Green Energy and Technology

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Protection of Wind Turbine Generators Using Microcontroller-Based Applications

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Green Energy and Technology

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This book dedicated to:
My mother, my sister, teachers, and friends for their love, encouragement, and endless support.
I give all thanks and gratitude to my dear husband Mohammed Eid, and to my little daughter Rodyna, wishing from God their protection.
Nagwa F. Ebrahim

Preface

We are presenting this book after study some applications on the Microcontroller Applications, specially protection of wind turbine generator. This work presents the design and implementation of a versatile digital Over Current (OC), Under Voltage (UV), Over Voltage (OV), Under Frequency (UF), Over Frequency (OF), and negative sequence relays using a single microcontroller. The software development and hardware testing are done using a microcontroller module based on an 8-bit microprocessor. Digital processing of measured currents is based on the CUSUM method in the programming. This protection provides reasonably fast tripping, even at terminal close to the power source were the most serve faults can occur, excluding the transient condition. So, this method provides an excellent balance between accuracy hardware and speed.

Motivated by economic and environmental concerns, renewable energies become of higher potential to meet the continuous increase of loads. Wind energy is one of the promising sources of renewable energy. Although the merits given by wind energy, the stochastic nature of wind is a big hinder of integrating wind power with utility grids. The wind changes over moments, hours, days, and year seasons. This book addresses the dynamic behaviour of a wind-driven induction generator (I.G.) connected to a power system grid through a transmission line. The transient responses of protective devices associated with the I.G. are also studied. A computer simulation of the system under different disturbances is conducted through the well-known matlab simulink. Disturbances considered are due to a variety of faults at the terminals of the generator as well as at the far end of the transmission line where it is connected to the load. Protective relaying strategy is proposed for the induction generator. The behaviour of different relays is studied under different disturbances.

Suez, Egypt — Nagwa F. Ibrahim
Port Said, Egypt — Sobhy S. Dessouky
Suez, Egypt — Hossam E. Mostafa Attia
Suez, Egypt — Ali H. Kasem Alaboudy

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List of Principal Symbols and Abbreviations

Symbols	Description
a, b, c, d, e, f, and g	The coefficients of the quadratic
b_{km}	The elements of this matrix
c	Filter output
g_1 and g_2	The cusum indices
i	Relay setting current
i_1, i_2, i_3, and i_4	Four equally spaced samples
K	Constant of induction Machine
N	Number of samples in a period
n, B	The quadratic form matrix
R_L, L_L	Resistance and inductance of load
Re, Le	Resistance and inductance of transmission line
s	Filter 2 outputs
S(n)	Sample value at instant n
T1	Threshold parameter
Y(n)	Index value
CUSUM	Cumulative sum method
CTs	Current transformers
cx	Three-phase static capacitors bank
CB	Circuit breaker
GWEC	Global Wind Energy Council
IG	Induction generator
IP	Pickup current
I_2	The negative phase sequence current
$I_2^2 t$	The rotor heating criterion
L-G	Single line to ground fault
L-L	Line to line fault
L-L-G	Double line to ground fault
L-L-L	Three phase fault
NREA	New and Renewable Energy Authority
PVES	Photovoltaic energy system
SCIG	Squirrel cage induction generator