

# INCORPORATING ARTIFICIAL INTELLIGENCE AND POWER ELECTRONIC DEVICES TO REVITALIZE THE NIGERIAN

## Abstract

This work covers an improvement upon hydropower supply in Nigeria. The major problem plaguing hydro-plants is the slow turbine rotation of the hydro turbines, which in turn causes unfavorable voltage fluctuations. Fuzzy Logic Control was employed to provide the solution, by using membership functions to analyze and increase slow turbine rotation. A model was employed using fuzzy software tool to control Hydropower Generator speed. Power transmission control was improved with the incorporation of Flexible AC Transmission Systems (FACTS). The type of FACTS controllers employed in this report are those based on voltage sourced converter (VSC), particularly the Static Synchronous Compensator (STATCOM), and also solid state var compensator (SSVC). Data gathered from previous research on the Nigerian 330kv transmission network show that the system is weak with power losses and voltage fluctuations from faulty buses. A MATLAB/Simulink model was employed to observe the results of application of these FACTS devices into the 3330kv National Grid. The results show that the devices greatly improved the voltage stability of the network and improved power losses.

**Keywords:** Fuzzy Logic Control, Fuzzy Software, FACTS, STATCOM, MATLAB/SIMULINK, Voltage Stability

## 1. INTRODUCTION

The unsteady state of power supply is an issue that has persisted in Nigeria since the discovery of electricity in the country. Various efforts have been made and government policies enacted, but the problem exists still. The Nigerian population has progressively increased over the years to 200 million people in 2021 according to the World Bank. With this population expansion comes increased demand for electricity supply. Estimated figures of around 22 million small-unit generators are used by Nigerians to meet their power needs every day; coupled with record high inflation rates, the financial strain of purchasing fossil fuels for these generators can be excruciatingly daunting for the average Nigerian.

It has been said that the level of erratic power supply in Nigeria is the bane of economic and industrial development in country [1]; this is reinforced by the fact that Nigeria is estimated to lose around \$26.2bn annually due to the lack of reliable electricity [2]. For a nation that is considered economically to be one of the greatest on the African continent, Nigeria ranks 171 out of 190 nations in terms of access to electricity, according to the World Bank.

The writer of the study [3] mentioned that need for electric energy in the modern life cannot be overemphasized; that the epileptic power supply to support the expanding population economy of developing countries is becoming an endemic problem, hence the purpose of this paper. This study suggests the application fuzzy logic software, a type of artificial intelligence software, to control the flow of water into the generator turbine, to balance with load demands. Hydropower industry is an area where artificial intelligence technology can be incorporated easily and with significant results. The hydro-turbine in dams is responsible for maintaining the active power and rated frequency at rated speed [4]. Variations in load due to customer demand can cause deviation in speed, which in turn disrupts the rated frequency and causes synchronism loss. But with artificial intelligence, speed governors can be employed to control the output of turbine, so it matches with the load shifts. Flexible AC Transmission Systems (FACTS) controllers are also employed during the transmission phase, for voltage magnitude control, active and reactive power flow control [7]. Numerous researches in the electrical engineering field have show that the integration of FACTS controllers into transmission network greatly enhances the efficiency and stability of the system.

The growing population of Nigeria has seen a strong demand in electricity supply from generating station. Thus these systems are being operated under very stressed conditions. A consequence to this is inefficiency power supply, leading to frequent blackouts and low power

supply, which can damage consumer equipment. Research shows that FACTS controllers ensure voltage stability in the substations. These devices also enable reactive compensation and power flow control on the transmission lines. In this study, we analyze the results of simulations of some of these FACTS controllers in the Nigerian National Grid [5] and the impact on electricity transmission efficiency when combined with the fuzzy logic software simulation.

### **1.1 Aim of Study**

The paper is at providing solution to the problem of epileptic supply of power in Nigeria. It focuses on the hydropower supply industry, and suggests Artificial Intelligence Software integration to balance generator turbine outputs with changing load demand. It does this by analyzing previous research on Fuzzy Logic rule-based system in hydropower turbines and incorporates FACTS control devices to enhance transmission efficiency in the transmission lines.

### **1.2 Extent of Past Work**

Various research has been done in the area of Artificial Intelligence integration into hydropower supply. Even with the complexity of modern power systems, novel technologies like Genetic Algorithm (GA)-based learning have been propagated to address the growing complexity of new technologies [9] [10]. But the Fuzzy Logic control suggested by [4] is user friendly does not present much challenges. It has a dynamic model and can readily provide adequate solutions to the issues of hydro turbines. The book by [6] provides an adequate foundation to why FACTS controllers were considered in transmission network, how they control operational parameters of the transmission system, and how they can be used. The work by [7] provides adequate mathematical relations concerning specific FACTS controllers, and the power flow analysis models when they are integrated into defined power systems.

### 1.3 Materials and Methods

The basic layout of a hydroelectric power plant is shown in Fig. 1 below

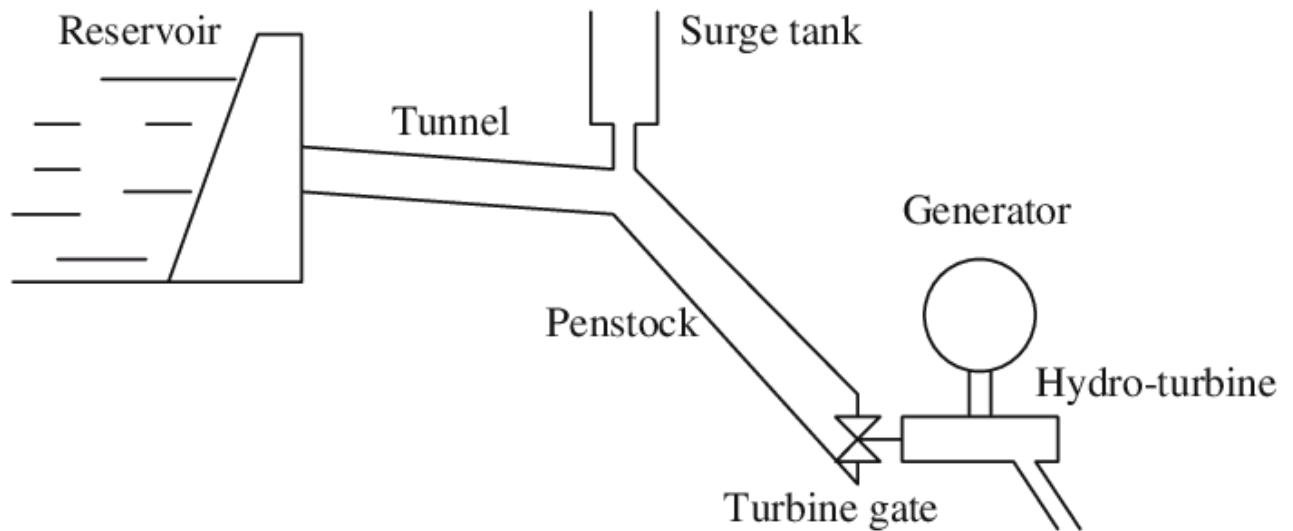


Figure 1 Basic Hydropower Station Layout

The fuzzy Logic software is used to control water flow from the reservoir, into the penstock to the turbine. A generating unit for the turbine can be in one of three modes: stillness, synchronization, or generation. When this said unit is powered, the speed governor regulates the turbine speed from standstill to nominal speed, synchronizing it with the networks required frequency [4].

The first step is to gather the required measurement of parameters from the hydropower station. The error in the process is proportional to the integral of the error and the rate of change (derivative) of the error, and the controller is proportional to both, according to [4].

That particular algorithm is known as a PID controller (proportional Integral derivative controller).

When the required parameters are known, the Fuzzy Logic controller can be used to make the required change in the control system.

- i. Design a Membership Function That Will Analyze the Causes of Slow Turbine Rotation.

The Fuzzy Inference System (FIS) is initially built by providing proportional electrical signal of two inputs, i.e., the first penstock and the second penstock. A turbine speed governor is used to in several ways by the station automation to ensure optimal speed management.

A human based, fuzzy if-then rules are used to analyze all that is needed, after which the weighted average is sent as a signal that decides the next phase

- ii. Design a Membership Function That Will Increase the Rotation of the turbine

The interface of this phase on the Fuzzy Software is shown below.

We know that for asynchronous alternating current generator, the generator, the generated Voltage (e.m.f) is directly proportional to the magnetic flux and the speed of rotation in revolution per minute (RPM) Equation

$$E = k_1 \phi N \quad \text{eqn ( 9)}$$

This equation explains the process in this phase.

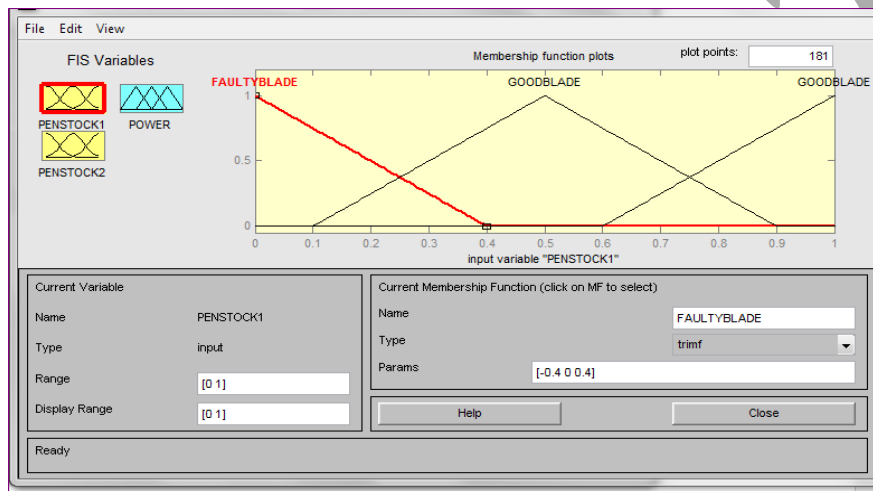


Figure 2. Interface on software on the design of membership function that will analyze the causes of slow turbine rotation

The required figures for Designing the Model for Hydropower Generator Speed Control With Fuzzy Software is Shown Below.

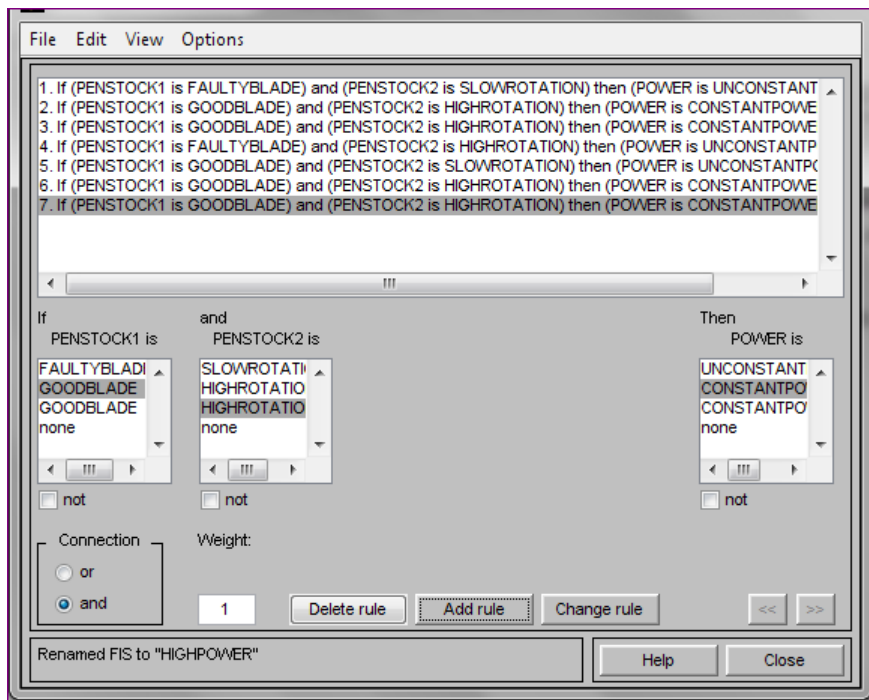


Figure 3. Designed fuzzy rule that will generate constnt power supply when the turbine rotates

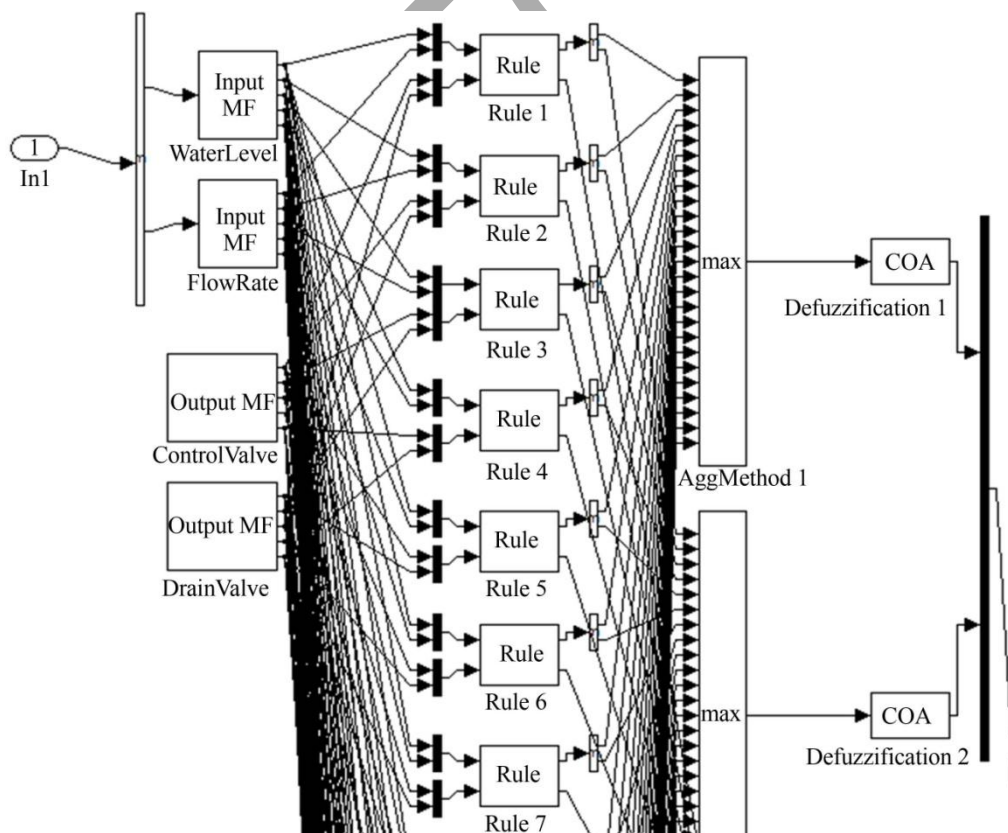


Figure 4: Simulated result of designed fuzzy rule that will generate constant power supply when the turbine rotates.

## RESULTS AND DISCUSSION

Epileptic power supply in Nigeria has forced industrialists to rely on private diesel engines to generate their electricity; generating plants are old and in need of a total overhaul in hydropower stations; turbines are easily affected when the water level in the dam changes, resulting in low-speed rotation of hydropower turbines. This paper has presented an application of the Fuzzy software technique to overcome the problem.

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