# Lab 5. Synchronous motor drive modelling

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## Objective

The purpose of the work is to get acquainted with the modeling of actuators based on synchronous machines with permanent magnets, the modeling of brushless DC motors and the development of vector control of synchronous motors.

## Initial data

| Parameter | $R_s$ | $L_s$ | $\Psi_f$ | $Z_p$ | $J$ | $U_{DC}$ | $T_S$ |
|---|---|---|---|---|---|---|---|
| Value | 19.4369 | 0.0311 | 0.125 | 16 | 3.4667 | 48 | 1e-4 |

**1. Build a mathematical model of a sinusoidal pulse-width modulator in Matlab / Simulink.**

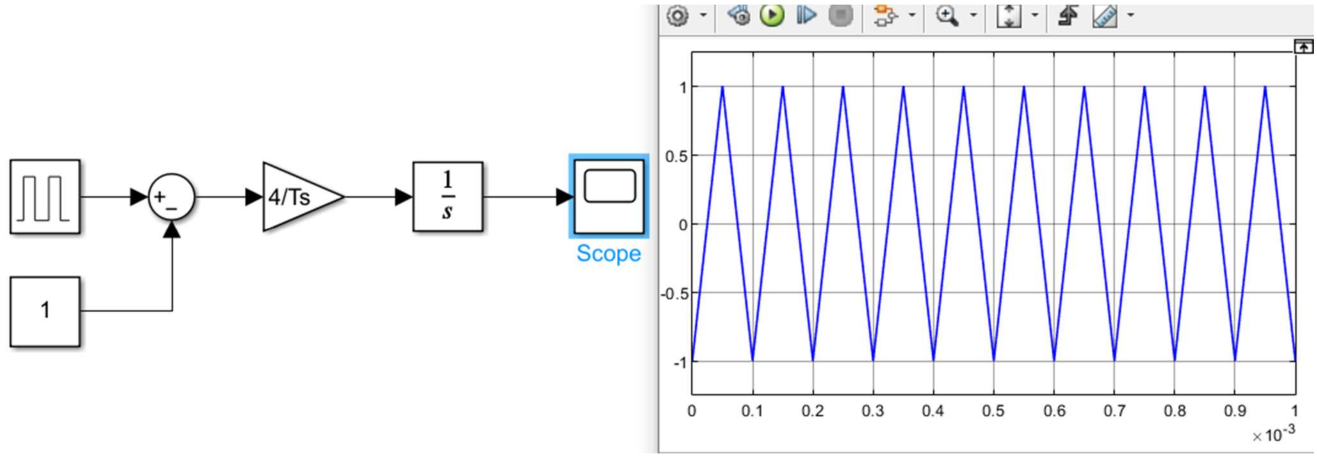


**Figure 1.a.** Triangle -Wave – Signal – Gengerator

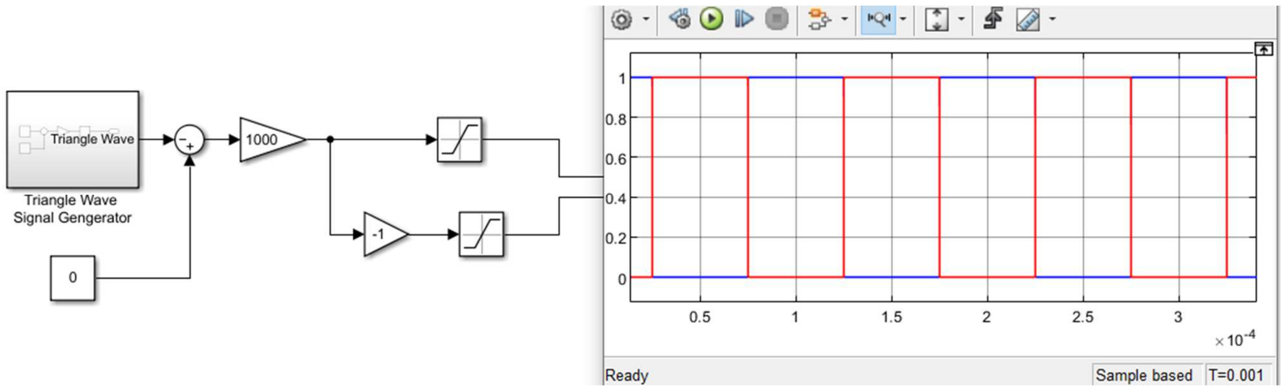


**Figure 1.b** PWM model.

## 2. Assemble a mathematical model of a three-phase inverter in Matlab / Simulink.

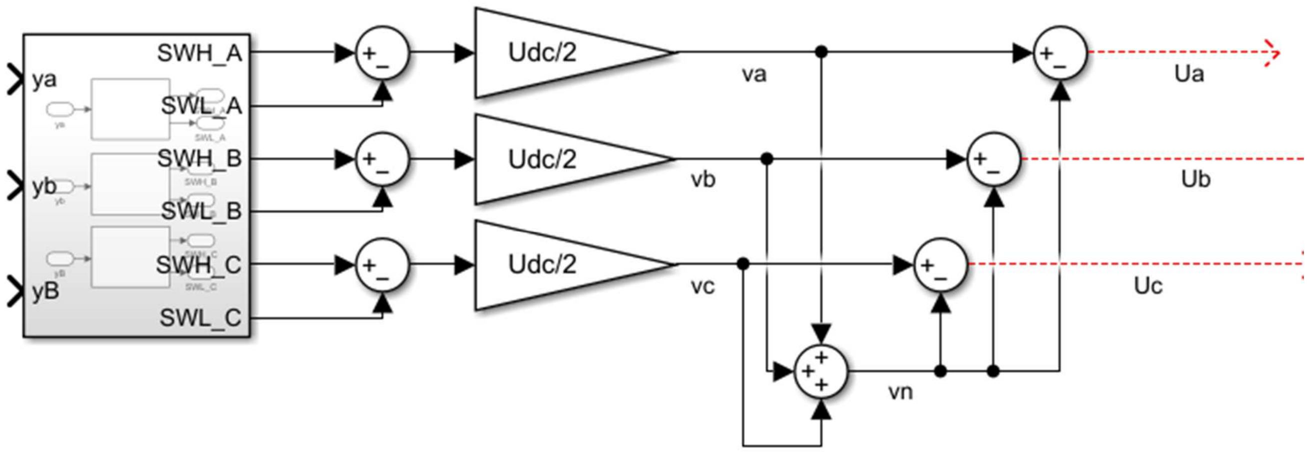


**Figure 2.** Mathematical model of three-phase inverter.

## 3. Assemble a mathematical model of a synchronous machine in the rotor coordinate system dq in Matlab/Simulink.

$$\frac{dI_d}{dt} = \frac{1}{L_s}\left(U_d - R_s I_d + Z_p L_s I_q \Omega\right)$$

$$\frac{dI_q}{dt} = \frac{1}{L_s}\left(U_d - R_s I_q - Z_p L_s I_d \Omega - Z_p \Omega \Psi_f\right)$$

$$\frac{d\Omega}{dt} = \frac{1}{J}\left(\frac{3}{2} Z_p \Psi_f I_q - T_{dist}\right)$$

Insert here simulation model.

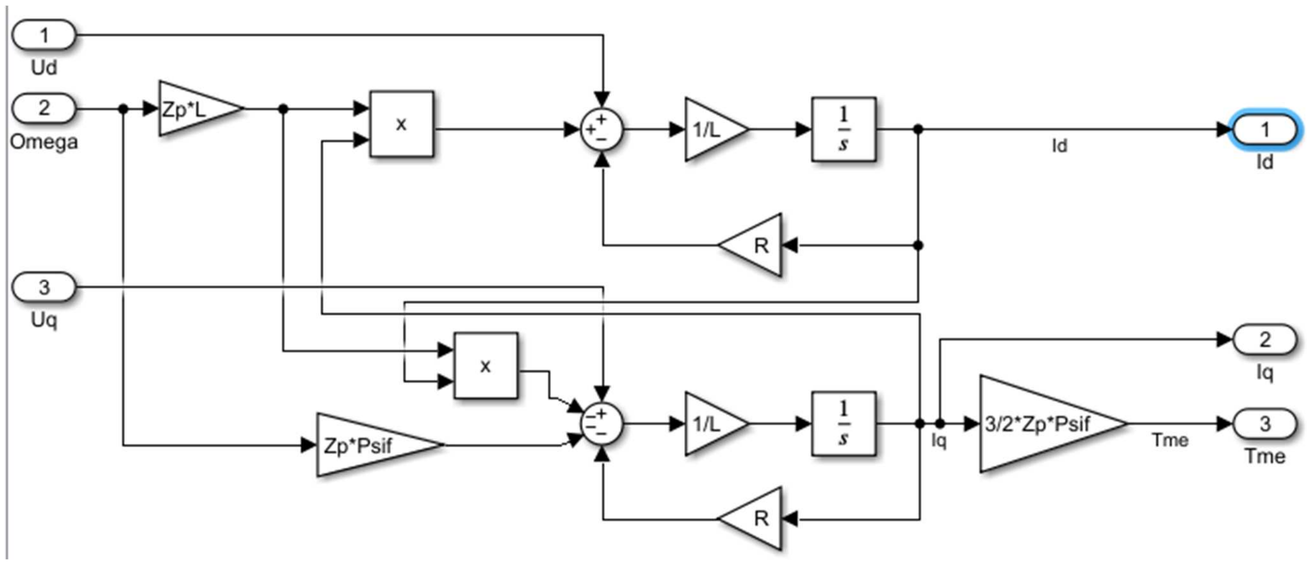


**Figure 3.a.** Simulation model of PMSM（Electrical Part）.

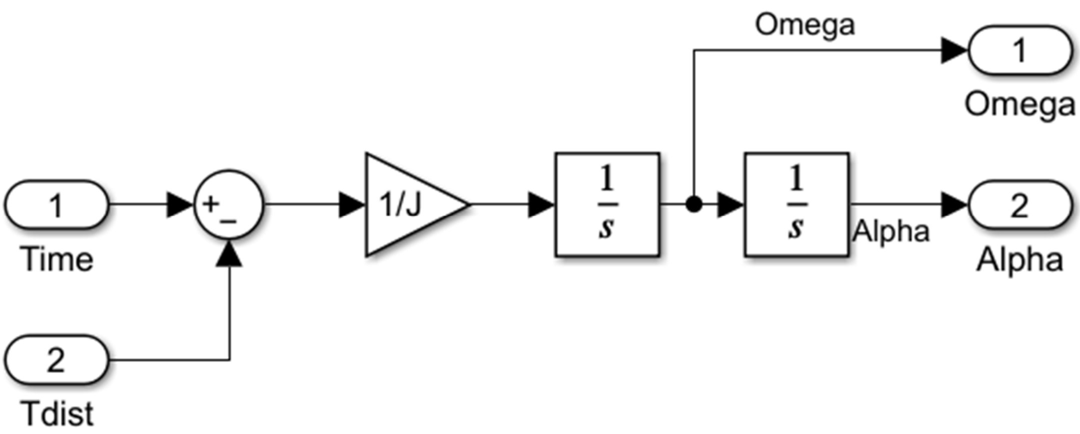


**Figure 3.b.** Simulation model of PMSM(Mechanical Part).

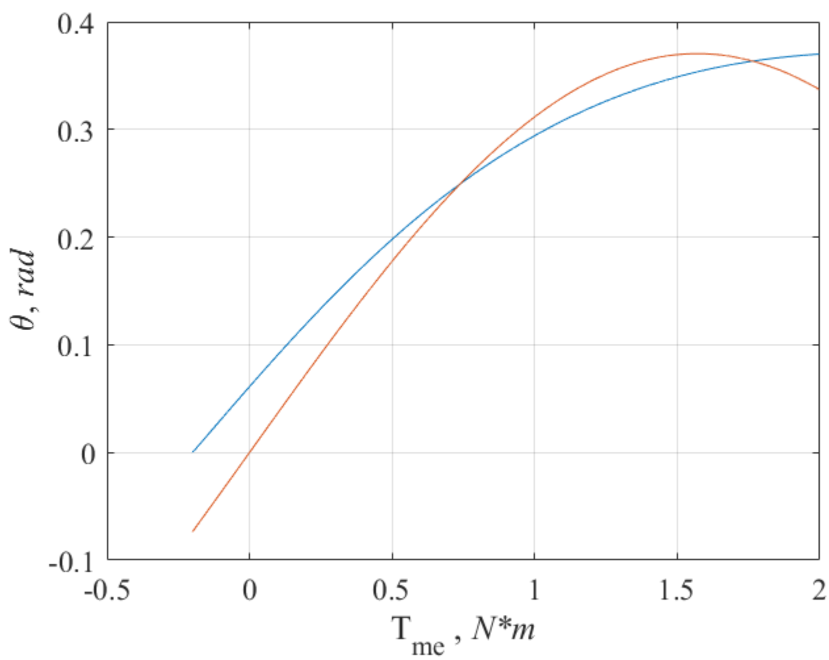


**Figure 4.** Experimental and calculated angle characteristics.

**4. Assemble a brushless DC motor based on the obtained mathematical models in Matlab / Simulink.**

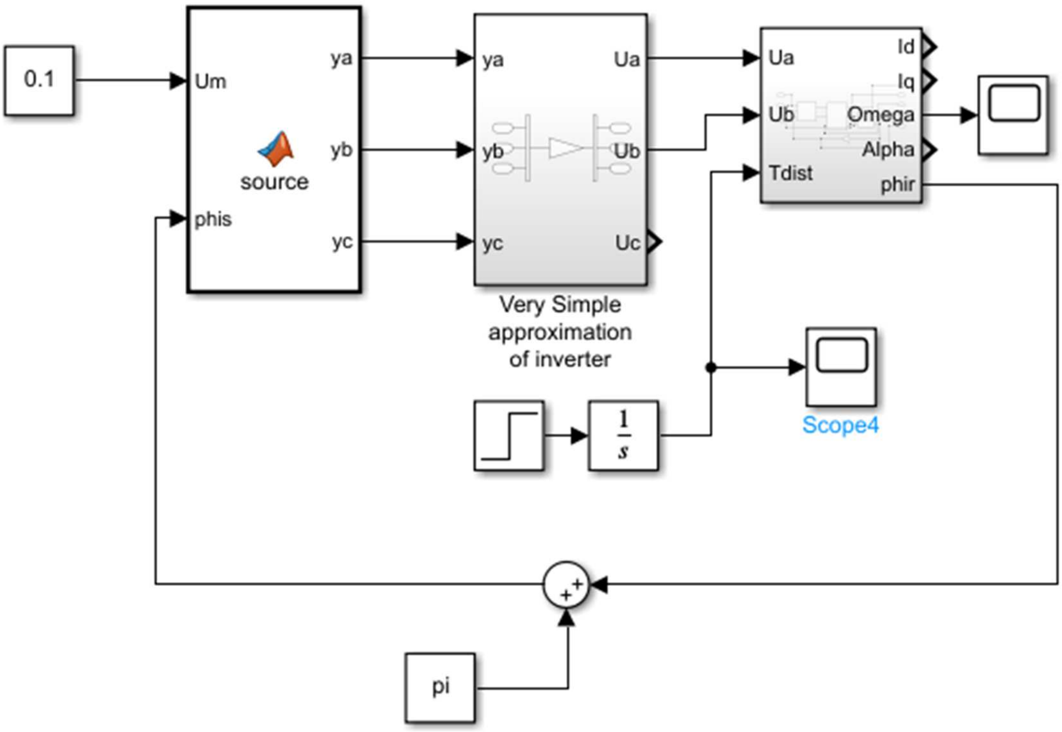


**Figure 5.** Simulation model of BLDC.

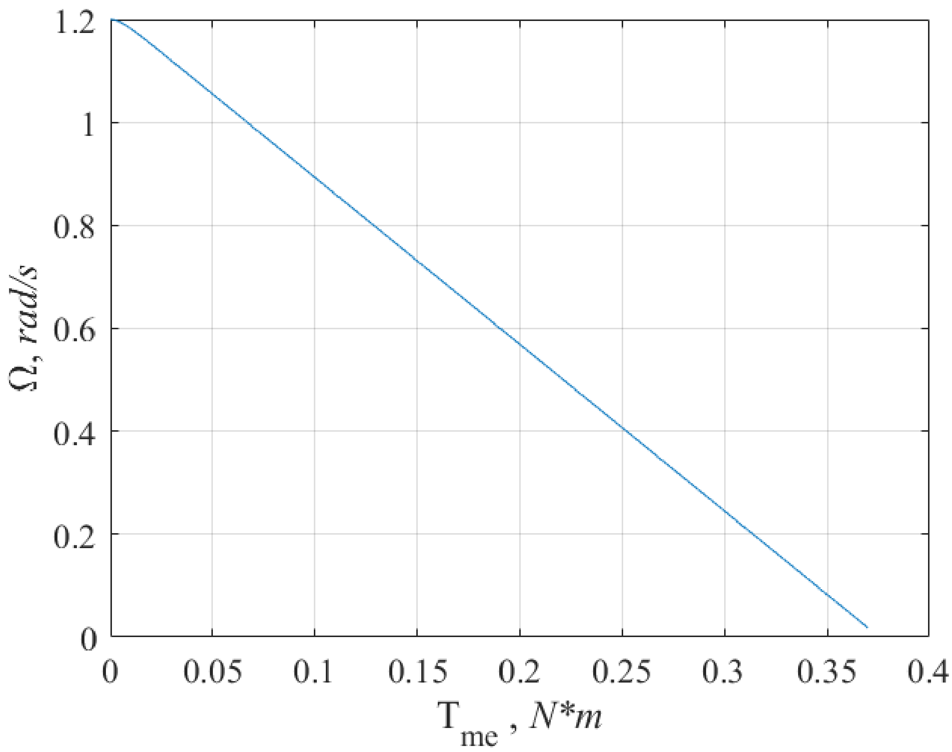


**Figure 6.** Experimental and calculated speed/torque characteristics.

**5. Create a vector control of a permanent magnet synchronous machine in Matlab/Simulink.**

$$T_T = 0.003$$

$$T_d = \frac{L}{R} = 0.0016$$

$$K_{pc} = \frac{RT_d}{T_T} = 10.3667$$

$$K_{ic} = \frac{R}{T_T} = 6479$$

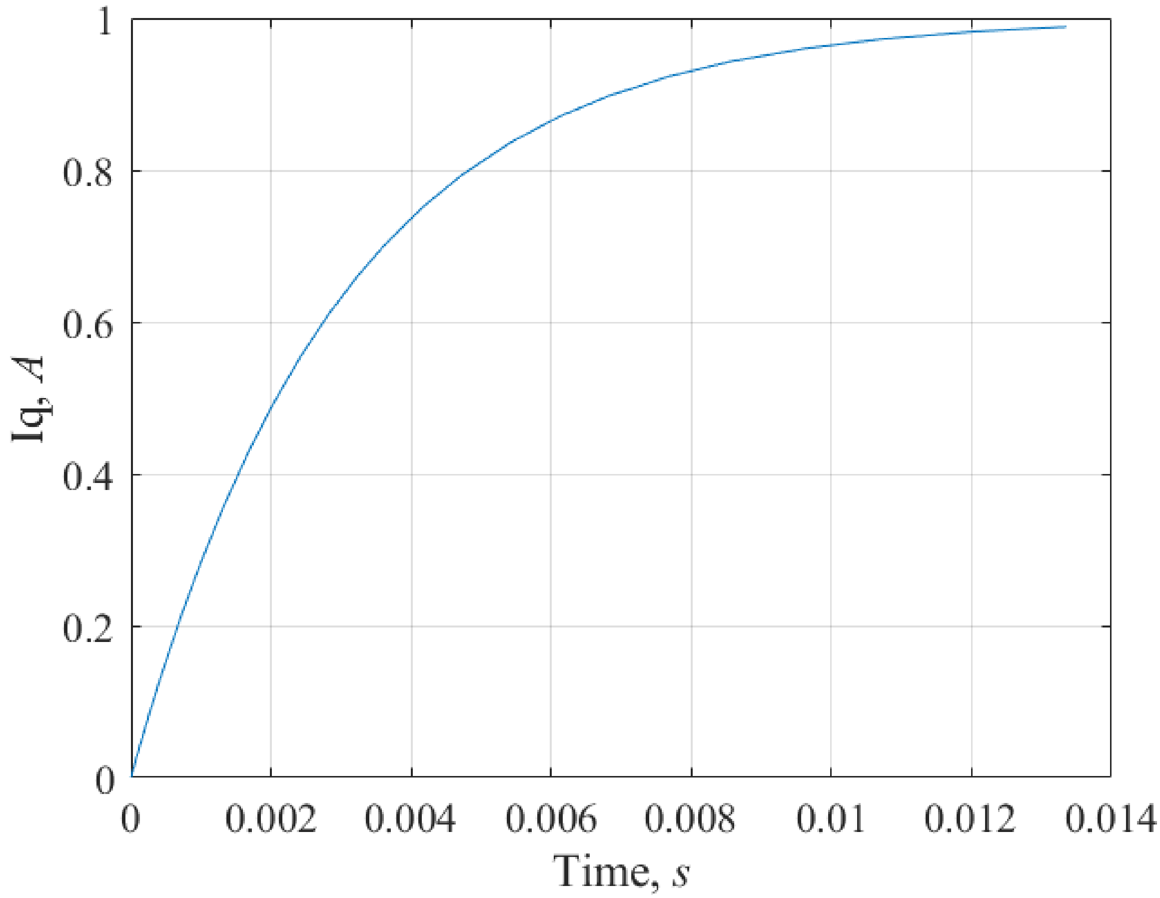


**Figure 7.** Transient process in current loop.

$$T_{mu} = T_T = 0.003$$

$$k_m = \frac{3}{2} \cdot Z_p \cdot \psi_f = 3$$

$$K_{ps} = \frac{J}{2 \cdot T_{mu} \cdot k_m} = 192.5929$$

$$K_{is} = \frac{J}{8 \cdot {T_{mu}}^2 \cdot k_m} = 16049$$

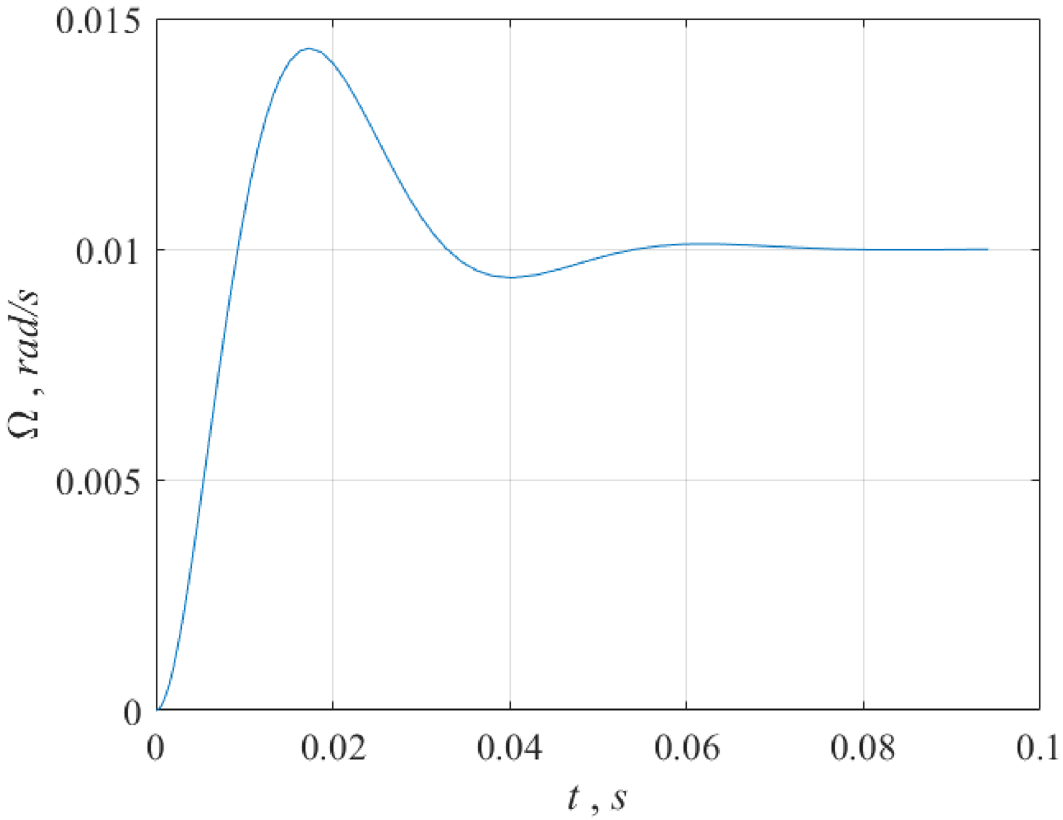


**Figure 8.** Transient process in speed loop.

## 6. Conclusion

1. Through the transformation of the coordinate system, we can more easily model and simulate the permanent magnet synchronous motor.

2. From the experimental results, the vector control can well achieve the desired steady-state effect of the motor within the specified time.