Generic Models for Type 3 and 4 Wind Turbine Generators

Pouyan Pourbeik
ppourbeik@epri.com
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OVERALL MODEL STRUCTURE

Electrical Controls (P and Q control)

Generator/Converter

Frame of Reference Transformation

Power System Grid Model

Aerodynamics/Drive Train

Pref

Vref or Qref or p pref

Vreg

ωg

Qe

ωref

Pm₀

θ₀

ω₀

Pref

P₀

Ipcmd

Iqcmd

I ≤ ϕ

I soc ≤ ϕ

Pe

Qe

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ELECTRICAL CONTROLS

Reactive Power Control

Active Power Control

Current Limit Logic

Vt
Vref or Qref or pfref
Qe
Pe
ωg
Pref

Iqord
Ipord
Iqcmd
Ipcmd

Pref or Qref or pfref
• Most recent proposal [1] & [2]. Not very different from [3] and only a few changes compared to current WECC model.

• Used Data graciously provided under NDA from Vestas and Siemens Wind Power, respectively.

• Acknowledgements:
  – Babak Badrzadeh, Vestas
  – Nikolaus Moeller Goldenbaum, Siemens
THE MODEL

P-CONTROL

V_{base} = (V_{ref} \text{ or } 1)

Freeze State Upon Voltage Dip

\frac{1}{1 + s \cdot T_{pord}}

P_{max} \text{ & } dP_{max}

P_{min} \text{ & } dP_{min}

Ip_{max} \times \text{ multp}

I_{rmax}

Ramp Rate (s15)

\frac{1}{1 + s \cdot T_{pord}}
THE MODEL

OPTIONAL DRIVE-TRAIN

\[ \frac{1}{2H_t s} \]

\[ \frac{1}{2H_g s} \]

\[ \frac{1}{s} \]

\[ D_{\text{shaft}} \]

\[ K_{\text{shaft}} \]

Pe

\[ \omega_g \]

\[ \omega_t \]

\[ \omega_0 \]

Pmo

Tm
THE MODEL

Q-CONTROL
FIELD MEASURED DATA
RESULTS WITH SIEMENS WTG [2]
ASIDE (see [2] for details)
RESULTS WITH VESTAS WTG [1]

- Eight (8) cases studied
EXAMPLE CASES
(RESULTS WITH VESTAS WTG [1])

[Graphs showing power output over time for measured and optimized scenarios]

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EXAMPLE CASES (RESULTS WITH VESTAS WTG [1])

Graphs showing comparison of measured, optimized, and simulation + filter responses in Real and Reactive Power over time (seconds).
ABB CASES SHOWN PREVIOUSLY [4] STILL VALID WITH THIS MODEL

Data provide by ABB under NDA to EPRI
CONCLUSION

• We believe that this model now caters to multiple vendor equipment, and has been shown to give good validation results

• Some minor conventions have to be discussed and finalized

• The “spike” issue need software resolution – several ideas are being pursued
REFERENCES


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