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Simulation and Comparative Study of Two Micro-Grid for THD and Cost Analysis

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Abstract: A smart micro-grid design is necessary for the combination of distributed energy sources into the electrical energy distribution chain. There are different classes of micro-grid constructions that have been produced and performed in the last decades. These micro-grid constructions have their essential benefits and constraints. This work has been developed to recognize and discuss, essential trials and solutions for combination of micro-grid into the distribution chain.
In this work two micro grids, one with combination of PV, Wind, Battery system, another with the combination of PV, DG, Battery system are developed the THD and cost analysis is been carried out to select best combination among the two.
Keywords: Smart Grid, Maximum Power Point Tracking, Voltage Source Controller, Permanent Magnetic Synchronous Generator, Virtual Power Plants.

I. INTRODUCTION

Micro grid can also be framed as electrical system which includes electricity generation, energy storage, loads that normally operates along with the main utility grid and can disconnect and operate autonomously as well. Micro grid consists of micro sources with power electronic interfaces. These micro sources are usually micro turbines, PV panels, and fuel cells, biomass, biogas are placed at customer sites. They are at low cost, low voltage with reduced carbon emissions level. Power electronics interface provides the control and flexibility required by Micro grid.

Depending on locally available energy sources, Hybrid Micro grid system can be developed often with combination of a storage element to match the available energy with the load. Many combinations are also possible in depending local conditions, such as Wind-Diesel, Wind- Bio, Wind- Battery, Hydro-Bio, Wind- Solar, Hydro-Solar. The Storage Systems includes Fuel Cells, Battery, Super Capacitor, Pump Storage and Flywheel [1].

The controller is a main part of grid inverter operation. Conventional PI (Proportional- Integral) voltage and current controllers have been usually used to control the harmonic current and DC (direct Current) voltage of the inverter. However, the conventional PI [2].

A micro grid can be considered as small electric power system that incorporates generation, transmission and distribution that can be achieve power balance and optimal energy allocation over a given area, or a virtual power source or load in the distribution network. Also, it can consist of one or more virtual power plants (VPPs) to meet the demand of a load centre, which can be important offices, factories or remote residences where traditional way of electricity supply is very expensive. Compared to traditional transmission and distribution (T&D) networks a micro grid is much more flexible structure as shown in Figure 1.1 [3].

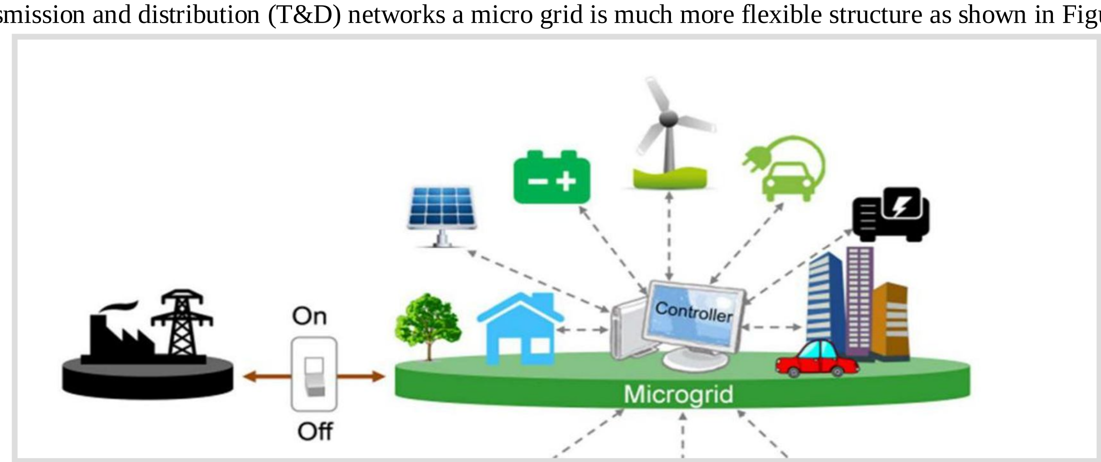

Figure1.1: Micro-Grid System

II. OBJECTIVES

A. To develop a micro-grid with solar PV, Wind, Battery system as sources
B. To develop a micro-grid with solar PV, Diesel, Battery System as sources.
C. To simulate the above model to analyse the harmonic distortion in the micro-grid.
D. To carry out the cost analysis of two models to select the most economic one.

III.MODELING OF MICRO GRID SYSTEM'S

A. Proposed Micro Grid System

We have modeled two micro grid first micro grid is modeled by integrating PV, wind and battery storage system and second micro grid modeled by integrating PV, DG, and Battery storage system with corresponding MPPT tracking in this system VSC controller is implemented in order to convert DC supply to AC supply and 100kVA rating transformer is used for step down, and the load of 100kW is proposed as shown in the figure 2.1 and 2.2.

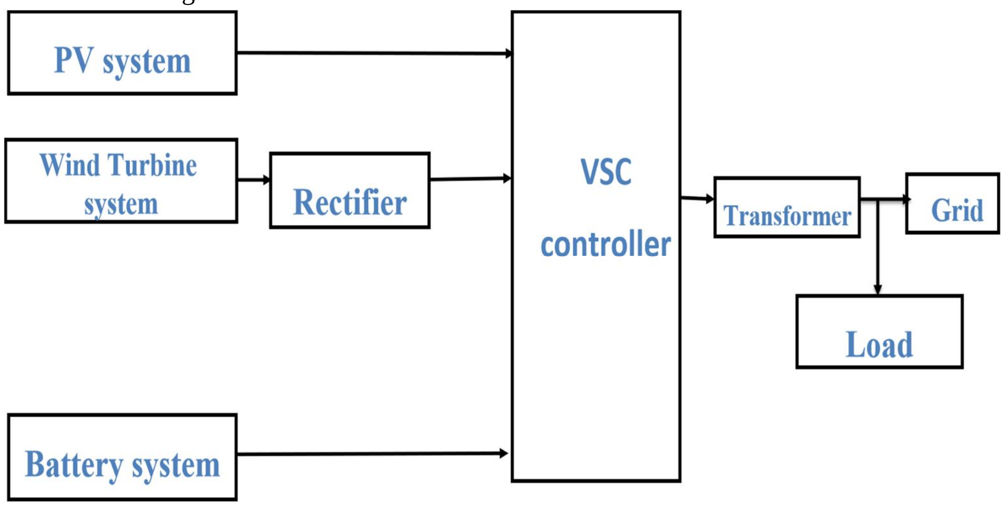

Figure 2.1 : Propsed Model of Micro Grid System 1(PV,Wind,Battery)

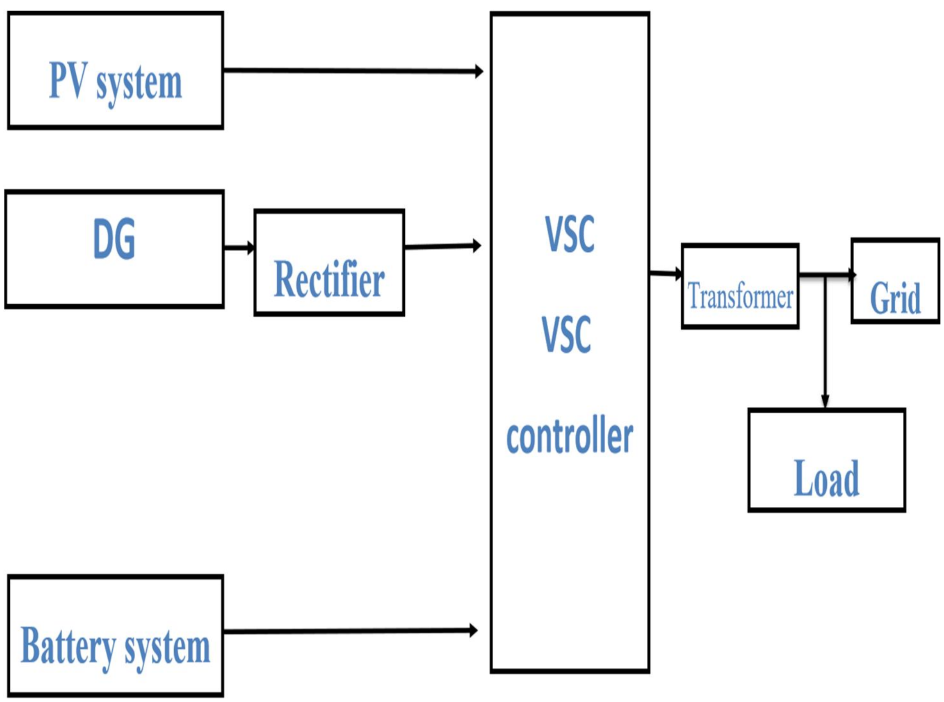

Figure 2.2 : Propsed Model of Micro Grid System 2(PV,Diesel,Battery)

B. PV System

MATLAB/SIMULINK software implements a PV array built of strings of PV modules connected in parallel. A 100KW PV module is modelled and the parameters are listed in below table 3.1

Parameters of PV system	Specifications
Number of parallel strings	64
Number of series connected model pre string	5
Module type	SunPower SPR-315E-WHT-D
Cell per module (Ncell)	96
Solar Irradiance(input)	1000W/m2
Operating temperature	25C
Output Voltage	320V
Output Power	100KW
Maximum Power	315.072
Open Circuit Voltage (Voc)	64.6
Voltage at maximum power point (Vmp)	64.7
Short circuit current (Isc)	6.14
Current at Maximum power point (Imp)	5.76

Table 3.1: Parameters of PV Module

Based on the specification defined in the table of the PV array is taken. The maximum power point tracking (MPPT) program is executed. The MPPT controller program applied is based on the PI controller.

C. Wind System

MATLAB/Simulink has a wind turbine block in the MATLAB library. These module devices a variable pitch wind turbine design. The initial input is feed through the generator speed value is per unit of the generator base velocity. The pitch angle(beta) of a blade angle in degree is used as other input and the wind speed in m/s other input. The torque output uses to the generator shaft in per unit of the generator specification.

The parameters chosen for modelling of Wind energy system is given in the below table 3.2

Parameters	Specification
Nominal mechanical output power	30kW
Base Wind speed	12
Pitch angle	0

Table 3.2: Parameters of Wind Module

The energy produced by the wind turbine is alternating current therefore a rectifier is combined to change the power to direct current source. The MPPT controller is included to produce the beats for the converter.

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D. Battery System

MATLAB/SIMULINK implements a generic battery model for most popular types. A Ni-MH battery is chosen with rated capacity of 6.5 Ah and nominal voltage of 200V

Rapidly increasing technology in wireless device, is demanding the battery technology field to increase its efficiency more and more day by day. Hybrid vehicles are introduced in the aim of reducing in use of fossil fuels, thus in last two decodes battery technology field has enriched the quality of battery to its extreme. Today the battery industries are considered as large-scale industry manufacturing millions of batteries per month. Improving the energy capacity & safety are two major challenges faces by industries [10]

E. Diesel System

A Diesel generator of 30kW nominal mechanical output power is design and stater resistance is 0.003 ohms and regulator gain K is 29, this are the specification is used for the modeling of DG

IV. SIMULATION AND RESULT DISCUSSION

The Simulation result of micro-grid-1, When the battery is in the charging position only the PV generation which have designed for 100kw will be supplied to the load whereas the wind generation which is designed for 30kw will be used for the charging of the battery. It can be observed from the graph shown in figure 4.1

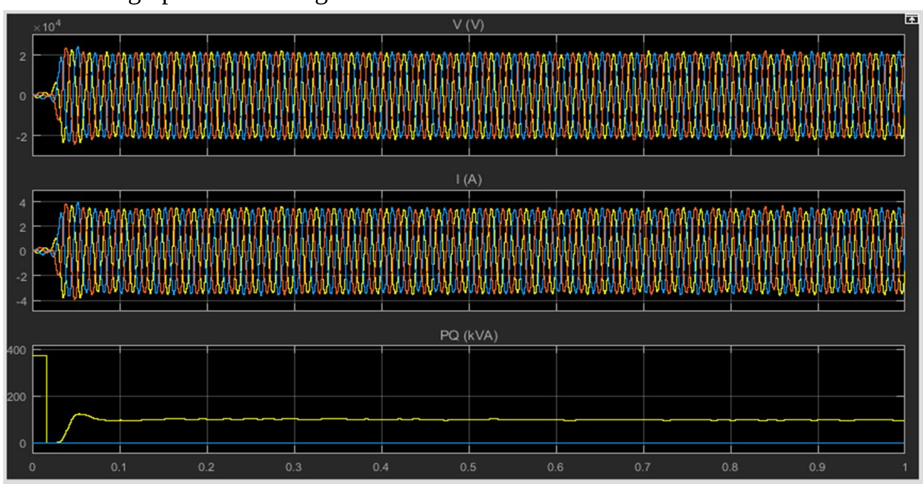

Figure 4.1: Graph When Battery is in Charging Mode

A. When the Battery is in the Discharging Mode

The Simulation result of micro-grid 1, When the battery is in the discharging position both PV generation which is designed for 100kW and the wind generation which is designed for 30kW will supply to the load. It can be observed from the graph shown in figure 4.2

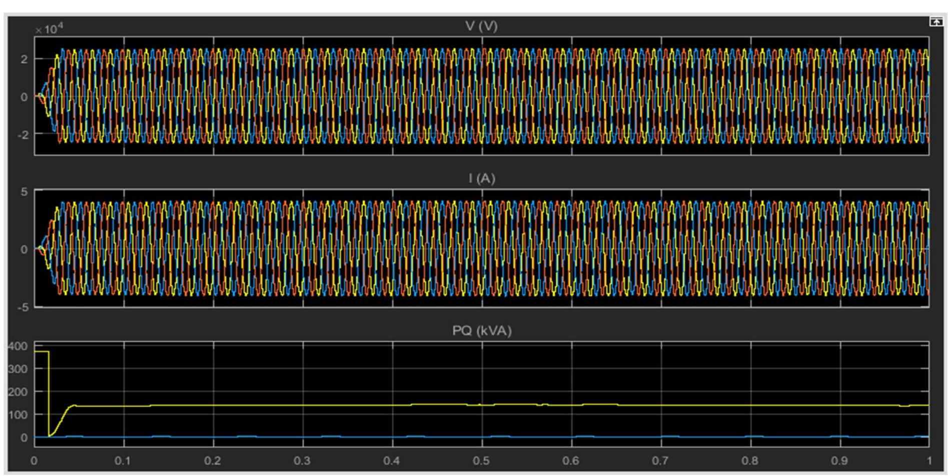

Figure 4.2:Graph When Battery is in Discharging Mode

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B. Simulation Results of Model 2 Micro-grid

As we can see in the following graph, we have plotted two possibilities

First when the battery is in charging position

The Simulation result of micro-grid-2, When the battery is in the charging position only the PV generation which have designed for 100kw will be supplied to the load whereas the diesel generation which have design for 30kw will be used for the charging of the battery. It can be observed from the graph shown in figure 4.3.

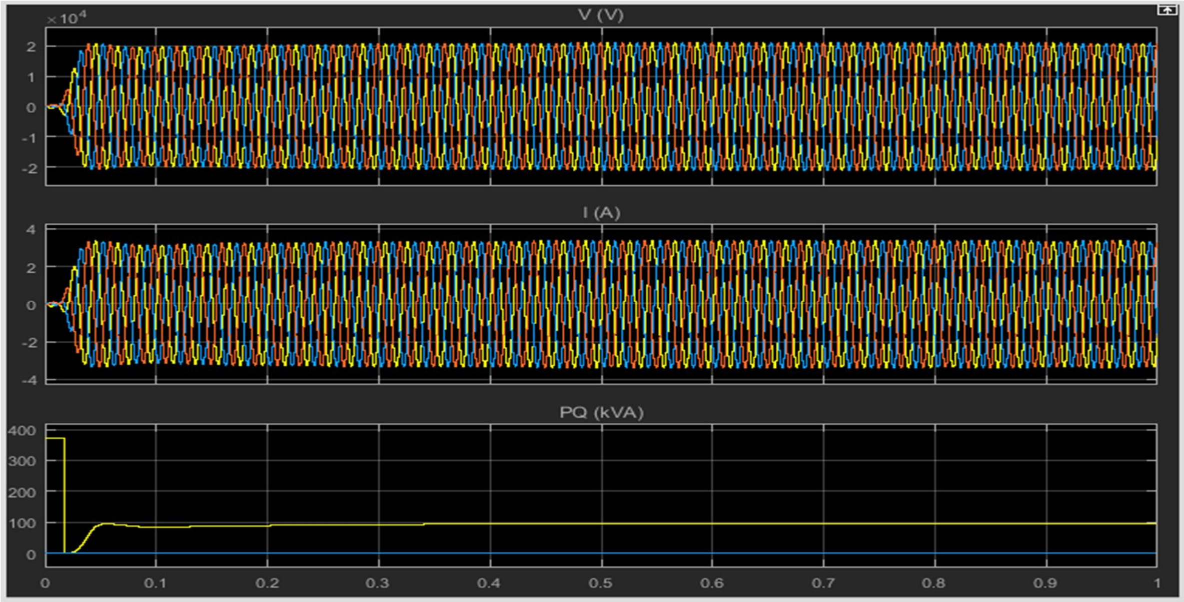

Figure 4.3:Graph When Battery is in Charging Mode

C. Second when the Battery is in the Discharging Mode

The Simulation result of micro-grid 2, When the battery is in the discharging position both PV generation which have designed for 100kw and the diesel generation which have design for 30kw will be supplied to the load. It can be observed from the graph shown in figure 4.4

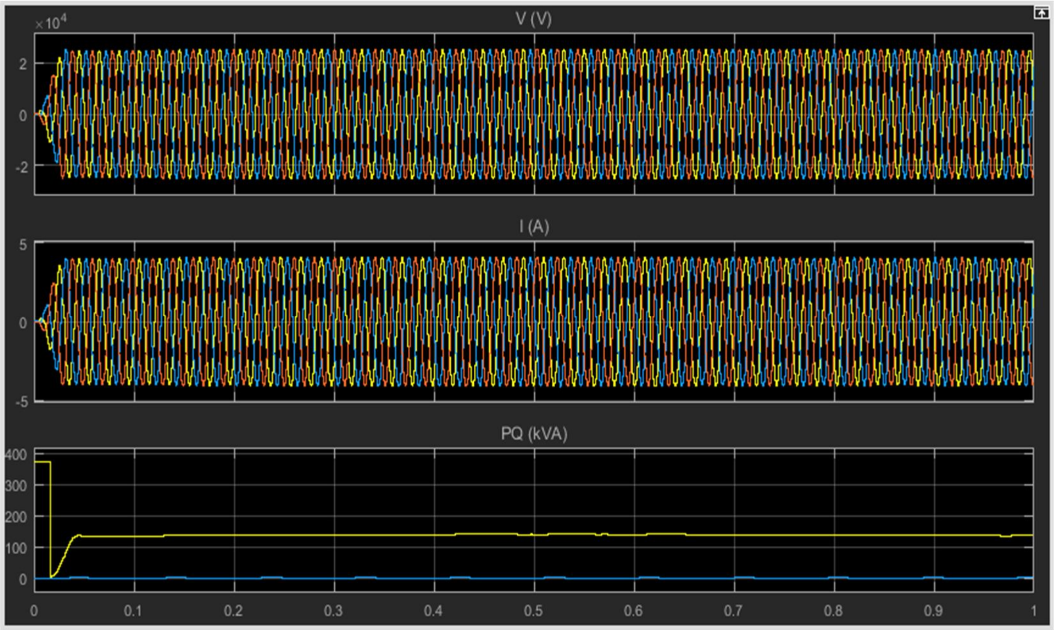

Figure 4.4:Graph when Battery is in Discharging Mode

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D. THD Analysis for microgrid- 1 [PV, Wind, Battery]

The FFT analysis is performed to study the THD behaviour of micro-grid 1

Considering two cases, one on charging of the battery and other on discharging of the battery,

During Charging of the battery, as shown in the figure 4.5 there will be less harmonics when the load is not accepting generations from the battery. From figure 4.5 we can observe THD is 0.29% with standard 50hz frequency.

During Charging of the battery, as shown in the figure 4.5 there will be more harmonics when the load is accepting generations from the battery and we can observe the THD is 2.04% with standard 50hz frequency.

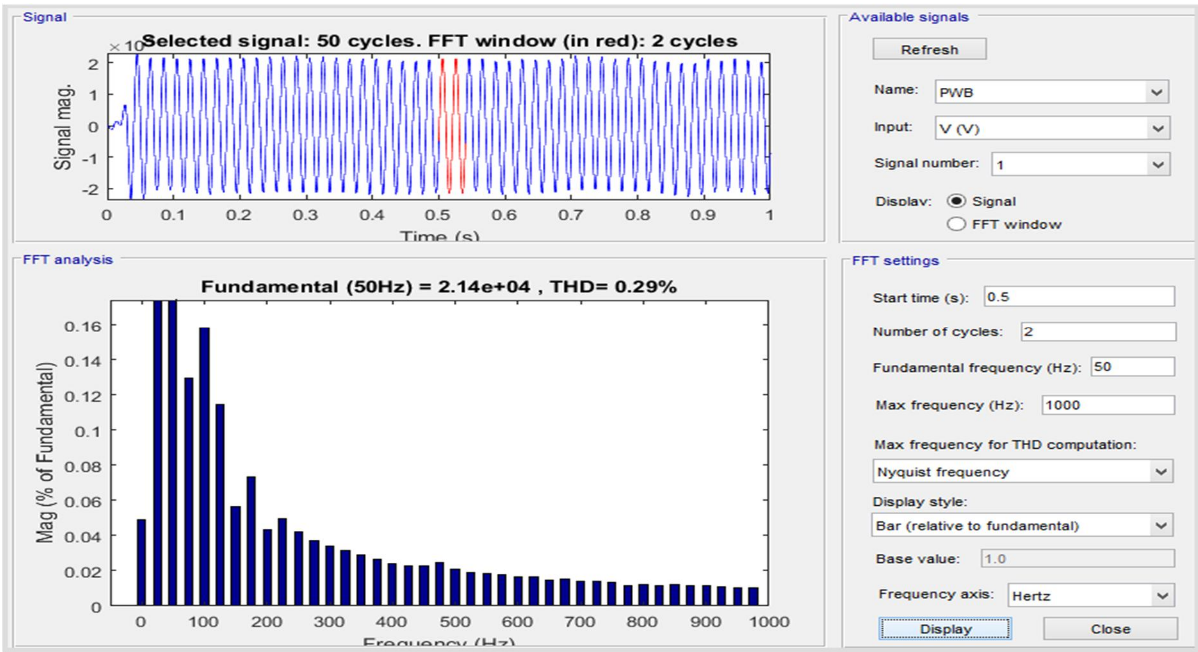

Figure 4.5: THD Analysis of Charging Mode

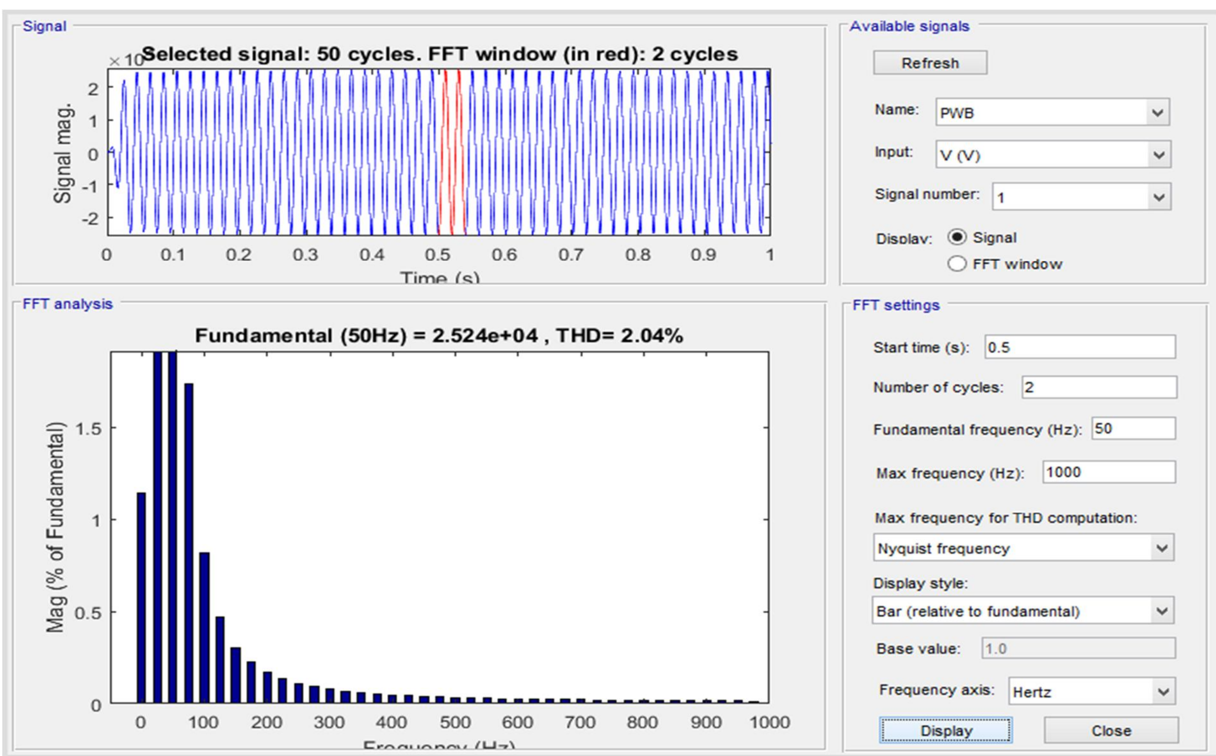

Figure 4.6: THD Analysis in Discharging Mode

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E. THD study for model 2 [PV, Diesel, Battery]

The FFT analysis is performed to study the THD behaviour of micro-grid -2

Considering two cases, one on charging of the battery and other on discharging of the battery,

During Charging of the battery, as shown in the figure 4.7 there will be less harmonics when the load is not accepting generations from the battery. From figure 4.5 we can observe THD is 0.28% with standard 50hz frequency.

During Charging of the battery, as shown in the figure 4.8 there will be more harmonics when the load is accepting generations from the battery and we can observe the THD is 2.63% with standard 50hz frequency

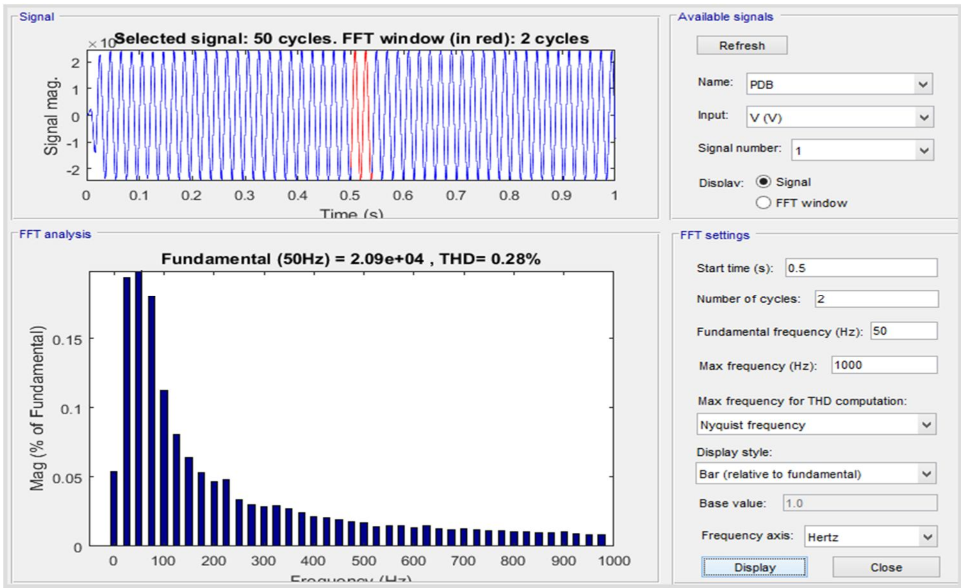

Figure 4.7: THD Analysis in Charging Mode

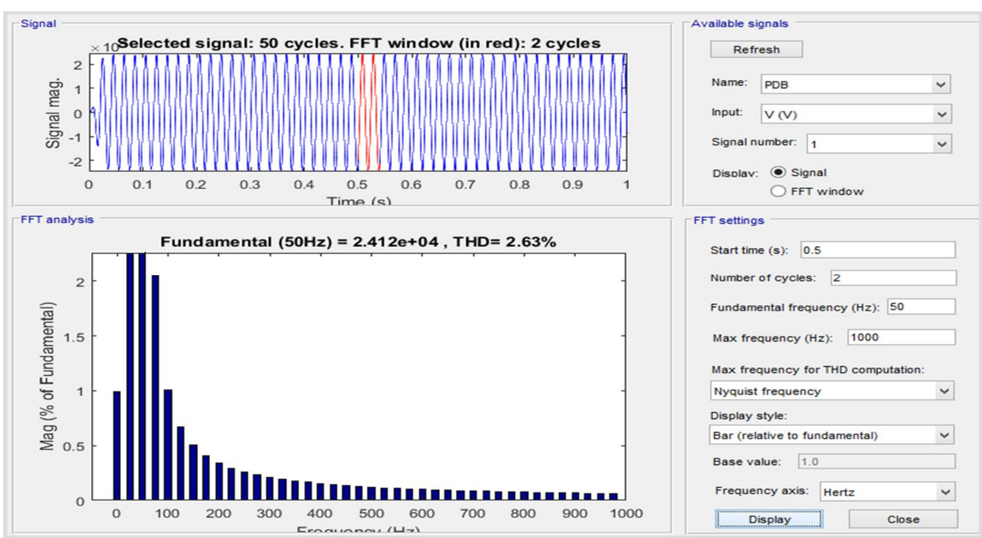

Figure 4.8: THD Analysis in Discharging Mode

The Summary of the simulation results of both the models are presented in Table below. From this it is observed that the harmonics and distortion in the voltage waveform varies differently in different scenario.

	Model 1[PV, wind, battery]		Model 2[PV, diesel, battery]	
	Charging	Discharging	Charging	Discharging
THD	0.29%	2.04%	0.28%	2.64%

Table 4.1:THD Result Table

F. Cost Analysis

Many factors involve a utility-scheming profit framework when assessing Micro-grids. This study analyzes the operational costs of micro-grids under consideration

Model 1[PV, Wind, Battery]
PV module
cost for single solar panel of 100w = 3,200 INR
cost per watt =32 INR
Cost for 100KW=1,00,000*32=32,00,000+3,00,000 (installation)
Total cost for 100KW=35,00,000INR

Wind module (30KWA)
Cost of wind generator per KW = 3,05,286INR
Cost for 30KW = 30*3,05,286 = 91,58,580INR+(installation)
Total cost for 30 KW = 91,58,580+5,00,000 = 96,58,580INR

For the transformer
100KVA transformer cost = 1,50,000INR
Total cost for module 1[PV, Diesel, Battery] = 1,33,08,580INR

Model 2[PV, Diesel, Battery]
PV module
cost for single solar panel of 100w = 3,200 INR
cost per watt =32 INR
Cost for 100KW=1,00,000*32=32,00,000+3,00,000 (installation)
Total cost for 100KW=35,00,000INR

Diesel generator module(30KWA)
For 30KWA Diesel plant requires 2.9gallon of diesel per hour
Cost of diesel for 1 year = 74,46,000INR
Cost of 30KWA diesel generator = 3,00,000INR
Total cost for 30KWA diesel generator = Cost of diesel annually cost of diesel generator + installation
Total Cost for diesel generator = 74,46,000+3,00,000+1,00,000=78,64,000
For the transformer
100KVA transformer cost = 1,50,000INR
Total cost for module 2[PV, Wind, Battery] = 1,15,14,000 INR

G. Discussion on the Above Results

As observed from the FFT analysis for THD of both the models we can see that the THD of both the are some when the battery is in the charging mode where values of the model 1 [PV, Wind, Battery] is 0.29% and model 2 [PV, Diesel, Battery] is 0.28% and when the switch is shifted to the discharging mode in battery controller, battery starts to discharged as a result the THD of both the models increases the THD values in discharging mode is 2.04% for 1st model and 2.64% for 2nd model so from the results we can conclude that by comparing THD of two models model 1 poses better outcome in THD than model 2

As for cost analysis approximate cost for the installation of model 1 [PV, Wind, Battery] is 1,33,08,580 INR and approximate cost for the installation of model 2[PV, Diesel, Battery] is 1,15,14,000 INR model 1 has higher value of installation cost compared to the model 2.

V. CONCLUSIONS

In this work a comparative study of Harmonics and cost analysis of two different combination of micro-grid that is (PV, Wind, Battery) and (PV, Diesel, Battery) are carried out with PV rating as 100KW for both models, wind and diesel rating of 30KW to maintain the balance between two models and battery of Ni-Mh with rated capacity go 6.5 Ah and rated voltage of 200 V.

On comparing THD of both the models in battery charging and discharging using state FFT analysis, it observed that THD remains same in both the models during the charging state but during the discharge mode of the battery (PV, Diesel, Battery) are observed to measure more THD when compared to (PV, wind, Battery) model.

On calculating the cost of installation of both the models it is observed that the (PV, Wind, Battery) model requires more financial support compared to (PV, Diesel, Battery), As we talk of environmental issues renewable energy plays a major role in the future. Wind generation is better option than diesel generation, therefore we can conclude that the PV, Wind, Battery combination has lesser harmonics and less impact on the environment apart from cost issues.

VI. ACKNOWLEDGMENT

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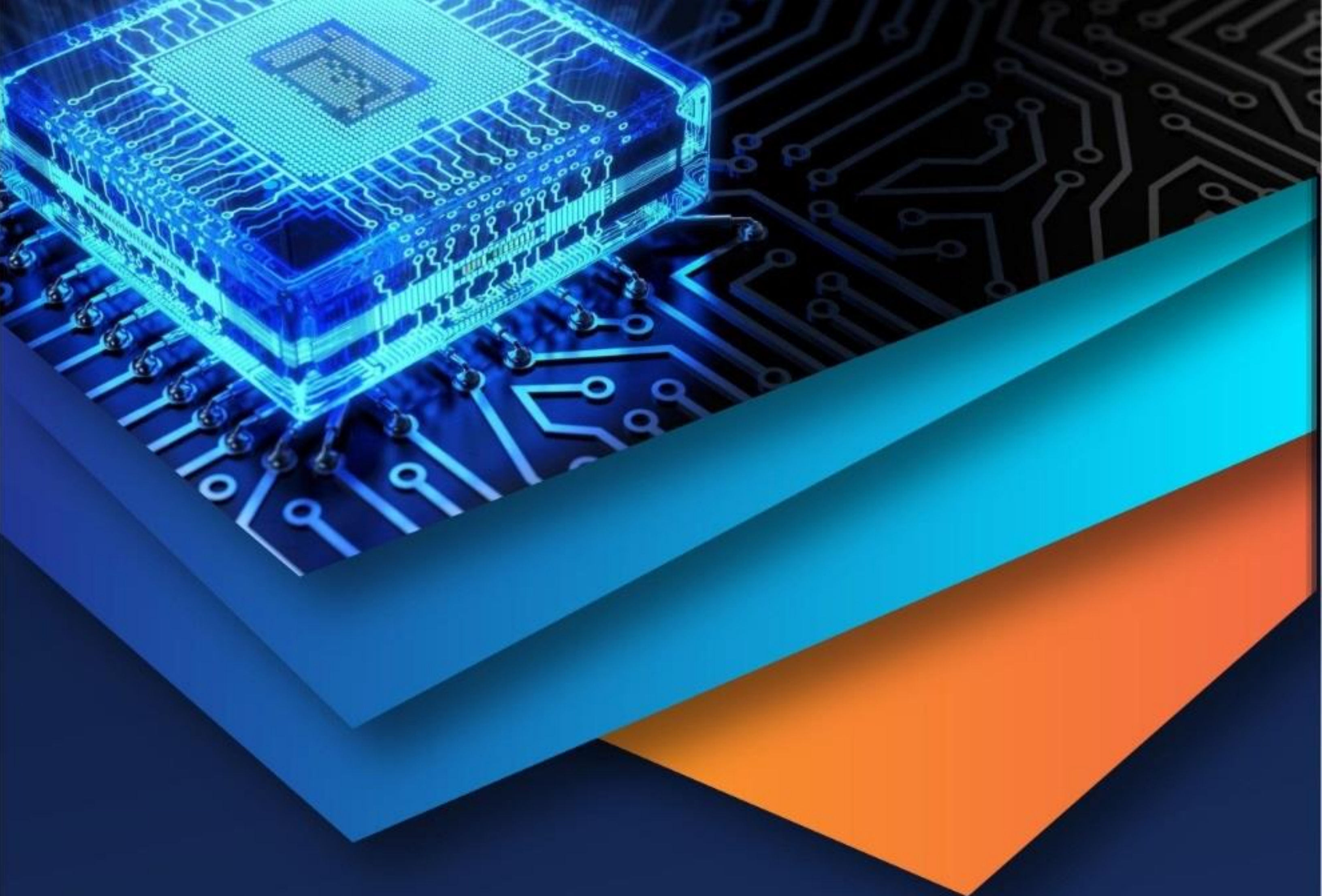

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