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Fuzzy Logic Based Proportional Integral Control of Frequency for Small Hydropower Plant

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Abstract Small hydropower is one of the most cost effective and reliable energy technologies to be considered for providing clean electricity. Any mismatch between generation and demand causes the system frequency to deviate from its nominal value. Thus high frequency deviation may lead to system collapse. This necessitates a very fast and accurate controller to maintain the system frequency. The frequencies of the existing small hydropower plants are controlled by mechanical governors. However, these governors are costive, complex and not fast in response. In this paper simple, less cost and fast response fuzzy logic based proportional integral (PI) controller of frequency for small hydropower plant is modeled, designed and simulated by Matlab/Simulink. The frequency controller controls the flow rate of water by acting on stepper motor and keeps the frequency of the small hydropower system nearly constant. Finally the simulation results of conventional PI controller is compared with fuzzy PI controller and proved that Fuzzy PI controller yields better control performance.

Keywords Fuzzy logic controller, Hydraulic turbine model, PM Stepper motor, PI Controller

1 Introduction

Nowadays renewable energy is becoming more and more popular as it is a sustainable and environment friendly source of energy. Hydropower plants are clean sources of energy that convert potential energy of water into electricity and they are much more reliable and efficient source of energy than the fossil fuel power plant. Energy is a fundamental thing for society and economic growth of any country. SHPP (Small Hydropower plant) are used to electrify residential homes, cottages, ranches, lodges, parks, factory, industries and small communities [1]. An increased access to electricity enhances opportunities form industrial development and improves health and education. A SHPP consists of diversion dam, conveyance of water system, forebay, penstock, wicket gate, powerhouse, tailrace structure of the body and electrical and mechanical equipments [2].

Generation capacity of small hydropower plants ranges from 1MW to 50MW [3]. One of the challenges in developing small hydropower plants is the control system. In a power system, usually, voltage and frequency are controlled separately. Voltage is maintained by control of reactive power of the synchronous generator. Most commercial synchronous generators have built-in automatic voltage regulators. The frequency of a small hydropower system exclusively depends on real power balance. Thus, the objective of this paper is to model, design and simulate a less expensive, less complex and fast response frequency control system for small hydropower plants.

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Appendix A

TableA 1 Specifications of SFW3150-8/1730 synchronous generator

Parameter	Values
Type	SFW3150-8/1730
Current rating	361 A
Power rating	3150kW/3938kVA
Power factor	0.8
Voltage rating	6.3kV
Rated speed	750 rpm
Rated frequency	50 Hz
Number of poles	3

TableA 2 Specifications of HLJ46-WJ-86 Hydraulic Turbine

Type	43HS2A200-654
Penstock length	95 m
Rated Head	95 m
Initial speed of water(Uo)	43.15 m/s
Acceleration due to gravity	9.8 m/s2
Rated speed	750 rpm
Rated power	3316 kW
Rated Discharge	3.9 m3/s

TableA 3 Specifications of 43HS2A200-654 PM stepper motor

Parameter	Values
Type	43HS2A200-654
phase Current	6.5A
Phase resistance	1 ohm
Phase inductance	21mH
Lead wire	4
weight	15kg
Holding torque	30 Nm
Step angle	1.8^o
Moment of inertia	$0.0015 kg.m^2$
Torque constant	0.109
Viscous Damping constant	0.5Nm/rad/sec
Total number of rotor teeth	50

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