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Analysis and Design of a Domestic Solar-Wind Hybrid Energy System for Low Wind Speeds

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ABSTRACT:

A solar-wind hybrid power generation system has been presented here. The application based system illustrated in this paper is designed on the basis of the solar and wind data for areas in Northern India. The power generated by the system is intended for domestic use. The most common source of unconventional power in homes is battery based UPS (Uninterrupted power supply) inverter. The UPS inverter charges the battery with conventional grid power. This system will charge the battery of UPS inverter by using only wind and solar power, which will make the system cost effective and more reliable. The reason for using both solar and wind is that recent studies have proven that combined system can be more productive and consistent and other thing is that neither of them can be used for continuous power generation. In the system illustrated in this paper the solar-wind system provides power periodically which is controlled by electronic methods and a microcontroller is used to monitor the power from both the inputs. The switching action is provided from the microcontroller to the battery charging based on the power received from solar photovoltaic panel and wind generators. In this paper, an efficient system has been presented comprising of solar panel, wind generator, charge controller and charge storage unit (battery). Solar panel is selected as the main input and the wind resource will be used only in the absence of the solar photovoltaic (PV) output.

Keywords: PIC Microcontroller**,** Solar Panel**,** LCD**,** Battery**,** Embedded C

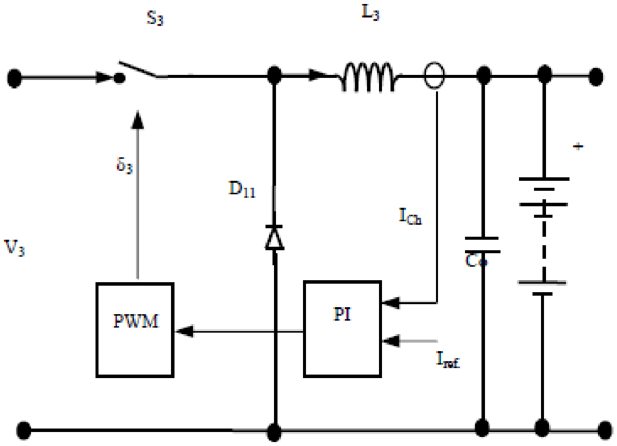
INTRODUCTION

While the global demand of energy is increasing constantly, the use of classic source of energy like oil and coal becomes problematic contributing among other things to climate change. One solution to address climate change is the use of clean renewable energy sources among other solar and wind. Most areas in South Africa average more than 2500 hours of sunshine per year with an annual 24 hour solar radiation of approx 220 W/m2, compared with 150 W/m2 in the USA and averaging 100 W/m2 for Europe. This makes South Africa's solar radiation resource one of the highest in the world. The progress in power electronics facilitated integration of these renewable energy sources either grid or as stand-alone for small scale use. Historically, the integration was started with wind farms. When the price for Photovoltaic panels became affordable, the penetration of PV became to be used more often but not necessarily at the same level of power as wind. For medium to high power the PV's are modularly used .Many studies propose small power integration (few kW) for both wind and solar PV as hybrid stand-alone systems. Other studies added fuel cells and batteries creating the concept of multi-port system.

SMALL SCALE RENEWABLE SYSTEM

The single input interface converts energy delivered by the PV array and wind generator in a comparable DC voltage when operating at nominal conditions. Due to the variable nature of wind and sun irradiation, the system must have a battery backup. In this proposed solution the corresponding DC output voltage for each renewable source is connected in series and thus increasing the power availability at partial solar irradiation
and weak wind.

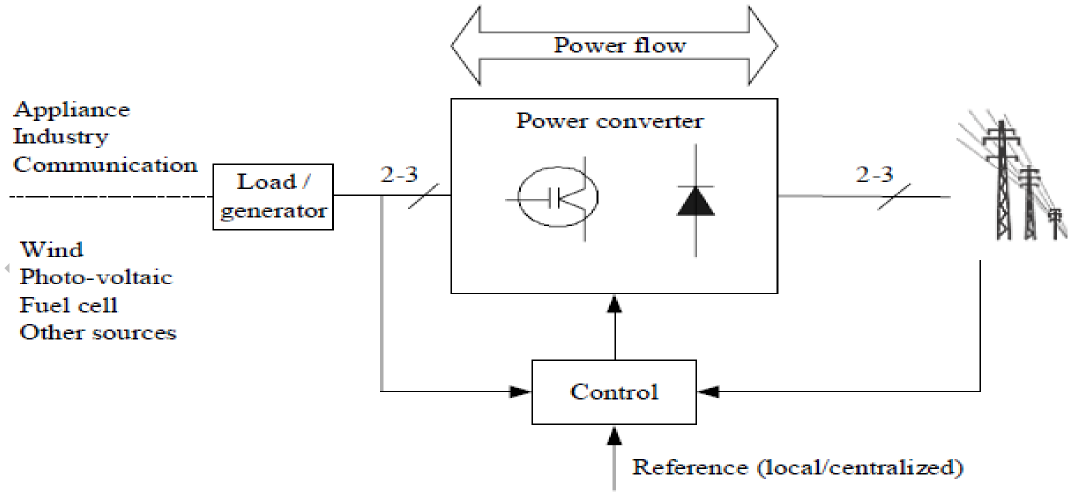
The third stage of the interface produces a charging current for the battery. During the day light, the consumption is lower than the PV can produce and the greatest part of this energy is stored into the battery. When the wind blows, the energy produced by the wind generator is also stored into battery



The interface proposed by this study has two input stages to connect wind generation. The first stage is a boost converter (L1, S1, D1 and C1)

Wind Input Control

The schematic for the control strategy. In order the turbine to operate efficiently, the electrical load of the generator should match mechanic power at MPP. Usually, the generator is a permanent magnet synchronous type and frequency of the three-phase output voltage is directly proportional with the wind turbine speed. Hence, the information needed to determine the maximum power point is taken from the output of the wind generator. One easy method to find the optimal load (and turbine speed) corresponding to that wind speed (vW), for maximum power point is using a look-up table which has been previously determined and stored.



Power electronics has changed rapidly during the last thirty years and the number of applications has been increasing, mainly due to the developments of the semiconductor devices and the microprocessor technology. For both cases higher performance is steadily given for the same area of silicon, and at the same time they are continuously reducing the price. A typical power electronic system consisting of a power converter, a load/source and a control unit.

2. **Power Electronics Converters for Wind Turbine Systems**

Frede Blaabjerg, Fellow, IEEE, Marco Liserre, Senior Member, IEEE

The steady growth of installed wind power together with the up scaling of the single wind turbine power capability has pushed the research and development of power converters toward full-scale power conversion, lowered cost pr kW, increased power density, and also the need for higher reliability. In this paper, power converter technologies are reviewed with focus on existing ones and on those that have potential for higher power but which have not been yet adopted due to the important risk associated with the high-power industry. The power converters are classified into single- and multi cell topologies, in the latter case with attention to series connection and parallel connection either electrical or magnetic ones (multiphase/windings machines/transformers). It is concluded that as the power level increases in wind turbines, medium-voltage power converters will be a dominant power converter configuration, but continuously cost and reliability are important issues to be addressed. Wind power has to play a much more active part in grid operation and control. The technology used in wind turbines was originally based on a squirrel-cage induction generator connected directly to the grid. Power pulsations in the wind were almost directly transferred to the electrical grid by using this technology as the Speed is fixed (limited slip range). Furthermore, no dynamic control of the active and reactive power exists except for a few capacitor banks which ensured unity power factor at the point of common coupling. As the power capacity of the wind turbines increases, regulating the frequency and the voltage in the grid become even more important, and in the last decade, it has become necessary to introduce power electronics as an intelligent interface between the wind turbine and the grid. Power electronics is changing the basic characteristic of the wind turbine from being an energy source to being an active power source for the grid. The electrical technology used in the wind turbine is not new. It has been discussed for several decades, but now the cost per kW of new wind power plant is comparable and even lower than coal power plant’s one; hence, solutions with power electronics are very attractive. In fact, the most recent finding of the Upwind European project are that 20 MW wind turbine is feasible provided some key innovations are developed and integrated. Given the limited technical literature details about power converter configuration in industrial products, the paper aims at classifying the solutions proposed in scientific literature but which have not been presented in a comprehensive way. First, the basic market developments are discussed with a focus on cost, size, and power density, also in respect to the adopted generator technology, to the filter and transformer, and to the switching devices used. Next, wind conversion is discussed with attention on two competing philosophies—one with reduced power converter which has been popular up to now—a second with a full-scale power converter which is becoming more and more the preferred choice. The most promising power converter topologies for wind turbines are further presented and compared by classifying them into single-cell and multicell structure. Reliability issues are also discussed in this context as they become more and more important. Synchronous generators, either externally excited or with permanent magnets, are becoming the preferred technology in the best seller power range .Multiple permanent magnet synchronous generator (PMSG) with a full power back to-back converter looks to become the most adopted generator in the near future due to the reduced losses and lower weight if compared to the externally excited SG that is manufactured successfully by, e.g., the German company Enercon. In the last case, the generator is an anular generator, and rotor current is used to regulate the dc link voltage. The transition seems mainly to be valid for larger wind turbines (3–6 MW). However, the increased prices of rare-earth magnets might change the philosophy of wind turbine drive trains to avoid high risk in expenses.

COMPOENTS USED

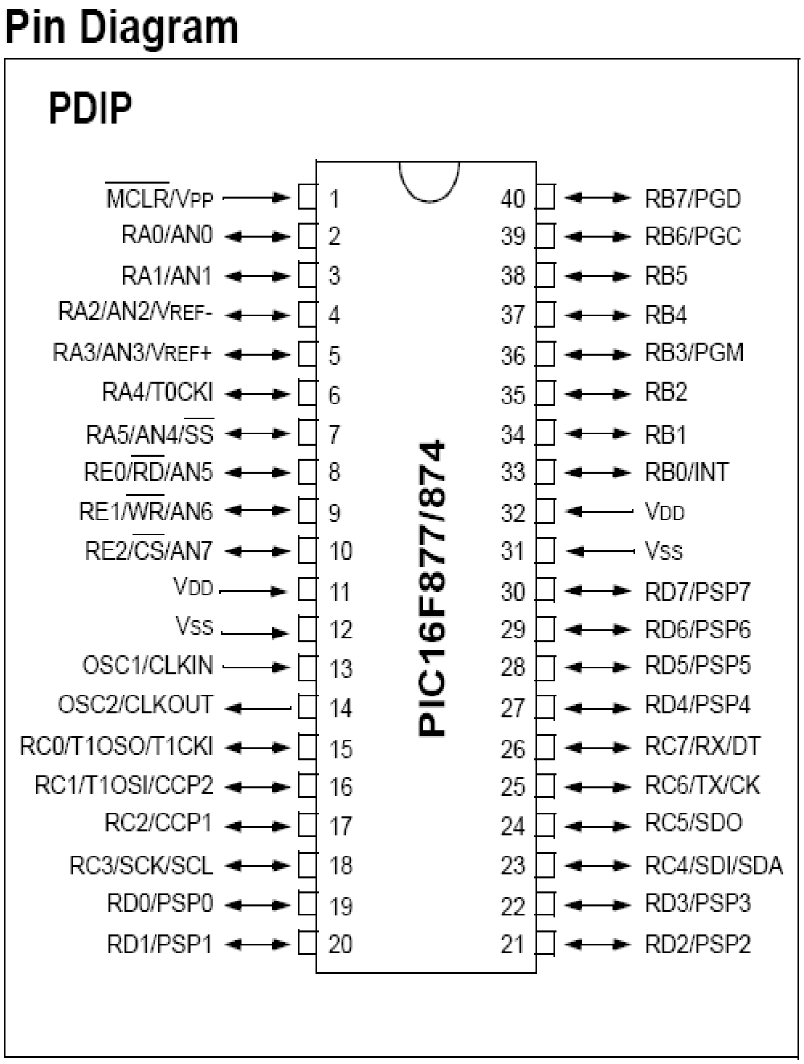
MICRO CONTROLLER

A micro controller (also MCU or µC) is a functional computer system-on-a-chip. It contains a processor core, memory, and programmable input/output peripherals.

Microcontrollers include an integrated CPU, memory (a small amount of RAM, program memory, or both) and peripherals capable of input and output.[1]

It emphasizes high integration, in contrast to a microprocessor which only contains a CPU (the kind used in a PC). In addition to the usual arithmetic and logic elements of a general purpose microprocessor, the microcontroller integrates additional elements such as read-write memory for data storage, read-only memory for program storage, Flash memory for permanent data storage, peripherals, and input/output interfaces. At clock speeds of as little as 32KHz, microcontrollers often operate at very low speed compared to microprocessors, but this is adequate for typical applications. They consume relatively little power (mill watts or even microwatts), and will generally have the ability to retain functionality while waiting for an event such as a button press or interrupt. Power consumption while sleeping (CPU clock and peripherals disabled) may be just nanowatts, making them ideal for low power and long lasting battery applications.

PIC 16F87



PIC Microcontrollers

PIC stands for Peripheral Interface Controller given by Microchip Technology to identify its single-chip microcontrollers. These devices have been very successful in 8-bit microcontrollers. The main reason is that Microchip Technology has continuously upgraded the device architecture and added needed peripherals to the microcontroller to suit customers' requirements. The development tools such as assembler and simulator are freely available on the internet at www.microchip.com

Low - end PIC Architectures:

Microchip PIC microcontrollers are available in various types. When PIC microcontroller MCU was first available from General Instruments in early 1980's, the microcontroller consisted of a simple processor executing 12-bit wide instructions with basic I/O functions. These devices are known as low-end architectures. They have limited program memory and are meant for applications requiring simple interface functions and small program & data memories. Some of the low-end device numbers are

- 12C5XX
- 16C5X
- 16C505

Mid range PIC Architectures

Mid range PIC architectures are built by upgrading low-end architectures with more number of peripherals, more number of registers and more data/program memory. Some of the mid-range devices are

- 16C6X
- 16C7X
- 16F87X

Program memory type is indicated by an alphabet.

- C = EPROM
- F = Flash
- RC = Mask ROM

Popularity of the PIC microcontrollers is due to the following factors.

Speed: Harvard Architecture, RISC architecture, 1 instruction cycle = 4 clock cycles.

Instruction set simplicity: The instruction set consists of just 35 instructions (as opposed to 111 instructions for 8051).

Power-on-reset and brown-out reset. Brown-out-reset means when the power supply goes below a specified voltage (say 4V), it causes PIC to reset; hence malfunction is avoided.

A watch dog timer (user programmable) resets the processor if the software/program ever malfunctions and deviates from its normal operation.

PIC microcontroller has four optional clock sources.

- Low power crystal
- Mid range crystal
- High range crystal
- RC oscillator (low cost).

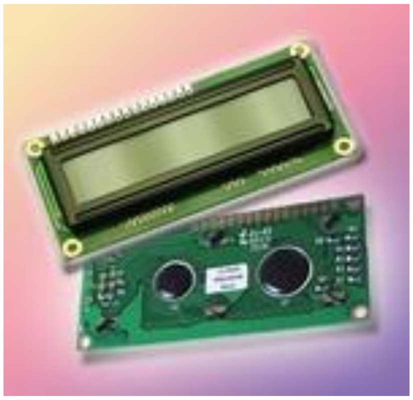
Programmable timers and on-chip ADC.

Up to 12 independent interrupt sources.

Powerful output pin control (25 mA (max.) current sourcing capability per pin.)

EPROM/OTP/ROM/Flash memory option. **I/O port expansion capability**

Interfacing 16 Character x 2 Line LCD

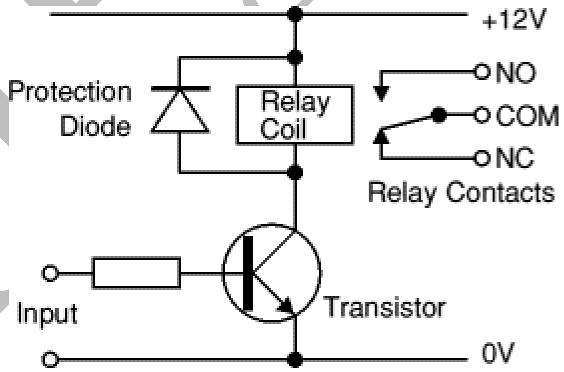


DESCRIPTION

The HD44780U dot-matrix liquid crystal display controller and driver LSI displays alphanumerics, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8-bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver. A single HD44780U can display up to one 8-character line or two 8-character lines. The HD44780U has pin function compatibility with the HD44780S which allows the user to easily replace an LCD-II with an HD44780U. The HD44780U character generator ROM is extended to generate 208 5 ´ 8 dot character fonts and 32 5 ´ 10 dot character fonts for a total of 240 different character fonts The low power supply (2.7V to 5.5V) of the HD44780U is suitable for any portable battery-driven Product requiring low power dissipation

Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.



Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. For further information about switch contacts and the terms used to describe them please see the page on switches.

Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

The supplier's catalogue should show you the relay's connections. The coil will be obvious and it may be connected either way round. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil.

Coil voltage

The relay's coil voltage rating and resistance must suit the circuit powering the relay coil. Many relays have a coil rated for a 12V supply but 5V and 24V relays are also readily available. Some relays operate perfectly well with a supply voltage which is a little lower than their rated value.

Coil resistance

The circuit must be able to supply the current required by the relay coil. You can use Ohm's law to calculate the current: Relay coil current = supply voltage

Switch ratings (voltage and current)

The relay's switch contacts must be suitable for the circuit they are to control. You will need to check the voltage and current ratings. Note that the voltage rating is usually higher for AC, for example: "5A at 24V DC or 125V AC".

Switch contact arrangement (SPDT, DPDT etc)

Most relays are SPDT or DPDT which are often described as "single pole changeover" (SPCO) or "double pole changeover" (DPCO). For further information please see the page on switches.

Protection diodes for relays

Transistors and ICs must be protected from the brief high voltage produced when a relay coil is switched off. The diagram shows how a signal diode (eg 1N4148) is connected 'backwards' across the relay coil to provide this protection.

Current flowing through a relay coil creates a magnetic field which collapses suddenly when the current is switched off. The sudden collapse of the magnetic field induces a brief high voltage across the relay coil which is very likely to damage transistors and ICs. The protection diode allows the induced voltage to drive a brief current through the coil (and diode) so the magnetic field dies away quickly rather than instantly. This prevents the induced voltage becoming high enough to cause damage to transistors and ICs.

General Description

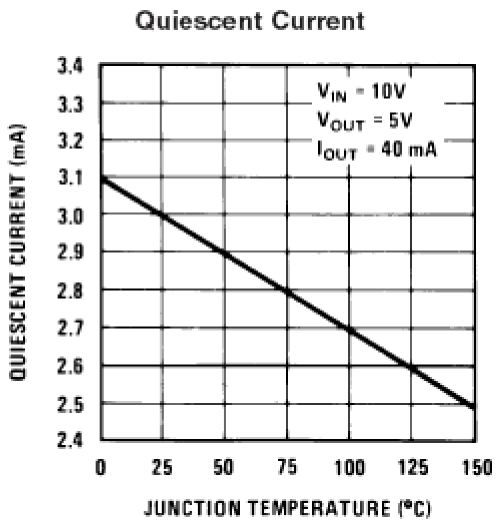
The LM78LXX series of three terminal positive regulators is available with several fixed output voltages making them useful in a wide range of applications. When used as a zener diode/resistor combination replacement, the LM78LXX usually results in an effective output impedance improvement of two orders of magnitude, and lower quiescent current. These regulators can provide local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow the LM78LXX to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment.

The LM78LXX is available in the plastic TO-92 (Z) package, the plastic SO-8 (M) package and a chip sized package (8-Bump micro SMD) using National's micro SMD package technology. With adequate heat sinking the regulator can deliver 100mA output current. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistors is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Features

- LM78L05 in micro SMD package
- Output voltage tolerances of ±5% over the temperature range
- Output current of 100mA
- Internal thermal overload protection
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-92 and plastic SO-8 low profile
- packages
- No external components
- Output voltages of 5.0V, 6.2V, 8.2V, 9.0V, 12V, 15V
- See AN-1112 for micro SMD considerations

Typical Performance Characteristics



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 a varying magnetic 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 inductive coupling.

If a load is connected to the secondary, current will flow in the secondary winding, and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (V_s) is in proportion to the primary voltage (V_p) and is given by the ratio of the number of turns in the secondary (N_s) to the number of turns in the primary (N_p) as follows:

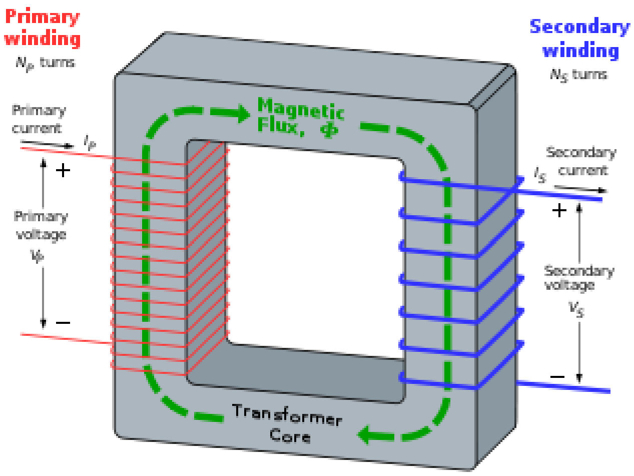
$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

By appropriate selection of the ratio of turns, a transformer thus enables an alternating current (AC) voltage to be "stepped up" by making N_s greater than N_p, or "stepped down" by making N_s less than N_p.

In the vast majority of transformers, the windings are coils wound around a ferromagnetic core, air-core transformers being a notable exception.

Transformers range in size from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used to interconnect portions of power grids. All operate on the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high-voltage electric power transmission, which makes long-distance transmission economically practical.

Basic principle



The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism) and second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

An ideal transformer is shown in the adjacent figure. Current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron, so that most of the magnetic flux passes through both the primary and secondary coils. If a load is connected to the secondary winding, the load current and voltage will be in the directions indicated, given the primary current and voltage in the directions indicated .

Advanced designs

H-bridge inverter circuit with transistor switches and antiparallel diodes There are many different power circuit topologies and control strategies used in inverter designs. Different design approaches address various issues that may be more or less important depending on the way that the inverter is intended to be used.

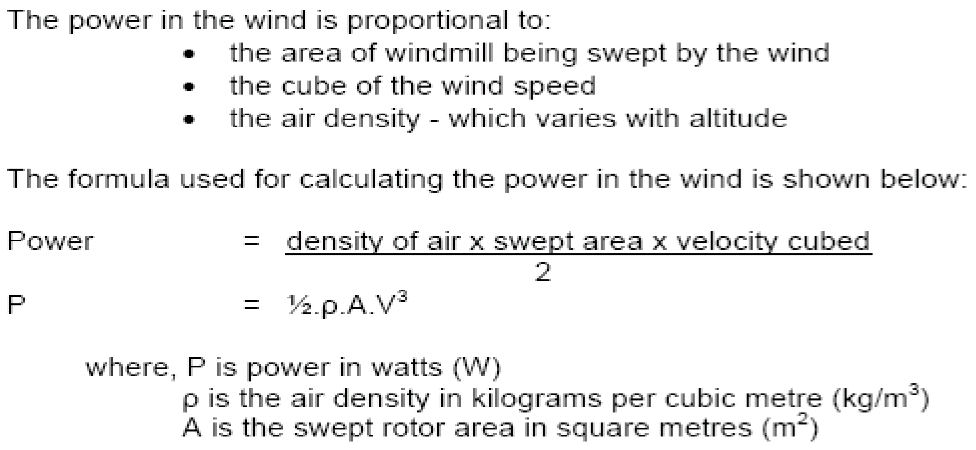
The issue of waveform quality can be addressed in many ways. Capacitors and inductors can be used to filter the waveform. If the design includes a transformer, filtering can be applied to the primary or the secondary side of the transformer or to both sides. Low-pass filters are applied to allow the fundamental component of the waveform to pass to the output while limiting the passage of the harmonic components. If the inverter is designed to provide power at a fixed frequency, a resonant filter can be used. For an adjustable frequency inverter, the filter must be tuned to a frequency that is above the maximum fundamental frequency.

Wind force

The roof ventilator absorbs the wind energy with their individual blade will move slower that the wind velocity. The different speed generates a drag force to drive the blades.

The power in the wind

The wind systems that exist over the earth's surface are a result of variations in air pressure. These are in turn due to the variations in solar heating. Warm air rises and cooler air rushes in to take its place. Wind is merely the movement of air from one place to another. There are global wind patterns related to large scale solar heating of different regions of the earth's surface and seasonal variations in solar incidence. There are also localised wind patterns due the effects of temperature differences between land and seas, or mountains and valleys. Wind speed generally increases with height above ground. This is because the roughness of ground features such as vegetation and houses cause the wind to be slowed. Wind speed data can be obtained from wind maps or from the meteorology office. Unfortunately the general availability and reliability of wind speed data is extremely poor in many regions of the world. However, significant areas of the world have mean annual wind speeds of above 4-5 m/s (meters per second) which makes small-scale wind powered electricity generation an attractive option. It is important to obtain accurate wind speed data for the site in mind before any decision can be made as to its suitability.



The power in the wind is proportional to:

- the area of windmill being swept by the wind
- the cube of the wind speed
- the air density - which varies with altitude

The formula used for calculating the power in the wind is shown below:

$$\text{Power} = \frac{\text{density of air x swept area x velocity cubed}}{2}$$

$$P = \tfrac{1}{2}.\rho.A.V^3$$

where, P is power in watts (W)
ρ is the air density in kilograms per cubic metre (kg/m^3)
A is the swept rotor area in square metres (m^2)

Wind into watts

Although the power equation above gives us the power in the wind, the actual power that we can extract from the wind is significantly less than this figure suggests. The actual power will depend on several factors, such as the type of machine and rotor used, the sophistication of blade design, friction losses, and the losses in the pump or other equipment connected to the wind machine. There are also physical limits to the amount of power that can be extracted realistically from the wind. It can been shown theoretically that any windmill can only possibly extract a maximum of 59.3% of the power from the wind (this is known as the Betz limit). In reality, this figure is usually around 45% (maximum) for a large electricity producing turbine and around 30% to 40% for a wind pump, (see the section on coefficient of performance below). So, modifying the formula for 'Power in the wind' we can say that the power which is produced by the wind machine can be given by:

PM = ½.Cp.ρ.A.V3

Where, PM is power (in watts) available from the machine Cp is the coefficient of performance of the wind machine It is also worth bearing in mind that a wind machine will only operate at its maximum efficiency for a fraction of the time it is running, due to variations in wind speed. A rough estimate of the output from a wind machine can be obtained using the following equation;

PA = 0.2 A V3

Where, PA is the average power output in watts over the year

V is the mean annual wind speed in m/s

Principles of wind energy conversion

There are two primary physical principles by which energy can be extracted from the wind; these are through the creation of either lift or drag force (or through a combination of the two). The difference between drag and lift is illustrated by the difference between using a spinnaker sail, which fills like a parachute and pulls a sailing boat with the wind, and a Bermuda rig, the familiar triangular sail which deflects with wind and allows a sailing boat to travel across the wind or slightly into the wind.

Drag forces provide the most obvious means of propulsion, these being the forces felt by a person (or object) exposed to the wind. Lift forces are the most efficient means of propulsion but being more subtle than drag forces are not so well understood.

The basic features that characterise lift and drag are:

- Drag is in the direction of air flow
- Lift is perpendicular to the direction of air flow
- Generation of lift always causes a certain amount of drag to be developed
- With a good aerofoil, the lift produced can be more than thirty times greater than the drag
- Lift devices are generally more efficient than drag devices

LIMITATIONS

Environmental concerns

Wind power is a clean renewable energy source. There are, however some environmental considerations to keep in mind when planning a wind power scheme. They include the following:

Initial Cost

- Minimum Power Generation
- Electromagnetic interference - some television frequency bands are susceptible to interference from wind generators.

- Noise - wind rotors, gearboxes and generators create acoustic noise when Functioning; this needs to be considered when sitting a machine.
- Visual impact - modern wind machines are large objects and have a significant visual impact on their surroundings. Some argue that it is a positive visual impact, others to the contrary.

CONCLUSION

In this paper a single-port interface has been presented. The specific of this interface consist on naturally series connection of the outputs of the two different dc/dc converters. The system is stable and there is no interference between the two input converters.

BIBILOGRAGPHY

Home Power Magazine http://www.homepower.com/
Hugh Piggott http://homepages.enterprise.net/hugh0piggott/
Wind Prospect Ltd. http://www.windprospect.com/
African Wind power http://www.power.co.zw/windpower/
Danish Wind Turbine Manufacturers Association http://www.windpower.dk
Centre for Renewable Energy and Sustainable Technology http://www.solstice.crest.org
National Renewable Energy Laboratory of the

REFERENCES

1. S.A. Papathanassiou, G.A. Vukas and M.P. Papadopoulos, USE OF POWER ELECTRONICS CONVERTERS IN WIND AND PHOTOVOLTAIC GENERATORS, Proceedings of IEEE International Symposium on Industrial Electronics, July, 1995
2. K.C Kalaistakis and G.J. Vachtsevanos, ON THE CONTROL AND STABILITY OF GRID CONNECTED PHOTOVOLTEAIC SOURCES, IEEE Transaction on Energy Conversion, Vol. EC-2, No. 4, Dec. 1987, pp. 556-562
3. F. Blaabjerg, Zhe Che and S.B. Kjaer, Power Electronics as Efficient Interface in Dispersed Power Generation Systems, IEEE Transaction on Power Electronics, Vol. 19, No. 5, Sept. 2004, pp.1184-1194
4. J.M. Carrasco, L.G. Franquelo, J.T. Bialasiewicz, E. Galvan, R.C. Portillo Guisado, M.A. Partin Prats, J.I. Leon and M. Moreno-Alfonso, Power-Electronics Systems for Grid Integration of Renewable Energy Sources: A survey, IEEE Transaction on Industrial Electronics, Vol. 53, No. 4, Aug. 2006, pp. 1002-1016
5. Z. Liang, R. Guo. J. Li and A.Q. Huang, A High-Efficiency PV Module-Integrated DC/DC Converter for PV Energy Harvest in FREEDM Systems, IEEE Transaction on Power Electronics, Vol. 26, No. 3, March 2011, pp. 897-909.