ANN-Based Adaptive PI Control for Wind Turbine with Doubly Fed Induction Generator

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***Abstract*—This paper focuses on developing a novel algorithm which dynamically optimizes the controllers of doubly fed induction generator (DFIG) driven by a wind turbine (WT) to increase DFIG transient performance in all wind speed conditions. Particle swarm optimization (PSO) is proposed to optimize parameters of PI controllers of DFIG's rotor side/grid side converters (RSC/GSC) at different wind speeds in order to maximize the damping ratios of the system eigenvalues in small signal stability analysis. Based on the optimal values and the wind speed data set, an artificial neural network (ANN) is designed, trained, and it has the ability to quickly forecast the optimal values of parameters. Adaptive PI controllers (including ANN) are designed which dynamically change PI gain values according to different wind speeds. Simulation is done via PSCAD software for a single machine connected to an infinite bus (SMIB) system. The results show that the DFIG of ANN-based adaptive PI control could significantly contribute in the transient performance improvement in a wide wind speed range.**

***Index Terms*—Particle swarm optimization, DFIG, small signal stability, artificial neural network, damping ratio, optimal control, transient performance, and PSCAD**

I. Introduction

Wind power capacity is growing at the rate of 20% annually on the average in the world, and its cost has decreased 50% in the last 10 years [1]. The quickly increasing widespread use of wind power extensively reduces carbon emissions, reduces the effect on global warming, and cuts down the dependence on fossil fuels.

With the rapid developments in power electronics, DFIG-WTs are very popular and the worldwide market share of DFIG is approximately 30% in recent years because of the advantages of higher efficiency, operation in a wide range, reactive power production, lower cost, and flexible control [2-6].

With the increasing high penetration of wind power, DFIG plays a more important role in power systems stability, and the improvement of DFIG transient performance is becoming increasingly significant. Previous researchers have attempted to improve this by developing different algorithms in the past

authors proved that adding a power system stabilizer to wind farms could significantly influence network dampi[n] achieved a good voltage control capacity. In [10], the a[u] presented an energy capacitor system with a fuzzy-controlled reference signal adjuster in the converter con[t] smoothen the output fluctuation. Others developed a algorithm to design the optimal PI controllers for the side converter to improve the transient performance [11 authors in [12] developed PSO to design the optim[al] controllers for the rotor side converter and grid side con[verter] of DFIG for a particular wind speed. More recentl[y] authors in [13] presented Bacteria Foraging techniq[ue] separately optimize the parameters of DFIG and the da[mping] controller to increase the damping of low frequency a[nd] oscillations of DFIG in three different wind speeds.

However, all of the approaches so far only optimi[ze] controller parameters at one special operating point optimal model) and the parameters are constant. controllers don't have the ability to dynamically adjust gain values according to the wind speed difference. Sec[ond] these approaches are based on SMIB system and the in[fluence] of transmission lines and multi-machines are [s] neglected.

The proposed ANN-based adaptive PI control DFIG [is] is designed to improve DFIG transient performance. P[SO is] used to optimize PI parameters of DFIG's rotor and gri[d side] converters at different operating points (different wind sp[eeds]) in order to maximize the damping ratios of the s[ystem] eigenvalues in small signal stability analysis. Based [on] calculated optimal values and the given wind speed data two-layer feed-forward artificial neural network is de[signed] and trained. The calculation for optimization and train[ing is] relatively slow and is done off-line. After that, ANN h[as the] ability to quickly forecast the optimal values at each [wind] speeds. The calculation for prediction is relatively fast [and] done on-line. A sensor captures the wind speed wh[ich is] ANN's input, and ANN forecasts the optimal value[s and] outputs them into the smart PI controllers. The cont[rollers] dynamically change values according to the different [wind] speeds to increase DFIG transient performance in a [wide] operating range.