SENSORLESS CONTROL OF TWO-PHASE HYBRID STEPPER MOTOR USING BACK EMF

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ABSTRACT

In this thesis we have developed sensorless control algorithm for two-phase HSM by using the measured the back-emf period information for new commutation calculation method. New method requires single or couple step excitation at the beginning of the operation which allows the measurement of the back-emf from the unexcited winding. The natural vibration is measured by detecting the zero crossings of the back-emf. The back-emf voltage also depicts the load level.

The development algorithm is tested in the simulation first. The control algorithm motor and driver is modeled in Matlab Simulink environment. With the adequate confidence from the simulation results the algorithm is implemented in the experimental system.

We designed new test bed for new sensorless open-loop drive technology. The test bed is composed of a Hybrid Stepper Motor (HSM), two couplings, a circular shaft, and set of semi circular load discs, and an incremental optical encoder. The HSM can be replaced with another HSM with different shaft size. Special couplings can tolerate vertical and horizontal misalignments without backlash. The load shaft is supported with two bearings at the two ends. A base load disc is mounted on the shaft and additional semi circular loads can be added to the base disc with four screw. An FPGA (Field Programmable Gate Array) card is used with the LabVIEW data acquisition software for motor control and data acquisition.

Two-phase HSM is driven one phase-on full step excitation mode. One phase is energized with rated motor current and the back-emf is measured from the unexcited phase winding. Several characteristics of this operation are worthy of note. First, the back-emf looks shows decaying oscillation (under-damped system). Second, the measured back-emf's period indicates natural vibration period, from which we can extract load level or the load inertia information. Third, mechanical anomalies can be seen from the back-emf wave form.

A constant current drive is used for the HSM control. The constant current drive is essential for the new commutation method. The new commutation method

is driven with two approaches. In the first approach the commutation is derived by neglecting the friction. In the second approach viscous damping is included in the solution of dynamic equations. The frictionless solution has negligible error in the application on the other hand it has a very practical use for real time experiment. The frictionless solution is calculated in a way that only unknown in the solution is natural vibration period. As soon as we obtain the natural vibration information by measuring the back-emf period from the unexcited winding, we can calculate the commutation pulses easily.

The solution with damping included has better accuracy whereas this solution requires iteration and solution takes times. We used the MATLAB m-file for the solution of the dynamic equation with friction. However it is very difficult to implement this method in real time experiment. Because each calculation step is performed by using the results from previous steps and each time there is a change in the vibration period we need to solve the dynamic equation from the beginning.

Simulation and experimental results showed that by using the new method we were able to suppress the vibration which was very high with conventional drive method. Also we achieved better accuracy in positioning the servo system.

We achieved smooth acceleration and constant profile speed by using the symmetrical acceleration and deceleration speed profile, but the final step had an oscillation in the simulation and experimental results. In order to overcome the final step oscillation we modified the deceleration operation, that resulted with little ringing at the final step.

We have demonstrated in this thesis that HSMs are very efficient, robust, reliable, and cheaper actuators with the use of inexpensive H-bridge drive and new commutation method.