ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 9(32), DOI: 10.17485/ijst/2016/v9i32/94240, August 2016 ISSN (Online) : 0974-5645

An Application of Fuzzy Logic Controller Renewable Energy Storage System

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Abstract

Background/Objectives: Embedded generation are futuristic energy system that penetrates in the conventional power system in a rapid manner. The wind energy system is which a typical non-conventional energy source faces the problem of stochastic nature which makes it not suitable to all energy applications. **Methods/Statistical Analysis:** The Electric vehicles are the novel energy transportations systems owing to their mobility and easy power transfer to the power drought areas. **Findings:** The stochastic control algorithm is used for scheduling of electric vehicles which effectively meets the gird requirements as well as meeting the energy requirements. The fuzzy logic controller is used in the energy storage system which is relatively advantageous compared to conventional PI controller. **Application/Improvements:** The control strategy is demonstrated from side to side model simulation swot up the results conform the significance of the control methodology incorporated in the paper.

Keywords: Fuzzy Logic Controller, Renewable Energy, Vehicle to Gird, Wind Power

1. Introduction

Non-conventional energy sources are need of the hour in view of energy thrust scenario prevailing in the electricity markets. Various renewable energy sources such as solar, hydro, wind, ocean, tide, geo-thermal, etc are explored to the notable extent in order to satisfy the energy thrust of the humans. Wind power is individual alternative starting places of energy which is easy to harness but the nature is basically stochastic, i.e., its characteristics cannot be predicted accurately which might increase the risk if we start relying on it for major share of energy demand. At times, if the wind alone may not be sufficient to meet the grid requirements, which requires the need of mobile power generators.

Electric Vehicles (EV) especially Plug-in EVs are commonly used mobile generators. They are basically energy storage devices which meet the deficit power requirements. On account of the irregular way of wind speed power, expansive range reconciliation of current air force represents a test on the power gird in both transient and relentless states. EV find their place in unit commitment problem and often address it with the help of energy storage by meeting the requirements of power during peak times. The usage of EVs significantly reduces the cost and well as maintenance. In order to optimise the process, the locations along with the V2G power characteristics are to considered and given utmost importance. At that point, the possibility investigation of EVs was led, which considered the restrictions forced on the V2G power because of the attributes of EV batteries[1-5]. In any case, to hand deficiencies that the power stream of EVs was unidirectional, charging speed was altered at most extreme farthest point, and the ideal arrangement was the chosen charging interims amid the module time frame.

With the regularly expanding prevalence of EVs[6], the recurrence control gave by V2G operation has been effectively researched. A few EV totals of various sizes and setups were controlled in light of the recurrence deviation signal[7]. In addition, EVs could give different assistant administrations, for example, the vitality booking for burden leveling[8], the minimization of charging expense[9], and the turning save[10]. Despite the fact that an assortment of direction administrations are recommended for V2G vitality administration, the multi-objective control

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technique to oversee EV vitality for different auxiliary administrations is missing in the writing.

2. Multilevel V2G Framework

The routine asset driven be in charge of model of the power framework is no more practical; in V2G have power over structure is cutting edge circulation matrix, which joins new electric parts, including renewable vitality sources, microgrids, and movable electric machines at the client end[11-19]. Vitality stockpiling gadgets the broad EVs in the power grid have great prospects of going about as appropriated vitality stockpiling because of the adequate force limit from countless locally available batteries and the adaptable force control gave by cutting.

Besides, as a crucial power stockpiling gadget in microgrids, EVs respond to the irregular wind control and settle the force vacillation at the basic coupling purpose of microgrids. The V2G structure[1] has been incorporated with the power grid as shown in Figure 1. The force system is conveyed to. The variety of wind power era profile contradicts the load request. Hence, the wind power generation compounds the unbalance between force free market activities.

Various EVs are associated to the test power system through different charging frameworks, for example, the expansive accusing stations of quick dc charging capacity, the ordinary air conditioning arraigning stations, and the residential chargers. The arraigning frameworks are expected to cover around 20% of the district; the quantity of transports with EVs can be spoken to by $n_x=\mathrm{int}(r_{EV}\ n_b) = 6$ where n_b is the aggregate transport number, and is the spatial entrance level of EVs. In this way, the arraigning heap of EVs is place over to six transports, haphazardly chosen[7-11].

The power required for battery is calculated for determination of charging load in case of EVs which is given by

$$\varepsilon_T = \sum_{i=1}^{N_{EV}} \frac{\left(SOC_{i,ed} - SOCi,\mathrm{int}\right)EC_i}{n} = \frac{\mu\left(SOC_{ed}\right) - \mu\left(SOC_{\mathrm{int}}\right)}{n} N_{EV} \left(\sum_{i=1}^{N_{EC}} EC_{i\gamma i}\right) \quad (1)$$

The initial SOC are assumed to be following standard normal distribution.

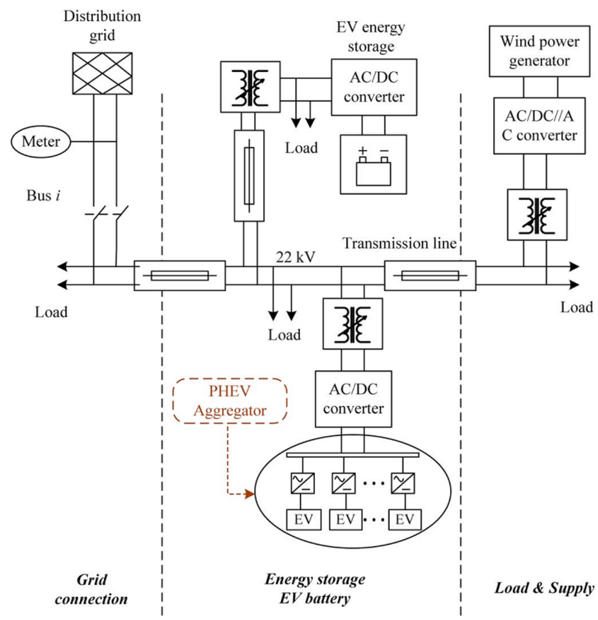

Figure 1. Schematic diagram of V2G dynamic regulation model with wind power.

3. V2G Optimisation

The V2G optimisation involves in reducing the total operating cost which include power supplied by the gird and the wind power. The total operating cost(TOC) is given by

$$TOC = \sum_{t}^{H}\sum_{gt}^{N_g} F_i\left(P_{gt,t}\right) + \sum_{t}^{H}\sum_{gt}^{N_g} F_i\left(Q_{gt,t}\right) + \sum_{t}^{H}\sum_{DG_i}^{N_{DG}}\left(a_i P_{DG_i}^2 + bP_{DGt,t} + C\right) + \sum_{EV_i}^{N_{ev}}\sum_{t}^{H} r_{EV_{i,t}} P_{EV_{i,t}} + \sum_{EV_i}^{N_{ev}} \rho_{EVi}\left(EL_{EVi} - \sum_{t}^{H} P_{EVi,t}\right) + \sum_{t}^{H}\sum_{i}^{N_{ES}} \rho_{cap} P_{ES_i} \quad (2)$$

This is the objective function which is to be optimised by following

$$P_{g,t} = \sum_{EV_i}^{N_{ev}} P_{EV_{i,t}} + \sum_{EG_i}^{N_{WG}} P_{WG_{i,t}} + \sum_{L_i}^{N_b} P_{L_i} + P_{Loss,t} \quad (3)$$

$$P_{EV,\min \le pEV_i}(t) \le P_{EV,\max} \quad (4)$$

$$0 \le E_{EV_{i,\mathrm{int}}} + \int pEV_i(t)dt \le E_{EV_{i,\max}} \quad (5)$$

$$\int pEV_i(t)dt = E_{EV_{i,\max}} - E_{EV_{i,\mathrm{int}}} \quad (6)$$

$$SOC_{\min} \le SOC_{id}(t) \le SOC_{\max}$$
$$SOC_{id}(H) \le SOC_{final} \quad (7)$$

4. V2G Aggregation

Utilized for giving occurrence parameter and ought to subordinate administration market[12-16]. The coordinated energy administration is intended to use the EVs are administered into five gatherings to execute the multi efficient be in command of plan, and sit out of gear EVs are tapped for recurrence control[19-22]. The gathering division is fundamentally controlled by the driving example, the SOC of locally available battery, and flight time[1].

- utmost rate of charging
- Co ordinate charring
- V2G power support
- Idle mode
- Driving mode

The categorisation of EVs is based on the following considerations.

$$g_I = \{EV_i \mid SOC_{I,\min} \le SOC_{EV_i} \le SOC_{I,\max}$$
$$T_{R_m,\min} \le t_{R_m,} EV_i \le t_{R_{m,\max}}$$
$$r_{F,EV_i} = 1 \, for \; V2G \; set\} \quad (8)$$

$$t_{R_{m,EV_i}} = t_{d,EV_i} - t + \frac{\left(SOC_{ed,EV_i} - SOC_{EV_i}(t)\right) E_{EV_{i,\max}}}{P_{EV_{i,\max}}} \quad (9)$$

$$p_{x_{i,k}} = p_{x_{i,\max}}, if \; EV_i \in Group \; I \quad (10)$$

$$if \; P_{x,k} > \sum_{i=1}^{i=N_{gI}} p_{x_{i,\max}} \quad (11)$$

The allocation of EV power is as follows.

- Divide the groups according the criterion listed above
- Assign priorities to the member in each group.
- Based on time interval and merit list update the EV allocation subjected to constraints like SOC, V2G power, etc.

In equation form, the above procedure is represented as

$$P_{x_{i,k}} = \frac{P_{x,k} - \sum_{i=1}^{i=N_{gI}} p_{x_{i,\max}}}{ng_{II}}, for \; EV_i \in Group \; II \quad (12)$$

$$if \; P_{x,k} < \sum_{i=1}^{i=N_{gI}} p_{x_{i,\max}} \quad (13)$$

$$P_{x_{i,k}} = \frac{P_{x,k} - \sum_{i=1}^{i=N_{gI}} p_{x_{i,\max}}}{ng_{II}}, for \; EV_i \in Group \; III \quad (14)$$

$$subject \; to \; p_{x_{i,\max}} < p_{x_{i,\max}} \; and$$
$$p_{x_{i,k}} = 0, \; for \; t < t_{s,EV_i} \; or \; t > t_{ed,EVi} \quad (15)$$

5. Results

The integrated management of energy with suitable stochastic EV scheduling is presented in this paper. The speed of wind fluctuates rapidly with EV or V2G system is depicted in Figure 2.

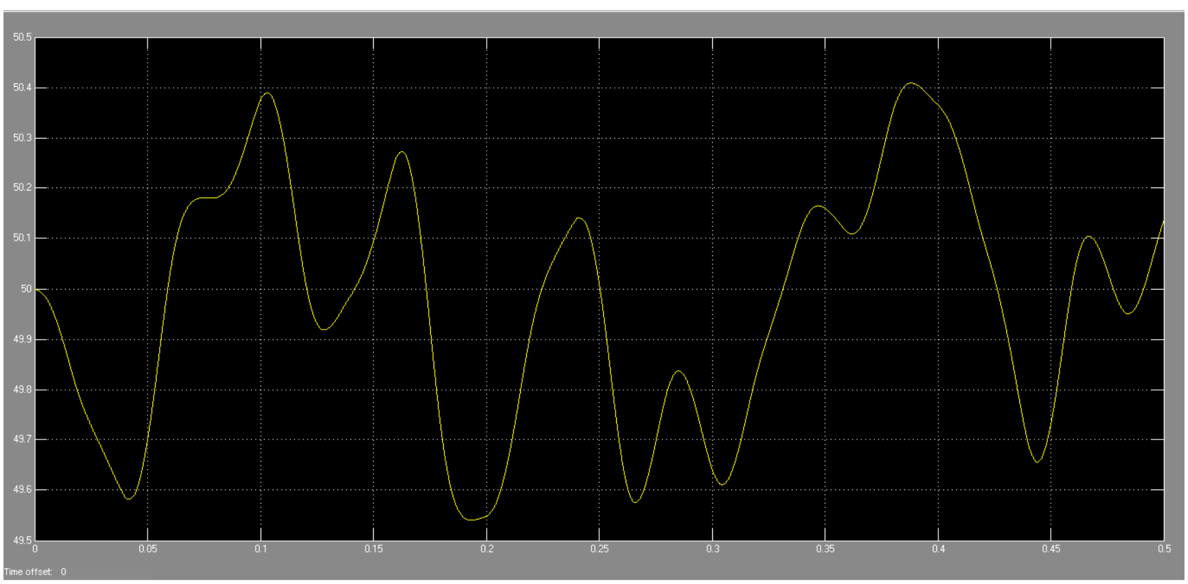

Figure 2(a). Airstream speed variation with respect to time without V2G strategy.

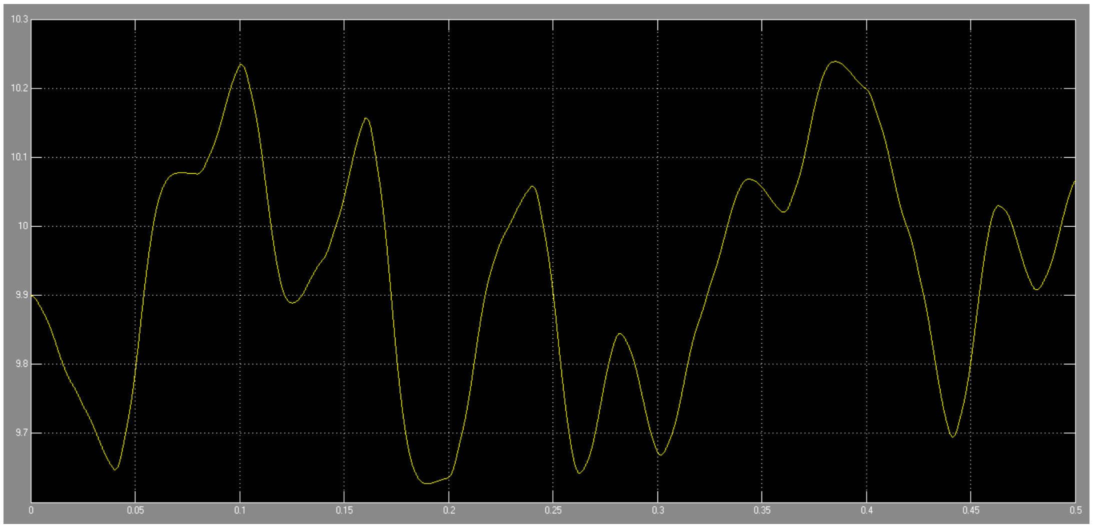

Figure 2(b). Air speed variation with respect to time with V2G strategy.

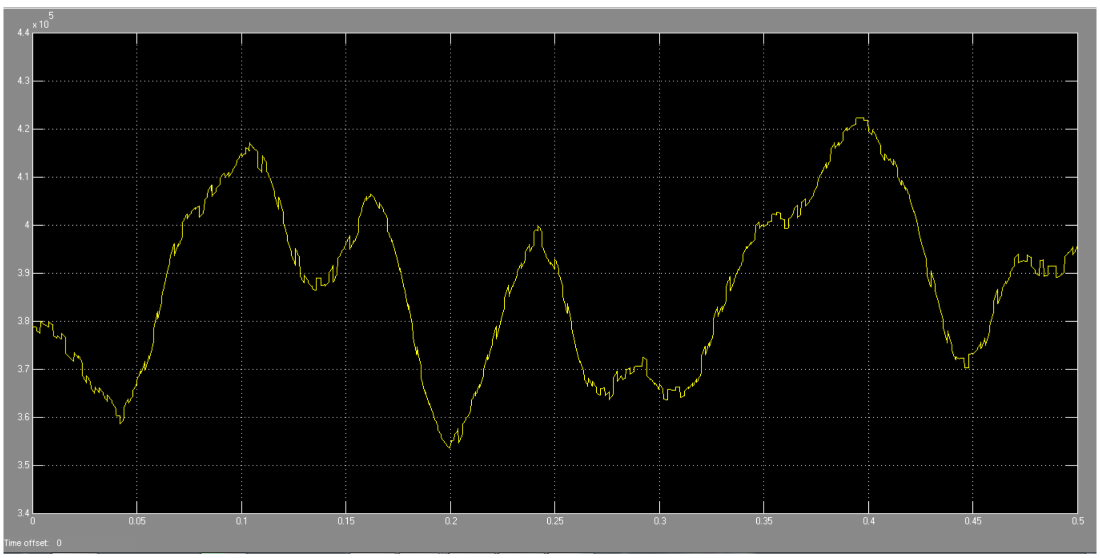

Figure 3(a). Variation of Air power with respect to time axis without V2G strategy.

The variation of wind power with respect to time without EV as given in Figure 3 .

The air speed and wind in nutshell is stochastic in nature whose characteristics are not predictable at any instant of time. The capacity of system is restricted to 40 Kw. Initially the EV power is used to the fullest possible extent and the percentage of utilisation is 100%. Then, only 75% of it is utilised in this case although the rating of EV is 100%.

The process of fuzzification involves in measurement of input values and proper scaling or mapping that transfers the range of values of input variables into corresponding universe of discourse. (FLC). FLC is effective manipulation of the fuzzy arithmetic in the fuzzy platform to achieve the desired results. It is relatively hassle-free, easy to implement and rapid control is possible in case of FLC. So, the FLC is incorporated in EV energy storage system in order to facilitate smooth control and the results are significantly found out to be encouraging as shown in the below figure.

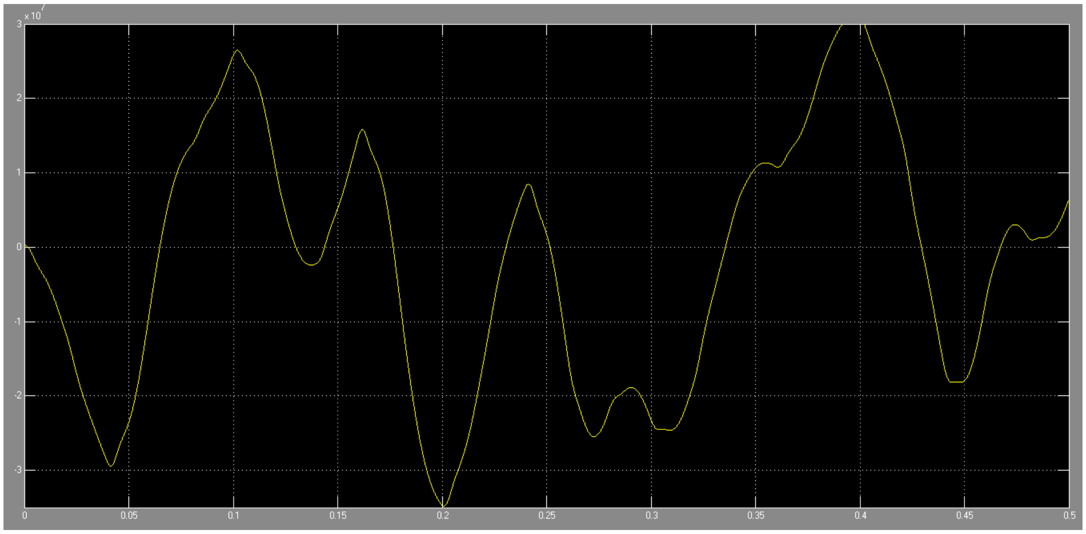

Figure 3(b). Variation of air control with respect to time with V2G strategy.

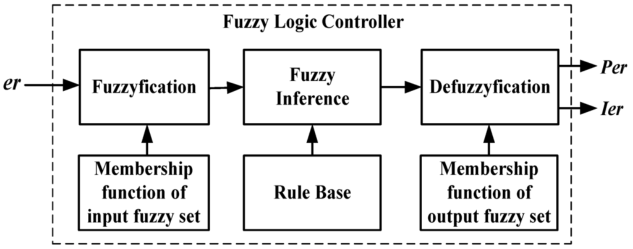

Figure 3(c). Fuzzy logic controller.

The deviation in the frequency without V2G control strategy is given in Figure 4

The EVs which are not used to meet the gird requirements can be easily used to achieve the regulation of frequency. The EVs apart from frequency regulation are used to meet the power required at peaking instants. The deviation in the frequency with V2G control strategy is given in Figure 4

The output of the energy with 75% and 100% (reduced) EV power utilisation is given in Figures 5 and 6. The power which is deficit during the operation of gird is normally supplied by the EVs.

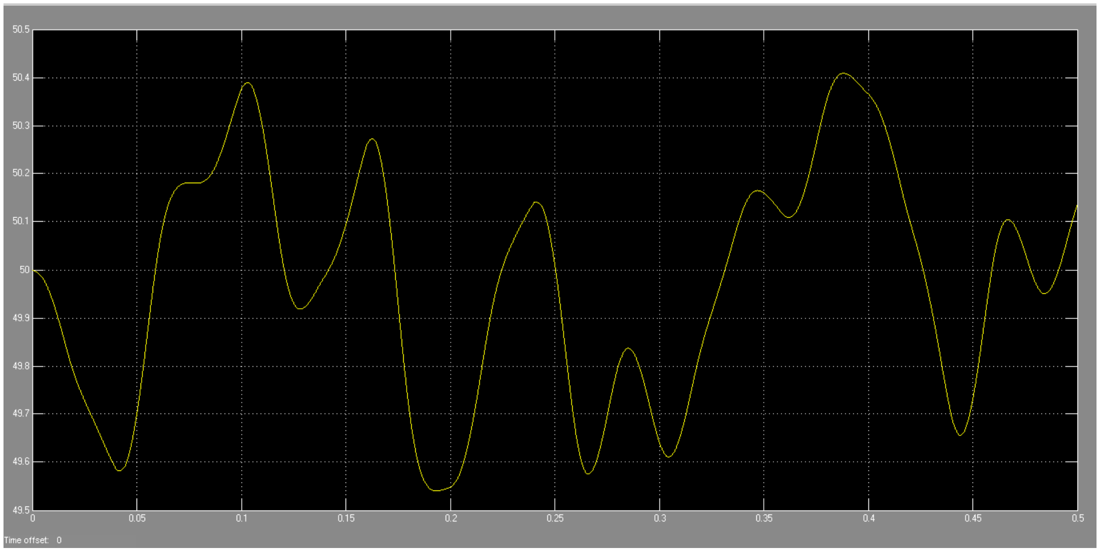

Figure 4(a). Deviation in the frequency without V2G control strategy.

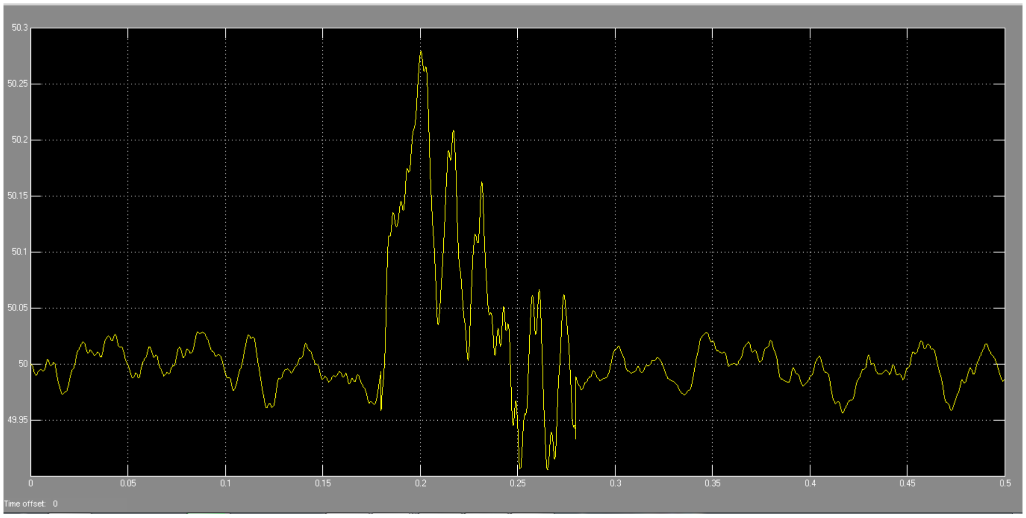

Figure 4(b). Deviation in the frequency with V2G control strategy.

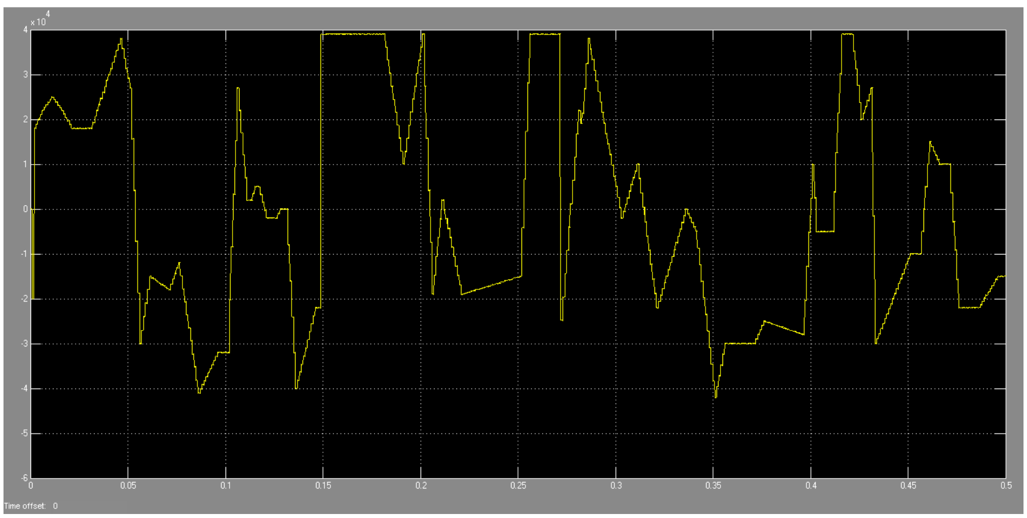

Figure 5. Power of the integrated system with V2G operation and 75% EV utilisation.

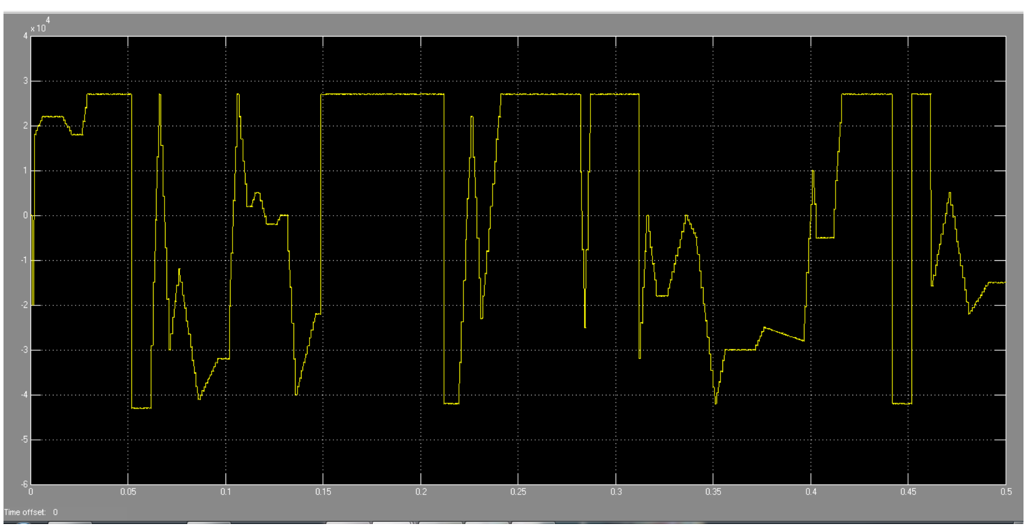

Figure 6. Output power with EV scheduling using V2G operation and with EV 100% utilisation.

6. Conclusion

The distribution gird is integrated with embedded generation and the performance is analyzed with EV scheduling which is done using stochastic control algorithm. The type of embedded generation chosen here is wind power which is stochastic in nature. Therefore, EVs came into picture which effectively meets the deficit power which might be due to increased demand or outages. The charging and discharging is optimised using the stochastic optimisation algorithm is incorporated which effectively reduces the cost of the operation subjected to limitations that occur in the PS. The simulation results make obvious the sanctity of the projected algorithm and the integrated energy management is successful due to stochastic optimisation algorithm and FLC in the energy storage system.

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