Wind Turbine Architecture and Interconnection for Offshore Wind Farms

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Introduction

- Opportunity to utilise Ireland's offshore wind resource is coming more into focus.
- A number of possibilities exist for connecting offshore wind to the grid, including:
  - AC connection only.
  - AC to DC with power electronics converters at both generator and transmission level, see Fig 1.
  - AC to DC conversion just at the transmission converter level [1,2,3], see Fig 2.
- Power electronics have the highest failure rate in the wind turbine system [4] - fewer power electronic converters means greater wind farm reliability.

Objectives:

Comparison of Different Offshore Wind Farm Architectures

- **Develop models for wind turbine machines with different interconnection possibilities**
- **Provide understanding of design and control for different architectures**
- **Simplify existing wind turbine topologies – propose robust solutions**

MOTIVATION

- SCIGs (Squirrel Cage Induction Generators) offer low maintenance simple generator design for wind turbines.
- VSC-HVDC converter can integrate control for wind farm at a centralised location, see Fig 2.

  - Eliminate power electronics from individual turbines

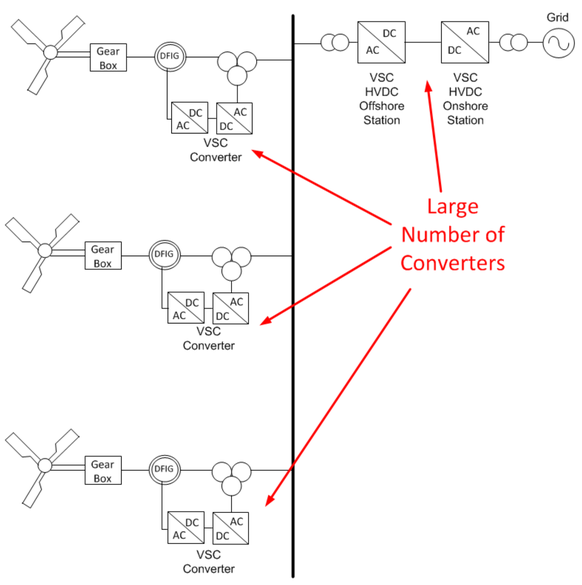

Fig. 1 DFIG Wind Farm configuration

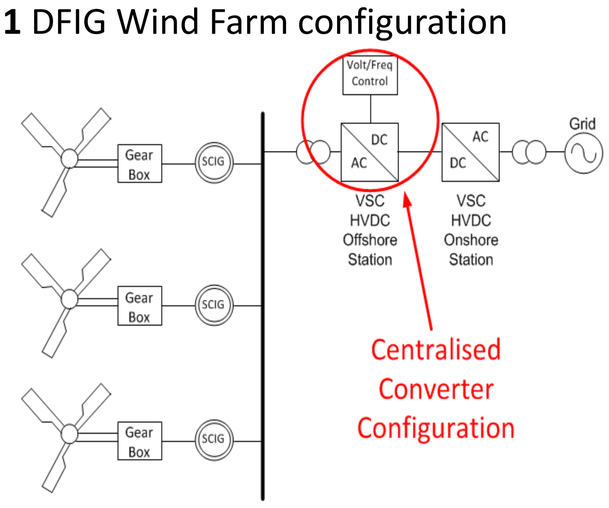

Fig. 2 SCIG Wind Farm configuration

VARIABLE SPEED WIND TURBINE CONTROL

- Power is maximised from wind - setting voltage/frequency at the offshore station.
- The operation of a number of turbines is optimised to operate at maximum power coefficient, Cp_{max}
- Calculate reference rotor speed from wind (*wref*) and voltage (*vset*)/frequency(*fset)* control looks to track this.
- Step by step operation of the system is displayed in Fig 3.

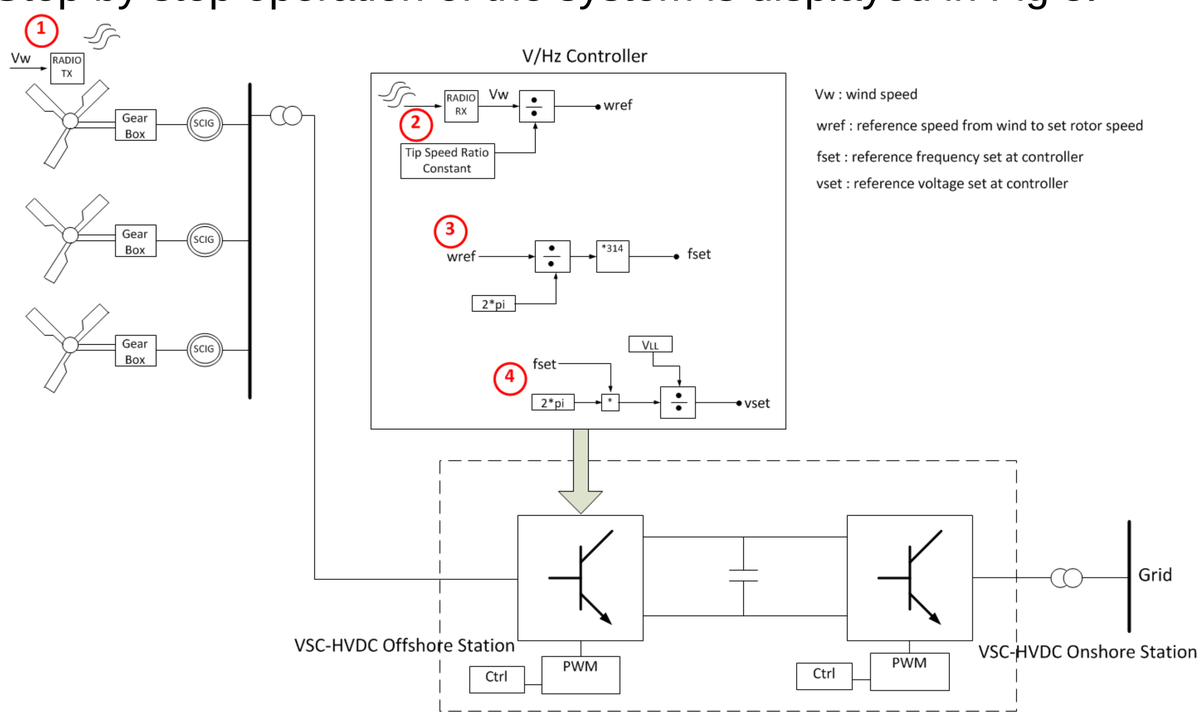

Fig. 3 Simple illustrative figure of system operation

INITIAL RESULTS

- Simulation analysis is undertaken using PSCAD/EMTDC.
- V/Hz controls rotor speed and tracks reference (*wref*) closely, see Fig 4.
- V/Hz response for wind step – constant V/Hz ratio, see Fig 5.

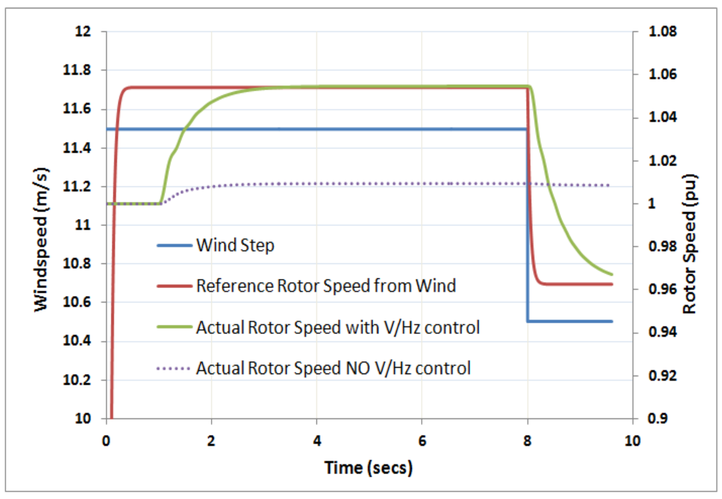

Fig. 4 V/Hz control response to step wind

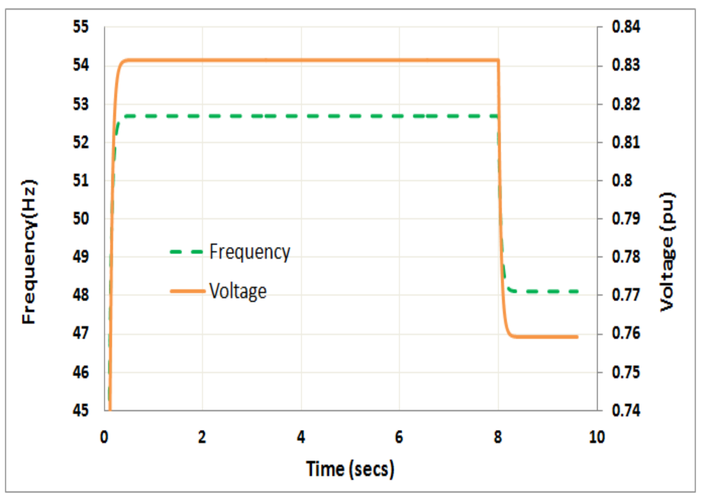

Fig. 5 V/Hz values for step wind of Fig 4

FUTURE WORK/QUESTIONS

- **Optimum wind farm configuration study must include technical feasibility, reliability analysis and cost metrics**
- **Selection of optimum frequency range for operation**
- **Detailed loss breakdown for the system, converter switching and transformer loss at different frequency settings**

REFERENCES

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