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Design of Wind Turbine for Rural Electrification

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ABSTRACT
The electricity requirements of the world including India are increasing at an alarming rate and the power demand has been running ahead of supply. It is now widely recognized that the fossil fuels and other conventional resources, may not be either sufficient or suitable to keep pace with ever increasing demand of the electrical energy of the world. Also generation of electrical power by coal based steam power plant or nuclear power plants causes pollution, which is likely to be more acute in future due to large generating capacity. In recent decades, the industry has been perfecting the wind turbine to convert the power of the wind into electricity. The wind turbine has many advantages that make it an attractive energy source especially in parts of the world where the transmission infrastructure is not fully developed. It is modular and can be installed relatively quickly, so it is easy to match electricity supply and demand. The fuel for this is wind which is free and abundant which reduces over cost of generation. In this paper the wind turbine has been designed which is used to generate the electrical energy. The electrical energy obtained from the wind is stored in a battery. The battery supply is fed to a inverter circuit which is capable of converting the DC power into the AC power. This is fed to a step-up transformer to generate required AC which can be utilized by electrical appliances.he electricity requirements of the world including India are increasing India are increasing at an alarming rate and the power demand has been ahead of supply.
Keywords— advanced discontinuous PWM, discontinuous PWM, imaginary switching times, stator flux ripple, and vector control

1. INTRODUCTION

Wind power is the conversion of the energy in wind into a more useful form of energy, like electricity. It is a renewable source of energy that helps to cut down on the pollution of earth's air. Wind power capacity has expanded quickly to 336 GW in June 2014, and wind energy production was about 4% of total worldwide electricity usage, and growing fast. Wind power is widely used in European countries, and more recently in the United States and Asia. In 2012 wind power accounted for approximately 30% of electricity generation in Denmark, 20% in Portugal and 18% in Spain.[8] A wind turbine is the popular name for a device that converts kinetic energy from the wind into electrical power. Technically there is no turbine used in the design but the term appears to have migrated from parallel hydroelectric technology. The correct description for this type of machine would be aerofoil-powered generator. A wind turbine used for charging batteries may be referred to as a wind charger.

Wind turbines are designed to exploit the wind energy that exists at a location. Aerodynamic modeling is used to determine the optimum tower height, control systems, number of blades and blade shape. Wind turbines convert wind energy to electricity for distribution. Conventional horizontal axis turbines can be divided into three components: The rotor component, which is approximately 20% of the wind turbine cost, includes the blades for converting wind energy to low speed rotational energy.The generator component, which is approximately 34% of the wind turbine cost, includes the electrical generator, the control electronics, and most likely a gearbox (e.g. planetary gearbox), adjustable-speed drive or continuously variable transmission component for converting the low speed incoming rotation to high speed rotation suitable for generating electricity. The word 'inverter' in the context of power-electronics denotes a class of power conversion (or power conditioning) circuits that operates from a dc voltage source or a dc current source and converts it into ac voltage or current. The 'inverter' does reverse of what ac-to-dc 'converter' does (refer to ac to dc converters).

2. PROPOSED DESIGN OF VSI

Drive and pulse generator circuit

A voltage-source inverter is one in which the dc source has negligible impedance. In other words, if the input dc is a voltage source, the inverter is called a voltage source inverter (VSI). One can similarly think of a current source inverter (CSI), where the input to the circuit is a current source. A current-source inverter is fed with adjustable current from a dc source of high impedance. The VSI circuit has direct control over 'output (ac) voltage' whereas the CSI directly controls 'output (ac) current'. Shape of voltage waveforms output by an ideal VSI should be independent of load connected at the output. The dc link voltage at the supply side depends on the load connected at the output. [10].some industrial applications of inverters are for adjustable-speed ac drives, induction heating, UPS (Uninterruptible Power Supplies) for computers, HVDC transmission lines etc. [10] The driver circuit is mainly needed for all the inverter circuits in order to provide the triggering pulse for the IGBT's. The driver circuit mainly comprises of following components. They are

1. Pulse Generator (MSP-430)
2. Mono stable Multivibrator (IC 74121)
3. XOR Gate (IC 7486)
4. NOT Gate(IC 7404)
5. TLP 250

The **MSP430** is a mixed-signal microcontroller family from Texas Instruments. Built around a 16-bit CPU, the MSP430 is designed for low cost and, specifically, low power consumption embedded applications. Texas Instruments released the MSP430

Launch pad in July 2010. The MSP430 Launch pad has an onboard flash emulator, USB, 2 programmable LEDs, and 1 programmable push button.[7]

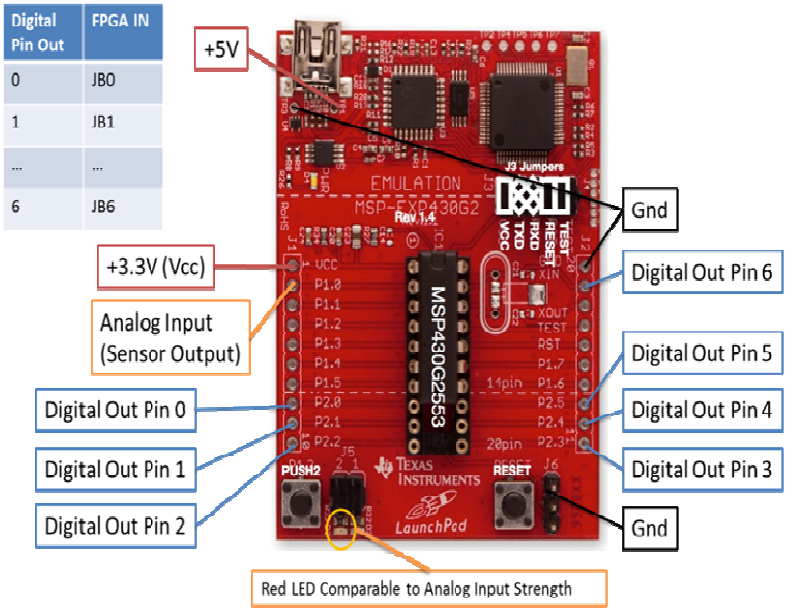


Fig 1. MSP launch pad

Power circuit

The circuit which converts the DC power to AC power (in inverter) and AC power to DC power (in rectifier) is known as power circuit. The major difference between power circuit and driver circuit is , the power circuit operates at high voltages and driver circuit operates at low voltages as it only provides the firing pulses. Whereas power circuit will handle the load current. Voltage source inverters are the most widely used power electronic converters for induction motor drive applications. The Pulse Width Modulation techniques are employed for control of output voltage and frequency which is an excellent control strategy to control various parameters in any circuit, without addition of any converter.

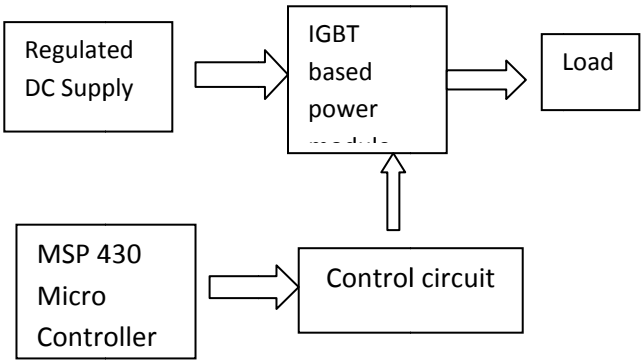


Fig 2 Block diagram of single-phase VSI

3. HARDWARE IMPLEMENTATION

Initially the wind turbine is placed on the roof of the buildings (or) in any place where it can expose to the wind. As the wind blows the blades of the wind turbine rotates and this wind turbine is mechanically coupled with the shaft of the DC motor. And as the turbine rotates with the speed automatically the mechanically coupled motor also rotates and output voltage is obtained across the terminals of the motor.

This output voltage is provided to battery through the charge controller in order to provide the uni-directional flow of current. The battery is connected in order to store the power as the wind energy does not remain constant through out the day. The supply from the battery is given to the inverter circuit in order to convert the DC power to AC power. And this inverter circuit is known as Power circuit. And a circuit which is used to give the triggering pulse to the IGBT's and is known as Driving circuit.

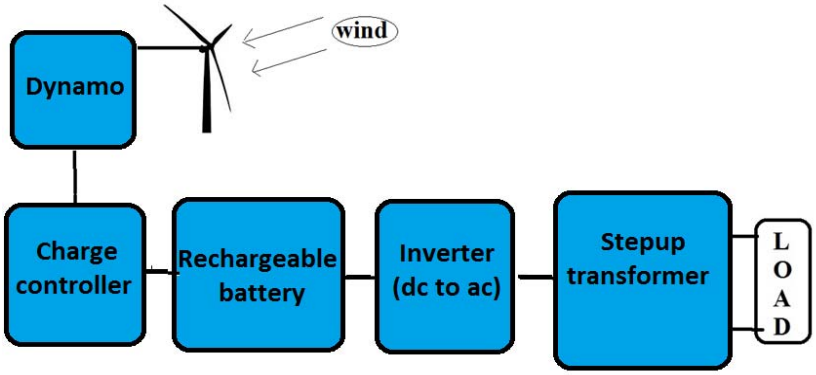
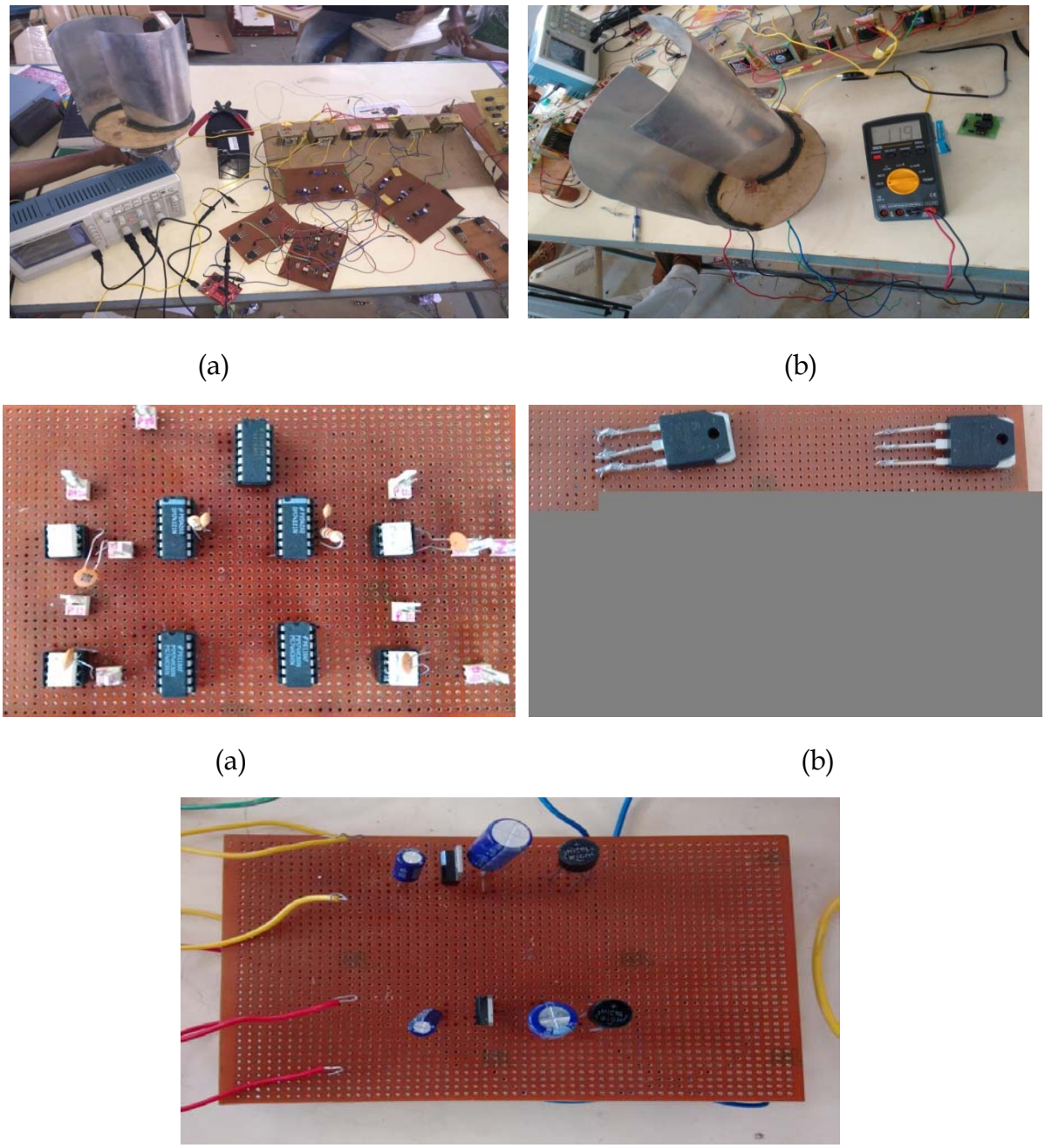


Fig 3.Main Block Diagram

Initially the wind turbine is placed on the roof of the buildings (or) in any place where it can expose to the wind. As the wind blows the blades of the wind turbine rotates and this wind turbine is mechanically coupled with the shaft of the DC motor. And as the turbine rotates with the speed automatically the mechanically coupled motor also rotates and output voltage is obtained across the terminals of the motor.This output voltage is provided to battery through the charge controller in order to provide the uni-directional flow of current. The battery is connected in order to store the power as the wind energy does not remain constant through out the day. The supply from the battery is given to the inverter circuit in order to convert the DC power to AC power. And this inverter circuit is known as Power circuit. And a circuit which is used to give the triggering pulse to the IGBT's and is known as Driver circuit.

Finally the output of the inverter circuit is connected to the transformer in order to step up the output to 230 volts. And that output can be use for general house hold applications. In this model initially the wind turbine is placed in an suitable

environment such that it can be rotated with the maximum speed so that maximum amount of voltage will be generated i.e., 12 V will be generated from the DC motor which is mechanically coupled with the turbine. And the designed wind turbine is as below.



(a) (b)

(a) (b)

Fig.4.Hardware Implementation

This 12V supply is fed to the charge controller with rating of 5AH in order to prevent the bidirectional flow of power . The output from the charge controller is

connected to the 12V battery with rating similar to that of the charge controller. Here battery is connected in order to provide the constant voltage as the wind energy is not constant through out the day.

This 12 V supply is provided to the input of the inverter circuit(power circuit) and the single pulse width modulation is provided from the MSP 430 microcontroller kit and from pin P1.6 the pulse of amplitude 3.6 V is taken. And the pulses of the MSP 430 are as shown above. And this amplitude is not required to trigger the IGBT's , so the pulses should be boosted. In order to boost the amplitude the pulse from the P1.6 is given to TLP 250 .And another important function of providing the supply to the TLP 250 is to provide ground isolation to the IGBT's. The TLP's are also fed with the pulses from mono stable multi vibrator and XOR gates in order to provide the dead time, So that no two IGBT's in one leg will be in ON state.

This circuit with TLP's ,XOR, Multi vibrators is called as Driver circuit. And the designed driver circuit is as above(c). And from the TLP's the pulse is provided to the IGBT's in order to trigger them. And hence by this process the 12 V AC power is obtained at the output of the Power circuit(IGBT circuit).The designed power circuit consists of four IGBT's and is as follows.Thus obtained 12 V AC power is provided to the 12 V-230V step up transformer. And finally the 230 V is obtained as the output of the transformer, which can be normally used in house hold applications . Especially this type of generating the DC power and converting into AC is employed in the places where there is no availability of the transmission and distribution networks.

4. RESULTS AND CONCLUSION

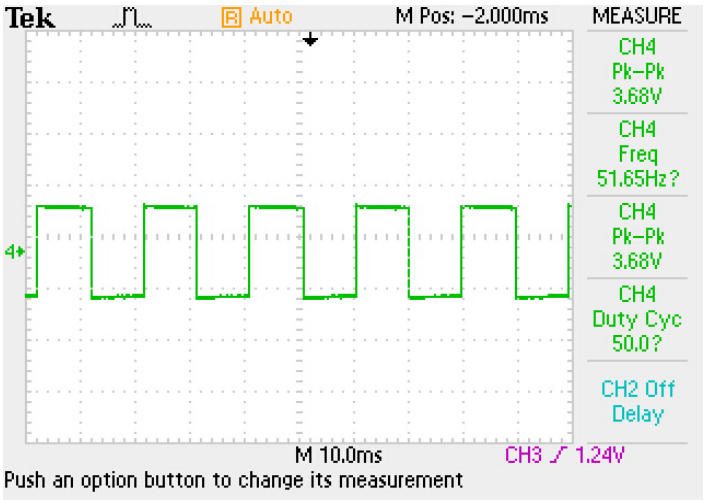


Fig.5.Pulses From Microcontroller

In this paper wind turbine has been designed and inverter circuit in order to generate the power. It is simple in construction and also viable from economic point of

view. Hence these models can be employed in the regions where there is no availability of power. Therefore, the lives of the people over there can be enlightened. Similar to this model we can establish the huge wind generation plants and by using the suitable conversion mechanisms (DC to AC) so that we can harness the large amount of wind energy and can generate the large amount of electrical energy. As it is pollution free it can save lots and lots of fossil fuels and can also save the economy of the nation.

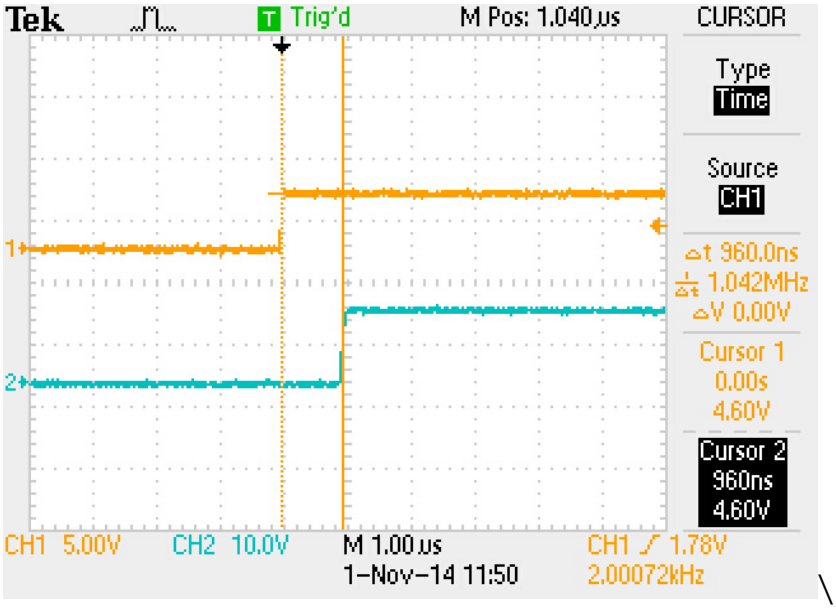


Fig.6. Dead-Time Implementation

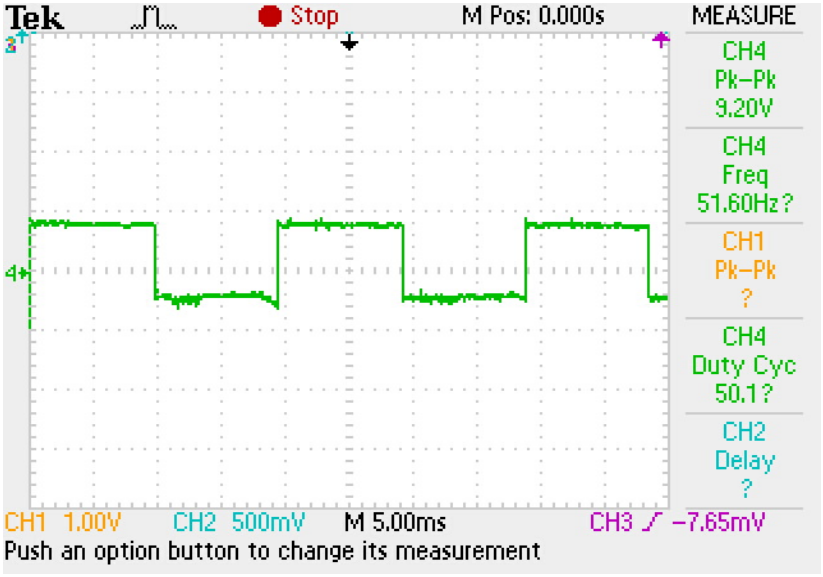


Fig.7 Output Of the Inverter circuit

2. LIST OF APPARATUS:

APPARATUS	Quantity
Wind Turbine	1
DC Machine (12 v, 1 A)	1
Charge controller (12 V,3.7 Ah)	1
Battery (12 v, 5 Ah)	1
Mono stable multi vibrator(IC 74121)	2
MSP 430 Microcontroller kit	1
XOR Gate(IC 7486)	2
NOT Gate(IC 7404)	1
TLP 250	4
IGBT's(FGA25N120ANTD)	4
Connecting wires	Required
12-0-12 Transformer	1
Bridge Rectifier (W04M)	2
Capacitors 1000µf,24v 100 µf,24v	2 2
Voltage regulators 7812 7806	2 2

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