Major Project (19EE706)
Report on

PERFORMANCE STUDY OF DAB CONVERTER

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Acknowledgment

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Abstract

This project report focuses on the study of Dual Active Bridge (DAB) converter, which is one of the most prominent topology of Isolated Bidirectional DC-DC (IBDC) converters. This type of DAB converter serves as interface between the energy storage devices for renewable energy systems applications and, highly applied in automotive applications like electric, hybrid and fuel cell vehicles and aerospace applications and personal electronic equipment. Hence, this type of DAB converter topology requires detail methodical study in terms of its reliability, efficiency, safety and durable performance operation. The main objective of this study is to learn the working principle cum performance of operation, design and case study simulation to validate DAB converter. DAB converter allows the power to flow in both directions between the two energy sources. Different type of these converter topologies will provide different functions and services in accordance to their structure and components, which depends upon the applications. Hence, they are widely used.

Contents

Chapter 1

Introduction

A dual active bridge is a bidirectional DC-DC converter with primary and secondary side full-bridges, a high frequency transformer, an energy transfer inductor and DC-link capacitors. Energy transfer inductance refers to the leakage inductance of the transformer plus any necessary external energy transfer inductance.The two legs of both full-bridges are driven with complimentary square-wave pulses.

1.1 Block Diagram

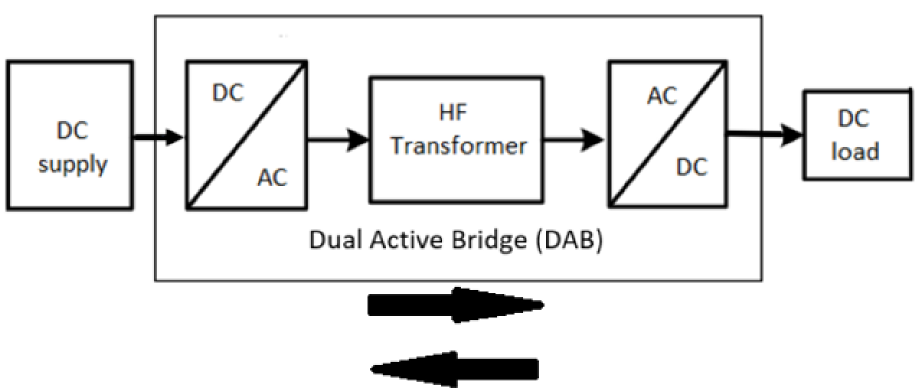

Figure 1.1: Block Diagram of DAB Converter

Power flow in the dual active bridge can be directed by phase-shifting the pulses of one bridge with respect to the other using phase shift modulation. The control directs power between the two DC buses such that the leading bridge delivers power to the lagging bridge. The applied square waves to the bridges create a voltage differential across the energy transfer inductance and direct its stored energy.

Its key features are:

- Isolated operation
- Power density (high frequency operation reduces the size of the isolation transformer)
- Bidirectional power flow

It is used in several applications such as in charging stations and electric vehicle traction. DAB model consists of two MOSFET full-bridges linked by a coupling inductor and a high frequency transformer.In this project study high voltage bridge is connected to an 24V DC source and the low voltage bridge is connected to a 12V DC source. It can achieve high efficiency, power density and bidirectional power flow by using phase-shift modulation which means changing the phase difference between the input and output voltages of the converter. The dual-active-bridge (DAB) dc-dc converter is originally proposed at the beginning of the 1990s. Due to the advantage of high-power density, soft switching performance, bidirectional power flow capability and high efficiency potential, the DAB dc-dc converter has attracted more and more attention in the dc-dc power systems, such as the energy storage system, the automotive application, the dc microgrid and the railway traction. In these power conversion systems, the DAB dc-dc converter has to face the variations of the load condition and the input voltage, which may result in the disturbances of the output voltage and affect the stability of DAB-based system. Thus, the robust and fast dynamic response is an essential requirement for DAB dc–dc converters in these applications. Traditionally, the single-loop voltage controller can be employed to deal with the change of the input voltage and the load. However, since the regulation of the output voltage is mainly dependent on the PI controller. Based on the natural switching surface of inductance current, the fast-transient boundary control scheme can provide the excellent dynamic performance without visible disturbance of output voltage for the DAB dc-dc converter when the load load and the input voltage are changed.

The DAB converter is bi-directional so by altering the control signals can be used for example to control charge to a battery from a primary DC voltage and also convert battery voltage back up to the primary voltage. The modern DAB can also be resonantly switched for high efficiency. It is normally configured with ‘phase shift’ control where every switch is fed with 50% duty cycle square waves and regulation is achieved by varying the relative phases of the drives.This makes gate drives very easy and resonant conversion (quite) easy. In short there are other topologies but the DAB converter is a good solution for high efficiency conversion at relatively high power where the complexity and cost of multiple switches is not so much an issue.

Applications

- Photovoltaic Applications: By using both the ‘renewable energy equipment and energy storage units’ to give a stable and continuous power is called as “renewable energy co-generation system.
- Applications of “Plug In Hybrid Electric Vehicle”: Another type of ‘bi-directional DAB DC - DC converter’ which is used in hybrid electric vehicle applications.
- High Frequency Isolation: It reduces the volume and weight of the transformer. Mostly the single phase full bridge ‘bi-directional dual active bridge’ that is “(DAB DC-DC converter)” used in the hybrid electric vehicle and also in plug-in hybrid electric vehicle.
- Three Phase Bidirectional Dual-Active Bridge (DAB) DC-DC Converter: This type of three phase converters has many advantages, they are isolation features, small capacitance, smaller switch current stress, high power flow, efficiency is high.

Chapter 2

Litrature Review

The dual active bridge (DAB) converter is a DC-DC power converter topology that is widely used in various applications, such as renewable energy systems, electric vehicles, and data centres. The DAB converter is a bidirectional converter that can transfer power from one DC source to another DC source with high efficiency.In the DAB converter, there are two active switches that are used to control the power transfer between the input and output sides. The DAB converter provides isolation between the input and output sides using a high-frequency transformer, which also helps in reducing the size and weight of the converter.

The DAB converter has several advantages over other DC-DC converters, such as high efficiency, bidirectional power flow, and high-frequency operation. The DAB converter is also suitable for high-power applications due to its modular structure, which allows for easy scalability.Several control strategies have been proposed for the DAB converter, such as phase-shift control, dual-phase-shift control, and direct frequency control. These control strategies aim to improve the efficiency and dynamic performance of the DAB converter.

In recent years, research has focused on improving the performance of the DAB converter by using advanced control techniques, such as model predictive control, and integrating it with other power electronics converters to form hybrid power conversion systems. The DAB converter has several control strategies that aim to improve its efficiency and dynamic performance, and research is ongoing to further improve the performance of this converter topology.

Chapter 3

Project Overview

3.1 Objectives

1. The main aim of this project is simulation performance of Dual Active Bridge (DAB) DC-DC converter for high power density applications.

2. 24V(input)-12V(output) DAB converter is modelled using Matlab software. Theoretically verify that the performance of the DAB DC-DC converter is suitable for high power density applications.

3.2 Methodology

- Go through the various research paper,documents of the DAB converter.

- Plan,design of DAB converter circuits for our requiremnets.

- Design Calculations.

- Design and developement of DAB converter circuit using Matlab simulink.

- Understanding phase shift control for bidirectional power flow.

- Verifying the Simulation using Matlab.

Chapter 4

The Topology Of DAB

The DAB converter circuit, shown in Figure 4.1, consists of a full bridge at the primary side of a high-frequency transformer composed of switches $S1$-$S4$, and a full bridge at the secondary side composed of switches $Q1$-$Q4$. The DC voltage on the primary side is denoted as V_P, and that of the secondary side is V_S. Capacitors C_{in} and C_o, connected in parallel to the DC voltage source, are used for voltage stabilization and filtering. The transformation ratio of the high-frequency transformer is $n : 1$. The inductor current is denoted as i_{Ls}, and the transformation ratio is given by $k = \frac{n_1}{n_2} = \frac{V_P}{V_S} = \frac{i_s}{i_p} = \frac{n_1(V_S)}{V_P}$. The load is represented by resistance R.

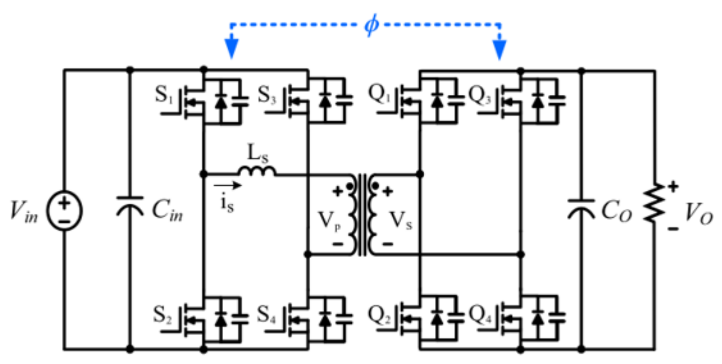

Figure 4.1: Dual Active Bridge converter circuit

In ideal cases with dual active bridge converters, zero voltage switching (ZVS) can be realized when the voltage transfer ratio (k) across the transformer is equal to 1:

$$k = \frac{V_{out}}{nV_{in}} \tag{4.1}$$

where n is the transformer turn ratio, V_{out} is the output voltage, and V_{in} is the input voltage.

In non-ideal cases, ZVS depends on the resonant relationship between the output capacitance across each device and the equivalent inductance of the circuit during different switching intervals. During switching events, the current through one of the complementary devices is interrupted, but due to the energy transfer inductance, current is supplied through the output capacitor and forced through the anti-parallel diode of the device.

Each switch is on for 50% of its respective switching period. The switch pairs in the two bridges all have the same switching period but are operated such that between each bridge a phase shift is introduced that varies based on the modulation derived from feedback measurements. An output voltage error signal is generated based on a set point value and this is fed through a digital PI regulator to generate the phase shift ratio for the PWM modulator.

4.1 Principle of operation:-

The simplified DAB converter circuit model is as shown in Fig.

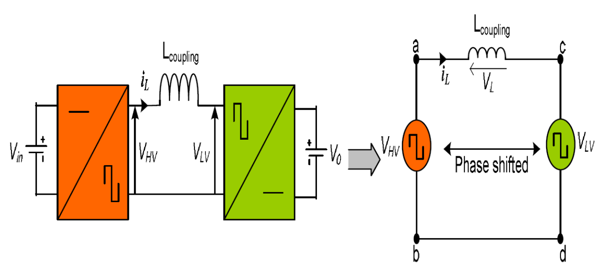

Figure 4.2: Simplified equivalent circuit

As shown in Fig 4.2, The inductance LS is termed as coupling inductance, which is the combination of both the series inductance and the leakage inductance of the high frequency transformer. This inductance LS, serve as power transfer component of the 1ph-DAB converter.

Each bridge is controlled to generate a high frequency square-wave voltage at its transformer terminals of the same frequency. The two square waves can be phase-shifted with respect to each other to control the power flow through the inductor and transformer. Thus power can be made to flow from V_{in} to V_0 or vice versa. Power always flows from the bridge generating the leading square wave to the other bridge. The simplified equivalent circuit and phasor diagrams are shown in Figures 4.3 (i) and (ii).

By changing the duty cycle of phase shift between bridges, the magnitude and direction of transmission power can be changed. The voltages generated by the two full-bridges, i.e., V_P on the primary side and V_S on the secondary side, are square wave voltages with a fixed 50% duty cycle. The phase shift between V_P and V_S is $\frac{d(T_S)}{2}$, where T_S is the switching period and d is the controlled duty ratio. The phase displacement between V_P and current i_L is denoted as θ

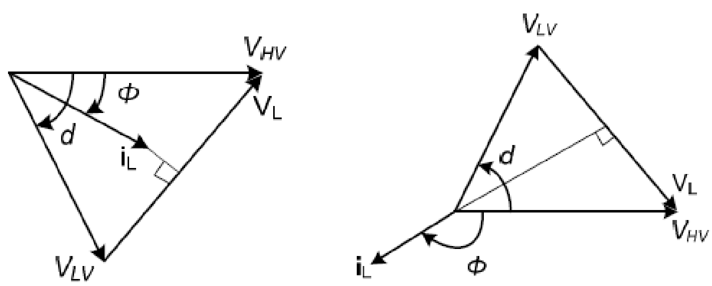

Figure 4.3: Phasor diagram for (i) lagging V_{HV} lags V_{LV}, and (ii) leading V_{HV} leads V_{LV} phase shifts

The theoretical waveforms of the 1ph-DAB converter under the charging mode/ forward power flow are shown in Fig. 3[. Principle of operation is based on single-phase shift (SPS) modulation technique.

Power is transferred from the primary side to the secondary side when the phase of the primary side leads to that of the secondary side, and vice versa. The ZVS operation procedure of the 1ph-DAB converter is shown in Fig 4.4(a) and the power flow is in the forward direction/ charging mode as shown in Fig 4.8

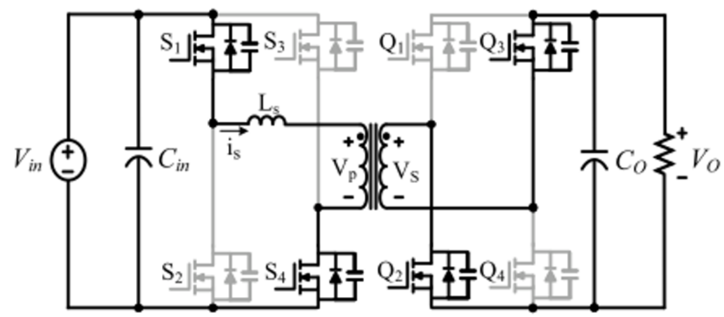

Figure 4.4: (a)

The output capacitor voltage of the switch S1 and S4 is discharged to the output capacitor of the switch Q2 and Q3 after the switch Q2 and Q3 is turned off as shown in Fig. 4.5(b).

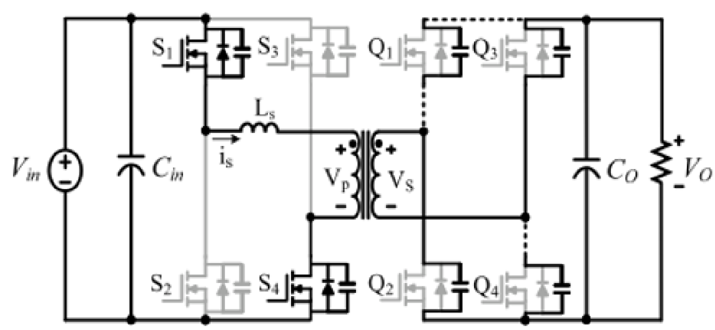

Figure 4.5: (b)

This is the turn-on condition of the body diode in the switch Q1 and Q4 as shown in Fig. 4.6(c).

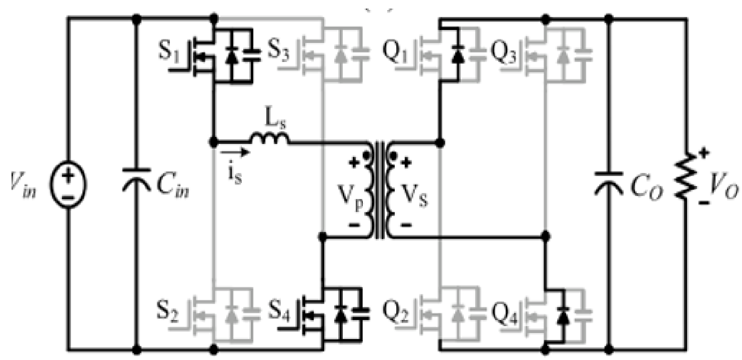

Figure 4.6: (c)

The switch Q1 and Q4 can be turned on with the ZVS condition while the current is flown to the channel of the switch Q1 and Q4 as shown in Fig. 4.7(d). The ZVS is achieved by repeating this procedure.

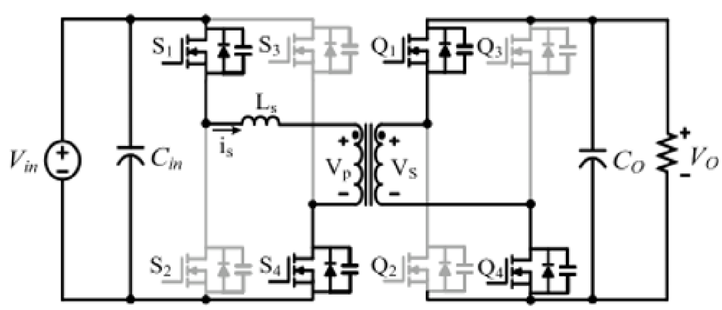

Figure 4.7: (d)

4.2 Operational circuit diagram

Charging mode

The various time instants are indicated in Figure 4.8 are explained as below:

- $t_0 - t_1$:

  The cycle starts at t_0 when the switches $S1$ and $S4$ are turned on while their body (anti-parallel) diodes are conducting. This develops the supply voltage, $V_{in} = V_P$, across the transformer primary winding. Transistors $Q2$ and $Q3$ are conducting on the RH bridge side; thereby the transformer secondary voltage is clamped to $-V_0$. As a result, inductor current gradually increases.

- $t_1 - t_2$:

  The switches $S1$ and $S4$ continue to be turned on. At t_1, switches $Q2$ and $Q3$ are turned off with ZVS (Fig. (b)). However, the current during turn-off is high and therefore, to benefit from soft-switching, a turn-off snubber is needed. As a result, current from the switch $Q2$ is transferred to the body (anti-parallel) diode. Similarly, in the case of switch $Q3$ under the condition of ZVS, the transformer secondary voltage is clamped to $+V_0$. As a result, inductor current increases to its peak value.

- $t_2 - t_3$:

  The switches $S1$ and $S4$ are turned off under ZVS. The current from switches $S1$ and $S4$ transfers to their body (anti-parallel) diodes under ZVS. Hence, the anti-parallel body diodes are conducting. As a result, the primary voltage is clamped to V_{in} in the opposite direction, whereas the body anti-parallel diodes of the secondary side continue to conduct so that transformer secondary voltage is retained at $+V_0$. As a result, inductor current falls to zero and charges in the opposite direction gradually. This completes one half cycle. At t_3, the cycle is repeated, except with the corresponding opposite set of bridge transistors and diodes.

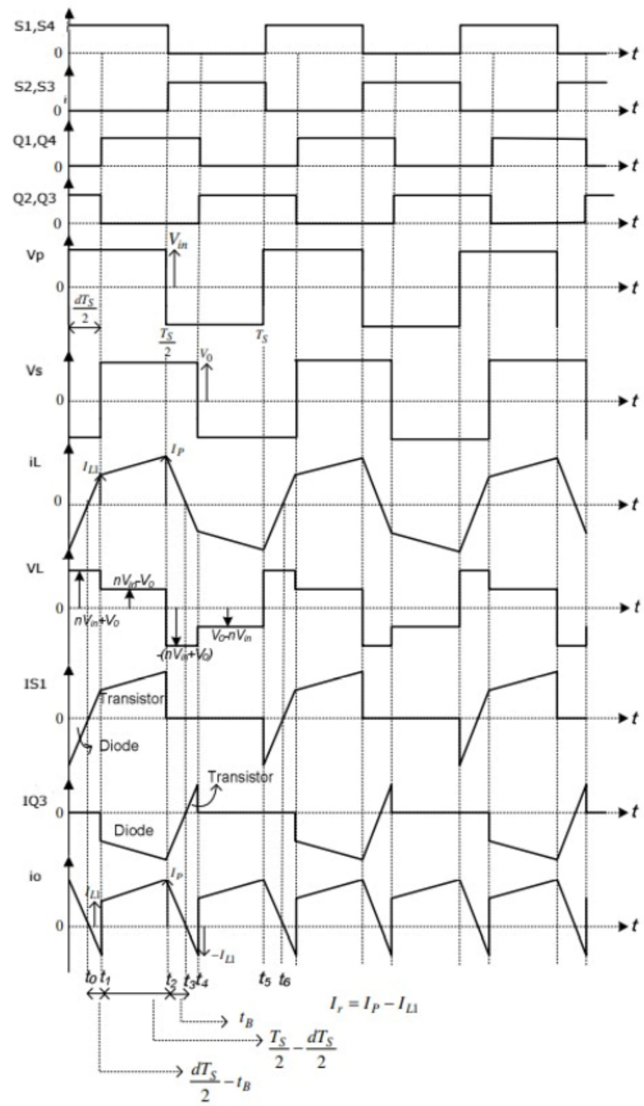

Figure 4.8: Waveforms of the 1ph-DAB converter under the charging mode/ forward power flow.

Discharging mode

The various time instants are indicated in Figure 4.9 are explained as below:

- $t_0 - t_1$: Just before t_0, the anti-parallel diodes are conducting. At time t_0, Switches $Q2$ and $Q3$ are turned-on. The voltage is applied across the transformer secondary. On the primary (HV side), Switches $S1$ and $S4$ are conducting; thereby the transformer primary is clamped to V_{in} in the reverse direction. Since the resultant voltage impressed across the inductor is negative, a gradual increase of inductor current in the reverse direction occurs until it attains its peak value at time t_1.

- $t_1 - t_2$: At t_1, Switches $S1$ and $S4$ are turned-off under ZVS. Therefore, current is transferred from transistors $S1$ and $S4$ to diodes. This clamps the transformer primary to ground. Switches $Q2$ and $Q3$ remain in conduction during this mode. The resultant voltage across the inductor is positive during this interval, which makes the inductor current fall from its negative peak.

- $t_2 - t_3$: During this interval, current flowing in $Q2$ and $Q3$ transfers to diodes, under ZVS, and transistors $Q2$ and $Q3$ turn-off. Now LV Side diodes are conducting, thereby the secondary of the transformer is kept at $-V_0$. Diodes continue to conduct during this interval. As a result, inductor current falls to zero and charges in the forward direction gradually. This completes one half cycle in discharging mode. The next half cycle repeats at t_3, except with the corresponding opposite set of bridge transistors and diodes.

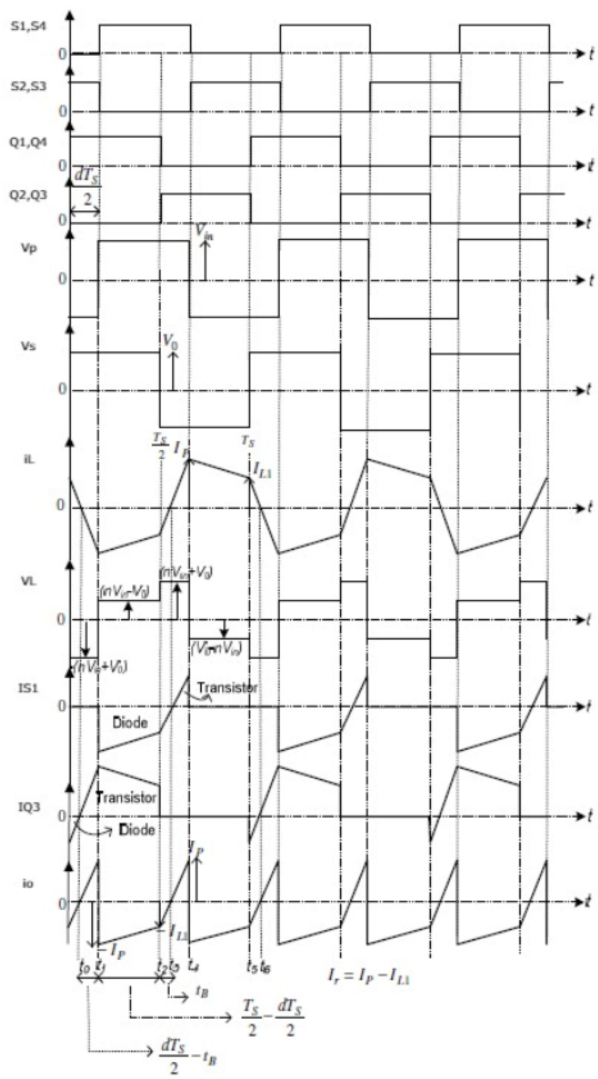

Figure 4.9: Waveforms of the 1ph-DAB converter under the discharging mode/ reverse power flow.

4.3 Zero Voltage Switching (ZVS)

During the transition from interval one to two, there exists a small dead time where the inductor-stored energy discharges the output capacitances of the MOSFETs and holds them close to zero voltage before they are turned on. This phenomenon, where the voltage across the MOSFET is close to zero at turn on, is referred to as zero voltage switching (ZVS). This is a major advantage with this topology, where due to the natural lagging current in one of the bridges, the inductive stored energy causes ZVS of all of the lagging bridge switches and some of the switches of the leading bridge.

Limitations of ZVS

The main operating conditions of the converters are to achieve almost lossless zero-voltage switching conditions, which are as below:

- At turn-on of any device, its anti-parallel diode is conducting and
- At turn-off of any device, the minimum current flow through the device is positive But, in practice the zero-voltage switching limits will be slightly different due to the requirement for the inductor current to be sufficient to ensure charge/discharge of the device output capacitances at the switching instants.

By applying the zero-voltage switching conditions to the device current waveforms shown in Figure 4.8, the current at the secondary side switching instant must be greater than zero to achieve ZVS in the secondary side bridge. Therefore using (2), the following condition must be satisfied for ZVS in the secondary bridge:

$$I_{L1} = \frac{T_s}{4L}[N \cdot V_{in}(2d-1) + V_o] \geq 0.........(A)$$

The current at the primary switching instant is expressed as:

$$I_P = \frac{T_s}{4L}[n \cdot V_{in} + V_o(2d-1)].........(1)$$

Where k is the transformer turns ratio. Solving for the secondary switching instant current based on the current slope during the interval $d(T_s)/2$ gives,

$$I_{L1} = \frac{T_s}{4L}[n \cdot V_{in} + V_o(2d - 1) + V1].........(2)$$

Solving for the inequality given in (A), the duty ratio at which ZVS occurs can be obtained as,

$$d \geq 0.5 - \frac{V_o'}{2}.........(B)$$

Where $V_o' = \frac{V_o}{nV_{in}}$ is the normalized voltage conversion ratio. To achieve ZVS in the primary side bridge, the current at the primary side switching instant given in (1) must be positive. However, this condition is normally achieved and the limiting condition for ZVS is that given in (B).

Equation (B) is applicable when $V_o' < 1$. If $V_o' > 1$, the shape of the inductor current in Figure 3 will change and the effect of this is to interchange the expressions for the currents at the primary side and secondary side switching instant. Therefore, $V_o' > 1$ with the expression for the secondary switching instant current is given by (1) and the expression for the primary switching instant current is given by (2). The zero-voltage switching limit still occurs in the secondary bridge, but is now given by requiring the current level in equation (1) to be greater than zero, which results in the condition that:

$$d \geq 0.5 - \frac{1}{2}V_o'$$

When the converter operates in the discharging mode and power transfers from the secondary side to the primary side, the zero voltage switching limit is again found to occur in the secondary bridge and may again be expressed by (A), (B) and (C).

4.4 Lossless DAB Model

The DAB converter topology is regarded as the most promising with respect to achievable converter efficiency and low converter volume. The DAB converter contains two voltage sourced full bridge circuits that are connected to the inductor L and the high frequency transformer. In order to transfer power, time-varying voltages $V_p(t)$ and $V_s(t)$ must be provided by the full bridge circuits to both the high frequency transformer and the converter inductor L. Thus, HV and LV side full bridge circuits can be replaced by the respective voltage sources $V_p(t)$ and $V_s(t)$ to simplify the analysis of the DAB converter. The following assumptions are made for the electric DAB converter model:

1. All losses are neglected.
2. The transformer magnetizing inductance and parasitic capacitances (e.g. transformer coupling capacitance between LV and HV sides) are neglected.
3. All LV side quantities are referred to the HV side.
4. Constant supply voltages V_{in} and V_o are considered.

4.5 DAB Inductor Current and Power Transfer

With the HV side full bridge, three different voltage levels are possible for $V_p(t)$:

$$V_p(t) = \begin{cases} +V_{in}, & \text{for state I: } S_1, S_4 \text{ on, } S_2, S_3 \text{ off} \\ 0, & \text{for state II: } S_1, S_3 \text{ on, } S_2, S_4 \text{ off, or} \\ & \text{for state III: } S_2, S_4 \text{ on, } S_1, S_3 \text{ off} \\ -V_{in}, & \text{for state IV: } S_2, S_3 \text{ on, } S_1, S_4 \text{ off} \end{cases}$$

On the assumption of an ideal full bridge, i.e. switching transients are not considered). Similarly, $V_s(t)$ is equal to V_o, 0, or $-V_o$ depending on the switching states of S_5, S_6, S_7, and S_8. The resulting voltage $v_R(t)$ is given by:

$$v_R(t) = V_p(t) - nV_s(t)$$

4.6 Phase Shift Modulation

Phase shift modulation operates the DAB with a constant switching frequency and with duty cycles, $D_1 = D_2 = 1/2$; it solely varies the phase shift ϕ in order to control the transferred power. Hence, $V_p(t)$ is either $-V_{in}$ or $+V_{in}$ and $V_s(t)$ is either $-V_o$ or $+V_o$. During steady-state operation, the voltages $V_p(t)$ and $V_s(t)$ and the inductor current repeat every half-cycle with reversed signs:

$$V_p(t + \frac{T_s}{2}) = -V_p(t)$$
$$V_s(t + \frac{T_s}{2}) = -V_s(t)$$
$$i_L(t + \frac{T_s}{2}) = -i_L(t)$$

In SPS-based control of DAB, the phase angle ϕ is adjusted between the voltages V_p and V_s, such that the phase angle is limited to $[-\frac{\pi}{2}, \frac{\pi}{2}]$ for maximum power.

Chapter 5

Converter Design

A number of factors are critical in the design of the power stage of a dual-active bridge. The most important factors are the selection of leakage inductor, desired phase shift of operation, output capacitor rating, switching frequency of operation.

Leakage inductor

The most important design parameter is the selection of leakage inductor. The power transfer relation of the dual-active bridge is given by Equation 1a.

$$P = \frac{nV_1V_2(\pi - \theta)}{2\pi^2 F_s L} = 12W \tag{1a}$$

Equation (1a) shows that a low value of inductance will lead to high power transfer capability. The maximum value of power transfer for a given switching frequency, leakage inductor, and input and output voltage will occur at $\theta = \frac{\pi}{2}$.

$$L_{ik} = \frac{\Phi(1-\Phi)nV_{in}V_{out}}{FSW \cdot P_{out}} = 482.59uH \tag{1b}$$

Figure 5.1 shows the inductor current waveform. The value of current at points i1 and i2 can be derived from this waveform.

$$i_1 = \frac{0.5(2\theta - 1 - d)\pi}{I_{nom}} \tag{1c}$$

$$i_2 = \frac{0.5(2d\theta + 1 - d)\pi}{I_{nom}} \tag{1d}$$

where d is the voltage transfer ratio of the converter given in Equation 1e and I_{nom} is the nominal base current of the converter.

$$d = \frac{V_2}{N \cdot V_1} \tag{1e}$$

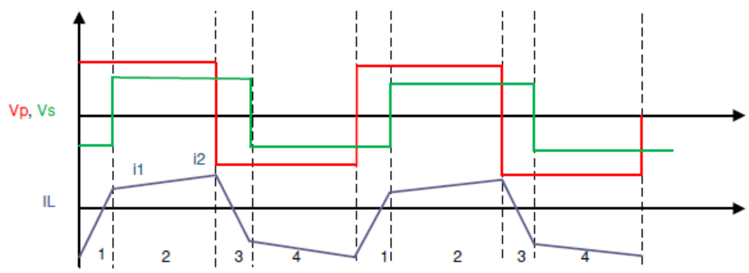

Figure 5.1: Inductor Current Waveform

From Equation 1c and Equation 1d, the conditions for zero voltage switching for leading and lagging bridge of the converter can be obtained.

Phase Shift

The phase shift of the converter is dependent on the value leakage inductor. The phase shift for required power transfer is given by Equation 1f

$$\Phi = \frac{\pi}{2}\left(1 - \sqrt{1 - \frac{8 \cdot F_s \cdot L \cdot P_{out}}{n \cdot V_1 \cdot V_2}}\right) \tag{1f}$$

$$= -0.8866 < \Phi < 0.8866 \text{ (rad)}$$

Capacitor Selection

The output capacitor in the dual-active bridge must be designed to handle the ripple. This value impacts the output voltage specification.

Switching Frequency

Switching frequency is another important design parameter which affects the efficiency and power density of power converter. The input and the output voltage levels primarily determine the type of switches used in the power stage. Usage of SiC MOSFETs in the power stage drives the switching frequencies to very high levels. fsw=5kHz

Transformer Selection

In a power supply design, transformers and inductors are major contributors to size. Increasing the operating frequency reduces their size, but increasing the switching frequency beyond a particular value affects the efficiency of the power module. This is because the skin effect becomes very high at that frequency where the current flows through the surface of the conductor.

System Parameters

Circuit Parameter	Value
Input Voltage	24V
Output Voltage	12V
Rated Power	12W
Turns Ratio	1:1
Total Leakage Inductance	482.59µH
Switching Frequency	5kHz
Load Resistance	12Ω
Input Current	2A
Output Current	1A
Phase Shift	$-0.8866 < \phi < 0.8866$ (rad)

Chapter 6

Simulation Results

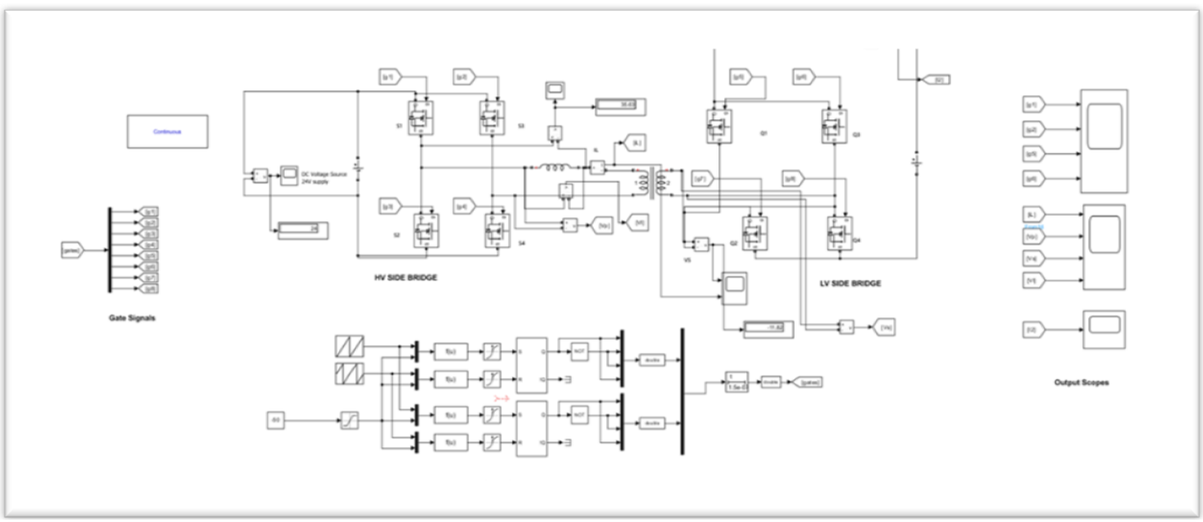

Figure 6.1: Simulation circuit of DAB converter

Charging Mode

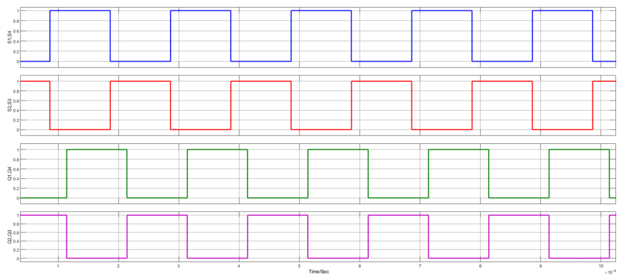

Figure 6.2: i)First graph represents voltage across s1,s4 ii)second graph represents voltage across s2,s3 iii)Third graph represents voltage across s5,s8 iv)fourth graph represents voltage across s6,s7

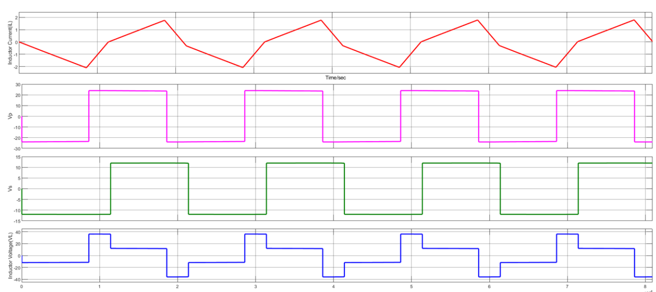

Figure 6.3: i)first graph represents inductor current ii)Second graph represents transformer primary voltage iii)third graph represents transformer secondary voltage iv)fourth graph represents inductor voltage

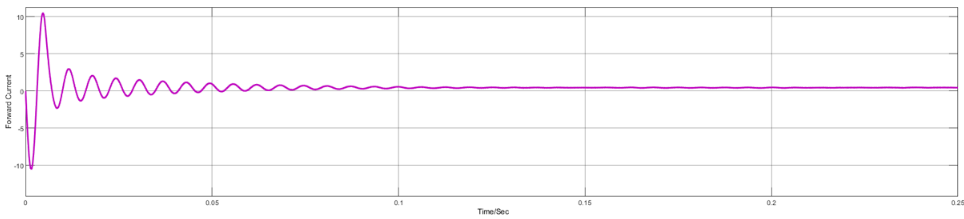

Figure 6.4: Graph represents output current

Dichraging Mode

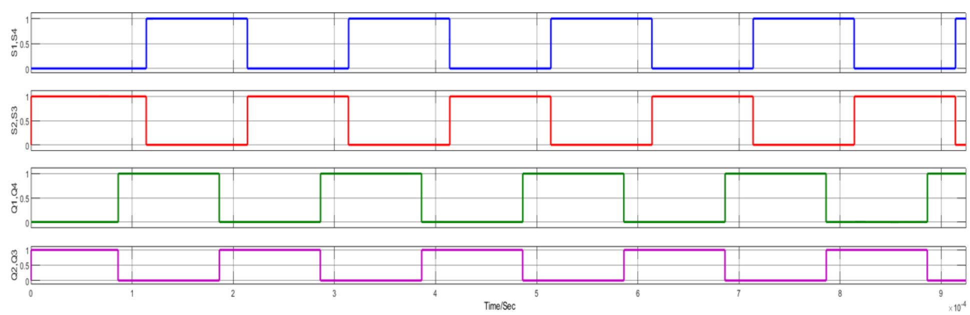

Figure 6.5: i)First graph represents voltage across s1,s4 ii)second graph represents voltage across s2,s3 iii)Third graph represents voltage across s5,s8 iv)fourth graph represents voltage across s6,s7

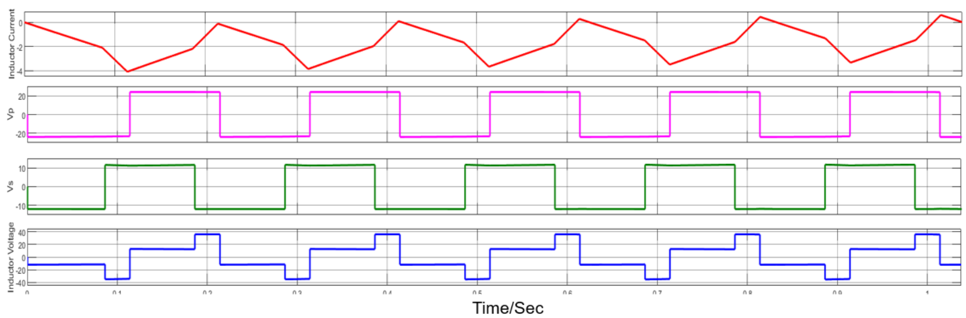

Figure 6.6: i)first graph represents inductor current ii)Second graph represents transformer primary voltage iii)third graph represents transformer secondary voltage iv)fourth graph represents inductor voltage

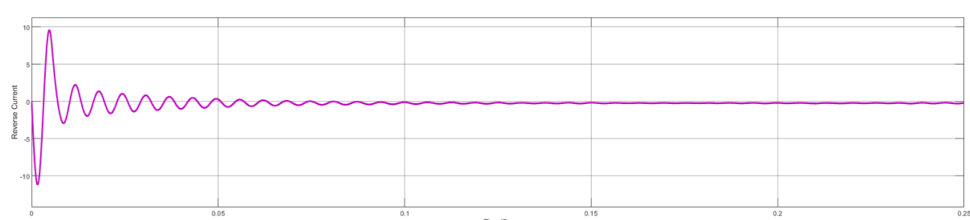

Figure 6.7: graph represents output current

6.1 Future scope

The future scope of DAB converters is promising, as they are widely used in

1. Hybrid electric vehicles, where DAB converters can be used for battery charging and power management.
2. Photovoltaic systems, where DAB converters can be used to interface the solar panels with the grid or the battery bank.
3. Electric locomotive traction, where DAB converters can be used to convert the high-voltage DC from the catenary to the low-voltage DC for the traction motors.
4. Energy storage systems, where DAB converters can be used to connect the battery bank with the DC bus or the AC grid.
5. Solid-state transformers, where DAB converters can be used to realize high-frequency isolation and voltage conversion between AC and DC.
6. high-frequency-link power conversion systems that offer high power density, reduced weight, and low noise. Some of the potential applications of DAB converters in HFL PCSs are solid-state transformers, transportation, and renewable energy.
7. It can used in several applications such as in charging stations and electric vehicle traction. Vehicle-to-Grid (V2G) systems are also using this type of converters.
8. DC microgrids, where DAB converters can be used to interconnect different DC sources and loads with different voltage levels.

Some of the research topics and challenges for DAB converters are:

- Developing new topologies and variants to improve performance and efficiency.
- Designing optimal high-frequency transformers with low leakage inductance and high insulation.
- Implementing advanced control techniques to achieve soft-switching, bidirectional power flow, and load regulation.

Chapter 7

Conclusion

The circuit model for bidirectional dc to dc dab converter is designed and obtained and same is used for simulation in Matlab Simulink software. An application is EV battery charging but with the ability to return energy to the battery for regeneration.Bidirectionality also requires the primary to be a 'bridge' of switches (at high power - at low power other arrangements are possible. It configured with 'phase shift' control where every switch is fed with 50% duty cycle square waves with 5khz switching frequency and regulation is achieved by varying the relative phases of the drive. The simulation results obtained for DAB converter verify its performance during ZVS operating modes.

Chapter 8

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