Design and Development of High Frequency Multitasking Inverter

M.G. Wani, Dr. V.N.Gohokar

Abstract— It is well known fact that the power crisis faced in recent times is the major issue today. This situation leads to frequent load shedding and power failure. Needless to say that this has boosted the requirement of uninterrupted power supply requirement. Major chunk of the requirement is met using storage batteries and DC to AC Converters[4]. Presently 50Hz/230V power generation is met using transformer (magnetic core based on metals and metal alloys). However they are heavy in weight, bulky in Volume and gives rise to weighty boxes and overall much higher volume. Additionally metal transformer has inherent loss factor of about 10%.To overcome these problems high frequency ferrite based transformer less systems are used.High-voltage high-frequency pulse power supply has been investigated for a long time and is largely industrialized at the fields of semiconductor manufacturing, packing, PCB and LCD panel manufacturing [1-5].The variable frequency inverters are used in wide applications especially three phase induction motor drive traction and it is popular in many high powers industrial applications such as speed and torque control. [1].

With the entire (DER) distributed Energy Resources technologies, (solar, wind, fuel cells, and micro turbines) the inverter is still an immature product that will result in reliability problems in fielded systems [6].There are many problems that are associated with analog or analog/microprocessor hybrid control systems. For example: aging effect and temperature drift of analog devices, higher component count (this leads to low life and quality), difficult field modifications, high cost, inflexible adoption to different electrical environments, low noise immunity, high EMI, and an advanced control algorithm that is not easily implemented.

The newly introduced low-cost, high performance DSPs, with features such as single-cycle multiplication and accumulation with on-chip PWM mechanism and A/D converters, provide the CPU bandwidth and peripheral mix needed to implement sophisticated control techniques required for interfacing with various renewable energy sources. A digital controller has many advantages over its analog counterpart. There are no hardware adjustments, fewer components, less aging effects and smaller temperature drifts in a digitally controlled system. With a digital controller, adjustment of control parameters for adapting to different electrical environments is easy and flexible. Software damping functions for output filters that are used in a power converter are easily implemented .Thus no hardware damping components are required for the output filter's resonance. They provide other advantages such as: fully digital control, fewer components, high noise/EMI immunity, high reliability, reduced heating of power switches, lower harmonics, less filtering, faster fault response, no dc components, higher efficiency. Additionally it is easy to include other system level functions such as battery charging, power factor correction, reactive power compensation, fuzzy logic control, parallel operation, and on the fly frequency change to adapt to different environments and applications. User interface and communication are also easily included.

DSP control can reduce heating of power switches and also can change the switching frequency on the fly; this means that they can use a higher switching frequency to ensure continuous current and smaller magnetic effects for the renewable source interface. This is done while using a lower switching frequency for battery charging, thus minimizing the switching losses and maximizing the system efficiency. The user parameters set-up feature can help to maximize the user control flexibility. Integrated digital control gives the maximized security and faster fault response leads to higher reliability. In addition, a user's interface and communications capability are also easily incorporated.

Another advantage of using a DSP control system is that the PWM converters used for power conversion compose a discrete system and should be treated as such when the control system is designed. Traditionally, a PWM converter (without DSP) is treated as a continuous system when the control system is designed. That means that higher bandwidth and higher switching frequency are required with an analog controller; this leads to high switching losses. With DSP control, PWM converters can be treated as a discrete system when the control system is designed. This means that to achieve the same performance as an analog control inverter, lower switching frequency is allowed with the same filter parameters. This will reduce the switching losses.

Commercially available battery generally operates at a nominal voltage of 12 Vdc, with a voltage variation window of 10.5to 13.7 V. However, at these voltage levels, the output power of the battery is limited to about 100 W. In order to obtain higher output powers, on the order of a couple of kW, many battery arrays have to be connected together.

Development of compact, Low weight, highly efficient high frequency multipurpose Inverter is the necessity of the future, which can be useful in mass applications. Use of digital signal Processor (Micro controller) for switching will provide more flexibility as compared to analog switching control scheme of Inverters. Once a design module for low power is developed the same design with some modification can easily be adopted for high power levels. At higher power, however much more precautions and care is needed for circuit and component layout, PCB design, proper shielding.

Index Terms— High Frequency, Inverter, Microcontroller, SMPS, UPS, Ferrite Core Transformer

1. Review of Research and the Subject

1.1. International Status

Inverter is the Universal requirement of the Society. e.g. it is useful in Industrial Automation , Home Appliances etc.. it is always required to update the technology and to improve the efficiency of the Inverter, therefore in every respect and every part the of the country the R& D work is always there. Some of the ongoing projects are as follows.[As these high frequency Inverters find many application like A.C. drives, Motion Control., Axis Control,]

1. Design and Implementation of a high frequency on line Interruptible Power supply by Krishman R. at Bradely Dept. of Electr. Eng. Virginal Polytech. Inst. & state university, Blacksburg, V.A.
2. High Efficiency electronic ballast for high Intensity discharge lamps by J.D. Paul, R.Redi in U.S.
3. Induction Heating Applications of high frequency Inverter, Xiaorong Zhu, Yonglong Peng
4. PRO sine Inverter, Xantrex Stat Power Pro sine 1000 and Prosine 1800 are the international 230 VAC rms-10%+4%, output frequency of 60 Hz.
5. Good Practices Inventory Wind Power Development, Consumption, a high frequency Inverter, tubular steel tower, a three independent braking work is going on both National and International level.
6. Energy efficiency solutions for Business and Green house.
7. China has made a pocket Inverter for multiple applicatons (X Power Pocket Inverter 100), which is very light in weight (227 gms) and Dimensions are (L × W× H) are 140 ×80×20 mm only
8. Major work is going on in the Wolf son Centre for Magnetics,which is a research and knowledge centre operating within School of Engineering at Cardiff University and at University of Cambridge, Department of Electrical Engineering.

1.2. NATIONAL STATUS

1. A work on High Frequency Inverter is in progress in Wind power development by private sector (India), a combination of international funding mechanism and public sector financing at Karnataka. Enercon India Limited, Vanivilas Wind Power Project, Karnataka Power Transmission Corporation Ltd., (KPTCL), Ministry of Environ.
2. 8200 smd frequency inverter is in progress.
3. Adjustable frequency drive system for North Sea gas pipe line, by the variation of shaft speed via the inverter frequency is in progress.

2 SIGNIFICANCE OF THE STUDY

Development of compact, Low Cost, Low weight, highly efficient high frequency ferrite core transformer multitasking Inverter is the necessity of the future, which can be useful in mass applications. Use of digital signal Processor (Micro controller) for switching will provide more flexibility as compared to analog switching control scheme of Inverters.

3 OBJECTIVE

The main objective is to design & develop a high efficiency, compact size Microcontroller Controlled PWM Multitasking Inverter with the use of the high performance switching devices.

a) Development of Algorithm for the temperature sensing of the Semiconductor Switches for the protection and to increase the efficiency of the System.
b) Generation of a variable duty cycle using PWM waveform as per the requirement of the output voltage and frequency for extending the application areas of variable-speed drives like A.C. drives and D.C. drives as well.
c) Development of Algorithm for checking the battery condition, over and under voltage protection, over current protection of Inverter and interfacing with the Processor.
d) Design and development of a Low Pass Filter to convert a quasi-square wave to pure sine wave for delicate instruments like PC, Television, etc.

4 BLOCK DIAGRAM AND FUNCTINAL DISCRIPTION

Fig. 1 is the Block diagram of Proposed High Frequency Inverter. Description of each block is as follows.

i. Lead acid battery:
   Lead acid battery provides input to the Push Pull converter. Lead acid battery also gets feedback from the microcontroller. If the battery voltage is less than preset voltage than the whole system shut down. Battery voltage will sense the low battery cut off signal. It will provide voltage varying from 10.5V to 13.7V.
ii. Push pull converter:
   Push Pull Converter will step up the input voltage. The switching frequency of 50 KHz is provided by the microcontroller. It provides input to the Full Bridge Converter. High frequency PWM signals with 180° phase shift is given to the push pull converter. Some dead band is incorporated between the PWM signals.
iii. Load current sense transformer:
   There is load current sense transformer provided to the system which is attached to the Push Pull Converter. If the system current increases a certain value feedback is provided by the controller and there is protection from overload.
iv. Microcontroller:
   It will denote battery drain condition. If battery voltage is below a preset level then microcontroller stops the PWM signal to the push pull converter. Also it will denote battery over and voltage condition. It will denote over current condition. It gives Signal output of 50 Hz for driving four switches in full bridge circuit. Depending on output Voltage feedback it varies the duty cycle of PWM signal to the MOSFET switches of the push pull converter to maintain output voltage constant. It also provides over current protection.
v. Voltage regulator:

It will receive input from the battery and will supply the desired voltage to the microcontroller.

vi. Temperature Sensor:
Temperature sensor will sense a power switch and controls heat sink temperature. It is controlled by the microcontroller. Push pull MOSFETS will provide input to the sensor. Sensors to all the elements can be provided to assure a more reliable system.

vii. Full Bridge Converter:
Push pull converter provides input to the Full Bridge Converter. Full bridge converts D.C input to A.C output. The switching frequency of 50 Hz is given by the microcontroller. Four P.W.M outputs of 50Hz are given to the four switches in full bridge circuits. The output of full bridge is quasi square wave.

viii. Low pass Filter:
It is used to avoid ripple to smooth the square wave and reduces the spikes present in it. The low pass filter is used to convert square wave into quasi square wave. Quasi square wave is used in household application because it is very close to sine wave. Use of sine wave Inverter is costlier and more complicated and costly therefore quasi square wave is preferred which is less harmful than square wave because spikes are almost minimized.

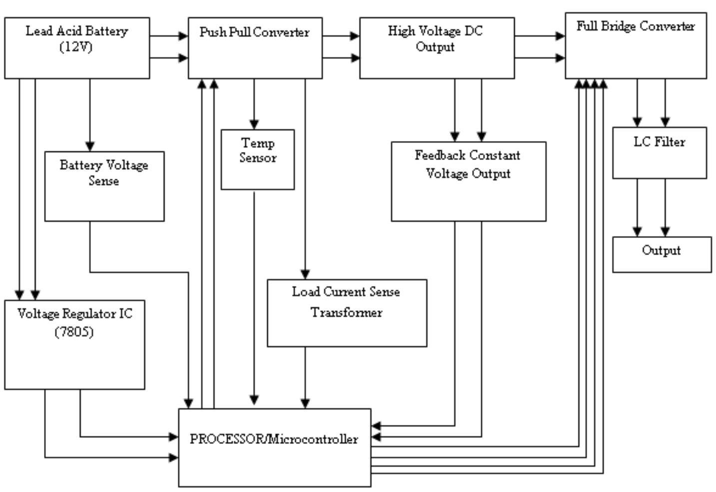

Fig. 1 Block Diagram of the proposed Inverter

5 METHODOLOGY

5.1 Design of Inverter Circuit based on SMPS Technique(Push Pull Circuit) and testing of the same on PSIM.

5.2 Development of Algorithm, Flow charts for checking the battery condition, over and under voltage protection, over current protection of Inverter and variable duty cycle algorithm for variable output voltage and frequency.Testing of the above algorithm with circuits

5.3 PCB Preparation

5.4 Mounting and Testing of final circuit.

6 CONCLUSION

Development of a 12V D.C. to 220V/50Hz, 300W high frequency, high efficient multipurpose Inverter with added protection features like short circuit, over voltage, under voltage and battery drain protection will overcome the disadvantages of the conventional Inverters. The use of micro controller for providing protection and switching flexibility makes the protection circuit more compact and corrective measures sharper compared to that provided by an analog circuit. This eliminates the need for additional analog control circuitry. Use of step up conversion topology can provide multipurpose operation of an Inverter and high operating frequency will further reduce the system size.

REFERENCES

[1] Khaled A. Madi Ali and Mohammad E. Salem Abozaed, “Microcontroller Based Variable Frequency Power Inverter”, Proceedings of the International Multi Conference of Engineers and Computer Scientists 2010 Vol II,IMCES2010,March 17-19,2010, Hongkong.

[2] Syafrudin Masri, Pui-Weng Chan, “Development of a Microcontroller-Based Boost Converter forPhotovoltaic System”, European Journal of Scientific Research ISSN 1450-216X Vol.41 No.1 (2010), pp.39-47

[3] N.S.Sakthivel Murugan, A.Nirmal Kumar, T.Vijaykumar, “Microcontroller Based Implementation of Multi-Level Inverrter Based Dynamic Voltage Regulator”, Asian Power Electronics Journal, Vol. 4 No. 1 April 2010, pp. 1-7.

[4] A.Ali Qazalbash, Awais Amin, Abdul Manan and Mahveen Khalid, “Design and Implementation of Microcontroller based PWM technique for Sine wave Inverter”, IEEE POWERENG 2009Lisbon, Portugal, March 18-20, 2009, pp.163-167.

[5] M.T. Tsai,C.W. Ke, “Design and implementation of a high-voltage high frequency pulse power generation system for plasma applications” IEEE 2009 International Conference on Power Electronics, Drives and Energy Systems for Industrial Growth PEDES-09.pp.1556-1560,December 2009.

[6] Nabil A. Ahmed, “Three-Phase High Frequency AC Conversion Circuit with Dual Mode PWM/PDM Control Strategy for High Power IH Applications”, World Academy of Science, Engineering and Technology 45 2008, pp 370-376, 2008.

[7] M.G.Wani, V.K.Sharma, and K.M.Soni,”High frequency SMPS Based Inverter with Improved Power Factor” IEEE 2006 International Conference on Power Electronics, Drives and Energy Systems for Industrial Growth PEDES-06, 0-78039771-1/06/$20.00@2006IEEE.

[8] M.G.Wani, V.K.Sharma, and R.D.Kharadkar, “Microcontroller Based High Frequency Inverter with ” IEEE(USA),Kolkata Proceeding of International Conference on Modeling and Simulation-07(MS-07) India, December 3-5, 2007,Vol.II pp.456-460.

ISSN 2229-5518

[9] Y. Liu, X. He, "PDM and PFM hybrid control of a series-resonant inverter for corona surface treatment, "IEE Proc.-Electr. Power Appl.Vol. 152, no.6, pp. 1445-1450, November 2005.

[10] Y. M. Kim, J. Y. Kim, S. P. Mun, H. W. Lee, S. K. Kwon, K. Y. Suh, "The design of inverter power system for plasma generator," IEEE Electrical Machines and Systems, pp. 1309-1312, 2005.

- Author M.G. Wani is currently pursuing Ph D. degree program in electrical engineering in Amravati University, India, PH-+9109225626881. E-mail: mgwanisir@gmail.com. Currently working as an Assistant Professor in the department of Electronics Engineering, at Maharashtra Academy of Engineering, Alandi (D), Pune.
- Co-Author Dr. V.N.Gohokar is currently working as Principal at Shri Sant Gajanan Maharaj College of Engineering , Shegaon in Amravati University, India.E-mail: vngohokar@rediffmail.com.