Distributed Generation: A Solution to Conventional Grid Limitations and Energy Crisis

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Abstract*: Increasing concern towards the energy crisis due to the depletion of fossil fuels and environmental issues like global warming has ignited a revolutionary change in the conventional power system in terms of production and outage. The conventional grid is characterized by unidirectional power flow that constitutes bulk power generation followed by transmission and distribution. The conventional power system experiences the following drawbacks stated below. The inability of conventional grid to accommodate the renewable energy sources due to unidirectional power flow and the instability problems due to variable power generation led to the concept of distributed generation with non-conventional energy sources. The penetration of renewable energy resources like solar energy, wind energy, bio-gas etc. and other non-conventional micro sources like diesel engines, microturbines modified the demography of the power system network in the distributed generation.*

I. INTRODUCTION

The demand for electricity is steadily increasing due to the increase in inhabitants and industrial development. Energy generated from natural sources such as coal or gas is not consistent with today's energy demand. Since coal (fossil fuel) is cheaply available, an enormous quantity of electrical energy is generated from fossil fuels. Fossil fuels cause significant damage to the environment by liberating carbon dioxide and mercury during energy conversion, which leads to global warming. Sustainable energy sources can be used in power generation to overcome the challenges faced by generating electrical power from fossil fuels.

Dealt with the net generation of electricity from renewable sources which is expected to be equal to coal production by 2040. Nearly half of renewable energy is obtained from wind and solar power. Recent advances lead to renewable energy systems which are low cost. The average cost reduction for Solar Photovoltaic (PV) and shore winds forecast at 40–70% and 10-20 % by 2040. The growing global energy crisis is affected by the depletion of conventional energy sources [3], and also has the following drawbacks:

- Emission of harmful pollutants
- Carbon dioxide and mercury emissions are anticipated to increase by 35% and 8% by 2021 as the electricity generation is projected to increase

Global warming is estimated to raise the earth's surface temperature from 30C to 60C by the end of this century as a result of the greenhouse effect. The power generated by conventional systems needs to be passed on to the end-user on a long-term basic basis, requiring costly, complex infrastructure and exposing the entire system to higher energy loss and safety risks.

II. CONCEPT OF CLASSICAL INVERTER

There is a heavy competition currently between the use of conventional configurations implemented with high voltage rating switches and modern converter configurations implemented with medium voltage rating switches. Figure 2.1 illustrates a full bridge inverter. The configuration of full bridge inverter comprises of four switches (S_1, S_2, S_3, S_4) with their respective diodes and one separate voltage source, V_Z. When the switch S1 and S2 are triggered, the load voltage obtained is $+V_Z$. When the switches S_3 and S_4 are triggered the load voltage obtained is $-V_Z$.

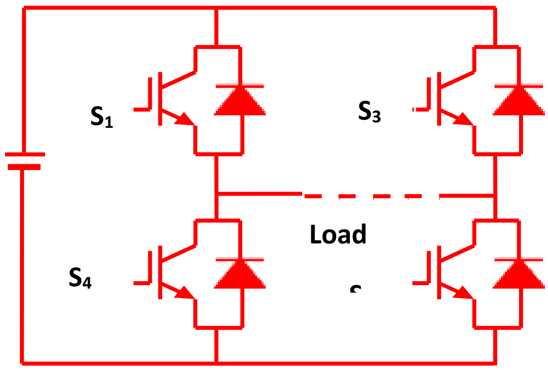

Figure 2.1: Full Bridge Inverter with its Output Waveform

A square waveform is obtained as the output from the positive and negative half cycles which are specified as two levels. The zero potential is also obtained which is also included as an additional level. Therefore, the full bridge inverter produced three levels of output voltage ($+V_Z, 0V_Z, -V_Z$).

III. DC-DC CONVERTER

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its data voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

3.1 Boost Converter

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its info voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

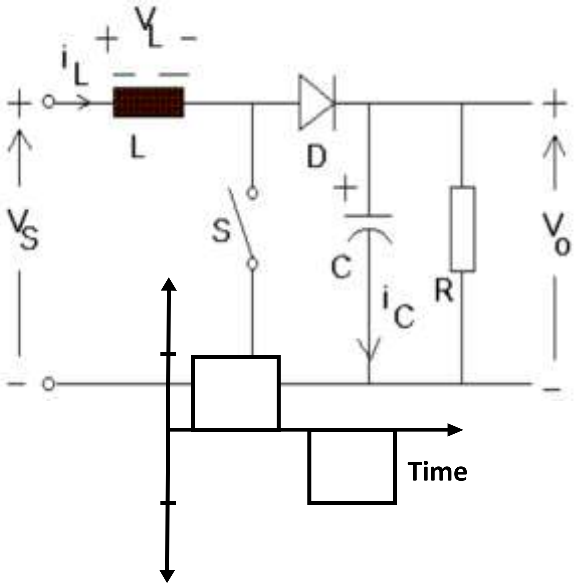

Figure 3.1: Boost Converter Circuit Diagram

IV. MICROGRID SYSTEM

In the present trend, Renewable energy sources are attractive choices for providing power in the places where an association to the utility network is either not possible or unduly costly. As electric distribution technology steps into next century, several trends have become noticeable which will modify the necessities of energy delivery. The ever-increasing energy consumption, soaring value and exhaustible nature of fossil fuels, and also the worsening international environment have created enhanced interest in green power generation systems. Renewable sources have gained worldwide attention because of quick depletion of fossil fuels in conjunction with growing energy demand Microgrid concept integrates large amounts of micro sources without disrupting the operation of main utility grid. This hybrid Microgrid consists of PV/wind energy sources for DC and AC networks respectively. Energy storage systems may be connected to either AC or DC Microgrids. The proposed hybrid Microgrid operates in grid-tied or isolated mode. AC sources and loads are connected to AC network, whereas DC sources and loads are connected to DC network. Uncertainty and intermittent characteristics of wind speed, solar irradiation level, ambient temperature and load are additionally considered in the system model and operation. Representation of microgrid system shown in figure 4.1.

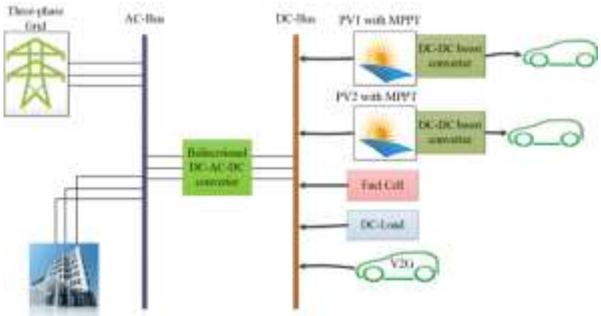

Fig. 4.1 Representation of microgrid system

V. GRID SYNCHRONISATION

The number of PV installations has an exponential growth, mainly due to the governments and utility companies that support programs that focus on grid-connected PV systems.

In a general structure distributed system, the input power is transformed into electricity by means of a power conversion unit whose configuration is closely related to the input power nature. The electricity produced can be delivered to the local loads or to the utility network, depending where the generation system is connected.

One important part of the distributed system is its control. The control tasks can be divided into two major parts:

(1) Input-side controller: Its main property is that it can extract the maximum power from the input source. Naturally, protection of the input-side converter is also important to be considered.

(2) Grid – side controller: It performs the following:

(a) It controls the active power generated

(b) It controls the reactive power transfer between the PV and the grid

(c) Control of the dc-link voltage is done by the grid-side controller

(d) It ensures high quality of the injected power

A PLL is a looped feedback device that contains a VCO, phase detector, and low pass filter. When the VCO is in lock, it is forced to replicate and monitor the frequency and phase at the input. PLL stands for phase lock loop, and it is a control mechanism that allows one oscillator to monitor another. It is possible to have a phase difference between the input and output, but the frequencies must track exactly when locked.

Benefits of PLL

- Eliminates the problem of frequency drift.
- Increase battery life of product
- Less manufacturing cost
- PLL System are very important in generating accurate and stable frequency.

PI controller used to regulate the voltage where output power equals to the sum of proportion and integration coefficients. It provides zero control error and is insensitive to interface of the measurement channel. The PI Controller disadvantage is slow reaction to disturbances. To adjust the PI Controller, you should first set the integration time equal to zero, and the maximum proportion time. By decreasing the coefficient of proportionality, achieve periodic oscillations in the system.

PLL stands for "phase-locked loop," and it is a control device that produces an output signal whose phase is related to the phase of an input signal. Though there are many varieties, it's easiest to think of it as an electronic circuit made up of a variable frequency oscillator and a phase detector. The phase detector compares the phase of the output periodic signal to the phase of the input periodic signal, changing the oscillator to keep the phases balanced. Since the output is "fed back" toward the input, creating a loop, bringing the output signal back toward the input signal for comparison is referred to as a feedback loop. PLL structure for this work shown in figure 5.1

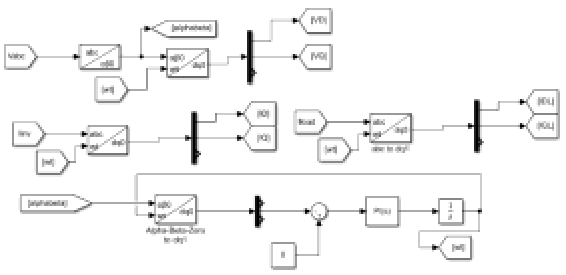

Figure 5.1: Phase locked loop (PLL)

VI. SIMULATION RESULTS

The proposed Microgrid operates in grid-tied or isolated mode. AC sources and loads are connected to AC network, whereas DC sources and loads are connected to DC network. Figure 5.1 shows the three-phase grid voltage and grid current. Which used to connect to AC bus by using LCL filter. This three-phase voltage and current stabilised unity power factor at the grid side and also its have lower harmonics

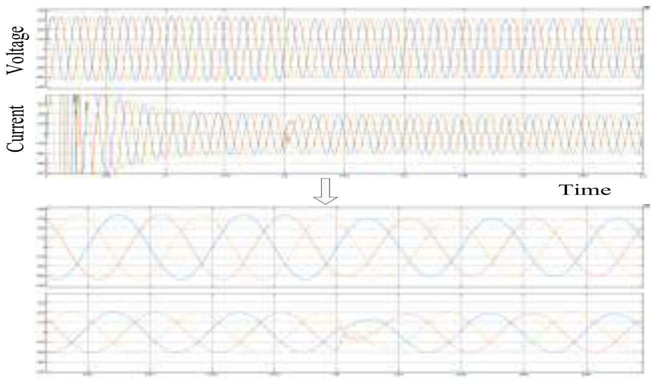

Figure 6.1: Three phase grid voltage and current

By creating some disturbance through grid at time of 0.2 sec it reduces a voltage by 10%. So, it created a sudden disturbance at this time renewable energy sources perform a role so it maintains this voltage to the same condition. In figure 6.1 voltage reduces by 10% but current maintain same peak to peak amplitude.

By the sudden change the grid voltage peak reduces simultaneously for the AC load. By the design of the filter which is perform a specific role in connected with AC and DC bus, load voltage and current are ripple free which is shown in figure 6.2 .

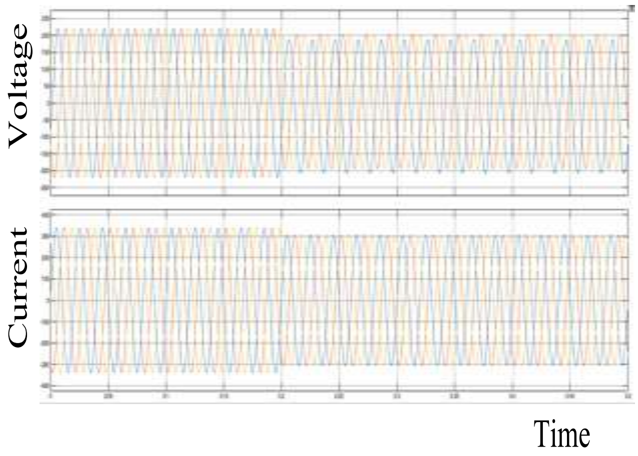

Figure 6.2: Three phase AC load voltage and current

VII. CONCLUSION

The AC/DC hybrid microgrid, which takes into account the access requirements of AC and DC sources and loads, optimizes the structure of traditional distribution networks. The application of power electronic transformers as the core of its energy management, with electrical isolation and accurate control of the voltage, current and power flow by the control system, enables the microgrid to achieve a more flexible and stable transmission mode. Because the power electronic transformer combines the power electronic device and the high-frequency transformer, its frequent switching causes the electromagnetic transient simulation to take too long.

Microgrid concept integrates large amounts of micro sources without disrupting the operation of main utility grid. This hybrid Microgrid consists of PV/wind energy sources for DC and AC networks respectively. Energy storage systems may be connected to either AC or DC Microgrids. The proposed hybrid Microgrid operates in grid-tied or isolated mode.

AC sources and loads are connected to AC network, whereas DC sources and loads are connected to DC network. Uncertainty and intermittent characteristics of wind speed, solar irradiation level, ambient temperature and load are additionally considered in the system model and operation.

Conflict of Interest: The corresponding author, on behalf of second author, confirms that there are no conflicts of interest to disclose.

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