Space Vector and Direct Torque Control

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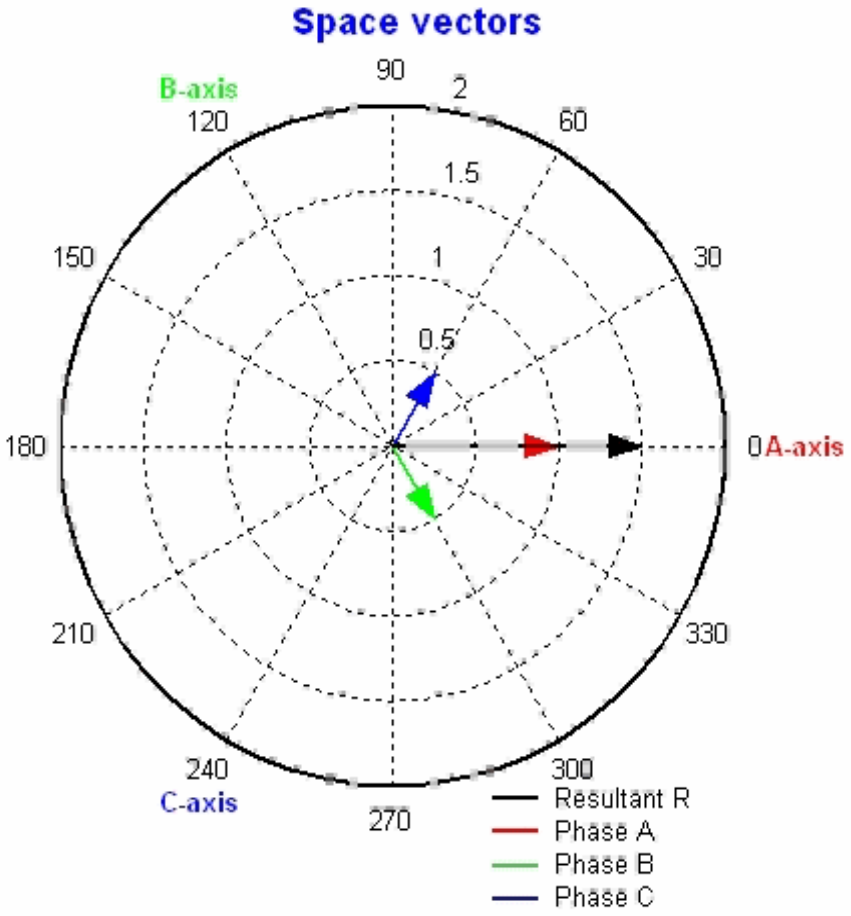
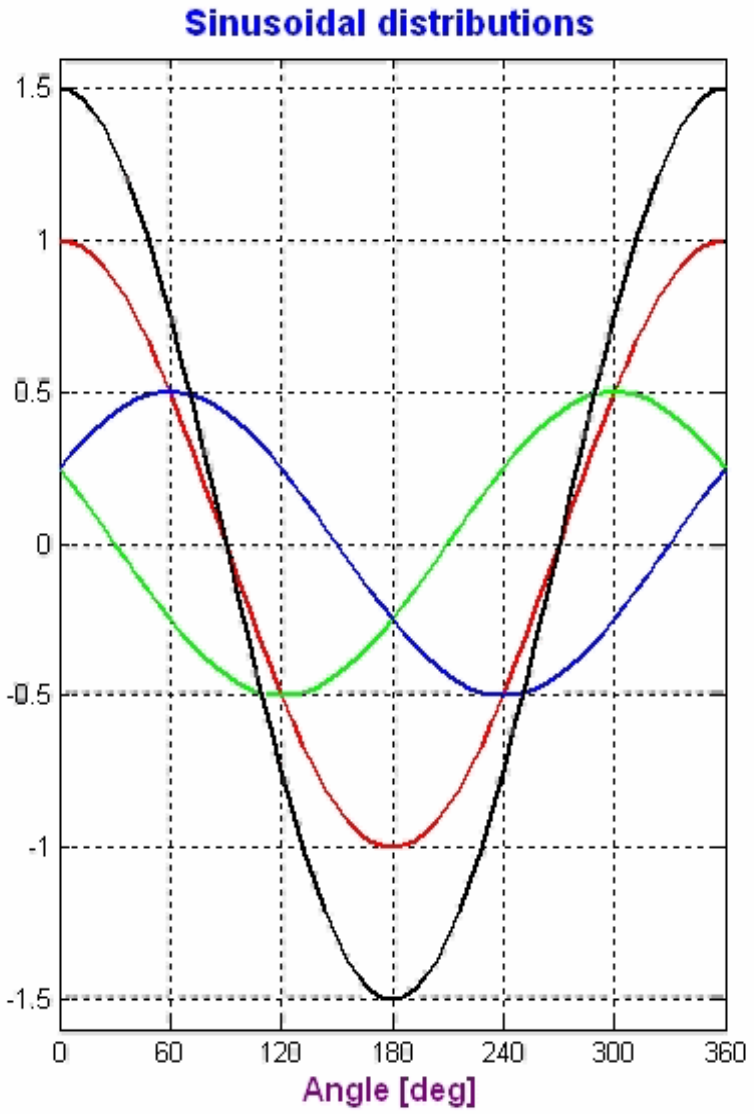
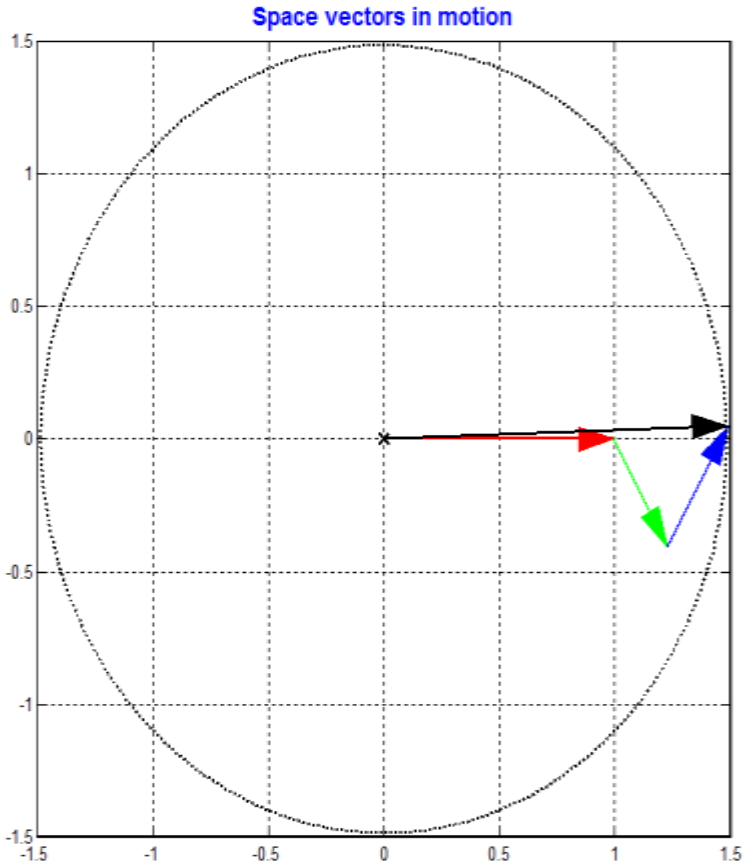
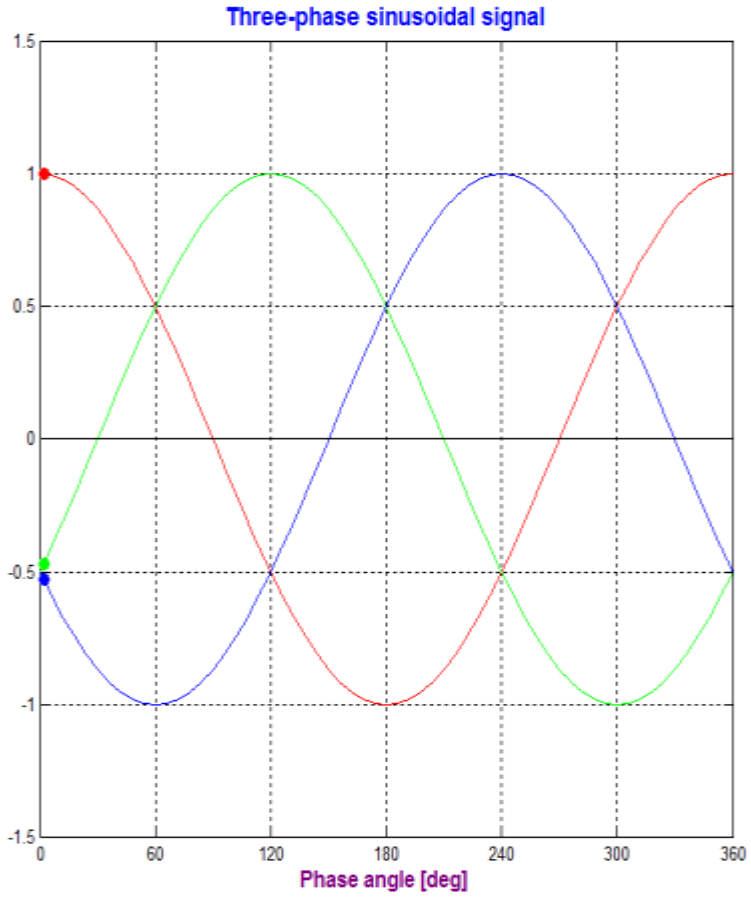
Space Vector Concept





Space Vector Concept

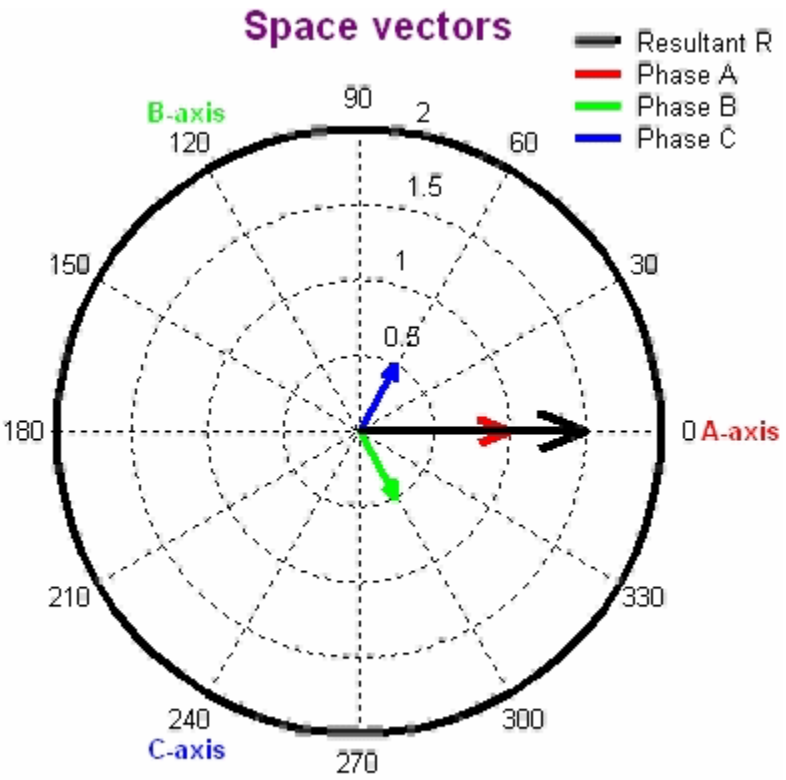


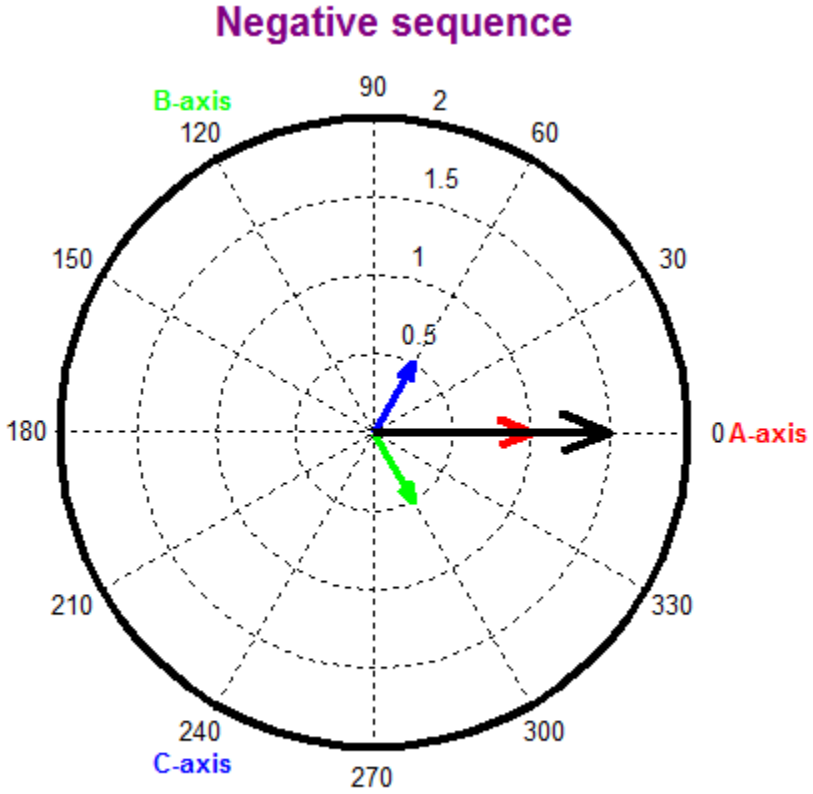


Phase A Phase B Phase C

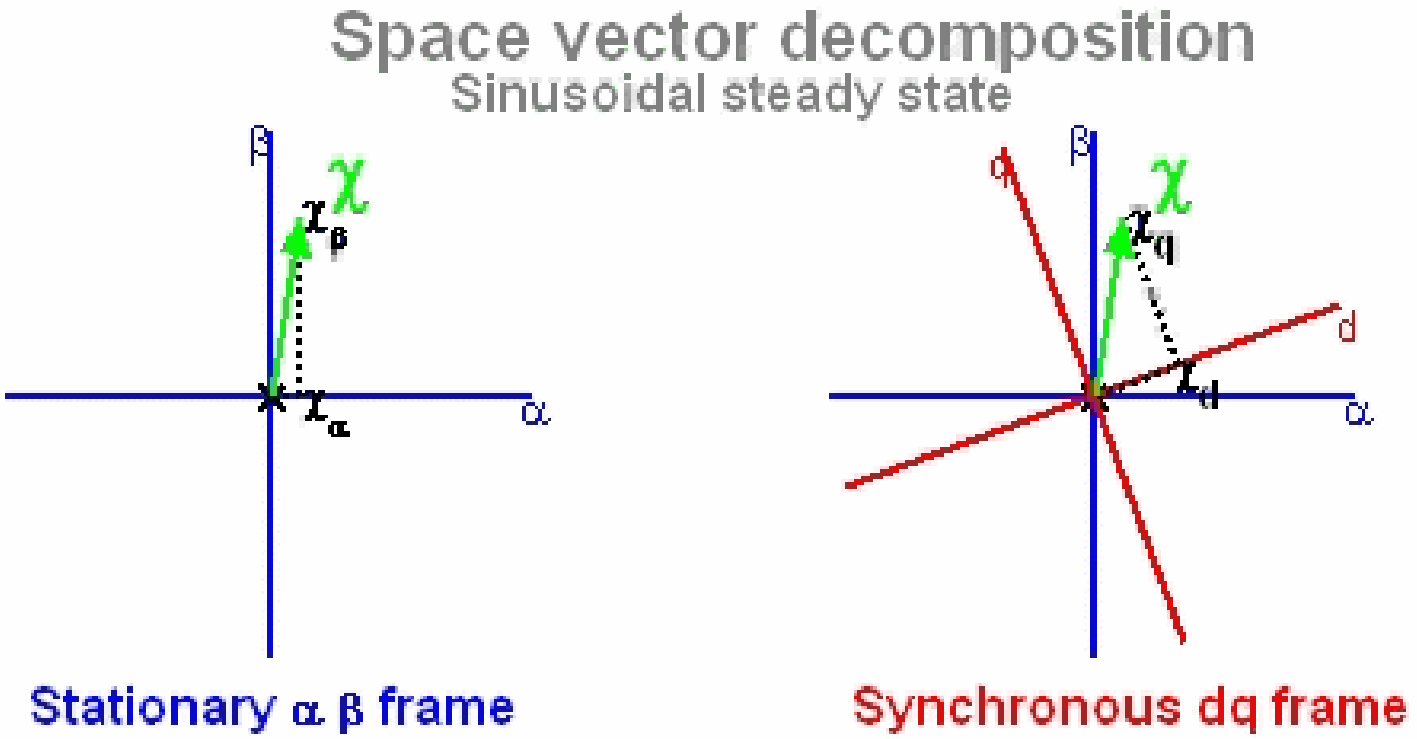
Resultant rotating space vector

Positive and Negative Sequence





Space Vector Concept

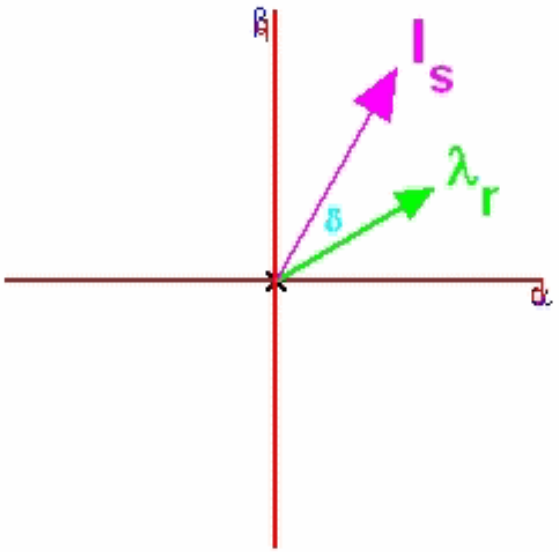


Space Vector Concept

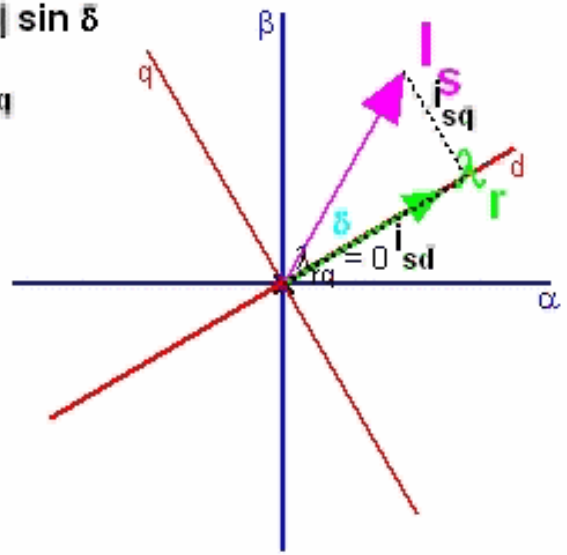
Torque = $k\ \lambda_r \otimes I_s$

$= k\ |\lambda_r|\ |I_s| \sin\delta$

$= k_1\ i_{sd}\ i_{sq}$



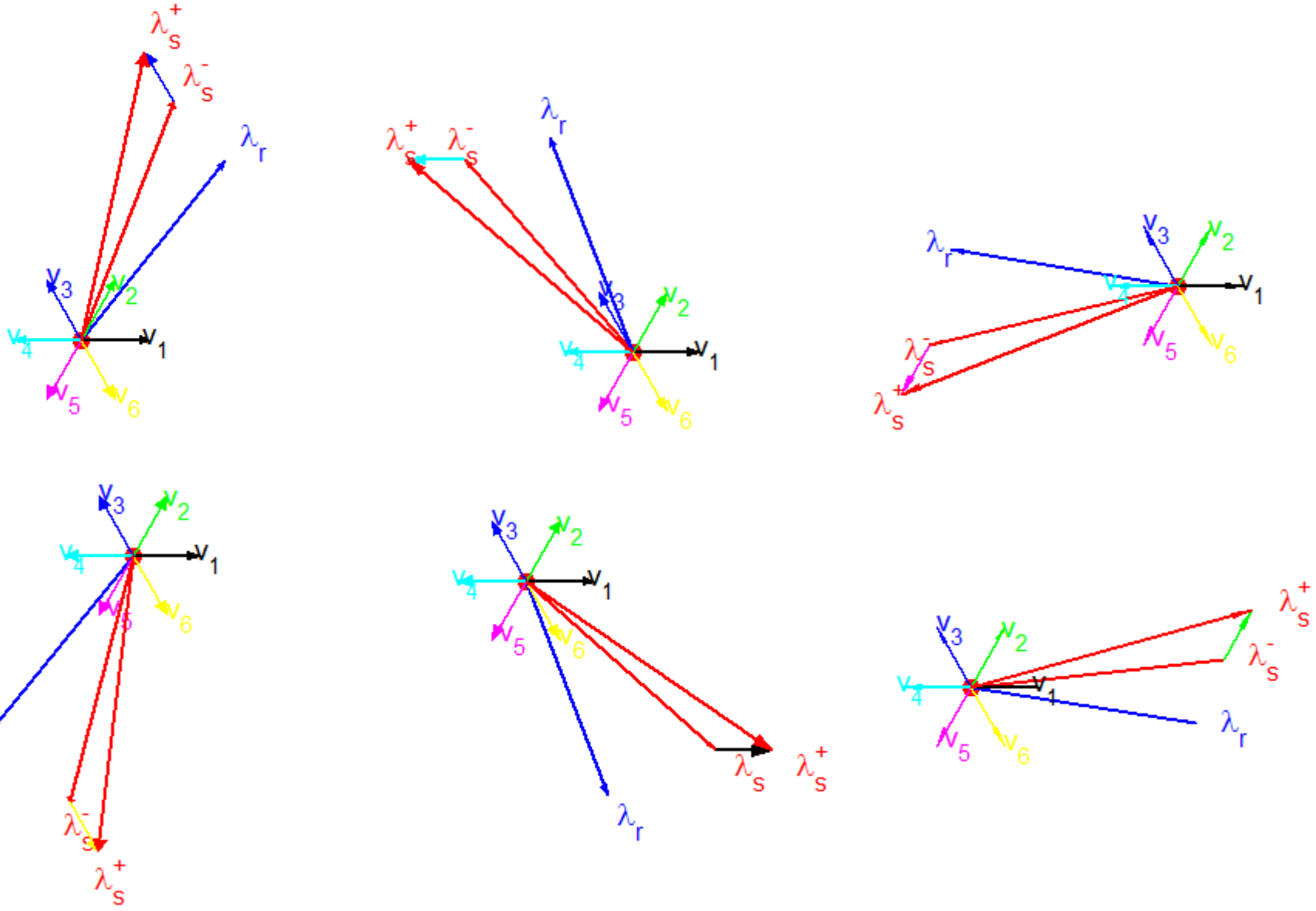
Synchronous dq frame
(arbitrary orientation)



Synchronous dq frame
(oriented on rotor flux linkage λ_r)

Direct Torque Control

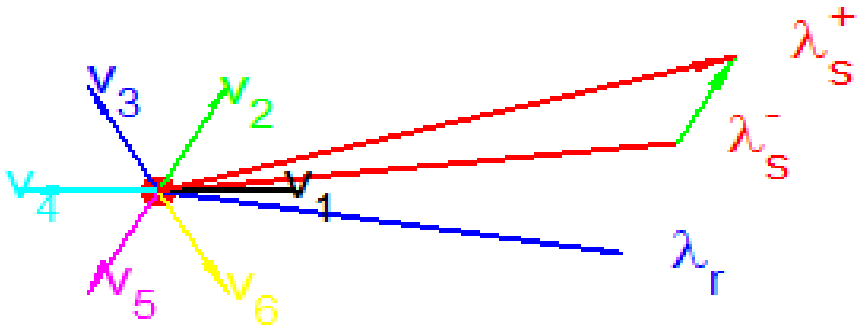
Case 1: Increase torque and increase flux



Direct Torque Control

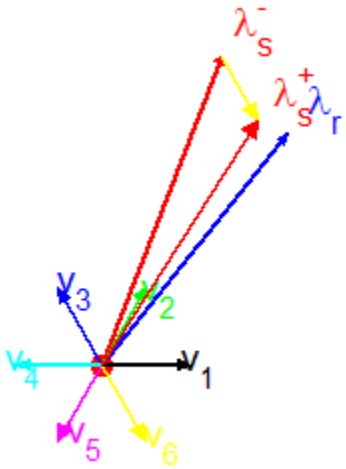
Case 1: Increase torque and increase flux

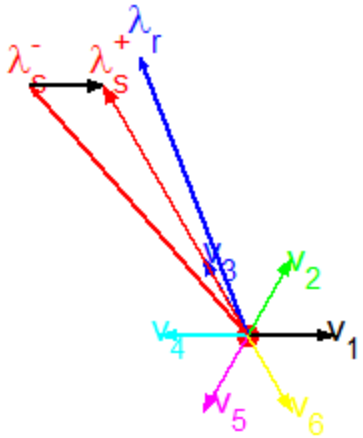
increase flux
increase torque

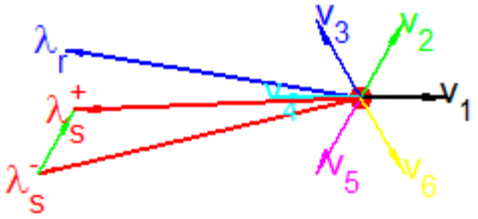


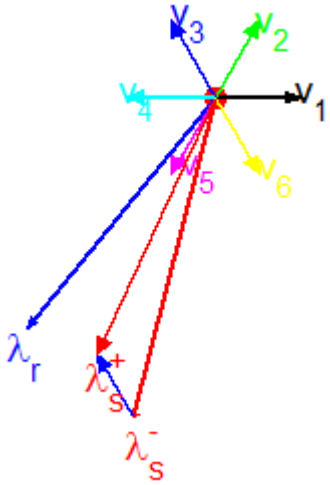
Direct Torque Control

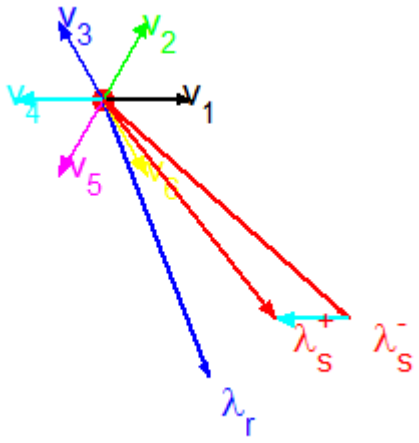
Case 2: Decrease torque and decrease flux

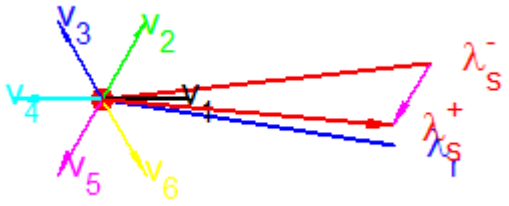








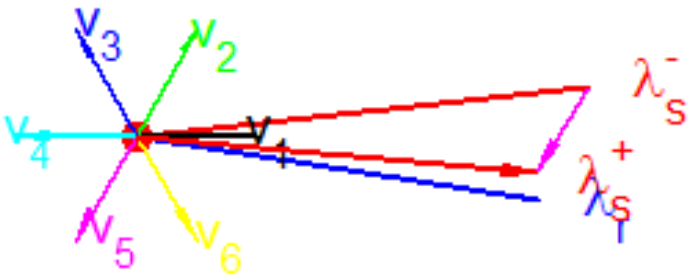




Direct Torque Control

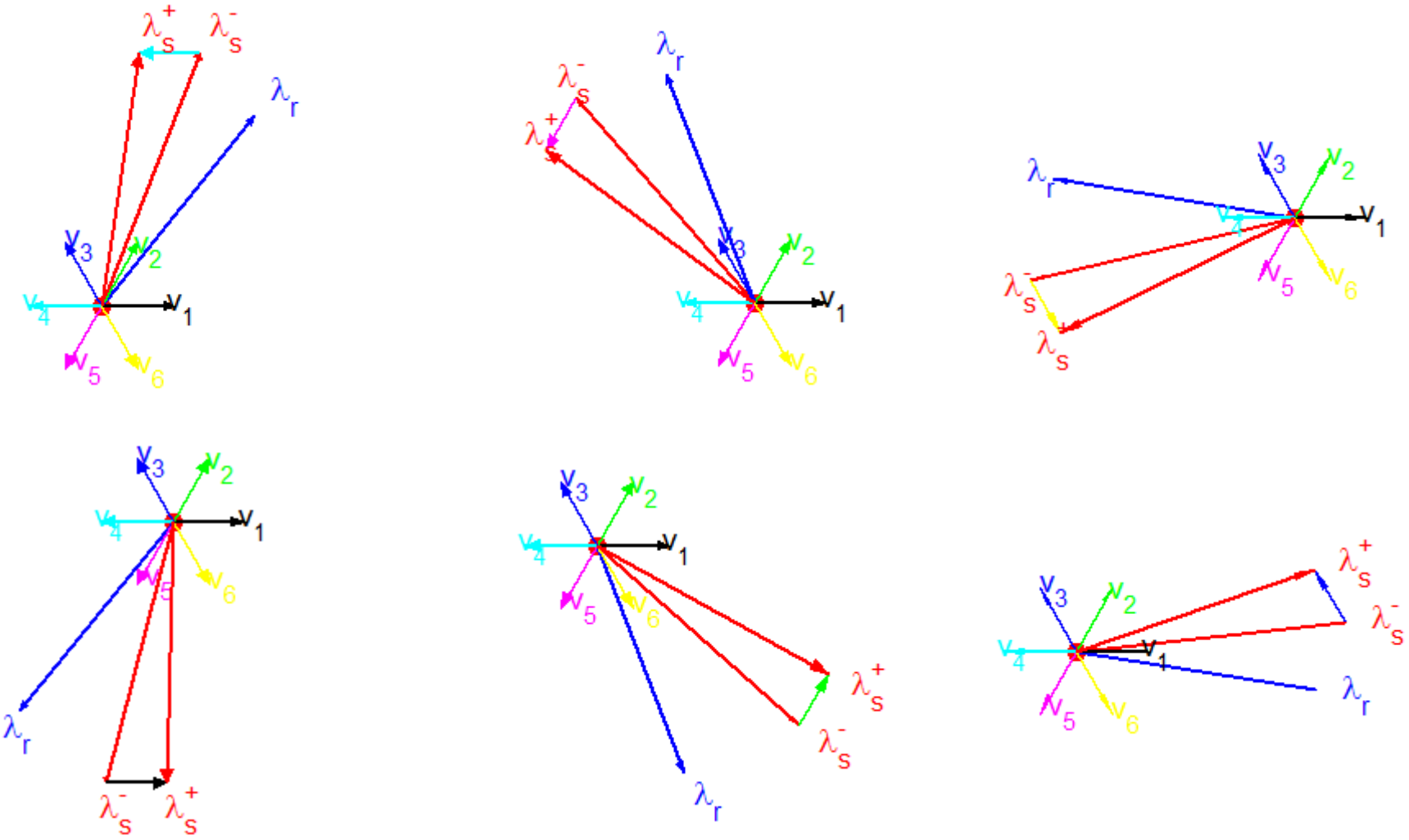
Case 2: Decrease torque and decrease flux

decrease flux
decrease torque



Direct Torque Control

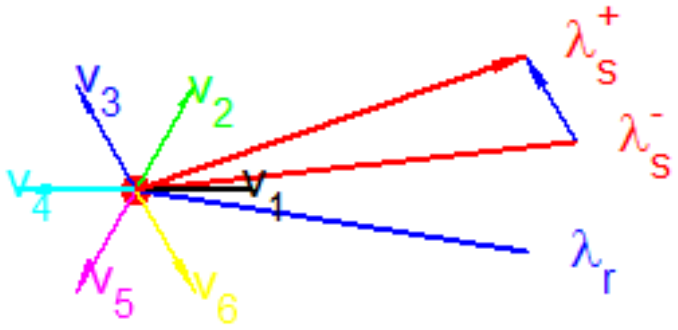
Case 3: Decrease flux and increase torque



Direct Torque Control

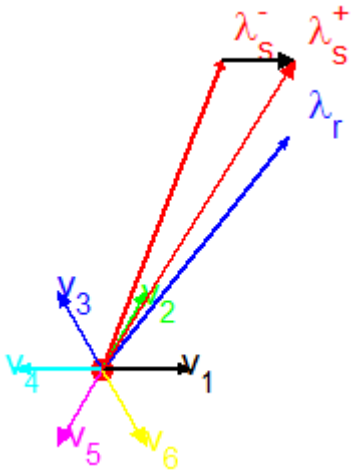
Case 3: Decrease flux and increase torque

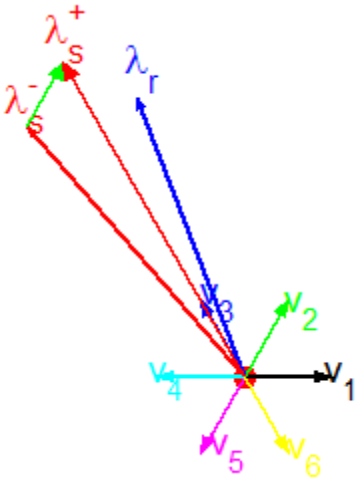
decrease flux
increase torque

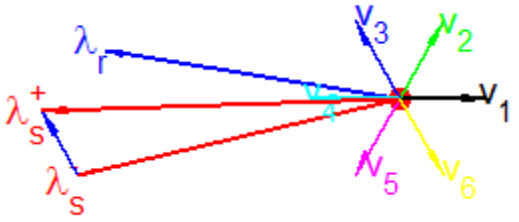


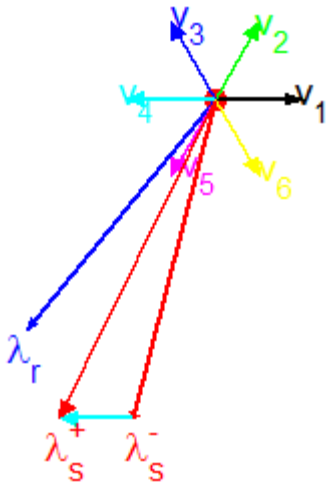
Direct Torque Control

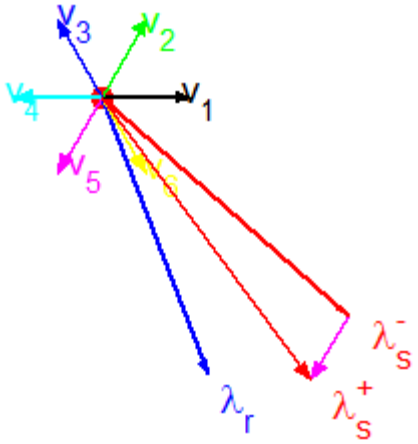
Case 4: Increase flux and decrease torque

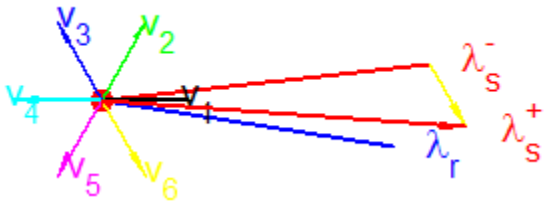










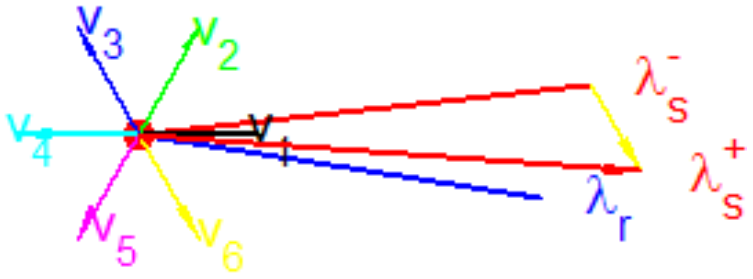


Direct Torque Control

Case 4: Increase flux and decrease torque

increase flux

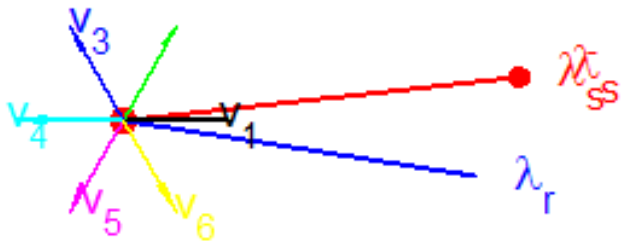
decrease torque



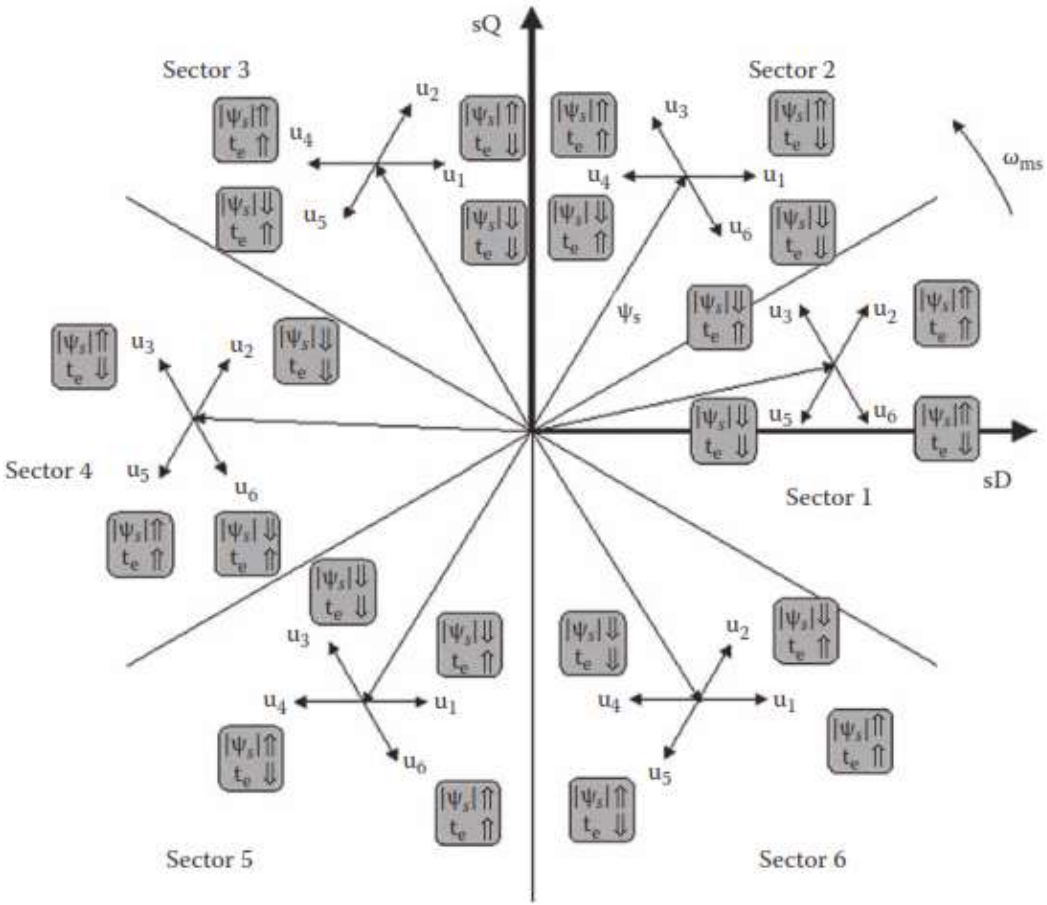
Direct Torque Control

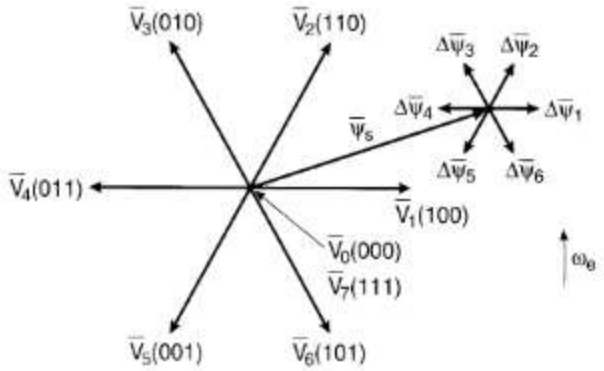
Case 5: No Change

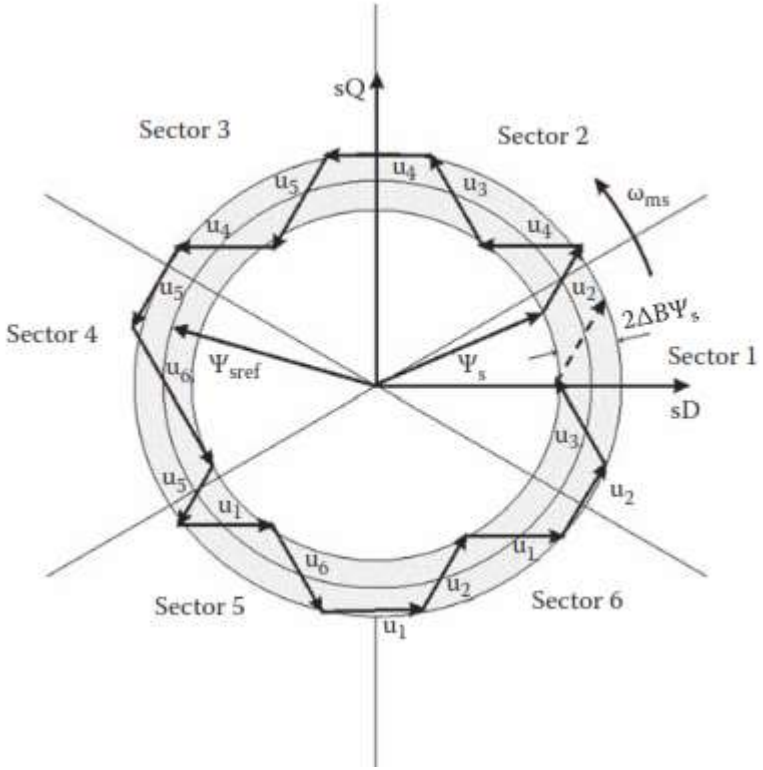
No change



Selection of Voltage Vector



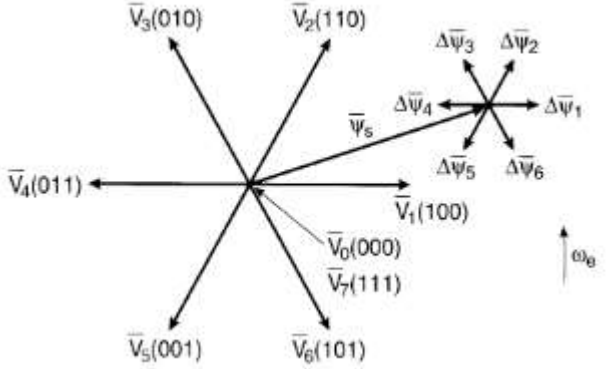




Switching Table for Inverter

H_ψ	H_{Te}	S(1)	S(2)	S(3)	S(4)	S(5)	S(6)
1	1	V_2	V_3	V_4	V_5	V_6	V_1
	0	V_0	V_7	V_0	V_7	V_0	V_7
	−1	V_6	V_1	V_2	V_3	V_4	V_5
−1	1	V_3	V_4	V_5	V_6	V_1	V_2
	0	V_7	V_0	V_7	V_0	V_7	V_0
	−1	V_5	V_6	V_1	V_2	V_3	V_4

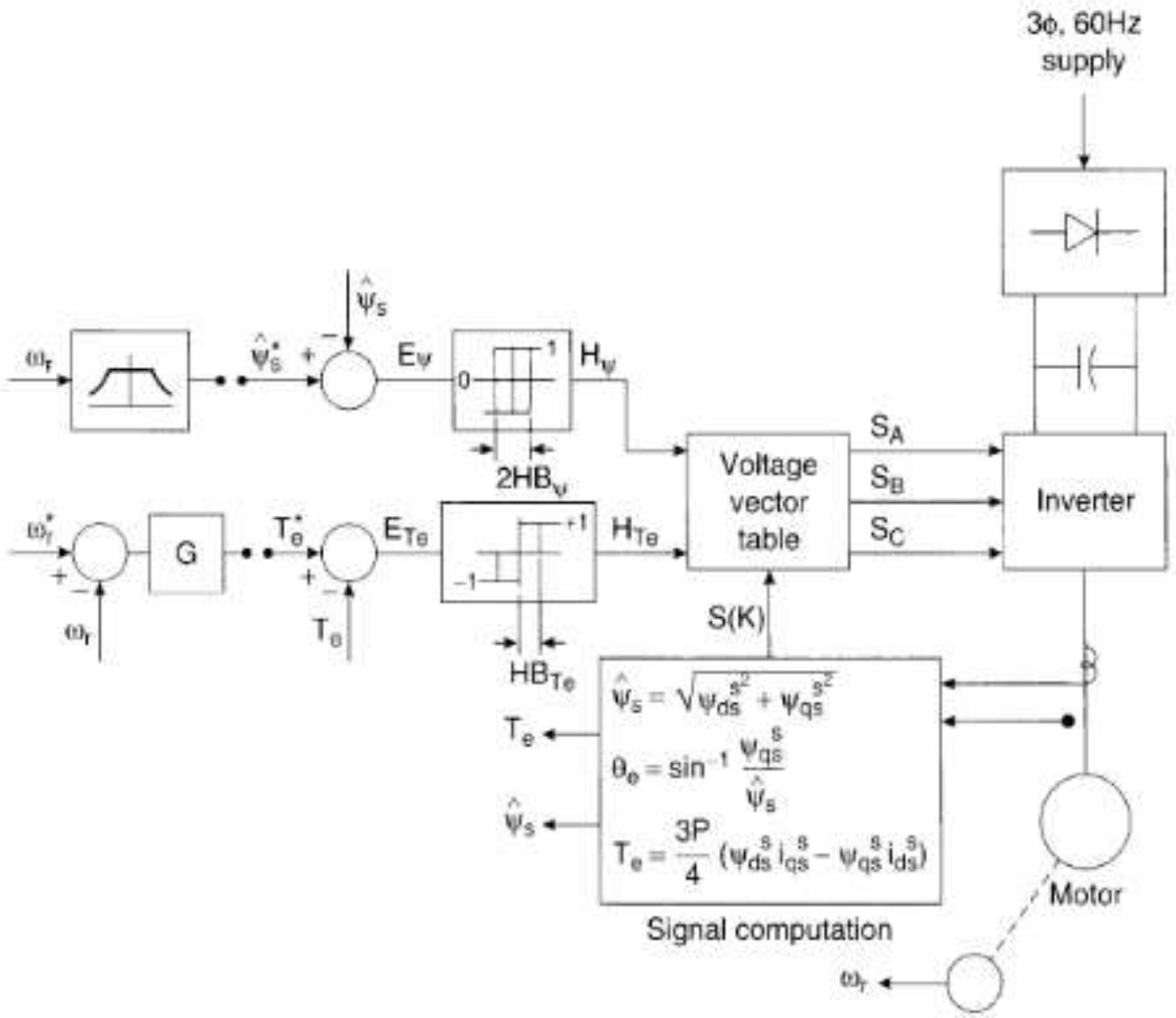
Table 8.1 Switching Table of Inverter Voltage Vectors



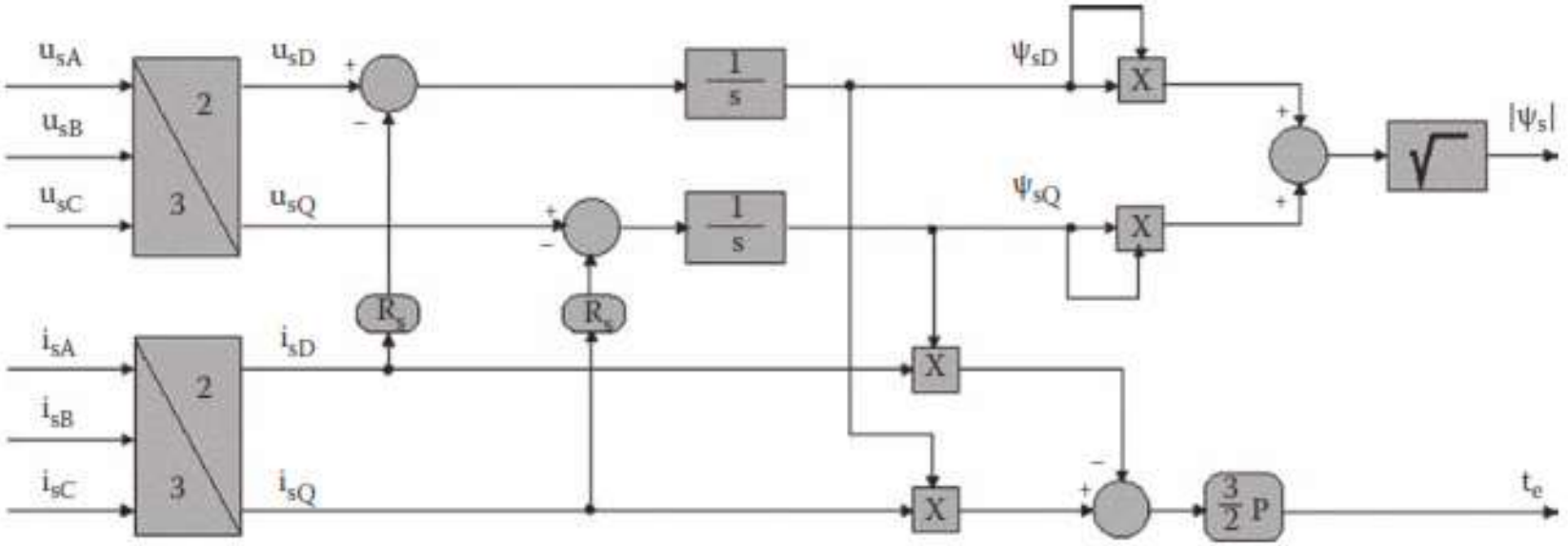
Voltage vector	V_1	V_2	V_3	V_4	V_5	V_6	V_0 or V_7
ψ_s	↑	↑	↓	↓	↓	↑	0
T_e	↓	↑	↑	↑	↓	↓	↓

Flux and Torque Variations Due to Applied Voltage Vector in Figure

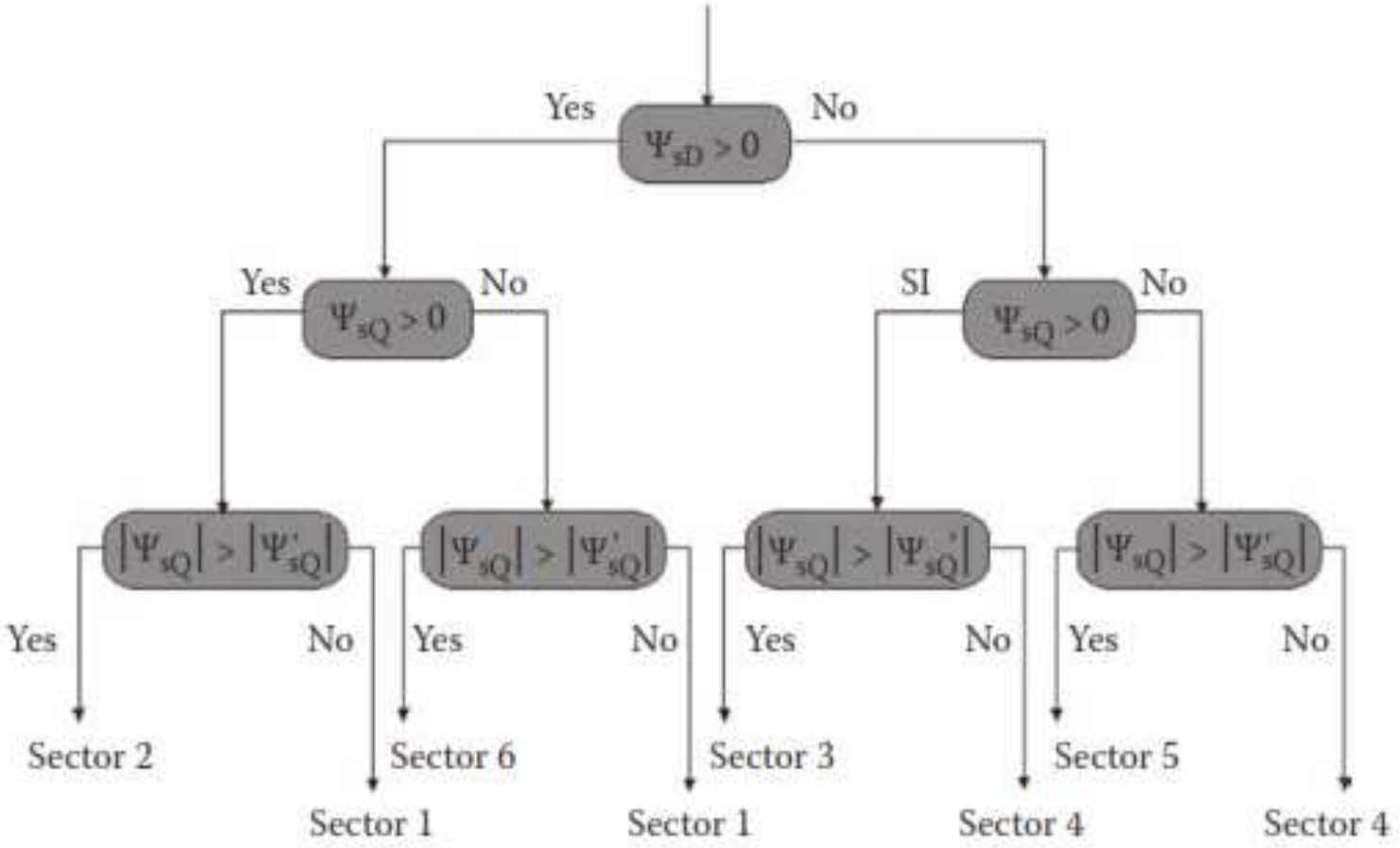
DTC Bock Diagram



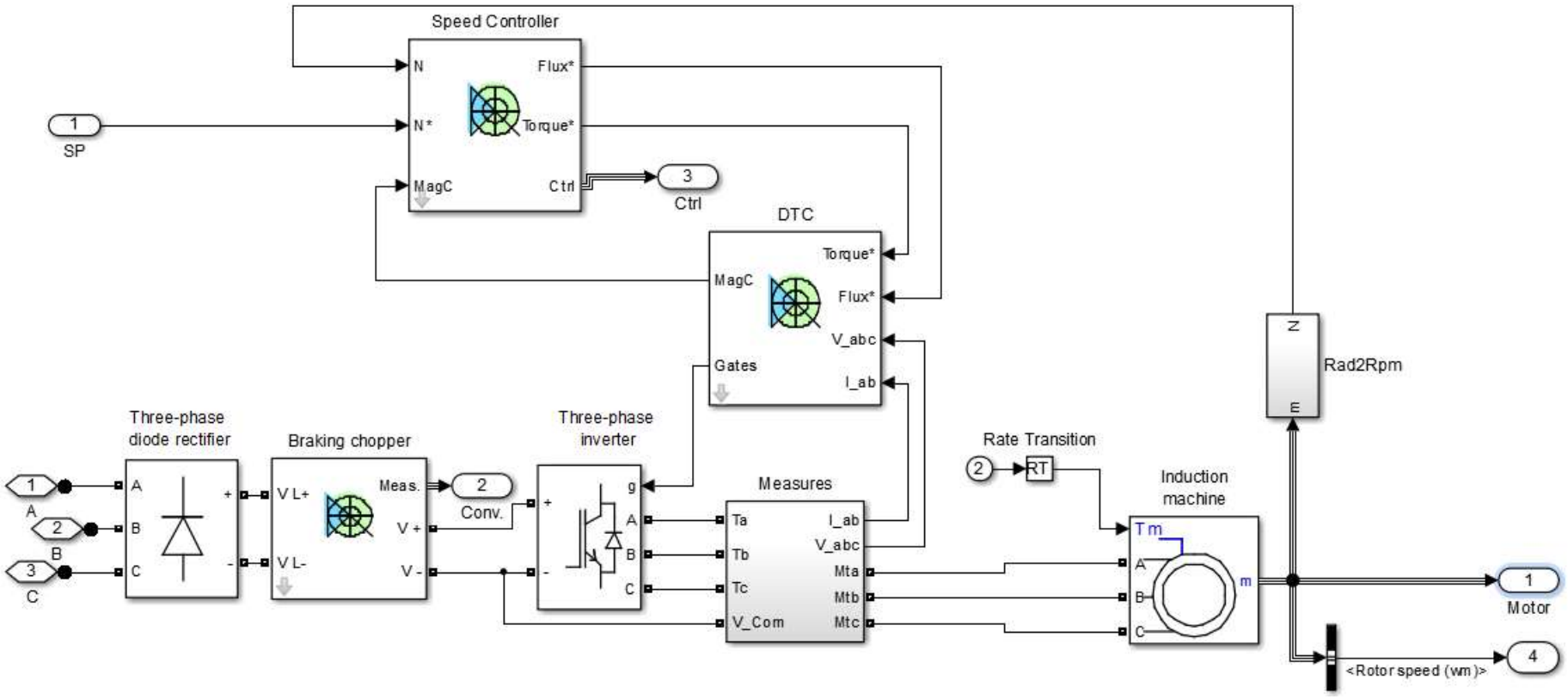
Flux and torque estimation

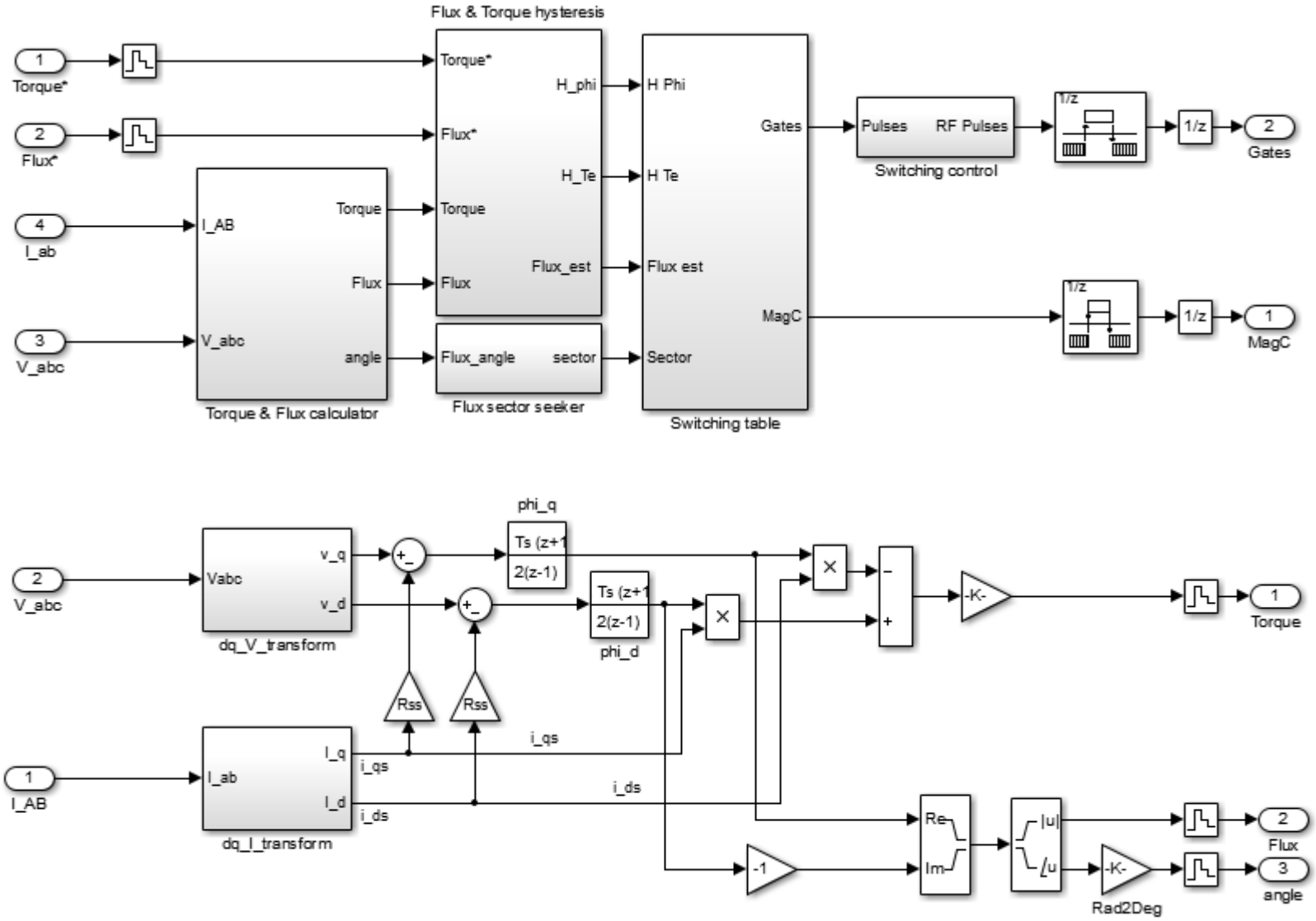


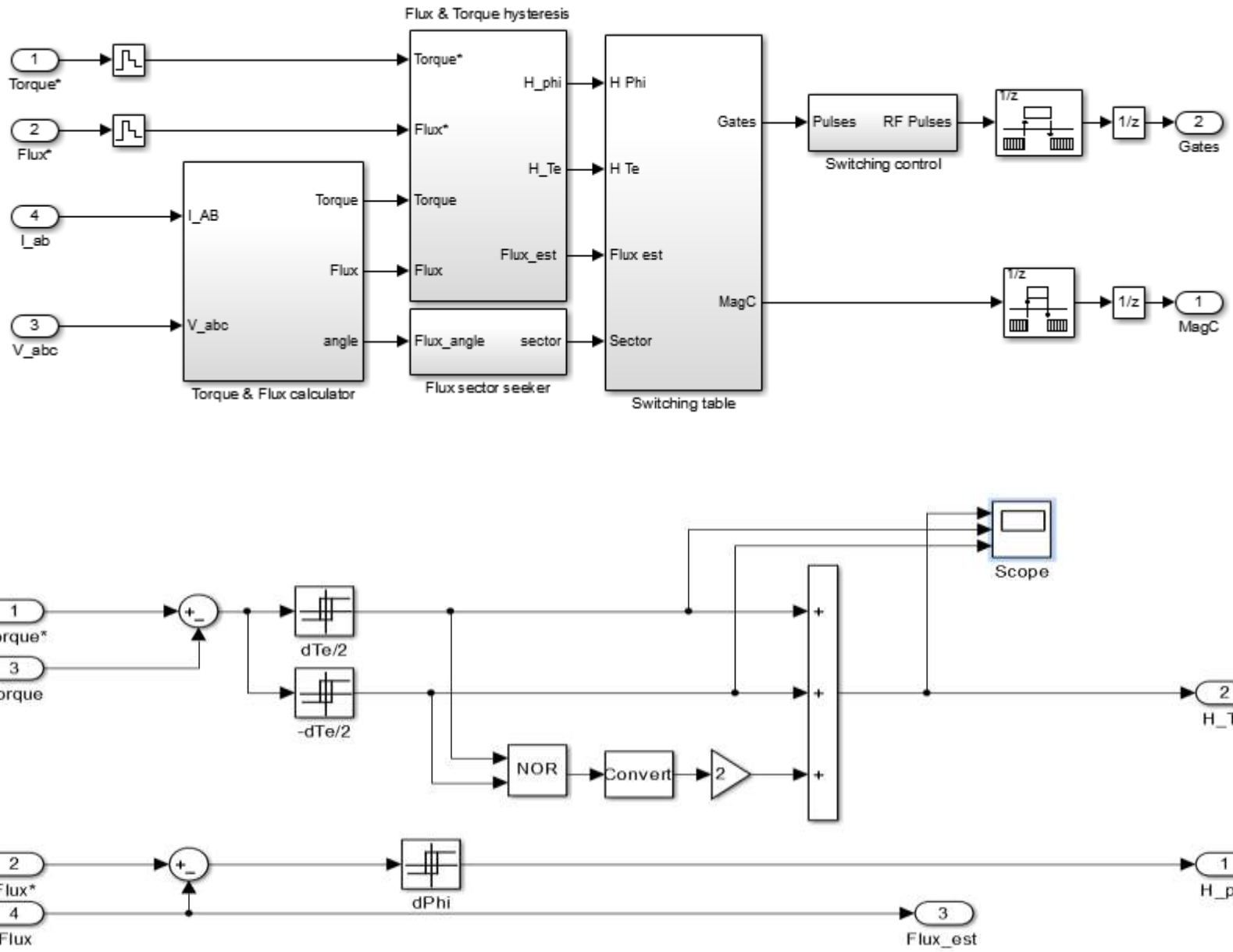
Flow Chart for the determination of sector number

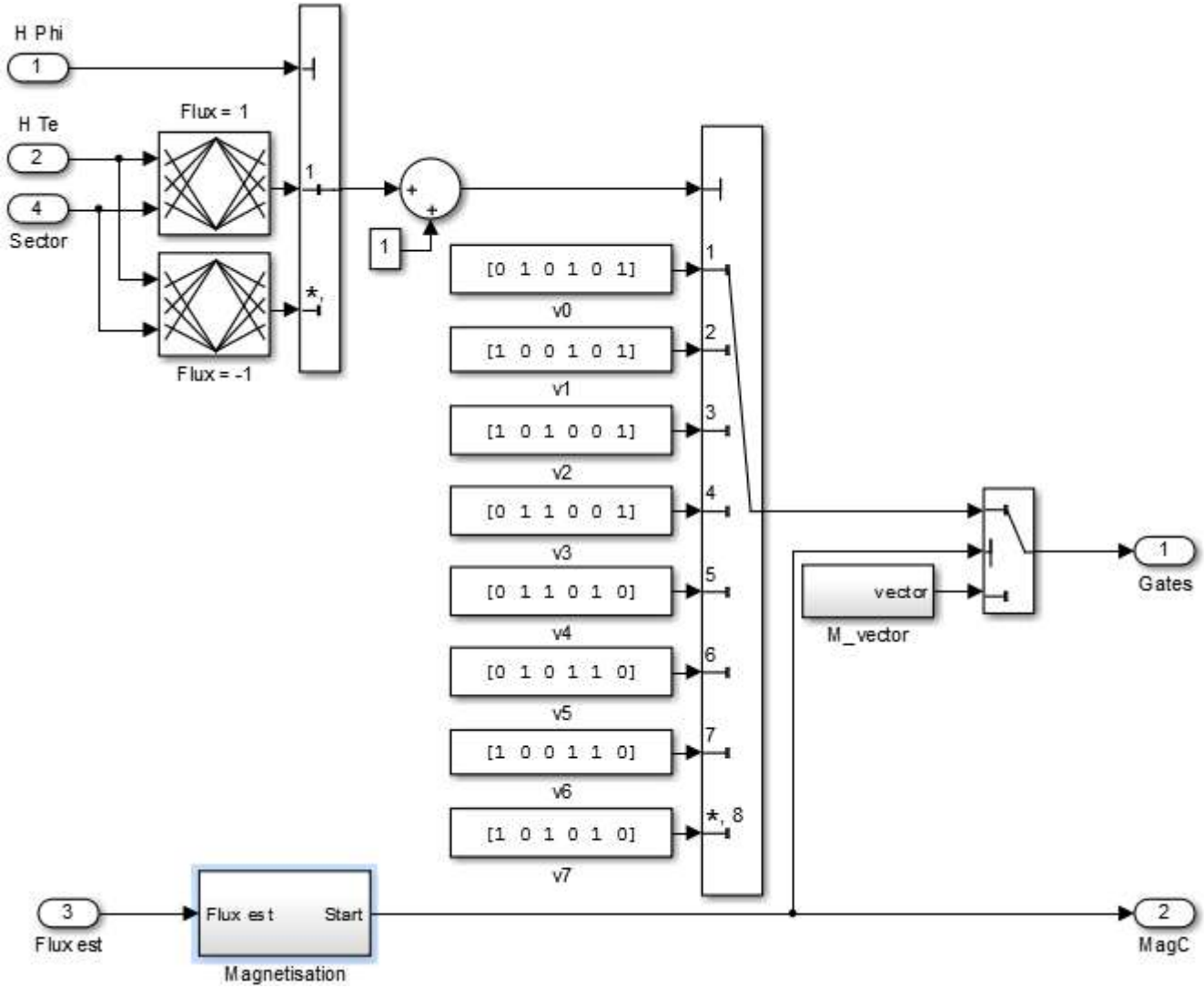


Simulink Implementation




Flux & Torque hysteresis
1
Torque*
2
Flux*
4
I_ab
3
V_abc
I_AB
V_abc
Torque
Flux
angle
Torque & Flux calculator
Torque*
Flux*
Torque
Flux
H_phi
H_Te
Flux_est
Flux_angle
sector
Flux sector seeker
H Phi
H Te
Flux est
Sector
Gates
MagC
Switching table
Pulses
RF Pulses
Switching control
1/z
2
Gates
1
MagC
phi_q
Ts (z+1)
2(z-1)
phi_d
Vabc
v_q
v_d
dq_V_transform
Rss
i_qs
i_ds
I_ab
I_q
I_d
dq_I_transform
-1
Re
Im
|u|
∠u
-K-
Rad2Deg
Torque
Flux
angle


Flux & Torque hysteresis
1
Torque*
2
Flux*
4
I_ab
3
V_abc
I_AB
V_abc
Torque
Flux
angle
Torque & Flux calculator
Torque*
Flux*
Torque
Flux
H_phi
H_Te
Flux_est
Flux_angle
sector
Flux sector seeker
H Phi
H Te
Flux est
Sector
Gates
MagC
Switching table
Pulses
RF Pulses
Switching control
1/z
2
Gates
1
MagC
Scope
dTe/2
-dTe/2
NOR
Convert
2
H_Te
dPhi
H_phi
Flux_est


H Phi
1
H Te
2
4
Sector
Flux = 1
Flux = -1
1
*,
+
+
1
[0 1 0 1 0 1]
v0
[1 0 0 1 0 1]
v1
[1 0 1 0 0 1]
v2
[0 1 1 0 0 1]
v3
[0 1 1 0 1 0]
v4
[0 1 0 1 1 0]
v5
[1 0 0 1 1 0]
v6
[1 0 1 0 1 0]
v7
1
2
3
4
5
6
7
*, 8
vector
M_vector
1
Gates
3
Flux est
Flux est
Start
Magnetisation
2
MagC