ABSTRACT

In this dissertation, new torque control strategies for interior permanent magnet synchronous motor (IPMSM) drives are proposed to fully exploit the reluctance torque as well as to preserve the merit of the simple linear torque control scheme. Main contributions of the dissertation are summarized as follows. Firstly, a novel linear torque control strategy is presented for IPMSM drives in the constant torque limit region such that the resulting torque is proportional to the line current magnitude. A sufficient condition for the existence of the linear torque control is derived and the corresponding torque constant is also maximized. In addition, a closed form relation between the i_{ds} and i_{qs} for the proposed torque control strategy is derived. Not only can the proposed linear torque control strategy fully exploit the reluctance torque to provide a much wider constant torque operation region, but also provide a much better performance at high speed region as compared with that of the surface mounted PMSM. Secondly, a new field weakening control of a linear torque controlled IPMSM drive is presented. The proposed control further extends the operational speed range of the previous linear torque control (LTC) from the constant torque limit range to the field weakening range such that the IPMSM drive can operate over much wider speed range. The theoretical basis of the proposed field weakening control is first proposed and the corresponding analytical forms are also derived. The entire operational regions of an IPMSM are divided into three regions according to the motor speed, namely the constant torque limit region (Region I), the partial field weakening region (Region II), and the full field weakening region (Region III). However, only two control modes, namely the constant torque limit control mode and the field weakening control mode, are required. A region detector is proposed to choose the correct control mode efficiently according to the motor speed and the demanded torque. In addition, to fully utilize the maximum torque capability in the field weakening region, a variable line current magnitude limiter is also proposed to simplify the complexity of the control algorithm. Thirdly, a linear maximum torque per ampere (LMTPA) control is proposed for IPMSM drives to further minimize the copper loss during the steady state operation as well as to achieve fast transient response. The proposed LMTPA is also extended to the entire field weakening region to achieve full range maximum torque per ampere control. Sound theoretical basis is also provided in the context. Finally, a new saturated q-axis flux linkage model for an IPMSM is proposed and the corresponding LMTPA control strategy over the full operational speed range is derived. Experimental results are provided to show the improvements of the dynamic as well as the steady state performances for these proposed linear torque control strategies.