SYNCHRONOUS BUCK CONVERTER

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ABSTRACT

This text deals with a proposal and realisation of a proper converter for a dash board supply in an electric vehicle. Due to high efficiency, which is demanded in the vehicle, a synchronous buck converter was used. First the whole concepcion of the vehicle is introduced and then the author focuses on the proposal and realization of the converter.

1. INTRODUCTION

Today we meet the problem of lack of oil. Its consumption is growing and extraction decreases. That is necessary to search other alternative sources of energy for transportation replacing oil. An electric vehicle appears as one of the alternatives.

This text deals with the construction of buck DC/DC converters with the highest possible efficiency. That's the reason why the converter will be designed as a synchronous buck converter. This converter will be used for supply of board appliances in an electric vehicle with hydrogen fuel cells. At first, we discuss the overall concept of this electric vehicle and then we focus on the design, construction, activation and measurement of this converter.

2. CONCEPTION OF THE ELECTRIC VEHICLE WITH A FUEL CELL

The electric vehicle is equipped with hydrogen fuel cells. The hydrogen in a chemical reaction with oxygen (acquired from the air) unlocks electric energy. The DC-link (electric traction battery) is supplied from the fuel cell. DC-link voltage is 42.9V. Due to the high internal resistence of the fuell cell its output voltage is varying in a range 22 to 50V (according to the load current). This is why an inverter between DC-link and fuel cell is required. The electric energy goes through the electric chopper to the electric motor [1].

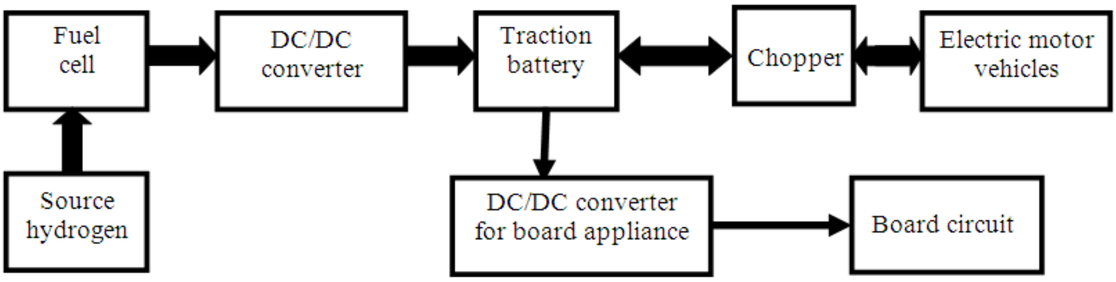

Figure 1: Block circuit diagram of the traction drive with a fuel cell [1].

The operator determines the desired torque using the gas or brake pedal.

It is also necessary to supply the onboard electric network. From there, lighting circuits, dashboard instruments, wipers, heater fan, etc. are powered. This will be solved by buck converter which will be supplied from a DC-link. The desired converter output voltage is 14.2 V, output power converter is required to cover the maximum onboard appliances power with a satisfying reserve.

3. CHOICE OF A PROPER CONVERTER

The converter will take the energy from the DC-link of the vehicle, its voltage level is 42.9V and the output voltage 14.2V from the inverter is required (on-board voltage electric). Converter is therefore designed as a buck converter. The electromobile is designed with the best possible efficiency, therefore it is necessary to design also the converter with the best possible effect. A synchronous buck converter was applied, where transistor is used in the lower sub-circuit instead of diode, as shown in figure 2 (schema of the synchronous buck converter is on the left side of the figure). During the phase when TH tranzistor is off, the current is going through the TD transistor and not through the diode as in classical buck converters. Conductiong losses of the transistor are lower than of the diode due to the low transisistor voltage drop in on-state. The low RDSon of the used MOSFET transistor is the reason for it.

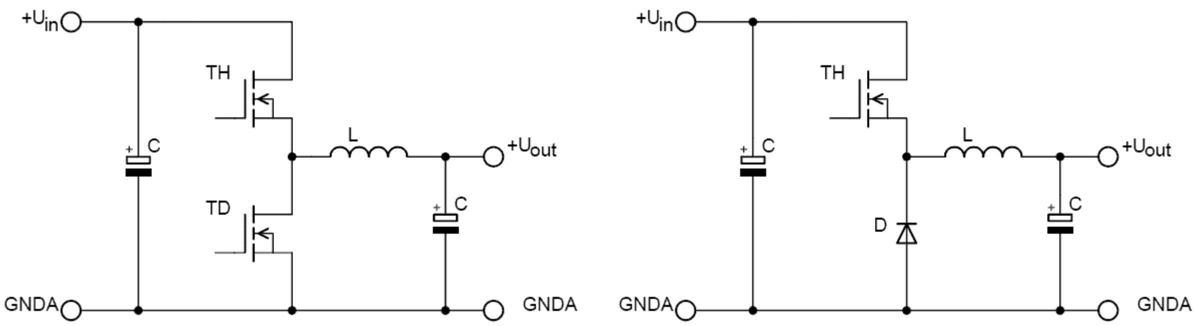

Figure 2: Synchronnous buck converter circuit and usual buck converter circuit.

3.1. The requirements for the converter

This device will also provides supply of vehicle's lightning. For this reason, it is necessary to place an additional small accumulator on the converter output to ensure the lighting power in an emergency case (converter failure).

Input power consumption of individual appliances is in table 1.

Appliance		Power
Light	front	2 x 60W
	side	2 x 5W
	back	2 x 5W
	brake	2 x 21W
	fog	21W
	reverse	21W
	licence number	2 x 5W
	distance	4 x 21W
	board desk	20W
	interior	5W
Sweeper		100W
Ventilator		125W
		P_{OUT} = 568W

Table 1: Input power appliance.

Maximum converter output current I_{OUT} is:

$$I_{OUT} = \frac{P_{OUT}}{U_{OUT}} = \frac{568}{14,2} = 40A \tag{1}$$

From the previous calculation we determine the maximum converter output current I_{OUT} = 40A, which should be with caution adequate.

Of course, this current is not required during normal operation of the vehicle (there is a very little likelihood of the current activities of all appliances at the same time).

Final converter parameters:

U_{IN} = 42,9V DC - DC-link voltage

U_{OUT} = 14,2V DC - DC voltage output converter

I_{OUT} = 40A - maximum output current converter

P_{OUT} = 568W - maximum power converter

f_S = 50kHz - switching frequency

4. REALIZATION OF THE CONVERTER

4.1. CONVERTER CONCEPT

The whole converter consists of three basic blocks: control circuit, power circuit of the synchronous buck converter and battery. Block diagram of the converter is shown in figure 3.

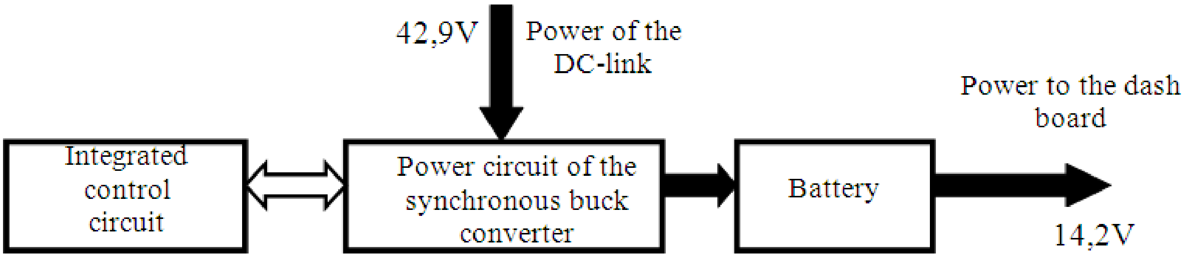

Figure 3: Converter block circuit diagram.

4.2. SCHEMA OF THE CONVERTER

The schema of the converter is in the figure 4.

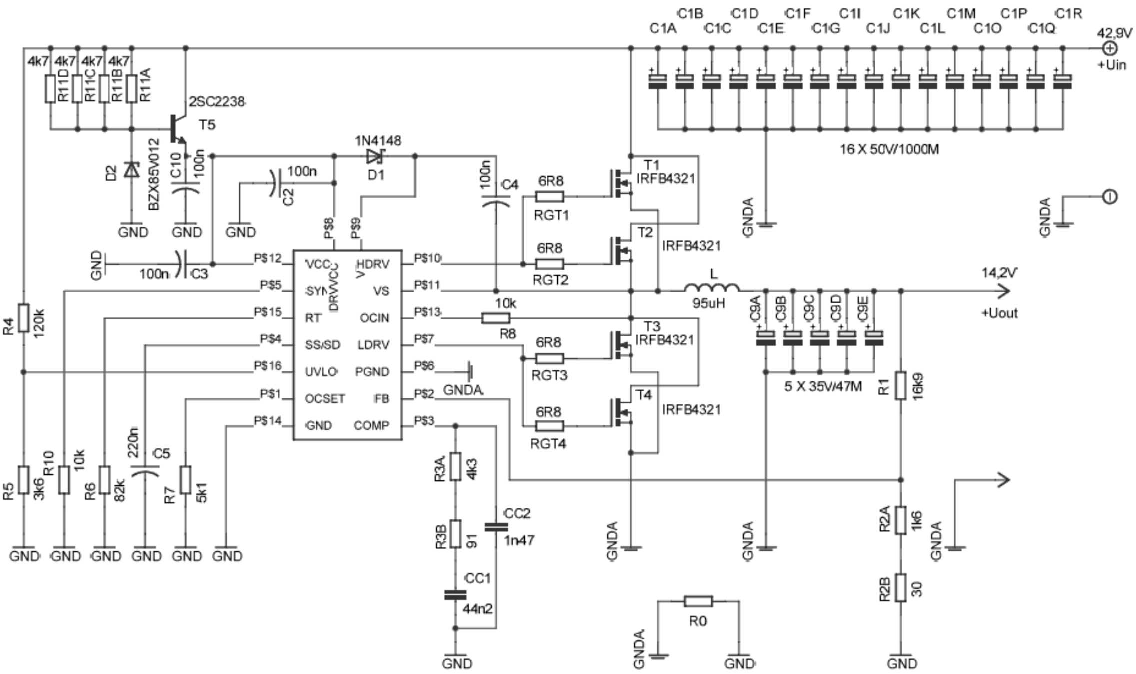

Figure 4: Schema of the converter.

5. CONCLUSION

Comparison of the power dissipation and efficiency of an ussual buck converter and our synchronous buck converter:

Usual buck converter

$$P_{dis} = P_{disT} + P_{disD} + P_{disS} = 3{,}2 + 19{,}3 + 1{,}8 = 24{,}3W \qquad (2)$$

$$\eta = \frac{P_{OUT} - P_{dis}}{P_{OUT}} = \frac{568 - 24{,}3}{568} = 0{,}957 \qquad (3)$$

Synchronous buck converter

$$P_{dis} = P_{disT} + P_{disS} = 9{,}6 + 3{,}6 = 13{,}2W \qquad (4)$$

$$\eta = \frac{P_{OUT} - P_{dis}}{P_{OUT}} = \frac{568 - 13{,}2}{568} = 0{,}976 \qquad (5)$$

P_{disT}	- conductive dissipation transistor
P_{disD}	- conductive dissipation diode
P_{disS}	- switching dissipation transistor
P_{dis}	- overall dissipation
η	- converter efficiency

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