Control of Switched Reluctance Drive

Ömer Faruk Bay, Çetin Elmas, "Modelling the Inductance Variation and Control of the Switched Reluctance Motor Based on Fuzzy Logic", Intelligent Automation and Soft Computing, Vol.10, No:3, pp. 233-244, 2004

- Nonlinear
- As operating conditions change, its dynamic characteristics change as well
- High efficiency
- High speed
- Better torque/inertia
- Low cost
- Low maintainance cost

Variable to be controlled: rotor speed (ω)

Control input: Δi_{ref} : incremental change in torque current

$u(k) = u(k-1) + \Delta i_{ref}$

By varying the current, you change the speed of the rotor.

$$e(k) = \omega_{ref}(k) - \omega(k)$$

$$ce(k) = e(k) - e(k-1)$$

$\omega_{ref}(k)$: reference speed at sampling time k

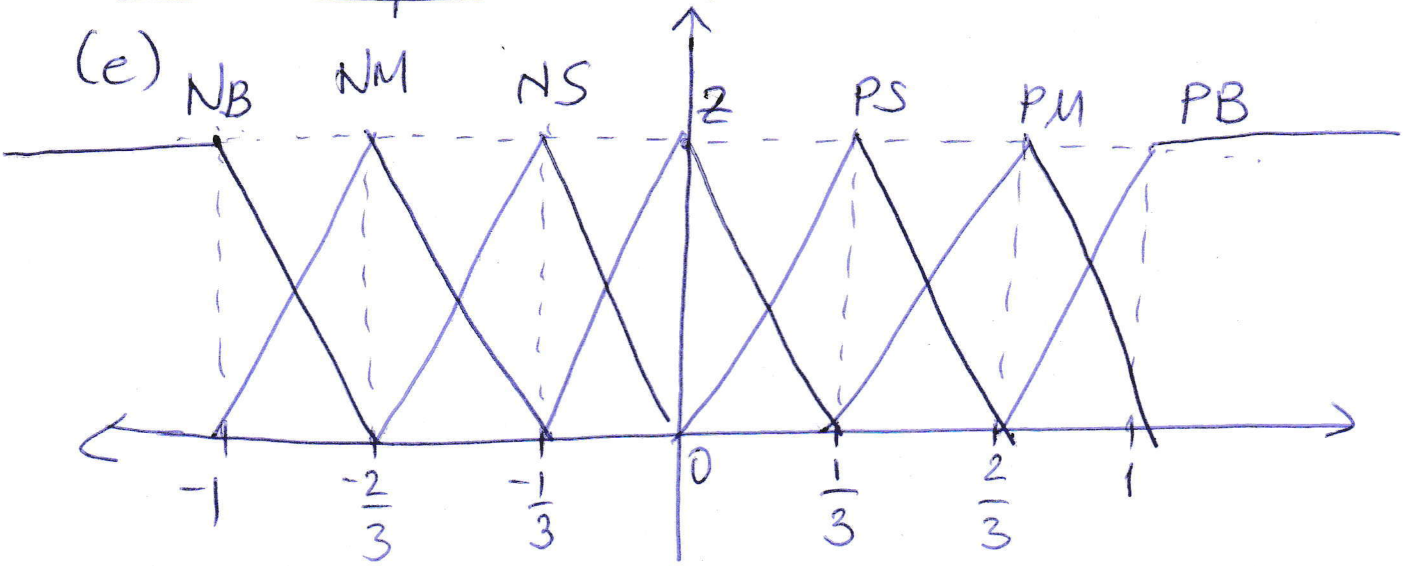
$\omega(k)$: rotor speed at sampling time k

$e(k)$: error in rotor speed at sampling time k.

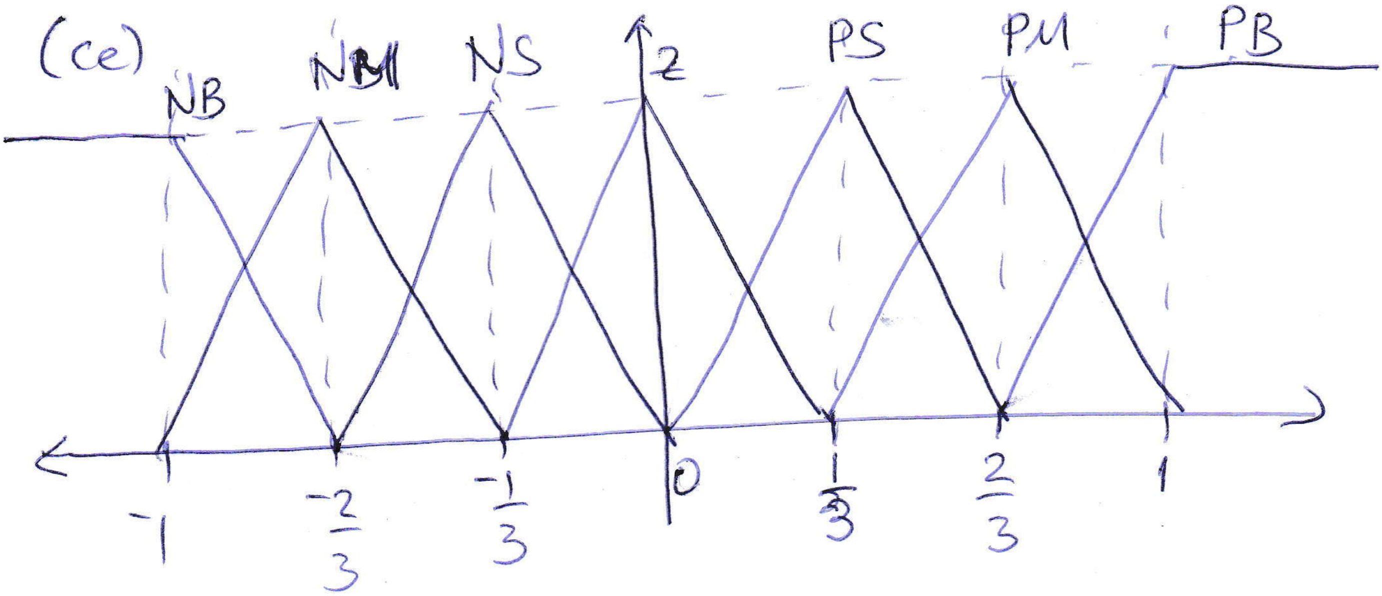
$ce(k)$: change of error in rotor speed at sampling time k.

Membership Functions

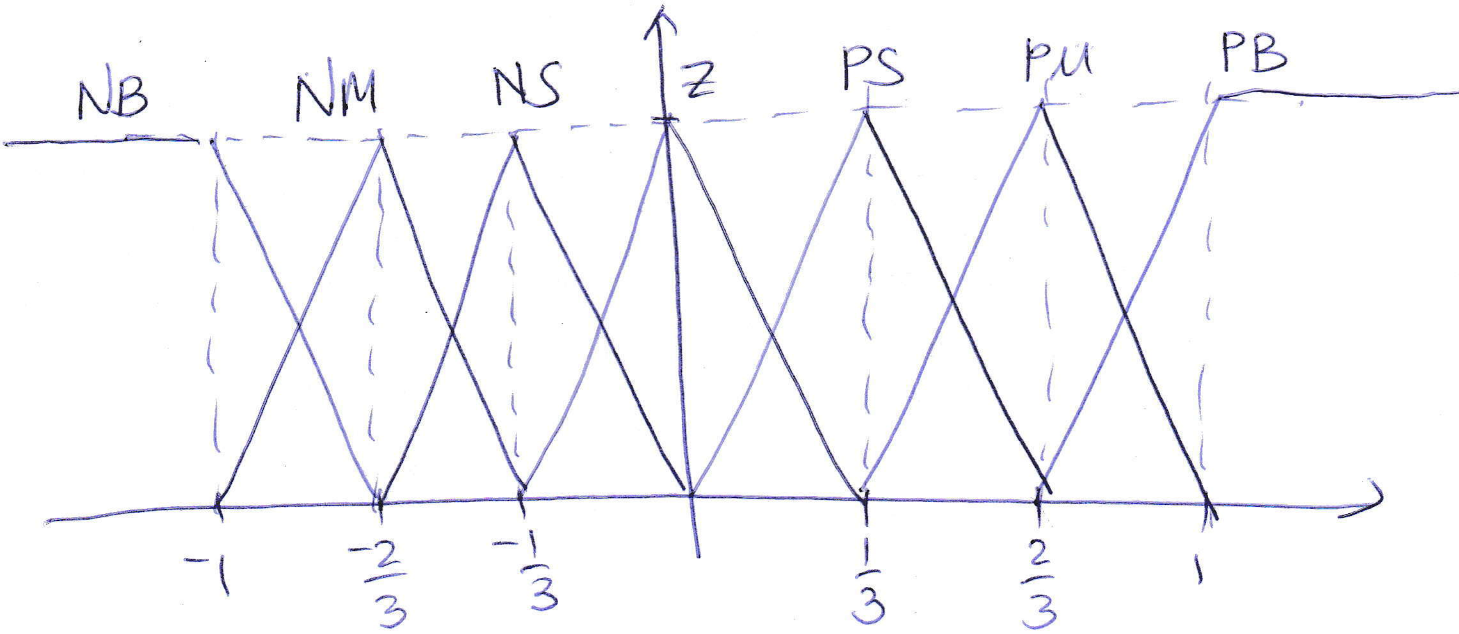
(e)



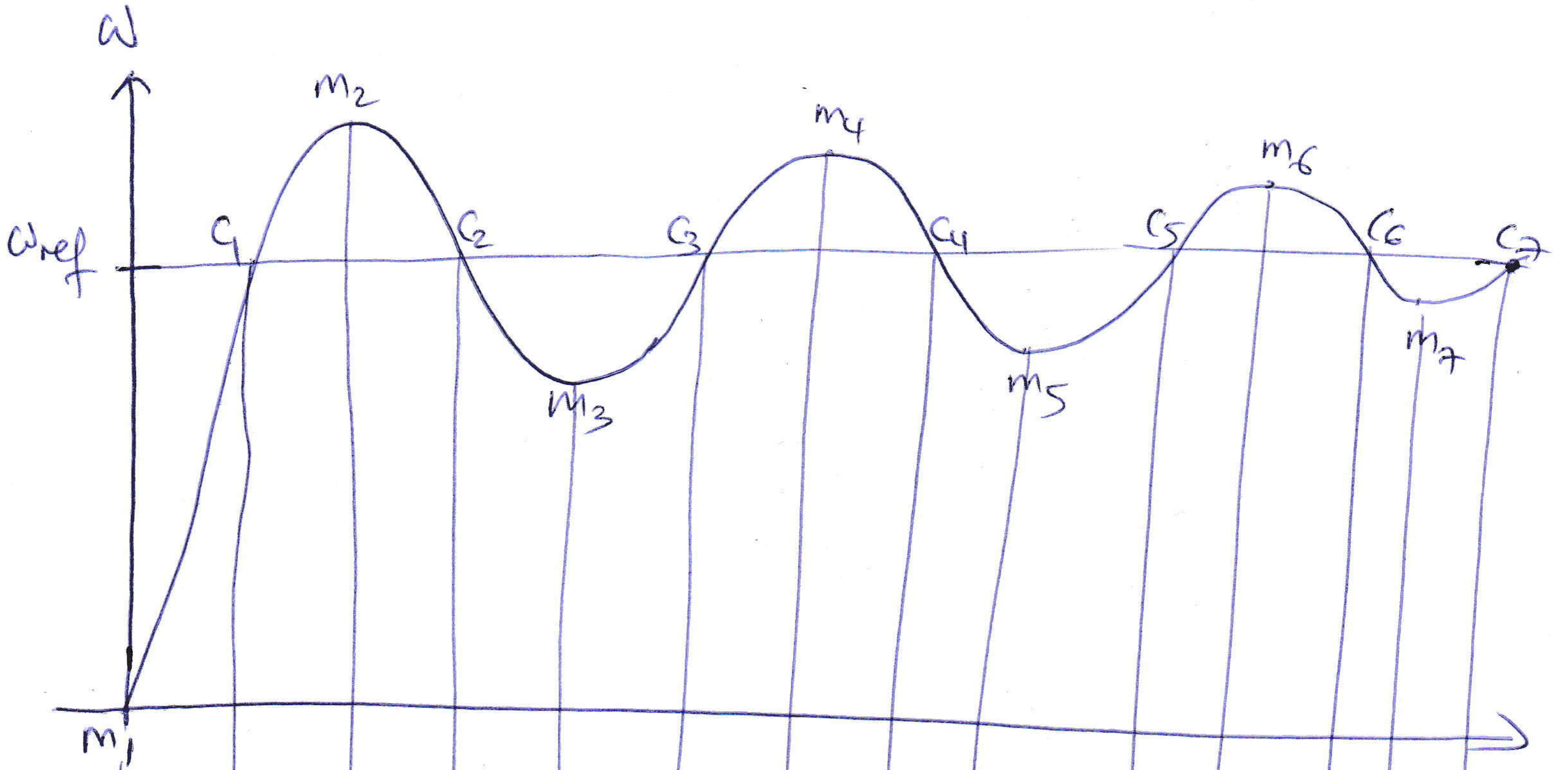
(ce)



(Δi_{ref})



Dynamic Sign Analysis



	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}
e	+	−	−	+	+	−	−	+	+	−	−	+	+
ce	−	−	+	+	−	−	+	+	−	−	+	+	−

c_1: $(e>0 \rightarrow e<0)$ and $ce <<< 0$

c_2: $(e<0 \rightarrow e>0)$ and $ce >>> 0$

c_3: $(e>0 \rightarrow e<0)$ and $ce << 0$

c_4: $(e<0 \rightarrow e>0)$ and $ce >> 0$

c_5: $(e>0 \rightarrow e<0)$ and $ce < 0$

c_6: $(e<0 \rightarrow e>0)$ and $ce > 0$

m_1: $ce \cong 0$ and $e >>> 0$

m_2: $ce \cong 0$ and $e <<< 0$

m_3: $ce \cong 0$ and $e >> 0$

m_4: $ce \cong 0$ and $e << 0$

m_5: $ce \cong 0$ and $e > 0$

m_6: $ce \cong 0$ and $e > 0$

ce \ e	NB	NM	NS	Z	PS	PM	PB
NB				C_1			
NM	A_2	A_6	A_{10}	C_3	A_9	A_5	A_1
NS				C_5			
Z	m_2	m_4	m_6	Z	m_5	m_3	m_1
PS				C_6			
PM	A_3	A_7	A_{11}	C_4	A_{12}	A_8	A_4
PB				C_2			

① In A_4, A_8, A_{12}, $e=$"+" and $ce=$"+", error is positive and increasing, so to decrease error apply positive "u"

→ Consider PD control: $u = K_P e + K_D \dot{e}$

② In A_1, A_5, A_9, $e=$"+" and $ce=$"−", error is positive but it is decreasing at the same time, apply positive "u", but with a small magnitude.

③ In A_2, A_6, A_{10}, $e=$"−" and $ce=$"−", opposite of condition in ①

④ In A_3, A_7, A_{11}, $e=$"−" and $ce=$"+", opposit of ②

	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	Z	Z	Z
NM	NB	NB	NM	NM	Z	Z	Z
NS	NB	NB	NS	NS	PS	PS	PM
Z	NB	NM	NS	Z	PB	PM	PB
PS	NM	NS	NS	PS	PS	PB	PB
PM	Z	Z	Z	PM	PM	PB	PB
PB	Z	Z	Z	PB	PB	PB	PB

Step-by-Step Design of the Fuzzy Controller for the Switched Reluctance Drive

1. Sample the rotor's speed
2. Compute error (E) and change in error (CE)
3. Multiply with input scaling factors

$$e = GE \times E \qquad ce = CGE \times CE$$

(GE, CGE are scaling factors)

4. Determine MF's for e and ce.
5. Use fuzzy inference mechanism to compute a fuzzy set for Δi_{ref}.
6. Defuzzify Δi_{ref} to find a crisp value Δi_{ref}^{*}
7. Multiply with output scaling factor

$$\Delta I_{ref}^{*} = GDU \times \Delta i_{ref}^{*}$$

CGDU is the output scaling factor.

8. Compute $u(k) = u(k-1) + \Delta I_{ref}^{*}$

Fuzzy PID Controller