Wind Power Plant Modeling

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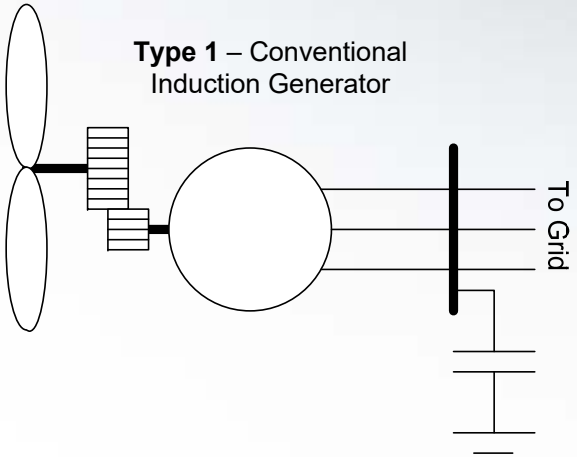
WECC MVS Workshop

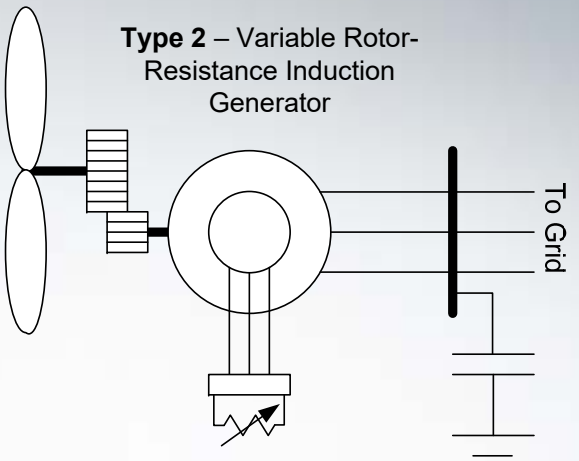
September 17th, 2020

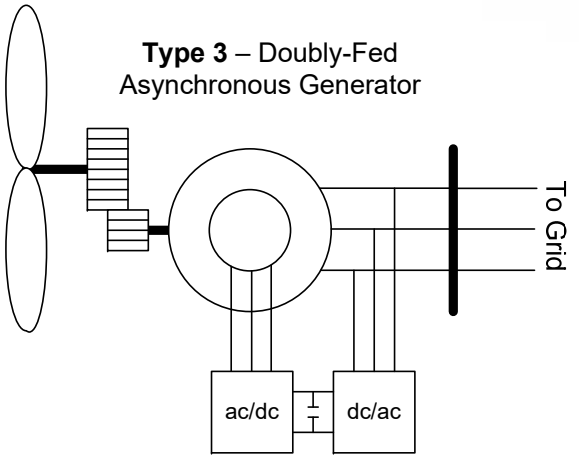
Key References

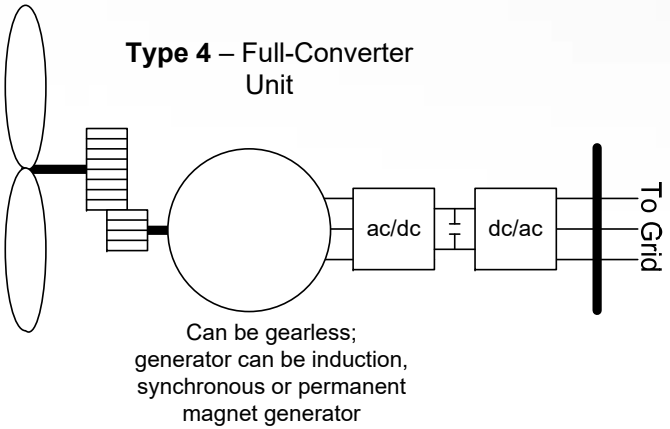
- EPRI has sponsored much of the model development work
- *Model User Guide for Generic Renewable Energy System Models, EPRI Report, July 2018*
  https://www.epri.com/research/products/000000003002014083
- WECC Wind Plant Dynamics Modeling Guide, 2014
  https://www.wecc.org/Reliability/WECC%20Wind%20Plant%20Dynamic%20Modeling%20Guidelines.pdf

The Types of WTG [1]

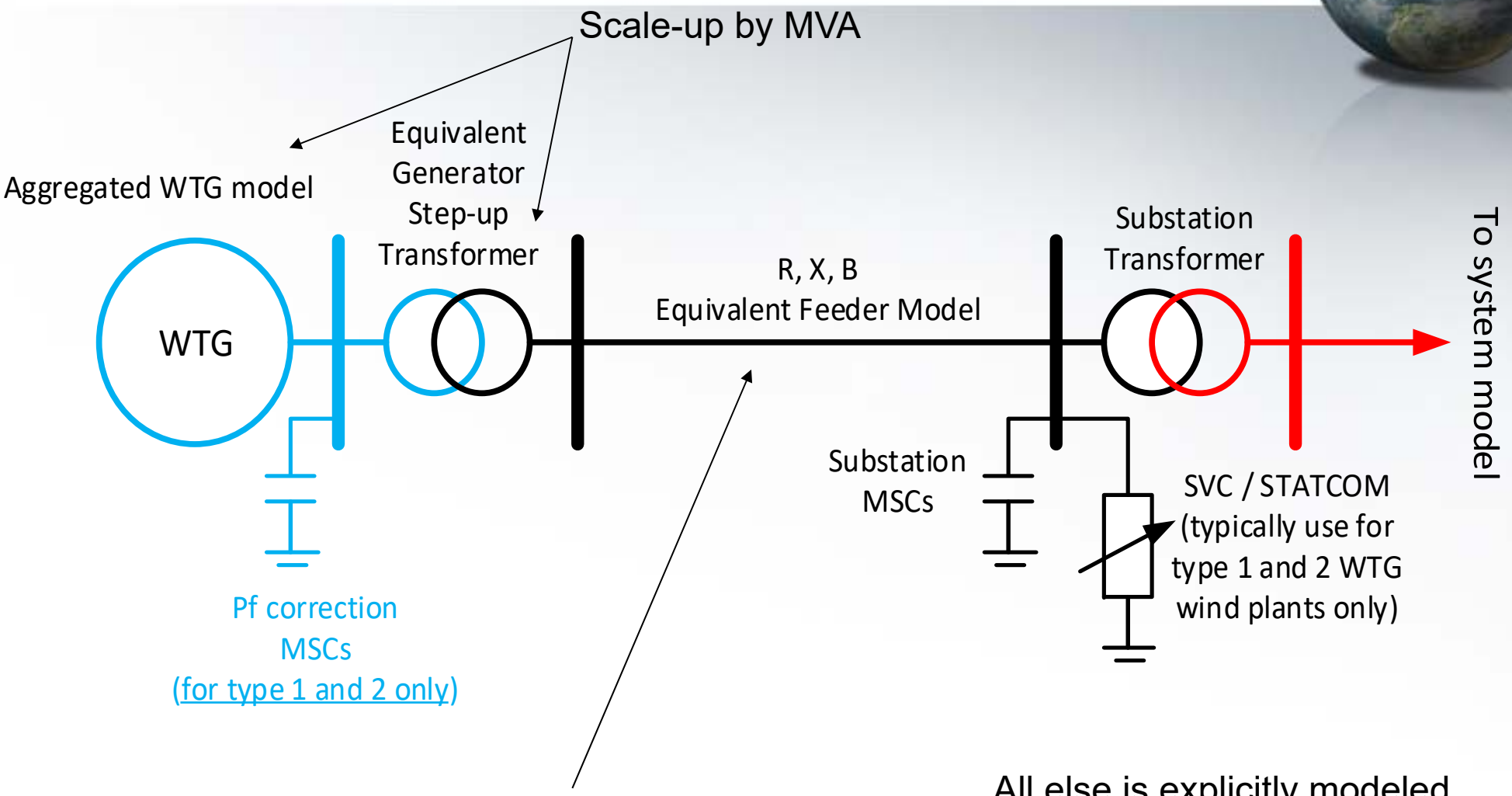








Wind Power Plant

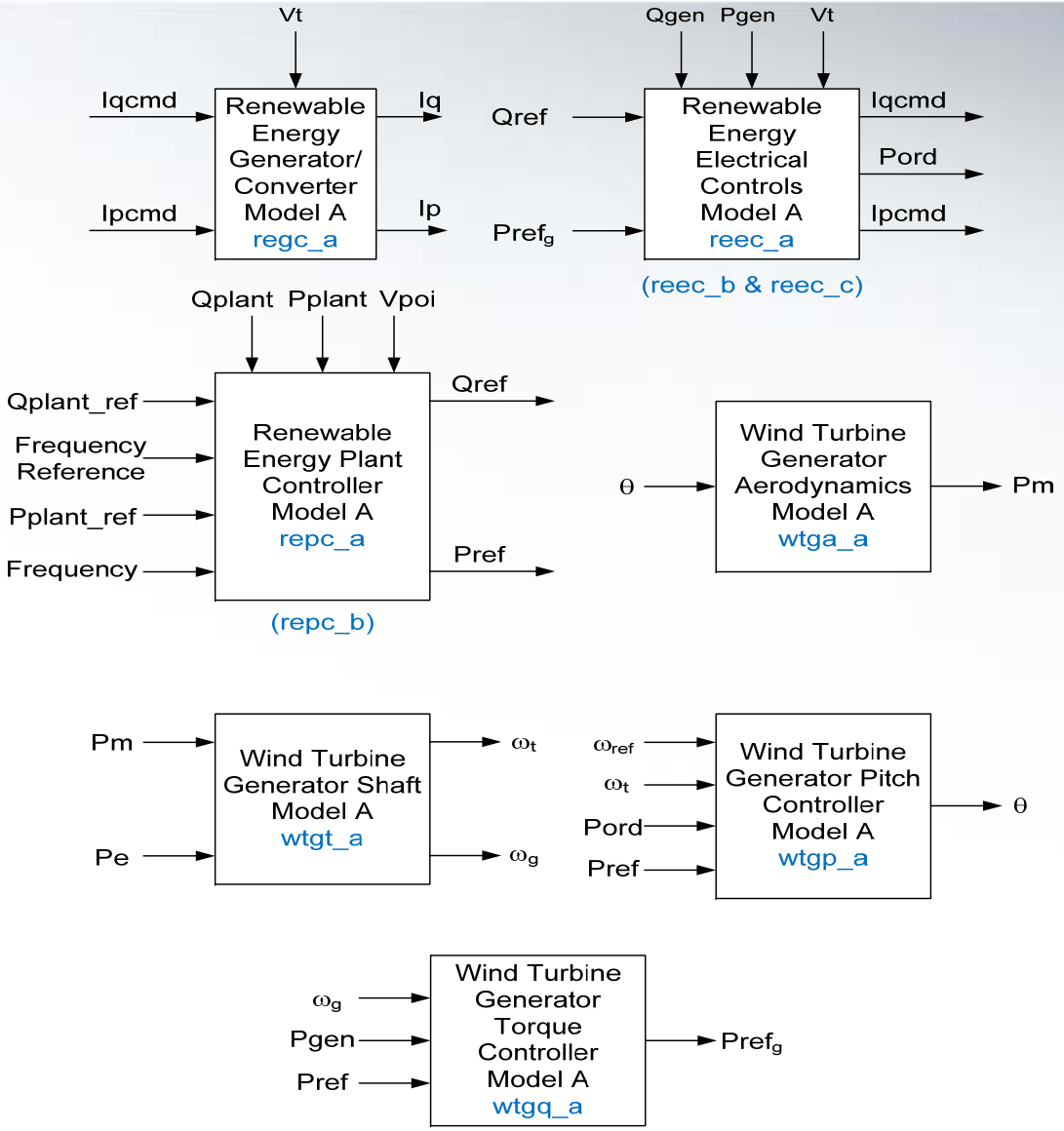


NREL Approach [2]

Power Flow Model

- Ensure substation transformer fixed tap-position is verified and properly modeled
- Ensure collector system properly and reasonably equivalenced
- Ensure all substation equipment explicitly modeled

The Building Blocks [3]

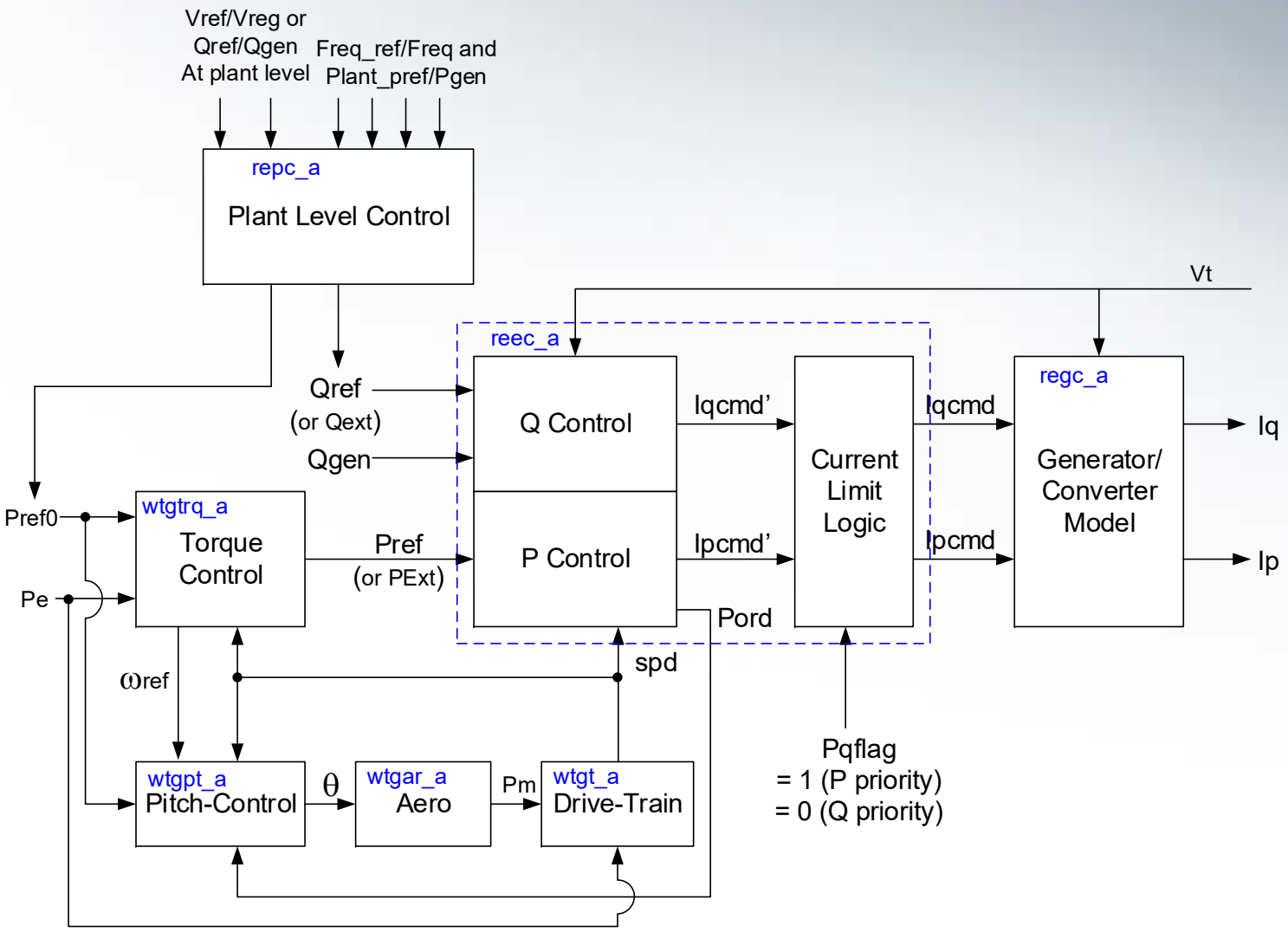


Putting the Models Together

RES	Model Combination
Type 1 WTG	wt1g, wt1t, wt1p_b
Type 2 WTG	wt2g, wt2e, wt2t, wt1p_b
Type 3 WTG	regc_a, reec_a, repc_a, wtgt_a, wtgar_a, wtgpt_a, wtgtrq_a
Type 4 WTG	regc_a, reec_a, repc_a (optional: wtgt_a)

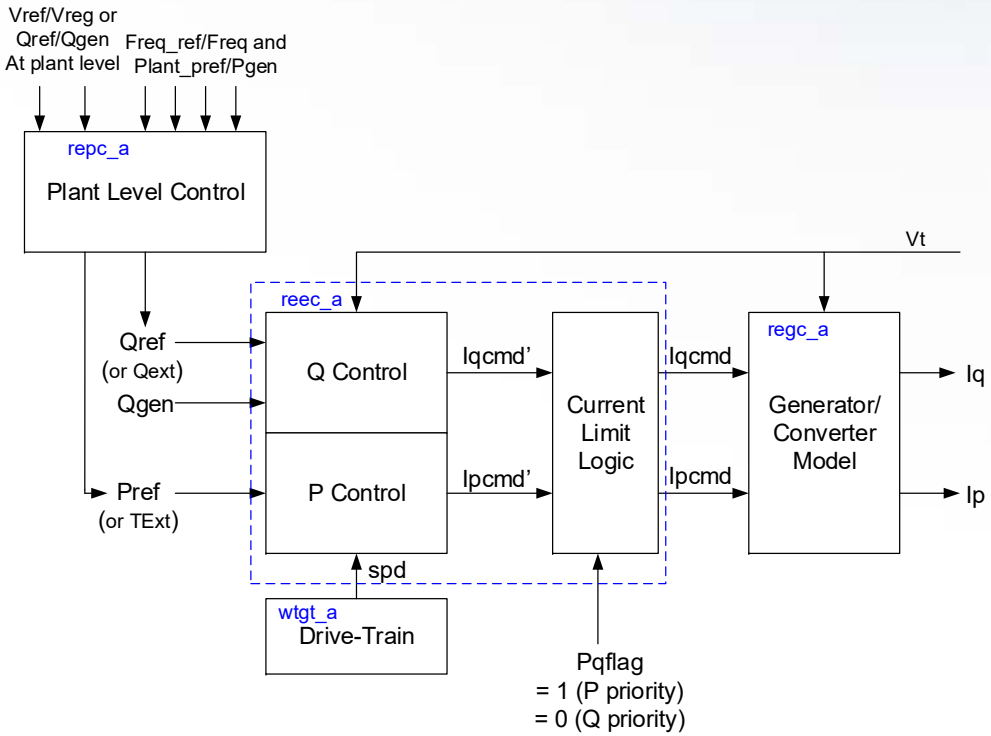
Model	Function	1st or 2nd Generation
regc_a	RES Generator/Converter Model (current source)	2nd
regc_b	*RES Generator/Converter Model (voltage source)*	*2nd (just approved)*
reec_a	RES Electrical Controls Model A	2nd
reec_c	RES Electrical Controls Model C	2nd
reec_d	RES Electircal Controls Model D	2nd (just approved)
repc_a	RES Plant Controls Model A	2nd
repc_b	RES Plant Controls Model B	2nd
repc_c	*RES Plant Controls Model C*	*2nd (in development)*
wtgt_a	WTG Turbine Shaft Model A	2nd
wtgt_b	*WTG Turbine Shaft Model B (for type 4 WTGs only)*	*2nd (in development)*
wtga_a	WTG Aero-dynamice Model A	2nd
wtgp_a	WTG Pitch Controller Model A	2nd
wtgp_b	*WTG Pitch Controller Model B*	*2nd (in development)*
wtgq_a	WTG Torque Controller Model A	2nd
wtgwgo	*WTG Weak Grid Option Controls*	*2nd (in development)*
wtgibffr	*WTG Inertial-Based FFR*	*2nd (in development)*
wt1p_b	Pitch Controller for type 1 WTG Model B	2nd
wt1g	Type 1 WTG generator model	1st
wt1t	Type 1 WTG turbine shaft model	1st
wt2g	Type 2 WTG generator model	1st
wt2e	Type 2 WTG variable external rotor resistance controller	1st
wt2t	Type 2 WTG turbine shaft model	1st
lhvrt	low/high voltage ride-through relay model	1st
lhfrt	low/high frequency ride-through relay model	1st

TYPE 3 WTG [1]

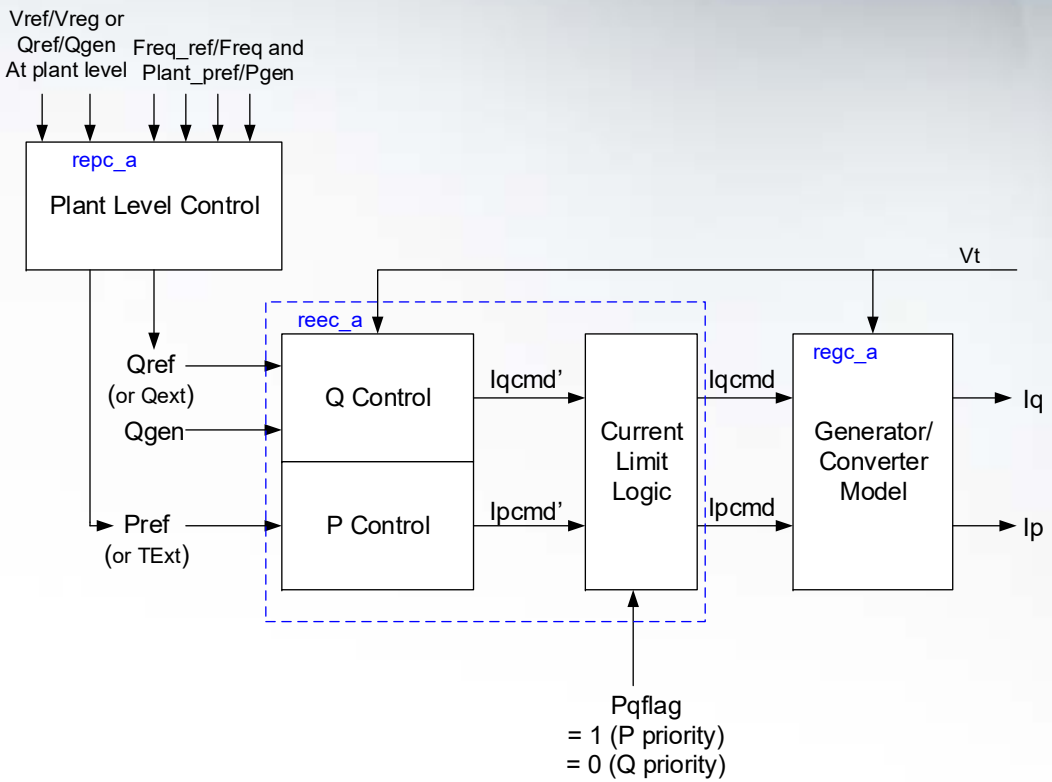


TYPE 4 WTG [1]

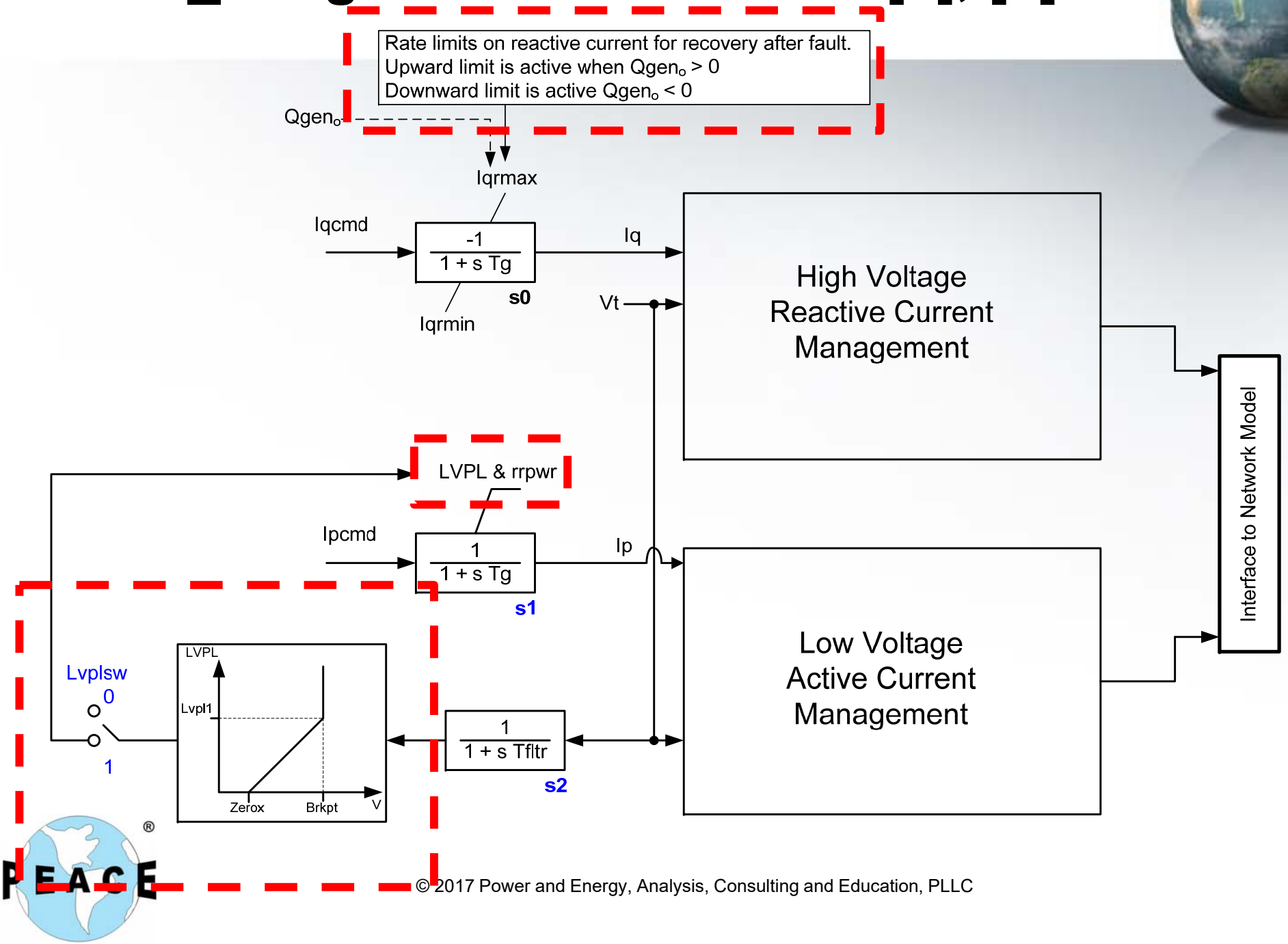
Type 4a



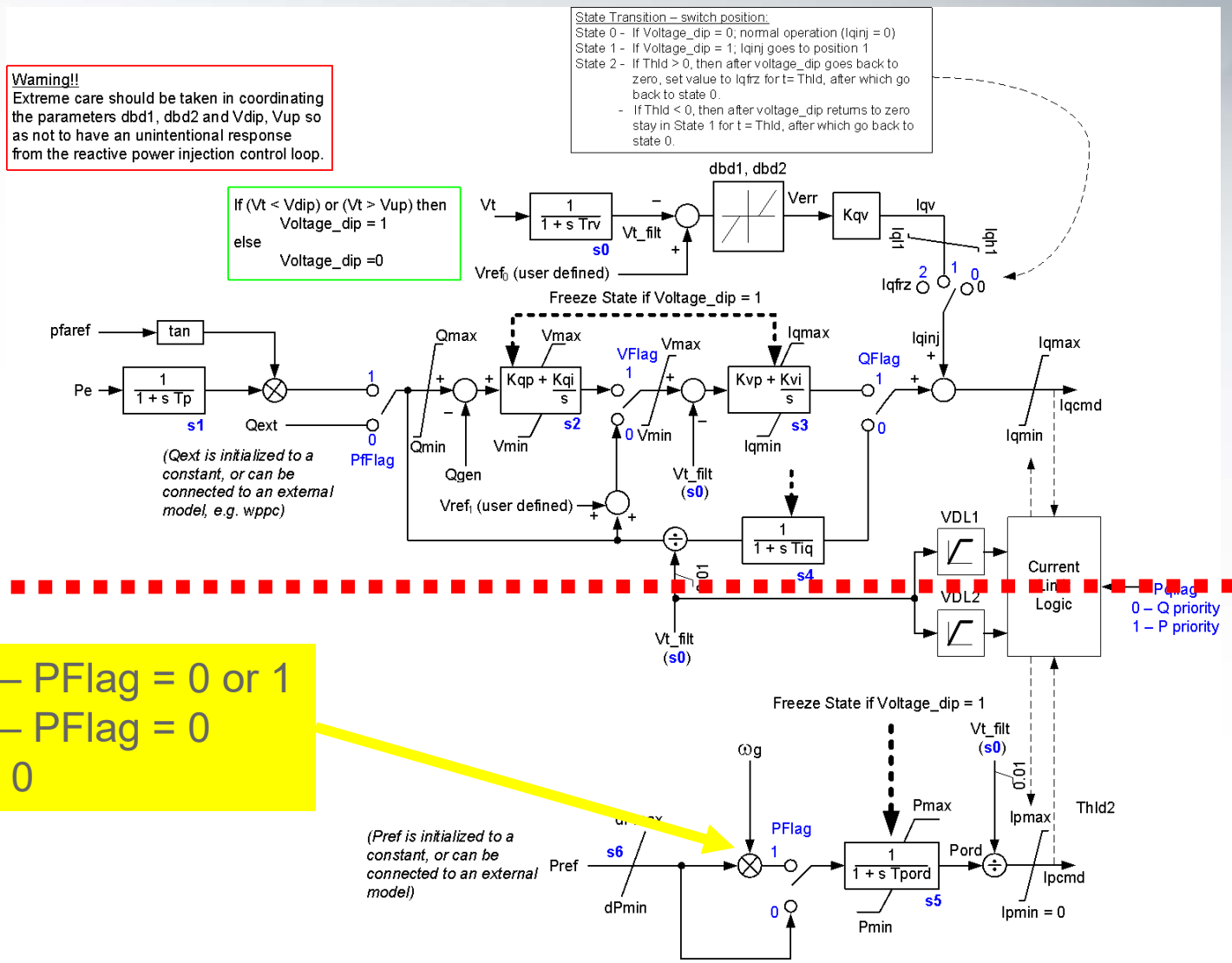
Type 4b



REGC_A – generator/converter [1], [4]

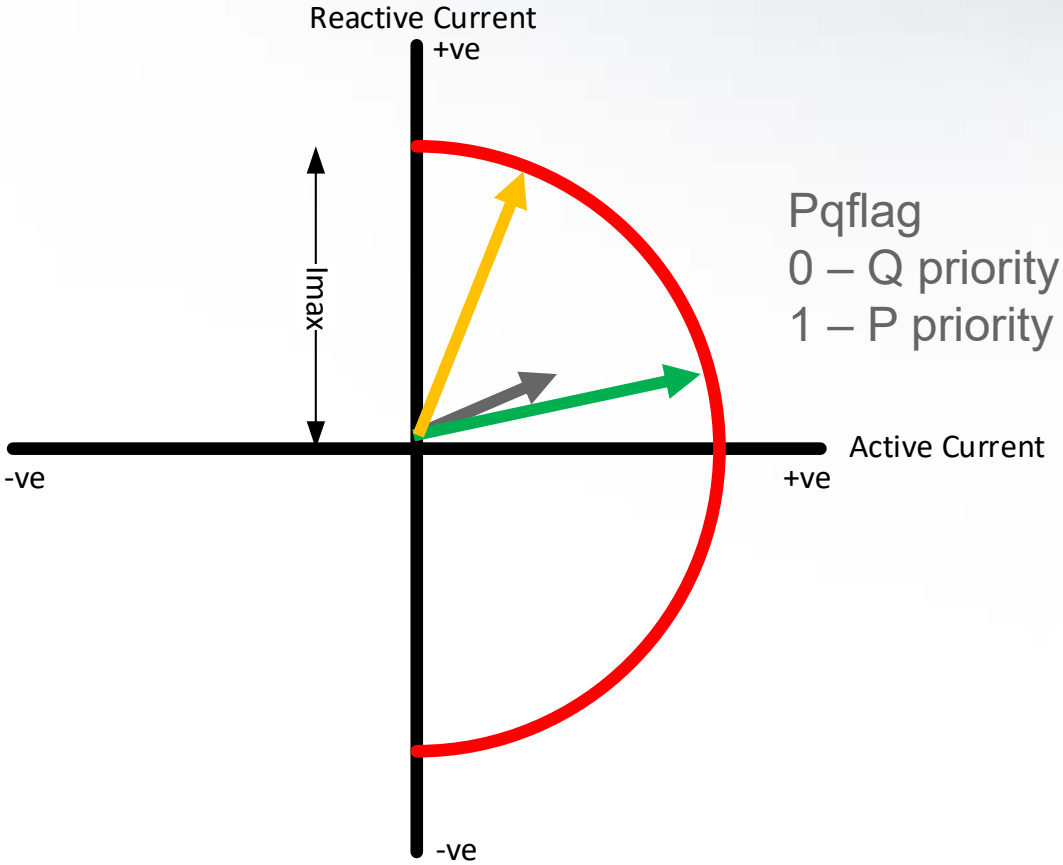


REEC_A – electrical controls [1], [4]

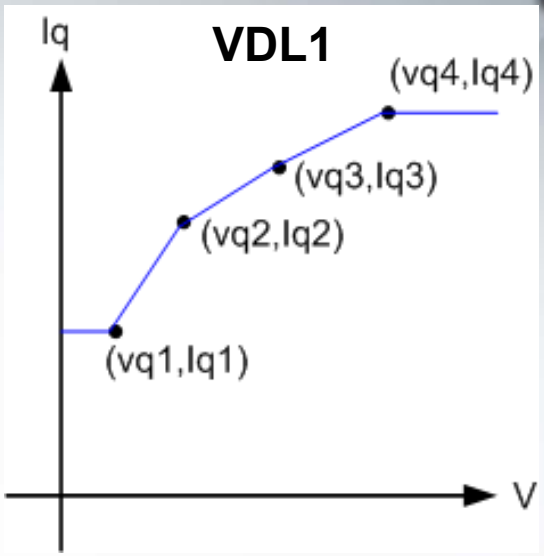


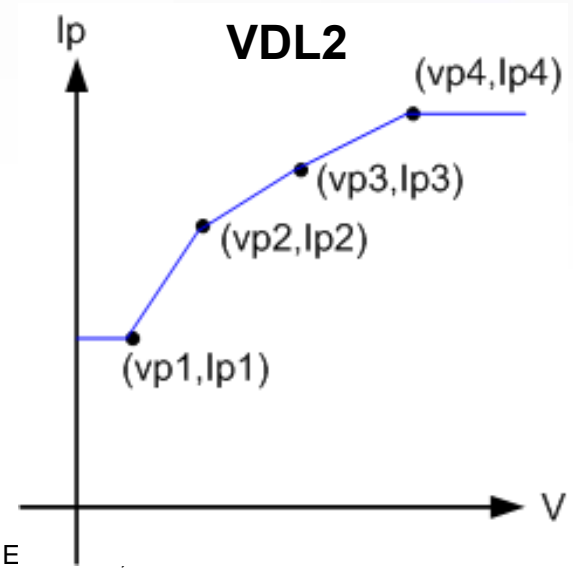
Current Limit Logic [1], [4]

Current Limit Logic



Pqflag
0 – Q priority
1 – P priority

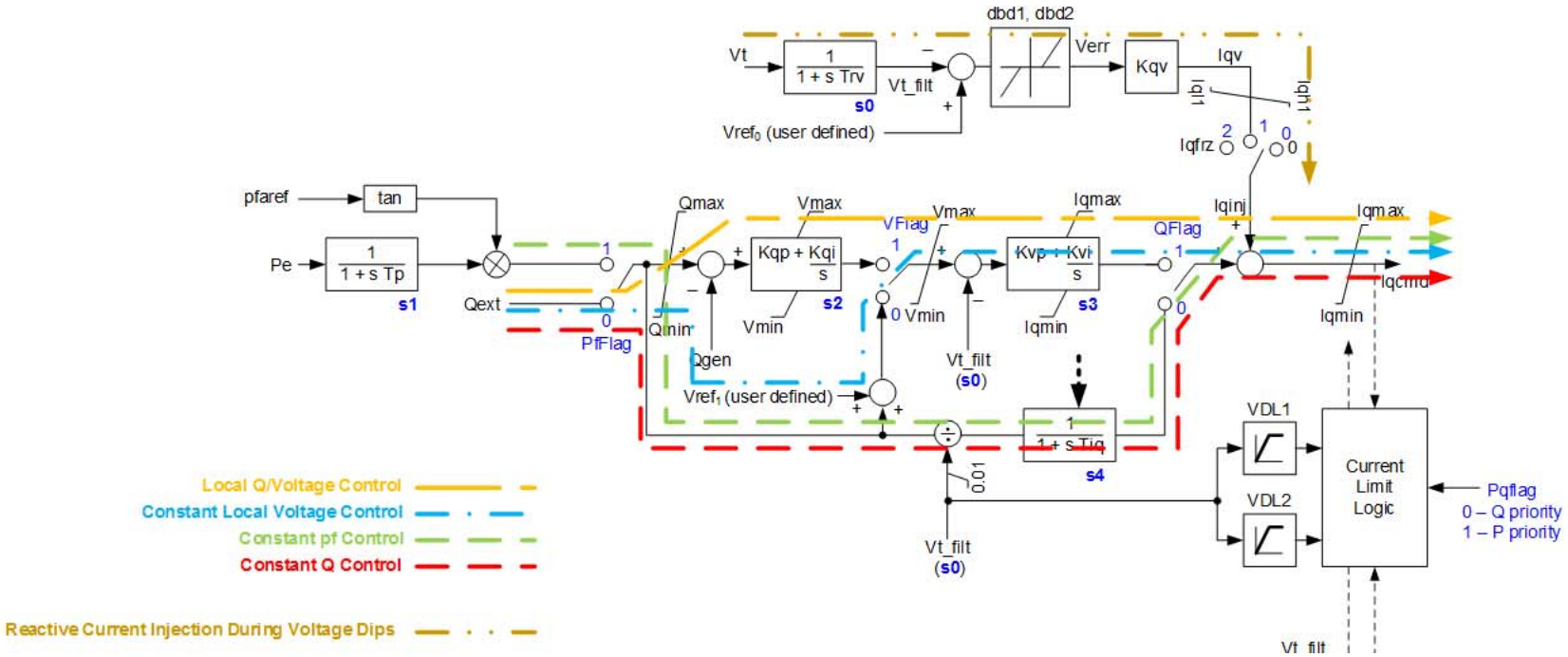




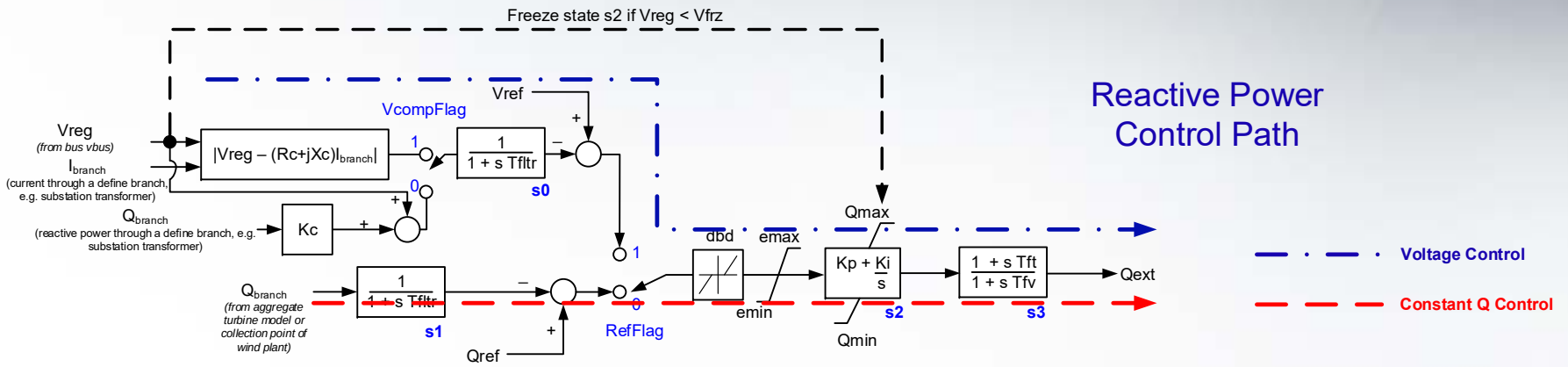
Control Options [4]

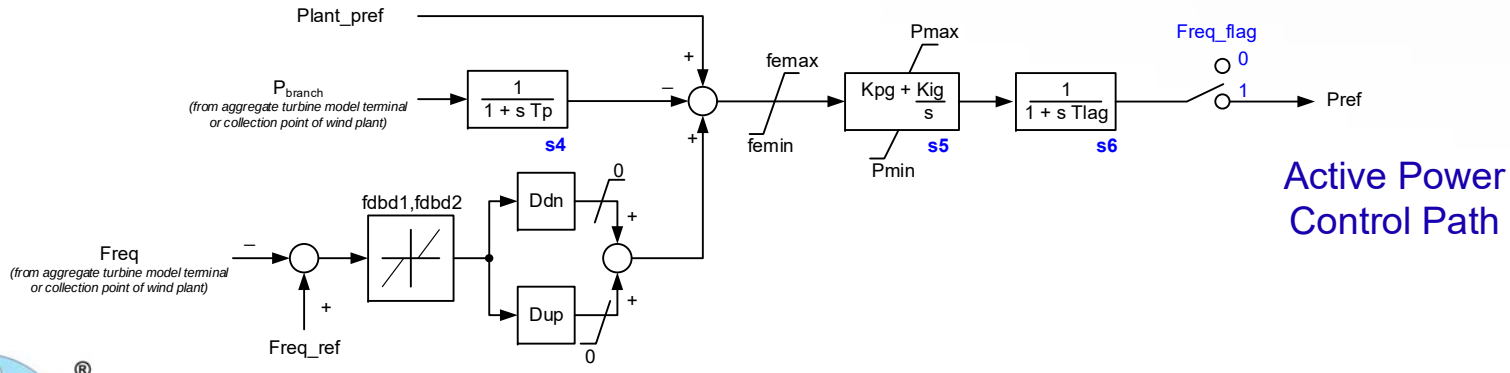
Control Mode	PfFlag	VFlag	QFlag
Local constant Q control	0	0 or 1	0
Local constant power factor (pf) contorl	1	0 or 1	0
Local voltage control	0	0	1
Local coordinated Q/V control	0	1	1

From ref. [4]

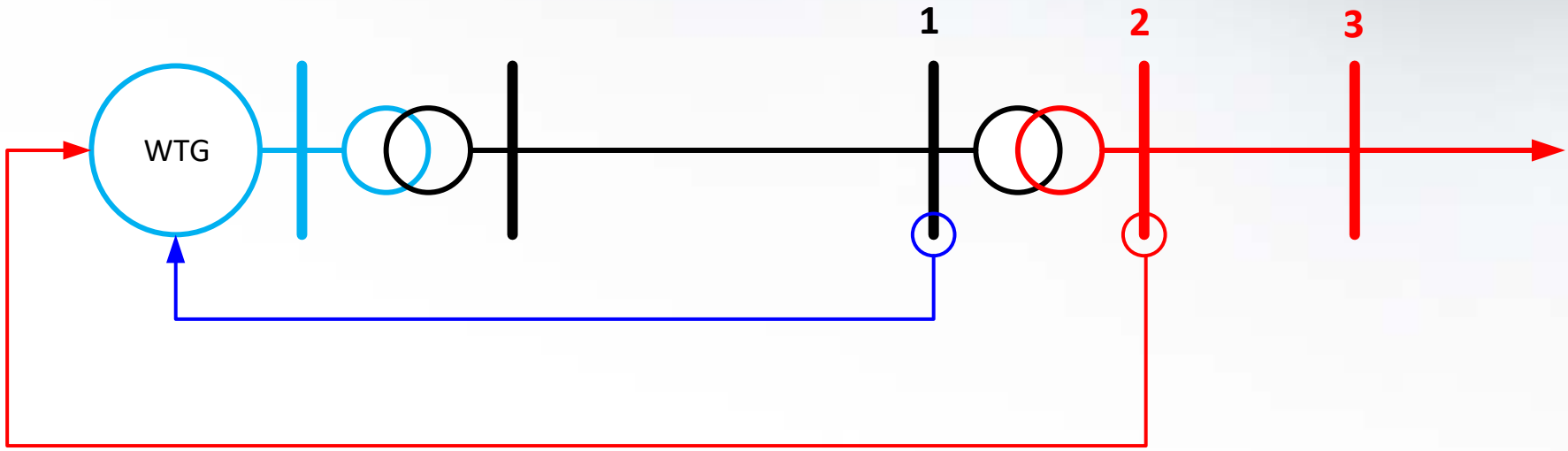


REPC_A – plant controller [4]



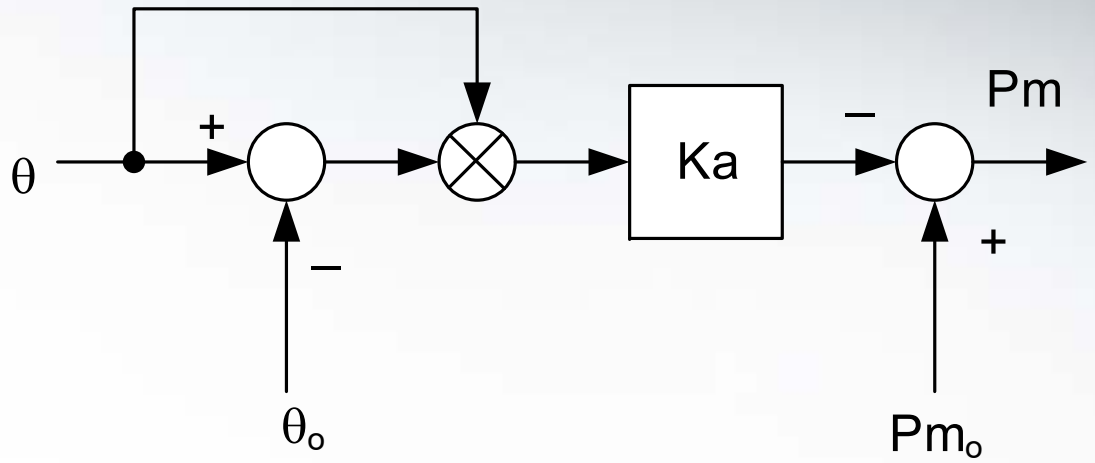


Ensure Branch is Properly Defined in REPC_* model



Blue: branch is from 1 to 2, cct. 1
Red: branch is from 2 to 3, cct. 1

WTGA_A – aerodynamics [1], [5]

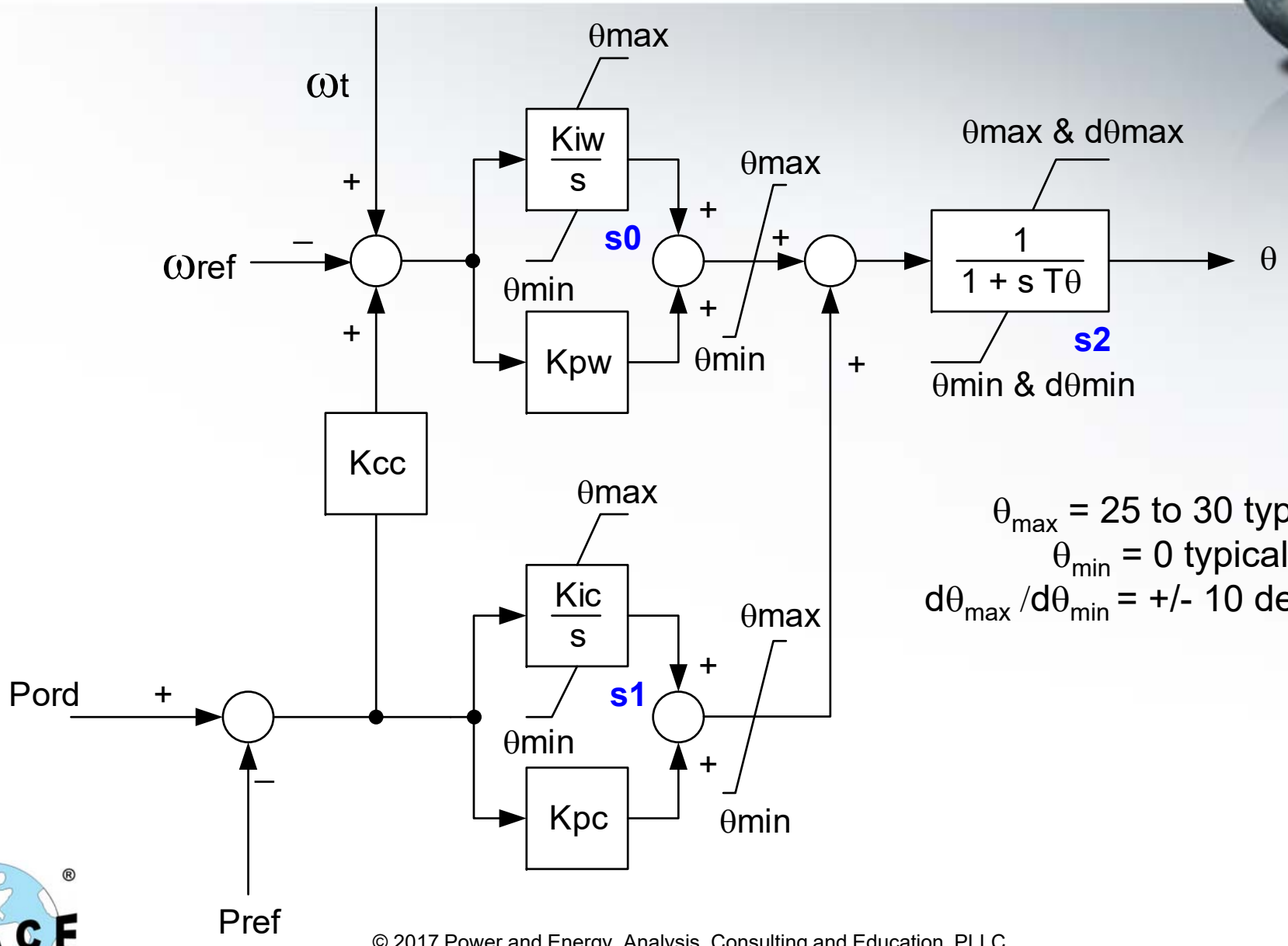


Ka = 0.007 (default)

θ_o = 0 (default)

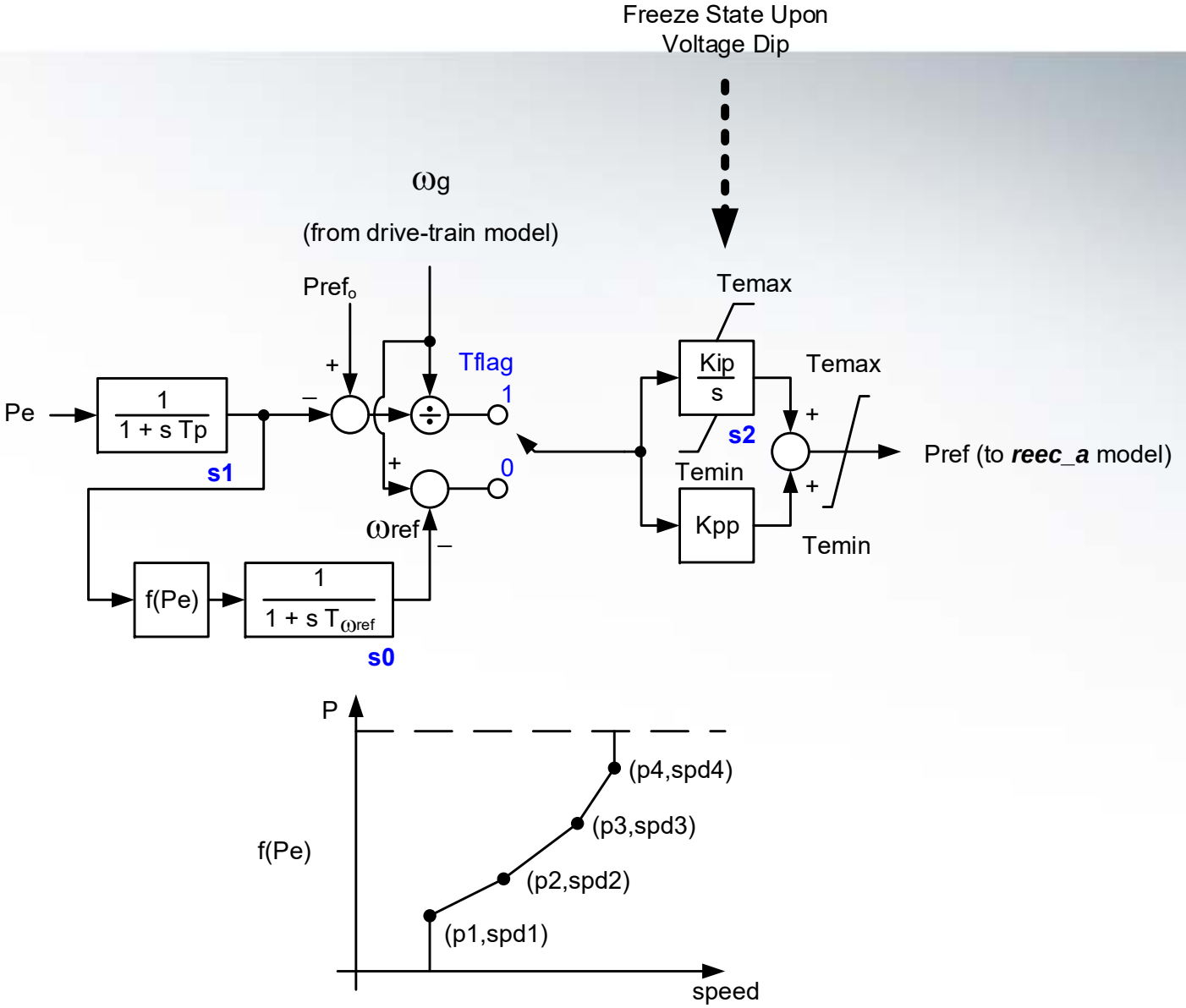
Must set θ_o to none zero (e.g. 5 to 10 degrees) when “emulating” some wind energy in reserve, e.g. frequency response.

WTGP_A – pitch controller [1]



θ_{max} = 25 to 30 typical
θ_{min} = 0 typical
$d\theta_{max}$ /$d\theta_{min}$ = +/- 10 degrees/s

WTGQ_A – torque controller [1]



References

[1] WECC 2nd Generation WTG Model Specifications
https://www.wecc.biz/Reliability/WECC-Second-Generation-Wind-Turbine-Models-012314.pdf

[2] . Muljadi, C. P. Butterfield, A. Ellis, J. Mechenbier, J. Hochheimer, R. Young, N. Miller, R. Delmerico, R. Zavadil, and J. C. Smith, "Equivalencing the collector system of a large wind power plant," in Proc. IEEE Power Eng. Soc. General Meeting, Montreal, QC, Canada, Jun. 2006.

[3] P. Pourbeik, J. Sanchez-Gasca, J. Senthil, J. Weber, P. Zadehkhost, Y. Kazachkov, S. Tacke and J. Wen, "Generic Dynamic Models for Modeling Wind Power Plants and other Renewable Technologies in Large Scale Power System Studies", *IEEE Trans. on Energy Conversion*, September 2017 https://ieeexplore.ieee.org/document/7782402

[4] Model User Guide for Generic Renewable Energy System Models, EPRI Report, July 2018
https://www.epri.com/research/products/000000003002014083

[5] W. W. Price, J.J. Sanchez-Gasca, "Simplified Wind Turbine Generator Aerodynamic Models for Transient Stability Studies", Proc. IEEE PES 2006 Power Systems Conference and Exposition (PSCE), Oct. 29-Nov. 1, 2006, Atlanta, GA, pp. 986-992