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Optimal Sizing, Economic Analysis and Dynamic Behaviour of an Isolated Integrated Wind Turbine, Microturbine, and Battery Storage

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Abstract – *In this paper dynamic modelling, simulation and synthetic operation of adaptive control, supervisory control and space vector control are considered in a stand-alone hybrid power generation system of wind turbine, microturbine and battery storage. Due to efficient and economical utilisation of the renewable energy resources, optimal sizing of the hybrid system is fulfilled based on economic analysis using genetic algorithms. For extraction of maximum energy from a variable speed wind turbine, a developed Lyapunov model reference adaptive feedback linearisation method accompanied by an indirect space vector control is applied. Because of more reliability, more fuel flexibility, less environmental pollution, less noise generation and less power fluctuation in comparison with a diesel generator, a hydrogen based microturbine integrated with battery storage is suggested as a back up for this system.*

Keywords: *Optimal Sizing, Wind Turbine, Microturbine, Battery Storage, Adaptive Control, Supervisory Control*

Nomenclature

VSWT	Variable Speed Wind Turbine
HCS	Hill Climb Searching
PID	Proportional Integral Derivative
MPPT	Maximum Power Point Tracking
WECS	Wind Energy Conversion System
SOC	State of Charge
ISVC	Indirect Space Vector Control
SCIG	Squirrel Cage Induction Generator
PWM	Pulse Width Modulation
VSI	Voltage Source Inverter
SEIG	Self Excited Induction Generator
IGBT	Insulated Gate Bipolar Junction Transistors
ω_{opt}	Optimum Rotor Angular Speed (rads−1)
λ_{opt}	Optimum Tip Speed Ratio
R	Radius of Turbine Blade (m)
V_{wn}	Wind Speed (ms−1)
P_r	Rated Power
V_{rat}	Rated Wind Speed
V_{cout}	Cut-off Wind Speed
T_t	Torque of Turbine
$P_{MT,ref}$	Microturbine Reference Power
P_e	Eexcess or Deficiency Power
ACS	Total Annualised Cost
C_{acap}	Annualised Capital Cost
C_{arep}	Annualised Replacement Cost
$C_{ao\&m}$	Annualised Operation and Maintenance Cost
$C_{a\ fuel}$	Annualised Fuel Cost
ARC	Annualised Replacement Cost
SFF	Sinking Fund Factor
$C_{afuel}(MT)$	Annualised Fuel Cost
PI	Proportional and Integral
GTO	Gate Turned-off
C_{cap}	Initial capital cost
Y_{proj}	Component lifetime
CRF	Capital recovery factor

I. Introduction

Renewable energy is derived from natural phenomena such as sunlight, wind, tides and geothermal replenished constantly. Energy crisis, climate changes such as rising in temperature of the earth atmosphere due to increase of greenhouse gases emission and the Kyoto Protocol restrictions in generation of these gases, coupled with high oil prices, limitation and depletion of fossil fuels reserves make renewable energies more noticeable. Among the renewable energy resources, the wind energy has the most growth over the last decade. There are two types of the wind turbines: fixed speed and variable

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