An investigation in the voltage response and fault handling capabilities of an Induction Generator Wind Turbine on the A1 Distribution Network

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Abstract

With projected increases in green energy production, the integration of these new technologies is becoming an increasing cause for concern. As such, this thesis aims to investigate the integration of a particular wind turbine technology, or configuration, on a specific section of the local South West grid (SWIS). This thesis will focus on steady state voltage stability, transient post fault generator response, and voltage decline due to the starting of the generators. It will also compare the transient findings of this turbine configuration to that of another turbine configuration.

The wind farm that is simulated will be called the *type A* Wind Farm, and consists of 12 Vestas V82 *type A* turbines. They are active stall controlled units, which connect the turbine rotor blade to the induction generator rotor via a gearbox. These are coupled with soft starters and are provided with reactive power compensation in the form of switchable capacitor banks. A step up transformer brings the generation voltage up to distribution level, which in this case is 22kV.

The A1 distribution network is a specific section of grid upon which all power flow calculations take place. This is an arbitrary name given to an actual section of network due to confidentiality reasons. It has been used as it lies on the extremities of the SWIS, and will best indicate how such a wind turbine generator will impact a weaker section of grid. It is also the same network used by Fidock (2010), for his studies on a *type D* turbine configuration, and as such will provide a good baseline for comparisons between the two technologies.

The findings of this thesis indicate that steady state operation of the *type A* turbine configuration produces voltages within acceptable limits. Starting of these generators can also be handled by

this section of the network, however soft starters are recommended and smart operator control is essential. Due to their high reactive power draw following a network fault, it is highly recommended that turbine configurations of this construct be disconnected from the grid post fault, and reconnected after the grid has stabilized. A comparison of the two different technologies indicates that *type A* has much less voltage and power flow control compared to *type D*. The results also indicate that widespread integration of *type A* wind turbine generators be extremely limited, and large wind farms of this technology should not be installed on the extremities of the grid.

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List of Abbreviations

t:	time
s:	seconds
SWIS:	South West Interconnected grid System
A1:	arbitrary name given to a specific section of distribution network on the SWIS
type A:	Induction generator fixed speed wind turbine generator concept
type D:	Variable speed with full scale frequency converter wind turbine generator concept
VA:	Volt amp, measurement of apparent power
VAr:	Volt amp reactive, measurement of reactive power
W:	Watt, measurement of real power
V:	Volt
p.u:	per unit
R_s:	Stator resistance
X_s:	Stator reactance
R_c:	Resistance representing core losses
X_m:	Magnetizing reactance
R'_r:	Rotor resistance
X'_r:	Rotor reactance
$R'_r(1\text{-}S) / S$:	Slip dependant rotor resistance
S:	Slip, percentage difference between rotor speed and synchronous speed
AC:	Alternating Current
DC:	Direct Current
rpm:	Revolutions per minute
Hz:	Cycles per second
k:	Kilo, x 10^3
M:	Mega, x 10^6
G:	Giga, x 10^9
α:	Blocking time per waveform, see Soft Starter
STATCOM:	Static synchronous compensator
I_{plant}:	Current flowing out of the wind generator
I_{shunt}:	Current flowing into capacitor banks
I_{line}:	Current flowing to the network
V_{pcc}:	Voltage level at point of common connection
$V_{inf.}$:	Voltage level at the network connection terminal
$k_{rl:}$	PowerFactory reduction factor for soft starters