International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 12 Ver. IV || Dec 2018 || PP 29-34

Single-Phase Uninterrupted Power Supply with Boost Converter

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Abstract*: To reduce the cost in the power system and achieve the maximum voltage and current in the load side. Bridge rectifier convert the Ac to Dc then a Battery will connect to this side then a boost converter will connected with the line to boost up the power on the output side. The MOSFET/ BJT control switching device use to make inverter which convert the AC power and stable the load power. And a switching Feedback connected from input side to output load that make the load power more stable and to reducing the number of switches and passive elements in uninterruptible power supply topologies not only reduces the cost of the whole system but also provides some other advantages such as greater compactness, smaller weight, and higher reliability.*
Key wor *: UPS system, Boost converter, BJT/MOSFET switching control.*

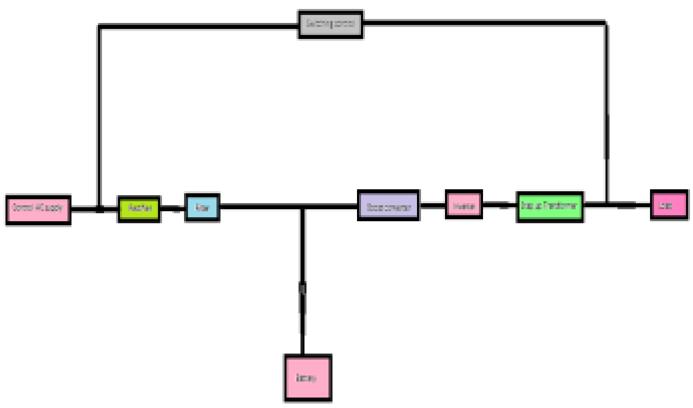
Date of Submission: 13-12-2018 Date of acceptance: 28-12-2018

I. Introduction

If we need to supply clean and uninterrupted power to equipment in critical applications, under essentially any normal or abnormal utility power conditions, including outages for up to 15 min, we will use an uninterruptible power supplies (UPS's). Such critical applications are:

Computers, industrial controls, life support systems, etc. In order to be able to supply power in the absence of input to the power source, the UPS employs some form of bulk energy-storage mechanism Most UPS systems use batteries, usually lead acid, as bulk energy-storage mechanism. The UPS system work on ON-line power supply and OFF line power supply, The UPS system is two type Low energy storage and another is Bulk energy storages. The low energy storage UPS system use in computer or house application.

The bulk energy storage battery is use in the high power supply to full fill the power demand in the load side. UPS system can use as bootstrap in the power generation system during black out . Otherwise in the distribution side UPS system has use to back up the load power during high load demand. Now a days in the rural area has a major problem that is the rolling back out, during rolling black out the load shutting will occur 2 or 3 hour to full fill the other load demand this processes frustrate the people but UPS system reduce the rolling black out process then load get continuous power.
There are many type of UPS system but basic UPS system block diagram are shown below.



Block diagram of UPS system

The above block diagram shows that control Ac supply which supply the 220 volt 50 Hz power to the rectifier circuit which convert the full wave dc power then filter will stable the dc power then some current flow in the Battery and other current flow in the boost converter which convert the low power to high power and inverter will convert the dc power to ac power. After converting the ac power a step up transformer connected to boost up the power, a feedback switching control are connected from input side to output side which control the load power.

On-Line Uninterruptible Power Supply (Ups):-

During On-line power supply the UPS system is directly connected to the main supply (input supply). This time ups does not supply the on the load side this time battery collect the charge from the main supply. When main power goes down and load demand does not full fill this time UPS system supply to the load. During on-line power supply battery can store the charge and supply the power to the load when load power need otherwise bypass the power to the load side.

Off-Line Uninterruptible Power Supply:-

During Off-line UPS system the main power is Zero. this time battery cannot charged from the input supply. This time battery release the charge to back up the load demand. When load increase then battery power will decrease. Various UPS system various battery backup system, for computer the UPS has 15 to 20 min power back up, for home UPS had 5 to 12 hour back up with low load condition.

Normal Mode Of Operation:-

From the UPS system topology, an AC control supply passing through the line. This line divided into two part one part for rectifier circuit which convert the ac power to dc power the filter will remove the distortion from the dc power line. this line divided into two part one for battery line and another for boost converter, the battery and boost converter both will be in parallel connection. In practically the battery charged voltage will be lower than the line voltage during On-line power system. Further the line voltage enter the boost converter which increase the voltage and current this voltage and current enter the inverter side which make the Dc input voltage to Ac input voltage during inverting some power has lost and increase the noise in the system this time filter and control transformer are connected to the load side. A feedback switching device connected to the with standard frequency which also control the output power in the load side.

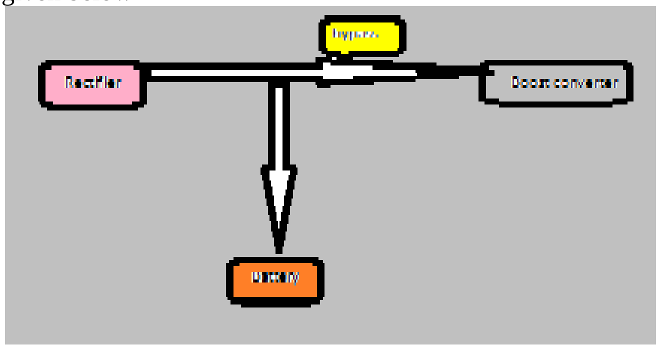
Stroage-Energy Operation:-

When ac power convert to the Dc power with the help of rectifier then a battery bank is connected to the rectifier then dc charge is store in the battery and full fill the battery charge storage. This operation will happen during main power supply to the load and some power has bypass. It will not happen during off-line condition.

Bypass Mode Of Operation:-

During ON-LINE condition this operation occur, this time rectifier power output divided into two part one for battery another for line, the line input is the boost converter input this power bypass the battery and goes to the load side,

The bypass operation are given below



Calculation

UPS system has contains Rectifier circuit, filter circuit, Battery, Boost converter and Inverter, Step up transformer

Calculation for rectifiers

$$Vdc = 2 * (\frac{vm}{\pi})$$
$$Vdc = 0.6366 * vm$$

where Vdc = DC power output, and vm=peak value of Ac voltage.

$$idc = 0.6366 * (\frac{vm}{z})$$

Where Z= resistance of the circuit
Rms value of the circuit is

$$Vrms = 0.707 * vm$$

Calculation for L-Type filter,
LC filter are connect to the rectifier circuit which filtering the Dc voltage and increasing the Dc voltage .
Now

$$Vdc = L * \left(\frac{di}{dt}\right) + \left(\frac{1}{c}\right) * \int i\,dt$$

$$Vdc = 10 * \left(\frac{di}{dt}\right) + \left(\frac{1}{1000}\right) * \int i\,dt = Vdc1$$

Calculation for branch voltage
Vdc1 voltage has divided by two side one for battery side and another is for line voltage

$$Vdc1 = Vb + Vlin$$

Practically Vlin > Vb because if line voltage will not greater than battery voltage then load voltage will be too low.
The Battery will connected parallel of the rectifier circuit
Now , assume that initial state of charge in battery is= X%
Final state of charge in battery is =Y%
initial time= t1 and final time = tf
Battery charging rate

$$C = \frac{Y\% - X\%}{tf - t1}$$

$$\Delta t = tf - t1$$

$$C = \frac{Y\% - X\%}{\Delta t}$$

So, charging rate will be

$$dC = (\frac{d(Y\% - X\%)}{d\Delta t})$$

Now assume that U% is the discharging percent and time tu is the discharging time
So, Discharging Rate

$$D = \frac{X\% - U\%}{t1 - tu}$$

$$\nabla t = t1 - tu$$

$$D = \frac{X\% - U\%}{\nabla t}$$

Discharge will be

$$dD = (\frac{d(X\% - U\%)}{d\nabla t})$$

Charging time $tc = q/i$
Charge $dQ = di * tc$

Calculation for Boost converter
Vlin is the Boost input
Now

$$Vlin = L * (\frac{\Delta I}{t1})$$

where L= inductance
t1= Switch On time

$$\Delta I = i1 - i2$$
$$t1 = L * (\frac{\Delta I}{Vlin})$$

During Switch Off ,
Time is t2, and load voltage is Vr

$$\mathrm{Vlin} - \mathrm{Vr} = -\mathrm{L} * (\frac{\Delta \mathrm{I}}{\mathrm{t2}})$$

$$\mathrm{t2} = \mathrm{L} * (\frac{\Delta \mathrm{I}}{\mathrm{Vr} - \mathrm{Vlin}})$$

Total time $\mathrm{T} = \mathrm{t1} + \mathrm{t2}$

$$T = \left(\frac{1}{f}\right) = L * \Delta I\left(\left(\frac{1}{Vlin}\right) + \left(\frac{1}{Vlin * (Vr - Vlin)}\right)\right)$$

Now , Inductance of the circuit

$L = Vlin * (\frac{k}{f * \Delta I})$

Where k= Duty cycle

Capacitance of the line

$C = Ir * (\frac{k}{f * Vc})$

Where Ir = Boost current output,

f= frequency

Vc=capacitance voltage

Duty cycle

$k = \frac{Vr - Vlin}{Vr}$

Calculation for Inverter

Inverter output voltage

$Vo = Vm * \sin(wt)$

Inverter Output current

$Io = (\frac{Vm}{z}) * \sin(wt)$

Frequency

$f = \frac{w}{2 * \pi} = \frac{1}{T}$

Where Vm= peak value of voltage

Im=peak value of current

w= angular velocity

T= Time

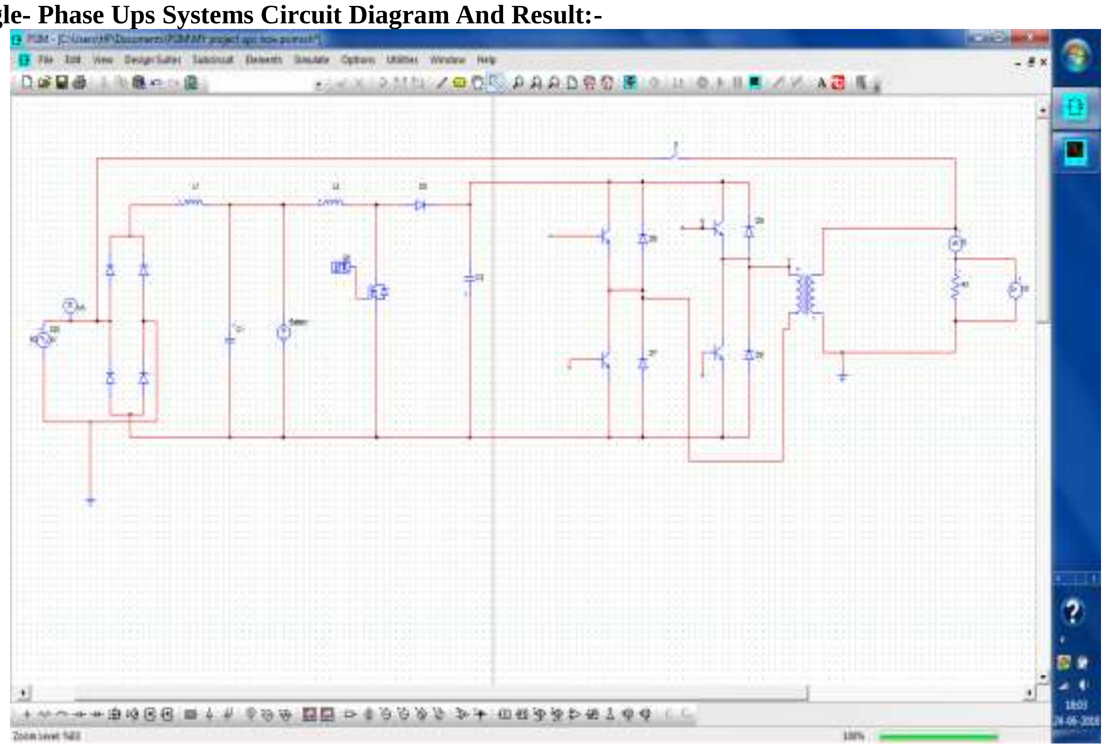
Z= Load resistance

$$\varphi = wt$$
$$Vo = Vm * \sin\varphi$$
$$Io = (\frac{Vm}{z}) * \sin\varphi$$

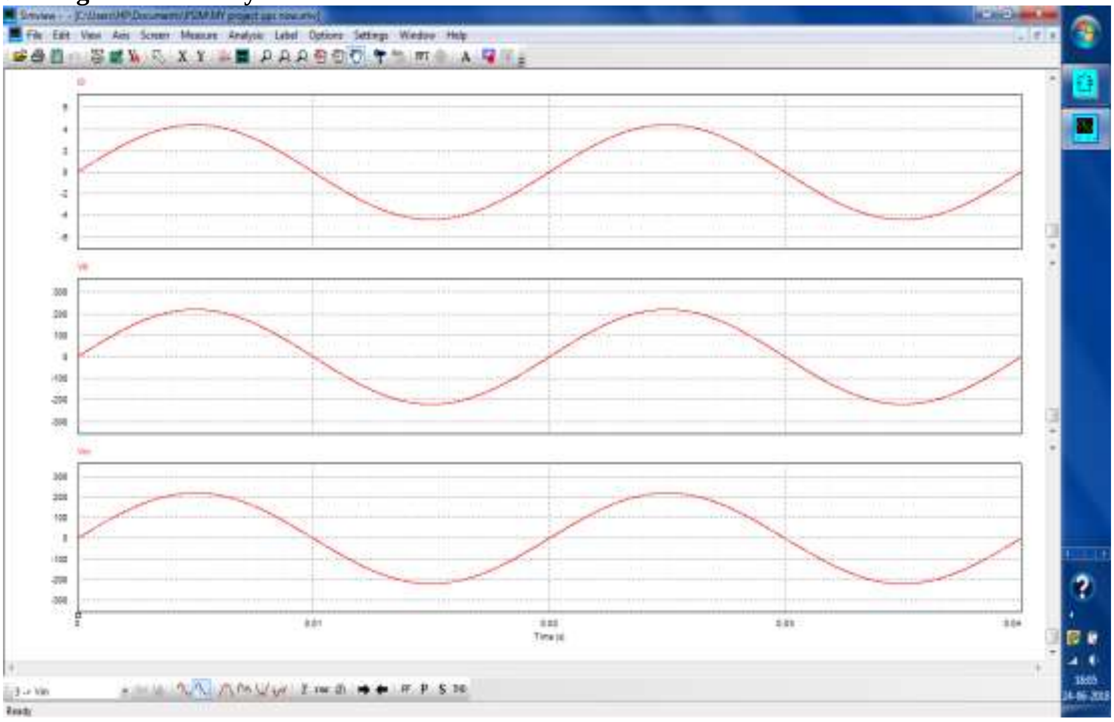
According to circuit the angle φ will be

$-90 \leq \varphi \leq 90$

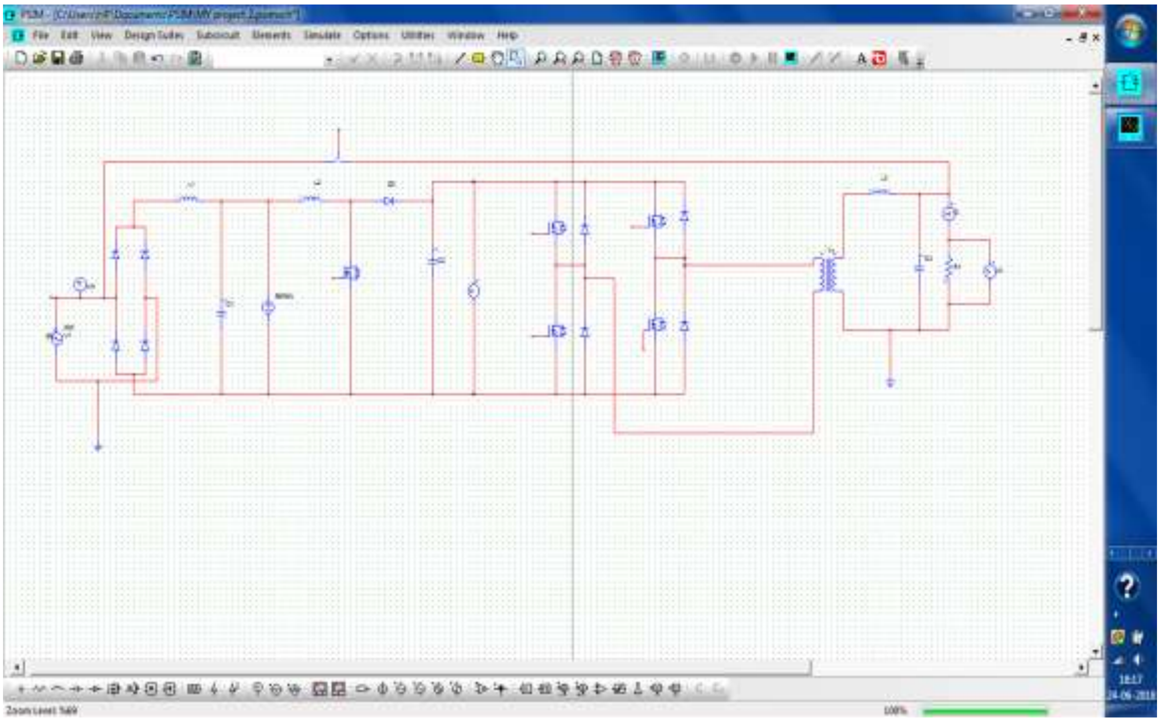
Single- Phase Ups Systems Circuit Diagram And Result:-



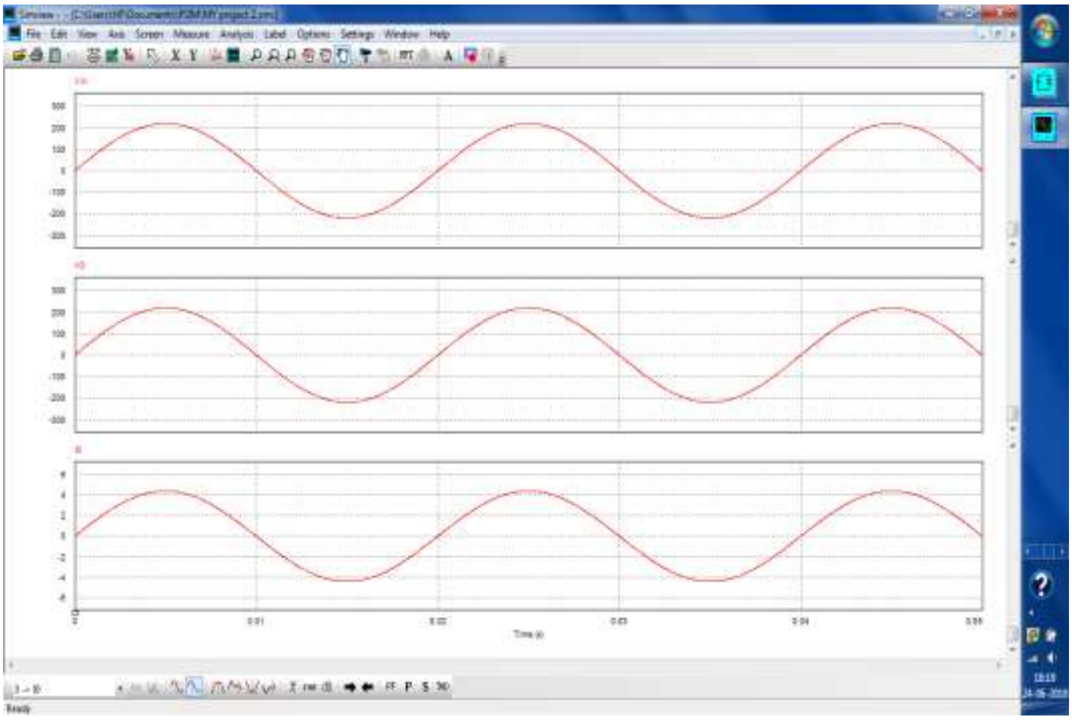
Circuit diagram of UPS System



Single phase BJT switching inverter A) Circuit diagram, B) output current (I0), C)output voltage(V0), D) input voltage (Vin).



Circuit diagram of UPS system



Single phase MOSFET control switch A) Circuit diagram. B) Input voltage(Vin). C) Output voltage (V0). D) Output Current (I0).

II. Conclusions:-

There are various type of UPS system this above UPS system is not so complex and easy to design. After many simulation on UPS system the output voltage and input voltage is equal but the output current will vary with respect to the load resistance. The load can be resistive , inductive and capacitive but with the change of load the current output graph will be change but output voltage graph will be same. Reduce the UPS side and switching performance is good, in this circuit easy to find out the error. The output voltage and current diagram is pure sinusoidal as like input voltage and current(AC). It is shows that circuit is highly stability and performance is good.

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Anawrul Islam" Single-Phase Uninterrupted Power Supply with Boost Converter" International Journal of Engineering Science Invention (IJESI), vol. 07, no. 12, 2018, pp 29-34