Design and Development of a 200 W Converter for Phosphoric Acid Fuel Cells

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Abstract– Power conversion is fundamental to fuel cell systems. Since the majority of telecommunication equipment operates from a DC supply voltage, the most convenient power electronics interface is a DC-DC converter. For this reason, the present work in progress paper reports on research focusing on DC conversion applied to a phosphoric acid fuel cell. Its purpose is to supply telecommunication equipment that cannot be connected to the AC power grid because of their mobility.

Index of terms— DC-DC converter, phosphoric acid fuel cell (PAFC), fuel cell (FC), telecommunications.

I. INTRODUCTION

Energy shortages, power quality, rotating outages and increasing oil prices have motivated many utilities and consumers to look for alternative forms of highly reliable energy [1]. Not forgetting environmental concerns which brought power generation under scrutiny. This explains why alternative energy sources such as Fuel Cells (FCs) are promoted today.

One area in which FCs are being explored to the fullest is in telecommunications. Due to recent developments in telecommunication networks, equipment is being located closer to the customers organized in dispersed networks [2].

Another challenge which comes with the expansion of telecom equipment is that some areas where these are located lack proper AC grid especially in remote areas. Consequently there is a need to design adequate FC power supplies to meet the power their power requirements.

II. PHOSPHORIC ACID FUEL CELL

Larminie and Dicks have well documented how a PAFC works [3]. A PAFC operates at temperatures around 200 °C and uses a proton-conducting electrolyte namely phosphoric acid (H_3PO_4). In PAFC, platinum (Pt) or Pt alloys are used as catalyst both for hydrogen and oxygen electrodes. Fig. 1 portrays the structure of a PAFC.

PAFC applications include commercial cogeneration plants, transportation and portable power.

The advantages of the PAFC are its simple construction, high heat waste and stable electrolyte characteristics. In addition, the use of concentrated phosphoric acid (100%) minimizes the water vapour pressure. Consequently, water management in the cells is not difficult. The few technical problems of PAFC probably assisted its earlier deployment into commercial systems compared to other fuel cell types

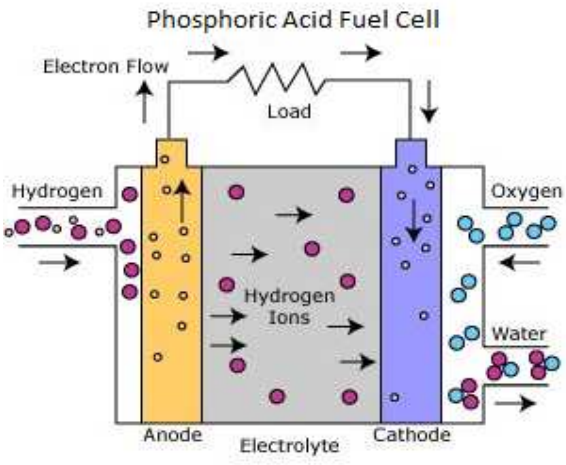

Figure 1. Structure of a PAFC

Like other fuel cells, PAFC's dynamically change potential with current. There is thus a requirement to stabilise the output voltage. This stabilisation is done means of wide input DC-AC inverters or DC-DC converters [4].

III. FUEL CELL CONVERTER

Basically, a FC DC-DC converter has two purposes: One is DC isolation and the second is to produce sufficient voltage when used in conjunction with an inverter [5]. A FC is an electrochemical device, where the output power is controlled and conditioned by a DC-DC converter, so the electric characteristic of the converter should match that of the FC. This is particularly important for three reasons: 1) The input side current/voltage ripple of the DC-DC converter should be minimum, so as to reduce the ripple current/voltage of the FC, 2) When the FC is working under load current pulses, the DC-DC converter must apply a suitable strategy to adjust the output power of the FC, so as to ensure high-efficiency and reliable operation, 3) The DC-DC converter should be able to the adjust power distribution in case of hybrid power configurations. Taking into account the above requirements, a DC-DC converter should be designed using a topology structure and control strategy, which is slightly different from those of conventional converters [6].

As most telecommunication equipment operate from a DC supply voltage, the most suitable power electronics interface is a DC-DC converter [2]. Therefore, this research focuses

on a 200 W converter, essential for converting the DC electrical power generated by a PAFC into usable stable DC power for Telecoms equipments.

IV. RESEARCH AIMS

The goal of this research is to show that a DC-DC converter can be used in conjunction with Phosphoric Acid Fuel Cell in a cost effective way in order to supply telecommunication equipment that cannot be connected to the AC power grid because of their mobility.

V. WORK DONE AND FUTURE WORK

A .Overall 200 W Converter Specifications

- Input voltage range: 60 – 80 V
- Output voltage: 48V
- Maximum output current: 6 A
- Output ripple voltage: ≤ 1%
- Switching frequency: 40 kHz

B. Power Stage

Three converter topologies have been investigated with regard to their wattage specifications. This includes: a two-switch forward converter, a half bridge converter and a push-pull converter. The latter was chosen due to the following advantages: 1) Dual drive winding isolation transformer, 2) Transformers and filters are much smaller, 3) Voltage step-down or step-up, 4) Multiple outputs possible, 5) Low output ripple current, 6) Lower input ripple current, 7) Simple dual gate drive, 8) Large achievable duty cycle range. Calculations for the design of the power stage have been completed. Magnetic components such as the transformer and inductors have been built. The proposed block diagram of the converter prototype for PAFC is shown in fig. 2.

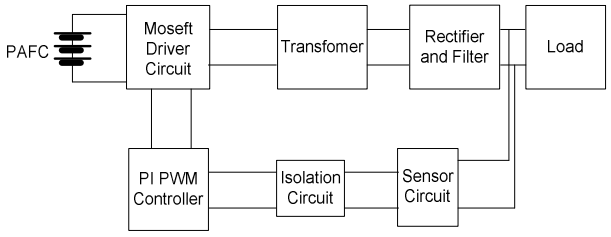

Figure 2. Block diagram of the proposed DC-DC converter

C. Control Stage

Currently, under construction is the control scheme with its switching made possible by the UC3825 IC to control the gates of two MOSFETs thereby provides the output voltage to an electronic load. Fig. 2 presents the gate driving pulses. The converter is designed to step down the input from a Phosphoric Acid Fuel Cell to a constant 48V. In this manner, the UC 3825 chip is maintaining a regulated output voltage.

Furthermore, a simulation is being implemented with MATLAB/SIMULINK software. This will help to acquire data which will be compared to the measurements of the practical setup in order to substantiate the research's results.

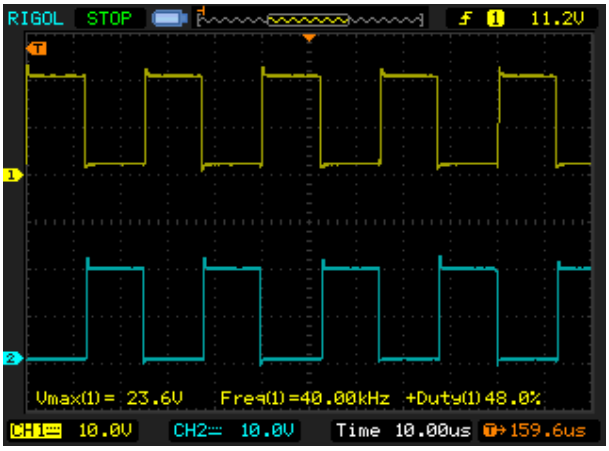

Figure 3. Switching pulses from UC3825 IC controller.

VI. CONCLUSION

Fuel Cells are an alternative energy technology with a promising future. Consequently, more than ever a need exists for cost effective and efficient DC-DC converters to be designed and developed. This will contribute in alleviating some of the annoyances which may result from poor power availability or lack of it especially in the telecommunication sector in Africa.

VII. REFERENCES

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