An AC-DC-AC converter with smaller DC-link capacitor for space power distribution systems

Wajiha Shireen

ABSTRACT—The power conditioning equipment used in a space power system contributes to the total system mass, reliability, and cost. The focus of this research was to reduce the weight and improve the reliability of an AC-DC-AC converter used in a large number of the power conditioning stages in a typical space power system.

PREMISE OF THE PROJECT

The DC link in any AC-DC-AC converter is normally equipped with an electrolytic capacitor, which provides decoupling between the rectifier and the inverter. However, the DC link capacitor is a large, heavy, and expensive component. Moreover, the DC bus capacitor is the prime factor of degradation of system reliability. However, a cost effective and efficient solution is not yet available. For space power distribution systems, these problems pose to be even more critical.

Wajiha Shireen

OBJECTIVES

Researchers hope to develop a Digital Signal Processor (DSP)-based modified space vector pulse width modulation (PWM) technique that will allow the use of a smaller DC-link capacitor without affecting the output performance of the converter. The proposed method implemented in AC-DC-AC converter applications will result in the following advantages:

- Reduced converter weight and volume.
- Significant improvement in system reliability by the use of a smaller link capacitor.
- Digital control by a DSP to provide fast transient response, high performance and increased reliability.
- A digital controller insensitive to the environment, offering a stable operation under most operating conditions. Moreover, the DSP-based controller, being programmable, can also be easily upgraded or modified to meet the specific system requirements.

RESULTS

Figure 1 shows the block diagram of the experimental setup used to test and verify the proposed technique. The experimental prototype of the AC-DC-AC converter consists of a diode rectifier, DC-link, and a PWM inverter used in a closed loop V/Hz motor drive. Researchers utilized the DSP-based controller (TMS320F240) to implement the proposed technique, which allowed the use of a smaller DC-link capacitor without affecting the output performance of the rectifier-inverter system. The use of smaller link capacitor introduced a ripple on the DC-bus voltage. The DC-link voltage ripple was sensed and fed as an input to the DSP controller.

Figure 2 shows a plot of the recorded experimental data of the inverter output voltage magnitude, with the DC bus voltage varying in the range of 25 V to 34 V (when the DC-link capacitor is 47°F), both with and without the proposed correction algorithm in effect. Without correction, the output voltage increases as the DC bus voltage is increased but with the modified SVPWM correction in place the output voltage magnitude is maintained constant (at 12 V) regardless of the DC bus voltage. Figure 3 shows a plot of the recorded experimental data when the DC bus voltage is manually varied over a wider range (55 V to 110 V). The plot in Fig. 3 shows that with modified SVPWM control in effect, the output voltage magnitude is maintained constant (at 26 V) even when the input DC voltage is varied over a wide range.

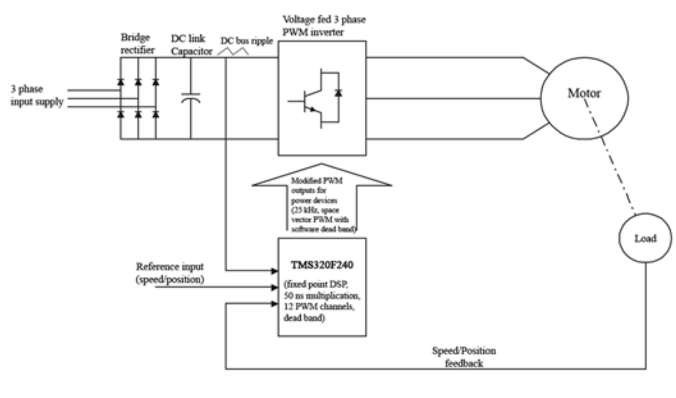

Figure 1. A closed loop V/Hz motor drive system with the proposed DSP based control

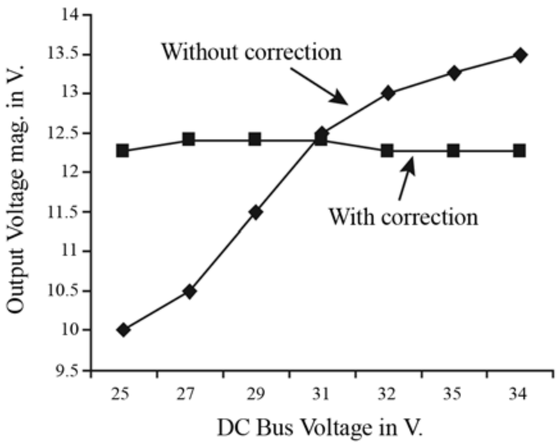

Figure 2. Inverter output voltage magnitude when the DC bus voltage varies in the range of 25 V to 34 V (with 47°F DC-link capacitor)

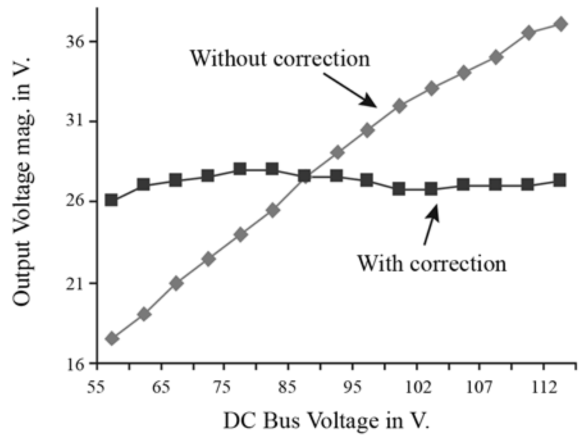

Figure 3. Inverter output voltage magnitude when the DC bus voltage is varied in the range of 55 V to 110 V

PUBLICATIONS

Shireen, W., Vanapalli, S., and Nene, H.R. DSP-based inverter control for alternate energy systems. *J. Power Sources* **166.2**, 445-449 (April 15, 2007).

FUNDING AND PROPOSALS

Shireen, W. Development of a modern DSP-based laboratory for power electronics education. National Science Foundation, $74,000 (2005–2007).

Shireen, W. A reliable low cost power electronics interface for renewable energy systems using a single DSP controller, California Energy Commission, $81,000 (Sept. 1, 2008–Aug. 31, 2009).

DESIGN—Lakshimi Gopal, M.S. student in electrical engineering, earned her B.E. in electrical engineering at Anna University in Chennai, India. Her research involves the design of a converter for photovoltaic cells.