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Mon-Mo-Po1.07-02 [77]: Study on Inter-turn Fault Diagnosis of the Six-Phase Interior Permanent Magnet Synchronous Motor Using d-Axis Current

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1. Introduction
   Compared to three-phase motors, multi-phase motors have higher torque density, smaller torque ripple, and higher reliability. In addition, multi-phase motors can be operated with other healthy phases, even if one phase fails. Therefore, with the increase in industrial applications that require fault-tolerance and continuous operation, such as EVs, military, and aerospace, multi-phase motors have received much attention. Similar to the three-phase IPMSM, faults of the six-phase IPMSM can be classified as: mechanical, magnetic, and electrical faults. An example of a mechanical fault is rotor eccentricity and bearing damage, an example of a magnetic fault is demagnetization, and an example of an electric fault is a turn-to-turn fault in an open-circuit phase. An inter-turn fault causes excessive current flow, which not only accelerates the breakdown of insulation but also can cause demagnetization. Therefore, if the inter-turn fault is detected in advance, the repair cost of the motor is reduced.
2. Body
   In this paper, the performance of the inter-turn fault diagnosis of a six-phase interior permanent magnet synchronous motor (IPMSM) was analyzed through d-axis current using finite element analysis (FEA). The high-frequency injection method was used to perform fault diagnosis with a current response before and after a fault. To obtain the response of the current versus the applied voltage, the voltage equation of the six-phase IPMSM was obtained for the occurrence of the inter-turn fault. In addition, the dq-axis current responses in the healthy and faulty conditions were derived from the voltage equations. Furthermore, since the response of the current is a function of the magnitude and frequency of the voltage, the performance of the fault diagnosis was determined from the magnitude and frequency of the applied voltage. To verify this, the inter-turn fault diagnosis performance was analyzed through FEA and the control simulation tool. As a result, we proposed a voltage and frequency to maximize the inter-turn fault diagnosis performance of the six-phase IPMSM.

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