PMSG based Stand alone Variable Speed Wind Turbine

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***ABSTRACT*−*This project presents an advanced control strategy for the operation of a direct-drive synchronous generator- based stand-alone variable-speed wind turbine. The control strategy for the generator-side converter with maximum power extraction is presented. The stand-alone control featured is constant output voltage and frequency that is capable of delivering to variable load. The main attention is dc link voltage control deals with the chopper control for various load condition.And also a battery storage system with converter and inverter has to be used to deliver continuous power at the time of fluctuated wind.The simulation results show this control strategy gives better regulating voltage and frequency under sudden varying load conditions. Dynamic representation of dc bus and small signal analysis are presented. The dynamic controller shows very good performance.*

Keywords: PMSM, boost converter, inverter, driver circuit and PIC/DSP

1, INTRODUCTION

In this paper to design advance control techniques in variable speed to give continuous Supply to load. Variable-speed wind turbines have many advantages over fixed-speed generation such as increased energy capture, operation at maximum power point, improved efficiency, and power quality. However, the presence of a gearbox that couples the wind turbine to the generator causes problems. The gearbox suffers from faults and requires regular maintenance. The reliability of the variable-speed wind turbine can be improved significantly by using a direct-drive synchronous generator. Synchronous machine has received much attention in wind-energy application because of their property of a high power factor and high efficiency. To extract maximum power from the fluctuating wind, variable-speed operation of the wind-turbine generator is necessary.

This requires a sophisticated control strategy for the generator. A control strategy for the generator-side converter with output maximization of a PMSG-based small-scale wind turbine is developed. It is simple and a low-cost solution for a small-scale wind turbine. For a stand-alone system, the output voltage of the load side converter has to be controlled in terms of amplitude and frequency and also a battery storage system with converter and inverter has to be used to deliver continuous power at the time of fluctuated wind.

II BLOCK DIAGRAM

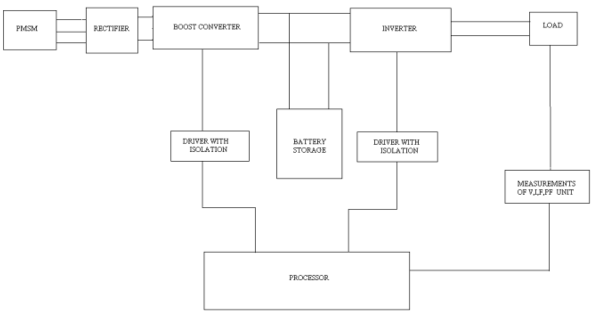

Fig 1.Block diagram of the project

A Block Diagram Description

Generator converts the variable speed mechanical power produced by the wind turbine into electrical power. The power produced in the generator having variable frequency and voltage AC power. This Ac power converted into DC power with the help of uncontrolled rectifier. The dc power will be have variable voltage. This variable voltage is boostered to rated level with the help of boosted converter. Boosted dc power is converted into fixed frequency AC power and it is delivered to load. Between load and inverter as storage system with converter and inverter is used to store the energy. This storage system will store the energy at the time of load lesser than maximum level. Also this storage system is used to deliver power to load when the boost converter unable to boost up the voltage. Microcontroller is used to control boost converter and inverter to get fixed frequency and voltage

B **Synchronous Generator**

Synchronous generators are the primary source of all electrical energy. Commonly used to convert the mechanical power output of steam turbines, gas turbines, reciprocating engines hydro turbines into electrical power for the grid can be extremely large – power ratings. Are known as synchronous machines because they operate at synchronous speed (speed of rotor always matches supply frequency).

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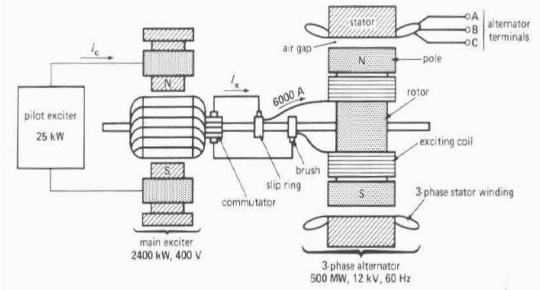

Fig 2. Synchronous Generator

The rotor is mounted on a shaft driven by mechanical prime mover. A field winding (rotating or stationary) carries a DC current to produce a constant magnetic field. An AC voltage is induced in the 3-phase armature winding (stationary or rotating) to produce electrical power. The electrical frequency of the 3-phase output depends upon the mechanical speed and the number of poles.

C Power Diode

A power diode is a two terminal p-n junction device and a p-n junction normally formed by allowing diffusion and epitaxial growth structure of a power diode and symbol are shown in figure below. High power diodes are silicon-rectifiers that can operate at high junction temperatures. Power diodes have larger Power, Voltage and Current handling capabilities than ordinary signal diodes. In addition, the switching frequencies of power diodes are low as compared to signal diodes. The voltage current characteristics of power diodes are shown in figure below.when the anode potential is positive with respect to cathode, the diode is said to be forward biased, the diode conducts and behaves essentially as a closed switch. A conducting diode has a relatively small forward voltage drop across it and the magnitude of the drop would depend on the manufacturing process and temperature. When cathode potential is positive with respect to anode, the diode is said to be reversed. It behaves essentially as an open circuit.

D Insulated-gate bipolar transistor

The IGBT is used in medium- to high-power applications such as switched-mode power supply, traction motor control and induction heating. Large IGBT modules typically consist of many devices in parallel and can have very high current handling capabilities in the order of hundreds of amperes with blocking voltages of 6000 V, equating to hundreds of kilowatts. The boundary within the crystal between these two regions, called a PN junction, is where the action of the diode takes place. The crystal conducts conventional current in a direction from the p-type side to the n-type side, but not in the opposite direction. Another type of semiconductor diode, the Scotty diode, is formed from the contact between a metal and a semiconductor rather than by a p-n junction.

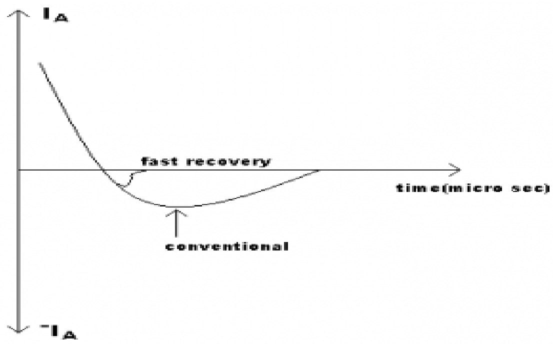

Fig 6 the Recovery Characteristics of Conventional and Fast Recovery Diodes

E. IC PIC16F877A

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology. It is the controller IC for controlling purpose and it convert the given voice signal into the digital signal and it will send the appropriate signal to receiver side.

F Features

1. Pin out compatible to the PIC16C73B/74B/76/77
2. Interrupt capability (up to 14 sources)
3. Eight level deep hardware stack
4. Direct, indirect and relative addressing modes
5. Power-on Reset (POR)
6. Power-up Timer (PWRT) and
7. Oscillator Start-up Timer (OST)
8. Watchdog Timer with its own on-chip RC oscillator.

G. Hall Effect Sensor

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A Hall effect sensor is a transducer that varies its output voltage in response to changes in magnetic field. Hall sensors are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analogue transducer directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined.

Using groups of sensors, the relative position of the magnet can be deduced. Electricity carried through a conductor will produce a magnetic field that varies with current, and a Hall sensor can be used to measure the current without interrupting the circuit. Typically, the sensor is integrated with a wound core or permanent magnet that surrounds the conductor to be measured. Frequently, a Hall sensor is combined with circuitry that allows the device to act in a digital (on/off) mode, and may be called a switch in this configuration.

Commonly seen in industrial applications such as the pictured pneumatic cylinder, they are also used in consumer equipment; for example some computer printers use them to detect missing paper and open covers. When high reliability is required, they are used in keyboards.

Fig 2.25 Hall sensor

Hall sensors are commonly used to time the speed of wheels and shafts, such as for internal combustion engine ignition timing, tachometers and anti-lock braking systems. They are used in brushless DC electric motors to detect the position of the permanent magnet. In the pictured wheel with two equally spaced magnets, the voltage from the sensor will peak twice for each revolution. This arrangement is commonly used to regulate the speed of disc drives. A hall probe contains an indium compound crystal such as indium antimonite, mounted on an aluminum backing plate, and encapsulated in the probe head.

I. Boost Converter

Boost Converter control strategy

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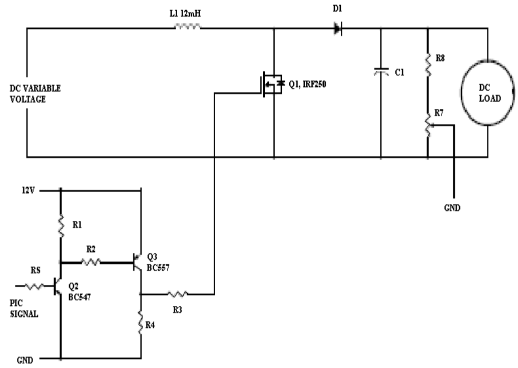

The power circuit is a dc-dc boost converter. The command circuit is the one, in which the analogue controller was replaced with a Fuzzy one. The output of the Fuzzy controller is v_c.

In average current control method, an input voltage sensing is required to obtain a sinusoidal reference, an analogue multiplier to combine this reference with the output information, and an error amplifier in current loop to extract the difference between the input current and the reference to generate the control signal for modulating the input current.

There are a lot of very sophisticated researches of boost converter dynamics. The most of PFC is based on boost converter, because of its input inductor which reduces the total harmonics distortion and avoids the transient impulse from power net, the voltage of semiconductor device below output voltage, the zero potential of Q's source side which makes it easy to drive Q and its simple structure. Therefore, satisfied teaching of advanced power electronics should be introduced by unity power factor and high efficiency by
Dc-dc boost converter.

In this section one inductor and an IGBT are used to boost up the voltage. When the Dc voltage is lesser than the rated level, it will boost up the voltage. IGBT is used to charging and discharging the inductor. This IGBT is control by micro controller.

J. Inverter

This is a controlled inverter which is control by v/f control method. This is used to convert Dc into AC.This is control by the help of micro controller. If will produce 1 to 50 Hz frequency Ac output.

K.Battery Storage

This is the section to store energy. This section has a battery with rectifier and inverter and a step down transformer. Transformer will reduce the voltage to 15v.This 15v Ac is converted into Dc in rectifier. This is 15v c is stored in battery. This is 15v Dc is converted into 230v Ac in inverter. This inverter is control by microcontroller.

III V, F, P.F & I Measurement

1. Current Transformer

A current transformer (CT) is used for measurement of electric currents. Current transformers, together with potential transformers (PT), are known as instrument transformers. When current in a circuit is too high to directly apply for measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays.

2. Potential Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core, and thus varying field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction.

3. Shunt Resistor

Current shunt resistors are low resistance precision resistors used to measure AC or DC electrical currents by the voltage drop those currents create across the resistance.

Ohm's law states that the Voltage (V in Volts) across a resistance (R in Ohms) is the product of the resistance and the current (I in Amps) flowing through the resistance.

$$V = I \times R. \qquad (2)$$

For example: A current shunt whose resistance is 0.001 Ohms ,having a current of 50 Amps flowing through it will produce a voltage of 0.001 ×50 = 0.05 Volts or 50 mV (millivolts).

So by inserting a current shunt into a circuit you can find the current by measuring the voltage drop across the shunt. Then knowing the resistance of the current shunt you can calculate the current using Ohm's law arranged as

$$I = V \div R \qquad (3)$$

A zero crossing detector literally detects the transition of a signal waveform from positive and negative, ideally providing a narrow pulse that coincides exactly with the zero voltage condition. At first glance, this would appear to be an easy enough
task, but in fact it is quite complex, especially where high frequencies are involved. In this instance, even 1 kHz starts to present a real challenge if extreme accuracy is needed.

The humble comparator plays a vital role, without it, most precision zero crossing detectors would not work, and we'd be without digital audio, PWM and a multitude of other applications.

The comparator used for a high speed zero crossing detectors, a PWM converter or conventional ADC is critical. Low propagation delay and extremely fast operation are not only desirable, they are essential.

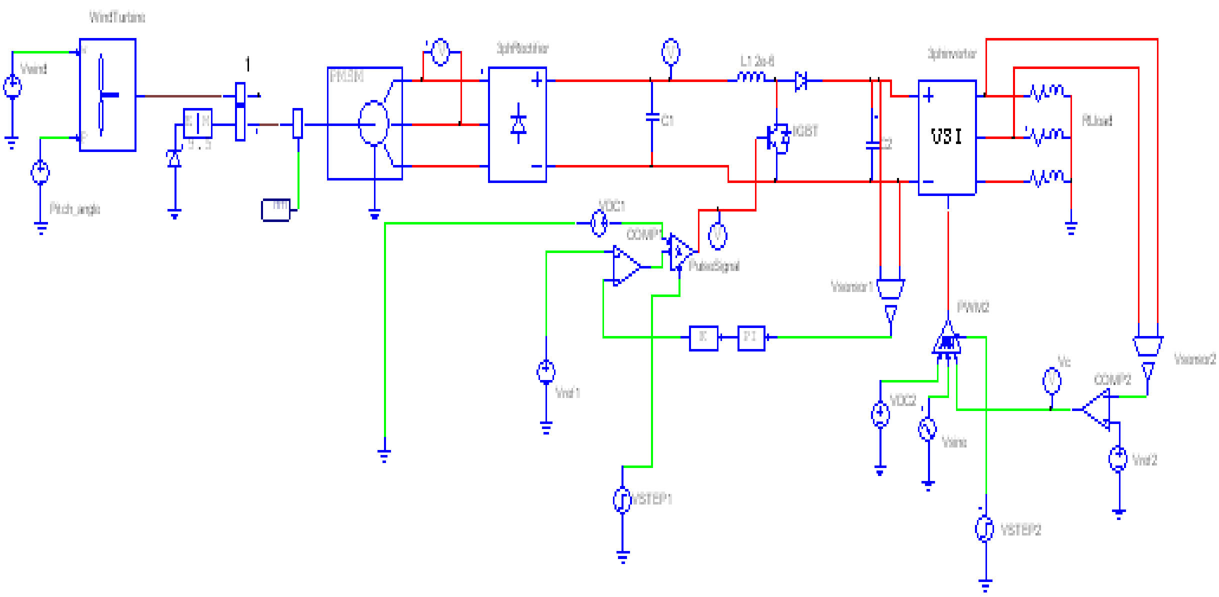

Figure 13: Simulation circuit for PMSG based stand alone variable speed wind turbine

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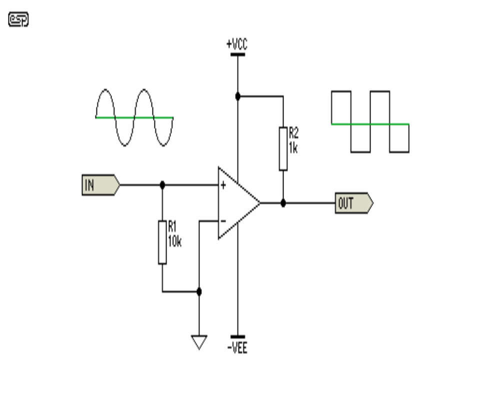


Fig. 3. Comparator Zero Crossing Detectors

4. XOR Gate

The XOR gate is a special case in logic circuit. It will output a 1 only when the inputs are different (i.e. one input must be at logic high (1) and the other at logic low (0v). The resistor and cap form a delay so that when an edge is presented (either rising or falling), the delayed input holds its previous value for a short time.

In the example shown, the pulse width is 50ns. The signal is delayed by the propagation time of the device itself (around 11ns), so a small phase error has been introduced. The rise and fall time of the square wave signal applied was 50ns, and this adds some more phase shift**.**

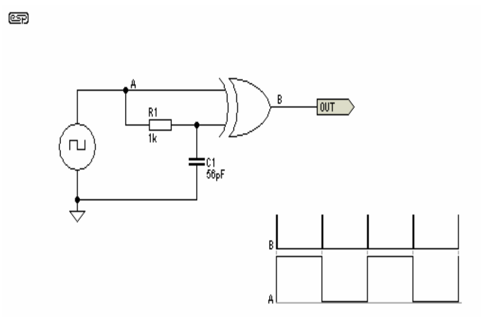


Fig. 4. Exclusive or gate edge detector

O. PIC Microcontroller

This PIC microcontroller is used to control all parts of the circuit. This is used to fire all IGBT's and relay. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

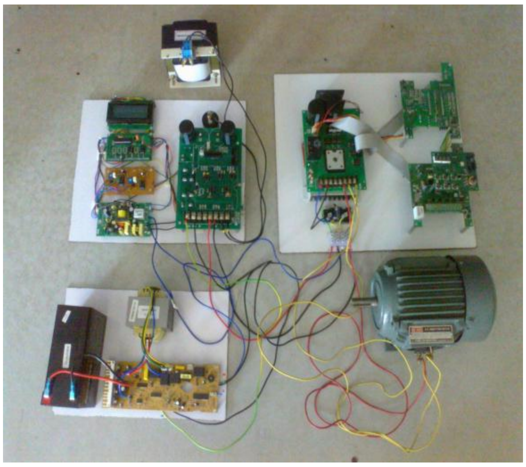
P. Driver Circuit

This circuit is used to drive all IGBT's .This circuit is used to isolate the IGBT from microcontroller. This is having two transistors as shown in the circuit diagram.

IV CONCLUSION

A control strategy for a direct-drive stand-alone variable speed wind turbine with a synchronous generator has been presented in this project. The controller is capable of maximizing output of the variable-speed wind turbine under fluctuating wind. The generating system with the proposed control strategy is suitable for a small-scale stand alone variable-speed wind-turbine installation for remote-area power supplythe simulation results has proves that Regulating the o/p voltage & frequency under sudden load variations and typical wind movement.

VSCREENSHOT



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