A Conceptual Mission to Power Streak Breakthrough for Four Bus Micro-Grid System by Sliding Mode Controller with HPFC Technique

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Abstract: HPFC (Hybrid Power Flow Controller) with Sliding Mode Control (SMC) in Micro-grids includes low voltage distribution systems with distributed energy resources and controllable loads that can operate in medium voltage grid connected mode or in islanded mode. It provides environmental and economic benefits for end-user, utilities and society. In this chapter, principles and the design procedure of the conventional HPFC with sliding mode control (SMC) is to be executed in simulation method as well as mathematical theory and execute the outbreak to option power streak breakthrough.

Key Word: Sliding Mode Controller (SMC), Variable Structure Control System (VSCS), Mass-Spring-Damper System (MSDS), Fuzzy Logic Controller (FLC), Hysteresis Control, FACTS, Multi Bus System (MBS)

1.INTRODUCTION

Economic growth and growing populations are changing customers’ demand for power. Governments and industry are moving towards renewable energy sources such as solar and wind power. At the same time, advancements in digitalization have already transformed many industries. Micro-grids and hybrid systems meet the growing demand for more flexible, sustainable and cost-effective solutions. Micro-grids are decentralized energy systems consisting of a combination of renewable power generation, power storage and conventional power generation in order to meet a given demand. A micro-grid may be off-grid or on-grid, and a centralized controller is in place to optimize the way the system operates.

Hybrid power is the best way to expand your energy supply while reducing its environmental impact. The region has a high availability of renewable resources such as wind and solar. These are currently of particular interest for urban, utility, and industrial applications. Hybrid power solutions can help you integrate renewable with energy storage, robust thermal power plants, and clean LNG to create sustainable solutions. The Hybrid Power Flow Controller (HPFC) is shown here to provide an adequate solution to the application of Flexible AC Transmission Systems (FACTS) controllers to distribution systems, and hence the merits and the added value of this controller are detailed with modeling and simulations, examining its impact on a distribution system under different conditions.
2. ANALYSIS OF EXCITING SYSTEM

2.1 Sustainable Multi Bus Micro-Grid System

Figure: 1 Layout of General Sustainable Multi Bus Micro-Grid System

Figure: 1 is shown as Micro-grid which is capable of operating in grid-connected and stand-alone modes and of handling the transition between the two. In the grid-connected mode, ancillary services can be provided by trading activity between the Micro-grid and the main grid. Other possible revenue streams exist.[2] In the islanded mode, the real and reactive power generated within the Micro-grid, including that provided by the energy storage system, should be in balance with the demand of local loads. Micro-grid’s offer an option to balancing the need to reduce carbon emissions while continuing to provide reliable electric energy in periods of time that renewable sources of power are not available. Micro-grid s also offer the security of being hardened from severe weather and natural disasters by not having large assets and miles of above-ground wires and other electric infrastructure that needs to be maintained or repaired following these events.[3][4]

A Micro-grid may transition between these two modes because of scheduled maintenance, degraded power quality or a shortage in the host grid, faults in the local grid, or for economical reasons.[4][5] By means of modifying energy flow through Micro-grid components, Micro-grid s facilitate the integration of renewable energy generation such as photovoltaic, wind and fuel cell generations without requiring re-design of the national distribution system.[4][5][6] Modern optimization methods can also be incorporated into the Micro-grid energy management system to improve efficiency, economics, and resiliency.
2.2 Hysteresis Controlled MBS-Micro-Grid with HPFC

Among hysteresis control methods, the most well-known is the hysteresis current control [4]. The implementation of hysteresis control methods has been done either in analog or digital form. A hysteresis band is defined, and if the feedback signal is above that band, the plant is operated in one state; if it is below that band it is operated in the other state. If the feedback is within the band, the operating state is left unchanged. Hysteresis control is widely employed.

Every time the error between control references and control variables crosses either the positive or negative hysteresis band's boundary, a significant change in the controller's output ($S_w$) occurs as shown in Fig. A. Thus the controller quickly reacts to any deviation from control references, which are the reason of the high gain behavior of these controllers. Notice that the digital implementation of hysteresis control methods does not guarantee the control variable ripples to be within the limits of a specified hysteresis band. This situation is illustrated in the zoomed view inside Fig. A. For that reason, in most of the cases, the operation of digital hysteresis controllers does not match the behavior of the analog ones.
2.3 Fuzzy Logic Controlled MBS-Micro-Grid with HPFC

Figure: 3 is shown as a typical fuzzy control system which consists of four components: Fuzzification Interface: The fuzzification interface performs a conversion from a crisp point into a fuzzy set. The shapes of the membership functions of the linguistic sets are determined according to the expert experience. Defuzzification Interface: The defuzzification interface converts the fuzzy output of the rule-base into a non-fuzzy value. The center of area (COA) is the often used method in defuzzification. It is a robust system where no precise inputs are required. These systems are able to accommodate several types of inputs including vague, distorted or imprecise data. In case the feedback sensor stops working, you can reprogram it according to the situation. The Fuzzy Logic algorithms can be coded using less data, so they do not occupy a huge memory space. As it resembles human reasoning, these systems are able to solve complex problems where ambiguous inputs are available and take decisions accordingly. These systems are flexible and the rules can be modified. The systems have a simple structure and can be constructed easily. The accuracy of these systems is compromised as the system mostly works on inaccurate data and inputs. There is no single systematic approach to solve a problem using Fuzzy Logic. As a result, many solutions arise for a particular problem, leading to confusion. A major drawback of Fuzzy Logic control systems is that they are completely dependent on human knowledge and expertise and regularly update the rules of a Fuzzy Logic control system. The systems require a lot of testing for validation and verification. Due to inaccuracy in results, research is going to be search advance technology.
3. PROPOSED SLIDING MODE CONTROLLED MBS-MICRO-GRID WITH HPFC

Sliding mode control is a particular type of the variable structure control system (VSCS), which is characterized by a discontinuous feedback control structure that switches as the system crosses certain manifold in the state space to force the system state to reach, and subsequently to remain on a specified surface within the state space called sliding surface. The switching function (sliding variable) is a function of the states and the sliding surface represents a relationship between the state variables. The system dynamics when confined to the sliding surface is referred as an ideal sliding motion and represents the controlled system behavior, which results in reduced order dynamics with respect to the original plant. This reduced order dynamics provides attractive advantages such as insensitivity to parameter variations and matched uncertainties and disturbances, making sliding mode control an appropriate method for robust control. Moreover, sliding mode control scheme offers a simple algorithm which can be implemented easily.

3.1 Layout of Sliding Mode Controller Signed with Grid

The design of sliding mode control law consists of the construction of a suitable sliding surface so that the dynamics of the system confined to the sliding manifold produces a desired behavior, and the design of a discontinuous control law which forces the system trajectory to the sliding manifold and maintains it there. This strategy provides good performance, such as insensitivity to non-linearity of system. Yet, the theory of first sliding mode has faced the problem of chattering, which proved to be a major drawback. To overcome this problem, a control strategy using sliding mode of higher order was implemented on the basis of the super-twisting algorithm.

Figure: 4 Sliding Mode Controlled MBS-Micro-Grid with HPFC

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3.2 Simulation

Figure 5 Simulation Link for Sliding Mode Controller with HPFC

Figure shows a trajectory of a system under sliding mode control. The sliding surface is described by and the sliding mode along the surface commences after the finite time when system trajectories have reached the surface. In the theoretical description of sliding modes, the system stays confined to the sliding surface and need only be viewed as sliding along the surface. However, real implementations of sliding mode control approximate this theoretical behavior with a high-frequency and generally non-deterministic switching control signal that causes the system to "chatter" in a tight neighborhood of the sliding surface. Chattering can be reduced through the use of dead bands or boundary layers around the sliding surface, or other compensatory methods. Although the system is nonlinear in general, the idealized (i.e., non-chattering) behavior of the system in Figure 1 when confined to the surface is an LTI system with an exponentially stable origin.
4. PERFORMANCE PLOT - SMC -MICRO-GRID WITH HPFC

4.1 Voltage and Current Response

![Voltage and Current Graph]

4.2 Active, Reactive Power and Power Factor Response

![Active and Reactive Power Graph]

5. CONCLUSION

The Simulation outcome, represent the ability of the H.P.F.C in improving the power-steak Breakthrough by using Slide mode controller in Micro Grid. Design procedure of the conventional sliding mode control is discussed. The main disadvantage of the conventional sliding mode control is the dangerous chattering phenomenon. The chattering effect can be reduced by sliding mode control with a boundary layer in which the discontinuous sign function of the sliding mode control is replaced by a saturation function. However, sliding mode controller with a boundary layer degrades the tracking performance. The tracking time and tracking error increases with an increase in the boundary layer thickness. If the boundary layer thickness is not properly chosen, the controller may lead to unacceptable performance. Due to that search go with Model Predictive Controller to be analyzed in next paper.
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