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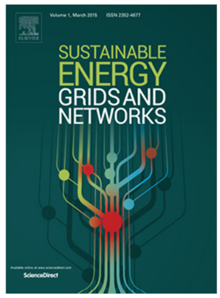

Submission to Sustainable Energy, Grid and Network Journal Stability of Renewable Energy based Microgrid in Autonomous Operation

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Stability of Renewable Energy based Microgrid in Autonomous Operation

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Abstract: This paper develops a comprehensive small-signal model of hybrid renewable-energy-based microgrid (MG) in an attempt to perceive oscillatory stability performance and capture the potential interaction between low-frequency critical modes within the MG. Trajectories of sensitive modes due to controller gain variations were evaluated in order to determine the stability boundaries. It was noticeable that various power-sharing schemes significantly influenced the small-signal stability of MG. Moreover, modal interaction emerged due to the proximity of RES-based DG units and non-linear dynamic behaviour of the sensitive modes. The interaction may result in a more oscillatory situation which potentially leads to instability of MG. The low-frequency critical modes obtained from eigenvalues analysis were then verified with the help of nonlinear time domain simulations. The presented work contributes to enhance the design and tuning of controller gain and proposes appropriate power-sharing scheme within MG.

Index Terms**—**Renewable MG, small-signal stability, eigenvalues, modal interaction.

Nomenclatures:

Notations of variables in the proposed MG model are given as follows:

Line and Load

i_{likDQ},	*D* and *Q* axis line current.
i_{loDQ}	*D* and *Q* axis load current.
v_{bkDQ}	D and Q axis local bus voltage.

Bio-Diesel (BDG) Generator

i_{kq1}, i_{kq2}	*q* axis rotor current.
i_{kd}	*d* axis rotor current.
i_{sdq}	*d* and *q* axis stator current.
i_{fd}	*d* axis field winding current.
T_{Mde}	Mechanical torque.
v_{fd}	*d* axis field winding voltage.
v_{sdq}	*d* and *q* axis stator voltage.
ω_{ref}	Angular frequency.
δ_d	Phase angle.

Two-stages PV system

i_b	DC/DC converter input current.
i_s	DC/DC converter output current.

Two-stages PV system

i_b	DC/DC converter input current.
i_s	DC/DC converter output current.
v_b	DC/DC converter output voltage.
v_{dc}	DC link/ DC side voltage of DC/AC inverter.
ρ_{pv}	auxiliary control variables of DC/DC converter
δ_{pv}	Phase angle of PV system.
p_{pv}	Active power of PV system.
q_{pv}	Reactive power of PV system.
φ_{dq}	Voltage control loop state variables.
β_{dq}	Current control loop state variables.
i_{idq}	*d* and *q* axis DC/AC inverter current.
v_{odq}	*d* and *q* axis output voltage.
i_{odq}	*d* and *q* axis output current.
i_{opvDQ}	*D* and *Q* axis PV output current in common reference frame.
v_g	Input voltage of PV system.
n_p	PV active power droop gain.
$\boldsymbol{n_q}$	PV reactive power droop gain.

Wind Energy Conversion System (WECS)

Induction generator

i_{sdq}	*d* and *q* axis stator current.
i_{rdq}	*d* and *q* axis rotor current.
ω_w	Angular frequency.
v_{sdq}	*d* and *q* axis stator voltage.
v_{sdq}	*d* and *q* axis stator voltage.
v_{rdq}	*d* and *q* axis rotor voltage.

DC/AC/DC system

γ	Variable of reference current calculation in Flux Oriented Control (FOC).
ρ_{wdq}	FOC state variables.
i_{indq}	*d* and *q* AC/DC converter current.
v_{dqin}	*d* and *q* input voltage of AC/DC converter.
δ_w	Phase angle of WECS.
p_w	Active power of WECS system.
q_w	Reactive power of WECS system.
φ_{wdq}	Voltage control loop state variables.
β_{wdq}	Current control loop state variables.
i_{iwdq}	*d* and *q* axis DC/AC inverter current.
v_{owdq}	*d* and *q* axis output voltage.
i_{owdq}	*d* and *q* axis output current.
v_{sdq}	*d* and *q* axis stator voltage.
v_{rdq}	*d* and *q* axis rotor voltage.
T_w	Mechanical torque.