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Ehybrid Vehicle – Next Generation and Energy Efficient Vehicle

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Abstract*: This paper proposes an eHybrid Vehicle system which helps to increase the overall efficiency of the system and also optimizes the energy cost by using the renewable source of energy like wind, solar radiation. Current major problem in an automobile systems is an environmental pollution which is directly related to the fossil fuel. In this paper, new hybrid vehicle is proposed which less is dependent on the diesel engine and more dependent on the solar power, AC power supply, and wind energy in an emergency conditions. The proposed vehicle is multi charging vehicle which charged by a diesel engine, Ac power supply, solar cell, the wind and also has the most feasible solar/electric/wind/diesel power generation system mounted on the vehicle to charge the battery bank during requirement. Diesel engine used in the vehicle works in two modes. In the first mode, it charges the battery with the help of DC generator and charging control unit, and on another side its shaft is directly connected to the gear box to drive the vehicle, through by bypass hole system. Engine work in this mode,when all batteries are not in a condition to provide the power to the vehicle for a drive. In the second mode, the diesel engine only charges the batteries. It is done when there is no sun or electric power supply. In these situations these sources act as an auxiliary energy sources and the system depends upon the diesel engine and charged power of the AC supply. The techniques used in this vehicle increases the running efficiency and reduces the running cost of the vehicle. The system consists of solar module, wind turbine, battery bank, PMDC motor, diesel engine, charging unit, accelerator, speed control rheostat, step-down transformer, rectifier, MMPT and other parts which are required for the vehicle. Experimental results are shown to confirm the theoretical analysis.
***Keywords*: eHybrid vehicle, Solar module, MPPT-Maximum power point tracking technique, Diesel engine.**

I. INTRODUCTION

The fossil fuels which are limited on earth such as petrol, diesel are a very expensive way to be extracted and used. The use of fossil fuel based vehicles is one of the major reasons that has accelerated the extraction of these non-renewable recourses in an unsustainable way. The transportation of these fuels from one place to another is also a major problem which increases the cost of these fuels. The major problem is green house effect caused due to the burning of fossil fuels where a large amount of CO_2 will be emitted which causes lots of problems. Solar vehicles depend upon the PV module to convert the sunlight into the electricity to drive the PMDC motor. According to the recent survey, the fossil fuels are depleting at a fast rate where in and around 50 years the whole fossil fuel is completely depleted from the earth. Therefore it is the time to switch from fossil fuel to natural energy and reduce dependency on nonrenewable energy recourses. Out of renewable source of energy, solar energy is promising one which may be implemented in various day to day application.

The ehybrid vehicle contains the solar module, wind turbine, battery bank, PMDC motor, diesel engine, charging unit, accelerator, speed control rheostat, step-down transformer, rectifier, MMPT and another controlling unit. The Ac power supply source is used when sunlight is absent due to weather conditions; supply is used to charge the batteries during standstill condition of the vehicle [1]. When sunlight is present the PV module convert the solar radiation into electricity which is used to charge the batteries in both condition i.e standstill and running conditions. To extract the maximum power from the PV module the maximum powerpoint tracking technique (MPPT) is used. To boost the efficiency of the PV system , the MPPT has to tracked and followed by regulating the output voltage to operate the system at maximum powerpoint [2]. One of the most important points of this vehicle is design, where the diesel engine. and other instrument will place to achieving a structural optimized work. So, in order to make the vehicle to move under low energy consumption and the redesign of chassis has to be done. The design of vehicle help in to achieve high efficiency, smoothly running condition, emission less transportation, lightweight vehicle etc [3]. In this paper mainly focus on the Solar energy to drive the vehicle, on another hand when there is no sunlight and batteries are not charge than energy provided by the

diesel engine to drive the vehicle. The efficiency of the whole system is increased by switching the diesel engine time to time. Alternate methods are designed which work according to the conditions.

The ehybrid vehicle can charge itself from the AC supply, solar panel, and diesel engine. For internal purpose wind turbine which is connected to DC generator to convert the wind energy into electricity. The vehicle is consisting 1.2HP, 24V permanent magnet DC [PMDC] motor and shaft which directly connected to the main shaft of a diesel engine to drive the vehicle. Two solar panels are attached to the top of the vehicle to grab the solar radiations each with a rating of 250 watts and controller is also to extract the maximum power from the PV system and help in to charge the battery. AC source is used to charge the battery Firstly the 230V is converted 24V further AC is converted into the DC by rectifier than this Dc is used to charge the battery with the help of battery charging unit. Wind energy is used as an auxiliary source to charge the separate battery which provides electricity for the vehicle internal purpose like lighting, headlamp, speaker etc.

II. SYSTEM MODEL AND OVERVIEW

The Fig.1 represents a block diagram of the eHybrid vehicle. Sun, diesel engine, AC power supply are the main source of energy and wind energy is an auxiliary source of energy for the vehicle.

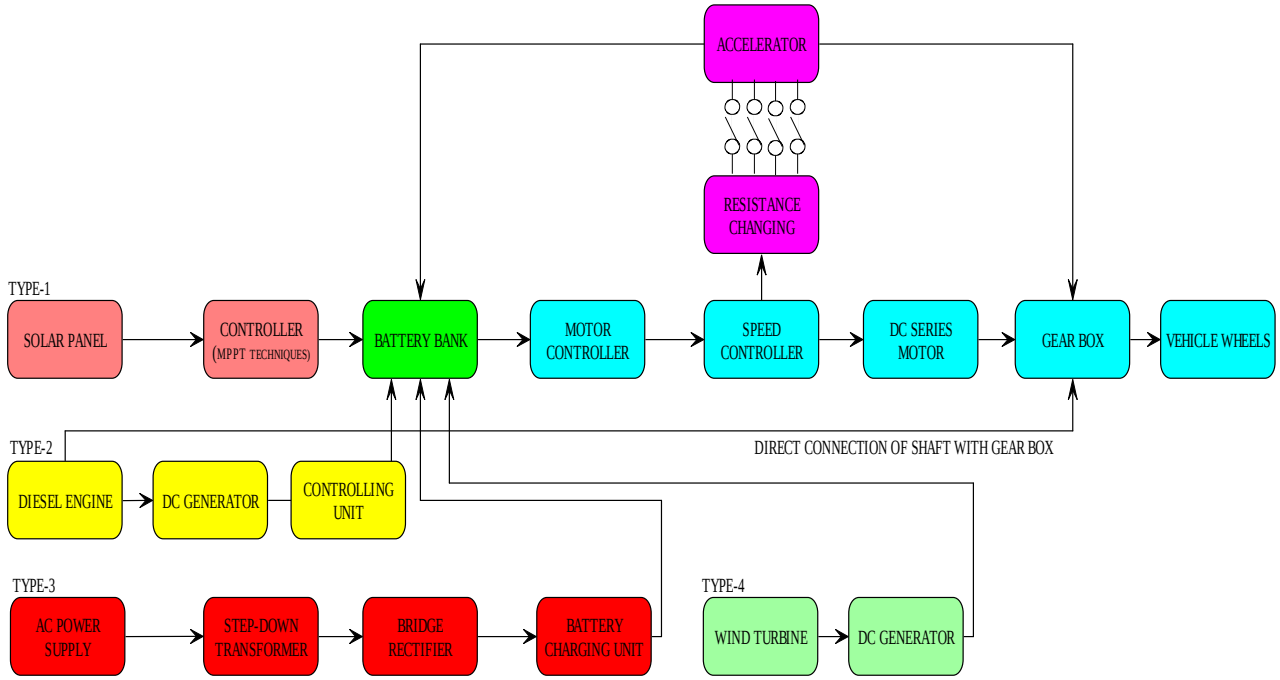

Fig.1Block Diagram of eHybrid Vehicle

In this paper, the configuration of the eHybrid vehicle system is composed of solar module, wind turbine, battery bank, PMDC motor, diesel engine, charging unit, accelerator, speed control rheostat, step-down transformer, rectifier, MMPT and another controlling unit. All sources used to charge the battery except one. The diesel engine is only one source which charged the battery as well as drives the vehicle directly by connecting the shaft directly to the gear box.

Its operated in multi modes. We discuss these modes in following sections :

A. Mode-1

In this mode, PV system converts the solar radiation into the electricity. To extract the maximum power from the PV system, the maximum power point tracking technique is used. The output of the solar module depends upon the radiations, solar radiation intensity, and temperature. Discrete power from the solar panel is connected to the controller circuit and fed to the batteries bank circuit. These charged batteries provide the power to the PMDC motor and speed is controlled by the speed controller which is connected to the accelerator and resistance changing circuit. The torque produced by the motor is fed to the gear box and gear box is connected to the rear wheels of the vehicle. Battery bank contains 8 numbers of the 12V battery. The accelerator will decide how much motor has connected to a system to drive the vehicle. In the Fig.2 , the operation of vehicle in this mode is discuss.

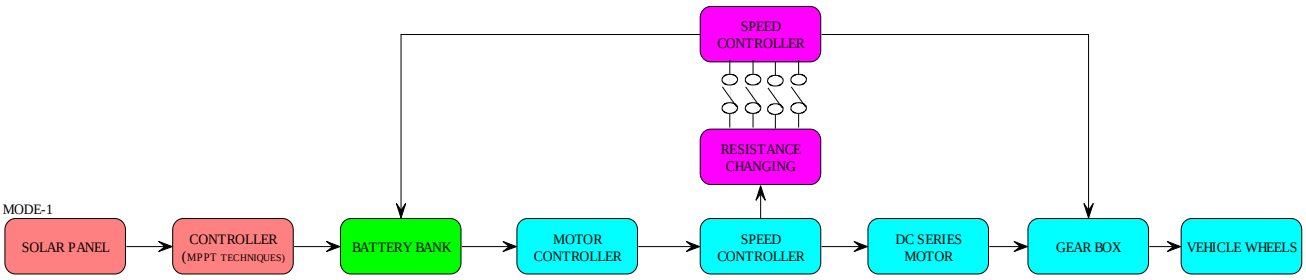

Fig.2.Block Diagram of Mode-1 operation.

1) Photovoltaic System

The system which converts solar energy into electrical energy is called as a photovoltaic (PV) system. The basic or smallest unit of PV system is PV cell. These cells are arranged in parallel, series or series-parallel as per requirement. The voltage and currently available at the terminal of PV system, it is directly fed to small loads like lighting, DC motors or connected to distributed grid by using energy conversion devices [4]. Main parts of PV system are PV module, charger, battery, inverter, and load.

A photovoltaic cell is a device used to convert solar radiation into electrical energy. The equivalent circuit diagram of the photovoltaic cell shown in Fig.3. PV cell is a current source, it is produced by breaking of bonds and generation of electron and hole which causes the flow of current in the cell. The equivalent circuit consists current source, diode, shunt resistance, series resistance and load. Shunt resistance represents the electron-hole combination before its reach to load. The generation current depends upon the characteristic of the material, solar cell age, irradiation and cell temperature, environmental conditions, spectral characteristics of sunlight, dirt, and shadow and so on[5]. The standard values of PV system is given in Table.1.

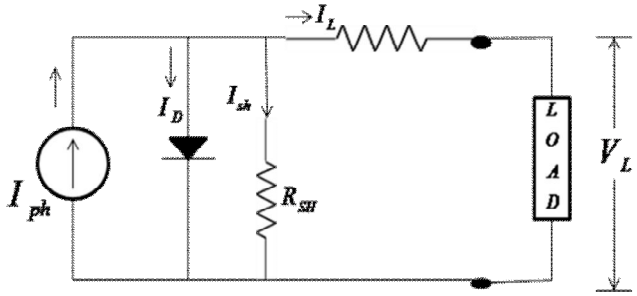

Fig.3.Equivalent single PV cell model

The normal diode current is given by

$$I_D = I_O[e^{\frac{q(V_L+I_L R_s)}{nKT}} - 1]$$

The net current is the difference between the photo current and the normal diode current is given by.

$$I_L = I_{ph} - I_D - I_{sh}$$

Shunt resistance (Rsh) represent the electron-hole combination before it reaches to load (for simplifying ignore Rsh), Ish current becomes zero.

$$I_L = I_{ph} - I_O[e^{\frac{q(V_L+I_L R_s)}{nKT}} - 1]$$

Where

I_L is the load current or cell current (A).

n is the ideality factor

q is the charge of the electron (coulomb).

K is the Boltzmann's constant (J/K)

T is the cell temperature (K).

I_{ph} is the photo current (A).

I_0 is the diode saturation current (A).

R_S, R_{SH} are cell series and shunt resistance (ohms)

V_L is the cell output voltage (V)

Table-I : Solar Panel Specification

Sr.No.	SPECIFICATION	VALUES
1	Maximum power (P_{MAX})	235 (Model no.-LPC235S)
2	Maximum power voltage (V_{PM})	29.9 V
3	Maximum power current (I_{PM})	7.88 A
4	Open-circuit voltage (V_{OC})	37.20 V
5	Short circuit current (I_{SC})	8.47 A
6	Module efficiency	14.68%

Performance at Standard Test Conditions (STC): Irradiance 1000W/㎡, AM 1.5, and cell temperature 25°C

B. Mode-2

In this mode, the main source of energy is a diesel engine. This source is used when vehicle is outside the house and all batteries are fully discharged. In this type, the diesel engine is connected to DC generator and gear box directly. The standard value of diesel engine and DC generator which use in this paper is given in Table-II. Through DC generator it charged the batteries and the main shaft of the engine is also connected to the gear box to drive the vehicle when batteries are not able to provide the power to drive the power. The diesel engine work in two modes[7]. In the Fig.4 , the operation of vehicle in this mode is discuss.

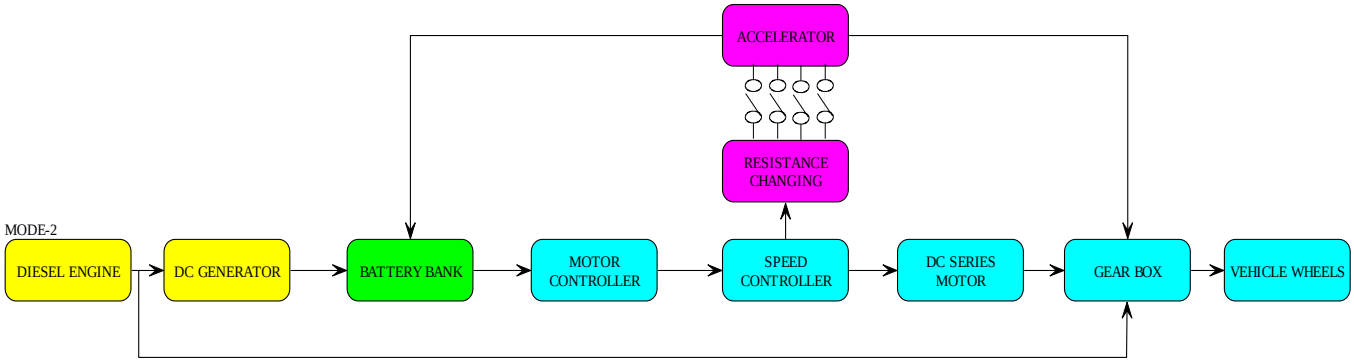

Fig.4.- Block Diagram of Mode-2 operation.

Table-Ii: Diesel Engine And Dc Generator Specification

Sr.No.	DIESEL ENGINE	VALUES	DC GENERATOR	VALUES
1	Engine	Mitsubishi diesel engine	Type	Permanent magnet alternator (PM)
2	No. Of cylinder	2	RPM range	1500-2400 rpm
3	Engine cooling	Radiator cooling	Efficiency	94 %
4	Fuel consumption	1.2-2.5 l/hr	System power output	4.3kw
5	Starting	Electric-12V	Output voltage	24 V
6	Starting battery	12 V	Output current	80 A

C. Mode-3

In this mode , battery is charged by the AC supply source. Firstly the 230 V is step down to 24 by using the step-down transformer than AC supply is converted into the DC supply with the help of bridge rectifier and this DC is fed to the battery charging unit to charge the battery. These batteries provide the power to a vehicle according to the requirement [8]. In the Fig.5 , the operation of vehicle in this mode is discuss.

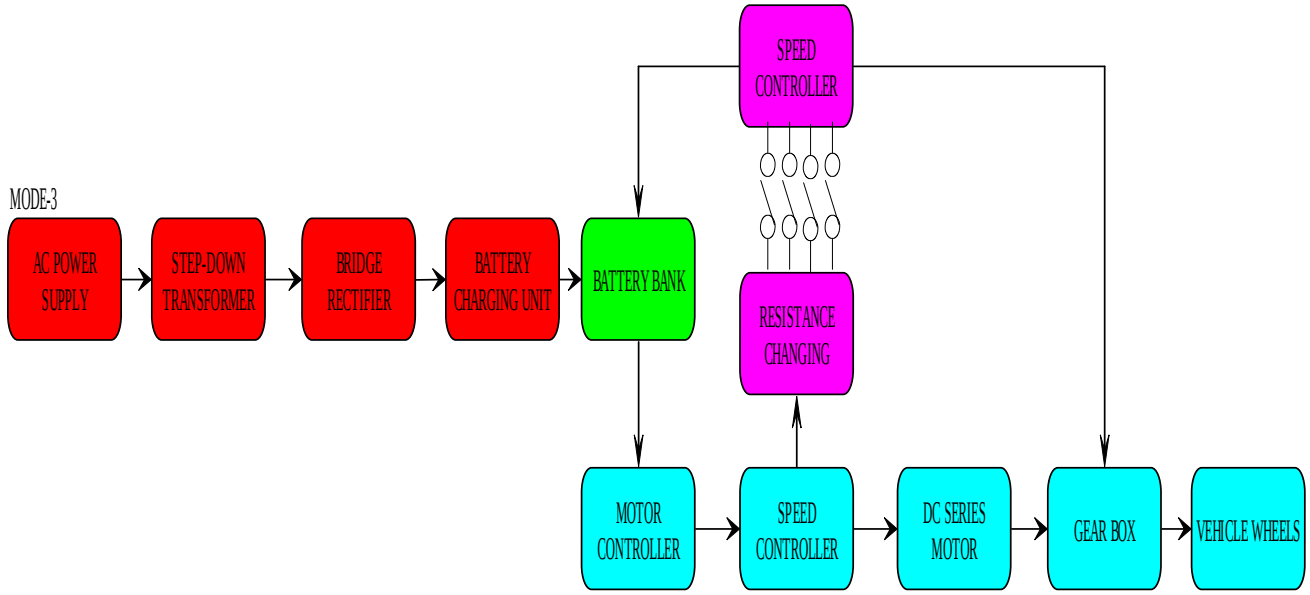

Fig.5.Block Diagram of Mode-3 operation.

D. Mode-4

In this mode, the main source of energy is wind. The wind turbine is connected to DC generator and output of DC generator is connected to separate battery to charge this battery. This battery is different from the battery bank with respect to storage. This charged battery is used to provide electricity to the interior part of the vehicle like to start the diesel engine, lighting, and other things [9]. In the Fig.6 , the operation of vehicle in this mode is discuss. Specification of wind turbine and DC generator is given in Table-III.

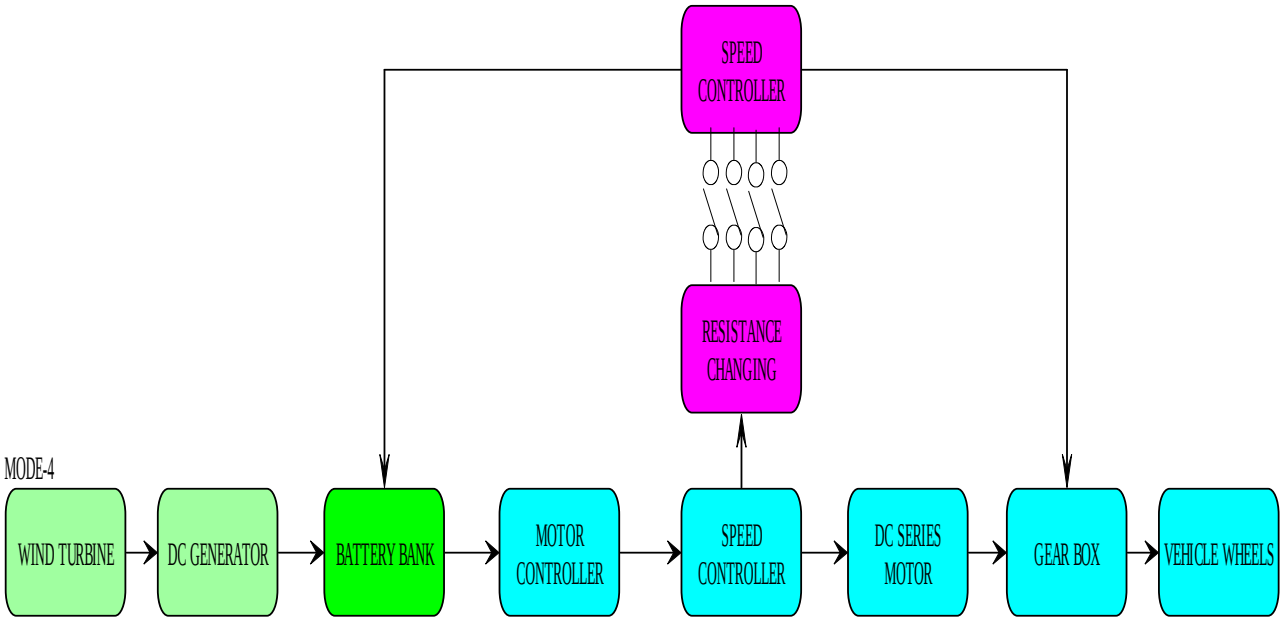

Fig.6 Block Diagram of Mode-4 operation.

Table-Iii : Wind Turbine And Dc Generator Specification

Sr.No.	sSPECIFICATION	VALUES
1	Rated Power	400W
2	Rated voltage	DC 12-24 V
3	Battery voltage	DC 12-24 V
4	Rated wind speed	8.5 m/s
5	Battery capacity	150-200 AH
6	Control system	Automatic fan dedicated controller

Table-Iv: Modes Of Operation

Sr.No.	BATTERY AND VEHICLE CONDITION	MODES	ACCELERATOR CONTACT	BATTERY LEVEL	SPEED	EFFICIENCY
1.	Battery is Fully Charged	No mode is active	1st contact to 4th contact	One to eighth battery is connected accordingly	15 Km/hr To 45 km/hr	98.20%
2.	Battery is Half charged/ running condition	Mode-1 is in active mode	1st contact to 4th contact	One to eighth battery is connected accordingly	15 Km/hr To 45 km/hr	97.20%
3.	Battery is Fully discharged/running condition	Mode-1and mode-2 is in active mode	1st contact to 4th contact	One to eighth battery is connected accordingly	15 Km/hr To 45 km/hr	System efficiency depends upon the diesel engine
4.	Battery is Fully discharged/not in running condition	Mode-3 is in active mode	1st contact to 4th contact	One to eighth battery is connected accordingly	15 Km/hr To 45 km/hr	System efficiency depends upon the diesel engine

In these different modes, the efficiency of the vehicle is different. Its depend upon the sources if solar sunlight used to charge the batteries of the vehicle the efficiency of the overall system is high compared to other sources. The efficiency of the vehicle decreases in the case of diesel engine used as a source. In this condition, the efficiency of the overall system is decreased due to the low efficiency of a diesel engine.

Efficiency of system = multiplication of efficiency of subsystem of the main system

If the efficiency of the subsystem is low than its affects the efficiency of main system i.e the efficiency of the eHybrid vehicle is decreased when diesel is in ON condition. But the diesel engine only in ON condition for short period of time to charge the batteries or drive the vehicle so that the average efficiency of the vehicle during running or charging condition through a diesel engine will increase. It is done by decreasing the charging time of batteries by controlling circuit. Speed control switch is connected to the accelerator pedal. The speed control of DC motor is the essential part of the vehicle. For controlling the speed of the motor, a switch was designed with 4 tapping, giving different values of resistance at each tapping, hence limiting the current that flows in the motor. The different mode of operation is explained in Table-IV.

III. RESULT AND DISCUSSION

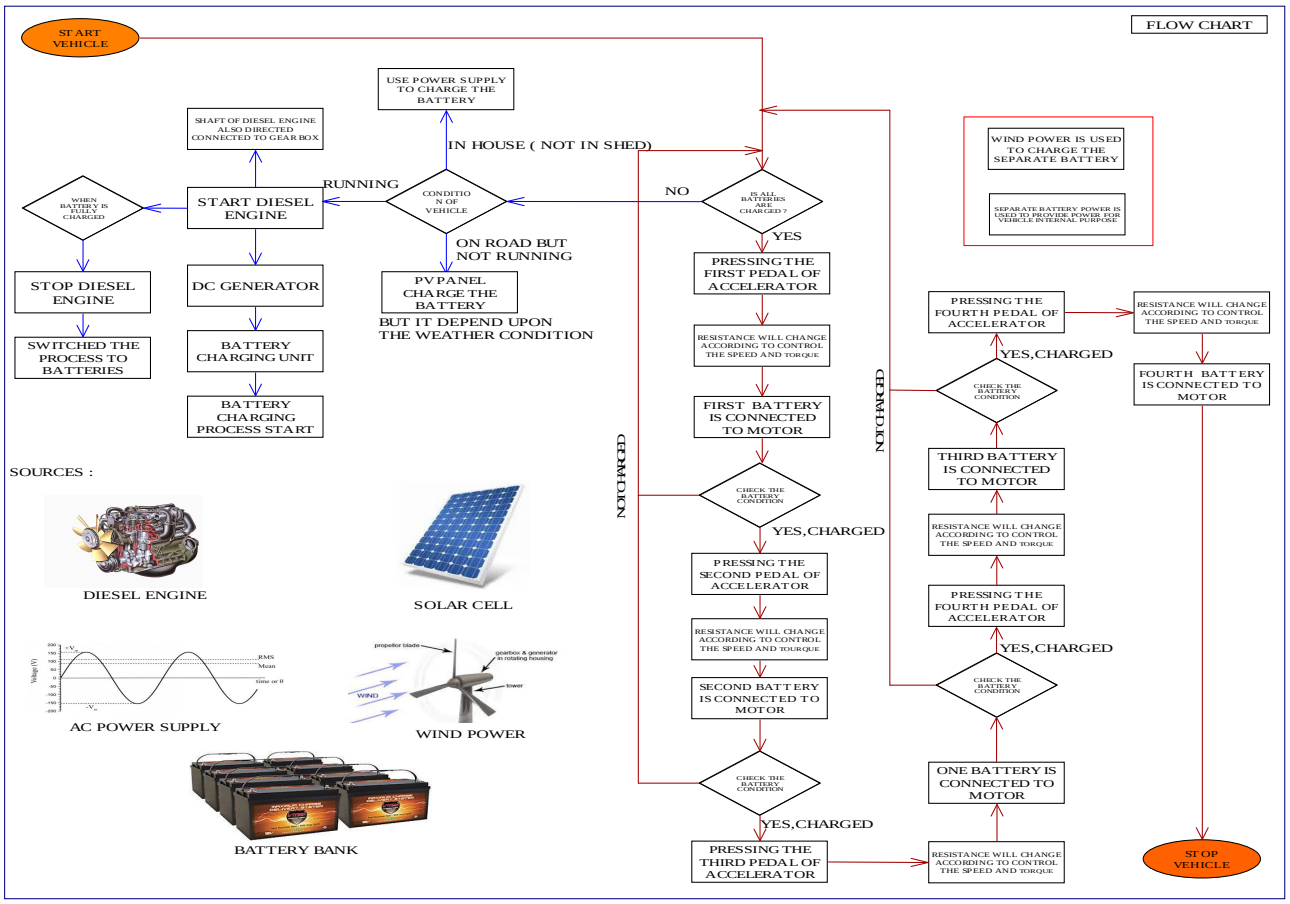

Fig.7. Control algorithm flow chart of eHybrid Vehicle.

The ehybrid vehicle is electric energy based vehicle, the diesel engine is also used to the charge the batteries but it only used when the batteries are fully discharged or in absence of sunlight or vehicle is running on the road. The main shaft of the diesel engine is connected to main gear box and shaft of DC generator through the proper arrangement. In this paper, the efficiency of the vehicle is increased by using latest high rated efficiency equipment. The efficiency of the diesel engine is only one whose efficiency is low otherwise all other equipment has high efficiency. In this paper, the efficiency of the whole system is also improved by switching the diesel engine according to the requirement of the vehicle. The comparisons of eHybrid vehicle with the other vehicles are shown in the Fig.8 and Fig.9 in respect to emission level and efficiency [10].

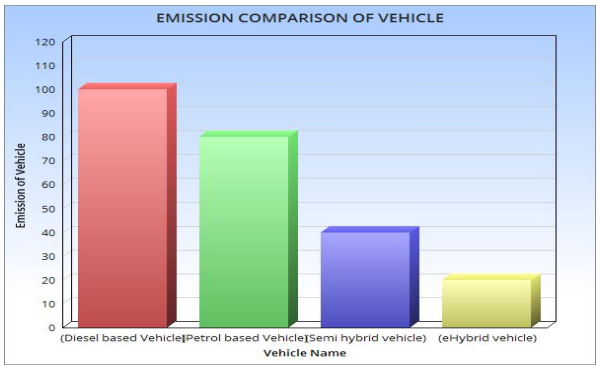

Fig.8.-Emission comparison of vehicles

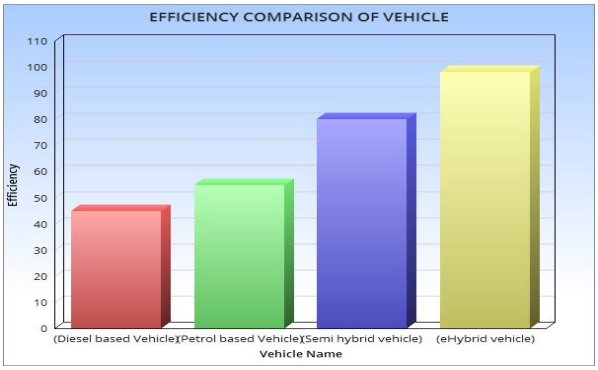

Fig.9.-Efficiency comparison of vehicles

IV. CONCLUSION

The eHybrid vehicle solves many problems related to the environment and it is a best pollution free method. This vehicle is work in any condition if there is no solar radiation, batteries are not charged or AC power supply not near to the vehicle. In the respect of efficiency and running condition, this vehicle is far better than the other vehicle. The fuel consumption of this vehicle is very less compare to other vehicles because it mainly depends on the renewable source of energy. The efficiency of the system when the diesel engine is working is improved by switching the diesel engine time to time. According to the battery charging conditions, the ehybrid vehicle is highly efficient in respect of running condition, emission, fuel consumption, efficiency and environmental friendly. The efficiency and running time of the hybrid vehicle is verified by the experimental result.

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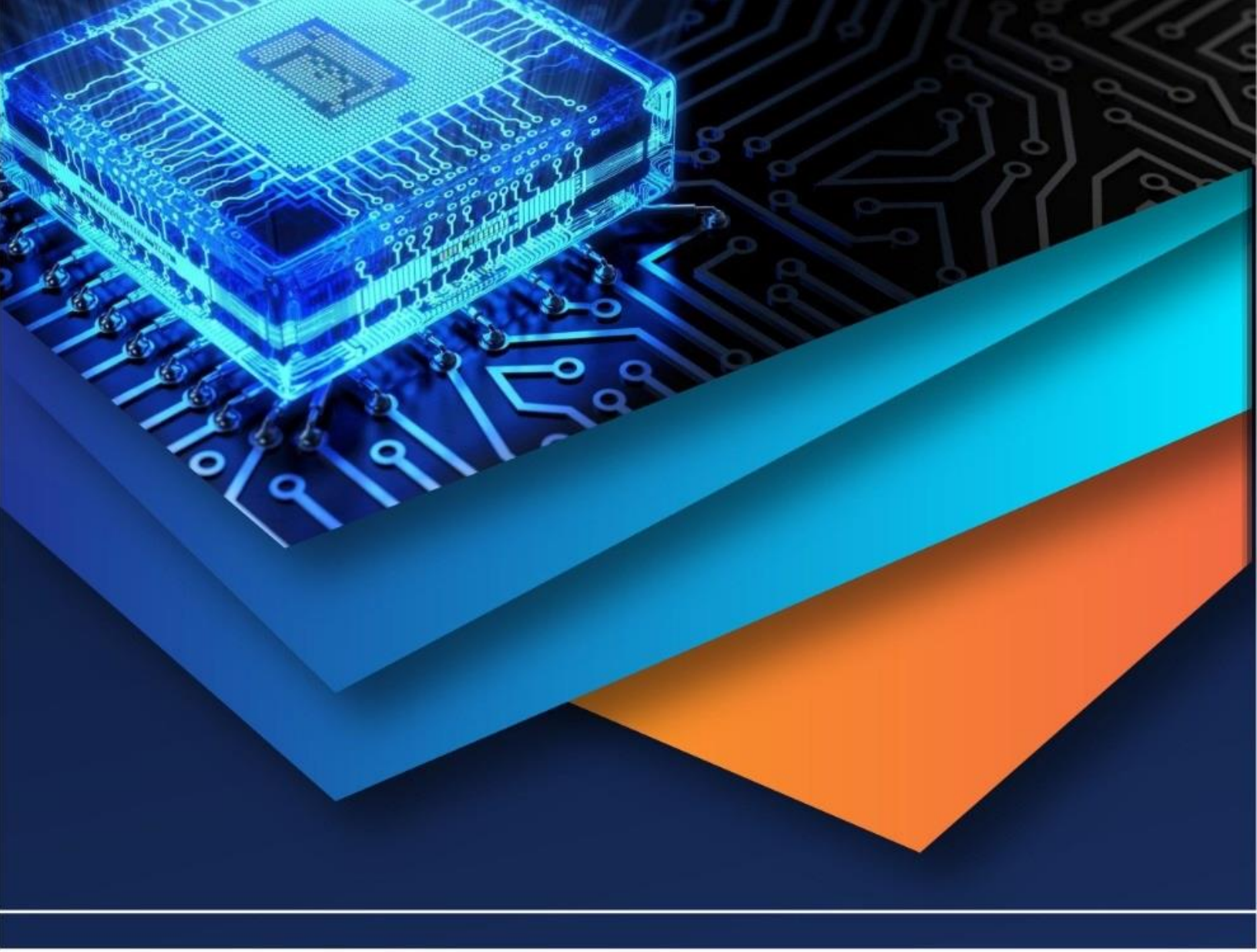

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