Journal of Chemical Technology and Metallurgy, 59, 3, 2024, 741-746

TOPOLOGY OF GALVANIC ISOLATED BATTERY CHARGING UNIT WITH POWER FACTOR CORRECTION

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Received: 09 July 2023
Accepted: 07 March 2024
DOI: 10.59957/jctm.v59.i3.2024.30

ABSTRACT

The present study investigates topology for battery charging units (BCU) with simple design and power factor correction. It has a galvanic isolation between the grid and the battery, which is one of the law and standard requirements. The impulse transformer ensures galvanic isolation, which makes the topology suitable for onboard electric vehicles (EV) charging units (OBC). The study also presents a simulation model a simulation model with the help of which a simulation is conducted and a result is obtained.
Keywords: BCU, battery charger, onboard charger, power factor correction, galvanic isolated charging unit.

INTRODUCTION

One of the solutions for the global climate and pollution problems is the use of electric vehicles (EV) [1]. The main problem for the owners of EV is the lower mileage, compared to the combust camber engine vehicles. That does not allow them to go far and back with only one charge, but they are also not sure if they would find a charger station on their way. The solution of this problem is in the own an onboard battery charging unit (BCU), and recharge the EV in the standard utility grid socket. For this reason, in recent years there has been significant growth in the development of improved topology design for BCU [2, 3]. The basic function for BCU is to convert AC grid power to DC power for charging of the EV batteries. Requirements are high efficiency, reliability and power factor on one side and low weight and cost on the other side [4 - 9]. In the references could be found many rectifying topologies [10, 11]. One of the recent proposed topologies has low switch number, and power factor correction [12, 13]. It is transformerless but unfortunately does not pass some of the world standards and law requirements for galvanic separation from the mains [4, 14]. In this study a solution for galvanic isolation by a small HF transformer is presented. The main function of the transformer is to provide the required insolation between the car body and the grid [15].

EXPERIMENTAL

The proposed topology, shown in Fig. 1, acts in buck-boost mode. Output transformer and the diode D6 ensure the desired galvanic isolation. There are no changes in the other part of the topology, it is the same as in and the mentioned advantages are kept [12].

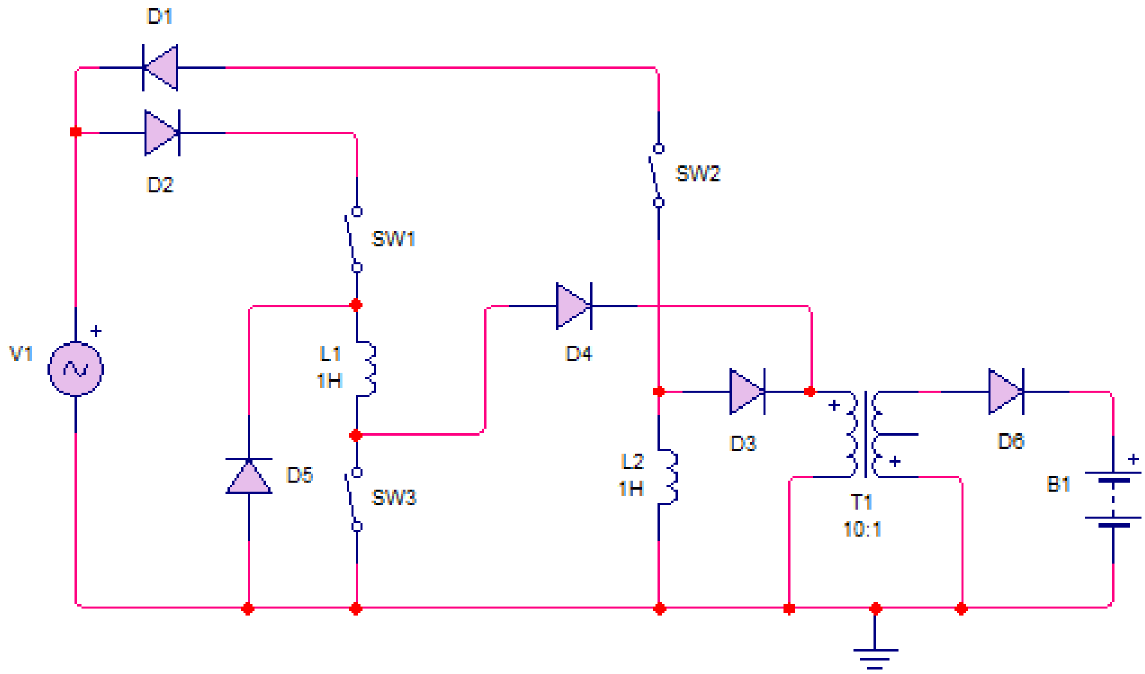

Fig. 1. Proposed topology.

For the period of positive grid half-wave, the inductor L1 is charged with energy from the grid (V1) through D2, SW1 and SW2. In the non-active switching period, the switches SW1 and SW2 are in off state and the stored energy is transferred to the primary coil of the transformer T1 through the diode D4 and D5. When the negative grid half-period starts, the acting switch is SW2 and L2 is charging with energy through the diode D1. That energy charges the primary coil of the transformer during the non-active switching period, when SW3 is in off state. The energy path is through D3. The secondary coil transfers the energy through the diode D6 as a charging current to the DC source and the transformer has to have an air gap of the magnetic core. To prove that theoretical principle, a simulation model is created and explained in the next chapter.

For creation of the model of the proposed design the software environment Simplis/Simetrix is used. It allows implementing not only real analog and logic components, but of ideal power switches, which is not typical for most of the modeling software products and very useful for scientific purposes in the area of power electronics. The simulation model of the proposed topology is shown in Fig. 2. The control strategy for the topology is borrowed from [16, 17]. The whole system is explained in detail in [12]. The only difference is the additionally connected transformer between the DC-source and the output of the circuit. The purpose of the model is to verify the functionality of the improved scheme and investigate the impact of the transformer on the parameters of the charging current.

For the output transformer is chosen the so-called DC transformer for avoiding saturation of the magnetic core. The other components parameters are shown in Table 1.

RESULTS AND DISCUSSION

In Fig. 3 some simulation results are shown. The red wave is the rectified output charging current and the green wave is the grid current. It is obvious that the phase angle between two waves is very close to zero and the power factor is high. The rectified current has low measured total harmonic distortion (4.71 %) and with a further optimization of the operating settings could achieve even better results and that is the subject of a future study.

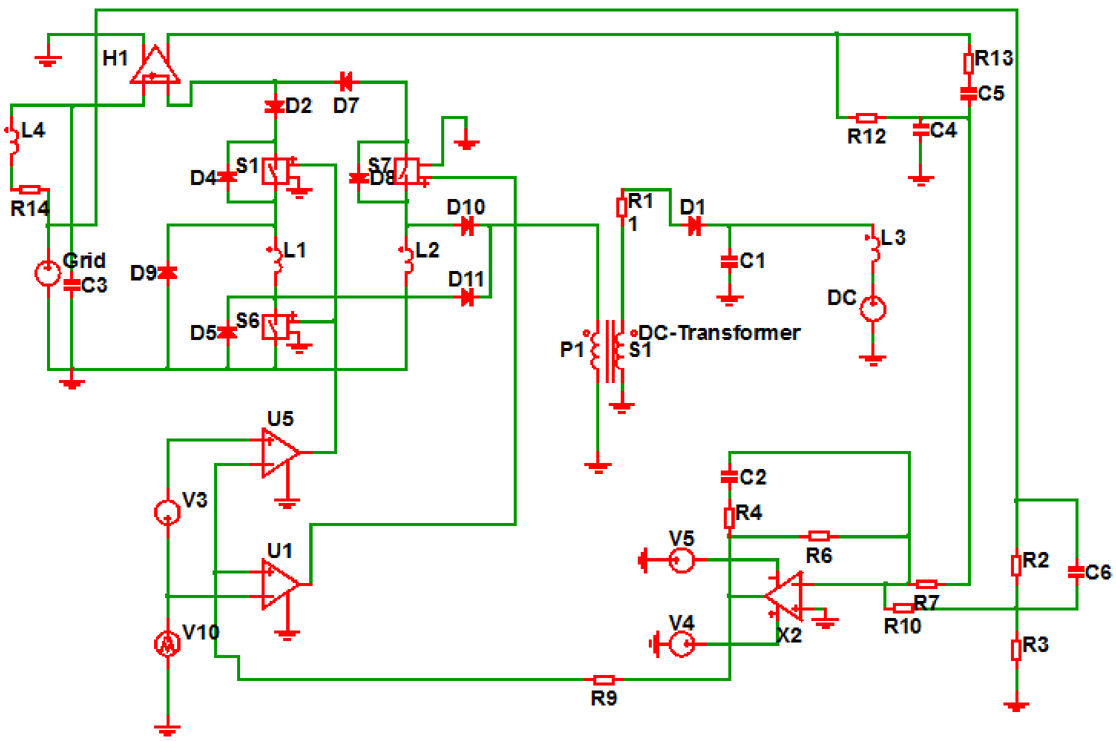

Fig. 2. Simulation model of the proposed topology.

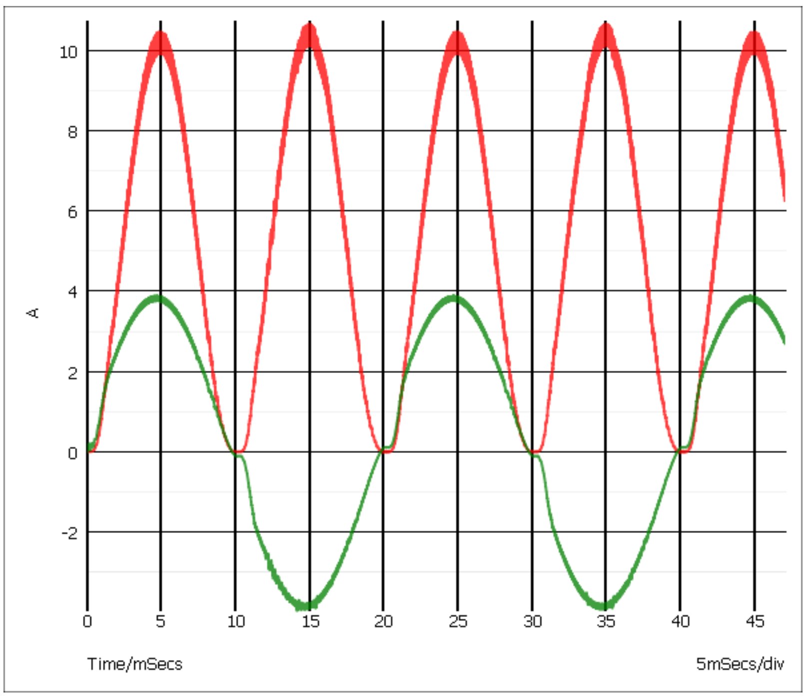

Fig. 3. The input and the output currents wave forms derived from the simulation.

Table 1. Parameters used in the simulation model.

Component	Value	Frequency [Hz]	
Grid	220	50	Volt
DC	100	0	Volt
L1	50u	-	Henry
L2	50u	-	Henry
L3	500u	-	Henry
L4	1m	-	Henry
P1	20	10k	Turns
S1	20	10k	Turns
COMPARATOR1	5	10k	Volt
COMPARATOR2	5	10k	Volt
V4	15	0	Volt
V5	15	0	Volt
V3	9,8	0	Volt
V10	15	10k triangular	Volt
Op Amp	TL072	-	-
H1	50m	-	Gain
C1	1u	-	Farad
C2	200p	-	Farad
C3	1u	-	Farad
C4	10n	-	Farad
C5	0	-	Farad
C6	2n	-	Farad
R1	1	-	Ohm
R2	100k	-	Ohm
R3	50	-	Ohm
R4	220k	-	Ohm
R5	-	-	Ohm
R6	10 Meg	-	Ohm
R7	50k	-	Ohm
R8	-	-	Ohm
R9	10k	-	Ohm
R10	50k	-	Ohm
R11	-	-	Ohm
R12	10k	-	Ohm
R13	1k	-	Ohm
R14	1	-	Ohm

CONCLUSIONS

The present study proposes a modification, simulation model simulation result for a galvanic isolated topology for battery charging unit. The conducted simulation verifies the theoretic concept of the topology and its power factor correction ability. The quality of the charging current is kept in its smooth waveform which is evident that properly chosen transformers will not affect too much the advantages of the transformerless variant of the topology and it is suitable for implementing in real chargers, which is a target for future research.

Acknowledgements

This work is developed as part of contract No: 12298, project name: "Develop of transformerless grid-tied inverter", funded by Scientific research sector of UCTM-Sofia.

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