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Single Phase Induction Motor Wind Supply Fed Water Pumping System in House Employing ZETA Converter

K.Hemanathan[1] and R.Preetha[2]

[1]*UG Scholar, Department of EEE, IFET College of Engineering, Villupuram. India. Email: vijvijay29@gmail.com*
[2]*Assistant Professor, Department of EEE, IFET College of Engineering, Villupuram. India. Email: preetharaj.20@gmail.com*

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ABSTRACT

In agricultural systems, significant amount of energy is consumed during irrigation periods. Therefore operating irrigation systems with electrical energy produced by wind energy is very important. It is be possible to operate irrigation systems which have small-pump power like irrigation with electrical energy produced by wind energy. Electrical energy produced by wind generator can vary from the estimated value due to environmental factors. Consequently analysis of a real system's performance is important. Thus, more correct projections can be made for the systems which will be designed. In this study, induction motor-pump mechanism for irrigation system is operated with wind generator. Wind energy capacity of the established system is evaluated by measurements in irrigation periods. By means of simulations, power values produced by system and gained from the actual system are compared. Additionally the performance of induction motor is analyzed with the help of the driver system that increases the efficiency and controls the motor.

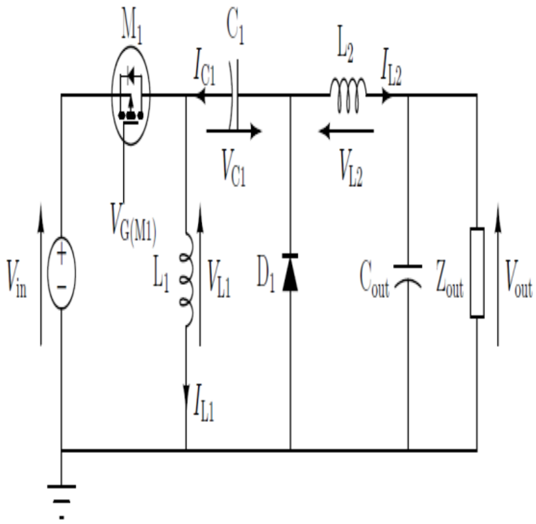
Keywords: Irrigation, Generator and Induction motor.

1. INTRODUCTION

Wind Energy Conversion Systems (WECS) have increased its penetration in the electrical grid of most countries during the last years. Integration of wind power in power systems is becoming a challenge especially in terms of power quality and fault ride-through capability. Detailed models of wind turbines are required, by grid operators, power companies, and wind farm developers and also in the research field, for grid integration studies both for analysis of the wind turbine under grid faults and for power system stability studies. Its use is especially interesting for WECS since their presence is increasing worldwide and it is expected that the installed capacity will keep growing in the next years. Wind turbines equipped with PMSG and full scale power converter seem to be the trend of the industry for offshore wind farm topology, the motivation of this choice is given by the new scale of size (diameter of more than 120 m) and power (more than 5 MW) of the next wind turbines generation. In any case, it is crucial to develop reliable WECS simulation models in order to test their operation, control system and their response in front of unexpected situations. In general, these models are not used to design the controllers, since most of the control design techniques use linear models based on simplifications and assumptions, but are useful to evaluate the controller's performance in a realistic environment. The idea is to check how accurate are the predictions obtained by means of simulation, for this reason the grid codes provide a set of rules to measure the accuracy of the model.

2. ZETA CONVERTER

The zeta converter shown in Figure 2.1 is built by interchanging the transistor M1and the diode D1 from the SEPIC topology, and by also interchanging the I/O power terminals. Thus, it is also known as the inverse of SEPIC converter. The operating principle of the zeta converter is comparable to the SEPIC converter. At the beginning of each switching period, the energizing transistor M1 is turned on and the current through the inductor L1 increases. During this phase, the diode D1 is reverse biased and the energy stored in the capacitor C1 makes the current through the inductorL2 to increase (i.e., energy is transferred to the output). When M1 is turned off, the current in the inductor L1 forces D1 to turn on. The energy stored in the inductor L1is transferred to the capacitor C1 and the current through the inductor L2 decreases.

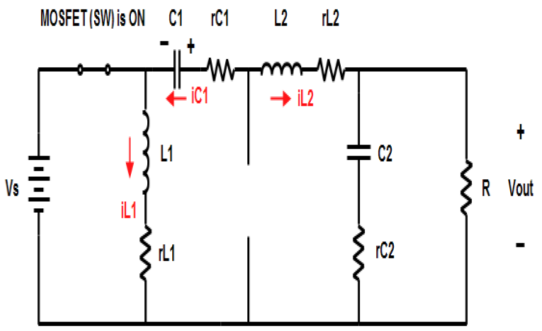


3. MODELING OF ZETA CONVERTER

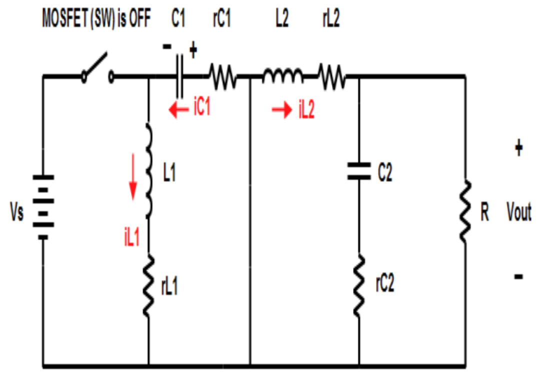
Zeta converter, as a power switched converter, contains a power switch (MOSFET) with a nominal duty cycle, which forms two circuit states of the converter circuit. The modeling of the converter starts from that each circuit state will have a state space model, and the overall model is obtained by the state space averaging technique (SSA) which is a matrix based approach from the two state space models by calculating the weighted average of the two sets of equations using the nominal values of the time spent in each circuit state as the weights.

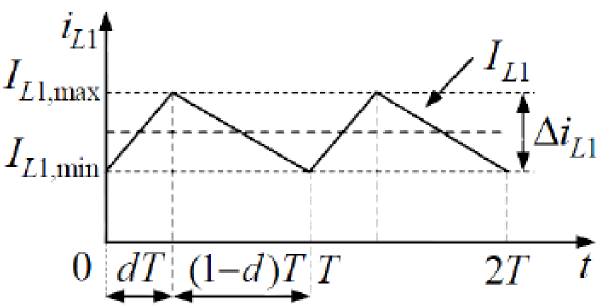
4. DESCRIPTION OF EACH CIRCUIT STATE

The Zeta converter circuit has two circuit states formed by the MOSFET switch. The first state is when the MOSFET switch is ON, the diode is reversed biased, thus, the diode will act as an open circuit as shown in Figure 2.3 below. In this state, the inductors L1 and L2 are in the charging state, and the inductors currents are increasing linearly.

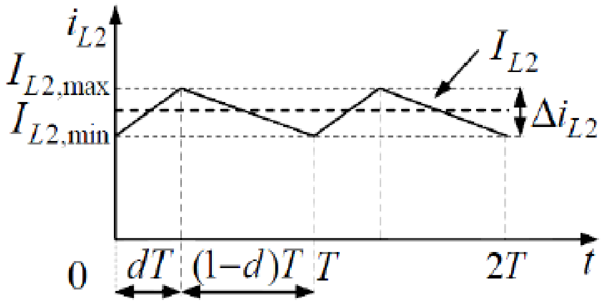


The equivalent Zeta converter circuit when the switch is ON the Second state is when the MOSFET switch is OFF, the diode is forward biased, thus, the diode will act as a short circuit as shown in Figure 2.4 below. In this state, the inductors are in the discharging state, and the energies in 1/2 L and L are discharged to capacitors 1/2 C and C which is the output part respectively, and the inductors currents are decreasing linearly.





i_{L1} waveform

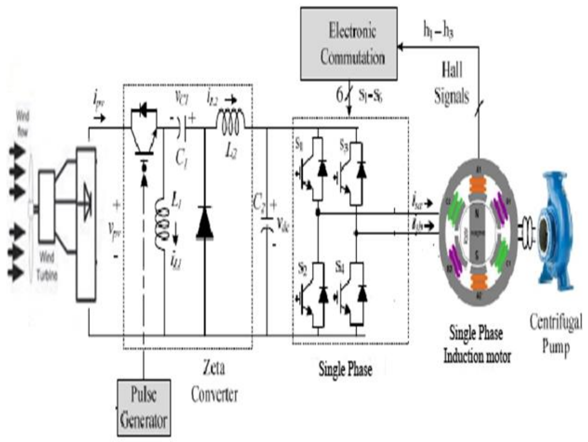


i_{L2} waveform

To insure that inductors currents are increasing and decreasing linearly, the following equations must be satisfied [8].

5. OPERATIOINAL DESCRIPTION

Block Diagram



Pulse Generator

Pulse generators can produce multiple-channels of independent widths and delays and independent outputs and polarities. Often called digital delay/pulse generators, the newest designs even offer differing repetition rates with each channel.

These digital delay generators are useful in synchronizing, delaying, gating and triggering multiple devices usually with respect to one event. One is also able to multiplex the timing of several channels onto one channel in order to trigger or even gate the same device multiple times.

A new class of pulse generator offers both multiple input trigger connections and multiple output connections. Multiple input triggers allows experimenters to synchronize both trigger events and data acquisition events using the same timing controller.

In general, generators for pulses with widths over a few microseconds employ digital counters for timing these pulses, while widths between approximately 1 nanosecond and several microseconds are typically generated by analog techniques such as RC (resistor-capacitor) networks or switched delay lines.

ZETA Converter

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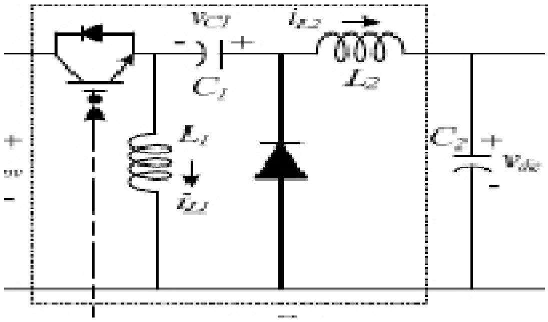
Zeta converter



Inverter

This chapter provides an overview of modulation techniques used for generating gate drive signals in solid-state inverter applications. The purpose of modulation is to obtain a variable output having the maximum fundamental component while minimizing switching losses and harmonics. Previous works indicate that careful choice of the PWM strategy can significantly improve the inverter output harmonic spectrum by moving harmonic components to higher frequencies. In addition, Space Vector PWM (SVPWM) strategy is described as preferable to other PWM strategies commonly used with three-phase inverters. It maximizes exploitation of the converter hardware, inherently limiting the effect of an inherent third harmonic injection mechanism and simplifies the control organization. All the PWM techniques have been applied to three-phase inverters as well as single-phase inverters, except SVPWM which has to date not been widely applied to the single-phase inverter.

Therefore, this chapter investigates the use of the SVPWM in the context of the single-phase inverter. The proposed SVPWM algorithm is implemented and simulated using MATLAB/SIMULINK for the control of a single-phase inverter. The results of the proposed SVPWM algorithm show a higher amplitude modulation index compared to that of Sinusoidal PWM (SPWM), as well as a reduction in the output harmonic distortion.

6. PIN DESCRIPTION

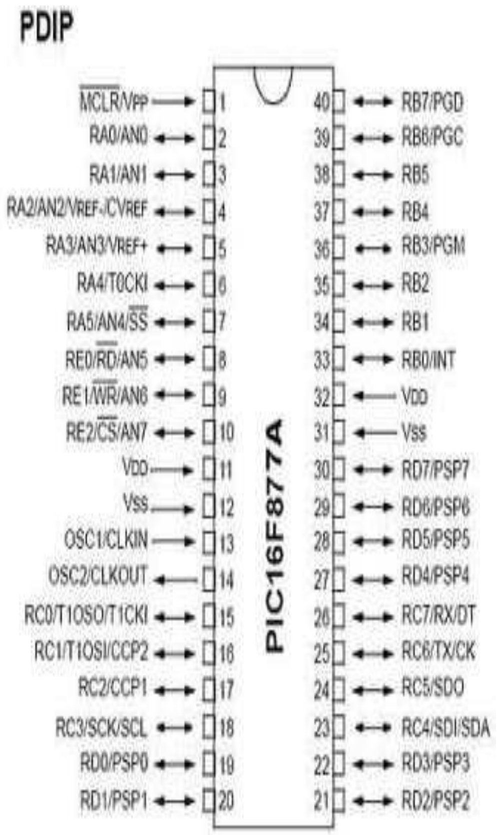
PIN DIAGRAM OF PIC16F877A

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This controller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it use FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used in many pic microcontroller projects. PIC16F877A also have much application in digital electronics circuits.

PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. It is flexible and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

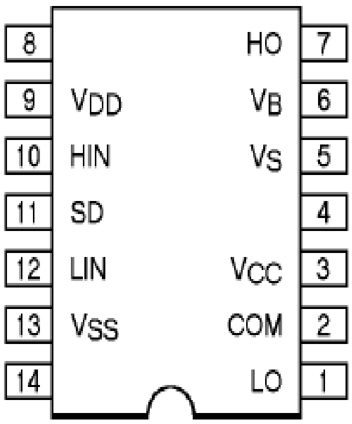
PIN CONFIGURATION OF PIC16F877A

As it has been mentioned before, there are 40 pins of this microcontroller IC. It consists of two 8 bit and one 16 bit timer. Capture and compare modules, serial ports, parallel ports and five input/output ports are also present in it.



MOSFET driver circuits are used to drive MOSFETS in high side or low side. Why we need MOSFET driver? Because MOSFETS are voltage control device and to drive MOSFET the gate capacitance should be charged to operating voltage which is usually between 9-10 volt. One can do it very easily but there is one issue. High voltage on drain of MOSFET cause problem by interaction with gate-drain capacitance. This problem is known as miller effect. MOSFET drivers are used to avoid these issues.

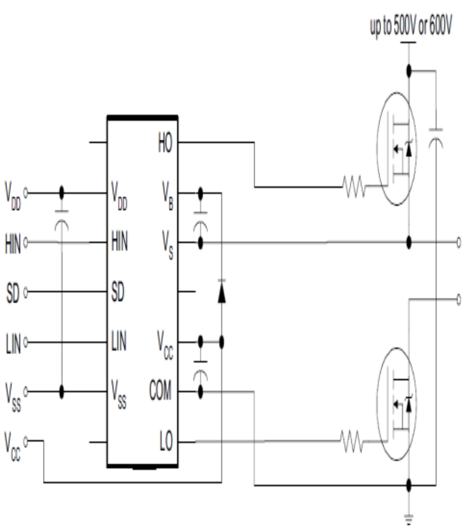
There are many types of MOSFET drivers available in market. But almost all MOSFET driver used totem pole output. Because it has low input impedance and high drive current.



IR2110 Mosfet Driver

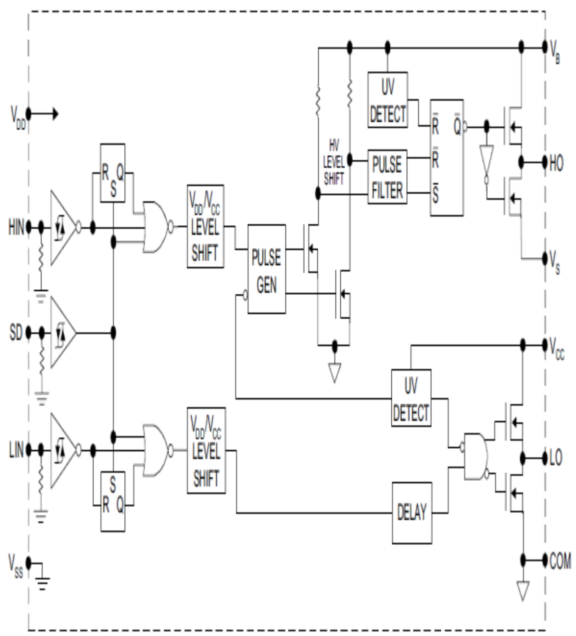
In many applications, floating circuit is required to drive high side MOSFET. In H Bridge used in pure sine wave inverter design 2 MOSFET are used as high side MOSFET and 2 MOSFET are uses as low side MOSFET. International rectifiers IR2110 MOSFET driver can be used as high side and low side MOSFET driver. It has a floating circuit to handle to bootstrap operation. IR2210 can with stand voltage up to 500v (offset voltage). Its output pins can provide peak current up to 2 ampere. It can also be used to as IGBT driver. IR2210 floating circuit can drive high side MOSFET up to 500 volt. Pin configuration and functionality of each pin is given below.

PIN Configuration of IR2110



- Pin 1 is output of low side MOSFET drive
- Pin2 is a return path for low side. It is at same potential as ground VSS pin 13. Because when input to low side at pin 12 Lin is high, LO output will be equal to value of Vcc voltage at pin 3 with respect to Vss and COM pin. When hen input to low side at pin 12 Lin is low, LO output will be equal to value of VSS and its means zero.
- VDD pin 9 is a logic supply pin. Its value should be should be between 5 volt. But if you used voltage less than 4 volt it many not give you required result.
- HIN pin 10 is input signal for high side mosfet driver output. It may be from microcontroller or any other device. But input signal logic level should be between 4-5 volt.
- LIN pin 12 is input signal for low side mosfet driver output. It may be from microcontroller or any other device. But input signal logic level should also be between 4-5 volt.
- SD pin 11 is used a shutdown pin. You can use it for protection circuit. For example in over voltage or over current protection circuit , if any of these values become greater than specified values, you can give 5 volt signal to shutdown IR2210 driver to stop driving MOSFETS. In return your circuit will stop working.

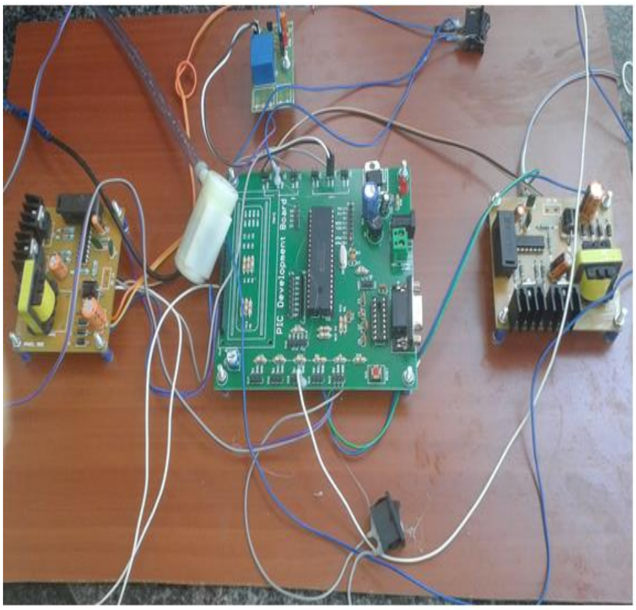
7. FUNCTIONAL BLOCK DIAGRAM



VB pin 6 is used as a high side floating supply or floating circuit to provide floating voltage to high side MOSFET. Bootstrap capacitor used between VB and VS to fully operate high side MOSFET. It plays a very important rule in H Bridge of pure sine wave inverter. You should use bootstrap capacitor value 22uf-40uf. I have successfully designed H Bridge after making many changes in H Bridge with 33uf/50v bootstrap capacitor value.

For more detail I recommend you to go through data sheet of IR2210 and one tip for those readers who are from Pakistan, Don't purchase IR2110 from Pakistan. Because low quality IR2110 IC's are available in Pakistan which burn again and again and will make you hopeless. I have already gone through this situation while working on my final year project "Hybrid pure sine wave inverter". Then I used IR2112 and its works perfectly. Because IR2212 and I2110 both are almost same and their pin out are same. I recommend you to use IR2112 also in your project.

8. HARDWARE IMPLEMENTATION



9. CONCLUSION

In this study, application of electrical energy gaining from wind in an irrigation system and performance of induction motor used in this system is investigated. In order to do that, data taken from this application system were analyzed and compared with simulation results. In such wind irrigation systems generally brushless DC motors are preferred due to their high efficiency, but cost of these machines are higher than induction motors. However, induction motors are commonly used in conventional irrigation systems. Therefore, induction motor was preferred in application system on account of being able to work even in worse conditions, being cheaper and not requiring much maintenance. Induction motor and its driver system cost are one third of brushless motor and driver system. As regards of result gained from study, it can be seen that induction motor works efficiently. Electrical losses can be prevented by speed control techniques. According to study results, gaining electrical energy from wind system is efficient at irrigation period. Thanks to controlling motor speed, water in demanded amount can be given into irrigation system by drip method. Due to eliminating valve losses energy is used more efficiently.

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