Permanent Magnet Synchronous Motor Control Interface Design and Implementation with TI F28335 DSP on Simulink External Mode

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Abstract – In recent years Permanent Magnet Synchronous Motors (PMSMs) are more preferred due to have several advantageous traits, such as high-power density, improved efficiency, enhanced torque capabilities, and precise speed control. In this study, speed control algorithm and a user interface panel are designed for PMSM on Simulink. Control algorithm is downloaded to TI F28335 DSP over Simulink embedded coder. Control panel is connected the DSP over Simulink external mode. Thanks to the external mode, the system data can be displayed on the panel in real time and the parameters can be changed. The system has been tested on the experimental setup and has been shown to work successfully.

Keywords –PMSM, Speed Control, PID Control, Simulink, External Mode

I. INTRODUCTION

In the realm of electrical machines, Permanent Magnet Synchronous Motors (PMSMs) have gained significant prominence due to their remarkable performance characteristics and wide-ranging applications [1]. PMSMs are a type of synchronous motor that utilize permanent magnets embedded in the rotor to generate the required magnetic field [2]. This distinctive feature sets them apart from other types of synchronous motors, such as induction motors [3–5] or synchronous reluctance motors, which rely on different methods to establish the magnetic field.

The utilization of permanent magnets in PMSMs bestows them with several advantageous traits, such as high-power density, improved efficiency, enhanced torque capabilities, and precise speed control [6]. These attributes make PMSMs highly suitable for various applications, including industrial machinery, electric vehicles, robotics, renewable energy systems, and more.

Simulink External Mode is a powerful feature of Simulink, a popular modeling and simulation tool used in the field of system design and control engineering [7]. Simulink External Mode enables real-time monitoring and interaction with a running Simulink model on a target hardware system, providing engineers and developers with a versatile tool for rapid prototyping, testing, and debugging of embedded systems [8].

Embedded systems often require complex algorithms and control strategies that need to be implemented and validated on target hardware platforms [9,10]. Simulink External Mode bridges the gap between the Simulink model running on a host computer and the target hardware system, allowing engineers to monitor and tune the behavior of the model in real time.

Microcontrollers are mostly preferred in applications where complex motor control algorithms need to be run [11,12]. The TI F28335 is a microcontroller from Texas Instruments that belongs to the TMS320C2000 Delfino MCU family. It is specifically designed for high-performance real-time control applications, making it a popular choice in industries such as industrial automation, power electronics, motor control, and renewable energy systems. The F28335 microcontroller features a powerful 32-bit C28x CPU core, which offers a rich set of digital signal processing (DSP)
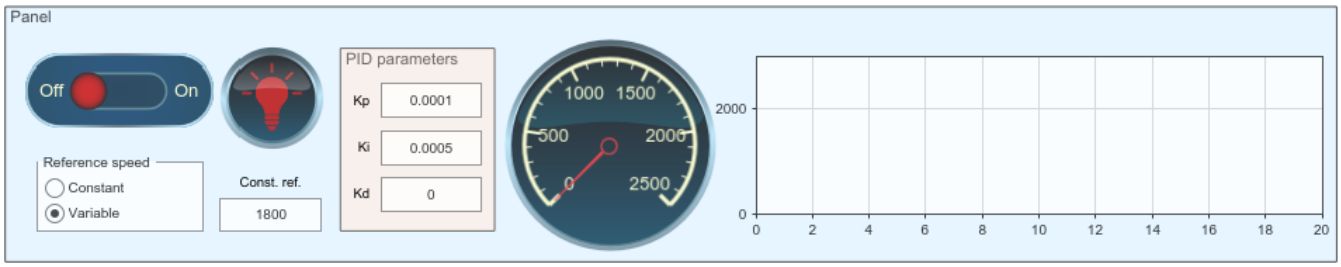
capabilities, enabling efficient execution of

Fig. 3 Control panel of the system

complex algorithms and control strategies. With its high computational power, extensive peripheral set, and integrated analog and digital peripherals, the F28335 provides a robust platform for developing sophisticated and responsive control systems [13].

II. MATERIALS AND METHOD

The dq axis current components i_d and i_q of PMSM can be written as in Eq. (1) and (2) [14].

$$\dot{i}_d = -\frac{R_s}{L_d}i_d + \omega_e\frac{L_q}{L_d}i_q + \frac{1}{L_d}v_d \qquad (1)$$

$$\dot{i}_q = -\omega_e\frac{L_d}{L_q}i_d - \frac{R_s}{L_q}i_q - \omega_e\frac{\lambda_f}{L_q} + \frac{1}{L_q}v_q \qquad (2)$$

v_d and v_q are the dq axis voltage components, R_s is the stator resistance, L_d and L_q are the dq axis inductance components, λ_f is permanent magnet flux linkage, and ω_e is electrical angular speed. Electromagnetic torque can be defined as in Eq. (3).

$$T_e = K_t i_q \ , \quad \left(K_t = \frac{3p}{4}\lambda_f\right) \qquad (3)$$

In Eq. (3) p is the pole pairs. Dynamic equation according to mechanical parameters and load of PMSM is presented in Eq. 4.

$$T_e = J\dot{\omega}_r + B\omega_r + T_L \qquad (4)$$

In Eq. (4) T_L is the load torque, J is the inertia of rotor, B is the friction factor and ω_r is the rotor angular speed.

PMSM speed control system is designed as shown in Fig. 1. And the experimental setup is presented in Fig. 2.

The experimental setup consists of a 0.4 kW 3 phase PMSM, a bridge rectifier, an inverter circuit, TI F28335 as DSP unit, and a PC.
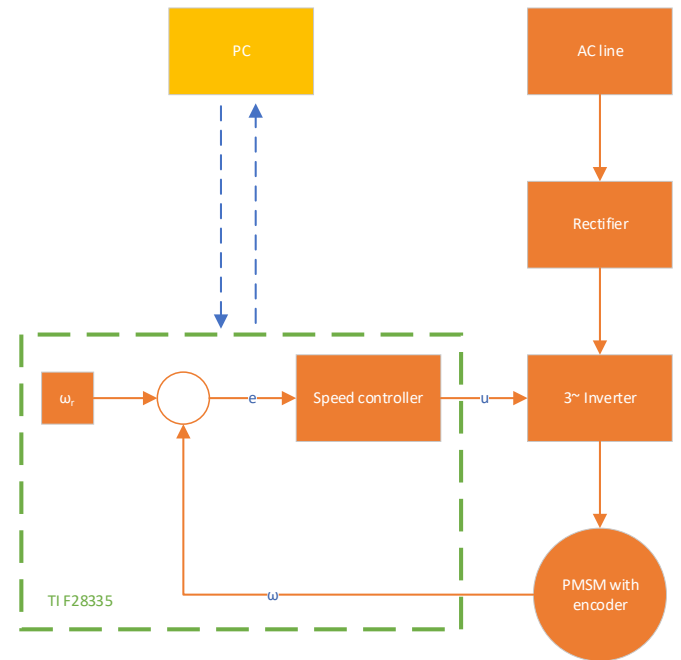

Fig. 1 Block diagram of the PMSM system

Fig. 2 Experimental setup

The control panel is designed with using Simulink dashboard library components as shown in Fig 3. While the panel is being designed, it is aimed to

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monitor the system in real-time and to easily change the system parameters.

downloaded to DSP via Simulink embedded coder. Thanks to the designed panel, the system can be monitored and controlled via Simulink external mode. As a result of the tests, it has been seen that the speed control algorithm and the user interface work successfully.

Fig. 4 Control block diagram of the system

The prepared PMSM speed control algorithm is presented in Fig. 4. With this algorithm, the amplitudes and frequencies of the voltages to be applied to the motor phases via the inverter can be adjusted, the position information of the motor can be read through the encoder and the PID speed control algorithm can be run.

III. RESULTS

The prepared speed control algorithm is downloaded to the DSP with Simulink embedded coder. Then, the control panel is connected to the DSP with external mode and the system tests are performed as shown in Fig. 5.

IV. DISCUSSION

When Fig. 5 is examined, it is seen that the system successfully follows the reference speed value. Variable or constant reference speed can be selected on the designed panel, PID controller parameters can be changed and results can be viewed via scope in real-time.

V. CONCLUSION

In this study, PMSM control interface is designed and implemented. The created control algorithm is

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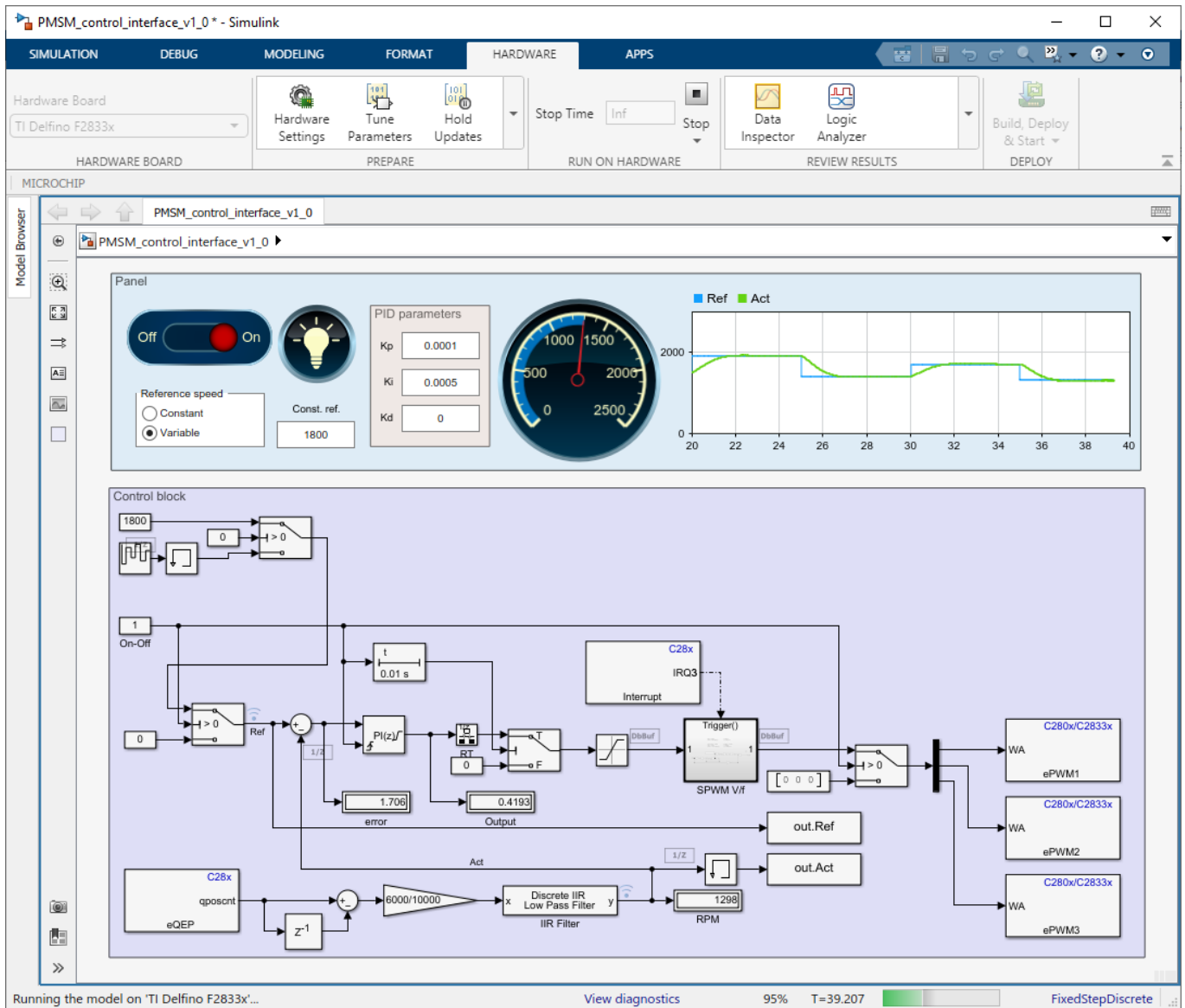[14]   Bose BK. Power electronics and variable frequency drives: technology and applications. IEEE press; 1997.

Fig. 5 Testing of the external mode panel