Design and Analysis of Multi-Output Hybrid Converter at Different Operating Conditions

Gaurav Kumar Mishra*,[1], A.K. Pandey*, and Anupama Mishra^

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Abstract *- This paper presents the design and analysis of a Multi-output Hybrid converter using MATLAB Simulink. Multi-output Hybrid converters combine the advantages of DC-DC Boost Converter, 1-phase Inverter, and 3-phase VSI topologies to achieve efficient power conversion across multiple output channels. The converter topology integrates switching and non-switching components to exploit both advantages, aiming to minimize losses and enhance overall reliability. Design considerations include selecting passive components, control strategies, and optimization techniques tailored to meet stringent performance criteria across multiple output channels such as DC output, 1-phase, and 3-phase AC output. The production of the multi-output hybrid converter will be a 3-phase balanced AC supply, 1-phase AC, and regulated DC supply. Simulation results validate the proposed design methodology and highlight the converter's ability to maintain stable operation while delivering power to different load requirements. The output of the hybrid converter gives a 3-phase Alternating Current Supply, 1-phase Alternating Current Supply, and regulated Direct Current Supply at the output from a single Direct Current input supply, taken from renewable energy sources like Solar Photo Voltaic Modules, Fuel cells, and BESS. Simulation results show that we can get multi-output supplies like DC,1-phase, and 3-phase AC supply from the single input DC Source with THD analysis having various loading conditions of the inverter like R load, RL load, and RLE load with their different values.*

Keywords – BESS (Battery Energy Storage Supply System), EMI (Electromagnetic Interference), MOHC (Multi-output Hybrid Converter), PV (Photo Voltaic), SBI (Switched Boost Inverter), THD (Total Harmonic Distortion), VSI (Voltage Source Inverter).

1. INTRODUCTION

In the current scenario of the electrical power industry, the concept of a nano grid is emerging very fast, which requires interlinking various renewable energy sources, especially solar energy, which is the most emerging and free-of-cost energy source available to us. Hence, we use solar PV cells as an input source and cater to local residential loads at different voltage levels. The idea of an MOI converter comes from the requirements for residential/household applications. In a house, we have all kinds of loads like 1-phase loads, which are very common like FAN, Refrigerators, Water Pumps, etc., and DC loads, which will directly work on DC supplies like smartphones, Laptops, Tablets, LED bulbs, LED TV, Routers, Trimmers and Battery powered Devices, requires a converter circuit in domestic applications to convert AC coming from the grid to DC that DC-AC converter we may replace while using Hybrid converter and lastly some residential loads also needs 3-phase AC like submersible pumps, Ovens etc. So, in a simple sentence, a hybrid converter may fulfill all the domestic as well as industrial load applications from a single-stage conversion known as a multi-output converter.

The Hybrid Converter will give us all available forms of energy from a single source, which is a solar photovoltaic cell. The Switched boost inverter is a single-stage power converter used to drive DC loads as well as AC loads derived from Inverse Watkins Johnson topology. Unlike the traditional buck-type voltage source inverter, the Switched Boost Inverter can produce an alternating current (AC) output voltage that is either greater or less than the available DC input voltage, which is taken from the solar PV Cells. The Switched Boost Inverter exhibits better electromagnetic interference (EMI) noise immunity than the VSI, which is capable of being a compact power converter design. SBI is able to supply both DC and AC loads at a time from a single DC Input. These qualities make the SBI suitable for DC Nano-Grid applications [1]. Integrated Dual Output converters are also proposed in the literature, which will provide multiple Direct Current (DC) outputs from a single DC input supply, IDOC used for Step up (Boost) and step down (Buck) the level of DC voltage from the single DC source in a single converter [2].

A switched boost inverter (SBI) is available in the literature, which gives boost-regulated DC and 3-phase AC output from the single DC input. It is also preferred because it will produce multi-output by utilizing a reduced Number of Passive elements in the circuit proposed in [3].

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The conventional micro-grid utilizes many converters like DC to AC converters for AC load requirements, DC to DC converters for DC load requirements [4], and bidirectional power converters for AC, DC loads, and storage systems shown in figure-1. Here, the output voltage is of shallow magnitude; hence, we need to Boost the voltage level before supplying it to the conventional Grid. This paper proposes a Hybrid multi-output converter capable of giving a regulated boost DC voltage from Low DC voltage obtained from renewable energy sources and then converting the DC voltage into 1-phase and 3-phase AC, which is required for Domestic applications [5].

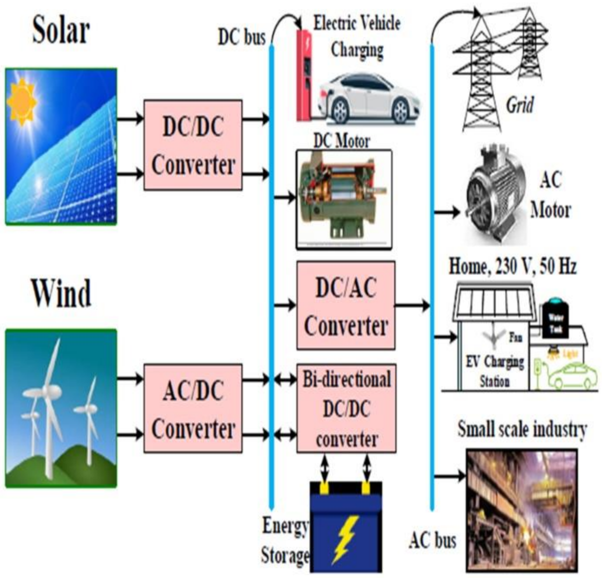

Figure-1. Conventional structure of micro-grid.

The converter discussed by [6,7] is used to control the field and armature current of the DC motor simultaneously from the same control circuit to enhance the efficiency of a DC motor drive as compared to a simple armature control of the DC Drive hence from that we motivate to control the switches of the converter from the same circuit and refer their name as Hybrid PWM Modulation technique which is used to turn on the switches of multi-output hybrid converter.

Power electronics play a vital role in developing AC and DC Drives. The advancement in electric traction is an example of this development, where traction drives can be easily controlled and operated with the help of Power Electronics devices [8]. From there, we may conclude that the power electronics concept motivates us to go for a multi-output hybrid converter.

The resonant switching of the DC-DC Converter for high output voltage from low input voltage is referred from the Novel switching of BLDC motors, which use the principle of switched inductance and capacitance to enhance the output voltage of the Power electronics converter [9,10].

Switched Z-source converter are used by [11] to enhance the level of DC voltage which is been utilized in this paper for enhancing the output from the low voltage input voltage. The concept of 3-Phase quasi Z-source inverter with balanced 3-phase load [12] is utilized in this paper for obtaining 3-phase balanced output to drive 3-phase star connected balanced load. 3-phase hybrid multi-output converter with single DC input [13] has been incorporated in this research for obtaining multi-output with less THD distortion. Hybrid converter modification technique for obtaining higher value of DC voltage from the boost converter is used and getting higher DC output from [14].

Switched inductance and capacitance technique are used for getting higher DC output are used and from the results is clear that we are getting very high voltage from [15,16]

Conventional converters used in micro-grids have various drawbacks, such as higher levels of conversions (like DC-DC and DC-AC conversions), a large number of switches, and a large number of Passive elements; hence, they require the use of multi-output Converters in Micro/Nano-grids. Figure 2 shows the block arrow Diagram of a Conventional multi-output Hybrid Converter, which is capable of producing multiple outputs from a single Direct Current (DC) input source.

The paper consists of various sections: Section 2 gives us an idea about Boost DC Converters and their control strategy; Section 3 discusses 1-phase VSI and the PWM technique used to control the switches of 1-phase VSI; Section 4 gives an idea about 3-phase VSI and their control technique; Section 5 discusses the Simulation of a Multi-output Hybrid converter using the MATLAB Simulink environment; and then the Result and Conclusions sections are discussed.

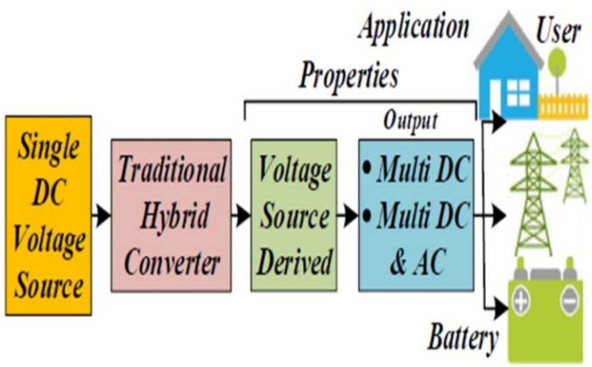

Figure-2. Flow Diagram of Hybrid Multi-output Converter.

2. BOOST DC CONVERTER

The Boost DC converter is used in this paper for two important purposes: to step up (Boost) the level of DC voltage because renewable energy sources, especially solar PV modules, will give a low voltage at their output; hence, we need to step up the level of DC voltage this is just like conventional AC generation where we generate low-level AC supply typically in the range of 11KV and with the help of step-up transformer we convert Low-level AC into high-level AC in the range of 220KV and above to transmit it and hence to decrease the size of the conductor and decrease the losses, in the same way, we get low-level DC voltage from solar PV cells and hence to get usable form of AC and DC we need to raise the level of DC voltage with the help of Boost DC Converter. The second purpose of using a boost converter is to Drive DC loads from the output of the boost converter in a controlled manner. In this paper, we use a Switched Boost DC Converter, which gives a higher value of DC output than normal boost converters.

The Switches used in boost DC converters are controlled by the Hybrid Pulse Width Modulation (HPWM) technique, which is also used to control the switches of VSI and Boost converters.

The Switches of the Boost Converter are controlled by comprising a triangular carrier waveform of 10 KHz frequency with DC voltage and getting the pulses for driving the switches of the boost DC converter. There are two modes of operation of the Boost Converter: Power Mode and shoot-through (ST) Mode.

Simulation of DC boost converter is done in MATLAB Simulink environment, and there are various factors on which the output voltage of the converter depends are Switching inductors and capacitors, the duty ratio (D) of the converter, the switching frequency of the converter on which the output voltage of the Step up (Boost) converter depends.

We used a switched impedance network to increase the output voltage of the Boost DC converter. Hence, by varying the values of the Inductor and capacitor, we are able to get the boost value of the output voltage from the converter's output.

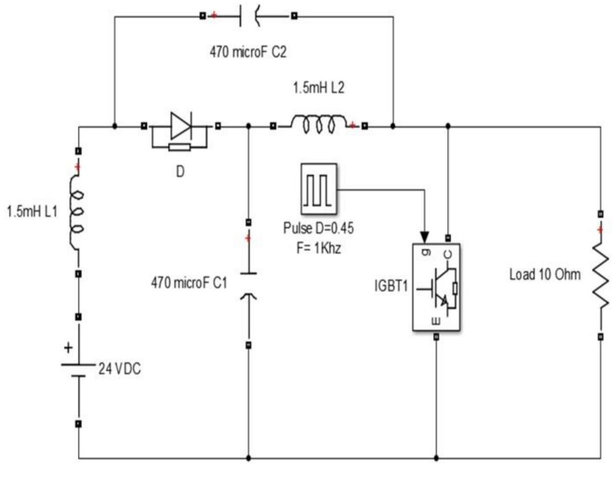

Figure 3. Circuit of Boost Converter.

The Boost Converter takes 24 Volts DC, which is basically received from the solar PV modules, and then boosts it as per our requirements and depending on the design parameters of the Boost Circuit.

The two operating modes of the Boost Converter are as follows:

2.1 Mode-1 (0<t<DT)

In this mode, the IGBT is turned on, which means conducting, and the Diode D is reversed biased, and their equivalent circuit is depicted in Figure 4. Output voltage in this mode is equal to zero. Capacitor C1, Input voltage, Vdc, and capacitor C2 charge the inductors L1 and L2. The time interval of this mode is from 0 to (D*T), where D denotes the Duty ratio, which depends on the Pulse width percentage, and T is the Time period, which depends on the switching frequency of the pulse generator.

On applying KVL, the Voltage across inductors L1 and L2 is given by the equation:

$$Vdc + VL1 - VC2 = 0$$

$$VL1 = Vdc + VC2 \qquad (1)$$

$$VL2 = VC1 \qquad (2)$$

From here, the Inductor (L1) is charged from input voltage (V_{dc}) and capacitor voltage (V_{C2}), and the Inductor L2 is charged from capacitor voltage V_{C1}.

During this mode, Diode D is off; hence, the voltage across the diode is :

$$VD = VC1 + VC2 \qquad (3)$$

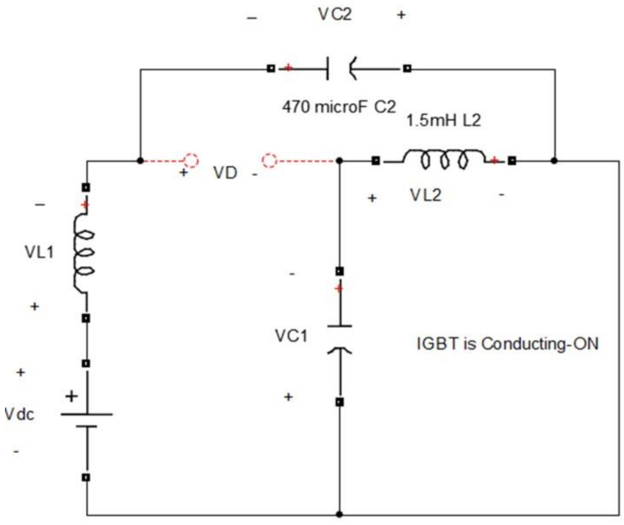

Figure 4. Mode-1 Operation of IGBT.

2.2 Mode 2 (DT<t<T)

The time interval of mode-2 in the proposed Boost DC Converter is (1-D)T, where D is the Duty ratio, and T is the Time period. In this mode, the IGBT switch is not conducting, which means the IGBT is turned off, and Diode D is forward. Biased means short-circuited. The inductors L1 and L2 start discharging and giving their energy to the load, and the Load voltage, V_{out}, is greater than the input voltage. So, we may conclude that the converter is operated in Boost mode. The Equivalent Circuit of mode-2 is shown in Figure 5, where the converter operates in Boost mode.

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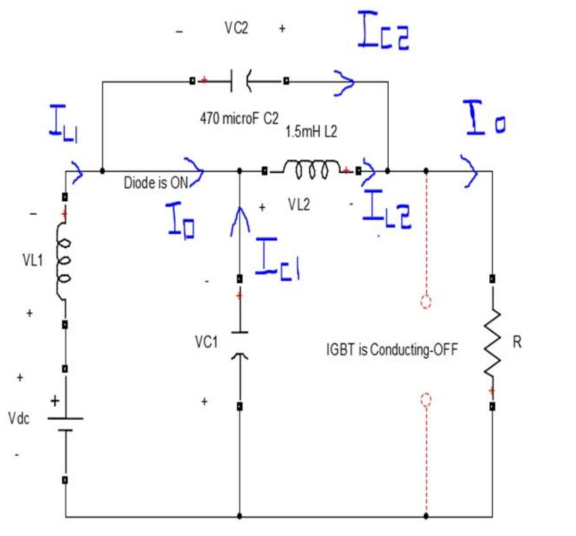

Figure 5. Equivalent Circuit of Converter in Mode 2.

This mode is also known as power mode because we get a boost in output voltage from the converter.

By using KVL in this mode, we get:

$$VL1 = Vdc - VC1 \quad (4)$$

$$VL2 = - VC2 \quad (5)$$

Load Voltage V_{out} across load resistance R is:

$$Vout = VC1 + VC2 \quad (6)$$

By using KCL, we get the following equations, which are used for the analysis of the circuit:

$$IC2 = Iout - IL2 \quad (7)$$

$$IC1 = Iout - IL1 \quad (8)$$

Under the steady state condition, the average voltage across voltage across the inductor (L1) and average current across the capacitor (C1) is zero.

2.3 DC Boost Factor

The Boost value of a DC converter is found by using the equations discussed above. Solving all the above equations and combining the boost converter's mode-1 and mode-2 operation gives the ratio of Output voltage (V_{out}) to input voltage (V_{dc}), which is called the DC Boost factor.

The Duty Cycle (D) of the Boost converter is 0.45, which gives the best output voltage after varying various Duty cycle values.

3. 1-PHASE VSI

3.1 1- Phase Voltage Source Inverter

This is part of a Hybrid multi-output converter circuit, which gives 1-phase AC by taking pulsating DC, which is taken from the output of the Boost DC converter. This 1-phase VSI inverter will provide another form of the production from a single DC source, which is known as a multi-output converter. This will produce a 1-phase AC output that contains harmonics. To make it sinusoidal, we design a filter circuit so that the harmonics get suppressed, and we may get a sine waveform.

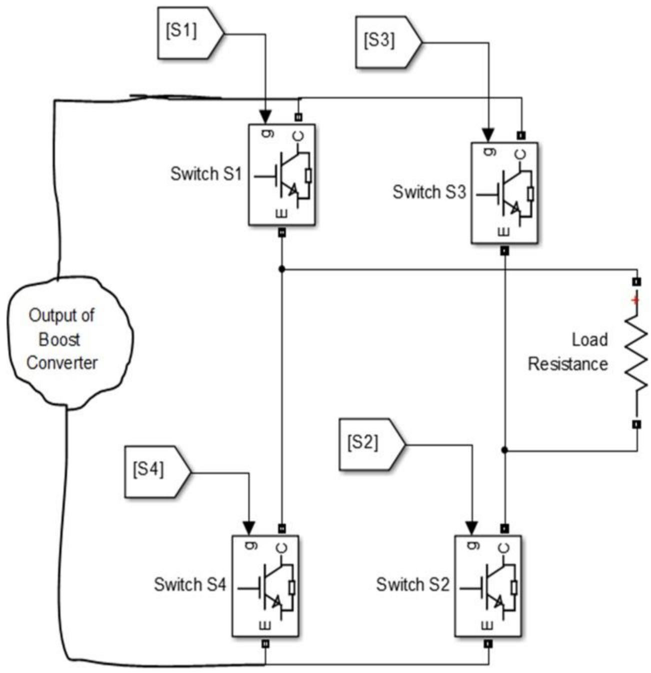

Figure 6. Circuit Diagram of 1-phase VSI.

The Filter Design of the 1-phase converter gives a sinusoidal output from the 1-phase VSI. The switching of MOSFETs used in this configuration is a sinusoidal PWM, which takes the Saw tooth wave as a carrier wave of Higher frequency and compares it with the Sine wave of fundamental frequency. Here, we are using Bipolar Sinusoidal PWM in which the Sine wave and Inverted sine wave are compared with the saw tooth wave to give firing pulses to the switches of the Inverter. Switches S1 & S2 are fired using a sine wave, and Switches S3 & S4 are fired with Inverted Sine Wave reference waveforms and Triangular waves of higher frequency carrier wave Shown in Figure 7.

The following sections discuss the inverter's analysis inverter's analysis in terms of THD with different loading conditions. Proper selection of the inductor and capacitor values gives a pure sinusoidal 1-phase AC waveform.

3.2 Modulation Technique Used for Inverter

The output of 1-phase VSI will depend on the control circuit's modulation index (m). We may also use the Hybrid modulation technique, which will discussed in later sections which is used for firing all the switches of the multi-output converter from a single saw tooth generator and single technique, but there is a restriction in this case that we cannot vary the duty ratio of the converter over a wide range of duty ratio because the sum of modulation Index (m) and duty ratio (D) of the boost converter is less than unity hence we are unable to vary the duty ratio and modulation index up to a certain level where we have to maintain:

$$m + D > 1 \quad (9)$$

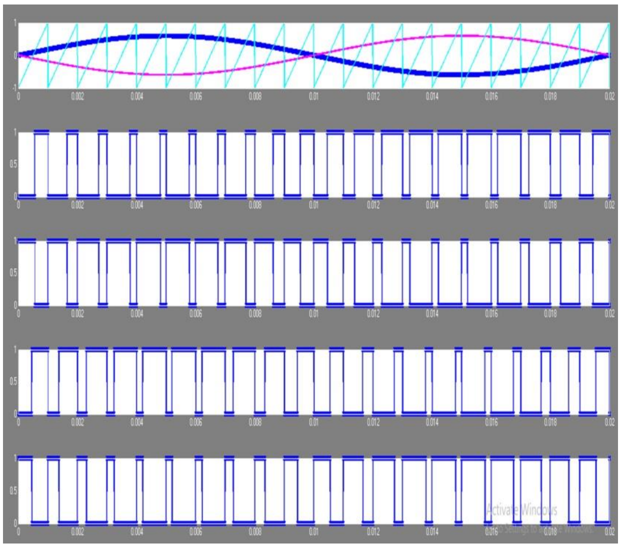

Figure 7. Firing Pulses for 1-Phase VSI.

4. 3-PHASE VSI

4.1 3- Phase Voltage Source Inverter

The 3-phase VSI is also fed from the output of the Boost DC converter; hence, we call it a multi-output converter. The 3-phase VSI is connected in parallel with the boost converter, and thus, it takes full voltage from the boost converter, but the current in the 1-phase and 3-phase inverters is distributed according to the load requirements. We may connect a 3-phase inverter in parallel according to the requirement of distributed voltage and fixed current. The Circuit of 3-phase VSI is shown in Figure with resistive load. We may also change the load to an RL and RLE load, and in the next section, we analyze the waveform of the 3-phase inverter.

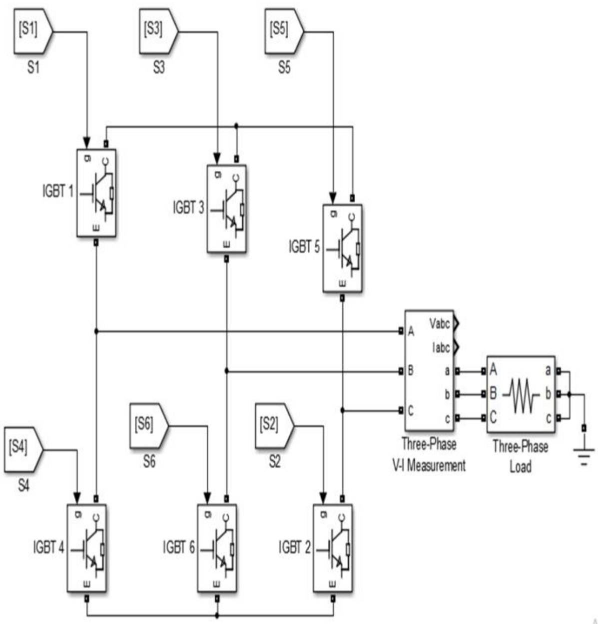

Figure 8- 3-phase VSI

By using multilevel inverters, the waveform of a 3-phase inverter is sinusoidal, and its THD is less than that of a normal inverter. So, from the analysis point of view, we preferred different multilevel inverters, such as 5-level,7-level, and more, to get less THD than the conventional 3-level VSI.

4.1 *Switching Technique of Inverter*

For 3-phase VSI, we also use the sinusoidal PWM technique, in which 3-phase sinusoidal waves of fundamental frequency are compared with sawtooth waves of high frequency to get firing pulses for controlling the IGBT switches of the inverter circuit. Here, the output voltage (V_{out}) will depend on the modulation index (m) of the control circuit.

5. SIMULATION OF HYBRID MULTI-OUTPUT CONVERTER

The design of a multi-output converter in MATLAB Simulink environment is discussed in this section. The Converter will take low DC voltage from Solar Panels and Give regulated DC, 1-phase, and 3-phase AC supply at the output of a multi-output converter; hence, it may also known as a hybrid converter.

The voltage DC obtained from the Solar Photovoltaic cells gets fed into the Switched boost-based Boost DC converter, where we get higher DC voltage from the low DC voltage. The pulsating DC supply obtained is fed into 1-phase VSI and 3-phase VSI for converting DC to AC supply. The same has been implemented in the MATLAB Simulink environment. When changing the values of inductors (L) and capacitors (C), we get Boost-regulated DC voltage from the converter.

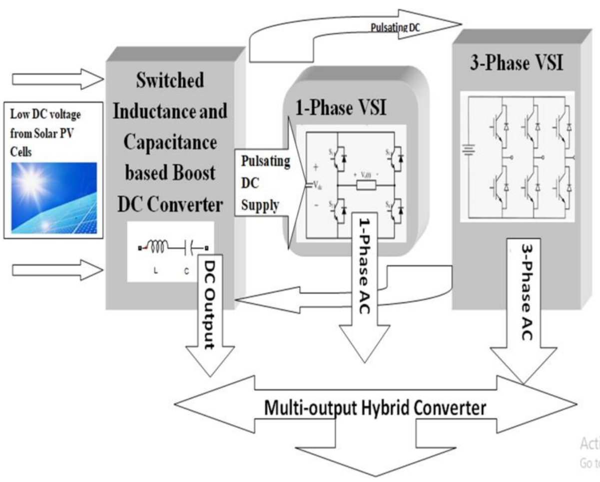

Figure 9. Flow Diagram of Hybrid Multi-output Converter

5.1 *Control method of Hybrid Multi-Output Converter*

For the multi-output Hybrid Converter proposed in this paper, we use the Hybrid Pulse Width Modulation (HPWM) technique, which triggers the switches of switched Boost DC Converter, 1-phase VSI, and 3-phase VSI units. We may fire all the control switches in the multi-output hybrid converter from the single control circuit. Figure 10 shows the combination of a carrier wave of higher frequency 3-phase Sinusoidal wave, a 1-phase Bipolar Sine wave, and a DC reference voltage for generating pulses of the Switched Boost converter.

Table 1. Hybrid Modulation Wave Nature Information.

Wave and Nature	Frequency	Phase
Carrier Wave (Saw tooth Nature)	10KHz	90
3-Phase Wave (Sinusoidal)	50Hz	R-0 Y-120 B-240
1-Phase wave (Sinusoidal)	50Hz	P-0 N-180
DC Calibrated	Constant	----

Table 1 shows the details about the carrier and reference wave nature for hybrid Pulse width modulation, which is used to get the firing pulses of the multi-output hybrid converter, which is used to turn on the switches of DC-DC Boost Converter, 1-phase, and 3-phase Inverter Circuit units.

Figure 10 shows the Complete waveform comprising the career wave with the reference wave of the 3 converter units: the Boost DC converter, the 3-phase VSI, and the 1-phase VSI unit of the hybrid converter.

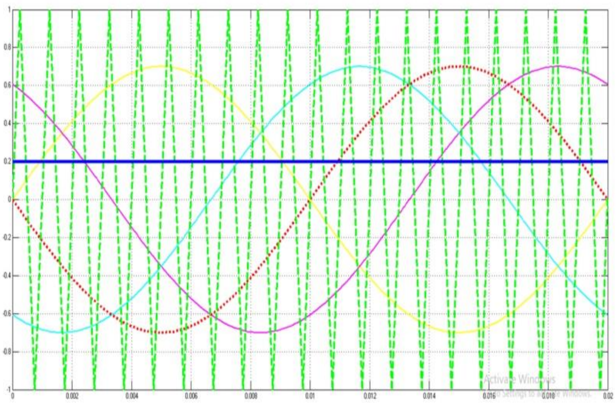

Figure 10. Waveform for Hybrid Modulation Technique.

The complete firing pulses of 3-phase VSI are obtained for controlling 6 IGBT switches by comparing the concern phase with the triangular wave and getting PWM pulses like the sinusoidal PWM technique. For 1-phase VSI, the control pulses are generated the same way as those in the Bipolar Sinusoidal PWM Technique. For the Switched Boost DC Converter, the firing pulse is generated by utilizing an Inverter's through (ST) Mode. Shoot-through (ST) mode is a technique in which all the switches from the same legs of the inverter are switched on, and we are getting a short circuit at the output of the inverter. To utilize this disadvantage of the inverter, we have used this as an opportunity to operate the Switched boost converter in that duration for the charging of inductors from the supply voltage in the shoot-through period, and we get boost voltage from the output of Step Up (Boost) DC converter. So, for generating the pulses for the Switched Boost DC converter, we compare a Constant calibrated DC Voltage with the same triangular carrier wave, and if the value of the career wave is higher than the DC reference voltage, we get a High Pulse, otherwise a Low Pulse. So from those pulses, we used to fire the Switches of the Boost DC Converter.

Figure 11 shows the MATLAB Simulink model for the Hybrid PWM technique, which is used for generating pulses of a multi-output hybrid converter. The scopes show that the pulses generated from a single Hybrid PWM model may fire pulses for the DC-DC Converter, 1-phase, and 3-phase inverter units of the multi-output hybrid converter.

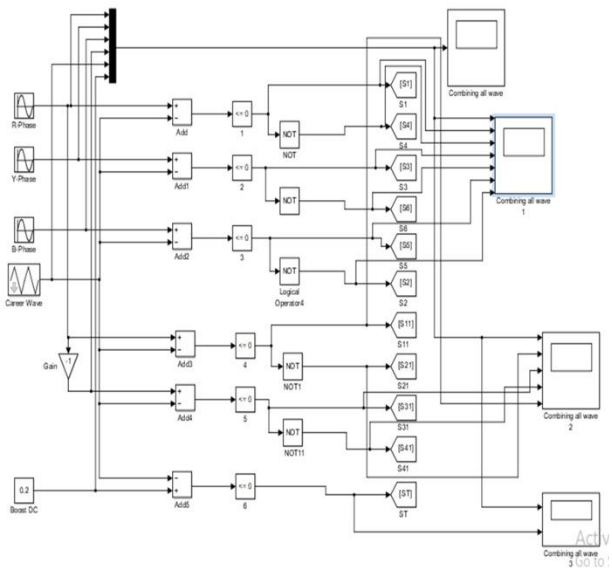

Figure 11. Simulation Diagram of Hybrid PWM.

5.2 Selection of Passive Components and Other Parameters for Switched Boost Converter

The Passive Components used in the designing of the multi-output converter are based on the Optimization technique because optimizing the passive components of the multi-output hybrid converter will give higher DC Voltage without distorting the Pulsating DC voltage from the Switched Boost DC converter. We select various values of the Inductors L1, L2, & Capacitors C1 and C2 to obtain a higher value of DC voltage without distortion. Finally, after many attempts and having various literature results, we came to apply the Values of Passive Components for the Switched Boost DC converter.

The optimization of various passive components is taken from RSM Design expert software, where we may give the higher and lower limits of the components as discussed in Table 2. Based on various values given by RSM Design expert software, we may get the best values of Passive components like Inductors, capacitors, and Duty ratios for the higher value of the output voltage.

We also analyzed the average value of DC obtained from the Converter and concluded that the value of the Duty Ratio and Switching Frequency of the Career Wave play a very important role in regularizing the Shape of pulsating DC voltage. Once we get a less distorted pulsating DC, we are able to get a pure sine wave at the outputs of the Inverter circuits, which is the main aim of this work.

Table 2 shows various parameters for Calculating the hybrid multi-output converter in MATLAB Simulink Environment.

Table 2. Parameters for Designing Hybrid Multi-output Converter

Parameter	Lower Limit	Higher Limit	The value used in Simulation
L1	1.2 mH	2.5mH	1.5mH
L2	1.2mH	2mH	1.875Mh
C1	10µF	600µF	470µF
C2	10µF	600µF	470µF
Duty Ratio	0.2	0.5	0.44
Switching frequency	850Hz	10Khz	1Khz
R_{dc}			100 Ohm
V_{dc}	12V	220V	60Volts
Diode	Snubber Circuit (Rs=500 Ohm & Cs=250nF) Ron=0.001ohm and Vf=0.8 V		
IGBT			

6. SIMULATION RESULTS AND DISCUSSION

This section discusses the simulation results of the multi-output hybrid Converter, as well as the THD and waveform analysis.

6.1 Switched Boost DC Converter

The pulsating boost DC obtained from the Boost Converter is given in Figure 12 with an A through duty ratio (D) of 0.44 and a switching frequency of 1 KHz. The maximum peak voltage in pulsating DC is 593 Volts from an input DC Voltage of 60 Volts.

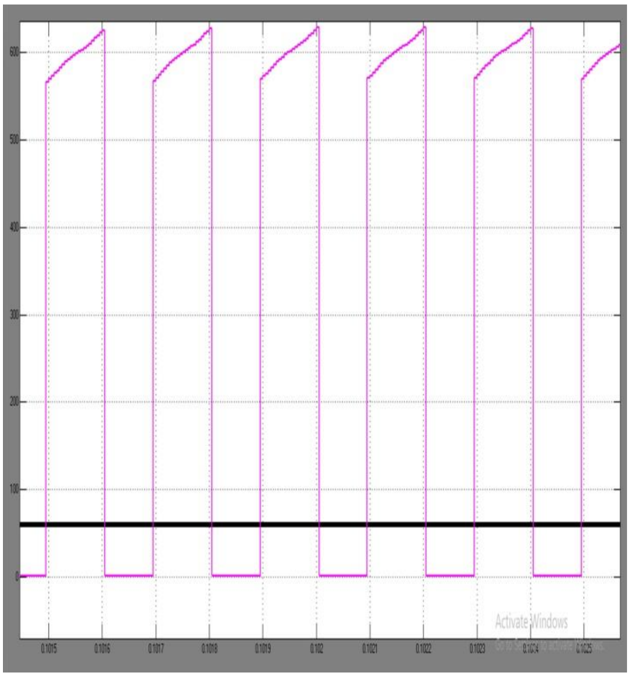

Figure 12. Pulsating DC at Output of Boost Converter with DC input Voltage

The average DC voltage we get from the output of the Boost DC Converter is 312 Volts DC. Figure 13 gives a THD analysis of the Pulsating DC voltage at the output of the Boost DC converter.

The THD of Pulsating DC is 4.05% at 50Hz Fundamental and 1000Hz Maximum Frequency with a Bar related to the DC component in the Display Analysis.

Table 3 shows the average DC and THD for all Switched Boost DC Converter components.

From Table 3, we may see a transient period, and we are getting 77.05% THD with a 244.5 volts average DC value. After setting to the steady state, we are getting constant DC and almost 4% THD at every component of the Switched Boost DC Converter.

Table 4 depicts the THD analysis and DC value analysis of the switched Boost DC Converter under different operating conditions. The RLE load is a motor load, and we get a very low THD value of current and almost constant average voltage under every operating condition.

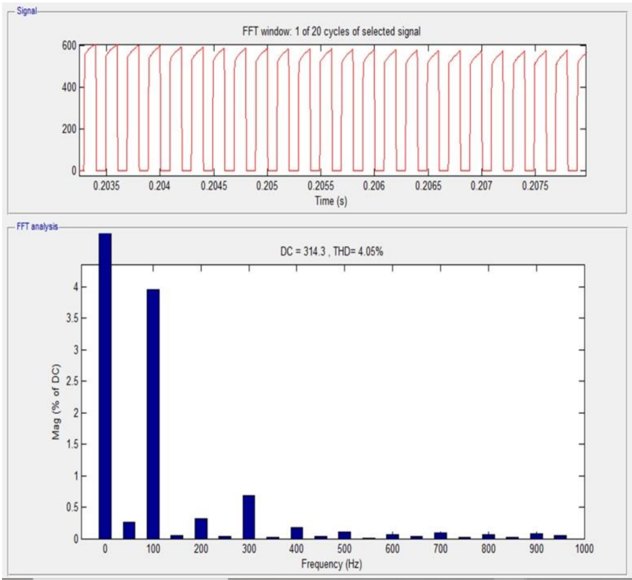

Figure 13. THD Analysis of Pulsating DC Voltage

Table 3. THD and DC values at Different Components of the Switched Boost Converter.

Signal Name	THD (%)	DC Value
Pulsating DC	4.05	314.3
The average value of Pulsating DC	0.69	316.3
At the time of Starting, the condition	77.05	244.6
Current across L1	4.86	159
Current across L2	4.86	159
Voltage across C1	6.63	255.7
Current across C1		0.0374
Current across Diode	3.08	159
Voltage across Diode	4.19	255.7
Current across ST Switch	3.04	140.3
Voltage across ST Switch	4.11	315.5

Table 4. THD Analysis at Different Loading Conditions.

Loading Condition of Boost DC Converter	THD (%)	DC Voltage	DC Current
Resistive Load R=100Ω	4.05	315.3V	3.157A
RL Load (R=100 Ω, L=5mH)	4.17	315.5V	3.155A
RL Load (R=10 Ω, L=5mH)	4.17 3.97	312.6V	31.26A
RL Load (R=20 Ω, L=5mH)	4.11 4.05	314.2V	15.71A
RLE Load (R=20 Ω, L=5mH and E= -100V)	4.11 3.08	313.7V	20.69A

6.2 3- Phase Voltage Source Inverter (VSI)

Figure 14 shows the simulation results of the 3-phase VSI. From this figure, we may conclude that the waveform of the output voltage at the output of the three-phase VSI (Voltage Source Inverter) is a unit of a multi-output hybrid converter with a maximum value of 462 Volts. It is a 3-phase balanced AC supply with a 50Hz Fundamental frequency from 60V DC input Voltage.

The THD analysis of output voltage from the output of one of the units of a multi-output converter, i.e., the output of 3-phase VSI, is 4.41%, and its fundamental value is 83.53 when the Max computation for THD Computation is the same as the Max Frequency.

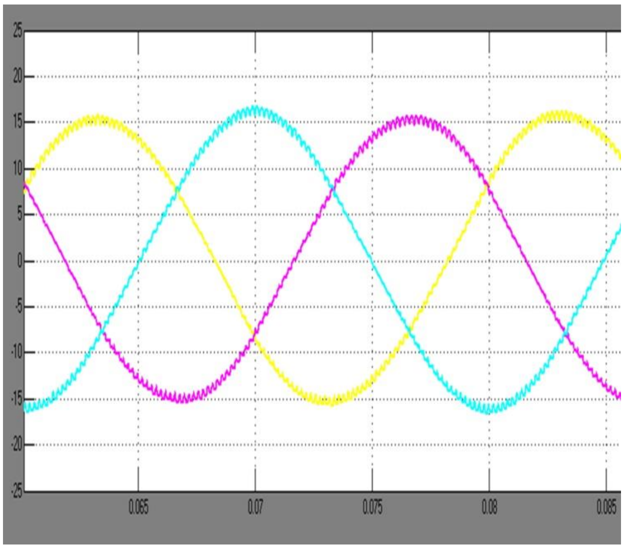

Figure 14. Waveform of Output voltage and Current at the output of Multi-Output Converter.

The THD of the average output voltage from 3-phase VSI is 2.67%, and its fundamental value is 1.583, which is shown in Figure 15. For the analysis purpose, a resistive load of R=10Ω balanced 3-phase Star-connected load is taken. We may also analyze the results by considering various operating conditions like RL and RLE loads.

6.3 Single-Phase Voltage Source Inverter (VSI)

Figure 16 shows the simulation results of 1-phase VSI. From that, we may say that the output voltage is sinusoidal, having a peak value of 182 Volts with an input DC value of 60 Volts. A multi-output hybrid converter is given in Figure 11, and for 1-phase VSI, a Boost DC converter is shown in Figure 12.

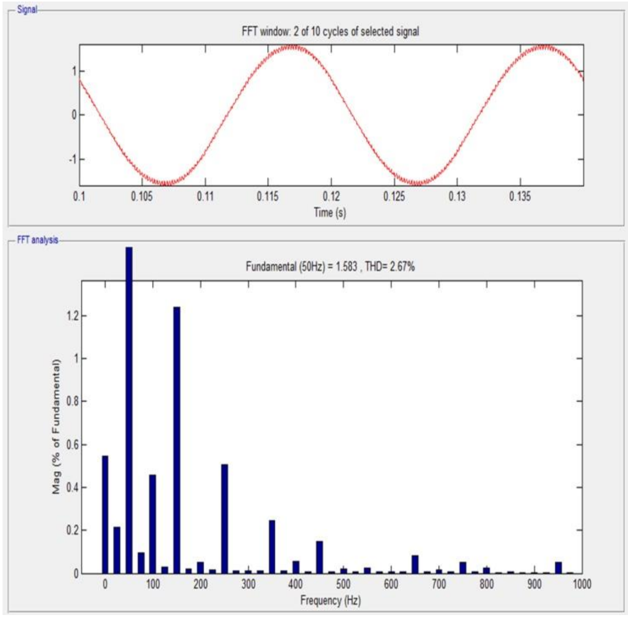

Figure 15. THD analysis of output of Three Phase VSI.

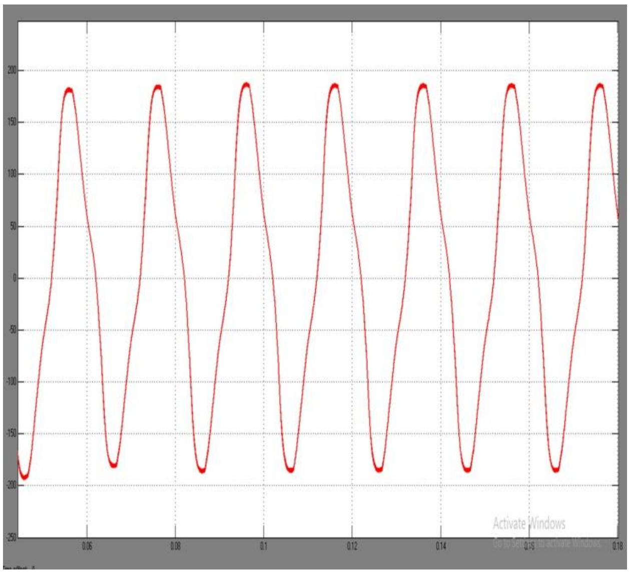

Figure 16. Output of 1-phase VSI.

Figure 17 shows that the 1-phase AC voltage's THD value is 14.67 %, and its fundamental value at 50 Hz fundamental frequency is 175.1 Volts.

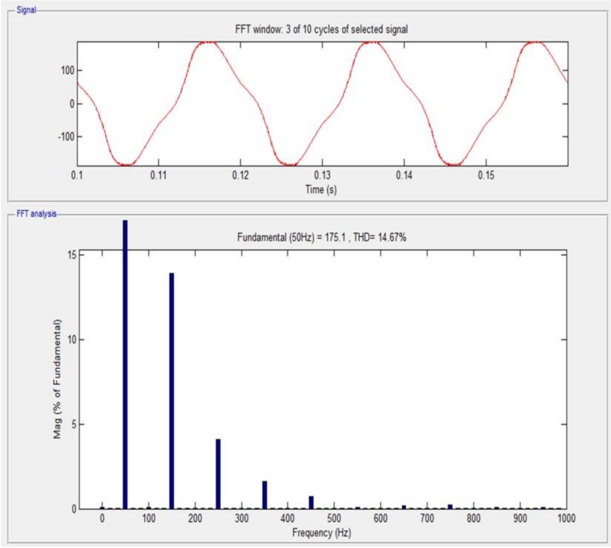

Figure 17. THD View of 1-phase VSI output voltage.

7. CONCLUSIONS AND FUTURE SCOPE

In this paper, we proposed a multi-output hybrid converter that is used to give regulated boost DC, 1-phase AC, and 3-phase AC from a single low-voltage DC supply; from the discussion, we concluded that at different operating conditions of the DC output, we are able to maintain the constant pulsating Boost DC voltage. From 60 volts DC input voltage, we are able to generate almost 315 volts DC from a switched impedance Boost DC converter, and upon applying a 1-phase and 3-phase inverter at the output of the converter, we are able to find the 3-phase AC and 1-phase AC at the different outputs, channels of the multi-output hybrid converter. Hence, we may conclude that from a single unit, we may be able to generate all supply voltage required for the proper functioning of domestic and industrial applications without using any extra converter.

The future scope of this work is to analyze the given work in parallel mode and again at various operating conditions for the 3-phase and 1-phase outputs.

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