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A Dynamic Approach for Energy Efficient and Compact Microcontroller Based Solar Power Conditioning System Using High Frequency Inverters

M. Gopikrishnan

Department of Electrical and Electronics Engineering,
Bharath Institute of Science and Technology, Selaiyur, Chennai-600073, India

Abstract: This paper proposes an efficient and reliable solar powered high frequency inverter. High frequency range is suggested so that transformer size and hence core loss is reduced. A single Microcontroller unit is used to drive the HF inverter with Pulse Width Modulation and also line frequency inverter with Sinusoidal Pulse Width Modulation. Also the Micro-controller drives the charge controller unit. Thus a regulated output voltage with reduced harmonics is obtained.

Key words: High frequency inverter, Pulse Width Modulation, Sinusoidal Pulse Width Modulation.

INTRODUCTION

With the increase in utilization of electrical energy day by day, the necessity of power generation from Non-Conventional energy sources is inevitable. These Non-Conventional energy sources are freely available in nature, pollution free and can lend themselves for use in a decentralized manner [1]. Solar Photovoltaic power system is one of the most promising sources of power in tropical country like ours. However the Solar Photovoltaic systems involve a high initial cost. This includes the cost of Solar Photovoltaic (SPV) Array, Storage Battery and the Power Conditioning circuits. Since the power from solar panel is DC, it should be inverted to AC for normal application [2]. The necessary isolation should be provided between input and output of the system. Microcontrollers play a vital role in modern power electronics systems. Microcontroller based systems can be used for parallel processing by suitable programming. They have flexibility through software besides being cost effective. The proposed system provides a cost effective and energy efficient power conditioning circuit for SPV system. Apart from voltage regulation, the circuit reduces the harmonic content. A single Micro controller unit drives the entire system.

Block Diagram:

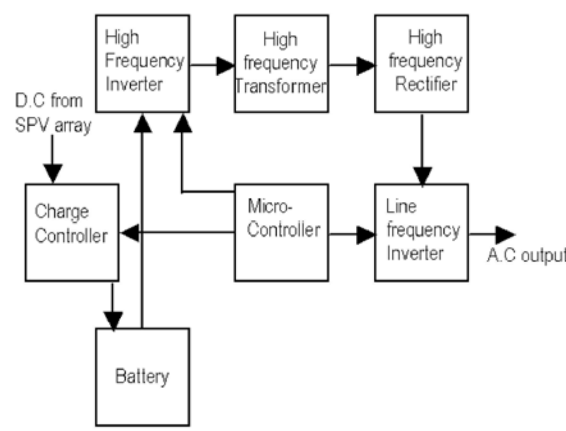

Fig. 1: Overall Block Diagram

Description: The D.C power generated from the Solar Panel is stored in the battery. The charge controller unit protects the battery from getting overcharged. The D.C output from the battery is inverted by means of HF inverter. The magnitude of A.C output from the inverter is regulated using Pulse Width Modulation Technique (PWM). Thus a high frequency (25 KHz) A.C square wave of constant magnitude is obtained. This is stepped up to the required level by means of HF transformer. The HF A.C output from the transformer is inverted to line

Corresponding Author: M. Gopikrishnan, Department of Electrical & Electronics Engineering, Bharath Institute of Science and Technology, Selaiyur, Chennai-600073, India.

frequency by means of rectifier-line frequency inverter arrangement. Sinusoidal Pulse Width Modulation (SPWM) technique is implemented to obtain smooth sine wave output without harmonic content. The entire circuit is controlled using Micro controller unit.

Solar Photovoltaic Panel: A photovoltaic cell is a semiconductor device such as Silicon, Germanium etc which converts sunlight into electricity directly. When the application requires a considerable amount of power, many cells are combined into assemblies called solar panels.

Charge Controller: The charge controller circuit is used to protect the battery. When the battery voltage reaches maximum level, it should be protected from getting overcharged by disconnecting the battery from the solar panel. The panel should be reconnected when the battery voltage drops to particular value.

The battery should also be protected from getting deeply discharged by disconnecting it from the load when the battery voltage drops below a certain level. The load should be reconnected when the battery voltage rises to a particular value.

Microcontroller driven charge controller circuit is shown in Fig 2.

The battery charge is sensed by means of an inbuilt Analog to Digital Converter (ADC) and sent in digital form to the Micro controller. A simple arrangement for voltage sensing is shown in Fig 3.

The Microcontroller receives the battery voltage in digital form, compares with the preset value and accordingly gives control signal to R_{L1} or R_{L2} as programmed. The battery / Load is connected / disconnected based on the battery voltage.

The analog voltage across the battery is converted into digital form by means of ADC and is given as parallel input to the Micro-controller. When the voltage is above the maximum limit, the Micro-controller drives signal through pin 1 of output port to energize R_{L1}. Similarly if the voltage is below a minimum limit, the Micro-controller drives another signal through pin 2 of output port to energize R_{L2}. Thus software control of battery voltage is achieved [3].

High Frequency Inverter: A 25 KHz D.C-A.C converter (HF Inverter) with PWM control provides a constant amplitude A.C output. The gate pulses for the MOSFETs are generated from the Micro-Controller. Constant output voltage is obtained by changing the duty cycle of the gate drive signal.

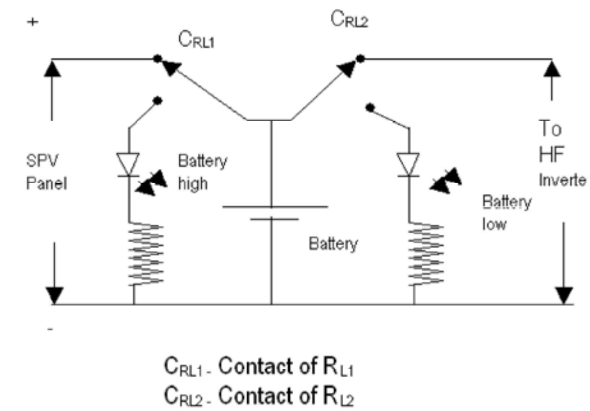

Fig. 2: Charge controller

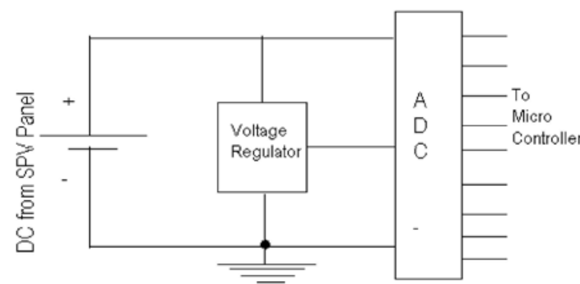

Fig. 3: Voltage Sensing Using ADC

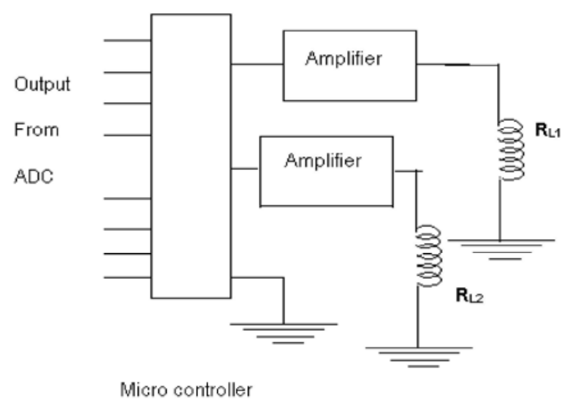

Fig. 4: Relay control through output port of Microcontroller

High Frequency Transformer: High Frequency step-up transformer is used to step-up the voltage to higher level and also to provide isolation. The frequency of the voltage is very high so that the size of the transformer is reduced resulting in a reduced core loss.

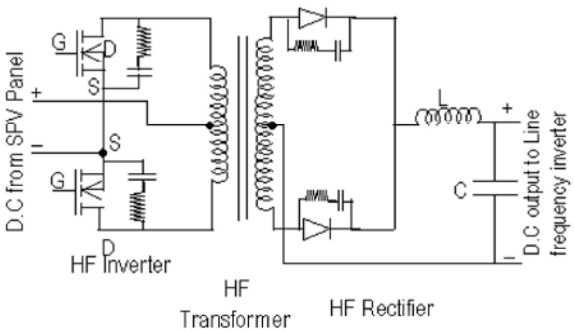

Fig. 5: D.C to D.C Converter

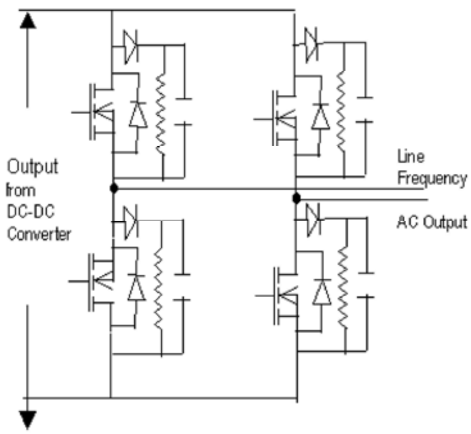

Fig. 6: Line frequency Inverter

Full Wave Rectifier: High frequency full wave rectifier requires fast recovery diodes. The circuit consists of two diodes and a center tapped transformer arrangement.

LC Filters may be used to obtain a steady D.C output voltage of constant magnitude.

Line Frequency Inverter: Line frequency inverter uses bridge arrangement of transistors or MOSFETs as shown in Fig. 6. The D.C. output from D.C.-D.C. converter is inverted to line frequency A.C. output.

The MOSFETs are driven by the Micro-Controller unit. Sinusoidal PWM technique is used so that the output voltage has minimum harmonic content [4].

Micro-Controller Unit: The Micro-Controller unit performs three functions namely controlling the battery charging and discharging, generation of control signals for H.F. PWM inverter and also control signals for SPWM line frequency inverter.

An inbuilt ADC converts the battery voltage into digital form. This digital voltage is compared with pre specified limiting values and control signals are sent to parallel output port to drive the relays for connecting / disconnecting the battery / load based on the battery voltage.

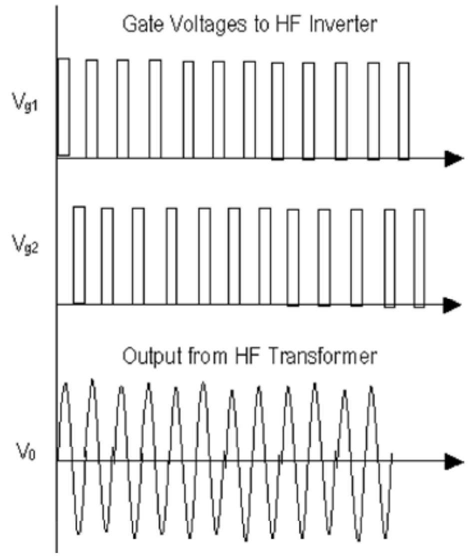

Fig. 7: Gate & output voltages of H.F inverter

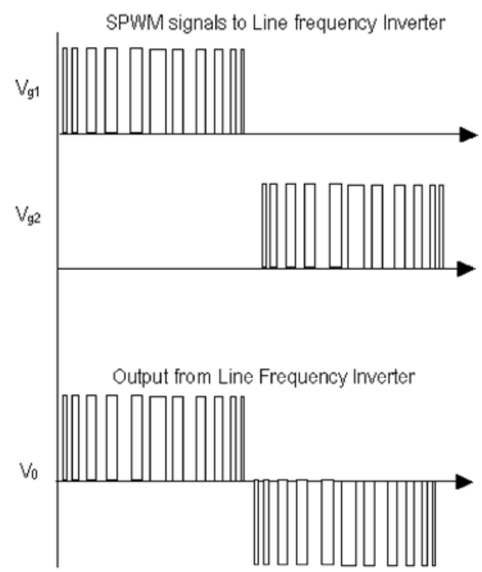

Fig. 8: Gate & output voltages of L.F inverter

A high frequency PWM signal is generated to drive the HF inverter. The duty cycle is varied according to the battery voltage in a pre-specified manner.

Another set of signals are generated and sent through output port of the Micro-Controller to drive the line frequency sinusoidal pulse width modulation inverter. The waveforms of gate signals generated and output voltages are shown in Fig. 7 and Fig. 8.

Merits: The use of HF inverter results in a considerable reduction in the size of transformer, cost and core loss. Therefore the efficiency of the proposed system can be improved considerably.

- The problem of core saturation is reduced in HF circuits.
- Harmonics are reduced by SPWM at the output stage.
- A single Micro-controller unit is used to control battery voltage and also to drive H.F PWM inverter and line frequency SPWM inverter.
- Modification and improvements can be done easily through software program.

CONCLUSION

Even though solar power is available free in nature it involves heavy cost in SPV array, storage battery and power conditioning systems. Also the efficiency is less. This paper proposes a cost effective and energy efficient Power condition system. In spite of many advantages discussed above, the circuits suffers a drawback that stress on the switching devices is high. Many works are being carried out in recent years to develop zero voltage and zero current switching to reduce switching stress on the devices and hence to improve their reliability.

REFERENCES

1. Mukherjee, M.K., 1997. Solar Photovoltaic Energy conversion", IE (I) Journal - EL, 78: 1- 5.
2. Motorola Power MOSFET Transistor Data, 1998. Motorola Inc. New York.
3. Abraham. I. Pressman, 1987. Switching power supply, Tata McGraw Hill publications, New Delhi.
4. Muhammad. H. Rashid, 1995. Power electronics - circuits, devices and applications, Prentice Hall of India Pvt. Ltd. New Delhi.