ABSTRACT

Large portion of electrical energy production in developed countries is consumed for ventilation and air conditioning in commercial and residential areas and for similar applications in the industrial sphere. Also it is well-known that adjustable speed drives (ASD) can be used in these fields to achieve great energy saving effect for partial loads by lowering motor speed. On the other hand, permanent-magnet brushless dc (PMBLDC) motors have been used in wide applications for their benefits of easy speed control and long life time expectation. Moreover, by using high energy product magnets, such as neodymium-iron-boron (NdFeB), a PMBLDC motor can provide rather high power density, high torque and high efficiency. In fact, due to the necessity of small volume and weight, PMBLDC motors are now replacing rapidly the traditional induction motors for variable frequency control of air conditioning units and compressors. However, the resulting mechanical noise due to the torque ripples of the PMBLDC motor remains to be further improved without increasing too much extra cost. Therefore, the objective of this dissertation is focused on further improvement of the dynamic response and reduction of the drive cost.

Major contributions of this dissertation can be outlined briefly as follows. First, an equivalent dc brush motor model is proposed for the concerned three-phase PMBLDC motors model to simplify greatly the drive control and enable the integration of the

controller into single chip. Second, for the current control loop, a low cost current sensing technique is proposed to get complete information of the motor current and a novel tri-mode control is presented to integrate with the current sensing technique to achieve instantaneous toque response and meanwhile minimizing the commutation torque ripples automatically over the whole speed range. Third, for the speed control loop, a phase-locked loop (PLL) assisted speed controller is proposed for the PMBLDC motor drives to achieve both fast transient response and high speed control accuracy. Furthermore, closed form expressions of the proposed controller parameters are also provided rendering the design of the proposed control rather trivial. Fourth, a prototype is also implemented and experimental results indeed validate the feasibility and effectiveness of the proposed adjustable speed drive.

Index Terms : permanent-magnet brushless motors, current control, adjustable speed control, motor drives, phase-locked loop (PLL).