(1)

Three Control Strategies to Improve the Microgrid Transient Dynamic Response During Isolated Mode: A Comparative Study

Rashad M. Kamel, Aymen Chaouachi, Member, IEEE, and Ken Nagasaka, Member, IEEE

Abstract:

The necessity to solve global warming problems by reducing CO2 emission in the electricity generation field had led to increasing interest in microgrids (MGs), particularly those containing the renewable sources such as solar and wind generation. Wind speed fluctuations cause high variations in the output power of a wind turbine which cause fluctuations in frequency and voltage of the MG during islanding mode and originate stability problems. In this paper, three techniques are proposed for solving and reducing the consequences of this problem. In the first technique, we develop a new fuzzy logic pitch angle controller. In the second technique, we design an energy-storage ultracapacitor which directly smoothes the output power of the wind turbine and enhances the performance of the MG during the islanding mode. In the third technique, storage batteries are used to support the MG in the islanding mode.

Keywords:

Index Terms—Dynamic response, fuzzy pitch controller, islanding, microgrid (MG), storage batteries, ultracapacitor, wind power smoothing.

Published In:

IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, APRIL 2013 , VOL. 60, NO. 4 ,

(2)

Multiobjective Intelligent Energy Management for a Microgrid

Aymen Chaouachi, Member, IEEE, Rashad M. Kamel, Ridha Andoulsi, and Ken Nagasaka, Member, IEEE

Abstract:

In this paper, a generalized formulation for intelligent energy management of amicrogrid is proposed using artificial intelligence techniques jointly with linear-programming-based multiobjective optimization. The proposed multiobjective intelligent energy management aims to minimize the operation cost and the environmental impact of a microgrid, taking into account its preoperational variables as future availability of renewable energies and load demand (LD). An artificial neural network ensemble is developed to predict 24-h-ahead photovoltaic generation and 1-h-ahead wind power generation and LD. The proposed machine learning is characterized by enhanced learning model and generalization capability. The efficiency of the microgrid operation strongly depends on the battery scheduling process, which cannot be achieved through conventional optimization formulation. In this paper, a fuzzy logic expert system is used for battery scheduling. The proposed approach can handle uncertainties regarding to the fuzzy environment of the overall microgrid operation and the uncertainty related to the forecasted parameters. The results show considerable minimization on operation cost and emission level compared to literature microgrid energy management approaches based on opportunity charging and Heuristic Flowchart (HF) battery management.

Keywords:

Index Terms—Fuzzy logic (FL), microgrid, multiobjective intelligent energy management (MIEM), neural network ensemble (NNE), short-term forecasting.

Published In:

IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, APRIL 2013 , VOL. 60, NO. 4 ,

(3)

Steady-state Modeling and Control of a Microgrid Supplying Irrigation Load in Toshka Area

Mazen Abdel-Salam, Adel Ahmed, Hamdy Ziedan, Rashad Kamel, Khairy Sayed, Mahmoud Amery and Mohamed Swify

Abstract:

This paper is aimed at sizing solar-wind-battery standalone microgrid for supplying irrigation and domestic loads in Toshka area, Toshka, Egypt. Not only the MG system components but also the interconnection cables and feeders are sized. Steady-state power flow through the MG system is analysed at varying sun irradiation and wind speed. Modeling of the MG components and their control of system voltages, currents and powers are investigated. Power flows during different MG operation conditions including absence of wind and sun as well as sudden disconnection of the load are studied

Keywords:

Hybrid Solar-Wind , Irrigation System , Toshka Area , control system , power flow

Published In:

IECON 2012 - 38th Annual Conference on IEEE Industrial Electronics Society , , 6

(4)

Maintaining stability of standalone Micro-Grid by employing electrical and mechanical fault ride through techniques upon fixed speed wind generation systems

Rashad M. Kamel

Abstract:

This study presents two different Fault Ride Through (FRT) techniques to keep and restore stability of Fixed Speed Wind Generation system (FSWGs) installed in standalone Micro-Grid (MG). The first technique is an electrical FRT and is implemented by inserting a series resistance with the terminals of FSWGs during fault to maintain reasonable value of terminal voltage and consequently help stability restoration. The second controller is a mechanical FRT controller and is performed by change the gear ratio of wind generation systems to spill part of extracted mechanical power and consequently improving stability issue. Obtained results proved that each controller able to maintain the stability of FSWGs under the most severe disturbance conditions (400 ms three phase fault at FSWGs terminals). The first controller is faster than the second controller in restoring FSWGs stability. Superior results and performances are obtained when the two FRT techniques are employed simultaneously. Without employing any one of the two FRT techniques, FSWGs is not able to maintain or restore its stability after fault clearing. Consequently, MG will lose one of its micro-sources and cannot keep its stability during the standalone mode, unless load shedding strategy is activated. The two proposed controllers are simple, effective, and economical attractive.

Keywords:

Micro-Grid Standalone mode Fixed speed wind generation system Fault ride through Series dynamic braking resistance Variable ratio gearbox

Published In:

Energy Conversion and Management , Vol. 74 , pp. 149- 161

(5)

Employing two novel mechanical fault ride through controllers for keeping stability of fixed speed wind generation systems hosted by standalone micro-grid

Rashad M. Kamel

Abstract:

This paper proposes and designs two novels Fault Ride Through (FRT) controllers for maintaining Fixed Speed Wind Generation system (FSWGs) stability during fault events. The first technique has been implemented by increasing the wind turbine blade pitch angle with maximum possible rate to reduce the mechanical extracted wind power and consequently suppress wind generation system acceleration. The second FRT technique has been verified by adapting gear ratio of wind generation system to run far from optimum maximum power point and help FRT process. Effectiveness of the two proposed FRT techniques has been proven by accurate simulation of the most severe disturbance conditions. Also, Results indicated that second technique gives faster response than the first one. Without employing any FRT technique, FSWGs cannot keep its stability and the standalone Micro-Grid (MG) transfers to the blackout mode. Implementation the two FRT techniques requires no additional hardware. Only, control algorithms need little modification to deal with fault event and help FRT process. This fact makes the two proposed FRT techniques are simple, practical and highly economical attractive.

Keywords:

Standalone micro-grid Fixed speed wind generation system Fault ride through Modified pitch angle controller Variable ratio gear box

Published In:

Applied Energy , , PP.398408

(6)

Effect of wind generation system types on Micro-Grid (MG) fault performance during both standalone and grid connected modes

Rashad M. Kamel

Abstract:

Recently, there are three wind generation (WG) system types. The first type is called Fixed Speed Wind Generation (FSWG) system, which employs squirrel cage induction generators. Double Fed Induction Generator (DFIG) is utilized in the second type. The third type is called Full Converter Wind Generation (FCWG) system, which is interfaced with Micro-Grid (MG) through a back to back converter. During fault occurrence, each WG has its performance and characteristics which are determined by the generator physical characteristics and the MG earthing system configuration. For some WG types, the fault current depends also on the control algorithm of the power converter. The main target of this paper is to investigate and estimate how the fault performance of MG during both standalone and grid-connected modes is influenced by the type of WG. It is found during standalone mode that the type of the employed WG has a dominant impact on the MG performance under fault disturbance. On the contrary, the type of the employed WG has a negligible effect on the MG fault performance during grid-connected mode. This is because the main grid contributes most of the fault current. Effects of earthing system type on MG performance are highlighted.

Keywords:

Micro-Grid Standalone mode Earthing systems Fault current Touch voltage Wind generation system type

Published In:

Energy Conversion and Management , vol.79 ,No.1 , 232-245

(7)

Three fault ride through controllers for wind systems running in isolated micro-grid and Effects of fault type on their performance: A review and comparative study

Rashad M.Kamel

Abstract:

This paper presents survey about Fault Ride Through (FRT) techniques and controllers which employed with all wind generation system types. After presenting a comprehensive FRT survey, paper proposes three Fault Ride Through (FRT) controllers for keeping stability of Fixed Speed Wind Generation (FSWG) system serving in isolated Micro-Grid (MG). The first controller has been implemented by inserting Superconductor Fault Current Limiter (SFCL) in series with wind generator terminals during fault instant. The second proposed FRT controller is modifying the conventional Pitch Angle Controllers (PAC) to can spill and reduce high percentage of extracted mechanical wind power during and subsequent fault occurrence which in turns help stability improvement and restoration. Third FRT technique is performed by adapting the wind turbine gearbox ratio which forces the wind generation system to run far from the maximum power point. The best performance is obtained with the SFCL controller. Superior results are obtained when the three proposed FRT controllers are employed simultaneously. The three developed FRT controllers are simple, reliable and economical attractive. Effects of fault type on SFCL FRT controller performance are analyzed and investigated in details. The proposed SFCL FRT controller has been tested under single phase, double phase, phase to phase, and three phases to ground faults. Results display that the three phases to ground fault is the most severe type on SFCL FRT performance from stability point of view. On the other hand, double phase to ground fault is the most severe one from fluctuations and oscillations points of view. Parameters of the SFCL must be adjusted based on the three phases to ground fault. If the SFCL FRT controller is designed to can deal with three phases fault, it sure can deal with the other fault types successfully.

Keywords:

Isolated micro-grid; Fault ride through; Fixed speed wind generation system; Super conductor fault current limiter; Modified pitch angle controller; Variable ratio gearbox; Fault type

Published In:

Renewable and Sustainable Energy Reviews , Vol.37 , No.6 , 698-714

(8)

Errors Analysis in Distance Relay Readings with Presence of FACTS Devices

Gaber El-Saady, Rashad M Kamel, Essam M Al

Abstract:

This paper presents studying the performance of distance impedance relay with the presence of FACTS devices. Also the measured impedance at the relaying point in the presence of series FACTS device SSSC, and shunt FACTS device called STATCOM are obtained. A detailed model of both SSSC and STATCOM is introduced and then the faulty system is studied analytically, where the errors in the measured impedance of distance impedance relay are introduced as a result of the presence of series and shunt FACTS

Keywords:

Distance Relay, FACTS devices, STATCOM

Published In:

Innovative Systems Design and Engineering , 4 , 112-130

(9)

Standalone micro grid power quality improvement using inertia and power reserves of the wind generation systems

Rashad M. Kamel a, b, *

Abstract:

This paper proposes two controllers for employing part of variable speed wind generation systems kinetic energy in supporting the standalone MG frequency. The first controller acts similar to the frequency droop control, while the second controller emulates both the inertia response and the frequency droop control simultaneously. The MG frequency dropped only to 49.9 Hz with employing the proposed controllers compared with 49.68 Hz without employing the proposed controllers. Also, the injected active power from the storage device dropped from 20 kW to only 3 kW after employing the proposed controllers. In addition, the reactive power capability of the Double Fed Induction Generator (DFIG) wind generation system has been employed to maintain the standalone MG bus voltage at acceptable level. If there are fixed speed wind generation systems in the standalone MG, this paper proposed using the pitch angle controller to employ a suitable wind turbine power reserve in MG frequency supporting during the standalone mode. Results proved the effectiveness of the proposed controllers in improvement the MG overall performance during and subsequent the islanding occurrence.

Keywords:

Standalone MG MG frequency regulation Inertia and frequency droop DFIG inertia Pitch angle power reserve DFIG reactive power capability

Published In:

Renewable Energy , Vol. 97 , pp. 572-584

(10)

Effect of load type on standalone micro grid fault performance

Rashad M. Kamel a,b,, Ken Nagasaka c

Abstract:

This paper studies the influence of the load type on the fault performance of the standalone Micro Grid (MG). Different load types (static and dynamic) are considered to show their effects on the standalone MG fault behavior. Specifically, the effects of constant power static loads, constant impedance static loads, and constant current static loads are analyzed. Also, effects of dynamic (rotating) loads are highlighted. Results show, that the rotating loads have dominant effects on the fault performance of the MG during the standalone (islanded) mode. Furthermore, rotating loads cause fault currents and touch voltages three times the values associated with the static loads. Consequently, the employed protective devices with the rotating loads MG must be rated three times larger than the employed protective devices with the static loads MG. Also, the time settings of the MG protection devices are highly influenced with the load type. For static load MG, it is equal to 250% of the rotating loads MG protection devices time settings. The three types of static load show different impacts on islanded MG fault performance. Constant power static load has the highest effect compared to the other two static load types (namely, constant impedance and constant current static loads). The results obtained in this study provide a guide for the MG protection designers and planners to consider the effects of load type on the MG protection devices rating and setting.

Keywords:

Stand alone MG MG fault performance Dynamic loads Static loads Protective device ratings and settings

Published In:

Applied Energy , Vol. 160 , pp. 532540

(11)

Newinvertercontrolforbalancingstandalonemicro-gridphase voltages:AreviewonMGpowerqualityimprovement

Rashad M.Kamel a,b,n

Abstract:

StandaloneMicroGrid(MG)suffersfromhighvoltageunbalancingduetobothsinglephaseandunba- lanced loads.Thispaperpresentsacomprehensivesurveyabouttheavailabletechniquesandcontrollers for MGpowerqualityimprovement.Recenttrendsandschemesforthestandalone MGpowerquality improvementarereportedindetail.Thetechniqueswhichconcernwiththe MGvoltageunbalancing issue arehighlighted.Inaddition,thispaperdevelopsasimpleschemeforbalancingtheMGphase voltages.Theproposedschemeemploysanewinterfacinginvertertopologyandcontrol.Thethreephase compact unitinterfacinginverteroftheDistributedGenerators(DGs)hasbeenrebuiltinformofthree single phaseinverterunits.Eachsinglephaseinverterunitiscontrolledindependentlytoachieve MG phase voltagebalancing.Atdifferentloadoperatingconditions,thethreesinglephaseinverterunitsrun at differentvaluesandtypes(leadingorlagging)powerfactors(PF).Employingtheproposedinverter control achievesperfectphasevoltagesbalancingatthemostMGbuses.Beforeemployingtheproposed invertercontrol,thevoltageunbalancingratioatsomebusesexceedsthan6%.Thisratioapproximately shrinks tozeroafterincludingtheproposedinvertercontrol.Theperformanceoftheproposedinverter control hasbeentestedunderdifferentloadconditions.Inaddition,theperformanceoftheproposed invertercontroliscomparedwithboththeoldinvertercontrol(unitypowerfactorinverter)andthe conventionalinvertercontrol(constantpowerfactorinverter)performance.Only,asimplemodification to theoldinvertercontrolissufficient toimplementthenewinvertercontrol.Theproposedinverter control isverysimpleandhighlyeconomicalattractive

Keywords:

StandaloneMG Powerqualityimprovement Phase voltagesunbalancing Invertercouplinginductance Adaptivepowerfactorinterfacinginverte

Published In:

RenewableandSustainableEnergyReviews , Vol. 63 , pp. 520□532

(12)

Hybrid and coordinated soft starting controller for wind generation system runs in the standalone Micro Grid

Rashad M. Kamel

Abstract:

Low rating and individual characteristics of the Distributed Generators (DGs) make the standalone Micro Grid (MG) weak power system. When the standalone MG contains wind generation system, special care should be taken during the starting process of the wind generation system to avoid the MG instability. This study proposes a new soft starting controller to improve the starting process of the wind generation system. In the proposed controller, both the wind turbine blade pitch angle (mechanical) and the thyristor switches firing angles (electrical) are coordinated, and controlled simultaneously. The coordination aims to minimize and suppress the undesirable effects and consequences of the wind generation system starting on the standalone MG performance. With employing the proposed hybrid and coordinated controller, the wind generator starting current grows very slowly until it reaches its rated value. On the other side, without employing the proposed controller, the wind generator starting current suddenly jumps and exceeds 400% of its rated value. Also, without employing the proposed controller, the MG frequency drops to less than 49.3 Hz. In addition, the voltage at MG buses drops to 0.9 p.u. in absence of the proposed controller compared with 0.95 p.u. if the controller is employed. The novelty on the proposed controller is the coordination between the thyristor valve firing angle (electronic) and the wind turbine blade pitch angle (mechanical) to achieve the desired performance. The overall performance and the power quality of the standaloneMGhave been highly improved after employing the proposed coordinated hybrid soft starting controller.

Keywords:

Standalone Micro Grid Wind generation system starting Coordinated & hybrid soft starting controller Thyristors firing angle, and wind turbine blade pitch angle

Published In:

Sustainable Energy, Grids and Networks , NULL , pp. 105 - 113

(13)

NovelandsimpleschemeforMicro-Gridprotectionbyconnectingits loads neutralpoints:AreviewonMicro-Gridprotectiontechniques

Rashad M.Kamel a,b,n, MohammadA.Alsaffar a, M.K.Habib a

Abstract:

ThelowfaultcurrentphenomenainthestandaloneMicro-Grid(MG)isaresultofelectronicinterfacingof theMGDistributedGenerators(DGs).DuetolowfaultcurrentphenomenaonthestandaloneMG,thereis a difficultyindifferentiatingbetweenthefaultdisturbanceandtheoverloadconditions.Thispaperpresentsacomprehensivesurveyaboutthestandalone MGprotectionissuesandschemes.Allnewtrendsand schemesavailableandsuggestedforMGprotectionduringboththegridconnectedandthestandalone modesaredescribedindetails.Also,thispaperpresentsasimpletechniqueforsolvingtheproblemsdueto lowfaultcurrentphenomenainthestandaloneMG.Theproposedtechniqueisimplementedbyconnectingall MGloadsneutralpointswiththeMGearthingsystemneutralline.Theproposedtechnique suppressesthetouchvoltagesatallMGbuses.Also,theproposedschemeresultsindoublingtheMGfault currentinthestandalonemode.Consequently,theMGprotectiondevicescaneasilydetectanddifferentiatebetweenthefaultdisturbancesandtheoverloadconditions.Also,theproposedtechniquedamps andsuppressesthetouchvoltagenotonlyatfaultlocationbutalsothroughalltheMGnetworkbuses.The mostcommonfaulttypes(singlephasetogroundanddoublephasetoground)areanalyzedindetails. Resultsprovedthat,employingtheproposedtechniqueabletosolvethelowfaultcurrentandthetouch voltagesproblemsfromtheirroots.Noadditionalhardwareisrequiredforimplementingthenewscheme. Theproposedtechniqueisverysimpleandhighlyeconomicalattractive.

Keywords:

StandaloneMG Adaptiveprotectionscheme Voltage basedprotectionscheme Differential protectionscheme Distance protectionscheme MG loadneutralpointconnection

Published In:

RenewableandSustainableEnergyReviews , NULL , pp. 931942

(14)

-Design and Implementation of a Multifunction DSP-based Numerical Relay

Mazen Abdel-Salam, Rashad Kamel, Khairy Fathy and Mohsen Khalaf

Abstract:

This paper is aimed at proposing a multifunction numerical relay (MNR) for protection against over-current, over- and under-voltage and over- and under-frequency. The MNR serves also as a directional relay. The performance of the MNR is investigated through simulation using MATLAB/Simulink and implementation of a prototype using TMS320F28335 Experimenter Kit. The MNR trips a circuit breaker at abnormal conditions of current, voltage and frequency. The novelty of the proposed relay lies on being a numerical compact-sized relay serving multi protection functions.

Keywords:

Protection; Photovoltaic; Numerical relay; DSP

Published In:

Electric Power System Research , Volume 143 , 32□43