

AI Based system Performance Enhancement Fed by BESS with grid Integration

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Abstract: The electric lattice should have the generation ability to satisfy the needs of power consumers. The point of this examination is to research how the force limit and situation of a battery energy stockpiling framework influence the force quality in a frail force lattice with variable loads. The system performance is expected to be improved by designing a compensator in line with the variable loads and whose control system is guided by artificial intelligence (AI) based techniques and algorithms. The grid performance enhancement shall be done in terms of power factor and active power improvement with stable outputs. The analysis has been focused on the low tension line (local loads) after the grid connection where the system is also driving the electric drive and reactive loads at the high tension line. The effect has been studied on of 400V phase to phase load line. The infers that the BESS framework is made effective for driving the heaps having improved dynamic force yield at its terminal. The voltage accessible has been made less mutilated to 3.07% and the THD level in current yield has also come down to 2.93%.

Keywords: THD, AI, BESS, DC, AC.

I. INTRODUCTION

The electricity grid must have the necessary production capacity to needs of electricity consumers. However, the electricity of demand in varies widely, both of the daily and seasonal, and it is the major challenge to the run generators to cope with loads with large peak-based deviations [1]. Power providers should have adequate introduced ability to fulfill top need and should oversee adequate limit constantly to satisfy need progressively. Meeting these prerequisites commonly implies that limit is overseen 20% more than assessed request and that on normal just 55% of introduced age limit is utilized in a year [2]. Large numbers of these failures are brought about by the transitory idea of the energy in the force network. Because of the absence of energy stockpiling in the matrix framework, the energy should be quickly conveyed to the purchaser and devoured by him [3]. The electrical capacity for energy storage in the grid is currently 125 GW (mostly in the form of pumped hydroelectric plants), which corresponds to around 3% of the world's electrical capacity [4].

Extra energy stockpiling in the network would permit numerous different frameworks to work nearer to full limit and decrease energy misfortune during influence transmission. Energy stockpiling is a vital piece of differentiating energy sources and adding renewable energy sources to the energy market. By using energy storage systems, production sources do not have to be started or stopped, but can instead operate with maximum efficiency, while energy storage systems compensate for power fluctuations. Applications that could benefit from energy storage in the power grid have different requirements. [5].

II. LITERATURE REVIEW

Feehally T et al. [6] this article presents two research bureaus for battery energy storage that are linked to the UK energy matrix. Their presentation is very detailed in addition to the results of the equipment and various administrations supporting the network are illustrated, always with the results presented.

Xu X et al. [7] this article presents meeting design from Battery Energy Stockpiling Framework (BESS) projects, which require the planning and implementation of specific facilities for troop transformation. These activities concern the sectors of aging, transport and circulation of electricity as well as benefits for final energy customers, for example guidelines on the recurrence of the grid, leveling and balancing of electricity respectful of the environment, distribution and exchange of energy, improvement of the quality and reliability of electricity for connected customers, isolation activities and sophisticated micro-grid applications.

Gallardo-Lozano J et al. [8] This article introduces an on-board charger compatible with the electric vehicle network. As with an original control technique, the charging hardware can operate bidirectional, requiring or infusing a reasonable sinusoidal musical flow into the matrix, so that the quality of the chassis voltage is neglected and the quality of the chassis voltage is neglected of influence is limited.

Qian H et al. [9] This item offers a high productivity lithium particle battery energy storage system, which consists of a LiFePO 4 battery based energy storage system and a highly efficient two-way AC-DC converter. The Battery-the-board framework evaluates the state of charge and strength of each battery cell and uses dynamic charge distribution to regulate the charge of the multitude of cells in the pack.

III. OBJECTIVE

the main objective in this study are the following are.

- The system performance is expected to be improved by designing of a compensator in line with the variable loads and whose control system is guided by the artificial intelligence (AI) based techniques and algorithms.
- The grid performance enhancement shall be done in terms of power factor and active power improvement with stable outputs
- The THD% in the voltage and current waveform should be considerably reduced by using the device making the finally developed system more efficient and stable.

IV. METHODOLOGY

Various modeling techniques are developed by researchers to model components of Battery energy systems. Performance of the individual components is either of the modeled by deterministic or probabilistic approaches.

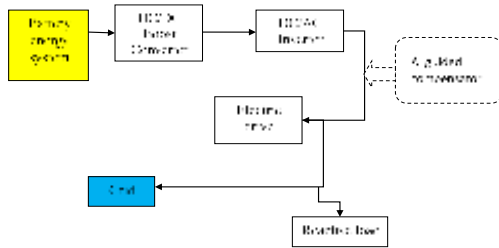


Fig. 1: Block diagram of battery system implementation with AI switched regulatory compensator

This study discusses the basic modeling structures of battery system connected with grid that is intended to drive the electric drive and reactive load at the load line of 400V.

AI switched regulatory compensator for guided power factor in the low voltage line.

A. Battery energy storage system

The BESS essentially consists of three parts, batteries, an energy conversion system and a control system called the battery management system. Batteries and PCs are the most important electronic components in the system and both technologies are developing rapidly.

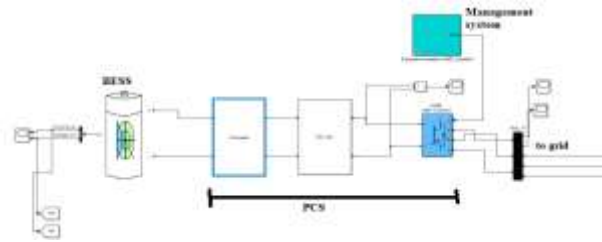


Fig. 2 BESS model in simulation for analysis

Batteries are the primary idea around which all that BESS is constructed and there are batteries that understand the capacity and arrival of energy. The remainder of the framework is utilized to make the batteries mains-accommodating. The PCS deals with the transformation and stream of energy for charging and releasing. The BMS is the control unit that chooses in which heading the energy stream should happen. Chooses whether the battery should charge or release power from the mains [7]. The control framework can be controlled severally. One approach to screen the framework is to decide the condition of charge of the batteries from the voltage.

B. Inverter modeling in PCS

The inverter framework portrayed in this report is a lattice associated three stage voltage source inverter arrangement regularly utilized in appropriated age interfaces. A SVPWM regulator with a simultaneous edge was chosen to control the inverter.

In the event that the produced power is taken care of into the lattice or utilized by AC purchasers, DC-AC converters should be utilized. Inverters can have single-stage or three-stage yield. There are four normal network coordinated inverters for photovoltaic frameworks: the focal framework inverter framework, the string inverter framework, the multi-string inverter framework and the microgrid inverter framework (AC modules).

The focal inverter is the past innovation and depends on focal inverters that have countless photovoltaic modules associated with the lattice. The photovoltaic modules are associated in series (this is known as a chain). These strings are associated in corresponding with string diodes to accomplish elite. String inverters are the current innovation, and are the little sort of plant inverter where each string is associated with the inverter. Multi-string inverters comprise of numerous strings and are associated with a common DC-AC inverter with its own DC-DC converter. String inverters are superior to focal framework inverters because of their singular controllability. The square outline of the three-stage DC-AC inverter associated with the lattice is displayed in figure 3.

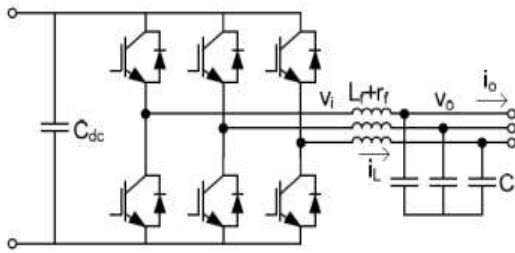


Fig.3 three phase inverter block diagram.

C. BMS control for PCS using vector modulation

Assuming the instantaneous voltage value of three-phase sine wave is respectively:

$$U_a = V_m \sin(\omega t), U_b = V_m \sin(\omega t - 2\pi/3), U_c = V_m \sin(\omega t + 2\pi/3)$$

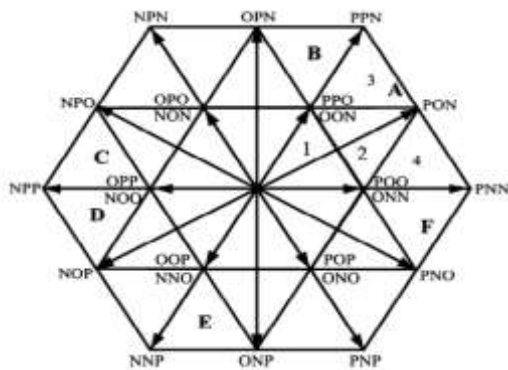


Fig. 4. Space-vector diagram of the three-level converter

The magnitude and angle of the rotating vector can be found as below:

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix}$$

$$\vec{V}_{ref} = V_\alpha + jV_\beta = \frac{2}{3} (U_a + aU_b + a^2U_c)$$

Where

$$a = e^{j2\pi/3}$$

$$|\vec{V}_{ref}| = \sqrt{V_\alpha^2 + V_\beta^2}, \theta = \tan^{-1}(V_\beta/V_\alpha)$$

- Sector A if θ is $0^\circ \leq \theta < 60^\circ$, then V_{ref} will be.
- Sector B If θ is $60^\circ \leq \theta < 120^\circ$, then V_{ref} will be.
- Sector C If θ is $120^\circ \leq \theta < 180^\circ$, then V_{ref} will be.
- Sector D If θ is $180^\circ \leq \theta < 240^\circ$, then V_{ref} will be.
- Sector E If θ is $240^\circ \leq \theta < 300^\circ$, then V_{ref} will be.
- Sector F If θ is $300^\circ \leq \theta < 360^\circ$, then V_{ref} will be.

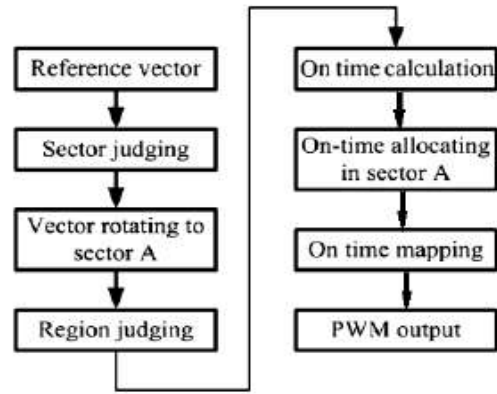


Fig. 5 three-level SVPWM Simplified calculations

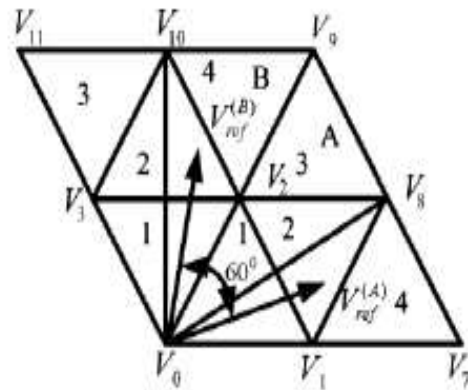


Fig.6. sector A and B vectors with the 60° shifting.

So the reference vector V_{ref} can be expressed in the following form.

$$V_{ref}^B = V_{ref}^A * e^{j\pi/3} = \frac{2}{3} (-U_b - U_c e^{j\frac{2\pi}{3}} - U_a e^{-j\frac{2\pi}{3}})$$

What's more, when the reference vector is in different areas, it will be pivoted to area A by $n\pi/3$ where $(n=1, 2, 3, 4, 5)$. The relating reference vector in different areas can be developed as given in Table 1.

Table 1. Relationships of Voltages Constructing the Reference Vectors in Six Sectors.

Sectors	Phase Voltage A	Phase Voltage B	Phase Voltage C
A	U_a	U_b	U_c
B	$-U_b$	$-U_c$	$-U_a$
C	U_c	U_a	U_b
D	$-U_a$	$-U_b$	$-U_c$
E	U_b	U_c	U_a
F	$-U_c$	$-U_a$	$-U_b$

PI controller: to the external control of the circuit is PI controller that the controls the input voltage to the converter. Pulse width modulation takes place in the PWM block with a significantly faster switching frequency of 100 KHz. In our simulation, KP is assumed to be 0.15 and KI to be 6.6. A

relatively of the high AI value to ensure that system stabilizes of faster. The PI controller works to minimize the error between Vref and measured of the voltage by varying the duty cycle across the switch.

Vdc regulator: Determine the active current reference required for the current regulator.

Current regulator: From the current references (reactive current), the regulator of the determines in the reference voltages required for the inverter.

PLL and Measurements: Required for synchronization and voltage / current measurements.

PWM Generator: Uses the bipolar PWM modulation method to generate turn-on signals for IGBTs.

D. AI guided Compensating device

The remunerating gadget is intended for keeping up with the steady voltage level and current with decreased bending to give a consistent stock notwithstanding any vacillations or changes because of variable burdens at the framework line. The planned compensator utilizes general three leg IGBT circuit having control framework directed by the AI calculations and learning strategies. The IGBTs are the gadgets whose yield is constrained by controlling the setting off heartbeats to them and thus creating more ideal yield. The control is additionally upgraded by exact checking of the key electrical boundaries utilizing the numerous swarm streamlining strategy and further learning the progressions in the framework boundaries.

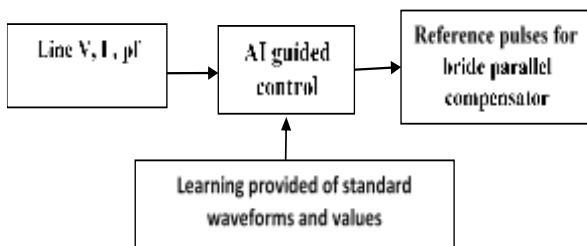


Fig. 7 Block diagram of control system function

E. DMS_DMS_PSO Control for device

Dynamic multi swarm Particle swarm advancement DMS_PSO is a clever multitude enhancement calculation that is right off the bat proposed by Kennedy as a developmental calculation dependent on conduct of birds. DMS_PSO utilizes a bunch of particles that every one proposes an answer for the enhancement issue.

It depends on the achievement of all particles that imitates a populace where the situation of every molecule depends to the specialist position to identify the best arrangement Pbest by

utilizing current particles in the populace G. The situation of any molecule xi is changed by,

$$x_i^{k+1} = x_i^k + v_i \tag{Eq 1}$$

where the vi represents velocity component the the step size and is the calculated by:

$$v_i^k = wv_i^k + c_1r_1(P_{best_i} - x_i^k) + c_2r_2(G - x_i^k) \tag{Eq 2}$$

where x is the inertial weight, c1 and c2 are the acceleration coefficients, r1 and r2 are random values that belong to the interval of [0, 1], Pbest_i is the best position of particle i, and G is the best position in the entire population.

step

where pbest_i and gbest are respectively determined.

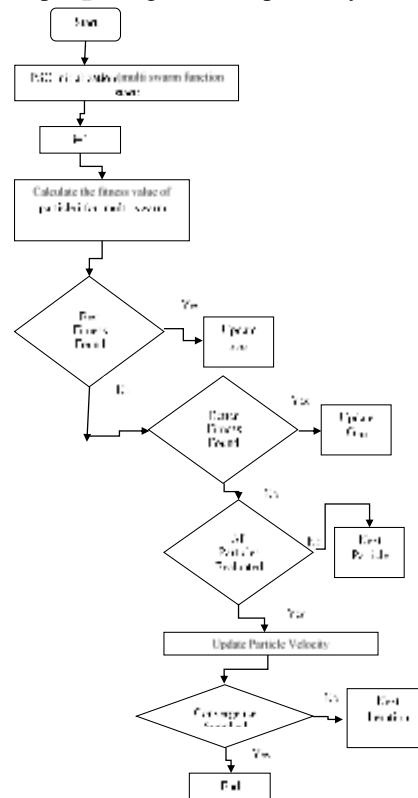


Fig. 8: DMS_PSO- controller Technique implemented in MATLAB/SIMULINK

Then, at that point the positions are refreshed and supplanted with better wellness esteems in case they are found. The speed and position of every molecule are refreshed in the fourth step. The last advance of the flowchart really looks at the union basis. In the event that the basis is met, the interaction is done. Something else, the emphasis number is expanded and technique gets back to step 2.

F. NMS_PSO with NN control

They are characterized into a few layers and interconnected with one another by characterizing loads. Synaptic loads show the cooperation between each pair of neurons. These designs disperse data through the neurons. The mappings of sources of info and assessed yield reactions are determined through blends of various exchange capacities. We can utilize the self-

versatile data design acknowledgment approach to dissect the preparation calculations of the counterfeit neural organizations. The most generally utilized calculation is the mistake back spread calculation.

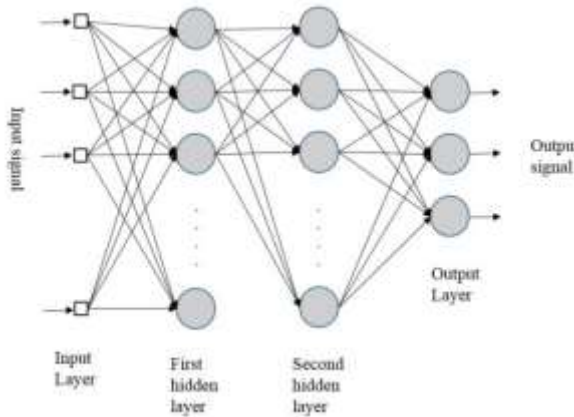


Fig. 9 Architectural Graph of an MLP Network with Two Hidden Layers.

The development of ANN models was based on studying the relationship of input variables and output variables. Basically, the neural architecture consisted of three or more layers, i.e. input layer, output layer and hidden layer as shown in Fig. 9. The function of this network was described as follows:

$$Y_j = f(\sum w_{ij} X_{ij}) \quad \text{Eq(3)}$$

where Y_j is the output of node j , $f(\cdot)$ is the transfer function. w_{ij} the connection weight between node j and node i in the lower layer and X_{ij} is the input signal from the node i in the lower layer to node j .

ANNs are data handling frameworks that reenact the conduct of the human. ANNs get the intrinsic data from the thought about highlights and gain from the info information, in any event, when our model has commotion. ANN structure is made out of fundamental data preparing units, which are neurons.

Neural organizations can be partitioned into single-layer insight and multi-facet discernment (MLP) organizations. The multi-facet insight network incorporates different layers of straightforward, two state, sigmoid exchange capacities having handling neurons that collaborate by applying weighted associations. An average feed-forward multi-facet discernment neural organization comprises of the info layer, the yield layer, and the secret layer. The multi-facet discernment (MLP) with the back spread learning calculation is utilized in this examination on the grounds that various past scientists utilized this kind of ANN, and it is likewise an overall capacity guess.

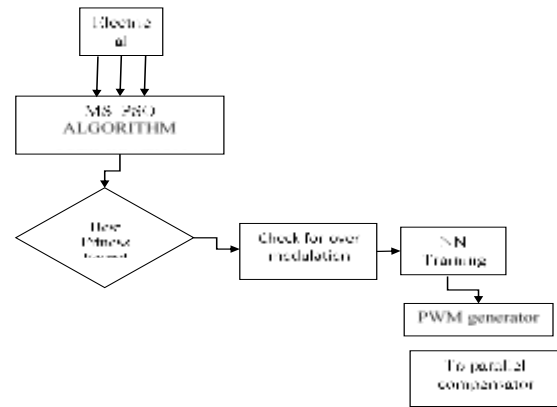


Fig. 10 NMS_PSO controller Technique implemented in MATLAB/SIMULINK

V. RESULTS

A. Simulation Environment

MATLAB represents MATrix LABoratory, which is a programming bundle only intended for expedient and easy legitimate estimations and Input/yield. It has really many inbuilt capacities for an enormous type of calculations and a lot of tool kits intended for explicit investigation disciplines, just as measurements, streamlining, arrangement of incomplete differential conditions, data examination.

In this exploration work MATLAB stage is utilized to show the execution or reproduction of carried out calculation execution. Estimation tool compartments are utilized and some inbuilt capacities for producing diagrams are utilized. Reenactment results and examination of the exhibition of executed model for certain current ones are determined by MATLAB capacities.

The work has zeroed in on the battery energy framework demonstrating and execution directed with an equal compensator that is driven by AI procedures. The framework is extraordinarily determined by the battery stockpiling energy as an asset and is then coordinated with the lattice while it is likewise made to drive receptive burden and electric drive at the high strain line. The compensator is planned explicitly for the battery energy stockpiling framework that has stable yield at the line having 400V and is advanced by the dynamic multi-swarm molecule swarm enhancing (DMS-PSO) regulator that is directed to keep up with the voltage at the line and right the force factor in the framework for driving different kinds of burdens.

The framework was then additionally read for development in the line power factor by consolidating the AI streamlining with the learning innovation. The regulator was planned with feed forward plan of the neural organization innovation of AI and renamed the control framework to NMS_PSO. The battery energy stockpiling framework incorporated with lattice and

afterward the front-end regular compensator configuration dependent on the scaffold converter innovation has been read for further developed execution by utilizing appropriate AI procedures for the further developed exhibition from a similar engineering.

The study has discussed output from the battery system connected with grid in the following mentioned cases:

CASE 1: Battery energy storage system grid integrated driving various loads.

CASE 2: Battery energy storage system grid integrated with (DMS-PSO) control for line compensation and quality enhancement.

CASE 3: Battery energy storage system grid integrated with (NMS-PSO) control for line parameters learning and enhancement.

The distortion level in the voltage output and current from the system by using various types of control for the parallel compensator before its integration with grid system is being analyzed. The comparative analysis of the power system electrical parameters is also done by comparing the power factor at the line and active power enhancement.

B. Modelling of BESS

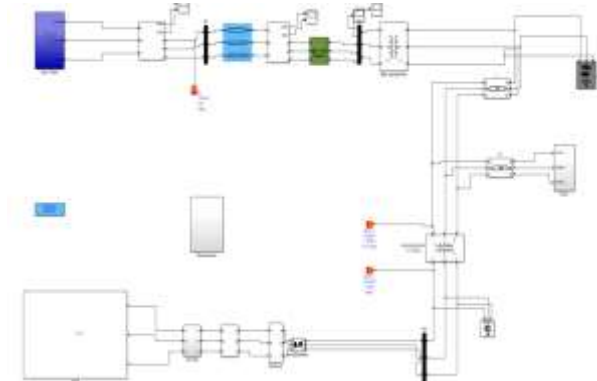


Fig. 11 Modeled BESS with grid integration in MATLAB/SIMULINK

CASE 1: Battery energy storage system grid integrated driving various loads (no parallel device).

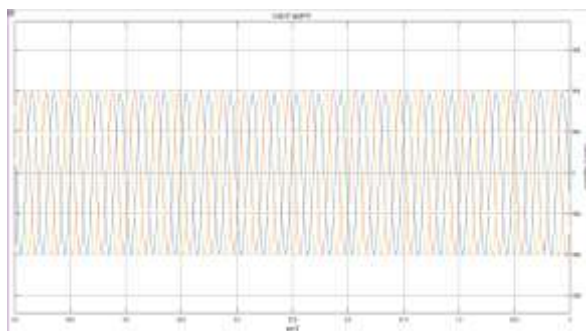


Fig.12 Voltage o/p from system without any line compensating device

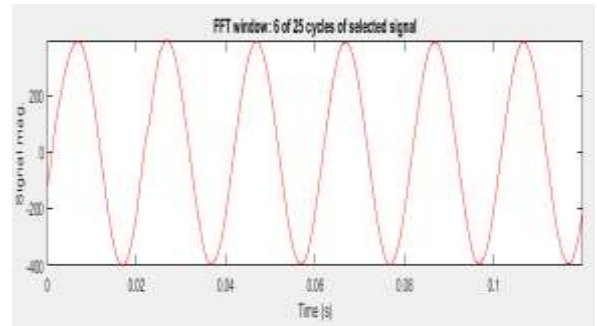


Fig.13 FFT analysis of Voltage o/p from system with out any line compensating device

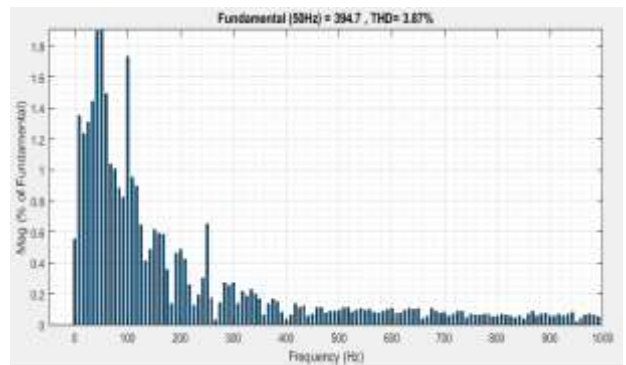


Fig.14 THD% in voltage o/p from system without any line compensating device

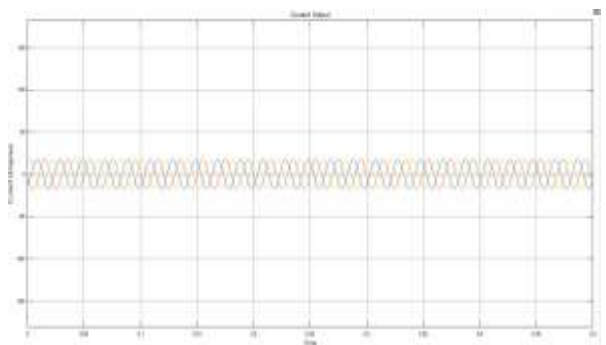


Fig.15 Current output from the system without any line compensating device

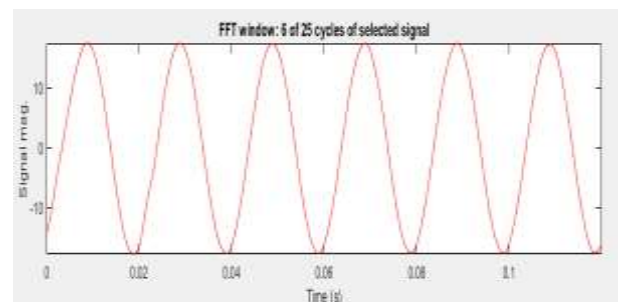


Fig.16 FFT analysis of the current o/p from system without any line compensating device

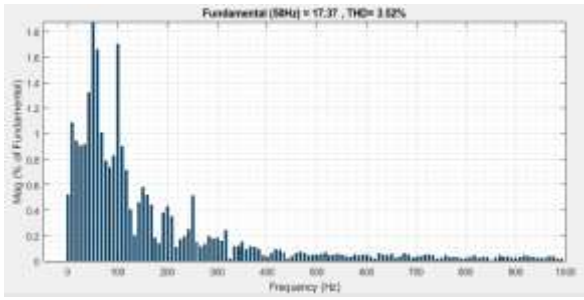


Fig.17 THD% in the current o/p from system without any line compensating device

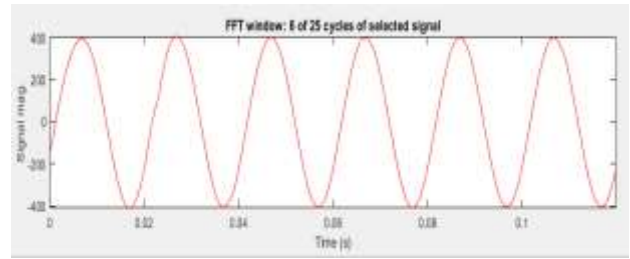


Fig.21 FFT analysis voltage in system with (DMS-PSO) control for quality enhancement

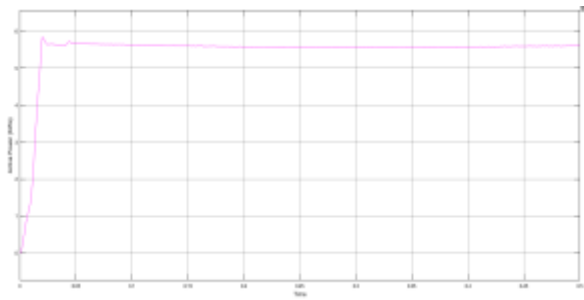


Fig.18 Active Power o/p from system without any line compensating device

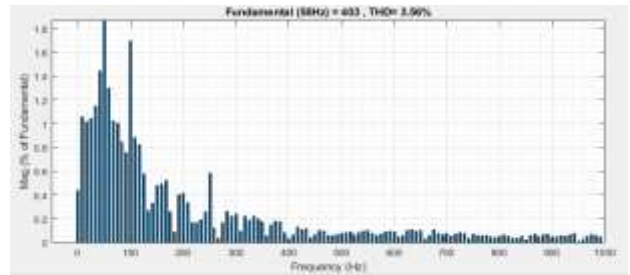


Fig. 22 THD% of voltage in system with (DMS-PSO) control for quality enhancement

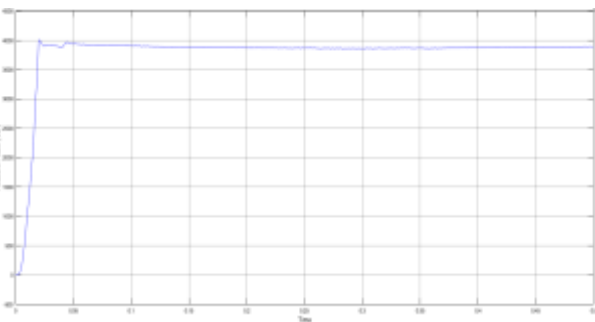


Fig.19 Reactive power o/p from system without any line compensating device

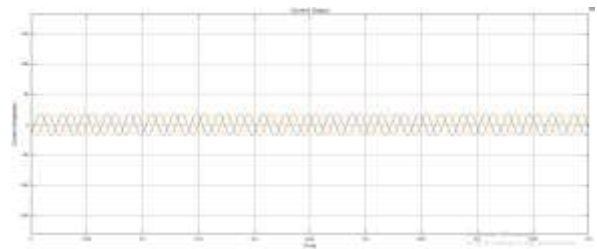


Fig. 23 Current in system with (DMS-PSO) control for line compensation & quality enhancement.

CASE 2: Battery energy storage system grid integrated with (DMS-PSO) control for line compensation and quality enhancement.



Fig.24 FFT analysis current in system with (DMS-PSO) control for quality enhancement

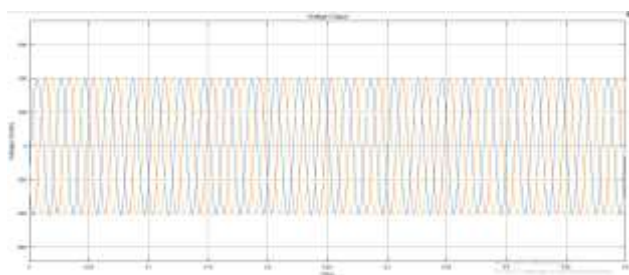


Fig.20 Voltage o/p from system with (DMS-PSO) control for line compensation & quality enhancement.



Fig. 25 THD% measured of current in system with (DMS-PSO) control for quality enhancement

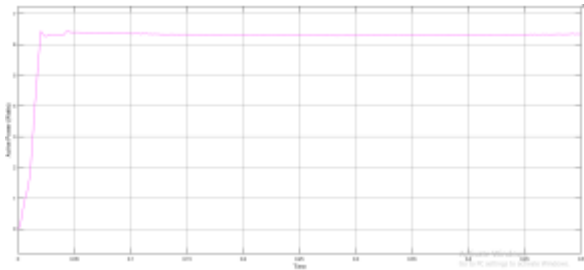


Fig. 26 Active power o/p from system with (DMS-PSO) control for line compensation & quality enhancement.

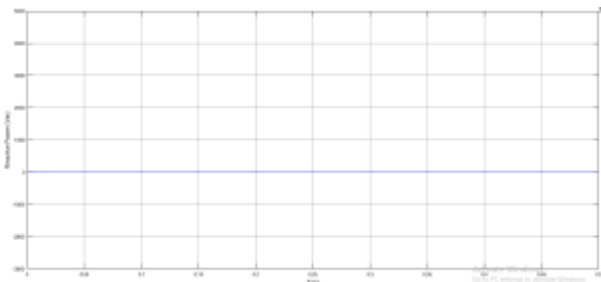


Fig. 27 Reactive Power output from the system with (DMS-PSO) control for line compensation & quality enhancement.

CASE 3: Battery energy storage system grid integrated with (NMS-PSO) control for line parameters learning and enhancement.

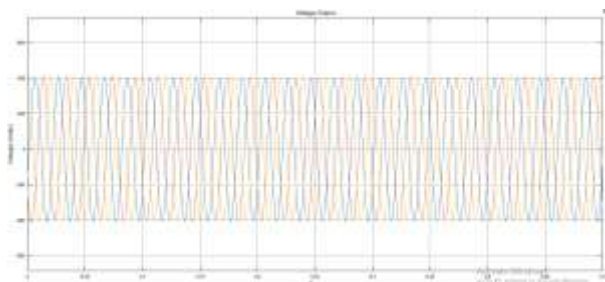


Fig.28 Voltage o/p from system with (NMS-PSO) control for line compensation & quality enhancement.

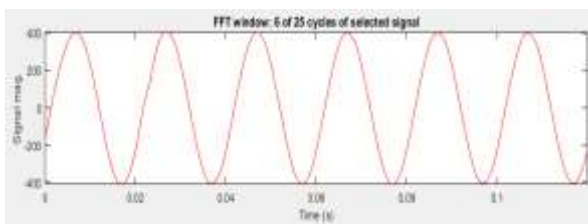


Fig.29 FFT analysis of voltage system with (NMS-PSO) control for quality enhancement

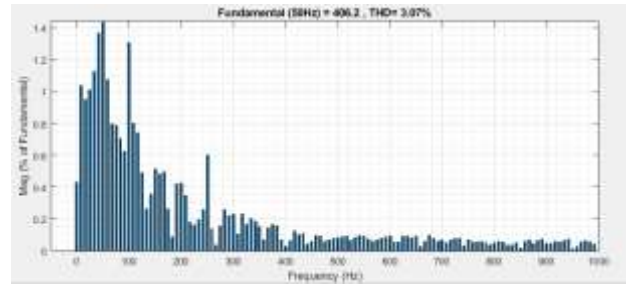


Fig.30 THD% in voltage system with (NMS-PSO) control for quality enhancement

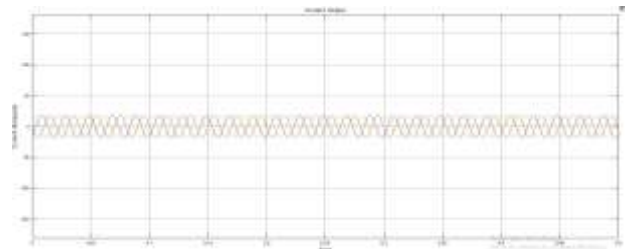


Fig.31 Current o/p from system with (NMS-PSO) control for line compensation & quality enhancement.

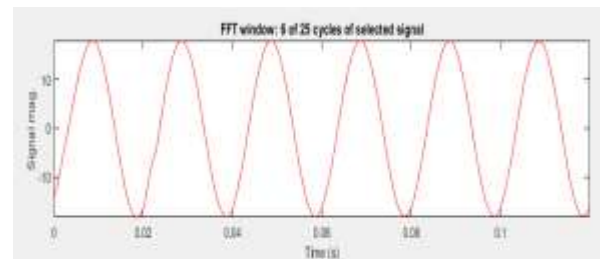


Fig.32 FFT analysis current system with (NMS-PSO) control for quality enhancement



Fig.33 THD% in current in the system with (NMS-PSO) control for quality enhancement

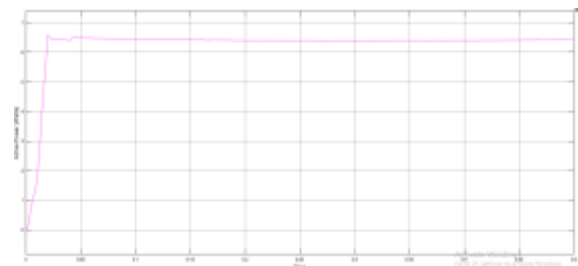


Fig.34 Active Power o/p from system with (NMS-PSO) control for line compensation & quality enhancement.

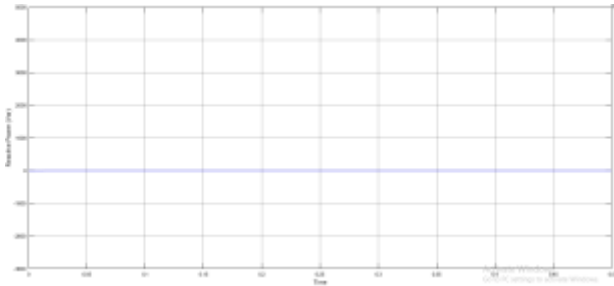


Fig. 35 Reactive Power o/p from system with (NMS-PSO) control for line compensation & quality enhancement.

VI. CONCLUSION

The work here presents a Battery energy stockpiling framework in MATLAB/SIMULINK climate for investigation. We have planned a regulator for the compensator dependent on the improving calculation which is a piece of man-made reasoning

The analysis has been focused on the low tension line (local loads) after the grid connection where the system is also driving the electric drive and reactive loads at high tension line. The effect has been studied on of 400V phase to phase load line. The analysis shall comprise of voltage and current profile analysis with focused area on power factor correction and reactive power compensation.

Parameters/ Model	system with no device for quality enhancement	system with (DMS-PSO) control for quality enhancement	system with (NMS-PSO) control for quality enhancement
Active Power (KWatts)	5.607	6.34	6.42
Voltage (Volts)	400	400	400
Current (Ampere)	17.32	17.81	17.96
THD% in voltage	3.87%	3.56%	3.07%
THD% Current	3.52%	3.37%	2.93%
Power Factor	0.81	0.88	0.89

- The dynamic force yield from the framework has improved to 6.42KW in the framework having compensator managed from the proposed regulator that NMS_PSO from 5.6KW.
- The calculations directed by the fake methods even saw decrease in THD% of voltage and current profile of the heap line alongside the force factor amendment.
- The above portrayal reasons that the BESS framework is made effective for driving the heaps having upgraded dynamic force yield at its terminal.

The voltage accessible has been made less contorted to 3.07% and the THD level in current yield has additionally boiled down to 2.93%.

VII. FUTURE SCOPE

The adjustment procedure is simple and easy to carry out; using the right Facts gadgets can make the inverter more strong and simpler to utilize. With the coming of all the more remarkable man-made brainpower, the low computational intricacy and memory utilization prerequisites of calculations will diminish and surprisingly more muddled and productive calculations could be carried out. The proposed controller demonstrated powerful in compensator plan. This calculation can be additionally improved by making a cross breed strategy for this calculation. Along these lines, it is positively a fact that the field of development joints is and will stay an open field for logical examination and business applications.

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