DISTRIBUTED GENERATION POWER QUALITY ASSESSMENT USING A UNIFIED POWER QUALITY INDEX

By

Ghada Said Abdelmoteleb Elbasuony

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electrical Power & Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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Title of Thesis:

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Key Words:
Unified power quality index; Power Quality; Distributed Generation; Smart Grid ; Analytic hierarchy process (AHP) .

Summary:
The increasing growth of renewable energy systems changes the behavior of traditional central generation electric power systems, and the transition towards the smart grids should accommodate these changes. There are a variety of distribution generation (DG) systems configurations that can cause severe problems to the security and power quality (PQ) of the systems. Hence, it is important to evaluate and compare the impact of each of them on the system PQ. To date, there is no agreed upon approach to quantify the overall power quality performance of a system in the presence of distributed generation units because of the numerous power quality definitions, perspectives, and phenomena. The main objective of this research is to introduce a new unified power quality index (UPQI) to evaluate, assess and compare the effectiveness of different interface configurations with different sizing and siting of DG systems such as wind, photovoltaic (PV), and fuel cell energy systems under different operating conditions.

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Last but not least, no words of thanks and feelings are sufficient.

Dedication

I dedicate this work to the memory of my son Mohamed.

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Nomenclature

CI	Consistency index
CR	Consistency ratio
CSI	Correction factors for change in cell output current
CSV	Correction factors for change in cell output voltage
C_{TI}	Photocurrent temperature coefficient
CTV	Temperature coefficient
e	Electron charge
FDR	Frequency deviation ratio
f_m	The measured frequency at the fundamental harmonic order
f_r	Rated frequency at the fundamental harmonic order
Fp	Measured value of the factor p
Fs	Inverter switching frequency
h	Harmonic order
h_t	Harmonic tuning order
I	Number of the DG systems
$I0$	Reverse saturation current of diode
Ic	Cell output current
$Iphx$	Photocurrent at radiation S_x
Iph	Photocurrent
IFL	Instantaneous flicker level
I_h	The hth harmonic line current
J	Number of buses
R_F	Fundamental resistance of the STPF
Rs	Series resistance of cell
SS	Sag score
S_x	Radiation
T_c	Reference cell operating temperature
T_x	Working temperature T_x
THD_I	Current total harmonic distortion
THD_V	Voltage total harmonic distortion
V_c	Cell output voltage
V_{cx}	Cell output voltage at radiation S_x
k	Boltzmann constant
λ_{max}	Maximum eigenvalue of a judgment matrix
n	The judgment matrix dimension
N_f	Number of the selected factors that affect the PQ performance
PF	Power factor
P_{lt}	Long-term flicker severity value
PQI_G	Power quality index at the gr d bus

PQI_L	Power quality index at the load bus
PQI_{PV}	Power quality index at the PV bus
PQI_w	Power quality index at the wind bus
P_{st}	Short-term flicker severity value
q	Quality factor
ρ	Air density
V_h	The *h*th harmonic load voltage
V_W	Wind speed
C_P	Power coefficient
w_p	Weight of the factor *p*
X_C	Fundamental capacitive reactance of the STPF
X_L	Fundamental inductive reactance of the STPF
Z_h	The *h*th harmonic impedance of the STPF

List of Abbreviation

AHP	Analytic hierarchy process
ANN	Artificial neural network
AVR	Automatic voltage regulator
BREEAM	British Building Research Establishment Environmental Assessment met
D-FACTS	Distributed flexible AC transmission systems
DFIG	Doubly-fed induction generator
DFIG	Doubly-fed induction generator
DG	Distributed generation
EGPRS	Egyptian green pyramids rating system
FC	Fuel cell
FD	Frequency deviation
GS	Green Stars
HC	Hosting capacity
LV	Low voltage
LEED	Leadership in Energy and Environmental Design
NPC	Neutral point clamped
MPPT	Maximum power point tracking
MV	Medium voltage
PCC	Point of common coupling
PAFC	Phosphoric acid membrane fuel cell
PEMFC	Polymer electrolyte membrane fuel cell
PQ	Power quality
PQI	Power quality index
PV	Photovoltaic
SOFC	Solid oxide fuel cell
STPF	Single-tuned passive filter
THD	Total harmonic distortion
UPQI	Unified power quality index
VSI	Voltage source inverter
WMPID	Weighted-modified PID

List of Publication

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