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# Volt/Var control in a distribution system by a fuzzy optimization approach

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ABSTRACT

This paper presents a fuzzy optimization approach for solving the Volt/Var control problem in a distribution system with uncertainties. Wind turbines are being considered in the study distribution system. The main purpose is to find an optimum combination of tap position for the main transformer under load tap changer (ULTC) and on/off status for switched capacitors in a day to minimize the voltage deviation on the secondary bus of the main transformer, reactive power flow through the main transformer and real power loss on feeders. When performing the Volt/Var control problem in conventional methods, the hourly load and wind speed must be forecasted to prevent errors. However, actually there are always errors in these forecasted values. A characteristic feature of the proposed fuzzy optimization approach is that the forecast hourly load and wind speed errors can be taken into account using fuzzy sets. Fuzzy set notations in the load demand, wind speed, voltage deviation on the secondary bus, reactive power flow through the main transformer and total real power loss on feeders are developed to obtain the optimal dispatching schedule under an uncertain environment. To demonstrate the effectiveness of the proposed method, the Volt/Var control problem is performed in a distribution system within the service area of Yunlin District Office of Taiwan Power Company (TPC). The results show that a proper dispatching schedule for ULTC position and capacitor switching operation can be reached using the proposed method.


## 1. Introduction

Volt/Var control in a daily system operation for a distribution system is very important. The utility usually controls the main transformer ULTC position and capacitor status to improve the voltage profile, reduce system loss and increase system efficiency. Reactive power and voltage are efficiently controlled to improve voltage quality and decrease power generation cost. However, Volt/Var control devices are operated independently by themselves, i.e., these devices are not coordinated. In this paper, all Volt/Var control devices that include ULTC, shunt capacitor and feeder capacitors have been taken into account in the study distribution system and properly coordinated. And in the past few years, renewable energy such as wind energy has been actively researched and developed in advanced countries. This paper also considers generating renewable energy connected to the power distribution system. This allows more effective voltage profile improvement, system loss reduction, increased system efficiency, and reduced power generation cost.

The purpose of analyzing the Volt/Var control in this paper is to find a proper dispatching schedule for ULTC tap position and shunt capacitors at substation and shunt capacitors on feeders so that the power loss is minimized, the reactive power flow through main transformer is reduced and the voltage profile is improved. A survey of the literature on this problem reveals that many approaches have been reported for solving the Volt/Var control problem in a distribution system [1–14]. Quite promising results in terms of proper dispatching schedules of ULTC position and capacitor status have been reached in most works. However, some uncertain factors were not involved in the Volt/Var control problem.

To perform the Volt/Var control problem in a distribution system with considering wind energy system, the hourly load at customer terminals and wind speed for wind turbines must be known. Hourly load and wind speed can only be known through short-term forecasting. Since load demand and wind speed depend on the social behavior of customers, weather variables, etc., there are always errors in these forecast values. A characteristic feature of the proposed fuzzy optimization approach is that the errors in the forecast load demand and wind speed can be taken into account using fuzzy sets. An approach based on fuzzy sets is proposed to reach the desired dispatching schedule based on uncertain load demand and wind speed. This method has been successfully applied to other optimization problems such as generation scheduling [15] and dynamic economic dispatch [16]. To reach an optimal dispatching schedule under a fuzzy environment, the load demand, wind speed, voltage deviation on the secondary bus, reactive power flow through the main transformer and total real power loss on feeders are all expressed in fuzzy set notations.

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