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Grid-Connected Hybrid Microgrids Using Modified UIPC for Power Flow Control of Interconnected AC-DC Microgrids Using ANN

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Abstract

This research proposes a new method for power flow regulation of interconnected AC-DC microgrids in grid-connected hybrid microgrids based on a modified unified interphase power controller (UIPC). The examined system is a standard grid-connected hybrid microgrid with one AC microgrid and one DC microgrid. These microgrids are linked together using a modified UIPC rather than parallel-connected power converters. The typical UIPC structure, which requires three power converters in each phase, is adjusted as the first contribution of this study, such that power exchange control across AC-DC microgrids is implemented with a lesser number of power converters. One power converter in each phase, referred to as a line power converter (LPC), and a power converter that regulates the DC bus voltage, referred to as a bus power converter (BPC), are included in the redesigned structure.

The AC microgrid is linked to the main grid by LPCs, which include DC buses that can function in either capacitance mode (CM) or inductance mode (IN) (IM). The LPCs' control structures use a fuzzy logic controller. To eliminate errors in membership function design, the fuzzy inference system is optimized using the H∞ filtering method. The DC microgrid supplies the LPCs' DC voltage via the BPC. The DC microgrid voltage is provided here by a PV system, hence the LPCs' DC link voltage fluctuates. As a second contribution, a new nonlinear disturbance observer-based robust multiple-surface sliding mode control (NDO-MS-SMC) technique for DC side control of the BPC is provided to stabilize the DC link fluctuations. The simulation results show that the proposed power flow control technique for hybrid microgrids in the upgraded UIPC is successful. In this research proposes further extension artificial neural network (ANN) is using to control the UIPC converters.

Index Terms: UIPC, power control, disturbance observer, multi-surface SMC, hybrid microgrid.

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I. INTRODUCTION

DC power resources such as photovoltaic (PV) systems, fuel cells (FCs), energy storage systems (ESSs), and newly introduced DC loads such as programmable DC electronic loads and others have entered traditional power networks through DC microgrids over the last ten years. AC power resources such as wind turbines and other AC loads such as electrical motors, on the other hand, can be connected to power networks via AC microgrids. The AC and DC microgrids, which include AC and DC power resources and loads, are integrated as a hybrid system called hybrid microgrids in future smart grids.

The power converters really link the AC and DC microgrids together. When the microgrids need to transfer electricity, they can do so using this link. To interchange a higher amount of power and improve reliability, power converters are frequently connected in parallel. A typical grid-connected hybrid microgrid's structure is shown in Fig. 1. PV systems, ESSs, and related loads are all connected to a common DC bus in this diagram. Wind turbines, diesel generators, and AC loads coupled to a common AC bus can all be found in an AC microgrid. The hybrid microgrid as a whole can be connected to the power system or isolated. Interlink power converters (ILCs) are parallel-connected bidirectional power converters that connect the common buses (links) of two microgrids, as shown in Fig. 1.

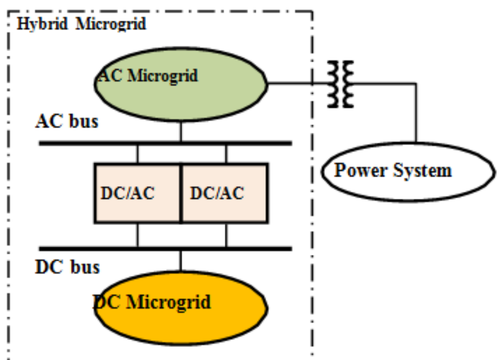

Fig.1. A typical grid-connected hybrid microgrid

Many methods and control strategies have been developed in the literature to overcome the challenges outlined above. Proposes a hierarchical control scheme for parallel-connected bidirectional ILCs. The control method's platform was created in a stationary reference frame (SRF), with no mutual terms between axes and harmonic correction. Because it was built in the SRF, this method has the advantage of being simple to implement. Proposes a droop control-based hierarchical control technique, with the first control level employing a droop scheme. Proportional-integral (PI) controllers were employed on the DC side, while the proportional-resonant (PR) controller was used on the AC side. The

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ripple caused by the first level control action was modulated by the second control level, and the third control level was utilized to connect the hybrid microgrid to the utility.

I. PROPOSED UIPC BASED HYBRID MICROGRID STRUCTURE AND DYNAMIC MODELING

The proposed hybrid microgrid topology for the UIPC is described in this section. This part also includes the dynamic model of the improved UIPC. The hybrid microgrid under investigation is depicted in Figure 2. One AC microgrid and one DC microgrid are interconnected through the UIPC in the grid-connected hybrid microgrid, as depicted. A diesel generator and associated AC and DC loads compose the AC microgrid. The DC microgrid includes a PV system, a battery, and AC and DC loads. The common DC bus connects the loads, the PV system, and the batteries (DC link).

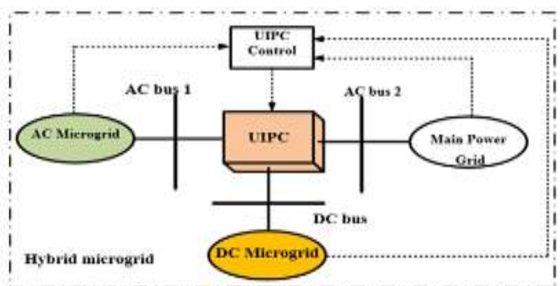

Fig.2. UIPC is used to connect AC-DC microgrids in a grid-connected hybrid microgrid.

A. Conventional UIPC

The UIPC's per-phase model has been presented in. And as seen in Fig. 3. The phase-shifting transformers of the interphase power controller (IPC) were replaced by voltage source converters in this construction (VSCs). Thus, in each phase, two AC buses, V1 and V2, are coupled through three VSCs, VSC1, VSC2, and VSC3. VSC1 and VSC2 are phase-shifting converters, whereas VSC3 is a voltage regulator. VSC1 is an inductive circuit that injects the series voltage Vse L into the line via transformer T1.

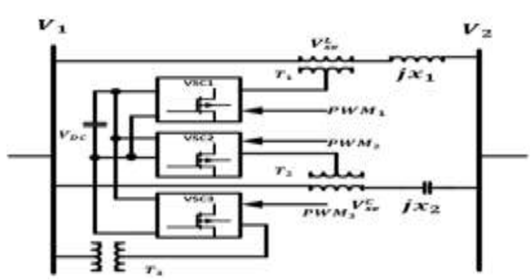

Fig.3.the UIPC's traditional structure, with three power converters in each phase.

B. Proposed structure of UIPC

To begin, the conventional UIPC's topology, as explained in the preceding subsection, will be altered. The improved UIPC's control technique will then be shown in the following subsection.

The UIPC's traditional structure, as seen in Fig. 3, has the following deficiencies:

- Since each phase uses three VSCs, connecting three phases of AC buses requires nine VCSs and nine power transformers, creating the design extremely expensive.

$$Vse = KAVDC\angle\, KP\varphi se \quad (1)$$

Where, KA and KP are voltage amplitude and phase coefficients, respectively. The voltage amplitude coefficient KA is indeed a function of pulse width modulation (PWM) strategy and the phase coefficient KP is ±1 and φse is usually equal to $\pi/2$. The switches $S1$and $S2$are anti-parallel thyristors and would be coordinated by the injected voltage phase angle through the control system.

$$\varphi_{se}^{L} = \varphi_1 + \alpha_1 \quad (2)$$

$$\varphi_{se}^{C} = \varphi_2 + \alpha_2 \quad (3)$$

These angles are calculated by considering different operation modes of the UIPC, i.e. IM or CM. In Equations (2)-(3), $\varphi se\ L$ and $\varphi se\ C$ are the phase angle of the voltage at the middle point of the transmission line, when the UIPC operates in IM and CM modes, respectively. According to complex power flow concept, the exchanged power between the two AC buses would be determined as follows:

$$S = V_2 \left(\frac{V_1 - V_2}{Z_L}\right)^{*} = \quad (4)$$

II. SIMULATION RESULTS

The performance of the suggested power flow strategy is verified in this portion using simulations in MATLAB® [27] based on comparison studies. The proposed improved UIPC model, presented in Section 2, is validated in the first of four case studies. The proposed technique is also used to verify power flow regulation between the AC microgrid and the main grid. The power flow regulation from the DC microgrid to the AC microgrid is examined in the second case study, while the power flow from the AC microgrid to the DC microgrid is verified in the third example. In case four, the proposed UIPC's stability and disturbance rejection qualities are studied.

A. Validation of modified UIPC model and power flow control between the AC microgrid and main grid

The proposed topology for the UIPC, indicated in Fig. 4, is compared to the conventional UIPC shown in Fig. 3 to verify the proposed structure and further its effectiveness over the conventional topology. The UIPCs parameters are the same as those in [24] for this purpose. A 2 km distribution line

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with impedance of RL = 0.01 and XL = 5mH per phase connects the AC microgrid to the main grid. The power flow from the main grid to the microgrid is investigated. To begin, the traditional UIPC is used to manage the power transfer between them. Figures 10-12 depict the simulation results.

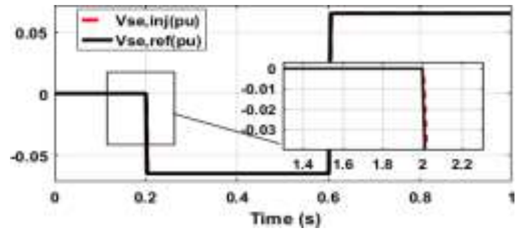

Fig.4. Predefined reference signal following performance of conventional UIPC

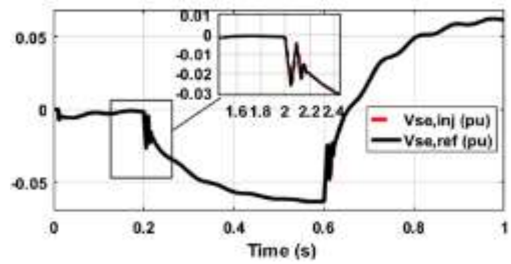

Fig.5. Reference signal tracking performance of proposed UIPC equipped with new control scheme

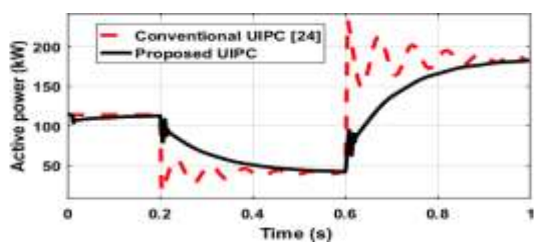

Fig.6. Exchanged power (absolute value) control between two AC microgrids using proposed and conventional UIPCs

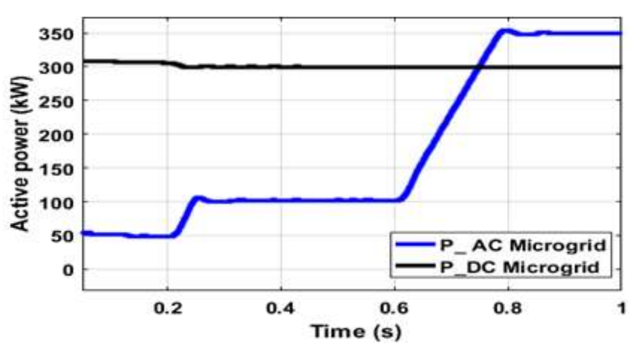

Fig.7. Generation in each microgrid

B. Power flow control from DC microgrid to AC microgrid

To test the performance of the proposed UIPC, the power flow performance from the DC microgrid to the AC microgrid is studied.

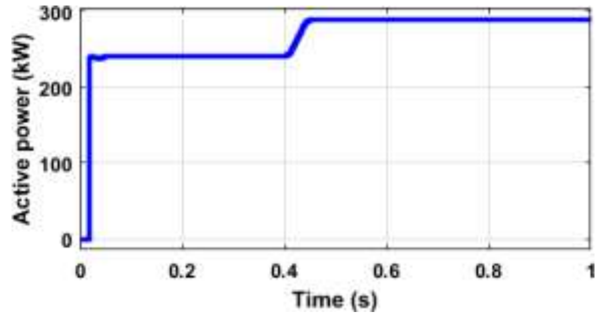

Fig.8. Active power of DC link when 40 kW is demanded from the AC side

ANN Controller

In power plants and power systems, promising Artificial Neural Networks (ANN) approaches have recently been developed to solve problems such as controller tuning, process identification, sensor validation, monitoring, and fault diagnosis, as well as security assessment, load identification, load modelling, forecasting, and fault diagnosis. Neural networks act in a similar fashion to the human brain when it comes to processing information. The network is made up of a large number of densely connected processing components (neurones) that operate in tandem to solve an issue.

Neural networks learn by observing others. They can't be programmed to do something specific. Neural networks differ not just in terms of learning processes, but also in terms of structure and topology. Bose (1996) divided neural networks into two types: recurrent (with feedback) and nonrecurrent (without feedback). Haykin has classified network designs into three categories in further detail: Feed-forward Signals in ANNs can only go one way: from input to output. There is no feed-back (loops), which means that the output of one layer does not impact the output of another.

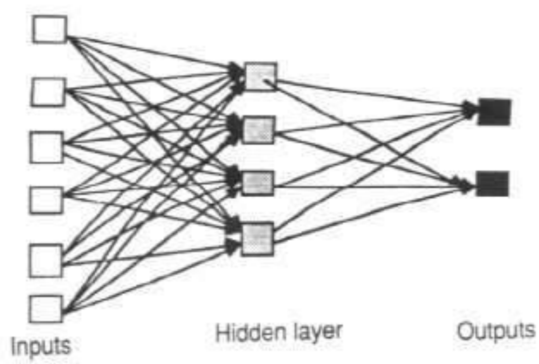

Fig.9. an example of a simple feed forward network

Comparison of simulation results

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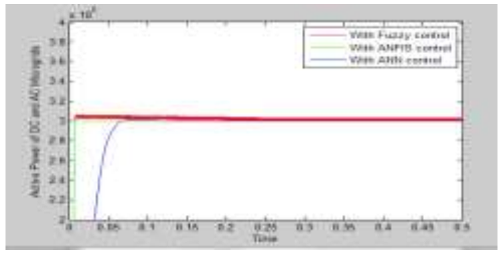

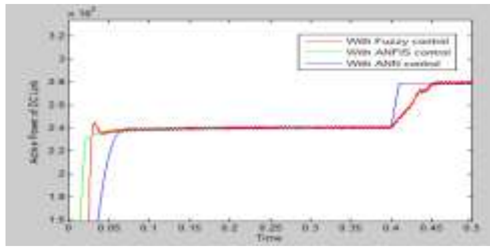

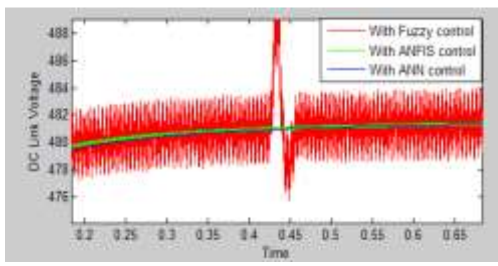

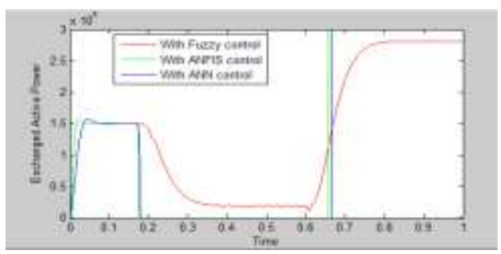

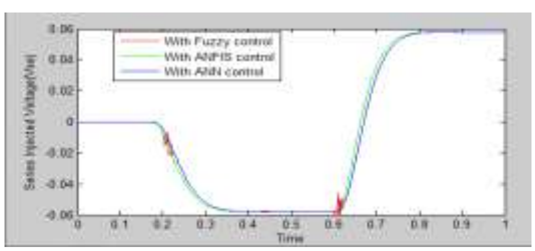

In this research proposes further extension artificial neural network (ANN) is using to control the UIPC converters and the transients are reduced. The artificial neural network (ANN) does dynamic performance and the UIPC converters are better performance than the conventional UIPC.

III. CONCLUSION

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In the future smart grids, the hybrid microgrid structure is the most likely solution for bringing together renewable resources and AC/DC loads. This is because this construction has the advantages of both AC and DC microgrids at the same time. The power exchange regulation between interconnected AC and DC microgrids is a common issue with this layout. A UIPC-based solution has been offered in this study as a preferable alternative to parallel-connected power converters, which have caused numerous issues. First, a modified UIPC structure was proposed, and then effective control strategies for the modified UIPC were introduced. The simulation results confirmed the improved model as well as the AC/DC microgrid power exchange control performance. Further expansion artificial neural network (ANN) is used to control the UIPC converters in this research, and transients are decreased. The artificial neural network (ANN) performs dynamically, and the UIPC converters perform better than conventional UIPC.

REFERENCES

[1] Runfan Zhang, Branislav Hredzak, "Distributed Finite-Time Multi-Agent Control for DC Microgrids with Time Delays", IEEE Transactions on Smart Grid, Early Access, 2018.

[2] Kumar Utkarsh, et al, "Distributed Model-predictive Real-time Optimal Operation of a Network of Smart Microgrids", IEEE Transactions on Smart Grid, Early Access, 2018.

[3] Haifeng Qiu, et al, "Bi-level Two-stage Robust Optimal Scheduling for AC/DC Hybrid Multi-microgrids", IEEE Transactions on Smart Grid, Early Access, 2018.

[4] Pengfeng Lin, et al, "A Distributed Control Architecture for Global System Economic Operation in Autonomous Hybrid AC/DC Microgrids", IEEE Transactions on Smart Grid, Early Access, 2018.

[5] Daniel E. Olivares, et al, "Trends in Microgrid Control", IEEE Transactions on Smart Grid Volume: 5, Issue: 4, pp. 1905 – 1919, 2014.

[6] Jongwoo Choi, et al, "Robust Control of a Microgrid Energy Storage System using Various Approaches", IEEE Transactions on Smart Grid, Early Access, 2018.

[7] Daniel K. Molzahn, et al, "A Survey of Distributed Optimization and Control Algorithms for Electric Power Systems", IEEE Transactions on Smart Grid, Early Access, 2018.

[8] Samrat Acharya, et al, "A Control Strategy for Voltage Unbalance Mitigation in an Islanded Microgrid Considering Demand Side Management Capability", IEEE Transactions on Smart Grid, Early Access, 2018.

ISSN: 2278-4632
Vol-12 Issue-01 No.01: 2022

[9] Pengcheng Yang, et al, "A Decentralized Coordination Control Method for Parallel Bidirectional Power Converters in a Hybrid AC/DC Microgrid", IEEE Transactions on Industrial Electronics, Early Access, 2017.

[10] Ignacio Gonzalez-Prieto, et al, "Impact of Post fault Flux Adaptation on Six-Phase Induction Motor Drives With Parallel Converters", IEEE Transactions on Power Electronics, Volume: 32, Issue: 1, pp. 515 – 528, 2017.