

# Motor drive control development: a new approach to learning and design

Vlado Porobic\*, Zoran Ivanovic\*, Evgenije Adzic\*, Marko Vekic\*, Nikola Celanovic\*, Hyounglok Oh\*\*

Typhoon HIL Inc.\* , Milim Syscon Co., Ltd\*\*

## ABSTRACT

This paper presents an intuitive and powerful way to study and design motor drive control. The control of induction motors, as most widely used machines, is discussed. Thanks to ultra low latency and high fidelity Hardware in the Loop systems, different aspects of up to date drive regulation are examined. A power stage, comprised of a grid voltage source, a rectifier, a VSC inverter and an induction motor, is emulated on the HIL platform in real time. A digital signal controller is plugged into the interface board and connected to the HIL emulation platform, without any hardware modifications. For motor control and power electronics applications, a dedicated Texas Instruments TMS320F2808 DSP is chosen. The same controller can drive an emulation platform and a real device with no modifications. Current and speed control loop test results are presented and discussed.

## 1. Introduction

Conventional, off the shelf computers provide simulation time that can hardly be satisfactorily small in order to ensure simulation execution in real time [1]. Therefore, the contemporary real time emulators could be useful, since they allow effortless studying and verification of motor drives control with different strategies, power levels, parameter mismatch, torque load profile, etc. In that sense, the ultra low latency (ULL) Hardware In the Loop (HIL) platform is recognized as a high end prototyping tool, which can be successfully utilized for motor drive control development process [2] [3].

This paper shows the main control aspects of an induction machine, implemented on the DSP which interacts directly with Hardware In the Loop system. The example of indirect field oriented control (IFOC) of induction machine drive illustrates the simplicity of the proposed system for fundamental aspects of drive control studying and design. System step responses for the current and speed control loops are shown for a common parameters selection procedure. [1]

## 2. System description

A HIL based system shown in Fig. 1. is used for the purpose of learning and testing drive control. A digital signal controller is placed in the docking station, which adjusts signal levels between the DSP and the HIL device. A devoted DSP, with peripherals such as PWM, ADC, a quadrature encoder and capture unit is chosen (TMS320F2808, Texas Instruments) for motor control and power electronics applications.

The power stage of the scheme, comprising of a grid voltage, rectifier, an inverter and a motor, is emulated in real time on the HIL system.

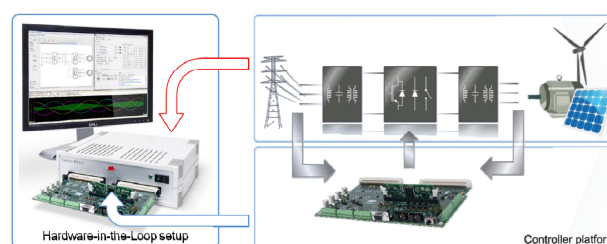


Fig. 1. Experimental setup with a HIL and a DSP controller

The aim of the described experimental setup is to guide students and researchers in obtaining hands on experience in building, developing and verifying control algorithms in a highly flexible and safe manner.

## 3. Design of a motor drive control using HIL

Based on the HIL system, a basic motor drive control design procedure for the IFOC induction machine drive is shown in Fig. 2. This widely used control is based on the transformation from stationary to synchronously rotating coordinates, which leads to a simple control structure, similar to that of a separately excited DC machine. Position of the reference frame tied to machine rotor flux is calculated as the integral term of sum of electrical rotor speed and estimated slip frequency.

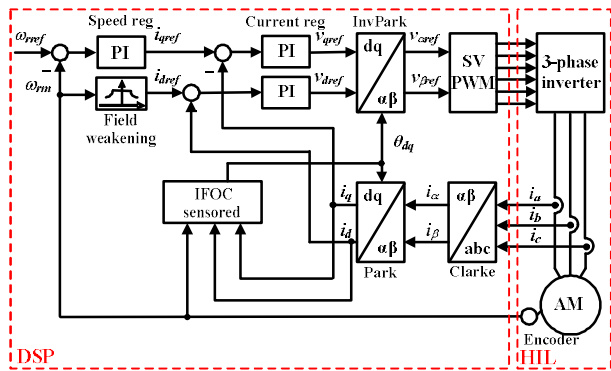


Fig. 2. Block diagram of indirect field oriented control of an induction motor

One important step in motor drive control design is to set up a current control loop. In that sense, limits and gains of a current loop PI controller's parameter arrangement is the most sensitive task. In order to eliminate side effects, constant DC bus (therefore DC link voltage ripple is zero), inverter zero dead time and a locked rotor (high possible torque load and/or high inertia coefficient) is easily selected in the HIL environment. Current controller responses are shown in Fig. 3

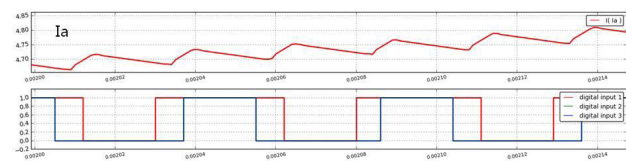
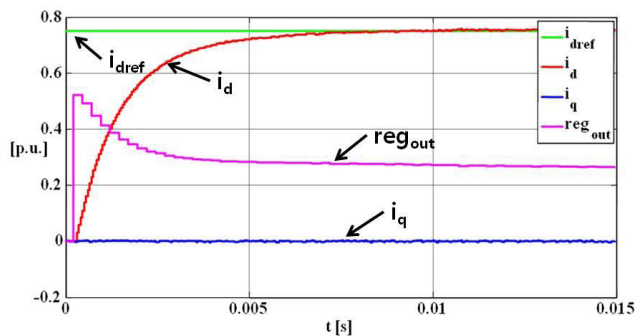


Fig. 3. Current step response (0.75 p.u.): controller variables (reference/actual currents and regulator output) and captured HIL model data: phase current and inverter leg voltages (zoomed).

The second important step in drive control design is testing the speed control loop. According to the block diagram in Fig. 2, parameters of the speed PI regulator are calculated [3]. In this case, speed is reached without overshoot and in minimal possible time. The implemented PI regulator has proportional gain in the local path, in order to avoid abrupt speed variation.

Speed step response is shown in Fig. 4. These results are completely in accordance with theoretical expectations.

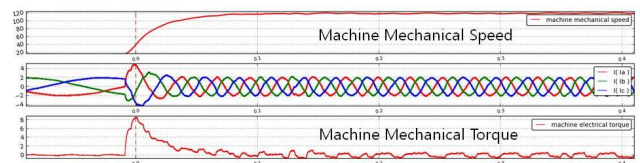
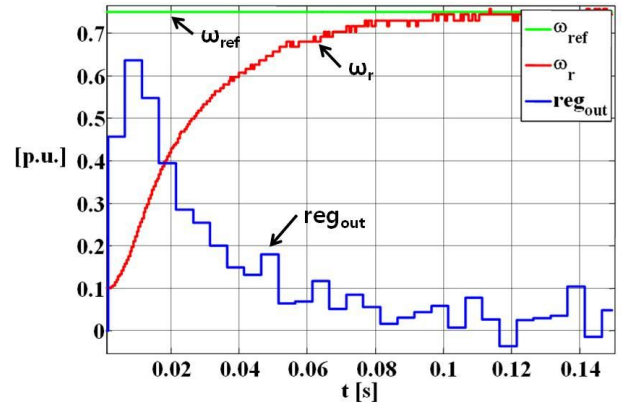


Fig. 4. Speed step response (0.75 p.u.): controller variables (reference/actual speed and regulator output) and captured HIL model data: speed, phase currents, and electrical torque, respectively

#### 4. Conclusion

In this paper, a modern approach for quick and flexible drive control design and education is presented. Using a Hardware in the Loop system, students, as well experienced specialists, are capable of learning, testing and verifying every aspect of their control procedure. Beside a great flexibility, this proposed system presents a highly safe environment. In that manner, it allows the user to completely focus on software based functionalities without any hardware concerns.

#### 5. References

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