Dynamic Analysis of Toroidal Winding Switched Reluctance Motor driven by Full Bridge Inverter

Ji-Young Lee, Tao Sun, Jung-Pyo Hong, and Woo-Taik Lee
ECAD Lab., Dept. of Electrical Engineering, Changwon National University
Sarimdong #9, Changwon, GyeongNam, 641-773, Korea
jyecad@korea.com, jphong@sarim.changwon.ac.kr, wootaik@sarim.changwon.ac.kr
Byung-Kook Lee
Korea Electrotechnology Research Institute
Seongjudong #28-1, Changwon, GyeongNam, 641-120, Korea
bklee@keri.re.kr

***Abstract*-- This paper deals with the dynamic analysis of toroidal winding SRM driven by full bridge inverter. Inductance profiles of toroidal winding SRM are first investigated, and then, voltage equations are made considering both the drive topology and the motor parameters. The dynamic analysis results will be compared with those of conventional winding SRM which are already examined for verification of analysis method.**

I. Introduction

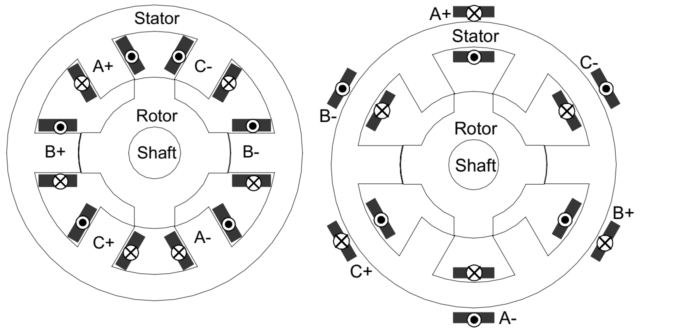
Now days, drive cost is more popular issue rather then motor manufacture cost in especially brushless reluctance motors. While conventional winding switched reluctance motor (SRM) can mainly be driven by an asymmetrical converter, toroidal winding SRM cannot only be driven by an asymmetric converter but can also be driven by a full-bridge inverter usually used as BLDC drive [1]. Since full-bridge inverter can be easily and cheaply constructed by commercial chip set, the toroidal windings in SRM become attractive.

However, it can be more or less complex to estimate the characteristics of toroidal winding SRM driven by full bridge because of irregular current shape due to the variation of inductance, and switching sequence. Even though it is said that the driving characteristic of a toroidal winding SRM are similar to those of the method of exciting two phase of a fully pitched winding SRM [1, 3], the direct study about toroidal winding SRM is needed to estimate exact its characteristics.

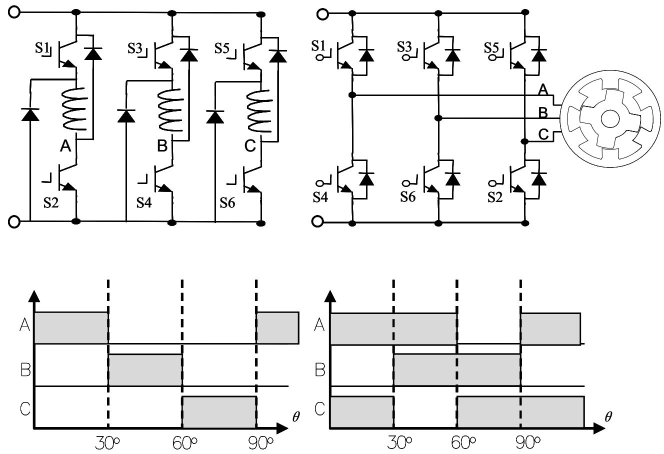
Therefore this paper deals with the dynamic analysis of toroidal winding SRM driven by full bridge inverter. Inductance profiles of toroidal winding SRM are first investigated, and then, voltage equations are made considering both the drive topology and the motor parameters. The dynamic analysis results will be compared with those of conventional winding SRM which are already examined for verification of analysis method.

II. Toroidal winding SRM

Fig. 1 shows the cross-sections of both the conventional and toroidal winding SRMs, and Fig. 2 shows the drive topology and their gating sequences, respectively. While conventional winding SRM is driven by asymmetric converter, toroidal winding SRM is considered to be driven by full bridge inverter in this paper.



(a) Conventional winding SRM (b) Toroidal winding SRM
Fig. 1 Configuration of three phase SRM



(a) Asymmetric converter (b) Full-bridge inverter
Fig. 2 SRM drives (upper) and its gating sequences (lower)

For the reliable characteristic analysis, not only complicated flux pattern of them, but also its terminal characteristics should be considered. To solve terminal equations and the flux equations at the same time, the coupled field circuit modeling method is effective [4, 5]. With the method, only terminal equations can be changed depending on drive, and [1] and [4] give the voltage equations for the conventional and toroidal winding SRMs, respectively.

Fig. 3 shows the equi-potential line distribution when phase A and B are excited in troidal winding SRM.

III. Analysis Results

Since inductances of SRM are variable depending on both current and rotor position, electro-magnetic characteristics can be changed depending on source characteristics such as constant voltage and constant current even under the same drive condition.

In the constant current condition, inductance profiles are shown in Fig. 4. Rotor displacement 0 degree is unaligned position between stator and rotor poles.

In conventional winding SRM each phase is magnetically decoupled so that there is only self inductance. In toroidal winding SRM, the line to line inductance is similar to that of conventional windings. However, there is changing mutual inductance as shown in Fig. 4 (d), so that the self inductance profiles are different from those of conventional windings. If there is no high current which can make core highly be saturated, self inductance is almost constant for both current and rotor position as shown in Fig. 4 (b) and (c), and mutual inductance profile looks like that of line to line inductance. These different winding inductances can make different torque characteristics.

In the extended paper, voltage equation of this motor with full bridge inverter and the dynamic analysis results will be presented and discussed in detail.

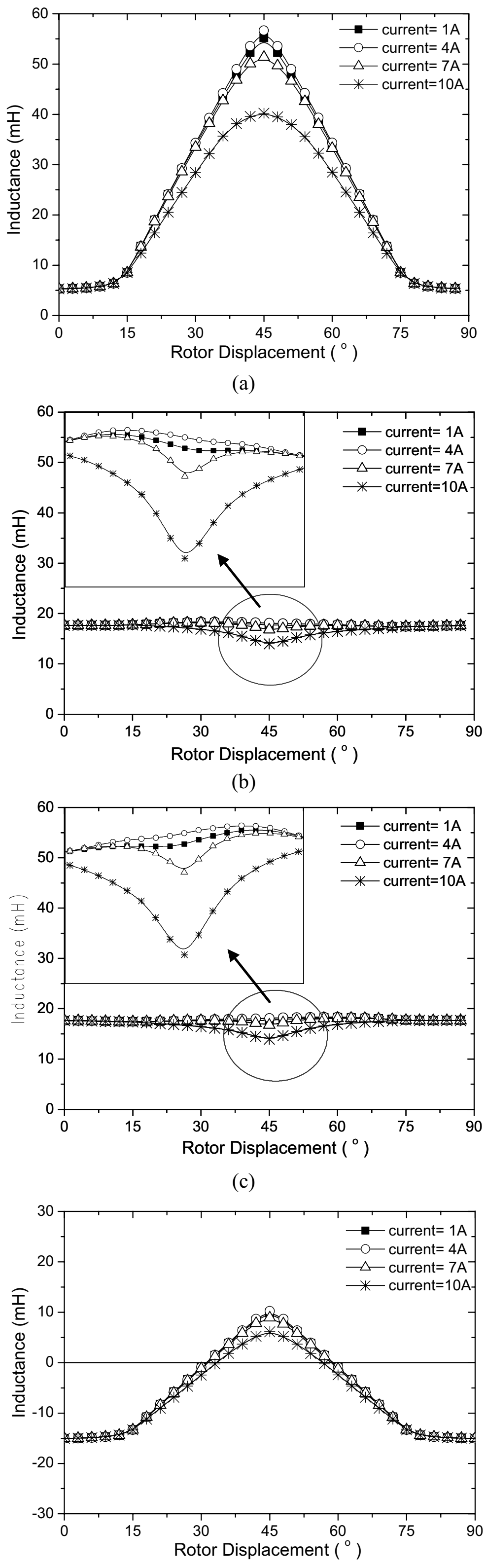


Fig. 4 Inductance profiles for rotor displacement and current. (a), (b), (c), and (d) : Line to line, Phase-A self, Phase-B self, and mutual inductance profiles at toroidal winding SRM

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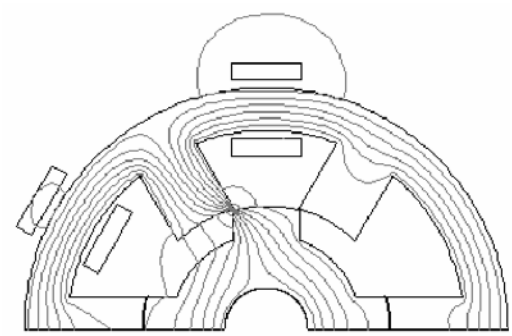
Fig. 3 Equi-potential line distribution of toroidal winding SRM