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PRACTICAL COURSE

Simulation and Optimization of Mechatronic Drive Systems for MSPE

Summer Semester 2024

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Experiment 5
Direct Torque Control of the AC Drive

5.3 Implementation of the Direct Torque Control

5.3.1 Flux and Torque Control Loop

1.) The signal flow diagram of the switching state to the output voltage is shown below:

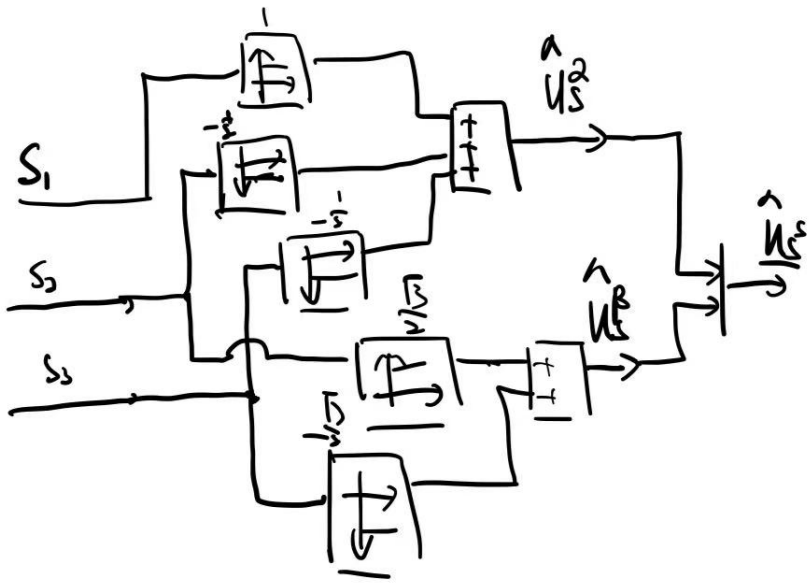

Figure 5.1: Switching State to Output Voltage Signal Flow Diagram

The table of the switching states and the corresponding voltage is given below:

S_1	S_3	S_5	$V_{s\alpha}$	$V_{s\beta}$
0	0	0	0	0
1	0	0	$\frac{2}{3}V_{dc}$	0
0	1	0	$-\frac{1}{3}V_{dc}$	$\frac{1}{\sqrt{3}}V_{dc}$
1	1	0	$\frac{1}{3}V_{dc}$	$\frac{1}{\sqrt{3}}V_{dc}$
0	0	1	$-\frac{1}{3}V_{dc}$	$-\frac{1}{\sqrt{3}}V_{dc}$
1	0	1	$\frac{1}{3}V_{dc}$	$-\frac{1}{\sqrt{3}}V_{dc}$
0	1	1	$-\frac{2}{3}V_{dc}$	0
1	1	1	0	0

Table 5.1: Switching States and Corresponding Voltages

These vcectors can be represented in a hexagonal diagram as shown below:

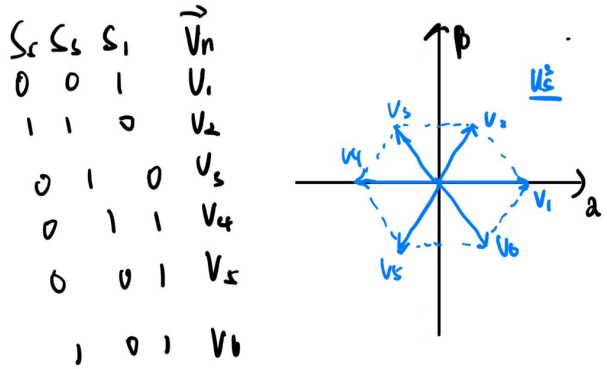

Figure 5.2: Hexagonal Diagram of Voltage Vectors

2.) The signal flow diagrams of the flux and the torque estimator:

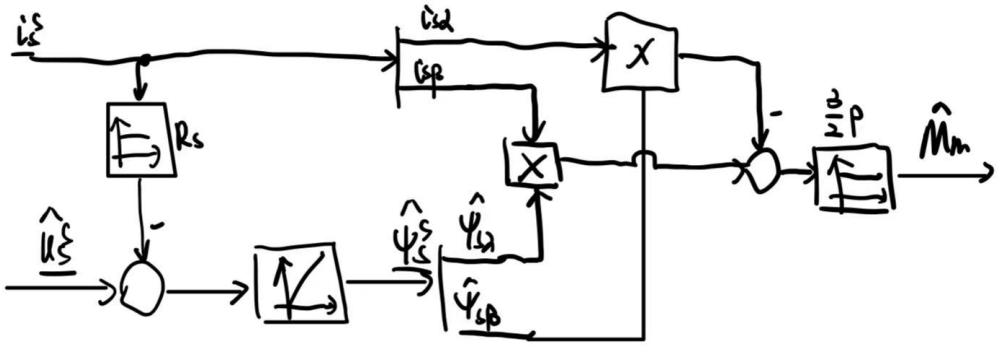

Figure 5.3: Flux Estimator Signal Flow Diagram

3.) The signal flow diagram for the determination of the absolute value and the angle of the space vector of the stator flux is shown below:

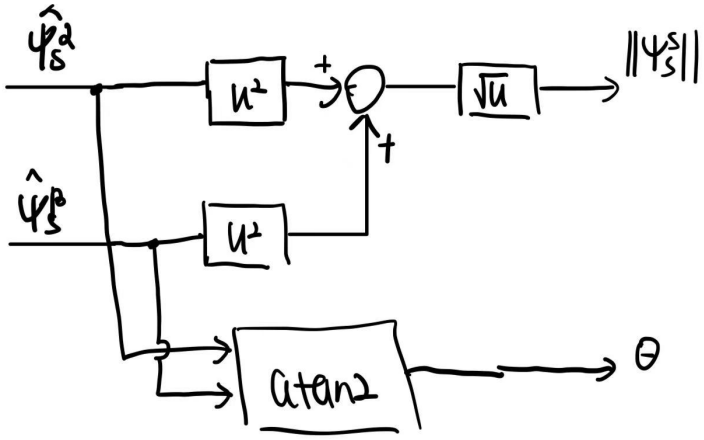

Figure 5.4: Flux Magnitude and Angle Determination Signal Flow Diagram

4.) we can use the angle of the stator flux to determine the sector. The matlab function Implementation is given below:

Listing 5.1: Sector Determination Function

```
theta = atan2(psi_beta, psi_alpha);
theta= mod(theta+pi/6, 2*pi);
sector = floor(theta/(pi/3)) + 1;
```

5.) For the torque comparator, when h_M is 1, it means that the actual torque is less than the reference torque, and when h_M is -1, it means that the actual torque is greater than the reference torque. When h_M is 0, it indicates that the actual torque is equal to the reference torque. Therefore, we have to increase, decrease or maintain the torque respectively.

For the flux comparator, when h_{ψ_s} is 1, it means that the actual flux is less than the reference flux, and when h_{ψ_s} is -1, it means that the actual flux is greater than the reference flux. Therefore, we have to increase or decrease the flux respectively.

The switching table for the DTC is given below. The underlined switching states are the ones that should be applied.

h_{ψ_s}	h_M	S_1	S_2	S_3	S_4	S_5	S_6
1	1	$\underline{v_2}$	$\underline{v_3}$	$\underline{v_4}$	$\underline{v_5}$	$\underline{v_6}$	$\underline{v_1}$
1	0	$\underline{v_1}$	$\underline{v_2}$	$\underline{v_3}$	$\underline{v_4}$	$\underline{v_5}$	$\underline{v_6}$
1	-1	$\underline{v_6}$	$\underline{v_1}$	$\underline{v_2}$	$\underline{v_3}$	$\underline{v_4}$	$\underline{v_5}$
-1	1	$\underline{v_3}$	$\underline{v_4}$	$\underline{v_5}$	$\underline{v_6}$	$\underline{v_1}$	$\underline{v_2}$
-1	0	$\underline{v_4}$	$\underline{v_5}$	$\underline{v_6}$	$\underline{v_1}$	$\underline{v_2}$	$\underline{v_3}$
-1	-1	$\underline{v_5}$	$\underline{v_6}$	$\underline{v_1}$	$\underline{v_2}$	$\underline{v_3}$	$\underline{v_4}$

Table 5.2: Switching Table for Direct Torque Control