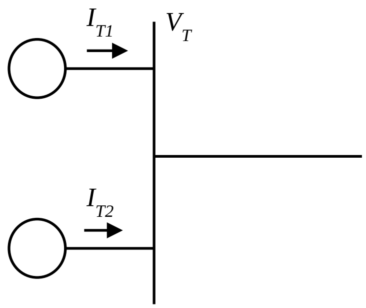
Voltage Regulator Current Compensating Model COMP



Model supported by PSSE

Generator Other Model COMPCC

Voltage Regulator Current Compensating Model for Cross-Compounds Units COMPCC



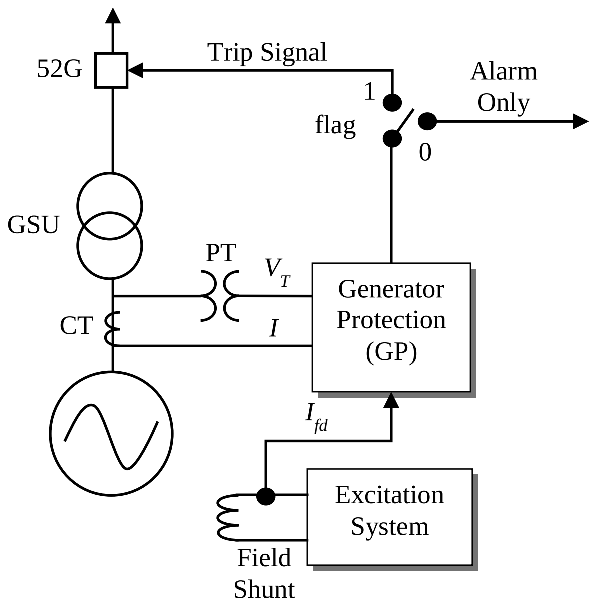
$$E_{COMP1} = V_T - \left(\frac{I_{T1} + I_{T2}}{2}\right) \cdot (R_1 + j \cdot X_1) + I_{T1} \cdot (R_2 + j \cdot X_2)$$

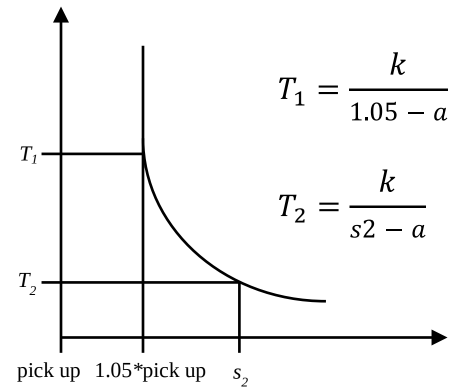
$$E_{COMP2} = V_T - \left(\frac{I_{T1} + I_{T2}}{2}\right) \cdot (R_1 + j \cdot X_1) + I_{T2} \cdot (R_2 + j \cdot X_2)$$

Model supported by PSSE

Generator Other Model GP1

Generic Generator Protection System GP1



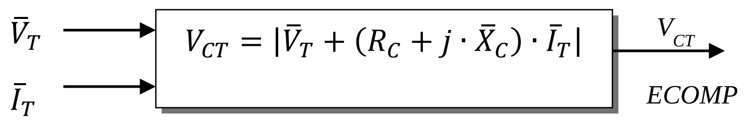


Notes:	= isoc or ifoc*affl
a	= asoc or afoc
k	= ksoc or kfoc

Model supported by PSLF

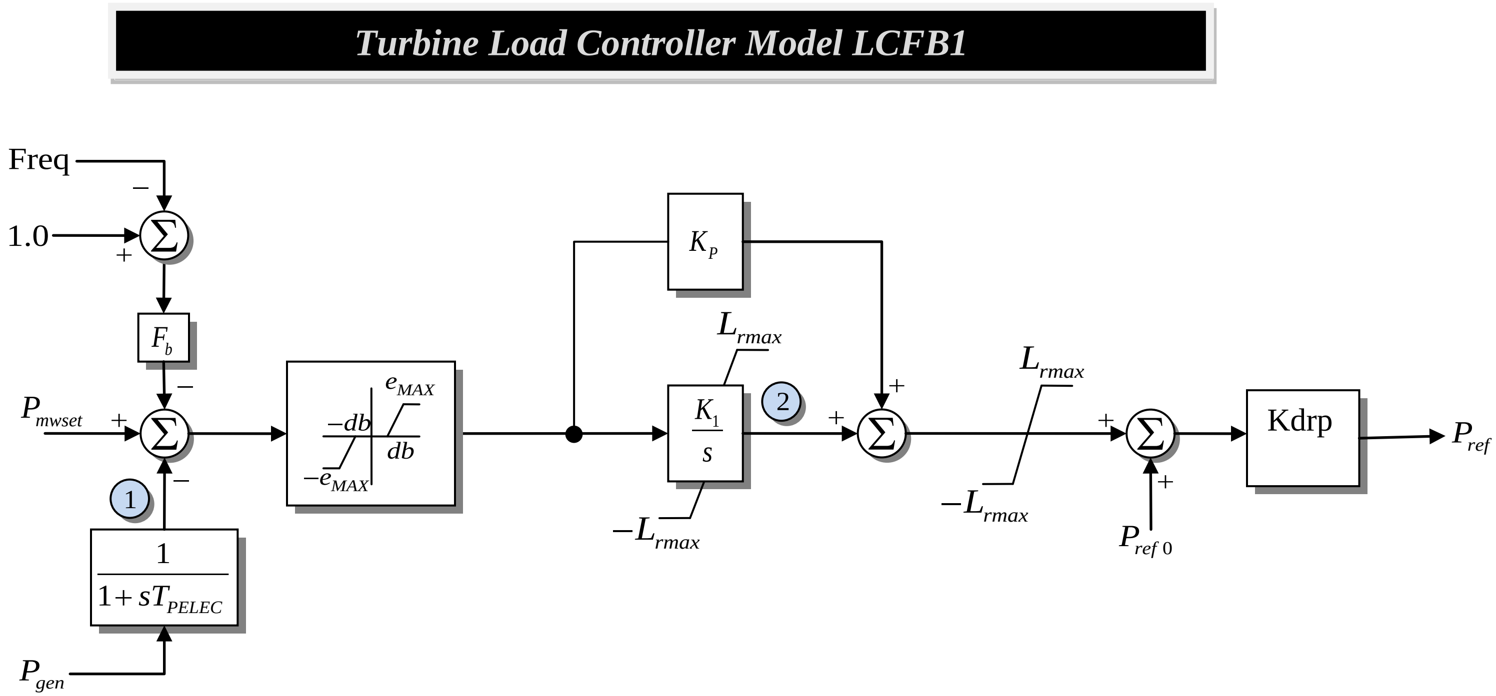
Generator Other Model IEEEVC

Voltage Regulator Current Compensating Model IEEEVC



Model supported by PSSE

Generator Other Model LCFB1



Frequency Bias Flag - fbf, set to 1 to enable or 0 to disable

Power Controller Flag - pbf, set to 1 to enable or 0 to disable

If Kdrp <= 0, then
Kdrp is set to 1.0 for speed reference governors
Kdrp = 25.0 for load reference governors

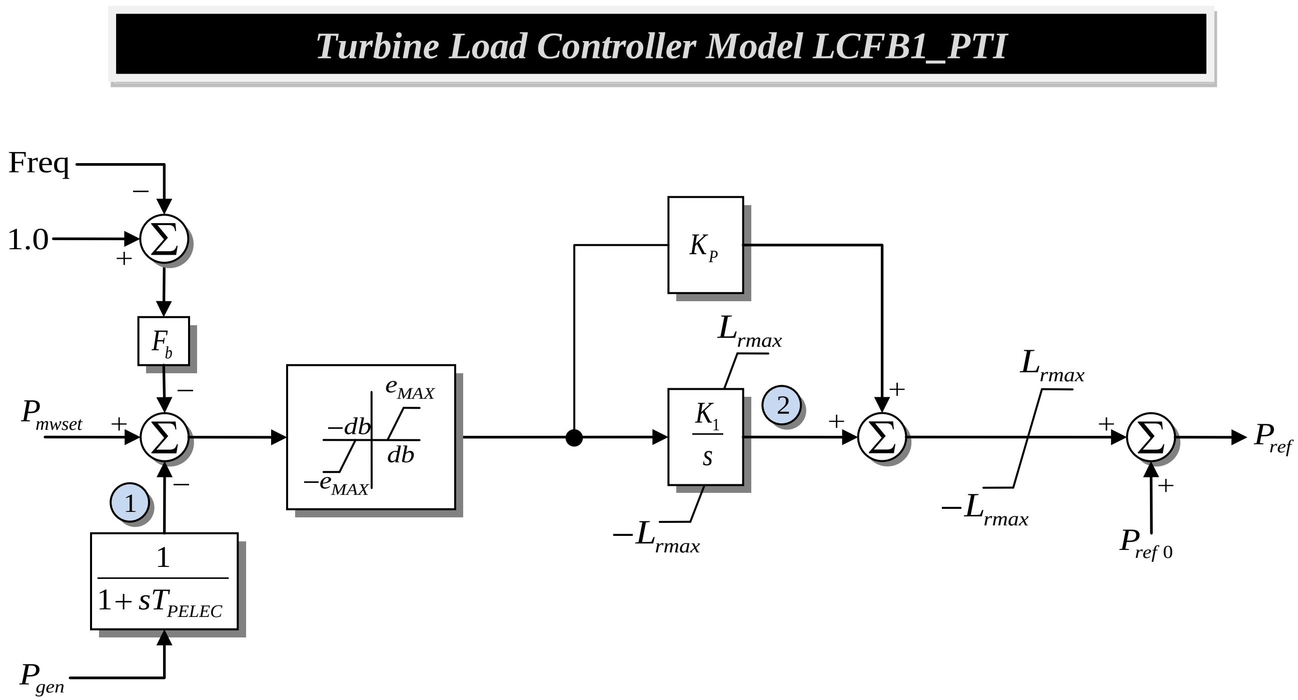
States

1 - P_{elec} Sensed

2 - K_I

Model supported by PSLF

Generator Other Model LCFB1_PTI



Frequency Bias Flag - fbf, set to 1 to enable or 0 to disable

Power Controller Flag - pbf, set to 1 to enable or 0 to disable

States

1 - P_{elec} Sensed

2 - K_I

Model supported by PSSE

Generator Other Model LHFRT

Low/High Frequency Ride through Generator Protection

Fref	Frequency ref. in Hz
dftrp1 to dftrp10	Delta Frequency Trip Level in p.u.
dttrp1 to dttrp10	Delta Frequency Trip Time Level in sec.

Model supported by PSLF

Generator Other Model LHVRT

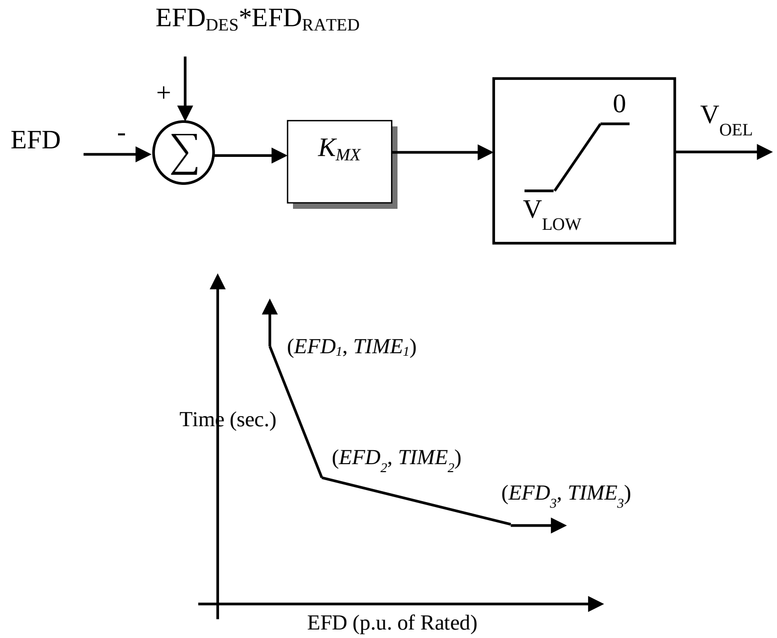
Low/High Voltage Ride through Generator Protection

Vref	Voltage ref. in p.u.
dvtrp1 to dftrp10	Delta Voltage Trip Level in p.u.
dttrp1 to dttrp10	Delta Voltage Trip Time Level in sec.

Model supported by PSLF

Generator Other Model MAXEX1 and MAXEX2

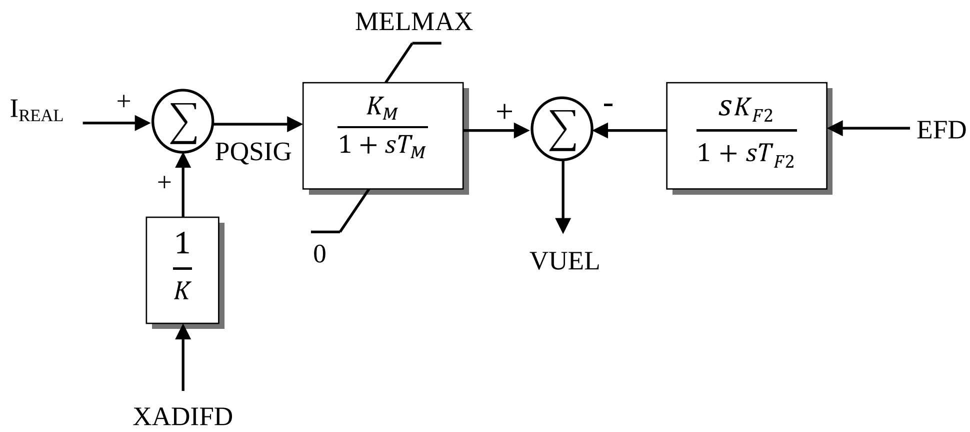
Maximum Excitation Limiter Model MAXEX1 and MAXEX2



Model supported by PSSE

Generator Other Model MNLEX1

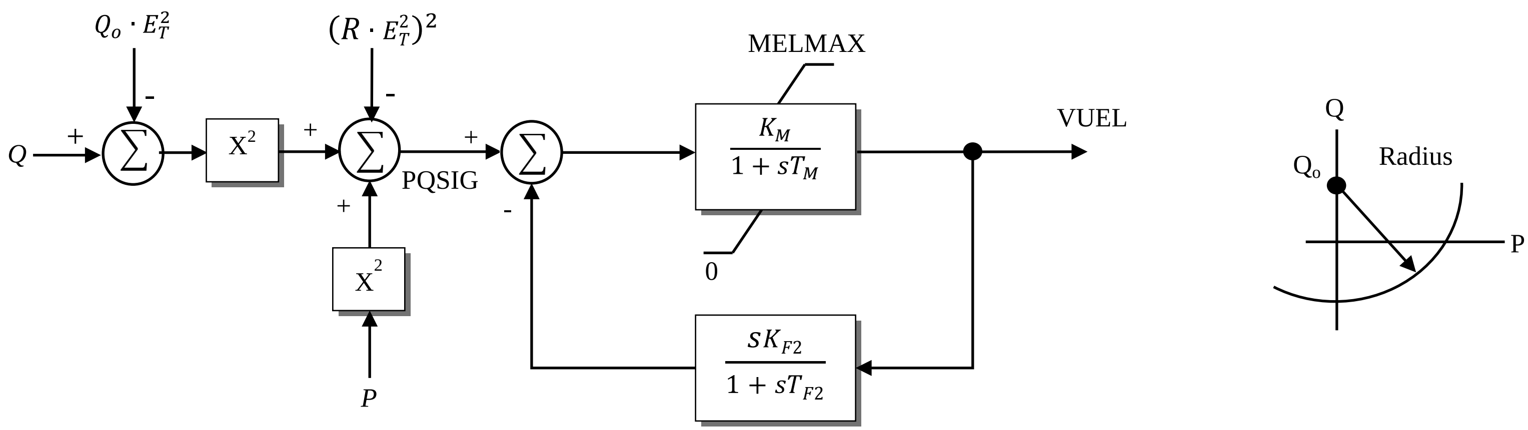
Minimum Excitation Limiter Model MNLEX1



Model supported by PSSE

Generator Other Model MNLEX2

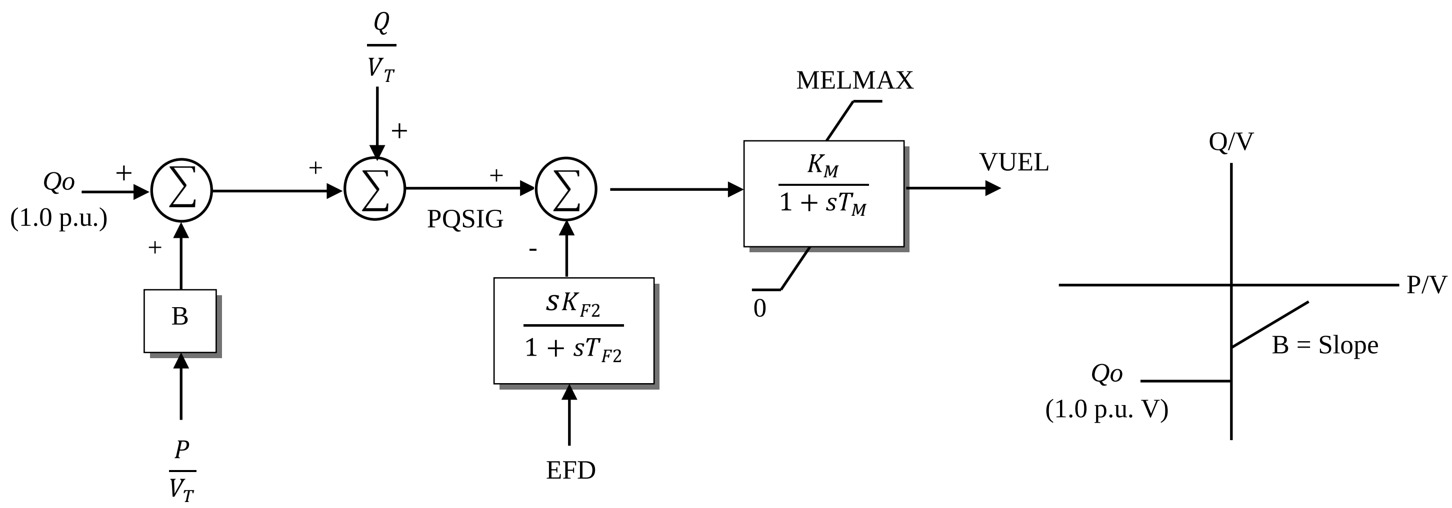
Minimum Excitation Limiter Model MNLEX2



Model supported by PSSE

Generator Other Model MNLEX3

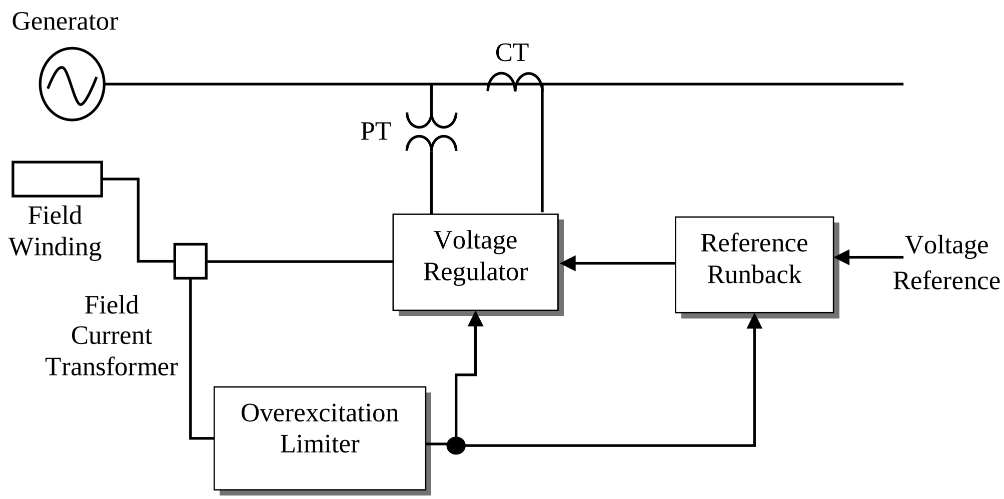
Minimum Excitation Limiter Model MNLEX3



Model supported by PSSE

Generator Other Model OEL1

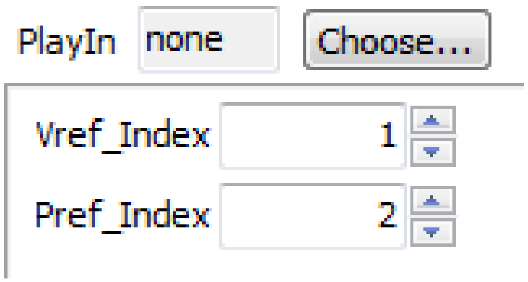
Over Excitation Limiter for Synchronous Machine Excitation Systems OEL1



Model supported by PSLF

Generator Other Model PLAYINREF

With the PLAYINREF model, specify the indices (Vref_Index and Pref_Index) of a specified PlayIn structure. Those signals will then be played into the model as either Pref of the Governor models or Vref of the Exciter models.



Generator Other Model REMCMP

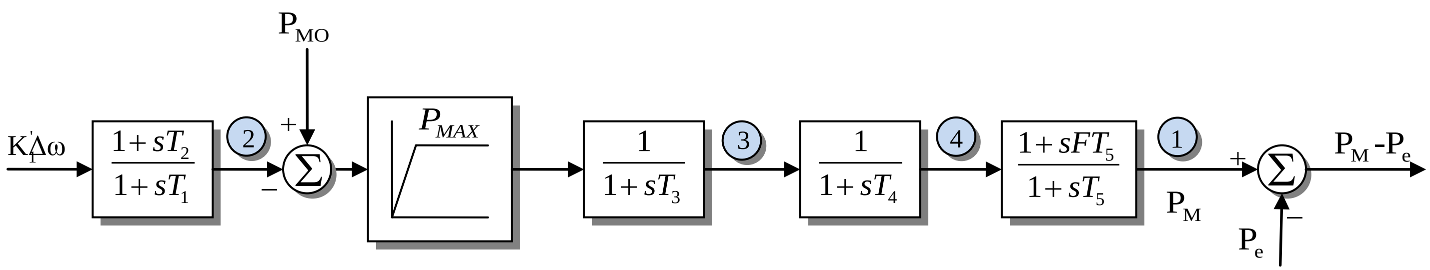
Voltage Regulator Current Compensating Model REMCMP

Remote bus	Remote bus number

Model supported by PSSE

Governor BPA GG

Governor BPA GG
WSCC Type G Governor Model



States

1 - P_{mech}

2 - Lead-Lag 1

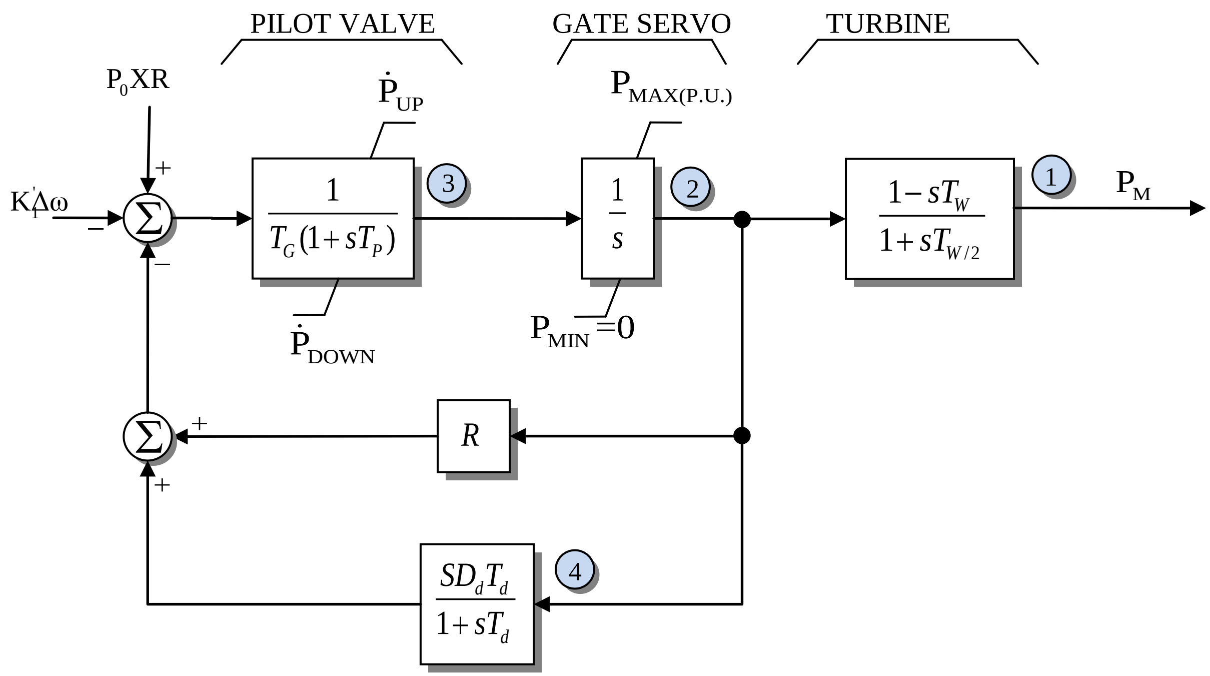
3 - Integrator 3

4 - Integrator 4

Model in the public domain, available from BPA

Governor BPA GH

Governor BPA GH
WSCC Type H Hydro-Mechanical Governor Turbine Model



States

1 - P_{mech}

2 - P gate valve

3 - y3

4 - Feedback

Model in the public domain, available from BPA

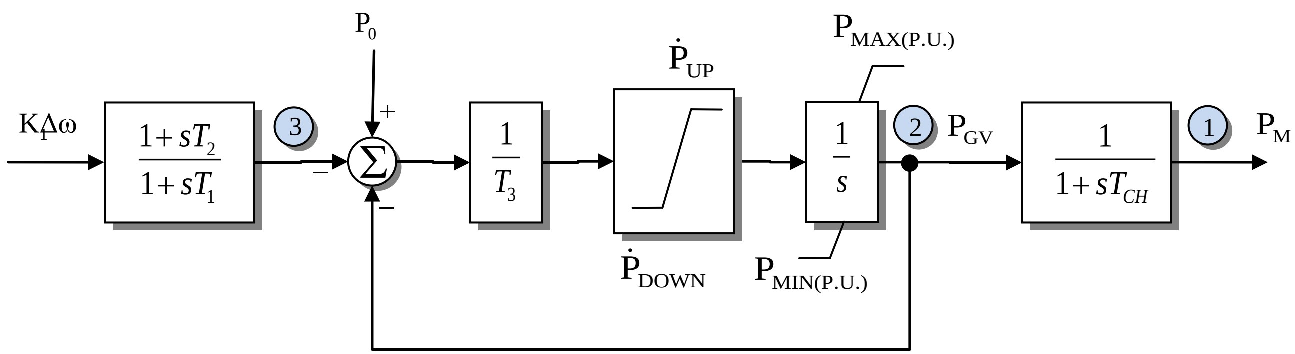
Governor BPA GIGATB, BPA GJGATB, BPA GKGATB, and BPA GLTB

Governor BPA GIGATB, BPA GJGATB, BPA GKGATB, and BPA GLTB

No block diagrams have been created

Governor BPA GSTA

Governor BPA GSTA
WSCC Type S Steam System Governor
And Nonreheat Turbine (Type A) Model



States

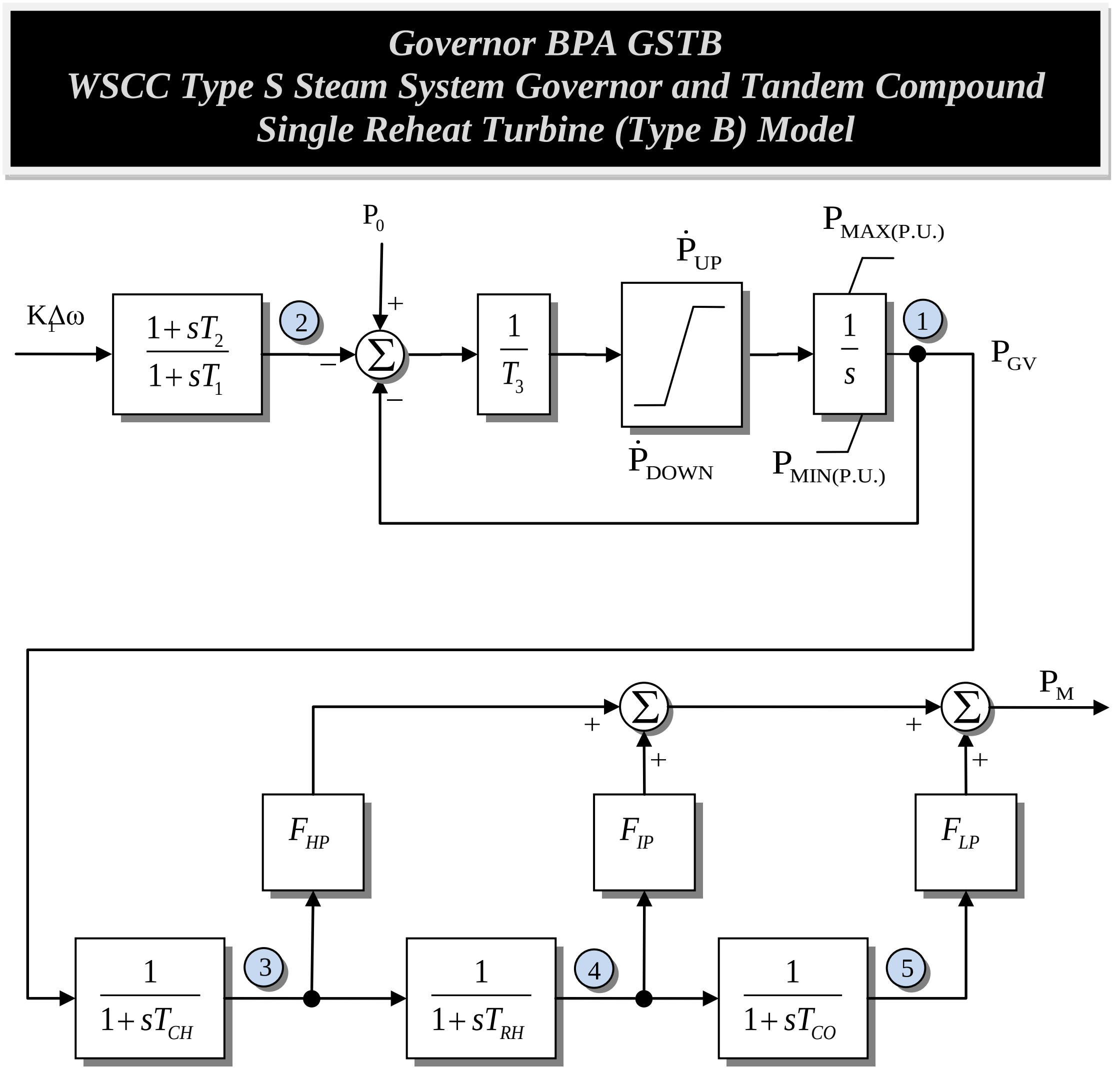
1 - P_{mech}

2 - P gate valve

3 - Lead-lag

Model in the public domain, available from BPA

Governor BPA GSTB



States

1 - P gate valve

2 - Lead-lag

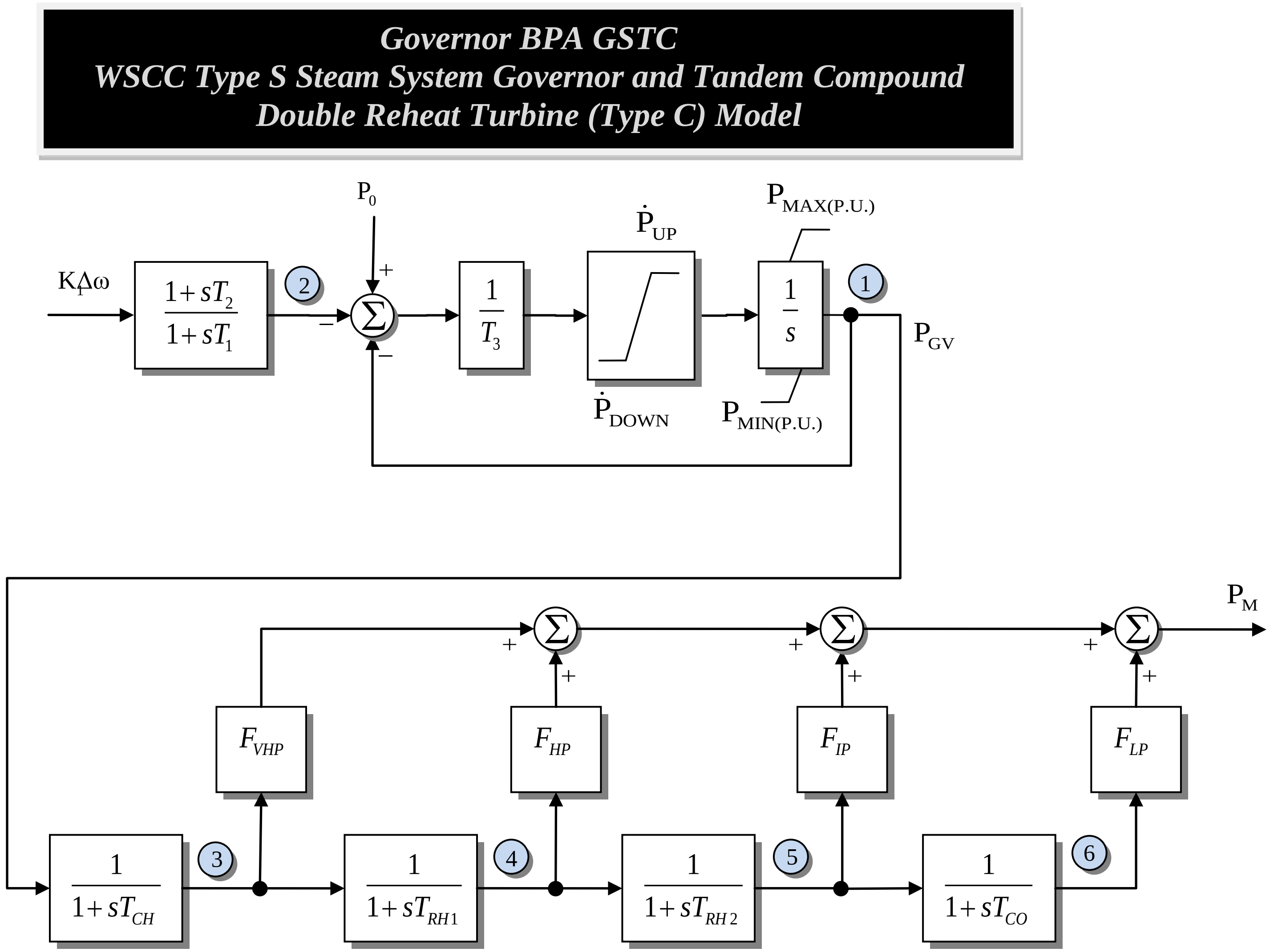
3 - y3

4 - y4

5 - y5

Model in the public domain, available from BPA

Governor BPA GSTC



States

1 - P gate valve

2 - Lead-lag

3 - y3

4 - y4

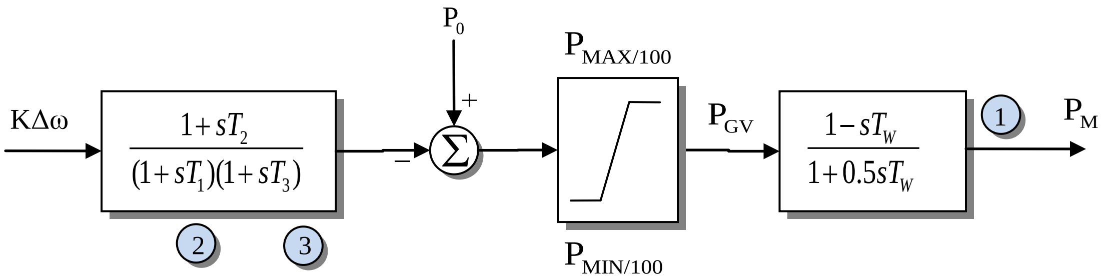
5 - y5

6 - y6

Model in the public domain, available from BPA

Governor BPA GWTW

Governor BPA GWTW
WSCC Type W Hydro Governor System
And Hydro Turbine (Type W) Model



States

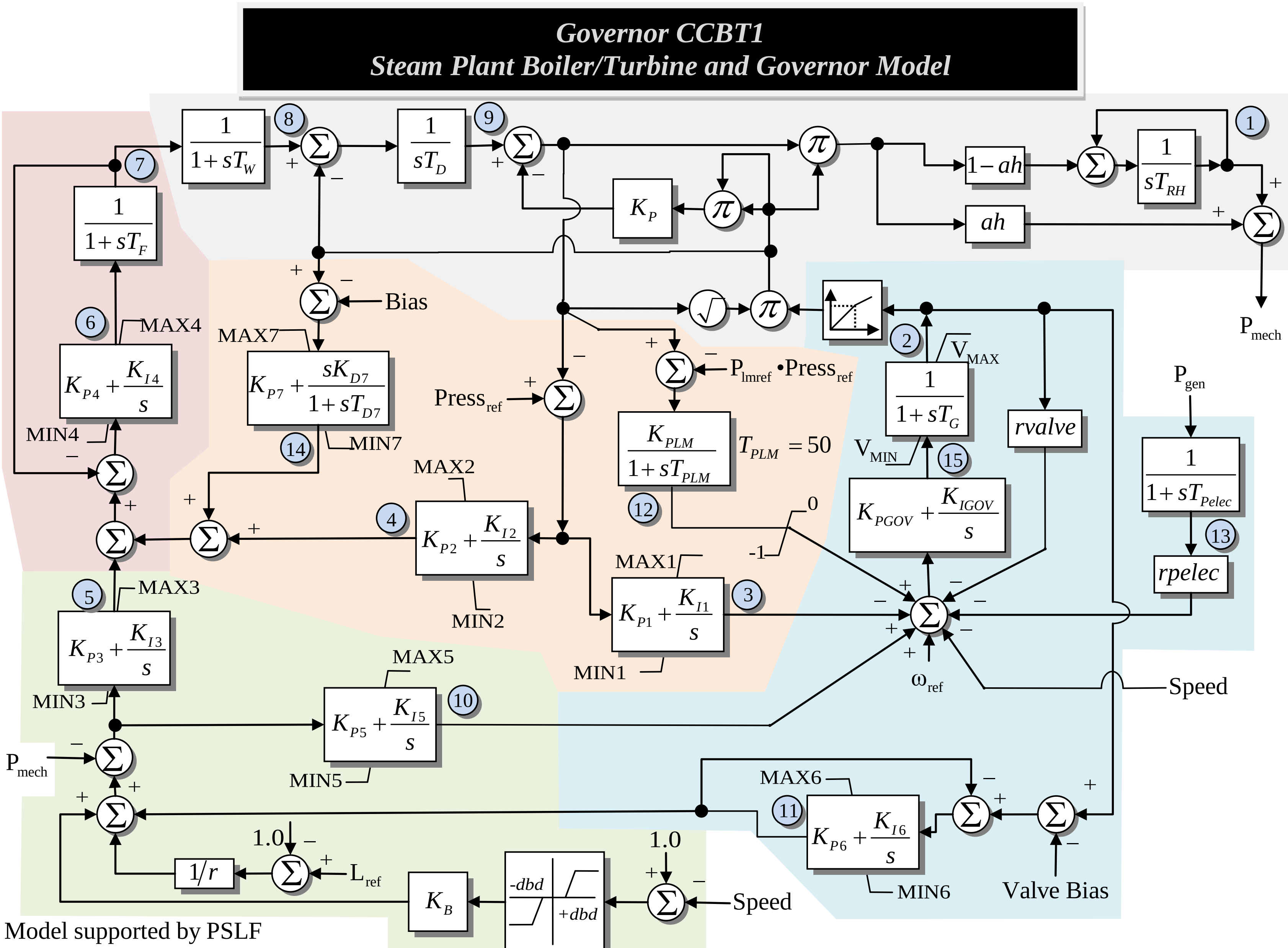
1 - P_{mech}

2 - y0

3 - y1

Model in the public domain, available from BPA

Governor CCBT1

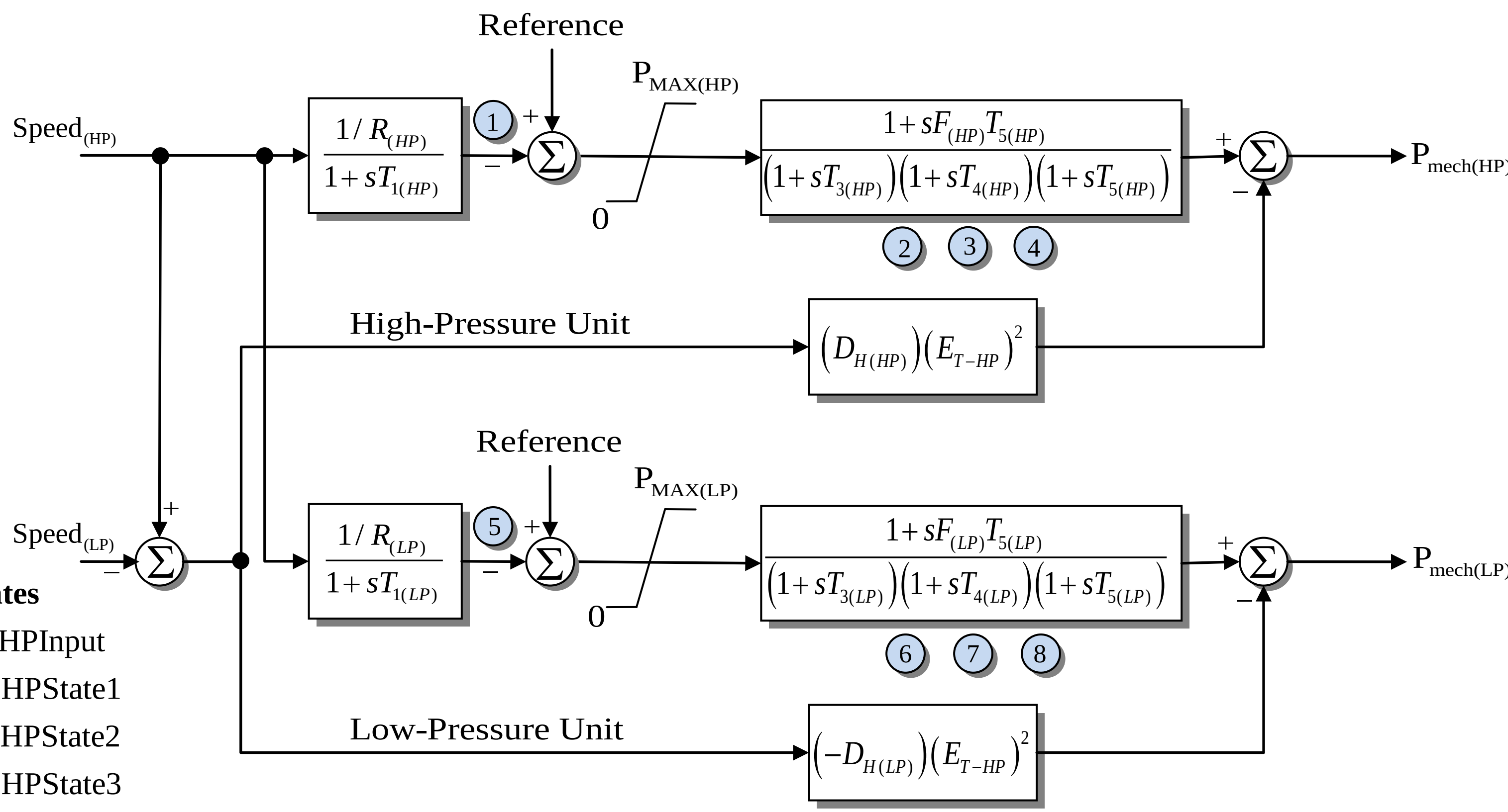


Model supported by PSLF

Proportional-integral blocks 1-6 also have rate limits not shown in the block diagram

Governor CRCMGV

Governor CRCMGV
Cross Compound Turbine-Governor Model



States

1 - HPInput

2 - HPState1

3 - HPState2

4 - HPState3

5 - LPInput

6 - LPState1

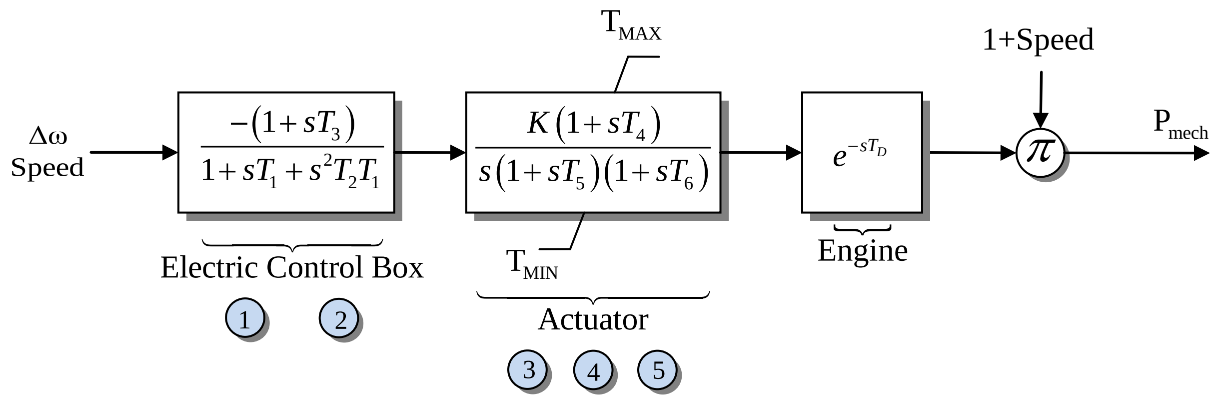
7 - LPState2

8 - LPState3

Model supported by PSLF and PSSE

Governor DEGOV

Governor DEGOV
Woodward Diesel Governor Model



States

1 - Control box 1

2 - Control box 2

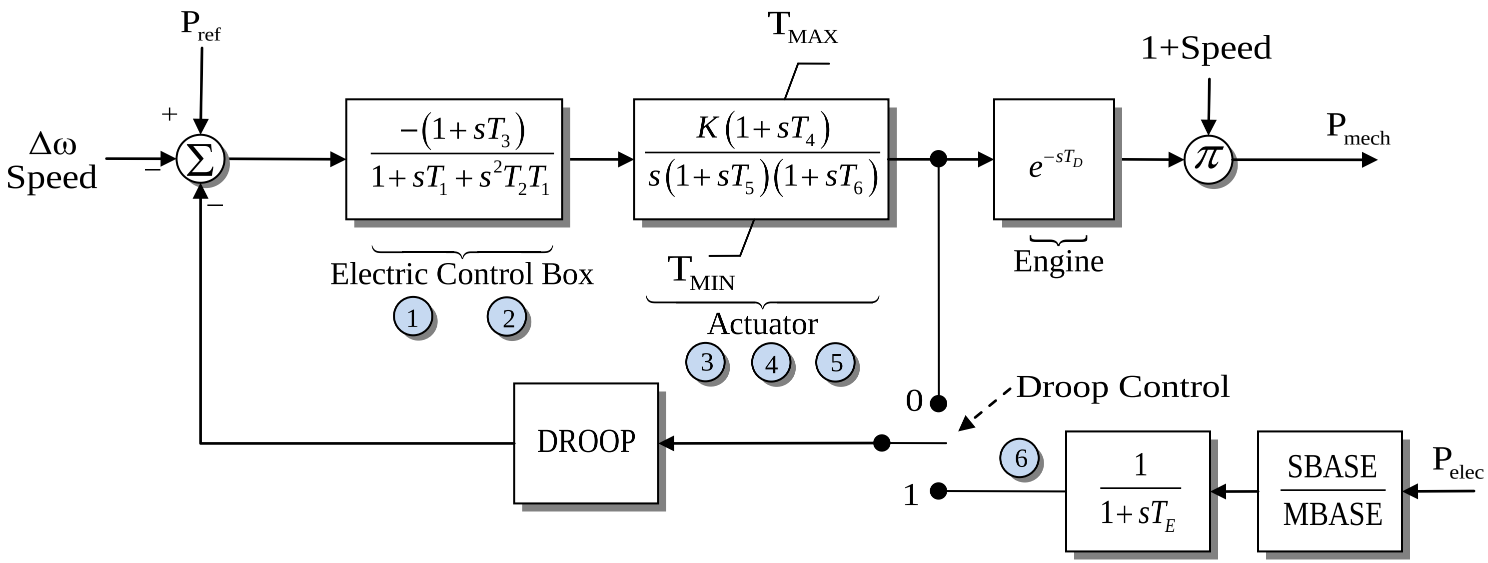
3 - Actuator 1

4 - Actuator 2

5 - Actuator 3

Model supported by PSSE

Governor DEGOV1



States

1 - Control box 1

2 - Control box 2

3 - Actuator 1

4 - Actuator 2

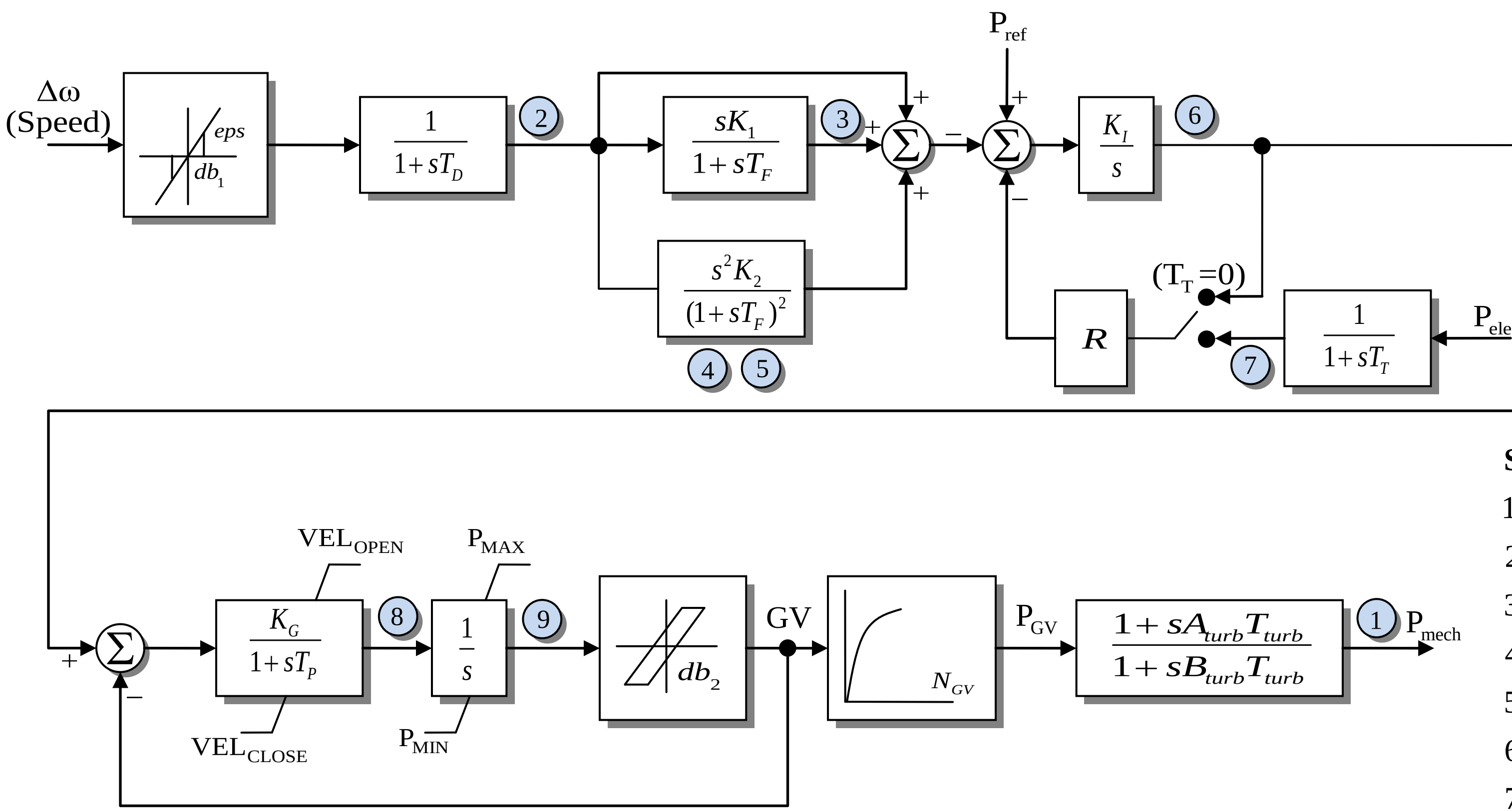
5 - Actuator 3

6 - Droop Input

Model supported by PSSE

Governor G2WSCC

Governor G2WSCC
Double Derivative Hydro Governor and Turbine
Represents WECC G2 Governor Plus Turbine Model



States

1 - P_{mech}

2 - T_D

3 - K_1

4 - K_2 first

5 - K_2 second

6 - Integrator

7 - P_{elec} Sensed

8 - Valve

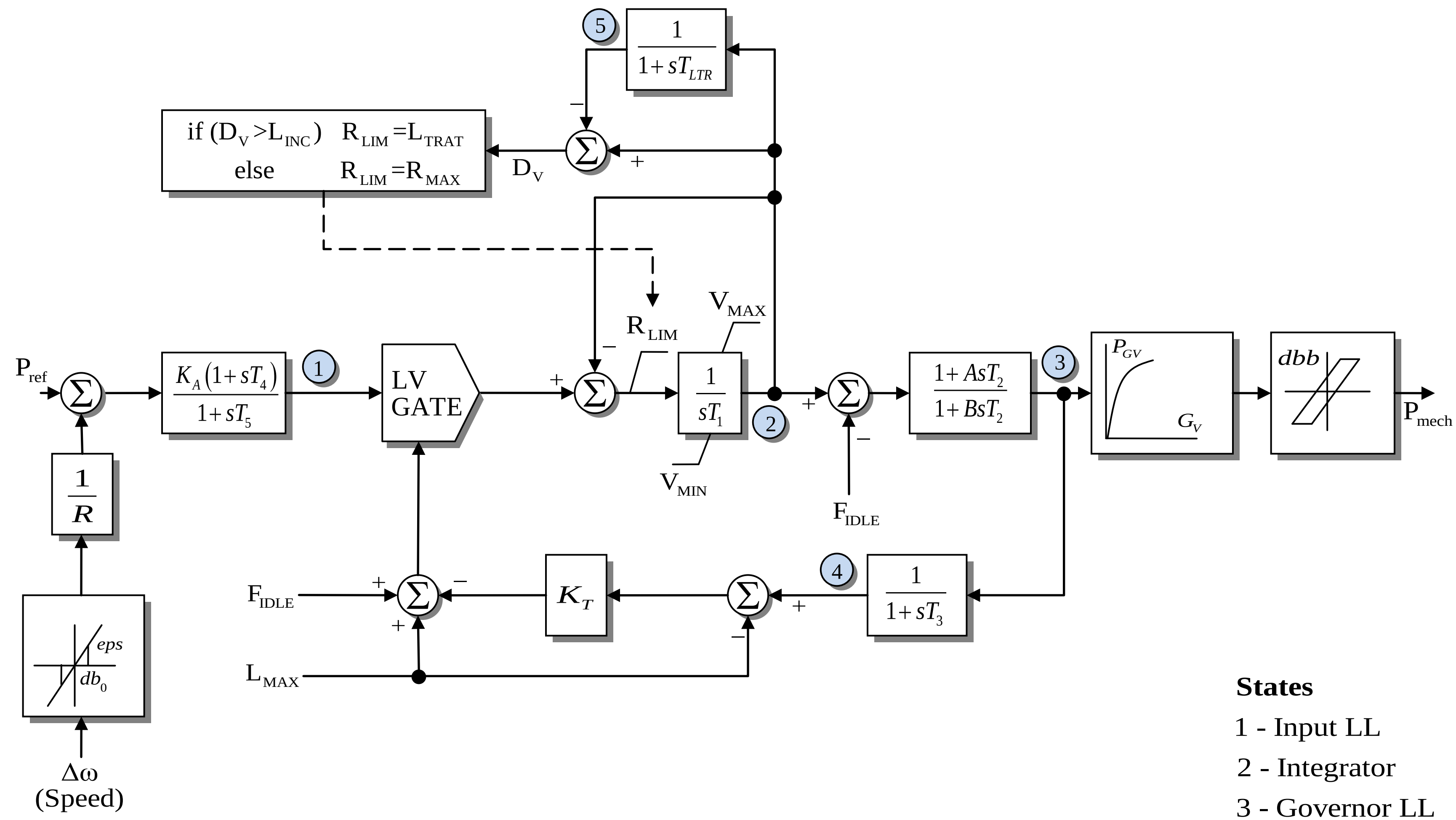
9 - Gate

Model supported by PSLF

GV1, PGV1...GV6, PGV6 are the x,y coordinates of N_{GV} block

Governor GAST_GE

Governor GAST_GE
Gas Turbine-Governor Model

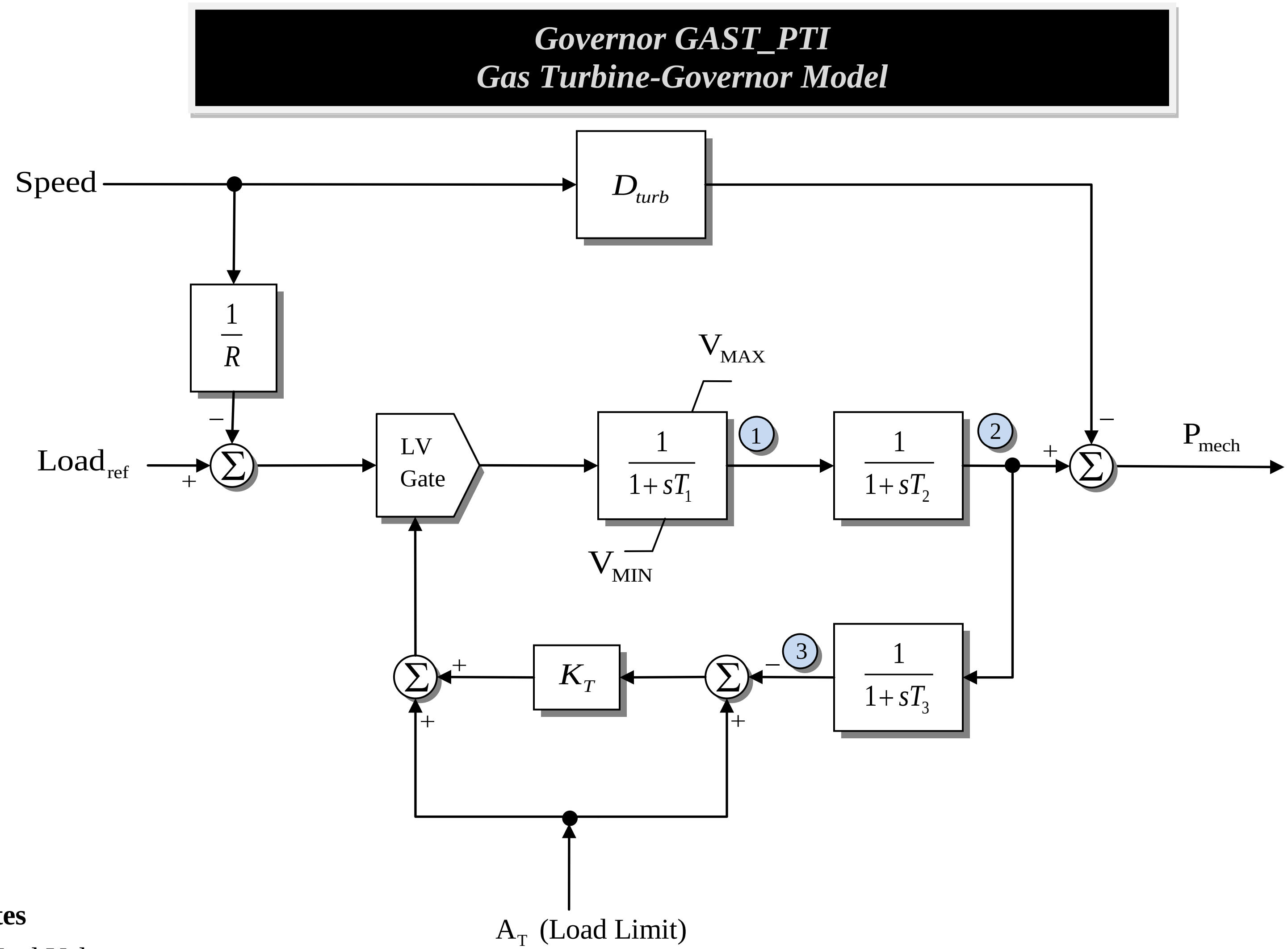


States
1 - Input LL
2 - Integrator
3 - Governor LL
4 - Load Limit
5 - Temperature

Model supported by PSLF

GV1, PGV1...GV6, PGV6 are the x,y coordinates of P_{GV} vs. GV block

Governor GAST_PTI



States

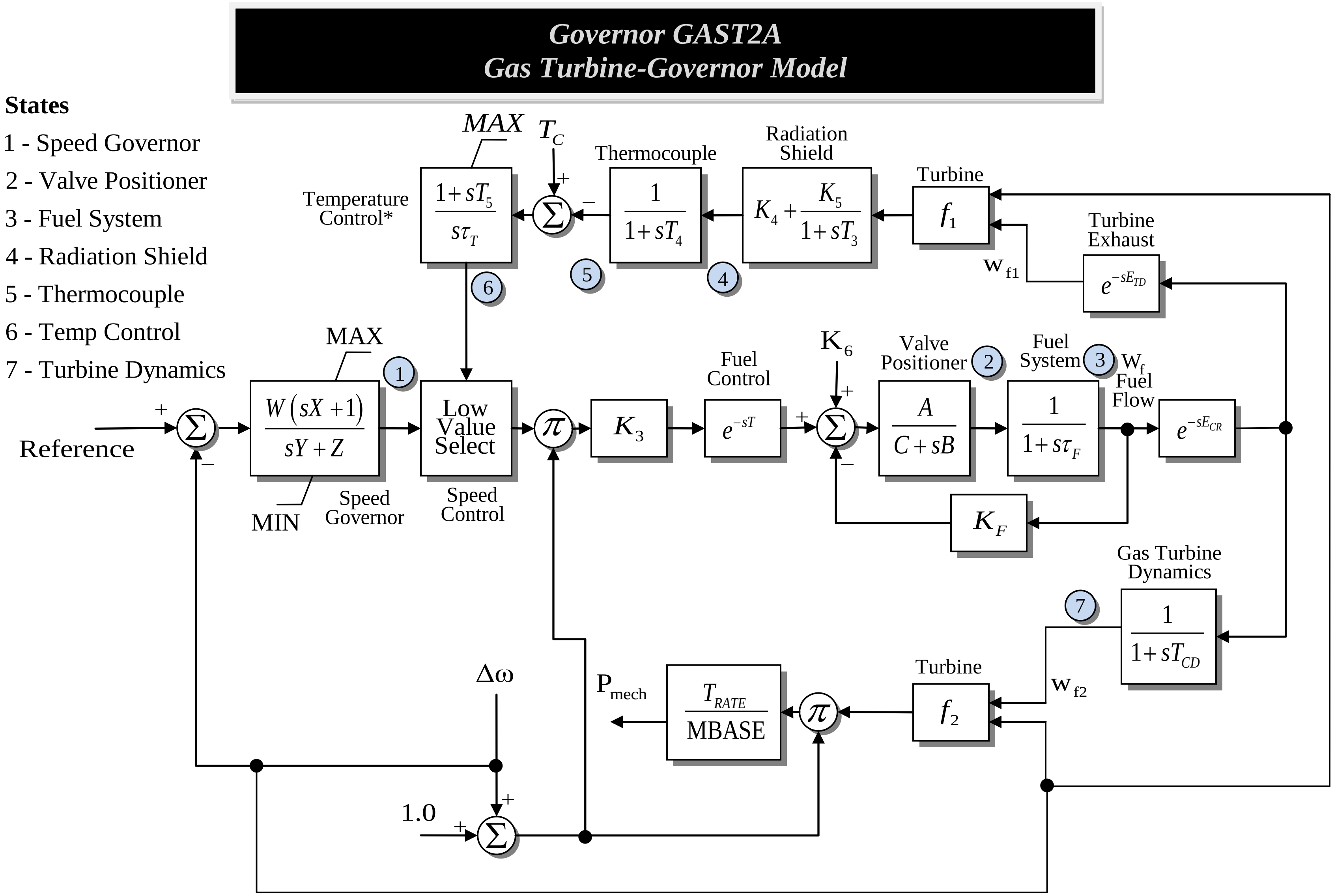
1 - Fuel Valve

2 - Fuel Flow

3 - Exhaust Temperature

Model supported by PSSE

Governor GAST2A

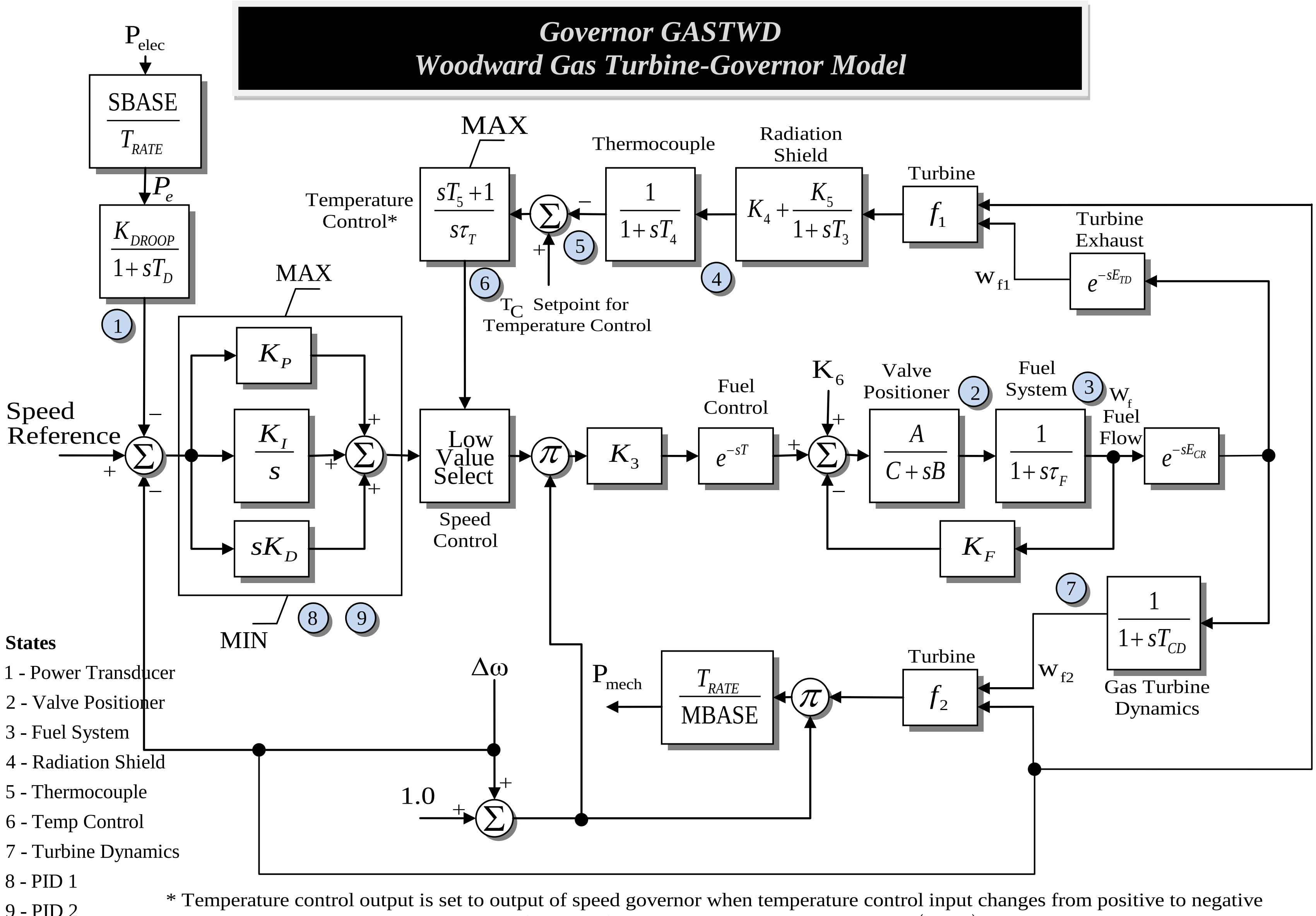


* Temperature control output is set to output of speed governor when temperature control input changes from positive to negative

Model supported by PSSE

$f_1 = T_R - A_{f1}\left(1.0 - w_{f1}\right) - B_{f1}\left(\text{Speed}\right)$ $\quad f_2 = A_{f2} - B_{f2}\left(w_{f2}\right) - C_{f2}\left(\text{Speed}\right)$

Governor GASTWD

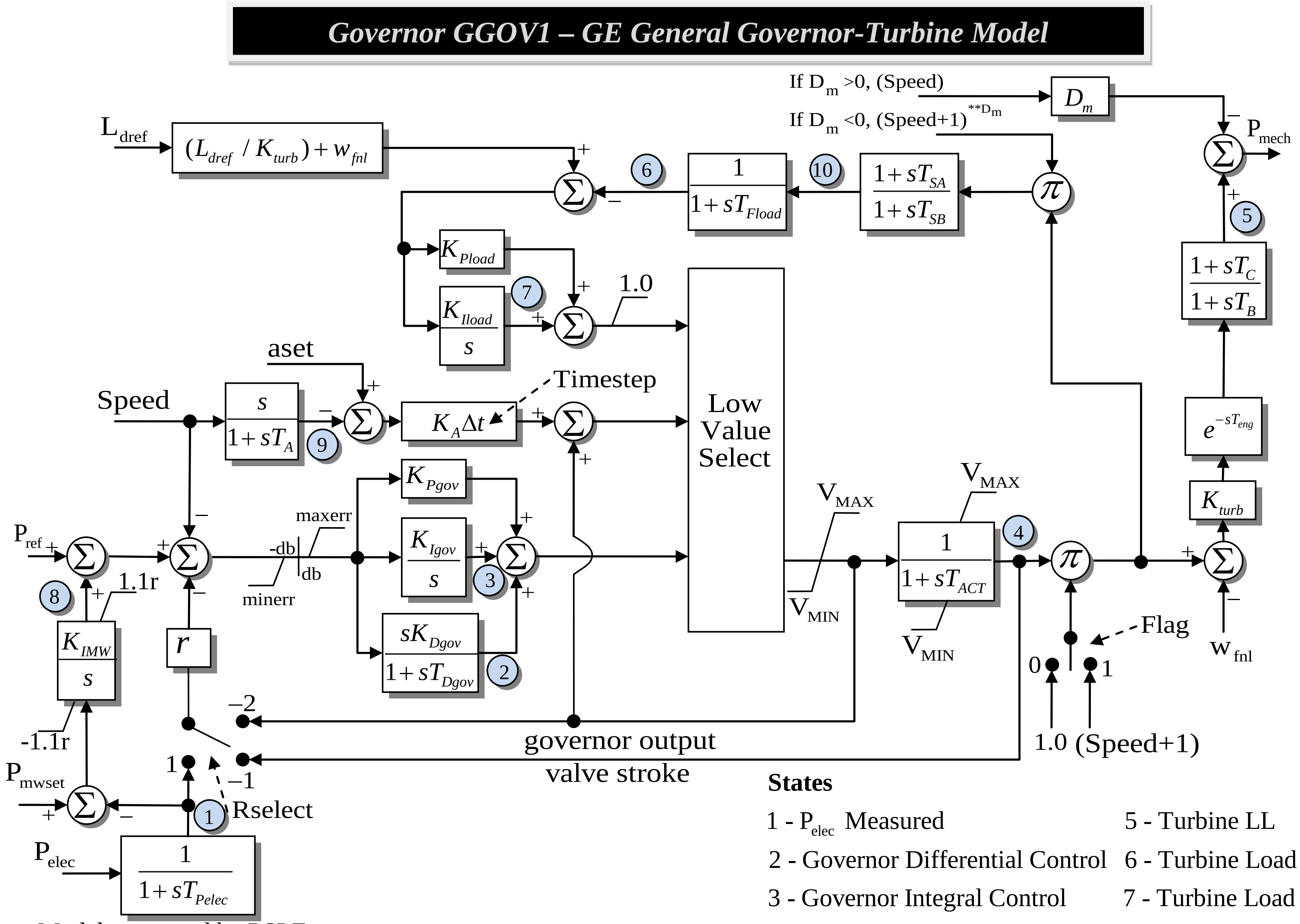


* Temperature control output is set to output of speed governor when temperature control input changes from positive to negative

Model supported by PSSE

$f_1 = T_R - A_{f1}\left(1.0 - w_{f1}\right) - B_{f1}\left(\text{Speed}\right)$ $\quad f_2 = A_{f2} - B_{f2}\left(w_{f2}\right) - C_{f2}\left(\text{Speed}\right)$

Governor GGOV1



States

1 - P_{elec} Measured

2 - Governor Differential Control

3 - Governor Integral Control

4 - Turbine Actuator

5 - Turbine LL

6 - Turbine Load Limiter

7 - Turbine Load Integral Control

8 - Supervisory Load Control

9 - Accel Control

10 - Temp Detection LL

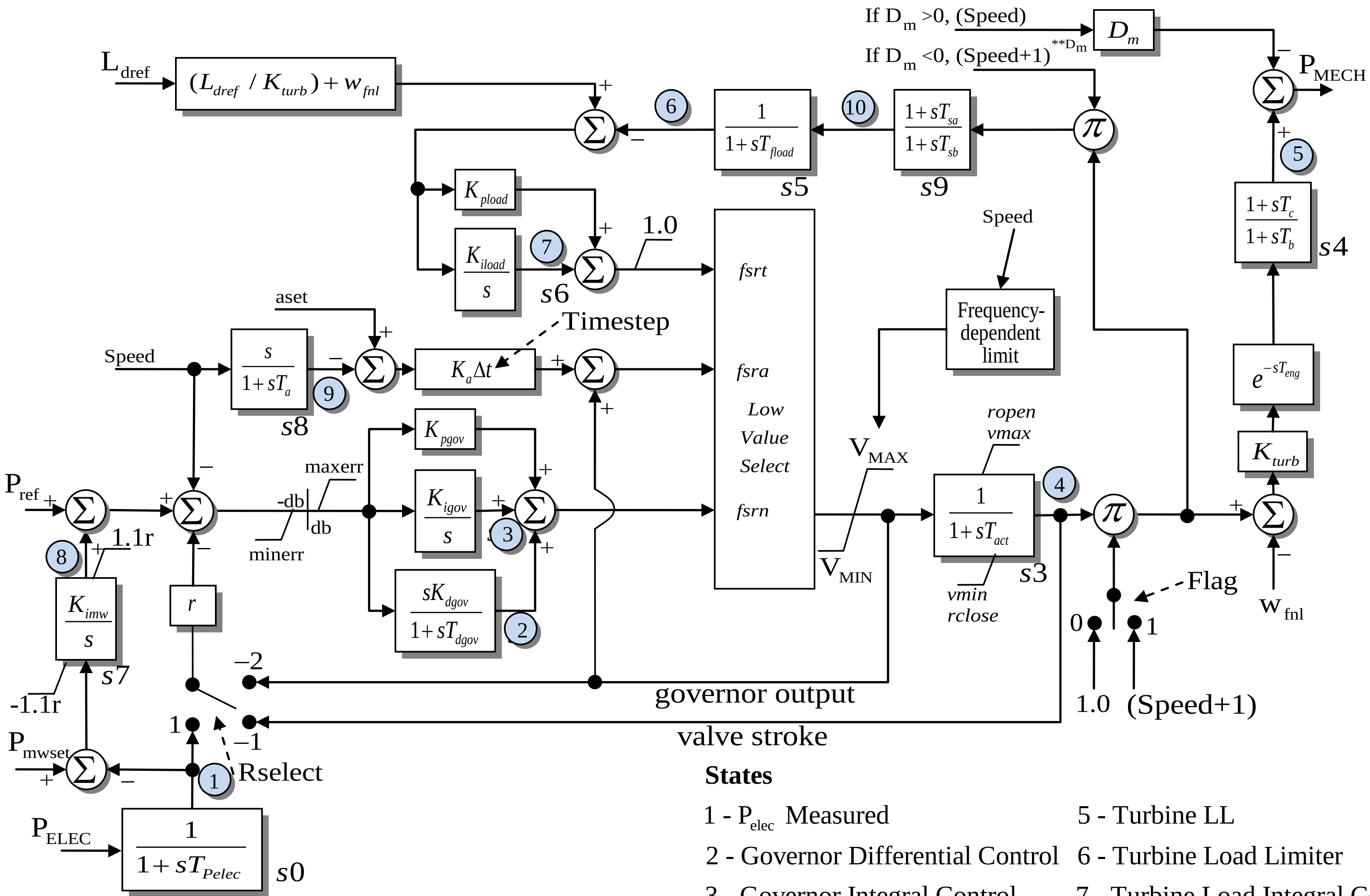
Model supported by PSLF

Model supported by PSSE does not include non-windup limits on K_{IMW} block

R_{UP}, R_{DOWN}, R_{CLOSE}, and R_{OPEN} inputs not implemented in Simulator

Governor GGOV2

Governor GGOV2 - GE General Governor-Turbine Model

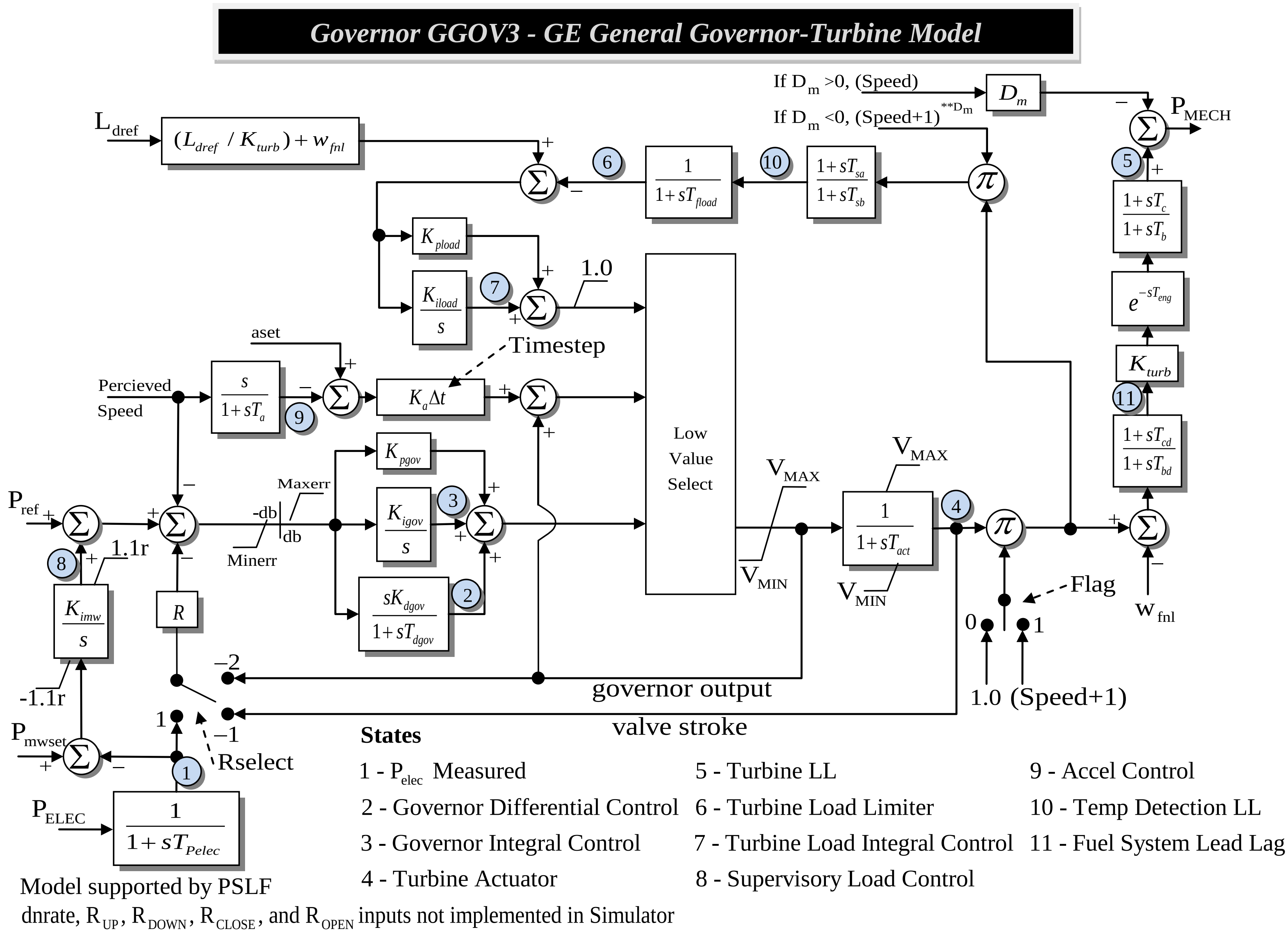


States

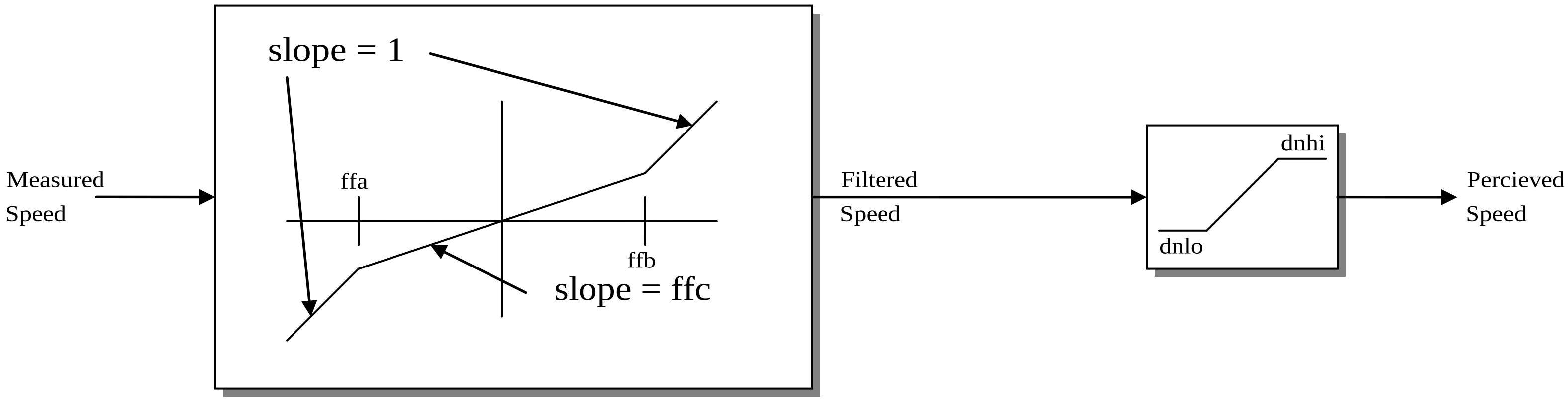
1 - P_{elec} Measured	5 - Turbine LL
2 - Governor Differential Control	6 - Turbine Load Limiter
3 - Governor Integral Control	7 - Turbine Load Integral Control
4 - Turbine Actuator	8 - Supervisory Load Control
	9 - Accel Control
	10 - Temp Detection LL

Model supported by PSLF

Governor GGOV3



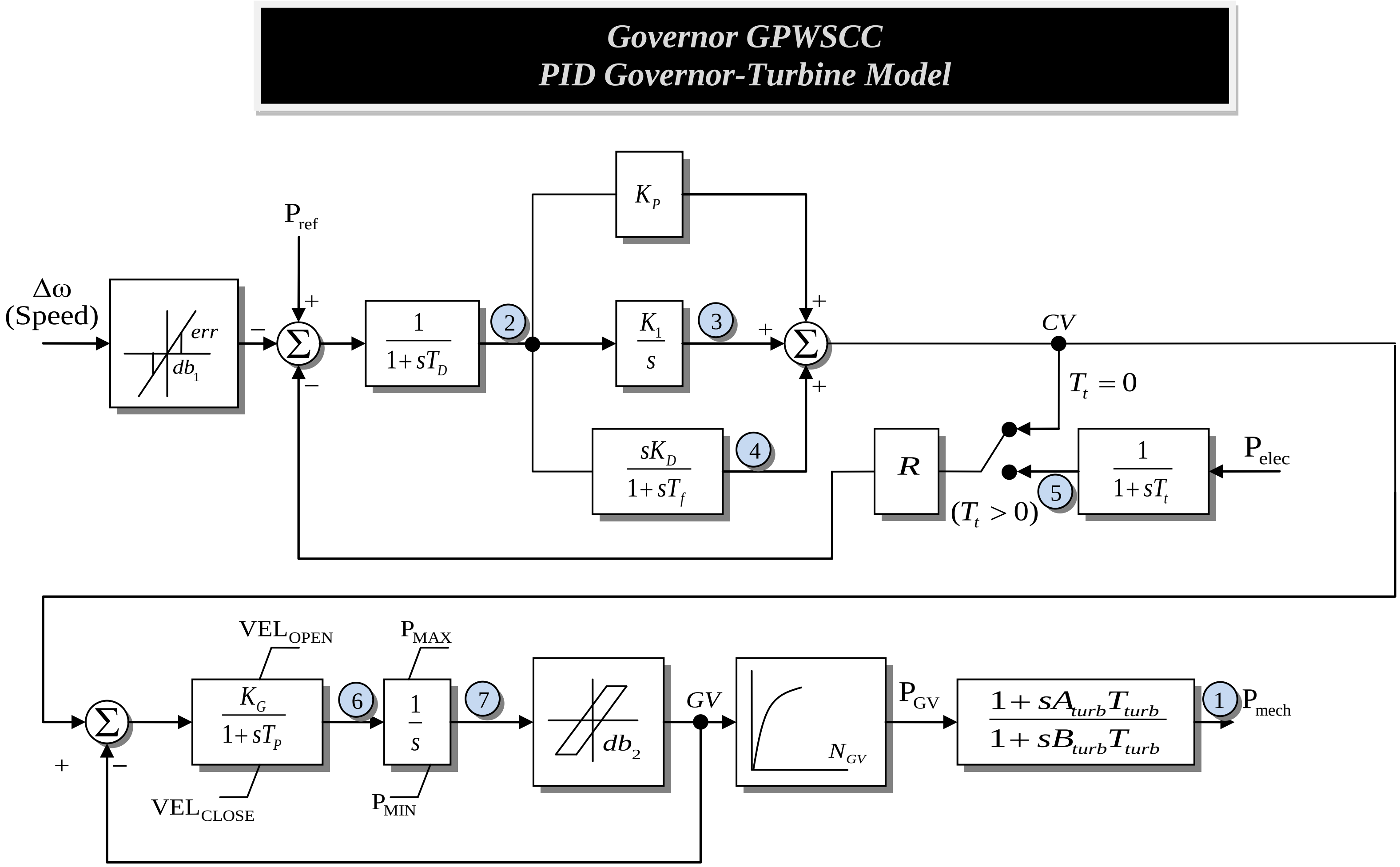
Governor GGOV3 - GE General Governor-Turbine Model



Nonlinear Speed Filter

Model supported by PSLF
Rate limit dnrate not used in Simulator

Governor GPWSCC



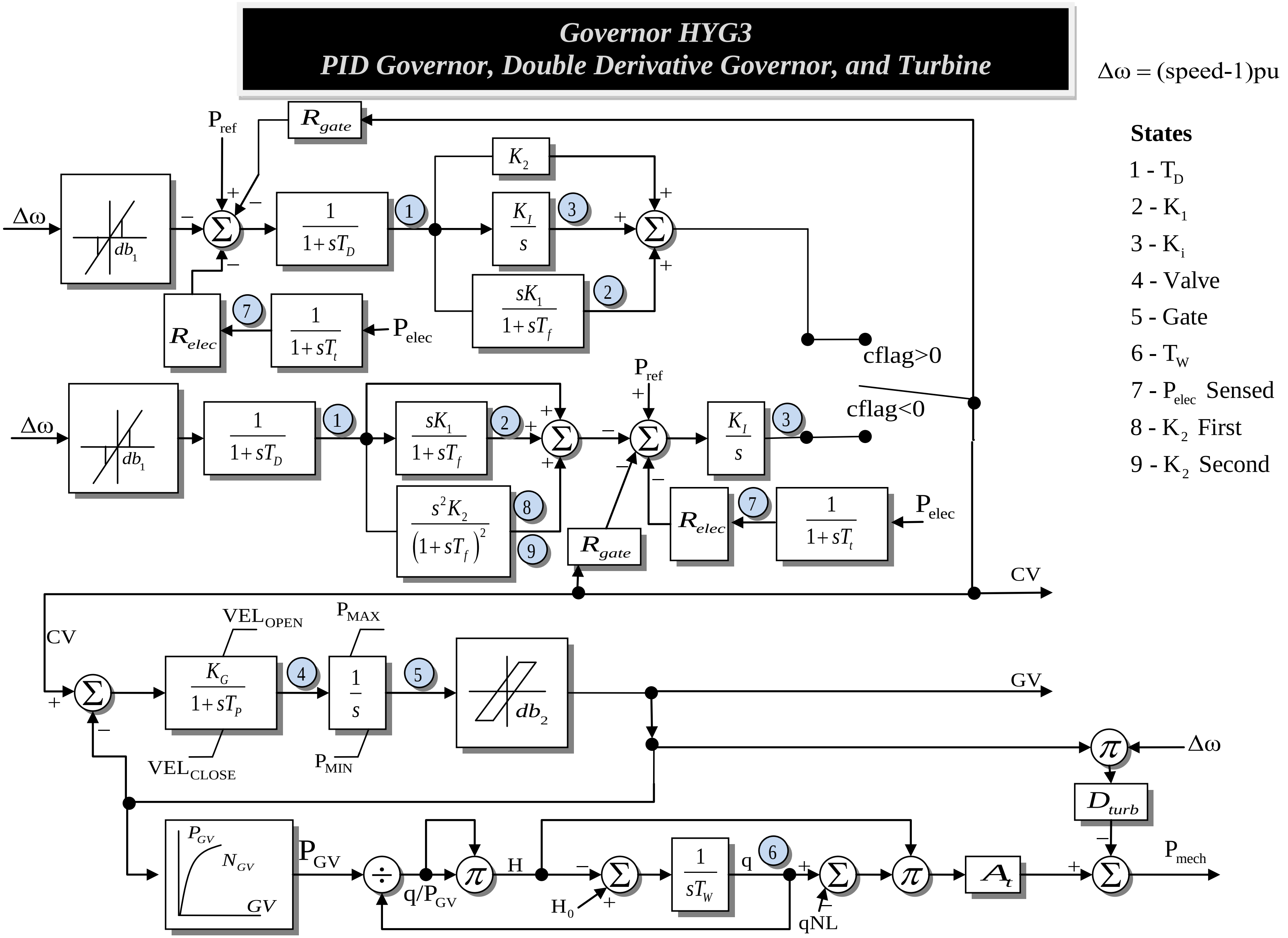
States

1 - P_{mech}
2 - T_D
3 - Integrator
4 - Derivative
5 - P_{elec} Sensed
6 - Valve
7 - Gate

Model supported by PSLF

GV1, PGV1...GV6, PGV6 are the x,y coordinates of N_{GV} block

Governor HYG3

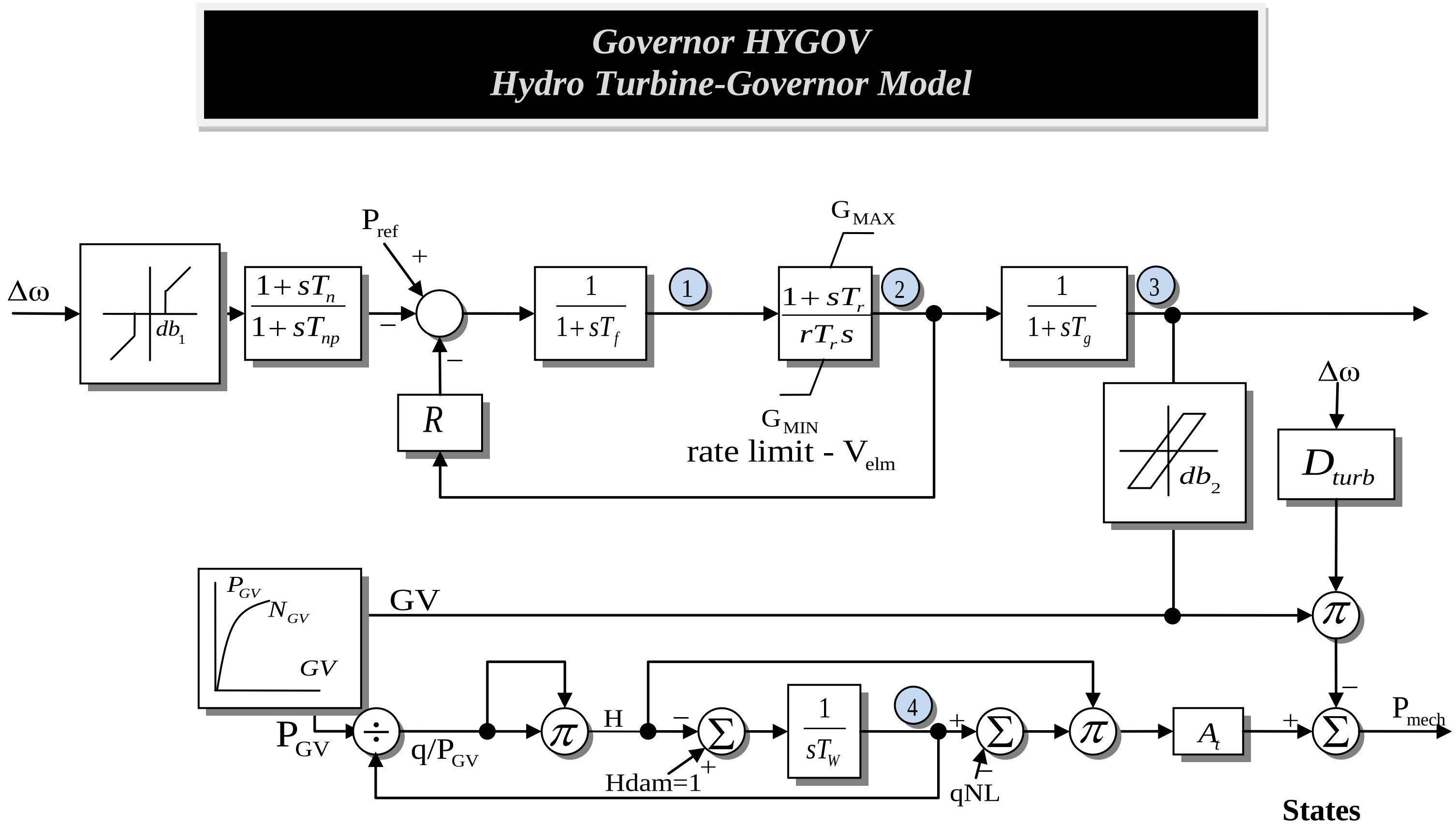


Model supported by PSLF

Note: cflag determines numbering of states

GV1, PGV1...GV6, PGV6 are the x,y coordinates of N_{GV} block

Governor HYGOV



States

1 - Filter Output

2 - Desired Gate

3 - Gate

4 - Turbine Flow

Model supported by PSSE and PSLF

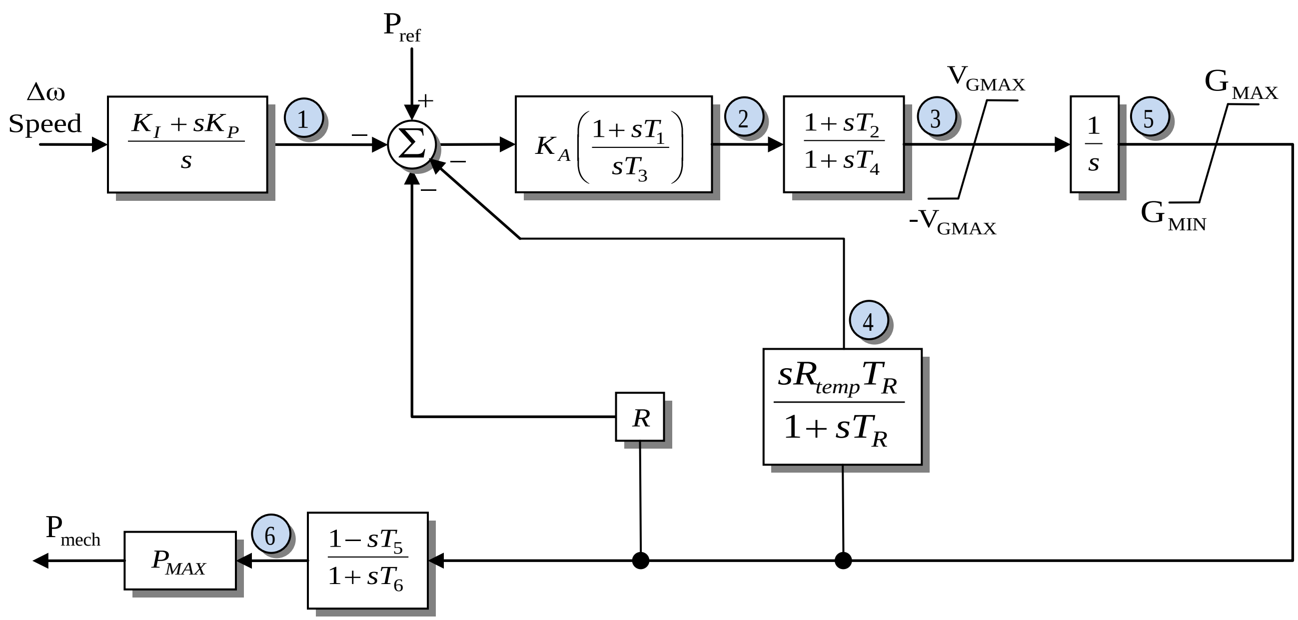
Rperm shown as R, Rtemp shown as r

GV0, PGV0...GV5, PGV5 are the x,y coordinates of N_{GV} block

Ttur, Tn, Tnp, db1, Eps, db2, Bgv0...Bgv5, Bmax, Tblade not implemented in Simulator

Governor HYGOV2

Governor HYGOV2
Hydro Turbine-Governor Model



States

1 - Filter Output

2 - Governor

3 - Governor Speed

4 - Droop

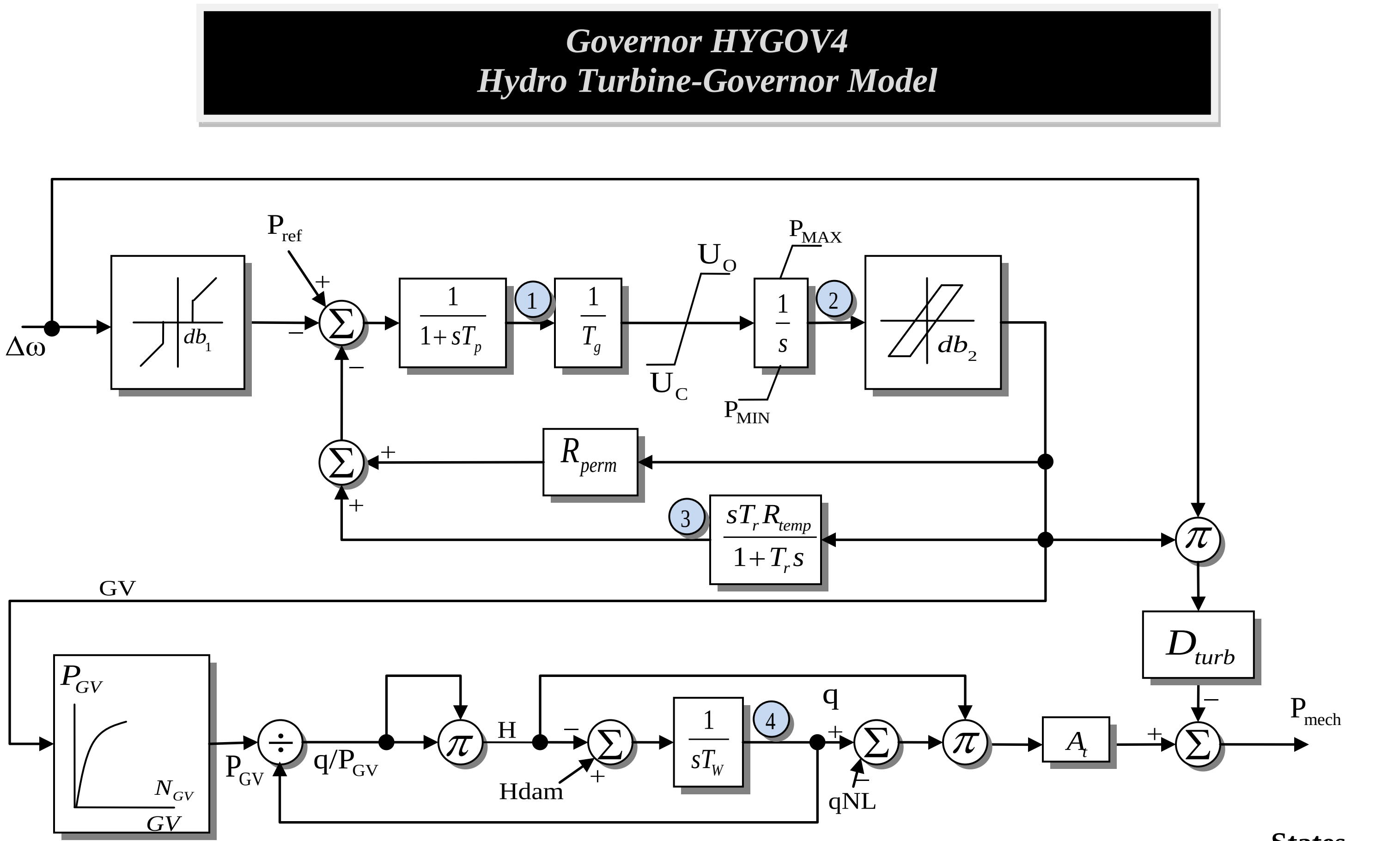
5 - Gate

6 - Penstock

The G_{MAX} G_{MIN} limit is modeled as non-windup in PSSE but as a windup limit in Simulator.

Model supported by PSSE

Governor HYGOV4



States

1 - Velocity

2 - Gate

3 - Rtemp

4 - T_W

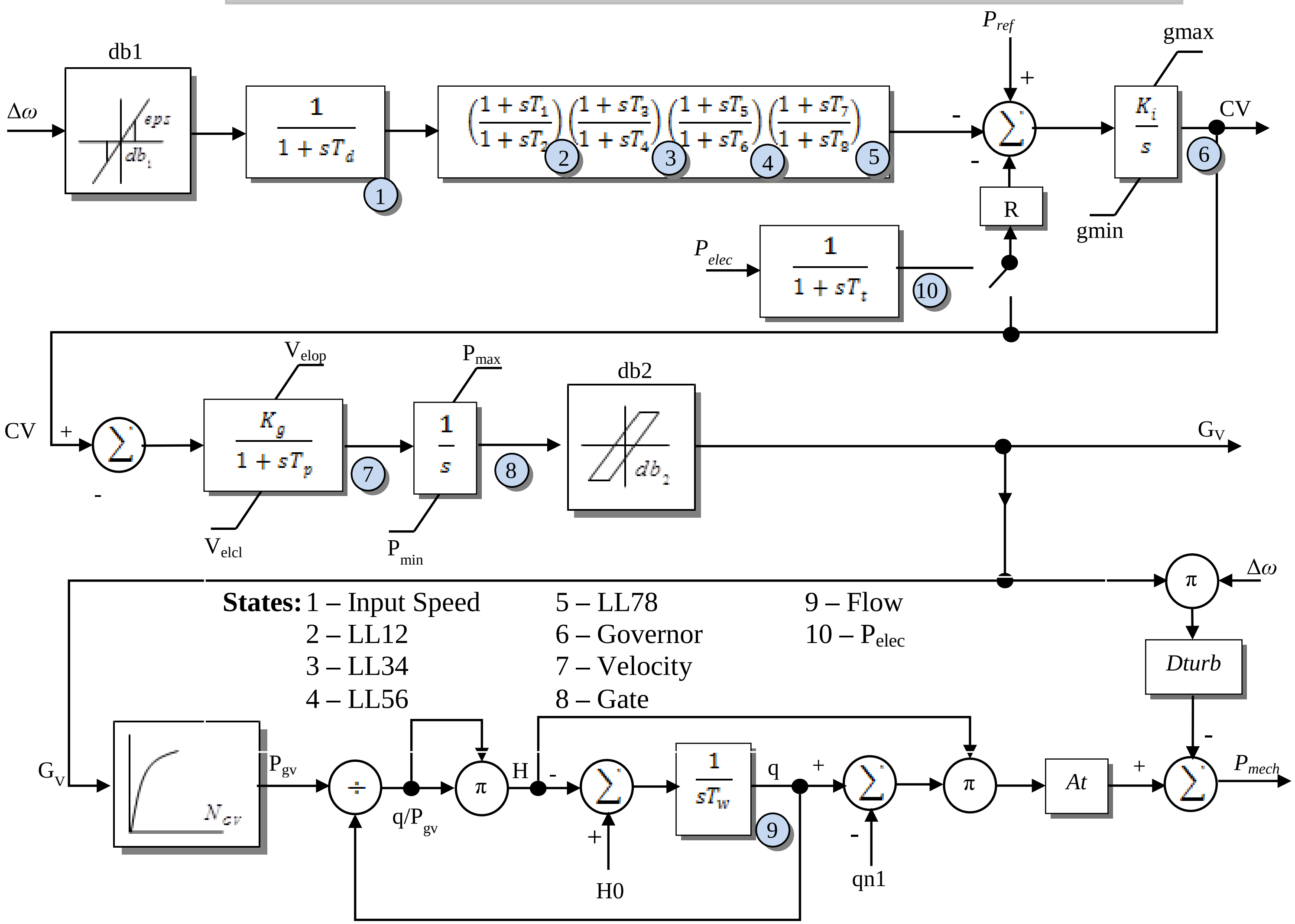
Bgv0...Bgv5, Bmax, Tblade not implemented in Simulator

GV0, PGV0...GV5, PGV5 are the x,y coordinates of N_{GV} block

Model supported by PSLF

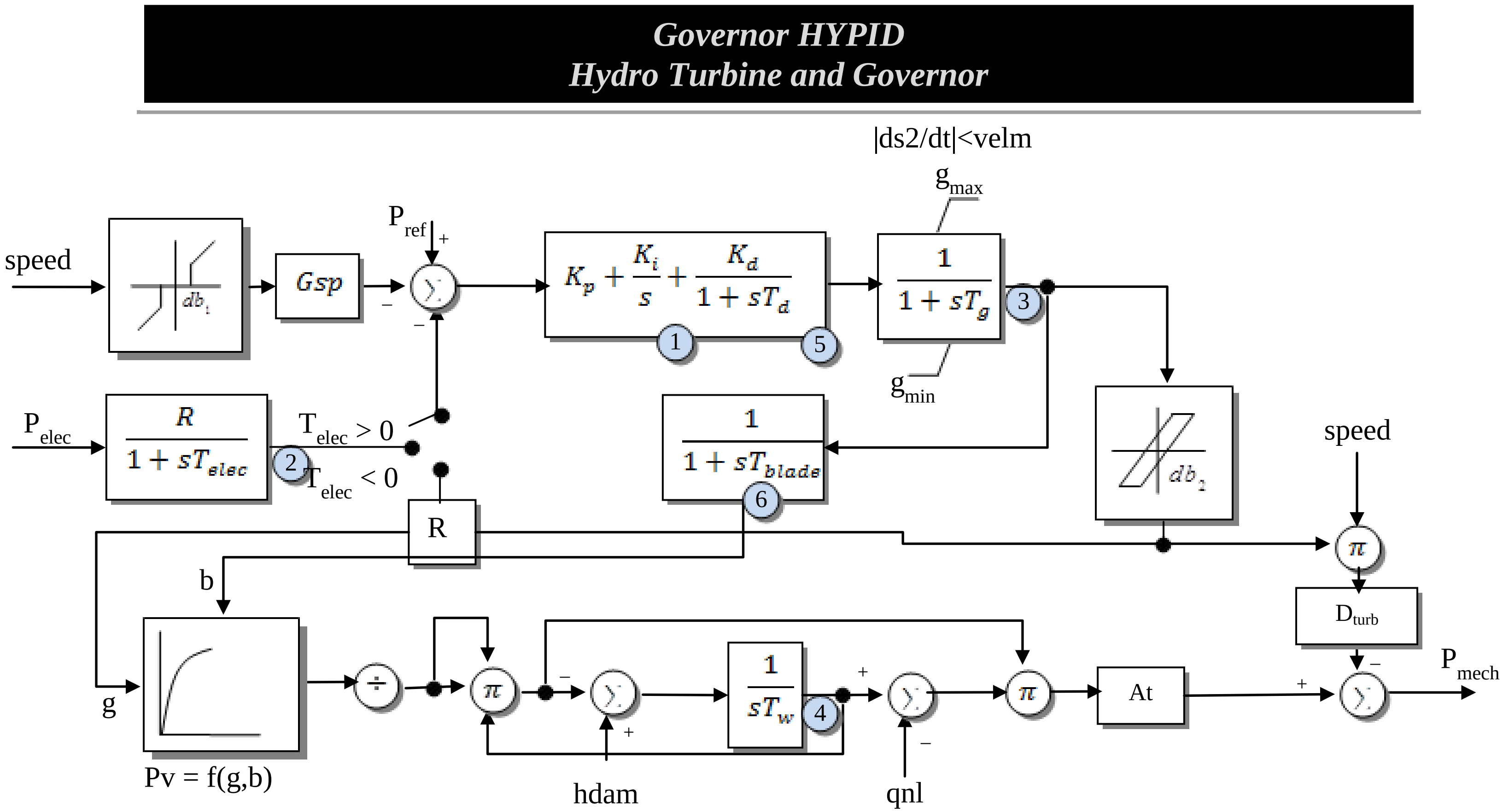
Governor HYGOVR

Fourth Order Lead-lag Governor and Hydro Turbine Model HYGOVR



Model supported by PSLF

Governor HYPID

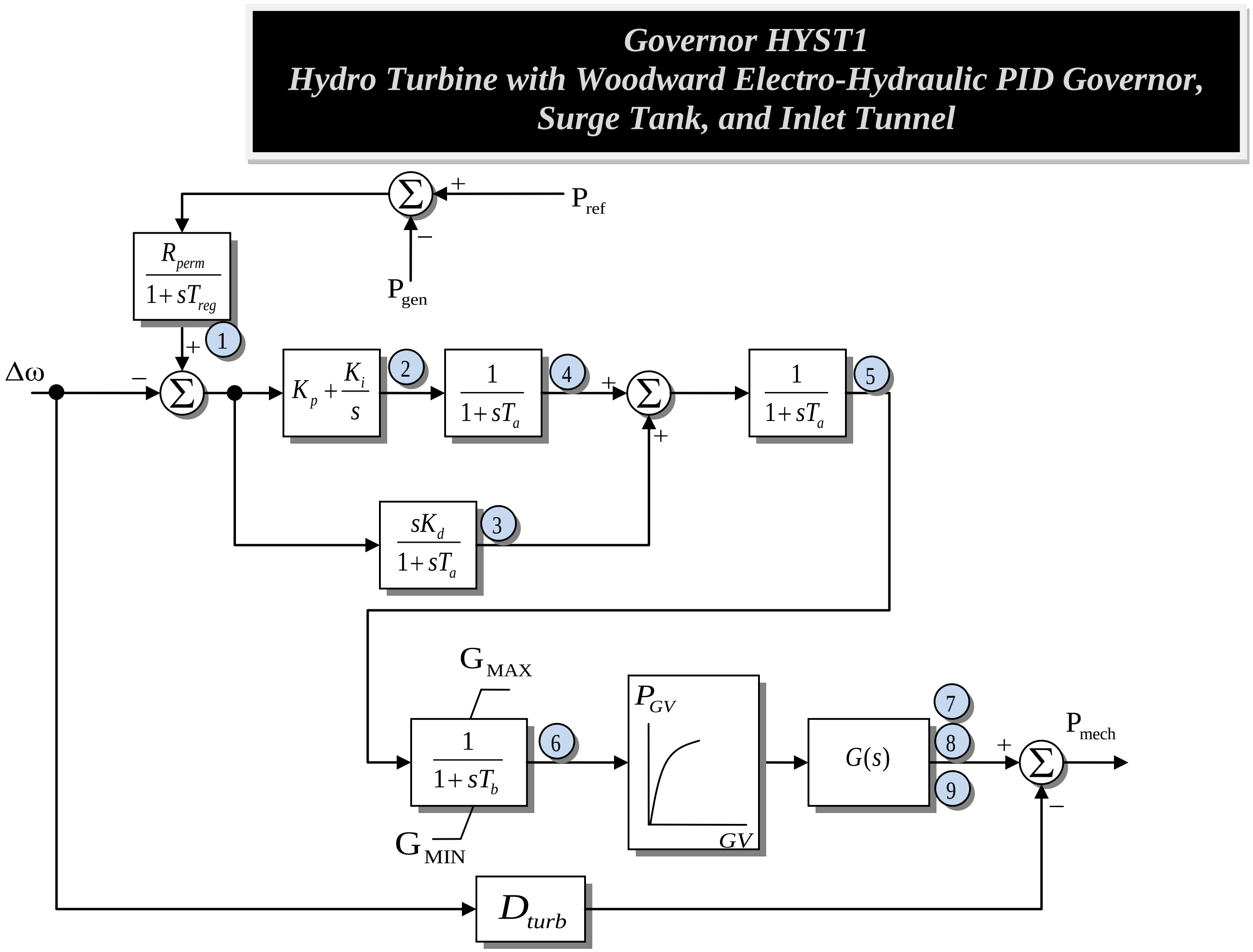


States:
1 – Ki
2 – RPelec
3 – Gate
4 – Turbine Flow
5 – Derivative
6 - Blade

+

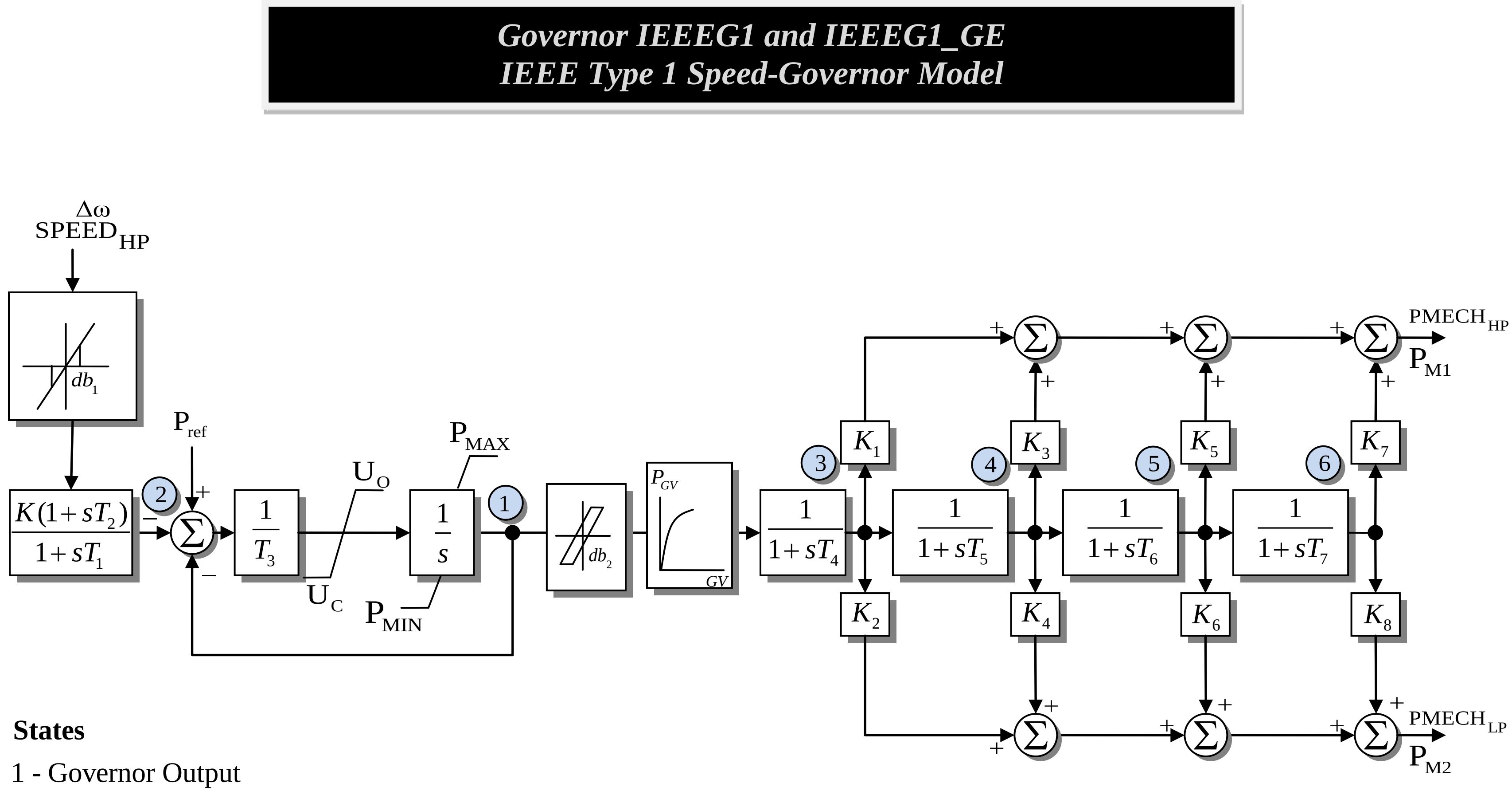
Model supported by PSLF

Governor HYST1



Not yet implemented in Simulator
Model supported by PSLF

Governor IEEEG1 and IEEEG1_GE



States

1 - Governor Output

2 - Lead-Lag

3 - Turbine Bowl

4 - Reheater

5 - Crossover

6 - Double Reheat

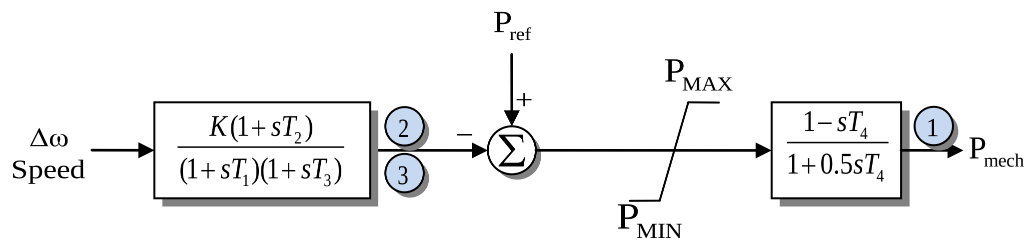
IEEEG1_GE is supported by PSLF. PowerWorld ignores the db2 term. All values are specified on the turbine rating which is a parameter in PowerWorld and PSLF. If the turbine rating is omitted or zero, then the generator MVABase is used. If there are two generators, then the SUM of the two MVABases is used.

IEEEG1 is supported by PSSE. PSSE does not include the db2, db1, non-linear gain term, or turbine rating. For the IEEEG1 model, if the turbine rating is omited then the MVABase of only the high-pressure generator is used.

GV1, PGV1...GV6, PGV6 are the x,y coordinates of P_{GV} vs. GV block

Governor IEEEG2

Governor IEEEG2
IEEE Type 2 Speed-Governor Model



States

1 - P_{mech}

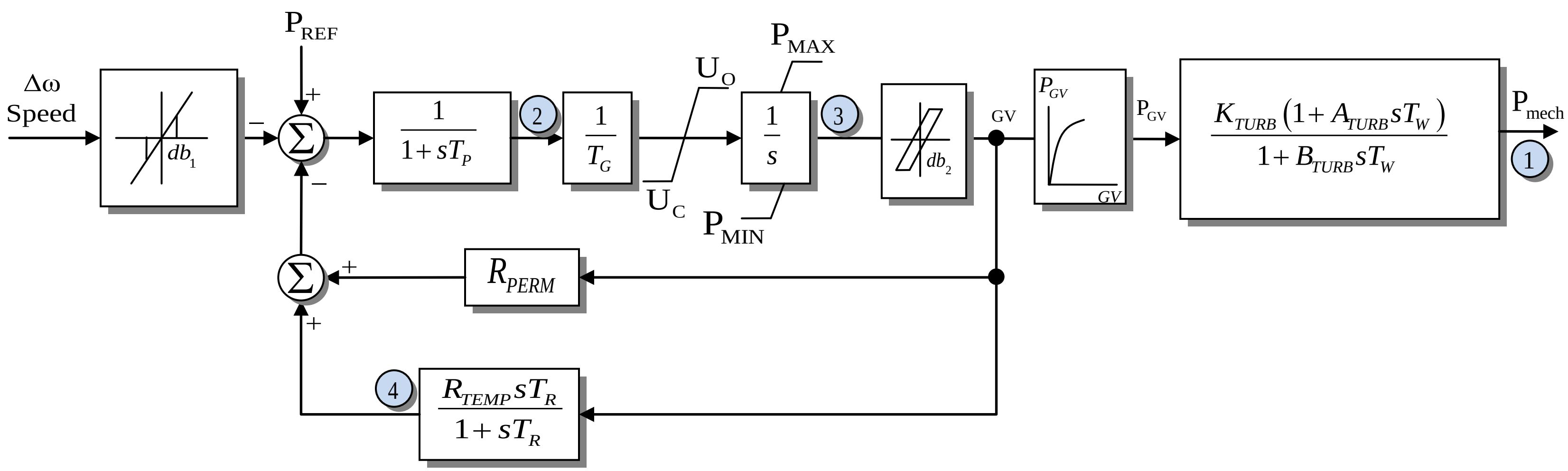
2 - First Integrator

3 - Second Integrator

Model supported by PSSE

Governor IEEEG3_GE

Governor IEEEG3_GE
IEEE Type 3 Speed-Governor Model IEEEG3



States

1 - P_{mech}

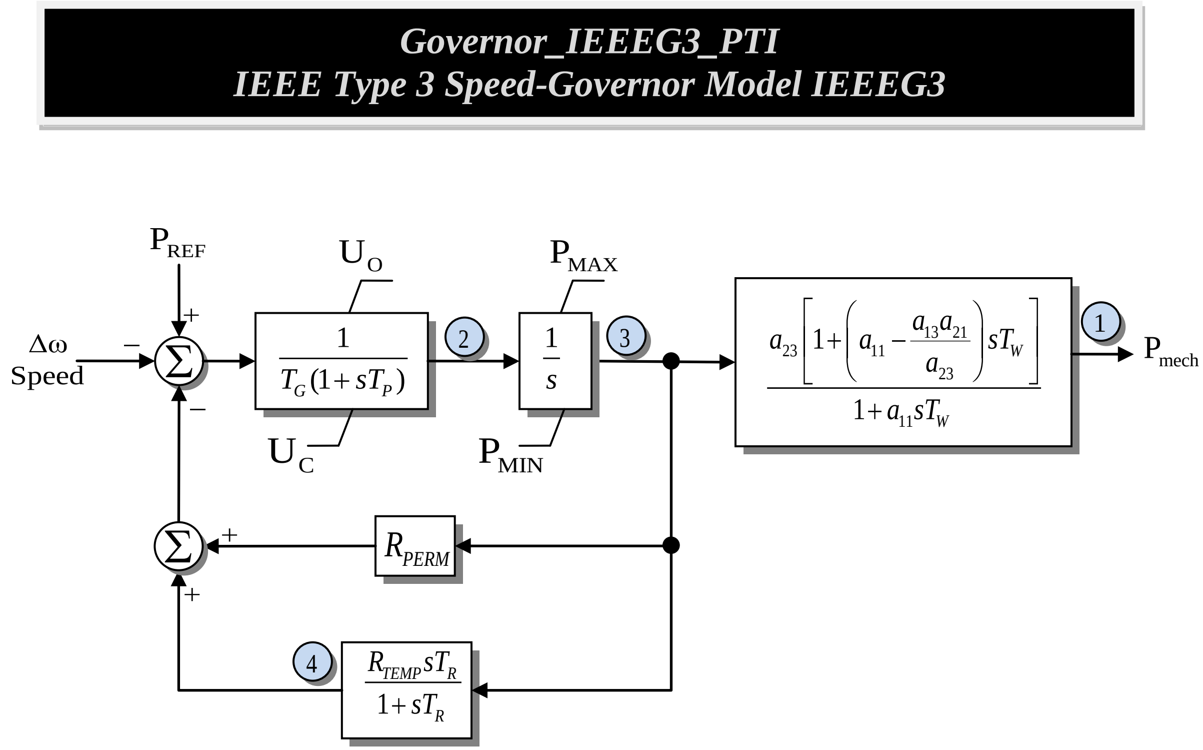
2 - Servomotor position

3 - Gate position

4 - Transient droop

PSLF model includes db1, db2, and Eps read but not implemented in Simulator
Model supported by PSLF

Governor IEEEG3_PTI



States

1 - P_{mech}

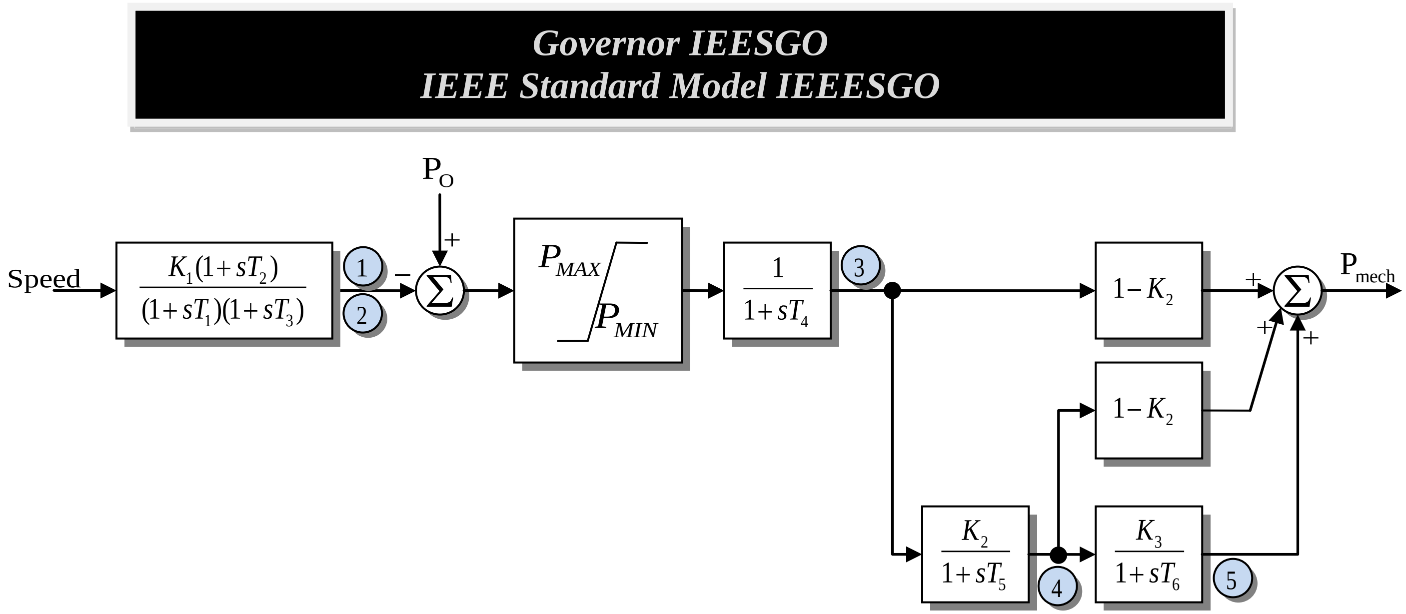
2 - Servomotor position

3 - Gate position

4 - Transient droop

Model supported by PSSE

Governor IEESGO



States

1 - First Integrator

2 - Second Integrator

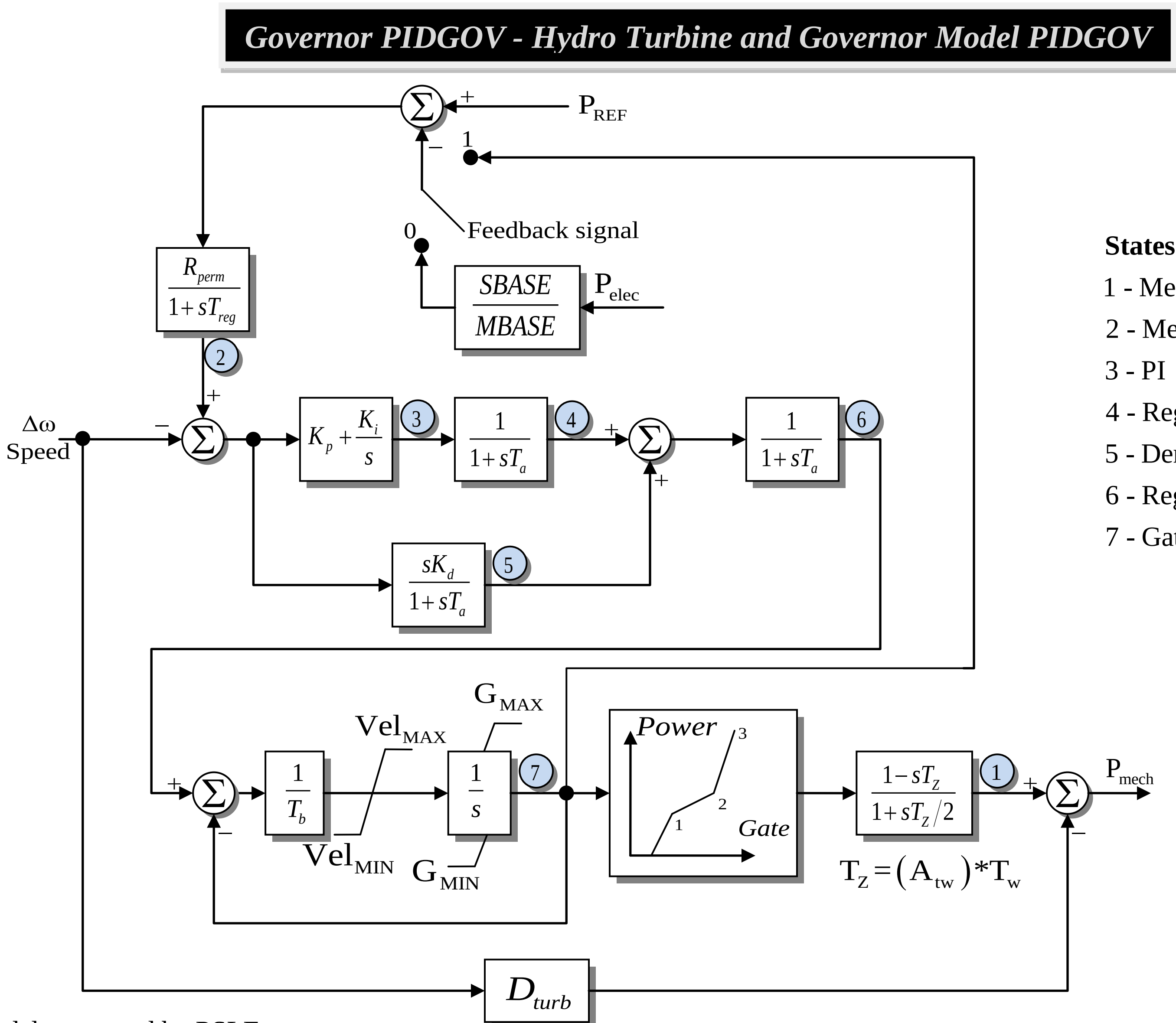
3 - Turbine T4

4 - Turbine T5

5 - Turbine T6

Model supported by PSSE

Governor PIDGOV



States

1 - Mechanical Output

2 - Measured Delta P

3 - PI

4 - Reg1

5 - Derivative

6 - Reg2

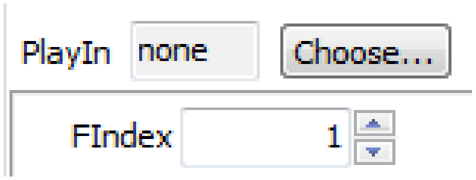
7 - Gate

Model supported by PSLF
Model supported by PSSE

(G0,0), (G1,P1), (G2,P2), (1,P3) are x,y coordinates of Power vs. Gate function

Governor PLAYINGOV

With the PLAYINGOV model, specify the index (FIndex) of a specified PlayIn structure. That signal will then be played into the model as the mechanical power (Pmech) during the simulation.



Governor SHAF25

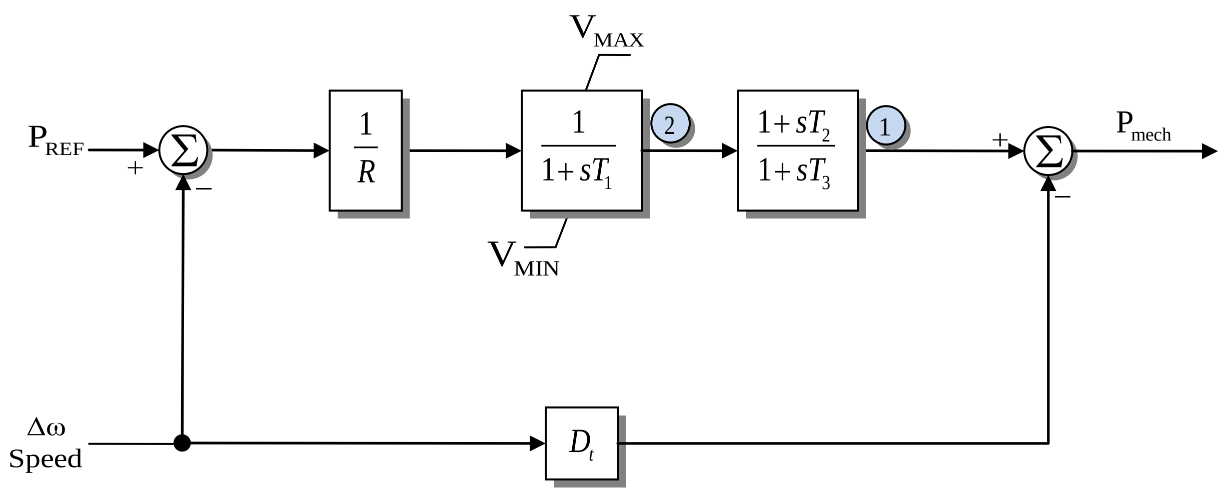
25 Masses Torsional Shaft Governor Model SHAF25

State #	State number containing delta speed
Var #	Variable number containing electrical torque
Xd - Xdp	X_d - X'_d
Tdop	T'_{do}
Exciter #	Exciter number
Gen #	Generator number
H 1 to H 25	H of mass 1 to H of mass 25
PF 1 to PF 25	Power fraction of 1 to power fraction of 25
D 1 to D 25	D of mass 1 to D of mass 25
K 1-2 to K 24-25	K shaft mass 1-2 to K shaft 25-25

Model supported by PSSE

Governor TGOV1

Governor TGOV1
Steam Turbine-Governor Model TGOV1



States

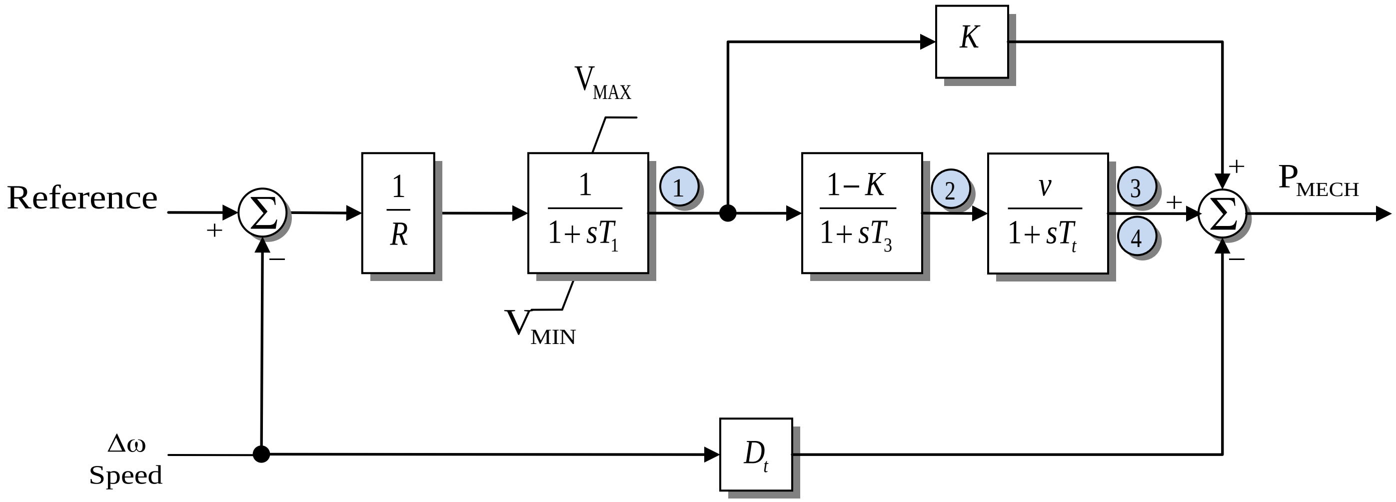
1 - Turbine Power

2 - Valve Position

Model supported by PSLF
Model supported by PSSE

Governor TGOV2

Governor TGOV2
Steam Turbine-Governor with Fast Valving Model TGOV2

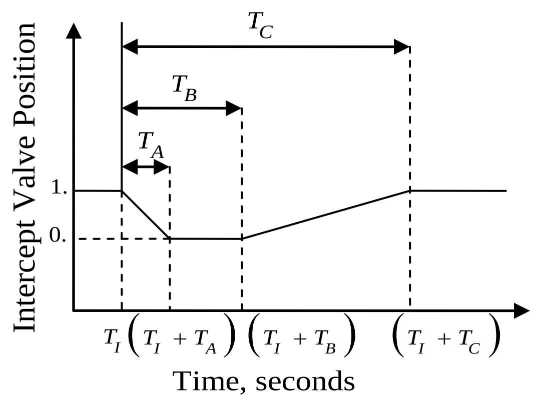


T_I: Time to initiate fast valving.

T_A: Intercept valve, *v*, fully closed T_A seconds after fast valving initiation.

T_B: Intercept valve starts to reopen T_B seconds after fast valving initiation.

T_C: Intercept valve again fully open T_C seconds after fast valving initiation.



States

1 - Throttle

2 - Reheat Pressure

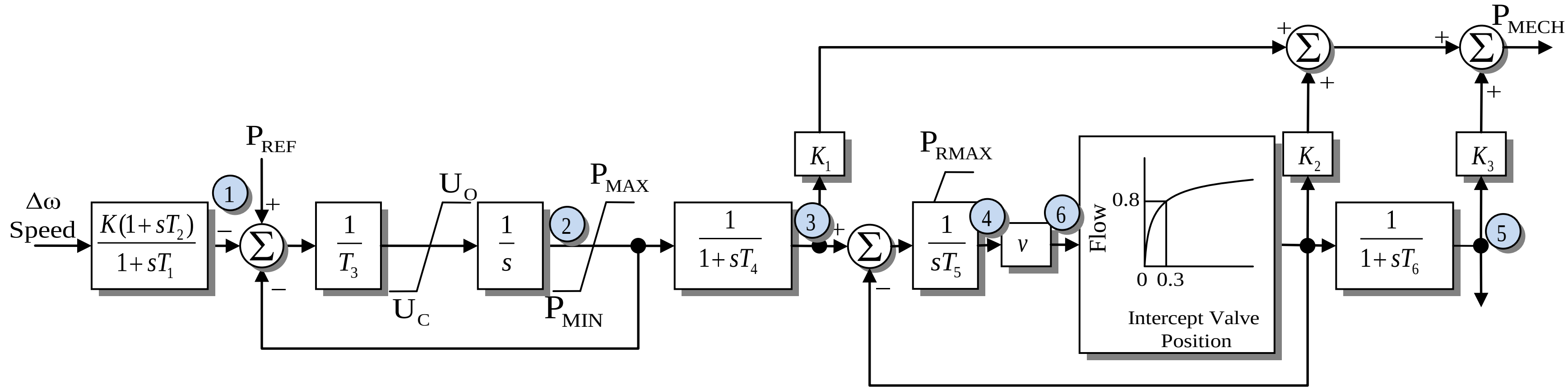
3 - Reheat Power

4 - Intercept Valve

Model supported by PSSE

Governor TGOV3

Governor TGOV3
Modified IEEE Type 1 Speed-Governor with Fast Valving Model

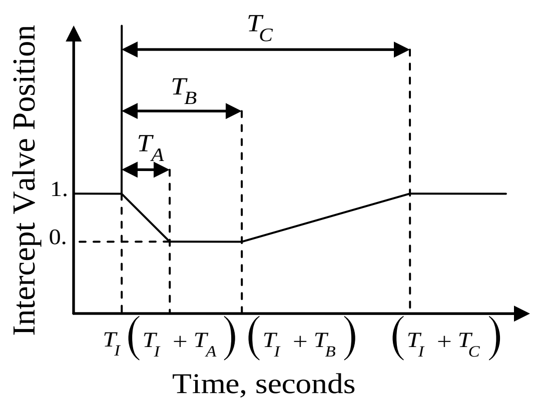


T_I: Time to initiate fast valving.

T_A: Intercept valve, *v*, fully closed T_A seconds after fast valving initiation.

T_B: Intercept valve starts to reopen T_B seconds after fast valving initiation.

T_C: Intercept valve again fully open T_C seconds after fast valving initiation.



States

1 - LL

2 - StateT3

3 - StateT4

4 - StateT5

5 - StateT6

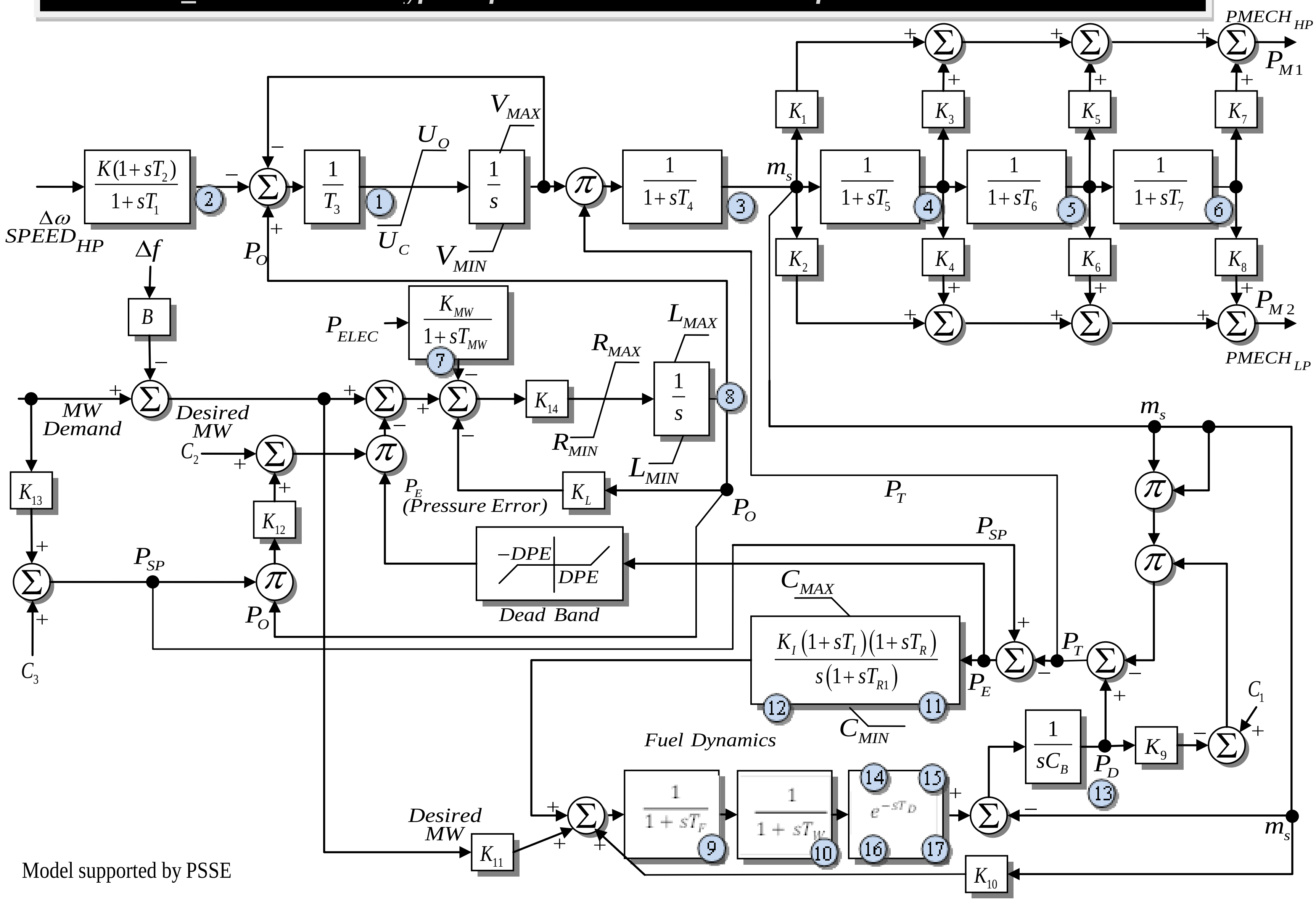
6 - Intercept Valve

Model supported by PSLF
Model supported by PSSE

Gv1,Pgv1 ... Gv6, Pgv6 are x,y coordinates of Flow vs. Intercept Valve Position function

Governor TGOV5

Governor_TGOV5 - IEEE Type 1 Speed-Governor Model Modified to Include Boiler Controls



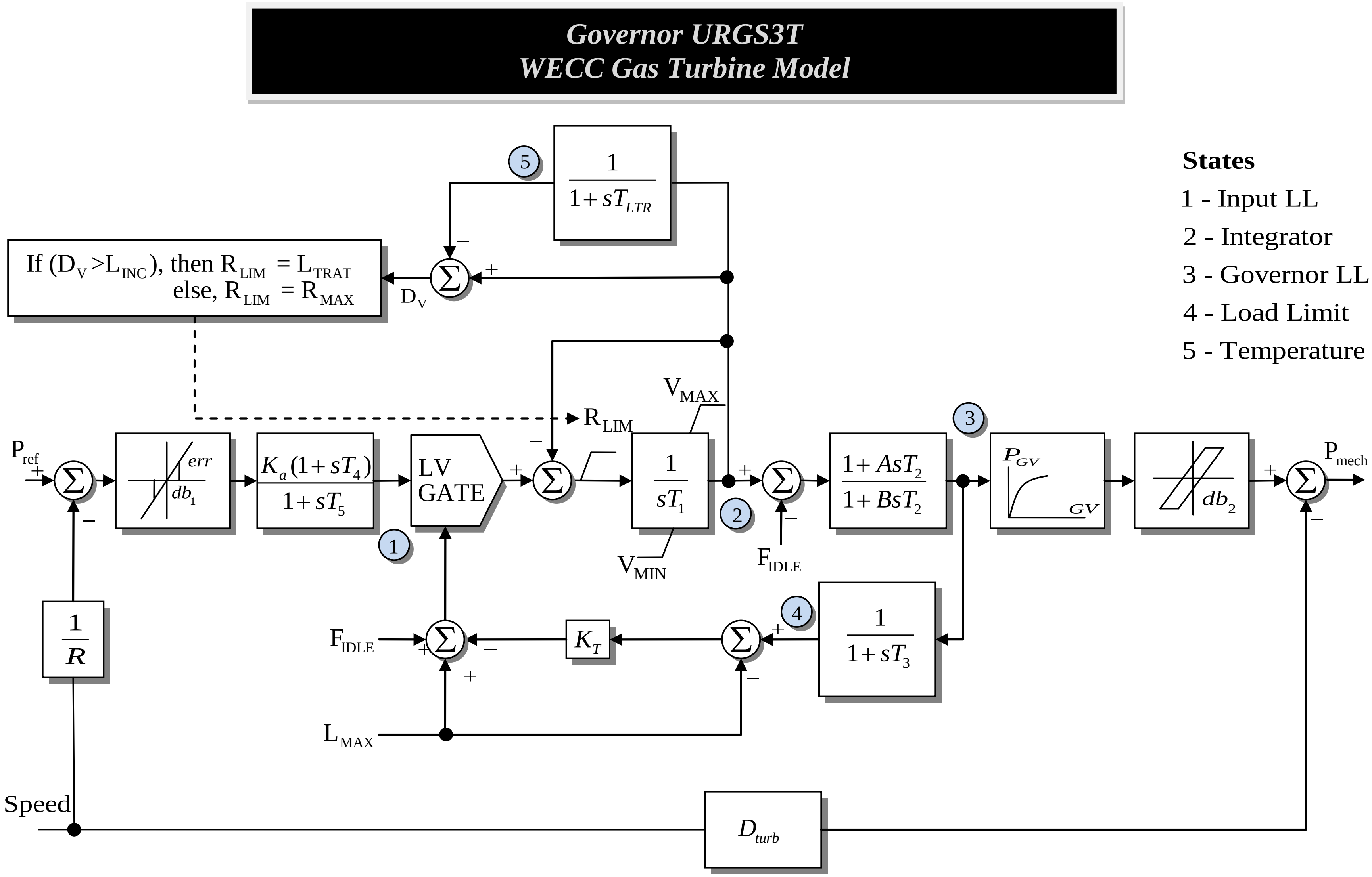
Model supported by PSSE

Governor_TGOV5 - IEEE Type 1 Speed-Governor Model Modified to Include Boiler Controls

States:
1 – Governor Output
2 – Speed Lead-Lag
3 – Turbine Bowl
4 – Reheater
5 – Crossover
6 – Double Reheat
7 – P_{ELEC}
8 – P_O
9 – FuelDyn1
10 – FuelDyn2
11 – Controller1
12 – Controller2
13 – P_D
14 – Delay1
15 – Delay2
16 – Delay3
17 – Delay4

Model supported by PSSE

Governor URGS3T

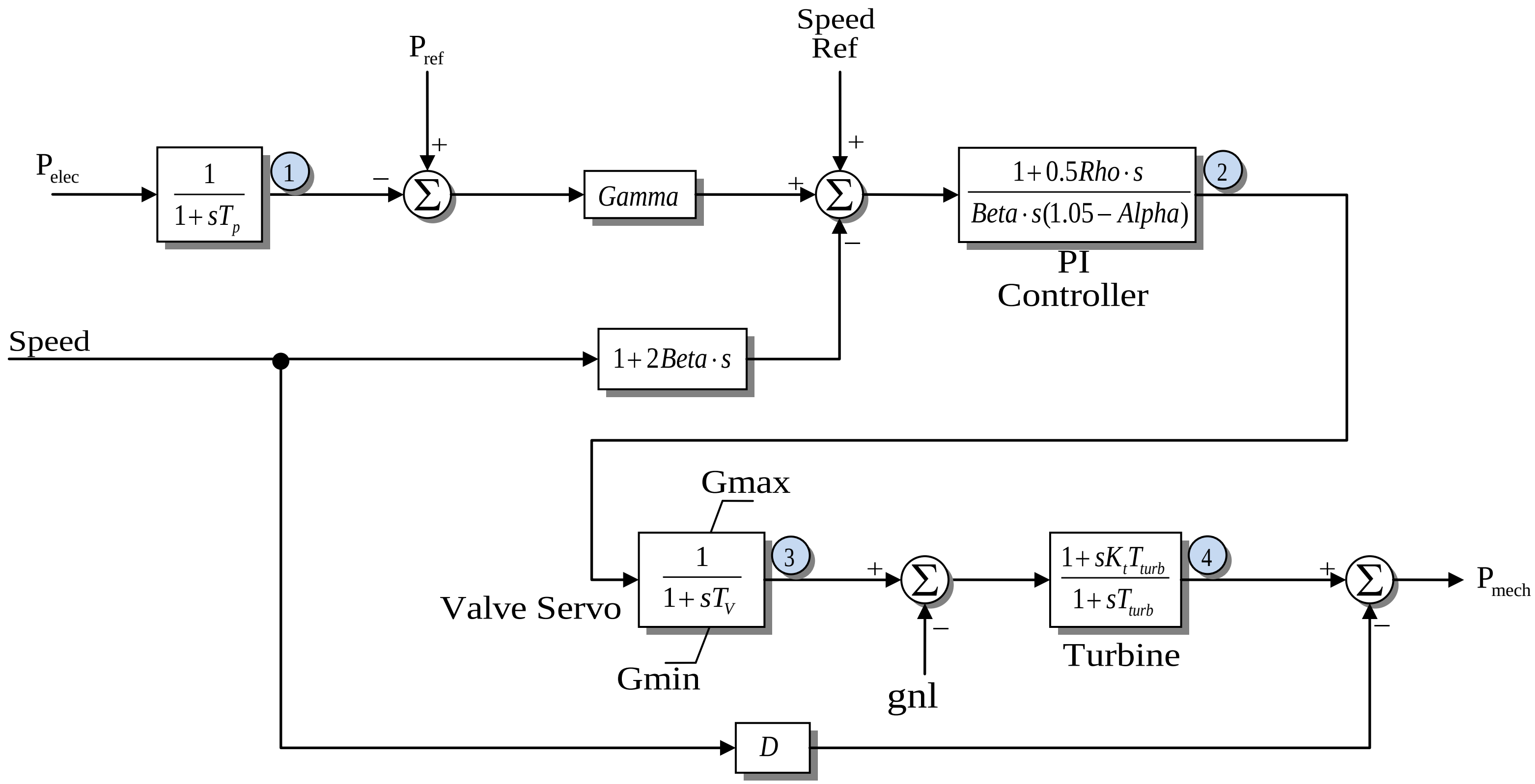


Model supported by PSSE

GV1, PGV1...GV5, PGV5 are the x,y coordinates of P_{GV} vs. GV block

Governor W2301

Governor W2301
Woodward 2301 Governor and Basic Turbine Model



States

1 - PelecSensed

2 - PI

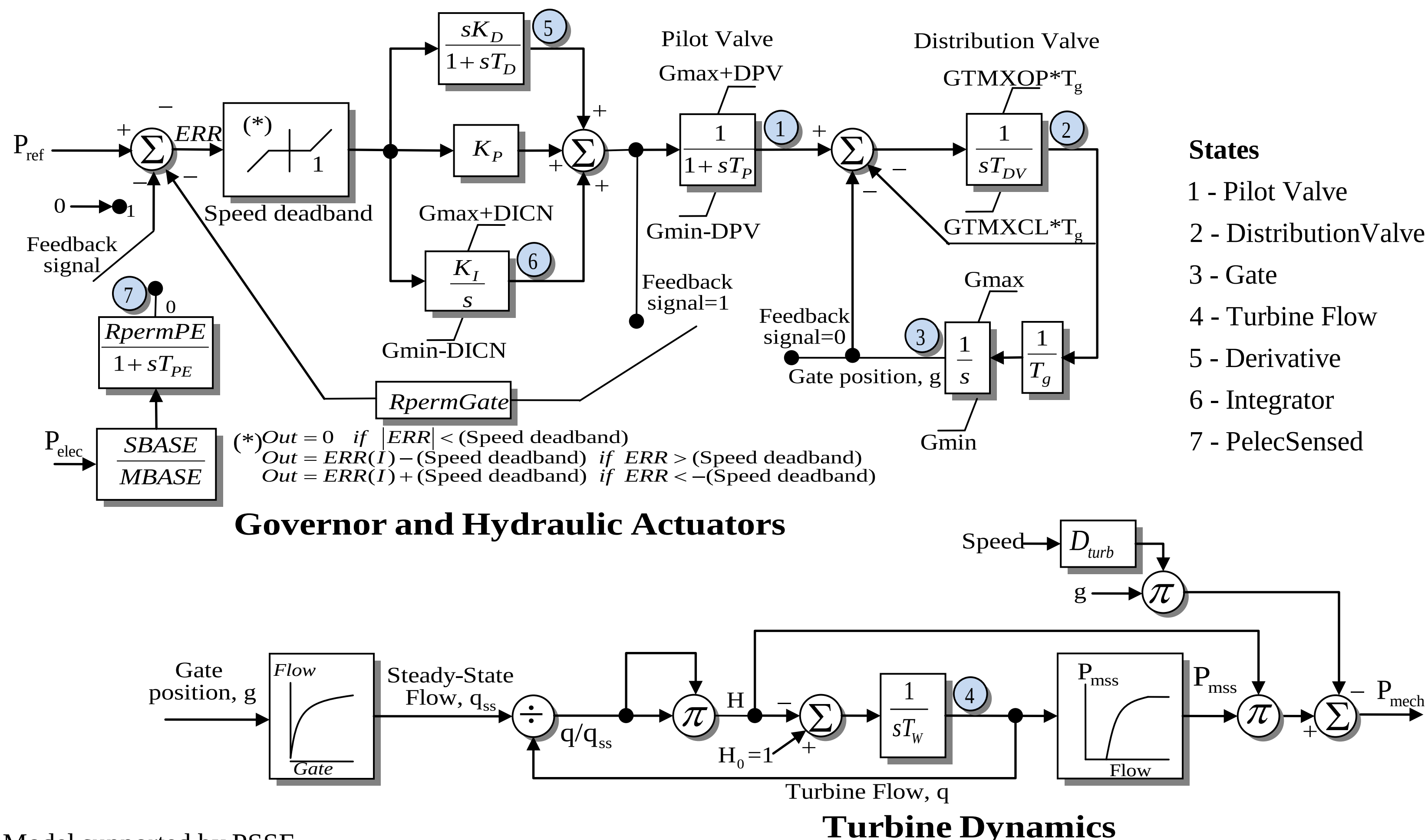
3 - Valve

4 - Turbine

Gain, Velamx read but not implemented in Simulator.
Model supported by PSLF

Governor WEHGOV

Governor WEHGOV
Woodward Electric Hvdro Governor Model



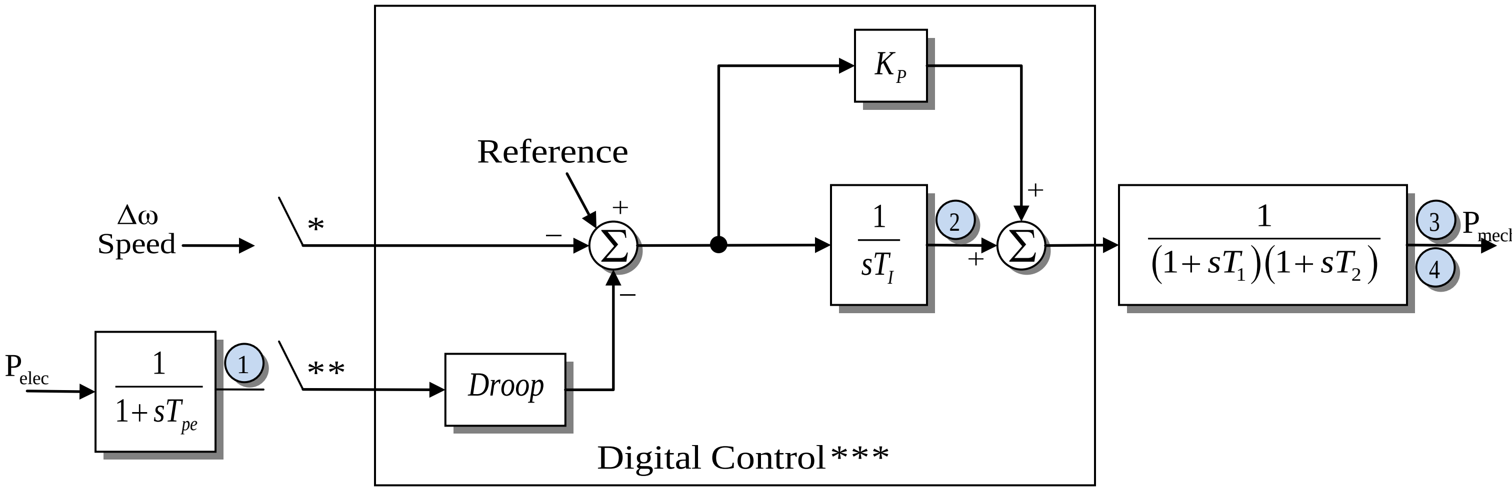
Model supported by PSSE

(Gate 1, Flow G1)...(Gate 5, Flow G5) are x,y coordinates of Flow vs. Gate function

(Flow P1, PMECH 1)...(Flow P10, PMECH 10) are x,y coordinates of Pmss vs. Flow function

Governor WESGOV

Governor WESGOV
Westinghouse Digital Governor for Gas Turbine Model



*Sample hold with sample period defined by Delta TC.
**Sample hold with sample period defined by Delta TP.
***Maximum change is limited to A_{lim} between sampling times.

States

1 - PEMeas

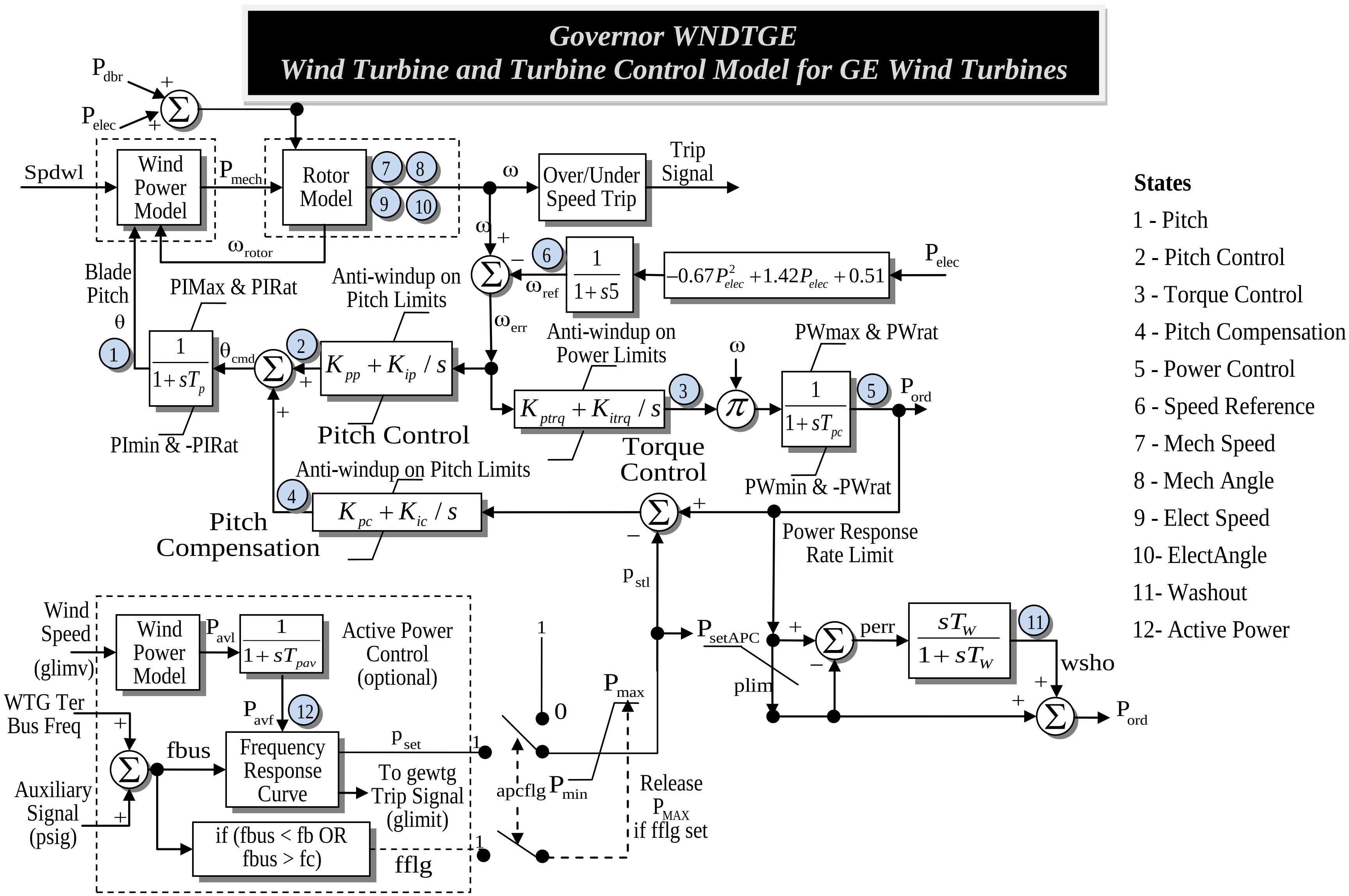
2 - Control

3 - Valve

4 - PMech

Model supported by PSSE
A_{lim} read but not implemented in Simulator

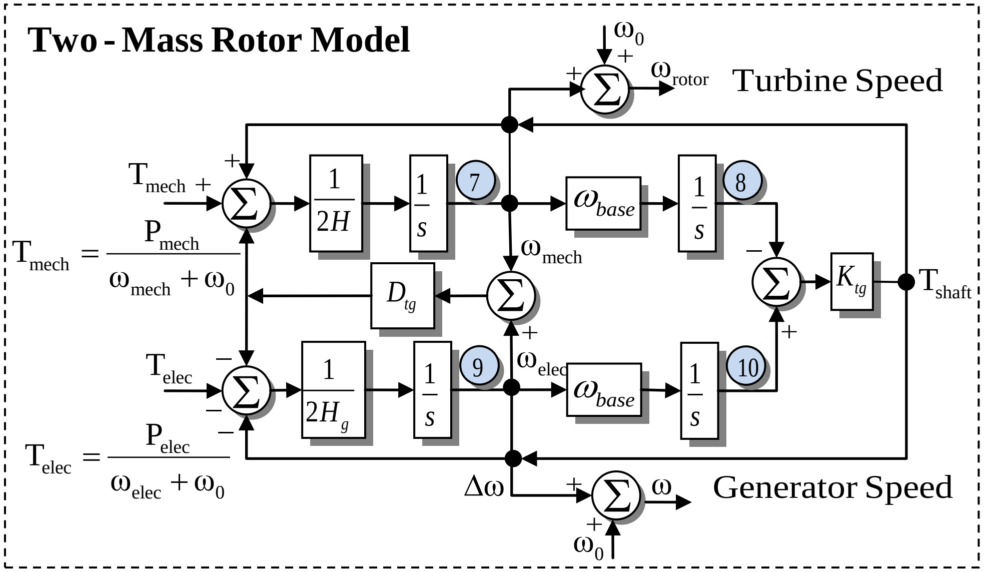
Governor WNDTGE



Model supported by PSLF

Apcflg is set to zero. Limits on states 2 and 3 and trip signal are not implemented. Simulator calculates initial windspeed Spdwl.

Governor WNDTGE
Wind Turbine and Turbine Control Model for GE Wind Turbines



Wind Power Model

$$P_{mech} = \frac{\rho}{2} A_r v_w^3 C_p(\lambda, \theta)$$

$$\lambda = K_b(\omega / v_w)$$

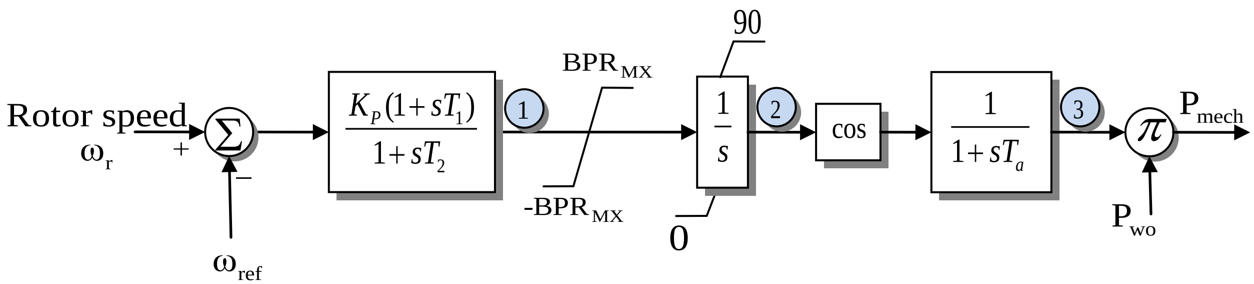
$$C_p(\lambda, \theta) = \sum_{i=0}^{4} \sum_{j=0}^{4} \alpha_{ij} \theta^i \lambda^j$$

See charts for curve fit values

Model supported by PSLF

Governor WNDTRB

Governor WNDTRB
Wind Turbine Control Model



States

1 - Input

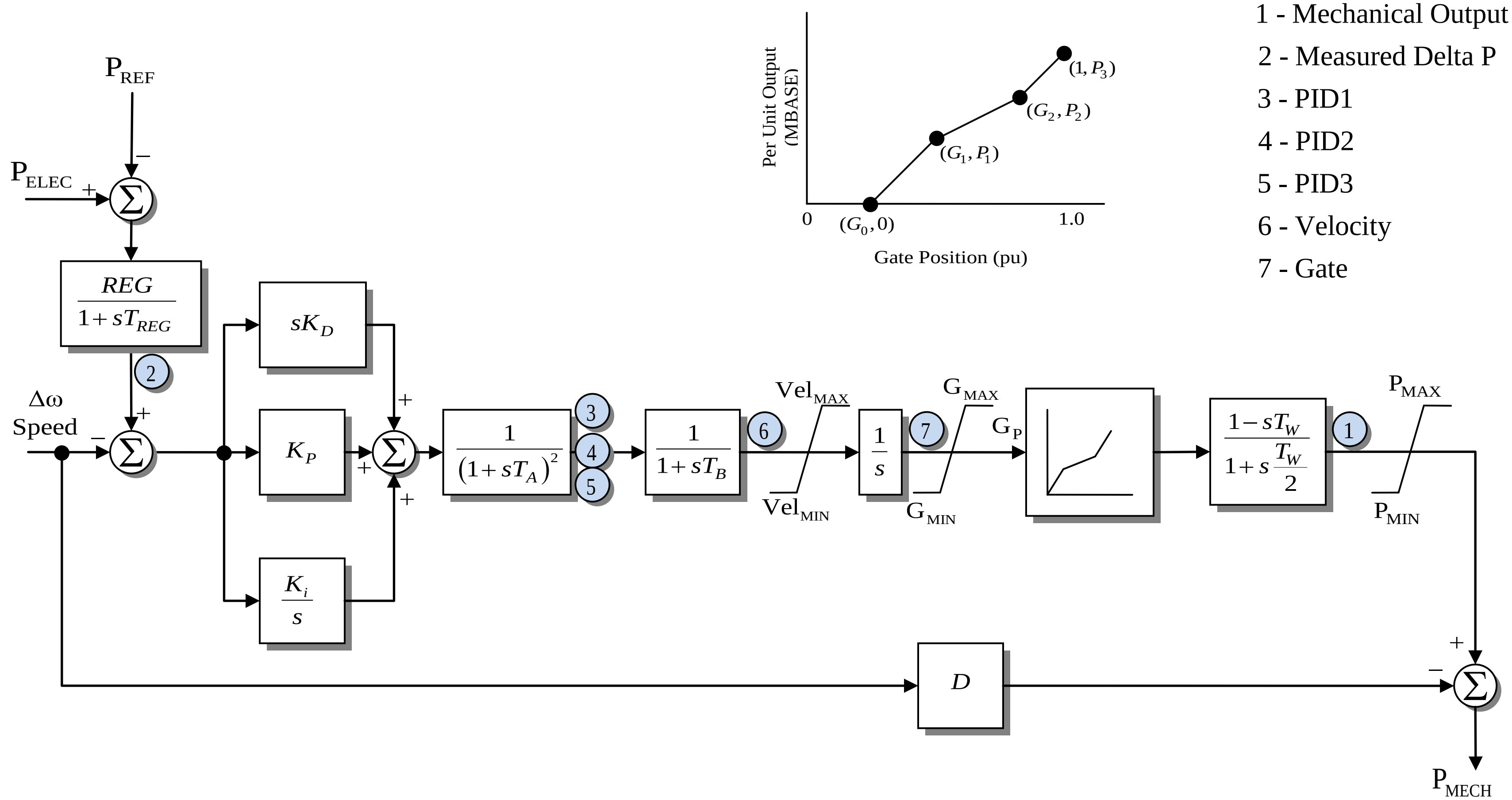
2 - Blade Angle (Deg)

3 - Blade Pitch Factor

Model supported by PSLF

Governor WPIDHY

Governor WPIDHY
Woodward PID Hydro Governor Model



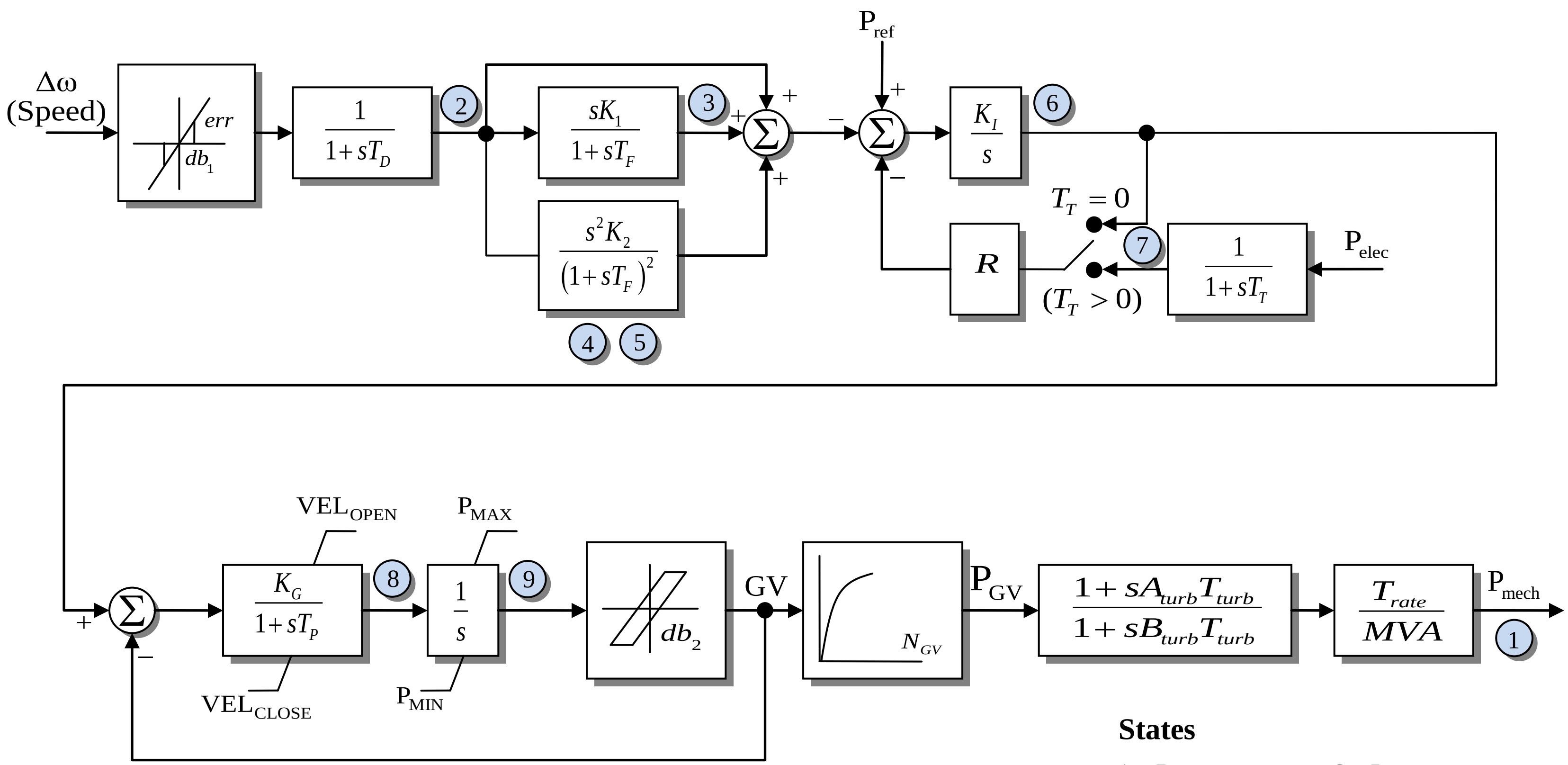
States

1 - Mechanical Output
2 - Measured Delta P
3 - PID1
4 - PID2
5 - PID3
6 - Velocity
7 - Gate

Model supported by PSSE

Governor WSHYDD

Governor WSHYDD
WECC Double-Derivative Hydro Governor Model



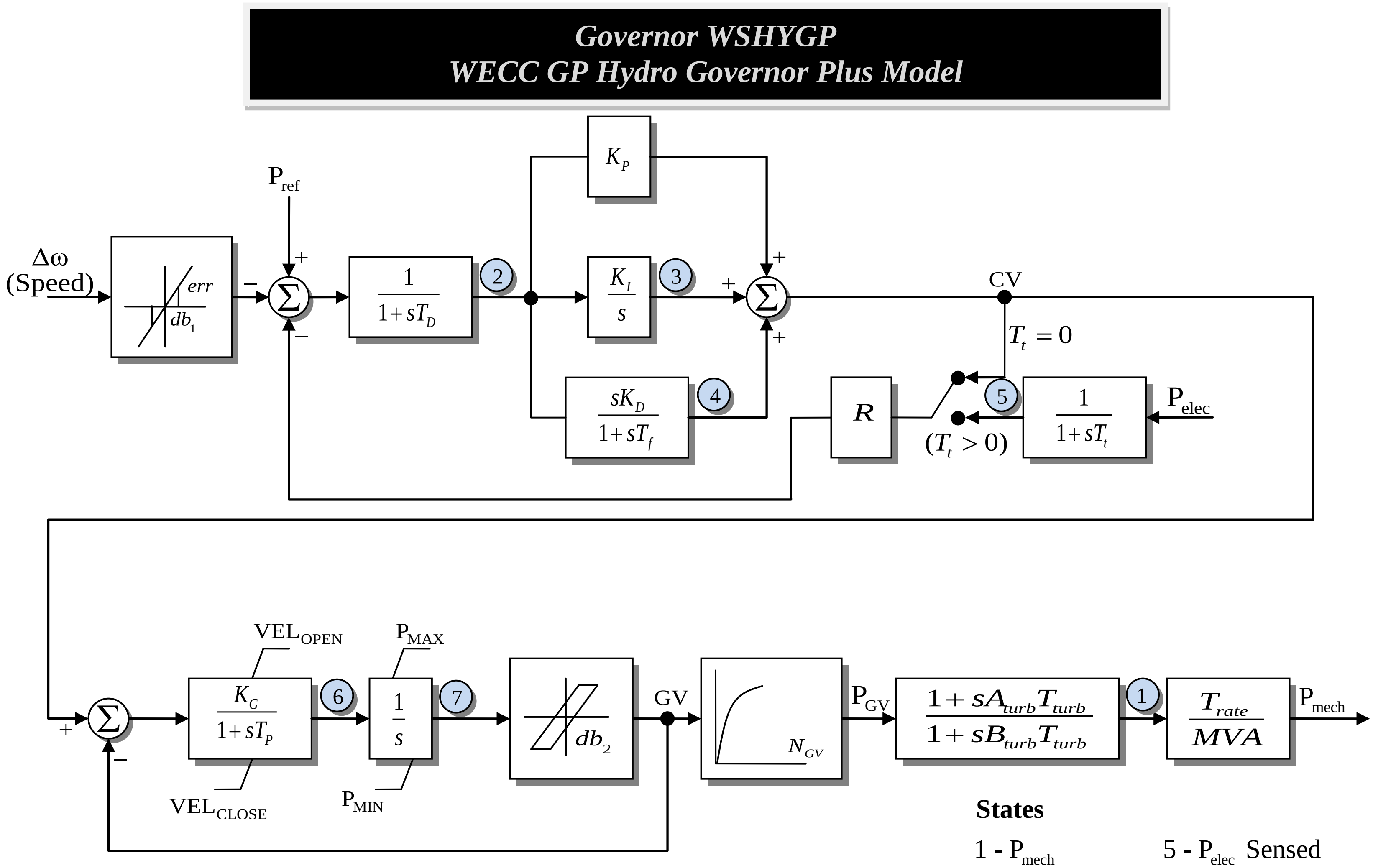
States

1 - P_{mech}
2 - T_D
3 - K_1
4 - K_2 first
5 - K_2 second
6 - Integrator
7 - P_{elec} Sensed
8 - Valve
9 - Gate

Model supported by PSSE

Inputs GV1, PGV1...GV5, PGV5 are the x,y coordinates of N_{GV} block

Governor WSHYGP



States

1 - P_{mech}

2 - T_D

3 - Integrator

4 - Derivative

5 - P_{elec} Sensed

6 - Valve

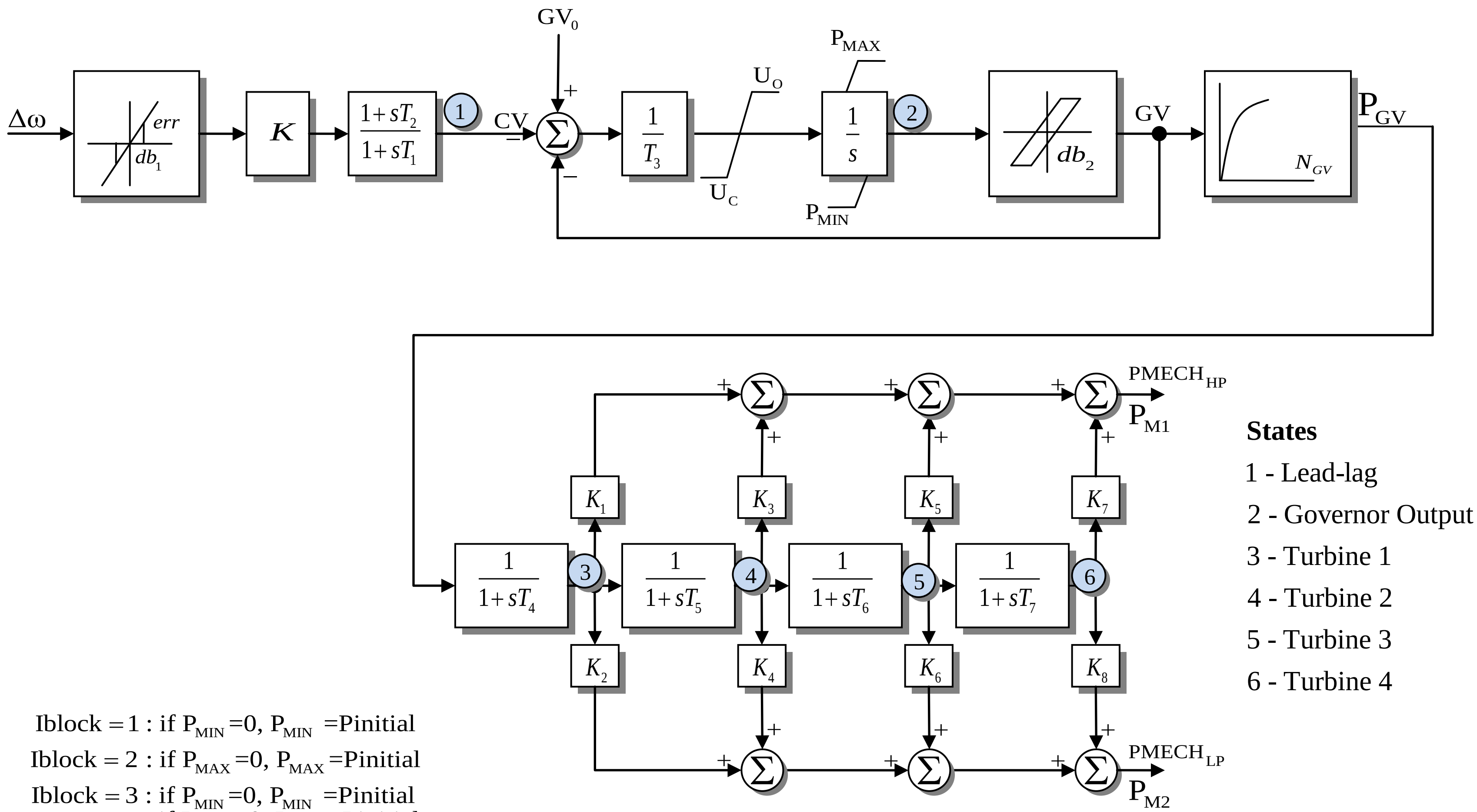
7 - Gate

Model supported by PSSE

GV1, PGV1...GV5, PGV5 are the x,y coordinates of N_{GV} block

Governor WSIEG1

Governor WSIEG1
WECC Modified IEEE Type 1 Speed-Governor Model



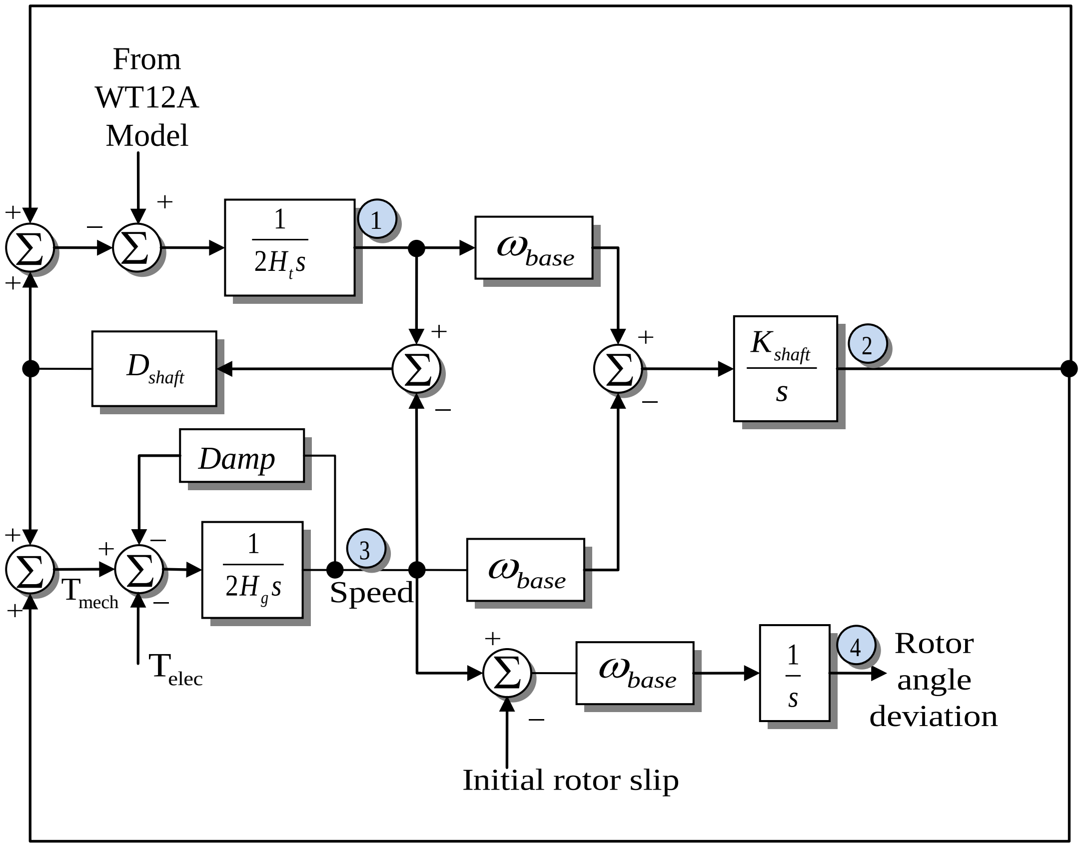
Iblock = 1 : if P_{MIN} =0, P_{MIN} =Pinitial
Iblock = 2 : if P_{MAX} =0, P_{MAX} =Pinitial
Iblock = 3 : if P_{MIN} =0, P_{MIN} =Pinitial
: if P_{MAX} =0, P_{MAX} =Pinitial

GV1, PGV1...GV5, PGV5 are the x,y coordinates of N_{GV} block

Model supported by PSSE

Governor WT12T1

Governor WT12T1
Two-Mass Turbine Model for Type 1 and Type 2 Wind Generators



$H_t = H \times H_{tfrac}$

$H_g = H - H_t$

$$K_{shaft} = \frac{2H_t \times H_g \times (2\pi \times Freq1)^2}{H \times \omega_0}$$

Model supported by PSSE

States

1 - TurbineSpeed

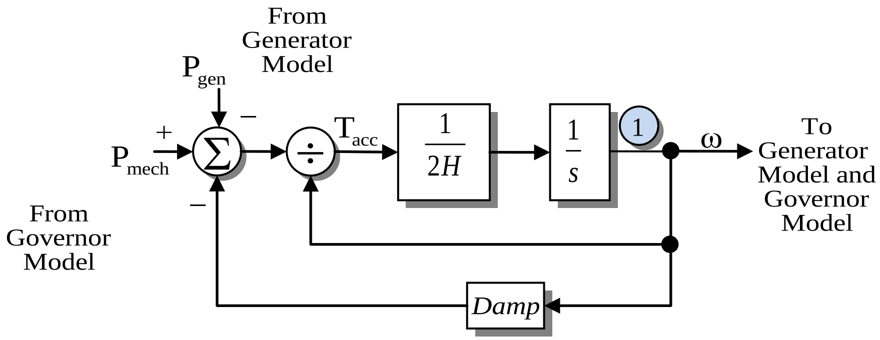
2 - ShaftAngle

3 - GenSpeed

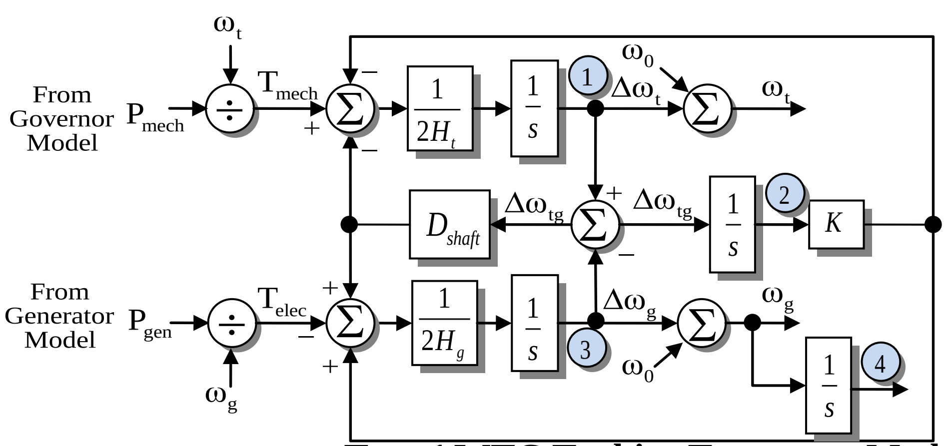
4 - GenDeltaAngle

Governor WT1T

Governor WT1T
Wind Turbine Model for Type-1 Wind Turbines



Type 1 WTG Turbine One-mass Model



Type 1 WTG Turbine Two-mass Model

States

1 - TurbineSpeed
2 - ShaftAngle
3 - GenSpeed
4 - GenDeltaAngle

$H_t = H \times H_{tfrac}$

$H_g = H - H_t$

$$K = \frac{2H_t \times H_g \times (2\pi \times Freq1)^2}{H}$$

Model supported by PSLF

Governor WT2T

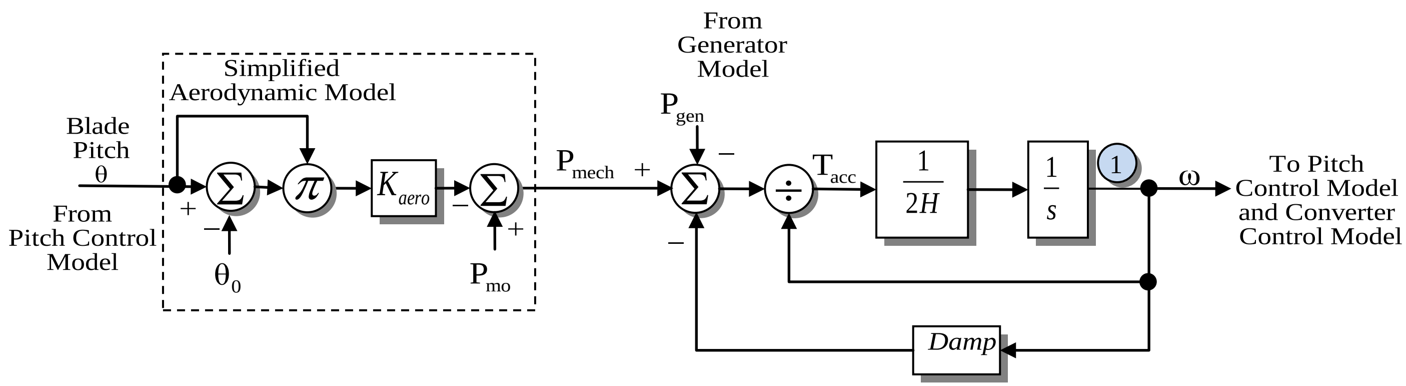
Governor Model WT2T

H	Inertia
Damp	Damping factor
Htfrac	Turbine inertia fraction
Freq1	First shaft torsional frequency
DShaft	Shaft damping factor

Model supported by PSLF

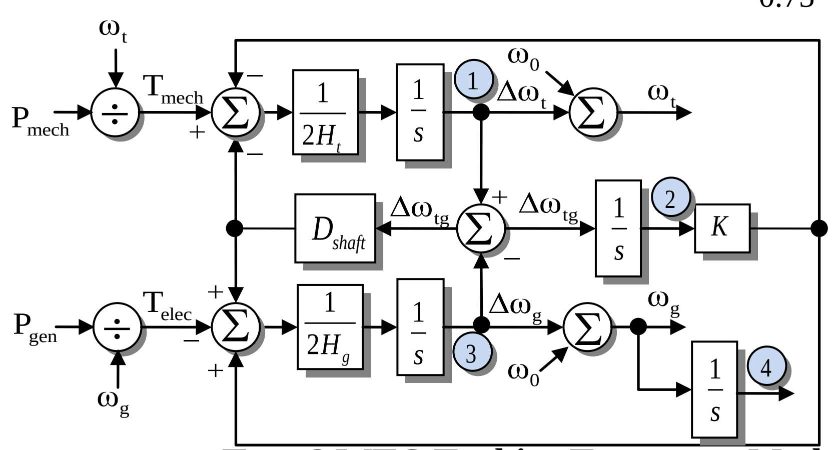
Governor WT3T

Governor WT3T
Wind Turbine Model for Type-3 (Doubly-fed) Wind Turbines



Type 3 WTG Turbine One-mass Model

When windspeed > rated windspeed, blade pitch initialized to $\theta = \frac{Theta2}{0.75}\left(1 - \frac{1}{V_W^{\ 2}}\right)$



Type 3 WTG Turbine Two-mass Model

States

1 - TurbineSpeed

2 - ShaftAngle

3 - GenSpeed

4 - GenDeltaAngle

$H_t = H \times H_{tfrac}$

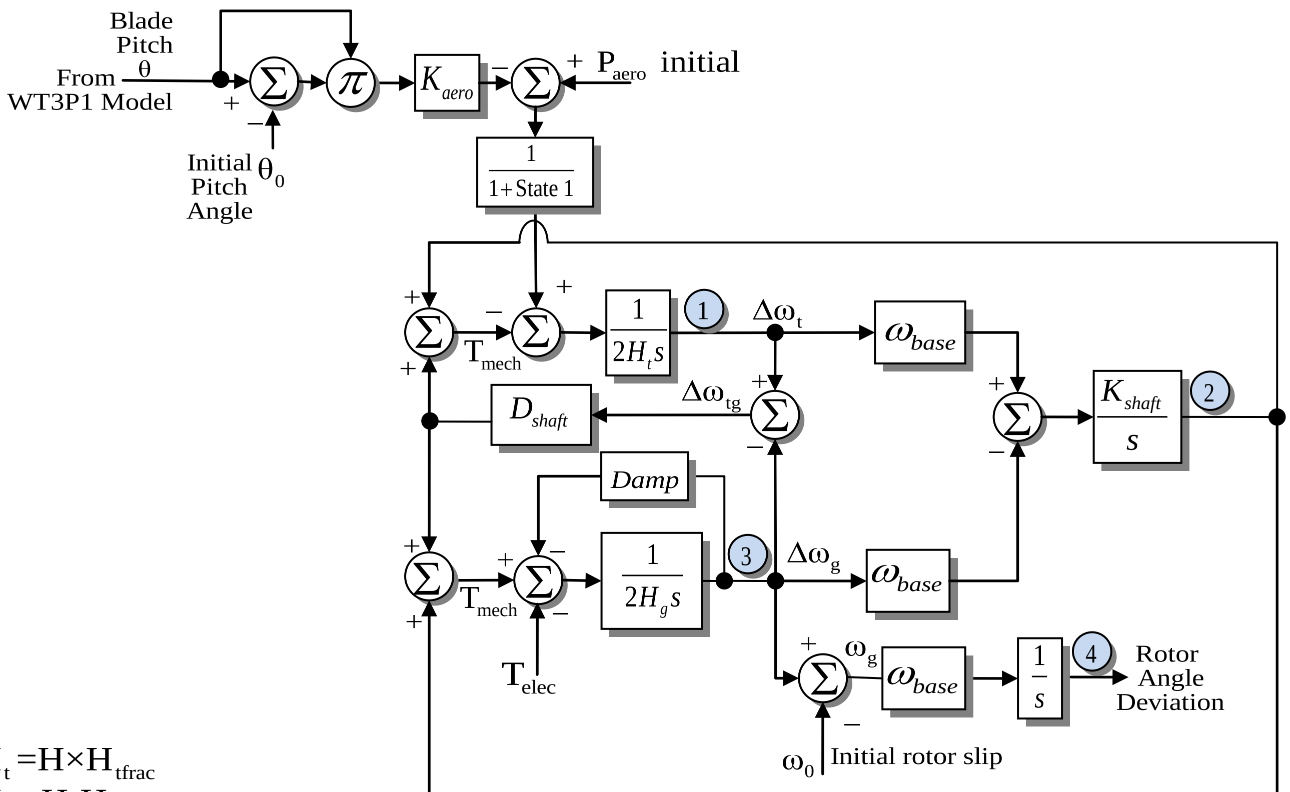
$H_g = H - H_t$

$$K = \frac{2H_t \times H_g \times (2\pi \times Freq1)^2}{H}$$

Model supported by PSLF

Governor WT3T1

Governor WT3T1
Mechanical System Model for Type 3 Wind Generator



$$H_t = H \times H_{tfrac}$$

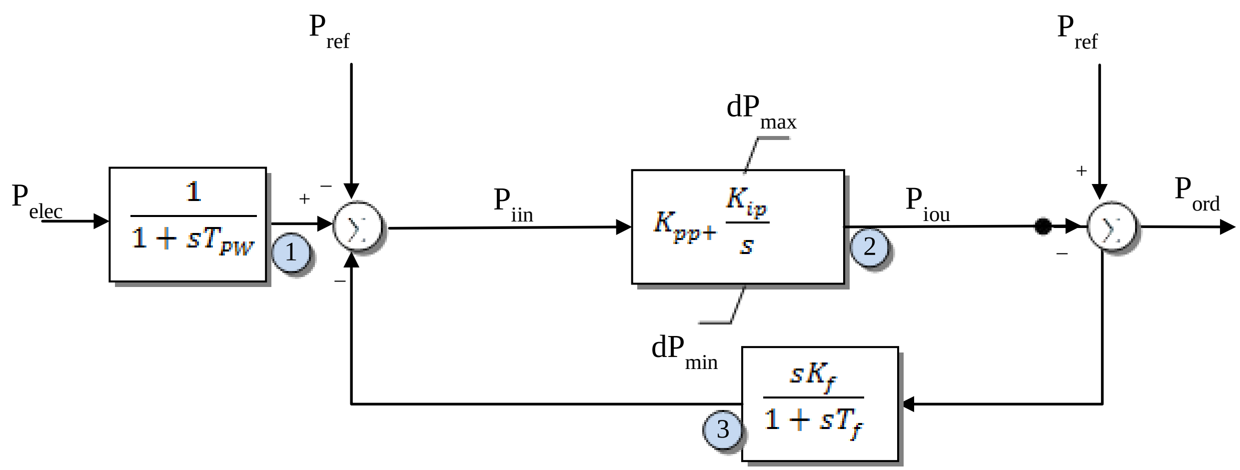
$$H_g = H - H_t$$

$$K_{shaft} = \frac{2H_t \times H_g \times (2\pi \times Freq1)^2}{H \times \omega_0}$$

Model supported by PSSE

Governor WT4T

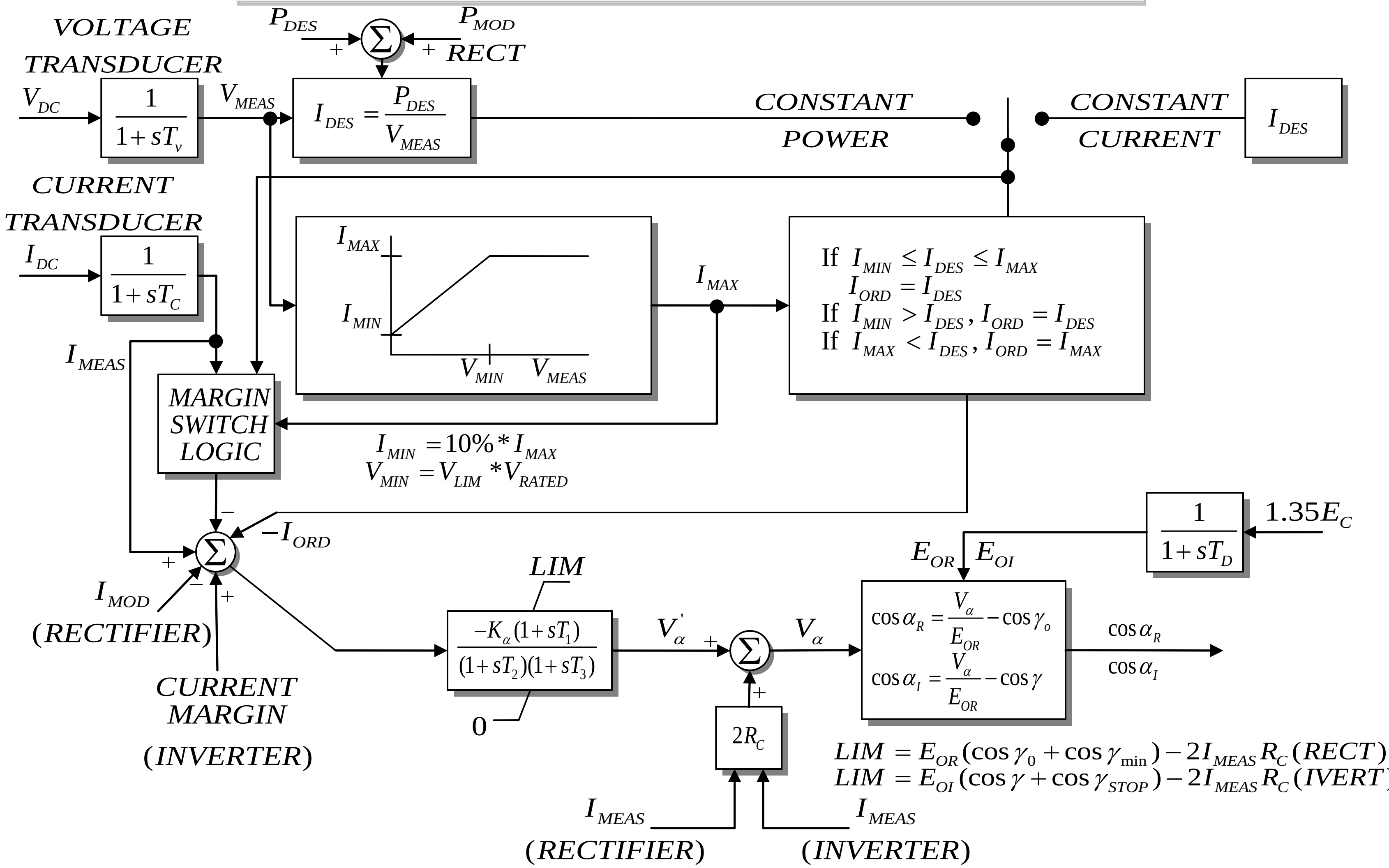
Governor WT4T
Simplified Type-4 (Full Converter) Wind Turbine



States:
1 – Pelec
2 – PIOut
3 – Feedback

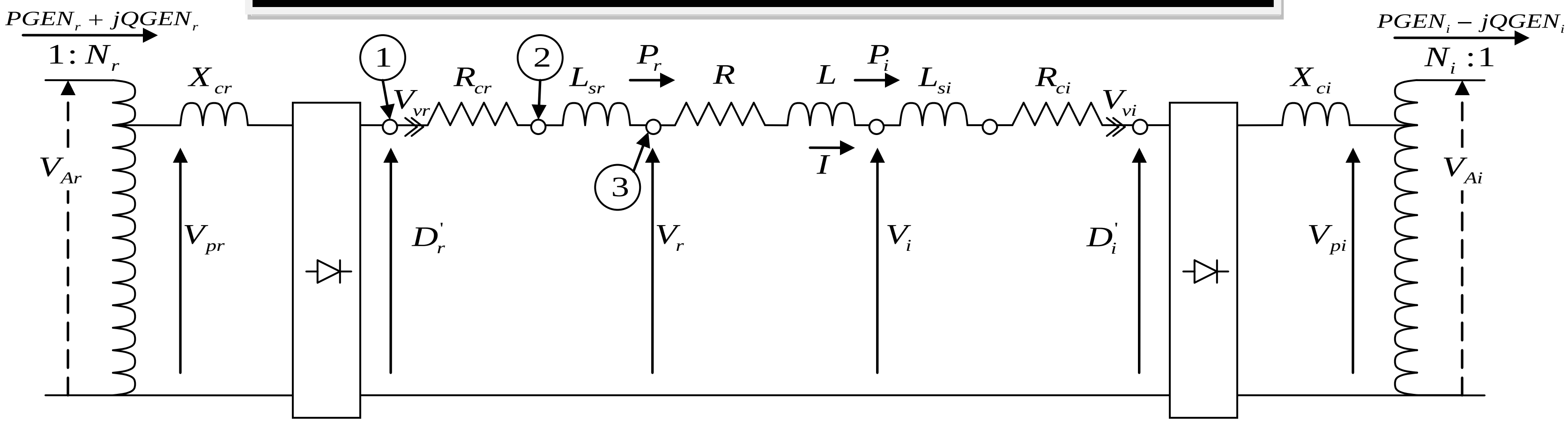
Model supported by PSSE

HVDC
Two Terminal DC Control Diagram



Available in old BPA IPF software

HVDC
WSCC Stability Program Two-Terminal DC Line Model



$$E_r = \frac{3\sqrt{2}}{\pi} N_r V_{AR} = \frac{3\sqrt{2}}{\pi} V_{pr} \qquad \cos\gamma_r = \frac{IX_{cr}}{\sqrt{2}V_{pr}} - \cos\theta_r$$

$$E_i = \frac{3\sqrt{2}}{\pi} N_i V_{Ai} = \frac{3\sqrt{2}}{\pi} V_{pi} \qquad \cos\beta_i = \cos\theta_i - \frac{IX_{ci}}{\sqrt{2}V_{pi}}$$

$$D_r' = E_r \cos\alpha - \frac{3I}{\pi} X_{cr} \qquad \mathrm{PGEN}_r = D_r' I$$

$$D_i' = E_i \cos\alpha - \frac{3I}{\pi} X_{ci} \qquad \mathrm{PGEN}_i = D_i' I$$

$$\cos\theta_r = \frac{D_r'}{E_r} \qquad \cos\theta_i = \frac{D_i'}{E_i}$$

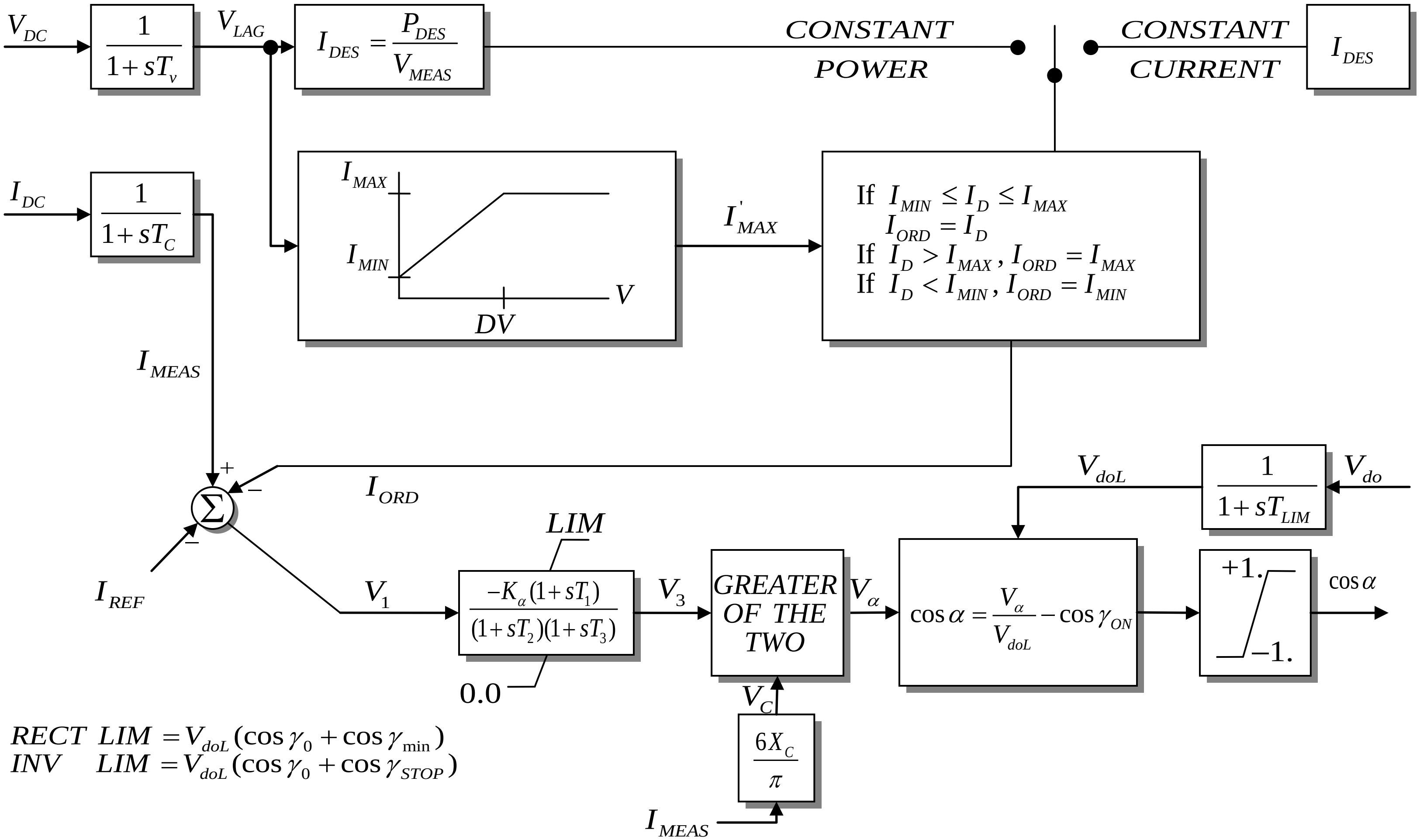
$$I'' = (E_r \cos\alpha_{MIN} - E_i \cos\gamma_{MIN} - V_{vr} - V_{vi}) / R_{TOT}$$

$$I''' = (E_r \cos\alpha_{MIN} + E_i \cos\gamma_{STOP} - V_{vr} - V_{vi}) / R_{TOT}$$

$$\text{WHERE } R_{TOT} = R + R_{cr} + R_{ci} + \frac{3}{\pi}(X_{cr} - X_{ci})$$

Available in old BPA IPF software

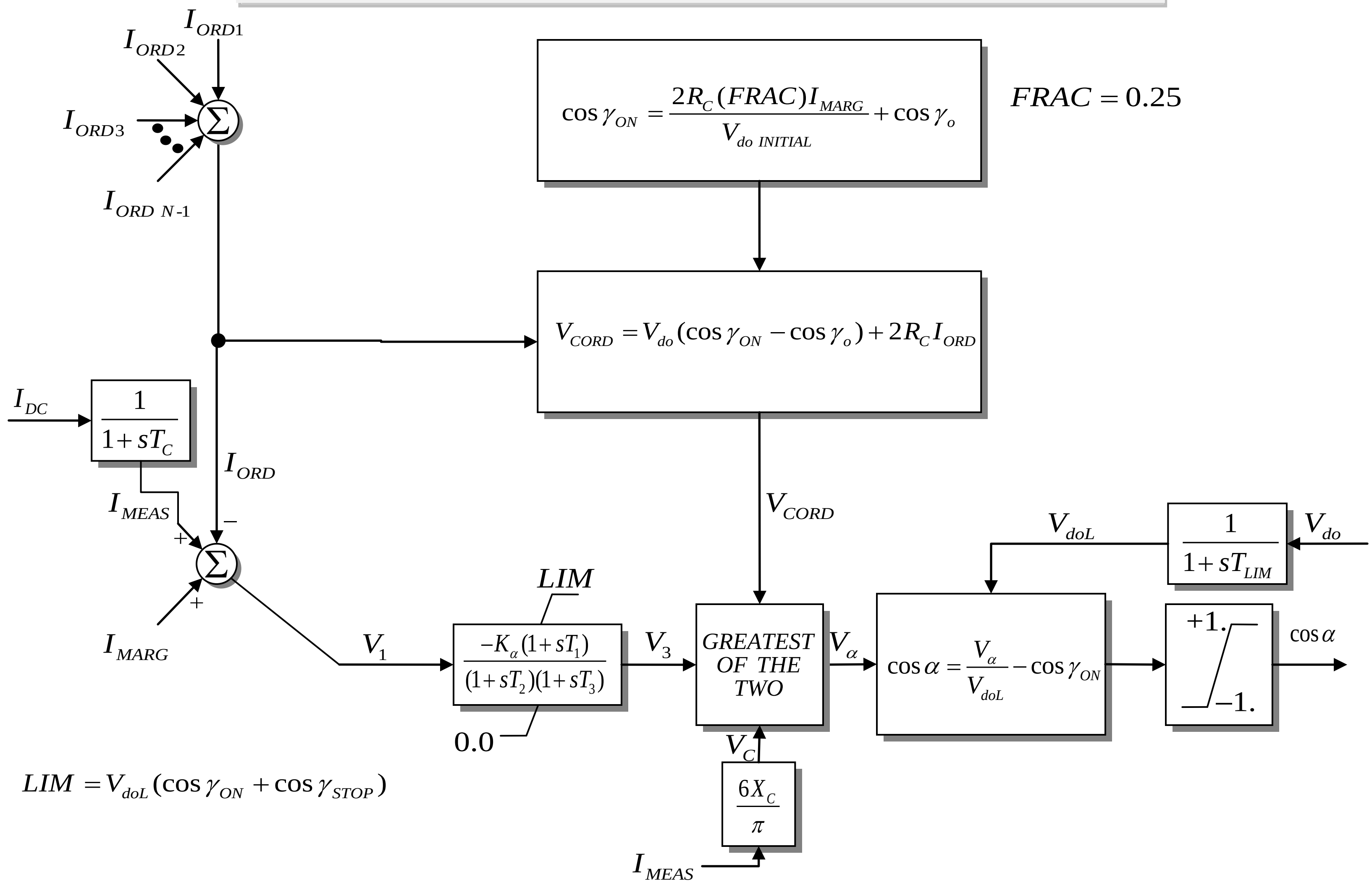
HVDC-MTDC Control System for Rectifiers and Inverters without Current Margin



$$RECT\ \ LIM = V_{doL}(\cos\gamma_0 + \cos\gamma_{\min})$$
$$INV\ \ \ \ LIM = V_{doL}(\cos\gamma_0 + \cos\gamma_{STOP})$$

Available in old BPA IPF software

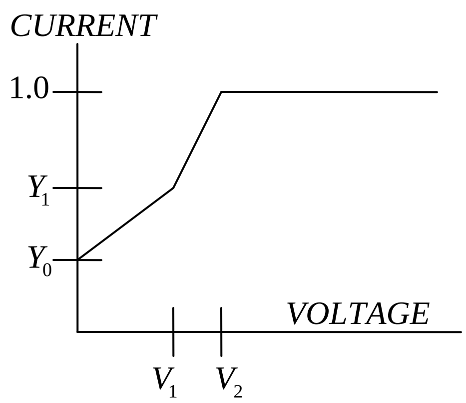
HVDC-MTDC Control System for Terminals with Current Margin

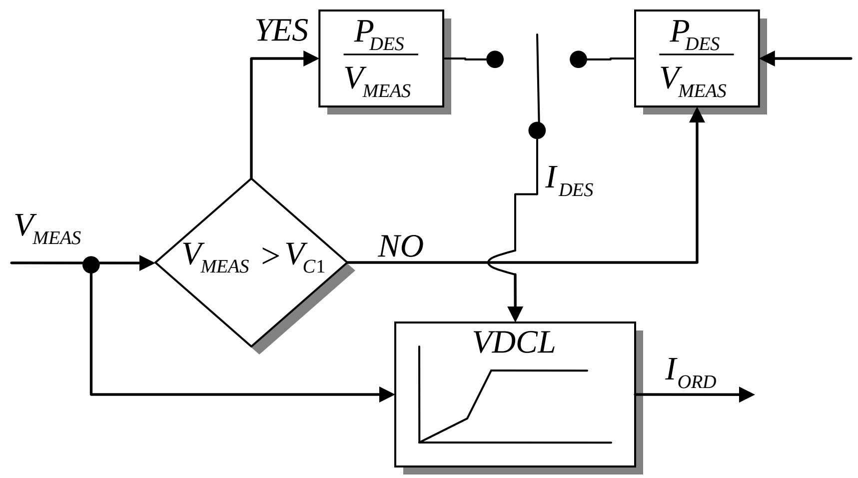


$$LIM = V_{doL}(\cos\gamma_{ON} + \cos\gamma_{STOP})$$

Available in old BPA IPF software

HVDC
Detailed VDCL and Mode Change Card Multi-Terminal





VDCL

Y_1, Y_0 PU Current on rated Current base

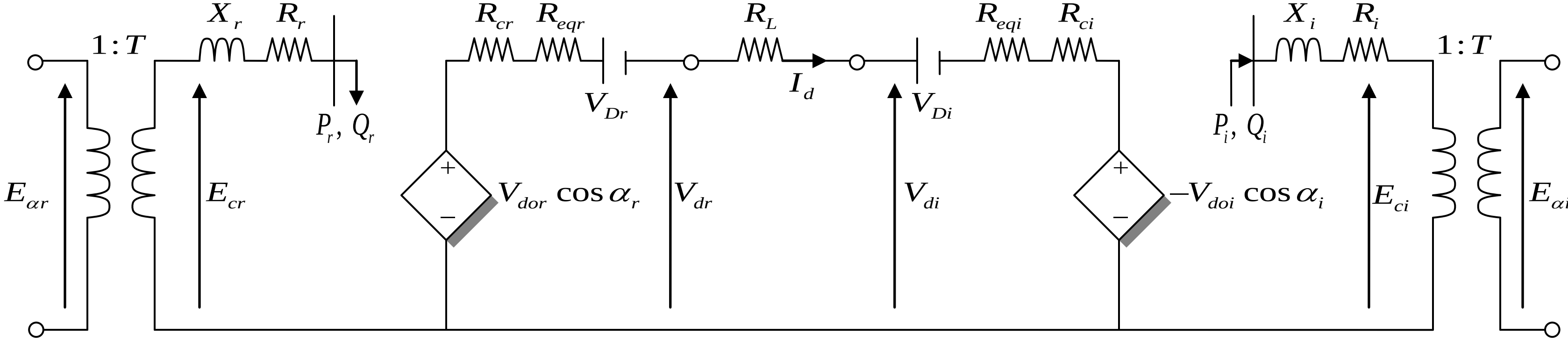
V_1, V_2 PU Voltage on rated Voltage base

Mode Change

V_{C1} PU rated DC Voltage below which mode is changed to constant I from constant P

Available in old BPA IPF software

HVDC
Equivalent Circuit of a Two Terminal DC Line



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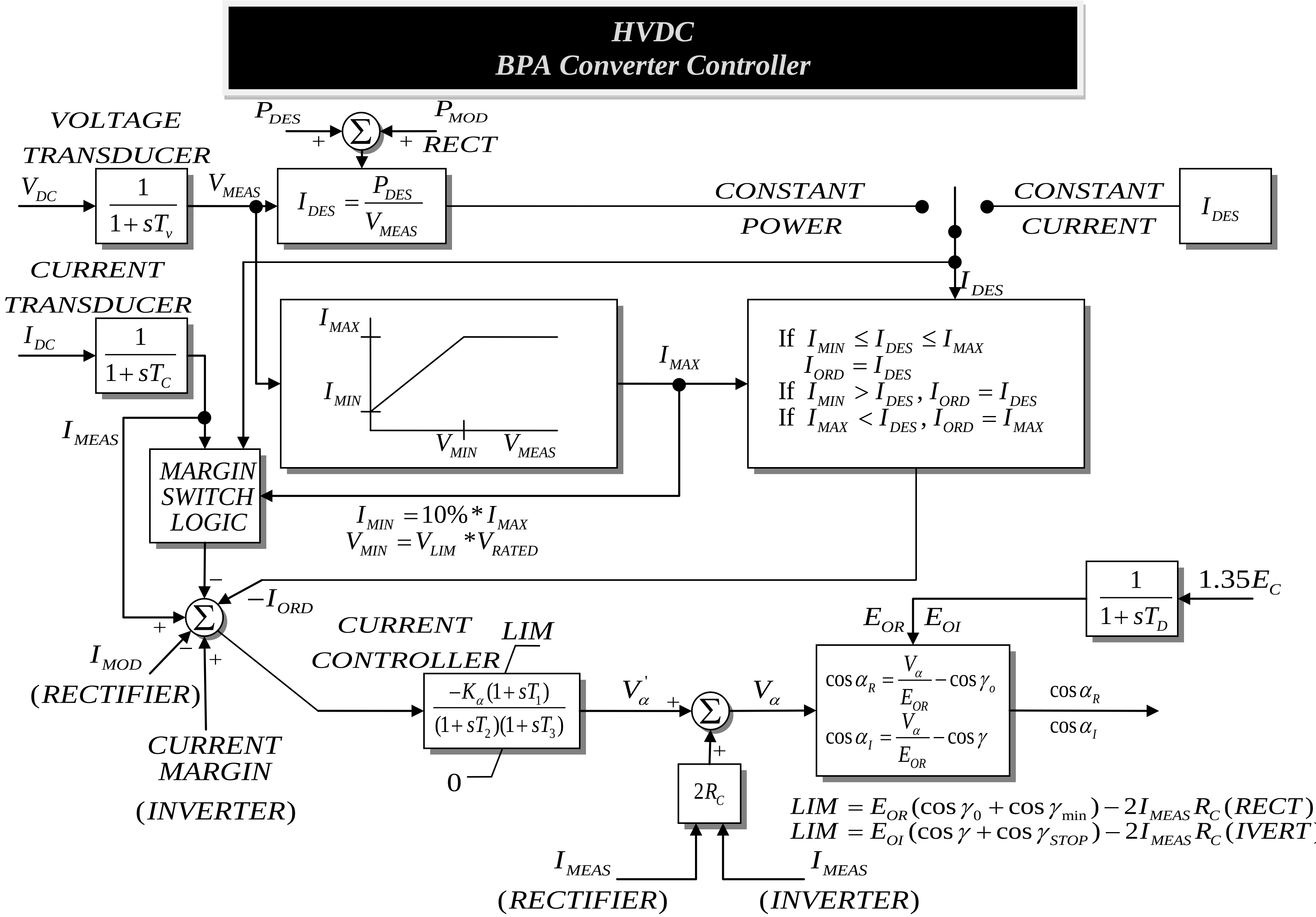

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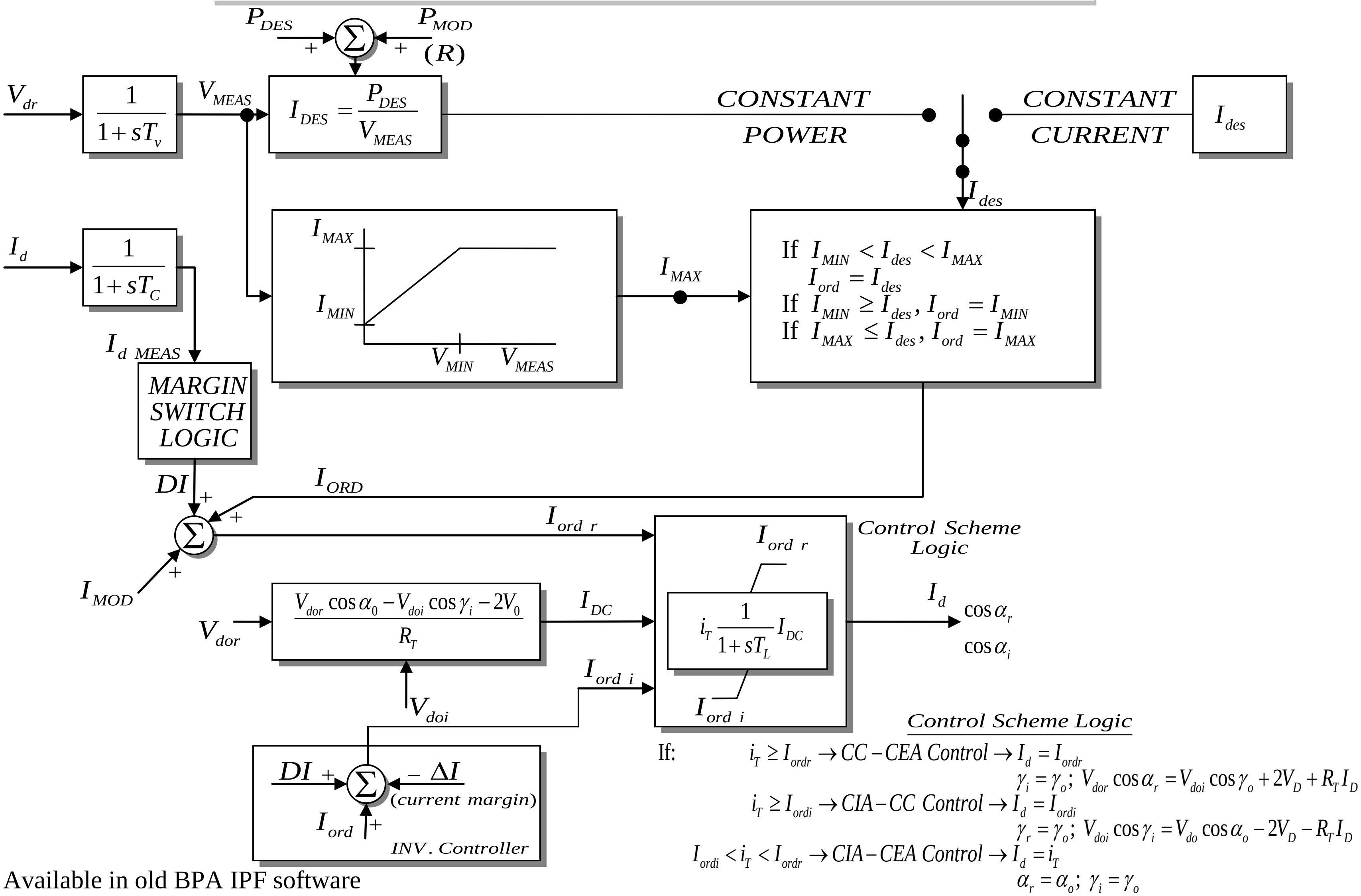
HVDC
BPA Block Diagram of Simplified Model



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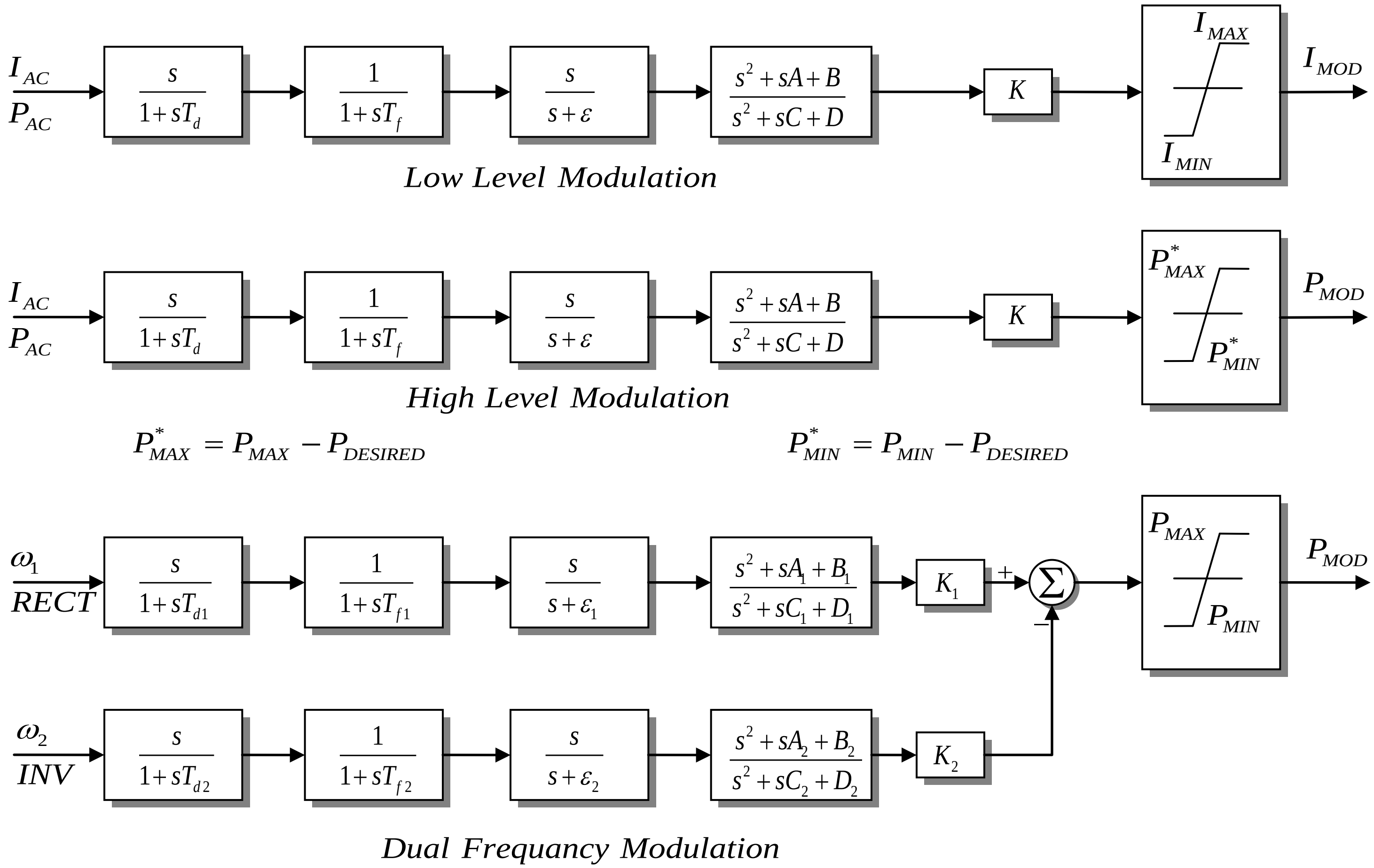
HVDC
BPA Block Diagram of Simplified Model



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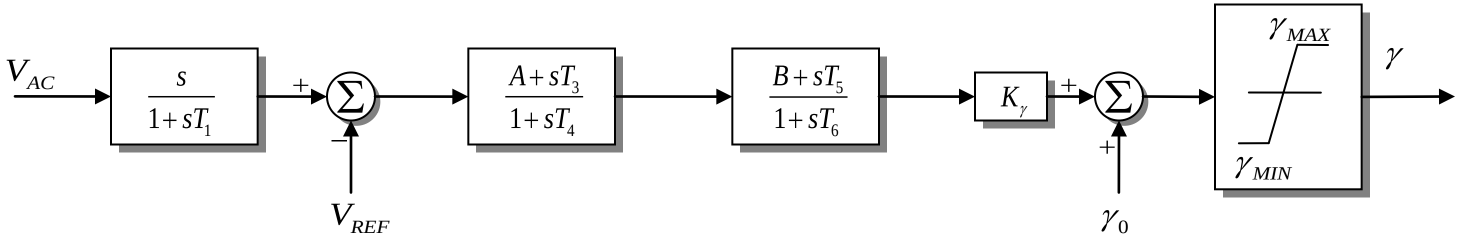
HVDC
BPA Block Diagram of Simplified Model

Gamma Modulation



$T_1,\ T_3,\ T_4,\ T_5$ are in secs. K_γ is in degrees/pu volts

$\gamma_{\rm MAX}, \gamma_{MIN}$ are in degrees $A,\ B$ must be 1 or zero

HILO must be 5

Available in old BPA IPF software

DC Converter Equations Revisited

Normally the rectifier and inverter equations are written in terms of the *firing angles* α and γ.

Rectifier Equations	Inverter Equations
$V_{dcr} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ac}}\cos(\alpha) - N\left[\frac{3X_c}{\pi} + 2R_c\right]I_{dc}$ $E_{ac} = \left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ac}}$ $\mu = \cos^{-1}\left[\cos\alpha - \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}\right] - \alpha$	$V_{dci} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ac}}\cos(\gamma) + N\left[-\frac{3X_c}{\pi} + 2R_c\right]I_{dc}$ $E_{ac} = \left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ac}}$ $\mu = \cos^{-1}\left[\cos\gamma - \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}\right] - \gamma$

For transient stability purposes it is more convenient to write the inverter equations in terms of β. β is related to γ by $\beta = \mu + \gamma$. During the simulation we will need to flip back and forth between β and γ, thus express β as a function of γ and vice versa.

$$\beta = \cos^{-1}\left[\cos\gamma - \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}\right] \quad \text{and} \quad \gamma = \cos^{-1}\left[\cos\beta + \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}\right].$$

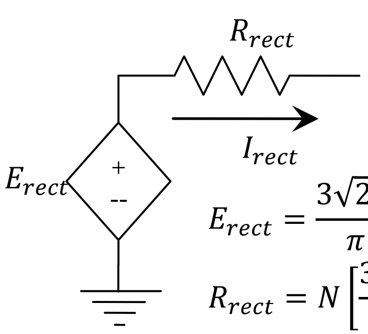
Now using the relationship $\cos\gamma = \cos\beta + \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}$, rewrite the DC voltage equation for the inverter in terms of β.

$$V_{dci} = \frac{3\sqrt{2}N}{\pi}E_{ac}\left[\cos\beta + \frac{\sqrt{2}I_{dc}X_c}{E_{ac}}\right] + N\left[-\frac{3X_c}{\pi} + 2R_c\right]I_{dc}$$

$$V_{dci} = \frac{3\sqrt{2}N}{\pi}E_{ac}\cos\beta + N\left[\frac{6X_c}{\pi}I_{dc}\right] + N\left[-\frac{3X_c}{\pi} + 2R_c\right]I_{dc}$$

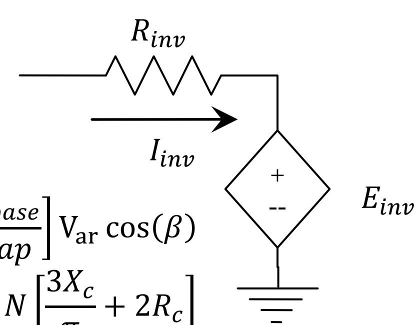
$$V_{dci} = \frac{3\sqrt{2}N}{\pi}E_{ac}\cos\beta + N\left[\frac{3X_c}{\pi} + 2R_c\right]I_{dc}$$

Using these equations, model the converter in the DC network equations as follows, with the extra constraint that the currents can NOT be negative.



$$E_{rect} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ac}}\cos(\alpha_r)$$

$$R_{rect} = N\left[\frac{3X_c}{\pi} + 2R_c\right]$$



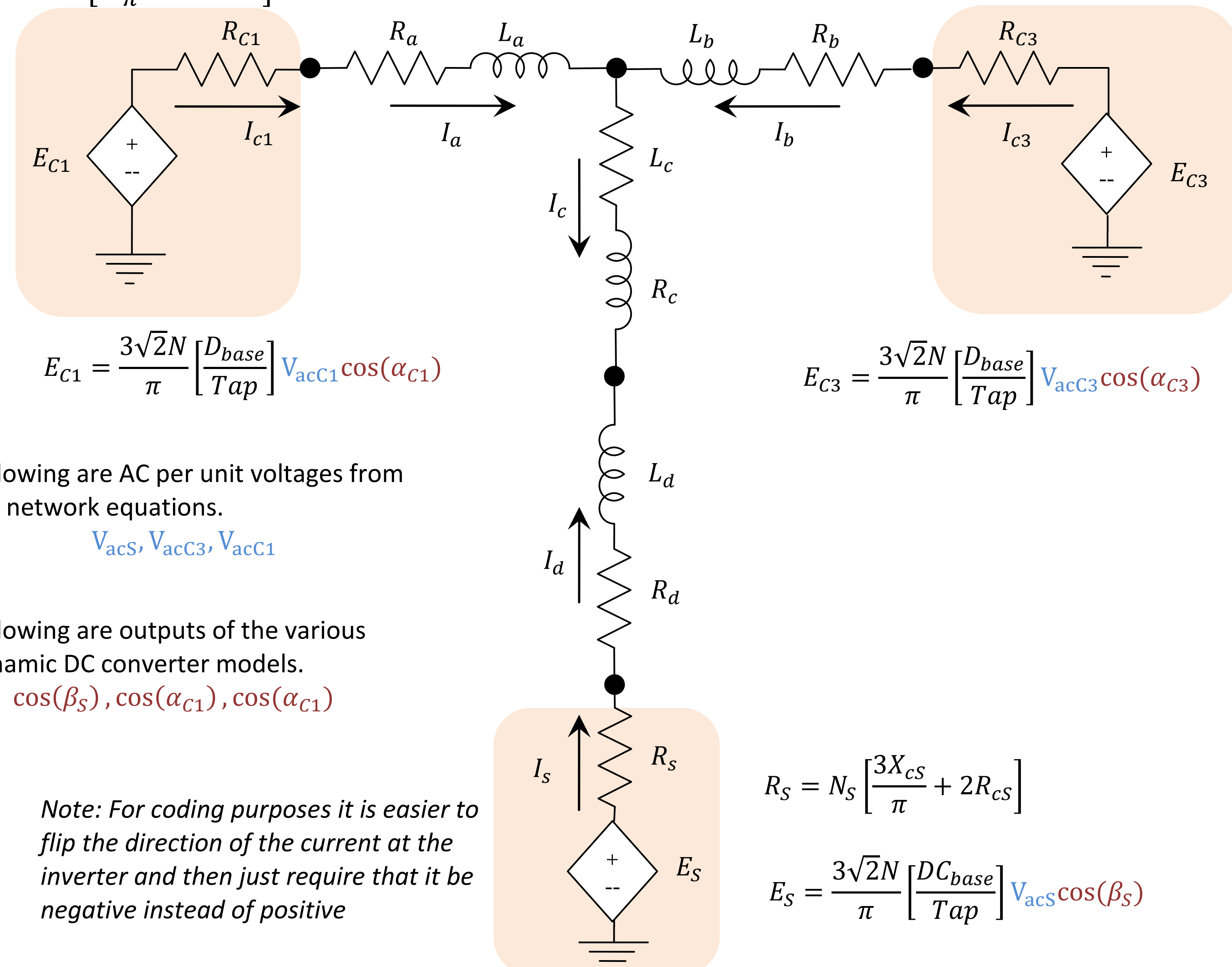
$$E_{inv} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V_{ar}}\cos(\beta)$$

$$R_{inv} = N\left[\frac{3X_c}{\pi} + 2R_c\right]$$

Multi-Terminal DC Network
DC Network Equations

$$R_{C1} = N_{C1}\left[\frac{3X_{cC1}}{\pi} + 2R_{cC1}\right]$$

$$R_{C3} = N_{C3}\left[\frac{3X_{cC3}}{\pi} + 2R_{cC3}\right]$$



$$E_{C1} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V}_{\mathrm{acC1}}\cos(\alpha_{C1})$$

$$E_{C3} = \frac{3\sqrt{2}N}{\pi}\left[\frac{D_{base}}{Tap}\right]\mathrm{V}_{\mathrm{acC3}}\cos(\alpha_{C3})$$

Following are AC per unit voltages from the network equations.

$\mathrm{V}_{\mathrm{acS}}, \mathrm{V}_{\mathrm{acC3}}, \mathrm{V}_{\mathrm{acC1}}$

Following are outputs of the various dynamic DC converter models.

$\cos(\beta_S), \cos(\alpha_{C1}), \cos(\alpha_{C1})$

Note: For coding purposes it is easier to flip the direction of the current at the inverter and then just require that it be negative instead of positive

$$R_S = N_S\left[\frac{3X_{cS}}{\pi} + 2R_{cS}\right]$$

$$E_S = \frac{3\sqrt{2}N}{\pi}\left[\frac{DC_{base}}{Tap}\right]\mathrm{V}_{\mathrm{acS}}\cos(\beta_S)$$

Implementation of the numerical solution of the PDCI

In the normal network boundary equations and in Simulator's power flow engine, the DC converter control is assumed to be instantaneous. We assume that firing angle move instantaneously to bring DC currents instantaneously to a new operating point. For the PDCI we will be removing these assumptions completely and modeling the dynamics of the firing angle control. It is convenient for numerical reasons to make the control output of the DC converter equal to either $\cos(\alpha)$ and $\cos(\beta)$ depending on whether the converter is acting as a rectifier or inverter. Here we will describe how this changes the numerical simulation of the multi-terminal DC line.

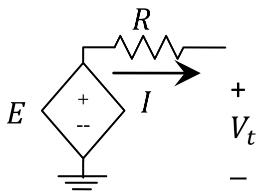
Inside the transient stability engine in Simulator, an explicit integration method is used. Thus the general process of solving the equations is to use a numerical integration time step to update all dynamic state variables and then another step to update all the algebraic variables such as the AC system voltage and angle (network boundary equations). The MTDC simulation is added into this framework as follows.

During each time-step of the numerical simulation of the multi-terminal DC Line, the following steps are taken

1. Using the standard routines within Simulator to calculate the new states for the dynamic models MTDC_PDCI, CONV_CELILO_E, CONV_CELILO_N, and CONV_SYLMAR. This is done along with all the other thousands of dynamic models.
   --> Updated Variables are $\cos(\alpha)$ or $\cos(\beta)$ terms for the DC converters
2. Before solving all the other algebraic equations using the AC network boundary equations, take the new $\cos(\alpha)$ and $\cos(\beta)$ terms and use them to model a step change in the DC voltages seen by the DC network equations. Use numerical integration to simulate the change in DC voltages and DC currents on the transmission lines for this time-step. Note that this is the only place in the numerical routines where the DC system currents in the system change.
   --> Updated Variables are the DC voltages and DC Currents
3. Finally, when the normal AC network boundary equations are being solved we must modify how the DC network equations are handled. Without the dynamic model for the MTDC line modeled, we assume that the DC currents respond instantaneously to a change in the DC voltages by an instantaneous change in the converter firing angles. Because the PDCI is modeling the actual dynamics of the DC converter firing angle change, we must assume that the firing angles remain constant during the network boundary equation solution instead. In addition, the PTDC is a very long transmission line and thus has a substantial inductance, therefore the current cannot change instantaneously either and must be assumed constant during the network boundary equation solution. This means that in order to solve the DC network equations we must allow the voltages in the DC network to change but since we're not allowing the currents to change, then this means all voltage changes from resistances must be zero. This means that the new voltage variations must be coming from the inductor L*dI/dt terms. We will show this below.
   --> Updated Variables are DC voltages

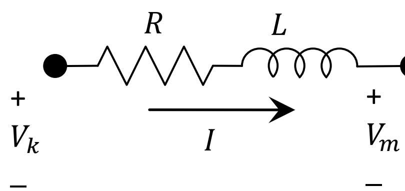
Numerical Integration to model the change in DC currents and DC voltages after a change in the $\cos(\alpha)$ and $\cos(\beta)$ terms

DC Converter equations are as follows, where *R* and *E* were described earlier. The unknown variable associated with this equation is the DC current. Note that it's possible for this to result in a current that is impossible (negative current injected into DC network for a rectifier or positive injection for an inverter). In that case we use a different equation which sets the current to zero.



$$RI + V_t = E \quad or \quad I = 0$$

DC transmission line equations are as follows. The unknown variable associate with this equation is the DC line current.



$$V_k(n) - V_m(n) - RI(n) = L\frac{dI}{dt}(n)$$

Remember the trapezoidal integration rule:

$$\frac{\frac{dx}{dt}(n) + \frac{dx}{dt}(n-1)}{2} = \frac{x(n) - x(n-1)}{h}$$

which gives

$$\frac{dx}{dt}(n) = \frac{2}{h}x(n) - \left[\frac{2}{h}x(n-1) + \frac{dx}{dt}(n-1)\right]$$

Where n = the present integer time step
h = the duration of the time step
x(n) = value at present time
$x(n-1)$ = value at previous time step

Use the trapezoidal rule to write the $dI/dt(n)$ term

$$V_k(n) - V_m(n) - RI(n) = \frac{2L}{h}I(n) - \left[\frac{2L}{h}I(n-1) + L\frac{dI}{dt}(n-1)\right]$$

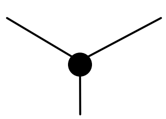
Use the standard relationship above to write the $LdI/dt(n-1)$ term

$$V_k(n) - V_m(n) - RI(n) = \frac{2L}{h}I(n) - \left[\frac{2L}{h}I(n-1)\right] - [V_k(n-1) - V_m(n-1) - RI(n-1)]$$

Finally, group the terms that are a function of values at time (n) on the left and time (n-1) on the right

$$V_k(n) - V_m(n) + \left(-R - \frac{2L}{h}\right)I(n) = \left(+R - \frac{2L}{h}\right)I(n-1) - V_k(n-1) + V_m(n-1)$$

DC Bus equation is just Kirchhoff's Current Law (KCL). The unknown variable associated with the equation is the DC bus voltage.



$$I_a + I_b + I_c + \cdots = 0$$

Using the PDCI as an example, the following matrix equations are created.

	Ic1	Ic3	Is	Ic	Ia	Ib	Id	v3	v4	v7	v8	v9	X		B
Celilo1	Rc1									1			$Ic1_{(n)}$		Ec1
Celilo3		Rc3									1		$Ic3_{(n)}$		Ec2
Sylmar1			Rs									1	$Is_{(n)}$		Es
LineC				(-Rc-2Lc/h)				1	-1				$Ic_{(n)}$		$(+Rc-2Lc/h)*Ic_{(n-1)} - v3_{(n-1)} + v4_{(n-1)}$
LineA					(-Ra-2La/h)			-1		1			$Ia_{(n)}$		$(+Ra-2La/h)*Ia_{(n-1)} - v7_{(n-1)} + v3_{(n-1)}$
LineB						(-Rb-2Lb/h)		-1			1		$Ib_{(n)}$	=	$(+Rb-2Lb/h)*Ib_{(n-1)} - v8_{(n-1)} + v3_{(n-1)}$
LineD							(-Rd-2Ld/h)		-1			1	$Id_{(n)}$		$(+Rd-2Ld/h)*Id_{(n-1)} - v9_{(n-1)} + v4_{(n-1)}$
KCL3				-1	1	1							$v3_{(n)}$		0
KCL4				1			1						$v4_{(n)}$		0
KCL7	1				-1								$v7_{(n)}$		0
KCL8		1				-1							$v8_{(n)}$		0
KCL9			1				-1						$v9_{(n)}$		0

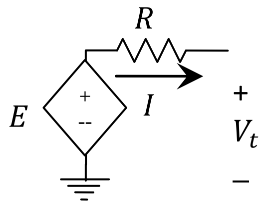
Simulator solves this set of equations by splitting the actual integration time-step used in the standard numerical integration and dividing it by 10. We set the h variable above to the time step divided by 10 then iterate this set of equations 10 times. When solving these equations, we initially assume that none of the currents end up the wrong sign. Then after each sub time step we check if the converter currents end up as the wrong sign. If converter currents have the wrong sign, we automatically change the equation for the offending converter to force that converter current to zero and redo this sub time step. We assume the converter current remains zero during the remainder of this time step and only allow it to back-off this limit during the following time step. I believe the current would never bounce around during a time step anyway, because this is fundamentally only a set of RL circuits so you will only get a first-order RL circuit exponential decay response toward the new steady state.

As an example, if the current at Celilo1 ended up the wrong sign, then its matrix equation would be rewritten as

	Ic1	Ic3	Is	Ic	Ia	Ib	Id	v3	v4	v7	v8	v9	X	B
Celilo1	1									0			$Ic1_{(n)}$	0

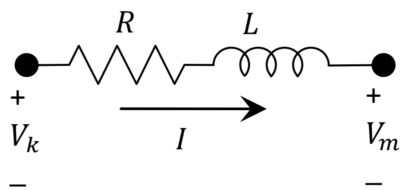
Solution of the algebraic change in DC voltages during the AC network boundary equation solution

DC Converter equations are as follows, where *R* and *E* were described earlier. Also note that the DC current is assumed constant so it is moved to the right side as a known quantity. The unknown variable associated with this equation is the voltage at the terminal.



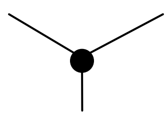
$$V_t = E - RI$$

DC transmission line equations are as follows. The unknown variable associated with equation is the *derivative* of the DC current. The DC current is assumed constant during the AC network boundary equation solution.



$$V_k - V_m - L\frac{dI}{dt} = RI$$

DC Bus equation is just Kirchhoff's Current Law (KCL), but for the derivatives of the currents instead of the actual currents. The unknown variable associated with the equation is DC bus voltage. Also note that we only add an equation for DC buses which are not connected to a DC converter terminal.



$$\frac{dI_a}{dt} + \frac{dI_b}{dt} + \frac{dI_c}{dt} + \cdots = 0$$

Using the PDCI as an example, the following matrix equations are created

LineC	-Lc							1	-1	dIc/dt		Ic*Rc
LineA		-La			1			-1		dIa/dt		Ia*Ra
LineB			-Lb			1		-1		dIb/dt		Ib*Rb
LineD				-Ld			1		-1	dId/dt		Id*Rd
Celilo1					1					v7	=	Ec1-Rc1*Ic1
Celilo3						1				v8		Ec3-Rc3*Ic3
Sylmar1							1			v9		Es-Rs*Is
KCL3	-1	1	1					0		v3		0
KCL4	1			1					0	v4		0

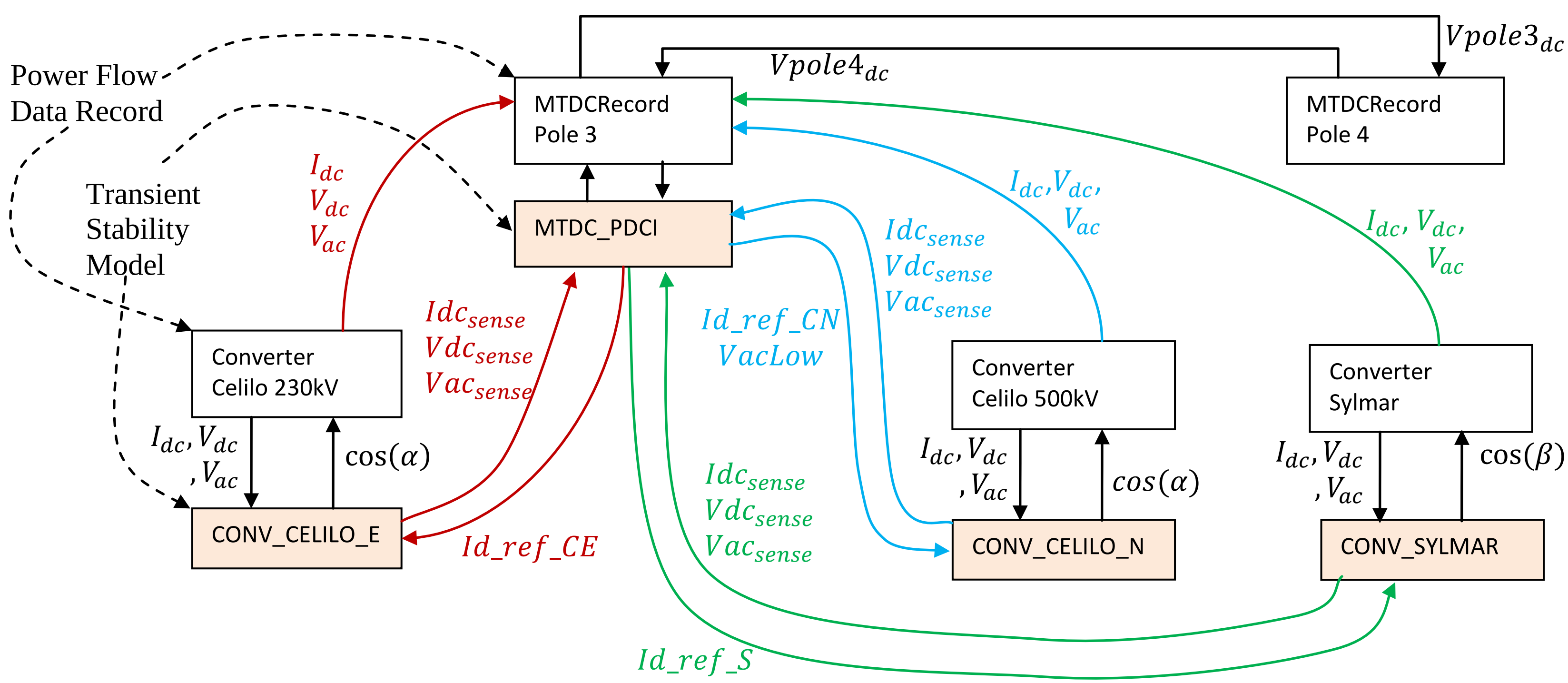
General Overview of Multi-Terminal DC Line Model for the Pacific DC Intertie

Simulator has a multi-terminal DC (MTDC) record which represents the grouping of the dc converters, dc buses and dc lines for a single pole of a MTDC transmission line. The Pacific DC Intertie (PDCI) is represented by two of these records: one for each pole of the PDCI. For the PDCI, each MTDC record contains three DC converters with two at Celilo (North end) and one at Sylmar (South end). In Simulator these DC converters are also represented by unique objects.

The transient stability model of the PDCI works by assigning a dynamic model to each of the two MTDC records, and also assigning a dynamic model to each of the DC converter objects. To model this, there are 4 dynamic models

MTDC_PDCI	Assigned to the MTDC record.
CONV_CELILO_E	Assigned to the Celilo DC converter at the 230 kV bus at Celilo (North). Note: "E" stands for "existing"
CONV_CELILO_N	Assigned to the Celilo DC converter at the 500 kV bus at Celilo (North). Note: "N" stands for "new"
CONV_SYLMAR	Assigned to the DC converter at Sylmar (South)

The flow of signals is depicted in the following image.



The function of the converts is generally described as follows.

MTDC_PDCI	Assigned to the MTDC record. Model will coordinate the allocation of current order reference signals sent to the three DC converters that it manages. Model may also pass on various flags such a *VacLow*. Model receives signals of sensed AC and DC voltage and DC current from the converters also. The two MTDC_PDCI models will act independently of one another, except that each record passes a measurement of the DC voltage at the rectifier end of each pole to the other pole.
CONV_CELILO_E	Assigned to the "existing" Celilo DC converter at the 230 kV bus at Celilo (North). Converter initializes its Isched and Psched values to those from the initial network boundary equation solution. Model will take as an input one signals from MTDC_PDCI: the current order reference signal (Id_ref_CE).
CONV_CELILO_N	Assigned to the "new" Celilo DC converter at the 500 kV bus at Celilo (North). Converter initializes its Isched and Psched values to those from the initial network boundary equation solution. Model will take as an input two signals from MTDC_PDCI: the current order reference signal (Id_ref_CN) and the flag *VacLow*.
CONV_SYLMAR	Assigned to the DC converter at Sylmar (South). Converter initializes its Isched and Psched values to those from the initial network boundary equation solution. Model will take as an input one signalsfrom MTDC_PDCI: the current order reference signal (Id_ref_S).

In addition the implementation of these four models will be automatically modify based on the initial flow in the initial system flow direction (depending whether the flow is from Celilo to Sylmar or Sylmar to Celilo). These modifications reflect the differences in how each converter behaves when acting as a rectifier or inverter. In the following block diagrams portions of the model which are only used for a flow from Celilo to Sylmar (North to South) are highlighted in green, while portion only used for a flow from Sylmar to Celilo (North to South) are highlighted in purple. Differences also have a red notation of $Flag_{NS}$ added to denote highlighting. Values which are passed between models are highlighted in orange. Outputs of the control angle for DC converters are highlighted in pink.

MTDC_PDCI (North to South Implementation)
Measurements and Low Voltage Detection Logic

Direct readings of AC voltage at converter buses:

$If\ (Vac_{Celilo230} < 0.5)\ \ OR\ \ (Vac_{Celilo500} < 0.5)\ Then\ \mathbf{VacLowCelilo} = TRUE$

$If\ (Vac_{Celilo230} > 0.6)\ AND\ (Vac_{Celilo500} < 0.6)\ Then\ \mathbf{VacLowCelilo} = FALSE$

$If\ (Vac_{Sylmar} < 0.5)\ Then\ \mathbf{VacLowSylmar} = TRUE$

$If\ (Vac_{Sylmar} > 0.6)\ Then\ \mathbf{VacLowSylmar} = FALSE$

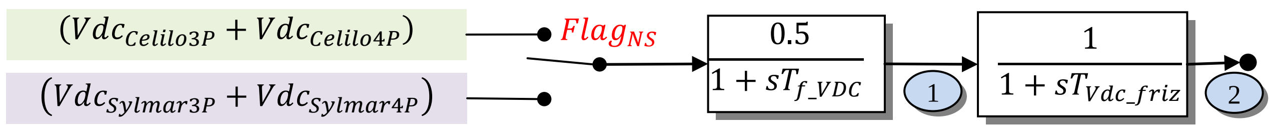
State 2 from the Celilo500 and Sylmar converter:

$If\ (Vdc_{senseCelilo500} < 150)\ \ OR\ \ (Vdc_{senseSylmar} < 150)\ Then\ \mathbf{VdcLow} = TRUE$

$If\ (Vdc_{senseCelilo500} > 350)\ AND\ (Vdc_{senseSylmar} > 350)\ Then\ \mathbf{VdcLow} = FALSE$

$\mathbf{VacLow} = \mathbf{VacLowCelilo}\ OR\ \mathbf{VdacLowSylmar}$

$\mathbf{VlowFlag} = \mathbf{VacLow}\ OR\ \mathbf{VdcLow}$



DC Voltage Measurement Freeze

If ***VLowFlag*** = TRUE then <u>activate</u> a timer ***TimerVDCFreeze*** and set timer to ***Tdel$_{friz}$***. Continue to set this timer up to ***Tdel$_{friz}$*** as long as ***VLowFlag*** is TRUE. If ***VLowFlag*** become FALSE then start having the timer count down to zero. Once the ***TimerVDCFreeze*** reaches zero then make it <u>inactive</u>.

Whenever ***TimerVDCFreeze*** is <u>inactive</u> then

Set ***VDCFreeze*** = (2)

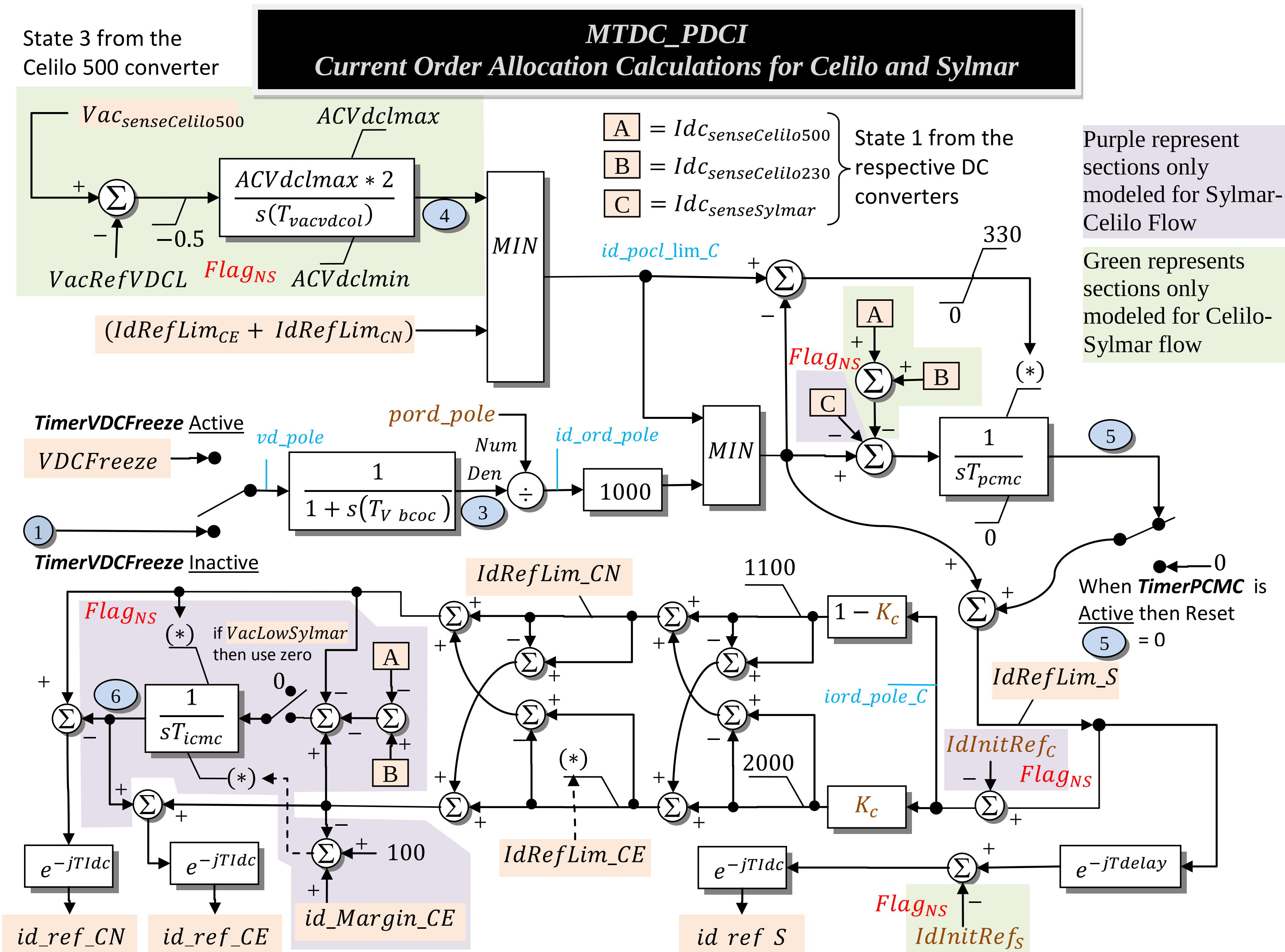
and pass (1) as the DC voltage to Current Order Allocation Calculation

Whenever ***TimerVDCFreeze*** is <u>active</u> then

Pass the variable ***VDCFreeze*** as the DC voltage to the Current Order Calculation

Pole Current Margin Compensator

If ***VLowFlag*** = TRUE then <u>activate</u> a timer ***TimerPCMC*** and set timer to ***Tpcmc_rst***. Continue to set this timer up to ***Tpcmc_rst*** as long as ***VLowFlag*** is TRUE. If ***VLowFlag*** become FALSE then start having the timer count down to zero. Once the ***TimerPCMC*** reaches zero then make it <u>inactive</u>.

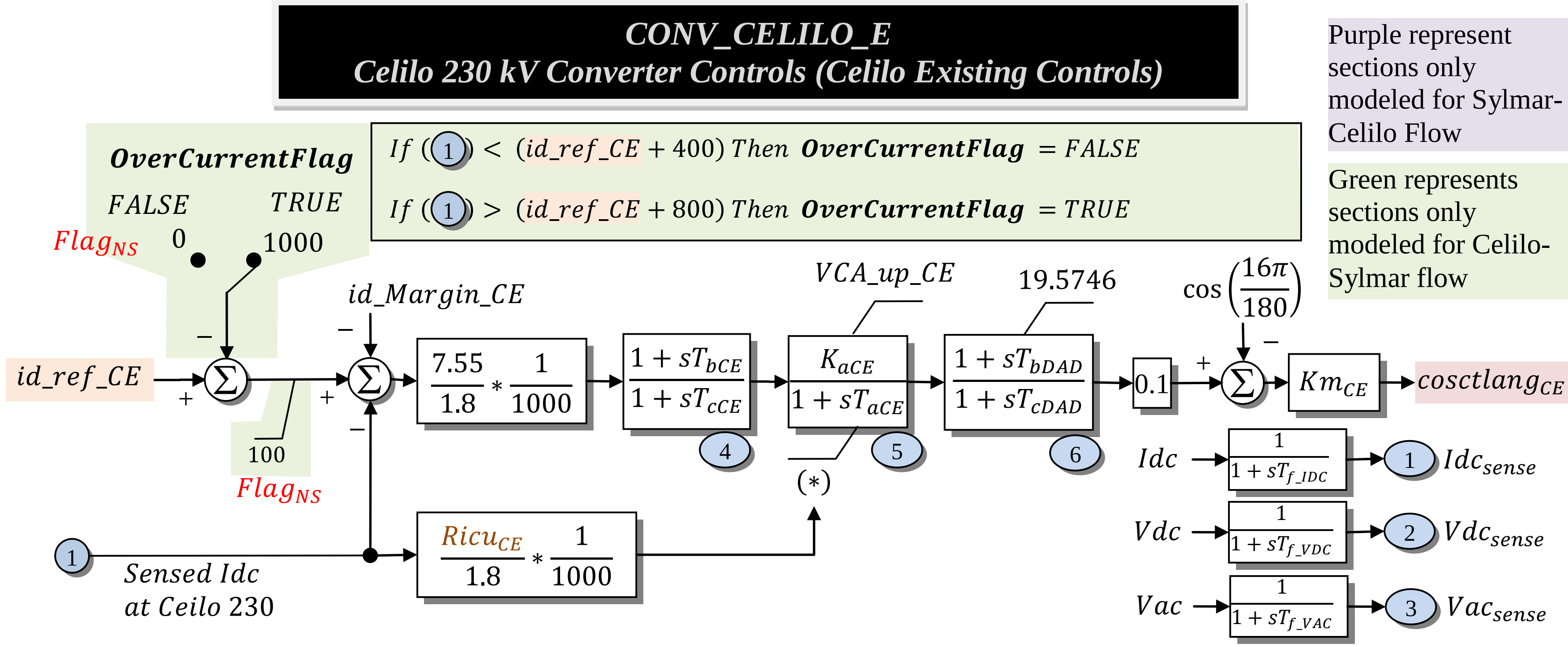

MTDC_PDCI
Current Order Allocation Calculations for Celilo and Sylmar
State 3 from the Celilo 500 converter
$Vac_{senseCelilo500}$
ACVdclmax
$\frac{ACVdclmax * 2}{s(T_{vacvdcol})}$
−0.5
VacRefVDCL
$Flag_{NS}$
ACVdclmin
4
MIN
$(IdRefLim_{CE} + IdRefLim_{CN})$
A = $Idc_{senseCelilo500}$
B = $Idc_{senseCelilo230}$
C = $Idc_{senseSylmar}$
State 1 from the respective DC converters
Purple represent sections only modeled for Sylmar-Celilo Flow
Green represents sections only modeled for Celilo-Sylmar flow
id_pocl_lim_C
330
0
(*)
$\frac{1}{sT_{pcmc}}$
5
TimerVDCFreeze Active
VDCFreeze
vd_pole
pord_pole
Num
Den
id_ord_pole
$\frac{1}{1+s(T_{V\ bcoc})}$
3
1000
1
TimerVDCFreeze Inactive
IdRefLim_CN
1100
$1 - K_c$
When TimerPCMC is Active then Reset 5 = 0
if VacLowSylmar then use zero
6
$\frac{1}{sT_{icmc}}$
iord_pole_C
IdRefLim_S
$IdInitRef_C$
2000
K_c
100
IdRefLim_CE
id_Margin_CE
e^{-jTIdc}
$e^{-jTdelay}$
id_ref_CN
id_ref_CE
id ref S
$IdInitRef_S$

MTDC_PDCI Parameters are all hard-coded based on whether the initial flow direction of the PDCI. The parameters and the initialization are different for Celilo to Sylmar (North to South) or Sylmar to Celilo (South to North) flow. The following table shows the differences

Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
T_{fpcmc_rst}	0.1	
T_{VDC_friz}	0.53	
$Tdel_{friz}$	0.44	
$VacRefVDCL$	228/230	n/a
$ACVdclmax$	3100	n/a
$ACVdclmin$	2400	n/a
$T_{vcacvdcol}$	0.5	n/a
$IdRefLim_{CE}$	Get from CONV_CELILO_E model	
$IdRefLim_{CN}$	Get from CONV_CELILO_N model	
$IdRefLim_{S}$	Get from CONV_SYLMAR model	
T_{v_bcoc}	0.05	
T_{pcmc}	0.5120	
T_{icmc}	n/a	0.2500
Id_margin_CE	Get from CONV_CELILO_E model	
$TIdc$	0.5 cycles	
$Tdelay$	2 cycles	

Initialization Reference Values	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
$pord\_pole$	Initialize to Sum of Psched at two Celilo Converters	Initialize to Psched at the Sylmar Converter
K_C	Initialize based on the following equation $K_C = \frac{id\_ref\_CE}{id\_ref\_CE + id\_ref\_CN}$	
$VacLowSylmar$	FALSE	
$VacLowCelilo$	FALSE	
$VdcLow$	FALSE	
$VLowFlag$	FALSE	
$IdInitRef_C$	n/a	Initialize equal to State 14 to handle difference between id_ord_pole and id_ref_S
$IdInitRef_S$	Initialize equal to State 14 to handle difference between id_ord_pole and $id\_ref\_CN + id\_ref\_CE$	n/a

CONV_CELILO_E
Celilo 230 kV Converter Controls (Celilo Existing Controls)



CONV_CELILO_E parameters are all hard-coded based on whether the initial flow direction of the PDCI. The parameters and the initialization are different for Celilo to Sylmar (North to South) or Sylmar to Celilo (South to North) flow. The following table shows the differences

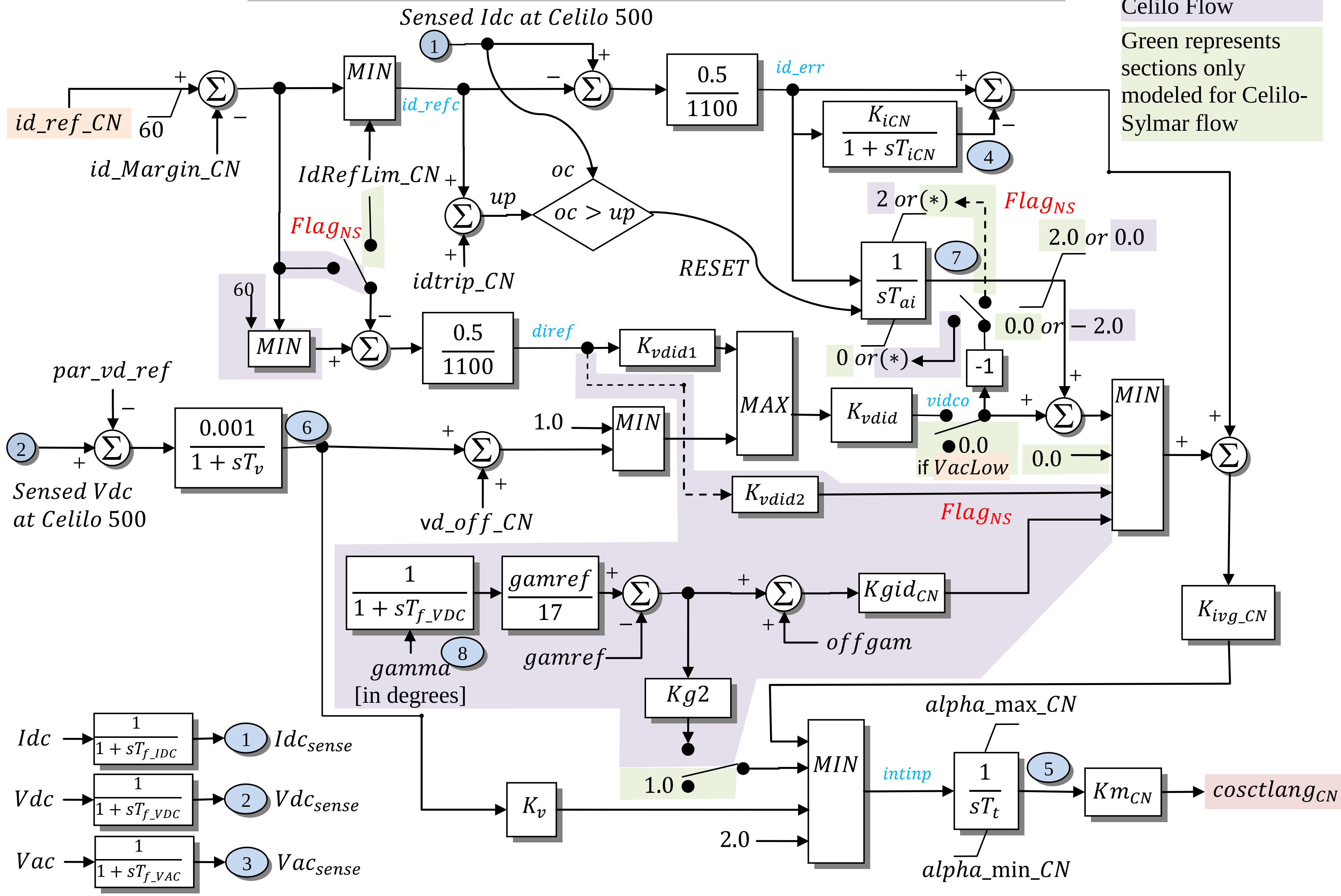
Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
T_{bCE}	0.0323	
T_{cCE}	0.0323	
K_{aCE}	330	82.5
T_{aCE}	8.1500	
VCA_up_CE	20	8.5
T_{bDAD}	0	1/240
T_{cDAD}	1/60	
Km_{CE}	1	-1
id_margin_CE	0	180

Initialization Reference Values	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
$Ricu_{CE}$	2.2	Initialize so State 5 is at its lower limit $Ricu_{CE} = \frac{(4) * 1.8 * 1000}{(1)}$
Parameter	**Celilo-Sylmar (North to South)**	**Sylmar - Celilo (South to North)**
$IdRefLim_{CE}$	2160	
T_{f_IDC}	0.004	0.0084
T_{f_VDC}	0.004	0.0084
T_{f_VAC}	0.0333	

CONV_CELILO_N
Celilo 500 kV Converter Controls (Celilo Expansion Controls)

Purple represent sections only modeled for Sylmar-Celilo Flow

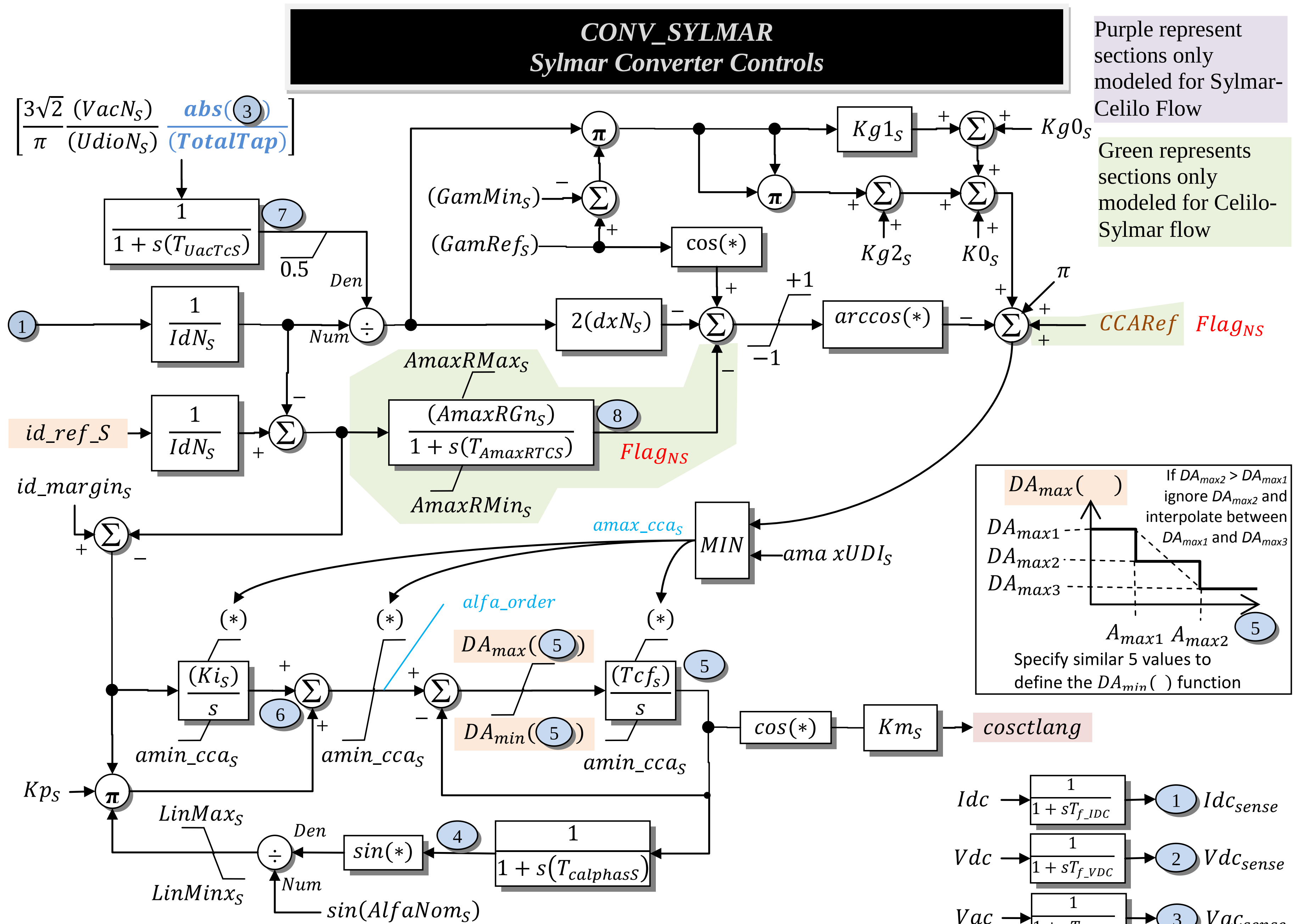
Green represents sections only modeled for Celilo-Sylmar flow



CONV_CELILO_N parameters are all hard-coded based on whether the initial flow direction of the PDCI. The parameters and the initialization are different for Celilo to Sylmar (North to South) or Sylmar to Celilo (South to North) flow. The following table shows the differences.

Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
id_Margin_CN	0	150
$IdRefLim\_CN$	1650	
$idtrip\_CN$	+110	-110
id_min_min	n/a	60
K_{iCN}	2/3	
T_{iCN}	1/120	
T_{ai}	0.1660	
K_{vdid1}	0.4400	
K_{vdid}	+0.7575	-0.7575
T_v	0.0138	
par_vd_ref	550	
K_v	-0.4000	
vd_off_CN	0.100	0.066

Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
K_{ivg_CN}	-0.264	+0.26400
T_t	-1/360	+1/360
$alpha\_\max\_CN$	+1.000	+1.91260
$alpha\_\min\_CN$	-1.992	+0.34700
Km_{CN}	-0.5	0.5
K_{vdid2}	n/a	-0.333
$gamref$	n/a	0.38428
$Kg2$	n/a	0.6
$Kgid_{CN}$	n/a	0.11694
$offgam$	n/a	-0.42743
T_{f_IDC}	0.004	0.0084
T_{f_VDC}	0.004	0.0084
T_{f_VAC}	0.0333	



CONV_SYLMAR
Sylmar Converter Controls
Purple represent sections only modeled for Sylmar-Celilo Flow
Green represents sections only modeled for Celilo-Sylmar flow
$\left[\frac{3\sqrt{2}}{\pi} \frac{(VacN_S)}{(UdioN_S)} \frac{abs(3)}{(TotalTap)}\right]$
$\frac{1}{1+s(T_{UacTcS})}$
0.5
Den
Num
$\frac{1}{IdN_S}$
id_ref_S
id_margin_S
$(GamMin_S)$
$(GamRef_S)$
cos(*)
$2(dxN_S)$
+1
−1
arccos(*)
$Kg1_S$
$Kg0_S$
$Kg2_S$
$K0_S$
π
CCARef
$Flag_{NS}$
$AmaxRMax_S$
$\frac{(AmaxRGn_S)}{1+s(T_{AmaxRTCS})}$
$AmaxRMin_S$
MIN
$amax\_cca_S$
ama xUDI_S
alfa_order
(*)
$\frac{(Ki_S)}{s}$
$amin\_cca_S$
$DA_{max}(5)$
$DA_{min}(5)$
$\frac{(Tcf_S)}{s}$
cos(*)
Km_S
cosctlang
Kp_S
$LinMax_S$
$LinMin_S$
sin(*)
$\frac{1}{1+s(T_{calphaS})}$
$sin(AlfaNom_S)$
$DA_{max}(\ )$
If $DA_{max2} > DA_{max1}$ ignore DA_{max2} and interpolate between DA_{max1} and DA_{max3}
DA_{max1}
DA_{max2}
DA_{max3}
A_{max1}
A_{max2}
Specify similar 5 values to define the $DA_{min}(\ )$ function
Idc
$\frac{1}{1+sT_{f\_IDC}}$
Idc_{sense}
Vdc
$\frac{1}{1+sT_{f\_VDC}}$
Vdc_{sense}
Vac
$\frac{1}{1+sT_{f\_VAC}}$
Vac_{sense}

CONV_SYLMAR parameters are all hard-coded based on whether the initial flow direction of the PDCI. The parameters and the initialization are different for Celilo to Sylmar (North to South) or Sylmar to Celilo (South to North) flow. The following table shows the differences.

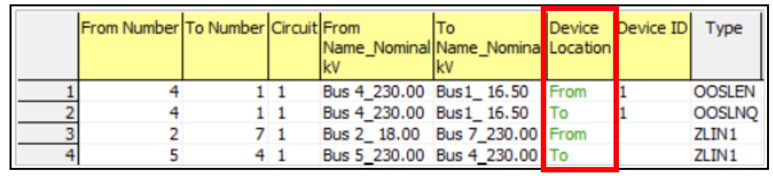
Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
$VacN_S$	230.0	
$UdioN_S$	286.7	
T_{UacTcS}	0.1	
IdN_S	3100.0	
$GamMin_S$	15 π/180	
$GamRef_S$	17 π/180	
$K0_S$	-0.018846501 π/180	
$Kg0_S$	0.0 π/180	
$Kg1_S$	-0.601288000 π/180	
$Kg2_S$	-0.029795800 π/180	
dxN_S	0.090	
$AmaxRGn_S$	0.150	n/a
$T_{AmaxRTCS}$	0.002	n/a
$AmaxRMax_S$	0.050	n/a
$AmaxRMin_S$	-0.050	n/a
id_margin_S	0.03	0.00
$amaxUDI_S$	200 π/180	
$amin\_cca_S$	95 π/180	5 π/180
T_{f_IDC}	0.004	0.0084
T_{f_VDC}	0.004	0.0084
T_{f_VAC}	0.0333	
Km_{CN}	-1	1

Parameter	Celilo-Sylmar (North to South)	Sylmar - Celilo (South to North)
Ki_S	180 π/200	
Kp_S	20 π/180	
$T_{calphasS}$	0.003	
$AlfaNom_S$	17.5 π/180	
$LinMax_S$	1.000	
$LinMinx_S$	0.300	
Tcf_s	1000	
DA_{max1}	10 π/180	90 π/180
DA_{max2}	2 π/180	999 π/180
DA_{max3}	1 π/180	5 π/180
A_{max1}	110 π/180	0 π/180
A_{max2}	140 π/180	120 π/180
DA_{min1}	-5 π/180	-6 π/180
DA_{min2}	-5 π/180	-8 π/180
DA_{min3}	-5 π/180	-15 π/180
A_{min1}	0 π/180	35 π/180
A_{min2}	10 π/180	70 π/180
$CCARef$	Initialize so State 32 is at the upper limit	n/a
$IdRefLim_S$	3100	

Line Relays DISTR1

Three-Zone Distance Relay with Transfer Trip

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End". When this relay's conditions are met, the entire branch is opened.



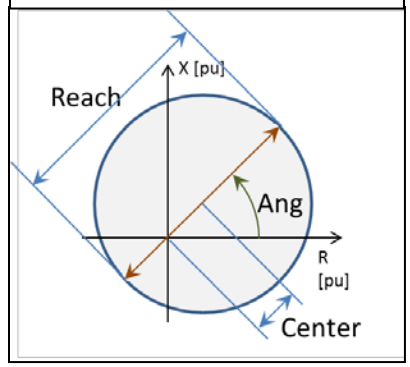
	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

There are three zones for the relay which depend on the zone shape specified. The zone shapes are determined by the Impedance Type integer. 1 = mho Distance shapes, 2 = impedance distance, and 3 = reactance distance. In addition to these shapes, two blinders may be specified which block all zones. These are described on the next page.

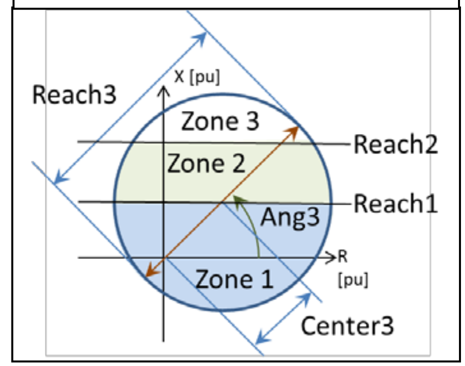
Each zone has a time in cycles associated it. When the apparent impedance enters the zone, a timer is started. If the impedance stays inside the zone for the specified number of cycles, then the relay will send a trip signal to the breaker. The breaker will then trip after the *Self Trip Breaker Time* has elapsed. Three additional branches may also be specified as *Transfer Trip Branch 1*, *2*, and *3*. These branches use the *Transfer Trip breaker time* instead.

Optionally, after the branches are tripped, the branches may reclose after a specified number of cycles according to the *Self Trip Reclosure Time* or *Transfer Trip Reclosure time*. This reclosure will happen only once during the simulation.

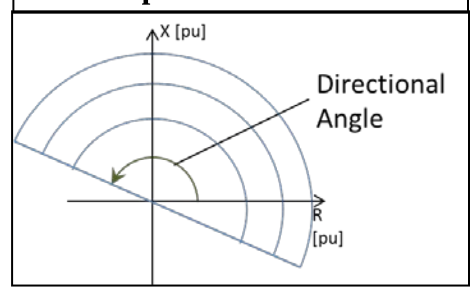
Mho Distance



Reactance Distance



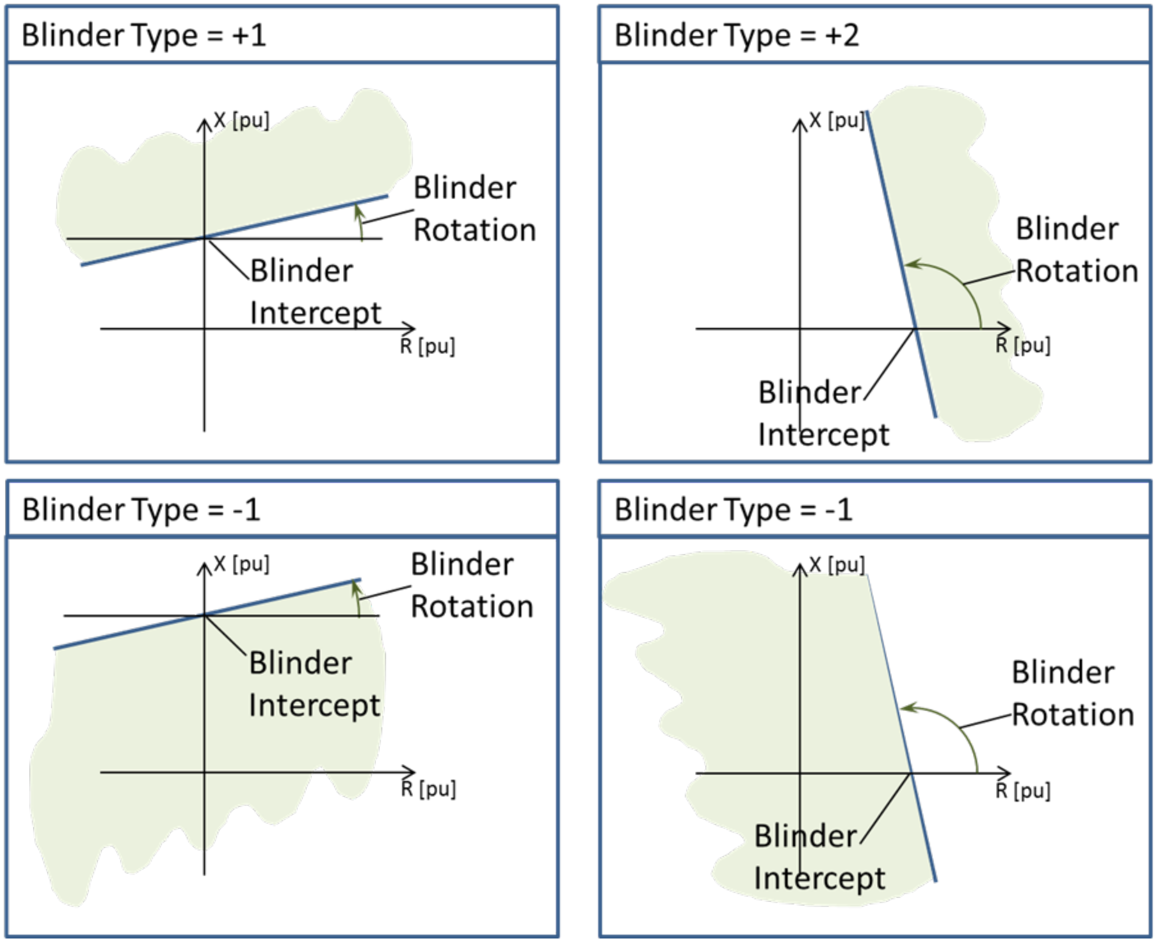
Impedance Distance



Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breaker signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Model Supported by PSSE



Model Supported by PSSE

Line Relay FACRI_SC

Fast AC Reactive Insertion for Series Capacitors (FACRI_SC)

Monitored Bus	Bus at which the voltage is monitored
volt_high	High cut-in voltage (pu)
volt_low	Low cut-in voltage (pu)
td_high	High cut-in time delay (sec)
td_low	Low cut-in time delay (sec)
Extra Object 1	Line 1
Extra Object 2	Line 2
Extra Object 3	Line 3
Extra Object 4	Line 4
Extra Object 5	Line 5
Extra Object 6	Line 6
Extra Object 7	Line 7
Extra Object 8	Interface 1

Extra Object 1 through 7 can be specified as lines, multi-section lines, or interfaces.

The following pseudo code describes how the inputs are used to determine series capacitor switching:

```
SeriesCap = Series capacitor to which this model is assigned
LineSectionsAreOpen = Any line section open for Extra Object 1 to 7
CapBlocked = ((Interface1 MW Flow < -50) OR (Interface1 MW Flow > 0)) AND LineSectionsAreOpen

If   ((not CapBlocked) and (SeriesCap.Status = Bypassed))
     AND
     ((Monitored Bus Voltage < volt_low for td_low) OR (Monitored Bus Voltage < volt_high for td_high))
Then Begin
     SeriesCap.Status = Not Bypassed
End
```

Line Relays LOCTI

Time Inverse Over-Current Relay

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

When this relay's conditions are met, the entire branch is opened.

<u>Relay Operation</u>

The TimeToClose varies according to the piecewise linear function of per unit current as shown to the right and as specified by the input values Threshold, m1..m5, and t1..t5. If m1 is greater than 1.0, then an additional point at the Threshold current of 1 hour (3,600 seconds) is added to the curve.

The time at which the relay will close is determined by integrating the following function. When the function equal 1.0 then the relay will close.

$$\theta = \int \left[\frac{1}{TimeToClose}\right] dt$$

<u>Relay Resetting</u>

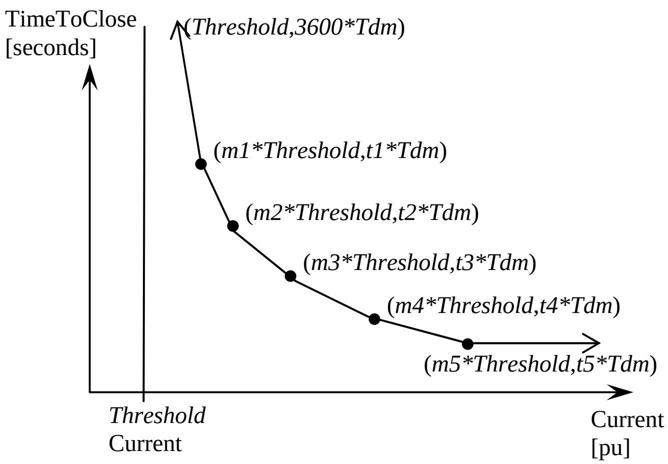
When the current drops below the *Threshold* current, then the relay resets according to the parameter *TReset*. If *TReset* is zero, then the relay resets to $\theta = 0$ instantaneously. Otherwise there is a timed reset which occurs by integrating using the function

$$\theta = \int \left[1 - \left(\frac{ICurrent}{Threshold}\right)^2\right]\left[\frac{-1}{TReset}\right] dt$$

This function means that at zero current, it completely resets in *TReset* seconds.

<u>Monitor Flag</u>

If the monitor flag is 0, then the relay will create result events to indicate that lines would have tripped, but will not actually trip any lines. If monitor flag is not zero, then the relay will send a trip signal to the branch when to $\theta \geq 1$ and the branch will trip after the *Breaker Time* seconds have elapsed.



Model Supported by PSLF

Line Relays OOSLEN

Out-of-step relay with 3 zones OOSLEN

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.

Multiple OOSLEN relays can be assigned to the same end of a branch. In order to distinguish between them there is an extra key field called Device ID which must be specified for the OOSLEN. When loading from an auxiliary file, if this field is omitted, Simulator assumes value of "1".

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

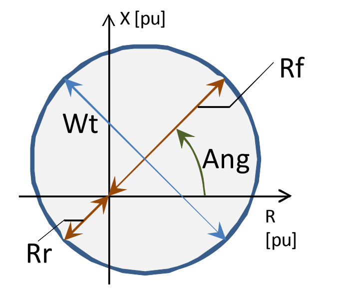
Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Parameter Meanings
Ang = Angle
Wt = Width Total
Rf = RForward
Rr = RReverse
(For backward reach specify a *positive* number)

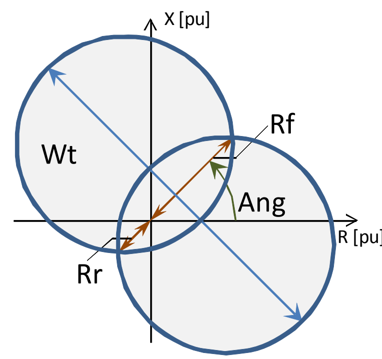
Note: In PSLF, the Rr values are given with the opposite sign for OOSLEN and ZLIN1 only. Simulator will flip signs when reading and writing Rr values from DYD files.

Circle Shape [Wt = Rf+Rr]

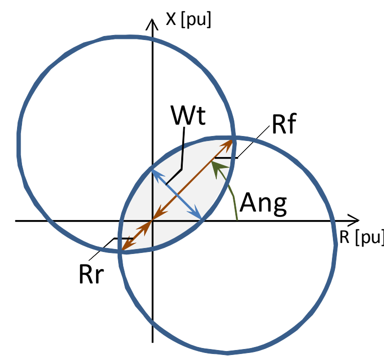
Also used when Wt = 0

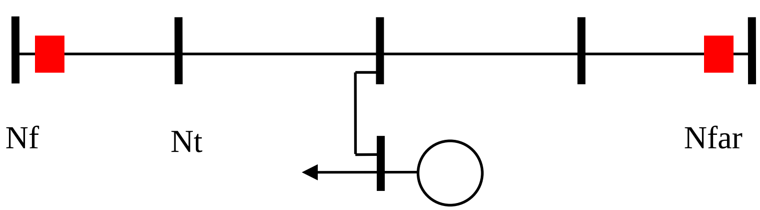


Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]





Model supported by PSLF

Line Relays OOSLNQ

Out-of-step relay with 3 zones OOSLNQ

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.

Multiple OOSLNQ relays can be assigned to the same end of a branch. In order to distinguish between them there is an extra key field called Device ID which must be specified for the OOSLEN. When loading from an auxiliary file, if this field is omitted, Simulator assumes value of "1".

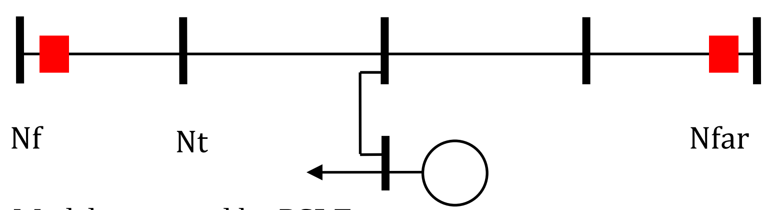
	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

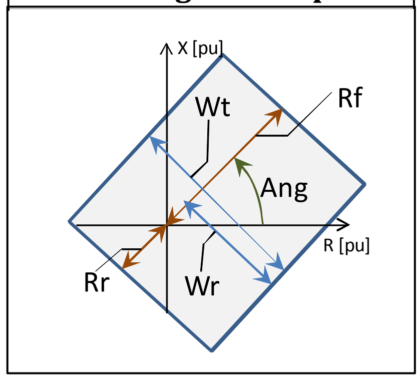
Parameter Meanings

Shape = 1 means Rectangle
0 means Circle, Lens, or Tomato
Ang = Angle
Wt = Width Total
Wr = Width Right
Rf = RForward
Rr = RReverse (For backward reach specify a *positive* number)



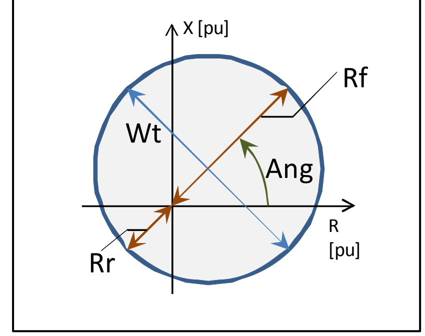
Model supported by PSLF

Rectangular Shape

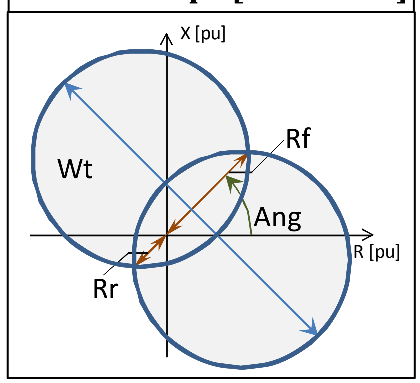


Circle Shape [Wt = Rf+Rr]

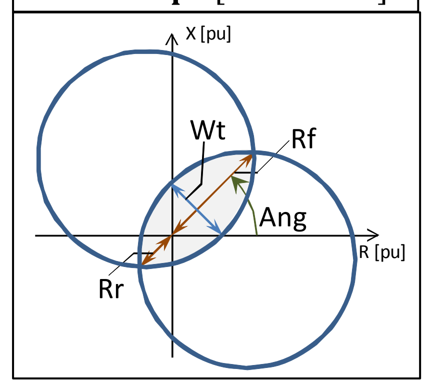
Also used when Wt = 0



Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]



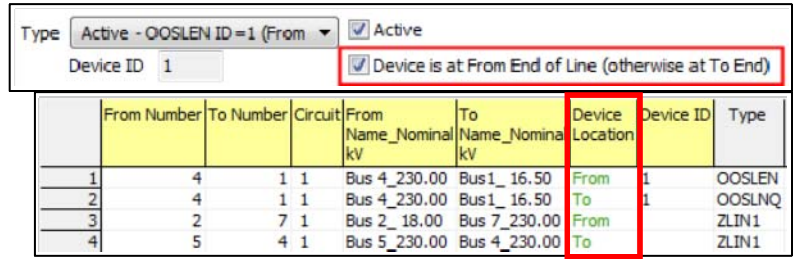
Line Relay SERIESCAPRELAY

Line Relay Model SERIESCAPRELAY

Tfilter	Voltage filter time constant in sec.
tbOn	Switching time On in sec.
tbOff	Switching time Off in sec.
V1On	First voltage threshold for switching series capacitor ON in p.u.
t1On	First time delay for switching series capacitor ON in sec.
V2On	Second voltage threshold for switching series capacitor ON in p.u.
t2On	Second time delay for switching series capacitor ON in sec.
V1Off	First voltage threshold for switching series capacitor OFF in p.u.
t1Off	First time delay for switching series capacitor OFF in sec.
V2Off	Second voltage threshold for switching series capacitor OFF in p.u.
t2Off	Second time delay for switching series capacitor OFF in sec.

Line Relays TIOCR1

Time Inverse Over-Current Relay



	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

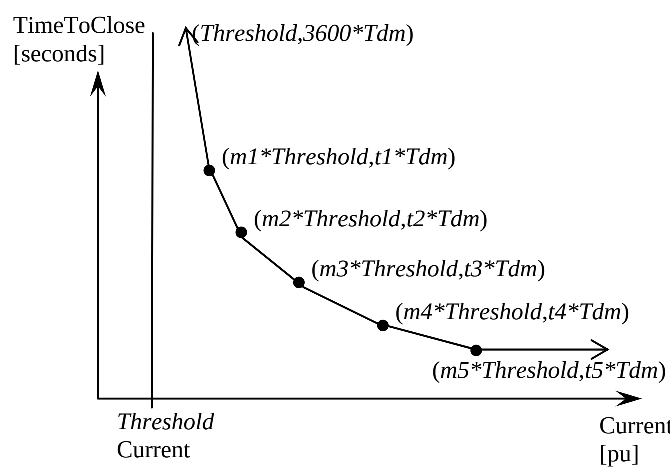
Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End". When this relay's conditions are met, the entire branch is opened.

Relay Operation

The TimeToClose varies according to the piecewise linear function of per unit current as shown to the right and as specified by the input values Threshold, m1..m5, and t1..t5. If m1 is greater than 1.0, then an additional point at the Threshold current of 1 hour (3,600 seconds) is added to the curve.

The time at which the relay will close is determined by integrating the following function. When the function equal 1.0 then the relay will close.

$$\theta = \int \left[\frac{1}{TimeToClose}\right] dt$$



Relay Resetting

When the current drops below the *Threshold* current, then the relay resets according to the parameter *TReset*. If *TReset* is zero, then the relay resets to $\theta = 0$ instantaneously. Otherwise there is a timed reset which occurs by integrating using the function

$$\theta = \int \left[1 - \left(\frac{ICurrent}{Threshold}\right)^2\right] \left[\frac{-1}{TReset}\right] dt$$

This function means that at zero current, it completely resets in *TReset* seconds.

Monitor Flag

If the monitor flag is 0, then the relay will create result events to indicate that lines would have tripped, but will not actually trip any lines. If monitor flag is not zero, then the relay will send a trip signal to the branch when to $\theta \geq 1$ and the branch will trip after the *Breaker Time* seconds have elapsed.

Transfer Trip

Trip signals for this relay may be sent to three different branches by pointing to branches for *Transfer Trip 1*, *Transfer Trip 2*, and *Transfer Trip 3*. In addition, a *Transfer Trip Load* record may also be pointed to with a corresponding parameter *Load Shed %* specifying what percentage of the load should be tripped.

Model Supported by PSSE

Line Relays TIOCRS

Time Inverse Over-Current Relay Standard

This relay is identical in all respects to the TIOCR1 relay, except for how the *TimeToClose* time-inverse overcurrent curve is specified. This includes the treatment of the Monitor Flag, Transfer Trip, and Reset functions. For TIOCRS, instead of using a piece-wise linear curve, a function as described in various world standards is used. To specify which standard to use, the parameter CurveType must be set to either 1, 2, or 3 which translates to the following standards.

1. IEEE C37.112-1996 standard
2. IEC 255-4 or British BS142
3. IAC Curves from GE

The *TimeToClose* functions are specified by the parameters Tdm, p, A, B, C, D, and E depending on the Curve Type. The three standards are shown below. (Note: The use of the reset time is identical for all standards and is the same as used in TIOCR1 and LOCTI).

IEEE C37.112-1996 Standard (*CurveType* = 1)

Using the parameters Threshold, Tdm, p, A, and B, the *TimeToClose* as a function of per unit current is calculated using the following equations

$$TimeToClose = T_{dm}\left(B + \frac{A}{\left(\frac{Icurrent}{Threshold}\right)^{p} - 1}\right)$$

IEC 255-4 or British BS142 Standard (*CurveType* = 2)

Using the parameters Threshold, Tdm, p, and A the *TimeToClose* as a function of per unit current is calculated using the following equations

$$TimeToClose = T_{dm}\left(\frac{A}{\left(\frac{Icurrent}{Threshold}\right)^{p} - 1}\right)$$

IAC GE Curves (*CurveType* = 3)

Using the parameters Threshold, Tdm, A, B, C, D, and E the *TimeToClose* as a function of per unit current is calculated using the fllowing equations

$$TimeToClose = T_{dm}\left(A + \frac{B}{\left(\frac{Icurrent}{Threshold} - C\right)} + \frac{D}{\left(\frac{Icurrent}{Threshold} - C\right)^{2}} + \frac{E}{\left(\frac{Icurrent}{Threshold} - C\right)^{3}}\right)$$

Extra note: Any current higher than 30 times the threshold is simply treated as though it is equal to 30 times the threshold in these equations.

Line Relays TLIN1

Under-voltage or Under-frequency Relay Tripping Line Circuit Breaker(s) TLIN1

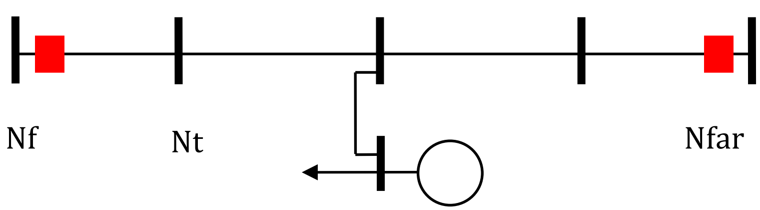
Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, the tripping which occurs depends on the Flag parameter as follows

0 : Only the Relay End of the branch is opened (determined by **Device Location**).

1 : Both ends of the branch are opened and the far end branch is also opened.

2 : Only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.



Model supported by PSLF

The value monitored by this relay is determined by the Input parameter.

0 : means frequency in Hz

1 : means per unit voltage

The bus at which this value is monitored is specified by signal bus (SBus). If a signal bus is not specified, then the Relay End bus will be used instead.

The relay condition is met if the monitored value falls below the pickup value (V1) at least the relay definite time settings (T1). When the relay is condition is met the trip will occur after the circuit breaker time delay (Tcb1)

An Other Field include a signal which have the following meanings.

0 : not picked up (not in Zone)

1 : Picked up, not timed out

2 : Picked up, timeout complete

3 : Circuit Breaker Trip Complete

Line Relays ZDCB

Distance Relay with Directional Comparison Blocking (ZDCB)

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

For Zone 1, the region is the same for both ends of the branch and each end trip independently if their Zone 1 conditions are met.

For higher zone tripping to occur, then Zone 2 conditions must be met at one end while simultaneously the Zone 3 conditions at the *other* end are *not* met.

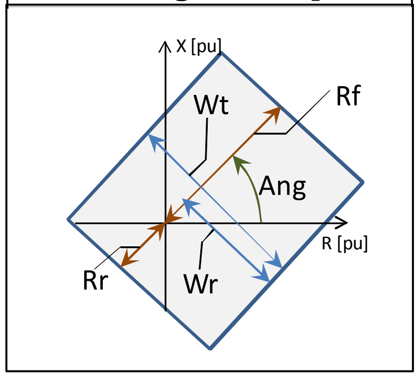
Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Parameter Meanings

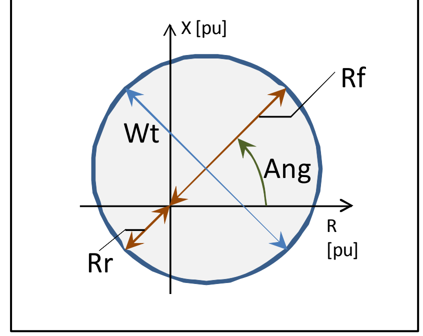
Shape	=	1 means Rectangle 0 means Circle, Lens, or Tomato
Ang	=	Angle
Wt	=	Width Total
Wr	=	Width Right
Rf	=	RForward
Rr	=	RReverse (For backward reach specify a *positive* number)

Rectangular Shape

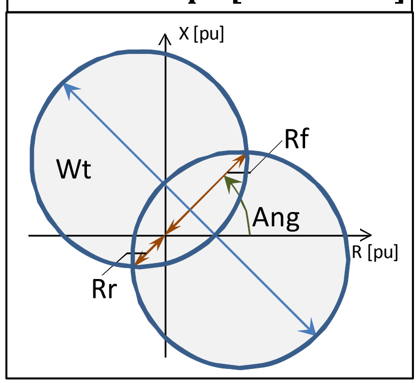


Circle Shape [Wt = Rf+Rr]

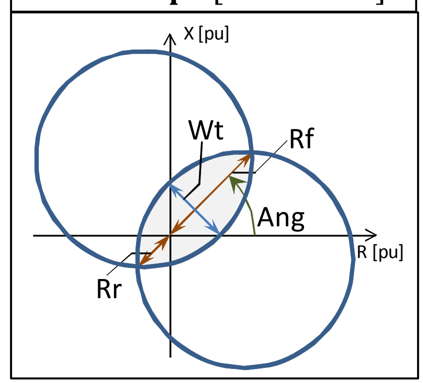
Also used when Wt = 0

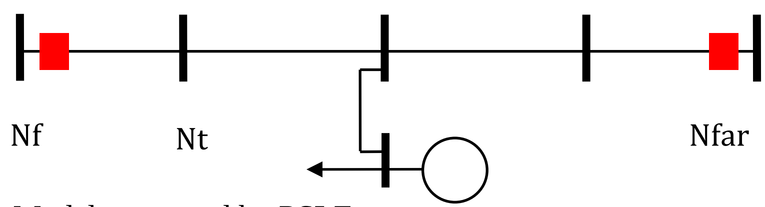


Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]





Model supported by PSLF

Line Relays ZLIN1

Distance Relay with 3 zones (ZLIN1)

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

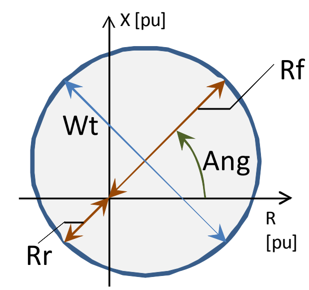
Parameter Meanings

Ang = Angle
Wt = Width Total
Rf = RForward
Rr = RReverse
(For backward reach specify a *positive* number)

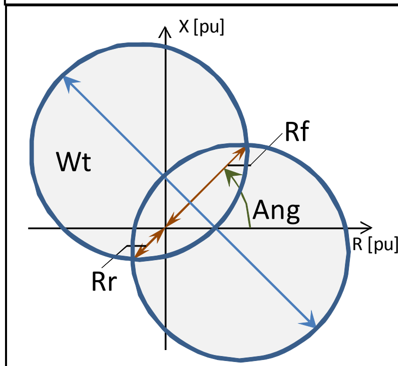
Note: In PSLF, the Rr values are given with the opposite sign for OOSLEN and ZLIN1 only. Simulator will flip signs when reading and writing Rr values from DYD files.

Circle Shape [Wt = Rf+Rr]

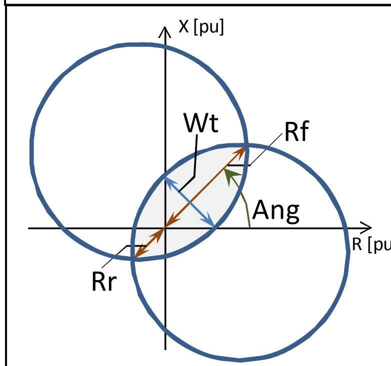
Also used when Wt = 0



Tomato Shape [Wt > Rf+Rr]

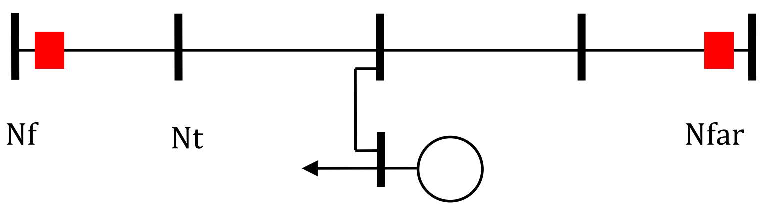


Lens Shape [Wt < Rf+Rr]



Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped



Model supported by PSLF

Line Relays ZPOTT

Distance Relay with Permissive Overreaching Transfer Trip (ZPOTT)

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

For Zone 1, the region is the same for both ends of the branch and each end trip independently if their Zone 1 conditions are met.

For higher Zone 2 tripping to occur, then Zone 2 conditions must be met at the *Relay* and *Other* ends simultaneously.

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nomina kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

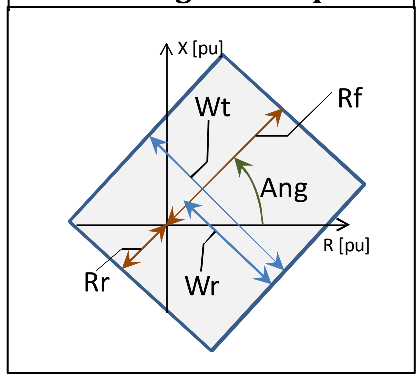
Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Parameter Meanings

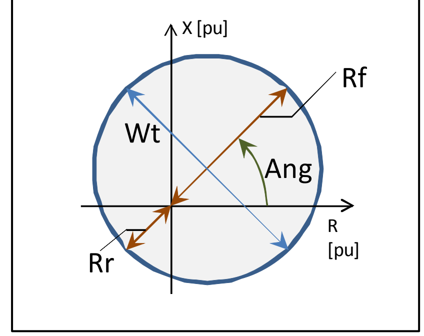
Shape = 1 means Rectangle
0 means Circle, Lens, or Tomato
Ang = Angle
Wt = Width Total
Wr = Width Right
Rf = RForward
Rr = RReverse (For backward reach specify a *positive* number)

Rectangular Shape

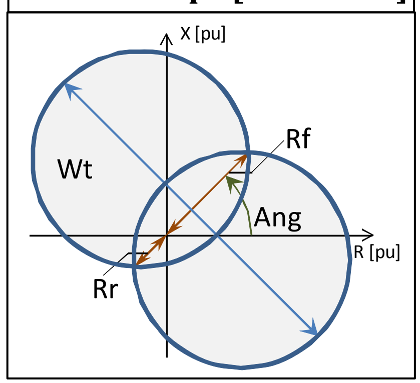


Circle Shape [Wt = Rf+Rr]

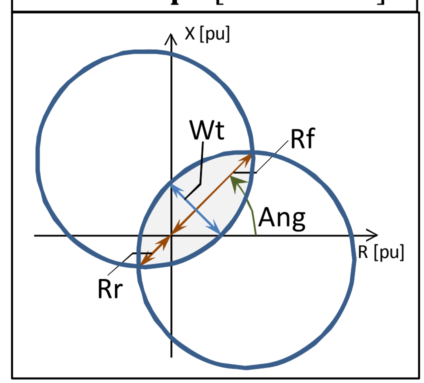
Also used when Wt = 0

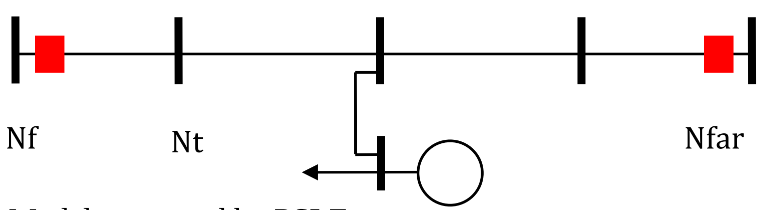


Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]





Model supported by PSLF

Line Relays ZQLIN1

Distance Relay with 3 Zones (ZQLIN1)

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nomina kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

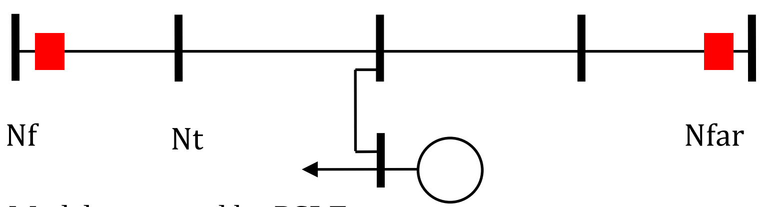
Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Parameter Meanings

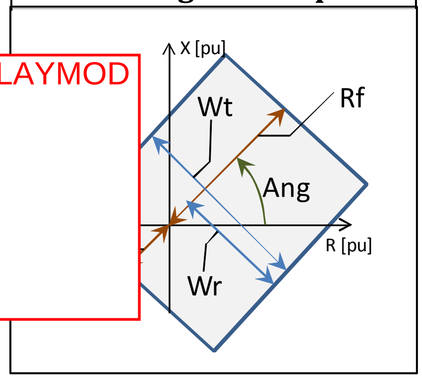
Shape = 1 means Rec
0 means Cir
Lens, or Ton
Ang = Angle
Wt = Width Total
Wr = Width Right
Rf = RForward
Rr = RReverse (For backward reach specify a *positive* number)

LINERELAYMODEL_



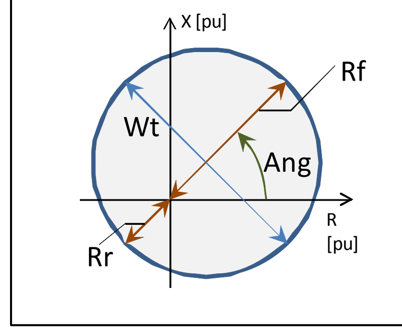
Model supported by PSLF

Rectangular Shape

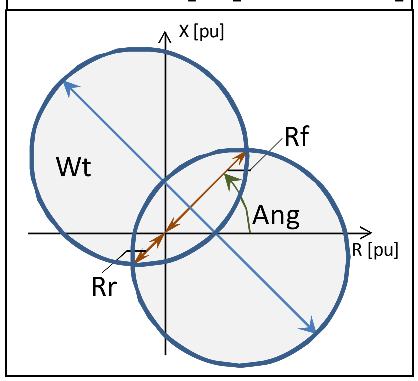


Circle Shape [Wt = Rf+Rr]

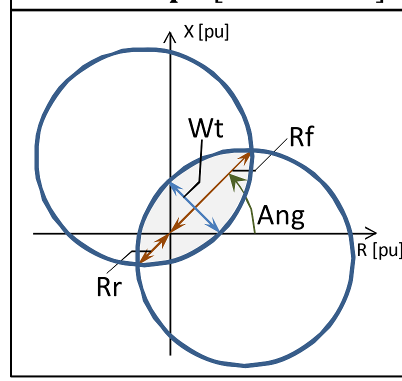
Also used when Wt = 0



Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]



Line Relays ZQLIN2

Distance Relay with 3 Zones (ZQLIN2)

Relays are assigned to a specific end of a branch. This end is specified by the column **Device Location** which can be set to either *From* or *To*. It is specified on the branch dialog by checking the box **Device is at From End of Line (otherwise at To End)**. The end specified by the **Device Location** is referred to as the "Relay End", while the other is referred to as the "Other End".

When this relay's conditions are met, only the Relay End of the branch is opened (determined by **Device Location**). However, the relay will determine if the line presently serves a radial system (i.e. the *Nfar* bus branch is already open). If a radial system is served, then all devices such as load or generation is also opened.

	From Number	To Number	Circuit	From Name_Nominal kV	To Name_Nominal kV	Device Location	Device ID	Type
1	4	1	1	Bus 4_230.00	Bus1_ 16.50	From	1	OOSLEN
2	4	1	1	Bus 4_230.00	Bus1_ 16.50	To	1	OOSLNQ
3	2	7	1	Bus 2_ 18.00	Bus 7_230.00	From		ZLIN1
4	5	4	1	Bus 5_230.00	Bus 4_230.00	To		ZLIN1

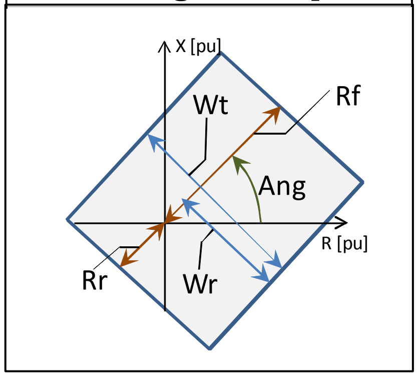
Other field results include signals associated with a particular zone which have the following meanings.
0 : not picked up (not in Zone)
1 : Picked up, not timed out
2 : Picked up, timeout complete

Other field results include signals associated with a breaker. For breach signals, the values have the following meanings.
0 : Trip not initiated
1 : Trip initiated, CB timer running
2 : Breaker has tripped

Parameter Meanings

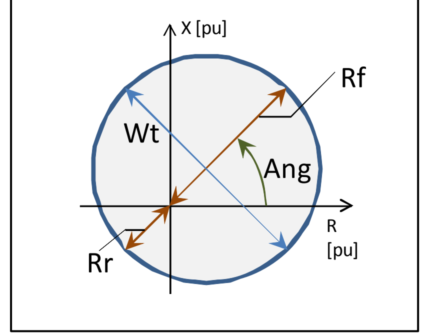
Shape = 1 means Rectangle
0 means Circle, Lens, or Tomato
Ang = Angle
Wt = Width Total
Wr = Width Right
Rf = RForward
Rr = RReverse (For backward reach specify a *positive* number)

Rectangular Shape

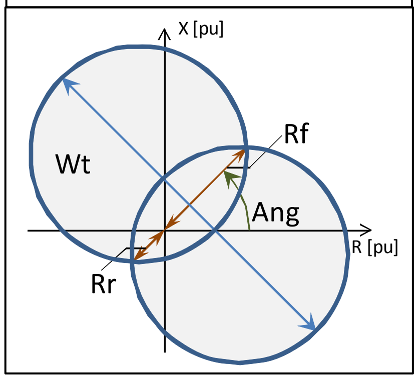


Circle Shape [Wt = Rf+Rr]

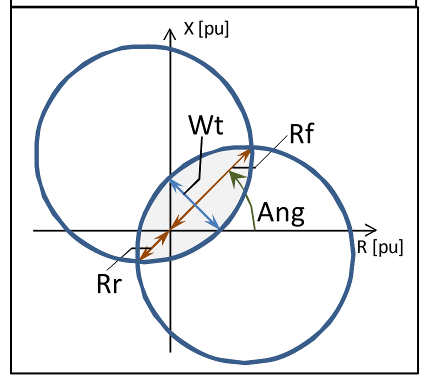
Also used when Wt = 0

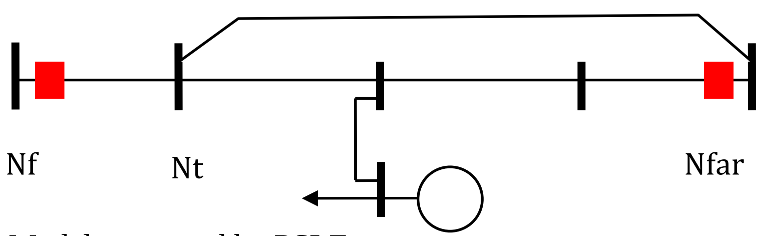


Tomato Shape [Wt > Rf+Rr]



Lens Shape [Wt < Rf+Rr]

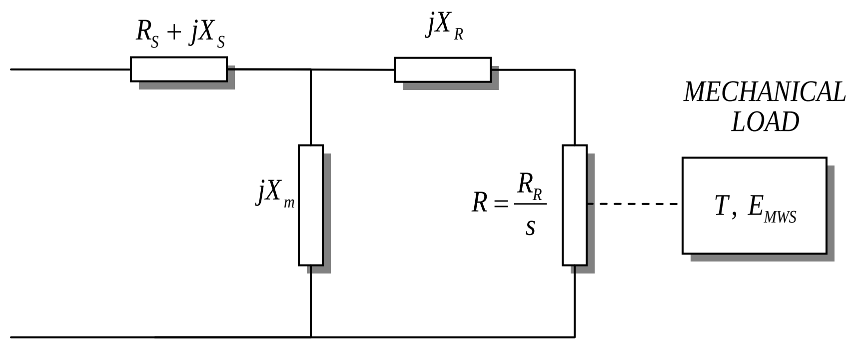




Model supported by PSLF

Load Characteristic BPA INDUCTION MOTOR I

Load Characteristic BPA Induction MotorI
Induction Motor Load Model



Model Notes:

Mechanical Load Torque, $T = (A\omega^2 + B\omega + C)T_O$

where C is calculated by the program such that

$$A\omega^2 + B\omega + C = 1.0$$

$$\omega = 1 - \omega$$

Model in the public domain, available from BPA

Load Characteristic BPA TYPE LA

Load Characteristic BPA Type LA
Load Model

$$P = P_0\left(P_1V^2 + P_2V + P_3 + P_4\left(1 + \Delta f * L_{DP}\right)\right)$$

Model in the public domain, available from BPA

Load Characteristic BPA TYPE LB

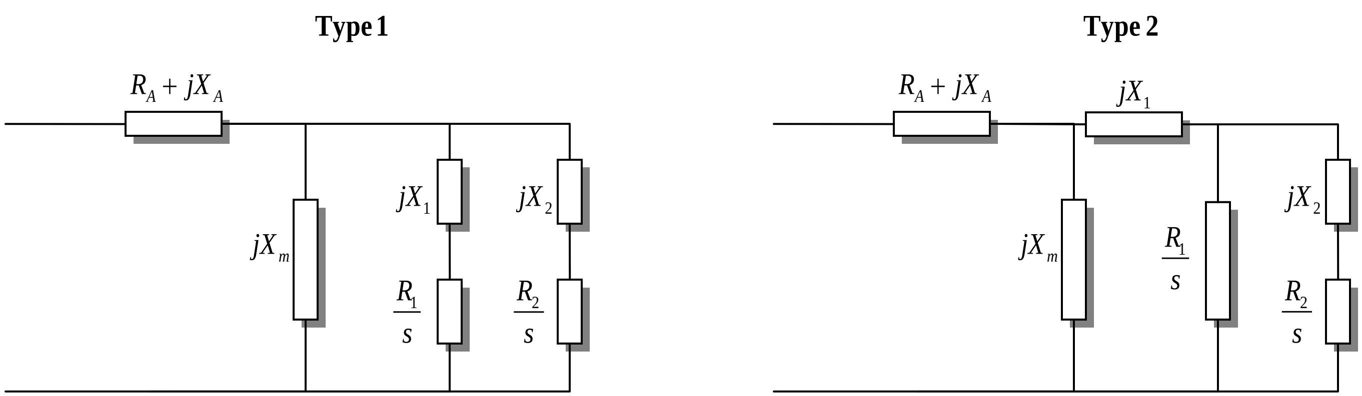
Load Characteristic BPA Type LB
Load Model

$$P = P_0\left(P_1V^2 + P_2V + P_3\right)\left(1 + \Delta f * L_{DP}\right)$$

Model in the public domain, available from BPA

Load Characteristic CIM5

Load Characteristic CIM5
Induction Motor Load Model



Impedances on Motor MVA Base

Model Notes:

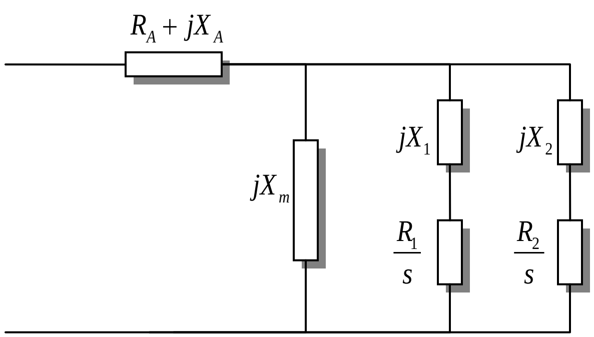
1. To model single cage motor: set $R_2 = X_2 = 0$.
2. When MBASE = 0.; motor MVA base = PMULT * MW load. When MBASE > 0.; motor MVA base = MBASE
3. Load Torque, $T_L = T(1 + D_\omega)^D$
4. For motor starting, $T=T_{nom}$ is specified by the user in CON(J+18). For motor online studies, $T=T_0$ is calculated in the code during initialization and stored in VAR(L+4).
5. $V_|$ is the per unit voltage level below which the relay to trip the motor will begin timing. To display relay, set $V_|=0$
6. $T_|$ is the time in cycles for which the voltage must remain below the threshold for the relay to trip. T_B is the breaker delay time cycles.

Model supported by PSSE

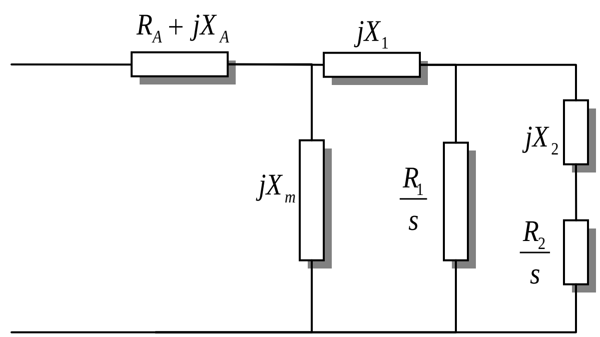
Load Characteristic CIM6

Load Characteristic CIM6
Induction Motor Load Model

Type 1



Type 2



Impedances on Motor MVA Base

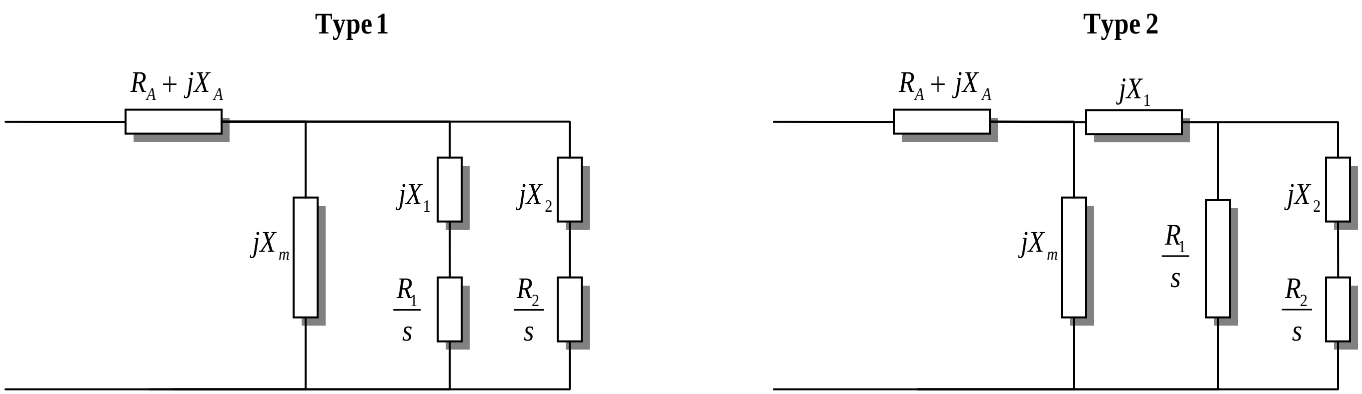
Model Notes:

1. To model single cage motor: set $R_2 = X_2 = 0$.
2. When MBASE = 0.; motor MVA base = PMULT * MW load. When MBASE > 0.; motor MVA base = MBASE
3. Load Torque, $T_L = T\left(A_\omega^2 + B_\omega + C_0 + D_\omega^E\right)^D$
4. For motor starting, $T=T_{nom}$ is specified by the user in CON(J+22). For motor online studies, $T=T_0$ is calculated in the code during initialization and stored in VAR(L+4).
5. V_l is the per unit voltage level below which the relay to trip the motor will begin timing. To display relay, set V_l=0
6. T_l is the time in cycles for which the voltage must remain below the threshold for the relay to trip. T_B is the breaker delay time cycles.

Model supported by PSSE

Load Characteristic CIMW

Load Characteristic CIMW
Induction Motor Load Model



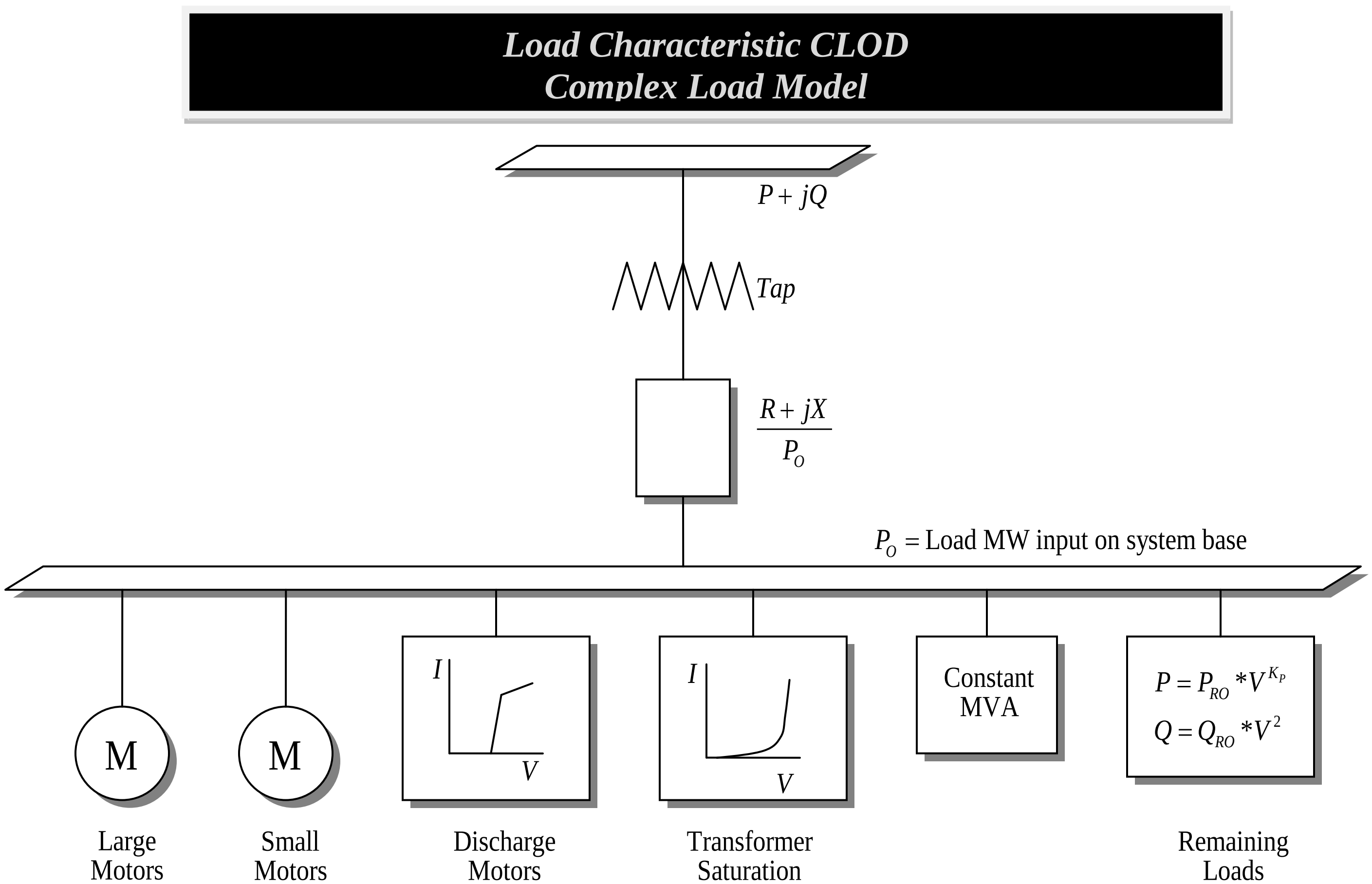
Impedances on Motor MVA Base

Model Notes:

1. To model single cage motor: set $R_2 = X_2 = 0$.
2. When MBASE = 0.; motor MVA base = PMULT * MW load. When MBASE > 0.; motor MVA base = MBASE
3. Load Torque, $T_L = T\left(A_\omega^2 + B_\omega + C_0 + D_\omega^E\right)^D$ where $C0=1-A_\omega^2 - B_{\omega_0} - D_{\omega_0}^E$.
4. This model cannot be used formotor starting studies. T_0 is calculated in the code during initialization and stored in VAR(L+4).
5. $V_|$ is the per unit voltage level below which the relay to trip the motor will begin timing. To display relay, set $V_|=0$
6. $T_|$ is the time in cycles for which the voltage must remain below the threshold for the relay to trip. T_B is the breaker delay time cycles.

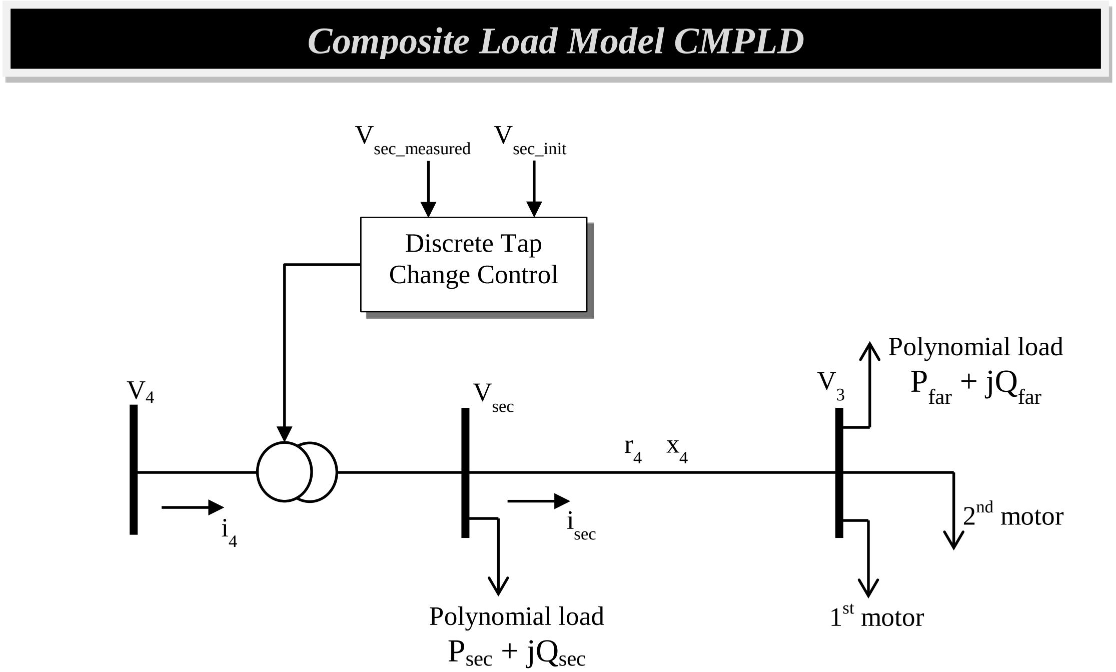
Model supported by PSSE

Load Characteristic CLOD



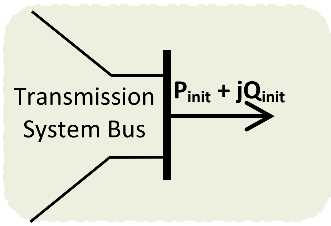
Model supported by PSSE

Load Characteristic CMPLD



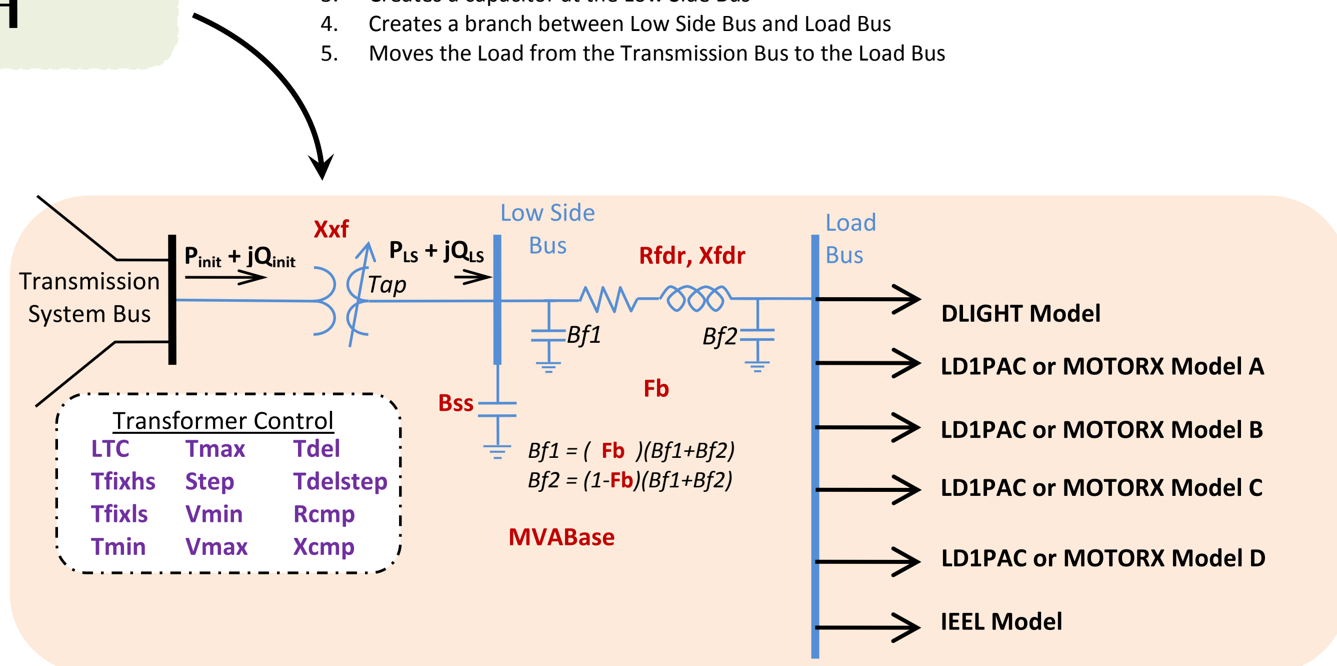
Model supported by PSLF

Load Characteristic CMPLDW



The internal model used by the transient stability numerical simulation structurally does the following.

1. Creates two buses called Low Side Bus and Load Bus
2. Creates a transformer between Transmission Bus and Low Side Bus
3. Creates a capacitor at the Low Side Bus
4. Creates a branch between Low Side Bus and Load Bus
5. Moves the Load from the Transmission Bus to the Load Bus



Model supported by PSLF

Load Characteristic CMPLDWNF

This represents a load model identical to the CMPLDW model, except that all the parameters related to the Distribution Equivalent have been removed (the first 17 parameters of CMPLDW and the MVABase).

Model supported by PowerWorld

Load Characteristic DISTRIBUTION EQUIVALENT TYPES

This equivalent model and the parameters used for the Load Distribution Equivalent Types are the same as the first 17 parameters of the CMPLDW load characteristic model, along with an MVA base parameter.

Model supported by PowerWorld

Load Characteristic DLIGHT

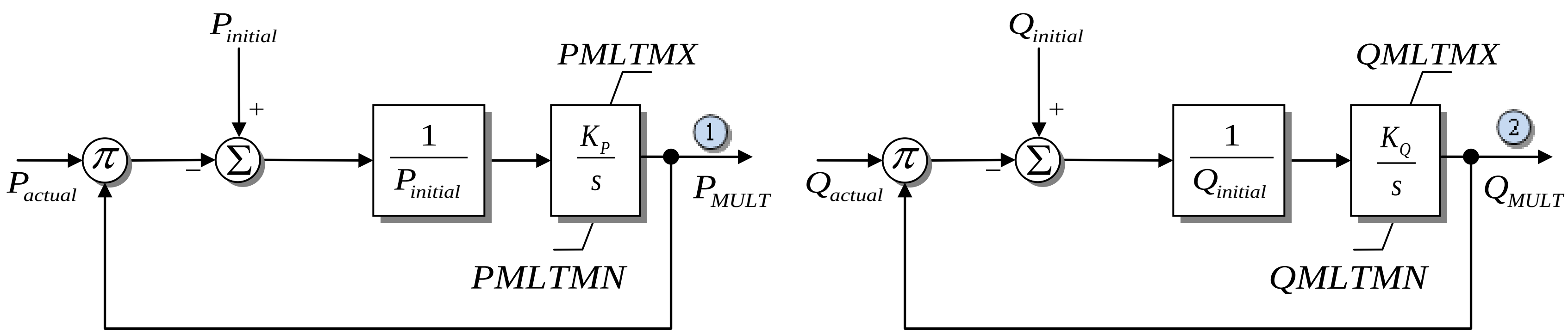
Load Characteristic Model DLIGHT

Real Power Coefficient	Real Power Coefficient
Reactive Power Coefficient	Reactive Power Coefficient
Breakpoint Voltage	Breakpoint Voltage
Extinction Voltage	Extinction Voltage

Model supported by PW

Load Characteristic EXTL

Load Characteristic EXTL
Complex Load Model



States:
1 – P_{MULT}
2 - Q_{MULT}

Load Characteristic IEEL

Load Characteristic IEEL
Complex Load Model

$$P = P_{load}\left(a_1 v^{n_1} + a_2 v^{n_2} + a_3 v^{n_3}\right)\left(1 + a_7 \Delta f\right)$$

$$Q = Q_{load}\left(a_4 v^{n_4} + a_5 v^{n_5} + a_6 v^{n_6}\right)\left(1 + a_8 \Delta f\right)$$

Model supported by PSSE

Load Characteristic LD1PAC

Load Characteristic Model LD1PAC

Pul	Fraction of constant power load
TV	Voltage input time in sec.
Tf	Frequency input time constant in sec.
CompPF	Compressor Power Factor
Vstall	Compressor Stalling Voltage in p.u.
Rstall	Compressor Stall resistance in p.u.
Xstall	Compressor Stall impedance in p.u.
Tstall	Compressor Stall delay time in sec.
LFadj	Vstall adjustment proportional lo loading factor
KP1 to KP2	Real power coefficient for running states, p.u.P/p.u.V
NP1 to NP2	Real power exponent for running states
KQ1 to KQ2	Reactive power coefficient for running states, p.u.Q/p.u.
NQ1 to NQ2	Reactive power exponent for running states
Vbrk	Compressor motor breakdown voltage in p.u
Frst	Restarting motor fraction
Vrst	Restart motor voltage in p.u.
Trst	Restarting time delay in sec.
CmpKpf	Real power frequency sensitivity, p.u.P/p.u.
CmpKqf	Reactive power frequency sensitivity, p.u.Q/p.u.

Vc1off	Voltage 1 contactor disconnect load in p.u.
Vc2off	Voltage 2 contactor disconnect load in p.u.
Vc1on	Voltage 1 contactor re-connect load in p.u.
Vc2on	Voltage 2 contactor re-connect load in p.u.
Tth	Compressor heating time constant in sec.
Th1t	Compressor motors begin tripping
Th2t	Compressor motors finished tripping
fuvr	Fraction of compressor motors with undervoltage relays
uvtr1 to uvtr2	Undervoltage pickup level in p.u.
ttr1 to ttr2	Undervoltage definite time in sec.

Model supported by PSLF

Load Characteristic LDFR

Load Characteristic LDFR
Complex Load Model

$$P = P_O \left(\frac{\omega}{\omega_O} \right)^m$$

$$Q = Q_O \left(\frac{\omega}{\omega_O} \right)^n$$

$$I_p = I_{po} \left(\frac{\omega}{\omega_O} \right)^r$$

$$I_q = I_{qo} \left(\frac{\omega}{\omega_O} \right)^s$$

Model supported by PSSE

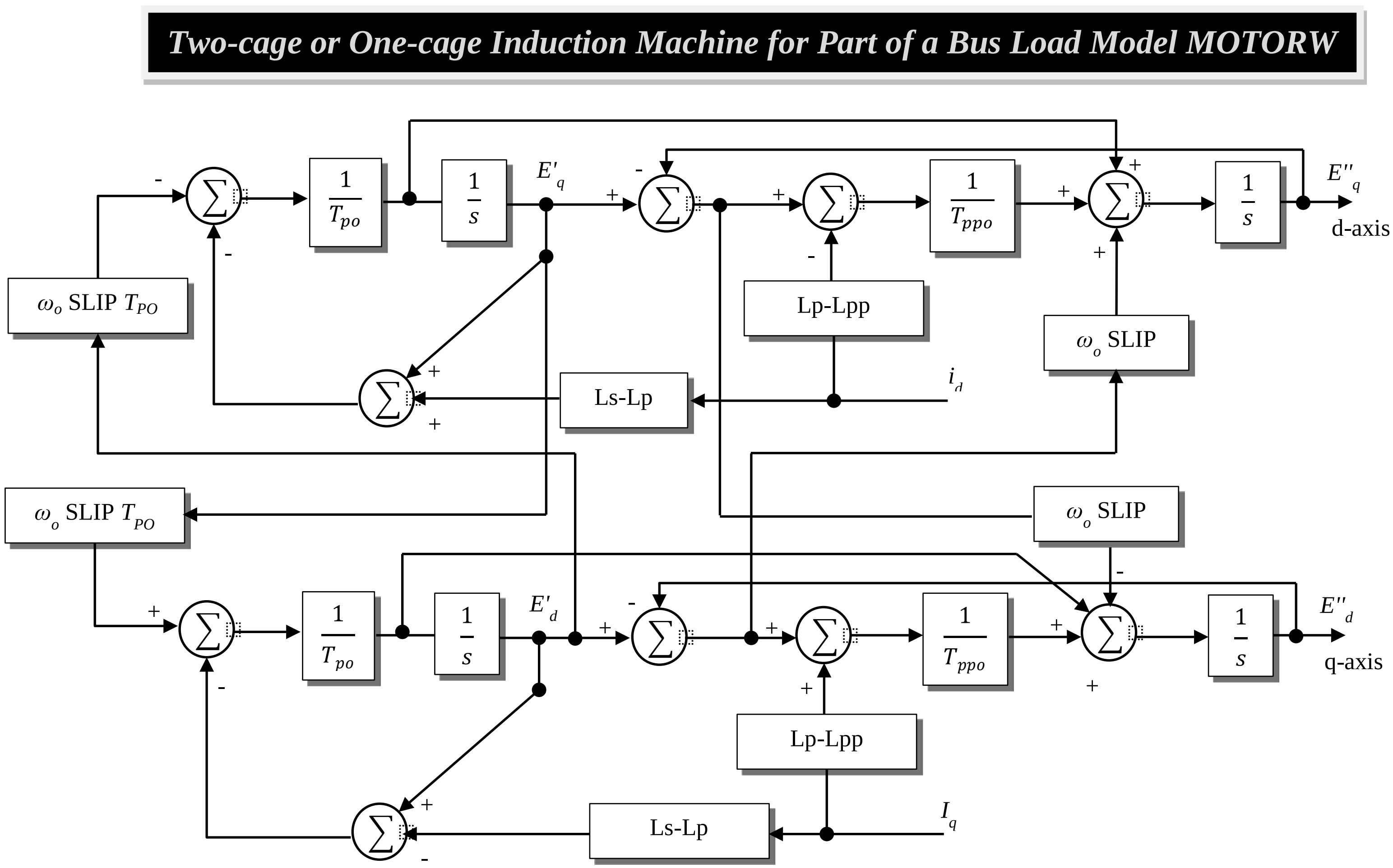
Load Characteristic LDRANDOM

Random Load Model LDRANDOM

The Random Load Model simulates a random load. The user needs to input the Percent of Standard Deviation to generate a random number; a Time for the filter and the Start time when the random load will start to be model. Once the random load model start internally it uses a filter and the generated random number to modify the load.

Model supported by PSLF

Load Characteristic MOTORW



Model supported by PSLF

Load Characteristic WSCC

Load Characteristic Model WSCC

p1	Constant impedance fraction in p.u.
q1	Constant impedance fraction in p.u.
p2	Constant current fraction in p.u.
q2	Constant current fraction in p.u.
p3	Constant power fraction in p.u.
q3	Constant power fraction in p.u.
p4	Frequency dependent power fraction in p.u.
q4	Frequency dependent power fraction in p.u.
lpd	Real power frequency index in p.u.
lqd	Reactive power frequency index in p.u.

Model supported by PSLF

Load Relays DLSH

Rate of Frequency Load Shedding Model DLSH

f1 to f3	Frequency load shedding point
t1 to t3	Pickup time
Frac1 to frac3	Fraction of load to shed
tb	Breaker time
df1 to df3	Rate of frequency shedding point

Model supported by PSSE

Load Relays LDS3

Underfrequency Load Shedding Model with Transfer Trip LDS3

Tran Trip Obj	Transfer Trip Object
SC	Shed Shunts
f1 to f5	Frequency load shedding point
t1 to t5	Pickup time
tb1 to tb5	Breaker time
Frac1 to frac5	Fraction of load to shed
ttb	Transfer trip breaker time

Model supported by PSSE

Load Relays LDSH

Underfrequency Load Shedding Model LDSH

f1 to f3	Frequency load shedding point
t1 to t3	Pickup time
frac1 to frac3	Fraction of load to shed
tb	Breaker time

Model supported by PSSE

Load Relays LDST

Time Underfrequency Load Shedding Model LDST

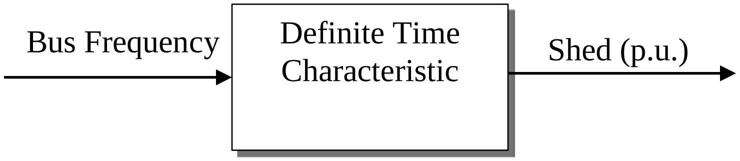
f1 to f4	Frequency load shedding point
z1 to z4	Nominal operating time
tb	Breaker time
frac	Fraction of load to shed
freset	Reset frequency
tres	Resetting time

Model supported by PSSE

Load Relays LSDT1

Definite-Time Underfrequency Load Shedding Relay Model LSDT1

Tfilter	Input transducer time constant
tres	Resetting time
f1 to f3	Frequency load shedding point
t1 to t3	Pickup time
tb1 to tb3	Breaker time
frac1 to frac3	Fraction of load to shed

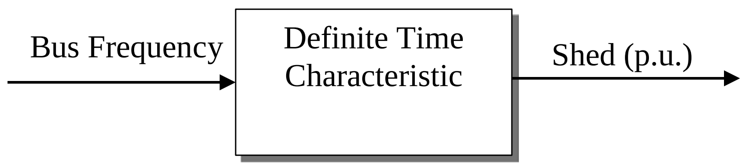


Model supported by PSLF

Load Relays LSDT2

Definite-Time Undervoltage Load Shedding Relay Model LSDT2

Rem Bus	Remote Bus
Voltage Mode	Voltage mode: 0 for deviation; 1 for absolute
Tfilter	Input transducer time constant
tres	Resetting time
v1 to v3	Voltage load shedding point
t1 to t3	Pickup time
tb1 to tb3	Breaker time
frac1 to frac3	Fraction of load to shed

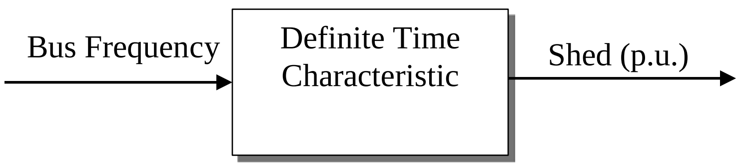


Model supported by PSLF

Load Relays LSDT8

Definite-Time Underfrequency Load Shedding Relay Model LSDT8

Tfilter	Input transducer time constant
tres	Resetting time
f1 to f3	Frequency load shedding point
t1 to t3	Pickup time
tb1 to tb3	Breaker time
frac1 to frac3	Fraction of load to shed
df1 to df3	Rate of frequency shedding point

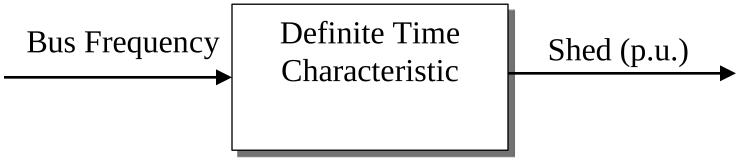


Model supported by PSLF

Load Relays LSDT9

Definite Time Underfrequency Load Shedding Relay Model LSDT9

Tfilter	Input transducer time constant
tres	Resetting time
f1 to f9	Frequency load shedding point
t1 to t9	Pickup time
tb1 to tb9	Breaker time
frac1 to frac9	Fraction of load to shed



Model supported by PSLF

Load Relays LVS3

Undervoltage Load Shedding Model with Transfer Trip LVS3

FirstTran Trip Obj	First Transfer Trip Object
SecondTran Trip Obj	First Transfer Trip Object
SC	Shed Shunts
v1 to v5	Voltage load shedding point
t1 to t5	Pickup time
tb1 to tb5	Breaker time
Frac1 to frac5	Fraction of load to shed
ttb1 to ttb2	Transfer trip breaker time

Model supported by PSSE

Load Relays LVSH

Undervoltage Load Shedding Model LVSH

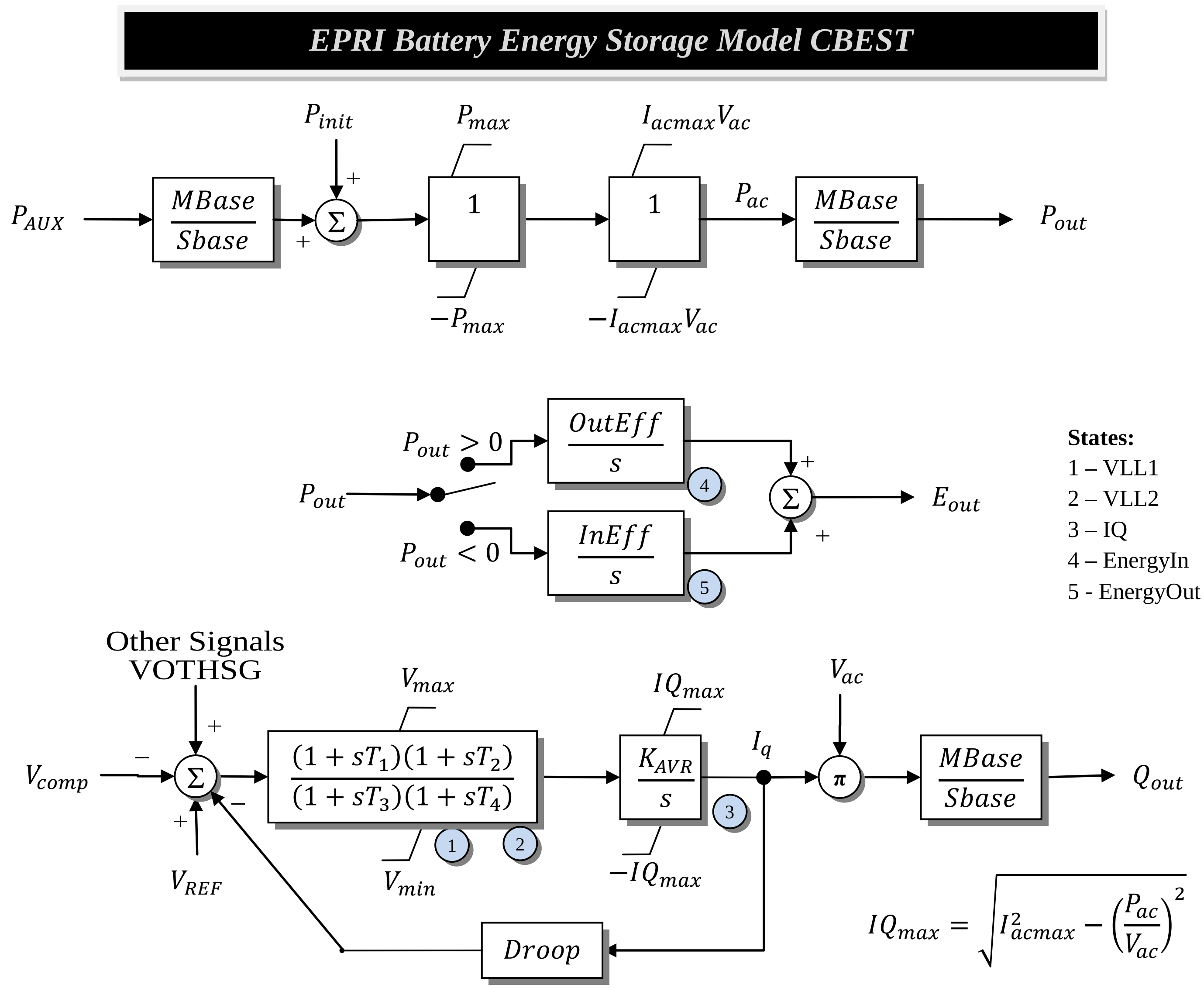
v1 to v3	Voltage load shedding point
t1 to t3	Pickup time
frac1 to frac3	Fraction of load to shed
tb	Breaker time

Model supported by PSSE

Machine Model BPASVC

No Block Diagram. Old BPA IPF program model.

Machine Model CBEST



Model supported by PSSE

Machine Model CIMTR1

Model CIMTR1

Tp	T' - Transient rotor time constant
Tpp	T" – Sub-transient rotor time constant in sec.
H	Inertia constant in sec.
X	Synchronous reactance
Xp	X' – Transient Reactance
Xpp	X" – Sub-transient Reactance
Xl	Stator leakage reactance in p.u.
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
SE2	Saturation value at E2
Switch	Switch
Ra	Stator resistance in p.u.

States:
1 – Epr
2 – Epi
3 – Ekr
4 – Eki
5 – Speed wr

Model supported by PSSE

Machine Model CIMTR2

Induction Motor Model CIMTR2

Tp	T' - Transient rotor time constant
Tpp	T" – Sub-transient rotor time constant in sec.
H	Inertia constant in sec.
X	Synchronous reactance
Xp	X' – Transient Reactance
Xpp	X" – Sub-transient Reactance
Xl	Stator leakage reactance in p.u.
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
SE2	Saturation value at E2
D	Damping

States:
1 – Epr
2 – Epi
3 – Ekr
4 – Eki
5 – Speed wr

Model supported by PSSE

Machine Model CIMTR3

Induction Generator Model CIMTR3

Tp	T' - Transient rotor time constant
Tpp	T" – Sub-transient rotor time constant in sec.
H	Inertia constant in sec.
X	Synchronous reactance
Xp	X' – Transient Reactance
Xpp	X" – Sub-transient Reactance
Xl	Stator leakage reactance in p.u.
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
Switch	Switch
SYN-POW	Mechanical power at synchronous speed (p.u. > 0)

States:
1 – Epr
2 – Epi
3 – Ekr
4 – Eki
5 – Speed wr

Model supported by PSSE

Machine Model CIMTR4

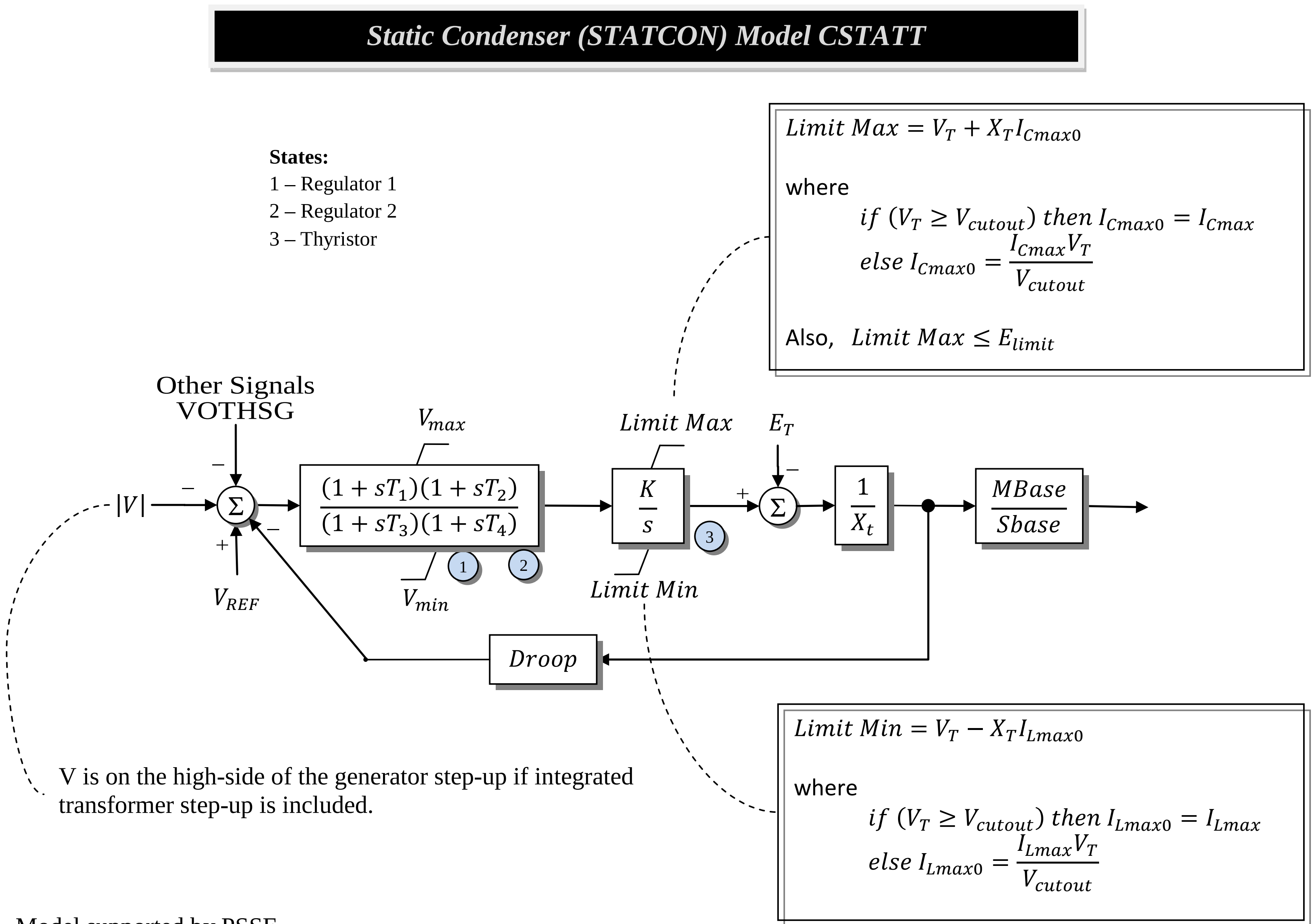
Induction Motor Model CIMTR4

Tp	T' - Transient rotor time constant
Tpp	T" – Sub-transient rotor time constant in sec.
H	Inertia constant in sec.
X	Synchronous reactance
Xp	X' – Transient Reactance
Xpp	X" – Sub-transient Reactance
Xl	Stator leakage reactance in p.u.
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
D	Damping
SYN-TOR	Synchronous torque (p.u. < 0)

States:
1 – Epr
2 – Epi
3 – Ekr
4 – Eki
5 – Speed wr

Model supported by PSSE

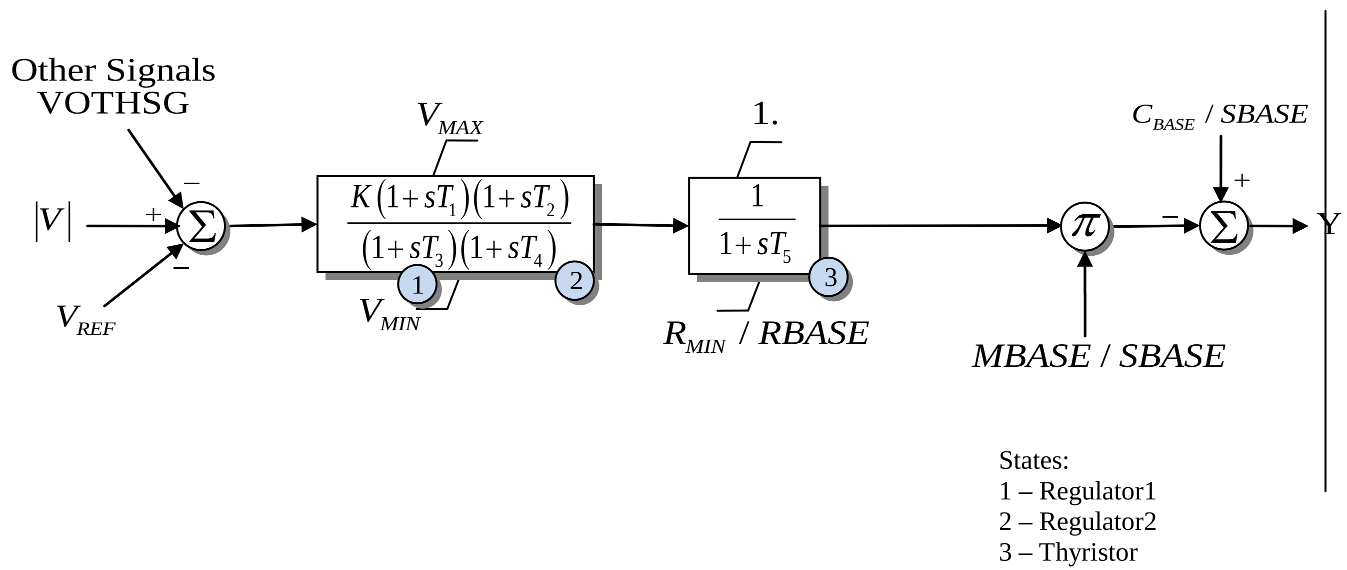
Machine Model CSTATT



Model supported by PSSE

Machine Model CSVGN1

Machine Model CSVGN1
Static Shunt Compensator CSVGN1

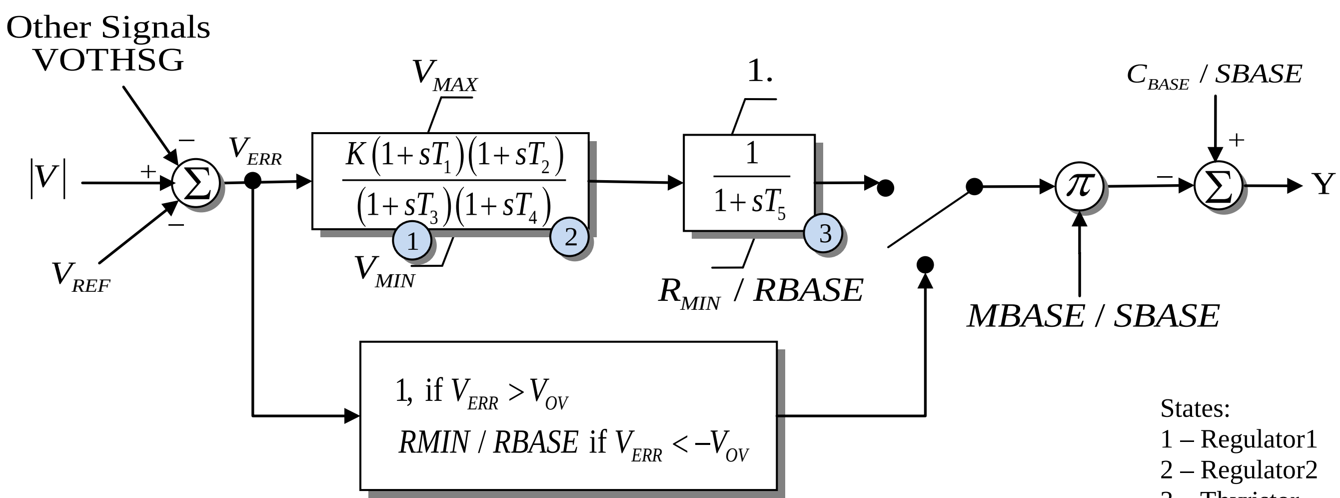


$RBASE = MBASE$

Note : $|V|$ is the voltage magnitude on the high side of generator step-up transformer if present.

Machine Model CSVGN3

Machine Model CSVGN3
Static Shunt Compensator CSVGN3

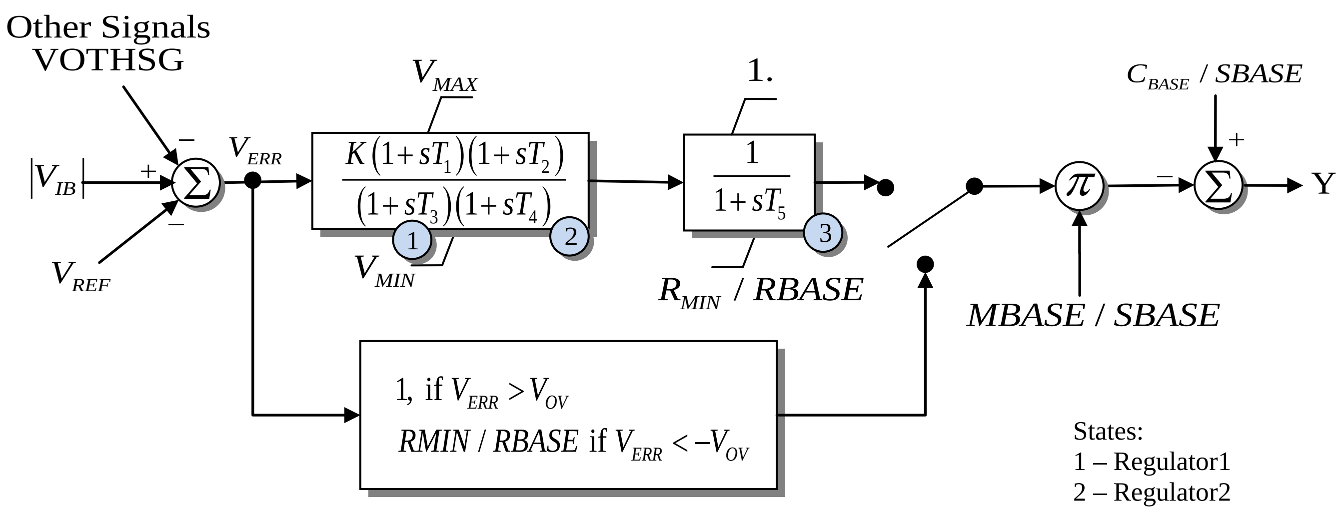


$RBASE = MBASE$

Note : $|V|$ is the voltage magnitude on the high side of generator step-up transformer if present.

Machine Model CSVGN4

Machine Model CSVGN4
Static Shunt Compensator CSVGN4

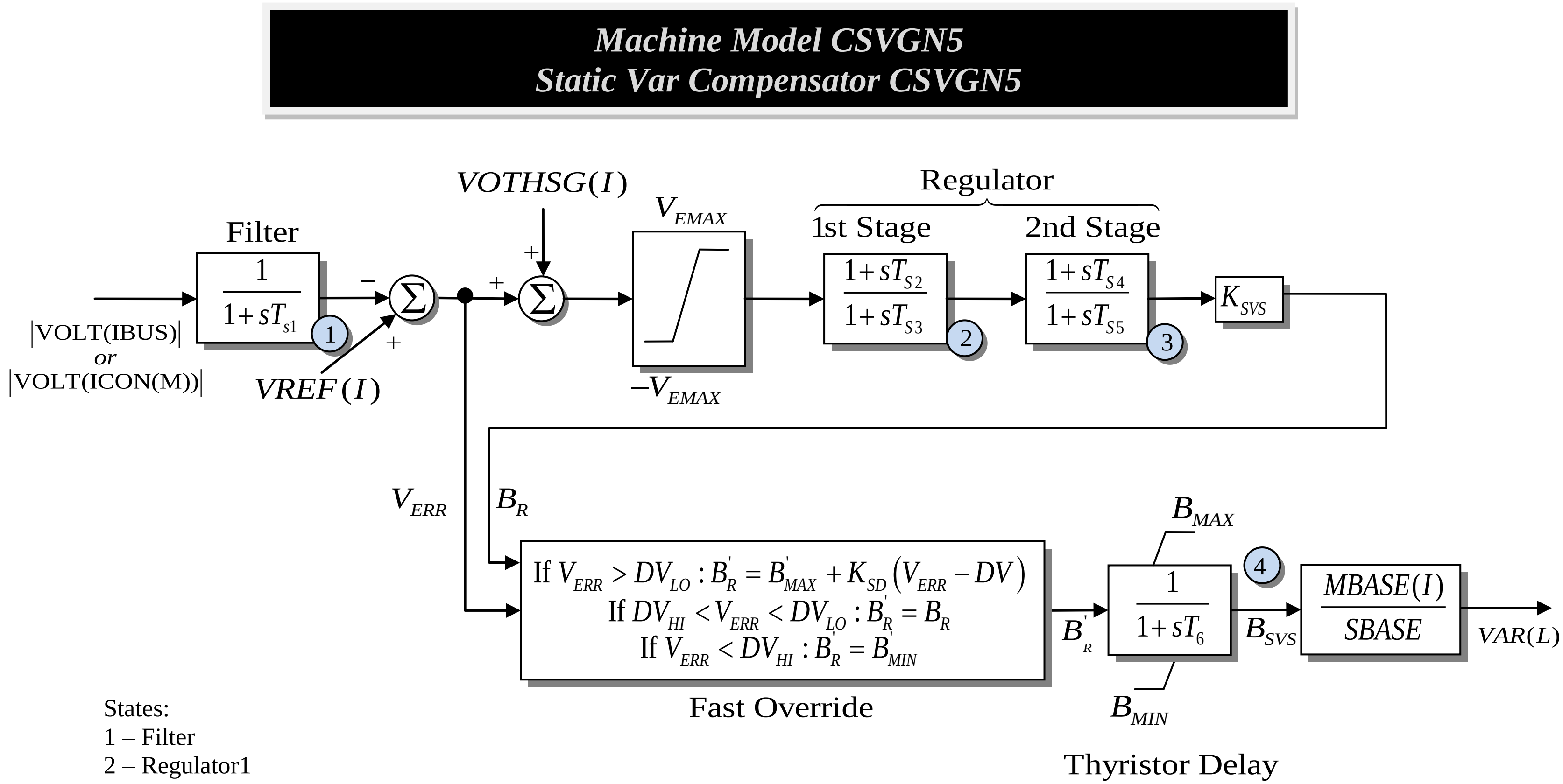


States:
1 – Regulator1
2 – Regulator2
3 – Thyristor

$RBASE = MBASE$

Model supported by PSSE

Machine Model CSVGN5



States:
1 – Filter
2 – Regulator1
3 – Regulator2
4 – Thyristor

If $DV = 0$,

$DV_{LO} = B'_{MAX} / K_{SVS}$

$DV_{HI} = B'_{MIN} / K_{SVS}$

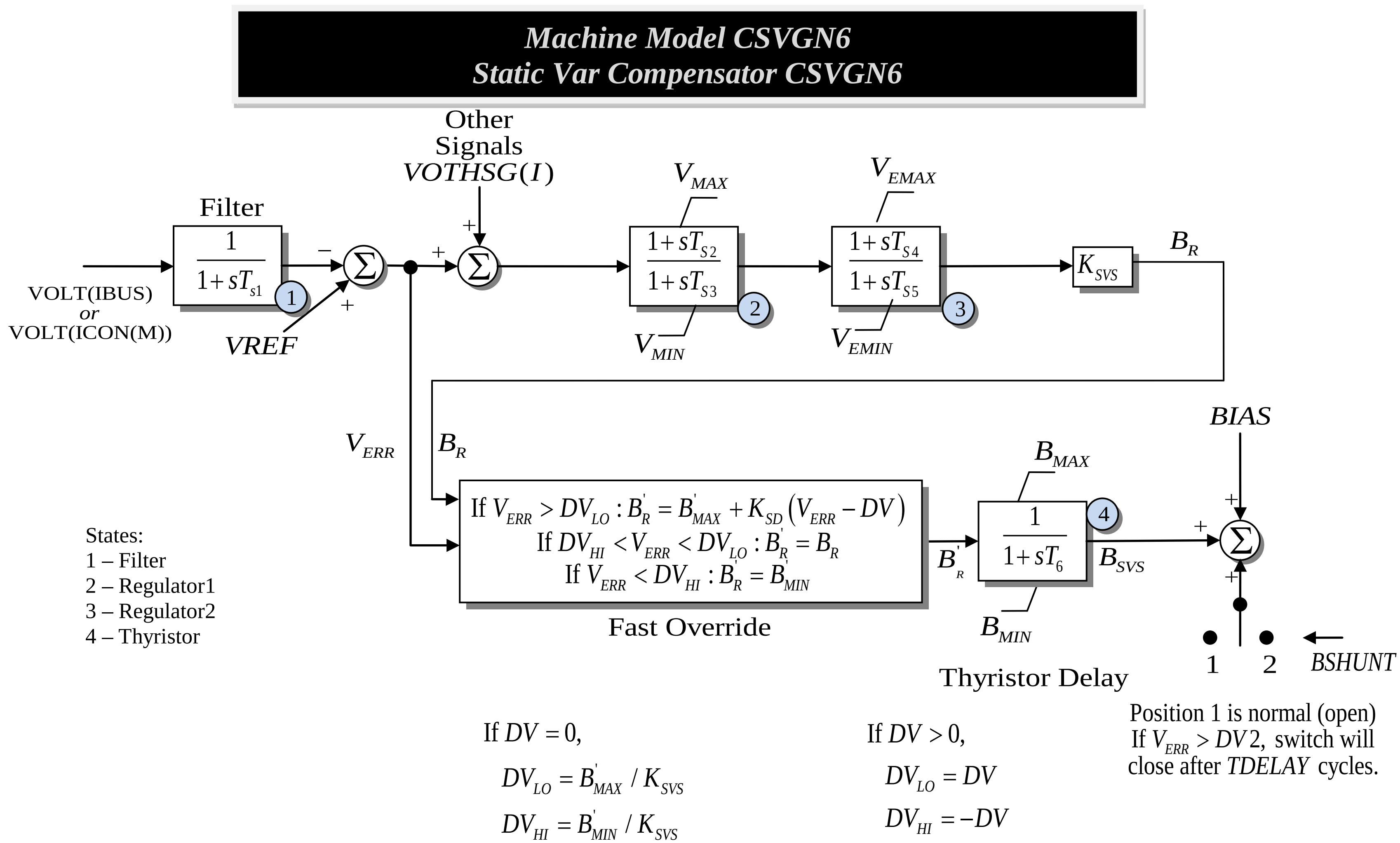
If $DV > 0$,

$DV_{LO} = DV$

$DV_{HI} = -DV$

Model supported by PSSE

Machine Model CSVGN6



Model supported by PSSE

Machine Model GEN_BPA_MMG2
No block diagram. 2 state machine model (Angle, Speed, and constant Eqp)

Machine Model GEN_BPA_MMG3
No block diagram. 3 state machine model (Angle, Speed, Eqp). Similar to GENTRA

Machine Model GEN_BPA_MMG4
No block diagram. 4 state machine model (Angle, Speed, Eqp, Edp).

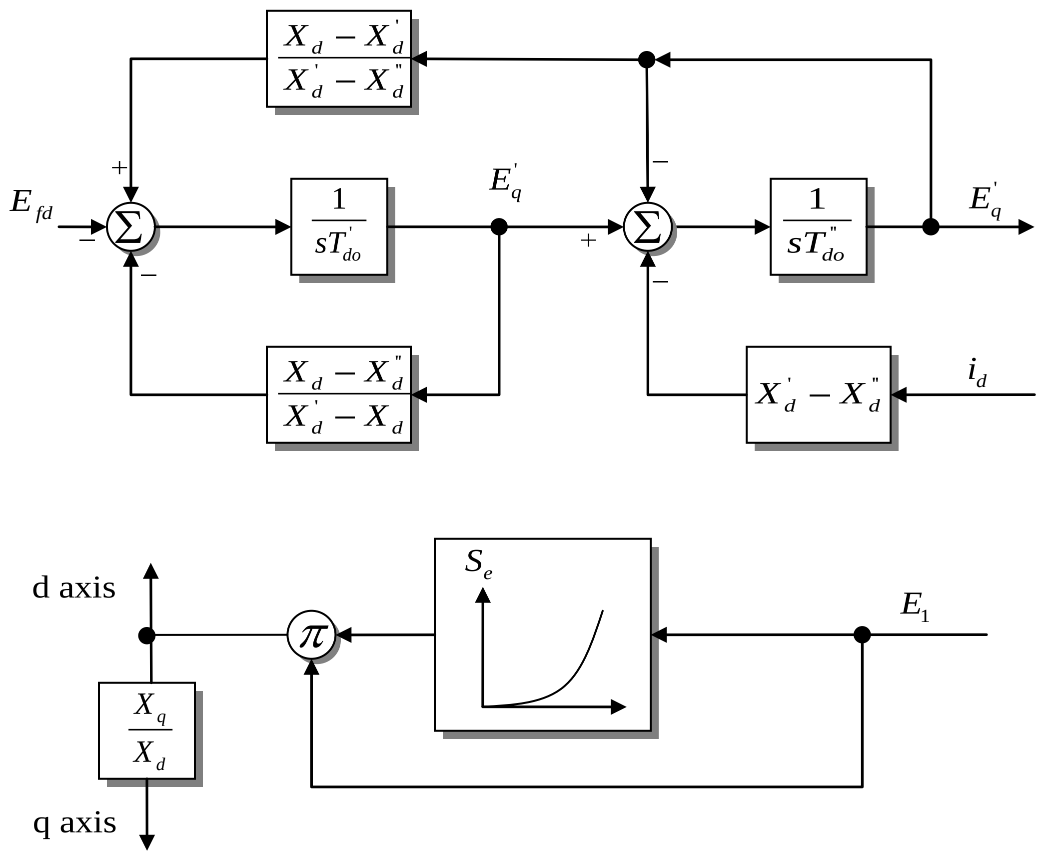
Machine Model GEN_BPA_MMG5
No block diagram, but similar to GENSAL and GENSAE. 5 states (Angle, Speed, Eqp, Eqpp, Edpp).

Machine Model GEN_BPA_MMG6
No block diagram, but similar to GENROU and GENROE. 6 states (Angle, Speed, Eqp, Eqpp, Edp, Edpp).

Machine Model GENCC

Machine Model GENCC
Generator represented by uniform inductance ratios rotor modeling to match WSCC type F

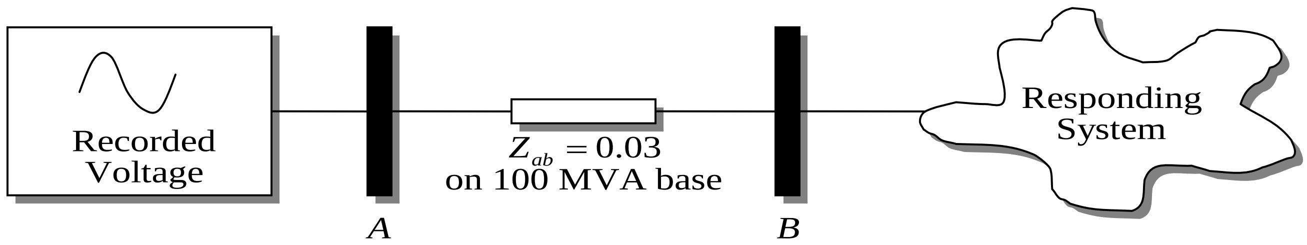
States:
1 – Angle
2 – Speed w
3 – Eqp
4 – Eqpp
5 – Edp
6 - Edpp



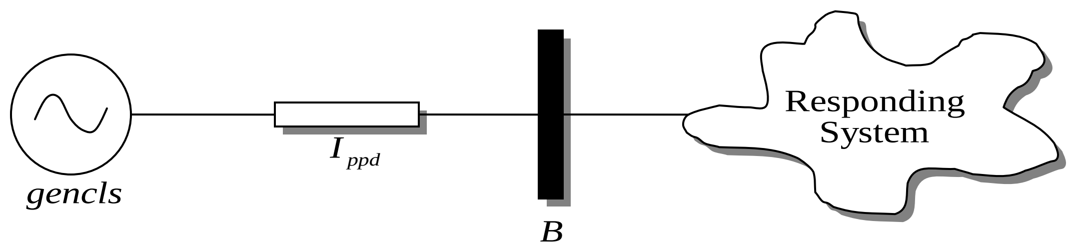
Model supported by PSLF

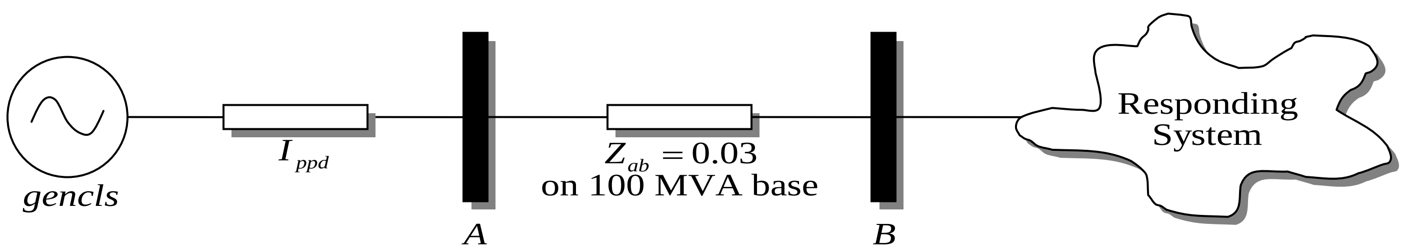
Machine Model GENCLS_PLAYBACK

Machine Model GENCLS_PLAYBACK
Synchronous machine represented by "classical" modeling or Thevenin Voltage Source to play Back known voltage/frequency signal



States:
1 – Angel
2 – Speed w





Model supported by PSLF

Machine Model GENDCO

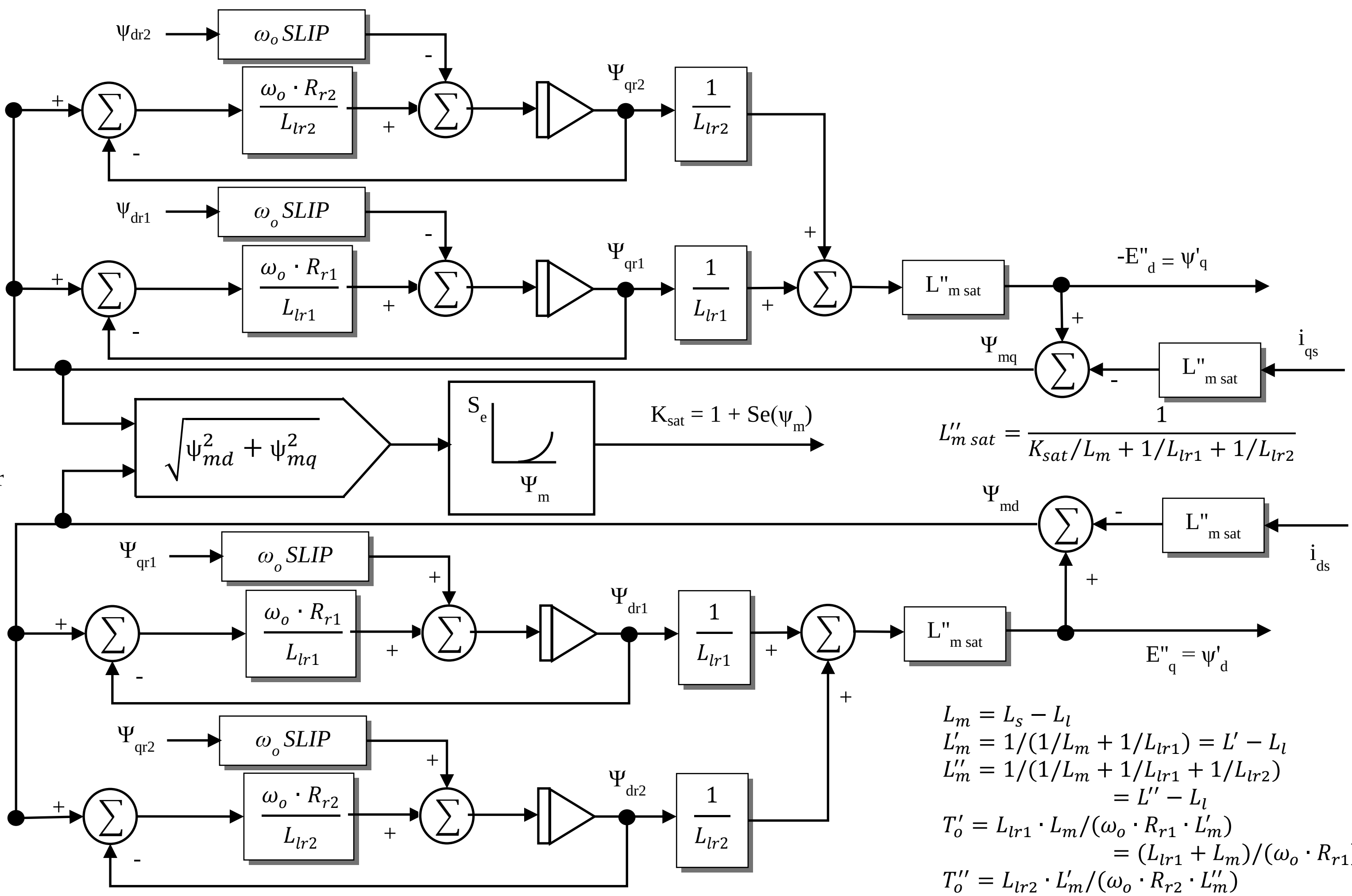
Round Rotor Generator Model Including DC Offset Torque Component GENDCO

H	Inertia constant in sec.
D	Damping
Ra	Stator resistance in p.u.
Xd	X_d – Direct axis synchronous reactance
Xq	X_q – Quadrature axis synchronous reactance
Xdp	X'_d – Direct axis synchronous reactance
Xqp	X'_q – Quadrature axis synchronous reactance
Xl	Stator leakage reactance in p.u.
Tdop	T'_{do} – Open circuit direct axis transient time constant
Tqop	T'_{qo} – Quadrature axis transient time constant
Tdopp	T''_{do} – Open circuit direct axis subtransient time constant
Tqopp	T''_{qo} – Quadrature axis subtransient time constant
S(1.0)	Saturation factor at 1.0 p.u. flux
S(1.2)	Saturation factor at 1.2 p.u. flux
Ta	T_a

Model supported by PSSE

Machine Model GENIND

Two Cage or One Cage Induction Generator Model GENIND



States:

1 – Epr
2 – Epi
3 – Ekr
4 – Eki
5 – Speed wr

$$L''_{m\,sat} = \frac{1}{K_{sat}/L_m + 1/L_{lr1} + 1/L_{lr2}}$$

$$L_m = L_s - L_l$$
$$L'_m = 1/(1/L_m + 1/L_{lr1}) = L' - L_l$$
$$L''_m = 1/(1/L_m + 1/L_{lr1} + 1/L_{lr2}) = L'' - L_l$$
$$T'_o = L_{lr1} \cdot L_m/(\omega_o \cdot R_{r1} \cdot L'_m) = (L_{lr1} + L_m)/(\omega_o \cdot R_{r1})$$
$$T''_o = L_{lr2} \cdot L'_m/(\omega_o \cdot R_{r2} \cdot L''_m) = (L_{lr2} + L'_m)/(\omega_o \cdot R_{r2})$$

Model supported by PSLF

Machine Model GEPWTwoAxis

Model GENPWTwoAxis

H	Inertia constant in sec.
D	Damping
Ra	Stator resistance in p.u.
Xd	X_d – Direct axis synchronous reactance
Xq	X_q – Quadrature axis synchronous reactance
Xdp	X'_d – Direct axis synchronous reactance
Xqp	X'_q – Quadrature axis synchronous reactance
Tdop	T'_{do} – Open circuit direct axis transient time constant
Tqop	T'_{qo} – Quadrature axis transient time constant

States:
1 – Angel
2 – Speed w
3 – Eqp
4 – Edp

Model supported by PW

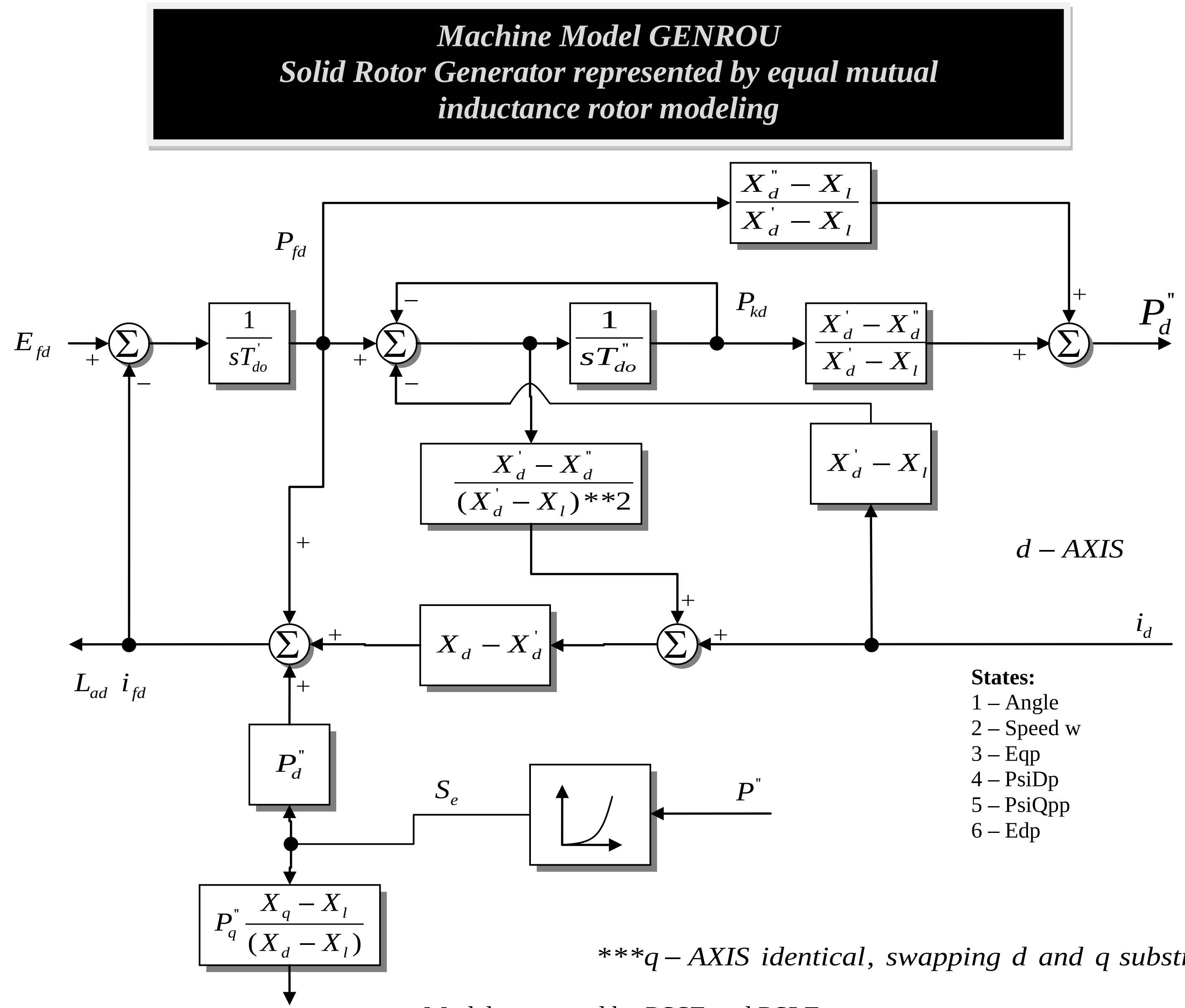
Machine Model GENROE

Round Rotor Generator Model GENROEInduction Generator

Same as the GENROU model, except that an exponential function is used for saturation

Model supported by PSSE

Machine Model GENROU



States:
1 – Angle
2 – Speed w
3 – Eqp
4 – PsiDp
5 – PsiQpp
6 – Edp

$***q - AXIS$ *identical, swapping d and q substripts*

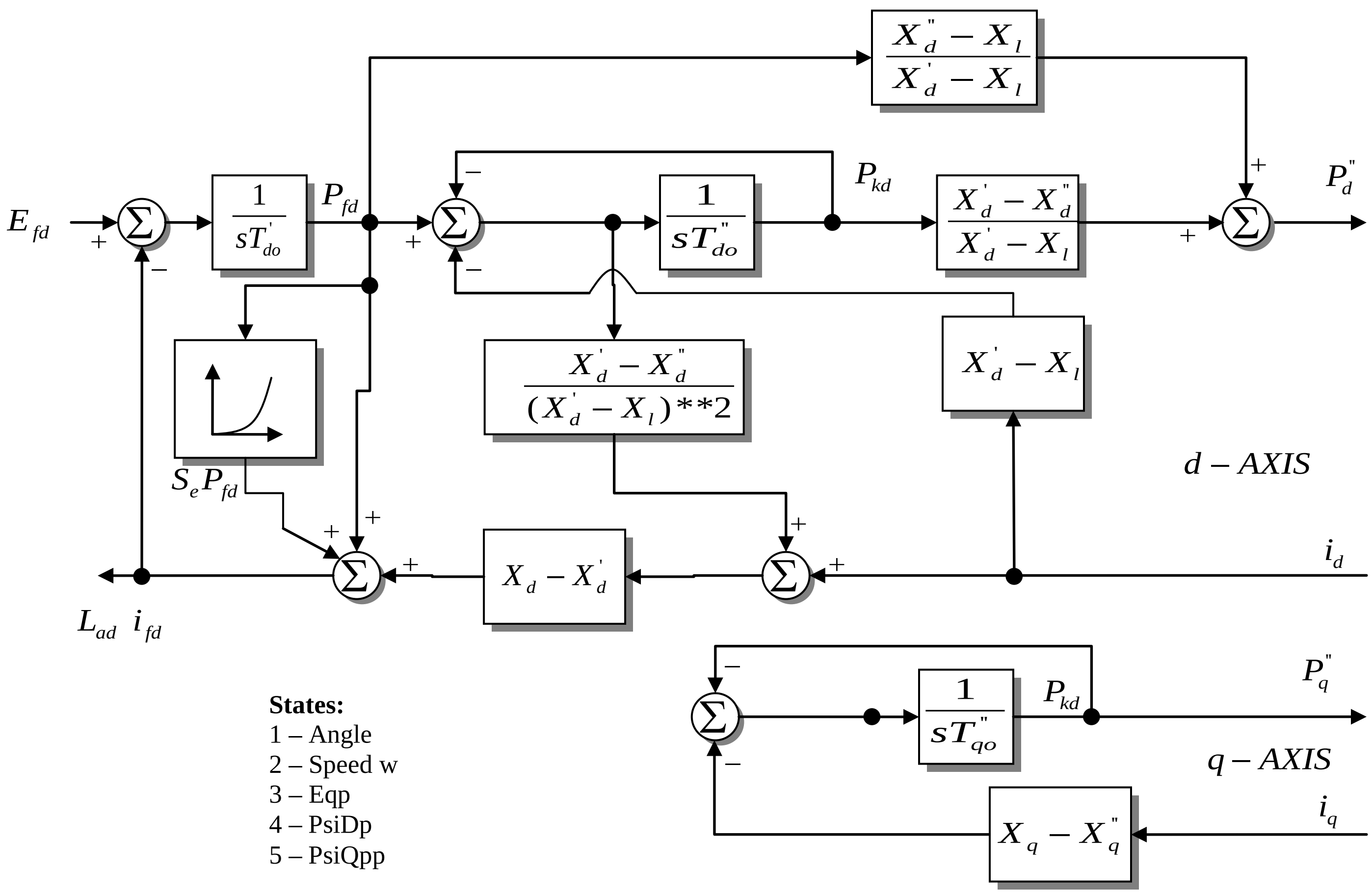
Model supported by PSSE and PSLF

Machine Model GENSAE

Same as the GENSAL model, except that an exponential function is used for saturation

Machine Model GENSAL

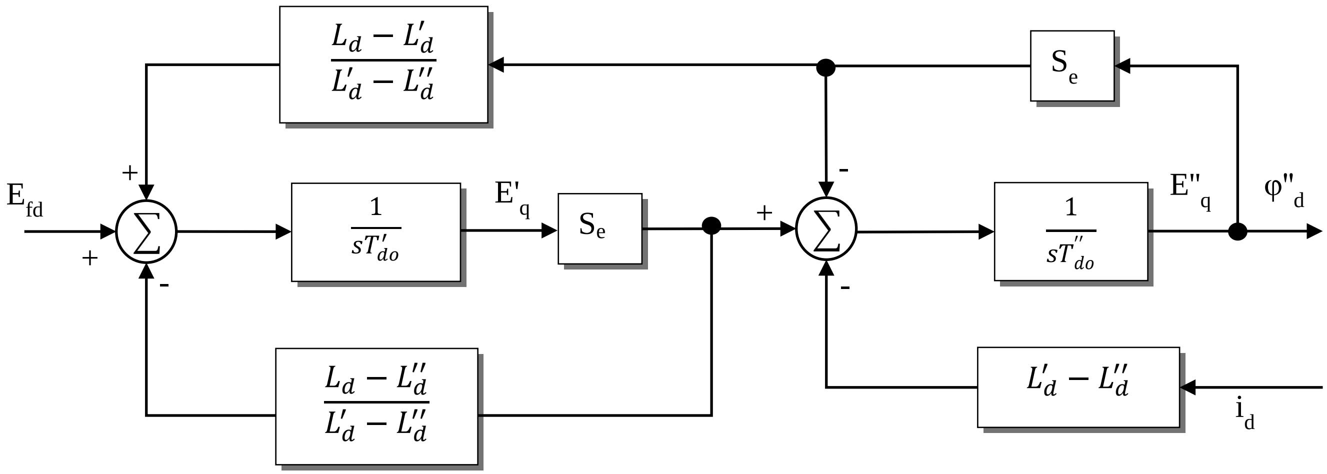
Machine Model GENSAL
Salient Pole Generator represented by equal mutual inductance rotor modeling



Model supported by PSSE and PSLF

Machine Model GENTPF

Generator Represented by Uniform Inductance Ratios Rotor Modeling to Match WSCC Type F Model GENTPF



$$S_e = 1 + SaturationFunction(\psi_{ag})$$

Q-Axis Similar except:

$$S_e = 1 + \frac{X_q}{X_d} SaturationFunction(\psi_{ag})$$

States:
1 – Angle
2 – Spped w
3 – Eqp
4 – Eqpp
5 – Edp
6 – Edpp

Model supported by PSLF

Machine Model GENTPJ

Same as the GENTPF model, except that the saturation function input is modeled with an extra term using the K_{is} value as follows.

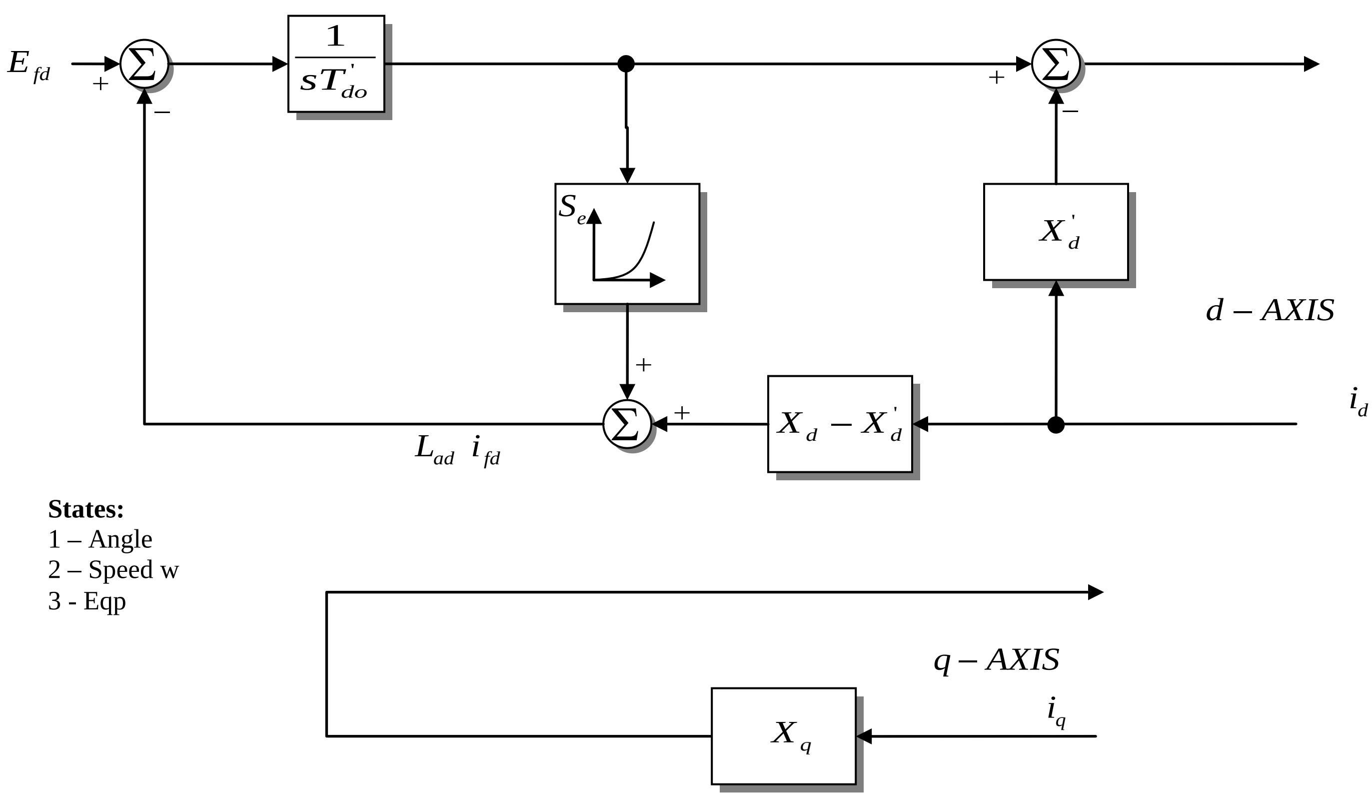
$$S_e = 1 + SaturationFunction\left(\psi_{ag} + K_{is} I_t * sign(I_d)\right)$$

Q-Axis Similar except:

$$S_e = 1 + \frac{X_q}{X_d} SaturationFunction\left(\psi_{ag} + K_{is} I_t * sign(I_d)\right)$$

Machine Model GENTRA

Machine Model GENTRA
Salient Pole Generator without Amortisseur Windings

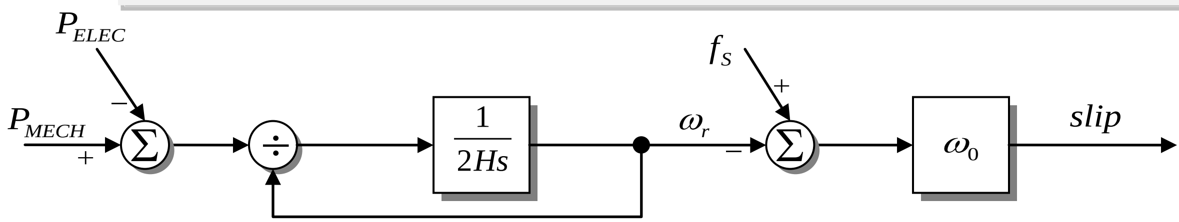


States:
1 – Angle
2 – Speed w
3 - Eqp

Model supported by PSLF

Machine Model GENWRI

Machine Model GENWRI
Wound-rotor Induction Generator Model with Variable External Rotor Resistance



$$R2Tpo = \frac{(L_s - L_l)}{\omega_0 (L_s - L')}$$

$$T_0' = \frac{R2Tpo}{(R2ex + R2)}$$

$$\dot{\varphi}_{fd} = -\frac{\left(\varphi_{fd} + S_d + (L_s - L') i_d\right)}{T_0'} + (slip)\varphi_{fq}$$

$$\dot{\varphi}_{fq} = -\frac{\left(\varphi_{fq} + S_q + (L_s - L') i_q\right)}{T_0'} + (slip)\varphi_{fd}$$

$$\varphi_d' = \varphi_{fd}$$

$$\varphi_q' = \varphi_{fq}$$

States:
1 – Epr
2 – Epi
3 – Speed wr

R2Tpo is a constant which is equal to T_0' times the total rotor resistance.

R2 is the internal rotor resistance

R2ex is the internal rotor resistance

$$e_q = \omega_s \varphi_d' - L' i_d - R_a i_q$$

$$e_d = -\omega_s \varphi_q' + L' i_q - R_a i_d$$

$$\varphi' = \sqrt{(\varphi_d')^2 + (\varphi_q')^2}$$

$$S_e = f_{sat}(\varphi')$$

$$S_d = S_e(\varphi_d')$$

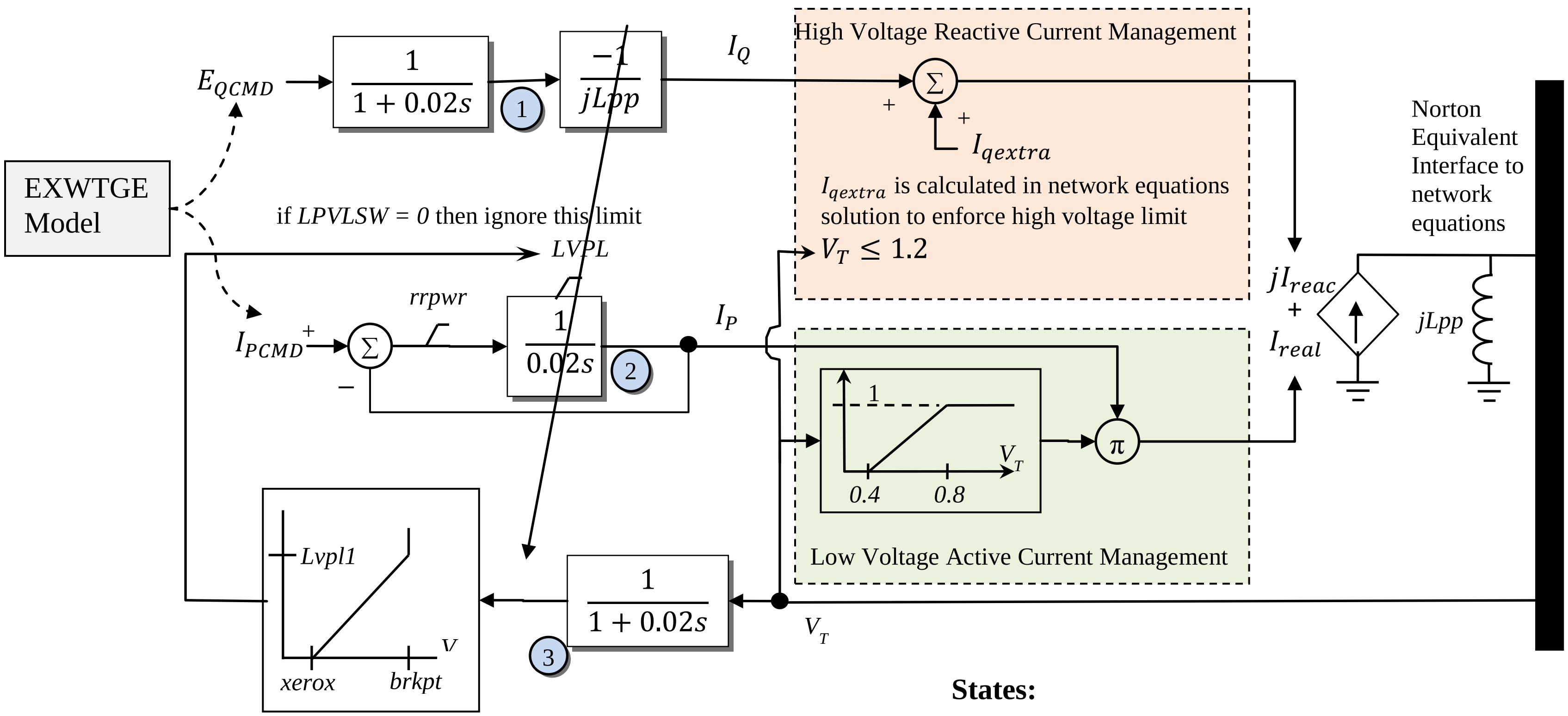
$$S_q = S_e(\varphi_d')$$

Model supported by PSLF

Machine Model GEWTG

Machine Model GEWTG
Generator/converter model for GE wind turbines –
Doubly Fed Asynchronous Generator (DFAG)

When fcflg = 0, this means a DFAG machine

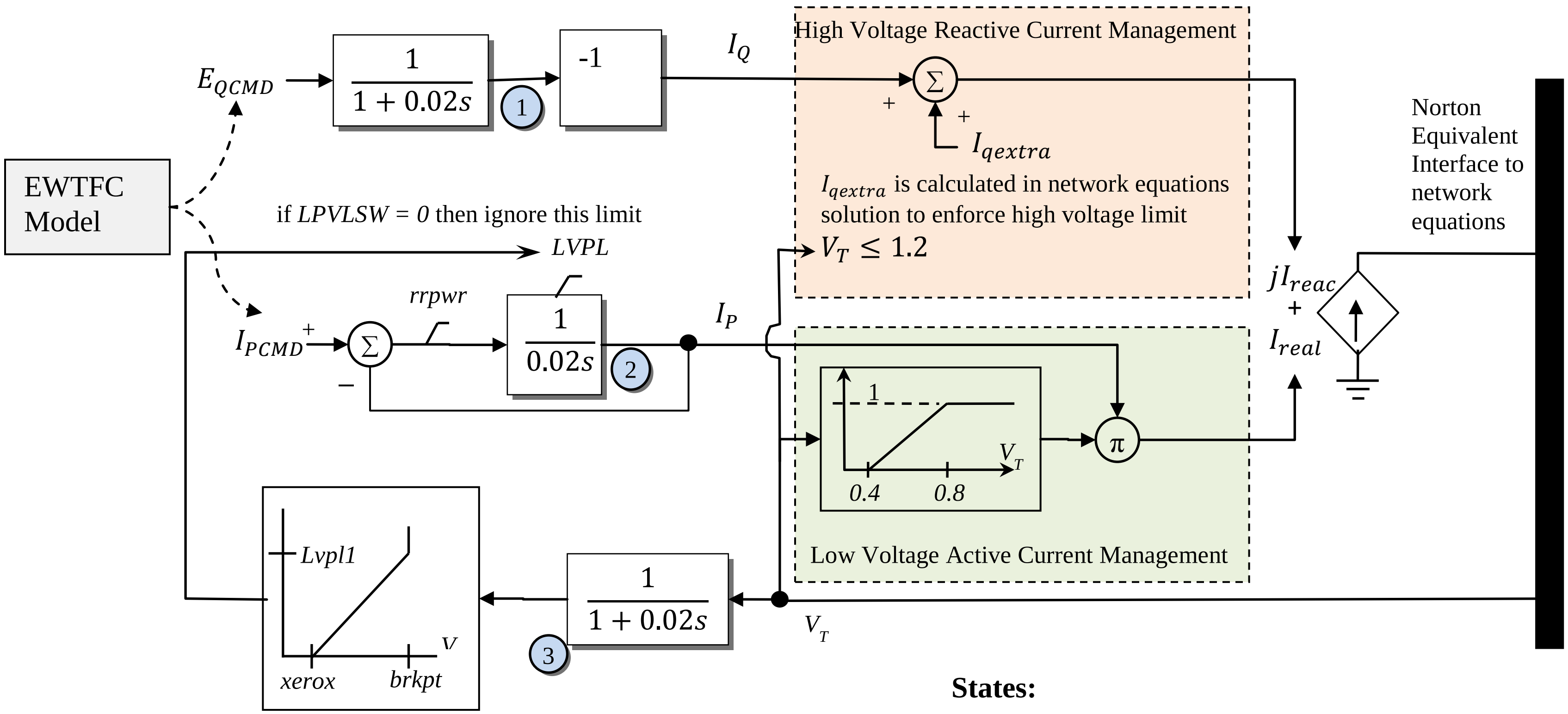


States:
1 – E_q
2 – I_p
3 – Vmeas

Model supported by PSLF

Machine Model GEWTG
Generator/converter model for GE wind turbines –
Full Converter (FC) Models

When fcflg = 1, this means a Full Converter machine



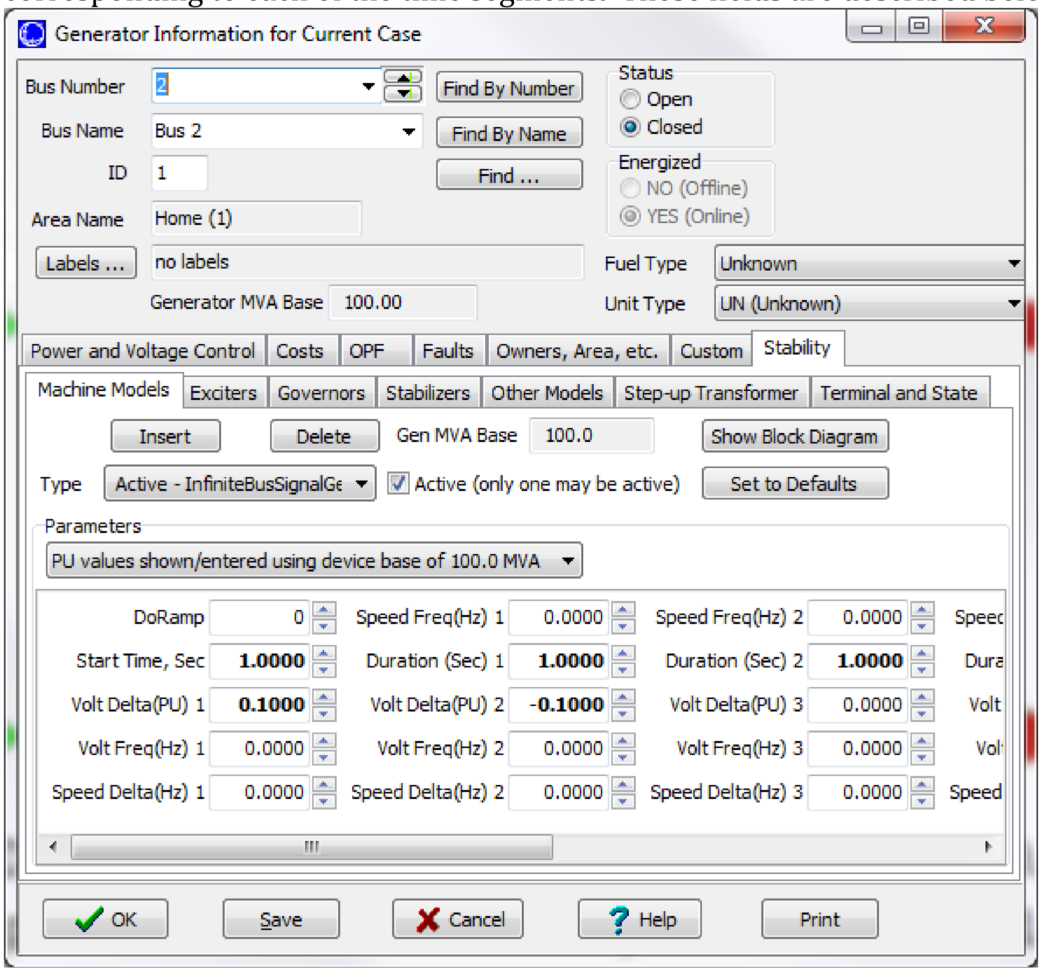
States:
1 – E_q
2 – I_p
3 – Vmeas

Model supported by PSLF

Machine Model InfiniteBusSignalGen

This model extends the functionality of an infinite bus model. Of course in power system dynamics an infinite bus is characterized by a fixed voltage magnitude and frequency. This model makes it easy to change both the voltage magnitude and frequency, hence making it easy to see how other models in the system respond to frequency and voltage disturbances. Presently the model has the ability to do either unit step changes, ramp changes, or constant frequency sinusoidal changes. Up to five separate time segments (changes) can be modeled.

The model dialog is shown as follows. It has two general fields (DoRamp and StartTime,Sec) and then five sets of five fields corresponding to each of the time segments. These fields are described below.



General Options

- **DoRamp** is an integer option that determines whether the non-sinusoidal changes should be discrete (**DoRamp** = 0) or ramping (**DoRamp** = 1). The default is zero.
- **Start Time, Sec** is the number of seconds before the first event occurs. The default is zero.

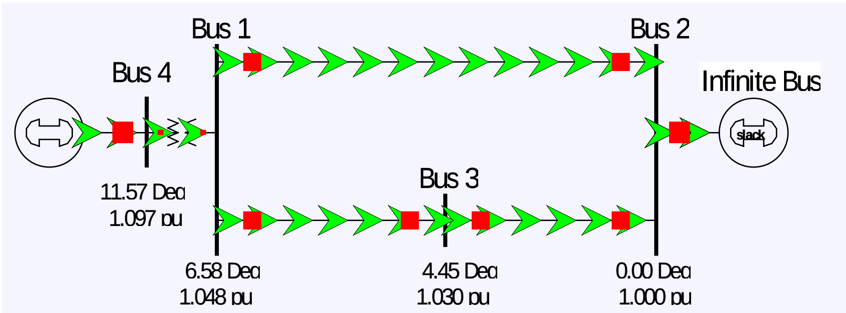
Segment Fields

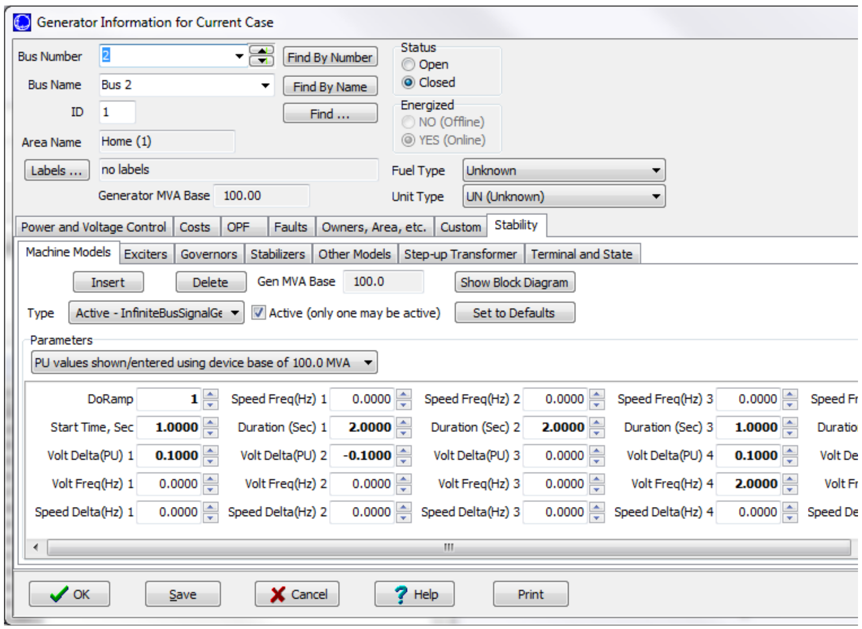
The next five fields are associated with each time segment.

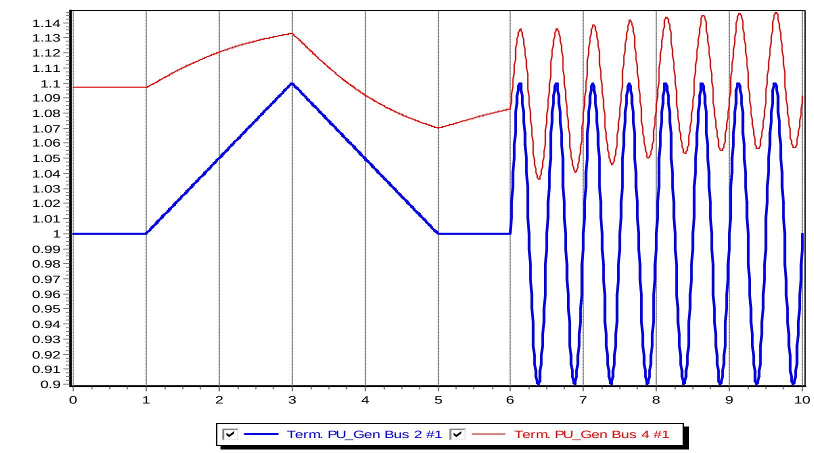
- **Volt Delta(PU)** : is the per unit magnitude of the voltage change to simulate.
- **Volt Freq(Hz)** : is the frequency of the sinusoidal function to apply to the voltage disturbance. If this value is greater than zero then the voltage disturbance is a sin function with a magnitude of VoltDeltaPU. Set this field to zero when simulating a unit step or ramp disturbance. The default is zero.
- **Speed Delta (Hz)** : is the magnitude of the speed (frequency) change to simulate.
- **Speed Freq(Hz)** : is the frequency of the sinusoidal function to apply to the speed disturbance.
- **Duration (Sec)** : is the duration of the event in seconds. Both the voltage and frequency events have the same duration, with the usual expectation that either one or the other will be applied. If the duration value is negative then this event is ignored. A value of zero indicates the event continues until the end of the simulation (except when a zero is used with a ramp event the ramp is assumed to be a unit step).

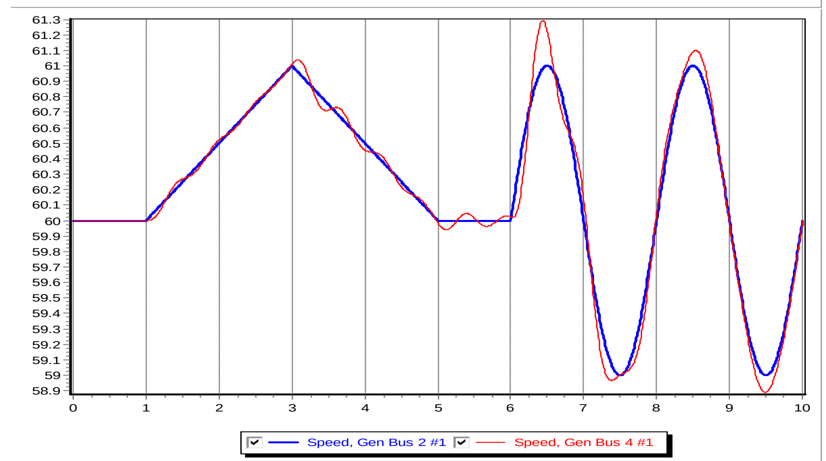
These fields are then repeated for the next time segment. Up to five segments can be simulated. The changes are cumulative, so the value assumed at the beginning of the next segment is the value that existed at the end of the previous time segment. The model used is very similar to the PLAYINGEN model.

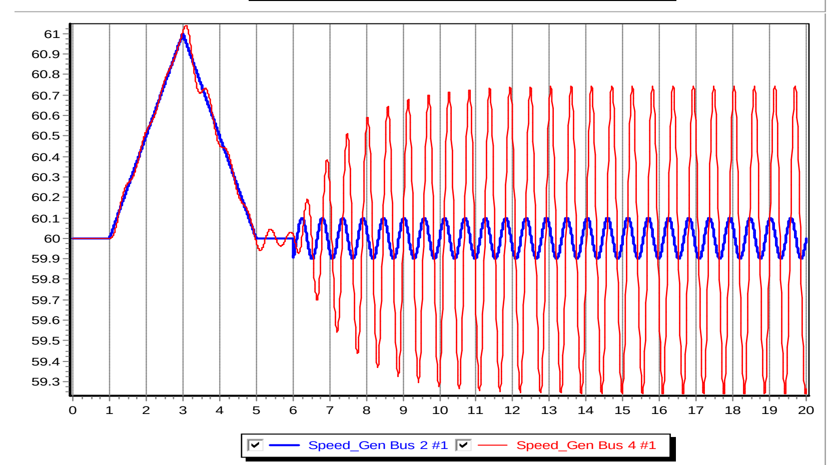
As an example, consider four bus system shown in upper-left figure on the following page with the generator at bus 2 represented with an **InfiniteBusSignalGen** model. The signal generator is set to run flat for 1 seconds (**Start Time,Sec** = 1), then ramp the voltage up by 0.1 per unit over two seconds, ramp it back down over two seconds, hold flat for one second, then start a 0.1 per unit, 2 Hz oscillation until the end. This input data is shown in bottom-left figure on the next page with the results shown in upper-right. In the results figure the Blue line shows the infinite bus voltage (bus 2), while the red shows the terminal voltage for the other generator (bus 4). The middle-right figure shows a similar test with the generator frequency except the frequency of the change is dropped to 0.5 Hz. Again blue shows the generator 2 value, in this case speed, while red shows the generator 4 speed. When the frequency of the infinite bus speed variation approaches the natural frequency of the bus 4 generator (about 1.8 Hz, calculated through single machine infinite bus analysis), resonance can be seen to occur. This is shown in lower-right figure; note now the input frequency has a magnitude of just 0.1 Hz and the simulation has been extended to twenty seconds.


Bus 1
Bus 2
Bus 4
Infinite Bus
slack
Bus 3
11.57 Deg
1.097 pu
6.58 Deg
1.048 pu
4.45 Deg
1.030 pu
0.00 Deg
1.000 pu


Generator Information for Current Case
Bus Number
Find By Number
Bus Name
Bus 2
Find By Name
ID
1
Find ...
Area Name
Home (1)
Labels ...
no labels
Generator MVA Base
100.00
Status
Open
Closed
Energized
NO (Offline)
YES (Online)
Fuel Type
Unknown
Unit Type
UN (Unknown)
Power and Voltage Control
Costs
OPF
Faults
Owners, Area, etc.
Custom
Stability
Machine Models
Exciters
Governors
Stabilizers
Other Models
Step-up Transformer
Terminal and State
Insert
Delete
Gen MVA Base
100.0
Show Block Diagram
Type
Active - InfiniteBusSignalGe
Active (only one may be active)
Set to Defaults
Parameters
PU values shown/entered using device base of 100.0 MVA
DoRamp 1
Start Time, Sec 1.0000
Volt Delta(PU) 1 0.1000
Volt Freq(Hz) 1 0.0000
Speed Delta(Hz) 1 0.0000
Speed Freq(Hz) 1 0.0000
Duration (Sec) 1 2.0000
Volt Delta(PU) 2 -0.1000
Volt Freq(Hz) 2 0.0000
Speed Delta(Hz) 2 0.0000
Speed Freq(Hz) 2 0.0000
Duration (Sec) 2 2.0000
Volt Delta(PU) 3 0.0000
Volt Freq(Hz) 3 0.0000
Speed Delta(Hz) 3 0.0000
Speed Freq(Hz) 3 0.0000
Duration (Sec) 3 1.0000
Volt Delta(PU) 4 0.1000
Volt Freq(Hz) 4 2.0000
Speed Delta(Hz) 4 0.0000
OK
Save
Cancel
Help
Print


Term. PU_Gen Bus 2 #1
Term. PU_Gen Bus 4 #1

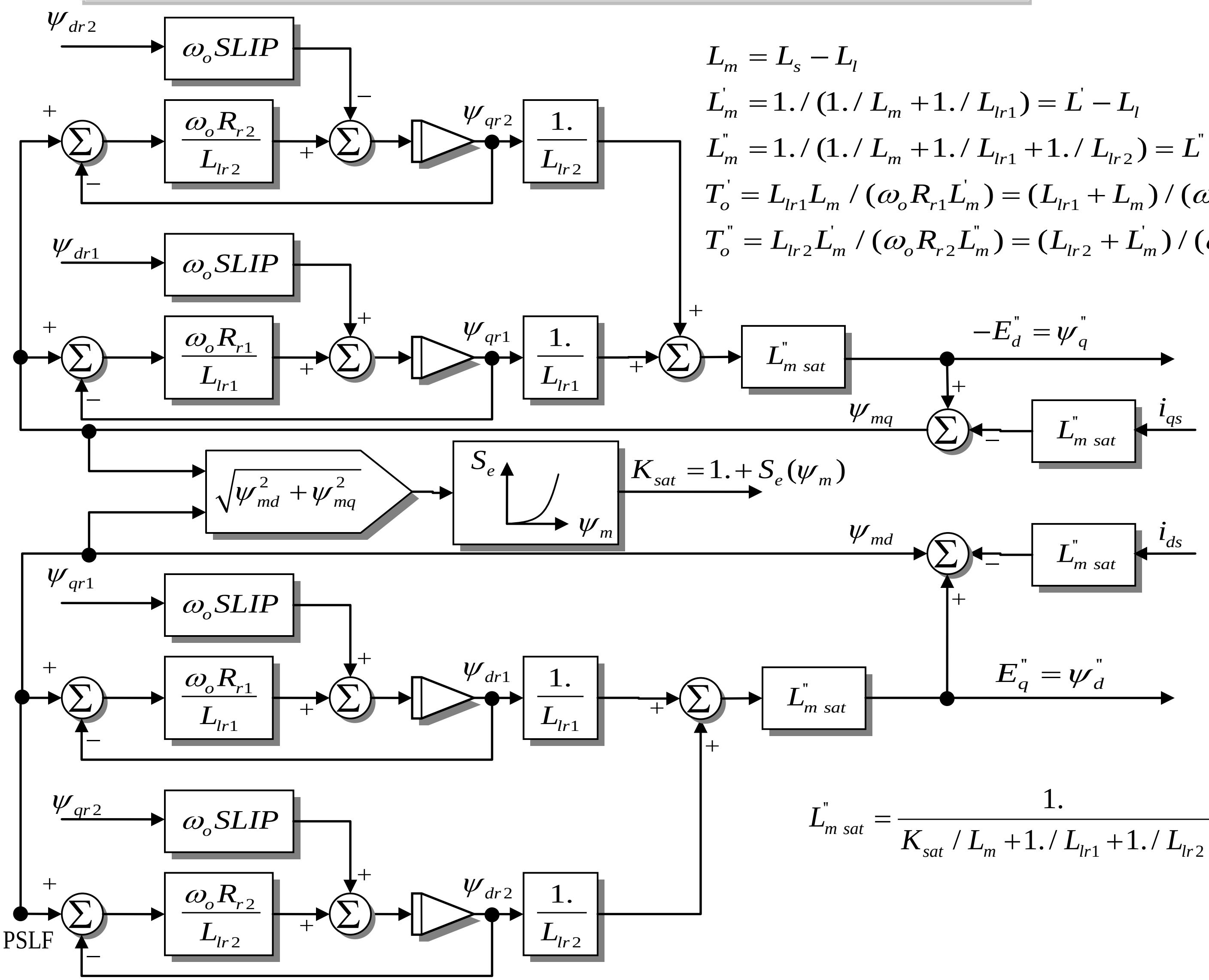

Speed, Gen Bus 2 #1
Speed, Gen Bus 4 #1


Speed_Gen Bus 2 #1
Speed_Gen Bus 4 #1

Machine Model MOTOR1

Machine Model MOTOR1
"Two-cage" or "one-cage" induction machine

States:
1 – Epr
2 – Epi
3 – Ekr
4 - Eki
5 – Speed wr

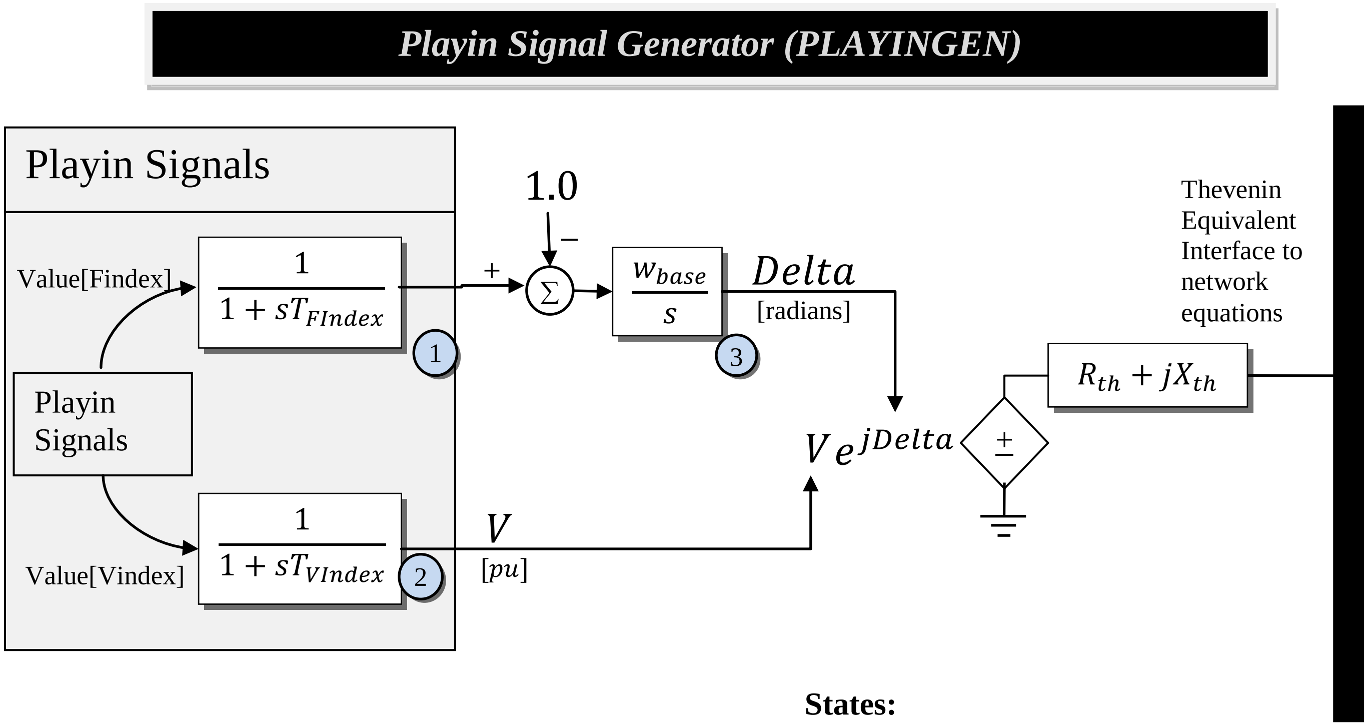


$$L_m = L_s - L_l$$
$$L^{'}_m = 1./(1./L_m + 1./L_{lr1}) = L^{'} - L_l$$
$$L^{"}_m = 1./(1./L_m + 1./L_{lr1} + 1./L_{lr2}) = L^{"} - L_l$$
$$T^{'}_o = L_{lr1}L_m/(\omega_o R_{r1} L^{'}_m) = (L_{lr1} + L_m)/(\omega_o R_{r1})$$
$$T^{"}_o = L_{lr2}L^{'}_m/(\omega_o R_{r2} L^{"}_m) = (L_{lr2} + L^{'}_m)/(\omega_o R_{r2})$$

$$L^{"}_{m\ sat} = \frac{1.}{K_{sat}/L_m + 1./L_{lr1} + 1./L_{lr2}}$$

Model supported by PSLF

Machine Model PLAYINGEN



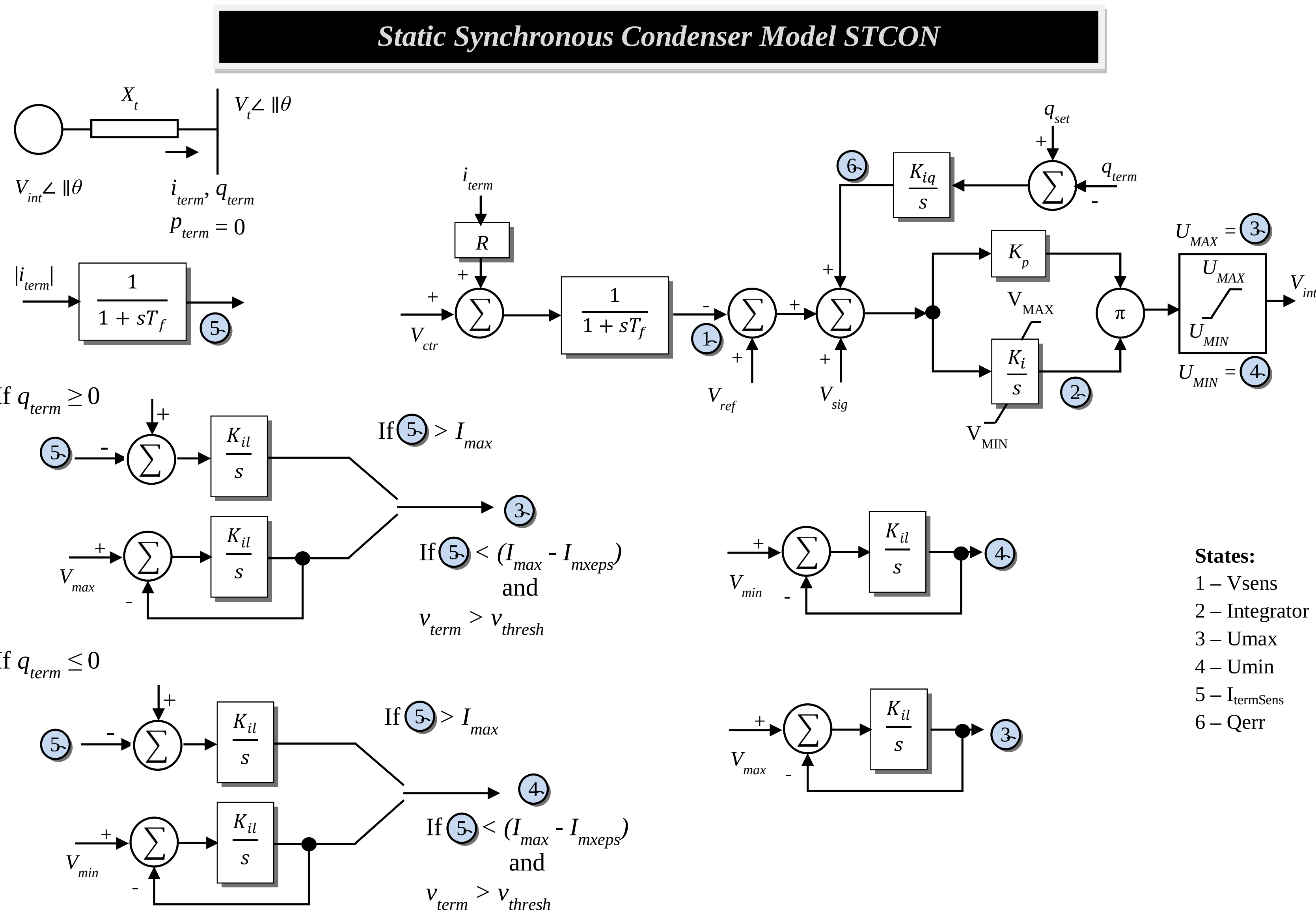
States:

1 – Frequency [per unit]

2 – Voltage [per unit]

3 – Delta [radians]

Machine Model STCON

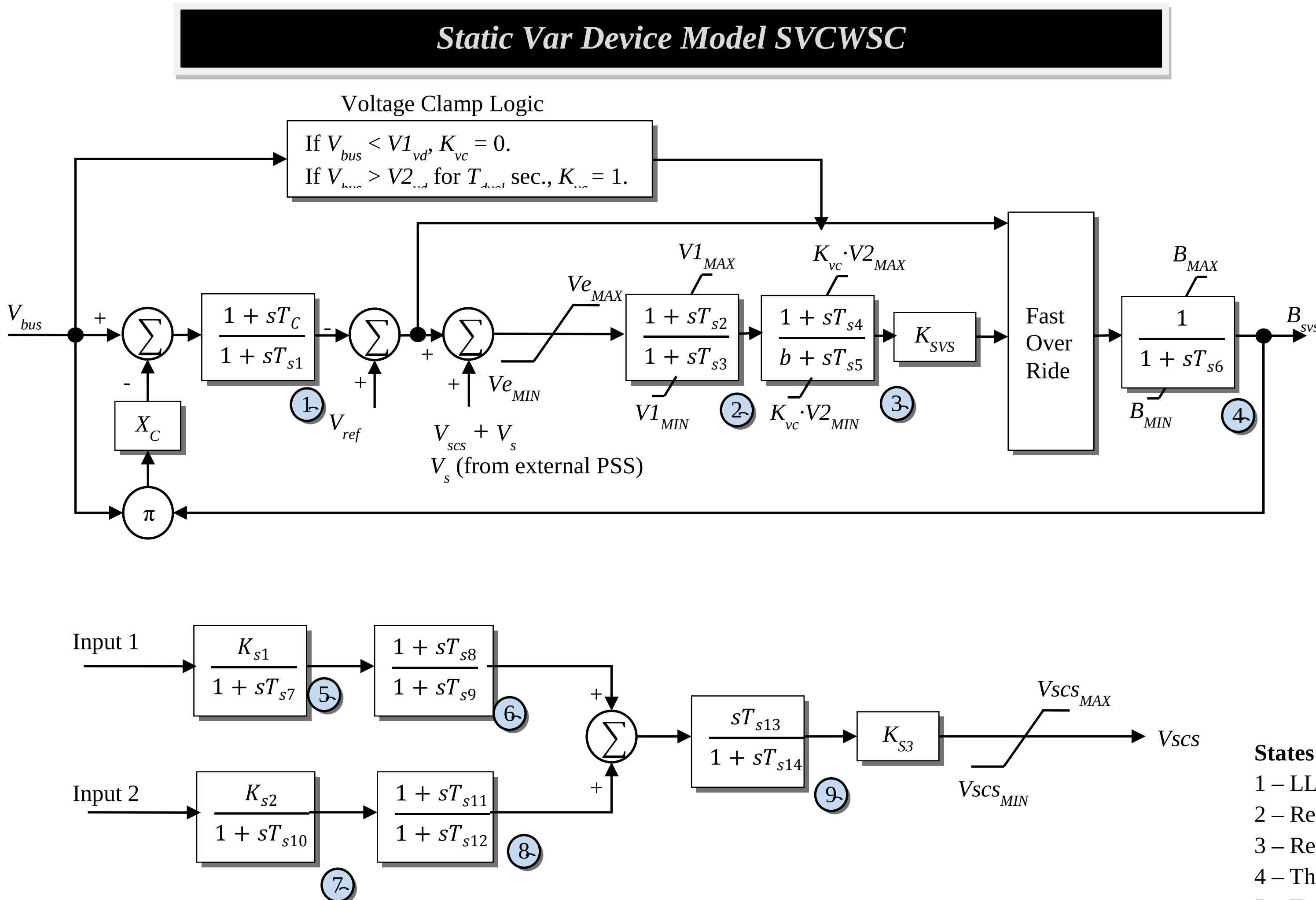


States:

1 – Vsens
2 – Integrator
3 – Umax
4 – Umin
5 – $I_{termSens}$
6 – Qerr

Model supported by PSLF

Machine Model SVCWSC

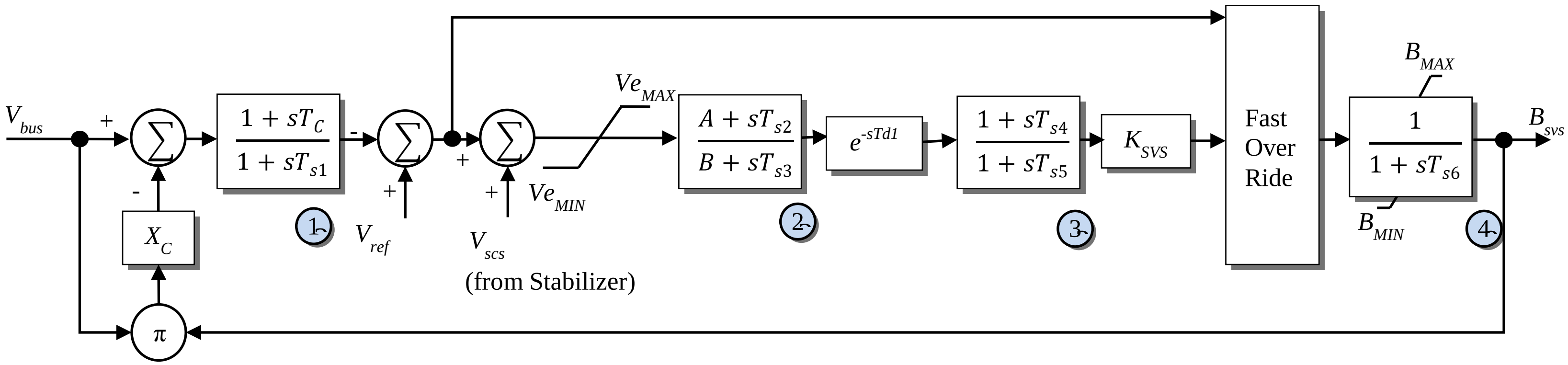


States:
1 – LLVbus
2 – Regulator1
3 – Regulator2
4 – Thyristor
5 – Transducer1
6 – LL1
7 – Transducer2
8 - LL2
9 – WO13

Model supported by PSLF

Machine Model VWSCC

Static Var Device Model VWSCC

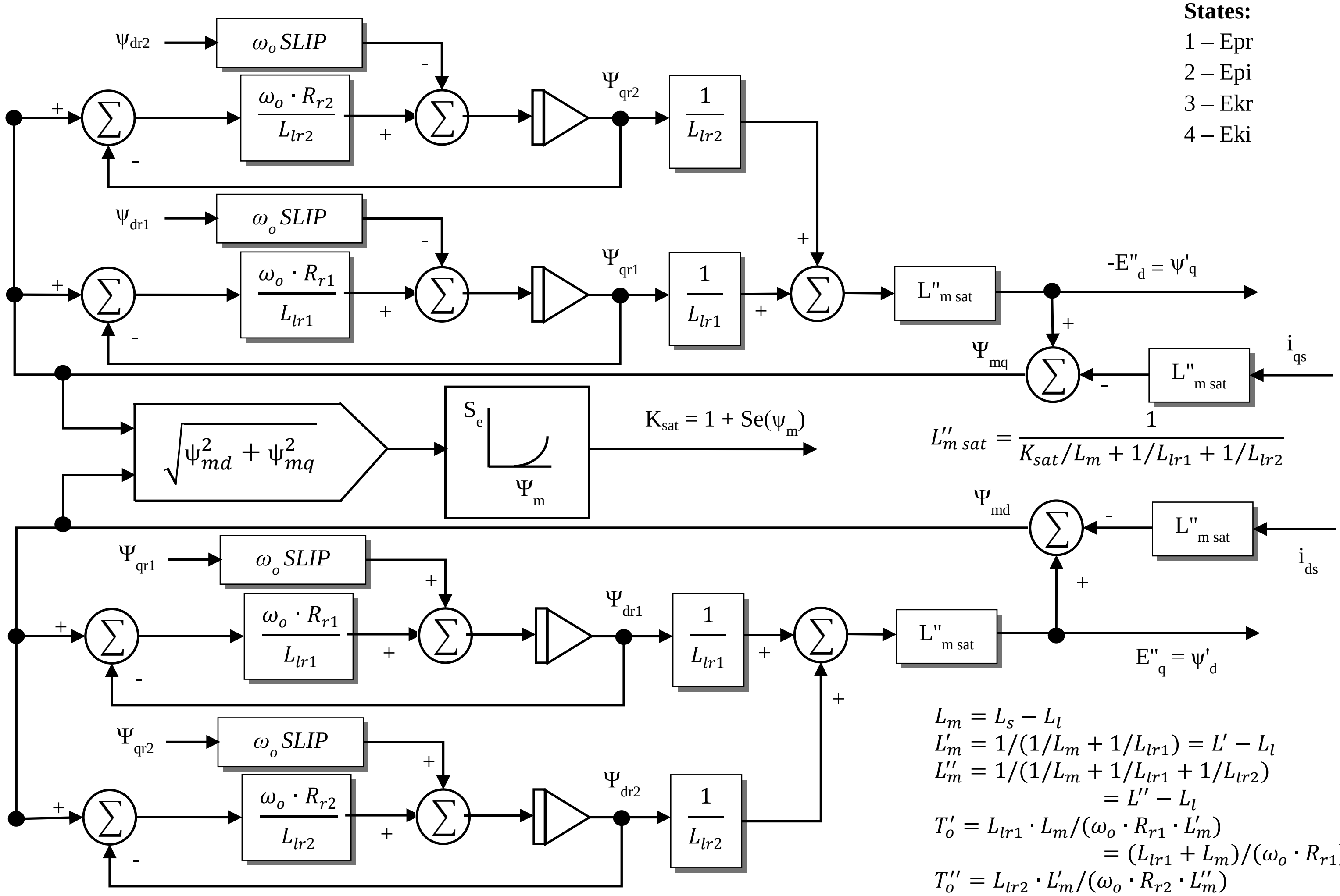


States:
1 – LLVBus
2 – Regulator1
3 – Regulator2
4 – Thyristor

Model supported by PSLF

Machine Model WT1G

Generator Model for Generic Type-1 Wind Turbines WT1G



States:

1 – Epr

2 – Epi

3 – Ekr

4 – Eki

$$L''_{m\,sat} = \frac{1}{K_{sat}/L_m + 1/L_{lr1} + 1/L_{lr2}}$$

$$L_m = L_s - L_l$$

$$L'_m = 1/(1/L_m + 1/L_{lr1}) = L' - L_l$$

$$L''_m = 1/(1/L_m + 1/L_{lr1} + 1/L_{lr2}) = L'' - L_l$$

$$T'_o = L_{lr1} \cdot L_m/(\omega_o \cdot R_{r1} \cdot L'_m) = (L_{lr1} + L_m)/(\omega_o \cdot R_{r1})$$

$$T''_o = L_{lr2} \cdot L'_m/(\omega_o \cdot R_{r2} \cdot L''_m) = (L_{lr2} + L'_m)/(\omega_o \cdot R_{r2})$$

Model supported by PSLF

Machine Model WT1G1

Direct Connected Type 1 Generator Model WT1G1

Tpo	T' – Open circuit transient rotor time constant
Tppo	T" – Open circuit sub-transient rotor time constant in sec.
Ls	Synchronous reactance
Lp	L' – Transient Reactance
Lpp	L" – Sub-transient Reactance
Ll	Stator leakage reactance (p.u. > 0)
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
SE2	Saturation value at E2

States:

1 – Epr
2 – Epi
3 – Ekr
4 – Eki

Model supported by PSSE

Machine Model WT2G

Model WT2G

Ls	Synchronous reactance, (p.u. > 0)
Lp	Transient reactance, (p.u. > 0)
Ll	Stator leakage reactance, (p.u. > 0)
Ra	Stator resistance in p.u.
Tpo	Transient rotor time constant in sec.
S(1.0)	Saturation factor at 1.0 p.u. flux
S(1.2)	Saturation factor at 1.2 p.u. flux
spdrot	Initial electrical rotor speed, p.u. of system frequency
Accel Factor	Acceleration factor

States:

1 – Epr
2 – Epi
3 – Ekr
4 – Eki

Model supported by PSLF

Machine Model WT2G1

Induction Generator with Controlled External Rotor Resistor Type 2 Model WT2G1

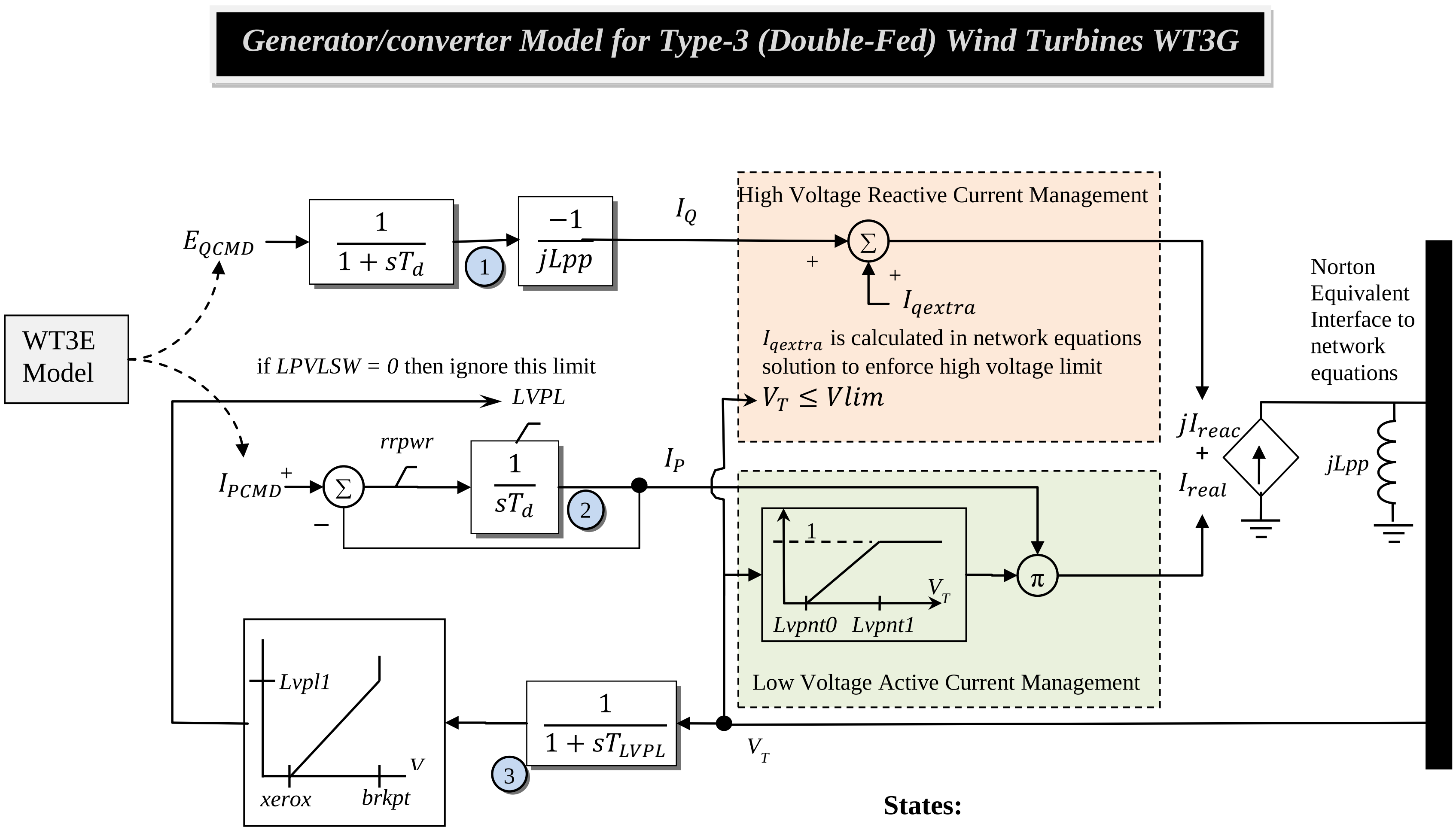
Xa	Stator reactance
Xm	Magnetizing reactance
X1	Rotor reactance
R_Rot_Mach	Rotor resistance
R_Rot_Max	Sum of R_Rot_Mach and total external resistance
E1	Field voltage value E1
SE1	Saturation value at E1
E2	Field voltage value E2
SE2	Saturation value at E2
Power_Ref1 to Power_Ref_5	Coordinate pairs of the power-slip curve
Slip_1 to Slip_5	Power-Slip

States:
1 – Epr
2 – Epi
3 – Ekr
4 – Eki

Note: The Power_Ref and Slip values specified here are actually used in conjunction with the WT2E1 model

Model supported by PSSE

Machine Model WT3G



States:

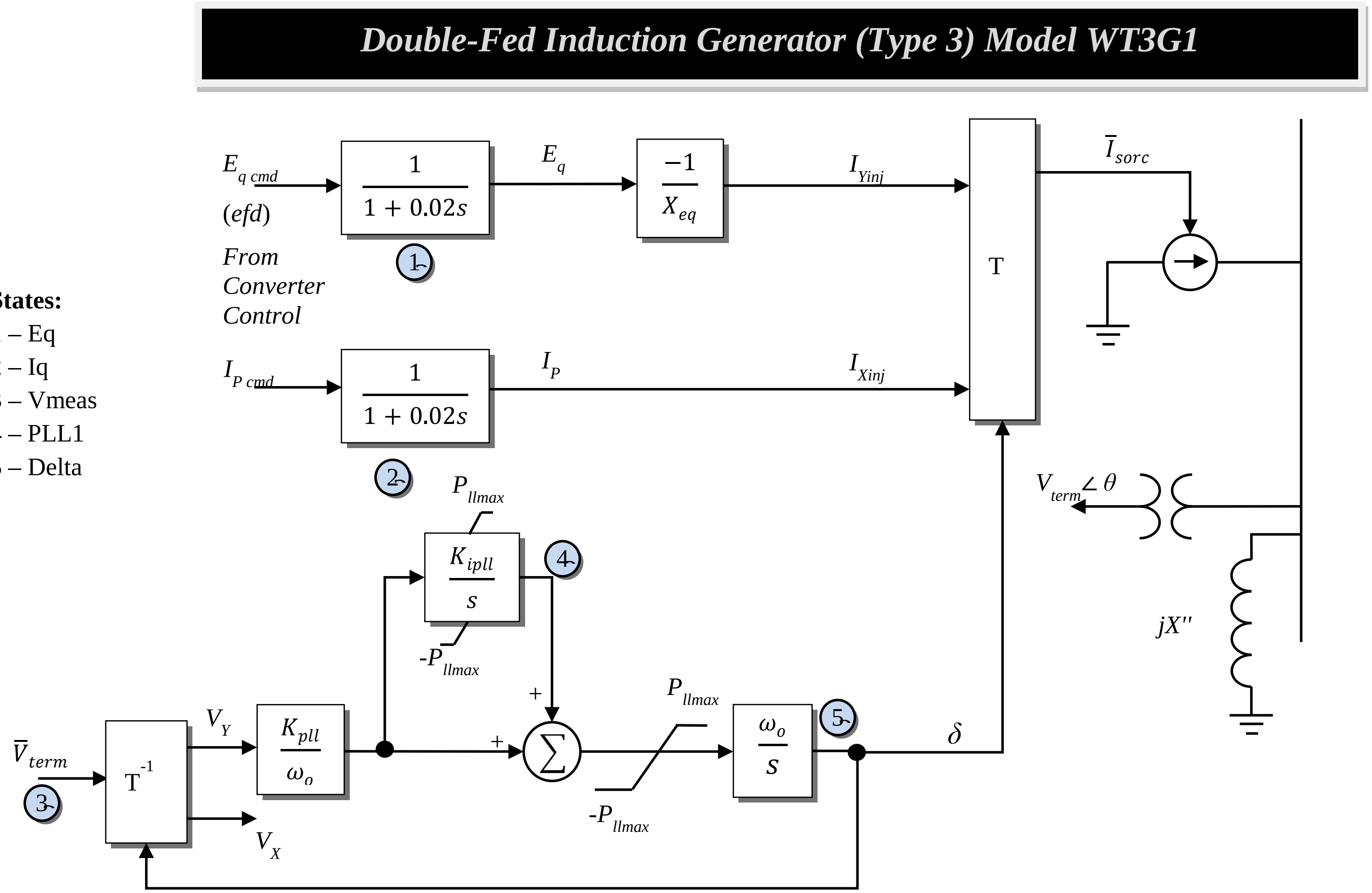
1 – E_q

2 – I_p

3 – Vmeas

Model supported by PSLF

Machine Model WT3G1



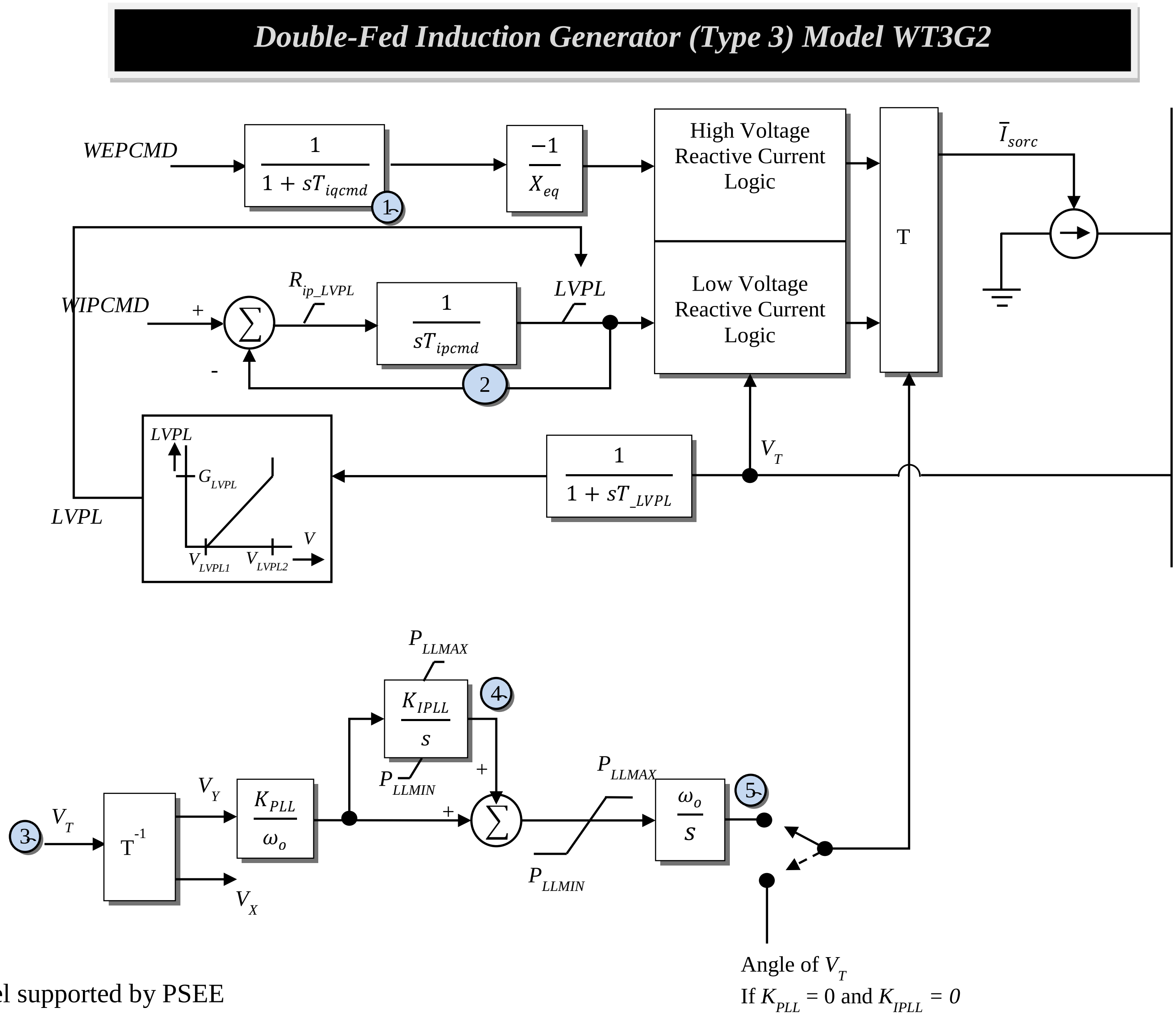
States:

1 – Eq
2 – Iq
3 – Vmeas
4 – PLL1
5 – Delta

Notes:
1. $\bar{V}_{term}$ and $\bar{I}_{sorc}$ are complex values on network reference frame.
2. In steady-state, $V_Y = 0$, $V_X = V_{term}$, and $\delta = \theta$.
3. X_{eq} = Imaginary (ZSOURCE)

Model supported by PSEE

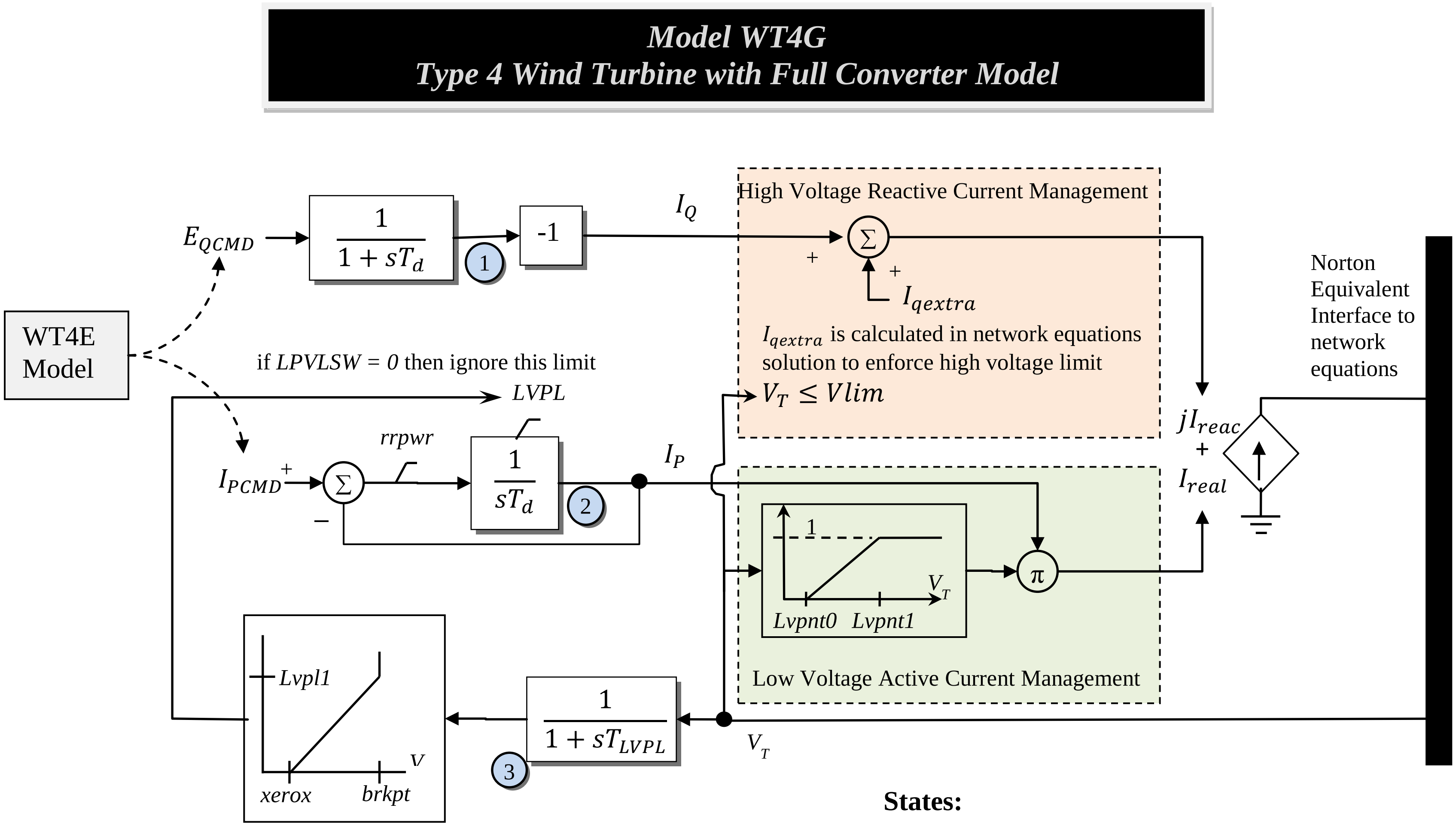
Machine Model WT3G2



States:
1 – Eq
2 – Iq
3 – Vmeas
4 – PLL1
5 – Delta

Model supported by PSEE

Machine Model WT4G



States:

1 – E_q

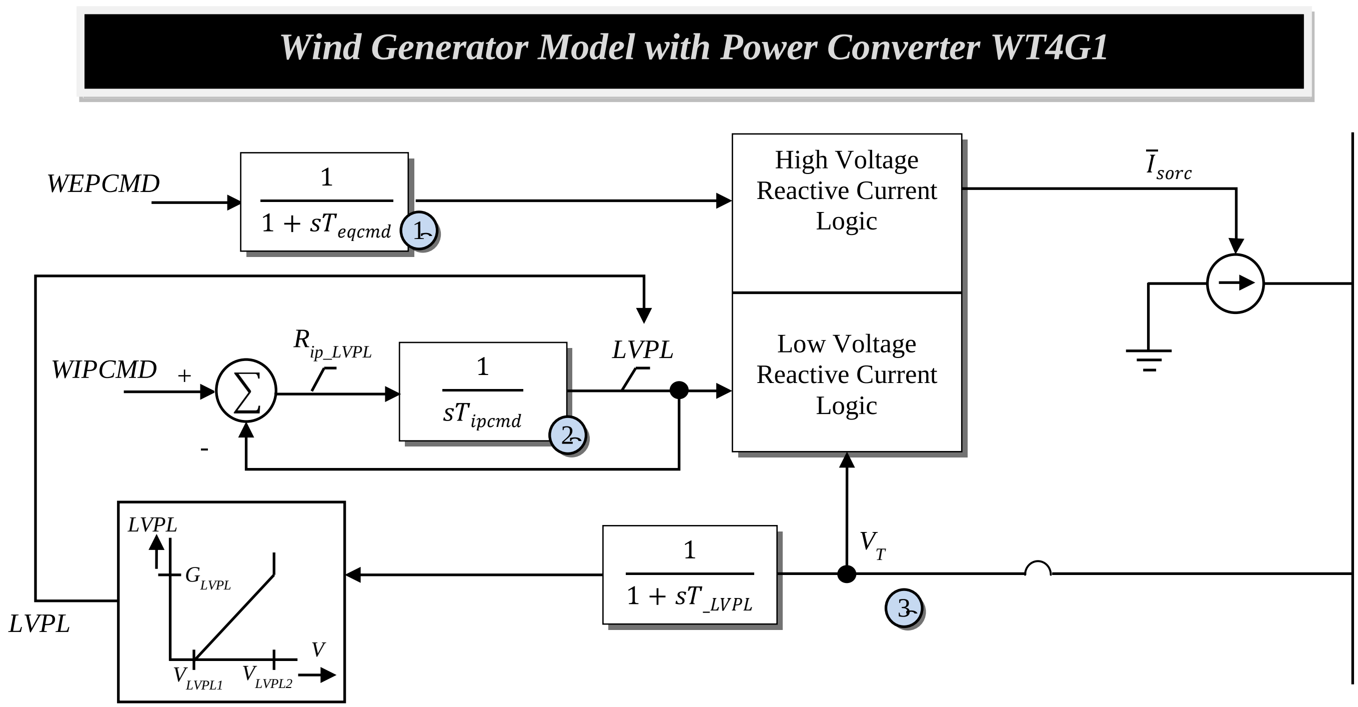
2 – I_p

3 – Vmeas

Model supported by PSLF

Machine Model WT4G1

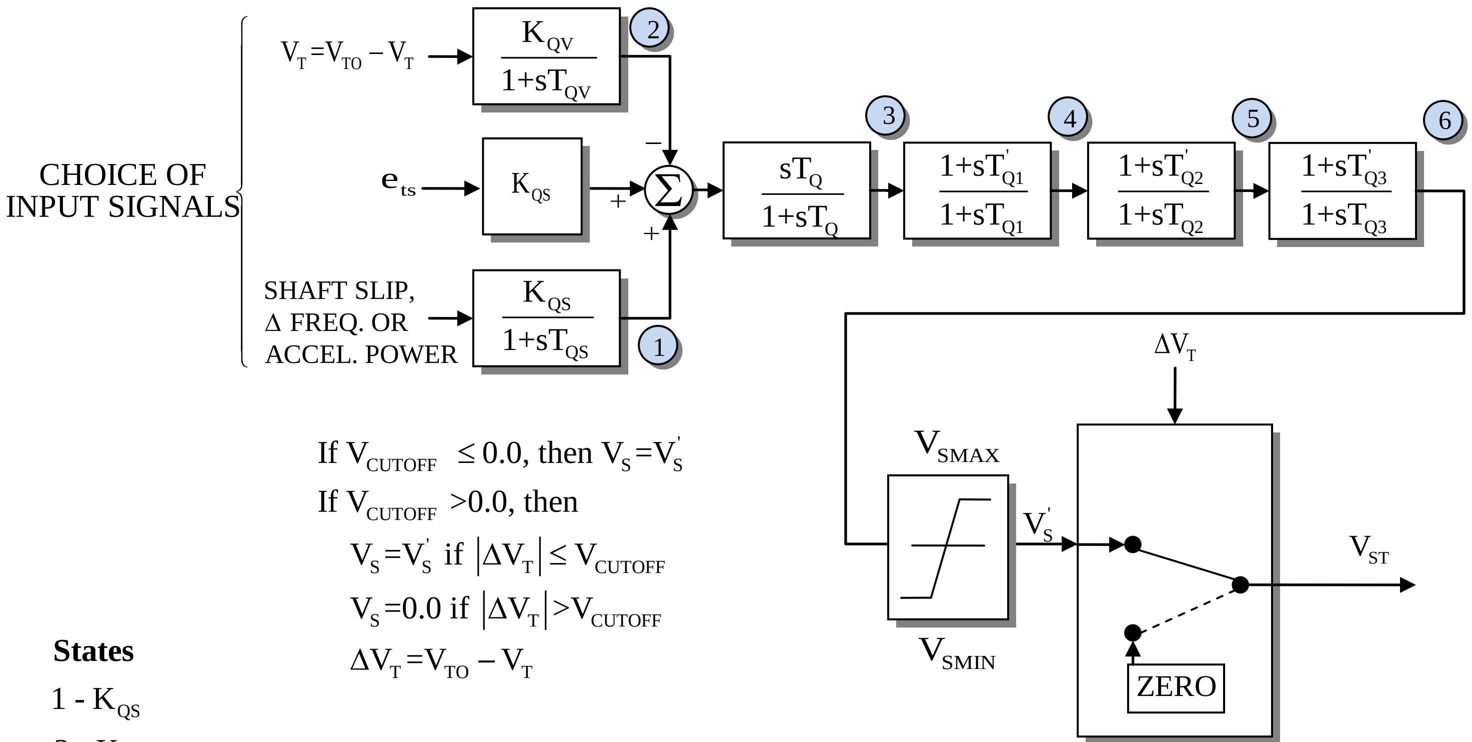
States:
1 – Eq
2 – Iq
3 – Vmeas



Model supported by PSEE

Stabilizer BPA SF, BPA SP, BPA SS, and BPA SG

Stabilizer BPA SF, BPA SP, BPA SS, and BPA SG
Stabilizer Models



If $V_{CUTOFF} \le 0.0$, then $V_S = V_S'$

If $V_{CUTOFF} > 0.0$, then

$V_S = V_S'$ if $|\Delta V_T| \le V_{CUTOFF}$

$V_S = 0.0$ if $|\Delta V_T| > V_{CUTOFF}$

$\Delta V_T = V_{TO} - V_T$

States

1 - K_{QS}

2 - K_{QV}

3 - T_Q

4 - T_{Q1}

5 - T_{Q2}

6 - T_{Q3}

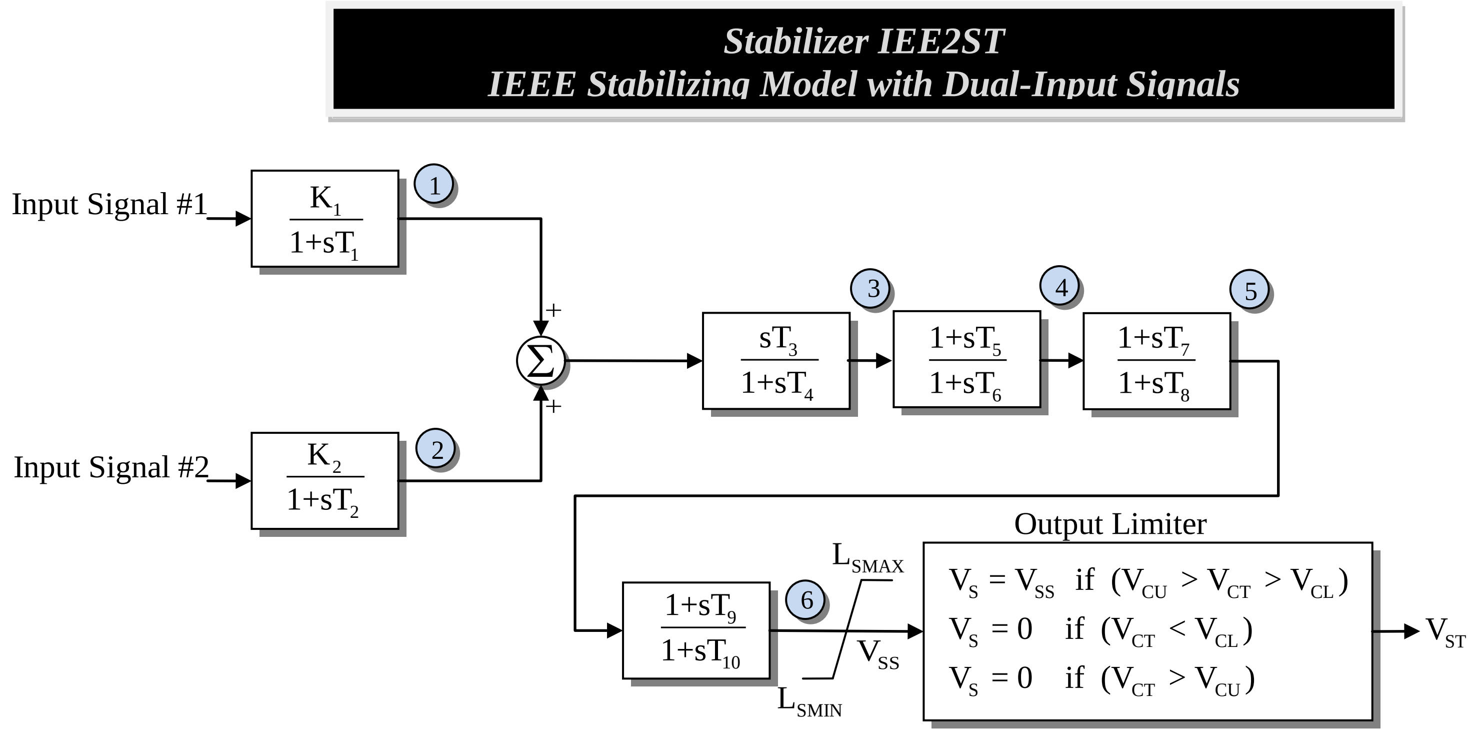
Model in the public domain, available from BPA

Stabilizer BPA SH, BPA SHPLUS, and BPA SI

Stabilizer BPA SH, BPA SHPLUS, and BPA SI
Stabilizer Models

No block diagrams have been created

Stabilizer IEE2ST



States

1 - Transducer1

2 - Transducer2

3 - Washout

4 - LL1

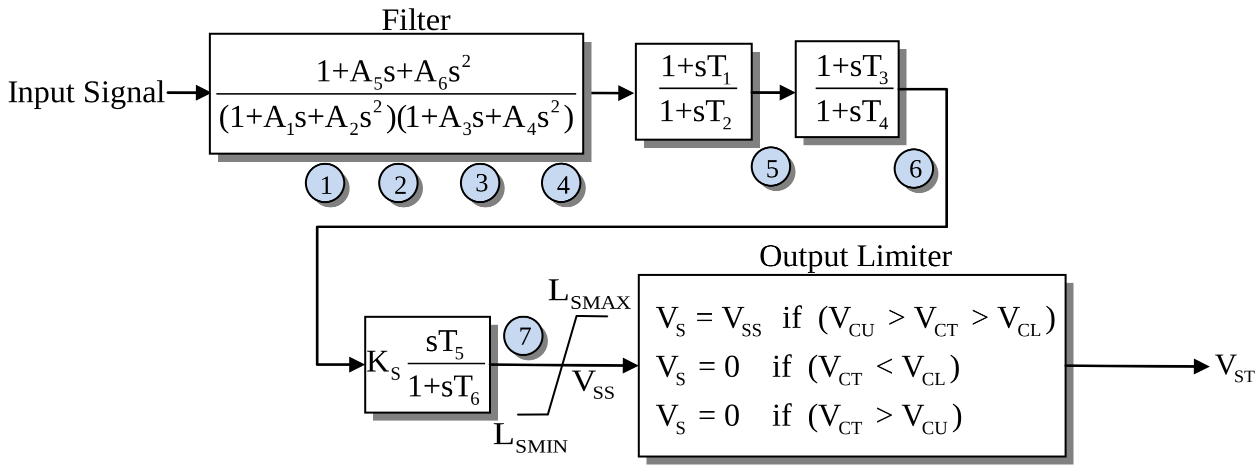
5 - LL2

6 - Unlimited Signal

Model supported by PSSE

Stabilizer IEEEST

Stabilizer IEEEST
IEEE Stabilizing Model



States

1 - Filter 1

2 - Filter 2

3 - Filter 3

4 - Filter Out

5 - LL1

6 - LL2

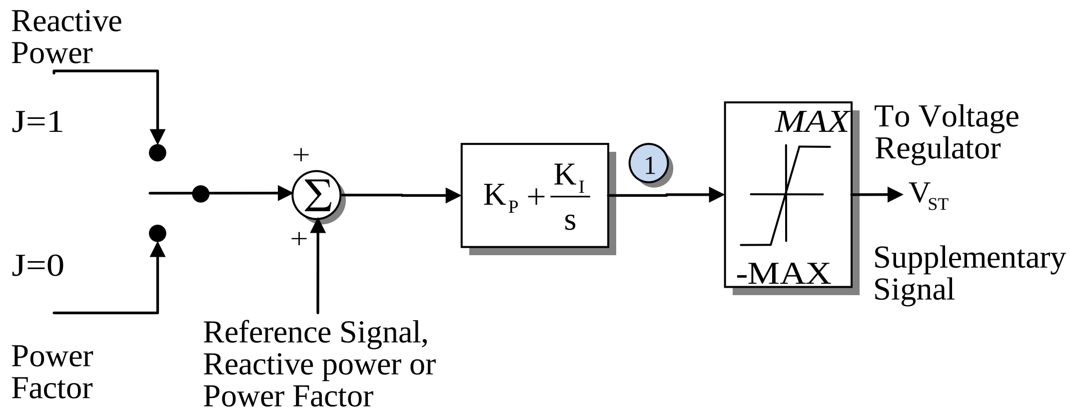
7 - Unlimited Signal

Model supported by PSLF with time delay that is not implemented in Simulator

Model supported by PSSE

Stabilizer PFQRG

Stabilizer PFQRG
Power-Sensitive Stabilizing Unit



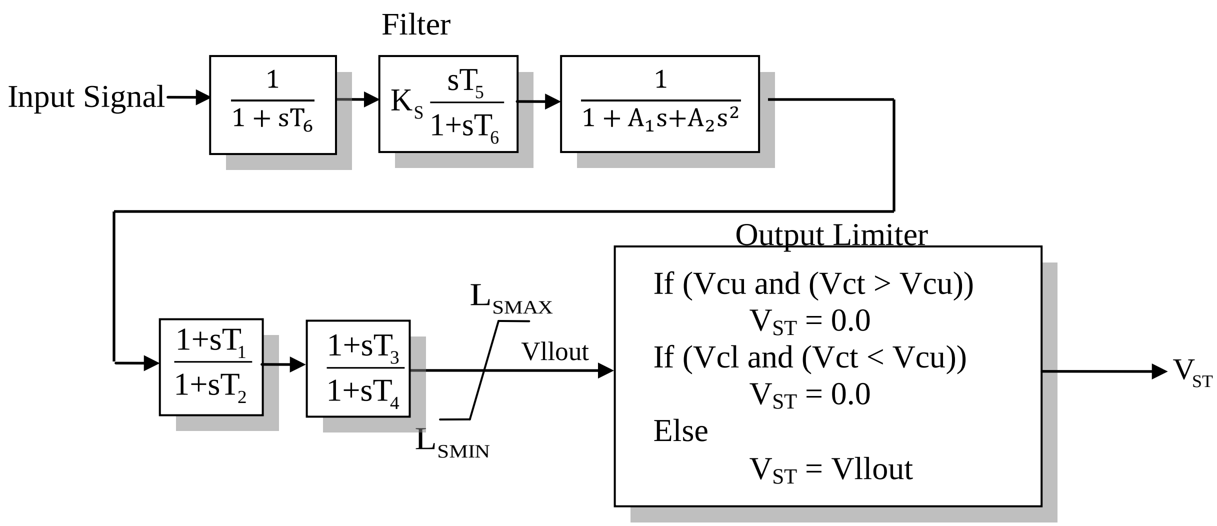
States

1 - PI

Model supported by PSLF

Stabilizer PSS1A

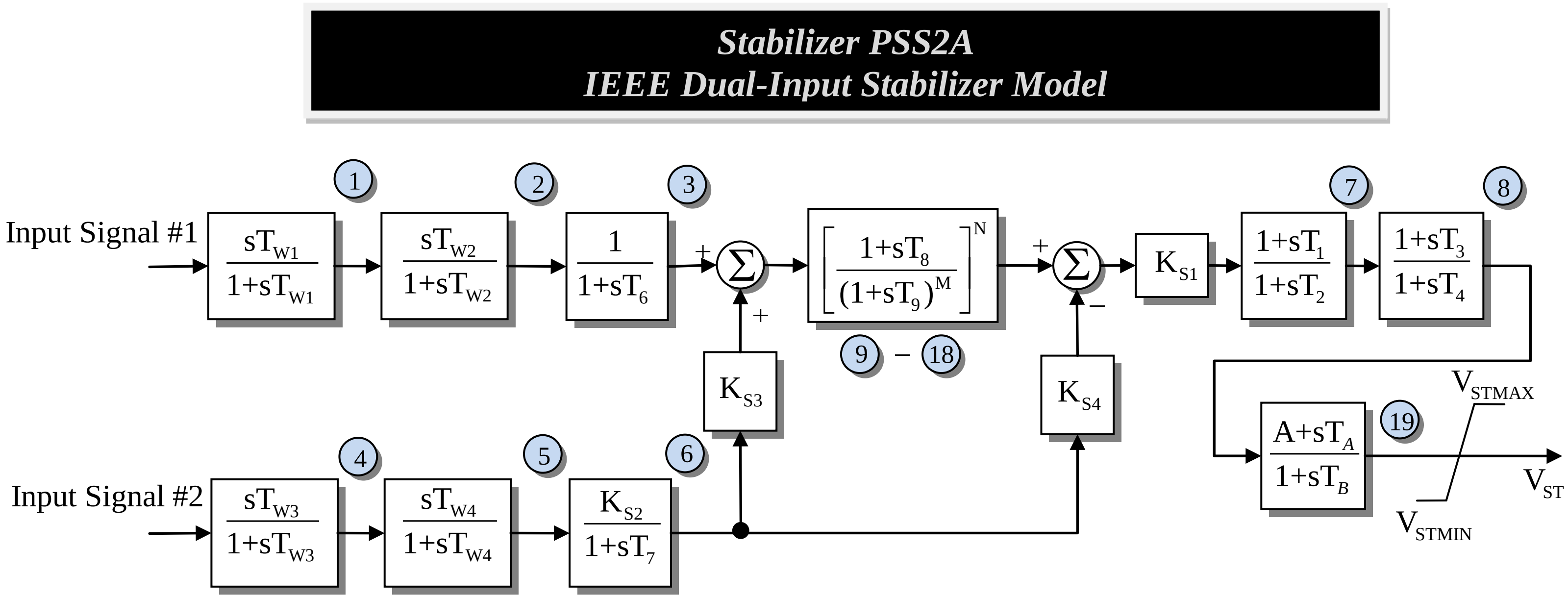
Stabilizer PSS1A
Single-Input Stabilizer Model



Model supported by PSLF with time delay that is not implemented in Simulator

Model supported by PSSE

Stabilizer PSS2A



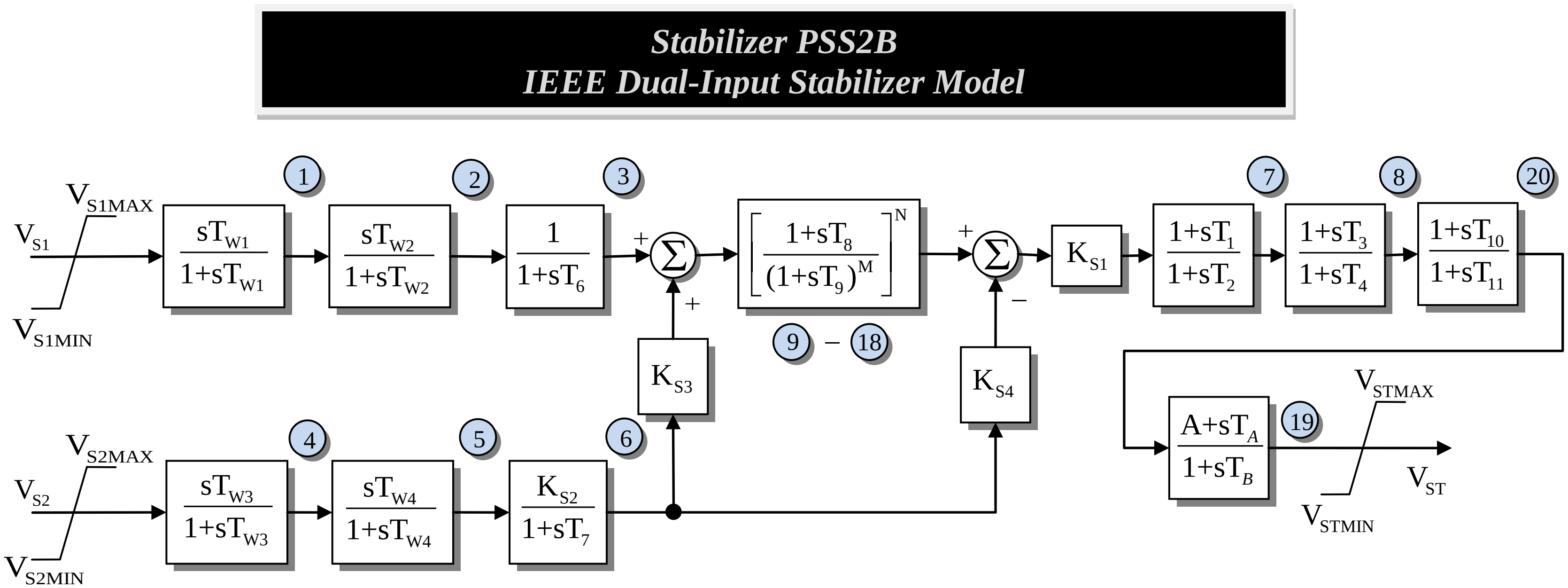
States

1 - WOTW1	11 - RampFilter3
2 - WOTW2	12 - RampFilter4
3 - Transducer1	13 - RampFilter5
4 - WOTW3	14 - RampFilter6
5 - WOTW4	15 - RampFilter7
6 - Transducer2	16 - RampFilter8
7 - LL1	17 - RampFilter9
8 - LL2	18 - RampFilter10
9 - RampFilter1	19 - LLGEOnly
10 - RampFilter2	

Model supported by PSLF

Model supported by PSSE without T_A, T_B lead/lag block and with $K_{S4} = 1$

Stabilizer PSS2B



States

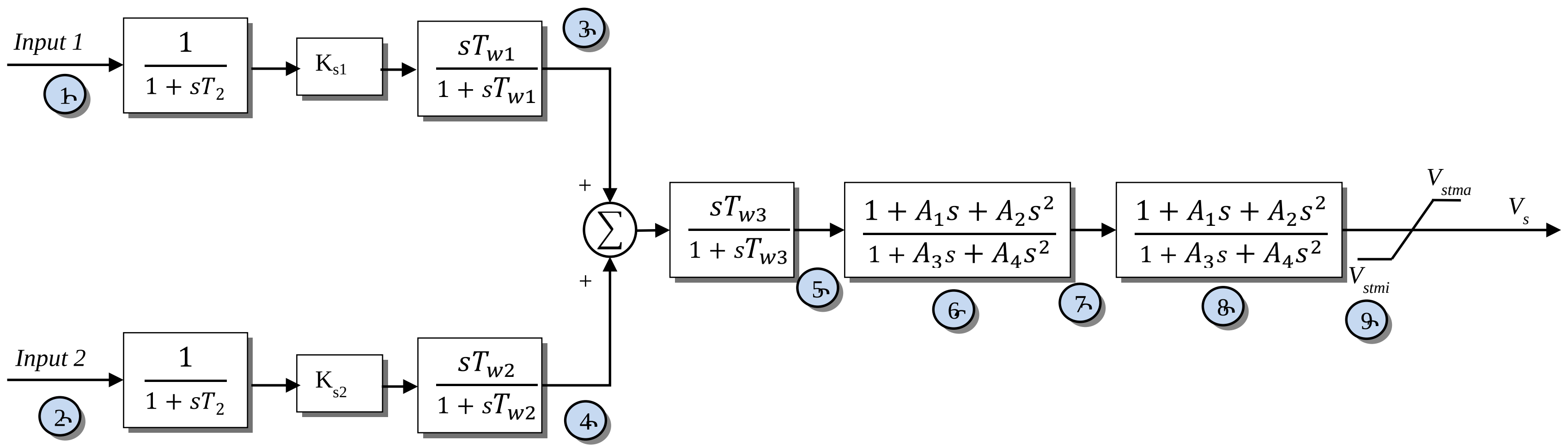
1 - WOTW1	11 - RampFilter3
2 - WOTW2	12 - RampFilter4
3 - Transducer1	13 - RampFilter5
4 - WOTW3	14 - RampFilter6
5 - WOTW4	15 - RampFilter7
6 - Transducer2	16 - RampFilter8
7 - LL1	17 - RampFilter9
8 - LL2	18 - RampFilter10
9 - RampFilter1	19 - LLGEOnly
10 - RampFilter2	20 - LL3

Model supported by PSLF

Model supported by PSSE without T_A, T_B lead/lag block and with $K_{S4} = 1$

Stabilizer PSS3B

Stabilizer PSS3B
IEEE (2005) Dual-Input Stabilizer Model

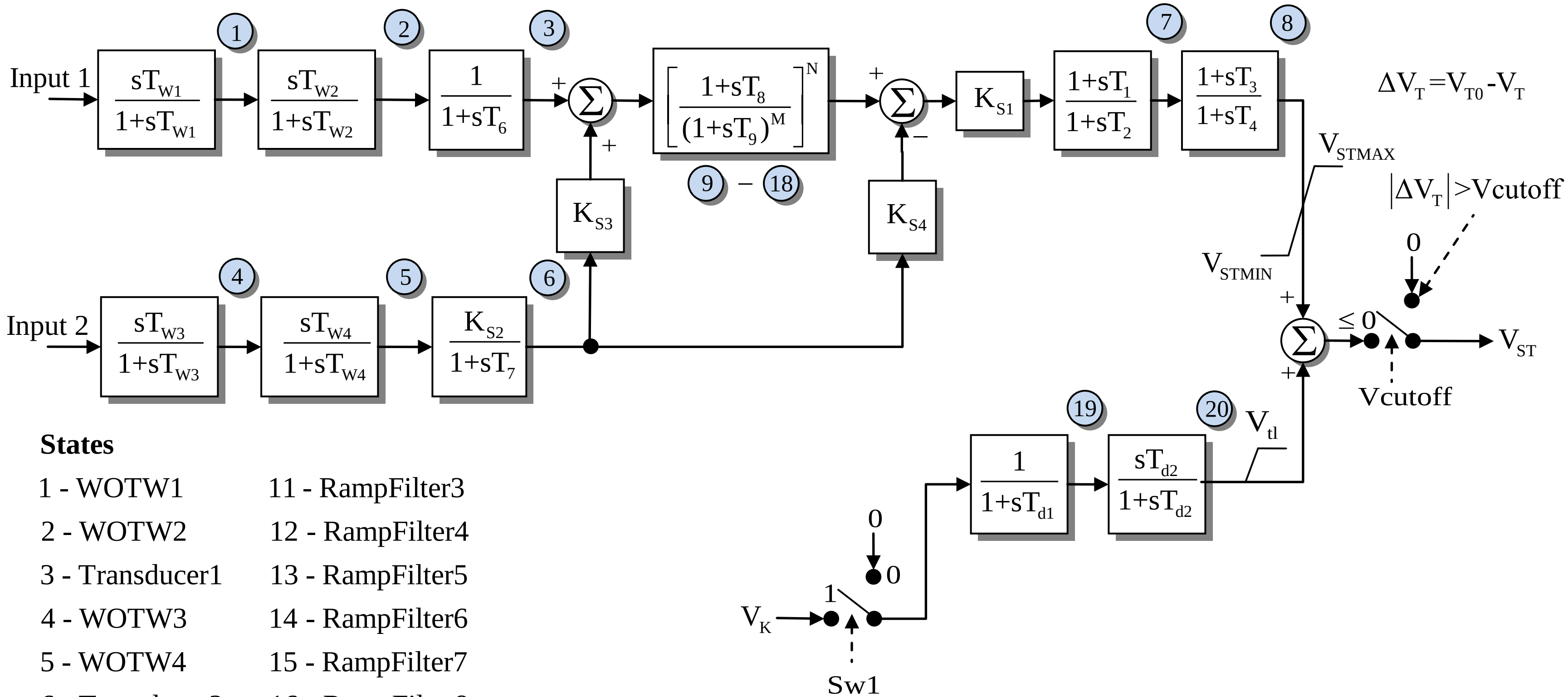


States:
1 – Input 1
2 – Input 2
3 – Washout 1
4 – Washout 2
5 – Washout 3
6 – Filter 1 Internal
7 – Filter 1 Output
8 – Filter 2 Internal
9 – Filter 2 Output

Model supported by PSLF

Stabilizer PSSSB

Stabilizer PSSSB
IEEE PSS2A Dual-Input Stabilizer Plus Voltage Boost Signal
Transient Stabilizer and Vcutoff



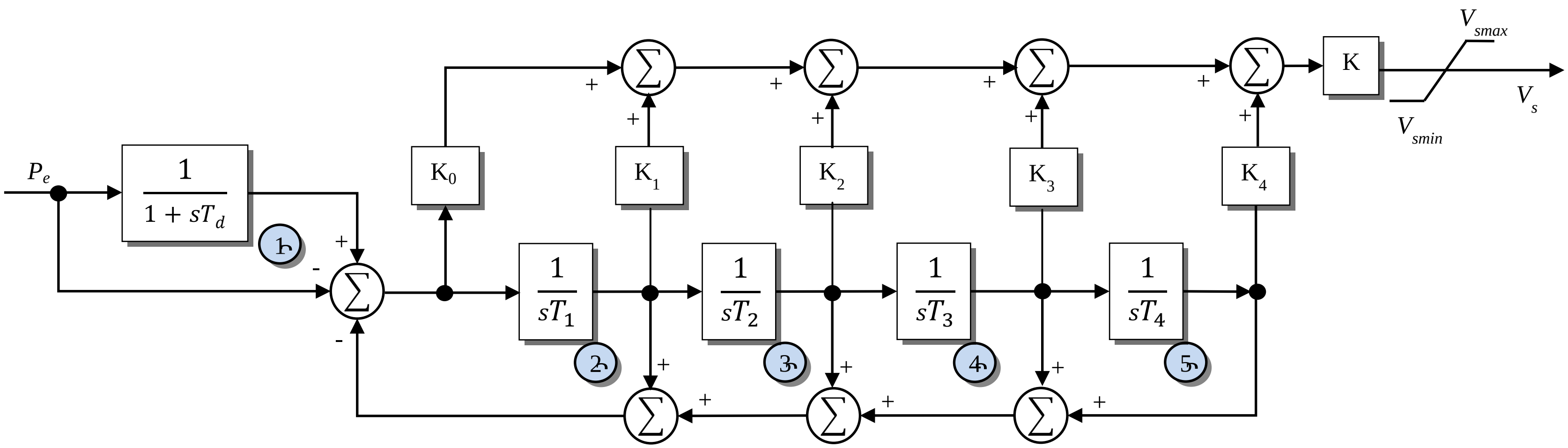
States

1 - WOTW1
2 - WOTW2
3 - Transducer1
4 - WOTW3
5 - WOTW4
6 - Transducer2
7 - LL1
8 - LL2
9 - RampFilter1
10 - RampFilter2
11 - RampFilter3
12 - RampFilter4
13 - RampFilter5
14 - RampFilter6
15 - RampFilter7
16 - RampFilter8
17 - RampFilter9
18 - RampFilter10
19 - TransducerTEB
20 - WOTEB

Model supported by PSLF

Stabilizer PSSSH

Stabilizer PSSSH
Model for Siemens "H Infinity" Stabilizer

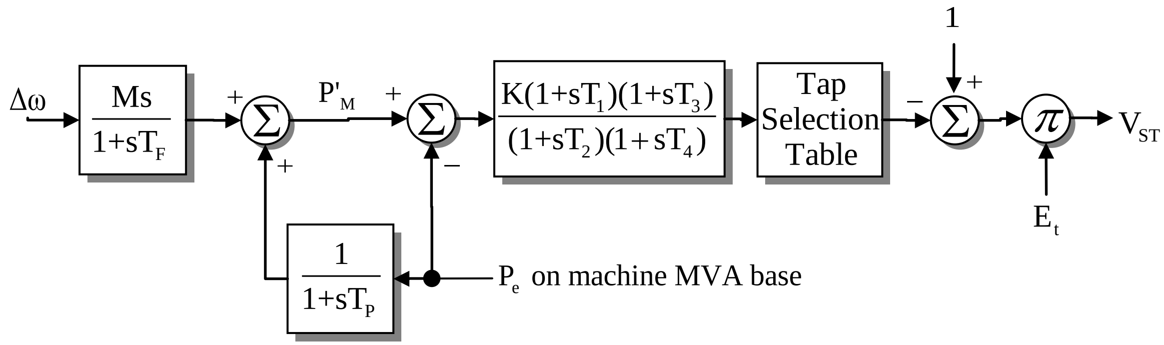


States:
1 – Pe
2 – Int1
3 – Int2
4 – Int3
5 – Int4

Model supported by PSLF

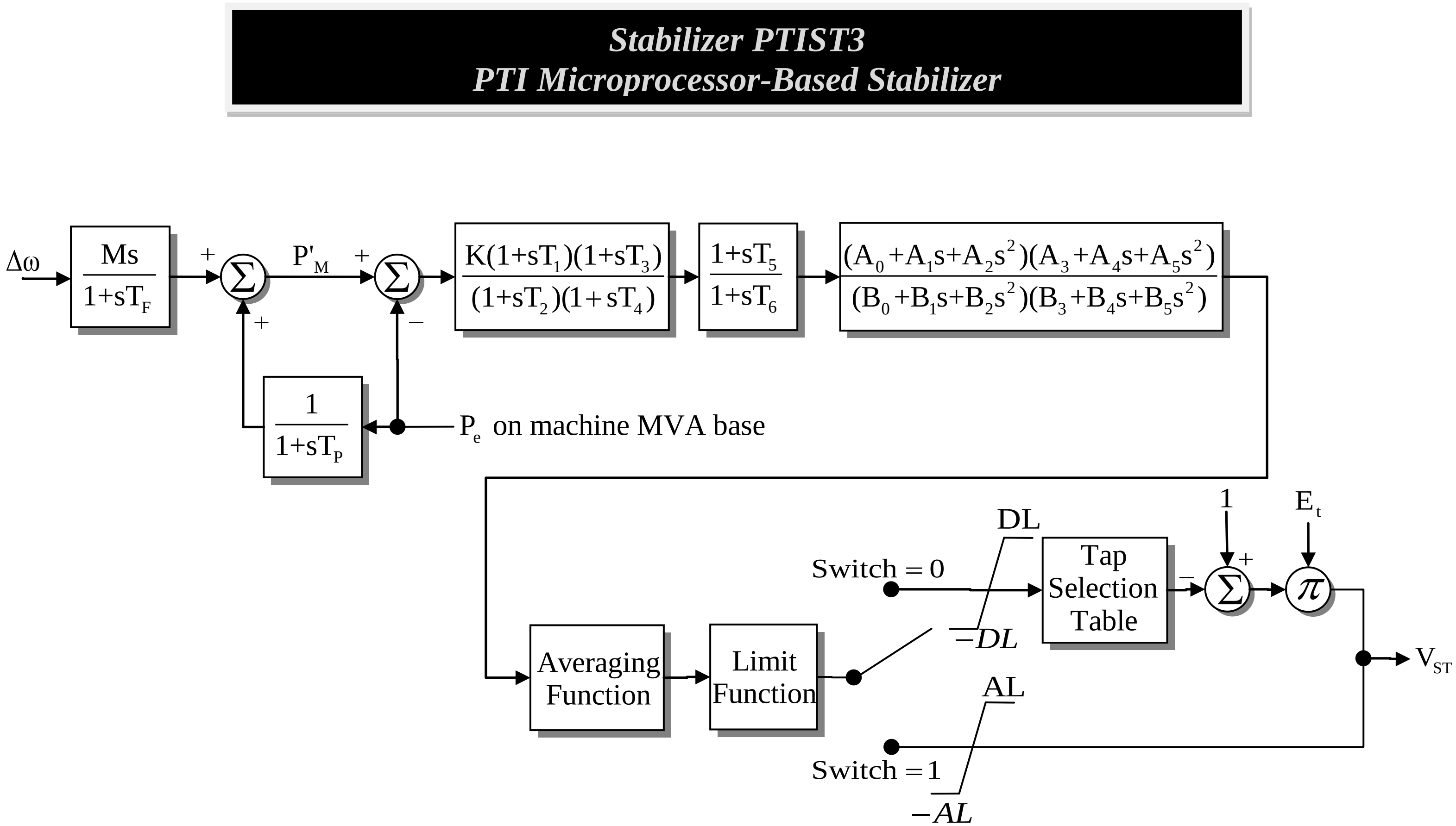
Stabilizer PTIST1

Stabilizer PTIST1
PTI Microprocessor-Based Stabilizer



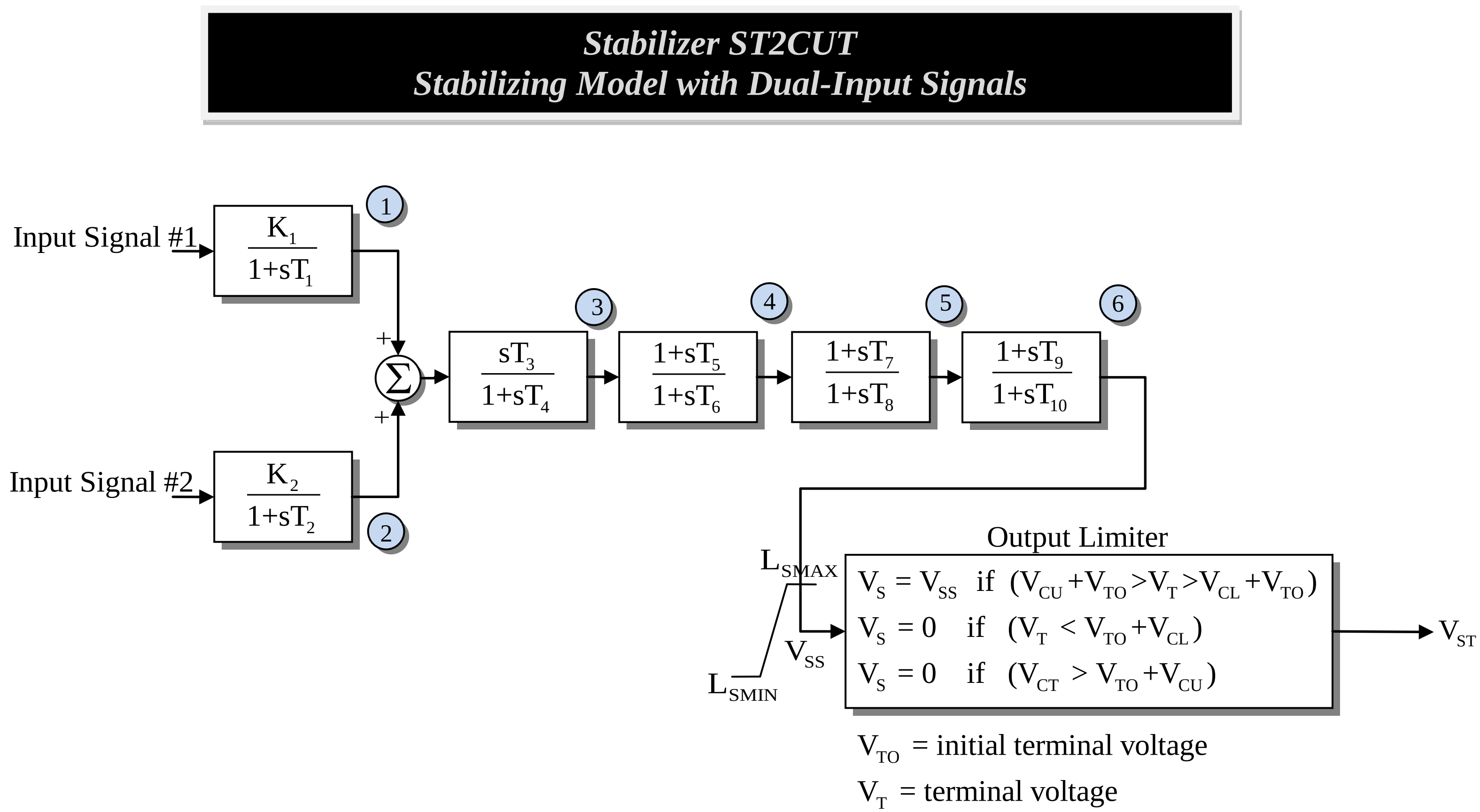
Model supported by PSSE but not yet implemented in Simulator

Stabilizer PTIST3



Model supported by PSSE but not yet implemented in Simulator

Stabilizer ST2CUT



States

1 - Transducer1

2 - Transducer2

3 - Washout

4 - LL1

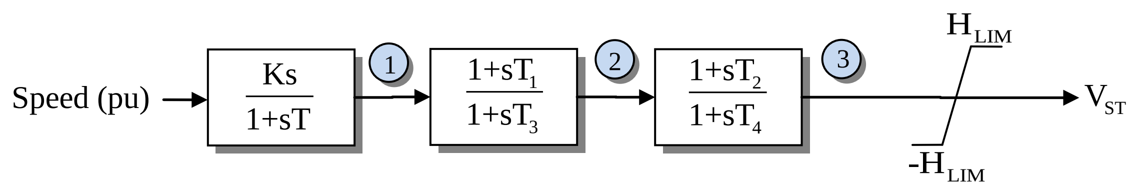
5 - LL2

6 - Unlimited Signal

Model supported by PSSE

Stabilizer STAB1

Stabilizer STAB1
Speed-Sensitive Stabilizing Model



States

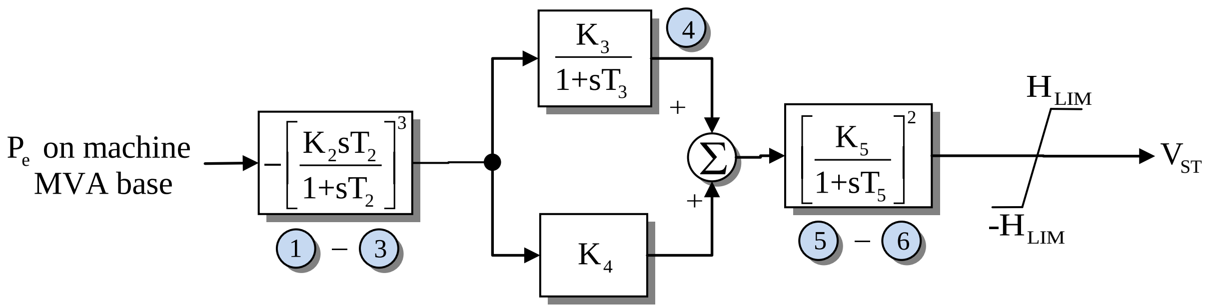
1 - Washout

2 - Lead-lag 1

3 - Lead-lag 2

Model supported by PSSE

Stabilizer STAB2A



States

1 - Input State 1

2 - Input State 2

3 - Input State 3

4 - T_3

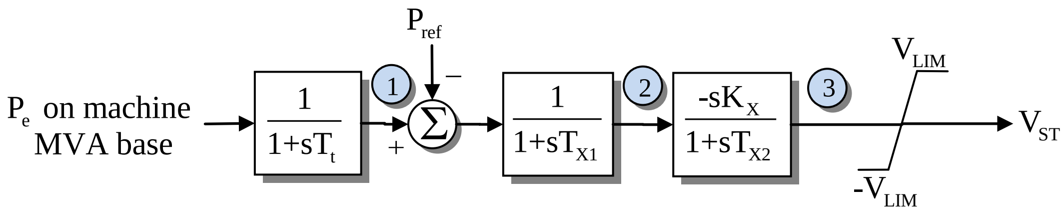
5 - Output State 1

6 - Output State 2

Model supported by PSSE

Stabilizer STAB3

Stabilizer STAB3
Power-Sensitive Stabilizing Unit



States

1 - Int T_t

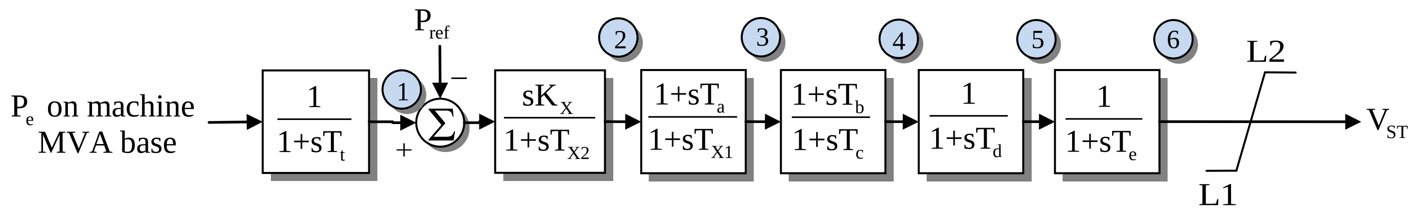
2 - Int T_{X1}

3 - Unlimited Signal

Model supported by PSSE

Stabilizer STAB4

Stabilizer STAB4
Power-Sensitive Stabilizer



States

1 - Input

2 - Reset

3 - LL1

4 - LL2

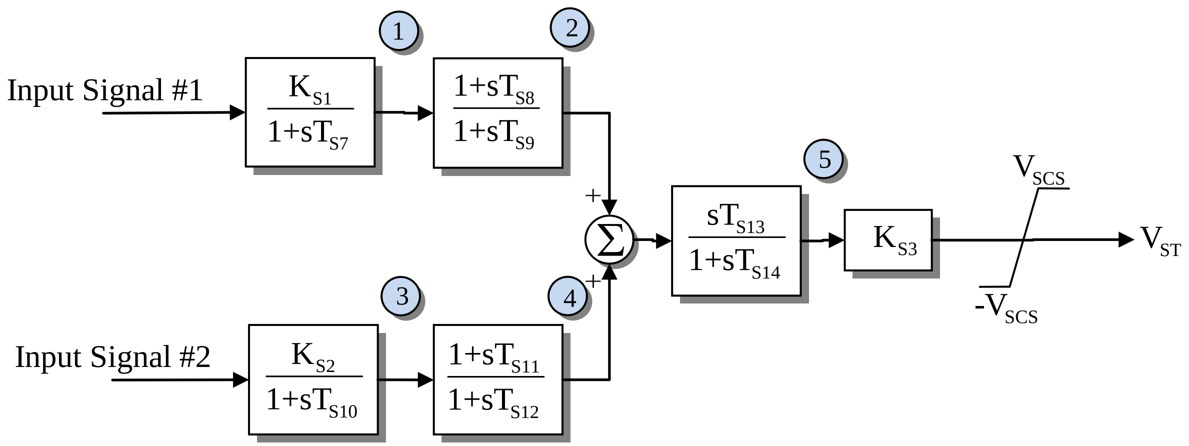
5 - T_d

6 - Unlimited Signal

Model supported by PSSE

Stabilizer STBSVC

Stabilizer STBSVC
WECC Supplementary Signal for Static var Compensator



States

1 - Transducer1

2 - LL1

3 - Transducer2

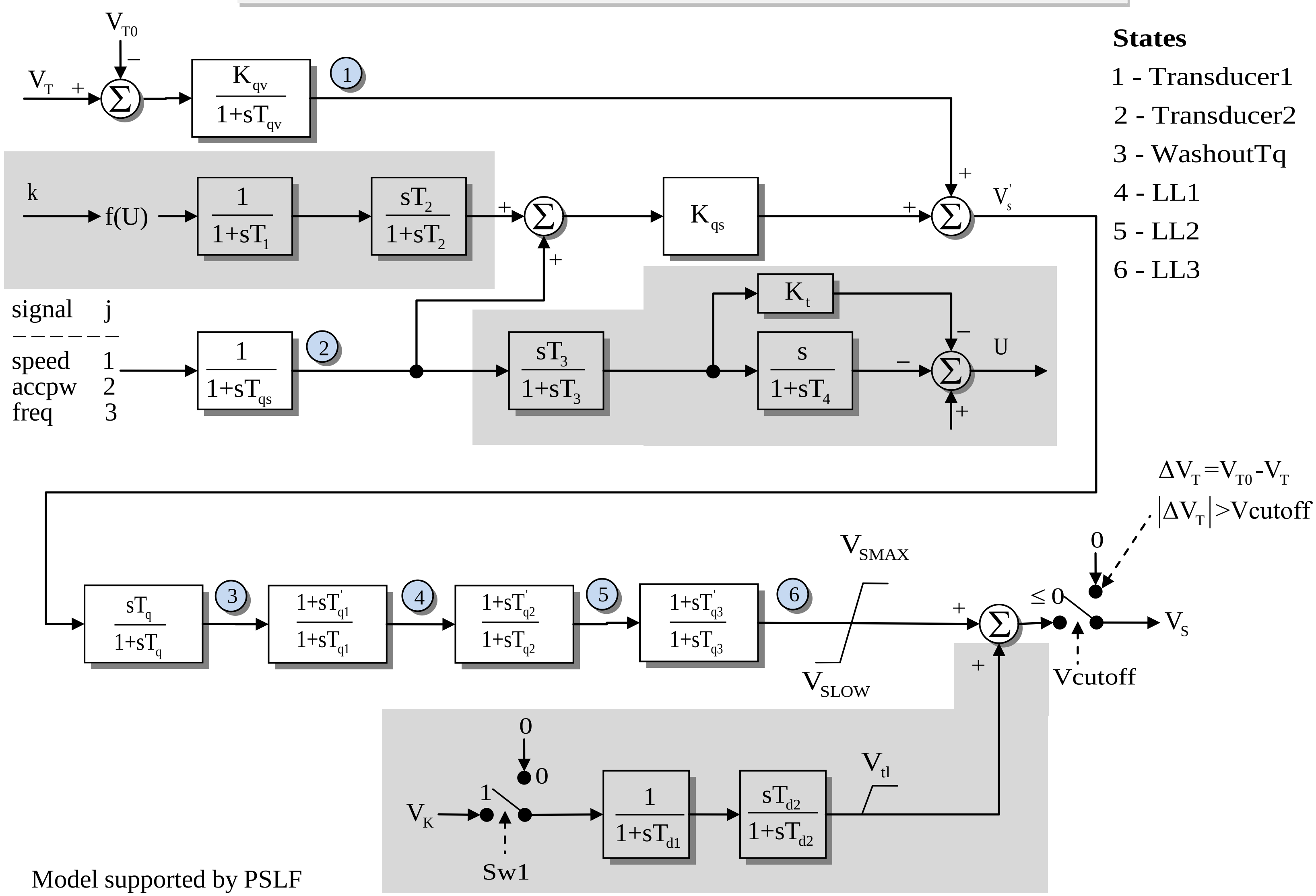
4 - LL2

5 - Washout

Model supported by PSSE

Stabilizer WSCCST

Stabilizer WSCCST
WSCC Power System Stabilizer



States

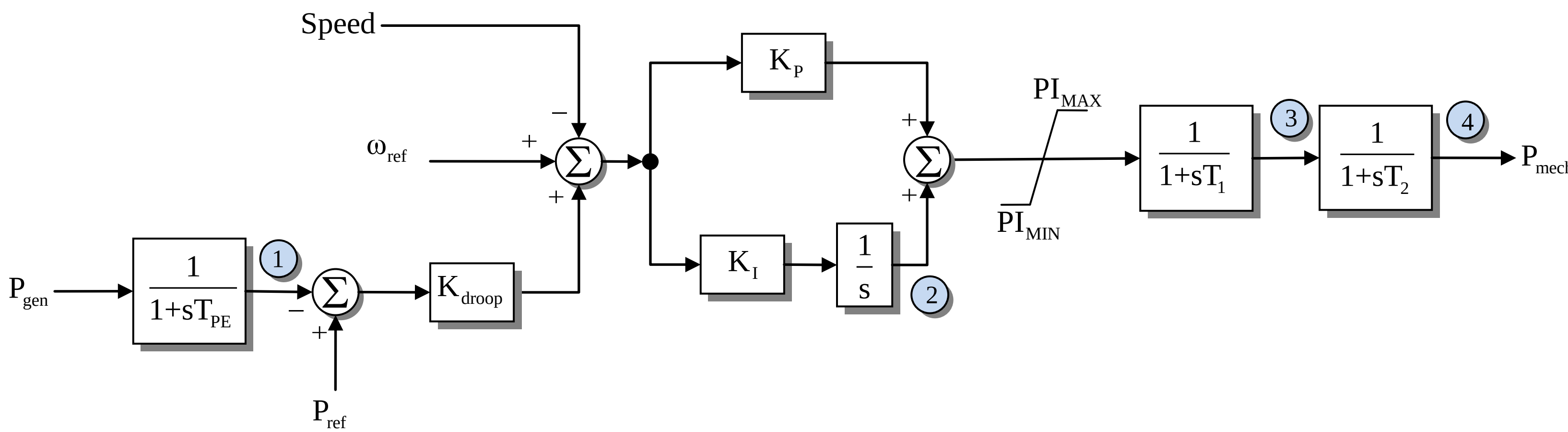
1 - Transducer1
2 - Transducer2
3 - WashoutTq
4 - LL1
5 - LL2
6 - LL3

Model supported by PSLF

Blocks in gray have not been implemented in Simulator

Stabilizer WT12A1 and WT1P

Stabilizer WT12A1 and WT1P
Pseudo Governor Model for Type 1 and Type 2 Wind Turbines



States

1 - P_{gen}

2 - K_I

3 - T_1

4 - P_{mech}

WT12A1 supported by PSSE with $K_I = \frac{1}{T_I}$

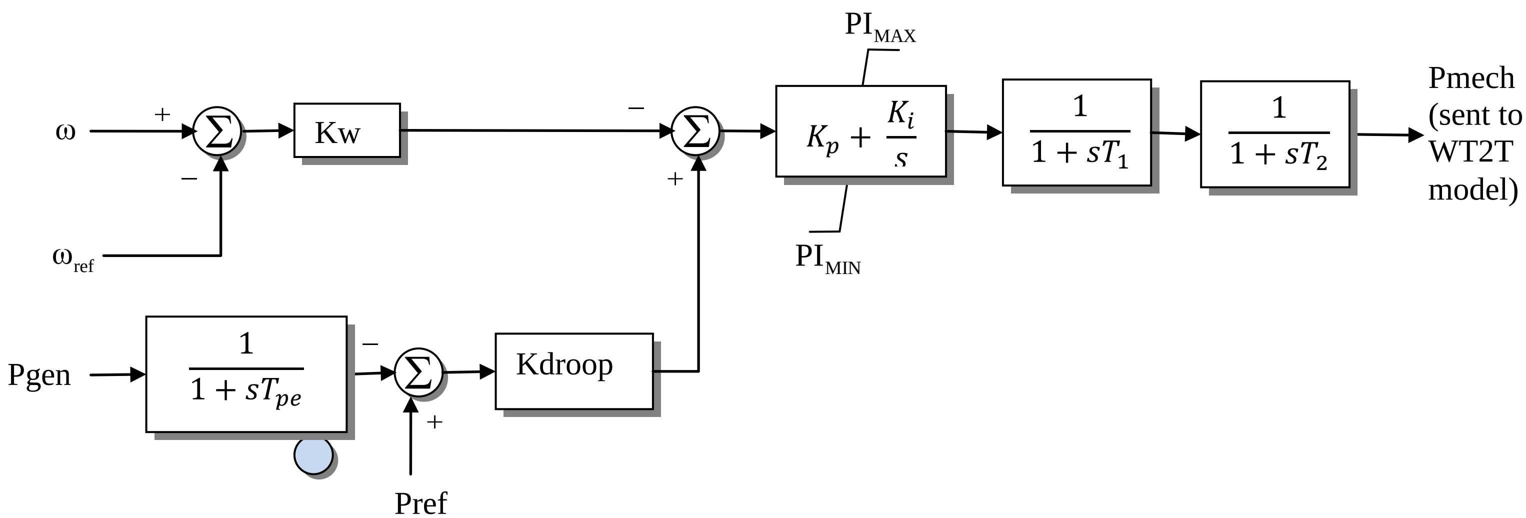
WT1P supported by PSLF

Stabilizer WT1P and WT12A1

WT1P is the same as WT12A1. See WT12A documentation

Stabilizer WT2P

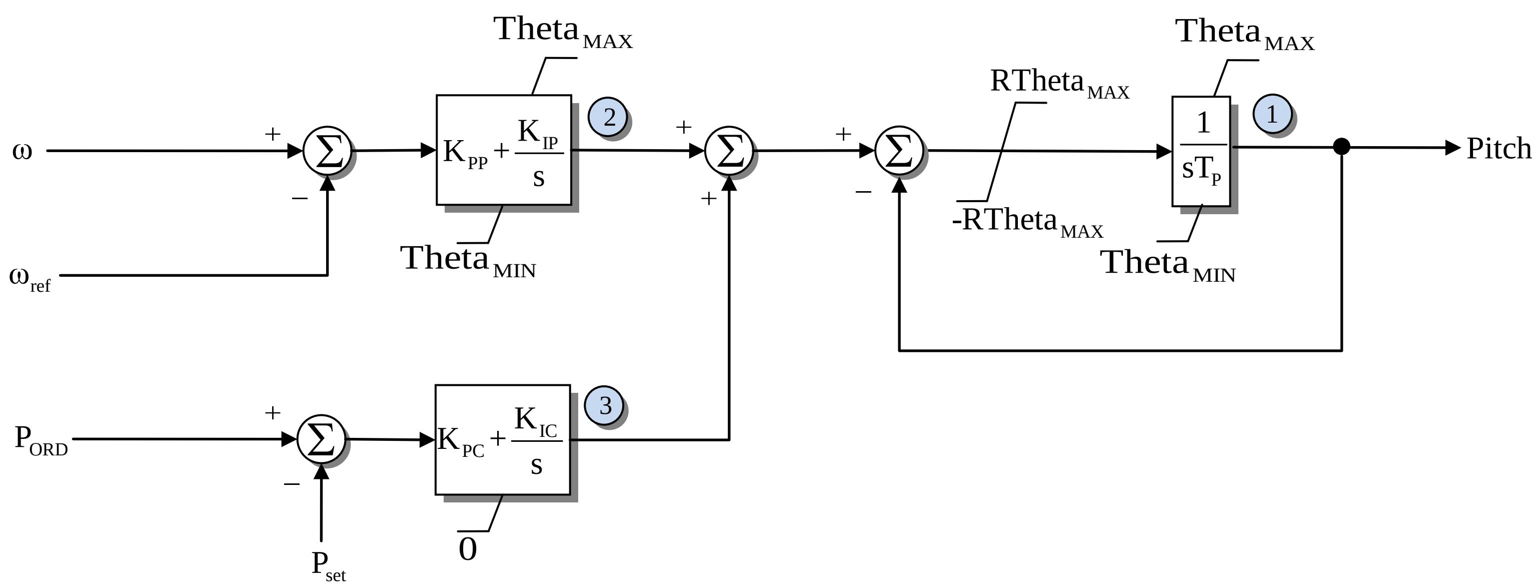
Stabilizer Model WT2P



Model supported by PSLF

Stabilizer WT3P and WT3P1

Stabilizer WT3P and WT3P1
Pitch Control Model for Type 3 Wind Generator



States

1 - Pitch

2 - PitchControl

3 - PitchComp

WT3P supported by PSLF

$T_P = T_{PI}$, $Theta_{MAX} = PI_{MAX}$, $Theta_{MIN} = PI_{MIN}$, and $RTheta_{MAX} = PI_{RATE}$

WT3P1 supported by PSSE with no non-windup limits on pitch control

Switched Shunt CAPRELAY

Switched Shunt CAPRELAY

Rem Bus	Remote Bus
Tfilter	Voltage filter time constant in sec.
tbClose	Circuit breaker closing time for switching shunt ON in sec.
tbOpen	Circuit breaker closing time for switching shunt OFF in sec.
V1On	First voltage threshold for switching shunt capacitor ON in sec.
T1On	First time delay for switching shunt capacitor ON in sec.
V2On	Second voltage threshold for switching shunt capacitor ON in sec.
T2On	Second time delay for switching shunt capacitor ON in sec.
V1Off	First voltage threshold for switching shunt capacitor OFF in sec.
T1Off	First time delay for switching shunt capacitor OFF in sec.
V2Off	Second voltage threshold for switching shunt capacitor OFF in sec.
T2Off	Second time delay for switching shunt capacitor OFF in sec.

Switched Shunt CSSCST

Static Var System Model CSSCST

See CSVGN1, CSVGN3 and CSVGN4 for more information.

Model supported by PSLF

Switched Shunt FACRI_SS

Fast AC Reactive Insertion for Switched Shunts (FACRI_SS)

uv1	Switching Group 1 under voltage level 1 (pu)
uv2	Switching Group 1 under voltage level 2 (pu)
uv1td	Switching Group 1 time delay level 1 (sec)
uv2td	Switching Group 1 time delay level 2 (sec)
inttd	Switching Group 1 first switch time delay, initial time delay (sec)
uv3	Voltage at terminal bus that triggers Switching Group 2 switching logic (pu)
uv4	Switching Group 2 under voltage low level (pu)
uv5	Switching Group 2 under voltage high level (pu)
td1	Switching Group 2 time delay for loop 1 (sec)
td2	Switching Group 2 time delay for loop 2 (sec)
td3	Switching Group 2 time delay for loop 3 (sec)
td4	Switching Group 2 time delay for loop checks (sec)
td5	Duration of time that conditions are checked Monitored Bus b while in each loop (sec)
Extra Object 1	Capacitor 1 – Switching Group 1
Extra Object 2	Capacitor 2 – Switching Group 1
Extra Object 3	Reactor 1 – Switching Group 1
Extra Object 4	Reactor 2 – Switching Group 1
Extra Object 5	Reactor 3 – Switching Group 1
Extra Object 6	Capacitor a1 – Switching Group 1
Extra Object 7	Capacitor a2 – Switching Group 1
Extra Object 8	Reactor a1 – Switching Group 1
Extra Object 9	Monitored Bus b – Switching Group 2
Extra Object 10	Reactor b1 – Switching Group 2
Extra Object 11	Capacitor b1 – Switching Group 2
Extra Object 12	Capacitor b2 – Switching Group 2

Switched Shunt FACRI_SS

Fast AC Reactive Insertion for Switched Shunts (FACRI_SS)

The following pseudo code describes how the inputs are used to determine switched shunt operation:

Switching Group 1 Switching Logic

Each time that voltage and time delay conditions are met for Switching Group 1, the reactors and capacitors are checked in the following order until a device is found that can be switched. Reactors are tripped and capacitors are closed. Only one device is switched each time switching is required.

(1) Reactor 1
(2) Reactor a1
(3) Reactor 2
(4) Reactor 3
(5) Capacitor 1
(6) Capacitor a1
(7) Capacitor 2
(8) Capacitor a2

Switching Group 2 Switching Logic

Each time that voltage and time delay conditions are met for Switching Group 2, if the reactor is online it will be tripped first before any capacitor switching. Depending on voltage conditions, capacitors may or may not be turned on. When capacitors are switched, they are checked in the following order until a device is found that can be switched. Only one capacitor is switched each time switching is required.

(1) Capacitor b1
(2) Capacitor b2

```
If (Reactor online) Then Begin
    Trip Reactor
    If (VoltMeasBusb <= uv4) Then Begin
        Do capacitor switching
    End
End
Else If (not Reactor online) Then Begin
    If (VoltMeasBusb <= uv4) or (VoltMeasBusb <= uv5) Then Begin
        Do capacitor switching
    End
End
```

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Switched Shunt FACRI_SS

Fast AC Reactive Insertion for Switched Shunts (FACRI_SS)

Continued from previous page

Initialization at the start of transient stability run
FirstSwitchComplete = False
Initialize Switching Group 2 Loop Trackers

Operations performed at each time step

```
VoltMeas = Voltage at the terminal bus of the switched shunt to which this model is assigned
// If voltage falls below specified thresholds, timers are started to record how long the voltages remain below these thresholds.
// The specific timer pseudo code is not shown here.
If (not FirstSwitchComplete) and ( (VoltMeas < uv1 for inttd) or (VoltMeas < uv2 for inttd))
Then Begin
    Check Group 1 Switching
    FirstSwitchComplete = True
End

If (FirstSwitchComplete) Then Begin
    If (VoltMeas < uv1 for uv1td)
    Then Begin
        Check Group 1 Switching
        Reset Group 1 Timer
    End

    If (VoltMeas < uv2 for uv2td)
    Then Begin
        Check Group 1 Switching
        Reset Group 1 Timer
    End
End
If (VoltMeas > uv1) Then Begin
    Reset Group 1 Timers
    FirstSwitchComplete = False
End
```

Continued on next page

Switched Shunt FACRI_SS

Fast AC Reactive Insertion for Switched Shunts (FACRI_SS)

Continued from previous page

```
// The condition of VoltMeas < uv3 triggers the checking of voltages at Monitored Bus b.  This latches on for the duration specified by
// td4.  The specific timer pseudo code is not shown here, but Group2Timer will be used to keep track of this.

VoltMeasBusb = Voltage at Monitored Bus b
If (VoltMeas < uv3) and (Group2Timer < td4) Then Begin
    If (Group2Timer > td1) and (not Group2Loop1Done) Then Begin
        Check Group 2 Switching
        Group2Loop1Done = True
        // Continue doing Check Group 2 Switching for td5 until some switching done
    End
    If (Group2Timer > td2) and (not Group2Loop2Done) Then Begin
        Check Group 2 Switching
        Group2Loop2Done = True
        // Continue doing Check Group 2 Switching for td5 until some switching done
    End
    If (Group2Timer > td3) and (not Group2Loop3Done) Then Begin
        Check Group 2 Switching
        Group2Loop3Done = True
        // Continue doing Check Group 2 Switching for td5 until some switching done
    End
End
Else If (Group2Timer > td4) Then Begin
    Reset Group 2 Timers
    Reset Group 2 Loop Trackers
End
```

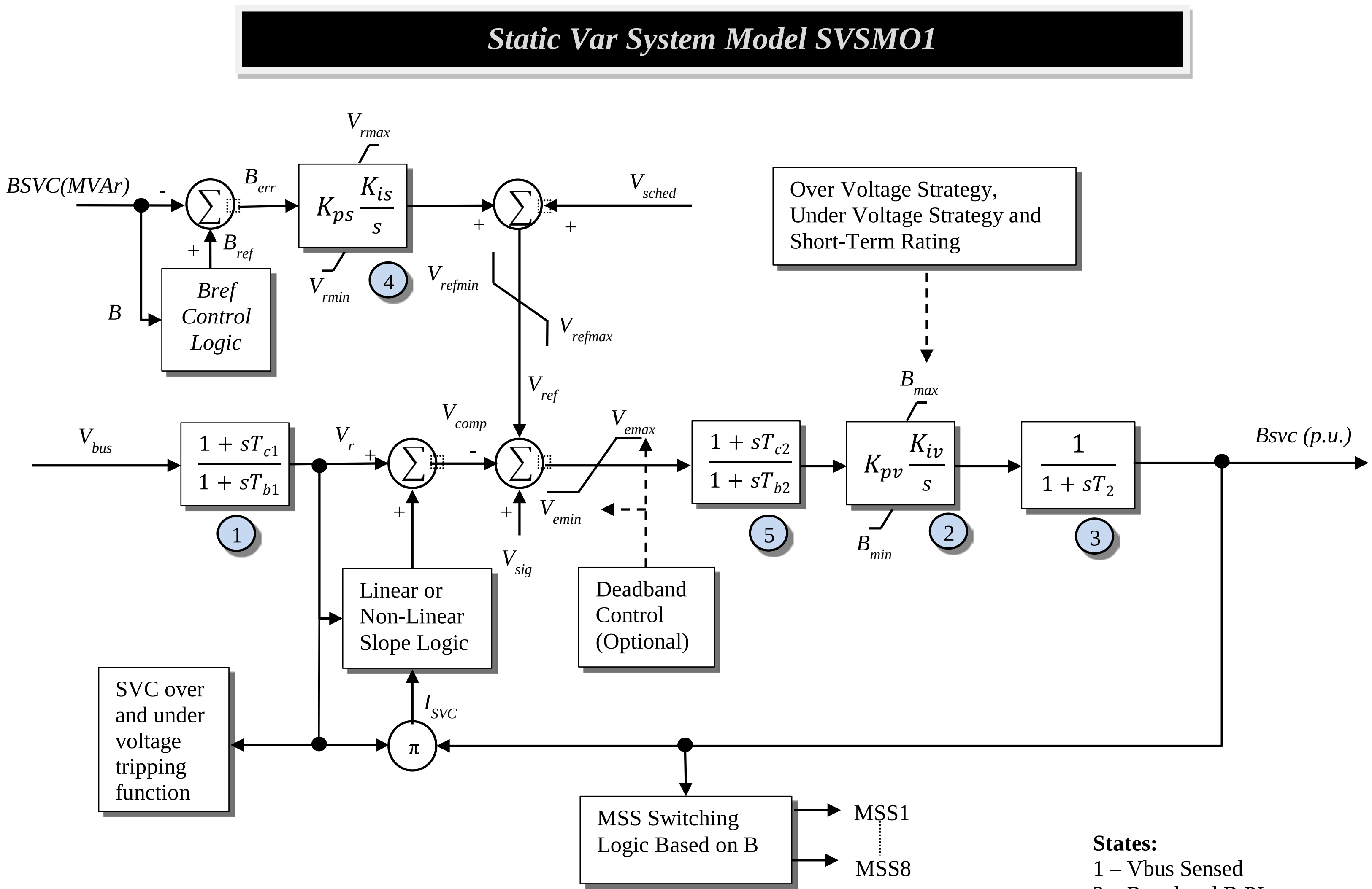
Switched Shunt MSC1

Static Var System Model MSC1

Tin1	Time 1 for Switching in (sec.)
Vmin1	Voltage lower limit 1 (p.u.)
Tout1	Time 1 for Switching out (sec.)
Vmax1	Voltage upper limit 1 (p.u.)
Tin2	Time 1 for Switching in (sec.)
Vmin2	Voltage lower limit 1 (p.u.)
Tout2	Time 1 for Switching out (sec.)
Vmax2	Voltage upper limit 1 (p.u.)
Tlck	Lock out time (sec.)

Model supported by PSLF

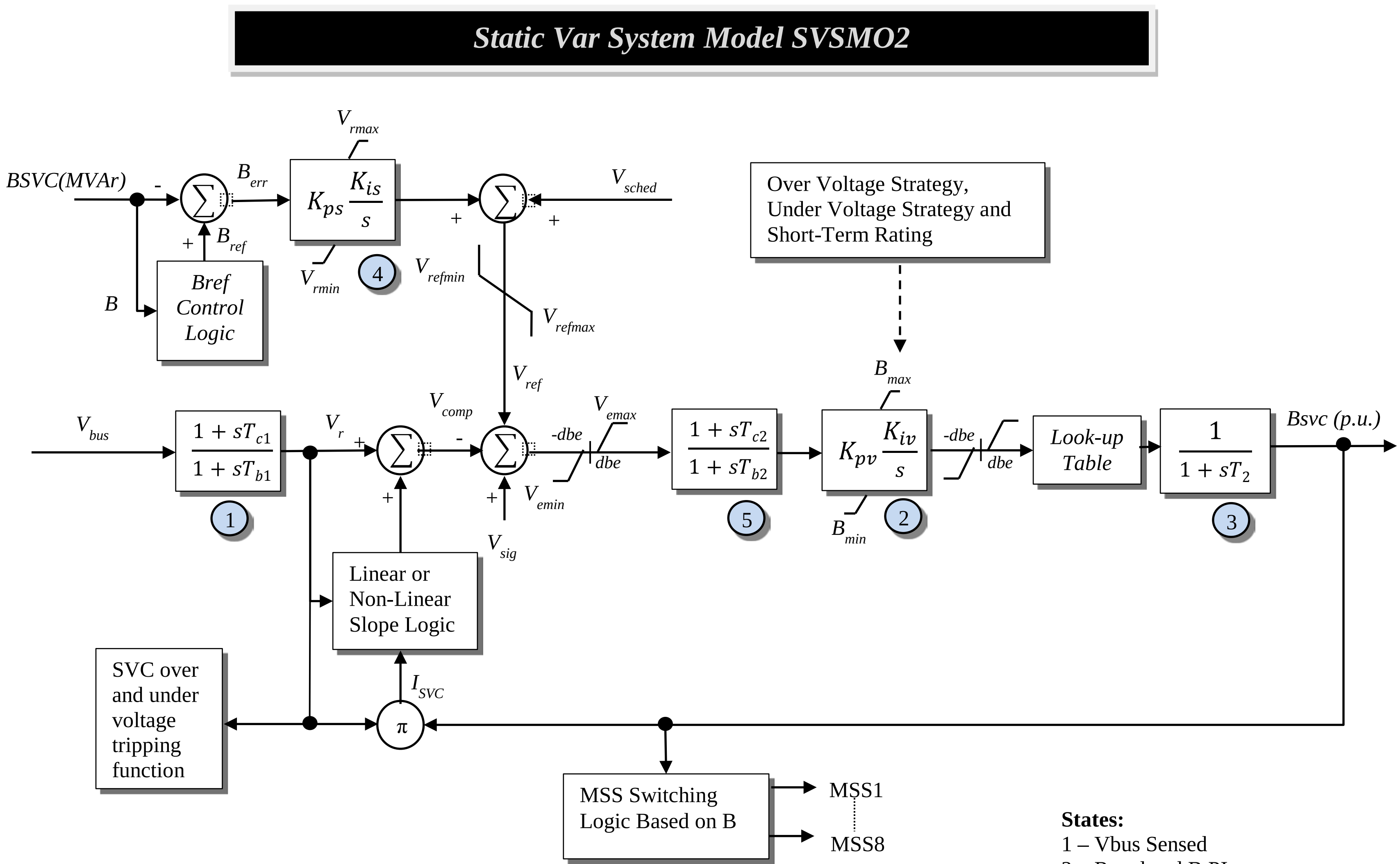
Switched Shunt SVSMO1



States:
1 – Vbus Sensed
2 – Regulated B PI
3 – PI Delay
4 – Regulated Slow B PI
5 – Verr LL

Model supported by PSLF

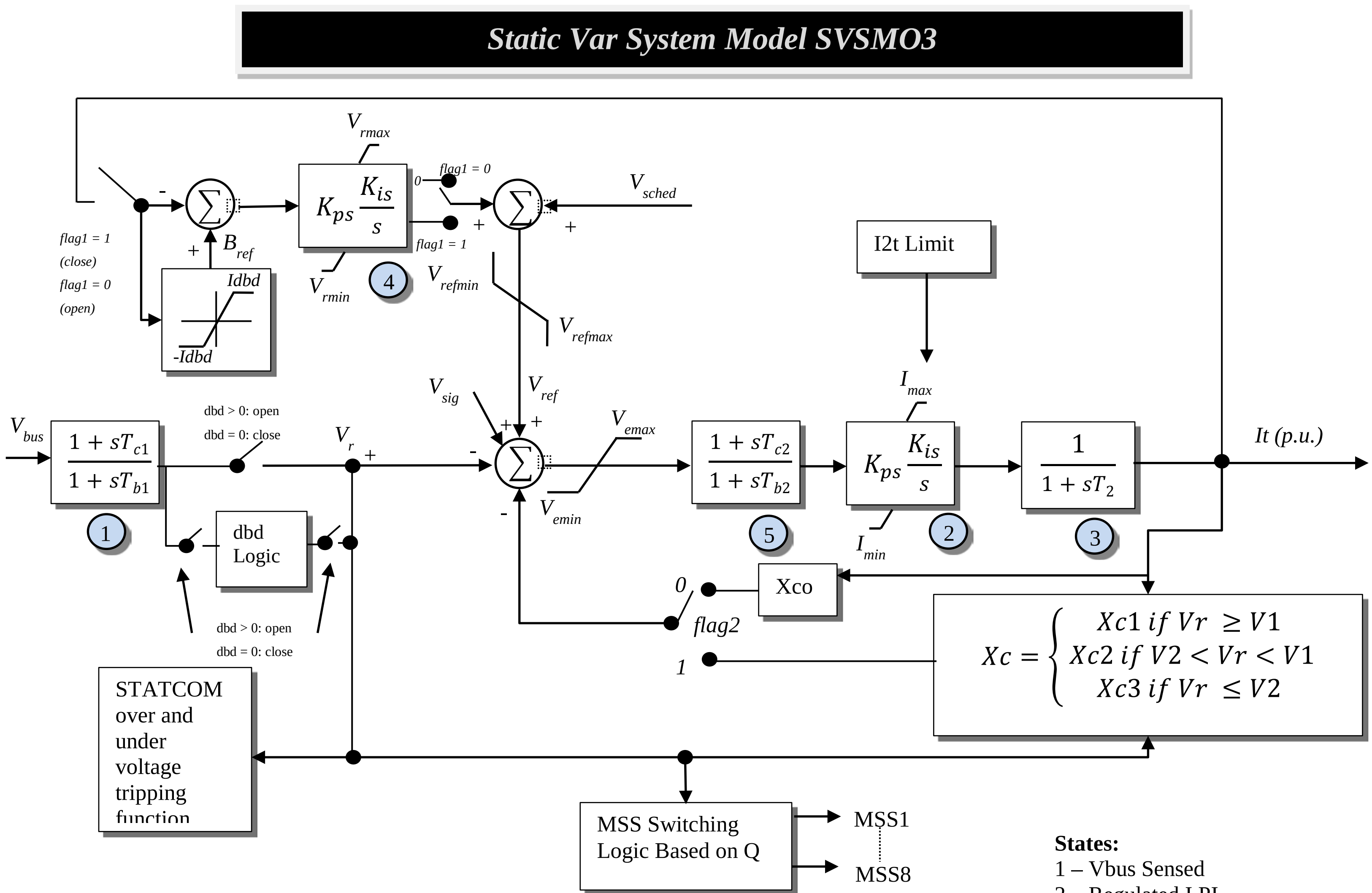
Switched Shunt SVSMO2



States:
1 – Vbus Sensed
2 – Regulated B PI
3 – PI Delay
4 – Regulated Slow B PI
5 – Verr LL

Model supported by PSLF

Switched Shunt SVSMO3



States:
1 – Vbus Sensed
2 – Regulated I PI
3 – PI Delay
4 – Regulated Slow Control PI
5 – Verr LL

Model supported by PSLF

Switched Shunt SWSHNT

Switched Shunt SWSHNT

Ib	Remote Bus
NS	Total number of switches allowed
VIN	High voltage limit
PT	Pickup time for high voltage in sec.
ST	Switch time to close if reactor or switch time to open if capacitor in sec.
VIN	Low voltage limit
PT	Pickup time for low voltage in sec.
ST	Switch time to close if reactor or switch time to open if capacitor in sec.

Model supported by PSEE