Design of a Controller for Canal Based Small Hydro Power Plant

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Abstract: Here in this paper the simulated model was created by modeling the various components of a practically operating canal based small hydro power plant in a Matlab/Simulik based environment. The plant is located in Bathinda Punjab and is connected to the local grid. Using the model, the aim is to study the behavior of mechanical input to the generator and the gate operation during its steady state operation and also the transient behavior. The corresponding results for these are obtained for analysis. Later a PID controller will be designed in order to increase its performance both under steady state and transient state.

***Index-Terms* - Mathematical models, Park Transformation, Small hydro-electric power plants, Controller, Proportional, Integral, Matlab/Simulink.**

I. INTRODUCTION

In Irrigation canal based Small Hydro plants, utilizing the heads available gives more or less constant power generation. But it is seen that the head available is almost constant whereas there are large variations in the discharge available. The power generation is completely dependent upon irrigation releases season wise through the canal which depends upon the crop pattern in the region. Power generation is for nine months as months of April, May and August are not considered since discharge is less than 1 cumecs. Modeling and simulation of small hydro power plant is valuable tool for planning power plant operations and judging the value of physical improvement by selecting proper system parameters. Earlier this was done for large or small hydro power plants. But for canal type small hydro power plants this study helps in verifying costs and safety conditions. It also helps in verifying the parameters of control equipment's like water level regulator, governor, exciter etc. and in determining the dynamic forces acting on the system which must be considered in structural analysis of the penstock and their support.

II. MATHEMATICAL MODELING

Generally differential equations are used to describe the various power system components. Study of the dynamic behavior of the system depends upon the nature of the differential equations.
Small System: If the system equations are linear, the techniques of linear system analysis are used to study dynamic behavior. Each component is simulated by transfer function and these transfer functions blocks are connected to represent the system under study.
Large System: Here state-space model will be used for system studies described by linear differential equations. However for transient stability study the nonlinear differential equations are used.

1. Mathematical Modeling of a Synchronous Machine:

The reason here to choose Park's transformation is because other approaches create us trouble because of inductances which are related to the stator-rotor mutual inductances that have time-varying inductances. In order to alleviate the trouble, we project the a-b-c currents Into a pair of axes which we will call the d and q axes or d-q axes. In making these projections, we want to obtain expressions for the components of the stator currents in phase with the d and q axes, respectively. Although we may specify the speed of these axes to be any speed that is convenient for us, we will generally specify it to be synchronous speed, ω_s. Decomposing the b-phase currents and the c-phase currents in the same way, and then adding them up, provides us with:

$$i_q = k_q\left(i_a \cos\theta + i_b \cos(\theta - 120°) + i_c \cos(\theta + 120°)\right)$$
$$i_d = k_d\left(i_a \sin\theta + i_b \sin(\theta - 120°) + i_c \sin(\theta + 120°)\right)$$

Constants k_q and k_d are chosen so as to simplify the numerical coefficients

We have transformed 3 variables i_a, i_b, and i_c into two variables i_d and i_q. This yields an undetermined system, meaning

- We can uniquely transform i_a, i_b, and i_c to i_d and i_q
- We cannot uniquely transform i_d and i_q to i_a, i_b, and i_c.

We will use as a third current the zero-sequence current whose value is zero under balanced conditions. This is being done in order to have a balance:

$$i_0 = k_0\left(i_a + i_b + i_c\right)$$