SYNCHRONISATION OF NONCONVENTIONAL ENERGY SOURCE

A Project report submitted in partial fulfilment

of the requirements for the degree of B. Tech in Electrical Engineering

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Full Signature of the Student

Place:

Date:

CERTIFICATE

<u>To whom it may concern</u>

This is to certify that the project work entitled **SYNCHRONISATION OF NONCONVENTIONAL ENERGY SOURCE**is the bona fide work carried out by the final year project group **'7'** of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year **2018-19**, in partial fulfilment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

Signature of the Guide

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Designation:

Signature of the HOD

Name:

Designation:

Signature of the External Examiner

Name:

Designation:

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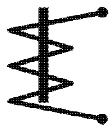
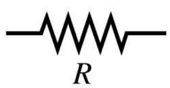
LIST OF NOMENCLATURE

1. Y-Y : Star-Star connected transformer

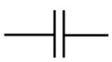
2.  : Moving iron

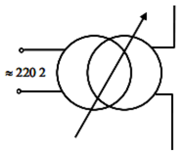
3. 

: AC & DC voltage respectively

4. 

: Resistance (R)

5.  : Capacitance (C)

6. 

: Variable autotransformer (Variac)

LIST OF ACRONYMS

1. I/P : Input
2. O/P : Output
3. Y-Y : Star-Star connected transformer
4. **3-Ph supply** : R→ Red
   Y→ Yellow
   B→ Blue
   N→ Neutral
5. DC & AC : Direct current & Alternating current respectively
6. V, kV : Volt, kilo Volt
7. A, mA : Ampere, milli Ampere
8. kΩ, Ω : Kilo ohm, Ohm
9. W : Watt
10. µF, pF : Micro farad, Pico farad
11. ns : Nano second
12. Hz : Hertz
13. MCB : Miniature Circuit Breaker
14. PWM : Pulse Width Modulation
15. RRV : Repetitive Reverse Voltage
16. RRT : Reverse Recovery Time
17. **1-Ph Inverter** : C→ Capacitor, R→ Resistor, D→ Diode, F→ Fuse, Q2,Q3→ n-channel power Mosfet, Q1→ Transistor, U1→ Pulse Width Modulator Control Circuit, J→ Junction, LED→ Light Emitting Diode, TG1,2→ Output terminals

ABSTRACT

The synopsis focuses on the synchronisation of non-conventional energy sources with the load. After a brief introduction of non- renewable energy we will go for detailing the process to connect these sources energy to use it in load.

Our analysis presents the conversion of this non-renewable energy sources to a useful energy which we can use in absence of conversion energy which we get from coal. There have some calculation of how much current and voltage we get in output by giving a sufficient amount of input and also there have some calculations for designing the rectifiers, transformer and inverter.

Also we use a prototype made for the wind source through a potentiometer connected with DC motor to show it as a variable wind supply. As we did not have sufficient amount of wind source present in lab. Then we have showcased the conversion of this 3-Ph supply to a 12V rectified output through Y-Y connected for protection and also stepdown transformer and used a capacitor to stable DC output. Then giving it to a 1-Ph inverter and to get sufficient amount AC supply to use it for load through a stepdown transformer.

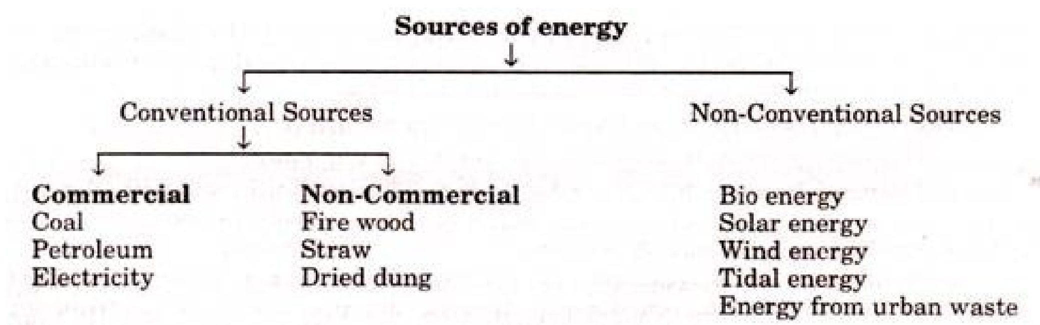
INTRODUCTION

SYNCHRONIZATION: In an alternating current electric power system, synchronization is the process of matching the speed and frequency of a generator or other source to a running network. An AC generator cannot deliver power to an electrical grid unless it is running at the same frequency as the network. If two segments of a grid are disconnected, they cannot exchange AC power again until they are brought back into exact synchronization.

A direct current (DC) generator can be connected to a power network by adjusting its open-circuit terminal voltage to match the network voltage, by either adjusting its speed or its field excitation. The exact engine speed is not critical. However, an AC generator must match both the amplitude and the timing of the network voltage, which requires both speed and excitation to be systematically controlled for synchronization. In modern grids, synchronization of generators is carried out by automatic systems.

TWO MAIN SOURCES OF ENERGY:

The sources of energy are of following types:

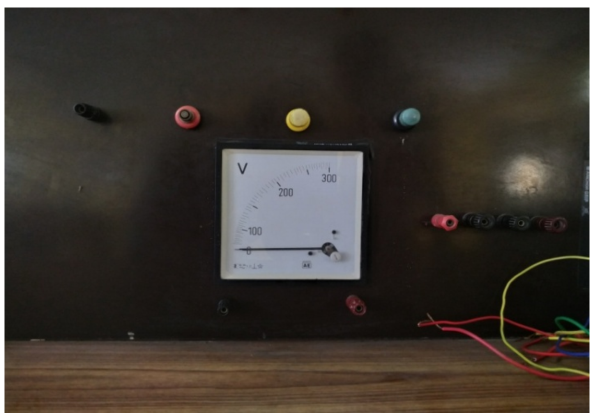


Due to their unsustainability and harmful effects on the environment, fossil fuels no longer stand as attractive sources of energy. International agreements and commitments for reducing carbon and other harmful emissions to the environment have recently been the driving force behind renewed interests in renewable energy sources (RES) such as wind and solar.RES are clean and sustainable; they never run out and present no threat to the environment. Many power electronic systems have been described in the literature for harvesting renewable energy and converting into a useable form. However, RES are intermittent because their output energy depends on weather conditions and consequently cannot be relied upon for continuous supply of electricity. To compact this problem, the harvested energy from a RES, such as photovoltaic (PV) generator, may be used to charge a bank of batteries which is then used to feed a voltage source dc-ac inverter (VSI) to provide the ac voltage with the required amplitude and frequency. Such a “standalone” system is commonly used for lighting and water pumping in remote areas where a utility grid is not available. When a grid is available, the utilization of the above PV system may be enhanced by integrating it with the grid. In this grid-connected system, when the weather conditions are not conducive for energy generation and if the batteries are not fully charged, the load can be met by the grid. On the other hand, when the harvested renewable energy is in excess of the load demands, the excess energy can be fed back “sold” to the grid. However, before the inverter can be connected to the grid, its output voltage waveform must be synchronized with the grid voltage. Furthermore, because the grid voltage may occasionally be subjected to sudden and unpredicted perturbations such as voltage sag and/or a phase change, which may lead to loss of synchronization, the inverter must be able to re-establish synchronization.

Our plan was to give a wind supply as a non-conventional energy source. But due to lack of supply of wind we have decided to show this wind mill by a prototype model and we make it through a DC motor with its speed controlled by the potentiometer. So that we can show wind speed differs at different time but output at the end does not change as its synchronised. Actually we had given direct three phase supply from the main source.

THEORY

- **THREE PHASE:** In electrical engineering, **three-phase** electric power systems have at least three conductors carrying alternating currentvoltages that are offset in time by one-third of the period. A three-phase system may be arranged in delta (Δ) or star (Y) (also denoted as Wye in some areas). A Wye system allows the use of two different voltages from all three phases, such as a 230/400 V system which provides 230 V between the neutral (centre hub) and any one of the phases, and 400 V across any two phases. A delta system arrangement only provides one voltage magnitude, but it has a greater redundancy as it may continue to operate normally with one of the three supply windings offline, albeit at 57.7% of total capacity. Harmonic current in the neutral may become very large if nonlinear loads are connected.



PRINCIPLE OF THREE PHASE SUPPLY: In a symmetric three-phase power supply system, three conductors each carry an alternating current of the same frequency and voltage amplitude relative to a common reference but with a phase difference of one third of a cycle between each. The common reference is usually connected to ground and often to a current-carrying conductor called the neutral. Due to the phase difference, the voltage on any conductor reaches its peak at one third of a cycle after one of the other conductors and one third of a cycle before the remaining conductor. This phase delay gives constant power transfer to a balanced linear load. It also makes it possible to produce a rotating magnetic field in an electric motor and generate other phase arrangements using transformers (for instance, a two phase system using a Scott-T transformer). The amplitude of the voltage difference between two phases is √3 (1.732...) times the amplitude of the voltage of the individual phases.

The symmetric three-phase systems described here are simply referred to as *three-phase systems* because, although it is possible to design and implement asymmetric three-phase power systems (i.e. with unequal voltages or phase shifts), they are not used in practice because they lack the most important advantages of symmetric systems.

In a three-phase system feeding a balanced and linear load, the sum of the instantaneous currents of the three conductors is zero. In other words, the current in each conductor is equal in magnitude to the sum of the currents in the other two, but with the opposite sign. The return path for the current in any phase conductor is the other two phase conductors.

GENERATION AND DISTRIBUTION: At the power station, an electrical generator converts mechanical power into a set of three AC electric currents, one from each coil (or winding) of the generator. The windings are arranged such that the currents vary sinusoidally at the same frequency but with the peaks and troughs of their wave forms offset to provide three complementary currents with a phase separation of one-third cycle (120° or $^{2\pi}/_{3}$ radians).
The generator frequency is typically 50 or 60 Hz, depending on the country. At the power station, transformers change the voltage from generators to a level suitable for transmission in order to minimize losses.After further voltage conversions in the transmission network, the voltage is finally transformed to the standard utilization before power is supplied to customers.Most automotive alternators generate three-phase AC and rectify it to DC with a diode bridge.

GENERATION OF 3 PHASE POWER IN 3 PHASE CIRCUITS:

POWER IN 3 PHASE CIRCUITS:

The three phase power is mainly used for generation, transmission and distribution of electrical power because of their superiority. It is more economical as compare to single phase power and requires three live conductors for power supply. Power in a single phase system or circuit is given by the relation shown below.

$$P = VI\cos\varphi$$

Where, V is the voltage of single phase, i.e. $\mathbf{V_{ph}}$
I is the current of single phase, i.e. $\mathbf{I_{ph}}$ and
Cosϕ is the power factor of the circuit

In a 3 phase circuits (balanced load), the power is defined as the sum of various powers in a three phase system. i.e.

$$P = 3V_{ph}I_{ph}Cos\varphi$$

Power in star connections in a 3 phase circuits is given as,

$$P = 3\ \frac{V_L}{\sqrt{3}}\ I_L Cos\varphi\ \ \ldots\ldots..(1)$$

As phase voltage and line voltage in star connection are represented as shown below,

$$V_{ph} = \frac{V_L}{\sqrt{3}}\ \text{ and }\ I_{ph} = I_L$$

Therefore, the equation (1) can be written as

$$P = \sqrt{3}\ V_L I_L Cos\varphi\ \ \ldots\ldots..(2)$$

Power in delta connections in 3 phase circuits is given by the equation shown below,

$$P = 3\ V_L\ \frac{I_L}{\sqrt{3}}\ Cos\varphi\ \ \ldots\ldots..(3)$$

In delta connections, relation between phase and line voltage and phase and line current is given as,

$$V_{ph} = V_L\ \text{ and }\ I_{ph} = \frac{I_L}{\sqrt{3}}$$

Hence, equation (3) can be written as,

$$P = 3\,V_L\,\frac{I_L}{\sqrt{3}}\,\text{Cos}\varphi \;\ldots\ldots\ldots(3)$$

Thus, the Total Power in a 3 Phase balanced load system, irrespective of their connections, whether the system in star connected or delta connected, the power is given by the relation

$\sqrt{3}\, V_L I_L \text{Cos}\phi$. Its units are kilowatt (kW) or Watt (W).

Apparent Power is given as,

$$P_a = \sqrt{3} V_L I_L$$

The unit of apparent power is kilovolt-ampere (kVA) or volt-ampere (VA).

Similarly, the **Reactive Power** is given by the equation.

$$P_r = \sqrt{3}\, V_L I_L\, \text{Sin}\varphi$$

Its units are kilovolt-ampere reactive (kvAR) or volt-ampere reactive (vAR).

GENERATION OF 3 PHASE E.M.FS IN A 3 PHASE CIRCUIT:

In a 3 phase system, there are three equal voltages or EMFs of the same frequency having a phase difference of 120 degrees. These voltages can be produced by a three-phase AC generator having three identical windings displaced apart from each other by 120 degrees electrical.

When these windings are kept stationary, and the magnetic field is rotated as shown in the figure A below or when the windings are kept stationary, and the magnetic field is rotated as shown below in figure B, an emf is induced in each winding. The magnitude and frequency of these EMFs are same but are displaced apart from one another by an angle of 120 degrees.

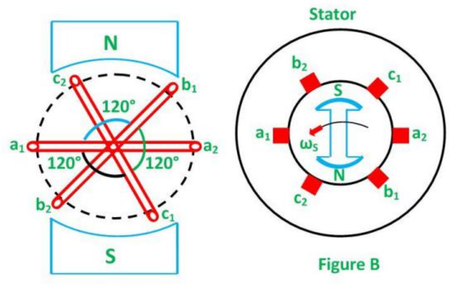


Figure A

Figure B

Consider three identical coils a_1a_2, b_1b_2 and c_1c_2 as shown in the above figure. In this figure a_1, b_1 and c_1 are the starting terminals, whereas a_2, b_2 and $c_2$are the finish terminals of the three coils. The phase difference of 120 degrees has to be maintained between the starts terminals a_1, b_1 and c_1. Now, let the three coils mounted on the same axis, and they are rotated by either keeping coil stationary and moving the magnetic field or vice versa in an anticlockwise direction at (ω) radians per seconds. Three EMFs are induced in the three coils respectively.

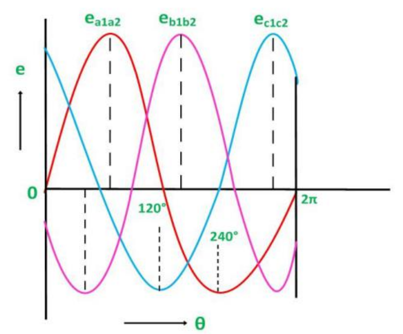
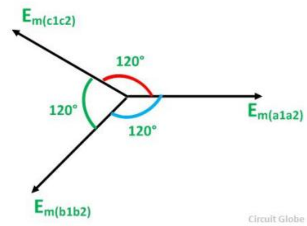


Figure C

Considering the figure C, the analysis about their magnitudes and directions are given as follows. The emf induced in the coil a_1a_2 is zero and is increasing in the positive direction as shown by the waveform in the above figure C represented as e_{a1a2}. The coil b_1b_2 is 120 degrees electrically behind the coil a_1a_2. The emf induced in this coil is negative and is becoming maximum negative as shown by the wave e_{b1b2}. Similarly, the coil c_1c_2 is 120 degrees electrically behind the coil b_1b_2, or we can also say that the coil c_1c_2 is 240 degrees behind the coil a_1a_2. The emf induced in the coil is positive and is decreasing as shown in the figure C represented by the waveform e_{c1c2}.

PHASOR DIAGRAM: The EMFs induced in the three coils in a 3 phase circuits are of the same magnitude and frequency and are displaced by an angle of 120 degrees from each other as shown below in the phasor diagram.



These EMFs of a 3 phase circuits can be expressed in the form of the various equations given below.

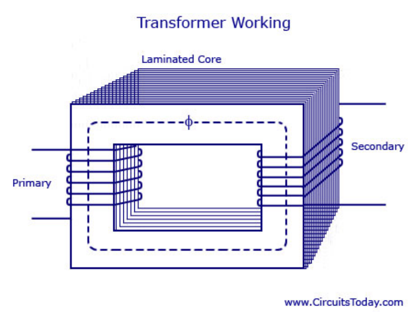
$$e_{a1a2} = E_m \sin \omega t$$

$$e_{b1b2} = E_m \sin(\omega t - 2\pi/3) = E_m \sin(\omega t - 120°)$$

$$e_{c1c2} = E_m \sin(\omega t - 4\pi/3) = E_m \sin(\omega t - 240°)$$

- **TRANSFORMER**: A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. The voltage can be raised or lowered in a circuit, but with a proportional increase or decrease in the current ratings.

WORKING PRINCIPLE: The main principle of operation of a transformer is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance. The working principle of the transformer can be understood from the figure below:



As shown above the electrical transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips you can see that there are some narrow gaps right through the cross-section of the core. These staggered joints are said to be imbricate. Both the coils have high mutual inductance. A mutual electro-motive force is induced in the transformer from the alternating flux that is set up in the laminated core, due to the coil that is connected to a source of alternating voltage. Most of the alternating flux developed by this coil is linked with the other coil and thus produces the mutual induced electro-motive force. The so produced electro-motive force can be explained with the help of Faraday's laws of Electromagnetic Induction as

$e=M*dI/dt$

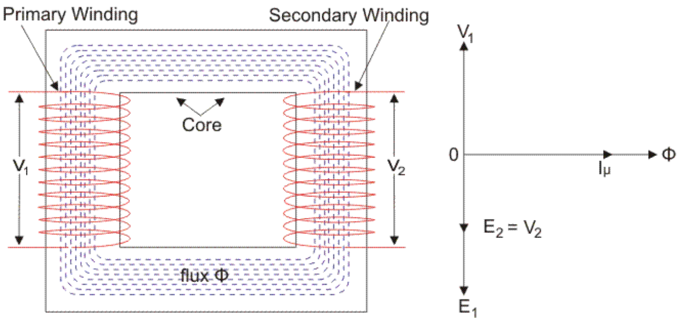
If the second coil circuit is closed, a current flows in it and thus electrical energy is transferred magnetically from the first to the second coil. The alternating current supply is given to the first coil and hence it can be called as the primary winding. The energy is drawn out from the second coil and thus can be called as the secondary winding.

In short, a transformer carries the operations shown below:

1. Transfer of electric power from one circuit to another.
2. Transfer of electric power without any change in frequency.
3. Transfer with the principle of electromagnetic induction.
4. The two electrical circuits are linked by mutual induction.

EMF EQUATION OF TRANSFORMER:

As the current source to primary is sinusoidal, the flux induced by it will be also sinusoidal. Hence, the function of flux may be considered as a sine function. Mathematically, the derivative of that function will give a function for the rate of change of flux linkage with respect to time. This latter function will be a cosine function since $d(\sin\theta)/dt = \cos\theta$. So, if we derive the expression for RMS value of this cosine wave and multiply it with the number of turns of the winding, we will easily get the expression for RMS value of induced emf of that winding. In this way, we can easily derive the **emf equation of transformer**.



Secondary Induced Voltage Ideal Transformer

Let's say, T is number of turns in a winding,
Φ_m is the maximum flux in the core in Wb.
As per Faraday's law of electromagnetic induction,

$$emf,\ e = -T\frac{d\phi}{dt}$$

Where φ is the instantaneous alternating flux and represented as,

$$\phi = \phi_m \sin 2\pi ft$$

$$Hence,\ e = -T\frac{d(\phi_m \sin 2\pi ft)}{dt}$$

$$\Rightarrow e = -T\phi_m \cos(2\pi ft) \times 2\pi f$$

$$\Rightarrow e = -T\phi_m \times 2\pi f \cos(2\pi ft)$$

As the maximum value of cos2πft is 1, the maximum value of induced emf e is,

$$e_m = T\phi_m \times 2\pi f$$

To obtain the rms value of induced counter emf, divide this maximum value of e by √2.

$$Then,\ E = \frac{2\pi}{\sqrt{2}} \times \phi_m fT$$

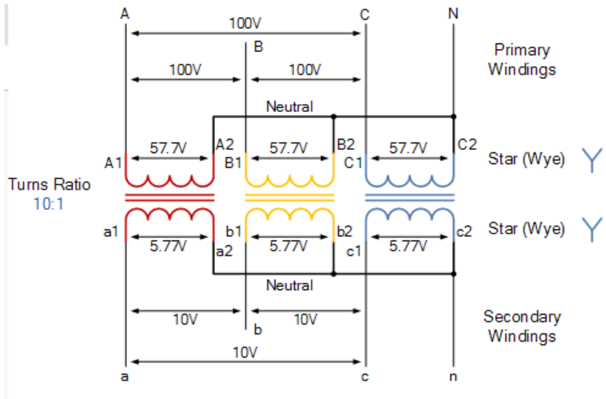
$$E = 4.44\phi_m fT\ Volts \quad (Since\ \frac{2\pi}{\sqrt{2}} = 4.44)$$

This is the EMF equation of transformer.

TRANSFORMER STAR AND STAR CONNECTIONS:

In the star-star arrangement (Yy), (wye-wye), each transformer has one terminal connected to a common junction, or neutral point with the three remaining ends of the primary windings connected to the three-phase mains supply. The number of turns in a transformer winding for star connection is 57.7 per cent, of that required for delta connection.

The star connection requires the use of three transformers, and if any one transformer becomes fault or disabled, the whole group might become disabled. Nevertheless, the star connected three phase transformer is especially convenient and economical in electrical power distributing systems, in that a fourth wire may be connected as a neutral point, (n) of the three star connected secondary as shown,



The voltage between any line of the three-phase transformer is called the “line voltage”, V_L, while the voltage between any line and the neutral point of a star connected transformer is called the “phase voltage”, V_P. This phase voltage between the neutral point and any one of the line connections is $1/\sqrt{3} \times V_L$ of the line voltage. Then above, the primary side phase voltage, V_P is given as.

$$V_P = \frac{1}{\sqrt{3}} \times V_L = \frac{1}{\sqrt{3}} \times 100 = 57.7 \text{ Volts}$$

The secondary current in each phase of a star-connected group of transformers is the same as that for the line current of the supply, then $I_L = I_S$.

Delta-star connected transformers are widely used in low power distribution with the primary windings providing a three-wire balanced load to the utility company while the secondary windings provide the required 4th-wire neutral or earth connection.

When the primary and secondary have different types of winding connections, star or delta, the overall turns ratio of the transformer becomes more complicated. If a three-phase transformer is connected as delta-delta (Dd) or star-star (Yy) then the transformer could potentially have a 1:1 turns ratio. That is the input and output voltages for the windings are the same.

However, if the 3-phase transformer is connected in star–delta, (Yd) each star-connected primary winding will receive the phase voltage, V_P of the supply, which is equal to $1/\sqrt{3} \times V_L$.

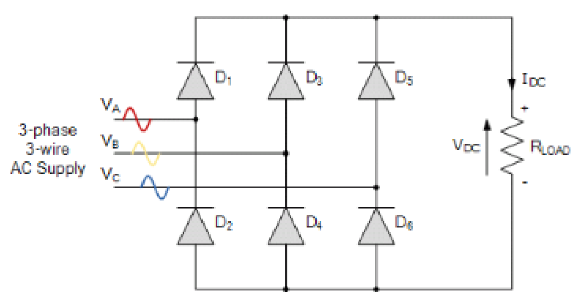
Then each corresponding secondary winding will then have this same voltage induced in it, and since these windings are delta-connected, the voltage $1/\sqrt{3} \times V_L$ will become the secondary line voltage. Then with a 1:1 turns ratio, a star–delta connected transformer will provide a √3:1 step-down line-voltage ratio.

Three-phase Transformer Line Voltage and Current:

Star - Star	$V_L \Rightarrow nV_L$	$I_L \Rightarrow \frac{I_L}{n}$

Where: n equals the transformers "turns ratio" (T.R.) of the number of secondary windings N_S, divided by the number of primary windings N_P. (N_S/N_P) and V_L is the line-to-line voltage with V_P being the phase-to-neutral voltage.

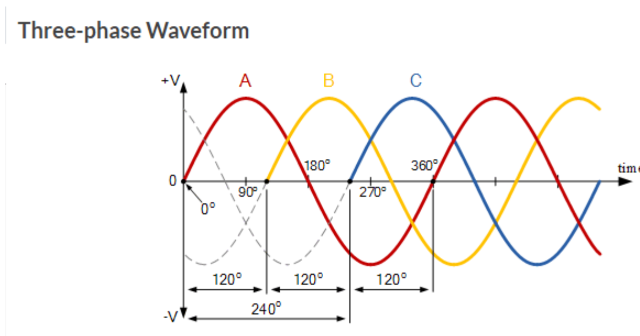
➢ THREE PHASE BRIDGE RECTIFIER:



Circuit diagram

Three Phase Rectification: 3-phase rectification is the process of converting a balanced 3-phase power supply into a fixed DC supply using solid state diodes or thyristors. In fact, rectification of alternating voltages is one of the most popular applications of diodes, as diodes are inexpensive, small and robust allowing us to create numerous types of rectifier circuits using either individually connected diodes or with just a single integrated bridge rectifier module. Single phase supplies such as those in houses and offices are generally 120 Vrms or 240 Vrms phase-to-neutral, also called line-to-neutral (L-N), and nominally of a fixed voltage and frequency producing an alternating voltage or current in the form of a sinusoidal waveform being given the abbreviation of "AC". Three-phase rectification, also known as poly-phase rectification circuits are similar to the previous single-phase rectifiers, the difference this time is that we are using three, single-phase supplies connected together that have been produced by one single three-phase generator.

The advantage here is that 3-phase rectification circuits can be used to power many industrial applications such as motor control or battery charging which require higher power requirements than a single-phase rectifier circuit is able to supply. 3-phase supplies take this idea one step further by combining together three AC voltages of identical frequency and amplitude with each AC voltage being called a “phase”. These three phases are 120 electrical degrees out-of-phase from each other producing a phase sequence, or phase rotation of: $360^o \div 3 = 120^o$ as shown.



Having seen that a 3-phase supply is just simply three single-phases combined together, we can use this multi-phase property to create 3-phase rectifier circuits. As with single-phase rectification, three-phase rectification uses diodes, thyristors, transistors, or converters to create half-wave, full-wave, uncontrolled and fully-controlled rectifier circuits transforming a given three-phase supply into a constant DC output level. In most applications a three-phase rectifier is supplied directly from the mains utility power grid or from a three-phase transformer if different DC output level is required by the connected load. As with the previous single-phase rectifier, the most basic three-phase rectifier circuit is that of an uncontrolled half-wave rectifier circuit which uses three semiconductor diodes, one diode per phase as shown.

In our project we have 12V, 0.5A from each transformer and we consider it as input. The three phase bridge rectifier converts this three phase AC voltage at the input to a DC voltage at the output. As result we get 12V DC as output.

➢ DC-LINK CAPACITOR :

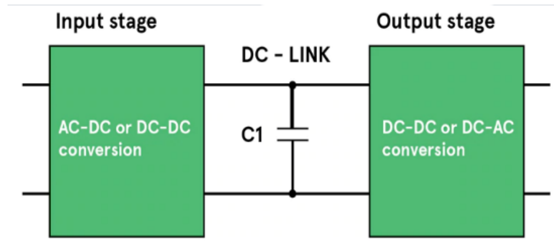
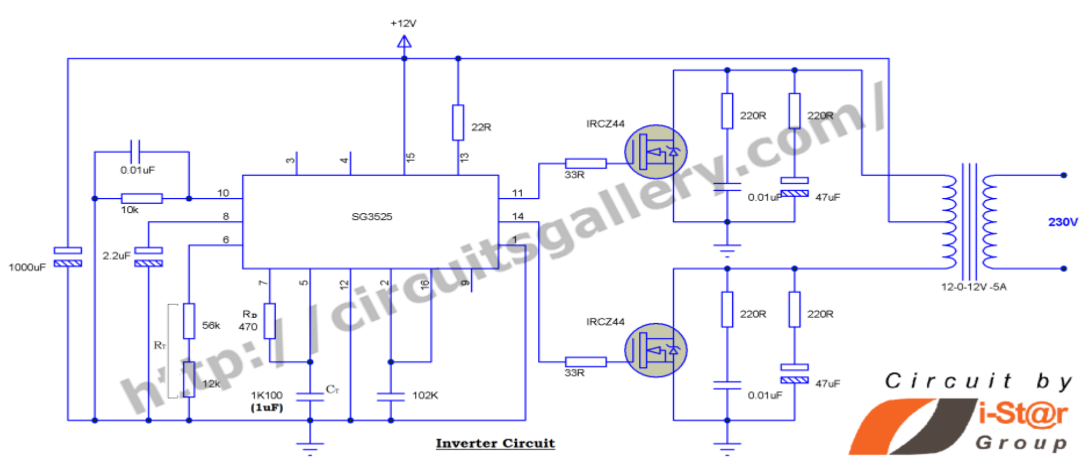


Figure 1: Position of DC-link capacitor

In applications from the simplest cell-phone charger to grid-tied inverters operating at hundreds of kW, power conversion schemes are used which incorporate an intermediate stage where energy is processed at DC. A 'DC-link' capacitor is fitted at this point to provide a low impedance path for high frequency switching currents and to provide energy storage. The input stage can be as simple as a rectifier off an AC line input voltage or it may be a power factor correction (PFC) circuit which generates a constant high voltage DC. The DC-link capacitor acts as the PFC stage output filter, absorbing switching currents for minimum ripple voltage. The output stage could be a switched mode converter or inverter taking bursts of high frequency current from the DC-link capacitor. The capacitor has to be sized to meet specifications for ripple voltage at the DC-link and energy storage between mains cycles or when input power is lost. This means it should have a low equivalent series resistance (ESR) and a minimum capacitance and ripple current rating. For low power AC-DC converters with no PFC stage, minimum capacitance is normally set by the allowed mains ripple voltage on the DC-link. In our project we use 1000μF, 25V DC-link capacitor.

➢ SINGLE PHASE INVERTER:

12v to 230v Inverter Circuit Schematic using Pulse Width Modulator IC SG3525:



Here we are mainly using the internal oscillator of PWM SG3525.

IC SG3525 is a pulse width modulator integrated circuit which has the following features:

- Wide operating voltage range from 8 to 35V
- Inbuilt oscillator and frequency range 100HZ to 500KHz
- Input and output synchronization terminals
- Variable dead time controller
- Soft-start facility
- Smooth shut down facility
- Input voltage checking facility
- Dual source/sink output driver

Components Required:

1. IC SG3525
2. MOFFETS IRFZ44N ×2
3. Resistors (12Ω×7, 47kΩ×1, 4.7kΩ×1, 5.1kΩ×1, 10kΩ×1, 1kΩ×1)
4. Capacitor (222m,2kV×2, 4.7µF,50V×2, 1000µF,25V×1, 1000Pf,630V×1)
5. Transformer 24-0-24V /5A
6. Push switch (5A-40A,250V×1)
7. Fuse (16V×1)
8. IN4148×2
9. BY299×4
10. IN5400×1
11. BC-547×1
12. Heat sink×2
13. LED×2

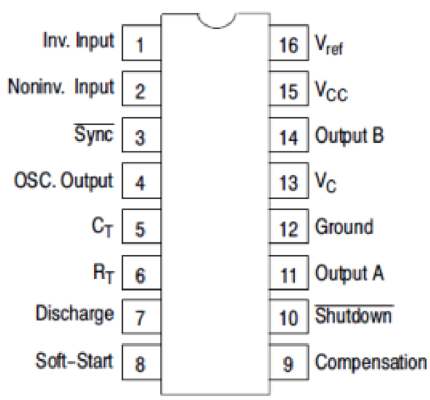
Working of 100 watt inverter circuit diagram:

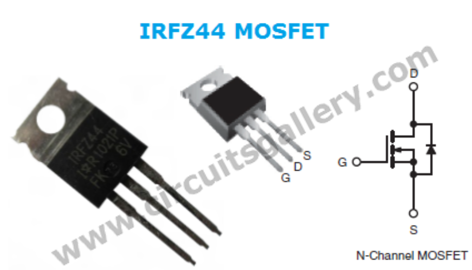
- SG3525 has an inbuilt oscillator whose frequency can be determined by connecting capacitor and resistor on pin 5 and pin 6 respectively.
- The frequency of oscillation can be calculated by the equation

$$f = \frac{1}{C_T(0.7\,R_T + 3\,R_D)}$$

- Output is taken from pins 11 and 14 which are connected to the gates of Mosfets.
- Pins 11 and 14 operate as totem pole configuration or a push pull manner. It never turns ON two pins at the same time.
- The signal from two pins 11 and 14 are connected to the gates of power Mosfets IRFZ44N which switch current to each winding of the transformer.
- Only one winding is activated at a time and both are energized in opposite directions.
- Activation of winding in opposite direction helps to produce an alternating EMF and thus alternating current (AC) on the secondary of the transformer.
- The frequency of the output AC is 50Hz which is determined by the CT and RT pins of SG3525 (pin 5 and 6).

Components Pin out:

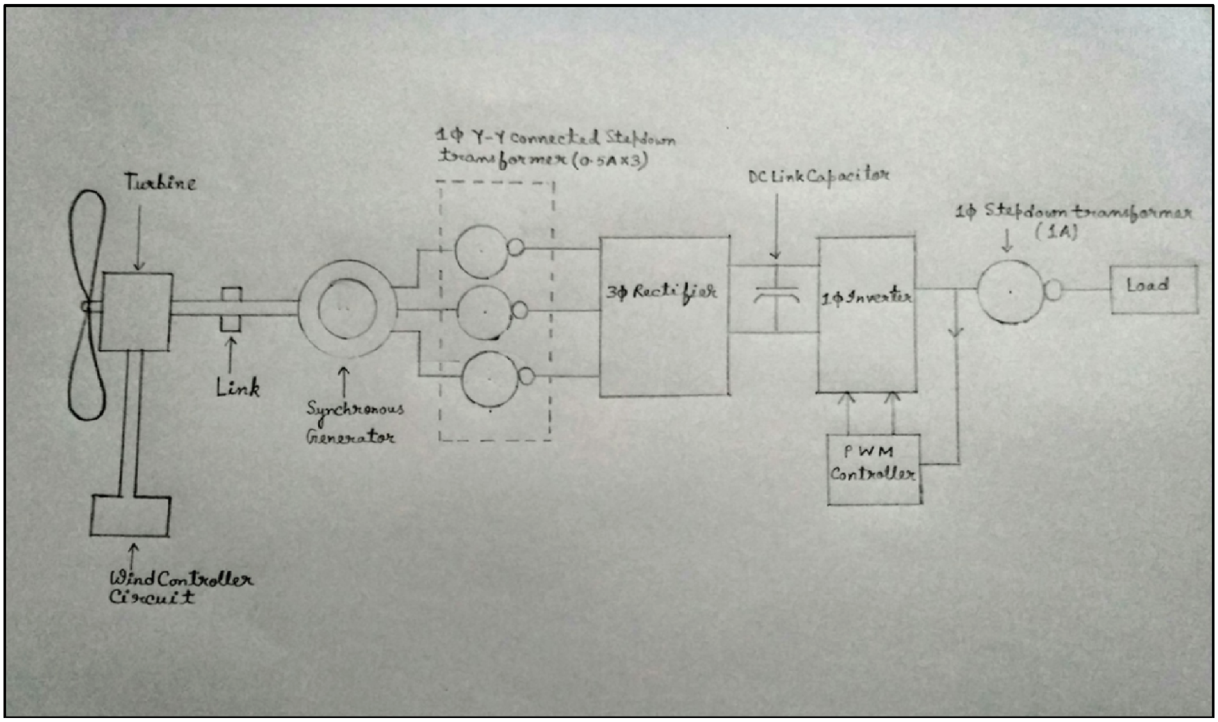




METHOD OF ANALYSIS

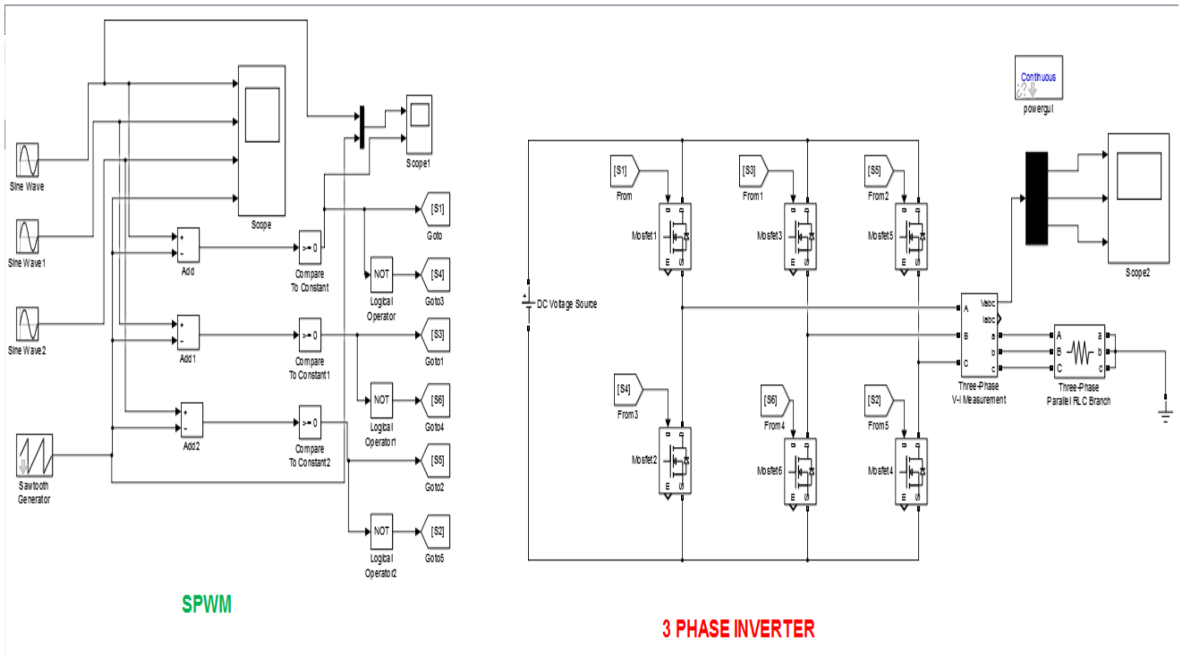
- First we have to select the supply of renewable energy source and we choose wind supply as our mentor suggest. But due to lack of availability of source of wind we make it prototype and give a 3-Ph supply from college lab as a output of wind turbine and synchronous generator output (PMSG).
- To make it suitable range for the rectifier input and rectification range we take 3, 1-Ph transformers each rated to 230V/(12-0-12)V/0.5A connected in each phase of a 3-Ph diode bridge rectifier with (Y-Y) connection as protection purpose.
- The rectified output contains some ripples, that's why we use an appropriate range capacitor to damp out the ripples and get a stable DC output. We can vary this voltage through a autotransformer (variac) as wind supply varies upto a certain range.
- Then we have designed a fast 3-Ph MOSFET triggered inverter bridge with SPWM controller in software (MATLAB) to change this DC into a ripple free AC (modulated). But due to lack of cost (cost efficiency) we have planned to make a 1-Ph PWM controlled inverter (I/P=12V, O/P=230V AC) to convert this DC to suitable AC by using (SG3525A) PWM controller.
- For filtration purpose we use suitable capacitors inbuilt into the inverter circuit and tripping elements in case of heavy load or supply voltage.
- These AC output is stepped down to a 230V/(12-0-12)V/1A transformer for connecting loads and in this way we can synchronized this input (non-conventional energy) to a certain stable voltage output which we cannot be varied in wide range if the input (wind power) changes and this voltage is also represented graphically.

CIRCUIT DIAGRAM



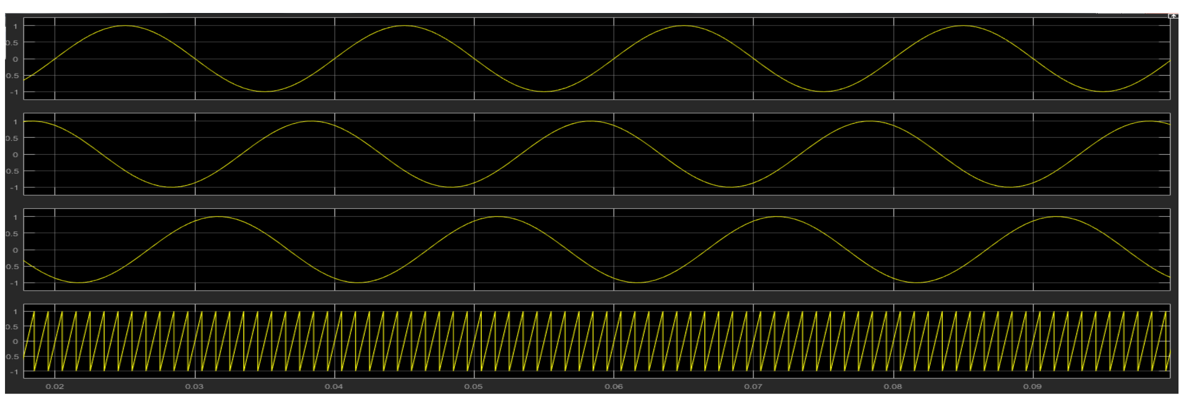
Circuit diagram of synchronization of non-conventional energy source

SOFTWARE MODEL AND OUTPUT

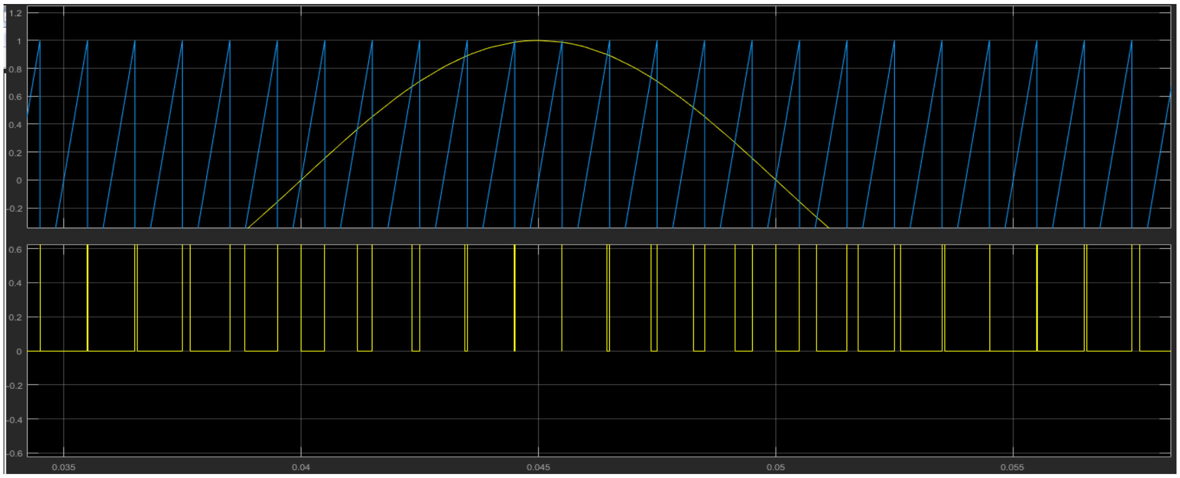


Simulink circuit diagram of SPWM & 3-phase inverter

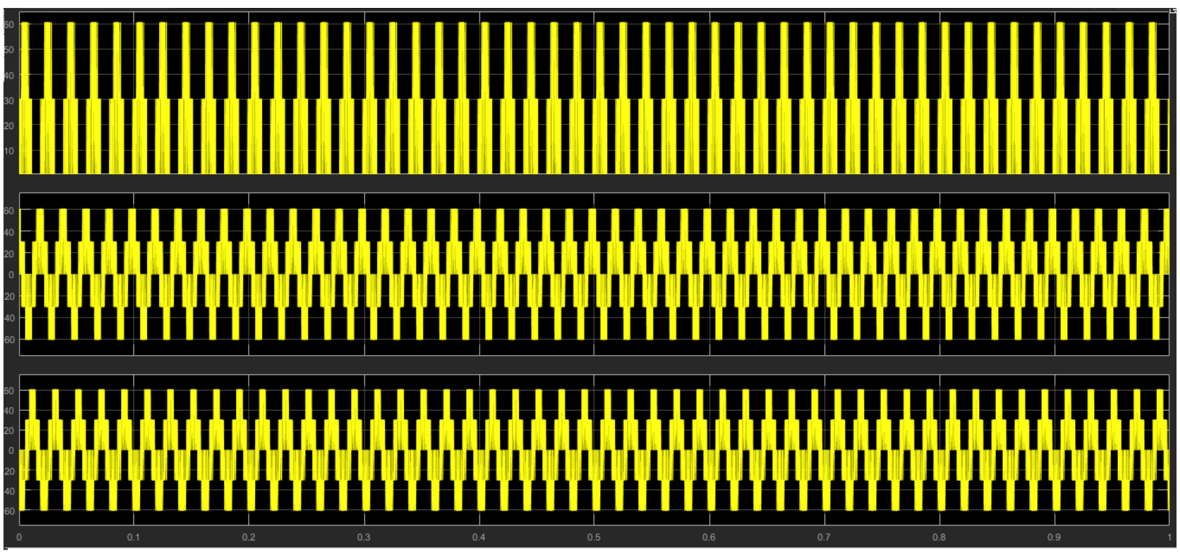
In our project at first we assemble a simulink circuit diagram of 3-phase inverter with SPWM in MATLAB but due to cost efficiency we have used 1-phase inverter with SPWM rather than 3-phase inverter with SPWM. The output/graphical plots are shown below:



3- phase supply O/P plots



O/P plot of SPWM



O/P plots of 3-phase inverter

CALCULATIONS AND RESULTS

- CALCULATION FOR TRANSFORMER (0.5A) [230V/(12-0-12)V/0.5A]:

MEASURED:

I/P= 110V (AC)
O/P=6.6V (AC)
Current= 0.5A

CALCULATED:

I/P= 110V
O/P (V_0) = n × V_S= 0.0795×110=8.7V [For star(Y-Y) connection, n= $\frac{Ns}{Np}$]

- CALCULATION FOR RECTIFIER:

MEASURED:

I/P= 6.2V (phase)
O/P= 13.8V DC
Current= 0.02A/phase

CALCULATED:

I/P= 6.6V (phase) on V_L= $V_0\sqrt{3}$= 11.58V (phase)
O/P (V_{out})= V_P × 2.33909= 6.6 × 2.33909= 15.437V

- MEASUREMENT OF DC-LINK CAPACITOR:

I/P= 13.8V DC
O/P= 12.6V (stable)

- CALCULATION FOR INVERTER:

I/P= 12.5V (DC)
O/P= 30V (AC)
Current= 1.78A (AC)
Frequency= 50Hz

- CALCULATION FOR TRANSFORMER (1A) [230V/(12-0-12)V/1A]:

MEASURED:

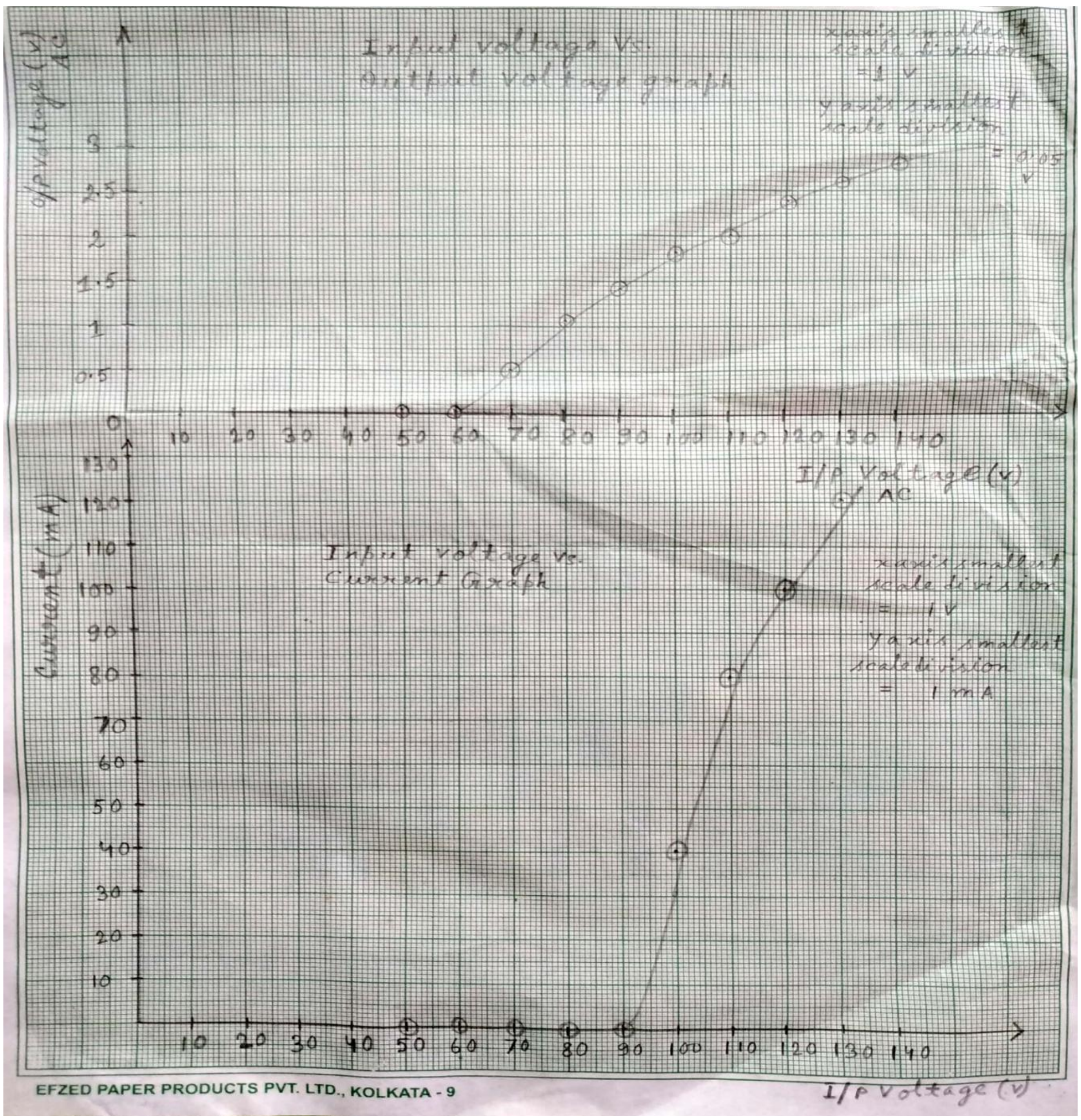
I/P= 26V
O/P= 2.5V
Current= 0.1A

CALCULATED:

I/P= 26V
O/P (V_0) =V_P × n= 26 × 0.0795=2.067V
[n= $\frac{Ns}{Np}$]

OBSERVATION TABLE:

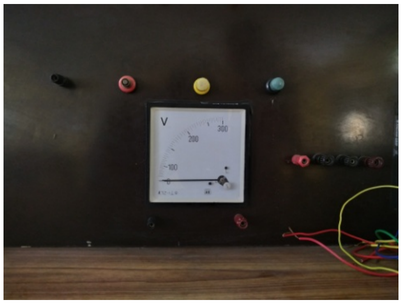
Sl. No.	I/P Voltage (V) AC	O/P Voltage(V) AC	Current (mA)
1	50	0	0
2	60	0	0
3	70	0.5	0
4	80	1.03	0
5	90	1.4	0
6	100	1.8	40
7	110	2.0	80
8	120	2.35	100
9	130	2.60	120
10	140	2.85	140



Output plots of I/P voltage Vs. O/P voltage and I/P voltage Vs. O/P Current

HARDWARE MODEL WITH SPECIFICATION OF COMPONENTS

- **3-PHASE SUPPLY:**



Specification:
Variable AC 415V, 50Hz, 120° Phase difference.

- **VOLTMETER:**

Specification:

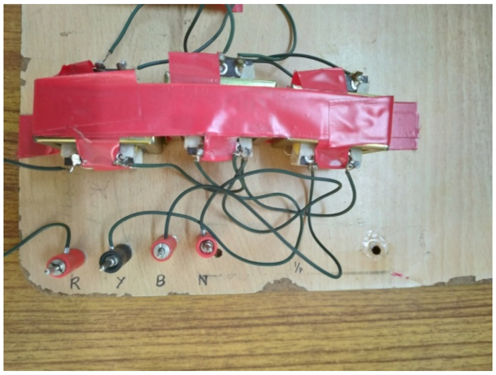
TYPE	RANGE	QUANTITY	MAKERS NAME
Moving iron	0-300V, 0-1A, 50-60Hz	1	Automatic Electric Limited

- **VARIAC:**

Specification:

TYPE	RANGE	QUANTITY	MAKERS NAME
Continously variable Autotransformer	I/P- 415V,3 Ph,50/60Hz O/P- (0-470)V, 3Ph, 50/60Hz Max load- 2A/line	1	Automatic Electric Limited

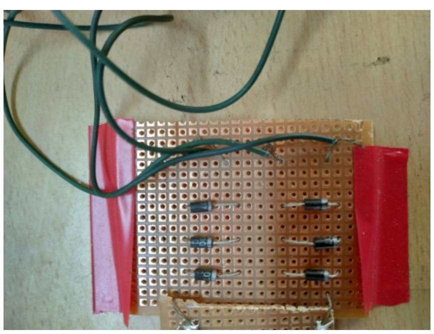
- **TRANSFORMER:**



Specification:

TYPE	RANGE	QUANTITY	FUNCTION
(Y-Y) connected 1-Ph stepdown transformer	I/P- 230V, 50Hz O/P- 12-0-12V, 50Hz 500mA	3	Protection and Stepdown purpose

- **BRIDGE RECTIFIER:**

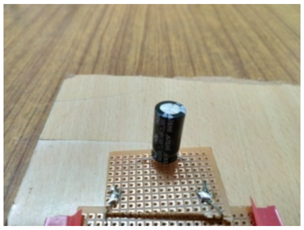


Specification:

Quantity- 1

IN4007 Diodes- 6 (Quantity)

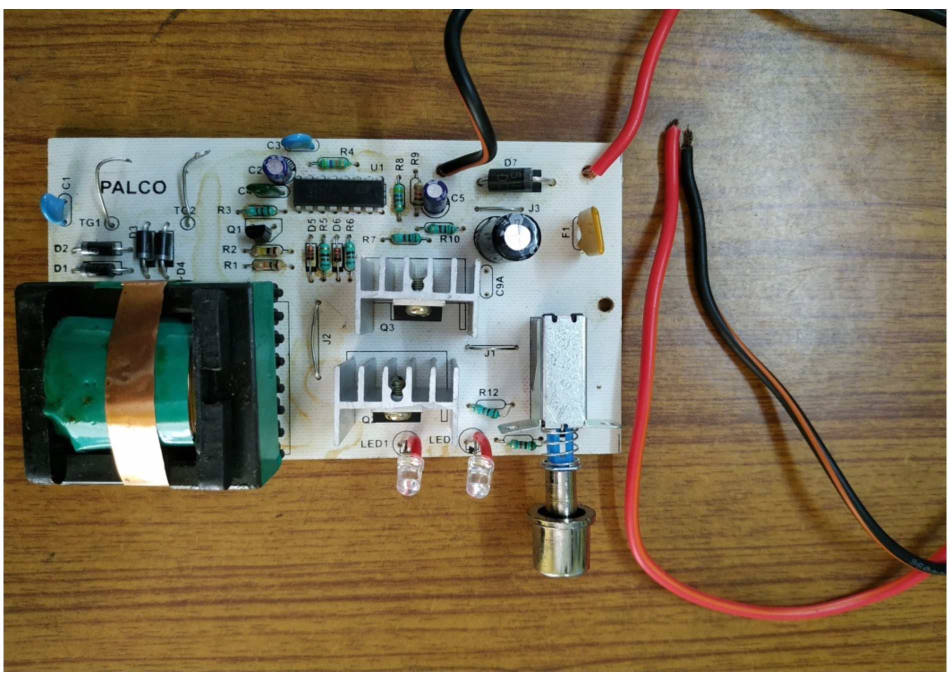
- **DC- LINK CAPACITOR:**



Specification:

RANGE	QUANTITY
1000µF, 25V	1

- **1-Ph INVERTER:**



Specification:

I/P- (12-24)V, 5A, 100Watt

O/P- 230

SPECIFICATION OF THE COMPONENTS OF 1-Ph INVERTER:

1. **TRANSFORMER:**

Specification:

RANGE	QUANTITY
I/P- 24-0-24V,5A O/P- 220V	1

2. **PUSH SWITCH:**

Specification:

RANGE	QUANTITY
250V, (5-40)A	1

3. **CAPACITOR:**

Specification:

COLOUR/SIZE	RANGE	QUANTITY
Blue	222m, 2kV	2
Black, small	50kV, 4.7μF	2
Black, big	25V, 1000μF	1
Green, small (Myler Film Capacitor)	630V, 1000pF 2J102J	1

4. **FRG 700-16F FUSE:**

Specification:

TYPE	RANGE	QUANTITY
Radial Leaded Ptc. Resetlable Fuse	16V	1

5. **HEAT SINK:**

QUANTITY→2

6. **LED (LIGHT EMITTING DIODE):**

QUANTITY→ 2

7. **ZENER DIODE (IN4148):**

QUANTITY→ 2 (D_5-D_6)

Specification:

Forward Current= 150mA

Repetitive Reverse Voltage= 100V

Forward Voltage= 1V

Reverse Recovery Time= 4ns

Forward Surge Current= 2A

8. **BY299 [ULTRAFAST DIODE(SOFT RECOVERY RECTIFIER)]:**

QUANTITY→ 4 (D_1-D_4)

Specification:

Repetitive Reverse Voltage max= 800V

Forward Current= 2A

Forward Voltage max= 1.3V

Reverse Recovery Time max= 70ns

Forward Surge Current max= 250A

No. of pins= 2

9. **IN5400 (POWER DIODE):**

Specification:

RANGE	QUANTITY	FUNCTION
3A	1	Reverse Polarity Protection

10. IRFZ44N (n-channel POWER MOSFET):

QUANTITY→ 2 (Q_2-Q_3)

Specification:

FET Type	MOSFET N-Channel, Metal Oxide
Drain to Source Voltage (Vdss)	55V
Current - Continuous Drain (Id) @ 25° C	49A
Rds On (Max) @ Id, Vgs	22 mOhm @ 25A, 10V
Input Capacitance (Ciss) @ Vds	1800pF @ 25V
Power - Max	110W
Packaging	Tube
Gate Charge (Qg) @ Vgs	62nC @ 10V
Package / Case	TO-220-3
FET Feature	Standard
Lead Free Status	Lead Free
RoHS Status	RoHS Compliant

11. BC-547 (TRANSISTOR):

QUANTITY→ 1 (Q_1)

Specification:

C-E Breakdown Voltage= 45V

Current max (I_c)= 100mA

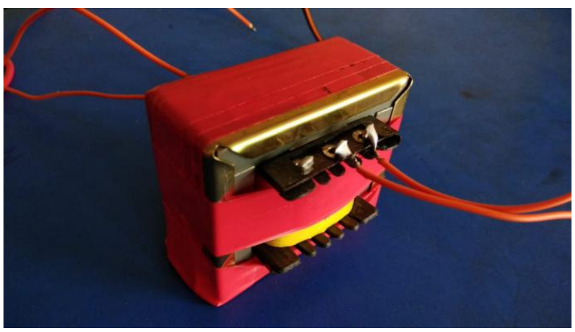
Power max= 625mW

12. RESISTOR:

Specification:

RESISTOR NUMBER	RANGE	QUANTITY
R_3,R_5,R_6,R_7,R_{10},R_{11},R_{12}	12Ω, ±5%	7
R_4	47kΩ, ±5%	1
R_8	4.7k Ω, ±5%	1
R_9	5.1k Ω, ±5%	1
R_2	10k Ω, ±5%	1
R_1	1 k Ω, ±5%	1

13. TRANSFORMER:



Specification:

RANGE	TYPE	QUANTITY
I/P- 230V O/P- (12-0-12)V 50Hz, 1A	Stepdown transformer	1

14. LOAD (40W BULB)

15. CROCODILE PINS:

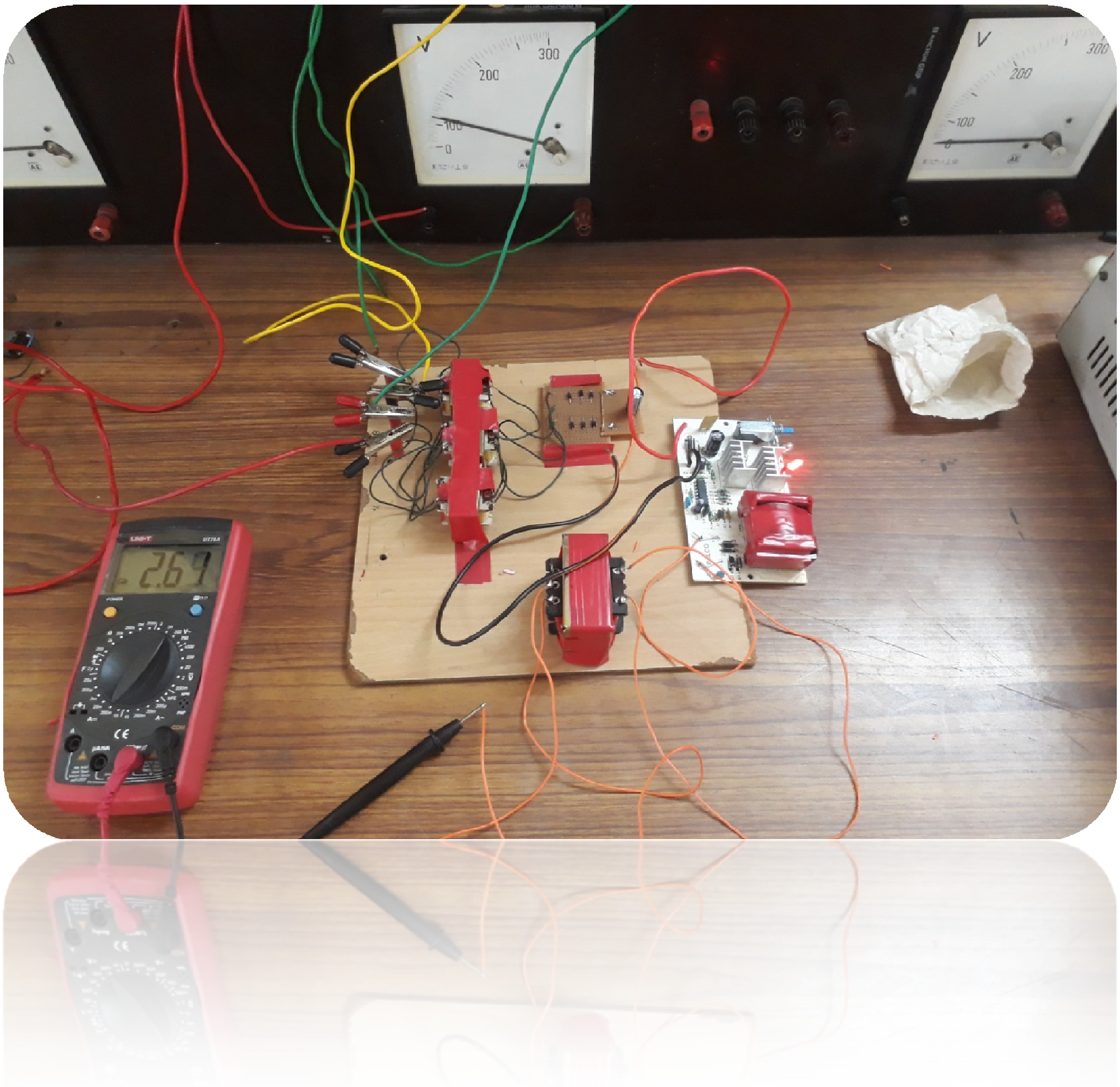
Quantity→ 6

16. CONNECTION WIRES→ as per required

17. MULTIMETER:

18. MCB (MINIATURE CIRCUIT BREAKER):

COMPLETE SETUP



COMPLETE SETUP OF THE HARDWARE MODEL

FUTURE SCOPE

i. Propose new synchronization methods for single-phase systems.

ii. Propose new advanced current controller as well as voltage controller for both single- and three-phase systems.

iii. Investigate the effect of large RES on the dynamic operation of power systems.

iv. Investigate novel control strategies for wind turbine and their effect on distribution networks.

CONCLUSION

In this project we first analyzed the circuit diagram and familiarized with the different components of the circuit like 3-phase rectifier, 1-phase inverter, PWM, PMSG, low pass filter etc. We get the knowledge about the synchronization method. We familiarized with Goto and From block from 2015 MATLAB software. We implemented the SPWM and 3-phase inverter's circuit diagram at simulink and analyzed the different plots. We designed 1-Ph PWM controlled inverter in hardware. Finally we complete our hardware model successfully and get the desired results. We have learnt how small changes in input will change the output and that's the reason why we controlled the input to get a stable output to synchronize with loads.We also know about the future scope of this project.

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