# POWER FLOW CONTROL OF HYBRID MICRO-GRIDS USING MODIFIED UIPC

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**Abstract:**This work introduces a replacement advent for power flow control of interconnected AC-DC micro-grids in hybrid micro-grids connected to grids. It also supports implementing an Adaptive Neuro Fuzzy Inference System (ANFIS) controlled modified Unified Inter-Phase Power Controller (UIPC). For study, a classic hybrid micro-grid connected to grid comprising of a AC micro-grid and a DC micro-grid is taken into account. These micro-grids are interconnected employing a modified UIPC, rather than using the power converters connected in parallel. As the first input of this paper is the standard structure of UIPC, which used three power converters in every phase. It was then modified such as number of power converters is used less and implemented for the control of the exchange of power between AC-DC microgrids. In every phase there is one power electronic converter in the improved structure. It is called as Line Power Converter (LPC). Also, there is Bus Power Converter (BPC) to regulate the voltage of the DC bus. The Line Power Converters links the AC micro-grid to the main grid. The DC buses are also linked with them. It can be operated in Inductance Mode (IM) as well as Capacitance Mode (CM). The control structure of LPCs has an Adaptive Fuzzy Logic Controller in it. For hybrid micro-grids, the capability of the suggested power flow control strategy is confirmed by the MATLAB simulation results.

**Keywords:** Microgrid, UIPC, Power quality, ANFIS

## I.INTRODUCTION

A micro-grid is said to be a small-scale power grid. It is able to operate both individually as well as combined with other small power grids. Micro-grids are usually decentralized, distributed, district, dispersed or embedded energy production. A small-scale, localized power station that generates its own power and also has storage capabilities and definite boundaries is contemplated as a micro-grid. When the micro-grid is linked to the area's main power grid, then it is known as a hybrid micro-grid. Micro-grids generally get due support from backup generators or other nonconventional energy sources like wind and solar. They usually give backup power and they also support the main power grid whenever there is a requirement of heavy demand. A micro-grid has definite plan of action to integrate local energy sources like solar or wind. It can also provide excess power for important services. This gives the main grid the strength to withstand local collapse in demand.

A hybrid micro-grid consisting of both alternating current and direct current (AC-DC) shows an efficient path to fix the issues which are created from the distributed generations of large-scale and also DC load access. Hence this micro-grid has become the dominant player in the development of distribution network terminals. The traditional distribution network consisting of alternating current could not meet the demand required for the development of the power system the distributed generation is of large-scale. So, the improvements in the technology of power electronic devices and the availability of huge chunk of DC load access helped for the development. The distribution network with direct current is advantageous in transmission of energy and has fast control. Hence it improves the stability of the system and decrease the number of converters used. To meet the demand for huge DC load and distributed generation, there should be a plan for collective optimization between alternating current and direct current distribution networks and hybrid micro-grids having AC and DC [1]. As shown in Figure 1, AC/DC converters interconnect the distribution networks having AC and DC components. Here, the converters are used to form a connection between the centralized distributed generators and large-scale distributed generators. This construction also curtails the utilization of converters and the access capacity and generation efficiency of distributed generators is improved. Based on the types of loads and demand the micro-grid in the network can prevail in many forms. AC or DC micro-grids can be set up to provide power for systems having genuine AC or DC loads. When loads with AC and DC need supply of power concurrently and simultaneously the load could not be transferred then it is the economical solution to construct a hybrid micro-grid containing AC and DC.

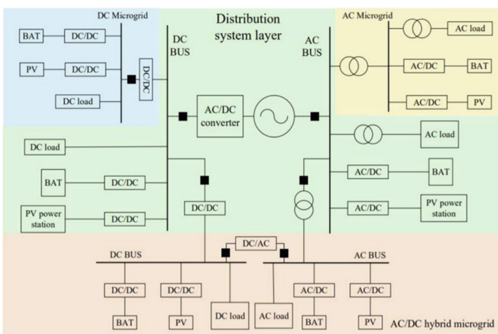


Figure 1. Typical arrangement of hybrid micro-grid containing AC/DC micro-grids connected to AC/DC distribution network.

This makes the system economical by reducing the losses and enhancing the capacity of power supply of the network. Typically, the arrangement of a network of hybrid micro-grid having AC/DC micro-grids has the power supplied at either ends from AC and DC distribution networks. The DC distribution network is linked to the DC bus of the hybrid micro-grid. Similarly, the AC distribution network is interlinked with the AC bus. Thus, the network has many operation modes, including ring network operation, DC distribution network operation, AC distribution network operation, hybrid micro-grid islanding operation, AC/DC sub-micro-grid islanding operation, and AC/DC sub-micro-grid disconnection operation. These operation modes immensely make the constancy and affability of hybrid micro-grids. A small sized sub micro-grid in a hybrid micro-grid having AC/DC micro-grids shall be removed from the respective distribution network. The stability needs of the network can also be attained from a single distribution network supply. A scientific approach to arbitrate the minimum target efficiency of power electric converters present in a network of DC distribution was presented in a study, due to the efforts of scholars across the world. That also wrapped up that a DC system may be studied only when one has to achieve minimum efficiency at low cost [2].

Controlling the micro-grids is a critical issue for ensuring reliability of the micro-grid. A variety of research is going on particularly about the control system and power management to enhance the system stability. The AC micro-grid as well as DC micro-grid has variously ranked controls. But those controls may be speculated into three levels based on the hierarchical control standard of International Society of Automation (ISA)-95: (1) the droop method based primary control, including an output impedance virtual loop; (2) the secondary control permits the reclamation of the aberrations from the primary control; and (3) the tertiary control manages the flow of power from and to micro-grid (MG) and external electrical distribution system [3 4].

A hybrid micro-grids having AC/DC micro-grids, Interlink AC/DC bidirectional converters (ICs) are used to connect the AC and DC. These IC are able to control and manage power suitably in working mode, grid-connected mode and stand-alone mode. The micro-grid while working in stand-alone mode leads to further challenges, especially there will be a lack of balance in generation and consumption because of flexible load and DERs. Various methods of droop control are suggested in order to sustain the stability of the system by sharing power between DC and AC sub-grids, as in. Including an energy storage system in the IC may refine the performance of its control. Also, the DC link capacitors back up the regulation of the voltage [5]

## II.LITERATURE SURVEY

**[1] H.a. Pan M. Ding R. Bi L. Sun Research on Cooperative Planning of Distributed Generation Access to AC/DC Distribution (Micro) Grids Based on Analytical Target Cascading Energies 12 10 2019 1847. (https://doi.org/10.3390/en12101847)**

This paper deals with DC distribution network for distributed generation, electric vehicle charging and discharging station access at first, and then put forward a DC network topology structure, finally with the using PSCAD/EMTDC to model and simulate the distributed generation and the DC distribution network; the distributed generation capacity will change when the environmental factors change, but the DC voltage and the power of DC lords in the DC distribution does not follow the distributed generation capacity, they stay in a constant value, at the same time the DC distribution can transfer energy with the AC network, the DC distribution network can also regulate the power flow in the AC network.

**[2] Du Yi, Jiang Daozhuo, Yin Rui, Pengfei Hu, Wang Yufen, ''Modeling and simulation of DC distribution network based on distributed energy" 2013 2nd International Symposium on Instrumentation & Measurement, Sensor Network and Automation (IMSNA)**

his paper presents a collaborative planning method for distributed generation access to AC/DC distribution (micro) grids. Based on the grid structure of the AC/DC distribution network, the typical interconnection structure of the AC/DC hybrid microgrid and AC/DC distribution network is designed. The optimal allocation models of distributed power supply for the AC/DC distribution network and microgrid are established based on analytical target cascading. The power interaction between the distribution network and microgrid is used to establish a coupling relationship, and the augmented Lagrangian penalty function is used to solve the collaborative programming problem. The results of distributed power supply allocation are obtained, solving the problem so that distribution generation with different capacity levels is connected to the power grid system in a single form.

**[3] J.M. Guerrero J.C. Vasquez J. Matas L.G. de Vicuna M. Castilla Hierarchical Control of Droop-Controlled AC and DC Microgrids—A General Approach Toward Standardization IEEE Trans. Ind. Electron. 58 1 2011 158 172 10.1109/ TIE.2010.2066534 http://ieeexplore.ieee.org/document/5546958/**

In this paper present the hierarchical control derived from ISA-95 and electrical dispatching standards to endow smartness and flexibility to microgrids. The hierarchical control proposed consist of three levels: i) the primary control is based on the droop method, including an output impedance virtual loop; ii) the secondary control allows restoring the deviations produced by the primary control; and iii) the tertiary control manage the power flow between the microgrid and the external electrical distribution system. Results from a hierarchical-controlled microgrid are provided to show the feasibility of the proposed approach.

**[4] JiaLihu, ''Architecture Design for New AC-DC Hybrid Micro-grid", DC Microgrids (ICDCM), IEEE First International Conference on, 2015.**

This paper describes several micro-grid architecture design principles, taking into consideration in the partition and hierarchy principle, as well as resource utilization maximization, energy complementary, energy storage and reactive power compensation. Therefore, according to the micro-grid design principles proposed in this paper, we designed three hybrid AC/DC micro-grid architectures: multiple rings, single ring and complementary ring architecture. Then, we make a comparative analysis of power supply reliability, fault detection and applications. It can be seen that AC/DC hybrid micro-grid is superior to traditional AC and DC micro-grid in power supply reliability, flexibility and economy aspects, and it can be a good solution to the problem of distributed energy connected to the distributed network

## III. EXISTING SYSTEM

### Power flow control of interconnected ac-dc micro-grids in grid connected hybrid micro-grids using modified uipc

Based on implementing a modified Unified Inter-phase Power Controller (UIPC), Mahdi Zolfaghari puts forth a novel advent for the control of the power flow interconnected AC-DC micro-grids present in hybrid micro-grids connected to grids. An emblematic hybrid micro-grid connected with grid, which has one DC microgrid as well as an AC micro-grid is considered to be studied. Rather utilizing the power converters which are connected in parallel, the considered micro-grids are interlinked with a modified UIPC. In the traditional structure of UIPC, each phase has three power converters. It is then modified such that it contains lesser power converters so as to control the exchange of power between AC-DC microgrids. This is the first input of this paper. This modified structure comprises of one power electronic converter that is Line Power Converter (LPC), for each phase. Additionally, it has another power electronic converter that controls the voltage regulation of the DC bus, called as Bus Power Converter (BPC).

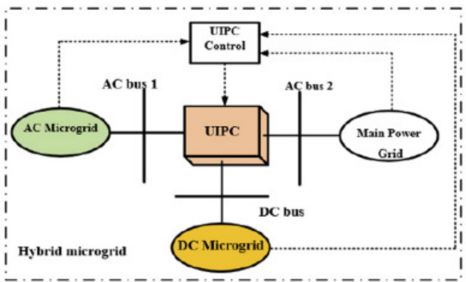


Figure.2 Interconnection of AC-DC micro-grids in hybrid micro-grid connected to grid using UIPC

The DC buses are connected to their respective AC micro-grid with the help of LPCs. These have two modes of operation namely Inductance Mode (IM) or Conductance Mode (CM). The control structure of the LPCs uses a Fuzzy Logic Controller (FLC). The errors produced in membership function model are reduced by introducing the fuzzy inference system which is improved by using H1 filtering method. The DC micro-grid supplies the DC voltage needed for LPCs through the BPC. The DC voltage used for linking in the LPCs is oscillating because the voltage of the DC micro-grid is supplied from a PV system. A sturdy and novel Multiple-Surface Sliding Mode Control based on Nonlinear Disturbance Observer (NDO-MS-SMC) scheme is brought in for the control of the DC side of the BPC so as to steady the change in the DC link voltage [6]. This is the second input of this paper. As noted from the above figure 2 and Fig 3., this section contains the dynamic model of the modified UIPC. As indicated, the hybrid micro-grid which is connected to grid contains a DC micro-grid as well as one AC micro-grid. UIPC interlinks both. The AC micro-grid includes a diesel generator and related AC/DC loads. The DC microgrid contains a battery, a PV system, and as usual AC/DC loads. The PV system, and the battery loads are linked to the same DC bus or DC link. Nine VSCs and nine power transformers are required to link three phases of the AC buses. This makes this structure expensive. The DC links are linked in parallel in all of the VSCs in every phase of the AC bus. However, as described, when there is a change in output powers of the VSCs or when the system model is disturbed, like when a system parameter changes, the VSCs connected to same DC links tend to fluctuate the common DC link voltage. The fluctuation in voltage of the DC link is an important issue with the VSCs connected to same DC link. This issue was not considered [7]

## IV. PROPOSED SYSTEM

### Control of nonlinear systems

No systematic tools are available to manage the vague and ambiguous systems.So, controlling the traditional mathematical tools based nonlinear systems is a hard issue. A fuzzy inference system that uses fuzzy if-then rules is able to design the subjective facets of human knowledge and interpretations but lacks standard design scheme to use definite quantitative analysis is a contradicting fact. Neural networks function by identifying patterns in data, learning the relationships and acclimating to them. The outcome of new data combinations is predicted using this knowledge. Notably, Takagi and Sugeno were the first to methodically introduce fuzzy identification or fuzzy modelling based on the control technique. This has plentiful utilizations in fuzzy control, for making decisions, diagnosing medically, and in working out data mining-based problems [8]. Yet, there are few elemental features of his way which requires more understanding. Even more clearly, the absence of accepted design procedure and optimization process to transform human knowledge or wisdom into data base and rule base of the fuzzy inference system. To understand membership function tuning to reduce output error index and to select apt arrangement of the network is hard [8 9].

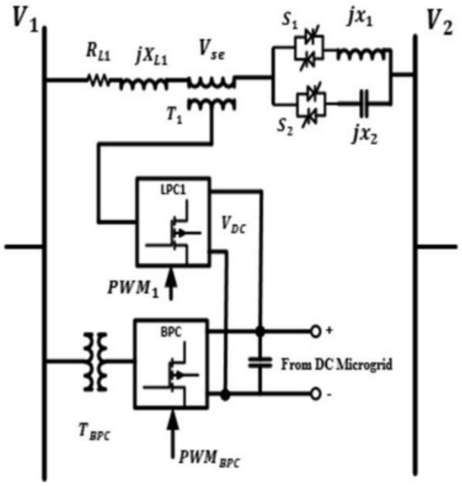


Figure 3 Proposed design of UIPC; each phase implements three power Converters

## V.ADAPTIVE NETWORK BASED FUZZY INFERENCE SYSTEM

The Adaptive Network Based Fuzzy Inference System (ANFIS) is said to be a procedure driven by data that represents an approach with neural network that is used to solve problems of function approximation. The procedures driven by data for the combination of ANFIS networks generally depends on assembling numerical samples training set of the unknown function which is to be approximated. An ANFIS network is favourably being used in classification of tasks, process control based on rules, recognition of pattern and problems similar to that, since it is introduced. The fuzzy model suggested by Takagi, Kang and Sugeno constitutes the fuzzy inference system, which establishes a methodical approach for the generation of fuzzy rules from input output data set [5].

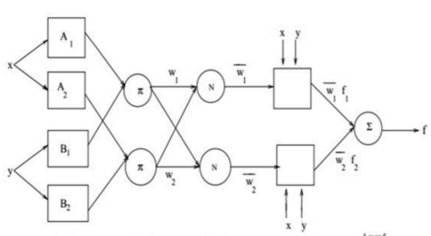


Figure.4 Type-3 Structure of ANFIS

In simple words, the ANFIS structure in the fuzzy inference system is considered to have two numbers of inputs and one number of outputs. The fuzzy if-then rules of Takagi and Sugeno's type constitute the rule base as given below: When x is A and y is B then z is f(x,y) where A and B are the sets of fuzzy in the antecedents and z = f (x, y) is a fresh function in the subsequent. Mostly f(x, y) is a polynomial for the given input variables x and y. Although it can be one other function that roughly define the system output inside the region of fuzzy as stated by the antecedent. If f(x,y) stays as a constant, a Sugeno's fuzzy model of zero order is set up which is contemplated as an exclusive Mamdani fuzzy inference system. Here every rule consequent is stated by a singleton of fuzzy. When f(x, y) is said to be a polynomial of first order then the output will be the fuzzy model proposed by Sugeno [10 11]. In two rule Sugeno fuzzy inference system of the first order, the two rules can be written as: Rule number 1: When x is considered as A1 and y as B1 then first order f1 equals p1x + q1y + r1 Rule number 2: When x is considered as A2 and y as B2 then second order f2 = p2x + q2y + r2 in this place, fuzzy inference system of type 3 designed by Sugeno and Takagi is applied. Within this system of inference, every rule output will be a linear mix of the variables of input added with a constant term. The ultimate output is the gross average of every rule's output. The corresponding analogous ANFIS arrangement can be noted in figure. As shown in figure 4, initial Fuzzy Model derivation in system modelling based on ANFIS for a given set of rules along with unchanged premise parameters, finding an optimal fuzzy model to the respective data of training decreases to a linear least-squares estimation problem. A quick and powerful method for identifying the fuzzy models from the available data of input and output was suggested by S.L.Chiu. The crucial input variables are selected in this approach while structuring a fuzzy model from data by the combination of cluster estimation scheme using least squares estimation algorithm. This procedure is pursued in two steps

i) Primary fuzzy model is derived from the data containing input and output with the help of the method of cluster estimation using all feasible input variables is the first step. ii) Next step includes identifying vital variables of input by testing the importance of every variable present in the primary fuzzy model [12]. Understanding procedure of ANFIS Neuro-adaptive learning methods is enriched using a plan for the procedure of fuzzy modelling and to understand the details of a data set. Membership function parameters which favourably permit the related fuzzy inference system to track the available input or output data are computed using this design. The functions of membership change depending on the associated parameters over the process of learning. The duty of the learning algorithm of the mentioned architecture is tuning all of the alterable parameters to cope with real world problems more efficiently, to devise the ANFIS output match the data of training. For enhancing the convergence rate, the hybrid network shall be trained by utilizing a hybrid learning algorithm by linking least square method and gradient descent method may be used. With assumed parameter fixed, the lease squares approach may be used to find the optimal values of the subsequent parameter on the layer 4. For available parameters, the idea of how good the fuzzy inference system is forming the input/output data is given by the vector of gradient. Any of the various optimization practices is used for changing the parameters to minimize some error measure, while obtaining the gradient. The search space grows bigger as the convergence of the training becomes slower, while the parameters present in the premise are not fixed. A forward pass (LSM) as well as a backward pass (GDM) constitutes the hybrid algorithm. Backward pass begins as soon as the optimal consequent parameters are launched. Errors are proliferated backward meanwhile the premise parameters of the fuzzy sets present in the input domain are updated by gradient descent method in the backward pass. Least squares estimation along with backpropagation is used in combination by ANFIS for parameter estimation of membership function [13]

## V.SIMULATION RESULTS

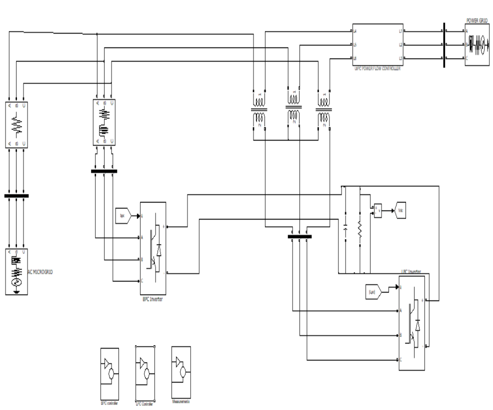

Figure.5 Overall SIMULINK/MATLAB circuit diagram of the system

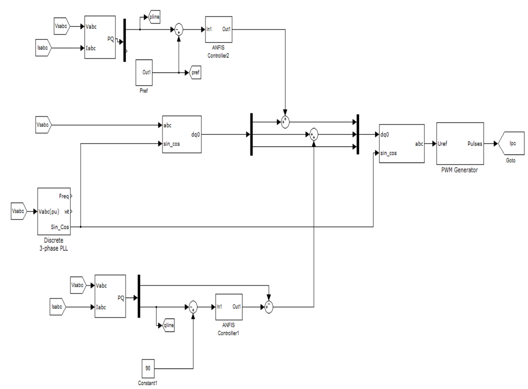

Figure.5.1 LPC ANFIS Control System

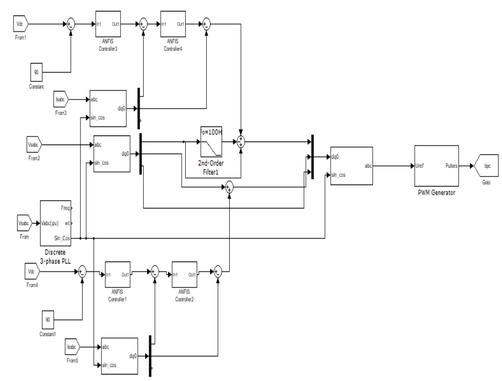

Figure.6 BPC Control System

To check the robust durability and harmonics performance, total harmonics distortion has been studies. The simulation results for themodified UIPC are shown in figure 10 As noted from the figures, thesuggested UIPC comprising of new strategy for control has better performance and keeps the system stable as well.

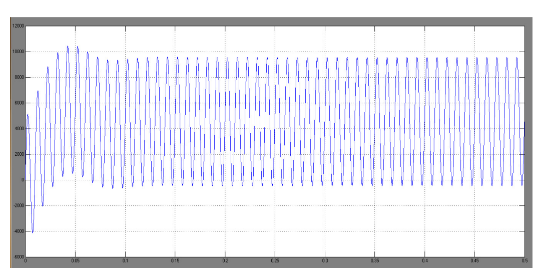

Figure.7 Input Waveform of the DC Micro-grid

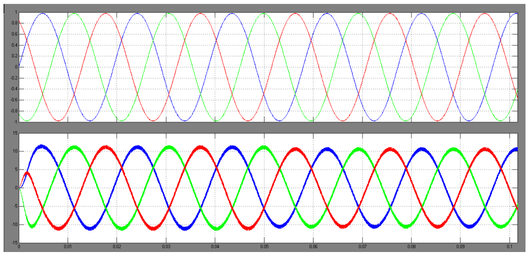

Figure.8 Input Waveform of the AC Micro-grid

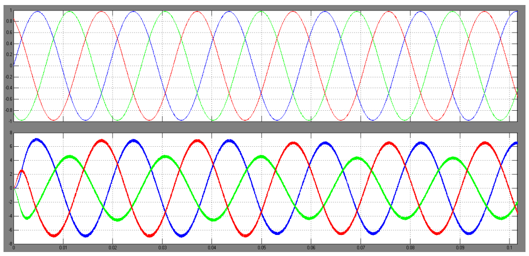

Figure.9 Output Waveform of the Power Grid

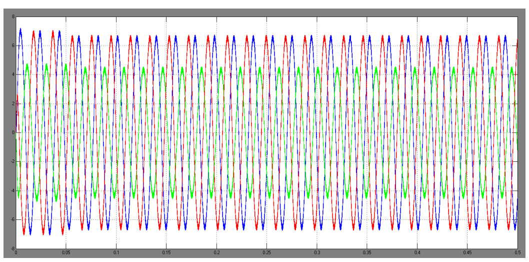

Figure.10 Suggested System Power Grid Current Waveform

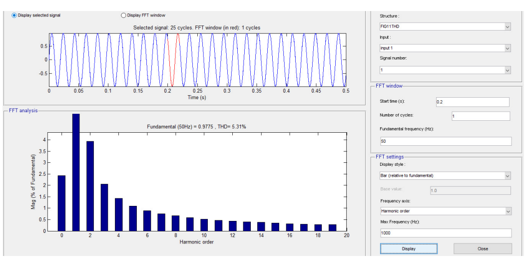

Figure.11 THD% OF SOURCE CURRENT IS 5.31%

## CONCLUSION

The hybrid micro-grid structure is the favourable option in the future smart grids to gather together the renewable resources for AC/DC loads. This is because of the fact that this structure holds the merits of AC as well as DC micro-grids simultaneously. There is one conventional problem with this structure. That is to efficiently control the exchange of power within interconnected micro-grids comprising of AC and DC system. In this particular work, an ANFIS controlled UIPC solution is suggested as a superior alternative to the power electronic converters connected in parallel which have brought many problems. An improved design of the UIPC was initially suggested and then effective strategies for control are presented for the modified UIPC. The results of simulation are used to validate the modified model along with performance of the control of power exchange between micro-grids having AC and DC system.

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