Development of New Variable Drive for DC bus load using ORCAD Software

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Abstract. This paper represents the various application using variable frequency drive like renewable energy sources such as control of solar, fuel cells etc. Here the DC is not consistent with these inputs and tends to differ and can cause disruptions to load. The AC to DC rectification process is done there are two types of rectification but here we use only uncontrolled rectification is preferred, since the controlled has some disadvantages like triggering, and it cannot used for higher frequencies. The requirement here is the source of the variable DC, so the source of the variable DC is obtained from varying the AC source. And the DC obtained distorted in the DC capacitor link. And sensing the DC bus is important to prevent the overcurrent and overvoltage damage of overall circuitry for sensing of DC bus current and voltage values, here isolated amplifiers are used. Major part of development of variable DC bus is Selection of the components like Rectifier, configuration of DC link Capacitors with Pre-charging circuit and the balancing resistors. The MATLAB and ORCAD models have been designed for 45kW load and the input is varying AC voltage range from (415V-600V) and the output obtained is varying DC maximum of 1000V and the simulation result is validated in the proposed system.

Keywords: Diode, Variable Frequency Drive, Operational Amplifier, Bus.

1 Introduction

Nowadays all our power system is working in AC only with single phase and three phase systems. In Distribution station it's been supplying the voltage as high voltage (HV) and low Voltage as known as (LV). But the HV lines are used in applications like industrial manufacturing industry and for commercial complex building like Malls, Hospitals etc., All our electronics components are working in DC supply only for that power is been rectified AC to DC for a standard voltage and current.

Here in AC to DC there need of rectifier. So, here some literatures of rectifiers and other components. It has provided the basics of the rectifier of both single phase and three phase with controlled and the uncontrolled methods. where in which the various configurations of the rectifiers and it's the designs has discussed and implemented. The relationships of voltage source rectifier (VSRs) and the current source rectifier (CSRs) between the AC side and DC link. The impedance of both the AC and DC-link is proven to be the crucial function in the interactions between ac / dc. It is observed that the correlations between AC to DC influence the dynamics of the low frequency spectrum in VSRs when the high frequency spectrum is in

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CSRs. The converter which converts AC to DC .and it also shows the importance of the DC supply. Thus, by converting AC to DC results in ripples so to reduce the ripple the filter with capacitor or inductor and the combinations of both inductor and capacitor is designed to reduce the ripple using the mathematical formulas. And the filters have been designed and the simulations has been done using each filter to reduce ripples. The exposure of adjusted velocity drive to voltage decreases and brief interrupts. Comparison and description of the tolerance of voltage curves for three following different forms of control like voltage-frequency control, direct torque control and oriented field control. Simulations have done for three control methods and results are compared.

In an AC to DC rectifier there we use of DC link capacitor for the boosting of voltage. The reviews of that also been discussed in the suggests a modern and cost-effectively approached for the DC contact voltage controller with Permanent Magnet Synchronous Motor (PMSM) motor and shows the importance of Keeping the DC link voltage constant. which provides better performance under variable load condition. A bidirectional boost converter with a variable duty cycle driven by PI is used to establish a steady DC link voltage. the existing sensing issues and difficulties with the use of DC-link shunt resistor in three-phase power inverter motor control applications. Key shunt resistor parameters important for the current sensing of the DC-link are addressed. This defines the key factors affecting the precision, including footprint form and soldering.

The Balancing Resistors are used for the voltage balancing of DC bus. the need and usage of balancing resistors. In DC voltage connections with three-phase power converters are mostly fitted with a series connection with two electrolytic condensers due to the high voltage stage. In such a setup, resistors normally have to be placed in addition to each condenser to match partial voltages. None the less, such regulating resistors must be dimensioned in terms of the worst-case scenario of the leakage currents of the condenser; such leakage will contribute to large permanent dissipative losses, which can occur in the case of small real leakage currents. To eliminate these losses to a very large degree, a modern low-cost and reliable active design is implemented to replace the static balance resistors.

The current paper proceeds with our examinations fill the field of supercapacitors and electrochemical Double Layer Capacitors, quickly called as ELDC. The arrangement association of ELDC is regular so as to get higher value of voltage levels. The innate lopsided condition of charge (SOC) and fabricating scatterings decide during its charging at consistent current which is on the capacitors arrives from the start the evaluated levels of voltage and be could further charging, be harmed. The adjusting resistors with the circuit and transistors used to sidestep the current charging can be improved utilizing the proposed ELDC circuit. We present here a mind-boggling variation, in light of incorporated circuit acting like a microcontroller. The circuit is adjusted from the circuits explored in the last 7-8 years for the batteries, particularly for Lithium-particle type. The test board worked around the circuit is performant, vitality proficient and can be additionally improved to guarantee the adjusting control for bigger capacitances.

This literature study helps to understand the various advantages and disadvantages of controlled and uncontrolled rectifications, Types of capacitors with its efficiency of storage and also to charges and discharge the two or more capacitors equally without any differences in charging and discharging process. This survey helps to Design the variable DC bus for the selected load range. Here the selected load range is about 45Kw, as well as to address the objectives required for this paper study.

A theoretical and functional study of one of the most common AC power supplies. Transforming topologies. This topology is used to provide a dual input voltage (230 Veff, 50

Hz/115 Veff, 60 Hz) DC voltage switching converter. The maximum rectifier bridge corresponds to IEC-61000-3-2 Class A norm for European grid voltages (220, 230 and 240 V), if the capacitor value is chosen with the parameters required. For both peak currents and voltages, Simple expressions are designed. The importance of a quasi-direct three-phase AC / DC/ AC converter with minimal energy capacity in the dc-link capacitor. The proposed digital control device will achieve unit power factor, lower current distortion on the utility side and fast reflex to dc-link voltage regulation to reduce the necessary DC-link capacitor a power balancing control scheme is used. The design procedure of the proposed method has been defined, followed by the results provided using simulation.

Variable DC bus is required for various application like Variable frequency drives, electric Vehicle applications. Where the variable DC output is obtained from the variable AC input and this can also support with the multiple loads i.e., Load sharing is possible and also we can replace the AC input to the other DC inputs like solar, Fuel cells, etc[1]. The Variable AC input is given to the Rectifier where AC is converted into DC and thus the generated DC is stored in the DC link capacitors. Where Dc link Configurations can be either series or parallel based on the requirement. And also it is important to maintain the DC link Voltage and current values because where the load gets connected. In order to prevent the load during the faulty conditions it can be isolated from the DC bus.

Nowadays VFD plays major role in motor speed control applications [4]. So to have reliable product in Market, there is an extensive inhouse validation has to be carried. To carry out the testing and validation of the part /Component the wide variety of variable DC source is required. Typically, the compact controlled DC sources that are used to provide are liable voltage to any circuit that needs it, without the need for a specific fixed-voltage power supply, generally for prototyping purposes (in industry) or for laboratory research. These are typically configured to regulate the output voltage by turning a potentiometer (smoothly) or a turning switch (in steps), and the output may then be controlled by an integrated digital or analogy voltmeter and, preferably, by an ammeter (for the current). And also these variable DC supply helps for speeding up the load test.

For converting the AC to DC the Rectification has to be done. The rectification can be controlled or uncontrolled based on the Load requirement [3]. while using controlled rectification the thyristors are used and they can be controlled are operated according to the input gating signal. while taking the uncontrolled rectification the Diodes are used for the DC conversion process.

The method of transforming of 3 phase balanced power supply change a static supply DC utilizing thyristors or IGBT or diodes. Rectification by Three phase circuits, often called as rectification poly- phase circuits, or identical past rectifiers of single phase, this distinction being that are utilizing 3 coupled multi-phase suppliers provided by a multi three-phase generator together. The benefit is that circuits with 3-phase rectification can be used to power many commercial applications like, motor function or battery charging circuits are able to higher power requirements than can be supplied by a rectifier circuit single-phase.

Full-wave three-phase rectification are two types as said before controlled and uncontrolled. The three phase full converter is a directly operated bridge operated rectifier that uses six thyristors attached in the shape of a full wave bridge configuration. All six thyristors are controlled switches that are switched on at the appropriate time by applying appropriate trigger signals to the gate. The tthyristors is activated at a time interval of (approximately 3) radian. The current ripple of voltage frequency and the filtering criterion is less than that of the three phase of semi-and half-wave converter.

The time period during value of wt = (pi/6 + α) to (pi/2 + α) the thyristors are been conducted together and line to line supply is checked by voltage across the load appeared. The value of wt = (pi/2 + α), the thyristor T2 is got triggered and T6 thyristor is reverse biased immediately and T6 turns off condition to natural commutation. This time period wt = (pi/0 + α) to (5pi/6 + α), T1 and T2 thyristor conducted together and the line-to-line supply voltage will appear across the connected load. The thyristors are given numbered in the circuit diagram to corresponding to the order in which that they are been triggered. The trigger of each sequence of firing angle to the thyristor is 12, 23, 34, 45, 56, 61, 12, 23, and so will be on. The waveforms of the three-phase supply input voltage, output voltage and the current of thyristor T1 and T4 through is found, the supply value of current through line ‘a’. Here the three-phase controlled rectification takes place in the circuit.

There are few disadvantages in the controlled rectifications so we are going to the uncontrolled rectifications, the disadvantages are in AC circuit, it needs to be turned on for every cycle, In higher frequencies it cannot be used. The rectifier with full bridge, unregulated rectifier three-phase bridge circuit uses Six numbers diodes, per step value will be two, equivalent to the one-phase bridge rectifier. Using two halve wave circuits, Three-phase full-wave rectifier is produced. The downside circuit generates pervious a lower ripple factor in 3-phase half-wave rectifier, which as a frequency of AC waveform is six time than entry. As there is no need of fourth neutral (N) wire is needed, the full-wave rectifier can also be fed from a balanced 3–phase 3-wire delta linked supply.

Here the D1, D2, D3 and D4 are the diodes create a network of bridge rectifiers phase A and phase B, likewise diode D3, D5, D4, and D6 are between phase B and phase C, the diodes D5, D1, D6, and D2 are between phase C and phase A. While the diodes D1, D3 and D5 feed will be in the positive rail and, depending on which one conducts a favourable will be at anode terminal voltage. Similarly, the diodes of D2, D4, and D6 negative voltage and that diode induces a further negative voltage at the cathode terminal. The simulation of full bridge diode rectifier is shown in chapter 5 and in chapter 8 the resulting waveform for diode bridge rectifier is shown. Thus Diode is the unidirectional and uncontrolled device so we can get constant output and there is no backflow to power from load to source. So, in this work the uncontrolled Diode bridge rectifier is preferred for three phase AC to DC conversion.

For conversion tools with solid state technology, such as variable speed drives (VSD) and switch mode power supplies. The AC power is then transformed into DC power by using rectifiers made up of appropriate control semiconductor components such as diodes or thyristors. The change to DC power is meant to make it simpler to control DC waveforms that are effectively a straight line than sinusoidal AC waveforms. The capacitor operates with the rectifier which functions as a store of DC power which filters out the DC voltage differences until more loading of the VSD or UPS inverter unit. The output of the rectifier section is given to the DC Link capacitor where the DC power is stored and from where after filtration the dc supply is given to the load. And there are two configurations of DC link setup they can be either series and parallel. In series arrangement the total capacitance is less than any one of the series capacitors’ individual capacitances. And in parallel configuration, the total capacitance is more than the any one of the capacitors connected. So, it is must to select proper configurations of DC link Capacitors [2]. The configurations are explained in the upcoming chapters.

Nowadays VFD plays major role in motor speed control applications. So, to have reliable product in Market, there is an extensive inhouse validation has to be carried. To carry out the testing and validation of the part /Component the wide variety of variable DC source is required. Typically, the compact controlled DC sources that are used to provide a reliable voltage to any circuit that needs it, without the need for a specific fixed-voltage power supply, generally for prototyping purposes (in industry) or for laboratory research. These are typically configured to regulate the output voltage by turning a potentiometer (smoothly) or a turning switch (in steps), and the output may then be controlled by an integrated digital or analog voltmeter and, preferably, by an ammeter (for the current). And also, these variable DC supply helps for speeding up the load test.

2 Problem statement and methodology

Problem Statement

The major objective of the proposed work is having reliable product in Market, there is an extensive inhouse validation has to be done. To carry out the testing and validation of the part /Component the wide variety of variable DC source is required. develop variable DC bus to support 45KW load with short circuit, high/Low voltage and high current protection. and the Product should meet industry reliability standard (EFT/Surge) [13].

Architecture of Variable DC Bus

The Variable DC bus consists of three phase AC supply, which is given to the three phase Diode bridge rectifier foe converting the AC to DC [6-7]. Then the converted DC is given to the pre charging circuit. The pre charging circuit consists of PTC resistors and the relay and finally this is connected with the DC link capacitors with the balancing resistors. The architecture schematic is shown in the Fig 1.

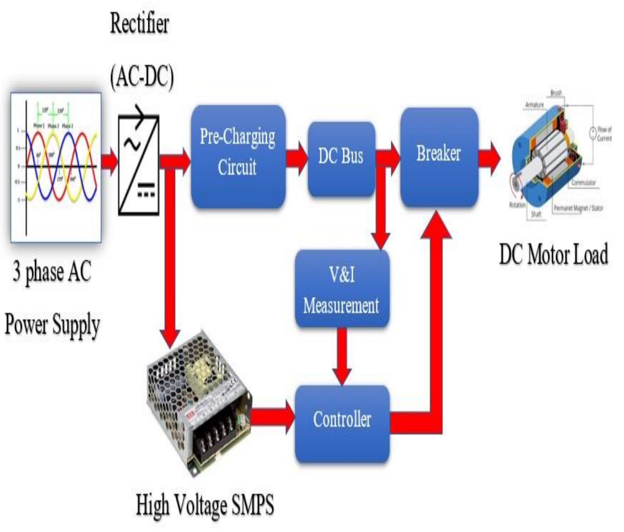

Fig. 1. Architecture of Variable DC Bus

3 Desing Of Variable DC Bus

The configurations of rectifiers, DC link capacitors. This chapter shows the design parameters and the design formulas of rectifiers, DC link capacitors [5], Pre charging circuits selection, Balancing resistors design is discussed. And also discussed about the problems and its effects and prevention of the each components.

Rectifier

Here the uncontrolled rectifier is used, where Input is given as 0-600V AC and the output is designed for 0-1000V DC.

- *Open Diodes*: Its effects on output voltage when the diode is opened. The ripple size has to be boosted by 2 times.
- *Shorted Diode:* It is because of the intense forward current and the huge reverse stress. The diode will experience mild resistance in this case. The current would flow back to the source instead of flowing in load due to short circuit.

Design of Capacitor Bank

The DC link capacitors can be designed from the formulae given below,

$$Vrpp = Vmax /6FRC \qquad (1)$$

Where Vmax is 1000V and let us assume the ripple voltage is 100V, f= 50Hz. Here f is the frequency, R is the value of resistance, Vmax is the Maximum Voltage.

Here the maximum voltage is around 1000V. The capacitance Value for having 1000v is 13300Uf and Its not possible to have single electrolytic capacitor so here we are going with two capacitors of each 26600Uf connected in series connection.

While linking capacitor in series sequence, some difference of values can allow each to operate at a different pace and at a specific voltage. When you power up a sequence bank all the way through, some capacitors can still get underloaded and some filled. Connect the Balancing resistors to make them divide voltage evenly.

A method in which capacitors are connected in series is used to obtain the required rated voltage; in this case, the voltage applied to all capacitors must be constant, and for this purpose balancing resistors are inserted in parallel with each of the capacitors [11-12]. The value of the balancing resistor can be approximated by the following formula:

$$R=10/C \qquad (2)$$

Thus, the balancing resistors are calculated from the above formula and the balancing resistors are connected in parallel with the capacitor 470 kohm resistors are connected in parallel with the capacitors [14-15]. Here R is the resistance in mega ohms and C in the capacitance in μF with the Figs 2 shown below.

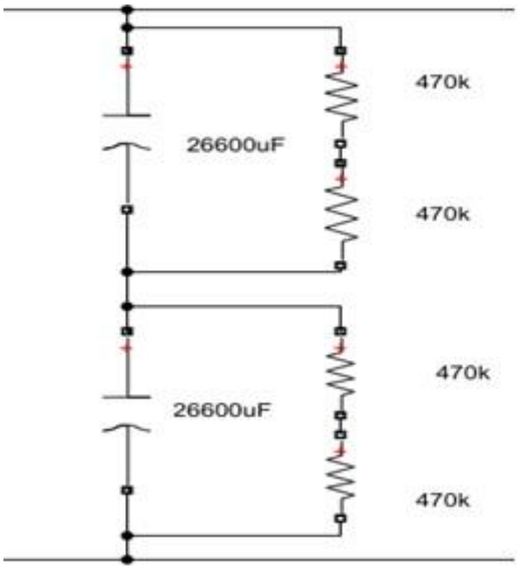

Fig. 2. DC Link with Balancing Resistors

Benefits of pre-charging

The main advantage of avoiding component stress when powering on is that a long system life is achieved due to reliable and durable components. There are additional benefits: Pre-charging reduces the electrical risks that can arise if the integrity of the system is compromised due to damage or hardware failure.

Here Pre-charging circuit connected in series and parallel with the line is shown. Initially the relay is kept open so when the supply is given the relay closes. It may damage the PTC Resistor due to the flow of inrush currents in series configuration. So, connecting the pre-charging circuit Parallel to the line is preferred.

Thus this chapter the complete design of the variable DC bus is discussed and the Design Failure Mode and Effective Analysis (DFMEA) for the Rectifiers, DC link capacitors and the pre charging circuit has been done.

4 Current and voltage sensing

The voltage and the current sensing of the DC link has been discussed [16]. Thus, DC link measurement is the most important parameter because if there any over voltage or high current issues it may damage the overall circuitry and in some cases the load may get damages so, it is most essential to sense the DC link [8]. Here the DC link current and the Voltage sensing in done with the isolated amplifiers.

Current Measurement

DC-Link sensing is an important parameter to be sensed with an accuracy of 1%.Here the voltage and current sensing is done with the help of Isolated Amplifiers. The voltage sensing is done with the AMC1311 isolated amplifier and current sensing is done by AMC1301 isolated amplifier. To convert differential end to single ended conversion the op amp(OPA320) is used [17].Selection of Shunt Resistor: The peak winding current can go up to 400A for 45KW load. Considering 400 A as the peak current, the shunt value can be calculated as given in R shunt = 250mv/400A, R shunt= 0.625m, Since +250 to -250mVis the input voltage range for AMC1301.

Reinforced Isolated AmplifierAMC1301:

The AMC1301 is a precision isolation amplifier with an output that is separated from the input circuit by an isolation barrier that is highly resistant to magnetic interference. The AMC1301 input is optimized for direct connection to shunt resistors. VDD1 is the power supply and GND1 is grounded to the hot side of the circuit where the VINP and VINN inputs come directly from the 5Mω shunt resistor. The 4.7 µF and 0.1 µF capacitors are used to decouple the VDD1 supply and should be kept very close to the VDD1 pin of the AMC1301. VDD2 is generated from a regulated supply (3.3 V). The 4.7 µF and 0.1 µF capacitors are used to decouple the VDD2 supply and should be kept very close to the VDD2 pin of the AMC1301. The AMC1301 output is available on the VOUTP and VOUTN pins. A differential filter with a cutoff frequency of 94 kHz is connected to the output with 4.5 Kω, 4.5 Kω and 180Pf.

DC link Voltage Sensing

The DC bus input voltage is lowered and supplied to the MCU with the AMC1311 Amplified Isolation Amplifier and OPA320 Operational Amplifier. To reduce the DC link voltage, a resistance divider network is selected taking into account (0-2) V and the maximum DC link voltage of 1000 V, taking into account the maximum voltage for the MCU ADC input. The input voltage of AMC1311 is less than 2V so the voltage divider is designed stepping down from 1000V to 2V. The figure shows six 1 MΩ resistors and a 10 Kω resistor, with which the VDC signal is removed.

5 Simulation of varaiable dc bus

A. Simulation of Variable DC Bus

Here the MATLAB simulations and ORCAD design has been done. In MATLAB Simulink the variable DC bus is developed the tested for the variable input and the variable DC output. While coming to DC link sensing there is no sufficient blocks in the MATLAB Simulink, the with the ORCAD software the variable DC bus is developed and the sensing design of the DC link has been done.

As discussed in the previous chapter the variable DC bus has been designed and simulated.

Table. 1. Description of the Input Signal

Input Supply	415V+20%
Frequency	50Hz
Power Rating	45Kw
R Load	2.5Ohm
DC Link capacitor	26600µF each
Balancing resistors	470kOhm each

The Fig. 3 shows the Simulink model of variable DC Bus. Here the programable three phase AC source is given to the diode bridge where the AC is converted to DC. Then the converted DC is stored in the DC link capacitors with the balancing resistors. Then the DC link is connected to the resistive load of 45 Kw.

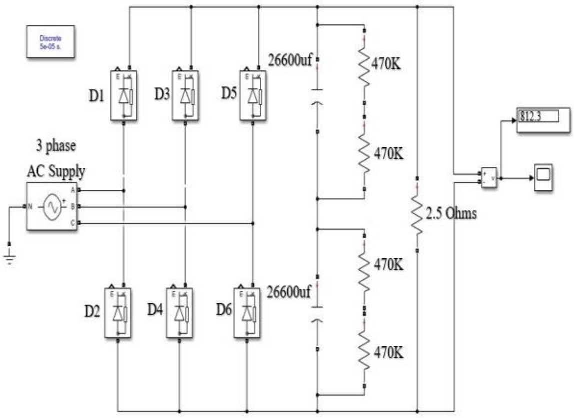

Fig. 3. Simulink Model of Variable DC bus

B. ORCAD Design Model

Though for the PCB manufacturing the ORCAD design can be used and also the sensing design blocks are not available in the MATLAB Simulink, the design of Variable DC bus with voltage and the current sensing is done with the help of the ORCAD software. The Fig. 4 shows the ORCAD design of variable DC bus where J3 represents the rectification module where C1 and C2 are the two DC link capacitors, RT1 represents the PTC resistor which is connected to the relay where the relay is connected to the input relay control circuit. Thus, the PTC resistor and the relay forms the pre charging circuit which are connected in between the two series connected capacitors. R1, R2, R3, R4 are the balancing resistors. Here the current measurement is done by the AMC1301 isolated amplifier and this will sense the current in the VFD.

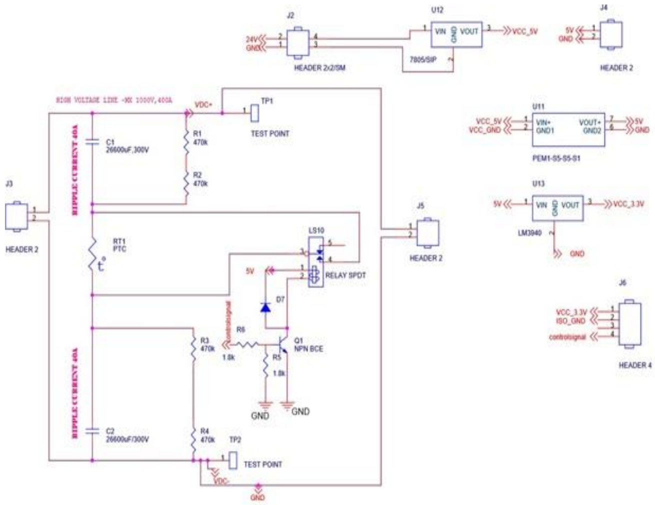

Fig. 4. ORCAD Design of Current Measurement

C. AMC1301 Isolated amplifier

The Fig. 5 shows the AMC1301 (U9) isolated amplifier. It has 8 pin configurations. The pin configurations are shown below. As the design shown the DC bus current value is sensed by the amplifier with the shunt resistor connected to it. Then the output of the amplifier is connected to OPA320 operational amplifier.

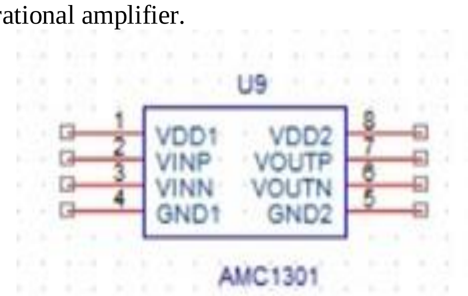

Fig. 5. Pin Diagram of AMC1301

Table. 2. Pin Configuration of AMC1301

Pin No	Representer	Descriptions
1	VDD1	High-side power supply,(3.0V-5V)
2	VINP	Inverting analog input
3	VINN	Non inverting analog input
4	GND1	High -side analog ground
5	GND2	Low-side analog ground
6	VOUTN	Inverting analog output
7	VOUTP	Noninverting analog output
8	VDD2	Low-side power supply,(3.0V-5.5V)

OPA320 Operational Amplifier

The Fig.4 shows the design of current measurement the DC link current has been measured with the help of AMC1301 with the shunt resistor connected to the DC link. and the output of the amplifier AMC1301 is given to the OP-AMP 320 with the RC filter connected to it in order to reduce the electromagnetic noise. The Fig. 6 shows the OPA320 amplifier and the pin configurations are shown below

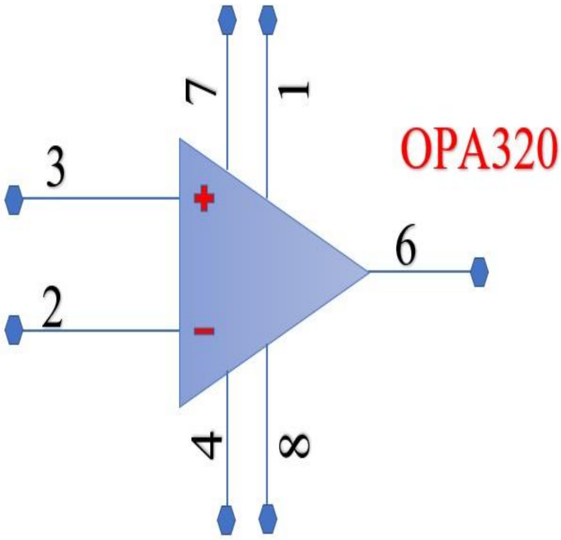

Fig. 6. OPA320

Table. 3.OPA320 Pin Configuration

Pin No	Representer	Descriptions
1	Out,Vout	Output
2	V-	Negative lowest power supply
3	-IN(A)	Inverting input channel A
4	+IN(A)	Non inverting input channel A
5	+IN(B)	Non inverting input channel B
6	-IN(B)	Inverting input channel B
7	OUT (B)	Output channel B
8	V+	Positive highest power supply

ORCAD Model of Voltage Measurment

The DC link voltage measurement here output maximum voltage is about 1000V and where the input voltage of the AMC1311 up to 2V so the voltage is step downed from 1000V to the 2V using the voltage divider. and this AMC1311 output is given OPA320 with the RC filters in order to reduce the noise.

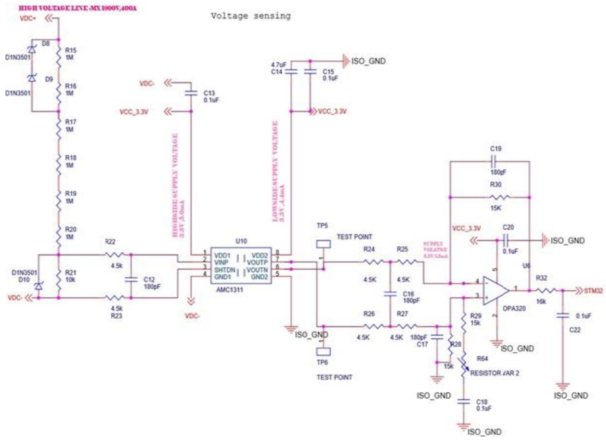

Fig. 7. ORCAD Design of Voltage Measurement

AMC1311 Isolated Amplifier

The Fig. 8 shows the AMC1311 isolated amplifier.it had eight pins and the pin configurations are given below. As the design shown the DC bus voltage value is sensed by the amplifier where the output maximum voltage is 1000V but the input to the amplifier is (0-2) V so the stepdown of voltage from 1000V to 2V is done with the voltage divider of six 1Mohm resistors the connected to it. Thus, the step-down voltage is given to the amplifier then the output of the amplifier is connected to OPA320 operational amplifier.

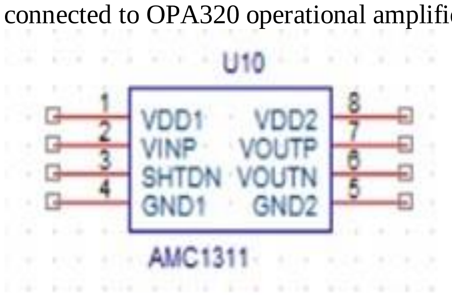

Fig. 8. AMC1311 Isolated Amplifier

Table. 4. Pin configuration of AMC1311 Amplifier

Pin No	Representer	Descriptions
1	VDD1	High-side power supply,(3.0V-5V)
2	VINP	Inverting analog input
3	VINN	Non inverting analog input
4	SHTDN	Shutdown input with internal pullup Resistor (100Kohm)
5	GND2	Low-side analog ground
6	VOUTN	Inverting analog output
7	VOUTP	Noninverting analog output
8	VDD2	Low-side power supply,(3.0V-5.5V)

Results and discussion

In the below Fig. 9 the diode bridge rectifier of input voltage of 415V with resistive load with the power rating of 45kW has been simulated and the output waveform has been observed.

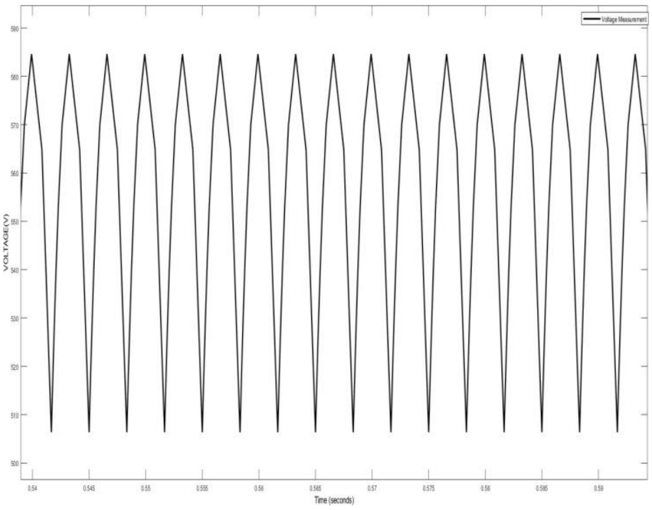

Fig. 9. Output Waveform of 3phase Diode Bridge Rectifier

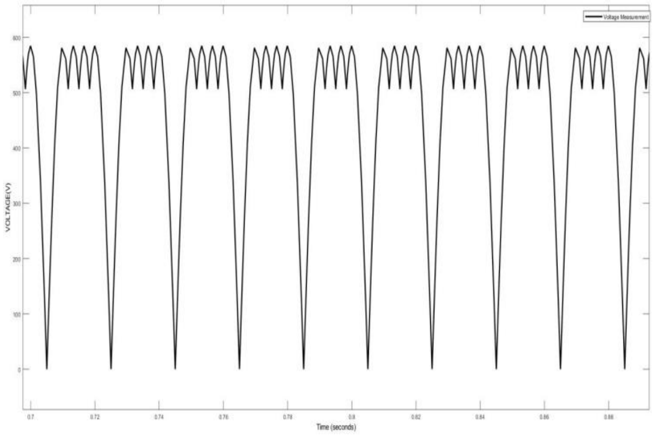

Fig. 10. Waveform of Open diode in Diode Bridge Rectifier

This Fig. 10 shows the waveform obtained for the three-phase diode bridge rectifier with the open diode condition and the effects are the ripple size has to be boosted by 2 times in the output.

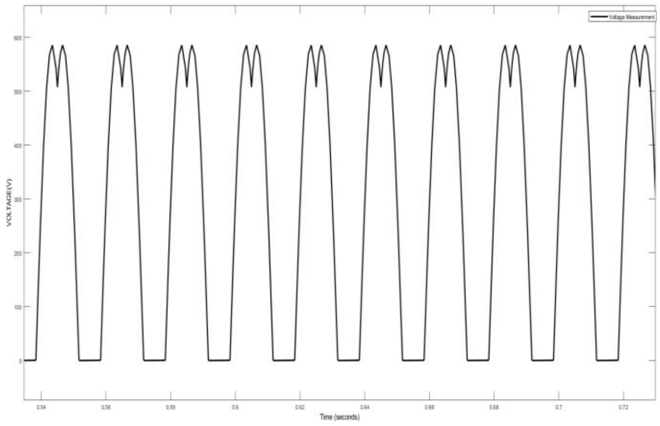

Fig. 11. Waveform of Shorted diode in Diode Bridge Rectifier

This Fig. 11 shows the diode bride rectifier with the shorted diode. In this case, the diode will experience mild resistance in this case. The current would flow back to the source instead of flowing in load due to short circuit. This below waveform Fig. 12 is variable DC with the varying input AC supply of 415-600V max. the output obtained is based on the varying input given. Then output obtained is around 1000V max. The design of variable DC bus by the designed shown in the previous chapters. And this result helps in verifying the design values. And it also shows the failure modes and the effects of the diode bridge rectifier. Thus, by this design formulas we can able to design for the different types of loads, but here the values are designed for the 45 Kw load.

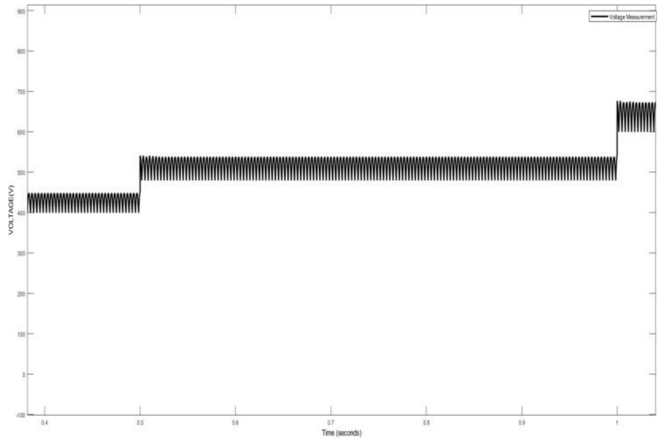

Fig. 12. Waveform of Variable DC Bus

6 Conclusion

Here the variable DC source has be designed and developed with the Voltage measurement and current measurement for 45kW load with the varying input AC supply from 415-600V and output obtained is variable DC maximum of 1000V. and the obtained DC is stored in the two DC link capacitors connected in series connection, thus one capacitor can able to store up to the range of 690V and also the voltage range is 1000V and the capacitor value for storing 1000V is 13300uf capacitance. So, the 26600uf capacitors are connected in series for storing of around 1000V max. And to prevent the inrush current faults the pre charging circuit is also designed. And to ensure the equal charging and the discharging of two series connected capacitors the balancing resistors are designed and implemented. The simulations and design are done with the two software's like MATLAB and ORCAD. The design parameters and the simulations has been mentioned. And also, the Design failure mode and effect analysis (DFMEA) for Diodes, capacitors, PTC resistors and its effects and its preventions is also done and mentioned in this Paper. As the future work, it can be implemented in the hardware and the results can be verified with the software results. And also, these simulations can be extended with the variable frequency drives and also in design of inverters. It can used in the applications were the load needs variable DC source. Here there is only one load of 45Kw is connected to the DC bus but the multiple loads can also be connected to the DC bus. And also, instead of varying DC output, the constant DC output can also be obtained by supplying constant AC as input. Then it caused for E- Vehicle charging purposes, DC in, DC out-converters and DC regulators and also DC in and AC out-inverters. Here the variable DC bus is developed for only 45kW load, But the DC source can be designed and developed for various load ranges based on the applications.

References

[1] Sanghun Kim;Honnyong Cha;Heung-Geun Kim, "High-Efficiency Voltage Balancer Having DC–DC Converter Function for EV Charging Station," IEEE Journal of Emerging and Selected Topics in Power Electronics, Volume: 9, Issue: 1, Feb 2021.

[2] Danyang Bao;Xuewei Pan;Yi Wang;Hao Huang;Bingyi Wu, "Integrated-Power-Control-Strategy-Based Electrolytic Capacitor-Less Back-to-Back Converter for Variable Frequency Speed Control System," IEEE Transactions on Industrial Electronics, Volume: 67, Issue: 12, Dec 2020.

[3] Jean-Marc Nwesaty;Antoneta Iuliana Bratcu;Alexandre Ravey;David Bouquain;Olivier Sename, "Robust Energy Management System for Multi-Source DC Energy Systems—Real-Time Setup and Validation," IEEE Transactions on Control Systems Technology, Volume: 28, Issue: 6, Nov 2020.

[4] Yu Wang;Si-Zhe Chen;Yizhen Wang;Lin Zhu;Yuanpeng Guan;Guidong Zhang;Ling Yang;Yun Zhang, "A Multiple Modular Isolated DC/DC Converter With Bidirectional Fault Handling and Efficient Energy Conversion for DC Distribution Network," IEEE Transactions on Power Electronics, Volume: 35, Issue: 11, Nov 2020

[5] Yuxin Liang;Hui Zhang;Mingqiao Du;Kai Sun, "Parallel coordination control of multi-port DC-DC converter for stand-alone photovoltaic-energy storage systems," CPSS Transactions on Power Electronics and Applications, Volume: 5, Issue: 3, Sept 2020.

[6] Niraja Swaminathan;Yue Cao, "An Overview of High-Conversion High-Voltage DC–DC Converters for Electrified Aviation Power Distribution System," IEEE Transactions on Transportation Electrification, Volume: 6, Issue: 4, Dec 2020.

[7] Fulong Li;Zhengyu Lin;Zhongnan Qian;Jiande Wu;Wei Jiang, "A Dual-Window DC Bus Interacting Method for DC Microgrids Hierarchical Control Scheme," IEEE Transactions on Sustainable Energy, Volume: 11, Issue: 2, April 2020

[8] Andrii Chub;Dmitri Vinnikov;Roman Kosenko;Elizaveta Liivik;Ilya Galkin, "Bidirectional DC–DC Converter for Modular Residential Battery Energy Storage Systems," IEEE Transactions on Industrial Electronics, Volume: 67, Issue: 3, March 2020.

[9] Ahmed M. I. Mohamad;Yasser Abdel-Rady I. Mohamed, "Investigation and Enhancement of Stability in Grid-Connected Active DC Distribution Systems With High Penetration Level of Dynamic Loads," IEEE Transactions on Power Electronics, Volume: 34, Issue: 9, Sept 2019.

[10] Pacha, M., Varecha, P., &Sumega, M. (2018, May). HW issues of current sensing by DC-link shunt resistor. In 2018 ELEKTRO (pp. 1-5).IEEE.

[11] Lu, D., Wang, X., &Blaabjerg, F. (2018, June). Investigation on the AC/DC Interactions in Voltage-Source Rectifiers and Current-Source Rectifiers. In 2018 IEEE 19th Workshop on Control and Modeling for Power Electronics (COMPEL) (pp. 1-6).IEEE.
[12] Saleque, A. M., Khan, A. M. A., Khan, S. H., Islam, E., & Chowdhury, M. N. (2017, February). Variable speed PMSM drive with DC link voltage controller for light weight electric vehicle. In 2-017 International Conference on Electrical, Computer and Communication Engineering (ECCE) (pp. 145-151).IEEE.
[13] Ertl, H., Wiesinger, T., & Kolar, J. W. (2008). Active voltage balancing of DC-link electrolytic capacitors. IET Power Electronics, 1(4),488-496.
[14] Pyakuryal, S., &Matin, M. (2013). Filter design for AC to DC converter. International Refereed Journal of Engineering and Science (IRJES), 2(6),42-49.
[15] Doval-Gandoy, J., Castro, C., & Martínez, M. C. (2003). Line input AC-to-DC conversion and filter capacitor design. IEEE Transactions on Industry Applications, 39(4), 1169-1176.
[16] Chien, W. S., &Tzou, Y. Y. (1998, May). Analysis and design on the reduction of DC-link electrolytic capacitor for AC/DC/AC converter applied to AC motor drives. In PESC 98 Record. 29th Annual IEEE Power Electronics Specialists Conference (Cat. No. 98CH36196) (Vol. 1, pp. 275-279). IEEE.
[17] W. M. Lin, M. M. Hernando, A. Fernadez, J. Sebastian, and P. J. Villegas, "A new topology for passive PFC circuit design to allow AC-to-DC converters to comply with the new version of IEC1000-3-2 regulation," in Proc. IEEE PESC, 2002, pp.2050–2055.
[18] Ionescu, C., Drumea, A., Vasile, A., &Codreanu, N. (2018, May). Investigations on Active Balancing Circuits for Supercapacitor Banks. In 2018 41st International Spring Seminar on Electronics Technology (ISSE) (pp. 1-5).IEEE.
[19] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
[20] Barrade, P., Pittet, S., &Rufer, A. (2000). Energy storage system using a series connection of supercapacitors, with an active device for equalizing the voltages. In IPEC 2000: International Power Electronics Conference (No.CONF).
[21] T. Messo, J. Jokipii, J. Puukko and T. Suntio, "Determining the Value of DC-Link Capacitance to Ensure Stable Operation of a Three-Phase Photovoltaic Inverter, " IEEE Trans. Power Electron., vol. 29, no. 2, pp. 665-673, Feb.2014.
[22] C. Ionescu, A. Vasile, R. Negroiu, "Investigations on Balancing Circuits for Supercapacitor Modules", 39th International Spring Seminar on Electronics Technology (ISSE) Location: Pilsen, Czech Republic,May 18-22, pp 521-526,2016
[23] Kraemer, A., Heusinger, V., Schad, S., Ali, A.: "Sensorless vector control of PMSM with observer-based phase current reconstruction using only a DC-link current sensor," 2017 IEEE International Symposium on Sensorless Control for Electrical Drives (SLED), Catania, 2017, pp. 145-150.
[24] Ziegler, S., Woodward, R., C., Iu, H., H., C., Borle, L., J.: "Current Sensing Techniques: A Review", in IEEE Sensors Journal, vol. 9, no. 4, pp. 354-376, April2009.
[25] Horowitz, P., Hill, W.: "The Art of Electronics", Cambridge Univeristy Press, 2015, 3rd edition, ISBN:978-0521370950.