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DC–DC DUAL ACTIVE BRIDGE CONVERTERS DRIVING THREE-PHASE INVERTERS

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ABSTRACT

A solid state transformer (SST) is a converter is used to convert ac to ac in distribution station. It is a high frequency power electronic converter. It consists of three common stages includes rectifier (ac-dc), DAB converter (dc-dc), and inverter (dc-ac). Switching frequency of inverter much higher than the DAB stages, the three phase inverter is modelled as a double line frequency (e.g. 120HZ). The effect of 120-Hz current by the three-phase inverter is studied. The limitation of a PI-controller is low gain at 120 Hz, is investigated. The proposed PID controller is to improve the regulation of the output voltage of DAB converters. Space Vector Pulse Width Modulation (SVPWM) is a high frequency modulation alternative to conventional PWM. Lower order harmonics can be eliminated by the Space Vector PWM technique and there is 15% increment in maximum voltage compared to conventional PWM.

Keywords: Dc-Dc Power Converter, Power Smoothing, PID Converter, SVPWM.

I INTRODUCTION

Each power electronic converter design has four aspects: converter topology, model of the converter, controller for the converter, and other characteristics related to the application specific background of the converter. The converter topology and operation must be analyzed in order to provide guidelines for designing a working converter. The power converter must be modelled accurately enough to capture the dynamics of the power converter and to provide insight for feedback and/or feed forward controller design.

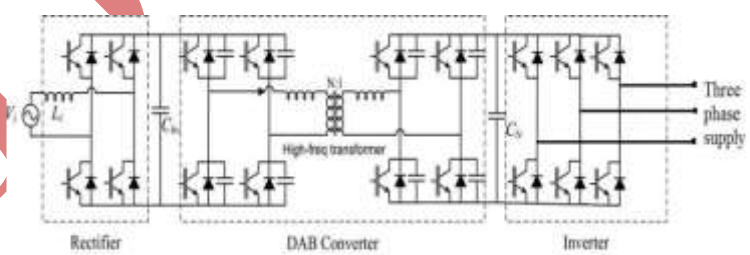

Fig.1.1 Circuit configurations of multistage SSTs

The controller should stabilize the control loop and achieve good steady-state and dynamic response. Overall, both the power converter and its controller must consider the application background and any application-specific attribute. The multistage ac–dc–ac–dc–ac configuration shown in fig. 1.1 is one of many feasible three-phase SST topologies. The output voltage and the output current of the inverter stage are grid frequency, while the input and output voltage of dual-active-bridge (DAB) converter stage are dc.

As a result, the instantaneous output power fluctuates at twice the line frequency and there is significant second-order harmonic current at the input side of the inverter stage. When a dc–dc DAB converter is driving an inverter, it is common to select a sufficiently large output capacitor bank to absorb the double-frequency harmonic current and to minimize the output voltage ripple. Because the second-order harmonic frequencies are relatively low, this might result in a large capacitor bank at the output side of the DAB converter, which increases the cost, weight and volume. Furthermore, large electrolytic capacitor is one major factor affecting their ability of power converters. For example, line frequency is assumed to be 60 Hz, so the ripple current in the output capacitor is at 120 Hz. One way to reduce the output capacitor bank is to enable dc– dc DAB converters with the ability to process power at 120 Hz. A result, both average power and 120 Hz power processed by the rectifier, DAB converter, and inverter, from the grid to the load. However, the control bandwidth is limited and the loop gain at 120 Hz is limited because the switching frequency of DAB converters is constrained by the availability of power devices. When a conventional PID controller is used, it only achieves infinite gain at dc. Small, finite gain leads to nonzero steady-state error, resulting in high voltage ripple at the output of DAB converters. This study addresses such limitations of a conventional PID controller for a dc–dc DAB converter driving a three-phase dc– ac inverter. This method proposes to solve the derivative issue. The proposed PID controller is to improve the regulation of the output voltage of DAB converters.

II. PROPOSED METHODS

A solid-state transformer (SST) is a high-frequency power electronic converter that is used as a distribution power transformer. A common three-stage of an SST consists of ac–dc rectifier, isolated dc–dc dual-active-bridge (DAB) converter and dc–ac inverter. This study addresses of the controller design issue for a dc–dc DAB converter when driving a regulated three-phase dc–ac inverter. The switching frequency of inverter stage is much higher than that of the DAB stage, the three- phase inverter is modeled as a double-line-frequency (e.g., 120 Hz) current sink. Lower order harmonics can be eliminated by the Space Vector PWM technique and there is 15% increment in maximum voltage compared to conventional PWM. The figure 2.1 shows the dc-dc dual active bridge converter driving three phase inverter.

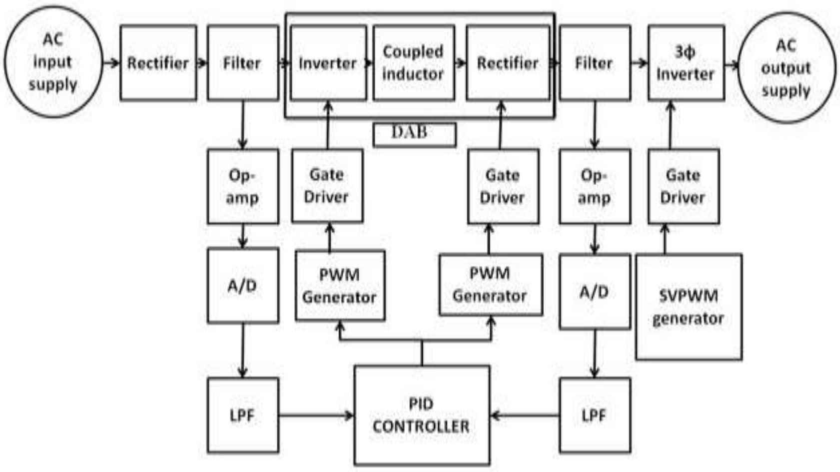

Fig 2.1 Functional block diagram

2.1 Solid State Transformers

SSTs are essentially high switching frequency power electronic converters that have the following functionalities: They provide galvanic isolation between the input and the output of the converter. They provide active control of power flow in both directions. They provide compensation to disturbances in the power grid, such as variations of input voltage, short-term sag or swell. They provide ports or interfaces to connect distributed power generators or energy storage devices. The main role of SSTs in the FREEDM System is that they acts as buffers among power grid and loads, distributed energy sources and energy storage devices. By decoupling the load from the source and the consumers could not see the disturbance at the grid side because the disturbance is compensated by the SSTs. This is the advantage of SSTs for consumers. At the same time, power grids not see the reactive power generated by loads, which compensated by SSTs. Therefore, the distribution system becomes more efficient and stable. This is the advantage of SSTs for the power grid. Additionally, SST is buffers for renewable power sources, which help reduce the impact of unpredictable and un schedulable fluctuations of renewable electric power sources on both power grids and loads. This the advantage of SSTs for renewable power generation.

2.2 Dc to Dc Converter

DC to DC converters are important in portable electronic device such as cellular phone and laptop computer, which are supplied with power from batteries primarily. Such electronic device contains several sub-circuits, each with it own voltage level requirement is different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltages declines the its stored energies are drained. Switched DC to DC converter offer the method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing. Most DC to DC converters also regulate the output voltage. The some exceptions include high-efficiency of LED power source, which is a kind of DC to DC converter that regulates the current through the LED, and simple charge pumps which double or triple the output voltages.

2.3 Inverter

This report focuses on DC to AC power inverter, which aim to the efficiently transform the DC power sources to a high voltage AC sources, similar to the power that would be available at electrical wall outlet. Inverter is used for many application, as in situations where low voltage DC sources such as batteries and solar panels or fuel cells must be converted so that devices can run off of AC power. One example of a situation would be converting electrical power from a car batterie to run a laptop and TV or cell phone. The method, in which the low voltage DC powers are inverted, is completed in two steps. The first is start the conversion of the low voltage DC power to a high voltage DC source, and the second step is start the conversion of high DC source to an AC waveform using the pulse width modulation. Another method is to complete the desired outcome would be to first convert the low voltages DC power to AC power and then use a transformer to boost the voltages to 120 volts. This project focused on first method described and specifically the transformation of a high voltage DC source into an AC output.

2.4 Dual Active Bridge (Dab) Converters

A DAB converter is a high-power, high-power-density, and high-efficiency power converter with galvanic isolation. It consists of two H-bridges of a active power switching devices and one high-frequency transformer.

The high-frequency transformers provide the both galvanic isolation and energy storage in its winding leakage of inductance. The two H-bridges operate at fixed 50% duty ratio and the phase shift between the two bridges control the amount and direction of power flow. Based-on configuration is switching devices, there are dc-dc DAB converters and ac-ac DAB converters.

2.5 Filters

Filters of some sort are essential to the operation of most electronic circuit. It is the interest of anyone involved in the electronic circuit design to have the ability to develop a filter circuit capable of meeting a given set of the specifications. Unfortunately, many of the electronics field are uncomfortable with the subjects, whether due to a lack of familiarity with it or a reluctance to grapple with the mathematics involved in the complex filter design. This Application Note is intended to serve as a very basic introduction to some of the fundamental concepts and term associated with filter. It will not turn the novice into the filter designer, but it serve as a starting point for those wishing to learn more about filter design.

III. METHODOOGY

The circuit diagram that has the schematic connection of all Sources with PIC controller and the relay circuit is shown in figure 3.1. The PIC controller pins are given to the each terminal of the gate driver circuits**.**

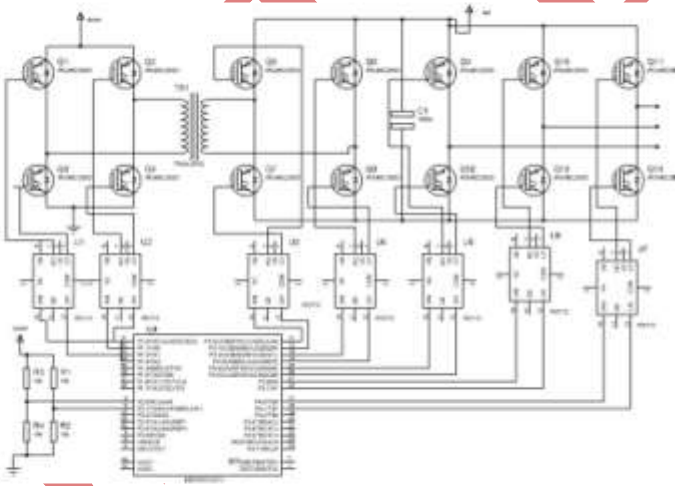

Fig 3.1 Circuit Diagram

The coupled inductor is used to interface between the inverter and rectifier. The switching devices of a MOSFET are connecting to the gate drivers.

3.1 Gate Driver

A gate driver is a power amplifier that accepts a low-power input from a controller IC and produces a high-current drive input for the gate of a high-power transistor such as an IGBT or power MOSFETs. Gate driver can be provided either on-chip or as a discrete module. A gate driver consists of a level of shifter in the combination with an amplifier.

3.2 Mosfet

MOSFET is an acronym for Metal Oxide Semiconductor Field Effect Transistor and it is the key component in high frequency and high efficiency of switching applications across the electronics industries. It might be surprising, but FET technologies were invented in 1930, some 20 years before the bipolar transistors. The first signal level FET transistor was built in the late 1950's while powers MOSFET have been available from the mid 70's. Today, millions of MOSFET transistor is integrated in modern electronic components, from microprocessors, through "discrete" power transistors. The focus on this topic is the gate drive requirements of the power MOSFET in various switch mode power conversion applications.

3.3 Coupled-Inductor

From power distribution across large distances to radio transmissions, coupled inductors are used extensively in electrical applications. Their properties allow for the increasing or decreasing voltages and current, transferring impedance through a circuit and they can isolate two circuits from each other electrically. There are a wide variety of the applications which exploit properties of transformer, such as tesla coils and impedance matching in audio frequency applications, potential transformers for reading very high voltages, Scott-T transformers which convert two phase components to three-phase (or vice versa) and many more.

IV. SOFTWARE REQUIREMENTS

4.1 Matlab

The MATLAB handles simple numerical expression and mathematical formula. Name of the MATLAB is stands for matrix laboratory. MATLAB was written in originally provide the easy access to matrix software to develop by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is a high-performance language in the technical computing. It is integrate computation, visualization and programming environment. MATLAB is a modern programming language environment. It has sophisticated data structure and contains built-in editing and debugging tools and supports object-oriented programming.

V. SIMULATION

The simulation of this project has done with the help of MATLAB simulation tool. The single phase ac input supply is converting into dc supply with help of rectifier. The scope view is to be obtained from the voltage measurement unit. The figure 4.1 shows the ac to dc supply voltage.

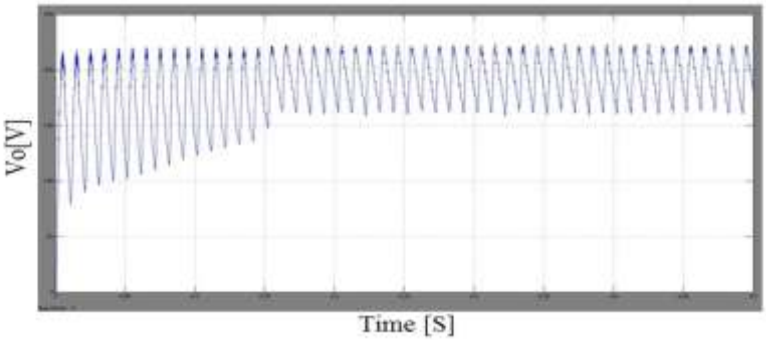

Fig 4.1: DC Supply Voltage.

The add or subtract output to PID controller using constant 220v. The output of feed forward is to be feed to the input of PID controller. The PID feed forward control is shown in the figure 4.2.

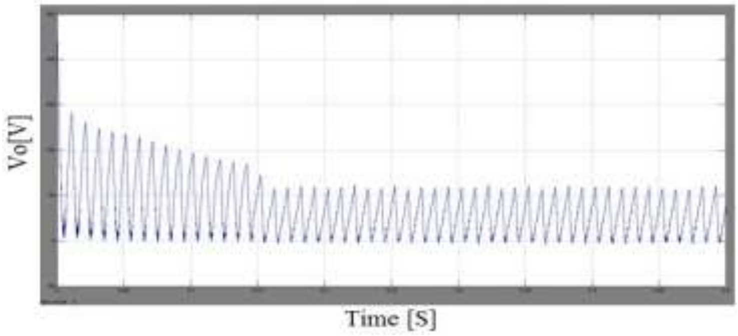

Fig 4.2: PID Feed Forward Control.

The dc to dc dual active bridge converter using high frequency transformer. The voltage and current measurement does verify to overcome the lag phases. The figure 4.3 shows the voltage and current output of dual active bridge.

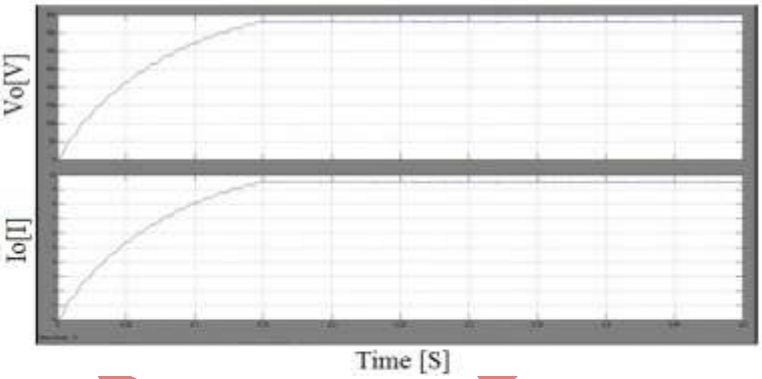

Fig 4.3: Output Of Dual Active Bridge.

The DAB output dc supply is converting into three phase ac supply with help of inverter. The overall performances do to be checked on the three phase inverter. The PI controller does can also be used to overcome the steady state error and oscillation error is less, increases performances and stability. The figure 4.4 shows the three phase output voltage and current.

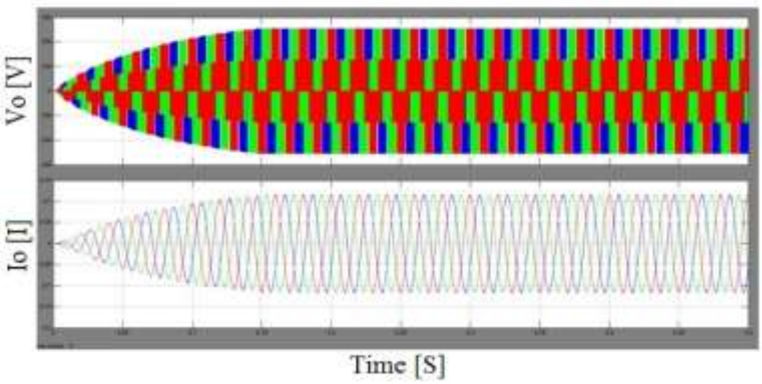

Fig 4.4: Three phase output.

VI RESULT AND CONCLUSION

In the multistage configuration of an SST, a dc–dc DAB converter drives a three-phase dc–ac inverter. The cascaded connection of the power converter poses a challenge for the closed loop controller design. A three-phase inverter has significant second-order (120 Hz) harmonic current in its input side. A conventional PID controller has limited bandwidth at 120 Hz because of the relatively low switching frequency of the DAB converter. What is more, simply increasing the switching frequency would not result in higher bandwidth.

One control methods are proposed to solve the aforementioned challenge without using a large dc bus capacitor between the DAB converter and the inverter. PID controller is to improve the regulation of the output voltage of DAB converters. Space Vector Pulse Width Modulation (SVPWM) is a high frequency modulation alternative to conventional PWM. Simulation and experimental results confirm the effectiveness of the proposed methods.

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