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MODEL LIBRARY

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Chapter 1

Generator Model Data Sheets

This chapter contains a collection of data sheets for the generator models contained in the PSS®E dynamics model library.

Model	Description
CBEST	EPRI battery energy storage FACTS model
CDSMS1	American Superconductor DSMES device model
CGEN1	Third order generator model
CIMTR1	Induction generator model with rotor flux transients
CIMTR2	Induction motor model with rotor flux transients
CIMTR3	Induction generator model with rotor flux transients
CIMTR4	Induction motor model with rotor flux transients
CSMEST	EPRI superconducting electromagnetic energy storage FACTS model
CSTATT	Static condenser FACTS model
CSVGN1	SCR controlled static var source model
CSVGN3	SCR controlled static var source model
CSVGN4	SCR controlled static var source model
CSVGN5	WECC controlled static var source model
CSVGN6	WECC controlled static var source model
FRECHG	Salient pole frequency changer model
GENCLS	Classical generator model
GENDCO	Round rotor generator model with dc offset torque component
GENROE	Round rotor generator model
GENROU	Round rotor generator model
GENSAE	Salient pole generator model
GENSAL	Salient pole generator model
GENTPJU1	WECC Type J Synchronous generator model
GENTRA	Transient level generator model

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1.1 CBEST

EPRI Battery Energy Storage

This model is at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			P_{MAX} (pu on MBASE)
J+1			$O_{UT}E_{FF}$, output efficiency (≥1)
J+2			$I_{NP}E_{FF}$, input efficiency (≤1)
J+3			I_{ACMAX} (pu)
J+4			K_{AVR}, AVR gain
J+5			T_1, AVR time constant (sec)
J+6			T_2, AVR time constant (sec)
J+7			T_3, AVR time constant (sec) (>0)
J+8			T_4, AVR time constant (sec)
J+9			V_{MAX}, AVR speed limit (pu)
J+10			V_{MIN}, AVR speed limit (pu) (<0)
J+11			DROOP (pu)

STATEs	#	Description
K		AVR state 1
K+1		AVR state 2
K+2		I_Q, reactive current (pu)
K+3		Energy output (pu sec)
K+4		Energy input (pu sec) (< 0)

VARs	#	Description
L		P_{AUX}, supply signal (MW)
L+1		P_{INIT} (pu on MBASE)
L+2		P_{OUT} (pu on SBASE)
L+3		Q_{OUT} (pu on SBASE)
L+4		E_{OUT} total energy (pu on SBASE, sec)

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VARs	#	Description
L+5		Memory

This incorporates technology developed for the United States Electric Power Industry under the sponsorship of the Electric Power Research Institute (EPRI).

IBUS, 'CBEST', ID, CON(J) to CON(J+11) /

1.2 CDSMS1

American Superconductor DSMES Device

This model incorporates technology of American Superconductor Corporation (ASC) and was developed under the sponsorship of ASC.

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			S_{RATED}, rated D-SMES MVA, must be equal to MBASE
J+1			V_{DC}, nominal coil voltage (kV)
J+2			I_{INIT}, initial coil current (kA)
J+3			I_{MIN}, minimum coil current (kA)
J+4			T_{DIS}, magnet full-discharge time (sec)
J+5			T_{ON}, minimum time interval after the magnet turning off before its new activating (sec)
J+6			T_{OFF}, minimum time interval after the magnet activating before turning it off (sec)
J+7			V_1, voltage threshold (pu) ($>V_2$)
J+8			V_2, voltage threshold (pu) ($>V_3$)
J+9			V_3, voltage threshold (pu) ($>V_4$)
J+10			V_4, voltage threshold (pu) (>0)
J+11			K_{AVR}, AVR (Q-path) gain
J+12			T_1, AVR time constant (sec)
J+13			T_2, AVR time constant (sec)
J+14			T_3, AVR time constant (sec) (>0)
J+15			T_4, AVR time constant (sec) (>0)
J+16			AVR_DROOP, AVR droop
J+17			PAUX_THRESH, PAUX threshold (MW) (>0)
J+18			TOVLD, time interval of overload, when MVA output limit is maximum – S_{LIMMAX} (sec)

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CONs	#	Value	Description
J+19			TBACK, time interval when MVA output limit S_{LIM} is ramping from maximum value S_{LIMMAX} to nominal value S_{RATED} (sec)
J+20			KOL, overload parameter (percent)
J+21			TBOOST_BEG, boost control starting time (sec)
J+22			BOOST_DUR, time interval when the boost control is active (sec)
J+23			STEP_VREF, voltage reference step used by the boost control (pu)
J+24			KOV, parameter determines the step-up transformer voltage when the remote bus control is abandoned (per cent)
J+25			V_{QMAX}, maximum limit for AVR state 2 (pu)
J+26			V_{QMIN}, minimum limit for AVR state 2 (pu)
J+27			I_{ACMAX}, maximum limit for the D-SMES AC current (pu)
J+28			P_{MAX}, maximum limit for P_{OUT} (pu on MBASE)
J+29			P_{MIN}, minimum limit for P_{OUT} (pu on MBASE)

STATEs	#	Description
K		IQ, Q-path reactive current (pu)
K+1		AVR state 1 (pu)
K+2		AVR state 2 (pu)

VARs	#	Description
L		P_{AUX}, active power control signal (MW)
L+1		P_{OUT}, output active power (pu on SBASE)
L+2		Q_{OUT}, output reactive power (pu on SBASE)
L+3		IDC, output D_SMES DC current (kA)
L+4		I_L, coil current (kA)
L+5		V_{TR}, D-SMES step-up transformer low voltage (pu)
L+6 • • • L+22		Internal Storage

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ICONs	#	Description
M		CONV_TYPE, converter type: 0 current-source converter 1 voltage source converter
M+1		IBUS_CONTR: number of remote control bus
M+2		BOOST_CONTR, boost control flag: 0 if no 1 if yes
M+3		VOLT_SEN_LOC, voltage control sensor location flag: 0 for the D-SMES bus 1 for controlling the remote control bus
M+4		TURN_ON_VOLT, voltage control flag: 0 if no 1 if yes No means that Vi thresholds are ignored by P-path.
M+5		TURN_ON_POWER, active power (damping control) flag: 0 if no 1 if yes No means that P_{AUX} signal is ignored.
M+6		TURN_ON_P, active power output flag: 0 if no 1 if yes No turns off P-paths (P_{OUT}=0).
M+7		TURN_ON_Q, reactive power output flag: 0 if no 1 if yes No turns off Q-path (Q_{OUT}=0).

IBUS, ’CDSMS1’, ID, ICON(M) to ICON(M+7), CON(J) to CON(J+29) /

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General Diagram

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Calculating the Voltage Mode (AVR_MODE)

$V_{AC} \geq V_1$	The MW-injection DSMES is disabled.
$V_1 > V_{AC} \geq V_2$	The MW-injection DSMES is disabled.
$V_2 > V_{AC} \geq V_3$	The MW-injection DSMES is enabled, but MW can only be absorbed from the power system.
$V3 > V_{AC} \geq V_4$	The MW-injection DSMES is enabled. MW can either be produced by the magnet discharge or absorbed from the power system, depending on the controls.
$V_4 > V_{AC}$	The MW-injection DSMES is enabled, but MW can only be absorbed from the power system.

The MW Injection of DSMES is also enabled immediately after V_{AC} quick crossing the $V_3 > V_{AC} \geq V_4$ range.

The Magnet Discharge Curve

Uninterrupted Discharge

Repetitive Discharge

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P-Path Algorithm

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Q-Path Algorithm

Overload Diagram

$$I_{QMAX} = \sqrt{I_{ACMAX}^2 - \left(\frac{P_{OUT}}{V_{DSMES}}\right)^2}$$

$$Q_{LIM} = \sqrt{S_{LIM}^2 - P_{OUT}^2}$$

$$S_{LIM\ MAX} = KOL \bullet S_{RATED}$$

$$\text{at } t^* : S = \sqrt{P_{OUT}^2 + Q^2} > S_{RATED}$$

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1.3 CGEN1

Third Order Complex Generator Model

This model is located at system bus #_____ IBUS,

Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K,

and VARs starting with #_____ L.

The machine MVA base is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is_____+ j _____on the above MBASE.

CONs	#	Value	Description
J			H, Inertia
J+1			S(1.0)
J+2			S(1.2)
J+3			$L_{ld} > 0$
J+4			$L_{ad} > 0$
J+5			$R_{fd} > 0$
J+6			$L_{fd} > 0$
J+7			R_{md} (1)
J+8			L_{md} (1)
J+9			R_{kd} (1)
J+10			L_{kd} (1)
J+11			R_{md} (2)
J+12			L_{md} (2)
J+13			R_{kd} (2)
J+14			L_{kd} (2)
J+15			$L_{lq} > 0$
J+16			$L_{aq} > 0$
J+17			R_{kq} (3) > 0
J+18			L_{kq} (3) > 0
J+19			R_{mq} (1)

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CONs	#	Value	Description
J+20			L_{mq} (1)
J+21			R_{kq} (1)
J+22			L_{kq} (1)
J+23			R_{mq} (2)
J+24			L_{mq} (2)
J+25			R_{kq} (2)
J+26			L_{kq} (2)

STATEs	#	Description
K		Δ speed (pu)
K+1		Angle (radians)
K+2		ψ_{rd} (1)
K+3		ψ_{rd} (2)
K+4		ψ_{rd} (3)
K+5		ψ_{rq} (1)
K+6		ψ_{rq} (2)
K+7		ψ_{rq} (3)

VARs	#	Description
L		Internal memory
L+1		Internal memory

All constants except S(1.0) and S(1.2) are in pu machine MVA base.

Set R_{md} (2), L_{md} (2), R_{kd} (2) and L_{kd} (2) to 0 for 2nd order d-axis model.

Set R_{mq} (2), L_{mq} (2), R_{kq} (2) and L_{kq} (2) to 0 for 2nd order q-axis model.

See diagram below for definition of various resistances and inductances.

IBUS, ’CGEN1’, ID, CON(J) to CON(J+26) /

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CGEN1 Equivalent Circuit

1.4 CIMTR1

Induction Generator Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICON #_____ M.
The machine MVA is _____ for each of _____ units = _____ MBASE.
ZSORCE for this machine is_____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			T´ (sec) (>0)
J+1			T″ (sec) (≥0)[1]
J+2			H, Inertia
J+3			X
J+4			X´
J+5			X″[1]
J+6			X_l
J+7			E_1 (≥0)
J+8			$S(E_1)$
J+9			E_2
J+10			$S(E_2)$
J+11		0	Switch

[1] If T″ = 0 or X″ = 0, motor is assumed to be single cage and ZSORCE should be set equal to X'.

Note: X, X´, X″, X_l, and H are in pu, machine MVA base.

STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)

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VARs	#	Description
L		Admittance of initial condition Mvar difference
L+1		Motor, Q
L+2		T_{elec}

ICON	#	Description
M		Memory

IBUS, ’CIMTR1’, ID, CON(J) to CON(J+11) /

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1.5 CIMTR2

Induction Motor Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICON #_____ M.
The machine MVA is _____ for each of
_____ units = _____ MBASE.
ZSORCE for this machine is _____ + j _____
on the above MBASE.

CONs	#	Value	Description
J			T´ (sec) (>0)
J+1			T″ (sec) (≥0)[1]
J+2			H, Inertia
J+3			X
J+4			X´
J+5			X″[1]
J+6			X_l
J+7			E_1 (≥0)
J+8			$S(E_1)$
J+9			E_2
J+10			$S(E_2)$
J+11			D

[1] If T″ = 0 or X″ = 0, motor is assumed to be single cage and ZSORCE should be set equal to X´.

Note: X, X´, X″, X_l, and H are in pu, machine MVA base.

STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		D speed (pu)

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VARs	#	Description
L		Admittance of initial condition Mvar difference
L+1		Motor, Q
L+2		T_{elec}

ICON	#	Description
M		Memory

IBUS, ’CIMTR2’, ID, CON(J) to CON(J+11) /

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1.6 CIMTR3

Induction Generator Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICON #_____ M.
The machine MVA is _____ for each of
_____ units = _____ MBASE.

CONs	#	Value	Description
J			T´ (sec) (>0)
J+1			T″ (sec) (≥0)[1]
J+2			Inertia, H
J+3			X
J+4			X´
J+5			X″[1]
J+6			X_l
J+7			E_1 (≥0)
J+8			$S(E_1)$
J+9			E_2
J+10			$S(E_2)$
J+11		0	Switch
J+12			SYN-POW, mechanical power at synchronous speed (>0). Used only to start Machine, otherwise ignored.

[1] If T″ = 0 or X″ = 0, Machine is assumed to be single cage and ZSORCE should be set equal to X´.

Note: X, X´, X″, X_l, and H are in pu, machine MVA base.

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STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	#	Description
L		Admittance of initial condition Mvar difference
L+1		Motor, Q
L+2		T_{elec}

ICON	#	Description
M		Memory

IBUS, ’CIMTR3’, ID, CON(J) to CON(J+12) /

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1.7 CIMTR4

Induction Motor Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICON #_____ M.
The machine MVA is _____ for each of
_____ units = _____ MBASE.
ZSORCE for this machine is _____
+ j _____ on the above MBASE.

CONs	#	Value	Description
J			T´ (sec) (>0)
J+1			T″ (sec) (≥0)[1]
J+2			Inertia, H
J+3			X
J+4			X´
J+5			X″[1]
J+6			X_l
J+7			E_1 (≥0)
J+8			$S(E_1)$
J+9			E_2
J+10			$S(E_2)$
J+11			D
J+12			SYN-TOR, synchronous torque (pu) (< 0). Used only to start machine, otherwise ignored.

[1] If T″ = 0 or X″ = 0, motor is assumed to be single cage and ZSORCE should be set equal to X´.

Note: X, X´, X″, X_l, and H are in pu, machine MVA base.

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STATEs	#	Description
K		E''_q
K+1		E'_d
K+2		E''_q
K+3		E''
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	#	Description
L		Admittance of initial condition Mvar difference
L+1		Motor, Q
L+2		T_{elec}

ICON	#	Description
M		Memory

IBUS, ’CIMTR4’, ID, CON(J) to CON(J+12) /

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1.8 CSMEST

EPRI Current and Voltage-Source SMES Device

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			L, coil inductance (pu)
J+1			P_{MAX} (pu on MBASE)
J+2			V_{DCMAX} (pu)
J+3			V_{DCMIN} (pu)(< 0)
J+4			I_{DCMAX1} (pu)
J+5			I_{DCMAX2} (pu)
J+6			I_{DCMIN1} (pu)
J+7			I_{DCMIN2} (pu)(< 0)
J+8			I_{ACMAX} (pu)
J+9			K, Limiter K factor
J+10			I_{DC0} (pu)
J+11			K_R, I_{DC} reset gain
J+12			K_{AVR}, AVR gain
J+13			T_1, AVR time constant (sec)
J+14			T_2, AVR time constant (sec)
J+15			T_3, AVR time constant (sec)
J+16			T_4, AVR time constant (sec)
J+17			V_{MAX}, AVR speed limit (pu)
J+18			V_{MIN}, AVR speed limit (pu) (< 0)
J+19			DROOP, AVR droop

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STATEs	#	Description
K		I_{DC}, coil dc current (pu)
K+1		AVR state 1
K+2		AVR state 2
K+3		I_Q, reactive current (pu)

VARs	#	Description
L		P_{AUX}, supplementary signal (MW)
L+1		P_{INIT} (pu on MBASE)
L+2		P_{OUT} (pu on SBASE)
L+3		Q_{OUT} (pu on SBASE)
L+4		V_{DC} (pu)
L+5		Memory

ICON	#	Description
M		0 current-source converter 1 voltage-source converter

This incorporates technology developed for the United States Electric Power Industry under the sponsorship of the Electric Power Research Institute (EPRI).

IBUS, ’CSMEST’, ID, ICON(M), CON(J) to CON(J+19) /

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Voltage-Source Converter:

$$I_{QMAX} = \sqrt{I_{ACMAX}^2 - \left(\frac{P_{DC}}{V_{AC}}\right)^2}$$

Current-Source Converter I_{QMAX} is lowest of:

$$\sqrt{I_{ACMAX}^2 - \left(\frac{P_{DC}}{V_{AC}}\right)^2} \quad \text{or} \quad \sqrt{(K \times I_{DC})^2 - \left(\frac{P_{DC}}{V_{AC}}\right)^2}$$

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1.9 CSTATT

Static Condenser (STATCON)

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L.
The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			T_1 (>0)
J+1			T_2 (>0)
J+2			T_3 (>0)
J+3			T_4 (>0)
J+4			K (Typical = 25/(dV/dEi)
J+5			DROOP (typical = 0.03)
J+6			V_{MAX} (typical = 999)
J+7			V_{MIN} (typical = -999)
J+8			I_{CMAX} (typical = 1.25)
J+9			I_{LMAX} (typical = 1.25)
J+10			V_{CUTOUT} (typical = 0.2)
J+11			E_{limit} (typical = 1.2)
J+12			X_T (typical = 0.1)
J+13			A_{CC} (typical = 0.5)

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Thyristor

VARs	#	Description
L		Ei, Internal voltage (pu)
L+1		ISTATC, STATCON current
L+2		Internal memory

IBUS, ’CSTATT’, ID, CON(J) to CON(J+13) /

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Limit Max = $V_T + X_T\, I_{CMAX0}$

Limit Min = $V_T - X_T\, I_{LMAX0}$

Limit Max $\leq E_{limit}$

where:

$I_{CMAX0} = I_{CMAX}$ when $V_T \geq V_{CUTOUT}$

$$I_{CMAX0} = \frac{I_{CMAX} \times V_T}{V_{CUTOUT}} \quad \text{otherwise}$$

$I_{LMAX0} = I_{LMAX}$ when $V_T \geq V_{CUTOUT}$

$$I_{LMAX0} = \frac{I_{LMAX} \times V_T}{V_{CUTOUT}} \quad \text{otherwise}$$

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

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1.10 CSVGN1

Static Shunt Compensator

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L,
and ICON #_____ M.
The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			K
J+1			T_1
J+2			T_2
J+3			T_3 (>0)
J+4			T_4
J+5			T_5
J+6			R_{MIN} (reactor minimum Mvar)
J+7			V_{MAX}
J+8			V_{MIN}
J+9			C_{BASE} (capacitor Mvar)

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Thyristor

VAR	#	Description
L		Y (model output)

ICON	#	Description
M		Memory

IBUS, 'CSVGN1', ID, CON(J) to CON(J+9) /

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RBASE = MBASE

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

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1.11 CSVGN3

Static Shunt Compensator

This device is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICON	#_____	M.

The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			K
J+1			T_1
J+2			T_2
J+3			T_3 (>0)
J+4			T_4
J+5			T_5
J+6			R_{MIN} (reactor minimum Mvar)
J+7			V_{MAX}
J+8			V_{MIN}
J+9			C_{BASE} (capacitor Mvar)
J+10			V_{OV} (override voltage)

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Thyristor

VAR	#	Description
L		Y (model output)

ICON	#	Description
M		Memory

IBUS, ’CSVGN3’, ID, CON(J) to CON(J+10) /

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

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1.12 CSVGN4

Static Shunt Compensator

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L,
and ICONs starting with #_____ M.
The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			K
J+1			T_1
J+2			T_2
J+3			T_3 (>0)
J+4			T_4
J+5			T_5
J+6			R_{MIN} (reactor minimum Mvar)
J+7			V_{MAX}
J+8			V_{MIN}
J+9			C_{BASE} (capacitor Mvar)
J+10			V_{OV} (override voltage)

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Thyristor

VAR	#	Description
L		Y (model output)

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ICONs	#	Value	Description
M			IB, remote bus to regulate or zero to regulate terminal voltage
M+1		X	Memory

BUS, 'CSVGN4', ID, ICON(M), CON(J) to CON(J+10) /

RBASE = MBASE

1.13 CSVGN5

Static var Compensator

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L,
and ICONs starting with #_____ M.
The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			T_{S1}
J+1			V_{EMAX}
J+2			T_{S2}
J+3			T_{S3} (>0)
J+4			T_{S4}
J+5			T_{S5}
J+6			K_{SVS}
J+7			K_{SD}
J+8			B_{MAX}
J+9			B'_{MAX}
J+10			B'_{MIN}
J+11			B_{MIN}
J+12			T_{S6} (>0)
J+13			DV

STATEs	#	Description
K		Filter output
K+1		First regulator state
K+2		Second regulator state
K+3		Thyristor delay

VAR	#	Description
L		Y (model output)

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ICONs	#	Value	Description
M			IB, remote bus number
M+1		X	Memory

IBUS, 'CSVGN5', ID, ICON(M), CON(J) to CON(J+13) /

If DV = 0,
$DV_{LO} = B'_{MAX}/K_{SVS}$
$DV_{HI} = B'_{MIN}/K_{SVS}$

If DV > 0,
$DV_{LO} = DV$
$DV_{HI} = -DV$

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1.14 CSVGN6

Static var Compensator

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.
The reactor Mvar base = _____ MBASE.

CONs	#	Value	Description
J			T_{S1}
J+1			V_{EMAX}
J+2			T_{S2}
J+3			T_{S3} (>0)
J+4			T_{S4}
J+5			T_{S5}
J+6			K_{SVS}
J+7			K_{SD}
J+8			B_{MAX}
J+9			B'_{MAX}
J+10			B'_{MIN}
J+11			B_{MIN}
J+12			T_{S6} (>0)
J+13			DV
J+14			V_{EMIN}
J+15			V_{MAX}
J+16			V_{MIN}
J+17			BIAS
J+18			DV2
J+19			BSHUNT
J+20			TDELAY

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STATEs	#	Description
K		Filter output
K+1		First regulator state
K+2		Second regulator state
K+3		Thyristor delay

VARs	#	Description
L		Y (model output)
L+1		BSHUNT switch timer

ICONs	#	Value	Description
M			IB, remote bus number
M+1		X	Memory

IBUS, 'CSVGN6', ID, ICON(M), CON(J) to CON(J+20) /

If DV = 0,
$DV_{LO} = B'_{MAX}/K_{SVS}$
$DV_{HI} = B'_{MIN}/K_{SVS}$

If DV > 0,
$DV_{LO} = DV$
$DV_{HI} = -DV$

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1.15 FRECHG

Frequency Changer Model

From bus unit is located at bus #____ IBUS,
Machine identifier #____ IM,
To bus unit is located at bus #____ JBUS,
Machine #____ JM.
This model uses CONs starting with #____ J,
and STATEs starting with #____ K.
For the from bus unit, the machine MVA base is _____ for each of _____ units = _____ MBASE.

ZSOURCE for this machine is _____ + j ____on the above MBASE.

For the to bus unit, the machine MVA base is _____ for each of _____ units = _____ MBASE.

ZSOURCE for this machine is _____ + j ____on the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T''_{qo} (>0) (sec)
J+3			H1, Inertia
J+4			D, Speed damping
J+5			X_d
J+6			X_q
J+7			X'_d
J+8			$X''_d = X''_q$
J+9			X_l
J+10			S(1.0)
J+11			S(1.2)
J+12			T'_{do} (>0) (sec)
J+13			T''_{do} (>0) (sec)
J+14			T''_{qo} (>0) (sec)
J+15			H2, Inertia
J+16			D, Speed damping

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CONs	#	Value	Description
J+17			X_d
J+18			X_q
J+19			X'_d
J+20			$X''_d = X''_q$
J+21			X_l
J+22			S(1.0)
J+23			S(1.2)
J+24			FB_2, base frequency of to bus (Hz)

STATEs	#	Description
K		E'_q
K+1		ψkd
K+2		ψ''_q
K+3		Δ speed (pu)
K+4		Angle (radians)
K+5		E'_q
K+6		ψkd
K+7		ψ''_q
K+8		Δ speed (pu)
K+9		Angle (radians)

Notes:

From bus unit assumed to be on the same system base frequency as that in the working case.

To bus unit base frequency must be specified via CON(J+24).

CON(J) through CON(J+11), STATE(K) through STATE(K+4) are quantities for the from bus unit.

CON(J+12) through CON(J+24), STATE(K+5) through STATE(K+9) are quantities for the to bus unit.

X_d, X_q, X'_d, X'', X''_q, X_l, H, and D are in pu on the corresponding Machine MVA base. X''_q must be equal to X''_d.

H1*MBASE1 = H2*MBASE2

IBUS, 'FRECHG', IM, JBUS, JM, CON(J) to CON(J+24) /

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1.16 GENCLS

Constant Internal Voltage Generator Model

This model is located at system bus #____ IBUS,
Machine identifier #____ ID,
This model uses CONs starting with #____ J,
and STATEs starting with #____ K.
The machine MVA base is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			H, Inertia[1]
J+1			D, Damping constant

[1] H and D are in pu machine MVA base.
If H is 0, then DSTATE(K) and DSTATE(K+1) will always be zero.

STATEs	#	Description
K		Δ speed (pu)
K+1		Angle (radians)

IBUS, 'GENCLS', ID, CON(J) and CON(J+1) /

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1.17 GENDCO

Round Rotor Generator Model Including dc Offset Torque Component

This model is located at system bus #_____ IBUS,

Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K,

and VARs starting with #_____ L.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T'_{qo} (>0) (sec)
J+3			T''_{qo} (>0) (sec)
J+4			H, Inertia
J+5			D, Speed damping
J+6			X_d
J+7			X_q
J+8			X'_d
J+9			X'_q
J+10			$X''_d = X''_q$
J+11			X_l
J+12			S(1.0)
J+13			S(1.2)
J+14			T_a

Note: X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

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STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		ψkd
K+3		ψkq
K+4		Δ speed (pu)
K+5		Angle (radians)

VARs	#	Description
L		T_{elec}
L+1		dc offset current
L+2		Phase at switch
L+3		Time of switch
L+4		i_d, Value at kPAUSE = 1
L+5		i_q, Value at kPAUSE = 1
L+6		i_d
L+7		i_q

IBUS, ’GENDCO’, ID, CON(J) to CON(J+14) /

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1.18 GENROE

Round Rotor Generator Model (Exponential Saturation)

This model is located at system bus #_____ IBUS,

Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T'_{qo} (>0) (sec)
J+3			T''_{qo} (>0) (sec)
J+4			H, Inertia
J+5			D, Speed damping
J+6			X_d
J+7			X_q
J+8			X'_d
J+9			X'_q
J+10			$X''_d = X''_q$
J+11			X_l
J+12			S(1.0)
J+13			S(1.2)

Note: X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

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STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		ψkd
K+3		ψkq
K+4		Δ speed (pu)
K+5		Angle (radians)

IBUS, ’GENROE’, ID, CON(J) to CON(J+13) /

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1.19 GENROU

Round Rotor Generator Model (Quadratic Saturation)

This model is located at system bus #_____ IBUS,

Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T'_{qo} (>0) (sec)
J+3			T''_{qo} (>0) (sec)
J+4			H, Inertia
J+5			D, Speed damping
J+6			X_d
J+7			X_q
J+8			X'_d
J+9			X'_q
J+10			$X''_d = X''_q$
J+11			X_l
J+12			S(1.0)
J+13			S(1.2)

Note: X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

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STATEs	#	Description
K		E'_q
K+1		E'_d
K+2		ψkd
K+3		ψkq
K+4		Δ speed (pu)
K+5		Angle (radians)

IBUS, ’GENROU’, ID, CON(J) to CON(J+13) /

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1.20 GENSAE

Salient Pole Generator Model (Exponential Saturation on Both Axes)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T''_{qo} (>0) (sec)
J+3			H, Inertia
J+4			D, Speed damping
J+5			X_d
J+6			X_q
J+7			X'_d
J+8			$X''_d = X''_q$
J+9			X_l
J+10			S(1.0)
J+11			S(1.2)

Note: X_d, X_q, X'_d, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

STATEs	#	Description
K		E'_q
K+1		ψ''_q
K+2		ψkd
K+3		Δ speed (pu)
K+4		Angle (radians)

IBUS, 'GENSAE', ID, CON(J) to CON(J+11) /

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1.21 GENSAL

Salient Pole Generator Model (Quadratic Saturation on d-Axis)

This model is located at system bus #_____ IBUS,

Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K.

The machine MVA is _____ for each of units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			T''_{do} (>0) (sec)
J+2			T''_{qo} (>0) (sec)
J+3			H, Inertia
J+4			D, Speed damping
J+5			X_d
J+6			X_q
J+7			X'_d
J+8			$X''_d = X''_q$
J+9			X_l
J+10			S(1.0)
J+11			S(1.2)

Note: X_d, X_q, X'_d, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

STATEs	#	Description
K		E'_q
K+1		ψkd
K+2		$\psi''q$
K+3		Δ speed (pu)
K+4		Angle (radians)

IBUS, 'GENSAL', ID, CON(J) to CON(J+11) /

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1.22 GENTPJU1

This model is located at system bus	#_____	IBUS,
Machine	#_____	ID
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.
and VAR	#_____	L.

CONs	#	Value	Description
J			T'_{do} (sec) , d-axis transient rotor time constant
J+1			T''_{d0} (sec) , d-axis sub-transient rotor time constant
J+2			T'_{q0} (sec) , q-axis transient rotor time constant
J+3			T''_{q0} (sec) , q-axis sub-transient rotor time constant
J+4			Inertia, H (>0) , Inertia constant
J+5			D (pu), Damping factor
J+6			X_d, d-axis synchronous reactance
J+7			X_q, q-axis synchronous reactance
J+8			X'_d, d-axis transient reactance
J+9			X'_q, q-axis transient reactance
J+10			X''_d, d-axis sub-transient reactance
J+11			X''_q, q-axis sub-transient reactance (set $X''_q = X''_d$)
J+12			X_l, stator leakage reactance
J+13			S(1.0), saturation factor at 1 pu flux
J+14			S(1.2) , saturation factor at 1.2 pu flux
J+15			K_{is} ($0 \leq K_{is} < 1$), current multiplier for saturation calculation

STATEs	#	Description
K		E''_q
K+1		E''_d
K+2		E'_q
K+3		E'_d
K+4		$\Delta\omega$ (Speed deviation)
K+5		Angle (radians)

VAR	#	Description
L		Internal VAR used for calculation (not to be changed by the user)

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IBUS, 'USRMDL', ID, 'GENTPJU1', 1, 1, 0, 16, 6, 1, CON(J) through CON(J+15) /

Notes:

1. Although the model is in a user-model format, use of this model will not require compilation or linking
2. GENTPJU1 is a generator model in which saturation is considered through inductances. The stator current affects saturation via parameter K_{is}.
3. The model requires that X''_d and X''_q (CON(J+10) and CON(J+11)) have the same value.
4. In power flow, the imaginary part of ZSORCE should be set equal to X''_d.
5. To represent a solid rotor machine, all rotor time constants and the reactances X'_d, X''_d, X'_q and X''_q should all be greater than zero
6. To represent a salient pole machine with a single amortisseur circuit on each axis, set $T'_{qo}=0$, $X'_q=X_q$
7. Reactance values to be entered must be the unsaturated values. Saturation is accounted for via a quadratic relation using the saturation factors S(1.0) and S(1.2) specified in the model DYR data record. The saturation level is calculated as a function of the air-gap flux plus K_{is} times the magnitude of terminal current.

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1.23 GENTRA

Transient Level Generator Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L.
The machine MVA is _____ for each of
_____ units = _____ MBASE.
ZSORCE for this machine is _____ + j _____ on
the above MBASE.

CONs	#	Value	Description
J			T'_{do} (>0) (sec)
J+1			H, Inertia
J+2			D, Speed damping
J+3			X_d
J+4			X_q
J+5			X'_d
J+6			S(1.0)
J+7			S(1.2)
J+8			AF, Acceleration factor

Note: X_d, X_q, X'_d, H, and D are in pu, machine MVA base.

STATEs	#	Description
K		E'_q
K+1		Δ speed (pu)
K+2		Angle (radians)

VAR	#	Description
L		E'_d

IBUS, 'GENTRA', ID, CON(J) to CON(J+8) /

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Chapter 2

Compensator Model Data Sheets

This chapter contains a collection of data sheets for the compensator models contained in the PSS®E dynamics model library.

Model	Description
COMP	Voltage regulator compensating model
COMPCC	Cross compound compensating model
IEEEVC	1981 IEEE voltage compensating model
REMCMP	Remote bus voltage signal model

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2.1 COMP

Voltage Regulator Current Compensating Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CON	#_____	J.

CONs	#	Value	Description
J			X_e (machine base)

This model allows the voltage regulator of machine I to sense the voltage at a point separated from the machine terminals by an impedance of X_e.

IBUS, 'COMP', ID, CON(J) /

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2.2 COMPCC

Voltage Regulator Current Compensating Model for Cross-Compound Units

This model is located at system bus	#_____	IBUS,
Machine #1 identifier	#_____	ID,
and Machine #2 identifier	#_____	M.
The model uses CONs starting with	#_____	J.

CONs	#	Value	Description
J			R_1 (system base)
J+1			X_1 (system base)
J+2			R_2 (system base)
J+3			X_2 (system base)

This model allows the voltage regulators of machines I and M to sense the voltage separated from the machine terminals.

IBUS, 'COMPCC', ID, M, CON(J) to CON(J+3) /

$$E_{COMP1} = V_T - \left(\frac{I_{T1} + I_{T2}}{2}\right)(R_1 + jX_1) + I_{T1}(R_2 + jX_2)$$

$$E_{COMP2} = V_T - \left(\frac{I_{T1} + I_{T2}}{2}\right)(R_1 + jX_1) + I_{T2}(R_2 + jX_2)$$

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2.3 IEEEVC

Voltage Regulator Current Compensating Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J.

CONs	#	Value	Description
J			R_C (machine base)
J+1			X_C (machine base)

This model allows the voltage regulator of mMachine I to sense the voltage at a point separated from the machine terminals by an impedance of $R_C + jX_C$.

IBUS, 'IEEEVC', ID, CON(J) and CON(J+1) /

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2.4 REMCMP

Voltage Regulator Current Compensating Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses ICON	#_____	M.

ICON	#	Value	Description
M			Remote bus number, JBUS

This model allows the voltage regulator of machine ID to sense the voltage at a remote bus.

IBUS, ’REMCMP’, ID, ICON(M) /

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Chapter 3

Stabilizer Model Data Sheets

This chapter contains a collection of data sheets for the stabilizer models contained in the PSS®E dynamics model library.

Model	Description
BEPSST	Transient excitation boosting stabilizer model
IEE2ST	Dual-input signal power system stabilizer model
IEEEST	1981 IEEE power system stabilizer model
IVOST	IVO stabilizer model
OSTB2T	Ontario Hydro delta-omega power system stabilizer
OSTB5T	Ontario Hydro delta-omega power system stabilizer
PSS1A	IEEE Std. 421.5-2005 PSS1A Single-Input Stabilizer model
PSS2A	1992 IEEE type PSS2A dual-input signal stabilizer model
PSS2B	IEEE 421.5 2005 PSS2B IEEE dual-input stabilizer model
PSS3B	IEEE Std. 421.5 2005 PSS3B IEEE dual-input stabilizer model
PSS4B	IEEE 421.5(2005) dual-input stabilizer model
PTIST1	PTI microprocessor-based stabilizer model
PTIST3	PTI microprocessor-based stabilizer model
ST2CUT	Dual-input signal power system stabilizer model
STAB1	Speed sensitive stabilizer model
STAB2A	ASEA power sensitive stabilizer model
STAB3	Power sensitive stabilizer model
STAB4	Power sensitive stabilizer model
STABNI	Power sensitive stabilizer model type NI (NVE)
STBSVC	WECC supplementary signal for static var system

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3.1 BEPSST

Transient Excitation Boosting PSS

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			K_1
J+1			K_2
J+2			T_1 (sec)
J+3			T_2 (sec)
J+4			T_3 (sec)[1]
J+5			T_4 (>0) (sec)
J+6			T_5 (sec)
J+7			T_6 (sec)
J+8			T_7 (sec)
J+9			T_8 (sec)
J+10			T_9 (sec)
J+11			T_{10} (sec)
J+12			L_{SMAX}
J+13			L_{SMIN}
J+14			V_{CU} (pu) (if equal zero, ignored)
J+15			V_{CL} (pu) (if equal zero, ignored)
J+16			K
J+17			T_{11} (sec)
J+18			T_{12} (sec)
J+19			C_{RT}
J+20			C_{LIM}

[1] If T_3 equals 0, sT_3 will equal 1.0.

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STATEs	#	Description
K		PSS state 1
K+1		PSS state 2
K+2		PSS state 3
K+3		PSS state 4
K+4		PSS state 5
K+5		PSS state 6
K+6		TEB state 1
K+7		TEB state 2

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage (first bus)
L+2		Memory
L+3		Derivative of pu bus voltage (second bus)
L+4		Initial bus voltage (pu)
L+5		RETREAT
L+6		V_{MAX}

ICONs	#	Value	Description
M			IC1, first stabilizer input code: 1 Rotor speed deviation (pu) 2 Bus frequency deviation (pu) 3 Generator electrical power (pu) 4 Generator accelerating power (pu) 5 Bus voltage (pu) 6 Derivative of pu bus voltage
M+1			IB1, first remote bus number
M+2			IC2, second stabilizer input code
M+3			IB2, second remote bus number
M+4			ITS, trip signal; > 0 ≥ trip

$$\text{RETREAT} = C_{RT} \times \frac{T_{12}}{T_{12} - T_{11}}$$

$V_{Limit} = C_{LIM} * ETERM_{Initial}$

IBUS, 'BEPSST', ID, ICON(M) to ICON(M+4), CON(J) to CON(J+20) /

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V_T is the terminal voltage at bus IBUS.
V_{TO} is the initial terminal voltage at bus IBUS.

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3.2 IEE2ST

IEEE Stabilizing Model With Dual-Input Signals

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONS starting with	#_____	M.

CONs	#	Value	Description
J			K_1
J+1			K_2
J+2			T_1 (sec)
J+3			T_2 (sec)
J+4			T_3 (sec)[1]
J+5			T_4 (>0) (sec)
J+6			T_5 (sec)
J+7			T_6 (sec)
J+8			T_7 (sec)
J+9			T_8 (sec)
J+10			T_9 (sec)
J+11			T_{10} (sec)
J+12			L_{SMAX}
J+13			L_{SMIN}
J+14			V_{CU} (pu) (if equal zero, ignored.)
J+15			V_{CL} (pu) (if equal zero, ignored.)

[1] If T_3 equals 0, sT_3 will equal 1.0.

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STATEs	#	Description
K		First signal transducer
K+1		Second signal transducer
K+2		Washout
K+3		First lead-lag
K+4		Second lead-lag
K+5		Third lead-lag

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage, first bus
L+2		Memory
L+3		Derivative of pu bus voltage, second bus

ICONs	#	Value	Description
M			ICS1, first stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage (pu) 6 derivative of pu bus voltage
M+1			IB1, first remote bus number
M+2			ICS2, second stabilizer input code
M+3			IB2, second remote bus number

IBUS, 'IEE2ST', ID, ICON(M) to ICON(M+3), CON(J) to CON(J+15) /

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3.3 IEEEST

IEEE Stabilizing Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			A_1
J+1			A_2
J+2			A_3
J+3			A_4
J+4			A_5
J+5			A_6
J+6			T_1 (sec)
J+7			T_2 (sec)
J+8			T_3 (sec)
J+9			T_4 (sec)
J+10			T_5 (sec)[1]
J+11			T_6 (>0) (sec)
J+12			K_S
J+13			L_{SMAX}
J+14			L_{SMIN}
J+15			V_{CU} (pu) (if equal zero, ignored)
J+16			V_{CL} (pu) (if equal zero, ignored.)

[1] If T_5 equals 0, sT_5 will equal 1.0.

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STATEs	#	Description
K		1st filter integration
K+1		2nd filter integration
K+2		3rd filter integration
K+3		4th filter integration
K+4		T_1/T_2 lead-lag integrator
K+5		T_3/T_4 lead-lag integrator
K+6		Last integer

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage

ICONs	#	Value	Description
M			Stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage (pu) 6 derivative of pu bus voltage
M+1			IB, remote bus number 2, 5, 6 [1, 2]

[1] ICON(M+1) may be nonzero only when ICON(M) is 2, 5, or 6.
[2] If ICON(M+1) is zero, the terminal quantity is used.

IBUS, 'IEEEST', ID, ICON(M) and ICON(M+1), CON(J) to CON(J+16) /

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3.4 IVOST

IVO Stabilizer Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			K_1
J+1			A_1
J+2			A_2
J+3			T_1
J+4			T_2
J+5			MAX_1
J+6			MIN_1
J+7			K_3
J+8			A_3
J+9			A_4
J+10			T_3
J+11			T_4
J+12			MAX_3
J+13			MIN_3
J+14			K_5
J+15			A_5
J+16			A_6
J+17			T_5
J+18			T_6
J+19			MAX_5
J+20			MIN_5

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STATEs	#	Description
K		Integrator 1
K+1		Integrator 2
K+2		Integrator 3

IBUS, 'IVOST', ID, CON(J) to CON(J+20) /

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3.5 OSTB2T

Ontario Hydro Delta-Omega Power System Stabilizer

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K
J+1			T_S (>0) (sec)
J+2			T_1/T_3
J+3			T_3 (>0) (sec)
J+4			T_2/T_4
J+5			T_4 (>0) (sec)
J+6			H_{LIM}
J+7			L_{LIM}
J+8			K_{ANG} (>0)
J+9			T_{ANG}
J+10			V_{NGMX}
J+11			V_{MGMX}
J+12			T-ON
J+13			T-OFF
J+14			V_{SMX}
J+15			V_{SMN}
J+16			$\Delta\omega_{THR}$
J+17			E_{THR}
J+18			EFD_{THR}
J+19			T_{SEAL}

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STATEs	#	Description
K		Washout T_S block
K+1		Lead-lag T_1/T_3 block
K+2		Lead-lag T_2/T_4 block
K+3		T_{ANG} block

VARs	#	Description
L		S_1
L+1		T_{SEC} duration
L+2		T_{SEAL} duration

IBUS, 'OSTB2T', ID, CON(J) to CON(J+19) /

TSEC Switching Logic

Notes:

1. S_1 normally open.
2. S_1 closes if $E_t < E_{THR}$ and $\Delta\omega > \Delta\omega_{THR}$ or $\Delta\omega > \Delta\omega_{THR}$ within T_{SEAL} seconds of last time $E_t < E_{THR}$.
3. Once closed, S_1 remains closed for at least T-ON seconds.
4. S_1 opens if:
   a. $\Delta\omega < \Delta\omega_{THR}$, or
   b. $EFD < EFD_{THR}$, or
   c. after being closed for T-OFF seconds.
5. Once open, stays open.

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3.6 OSTB5T

Ontario Hydro Delta-Omega Power System Stabilizer

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K
J+1			T_S (>0) (sec)
J+2			T_1 (sec)
J+3			T_2(sec)
J+4			T_3/T_4
J+5			T_4 (>0) (sec)
J+6			H_{LIM}
J+7			L_{LIM}
J+8			K_{ANG} (>0)
J+9			T_{ANG}
J+10			V_{NGMX}
J+11			V_{MGMX}
J+12			T-ON
J+13			T-OFF
J+14			V_{SMX}
J+15			V_{SMN}
J+16			$\Delta\omega_{THR}$
J+17			E_{THR}
J+18			EFD_{THR}
J+19			T_{SEAL}

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STATEs	#	Description
K		Washout T_S block
K+1		Quadratic lead-lag block
K+2		Quadratic lead-lag block
K+3		T_{ANG} block

VARs	#	Description
L		S_1
L+1		T_{SEC} duration
L+2		T_{SEAL} duration

IBUS, 'OSTB5T', ID, CON(J) to CON(J+19) /

TSEC Switching Logic

Notes:

1. S_1 normally open.
2. S_1 closes if $E_t < E_{THR}$ and $\Delta\omega > \Delta\omega_{THR}$ or $\Delta\omega > \Delta\omega_{THR}$ within T_{SEAL} seconds of last time $E_t < E_{THR}$.
3. Once closed, S_1 remains closed for at least T-ON seconds.
4. S_1 opens if:
   a. $\Delta\omega < \Delta\omega_{THR}$, or
   b. $EFD < EFD_{THR}$, or
   c. after being closed for T-OFF seconds.
5. Once open, stays open.

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3.7 PSS1A

IEEE Std. 421.5-2005 PSS1A Single-Input Stabilizer Model

The PSS®E model IEEEST can be used to simulate the PSS1A model. The correspondence between the IEEEST model CONs and the PSS1A parameters (shown in the block) diagram are as given in the table below.

CONs	IEEEST CON	PSS1A parameter (as shown in the PSS1A block diagram)
J	A_1	A_1
J+1	A_2	A_2
J+2	A_3	T_R
J+3	A_4	0.0
J+4	A_5	0.0
J+5	A_6	0.0
J+6	T_1	T_1
J+7	T_2	T_2
J+8	T_3	T_3
J+9	T_4	T_4
J+10	T_5	T_w
J+11	T_6	T_w
J+12	K_S	K_S
J+13	L_{SMAX}	V_{STMAX}
J+14	L_{SMIN}	V_{STMIN}
J+15	V_{CU}	0.0
J+16	V_{CL}	0.0

IBUS, 'IEEEST', ID, ICON(M), ICON(M+1), CON(J) to CON(J+16) /

3.8 PSS2A

IEEE Dual-Input Stabilizer Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			T_{w1} (>0)
J+1			T_{w2}
J+2			T_6
J+3			T_{w3} (>0)
J+4			T_{w4}
J+5			T_7
J+6			K_{S2}
J+7			K_{S3}
J+8			T_8
J+9			T_9 (>0)
J+10			K_{S1}
J+11			T_1
J+12			T_2
J+13			T_3
J+14			T_4
J+15			V_{STMAX}
J+16			V_{STMIN}

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STATEs	#	Description
K		Washout, first signal
K+1		Washout, first signal
K+2		Transducer, first signal
K+3		Washout, second signal
K+4		Washout, second signal
K+5		Transducer, second signal
K+6 . . . K+13		Ramp Tracking Filter
K+14		First lead-lag
K+15		Second lead-lag

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage, first bus
L+2		Memory
L+3		Derivative of pu bus voltage, second bus

ICONs	#	Value	Description
M			ICS1, first stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage (pu) 6 derivative of pu bus voltage
M+1			REMBUS1, first remote bus number
M+2			ICS2, second stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage (pu) 6 derivative of pu bus voltage

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ICONs	#	Value	Description
M+3			REMBUS2, second remote bus number
M+4			M, ramp tracking filter
M+5			N, ramp tracking filter

Model Notes:

Ramp Tracking Filter

$M \geq 0$
$N \geq 0$
$M * N \leq 8$
If M = 0, then N is set equal to 0

To bypass: set M = N = 0

Washouts

To bypass second washout, first signal: set $T_{w2} = 0$
To bypass second washout, second signal: set $T_{w4} = 0$

Transducers

To bypass first signal transducer: set $T_6 = 0$
To bypass second signal transducer: set $T_7 = 0$

Lead-Lags

To bypass first lead-lag: set $T_1 = T_2 = 0$
To bypass second lead-lag: set $T_3 = T_4 = 0$

IBUS, 'PSS2A', ID, ICON(M) to ICON(M+5), CON(J) to CON(J+16) /

3.9 PSS2B

IEEE 421.5 2005 PSS2B IEEE Dual-Input Stabilizer Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID.
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{w1} (> 0)
J+1			T_{w2}
J+2			T_6
J+3			T_{w3}
J+4			T_{w4}
J+5			T_7
J+6			K_{S2}
J+7			K_{S3}
J+8			T_8
J+9			T_9 (> 0)
J+10			K_{S1}
J+11			T_1
J+12			T_2
J+13			T_3
J+14			T_4
J+15			T_{10}
J+16			T_{11}
J+17			V_{S1MAX}
J+18			V_{S1MIN}
J+19			V_{S2MAX}
J+20			V_{S2MIN}
J+21			V_{STMAX}
J+22			V_{STMIN}

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STATEs	#	Description
K		Washout-first signal
K+1		Washout-first signal
K+2		Transducer-first signal
K+3		Washout-second signal
K+4		Washout-second signal
K+5		Transducer-second signal
K+6 . . . K+13		Ramp tracking filter
K+14		First lead-lag
K+15		Second lead-lag
K+16		Third lead-lag

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage-first bus
L+2		Memory
L+3		Derivative of pu bus voltage-second bus

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ICON	#	Value	Description
M			ICS1, first stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage 6 derivative of pu bus voltage
M+1			REMBUS1, first remote bus to be entered as 0 for input codes 1, 3, and 4.
M+2			ICS2, second stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage 6 derivative of pu bus voltage
M+3			REMBUS2, second remote bus to be entered as 0 for input codes 1, 3, and 4.
M+4			M, ramp tracking filter
M+5			N, ramp tracking filter

IBUS, ’PSS2B’, ID, ICON(M) to ICON(M+5), CON(J) to CON(J+22) /

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V_{S1MAX}
V_{S1}
V_{S1MIN}
$\frac{sT_{w1}}{1+sT_{w1}}$
$\frac{sT_{w2}}{1+sT_{w2}}$
$\frac{1}{1+sT_6}$
V_{S2MAX}
V_{S2}
V_{S2MIN}
$\frac{sT_{w3}}{1+sT_{w3}}$
$\frac{sT_{w4}}{1+sT_{w4}}$
$\frac{K_{S2}}{1+sT_7}$
K_{S3}
$\left[\frac{1+sT_8}{(1+sT_9)^M}\right]^N$
K_{S1}
$\frac{1+sT_1}{1+sT_2}$
$\frac{1+sT_3}{1+sT_4}$
$\frac{1+sT_{10}}{1+sT_{11}}$
V_{STMAX}
V_{STMIN}
VOTHSG

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3.10 PSS3B

IEEE Std. 421.5 2005 PSS3B IEEE Dual-Input Stabilizer Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			K_{S1} (pu) (≠0), input channel #1 gain
J+1			T_1 input channel #1 transducer time constant (sec)
J+2			T_{w1} input channel #1 washout time constant (sec)
J+3			K_{S2} (pu) (≠0), input channel #2 gain
J+4			T_2 input channel #2 transducer time constant (sec)
J+5			T_{w2} input channel #2 washout time constant (sec)
J+6			T_{w3} (0), main washout time constant (sec)
J+7			A_1
J+8			A_2
J+9			A_3
J+10			A_4
J+11			A_5
J+12			A_6
J+13			A_7
J+14			A_8
J+15			V_{STMAX} (pu), stabilizer output maximum limit
J+16			V_{STMIN} (pu), stabilizer output minimum limit

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STATEs	#	Description
K		Time lead block (first signal)
K+1		Time lead block (second signal)
K+2		First signal washout
K+3		Second signal washout
K+4		Washout block
K+5		First two-order block
K+6		
K+7		Second two-order block
K+8		

ICON	#	Value	Description
M			ICS1, code for first channel stabilizer input variable: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power (pu of MBASE) 4 generator accelerating power (pu) 5 bus voltage (pu)
M+1			Remote bus number associated with input variable for channel 1
M+2			ICS2, code for second channel stabilizer input variable: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power (pu of MBASE) 4 generator accelerating power (pu) 5 bus voltage (pu)
M+3			Remote bus number associated with input variable for channel 2

IBUS, ’PSS3B’, ID, ICON(M) to ICON(M+3), CON(J) to CON(J+16) /

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3.11 PSS4B

IEEE 421.5(2005) Dual-Input Stabilizer Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			C_{L-I}
J+1			D_{L-I}
J+2			A_{L-I} (>0)
J+3			B_{L-I}
J+4			$B\omega_{L-I1}$
J+5			ω_{L-I1}
J+6			$B\omega_{L-I2}$
J+7			ω_{L-I2}
J+8			T_H (>0)
J+9			A_H (>0)
J+10			B_H
J+11			M
J+12			$B\omega_{H1}$
J+13			ω_{H1}
J+14			$B\omega_{H2}$
J+15			ω_{H2}
J+16			K_{L1}
J+17			K_{L11}
J+18			T_{L1}
J+19			T_{L2}
J+20			T_{L3}
J+21			T_{L4}
J+22			T_{L5}
J+23			T_{L6}

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CONs	#	Value	Description
J+24			K_{L2}
J+25			K_{L17}
J+26			T_{L7}
J+27			T_{L8}
J+28			T_{L9}
J+29			T_{L10}
J+30			T_{L11}
J+31			T_{L12}
J+32			K_L
J+33			V_{Lmax}
J+34			V_{Lmin}
J+35			KI1
J+36			KI11
J+37			T_{I1}
J+38			T_{I2}
J+39			T_{I3}
J+40			T_{I4}
J+41			T_{I5}
J+42			T_{I6}
J+43			K_{I2}
J+44			K_{I17}
J+45			T_{I7}
J+46			T_{I8}
J+47			T_{I9}
J+48			T_{I10}
J+49			T_{I11}
J+50			T_{I12}
J+51			K_I
J+52			V_{Imax}
J+53			V_{Imin}
J+54			K_{H1}

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CONs	#	Value	Description
J+55			K_{H11}
J+56			T_{H1}
J+57			T_{H2}
J+58			T_{H3}
J+59			T_{H4}
J+60			T_{H5}
J+61			T_{H6}
J+62			K_{H2}
J+63			K_{H17}
J+64			T_{H7}
J+65			T_{H8}
J+66			T_{H9}
J+67			T_{H10}
J+68			T_{H11}
J+69			T_{H12}
J+70			K_{H}
J+71			V_{Hmax}
J+72			V_{Hmin}
J+73			V_{STmax}
J+74			V_{STmin}

STATEs	#	Description
K K+1		First signal transducer
K+2 K+3		First notch filter (first signal)
K+4 K+5		Second notch filter (first signal)
K+6 K+7 K+8		Second signal transducer
K+9		Time lag block (second signal)

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STATEs	#	Description
K+10 K+11		First Notch filter (second signal)
K+12 K+13		Second notch filter (second signal)
K+14		Lead-lag (low frequency, part 1)
K+15		Lead-lag (low frequency, part 1)
K+16		Lead-lag (low frequency, part 1)
K+17		Lead-lag (low frequency, part 2)
K+18		Lead-lag (low frequency, part 2)
K+19		Lead-lag (low frequency, part 2)
K+20		Lead-lag (medium frequency, part 1)
K+21		Lead-lag (medium frequency, part 1)
K+22		Lead-lag (medium frequency, part 1)
K+23		Lead-lag (medium frequency, part 2)
K+24		Lead-lag (medium frequency, part 2)
K+25		Lead-lag (medium frequency, part 2)
K+26		Lead-lag (high frequency, part 1)
K+27		Lead-lag (high frequency, part 1)
K+28		Lead-lag (high frequency, part 1)
K+29		Lead-lag (high frequency, part 2)
K+30		Lead-lag (high frequency, part 2)
K+31		Lead-lag (high frequency, part 2)

VARs	#	Description
L		$\Delta\omega_{L-I}$
L+1		$\Delta\omega_{H}$
L+2		V_L
L+3		V_I
L+4		V_H

IBUS, ’PSS4B’, ID, CON(J) to CON(J+74) /

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3.12 PTIST1

PTI Microprocessor-Based Stabilizer

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and VARs starting with #_____ L,
and ICONS starting with #_____ M.

CONs	#	Value	Description
J			Δt_F
J+1			Δt_P
J+2			Δt_C
J+3			X_q
J+4			M
J+5			T_P
J+6			T_F
J+7			K
J+8			T_1
J+9			T_2
J+10			T_3
J+11			T_4

VARs	#	Description
L		$\Delta\omega$ from E_Q
L+1		P_e average
L+2		V_{dl}
L+3		V_{ql}
L+4		States for transfer
L+5		
L+6		
L+7		Function
L+8		Tap setting
L+9		P_e last

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ICONs	#	Description
M		Number of time steps to activate frequency calculation
M+1		Number of time steps to activate power calculation
M+2		Number of time steps to activate controls

IBUS, 'PTIST1', ID, CON(J) to CON(J+11) /

M = 2. ∗ H

$T_F = T_P \approx 0.2$ sec

K = 1 to 10, depends on tuning

T_1 = 0.1 to 0.5, depends on tuning

T_2 = 1 to 3 sec

T3 = 0.1 to 0.5, depends on tuning

T4 = 0.05 sec

$\Delta t_F = \Delta tC = 0.025$ sec

$\Delta t_P = 0.0125$ sec

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3.13 PTIST3

PTI Microprocessor-Based Stabilizer

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			Δt_F
J+1			Δt_P
J+2			Δt_C
J+3			X'_q
J+4			M
J+5			$T_P > 0$
J+6			$T_F > 0$
J+7			K
J+8			T_1
J+9			$T_2 > 0$
J+10			T_3
J+11			$T_4 > 0$
J+12			T_5
J+13			T_6 (see Note 1)
J+14			A_0
J+15			A_1
J+16			A_2
J+17			B_0
J+18			B_1
J+19			B_2 (see Note 2)
J+20			A_3
J+21			A_4
J+22			A_5

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CONs	#	Value	Description
J+23			B_3
J+24			B_4
J+25			B_5 (see Note 2)
J+26			A_{THRES} (see Note 3)
J+27			D_L
J+28			A_L
J+29			L_{THRES} (see Note 4)
J+30			P_{MIN} (see Note 6)

VARs	#	Description
L		$\Delta\omega$ from E_Q
L+1		P_e average
L+2		V_{dl}
L+3		V_{ql}
L+4		Frequency filter state or store
L+5		Power filter state or store
L+6		1st lead/lag state or store
L+7		2nd lead/lag state or store
L+8		Tap setting or analog output
L+9		PE_{LAST}
L+10		3rd lead/lag state or store
L+11		Torsional filter store
L+12		Torsional filter store
L+13		Torsional filter store
L+14		Torsional filter store
L+15		Frequency filter output
L+16		Power filter output
L+17		1st lead/lag output
L+18		2nd lead/lag output
L+19		3rd lead/lag output
L+20		1st stage torsional filter output
L+21		2nd stage torsional filter output

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VARs	#	Description
L+22 . . . L+37		Output averaging table
L+38		Output accumulator
L+39		Analog ramp

ICONs	#	Value	Description
M			ISW, Digital/analog output switch (ISW = 0 or 1) (see Note 5)
M+1			NAV, Number of control outputs to average (1 ≤ NAV ≤ 16) (see Note 3
M+2			NCL, Number of counts at limit to active limit function (NCL > 0) (see Note 4)
M+3			NCR, Number of counts until reset after limit function is triggered (see Note 4)
M+4 . . . M+8			ICONs reserved for internal logic

IBUS, 'PTIST3', ID, ICON(M) to ICON(M+3), CON(J) to CON(J+30) /

Model Notes:
M = 2. ∗ H
$T_F = T_P \approx 0.2$ sec
K = 1 to 10 (depends on tuning)
T_1 = 0.1 to 0.5 (depends on tuning)
T_2 = 1 to 3 sec
T_3 = 0.1 to 0.5 (depends on tuning)
T_4 = 0.05 sec
$\Delta t_F = \Delta t_C$ = 0.025 sec for 60 Hz
$\Delta t_F = \Delta t_C$ = 0.03 sec for 50 Hz
Δt_P = 0.0125 sec for 60 Hz
Δt_P = 0.015 sec for 50 Hz

Optional Features:

1. Third Lead/Lag

   To disable: set $T_6 = 0$

   If enabled: $T_6 > 0$

2. Torsional Filter

   To disable: set $B_2 = 0$ (both stages will be disabled)

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If enabled: $B_2 > 0$, $B_5 > 0$ (both stages are active)

3. Averaging Function

   To disable: set ICON(M+1) = 1

   Maximum number of outputs to average = 16

   CON(J+26) is the threshold value above which output averaging will be bypassed

   A recommended value for ICON(M+1) is 4

   A recommended default value for CON(J+26) is 0.005

4. Limit Function

   To disable: set ICON(M+2) = 9999 and
   CON(J+29) = 9999

   If enabled: ICON(M+3) is the number of counts to reset to normal operation after LIMIT function has activated

5. Analog Output

   To enable: set ICON(M) = 1

   For digital output: set ICON(M) = 0

6. Minimum Power

   CON(J+30) sets the minimum power output for stabilizer operation

   In pu on MBASE

   Unit operation below this threshold will force zero stabilizer output

3.14 ST2CUT

Stabilizing Model With Dual-Input Signals

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L.
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			K_1
J+1			K_2
J+2			T_1 (sec)
J+3			T_2 (sec)
J+4			T_3 (sec)[1]
J+5			T_4 (>0) (sec)
J+6			T_5 (sec)
J+7			T_6 (sec)
J+8			T_7 (sec)
J+9			T_8 (sec)
J+10			T_9 (sec)
J+11			T_{10} (sec)
J+12			L_{SMAX}
J+13			L_{SMIN}
J+14			V_{CU} (pu) (if equal zero, ignored)
J+15			V_{CL} (pu) (if equal zero, ignored)

[1] If T_3 equals 0_1, sT_3 will equal 1.0.

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STATEs	#	Description
K		First signal transducer
K+1		Second signal transducer
K+2		Washout
K+3		First lead-lag
K+4		Second lead-lag
K+5		Third lead-lag

VARs	#	Description
L		Memory
L+1		Derivative of pu bus voltage, first bus
L+2		Memory
L+3		Derivative of pu bus voltage, second bus
L+4		Initial bus voltage (pu)

ICONs	#	Value	Description
M			IC1, first stabilizer input code: 1 rotor speed deviation (pu) 2 bus frequency deviation (pu) 3 generator electrical power on MBASE base (pu) 4 generator accelerating power (pu) 5 bus voltage (pu) 6 derivative of pu bus voltage
M+1			IB1, first remote bus number
M+2			IC2, second stabilizer input code
M+3			IB2, second remote bus number

IBUS, ’ST2CUT’, ID, ICON(M) to ICON(M+3), CON(J) to CON(J+15) /

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V_T is the terminal voltage at bus IBUS.
V_{TO} is the initial terminal voltage at bus IBUS.

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3.15 STAB1

Speed Sensitive Stabilizing Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			K/T $(sec)^{-1}$
J+1			T (sec) (>0)
J+2			T_1/T_3
J+3			T_3 (sec) (>0)
J+4			T_2/T_4
J+5			T_4 (sec) (>0)
J+6			H_{LIM}

STATEs	#	Description
K		Washout
K+1		First lead-lag
K+2		Second lead-lag

IBUS, 'STAB1', ID, CON(J) to CON(J+6) /

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3.16 STAB2A

Power Sensitive Stabilizing Unit (ASEA)

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			K_2
J+1			T_2 (sec) (>0)
J+2			K_3
J+3			T_3 (sec) (>0)
J+4			K_4
J+5			K_5
J+6			T_5 (sec) (>0)
J+7			H_{LIM}

STATEs	#	Description
K		Implicit
K+1		Integration
K+2		State
K+3		Variables

IBUS, 'STAB2A', ID, CON(J) to CON(J+7) /

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3.17 STAB3

Power Sensitive Stabilizing Unit

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L.

CONs	#	Value	Description
J			T_t (sec)
J+1			T_{X1} (sec) (>0)
J+2			T_{X2} (sec) (>0)
J+3			K_X
J+4			V_{LIM}

STATEs	#	Description
K		First time constant output
K+1		Second time constant output
K+2		Unlimited signal

VAR	#	Description
L		Power reference signal

IBUS, 'STAB3', ID, CON(J) to CON(J+4) /

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3.18 STAB4

Power Sensitive Stabilizer

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_X (gain)
J+1			T_T, watt transducer time constant (sec)
J+2			T_{X1} (sec) (>0)
J+3			T_{X2}, reset time constant (sec) (>0)
J+4			T_a (sec)
J+5			T_b (sec)
J+6			T_c (sec) (>0)
J+7			T_d (sec)
J+8			T_e (sec)
J+9			L1 (pu) low limit
J+10			L2 (pu) high limit

STATEs	#	Description
K		Transducer output
K+1		Reset state
K+2		1st lead lag
K+3		2nd lead lag
K+4		5th state
K+5		Unlimited signal

VAR	#	Description
L		Initial electrical power

IBUS, 'STAB4', ID, CON(J) to CON(J+10) /

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3.19 STABNI

Power Sensitive Stabilizer Model Type NI (NVE)

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			K (≥0)
J+1			T_1 (>0) (sec)
J+2			T_2 (≥0) (sec)
J+3			T_0 (>0) (sec)
J+4			LIMIT (± pu)

STATEs	#	Description
K		Filter
K+1		Filter
K+2		Filter
K+3		Filter
K+4		Output

IBUS, 'STABNI', ID, CON(J) to CON(J+4) /

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3.20 STBSVC

WECC Supplementary Signal for Static var Compensator

This device is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L,
and ICONs starting with #_____ M.
The reactor MVAR base = _____ MBASE.

CONs	#	Value	Description
J			K_{S1} (>0)
J+1			T_{S7} (sec)
J+2			T_{S8} (sec)
J+3			T_{S9} (>0) (sec)
J+4			T_{S13} (>0) (sec)
J+5			T_{S14} (>0) (sec)
J+6			K_{S3} (>0)
J+7			V_{SCS}
J+8			K_{S2}
J+9			T_{S10} (sec)
J+10			T_{S11} (sec)
J+11			T_{S12} (>0, if $K_{S2} \neq 0$) sec

STATEs	#	Description
K		Filter for signal (1)
K+1		Lead-lag for signal (1)
K+2		Filter for signal (2)
K+3		Lead-lag for signal (2)
K+4		Wash out with time constant for both signals

VAR	#	Description
L		MW flow-through branch

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ICONs	#	Value	Description
M			IC1, signal 1 input code: 1 accelerating power from remote machine (pu) 2 electrical power from branch (pu) 3 frequency deviation from remote bus (pu)
M+1			IC2, signal 2 input code: 0 no signal bus 1 bus voltage (pu) 2 VARs from SVC to system (pu) 3 current from SVC to system (pu)
M+2			IR1, remote machine bus number or from bus number for branch
M+3			IT, to bus number for branch
M+4			IR2, remote machine ID or circuit number for branch
M+5			IB, remote bus number for signal (2) = 1

IBUS, 'STBSVC', ID, ICON(M) to ICON(M+5), CON(J) to CON(J+11) /

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Chapter 4

Minimum Excitation Limiter Model Data Sheets

This chapter contains a collection of data sheets for the minimum excitation limiter models contained in the PSS®E dynamics model library.

Model	Description
MNLEX1	Minimum excitation limiter model
MNLEX2	Minimum excitation limiter model
MNLEX3	Minimum excitation limiter model
UEL1	IEEE 421.5 2005 UEL1 under-excitation limiter
UEL2	IEEE 421.5 2005 UEL2 minimum excitation limiter

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4.1 MNLEX1

Minimum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_{F2}
J+1			T_{F2} > 0 (sec)
J+2			K_M, MEL gain
J+3			T_M, MEL time constant (sec)
J+4			MELMAX
J+5			K, MEL slope (>0)

STATEs	#	Description
K		MEL feedback integrator
K+1		MEL

VAR	#	Description
L		PQSIG

IBUS, 'MNLEX1', ID, CON(J) to CON(J+5) /

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4.2 MNLEX2

Minimum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_{F2}
J+1			T_{F2} > 0 (sec)
J+2			K_M, MEL Gain
J+3			T_M, MEL time constant (sec)
J+4			MELMAX
J+5			Q_o (pu on machine base)
J+6			Radius (pu on machine base)

STATEs	#	Description
K		MEL feedback integrator
K+1		MEL

VAR	#	Description
L		PQSIG

IBUS, 'MNLEX2', ID, CON(J) to CON(J+6) /

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Qo*ET2
(R*ET2)2
MELMAX
Q
Σ
X2
Σ
PQSIG
Σ
KM
1 + sTM
VUEL
0
X2
P
sKF2
1 + sTF2
Q
Qo
Radius
P

4.3 MNLEX3

Minimum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_{F2}
J+1			T_{F2} > 0 (sec)
J+2			K_M, MEL gain
J+3			T_M, MEL time constant (sec)
J+4			MELMAX
J+5			Q_o (pu on machine base)<0
J+6			B, slope

STATEs	#	Description
K		MEL feedback integrator
K+1		MEL

VAR	#	Description
L		PQSIG

IBUS, 'MNLEX3', ID, CON(J) to CON(J+6) /

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4.4 UEL1

IEEE 421.5 2005 UEL1 Under-Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K_{UR}, UEL radius setting (pu)
J+1			K_{UC}, (pu) UEL center setting (pu)
J+2			K_{UF}, (pu) UEL excitation system stabilizer gain (pu)
J+3			V_{URMAX}, UEL maximum limit for radius phasor magnitude (pu)
J+4			V_{UCMAX}, UEL maximum limit for operating point phasor magnitude (pu)
J+5			K_{UI}, UEL integral gain (pu)
J+6			K_{UL}, UEL proportional gain (pu)
J+7			V_{UIMAX}, UEL integrator output maximum limit (pu)
J+8			V_{UIMIN}, UEL integrator output minimum limit (pu)[1]
J+9			T_{U1}, UEL lead time constant (sec)
J+10			T_{U2}, UEL lag time constant (sec)
J+11			T_{U3}, UEL lead time constant (sec)
J+12			T_{U4}, UEL lag time constant (sec)
J+13			V_{ULMAX}, UEL output maximum limit (pu)
J+14			V_{ULMIN}, UEL output minimum limit (pu)[1]

[1] V_{UIMIN} and V_{ULMIN} should be set to 0.0 for excitation systems where V_{UEL} is added to the summing junction of AVR reference, and should be set to a negative number of a relatively large magnitude if V_{UEL} enters the AVR through a HV (high value) gate.

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STATEs	#	Description
K		Integrator
K+1		First lead-lag
K+2		Second lead-lag

VARs	#	Description
L		Reference input signal
L+1		V_{UC}
L+2		V_{UR}
L+3		V_{Uerr}

IBUS, 'UEL1', ID, CON(J) to CON(J+14) /

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Q (p.u. of gen. MVA base)
Center = K_{UC}
radius = K_{UR}
Vars out (+)
P (p.u. of gen. MVA base)
P_T
Q_T
op. point
UEL not limiting
Vars in (-)
K_{UR} - K_{UC}
UEL limiting
Note 1: Normalized limit function specified for V_T = 1 p.u.

4.5 UEL2

IEEE 421.5 2005 UEL2 Minimum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID.
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{UV} (sec) voltage filter time constant
J+1			T_{UP} (sec) real power filter time constant
J+2			T_{UQ} (sec) reactive power filter time constant
J+3			K_{UI} (pu) UEL integral gain
J+4			K_{UL} (pu) UEL proportional gain
J+5			V_{UIMAX} (pu) UEL integrator output maximum limit
J+6			V_{UIMIN} (pu) UEL integrator output minimum limit
J+7			K_{UF} (pu) UEL excitation system stabilizer gain
J+8			K_{FB} (pu)
J+9			T_{UL} (sec)
J+10			T_{U1} UEL lead time constant (sec)
J+11			T_{U2} UEL lag time constant (sec)
J+12			T_{U3} UEL lead time constant (sec)
J+13			T_{U4} UEL lag time constant (sec)
J+14			P_0 (pu on gen. MVA base)[1]
J+15			Q_0 (pu on gen. MVA base)[1]
J+16			P_1 (pu on gen. MVA base)
J+17			Q_1 (pu on gen. MVA base)
J+18			P_2 (pu on gen. MVA base)
J+19			Q_2 (pu on gen. MVA base)
J+20			P_3 (pu on gen. MVA base)
J+21			Q3 (pu on gen. MVA base)
J+22			P_4 (pu on gen. MVA base)

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CONs	#	Value	Description
J+23			Q_4 (pu on gen. MVA base)
J+24			P_5 (pu on gen. MVA base)
J+25			Q_5 (pu on gen. MVA base)
J+26			P_6 (pu on gen. MVA base)
J+27			Q_6 (pu on gen. MVA base)
J+28			P_7 (pu on gen. MVA base)
J+29			Q_7 (pu on gen. MVA base)
J+30			P_8 (pu on gen. MVA base)
J+31			Q_8 (pu on gen. MVA base)
J+32			P_9 (pu on gen. MVA base)
J+33			Q_9 (pu on gen. MVA base)
J+34			P_{10} (pu on gen. MVA base)
J+35			Q_{10} (pu on gen. MVA base)
J+36			V_{ULMAX} (pu) UEL output maximum limit[2]
J+37			V_{ULMIN} (pu) UEL output minimum limit[1]

[1] A maximum if 10 pairs may be specified. The unused pairs should be entered as zero.

[2] V_{UIMIN} and V_{ULMIN} should be set to 0.0 for excitation systems where V_{UEL} is added to the reference.

STATEs	#	Description
K		Voltage filter output
K+1		Real power filter output
K+2		Reactive power filter output
K+3		Integrator
K+4		Reference feedback block
K+5		First lead-lag
K+6		Second lead-lag

VARs	#	Description
L		Reference input signal
L+1		Q´, normalized reactive power output for 1 pu voltage
L+2		Q_{REF}

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ICON	#	Value	Description
M			k_1, exponent in function F_1
M+1			k_2, exponent in function F_2
M+2			0 for transient swings in MW that move to the third quadrant, MVAR curve interpreted as mirror image around MVAR axis 1 for transient swings in MW that move to the third quadrant, MVAR is found by linear extrapolation

IBUS, 'UEL2', ID, ICON(M) to ICON(M+2), CON(J) to CON(J+37) /

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Chapter 5

Maximum Excitation Limiter Model Data Sheets

This chapter contains a collection of data sheets for the maximum excitation limiter models contained in the PSS®E dynamics model library.

Model	Description
MAXEX1	Maximum excitation limiter model
MAXEX2	Maximum excitation limiter model

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5.1 MAXEX1

Maximum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and VAR	#_____	K,
and ICON	#_____	M.

CONs	#	Value	Description
J			EFD_{RATED}
J+1			EFD_1 (pu of rated)
J+2			$TIME_1$
J+3			EFD_2 (pu of rated)
J+4			$TIME_2$
J+5			EFD_3 (pu of rated)
J+6			$TIME_3$
J+7			EFD_{DES} (pu of rated)
J+8			K_{MX}
J+9			V_{LOW}

VAR	#	Description
K		Contact position

ICON	#	Value	Description
M			Status

IBUS, 'MAXEX1', ID, CON(J) to CON(J+9) /

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5.2 MAXEX2

Maximum Excitation Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and VAR	#_____	K,
and STATE	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			EFD_{RATED} or IFD_{RATED}
J+1			EFD_1 or IFD_1 (pu of rated)
J+2			$TIME_1$
J+3			EFD_2 or IFD_2 (pu of rated)
J+4			$TIME_2$
J+5			EFD_3 or IFD_3 (pu of rated)
J+6			$TIME_3$
J+7			EFD_{DES} or IFD_{DES} (pu of rated)
J+8			K_{MX}
J+9			V_{LOW} (< 0)

VAR	#	Description
K		Contact position

STATE	#	Description
L		Reset integrator

ICON	#	Value	Description
M			0 for EFD limiting, 1 for IFD limiting

IBUS, 'MAXEX2', ID, ICON(M), CON(J) to CON(J+9) /

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Chapter 6

Excitation System Model Data Sheets

This chapter contains a collection of data sheets for the excitation system models contained in the PSS®E dynamics model library.

Model	Description
AC7B	IEEE 421.5 2005 AC7B excitation system
AC8B	IEEE 421.5 2005 AC8B excitation system
BBSEX1	Brown-Boveri static excitation system model
BUDCZT	Czech proportional/integral excitation system model
CELIN	ELIN brushless excitation system model
DC3A	IEEE 421.5 2005 DC3A excitation system
DC4B	IEEE 421.5 2005 DC4B excitation system
EMAC1T	AEP Rockport excitation system model
ESAC1A	1992 IEEE type AC1A excitation system model
ESAC2A	1992 IEEE type AC2A excitation system model
ESAC3A	1992 IEEE type AC3A excitation system model
ESAC4A	1992 IEEE type AC4A excitation system model
ESAC5A	1992 IEEE type AC5A excitation system model
ESAC6A	1992 IEEE type AC6A excitation system model
ESAC8B	Basler DECS model
ESDC1A	1992 IEEE type DC1A excitation system model
ESDC2A	1992 IEEE type DC2A excitation system model
ESST1A	1992 IEEE type ST1A excitation system model
ESST2A	1992 IEEE type ST2A excitation system model
ESST3A	1992 IEEE type ST3A excitation system model
ESST4B	IEEE type ST4B potential or compounded source-controlled rectifier exciter
ESURRY	Modified IEEE Type AC1A excitation model
EX2000	EX2000 Excitation System

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Model	Description
EXAC1	1981 IEEE type AC1 excitation system model
EXAC1A	Modified type AC1 excitation system model
EXAC2	1981 IEEE type AC2 excitation system model
EXAC3	1981 IEEE type AC3 excitation system model
EXAC4	1981 IEEE type AC4 excitation system model
EXBAS	Basler static voltage regulator feeding dc or ac rotating exciter model
EXDC2	1981 IEEE type DC2 excitation system model
EXELI	Static PI transformer fed excitation system model
EXNEBB	Bus or solid fed SCR bridge excitation system model type NEBB (NVE)
EXNI	Bus or solid fed SCR bridge excitation system model type NI (NVE)
EXPIC1	Proportional/integral excitation system model
EXST1	1981 IEEE type ST1 excitation system model
EXST2	1981 IEEE type ST2 excitation system model
EXST2A	Modified 1981 IEEE type ST2 excitation system model
EXST3	1981 IEEE type ST3 excitation system model
IEEET1	1968 IEEE type 1 excitation system model
IEEET2	1968 IEEE type 2 excitation system model
IEEET3	1968 IEEE type 3 excitation system model
IEEET4	1968 IEEE type 4 excitation system model
IEEET5	Modified 1968 IEEE type 4 excitation system model
IEEEX1	1979 IEEE type 1 excitation system model and 1981 IEEE type DC1 model
IEEEX2	1979 IEEE type 2 excitation system model
IEEEX3	1979 IEEE type 3 excitation system model
IEEEX4	1979 IEEE type 4 excitation system, 1981 IEEE type DC3 and 1992 IEEE type DC3A models
IEET1A	Modified 1968 IEEE type 1 excitation system model
IEET1B	Modified 1968 IEEE type 1 excitation system model
IEET5A	Modified 1968 IEEE type 4 excitation system model
IEEX2A	1979 IEEE type 2A excitation system model
IVOEX	IVO excitation system model
OEX12T	Ontario Hydro IEEE Type ST1 excitation system with continuous and bang bang terminal voltage limiter
OEX3T	Ontario Hydro IEEE Type ST1 excitation system with semicontinuous and acting terminal voltage limiter
REXSYS	General purpose rotating excitation system model

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Model	Description
REXSY1	General purpose rotating excitation system model
SCRX	Bus or solid fed SCR bridge excitation system model
SEXS	Simplified excitation system model
ST5B	IEEE 421.5 2005 ST5B excitation system
ST6B	IEEE 421.5 2005 ST6B excitation system
ST7B	IEEE 421.5 2005 ST7B excitation system
USAC6AU	Modified ESAC6A Model
URHIDT	High dam excitation system model
URST5T	IEEE proposed type ST5B excitation system

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6.1 AC7B

IEEE 421.5 2005 AC7B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_R (sec) regulator input filter time constant
J+1			K_{PR} (pu) regulator proportional gain
J+2			K_{IR} (pu) regulator integral gain
J+3			K_{DR} (pu) regulator derivative gain
J+4			T_{DR} (sec) regulator derivative block time constant
J+5			V_{RMAX} (pu) regulator output maximum limit
J+6			V_{RMIN} (pu) regulator output minimum limit
J+7			K_{PA} (pu) voltage regulator proportional gain
J+8			K_{IA} (pu) voltage regulator integral gain
J+9			V_{AMAX} (pu) regulator output maximum limit
J+10			V_{AMIN} (pu) regulator output minimum limit
J+11			K_P (pu)[1]
J+12			K_L (pu)
J+13			K_{F1} (pu)
J+14			K_{F2} (pu)
J+15			K_{F3} (pu)
J+16			T_{F3} (sec) time constant (> 0)
J+17			K_C (pu) rectifier loading factor proportional to commutating reactance
J+18			K_D (pu) demagnetizing factor, function of AC exciter reactances
J+19			K_E (pu) exciter constant related fo self-excited field
J+20			T_E (pu) exciter time constant (>0)
J+21			V_{FEMAX} (pu) exciter field current limit (> 0)
J+22			V_{EMIN} (pu)

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CONs	#	Value	Description
J+23			E1
J+24			S(E1)
J+25			E2
J+26			S(E2)

[1] Setting KP = 0 eliminates the multiplication of VA by terminal voltage VT.

STATEs	#	Description
K		Sensed V_t
K+1		Integral channel 1
K+2		Derivative channel 1
K+3		Integral channel 2
K+4		V_E
K+5		Rate feedback

VARs	#	Description
L		V_R
L+1		V_A

IBUS, ’AC7B’, ID, CON(J) to CON(J+26) /

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$$F_{EX}(I_N)=\begin{cases}1 & I_N \le 0\\ 1-0.577 I_N & 0 < I_N \le 0.433\\ \sqrt{0.75-I_N^2} & 0.433 < I_N < 0.75\\ 1.732(1-I_N) & 0.75 \le I_N \le 1\\ 0 & I_N > 1\end{cases}$$

Note: If K_p is zero, the factor K_p * V_t is ignored.

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6.2 AC8B

IEEE 421.5 2005 AC8B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_R (sec) regulator input filter time constant
J+1			K_{PR} (pu) regulator proportional gain
J+2			K_{IR} (pu) regulator integral gain
J+3			K_{DR} (pu) regulator derivative gain
J+4			T_{DR} (sec) regulator derivative block time constant
J+5			V_{PIDMAX} (pu) PID maximum limit
J+6			V_{PIDMIN} (pu) PID minimum limit
J+7			K_A (pu) voltage regulator proportional gain
J+8			T_A (sec) voltage regulator time constant
J+9			V_{RMAX} (pu) regulator output maximum limit
J+10			V_{RMIN} (pu) regulator output minimum limit
J+11			K_C (pu) rectifier loading factor proportional to commutating reactance
J+12			K_D (pu) demagnetizing factor, function of AC exciter reactances
J+13			K_E (pu) exciter constant related fo self-excited field
J+14			T_E (pu) exciter time constant (>0)
J+15			V_{FEMAX} (pu) exciter field current limit (> 0)
J+16			V_{EMIN} (pu)
J+17			E1
J+18			S(E1)
J+19			E2
J+20			S(E2)

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STATEs	#	Description
K		Sensed V_t
K+1		Integral channel PID
K+2		Derivative channel PID
K+3		V_R
K+4		V_E

VARs	#	Description
L		V_{PID}
L+1		FEX
L+2		VEMAX

IBUS, ’AC8B’, ID, CON(J) to CON(J+20) /

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6.3 BBSEX1

Brown Boveri Static Exciter

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_F (sec)
J+1			K
J+2			T_1 (>0) (sec)
J+3			T_2 (>0) (sec)
J+4			T_3 (sec)
J+5			T_4 (sec)
J+6			V_{RMAX}
J+7			V_{RMIN}
J+8			EFD_{MAX}
J+9			EFD_{MIN}
J+10			Switch

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag
K+2		Regulator feedback

IBUS, 'BBSEX1', ID, CON(J) to CON(J+10) /

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VREF
EC
(pu)
1
1 + sTF
Σ
1 + sT3
1 + sT4
K T2/T1
VRMAX
VRMIN
VT*EFDMAX
VT*EFDMIN
EFD
(pu)
1/K (T1/T2 − 1) 1/(1 + sT2)
0 ≠ Switch = 0
VS = VOTHSG + VUEL + VOEL
VS

6.4 BUDCZT

Czech Proportion/Integral Exciter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_P (pu)
J+1			$K_A > 0$ (pu)
J+2			$K_E > 0$ (pu)
J+3			T_R (sec)
J+4			$T_I > 0$ (sec)
J+5			T_A (sec)
J+6			T_E (sec)
J+7			U_{RMAX} (pu)
J+8			U_{RMIN} (pu)
J+9			EFD_{MAX} (pu)
J+10			EFD_{MIN} (pu)

STATEs	#	Description
K		Transducer
K+1		PI regulator
K+2		Actuator
K+3		Exciter

VAR	#	Description
L		Actuator input U_{REG}

IBUS, 'BUDCZT', ID, CON(J) to CON(J+10) /

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V_S = VOTHSG + VUEL + VOEL

6.5 CELIN

ELIN Excitation System

This model is at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_{R1}
J+1			T_{R2}
J+2			T_{R3}
J+3			α
J+4			β
J+5			TE2
J+6			Nominal full load EFD in IEEE pu[1]
J+7			KE2
J+8			T_{R4}
J+9			T_1
J+10			T_2
J+11			T_3
J+12			T_4
J+13			T_5
J+14			T_6
J+15			K_{12}
J+16			K_2
J+17			p_PSS
J+18			a_PSS
J+19			Psslim
J+20			K_1
J+21			K_{IEC}
J+22			K_{D1}
J+23			T_{B1} (>0)
J+24			T_{11}

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CONs	#	Value	Description
J+25			LIMMAX_PID1
J+26			LIMMIN_PID1
J+27			K_{21}
J+28			Spare
J+29			U_p+
J+30			U_p-
J+31			K_3
J+32			T_{13}
J+33			K_4
J+34			T_{14}
J+35			KETB
J+36			TE
J+37			Xp
J+38			$I_{ef\ max1}$[2]
J+39			$I_{ef\ max2}$[3]
J+40			$I_{ef\ min}$
J+41			E1
J+42			SE(E1)
J+43			E2
J+44			SE(E2)

[1] Should be adjusted to the specific machine.
[2] Corresponds to the ceiling of 1.6 pu.
[3] This limit is actually disabled.

STATEs	#	Description
K		Sensed Vt
K+1		Uw
K+2		Ub
K+3		Efd
K+4		Sensed Ief
K+5		PSS_first lag
K+6		PSS_second lag
K+7		PSS_first washout
K+8		PSS_second washout
K+9		PSS_third washout

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STATEs	#	Description
K+10		PSS_third lag
K+11		PID1_rate-lag
K+12		PID1_integrator
K+13		Spare
K+14		PID3_integrator
K+15		PID4_integrator
K+16		Converter_lag

VARs	#	Description
L		IEF, pu
L+1		IEF_REF, pu

IBUS, ’CELIN’, ID, CON(J) to CON(J+44) /

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POWER SYSTEM STABILIZER

VOLTAGE REGULATOR

$0 \leq p_PSS \leq 2$

$F(s) = a_PSS[B(s)(1 - p_PSS) + V(s)(1 - |p_PSS - 1|)]$

$2 \leq p_PSS \leq 4$

$F(s) = a_PSS[B(s)(3 - p_PSS) + V(s)(1 - |p_PSS - 3|)]$

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EXCITER FIELD CURRENT REGULATOR
THYRISTOR CONVERTER
EXCITER FIELD CURRENT MINIMUM LIMITER
EXCITER FIELD CURRENT MAXIMUM LIMITER
BRUSHLESS EXCITATION
K21
KETB
KE2
SE + KE2
K3
K4
+3.56KIEC
–3.56KIEC
DT02_004

6.6 DC3A

IEEE 421.5 2005 DC3A Excitation System

This model is at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,

CONs	#	Value	Description
J			T_R Regulator input time constant (sec)
J+1			K_V (pu) limit on fast raise/lower contact setting
J+2			V_{RMAX} (pu) regulator maximum limit
J+3			V_{RMIN} (pu) regulator minimum limit
J+4			T_{RH} (> 0) Rheostat motor travel time (sec)
J+5			T_E (> 0) exciter time-constant (sec)
J+6			K_E (pu) exciter constant related to self-excited field
J+7			V_{EMIN} (pu) exciter minimum limit
J+8			E1
J+9			S(E1)
J+10			E2
J+11			S(E2)

STATEs	#	Description
K		Sensed E_{comp}
K+1		Rheostat setting
K+2		Exciter (E_{FD})

VARs	#	Description
L		V_{ERR}
L+1		V_R

IBUS, 'DC3A', ID, CON(J) to CON(J+11) /

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6.7 DC4B

IEEE 421.5 2005 DC4B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_R regulator input filter time constant (sec)
J+1			K_P (pu) (> 0) voltage regulator proportional gain
J+2			K_I (pu) voltage regulator integral gain
J+3			K_D (pu) voltage regulator derivative gain
J+4			T_D voltage regulator derivative channel time constant (sec)
J+5			V_{RMAX} (pu) regulator output maximum limit
J+6			V_{RMIN} (pu) regulator output minimum limit
J+7			K_A (> 0) (pu) voltage regulator gain
J+8			T_A voltage regulator time constant (sec)
J+9			K_E (pu) exciter constant related to self-excited field
J+10			T_E (> 0) rotating exciter time constant (sec)
J+11			K_F (pu) rate feedback gain
J+12			T_F (> 0) rate feedback time constant (sec)
J+13			V_{EMIN} (pu) minimum exciter voltage output
J+14			E_1 (pu)
J+15			$SE(E_1)$
J+16			E_2 (pu)
J+17			$SE(E_2)$

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STATEs	#	Description
K		Sensed V_T
K+1		Integral channel
K+2		Derivative Channel
K+3		V_R
K+4		E_{FD}
K+5		Rate feedback

VARs	#	Description
L		V_{PID}
L+1		K_E

ICONs	#	Value	Description
M			OEL flag (1 or 2, default = 1)
M+1			UEL flag (1 or 2, default = 1

IBUS, 'DC4B', ID, ICON(M), ICON(M+1), CON(J) to CON(J+17) /

6.8 EMAC1T

Modified IEEE Type AC1 Excitation System

(AEP Rockport Excitation Model)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_4 (sec)
J+2			T_3 (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{RMAX}
J+6			V_{RMIN}
J+7			$T_E > 0$ (sec)
J+8			K_F
J+9			$T_F > 0$ (sec)
J+10			K_C
J+11			K_D
J+12			K_E
J+13			E_1
J+14			$S_E(E_1)$
J+15			E_2
J+16			$S_E(E_2)$
J+17			T_6 (sec)
J+18			T_5 (sec)
J+19			T_2 (sec)
J+20			T_1 (sec)
J+21			K_{FE}

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CONs	#	Value	Description
J+22			T_{FE} (sec)

STATEs	#	Description
K		Sensed E_T
K+1		2nd lead lag output
K+2		3rd lead lag output
K+3		Regulator output, V_R
K+4		V_E
K+5		Feedback output, V_F
K+6		1st lead lag output
K+7		Rate feedback output

VARs	#	Description
L		Feedback output, V_F
L+1		2nd summer output
L+2		3rd lead lag output
L+3		V_{FE}
L+4		2nd lead lag output
L+5		1st lead lag output
L+6		Rate feedback output

IBUS, ’EMAC1T’, ID, CON(J) to CON(J+22) /

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V_S = VOTHSG + VUEL + VOEL

6.9 ESAC1A

IEEE Type AC1A Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{AMAX}
J+6			V_{AMIN}
J+7			$T_E > 0$ (sec)
J+8			K_F
J+9			$T_F > 0$ (sec)
J+10			K_C
J+11			K_D
J+12			K_E
J+13			E_1
J+14			$S_E(E_1)$
J+15			E_2
J+16			$S_E(E_2)$
J+17			V_{RMAX}
J+18			V_{RMIN}

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'ESAC1A', ID, CON(J) to CON(J+18) /

6.10 ESAC2A

IEEE Type AC2A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{AMAX}
J+6			V_{AMIN}
J+7			K_B
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			$T_E > 0$ (sec)
J+11			V_{FEMAX}
J+12			K_H
J+13			K_F
J+14			$T_F > 0$ (sec)
J+15			K_C
J+16			K_D
J+17			K_E
J+18			E_1
J+19			$S_E(E_1)$
J+20			E_2
J+21			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'ESAC2A', ID, CON(J) to CON(J+21) /

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If $I_N \le 0.$	$F_{EX} = 1$	
If $I_N \le 0.433$	$F_{EX} = 1 - 0.577\ I_N$	
If $0.433 < I_N < 0.75$	$F_{EX} = \sqrt{0.75 - I_N^2}$	
If $I_N \ge 0.75$	$F_{EX} = 1.732(1 - I_N)$	
If $I_N > 1$	$F_{EX} = 0$	

$I_N \rightarrow$ (table) $\rightarrow F_{EX}$

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6.11 ESAC3A

IEEE Type AC3A Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{AMAX}
J+6			V_{AMIN}
J+7			$T_E > 0$ (sec)
J+8			V_{EMIN}
J+9			K_R (>0)
J+10			K_F
J+11			$T_F > 0$ (sec)
J+12			K_N
J+13			EFD_N
J+14			K_C
J+15			K_D
J+16			K_E
J+17			V_{FEMAX}
J+18			E_1
J+19			$S_E(E_1)$
J+20			E_2
J+21			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'ESAC3A', ID, CON(J) to CON(J+21) /

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6.12 ESAC4A

IEEE Type AC4A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_R
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C
J+4			T_B (sec)
J+5			K_A
J+6			T_A
J+7			V_{RMAX}
J+8			V_{RMIN}
J+9			K_C

STATEs	#	Description
K		$V_{measured}$
K+1		Lead lag
K+2		V_R

IBUS, 'ESAC4A', ID, CON(J) to CON(J+9) /

V_S = VOTHSG + VOEL

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6.13 ESAC5A

IEEE Type AC5A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX} or zero
J+4			V_{RMIN}
J+5			K_E or zero
J+6			$T_E > 0$ (sec)
J+7			K_F
J+8			$T_{F1} > 0$ (sec)
J+9			T_{F2} (sec)
J+10			T_{F3} (sec)
J+11			E_1
J+12			$S_E(E_1)$
J+13			E_2
J+14			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		First feedback integrator
K+4		Second feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'ESAC5A', ID, CON(J) to CON(J+14) /

6.14 ESAC6A

IEEE Type AC6A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_K (sec)
J+4			T_B (sec)
J+5			T_C (sec)
J+6			V_{AMAX}
J+7			V_{AMIN}
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			T_E (>0) (sec)
J+11			V_{FELIM}
J+12			K_H
J+13			V_{HMAX}
J+14			T_H (sec)
J+15			T_J (sec)
J+16			K_C
J+17			K_D
J+18			K_E
J+19			E_1
J+20			$S_E(E_1)$
J+21			E_2
J+22			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		First block
K+2		Lead lag
K+3		V_E
K+4		Feedback

IBUS, 'ESAC6A', ID, CON(J) to CON(J+22) /

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6.15 ESAC8B

Basler DECS

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_P
J+2			K_I
J+3			K_D
J+4			T_D (sec)
J+5			K_A
J+6			T_A
J+7			V_{RMAX} or zero
J+8			V_{RMIN}
J+9			$T_E > 0$ (sec)
J+10			K_E or zero
J+11			E_1
J+12			$S_E(E_1)$
J+13			E_2
J+14			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Integral controller
K+2		Derivative controller
K+3		Voltage regulator
K+4		Exciter output, EFD

VAR	#	Description
L		K_E

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IBUS, 'ESAC8B', ID, CON(J) to CON(J+14) /

6.16 ESDC1A

IEEE Type DC1A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11		0.0	Switch
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		Rate feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'ESDC1A', ID, CON(J) to CON(J+15) /

6.17 ESDC2A

IEEE Type DC2A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11			Switch
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag output
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		Rate feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'ESDC2A', ID, CON(J) to CON(J+15) /

6.18 ESST1A

IEEE Type ST1A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_R (sec)
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C (sec)
J+4			T_B (sec)
J+5			T_{C1} (sec)
J+6			T_{B1} (sec)
J+7			K_A
J+8			T_A (sec)
J+9			V_{AMAX}
J+10			V_{AMIN}
J+11			V_{RMAX}
J+12			V_{RMIN}
J+13			K_C
J+14			K_F
J+15			$T_F > 0$ (sec)
J+16			K_{LR}
J+17			I_{LR}

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STATEs	#	Description
K		$V_{measured}$
K+1		First lead lag
K+2		Second lead lag
K+3		V_A
K+4		Feedback

ICONs	#	Value	Description
M			UEL (1, 2, or 3)
M+1			VOS (1 or 2)

IBUS, 'ESST1A', ID, ICON(M), ICON(M+1), CON(J) to CON(J+17) /

6.19 ESST2A

Modified IEEE Type ST2A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			K_E
J+6			T_E (>0) (sec)
J+7			K_F
J+8			T_F (>0) (sec)
J+9			K_P
J+10			K_I
J+11			K_C
J+12			EFD_{MAX}

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback integral

VAR	#	Description
L		K_I

IBUS, 'ESST2A', ID, CON(J) to CON(J+12) /

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V_S = VOTHSG + VOEL

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

6.20 ESST3A

IEEE Type ST3A Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ L.

CONs	#	Value	Description
J			T_R (sec)
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			K_M
J+4			T_C (sec)
J+5			T_B (sec)
J+6			K_A
J+7			T_A (sec)
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			K_G
J+11			K_P
J+12			K_I
J+13			V_{BMAX}
J+14			K_C
J+15			X_L
J+16			V_{GMAX}
J+17			θ_P (degrees)
J+18			T_M (sec)
J+19			V_{MMAX}
J+20			V_{MMIN}

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STATEs	#	Description
K		Sensed V_T
K+1		V_A
K+2		V_R
K+3		V_M

IBUS, 'ESST3A', ID, CON(J) to CON(J+20) /

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6.21 ESST4B

IEEE Type ST4B Potential or Compounded Source-Controlled Rectifier Exciter

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_{PR}
J+2			K_{IR}
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_A (sec)
J+6			K_{PM}
J+7			K_{IM}
J+8			V_{MMAX}
J+9			V_{MMIN}
J+10			K_G
J+11			K_P
J+12			K_I
J+13			V_{BMAX}
J+14			K_C
J+15			X_L
J+16			THETAP

STATEs	#	Description
K		Sensed V_T
K+1		Regulator integrator
K+2		Regulator output, V_R
K+3		V_M

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IBUS, 'ESST4B', ID, CON(J) to CON(J+16) /

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6.22 ESURRY

Modified IEEE Type AC1A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_A (sec)
J+2			T_B (sec)
J+3			T_C (sec)
J+4			T_D (sec)
J+5			K_{10}
J+6			T_1 (sec)
J+7			K_{16}
J+8			K_F
J+9			$T_F > 0$ (sec)
J+10			V_{RMAX}
J+11			V_{RMIN}
J+12			$T_E > 0$ (sec)
J+13			E_1
J+14			$S(E_1)$
J+15			E_2
J+16			$S(E_2)$
J+17			K_C ($0<K_C\leq1$)
J+18			K_D
J+19			K_E

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STATEs	#	Description
K		Sensor
K+1		1st lead lag
K+2		2nd lead lag
K+3		Exciter field current sensor
K+4		Feed forward output
K+5		Exciter

VAR	#	Description
L		Exciter field current reference

IBUS, 'ESURRY', ID, CON(J) to CON(J+19) /

I_N →

If $I_N \le 0.$	$F_{EX} = 1$
If $I_N \le 0.433$	$F_{EX} = 1 - 0.577\ I_N$
If $0.433 < I_N < 0.75$	$F_{EX} = \sqrt{0.75 - I_N^2}$
If $I_N \ge 0.75$	$F_{EX} = 1.732(1 - I_N)$
If $I_N > 1$	$F_{EX} = 0$

→ F_{EX}

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6.23 EX2000

EX2000 Excitation System

also represents

IEEE Type AC7B Alternator-Rectifier Excitation System

(Under Excitation Limiter is not included)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			K_{PR}, proportional gain
J+1			K_{IR}, integral gain
J+2			VRMAX, maximum output
J+3			VRMIN, minimum output
J+4			K_{PA}, proportional gain
J+5			K_{IA}, integral gain
J+6			VAMAX, maximum output
J+7			VAMIN, minimum output
J+8			K_P, constant
J+9			K_L, constant
J+10			T_E, exciter field time constant (sec), (>0)
J+11			V_{FEMAX}, parameter of VEMAX, exciter field maximum output
J+12			K_E, exciter field proportional constant
J+13			K_C, rectifier regulation factor
J+14			K_D, exciter regulation factor
J+15			K_{F1}
J+16			K_{F2}
J+17			E1, exciter flux at knee of curve
J+18			S(E1), saturation factor at knee of curve
J+19			E2, maximum exciter flux
J+20			S(E2), saturation factor at maximum exciter flux

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CONs	#	Value	Description
J+21			KVHZ, Volt/Hz gain
J+22			KRCC, Volt/reactive current gain
J+23			T_R, voltage transducer time constant (sec)
J+24			IFDREF1, field current 1st reference
J+25			IFDFEF2, field current 2nd
J+26			IFDREF3, field current 3rd reference
J+27			IFDREF4, field current 4th reference
J+28			I_1, inverse timing constant
J+29			T_1, inverse timing constant (sec)
J+30			I_2, inverse timing constant
J+31			T_2, inverse timing constant (sec)
J+32			I_3, inverse timing constant
J+33			T_3, inverse timing constant (sec)
J+34			I_4, inverse timing constant
J+35			T_4, inverse timing constant (sec)
J+36			TLEAD, field current limiter time constant (sec)
J+37			TLAG, field current limiter time constant (sec)
J+38			KPIFD, proportional gain
J+39			KIIFD, integral gain
J+40			IFDLIMP, maximum output
J+41			IFDLIMN, minimum output
J+42			IFDADVLIM, advance field current limit
J+43			VEMIN, exciter field minimum output
J+44			REFLIMP, voltage reference signal limit

The values are given in per unit unless the unit is shown. For field current references and inverse timing constants the value of the current is in per unit of the generator Air Gap Line base.

STATEs	#	Description
K		Voltage Transducer
K+1		1st PI controller
K+2		2nd PI controller
K+3		Exciter field voltage
K+4		3rd PI controller (Field Current Limiter)
K+5		Lead-lag element (Field Voltage Limiter)

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VARs	#	Description
L		Inverse Timing Function Memory <1: Latch Gate 2 signal is 0 ≥1: Latch Gate 2 signal is 1

ICONs	#	Description
M		0: Field Current Limiter is excluded (and upper limit VEMAX is on) 1: Field Current Limiter is included (and upper limit VEMAX is off)
M+1		0: Minimum Gate 2 is excluded. 1: Minimum Gate 2 is included.
M+2		Memory. Set to 0. 0: Latch Gate 1 signal is 0 1: Latch Gate 1 signal is 1
M+3		Memory. Set to 0. 0: Field Current Limiter Timer is not active 1: Field Current Limiter Timer is active

IBUS, 'EX2000', ID, ICON(M), ICON(M+1), CON(J) to CON(J+44) /

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Note: If K_p is zero, K_p is assumed equal to 1.

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Reference Signal

To represent IEEE Type AC7B System you need to set KVHZ = 0 and KRCC = 0, to set ICON(M+1) = 0 (to exclude Minimum Gate 2) and to set T_R = 0 (to exclude the Voltage Transducer).

Field Current Limiter
(Over Excitation Limiter)

To represent IEEE Type AC7B System you need to set ICON(M) = 0 (to exclude this limiter).

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6.24 EXAC1

IEEE Type AC1 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{RMAX}
J+6			V_{RMIN}
J+7			$T_E > 0$ (sec)
J+8			K_F
J+9			$T_F > 0$ (sec)
J+10			K_C
J+11			K_D
J+12			K_E
J+13			E_1
J+14			$S_E(E_1)$
J+15			E_2
J+16			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'EXAC1', ID, CON(J) to CON(J+16) /

V_S = VOTHSG + VUEL + VOEL

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6.25 EXAC1A

IEEE Modified Type AC1 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{RMAX}
J+6			V_{RMIN}
J+7			$T_E > 0$ (sec)
J+8			K_F
J+9			$T_F > 0$ (sec)
J+10			K_C
J+11			K_D
J+12			K_E
J+13			E_1
J+14			$S_E(E_1)$
J+15			E_2
J+16			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'EXAC1A', ID, CON(J) to CON(J+16) /

V_S = VOTHSG + VUEL + VOEL

6.26 EXAC2

IEEE Type AC2 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{AMAX}
J+6			V_{AMIN}
J+7			K_B
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			$T_E > 0$ (sec)
J+11			K_L
J+12			K_H
J+13			K_F
J+14			$T_F > 0$ (sec)
J+15			K_C
J+16			K_D
J+17			K_E
J+18			V_{LR}
J+19			E_1
J+20			$S_E(E_1)$
J+21			E_2
J+22			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

BUS, 'EXAC2', ID, CON(J) to CON(J+22) /

V_S = VOTHSG + VUEL + VOEL

6.27 EXAC3

IEEE Type AC3 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_B (sec)
J+2			T_C (sec)
J+3			K_A
J+4			T_A (sec)
J+5			V_{AMAX}
J+6			V_{AMIN}
J+7			$T_E > 0$ (sec)
J+8			K_{LV}
J+9			K_R (>0)
J+10			K_F
J+11			$T_F > 0$ (sec)
J+12			K_N
J+13			EFD_N
J+14			K_C
J+15			K_D
J+16			K_E
J+17			V_{LV}
J+18			E_1
J+19			$S_E(E_1)$
J+20			E_2
J+21			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		Lead lag
K+2		Regulator output
K+3		V_E
K+4		Feedback output

IBUS, 'EXAC3', ID, CON(J) to CON(J+21) /

V_S = VOTHSG + VUEL + VOEL

6.28 EXAC4

IEEE Type AC4 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C
J+4			T_B (sec)
J+5			K_A
J+6			T_A
J+7			V_{RMAX}
J+8			V_{RMIN}
J+9			K_C

STATEs	#	Description
K		$V_{measured}$
K+1		Lead lag
K+2		V_R

IBUS, 'EXAC4', ID, CON(J) to CON(J+9) /

VS = VOTHSG + VUEL + VOEL

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6.29 EXBAS

Basler Static Voltage Regulator Feeding dc or ac Rotating Exciter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_R, voltage transducer time constant (sec)
J+1			K_P, proportional gain
J+2			K_I, integral (reset) gain
J+3			K_A, gain
J+4			T_A, bridge time constant (sec)
J+5			T_B, lag time constant (sec)
J+6			T_C, lead time constant (sec)
J+7			V_{RMAX}, maximum control output (pu)
J+8			V_{RMIN}, minimum control output (pu)
J+9			K_F, rate feedback gain
J+10			T_F, rate feedback time constant (>0) (sec)
J+11			T_{F1}, feedback lead time constant (sec)
J+12			T_{F2}, feedback lag time constant (sec)
J+13			K_E, exciter field proportional constant
J+14			T_E, exciter field time constant (>0) (sec)
J+15			K_C, rectifier regulation factor (pu)
J+16			K_D, exciter regulation factor (pu)
J+17			E_1, exciter flux at knee of curve (pu)
J+18			$S_E(E_1)$, saturation factor at knee of curve
J+19			E_2, maximum exciter flux (pu)
J+20			$S_E(E_2)$, saturation factor at maximum exciter flux (pu)

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STATEs	#	Description
K		Sensed E_T
K+1		Integral gain
K+2		Lead lag
K+3		Regulator output
K+4		V_E
K+5		Feedback washout
K+6		Feedback lead lag

IBUS, 'EXBAS', ID, CON(J) to CON(J+20) /

6.30 EXDC2

IEEE Type DC2 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11		0	Switch
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag output
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		Rate feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'EXDC2', ID, CON(J) to CON(J+15) /

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6.31 EXELI

Static PI Transformer Fed Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			$T_{FV} \geq 0$, voltage transducer time constant (sec)
J+1			$T_{FI} \geq 0$, current transducer time constant (sec)
J+2			$T_{NU} > 0$, controller reset time constant (sec)
J+3			V_{PU}, voltage controller proportional gain
J+4			V_{PI}, current controller gain
J+5			$V_{PNF} \geq 0$, controller follow-up gain
J+6			$D_{PNF} \geq 0$, controller follow-up dead band (pu)
J+7			EFD_{MIN}, minimum open circuit excitation voltage (pu)
J+8			$EFD_{MAX} \geq E_{FDMIN}$, maximum open circuit excitation voltage (pu)
J+9			$X_E \geq 0$, excitation transformer effective reactance (pu)
J+10			$T_W \geq 0$, stabilizer feedback time constant (sec)
J+11			K_{S1}, first stabilizer gain
J+12			K_{S2}, second stabilizer gain
J+13			$T_{S1} \geq 0$, first stabilizer time constant (sec)
J+14			$T_{S2} \geq 0$, second stabilizer feedback time constant (sec)
J+15			$S_{MAX} > 0$, stabilizer limit (pu)

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STATEs	#	Description
K		First washout stabilizer state
K+1		Lag stabilizer state
K+2		Negative washout stabilizer state
K+3		Sensed voltage state
K+4		Sensed field current state
K+5		Controlled voltage state
K+6		Second washout stabilizer state
K+7		Third washout stabilizer state

VAR	#	Description
L		Stabilizer signal

IBUS, 'EXELI', ID, CON(J) to CON(J+15) /

6.32 EXNEBB

Bus or Solid Fed SCR Bridge Excitation System Model Type NEBB (NVE)

This model is connected at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			$T_R \geq 0$ (sec)
J+1			$K_1 > 0$ (sec)
J+2			$T_{11} \geq 0$ (sec)
J+3			$T_{12} > 0$ (sec)
J+4			$T_{13} > 0$ (sec)
J+5			$K_2 > 0$
J+6			$T_{21} \geq 0$ (sec)
J+7			$T_{22} > 0$ (sec)
J+8			$T_{23} > 0$ (sec)
J+9			V_{RMAX} pu
J+10			V_{RMIN} pu
J+11			I_{FMAX} (maximum field current) pu[1]
J+12			I_{FMIN} (minimum field current) pu
J+13			FLAG: 0 bus fed 1 solid fed

[1] If $I_{FMAX} \leq I_{FMIN}$, only current regulation (IREF = VREF(I))

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STATEs	#	Description
K		Measuring circuit
K+1		1st amplifier
K+2		1st amplifier output
K+3		2nd amplifier
K+4		2nd amplifier output

VARs	#	Description
L		For tests
L+1		Field current limiter

IBUS, 'EXNEBB', ID, CON(J) to CON(J+13) /

V_S = VOTHSG + VUEL + VOEL

6.33 EXNI

Bus or Solid Fed SCR Bridge Excitation System Model Type NI (NVE)

This model is connected at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			$T_R \geq 0$ (sec)
J+1			$K_A > 0$
J+2			$T_A > 0$ (sec)
J+3			V_{RMAX} pu
J+4			V_{RMIN} pu
J+5			$K_F \geq 0$
J+6			$T_{F1} > 0$ (sec)
J+7			$T_{F2} > 0$ (sec)
J+8			SWITCH[1]
J+9			$R = r_c / r_{fd}$[2]

[1] SWITCH = 0 for bus fed, 1 for solid fed

[2] r_c / r_{fd} = 0 for exciter with negative current capability
> 0 without (typical = 10)

STATEs	#	Description
K		Measuring circuit
K+1		Amplifier
K+2		Feedback
K+3		Feedback output

VAR	#	Description
L		For tests

IBUS, 'EXNI', ID, CON(J) to CON(J+9) /

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V_S = VOTHSG + VUEL + VOEL

6.34 EXPIC1

Proportional/Integral Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_{A1} (sec)
J+3			V_{R1}
J+4			V_{R2}
J+5			T_{A2} (sec)
J+6			T_{A3} (sec)
J+7			T_{A4} (sec)
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			K_F
J+11			T_{F1} (>0) (sec)
J+12			T_{F2} (sec)
J+13			EFD_{MAX}
J+14			EFD_{MIN}
J+15			K_E
J+16			T_E (sec)
J+17			E_1
J+18			SE_1
J+19			E_2
J+20			SE_2
J+21			K_P
J+22			K_I

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CONs	#	Value	Description
J+23			K_C

STATEs	#	Description
K		Sensed E_T
K+1		First regulator, V_A
K+2		Second regulator
K+3		Third regulator, V_R
K+4		Exciter output, EFD
K+5		First feedback integrator
K+6		Second feedback integrator

IBUS, ’EXPIC1’, ID, CON(J) to CON(J+23) /

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If (K_P = 0 and K_I = 0), then V_B = 1

If T_E = 0, then EFD = E_0

V_S = VOTHSG + VUEL + VOEL

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6.35 EXST1

IEEE Type ST1 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C
J+4			T_B (sec)
J+5			K_A
J+6			T_A (sec)
J+7			V_{RMAX}
J+8			V_{RMIN}
J+9			K_C
J+10			K_F
J+11			T_F (> 0) (sec)

STATEs	#	Description
K		$V_{measured}$
K+1		Lead lag
K+2		V_R
K+3		Feedback

IBUS, 'EXST1', ID, CON(J) to CON(J+11) /

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V_S = VOTHSG + VUEL + VOEL

6.36 EXST2

IEEE Type ST2 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			K_E
J+6			T_E (>0) (sec)
J+7			K_F
J+8			T_F (>0) (sec)
J+9			K_P
J+10			K_I or zero
J+11			K_C
J+12			EFD_{MAX}

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback integral

VAR	#	Description
L		K_I

IBUS, 'EXST2', ID, CON(J) to CON(J+12) /

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V_S = VOTHSG + VUEL + VOEL

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

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6.37 EXST2A

Modified IEEE Type ST2 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			K_E
J+6			T_E (>0) (sec)
J+7			K_F
J+8			T_F (>0) (sec)
J+9			K_P
J+10			K_I
J+11			K_C
J+12			EFD_{MAX}

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback integral

VAR	#	Description
L		K_I

IBUS, 'EXST2A', ID, CON(J) to CON(J+12) /

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V_S = VOTHSG + VUEL + VOEL
If $K_P = 0$ and $K_I = 0$, $V_B = 1$

6.38 EXST3

IEEE Type ST3 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			K_J
J+4			T_C (sec)
J+5			T_B (sec)
J+6			K_A
J+7			T_A (sec)
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			K_G
J+11			K_P
J+12			K_I
J+13			EFD_{MAX}
J+14			K_C
J+15			X_L
J+16			V_{GMAX}
J+17			θ_P (degrees)

STATEs	#	Description
K		Sensed V_T
K+1		V_A
K+2		V_R

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IBUS, 'EXST3', ID, CON(J) to CON(J+17) /

$\bar{K}_P = K_P \varepsilon^{j\theta_P}$

V_S = VOTHSG + VUEL + VOEL

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6.39 IEEET1

IEEE Type 1 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX} or zero
J+4			V_{RMIN}
J+5			K_E or zero
J+6			T_E (>0) (sec)
J+7			K_F
J+8			T_F (>0) (sec)
J+9		0	Switch
J+10			E_1
J+11			$S_E(E_1)$
J+12			E_2
J+13			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback integrator

VAR	#	Description
L		K_E

IBUS, 'IEEET1', ID, CON(J) to CON(J+13) /

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V_S = VOTHSG + VUEL + VOEL

Note: S_E is the saturation function.

6.40 IEEET2

IEEE Type 2 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX} or zero
J+4			V_{RMIN}
J+5			K_E
J+6			T_E (>0) (sec)
J+7			K_F
J+8			T_{F1} (>0) (sec)
J+9			T_{F2} (>0) (sec)
J+10			E_1
J+11			$S_E(E_1)$
J+12			E_2
J+13			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		First feedback integrator
K+4		Second feedback integrator

VAR	#	Description
L		K_E

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IBUS, 'IEEET2', ID, CON(J) to CON(J+13) /

V_S = VOTHSG + VUEL + VOEL

Note: S_E is the saturation function.

6.41 IEEET3

IEEE Type 3 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_E (>0) (sec)
J+6			K_F
J+7			T_F (>0) (sec)
J+8			K_P (>0)
J+9			K_I or zero
J+10			V_{BMAX} (pu voltage base)
J+11			K_E

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback internal

VAR	#	Description
L		K_I

IBUS, 'IEEET3', ID, CON(J) to CON(J+11) /

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$$A = \left(\frac{0.78 \times L_{ad} I_{fd}}{V_{THEV}}\right)^2$$

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

V_S = VOTHSG + VUEL + VOEL

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6.42 IEEET4

IEEE Type 4 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_R
J+1			T_{RH} (>0) (sec)
J+2			K_V
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_E (>0) (sec)
J+6			K_E
J+7			E_1
J+8			$S_E(E_1)$
J+9			E_2
J+10			$S_E(E_2)$

STATEs	#	Description
K		V_{RH}
K+1		EFD

VAR	#	Description
L		K_E

IBUS, 'IEEET4', ID, CON(J) to CON(J+10) /

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VREF
+
EC
(pu)
−
Σ
ΔV
-KR
1
-1
KR
VRMAX
1
sTRH
VRMIN
VRH
|ΔV|<KV
|ΔV|>KV
−KV
VRMAX
KV
VRMIN
SE
ψ
X
−
+
VR
Σ
1
KE + sTE
EFD
(pu)

6.43 IEEET5

Modified IEEE Type 4 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_{RH} (>0) (sec)
J+1			K_V
J+2			V_{RMAX}
J+3			V_{RMIN}
J+4			T_E (>0) (sec)
J+5			K_E
J+6			E_1
J+7			$S_E(E_1)$
J+8			E_2
J+9			$S_E(E_2)$

STATEs	#	Description
K		V_{RH}
K+1		EFD

VAR	#	Description
L		K_E

IBUS, 'IEEET5', ID, CON(J) to CON(J+9) /

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SE
ψ
X
VREF
+
VRMAX
EC
(pu)
−
Σ
ΔV
1
sTRH
|ΔV|<KV
VRH
VRMIN
−
+
VR
Σ
1
KE + sTE
EFD
(pu)
|ΔV|>KV
−KV
VRMAX
KV
VRMIN

6.44 IEEEX1

IEEE Type 1 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11		0.0	Switch
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		Rate feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'IEEEX1', ID, CON(J) to CON(J+15) /

6.45 IEEEX2

IEEE Type 2 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11			T_{F2} (>0) (sec)
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		First feedback integrator
K+5		Second feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'IEEEX2', ID, CON(J) to CON(J+15) /

6.46 IEEEX3

IEEE Type 3 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_E (>0) (sec)
J+6			K_F
J+7			T_F (>0) (sec)
J+8			K_P (>0)
J+9			K_I or zero
J+10			V_{BMAX} (pu voltage base)
J+11			K_E

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		Rate feedback integrator

VAR	#	Description
L		K_I

IBUS, 'IEEEX3', ID, CON(J) to CON(J+11) /

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VREF
VS
VRMAX
Regulator
EC (pu)
1 / 1 + sTR
Σ
VERR
KA / 1 + sTA
VR
1 / KE + sTE
EFD (pu)
VRMIN
0
VFB
Damping
sKF / 1 + sTF
VTH
VBMAX
VB
0
Lad Ifd
VS = VOTHSG + VUEL + VOEL

6.47 IEEEX4

IEEE Type 4 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_{RH} (>0) (sec)
J+2			K_V
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_E (>0) (sec)
J+6			K_E
J+7			E_1
J+8			$S_E(E_1)$
J+9			E_2
J+10			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		V_{RH}
K+2		EFD

VAR	#	Description
L		K_E

IBUS, 'IEEEX4', ID, CON(J) to CON(J+10) /

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VREF
+
EC
(pu)
1
1 + sTR
–
Σ
VERR
KV
–KV
VRMAX
VRMAX - VRMIN
sKVTRH
VRMIN
VRH
If VERR ≥ KV, VR = VRMAX
If |VERR| < KV, VR = VRH
If VERR ≤ -KV, VR = VRMIN
+
VR
Σ
–
1
sTE
EFD
(pu)
SE + KE

6.48 IEET1A

Modified IEEE Type 1 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			K_A
J+1			T_A (sec)
J+2			V_{RMAX}
J+3			V_{RMIN}
J+4			K_E
J+5			T_E (>0) (sec)
J+6			K_F
J+7			T_F (>0) (sec)
J+8			EFD_{MIN}
J+9			E_1
J+10			$S_E(E_1)$
J+11			EFD_{MAX}
J+12			$S_E(EFD_{MAX})$

STATEs	#	Description
K		Regulator output
K+1		Exciter output, EFD
K+2		Rate feedback integrator

IBUS, 'IEET1A', ID, CON(J) to CON(J+12) /

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V_S = VOTHSG + VUEL + VOEL

6.49 IEET1B

Modified Type 1 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			V_{SMAX}
J+2			V_{SMIN}
J+3			K_A
J+4			T_{A1} (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			T_{A2} (sec)
J+8			K_{F1}
J+9			T_{F1}(>0) (sec)
J+10			K_E or zero
J+11			T_E (>0) (sec)
J+12			E_1
J+13			$S_E(E_1)$
J+14			E_2
J+15			$S_E(E_2)$
J+16			Switch
J+17			X_e, compensation

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STATEs	#	Description
K		Sensed V_T
K+1		Amplified output, V_R
K+2		Regulator output, V_{REG}
K+3		Feedback integrator
K+4		Exciter output, EFD

VARs	#	Description
L		K_E
L+1		Bias

IBUS, 'IEET1B', ID, CON(J) to CON(J+17) /

6.50 IEET5A

Modified IEEE Type 4 Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K_A
J+1			T_{RH} (sec)
J+2			K_V
J+3			V_{RMAX}
J+4			V_{RMIN}
J+5			T_E (>0) (sec)
J+6			K_E
J+7			E_1
J+8			$S_E(E_1)$
J+9			E_2
J+10			$S_E(E_2)$
J+11			EFD_{MAX}
J+12			EFD_{MIN}

STATEs	#	Description
K		V_{RH}
K+1		Exciter output

VARs	#	Description
L		K_E
L+1		V_{TO}

IBUS, 'IEET5A', ID, CON(J) to CON(J+12) /

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*If T_{RH} equals zero, block becomes $\frac{K_A}{s}$

6.51 IEEX2A

IEEE Type 2A Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_B (sec)
J+4			T_C (sec)
J+5			V_{RMAX} or zero
J+6			V_{RMIN}
J+7			K_E or zero
J+8			T_E (>0) (sec)
J+9			K_F
J+10			T_{F1} (>0) (sec)
J+11			E_1
J+12			$S_E(E_1)$
J+13			E_2
J+14			$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Lead lag
K+2		Regulator output, V_R
K+3		Exciter output, EFD
K+4		Rate feedback integrator

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VAR	#	Description
L		K_E

IBUS, 'IEEX2A', ID, CON(J) to CON(J+14) /

6.52 IVOEX

IVO Excitation Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			K_1
J+1			A_1
J+2			A_2
J+3			T_1
J+4			T_2
J+5			MAX_1
J+6			MIN_1
J+7			K_3
J+8			A_3
J+9			A_4
J+10			T_3
J+11			T_4
J+12			MAX_3
J+13			MIN_3
J+14			K_5
J+15			A_5
J+16			A_6
J+17			T_5
J+18			T_6
J+19			MAX_5
J+20			MIN_5

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STATEs	#	Description
K		Integrator 1
K+1		Integrator 2
K+2		Integrator 3

IBUS, 'IVOEX', ID, CON(J) to CON(J+20) /

V_S = VOTHSG + VUEL + VOEL

6.53 OEX12T

Ontario Hydro IEEE Type ST1 Excitation System With Continuous and Bang Bang Terminal Voltage Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_R
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C
J+4			T_B (>0) (sec)
J+5			K_A
J+6			T_A (sec)
J+7			V_{RMAX}
J+8			V_{RMIN}
J+9			K_C
J+10			K_F
J+11			T_F (>0) (sec)
J+12			E_{TMIN}
J+13			V_{TMAX}
J+14			V_{TMIN}
J+15			LIMOUT
J+16			ACON
J+17			BCON
J+18			V_{EMAX}
J+19			V_{EMIN}
J+20			I_{FLMT}
J+21			K_{IFL}

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CONs	#	Value	Description
J+22			E_{TLMT}
J+23			K_{ETL}
J+24			T_{L1} ($\leq T_{L2}$)
J+25			T_{L2}
J+26			V_{OMX}
J+27			$V_{OMN} \leq 0$

Note: Parameters (J+23) through (J+27) are for the continuous voltage limiter.

STATEs	#	Description
K		Voltage sensing block
K+1		Lead lag T_C/T_B block
K+2		Regulator T_A block
K+3		T_F feedback block
K+4		Voltage limiter TL1/TL2

VARs	#	Description
L		Limiter status
L+1		Period of decay
L+2		Monitored voltage V_{m1}
L+3		Monitored voltage V_{m2}
L+4		Monitored voltage V_{m3}
L+5		Monitored voltage V_{m4}
L+6		Monitored voltage V_{m5}

IBUS, ’OEX12T’, ID, CON(J) to CON(J+27) /

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V_S = VOTHSG + VUEL + VOEL

$$V_{OD} = V_{OMX}\mathrm{EXP}[-ACON(t-t_2)] \quad \text{if } t < t_3$$
$$= 0 \quad \text{if } t \geq t_3$$

$$t_3 = t_2 + \frac{B_{CON}}{A_{CON}}$$

t_2 = time at which E_T drops below V_{TMIN}

Voltage Limiter

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6.54 OEX3T

Ontario Hydro IEEE Type ST1 Excitation System
With Semicontinuous and Acting Terminal Voltage Limiter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_R
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (sec)
J+4			T_4 (sec)
J+5			K_A
J+6			T_5 (sec)
J+7			T_6 (sec) ($\leq T_5$)
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			T_E (>0) (sec)
J+11			K_F
J+12			T_F (>0) (sec)
J+13			K_C
J+14			K_D
J+15			K_E
J+16			E_1
J+17			$S_E(E_1)$
J+18			E_2 ($E_2 > E_1$)
J+19			$S_E(E_2)$

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STATEs	#	Description
K		Voltage sensing block
K+1		Lead lag T_2/T_1 block
K+2		Lead lag T_4/T_3 block
K+3		Regulator T_6/T_5 block
K+4		T_E block
K+5		T_F feedback block

VAR	#	Description
L		Input to V_{REF} junction

IBUS, 'OEX3T', ID, CON(J) to CON(J+19) /

$$F_{EX} = 1.0 - 0.58\ I_N \text{ for } I_N \le 0.433 \quad S_E = \frac{[A_{EX}\mathrm{EXP}(B_{EX}V_E)]}{V_E}$$

$$F_{EX} = \sqrt{0.75 - (I_N)^2} \text{ for } 0.433 < I_N < 0.75 \quad \frac{\text{Restrictions}}{T_E \ne 0}$$

$$F_{EX} = 1.732(1.0 - I_N) \text{ for } I_N > 0.75 \quad V_S = \mathrm{VOTHSG} + \mathrm{VUEL} + \mathrm{VOEL}$$

Alternator-Supplied Diode Exciter Type OEX3

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6.55 REXSY1

General-Purpose Rotating Excitation System Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R, voltage transducer time constant (sec)
J+1			K_{VP}, voltage regulator proportional gain
J+2			K_{VI}, voltage regulator integral gain
J+3			V_{IMAX}, voltage regulator input limit (pu)
J+4			T_A, voltage regulator time constant (sec)
J+5			T_{B1}, lag-time constant (sec)
J+6			T_{C1}, lead-time constant (sec)
J+7			T_{B2}, lag-time constant (sec)
J+8			T_{C2}, lead-time constant (sec)
J+9			V_{RMAX}, maximum controller output (pu)
J+10			V_{RMIN}, minimum controller output (pu)
J+11			K_F, rate feedback gain
J+12			T_F, rate feedback >0 time constant (sec)
J+13			T_{F1}, feedback lead-time constant (sec)
J+14			T_{F2}, feedback lag-time constant (sec)
J+15			F_{BF}, [0,1,2] rate feedback signal flag
J+16			K_{IP}, field current regulator proportional gain
J+17			K_{II}, field current regulator integral gain
J+18			T_P, field current bridge time constant (sec)
J+19			V_{FMAX}, maximum exciter field current (pu)
J+20			V_{FMIN}, minimum exciter field current (pu)
J+21			K_H, field voltage controller feedback gain
J+22			K_E, exciter field proportional constant

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CONs	#	Value	Description
J+23			T_E, exciter field time constant (sec >0)
J+24			K_C, rectifier regulation factor (pu)
J+25			K_D, exciter regulation factor (pu)
J+26			E_1, exciter flux at knee of curve (pu)
J+27			$S_E(E_1)$, saturation factor at knee
J+28			E_2, maximum exciter (pu)
J+29			$S_E(E_2)$, saturation factor at maximum flux
J+30			F_{1IMF}, power supply limit factor
J+31			X_C, compounding resistance (pu)
J+32			V_{CMAX}, maximum compounding voltage

STATEs	#	Description
K		Sense voltage
K+1		Proportional voltage
K+2		Regulator lead-lag, first stage
K+3		Regulator output
K+4		Feedback lead-lag
K+5		Feedback state
K+6		Proportional field current
K+7		V_E
K+8		Regulator lead-lag, second state
K+9		Exciter field current regulator output

IBUS, ’REXSY1’, ID, CON(J) to CON(J+32) /

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REXSY1 Model Voltage Regulator

Feedback Signal Selector (F_{BF}): 0 A_{VR} output signal
1 I_{FE} exciter field current
2 EFD exciter output voltage

V_S = VOTHSG + VUEL + VOEL
$F = [1.0 + F_{1IMF} (E_T - 1.0)]*(K_E + K_D + S_E)$

I_N	If $I_N \le 0.$	$F_{EX} = 1$
	If $I_N \le 0.433$	$F_{EX} = 1 - 0.577\ I_N$
	If $0.433 < I_N < 0.75$	$F_{EX} = \sqrt{0.75 - I_N^2}$
	If $I_N \ge 0.75$	$F_{EX} = 1.732(1 - I_N)$
	If $I_N > 1$	$F_{EX} = 0$

6.56 REXSYS

General-Purpose Rotating Excitation System Model

This model is located at system bus	#____	IBUS,
Machine identifier	#____	ID,
This model uses CONs starting with	#____	J,
and STATEs starting with	#____	K.

CONs	#	Value	Description
J			T_R, voltage transducer time constant (sec)
J+1			K_{VP}, voltage regulator proportional gain
J+2			K_{VI}, voltage regulator integral gain
J+3			V_{IMAX}, voltage regulator input limit (pu)
J+4			T_A, voltage regulator time constant (sec)
J+5			T_{B1}, lag-time constant (sec)
J+6			T_{C1}, lead-time constant (sec)
J+7			T_{B2}, lag-time constant (sec)
J+8			T_{C2}, lead-time constant (sec)
J+9			V_{RMAX}, maximum controller output (pu)
J+10			V_{RMIN}, minimum controller output (pu)
J+11			K_F, rate feedback gain
J+12			T_F, rate feedback >0 time constant (sec)
J+13			T_{F1}, feedback lead-time constant (sec)
J+14			T_{F2}, feedback lag-time constant (sec)
J+15			F_{BF}, [0,1,2] rate feedback signal flag
J+16			K_{IP}, field current regulator proportional gain
J+17			K_{II}, field current regulator integral gain
J+18			T_P, field current bridge time constant (sec)
J+19			V_{FMAX}, maximum exciter field current (pu)
J+20			V_{FMIN}, minimum exciter field current (pu)
J+21			K_H, field voltage controller feedback gain
J+22			K_E, exciter field proportional constant

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CONs	#	Value	Description
J+23			T_E, exciter field time constant (sec >0)
J+24			K_C, rectifier regulation factor (pu)
J+25			K_D, exciter regulation factor (pu)
J+26			E_1, exciter flux at knee of curve (pu)
J+27			$S_E(E_1)$, saturation factor at knee
J+28			E_2, maximum exciter (pu)
J+29			$S_E(E_2)$, saturation factor at maximum flux
J+30			F_{1IMF}, power supply limit factor

STATEs	#	Description
K		Sense voltage
K+1		Proportional voltage
K+2		Regulator lead-lag, first stage
K+3		Regulator output
K+4		Feedback lead-lag
K+5		Feedback state
K+6		Proportional field current
K+7		V_E
K+8		Regulator lead-lag, second stage
K+9		Exciter field current regulator output

IBUS, ’REXSYS’, ID, CON(J) to CON(J+30) /

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REXSYS Model Voltage Regulator

Feedback Signal Selector (F_{BF}): 0 A_{VR} output signal
1 I_{FE} exciter field current
2 EFD exciter output voltage

V_S = VOTHSG + VUEL + VOEL
$F = [1.0 + F_{1IMF} (E_T - 1.0)]*(K_E + K_D + S_E)$

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6.57 SCRX

Bus Fed or Solid Fed Static Exciter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_A/T_B
J+1			T_B (>0) (sec)
J+2			K
J+3			T_E (sec)
J+4			E_{MIN} (pu on EFD base)
J+5			E_{MAX} (pu on EFD base)
J+6			C_{SWITCH}[1]
J+7			r_c / r_{fd}[2]

[1] Set C_{SWITCH} = 0 for bus fed.
Set C_{SWITCH} = 1 for solid fed.
[2] Set CON(J+7) = 0 for exciter with negative field current capability.
Set CON(J+7) > 0 for exciter without negative field current capability.
(Typical CON(J+7) = 10)

STATEs	#	Description
K		First integrator
K+1		Second integrator

IBUS, 'SCRX', ID, CON(J) to CON(J+7) /

V_S = VOTHSG + VUEL + VOEL

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6.58 SEXS

Simplified Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_A/T_B
J+1			T_B (>0) (sec)
J+2			K
J+3			T_E (sec)
J+4			E_{MIN} (pu on EFD base)
J+5			E_{MAX} (pu on EFD base)

STATEs	#	Description
K		First integrator
K+1		Second integrator

IBUS, 'SEXS', ID, CON(J) to CON(J+5) /

V_S = VOTHSG + VUEL + VOEL

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6.59 ST5B

IEEE 421.5 2005 ST5B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,

CONs	#	Value	Description
J			T_R regulator input filter time constant (sec)
J+1			T_{C1} lead time constant of first lead-lag block (voltage regulator channel) (sec)
J+2			T_{B1} lag time constant of first lead-lag block (voltage regulator channel) (sec)
J+3			T_{C2} lead time constant of second lead-lag block (voltage regulator channel) (sec)
J+4			T_{B2} lag time constant of second lead-lag block (voltage regulator channel) (sec)
J+5			K_R (>0) (pu) voltage regulator gain
J+6			V_{RMAX} (pu) voltage regulator maximum limit
J+7			V_{RMIN} (pu) voltage regulator minimum limit
J+8			T_1 voltage regulator time constant (sec)
J+9			K_C (pu)
J+10			T_{UC1} lead time constant of first lead-lag block (under-excitation channel) (sec)
J+11			T_{UB1} lag time constant of first lead-lag block (under-excitation channel) (sec)
J+12			T_{UC2} lead time constant of second lead-lag block (under-excitation channel) (sec)
J+13			T_{UB2} lag time constant of second lead-lag block (under-excitation channel) (sec)
J+14			T_{OC1} lead time constant of first lead-lag block (over-excitation channel) (sec)
J+15			T_{OB1} lag time constant of first lead-lag block (over-excitation channel) (sec)

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CONs	#	Value	Description
J+16			T_{OC2} lead time constant of second lead-lag block (over-excitation channel) (sec)
J+17			T_{OB2} lag time constant of second lead-lag block (over-excitation channel) (sec)

STATEs	#	Description
K		Sensed V_T
K+1		First lead-lag (voltage regulator channel)
K+2		Second lead-lag (voltage regulator channel)
K+3		E_{FD}
K+4		First lead-lag (under-excitation channel)
K+5		Second lead-lag (under-excitation channel)
K+6		First lead-lag (over-excitation channel)
K+7		Second lead-lag (over-excitation channel)

VARs	#	Description
L		V_1
L+1		V_2
L+2		V_3

IBUS, ’ST5B’, ID, CON(J) to CON(J+17) /

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6.60 ST6B

IEEE 421.5 2005 ST6B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
STATEs starting with	#_____	K,
VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_R regulator input filter time constant (sec)
J+1			K_{PA} (pu) (> 0) voltage regulator proportional gain
J+2			K_{IA} (pu) voltage regulator integral gain
J+3			K_{DA} (pu) voltage regulator derivative gain
J+4			T_{DA} voltage regulator derivative channel time constant (sec)
J+5			V_{AMAX} (pu) regulator output maximum limit
J+6			V_{AMIN} (pu) regulator output minimum limit
J+7			K_{FF} (pu) pre-control gain of the inner loop field regulator
J+8			K_M (pu) forward gain of the inner loop field regulator
J+9			K_{CI} (pu) exciter output current limit adjustment gain
J+10			K_{LR} (pu) exciter output current limiter gain
J+11			I_{LR} (pu) exciter current limit reference
J+12			V_{RMAX} (pu) voltage regulator output maximum limit
J+13			V_{RMIN} (pu) voltage regulator output minimum limit
J+14			K_G (pu) feedback gain of the inner loop field voltage regulator
J+15			T_G (> 0) feedback time constant of the inner loop field voltage regulator (sec)

STATEs	#	Description
K		Sensed V_T
K+1		Integral channel
K+2		Derivative channel
K+3		V_G

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VARs	#	Description
L		V_A
L+1		V_R
L+2		V_I

ICONs	#	Value	Description
M			OEL flag (1 or 2, default = 1)

IBUS, 'ST6B', ID, ICON(M), CON(J) to CON(J+15) /

6.61 ST7B

IEEE 421.5 2005 ST7B Excitation System

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_R regulator input filter time constant (sec)
J+1			T_G lead time constant of voltage input (sec)
J+2			T_F lag time constant of voltage input (sec)
J+3			V_{max} (pu) voltage reference maximum limit
J+4			V_{min} (pu) voltage reference minimum limit
J+5			K_{PA} (pu) (>0) voltage regulator gain
J+6			V_{RMAX} (pu) voltage regulator output maximum limit
J+7			V_{RMIN} (pu) voltage regulator output minimum limit
J+8			K_H (pu) feedback gain
J+9			K_L (pu) feedback gain
J+10			T_C lead time constant of voltage regulator (sec)
J+11			T_B lag time constant of voltage regulator (sec)
J+12			K_{IA} (pu) (>0) gain of the first order feedback block
J+13			T_{IA} (>0) time constant of the first order feedback block (sec)

STATEs	#	Description
K		Sensed V_T
K+1		Lead-lag block 1
K+2		Lead-lag block 2
K+3		First order feedback block

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VARs	#	Description
L		V_1
L+1		V_2
L+2		V_{ref_FB}

ICONs	#	Value	Description
M			OEL flag (1, 2 or 3, default = 1)
M+1			UEL flag (1, 2 or 3, default = 1)

IBUS, 'ST7B', ID, ICON(M) and ICON(M+1), CON(J) to CON(J+13) /

Note: V_{droop} and V_{SCL} are related to the reactive current droop and the stator current limiter, respectively. These are not available in PSS®E and hence these variables are considered constant during the simulation and lumped into the array VREF.

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6.62 USAC6AU

Modified ESAC6A Model

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_R (sec)
J+1			K_A
J+2			T_A (sec)
J+3			T_K (sec)
J+4			T_B (sec)
J+5			T_C (sec)
J+6			V_{AMAX}
J+7			V_{AMIN}
J+8			V_{RMAX}
J+9			V_{RMIN}
J+10			T_E (>0) (sec)
J+11			V_{FELIM}
J+12			K_H
J+13			V_{HMAX}
J+14			T_H (sec)
J+15			T_J (sec)
J+16			K_C
J+17			K_D
J+18			K_E
J+19			E_1
J+20			$S_E(E_1)$
J+21			E_2
J+22			$S_E(E_2)$

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STATEs	#	Description
K		Sensed E_T
K+1		First block
K+2		Lead lag
K+3		V_E
K+4		Feedback

IBUS, 'USRMDL', ID, 'USAC6AU', 4, 0, 0, 23, 5, 0, CON(J) to CON(J+22) /

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6.63 URHIDT

High Dam Excitation Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
STATEs starting with	#_____	K,
VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			K_{dv}
J+1			T_{dv}
J+2			K_i
J+3			T_{di} (> 0)
J+4			T_{ie}
J+5			K_{di}
J+6			K_{d2i}
J+7			K_{difd}
J+8			T_{difd} (> 0)
J+9			T_r
J+10			V_{imax}
J+11			V_{imin}
J+12			T_b
J+13			T_c
J+14			T_{b1}
J+15			T_{c1}
J+16			K_a
J+17			T_{aw} (> 0)
J+18			V_{amax}
J+19			V_{amin}
J+20			a
J+21			T_{b2} (> 0)
J+22			K_{ir}

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CONs	#	Value	Description
J+23			I_{lr}
J+24			X_e
J+25			$V_{lothrsh}$
J+26			$T_{lodelay}$
J+27			T_{af}
J+28			$V_{hithrsh}$
J+29			b

STATEs	#	Description
K		Compensating voltage
K+1		First exciter stabilizing
K+2		Second exciter stabilizing
K+3		Regulator
K+4		Feedback
K+5		Voltage stabilizer
K+6		First current
K+7		Current filter
K+8		Second current
K+9		Field current stabilization

VARs	#	Description
L		Initial current
L+1		Current flow
L+2		Timer

ICONs	#	Value	Description
M			IF, from bus for current input
M+1			IT, to bus
M+2			CKT, circuit ID
M+3			FF, forcing flag

IBUS, ’URHIDT’, ID, ICON(M) to ICON(M+3), CON(J) to CON(J+29) /

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Working Bridge Operation:

$T_a = T_{aw}$

Forcing Before Operation:

$V_{terr} = V_{ref} - E_c$

If $V_{terr} > V_{lothrsh}$, start low-voltage timer

If timer > $T_{lodelay}$,

T_a = forcing bridge time constant (T_{af})

Input of regulator (ds2) = V_{amax}/T_a

Reset to normal regulator when $V_{terr} > V_{hithrsh}$ for $T_{lodelay}$

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6.64 URST5T

IEEE Proposed Type ST5B Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K.

CONs	#	Value	Description
J			T_r (sec)
J+1			T_{C1} (sec)
J+2			T_{B1} (sec)
J+3			T_{C2} (sec)
J+4			T_{B2} (sec)
J+5			KR
J+6			V_{RMAX}
J+7			V_{RMIN}
J+8			T_1
J+9			K_C

STATEs	#	Description
K		Sensed V_T
K+1		First lead lag
K+2		Second lead lag
K+3		Final filter

IBUS, 'URST5T', ID, CON(J) to CON(J+9) /

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Chapter 7

Turbine-Governor Model Data Sheets

This chapter contains a collection of data sheets for the turbine-governor models contained in the PSS®E dynamics model library.

Model	Description
BBGOV1	Brown-Boveri turbine-governor model
CRCMGV	Cross compound turbine-governor model
DEGOV	Woodward diesel governor model
DEGOV1	Woodward diesel governor model
GAST	Gas turbine-governor model
GAST2A	Gas turbine-governor model
GASTWD	Gas turbine-governor model
GGOV1	GE general purpose turbine-governor model
HYGOV	Hydro turbine-governor model
HYGOV2	Hydro turbine-governor model
HYGOVM	Hydro turbine-governor lumped parameter model
HYGOVRU	Fourth order lead-lag hydro-turbine
HYGOVT	Hydro turbine-governor traveling wave model
IEEEG1	1981 IEEE type 1 turbine-governor model
IEEEG2	1981 IEEE type 2 turbine-governor model
IEEEG3	1981 IEEE type 3 turbine-governor model
IEESGO	1973 IEEE standard turbine-governor model
IVOGO	IVO turbine-governor model
PIDGOV	Hydro turbine and governor model
SHAF25	Torsional-elastic shaft model for 25 masses
TGOV1	Steam turbine-governor model
TGOV2	Steam turbine-governor model with fast valving
TGOV3	Modified IEEE type 1 turbine-governor model with fast valving
TGOV4	Modified IEEE type 1 speed governing model with PLU and EVA

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Model	Description
TGOV5	Modified IEEE type 1 turbine-governor model with boiler controls
TURCZT	Czech hydro or steam turbine-governor model
TWDM1T	Tail water depression hydro governor model 1
TWDM2T	Tail water depression hydro governor model 2
URCSCT	Combined cycle, single shaft turbine-governor model
URGS3T	WECC gas turbine governor model
WEHGOV	Woodward electronic hydro governor model
WESGOV	Westinghouse digital governor for gas turbine
WPIDHY	Woodward PID hydro governor model
WSHYDD	WECC double derivative hydro governor model
WSHYGP	WECC GP hydro governor plus turbine model
WSIEG1	WECC modified 1981 IEEE type 1 turbine-governor model

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7.1 BBGOV1

European Governor Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			f_{cut} (≥ 0) (pu)
J+1			K_S
J+2			K_{LS} (> 0)
J+3			K_G
J+4			K_P
J+5			T_N (sec) (> 0)
J+6			K_D
J+7			T_D (sec) (> 0)
J+8			T_4 (sec)
J+9			K_2
J+10			T_5 (sec)
J+11			K_3
J+12			T_6 (sec)
J+13			T_1 (sec)
J+14			SWITCH
J+15			P_{MAX}
J+16			P_{MIN}

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STATEs	#	Description
K		Step and gradient limiter
K+1		PI controller
K+2		Valve output
K+3		Steam output
K+4		Turbine power
K+5		Turbine power
K+6		Electrical damping feedback

VAR	#	Description
L		Reference, P_o

Govenor gain K_S =1/R, P_{MAX} and P_{MIN} are in pu on generator MVA base.

IBUS, 'BBGOV1', ID, CON(J) to CON(J+16) /

7.2 CRCMGV

Cross Compound Turbine-Governor

High-pressure unit is located at bus	#_____	IBUS,
Machine identifier	#_____	ID,
Low-pressure unit is located at bus	#_____	JBUS,
Machine identifier	#_____	M.
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			P_{MAX} (HP)[1]
J+1			R (HP)
J+2			T_1 (HP) (>0)
J+3			T_3 (HP) (>0)
J+4			T_4 (HP) (>0)
J+5			T_5 (HP) (>0)
J+6			F (HP)
J+7			D_H (HP)[1]
J+8			P_{MAX} (LP)
J+9			R (LP)
J+10			T_1 (LP) (>0)
J+11			T_3 (LP) (>0)
J+12			T_4 (LP) (>0)
J+13			T_5 (LP) (>0)
J+14			F (LP)
J+15			D_H (LP)

[1] P_{MAX} and D_H Ri are mpu on generator MVA base. PMAX, DH, and R are in pu on generator MWA base.

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STATEs	#	Description
K		High-pressure unit
K+1		
K+2		
K+3		
K+4		Low-pressure unit
K+5		
K+6		
K+7		

VARs	#	Description
L		$PMECH_1$ REF
L+1		$PMECH_2$ REF

IBUS, 'CRCMGV', ID, JBUS, M, CON(J) to CON(J+15) /

7.3 DEGOV

Woodward Diesel Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_1 (sec)
J+1			T_2 (sec)
J+2			T_3 (sec)
J+3			K (pu)
J+4			T_4 (sec)
J+5			T_5 (sec)
J+6			T_6 (sec)
J+7			T_D ($0 \leq T_D \leq 12 * DELT$) (sec)
J+8			T_{MAX}
J+9			T_{MIN}

STATEs	#	Description
K		Electric control box 1
K+1		Electric control box 2
K+2		Actuator 1
K+3		Actuator 2
K+4		Actuator 3

VARs	#	Description
L		Delay table
L+1		
. . .		
L+12		

Governor gain K=1/R is in pu on generator MVA base.

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IBUS, 'DEGOV', ID, CON(J) to CON(J+9) /

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7.4 DEGOV1

Woodward Diesel Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_1 (sec)
J+1			T_2 (sec)
J+2			T_3 (sec)
J+3			K
J+4			T_4 (sec)
J+5			T_5 (sec)
J+6			T_6 (sec)
J+7			T_D ($0 \le T_D \le 12 * DELT$) (sec)
J+8			T_{MAX}
J+9			T_{MIN}
J+10			DROOP
J+11			T_E

STATEs	#	Description
K		Electric control box 1
K+1		Electric control box 2
K+2		Actuator 1
K+3		Actuator 2
K+4		Actuator 3
K+5		Power transducer

Governor gain K=1/R is in pu on generator MVA base.

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VARs	#	Description
L		Reference
L+1		Delay table
. . .		
L+13		

ICON	#	Value	Description
M			Droop control: 0 Throttle feedback 1 Electric power feedback

IBUS, 'DEGOV1', ID, ICON(M), CON(J) to CON(J+11) /

7.5 GAST

Gas Turbine-Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			R (speed droop)
J+1			T_1 (>0) (sec)
J+2			T_2 (>0) (sec)
J+3			T_3 (>0) (sec)
J+4			Ambient temperature load limit, AT
J+5			K_T
J+6			V_{MAX}
J+7			V_{MIN}
J+8			D_{turb}

STATEs	#	Description
K		Fuel valve
K+1		Fuel flow
K+2		Exhaust temperature

VAR	#	Description
L		Load reference

Vmax, Vmin, D_{turb} and R are in pu on generator MVA base.

IBUS, 'GAST', ID, CON(J) to CON(J+8) /

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Speed
SPEED
Dturb
1
R
VMAX
Load
Reference
VAR(L)
Σ
Low
Value
Gate
1
1 + T1s
1
1 + T2s
Σ
PMECH
VMIN
Σ
KT
Σ
1
1 + T3s
Load Limit

7.6 GAST2A

Gas Turbine Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			W, governor gain (1/droop) (on turbine rating)
J+1			X (sec) governor lead time constant
J+2			Y (sec) (> 0) governor lag time constant
J+3			Z, governor mode: 1 Droop 0 ISO
J+4			E_{TD} (sec)
J+5			T_{CD} (sec)
J+6			T_{RATE} turbine rating (MW)
J+7			T (sec)
J+8			MAX (pu) limit (on turbine rating)
J+9			MIN (pu) limit (on turbine rating)
J+10			E_{CR} (sec)
J+11			K_3
J+12			a (> 0) valve positioner
J+13			b (sec) (> 0) valve positioner
J+14			c valve positioner
J+15			τ_f (sec) (> 0)
J+16			K_f
J+17			K_5
J+18			K_4
J+19			T_3 (sec) (> 0)
J+20			T_4 (sec) (> 0)
J+21			τ_t (> 0)
J+22			T_5 (sec) (> 0)
J+23			a_{f1}

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CONs	#	Value	Description
J+24			b_{f1}
J+25			a_{f2}
J+26			b_{f2}
J+27			c_{f2}
J+28			T_R (degree), Rated temperature[1]
J+29			K_6 (pu), Minimum fuel flow
J+30			T_C (degree), Temperature control[1]

[1] Units can be ℉ or ℃ depending on constants a_{f1} and b_{f1}.

STATEs	#	Description
K		Speed governor
K+1		Valve positioner
K+2		Fuel system
K+3		Radiation shield
K+4		Thermocouple
K+5		Temperature control
K+6		Gas turbine dynamics
K+7		Combustor
K+8		Combustor
K+9		Turbine/exhaust
K+10		Turbine/exhaust
K+11		Fuel controller delay
K+12		Fuel controller delay

VARs	#	Description
L		Governor reference
L+1		Temperature reference flag
L+2		Low value select output
L+3		Output of temperature control

IBUS, ’GAST2A’, ID, CON(J) to CON(J+30) /

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

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7.7 GASTWD

Woodward Gas Turbine-Governor Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K_{DROOP} (on turbine rating)
J+1			K_P
J+2			K_I
J+3			K_D
J+4			E_{TD} (sec)
J+5			T_{CD} (sec)
J+6			T_{RATE} turbine rating (MW)
J+7			T (sec)
J+8			MAX (pu) limit (on turbine rating)
J+9			MIN (pu) limit (on turbine rating)
J+10			E_{CR} (sec)
J+11			K_3
J+12			a (> 0) valve positioner
J+13			b (sec) (> 0) valve positioner
J+14			c valve positioner
J+15			τ_f (sec) (> 0)
J+16			K_f
J+17			K_5
J+18			K_4
J+19			T_3 (sec) (> 0)
J+20			T_4 (sec) (> 0)
J+21			τ_t (> 0)
J+22			T_5 (sec) (> 0)
J+23			a_{f1}
J+24			b_{f1}

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CONs	#	Value	Description
J+25			a_{f2}
J+26			b_{f2} (>0)
J+27			c_{f2}
J+28			T_R(degree), Rated temperature[1]
J+29			K_6 (pu), Minimum fuel flow
J+30			T_C (degree), Temperature control[1]
J+31			T_D (sec) (> 0), Power transducer

[1] Units can be ºF or ºC depending on constants a_{f1} and b_{f1}.

STATEs	#	Description
K		Speed governor
K+1		Valve positioner
K+2		Fuel system
K+3		Radiation shield
K+4		Thermocouple
K+5		Temperature control
K+6		Gas turbine dynamics
K+7		Combustor
K+8		Combustor
K+9		Turbine/exhaust
K+10		Turbine/exhaust
K+11		Fuel controller delay
K+12		Fuel controller delay
K+13		Power transducer

VARs	#	Description
L		Governor reference
L+1		Temperature reference flag
L+2		Low value select output
L+3		Output of temperature control
L+4		Derivative control

IBUS, ’GASTWD’, ID, CON(J) to CON(J+31) /

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

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7.8 GGOV1

GE General Governor/Turbine Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			R, Permanent droop, pu
J+1			Tpelec, Electrical power transducer time constant, sec
J+2			maxerr, Maximum value for speed error signal
J+3			minerr, Minimum value for speed error signal
J+4			Kpgov, Governor proportional gain
J+5			Kigov, Governor integral gain
J+6			Kdgov, Governor derivative gain
J+7			Tdgov, Governor derivative controller time constant, sec
J+8			vmax, Maximum valve position limit
J+9			vmin, Minimum valve position limit
J+10			Tact, Actuator time constant, sec
J+11			Kturb, Turbine gain
J+12			Wfnl, No load fuel flow, pu
J+13			Tb, Turbine lag time constant, sec
J+14			Tc, Turbine lead time constant, sec
J+15			Teng, Transport lag time constant for diesel engine, sec
J+16			Tfload, Load Limiter time constant, sec
J+17			Kpload, Load limiter proportional gain for PI controller
J+18			Kiload, Load limiter integral gain for PI controller
J+19			Ldref, Load limiter reference value pu
J+20			Dm, Mechanical damping coefficient, pu
J+21			Ropen, Maximum valve opening rate, pu/sec
J+22			Rclose, Maximum valve closing rate, pu/sec
J+23			Kimw, Power controller (reset) gain
J+24			Aset, Acceleration limiter setpoint, pu/sec
J+25			Ka, Acceleration limiter gain

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CONs	#	Value	Description
J+26			Ta, Acceleration limiter time constant, sec (> 0)
J+27			Trate, Turbine rating (MW)[1]
J+28			db, Speed governor deadband
J+29			Tsa, Temperature detection lead time constant, sec
J+30			Tsb, Temperature detection lag time constant, sec
J+31			Rup, Maximum rate of load limit increase
J+32			Rdown, Maximum rate of load limit decrease

[1] If the turbine rating [CON(J+27)] is greater than zero, the input PELEC is converted in the model to per unit on turbine rating base, else PELEC is converted to per unit on machine base.

STATEs	#	Description
K		Machine Electrical Power Measurement
K+1		Governor Differential Control
K+2		Governor Integral Control
K+3		Turbine Actuator
K+4		Turbine Lead-Lag
K+5		Turbine load limiter measurement
K+6		Turbine Load Limiter Integral Control
K+7		Supervisory Load Control
K+8		Acceleration Control
K+9		Temperature Detection Lead-Lag

VARs	#	Description
L		Load Reference
L+1		Output of Load Limiter PI Control
L+2		Output of Governor PID Control
L+3		Low Value Select Output
L+4		Output of Turbine Actuator
L+5		Output of Turbine Lead-Lag
L+6		Supervisory Load Controller Setpoint, P_{mwset}
L+7 . . . L+19		Delay Table
L+20		Dead Band

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ICONs	#	Value	Description
M		1	Rselect, Feedback signal for governor droop: 1 electrical power 0 none (isochronous governor) -1 fuel valve stroke (true stroke) -2 governor output (requested stroke)
M+1		0	Flag Switch for fuel source characteristic: 0 fuel flow independent of speed 1 fuel flow proportional to speed

R and DM in pu on Turbine MW base when Trate is specified and in pu on generator MVA base when Trate is not entered.

IBUS, 'GGOV1', ID, ICON(M) and ICON(M+1), CON(J) to CON(J+32) /

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Notes:

a. This model can be used to represent a variety of prime movers controlled by PID governors. It is suitable, for example, for representation of:

- gas turbine and single shaft combined cycle turbines
- diesel engines with modern electronic or digital governors
- steam turbines where steam is supplied from a large boiler drum or a large header whose pressure is substantially constant over the period under study
- simple hydro turbines in dam configurations where the water column length is short and water inertia effects are minimal

b. Per unit parameters are on base of the turbine MW base (T_{rate}). If no value is entered for T_{rate}, parameters are specified on generator MVA base.

c. The range of fuel valve travel and of fuel flow is unity. Thus the largest possible value of V_{max} is 1.0 and the smallest possible value of V_{min} is zero. V_{max} may, however, be reduced below unity to represent a loading limit that may be imposed by the operator or a supervisory control system. For gas turbines V_{min} should normally be greater than zero and less than w_{fnl} to represent a minimum firing limit. The value of fuel flow at maximum output must be less than, or equal to unity, depending on the value of k_{turb}.

d. The parameter T_{eng} is provided for use in representing diesel engines where there is a small but measurable transport delay between a change in fuel flow setting and the development of torque. In the majority of cases T_{eng} should be zero.

e. The parameter Flag is provided to recognize that fuel flow, for a given fuel valve stroke, can be proportional to engine speed. This is the case for GE gas turbines and for diesel engines with positive displacement fuel injectors. Flag should be set to unity for all GE gas turbines and most diesel engines. Flag should be set to zero where it is known that the fuel control system keeps fuel flow independent of engine speed.

f. The load limiter module may be used to impose a maximum output limit such as an exhaust temperature limit. To do this the time constant T_{fload} should be set to represent the time constant in the measurement of temperature (or other signal), and the gains of the limiter, K_{pload}, K_{iload}, should be set to give prompt stable control when on limit. The load limit can be deactivated by setting the parameter L_{dref} to a high value.

g. The parameter D_m can represent either the variation of engine power with shaft speed or the variation of maximum power capability with shaft speed.

   If D_m is positive it describes the falling slope of the engine speed versus power characteristic as speed increases. A slightly falling characteristic is typical for reciprocating engines and some aeroderivative turbines.

   If D_m is negative the engine power is assumed to be unaffected by shaft speed, but the maximum permissible fuel flow is taken to fall with falling shaft speed. This is characteristic of single shaft industrial gas turbines.

h. This model includes a simple representation of a supervisory load controller. This controller is active if the parameter K_{imw} is non-zero. The load controller is a slow acting reset loop that adjusts the speed/load reference of the turbine governor to hold the electrical power output of the unit at its initial condition value P_{mwset}.

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P_{mwset} is given a value automatically when the model is initialized and stored in VAR(L+6), and can be changed thereafter. The load controller must be adjusted to respond gently relative to the speed governor. A typical value for K_{imw} is 0.01, corresponding to a reset time of 100 seconds. Setting K_{imw} to 0.001 corresponds to a relatively slow acting load controller.

i. The parameters A_{set}, K_a, and T_a describe an acceleration limiter. These parameters may be set to zero if the limiter is not active.

j. The parameter db is the speed governor dead band. This parameter is in terms of per unit speed.

k. T_{sa} and T_{sb} are provided to augment the exhaust gas temperature measurement subsystem in gas turbines.

l. R_{up} and R_{down} specify the maximum rate of increase and decrease of the output of the load limit controller (K_{pload}/K_{iload}).

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7.9 HYGOV

Hydro Turbine-Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			R, permanent droop
J+1			r, temporary droop
J+2			T_r (>0) governor time constant
J+3			T_f (>0) filter time constant
J+4			T_g (>0) servo time constant
J+5			± VELM, gate velocity limit
J+6			G_{MAX}, maximum gate limit
J+7			G_{MIN}, minimum gate limit
J+8			T_W (>0) water time constant
J+9			A_t, turbine gain
J+10			D_{turb}, turbine damping
J+11			q_{NL}, no power flow

STATEs	#	Description
K		e, filter output
K+1		c, desired gate
K+2		g, gate opening
K+3		q, turbine flow

VARs	#	Description
L		Speed reference
L+1		h, turbine head

R, r, and D_{turb} are in pu on generator MVA base.

IBUS, 'HYGOV', ID, CON(J) to CON(J+11) /

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VAR(L)
nref
Speed
SPEED
Σ
1 / 1 + Tfs
e
1 + Trs / rTrs
Velocity and
Position Limits
c
1 / 1 + Tgs
g
R
SPEED
Dturb
X
÷
q
h
1 / Tws
1
qNL
At
PMECH

7.10 HYGOV2

Hydro Turbine-Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_p
J+1			K_i
J+2			K_A
J+3			T_1
J+4			T_2
J+5			T_3 (> 0)
J+6			T_4 (> 0)
J+7			T_5
J+8			T_6 (> 0)
J+9			T_R (> 0)
J+10			r, temporary droop
J+11			R, permanent droop
J+12			$\pm V_{GMAX}$
J+13			Maximum gate position, G_{MAX}
J+14			Minimum gate position, G_{MIN}
J+15			P_{MAX}

STATEs	#	Description
K		Filter
K+1		Governor
K+2		Governor speed
K+3		Droop
K+4		Gate position
K+5		Penstock

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VAR	#	Description
L		Reference

R. r, and P_{MAX} are in pu on generator MVA base.

IBUS, 'HYGOV2', ID, CON(J) to CON(J+15) /

7.11 HYGOVM

Hydro Turbine-Governor Lumped Parameter Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting	#_____	L.

CONs	#	Value	Description
J			OPTIONS: 0 English units, relief valve 1 Metric units, relief valve 10 English units, jet deflector 11 Metric units, jet deflector
J+1			P_{rated}, rated turbine power (MW)
J+2			Q_{rated}, rated turbine flow (cfs or cms)
J+3			H_{rated}, rated turbine head (ft or m)
J+4			G_{rated}, gate position at rated conditions (pu)
J+5			QNL, no power flow (pu of Q_{rated})
J+6			R, permanent droop (pu)
J+7			r, temporary droop (pu)
J+8			Tr, governor time constant (> 0) (sec)
J+9			Tf, filter time constant (> 0) (sec)
J+10			Tg, servo time constant (> 0) (sec)
J+11			MXGTOR, maximum gate opening rate (pu/sec)
J+12			MXGTCR, maximum gate closing rate (< 0) (pu/sec)
J+13			MXBGOR, maximum buffered gate opening rate (pu/sec)
J+14			MXBGCR, maximum buffered gate closing rate (< 0) (pu/sec)
J+15			BUFLIM, buffer upper limit (pu)
J+16			G_{MAX}, maximum gate limit (pu)
J+17			G_{MIN}, minimum gate limit (pu)
J+18			RVLVCR, relief valve closing rate (< 0) (pu/sec) or MXJDOR, maximum jet deflector opening rate (pu/sec)
J+19			RVLMAX, maximum relief valve limit (pu) or MXJDCR, maximum jet deflector closing rate (< 0) (pu/sec)
J+20			H_{LAKE}, lake head (ft or m)

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CONs	#	Value	Description
J+21			H_{TAIL}, tail head (ft or m)
J+22			PENL/A, summation of penstock, scroll case and draft tube lengths/ cross sections (> 0) (1/ft or 1/m)
J+23			PENLOS, penstock head loss coefficient (ft/cfs^2 or m/cms^2)
J+24			TUNL/A, summation of tunnel lengths/cross sections (>0) (1/ft or 1/m)
J+25			TUNLOS, tunnel head loss coefficient (ft/cfs^2 or m/cms^2)
J+26			SCHARE, surge chamber effective cross section (>0) (ft^2 or m^2)
J+27			SCHMAX, maximum water level in surge chamber (ft or m)
J+28			SCHMIN, minimum water level in surge chamber (ft or m)
J+29			SCHLOS, surge chamber orifice head loss coefficient (ft/cfs^2 or m/cms^2)
J+30			DAMP1, turbine damping under RPM1
J+31			RPM1, overspeed (pu)
J+32			DAMP2, turbine damping above RPM2
J+33			RPM2, overspeed (pu)

STATEs	#	Description
K		e, filter output
K+1		c, desired gate
K+2		g, gate opening
K+3		Relief valve opening or jet deflector position
K+4		Q_{PEN}, penstock flow (cfs or cms)
K+5		Q_{TUN}, tunnel flow (cfs or cms)
K+6		H_{SCH}, surge chamber head (ft or m)

VARs	#	Description
L		Speed reference
L+1		Turbine head (ft or m)
L+2		Turbine flow (cfs or cms)
L+3		Relieve valve flow or deflected jet flow (cfs or cms)
L+4		Head at surge chamber base (ft or m)
L+5		Internal memory

IBUS, ’HYGOVM’, ID, CON(J) to CON(J+33) /

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LEGEND

gv	Gravitational acceleration	A_t	Turbine flow gain
TUNL/A	Summation of length/cross section of tunnel	O	Gate + relief valve opening
SCHARE	Surge chamber cross section	HSCH	Water level in surge chamber
PENLOS	Penstock head loss coefficient	QPEN	Penstock flow
TUNLOS	Tunnel head loss coefficient	QTUN	Tunnel flow
FSCH	Surge chamber orifice head loss coefficient	QSCH	Surge chamber flow
PENL/A	Summation of length/cross section of penstock, scroll case and draft tube		

Hydro Turbine Governor Lumped Parameter Model

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LEGEND

R	Permanent droop	MXBGCR	Maximum buffered gate closing rate
r	Temporary droop	GMAX	Maximum gate limit
Tr	Governor time constant	GMIN	Minimum gate limit
Tf	Filter time constant	RVLVCR	Relief valve closing rate
Tg	Servo time constant	RVLMAX	Maximum relief valve limit
MXGTOR	Maximum gate opening rate	MXJDOR	Maximum jet deflector opening rate
MXGTCR	Maximum gate closing rate	MXJDCR	Maximum jet deflector closing rate
MXBGOR	Maximum buffered gate opening rate		

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7.12 HYGOVRU

Fourth order lead-lag hydro-turbine

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting	#_____	L,

CONs	#	Value	Description
J			db_1
J+1			err
J+2			T_d (sec)
J+3			T_1 (sec)
J+4			T_2 (sec) q
J+5			T_3 (sec)
J+6			T_4 (sec)
J+7			T_5 (sec)
J+8			T_6 (sec)
J+9			T_7 (sec)
J+10			T_8 (sec)
J+11			K_P
J+12			R
J+13			T_t
J+14			K_G
J+15			T_P (sec)
J+16			VEL_{OPEN}
J+17			VEL_{CLOSE}
J+18			P_{MAX}
J+19			P_{MIN}
J+20			db_2
J+21			T_W (>0) water time constant

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J+22			A_t, turbine gain
J+23			D_{turb}, turbine damping
J+24			q_{NL}, no power flow
J+25			T_{rate} (Turbine MW rating)

STATEs	#	Description
K		Output, T_d
K+1		Lead-lag T_1
K+2		Lead-lag T_2
K+3		Lead-lag T_3
K+4		Integrator K_p
K+5		Valve speed
K+6		Gate position
K+7		Generator power
K+8		Lead-lag T_3
K+9		q, turbine flow

VARs	#	Description
L		Reference
L+1		$Deadband_1$ In
L+2		$Deadband_1$ Out
L+3		$Deadband_2$ In
L+4		$Deadband_2$ Out
L+5		h, turbine head

R, P_{MAX}, and P_{MIN} are in pu on turbine MW base if T_{rate} is > 0, else in pu of generator MVA

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IBUS, ‘USRMDL’, ID, ‘HYGOVRU’, 5, 0, 0, 26, 10, 6, CON(J) to CON(J+25) /

7.13 HYGOVT

Hydro Turbine-Governor Traveling Wave Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting	#_____	L,
and ICONs starting	#_____	M.

CONs	#	Value	Description
J			OPTIONS: 0 English units, relief valve 1 Metric units, relief valve 10 English units, jet deflector 11 Metric units, jet deflector
J+1			P_{rated}, rated turbine power (MW)
J+2			Q_{rated}, rated turbine flow (cfs or cms)
J+3			H_{rated}, rated turbine head (ft or m)
J+4			G_{rated}, gate position at rated conditions (pu)
J+5			QNL, no power flow (pu of Q_{rated})
J+6			R, permanent droop
J+7			r, temporary droop (pu)
J+8			Tr, governor time constant (> 0) (sec)
J+9			Tf, filter time constant (> 0) (sec)
J+10			Tg, servo time constant (> 0) (sec)
J+11			MXGTOR, maximum gate opening rate (pu/sec)
J+12			MXGTCR, maximum gate closing rate (< 0) (pu/sec)
J+13			MXBGOR, maximum buffered gate opening rate (pu/sec)
J+14			MXBGCR, maximum buffered gate closing rate (< 0) (pu/sec)
J+15			BUFLIM, buffer upper limit (pu)
J+16			G_{MAX}, maximum gate limit (pu)
J+17			G_{MIN}, minimum gate limit (pu)
J+18			RVLVCR, relief valve closing rate (< 0) (pu/sec) or MXJDOR, maximum jet deflector opening rate (pu/sec)
J+19			RVLMAX, maximum relief valve limit (pu) or MXJDCR, maximum jet deflector closing rate (< 0) (pu/sec)
J+20			H_{LAKE}, lake head (ft or m)

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CONs	#	Value	Description
J+21			H_{TAIL}, tail head (ft or m)
J+22			PENLGTH, penstock length (ft or m)
J+23			PENLOS, penstock head loss coefficient (ft/cfs^2 or m/cms^2)
J+24			TUNLGTH, tunnel length (ft or m)
J+25			TUNLOS, tunnel head loss coefficient (ft/cfs^2 or m/cms^2)
J+26			SCHARE, surge chamber effective cross section (>0) (ft^2 or m^2)
J+27			SCHMAX, maximum water level in surge chamber (ft or m)
J+28			SCHMIN, minimum water level in surge chamber (ft or m)
J+29			SCHLOS, surge chamber orifice head loss coefficient (ft/cfs^2 or m/cms^2)
J+30			DAMP1, turbine damping under RPM1
J+31			RPM1, overspeed (pu)
J+32			DAMP2, turbine damping above RPM2
J+33			RPM2, overspeed (pu)
J+34			PENSPD, penstock wave velocity (>0) (ft/sec or m/sec)
J+35			PENARE, penstock cross section (>0) (ft^2 or m^2)
J+36			TUNSPD, tunnel wave velocity (>0) (ft/sec or m/sec)
J+37			TUNARE, tunnel cross section (>0) (ft^2 or m^2)

STATEs	#	Description
K		e, filter output
K+1		c, desired gate
K+2		g, gate opening
K+3		Relief valve opening or jet deflector position
K+4		Q_{PEN}, Penstock flow at the surge chamber end
K+5		Q_{TUN}, Tunnel flow at the surge chamber end
K+6		H_{SCH}, surge chamber head (ft or m)

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VARs	#	Description
L		Speed reference
L+1		Turbine head (ft or m)
L+2		Turbine flow (cfs or cms)
L+3		Relieve valve flow or deflected jet flow (cfs or cms)
L+4		Head at surge chamber base (ft or m)
L+5		Internal memory
L+6		Penstock flow at surge chamber ends (cfs or cms)
L+7 . . . L+25		Flows along the penstock (cfs or cms)
L+26 . . . L+45		Heads along the penstock (ft or m)
L+46		Penstock head at surge chamber end (ft or m)
L+47 . . . L+65		Flows along the tunnel (cfs or cms)
L+66		Tunnel head at lake end (ft or m)
L+67 . . . L+85		Heads along the tunnel (ft or m)

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ICONs	#	Value	Description
M[1]			Number of VARs representing the penstock
M+1			Travel time between VARs at the penstock, in time steps
M+2			Number of VARs representing the tunnel
M+3			Travel time between VARs at the tunnel, in time steps
M+4			Number of time steps since the last penstock update
M+5			Number of time steps since the last tunnel update

[1] ICON(M) through ICON(M+5) are internal ICONs. Users need not input any values for these ICONs in the DYR record.

IBUS, 'HYGOVT', ID, CON(J) to CON(J+37) /

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Hydro Turbine-Governor Traveling Wave Model

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Hydro Turbine-Governor Traveling Wave Model

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LEGEND:

R	Permanent droop	MXBGCR	Maximum buffered gate closing rate
r	Temporary droop	GMAX	Maximum gate limit
Tr	Governor time constant	GMIN	Minimum gate limit
Tf	Filter time constant	RVLVCR	Relief valve closing rate
Tg	Servo time constant	RVLMAX	Maximum relief valve limit
MXGTOR	Maximum gate opening rate	MXJDOR	Maximum jet deflector opening rate
MXGTCR	Maximum gate closing rate	MXJDCR	Maximum jet deflector closing rate
MXBGOR	Maximum buffered gate opening rate		

Hydro Turbine-Governor Traveling Wave Model

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7.14 IEEEG1

IEEE Type 1 Speed-Governing Model

This model is located at system bus	#____	IBUS,
Machine identifier	#____	ID,
This model may be located at system bus	#____	JBUS,
Machine identifier	#____	M.
This model uses CONs starting with	#____	J,
and STATEs starting with	#____	K,
and VARs starting with	#____	L.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (> 0) (sec)
J+4			U_o (pu/sec)
J+5			U_c (< 0) (pu/sec)
J+6			P_{MAX} (pu on machine MVA rating)
J+7			P_{MIN} (pu on machine MVA rating)
J+8			T_4 (sec)
J+9			K_1
J+10			K_2
J+11			T_5 (sec)
J+12			K_3
J+13			K_4
J+14			T_6 (sec)
J+15			K_5
J+16			K_6
J+17			T_7 (sec)
J+18			K_7
J+19			K_8

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STATEs	#	Description
K		First governor integrator
K+1		Governor output
K+2		First turbine integrator
K+3		Second turbine integrator
K+4		Third turbine integrator
K+5		Fourth turbine integrator

VARs	#	Description
L		Reference, P_0
L+1		Internal memory

Govenor gain K = 1/R is in pu on generator MVA base

IBUS, 'IEEEG1', ID, JBUS, M, CON(J) to CON(J+19) /

7.15 IEEEG2

IEEE Type 2 Speed-Governing Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (>0) (sec)
J+4			P_{MAX} (pu on machine MVA rating)
J+5			P_{MIN} (pu on machine MVA rating)
J+6			T_4 (>0) (sec), water starting time

STATEs	#	Description
K		First integrator
K+1		Second integrator
K+2		Hydro turbine

VAR	#	Description
L		Reference, P_0

Govenor gain K = 1/R is in pu on generator MVA base

IBUS, 'IEEEG2', ID, CON(J) to CON(J+6) /

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7.16 IEEEG3

IEEE Type 3 Speed-Governing Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.
and VAR	#_____	L.

CONs	#	Value	Description
J			T_G, (>0) (sec), gate servomotor time constant
J+1			T_P (>0) (sec), pilot value time constant
J+2			U_o (pu per sec), opening gate rate limit
J+3			U_c (pu per sec), closing gate rate limit (< 0)
J+4			P_{MAX} maximum gate position (pu on machine MVA rating)
J+5			P_{MIN} minimum gate position (pu on machine MVA rating)
J+6			σ, permanent speed droop coefficient
J+7			δ, transient speed droop coefficient
J+8			T_R, (>0) (sec)
J+9			T_W (>0) (sec), water starting time
J+10			a_{11} (>0)
J+11			a_{13}
J+12			a_{21}
J+13			a_{23} (>0)

STATEs	#	Description
K		Servomotor position
K+1		Gate position
K+2		Transient droop compensation
K+3		Hydroturbine

VAR	#	Description
L		Reference, P_0

σ and δ are in pu on generator MVA base.

IBUS, 'IEEEG3', ID, CON(J) to CON(J+13) /

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Po
Uo
PMAX
Δω
SPEED
Σ
1
TG(1 + sTP)
1
S
a23[1 + (a11 − a13a21/a23) sTW]
1 + a11sTW
PM
PMECH
Uc
PMIN
Σ
σ
δsTR
1 + sTR

7.17 IEESGO

IEEE Standard Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_1, controller lag (sec)
J+1			T_2, controller lead compensation (sec)
J+2			T_3, governor lag (>0) (sec)
J+3			T_4, delay due to steam inlet volumes associated with steam chest and inlet piping (sec)
J+4			T_5, reheater delay including hot and cold leads (sec)
J+5			T_6, delay due to IP-LP turbine, crossover pipes, and LP end hoods (sec)
J+6			K_1, 1/per unit regulation
J+7			K_2, fraction
J+8			K_3, fraction
J+9			P_{MAX}, upper power limit
J+10			P_{MIN}, lower power limit

STATEs	#	Description
K		Filter output
K+1		Valve or gate servo output
K+2		Turbine powers
K+3		Turbine powers
K+4		Turbine powers

VAR	#	Description
L		Reference, P_o

Govenor gain K1 = 1/R, Pmax and Pmin are in pu on generator MVA base.

IBUS, 'IEESGO', ID, CON(J) to CON(J+10) /

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7.18 IVOGO

IVO Governor Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			K_1
J+1			A_1
J+2			A_2
J+3			T_1
J+4			T_2
J+5			MAX_1
J+6			MIN_1
J+7			K_3
J+8			A_3
J+9			A_4
J+10			T_3
J+11			T_4
J+12			MAX_3
J+13			MIN_3
J+14			K_5
J+15			A_5
J+16			A_6
J+17			T_5
J+18			T_6
J+19			MAX_5
J+20			MIN_5

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STATEs	#	Description
K		Integrator 1
K+1		Integrator 2
K+2		Integrator 3

VAR	#	Description
L		Reference

Govenor gain K_1 = 1/R, MAX_5 and MIN_5 are in pu on generator MVA base.

IBUS, 'IVOGO', ID, CON(J) to CON(J+20) /

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7.19 PIDGOV

Hydro Turbine-Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			R_{perm}, permanent drop, pu
J+1			T_{reg} (sec), speed detector time constant
J+2			K_p, proportional gain, pu/sec
J+3			K_i, reset gain, pu/sec
J+4			K_d, derivative gain, pu
J+5			T_a (sec) > 0, controller time constant
J+6			T_b (sec) > 0, gate servo time constant
J+7			D_{turb}, turbine damping factor, pu
J+8			G_0, gate opening at speed no load, pu
J+9			G_1, intermediate gate opening, pu
J+10			P_1, power at gate opening G_1, pu
J+11			G_2, intermediate gate opening, pu
J+12			P_2, power at gate opening G_2, pu
J+13			P_3, power at full opened gate, pu
J+14			G_{max}, maximum gate opening, pu
J+15			G_{min}, minimum gate opening, pu
J+16			A_{tw} > 0, factor multiplying T_w, pu
J+17			T_w (sec) > 0, water inertia time constant
J+18			Vel_{max}, minimum gate opening velocity, pu/sec
J+19			Vel_{min} < 0, minimum gate closing velocity, pu/sec

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STATEs	#	Description
K		Input sensor
K+1		PI controller
K+2		First regulator
K+3		Derivative controller
K+4		Second regulator
K+5		Gate position
K+6		Water inertia

VAR	#	Description
L		Reference

ICON	#	Value	Description
M			Feedback signal: 0 Electrical power feedback 1 Gate position

R_{perm} and D_{turb} are in pu on generator MVA base.

IBUS, 'PIDGOV', ID, ICON(M), CON(J) to CON(J+19) /

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VAR(L) = Pref
Flag
ICON(M) = 0
ICON(M) = 1
Rperm / 1 + sTreg
SBASE / MBASE
PELEC
Speed (Δω)
Kp + Ki / s
1 / 1 + sTa
sKd / 1 + sTa
Velmax
Gmax
Velmin
Gmin
1 / Tb
1 / s
Power
Gate
1 - sTz / 1 + sTz/2
Tz = (Atw) * Tw
PMECH
Dturb
DT01_005

7.20 SHAF25

Torsional Shaft Model for 25 Masses

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

This model must be used in conjunction with the GENDCO generator model.

CONs	#	Value	Description
J			X_d - X'_d
J+1			T'_{do}
J+2			Mass number for exciter
J+3			Mass number for generator
J+4			H of mass 1
J+5			H of mass 2
J+6			H of mass 3
J+7			H of mass 4
J+8			H of mass 5
J+9			H of mass 6
J+10			H of mass 7
J+11			H of mass 8
J+12			H of mass 9
J+13			H of mass 10
J+14			H of mass 11
J+15			H of mass 12
J+16			H of mass 13
J+17			H of mass 14
J+18			H of mass 15
J+19			H of mass 16
J+20			H of mass 17
J+21			H of mass 18
J+22			H of mass 19
J+23			H of mass 20
J+24			H of mass 21

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CONs	#	Value	Description
J+25			H of mass 22
J+26			H of mass 23
J+27			H of mass 24
J+28			H of mass 25
J+29			Power fraction of 1
J+30			Power fraction of 2
J+31			Power fraction of 3
J+32			Power fraction of 4
J+33			Power fraction of 5
J+34			Power fraction of 6
J+35			Power fraction of 7
J+36			Power fraction of 8
J+37			Power fraction of 9
J+38			Power fraction of 10
J+39			Power fraction of 11
J+40			Power fraction of 12
J+41			Power fraction of 13
J+42			Power fraction of 14
J+43			Power fraction of 15
J+44			Power fraction of 16
J+45			Power fraction of 17
J+46			Power fraction of 18
J+47			Power fraction of 19
J+48			Power fraction of 20
J+49			Power fraction of 21
J+50			Power fraction of 22
J+51			Power fraction of 23
J+52			Power fraction of 24
J+53			Power fraction of 25
J+54			D of mass 1
J+55			D of mass 2
J+56			D of mass 3
J+57			D of mass 4
J+58			D of mass 5
J+59			D of mass 6
J+60			D of mass 7

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CONs	#	Value	Description
J+61			D of mass 8
J+62			D of mass 9
J+63			D of mass 10
J+64			D of mass 11
J+65			D of mass 12
J+66			D of mass 13
J+67			D of mass 14
J+68			D of mass 15
J+69			D of mass 16
J+70			D of mass 17
J+71			D of mass 18
J+72			D of mass 19
J+73			D of mass 20
J+74			D of mass 21
J+75			D of mass 22
J+76			D of mass 23
J+77			D of mass 24
J+78			D of mass 25
J+79			K shaft mass 1-2
J+80			K shaft mass 2-3
J+81			K shaft mass 3-4
J+82			K shaft mass 4-5
J+83			K shaft mass 5-6
J+84			K shaft mass 6-7
J+85			K shaft mass 7-8
J+86			K shaft mass 8-9
J+87			K shaft mass 9-10
J+88			K shaft mass 10-11
J+89			K shaft mass 11-12
J+90			K shaft mass 12-13
J+91			K shaft mass 13-14
J+92			K shaft mass 14-15
J+93			K shaft mass 15-16
J+94			K shaft mass 16-17
J+95			K shaft mass 17-18
J+96			K shaft mass 18-19

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CONs	#	Value	Description
J+97			K shaft mass 19-20
J+98			K shaft mass 20-21
J+99			K shaft mass 21-22
J+100			K shaft mass 22-23
J+101			K shaft mass 23-24
J+102			K shaft mass 24-25

STATEs	#	Description
K		Slip at mass 1
K+1		Slip at mass 2
K+2		Slip at mass 3
K+3		Slip at mass 4
K+4		Slip at mass 5
K+5		Slip at mass 6
K+6		Slip at mass 7
K+7		Slip at mass 8
K+8		Slip at mass 9
K+9		Slip at mass 10
K+10		Slip at mass 11
K+11		Slip at mass 12
K+12		Slip at mass 13
K+13		Slip at mass 14
K+14		Slip at mass 15
K+15		Slip at mass 16
K+16		Slip at mass 17
K+17		Slip at mass 18
K+18		Slip at mass 19
K+19		Slip at mass 20
K+20		Slip at mass 21
K+21		Slip at mass 22
K+22		Slip at mass 23
K+23		Slip at mass 24
K+24		Slip at mass 25

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VARs	#	Description
L		T electrical of exciter
L+1		T shaft 1-2
L+2		T shaft 2-3
L+3		T shaft 3-4
L+4		T shaft 4-5
L+5		T shaft 5-6
L+6		T shaft 6-7
L+7		T shaft 7-8
L+8		T shaft 8-9
L+9		T shaft 9-10
L+10		T shaft 10-11
L+11		T shaft 11-12
L+12		T shaft 12-13
L+13		T shaft 13-14
L+14		T shaft 14-15
L+15		T shaft 15-16
L+16		T shaft 16-17
L+17		T shaft 17-18
L+18		T shaft 18-19
L+19		T shaft 19-20
L+20		T shaft 20-21
L+21		T shaft 21-22
L+22		T shaft 22-23
L+23		T shaft 23-24
L+24		T shaft 24-25
L+25		Angle at mass 1
L+26		Angle at mass 2
L+27		Angle at mass 3
L+28		Angle at mass 4
L+29		Angle at mass 5
L+30		Angle at mass 6
L+31		Angle at mass 7
L+32		Angle at mass 8
L+33		Angle at mass 9
L+34		Angle at mass 10

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VARs	#	Description
L+35		Angle at mass 11
L+36		Angle at mass 12
L+37		Angle at mass 13
L+38		Angle at mass 14
L+39		Angle at mass 15
L+40		Angle at mass 16
L+41		Angle at mass 17
L+42		Angle at mass 18
L+43		Angle at mass 19
L+44		Angle at mass 20
L+45		Angle at mass 21
L+46		Angle at mass 22
L+47		Angle at mass 23
L+48		Angle at mass 24
L+49		Angle at mass 25
L+50		Working storage locations
L+51		
L+52		
.		
.		
.		
L+74		

ICONs	#	Value	Description
M			STATE number containing Δ speed from GENDCO
M+1			VAR number containing electrical torque (from GENDCO)

IBUS, 'SHAF25', ID, CON(J) to CON(J+102) /

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7.21 TGOV1

Steam Turbine-Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			R
J+1			T_1 (>0) (sec)
J+2			V_{MAX}[1]
J+3			V_{MIN}[1]
J+4			T_2 (sec)[2]
J+5			T_3 (>0) (sec)[3]
J+6			D_t[1]

[1] V_{MAX}, V_{MIN}, D_t and R are in per unit on generator MVA base.
[2] T_2/T_3 = high-pressure fraction.
[3] T_3 = reheater time constant.

STATEs	#	Description
K		Valve opening
K+1		Turbine power

VARs	#	Description
L		Reference

IBUS, 'TGOV1', ID, CON(J) to CON(J+6) /

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7.22 TGOV2

Steam Turbine-Governor With Fast Valving

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			R (pu)
J+1			T_1 (>0) (sec)
J+2			V_{MAX} (pu)
J+3			V_{MIN} (pu)
J+4			K (pu)
J+5			T_3 (>0) (sec)
J+6			D_t (pu)
J+7			T_t (>0) (sec)
J+8			T_A
J+9			T_B
J+10			T_C

STATEs	#	Description
K		Throttle
K+1		Reheat pressure
K+2		Reheat power
K+3		Intercept valve position, V

VARs	#	Description
L		Speed reference
L+1		Fast valving initial time, T_I

V_{MAX}, V_{MIN} and R are in pu on generator MVA base.

IBUS, 'TGOV2', ID, CON(J) to CON(J+10) /

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T_I [VAR(L+1)]: TIME to initiate fast valving.

T_A [CON(J+8)]: Intercept valve, v, fully closed T_A seconds after fast valving initiation.

T_B [CON(J+9)]: Intercept valve starts to reopen T_B seconds after fast valving initiation.

T_C [CON(J+10)]: Intercept valve again fully open T_C seconds after fast valving initiation.

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7.23 TGOV3

Modified IEEE Type 1 Speed-Governing Model With Fast Valving

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (>0) (sec)
J+4			U_o
J+5			U_c (< 0)
J+6			P_{MAX}
J+7			P_{MIN}
J+8			T_4 (sec)
J+9			K_1
J+10			T_5 (> 0) (sec)
J+11			K_2
J+12			T_6 (sec)
J+13			K_3
J+14			T_A (sec)
J+15			T_B (sec)
J+16			T_C (sec)
J+17			P_{RMAX} (pu)

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STATEs	#	Description
K		First governor integrator
K+1		Governor output
K+2		First turbine integrator
K+3		Second turbine integrator
K+4		Third turbine integrator
K+5		Intercept valve position, v

VARs	#	Description
L		Reference
L+1		Fast valving initial time, T_I

Govenor gain K = 1/R, P_{MAX} and P_{MIN} are in pu on generator MVA base.

IBUS, 'TGOV3', ID, CON(J) to CON(J+17) /

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PMECH
Δω
SPEED
Po
K(1 + sT2) / (1 + sT1)
1 / T3
Uo
Uc
1 / S
PMAX
PMIN
1 / (1 + sT4)
K1
PRMAX
1 / T5s
V
Flow
0.8
0 0.3
Intercept Valve Position
1 / (1 + sT6)
K2
K3
Σ
Intercept Valve Position
1
0
TC
TB
TA
TI (TI + TA) (TI + TB) (TI+TC)
PSS®E Time Variable, TIME
TI [VAR(L+1)]: TIME to initiate fast valving.
TA [CON(J+8)]: Intercept valve, v, fully closed TA seconds after fast valving initiation.
TB [CON(J+9)]: Intercept valve starts to reopen TB seconds after fast valving initiation.
TC [CON(J+10)]: Intercept valve again fully open TC seconds after fast valving initiation.

7.24 TGOV4

Modified IEEE Type 1 Speed-Governing Model With PLU and EVA

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (> 0) (sec)
J+4			U_o
J+5			U_c (< 0)
J+6			K_{CAL}
J+7			T_4 (sec)
J+8			K_1
J+9			T_5 (> 0) (sec)
J+10			K_2
J+11			T_6 (sec)
J+12			P_{RMAX}
J+13			K_P
J+14			K_I
J+15			T_{Fuel} (sec)
J+16			T_{FD1} (sec)
J+17			T_{FD2} (sec)
J+18			K_b
J+19			C_b (> 0) (sec)
J+20			T_{IV} (> 0) (sec)
J+21			U_{OIV}
J+22			U_{CIV}
J+23			R (>0)

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CONs	#	Value	Description
J+24			Offset
J+25			CV position demand characteristic
J+26			CV #2 offset
J+27			CV #3 offset
J+28			CV #4 offset
J+29			IV position demand characteristic
J+30			IV #2 offset
J+31			CV valve characteristic
J+32			IV valve characteristic
J+33			CV starting time for valve closing (sec)
J+34			CV closing rate (pu/sec)
J+35			Time closed for CV #1 (sec)
J+36			Time closed for CV #2
J+37			Time closed for CV #3
J+38			Time closed for CV #4
J+39			IV starting time for valve closing (sec)
J+40			IV closing rate (pu/sec)
J+41			Time closed for IV #1 (sec)
J+42			Time closed for IV #2 (sec)
J+43			TRPLU (>0) (sec)
J+44			PLU rate level
J+45			Timer
J+46			PLU unbalance level
J+47			TREVA (>0) (sec)
J+48			EVA rate level
J+49			EVA unbalance level
J+50			Minimum load reference (pu)
J+51			Load reference ramp rate (pu/sec)

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STATEs	#	Description
K		CV speed controller integrator
K+1		CV #1 valve position
K+2		CV #2 valve position
K+3		CV #3 valve position
K+4		CV #4 valve position
K+5		HP steam flow ($\dot{m}_{SHP}$)
K+6		Reheat pressure
K+7		LP steam flow ($\dot{m}_{SLP}$)
K+8		IV #1 valve position
K+9		IV #2 valve position
K+10		Boiler pressure controller integrator
K+11		Fuel integrator
K+12		Fuel delay #1 integrator
K+13		Fuel delay #2 integrator
K+14		Drum pressure
K+15		PLU rate integrator
K+16		EVA rate integrator

VARs	#	Description
L		Load reference
L+1		Boiler pressure reference
L+2		IV load reference
L+3		Boiler pressure
L+4		CV flow area
L+5		IV flow area
L+6		K_{CV}
L+7		K_{IV}
L+8		CV position demand characteristic, K
L+9		CV position demand characteristic, A
L+10		IV position demand characteristic, K
L+11		IV position demand characteristic, A
L+12		CV valve characteristic, K
L+13		CV valve characteristic, A
L+14		IV valve characteristic, K

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VARs	#	Description
L+15		IV valve characteristic, A
L+16		Generator current (pu on machine base)
L+17		PLU rate output signal
L+18		Time when TIMER initialized
L+19		PLU unbalance signal
L+20		EVA unbalance signal
L+21		EVA rate output signal
L+22		Time of CV signal to close
L+23		Time of IV signal to close
L+24		Time when CVs closed
L+25		Time when IVs closed

ICONs	#	Value	Description
M			NCV, Number of control valves
M+1			NIV, Number of intercept valves
M+2			MODE, Control mode: 0 No PLU or EVA 1 User-controlled PLU/EVA 2 PLU 3 PLU and EVA
M+3		X	Internal (CV status)
M+4		X	Internal (IV status)
M+5		X	Internal (PLU or EVA switch)
M+6		X	Internal (latch/unlatch switch)

IBUS, 'TGOV4', ID, ICON(M) to ICON(M+2), CON(J) to CON(J+26) /

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7.25 TGOV5

IEEE Type 1 Speed-Governing Model Modified to Include Boiler Controls

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model may be located at system bus	#_____	JBUS,
Machine identifier	#_____	M.
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (>0) (sec)
J+4			U_o
J+5			U_c (<0)
J+6			V_{MAX}
J+7			V_{MIN}
J+8			T_4 (sec)
J+9			K_1
J+10			K_2
J+11			T_5 (sec)
J+12			K_3
J+13			K_4
J+14			T_6 (sec)
J+15			K_5
J+16			K_6
J+17			T_7 (sec)
J+18			K_7
J+19			K_8
J+20			K_9
J+21			K_{10}
J+22			K_{11}

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CONs	#	Value	Description
J+23			K_{12}
J+24			K_{13}
J+25			K_{14}
J+26			R_{MAX}
J+27			R_{MIN}
J+28			L_{MAX}
J+29			L_{MIN}
J+30			C_1
J+31			C_2
J+32			C_3
J+33			B
J+34			C_B (>0) (sec)
J+35			K_I
J+36			T_I (sec)
J+37			T_R (sec)
J+38			T_{R1} (sec)
J+39			C_{MAX}
J+40			C_{MIN}
J+41			T_D (sec)
J+42			T_F (sec)
J+43			T_W (sec)
J+44			P_{sp} (initial) (>0)
J+45			T_{MW} (sec)
J+46			K_L (0.0 or 1.0)
J+47			K_{MW} (0.0 or 1.0)
J+48			ΔP_E (pu pressure)

STATEs	#	Description
K		First governor integrator
K+1		Valve area
K+2		First turbine integrator, $\dot{m}_s$
K+3		Second turbine integrator

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STATEs	#	Description
K+4		Third turbine integrator
K+5		Fourth turbine integrator
K+6		P_o
K+7		Drum pressure, P_D
K+8		First controller integrator
K+9		Second controller integrator
K+10		Fuel
K+11		Water walls
K+12		First delay integrator
K+13		Second delay integrator
K+14		Third delay integrator
K+14		Fourth delay integrator
K+16		Measured MW

VARs	#	Description
L		Internal memory
L+1		Pressure setpoint, P_{sp}
L+2		MW demand
L+3		Pressure error, P_E
L+4		Throttle pressure, P_T
L+5		C_2 VAR
L+6		C_3 VAR

Govenor gain K-1/R, L_{MAX} and L_{MIN} in pu on generator MVA base.

IBUS, 'TGOV5', ID, JBUS, M, CON(J) to CON(J+48) /

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Δω
SPEEDHP
K(1 + sT2) / 1 + sT1
1/T3
Uo
Uc
VMAX
VMIN
1/S
x
1/(1 + sT4)
ṁs
1/(1 + sT5)
1/(1 + sT6)
1/(1 + sT7)
K1
K2
K3
K4
K5
K6
K7
K8
PMECHHP
PM1
PMECHLP
PM2
Po
PT
PELEC
Δf
B
KMW / 1 + sTMW
LMAX
LMIN
RMAX
RMIN
K14
KL
MW Demand
Desired MW
C2
K13
K12
PE (Pressure Error)
Dead Band
−ΔPE
ΔPE
PSP
C3
CMAX
Controller
KI(1 + sTI) (1 + sTR) / s(1 + sTR1)
PE
PD
K9
C1
1/CBs
Fuel Dynamics
e-sTD / (1 + sTF) (1 + sTW)
K11
K10
Desired MW

7.26 TURCZT

Czech Hydro and Steam Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.
and ICON	#_____	M.

CONs	#	Value	Description
J			f_{DEAD} (pu)
J+1			f_{MIN} (pu)
J+2			f_{MAX} (pu)
J+3			K_{KOR} (pu)
J+4			$K_M > 0$ (pu)
J+5			K_P (pu)
J+6			SDEAD (pu)
J+7			K_{STAT} (pu)
J+8			K_{HP} (pu)
J+9			T_C (sec)
J+10			$T_I{}^1$ (sec)
J+11			T_{EHP} (sec)
J+12			$T_V > 0$ (sec)
J+13			T_{HP} (sec)
J+14			T_R (sec)
J+15			T_W (sec)
J+16			N_{TMAX} (pu)
J+17			N_{TMIN} (pu)
J+18			G_{MAX} (pu)
J+19			G_{MIN} (pu)
J+20			V_{MIN} (pu/sec)
J+21			V_{MAX} (pu/sec)

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[1] For T_I = 0, STATE(K) and STATE(K+1) are both zero and K_P must be greater than zero.

STATEs	#	Description
K		Transducer
K+1		PI regulator
K+2		Hydro converter
K+3		Regulation valves
K+4		Hydro unit/HP part
K+5		Reheater

VARs	#	Description
L		N_{TREF}
L+1		dF_{REF}
L+2		Y_{REG}

ICON	#	Value	Description
M			SWITCH: 0 Hydro 1 Steam

Govenor gain K_{KOR} = 1/R is in pu on generator MVA base.

IBUS, 'TURCZT', ID, ICON (M), CON(J) to CON(J+21) /

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Governor

Turbine

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7.27 TWDM1T

Tail Water Depression Hydro Governor Model 1

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			R, permanent droop
J+1			r, temporary droop
J+2			T_r, governor time constant (>0)
J+3			T_f, filter time constant (>0)
J+4			T_g, servo time constant (>0)
J+5			VELMX, open gate velocity limit (pu/sec)
J+6			VELMN, close gate velocity limit (pu/sec) (<0)
J+7			G_{MAX}, maximum gate limit
J+8			G_{MIN}, minimum gate limit
J+9			T_W, water time constant (sec) (>0)
J+10			A_t, turbine gain
J+11			D_{turb}, turbine damping
J+12			q_{NL}, no power flow
J+13			F_1, frequency deviation (pu)
J+14			T_{F1}, time delay (sec)
J+15			F_2, frequency deviation (pu)
J+16			sF_2, frequency (pu/sec)
J+17			T_{F2}, time delay (sec)
J+18			GMXRT, rate with which G_{MAX} changes when TWD is tripped (pu/sec)
J+19			N_{REF}, setpoint frequency deviation (pu)
J+20			T_{ft}, frequency filter time constant (>0

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STATEs	#	Description
K		e, filter output
K+1		e, filter output
K+2		c, desired Gate
K+3		g, gate opening
K+4		q, turbine flow
K+5		G_{MAX} state

VARs	#	Description
L		N_{REF}, speed reference
L+1		h, turbine head
L+2		Internal memory
L+3		Internal memory
L+4		Measured frequency rate

ICONs	#	Value	Description
M			0 TWD has not tripped 1 TWD has tripped
M+1			= 0, calculate N_{REF} $\neq$ 0, N_{REF} = CON(J+19)

IBUS,'TWDM1T', ID, ICON (M) and ICON (M+1), CON(J) to CON(J+20) /

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Tail Water Depression Model 1

Tail Water Depression Trip Model

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7.28 TWDM2T

Tail Water Depression Hydro Governor Model 2

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{REG} (sec)
J+1			Reg
J+2			K_P
J+3			K_I
J+4			K_D
J+5			T_A (sec) (> 0)
J+6			T_B (sec) (> 0)
J+7			VELMX (pu/sec)
J+8			VELMN (pu/sec) (> 0)
J+9			GATMX (pu)
J+10			GATMN (pu)
J+11			T_W (sec) (> 0)
J+12			A_t, turbine gain
J+13			q_{NL}, no power flow
J+14			D_{turb}, turbine damping
J+15			F_1, frequency deviation (pu)
J+16			T_{F1}, time delay (sec)
J+17			F_2, frequency deviation (pu)
J+18			sF_2, frequency (pu/sec)
J+19			T_{F2}, time delay (sec)
J+20			P_{REF}, power reference (pu)
J+21			T_{ft}, frequency filter time constant (sec) (>0)

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STATEs	#	Description
K		Measured electrical power deviation
K+1		PID controller
K+2		First lag
K+3		Second lag
K+4		Rate
K+5		Rate
K+6		q, turbine flow
K+7		Measured frequency

VARs	#	Description
L		P_{REF}, electrical power reference
L+1		h, turbine head
L+2		Internal memory
L+3		Internal memory
L+4		Measured frequency rate

ICONs	#	Value	Description
M			0 TWD has not tripped 1 TWD has tripped
M+1			= 0, calculate P_{REF} $\neq$ 0, P_{REF} = CON(J+20)

IBUS, 'TWDM2T', ID, ICON (M) and ICON (M+1), CON(J) to CON(J+21) /

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Tail Water Depression Model 2

Tail Water Depression Trip Model

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7.29 URCSCT

Combined Cycle on Single Shaft

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J • • • J+30			Refer to model GAST2A CONs
J+31 • • • J+50			Refer to model IEEEG1 CONs
J+51			ST Rating, Steam turbine rating (MW)
J+52			POUT A, Plant total, point A (MW)
J+53			STOUT A, Steam turbine output, point A (MW)
J+54			POUT B, Plant total, point B (MW)
J+55			STOUT B, Steam turbine output, point B (MW)
J+56			POUT C, Plant total, point C (MW)
J+57			STOUT C, Steam turbine output, point C (MW)

Note: CON(J+37) and CON(J+38) of the URCST model (which are PMAX and PMIN values corresponding to the IEEEG1 model) are the pu on steam turbine MW rating specified in CON(J+51).

STATEs	#	Description
K • • • K+12		Refer to model GAST2A STATEs
K+13 • • • K+18		Refer to model IEEEG1 STATEs

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VARs	#	Description
L • • • L+3		Refer to model GAST2A VARs
L+4		Refer to model IEEEG1 VARs
L+5		

IBUS, 'URCSCT', ID, GAST2A CONs, IEEEG1 CONs, CON(J+51) to CON(J+57) /

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7.30 URGS3T

WECC Gas Turbine Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			R
J+1			T_1 (> 0) (sec)
J+2			T_2 (> 0) (sec)
J+3			T_3 (> 0) (sec)
J+4			Lmax
J+5			Kt
J+6			Vmax
J+7			Vmin
J+8			Dturb
J+9			Fidle
J+10			Rmax
J+11			Linc (> 0)
J+12			T_{ltr} (>0) (sec)
J+13			Ltrat
J+14			a
J+15			b (> 0)
J+16			db_1
J+17			err
J+18			db_2
J+19			GV1
J+20			P_{GV1}
J+21			GV2
J+22			P_{GV2}
J+23			GV3

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CONs	#	Value	Description
J+24			P_{GV3}
J+25			GV4
J+26			P_{GV4}
J+27			GV5
J+28			P_{GV5}
J+29			Ka
J+30			T_4
J+31			T_5
J+32			MWCAP

STATEs	#	Description
K		Governor output
K+1		Engine output
K+2		Exhaust temperature delay
K+3		Load limit
K+4		Governor lead/lag

VARs	#	Description
L		Reference
L+1		Deadband, In
L+2		Deadband, Out
L+3		$Deadband_2$, In
L+4		$Deadband_2$, Out

R and D_{turb} are in pu on generator MVA base.

IBUS, 'URGS3T', ID, CON(J) to CON(J+32) /

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1 / (1 + sT_ltr)
If (Dv > Linc), then Rlim = Ltrat
else, Rlim = Rmax
Dv
Vmax
Rlim
Pref
err
db1
Ka(1 + sT4) / (1 + sT5)
LV Gate
1 / sT1
Vmin
Fidle
1 + asT2 / 1 + bsT2
PGV
GV
db2
Pmec
1 / R
Fidle
Kt
1 / (1 + sT3)
Lmax
Speed
Dturb

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7.31 WEHGOV

Woodward Electric Hydro Governor Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			R-PERM-GATE[1]
J+1			R-PERM-PE[1]
J+2			T_{PE} (sec)
J+3			K_p
J+4			K_I
J+5			K_D
J+6			T_D (sec)
J+7			T_P (sec)
J+8			T_{DV} (sec)
J+9			T_g (sec)
J+10			GTMXOP (>0)
J+11			GTMXCL (<0)

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CONs	#	Value	Description
J+12			GMAX
J+13			GMIN
J+14			D_{TURB}
J+15			T_W (sec)
J+16			Speed Dead Band (DBAND)
J+17			DPV
J+18			DICN
J+19			GATE 1
J+20			GATE 2
J+21			GATE 3
J+22			GATE 4
J+23			GATE 5
J+24			FLOW G1
J+25			FLOW G2
J+26			FLOW G3
J+27			FLOW G4
J+28			FLOW G5
J+29			FLOW P1
J+30			FLOW P2
J+31			FLOW P3
J+32			FLOW P4
J+33			FLOW P5
J+34			FLOW P6
J+35			FLOW P7
J+36			FLOW P8
J+37			FLOW P9
J+38			FLOW P10
J+39			PMECH 1
J+40			PMECH 2
J+41			PMECH 3
J+42			PMECH 4
J+43			PMECH 5
J+44			PMECH 6
J+45			PMECH 7
J+46			PMECH 8

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CONs	#	Value	Description
J+47			PMECH 9
J+48			PMECH 10

[1] Feedback settings.

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STATEs	#	Description
K		Pilot valve position
K+1		Distribution valve position
K+2		Gate position
K+3		Turbine flow
K+4		Derivative controller
K+5		Integral controller
K+6		PE transducer output

VARs	#	Description
L		Reference
L+1		Turbine head
L+2		Controller output
L+3		Gate position

ICON	#	Value	Description
M			Feedback signal switch[1] (0 or 1)

[1] Feedback settings.

Feedback Signal	CON(J)	CON(J+1)	ICON(M)
Electrical Power	0	Droop	0
Gate Position	Droop	0	0
PID Output	Droop	0	1

R-PERM-GATE, R-PERM-PE and D_{TURB} are i n pu on generator MVA base.

IBUS, 'WEHGOV', ID, ICON(M), CON(J) to CON(J+48) /

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Turbine Dynamics

7.32 WESGOV

Westinghouse Digital Governor for Gas Turbine

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			ΔTC (sec), Δt sample for controls
J+1			ΔTP (sec), Δt sample for PE
J+2			Droop
J+3			K_p
J+4			T_I (> 0) (sec)
J+5			T_1 (sec)
J+6			T_2 (sec)
J+7			A_{LIM}
J+8			T_{pe} (sec)

STATEs	#	Description
K		PE transducer
K+1		Valve position
K+2		PMECH

VARs	#	Description
L		References
L+1		PI output
L+2		Integration for PI
L+3		Integration for PI
L+4		P_E transducer output
L+5		Speed measurement

Droop is in pu on generator MVA base.

IBUS, 'WESGOV', ID, CON(J) to CON(J+8) /

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*Sample hold with sample period defined by ΔTC.

**Sample hold with sample period defined by ΔTP.

***Maximum change is limited to A_{LIM} between sampling times.

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7.33 WPIDHY

Woodward PID Hydro Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L.

CONs	#	Value	Description
J			T_{REG} (sec)
J+1			REG[1]
J+2			K_P
J+3			K_I
J+4			K_D
J+5			T_A (>0) (sec)
J+6			T_B (>0) (sec)
J+7			VELMX (>0)
J+8			VELMN (<0)
J+9			GATMX
J+10			GATMN
J+11			T_W (>0) (sec)
J+12			P_{MAX}
J+13			P_{MIN}
J+14			D
J+15			G_0
J+16			G_1
J+17			P_1
J+18			G_2
J+19			P_2
J+20			P_3

[1] REG has to be input as a negative value because the input to REG block is P_{ELEC} - P_{REF} instead of P_{REF} - P_{ELEC}.

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STATEs	#	Description
K		Measured electrical power deviation
K+1		PID controller
K+2		First lag
K+3		Second lag
K+4		Rate
K+5		Gate
K+6		Mechanical power

VAR	#	Description
L		Electrical power reference

REG, P_{MAX}, P_{MIN}, and D are in pu on generator MVA base.

IBUS, 'WPIDHY', ID, CON(J) to CON(J+20) /

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7.34 WSHYDD

WECC Double-Derivative Hydro Governor

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			db_1
J+1			err
J+2			T_d (sec)
J+3			K_1
J+4			T_f (sec)
J+5			K_D
J+6			K_P
J+7			R
J+8			T_t
J+9			K_G
J+10			T_P (sec)
J+11			VEL_{OPEN} (>0)
J+12			VEL_{CLOSE} (>0)
J+13			P_{MAX}
J+14			P_{MIN}
J+15			db_2
J+16			GV_1
J+17			P_{GV1}
J+18			GV_2
J+19			P_{GV2}
J+20			GV_3
J+21			P_{GV3}
J+22			GV_4

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CONs	#	Value	Description
J+23			P_{GV4}
J+24			GV_5
J+25			P_{GV5}
J+26			A_{turb}
J+27			B_{turb} (> 0)
J+28			T_{turb} (> 0) (sec)
J+29			T_{rate}

STATEs	#	Description
K		Output, T_d
K+1		K_1 state
K+2		K_D first
K+3		K_D second
K+4		CV
K+5		Valve speed
K+6		Gate position
K+7		Generator power
K+8		Turbine

VARs	#	Description
L		Reference
L+1		$Deadband_1$ In
L+2		$Deadband_1$ Out
L+3		P_{MAX}
L+4		P_{MIN}
L+5		$Deadband_2$ In
L+6		$Deadband_2$ Out

R_1, P_{MAX}, and P_{MIN} are in pu on turbine MW base.

IBUS, 'WSHYDD', ID, CON(J) to CON(J+29) /

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7.35 WSHYGP

WECC GP Hydro Governor Plus Turbine

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			db_1
J+1			err
J+2			T_d (sec)
J+3			K_I
J+4			T_f (sec)
J+5			K_D
J+6			K_P
J+7			R
J+8			T_t
J+9			K_G
J+10			T_P (sec)
J+11			VEL_{OPEN} (>0)
J+12			VEL_{CLOSE} (>0)
J+13			P_{MAX}
J+14			P_{MIN}
J+15			db_2
J+16			GV_1
J+17			P_{GV1}
J+18			GV_2
J+19			P_{GV2}
J+20			GV_3
J+21			P_{GV3}
J+22			GV_4

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CONs	#	Value	Description
J+23			P_{GV4}
J+24			GV_5
J+25			P_{GV5}
J+26			A_{turb}
J+27			B_{turb} (> 0)
J+28			T_{turb} (sec)
J+29			T_{rate}

STATEs	#	Description
K		Output, T_d
K+1		Integrator state
K+2		Derivative state
K+3		Valve speed
K+4		Gate position
K+5		Generator power
K+6		Turbine

VARs	#	Description
L		Reference
L+1		$Deadband_1$ In
L+2		$Deadband_1$ Out
L+3		P_{MAX}
L+4		P_{MIN}
L+5		$Deadband_2$ In
L+6		$Deadband_2$ Out

IBUS, 'WSHYGP', ID, CON(J) to CON(J+29) /

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SW
(Speed)
err
db1
PREF
+
−
Σ
1
1 + sTd
KP
KI
S
sKD
1 + sTf
CV
(Tt = 0)
R
(Tt > 0)
1
1 + sTt
PE
PELEC
VELOPEN
PMAX
KG
1 + sTP
1
S
GVdes
db2
GV
NGV
PGV
1 + s Aturb Tturb
1 + s Bturb Tturb
Trate
MVA
PM
PMECH
VELCLOSE
PMIN

7.36 WSIEG1

WECC Modified IEEE Type 1 Speed-Governing Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model may be located at system bus	#_____	JBUS,
Machine	#_____	M,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

Note: JBUS and JM are zero for non-crosscompound.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3(> 0) (sec)
J+4			U_o
J+5			U_c (< 0)
J+6			P_{MAX}
J+7			P_{MIN}
J+8			T_4 (sec)
J+9			K_1
J+10			K_2
J+11			T_5 (sec)
J+12			K_3
J+13			K_4
J+14			T_6 (sec)
J+15			K_5
J+16			K_6
J+17			T_7 (sec)
J+18			K_7
J+19			K_8
J+20			db_1
J+21			err

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CONs	#	Value	Description
J+22			db_2
J+23			GV_1
J+24			P_{GV1}
J+25			GV_2
J+26			P_{GV2}
J+27			GV_3
J+28			P_{GV3}
J+29			GV_4
J+30			P_{GV4}
J+31			GV_5
J+32			P_{GV5}
J+33			IBLOCK

STATEs	#	Description
K		1st governor integrator
K+1		Governor output
K+2		1st turbine integrator
K+3		2nd turbine integrator
K+4		3rd turbine integrator
K+5		4th turbine integrator

VARs	#	Description
L		Reference
L+1		Internal memory
L+2		$Deadband_1$ in
L+3		$Deadband_1$ out
L+4		P'_{MAX}
L+5		P'_{MIN}
L+6		$Deadband_2$ in
L+7		$Deadband_2$ out

IBUS, 'WSIEG1', ID, JBUS, M, CON(J) to CON(J+33) /

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At initialization:

IBLOCK = 0	$P'_{MAX} = P_{MAX}$	$P'_{MIN} = P_{MIN}$
IBLOCK = 1	If $P_{MIN} = 0$	$P'_{MIN} = P_{INITIAL}$
IBLOCK = 2	If $P_{MAX} = 0$	$P'_{MAX} = P_{INITIAL}$
IBLOCK = 3	If $P_{MIN} = 0$ If $P_{MAX} = 0$	$P'_{MIN} = P_{INITIAL}$ $P'_{MAX} = P_{INITIAL}$

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Chapter 8

Turbine Load Controller Model Data Sheets

This chapter contains a collection of data sheets for the turbine-load controller models contained in the PSS®E dynamics model library.

Model	Description
LCFB1	Turbine load controller model

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8.1 LCFB1

Turbine Load Controller Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICONs starting with #_____ M.

CONs	#	Value	Description
J			Fb
J+1			Tpelec
J+2			db
J+3			emax
J+4			Kp
J+5			KI
J+6			Irmax

STATEs	#	Description
K		Measured power
K+1		Integrator

VARs	#	Description
L		Deadband input
L+1		Deadband output
L+2		Pref 0

ICONs	#	Value	Description
M			Frequency bias flag, 0 or 1
M+1			Power controller flag, 0 or 1

IBUS, 'LCFB1', ID, ICON(M), ICON(M+1), CON(J) to CON(J+6) /

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This model can be used with the following turbine governor models.

DEGOV1	PIDGOV	HYGOVM	WSHYGP
GAST	TGOV1	HYGOVT	WSIEG1
GAST2A	TGOV2	IVOGO	TGOV5
GASTWD	TGOV3	TGOV4	
HYGOV	WEHGOV	TURGZT	
IEEEG1	WESGOV	TWDM1T	
IEEEG2	WPIDHY	TWDM2T	
IEEEG3	BBGOV1	URGS3T	
IEESGO	HYGOV2	WSHYDD	

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Chapter 9

Load Characteristic Model Data Sheets

This chapter contains a collection of data sheets for the load characteristic models contained in the PSS®E dynamics model library.

Model	Description
ACMTBLU1, ACMTOWU1, ACMTZNU1, ACMTARU1, ACMTALU1	User written performance based model of single phase air conditioner motor.
CIM5BL, CIM5OW, CIM5ZN, CIM5AR, CIM5AL	Induction motor model.
CIM6BL, CIM6OW, CIM6ZN, CIM6AR, CIM6AL	Induction motor model.
CIMWBL, CIMWOW, CIMWZN, CIMWAR, CIMWAL	Induction motor model (WECC).
CLODBL, CLODOW, CLODZN, CLODAR, CLODAL	Complex load model.
CMLDBLU1, CMLDOWU1, CMLDZNU1, CMLDARU1, CMLDALU1	User-written composite load model
EXTLBL, EXTLOW, EXTLZN, EXTLAR, EXTLAL	Extended-term load reset model.
IEELBL, IEELOW, IEELZN, IEELAR, IEELAL	IEEE load model.
LDFRBL, LDFROW, LDFRZN, LDFRAR, LDFRAL	Load frequency model.

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9.1 ACMTBLU1, ACMTOWU1, ACMTZNU1, ACMTARU1, ACMTALU1

Single-phase Air Conditioner Motor Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and Reserved ICONs starting with	#_____	N.

CONs	#	Value	Description
J			T_{stall}, Stall Delay (sec)
J+1			$T_{restart}$, Restart Delay (sec)
J+2			T_v, Voltage Input time constant (sec)
J+3			T_f, Frequency Input time constant (sec)
J+4			CompLF, Compressor Load Factor[1]
J+5			CompPF, Compressor Power Factor
J+6			V_{stall}, compressor stall voltage at base condition (pu)
J+7			R_{stall}, compressor motor resistance with 1.0 pu current[2]
J+8			X_{stall}, compressor motor stall reactance - unsaturated (at 1.0 pu current)
J+9			LF_{adj}, adjustment to the stall voltage proportional to compressor LF[3]
J+10			K_{p1}, real power constant for running state 1, pu W/ pu V[4]
J+11			N_{p1}, real power exponent for running state 1[4]
J+12			K_{q1}, reactive power constant for running state 1, pu VAR/ pu V[4]
J+13			N_{q1}, reactive power exponent for running state 1[4]
J+14			K_{p2}, real power constant for running state 2, pu W/ pu V[4]
J+15			N_{p2}, real power exponent for running state 2[4]
J+16			K_{q2}, reactive power constant for running state 2, pu VAR/ pu V[4]
J+17			N_{q2}, reactive power exponent for running state 2[4]

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CONs	#	Value	Description
J+18			V_{brk}, compressor motor "break-down" voltage (pu)
J+19			F_{rst}, fraction of motors that are capable of restart[5]
J+20			V_{rst}, voltage at which motors can restart (pu)[6]
J+21			$CmpK_{pf}$, real power constant for frequency dependency[6]
J+22			$CmpK_{qf}$, reactive power constant for frequency dependency[6]
J+23			Vc_{1off}, Control voltage 1 at which contactors start dropping out (pu)
J+24			Vc_{2off}, Control voltage 2 at which all contactors drop out (pu)
J+25			Vc_{1on}, Control voltage 1 at which all contactors reclose (pu)
J+26			Vc_{2on}, Control voltage 2 at which contactors start reclosing (pu)
J+27			T_{th}, Compressor motor heating time constant (sec)[7]
J+28			Th_{1t}, Temperature at which compressor motor begin tripping[7]
J+29			Th_{2t}, Temperature at which all compressor motors are tripped[7]
J+30			F_{uvr}, fraction of compressor motors with Under Voltage relays
J+31			UV_{tr1}, 1st voltage pick-up (pu)
J+32			T_{tr1}, 1st definite time voltage pick-up (sec)
J+33			UV_{tr2}, 2nd voltage pick-up (pu)
J+34			T_{tr2}, 2nd definite time voltage pick-up (sec)

1 If "CompLF" is zero, it is initialized to 1.
If "CompLF" is greater than zero, motor MVA base is adjusted.
Load Factor is defined as initial kW loading / kW rated.

2 Stall state is characterized by an equivalent impedance, (Rstall + j Xstall).

3 LF_{adj} factor is used to update the V_{stall} and V_{brk} as defined below:
$V_{stall}(adj)=V_{stall}*(1+LF_{adj}*(CompLF-1))$
$V_{brk}(adj)=V_{brk}*(1+LF_{adj}*(CompLF-1))$

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4 The motor run state is characterized by an exponential characteristic. The run characteristic is divided into two states as a function of bus voltage, State 1 for Bus voltage Vbrk, and State 2 for Vstall < Bus Voltage < Vbrk.

State 0, corresponds to 1.0 p.u. Bus voltage

$P_0=1-K_{p1}*(1-V_{brk})**N_{p1}$
$Q_0=(\sqrt{(1-CompPF**2)}/CompPF)-K_{q1}*(1-V_{brk})**N_{q1}$

State 1 for Bus voltage V_{brk}
$P=P_0+K_{p1}*(V-V_{brk})**N_{p1}$
$Q=Q_0+K_{q1}*(V-V_{brk})**N_{q1}$

State 2 for V_{stall} < Bus Voltage < V_{brk}
$P=P_0+K_{p2}*(V_{brk}-V)**N_{p2}$
$Q=Q_0+K_{q2}*(V_{brk}-V)**N_{q2}$

5 See **Compressor Unit Model Structure**, below.
Motor A once stalled remains stalled.
Motor B can restart if the voltage recovers above Vrst level.
Frst is the fraction of motors that are capable of restart.

6 Frequency dependency of the load is defined by following characteristics:
$P(f)=P*(1+CmpK_{pf}*\Delta f)$
$Q(f)=Q*(1+CmpK_{qf}*\Delta f/\sqrt{(1-CompPF**2)})$

7 See **Thermal Relay Model**, below.
Thermal relay is modelled by the following characteristics:
If Th_{2t} is equal to zero or if Th_{1t} is greater than or equal to Th_{2t}, all motors are tripped instantaneously when temperature reaches Th_{1t}.

STATEs	#	Description
K		Bus Voltage (pu)
K+1		Bus Frequency (pu)
K+2		Compressor Motor A Temperature
K+3		Compressor Motor B Temperature
K+4		U/V Relay Timer 1
K+5		U/V Relay Timer 2
K+6		Motor A Stall Timer
K+7		Motor B Stall Timer
K+8		Motor B Restart Timer

VARs	#	Description
L		Bus Voltage (pu)
L+1		Bus Frequency (pu)
L+2		Aggregated AC unit real power (MW)
L+3		Aggregated AC unit reactive power (MVAr)
L+4		Aggregated AC unit current (pu on system MVA base)
L+5		Terminal current component in phase with voltage (in pu on Motor MVA Base)

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VARs	#	Description
L+6		Terminal current component lagging voltage (in pu on Motor MVA Base)
L+7		Terminal current comp on network real axis on system MVA base (pu)
L+8		Terminal current comp on network imag axis on system MVA base (pu)
L+9		Motor A and B Initial Temperature
L+10		Fraction of motors not tripped by U/V Relay - gain K_{uv}
L+11		Fraction of motors not tripped by contactors - gain K_{con}
L+12		Contactor status for compressor voltage calculation 0=off, 1=on
L+13		Input voltage from a previous step (pu)
L+14		K_{thA} compressor motor A fraction not tripped by thermal protection
L+15		Shunt admittance (in pu on Motor MVA Base), computed during the initialization
L+16		Motor A run / stall state (run=1/stall=0)
L+17		Motor B run / stall state (run=1/stall=0)
L+18		K_{thB} compressor motor B fraction not tripped by thermal protection
L+19		Internal variable used for determining Motor A Temperature
L+20		Internal variable used for determining Motor B Temperature
L+21		Real component of voltage at pervious time step (pu)
L+22		Reactive component of voltage at previous time step (pu)
L+23		Time instant at which the model was called previous time
L+24		Internal variable, P_0 for active power at 1.0 pu voltage[4]
L+25		Internal variable, Q_0 for reactive power at 1.0 pu voltage[4]
L+26		Computed Motor MVA base
L+27		Adjusted V_{stall} based on load factor (pu)
L+28		Adjusted V_{brk} based on load factor (pu)

Reserved ICONs	Value	Description
N		Motor A Run/Stall Status, Run=1, Stall=0
N+1		Motor B Run, Restart, Stall Status, Run=1, Restart=2, Stall=0
N+2		Under Voltage Relay Trip Status, Non-Trip=1, Trip=0
N+3		Under Voltage Relay First Pick Up Flag, Becomes 0 on Pick Up

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Reserved ICONs	Value	Description
N+4		Under Voltage Relay Second Pick Up Flag, Becomes 0 on Pick Up
N+5		Thermal Relay Trip 1 Status for Motor A, Non-trip=1. Trip=0
N+6		Thermal Relay Trip 2 Status for Motor A, Non-trip=1. Trip=0
N+7		Thermal Relay Trip 1 Status for Motor B, Non-trip=1. Trip=0
N+8		Thermal Relay Trip 2 Status for Motor B, Non-trip=1. Trip=0
N+9		Contactors Started to Drop Out Flag, Not Started to Drop Out=1, Started to Drop Out=0
N+10		All Contactors Dropped out Flag, All Not Dropped Out=1, All Dropped Out=0
N+11		Contactors Started to Reclose Flag, Not Started to Reclose=1, Started to Reclose=0
N+12		All Contactors Reclosed Flag, All Not Reclosed=1, All Reclosed=0
N+13		Motor A Stall Relay Pick Up Flag, Becomes 0 on Pick Up
N+14		Motor B Stall Relay Pick Up Flag, Becomes 0 on Pick Up
N+15		Motor B Restart Relay Pick Up Flag, Becomes 0 on Pick Up

DYRE Data Record:

I, 'USRLOD', LID, 'ACMTxxU1', 12, IT, 0, 35, 9, 29, 16, CON(J) to CON(J+34) /

LID is an explicit load identifier or may be '*' for application to loads of any ID associated with the subsystem type.

Model suffix xx	IT Description	"I" Description
BL	1	Bus number
OW	2	Owner number
ZN	3	Zone number
AR	4	Area number
AL	5	0

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"Run" and "Stall" Characteristics of Compressor Motor[1]

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Compressor Unit Model Structure[1]

Thermal Relay Model[1]

[1] AC Unit Model specifications", WECC Load Modeling task Force, April 2008

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9.2 CIM5BL, CIM5OW, CIM5ZN, CIM5AR, CIM5AL

Induction Motor Load Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		R_A
J+1		X_A
J+2		$X_m > 0$
J+3		$R_1 > 0$
J+4		$X_1 > 0$
J+5		R_2 (0 for single cage)[1]
J+6		X_2 (0 for single cage)
J+7		$E_1 \geq 0$
J+8		$S(E_1)$
J+9		E_2
J+10		$S(E_2)$
J+11		MBASE[2]
J+12		PMULT
J+13		H (inertia, per unit motor base)
J+14		V_I (pu)[3]
J+15		T_I (cycles)[4]
J+16		T_B (cycles)
J+17		D (load damping factor)
J+18		T_{nom}, Load torque at 1 pu speed (used for motor starting only) (≥ 0)

1 To model single cage motor: set $R_2 = X_2 = 0$.

2 When MBASE = 0, motor MVA base = PMULT x MW load. When MBASE > 0, motor MVA base = MBASE.

3 V_I is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set $V_I = 0$.

4 T_I 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.

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STATEs	Value	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	Value	Description
L		Admittance of initial condition Mvar difference
L+1		Motor Q
L+2		T_{elec} (pu motor base)
L+3		$\Delta\omega$
L+4		T (pu on motor base)[1, 2]
L+5		I_Q
L+6		I_D
L+7		Motor current (pu motor base)
L+8		Relay trip time
L+9		Breaker trip time
L+10		MVA rating

[1] Load torque, $T_L = T (1 + D\omega)^D$

[2] For motor starting, $T=T_{nom}$ is specified by the user in CON (J+18). For motor online studies, T=To is calculated in the code during initialization and stored in VAR (L+4).

ICON	Value	Description
M		IT, motor type (1 or 2)

Reserved ICONs	Value	Description
N		Relay action code
N+1		Relay trip flag
N+2		Breaker action code
N+3		Breaker trip flag

I, 'CIM5xx', LID, ICON(M), CON(J) to CON(J+18) /

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LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

Type 1

Type 2

Impedances on Motor MVA Base

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9.3 CIM6BL, CIM6OW, CIM6ZN, CIM6AR, CIM6AL

Induction Motor Load Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		R_A
J+1		X_A
J+2		$X_m > 0$
J+3		$R_1 > 0$
J+4		$X_1 > 0$
J+5		R_2 (0 for single cage)[1]
J+6		X_2 (0 for single cage)
J+7		$E_1 \geq 0$
J+8		$S(E_1)$
J+9		E_2
J+10		$S(E_2)$
J+11		MBASE[2]
J+12		PMULT
J+13		H (inertia, per unit motor base)
J+14		V_I (pu)[3]
J+15		T_I (cycles)[4]
J+16		T_B (cycles)
J+17		A
J+18		B
J+19		D
J+20		E
J+21		C_0
J+22		T_{nom}, Load torque at 1 pu speed (used for motor starting only) (≥ 0)

[1] To model single cage motor: set $R_2 = X_2 = 0$.

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[2] When MBASE = 0, motor MVA base = PMULT x MW load. When MBASE > 0, motor MVA base = MBASE.

[3] V_I is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set $V_I = 0$.

[4] T_I 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.

STATEs	Value	Description
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	Value	Description
L		Admittance of initial condition Mvar difference
L+1		Motor Q
L+2		T_{elec} (pu motor base)
L+3		$\Delta\omega$
L+4		T (pu on motor base)[1 2]
L+5		I_Q
L+6		I_D
L+7		Motor current (pu motor base)
L+8		Relay trip time
L+9		Breaker trip time
L+10		MVA rating
L+11		T_L (pu load torque)

[1] Load torque, $T_L = T\,(A\omega^2 + B\omega + C_o + D\omega^E)$

[2] For motor starting, $T=T_{nom}$ is specified by the user in CON (J+22). For motor online studies, $T=T_o$ is calculated in the code during initialization and stored in VAR (L+4).

ICON	Value	Description
M		IT, motor type

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Reserved ICONs	Value	Description
N		Relay action code
N+1		Relay trip flag
N+2		Breaker action code
N+3		Breaker trip flag

I, 'CIM6xx', LID, ICON(M), CON(J) to CON(J+22) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

Type 1

Type 2

Impedances on Motor MVA Base

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9.4 CIMWBL, CIMWOW, CIMWZN, CIMWAR, CIMWAL

Induction Motor Load Model (WECC)

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		R_A
J+1		X_A
J+2		$X_m > 0$
J+3		$R_1 > 0$
J+4		$X_1 > 0$
J+5		R_2 (0 for single cage)[1]
J+6		X_2 (0 for single cage)
J+7		$E_1 \geq 0$
J+8		$S(E_1)$
J+9		E_2
J+10		$S(E_2)$
J+11		MBASE[2]
J+12		PMULT
J+13		H (inertia, per unit motor base)
J+14		V_I (pu)[3]
J+15		T_I (cycles)[4]
J+16		T_B (cycles)
J+17		A
J+18		B
J+19		D
J+20		E

1 To model single cage motor: set $R_2 = X_2 = 0$.

2 When MBASE = 0, motor MVA base = PMULT x MW load. When MBASE > 0, motor MVA base = MBASE.

3 V_I is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set $V_I = 0$.

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[4] T_I 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.

STATEs	Value	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	Value	Description
L		Admittance of initial condition Mvar difference
L+1		Motor Q
L+2		T_{elec} (pu motor base)
L+3		$\Delta\omega$
L+4		T_o (pu motor base), initial load torque[1 2]
L+5		I_Q
L+6		I_D
L+7		Motor current (pu motor base)
L+8		Relay trip time
L+9		Breaker trip time
L+10		MVA rating
L+11		C_o

[1] Load torque $T_L = T_o(A\omega^2 + B\omega + C_o + D\omega^E)$
where $C_o = 1 - A\omega_o^2 - B\omega_o - D\omega_o^E$.

[2] This model cannot be used for motor starting studies. T_o is calculated in the code during initialization and stored in VAR (L+4).

ICON	Value	Description
M		IT, motor type

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Reserved ICONs	Value	Description
N		Relay action code
N+1		Relay trip flag
N+2		Breaker action code
N+3		Breaker trip flag

I, 'CIMWxx', LID, ICON(M), CON(J) to CON(J+20) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

Type 1

Type 2

Impedances on Motor MVA Base

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9.5 CLODBL, CLODOW, CLODZN, CLODAR, CLODAL

Complex Load Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		% large motor
J+1		% small motor
J+2		% transformer exciting current
J+3		% discharge lighting
J+4		% constant power
J+5		K_P of remaining
J+6		Branch R (pu on load MW base)
J+7		Branch X (pu on load MW base)

STATEs	Value	Description
K		Speed deviation of large motor
K+1		Speed deviation of small motor

VARs	Value	Description
L		Branch R (pu on system base)
L+1		Branch X (pu on system base)
L+2		Tap
L+3		Large motor MVA base
L+4		Large motor old speed
L+5		Large motor present speed
L+6		Large motor, P
L+7		Large motor, Q
L+8		Small motor MVA base
L+9		Small motor old speed
L+10		Small motor present speed
L+11		Small motor, P
L+12		Small motor, Q
L+13		Memory of transformer exciting current

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VARs	Value	Description
L+14		Transformer MVA base
L+15		Magnitude of low voltage
L+16		Discharge lighting
L+17		Discharge memory
L+18		Constant power
L+19		Constant reactive power
L+20		Remaining power storage
L+21		Remaining reactive storage
L+22		Local bus frequency deviation
L+23		Memory of frequency deviation
L+24		Discharge reactive
L+25		Discharge reactive memory
L+26		REAL (VLOW)
L+27		AIMAG (VLOW)

Reserved ICON	Value	Description
N		Service status memory

I, ’CLODxx’, LID, CON(J) to CON(J+7) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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9.6 CMLDBLU1, CMLDOWU1, CMLDZNU1, CMLDARU1, CMLDALU1

Composite Load Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR starting with	#_____	L,
and Reserved ICON	#_____	N.

CONs	Value	Description
J		Load MVA base[1]
J+1		Substation shunt B (pu on Load MVA base)
J+2		Rfdr - Feeder R (pu on Load MVA base)
J+3		Xfdr - Feeder X (pu on Load MVA base)[2]
J+4		Fb - Fraction of Feeder Compensation at substation end
J+5		Xxf - Transformer Reactance - pu on load MVA base[3]
J+6		Tfixhs - High side fixed transformer tap
J+7		Tfixls - Low side fixed transformer tap
J+8		LTC - LTC flag (1 active, 0 inactive)
J+9		Tmin - LTC min tap (on low side)
J+10		Tmax - LTC max tap (on low side)
J+11		Step - LTC Tstep (on low side)
J+12		Vmin - LTC Vmin tap (low side pu)
J+13		Vmax - LTC Vmax tap (low side pu)
J+14		TD - LTC Control time delay (sec)
J+15		TC - LTC Tap adjustment time delay (sec)

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CONs	Value	Description
J+16		Rcmp - LTC Rcomp (pu on load MVA base)
J+17		Xcmp - LTC Xcomp (pu on load MVA base)
J+18		FmA - Motor A Fraction
J+19		FmB - Motor B Fraction
J+20		FmC - Motor C Fraction
J+21		FmD - Motor D Fraction
J+22		Fel - Electronic Load Fraction[4]
J+23		PFel - PF of Electronic Loads
J+24		Vd1 - Voltage at which elect. loads start to drop
J+25		Vd2 - Voltage at which all elect.load have dropped
J+26		PFs - Static Load Power Factor
J+27		P1e - P1 exponent[5]
J+28		P1c - P1 coefficient
J+29		P2e - P2 exponent
J+30		P2c - P2 coefficient
J+31		Pfrq - Frequency sensitivity
J+32		Q1e - Q1 exponent
J+33		Q1c - Q1 coefficient
J+34		Q2e - Q2 exponent
J+35		Q2c - Q2 coefficient
J+36		Qfrq - Frequency sensitivity
J+37		MtypA - Motor type[6]
J+38		LFmA - Loading factor (MW/MVA rating)
J+39		RaA - Stator resistance
J+40		LsA - Synchronous reactance
J+41		LpA - Transient reactance
J+42		LppA - Sub-transient reactance

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CONs	Value	Description
J+43		TpoA - Transient open circuit time constant
J+44		TppoA - Sub-transient open circuit time constant
J+45		HA - Inertia constant
J+46		etrqA - Torque speed exponent
J+47		Vtr1A - U/V Trip1 V (pu)
J+48		Ttr1A - U/V Trip1 Time (sec)
J+49		Ftr1A - U/V Trip1 fraction
J+50		Vrc1A - U/V Trip1 reclose V (pu)
J+51		Trc1A - U/V Trip1 reclose Time (sec)
J+52		Vtr2A - U/V Trip2 V (pu)
J+53		Ttr2A - U/V Trip2 Time (sec)
J+54		Ftr2A - U/V Trip2 fraction
J+55		Vrc2A - U/V Trip2 reclose V (pu)
J+56		Trc2A - U/V Trip2 reclose Time (sec)
J+57		MtypB - Motor type
J+58		LFmB - Loading factor (MW/MVA rating)
J+59		RaB - Stator resistance
J+60		LsB - Synchronous reactance
J+61		LpB - Transient reactance
J+62		LppB - Sub-transient reactance
J+63		TpoB - Transient open circuit time constant
J+64		TppoB - Sub-transient open circuit time constant
J+65		HB - Inertia constant
J+66		etrqB - Torque speed exponent
J+67		Vtr1B - U/V Trip1 V (pu)
J+68		Ttr1B - U/V Trip1 Time (sec)

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CONs	Value	Description
J+69		Ftr1B - U/V Trip1 fraction
J+70		Vrc1B - U/V Trip1 reclose V (pu)
J+71		Trc1B - U/V Trip1 reclose Time (sec)
J+72		Vtr2B - U/V Trip2 V (pu)
J+73		Ttr2B - U/V Trip2 Time (sec)
J+74		Ftr2B - U/V Trip2 fraction
J+75		Vrc2B - U/V Trip2 reclose V (pu)
J+76		Trc2B - U/V Trip2 reclose Time (sec)
J+77		MtypC - Motor type
J+78		LFmC - Loading factor (MW/MVA rating)
J+79		RaC - Stator resistance
J+80		LsC - Synchronous reactance
J+81		LpC - Transient reactance
J+82		LppC - Sub-transient reactance
J+83		TpoC - Transient open circuit time constant
J+84		TppoC - Sub-transient open circuit time constant
J+85		HC - Inertia constant
J+86		etrqC - Torque speed exponent
J+87		Vtr1C - U/V Trip1 V (pu)
J+88		Ttr1C - U/V Trip1 Time (sec)
J+89		Ftr1C - U/V Trip1 fraction
J+90		Vrc1C - U/V Trip1 reclose V (pu)
J+91		Trc1C - U/V Trip1 reclose Time (sec)
J+92		Vtr2C - U/V Trip2 V (pu)
J+93		Ttr2C - U/V Trip2 Time (sec)
J+94		Ftr2C - U/V Trip2 fraction
J+95		Vrc2C - U/V Trip2 reclose V (pu)

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CONs	Value	Description
J+96		Trc2C - U/V Trip2 reclose Time (sec)
J+97		Tstall - stall delay (sec)[7]
J+98		Trestart - restart delay (sec)
J+99		Tv - voltage input time constant(sec)
J+100		Tf - frequency input time constant(sec)
J+101		CompLF - compressor load factor, p.u. of rated power[8]
J+102		CompPF - compressor power factor at 1.0 p.u. voltage
J+103		Vstall - compressor stall voltage at base condition (p.u.)
J+104		Rstall - compressor motor res. with 1.0 p.u. current[9]
J+105		Xstall - compressor motor stall reactance - unsat.
J+106		LFadj - Load factor adjustment to the stall voltage[10]
J+107		Kp1 - real power constant for running state 1[11]
J+108		Np1 - real power exponent for running state 1
J+109		Kq1 - reactive power constant for running state 1
J+110		Nq1 - reactive power exponent for running state 1
J+111		Kp2 - real power constant for running state 2
J+112		Np2 - real power exponent for running state 2
J+113		Kq2 - reactive power constant for running state 2

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CONs	Value	Description
J+114		Nq2 - reactive power exponent for running state 2
J+115		Vbrk - compressor motor "break-down" voltage (p.u.)
J+116		Frst - fraction of motors capable of restart
J+117		Vrst - voltage at which motors can restart (p.u.)
J+118		CmpKpf - real power constant for freq dependency[12]
J+119		CmpKqf - reactive power constnt for freq dependency
J+120		Vc1off - Voltage 1 at which contactors start dropping out (p.u.)
J+121		Vc2off - Voltage 2 at which all contactors drop out (p.u.)
J+122		Vc1on - Voltage 1 at which all contactors reclose (p.u.)
J+123		Vc2on - Voltage 2 at which contactors start reclosing (p.u.)
J+124		Tth - compressor motor heating time constant(sec)[13]
J+125		Th1t - temp at which comp. motor begin tripping
J+126		Th2t - temp at which comp. all motors are tripped
J+127		Fuvr - fraction of comp. motors with U/V relays
J+128		UVtr1 - 1st voltage pick-up (p.u.)
J+129		Ttr1 - 1st definite time voltage pick-up (sec)
J+130		UVtr2 - 2nd voltage pick-up (p.u.)
J+131		Ttr2 - 2nd definite time voltage pick-up (sec)

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1 Load MVA base=x,
if x>0., x is MVA base
if x<0., abs. value=loading factor=load MW/MVA base
if X=0., loading factor=default value(0.8)
When model is applied on a subsystem basis (OW, ZN, AR, AL), CON(J) has to be les than or equal to 0

2 If Xfdr<=jumper threshold, feeder is omitted from the model

3 If Xxfr<=jumper threshold, transformer is omitted from the model

4 If sum of load fractions FmA, FmB, FmC, FmD, Fel is <1, remainder is static load;
If sum of fractions FmA, FmB, FmC, FmD, Fel is >1, fractions are normalized to 1 and there will be no static load

5 The static load model uses the following equations;
$P=P_0 * (P1c * V/V0^{P1e}+P2c * V/V0^{P2e}+P3)*(1+Pf * \Delta f)$
$Q=Q_0 * (Q1c * V/V0^{Q1e}+Q2c * V/V0^{Q2e}+Q3)*(1+Qf * \Delta f)$
$P_0=Pload * (1.-FmA-FmB-FmC-FmD-Fel)$
$Q_0=P_0 * \tan(acos(PFs))$
P3=1.-P1c-P2c
Q3=1-Q1c-Q2c

6 Motor A, Motor B, and Motor C are 3-phase motors. MtypA (CON(J+37)), MtypB (CON(j+57)), and MtypC (CON(J+77)) =3 to represent three phase motor. These motors use the induction motor model CIM6BL from PSSE standard model library. The load torque is computed as
$T_L=T_0*\omega^{Etrq}$

7 CON(J+99) to CON(J+131) are the parameters of Motor D. Motor D is single phase air conditioner. This model uses the user-defined ACMTBL model.

8 If "CompLF" is zero, it is computed during the initialization.
If "CompLF" is greater than zero, motor MVA base is adjusted.
Load Factor is defined as initial kW loading / kW rated.

9 Stall state is characterized by an equivalent impedance, (Rstall + j Xstall).

10 Lfadj factor is used to update the Vstall and Vbrk as defined below:
Vstall(adj)=Vstall*(1+Lfadj*(CompLF-1))
Vbrk(adj)=Vbrk*(1+Lfadj*(CompLF-1))

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[11] The motor run state is characterized by an exponential characteristic. The run characteristic is divided into two states as a function of bus voltage, State 1 for Bus voltage Vbrk, and State 2 for Vstall < Bus Voltage < Vbrk.

State 0, corresponds to 1.0 p.u. Bus voltage
P0=1-KP1*(1-Vbrk)**NP1
Q0=(√(1-CompPF**2)/CompPF)-KQ1*(1-Vbrk)**NQ1

State 1 for Bus voltage Vbrk
P=P0+KP1*(V-Vbrk)**NP1
Q=Q0+KQ1*(V-Vbrk)**NQ1

State 2 for Vstall < Bus Voltage < Vbrk
P=P0+KP2*(Vbrk-V)**NP2
Q=Q0+KQ2*(Vbrk-V)**NQ2

[12] Frequency dependency of the load is defined by following characteristics:
P(f)=P*(1+CmpKpf*Δf)
Q(f)=Q*(1+CmpKqf*Δf/√(1-CompPF**2))

[13] Thermal relay is modelled by the following characteristics:
If Th2t is equal to zero or if Th1t is greater than or equal to Th2t, all motors are tripped instantaneously when temperature reaches Th1t.

K	Motor A: E'q
K+1	Motor A: E'd
K+2	Motor A: E"q
K+3	Motor A: E"d
K+4	Motor A: speed deviation (pu)
K+5	Motor A: angle deviation
K+6	Motor B: E'q
K+7	Motor B: E'd
K+8	Motor B: E"q
K+9	Motor B: E"d
K+10	Motor B: speed deviation (pu)
K+11	Motor B: angle deviation
K+12	Motor C:: E'q
K+13	Motor C:: E'd
K+14	Motor C:: E"q
K+15	Motor C:: E"d
K+16	Motor C:: speed deviation (pu)
K+17	Motor C: angle deviation

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K+18	Motor D: bus voltage (pu)
K+19	Motor D: bus frequency (pu)
K+20	Motor D: non-restartable compressor motor A temperature
K+21	Motor D: restartable compressor motor B temperature
K+22	Motor D: U/V relay timer 1
K+23	Motor D: U/V relay timer 2
K+24	Motor D: non-restartable motor A stall timer
K+25	Motor D: restartable Motor B stall timer
K+26	Motor D: restartable Motor B restart timer

VARs	Description
L	Load MVA base
L+1	Motor A fraction
L+2	Motor B fraction
L+3	Motor C fraction
L+4	Motor D: fraction
L+5	Electronic load fraction
L+6	Static load fraction
L+7	Initial value of static load real part (pu on system MVA base)
L+8	Initial value of static load reactive part (pu on system MVA base)
L+9	P3 component of static load
L+10	Q3 component of static load
L+11	Calculated substation shunt compensation (pu on system MVA base)
L+12	Transformer tap
L+13	Transformer low side voltage real part
L+14	Transformer low side voltage imaginary part
L+15	Load bus voltage real part
L+16	Load bus voltage imaginary part
L+17	Initial value of load bus voltage magnitude
L+18	Feeder resistance (pu on system MVA base)

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VARs	Description
L+19	Feeder reactance (pu on system MVA base)
L+20	Sum of substation shunt admittance and feeder compensation admittance at substation end
L+21	Substation shunt admittance
L+22	Initial value of electronic load real part (pu on system MVA base)
L+23	Initial value of electronic load reactive part (pu on system MVA base)
L+24	Transformer reactance (pu on system MVA base)
L+25	Static load real part (pu on system MVA base)
L+26	Static load reactive part (pu on system MVA base)
L+27	Electronic load real part (pu on system MVA base)
L+28	Electronic load reactive part (pu on system MVA base)
L+29	Load bus voltage magnitude
L+30	Low side bus voltage magnitude
L+31	Motor A P (pu on system MVA base)
L+32	Motor A Q (pu on system MVA base)
L+33	Motor B P (pu on system MVA base)
L+34	Motor B Q (pu on system MVA base)
L+35	Motor C P (pu on system MVA base)
L+36	Motor C Q (pu on system MVA base)
L+37	Motor D P (pu on system MVA base)
L+38	Motor D Q (pu on system MVA base)
L+39	Transformer controlled bus voltage
L+40	Initial value of feeder resistance (pu on system MVA base)
L+41	Initial value of feeder reactance (pu on system MVA base)
L+42	Composite load real before load shed (pu on system MVA base)
L+43	Real part of composite load shed in a particular stage (pu on system MVA base)
L+44	Real part of composite load shed upto a particular stage (pu on system MVA base)
L+45	LTC control time delay counter
L+46	Tap changer timer
L+47	Initial value of Motor A P (pu on system MVA base)

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VARs	Description
L+48	Initial value of Motor A Q (pu on system MVA base)
L+49	Initial value of Motor B P (pu on system MVA base)
L+50	Initial value of Motor B Q (pu on system MVA base)
L+51	Initial value of Motor C P (pu on system MVA base)
L+52	Initial value of Motor C Q (pu on system MVA base)
L+53	Initial value of Motor D P (pu on system MVA base)
L+54	Initial value of Motor D Q (pu on system MVA base)
L+55	Feeder compensation admittance at substation end
L+56	Feeder compensation admittance at far end
L+57	Static load conductance
L+58	Static load susceptance
L+59	Spare
L+60	Spare
L+61	Real component of current injection at system load bus
L+62	Reactive component of current injection at system load bus
L+63	Initial value of Motor A MVA base
L+64	Initial value of Motor B MVA base
L+65	Initial value of Motor C MVA base
L+66	Initial value of Motor D MVA base
L+67	Initial value of feeder compensation admittance at substation end
L+68	Initial value of feeder compensation admittance at far end
L+69	Motor A: Admittance of initial condition MVAr difference
L+70	Motor A: Q
L+71	Motor A: Tele (pu on motor MVA base)
L+72	Motor A: Speed deviation
L+73	Motor A: Initial load torque (pu on motor MVA base)
L+74	Motor A: Iq
L+75	Motor A: Id
L+76	Motor A: Current (pu on motor MVA base)
L+77	Motor A: UV relay1 trip time
L+78	Motor A: UV relay2 trip time

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VARs	Description
L+79	Motor A: MVA base
L+80	Motor A: TL - Load torque (pu)
L+81	Motor A: UV relay1 reclose time
L+82	Motor A: UV relay2 reclose time
L+83	Motor A: Trip-reclose factor
L+84	Motor A: Nominal load torque
L+85	Motor B: Admittance of initial condition MVAr difference
L+86	Motor B: Q
L+87	Motor B: Tele (pu on motor MVA base)
L+88	Motor B: Speed deviation
L+89	Motor B: Initial load torque (pu on motor MVA base)
L+90	Motor B: Iq
L+91	Motor B: Id
L+92	Motor B: Current (pu on motor MVA base)
L+93	Motor B: UV relay1 trip time
L+94	Motor B: UV relay2 trip time
L+95	Motor B: MVA base
L+96	Motor B: TL - Load torque (pu)
L+97	Motor B: UV relay1 reclose time
L+98	Motor B: UV relay2 reclose time
L+99	Motor B: Trip-reclose factor
L+100	Motor B: Nominal load torque
L+101	Motor C: Admittance of initial condition MVAr difference
L+102	Motor C: Q
L+103	Motor C: Tele (pu on motor MVA base)
L+104	Motor C: Speed deviation
L+105	Motor C: Initial load torque (pu on motor MVA base)
L+106	Motor C: Iq
L+107	Motor C: Id
L+108	Motor C: Current (pu on motor MVA base)
L+109	Motor C: UV relay1 trip time

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VARs	Description
L+110	Motor C: UV relay2 trip time
L+111	Motor C: MVA base
L+112	Motor C: TL - Load torque (pu)
L+113	Motor C: UV relay1 reclose time
L+114	Motor C: UV relay2 reclose time
L+115	Motor C: Trip-reclose factor
L+116	Motor C: Nominal load torque
L+117	Motor D: Bus voltage (pu)
L+118	Motor D: Bus frequency (pu)
L+119	Motor D: Aggregated AC unit real power (MW)
L+120	Motor D: Aggregated AC unit reactive power (MVAr)
L+121	Motor D: Aggregated AC unit current (pu on system MVA base)
L+122	Motor D: Terminal current component in phase with voltage (in pu on motor MVA base)
L+123	Motor D: Terminal current component lagging voltage (in pu on motor MVA base)
L+124	Motor D: Terminal current component on network real axis on system MVA base (pu)
L+125	Motor D: Terminal current comp on network imaginary axis on system MVA base (pu)
L+126	Motor D: non-restartable motor A and restartable motor B Initial Temperature
L+127	Motor D: Fraction of motors not tripped by U/V relay - gain Kuv
L+128	Motor D: Fraction of motors not tripped by contactors - gain Kcon
L+129	Motor D: Contactor status for compressor voltage calculation 0=off, 1=on
L+130	Motor D: Input voltage from a previous step (pu)
L+131	Motor D: KthA non-restartable compressor motor A fraction not tripped by thermal protection
L+132	Motor D: Shunt admittance (in pu on motor MVA base), computed during the initialization
L+133	Motor D: non-restartable Motor A run / stall state (run=1/stall=0)
L+134	Motor D: restartable Motor B run / stall state (run=1/stall=0)

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VARs	Description
L+135	Motor D: KthB restartable compressor motor B fraction not tripped by thermal protection
L+136	Motor D: Internal variable used for determining non-restartable motor A temperature
L+137	Motor D: Internal variable used for determining restartable motor B temperature
L+138	Motor D: Real component of voltage at pervious time step (pu)
L+139	Motor D: Reactive component of voltage at previous time step (pu)
L+140	Motor D: Time instant at which the model was called previous time
L+141	Motor D: Internal variable, P0 for active power at 1.0 pu voltage4
L+142	Motor D: Internal variable, Q0 for reactive power at 1.0 pu voltage4
L+143	Motor D: Computed motor MVA base
L+144	Motor D: Adjusted Vstall based on load factor (pu)
L+145	Motor D: Adjusted Vbrk based on load factor (pu)

Reserved ICONs	Description
N+1	LTC control delay flag
N+2	LTC control timeout flag
N+3	Tap adjustment timer status flag
N+4	Static load admittance storage status flag
N+5	Motor A: UV trip relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+6	Motor A: UV trip relay1 status (1=Delay complete, motor should be tripped)
N+7	Motor A: UV trip relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+8	Motor A: UV trip relay2 status (1=Delay complete, motor should be tripped)
N+9	Motor A: UV reclose relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+10	Motor A: UV reclose relay1 status (1=Delay complete, motor should be reclosed)
N+11	Motor A: UV reclose relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)

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Reserved ICONs	Description
N+12	Motor A: UV reclose relay2 status (1=Delay complete, motor should be reclosed)
N+13	Motor A: starting status (1=starting phase, 0=already started)
N+14	Motor B: UV trip relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+15	Motor B: UV trip relay1 status (1=Delay complete, motor should be tripped)
N+16	Motor B: UV trip relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+17	Motor B: UV trip relay2 status (1=Delay complete, motor should be tripped)
N+18	Motor B: UV reclose relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+19	Motor B: UV reclose relay1 status (1=Delay complete, motor should be reclosed)
N+20	Motor B: UV reclose relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+21	Motor B: UV reclose relay2 status (1=Delay complete, motor should be reclosed)
N+22	Motor B: starting status (1=starting phase, 0=already started)
N+23	Motor C: UV trip relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+24	Motor C: UV trip relay1 status (1=Delay complete, motor should be tripped)
N+25	Motor C: UV trip relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+26	Motor C: UV trip relay2 status (1=Delay complete, motor should be tripped)
N+27	Motor C: UV reclose relay1 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+28	Motor C: UV reclose relay1 status (1=Delay complete, motor should be reclosed)
N+29	Motor C: UV reclose relay2 flag (0=Reset timer, 1=Start timer, 2=Test timer)
N+30	Motor C: UV reclose relay2 status (1=Delay complete, motor should be reclosed)
N+31	Motor C: starting status (1=starting phase, 0=already started)
N+32	Motor D: non-restartable Motor A Run/Stall status, Run=1, Stall=0

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Reserved ICONs	Description
N+33	Motor D: restartable Motor B Run, Restart, Stall status, Run=1, Restart=2, Stall=0
N+34	Motor D: Under voltage relay trip status, Non-Trip=1, Trip=0
N+35	Motor D: Under voltage relay first pick up flag, becomes 0 on Pick Up
N+36	Motor D: Under voltage relay second pick up flag, becomes 0 on Pick Up
N+37	Motor D: Thermal relay trip 1 status for non-restartable motor A, Non-trip=1. Trip=0
N+38	Motor D: Thermal relay trip 2 status for non-restartable motor A, Non-trip=1. Trip=0
N+39	Motor D: Thermal relay trip 1 status for restartable motor B, Non-trip=1. Trip=0
N+40	Motor D: Thermal relay Trip 2 status for restartable motor B, Non-trip=1. Trip=0
N+41	Motor D: Contactors sarted to drop out flag, Not started to drop out=1, Started to drop out=0
N+42	Motor D: All contactors dropped out flag, All not dropped out=1, All dropped out=0
N+43	Motor D: Contactors started to reclose flag, Not started to reclose=1, Started to reclose=0
N+44	Motor D: All Contactors reclosed flag, All not reclosed=1, All reclosed=0
N+45	Motor D: non-restartable motor A stall relay pick up flag, becomes 0 on pick up
N+46	Motor D: restartable motor B stall relay pick up flag, becomes 0 on pick up
N+47	Motor D: restartable motor B restart relay pick up flag, becomes 0 on pick up

DYRE Data Record:

I, 'USRLOD', LID, 'CMLDxxU1', 12, IT, 0, 132, 27, 146, 48, CON(J) to CON(J+131) /

LID is an explicit load identifier or may be '*' for application to loads of any ID associated with the subsystem type.

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Model suffix "xx"	"IT" Description	"I" Description
BL	1	Bus number
OW	2	Owner number
ZN	3	Zone number
AR	4	Area number
AL	5	0

Note: CMLDBL internally uses induction motor model to simulate three phase motors. In case of non-convergence, number of iterations may be increased and time step may be reduced.

Composite load model structure[1]

[1] "Load modeling", MMWG report to TSS, August 2009

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9.7 EXTLBL, EXTLOW, EXTLZN, EXTLAR, EXTLAL

Extended-Term Load Reset Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and Reserved ICON	#_____	N.

CONs	Value	Description
J		K_P
J+1		PMLTMX
J+2		PMLTMN
J+3		K_Q
J+4		QMLTMX
J+5		QMLTMN

STATEs	Value	Description
K		P_{MULT}
K+1		Q_{MULT}

VAR	Value	Description
L		$V_{initial}$

Reserved ICON	Value	Description
N		Service status memory

I, 'EXTLxx', LID, CON(J) to CON(J+5) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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9.8 IEELBL, IEELOW, IEELZN, IEELAR, IEELAL

IEEE Load Model

This model uses CONs starting with #_____ J.

CONs	Value	Description
J		a_1
J+1		a_2
J+2		a_3
J+3		a_4
J+4		a_5
J+5		a_6
J+6		a_7
J+7		a_8
J+8		n_1
J+9		n_2
J+10		n_3
J+11		n_4
J+12		n_5
J+13		n_6

I, 'IEELxx', LID, CON(J) to CON(J+13) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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

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

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9.9 LDFRBL, LDFROW, LDFRZN, LDFRAR, LDFRAL

Load Frequency Model

This model uses CONs starting with #_____ J.

CONs	Value	Description
J		m, real power load exponent
J+1		n, reactive power load exponent
J+2		r, real current load exponent
J+3		s, reactive current load exponent

I, 'LDFRxx', LID, CON(J) to CON(J+3) /

LID is an explicit load identifier or may be '*' for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

The constant power and constant current load components are made sensitive to bus frequency according to:

$$P = P_o\left(\frac{\omega}{\omega_o}\right)^m$$

$$Q = Q_o\left(\frac{\omega}{\omega_o}\right)^n$$

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

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

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Chapter 10

Load Relay Model Data Sheets

This chapter contains a collection of data sheets for the load relay models contained in the PSS®E dynamics model library.

Model	Description
DLSHBL, DLSHOW, DLSHZN, DLSHAR, DLSHAL	Rate of frequency load shedding model
LDS3BL, LDS3OW, LDS3ZN, LDS3AR, LDS3AL	Underfrequency load shedding model with transfer trip
LDSHBL, LDSHOW, LDSHZN, LDSHAR, LDSHAL	Underfrequency load shedding model
LDSTBL, LDSTOW, LDSTZN, LDSTAR, LDSTAL	Time underfrequency load shedding model
LVS3BL, LVS3OW, LVS3ZN, LVS3AR, LVS3AL	Undervoltage load shedding model with transfer trip
LVSHBL, LVSHOW, LVSHZN, LVSHAR, LVSHAL	Undervoltage load shedding model
UVUFBLU1, UVUFOWU1, UVUFZNU1, UVUFARU1, UVUFALU1	User written under-voltage and under-frequencey load shedding model

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10.1 DLSHBL, DLSHOW, DLSHZN, DLSHAR, DLSHAL

Rate of Frequency Load Shedding Model

This model uses CONs starting with #_____ J,
and VARs starting with #_____ L,
and Reserved ICONs starting with #_____ N.

CONs	Value	Description
J		f_1, first load shedding point (Hz)
J+1		t_1, first point pickup time (sec)
J+2		$frac_1$, first fraction of load to be shed
J+3		f_2, second load shedding point (Hz)
J+4		t_2, second point pickup time (sec)
J+5		$frac_2$, second fraction of load to be shed
J+6		f_3, third load shedding point (Hz)
J+7		t_3, third point pickup time (sec)
J+8		$frac_3$, third fraction of load to be shed
J+9		T_B, breaker time (sec)
J+10		df_1, first rate of frequency shedding point (Hz/sec)
J+11		df_2, second rate of frequency shedding point (Hz/sec)
J+12		df_3, third rate of frequency shedding point (Hz/sec)

VARs	Value	Description
L		First timer memory
L+1		Second timer memory
L+2		Third timer memory
L+3		Memory for derivative of bus frequency
L+4		Bus frequency derivative

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Reserved ICONs	Value	Description
N		First point delay flag
N+1		First point timeout flag
N+2		First timer status
N+3		Second point delay flag
N+4		Second point timeout flag
N+5		Second timer status
N+6		Third point delay flag
N+7		Third point timeout flag
N+8		Third timer status

I, 'DLSHxx', LID, CON(J) to CON(J+12) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.2 LDS3BL, LDS3OW, LDS3ZN, LDS3AR, LDS3AL

Underfrequency Load Shedding Model With Transfer Trip

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		f_1, first load shedding point (Hz)
J+1		t_1, first point pickup time (sec)
J+2		tb_1, first breaker time (sec)
J+3		$frac_1$, first fraction of load to be shed
J+4		f_2, second load shedding point (Hz)
J+5		t_2, second point pickup time (sec)
J+6		tb_2, second breaker time (sec)
J+7		$frac_2$, second fraction of load to be shed
J+8		f_3, third load shedding point (Hz)
J+9		t_3, third point pickup time (sec)
J+10		tb_3, third breaker time (sec)
J+11		$frac_3$, third fraction of load to be shed
J+12		f_4, fourth load shedding point (Hz)
J+13		t_4, fourth point pickup time (sec)
J+14		tb_4, fourth breaker time (sec)
J+15		$frac_4$, fourth fraction of load to be shed
J+16		f_5, fifth load shedding point (Hz)
J+17		t_5, fifth point pickup time (sec)
J+18		tb_5, fifth breaker time (sec)
J+19		$frac_5$, fifth fraction of load to be shed
J+20		ttb, transfer trip breaker time (sec)

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VARs	Value	Description
L		First timer memory
L+1		Second timer memory
L+2		Third timer memory
L+3		Fourth timer memory
L+4		Fifth timer memory
L+5		Transfer trip timer

ICONs	Value	Description
M		GBUS, bus number of transfer trip generator
M+1		GID, machine ID of transfer trip, -1 if plant
M+2		SC: 0 Do not shed shunt 1 Shed shunt with same fraction as load

Reserved ICONs	Value	Description
N		First point delay flag
N+1		First point timeout flag
N+2		First point timer status
N+3		Second point delay flag
N+4		Second point timeout flag
N+5		Second point timer status
N+6		Third point delay flag
N+7		Third point timeout flag
N+8		Third point timer status
N+9		Fourth point delay flag
N+10		Fourth point timeout flag
N+11		Fourth point timer status
N+12		Fifth point delay flag
N+13		Fifth point timeout flag
N+14		Fifth point timer status
N+15		Transfer trip breaker status
N+16		Transfer trip timer status

I, ’LDS3xx’, LID, ICON(M) to ICON(M+2), CON(J) to CON(J+20) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

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Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.3 LDSHBL, LDSHOW, LDSHZN, LDSHAR, LDSHAL

Underfrequency Load Shedding Model

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		f_1, first load shedding point (Hz)
J+1		t_1, first point pickup time (sec)
J+2		$frac_1$, first fraction of load to be shed
J+3		f_2, second load shedding point (Hz)
J+4		t_2, second fraction pickup time (sec)
J+5		$frac_2$, second fraction of load to be shed
J+6		f_3, third load shedding point (Hz)
J+7		t_3, third point pickup time (sec)
J+8		$frac_3$, third fraction of load to be shed
J+9		T_b, breaker time (sec)

VARs	Value	Description
L		First timer memory
L+1		Second timer memory
L+2		Third timer memory

Reserved ICONs	Value	Description
N		First point delay flag
N+1		First point timeout flag
N+2		First timer status
N+3		Second point delay flag
N+4		Second point timeout flag
N+5		Second timer status
N+6		Third point delay flag
N+7		Third point timeout flag
N+8		Third timer status

I, ’LDSHxx’, LID, CON(J) to CON(J+9) /

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LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.4 LDSTBL, LDSTOW, LDSTZN, LDSTAR, LDSTAL

Time Underfrequency Load Shedding Model

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		f_1, pickup frequency (Hz)
J+1		z_1, nominal operating time (sec)
J+2		f_2, second frequency point (Hz)
J+3		z_2, nominal operating time (sec)
J+4		f_3, third frequency point (Hz)
J+5		z_3, nominal operating time (sec)
J+6		f_4, fourth frequency point (Hz)
J+7		z_4, nominal operating time (sec)
J+8		T_B, breaker time (sec)
J+9		frac, fraction of load to be shed
J+10		f_{reset}, reset frequency (Hz)
J+11		t_{res}, resetting time (sec)

VARs	Value	Description
L		Frequency (Hz)
L+1		Relay trip contact position
L+2		Breaker timer memory

Reserved ICONs	Value	Description
N		Relay status
N+1		Breaker timer flag
N+2		Breaker timeout flag

I, ’LDSTxx’, LID, CON(J) to CON(J+11) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

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Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.5 LVS3BL, LVS3OW, LVS3ZN, LVS3AR, LVS3AL

Undervoltage Load Shedding Model With Transfer Trip

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		f_1, first load shedding point (pu)
J+1		t_1, first point pickup time (sec)
J+2		tb_1, first breaker time (sec)
J+3		$frac_1$, first fraction of load to be shed
J+4		f_2, second load shedding point (pu)
J+5		t_2, second point pickup time (sec)
J+6		tb_2, second breaker time (sec)
J+7		$frac_2$, second fraction of load to be shed
J+8		f_3, third load shedding point (pu)
J+9		t_3, third point pickup time (sec)
J+10		tb_3, third breaker time (sec)
J+11		$frac_3$, third fraction of load to be shed
J+12		f_4, fourth load shedding point (pu)
J+13		t_4, fourth point pickup time (sec)
J+14		tb_4, fourth breaker time (sec)
J+15		$frac_4$, fourth fraction of load to be shed
J+16		f_5, fifth load shedding point (pu)
J+17		t_5, fifth point pickup time (sec)
J+18		tb_5, fifth breaker time (sec)
J+19		$frac_5$, fifth fraction of load to be shed
J+20		ttb_1, first transfer trip breaker time (sec)
J+21		ttb_2, second transfer trip breaker time (sec)

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VARs	Value	Description
L		First timer memory
L+1		Second timer memory
L+2		Third timer memory
L+3		Fourth timer memory
L+4		Fifth timer memory
L+5		First transfer trip timer
L+6		Second transfer trip timer

ICONs	Value	Description	
M		FBUS1, from bus number	First transfer trip
M+1		TBUS1, to bus number	
M+2		ID1, Circuit ID	
M+3		FBUS2, from bus number	Second transfer trip
M+4		TBUS2, to bus number	
M+5		ID2, Circuit ID	
M+6		SC: 0 Do not shed shunt 1 Shed shunt with same fraction as load	

Reserved ICONs	Value	Description
N		First point delay flag
N+1		First point timeout flag
N+2		First point timer status
N+3		Second point delay flag
N+4		Second point timeout flag
N+5		Second point timer status
N+6		Third point delay flag
N+7		Third point timeout flag
N+8		Third point timer status
N+9		Fourth point delay flag
N+10		Fourth point timeout flag
N+11		Fourth point timer status
N+12		Fifth point delay flag
N+13		Fifth point timeout flag
N+14		Fifth point timer status

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Reserved ICONs	Value	Description
N+15		First transfer trip breaker status
N+16		First transfer trip timer status
N+17		Second transfer trip breaker status
N+18		Second transfer trip timer status

I, 'LVS3xx', LID, ICON(M) to ICON(M+6), CON(J) to CON(J+21) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.6 LVSHBL, LVSHOW, LVSHZN, LVSHAR, LVSHAL

Undervoltage Load Shedding Model

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICON	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J		V1, first load shedding point (pu)
J+1		T1, first point pickup time (sec)
J+2		F1, first fraction of load to be shed
J+3		V2, second load shedding point (pu)
J+4		T2, second fraction pickup time (sec)
J+5		F2, second fraction of load to be shed
J+6		V3, third load shedding point (pu)
J+7		T3, third point pickup time (sec)
J+8		F3, third fraction of load to be shed
J+9		TB, breaker time (sec)

VARs	Value	Description
L		First timer memory
L+1		Second timer memory
L+2		Third timer memory

ICON	Value	Description
M		JBUS, remote bus number where voltage is measured[1]

[1] Set JBUS = 0, if remote bus is same as the local bus to which the load is connected.

Reserved ICONs	Value	Description
N		First point delay flag
N+1		First point timeout flag
N+2		First timer status
N+3		Second point delay flag
N+4		Second point timeout flag

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Reserved ICONs	Value	Description
N+5		Second timer status
N+6		Third point delay flag
N+7		Third point timeout flag
N+8		Third point status

I, 'LVSHxx', LID, ICON(M), CON(J) to CON(J+9) /

LID is an explicit load identifier or may be ∗ for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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10.7 UVUFBLU1, UVUFOWU1, UVUFZNU1, UVUFARU1, UVUFALU1

Undervoltage and Underfrequency Load Shedding Model

This model uses CONs starting with #_____ J,
and VARs starting with #_____ L,
and ICONs starting with #_____ M,
and Reserved ICONs starting with #_____ N.

CONs	#	Value	Description
J			V1, first voltage-based load shedding point (pu)
J+1			TV1, first voltage-based point pickup time (sec)
J+2			FV1, first voltage-based fraction of load to be shed
J+3			V2, second voltage-based load shedding point (pu)
J+4			TV2, second voltage-based point pickup time (sec)
J+5			FV2, second voltage-based fraction of load to be shed
J+6			V3, third voltage-based load shedding point (pu)
J+7			TV3, third voltage-based point pickup time (sec)
J+8			FV3, third voltage-based fraction of load to be shed
J+9			TVB, voltage-based breaker time (sec)
J+10			F1, first frequency-based load shedding point (Hz)
J+11			TF1, first frequency-based point pickup time (sec)
J+12			FF1, first frequency-based fraction of load to be shed
J+13			F2,second frequency-based load shedding point (Hz)
J+14			TF2, second frequency-based point pickup time (sec)
J+15			FF2, second frequency-based fraction of load to be shed

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CONs	#	Value	Description
J+16			F3, third frequency-based load shedding point (Hz)
J+17			TF3, third frequency-based point pickup time (sec)
J+18			FF3, third frequency-based fraction of load to be shed
J+19			TFB, frequency-based breaker time (sec)

VARs	#	Description
L		First voltage-based timer memory
L+1		Second voltage-based timer memory (pu)
L+2		Third voltage-based timer memory
L+3		First frequncy-based timer memory
L+4		Second frequncy-based timer memory
L+5		Third frequncy-based timer memory
L+6		Load fractions already shed in previous stages

ICON	#	Value	Description
M			JBUS, remote bus number where voltage is measured[1]

[1] Set JBUS = 0, if remote bus is same as the local bus to which the load is connected.

Reserved ICONs	#	Description
N		First voltage-based point delay flag
N+1		First voltage-based point timeout flag
N+2		First voltage-based timer status
N+3		Second voltage-based point delay flag
N+4		Second voltage-based point timeout flag
N+5		Second voltage-based timer status
N+6		Third voltage-based point delay flag
N+7		Third voltage-based point timeout flag
N+8		Third voltage-based timer status

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Reserved ICONs	#	Description
N+9		First frequncy-based point delay flag
N+10		First frequncy-based point timeout flag
N+11		First frequncy-based timer status
N+12		Second frequncy-based point delay flag
N+13		Second frequncy-based point timeout flag
N+14		Second frequncy-based timer status
N+15		Third frequncy-based point delay flag
N+16		Third frequncy-based point timeout flag
N+17		Third frequncy-based timer status

DYRE Data Record:

I, 'USRLOD', LID, 'UVUFxxU1', 13, IT, 1, 20, 0, 7, 18, JBUS, CON(J) to CON(J+19) /

LID is an explicit load identifier or may be '*' for application to loads of any ID associated with the subsystem type.

Model suffix "xx"	"IT" Description	"I" Description
BL	1	Bus number
OW	2	Owner number
ZN	3	Zone number
AR	4	Area number
AL	5	0

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Chapter 11

Line Relay Model Data Sheets

This chapter contains a collection of data sheets for the line relay models contained in the PSS®E dynamics model library.

Model	Description
CIROS1	Double circle or lens out-of-step tripping or blocking relay
DISTR1	mho, impedance, or reactance distance relay
DPDTR1	Rate of change of power relay
RXR1	RXR distance relay
SCGAP2	Series capacitor gap relay
SLLP1	SLLP tripping relay
SLNOS1	Straight line blinder out-of-step relay
SLYPN1	G.E. directional comparison and overcurrent relay
TIOCR1	Time inverse overcurrent relay

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11.1 CIROS1

Double Circle or Lens Out-of-Step Tripping or Blocking Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Interzone travel time (cycles)
J+1		Zone 1 (inner zone) diameter (pu)
J+2		Centerline angle (degrees)
J+3		Centerline distance (pu)
J+4		Zone 2 (outer zone) diameter
J+5		Centerline angle (degrees)
J+6		Centerline distance (pu)
J+7		Threshold current (pu)
J+8		Self trip breaker time (cycles)
J+9		Transfer trip breaker and delay time
J+10		First blinder type (±1 or ±2)
J+11		First blinder intercept (pu)
J+12		First blinder rotation (degrees)
J+13		Second blinder type
J+14		Second blinder intercept (pu)
J+15		Second blinder rotation (degrees)

VARs	Value	Description
L		Apparent R
L+1		Apparent X
L+2		Current
L+3		VARs required for internal program logic
L+4		
L+5		

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ICONs	Value	Description	
M		Type +1 double circle tripping Type -1 double circle blocking Type +2 lens type tripping Type -2 lens type blocking	
M+1		Operation mode: 0 Monitor 1 Monitor and operate	
M+2		From bus number	First transfer trip
M+3		To bus number	
M+4		Circuit ID	
M+5		From bus number	Second transfer trip
M+6		To bus number	
M+7		Circuit ID	
M+8		From bus number	Third transfer trip
M+9		To bus number	
M+10		Circuit ID	
M+11		Supervisory ICON (permissive flag ICON of another model)	
M+12	X	Permissive flag for self trip[1]	
M+13	X	Permissive flag for transfer trip[2]	
M+14 . . . M+20	X	ICONs required for internal program logic	

[1] Set to 1 and -1 by supervisory relay to block trip and force trip, respectively.
[2] Set to 1 by supervisory relay to block trip.

IBUS, 'CIROS1', JBUS, ID, RS, ICON(M) to ICON(M+11), CON(J) to CON(J+15) /

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Double Circle

Lens Type

Blinder Types

Specification of Lens

Double Circle or Lens Out-of-Step Tripping or Blocking Relay

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11.2 DISTR1

mho, Impedance, or Reactance Distance Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Zone 1 operating time (cycles)
J+1		Zone 1 reach (diameter or reactance) (pu)
J+2		Zone 1 centerline angle in degrees (0 for reactance relay)
J+3		Zone 1 center distance (0 for reactance relay)
J+4		Zone 2 pickup time (cycles)
J+5		Zone 2 reach (diameter or reactance) (pu)
J+6		Zone 2 centerline angle (0 for reactance relay)
J+7		Zone 2 center distance (0 for reactance relay)
J+8		Zone 3 pickup time (cycles)
J+9		Zone 3 reach (diameter)
J+10		Zone 3 centerline angle (degrees)
J+11		Zone 3 center distance (pu)
J+12		Angle of directional unit (only for impedance relay)
J+13		Threshold current (pu)
J+14		Self trip breaker time (cycles)
J+15		Self trip reclosure time (cycles)
J+16		Transfer trip breaker time (cycles)
J+17		Transfer trip reclosure time (cycles)
J+18		1st blinder type (±1 or ±2)
J+19		1st blinder intercept (pu)
J+20		1st blinder rotation (degrees)
J+21		2nd blinder type (±1 or ±2)
J+22		2nd blinder intercept (pu)
J+23		2nd blinder rotation (degrees)

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VARs	Value	Description
L		Apparent R
L+1		Apparent X
L+2		Current
L+3 . . . L+9		VARs required for internal program logic

ICONs	Value	Description	
M		Type 1, mho distance Type 2, impedance distance Type 3, reactance distance	
M+1		0 Monitor 1 Monitor and operate	
M+2		From bus number	First transfer trip
M+3		To bus number	
M+4		Circuit ID	
M+5		From bus number	Second transfer trip
M+6		To bus number	
M+7		Circuit ID	
M+8		From bus number	Third transfer trip
M+9		To bus number	
M+10		Circuit ID	
M+11	X	Permissive flag for self trip[1]	
M+12	X	Permissive flag for transfer trip[2]	
M+13 . . . M+28	X	ICONs required for internal program logic	

[1] Set to 1 and -1 by supervisory relay to block trip and force trip, respectively.
[2] Set to 1 by supervisory relay to block trip.

IBUS, 'DISTR1', JBUS, ID, RS, ICON(M) to ICON(M+10), CON(J) to CON(J+23) /

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Zone Reach

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mho Distance

Reactance Distance

Impedance Distance

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Blinder Types

mho, Impedance, or Reactance Distance Relay

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11.3 DPDTR1

Rate of Change of Power Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Breaker time (>0) (sec)
J+1		Delay time (sec)
J+2		Derivative threshold (>0) (MW/sec)
J+3		Power threshold (>0) (MW)
J+4		Filter constant in number of time steps

VARs	Value	Description
L		Real power flow
L+1		Rate of change of power
L+2		Memory (for delay)
L+3		Mvar flow
L+4		MVA flow

ICONs	Value	Description
M		Operation mode: 0 Monitor 1 Monitor and operate
M+1		From bus number for transfer trip
M+2		To bus number
M+3		Circuit identifier
M+4	X	Delay flag
M+5	X	Time out flag for delay
M+6	X	Timer status

IBUS, ’DPDTR1’, JBUS, ID, RS, ICON(M) to ICON(M+3), CON(J) to CON(J+4) /

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11.4 RXR1

RXR Distance Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description	
J		R1 (> 0)	Polygon resistance and impedances to define four zones (as shown in the adjacent figure) are in per unit on system base.
J+1		X1	
J+2		R2	
J+3		X2 (> X1)	
J+4		R3 (< R2)	
J+5		X3 (> 0)	
J+6		R4	
J+7		X4 (> X1)	
J+8		R5 (< R4)	
J+9		X5 (> 0)	
J+10		R6	
J+11		X6	
J+12		R7 (> R6)	
J+13		X7	
J+14		R8	
J+15		X8 (> X7)	
J+16		R9 (≥ R10, < R8)	
J+17		X9	
J+18		R10 (≤ R6)	
J+19		X10 (< X9, > X6)	
J+20		R11	
J+21		X11	
J+22		R12	
J+23		X12 (> X11)	
J+24		R13 (< R12)	

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CONs	Value	Description	
J+25		X13	Polygon resistance and impedances (*continued*)
J+26		R14 (< R11)	
J+27		X14 (< X13)	
J+28		Zone 1 delay time (cycles)	
J+29		Zone 2 delay time (cycles)	
J+30		Zone 3 delay time (cycles)	
J+31		Zone 4 delay time (cycles)	
J+32		Threshold current (pu)	
J+33		Self trip breaker time (cycles)	
J+34		Self trip reclosure time (cycles)	
J+35		Transfer trip breaker time (cycles)	
J+36		Transfer trip reclosure time (cycles)	

VARs	Value	Description
L		Apparent R
L+1		Apparent X
L+2		Current magnitude
L+3		VARs required for internal program logic
L+4		
L+5		
L+6		
L+7		

ICONs	Value	Description	
M		0 Monitor 1 Monitor and trip	
M+1		From bus number	First transfer trip
M+2		To bus number	
M+3		Circuit ID	
M+4		From bus number	Second transfer trip
M+5		To bus number	
M+6		Circuit ID	
M+7		From bus number	Third transfer trip
M+8		To bus number	
M+9		Circuit ID	
M+10	X	Permissive flag for self trip[1]	

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ICONs	Value	Description
M+11	X	Permissive flag for transfer trip[2]
M+12 . . . M+24	X	ICONs required for internal program logic

[1] Set to 1 and -1 by supervisory relay to block trip and force trip, respectively.
[2] Set to 1 by supervisory relay to block trip.

IBUS, 'RXR1', JBUS, ID, RS, ICON(M) to ICON(M+9), CON(J) to CON(J+36) /

0, 'RXR', ICON(M) to ICON(M+14), CON(J) to CON(J+36) /

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11.5 SCGAP2

Series Capacitor Gap Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Gap firing current (pu)
J+1		Communication delay, T_d (cycles)
J+2		Gap reinsertion current (pu)
J+3		Reinsertion time delay (cycles)
J+4		Shorting switch time (cycles)
J+5		Transfer trip breaker time (cycles)

VARs	Value	Description
L		Current in monitored element
L+1		Original reactance
L+2		VARs required for internal logic
L+3		
L+4		
L+5		

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ICONs	Value	Description	
M		Number of reinsertion attempts	
M+1		From bus number	Series capacitor branch
M+2		To bus number	
M+3		Circuit ID	
M+4		From bus number	First transfer trip
M+5		To bus number	
M+6		Circuit ID	
M+7		From bus number	Second transfer trip
M+8		To bus number	
M+9		Circuit ID	
M+10		From bus number	Third transfer trip
M+11		To bus number	
M+12		Circuit ID	
M+13		Transfer trip option: 0 When gap flashes first time 1 When shorting switch closes	
M+14 . . . M+22	X	ICONs required for internal program logic	

IBUS, ’SCGAP2’, JBUS, ID, RS, ICON(M) to ICON(M+13), CON(J) to CON(J+5) /

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11.6 SLLP1

SLLP Tripping Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		T1 (cycles) (>0)
J+1		T2 (cycles) (>0)
J+2		T3 (cycles)[1]
J+3		T4 (cycles)[1]
J+4		R_1, resistance value of upper intersection (pu)
J+5		X_1, reactance value of upper intersection (pu)
J+6		R_2, resistance value of lower intersection (pu)
J+7		X_2, reactance value of lower intersection (pu)
J+8		P1, perpendicular distance to inner center (pu)[2]
J+9		P2, perpendicular distance to middle center (pu)
J+10		P3, perpendicular distance to outer center (pu)
J+11		Threshold current (pu)
J+12		Self trip breaker time (cycles)
J+13		Transfer trip breaker time (cycles)

1 Both T3 and T4 must be nonzero to cause tripping on the way out.
2 $P1 < P2 < P3 \leq$ one-half distance between (R_1, X_1) and (R_m, X_m).

VARs	Value	Description
L		Apparent R
L+1		Apparent X
L+2		Current
L+3		VARs required for internal program logic
L+4		
L+5		

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ICONs	Value	Description	
M		0 Monitor 1 Monitor and operate	
M+1		From bus number	First transfer trip
M+2		To bus number	
M+3		Circuit ID	
M+4		From bus number	Second transfer trip
M+5		To bus number	
M+6		Circuit ID	
M+7		From bus number	Third transfer trip
M+8		To bus number	
M+9		Circuit ID	
M+10	X	Permissive flag for self trip[1]	
M+11	X	Permissive flag for transfer trip[2]	
M+12 . . . M+20	X	ICONs required for internal program logic	

[1] Set to 1 and -1 by supervisory relay to block trip and force trip, respectively.
[2] Set to 1 by supervisory relay to block trip.

IBUS, ’SLLP1’, JBUS, ID, RS, ICON(M) to ICON(M+9), CON(J) to CON(J+13) /

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(R_m,X_m) is Center of Segment Connecting (R1,X1) to (R2,X2)

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11.7 SLNOS1

Straight Line Blinder Out-of-Step Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Interzone travel time (cycles)
J+1		Angle of first pair of impedance units (α)
J+2		Intercept of first line
J+3		Intercept of second line
J+4		Angle of second pair of impedance units (β)
J+5		Intercept of third line
J+6		Intercept of fourth line
J+7		Threshold current (pu)
J+8		Self trip breaker time (cycles)
J+9		Transfer trip breaker and delay time (cycles)
J+10		First blinder type ($\pm$1 or $\pm$2)
J+11		First blinder intercept (pu)
J+12		First blinder rotation (degrees)
J+13		Second blinder type
J+14		Second blinder intercept (pu)
J+15		Second blinder rotation (degrees)

VARs	Value	Description
L		Apparent R
L+1		Apparent X
L+2		Current
L+3		VARs required for internal program logic
L+4		
L+5		

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ICONs	Value	Description	
M		Type +1, single blinder tripping Type -1, single blinder blocking Type +2, double blinder tripping Type -2, double blinder blocking	
M+1		Operation mode: 0 Monitor 1 Monitor and operate	
M+2		From bus number	Second transfer trip
M+3		To bus number	
M+4		Circuit ID	
M+5		From bus number	Third transfer trip
M+6		To bus number	
M+7		Circuit ID	
M+8		From bus number	Third transfer trip
M+9		To bus number	
M+10		Circuit ID	
M+11		Supervisory ICON number (permissive ICON of another model)	
M+12	X	Permissive flag for self trip[1]	
M+13	X	Permissive flag for transfer trip[2]	
M+14 . . . M+21	X	ICONs required for internal program logic	

[1] Set to 1 and -1 by supervisory relay to block trip and force trip, respectively.
[2] Set to 1 by supervisory relay to block trip.

IBUS, ’SLNOS1’, JBUS, ID, RS, ICON(M) to ICON(M+11), CON(J) to CON(J+15) /

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Blinder Type Relay Characteristics

Single Blinder

Double Blinder

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11.8 SLYPN1

G.E. Directional Comparison and Overcurrent Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Zone 1 operating time (cycles)
J+1		Zone 1 reach (diameter in pu)
J+2		Zone 1 centerline angle (degrees)
J+3		Zone 1 center distance (pu)
J+4		Zone 2 pickup time bus IBUS (cycles)
J+5		Zone 2 forward reach bus IBUS (pu)
J+6		Zone 2 reverse reach bus IBUS (pu) (>0)
J+7		Zone 2 centerline angle bus IBUS (degrees)
J+8		Zone 2 circle diameter bus IBUS (pu)
J+9		Zone 2 pickup time bus JBUS (cycles)
J+10		Zone 2 for reach bus JBUS (pu)
J+11		Zone 2 reverse reach bus JBUS (pu) (>0)
J+12		Zone 2 centerline angle bus JBUS (degrees)
J+13		Zone 2 circle diameter bus JBUS (pu)
J+14		Reverse reaching block bus IBUS (diameter in pu) (>0)
J+15		Reverse reaching centerline angle bus IBUS (degrees) (>0)
J+16		Reverse reaching center distance bus IBUS (pu)
J+17		Reverse reaching block bus JBUS (diameter in pu) (>0)
J+18		Reverse reaching centerline angle bus JBUS (degrees) (>0)
J+19		Reverse reaching center distance bus JBUS (pu)
J+20		Overcurrent supervisory level bus IBUS (pu)
J+21		Overcurrent supervisory level bus JBUS (pu)
J+22		Interzone travel time bus IBUS (cycles)
J+23		Interzone travel time bus JBUS (cycles)

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CONs	Value	Description	
J+24		R	Equivalent values for single pole trip[1]
J+25		X[2]	
J+26		B	
J+27		G_{IBUS}	
J+28		B_{IBUS}	
J+29		G_{JBUS}	
J+30		B_{JBUS}	
J+31		Breaker time (cycles)	
J+32		Reclosure time (cycles)	

1 These values may be obtained from activity SPCB.
2 if (X > 1000) all three phases are tripped.

VARs	Value	Description
L		Apparent R at bus IBUS
L+1		Apparent X at bus IBUS
L+2		Current at bus IBUS
L+3		Apparent R at bus JBUS
L+4		Apparent X at bus JBUS
L+5		Current at bus JBUS
L+6 . . . L+21		VARs required for internal logic

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ICONs	Value	Description
M		Operation mode: 0 Monitor 1 Monitor and operate
M+1		Overcurrent supervision bus IBUS: +1 Trip -1 Block 0 None
M+2		Overcurrent supervision bus JBUS: +1 Trip -1 Block 0 None
M+3		Out-of-step blocking: 1 Yes 0 No
M+4 . . . M+22	X	ICONs required for internal program logic

IBUS, ’SLYPN1’, JBUS, ID, RS, ICON(M) to ICON(M+3), CON(J) to CON(J+32) /

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11.9 TIOCR1

Time Inverse Overcurrent Relay

Relay is located from bus	#_____	IBUS,
To bus	#_____	JBUS,
Circuit identifier	#_____	ID,
relay slot (1 or 2)	#_____	RS.
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	Value	Description
J		Current threshold (pu on system base)
J+1		Zero current reset time (sec)
J+2		Lowest operating current (as a multiple of pickup)
J+3		Time to close relay (sec)
J+4		Second current point (as a multiple of pickup)
J+5		Time to close relay (sec)
J+6		Third current point (as a multiple of pickup)
J+7		Time to close relay (sec)
J+8		Fourth current point (as a multiple of pickup)
J+9		Time to close relay (sec)
J+10		Largest or saturation current (as a multiple of pickup)
J+11		Time to close relay (sec)
J+12		Breaker time (sec)
J+13		Fraction of load to be shed

VARs	Value	Description
L		Current flow magnitude (pu)
L+1		Relay trip contact position
L+2		Breaker timer memory

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ICONs	Value	Description	
M		Operation mode: 0 Monitor 1 Monitor and operate	
M+1		Bus number for load shedding	
M+2		Load ID for load shedding	
M+3		From bus number	First transfer trip
M+4		To bus number	
M+5		Circuit ID	
M+6		From bus number	Second transfer trip
M+7		To bus number	
M+8		Circuit ID	
M+9		From bus number	Third transfer trip
M+10		To bus number	
M+11		Circuit ID	
M+12	X	Relay status	
M+13	X	Breaker timer flag	
M+14	X	Breaker timeout flag	

IBUS, ’TIOCR1’, JBUS, ID, RS, ICON(M) to ICON(M+11), CON(J) to CON(J+13) /

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SIEMENS

Chapter 12

Auxiliary-Signal Model Data Sheets

This chapter contains a collection of data sheets for the auxiliary-signal models contained in the PSS®E dynamics model library.

Model	Description
CHAAUT	Chateauguay auxiliary signal model
CPAAUT	Frequency sensitive auxiliary signal model
DCCAUT	Comerford auxiliary signal model
DCVRFT	HVDC ac voltage controller model
HVDCAT	General purpose auxiliary signal model
PAUX1T	Frequency sensitive auxiliary signal model
PAUX2T	Bus voltage angle sensitive auxiliary signal model
RBKELT	Runback model (can be used only with two-terminal dc line models)
SQBAUT	dc line auxiliary signal model (can be used only with two-terminal dc line models)

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12.1 CHAAUT

Chateauguay Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			F_{P1}, positive frequency deviation dead band threshold (Hz)
J+1			F_{N1}, negative frequency deviation dead band threshold (Hz)
J+2			M_{P1}, positive slope (MW/Hz)
J+3			M_{N1}, negative slope (MW/Hz)
J+4			K_{P1}
J+5			K_{D1}
J+6			T_1, time constants (sec)
J+7			T_2, time constants (sec)
J+8			F_{P2}, positive frequency deviation dead band threshold (Hz)
J+9			F_{N2}, negative frequency deviation dead band threshold (Hz)
J+10			M_{P2}, positive slope (MW/Hz)
J+11			M_{N2}, negative slope (MW/Hz)
J+12			K_{P2}
J+13			K_{D2}
J+14			T_3, time constants (sec)
J+15			T_4, time constants (sec)
J+16			P_{MAX} (MW)
J+17			P_{MIN} (MW)
J+18			T_{M1}, transducer time constant (sec)
J+19			T_{M2}, transducer time constant (sec)
J+20			P_{1POS} (MW)
J+21			P_{1NEG} (MW)
J+22			P_{2POS} (MW)

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CONs	#	Value	Description
J+23			P_{2NEG} (MW)

STATEs	#	Description
K		Integrator
K+1		Integrator
K+2		Integrator
K+3		Integrator
K+4		Transducer 1
K+5		Transducer 2

VAR	#	Description
L		Signal, MW

ICONs	#	Value	Description
M			IB, number of first bus where model is attached
M+1			JB, number of second bus where model is attached
M+2			ISW: ≥ 0 to subtract second signal from first < 0 to subtract first signal from second

IDVX, 'CHAAUT', IDVT, ISG, ICON(M) to ICON(M+2), CON(J) to CON(J+23) /

* + for ICON(M) input and – for ICON(M+1) input if ICON(M+2) > 0
– for ICON(M) input and + for ICON(M+1) input if ICON(M+2) < 0

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12.2 CPAAUT

Frequency Sensitive Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			C_m (MW per pu frequency)
J+1			T_B (>0) (sec)
J+2			T_A (>0) (sec)
J+3			P_{MAX} (MW)
J+4			P_{MIN} (MW)

STATEs	#	Description
K		Washout
K+1		Time constant

VAR	#	Description
L		Signal, MW

ICON	#	Description
M		Bus number

IDVX, 'CPAAUT', IDVT, ISG, ICON(M), CON(J) to CON(J+4) /

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12.3 DCCAUT

Comerford Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			F_{P1}, positive frequency deviation dead band threshold (Hz)
J+1			F_{N1}, negative frequency deviation dead band threshold (Hz)
J+2			M_{P1}, positive slope (MW/Hz)
J+3			M_{N1}, negative slope (MW/Hz)
J+4			K_{P1}
J+5			K_{D1}
J+6			T_1, time constants (sec)
J+7			T_2, time constants (sec)
J+8			F_{P2}, positive frequency deviation dead band threshold (Hz)
J+9			F_{N2}, negative frequency deviation dead band threshold (Hz)
J+10			M_{P2}, positive slope (MW/Hz)
J+11			M_{N2}, negative slope (MW/Hz)
J+12			K_{P2}
J+13			K_{D2}
J+14			T_3, time constants (sec)
J+15			T_4, time constants (sec)
J+16			DPDTMX, rate limit (MW/sec)
J+17			DPDTMN, rate limit (MW/sec)
J+18			T_{M1}, transducer time constant (sec)
J+19			T_{M2}, transducer time constant (sec)
J+20			P_{1POS} (MW)
J+21			P_{1NEG} (MW)
J+22			P_{2POS} (MW)
J+23			P_{2NEG} (MW)

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STATEs	#	Description
K		Integrator
K+1		Integrator
K+2		Integrator
K+3		Integrator
K+4		Transducer 1
K+5		Transducer 2

VAR	#	Description
L		Signal, MW

ICONs	#	Value	Description
M			IB, number of first bus where model is attached
M+1			JB, number of second bus where model is attached
M+2			ISW, ≥0 to subtract second signal from first, <0 to subtract first signal from second

IDVX, 'DCCAUT', IDVT, ISG, ICON(M) to ICON(M+2), CON(J) to CON(J+23) /

* + for ICON(M) input and – for ICON(M+1) input if ICON(M+2) ≥ 0
– for ICON(M) input and + for ICON(M+1) input if ICON(M+2) < 0

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12.4 DCVRFT

HVDC ac Voltage Controller

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_R (sec)
J+1			V_{IMAX}
J+2			V_{IMIN}
J+3			T_C (sec)
J+4			T_B (sec)
J+5			K_A
J+6			T_A (sec)
J+7			V_{RMAX}
J+8			V_{RMIN}

STATEs	#	Description
K		$V_{measured}$
K+1		Lead lag
K+2		V_R

VARs	#	Description
L		HVDC DCV delta
L+1		Reference voltage

ICON	#	Value	Description
M			Bus number

IDVX, 'DCVRFT', IDVT, ISG, ICON(M), CON(J) to CON(J+8) /

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12.5 HVDCAT

General Purpose Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			MININ
J+1			MAXIN
J+2			K_s
J+3			T_1 (> 0) (sec)
J+4			A (0 or 1)
J+5			T_2 (sec)
J+6			T_3 (sec)
J+7			B (0 or 1)
J+8			T_4 (sec)
J+9			T_5 (sec)
J+10			C
J+11			D
J+12			E
J+13			F
J+14			MINOUT
J+15			MAXOUT

STATEs	#	Description
K		Lag block
K+1		First lead-lag
K+2		Second lead-lag
K+3		2nd order block
K+4		2nd order block

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VARs	#	Description
L		Signal
L+1		Internal
L+2		Storage

ICONs	#	Description
M		Input code: 1 Current on branch (pu) 2 Power on branch (pu) 3 Frequency difference bus_i - bus_j (pu) 4 Voltage bus_i (pu) 5 Frequency bus_i (pu)
M+1		Bus i number
M+2		Bus j number or zero for input 4 and 5
M+3		Branch ID or zero for inputs 3, 4, and 5, or -1 for sum of parallel line flows

IDVX, 'HVDCAT', IDVT, ISG, ICON(M) to ICON(M+3), CON(J) to CON(J+15) /

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12.6 PAUX1T

Frequency Sensitive Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATE	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_R (>0) (sec)
J+1			T_D (sec) (≤10 time steps)
J+2			K_C
J+3			MAX (MW)
J+4			MIN (MW)

STATE	#	Description
K		Sensor

VARs	#	Description
L		Signal, MW
L+1 . . . L+10		Delay table

ICON	#	Description
M		Bus number

IDVX, 'PAUX1T', IDVT, ISG, ICON(M), CON(J) to CON(J+4) /

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12.7 PAUX2T

Bus Voltage Angle Sensitive Auxiliary Signal Model

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_R (sec)
J+1			T_D (sec) ($\leq$9 time steps)
J+2			K_C
J+3			T_1 (>0) (sec)
J+4			T_2 (>0) (sec)
J+5			T_3 (>0) (sec)
J+6			T_4 (>0) (sec)
J+7			MAX (MW)
J+8			MIN (MW)

STATEs	#	Description
K		Sensor
K+1		Washout
K+2		Washout

VARs	#	Description
L		Signal, MW
L+1 . . . L+9		Delay table
L+10		Memory
L+11		Reference

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ICON	#	Description
M		Bus number

IDVX, 'PAUX2T', IDVT, ISG, ICON(M), CON(J) to CON(J+8) /

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12.8 RBKELT

Eel River Runback

(can be used with two-terminal dc line models only)

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATE	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			FCOUT, final converter output (MW)
J+1			RBKTI, runback time (sec)
J+2			DELAY, time delay after ICON(M+1) set before runback starts

STATE	#	Description
K		Output signal (MW)

VARs	#	Description
L		Memory
L+1		Memory

ICONs	#	Value	Description
M			Runback Flag: 0 Not active 1 Start runback
M+1			Internal ICON Value need not be input by user.

IDVX, 'RBKELT', 1, ISG, ICON(M), CON(J) to CON(J+2) /

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12.9 RUNBKT

Two-Terminal dc Line Runback Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			Slope, change in SETVAL per second1
J+1			Duration of runback (sec)
J+2			Final level of SETVAL

1 When CON(J) $\neq$ 0, the magnitude of runback slope will be smaller of CON(J) or SETVAL – CON(J+2)/CON(J+1).

STATE	#	Description
K		Level of SETVAL

VARs	#	Description
L		Starting time for ramp
L+1		Final time for ramp

ICON	#	Value	Description
M			RB: 1 to runback 0 otherwise

’2-Terminal DC Line Name’, ’RUNBKT’, 1, 1, ICON(M), CON(J) to CON(J+2)..../

Note: This auxiliary signal modifies the SETVAL of 2-terminal DC lines.

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12.10 SQBAUT

Frequency Sensitive dc Line Auxiliary Signal Model

(can be used with two-terminal dc lines only)

This model is attached to device:	IDVX	
Device type:	IDVT	
Signal injection point number:	ISG	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			K_{DC} (amps per pu frequency)
J+1			K_{AC} (amps per pu frequency)
J+2			T_2 (>0) (sec)
J+3			A_1
J+4			A_2
J+5			B_1
J+6			B_2 (>0)
J+7			I_{MAX} (amps)
J+8			I_{MIN} (amps)
J+9			Current step (amps)
J+10			T_d Communication delay (sec) $\leq$10 time steps
J+11			T_L (sec)

STATEs	#	Description
K		Input filter
K+1		First notch filter STATE
K+2		Second notch filter STATE
K+3		First lag
K+4		Second lag

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VARs	#	Description
L		Signal, MW
L+1 . . . L+10		Delay table

ICON	#	Value	Description
M			Bus number

IDVX, 'SQBUAT', 1, ISG, ICON(M), CON(J) to CON(J+11) /

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SIEMENS

Chapter 13

Two-Terminal dc Line Model Data Sheets

This chapter contains a collection of data sheets for the two-terminal dc line models contained in the PSS®E dynamics model library.

Model	Description
CDC1T	Two-terminal dc line model
CDC4T	Two-terminal dc line model
CDC6T	Two-terminal dc line model
CDC6TA	Two-terminal dc line model
CDC7T	dc line model
CDCABT	ABB dc line model for Kontek line
CEELT	New Eel River dc line and auxiliaries model. This model internally uses the following models: CHAAUT (auxiliary-signal model), CEEL2T (two-terminal dc line model), and RUNBKT (dc line runback model).
CEEL2T	New Eel River dc line model
CHIGATT	Highgate dc line model.
CMDWAST	Madawaska dc line model.
CMDWS2T	New Madawaska dc line model.
CMFORDT	Comerford dc line model.

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13.1 CDC1T

Two-terminal dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_1, dc voltage transducer time constant
J+1			T_2, dc line or firing angle time constant
J+2			I_{MIN}, minimum current demand (amps)
J+3			I_1, limit point 1, current (amps)
J+4			V_2, limit point 2, voltage (V)
J+5			I_2, limit point 2, current (amps)
J+6			V_3, limit point 3, voltage (V)
J+7			I_3, limit point 3, current (amps)
J+8			DELTI, current margin (pu)
J+9			V_{MIN}, shutdown voltage (pu)
J+10			V_{ON}, unblocking voltage (pu)
J+11			T_{MIN}, minimum blocking time (sec)
J+12			RAMP, recovery rate (pu/sec)

STATEs	#	Description
K		Measured inverter dc voltage
K+1		Measured line dc current

VARs	#	Description
L		Other signals (MW) [DC2SIG(1,I)]
L+1		VPCR, rectifier dc voltage
L+2		VDCI, inverter dc voltage
L+3		SETVAL, current (amps) or power (MW) demand
L+4		DC, dc current (amps)
L+5		ALPHA, alpha-rectifier (degrees)
L+6		GAMMA, gamma-inverter (degrees)
L+7		PACR, rectifier ac real power (pu)

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VARs	#	Description
L+8		QACR, rectifier ac reactive power (pu)
L+9		PACI, inverter ac real power (pu)
L+10		QACI, inverter ac reactive power (pu)
L+11		KF, ramping factor
L+12		TON, unblocking time

ICON	#	Description
M		Control mode:[1] 0 Blocked 1 Power 2 Current

[1] Not intended to be changed by user.

Note: If GAMMIN = GAMMX in power flow, line is assumed to be in GAMMA control. This model uses auxiliary signal output stored in DC2SIG(1,I) (i.e., auxiliary signal index 1).

'DC Line Name', 'CDC1T', CON(J) to CON(J+12) /

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13.2 CDC4T

Two-terminal dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			TVDC, dc voltage transducer time constant (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VBLOCK, rectifier ac blocking voltage (pu)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLOCK, minimum blocking time (sec)
J+7			VBYPAS, inverter dc bypassing voltage (kV)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			TBYPAS, minimum bypassing time (sec)
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1 (kV)
J+16			C1, Current limit point 1 (amps); ≥C0
J+17			V2, voltage limit point 2 (kV)
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3 (kV)
J+20			C3, current limit point 3 (amps)
J+21			TCMODE, minimum time stays in switched mode (sec)

[1] Ignored if in gamma control (i.e., GAMMAX = GAMMIN in power flow).

STATEs	#	Description
K		Measured inverter dc voltage (V)
K+1		Measured inverter dc current (amps)

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VARs	#	Description
L		Other signals, MW [DC2SIG(1,I)]
L+1		RESTR, time unblocks or) unbypasses (sec
L+2		VRF, voltage ramping factor
L+3		CRF, current ramping factor
L+4		VCOMP, compensating dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		TIME, reswitches mode

ICONs	#	Description
M		Bypass control flag:[1] 0 Not bypassed 1 Bypassed 2 Unbypass
M+1		Blocking control flag:[1] 0 Not blocked 1 Blocked 2 Unblocked
M+2		Switched mode control flag:[1] 0 Normal 1 Mode switched

[1] Not intended to be changed by the user.

Note: This model uses auxiliary signal output stored in DC2SIG(1,I) (i.e., auxiliary signal index 1).

’DC Line Name’, ’CDC4T’, CON(J) to CON(J+21) /

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Voltage-Dependent Upper Current Limit

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13.3 CDC6T

Two-terminal dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			TVDC, dc voltage transducer time constant (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VBLOCK, rectifier ac blocking voltage (pu)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLOCK, minimum blocking time (sec)
J+7			VBYPAS, inverter dc bypassing voltage (kV)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			TBYPAS, minimum bypassing time (sec)
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1 (kV)
J+16			C1, current limit point 1 (amps); ≥C0
J+17			V2, voltage limit point 2 (kV)
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3 (kV)
J+20			C3, current limit point 3 (amps)
J+21			TCMODE, minimum time stays in switched mode (sec)
J+22			VDEBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, Time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVRDC, rectifier dc voltage transducer time constant (sec)

[1] Ignored if in gamma control (i.e., GAMMAX = GAMMIN in power flow).

STATEs	#	Description
K		Measured inverter dc voltage (V)
K+1		Measured inverter dc current (amps)
K+2		Measured rectifier dc voltage (V)

VARs	#	Description
L		Other signals, MW [DC2SIG(1,I)]
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage ramping factor
L+3		CRF, current ramping factor
L+4		VCOMP, compensating dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		TIME, reswitches mode
L+15		TIMER, rectifier blocking and unblocking timer

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VARs	#	Description
L+16		TIMEI, inverter blocking and unblocking timer
L+17		TIBYP, inverter bypass and unbypass timer

ICONs	#	Description
M		Bypass control flag:[1] 0 Not bypassed 1 Bypassed 2 Unbypass
M+1		Blocking control flag:[1] 0 Not blocked 1 Blocked 2 Unblocked
M+2		Switched mode control flag:[1] 0 Normal 1 Mode switched

[1] Not intended to be changed by the user.

Note: This model uses auxiliary signal output stored in DC2SIG(1,I) (i.e., auxiliary signal index 1).

’DC Line Name’, ’CDC6T’, CON(J) to CON(J+31) /

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13.4 CDC6TA

Two-terminal dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			TVDC, dc voltage transducer time constant (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VBLOCK, rectifier ac blocking voltage (pu)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLOCK, minimum blocking time (sec)
J+7			VBYPAS, inverter dc bypassing voltage (kV)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			TBYPAS, minimum bypassing time (sec)
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1 (kV)
J+16			C1, Current limit point 1 (amps); ≥C0
J+17			V2, Voltage limit point 2 (kV)
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3 (kV)
J+20			C3, current limit point 3 (amps)
J+21			TCMODE, minimum time stays in switched mode (sec)
J+22			VDEBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVRDC, rectifier dc voltage transducer time constant (sec)

[1] Ignored if in gamma control (i.e., GAMMAX = GAMMIN in power flow).

STATEs	#	Description
K		Measured inverter dc voltage (V)
K+1		Measured inverter dc current (amps)
K+2		Measured rectifier dc voltage (V)

VARs	#	Description
L		Other signals, MW [DC2SIG(1,I)]
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage ramping factor
L+3		CRF, current ramping factor
L+4		VCOMP, compensating dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		TIME, reswitches mode
L+15		TIMER, rectifier blocking and unblocking, timer
L+16		TIMEI, inverter blocking and unblocking, timer
L+17		TIBYP, inverter bypass and unbypass timer

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VARs	#	Description
L+18		$I_{measured}$ current in amps (I´r)
L+19		$I_{desired}$ before VDCL in amps (I_{DESr})
L+20		VDCL output in amps I''_{MAXr})
L+21		GAMMOD,[1] gamma modulation in degrees [DC2SIG (2, I)]
L+22		Low level modulation and current margin; makeup applied at rectifier in amps [DC2SIG (3, I)]
L+23		Low level modulation and current margin; makeup applied at inverter in amps [DC2SIG (4, I)]

[1] Only used if in constant gamma control (i.e., GAMMAX = GAMMIN in power flow.

ICONs	#	Description
M		Bypass control flag:[1] 0 Not bypassed 1 Bypassed 2 Unbypass
M+1		Blocking control flag:[1] 0 Not blocked 1 Blocked 2 Unblocked
M+2		Switched mode control flag:[1] 0 Normal 1 Mode switched

[1] Not intended to be changed by the user.

Note: This model uses auxiliary signal outputs stored in DC2SIG(1,I) through DC2SIG(4,I) (i.e., auxiliary signal index 1 through 4).

'DC Line Name','CDC6TA', CON(J) to CON(J+31) /

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13.5 CDC7T

dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Notation	Description
J			Ts_vdc	dc voltage sensor time constant, sec.
J+1			Ts_idc	dc current sensor time constant, sec.
J+2			LRR	Rectifier smoothing reactor inductance, mH
J+3			RRR	Rectifier smoothing reactor resistance, ohm
J+4			LRI	Inverter smoothing reactor inductance, mH
J+5			RRI	Inverter smoothing reactor resistance, ohm
J+6			LOHR	Inductance of O/H dc line from rectifier side, mH
J+7			ROHR	Resistance of O/H dc line from rectifier side, ohm
J+8			LOHI	Inductance of O/H dc line from inverter side, mH
J+9			ROHI	Resistance of O/H dc line from inverter side, ohm
J+10			LDCC	Inductance of dc cable line, mH
J+11			RDCC	Damping resistance of dc cable line, ohm
J+12			CDCC	dc line capacitance, μF
J+13			LF1	dc fault shunt inductance, rectifier side, mH
J+14			RF1	dc fault shunt resistance, rectifier side, ohm
J+15			LF2	dc fault shunt inductance, mid-line, mH
J+16			RF2	dc fault shunt resistance, mid-line, ohm
J+17			LF3	dc fault shunt inductance, inverter side, mH
J+18			RF3	dc fault shunt resistance, inverter side, ohm
J+19			RCDCC	dc cable damping resistor
J+20			IDCRated	Rated dc current, A
J+21			VDCRated	Rated dc voltage, kV
J+22			VDCompR_Tdown	VDComp down time constant for VDCL, rectifier, sec
J+23			VDCompR_Tup	VDComp up time constant for VDCL, rectifier, sec

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CONs	#	Value	Notation	Description
J+24			VDCompI_Tdown	VDComp down time constant for VDCL, inverter, sec
J+25			VDCompI_Tup	VDComp up time constant for VDCL, inverter, sec
J+26			IMargR	Current margin, rectifier, pu
J+27			IMargI	Current margin, inverter, pu
J+28			VMargR	Voltage margin, rectifier, pu
J+29			VMargI	Voltage margin, inverter, pu
J+30			GMargR	Gamma margin, rectifier, pu
J+31			GMargI	Gamma margin, inverter, pu
J+32			IDCERR_toV_GAIN_R	IDC error to V-control gain, rectifier
J+33			IDCERR_toV_GAIN_I	IDC error to V-control gain, inverter
J+34			IDCERR_toG_GAIN_I	IDC error to Gamma-control gain, inverter
J+35			VDComp_MEAS_GR	VDComp filter gain, rectifier, pu
J+36			VDComp_MEAS_GI	VDComp filter gain, inverter, pu
J+37			VDComp_MEAS_TR	VDComp filter time constant, rectifier, sec.
J+38			VDComp_MEAS_TR	VDComp filter time constant, inverter, sec.
J+39			DSEL_KBR	Selected controller output gain, rectifier
J+40			DSEL_KBI	Selected controller output gain, inverter
J+41			GPGR	PI-controller proportional gain, rectifier
J+42			TIGR	PI-controller integrator time constant, rectifier, sec.
J+43			GPGI	PI-controller proportional gain, inverter
J+44			TIGI	PI-controller integrator time constant, inverter, sec.
J+45			MAXALR	Max Alfa limit, rectifier
J+46			MINALR	Min Alfa limit, rectifier
J+47			MAXALI	Max Alfa limit, inverter
J+48			MINALI	Min Alfa limit, inverter
J+49			GAMA_ORDER1	Control configuration 1
J+50			GAMA_ORDER2	Control configuration 3
J+51			GAMDY	Min GAMA in dynamics
J+52			BLOCK_RATE	Rate of current order change when blocking, A/sec
J+53			UNBLOCK_RATE	Rate of current order change when unblocking, A/sec
J+54			TVDCP	VDC filter time constant for Pordr calculation, sec.

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CONs	#	Value	Notation	Description
J+55 to J+64				5 pairs of rectifier VDCL coordinates (Vd1, Id1) … (Vd5, Id5)[1]
J+65 to J+74				5 pairs of inverter VDCL coordinates (Vd1, Id1) … (Vd5, Id5)[1]

[1] The VDCL characteristics can be specified using a minimum of 2 pairs and a maximum of 5 pairs of (Vd - Id) points. The rectifier data points are specified in CON (J+55) through CON(J+64), while the inverter data points are specified in CON(J+65) through CON(J+74). The first zero value for the (Vd - Id) pair signifies the end of VDCL data points.

STATEs	#	Description
K		Measured dc voltage, inverter, V
K+1		Measured dc current, inverter, A
K+2		Measured dc voltage, rectifier, V
K+3		Measured dc current, rectifier, A
K+4		IDCR, Rectifier dc current, A
K+5		IDCI, Inverter dc current, A
K+6		VCDC, DC line capacitor voltage, V
K+7		Rectifier VDComp filter, pu
K+8		Inverter VDComp filter, pu
K+9		Rectifier VDComp measured, pu
K+10		Inverter VDComp measured, pu
K+11		PI controller integrator, rectifier, rad
K+12		PI controller integrator, inverter, rad
K+13		IF1, fault current dc fault 1
K+14		IF2, fault current dc fault 2
K+15		IF3, fault current dc fault 3
K+16		VDC filter for power order calculation

VARs	#	Description
L		Other signals, MW [DC2SIG (1, I)][1]
L+1		PACR, pu active power at rectifier ac bus
L+2		QACR, pu reactive power at rectifier ac bus
L+3		PACI, pu active power at inverter ac bus
L+4		QACI, pu reactive power at inverter ac bus
L+5		VDCI, inverter dc voltage, V
L+6		VDCR, rectifier dc voltage, V
L+7		ALFA, degrees

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VARs	#	Description
L+8		GAMA, degrees
L+9		Initial rectifier DC current order, A
L+10		Rectifier current order, limited by VDCL, pu
L+11		Inverter current order, limited by VDCL, pu
L+12		Current controller output, rectifier
L+13		Current controller output, inverter
L+14		Voltage controller output, rectifier
L+15		Voltage controller output, inverter
L+16		Gamma controller output, inverter
L+17		Selected controller output, rectifier
L+18		Selected controller output, inverter
L+19		Inverter Alpha, degrees
L+20		Initial VDComp (compensated dc voltage)
L+21		DC current order for block/unblock and overload, A
L+22		IDC1, sending end dc current, A
L+23		IDC2, receiving end dc current, A
L+24		P_{ORD}, power order, pu
L+25		I_{order}, dc current order, pu

[1] CDC7T model can accept one auxiliary signal input (auxiliary signal index 1). The auxiliary signal has to be in units of MW. The auxiliary signal is summed with the power order, which is then used to derive the current order.

ICONs	#	Description
M		Blocking and Unblocking Simulation Flag: 0 none 1 blocking 2 unblocking
M+1		Overload Simulation Flag: 0 none 1 overload
M+2		Control configuration: 1, 2, or 3[1]
M+3		1 cable or cable + overhead 2 overhead

[1] ICON(M+2) = 1 : Rectifier in dc current control; inverter in gamma control
ICON(M+2) = 2 : Rectifier in dc current control; inverter in dc voltage control
ICON(M+2) = 3 : Rectifier in dc voltage control; inverter in dc current control

‘DC Line Name’, CDC7T ', 0, 0, ICON(M+2), ICON(M+3), CON(J) to CON(J+74) /

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VDCL Characteristics

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13.6 CDCABT

Kontek ABB dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

Refer to the *PSS®E Program Application Guide* for complete block diagrams of the controls and description of various functions.

CONs	#	Value	Description
J			DELTMAX, user-specified time step (sec)
J+1			MANBYP_R, rectifier manually bypassed if 1
J+2			MANBYP_I, inverter manually bypassed if 1
J+3			T-BYPASS_MIN, minimum bypass time (sec)
J+4			GAMMACF, inverter gamma limit for commutation failure (deg)
J+5			VAC_NO_CF, inverter ac unbypass voltage (pu)
J+6			IdN, nominal dc current (amp)
J+7			CURMARG, current margin (amp)
J+8			TIDC_R, rectifier current measurement time constant (sec)
J+9			TVDC_R, rectifier current measurement time constant (sec)
J+10			RS_R, rectifier smoothing reactor resistance (Ω)
J+11			LS_R, rectifier smoothing reactor inductance (mH)
J+12			L_R, rectifier cable inductance (mH)
J+13			TIDC_I, inverter current measurement time constant (sec)
J+14			TVDC_I, inverter current measurement time constant (sec)
J+15			RS_I, inverter smoothing reactor resistance (Ω)
J+16			LS_I, inverter smoothing reactor (mH)
J+17			L_I, inverter cable inductance (mH)
J+18			CC, cable capacitance (μF)
J+19			RC, cable resistance (Ω)
J+20			IOMAX_MASTER, maximum current order for master controller (amp)
J+21			TMASTER_HIGH, master voltage time constant (sec)
J+22			TMASTER_LOW, master voltage time constant (sec)
J+23			UMASTERLIM, master voltage limit (V)
J+24			T_DOWN_R, rectifier VDCL time constant for decreasing voltage (sec)
J+25			T_UP_R, rectifier VDCL time constant for increasing voltage (sec)
J+26			Udbr_R, rectifier voltage knee for VDCL characteristic (kV)

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CONs	#	Value	Description
J+27			IOMAXM_R, rectifier VDCL maximum lower current limit (amp)
J+28			IOMIN_R, rectifier VDCL minimum lower current limit (amp)
J+29			IMAX_R, rectifier VDCL maximum current limit (amp)
J+30			T_DOWN_I, inverter VDCL time constant for decreasing voltage (sec)
J+31			T_UP_I, inverter VDCL time constant for increasing voltage (sec)
J+32			Udbr_I, inverter voltage knee for VDCL characteristics (kV)
J+33			IOMAXIM_I, inverter VDCL maximum lower current limit (amp)
J+34			IOMIN_I, inverter VDCL minimum lower current limit (amp)
J+35			IMAX_I, inverter VDCL maximum current limit (amp)
J+36			T_IOF_R, rectifier CCA current order filter time constant (sec)
J+37			A_MAX_R, rectifier CCA limit (degrees)
J+38			A_MIN_R, rectifier CCA limit (degrees)
J+39			A_NOM_R, rectifier CCA nominal alpha used in linearization (degrees)
J+40			LINMAX_R, rectifier CCA limit of linearized alpha
J+41			LIN_MIN_R, rectifier CCA limit of linearized alpha
J+42			KP_R, rectifier CCA proportional gain (degrees/amps)
J+43			KI_TI_R, rectifier CCA integral constant (degrees/sec*amps)
J+44			APROP_MAX_R, rectifier CCA limit of proportional part (degrees)
J+45			APROP_MIN_R, rectifier CCA limit of proportional part (degrees)
J+46			AORDER_MIN_R, rectifier CCA limit of integral part (degrees)
J+47			T_IOF_I, inverter CCA current order filter time constant (sec)
J+48			A_MAX_I, inverter CCA limit (degrees)
J+49			A_MIN_I, inverter CCA limit (degrees)
J+50			A_NOM_I, inverter CCA nominal alpha used in linearization (degrees)
J+51			LIN_MAX_I, inverter CCA limit of linearized alpha
J+52			LIN_MIN_I, inverter CCA limit of linearized alpha
J+53			KP_I, inverter CCA proportional gain (degrees/amps)
J+54			KI_TI_I, inverter CCA integral constant (degrees/sec*amp)
J+55			APROP_MAX_I, inverter CCA limit of proportional part (degrees)
J+56			APROP_MIN_I, inverter CCA limit of proportional part (degrees)
J+57			AORDER_MIN_I, inverter CCA limit of integral part (degrees)
J+58			K1_R, rectifier alpha-max gain (A^{-1})
J+59			T1_R, rectifier alpha-max time constant (sec)

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CONs	#	Value	Description
J+60			T2_R, rectifier alpha-max time constant (sec)
J+61			K1_MAX_R, rectifier alpha-max limit (A^{-1})
J+62			U_NORM_MAX_R, rectifier alpha-max voltage limit (pu)
J+63			U_NORM_MIN_R, rectifier alpha-max voltage limit (pu)
J+64			S1_MIN_R, rectifier alpha-max limits
J+65			MIN_AMAX_R, rectifier alpha-max limit (degrees)
J+66			GAMMAMIN_R, rectifier minimum nominal gamma (degrees)
J+67			K1_I, inverter alpha-max gain, (A^{-1})
J+68			T1_1, inverter alpha-max time constant (sec)
J+69			T2_I, inverter alpha-max time constant (sec)
J+70			K1_MAX_I, inverter alpha-max limit (A^{-1})
J+71			U_NORM_MAX_I, inverter alpha-max voltage limit (pu)
J+72			U_NORM_MIN_I, inverter alpha-max voltage limit (pu)
J+73			S1_MIN_I, inverter alpha-max limit
J+74			MIN_AMAX_I, inverter alpha-max limit (degrees)
J+75			GAMMAMIN_I, inverter minimum nominal gamma (degrees)
J+76			T_CFC_R, rectifier CFC time constant (sec)
J+77			ALFA_MAX_R, rectifier upper limit on alpha (degrees)
J+78			TALFA_MAX_I, inverter ac voltage measurement time constant (sec)
J+79			T_CFC_I, inverter CFC time constant (s^{-1})
J+80			ALFA_MIN_I, inverter CFC lower limit on alpha (degrees)
J+81			DELTGAM, inverter CFC gamma margin (degrees)
J+82			ALFA1 in CFC (degrees)
J+83			ALFA2 in CFC (degrees)
J+84			ALFA3 in CFC (degrees)
J+85			ALFA4 in CFC (degrees)
J+86			ALFA5 in CFC (degrees)
J+87			ALFA6 in CFC (degrees)
J+88			DALFA_MAX1 in CFC (degrees/sec)
J+89			DALFA_MAX2 in CFC (degrees/sec)
J+90			DALFA_MAX3 in CFC (degrees/sec)
J+91			DALFA_MAX4 in CFC (degrees/sec)
J+92			DALFA_MAX5 in CFC (degrees/sec)
J+93			DALFA_MIN1 in CFC (degrees/sec)

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CONs	#	Value	Description
J+94			DALFA_MIN2 in CFC (degrees/sec)
J+95			DALFA_MIN3 in CFC (degrees/sec)
J+96			DALFA_MIN4 in CFC (degrees/sec)
J+97			T_PSC_R, rectifier phase shift correction time constant (sec)
J+98			T_PSC_I, inverter phase shift correction time constant (sec)
J+99			K_CC, inverter dynamic current compound gain (degrees)
J+100			T_CC1, inverter dynamic current compound time constant (sec)
J+101			T_CC2, inverter dynamic current compound time constant (sec)
J+102			DA_CC_LIMU, inverter dynamic current compound upper limit (degrees)
J+103			DA_CC_LIML, inverter dynamic current compound lower limit (degrees)
J+104			MAX_AORDER_MIN_R, transient controller rectifier maximum alpha (degrees)
J+105			TEN_TRCONR, transient controller rectifier time enable (sec)
J+106			TDIS_TRCONR, transient controller rectifier time disable (sec)
J+107			UAC_TRCONR, transient controller rectifier ac voltage limit (pu)
J+108			D_AORDER_MIN_R, transient controller rectifier alpha ramp down rate (degrees/sec)
J+109			TRCONI_DGAMA, transient controller inverter gamma increase (degrees)
J+110			TRCONI_TUP, transient controller inverter time constant (sec)
J+111			TRCONI_TDOWN, transient controller inverter time constant (sec)
J+112			TRCONI_ACVOLT_ACTIVE, transient controller inverter ac voltage limit (pu)
J+113			TRCONI_ACVOLT_DEACTIV, transient controller inverter ac voltage limit (pu)
J+114			GAMST_LIM, inverter gamma O start ac voltage limit (pu)
J+115			GANST_IORD, inverter gamma O start current order added to CCA (amp)
J+116			TIME_EN, inverter gamma O start time constant (sec)
J+117			TIME_DIS, inverter gamma O start time constant (sec)
J+118			VOLT_EN, inverter gamma O start dc voltage limit (V)
J+119			VOLT_DIS, inverter gamma O start dc voltage limit (V)
J+120			DB_R, rectifier frequency controller dead band (Hz)
J+121			K_FREQ_R, rectifier frequency controller gain (MW/Hz)
J+122			T_FREQ_R, rectifier frequency controller time constant (sec)
J+123			UL_FREQ_R, rectifier frequency controller upper limit (MW)

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CONs	#	Value	Description
J+124			LL_FREQ_R, rectifier frequency controller lower limit (MW)
J+125			DB_I, inverter frequency controller dead band (Hz)
J+126			K_FREQ_I, inverter frequency controller gain (MW/Hz)
J+127			T_FREQ_I, inverter frequency controller time constant (sec)
J+128			UL_FREQ_I, inverter frequency controller upper limit (MW)
J+129			LL_FREQ_I, inverter frequency controller lower limit (MW)
J+130			T1DAMP_R, rectifier damping controller time constant (<> T2DAMP_R) (sec)
J+131			T2DAMP_R, rectifier damping controller time constant (sec)
J+132			KDAMP_R, rectifier damping controller gain (MW/Hz)
J+133			ULDAMP_R, rectifier damping controller upper limit (MW)
J+134			LLDAMP_R, rectifier damping controller lower limit (MW)
J+135			T1DAMP_I, inverter damping controller time constant (<>T2DAMP_I) (sec)
J+136			T2_DAMP_I, inverter damping controller time constant (sec)
J+137			KDAMP_I, inverter damping controller gain (MW/Hz)
J+138			ULDAMP_I, inverter damping controller upper limit (MW)
J+139			LLDAMP_I, inverter damping controller lower limit (MW)
J+140 to J+159			EPC_FLIMIT, EPC frequency limit (Hz)
J+160 to J+179			EPC_TIME EPC, time to apply active power (sec)
J+180 to J+199			EPC_DP EPC, active power step (MW)
J+200			KP_VC, inverter voltage controller gain (degrees (degrees/kV UdN)
J+201			TI_VC inverter voltage controller time constant (s*kV UdN/degrees)
J+202			DALFA_MAX_VC, inverter voltage control upper limit (degrees)
J+203			DALFA_MIN_VC, inverter voltage controller lower limit (degrees)

STATEs	#	Description
K		IDC_R, rectifier dc current (amps)
K+1		IM_R, rectifier dc current measurement (amps)
K+2		VM_R, rectifier dc voltage measurement (V)
K+3		IDC_I, inverter dc current (amps)
K+4		IM_I, inverter dc current measurement (amps)

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STATEs	#	Description
K+5		VM_I, inverter dc voltage measurement (V)
K+6		VC, cable voltage (V)
K+7		UVDCOL_R, rectifier voltage measurement VDCL (V)
K+8		UVDCOL_I, inverter voltage measurement VDCL (V)
K+9		AINT_R, rectifier integral part of alpha-order CCA
K+10		AINT_I, inverter integral part of alpha-order CCA
K+11		Rectifier alpha integrator CFC (rad)
K+12		Inverter alpha integrator CFC (rad)
K+13		S1_R, rectifier state 1, alpha-max limitation
K+14		S1_I, inverter state 1, alpha-max limitation
K+15		S2_R, rectifier state 2, alpha-max limitation
K+16		S1_I, inverter state 2, alpha-max limitation
K+17		Inverter ac voltage measurement (pu)
K+18		Inverter transient controller state (rad)
K+19		FREQ_R, rectifier frequency control (MW)
K+20		FREQ_I, inverter frequency control (MW)
K+21		DAMP1_R, rectifier power modulation state 1
K+22		DAMP2_R, rectifier power modulation state 2
K+23		DAMP1_I, inverter power modulation state 1
K+24		DAMP2_I, inverter power modulation state 2
K+25		Master dc voltage rectifier (V)
K+26		Master dc voltage inverter (V)
K+27		Phase shift correction rectifier (rad)
K+28		Phase shift correction inverter (rad)
K+29		Dynamic current compound inverter state 1 (rad)
K+30		Dynamic current compound inverter state 2 (rad)
K+31		Current order filter rectifier alpha-max (amps)
K+32		Current order filter inverter alpha-max (amps)
K+33		Voltage control for long cables (rad)

VARs	#	Description
L		PRECT, rectifier dc active power (W)
L+1		QRECT, inverter dc reactive power (var)
L+2		PINVRT, inverter dc active power (W)
L+3		QINVRT, inverter dc reactive power (var)
L+4		UDC_R, rectifier dc voltage (V)

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VARs	#	Description
L+5		UDC_I, inverter dc voltage (V)
L+6		MU_I, inverter overlap angle (rad)
L+7		GAMA_I, inverter gamma (rad)
L+8		IC, current in cable capacitance (amps)
L+9		PORDER, power order master controller (W)
L+10		IOO, current order master controller (amps)
L+11		TMASTER_R, master voltage time constant if rectifier is master (sec)
L+12		TMASTER_I, master voltage time constant if inverter is master (sec)
L+13		T_R, rectifier time constant VDCL
L+14		IOMAX_R, rectifier maximum current (amps)
L+15		IORDER_R, rectifier current order from VDCL (amps)
L+16		T_I, inverter time constant VDCL
L+17		IOMAX_I, inverter maximum current order VDCL (amps)
L+18		IORDER_I, inverter current order from VDCL (amps)
L+19		I_ERROR_R, rectifier current error CCA (amps)
L+20		APROP_R, rectifier proportional part of alpha CCA (rad)
L+21		ALPHA_ORDER_R, rectifier alpha order from CCA (rad)
L+22		I_ERROR_I, inverter current error CCA (amps)
L+23		APROP_I, inverter proportional part of alpha CCA (rad)
L+24		ALFA_ORDER_I, inverter alpha order from CCA (rad)
L+25		ALFA_MAX_ORDER_R, rectifier alpha maximum segment (rad)
L+26		ALFA_MAX_ORDER_I, inverter alpha maximum segment (rad)
L+27		GAMMIN_I, inverter minimum gamma in CFC (rad)
L+28		DELT_ALFA_MAX_R, rectifier upper limit of alpha error CFC (rad)
L+29		DELT_ALFA_MIN_R, rectifier lower limit of alpha error CFC (rad)
L+30		DELT_ALFA_MAX_I, inverter upper limit of alpha error CFC (rad)
L+31		DELT_ALFA_MIN_I, inverter lower limit of alpha error CFC (rad)
L+32		ALFA_MIN_R, rectifier lower limit of alpha order CFC (rad)
L+33		ALFA_MAX_I, inverter maximum limit of alpha order CFC (rad)
L+34		ALFA_R, alpha from rectifier CFC to the converter equations (rad)
L+35		ALFA_I, alpha from inverter CFC to the converter equations (rad)
L+36		DANG_R, rectifier phase shift correction contribution to alpha (rad)
L+37		DANG_I, inverter phase shift correction contribution to alpha (rad)
L+38		TRCONR_AORDER_MIN_R, rectifier transient controller added to the lower limit on alpha in CCA
L+39		TRCONI_T, inverter transient controller time constant (sec)

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VARs	#	Description
L+40		DELT_PO_FREQ_R, rectifier active power modulation from frequency controller (W)
L+41		DELT_PO_FREQ_I, inverter active power modulation from frequency controller (W)
L+42		DELT_PO_DAMP_R, rectifier active power modulation from power modulation (W)
L+43		DELT_PO_DAMP_I, inverter active power modulation from power modulation (W)
L+44		EPC_POWER_R, rectifier EPC power (W)
L+45		EPC_POWER_I, inverter EPC power (W)
L+46		EPC_POWER, total EPC power (W)
L+47		DALFA_VC, inverter voltage control contribution to alpha (rad)
L+48 to L+158		Model internal memory

ICONs	#	Description
M		CURRENT DIRECTION, current from: 1 rectifier 0 inverter
M+1		Rectifier frequency control: 1 enable 0 disable
M+2		Inverter frequency control: 1 enable 0 disable
M+3		Rectifier power modulation: 1 enable 0 disable
M+4		Inverter power modulation: 1 enable 0 disable
M+5		Rectifier emergency power control: 1 enable 0 disable
M+6		Inverter emergency power control: 1 enable 0 disable

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ICONs	#	Description
M+7		Inverter voltage control: 1 enable 0 disable
M+8		Rectifier phase shift correction: 1 enable 0 disable
M+9		Inverter phase shift correction: 1 enable 0 disable

Note: This model does not use auxiliary signal model outputs.

'DC Line Name', 'CDCABT', ICON(M) to ICON(M+9), CON(J) to CON(J+203) /

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13.7 CEELRIT

dc Line Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			VDCOLUP, VDCL time constant up (sec)
J+3			TIDR, current order time constant (sec)
J+4			VDCOLDN, VDCL time constants down (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypass time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1
J+16			C1, current limit point 1 (amps); ≥C0
J+17			V2, voltage limit point 2
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3
J+20			C3, current limit point 3 (amps)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDEBLK, rectifier ac voltage which causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage which causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage which causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVP, power control VDC transducer time constant (sec)

[1] Ignored if in gamma control (i.e., GAMMX = GAMMN in power flow).

STATEs	#	Description
K		VDCOL, dc or ac voltage (kV or pu), V_{DCOL}
K+1		Current order (amps)
K+2		Power controller dc voltage (V), V_{DCP}

VARs	#	Description
L		Other signals, MW
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		CRF, current setpoint multiplier
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV)
L+15		TIMER, rectifier blocking and unblocking, timer
L+16		TIMEI, inverter blocking and unblocking, timer
L+17		TIBYP, inverter bypass and unbypass timer

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’DC Line Name’, ’CEELRIT’, CON(J) to CON(J+31) /

Note:

1. This model represents:
    - Constant margin angle limits.
    - Constant firing angle limits.
    - VDCL time constants for up and down.
    - Power controller time constant and limit on sensed DCV.
    - Limit on sensed power order.
    - Current order time constant.
    - Voltage and current setpoint multiplier and ramp up.
    - Inverter mode switch DV/DI characteristic.
    - Maximum inverter firing angle limits
2. This model uses auxiliary signal index 1 for auxiliary signal in VAR(L), and auxiliary signal index 2 for the auxiliary signal in VAR(L), and auxiliary signal index 2 for the auxiliary signal in VAR(L+14).

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$$\text{If (MDC(I) = 1)}, R_{LOW} = \frac{\text{CON(J+11)*VSCHED(I)}}{1000 * |\text{SETVAL (I)}|}$$

$$\text{If (MDC(I) = 2)}, R_{LOW} = \frac{\text{CON(J+11)}}{|\text{SETVAL (I)}|}$$

dc Setpoint Control

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dc Setpoint Control (continued)

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13.8 CEELT

Eel River dc Line and Auxiliaries Model

(combines CHAAUT, CEEL2T and RUNBK models)

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

’DC Line Name’, ’CEELT’, 3 CHAAUT ICONs, 24 CHAAUT CONs, 32 CEEL2T CONs, 3RUNBK CONs /

Notes:

1. This model uses the following ICON, CON, STATE, and VAR assignments:

   ICON: M to M+7 (3 CHAAUT ICONs, 4 CEEL2T INTERNAL ICONs and 1 RUNBK ICON)

   CON: J to J+58

   STATE: K to K+8 (6 CHAAUT STATEs, 2 CEEL2T STATEs, and 1 RUNBK STATE)

   VAR: L to L+24 (1 CHAAUT VAR, 22 CEEL2T VARs and 2 RUNBK VARs)

2. This model sets ICON(M+5) (ICON belonging to model CEEL2T) to L+22 and places into VAR(L+22) the lower of the ac voltage at the inverter bus (or at the inverter firing angle measuring bus if one had been designated) or rectifier bus (or at the rectifier firing angle measuring bus if one had been designated).

3. The auxiliary-signal model output is in VAR(L).

4. 4. Initially the model sets ICON(M+7) to 0. When the user wants to initiate runback of the dc line, ICON(M+7) has to be set to 1.

5. Since CEELT has an in-built auxiliary signal model, do not attach any other external auxiliary signal model.

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13.9 CEEL2T

Eel River dc Line Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L.
and ICONs starting with #_____ M.

This model represents:

- Constant margin angle limits.
- Constant firing angle limits.
- Power controller time constant and limit on sensed DCV.
- Limit on sensed power order.
- Current order time constant.
- Voltage and current setpoint multiplier and ramp up.
- Inverter mode switch DV/DI characteristic.
- Maximum inverter firing angle limits.

Current order auxiliary signal

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			DELAY for VDCL (sec)
J+3			TIDR, current order time constant (sec)
J+4			Sample rate for VDCL (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypass time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			CL (amps)
J+16			CH, current limit (amps); ≥ CL
J+17			VL1, voltage limit point 1 (pu)
J+18			VL2, voltage limit point 2 (pu)
J+19			VH1, voltage limit point 3 (pu)
J+20			VH2, voltage limit point 4 (pu)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDEBLK, rectifier ac voltage which causes a block if remains for time TDEBLK (pu)

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CONs	#	Value	Description
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage which causes block after communication delay TCOMB (pu)
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage which causes bypass if remains for time TDEBYP (pu)[2]
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVP, power control VDC transducer time constant (sec)

1 Ignored if in gamma control (i.e., GAMMX = GAMMN in power flow).

2 The user can force a bypass by putting appropriate values in CON(J+27) and CON(J+28) of this model.

STATEs	#	Description
K		Power controller dc voltage (V), V_{DCP}
K+1		Current order (amps)

VARs	#	Description
L		Other signals, MW [DC2SIG(1,I)]
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		CRF, current setpoint multiplier
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)

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VARs	#	Description
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV) [DC2SIG(2,I)]
L+15		TIMER, rectifier blocking and unblocking, timer
L+16		TIMEI, inverter blocking and unblocking, timer
L+17		TIBYP, inverter bypass and unbypass timer
L+18		TDELAY, reference time for current limit delay
L+19		TSAMPL, reference time for current limit sampling
L+20		DCLVAC, current limit (amps)
L+21		VACIN, voltage which determines current limit

ICONs	#	Description
M		Inverter status:[1] 0 Normal 1 Blocked 2 Ramping
M+1		Rectifier status:[1] 0 Normal 1 Blocked 2 Ramping
M+2		0 current limit uses inverter VDC[1] > 0 current limit uses VAR (ICON(M+2))
M+3		1 VDCL on upper hysteresis path[1] 1 VDCL on lower hysteresis path

[1] All the ICONs are set by the program.

'DC Line Name', 'CEEL2T', CON(J) to CON(J+31) /

Notes:

1. When this model is called directly (i.e., not via model CEELT), the current limit uses inverter VDC (i.e., ICON(M+2) of this model is always 0 when called directly).

2. If the user wishes to block the converter, MDC(I) should be set to zero.

3. When called directly, this model uses auxiliary signal outputs stored in DC2SIG(1,I) (i.e., auxiliary signal index 1), and DC2SIG(2,I) (i.e., auxiliary signal index 2).

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$$\text{If (MDC(I) = 1), } R_{LOW} = \frac{\text{CON(J+11)} * \text{VSCHED}}{1000 * |\text{SETVAL (I)}|}$$

$$\text{If (MDC(I) = 2), } R_{LOW} = \frac{\text{CON(J+11)}}{|\text{SETVAL (I)}|}$$

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Inverter and Rectifier Coordination

*VAR(L+2) is also used by the power controller so that the current order is not increased when voltage is depressed. VAR(L+2) is started at the lower limit when unblocking or unbypassing.

dc Setpoint Control

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13.10 CHIGATT

dc Line Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY, minimum gamma for dynamics (degrees)
J+2			VDCOLUP, voltage transducer time constant up (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VDCOLDN, voltage transducer time constant down (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypassing time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1
J+16			C1, current limit (amps); $\geq$ C0
J+17			V2, voltage limit point 2
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3
J+20			C3, current limit point 3 (amps)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDEBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVP, power control VDC transducer time constant (sec)

STATEs	#	Description
K		VDCOL, dc or ac voltage (kV or pu), V_{VDCOL}
K+1		Measured inverter dc current (amps)
K+2		Power controller dc voltage (V), V_{DCP}

VARs	#	Description
L		Other signals, MW
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		CRF, current setpoint multiplier
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV)
L+15		TIMER, rectifier blocking and unblocking timer
L+16		TIMEI, inverter blocking and unblocking timer
L+17		TIBYP, inverter bypass and unbypass timer

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'DC Line Name', 'CHIGATT', CON(J) to CON(J+31) /

Notes:

1. This model represents:
    - Constant margin angle limits.
    - Constant commutation limits.
    - VDCL time constants for up and down.
    - Power controller time constant and limit on sensed DCV.
    - Voltage and current setpoint multiplier and ramp up.
    - Inverter mode switch DV/DI characteristic.
    - Maximum inverter firing angle limits.
2. This model uses auxiliary signal index 1 for the auxiliary signal in VAR(L), and auxiliary signal index 2 for the auxiliary signal in VAR(L+14).

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$$\text{If (MDC(I) = 1)}, R_{LOW} = \frac{\text{CON(J+11)} * \text{VSCHED(I)}}{1000 * |\text{SETVAL (I)}|}$$

$$\text{If (MDC(I) = 2)}, R_{LOW} = \frac{\text{CON(J+11)}}{|\text{SETVAL (I)}|}$$

dc Setpoint Control

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13.11 CMDWAST

dc Line Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY, minimum gamma for dynamics (degrees)[1]
J+2			VDCOLUP, VDCOL time constant up (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VDCOLDN, VDCOL time constants down (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypass time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1
J+16			C1, current limit point 1 (amps); ≥C0
J+17			V2, voltage limit point 2
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3
J+20			C3, current limit point 3 (amps)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDEBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			VRAMPI, dc voltage threshold to ramp current up or down (kV)
J+31			TVP, power control VDC transducer time constant (sec)

[1] Ignored if in gamma control (i.e. GAMMX = GAMMN in power flow).

STATEs	#	Description
K		VDCOL, dc or ac voltage (kV or pu), V_{VDCOL}
K+1		Measured inverter dc current (amps)
K+2		Power controller dc voltage (V), V_{DCP}

VARs	#	Description
L		Other signals, KA
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		CRF, current setpoint multiplier
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV)
L+15		TIMER, rectifier blocking and unblocking timer
L+16		TIMEI, inverter blocking and unblocking timer
L+17		TIBYP, inverter bypass and unbypass timer

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'DC Line Name', 'CMDWAST', CON(J) to CON(J+31) /

Notes:

1. This model represents:
   - Constant margin angle limits.
   - Constant firing angle limits.
   - VDCL time constants for up and down.
   - Power controller time constant and limit on sensed DCV.
   - Voltage and current setpoint multiplier and ramp up.
   - Inverter mode switch $\Delta V/\Delta I$ characteristic.
   - Maximum inverter firing angle limits.
   - Current order auxiliary signal
2. This model uses auxiliary signal index 1 for auxiliary signal index 1 for auxiliary signal VAR(L) and auxiliary signal index 2 for the auxiliary signal VAR(L+14).

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$$\text{If (MDC(I) = 1), } R_{LOW} = \frac{\text{CON(J+11)} * \text{VSCHED(I)}}{1000 * |\text{SETVAL (I)}|}$$

$$\text{If (MDC(I) = 2), } R_{LOW} = \frac{\text{CON(J+11)}}{|\text{SETVAL (I)}|}$$

dc Setpoint Control

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13.12 CMDWS2T

Madawaska dc Line Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY,[1] minimum gamma for dynamics (degrees)
J+2			DELAY for VDCL (sec)
J+3			TIODC, TIDC, dc current order time constant (sec)
J+4			Sample rate for VDCL (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypass time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing and unblocking voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (amps/sec)
J+14			C0, minimum current demand (amps)
J+15			CL (amps)
J+16			CH, current limit (amps); ≥ C0
J+17			VL1, voltage limit point 1 (pu)
J+18			VL2, voltage limit point 2 (pu)
J+19			VH1, voltage limit point 3 (pu)
J+20			VH2, voltage limit point 4 (pu)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDEBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks or unbypasses
J+30			VRAMPI, dc voltage threshold to ramp current up or down
J+31			TVP, power control VDC transducer time constant (sec)

[1] Ignored if in gamma control (i.e. GAMMX = GAMMN in power flow).

STATEs	#	Description
K		Power controller dc voltage (V),V_{DCP}
K+1		Measured inverter dc current (amps)

VARs	#	Description
L		Other signals, KA
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		DCLVDC, dc voltage dependent current limit
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)(V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV)
L+15		TIMER, rectifier blocking and unblocking timer
L+16		TIMEI, inverter blocking and unblocking timer
L+17		TIBYP, inverter bypass and unbypass timer
L+18		TDELAY, reference time for current limit delay
L+19		TSAMPL, reference time for current limit sampling

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VARs	#	Description
L+20		DCLVAC, ac voltage dependent current limit (amps)
L+21		VACIN, voltage that determines current limit
L+22		DCSET

’DC Line Name’, "CMDWS2T’, CON(J) to CON(J+31) /

Notes:

1. This model represents:

   - Constant margin angle limits.
   - Constant firing angle limits.
   - Power controller time constant and limit on sensed DCV.
   - Voltage setpoint ramp.
   - Inverter mode switch $\Delta V/\Delta I$ characteristic.
   - Maximum inverter firing angle limits.
   - Current order auxiliary signal

Model uses two auxiliary signals. Auxiliary signal index 1 is the, "other signals’ (KA)," i.e. VAR(L), while auxiliary signal index 2 is the, "VDC Signal (KV)," i.e. VAR(L+14).

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dc Current Setpoint Control

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*This VAR is also used by the power controller so that the current order is not increased when voltage is depressed. VAR(L+2) is started at the lower limit when unblocking or unbypassing.

dc Voltage Setpoint Control (continued)

Inverter and Rectifier Coordination

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13.13 CMFORDT

dc Line Model

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
This model uses ICONs starting with #_____ M.

CONs	#	Value	Description
J			ALFDY, minimum alpha for dynamics (degrees)
J+1			GAMDY, minimum gamma for dynamics (degrees)
J+2			VDCOLUP, VDCOL time constant up (sec)
J+3			TIDC, dc current transducer time constant (sec)
J+4			VDCDLDN, VDCOL time constants down (sec)
J+5			VUNBL, rectifier ac unblocking voltage (pu)
J+6			TBLKBY, minimum blocking and bypass time (sec)
J+7			Inverter $\Delta V/\Delta I$ slope characteristic (V/amps)
J+8			VUNBY, inverter ac unbypassing voltage (pu)
J+9			ACCL, model acceleration factor
J+10			RSVOLT, minimum dc voltage following block (kV)
J+11			RSCUR, minimum dc current following block (amps)
J+12			VRAMP, voltage recovery rate (pu/sec)
J+13			CRAMP, current recovery rate (pu/sec)
J+14			C0, minimum current demand (amps)
J+15			V1, voltage limit point 1
J+16			C1, current limit point 1 (amps); ≥C0
J+17			V2, voltage limit point 2
J+18			C2, current limit point 2 (amps)
J+19			V3, voltage limit point 3
J+20			C3, current limit point 3 (amps)
J+21			ALFMXI, maximum inverter firing angle (degrees)
J+22			VDCBLK, rectifier ac voltage that causes a block if remains for time TDEBLK (pu)
J+23			TDEBLK, time delay for block (sec)
J+24			TREBLK, time delay after rectifier ac voltage recovers above VUNBL before line unblocks (sec)
J+25			VINBLK, inverter ac voltage that causes block after communication delay TCOMB (pu)

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CONs	#	Value	Description
J+26			TCOMB, communication delay to signal rectifier to block because of low inverter voltage (sec)
J+27			VACBYP, inverter ac voltage that causes bypass if remains for time TDEBYP (pu)
J+28			TDEBYP, time delay for bypass (sec)
J+29			TINBLK, time delay after inverter ac voltage recovers above VUNBY before line unblocks (this value should also include communication delay) (sec)
J+30			TINBYP, time delay after inverter ac voltage recovers above VUNBY before line unbypasses (sec)
J+31			TVP, power control VDC transducer time constant (sec)

STATEs	#	Description
K		VDCOL, dc or ac voltage (kV or pu), V_{VDCOL}
K+1		Measured inverter dc current (amps)
K+2		Power controller dc voltage (V), V_{DCP}

VARs	#	Description
L		Other signals, MW
L+1		RESTR, time unblocks or unbypasses (sec)
L+2		VRF, voltage setpoint multiplier
L+3		CRF, current setpoint multiplier
L+4		VCOMP, compensated dc voltage (V)
L+5		PACR, rectifier ac real power (pu)
L+6		QACR, rectifier ac reactive power (pu)
L+7		PACI, inverter ac real power (pu)
L+8		QACI, inverter ac reactive power (pu)
L+9		VDCI, inverter dc voltage (V)
L+10		VDCR, rectifier dc voltage (V)
L+11		DC, dc current (amps)
L+12		ALFA, alpha (degrees)
L+13		GAMA, gamma (degrees)
L+14		Other VDC signals (kV)
L+15		TIMER, rectifier blocking and unblocking timer
L+16		TIMEI, inverter blocking and unblocking timer

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VARs	#	Description
L+17		TIBYP, inverter bypass and unbypass timer

’DC Line Name’, ’CMFORDT’, CON(J) to CON(J+31) /

Notes:

1. This model represents:
   - Constant margin angle limits.
   - Constant firing angle limits.
   - VDCL time constants for up and down.
   - Power controller time constant and limit on sensed DCV.
   - Voltage and current setpoint multiplier and ramp up.
   - Inverter mode switch DV/DI characteristic.
   - Maximum inverter firing angle limits.
2. Model uses two auxiliary signals. Auxiliary signal index 1 is the, "other signals (MW)’, i.e. VAR(L), while auxiliary signal index 2 is the, "VDC Signal (KV)", i.e. VAR(L+14).

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$$\text{If (MDC(I) = 1), } R_{LOW} = \frac{\text{CON(J+11) * VSCHED(I)}}{1000 * |\text{SETVAL (I)}|}$$

$$\text{If (MDC(I) = 2), } R_{LOW} = \frac{\text{CON(J+11)}}{|\text{SETVAL (I)}|}$$

dc Setpoint Control

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Chapter 14

Multi-Terminal dc Line Model Data Sheets

This chapter contains a collection of data sheets for the multi-terminal dc line models contained in the PSS®E dynamics model library.

Model	Description
MTDC1T	Multiterminal (five converter) dc line model
MTDC2T	Multiterminal (five converter) dc line model
MTDC3T	Multiterminal (eight converter) dc line model

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14.1 MTDC1T

Multiterminal (Five Converter) dc Line Model

This model uses CONs starting with	#_____	J,	
and STATEs starting with	#_____	K,	
and VARs starting with	#_____	L,	(L=LAUX +5)
and ICONs starting with	#_____	M,	
and VARs for auxiliary signals starting with	#_____	LAUX.	

CONs	#	Value	Description
J			DY1, minimum angle converter 1 (degrees)
J+1			TVAC1, ac voltage transducer converter 1 (sec)
J+2			TVDC1, dc voltage transducer converter 1 (sec)
J+3			TIDC1, current transducer converter 1 (sec)
J+4			RSVLT1, minimum dc voltage following block, converter 1 (kV)[1]
J+5			RSCUR1, minimum dc current following block, converter 1 (amps)[2]
J+6			VRMP1, voltage recovery rate, converter 1 (pu/sec)[1]
J+7			CRMP1, current recovery rate, converter 1 (pu/sec)[2]
J+8			C0-1, minimum current demand converter 1 (amps)[3]
J+9			V1-1, voltage limit point 1, converter 1 (kV)[2]
J+10			C1-1, current limit point 1, converter 1 (amps)[2]
J+11			V2-1, voltage limit point 2, converter 1 (kV)[2]
J+12			C2-1, current limit point 2, converter 1 (amps)[2]
J+13			V3-1, voltage limit point 3, converter 1 (kV)[2]
J+14			C3-1, current limit point 3, converter 1 (amps)[2]
J+15			DY2, minimum angle converter 2 (degrees)
J+16			TVAC2, ac voltage transducer converter 2 (sec)
J+17			TVDC2, dc voltage transducer converter 2 (sec)
J+18			TIDC2, current transducer converter 2 (sec)
J+19			RSVLT2, minimum dc voltage following block, converter 2 (kV)[1]
J+20			RSCUR2, minimum dc current following block, converter 2 (amps)[2]
J+21			VRMP2, voltage recovery rate, converter 2 (pu/sec)[1]
J+22			CRMP2, current recovery rate, converter 2 (pu/sec)[2]
J+23			C0-2, minimum current demand converter 2 (amps)[3]

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CONs	#	Value	Description
J+24			V1-2, voltage limit point 1, converter 2 (kV)[2]
J+25			C1-2, current limit point 1, converter 2 (amps)[2]
J+26			V2-2, voltage limit point 2, converter 2 (kV)[2]
J+27			C2-2, current limit point 2, converter 2 (amps)[2]
J+28			V3-2, voltage limit point 3, converter 2 (kV)[2]
J+29			C3-2, current limit point 3, converter 2 (amps)[2]
J+30			DY3, minimum angle converter 3 (degrees)
J+31			TVAC3, ac voltage transducer converter 3 (sec)
J+32			TVDC3, dc voltage transducer converter 3 (sec)
J+33			TIDC3, current transducer converter 3 (sec)
J+34			RSVLT3, minimum dc voltage following block, converter 3 (kV)[1]
J+35			RSCUR3, minimum dc current following block, converter 3 (amps)[2]
J+36			VRMP3, voltage recovery rate, converter 3 (pu/sec)[1]
J+37			CRMP3, current recovery rate, converter 3 (pu/sec)[2]
J+38			C0-3, minimum current demand converter 3 (amps)[3]
J+39			V1-3, current limit point 1, converter 3 (kV)[2]
J+40			C1-3, current limit point 1, converter 3 (amps)[2]
J+41			V2-3, voltage limit point 2, converter 3 (kV)[2]
J+42			C2-3, current limit point 2, converter 3 (amps)[2]
J+43			V3-3, voltage limit point 3, converter 3 (kV)[2]
J+44			C3-3, current limit point 3, converter 3 (amps)[2]
J+45			DY4, minimum angle converter 4 (degrees)
J+46			TVAC4, ac voltage transducer converter 4 (sec)
J+47			TVDC4, dc voltage transducer converter 4 (sec)
J+48			TIDC4, current transducer converter 4 (sec)
J+49			RSVLT4, minimum dc voltage following block, converter 4 (kV)[1]
J+50			RSCUR4, minimum dc current following block, converter 4 (amps)[2]
J+51			VRMP4, voltage recovery rate, converter 4 (pu/sec)[1]
J+52			CRMP4, current recovery rate, converter 4 (pu/sec)[2]
J+53			C0-4, minimum current demand converter 4 (amps)[3]
J+54			V1-4, voltage limit point 1, converter 4 (kV)[2]
J+55			C1-4, current limit point 1, converter 4 (amps)[2]

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CONs	#	Value	Description
J+56			V2-4, voltage limit point 2, converter 4 (kV)[2]
J+57			C2-4, current limit point 2, converter 4 (amps)[2]
J+58			V3-4, voltage limit point 3, converter 4 (kV)[2]
J+59			C3-4, current limit point 3, converter 4 (amps)[2]
J+60			DY5, minimum angle converter 5 (degrees)
J+61			TVAC5, ac voltage transducer converter 5 (sec)
J+62			TVDC5, dc voltage transducer converter 5 (sec)
J+63			TIDC5, current transducer converter 5 (sec)
J+64			RSVLT5, minimum dc voltage following block, converter 5 (kV)[1]
J+65			RSCUR5, minimum dc current following block, converter 5 (amps)[2]
J+66			VRMP5, Voltage recovery rate, converter 5 (pu/sec)[1]
J+67			CRMP5, current recovery rate, converter 5 (pu/sec)[2]
J+68			C0-5, minimum current demand converter 5 (amps)[3]
J+69			V1-5, voltage limit point 1, converter 5 (kV)[2]
J+70			C1-5, current limit point 1, converter 5 (amps)[2]
J+71			V2-5, voltage limit point 2, converter 5 (kV)[2]
J+72			C2-5, current limit point 2, converter 5 (amps)[2]
J+73			V3-5, voltage limit point 3, converter 5 (kV)[2]
J+74			C3-5, current limit point 3, converter 5 (amps)[2]
J+75			TCMODE (sec)

[1] Used only at voltage controlling converter.
[2] Used at all converters except voltage controlling converter.
[3] Used as minimum current allowed even at voltage controlling bus.

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STATEs	#	Description
K		Measured ac voltage, converter 1
K+1		Measured dc voltage, converter 1
K+2		Measured dc current, converter 1
K+3		Measured ac voltage, converter 2
K+4		Measured dc voltage, converter 2
K+5		Measured dc current, converter 2
K+6		Measured ac voltage, converter 3
K+7		Measured dc voltage, converter 3
K+8		Measured dc current, converter 3
K+9		Measured ac voltage, converter 4
K+10		Measured dc voltage, converter 4
K+11		Measured dc current, converter 4
K+12		Measured ac voltage, converter 5
K+13		Measured dc voltage, converter 5
K+14		Measured dc current, converter 5

VARs	#	Description
L		V_{AC} bus converter 1
L+1		P_{AC} bus converter 1
L+2		Q_{AC} bus converter 1
L+3		V_{DC} converter 1
L+4		IDC converter 1
L+5		Angle converter 1
L+6		V_{AC} bus converter 2
L+7		P_{AC} bus converter 2
L+8		Q_{AC} bus converter 2
L+9		V_{DC} converter 2
L+10		IDC converter 2
L+11		Angle converter 2
L+12		V_{AC} bus converter 3
L+13		P_{AC} bus converter 3
L+14		Q_{AC} bus converter 3
L+15		V_{DC} converter 3
L+16		IDC converter 3

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VARs	#	Description
L+17		Angle converter 3
L+18		V_{AC} bus converter 4
L+19		P_{AC} bus converter 4
L+20		Q_{AC} bus converter 4
L+21		V_{DC} converter 4
L+22		IDC converter 4
L+23		Angle converter 4
L+24		V_{AC} bus converter 5
L+25		P_{AC} bus converter 5
L+26		Q_{AC} bus converter 5
L+27		V_{DC} converter 5
L+28		IDC converter 5
L+29		Angle converter 5
L+30		Internal VARs required by model
L+31		
L+32		
L+33		
L+34		
L+35		

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ICONs	#	Description
M		Entire line blocking flag:[1] 0 Not blocked 1 Blocked 2 Unblocking
M+1		Converter 1 flag:[1, 2] 0 Normal operation 1 Blocked 2 Unblocking
M+2		Converter 2 flag[1, 2]
M+3		Converter 3 flag[1, 2]
M+4		Converter 4 flag[1, 2]
M+5		Converter 5 flag[1, 2]
M+6		Mode switch flag:[3] 0 Normal 1 Mode switch

1 Need not be input in DYRE data record. Can be changed by user for blocking/unblocking.
2 Set to zero if this is voltage controlling converter (i.e., not used).
3 Need not be input in DYRE data record. Flag set by model.

VARs	#	Description
LAUX		Auxiliary signal converter 1[1, 2] [DCMSIG(1,I)]
LAUX+1		Auxiliary signal converter 2[2] [DCMSIG(2,I)
LAUX+2		Auxiliary signal converter 3[2] [DCMSIG(3,I)]
LAUX+3		Auxiliary signal converter 4[2] [DCMSIG(4,I)]
LAUX+4		Auxiliary signal converter 5[2] [DCMSIG(5,I)]

1 This model uses auxiliary signal outputs stored in DCMSIG(1,I) through DCMSIG(5,I) (i.e., auxiliary signal index 1 through 5).
2 At voltage controlling inverter, only used if in gamma control (i.e., ANGMX = ANGMN in power flow).

’DC Line Name’, ’MTDC1T’, CON(J) to CON(J+75) /

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14.2 MTDC2T

Multiterminal (Five Converter) dc Line Model

This model uses CONs starting with	#_____	J,	
and STATEs starting with	#_____	K,	
and VARs starting with	#_____	L,	(L=LAUX +5)
and ICONs starting with	#_____	M,	
and VARs for auxiliary signals starting with	#_____	LAUX.	

CONs	#	Value	Description
J			DY1, minimum angle converter 1 (degrees)
J+1			TVAC1, ac voltage transducer converter 1 (sec)
J+2			TVDC1, dc voltage transducer converter 1 (sec)
J+3			TIDC1, current transducer converter 1 (sec)
J+4			RSVLT1, minimum dc voltage following block, converter 1 (kV)[1]
J+5			RSCUR1, minimum dc current following block, converter 1 (amps)
J+6			VRMP1, voltage recovery rate, converter 1 (pu/sec)[1]
J+7			CRMP1, current recover rate, converter 1 (pu/sec)
J+8			C0-1, minimum current demand converter 1 (amps)
J+9			V1-1, minimum current demand converter 1
J+10			C1-1, minimum current demand converter 1 (amps)
J+11			V2-1, minimum current demand converter 1
J+12			C2-1, minimum current demand converter 1 (amps)
J+13			V3-1, minimum current demand converter 1
J+14			C3-1, minimum current demand converter 1 (amps)
J+15			DY2, minimum angle converter 2 (degrees)
J+16			TVAC2, ac voltage transducer converter 2 (sec)
J+17			TVDC2, dc voltage transducer converter 2 (sec)
J+18			TIDC2, current transducer converter 2 (sec)
J+19			RSVLT2, minimum dc voltage following block, converter 2 (kV)[1]
J+20			RSCUR2, minimum dc current following block, converter 2 (amps)
J+21			VRMP2, voltage recovery rate, converter 2 (pu/sec)[1]
J+22			CRMP2, current recover rate, converter 2 (pu/sec)
J+23			C0-2, minimum current demand converter 2 (amps)
J+24			V1-2, minimum current demand converter 2
J+25			C1-2, minimum current demand converter 2 (amps)

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CONs	#	Value	Description
J+26			V2-2, minimum current demand converter 2
J+27			C2-2, minimum current demand converter 2 (amps)
J+28			V3-2, minimum current demand converter 2
J+29			C3-2, minimum current demand converter 2 (amps)
J+30			DY3, minimum angle converter 3 (degrees)
J+31			TVAC3, ac voltage transducer converter 3 (sec)
J+32			TVDC3, dc voltage transducer converter 3 (sec)
J+33			TIDC3, current transducer converter 3 (sec)
J+34			RSVLT3, minimum dc voltage following block, converter 3 (kV)[1]
J+35			RSCUR3, minimum dc current following block, converter 3 (amps)
J+36			VRMP3, voltage recovery rate, converter 3 (pu/sec)[1]
J+37			CRMP3, current recover rate, converter 3 (pu/sec)
J+38			C0-3, minimum current demand converter 3 (amps)
J+39			V1-3, minimum current demand converter 3
J+40			C1-3, minimum current demand converter 3 (amps)
J+41			V2-3, minimum current demand converter 3
J+42			C2-3, minimum current demand converter 3 (amps)
J+43			V3-3, minimum current demand converter 3
J+44			C3-3, minimum current demand converter 3 (amps)
J+45			DY4, minimum angle converter 4 (degrees)
J+46			TVAC4, ac voltage transducer converter 4 (sec)
J+47			TVDC4, dc voltage transducer converter 4 (sec)
J+48			TIDC4, current transducer converter 4 (sec)
J+49			RSVLT4, minimum dc voltage following block, converter 4 (kV)[1]
J+50			RSCUR4, minimum dc current following block, converter 4 (amps)
J+51			VRMP4, voltage recovery rate, converter 4 (pu/sec)[1]
J+52			CRMP4, current recovery rate, converter 4 (pu/sec)
J+53			C0-4, minimum current demand converter 4 (amps)
J+54			V1-4, minimum current demand converter 4
J+55			C1-4, minimum current demand converter 4 (amps)
J+56			V2-4, minimum current demand converter 4
J+57			C2-4, minimum current demand converter 4 (amps)
J+58			V3-4, minimum current demand converter 4
J+59			C3-4, minimum current demand converter 4 (amps)
J+60			DY5, minimum angle converter 5 (degrees)

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CONs	#	Value	Description
J+61			TVAC5, ac voltage transducer converter 5 (seconds)
J+62			TVDC5, dc voltage transducer converter 5 (seconds)
J+63			TIDC5, current transducer converter 5 (seconds)
J+64			RSVLT5, minimum dc voltage following block, converter 5 (kV)[1]
J+65			RSCUR5, minimum dc current following block, converter 5 (amps)
J+66			VRMP5, voltage recovery rate, converter 5 (pu/sec)[1]
J+67			CRMP5, current recovery rate, converter 5 (pu/sec)
J+68			C0-5, minimum current demand converter 5 (amps)
J+69			V1-5, minimum current demand converter 5
J+70			C1-5, minimum current demand converter 5 (amps)
J+71			V2-5, minimum current demand converter 5
J+72			C2-5, minimum current demand converter 5 (amps)
J+73			V3-5, minimum current demand converter 5
J+74			C3-5, minimum current demand converter 5 (amps)
J+75			TVF, power control VDC transducer time constant (sec)
J+76			VDCOLUP, voltage transducer time constants (sec)
J+77			VDCOLON, voltage transducer time constants (sec)
J+78			Current margin (amps)
J+79			Converter 1 $\Delta V/\Delta I$ multiplier (pu)[2]
J+80			Converter 2 $\Delta V/\Delta I$ multiplier (pu)[2]
J+81			Converter 3 $\Delta V/\Delta I$ multiplier (pu)[2]
J+82			Converter 4 $\Delta V/\Delta I$ multiplier (pu)[2]
J+83			Converter 5 $\Delta V/\Delta I$ multiplier (pu)[2]

[1] Used only at voltage controlling converter.
[2] Used only at inverter.

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STATEs	#	Description
K		Measured ac voltage, converter 1
K+1		Measured dc voltage, converter 1
K+2		Measured dc current, converter 1
K+3		Measured ac voltage, converter 2
K+4		Measured dc voltage, converter 2
K+5		Measured dc current, converter 2
K+6		Measured ac voltage, converter 3
K+7		Measured dc voltage, converter 3
K+8		Measured dc current, converter 3
K+9		Measured ac voltage, converter 4
K+10		Measured dc voltage, converter 4
K+11		Measured dc current, converter 4
K+12		Measured ac voltage, converter 5
K+13		Measured dc voltage, converter 5
K+14		Measured dc current, converter 5
K+15		Power controller voltage
K+16		VDCL voltage

VARs	#	Description
L		V_{AC} bus converter 1
L+1		P_{AC} bus converter 1
L+2		Q_{AC} bus converter 1
L+3		V_{DC} converter 1
L+4		I_{DC} converter 1
L+5		Angle converter 1
L+6		V_{AC} bus converter 2
L+7		P_{AC} bus converter 2
L+8		Q_{AC} bus converter 2
L+9		V_{DC} converter 2
L+10		I_{DC} converter 2
L+11		Angle converter 2
L+12		V_{AC} bus converter 3
L+13		P_{AC} bus converter 3
L+14		Q_{AC} bus converter 3

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VARs	#	Description
L+15		V_{DC} converter 3
L+16		I_{DC} converter 3
L+17		Angle converter 3
L+18		V_{AC} bus converter 4
L+19		P_{AC} bus converter 4
L+20		Q_{AC} bus converter 4
L+21		V_{DC} converter 4
L+22		I_{DC} converter 4
L+23		Angle converter 4
L+24		V_{AC} bus converter 5
L+25		P_{AC} bus converter 5
L+26		Q_{AC} bus converter 5
L+27		V_{DC} converter 5
L+28		I_{DC} converter 5
L+29		Angle converter 5
L+30		CRF1 current setpoint multiplier
L+31		CRF2 current setpoint multiplier
L+32		CRF3 current setpoint multiplier
L+33		CRF4 current setpoint multiplier
L+34		CRF5 current setpoint multiplier
L+35		VRF voltage setpoint multiplier
L+36		Internal memory
L+37		
L+38		
L+39		
L+40		
L+41		

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ICONs	#	Description
M		Entire line blocking flag:[1] 0 Not blocked 1 Blocked 2 Ramp all current and voltage
M+1		Converter 1 flag:[1] 0 Normal operation 1 Blocked 2 Ramp current
M+2		Converter 2 flag[1]
M+3		Converter 3 flag[1]
M+4		Converter 4 flag[1]
M+5		Converter 5 flag[1]
M+6		Voltage ramping flag:[2] 0 Normal operation 1 Ramp voltage

[1] Need not be input in DYRE data record. Can be changed by user for blocking/unblocking.
[2] Need not be input in DYRE data record. Flag set by model.

VARs	#	Description
LAUX		Auxiliary signal converter 1[1, 2] [DCMSIG(1,I)]
LAUX+1		Auxiliary signal converter 2[2] [DCMSIG(2,I)]
LAUX+2		Auxiliary signal converter 3[2] [DCMSIG(3,I)]
LAUX+3		Auxiliary signal converter 4[2] [DCMSIG(4,I)]
LAUX+4		Auxiliary signal converter 5[2] [DCMSIG(5,I)]

[1] This model uses auxiliary signal outputs stored in DCMSIG(1,I) through DCMSIG(5,I) (i.e., auxiliary signal index 1 through 5).
[2] Used at all except voltage controlling converter.

’DC Line Name’, ’MTDC2T’, CON(J) to CON(J+83) /

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Diagram A
Block Diagram Assuming Converter #5 is a Voltage Controlling Converter

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Diagram B
Current Ramping

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Diagram C
Converter Power Controller and Voltage-Dependent Current Limiter

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Diagram D
dc Voltage Setpoint Control

Diagram E
Converter Characteristics

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14.3 MTDC3T

Multiterminal (Eight Converter) dc Line Model

This model uses CONs starting with	#_____	J,	
and STATEs starting with	#_____	K,	
and VARs starting with	#_____	L,	(L=LAUX +8)
and ICONs starting with	#_____	M,	
and VARs for auxiliary signals starting with	#_____	LAUX.	

CONs	#	Value	Description
J			DY1, minimum angle converter 1 (degrees)
J+1			TVAC1, ac voltage transducer converter 1 (sec)
J+2			TVDC1, dc voltage transducer converter 1 (sec)
J+3			TIDC1, current transducer converter 1 (sec)
J+4			RSVLT1, minimum dc voltage following block, converter 1(kV)[1]
J+5			RSCUR1, minimum dc current following block, converter 1 (amps)[2]
J+6			VRMP1, voltage recovery rate, converter 1 (pu/sec)[1]
J+7			CRMP1, current recovery rate, converter 1 (pu/sec)[2]
J+8			C0-1, minimum current demand converter 1 (amps)[3]
J+9			V1-1, voltage limit point, converter 1 (kV)[2]
J+10			C1-1, current limit point 1, converter 1 (amps)[2]
J+11			V2-1, voltage limit point 2, converter 1 (kV)[2]
J+12			C2-1, current limit point 2, converter 1 (amps)[2]
J+13			V3-1, voltage limit point 3, converter 1 (kV)[2]
J+14			C3-1, current limit point 3, converter 1 (amps)[2]
J+15			DY2, minimum angle converter 2 (degrees)
J+16			TVAC2, ac voltage transducer converter 2 (sec)
J+17			TVDC2, dc voltage transducer converter 2 (sec)
J+18			TIDC2, current transducer converter 2 (sec)
J+19			RSVLT2, minimum dc voltage following block, converter 2 (kV)[1]
J+20			RSCUR2, minimum dc current following block, converter 2 (amps)[2]
J+21			VRMP2, voltage recovery rate, converter 2 (pu/sec)[1]
J+22			CRMP2, current recovery rate, converter 2 (pu/sec)[2]

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CONs	#	Value	Description
J+23			C0-2, minimum current demand converter 2 (amps)[3]
J+24			V1-2, voltage limit point 1, converter 2 (kV)[2]
J+25			C1-2, current limit point 1, converter 2 (amps)[2]
J+26			V2-2, voltage limit point 2, converter 2 (kV)[2]
J+27			C2-2, current limit point 2, converter 2 (amps)[2]
J+28			V3-2, voltage limit point 3, converter 2 (kV)[2]
J+29			C3-2, current limit point 3, converter 2 (amps)[2]
J+30			DY3, minimum angle converter 3 (degrees)
J+31			TVAC3, ac voltage transducer converter 3 (sec)
J+32			TVDC3, dc voltage transducer converter 3 (sec)
J+33			TIDC3, current transducer converter 3 (sec)
J+34			RSVLT3, minimum dc voltage following block, converter 3 (kV)[1]
J+35			RSCUR3, minimum dc current following block, converter 3 (amps)[2]
J+36			VRMP3, voltage recovery rate, converter 3 (pu/sec)[1]
J+37			CRMP3, current recovery rate, converter 3 (pu/sec)[2]
J+38			C0-3, minimum current demand converter 3 (amps)[3]
J+39			V1-3, voltage limit point 1, converter 3 (kV)[2]
J+40			C1-3, current limit point 1, converter 3 (amps)[2]
J+41			V2-3, voltage limit point 2, converter 3 (kV)[2]
J+42			C2-3, current limit point 2, converter 3 (amps)[2]
J+43			V3-3, voltage limit point 3, converter 3 (kV)[2]
J+44			C3-3, current limit point 3, converter 3 (amps)[2]
J+45			DY4, minimum angle converter 4 (degrees)
J+46			TVAC4, ac voltage transducer converter 4 (sec)
J+47			TVDC4, dc voltage transducer converter 4 (sec)
J+48			TIDC4, current transducer converter 4 (sec)
J+49			RSVLT4, minimum dc voltage following block, converter 4 (kV)[1]
J+50			RSCUR4, minimum dc current following block, converter 4 (amps)[2]
J+51			VRMP4, voltage recovery rate, converter 4 (pu/sec)[1]
J+52			CRMP4, current recovery rate, converter 4 (pu/sec)[2]
J+53			C0-4, minimum current demand converter 4 (amps)[3]

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CONs	#	Value	Description
J+54			V1-4, voltage limit point 1, converter 4 (kV)[2]
J+55			C1-4, current limit point 1, converter 4 (amps)[2]
J+56			V2-4, voltage limit point 2, converter 4 (kV)[2]
J+57			C2-4, current limit point 2, converter 4 (amps)[2]
J+58			V3-4, voltage limit point 3, converter 4 (kV)[2]
J+59			C3-4, current limit point 3, converter 4 (amps)[2]
J+60			DY5, minimum angle converter 5 (degrees)
J+61			TVAC5, ac voltage transducer converter 5 (sec)
J+62			TVDC5, dc voltage transducer converter 5 (sec)
J+63			TIDC5, current transducer converter 5 (sec)
J+64			RSVLT5, minimum dc voltage following block, converter 5 (kV)
J+65			RSCUR5, minimum dc current following block, converter 5 (amps)[2]
J+66			VRMP5, voltage recovery rate, converter 5 (pu/sec)[1]
J+67			CRMP5, current recovery rate, converter 5 (pu/sec)[2]
J+68			C0-5, minimum current demand converter 5 (amps)[3]
J+69			V1-5, voltage limit point 1, converter 5 (kV)[2]
J+70			C1-5, current limit point 1, converter 5 (amps)[2]
J+71			V2-5, voltage limit point 2, converter 5 (kV)[2]
J+72			C2-5, current limit point 2, converter 5 (amps)[2]
J+73			V3-5, voltage limit point 3, converter 5 (kV)[2]
J+74			C3-5, current limit point 3, converter 5 (amps)[2]
J+75			DY6, minimum angle converter 6 (degrees)
J+76			TVAC6, ac voltage transducer converter 6 (sec)
J+77			TVDC6, dc voltage transducer converter 6 (sec)
J+78			TIDC6, current transducer converter 6 (sec)
J+79			RSVLT6, minimum dc voltage following block, converter 6 (kV)[1]
J+80			RSCUR6, minimum dc current following block, converter 6 (amps)[2]
J+81			VRMP6, voltage recovery rate, converter 6 (pu/sec)[1]
J+82			CRMP6, current recovery rate, converter 6 (pu/sec)[2]
J+83			C0-6, minimum current demand converter 6 (amps)[3]
J+84			V1-6, voltage limit point 1, converter 6 (kV)[2]
J+85			C1-6, current limit point 1, converter 6 (amps)[2]

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CONs	#	Value	Description
J+86			V2-6, voltage limit point 2, converter 6 (kV)[2]
J+87			C2-6, current limit point 2, converter 6 (amps)[2]
J+88			V3-6, voltage limit point 3, converter 6 (kV)[2]
J+89			C3-6, current limit point 3, converter 6 (amps)[2]
J+90			DY7, minimum angle converter 7 (degrees)
J+91			TVAC7, ac voltage transducer converter 7 (sec)
J+92			TVDC7, dc voltage transducer converter 7 (sec)
J+93			TIDC7, current transducer converter 7 (sec)
J+94			RSVLT7, minimum dc voltage following block, converter 7 (kV)[1]
J+95			RSCUR7, minimum dc current following block, converter 7 (amps)[2]
J+96			VRMP7, voltage recovery rate, converter 7 (pu/sec)[1]
J+97			CRMP7, current recovery rate, converter 7 (pu/sec)[2]
J+98			C0-7, minimum current demand converter 7 (amps)[4]
J+99			V1-7, voltage limit point 1, converter 7 (kV)[2]
J+100			C1-7, current limit point 1, converter 7 (amps)[2]
J+101			V2-7, voltage limit point 2, converter 7 (kV)[2]
J+102			C2-7, current limit point 2, converter 7 (amps)[2]
J+103			V3-7, voltage limit point 3, converter 7 (kV)[2]
J+104			C3-7, current limit point 3, converter 7 (amps)[2]
J+105			DY8, minimum angle converter 8 (degrees)
J+106			TVAC8, ac voltage transducer converter 8 (sec)
J+107			TVDC8, dc voltage transducer converter 8 (sec)
J+108			TIDC8, current transducer converter 8 (sec)
J+109			RSVLT8, minimum dc voltage following block, converter 8 (kV)[1]
J+110			RSCUR8, minimum dc current following block, converter 8 (amps)[2]
J+111			VRMP8, voltage recovery rate, converter 8 (pu/sec)[1]
J+112			CRMP8, current recovery rate, converter 8 (pu/sec)[2]
J+113			C0-8, minimum current demand converter 8 (amps)[4]
J+114			V1-8, voltage limit point 1, converter 8 (kV)[2]
J+115			C1-8, current limit point 1, converter 8 (amps)[2]
J+116			V2-8, voltage limit point 2, converter 8 (kV)[2]

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CONs	#	Value	Description
J+117			C2-8, current limit point 2, converter 8 (amps)[2]
J+118			V3-8, voltage limit point 3, converter 8 (kV)[2]
J+119			C3-8, current limit point 3, converter 8 (amps)[2]
J+120			TCMODE (sec)

1 Used only at voltage controlling converter.
2 Used at all except voltage controlling converter.
3 Used as minimum current allowed even at voltage controlling bus.

STATEs	#	Description
K		Measured ac voltage, converter 1
K+1		Measured dc voltage, converter 1
K+2		Measured dc current, converter 1
K+3		Measured ac voltage, converter 2
K+4		Measured dc voltage, converter 2
K+5		Measured dc current, converter 2
K+6		Measured ac voltage, converter 3
K+7		Measured dc voltage, converter 3
K+8		Measured dc current, converter 3
K+9		Measured ac voltage, converter 4
K+10		Measured dc voltage, converter 4
K+11		Measured dc current, converter 4
K+12		Measured ac voltage, converter 5
K+13		Measured dc voltage, converter 5
K+14		Measured dc current, converter 5
K+15		Measured ac voltage, converter 6
K+16		Measured dc voltage, converter 6
K+17		Measured dc current, converter 6
K+18		Measured ac voltage, converter 7
K+19		Measured dc voltage, converter 7
K+20		Measured dc current, converter 7
K+21		Measured ac voltage, converter 8
K+22		Measured dc voltage, converter 8
K+23		Measured dc current, converter 8

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VARs	#	Description
L		V_{AC} bus converter 1
L+1		P_{AC} bus converter 1
L+2		Q_{AC} bus converter 1
L+3		V_{DC} converter 1
L+4		I_{DC} converter 1
L+5		Angle converter 1
L+6		V_{AC} bus converter 2
L+7		P_{AC} bus converter 2
L+8		Q_{AC} bus converter 2
L+9		V_{DC} converter 2
L+10		I_{DC} converter 2
L+11		Angle converter 2
L+12		V_{AC} bus converter 3
L+13		P_{AC} bus converter 3
L+14		Q_{AC} bus converter 3
L+15		V_{DC} converter 3
L+16		I_{DC} converter 3
L+17		Angle converter 3
L+18		V_{AC} bus converter 4
L+19		P_{AC} bus converter 4
L+20		Q_{AC} bus converter 4
L+21		V_{DC} converter 4
L+22		I_{DC} converter 4
L+23		Angle converter 4
L+24		V_{AC} bus converter 5
L+25		P_{AC} bus converter 5
L+26		Q_{AC} bus converter 5
L+27		V_{DC} converter 5
L+28		I_{DC} converter 5
L+29		Angle converter 5
L+30		V_{AC} bus converter 6
L+31		P_{AC} bus converter 6

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VARs	#	Description
L+32		Q_{AC} bus converter 6
L+33		V_{DC} converter 6
L+34		IDC converter 6
L+35		Angle converter 6
L+36		V_{AC} bus converter 7
L+37		P_{AC} bus converter 7
L+38		Q_{AC} bus converter 7
L+39		V_{DC} converter 7
L+40		IDC converter 7
L+41		Angle converter 7
L+42		V_{AC} bus converter 8
L+43		P_{AC} bus converter 8
L+44		Q_{AC} bus converter 8
L+45		V_{DC} converter 8
L+46		IDC converter 8
L+47		Angle converter 8
L+48 . . . L+56		Internal VARs required by model

ICONs	#	Description
M		Entire line blocking flag:[1] 0 Not blocked 1 Blocked 2 Unblocking
M+1		Converter 1 flag:[1, 2] 0 Normal operation 1 Blocked 2 Unblocking
M+2		Converter 2 flag[1, 2]
M+3		Converter 3 flag[1, 2]
M+4		Converter 4 flag[1, 2]
M+5		Converter 5 flag[1, 2]

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ICONs	#	Description
M+6		Converter 6 flag[1, 2]
M+7		Converter 7 flag[1, 2]
M+8		Converter 8 flag[1, 2]
M+9		Mode switch flag:[3] 0 Normal 1 Mode switch

[1] Set to zero if this is voltage controlling converter (i.e., not used).
[2] Need not be input in DYRE data record. Can be changed by user for blocking/unblocking.
[3] Need not be input in DYRE data record. Flag set by model.

VARs	#	Description
LAUX		Auxiliary signal converter 1[1, 2] [DCMSIG(1,I)]
LAUX+1		Auxiliary signal converter 2[2] [DCMSIG(2,I)]
LAUX+2		Auxiliary signal converter 3[2] [DCMSIG(3,I)]
LAUX+3		Auxiliary signal converter 4[2] [DCMSIG(4,I)]
LAUX+4		Auxiliary signal converter 5[2] [DCMSIG(5,I)]
LAUX+5		Auxiliary signal converter 6[2] [DCMSIG(6,I)]
LAUX+6		Auxiliary signal converter 7[2] [DCMSIG(7,I)]
LAUX+7		Auxiliary signal converter 8[2] [DCMSIG(8,I)]

[1] This model uses auxiliary signal outputs stored in DCMSIG(1,I) through DCMSIG(8,I) (i.e., auxiliary signal index 1 through 8).
[2] At voltage controlling inverter, only used if in gamma control (i.e., ANGMX = ANGMN in power flow).

’DC Line Name’, ’MTDC3T’, CON(J) to CON(J+120) /

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Chapter 15

VSC dc Line Model Data Sheets

This chapter contains a collection of data sheets for the VSC dc line models contained in the PSS®E dynamics model library.

Table 15-1. Voltage Source Converter (VSC) dc Line Models

Model	Description
HVDCPLU1	Siemens HVDC plus model
VSCDCT	Two-terminal VSC dc line model

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15.1 HVDCPLU1

Siemens VSC DC line model for the HVDC Plus

VSC DC Line Name	'VSC DC Name', in single quotes as defined in power flow data	
This model uses ICONs starting with	#_____	M
CONs starting with	#_____	J,
STATEs starting with	#_____	K,
VARs starting with	#_____	L.

ICONs	#	Value	Description
M			Type of application: 1 = interconnected power systems (IPS application) 2 = wind park (WP application)

CONs	#	Values	Description
J			Rated AC voltage on DC side of converter Xfmr [kV]
J+1			Rectifier transformer impedance [pu of SBASE]
J+2			Inverter transformer impedance [pu of SBASE]
J+3			DC line total inductance [H]
J+4			DC line total capacitance [F]
J+5			Gain G_{Qr} of the rectifier reactive power controller
J+6			Lead time constant T_{LeadQr} of the rectifier reactive power controller [s]
J+7			Lag time constant T_{LagQr} of the rectifier reactive power controller [s]
J+8			Gain GQi of the inverter reactive power controller
J+9			Lead time constant T_{LeadQi} of the inverter reactive power controller [s]
J+10			Lag time constant T_{LagQi} of the inverter reactive power controller [s]
J+11			Gain G_{1Ud} of the DC voltage controller
J+12			Lead time constant $T_{Lead1Ud}$ of the DC voltage controller [s]
J+13			Lag time constant T_{Lag1Ud} of the DC voltage controller [s]
J+14			Gain G_{2Ud} of the DC voltage controller
J+15			Lead time constant $T_{Lead2Ud}$ of the DC voltage controller [s]
J+16			Lag time constant T_{Lag2Ud} of the DC voltage controller [s]
J+17			Ramp rate of the inverter active power setting value [p.u./s] (used for interconnected application)

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CONs	#	Values	Description
J+18			Gain G_{1P} of the inverter active power controller (interconnected application)
J+19			Lead time constant T_{Lead1P} of the inverter active power controller [s] (interconnected application)
J+20			Lag time constant T_{Lag1P} of the inverter active power controller [s] (interconnected application)
J+21			Gain G_{2P} of the inverter active power controller (interconnected application)
J+22			Lead time constant T_{Lead2P} of the inverter active power controller [s] (interconnected application)
J+23			Lag time constant T_{Lag2P} of the inverter active power controller [s] (interconnected application)
J+24			TIntQr (s); Rectifier Q controller integrator time constant
J+25			LMXQr (pu); Rectifier Q controller integrator upper limit
J+26			LMNQr (pu); Rectifier Q controller integrator lower limit
J+27			TIntQi (s); Inverter Q controller integrator time constant
J+28			LMXQi (pu); Inverter Q controller integrator upper limit
J+29			LMNQi (pu); Inverter Q controller integrator lower limit
J+30			TIntUd (s); Inverter dc voltage controller integrator time constant
J+31			LMXIUd (pu); Inverter dc voltage controller integrator upper limit
J+32			LMNIUd(pu); Inverter dc voltage controller integrator lower limit
J+33			TIntP (s); Inverter P controller integrator integrator time constant
J+34			LMXP (pu); Inverter P controller integrator upper limit
J+35			LMNP (pu); Inverter P controller integrator lower limit
J+36			Tsync (s); Inverter POI Angle measurement delay
J+37			LMX1Ud (deg.); Rectifier dc voltage controller first lead-lag upper limit
J+38			LMN1Ud (deg.); Rectifier dc voltage controller first lead-lag lower limit
J+39			LMX2Ud (deg.); Rectifier dc voltage controller second lead-lag upper limit
J+40			LMN2Ud (deg.); Rectifier dc voltage controller second lead-lag lower limit
J+41			LMX1P (deg.); Inverter P controller first lead-lag upper limit
J+42			LMN1P (deg.); Inverter P controller first lead-lag lower limit
J+43			LMX2P (deg.); Inverter P controller second lead-lag upper limit
J+44			LMN2P (deg.); Inverter P controller second lead-lag lower limit
J+45			C_Module (F),Converter module capacitor
J+46			V_Module (kV), Converter module rated capacitor voltage

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CONs	#	Values	Description
J+47			Protection threshold peak current of the IGBTs, kA
J+48			Model Acceleration factor(>0 and <=1)
J+49			Undervoltage characteristics, X1 (measured AC-voltage in pu)
J+50			Undervoltage characteristics, Y1 (AC-voltage reference in pu)
J+51			Undervoltage characteristics, X2
J+52			Undervoltage characteristics, Y2
J+53			Undervoltage characteristics, X3
J+54			Undervoltage characteristics, Y3
J+55			Undervoltage characteristics, X4
J+56			Undervoltage characteristics, Y4
J+57			Undervoltage characteristics, X5
J+58			Undervoltage characteristics, Y5
J+59			Undervoltage characteristics, X6
J+60			Undervoltage characteristics, Y6
J+61			Undervoltage characteristics, X7
J+62			Undervoltage characteristics, Y7
J+63			Undervoltage characteristics, X8
J+64			Undervoltage characteristics, Y8
J+65			Undervoltage characteristics, X9
J+66			Undervoltage characteristics, Y9
J+67			Undervoltage characteristics, X10
J+68			Undervoltage characteristics, Y10
J+69			Power-Voltage characteristics, X1 (measured AC-voltage in pu)
J+70			Power-Voltage characteristics, Y1 (maximum active power in pu of MVA rating of second converter)
J+71			Power-Voltage characteristics, X2
J+72			Power-Voltage characteristics, Y2
J+73			Power-Voltage characteristics, X3
J+74			Power-Voltage characteristics, Y3
J+75			Power-Voltage characteristics, X4
J+76			Power-Voltage characteristics, Y4
J+77			Power-Voltage characteristics, X5
J+78			Power-Voltage characteristics, Y5
J+79			Power-Voltage characteristics, X6
J+80			Power-Voltage characteristics, Y6
J+81			DC Chopper characteristics, X1 (Direct voltage in pu)

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CONs	#	Values	Description
J+82			DC Chopper V-I characteristics, Y1 (chopper current in kA)
J+83			DC Chopper characteristics, X2
J+84			DC Chopper characteristics, Y2
J+85			DC Chopper characteristics, X3
J+86			DC Chopper characteristics, Y3
J+87			DC Chopper characteristics, X4
J+88			DC Chopper characteristics, Y4
J+89			DC Chopper characteristics, X5
J+90			DC Chopper characteristics, Y5
J+91			DC Chopper characteristics, X6
J+92			DC Chopper characteristics, Y6
J+93			DC Chopper characteristics, X7
J+94			DC Chopper characteristics, X7
J+95			DC Chopper characteristics, X8
J+96			DC Chopper characteristics, X8
J+97			DC Chopper characteristics, X9
J+98			DC Chopper characteristics, X9
J+99			DC Chopper characteristics, X10
J+100			DC Chopper characteristics, X10

STATEs	#	Description
K		Rectifier Q-control lead-lag
K+1		Rectifier Q-control integrator
K+2		Ud-control lead-lag 1
K+3		Ud-control lead-lag 2
K+4		Ud-control integrator
K+5		Inverter POI synchronisation angle [deg]
K+6		Inverter Q-control lead-lag
K+7		Inverter Q-control integrator
K+8		Rectifier capacitor voltage [V]
K+9		Rectifier DC line current [A]
K+10		Voltage of the DC line's equivalent capacitor [V]
K+11		Inverter DC line current [A]
K+12		Inverter capacitor voltage [V]
K+13		Inverter P-control lead-lag 1 (used only for an Interconnected application)
K+14		Inverter P-control lead-lag 2 (used only for an Interconnected application)

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STATEs	#	Description
K+15		Inverter P-control integrator (used only for an Interconnected application)
K+16		Rectifier POI synchronisation angle [deg]
K+17		Inverter P-control rate limiter (used only for an Interconnected application)

VARs	#	Description
L		Rectifier Q-reference [pu of rectifier MVA rating]
L+1		Inverter Ud-reference [V] (only for a WP application)
L+2		Inverter Q-reference [pu of rectifier MVA rating]
L+3		Rectifier Q at the Point of Interconnection (POI) [pu of rectifier MVA rating]
L+4		Inverter voltage phase angle [rad]
L+5		Inverter Q at the POI [pu of rectifier MVA rating]
L+6		AC voltage reference [pu] (inverter Q-control)
L+7		Rectifier voltage magnitude [p.u.]
L+8		Inverter voltage magnitude [pu]
L+9		Rectifier voltage phase angle [rad]
L+10		Inverter direct current [A]
L+11		Rectifier direct current [A]
L+12		Chopper current [A]
L+13		Limit of the active power setting value [pu]
L+14		Rectifier active power at the POI [pu of rectifier MVA rating]
L+15		Setpoint of the rectifier voltage magnitude [pu]
L+16		Rectifier AC current [kA peak]
L+17		Inverter AC current [kA peak]
L+18		Setpoint of the inverter voltage magnitude [pu]
L+19		AC voltage reference [pu] rectifier Q-control)
L+20		Inverter active power at the POI [pu of inverter MVA rating]
L+21		Rectifier Vd-reference [V], used only for Interconnected application
L+22		Inverter real power-reference from the load flow [pu of inverter MVA rating]
L+23 ... L+26		Internal storage

Dynamic data record:

'VSC DC line name' 'USRDCL' HVDCPLU1' 20 1 1 101 18 27

ICON(M), CON(J) to CON(J+100) /

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Model notes:

1. The model is suitable for time step increments in the range of 1ms - 10ms.
2. The converter transformer is a part of the model. It's reactance is used internally.
3. The model does not have provision for auxiliary signals (like damping controllers etc.).
4. Converter losses can be considered using the Aloss and Bloss coefficients, which are part of the VSC load flow data power record.
5. The respective VSC load flow model must not have a converter MVA rating (SMAX) of zero. If the user specifies a converter MVA rating of zero the model is ignored.
6. The DC chopper characteristics are required only for Wind park application. For inter-connected applications, the 10 pairs of (X,Y) points representing the DC chopper characteristics can be set to zero.

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Model Configuration

Model of the DC Circuit

HVDC Plus common control functions for all types of application

Rectifier reactive power controller

HVDC Plus control functions for a wind park application

HVDC Plus control functions for an interconnected system application

Inverter active power controller
Active power setting value [p.u.]
STATE(K+20)
Measured active power [p.u.] at the POI
VAR(L+20)
LMX1P
LMN1P
STATE(K+13)
LMXP
LMNP
STATE(K+15)
LMX2P
LMN2P
STATE(K+14)
DEG_to_RAD
VAR(L+4)
Inverter voltage angle [rad]
RAD_to_DEG
Voltage angle [rad] at the inverter POI bus
STATE(K+5)

15.2 VSCDCT

VSC DC Model with Two VSC Converters

VSC DC Line Name	'VSC DC Name', as defined in power flow data	
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Values	Description
J			Tpo_1, Time constant of active power order controller, sec (For VSC # 1).
J+1			AC_VC_Limits_1, Reactive power limit for ac voltage control, pu on converter MVA rating. When 0, it is not used and Qmax/Qmin pair is used instead (For VSC # 1).
J+2			AC_Vctrl_kp_1, AC Voltage control proportional gain, converter MVA rating/BASEKV (For VSC # 1).
J+3			Tac_1 > 0.0, Time constant for AC voltage PI integral, sec (For VSC # 1). When 0, VSC#1 is ignored.
J+4			Tacm_1, Time constant of the ac voltage transducer, sec (For VSC # 1).
J+5			Iacmax_1, Current Limit, pu on converter MVA rating (For VSC # 1).
J+6			Droop_1, AC Voltage control droop, converter MVA rating/BASEKV (For VSC # 1).
J+7			VCMX_1, Maximum VSC Bridge Internal Voltage (For VSC # 1).
J+8			XREACT_1 > 0.0, Pu reactance of the ac series reactor on converter MVA rating (For VSC # 1). When 0.0, default value 0.17 is used.
J+9			QMAX_1, Maximum system reactive limits in Mvars (For VSC # 1). When AC-VC_Limits_1 >0, QMAX_1 is not used.
J+10			QMIN_1, Minimum system reactive limits in MVARs (For VSC # 1). When AC-VC_Limits_1 >0, QMIN_1 is not used.
J+11			AC_VC_KT_1, Adjustment Parameter for the feedback from reactive power limiter to ac voltage controller (For VSC #1).
J+12			AC_VC_KTP_1, Adjustment Parameter for the feedback from current order limiter to ac voltage controller (For VSC #1).
J+13			Tpo_2, Time constant of active power order controller, sec (For VSC # 2).
J+14			AC_VC_Limits_2, Reactive power limit for ac voltage control, pu on converter MVA rating. When 0, it is not used and Qmax/Qmin pair is used instead (For VSC # 2).

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CONs	#	Values	Description
J+15			AC_Vctrl_kp_2, AC Voltage control proportional gain, converter MVA rating/BASEKV (For VSC # 2).
J+16			Tac_2 > 0.0, Time constant for AC voltage PI integral, sec (For VSC # 2). When 0, VSC#2 is ignored.
J+17			Tacm_2, Time constant of the ac voltage transducer, sec (For VSC # 2).
J+18			Iacmax_2, Current Limit, pu on converter MVA rating (For VSC # 2).
J+19			Droop_2, AC Voltage control droop, converter MVA rating/BASEKV (For VSC # 2).
J+20			VCMX_2, Maximum VSC Bridge Internal Voltage (For VSC # 2).
J+21			XREACT_2 > 0.0, Pu reactance of the ac series reactor on converter MVA rating (For VSC # 2). When 0.0, default value 0.17 is used.
J+22			QMAX_2, Maximum system reactive limits in MVARs (For VSC # 2). When AC-VC_Limits_2 >0, QMAX_2 is not used.
J+23			QMIN_2, Minimum system reactive limits in MVARs (For VSC # 2). When AC-VC_Limits_2 >0, QMIN_2 is not used.
J+24			AC_VC_KT_2, Adjustment Parameter for the feedback from reactive power limiter to ac voltage controller (For VSC #2).
J+25			AC_VC_KTP_2, Adjustment Parameter for the feedback from current order limiter to ac voltage controller (For VSC #2).
J+26			Tpo_DCL, Time constant of the power order controller, sec (For DC Line).
J+27			Tpo_lim, Time constant of the power order limit controller, sec (For DC Line).

STATEs	#	Description
K		P_ref_pu, Active power reference auxiliary input, pu on CONVERTER MVA RATING (For VSC # 1).
K+1		Uac_int, AC Voltage controller integral output, pu on converter MVA rating (For VSC # 1.
K+2		Uac_p_filt, AC voltage measured, pu (For VSC # 1).
K+3		P_ref_pu, Active power reference auxiliary input, pu on converter MVA rating (For VSC # 2).
K+4		Uac_int, AC Voltage controller integral output, pu on converter MVA rating (For VSC # 2).
K+5		Uac_p_filt, AC voltage measured, pu (For VSC # 2).
K+6		P_ret_pu, Power Order, pu on SBASE (For DC Line).
K+7		Plimit, Power Order Limit, pu on SBASE (For DC Line).

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VARs	#	Description
L		P_aux, Active power reference auxiliary order, MW (For VSC # 1); uses auxiliary signal index # 1
L+6		Q_ref, Reactive power order, pu on converter MVA rating (For VSC # 1).
L+7		P_ref, Interface Active power, pu on SBASE (For VSC # 1).
L+10		PELE, Active power, pu on SBASE (For VSC # 1).
L+11		QELE, Reactive power, pu on SBASE (For VSC # 1).
L+12		P_aux, Active power reference auxiliary order, MW (For VSC # 2); uses auxiliary signal index # 2
L+18		Q_ref, Reactive power order, pu on converter MVA rating (For VSC # 2).
L+19		P_ref, Interface Active power, pu on SBASE (For VSC # 2).
L+22		PELE, Active power, pu on SBASE (For VSC # 2).
L+23		QELE, Reactive power, pu on SBASE (For VSC # 2).
L+24		P_ref_main, Active power main order, pu on SBASE (For DC Line).
L+32		Pzero_loss, DC system losses at zero current, MW (For DC Line).
L+33		Pdc_loss, DC losses, MW (For DC Line).
L+34 • • • L+45		Isormod History, PSSE Variables for internal usage as well as: L+1 through L+5, L+8, L+9, L+13 through L+17, L+20, L+21, L+25 through L+31.

Note: Smax (Converter MVA rating) should be non-zero in power flow input data when VSCDCT model is used for stability simulations.

'VSC Name' , 'VSCDCT', ICON(M) to ICON(M+3), CON(J) to CON(J+27) /

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Chapter 16

FACTS Device Model Data Sheets

This chapter contains a collection of data sheets for the FACTS device (device modeled as FACTS in power flow) models contained in the PSS®E dynamics model library.

Model	Description
CSTCNT	Static Condenser (modeled as FACTS device in power flow).
SVSMO3U2	WECC Generic STATCOM based SVC Model

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16.1 CSTCNT

FACTS Device Static Condenser (STATCON)

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			T_1 (>0)
J+1			T_2 (>0)
J+2			T_3 (>0)
J+3			T_4 (>0)
J+4			$K\left(\text{typical} = \frac{25}{dv/de_i}\right)$
J+5			Droop (typical = 0.03)
J+6			V_{MAX} (typical = 999)
J+7			V_{MIN} (typical = -999)
J+8			I_{CMAX} (typical = 1.25) Max capacitive current
J+9			I_{LMAX} (typical = 1.25) Max inductive current
J+10			V_{cutout} (typical = 0.2)
J+11			E_{limit} (typical = 1.2)
J+12			X_t (>0) (transformer reactance, typical = 0.1)
J+13			A_{cc} (acceleration factor, typical = 0.5)
J+14			STBASE (>0) STATCON base MVA

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Integrator

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VARs	#	Description
L		Other signals [FCTSIG (1, NF)][1]
L+1		V_{ref}
L+2		STATCON internal voltage (E_i)
L+3		STATCON current [2, 3, 4]

1 This model uses auxiliary signal output stored in FCTSIG (1, NF), (i.e., auxiliary signal index 1).
2 Positive STATCON current [VAR(L+3)] corresponds to STATCON performance as capacitor.
3 VAR(L+3) is on SBASE.
4 Specify STATCON input parameters on STATCON base MVA.

ICON	#	Value	Description
M			IB, remotely regulated bus[1]

1 The remote bus has to be either a load bus or a generator bus. If this is not the case, internally the remote bus will be set same as local bus. If the user wants to input a remote bus that is the same as the local bus, IB can either be specified to be the local bus number, or can be set to 0.

DYRE Data Record:

BUSID 'CSTCNT',IB,T1,T2,T3,T4,K,Droop,VMAX,VMIN,ICMAX,ILMAX,Vcut-out,Elimit,Xt,Acc,STBASE/

Where:

BUSID is the FACTS device name (in single quotes)

|V| : Voltage of the regulated bus, $|V_T|$: Voltage at the STATCON bus.

Limit Max = $|V_T| + X_t I_{CMAXØ}$
Limit Min = $|V_T| - X_t I_{LMAXØ}$
Limit Max $\leq E_{limit}$

where:

$I_{CMAXØ} = I_{CMAX}$ when $|V_T| \geq V_{cutout}$

$$= \frac{I_{CMAX} * |V_T|}{V_{cutout}} \quad \text{otherwise}$$

$I_{LMAXØ} = I_{LMAX}$ when $|V_T| \geq V_{cutout}$

$$= \frac{I_{LMAX} * |V_T|}{V_{cutout}} \quad \text{otherwise}$$

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16.2 SVSMO3U2

This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VARs starting with #_____ L,
and ICON #_____ M.

CONs	#	Value	Description
J			Xc0, Linear droop
J+ 1			Tc1, Voltage measurement lead time constant
J+ 2			Tb1, Voltage measurement lag time constant
J+ 3			Kp, Proportional gain
J+ 4			Ki, Integral gain
J+ 5			Vemax, Voltage error max. (pu)
J+ 6			Vemin, Voltage error min. (pu)
J+ 7			T0, Firing sequence control delay (sec)
J+ 8			Imax1, Max. continuous current rating (pu on STATCOM BASE MVA (STBASE))
J+ 9			dbd, Deadband in voltage control (pu)
J+10			Kdbd, Ratio of outer to inner deadband
J+11			Tdbd, Deadband time (sec)
J+12			Kpr, Proportional gain for slow-reset control
J+13			Kir, Integral gain for slow-reset control
J+14			Idbd, Deadband range for slow-reset control (pu on STBASE)
J+15			Vrmax, Max. limit on slow-reset control output (pu)
J+16			Vrmin, Min. limit on slow-reset control output (pu)
J+17			Max. short-term current rating as a multiplier of max. continuous current rating pu
J+18			UV1, Voltage at which STATCOM limit starts to be reduced linearly (pu)
J+19			UV2, Voltage below which STATCOM is blocked (pu)
J+20			OV1, Voltage above which STATCOM limit linearly drops (pu)
J+21			OV2, Voltage above which STATCOM blocks (pu)
J+22			Vtrip, Voltage above which STATCOM trips after time dealy, Tdelay2 (pu)
J+23			Tdelay1, duration of short-term rating(sec)
J+24			Tdelay2, Trip time for V > Vtrip (sec)
J+25			Vrefmax, Max. voltage reference limit (pu)
J+26			Vrefmin, Min. voltage reference limit (pu)

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CONs	#	Value	Description
J+27			Tc2, lead time constant (sec)
J+28			Tb2, lag time constant (sec)
J+29			I2t, short-term limit
J+30			Reset, Reset rate for I2t limit
J+31			hyst, Width of hysteresis loop for I2t limit
J+32			Xc1, Non-linear droop slope 1
J+33			Xc2, Non-linear droop slope 2
J+34			Xc3, Non-linear droop slope 3
J+35			V1, Non-linear droop upper voltage (pu)
J+36			V2, Non-linear droop lower voltage (pu)
J+37			Tmssbrk, time for MSS breaker to operate - typically ignore (sec)
J+38			Tout, Time MSC should be out before switching back in (sec)
J+39			TdelLC, time delay for switching in a MSS (sec)
J+40			Iupr, Upper threshold for switching MSSs (pu on STBASE)
J+41			Ilwr, Lower threshold for switching MSSs (pu on STBASE)
J+42			Sdelay, time for which STATCOM to remain blocked before being unblocked (sec)
J+43			STBASE(>0), STATCOM base MVA

STATEs	#	Description
K+1		STATCOM main PI controller integrator
K+2		STATCOM output Lag
K+3		STATCOM slow-reset PI controller integrator
K+4		Short-term rating integrator
K+5		Lead-lag block

VARs	#	Value	Description
L			STATCOM output, STATCOM terminal current (pu on STATCOM BASE MVA (STBASE))
L+1			STATCOM reactive power output (pu on STBASE)
L+2			STATCOM output in MVAr
L+3			Output of main PI controller
L+4			STATCOM lead-lag output before PI controller
L+5			STATCOM voltage error signal into lead-lag block

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L+6			Reference voltage of STATCOM
L+7			Output of slow-secondary loop current PI regulator
L+8			Measurement lead-lag transducer output
L+9			Imax timer
L+10			Imax1*Ishrt
L+11			Timer for MSS starting >I demand
L+12			Timer for MSS starting <I demand
L+13 through L+20			Timer for MSS1 through MSS8
L+21			MSS timer monitors Tdelay+Tmssbrk
L+22			Deadband timer
L+23			I block timer
L+24			Time at which VBUS .GT. Vtrip
L+25			Scheduled voltage of STATCOM
L+26			Optional auxiliary signal (Vsig) input

ICON	#	Value	Description
M			Remote bus number for voltage regulation
M+1			Disable or enable coordinated MSS switching, 0 - no MSS switching, 1 - MSS switching based on STATCOM current
M+2			flag1, slow-reset off/on, flag1 (0/1)
M+3			flag2, non-linear droop off/on, flag2 (0/1)
M+4			1st MSS bus #
M+5			1st MSS Id (to be entered within single quotes)
M+6			2nd MSS bus #
M+7			2nd MSS Id (to be entered within single quotes)
M+8			3rd MSS bus #
M+9			3rd MSS Id (to be entered within single quotes)
M+10			4th MSS bus #
M+11			4th MSS Id (to be entered within single quotes)
M+12			5th MSS bus #
M+13			5th MSS Id (to be entered within single quotes)
M+14			6th MSS bus #
M+15			6th MSS Id (to be entered within single quotes)

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M+16			7th MSS bus #
M+17			7th MSS Id (to be entered within single quotes)
M+18			8th MSS bus #
M+19			8th MSS Id (to be entered within single quotes)

DYRE Data Record:

'FACTS Name' 'USRFCT' 'SVSMO3U2' 21, 1, 20, 44, 6, 27, ICON(M) to ICON(M+19), CON(J) to CON(J+42) /

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Chapter 17

Generic Wind Generator Model Data Sheets

This chapter contains a collection of data sheets for the generic wind generator models contained in the PSS®E dynamics model library.

Model	Description
PVGU1	User written generator model to represent photo-voltaic (PV) systems
REGCAU1	Renewable Energy Generator/Converter Model
WT1G1	Direct connected (Type 1) generator
WT2G1	Induction generator with controlled external rotor resistor (Type 2)
WT3G1	Doubly-fed induction generator (Type 3)
WT3G2	Doubly-fed induction generator (Type 3), version 2
WT4G1	Wind generator model with power converter (Type 4)
WT4G2	Wind generator model with power converter (Type 4), version 2

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17.1 PVGU1

PV Converter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			TIqCmd, Converter time constant for IQcmd, second
J+1			TIpCmd, Converter time constant for IPcmd, second
J+2			VLVPL1, Low voltage power logic (LVPL) voltage 1, pu
J+3			VLVPL2, LVPL voltage 2, pu
J+4			GLVPL gain
J+5			VHVRCR, High voltage reactive current (HVRC) logic voltage, pu
J+6			CURHVRCR, max. reactive current at VHVRCR, pu
J+7			Rip_LVPL, Rate of LVACR active current change
J+8			T_LVPL, voltage sensor for LVACR time constants

STATEs	#	Value	Description
K			Converter lag for Ipcmd
K+1			Converter lag for Iqcmd
K+2			Voltage sensor for LVACR

VARs	#	Value	Description
L through L+2			For internal use

IBUS 'USRMDL' ID 'PVGU1' 101 1 0 9 3 3 CON(J) to CON(J+8) /

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17.2 REGCAU1

Renewable Energy Generator/Converter Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			Tg, Converter time constant (s)
J+1			Rrpwr, Low Voltage Power Logic (LVPL) ramp rate limit (pu)
J+2			Brkpt, LVPL characteristic voltage 2 (pu)
J+3			Zerox, LVPL characteristic voltage 1 (pu)
J+4			Lvpl1, LVPL gain (pu)
J+5			Volim, Voltage limit (pu) for high voltage reactive current management
J+6			Lvpnt1, High voltage point for low voltage active current management (pu)
J+7			Lvpnt0, Low voltage point for low voltage active current management (pu)
J+8			Iolim, Current limit (pu) for high voltage reactive current management (specified as a negative value)
J+9			Tfltr, Voltage filter time constant for low voltage active current management (s)
J+10			Khv, Overvoltage compensation gain used in the high voltage reactive current management
J+11			Iqrmax, Upper limit on rate of change for reactive current (pu)
J+12			Iqrmin, Lower limit on rate of change for reactive current (pu)
J+13			Accel, acceleration factor ($0 < \text{Accel} \leq 1$)

STATEs	#	Description
K		Converter lag for Iqcmd
K+1		Converter lag for Ipcmd
K+2		Voltage filter for low voltage active current management

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VARs	#	Description
L		Previous terminal voltage
L+1		Previous terminal voltage angle
L+2		reactive current overvoltage correction
L+3		Initial machine reactive power from power flow

CON	#	Description
M		Lvplsw (Low Voltage Power Logic) switch (0: LVPL not present, 1: LVPL present)

IBUS, 'USRMDL', ID, 'REGCAU1', 101, 1, 1, 14, 3, 4, ICON(M), CON(J) to CON(J+13) /

Notes:

1. This model can be used with Type 3 and 4 wind machines. When used for modeling of Type 3 wind machine, the other models to be used along with this model are reecau1, repcau1 (optional), wtdtau1, wtptau1, wtarau1, and wttqau1. When used for modeling of Type 4 machines, the other models to be used along with this model are reecau1, wtdtau1, and repcau1 (optional).

1.

Rate limits on reactive current for recovery after fault.
Upward limit is active when Qgen0 > 0
Downward limit is active when Qgen0 < 0
Qgen0
Iqmax
Iqcmd
-1
1 + sTg
s1
Iqmin
High Voltage Reactive Current Management
Iq
Iolim
Vt
Khv
0
Volim
Interface to Network Model
LVPL & rrpwr
Low Voltage Reactive Current Management
Ipcmd
1
1+sTg
s0
Ip
LVPL
Lvplsw
0
Lvpl1
1
Zerox
Brkpt
V
1
1+sTfltr
s2
Gain
1
0
Lypnt0
Lypnt1
V

17.3 WT1G1

Direct Connected (Type 1) Generator

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T open circuit transient time constant, sec. (>0)
J+1			T″, open circuit subtransient time constant,sec. (≥ 0); if T″ = 0, single cage
J+2			X, synchronous reactance, pu
J+3			X´, transient reactance, pu
J+4			X″, subtransient reactance, pu (≥ 0); if X″ = 0, single cage
J+5			Xl, leakage reactance, pu
J+6			E1
J+7			S(E1)
J+8			E2
J+9			S(E2)

STATEs	#	Description
K		Eq´, transient flux q-component
K+1		Ed´, transient flux d-component
K+2		Eq″, subtransient flux q-component
K+3		Ed″, subtransient flux d-component
K+4		Internal

VARs	#	Description
L		Admittance of initial condition MVAr difference
L+1		Machine Q
L+2		Telec

IBUS, ’WT1G1’, ID, CON(J) to CON(J+9) /

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17.4 WT2G1

Induction Generator with Controlled External Rotor Resistor (Type 2)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			XA, stator reactance, pu
J+1			XM, magnetizing reactance, pu
J+2			X1, rotor reactance, pu
J+3			R_ROT_MACH, rotor resistance, pu
J+4			R_ROT_MAX, a sum of R_ROT_MACH and total external resistance, pu
J+5			E1, first saturation coordinate
J+6			SE1, first saturation factor
J+7			E2, second saturation coordinate
J+8			SE2, second saturation factor
J+9			POWER_REF_1, first of 5 coordinate pairs of the power-slip curve
J+10			POWER_REF_2
J+11			POWER_REF_3
J+12			POWER_REF_4
J+13			POWER_REF_5
J+14			SLIP_1
J+15			SLIP_2
J+16			SLIP_3
J+17			SLIP_4
J+18			SLIP_5

STATEs	#	Description
K		Eq´, transient flux q-component
K+1		Ed´, transient flux d-component
K+2		Internal

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VARs	#	Description
L		Admittance of the hidden shunt
L+1		Machine Q
L+2		Telec

IBUS, 'WT2G1', ID, CON(J) to CON(J+18) /

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17.5 WT3G1

Doubly-Fed Induction Generator (Type 3)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			X_{eq}, Equivalent reactance for current injection (pu)
J+1			K_{pll}, PLL first integrator gain
J+2			K_{ipll}, PLL second integrator gain
J+3			P_{llmax}, PLL maximum limit
J+4			Prated, Turbine MW rating

STATEs	#	Description
K		Converter lag for Ipcmd
K+1		Converter lag for Eqcmd
K+2		PLL first integrator
K+3		PLL second integrator

VARs	#	Description
L		V_X, Real component of Vterm in generator ref. frame
L+1		V_Y, Imaginary component of Vterm in generator ref. frame
L+2		I_{xinj}, Active component of the injected current
L+3		I_{yinj}, Reactive component of the injected current

ICON	#	Description
M		Number of lumped wind turbines

IBUS, 'WT3G1', ID, ICON(M), CON(J) to CON(J+4) /

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Notes: 1. $\overline{V}_{term}$ and $\overline{I}_{sorc}$ 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 (ZSORCE)

17.6 WT3G2

Doubly-Fed Induction Generator (Type 3)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VAR	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			Tiqcmd, Converter time constant for IQcmd
J+1			Tipcmd, Converter time constant for IPcmd
J+2			K_{PLL}, PLL gain
J+3			K_{IPLL}, PLL integrator gain
J+4			PLL_{MAX}, PLL max. limit
J+5			Prated
J+6			V_{LVPL1}, LVPL voltage 1 Low voltage power logic
J+7			V_{LVPL2}, LVPL voltage 2
J+8			G_{LVPL}, LVPL gain
J+9			V_{HVRCR}, High Voltage Reactive Current (HVRC) logic, pu voltage
J+10			CUR_{HVRCR}, HVRC logic, current (pu)
J+11			R_{Ip_LVPL}, Rate of active current change
J+12			$T_{_LVPL}$, Voltage sensor for LVPL, second

STATEs	#	Description
K		Converter lag for Ipcmd
K+1		Converter lag for Iqcmd
K+2		PLL first integrator
K+3		PLL second integrator
K+4		Voltage sensor for LVPL

VAR	#	Description
L		deltaQ, overvoltage correction factor

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ICON	#	Description
M		Number of lumped wind turbines

IBUS, 'WT3G2', ID, ICON(M), CON(J) TO COM(J+12)

17.7 WT4G1

Wind Generator Model with Power Converter (Type 4)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_{IQCmd}, Converter time constant for IQcmd
J+1			T_{IPCmd}, Converter time constant for IPcmd
J+2			V_{LVPL1}, LVPL voltage 1 (Low voltage power logic)
J+3			V_{LVPL2}, LVPL voltage 2
J+4			G_{LVPL}, LVPL gain
J+5			V_{HVRCR}, HVRCR voltage (High voltage reactive current limiter)
J+6			CUR_{HVRCR}, HVRCR current (Max. reactive current at VHVRCR)
J+7			R_{Ip_LVPL}, Rate of LVACR active current change
J+8			T_{LVPL}, Voltage sensor for LVACR time constant

STATEs	#	Description
K		Converter lag for Ipcmd
K+1		Converter lag for Eqcmd
K+2		Voltage sensor for LVACR

VARs	#	Description
L through L+4		For internal use
L+1		VAACC, previous Vterm angle
L+2		deltaQ, overvoltage correction factor

IBUS, 'WT4G1', ID, CON(J) to CON(J+8) /

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WIQCMD
1
1 + sTEqcmd
K + 1
High Voltage
Reactive Current
Logic
Low Voltage
Active Current
Logic
LVPL
RIp_LVPL
WIPCMD
+
-
Σ
1
sTIpcmd
K
Vt
LVPL
GLVPL
LVPL
VLVPL1
VLVPL2
V
1
1 + sT_LVPL
K + 2

17.8 WT4G2

Wind Generator Model with Power Converter (Type 4)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			T_{IQCmd}, Converter time constant for IQcmd
J+1			T_{IPCmd}, Converter time constant for IPcmd
J+2			V_{LVPL1}, LVPL voltage 1 (Low voltage power logic)
J+3			V_{LVPL2}, LVPL voltage 2
J+4			G_{LVPL}, LVPL gain
J+5			V_{HVRCR}, HVRCR voltage (High voltage reactive current limiter)
J+6			CUR_{HVRCR}, HVRCR current (Max. reactive current at VHVRCR)
J+7			R_{Ip_LVPL}, Rate of LVACR active current change
J+8			T_{LVPL}, Voltage sensor for LVACR time constant

STATEs	#	Description
K		Converter lag for Ipcmd
K+1		Converter lag for Eqcmd
K+2		Voltage sensor for LVACR

VARs	#	Description
L through L+4		For Internal Use

IBUS, 'WT4G2', ID CON(J) to CON(J+8) /

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WIQCMD
1
1 + sTEqcmd
K + 1
High Voltage
Reactive Current
Logic
Low Voltage
Active Current
Logic
LVPL
RIp_LVPL
WIPCMD
+
-
Σ
1
sTIpcmd
K
Vt
LVPL
GLVPL
LVPL
VLVPL1
VLVPL2
V
1
1 + sT_LVPL
K + 2

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Chapter 18

Generic Wind Electrical Model Data Sheets

This chapter contains a collection of data sheets for the generic wind electrical models contained in the PSS®E dynamics model library.

Model	Description
PVEU1	User written electrical control model for photo-voltaic (PV) systems
REECAU1	Generic Renewable Electrical Control Model
WT2E1	Rotor resistance control model for Type 2 wind generator
WT3E1	Electrical control for Type 3 wind generator
WT4E1	Electrical control models for Type 4 wind generator
WT4E2	Electrical control for Type 4 wind generator, version 2

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18.1 PVEU1

Electrical Control Model for PV Converter

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses:		
This model uses: CONs starting with	#_____	J,
STATEs starting with	#_____	K
VARs starting with	#_____	L
ICONs starting with	#_____	M

CONs	#	Value	Description
J			Tw, Filter time constant in voltage regulator (sec(
J+1			Kpv, Proportionalgain in voltage regulator(pu)
J+2			Kiv, Integrator gain in voltage regulator (pu)
J+3			Kpp, Proportional gain in torque regulator (pu)
J+4			Kip, Integrator gain in torque regulator (pu
J+5			Kf, rate feedback gain (pu)
J+6			Tf, rate feedback time constant (sec.)
J+7			Qmx, Max limit in voltage regulator (pu)
J+8			Qmn, Min limit in voltage regulator (pu)
J+9			IPmax, Max active current limit (pu)
J+10			Trv, voltage sensor time constant (sec.)
J+11			dPMX, maximum power order rate (pu)
J+12			dPMN, minimum power order rate (pu)
J+13			Tpower, Power reference filter time constant, sec.
J+14			KQi, volt/Mvar gain
J+15			Vmincl, min. voltage limit
J+16			Vmaxcl, max. voltage limit
J+17			KVi, Int. volt/Term. voltage gain
J+18			Tv, Lag in WindVar controller (sec)
J+19			Tp, Pelec filter in fast PF controller (sec)
J+20			ImaxTD, Converter current limit (pu)
J+21			Iphl, Hard active current limit (pu)
J+22			Iqhl, Hard reactive current limit (pu)
J+23			PMX, Max power from PV plant, MW

STATEs	#	Value	Description
K			Filter in Voltage regulator

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STATEs	#	Value	Description
K+1			Integrator in Voltage regulator
K+2			Integrator in active power regulator
K+3			Active power regulator feedback
K+4			Voltage sensor
K+5			Power reference filter
K+6			Mvar/Vref integrator
K+7			Verror/Internal machine voltage integrator
K+8			Lag of the WindVar controller
K+9			Input filter of PELEC for fast PF controller

VARs	#	Value	Description
L			Remote bus reference voltage
L+1			Q ref. if PFAFLG=0 & VARFLG=0
L+2			PF angle ref if PFAFLG=1
L+3			Power reference

ICONs	#	Value	Description
M			Remote bus # for voltage control; 0 for local control
M+1			PFAFLG: 1 if PF fast control enabled 0 if PF fast control disabled
M+2			VARFLG: 1 if Qord is provided by WindVar 0 if Qord is not provided by WindVar if VARFLG=PFAFLG=0 then Qord is provided as a Qref=const
M+3			PQFLAG: P/Q priority flag: 0 - Q priority, 1- P priority

Four possible configurations:

1. Current North American configuration with WindVAR:

   VARFLG=1, PFAFLG=0, KQi small (e.g., KQi = 0.1)

2. Current North American configuration without WindVAR:

   VARFLG=0, PFAFLG=0, KQi very small (e.g., KQi = 0.001)

3. European (PFA control) with WindVAR:

   VARFLG=1, PFAFLG=0, KQi large (e.g., KQi = 0.5), KVi large

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4. European (PFA control) without WindVAR:

   VARFLG=0, PFAFLG=1, Specify desired PFA, KQi

   large (e.g., KQi = 0.5), KVi large

IBUS ' USRMDL' ID 'PVEU1' 102 0 4 24 10 4 ICON(M) to ICON(M+3) CON(J) to CON(J+23) /

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18.2 REECAU1

Generic Renewable Electrical Control Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			Vdip (pu), low voltage threshold to activate reactive current injection logic
J+1			Vup (pu), Voltage above which reactive current injection logic is activated
J+2			Trv (s), Voltage filter time constant
J+3			dbd1 (pu), Voltage error dead band lower threshold (<=0)
J+4			dbd2 (pu), Voltage error dead band upper threshold (>=0)
J+5			Kqv (pu), Reactive current injection gain during over and undervoltage conditions
J+6			Iqhl (pu), Upper limit on reactive current injection Iqinj
J+7			Iqll (pu), Lower limit on reactive current injection Iqinj
J+8			Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)
J+9			Iqfrz (pu), Value at which Iqinj is held for Thld seconds following a voltage dip if Thld > 0
J+10			Thld (s), Time for which Iqinj is held at Iqfrz after voltage dip returns to zero (see Note 1)
J+11			Thld2 (s) (>=0), Time for which the active current limit (IPMAX) is held at the faulted value after voltage dip returns to zero
J+12			Tp (s), Filter time constant for electrical power
J+13			QMax (pu), limit for reactive power regulator
J+14			QMin (pu) limit for reactive power regulator
J+15			VMAX (pu), Max. limit for voltage control
J+16			VMIN (pu), Min. limit for voltage control
J+17			Kqp (pu), Reactive power regulator proportional gain
J+18			Kqi (pu), Reactive power regulator integral gain
J+19			Kvp (pu), Voltage regulator proportional gain
J+20			Kvi (pu), Voltage regulator integral gain

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CONs	#	Value	Description
J+21			Vbias (pu), User-defined bias (normally 0)
J+22			Tiq (s), Time constant on delay s4
J+23			dPmax (pu/s) (>0) Power reference max. ramp rate
J+24			dPmin (pu/s) (<0) Power reference min. ramp rate
J+25			PMAX (pu), Max. power limit
J+26			PMIN (pu), Min. power limit
J+27			Imax (pu), Maximum limit on total converter current
J+28			Tpord (s), Power filter time constant
J+29			Vq1 (pu), Reactive Power V-I pair, voltage
J+30			Iq1 (pu), Reactive Power V-I pair, current
J+31			Vq2 (pu) (Vq2>Vq1), Reactive Power V-I pair, voltage
J+32			Iq2 (pu) (Iq2>Iq1), Reactive Power V-I pair, current
J+33			Vq3 (pu) (Vq3>Vq2), Reactive Power V-I pair, voltage
J+34			Iq3 (pu) (Iq3>Iq2), Reactive Power V-I pair, current
J+35			Vq4 (pu) (Vq4>Vq3), Reactive Power V-I pair, voltage
J+36			Iq4 (pu) (Iq4>Iq3), Reactive Power V-I pair, current
J+37			Vp1 (pu), Real Power V-I pair, voltage
J+38			Ip1 (pu), Real Power V-I pair, current
J+39			Vp2 (pu) (Vp2>Vp1), Real Power V-I pair, voltage
J+40			Ip2 (pu) (Ip2>Ip1), Real Power V-I pair, current
J+41			Vp3 (pu) (Vp3>Vp2), Real Power V-I pair, voltage
J+42			Ip3 (pu) (Ip3>Ip2), Real Power V-I pair, current
J+43			Vp4 (pu) (Vp4>Vp3), Real Power V-I pair, voltage
J+44			Ip4 (pu) (Ip4>Ip3), Real Power V-I pair, current

STATEs	#	Description
K		Voltage Measurement filter
K+1		Real power filter
K+2		PI controller for reactive power
K+3		PI controller for voltage error
K+4		First Order lag for reactive current
K+5		First order lag for Pord

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VARs	#	Description
L		Bus reference voltage (Vref0)
L+1		Storage of current state for state transition (possible values: 0, 1 or 2)
L+2		Power factor reference angle (pfaref), radians
L+3		user defined bias as calculated by the model
L+4		Timer for Thld counter
L+5		Previous value of power reference
L+6		Stored Ipmax value
L+7		Timer for Thld2 counter
L+8		Storage for voltage_dip

ICONs	#	Description
M		**Bus number for voltage control; local control if 0**
M+1		**PFFLAG (Power factor control flag):** **1 if power factor control** **0 if Q control (which can be controlled by an external signal)**
M+2		**VFLAG:** **1 if Q control** **0 if voltage control**
M+3		**QFLAG:** **1 if voltage or Q control** **0 if constant pf or Q control**
M+4		**PFLAG:** **1 if active current command has speed dependency** **0 for no dependency**
M+5		**PQFLAG, P/Q priority flag for current limit:** **0 for Q priority** **1 for P priority**

IBUS, 'USRMDL', ID, 'REECAU1', 102, 0, 6, 45, 6, 9, ICON(M) to ICON(M+5), CON(J) to CON(J+44) /

Notes:

1. This model can be used with Type 3 and 4 wind machines. When used for modeling of Type 3 wind machine, the other models to be used along with this model are regcau1, repcau1 (optional), wtdtau1, wtptau1, wtarau1, wttqau1. When used for modeling of Type 4 machines, the other models to be used along with this control model are regcau1, wtdtau1, and repcau1 (optional).

2. Thld could be either zero, or less than zero or greater than zero.

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a) If Thld > 0, then once voltage_dip (voltage_dip is a flag which is set and reset in the model. Voltage_dip is 0 if the Vdip<VT<Vup, else it is 1) becomes 0, Iqinj is held at Iqfrz for Thld seconds.

b) If Thld < 0, then once voltage_dip goes to 0, Iqinj remains state (equal to I_{qv}) for Thld seconds.

c) If Thld = 0 , then Iqinj goes back to zero as soon as Voltage_dip becomes 0.

3. pfaref (the power factor angle reference) value is initialized by the model based on initial real and reactive power outputs from the machine.

4. ωg is the per unit generator speed and is set in the drive train model.

5. Qref is initialized by the model to a constant or can be connected to an external plant controller model).

6. Pref is initialized by the model to a constant or can be connected to an external plant controller model).

7. Normally Vbias is zero. The user specified Vbias value (which is in CON(J+21)) is used only when the QFlag=1, VFlag=0 and PfFlag=0. For all other combinations of QFlag, VFlag and PfFlag values, the Vbias value is either not required or is calculated and stored in VAR(L+3).

8. ICON(M) contains the remote bus number. If this is 0 or if the remote bus number is not specified then the local bus is used for control.

9. The VDL1 characteristics are defined by 4 pairs of Vq-Iq points (pu voltage versus reactive current). Data for the first two pairs (Vq1, Iq1) and (Vq2, Iq2) is mandatory (i.e., these cannot be specified as zero). A maximum of 4 pairs of Vq-Iq points can be specified. The first Vq entry that has a zero value, signals the end of Vq-Iq data. Unused Vq-Iq pairs should be entered as zero. The Vq-Iq values should be such that Vq1 < Vq2 < Vq3 < Vq4, and Iq1 ≤ Iq2 ≤ Iq3 ≤ Iq4.

10. The VDL2 characteristics are defined by 4 pairs of Vp-Ip points (pu voltage versus active current). Data for the first two pairs (Vp1, Ip1) and (Vp2, Ip2) is mandatory (i.e., these cannot be specified as zero). A maximum of 4 pairs of Vp-Ip points can be specified. The first Vp entry that has a zero value, signals the end of Vp-Ip data. Unused Vp-Ip pairs should be entered as zero. The Vp-Ip values should be such that Vp1 < Vp2 < Vp3 < Vp4, and Ip1 ≤ Ip2 ≤ Ip3 ≤ Ip4.

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Iqinj=0
0
After Thld seconds, go to state 0
If voltage_dip=0
If voltage_dip=1
Iqinj=Iqfrz
Iqinj=Iqv
2
1
Stay in state 2 for Thld seconds
If Thld > 0 & voltage_dip=0, go to state 2
If (VT < Vdip) or (Vt >Vup) Voltage_dip =1
else Voltage_dip =0
State Transition – switch position
State 0 – If Voltage_dip = 0; normal operation (Iqinj = 0)
State 1 – If Voltage_dip = 1; Iqinj goes to position 1
State 2 – If Thid > 0; then after voltage_dip goes back to zero, set value to Iqfrz for Thld seconds, after which go back to state 0
If Thld <0, then after voltage_dip returns to zero stay in State 1 for 1- Thld, after which go back to state 0.
Vt
1 / 1 + s Trv
Vt_filt
s0
Vref0
dbd1
dbd2
Verr
Kqv
Iqv
Iqfr1
(Iqfrz)
(Iqinj=0)
Freeze State if Voltage_dp = 1
pfaref
tan
Pelec
1 / 1 + s Tp
s1
Qref
PfFlag
Qmax
Qmin
Qelec
Vmax
Vmin
Kqp + Kqi / s
s2
VFlag
Kvp + Kvi / s
s3
Iqmax
Iqmin
QFlag
Iqinj
Iqcmd
Vbias
Vt_filt (s0)
Freeze State if Voltage_dp = 1
1 / 1 + s Tiq
s4
0.01
VDL1
VDL2
Current Limit Logic
Pqflag
0 – Q priority
1 – P priority
Freeze State if Voltage_dp = 1
Vt_filt (s0)
0.01
Pmax
Ipmax
dPmax
dPmin
Pref
PFlag
1 / 1 + s Tpord
s5
Pmin
Pord
Ipcmd
Vq-Iq characteristics (VDL1)
Vp-Ip characteristics (VDL2)
Iq (pu)
Ip (pu)
Vq (pu)
Vp (pu)

18.1 WT2E1

Rotor Resistance Control Model for the Type 2 Wind Generator

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

CONs	#	Value	Description
J			T_{sP}, rotor speed filter time constant, sec.
J+1			T_{pe}, power filter time constant, sec.
J+2			T_i, PI-controller integrator time constant, sec.
J+3			K_p, PI-controller proportional gain, pu
J+4			ROTRV_MAX, Output MAX limit
J+5			ROTRV_MIN, Output MIN limit

STATEs	#	Description
K		Rotor speed filter
K+1		Power filter
K+2		PI integrator

IBUS, 'WT2E1', ID, CON(J) to CON(J+5) /

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18.2 WT3E1

Electrical Control for Type 3 Wind Generator (for WT3G1 and WT3G2)

This model is located at system bus	#_____	IBUS
Machine identifier	#_____	ID
This model uses CONs starting with	#_____	J
and STATEs starting with	#_____	K
and VARs starting with	#_____	L
and ICONs starting with	#_____	M

CONs	#	Value	Description
J			T_{fv}, Filter time constant in voltage regulator (sec)
J+1			K_{pv}, Proportional gain in voltage regulator (pu)
J+2			K_{IV}, Integrator gain in voltage regulator (pu)
J+3			X_c, Line drop compensation reactance (pu)
J+4			T_{FP}, Filter time constant in torque regulator
J+5			K_{pp}, Proportional gain in torque regulator (pu)
J+6			K_{IP}, Integrator gain in torque regulator (pu)
J+7			P_{MX}, Max limit in torque regulator (pu)
J+8			P_{MN}, Min limit in torque regulator (pu)
J+9			Q_{MX}, Max limit in voltage regulator (pu)
J+10			Q_{MN}, Min limit in voltage regulator (pu)
J+11			IP_{MAX}, Max active current limit
J+12			T_{RV}, Voltage sensor time constant
J+13			RP_{MX}, Max power order derivative
J+14			RP_{MN}, Min power order derivative
J+15			$T_{_Power}$, Power filter time constant
J+16			K_{qi}, MVAR/Voltage gain
J+17			V_{MINCL}, Min voltage limit
J+18			V_{MAXCL}, Max voltage limit
J+19			K_{qv}, Voltage/MVAR gain
J+20			XIQ_{min}
J+21			XIQmax
J+22			T_v, Lag time constant in WindVar controller
J+23			T_p, P_{elec} filter in fast PF controller

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CONs	#	Value	Description
J+24			Fn, A portion of online wind turbines
J+25			ωP_{min}, Shaft speed at P_{min} (pu)
J+26			ωP_{20}, Shaft speed at 20% rated power (pu)
J+27			ωP_{40}, Shaft speed at 40% rated power (pu)
J+28			ωP_{60}, Shaft speed at 60% rated power (pu)
J+29			P_{min}, Minimum power for operating at ωP_{100} speed (pu)
J+30			ωP_{100}, Shaft speed at 100% rated power (pu)

STATEs	#	Description
K		Filter in voltage regulator
K+1		Integrator in voltage regulator
K+2		Filter in torque regulator
K+3		Integrator in torque regulator
K+4		Voltage sensor
K+5		Power filter
K+6		MVAR/Vref integrator
K+7		Verror/internal machine voltage integrator
K+8		Lag of the WindVar controller
K+9		Input filter of P_{elec} for PF fast controller

VARs	#	Description
L		Remote bus ref voltage
L+1		MVAR order from MVAR emulator
L+2		Q reference if PFAFLG=0 & VARFLG=0
L+3		PF angle reference if PFAFLG=1
L+4		Storage of MW for computation of compensated voltage
L+5		Storage of MVAR for computation of compensated voltage
L+6		Storage of MVA for computation of compensated voltage

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ICONs	#	Description
M		Remote bus # for voltage control; 0 for local voltage control
M+1		VARFLG: 0 Constant Q control 1 Use Wind Plant reactive power control -1 Constant power factor control
M+2[1]		VLTFLG: 0 Bypass terminal voltage control 1 Eqcmd limits are calculated as VTerm + XIQmin and VTerm + XIQmax, i.e., limits are functions of terminal voltage 2 Eqcmd limits are equal to XIQmin and XIQ max
M+3		From bus of the interconnection transformer
M+4		To bus of the interconnection transformer
M+5		Interconnection transformer ID

[1] WT3E1 model can be used with WT3G1 as well as WT3G2 models. When used with WT3G1 model, it is recommended that ICON(M+2) be set to 1; and when used with WT3G2 model, the ICON(M+2) be set to 2.

IBUS, 'WT3E1', ID, ICON(M) to ICON(M+5), CON(J) to CON(J+30) /

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| V |
IXc
1 / 1 + sTRV
K+4
VAR (L)
1 / Fn
QMX
KIV / s
QMN
K+1
KPV / 1 + sTV
K+8
1 / 1 + sTfv
K
VAR (L+1)
VARFLG = 1
VAR (L+3)
tan
Pelec
1 / 1 + sTp
K+9
VARFLG = - 1
VAR (L+2)
VARFLG = 0
QCMD
Qelec
VMAXCL
Kqi / s
K+6
VMINCL
VTerm
VLTFL
VLTFLG = 1 o
Speed
(P = 100%, ωP100)
(P = 60%, ωP60)
(P = 40%, ωP40)
(P = 20%, ωP20)
(Pmin, ωPmin)
P
WNDSP1
1 / 1 + sT_Power
K+5
SPEED
Kpp + KIP / s
K+3
1 + SPEED
RPMX
PMX
1 / sTFP
K+2
RPMN
PMN

18.3 WT4E1

Electrical Control for Type 4 Wind Generator

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{fv}, Filter time constant in Voltage regulator (sec)
J+1			K_{PV}, Proportional gain in Voltage regulator(pu)
J+2			K_{IV}, Integrator gain in Voltage regulator (pu)
J+3			Kpp, Proportional gain in Active Power regulator(pu)
J+4			K_{IP}, Integrator gain in Active Power regulator (pu)
J+5			K_f, Rate feedback gain (pu)
J+6			T_f, Rate feedback time constant (sec.)
J+7			Q_{MX}, Max limit in Voltage regulator (pu)
J+8			Q_{MN}, Min limit in Voltage regulator (pu)
J+9			IP_{max}, Max active current limit
J+10			T_{RV}, Voltage sensor time constant
J+11			dP_{MX}, Max limit in power PI controller (pu)
J+12			dP_{MN}, Min limit in power PI controller (pu)
J+13			$T_{_Power}$, Power filter time constant
J+14			K_{QI}, MVAR/Voltage gain
J+15			V_{MINCL}, Min. voltage limit
J+16			V_{MAXCL}, Max. voltage limit
J+17			K_{VI}, Voltage/MVAR Gain
J+18			T_v, Lag time constant in WindVar controller
J+19			T_p, Pelec filter in fast PF controller
J+20			ImaxTD, Converter current limit
J+21			Iphl, Hard active current limit
J+22			Iqhl, Hard reactive current limit

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STATEs	#	Description
K		Filter in voltage regulator
K+1		Integrator in voltage regulator
K+2		Integrator in active power regulator
K+3		Active power regulator feedback
K+4		Voltage sensor
K+5		Power filter
K+6		MVAR/Vref integrator
K+7		Verror/Internal machine voltage integrator
K+8		Lag of the WindVar controller
K+9		Input filter of Pelec for PF fast controller

VARs	#	Description
L		Remote bus reference voltage
L+1		Q reference if PFAFLG=0 & VARFLG=0
L+2		PFangle reference if PFAFLG=1
L+3		Power reference

ICONs	#	Description
M		Remote bus # for voltage control; 0 for local control
M+1		PFAFLG: 1 if PF fast control enabled 0 if PF fast control disabled
M+2		VARFLG: 1 if Qord is provided by WindVar 0 if Qord is not provided by WindVar if VARFLG=PFAFLG=0 then Qord is provided as a Qref=const
M+3		PQFLAG, P/Q priority flag: 0 Q priority 1 P priority

IBUS, 'WT4E1', ID, ICON(M) to ICON(M+3), CON(J) to CON(J+22) /

Four possible configurations:

1. Current North American configuration with WindVAR:
   varflg = 1; pfaflg = 0; Kqi small (0.1)

2. Current North American configuration without WindVAR:
   varflg = 0; pfaflg = 0; Kqi = very small (or 0.).

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3. European (PFA control) with WindVAR:
   varflg = 1; pfaflg = 0;Kqi large; Kvi larger

4. European (PFA control) without WindVAR:
   varflg = 0; pfaflg =1; hold desired PFA Kqi large ; Kvi larger

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the local bus voltage
CON(M) is zero;
t is the remote bus
voltage.

Electrical Control for Type 4 Wind Generator

18.4 WT4E2

Electrical Control for Type 4 Wind Generator

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{fv}, Filter time constant in Voltage regulator (sec)
J+1			K_{PV}, Proportional gain in Voltage regulator(pu)
J+2			K_{IV}, Integrator gain in Voltage regulator (pu)
J+3			Kpp, Proportional gain in Active Power regulator(pu)
J+4			K_{IP}, Integrator gain in Active Power regulator (pu)
J+5			K_f, Rate feedback gain (pu)
J+6			T_f, Rate feedback time constant (sec.)
J+7			Q_{MX}, Max limit in Voltage regulator (pu)
J+8			Q_{MN}, Min limit in Voltage regulator (pu)
J+9			IP_{max}, Max active current limit
J+10			T_{RV}, Voltage sensor time constant
J+11			dP_{MX}, Max limit in power PI controller (pu)
J+12			dP_{MN}, Min limit in power PI controller (pu)
J+13			$T_{_Power}$, Power filter time constant
J+14			K_{QI}, MVAR/Voltage gain
J+15			V_{MINCL}, Min. voltage limit
J+16			V_{MAXCL}, Max. voltage limit
J+17			K_{VI}, Voltage/MVAR Gain
J+18			T_v, Lag time constant in WindVar controller
J+19			T_p, Pelec filter in fast PF controller
J+20			ImaxTD, Converter current limit
J+21			Iphl, Hard active current limit
J+22			Iqhl, Hard reactive current limit
J+23			Tiqf, IQmax filter time constant, sec.
J+24			FRT_Thres, Voltage Threshold for FRT activation (pu)

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CONs	#	Value	Description
J+25			FRT_Hys, FRT De-activation Hysteresis (pu)
J+26			FRT_Droop, FRT Droop
J+27			FRT_Iq_Gain, FRT Iq Gain
J+28			Max_FRT_Iq, Max FRT Iq
J+29			IQMax_Fact1, Factor 1 to adjust IQMX (pu)
J+30			IQMax_Fact2, Factor 2 to adjust IQMX (pu)
J+31			DC_Link_Droop, Voltage Drop in DC-Link cables (pu)
J+32			VinvMax0, Maximum inverter no-load voltage (pu)
J+33			NBR_X, Network bridge reactor reactance

STATEs	#	Description
K		Filter in voltage regulator
K+1		Integrator in voltage regulator
K+2		Integrator in active power regulator
K+3		Active power regulator feedback
K+4		Voltage sensor
K+5		Power filter
K+6		MVAR/Vref integrator
K+7		Verror/Internal machine voltage integrator
K+8		Lag of the WindVar controller
K+9		Input filter of Pelec for PF fast controller
K+10		IQmax filter

VARs	#	Description
L		Remote bus reference voltage
L+1		Q reference if PFAFLG=0 & VARFLG=0
L+2		PFangle reference if PFAFLG=1
L+3		Power reference

ICONs	#	Description
M		Remote bus # for voltage control; 0 for local control
M+1		PFAFLG: 1 if PF fast control enabled 0 if PF fast control disabled

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ICONs	#	Description
M+2		VARFLG: 1 if Qord is provided by WindVar 0 if Qord is not provided by WindVar if VARFLG=PFAFLG=0 then Qord is provided as a Qref=const
M+3		PQFLAG, P/Q priority flag: 0 Q priority 1 P priority

IBUS, ''WT4E2', ID, ICON(M) to ICON(M+3), CON(J) to CON(J+33) /

Four possible configurations:

1. Current North American configuration with WindVAR:
   varflg = 1; pfaflg = 0; Kqi small (0.1)

2. Current North American configuration without WindVAR:
   varflg = 0; pfaflg = 0; Kqi = very small (or 0.).

3. European (PFA control) with WindVAR:
   varflg = 1; pfaflg = 0;Kqi large; Kvi larger

4. European (PFA control) without WindVAR:
   varflg = 0; pfaflg =1; hold desired PFA Kqi large ; Kvi larger

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VAR(L)
K+4
K+1
K+8
K
VARFLG = 1
VARFLG = 0
VAR(L + 2)
tan
K+9
VAR(L + 1)
PFAFLG = 1
PFAFLG = 0
K+6
K+7
PQFLG
Converter Current Limiter
WIQCMD
To
WT4G
Model
WIPCMD
To
WT4G
Model
is the local bus voltage
if ICON(M) is zero;
e it is the remote bus
voltage.
K+5
VAR(L + 3)
K+2
K+3
0.01
ETERM

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Chapter 19

Generic Wind Mechanical Model Data Sheets

This chapter contains a collection of data sheets for the generic wind mechanical models contained in the PSS®E dynamics model library.

Model	Description
PANELU1	User written model to represent the linearized model of PV panel's output curve
WT12T1	Two mass turbine model for Type 1 and Type 2 wind generators
WT3T1	Mechanical system model for Type 3 wind generator
WTDTAU1	Generic Drive Train Model for Type 3 and Type 4 Wind Machines

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19.1 PANELU1

PV I-P Characteristics

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
And VARs starting with	#_____	L

CONs	#	Description
J		PDCMAX200, maximum power of panel at an irradiance of 200 W/m2, pu on PDCMAX1000 base
J+1		PDCMAX400, maximum power of panel at an irradiance of 400 W/m2, pu on PDCMAX1000 base
J+2		PDCMAX600, maximum power of panel at an irradiance of 600 W/m2, pu on PDCMAX1000 base
J+3		PDCMAX800, maximum power of panel at an irradiance of 800 W/m2, pu on PDCMAX1000 base
J+4		PDCMAX1000, maximum power of panel at an irradiance of 1000 W/m2, pu on PDCMAX1000 base

VARs	#	Description
L		DC power from PV array

IBUS 'USRMDL' ID 'PANELU1' 103 0 0 5 0 1 CON(J) to CON(J+4) /

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19.2 WT12T1

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

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			H, Total inertia constant, sec
J+1			DAMP, Machine damping factor, pu P/pu speed
J+2			H_{tfrac}, Turbine inertia fraction (Hturb/H)[1]
J+3			Freq1, First shaft torsional resonant frequency, Hz
J+4			D_{shaft}, Shaft damping factor (pu)

[1] To simulate one-mass mechanical system, set $H_{tfrac} = 0$.
To simulate two-mass mechanical system, set H_{tfrac} as $0 < H_{tfrac} < 1$

STATEs	#	Description
K		Shaft twist angle, rad.
K+1		Turbine rotor speed deviation, pu
K+2		Generator speed deviation, pu
K+3		Generator rotor angle deviation, pu

VARs	#	Description
L		P_{aero} on the rotor blade side, pu
L+1		Initial rotor slip
L+2		Initial internal angle

IBUS, 'WT12T1', ID, CON(J) to CON(J+4) /

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$H_t = H \times H_{tfrac}$

$H_g = H - H_t$

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

Two-Mass Shaft WT12T Model
for Type 1 & 2 Generic Wind Machines

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19.3 WT3T1

Mechanical System Model for Type 3 Wind Generator (for WT3G1 and WT3G2)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

In blkmdl, this model requires one reserved ICON.

CONs	#	Value	Description
J			VW, Initial wind, pu of rated wind speed
J+1			H, Total inertia constant, sec
J+2			DAMP, Machine damping factor, pu P/pu speed
J+3			K_{aero}, Aerodynamic gain factor
J+4			Theta2, Blade pitch at twice rated wind speed, deg.
J+5			H_{tfrac}, Turbine inertia fraction (Hturb/H)[1]
J+6			Freq1, First shaft torsional resonant frequency, Hz
J+7			D_{shaft}, Shaft damping factor (pu)

[1] To simulate one-mass mechanical system, set $H_{tfrac} = 0$.
To simulate two-mass mechanical system, set H_{tfrac} as $0 < H_{tfrac} < 1$.

STATEs	#	Description
K		Shaft twist angle, rad.
K+1		Turbine rotor speed deviation, pu
K+2		Generator speed deviation, pu
K+3		Generator rotor angle deviation, pu

VARs	#	Description
L		P_{aero} on the rotor blade side, pu
L+1		Initial rotor slip
L+2		Initial internal angle
L+3		Initial pitch angle
L+4		P_{aero} initial

IBUS, 'WT3T1', ID, CON(J) to CON (J+7) /

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

$$H_g = H - H_t$$

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

19.4 WTDTAU1

Generic Drive Train Model for Type 3 and Type 4 Wind Machines

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,

CONs	#	Value	Description
J			H, Total inertia constant constant (s) (>0)
J+1			DAMP, Machine damping factor (pu)
J+2			Htfrac, Turbine inertia fraction (Ht/H)
J+3			Freq1, First Shaft Torsional resonant frequency (Hz)
J+4			Dshaft, Shaft damping factor (pu)

STATEs	#	Description
K		Shaft twist angle, rad.
K+1		Turbine rotor speed deviation, pu
K+2		Generator speed deviation, pu
K+3		Generator rotor angle deviation, pu

VARs	#	Description
L		Aero-dynamic power on rotor blade, pu
L+1		Initial rotor slip
L+2		Initial internal angle

IBUS, 'USRMDL', ID, 'WTDTAU1', 103, 0, 0, 5, 4, 3, CON(J) to CON(J+4) /

Notes:

1. To simulate a one-mass mechanical system, set Htfrac=0. To simulate a two-mass mechanical system, set Htfrac such that 0 < Htfrac < 1.

2. This model can be used with Type 3 and 4 wind machines. When used for modeling of Type 3 wind machine, the other models to be used along with the drive train control model are regcau1, reecau1, repcau1 (optional), wtptau1, wtarau1, wttqau1. When used for modeling of Type 4 machines, the other models to be used along with the drive train control model are regcau1, reecau1, repcau1 (optional).

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

$$H_g = H - H_t$$

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

$\omega_0 = 2 \times \pi \times$ system nominal frequency

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Chapter 20

Generic Wind Pitch Control Model Data Sheets

This chapter contains a collection of data sheets for the generic wind pitch control models contained in the PSS®E dynamics model library.

Model	Description
IRRADU1	User written model to represent the linearized model of PV panel's solar irradiance profile.
WT3P1	Pitch control model for Type 3 wind generator
WTPTAU1	Generic Pitch Control Model for Type 3 Wind Machines

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20.1 IRRADU1

PV Irradiance Profile

This model is located at system bus	#_____	IBUS
Machine identifier	#_____	ID
This model uses CONs starting with	#_____	J
ICONs starting with	#_____	M
And VARs starting with	#_____	L

CONs	#	Description
J		TIME1, Time of first data point, sec
J+1		IRRADIANCE1, Irradiance at first data point, W/m2
J+2		TIME2, Time of second data point, sec
J+3		IRRADIANCE2, Irradiance at second data point, W/m2
J+4		TIME3, Time of third data point, sec
J+5		IRRADIANCE3, Irradiance at third data point, W/m2
J+6		TIME4, Time of forth data point, sec
J+7		IRRADIANCE4, Irradiance at forth data point, W/m2
J+8		TIME5, Time of fith data point, sec
J+9		IRRADIANCE5, Irradiance at fith data point, W/m2
J+10		TIME6, Time of sixth data point, sec
J+11		IRRADIANCE6, Irradiance at sixth data point, W/m2
J+12		TIME7, Time of seventh data point, sec
J+13		IRRADIANCE7, Irradiance at seventh data point, W/m2
J+14		TIME8, Time of eigth data point, sec
J+15		IRRADIANCE8, Irradiance at eigth at point, W/m2
J+16		TIME9, Time of ninth data point, sec
J+17		IRRADIANCE9, Irradiance at ninth data point, W/m2
J+18		TIME10, Time of tenth data point, sec
J+19		IRRADIANCE10, Irradiance at tenth data point, W/m2

ICONs	#	Description
M		In Service Flag, 1: model is in-service 0: model is OFF

VARs	#	Description
L		DC power from PV array

NOTE: A maximum of 10 pairs of time versus irradiance may be specified. The unused pairs should be entered as zero. TIME1 should be greater than 0 as the initial irradiance calculated from the load flow output.

IBUS 'USRMDL' ID 'IRRADU1' 104 0 1 20 0 1 ICON(M), CON(J) to CON(J+19) /

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20.2 WT3P1

Pitch Control Model for Type 3 Wind Generator (for WT3G1 and WT3G2)

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K.

In blkmdl, this model requires one reserved ICON.

CONs	#	Value	Description
J			T_p, Blade response time constant
J+1			K_{pp}, Proportional gain of PI regulator (pu)
J+2			K_{ip}, Integrator gain of PI regulator (pu)
J+3			K_{pc}, Proportional gain of the compensator (pu)
J+4			K_{ic}, Integrator gain of the compensator (pu)
J+5			TetaMin, Lower pitch angle limit (degrees)
J+6			TetaMax, Upper pitch angle limit (degrees)
J+7			RTetaMax, Upper pitch angle rate limit (degrees/sec)
J+8			P_{MX}, Power reference, pu on MBASE

Note: When a WT operates with a partial output, the DSTATE(K+2) may show INITIAL CONDITION SUSPECT. In this case no actions are needed.

STATEs	#	Description
K		Output lag
K+1		Pitch control
K+2		Pitch compensation

IBUS, 'WT3P1', ID, CON(J) to CON (J+8) /

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SPEED
From
WT3T1
Model
WNDSP1
ωerr
Kpp
Kip
s
Pitch Control
θ cmd
RTetaMax
TetaMax
1
sTp
WPITCH
- RTetaMax
TetaMin
WPCMND
From
WT3E1
Model
PMX
Kpc
Kic
s
0
Non-windup limit
Pitch
Compensation

20.3 WTPTAU1

Generic Pitch Control Model for Type 3 Wind Generator

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K
and VARs starting with	#_____	L

CONs	#	Value	Description
J			Kiw, Pitch-control Integral Gain (pu)
J+1			Kpw, Pitch-control proportional gain (pu)
J+2			Kic, Pitch-compensation integral gain (pu)
J+3			Kpc, Pitch-compensation proportional gain (pu)
J+4			Kcc, Gain (pu)
J+5			Tp, Blade response time constant (s)
J+6			TetaMax, Maximum pitch angle (degrees)
J+7			TetaMin, Minimum pitch angle (degrees)
J+8			RTetaMax, Maximum pitch angle rate (degrees/s)
J+9			RTetaMin, Minimum pitch angle rate (degrees/s) (< 0)

STATEs	#	Description
K		Output lag
K+1		Pitch control
K+2		Pitch compensation

VARs	#	Description
L		Initial value of Pord

IBUS, 'USRMDL', ID, 'WTPTAU1', 104, 0, 0, 10, 3, 1, CON(J) to CON (J+9) /

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Notes:

1. In modeling a Type 3 wind machine, the other models to be used along with this model are regcau1, reecau1, repcau1 (optional), wtdtau1, wtarau1, wttqau1.

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Chapter 21

Generic Wind Aerodynamic Model Data Sheets

This chapter contains a collection of data sheets for the generic aerodynamic wind models contained in the PSS®E dynamics model library.

Model	Description
WT12A1	Pseudo-governor model for Type 1 and Type 2 wind generators
WTARAU1	Generic Aerodynamic Model for Type 3 wind machine

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21.1 WT12A1

Pseudo-Governor Model for Type 1 and Type 2 Wind Generators

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L.

CONs	#	Value	Description
J			Droop
J+1			K_p, proportional gain, pu
J+2			T_i, integrator time constant, sec.
J+3			T_1, output filter 1 time constant, sec.
J+4			T_2, output filter 2 time constant, sec.
J+5			T_p, power filter time constant, sec.
J+6			Lim_{max}, maximum output limit
J+7			Lim_{min}, minimum output limit

STATEs	#	Description
K		Power filter
K+1		PI integrator
K+2		Output filter 1
K+3		Output filter 2

VARs	#	Description
L		Reference
L+1		Power reference

IBUS, 'WT12A1', ID, CON(J) to CON(J+7) /

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Slip Reference
VAR(L)
Rotor Slip
WTRBSP
From
WT12T
Model
Lim_Max
Lim_Min
K+1
K+2
K+3
WAEROT
To
WT12T
Model
P_elec
From
WT1G
or
WT2G
Model
K
Droop
Power Reference
VAR(L+1)

21.2 WTARAU1

Generic Aerodynamic Model for Type 3 wind machine

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,

CONs	#	Value	Description
J			Ka, Aerodynamic gain factor (pu/degrees)
J+1			Theta 0 Initial pitch angle (degrees)

VARs	#	Description
L		Initial mechanical power

IBUS, 'USRMDL', ID, 'WTARAU1', 105, 0, 0, 2, 0, 1, CON(J) through CON(J+1) /

Notes:

1. In modeling a Type 3 wind machine, the other models to be used along with this model are regcau1, reecau1, repcau1 (optional), wtdtau1, wtptau1, wttqau1.

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Chapter 22

Generic Wind Auxiliary Control Model Data Sheet

This chapter contains a collection of data sheets for the generic wind auxiliary control models contained in the PSS®E dynamics model library.

Model	Description
REPCAU1 & REPCTAU1	Generic Renewable Plant Control Model

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22.1 REPCAU1 & REPCTAU1

Generic Renewable Plant Control Model

This model is located at system bus	#_____	IBUS,
Machine identifier	#_____	ID,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			Tfltr, Voltage or reactive power measurement filter time constant (s)
J+1			Kp, Reactive power PI control proportional gain (pu)
J+2			Ki, Reactive power PI control integral gain (pu)
J+3			Tft, Lead time constant (s)
J+4			Tfv, Lag time constant (s)
J+5			Vfrz, Voltage below which State s2 is frozen (pu)
J+6			Rc, Line drop compensation resistance (pu)
J+7			Xc, Line drop compensation reactance (pu)
J+8			Kc, Reactive current compensation gain (pu)
J+9			emax, upper limit on deadband output (pu)
J+10			emin, lower limit on deadband output (pu)
J+11			dbd1, lower threshold for reactive power control deadband (<=0)
J+12			dbd2, upper threshold for reactive power control deadband (>=0)
J+13			Qmax, Upper limit on output of V/Q control (pu)
J+14			Qmin, Lower limit on output of V/Q control (pu)
J+15			Kpg, Proportional gain for power control (pu)
J+16			Kig, Proportional gain for power control (pu)
J+17			Tp, Real power measurement filter time constant (s)
J+18			fdbd1, Deadband for frequency control, lower threshold (<=0)
J+19			Fdbd2, Deadband for frequency control, upper threshold (>=0)
J+20			femax, frequency error upper limit (pu)
J+21			femin, frequency error lower limit (pu)
J+22			Pmax, upper limit on power reference (pu)
J+23			Pmin, lower limit on power reference (pu)
J+24			Tg, Power Controller lag time constant (s)
J+25			Ddn, droop for over-frequency conditions (pu)

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CONs	#	Value	Description
J+26			Dup, droop for under-frequency conditions (pu)

STATEs	#	Description
K		Voltage Measurement filter
K+1		Reactive power control filter
K+2		PI controller for reactive power
K+3		Lead-lag in reactive power path
K+4		Real power filter
K+5		PI controller for real power
K+6		Power controller first order lag

VARs	#	Description
L		Reference for voltage control (Vref)
L+1		Reactive power reference (Qref)
L+2		Frequency reference (Freq_ref)
L+3		Active Power reference (Plant_pref)
L+4		Line flow P MW
L+5		Line flow Q MVAr
L+6		Line flow MVA
L+7		Q/V Deadband output
L+8		Frequency deadband output

ICONs	#	Description
M		Bus number for voltage control; local control if 0
M+1		Monitored branch FROM bus number for line drop compensation (if 0 generator power will be used)
M+2		Monitored branch TO bus number for line drop compensation (if 0 generator power will be used)
M+3		Branch circuit id for line drop compensation (enter in single quotes) (if 0 generator power will be used)
M+4		VCFlag (droop flag): 0: with droop if power factor control 1: with line drop compensation
M+5		RefFlag (flag for V or Q control): 0: Q control 1: voltage control
M+6		Fflag (flag to disable frequency control): 1: Enable control 0: disable

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DYR record when used with Type 4 machines:

IBUS, 'USRMDL', ID, 'REPCAU1', 107, 0, 7, 27, 7, 9, ICON(M) to ICON(M+6), CON(J) to CON(J+26) /

DYR record when used with Type 3 machines:

IBUS, 'USRMDL', ID, 'REPCTAU1', 107, 0, 7, 27, 7, 9, ICON(M) to ICON(M+6), CON(J) to CON(J+26) /

Notes:

1. This model can be used with Type 3 and 4 wind machines. When used for modeling of Type 3 wind machine, the model name is REPCTAU1, and the other models to be used along with this model are regcau1, reecau1, wtdtau1, wtptau1, wtarau1, wttqau1. When used for modeling of Type 4 machines, the model name is REPCAU1, and the other models to be used along with the this model are regcau1, reecau1, wtdtau1.

2. When used with Type 3 wind machine, the output (Pref) of the REPCTAU1 model goes as an input Pref 0 into the Torque control model (wttqau1). When used with Type 4 wind ma-chine, the output (Pref) of the REPCAU1 model goes as an input into the electrical con-trol model (reecau1).

3. If ICON(M+1) is zero, then the generator active and reactive powers are used for line-drop compensation calculation.

4. If ICON(M+1) is a negative value (any value less than zero), then the Pbranch control in real power path is assumed to be disabled (i.e., Pbranch and and plant_ref are set equal to zero). In this case the real power path is responsive only to frequency changes.

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Chapter 23

Switched Shunt Model Data Sheets

This chapter contains a collection of data sheets for the Switched Shunt models contained in the PSS®E dynamics model library.

Model	Description
ABBSVC1	ABB SVC Model
CHSVCT	SVC for switched shunt
CSSCST	SVC for switched shunt
SWSHNT	Switched shunt model
SVSMO1U2	WECC Generic Continuous Control SVC Model
SVSMO2U2	WECC Generic Discrete Control SVC Model

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23.1 ABBSVC1

ABB SVC Model

This model is attached to switched shunt at bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
This model uses ICONs starting with	#_____	M.

CONs	#	Value	Description
J			SVC Base MVA (>0)
J+1			T_4, Integrator time constant (s) (>0)
J+2			T_S, Thyristor firing delay (s)
J+3			T_{TH}, Thyristor firing time constant (s)
J+4			XCC, Slope for capacitive range, on SVC base (pu voltage/pu current)
J+5			XCI, Slope for inductive range, on SVC base (pu voltage/pu current)
J+6			T_{LL1}, Voltage controller lead time constant (s)
J+7			T_{LL2}, Voltage controller lag time constant (s)
J+8			B1MAX, max. limit for voltage controller (pu on SVC base)
J+9			B1MIN, min. limit for voltage controller (pu on SVC base)
J+10			B2MAX, max. susceptance of SVC (pu on SVC base)
J+11			B2MIN, min. susceptance of SVC (pu on SVC base)
J+12			OVTHRSLD, overvoltage tripping threshold (pu)
J+13			OVDELAY, overvoltage tripping delay (s)
J+14			SVLOW, severe undervoltage strategy low voltage threshold (pu)
J+15			SVHIGH, severe undervoltage strategy high voltage threshold (pu)
J+16			SBFCLEAR, severe undervoltage strategy susceptance (pu on SVC base)
J+17			STBFCLEAR, timing of severe undervoltage strategy (s)
J+18			VLOW, undervoltage strategy low voltage threshold (pu)
J+19			VHIGH, undervoltage strategy high voltage threshold (pu)
J+20			USDELAY, undervoltage strategy delay (s)
J+21			BFCLEAR, undervoltage strategy susceptance (pu on SVC base)
J+22			TBFCLEAR, timing of undervoltage strategy (s)
J+23			V2MAX, max. SVC bus voltage limit (pu)
J+24			K_6, controller (V2) gain (pu)

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CONs	#	Value	Description
J+25			T_6, controller (V2) time constant (s)
J+26			T_7, controller (V2) integrator time constant (s) (>0)
J+27			V2CLIM, controller (V2) minimum limit (pu on SVC base) (<0)
J+28			I1MAXC, maximum capacitive current limit (pu on SVC base) (>0)
J+29			K_8, controller (I1MAXC) gain (pu)
J+30			T_8, controller (I1MAXC) time constant (s)
J+31			T_9, controller (I1MAXC) integrator time constant (s) (>0)
J+32			IMAXCLIM, controller (I1MAXC) minimum limit (pu on SVC base) (<0)
J+33			IMINI, maximum inductive current limit (pu on SVC base) (< 0)
J+34			K_{10}, controller (I1MINI) gain (pu)
J+35			T_{10}, controller (I1MINI) time constant (s)
J+36			T_{11}, controller (I1MINI) integrator time constant (s) (>0)
J+37			IMINCLIM, controller (I1MINI) minimum limit (pu on SVC base) (>0)
J+38			ITCRMAX, maximum TCR current limit (pu on SVC base) (≥ 0)
J+39			K_1, controller (ITCR) gain (pu)
J+40			T_1, controller (ITCR) time constant (s)
J+41			T_2, controller (ITCR) integrator time constant (s) (>0)
J+42			TCRLIMTRG, TCR current limiter voltage trigger (pu)
J+43			TCRMIN, minimum TCR limit for ITCR control (pu on SVC base)
J+44			FSHUNT, fixed shunt compensation (pu on SVC base) (≥ 0) (this is always the filters, which are always capacitive; hence≥ zero)
J+45			BREGMAX, supplementary control capacitive threshold (pu on SVC base)
J+46			BREGMIN, supplementary control inductive threshold (pu on SVC base)
J+47			VREFMAX, maximum reference voltage for regulated bus voltage (pu)
J+48			VREFMIN, minimum reference voltage for regulated bus voltage (pu)
J+49			TBREG, integrator time constant for supplementary control (s) (>0)
J+50			DVBREGMAX, max. output of supplementary control (pu)
J+51			DVBREGMIN, min. output of supplementary control (pu)
J+52			BMAXDES, MSC slow switching capacitive threshold (pu on system base)
J+53			BMINDES, MSC slow switching inductive threshold (pu on system base)
J+54			TDELAY1, time delay for slow switching of MSCs (s)
J+55			BMAXDES2, MSC fast switching capacitive threshold (pu on system base)
J+56			BMINDES2, MSC fast switching inductive threshold (pu on system base)

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CONs	#	Value	Description
J+57			TDELAY2, time delay for fast switching of MSCs, (s)
J+58			PODTW1, washout filter 1 time constant (s) (if zero, the washout is disabled)
J+59			PODTW2, washout filter 1 time constant (s) (>0) (if zero, the washout is disabled)
J+60			PODTM1, POD 1st lead-lag block lead time constant (s)
J+61			PODTM2, POD 1st lead-lag block lag time constant (s)
J+62			PODTM3, POD 2nd lead-lag block lead time constant (s)
J+63			PODTM4, POD 2nd lead-lag block lag time constant (s)
J+64			PODTM5, 3rd POD lead-lag block lead time constant (s)
J+65			PODTM6, 3rd POD lead-lag block lag time constant (s)
J+66			KPOD - POD gain (pu)
J+67			VPODMAX - POD max. output limit (pu)
J+68			VPODMIN - POD min. output limit (pu)
J+69			PODTW4 - washout filter 4 time constant (s)

STATEs	#	Description
K		Thyristor controller output (T_{TH}) state
K+1		Lead-lag state
K+2		Voltage regulator integrator
K+3		Thyristor controller transport delay - State 1
K+4		Thyristor controller transport delay - State 2
K+5		ITCR controller time constant (T1) state
K+6		ITCR controller integrator (T2) state
K+7		V_2 controller time constant (T6) state
K+8		V_2 controller integrator (T7) state
K+9		I1MAX controller time constant (T8) state
K+10		I1MAX controller time constant (T9) state
K+11		I1MIN controller time constant (T10) state
K+12		I1MIN controller integrator (T11) state
K+13		Integral part of supplementary controller, Max
K+14		Integral part of supplementary controller, Min
K+15		POD TW1 state

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STATEs	#	Description
K+16		POD TW2 state
K+17		POD 1st lead-lag block state
K+18		POD 2nd lead-lag block state
K+19		POD 3rd lead-lag block state
K+20		POD T_{W4} state

VARs	#	Description
L		Auxiliary Signal
L+1		Switched Shunt Vref
L+2		B2 (pu SVC base), effective SVC admittance
L+3		B2 effective SVC admittance (pu system base, corrected for frequency)
L+4		B1 (pu system base), effective SVC admittance seen from HV side
L+5		Mvar1 - Mvar flow as measured from the "from" (HV) end of the transformer towards the "to" (LV) end
L+6		EFFB1MAX - Effective B1MAX
L+7		EFFB1MIN - Effective B1MIN
L+8		I1 - Current on high side of step-up transformer (pu on SVC base)
L+9		Itcr - Reactor current when all TSCs are off; in pu on SVC base - frequency corrected
L+10 through L+21		Delay table
L+22		Auxiliary for Undervoltage Strategy
L+23		Auxiliary for Severe Undervoltage Strategy
L+24		Timer for Overvoltage Trip
L+25		Timer 1 for Slow Switching of MSCs (used with BMAXDES and BMINDES)
L+26		Timer 2 for Fast Switching of MSCs (used with BMAXDES2 and BMINDES2)
L+27		IN - POD Model VAR Input
L+28		ΔVREF - POD Model Output
L+29		POD Auxiliary Variable - Z^{-1}
L+30		Transformer XT as retrieved from power flow (pu on SVC base)
L+31	‘	0: POD not disabled 1: POD disabled by over/under voltage strategies -1: POD disabled by user

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ICONs	#	Description
M		IRGBUS, bus number of the regulated bus (this cannot be the bus at which the SVC is connected)
M+1		RPC, reactive power control flag 0: None, 1: Supplementary Control, 2: External Caps, 3: Supplementary+External Caps
M+2		MSCBUS, external bus number where the MSCs are connected (this cannot be the bus at which the SVC is connected)
M+3		POD_ST, flag to indicate status of the aux. signal 0: No POD, 1: IRGBUS Frequency Input, 2: User input in VAR(L+27), -1: POD disabled by user
M+4		ENAB_IN, flag to indicate if sign of the aux. signal to be changed or not 1: change POD output sign when input signal become negative, 0: do not change sign

DYRE Record:

IBUS 'ABBSVC1' ICON(M) through ICON(M+4), CON(J) to CON(J+69) /

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ABBSVC1 Static Var Compensator Model
V2 - Voltage at LV Bus IBUS
I1 – Current at HV Bus IB
VAR (L+1) VREF
Supplementary Control
VREFMOD
VAR (L) VAUX
Y1 – pu SVC Admittance as seen from HV Bus IB
External Capacitor Bank Control
MSCBUS
Power Oscillation Damper
ΔVREF
Δω(IR) or VAR(L+27)
Xcc if B1≥0, Xci if otherwise
B1 – Admittance Order at HV Bus IB
VR - Voltage at Bus IRGBUS
V2MAX
I1MAXC
B1MAX
V2CLIM
IMAXCLIM
B1Max
EFFB1MAX
B2MAX
B2MIN
YSVCBASE
YSBASE
ITCR = V2(-YSVCBASE+FSHUNT)
If ITCR < 0, ITCR = 0
ITCRMAX
TCRMIN if V1>TCRLIMTRIG;
1 if otherwise
IMINCLIM
i1MINI
EFFB1MIN
B1MIN
Overvoltage Strategy:
If VR > OVTRIPTHRESH set B1 to B1MIN
Overvoltage Tripping:
If VR > OVTRIPTHRESH for more than OVTRIPDELAY, disable the SVC
Undervoltage Strategy:
If VR < VLOW for USDELAY set B1 to BFCLEAR, releasing TBFCLEAR sec after VR > VHIGH
Severe Undervoltage Strategy:
If VR < SVLOW set B1 to SBFCLEAR, releasing STBFCLEAR sec after VR > SVHIGH
HV
IB
From
Ckt
To
IBUS
LV
Itcr
TCRs
TSCs
FSHUNT

ABBSVC1 Model – Supplementary Control

ABBSVC1 Model – Power Oscillation Damper

23.2 CHSVCT

SVC for Switched Shunt

This model is at system bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
This model uses ICONs starting with	#_____	M.

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CONs	#	Value	Description
J			XC
J+1			V_1
J+2			V_2
J+3			TD_2
J+4			T_1
J+5			$T_2 > 0$
J+6			T_3
J+7			T_4
J+8			K
J+9			BF_{MAX}
J+10			BF_{MIN}
J+11			TD_1
J+12			B_{MAX}
J+13			B_{MIN}
J+14			K_m
J+15			T_w
J+16			TD_3
J+17			TM_1
J+18			$TM_2 > 0$
J+19			TM_3
J+20			TM_4
J+21			VS_{MAX}
J+22			VS_{MIN}

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STATEs	#	Description
K		First VSF lag-lead
K+1		Second VSF lag-lead
K+2		Thyristor
K+3		First thyristor time delay
K+4		Second thyristor time delay
K+5		SMF control
K+6		First SMF time delay
K+7		Second SMF time delay
K+8		First SMF lead-lag
K+9		Second SMF lead-lag

VARs	#	Description
L		Other signals
L+1		V_{REF}
L+2		Y (system base)
L+3		Voltage clamp timer
L+4		I Line (system base)

ICONs	#	Value	Description
M			IB, Remotely regulated bus
M+1			SWITCH, for SMF input
M+2			I, from bus for SMF signal
M+3			J, to bus for SMF signal
M+4			CKT, circuit ID for SMF signal

SVCBASE = ΣCapacitors - ΣReactors
If BF_{MAX} = 0.0, BF_{MAX} = ΣCapacitors/SVCBASE
If BF_{MIN} = 0.0, BF_{MIN} = ΣReactors/SVCBASE

If B_{MAX} = 0.0, B_{MAX} = ΣCapacitors/SVCBASE
If B_{MIN} = 0.0, B_{MIN} = ΣReactors/SVCBASE
If IB = 0, $|V_{IB}| = |V_{IBUS}|$

IBUS, 'CHSVCT', ICON(M) to ICON(M+4), CON(J) to CON(J+22) /

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Voltage Clamp
VCL
1
0
V1
V2
Vpu
e-sTD2
VCL = 1
VCL = 0
|VIB|
+
-
Σ
XC
1 pu
(SVCBASE)
Slope
(1 + sT1) (1 + sT3)
(1 + sT2) (1 + sT4)
Voltage
Stabilization
Function (VSF)
VC
-
(BFMAX) x (VCL)
BMAX
VREF
(pu)
+
Σ
K
(Bpu/Vpu)
1
S
e-sTD1
B
SVCBASE
SBASE
Switched
Shunt
-
VS
+
Other
Signals
(BFMIN) x (VCL)
BMIN
Switch=0
VSMAX
Supplemental Modulation
Function (SMF)
(1 + sTM1) (1 + sTM3)
(1 + sTM2) (1 + sTM4)
e-sTD3
sKm
1+sTW
I From Line
(SBASE)
VSMIN

23.3 CSSCST

SVC for Switched Shunt

This model is at system bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs	#	Value	Description
J			K
J+1			T_1 (sec)
J+2			T_2 (sec)
J+3			T_3 (> 0) (sec)
J+4			T_4 (sec)
J+5			T_5 (sec)
J+6			V_{MAX}, Mvars
J+7			V_{MIN}, Mvars
J+8			V_{OV} (override voltage) (pu)

STATEs	#	Description
K		First regulator
K+1		Second regulator
K+2		Thyristor

VARs	#	Description
L		Other signals
L+1		V_{REF}
L+2		Y (system base)
L+3		B_{REF}

ICON	#	Description
M		IB, remotely regulated bus

IBUS, ’CSSCST’, ICON(M), CON(J) to CON(J+8) /

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If IB > 0, V_{REF} is initial voltage at bus IB

Otherwise, $V_{REF} = \frac{VSWHI + VSWLO}{2}$

If V_{MAX} = 0.0, V_{MAX} = ΣCapacitors

f V_{MIN} = 0.0, V_{MIN} = ΣReactors

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23.4 SWSHNT

Switched Shunt Model

This model is at system bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			VIN1, zero or DEL_{VUP} or V_{HI} (pu)
J+1			PT1, pickup timer for high voltage (sec)
J+2			ST1 (sec)[1] switch time to close if reactor; switch time to open if capacitor
J+3			VIN2, zero or DEL_{VDO} or V_{LO} (pu)
J+4			PT2, pickup timer for low voltage (sec)
J+5			ST1 (sec)* switch time to close if reactor; switch time to open if capacitor

[1] Switch closing and opening can occur as a result of either high or low voltage. The switching action taken for high or low voltage is a function of the type of switched device (i.e., reactor or capacitor) and its status at the time the voltage limit is exceeded.

VARs	#	Description
L		Initial voltage
L+1		Timer
L+2		Maximum reactive
L+3		Maximum capacitive

ICONs	#	Value	Description
M			IB, Remotely regulated bus
M+1			NS, Total number of switches allowed
M+2		X	Switch counter (Reserved ICON)
M+3		X	Delay flag (Reserved ICON)
M+4		X	Timeout flag (Reserved ICON)
M+5		X	Timer status (Reserved ICON)

IBUS, 'SWSHNT', ICON(M) to ICON(M+1), CON(J) to CON(J+5) /

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23.5 SVSMO1U2

This model is at system bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs#	#	Tentative Value	Description
J			UVSBmax, max cap limit during undervoltage (assumed filter size), pu on SBASE
J+1			UV1, undervoltage setting 1, p.u.
J+2			UV2, undervoltage setting 2, p.u.
J+3			UVT, undervoltage trip setting, p.u.
J+4			OV1, overvoltage setting 1, p.u.
J+5			OV2, overvoltage setting 2, p.u.
J+6			UVtm1, undervoltage trip time 1, sec.
J+7			UVtm2, undervoltage trip time 2, sec.
J+8			OVtm1, overvoltage trip time 1, sec.
J+9			OVtm2, overvoltage trip time 2, sec.
J+10			Xs1, slope/droop, p.u. on SBASE
J+11			Xs2, slope/droop, p.u. on SBASE
J+12			Xs3, slope/droop, p.u. on SBASE
J+13			Vup, upper voltage break-point for non-linear Slope/droop, p.u.
J+14			Vlow, lower voltage break-point for non-linear Slope/droop, p.u.
J+15			Tc1, voltage measurement lead time constant, sec.
J+16			Tb1, voltage measurment lag time constant, sec.
J+17			Tc2, lead time constant
J+18			Tb2, lag time constant
J+19			Kpv, proportional gain, p.u.
J+20			Kiv, integral gain, p.u./sec.
J+21			Vemax, voltage error max, p.u.
J+22			Vemin, voltage error min, p.u.
J+23			T2, thyristor firing sequence control delay, T2>0, sec.
J+24			Bshrt, short-term max. suceptance of SVC (short-term rating) , p.u. on SBASE
J+25			Bmax, max. suceptance of SVC (continuous rating), p.u. on SBASE

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J+26			Bmin, min. suceptance of SVC, p.u. on SBASE
J+27			Tshrt, duration of short-term rating, sec.
J+28			Kps, proportional gain of slow suceptance control, p.u.
J+29			Kis, integral gain of slow suceptance control, p.u./sec.
J+30			Vrmax, max. output of slow suceptance control, p.u.
J+31			Vrmin, min. output of slow suceptance control, p.u.
J+32			Vdbd1, steady-state Voltage deadband; SVC is inactive between Vref+Vdbd1 to Vref-Vdbd1, p.u.
J+33			Vdbd2, inner deadband, p.u.
J+34			Tdbd, Vdbd2 locked time, sec.
J+35			PLLdelay, delay in recovering if voltage remains below UV1 for longer than UVtm1, sec.
J+36			xeps, small delta added to the susceptance bandwidth of the slow-susceptance regulator in order to ensure its limits are not exactly identical to the MSS switching point, p.u.
J+37			Blcs, larger threshold for switching MSCs, MVAr
J+38			Bscs, smaller threshold for switching MSCs, MVAr
J+39			Blis, larger threshold for switching MSRs, MVAr
J+40			Bsis, smaller threshold for switching MSRs, MVAr
J+41			Tmssbrk, time for MSS breaker to operate, sec.
J+42			Tdelay1, time delay for larger threshold, sec.
J+43			Tdelay2, Time delay for smaller threshold (should be much larger than Tdelay1), sec.
J+44			Tout, time cap. bank should be off before switching back on, sec.
J+45			Vrefmin, lower limit of Vref, p.u.
J+46			Vrefmax, upper limit of Vref, p.u.

SKATE	#	Description
K		Controlled voltage sensor
K+1		SVC main PI controller integrator
K+2		SVC output lag
K+3		SSC PI controller imtegrator
K+4		SVC lead/lag

VAR	#	Description
L		SVC output admittance, p.u. on SBASE

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VAR	#	Description
L+1		SVC PI controller output, p.u. on SBASE
L+2		SSC PI controller output, p.u.
L+3		Undervoltage timer, sec.
L+4		Rating dependent on voltage, p.u. on SBASE
L+5 through L+18		Timers, delays set up by the model
L+19		Vmsrd, Vreg lead/lag output
L+20 through L+22		Timers set up by the model
L+23		SVC VREF, p.u.
L+24		SVC VSCHED, p.u.
L+25		optional POD input
L+26		SVC lead-lag output before PI controller
L+27		SVC voltage error
L+28		SVC output in MVAR
ICON	#	Description
M		SVC remote bus # for voltage control (if 0 then SVC bus is used)
M+1		Flag for Mechanically Switched Shunt (MSS) switching: 0 - no MSS switching, 1 - MSS switching on Q [MVAr]
M+2		Flag for droop Control: 0 - linear droop; 1 - non-linear droop
M+3		1st MSS bus #
M+4		1st MSS Id (to be entered within single quotes)
M+5		2nd MSS bus #
M+6		2nd MSS Id (to be entered within single quotes)
M+7		3rd MSS bus #
M+8		3rd MSS Id (to be entered within single quotes)
M+9		4th MSS bus #
M+10		4th MSS Id (to be entered within single quotes)
M+11		5th MSS bus #
M+12		5th MSS Id (to be entered within single quotes)
M+13		6th MSS bus #
M+14		6th MSS Id (to be entered within single quotes)
M+15		7th MSS bus #

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VAR	#	Description
M+16		7th MSS Id (to be entered within single quotes)
M+17		8th MSS bus #
M+18		8th MSS Id (to be entered within single quotes)

IBUS, 'USRSWS', 'SVSMO1U2', 24 1 19 47 5 29 ICON(M) to ICON(M+18), CON(J) to CON(J+46) /

Notes:

1. SVSMO1U2 is a dynamic model of a continuously controlled Static Var Compensator (SVC) coupled with coordinated with mechanically switched shunts (MSS).
2. The SVC is to be modeled in PSSE power flow as a continuously controlled switched shunt. The SVC can coordinate with up to eight mechanically switched shunts (MSS). The MSS are modeled as fixed shunts in PSSE. The MSS can be capacitive or inductive.
3. The MSS can all be on the same bus (with different id), or they can be on eight different bus.
4. MSS id has to be entered within single quotes.
5. It is not necessary to input the MSS at all the eight buses. If MSS is not present, the MSS bus number and the MS bus id should be set to 0.

23.6 SVSMO2U2

This model is at system bus	#_____	IBUS,
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M.

CONs#	#	Tentative Value	Description
J			UVSBmax, max cap limit during undervoltage (assumed filter size), pu on SBASE
J+1			UV1, undervoltage setting 1, p.u.
J+2			UV2, undervoltage setting 2, p.u.
J+3			UVT, undervoltage trip setting, p.u.
J+4			OV1, overvoltage setting 1, p.u.
J+5			OV2, overvoltage setting 2, p.u.
J+6			UVtm1, undervoltage trip time 1, sec.
J+7			UVtm2, undervoltage trip time 2, sec.
J+8			OVtm1, overvoltage trip time 1, sec.
J+9			OVtm2, overvoltage trip time 2, sec.
J+10			Xs1, slope/droop, p.u. on SBASE
J+11			Xs2, slope/droop, p.u. on SBASE
J+12			Xs3, slope/droop, p.u. on SBASE
J+13			Vup, upper voltage break-point for non-linear Slope/droop, p.u.
J+14			Vlow, lower voltage break-point for non-linear Slope/droop, p.u.
J+15			Tc1, voltage measurement lead time constant, sec.
J+16			Tb1, voltage measurment lag time constant, sec.
J+17			Tc2, lead time constant
J+18			Tb2, lag time constant
J+19			Kpv, proportional gain, p.u.
J+20			Kiv, integral gain, p.u./sec.
J+21			Vemax, voltage error max, p.u.
J+22			Vemin, voltage error min, p.u.
J+23			T2, thyristor firing sequence control delay, T2>0, sec.
J+24			dbe voltage error deadband (pu)
J+25			dbb, suceptance deadband (pu)
J+26			Bmin, min. suceptance of SVC, p.u. on SBASE
J+27			Tshrt, duration of short-term rating, sec.

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J+28			Kps, proportional gain of slow suceptance control, p.u.
J+29			Kis, integral gain of slow suceptance control, p.u./sec.
J+30			Vrmax, max. output of slow suceptance control, p.u.
J+31			Vrmin, min. output of slow suceptance control, p.u.
J+32			Vdbd1, steady-state Voltage deadband; SVC is inactive between Vref+Vdbd1 to Vref-Vdbd1, p.u.
J+33			Vdbd2, inner deadband, p.u.
J+34			Tdbd, Vdbd2 locked time, sec.
J+35			PLLdelay, delay in recovering if voltage remains below UV1 for longer than UVtm1, sec.
J+36			xeps, small delta added to the susceptance bandwidth of the slow-susceptance regulator in order to ensure its limits are not exactly identical to the MSS switching point, p.u.
J+37			Blcs, larger threshold for switching MSCs, MVAr
J+38			Bscs, smaller threshold for switching MSCs, MVAr
J+39			Blis, larger threshold for switching MSRs, MVAr
J+40			Bsis, smaller threshold for switching MSRs, MVAr
J+41			Tmssbrk, time for MSS breaker to operate, sec.
J+42			Tdelay1, time delay for larger threshold, sec.
J+43			Tdelay2, Time delay for smaller threshold (should be much larger than Tdelay1), sec.
J+44			Tout, time cap. bank should be off before switching back on, sec.
J+45			Vrefmin, lower limit of Vref, p.u.
J+46			Vrefmax, upper limit of Vref, p.u.

SKATE	#	Description
K		Controlled voltage sensor
K+1		SVC main PI controller integrator
K+2		SVC output lag
K+3		SSC PI controller integrator
K+4		SVC lead/lag

VAR	#	Description
L		SVC output admittance, p.u. on SBASE
L+1		SVC PI controller output, p.u. on SBASE
L+2		SSC PI controller output, p.u.
L+3		Undervoltage timer, sec.

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VAR	#	Description
L+4		Rating dependent on voltage, p.u. on SBASE
L+5 through L+18		Timers, delays set up by the model
L+19		Vmsrd, Vreg lead/lag output
L+20 through L+22		Timers set up by the model
L+23		SVC VREF, p.u.
L+24		SVC VSCHED, p.u.
L+25		optional POD input
L+26		SVC lead-lag output before PI controller
L+27		SVC voltage error
L+28		SVC output in MVAR
L+29		Total SVC capacitor admittance, pu on SBASE
L+30		Total SVC reactor admittance, pu on SBASE
L+31		Output of Look-up table
L+32 through L+103		Internal VARs

ICON	#	Description
M		SVC remote bus # for voltage control (if 0 then SVC bus is used)
M+1		Flag for Mechanically Switched Shunt (MSS) switching: 0 - no MSS switching, 1 - MSS switching on Q [MVAr]
M+2		Flag for droop Control: 0 - linear droop; 1 - non-linear droop
M+3		1st MSS bus #
M+4		1st MSS Id (to be entered within single quotes)
M+5		2nd MSS bus #
M+6		2nd MSS Id (to be entered within single quotes)
M+7		3rd MSS bus #
M+8		3rd MSS Id (to be entered within single quotes)
M+9		4th MSS bus #
M+10		4th MSS Id (to be entered within single quotes)
M+11		5th MSS bus #
M+12		5th MSS Id (to be entered within single quotes)

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ICON	#	Description
M+13		6th MSS bus #
M+14		6th MSS Id (to be entered within single quotes)
M+15		7th MSS bus #
M+16		7th MSS Id (to be entered within single quotes)
M+17		8th MSS bus #
M+18		8th MSS Id (to be entered within single quotes)

IBUS, 'USRSWS', 'SVSMO2U2', 24 1 22 47 5 104 ICON(M) to ICON(M+18), 0, 0, 0, CON(J) to CON(J+46) /

Notes:

1. SVSMO2U2 is a dynamic model of a discretely controlled Static Var Compensator (SVC) coupled with coordinated with mechanically switched shunts (MSS).
2. The SVC is to be modeled in PSSE power flow as a discretely controlled switched shunt. The SVC can coordinate with up to eight mechanically switched shunts (MSS). The MSS are modeled as fixed shunts in PSSE. The MSS can be capacitive or inductive.
3. The MSS can all be on the same bus (with different id), or they can be on eight different bus.
4. MSS id has to be entered within single quotes.
5. It is not necessary to input the MSS at all the eight buses. If MSS is not present, the MSS bus number and the MS bus id should be set to 0.
6. The limits Bmax and Bmin shown on STATE(K+1) are the maximum capacitive rating in pu (Bmax), and the minimum inductive rating in pu (Bmin) of the SVC. These are computed by the model based on the possible combinations of available capacitor and the inductors in power flow.
7. The undervoltage setting values (UV1 and UV2) to be specified in the dyr data record should be such that UV1 > UV2.
8. The overvoltage setting values (OV1 and OV2) to be specified in the dyr data record should be such that OV1 < UV2.
9. Vdb1 and Vdb2 must both be zero or positive.

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BSVC (MVAr)
Berr
Vrmax
Vrmin
s3
Vsched
Bref
B
Bref control logic
Vrefmin
Vrefmax
Vref
Over Voltage Strategy, Under Voltage Strategy & Short-Term Rating
externally controllable
Bmax
Vbus
s0
Vr
Vcomp
Verr
-dbe
dbe
Vemax
Vemin
Vsig
s4
s1
Bmin
Bdemand
-dbb
dbb
Look-Up table
s2
Bsvc (p.u.)
Deadband Control (Optional)
externally controllable
Look-up table finds the susceptance closest to Bdemand
Linear or Non-Linear Slope Logic
Isvc
SVC over- and under- voltage tripping function
MSS Switching Logic based on Q
MSS1
MSS8

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Chapter 24

Branch Device Models

This chapter contains a collection of data sheets for the Branch Device models contained in the PSS®E dynamics model library.

Model	Description
CRANIT	Series reactor model.

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24.1 CRANIT

Series Reactor Model

The reactor is connected as a branch at from	#_____	IBUS,
To bus	#_____	JBUS
This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
This model uses ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_1 (s)
J+1			T_2 (s)
J+2			T_3 (s) (> 0)
J+3			T_W (s) (> 0)
J+4			K
J+5			X_{max} (pu) max. limit on output
J+6			X_{min} (pu) min. limit on output
J+7			IN_{max} (pu) max. limit on input signal
J+8			IN_{min} (pu) min. limit on input signal

STATEs	#	Description
K		Transducer filter
K+1		Washout
K+2		Lead/lag

VARs	#	Description
L		Input signal
L+1		Initial output
L+2		Desired reactance

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ICONs	#	Value	Description
M			CRANIT input code: 1- pu current on branch (branch between bus i and bus j) 2- pu power on branch (branc between bus i and bus j) 3- pu frequency difference between two buses (bus i and bus j) 4- pu bus voltage (bus i) 5- pu frequency devation on bus (bus i) 6- machine speed devation (machine at bus i)
M+1			External bus number of bus i.
M+2			External bus number of bus j (or zero for input 4 through 6).
M+3			Branch ID (for inputs 1 and 2), machine id (for input 6), or zero for inptus 3, 4, and 5. For input 2, an id of -1 indicates sum of parallel line flows.
M+4			Internal ICON(1)

(1) No user input is requred for interal ICON.

IBUS,'CRANIT',JBUS,IDICON(M) to ICON(M+3), CON(J) TO CON(J+8)

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Chapter 25

Machine and Wind Machine Protection Models

This chapter contains a collection of data sheets for the Machine and Wind Protection models contained in the PSS®E dynamics model library.

Model	Description
LOEXR1T	Loss of excitation distance relay.

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25.1 LOEXR1T

Loss of Excitation Distance Relay

(for use with non-wind machines)

This model is located at bus	#_____	IBUS
Machine	#_____	ID
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Description
J		T1, zone 1 operating time (cycles)
J+1		R1, zone 1 reach (diameter in pu)
J+2		A1, zone 1 centerline angle (degrees)
J+3		D1, zone 1 center distance (pu)
J+4		T2, zone 2 operating time (cycles)
J+5		R2, zone 2 reach (diameter in pu)
J+6		A2, zone 2 centerline angle (degrees)
J+7		D2, zone 2 center distance (pu)
J+8		T3, zone 3 operating time (cycles)
J+9		R3, zone 3 reach (diameter in pu)
J+10		A3, zone 3 centerline angle (degrees)
J+11		D3, zone 3 center distance (pu)
J+12		VPV, voltage pickup value (pu)
J+13		STB, self trip breaker time (cycles)

VARs	#	Description
L		Apparent R
L+1		Apparent X
L+2		VARS required for internal program logic
L+3		
L+4		
L+5		

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ICONs	#	Value	Description
M . . . M+7			ICONs required for internal logic (internal ICON)(1)

Notes:

1. Any zone reach can be set to zero to disable a circle.
2. The center distances are normally negative since R and X are assumed looking out from terminals.
3. The reaches and distances should be entered on MBASE.
4. The voltage pickup value should be set to a high value (10.0 pu) to disable it.

IBUS, 'LOEXR1T', ID, CON(J) to CON(J+13) /

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Chapter 26

Two-winding Transformer Device Models

This chapter contains a collection of data sheets for the Two-winding Device Transformer models contained in the PSS®E dynamics model library.

Model	Description
OLTC1T	Two-winding transformer online tap changer model.
OLPS1T	Two-winding transformer phase shift regulator model.
VFT1	Variable frequency transformer model.

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26.1 OLTC1T

Two-winding Transformer Online Tap Changer Model

Model connected at from Bus	#_____	IBUS
To bus	#_____	JBUS
and Circuit ID	#_____	ID
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
This model represents an online tap changer on the branch described in ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_D, time delay (sec)
J+1			T_C, time constant of tap changer (sec)
J+2			T_{SD}, time before subsequent tap signal sent (sec)

VARs	#	Description
L		Time delay
L+1		Tap changer timer
L+2		Subsequent timer

ICONs	#	Value	Description
M			Delay flag (Internal ICON) (1)
M+1			Timeout flag (Internal ICON) (1)
M+2			Timer status flag (Internal ICON) (1)

(1) No user input is required for internal ICON.

IBUS,'OLTC1T',JBUS,ID,CON(J) TO CON(J+3)

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26.2 OLPS1T

Two-Winding Transformer Phase Shifter Model

Model connected at from Bus	#_____	I Bus
To bus	#_____	J Bus
and Circuit ID	#_____	ID
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
This model represents an online phase shifter on the branch described in ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_D, time delay (sec)
J+1			T_C, time constant of shift mechanism (sec)
J+2			T_{SD}, time before subsequent signal sent (sec)

VARs	#	Description
L		Time delay
L+1		Phase shifter timer
L+2		Subsequent timer
L+3		MW flow

ICONs	#	Value	Description
M			Delay flag (Internal ICON)(1)
M+1			Timeout flag (Internal ICON)(1)
M+2			Timer status flag (Internal ICON)(1)

(1) No user input is required for intenral ICON.

IBUS,'OLPS1T',JBUS,ID,CON(J) to CON(J+2) /

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26.3 VFT1

GE Variable Frequency Transformer

This model connects from system bus	#_____	IBUS
To system bus	#_____	JBUS
Circuit ID	#_____	ID
This model uses CONs starting with	#_____	J
and STATEs starting with	#_____	K
and VARs starting with	#_____	L
and ICONs starting with	#_____	M

CONs	#	Value	Description
J			H, Inertia (sec)
J+1			X_{th1}, Thevenin Impedance Side 1 (pu)
J+2			X_{th2}, Thevenin Impedance Side 2 (pu)
J+3			T_{fx}, Frequency Transducer Time Constant(pu)
J+4			K_{PP}, Proportional Gain, Power Control
J+5			K_{PI}, Integral Gain, Power Control
J+6			Fp_{lim}, Limit Freq. Control (pu)
J+7			Fp_{limi}, Limit Freq. Control integrator (pu)
J+8			T_{fSRx}, Frequency branch Time Constant (s)
J+9			Fsr_{Lim}, Frequency Control, max & min Limits (pu)
J+10			$Frate_{Lim}$, (±)Frequency Control, max & min rate Limits (pu/s)
J+11			Kp_{stab}, Proportional Gain, Speed Stabilizing
J+12			Wp_{stab}, LP Filter Freq, Speed Stabilizing (rad/s)
J+13			Fp_stab_{Lim}, Max & Min Limits, Speed Stabilizing (pu/s)
J+14			Td FP_{stab}, Time Constant, Stabilizing branch from Freq Ctrl (s)
J+15			K_{WP}, Proportional Gain, Speed Controller
J+16			K_{WI}, Integral Gain, Speed Controller
J+17			T_{drv}, Motor Drive Time Constant (s)
J+18			TRQ_{rate}, Torque Rate Limits (pu)
J+19			TRQ_{vdtl_max}, Torque Voltage Dependance Max Limit (pu)
J+20			TRQ_{vdtl_min}, Torque Voltage Dependance Min Limit (pu)
J+21			Tv_{dtl} Time Constant, Torque Voltage Dependance (pu)

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CONs	#	Value	Description
J+22			SPD_rtr_base, Base Speed, Rotor (rpm)
J+23			SPD_mtr_base, Base Speed, Motor (rpm)
J+24			$IMTR_{max}$, Drive motor Tapered Current limit, Max Current (pu)
J+25			$IMTR_{Taper}$ Drive motor Tapered Current limit, Current Gain (pu)
J+26			Spd_{Taper} Drive motor Tapered Current limit, Speed Gain (pu)
J+27			Trq_{Acel_Lim}, Acceleration Limit, Torque (pu)
J+28			V_{PX}, Shut Down Voltage, Voltage Dependant Power Limit (pu)
J+29			V_{P1}, Unrestricted Voltage, Voltage Dependant Power Limit (pu)
J+30			Tup, Time Constant on up ramp, Voltage Dependant Power Limit (s)
J+31			Tdown, Time Constant on down ramp, Voltage Dependant Power Limit (s)
J+32			Plim0, Max Power Limit, Voltage Dependant Power Limit (pu)
J+33			R1, dFth Ramp Rate Side 1, VFT Governor (pu)
J+34			R2, dFth Ramp Rate Side 2, VFT Governor (pu)
J+35			FDB1, dFth deadband Side 1, VFT Governor (pu)
J+36			FDB2, dFth deadband Side 1, VFT Governor (pu)
J+37			TGOV, Time Constant, VFT Governor (s)
J+38			Dpg_mx1, Upper Frequency Input Limit, VFT Governor (pu)
J+39			Dpg_mx2, Lower Frequency Input Limit, VFT Governor (pu)
J+40			Deph_F, Admittance Matrix Re-factorizing Angle (degree)
J+41			T_{Pfbk}, Power Feedback Time Constant (s)

STATEs	#	Value	Description
K			Rotor Angle (rad)
K+1			Rotor Speed (rad/s)
K+2			Speed PI Controller
K+3			Power PI Controller
K+4			Frequency PI Controller
K+5			Frequency Stabilizing Path
K+6			Speed Stabilizing Path
K+7			VDTL Filter
K+8			VDPL Filter
K+9			Governor Output
K+10			Thevenin Freq Transducer 1
K+11			Thevenin Freq Transducer 2
K+12			Rotor Drive Torque (pu)

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STATEs	#	Value	Description
K+13			Power Feedback (MW)

VARs	#	Value	Description
L			VFT Angle (deg)
L+1			P side 1 (MW)
L+2			P side 2 (MW)
L+3			Te, Electric Torque (pu)
L+4			Q side 1 (Mvar)
L+5			Q side 2 (Mvar)
L+6			dFth1, Thevenin Frequency 1 (pu)
L+7			dFth2, Thevenin Frequency 2 (pu)
L+8			Vth1, Thevenin Voltage 1 (pu)
L+9			Vth2, Thevenin Voltage 2 (pu)
L+10			Pcmd, Power Command Setpt (MW)
L+11			Pcmd_f, Final Power Cmd (pu)
L+12			Spd_cmd, Speed Command (pu)
L+13			Fpstab, Stabilizing Feedback (pu)
L+14			LFpu_low (pu)
L+15			LFpu_high (pu)
L+16			Drive Torque Limit (pu)
L+17			Final Torque Limit, High (pu)
L+18			Final Torque Limit, Low (pu)

Internal ICONs*	#	Value	Description
M			Bus sequence number of IBUS
M+1			Bus sequence number of JBUS
M+2			Circuit ID
M+3			Direction of rotation

*Internal Icons need not be input by users.

IBUS, ’VFT1’, JBUS, ID, CON(J) to CON (J+41)/

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VFT:
Governor Control
To Power
Freq Co
gov_lim
-gov_lim
Min
V1 (Voltage at IBUS)
V2 (Voltage at JBUS)
State(K+8)
gov_lim
DPth1
Var(L+6)
DPth2
Var(L+7)

VFT Drive System
Var(L+12)
spd_cmd
Var(L+13)
K+6
K+3
K+4
K+5
VFT Governor Output
Var(L+11)
VFT Power
Var(L+1)
or
Var(L+2)
STATE(K+13)
STATE(K+1)
GE VFT:
Power and Frequency
Controller

VFT Torque Limiter

VFT: Drive System

Notes:

The real power flowing across the VFT is stored in VAR(L+1) and VAR(L+2) for the from and to side flows respectively, with the convention of positive flow from the bus into the VFT. Similarly the reactive power is stored in VAR(L+4) and VAR(L+5). Note that the default channels for branch flow for the VFT should NOT be used as they do not generally take into account the movement in VFT. That is, if plotting the VTF flow is desired, the VFT model VARS should be used.

At initialization, the initial active power flow is stored in Pcmd. To simulate a change in the active power flow setpoint, change Pcmd, VAR(L+10), to the new setpoint. Note that the relative direction of the power flow must be taken into account.

When the VFT rotates by an angle greater than the admittance re-factorizing angle, CON(J+40), the power flow admittance matrix will be re-factorized. This re-factorization speeds up the network solution and prevents a potential divergent solution when the VFT alters the power flow significantly from the initial conditions. As a starting point, Siemens PTI recommends a value of 20 degrees for this re-factorization angle, but this angle may need to be adjusted based on the characteristics of the power system modeled.

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Chapter 27

Three-winding Transformer Device Models

This chapter contains a collection of data sheets for the Three-winding Device Transformer models contained in the PSS®E dynamics model library.

Model	Description
OLTC3T	Online tap changer model for three-winding transformers.
OLPS3T	Online phase shift regulator model for three-winding transformers.

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27.1 OLTC3T

Online Tap Changer Model for Three-Winding Transformers

Model connected at from Bus	#_____	IBUS
To bus	#_____	JBUS
Third bus	#_____	KBUS
Circuit ID	#_____	ID
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L.
And ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_D, time delay (sec)
J+1			T_C, time constant of tap changer (sec)
J+2			T_{SD}, time before subsequent tap signal sent (sec)

VARs	#	Description
L		Time delay
L+1		Tap changer timer
L+2		Subsequent timer

ICONs	#	Value	Description
M			Delay flag (Internal ICON)(1)
M+1			Timeout flag (Internal ICON)(1)
M+2			Timer status flag (Internal ICON)(1)
M+3			(Internal ICON)(1)

(1) No user input is required for intenral ICON.

IBUS,'OLTC3T',JBUS,KBUS,ID,CON(J) to CON(J+2) /

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27.2 OLPS3T

Online Phase Shift Regulator Model for Three-Winding Transformers

Model connected at from Bus	#_____	IBUS
To bus	#_____	JBUS
Third bus	#_____	KBUS
and Circuit ID	#_____	ID
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
And ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_D, time delay (sec)
J+1			T_C, time constant of shift mechanism (sec)
J+2			T_{SD}, time before subsequent signal sent (sec)

VARs	#	Description
L		Time delay
L+1		Phase shift timer
L+2		Subsequent timer
L+3		MW flow

ICONs	#	Value	Description
M			Delay flag (Internal ICON) (1)
M+1			Timeout flag (Internal ICON) (1)
M+2			Timer status flag (Internal ICON) (1)
M+3			(Internal ICON) (1)

(1) No user input is required for intenral ICON.

IBUS,'OLPS3T',JBUS,KBUS,ID,CON(J) to CON(J+2) /

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Chapter 28

Two-terminal dc Other Models

This chapter contains a collection of data sheets for the Two-terminal dc Other models contained in the PSS®E dynamics model library.

Model	Description
DCTC1T	Two-terminal dc line tap changer model.

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28.1 DCTC1T

Two Terminal Online dc Tap Changer Model

This model is conneted to DC line	#_____	DC Name
This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.

CONs	#	Value	Description
J			T_{DR}, time delay for rectifier (sec)
J+1			T_{CR}, time constant of rectifier tap changer (sec)
J+2			T_{SDR}, time before subsequent rectifier tap signal sent (sec)
J+3			T_{DI}, time delay for inverter (sec)
J+4			T_{CI}, time constant of inverter tap changer (sec)
J+5			T_{SDI}, time before subsequent inverter tap signal sent (sec)

VARs	#	Description
L		Time delay (rectifier)
L+1		Tap changer timer (rectifier)
L+2		Subsequent timer (rectifier)
L+3		Time delay (inverter)
L+4		Tap changer timer (inverter)
L+5		Subsequent timer (inverter)

ICONs	#	Value	Description
M			Delay flag rectifier (Internal ICON)(1)
M+1			timeout flag rectifier (Internal ICON)(1)
M+2			Timer status flag rectifier (Internal ICON)(1)
M+3			Delay flag inverter (Internal ICON)(1)
M+4			timeout flag inverter (Internal ICON)(1)
M+5			Timer status flag inverter (Internal ICON)(1)

(1) No user input is required for internal ICON.

'DC NAME', 'DCTC1T', CON(J) to CON(J+5) /

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Chapter 29

Miscellaneous Other Models

This chapter contains a collection of data sheets for the Miscellaneous Other models contained in the PSS®E dynamics model library.

Model	Description
VTGDCAT/VTGTPAT	Under/over voltage generator bus disconnection relay. Under/over voltage generator trip relay.
FRQDCAT/FRQTPAT	Under/over frequency generator bus disconnection relay. Under/over frequency generator trip relay.
SAT2T	Transformer saturation model.
SWCAPT	Switched capacitor bank model.

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29.1 VTGDCAT/VTGTPAT

Under/Over Voltage Generator Bus Disconnection Relay

Under/Over Voltage Generator Trip Relay

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L,
and ICONs starting with	#_____	M.
and model instance	#_____	MINS (>0)

CONs	#	Value	Description
J			VL, Lower voltage threshold (pu)
J+1			VU, Upper voltage threshold (pu)
J+2			TP, Relay pickup time (sec)
J+3			TB, Breaker time (sec)

VAR	#	Description
L		Timer memory

ICONs	#	Description
M		Bus number where voltage is monitored
M+1		Bus number of generator bus where relay is located
M+2		Generator ID
M+3		Delay flag (internal ICON) (1)
M+4		Timeout flag (internal ICON) (1)
M+5		Timer status (internal ICON) (1)

(1) User input not required for internal ICONs.

Note: ICONs (M+3) through (M+5) are control flags that are not to be changed by the user.

MINS, 'VTGDCAT', ICON(M) TO ICON(M+2), CON(J) to CON(J+3) /

or

MINS,'VTGTPAT',ICON(M) to ICON(M+2), CON(J) TO CON(J+3) /

Note: Model VTGDCAT disconnects generator bus (i.e., disconnects all equipment attached to the generator bus).

Model VTGTPAT disconnects generators only.

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29.2 FRQDCAT/FRQTPAT

Under/Over Frequency Generator Bus Disconnection Relay

Under/Over Frequency Generator Trip Relay

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L
and ICONs starting with	#_____	M.
and model instance	#_____	MINS (>0)

CONs	#	Value	Description
J			FL, Lower frequency threshold (Hz)
J+1			FU, Upper frequency threshold (Hz)
J+2			TP, Relay pickup time (sec)
J+3			TB, Breaker time (sec)

VAR	#	Description
L		Timer memory

ICONs	#	Description
M		Bus number where frequency is monitored
M+1		Bus number of generator bus where relay is located
M+2		Generator ID
M+3		Delay flag (internal ICON) (1)
M+4		Timeout flag (internal ICON) (1)
M+5		Timer status (internal ICON) (1)

(1): User input not required for internal ICON. ICONS (M+3) through (M+5) are control flags and are not to be changed by the user.

MINS, 'FRQDCAT', ICON(M) to ICON(M+2), CON(J) TO CON(J+3) /

or

MINS, 'FRQTPAT',ICON(M) to ICON(M+2), CON(J) TO CON(J+3) /

Note: Model FRQDCAT disconnects generator bus (i.e., disconnects all equipment attached to the generator bus).

Model FRQTPAT disconnects generators only.

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29.3 SAT2T

Transformer Saturation Model

This model uses CONs starting with	#_____	J,
and VARs starting with	#_____	L
and ICONs starting with	#_____	M.
and model instance	#_____	MINS

CONs	#	Value	Description
J			ψ_1
J+1			I_1
J+2			ψ_2
J+3			I_2
J+4			ψ_3
J+5			I_3
J+6			ψ_4
J+7			I_4
J+8			Acceleration factor
J+9			Transformer MVA base

VAR	#	Description
L		Memory

ICON	#	Value	Description
M			Bus number

MINS,'SAT2T', ICON(M), CON(J) TO CON(J+9) /

Note:

1. The ψ-I (flux linkage-Current) values have to increase monotonically.

2. The SAT curve is speified as a set of 4 pairs of ψ-I points. It is not necessary to specify all the 4 pairs of (ψ-I) data points. CON(J) (i.e., ψ1) and CON(J+1) (i.e., I1) have to be greater than zero. After that the first ψ that is specified as zero signifies the end of the SAT curve points.

3. The SAT curve is specified in per unit on TRMVA. If TRMVA is zero, the data points are assumed to be on SBASE.

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No Slope Change
1
2
3
4
ψ = E / (1 + f) (on Transformer Base)
Imag (on Transformer Base)

29.4 SWCAPT

Switched Capacitor Bank Model

This model uses CONs starting with	#_____	J,
VAR starting with	#_____	L.
and ICONs starting with	#_____	M.
and model instance	#_____	MINS (>0)

CONs	#	Value	Description
J			Capacitor Mvar
J+1			VSP, voltage setpoint (pu)
J+2			T_D, delay (sec)

VAR	#	Description
L		Memory

ICON	#	Value	Description
M			Bus number

MINS,'SWCAPT', ICON(M),CON(J) TO CON(J+2) /

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Chapter 30

Machine Other Models

This chapter contains a collection of data sheets for the Other models contained in the PSS®E dynamics model library.

Model	Description
TSTGOV1	Frequency playback model
WTTQAU1	Generic Torque controller for Type 3 wind machines

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30.1 TSTGOV1

This model is located at system bus	#_____	IBUS,
Machine	#_____	ID
Model Uses CONs starting with	#_____	J
And VARs starting with	#_____	L
And ICONs starting with	#_____	M

CONs	#	Value	Description
J			TSTART1 (seconds)
J+1			TEND1 (seconds)
J+2			FREQUENCY1 (Hz)
J+3			TSTART2 (seconds)
J+4			TEND2 (SECONDS)
J+5			FREQUENCY2 (Hz)

VAR	#	Description
L		Measured frequency from file
L+!		Measured Pelec of generator from file

ICONs	#	Description
M		0 : for grid code test (trapezoidal frequency shape 1: to read frequency and power data points from a file
M+1		Load id (enter in single quotes)

IBUS 'USRMDL' ID 'TSTGOV1' 505 0 2 6 0 2 ICON(M) to ICON(M+1), CON (J) to (J+5) /

Notes:

1. Although the model is in a user-written model format, use of this model will not require compile or link.

2. In order to use this model, a single-machine with a load connected to it has to be created. For details, please see Program Application Guide, Volume II, chapter on "Other PSS/E Models"

3. If ICON(M) is 1 (i.e, read measured frequency and power data from a file), then CON(J) through CON(J+5) can be specified as zero. The file containing the measurement has to be supplied in a file whose name is 'FTIME1.DAT'. The file must be present in the folder from where PSS®E is started. The format of this data file must be one data record per line, with each data record containing the measured data in this order:

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Time, Frequency, Power

The data is read free format. The units of time should be seconds; the units of frequency should be Hz, and the units of power are MW. There is no restriction in the number of data points supplied in the data file 'FTIME1.DAT'.

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30.2 WTTQAU1

Generic Torque controller for Type 3 wind machines

This model is located at bus	#_____	IBUS
Machine identifier	#_____	ID
This model uses CONs starting with	#_____	J
and STATEs starting with	#_____	K
and VARs starting with	#_____	L
And ICONs starting with	#_____	M

CONs	#	Value	Description
J			Kpp, Proportional gain in torque regulator (pu)
J+1			KIP, Integrator gain in torque regulator (pu)
J+2			Tp, Electrical power filter time constant (s)
J+3			Twref, Speed-reference time constant (s)
J+4			Temax, Max limit in torque regulator (pu)
J+5			Temin, Min limit in torque regulator (pu)
J+6			p1, power (pu)
J+7			spd1, shaft speed for power p1 (pu)
J+8			p2, power (pu)
J+9			spd2, shaft speed for power p2 (pu)
J+10			p3, power (pu)
J+11			spd3, shaft speed for power p3 (pu)
J+12			p4, power (pu)
J+13			spd4, shaft speed for power p3 (pu)
J+14			TRATE, Total turbine rating (MW)

STATEs	#	Description
K		Electrical Power filter
K+1		Speed reference filter
K+2		PI controller

VARs	#	Description
L		Output of power-speed curve
L+1		Vdip value from electrical control model
L+2		Vup value from electrical control model

ICONs	#	Description
M		Tflag, 0: for speed control, 1: for power control

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IBUS, 'USRMDL', ID, 'WTTQAU1', 505, 0, 1, 15, 3, 3, ICON(M), CON(J) to CON(J+14) /

Notes:

1. The power-speed curve points have to be specified as monotonically increasing pairs. If the power-speed curve points are all specified as zero, then the reference speed (Wref) is assumed to be 1.0 pu.

2. The speed points are per unit shaft speed values (these are not speed deviation values).

3. The turbine rating (TRATE) is the rating of each turbine times the total number of lumped machines being represented. The power points specified in CONs J+6, J+8, J+10 and J+12 are in per unit of TRATE. If TRATE is specified as zero, then the power points are assumed to be in per unit of machine MVA base (MBASE).

4. In modeling a Type 3 wind machine, the other models to be used along with torque control model are regcau1, reecau1, repcau1 (optional), wtdtau1, wtarau1, wtptau1.

5. This model can be accessed on the PSS®E Dynamics GUI under "Other Moels" and then select the "Machine" tab.

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Chapter 31

Model Functions

This chapter contains a collection of data sheets for the models functions for Models contained in the PSS®E dynamics model library.

Model	Description
FLOW1	Function to obtain branch flow.
FLOW3	Function to obtain branch flow for a winding of a three-winding transformer.
GENTMC	Function to calculate Generator terminal current.
GENTMZ	Function to calculate Generator apparent impedance.
PTOTOW, PTOTZN, PTOTAR, PTOTAL	Calculation of Power totals by subsystem. Subsystem type is indicated by characters of five and six of the model name as follows: OW for Owner, ZN for Zone, AR for Area, and AL for all buses.
RELAY2	Apparent impedance monitoring.
RELAY3	Apparent impedance monitoring for a winding of three-winding transformer.
VOLMAG	Bus voltage monitoring.

Model	Description
BSDSCN	Function for bus disconnection.
FLOW	Function to obtain branch flow.
FLOW2	Function to obtain branch flow for a winding of a three0winding transformer.
GENTRP	Function to trip a generator.
LINESW	Function to switch a branch.
LINRCL	Line reclose function.
LINTRP	Function to trip a line.

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31.1 FLOW1

Branch Flow Model

Function to calculate branch flow

Function call: CALL FLOW1 (I,N,M,L)

This function uses ICONs starting with #_____ I,
It stores the real component of flow in VAR #_____ N,
the imaginary component in VAR #_____ M,
and the MVA flow in VAR #_____ L.
Flow is calculated out the bus number contain in ICON(I).
N, M, and/or L may be zero to bypass storing of the respective quantity.

VARs	#	Description
N		MW
M		Mvar
L		MVA

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Circuit identifier[1]

[1] Enter circuit identifier of -1 to sum flows of all parallel circuits between the two buses.

Note: Flows include the line shunt component at the from bus end.

This function can also be be selected in activity CHAN or CHSB.

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31.2 FLOW3

Function to calculate Three-Winding Transformer Flow Model

Function call: CALL FLOW3 (I,N,M,L)

This model uses ICONs starting with #_____ I,
It stores the real component of flow in VAR #_____ N,
the imaginary component in VAR #_____ M,
and the MVA flow in VAR #_____ L.
Flow is calculated out the bus number contain in ICON(I).
N, M, and/or L may be zero to bypass storing of the respective quantity.

VARs	#	Description
N		MW
M		Mvar
L		MVA

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Third bus number
I+3			Circuit identifier

Note: Flows include the magnetizing admittance component at the from bus end if it is the bus to which winding one is connected.

This function can also be selected in activity CHAN or CHSB.

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31.3 GENTMC

Function to calculate Generator Terminal Current Model

Function call: CALL GENTMC(L,M)

This model uses VARs starting with #_____ L,
and ICONs starting with #_____ M.

VARs	#	Description
L		Current magnitude on MBASE
L+1		Current angle (radians)

ICONs	#	Value	Description
M			Bus number
M+1			Machine identifier

This funtion can also be selected in activity CHAN or CHSB.

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31.4 GENTMZ

Function to call

Generator Apparent Impedance Model

Function call: GENTMZ (L,I)

This model uses VARs starting with #_____ L,
and ICONs starting with #_____ M.

VARs	#	Description
L		Apparent resistance on MBASE
L+1		Apparent reactance on MBASE

ICONs	#	Value	Description
M			Bus number
M+1			Machine identifier

The apparent impedance is expressed from the terminals looking out into the system.

This function can also be selected in activity CHAN or CHSB.

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31.5 PTOTOW, PTOTZN, PTOTAR, PTOTAL

Function to Calculate

Power Totals by Subsystem

Function call: CALL PTOTxx (I,L)

This model uses VARs starting with #_____ L,
and ICONs starting with #_____ M.

VARs	#	Description
L		Mechanical power, PM
L+1		Electrical power, PE
L+2		Accelerating power, PM-PE
L+3		Load power, PL
L+4		PE-PL

ICON	#	Value	Description
M			Subsystem number or zero for PTOTAL

This function can also be selected in activity CHSB.SU or by employing the subsystem power totals selection of the selet channels by subsystem dialog.

Model suffix xx	ICON(I) Description
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

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31.6 RELAY2

Relay Checking Model

The model performs a relay check on the branch described in ICONs #_____ I,

It stores the real component of the apparent impedance in VAR #_____ N,

and the imaginary component in VAR #_____ M.

M and/or N may be zero to bypass storing of the respective component of the apparent impedance

VARs	#	Description
N		Apparent resistance
M		Apparent reactance

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Circuit identifier

This function can also be selected in activity CHAN or CHSB.

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31.7 RELAY3

Three-Winding Transformer Relay Checking function

Function call: CALL RELAY3 (I,N,M)

The model performs a relay check on the branch described in ICONs #_____ I,

It stores the real component of the apparent impedance in VAR #_____ N,

and the imaginary component in VAR #_____ M.

M and/or N may be zero to bypass storing of the respective component of the apparent impedance.

VARs	#	Description
N		Apparent resistance
M		Apparent reactance

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Third bus number
I+3			Circuit identifier

This function can also be selected in activity CHAN or CHSB.

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31.8 VOLMAG

Voltage Monitoring Function

Function Call: CALL VOLMAG (I,J,K)

The voltage magnitude is stored in VAR	#_____	J,
and the angle (in degrees) is stored in VAR	#_____	K.
The bus number at which this model is called is in ICON	#_____	M.

VARs[1]	#	Description
J		Voltage magnitude
K		Phase angle

[1] J or K may be zero to bypass storing of that quantity.

ICON	#	Value	Description
M			Bus number

This function can also be selected in activity CHAN or CHSB.

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31.9 BSDSCN

Function to disconnect a bus

Function call: CALL BSDSCN(M)

This function will disconnect the bus whose number is in ICON #_____ M.

ICON	#	Value	Description
M			Bus number

BSDSCN takes no action when called at a t^+ (i.e., if KPAUSE is two).

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31.10 FLOW

Function to calculate Branch Flow

Function call: CALL FLOW (I,N,M,L)

This function used ICONs starting with	#_____	I,
It stores the real component of flow in VAR	#_____	N,
the imaginary component in VAR	#_____	M,
and the MVA flow in VAR	#_____	L.

Flow is calculated out of the bus number contained in ICON(I).

N, M, and/or L may be zero to bypass storing of the respective quantity.

VARs	#	Description
N		MW
M		Mvar
L		MVA

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Circuit identifier[1]
I+3			Switch: 0 to ignore line shunt component 1 to include it

[1] Enter circuit identifier of -1 to sum flows of all parallel circuits between the two buses.

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31.11 FLOW2

Function to calculate Branch Flow

Function call: CALL FLOW2 (I,N,M,L)

This function uses ICONs starting with	#_____	I,
It stores the real component of flow in VAR	#_____	N,
the imaginary component in VAR	#_____	M,
and the MVA flow in VAR	#_____	L.

Flow is calculated out of the bus number contained in ICON(I).

N, M, and/or L may be zero to bypass storing of the respective quantity.

VARs	#	Description
N		MW
M		Mvar
L		MVA

ICONs	#	Value	Description
I			From bus number
I+1			To bus number
I+2			Circuit identifier[1]

[1] Enter circuit identifier of -1 to sum flows of all parallel circuits between the two buses.

Note: Flows do not include the line shunt components.

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31.12 GENTRP

Function to trip a Generator

Function call: CALL GENTRP (IBUS, 'I')

This function will trip machine	#_____	I,
at bus	#_____	IBUS.

GENTRP takes no action when called at a t^+ (i.e., if KPAUSE is two).

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31.13 LINESW

Function for Branch Switching

Function call: CALL LINESW (I,IS)

This function will switch the line described in ICONs starting with #_____ M.

The line is tripped if IS is zero; otherwise, the line status is set to in-service.

ICONs	#	Value	Description
M			From bus number
M+1			To bus number
M+2			Circuit identifier

LINESW takes no action when called at a t^+ (i.e., if KPAUSE is two).

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31.14 LINRCL

Function for Branch Reclosing

Function call: CALL LINRCL (M)

This function will close the branch described in ICONs starting with #_____ M.

ICONs	#	Value	Description
M			From bus number
M+1			To bus number
M+2			Circuit identifier

LINRCL takes no action when called at a t^+ (i.e., if KPAUSE is two).

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31.15 LINTRP

Function for Branch Tripping

Function call: CALL LINTRP (M)

This function will trip the line
described in ICONs starting with #_____ M.

ICONs	#	Value	Description
M			From bus number
M+1			To bus number
M+2			Circuit identifier

LINTRP takes no action when called at a t^+ (i.e., if KPAUSE is two).

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