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An Efficient Approach to Design Switch Mode Power Supply for LED Lamp

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ABSTRACT

This paper presents the multistage switch mode power supply for LED lamp with output power of 98W and possesses 95 % efficiency. Proposed scheme for switch mode power supply has designed using forward converter satureable transformer. In this topology three stages are used to optimize the power, first stage is AC to DC rectification, second is DC to DC conversion in which forward converter has used to step down the voltage at specific level. This converter operates in the 36 KHz frequency which allows to reduce the size of passive elements i.e. capacitors, transformers and inductors, and third stage is filtration. Half wave rectifier is connected at the secondary side of the transformer. The half wave rectifier provides dc output, which is directly connected to the string of LEDs, and desired voltages are obtained across LED lamp. All the dynamics in these stages are in the form of closed loop to implement a suitable controller in LABVIEW. The overall topology is controlled by using PID controller. The converter regulates the current of LEDs by using constant current feedback circuit. As LEDs current is nonlinear so we must have to regulate current rather than voltage. Proposed scheme does not need any input voltage feedback or input current sensing devices. THD in voltage has been reduced to 2% at main AC lines and overall efficiency of proposed scheme is 95%. PCB layout of proposed scheme and experimental simulations has been done on NI MULTISIM.

INTRODUCTION

Switch mode power supplies for LED lamps provide large amount of power to LEDs either it can be connected in series or parallel configuration. These power supplies use feedback of current controller .This attention is colossal. Now a days power conversion has focused by following objectives like good efficiency, higher power density, low voltage and maximum current .All these objectives create various criteria for managing power control and circulation [1].

AC to DC Bridge converters can work around unity power factor without using DC link capacitors .such types of circuits has serious drawbacks of overshoots and influence of ringing on capacitor .These types of converters involve extra circuitry to improve well performance [2].Fig 1 shows AC to DC bridge converter .

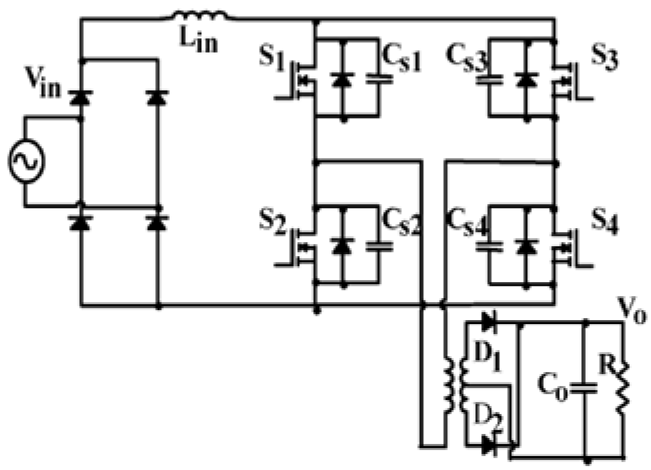

FIG 1: AC TO DC BRIDGE CONVERTER

For High intensity discharge lamps Reduced constituent number electronic ballast has implemented ,dc to dc buck converter has used to regulate the current of lamp ,and boost converter is use for power factor correction and it is working in discontinuous conduction mode .Inverter is integrated with boost converter and rectifier ,that works with a line frequency ,signals are given by micro controller .This ballast has derived for lamp of 70W .Total harmonic distortion is 22% and 84% efficiency has achieved. Low frequency electronic ballast prevents acoustic reverberation, number of capacitors and inductors are same, but the cascaded connections of converters reduce the efficiency of overall system. In semiconductor devices differences can be find due to these factors cost can be rise ,reliability can be reduces ,number of components can increases .If we design three stage ballast system ,it consists of six switches and six diodes ,in contrast one stage ballast contains four switches and two diodes [12]. Igniter circuit for HID lamps is driven from a inverter having dual frequency .This igniter has designed by using voltage doubler circuit, that is drive by an inverter have frequency of $1-10\text{KHz}$.Microcontroller is used to generate PWM, lamp status, and detects ignition too. All these parameters have tested on 35W lamp HID lamps have high light intensity than fluorescent lamps. As we know efficiency plays an important role in lighting applications that reduces consumption of power and increases reliability, power output. A high power factor fly back converter has designed for HID lamps in which for reducing effects of electromagnetic interference, EMI filter is added and PF has improved to 0.998 in this methodology [15].An electronic ballast for 75W lamp has implemented, in this topology fly back converter has used that is operating in CCM (critical conduction mode) .LEDs string is connected at secondary side of the transformer In this proposed scheme no current or voltage sensing devices are used ,we can get higher power .Efficiency and others results are also discussed in [27]. For dc to ac electric power supplies which are used in LEDs lamps have two techniques for dropping the storing capacitance, so for obtaining good electric power supply's life time we can replace electrolytic capacitor by film capacitors. The technique for finding the storage capacitance to ensure that boost PFC will operate in normal way, so for this purpose range of input voltage has also discussed. For further reduction in value of storage capacitance, technique of third harmonic injection is presented here. Lamp of 40W have derived using 50KHz frequency ,basically in this topology cascaded connection of fly back converter and frequency converter that is known as push pull converter is used. It works in three modes .Main disadvantage of this topology is high stress of current and voltage on main switch, which can reduce its efficiency. And for driving small power of lamp there is high requirement of frequency that is not good. Circuit diagram for electronic ballast is shown in figure [19].

In LCD TVs, for design of electronic ballast, SMPS is normally use, this topology uses the ZVS method, while works in eight modes .but due to some restrictions it is not efficient because ZVS method is very slow [3]. For mercury vapor lamps, two stages are employed in the design of electronic ballast, in which first phase is power factor correction phase which is done by boost converter and second phase is inverter, Boost converter is working in DCM mode that is called as discontinuous conduction mode, inverter is essentially use to permit the ballasting for lamp. Main resolution of inverter is to give essential protection in contradiction of short circuit, it also defend the lamp against damaged circumstances [4]. Power factor correction method is use to stabilize the voltage at input, because some deviations happen due to ignition of lamp and some additional amount of voltage is needed for it [5]. In LED lighting we know that current is differ so we need to control the current in LED .For this purpose we use persistent current controller for regulation of brightness and current .A fly back converter topology is use for luminance of LED lamp, current of this lamp is under variations of voltage [6].If we use multiple lamps in a string then we need to control the brightness and current of these lamps, proposed electronic ballast is described with details in [7].

Another methodology for implementation of electronic ballast for fluorescent lamp contains boost converter and fly back converter. Boost converter is use for PFC and maximum power factor can be accomplish by using fly back converter .Basically fly back converter is appropriate for low power applications [8]..Normally fly back converter is use in supplies, an electronic ballast for lamp is design in [9].Both these converters operate in discontinuous conduction mode .Disadvantage of discontinuous mode is that value of RMS voltage is higher rather than continuous conduction mode.

Design of electronic ballast for universal power supplies is presented in [10]. Which is also based upon fly back converter Another Fly back converter scheme is presented .Electronic ballast has extensive applications, from past years UV water treatment is using, for increasing better water eminence and health awareness this management system has used now [11].

LEDs are more compact and have proficiency to change the color in a real time, less dissipative, most robust .which can be used in many applications i.e. home purposes, industrial environments and commercial purposes. Although its requirements is precision in current control, long life span, and higher power factor ,all these trials would be consider in scheme of LEDs ballast circuit[12].

PROPOSED SCHEME

Proposed scheme is based upon Multistage switched mode power supply by using PID controller that is use to control the circuitry. An AC signal of 220V with 50 Hz has applied to full bridge rectifier .when positive AC cycle comes diodes D2 and D4 begin to conduct, and other two diodes D1 and D3 are OFF, similarly in negative cycle D1 and D3 are forward biased both these diodes start to conducts and remaining two diodes are OFF. Then we get DC output but output achieved by full wave rectifier is not pure DC .Some ripples are present in it .A capacitor has connected at its output to remove ripples. This capacitor is using as low pass filter that passes low frequencies and stops the higher frequencies. DC output has employed to transformer of forward converter, that is made up of ferrite core have two coils primary and secondary, third winding is introduced with diode in series with primary winding that is known as tertiary coil. Tertiary winding has used in place of snubber because snubber circuit dissipates high energy that leads to reduce the efficiency of overall system .so proposed power supply for LEDs lamp consists of rectifier. Duty cycle of this forward converter can increase from 50% it can be used under extensive ranges of input, and this tertiary winding decreases the effect of EMI. When the switch S is turn ON, current of transformer increases and diode D5 does not conduct due to reverse biased magnetizing current of transformer will be

$$i_M = \frac{v_{in} \times t_{on}}{L_M} \qquad (1)$$

In the above expression T_{On} is on time and L_M is mutual inductance. In the period of switching current will flow in primary winding that is equal to

$$i_P = \frac{i_o \times n_S}{n_P} \qquad (2)$$

Voltage across load will be

$$v_o = \frac{v_{in} \times D \times n_S}{n_P} \qquad (3)$$

When switch S is turned OFF, voltage of transformer reverses, and voltage of D3 starts to rise until it is ON. Now magnetizing current of transformer decays to zero. Transformer becomes reset and voltage remains zero until next switching period starts. This converter works in CCM mode because inductor current is continues due to freewheeling diode .Output of converter is not pure dc .LC filter has linked to eliminate the ripples and harmonics. An array of LEDs is connected to rectifier and 14V has appeared and current is 7A .and power of LED lamp is 98W.PID controller is used as a feedback controller. Block diagram of proposed SMPS is shown in fig 2.

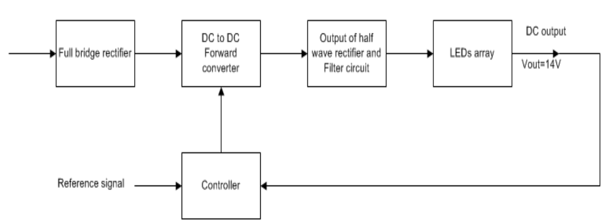

FIG 2: BLOCK DIAGRAM OF SMPS FOR LEDS LAMP

WORKING PRINCIPLE OF SMPS

A. INPUT STAGE OF RECTIFIER

When AC input is converted into DC then rectifier is require if input is DC then it is not necessary to use rectifier, because rectifier is use to alter the AC to DC. If AC input seems by nature then first stage is to transform AC into DC This procedure is called rectification .Unregulated DC output is produced by rectifier so this unregulated DC output is directed to filter for minimal value. The design of switch mode power supply with AC input can be apply for DC output. This type of use can show to be disapproving impacts for rectification period and in full load condition this type of arrangement would use half semiconductor diodes in AC to DC rectifier .Finally, it may cause to warmness of components, and can lead to precocious failure of electrical components, For power factor correction technique, designer must have to apply specific control strategies for sinusoidal input voltages.

B. OUTPUT STAGE OF RECTIFICATION

If DC voltage is require at output then there is need to rectify that output .Diodes which are used in this scheme are not simple or normal diodes ,these diodes are used at higher frequencies. Therefore, for high voltage we choose fast switching semiconductor diodes. Schottky diodes are usually use in low voltage applications. Although rectified dc output voltage is passed through filter capacitor or inductor for filtering, then final output will be free from ripples.

C. FULL BRIDGE RECTIFIER

In this arrangement basically four diodes are connected in a bridge Its output is same like full wave rectifier .Advantage of this configuration is it does not need any center tapped transformer for isolation that is use to isolate input from output .

D. WHEN THE HALF CYCLE IS POSITIVE

When the positive cycle come diodes D2 and D4 gets forward biased so both diodes start to conduct in series way and D1 and D3 are reversed biased, these diodes are switched OFF

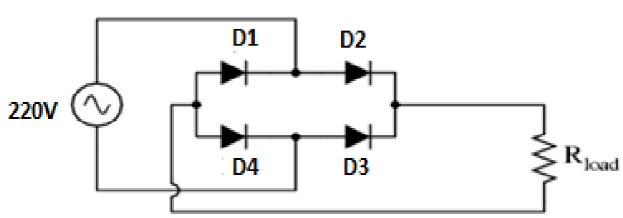

FIGURE 3” CONDUCTION OF D2 AND D4

E. WHEN THE HALF CYCLE IS NEGATIVE

When negative cycle come diodes D1 and D3 star to conduct because both these diodes are forward biased and other two diodes D2 and D4 are reverse biased so both these diodes are switched OFF, and unidirectional current will flow from D1 to D3.Voltage would be also unidirectional across load as shown in figure.

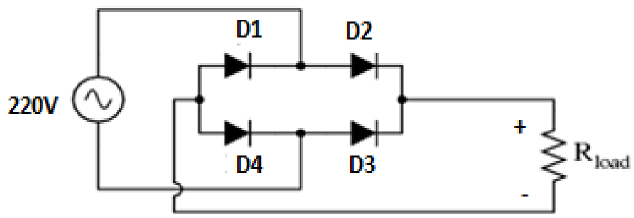

FIGURE 4: CONDUCTION OF D1 AND D3

Average dc voltage will be

$$V_{avg} = 0.637V_{max} \tag{4}$$

Voltage drop in output voltage is 2×0.7=1.4V,if input frequency is 60Hz then output frequency will be 100 Hz because it is the twice of input frequency.

F. THE FILTERING CAPACITOR

The output across load is not pure DC, some ripples exists .Full bridge rectifier gives dc voltage (0.637V_max).If we connect a capacitor across the load, then we can increase DC output voltage and ripples can be remove .basically this capacitor is called smoothing capacitor, that is use to smooth the dc voltage as shown in fig;

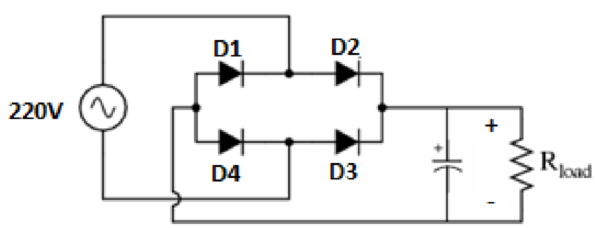

FIG 5: CAPACITOR AS A FILTER IN FULL BRIDGE RECTIFIER

In power supplies basically aluminum is use as a electrolyte in capacitors and its capacitance is 100uF.

Two parameters are very important in smoothing capacitor.

1: Operational voltage

2: Value of capacitance

Operational voltage must be greater than the no load in rectifier and value of capacitance depend upon ripples .if capacitance value is large then ripples would be small if capacitance value is small, ripples will increase. Very small value of capacitance have little effect on output voltage ,if we take large value of capacitance and load current is not large ,then we obtain smooth dc output voltage .Ripple voltage cannot be find out by using capacitor ,but can be designed by using current and frequency.

G. CALCULATION OF RIPPLE VOLTAGE

Formula for calculating ripple voltage can be defined as;

$$v_{ripple} = \frac{i_{load}}{f \times C}, volts \qquad (5)$$

In the above equation i_{load} stands for load current, f is frequency and C is capacitance .Big advantage of use of bridge rectifier is appearance of smaller ripple voltage at output, and frequency of output voltage is twice of input voltage, and in half bridge rectifiers this frequency is equal to input frequency.

The amount of ripple voltage can be decrease by using low pass filter, this type of filter contains capacitor, inductor, and introduce a high impedance path for a ripple component.

BASIC OPERATIONAL WORKING OF FORWARD CONVERTER

Circuit diagram is basically dc to dc forward converter, transformer has added for voltage scaling and isolation, when the switch is closed dc input is applied to primary coil and instantaneously scaled voltage is generated across the secondary winding of transformer .Dot sign shows that both coils have positive polarity. Diode is connected with secondary coil in series .It becomes forward biased and low pass filter is applied.

Dot sign that is declare in primary coil, this primary current enters through that dotted point, similarly current through secondary coil leave out through dotted point. Magnitude of current is inversely proportional to turns ratio of transformer. In case of ideal transformer ampere turns are zero, and in transformer core energy storage is zero .When the switch is OFF then current of primary and secondary winding approaches to zero but current of load and Inductor current is continues. Diode is called as freewheeling diode because it gives freewheeling path for this inductor current. Design of dc to dc forward converter is shown in fig 6.

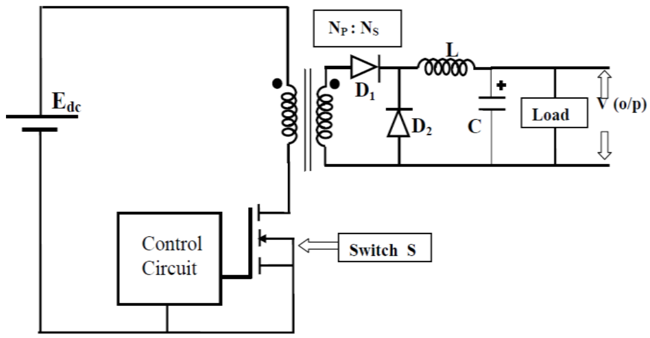

FIG 6; FORWARD CONVERTER

In the freewheeling mode, current of inductor decays, but dc output voltage remain constant due to use of capacitor. This output should be in limit, Switching frequency of switch is 36KHz ,magnitudes of filter capacitor and inductor have selected properly .Both capacitor and inductor dividends the current of load .At steady state dc current in capacitor is zero ,if we want to sustain the constant output then magnitude of inductor and capacitor should be identical but opposite.

For understanding behavior at steady state, operation of circuit has divided in two operational modes; mode 1 and mode 2, when the switch is ON it relates with mode 1, and when the switch is OFF it relates to mode 2.

A. MODE1

In this mode when the switch is closed, it connects with primary side of transformer, then the primary winding as well as secondary winding starts to conduct instantaneously when the switch is turned ON, turns ratio relates to voltage and current of primary and secondary windings.

Fig 7 is basically equivalent model of mode 1. When the switch is closed diode becomes forward biased and current start to flows. Transformer has used to scale input voltage.

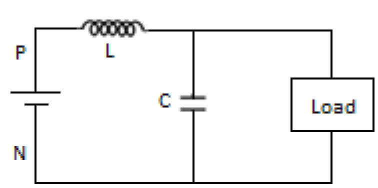

FIG 7: FORWARD CONVERTER IN MODE 1

LC filter circuit is connected and in mode 1, output voltage is equal to $\frac{N_s}{N_p} E_{dc}$.In fig 7 at point P

and N voltage is shown, this is the maximum output dc voltage across a load, so this mode is known as powering mode.

B. Mode2

When the switch is OFF, current decays to zero through primary and secondary winding although current through inductor that is connected to secondary side of transformer remains continues. Diode remains OFF in this mode.

Current of inductor is continues through combination of capacitor and load .There is no flow of power in mode but voltage across load is constant due to capacitor. Inductor and this output capacitor gives voltage continuity .There is no, energy stored in filter capacitor, and inductor dissipates slowly. When switch is ON, that starts the mode 1 and ends the freewheeling mode, that's why mode 2 is known as freewheeling mode.

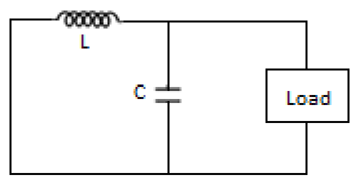

FIG 8: FORWARD CONVERTER IN MODE 2

Most significant feature in designing of filters is switching frequency of converter, by keeping higher frequency it would help in designing small size of filter.

If we use ideal components then there will be no losses ,Fig 9 shows the practical scheme of forward converter .Non idealities seems due to diode, inductors and capacitors ,Main purpose of designing in a circuit design is to attain higher efficiency ,that is equal to $\eta = \frac{P_{out}}{P_{in}}$ Here P_{out}stands for output power and P_{in} stands for input power.some ther non idealities arises due to variations and ripples .Basically input voltage remains constant in ideal circumstances but in practically it diverges due to variation of duty cycle .The transformer which is use in dc to dc forward converter hasleakage inductance and some magnetizing current ,but this leakage inductance of windings is smaller than transformer of fly back converter .In fly back converter some air gap is added in core of transformer ,then leakage inductance increases due to this air gap ,In the transformer of forward converter no air gap is added.

When the both windings conducts instantaneously with opposing polarities then transformer of forward converter works as a normal transformer and magneto motive force generates. When the switch is OFF dotted point of the secondary side of transformer faces the disturbance current, and primary current also disturbed. Practical scheme of circuit do not supports sudden change of flux. By using Lenz's law this sudden change of flux can leads to infinite or higher magnitude of voltage .This voltage have dangerous effects in whole circuitry, so one should avoid from these voltages. When the switch is OFF there should be a suitable route for flow of energy in primary winding. One perseverance is to familiarize a snubber circuit in primary side when the switch will be OFF this snubber circuit would dissipate small amount of energy but disadvantage of this circuit is that it decreases the efficiency of input. Good solution to solve this problem is to introduce tertiary winding with a diode in series configuration with primary winding .When the switch and diode would OFF together current will flow through diode and tertiary coil .Magnetic flux will be produce by any coupled winding. When switch S is OFF by using Lenz's law .This negative voltage increases abruptly due to flow of current through tertiary winding and flux transfers from primary winding to tertiary winding, so there should be a good coupling between both windings .Tertiary and primary windings are wounded.

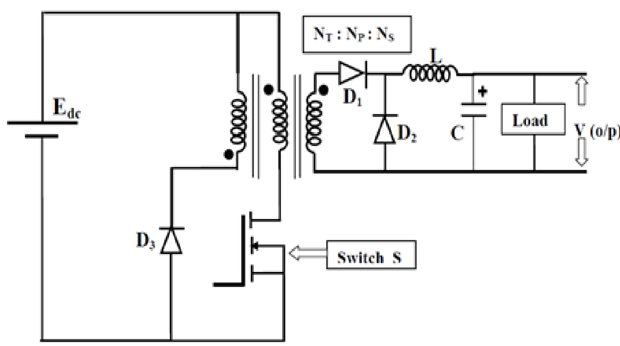

FIG 9: FORWARD CONVERTER WITH TERTIARY WINDING

When switch S is ON, input voltage supply voltage to primary coil, voltages induced by windings would be directly proportional to number of turns ratio, diode D3 gets reverse biased, then total voltage will be

$$-e_{dc} = \left(1 + \frac{n_T}{n_p}\right) \qquad (6)$$

When the switch S is OFF ,flow of current through primary and secondary coils decreases to zero, diode D3 starts to conduct, although D3 forward biased; voltage of tertiary winding get stable to input voltage within negative end of dot point. Due to action of transformer, voltage induced by primary and secondary coils.so voltage in primary winding will be

$$e_{dc}\frac{n_P}{n_T} \qquad (7)$$

Current through tertiary winding passes and magnetizing current decays linearly, relation between this current and input supply is mention here

$$n_T\frac{d\Phi_m}{dt} = -e_{dc} \qquad (8)$$

In above equation

$$\phi_m = \text{flux through transformer core}$$

When transformer becomes totally de magnetized diode $D3$ switched OFF and voltage in transformer will fall to zero, and this transformer will demagnetized until mode2 does not start.

Switch S is turned ON again, flux of transformer shows linear behavior in switching period ,relation can be represented as;

$$n_P\frac{d\phi_m}{dt} = e_{dc} \qquad (9)$$

At steady state, flux increases during conduction period of switch .Combining equation A and equation B;

$$\frac{T_T}{n_T} = \frac{T_P}{n_P} \qquad (8)$$

$t_T$and t_P are time in each conducting cycle for primary and tertiary winding ,now

$$T_P = DT \qquad (11)$$

Tertiary winding conducts in mode2.so

$$DT \geq T_T \qquad (12)$$

$$\frac{D}{1-D} \leq \frac{n}{n_T} \qquad (13)$$

$$D \leq \frac{n_P}{n_P+n_T} \qquad (14)$$

If $n_p = n_T$ .duty cycle will be less or equal to 0.5 ,then in mode2 magnetic circuit of transformer would not acquire time to reset ,less duty cycle will leads to less powering mode .higher value of $\frac{n_P}{n_T}$ will increase losess.

C. DSIGN OF CAPACITOR AND INDUCTOR FILTER CIRCUIT

Output is measure at secondary side of transformer ,then after rectification process it is filter out ,so design of capacitor and inductor in filter design plays an importanat role .During switching current of inductor is equal to load current and ac current is supplied due to switching frequency,it was discussed that inductor current should be continues ,but in this case inductor current does not continues because the linearity between output voltage and duty cycly diminish ,so output voltage could be constant and some variations appears in load current ,so inductor must be chosen large under variations of load current

,$i_{min} = 0$

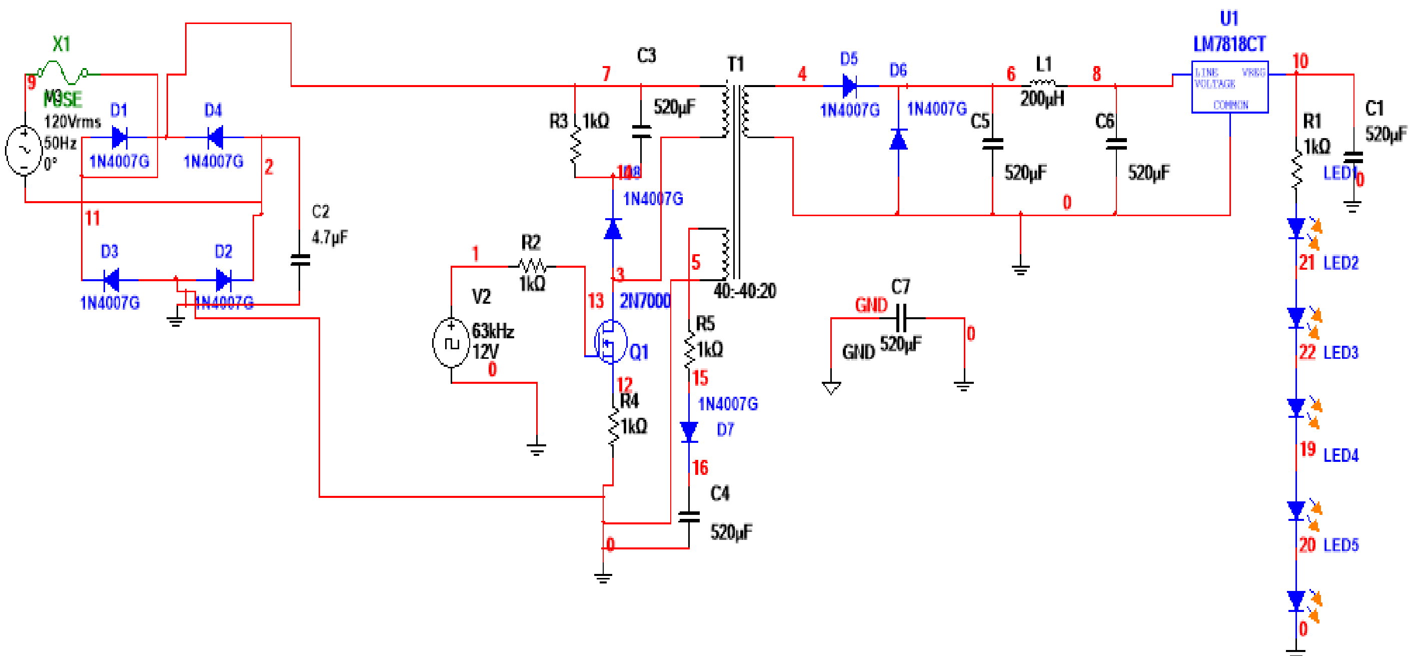

FIG 10: SIMULATION OF SMPS FOR LED LAMP ON NI MULTISIM

$$i_{load} = 0.5(i_{min} + i_{max}) = 0.5i_{max} \qquad (15)$$

Using Above equation

$$(\mathrm{i}_{\mathrm{max}} - \mathrm{i}_{\mathrm{min}}) = \frac{\mathrm{DT}\left(\frac{\mathrm{n_S}}{\mathrm{n_P}}\mathrm{e_{dc}} - \mathrm{v_o}\right)}{\mathrm{L}} \qquad (16)$$

Now for $i_{min} = 0$ and $i_{max} = 0.2i_{rated}$

$$L = \frac{DT\left(\frac{n_S}{n}e_{dc} - v_o\right)}{(0.2i_{rated})} \qquad (17)$$

Simulations of SMPS has implemented on NIMULTISIM and LABVIEW as shown in fig 10.

In above equation

L = inductor

D = duty cucle ; T = time period

n_s = number of turns of secondary winding

n = number of turns of primary winding

e_{dc} is input voltage that varies with duty cycle and keep the output voltage V_o consatant.

Duty cycle must be corresponds to inductor,that can be written as;

$$L = \frac{5v_o}{i_{rated}f_{sw}}(1 - D_{min}) \qquad (18)$$

Here D_{min} is minimum duty cycle ,and f_{sw} is known as switching frequency .Maximum value of duty cycle can be adjusted as;

$$D_{max} = \frac{n_P}{n_P+n_T} \qquad (19)$$

For maintainning constant output voltage

$$\frac{D_{max}}{D_{min}} = \frac{e_{dc,max}}{e_{dc,min}} \qquad (20)$$

$e_{dc,max}$ and e_{min} are maximum and minimum amplitudes

of input supply

$$D_{min} = \frac{e_{dc,min}}{e_{dc,max}}\frac{n_P}{n_P+n_T} \qquad (21)$$

And

$$L = \frac{5v_o}{I_{rated}f_{sw}}\left[1 - \frac{e_{dc,min}}{E_{dc,max}}\frac{n_P}{n_P+n_T}\right] \qquad (22)$$

Inducdepends upon rated current as well as switching frequency ,it may be noted that ripple current do not influence by dc voltage .In our work the value of capacitor will be constant.Small amount of ripple will be present in voltage of capacitor .It will generate insignificant significances.We can choose the value of capacitor by this expression

$$v_{o.p-p} = \frac{i_{rated}}{20Cf_{sw}} \qquad (21)$$

Here C is the capacitance and f_{sw} is switching frequency.

SIMULATIONS AND RESULTS

Proposed methodology of SMPS is based upon PID controller that is use to stabilize the output voltage .An AC signal of $220V$ with 50 Hz has applied to full bridge rectifier .when positive AC cycle arises diodes D2 and D4 begin to conduct ,and other two diodes D1 and D4 are OFF,similarly in next negative cycle D1 and D3 are forward biased both these diodes connducts and other diodes are OFF.then DC output is achieve but this output is not pure DC some ripples exist in it .A capacitor has coupled at it's output to remove the ripples capacitor acts as low pass filter that passes the low frequencies and stops higher frequencies.Obtain output is given to transformer of forward converter ,that is made up of ferrite core have two coils primary and secondary ,third coil has introduced with diode in series with primary coil that is known as tertiary winding this winding has used instead of snubber because snubber circuit dissipates energy that reduces the efficiency of overall system.Duty cycle of switch increase from 50% and can be use under wide ranges of input . Tertiary winding reduces the effect of EMI.When the switch S is switched ON current of transformer rise and diode D5 do not conduct due to reverse biased magnetizing current of transformer will be

$$i_M = \frac{v_{in} \times t_{ON}}{L_M} \qquad (22)$$

In the above expression t_{ON} is on time and L_M is mutual inductance .In the period of swithching current will flow in primary winding,that is equal to

$$i = \frac{i_o \times n_S}{n_P} \qquad (23)$$

Voltage across loadwill be

$$v_o = \frac{v_{in} \times D \times n_S}{n_P} \qquad (24)$$

When switch S is turn OFF ,voltage of transformer contraries ,and voltage of D starts to rises until its ON.Now magnetizing current of transformer fall to zero after that transformer becomes reset and voltage remains zero untill nxt switching period starts.this converter operates in CCM mode because the current of inductor flows continuesly due to free wheeling diode .Output of converter is not pure dc .LC filter has introduced to remove the ripples and harmonics.An array of LEDs is connected to rectifier and 14V has appeared across it with 7A current . power of LED lamp is 98W.

A. DESIGN OF PID CONTROLLER

In a control scheme, process must have to be control i.e. pressure, temperature, sensor. In process, Setting points are desired values, for example temperature. Difference between the process and these set points can be considered by using control methods.

In some circumstances output of actuator does not only effect a system i.e. moisture can be appear in a chamber it effects output signal, that is called as disturbance. Basically we design such a system in which disturbance is reduced. Block diagram of PID controller is shown in fig 11.

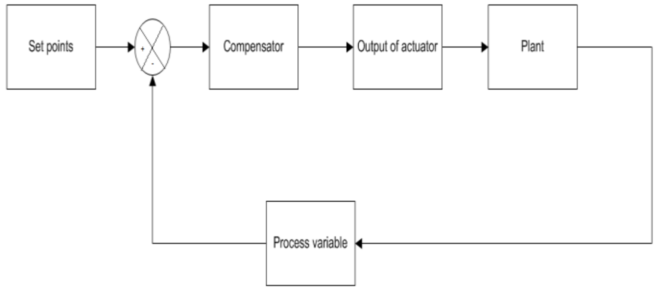

FIG 11: BLOCK DIAGRAM OF PID CONTROLLER

In this block diagram first of all set points are added which are basically desired points. Difference between process variables and set point is calculated that is known as error, this error signal is given to compensator; compensators compensate it and provide its output to actuator. Plant is connected to actuator, basically output of plant must have to be stabilized so actuator actuates the compensated value and give output to plant.

In most cases, reaction of system differs due to some variables .output waveform of step response is shown in figure. Usually in closed loop systems PID controller is used. Basically PID reads the value of sensor and examines the output of actuator.it also computes the three coefficients which are proportional, integral and derivative for preferred output value

B. DESIGN PROBLEM

Gain of PID controller is shown in fig 12.that has obtain by above technique, after that gain of proportional is slowly increased until loop's output oscillate ,when gain increases system and integral term is added to stop oscillations. Three outputs are shown in figure, one is for proportional second is integral and third is derivative. Maximum limited range for all three signals is presented .

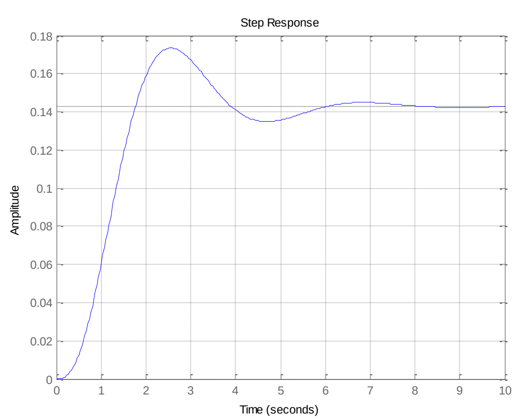

FIG 12: OUTPUT OF PID

D. PCB LAYOUT OF SMPS FOR LEDS LAMP

The required circuit is made in Multisim software all the components as were required and then made it PCB layout by auto routing we can rout it manually but it's a complex way then we check all the components and its connection then we print it on a special paper. Then the printed circuit is pasted on the copper sheet through applying heat by iron carefully. After the circuit is pasted the copper sheet is put in acid solution (nitric acid). Acid dissolve the rest of the portion and only the circuit remains there on sheet which acts as copper wires for the required circuit. This process is called etching. After etching holes are made through drill machine for different components and then components are placed in the respected holes and are soldered and we get our required hardware circuit. Thus PCB has many advantages over convictional circuit boards. Since the copper tracks are embedded to the circuit board so there are fewer chances of wrong wrings and short circuit occurrence. Hence it is reliable and more compatible way of designing electric circuit board. So layout of SMPS has shown in fig

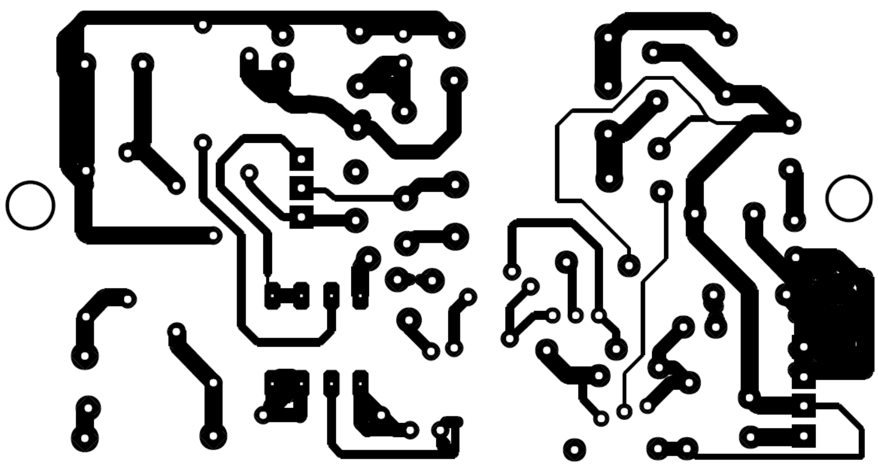

FIG 13 LAYOUT DESIGN OF SMPS FOR LEDS LAMP ON NI MULTISIM

HARDWARE DESIGN OF SMPS FOR LEDS LAMP

Hardware strategy of power supply for LEDs lamp is shown in fig 14and fig 15.

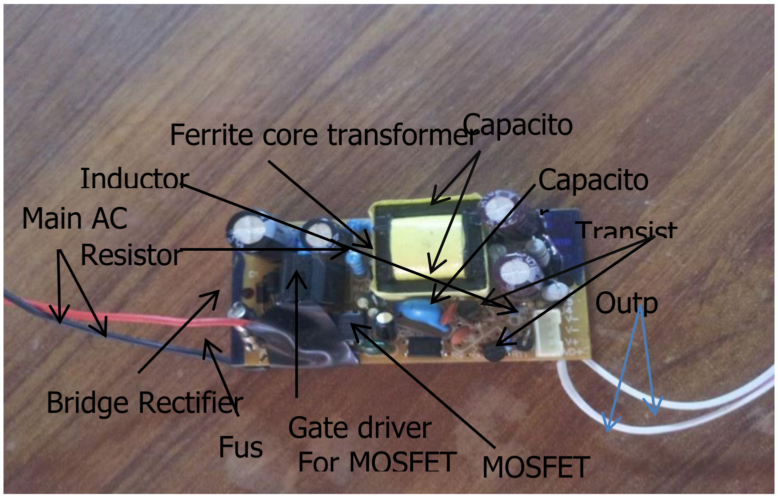

FIG 14 HARDWARE DESIGN OF SMPS

FIG 15 GLOW OF LEDS LAMP

Hardware is tested in laboratory, the results are very hopeful.220 volts with frequency of 60 Hz are applied to circuit, and voltmeter is connected in parallel to LED lamp. At output 13.94$\cong$ 14 volts is produced. Pure DC is achieved without any ripples at all. Output is shown in figure.

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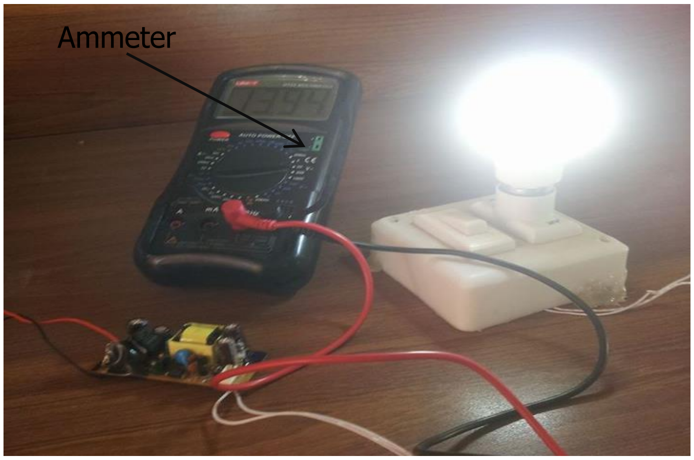

FIG 16 OUTPUT VOLTAGE OF LEDS LAMP

Output of LEDs lamp has also observed on oscilloscope .Channel 2 of oscilloscope has used .Positive probe of channel 2 is connected to positive end of LEDs lamp and negative probe is connected to negative end. First of all level of signal in oscilloscope is set at ground as can be observe in fig 17.

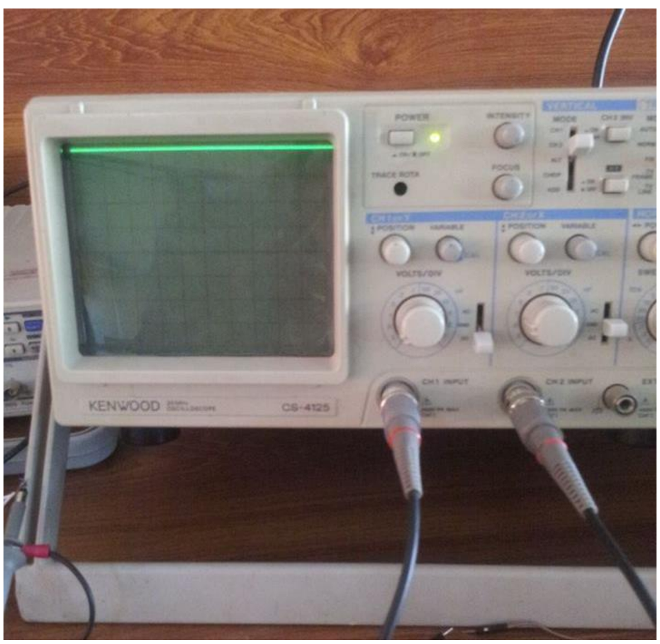

FIG 17 SETTING GROUND LEVEL

Pure DC voltages would be appear at output so button of scope has selected to dc level and it can be observe that nearly 14V has generated . One box of oscilloscope is equal to 1V.Here are 7 boxes and volts/div is at point 2.So $V_{out} = 7 \times 2 = 14Volts$ .as shown in fig 18 and 19.Proper scale of output is presented in fig 18 and 19.

FIG 18 DC OUTPUT ON OSCILLOSCOPE

FIG 19 SCALE VOLTS/DIV ON OSCILLOSCOPE USING CHANNEL 2

Current is also measured by using Ammeter as shown in fig 21.So 7A current has drawn by lamp.

FIG 20 CURRENT OF 7A ON AMMETER

All these results show that pure DC voltage has achieved by using proposed methodology and switching losses has also reduced .Use of ferrite core of transformer has reduce the transformer, and thermal losses. Size of power supply has also reduced and power density has increased. In this scheme basic purpose of use of fuse in hardware is to offer protection at main AC lines, and two transistors have also used to prevent from overheating because 310 V are producing at output of transformer .its windings can be burn out and there may be a chance of short circuit.

TRANSFORMER LOSSES

In transformer of forward converter ferirte core has used.For avoiding higher magnetizing current.There is need to reduce losses ,For this purpose air gap is introduce .First reason to introduce airgap is; it would prevent saturaion sensation ,secondly this air gap will measure precise value of magnetizing inductance so leakage inductance would be;

$$L_{leakage} = L_1 + \left(\frac{n_p}{n_s}\right)^2 L_2 \qquad (25)$$

L_1 =Primary Inductance

$\left(\frac{n_p}{n_s}\right)^2 L_2$=secondary inductance refer to primary side

By putting the values in above equation value of leakage inductance is $L_{leakage} = 33uH$.

Magnetizing current can be calculated as;

$$v_{in}dt = Mdi_m \qquad (26)$$

$$i_m = \frac{V_{in}T}{M} = \frac{V_{in}D_{max}}{Mf} \qquad (27)$$

Here

M = magnetizing inductance=1.9mH

$$i_m = 1.4A \qquad (28)$$

It is a very small value ,indeed demagnetizing current in forward converter is very negligible . Leakage power will be;

$$p_{leakage} = \frac{1}{2} L_{leakage} \left[i_{out} \left(\frac{n_s}{n_p} \right) + i_m \right]^2 \times f \quad (29)$$

$$p_{leakage} = 5.2W$$

This power is not too much high as our expectations.Thermal calculations of transformer are very vital ,which indicates either design of transformer is good or not ,basic form of equations are presented here .

$$p_{c1} = \Delta B^{2.4} (K_h f + K_e f^2) with | K_h = 4.10^{-5}, K_e = 4.10^{-10}$$

$$p_{c1} = 0.124W/cm^3 \quad (30)$$

Magnetic power losses will be

$$p_c = p_{c1} v_e = 1.1W \quad (31)$$

Losses at primary side would be

$$p_{wp} = n_p l_1 i_{rmsP^2} \quad (32)$$

Here

$$l_1 = 4\sqrt{A_e} = 5.4cm \quad (33)$$

And

$$\text{resistance per meter will be equal to} = R_{PJ} = \frac{0.000708\Omega}{cm}$$

$$p_{wp} = 0.17W \quad (34)$$

Similarly at secondary side

$$p_{ws} = n_s l_2 R_{SJ} i_{rmsS^2} \text{ with } l_2 = l_1$$

$$R_{SJ} = \frac{0.000280\Omega}{cm} \quad (35)$$

Total losses can be found as;

$$p = p_{WP} + p_{WS} + p_c$$

$$p_{transfo} = 1.42W \quad (36)$$

$$p_{WS} = n_P l_1 R_{PJ} i_{rmsS^2} \, with \, l_1 = l_2 \, and \, R_{SJ} = 0.000280\Omega/cm$$

$$p_{WS} = 0.18W \quad (37)$$

CONCLUSION

Proposed scheme of SMPS for LED lamp has been presented and verified with experiments that can be use in applications of upto 200W LED lamps.The converter charecterestics are very good ,which have low distorion in input voltage and posses good efficiency and total harmonic distortion has reduced to 2%.Integration of forward converter with full bridge rectifier allows this converter to achieve the necessary and acceptable voltage by using turns ratio of transformer.Secondly the addition of LC filter is use to reduce ripples ,so both these stages have advantages .similarly film capacitors can be introduce instead of electrolytic capacitors that is use to decrease the mean time of converter in failures ,and make it compatible with LEDs.Proposed topology reduces the cost for delivering large amount of power .Transformer which is used in forward converter has operated on high frequency which is 36KHz that helps to reduce size and weight of switched mode power supply and increases power density .Pure dc 14V voltage has apperaed across LEDs lamp that draws current of 7A.Fuse is connected at main ac input lines to prevent short circuit or another loss.This topology can be use in wide range of power i.e. in those applications where 100W-200W is require for load. Forward converter require inductor that is additional element at output.In hardware design of SMPS, MOSFET has used for switching of forward converter and IC7848 is use for generating PWM.Transfomer is made up of ferrite core tha reduces overall weight of switched mode power supply and provides 95% efficiency.So,forward converter is more suitable in higher current or power applications.

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