# Elimination of harmonic in a single phase dc-ac converter without filter

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*Abstract* - **In this project, we provide the simple, effective and improvised Sine-wave modulated High step-up converter, so that the output capacitor's voltage is reduced when the inverter swaps output polarity. The main aim of the paper, High steps up gain without operating extreme the duty cycle and Also reduce the current stress and input current ripples, Improving the harmonic content in the output and reduce the harmonic distortion caused by the source to the load, the synchronized grid and the combination of the elements in the system without output filter. A prototype converter is created with both the High step-up converter and the inverter is controlled by the single DSP processor. Experimental results demonstrated to achieve the quality power from the converter, without addition of any new hardware.**

## 1. INTRODUCTON

### 1.1 OUTLINE OF PROJECT

The fast development of renewable energy generation requires efficient, cheap and robust converters that connected to the grid, without bringing down the quality of supply to the consumer. Most of the renewable sources provide DC supply, and then it needed an inverter for proper interfacing to the grid. Some of the renewable energy source is generating low AC voltage such as domestic wind turbine, solar panel or fuel cell, they are required boost converter or/and isolated transformer to produce an appropriate voltage level. The most common types of inverters are sinusoidal pulse width modulation full bridge inverter, these inverters are simple in design and provide the robust control, but to reduce the harmonic content in output needs low pass filters to get standard output.

The main disadvantages of this system have increased in size and cost due to the filters and switching losses in the inverter and converter operation. Several PWM methods can be developed to reduce the harmonic content. Selective harmonics solve the transcendental equation characterizing harmonics, so that the specific switching angle to be done to reduce the selective harmonic content. Theoretically, these methods can provide the standard elimination of harmonics, the results of these equations are computationally intensive, this method is rather difficult in online. In small-scale application, the powerful digital signal processors (DSP) are not used mainly due to the higher price, either switching angles are calculated in offline or an approximation solution is to find where the topology to allow it.

Other methods having modification of a carrier signal and reference signal. This all methods are open loop control, which puts on the constant DC voltage, this method ignores the harmonic content in the grid and caused by the load distortion. The main object of this method to reduce harmonic content created by the PWM itself. Rather than improving harmonic content at the terminal bus, this is regarded by the PWM only partially.

The sin-wave modulated buck-boost cascades with the polarity changing inverter are used. In this method the simulation output is showing that this topology works exceptionally well, produces the AC sine wave output which depends upon the reference sine-wave amplitude and it also achieves the low THD value. While providing the constant DC voltage supply, causing the role of filter redundant. Furthermore, reducing the switching loss practically due to switching in the High step-up converter and also there is no need of large and expensive electrolytic capacitors in the DC bus. It requires low inertia at the common bus of the two converters, so low capacity; thin film and long life capacitor are efficient.

The primary drawbacks of previous modulation methods are. First, the voltage is usually not zero when the inverter swap polarity, low order harmonics are created and THD is comprised. Second, When the DC source is inductive like a wind turbine generator, the yield of the SWM Buck-Boost converter is not an optimal rectified Sine wave. In this case the output waveform is shifted higher than to $90^o$

CHAPTER 2

### 2.1 DC-DC CONVERTER

DC-DC converters are widely used in regulated switch mode DC power supplies and in DC motor drive applications. Often the input to these converters is an unregulated DC voltage, which is obtained by rectifying the line voltage and therefore it will fluctuate due to change in the line voltage magnitude.DC converters can be used as switching mode DC regulators to convert an unregulated DC voltage into regulated DC output voltage. This voltage regulation is achieved by Pulse Width Modulation (PWM) technique and the switching device is normally a BJT, a MOSFET or an IGBT.

2.2 TYPES OF CONVERTERS

There are many different types of DC-DC converter, each of which tends to be more suitable for individual application. They are,

- Non-Isolating converters
  a. Buck converter
  b. Boost converter
  c. Buck-Boost converter
  d. Cuk converter
- Isolating converters
  a. Fly back converter
  b. Forward converter

2.3 ISOLATED DC-DC CONVERTERS

In many DC-DC applications, multiple outputs are required and output isolation may need to be implemented depending on the application. In addition, input to output isolation may be required to meet safety standards and / or provide impedance matching. The above discussed DC-DC topologies can be adapted to provide isolation between input and output.

2.3.1. Fly back converter

The Fly back converter can be developed as an extension of the Buck-Boost converter. Fig 2.3(a) shows the basic converter; Fig 2.3(b) replaces the inductor by a transformer. The buck-boost converter works by storing energy in the inductor during the ON phase and releasing it to the output during the OFF phase. With the transformer the energy storage is in the magnetization of the transformer core. To increase the stored energy a gapped core is often used.In Fig 2.3(c) the isolated output is clarified by removal of the common reference of the input and output circuits.

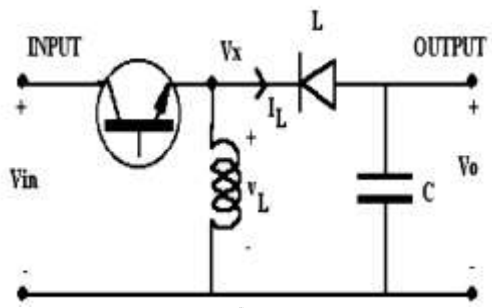



Fig.2.3 (a) Buck-Boost Converter

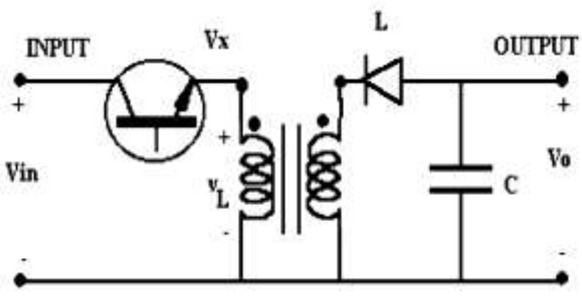



Fig.3.11 (b) Replacing inductor by transformer

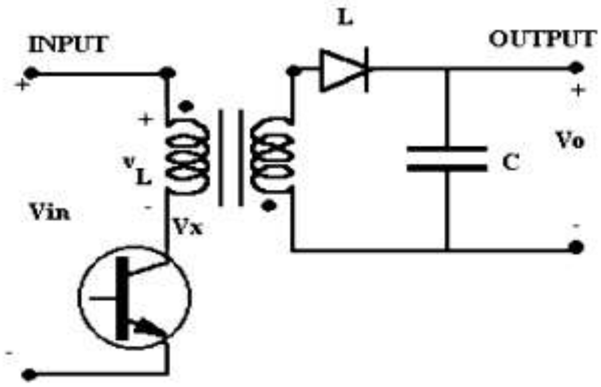



Fig.3.11(c) Fly back converter re-configured

### 2.3.2. Forward converter

The concept behind the forward converter is that of the ideal transformer converting the input AC voltage to an isolated secondary output voltage. For the circuit in Fig. 2.3 (a), when the transistor is ON, Vin appears across the primary and then generates.

$$Vx = \frac{N_1}{N_2} Vin \quad \text{------------------------ (1)}$$

The diode D1 on the secondary ensures that only positive voltages are applied to the output circuit while D2 provides a circulating path for inductor current if the transformer voltage is zero or negative.

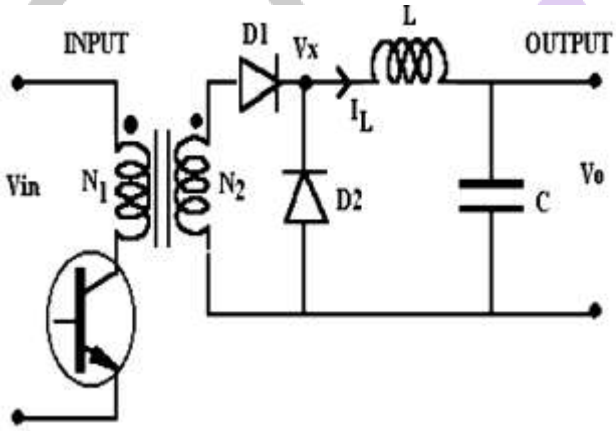



Fig. 2.3.2 (a) Forward Converter

The problem with the operation of the circuit in Fig.2.3.2 (a) is that only positive voltage is applied across the core, thus flux can only increase with the application of the supply. The flux will increase until the core saturates when the magnetizing current increases significantly and circuit failure occurs. The transformer can only sustain operation when there is no significant DC component to the input voltage. While the switch is ON there is positive voltage across the core and the flux increases. When the switch turns OFF We need to supply negative voltage to reset the core flux. The circuit in Fig.2.3.2(b) shows a tertiary winding with a diode connection to permit reverse current. Note that the "dot" convention for the tertiary winding is opposite those of the other windings. When the switch turns OFF current was flowing in a "dot" terminal. The core inductance act to continue current in a dotted terminal, thus

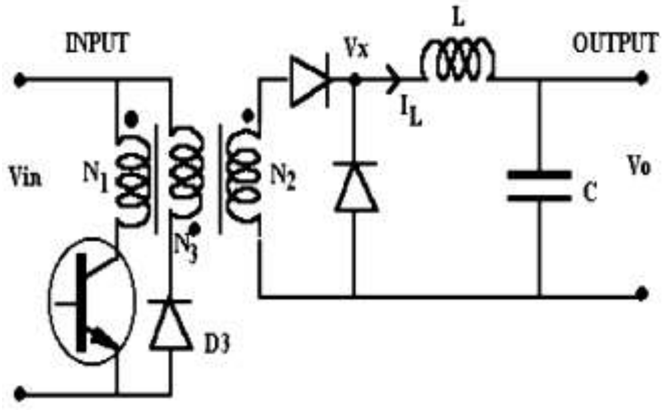



Fig. 2.3.2 (b): Forward converter with tertiary winding

## CHAPTER 3 HIGH STEP UP CONVERTER

### 3.1 INTRODUCTION

The DC-AC conversion circuit is used in this study, the High Step-up converter is coupled to voltage changing polarity inverter. The High step-up converter continuously produces the rectified output voltage Vdc, out with double frequency f of the output. The full bridge inverter is swapped the voltage polarity when the DC voltage is ideally zero. In real time the DC voltage attains zero only under a specific heavy load and low frequency in the AC side. The Buck-Boost converter is not used for high voltage range appliance, and complicated conversion method. So, the high step up converter is used besides of the Buck-boost converter, its main advantage is High step up gain in the output voltages and increasing the efficiency level above 95%, reducing the current stress and input current ripple. Therefore, generally the polarity changing inverter swaps at the voltage drops at the minimum Vdc, Min and not a ideally zero. In Reality, the voltage is continuously monitoring the Vdc,out and provides the minimum voltages Vdc,min.

### 3.2 PROPOSED CIRCUIT DIAGRAM AND WORKING

The proposed High step up converters with the voltage multiplier module cascade with full bridge inverter is shown in fig. 4.1(a). The voltage multiplier module contains of two paired inductors and two polarity changing capacitors and is connected between conventional boost converters to form a modified boost, fly-back, forward inverter structure. When the switched turn off by turn, the phase switch is turned ON state acts as a Fly back converter, the other phase switch is turned ON state acts as a Forward converter. Primary windings of the paired inductors with Np turns are used to decrease input current ripple, and the secondary winding of the paired inductors with NS turns are connected in series to increase the voltage gain in output. The equivalent circuit for the purpose converter as shown in the fig.4.1 (b). Where the $L_{m1}$, $L_{m2}$ and $L_{k1}$, $L_{k2}$ are respectively the magnetizing inductors, and leakage inductors in the secondary winding. $S_1$ and $S_2$ is the power switch, $C_{c1}$ and $C_{c2}$ ate the switching capacitors and $D_{c1}$ and $D_{c2}$ are represented as a clamp diode. $D_{b1}$, $D_{b2}$ and $D_{f1}$, $D_{f2}$ are the output diodes for the Boost and Fly back forward converter operations. The steady waveform of the high step-up converter is shown in the fig 4.1(c)

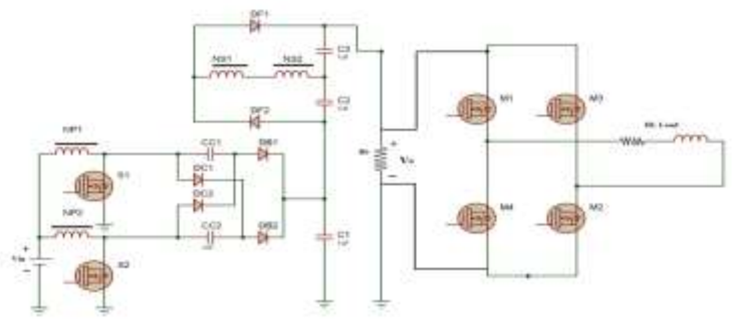


Fig.3.2 (a) High step up converter cascade with full bridge inverter

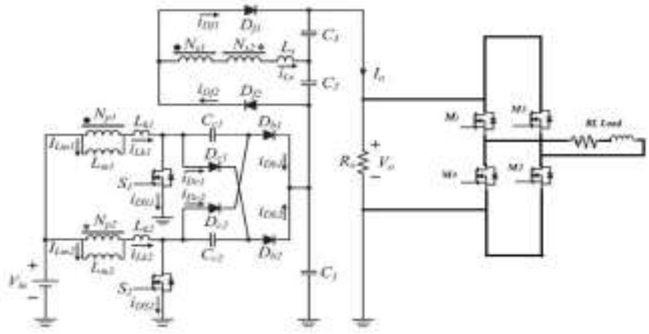


Fig.3.2 (b) Equivalent circuit for High step up

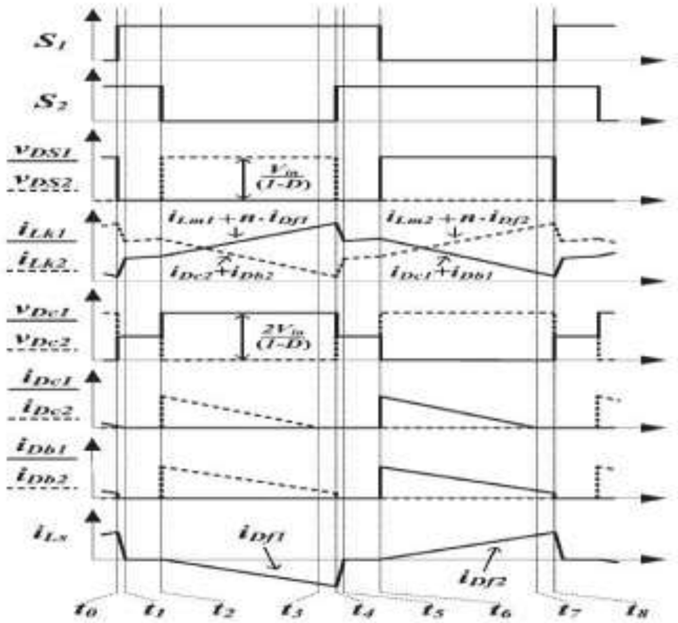



Fig.3.2 (c) Steady waveform of the high step-up converter

### 3.3 MODE OF OPERATIONS

The Proposed converter contains six modes of operations,

Mode I [t1, t2]: At t=t1, the switch $S_1$ is turned ON, when the power switch $S_2$ is in ON state period, All the diodes are getting reverse biased. Both the leakage inductance $L_{k1}$and $L_{k2}$ is increased gradually due to the input voltage $V_{in}$ shown in the fig. 3.3(a)

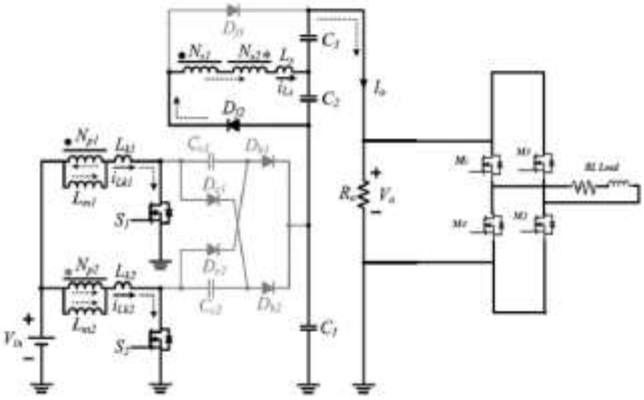


Fig 3.3 (a) Mode I

Mode II [t2, t3]: At t=t2, the power witch $S_1$ still remains in ON state and switch $S_2$ is starting to turn OFF. By turning ON the diodes $D_2$ and $D_4$. The energy stored in the magnetizing inductor Lm2 is distributed to the secondary side, it charges the capacitor $C_3$.The input source voltage, magnetizing inductor $L_{m2}$, leakage inductor $L_{k2,}$ and voltage-lift capacitor $C_b$ transferred the energy to the capacitor c1 through diode $D_2$, by it extending the voltage on $C_1$ shown in the fig.3.3(b).

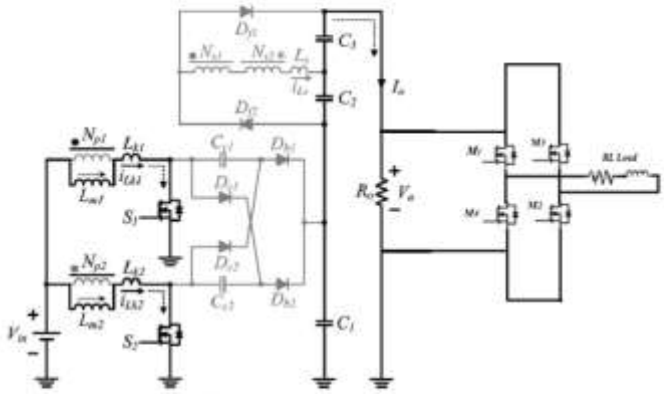


Fig. 3.3(b) Mode II

Mode III [t3, t4]: At t=t3, The $i_{Dc2}$ current is inherently decreasing to zero due to the magnetizing current transferring and the diode recovery and conduction losses is less. Both the power switch and all the diodes are same as the previous mode expect the clamp diode shown in the fig.3.3(c).

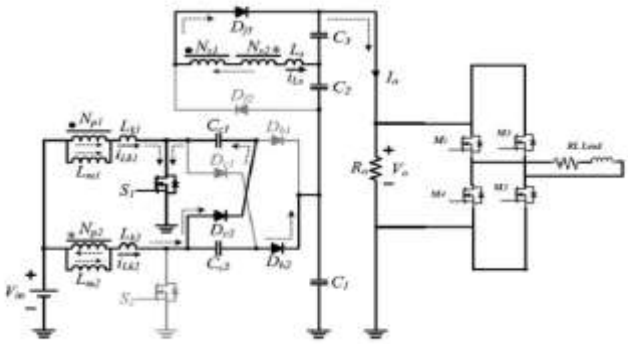


Fig. 3.3 (c) Mode III

Mode IV [t4, t5]:At t=t4, by turning ON theower switch $S_2$ and the switch $S_1$ is still in ON state. These diodes $D_{c1}$, $D_{c2}$, $D_{b1}$, $D_{b2}$ and $D_{f2}$ are reverse biased. The series leakage inductors $L_s$ distributed the stored energy to the output terminal through the fly back-forward-diode $D_{f1}$ shown in the fig.3.3 (d).

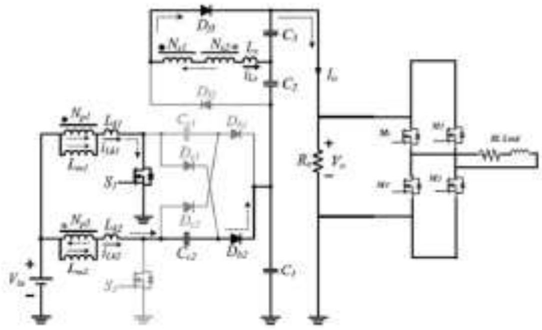


Fig.3.3(d) Mode IV

Mode V [t5, t6]: At t=t5, both the power switches are remains ON state, all the diodes are reverse biased and the leakage inductors $L_{k1}$ and $L_{k2}$ are gradually increased due to the Input voltage $V_{in}$ shown in the fig.3.3(e).

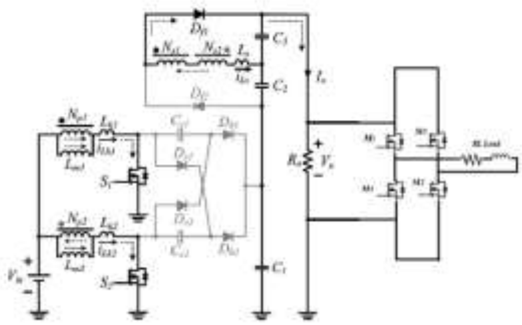


Fig. 3.3 (e) Mode V

Mode VI [t6, t7]: At t=t6, the power switch S2 still remains in ON state and the power switch S1 is starting to turn OFF. The Dc2, Db2, and Df1 diodes are reverse biased. The Lm2 magnetizing inductor transfers the energy to the secondary side, the leakage inductor flows to the output capacitor C2 through fly back diode Df2. The input source voltage (Vin) , leakage and magnetizing inductors(Lk1,Lm1), clamp capacitor (Cc2) are transferring the energy to the output terminal , thus Vc1 getting the doubles input voltage shown in the fig.3.3 (f).

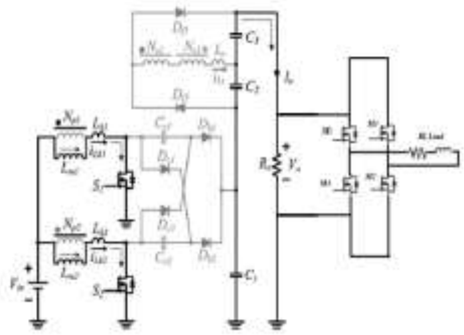


Fig.3.3(f) Mode VI

Mode VII [t7, t8]: At t=t7, The $i_{Dc2}$ current is inherently decreasing to zero due to the magnetizing current released and the diode recovery and conduction losses is less. Both the power switch and all the diodes are same as the previous mode expect the clamp diode shown in the fig.4.2 (g).

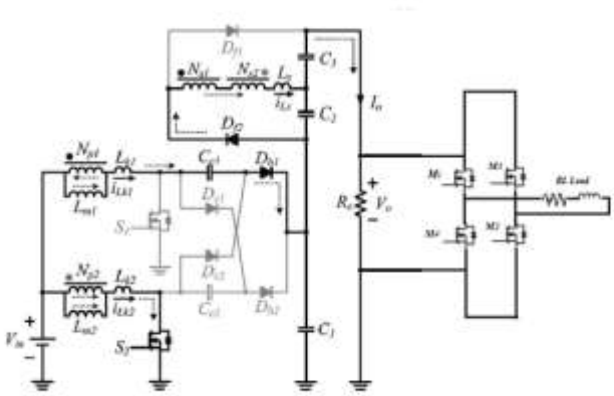


Fig.3.3(g) Mode VII

**CHAPTER 4 SIMULATION**

SIMULATION RESULTS

**4.1Existing system operation**

In the sine-wave modulated buck–boost (DC-DC) converter connected in series with a full bridge inverter producing an AC sine-wave output. Specific harmonic can be reduced depends upon by the application. In this model output is low due to buck boost converter and inverter operations.

**4.1.1Existing simulation diagram**

An experimental existing model is constructed in the MATLAB simulink model in fig .4.1 (a) in order to analyze the theoretical model. The output voltage and current waveform for existing model is shown in fig 4.1 (b) and 4.1 (c).

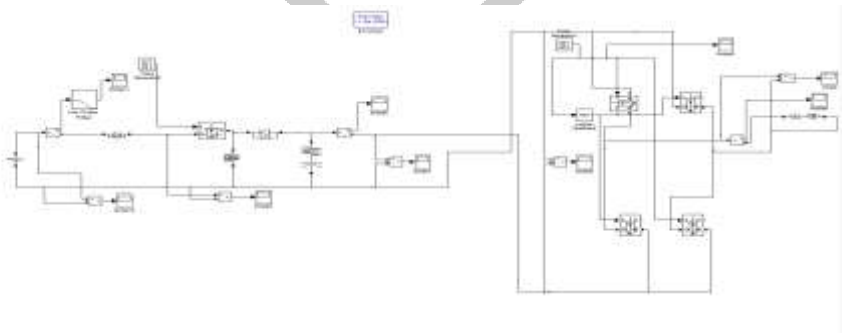
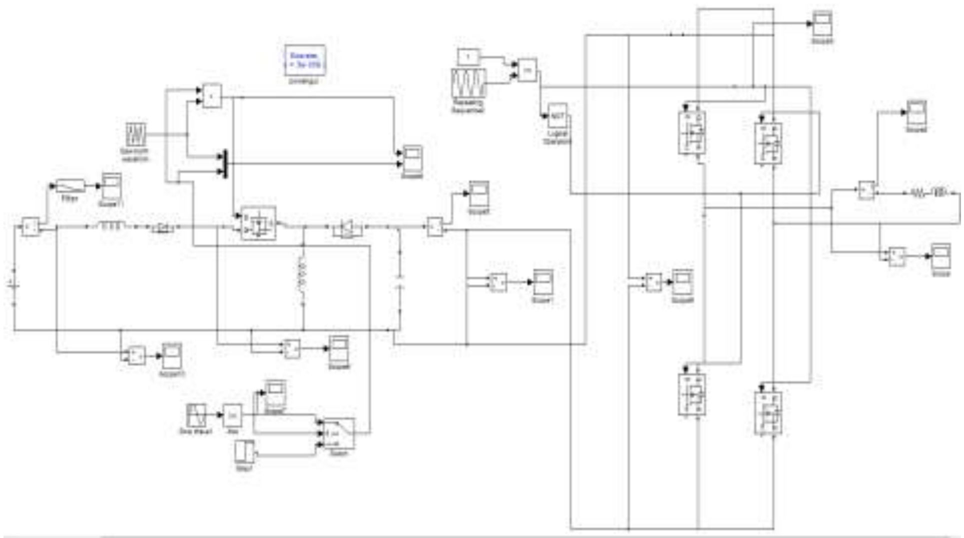


Fig.4.1 (a) Simulation diagram for existing model

**4.1.2.Proposed simulation diagram**

An experimental proposed model is constructed in the MATLAB simulink model in fig 4.1(a) in order to analyze the theoretical model. A proposed converter prototype element is show in the fig.4.1 (b)



A dc source supplying three voltage levels (30v, 60v and 90v). The renewable energy source supply the different voltage levels, the load must be purely resistive or inductive. So, that the THD is improvements is needed this can be done by the proposed method as well as increasing the output voltage.

The output voltage and current waveform High step up converter cascade with full bridge inverter without output filter shown in the fig.5.2 (c) and 5.3 (d).

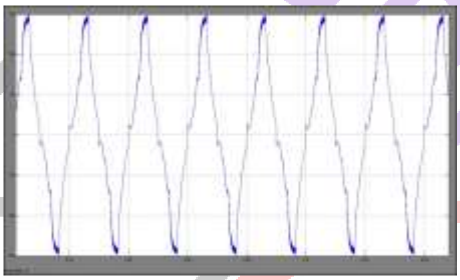


Fig. 4.1(b) Output voltage waveform

**CHAPTER – 5 HARDWARE BLOCK DESCRIPTION**

5.1 Dual regulated power supply

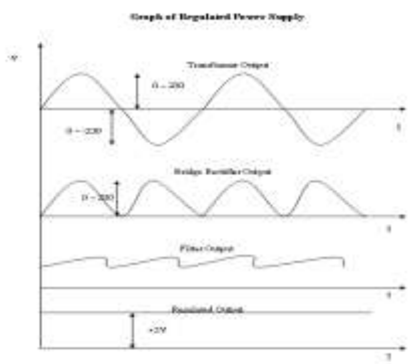
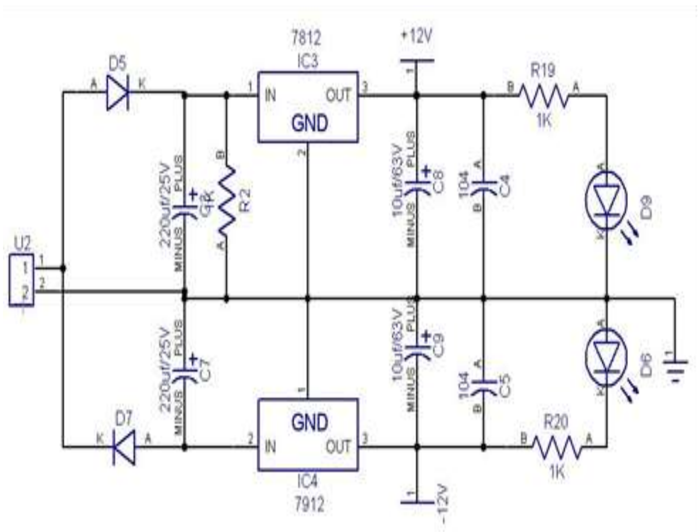


Fig. 5.1.(a) Circuit Diagram Of Dual Regulated Power Supply




This is the circuit diagram for the dual voltage regulator power supply. That can be designed by two fixed voltage regulator that is 7812&7912.the 7812 is positive regulation, 7912 is the negative regulation is shown in the fig.6.2 (a) and the graph is shown in the fig.6.2 (b)

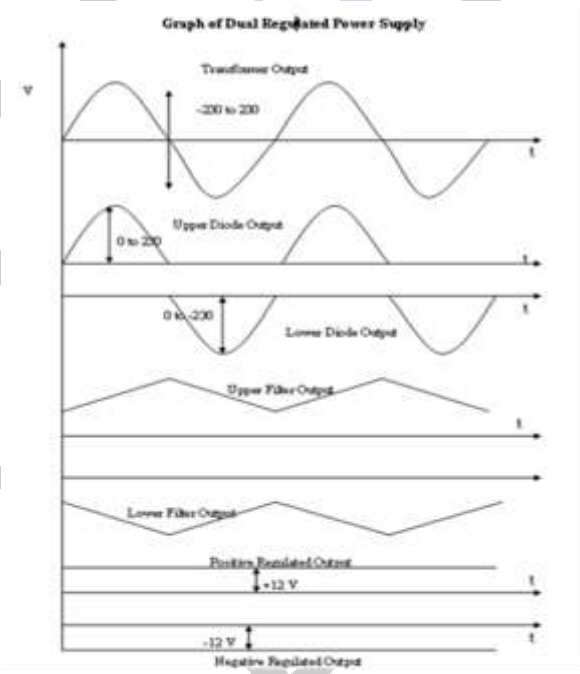
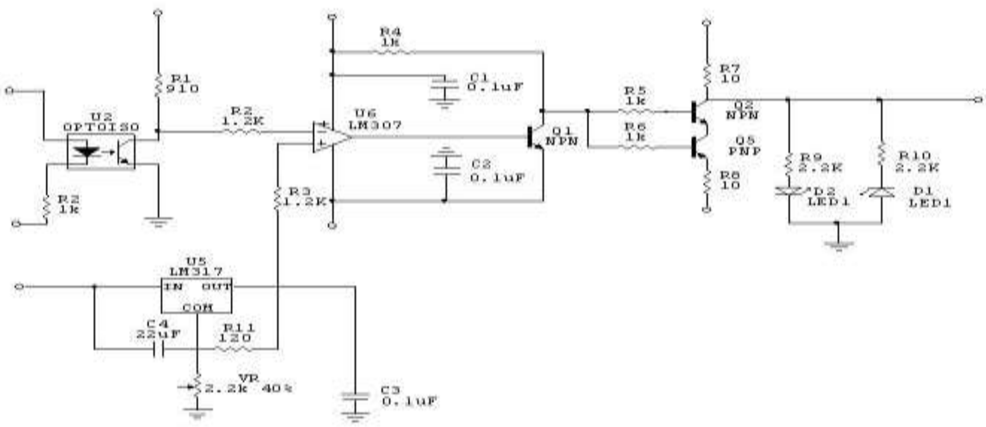



Fig.5.1 (b) Graph of Dual Regulated Power Supply



### 5.2 OPTO ISOLATION CIRCUIT

**5.2.1 Introduction** Since the MODFET's used to switch the capacitor voltage into the supply line there will be switching transients produced by them. These switching transients in turn will affect the pulses developed by the dsPIC30F2010 and by time the micro controller itself. So in order to protect the microcontroller and the control circuit from power circuit we are providing isolation circuit.

**5.2.2 Description** Once the logical gate signals G1-G4 are available for four MOSFET switches, these have to be isolated before giving to the gate terminals of the switches. An opto-coupler (IC 6N136) is used to provide isolation of logic gate pulse from power circuit is shown in the fig.6.3. Since there are four switches in VSI, therefore four units of opto-couplers are used. However, only three isolated regulated DC voltage supplies are required. Two isolated DC power supplies for upper two switches of the inverter and one isolated power supply for lower two switches as emitter is common for these switches

**5.3.Calculation** A voltage divider referenced to ground is created by connecting two electrical impedances in series, as shown in Figure 1. The input voltage is applied across the series impedances $Z_1$ and $Z_2$ and the output is the voltage across $Z_2$. $Z_1$and $Z_2$ may be composed of any combination of elements such as resistors, inductors and capacitors.

Applying Ohm's Law, the relationship between the input voltage, $V_{in}$, and the output voltage, $V_{out}$, can be found:

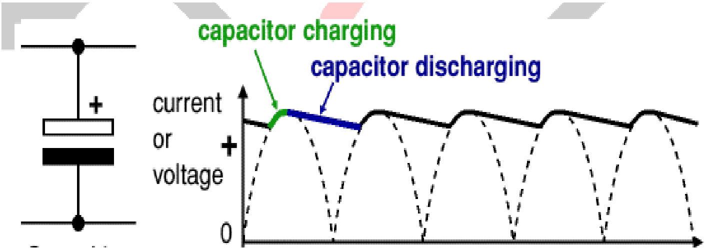
$$V_{\text{out}} = \frac{Z_2}{Z_1 + Z_2} \cdot V_{\text{in}} \qquad (1)$$

$$V_{\text{in}} = I \cdot (Z_1 + Z_2) \qquad (2)$$

$$V_{\text{out}} = I \cdot Z_2 \qquad (3)$$

$$I = \frac{V_{\text{in}}}{Z_1 + Z_2}$$

$$V_{\text{out}} = V_{\text{in}} \cdot \frac{Z_2}{Z_1 + Z_2}$$




:

$$H = \frac{V_{out}}{V_{in}} = \frac{Z_2}{Z_1 + Z_2}$$

In general this transfer function is a complex, rational function of frequency.

### 5.4. BRIDGE RECTIFIER

As shown in fig.6.4 (a) and 6.4(b), a bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier. Smoothing is performed by a large value electrolytic capacitor connected across the DC Supply to act as a reservoir, supplying current to the output when the varying DC Voltage from the rectifier is falling.


Fig.5.4 (a) Bridge rectifier Fig.5.4 (b) Output: FW varying DC smoothing

5.5. MULTI - OUTPUT POWER SUPPLY

As shown in figure 6.5, multi output power supply outputs are +5V, +12V and –12V. Input AC signal is applied to primary of transformer, transformer secondary is two outputs; one is 0-9V AC and another is 18-0-18V. Transformer secondary output is connected to regulator through Full bridge rectifier and filtering capacitor. Diode is used for convert the AC voltage to DC Voltage with AC ripples; capacitor is used for remove the AC ripples. Regulator output is regulating the DC output voltage

Transformer

Primary Voltage = 230V AC

Secondary Voltage = 0-9V AC and 18-0-18V AC

Regulator

IC - 7805 and 7812 = Positive Voltage Regulator (+5v and +12V).

IC - 7812 = Negative Voltage Regulator (-12V)

Diode = 1N4007

Capacitor = 4700µf/16V, 4700µf/25V and 10µf/63V

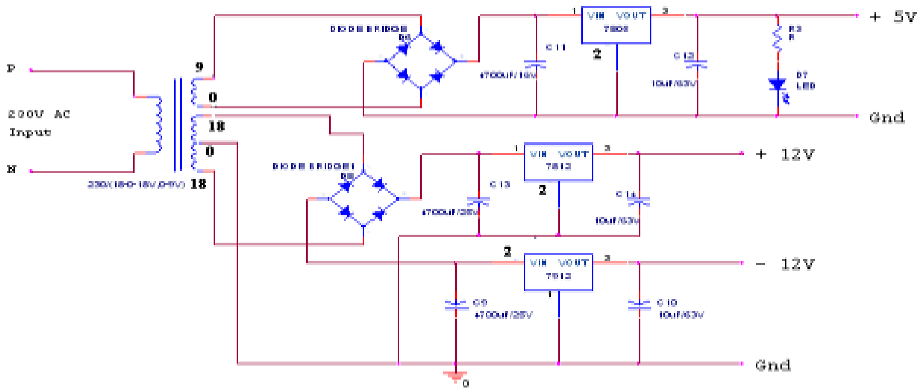



Fig.5.5 Multiple Power Supply (+5V, +12V and –12)

**5.6. DRIVER UNIT**

As shown in fig 5.5, the IR2110 is a high voltage, high speed power MOSFET driver with over-current limiting protection circuitry. Logic inputs are compatible with standard CMOS or LSTTL outputs, down to 2.5V logic. The output driver features a high pulse current buffer stage designed for minimum driver cross-conduction. The protection circuitry detects over-current in the driven power transistor and limits the gate drive voltage. Cycle by cycle shutdown is programmed by an external capacitor which directly controls the time interval between detection of the over-current limiting conditions and latched shutdown. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high or low side configuration which operates up to 500 volts.

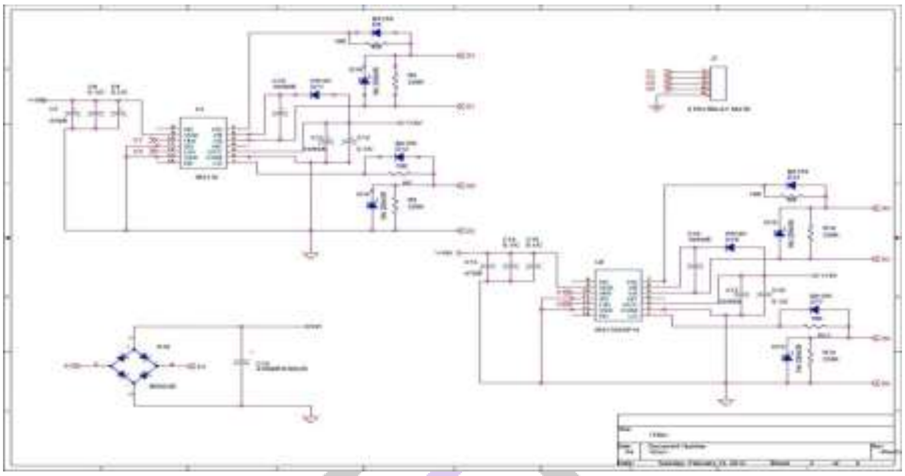


Fig5.5. Driver circuit diagram

### 5.7. HARDWARE RESULT

The hardware results are shown in fig. 1.24, CRO shows the output voltage for high speed step up converter using in DC-AC converter without output filter.

Fig 5.7 Hardware result of the high speed step up converter in DC-AC converter

### CONCLUSION

Here, we have presented a modulation method for the reduction of harmonics at the connection point of a dc–ac converter. High step up AC-DC converter in series with a changing polarity inverter. Specific harmonics can be canceled, if this is required by the application. A prototype was built and the experimental results demonstrate the improvement of THD, through the cancellation of low-order harmonics, so that the output voltage complies with the limit imposed by the standards, without the use of a filter. The method makes no distinction whether harmonics are created from the converter itself or they are supplied by other sources to the connection point. Therefore, further research could lead to the creation of a grid-connected dc–ac converter with harmonic cancellation capabilities, without changing the hardware.

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