High Performance Motor Control System

– A Gain Scheduled Controller for Sinusoidal Ripple Elimination of AC PM Motor Systems

Project code: QL2-07
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1. Introduction

*AC Permanent Magnet (PM) motors* have been used in numerous industrial areas because of brushless and maintenance-free operation. However, an AC Permanent Magnet motor control system usually has multiple output sinusoidal ripples. The torque ripples due to DC current offsets from the current sensors are dominant compared to other ripples in a typical AC Permanent Magnet motor control system. In this project, a speed regulator has been built and tested by both simulation and real-time experiment as the disturbance torque ripples were modeled as 2 sinusoidal functions. In real-time experiment, the control algorithm was designed and implemented under Simulink and a PC running xPC Target™ was acted as motion controller of the AC Permanent Magnet motor control system.

The **Objective** of the project is to perform real-time experiment in order to verify the effectiveness of the designed speed regulator in eliminating the torque ripples caused by DC current offset. Then, such regulator can be introduced to AC PM motor control systems to solve the torque ripple problem which limited the applications of AC PM motors in high-performance speed and position control systems in the past.
2. Methodology

An AC PM motor control system typically consists of a motion controller, a current tracking amplifier and a feedback encoder and an AC PM motor as illustrated in the figure below. The Target PC in the control system was running the xPC Target real-time kernel which guarantees the whole system was in the real-time environment.

- PC controls the I/O card inside it.
- I/O card sends command to the driver and receives data from encoder
- PC and I/O form Motion Controller
- Driver receives command from Motion Controller and generates 3-phase current to the AC PM motor
- AC PM motor rotates correspond to the input 3-phase current.
- Encoder checks the rotation of motor and sends detected position data to the Motion Controller

The speed regulator structure employed in the project is shown in the Figure below. The transfer functions in the structure were designed using a specified pole-zero placement technique.

![Figure of AC PM motor control system](image)

![Figure of speed regulator structure](image)
3. Results

The real-time experiments were performed on the AC PM motor control system. The input profile is shown in the right figure which is an input profile combining ramp inputs, low speed inputs, high speed inputs and very low speed inputs. Such profile would test the comprehensive performance of the speed regulator on different inputs and the flexibility in following from one kind of input to another.

The output without our speed regulator is shown in Fig.1 and the output with our speed regulator is shown in Fig.2.

In Fig.1, the ripples appear everywhere. However in Fig. 2, we can see the output responses track the reference inputs quite accurately, only a little ripples at constant region. Thus, the proposed speed regulator has achieved its objective in eliminating the torque ripples cause by DC current offsets.