Autonomous Control and Conversion System for the Transformation of Fixed Speed Wind Turbines into Variable Speed Wind Turbines (FIX2VAR SPEED)

INGETEAM POWER TECHNOLOGY, S.A. has been received grant funding for its Research and Development Project named “Autonomous control and conversion system for the transformation of fixed speed wind turbines into variable speed wind turbines”. The Centre for the Development of Industrial Technology (CDTI) manages this financial aid that is co-funded by the European Regional Development Funds 2014 - 2020.

OBJECTIVE

To develop a highly competitive solution, in order to allow the transformation of Fixed Speed Wind Turbines (FSWT) into Variable Speed Wind Turbines (VSWT).

In the project, a ground breaking “autonomous converter” is developed, that allows for keeping, not only the main electrical components (generators, transformers, auxiliary circuits) of the turbine, but also the main wind turbine controller (PLC), since its conversion controller unit is able to manage independently the turbine speed.

The solution for the transformation into variable speed permits:

- **To improve the Annual Energy Production (AEP):** Allows the turbine to operate in its optimal performance point (MPPT, Maximum Power Point Tracking).
- **Maximize wind turbine Lifetime Extension (LTE):** An optimized increase in the Wind turbine LTE is possible through several control strategies.
- **Energy Quality:**
    - Allows for regulation of the power fed to the grid, preventing from disconnections when excess of demand.
    - Power Factor: Since its Full Conversion configuration, the system permits power factor control.
    - Grid Codes: Ability to comply with the most demanding grid codes.

REQUIREMENTS

Power conversion system requirements:

- Obtain an increase in the energy production (AEP)
- Increase the wind turbine lifetime (loads relaxation in the drive train and other main components)
- Energy Quality improvement (flickr, suppression of harmonics…)
- Power Factor regulation
- Fully integrated in the original Fixed Speed Wind Turbine (FSWT)
- Ensure the solution reliability

THEORETICAL CONCEPTS

FSWT operation principle

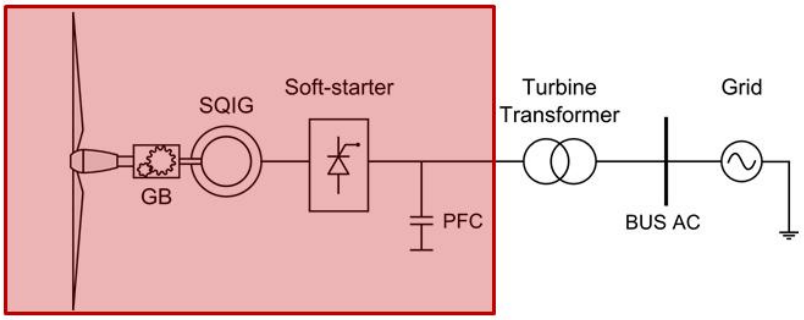


Figura. 1. ***FSWT solution schematic.***

- It is a very simple and robust topology for low power Wind turbines.
- Since the Grid frequency is fixed, the WT spins at almost constant speed (Ω = 1,0÷1,03 pu) regardless of the wind speed. (Ω (rpm) = Ω_s = 60·freq/pp)
- Usually with double speed generators (2 or 3 pair of poles – 2PP/ 3PP).
- FSWT Power curve / generator (2PP/3PP)
    - Below 5m/s wind speeds, far from optimal power extraction.
    - Close to the optimal power extraction for medium speed winds 5-11 m/s.
    - Above 11 m/s winds, far from optimal power extraction.

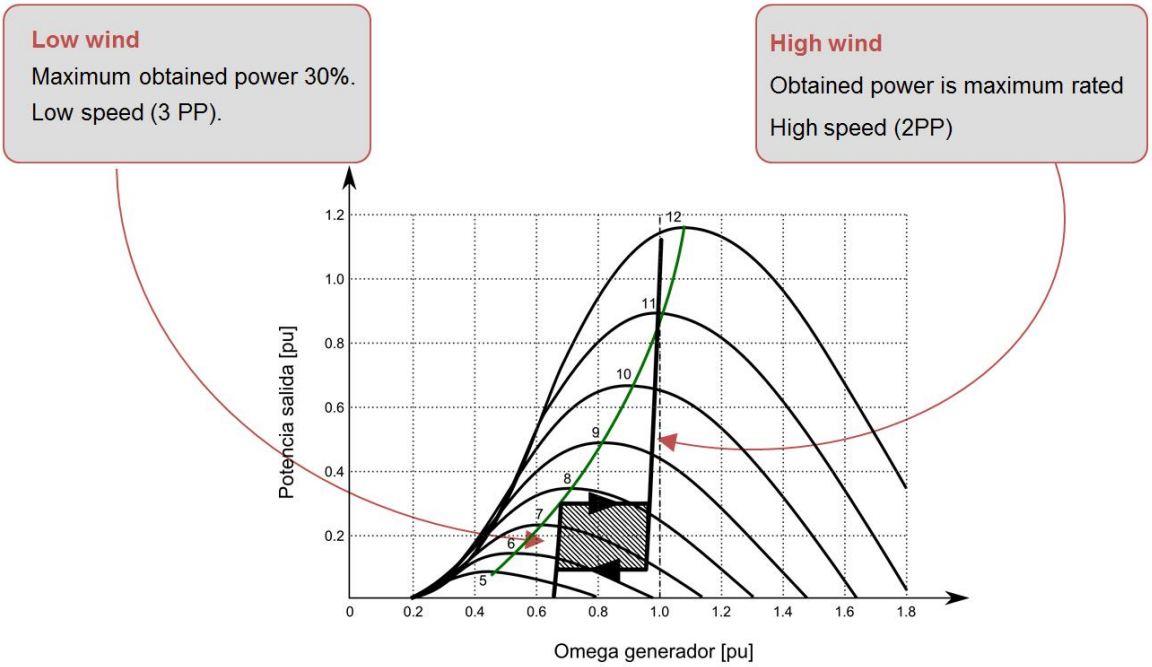


Figura. 2. ***Power Curve***

- Low energy efficiency.
- Mechanical stress, since the generator is directly connected to the grid, wind gusts represent energy produced through the drive train.
- Low frequency harmonics are fed into the grid, reducing the transport grid efficiency and disturbing consuming loads.
- Poor Power Factor (PF), reducing transport grid efficiency.
- FSWT turbines add capacitor banks and cause resonances in the PCC that may make unstable the transport grid.
- FSWT are not able to fulfill the FRT requirements.

CHALLENGES

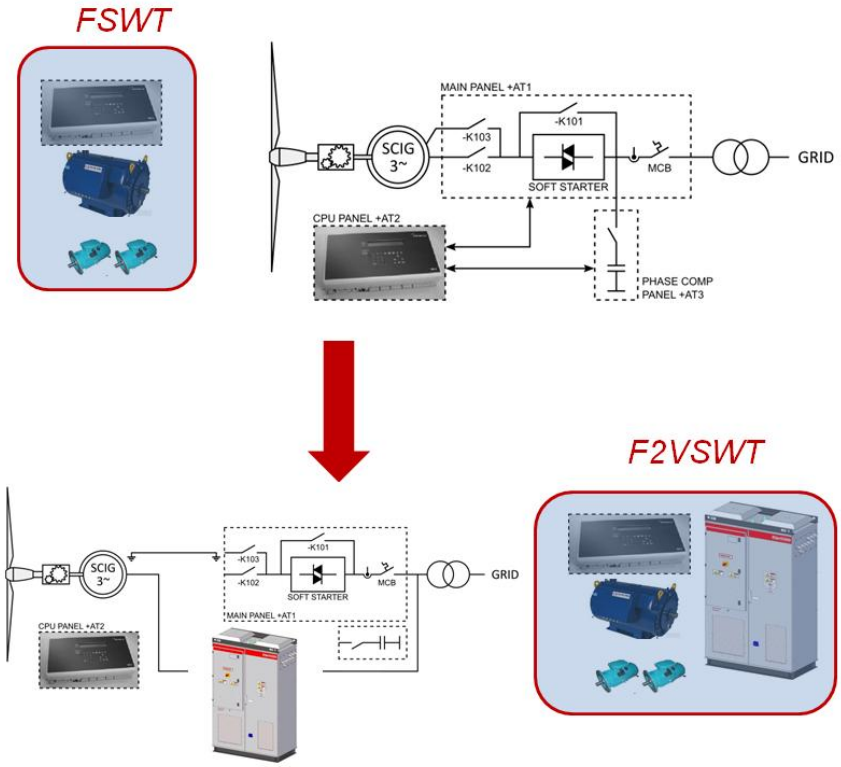
Challenges of the power conversion system to be developed:

- Fully autonomous solution, that does not require a new PLC controller
- Provide the WT with a variable speed (FC topology) performance.
- Control development to optimize the power curve (optimal Cp)
- Develop and integrate technology to:
    - Reduce the electrical generators demands.
    - Reduce mechanical stress
    - Improve the quality of the fed energy into the grid.
    - To comply with the requirements of the present grid codes.
    - Grid filter (comply with IEC61000-3-6)
- Control choice, so that several ΔAEP vs LTE strategies can be chosen.
- The solution must have a important ROI (Return on Investment).

SOLUTION

The goals proposed in the project have been achieved and a ground-breaking solution has been developed, allowing for the transformation of the FSWT into VSWT. Ingeteam has broadened its product portfolio integrating this technology in its new **INGECONWIND® FIX2VAR SPEED.**

The technological solution consists of a power converter between the SCIG generator and the grid transformer:



Transformation FSWT-VSWT.