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Estimating the Stability of an AC-DC Hybrid Micro Grid with Multilayer Power Flow While Using Interconnected Converter

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Abstract: Regionalized networks, also known as micro grids, must be able to operate independently by cutting off their connection to the main grid in order for a system to stay stable. Customers' reliability can be raised by providing a more robust power supply. Due to reversed energy flow from distributed generator units, regional fluctuations, temporary micro grid modes, significant frequency discrepancies in electrically isolated mode operation, as well as financial and supply demand uncertainties, consistency, dependability, and security are in fact the main problems with micro grids. The system is more unstable when electrical energy is transmitted from the AC side to the DC side and from the DC side to the AC side, despite the fact that strengthening the stability of the hybrid micro grid is their main objective.

Therefore, a variety of circuit breakers, buck boost converters, grid bidirectional converters, and intermediate IC (Interlinking converter) are utilized to preserve the stability of the hybrid micro grid. This article explains how to build a bidirectional power flow through an interactive converter using stability evaluation using MATLAB. Simulation may improve the circuit's performance for the best outcomes achievable. The most stable hybrid micro grid findings were shown. An interlinking converter is utilized in this work to improve micro grid stability while power is flowing via the AC and DC grids in both directions. The findings might be acquired using a MATLAB simulation. This method also has the advantage of reducing the amount of time needed for the system to stabilize. Consequently, the system will be more dependable and will provide excellent supplies.
Keywords: Interlinking converter, distributed generators, bidirectional power flow, and hybrid micro grids (HMGs) are some related terms.

I. INTRODUCTION

The hybrid micro grid is powered by a variety of power generating systems, such as photovoltaic solar panels, wind turbines, diesel engines, and any other power sources. Several power plants can be operated using the hybrid energy source. Both non-renewable energy sources and renewable energy production facilities are included in this. One of the key advantages of adopting a hybrid micro grid like this is the capacity to ensure power supply continuity. Give users a source of high-quality energy. Stability is the capacity of the grid-connected solar system to continue functioning regularly or steadily in the case of an interruption. Destabilization, on the other hand, is a situation that shows a lack of synchronism or a falling out of synchronism. It has long been understood how important electrical grid factors are to grid integration. It is harder to maintain the different components of a power grid in sync as linked networks get bigger and span more areas. HMG constancy has previously been acknowledged as crucial to location throughout working hours despite the lack of connectivity. The power grid's many networks link a number of power rails. On the grid, there are several devices that can run continually. These devices are safeguarded using various circuit breakers. Before the hybrid micro grid was introduced, there was only one grid available. If a fault appears, the entire grid will be shut down. The grid is unable to deliver uninterrupted power as a result. Following the introduction of the hybrid micro grid, this sort of problem will be resolved. The HMG has a wide range of equipment. Decentralized power producing technologies have advanced significantly in recent years as a result of the rising electrical market and environmental concerns. The benefits of both the AC/DC linked micro grid, which also has a distinctive power generating structure, and the micro grid based on the AC micro grid are integrated. Multiple needs may be met simultaneously by the AC/DC linked power plants of the micro grid. The method makes the most of dispersed renewable energy sources while improving the efficiency of power delivery. A power converter known as a "compound converters" (IC) controls the power conversion between the AC and DC grids in an AC/DC mixed system. The IC must manage the reversible active power connection between the two sub-micro grids in order to appropriately align and optimize the flow of electricity between the AC sub-micro grid and the DC sub-micro grid.

On the other hand, the IC for sub-micro grids must simultaneously display two separate energy and demand parameters at opposite ends of the grid. Utilizing the integrated distributed generation, which is currently under development, electricity may be transported across both AC and DC grids. A dual power flow is used by the combination converter (IC) in the HMG sub-grids to transition power between the AC and DC electrical systems. The HMG can be controlled centrally, decentralized, electrically or not. an organization with weak management. The qualities of energy that are employed for participation and cooperation can be utilized in a variety of ways. Decentralized organizational approaches are still in use even though decentralized management is employed in both AC and DC sub grids. It was already understood that HMG's reliability is crucial for the site during working hours despite the lack of connection. The multifunctional power converter design aims to address a number of issues with the functioning of the micro grid in islanding mode as well as the transfer of power from AC to the sub grid's DC and AC. Through a number of auxiliary services, it improves both the power quality and the power flow. It can enhance the power supply and lessen the system's harmonics and transients. In comparison to other systems, the system is hence more stable (literature review).

The typical droop models employed by the causers coupled to the sub-micro grids, both DC and AC, are thoroughly examined in this work. To guarantee the voltage stability of autonomous linked micro grids, connected converters should employ a unidirectional sliding mode control method based on PI. The properties of connected generators, which need to maintain AC bus frequencies, DC bus voltage stability, and reversible power exchange, are taken into consideration by this technique supportive power is sent between the AC and DC modules. When a single module departs from the required system requirements, the consequences on the other systems may be mitigated [1]. Photovoltaic (PV) generation and storage technologies are essential for managing system stability and producing power in islanded micro grids. The producing and storing systems must be synchronized in order to prevent an increase in the DC link voltage as well as overcharging and over discharging.

In this work, a distributed strategy based on DC bus voltage signaling is devised to synchronize power producers and storage devices. A novel state-of-charge (SOC) dependent buffer management approach for storage regions is first created to balance their SOCs and enable the DC bus voltage. By using this technique, an overcharge for a storage unit can be avoided. When the power generating units are not operating to their full power point tracking capability, power generation may be continuously controlled using an upgraded power control approach. It is possible to successfully combine these two methods of collaboration between generators and storage units utilizing DC voltage signaling. Additionally, the dependability of the relevant control mechanism is looked at. [2] It is possible to control a grid-connected interconnected grid DC/AC made up of a photovoltaic DC/DC converter, a multimodal lithium battery (LB)-based DC/DC converter, and a grid-connected DC/AC inverter topology by suggesting linear regression compensators built into the internal dynamics of the two energy converters used.

The suggested control strategies for the energy converters make use of a suitable compensation architecture to simultaneously link these power supply changes with other parts of the control loop.

The evaluation of the natural system variables' amplitude and frequency as determined from the recommended management-based control loops yields the biggest overall result for the compensating components. [3] Rooftop solar power generation has a positive environmental impact even though its output varies. Energy storage systems may make up for the discrepancy between solar power generation and consumer energy usage by controlling the charging and discharging process. As a result, one area of growth is the administration and control of micro grids employing parallel hybrid converters and solar inverters. Because solar module storage, illumination, storage capacity, and SOC can vary, each combination inverter in a grid has a different capability to produce electricity. Realizing each inverter's actual power capacity is crucial for controlling the electrical output. These works examine the fundamental properties of parallel inverters used in micro grids, which rely on control, and they create a method for figuring out each inverter's dynamic power status. To regulate the energy output of the inverters, they analyses the impacts of DC connection voltage DC and modify the decaying process parameters. The modelling and practical findings demonstrate that the power requirement of the loads may be satisfied by progressively adjusting the electrical power of each inverter in accordance with its real performance. This technique can produce the hybrid system's power dynamics [4].

The bidirectional power flow in the interconnected inverters (IC) of hybrid ac/dc micro grids (HMGs), made up of distributed energy resources (DGs) with shuttle devices, is a vital aspect of the stability of these grids under islanding scenarios. This work investigates the effect of energy flow direction on the HMGs with the moderate dependability of islanding control. The first step is to create a linearized state space model of an HMG. The equations in the top right corner, which were found via Eigen analysis, reflect the dominant modes. The third method, principal component evaluation, identifies the network of variables and control factors that has the greatest impact on stability. The evaluation is then used to determine the biggest shifts in reliance and stabilization. The assessment and vulnerability evaluations show that when more energy is transferred from the DC sub grid to the AC sub grid, the dominating modes of the HMGs stabilize.

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Any improvement to the power transmission from the AC to DC sub grid reduces the overall dependability of the HMGs. It is also investigated how sensitive the dominant modes are to these alterations in order to comprehend how differences in ac and dc drop gain effect the study methodologies. While doing this, power is transmitted through the IC [5].

For combination ac/dc micro grids connected by one type of compound transformer (IC), the power transfer between the ac and dc sub grids may always be adequately performed. Due to the effect of line opposition numbers, the employment of several ICs along with their corresponding AC and DC sub-networks may result in power circulation and IC overload. By creating clashing frequencies inside the DC sub grid 4, this research endeavor provides a single power-exchanging technique for composite micro grids connected by a number of ICs. Genuine filtering refers to the power management mechanism between the ICs and the DC and AC generators.

As a consequence, the ICs receive sufficient DC power, consistent power distribution, and no power circulation. [6] An electrical system's main objective is to give society access to inexpensive, sustainable energy sources. In order to satisfy all energy demands using sustainable resources, some nations have added a second aim to this one, which has resulted in a transition to low- or zero-carbon power generation. In this shift, which is happening quickly all over the world, distributed generation (DER), inverter-based resources (IBR), and differentiated alternative energy sources (AER) are becoming increasingly prevalent. [9]

II. PROPOSED METHOD

A. Structure of Microgrid with an ac/dc hybrid system

Figure 3.1 depicts the architecture of such an HMG with distributed ac or load demand and distributed producing. (DGs). The voltage and current sub grids are connected via a bidirectional Converters IC. It provides the IC's attributes. The recommended system consists of solar panels, a wind turbine, and a battery for DGs. The system is divided into two segments using two buses. There are also a DC bus and an AC bus available. Between these two buses is an installed DC link converter. The solar system is connected to the dc bus using a dc-to-dc converter, and the wind turbine is connected to the ac bus using a two-stage conversion. IC maintains steady AC and DC grid voltages to run the power grid.

Therefore, it is crucial to create a suitable control plan. Both the active power of the AC subnetwork and the energy of the DC subnetwork must be allowed to flow freely for voltage control on the DC side and bus frequencies on the AC side to be correctly maintained. When the grid is in islanding mode, the ICs must boost the DC bus voltage and the AC bus duty cycle since it seems that there is no primary power supply. Between these two buses is built a DC DC link converter. A DC-DC converter connects the solar array to the DC bus, and a two-stage conversion connects the wind turbine to the DC bus.

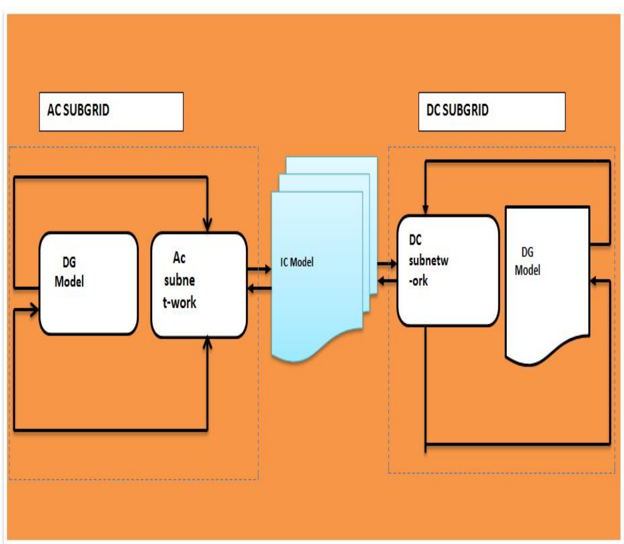

Fig 3.1 Schematic Representation for The Suggested System

So it is necessary to suggest a suitable control method. In order to properly maintain the bus frequencies on the AC side and the voltage control on the DC side, it is important to make sure that both the active power of the AC sub-network and the energy of the DC sub-network may flow freely. There doesn't seem to be a primary power supply while the grid is in isolated operation mode, thus the ICs must boost the DC bus voltage and the AC bus duty cycle.

The decentralised sub-micro grid as it is could be able to provide the total load demand of the AC/DC hybrid micro grid. The collaboration and sharing of energy resources affects control tactics. The decentralised power generation and load variations in the AC/DC hybrid micro grid are unexpected when the IC is operational. It is challenging to put the stated operating control for this particular AC/DC micro grid into practise due to the complexity of the energy transfer connection and operational requirements in the autonomous mode.

B. Methodology & Implementation

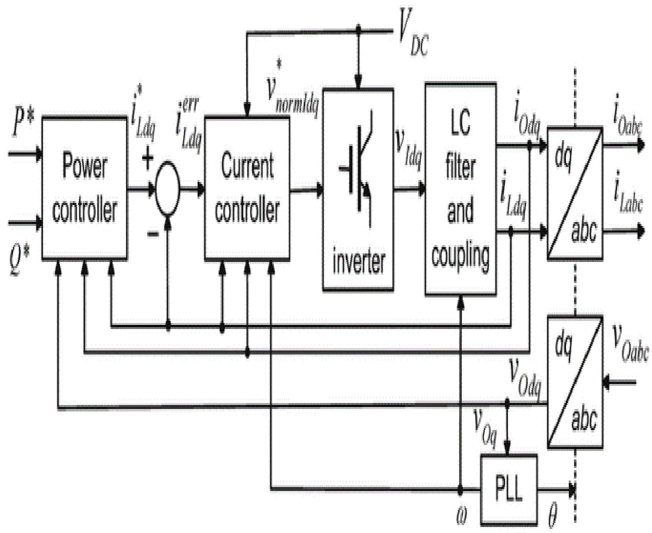

Fig 3.2 VSI's simulating Inside the AC Sub grid

1) VSI's Simulating Inside The AC Sub grid

The input voltage is kept constant by the voltage source inverter. In situations where there is a strong demand for power, three-phase converters employ VSI. These three inverters' three control signals have a 120° phase angle. Only a buck (step-down) converter mechanism is used by the voltage control to convert DC energy into AC power.

2) Dc/Dc Converter Designing In The Dc Sub grid

Even while a control system typically relies simply on a single conversion architecture to operate in a single procedure, it is unable to handle power quality and load fluctuations in both phases in an effective manner. One microcontroller is unable to manage the unique qualities that two converters (Buck and Boost) present. (In actuality, the voltage gain in activities involving bi-directional power is not constant. This difference results from the two modes' different circuit architecture. By choosing a battery voltage that is substantially lower than the utility grid, which produces a huge difference in the electrical potential sides, this problem is mostly handled; otherwise, the Buck implementation wouldn't be as efficient.

3) PI Controlled Buck Converter

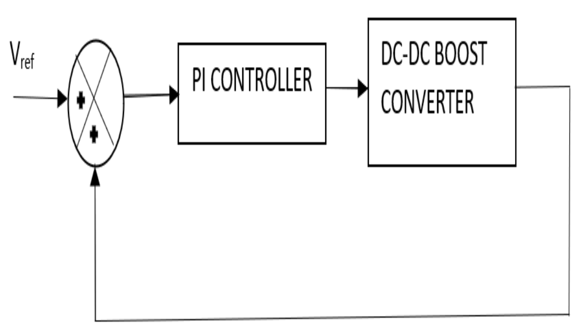

Fig 3.3 PI controlled buck converter

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A form of DC-to-DC conversion is the buck converter. This approach involves employing a converting electrical supply to change a current source into a regulated DC supply. MOSFETs were utilized in the converter design in place of ideal switches to accurately characterize the on-resistance of the components. The converter's response to the voltage level in relation to the reference energy is controlled by the MOSFET switches. For the PID design, the reference signal to the measured voltage must be continually modelled. On the other side, the automated identification regulation's transitions lead to a null system. In this case, the PID tuner determines a linear system notion rather of a linear system.

III. RESULT AND DISCUSSION

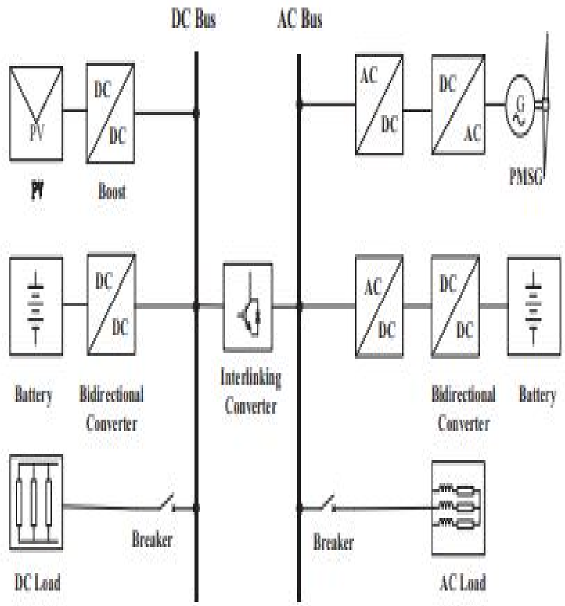

Fig 4.1 Detail block diagram

Figure 4.1 shows a PV array made up of parallel-connected strings of PV modules. To build each string, modules are connected in sequence. This has 300 parallel strings. Each string consists of 10 modules linked in sequence. The PV panel's maximum power when a grid inverter control block is used is 414.801 W. An MPPT system that employs the Perturb & Observe algorithm, a DC voltage regulator, a current regulator, and a PWM modulator are also included, in addition to the PLL and measurements.

This grid inverter control block performs a number of beneficial tasks that increase system efficiency. theoretical three-phase energy of around 380 V and 400 V, respectively, at 50 Hz. The sub voltage signal (380 V) was reduced to 220 V using an isolation transformer (380/220 V) before making contact with the IC. One DG with a 10 kVA output is added in an effort to keep up with the 20 kVA AC maximum output. Despite the fact that each DG only has a 10 kW rating, the DC sub grid has a 20 kW storage capacity. When evaluating both DGs and ICs, the working ranges for frequency and voltage measurements as well as the financial advantages must be taken into account.

a) Ac To Dc Operation Of Subgrid Power Flow

In order to operate the nonlinear energy flow (Dc to Ac) without integrating a reactive power adjustment, it is being investigated if the IC can manage reactive power even without the sub-grid energy direction of flow changing from dc to ac. The constant current micro grid of the HMG in Fig. 4.2 will first be charged with such a power consumed producing capacity of 1.0 p.u. to analyse the impacts of the transfer of power from either the dc to the ac sub network here on Hybrid micro grid consistency. The demands on the ac sub grid are changed so that: a) 2.0 p.u. is transmitted to the micro grids during the duration of t = 0 to 5 s. b) At time t = 5 s, Bus-A1's ac micro grids are 2.5 p.u. overloaded due to the introduction of a 0.5 p.u. demand. c) The load demand on the ac sub network increases to 3.0 p.u at t = 10 s by adding an additional 0.5 p.u load at Bus-A2. The load demand of the ac sub grid increased to 2.5 & 3.0 p.u. continuously throughout the same durations, however the dc sub network is overloaded at 1.0 p.u. for intervals of 5 to 10 and 10 to 15 s.

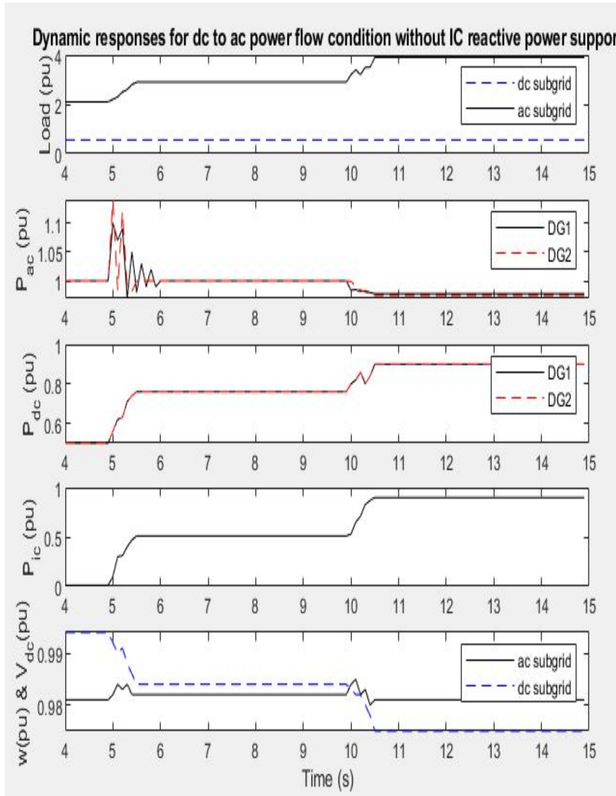

Fig 4.2: -dynamic responses for the absence of IC reactive power support in the dc to ac power flow scenario

These sub circuits aren't actually being used to their maximum potential, therefore the IC isn't getting any power. Its IC signals its dc sub network to aid its ac sub matrix when it detects a reduction in the ac frequencies slightly below the lower limit at t = 5 s and 10 s as a result of the strain inside the ac sub network, in order to reduce the disparity in loads between both the two main sub squares to zero. For a loading in the ac sub network at time t = 5 seconds, the power supply from the dc sub grid and through the IC is estimated to be 0.5 p.u., which is about 1.0 p.u. by period interval = three seconds. Only two DGs within the DC sub grid need the lower voltage that was first sought to supply electricity. are discovered to be almost identical. The example research that follows demonstrates the active power transfer between Excellent dynamic efficiency is feasible for dc to ac.

b) Ac To Dc Ic Reactive Power Support For Subgrid Power Flow

When actively transferring power from the dc to the ac, its IC may very possibly get instructions to only provide a very small power factor to the ac. This (QICV) slow network is once again used for IC and the approximate findings are presented in order to account for the VAR development caused by the ac.

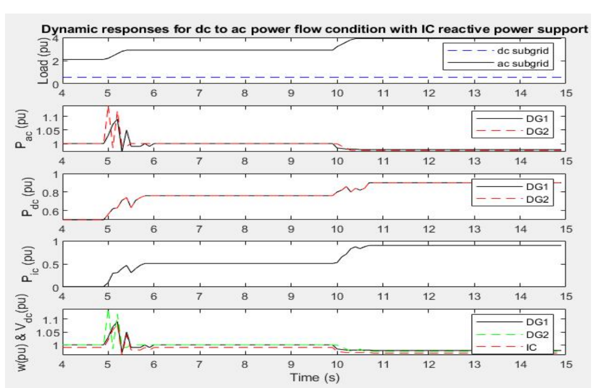

Fig 4.3: - Dynamic responses for dc to state of ac power flow with IC reactive power support.

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It is demonstrated that such an IC provides all the reactive power necessary for an increase in ac power based on its inherent features. The IC would have to cease creating reactive energy if there was adequate room, but the AC would strive to keep producing the additional output as long as its limitations would allow. If the active and reactive resources of something like the ac sub grid are truly restricted, the modelling result supports the IC characteristics. When making judgments, it's also possible to take into account a device's capacity to transfer power from the ac sub grid to the dc sub grid, such as the IC VAR correction. The intermittent energy transmission from the dc to the ac shouldn't oscillate the ac sub grid.

c) An Increase In The Dc Power Generation Capacity

By attaching a 1.0 p.u. DG device to Bus-B3, the program's capacity to produce dc is improved, and the program's dynamical sensitivity is examined. The energy needs for the ac and dc sub grids in Figure 4.4 are set to 1.0 and 2.0 p.u., respectively, from t = 0 to t = 5 seconds. The electrical output of the DGs as it varies dynamically in both ac and dc power networks is shown in Figure 4.4. Even though it is extremely little, it is clear that the additional DG unit helps the utility grid from inside the DC. At t = 5 and 10 s, the three DGs in the DC sub grid split the additional dc load evenly, as shown in Figure 4.2. The dc and ac sub grids are not currently overloaded, hence the IC would not transfer any power at that time. A constant ac frequency and dc voltage are also preserved. We may assume that when the number of DGs increases, the performance characteristics of the DC sub grid should be maintained.

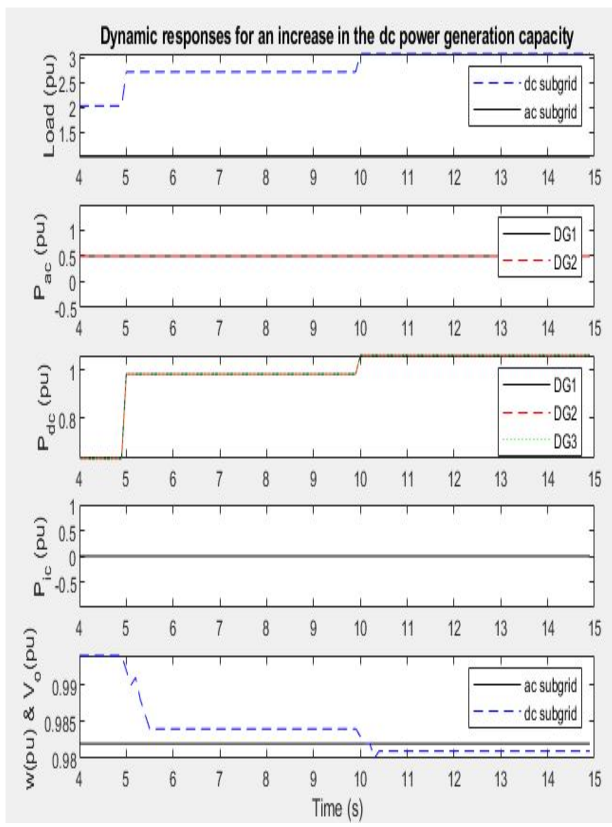

Fig 4.4: - Dynamic reactions to an improvement in the ability to generate dc electricity

IV. CONCLUSION

In terms of both amount and direction, the energy transfer between ac and dc sub grids covered by such MATLAB/Simulink state development and creation before circuitry. This study looked at how the overall power affected the reliability of HMGs produced in this method since ac and dc sub grids are connected by two-way ICs. The heavy dependency of the HMG might be decreased if the combined power from either the ac to dc sub grid grows. This is partly due to the fact that only certain attributes associated with the ac sub grid have a greater influence on HMG consistency than those related with the dc sub grid when such energy is transferred from an ac to a dc sub grid. Increased energy transfer to the dc sub grid to generate grid current would be necessary to increase the ac sub grid's substation capacity, which might lower the HMG's dependability.

Because HMG only draws energy from a dc sub grid, it should really be constructed with an ac sub grid. Instead of focusing on the potential disruption of power exchanges from one sub grid to another, the convergence analysis discussed in this work seeks to emphasize the necessity of prudence. More research on the energy variation component of AC/DC hybrid micro grid ICs has to be done soon.

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