PRIMENA SUPERKONDENZATORA U MIKROMREŽAMA

APPLICATION OF SUPERCAPACITORS IN MICROGRID

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Superkondenzatori se mogu koristiti za skladištenje energije u cilju poboljšanja dinamičkih performansi mikro mreža napajanih samopobudnim indukcionim generatorima. Kontrolna strategija sastoji se od ubrizgavanja energije u DC liniju kada dođe do prevelikog pada napona zbog preopterećenja. Kod PV napajanja sitacija je jednostavnija zbog stabilnog DC napona na baterijama, pa superkondenzatori pokrivaju brze promene opterećenja. U radu je dat pregled dosadašnjih istraživanja, kao i primer sopstvenih rezultata. Simulacije i eksperimentalni rezultati postignuti na laboratorijskom nivou potvrdili su efikasnost takvog sistema.

Ključne reči: *Superkondenzatori; Hibrid; Mikromreže; Solarno napajanje; Impulsno opterećenje*

Supercapacitors can be used for energy storage in order to improve the dynamic performance of microgrids powered by self-excited induction generators. The control strategy consists of injecting energy into the DC line when there is an excessive voltage drop due to overload. With PV power supply, the situation is simpler due to the stable DC voltage on the batteries, so supercapacitors cover rapid load changes. This paper provides an overview of the previous research, as well as an example of our own results. The laboratory achieved simulations and experimental results confirmed the efficiency of such a system.

Key words: *Supercapacitors, Hybrid systems, Microgrid, Solar supply, Pulse load*

1 Introduction

Nowadays, with portable electronic devices, electric vehicles and microgrids, there is a problem of load profile, a large ratio of peak and average power. In order to meet the requirements of such a load, a source of high power with high energy density is necessary. Modern batteries do not meet the first condition [1-3]. Lithium-ion batteries have a higher power density than other batteries, but their main characteristic is still a high energy density. Therefore, the hybridization of high-energy batteries with supercapacitors that have a high power density is imposed [4]. The rapidly evolving technology of supercapacitors enables the achievement of a power density of several thousand W kg-1 at a reasonable price. A representation of power density and energy density for different energy storage elements is given in Figure 1.

There are three different types of battery hybrids - supercapacitor: passive, semi-active and fully active topology. In passive topology, batteries and supercapacitor banks are connected in parallel and directly connected to the load. The semi-active topology improves the performance of the passive hybrid by adding at least one DC-DC converter. The fully active topologies contain multiple converters and complex control algorithms, but they provide maximum system performance.

An illustration of the battery-powered pulse load problem is given in Figure 2. The battery voltage reaches its local minimum/maximum level when the pulse load current level is at its high/low level iL, MAX/iL, MIN, respectively. The three battery discharge curves characterize the discharge on iL, MIN, IL, AVE and iL, MAX. The solid line represents the battery voltage at discharge at the load current pulse [1].

This paper provides an overview of the previous research, as well as an example of our own results.

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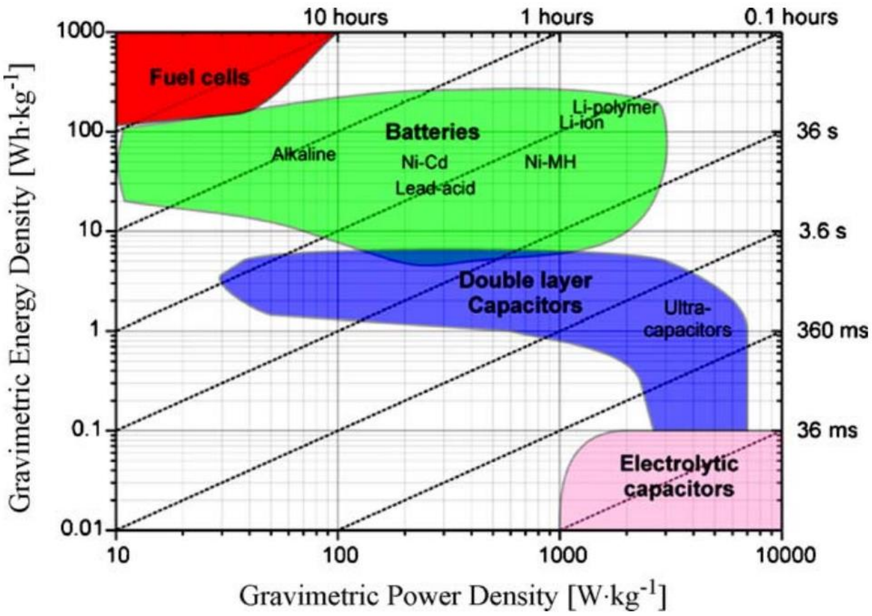

Fig. 1. The Ragone plot

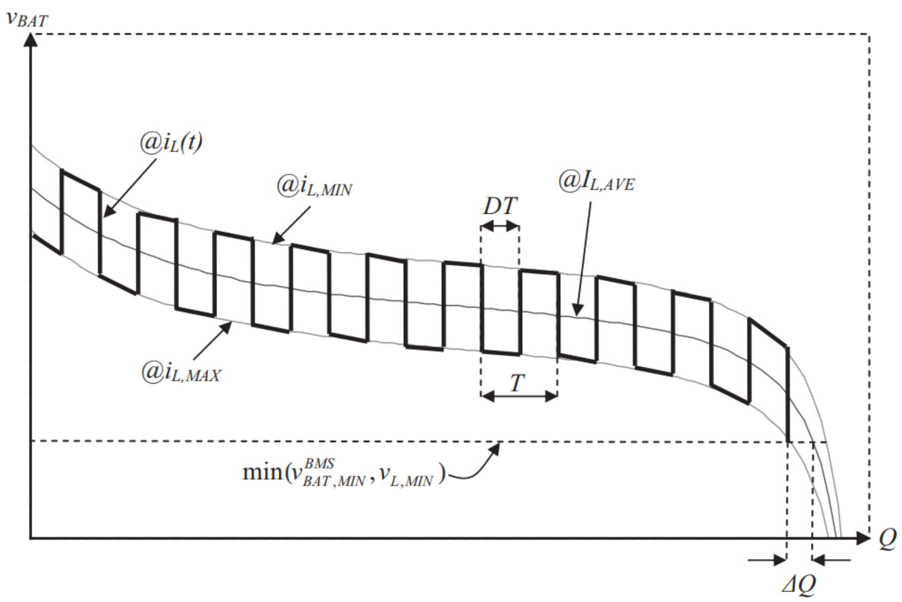

Fig. 2. Battery discharge curves when connected to a pulsed current load [1]

2 Experimental part

A sample PV power supply 2 x 125 W, 12V was used in a passive hybrid combination battery - supercapacitor. The block diagram of the system is given in Figure 3.

The bank of supercapacitors (Figure 4) consists of 10 lines connected in parallel with 6 series-connected supercapacitors 10F, 5.5V, therefore the module of 16.7F, 33V has been obtained. A resistor 1k is connected in parallel to each unit in order to evenly distribute the voltage in a series connection.

The series of tests for different impulse loads are planned, and here is the result of the charging and discharging supercapacitor test with a constant current of 16.7mA (Figure 5). The same figure shows the simulation result in LT SPICE.

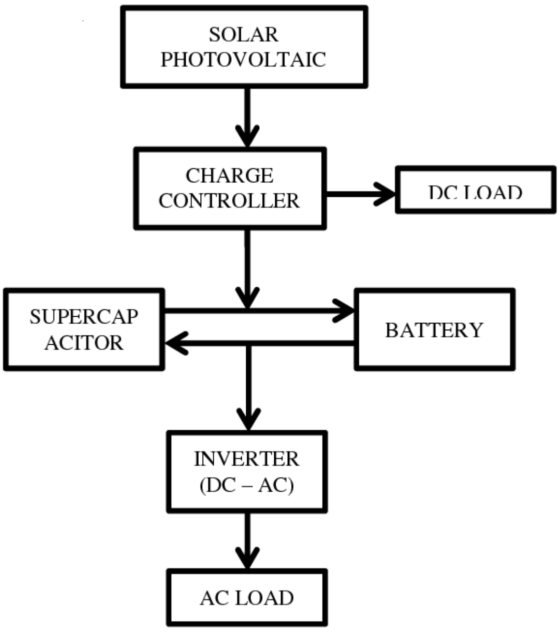

Fig. 3. PV power supply block diagram

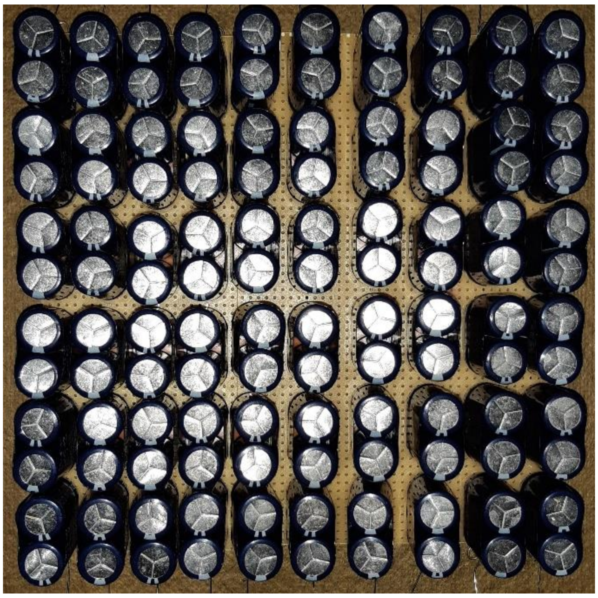

Fig. 4. Supercapacitor bank

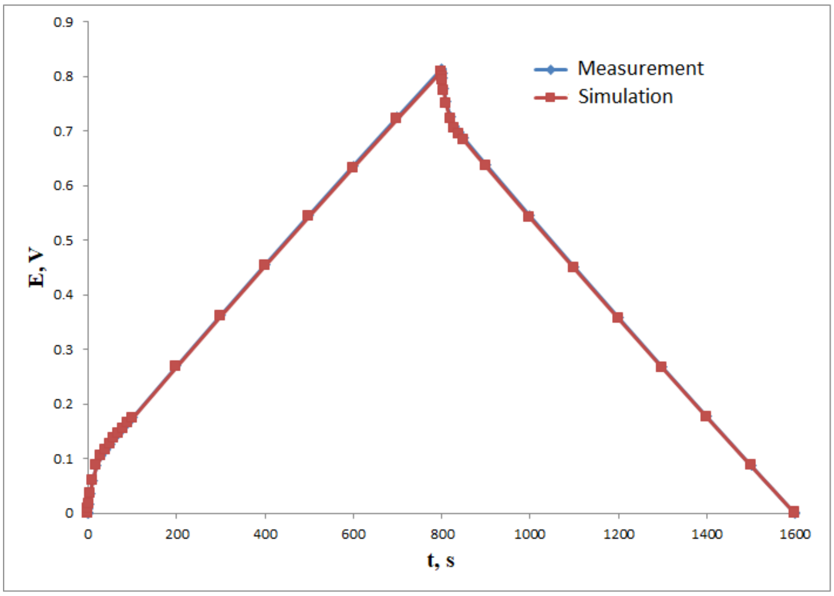

Fig. 5. Charge-discharge diagram SC

3 Conclusion

The possibilities of battery - supercapacitor hybrids in microgrids are presented, especially in the case of impulse loads. Disadvantages of battery-only power supplies and advantages of hybrid ones are presented. Hybridization of high-energy density batteries and high-power supercapacitors are designed in several topologies (passive, semi-active and fully active hybrids). A passive hybrid is the simplest and cheapest topology with the weakest performance, while a fully active hybrid achieves the best performance, but on the other hand, it is complex and expensive. A semi-active hybrid could be a good compromise between performance and complexity. The laboratory achieved simulations and experimental results confirmed the efficiency of such a system.

4 References

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