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A NOVEL CONTROLLER FOR GRID CONNECTED DUAL INPUT PV CONVERTER WITH LESS CONVERSION STAGES

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Abstract:-A dual-input dual-buck inverter (DIDBI) with integrated Boost converters (IBCs) is recommended for grid-connected applications. The proposed DIDBI has two IBCs and two Buck-type inverter-legs. Two renewable DC sources with various maximum power point monitoring are made possible by the DIDBI (MPPT). The use of the IBCs, which provide a constant and stable DC-Bus voltage for the inverter legs, allows the inverter to operate well even when the DC source voltage varies significantly and is lower than the peak amplitude of the grid voltage. The IBCs only need to handle a small amount of the incoming power, unlike a conventional two-stage DC-AC inverter. Comparing the DIDBI to a conventional DC-DC converter and inverter cascaded two-stage system, the conversion stages, power rating, and losses are all reduced. This is brought on by the quick transfer of the remaining input power to the grid through the inverter-legs. Switching loss might be reduced as a result of the multi voltage-level characteristics of the proposed DIDBI. The result is a rise in production. To offer independent regulation of the two DC inputs, modulation and control techniques should be used. Additionally, the overall harmonic distortion at the grid side is evaluated and reduced using a fuzzy logic controller. The features and essential principles of the proposed DIDBI are carefully taken into account. The efficacy and benefits of the suggested technique have been confirmed by the simulation's outcomes.

Index Terms—fuzzy logic controller, THD, Inverter, circuit topology, dual-input, Boost Buck conversion, wide voltage range.

1. INTRODUCTION

In the last ten years, photovoltaic (PV) power producing technologies in particular have drawn increased interest from both industry and academia. Grid-connected inverters are necessary for a power production system to be dependable, economical, and effective. Installing single-phase grid-connected inverters is crucial for the production of PV electricity for homes. Grid-connected inverters are continually being developed despite the fact that numerous inverter topologies have been made available to the public. To fulfil the requirements of diverse applications, several compromises between conversion efficiency, reliability, and cost are still required.

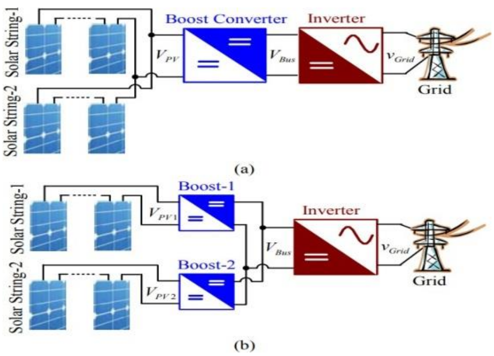

Fig.1."Two-stage grid-connected inverter with (a) one centralized input ,(b) two independent inputs".

There is need for improvement in the cost-effectiveness, high here liability, and inverter topologies. PV panels' current-voltage characteristics, which are influenced by light and temperature, may cause significant voltage changes. An inverter that is linked to the grid has to perform both step-up and step-down voltage conversions in order to maximise the amount of energy produced by PV panels. A front-end Boost DCDC converter and a downstream DC-AC inverter make up the majority of PV inverters' two-stage architecture, as shown in Fig. 1. (a). The boost converter supplies the downstream DC-AC inverter with a continuous DC Bus voltage that is larger than the peak amplitude of the grid voltage while simultaneously performing maximum power point tracking (MPPT) of PV panels across a broad PV voltage range. When using several solar strings, it is difficult to gather the independent MPPT of each solar string without a centralised front-end Boost converter. In this instance, distributed MPPT is achieved by using many Boost converters, and more energy is collected from the PV panels, as illustrated in Fig. 1. (b). Due to the fact that both the Boost converter and the inverter must manage the whole amount of energy at once, a two-stage system finds it challenging to attain high efficiency. The vast space and high cost demands of the Boost converter idea are detrimental to a two-stage system.

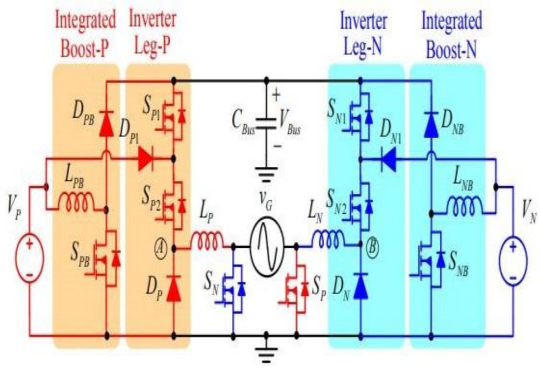

Fig.2."Topology of the proposed dual-input dual-buck inverter (DI-DBI) with integrated boost converter (IBC)".

Reflect the whole solar panel's energy. The development of grid-tied inverters required a lot of work. Improved topologies, modulation and control methods, and optimised design procedures have all been developed during the last ten years. By adopting a single-stage DC-AC converter with both step-up and step-down capabilities, such as Z-source and quasi-Z-source inverters, the shortcomings of a two-stage design may be readily overcome. Due to restrictions on step-up ratio, modulation index, and device stress, high efficiency with a Z- or quasi-Z-source inverter is still challenging to achieve. Due to its simple topology, flexible control, compact size, and high efficiency, Buck-type inverters are superior than Boost-type and Buck/Boost type inverters. A popular implementation of Buck-type inverters is non-isolated Buck converters. Buck-type inverters are more often used in practise as a result of these characteristics. Dual-buck inverters (DBIs), which consist of two buck type inverter-legs, are utilised for modest power generating systems of several kilowatts due to their efficiency and robustness. To reduce conduction and switching losses, DBIs may substitute MOSFETs and independent fast switching diodes for active switches' body diodes.

Given that the switching leg of a DBI is made up of MOSFETs and diodes linked in series, there is no problem with current shot through and no need for dead time. The system dependability and PWM voltage utilisation are greatly increased as a result of these characteristics. The low common-mode leakage current of a DBI has also been shown. The DBI topologies are advantageous for highly effective and dependable grid-tied power generating systems because of these characteristics. These factors have led to the recommendation of a wide variety of DBIs for usage in grid-connected systems. Since a DBI can only perform a step-down voltage conversion, a front-end Boost converter is still required to run the inverter over a broad range of DC voltages. Therefore, it is difficult to resolve the problems with the two-stage structure. The main contribution of this work is the development of a novel dual-input dual-buck inverter (DI-DBI) with an integrated Boost converter (IBC), which is offered as a method of bypassing the problems with a traditional two-stage construction and obtaining enhanced conversion efficiency. The IBC's power rating, loss, and cost are greatly decreased as compared to the conventional two-stage design since only a tiny portion of the input power needs to be processed by the IBC and the majority of the power is only handled inside one stage. Additionally, the suggested DI-DBI may use two DC inputs with different MPPTs to increase the amount of renewable energy captured.

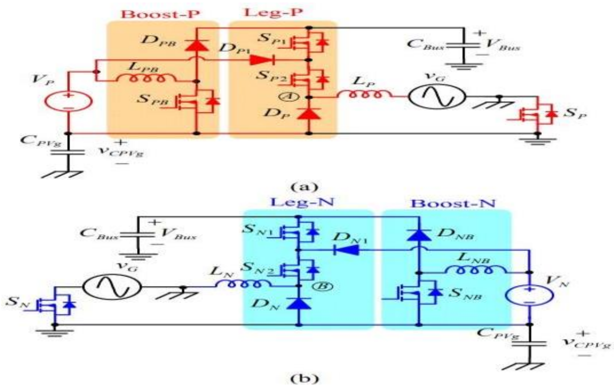

Fig..3.“Equivalentcircuitof(a)positivehalf-cycle,and(b)negativeHalf-cycle”.

2.SYSTEM CONFIGURATION AND CONTROLTHEORY

A. SYSTEMCONFIGURATION

A schematic of the suggested inverter's construction is shown in Figure 2. Two inductors, LP and LN, two integrated boost converters, Boost-P and Boost-N, two low-frequency switches, SP and SN, and two inverter branches, P and N, make up the inverter. The two independent DC power sources VP and VN might be linked to the recommended inverter's two DC inputs. Each inverter leg includes two switches and two diodes, as shown in Fig. 2. The two boost converters together form the DC bus known as VBus, which is shared by the two inverter branches. The inverter branch uses a DC source (VP or VN) and a DC bus to function as a two-input switch cell that supplies energy to the AC grid (vG). The main advantage of the proposed inverter is that it only has to go through one conversion procedure in order to enable the low-voltage DC source to power the AC grid via the inverter branch. When vG is in its negative half cycle, the inverter leg-N and switch SN operate, whereas vG is in its positive half cycle when the inverter leg-P and switch SP function.

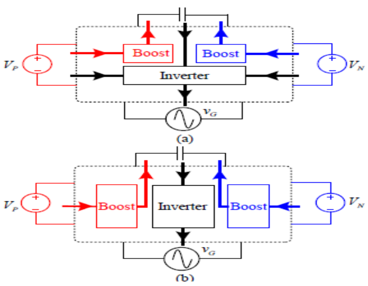

Fig.4.Power flow diagrams of (a) proposed inverter, and (b) conventional two-stage inverter".

The parasitic PV-to-ground capacitor CPVg and the circuits for the suggested inverter are shown in Fig. 1 for both the positive and negative half cycles. As shown in Figure 1, SP is always active for the duration of the vG positive half cycle. (a). Since CPVg, the supplied voltage, is 0, the parasitic capacitance is not charged. Fig. The switch SN is always on during the negative half cycle of vG, as illustrated in Fig. 1.3(b), hence vG serves as the voltage across the parasitic capacitance of CPVg. The voltage supplied to the CPVg has minimal leakage current characteristics since switching frequency voltage fluctuations are absent. Figure 4 depicts the power flow diagram for the recommended inverter. (a). As a point of reference, Fig. 4(b) displays the power flow diagram of a typical two-level inverter with two distinct DC inputs. Figure 1 shows this inverter in action. (b). There are obvious differences between the two diagrams. Two different DC inputs (VP and VN) and DC buses serve as the inputs to the inverter branches of the proposed converter; a simple inverter can only draw power from the DC bus. Typically, the whole DC input power must be able to be handled by the front-end boost converter.

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Since an integrated boost converter only modifies a very tiny amount of the incoming power, the power rating and losses of boost converters are reduced. An integrated boost converter maintains the intermediate circuit voltage for the inverter branches. Compared to the peak amplitude of vG, the voltage of DC sources exhibits far bigger fluctuations and is much less stable. As shown in Fig.1.3, the proposed DI-comparable DBI's circuits are analogous for both the positive and negative half-cycles of vG, demonstrating that the fundamental ideas are the same for both half-cycles. For Boost-P, Boost N, Boost SN, and SP, the same is true. Only positive half-wave operation is examined in this study to simplify the analysis.

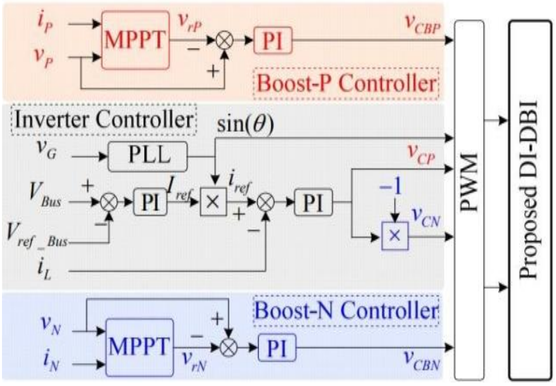
3.MODULATION AND CONTROL

A. CONTROL STRATEGY

The Fig. displays the block diagram for the proposed DI-control DBI. The MPPT of the two DC input sources, VP and VN, as well as the grid current are separately controlled by three controllers: the Boost P, Boost N, and Inverter controllers. That is the analogue of an inverter in a conventional two-level DC-AC converter.

The Boost-P and Boost-N controllers govern the power of the VP and VN, whilst the inverter controller regulates grid current and DC bus voltage.

The outer voltage loop and the inner current loop make up the inverter control. The reference voltage Vref bus is connected to the intermediate circuit voltage VBus in Fig. 4.6. By combining the outputs of the phase-locked loop and the DC bus voltage loop, the grid current reference Iref is created (PLL). In the positive and negative half cycles of vG, the output of the internal current



loop, denoted by vCP and vCN, respectively, controls the inverter.

The controllers for Boost-N and Boost-P are identical to one another. Consider the potential impact of this research on the Boost P controller. The DC power supply VP's voltage and current are denoted by the letters vP and iP. The foundation of all contemporary MPPT methods is vP and iP, including jamming and monitoring.

Fig.5.ControlblockdiagramoftheproposedDI-DBI.

4. DESIGNOFFUZZY CONTROL

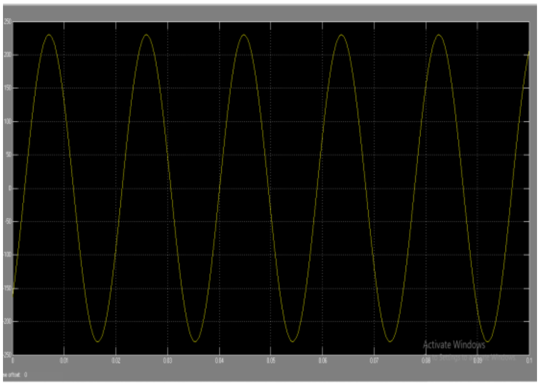
The number and diversity of applications for fuzzy logic have greatly increased during the last several years. Medical equipment, industrial process control, portfolio selection, and consumer electronics including cameras, camcorders, washing machines, and microwave ovens are just a few examples of the uses. There are two types of fuzzy logic. Fuzzy logic is a limited application of the multivalve logic framework. Fuzzy sets theory and fuzzy logic (FL) are virtually equivalent since they both deal with classes of objects that have fuzzy borders and degree-dependent membership. According to this argument, fuzzy logic in its narrow sense includes fuzzy logic as a subset. Fuzzy logic varies theoretically and significantly from traditional multi-valve logic systems, even in its more constrained form. The foundation of FL and a need for several applications is the fuzzy rule, sometimes referred to as the fuzzy if-then rule. Despite having a long history in AI, rule-based systems struggle to handle complex sequences and ambiguous precedents. This approach is provided by fuzzy logic's calculus of fuzzy rules. The Calculus of Fuzzy Rules serves as the foundation for the so-called Fuzzy Dependency and Command Language (FDCL) (FDCL). FDCL is not formally mentioned in the toolkit, but it plays a crucial role in it. In fuzzy logic applications, FDCL translations of human responses are often used as fuzzy logic solutions.

5. SIMULATATIONRESULTS

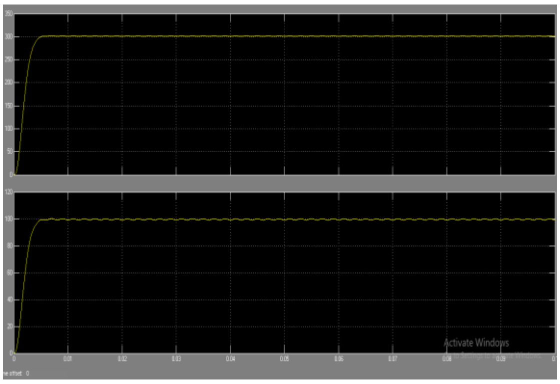
In the P-inverter branch, waveforms at VP = 300 V and UN = 100 V are used. The waveforms below show the drive and output waveforms. The output voltage is vG, while the drive waveforms for switches SP1, SP2, and SP are vGSP1, vGSP2, and vGSP, respectively.

Despite the fact that SP always conducts during the positive half cycle of vG, SP1 and SP2 switch at a high frequency. SP2 is switched on and displays vG rather than VP when SP1 is often turned on and off. VP vG occurs because SP1 is often dormant while SP2 is active. Given that VP = 300 V is a rather high voltage, SP2's high-frequency switching time is very lengthy.

GRIDVOLTAGE



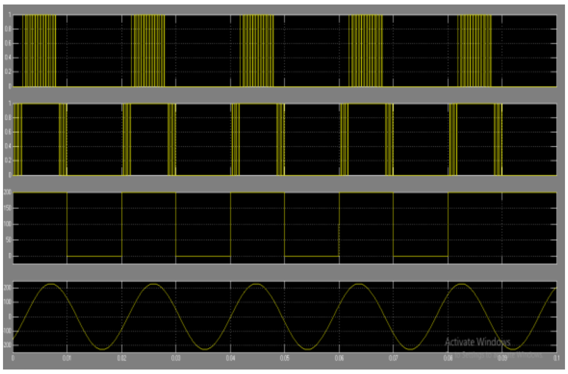
PV-VOLTAGE

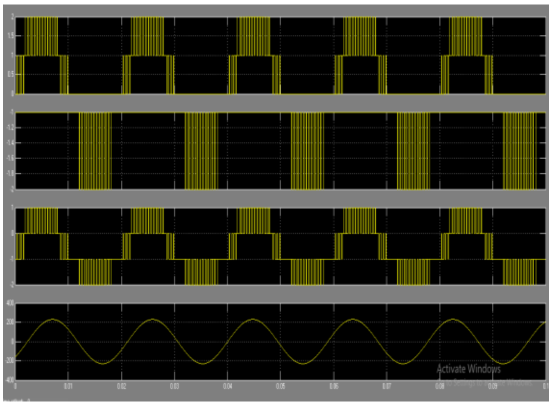


If VP = VN = 190V, the inverter leg-P in Case II operates as shown in the waveforms below. When vG> VP and DC bus operating mode are employed, the dual input mode's range of operation is constrained. Only positive half-waves are allowed with inductance LP. Since VP and VN have the same voltage, the five-level voltage is symmetrical.

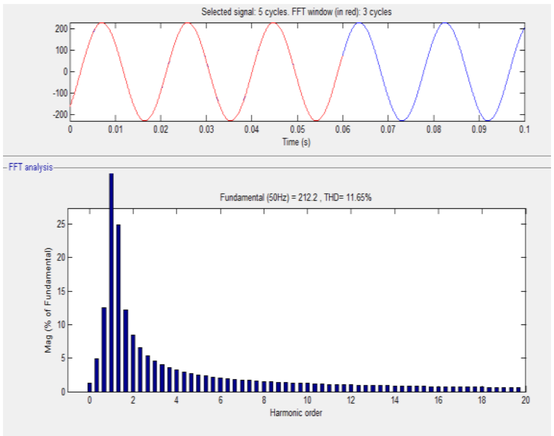
On the waveforms VA, VB, VC, and vG, the voltage between each of the two circuit branches is shown. By switching branch P, three voltage levels +VBus, +VP, and 0 are created. As soon as branch N is modified, VBus, VN, and 0 happen.

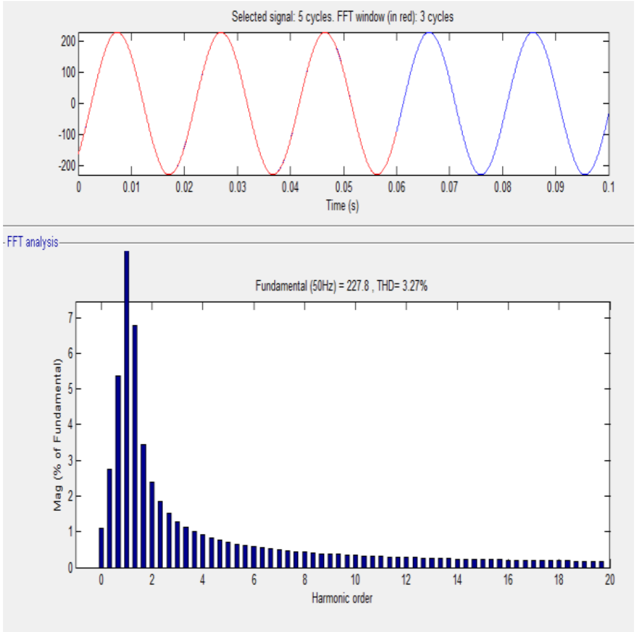
WAVE FORMS OF Vp=300VA ND Vn=100V





Total Harmonic distortion with PI-CONTROLLER





Total Harmonic distortion with FUZZY-CONTROLLER.

Simulation results have been provided for the fuzzy and pi controllers to support the effectiveness and advantages of the proposed strategy.

Fuzzy logic is used to calculate total harmonic distortion, which is found to be 3.27 percent, falling under the IEEE standard's 5% limit. It is discovered to be 11.65 percent when utilising a conventional controller, which has an effect on the grid's power quality.

6. CONCLUSION

In this research, we study the construction, behaviour, and control of a DI-DBI with two IBCs. The following is what theoretical analysis and computerised verifications suggest:

1) Compared to traditional two-stage techniques, fewer stages of power conversion are needed, and

the conversion efficiency is better. Since the IBCs only need to handle a tiny portion of the incoming electricity, the recommended inverter lowers their power rating, losses, and cost. Due to the intended DI-DBI with the IBCs' capabilities for Buck and Boost voltage conversion, the input voltages of the inverter may shift dramatically.

2) The two DC inputs' voltage and power may be separately changed, allowing two PV arrays to monitor their dispersed maximum power. The results demonstrate that the overall harmonic distortion, estimated using fuzzy logic on the grid side, is 3.27%. IEEE standards provide for 5%, however when a typical controller was used, 11.65% was discovered. The benefits and efficacy of the suggested solutions are supported by the simulation results.

The pv system can also be implemented with additional fuel cell and battery applications and advanced controller architecture can be further implemented for more betterment of the system

7. REFERENCES

[1] S. Saridakis, E. Koutroulis, F. Blaabjerg, "Optimal design of modern transformer less PV inverter topologies," IEEE Trans. Energy Conversion, vol. 28, no. 2, pp. 394-404, June 2013.

[2] W. Li, Y. Gu, H. Luo, W. Cui, X. He, C. Xia, "Topology Review and Derivation Methodology of Single-Phase Transformer less Photovoltaic Inverters for Leakage Current Suppression," IEEE Trans. Ind. Electron., vol. 62, no. 7, pp. 4537-4551, July 2015.

[3] H. S. Sahu, S. K. Nayak, S. Mishra, "Maximizing the Power Generation of a Partially Shaded PV Array," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 4, no. 2, pp. 626-637, June 2016.

[4] T. Sreekanth, N. Lakshminarasamma, M. K. Mishra, "A Single-Stage Grid-Connected High Gain Buck-Boost Inverter with Maximum Power Point Tracking," IEEE Trans. Energy Conversion, vol. 32, no. 1, pp. 330-339, Mar. 2017.

[5] A. Kumar, P. Sensarma, "A Four-Switch Single-Stage Single-Phase Buck-Boost Inverter," IEEE Trans. Power Electronics, vol. 32, no. 7, pp. 5282-5292, July 2017.

[6] J.-M. Shen, H.-L. Jou, J.-C. Wu, K.-D. Wu, "Five-Level Inverter for Renewable Power Generation System," IEEE Trans. Energy Conversion, vol. 28, no. 2, pp. 257-266, June 2013.

[7] T.F. Wu, C.-L. Kuo, L.-C. Lin, Y.-K. Chen, "DC-Bus Voltage Regulation for a DC Distribution System with a Single-Phase Bidirectional Inverter," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 4, no. 1, pp. 210-220, Mar. 2016.

[8] L. Zhang, X. Ruan, X. Ren, "Second Harmonic Current Reduction for Two-Stage Inverter with Boost-Derived Front-End Converter: Control Schemes and Design Considerations," IEEE Trans. Power Electron., DOI: 10.1109/TPEL.2017.2746878, 2017.

[9] C. J.O. Junior, L. P. Pires, L. C. Freitas, E. A.A. Coelho, G. B. Lima, L. Freitas, "Design, analysis and performance of a bidirectional solar

inverter with a global and independent maximum power extraction technique," IET Power Electronics, vo. 11, no. 1, pp. 221-228, Jan. 2018.

[10] E. Serban, F. Paz, M. Ordonez, "Improved PV Inverter Operating Range Using a Miniboost," IEEE Trans. Power Electron., vol. 32, no. 11, pp. 8470-8485, Nov. 2017.

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