An Improved Power Converter for ADNOC Solar Power Supply

Abdul Rahiman Beig and Majid Postan

Electrical Engineering Program, The Petroleum Institute, PO Box 2533, Abu Dhabi, UAE

bbeig@pi.ac.ae, mpostan@pi.ac.ae

1. Introduction

Solar energy is a non-conventional source of energy; it is environment friendly and available abundantly. Power converter circuits are required to convert the solar energy from available form (dc) to the required form (normally ac). At present the cost of solar power is too high, hence the power converters should be highly efficient, reliable and cost effective. In this paper, a novel power converter circuit which has improved efficiency, reliability and low cost over conventional circuits is proposed. The proposed circuit is based on cascaded H-bridge inverter topology in which higher voltages can be synthesized using devices of lower voltage rating. A 15-level cascaded H-Bridge inverter configuration is used. This results in sinusoidal output voltages with very low THD with the devices switching at fundamental frequency. The low switching frequency results in reduced switching losses, simple power and gate circuit. MOSFETs with low on state resistance help in keeping the conduction loss at low levels.

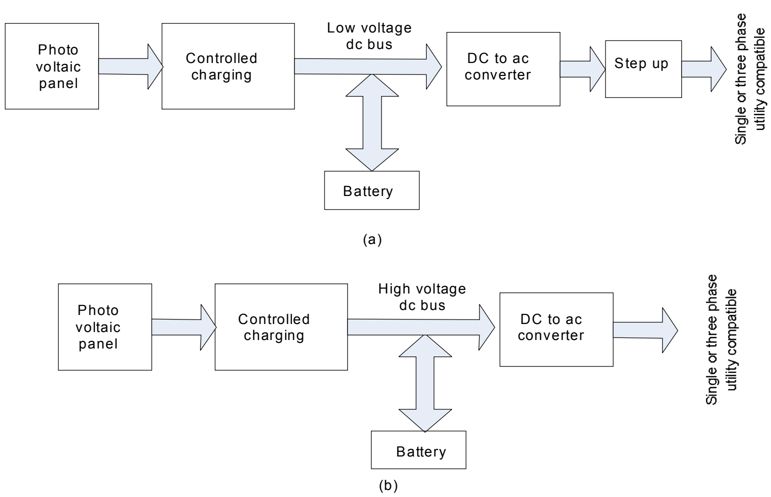

Fig.1. Functional Block diagram of photovoltaic system, (a) Low voltage dc bus, (b) High voltage dc bus.

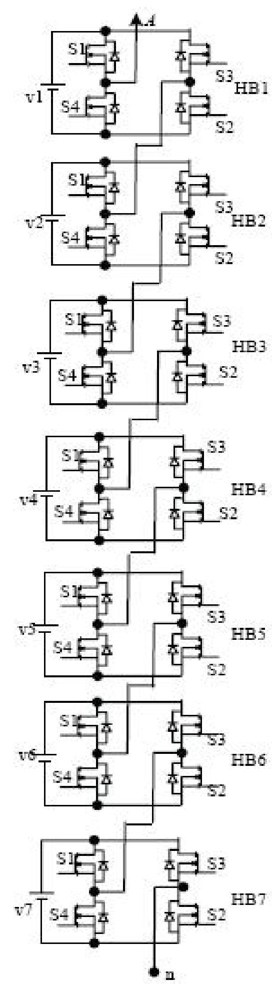

Fig.2. Proposed power circuit.

2. Key Features

Fig. 1 shows the functional block diagram of the solar photovoltaic system. Conventional systems make use of following two inverter circuits: (a) Connect the cells in series to obtain higher voltage and use high voltage devices to generate ac voltage: this requires devices of higher voltage rating, which expensive and have high on state resistance, (b) Use low voltage devices and convert from dc to ac at low voltage levels and then step up using step up transformer. This approach requires, additional transformer. In both the cases high switching frequency is used which results in increased complexity of the power and gate control circuit, increased switching losses and EMI problems.

The proposed dc to ac converter circuit overcomes the drawbacks of the existing system. In the proposed system switching frequency is low and uses devices of low voltage rating to synthesize higher voltages using cascaded H-bridge topology. The design specifications are, output voltage: 220V, 50Hz, Single phase ac., power: 2KVA DC bus voltage: 48V. This requires about 7 H- bridge cells in cascade as shown in Fig. 2. The power circuit of individual cell is given in Fig. 3. All the cells are identical. In each cell, three numbers of 105W, 18V solar panels are connected in series to get the required power and voltage. The gating signals of the cells are shown in Fig. 4. The system under consideration is simulated in SIMULINK-MATLAB for an R-L load of 2KVA with 0.86 power factor. The simulation results of the output voltage and current are shown in Fig. 5.

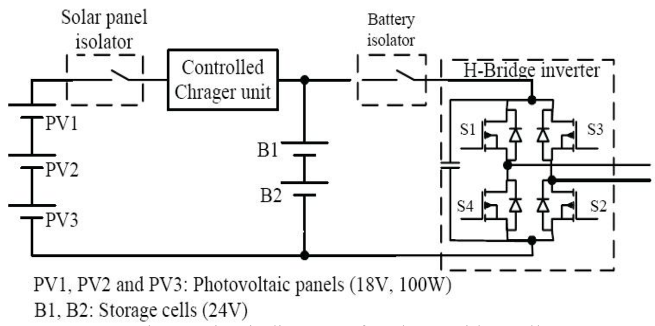

Fig 3. Circuit diagram of each H-Bridge cell.

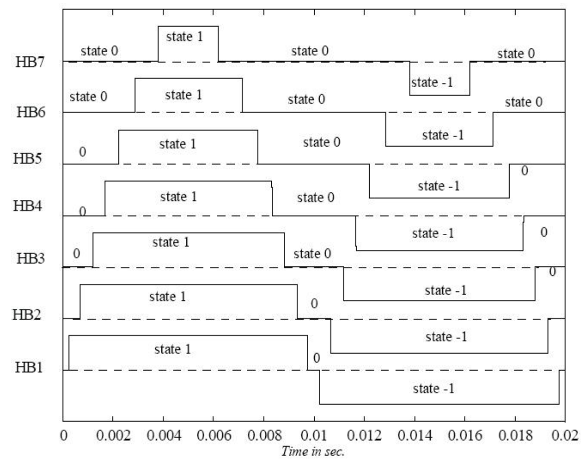

Fig 4. Gating signal for the Cascaded H- Bridge.

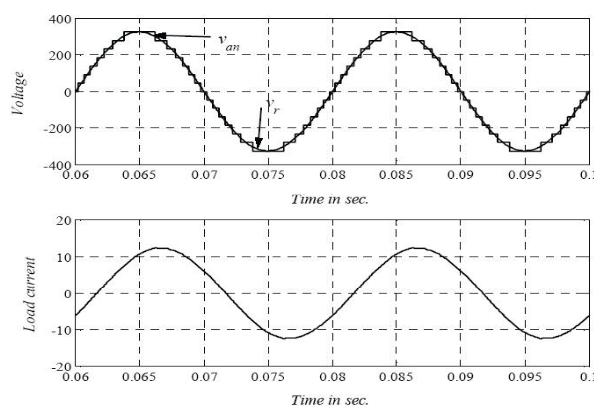

Fig 5. Output voltage and current for 220V, 2KVA R-L load.

3. Conclusions

Compared to the existing system, the proposed circuit has several advantages: (i) The fifteen level inverter results in sinusoidal waveforms even at fundamental frequency switching, (ii) The fundamental frequency switching results in low switching losses, reduced EMI, simple power circuit and gating signal, (iii) The dc bus is operated at low voltage; hence low voltage MOSFETS arte used which results in reduced switching losses, (iv) The identical cells result in reduced down time under fault. The faulty cells can be by passed and circuit can be used without much loss of performance.

4. References and Bibliography

1. Imamura, M.S., and Palz, 1992, W., "Photovoltaic system technology- A European system handbook," H.S. Stephens and associates, ISBN 0-9510271-9-0.
2. Lai, J.S., and Peng, F.Z., 1996, "Multilevel inverters - A new breed of power converters," *IEEE Transaction on Industry Applications*, vol. 32, no 3, May/June 1996, pp. 509-517.
3. Beig, A.R., Udaykumar, R.Y., and Raganthan, V.T., 2004, "A Novel Fifteen Level Inverter for Photovoltaic Power Supply System," *Proc. of the 39th IEEE-IAS international Conf*erence, Oct 3-7, Seattle, Washington, USA, pp. 1165-1171.

Author Biographies

Dr. Abdul Rahiman Beig is currently an Assistant Professor in the Electrical Engineering Program at the Petroleum Institute (PI), Abu Dhabi, UAE. He has obtained his Ph.D. in Electrical Engineering from the Indian Institute of Science, Bangalore, India in 2004. Before joining PI, he was with the department of Electrical Engineering at NITK Suratkal India. From 1989 to 1992, he was the R&D Engineer at Kirloskar Electric Co. India. His research interests are in power electronics, electric drives; DSP/FPGA based controllers for power electronic systems.

Dr. Majid Poshtan is currently an Assistant Professor in the Electrical Engineering Program at the PI. He has obtained his PhD in Electrical Engineering from Tulane University, USA in 2000. He worked in Entergy Corp, USA as a part-time Researcher during his graduate studies, and Post Doctoral fellowship till 2003. His research interest areas include power systems simulation, electric machines and drives, and fault detection.