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Modeling Stability Analysis And Simulation Of Interaction Between Buck Converter In AC And DC Microgrid

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Abstract:
There has been a significant improvement in Micro grid Technology to utilize the local distributed sources and also to minimize the transmission losses. In certain cases of power blackouts, they serve as main sources of power for some emergency loads. Traditionally A.C grids are preferred over DC grids to transmit power over long distances even though there are many problems associated with A.C grids such as frequency dip, voltage drop due to reactance, charging currents, leakage currents, low power factor problems, skin effect, Ferranti effect etc. because the voltages can be easily stepped up or stepped down using transformers. The Rapid development in power semiconductor technology makes it possible to convert voltages in DC with low cost and reduced power losses. Most of the problems associated with A.C grid can also be overcome by moving to D.C grid.AC and DC microgrid models were developed in MATLAB/SIMULINK environment and the stability and transient analysis is performed during faults and sudden load variations on both microgrids in real time using OPAL-RT real time digital simulator. Effects of weak main grid on stability of both micro grids have been analysed.
KEYWORDS: DC micro grid, AC micro grid buck converter, drop control, PI controller, voltage Controller

Introduction

Renewable-based sources can be connected to the grid through power electronic converters or to be combined with local loads and BESS to form an independent power system (microgrid) [1]. While remarkable progress has been made in improving the performance of AC microgrids, DC microgrids have also been recognized as an attractive option for many applications because of their higher efficiency, higher reliability, improved stability, more natural interface to many types of renewable energy sources and energy storage systems, and better compliance with modern consumer loads To address the mentioned challenge, various droop based control methods have been proposed. Voltage droop control method is a well-known method in DC microgrids, where the reference voltage of each source is calculated using its nominal output voltage, output current and a droop coefficient. In a parallel system utilizing droop controller, the output power of each source is proportional to its droop co efficient. In this method, the stability is commonly obtained by sources quality, improved efficiency and stability. Studies Depending on the coupling bus, microgrids can be classified into AC, DC, and hybrid AC/DC. They can be operated as stand-alone or grid connected. Over the years, great strides have been achieved to improve the operation of AC microgrids [4]. However, DC microgrids are receiving appreciable attention in recent times because of their similar interface (DC) to most RESs and distributed generators (DGs), reduced control complexity (no frequency and reactive power controls), and better power conducted in [6] showed that DC systems have a 15%improvement in voltage stability when compared with AC systems.

Dc microgrid

In recent times, DCMGs have proven to be more popular and superior to the AC microgrids due to several reasons. The DC networks do not face reactive power issues. This aids in simplifying the control loop design. Secondly, it results in reduced power cables, thereby reducing the cost of the grid. Thus, the implementation of DCMG aids in eliminating long transmission and distribution lines that helps in providing a reliable and efficient DG systems. Also, the integration of renewable energy sources, fuel cells, energy storage with the conventional power systems has become indispensable.

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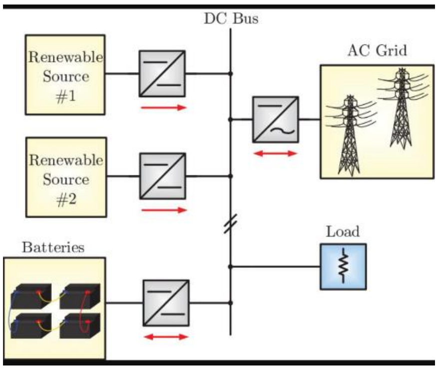

Fig 1: DIAGRAM OF DC MICROGRID

Advantages of DC Microgrid

- Higher conversion efficiency makes them an ideal option to run high-performance electrical machinery
- Lower cost converter systems that can provide the additional cost benefits apart from the renewable energy cost reduction factor
- Higher transmission efficiency due to no reactive current
- Higher power supply reliability even in the remote locations
- Relatively small cabling due to high voltage at low amperages
- Convenient controllability system that suffices without causing complexities such as synchronization, reactive power control, and frequency control.

Ac microgrid

AC microgrids connect the various energy generation sources and loads in their network using an AC bus system. Typically, AC microgrids consist of distributed generation sources such as renewables, and conventional power generation sources such as engine-based generators. These distributed generators are connected through an AC bus system with an energy storage medium like battery energy storage system (BESS). Renewable generators such as solar photovoltaic, wind turbines, etc. produce DC output. This output can be converted into AC through power electronic-based converters

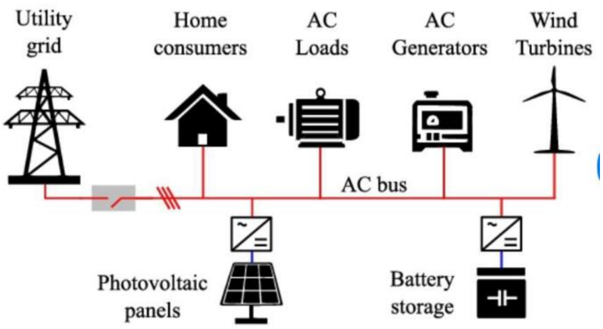

Fig 2: DIAGRAM OF AC MICROGRID

Advantages of AC Microgrid

- Capability of integrating with conventional utility grid or in islanded mode make them versatile
- Compatibility with AC equipment such as AC-based loads like motors. This equipment can be powered easily with the AC supplied from the microgrid
- No inverter requirement for AC loads
- Cost efficiency in the power protection systems
- Higher load availability for AC loads
- Expensive converters (such as DC-AC converters)

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- Difficult controllability due to the factors of frequency, voltage regulation, and unbalance compensation
- Lower power supply reliability can hinder the performance of equipment that requires an adequate power supply for high-performance needs
- Lower transmission efficiency than their DC counterparts
- AC and DC Microgrids
- Disadvantages of AC Microgrids
- Lower conversion efficiency

CONTROLLER DESIGN OF SOURCE SIDE BUCK CONVERTER

In the present literature, droop control is the most practical and viable voltage control scheme [6]. However, the equivalent circuit of a converter in boost, buck-boost topologies, consists of transformers having non-linear turn ratio. This hinders the use of linear droop control for such converters [7]. Thus, to implement linear droop scheme, the voltage source is modelled using DC-DC buck converter topology. Moreover, PI controller is incorporated as a fast controller to control the current flow through the power converters. The two controllers are proposed in this section. A buck converter with the predefined parameters is shown in Fig. 3.

The stepping down is governed by an adjustable duty ratio which can be realized by designing the PI controller for the given buck converter. The nomenclature used for the buck converter in this paper. From the control point of view, the buck converter can be considered as a power stage, as shown in Fig. 2 which is controlled by a controller, like a PI controller. The complete control model for the buck converter is shown in Fig. 2 with the mentioned parameters. The key is to design the controllers so that we get the desired output voltage of 120V from an input supply of 140V. This can be done by controlling the voltage and current flowing through the power stage. For this purpose, the voltage controller and current controller are designed as shown in Fig. 3. Here, the voltage controller compares the output voltage with the setting value of voltage (here 120V). Using the droop control governed by droop characteristic shown in Fig. 4, the setting value of load current can be obtained which is the input to the current controller.

The simulation platform of the source side buck converter based on Fig. 5 is shown in Fig. 6. This set up is implemented in Simulink (MathWorks, Inc). The parameters of PI controller are mentioned in Table I. Using these values of the PI controller, the next section will explain the stability analysis of the simulation platform.

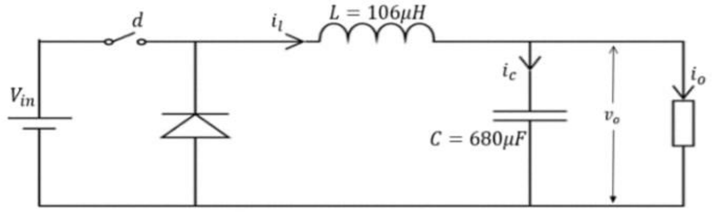

Fig. 3. Source side buck converter mode

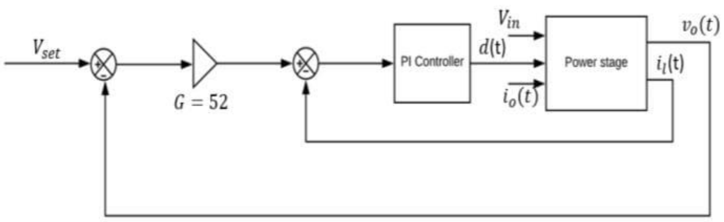

Fig. 4. Controller model for the buck converter

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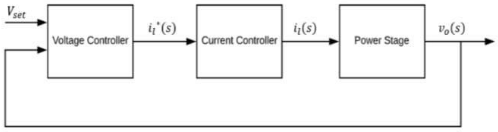

Fig. 5. Voltage and current controller for buck converter

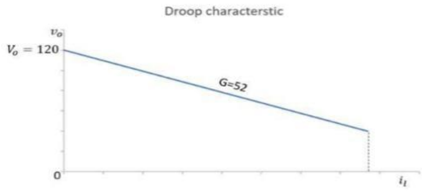

Fig. 6. Drop characteristics

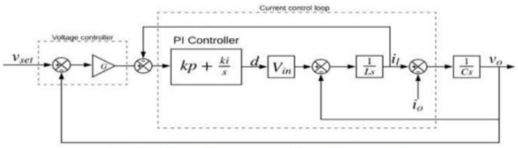

Fig.7 Closed loop control for buck converter

Simulation diagram of dc Microgrid

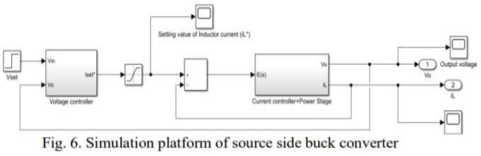

Fig.8. Simulation platform of source side buck converter

PI converter in Simulation Diagram

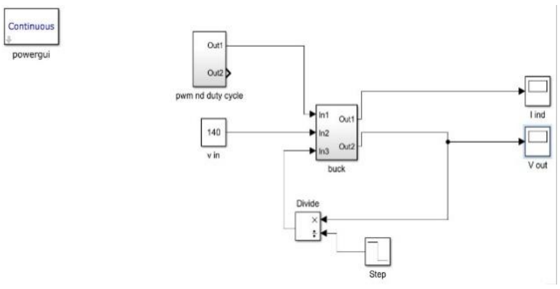

Fig.9.Simulation diagram of source side Buck converter

Simulation diagram of ac grid

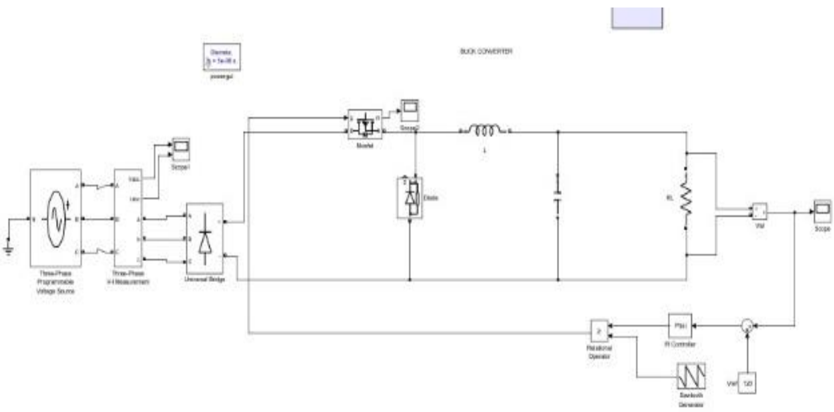

Fig. 10. Simulation platform of source at buck converter

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Results

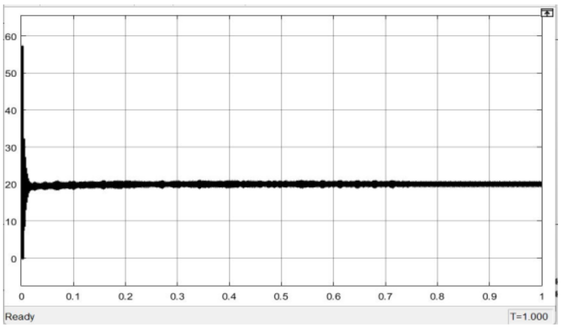

Fig.11. Constant line of PI controller in DC

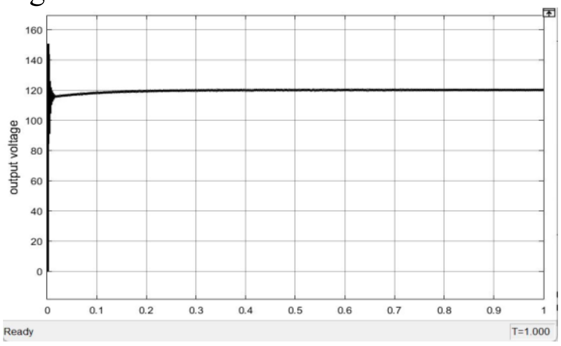

Fig.12.Output voltage for DC microgrid

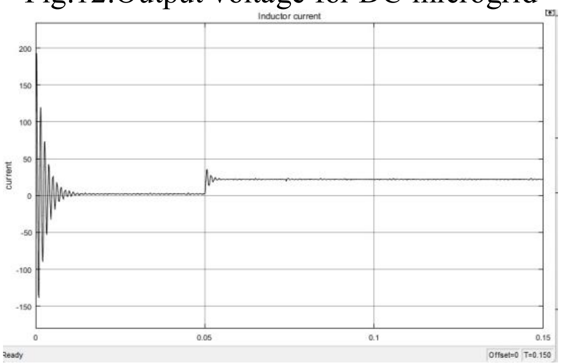

Fig. 13. Wave form of the inductor current in DC microgrid

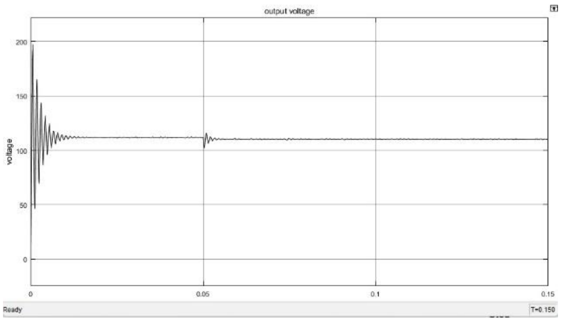

Fig. 14. Wave form of the output voltage in DC microgrid

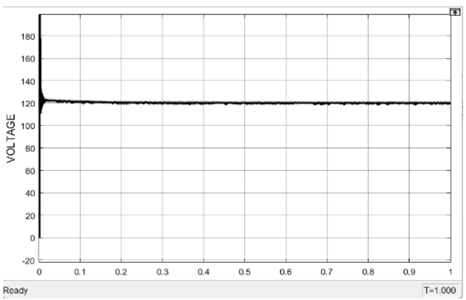

Fig .15: Output voltage for Ac microgrid

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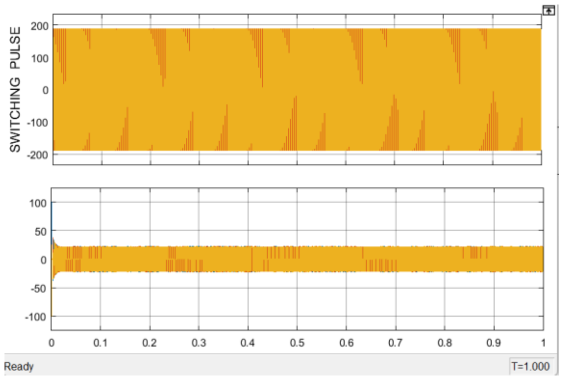

Fig .16. Switching pulse for single phase in AC microgrid

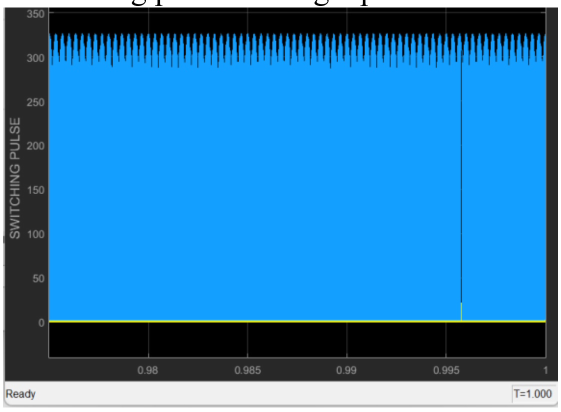

Fig.17. switching pulse for buck converter in AC microgrid

Conclusion

By comparing Ac to DC Microgrid DC Microgrid has low transient stability and low losses compared to AC Microgrid. However, DC microgrids are receiving appreciable attention in recent times because of their similar interface (DC) to most RESs and distributed generators (DGs), reduced control complexity (no frequency and reactive power controls), and better power conducted in [6] showed that DC systems have a 15%improvement in voltage stability when compared with AC systems.

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