International Journal of Engineering Innovation & Research
Volume 8, Issue 3, ISSN: 2277 – 5668

Design of Wind- Solar Micro-Hydro System using Anfis for Generation of Sustainable Power in Context of Nepal

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Date of publication (dd/mm/yyyy): 17/05/2019

Abstract – **This work presents an adaptive add-on controller for the unbalance voltage compensation in low voltage Microgrid (LVMG) constituting multiple voltage source converters (VSC) based distributed generation. Since, the VSC based LVMG is almost inertia-less system and any kind of load variations have very significant impact on voltage profile, which is highly undesirable. Presence of unbalance load at point of common coupling (PCC) further exaggerates the problem. In order to mitigate the negative effect of unbalance load, an ANFIS based add on control loop has been added in to the conventional VSC control. Here, the add-on controller sets the reference current gains equivalent to voltage unbalance factor. These reference current gains obtained from add-on controller are added to the output of voltage control loop to set the modified reference current for inner current control loop.**

Keywords – **Wind, Solar, Micro-Grid, Micro-Hybrid, Nepal, ANFIS.**

I. Introduction

Nepal is situated in between 26.37º - 30.45º N latitude and 80.07º - 88.2º E longitude so it is closer to the solar belt. The annual average global solar radiation is 3.6-6.2 kWh/m2 /day and the sun shines for about 300 days in a year [1]. The global solar radiation increases in altitude mainly due to decreasing amounts of air molecules, ozone, aerosols and clouds in the atmosphere. Thus there is not only the single source dependence factor [2]. The global solar radiation is an important weather variable for several environmental studies. This paper describes RadEst 3.00 software that allows the user to estimate daily global solar radiation data from maximum and minimum air temperatures and precipitation and geographical location. 200 models can be used to relate global solar radiation, temperature and precipitation for the further study in similar geographical regions as well as for the development of solar energy technology in Nepal [3].

Nepal is situated in the lap of the Himalayas, Nepal is located between the latitude 26*22’ to 30*27’ North and longitude 80*4’ E to 88*12’ East, and elevation ranges from 90 to 8848 meters. The average length being 885 km east to west and the average breadth is 193 km from north to south. Nepal has occupied 0.03 % land on the world and 0.3 % of Asia Continent. The country is bordering between the two most populous countries in the world, India in the East, South, and West, and China in the North. Nepal is a land locked country and home place of natural beauty with traces of artefacts. The Northern range (Himalayas) is covered with snow over the year where the highest peak of the world, the Mount Everest, stands. The middle range (Hill) is captured by gorgeous mountains, high peaks, hills, valleys and lakes. Southern range (Terai) is the gangetic plain of alluvial soil and consist of dense forest area, national parks, wildlife reserves and conservation areas [4][5].

Fig. 1. Map of Nepal [6].

Nepal is one of the least developed countries with more than 80% of its population residing in rural areas [7]. It has no oil, gas, or coal reserves, and its energy sector is dominated by the traditional energy sources like firewood, crop residues, and animal dung mainly for domestic use [8]. The majority of rural populations are meeting their energy needs by burning biomass in traditional stoves, and mostly fossil-derived fuels are imported. Also, the continuous increase of petroleum imports has an adverse impact on its fragile economy. The major sources of renewable energy are mini and micro hydropower, solar energy, various forms of biomass energy, biogas and wind energy etc. But still around 85% of the total final energy consumption in Nepal is met by traditional biomass energy and around 28% of households in Nepal do not have access to electricity [9][6].

II. Research Environment

The research and all the significant information required for the subject of the thesis is taken from Nepal and its hydropower industry. Case study is done with the information from past and present collected from authentic sources from Nepal and its hydropower industry. Pre assumption is done on the basis of old and new facts obtain from Nepal and its hydropower industry. The following paragraphs explain the size, chronological development, the potential and current situation of hydropower industry of Nepal in details. The main objective of the study is to project and analyse the national energy demand of the country. Apart from the main objective, following are the specific objectives of this study: To study existing energy consumption pattern of the country. To project and analyse sector wise energy demand of the country. To evaluate the change in electricity demand through substitution of LPG fuel in residential sector. To figure out change in energy demand in industrial sector through intervention of energy saving opportunities. To evaluate and compare per capita energy consumption of Nepal.

III. Related Work

The goal of the research was to determine the technical and economic feasibility and the potential livelihood contribution of solar photovoltaic and wind electricity and hydro integration. The use of methodology tools to optimize the energy systems, and encompassing factors such as accurate demand estimation, renewable resource estimation, adequacy of storage technologies, and real investment projection is essential. Therefore the research set the following six objectives as follows:

1. To conduct wind and solar resource assessment.
2. To model the technical performance of solar photovoltaic and wind electricity generation systems.

3. To devise an energy-system deployment model that could enhance sustainable livelihoods on Surkhet Midwestern, Nepal.
4. To investigate the micro hydropower system design problem.
5. To develop the modelling of solar and micro hydropower system structure using MATLAB SIMULINK.
6. To test the system of modelling solar micro hydropower system designs using MATLAB SIMULINK.

IV. Project Background

This research is using the MATLAB SIMULINK software to build the modelling and regulation of the output power of a micro hydroelectric power system. This modelling is built depends on the real parameters which are setting first such as the voltage, frequency and so on to produce the power output is less than 100 kW. This research concerned about the implementation of MATLAB SIMULINK software to build the modelling and regulation output power of a micro hydroelectric power system design. To design this modelling, the actual parameters of micro hydroelectric plant such as the water flows, types of turbine, head and other parameters must be known. Shown in fig 2.

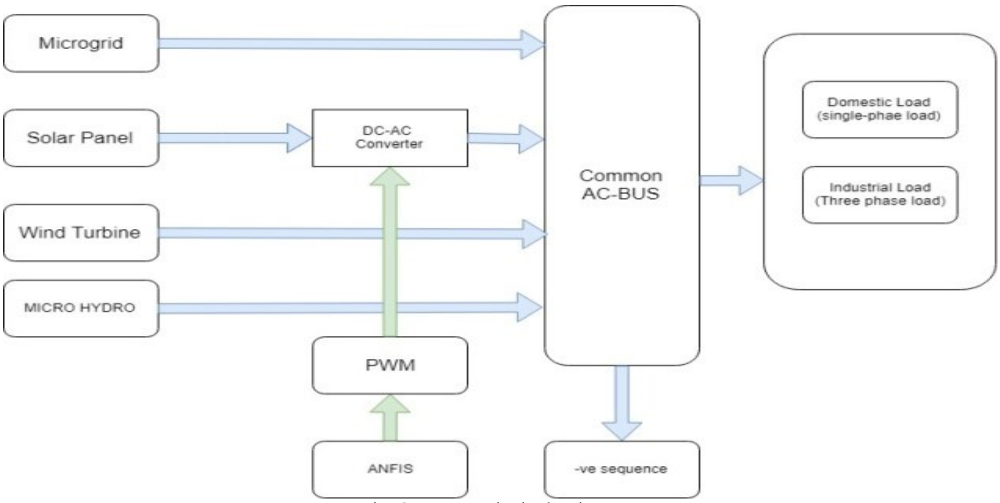

Fig. 2. Proposed Block Diagram.

V. Proposed Model

The proposed model consist of micro hydro wind turbine and solar. The optimal utilization of available renewable energy sources (RES) in a coordinated way in order to feed remotely placed isolated locations where grid is not readily available. Thus, the micro grid is expected to work both in grid tied mode and off grid (islanded) mode. In grid tied mode, the grid voltage sets the reference for DG interfacing VSC's and chances of internal conflict among different VSC's are very rare. However, in islanded mode of operation, the different VSC's are needed to be controlled in such a way that the load demand must be shared by all interconnected VSC's in proportion to their individual rating. Therefore, the VSC's in microgrid may either be controlled in centralised manner with dedicated communication channel between them or they may be controlled individually with droop control which may require low bandwidth communication channel or no communication channel at all. The later one is more preferable; as it is easily implementable with enhanced security and reliability. The traditional droop control method have some issues related to the inaccuracy in determining the power to be shared by individual DG and deviation in voltage at PCC due to fluctuation as well as unbalance in load demand.

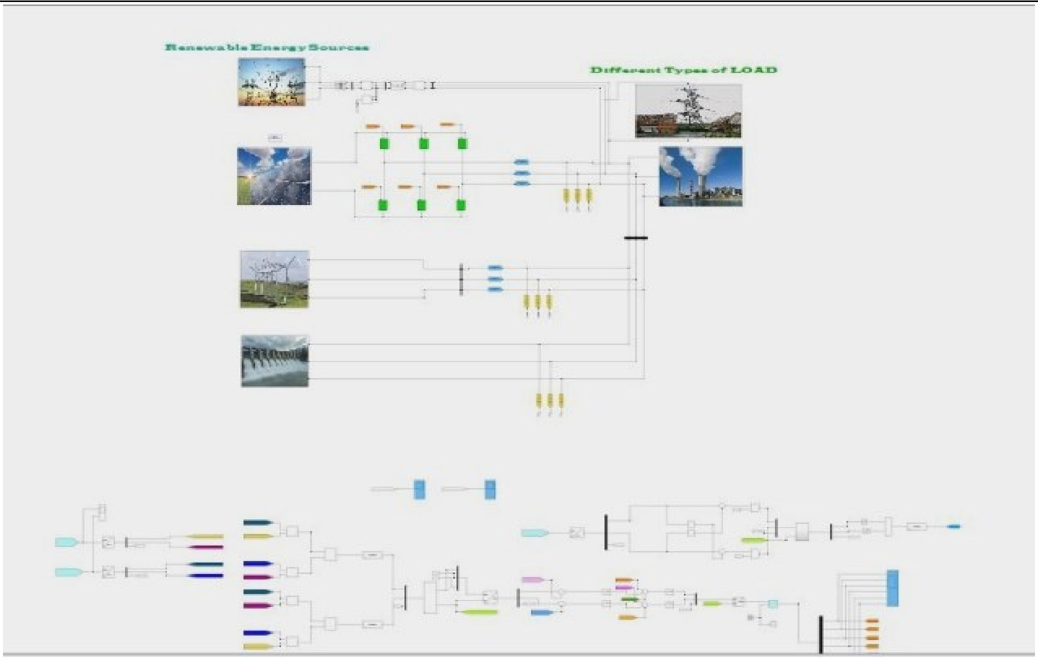

Fig. 3. Proposed Simulation Model.

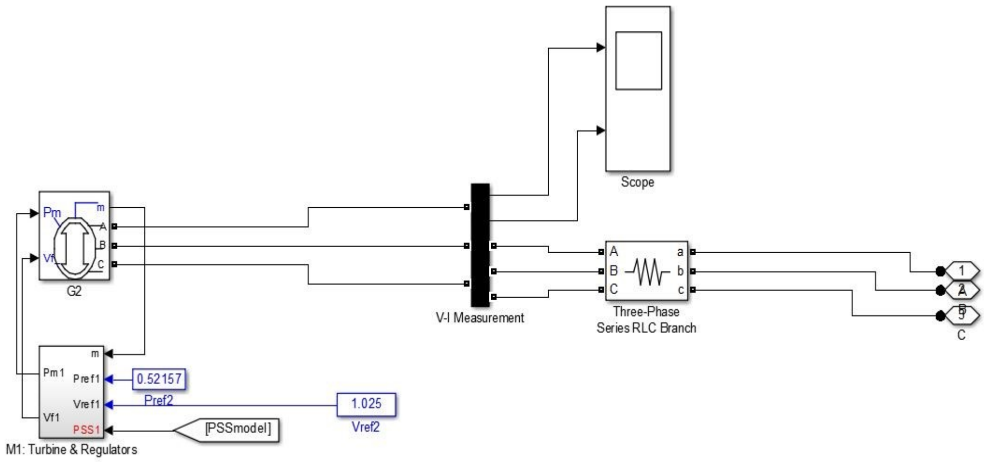

Fig. 4. Micro Hydro Module.

A wind electric system is made up of a wind turbine mounted on a tower to provide better access to stronger winds. In addition to the turbine and tower, small wind electric systems also require balance-of-system components Micro Hydro parameters: Nominal power----->187e6 (VA) line-line voltage----->13800 (Vrms) frequency----->60Hz

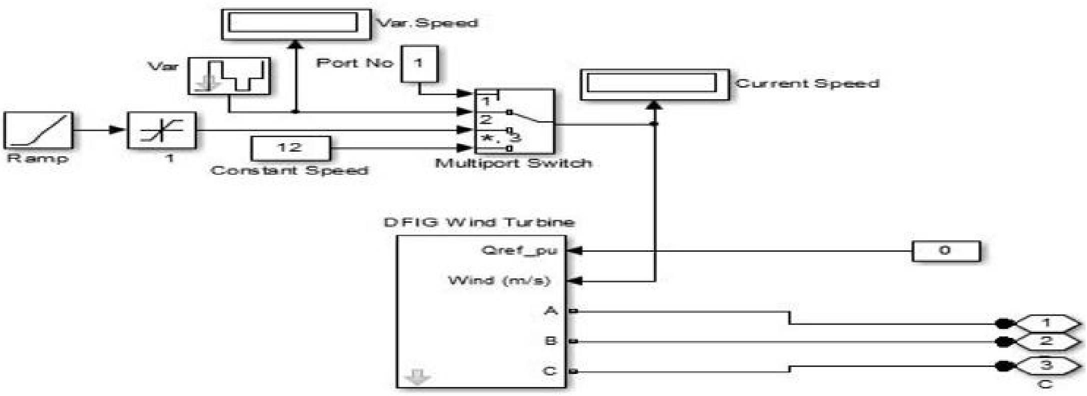

Fig. 5. Wind Turbine Module.

Wind Turbine:

Wind is created by the unequal heating of the Earth's surface by the sun. Wind turbines convert the kinetic energy in wind into clean electricity. When the wind spins the wind turbine's blades, a rotor captures the kinetic energy of the wind and converts it into rotary motion to drive the generator. Most turbines have automatic over speed-governing systems to keep the rotor from spinning out of control in very high wind A small wind system can be connected to the electric grid through your power provider or it can stand alone (off-grid).

VI. Simulation Result

According to many renewable energy experts, a small "hybrid" electric system that combines home wind electric and home solar electric (photovoltaic or PV) technologies offers several advantages over either single system.

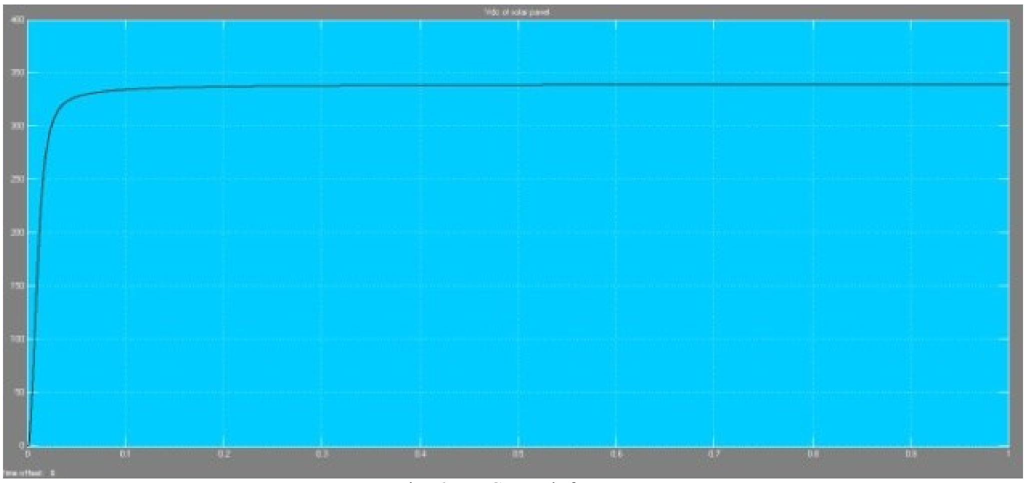

Fig. 6. VDC Result for PV.

The power delivered by a PV cell attains a maximum value at the points. The short circuit current is measured by shorting the output terminals and measuring the terminal current.

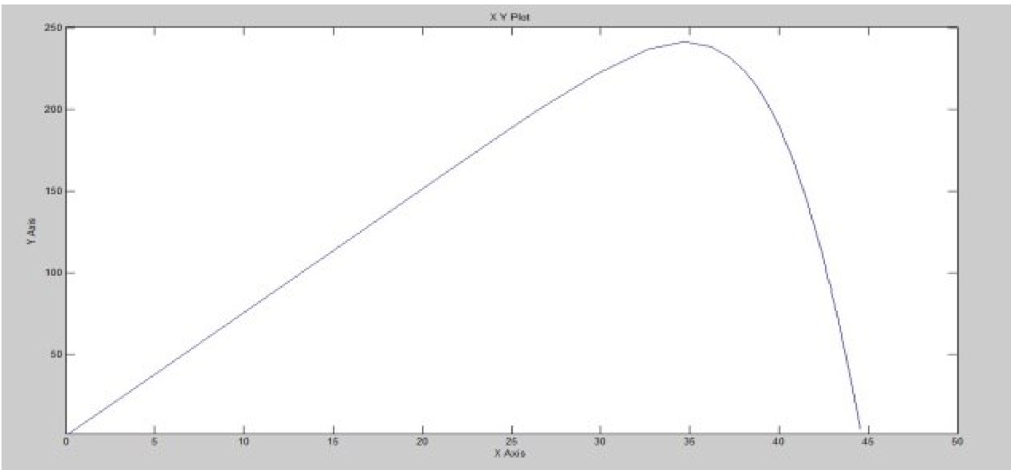

Fig. 7 PV Characteristics waveform

The power delivered by a PV cell attains a maximum value at the points. The short circuit current is measured by shorting the output terminals and measuring the terminal current indicate that the machine is working in generating mode. As the battery storage system is designed to supply the load during peak demand, the daily fluctuation in the households energy demand does not change the machine variable significantly.

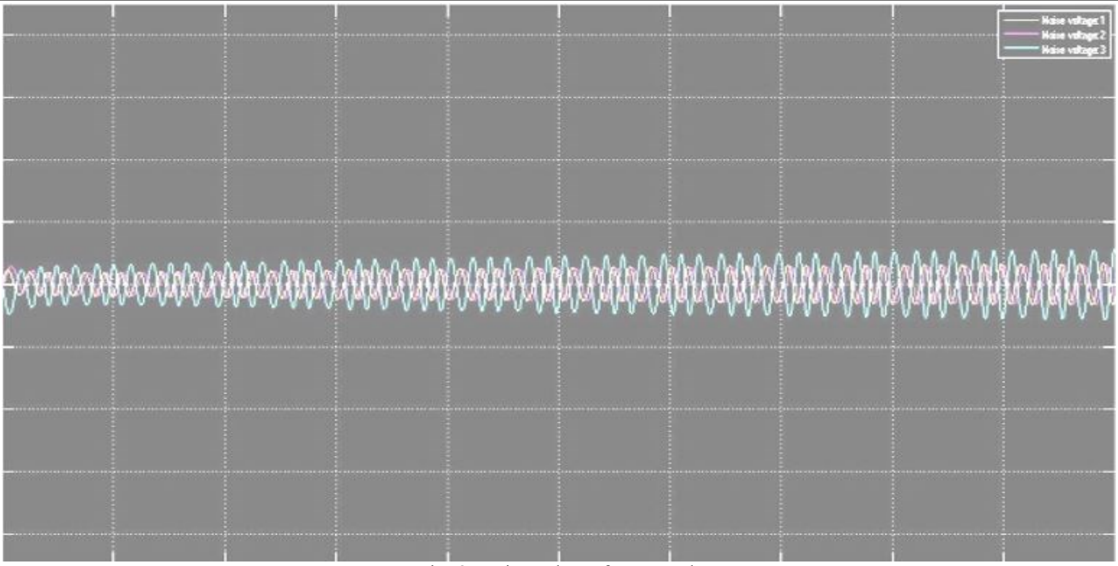

Fig. 8. Noise voltage from panel.

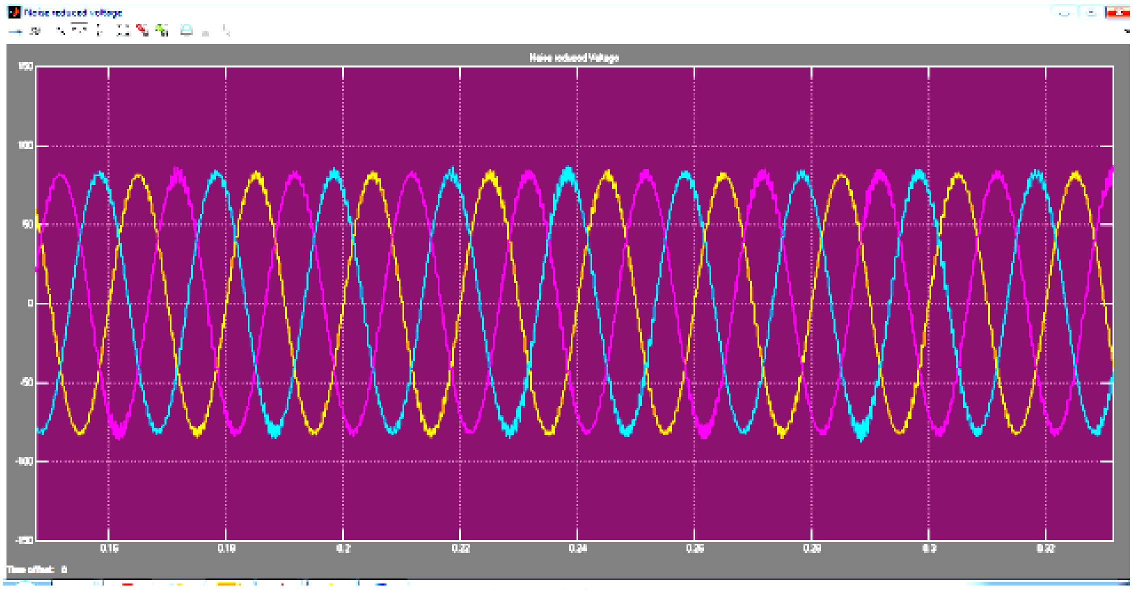

Fig. 9. Wind Power.

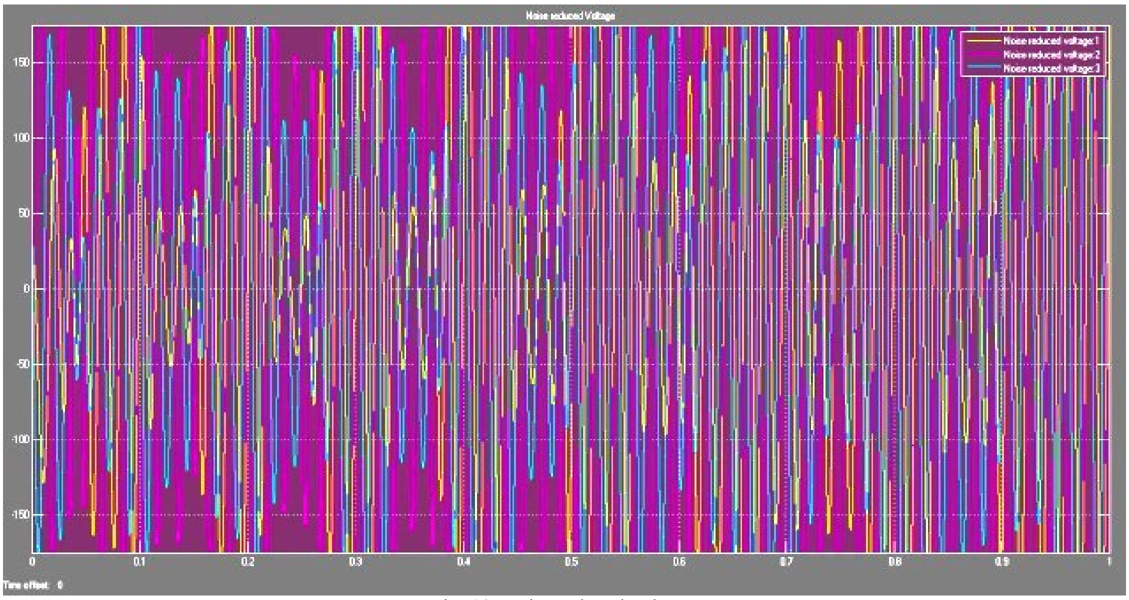

Fig. 10. Noise reduced voltage.

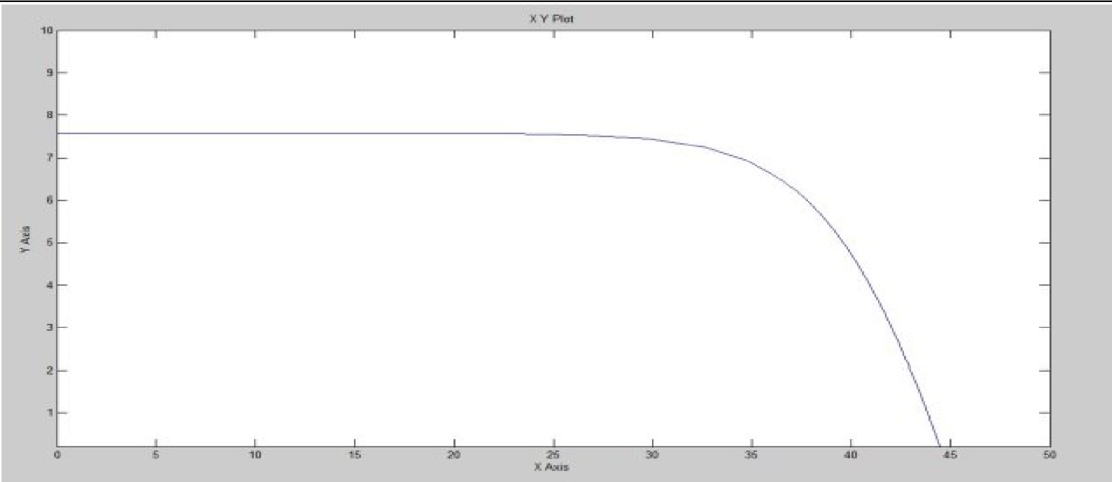

Fig. 11. I-V axis.

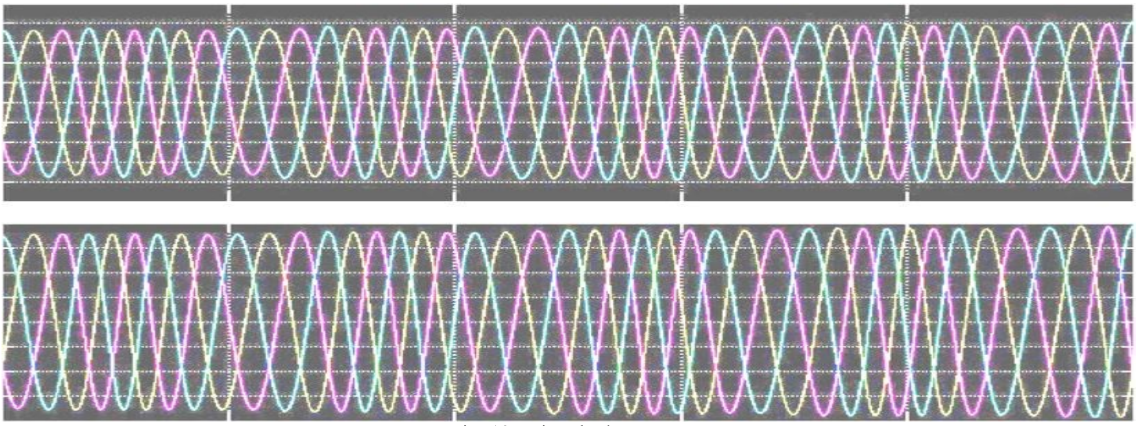

Fig. 12. Micro hydro scope.

As per Capita Electric consumption in Nepal is 139.144 kWh. As per World Bank data for the population of Surkhet District (52,137 in 12,045 households) according to government of Nepal [10]. Total Mid-Western region population 2011 census (3,546,682) Electric consumption in Surkhet Nepal = 12,045*139.144

= 1,675,989.48 KWh

= 1675.989 MWh

= 1.676 GWh

Power Output Form Wind in Surkhet is [Wind Speed 3.5 M/Square] – 200 MW.

VII. Conclusion

The feasibility study of the hybrid system which consists of Small Hydropower, Solar PV and Wind for electrification of the Nepal settlement area with Per Capita Electric consumption in Nepal is 139.144 kWh. As per World Bank data for the population of Surkhet District (52,137 in 12,045 households) according to Govt. of Nepal. Total Mid-Western region population 2011 census (3,546,682) has been carried out. The small hydropower, solar PV potentials and the wind power potential in the site are studied and evaluated. This makes the small hydropower as a generator using water as a fuel for operation. The hydropower has a mean power output of 200 MW with capacity factor of 96% and generates a total of 1.676 GWh which covers 81% of the total electrical production. The daily and monthly solar radiation data for the site has been collected from NASA website using its latitude and longitude, and it is 3.5 M/Square per day. In the optimum hybrid system of Hydro/ PV/ Battery configuration.

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