Implementation of Graphical User Interface for Single Area Load Frequency Control

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***Abstract*—Load frequency control issue is being approached by many different techniques by many scholars. But there are many variables that must be considered even for a single area case. Depending upon the type of system and the configuration of equipment used the number of variables in the model changes, which changes the modeling parameters. As a result, the response of the system subject also changes. This makes the choice of control strategy complex. This paper focuses on the graphical aspect of this issue. The building of a user interface of load frequency control enables the user to verify values for different component as well as for different configurations of components in an easy manner. MATLAB provides a great environment to simulate as well as to build an interface. The advantage of using MATLAB GUIDE lies in its easy link-up with the SIMULINK model that has been created. This approach enables the user to analyze different values easily and at a faster rate. This paper deals with a normal single area thermal system and its graphical user interface linking with the model of the system using MATLAB.**

Keywords—Load frequency control; MATLAB; GUIDE; SIMULINK; Graphical User Interface

I. INTRODUCTION

To characterize any system, it is a must to observe its voltage profile, load flow configurations, and its nominal frequency. Any system which violates one of these parameters is considered to be a faulty system. To keep a certain power system in controlled state is a very complex issue to deal with. As it is known that the load is never constant, hence to maintain the coherence in the generation and the demand is difficult. The generation always tries to manage the load which leads to imbalance which reflects in speed and frequency variations. The mismatch in real power leads to fluctuations in frequency whereas in case of reactive power the voltage magnitude gets affected. Hence, both these problems are considered as separate loops and dealt separately [1].

Load Frequency Control only monitors and controls the active power of the system. Constant frequency is the desired characteristic of any given power system. The load frequency control otherwise known as ALFC is one of the automatic generation control loops. The other loop is automatic voltage regulator which is used to control the reactive power of the system. In load frequency control technique, changes in the rotor angle are sensed and the error signal generated is used to increment the torque of the prime mover. Then the required changes are brought in the generator output within the specified tolerance limits [2].

The first step towards understanding load frequency control is preparation and implementation of mathematical models of all the components of a given system. The system can be single area thermal, hydro etc. [3] or it can be a two-area system with both areas having similar configuration or it may be different [4]. The main problem with any system is the number of variables that has to be dealt with while analyzing the behavior of the system. This paper focuses on single area thermal system. It itself contains different configurations due to the components present in the system.

Then, the graphical interface comes into the picture. There are various platforms where an interface can be built. But we chose GUIDE [5] provided by MATLAB. The reason behind this was that, even though there are certain platforms which are better than MATLAB as far as a GUI (Graphical User Interface) is concerned but it is quite difficult to link the model with it. As MATLAB contains tools for both simulation as well as for building an interface, it is quite simple to link them.

The building of an interface helps in achieving an easier access to all the variables. And also, helps in analysis of a larger set of values in a less time. Howsoever complex the model be , the GUI helps in providing simplicity and acquiring faster results. The model configuration can also vary as desired with the help of this interface.

This approach of analysis can also be extended to multi-area problem. This will be helpful to deal with a large amount of data and a wide range of calculations involved in load frequency control. As the control technique differs depending upon the various controllers, the interface can be programmed in order to deal with the type of controller or might be used to compare the response of different control schemes within a same model. This can help in selection of the optimum control strategy which would help in attaining desired response of the system.

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II. SIMULATION OF THE SYSTEM

The normal isolated system contains the components as shown in Fig:1. While considering a thermal system input to the system is steam.

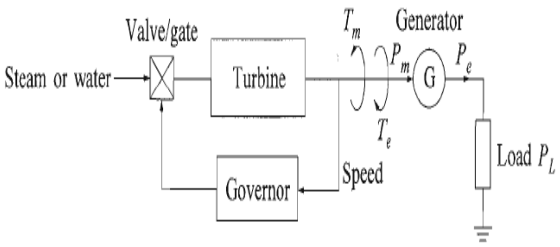

Fig 1: General Blocks in Isolated System [3]

The main components of this system are as follows:

- **Steam Turbine** [1][2][3]

The steam turbine used for simulation is a single reheat tandem compound turbine [6]. The main function of the turbine is to convert the high pressure and high temperature steam to rotating energy which is then converted to electrical energy by with the help of generator. The turbine is further divided into high pressure, intermediate pressure and low pressure sections depending upon the pressure of the steam in a particular section. It also consists of a steam chest, re-heater and cross-over piping sections to deal with loss of steam pressure and temperature.

- **Speed Governor** [1] [4]

The speed governor is a fly-ball speed governor. When the electrical load increases, the electrical power exceeds the mechanical power input. This causes the reduction in the kinetic energy stored in the rotating system. Hence, the turbine speed and consequently the generator frequency fall causing the system to collapse. Thus, the governor helps in maintaining the desirable speed of the overall system. The main parts of the governor are:

- Speed Governor.
- Linkage Mechanism.
- Hydraulic Amplifier.
- Speed Changer.

- **Generator-Load** [2]

The generator-load model gives relationship between the mechanical and the electrical torque, or that between mechanical and electrical power. This is helpful when there is an instantaneous load change which changes the torque of the system.

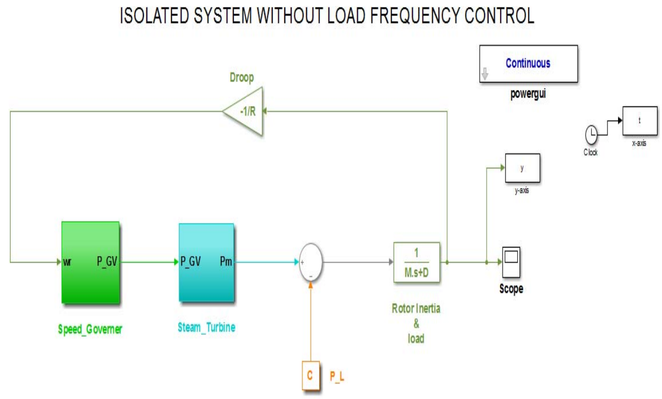

Fig 2: Simulink Model of Single Area System Without LFC

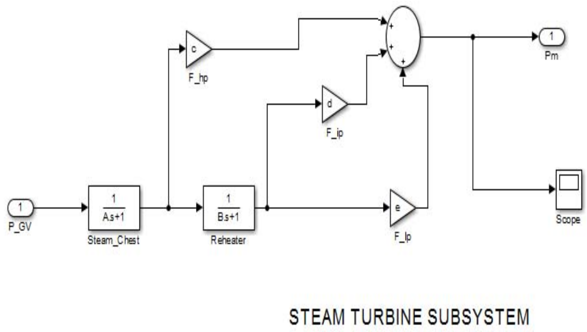

Fig 3: Steam Turbine Sub-system

As shown in Fig 3, the block diagram consists of different parts of steam turbine. Here the cross-over piping block is neglected its time constant is very less as compared to the other components. The output of the governor is input to this block as shown in Fig 2. At every stage, some amount of power is generated which is then added to give the total mechanical output.

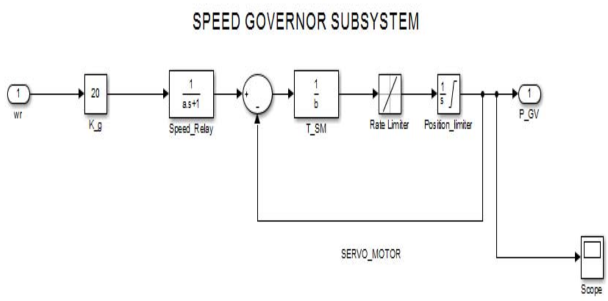

Fig 4: Speed Governor Sub-System

The speed governor system consists of a speed relay block and a speed servo motor block. The rate limiter and the position limiter are used in order to ensure that the operation of the speed governor is within the tolerance limits. As the speed governor is a fly-ball type governor, it has a constant 'K_g' as shown in first block of Fig 4.

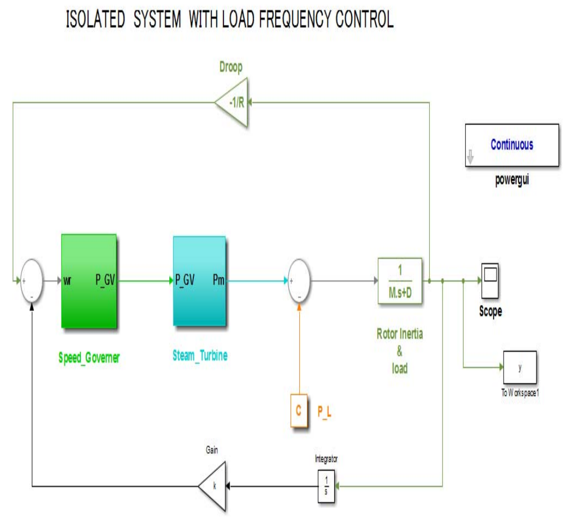

Fig 5: Simulink Model of Single Area System with LFC

The figures Fig1 and Fig4 show the simulation models for both i.e. without load frequency control loop and with load frequency control loop. The simulation is carried out with the help of SIMULINK.

The system consists of two subsystem as it can be seen. One is steam turbine subsystem and the other is speed governor subsystem.The controller used here is a PI controller [7][8]. The control strategy can be different depending upon the type of control needed. Here, the use of a PI controller [9] has provided the desired results. It gives a simpler control scheme.

The results of simulation are shown in Fig 5 and Fig 6.

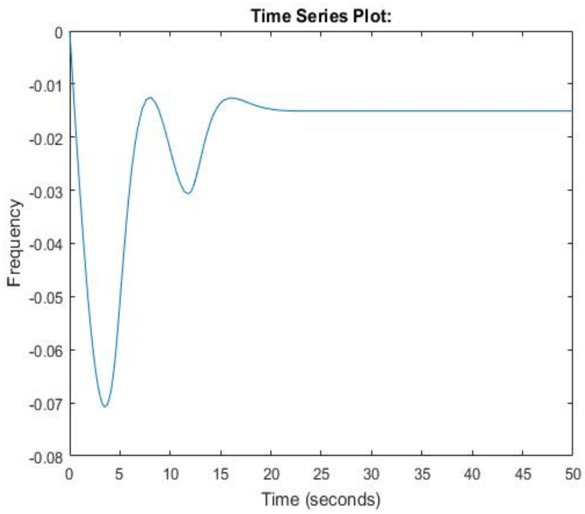

Fig 5: Response of System without LFC

As shown in Fig 5, when the system runs without the load frequency control, the frequency response of the system settles at a negative indicating that the system is unstable due to errors.

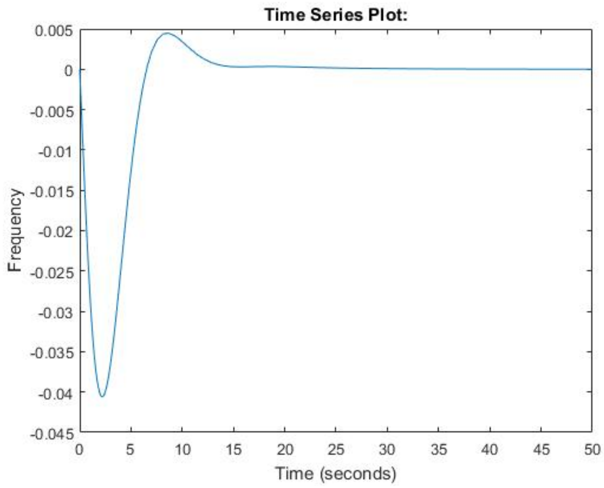

Fig 6: Response of System with LFC

After using the load frequency control loop, it can be seen in Fig 6, that deviation in load causes variation in speed (i.e. frequency) but due to the LFC mechanism the frequency response is settled at zero indicating zero errors.

III. Graphical User Interface for Single Area System

MATLAB Guide [5] is a very unique, but a simple environment for building simple and powerful user interfaces which can be linked to either a model or a script in MATLAB. Hence one can execute different models and scripts at the same time using only one interface, or can link two or more interfaces in order to make it more appealing and productive.

GUIDE, it stands for Graphical User Interface Development Environment [5]. It's a user-friendly space where one can program each element in the interface or simply can "drag and drop" the elements from the menu. Elements include push button, drop down list, radio button etc. One can code the event after the click. Hence once can run a script or simulate a SIMULINK model or do both in only single click. Fig 7 to 9 show the development of the overall interface for the single area load frequency control.

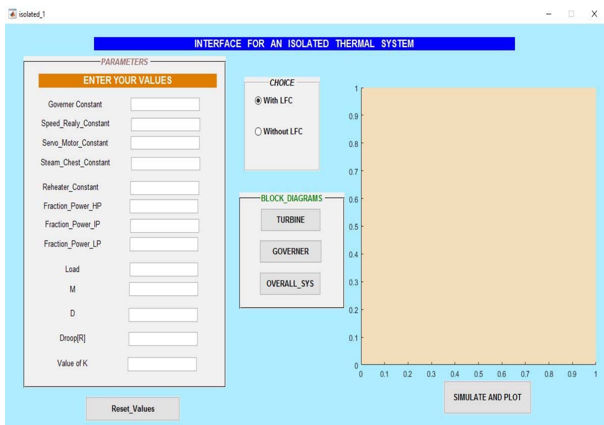

Fig 7: Graphical User Interface for Single Area System

Fig 7 shows the basic layout of the interface. The interface offers both the options of simulating model shown in Fig 1 and in Fig 4. As it can be seen that the number of variables used in the "Parameters" window is the same as that of the SIMULINK model. Hence for a wide range of values for the same system one can easily modify each block by simply changing the corresponding values in the interface. The modified values will be reflected in the model while simulating directly. One can also view the model from the "Block Diagrams" window, or can choose to view sub-systems for some model related modifications.

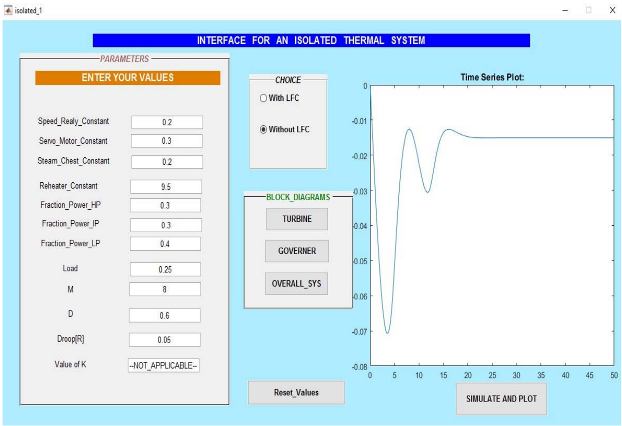

Fig 8: Graphical User Interface for Single Area System without LFC

As shown in Fig 8 the output matches to that of simulated model because the same model is being simulated using a different approach. On selection "Without LFC" option in the "CHOICE" window, the value for the integral constant 'K' automatically becomes "NA". Hence by using only one selection a different model is simulated giving the desired result at a faster rate. This is one type of interface. One can attempt a different design depending upon requirements and number of components.

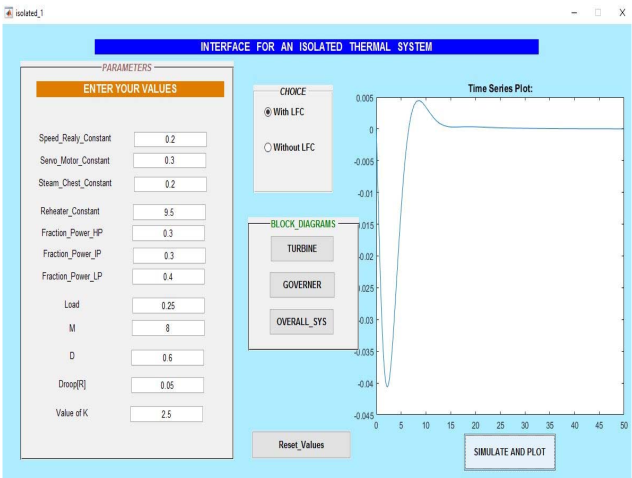

Fig 9: Graphical User Interface for Single Area System with LFC

Similarly, same methodology has followed for LFC of the system. Choosing proper values for all the constants and choice of a proper model provides the user with the desired output.

IV. Conclusion

This type of methodology of using a GUI for frequency control is unique and never been attempted for such type of situation. Though the development of interface and its linking to the model requires some time, this approach is much faster and simpler than the conventional way of simulating the model. Using this technique, the user is able to experiment and analyze wide range of data for all the parameters in less amount of time. The overall system can be extended for analysis of two area or multi area systems. And it is not necessary that the areas used are identical. One can model different areas (e.g. Hydro-Thermal etc.) and develop a common interface. The data which gives desired result can be exported easily to different file format (e.g. Excel) for further purposes. If the user desires, then he can compare two different models or control schemes for the same model in the same interface. Thus, providing an option for accurate, better performing and an efficient system. The use of MATLAB not only makes it easy to understand the interface but also keeps the possibility of optimization of the overall system intact.

V. Future Scope

This methodology of using Graphical User Interface can be used for multiple systems . And even if the configurations of the system tend to be different, one can perform analysis without any difficulty.

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Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS 2017)
IEEE Xplore Compliant - Part Number:CFP17M19-ART,ISBN:978-1-5386-1959-9

Calculation and Modeling of Hybrid Power Generation System Using Solar Energy

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Abstract— Electricity is most needed facility for the human being in latest scenario. All the non-renewable energy resources are reducing now a days so we have to shift from non-renewable to renewable energy resources. In this the mixture of two energy resources, i.e. Solar energy and generator. We can give uninterrupted power by using hybrid energy system. This gives the uninterrupted power. Solar panels are used for converting solar energy and generator is used for a holdup power. This electrical power can utilize for various uses. The cost of this system is reasonable. This paper is contracts with generating electricity by two combine energy resources and it generate electricity with a minimum charge.

Keywords—- ***electricity, hybrid, solar, power, generator***

I. Introduction

Electricity is most needed for our everyday lifespan. There are two ways of electricity generation either by non-renewable energy resources or by renewable energy resources. Now a days the demand of electricity is increases in the world so to fulfill demand we have to produce electrical energy. [1] Now a day's electrical energy is produced by the non-renewable energy resources like coal, diesel, and nuclear etc. The expenditure of the non-renewable plants is very high in price and it also harms the environment. The nuclear renewable energy resources are reduce grad ual ly. The new source should be reliable, pollution free and inexpensive. [10]There are many renewable energy resources like geothermal, tidal, wind, solar etc. the tidal energy has disadvantages like it can only applied on sea shores. While geothermal energy wants very lager step to extract heat from earth. Solar and wind are easily available in all situation. The Renewable energy resources like solar, wind can be good alternative source. Solar energy has disadvantage that it could not produce electrical energy in raining and gloomy season so we need to overcome this disadvantage we can use two energy resources so that any one of source fails other source will keep generating the electricity. And in good weather situation we can use both sources combine. [2]

II. Hybrid energy scheme

Hybrid energy scheme is the mixture of two energy sources for giving power to the load. In other word it can defined as "Energy system which is fabricated or designed to extract power by using two energy sources is called as the hybrid energy system or scheme." Hybrid energy system has good consistency, efficiency, less emission, and lesser cost. [3]

In this proposed system solar and generator power is used for producing power. Solar has good advantages than other than any other renewable energy sources. Both the energy sources have greater accessibility in all areas. It needs lesser cost. There is no necessity to find special location to install this system. [10]

1. Solar Energy

Solar energy is that energy which is gets by the radiation of the sun. Solar energy is present the earth uninterruptedly and in abundant manner. Solar energy is spontaneously available. It doesn't produce any gases that mean it is pollution free. It is reasonable in cost. It has less maintenance cost. Only problem with solar system it cannot produce energy in bad weather situation. But it has greater efficiency than other energy sources. It only need primary investment. It has lengthy life span and has lesser emission. [5]

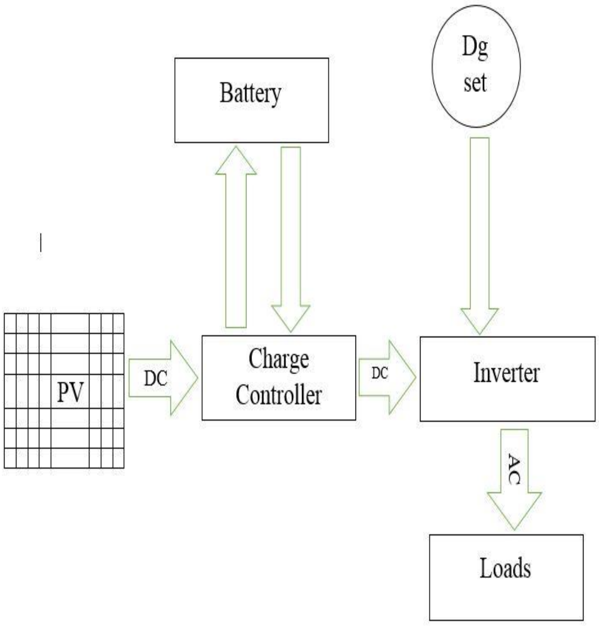

Fig.1 Block Diagram of Solar generator hybrid System

III. Modeling of the System

1. Modeling of Solar-Photovoltaic Generator

Using the solar radiation accessible, the hourly energy output of the PV generator can be calculated according to [4]

$$E_{PV} = G(t) * A * P * \eta_{PV}$$

2. Modeling of Diesel Generator

Hourly energy created by diesel generator with rated power output is distinct by the following expression: [4]

$$E_{DG}(t) = P_{DG}(t) * \eta_{DG}$$

3. Modeling of converter:

In the proposed arrangement, a converter contains both rectifier and inverter. PV energy generator and battery subsystems are linked with DC bus while diesel generating unit subsystem is linked with AC bus. The electric loads connected in this scheme are AC loads. [4]

The rectifier is used to convert the surplus AC power from the diesel electric generator to charge the battery. The diesel electric generator will be powering the load and at the same time charging the battery. The rectifier model is given below: [4]

$$E_{RE\text{-}OUT}(t) = E_{RE\text{-}IN}(t) * \eta_{RE}$$

$$E_{RE\text{-}IN}(t) = E_{SUR\text{-}AC}(t)$$

At any time t,

$$E_{SUR\text{-}AC}(t) = E_{DG}(t) – E_{L}(t)$$

The inverter model for photovoltaic generator and battery bank are given below:

$$E_{PV\text{-}IN}(t) = E_{PV\text{-}IN}(t) * \eta_{INV}$$

$$E_{BAT\text{--}INV}(t) = E_{BAT}(t\text{-}1) - E_{L}(t) / \eta_{INV} * \eta_{DISCHARGING}$$

4. Modeling of Charge Controller:

To stop overcharging of a battery, a charge controller is used to sense when the batteries are completely charged and to stop or decrease the amount of energy flowing from the energy source to the batteries. The model of the charge controller is presented below: [4]

$$E_{CC\text{-}OUT}(t) = E_{CC\text{-}IN}(t) * \eta_{CC}$$

$$E_{CC\text{-}IN}(t) = E_{RE\text{-}OUT}(t) + E_{SUR\text{-}DC}(t)$$

5. Modeling of Battery Bank:

The battery state of charge (SOC) is the cumulative sum of the daily charge/discharge transfers. The battery helps as an energy source entity when discharging and a load when charging. At any time, the state of battery is related to the preceding state of charge and to the energy manufacture and consumption situation of the system during the time from t - 1 to t. [4]

During the charging process, when the whole output of all generators exceeds the load demand, the available battery bank capacity at time t, can be defined by

$$E_{BAT}(t) = E_{BAT}(t\text{-}1) - E_{CC\text{-}OUT}(t) * \eta_{CH}$$

On the other hand, when the load demand is greater than the existing energy produced, the battery bank is in discharging state. Therefore, the existing battery bank capacity at time t, can be expressed **as**

$$E_{BAT}(t) = E_{BAT}(t-1) – E_{need}(t)$$

Let be the ratio of minimum allowable SOC voltage limit to the maximum SOC voltage across the battery terminals when it is completely charged. So, the depth of discharge (DOD) is [6]

$$DOD = (1-d) * 100$$

DOD is a quantity of how much energy has been withdrawn from a storing device, expressed as a percentage of full capacity. The extreme value of SOC is 1, and the minimum SOC is determined by maximum depth of discharge (DOD): [6]

$$SOC_{min} = 1 – DOD / 100$$

IV. Budget of System

1. The Cost of a Component

   The cost of a component includes capital cost, replacement cost, annual O&M cost, emissions cost, and fuel cost (generator). Operation cost is calculated hourly on daily basis [7]

2. Capital Cost

   The investment cost of a system component is equivalent to the total primary capital cost multiplied by the capital recovery factor. Capital cost is calculated using [7]

$$C_{RC} = C_{CAPITAL} * CRF(i,R_{proj})$$

3. Replacement Cost

   The replacement cost of a system component is the value of all the replacement costs occurring during the lifetime of the project minus the salvage value at the end of the project lifetime. Replacement cost is calculated using [7]

$$C_{RC} = C_{RC} * F_{RC} * SFF(i,R_{proj})$$

   A factor arising because the component lifetime can be dissimilar from the project lifetime, is given by

$$F_{RC} = \begin{cases} CRF(i,R_{proj}) / CRF(i,R_{RC}), & R_{RC} > 0 \\ 0, & R_{RC} = 0 \end{cases}$$

   The replacement cost period, is given by

$$R_{RC} = R_{COMP} * INT(R_{proj} / R_{com})$$

   The sinking fund factor which is a ratio used to calculate the future value of a series of equivalent cash flows, is given by [7]

$$SFF(i,N) = i / (1+i)^N - 1$$

   The salvaged value of the component at the end of the project lifetime is comparative to its remaining life. Therefore, the salvage value S is given by

$$S = C_{RC} * (R_{rem} / R_{comp})$$

   The remaining life of the component at the end of the project lifetime, is given by [7]

$$R_{rem} = R_{comp} – (R_{proj} – R_{RC})$$

4. Operational Cost

   The operational cost is the value of all costs and revenues other than initial capital costs and is calculated using [8]

$$C_{occ} = \sum_{t=1}^{365} Coc(t)$$

5. Cost of Emissions

   The following equation is used to calculate the cost of emissions

$$C_{emission} = Cc_{o2}\, Mc_{o2} + Cc_{o}\, Mc_{ov} + C_{UHC}\, M_{UHC} + C_{SO2}\, M_{SO2} + C_{PM}\, M_{PM} + C_{NOx}\, M_{NOx} / 1000$$

Total cost of a component = economic cost + environmental cost, where economic cost = capital cost + replacement cost + operational and maintenance emissions cost.

Price of a Component Is Calculated Using

$$C_{\text{ann-total}} = \sum_{c=1}^{365} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right)$$

Total Cost of a Component Is Calculated Using

$$C_{\text{ann-total,C}} = \sum_{c=1}^{Nc} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right)$$

The economic and ecological cost model through total cost of dissimilar configurations of power system results in the hybridizing of the renewable energy generator (PV) with existing energy (diesel) is given below.

Economic and environmental cost model of consecutively solar + diesel generator + batteries + converter is calculated a [8]

$$C_{\text{ann-total-source+enerator+battery+converter}} = \sum_{s=1}^{Ns} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right) + \sum_{g=1}^{Ng} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right) + \sum_{b=1}^{Nb} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right) + \sum_{c=1}^{Nc} \left(C_{\text{capital}} + C_{\text{RC,C}} + C_{\text{occ}} + C_{\text{emission}} \right)$$

V. CASE STUDY OF SYSTEM

Consider Residential Load is

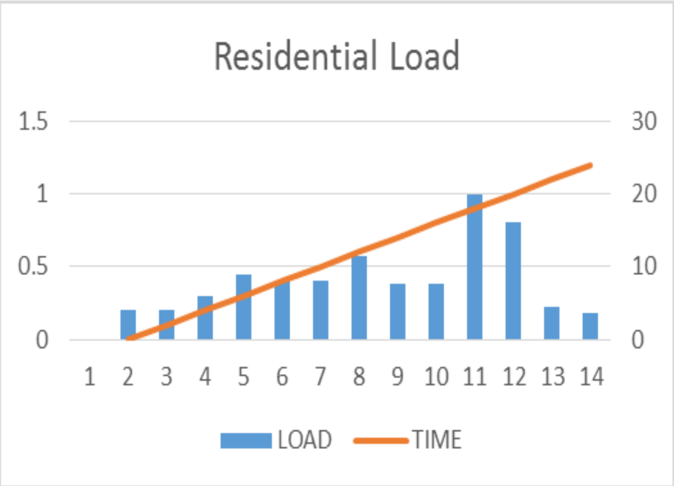

Fig.2 Residential load profile

The system will be powered by 12 Vdc, 110 Wp PV module. [9]

1. Determine the power consumption demands :-
   After calculation our total power consumption is 3000 wh/day
   so, the total PV panels energy needed is,
   = 3000 * 1.3 (the energy lost in system)
   = 3900 wh/day
2. Size of PV panel :-
   Total Wp of PV panel capacity needed,
   = 3900/3.4
   = 1147.05 Wp
   Here we assume 3.4 because to get the total watt Peak rating needed for the PV panels needed to Operate the appliances.
   The number of PV panels needed is,
   = 1147.05/110
   = 10.427 modules
   So, the actual requirement = 11 modules
3. Inverter Rating

   Total watt of all appliances = 950 W
   For safety the inverter should be considered 25-30 % bigger size.
   The inverter size should be about 1000 W or greater.
4. Solar Charge Controller Sizing :-
   PV module specification
   P_m = 110 Wp
   V_m = 16.7 Vdc
   I_m = 6.6 A
   V_{oc} = 20.7 V
   I_{sc} = 7.5 A
   So, solar charge controller rating is,
   = (11 string * 7.5 A) * 1.3
   = 107.25
   Approximate 108 A.
   So, the solar charge controller should be rated 108 A at 12 V or greater.
5. Battery Sizing :-
   The total appliances watt = 3000 wh/day
   Nominal battery voltage = 12 V
   Suppose days of autonomy = x days
   So, battery capacity = 3000/0.85 * 0.6 *12
   = 490.196x Ah
   For, x=1 days = 490.196*1 = 490.196 Ah
   x=2 days = 490.196*2 = 980.392 Ah
   x=3 days = 490.196*3 = 1470.588 Ah
   x=4 days = 490.196*4 = 1960.780 Ah
   x=5 days = 490.196*5 = 2450.980 Ah
   x=6 days = 490.196*6 = 2941.176 Ah

So, we use 5 battery in series.
Here 0.85 = battery loss

0.6 = depth of discharge
12 = nominal voltage

VI. Nomenclature

A : area surface area in m^2
$C_{capital,c}$: capital cost of a component
$C_{RC,C}$: replacement cost of a component
C_{occ} :operating cost of a component
$C_{capital,s}$:capital cost of solar power
$C_{RC,s}$:replacement cost of solar power
$C_{occ,s}$:operating cost of solar power
$C_{capital,g}$:capital cost of diesel generator
$C_{RC,g}$:replacement cost of diesel generator
$C_{occ,g}$:operating cost of diesel generator
$C_{af,g}$:operating cost of diesel generator
$C_{capital,b}$: capital cost of batteries power
$C_{RC,b}$: replacement cost of batteries power
$C_{occ,b}$:operating cost of batteries power
$C_{capital,c}$:capital cost of converter power
$C_{RC,C}$:replacement cost of converter power
$C_{occ,c}$:operating cost of converter power
C_{RC} :Initial capital cost of the component
Cc_{o2} :Cost for emissions of carbon dioxide
Cc_{o} :Cost for emissions of carbon monoxide
C_{UHC} :Cost for emissions of unburned hydrocarbons
C_{SO2} :Cost for emissions of sulfur oxide
C_{PM} :Cost for emissions of particulate matter
C_{NOx} :Cost for emissions of nitrogen oxide
$Cc_o(t)$:the cost of operating component
$E_{BAT}(t-1)$: Replacement cost of the component
$E_{need}(t)$: the hourly load demand or energy needed at a particular period of time
$CRF(i,R_{proj})$: Capital recovery factor
E_{PV} :Energy generated by the PV array
$E_{RE-OUT}(t)$: hourly energy output from recti□er
$E_{RE-IN}(t)$:hourly energy input to recti□er
$E_{SUR-AC}(t)$:amount of surplus energy from AC sources
$E_{DG}(t)$:hourly energy generated by diesel generator
$E_{PV-IN}(t)$:hourly energy output from inverter
$E_{BAT--INV}(t)$: hourly energy output from inverter
$E_L(t)$:Energy supplied to the load (kWh)
$E_{CC-OUT}(t)$: hourly energy output from charge controller, kWh
$E_{CC-IN}(t)$: hourly energy input to charge controller, kWh
$E_{SUR-DC}(t)$:amount of surplus energy from DC source (PV panels), kWh
$E_{BAT}(t)$:energy stored in battery at hour , kWh
E_{MG} :Energy generated by the motor generator (kWh)
G(t) :the hourly irradiance in kWh/m^2
i :Interest rate
INT():the integer function, returning the integer portion of a real value
Mc_{o2} :emissions of CO_2
Mc_o :emissions of CO
M_{UHC} : emissions of unburned hydrocarbons
M_{SO2} :emissions of SO_2
M_{PM} : emissions of particulate matter (PM) (kg/yr)
M_{NOx} : emissions of NO_x
N : Number of years
P : the PV penetration level factor
R_{comp} : Lifetime of the component
R_{proj} : Project lifetime
SFF() : Sinking fund factor
η_{PV} : efficiency of PV generator
η_{DG} : diesel generator efficiency
η_{INV} : efficiency of inverter
η_{CC} : battery discharging efficiency

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Genetic Algorithm, Particle swam Optimization and Differential Evolution Algorithm for optimal hydro generation scheduling

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Abstract- **Optimum scheduling of hydro plants generation is of great importance to electric utilities. Hydro generation scheduling is a nonlinear programming problem. The nonlinearity is due to the generating characteristic of hydro plant, whose outputs are generally a non linear function of water discharge and net hydraulic head. Evolutionary algorithms are popular due to their low convergence time and high accuracy. In this paper the comparison of Particle swam optimization(PSO), Differential Evolution (DE) algorithm and Genetic Algorithm (GA) are use to show the optimal generation scheduling of hydro generation. The comparisons of these methods are shown for four generating plants of hydro here.**

Keywords- Genetic Algorithm (GA), Particle swam optimization (PSO), Differential Evolution (DE) Algorithm, Hydro Generation Scheduling Problem on Daily basis(HGSPDB).

I. INTRODUCTION

As a major source of energy, the proper utilization of hydro sources are an important task. For economic operation of a power system where the hydro plants constitute a significant portion of the installed capacity the efficient utilization of hydro resources plays important role. The optimum scheduling of hydrothermal plants is one of the important planning task in power system operation. The generation scheduling problem consists of deter-mining the optimal operation strategy for the next scheduling period, subjected to a variety of constraints. Determination of daily optimal hydroelectric generation scheduling is a crucial task in water resource management. By utilizing the limited water resource, the purpose of hydroelectric generation scheduling is to find out the magnitude of water releases from each reservoir and hydro plant so that the total benefit of hydro generated energy can be maximized, while the various physical and operational constraints are satisfied. Mathematically Hydro Generation scheduling problem on Daily basis(HGSPDB) is a dynamic, nonlinear and non-convex optimization problem. Nonlinearity occurs due to the nonlinear function of water discharge and net hydraulic head. The main constraints include the cascaded nature of the hydraulic network, the time coupling effect of the hydro sub problem where the water inflow of an earlier time interval affects the discharge capability at a later period of time, the varying hourly reservoir inflows, the physical limitations on the reservoir storage and turbine flow rate, the varying system load demand and the loading limits of hydro plants.

The hydro scheduling problem has been the subject of investigation for several decades and many methods have been applied to solve this problem. Some of these solution methods include decomposition techniques [1], dynamic programming [2], semi-definite programming [3] and concept of non-linear network flow [4]. In recent times, optimal hydro scheduling problems have been solved by different heuristic techniques such as simulated annealing technique [6], evolutionary programming technique [7] etc.

In most real applications of Evolutionary Algorithm (EAs), computational complexity is a prohibiting factor. In fact, this computational complexity is due to fitness function evaluation. Fitness approximation is one of the solutions to overcome this difficulty. However, seemingly simple EA can solve often complex problems; therefore, there may be no direct link between algorithm complexity and problem complexity.

Modern optimization techniques have aroused great interest among the scientific and technical community in a wide variety of fields recently, because of their ability to solve problems with a non-linear and non-convex dependence of design parameters. Several new optimization techniques have emerged in the past two decades that mimic biological evolution, or the way biological entities communicate in nature. Some of these algorithms have been used successfully in many electromagnetism and antenna problems with many constraints and non-linear processes. The most representative algorithms include Genetic Algorithms (GA) [8-9], particle swam optimization (PSO) and the method of Differential Evolution (DE) [10-11].

Particle swarm optimization is a heuristic global optimization method and also an optimization algorithm, which is based on swarm intelligence. It comes from the research on the bird and fish flock movement behavior. The algorithm is widely used and rapidly developed for its easy implementation and few particles required to be tuned.

Particle swarm optimization is a heuristic global optimization method put forward originally by Doctor Kennedy and Eberhart in 1995(Kennedy J,Eberhart R,1995;Eberhart R,Kennedy J,1995) It is developed from swarm intelligence and is based on the research of bird and fish flock movement behavior. While searching for food, the birds are either scattered or go together before they locate the place where they can find the food. While the birds are searching for food from one place to another, there is always a bird that can smell the food very well, that is, the bird is perceptible of the place where the food can be found, having the better food resource information. Because they are transmitting the information, especially the good information at any time while searching the food from one place to another, conducted by the good information, the birds will eventually flock to the place where food can be found. As far as particle swam optimization algorithm is concerned, solution swam is compared to the bird swarm, the birds' moving from one place to another is equal to the development of the solution swarm, good information is equal to the most optimist solution, and the food resource is equal to the most optimist solution during the whole course. The most optimist solution can be worked out in particle swarm optimization algorithm by the cooperation of each individual. The particle without quality and volume serves as each individual, and the simple behavioral pattern is regulated for each particle to show the complexity of the whole particle swarm. This algorithm can be used to work out the complex optimist problems.

To date, Different GA, PSO and DE algorithms have been successfully applied to different problems of HGSP.PSO is a simple yet powerful algorithm that outperforms Genetic GA and DE on many numerical single objective optimization problems. This paper shows that PSO can achieve better results than GAsand DEs on HGSPDB.

The test performed on a four cascaded hydro power plants with multi reservoir for each time interval of a day. Algorithms applied for each and every time intervals and result demonstrated.

II. PROBLEM FORMULATION

A. Notations

For defining HGSPDB following notations are introduced

$P_i(t)$ Power generation of i^{th} plant for t time interval

$P_i^{\min}$ Minimum power generation of i^{th} hydro power plant

$P_i^{\max}$ Maximum power limit of i^{th} hydro plant

$P_D(t)$ Power demand for t time interval

$P_L(t)$ Power loss for time interval t

$Q_i(t)$ Water discharge of i^{th} hydro plant for t time interval

$Q_i^{\min}$ Minimum water discharge for i^{th} hydro plant

$Q_i^{\max}$ Maximum water discharge for i^{th} hydro plant

$V_i(t)$ Reservoir volume of i^{th} hydro plant for t time interval

$V_i^{\min}$ Minimum reservoir volume at the end of time interval

$V_i^{\max}$ Maximum reservoir volume at the end of time interval t

V_i^{start} initial reservoir volume of i^{th} hydro plant at the start of dispatching horizon

V_i^{finish} finial reservoir volume of i^{th} hydro plant at the end of dispatching horizon

H Water head

$x_j,\ y_j,\ z_j$ Discharge coefficients

N Number of hydro plant

t Time index

T Time duration

CR Crossover rate

F Mutation factor

η_c Distribution index of crossover

η_m Distribution index for mutation

B. Objective functions and constraints

In a large interconnected power system various sources of electric energy e.g., thermal, hydro, nuclear etc. are interconnected and attempt is made to optimize the operation of the system in terms of cost of generation to meet a certain load. The efficient scheduling of available energy resources for satisfying load demand has became an important task in modern power systems. The generation scheduling problem consists of determining the optimal operation strategy for the next scheduling period, subject to a variety of constraints. The objective function is to minimize the deviation between hourly load demand and hydro system total power generation throughout the whole day dispatching time horizon, while satisfying all kinds of physical and operational constraints. The equality and inequality constraints is shown in equation number (1)

$$\sum_{i=1}^{N} P_i(t) = P_D(t) + P_L(t) \tag{1}$$

Considering $P_L = 0$ equation (1) becomes $\sum_{i=1}^{N} P_i(t) = P_D(t)$

The objective of the Hydro system generation scheduling problem is to minimize the summation of the deviation between the hourly load demand and hydro system total power generation throughout the whole day dispatching time horizon, while satisfying all kinds of physical and operational constraints. So the HGSP can be expressed as a constrained nonlinear optimization problem as follows:

$$\min\{\sum_{t=1}^{T}[P_D^t - \sum_{i=1}^{N} P_i(t)]^2 \qquad (2)$$

The objective function of equation (2) is subjected to following constraints

- Power Generation limit of hydro plant

$$P_i^{\min} \le P_i(t) \le P_i^{\max} \qquad i = 1,2,...N; \;\; t = 1,2,...,T; \qquad (3)$$

- Water discharge limit of hydro plant

$$Q_i^{\min} \le Q_i(t) \le Q_i^{\max} \qquad i = 1,2,...N; \;\; t = 1,2,...,T; \qquad (4)$$

- Reservoir volume limit of hydro plant

$$V_i^{\min} \le V_i(t) \le V_i^{\max} \qquad i = 1,2,...N; \;\; t = 1,2,...,T; \qquad (5)$$

- Starting and terminating reservoir volume limit

$$V_i^{'} = V_i^{start}, \qquad V_i^{T} = V_i^{finsh} \quad i = 1,2,...,N; \qquad (6)$$

- Hydro performance model equation for water discharge

$$Q_j(t) = x_j P_{j+N(t)}^2 + y_j P_{j+N(t)} + Z_j \qquad m^3 / hour; \qquad (7)$$

C. Hydro power generation characteristics

Any plants generation characteristics depends upon it's input output curve. Turbine efficiency of hydro plant verses water flow shown in Fig 1.It shows that as the flow increases the efficiency of turbine increases.

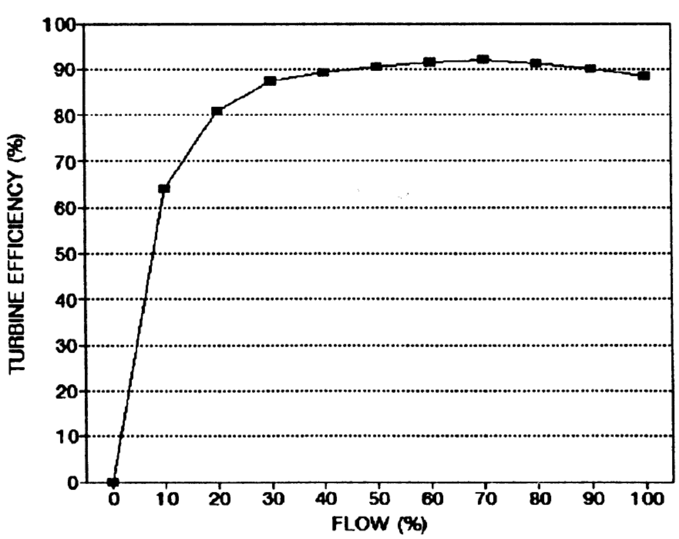

Fig. 1 Characteristics of Turbine efficiency and water flow

If a flow path is a power station, the electrical power generated is computed as a function of the flow and upper and lower reservoir levels. The relation between the net head and the reservoir volume, $H = g(v)$ is determined by the shape of the reservoir[12]. Therefore the characteristic surface can also be stated in terms of water discharge and reservoir volume, $P = f(Q,V)$ which could be non-convex.

III. Evolutionary algorithms(EAs)

The term evolutionary algorithm (EA) is used to designate a collection of optimization techniques whose functioning is loosely based on metaphors of biological processes. This random initialization can be complemented with the inclusion of heuristic solutions in the initial population. The EA can thus benefit from the existence of other algorithms, using the solutions they provide. This is termed seeding, and it is known to be very beneficial in terms of convergence speed, and quality of the solutions achieved . Particle swam optimization(PSO), Genetic Algorithm (GA) and Differential Evolution (DE)[13] Algorithm's are popular evolutionary algorithm.PSO is a simple yet powerful algorithm that outperforms Gas and DEs on many numerical single objective optimization problems.

A. Genetic Algorithm (GA)

By analogy with natural selection and evolution, in classical GA the set of parameters to be optimized (genes) defines an individual or potential solution *X* (chromosome) and a set of individuals makes up the population, which is evolved by means of the selection, crossover, and mutation genetic operators. The optimization process used by the GA follows the next steps.

The step wise Genetic Algorithm for optimal scheduling of hydro generation is outlined below

1. Initialize discharge coefficients x_j, y_j, z_j, convergence tolerance, maximum allowed iterations , length of the string , population size, η_c, η_m, F, CR ,lower and upper bound of power generation, water discharge , reservoir volume.
2. Generating an array of random numbers. Generating the population randomly.
3. Set generation counter, $k = 0$
4. Increment generating counter, $k = k + 1$ and set population counter $j = 0$.
5. Increment population counter, $j = j + 1$.
6. Decoded the string using

$$P_i = P_i^L + \frac{P_i^U - P_i^L}{2^{l_i} - 1} \text{ decoded value of string} \qquad (8)$$

7. Using Gauss elimination method, find $P_i^j (i = 1,2,..., NG)$
8. Find fitness function using $F(x) = 1/(1 + f(x))$ (9)
9. If $j < L$ then GOTO Step 5 and repeat

10. Find population with maximum fitness and average fitness of the population.
11. Select parent for crossover using Roulette wheel selection[14]
12. Perform single point crossover for selected parents.
13. Perform the mutation.
14. If $k < P^{\max}$ then GOTO step 4 and repeat.
15. Stop.

B. Differential evolution (DE) Algorithm

Differential Evolution is a Stochastic Direct Search and Global Optimization algorithm, and is an instance of an Evolutionary Algorithm from the field of Evolutionary Computation. Differential evolution was invented by Ken Price's attempts to solve the Chebychev Polynomial fitting problem in 1996 and in the same year differential evolution was outstanding at the First International Contest on Evolutionary Computation which was held in Nagoya. Differential evolution turned out to be the best evolution type of algorithm for solving the real valued test function. From 1996 to now, Differential evolution has obtained great develop and was applied wildly.

The step wise Genetic Algorithm for HGSP is outlined below

1. Initialize discharge coefficients x_j, y_j, z_j, convergence tolerance, maximum allowed iterations , length of the string , population size, η_c, η_m, F, CR ,lower and upper bound of power generation, water discharge , reservoir volume.
2. Generate an array of ($NG \times L$) uniform random numbers.
3. Set the population counter, $i = 0$, increment the population counter $i = i + 1$.
4. Set the generation counter, $j = 0$, increment the generation counter, $j = j + 1$.
5. Generate population P_i^j.
6. Mutation is done by
$$P_{i,G+1} = P_{r1.G} + F(P_{r2.G} - P_{r3.G}), r1 \neq r2 \neq r3 \neq i \tag{10}$$
7. Target and Trial vectors are set.
8. Cross over using
$$U_{ji.G+1} = \begin{Bmatrix} V_{ji.G+1} & \text{if rand } \leq CR \text{ or } j=rnb(i) \\ P_{j,i.G} & \text{otherwise} \end{Bmatrix} \tag{11}$$
9. Selection using $P_{i.G+1} = \begin{Bmatrix} U_{i.G+1} & \text{if } f(U_{i.G+1}) \leq f(X_{i.G}) \\ P_{i.G} & \text{otherwise} \end{Bmatrix}$
$$\tag{12}$$
10. If $\text{Target } generation < P_{i.G+1}$ GOTO step 6 and repeat
11. Stop

C. Particle Swam Optimization(PSO)

PSO was formulated by Edward and Kennedy in 1995. The thought process behind the algorithm was inspired by the social behavior of animals, such as bird flocking or fish schooling. PSO is similar to the continuous GA in that it begins with a random population matrix. Unlike the GA, PSO has no evolution operators such as crossover and mutation. The rows in the matrix are called particles (same as the GA chromosome). They contain the variable values and are not binary encoded. Each particle moves about the cost surface with a velocity.

Particle swarm optimization uses particles which represent potential solutions of the problem. Each particles fly in search space at a certain velocity which can be adjusted in light of proceeding flight experiences. The projected position of ith particle of the swarm xi, and the velocity of this particle vi at (t+1)th iteration are defined as the following two equations in this study:

$$v_{iD}^{t+1} = K.(v_{iD}^{t} + c_1 r_1 (p_{iD}^{t} - x_{iD}^{t}) + c_2 r_2 (g_{i}^{t} - x_{iD}^{t})) \tag{13}$$

$$x_{iD}^{t+1} = x_{iD}^{t} + v_{iD}^{t+1} \tag{14}$$

where, i = 1, ..., n and n is the size of the swarm, D is dimension of the problem space, c1 and c2 are positive constants, r1 and r2 are random numbers which are uniformly distributed in [0, 1], t determines the iteration number, pi represents the best previous position (the position giving the best fitness value) of the ith particle, and g represents the best particle among all the particles in the swarm. The algorithm of PSO can be depicted as follows:

1. Initialize a population of particles with random positions and velocities on D-dimensions in the problem space,
2. Evaluate desired optimization fitness function in D variables for each particle,
3. Compare particle's fitness evaluation with its best previous position. If current value is better, then set best previous position equal to the current value, and pi equals to the current location xi in D-dimensional space,
4. Identify the particle in the neighborhood with the best fitness so far, and assign its index to the variable g,
5. Change velocity and position of the particle according to Equation (13) and (14).
6. Loop to step 2 until a criterion is met or end of iterations.

At the end of the iterations, the best position of the swarm will be the solution of the problem. It is not possible to get an optimum result of the problem always, but the obtained solution will be an optimal one. it cannot be able to an optimum result of the problem, but certainly it will be an optimal one.

IV. RESULTS

GA ,DE and PSO algorithms for HGSPDB is define by taking following constraint values for plants shown in Fig 2
Population size = 100,
Number of generations = 300,
Size of the mating pool = 100,
Individual crossover probability = 1,
Variable probability for crossover = 1,
Distribution index for crossover = 15,

Variable uniform crossover probability η_c = 0.5,
Individual mutation probability = 1,
Variable polynomial mutation probability = 1/*n*,

Distribution index for mutation η_m = 20.
Mutation factor, $F = 0.48$.

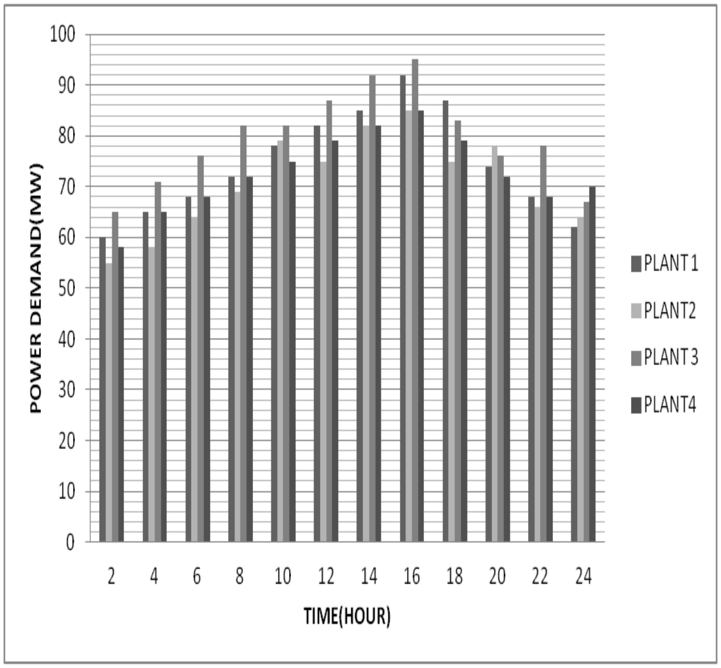

Fig 2 Power Demand of plants for each time interval

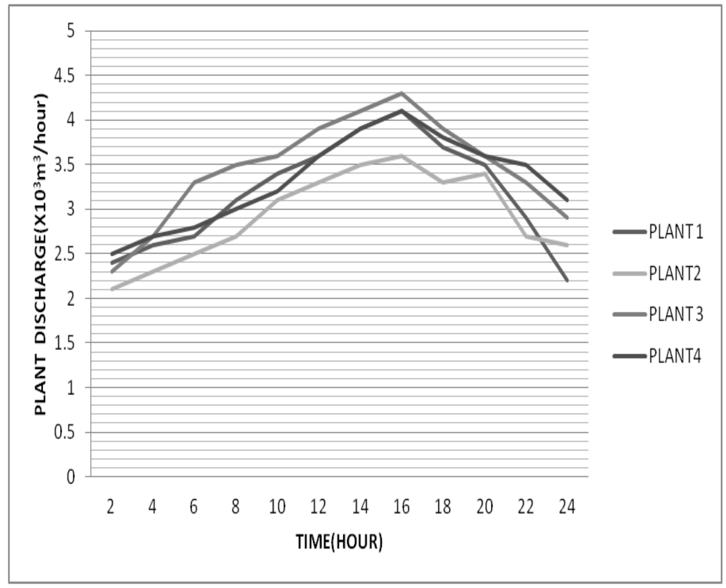

Fig 3 Plant Discharge for each plant

Fig 2 and Fig 3 shows as the demand increase the water discharge also increase. The plant of Fig 2 is optimize using DE,GA and PSO shown in Table 1. The plant water discharge shown in Table 2. The Result is taken after the same iteration applied for GA ,DE and PSO.

Time (hour)	Genetic Algorithm(GA)				Differential Evolution(DE) Algorithm				Particle Swam Optimization(PSO)			
	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)
0-2	61.234	53.876	64.282	56.876	58.985	53.983	63.938	56.984	59.837	54.748	64.482	57.736
2-4	66.567	56.764	70.093	63.367	64.657	56,873	70.938	63.363	64.736	57.564	70.938	64.847
4-6	68.000	63.237	73.582	66.763	67.435	63.752	74.746	66.635	68.000	63.385	75.574	66.968
6-8	73.342	67.764	81.187	71.007	70.987	67.736	81.928	71.000	71.354	68.746	81.981	71.198
8-10	77.743	80.098	80.098	73.973	77.376	77.873	81.837	73.735	77.837	78.376	81.972	74.383
10-12	80.076	74.478	85.598	77.675	80.964	73.837	85.598	77.746	81.283	73.372	86.847	78.847
12-14	84.342	80.098	91.987	80.956	83.357	80.938	90.789	80.048	83.982	80.098	91.918	81.183
14-16	90.975	84.753	93.397	84.497	90.024	84.331	94.487	83.365	91.911	84.473	94.473	84.494
16-18	86.456	73.739	81.987	77.973	86.358	73.383	82.293	77.373	86.467	74.393	82.827	79.000
18-20	72.832	76.378	75.987	70.837	72.694	76.454	75.543	70.938	73.392	78.000	75.594	71.989
20-22	66.983	66.000	77.257	66.783	66.784	65.864	76.645	66.837	66.938	65.583	78.000	68.000
22-24	60.065	62.973	65.875	68.876	63.973	63.093	64.938	68.123	61.193	62.927	66.874	69.847

Table 1 Results after Scheduling of each plant

Time(hour)	GA(m^3/hour)	DE(m^3/hour)	PSO(m^3/hour)
0-2	122.7367	121.8475	121.7363
2-4	129.4440	129.8474	129.0000
4-6	137.7654	136.6964	135.8674
6-8	144.4833	142.8475	142.2342
8-10	165.4844	164.9584	163.9553
10-12	171.1944	170.0383	168.8475
12-14	175.4785	175.3328	173.5968
14-16	178.9785	178.6854	177.7548
16-18	167.7987	166.8575	165.5866
18-20	165.6978	164.9483	163.5876
20-22	163.9686	162.2844	162.1244
22-24	153.9585	152.2847	151.5867

Table 2 Average water discharge calculation of the plants for Each time interval

With respect to the power demand shows in Fig 2, Table 1 shows the generation scheduling of all the 4 plants using GA, DE and PSO.

V. CONCLUSION

This paper illustrated a model of hydro system for scheduling of hydro generation.GA ,DE and PSO are applied to solve the optimal scheduling. The comparison of water discharge for each time interval shown in Table 2 and it's clear that the PSO have the lesser water discharge then GA and DE in a given time interval.

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A Novel Pulse Generation Technique for PFC Half Bridge Boost Converter Fed PMBLDCM Drive

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Abstract— **This paper deals with the pulse generation technique which is apart from the conventional PWM techniques of pulse generation. Generally this technique is used for switching in the half bridge boost converters which are used in PMBLDC motor drive. Half bridge boost converter is used for power factor correction (PFC) in the PMBLDC motor drive. The ON-OFF control of power switches (IGBT's or MOSFET's) of the half bridge converter can be done by this novel technique of pulse generation.**

Keywords—Logic gate, Boost converter, PMBLDC Motor, PWM technique, Triangular wave, Square wave, PFC, PSIM, Hall Sensors.

I. Introduction

In many aspects of our daily life, electric motors play animportant role. PMBLDC motors are generally used in compressor of an air conditioning system due to its features likewide speed range,high efficiency and requirement of low maintenance. The compressor operation with the speed control gives the result of an improved efficiency of the system while consistently maintaining the temperature in the air conditioned zone at the set reference. Nowadays, the air conditioning system mostly uses a singlephase induction motor to drive the compressor. The single phase induction motor achieves maximum efficiency near rated load only, therefore,to regulate the temperature of the air conditioned zone in a hysteresis bandit is operated at either full load means compressor on or not at all (compressor 'off'). The on-off operation which is done frequently results in increased losses and wear-tear of the motor, thereby poor efficiency and reduced life of the motor. The temperatureis maintained constant at the set reference by using a PMBLDCM alternatively with the speed control to drive the compressor of the air conditioner. It results in reduced consumption of electrical energy and maintains the roomtemperatureat set reference efficiently while delivering desired cooling capacity [02].

To replace the function of commutator and brushes, the commutation of the BLDC motor drive is controlled electronically. This whole electroniccontrol circuit involves half bridge boost converter. Half bridge boost converter requires gate pulses to ON-OFF the switches. This pulse Generation technique is having an additional to conventional PWM schemes [06].

For low power equipment the PQ (Power Quality) standardsuch as IEC 61000-3-2require a pure sinusoidal current to be drawn from AC mains by this equipment [01]. Therefore a power factor correction (PFC) circuit is required at the utility interface of any equipmentwhichgenerating harmonics. The half bridge boost converter which is used for power factor correction is connected between DBR and VSIof PMBLDC motor drive circuit. There are many DC-DC converter topologiesavailable amongst which half-bridge boost convertertopology is selected for PFC due to its features of low input current ripple, high-voltage conversion ratio and low conduction loss of switches [4].

II. Fundamentals of PMBLDC Motor Drive

Several Asian countries like Japan, which have been under pressure From the past two decades due to high energy prices, they implemented variable speed PM motor drives for saving energy applications such as air conditioners and refrigerators. Some countries like the U.S.A. has kept on using cheap I.M. drives, which have around 10% lower efficiency than adjustable PM motor drives for energy saving applications. Therefore recently, the increase in energy prices results increasing demands of variable speed permanent magnet motor drives. Also, recent fast proliferation of motor drives into the industries of automobile, based on hybrid drives, generates a serious need for high efficient PM motor drives, and this was the beginning of interest in BLDC motors [4].

Fig. 1: Electromagnet Stator and Permanent Magnet Rotor [3].

Brushless DC (BLDC) motors are synchronous motors having permanent magnets on the rotor and armature windings (Electro magnets) on the stator which is shown in fig.1. Hence, from a construction point of view, they are the inside-out version of DC motors in which the permanent magnets or field windings on the stator and armature windings on the rotor [09]. The most obvious advantage of the brushless type is the removal of the brushes, which eliminates brush maintenance and the sparking which is associated with brushes. BLDC motor is having the armature windings on the stator which helps the conduction of heat from the windings. There are no windings on the rotor, due to it electrical losses in the rotor are minimum [08]. The brushless dc motor compares with induction motors in the fractional horsepower range. The former will have better power factor and better efficiency and, therefore, a high output power for the same frame,because thepermanent magnets contributesthe field excitation and does not have to be supplied by the armature current.

A. Working of PMBLDC Motor

Working of the PMBLDC Motor is explained below. It can be understand by the following Fig. 2.

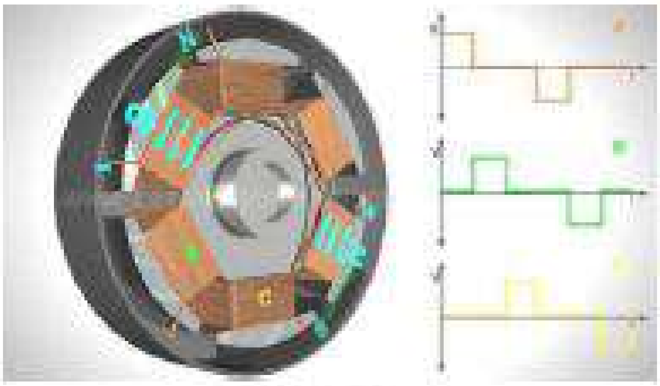

Fig.2: BLDCM Working [3]

a. While apply the dc power to the electromagnetic coil, it will get energized.
b. The Operation of BLDC is based on the simple force interaction between the permanent magnet and electro-magnet.
c. When coil A is energized opposite poles of rotor and stator are attracted to each other.
d. As rotor leaves coil A, coil B is energized.
e. As rotor leaves coil B, coil C is energized.
f. After that coil A energized with the opposite polarity.
g. After that coil A energized with the opposite polarity.
h. This process is repeated and rotor continues rotate.
i. In the whole process the position of rotor sense by three Hall Effect sensors.

III. Half Bridge Boost PFC Converter based PMBLDCM Drive for Air Conditioner

Fig.3 shows detailed diagram of a half-bridge boost PFC converter based PMBLDCM drive where the control loops along with necessary control signals are mentioned for further reference. It has two control loops - speed control loop and voltage control loop. For the speed control of the PMBLDCM proportional-integral (PI) controller is used along with PWM current control through a VSI. The speed control loop begins with comparison of reference speed with speed signal obtained from signals of Hall Effect position sensors of the PMBLDCM.

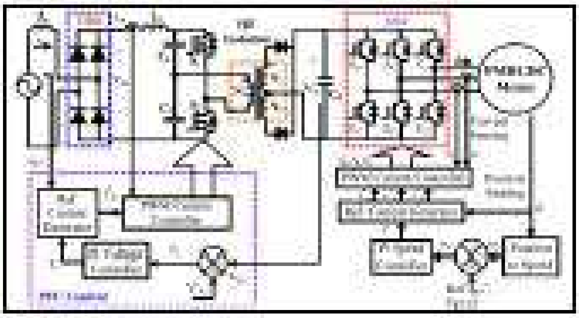

Fig 3: Control scheme of Proposed Half-bridge PFCconverter fed PMBLDCM drive [3]

The resulting error speed is passed through or given to a PI speed controller to achieve the required torque which is converted to an equivalent current using motor's torque constant. This current signal is multiplied with a rectangular unit template which is in phase with motor's back EMF for generation of reference three-phase currents of the motor. These obtained reference motor currents are compared with the motor currents which are sensed to get current error. This error is amplified and compared with triangular carrier wave for generation of the PWM pulses for the VSI switches.

In a half-bridge boost converter, for boost action the switches are operated alternatively with shorting of inductor in between through both switches. The value of Li (Boost Inductor)and D(Duty Ratio) control its DC link voltage. A high switching frequency (fs) is used for reduced size of inductors and transformers and fast control operation. However the switching frequency is limited by the factors like switching devices used, switching losses of the device, operating voltage and power level. MOSFET's (Metal oxide field effect transistors) are used as the switching device for high switching frequency in the proposed converter. However, the IGBT's (Insulated Gate Bipolar Transistors) are used in VSI bridge which is feeding PMBLDCM, as it operates at low frequency compared to the Power Factor Correction (PFC) switches therefore the switching stresses are reduced.

Modeling of the proposed PMBLDCM drive consists of two components:-PFC Converter and PMBLDCM Drive as a main component. PFC converter having 3 major parts-

ISBN : 978-93-5267-370-4

DC link voltage controller, reference input voltage generator and PWM current controller [5].

IV. Modeling of the Pulse Generator Circuit for Half Bridge Boost Converter

Fig.4 shows the pulse generator circuit for the switching for the half bridge boost converter. In the voltage control loop an inner loop is for current control employing current multiplier approach. The half bridge boost converter is operated in CCM with the scheme of average current control to maintain the constant DC link voltage (V_{dc}) with PFC action. The voltage controller is a PI controller which processes the voltage error generated after comparison of the sensed DC link voltage (V_{dc}) with a reference voltage (V_{dc}*). The resultant modulating current signal from voltage controller is multiplied with a unit template (u) of input AC voltage and compared with DC current sensed after the DBR resulting in a current error. This current error is amplified and used in the following circuit to generate the PWM pulse for the devices of the half-bridge boost DC-DC converter.

This technique is different from the previous techniques. In previous techniques current error is amplified and compared with saw-tooth which is carrier wave of fixed frequency (f_s) to generate the PWM pulse for the devices of the half-bridge boost converter. The reference input current of the half-bridge boost converter (i*dc) is compared with the current (idc) sensed after the DBR which results in a current errorΔidc= (i*dc - idc). This current error is amplified by gain kdcand compared with fixed frequency (f_s) carrier waveforms md1(t) and md2(t) as shown in Fig.4 to get the switching signals for the MOSFETs of the PFC half-bridge boost converter as,

If kdc Δidc is greater than md1 (t) then $S1 = 1$ else 0 (1)
If kdc Δidc is greater than md2 (t) then $S2 = 1$ else 0 (2)

where S1, S2 are upper and lower switches of the half-bridge converter as shown in Fig. 4 and the values '1' and '0'

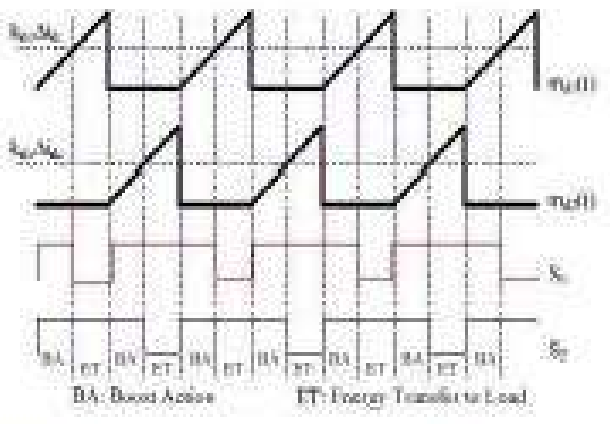

Fig. 4: Pulse generation through conventional PWM techniques [5]

The novel concept of pulse generation is more controlled and suitable for PMBLDC drives. The following fig. 5(A) shows the circuit diagram of the pulse generation circuit.

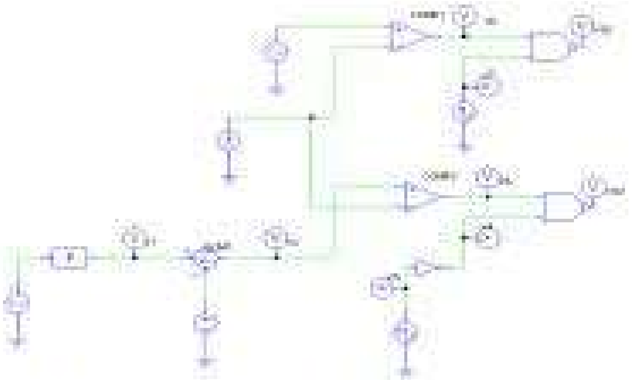

Fig. 5(A): Novel pulse generation technique for half bridge boost converter

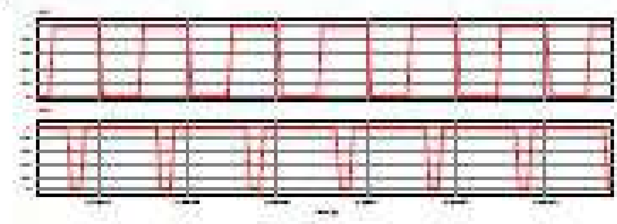

Fig. 5(B): switching signals for the MOSFETs of the PFC half-bridge boost converter

V. Algorithm To Generate Gate Pulses

Step1:- Start

Step2:-Two signals are selected. 1) Triangular Wave (1) 2)DC Signal (1)

Step3:- Triangular wave (1) is connected to Proportional (Gain) block.

Step4:- One Summer block (+/-) is taken.

Step5:- Triangular Wave (1) is connected to Summer block through proportional block at positive terminal.

Step6:- DC Signal (1) is connected to the negative terminal of the summer block directly.

Step7:- Select the Comparator (1).

Step8:- Output of the summer block is given to the non-inverting (positive) terminal of the Comparator (1).

Step9:- DC Signal (2) is taken which is connected to the inverting terminal (Negative) of the comparator (1).

Step10:- NAND gate (1) is selected.

Step11:- One input terminal of the NAND gate is connected to the output of the comparator (1).

Step12:- Now select Square Wave (1) which is connected to another input terminal of the NAND gate (1) through NOT gate.

Step13:- Output signals of NAND gate (1) are the switching pulses which are given to the one MOSFET of the half bridge boost converter.

Step14:- Now Select the Comparator (2) and Triangular Wave (2).

Step15:- Triangular Wave (2) is connected to the non-inverting (positive) terminal of the Comparator (2).

Step16:- DC Signal (2) is connected with the inverting terminal (Negative) of Comparator (2).

Step17:- Now select NAND gate (2).

Step18:- Output of the comparator (2) is connected with the one input terminal of the NAND gate (2).

Step19:- Square Wave (2) is taken which is directly connected to the another input terminal of the NAND gate (2).

Step20:- Output signals of the NAND gate (2) are switching pulses which connected with another MOSFET of the half bridge boost converter.

Step21:- End.

The Whole algorithm can be Understand by the following fig. 5.

1.5 kW,400 V, L_i = 5 mH and C_d = 1600 μF, C1= 15nF, C2= 15nF , f_s = 40 kHz , R=100 Ω

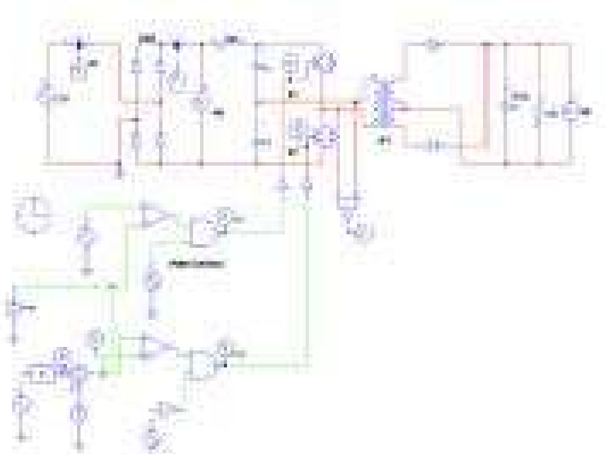

Fig.6: Circuit of Open Loop Control of PMBLDC Motor Drive

Acknowledgement

We are thankful to the GTU who encouragement to us to make this type of project activity in the BE (Electrical) final year. We would like to give heartily thanks to our collage Shroff S.R. Rotary Institute of Chemical Technology (SRICT) to providing a great environment for project work in their premises.

We will be obliged to our guide Ms. Richa Dubeyfor their valuable instructions throughout the work. We would also like to thank to Mr. K.B. Shahfor their suggestions regarding the project.

Conclusion

This paper represents a novel PWM technique for half bridge boost converter used in air conditioning system. In every cycle of pulse, boosting as well as energy transfer action takes place necessary for above application.

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A Pulse Generation Technique for PFC Half-bridge Boost Converters used in PMBLDCM through C-Programming in PSIM

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***Abstract*— This paper deals with the pulse generation technique of PFC converter using C program. Generally this technique is used for switching in the half bridge boost converters which are used in PMBLDC motor drive. Half bridge boost converter is used for power factor correction (PFC) in the PMBLDC motor drive. The ON-OFF control of power switches (IGBT's or MOSFET's) of the half bridge converter can be done by this novel technique of pulse generation. Digital control for BLDC motor drives will help to reduce the cost and complexity of the motor control hardware; this, in turn, can boost the acceptance level of BLDC motors for commercial mass production applications, successfully fulfill the promises of energy savings associated with adjustable speed drives.**

Keywords—Logic gate, Boost converter, PMBLDC Motor, PWM technique, Triangular wave, Square wave, PFC, C-Program, PSIM.

I. INTRODUCTION

In many aspects of our daily life, electric motors play an important role. PMBLDC motors find their uses for compressor of an air conditioning system due to its features like high efficiency, wide speed range and low maintenance requirements. The operation of the compressor with the speed control results in an improved efficiency of the system while maintaining the temperature in the air conditioned zone at the set reference consistently. At present, the air conditioning system mostly uses a single phase induction motor to drive the compressor. The single phase induction motor achieves maximum efficiency near rated load only; therefore, it is operated at either full load (compressor 'on') or not at all (compressor 'off') to regulate the temperature of the air conditioned zone in a hysteresis band. The frequent 'on/off' operation results in increased losses and wear-tear of the motor, thereby poor efficiency and reduced life of the motor. Alternately, the temperature is maintained constant at the set reference by using a PMBLDCM with the speed control to drive the compressor of the air conditioner. It results in reduced electrical energy consumption and efficiently maintains the room temperature at set reference while delivering desired cooling capacity [1]. To replace the function of commutator and brushes, the commutation of the BLDC motor drive is controlled electronically. This whole electronic control circuit involves half bridge boost converter. Half bridge boost converter requires gate pulses to ON-OFF the switches. This pulse generation technique is having an additional to conventional PWM schemes [2].

The power quality standards for low power equipment require a sinusoidal current to be drawn from AC mains by this equipment. Therefore a power factor correction (PFC) circuit is almost required at the utility interface of any equipment generating harmonics. The half bridge boost converter which is used for PFC is connected between DBR and VSI of PMBLDCM drive circuit. There are many DC-DC converter topologies available amongst which half-bridge boost converter topology is selected for PFC due to its features of high-voltage conversion ratio, low input current ripple and low conduction loss of switches [2].

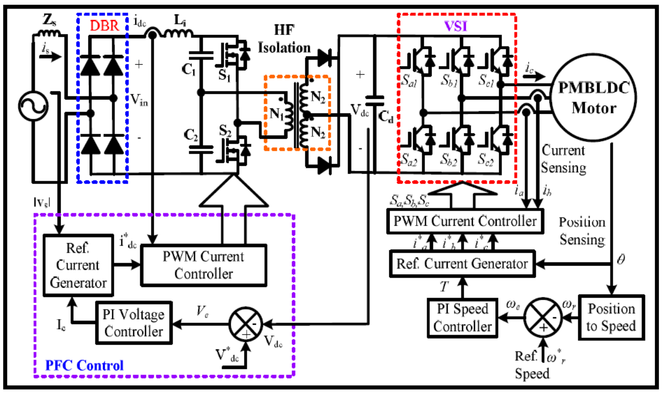


Fig 1: Control scheme of Proposed Half-bridge PFC converter

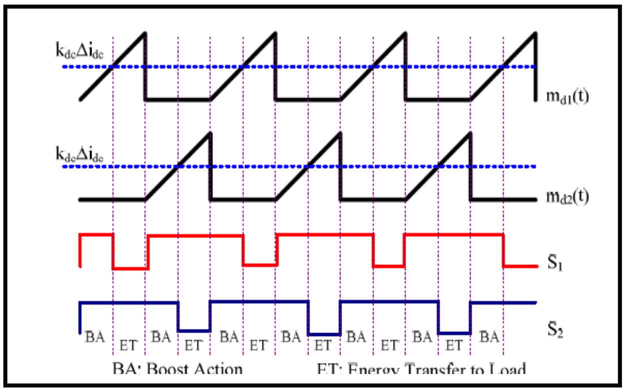


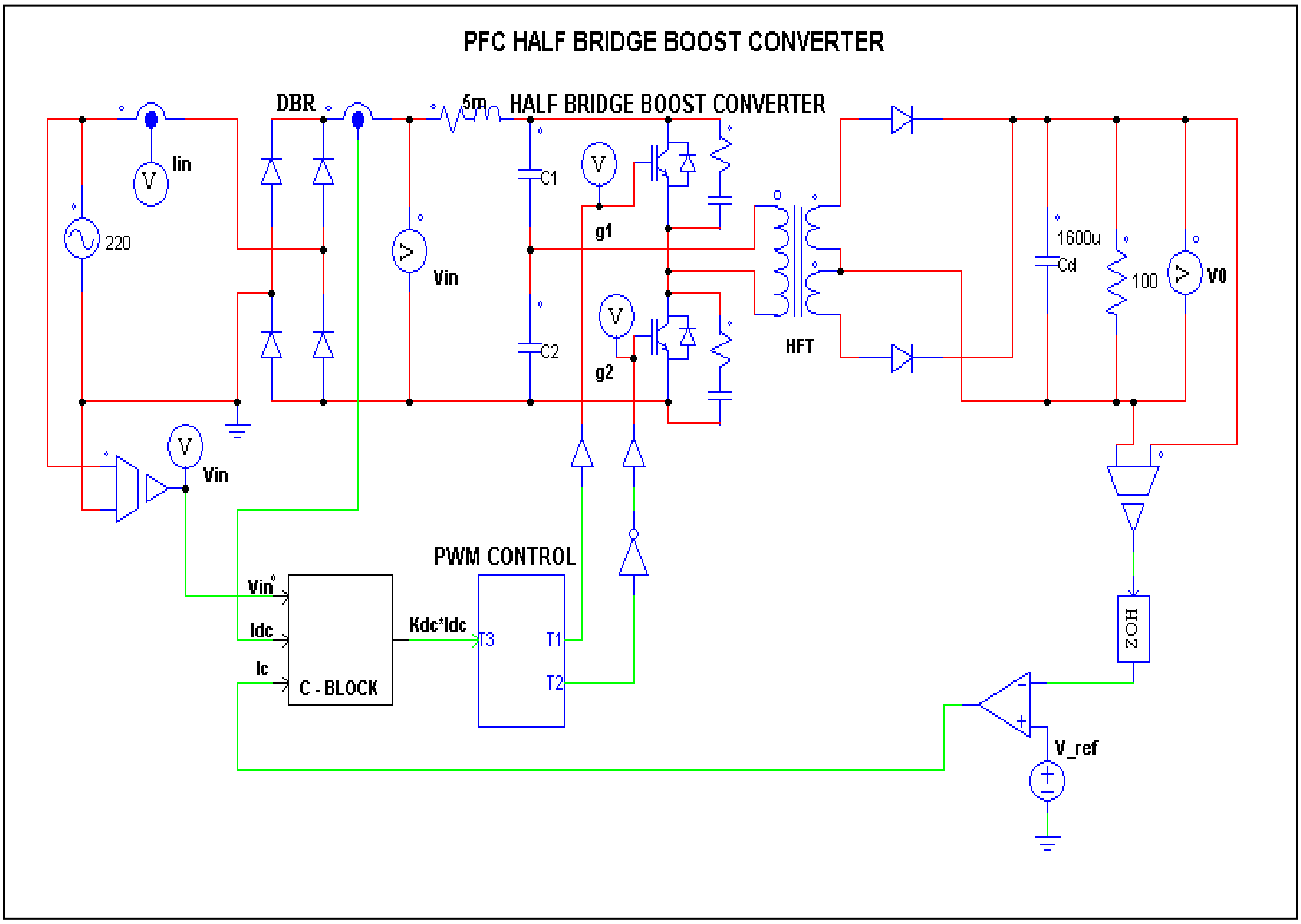
Fig. 2: PWM control of the boost converter.[1]

II. HALF BRIDGE BOOST PFC CONVERTER BASED PMBLDCM DRIVE FOR AIR CONDITIONER [1]

The design values of the PFC half-bridge boost converter for a DC link voltage (Vdc) of 400 V, with Vin = 198 V for Vs = 220 V, the turns ratio (N2/N1)=1, fs = 40 kHz, ΔILi = 0.12A (3% of Iav), ΔVCd = 4V (1% of Vdc), Iav = 4A are calculated as Li = 5 mH and Cd = 1600 μF.

- The output voltage (Vdc) of the PFC half-bridge boost converter is given as,
  Vdc= 0.5 Vin (N2/N1)/(1-D) (1)
- where N1, N2 are the number of turns in primary and secondary windings of the high frequency (HF) transformer, respectively and Vin is the average output DC voltage of a DBR connected to a single-phase AC mains voltage (Vs) given as,
  $Vin = 2\sqrt{2}Vs/\pi$ (2)
- The boost inductor (Li) provides necessary voltage boost for a given peak to peak current ripple (ΔILi) in the inductor for the given switching frequency (fs), given as
  Li= DVin/{4fs(ΔILi).} (3)
- For a constant output voltage of the half-bridge boost converter, a capacitor (Cd) is used to minimize the ripples introduced due to high switching frequency of the converter. Its value is calculated for a specified ripple in output voltage (ΔVCd) given as,
  Cd=Iav/(2ωΔVCd) (4)
- The design values of the PFC half-bridge boost converter for a DC link voltage (Vdc) of 400 V, with Vin = 198 V for Vs = 220 V, the turns ratio (N2/N1)=1, fs = 40 kHz, ΔILi = 0.12A (3% of Iav), ΔVCd = 4V (1% of Vdc), Iav = 4A are calculated as
- Li = 5 mH and Cd = 1600 μF.

The fig.3 below is the Simulation of PFC Half bridge boost converter used in air conditioning system where gate pulses for Half bridge is generated through C-programming using C-block in PSIM-9



III PFC MODELLING [1]

PFC Converter

The PFC converter using average current control is constituted by a DC link voltage controller, a reference input current generator and a PWM current controller as given below.

1) DC LINK VOLTAGE CONTROLLER: The DC link voltage controller is a PI controller which closely tracks the reference voltage and gives control signal (Ic) to minimize voltage error. At kth instant of time, the voltage error Ve(k) is calculated from reference DC link voltage V*dc(k) and sensed DC link voltage Vdc(k) as,

$$Ve(k)=V^*dc(k)-Vdc(k) \qquad (5)$$

The output of the controller Ic(k) at kth instant is given as,

$$Ic\,(k) = Ic\,(k-1) + Kpv\{Ve(k) – Ve(k-1)\} + KivVe(k) \qquad (6)$$

where Kpv and Kiv are the proportional and integral gains of the voltage controller.

1) REFERANCE INPUT CURRENT GENERTAOR: The reference input current of the half-bridge boost converter (i*dc) is given as,

$$i^*dc = Ic\,(k)\, uVs \qquad (7)$$

where uvs is the unit template of the voltage at input AC mains, calculated as,

$$uVs = vd/Vsm;\ vd = |vs|;\ vs = Vsm \sin \omega t \qquad (8)$$

where ω is frequency in rad/sec at AC mains.

1) PWM CURRENT CONTROLLER: The reference input current of the half-bridge boost converter (i* dc) is compared with the current (idc) sensed after the DBR which results in a current error Δidc=(i* dc - idc). This current error is amplified by gain kdc and compared with fixed frequency (fs) carrier waveforms md1(t) and md2(t) as shown in Fig. 4.3 to get the switching signals for the MOSFETs of the PFC half-bridge boost converter as,

$$\text{If } k_{dc}\, \Delta i_{dc} > md1\,(t) \text{ then } S1 = 1 \text{ else } 0 \qquad (9)$$

$$\text{If } k_{dc}\, \Delta i_{dc} > md2\,(t) \text{ then } S2 = 1 \text{ else } 0 \qquad (10)$$

where S1, S2 are upper and lower switches of the half-bridge converter as shown in Fig.5.1 and the values ‘1’ and ‘0’ represent their ‘on’ and ‘off’ position.

IV PFC CONVERTER USING C-BLOCK.

In a half-bridge boost converter, the switches are operated alternatively with shorting of inductor in between through both switches for boost action. The duty ratio (D) and the value of boost inductor (Li) control its DC link voltage. A high switching frequency (fs) is used for fast control and reduced size of inductors and transformers; however, the switching frequency is limited by the factors such as switching devices used, switching losses of the device, operating voltage and power level. Metal oxide field effect transistors (MOSFETs) are used as the switching device for high switching frequency in the proposed converter

The Algorithm for C-programming and step by step procedure in given below.

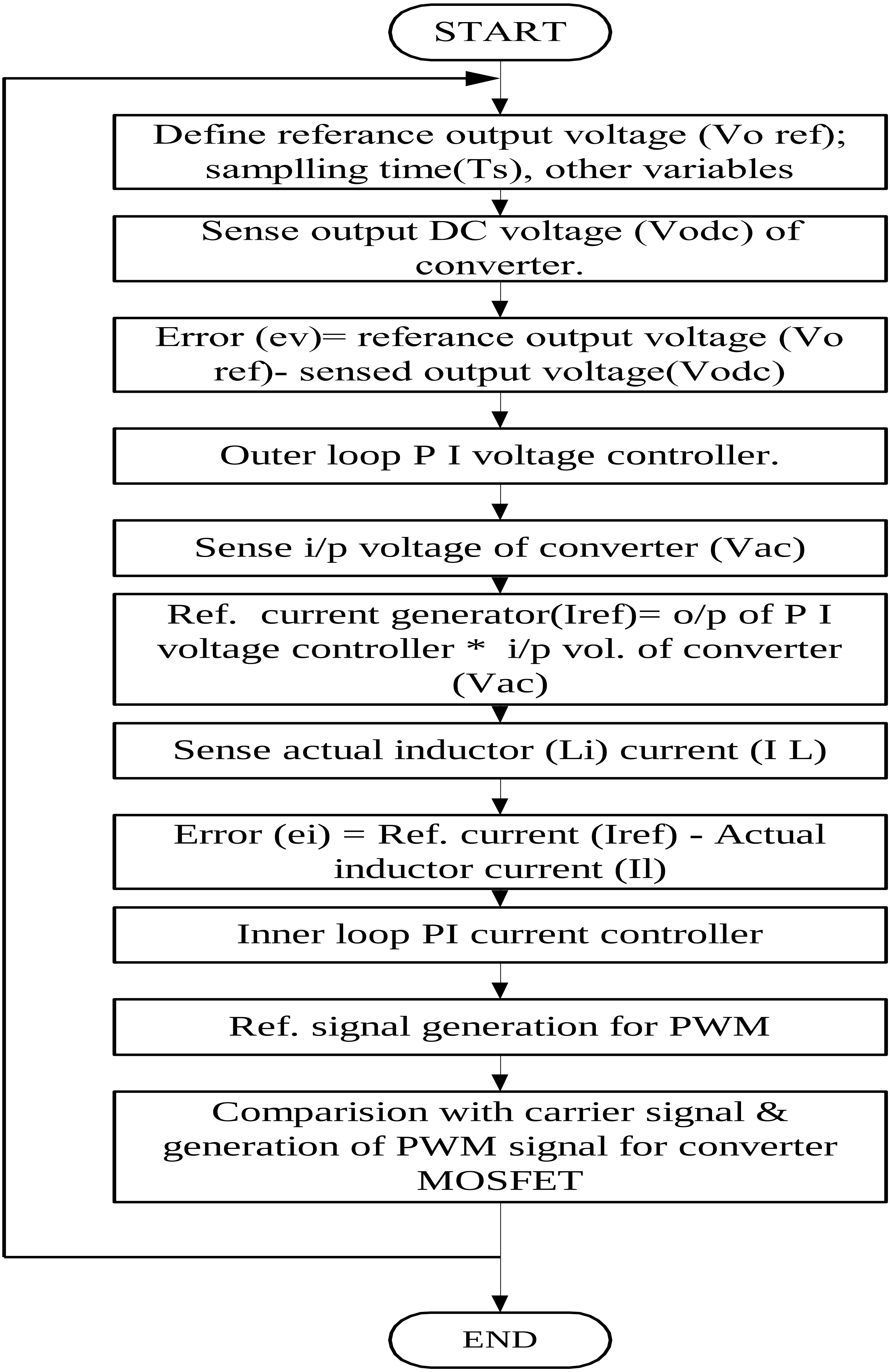


Fig. 4: Algorithm for pulse generation

V ALGORITHM TO GENERATE GATE PULSES

Step1:- Start

Step2:-Two signals are selected. 1) Triangular Wave (1) 2) DC Signal (1)

Step3:- Triangular wave (1) is connected to Proportional (Gain) block.

Step4:- One Summer block (+/-) is taken.

Step5:- Triangular Wave (1) is connected to Summer block through proportional block at positive terminal.

Step6:- DC Signal (1) is connected to the negative terminal of the summer block directly.

Step7:- Select the Comparator (1).

Step8:- Output of the summer block is given to the non-inverting (positive) terminal of the Comparator (1).

Step9:- DC Signal (2) is taken which is connected to the inverting terminal (Negative) of the comparator (1).

Step10:- NAND gate (1) is selected.

Step11:- One input terminal of the NAND gate is connected to the output of the comparator (1).

Step12:- Now select Square Wave (1) which is connected to another input terminal of the NAND gate (1) through NOT gate.

Step13:- Output signals of NAND gate (1) are the switching pulses which are given to the one MOSFET of the half bridge boost converter.

Step14:- Now Select the Comparator (2) and Triangular Wave (2).

Step15:- Triangular Wave (2) is connected to the non-inverting (positive) terminal of the Comparator (2).

Step16:- DC Signal (2) is connected with the inverting terminal (Negative) of Comparator (2).

Step17:- Now select NAND gate (2).

Step18:- Output of the comparator (2) is connected with the one input terminal of the NAND gate (2).

Step19:- Square Wave (2) is taken which is directly connected to the another input terminal of the NAND gate (2).

Step20:- Output signals of the NAND gate (2) are switching pulses which connected with another MOSFET of the half bridge boost converter.

Step21:- End.

The Whole algorithm can be Understand by the fig.4

However, insulated gate bipolar transistors (IGBTs) are used in VSI bridge feeding PMBLDCM, as it operates at lower frequency compared to PFC switches thereby the switching stresses are reduced.

VI RESULTS

Simulation Results of Generated gate pulses ,output Voltage ,input current and input Voltage for PFC converter using C Programming in PSIM-9 are shown below. Satisfactory results of Power factor (0.996),THD and Crest factor is obtained using above mentioned technique which are same as obtained through conventional PWM techniques.

This concept of pulse generation is more controlled and suitable for PMBLDC drives and it is giving the same results as proposed in PFC Modelling. The following fig.3 shows the circuit diagram of the pulse generation circuit .

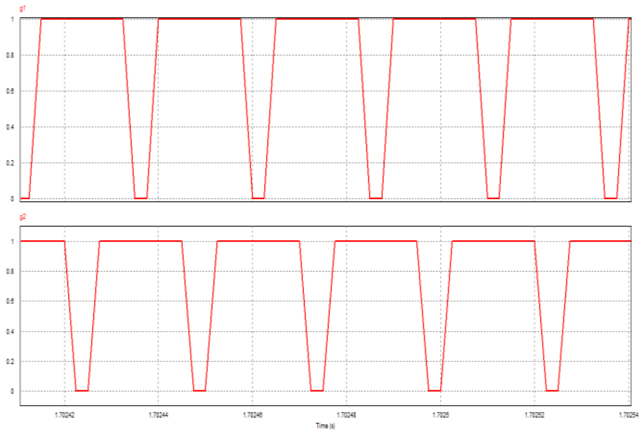


Fig. 5: PWM Pulses (g1& g2)

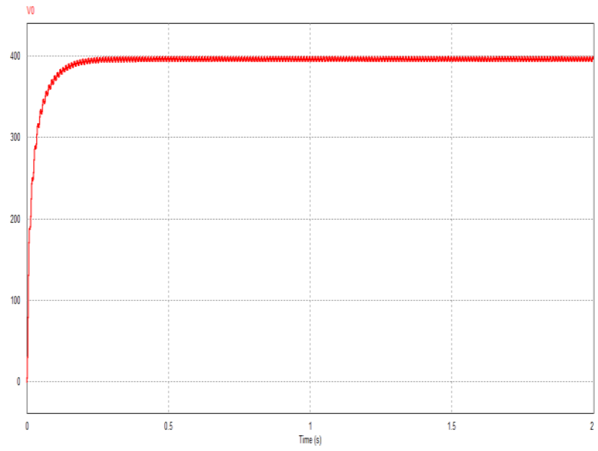


Fig.6: Output voltage (400V) (y axis-1 div. = 100V)

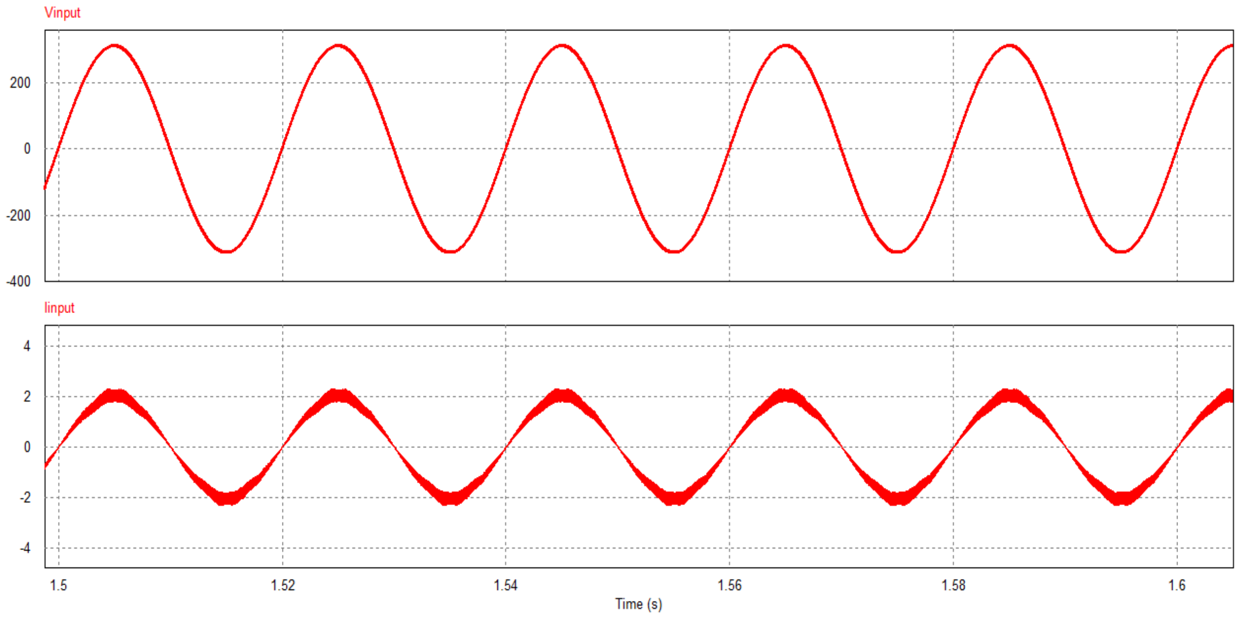


Fig.7: Input voltage(220V rms) & input current (1.49A rms) PF(0.996)

VI Conclusion

This technique gives the satisfactory results as that of conventional PWM techniques such as Power Factor, THD, Crest Factor. Further more , PWM generation through C-programming can be used with different family of microcontrollers for PMBLDC drive and commercially mass produced appliances like fans, blowers, washers, dryers vacuum cleaners, etc, Therefore, it is expected that the digital control for BLDC motor drives will help reduce the cost and complexity of the motor control hardware; this, in turn, can boost the acceptance level of BLDC motors for commercial mass production applications, successfully fulfill the promises of energy savings associated with adjustable speed drives.

Table 1: Simulation Results using C-programming

Results	V_{input}	I_{input}
Power Factor (P.F)	**0.996**	
Total Harmonic Distortion(T.H.D)	**0.992%**	**1.88%**
Crest Factor (C.F)	**1.44**	**1.4**

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Tension Control by Servo Motor in Textile Application using Electronic Let Off and Electronic Take Up Technique

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***Abstract*— Weaving is the mostly used method of fabric production for the decoration, clothing and home furnishing textile sectors and paper industry. However, in textiles including cloth and produced on weaving machines Irregular of the weft insertion method used. For weaving very high cycle and acceleration rates is required for weaving machines. Furthermore, weaving machines has very large number of non linear motion sequences and timing. As per Mechatronic solution using the combination of servo drives for warp let-off and fabric take-up are used. More recently, non linear motion and weft insertion have also been implemented with electric drives in some instances.**

That type of let off motion in which the weaver's beam is driven with the help of servo motor, as the beam diameter changes, RPM of the beam are controlled through load cell. Take-up is used to draw the fabric of cloth at regular rate (picks/inch). It is synchronized with let off motion. The speed of take up is less than let off motion due to crimp of warp.

***Keywords*— ELO-ETU drive, SERVO MOTOR, programmable logic control and human machine interfacing**

I. INTRODUCTION

Weaving is the most widely used method of fabric production for the decoration clothing and home furnishing. Due to non-linear motion sequence and critical starting time it makes the system less reliable. As the fashion changes day by day so it is one of the most important factors. This problem is solved using servo mechanism, load cell, weft sensor, servo drive (electronic let off and electronic take up) and programmable logic control which take action according to real time problems. This Programmable logic control is interfaced with HUMAN machine interfaced.

II. CONTROL SYSTEM STRAGIES

A rapier loom consists of servo motor, ELO (electronic let off), ETU (electronic take up), load cell, wrap sensor and weft sensor. In rapier loom there are total two servo motors are there, which are connected with ELO and ETU. Load cell continues measured tension on ELO. If tension is changes then comparator makes an error. According to the type of error programmable logic control takes an action. Electronic take up (ETU) rotate at a speed of pick per inch. Between ELO and ETU the air jet and stepper motor arrangement is kept. Typically or according to this design wrap sensor doesn't give any error because load cell continuously monitor the whole system. Weft sensor sense when any thread in weft is loosen or not [1].

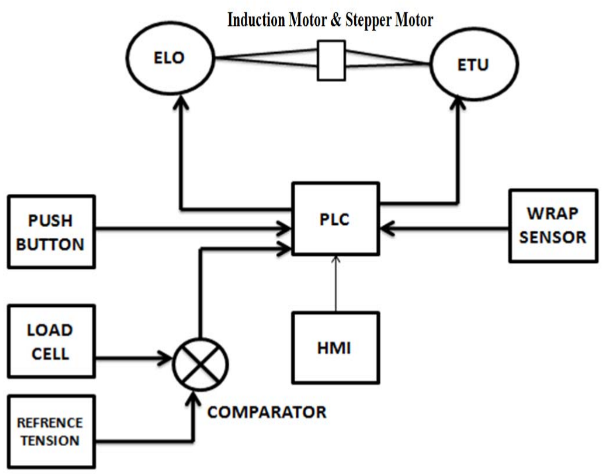

Fig. 1 Control mechanism

III. CONNECTION SCHEME

As shown in below figure there is a one step down transformer of 2KVA of step down transformer is used which steps down to 220v between two phase. Current rating of servo drive is 4.5A each of Dsl3e series. There are two SMPS are connected of 2.5A rating. Input 3phase 440v is directly given to induction motor. One single phase and neutral is given to the SMPS. One MCB is kept whose rating should not be more than 12A, so when servo drive and SMPS are operating at full load is doesn't trip at the input three terminal of servo drive 4.2 A of fuse is kept for protection purpose.

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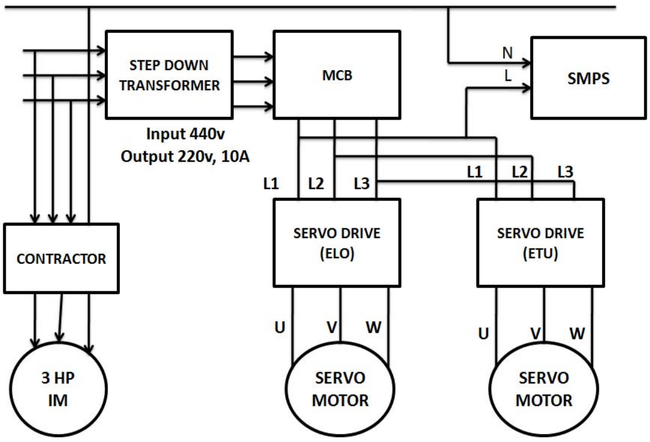

Fig. 2 Connection Scheme

IV. HARDWARE TO BE USED

SERVO MOTOR: - Servo motor contains servo mechanism. It consists of two types AC servo motor and DC servo motor. In DC motor armature consist of winding, commutator and commutator segment so due to this it has very large inertia. So it cannot stop at regular displacement. While AC servo motor are used because it has very low inertia. Its rotor is made up of drag cup shape. So there is no winding are wounded on the rotor. So it has very less inertia. So proper displacement can obtained using AC servo motor. Drag cup shape is made up of permanent magnet [2].

The torque produced by the current-carrying conductors in the magnetic field will cause rotation of the rotor until the torque angle is zero degrees and further motion would not be possible. In dc servo motor this condition is eliminated by using a commutator on the rotor.

$$\textbf{Torque} = \textbf{K B I} \sin\theta$$

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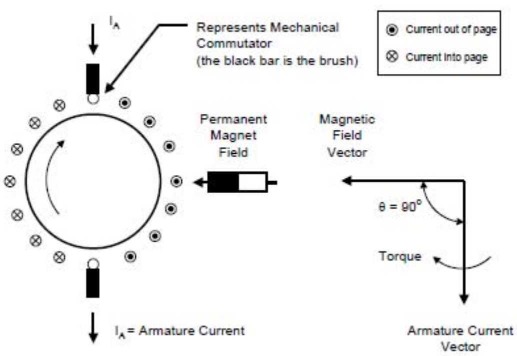

Fig. 3 DC servo motor [2]

The commutator causes the current in each conductor. This is to be progressively reversed as the conductor connected to a commutator bar passes the brushes. The physical location of the brushes in a dc servo motor is such that the torque angle is 90 degrees with respect to current for both directions of rotation.

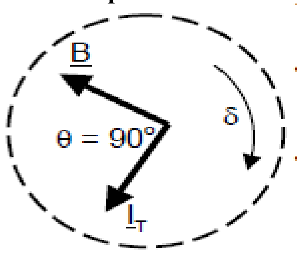

Fig. 4 servo motor torque production [2]

LOAD CELL: - It is a one type of mental conductor which is stressed or compressed. Its resistance changes and according to its length the diameter of conductor is change. So due to this the value of resistivity of the conductor change when it is strained and such a property is known as piezoresistive effect. Therefore the resistance strain gauge is also known as piezoresistive gauge. The strain gauge is used for measurement of strain and associated stress in experimental stress analysis. Secondary many others detectors and transducer notably the load cell, diaphragm, torque metered. Output of the strain gauge transducer is given to the Wheatstone bridge where four resistances are there. As it is strain gauge transducer so when the tension is change the length and diameter is changes. So due to this all the resistance are equal at that time. Output of the Wheatstone bridge is same. When the resistances are not same, it gives some amount of output voltage [3].

A. Requirement specification of LOAD CELL

For continuous monitoring purpose we used S type transducer, because it is small in size. So it is easily fitted in the system. Its rating is according to requirement.

TABLE I Selection of Load Cell

Sr. no.	Requirement	Rating
1	weight	0- 200 kg
2	Output voltage	0-1.98 mv/V
3	Current rating	4 – 20 mA

ELO/ETU DRIVE: ELO/ETU drive is a one type of terminology. ELO released required amount of wrap. ETU is used to make targeted thread density and to roll the cloth in rapier loom. This ELO/ETU drive is connected with their own servo motor. ELO is known as electronic let off and ETU is known as electronic take up [1].

This drive is not only used for controlling purpose but it can be used for future purpose. To control this drive servo motor are used. PLC is connected with Load cell and wrap sensors. When load cell and wrap sense gives the signal to PLC at that time according to error electronic let off take the action. [4], [5].

V. PLC AND HMI INTERFACING

Combination of PLC and HMI interfacing gives continuous monitoring, supervising and controlling to the whole process of plant.

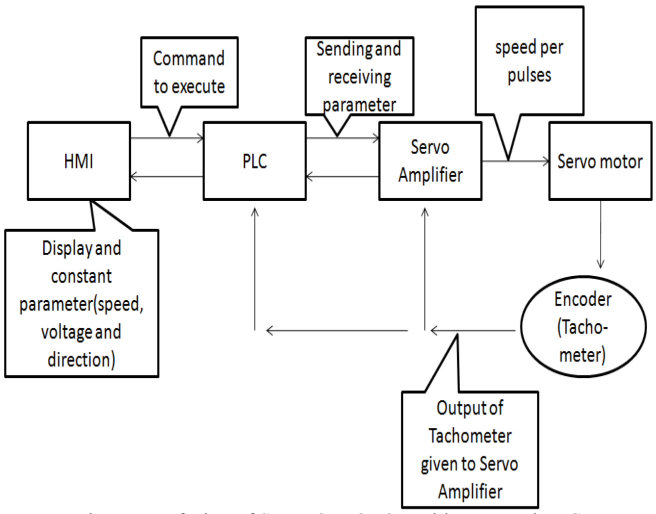

Fig. 5 Interfacing of SERVO MOTOR with HMI and PLC

As shown in the above figure HMI receive and send the data to PLC. So according to the requirement PLC send the data to servo amplifier and it control the servo motor. The output is measured through tachometer. Hence it is a closed loop control mechanism it gives feedback to servo amplifier and PLC [6].

A. *Requirement specification of PLC*

Most probably ladder logic is used. PLC contains various types feature like timer, counter, arithmetic and some special function. PLC supports communication using RS232 and Ethernet protocol.

TABLE II Selection Of PLC

Sr no	Requirement	Rating
1	Input terminal	NPN,PNP
2	Output terminal	NPN
3	Input voltage	24V DC
4	Output voltage	24V DC

B. *Requirement of servo drive and servo motor*

Servo amplifier is also known as servo drive. Servo drive consists of position sensor, speed and displacement. Encoder continues sense the rotor position and gives the error. It continuous sense the error till the error become zero. At zero error it position is equal to required position or targeted position.

TABLE III Selection criteria for AC servo motor

Sr no	Requirement	Rating
1	Voltage range	3phase 100-200VAC
2	Frequency range	50,60 Hz ± 5 %
3	Encoder	2000 ppr
4	Output rating	P phase, 0-440V, 5A
5	Modes	Auto/manual
6	Power rating	400W for ELO, 750W for ETU

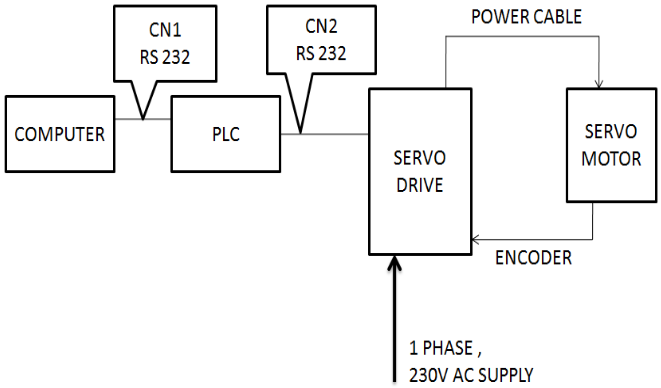

Fig. 6 Interfacing with single phase servo motor using PLC and computer

In figure 5 determine simple interfacing of computer with plc. According to criteria or requirement logic is build in computer that programming is most probably done in ladder logic. It is transferred to plc through RS 232 and then PLC execute that instruction and give to servo drive. Like this the whole interfacing work [6].

VI. SOFTWARE ALGORITHM

As shown in flow chart, when push button is pressed, software starts executing. First ELO is started. At rotor transducer is kept which continues monitor the tension of ELO. Whenever tension is changes, transducer gives an error. There are two types of error positive error and negative error. This output is directly given to PLC. According to type of error it takes the action. If there is no error than start air jet and stepper motor and give them continues latch. When continues latch is given, it is necessary that they have to stop when error is occur. When no error is there so its output is given to sensor. There are wrap and weft sensor are there. If error is there so program should stop executing and if error is not there so its output is given to ETU. One most important condition is that ETU rotate in pick per inch [1].

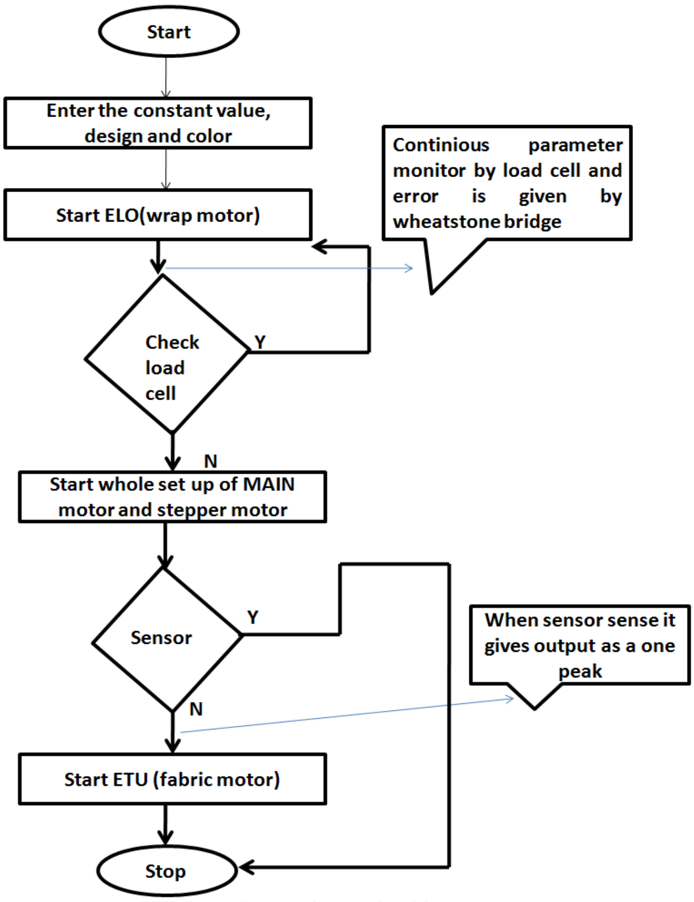

Fig. 7 software algorithm

Conclusion

The control system of rapier machine based on PLC not only implements all kinds of function such as electronic let-off, electronic take-up, but also provide varied weft density and varying warp length which are hard to be implemented in the system. However, we have reduced wrap and weft breakages. So due to this weft wastage is reduced even in rapier loom as we compared it with air jets system.

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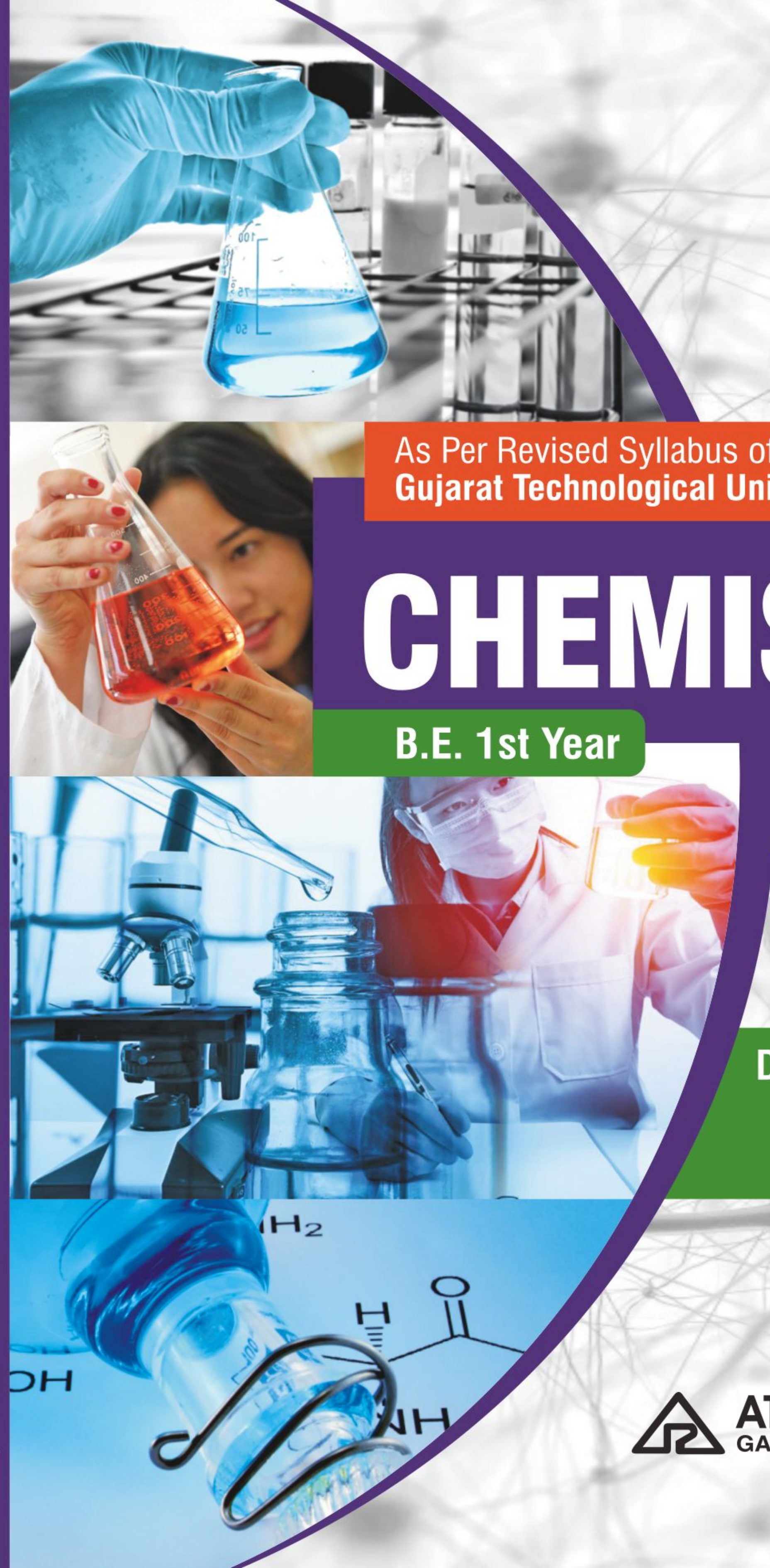
ISBN 978-93-85173-29-5

CHEMISTRY ● Dr. Himanshu Patel | Dr. Hiral Tailor | Dr. Nikhil Parekh



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CHEMISTRY

B.E. 1st Year

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3

Modern Energy Recovery from Renewable Landfill or Bio-Covers of Landfills

Rena, Pratibha Gautam, and Sunil Kumar

CONTENTS

3.1 Introduction

The stream of garbage generated from households and businesses and collected by the municipal corporation, the department of public works, or the sanitation service is known as municipal solid waste (MSW). MSW is

Waste Treatment Processes/Technologies for Energy Recovery

Rucha V. Moharir[1], Pratibha Gautam[2], Sunil Kumar[1]
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1. Introduction

1.1 Worldwide Scenario of Waste Management

During the period of 2001–07, the capacity for waste-to-energy (WTE) conversion was increased to about 3 million metric tons per annum. Some fluidized-bed combustion units for solid waste were installed by Japan and China. China had more than 434 WTE plants by 2016. Japan is known for using the most thermal treatments of municipal solid waste (MSW) in the world [1]. Nowadays new technologies are being adapted for MSW treatment, such as oxygen enrichment technology. Some thermal plants are based on unique technologies such as the melting technology process, direct casting, fluidization processes, and gasification processes [2]. In 2015, a company in Greece tested the potential of a certain system that generated approximately 24 kW of electricity and nearly 26 kW of heat from wastewater [3]. The first energy bioscience center is operating in India, which was established for the purpose of reducing the country's fossil fuel need and greenhouse gases [4].

Treating solid waste in an environmentally sound way is a challenge for developing as well as developed countries. Widely utilized treatments for solid waste include incineration and landfilling. Incineration is directly related to the amount of trash generated. Burning of MSW is a very old practice, in use since the 1880s. But since then the environmental hazards [5] have been noticed and a major focus has been placed on the gases released from the burning of MSW in incinerators, including dioxins, furans, nitrous oxides, and others [6,7]. In the search for the most reliable and environmentally friendly treatments, the environmental merits of reusing and reprocessing the resources have become an area of great concern. There are certain methods by which the WTE concept can be achieved, which will reduce the burden of MSW on the environment and help turn

Current Developments in Biotechnology and Bioengineering. https://doi.org/10.1016/B978-0-444-64083-3.00004-X

CHAPTER 6

Landfill Gas as an Energy Source

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1. Introduction to Landfill

An important constituent of integrated solid waste management is safe and dependable long-term dumping of solid waste [1]. Since the primitive era people have been disposing of waste on the land. With the passing of time, the population increased and society began to expand, and along with the increasing population the amount of solid waste also increased, thus creating glitches in the management and disposal of waste [2]. The piling of waste on land has always brought questions of land encroachment, health issues, and esthetic value. This condition leads to design innovations for landfills. Landfilling is a simple and cost-efficient technique, so it is the most-used practice for municipal solid waste (MSW) disposal [3,4]. In Asian countries, for example, China, 77% of the total MSW is treated in 476 large- and medium-scale waste-to-energy plants. MSW is highly heterogeneous in nature, containing different types of waste. These wastes get disposed of, and thus the landfill becomes a hub of availability of the different types of materials. Even after the long term of deposition, due to the availability of massive materials near about 60–80% of total fresh waste gets accumulated in landfills [5–11]. Although many options are available for waste-to-energy conversion of MSW, waste is still diverted to the land.

1.1 Essential Components of Landfill

The basic concept of a secure landfill is a properly designed landfill that can restrict the contact of trash and its subsequent seepage into the ground with the underlying aquifers. In general, leakage through the base of the landfill is unavoidable but can be reduced to practically zero. The essential components of the secure landfill are a bottom liner/liner system, waste disposal cells, leachate collection system, cover system, and gas recovery system (Fig. 6.1).

Current Developments in Biotechnology and Bioengineering. https://doi.org/10.1016/B978-0-444-64083-3.00006-3

7

Bio-Drying of Solid Waste

Rucha V. Moharir, Rena, Pratibha Gautam, and Sunil Kumar

CONTENTS

7.1 Introduction

Biodegradable waste is bio-dried to remove the moisture from the waste stream; as a result, its weight is reduced (Choi et al., 2001). Bio-drying processes are achieved by the drying rates that are amplified by using biological heat and by adding required aeration. The biologically heated major portion, available naturally by means of aerobic degradation of organic matter, is used to evaporate bound and surface water that is combined with mixed sludge. This generated heat assists in reducing the biomass moisture content without any additional fossil fuels and with negligible electricity consumption (Navaee-Ardeh et al., 2006). It takes a minimum of 7–8 days to dry the waste by this method (Sugni et al., 2005). This allows reduced cost for

CHAPTER 11

Energy-Aware Intelligence in Megacities

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1. Introduction

The major input for the economic development of any country is energy. Globally, the energy sector has acquired major importance for developing countries due to ever-increasing energy needs and the huge capital investment needed to meet it. Energy resources have enlightened our residence and work places, enhanced economic growth, provided mobility and comfort, and made essentials available. The industrial revolution was the transition from manual labor intensive jobs to energy-driven technologies. Formerly, there were abundant energy resources, and concern for their availability and use was very little, but now the gap between available energy supply and demand is increasing rapidly. The reasons behind this imbalance can be population growth, luxury in living standards, uncalculated usage, technological advancements, etc. To minimize the gap the options available may be reducing consumption of energy through economic constraints, technological advancements to increase energy supply, and alternate resources of energy like various renewable energy forms and converting solid waste to energy, which are more sustainable. An associated concern with using the present energy resources is the environmental consequences, which directly correspond to the usage of primary energy resources. Technology that can make use of alternative renewable resources seems to be the only future remedy for sustainability.

1.1 General Requirements of Energy

Societal and regional variations play an important role in energy demand, and high energy consumption is usually attributed to high standards of living in developed countries. Although the majority of the world's population (around 80%) is settled in developing countries, their energy consumption is 40% of the world's total energy consumption.

Current Developments in Biotechnology and Bioengineering. https://doi.org/10.1016/B978-0-444-64083-3.00011-7

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Review

Advanced oxidation processes for treatment of leachate from hazardous waste landfill: A critical review

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ARTICLE INFO

Article history:
Received 15 August 2018
Received in revised form
13 June 2019
Accepted 13 July 2019
Available online 14 July 2019

Handling Editor: CT Lee

Keywords:
Hazardous waste landfill
Leachate
Advanced oxidation process
COD reduction

ABSTRACT

Leachate produced from hazardous waste landfills (HWLs) is toxic and contain high concentration of refractory organics, ammoniacal-nitrogen, heavy metals, inorganic salts and organo-chloro compounds. Various Advanced Oxidation Processes (AOPs) have been developed in last few decades for efficiently treating the landfill leachate and many are still under development. Researchers have reviewed the performance of conventional AOPs for treating leachate produced from municipal solid waste landfills (MSWLs) but as this leachate is entirely different in characteristics from HWL leachate, these studies are not very useful when it comes to management of HWL leachate; also, specific studies focused on HWL leachate are rarely available. Present study critically reviews various AOPs involving ozone, UV radiation, hydrogen peroxide, electrocoagulation and electrochemical oxidation for their mechanism, treatment efficacy, advantages and limitations with a focus on HWL leachate. A brief review of emerging AOPs like wet air oxidation, hydrodynamic cavitation and ultrasound assisted AOPs is also discussed. This study also aims to identify the AOP which is user friendly, capable to treat the HWL leachate efficiently, discourage the use of chemicals and can be operated at ambient temperature and pressure. After thorough review of different AOPs, Electrocoagulation appears to be a very promising and effective AOP involving in-situ generation of coagulants and converting the organic pollutants in simpler and noble compounds like carbon dioxide and water. Electrocoagulation can be considered as one of the greener and cleaner technology for treatment of HWL leachate, which on optimization can result in a reduction of COD up to 60% along with considerable decrease in metal content in range of 70%–90% and has further potential of improvement and research.

Contents

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https://doi.org/10.1016/j.jclepro.2019.[illegible]
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A Pulse Generation Technique for PFC Half-bridge Boost Converters used in PMBLDCM through C-Programming in PSIM

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***Abstract*— This paper deals with the pulse generation technique of PFC converter using C program. Generally this technique is used for switching in the half bridge boost converters which are used in PMBLDC motor drive. Half bridge boost converter is used for power factor correction (PFC) in the PMBLDC motor drive. The ON-OFF control of power switches (IGBT's or MOSFET's) of the half bridge converter can be done by this novel technique of pulse generation. Digital control for BLDC motor drives will help to reduce the cost and complexity of the motor control hardware; this, in turn, can boost the acceptance level of BLDC motors for commercial mass production applications, successfully fulfill the promises of energy savings associated with adjustable speed drives.**

Keywords—Logic gate, Boost converter, PMBLDC Motor, PWM technique, Triangular wave, Square wave, PFC, C-Program, PSIM.

I. Introduction

In many aspects of our daily life, electric motors play an important role. PMBLDC motors find their uses for compressor of an air conditioning system due to its features like high efficiency, wide speed range and low maintenance requirements. The operation of the compressor with the speed control results in an improved efficiency of the system while maintaining the temperature in the air conditioned zone at the set reference consistently. At present, the air conditioning system mostly uses a single phase induction motor to drive the compressor. The single phase induction motor achieves maximum efficiency near rated load only; therefore, it is operated at either full load (compressor 'on') or not at all (compressor 'off') to regulate the temperature of the air conditioned zone in a hysteresis band. The frequent 'on/off' operation results in increased losses and wear-tear of the motor, thereby poor efficiency and reduced life of the motor. Alternately, the temperature is maintained constant at the set reference by using a PMBLDCM with the speed control to drive the compressor of the air conditioner. It results in reduced electrical energy consumption and efficiently maintains the room temperature at set reference while delivering desired cooling capacity [1]. To replace the function of commutator and brushes, the commutation of the BLDC motor drive is controlled electronically. This whole electronic control circuit involves half bridge boost converter. Half bridge boost converter requires gate pulses to ON-OFF the switches. This pulse generation technique is having an additional to conventional PWM schemes [2].

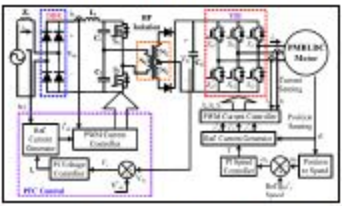

Fig 1: Control scheme of Proposed Half-bridge PFC converter

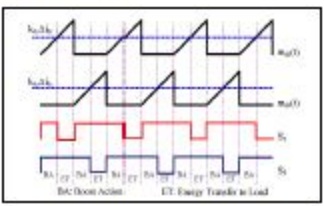

Fig. 2: PWM control of the boost converter [1]

The power quality standards for low power equipment require a sinusoidal current to be drawn from AC mains by this equipment. Therefore a power factor correction (PFC) circuit is almost required at the

Sankalchand Patel College of Engineering, Visnagar, Gujarat
Faculty of Engineering & Technology

ICTM-2017

International Conference on Technology and Management

17-18 February, 2017

ISBN: 978-93-5267-370-4

SANKALCHAND PATEL UNIVERSITY

Certificate

This is to certify that Richa Dubey of SRICT, Vataria has presented/published/participated paper titled "A Novel Pulse Generation Technique for PFC Half Bridge Boost Converter Fed PMBLDCM Drive" in the Electrical Engineering track of International Conference on Technology and Management (ICTM-2017) held during 17-18 February, 2017 at Sankalchand Patel College of Engineering, Visnagar, Gujarat.

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ISBN : 978-93-5267-370-4

A Novel Pulse Generation Technique for PFC Half Bridge Boost Converter Fed PMBLDCM Drive

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***Abstract*— This paper deals with the pulse generation technique which is apart from the conventional PWM techniques of pulse generation. Generally this technique is used for switching in the half bridge boost converters which are used in PMBLDC motor drive. Half bridge boost converter is used for power factor correction (PFC) in the PMBLDC motor drive. The ON-OFF control of power switches (IGBT's or MOSFET's) of the half bridge converter can be done by this novel technique of pulse generation.**

Keywords—Logic gate, Boost converter, PMBLDC Motor, PWM technique, Triangular wave, Square wave, PFC, PSIM, Hall Sensors.

I. Introduction

In many aspects of our daily life, electric motors play animportant role. PMBLDC motors are generally used in compressor of an air conditioning system due to its features likewide speed range,high efficiency and requirement of low maintenance. The compressor operation with the speed control gives the result of an improved efficiency of the system while consistently maintaining the temperature in the air conditioned zone at the set reference. Nowadays, the air conditioning system mostly uses a singlephase induction motor to drive the compressor. The single phase induction motor achieves maximum efficiency near rated load only, therefore,to regulate the temperature of the air conditioned zone in a hysteresis bandit is operated at either full load means compressor on or not at all (compressor 'off'). The on-off operation which is done frequently results in increased losses and wear-tear of the motor, thereby poor efficiency and reduced life of the motor. The temperatureis maintained constant at the set reference by using a PMBLDCM alternatively with the speed control to drive the compressor of the air conditioner. It results in reduced consumption of electrical energy and maintains the roomtemperatureat set reference efficiently while delivering desired cooling capacity [02].

To replace the function of commutator and brushes, the commutation of the BLDC motor drive is controlled electronically. This whole electroniccontrol circuit involves half bridge boost converter. Half bridge boost converter requires gate pulses to ON-OFF the switches. This pulse Generation technique is having an additional to conventional PWM schemes [06].

For low power equipment the PQ (Power Quality) standardssuch as IEC 61000-3-2require a pure sinusoidal current to be drawn from AC mains by this equipment [01]. Therefore a power factor correction (PFC) circuit is required at the utility interface of any equipmentwhichgenerating harmonics. The half bridge boost converter which is used for power factor correction is connected between DBR and VSIof PMBLDC motor drive circuit. There are many DC-DC converter topologiesavailable amongst which half-bridge boost convertertopology is selected for PFC due to its features of low input current ripple, high-voltage conversion ratio and low conduction loss of switches [4].

II. Fundamentals of PMBLDC Motor Drive

Several Asian countries like Japan, which have been under pressure From the past two decades due to high energy prices, they implemented variable speed PM motor drives for saving energy applications such as air conditioners and refrigerators. Some countries like the U.S.A. has kept on using cheap I.M. drives, which have around 10% lower efficiency than adjustable PM motor drives for energy saving applications. Therefore recently, the increase in energy prices results increasing demands of variable speed permanent magnet motor drives. Also, recent fast proliferation of motor drives into the industries of automobile, based on hybrid drives, generates a serious need for high efficient PM motor drives, and this was the beginning of interest in BLDC motors [4].

Fig. 1: Electromagnet Stator and Permanent Magnet Rotor [3].

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