

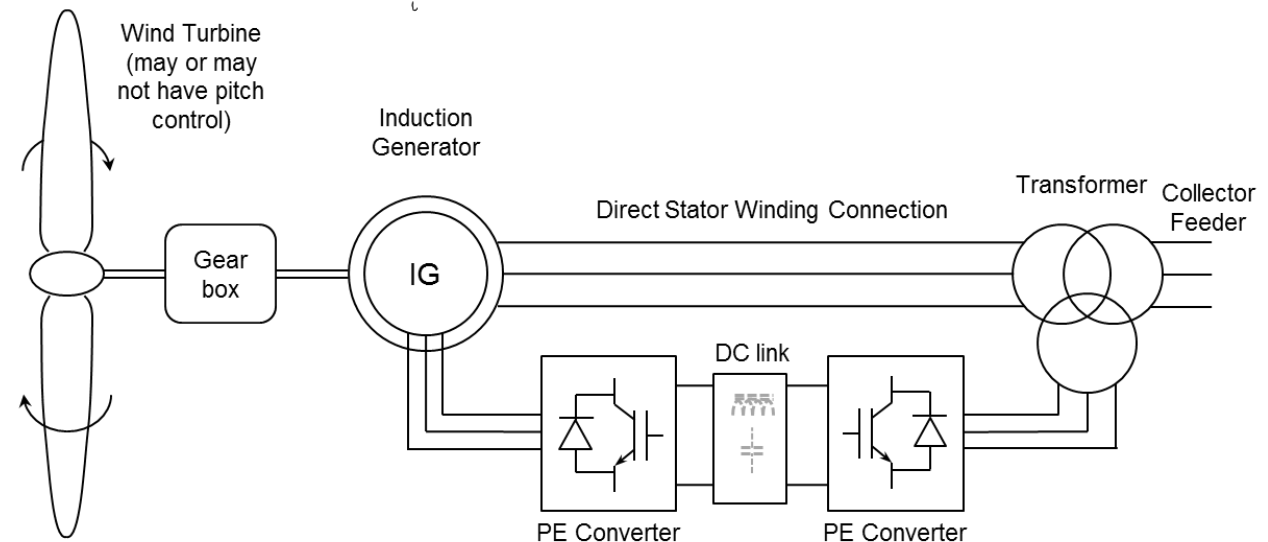
IBR Controls Review

IBR Controls?

- Understanding IBR controls is important to:
 - Understand how device will act on the system
 - Understand what “expected behaviour” may be
 - Understanding nature of inverter-related instability
 - Diagnose / debug EMT model issues
 - Facilitate constructive conversations with OEMs / developers
 - Understand difference in types of controls for wind / PV / BESS / GFM

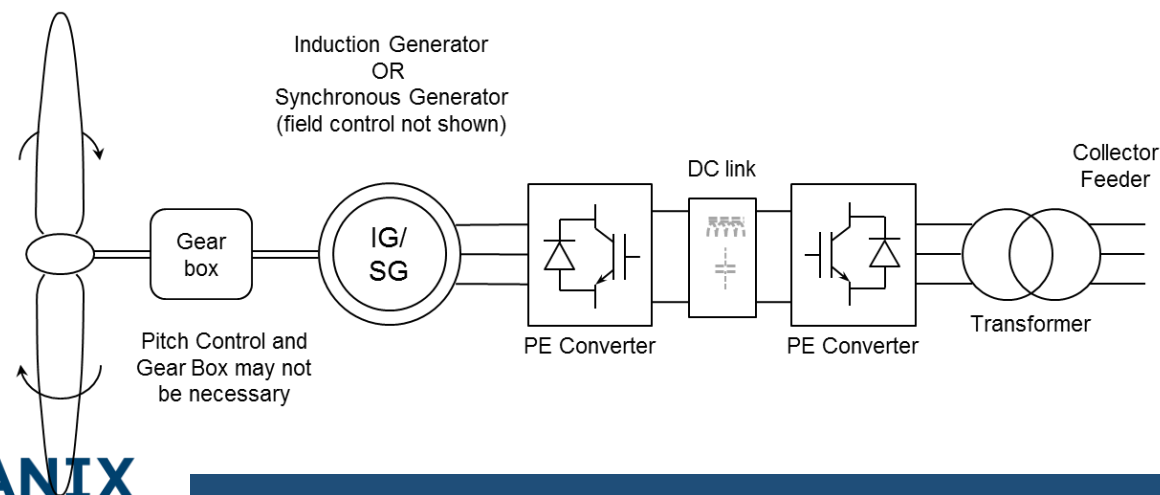
Wind Turbine – Type 3

- *Type 3: Doubly Fed Asynchronous Generator*
 - *Wound rotor connected through a converter to the grid.*
 - *Converters rated to approximately 30% of machine rating*
 - *Rotor speed can vary +/- 30% of synchronous speed*
 - *Much improved energy harvesting compared to older fixed-speed designs*
 - *Independent P/Q control*

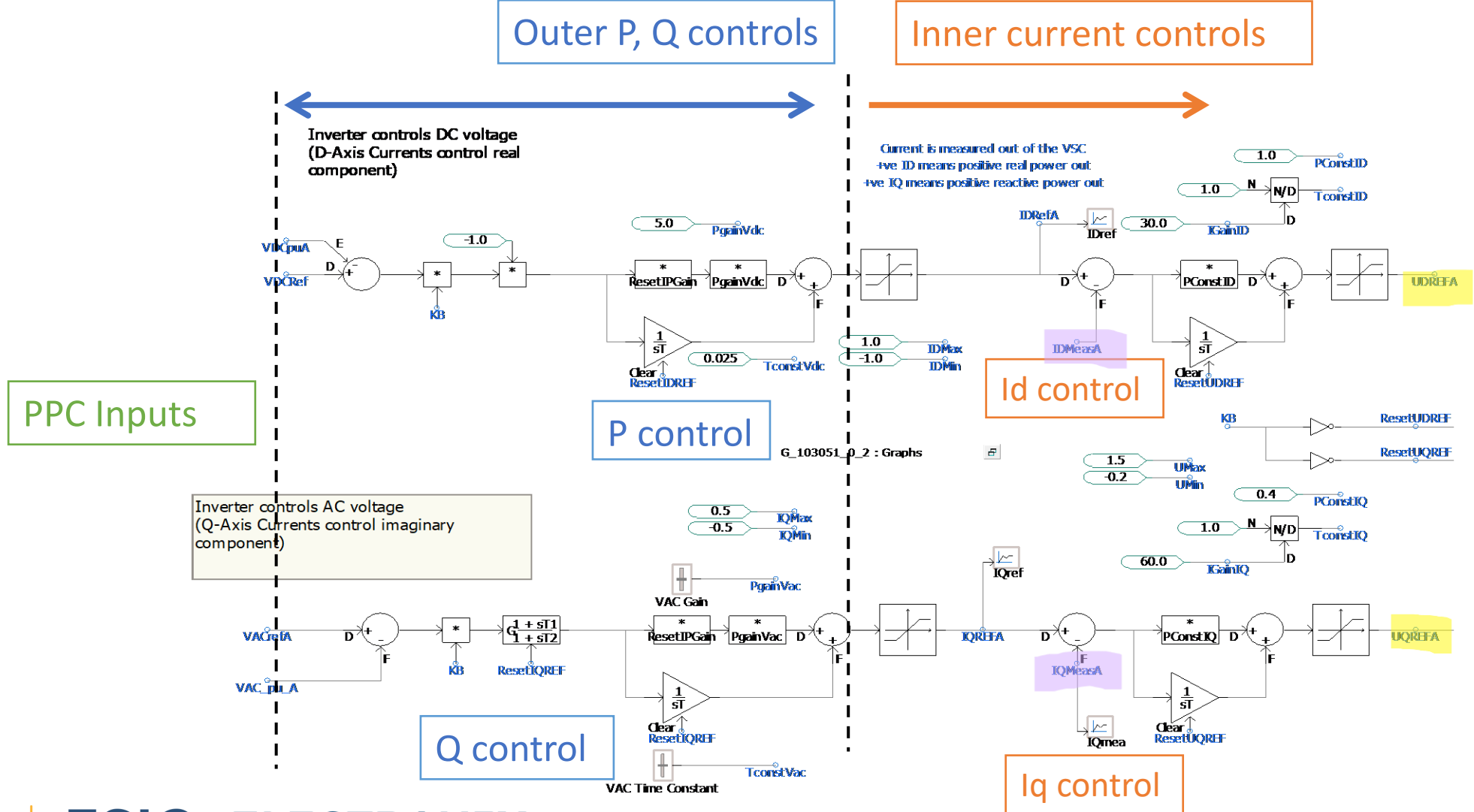


Full Converter

- *Type 4 WTG: Generator connected through fully rated converters*
 - *Can use induction or synchronous generators*
 - *Generator speed is decoupled from grid frequency*
 - *Gearbox optional*
- *PV Inverter:*
 - *Interface similar to Type 4 (full converter), with fewer mechanical constraints (e.g. can reduce power from PV immediately, no crowbar needed)*
- *BESS Inverter:*
 - *Similar to PV, plus fast bi-directional power flow*

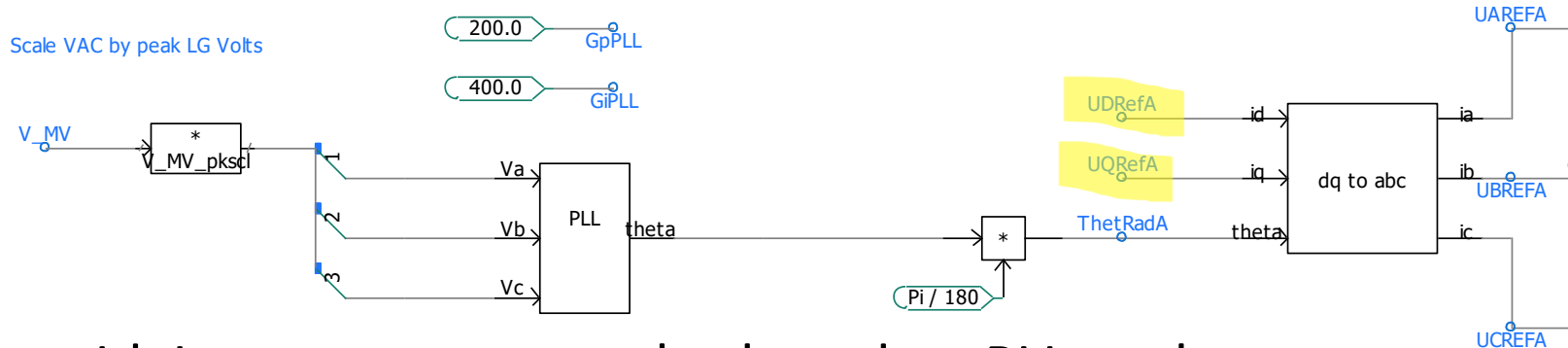


Outer and Inner Controls

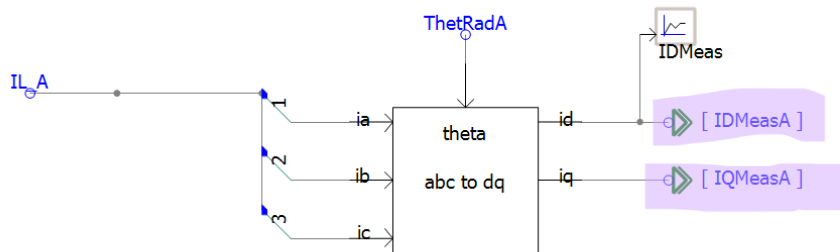


PLL and firing controls

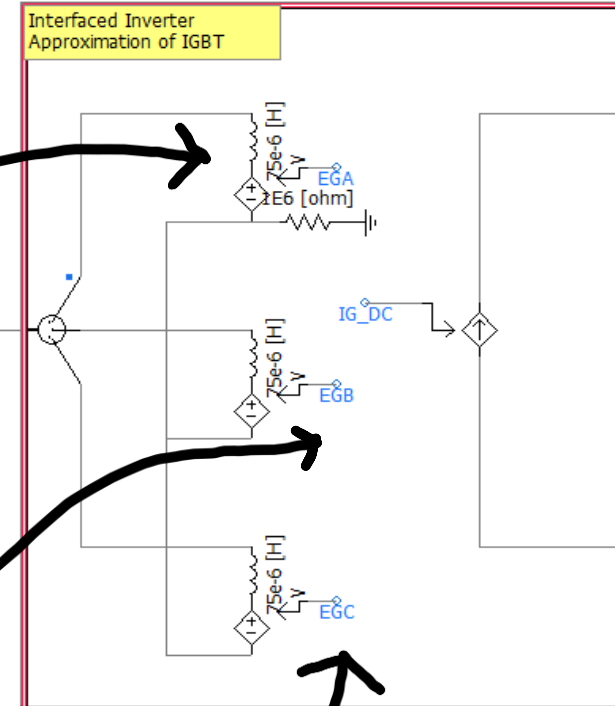
- Simplified voltage source approximation of IGBT bridge (average source model):



- Id, Iq measurements also based on PLL angle:



$I = \frac{V_g - V_{IBR}}{Z_g}$



PLL and firing controls

- Full IGBT representation:

