Example 9-1

In this example, the "test" induction motor is speed controlled using encoder-less DTC. It is initially operating in steady state as described in Chapter 1.

At time $t = 0.4\ s$, a load-torque disturbance causes it to reduce to one-half of its initial value. The objective is to keep the load speed constant at its initial value.

The crossover-frequency for the speed controller is 25 rad/s and the phase margin is 60 degrees.

Simulate the above system using Simulink, assuming the following additional parameters:

Maximum simulation time $T_{max} = 1.0s$
Sampling time in the stator voltage vector selection portion $\Delta T = 25ms$
Sampling time in the speed estimation portion $\Delta T_w = 500ms$
Hysteresis band for torque $\Delta T_{em} = 5\% * T_{em}(0)$
Hysteresis band for flux $\Delta \hat{\lambda}_s = 0.5\% * \hat{\lambda}_s(0)$
DC-bus voltage of the inverter $V_d = 1000V$
Switching frequency 10 $s\ f = kHz$
Triangular waveform peak $\hat{V}_{tri} = 5V$

Note that tables in Simulink have zero-based indices. However, the tables in MATLAB have unity-based indices.

Selection of Stator Voltage Vector. To increase torque in the torque controller, a nonzero voltage vector is applied whose selection is based on the output of the flux controller (see Table 9-1 in Chapter 9). However, a zero voltage vector (v_0 or v_7) is applied to decrease torque unless the estimated torque exceeds the reference torque by 2* ΔT_{em} , in which case a non-zero voltage vector is applied to decrease torque, taking the output of the flux controller into account (see Table 9-1 in Chapter 9). If the torque controller determines to apply a zero voltage vector, this is done regardless of the output of the flux controller.

Plot various results such as 1) torque (reference and estimated), 2) speed (reference, actual and estimated), and 3) stator flux (reference and estimated).
Modify the simulation to get the alfa and the beta components of the estimated stator and rotor fluxes. Plot them on X-Y plots.

Fig. 1 shows the lop-level diagram of the system simulation. Torque waveforms are shown in Fig. 2. Fig. 3 shows the speed waveforms. Fig. 4 shows the stator flux. Plots of stator and rotor fluxes in α-β coordinates (fl_s_a versus fl_s_b and fl_r_a versus fl_r_b) are shown in Fig. 5.

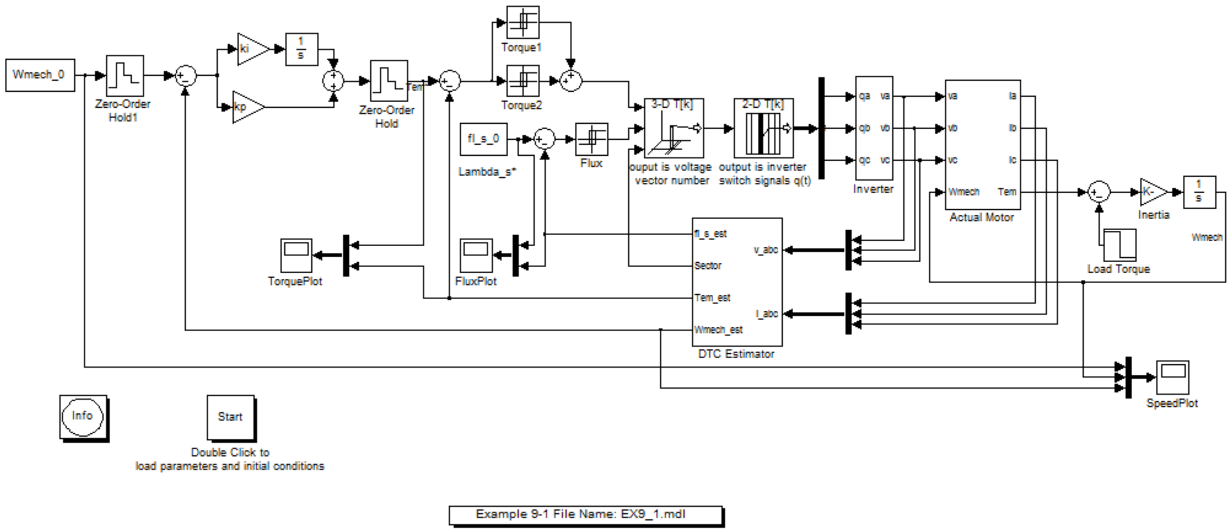

Fig. 1 Top Level Diagram of the System Simulation.

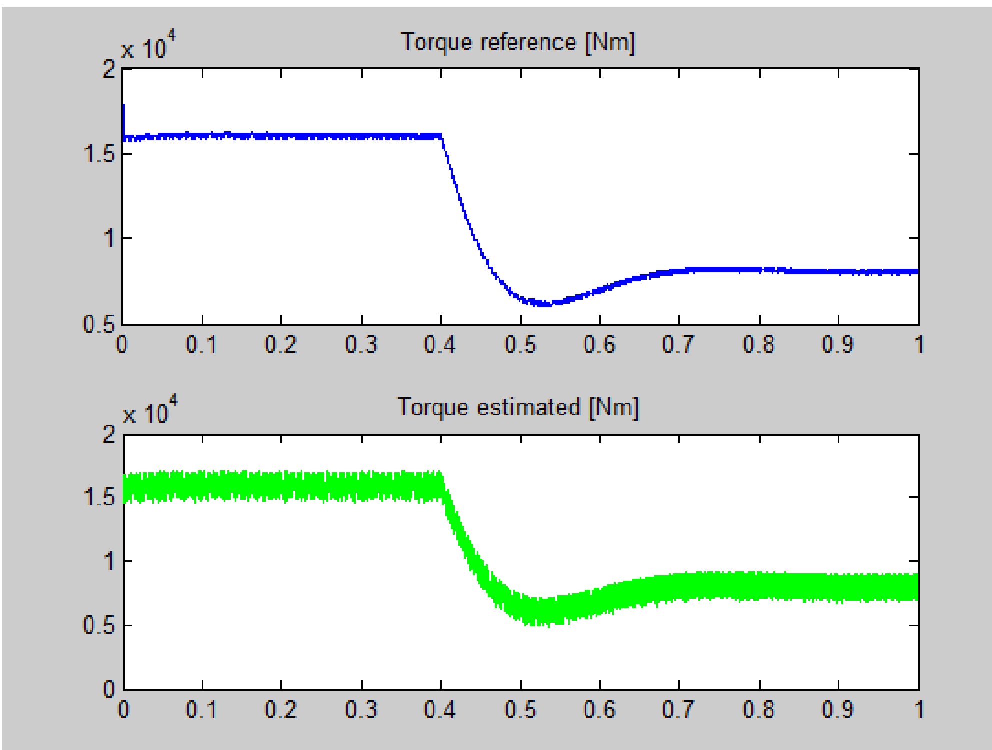

Fig. 2 Torque Waveforms

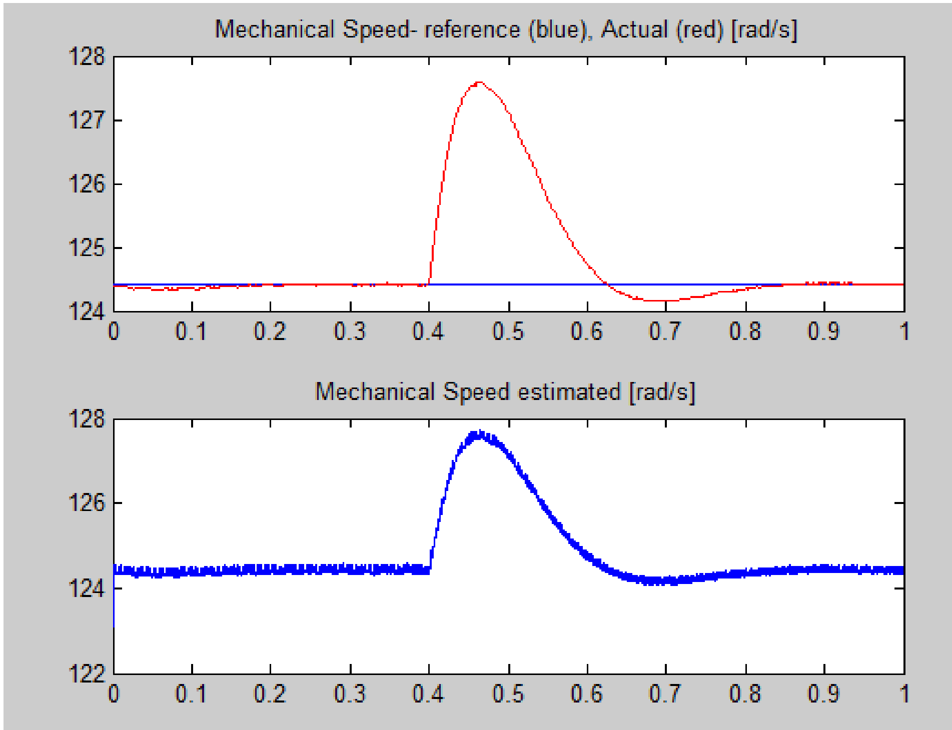

Fig. 3 Speed Waveforms

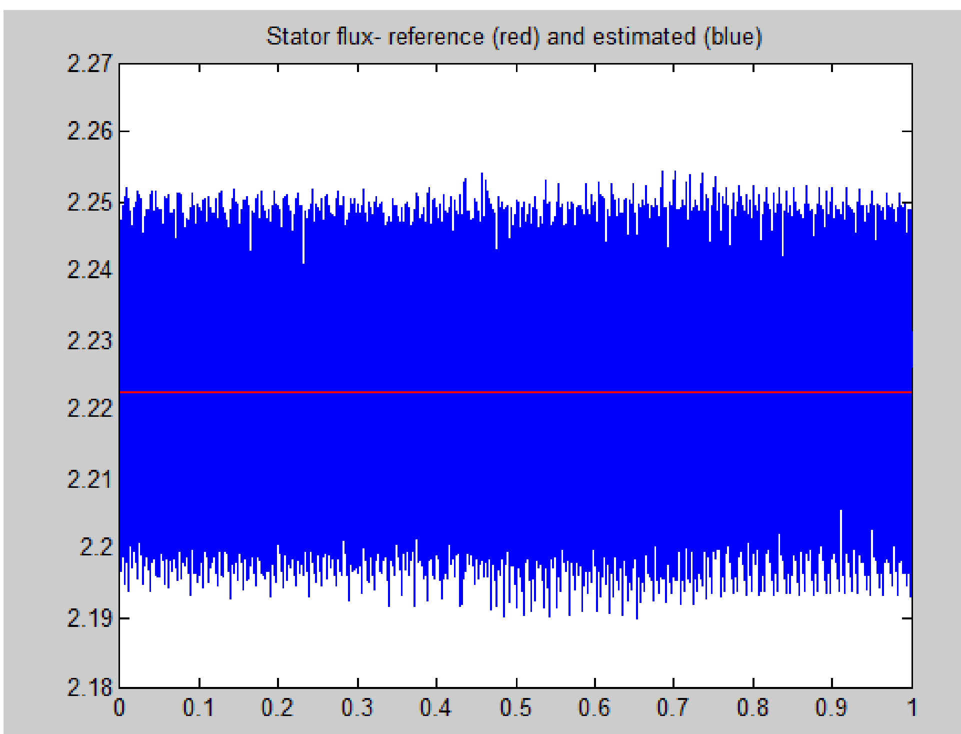

Fig. 4 Stator Flux.

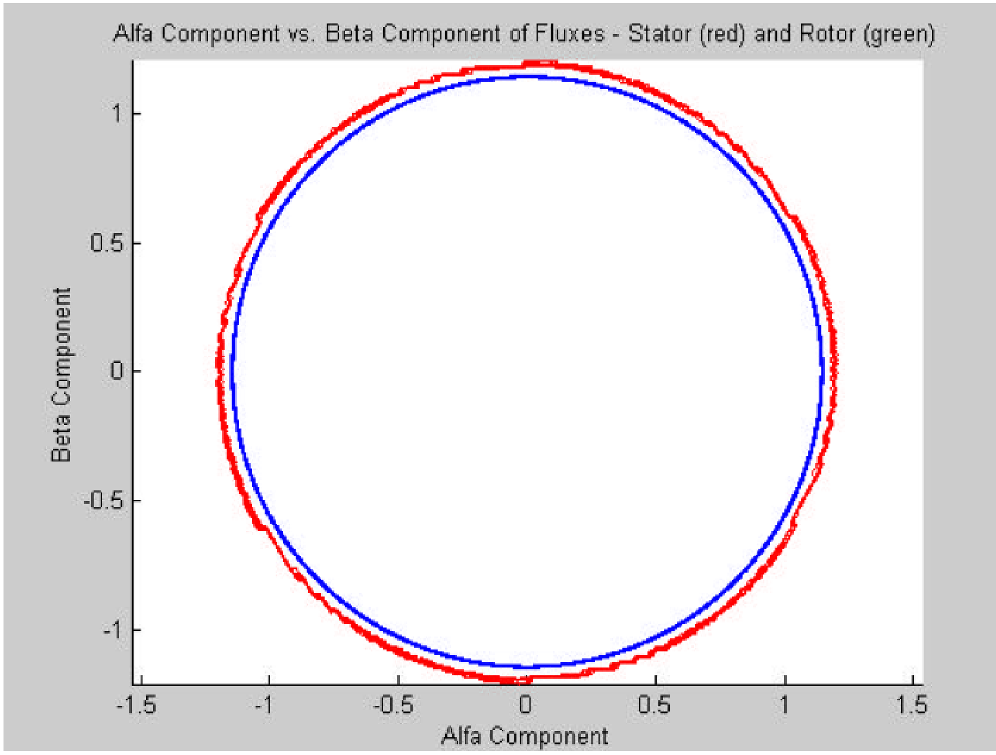

Fig. 5 Stator and Rotor Fluxes.