Design a Multi-input Multi-output Microgrid Controller

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Abstract— Local power plants, such as micro-grids and nano-grids, are commonly utilized to reduce power losses caused by electricity transmission from oil and gas power plants to cities. Microgrids require power dc-dc converters, batteries, renewable resources, and inverters, among other things. This research includes a microgrid controller with several voltage inputs and outputs. According to simulation findings, the size of the complete system is decreased, as is the cost of the system, since instead of using many conventional converters, just one multiport converter is required to change the voltage level. In addition, pure sinusoidal waveforms are generated using the suggested approach.

Keywords- Inverter, Micro-grids, Nano-grids, Renewable Energy Sources, Multiport converter

I. INTRODUCTION

The present electricity cannot meet the enormous demand due to a scarcity of oil and gas, as well as the growing population, and there are numerous outages in all nations [1, 2]. As a result, the only option is to use renewable energy sources such as wind, solar, fuel cells, and other types of renewable energy sources [3-5]. A microgrid or nano-grid is used to take use of renewable energy sources, such as solar energy [6-9]. Each local grid requires a bank of batteries, power converters, a power management system, a wind power plant, a solar power plant, a fuel cell system, and inverters [10-12]. The electricity generated by the solar system and the fuel cell is DC, and it must be converted to AC before it can be used by people [13]. As a result, an inverter to convert DC electricity to AC is especially important. To complete the process of using renewable energy sources the traditional manner, numerous dc-dc converters are required [14]. In this work, however, a multi-input multi-output converter is used to transform the dc voltage from a solar or fuel cell system to an appropriate dc voltage for the inverter [15]. The microgrid is depicted in Section 2 of this study. The third section describes the micro-grid converter that has been shown. Section five concludes by demonstrating the simulation and results of the suggested technique.

II. MICROGRID SYSTEM

There is a considerable need for small local power plants in today's local areas. Some people utilize solar panels on their roofs, while others opt for a wind turbine or a fuel cell system [16]. The fossil-fuel-powered national power plants are located distant from cities. As a result, the three-phase power transmission system is used to deliver power to cities, resulting in significant power losses [17]. In recent years, certain renewable energy has been used in a number of locations to meet the rising demand for electricity [18]. Three distinct energy sources are employed as inputs to the microgrid system in this paper: solar energy, fuel cell energy, and wind energy by using MPPT tracking techniques such as fuzzy control and intelligent methods [19-22]. In addition, a bank of batteries with bi-directional power flow capability is utilized. DC to DC converters and inverters are used to convert the DC and AC power of each source [23]. A separate DC-DC converter must be used for each DC source in the old method. A multiport dc-dc converter is used in this work, which is capable of converting all dc sources to the DC bus using just one power converter, also known as a multi-input multi-output dc-dc converter [24]. The suggested microgrid system in this work is depicted on Fig. 1.

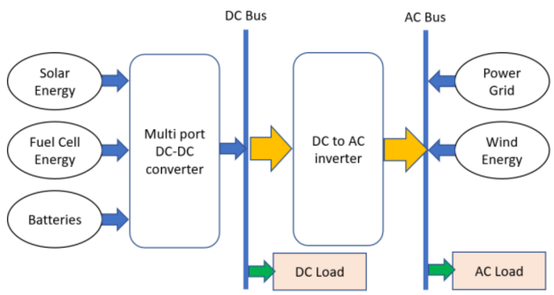

Fig. 1. Proposed Micro-grid

According to Fig. 1, the suggested system operates utilizing a simple technique of using optimized multiport DC-DC converter that does not require the use of several conventional converters [25-27]. As can be seen in the diagram above, DC loads can be supplied using the DC bus, while AC loads can be fed using the AC bus.

III. PROPOSED MICROGRID CONTROLLER

In order to convert DC power of the renewable sources to DC bus, a DC-DC converter is required. In this paper instead of using separated conventional converters for each source, a multiport DC-DC converter is implemented which this multiport DC-DC converter can be a boost converter, or a double cascaded boost, or even quadratic boost converter [28, 29]. Fig. 2, shows the multiport DC-DC converter.

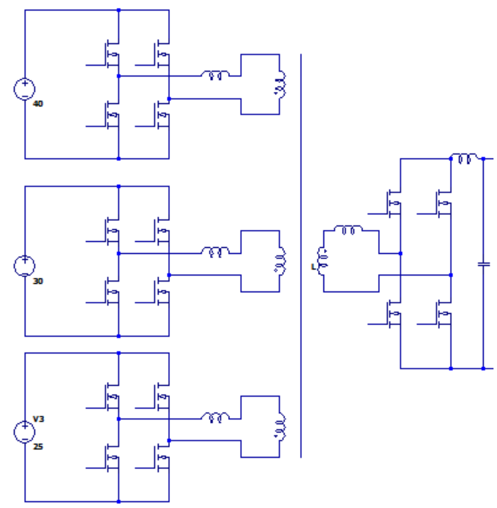

Fig. 2. Multiport DC-DC Converter

Based on Fig. 2, each part of multiport converter uses four switches, MOSFET or IGBT, one inductor. A high frequency dual active transformer is used to increase or decrease the voltage of the source [30, 31]. The frequency of the system is 20 kHz. In the secondary side of the transformer o MOSFET bridge is used to convert the pulse to the DC voltage which feeds the DC bus. Fig. 3 shows the three-phase inverter to convert the DC voltage to AC in order to feed the AC bus.

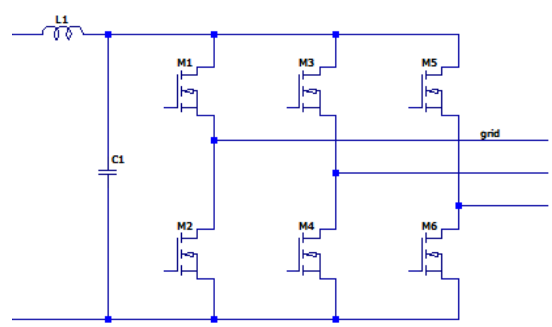

Fig. 3. Three-phase Inverter

According to Fig. 3, a three-phase inverter is utilized in such a way that the output voltage should be pure sinusoidal in case the microgrid system wants to feed the power grid [32].

IV. SIMULATION RESULTS

The simulation is done by LTSPICE and MATLAB. Fig. 4 indicates the input and output voltage of the micro-grid system when using PV system as the source of energy.

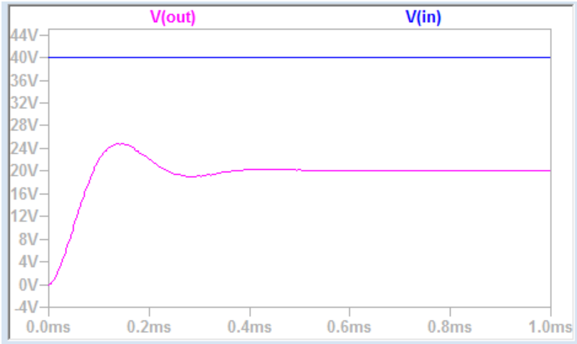

Figure. 4. Input voltage of PV system and output load voltage

According to Fig. 4, the input voltage is 40 volts and the output voltage is 20 volts which charge the DC bus of the system. When employing a fuel cell system as a source of energy, Fig. 5 shows the input and output voltage of the micro-grid system.

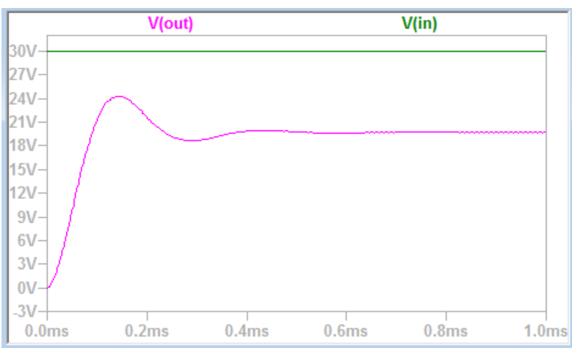

Figure. 5. Input voltage of FC system and output load voltage

According to Fig. 5, the input voltage is 30 volts which comes from FC system and the output voltage is 20 volts which feeds the DC bus. Fig. 6 shows the input and output voltage of the local micro-grid system via using a bank of batteries as the source of energy.

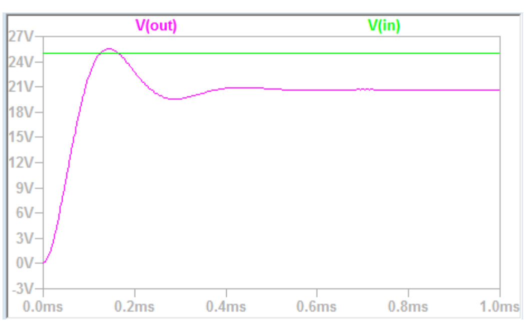

Figure. 6. Input voltage of the storage system and output load voltage

According to Fig. 6, the input voltage is 25 volts which comes from storage system and the output voltage is 20 volts which again feeds the DC bus. After feeding the DC bus, the voltage is required to be converted to AC voltage by using a three-phase inverter. Fig. 7 depicts the inductor current of the proposed controller.

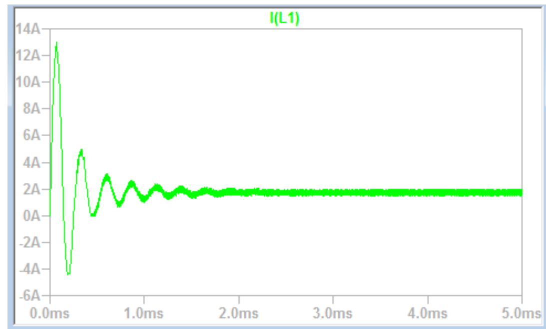

Figure. 7. The inductor current

Based on Fig. 7, the inductor current is higher than zero and therefore the system is working in continuous conduction mode (CCM). Finally, the FFT of the output voltage of the micro-grid system is shown in Fig. 8.

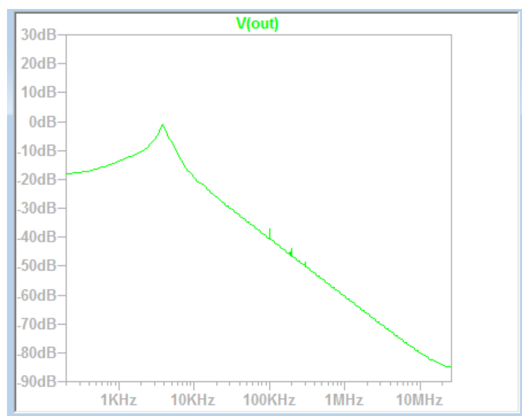

Figure. 8. The output voltage FFT

As can be seen, the system's harmonics are low, implying that the output power will be higher and losses would be lower.

V. CONCLUSION

A micro-grid requires power converters, a battery bank, renewable energy sources, and three-phase inverters. A power converter with multiple voltage inputs and outputs is part of this study. According to simulation results, the size of the entire system is reduced, as is the cost of the system, since instead of utilizing multiple traditional converters to adjust the voltage level, only one multiport converter is required. In addition, the recommended method generates pure sinusoidal waveforms.

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