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Improved voltage fluctuations in improved microgrid based dual packet loop Flywheel battery control and harmonic system reduction by NPC three-level inverter

Omid Feizollahzade
Department of Electrical Engineering, Tehran Branch, Islamic Azad University, Tehran, Iran,
Email: omidfeizollahzade@gmail.com
Orcid: 0000-0002-5176-0320.

***Abstract*---**Clean power sources like PV and wind power consist of prodigious randomness as well as volatility, and random variations in solar irradiance and wind speed are vulnerable to the voltages variations. As a result of the effect of photovoltaic and energy wind in relation to the power quality of the Microgrid and the reduction of system harmonics, this study describes the parallel mode of connection of a carousel battery with two small voltage sources with the adjustment of each output micro source voltage done by the AC output side. The inverter comes with an NPC three-level inverter MATLAB / Simulink software simulation results show that From the closed-loop control strategy and the use of the NPC three-level inverter, the system voltage stabilization and power quality are improved, and the system harmonics are reduced, so we will have a better result.

***Keywords*---**Double-Loop Control, Three-Level Inverter, Flywheel Battery, Micro Grid, Fuzzy PID Controller, Voltage Fluctuation.

1. Introduction

As the economy continues to grow, the scarcity of resources also continues to be more apparent[1, 2]. One of the method methods adopted to alleviate this problem was the introduction of Renewable energy power generation technology, where the most commonly employed methods are photovoltaic and wind power. The employment of hybrid solar and wind micro-grid energy generation can solve the inadequacies of single method sustainable generation of energy. However, PV and wind energy are extremely irrepressible. More particularly when the micro-grid is working distinctively, variations in photovoltaic output energy and wind energy

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leads to fluctuations in the output micro-grid voltage, leading to a weakening of the system power quality. So, it is crucial to adjust the buffer effect of the energy storage device. There are several kinds of literature concerning above mentioned, the main target for regulating the DC voltage and reducing the harmonic and fluctuations of the system was studied from the system of generation of wind power in particular its flywheel battery to enhance the quality of the power produced. In [1], the oscillating power of the microgrid system is gently put in, and the gear battery is managed by a vector control [1]. These approaches showed acceptable control consults, but there are drawbacks as well. On the contrary, using the device's stored energy to regulate the voltage on the DC side can not respond to the micro-network output voltage change promptly. Whereas, the normal (current) PI regulator response speed is disregarded. [2] among the reasons for voltage fluctuation in the Microgrid can be related to solar radiation as well as wind speed, so to decrease the fluctuations in the first stage, we analyze the input information and then reduce the response time of current and voltage. We use the PI control loop, and in the third step, we use the NPC three-level inverter to improve the system performance and reduce the system harmonics.

2. Micro-Grid With Wind Power And Pv

A. Reasons for Fluctuation of Voltage in Micro-grid

In a micro-grid with photovoltaic and wind, Wind speed together with illuminance randomness and variability act on the output energy of distributed energy supplies. Supposing the microgrid load system is constant, circuit equivalence is presented in Fig.1.
In Fig.1, E is the distributed power supply's outlet voltage, R is the resistance of the line, X is the line reactance, I is the current in the line, and U is the output voltage of the system. P is the distributed power supply's active power output While Q is the reactive power then,

$$V = E - \frac{PR + QX}{E} \qquad \textbf{(1)}$$

It can be seen from (1) that flowing the fluctuations of the power output of the PV and the wind energy, which is the reactive energy and active energy in the output energy change, the output voltage U of the micro-source fluctuates accordingly. Briefly, when the load is constant, whenever an imbalance exists between the power output of the micro-grid system and the energy required by the load, it can lead to voltage fluctuation of the micro-grid system.

B. System Structure and Working Principle

In Fig.2, the micro-grid system structure with PV and wind energy can be seen. The structure primarily comprises a wind power generation unit, PV generation unit, and flywheel battery Etc. Flywheel batteries, like energy storage units, are parallel and integrated with the AC output of micro-sources to realize the bidirectional energy flow. The output power of PV and wind energy differs with solar irradiance and wind speed. The voltage of the microgrid system remains unstable if the load is constant. N, according to the structure of the system, at the drop of the micro source’s output voltage, the flywheel battery acts as a generator unit, releasing the power to the AC bus from the flywheel storage for the AC load. The flywheel battery functions as a load unit when the voltage of the micro-output source rises and the excess power is withheld in the flywheel battery. The flywheel battery function is the real-time spotting of changes in the produced voltage of the micro-source and managing the output or input of the inverter as needed to stabilize and improve the output voltage of the Microgrid. Power quality.

3. Flywheel Battery System Control

A. Control Strategy

The flywheel storage management technique is implemented in the corresponding inverter within the Microgrid. Here, with the micro-source system of energy generation, The flywheel battery is regulated as a unit. First, the voltage setting is determined for the steady working of the Microgrid. Subsequently, for the flywheel battery inverter, a micro-source LCL filter structure is used to implement a double-loop capacitor voltage and inductor current control strategy. The system voltage aims to adjust and improve the flywheel's power quality on the condition that the system reference voltage is followed by the flywheel battery inverter’s output voltage.

Fluctuations in the voltage of the Microgrid can reach the battery if the flywheel battery uses dual current and voltage loop control to increase the output voltage of the micro-source fast dynamic and precise control of the system current and voltage is required. However, PI controllers are used for output non-linearity and time-varying problems, as well as traditional double-loop control where parameters cannot be controlled accurately and quickly. Choosing a regulator is not easy. Insufficient parameters will not meet the exact requirements and will affect the flywheel battery’s quick discharging and charging. As a result, instead of the PI controller, the fuzzy PID controller is used in conventional double-loop systems. This will improve the flywheel battery response speed effect and voltage stabilization. [3].

In Figure 3, the flywheel battery is controlled by a rotating DQ coordinate system. By contrasting the reference voltage to the instantaneous capacitor voltage output of the inverter, the dissimilarity signal obtained by the voltage loop fuzzy PID controller is used as the required internal loop reference current. The difference signal is used as the SVPWM modulated voltage signal in the current loop Fuzzy PID controller, which compares the microinverter's output inductance current to the reference current.

B. Construction of Fuzzy PID Regulator

This study designs a fuzzy PID controller and extends the basic double-loop regulated voltage (current) PI controller to improve the flywheel's battery performance [3]. The fuzzy link between the three elements deviation E, deviation rate E, and PID, C has been discovered. After the detection of E and E_ C in real-time, the three PID parameters are fuzzy revised to be different

Requirements. The structure is shown in Fig.4.
The voltage (current deviation rate) e_c and the signal deviation e are used as input and output variables, respectively. Positive large (PL), positive medium (PM), positive small (PS), zero (ZE), negative tiny (NS), negative medium (NM), and Negative large (NB), are their linguistic subsets (PB). The Gauss type curves are used for both the input and output membership value curves. 49 fuzzy rules are established based on the experience of predecessors, as per the following table of fuzzy rules. The control effect is significantly influenced by the accuracy and resolution of fuzzy rules, as illustrated in Table 1.

Table 1. FUZZY RULES TABLE

		$de(t)/dt$		
		Δkp	Δki	Δkd
		NB NM NS ZE PS PM PB	NB NM NS ZE PS PM PB	NB NM NS ZE PS PM PB
e(t)	NB	PB PB PM PM PS ZE ZE	NB NB NM NM NS ZE ZE	PS NS NB NB NB NM PS
	NM	PB PB PM PS PS ZE ZE	NB NB NM NS NS ZE ZE	PS NS NB NB NB NM PS
	NS	PM PM PM PM ZE NS NS	NB NM NS NS ZE PS PS	ZE NS NM NM NS NS ZE
	ZE	PM PM PS ZE NS NM NM	NM NM NS ZE PS PM PM	ZE NS NS NS NS NS ZE
	PS	PS PS ZE NS NS NM NM	NM NS ZE PS PS PM PB	ZE ZE ZE ZE ZE ZE ZE
	PM	PS ZE NS NM NM NM NB	ZE ZE PS PS PM PB PB	PB NS PS PS PS PS PB
	PB	ZE ZE NM NM NM NB NB	ZE ZE PS PM PM PB PB	PB PM PM PM PS PS PB

C. NPC three-level inverter
This inverter consists of three legs; in each leg, there are four switches and two clamp diodes [4]. The orbital structure of this inverter is shown in Figure 5.

The switching pattern is based on the PWM method and is as follows:

Table 2. Three-level inverter switching pattern based on the PWM method

	Q_{u1}	Q_{u2}	Q_{u3}	Q_{u4}	V_u
Switching state	ON	ON	OFF	OFF	+E/2
	OFF	OFF	ON	ON	-E/2
	OFF	ON	ON	OFF	0

C-1- Keying modes
In the first case, keys 1 and 2 are on, and keys 3 and 4 are off, as shown in Figure 6:

- S1=S2=ON
  S3=S4=OFF

Which is the first case works according to Figure 7:
In the second case, keys 2 and 3 are on, and keys 1 and 4 are off:

- S2=S3=ON
  S1=S4=OFF

The diagram in Figure 9 shows the key turned on in the second mode:
And in the third case, keys 3 and 4 are on, and keys 1 and 2 are off:

- S3=S4=ON
  S1=S2=OFF

The diagram in Figure 11 shows the area where the key is turned on:

4. System Simulation Analysis

On the platform, Simulink and the Fuzzy Toolbox in MATLAB are used to develop the system's simulation model. The effect of good flywheel battery control and the three-level inverter design of NPC output harmonics on system improvement under dual-loop control, double control, and loop control is investigated in this study. As a result, it decreases, and the system's performance improves. The three-phase energy output of the flywheel battery generator is represented in the simulation by a three-phase AC voltage source. The micro-AC source's filter inductance L is 0.05 mH, while the filter capacitance C is 100 mF. The system continuously supplies 380V/50Hz of AC power to the AC load.
First, we simulate the Figure 12 system that comes with the NPC three-level inverter:
The simulation results are presented in exchange for changes in wind speed and radiation density in wind turbines and solar systems:

A- The waveform of wind speed changes is as shown in Figure 13
The wave of radiation density changes is shown in Figure 14:
The output voltage wave of wind turbine and solar system is 15:
The load voltage wave is presented in Figure 16:
The amplitude wave of the voltage under turbulence is shown in Figure 17:

5. Conclusion

This study aims to look into the influence on the micro-grid system’s energy quality by solar and wind micro-sources looking at the challenges that flywheel batteries can enhance output voltage fluctuation in the solar and wind micro-source, a fuzzy PID regulator has been recommended as an alternative to the conventional double-loop control PI regulators. The outcomes of the simulation indicate that the upgraded double-loop control is superior to its predecessor in the enhancement of the voltage fluctuations of the flywheel battery. It has proper voltage-fluctuation suppression capabilities due to changes in the amount of solar radiation and wind speed, and can efficiently increase power quality when the Microgrid operates autonomously. According to the simulation results, it is apparent that abrupt vicissitudes in solar system voltage and wind turbine are compensated by the active filter and the load voltage is balanced, which is hugely decreased by the addition of a three-level converter with NPC arrangement to the circuit, harmonics, and distortion in the output voltage. We conclude that multilevel inverters increase the output harmonics by reducing the voltage level and the simulation results will be more favorable.

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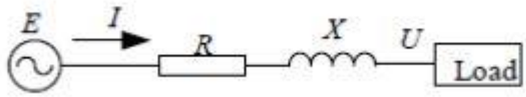
References

1. Sadovnikova NA, Lebedinskaya OG, Bezrukov AV, Davletshina LA. The indicator system of regional socio-economic situation based on harmonized information resources. Journal of Advanced Pharmacy Education & Research| Jan-Mar. 2021;11(1):147-55
2. Çora H, MikailL EH, Çora AN. A Review Of Turkish Union With A Global Economic And Political Perspective. Journal Of Organizational Behavior Research. 2019;4(2):163-78.
3. Xikun Ch, Shuangqing T, Gang L. Application of flywheel energy storage battery in grid-connected wind power generation system [J]. Machinery and Electronics 2005;(3): 26-28.
4. Herliah, A., Baso, Y. S., Hidayanty, H., Syarif, S., Aminuddin, A., & Bahar, B. (2022). Effect of web-based she smart education models on adolescent girl's knowledge, attitudes, and practice about obesity. International Journal of Health & Medical Sciences, 5(1), 50-55. https://doi.org/10.21744/ijhms.v5n1.1832
5. Cardenas R, Pena R, Glare J. Control strategy for power smoothing using vector controlled induction machine and flywheel. Electronics letters 2000;36(8): 765-766.
6. Li X, Zhu P, Yang Y, Chen J. Study of the Three-phase SVPWM Inverter based on Double Loop Control. Power Electronics 2003;37(5): 30-32.
7. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Get vaccinated when it is your turn and follow the local guidelines. International Journal of Health Sciences, 5(3), x-xv. https://doi.org/10.53730/ijhs.v5n3.2938
8. Wang J, Wang K, CHEN QS. Fuzzy Neural Network Control Strategy of Wind Generation and Flywheel Energy Storage Combined System [J]. Journal of System Simulation 2007;17.

Figure captions

Figure 1. System equivalent diagram
Figure 2. The micro-grid system's Structural block diagram with PV and wind energy
Figure 3. Schematic diagram of the flywheel's upgraded dual-loop control structure of battery inverters
Figure 4. Structural Diagram of Fuzzy PID regulator control
Figure 5. A three-level inverter circuit structure
Figure 6. Keys on and off in the first mode
Figure7. Keying diagram in the first mode
Figure 8. Turn the key on and off in the second mode
Figure 9. Turning on the key in the second mode
Figure 10. Turning the key on and off in the third mode
Figure 11. Key turning area in the third mode
Figure 12. System simulation with NPC three-level inverter
Figure 13. The waveform of wind speed changes
Figure 14. Radiation density changes
Figure 15. Output voltage wave of wind turbine and solar system
Figure 16. Load voltage wave
Figure 17. Voltage amplitude wave under perturbation by NPC three-level inverter method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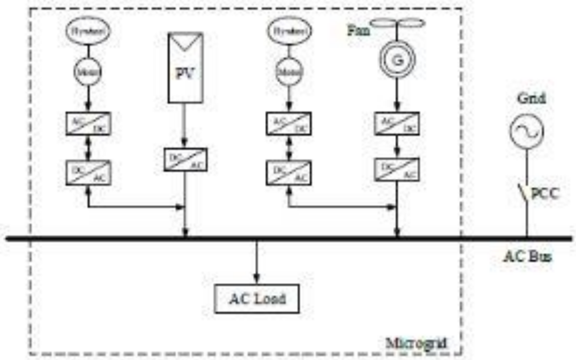
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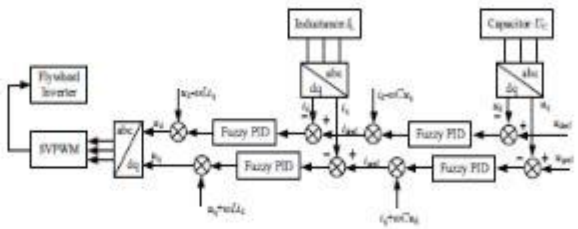
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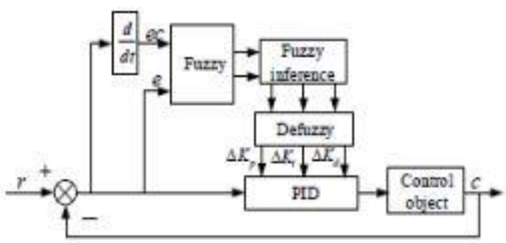
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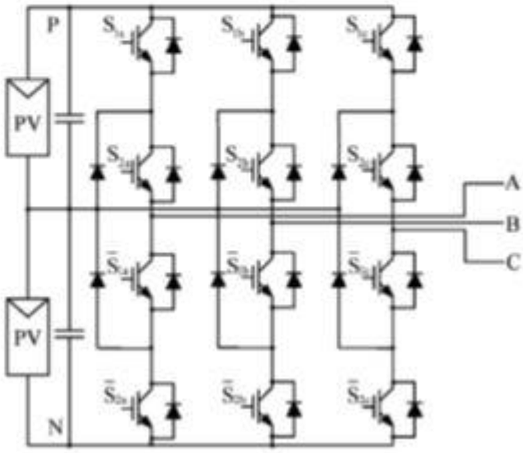
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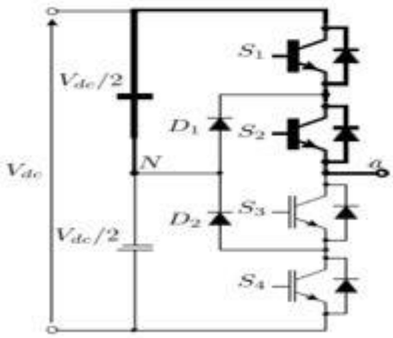
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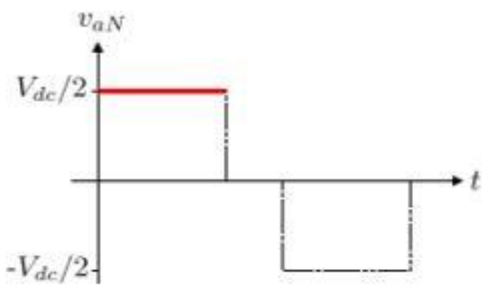
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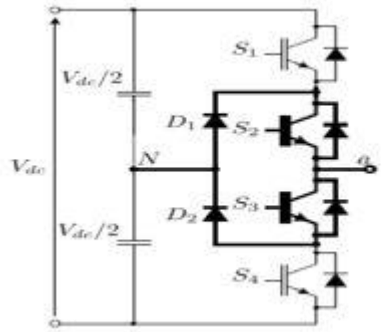
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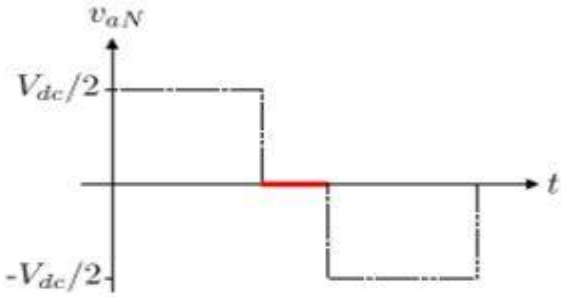
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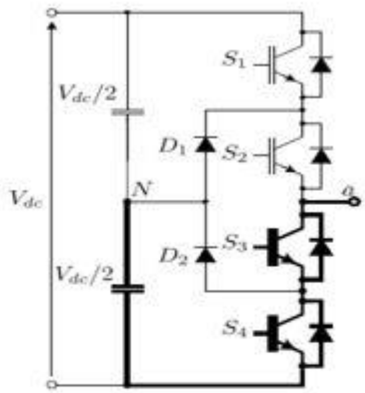
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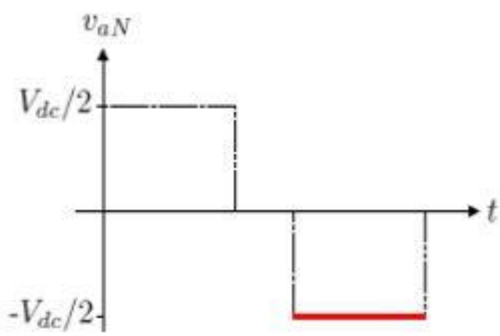
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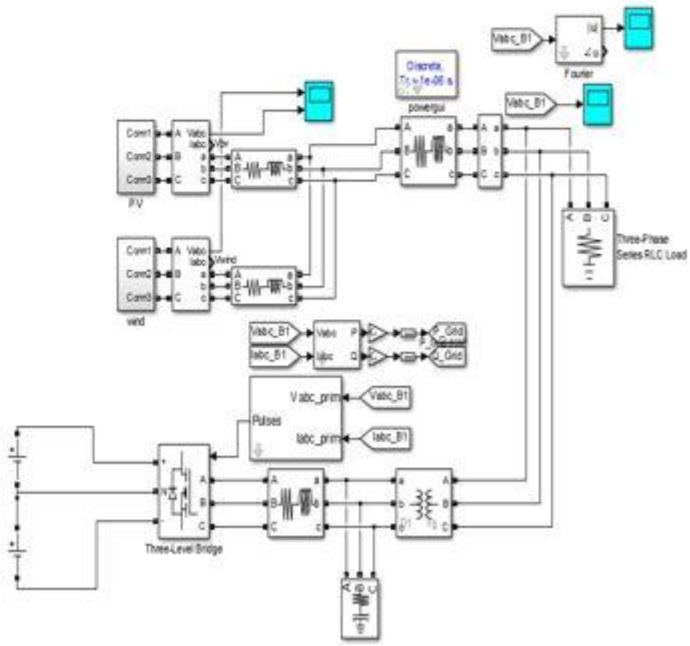
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