

Variable Speed Drive Volumetric Tracking for Airflow Control in Variable Air Volume Systems

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Airflow control of VAV systems has been an important design and research subject, since the VAV system was first introduced. An airflow control method should: (1) ensure the airflow to each space or zone; (2) control outside air intake properly; and (3) maintain a positive building pressure. Several methods have been developed to ensure air delivery to each space or zone. These methods include static pressure control and damper position control. The static pressure control method maintains a sufficient static pressure in the main duct to ensure the required airflow to each space or zone. Its performance has been proven to be reliable over many years of use. The fan power is lower under partial load conditions. Static pressure reset can further decrease the fan energy under partial load conditions. The optimal reset of the static pressure is critical for minimizing supply fan energy.

A recent proposal requires modulating fan speed to maintain at least one terminal box damper full open for modern DDC systems, where the AHU controller can access all terminal box information directly. When properly designed and maintained, this method can produce significant fan energy savings. Recently, this method was improved by integrating it with static pressure reset techniques to prevent it from malfunctioning under several typical building operating problems. In buildings with pneumatic terminal box controllers, this method cannot be used. For illustrative purposes, an ideal static pressure reset schedule is assumed.

The typical building pressure control methods include fan tracking (FT), direct building pressure control (DBP), and volumetric tracking (VT). The FT method sets the return fan speed at or slightly lagging the supply fan speed. Under partial load conditions, the building pressure decreases as the total airflow decreases, since the return air fan draws a relatively larger amount of air from the building. The FT does not ensure constant or positive building pressure under partial load conditions.

The DBP method modulates the return air fan speed to maintain the set point of the pressure difference across the building envelope. This can be problematic in a large building, where it is difficult to measure the pressure difference properly since the variation of the pressure difference across the entire envelope is far larger than the set point. Hence, if the pressure difference across the envelope cannot be measured accurately, this method should not be used.

The VT method measures both the supply and return airflows using flow stations. The return air speed is modulated to maintain the required difference of the supply and return airflows. This method is very effective when the equipment location and space are available for the airflow stations. However, accurate measurement of airflow has proved difficult if not impossible for most systems due to the lack of the appropriate length of straight ductwork. Due to the lack of other alternatives, the VT method is commonly used. The inaccurate measurement of airflow is the major cause of airflow control problem in existing buildings. In the new control method presented in this paper, the volumetric tracking method is used; however, instead of determining the airflow rate by measuring a differential pressure, VSD signals, and the fan head are used to determine the airflow rate.

Outside air intake control often uses one of the following methods: fixed damper position, direct method, plenum-pressure control, and CO₂ demand control. In many buildings, it is a common practice to set both the outside and the return air dampers to fixed positions to control the outside air intake. The damper positions are determined during system testing and balancing. The outside air intake is either higher or lower than the required airflow when the total airflow is different from the testing condition.

The direct method measures the outside airflow directly using a flow station. The controller modulates the outside air damper to maintain the required outside airflow. A minimum outside air duct or a fan is often required in order to measure the airflow accurately. The direct method provides good outside air control when the outside airflow can be measured accurately. Unfortunately, in many buildings, air leakage through the

maximum outside air damper may by-pass the flow station and therefore, reduces the accuracy of the outside air measurement.

The plenum-pressure control method maintains the mixed air chamber pressure at a required level by adjusting the return air fan speed or the return air damper. The outside air damper serves as the flow meter. Since the damper has to be modulated during the economizer cycle, the hysteresis of the air damper can cause significant airflow variation. The outside airflow may vary significantly even if the plenum static pressure is controlled properly since the pressure drop across the outside air filter increases as dirt builds up.

The CO₂ demand control method maintains the carbon dioxide level at its set point by modulating the outside air damper. This method provides reliable outside air intake control for typical occupancy. In this study, the CO₂ demand control method is used. An improvement is made to prevent the outside air backflow through the relief duct and/or negative building pressure when the mechanical exhaust is higher than the occupancy fresh air requirement.

A new airflow control method has been developed for VAV systems. This method implements volumetric tracking control using the VSD speed signals and the fan pressure heads instead of airflow stations, controls the outside air intake using the improved CO₂ demand control techniques, and controls the supply air fan using an ideal static pressure reset schedule. Since volumetric tracking is implemented using the VSD signals, this method is called the VSD volumetric tracking (VSDVT).