APPLICATION OF SUPERCAPACITORS IN ELECTRIC VEHICLES

Zoran STEVIĆ,
School of Electrical Engineering - University of Belgrade, Technical Faculty Bor, University of Belgrade, CIK, Belgrade, Serbia
zstevic@tfbor.bg.ac.rs

Ilija RADOVANOVIĆ,
School of Electrical Engineering - University of Belgrade, Innovation center of School of Electrical Engineering in Belgrade, Serbia
ilija.radovanovic@ic.etf.rs

Miša STEVIĆ,
Mikroelektronika, Belgrade
misa.stevic@live.com

Abstract

The paper gives an overview of the state and directions of further development of the Electricity Storage Systems based on supercapacitors. Critical component at each hybrid or pure electrical vehicle presents electrical storage. Supercapacitors are nowadays the only available technology, which can provide great specific power and great number of cycles at reasonable price and save and reliable work. Supercapacitors have other characteristics that make them attractive in hybrid vehicles such as possibility of complete energy using (so called regenerative breaking) for increasing energy efficiency, with no additional maintenance, great recovery of electrical energy, little toxicity and easy disposal after usage.

Key words: Supercapacitors, EV, Energy storage

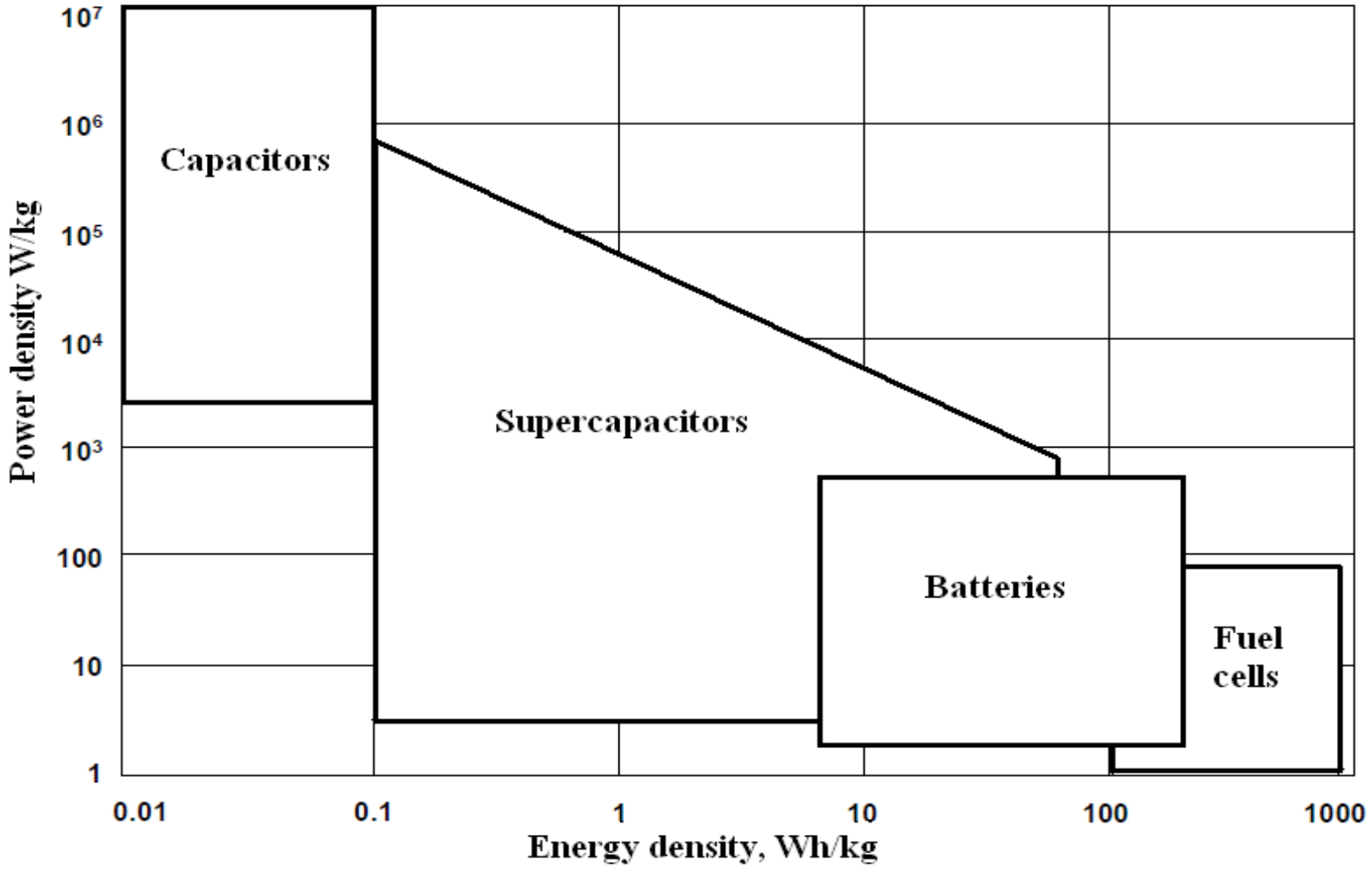
INTRODUCTION

Electric drive vehicles present one of the most important technological advances having in mind spread of this kind of nature pollution. Lately there is increased world interest for so called hybrid vehicles that have reduced fuel consumption and much less pollutants emission than regular vehicles. Hybrid vehicles can in broadest sense be described as vehicles utilizing combination of production and storage of energy. Good properties of conventional vehicles are combined (long range and acceleration, very good supply network) and electrical vehicles (zero emission, quiet operation, regenerative use of braking energy). Supercapacitors are increasingly used in the power supply of electric motor drives, as well as electronic circuits in EVs.

Supercapacitors vs. accumulator batteries and fuel cells

Supercapacitors are relatively new type of capacitors distinguished by phenomenon of electrochemical double-layer, diffusion and large effective area, which leads to extremely large capacitance per unit of geometrical area (in order of multiple times compared to conventional capacitors). They are taking place in the area in-between lead batteries and conventional capacitors. In terms of specific energy (accumulated energy per mass unity or volume) and in terms of specific power (power per mass unity or volume) they take place in the area that covers the order of several magnitudes. Supercapacitors fulfill a very wide area between accumulator batteries and conventional capacitors taking into account specific energy and specific power

Area diagram for various energy storage systems

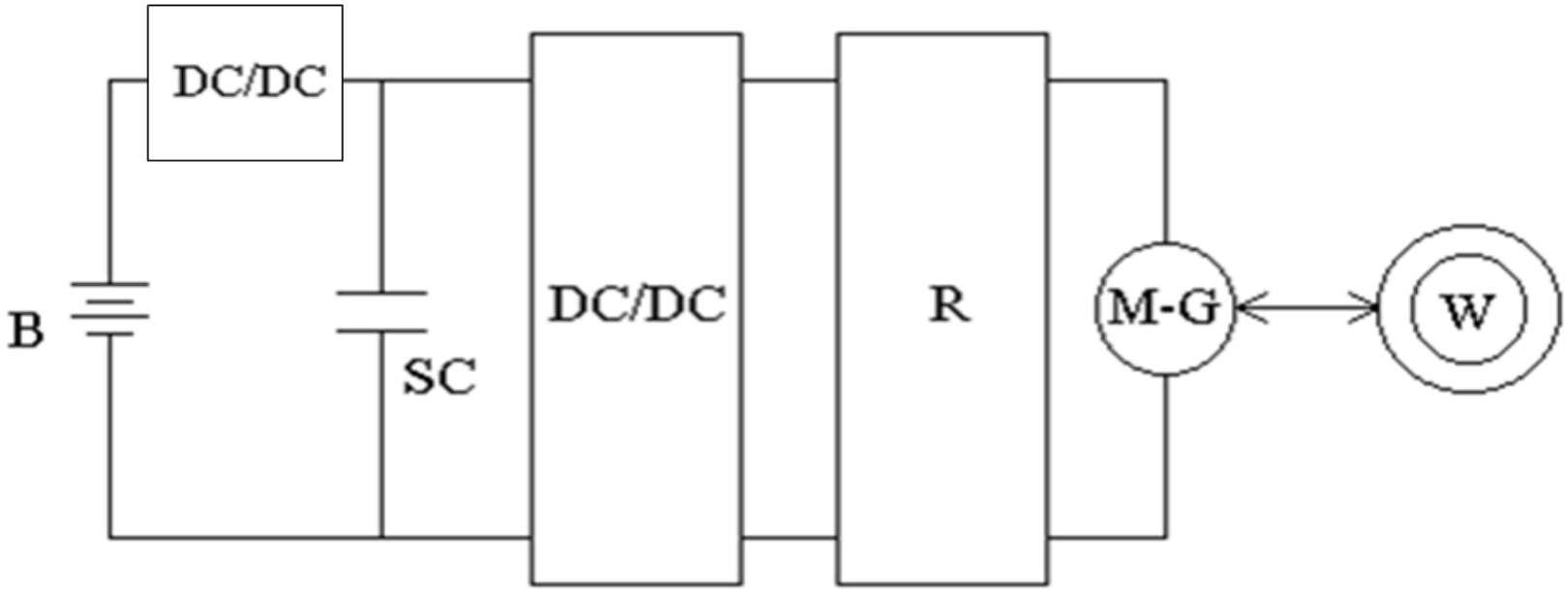


Capacitor, supercapacitor and accumulator basic characteristics

Characteristic	Classical capacitor	Supercapacitor	Accumulator
Discharging time	ms – ms	ms – weeks	min - months
Charging time	ms – ms	ms – minutes	hours
Specific energy	< 0,01 Wh/dm^3	0,5 – 5 Wh/dm^3	< 500 Wh/dm^3
Specific power	> 10^4 W/dm^3	(1-3) 10^3 W/dm^3	< 500 W/dm^3
Cycles number	10^6 - 10^8 (unlimited)	10^6 - 10^8	200 - 1000

Supercapacitor applications in EV

Depending on applying place, different characteristics of supercapacitors can be more or less taken into account. Some of them are of crucial importance for capacitor choice, and some of them can be of no importance at all. Most strict requirements are related to capacitors of fourth group applying in electric haulage, i.e. for vehicles of the future. Nowadays, batteries of several hundreds farad capacitance are with working voltage of several hundred volts have been produced. Beside great capacitance and relatively high working voltage, these capacitors must have great specific energy and power (because of limited space in vehicle). Considering their specific power, they have great advantage in relation to accumulator batteries, but, on the other side, they are incomparably weaker considering specific energy. Hence, ideal combination is parallel connection of accumulator and condenser batteries. In an established regime (normal drawing) vehicle engine is supplied from accu-battery, and in the case of rapidly speeding, from supercapacitor. Very important is the fact that in the case of abrupt breaking, complete mechanical energy could be taken back to system by converting into electrical energy only in presence of supercapacitor with great specific power. Because of mentioned reasons, inner resistance of these supercapacitors has to be extremely small.



Scheme of electrical drive vehicle with supercapacitor with possibitlity for using breaking energy; B – one-way voltage source, SC – supercapacitor; DC/DC – direct voltage converter; R – regulator; M-G – engine – generator (depending on working regime; W – drive wheels

CONCLUSIONS

Critical component in every hybrid or purely electrical vehicle is energy storing. Possible solutions are accumulators, supercapacitors, flying wheels, hydraulic devices and new special materials for hydrogen storing. Supercapacitors are only available technology today that can provide high power and great cycle numbers at acceptable price. Supercapacitors have other properties that makes them interesting in hybrid vehicles, and it's ability of complete regeneration of energy of braking (so called regenerative braking), which increases energy efficiency, no special maintenance needed, great utilization of electric energy, small toxicity and easy storage after use.

Thank you for your attention