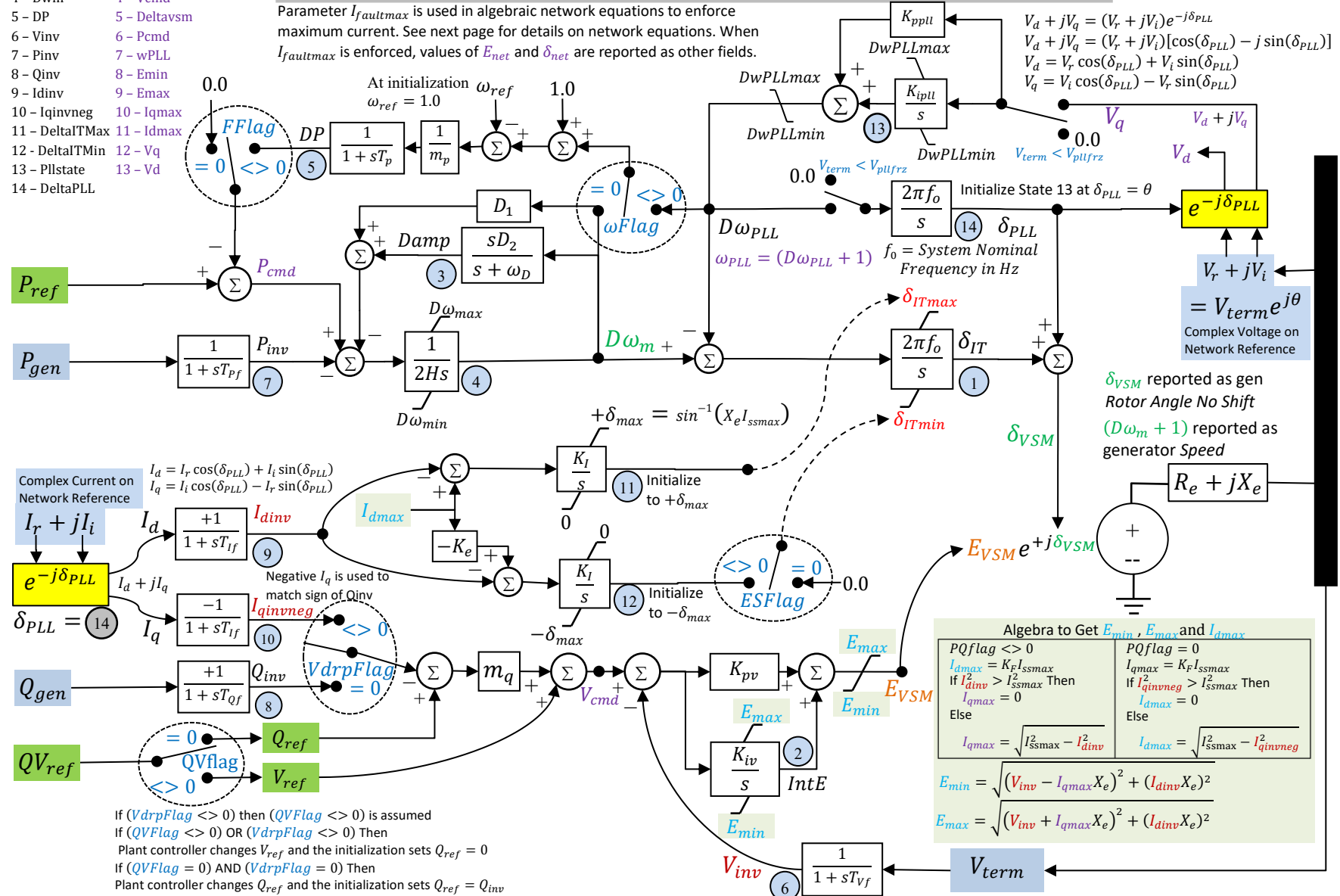


States:	Other Fields:
1 - DeltaIT	1 - Evsm
2 - IntE	2 - Enet
3 - Damp	3 - DeltaEnet
4 - Dwm	4 - Vcmd
5 - DP	5 - Delatvsm
6 - Vinv	6 - Pcmd
7 - Pinv	7 - wPLL
8 - Qinv	8 - Emin
9 - Idinv	9 - Emax
10 - Iqinvneg	10 - Iqmax
11 - DeltaITMax	11 - Idmax
12 - DeltaTMin	12 - Vq
13 - PlIstate	13 - Vd
14 - DeltaPLL	

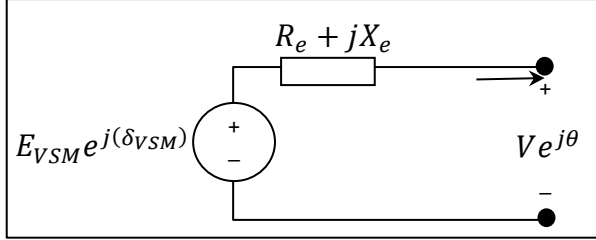
Parameter $I_{faultmax}$ is used in algebraic network equations to enforce maximum current. See next page for details on network equations. When $I_{faultmax}$ is enforced, values of E_{net} and δ_{net} are reported as other fields.



Network Boundary Equations Explanation

The network boundary equations for REGFM_B1 are the same as REGFM_A1 bus with the internal angle held as a constant during the network solution ($\delta_{VSM} = \delta_{IT} + \delta_{PLL}$).

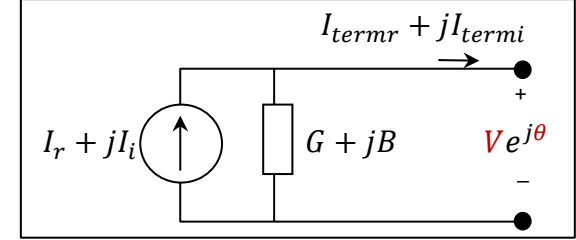
Model States: E_{VSM} , $\delta_{VSM} = \delta_{IT} + \delta_{PLL}$ Model Parameters: R_e , X_e , and $I_{faultmax}$.



$$G + jB = \frac{1}{R_e + jX_e}$$

$$G = \frac{R_e}{R_e^2 + X_e^2}$$

$$B = \frac{-X_e}{R_e^2 + X_e^2}$$



When the current limit is not active, the Norton current on the network reference frame ($I_r + jI_i$) is calculated as follows.

$$I_r = G E_{VSM} \cos(\delta_{VSM}) - B E_{VSM} \sin(\delta_{VSM})$$

$$I_i = B E_{VSM} \cos(\delta_{VSM}) + G E_{VSM} \sin(\delta_{VSM})$$

During the network algebraic solution, if the terminal current exceeds the maximum current limit ($I_{faultmax}$), then the algebraic network equations transition to current equations that have a total current of $I_{faultmax}$, but the component currents maintain the same ratio as the models desired currents. By assuming they maintain the same ratio, the assumption is that power factor is maintained.

Assuming $I_{term} \leq I_{faultmax}$, then terminal currents are the following (subtract off the currents through the Norton admittance).

$$I_{termr} = I_r - [GV \cos(\theta) - B\theta \sin(\theta)]$$

$$I_{termi} = I_i - [B\theta \cos(\theta) + G\theta \sin(\theta)]$$

($I_{termr} + jI_{termi}$) represents the desired terminal current.

If $\sqrt{I_{termr}^2 + I_{termi}^2} \leq I_{faultmax}$, then the model terminal currents used are ($I_{usedr} + jI_{usedi}$) = ($I_{termr} + jI_{termi}$)

If $\sqrt{I_{termr}^2 + I_{termi}^2} > I_{faultmax}$, then the model terminal currents used transition to scaled desired currents as follows.

$$I_{usedr} = I_{termr} \frac{I_{faultmax}}{\sqrt{I_{termr}^2 + I_{termi}^2}}$$

$$I_{usedi} = I_{termi} \frac{I_{faultmax}}{\sqrt{I_{termr}^2 + I_{termi}^2}}$$

When the current limit is being enforced the model injects this current at the network.

Users may report results for Other Fields for E_{net} and δ_{net} which are calculated from the following equation. This is for information only. $E_{net} e^{j\delta_{net}} = V e^{j\theta} + (I_{usedr} + jI_{usedi})(R_e + jX_e)$

Under normal operation when $\sqrt{I_{termr}^2 + I_{termi}^2} \leq I_{faultmax}$, then $E_{net} = E_{VSM}$ and $\delta_{net} = \delta_{VSM}$.

Parameter	Description	Default
wFlag	Flag to select which speed deviation to use for Power-Frequency droop. =0 to use Dwm; <>0 to use DwPLL	0
VdrpFlag	Flag to select either Current or Reactive Power Droop. If QVFlag=0 then VdrpFlag will be ignored and treated as 0. =0 for Power; <>0 for Current	1
QVflag	Input Mode Selection determines whether input value is Qref or Vref. =0 to use Reactive Power Q as an input; <>0 to use Voltage as an input	1
PQflag	PQ priority flag specifies a priority used for the steady state current limitation. =0 to use Q priority; <>0 to use P priority	1
FFlag	Flag determine if the Power-Frequency droop is enabled =0 to disable Power-Frequency Droop; <> 0 to enable Power-Frequency Droop	1
ESFlag	Flag determines if the model supports energy storage (negative real power or current) =0 to prevent negative angle; <> 0 to enabled negative angles for energy storage	1
Re	Inverter coupling resistance [pu] ($0.00 \leq Re \leq 0.25 \cdot Xe$)	0.00
Xe	Inverter coupling reactance [pu] ($0.04 \leq Xe \leq 0.40$)	0.10
m _q	Q-V droop gain. When Vdrpflag<>0, m _q represents a per unit virtual impedance [pu]	0.05
k _{pv}	Proportional gain of the voltage controller [pu]	0
k _{iv}	Integral gain of the voltage controller (>0) [pu/s]	5
m _p	Power-Frequency Droop gain [pu]	0.02
Dw _{max}	Upper limit of Dwm (>=0) [pu]	0.050
Dw _{min}	Lower limit of Dwm (<=0) [pu]	-0.050
k _p PLL	Proportional gain of PLL [pu]	0.265
k _i PLL	Integral gain of PLL (>0) [pu/s]	2.650
DwPLL _{max}	Upper limit of the PLL output (>=0) [pu]	0.20
DwPLL _{min}	Lower limit of the PLL output (<=0) [pu]	-0.20
T _p	Time constant of the low-pass filter in the VSM control block (>=0) [seconds]	0
H	Inertia time constant [seconds]	0.50
D1	Damping [pu]	0
D2	Transient damping [pu]	100
w _D	Angular frequency of the washout block [1/seconds]	50
I _{ssmax}	Steady state current limit [pu] (I _{ssmax} <= 0 is treated as 1/Xe) (I _{ssmax} <= 1/Xe) (I _{ssmax} <= I _{faultmax})	1.2
K _f	PQFlag determines if I _{dmax} = K _f *I _{ssmax} or I _{qmax} = K _f *I _{ssmax} (K _f <=0 is treated 1.0)	0.8
k _i	Integral gain for the active current limiting loop [pu/s]	2.00
I _{faultmax}	Transient fault current limit [pu] (If I _{faultmax} <=0 the limit is ignored, but not recommended)	2.0
T _{pf}	Time constant of the low-pass filter for active power measurement (>=0) [seconds]	0.02
T _{Qf}	Time constant of the low-pass filter for reactive power measurement (>=0) [seconds]	0.02
T _{Vf}	Time constant of the low-pass filter for voltage measurement (>=0) [seconds]	0.02
T _{If}	Time constant of the low-pass filter for current measurement (>=0) [seconds]	0.02
K _e	Scalar on I _{dmax} for negative real steady state current limitation ($0 \leq K_e \leq 1.0$)	1.00
V _{pllfrz}	Terminal voltage below which special PLL state freezing is implemented [pu]	0.05

