DESIGN AND DEVELOP A PICO-HYDRO GENERATION SYSTEM FOR RESIDENTIAL USE

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MAY 2009

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of
Bachelor of Electrical Engineering (Power Electronic and Drive)"

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Date : 13 MAY 2009

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This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree Of Bachelor In Electrical Engineering (Power Electronic and Drive)

Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

May 2009

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the reference."

Signature : .....

Name : MOHD HANIF BIN DIDI

Date : 13 MAY 2009

Dedicated especially to my beloved
father and mother.

ACKNOWLEDGEMENTS

بسم الله الرحمن الرحيم

نحمد الله العلي العظيم و نصلي على رسوله الكريم

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Last but not least, I take this opportunity to dedicate this thesis for all electrical engineering students. All suggestions for further improvement of this thesis are welcome and will be gratefully acknowledged.

ABSTRACT

In a country where there is enough power to distribute, people start to think alternative way to reduce the monthly electricity bill by manipulating natural resources as alternative energy such as wind and solar to generate electricity. However both of the systems are not suitable for all areas and locations. The purpose of this project is to develop a system of Pico-hydro generations that can operate as an alternative power generator for residential use. By using permanent magnet DC generator, adjustable nozzle, Pelton turbine and ball valve, this system will operate as long as running water is available, no matter how the weather behalves. To ensure the system run in high output power and efficiency, power loss in the pipeline system should be decreased and the selection of generator and turbine must be right ones depending on head during system design. The performance analysis shows that the product of this project able to generate electricity up to approximately 1.5watt. This amount of power is suitable for energy storage purpose by charging batteries for mobile phone, toys and etc. Additionally, it also can be used to supply small loads such as Led Emitting Diode, LED lighting. Thus, the Pico-hydro generation system is very useful during blackout.

ABSTRAK

Di dalam negara yang mempunyai sumber tenaga yang cukup untuk diagihkan, masyarakat mula berfikir cara lain untuk mengurangkan bil elektrik bulanan dengan memanipulasikan sumber semulajadi seperti solar dan angin untuk menjana tenaga elektrik tetapi keduanya tidak boleh digunakan di semua lokasi. Oleh yang demikian, cadangan projek ini adalah untuk mereka bentuk dan membangunkan Pico-hydro sistem yang boleh beroperasi sebagai altenatif untuk menjana sumber tenaga di rumah. Dengan menggunakan penjana arus terus, nozel boleh laras, Pelton turbin dan injap bebola, sistem ini boleh beroperasi selagi terdapatnya sumber air yang mengalir tidak kira dalam cuaca apa sekalipun. Untuk memastikan sistem ini berkendali dalam tahap kecekapan yang tinggi, kehilangan kuasa di dalam sistem perpaipan mestilah dikurangkan serta pemilihan penjana dan turbin mestilah tepat bergantung kepada sumber bekalan air ketika mereka bentuk sistem. Analisa keupayaan sistem menunjukkan bahawa hasil daripada projek ini mampu untuk menjana elektrik sehingga 1.5watt. Jumlah kuasa ini mampu untuk tujuan penyimpanan tenaga pada bateri cas semula untuk telefon selular, alat mainan dan lain-lain lagi. Selain itu juga ia boleh digunakan untuk menyalakan beban yang kecil seperti lampu yang menggunakan diod pemancar cahaya. Oleh yang demikian Pico-hydro adalah sistem yang amat berguna jika berlakunya gangguan bekalan elektrik.

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AC	-	Alternating Current
DC	-	Direct Current
g	-	Gravity
H	-	Head
HP	-	Horse Power
KW	-	Kilo Watt
MW	-	Mega Watt
PAT	-	Pump as Turbine
PMA	-	Permanent Magnet Alternator
PMDC	-	Permanent Magnet Direct Current Generator
Q	-	Flow Rates
RPM	-	Rotation per Minutes
SHP	-	Small Hydropower

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CHAPTER 1

INTRODUCTION

1.1 Background and Problem Statements

Pico hydro is hydro power with a maximum electrical output of five kilowatts. Hydro power systems of this size benefit in terms of cost and simplicity from different approaches in the design, planning and installation than those which are applied to larger hydro power. Recent innovations in Pico-hydro technology have made it an economic source of power even in some of the world's poorest and most inaccessible places. It is also a versatile power source. AC electricity can be produced enabling standard electrical appliances to be used. Common examples of devices which can be powered by Pico-hydro are light bulbs, radio and televisions. In country where they have enough power to distribute, people start to think alternative way to reduce the monthly electricity bill. They use wind energy to rotate the generator and solar as source to produce electricity energy. Wind and solar energy is not suitable for all area and location. Therefore, this project is proposing a Pico-hydro system to be mounted at water piping system as a solution for that problem. It is because one relatively small water turbine has potential produce power non-stop, as long as running water is available, no matter what the weather.

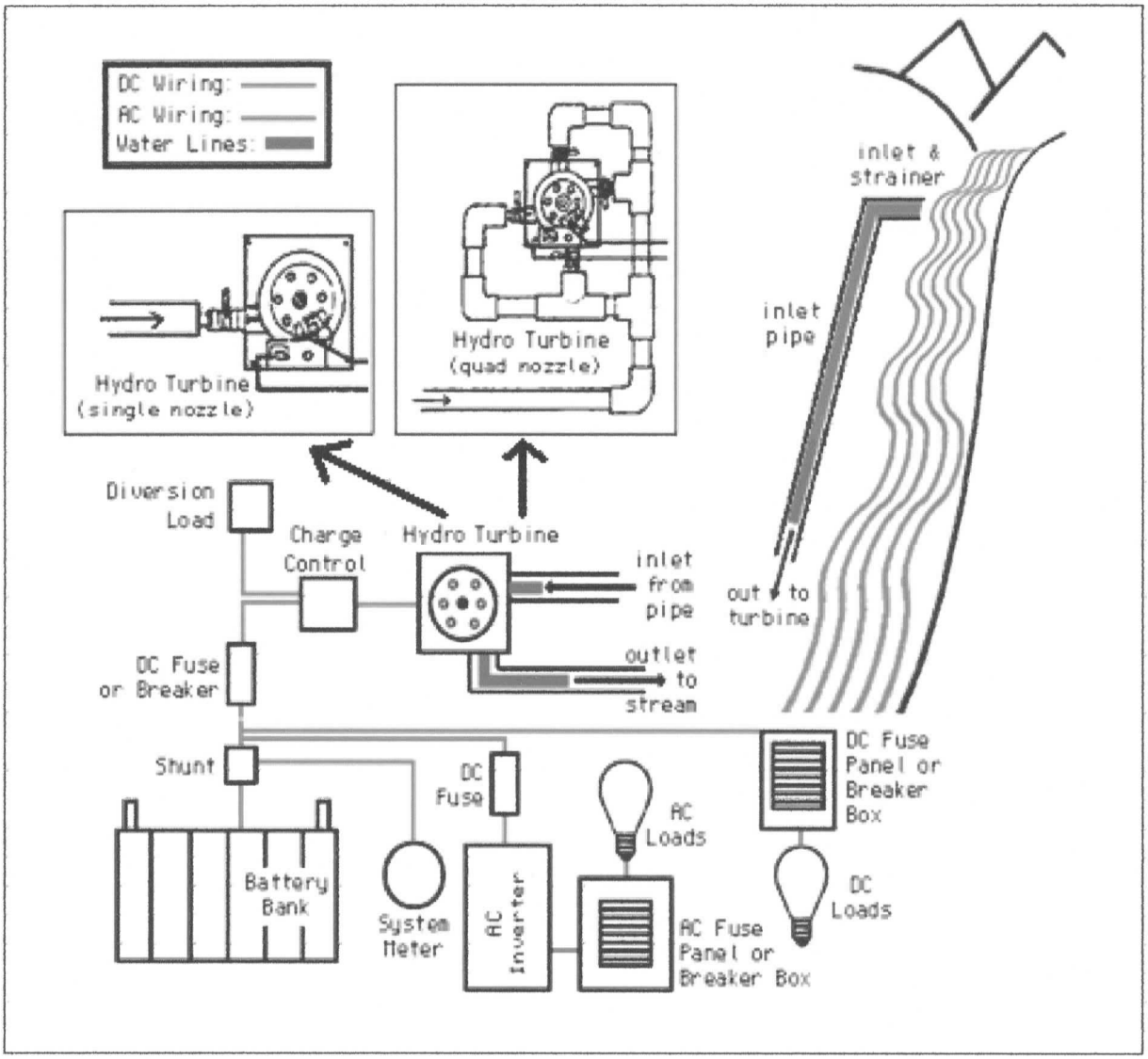

Figure 1.1 : Example of Pico-hydro power system

Figure 1.1 shows an example of Pico-hydro power system with necessary protection devices, battery storage, inverter and etc. The most important parts to create the electricity are power source (water), turbine, nozzle, pulley system and alternator. In general, this system will operate using upper water reservoir which is a few meter high from ground. From the reservoir, water flows downhill through the piping system. This downhill distance is called "head" and it allows the water to accelerate for prime moving system. Thus, the turbine will rotate the alternator to produce electricity. In cold climates, the inlet pipe should be well insulated, and even buried underground if possible, to minimize the chance of freezing. A small, one-nozzle turbine can well operate with a 2" diameter pipe, while a larger 4 nozzle turbine would require a 4" pipe to allow sufficient

water flow to reach the generator wheel. Smaller diameter penstock would cause excessive friction and energy loss as the water flowed through the pipe.

1.2 Project Objective

Based on the problem statement that has been discussed, the objectives of this project are:

1. To develop a system of Pico-hydro power that can operate as an alternative power generator for residential user.
2. To determine appropriate features and specification to be used for Pico-hydro system.
3. To analyze the performance of the Pico-hydro system for voltage supply and battery charging.

1.3 Project Scope

This project is conducted to design and develop a Pico-hydro power generation system using permanent magnet direct current motor. The system has capacity to generate less than 10W power (for home application) that able to switch ON small load less than total power. Power produced will direct connect to the load.

1.4 Thesis Outline

Chapter 1 describes the problem statement, objective and scope of this project.

Chapter 2 discusses the literature study related to this project. Study on previous research by other researcher, project design and system are conducted to ensure the successfulness of the project. This chapter also describes the part and component comparison that suitable use for this project.

Chapter 3 describes the methodology to determine head, water flow, losses in pipeline system and calculation output power from the system.

Chapter 4 discusses the result and analysis from the performance test of the system. Several calculations have been done to execute this system.

Chapter 5 gives conclusion and recommendation for further work of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The first method is to make a utility study on the fundamental of Pico-hydro System which includes the application and generation system. In addition, make a detail study on the possible of Pico hydro system components which focuses on the generator, valve, turbine and piping system.

2.2 Pico-hydro Power Generation Case Study

2.2.1 Peltric Set

The 'Peltric Set' was developed at Kathmandu Metal Industry in Nepal and is shown in Figure 2.1. A vertically mounted induction generator is directly coupled to a Pelton turbine. The turbine casing also forms the base for the generator which makes the design simple and economical with material. AC electricity is generated which means that the power can be distributed economically over hundreds of metres. There are approximately 500 units of this type electrifying villages in Nepal at the present time based on reference [1].

Figure 2.1: The 'Peltric Set' has provided many rural village with an economical electricity supply in Nepal

2.2.2 Columbian Alternator System

Columbian Alternator System in reference [1] has been designed at FDTA (Fundacion Desarollo de Technologias Appropriadas) in Colombia, South America. The turbine runner is also a small Pelton wheel but a 12V DC car or truck alternator is used as a generator. The turbine is coupled to the alternator using a pulley belt and mounted on a simple steel-angle frame that is easy to manufacture. The installations of this design in shown in Figure 2.2.

Figure 2.2: A Colombian manufacturer (right) installs a DC Pico-hydro Generation System

The turbine shaft of the system is horizontal; it is also possible to run other machines with hydro-power in addition to the generator. It has been highlighted that this design has been used to provide the energy source for a mechanical refrigerator. No extra control system is required other than the voltage regulator which is already included with the alternator. Since Direct Current (DC) is generated, no frequency regulation is required but the electricity must be used close to or at the powerhouse. Pico Power Pack combines the low-cost steel-angle base and horizontal shaft of the Colombian alternator unit with the simple design of a Pelton turbine directly driving an induction motor used with the Peltric Set.

2.2.3 Pico Power Pack

The 'Pico Power Pack' components are shown in Figure 2.3. The generator is mounted horizontally on a steel angle base frame based on reference [1]. Since AC (Alternating Current) is generated, the system is suitable for electrifying houses that are up to one kilometer away from the powerhouse, like with the 'Peltric Set'. The removable case makes it easy to inspect the turbine and the nozzle and to clean them when necessary. The generator shaft is extended at the opposite end from where the turbine is attached. This allows a pulley to be fitted. Small machines such as mills, grinding wheels or saws can be driven with a pulley. In this way, the hydro-power can be used for a wider range of productive purposes. The extra money made through running a small business using Pico-hydro power, makes it easier to repay the cost of the scheme.

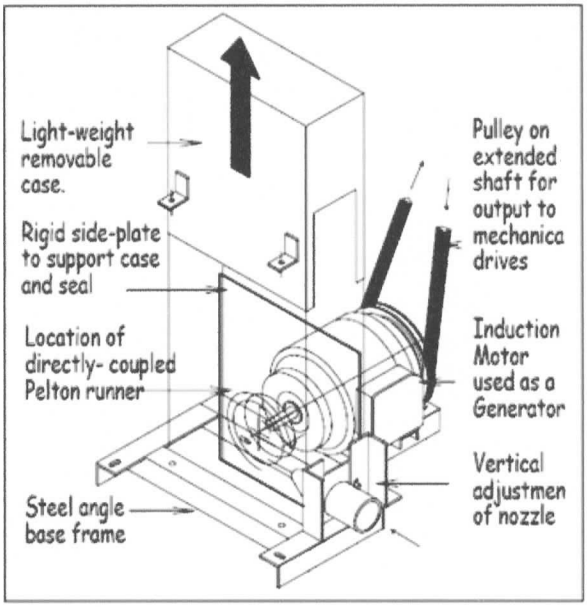

Figure 2.3: The Pico Power Pack generates AC electricity and allows mechanical equipment to be driven

2.2.4 Final Year Project May 2008: Pico-hydro

The project [2] was conducted to study and produce Pico-hydro system using hydroelectric concept. This project was designed of water-powered turbine and generator unit which the intention was to be installed at small area such as at home or other commercial building but the system produced was big and not suitable at such places. The turbine is directly coupled with 500 watts permanent magnet alternator as generator. Pulley or belting system is not necessary as this type of permanent magnet alternator is designed to produce high power at low speed. Thus, this system is expected able to reduce transmission losses when using pulley system. Figure 2.4 shows the turbine assembly and components for the Pico-hydro system.