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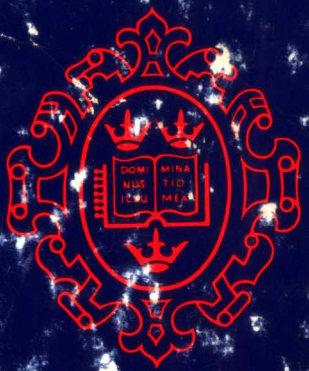
Vector Control of AC Machines

PETER VAS



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To my wife Zsuzsanna,
my son Peter
and also to the memory of
my father and identical twin brother

Glossary of symbols

$\bar{a}$	complex spatial operator ($e^{j2\pi/3}$)	
$\mathbf{C}_2$	commutator transformation matrix	
f	magnetomotive force (m.m.f.)	At
i_a	instantaneous value of the armature current	A
i_D	instantaneous value of the d.c. link current	A
$\bar{i}_{ms}$ ($\bar{I}_{ms}$)	space phasor of the stator magnetizing currents expressed in the magnetizing-flux-oriented reference frame	A
$\bar{i}_{mr}$ ($\bar{I}_{mr}$)	space phasor of the rotor magnetizing currents expressed in the magnetizing-flux-oriented reference frame	A
$\bar{i}_r$ ($\bar{I}_r$)	space phasor of the rotor currents expressed in the rotor reference frame	A
$\bar{i}'_r$ ($\bar{I}'_r$)	space phasor of the rotor currents expressed in the stator reference frame	A
$\bar{i}_{rg}$ ($\bar{I}_{rg}$)	space phasor of the rotor currents expressed in the general reference frame	A
$\bar{i}_{rm}$ ($\bar{I}_{rm}$)	space phasor of the rotor currents expressed in the magnetizing-flux-oriented reference frame	A
$\bar{i}_{r\psi s}$ ($\bar{I}_{r\psi s}$)	space phasor of the rotor currents expressed in the stator-flux-oriented reference frame	A
i_{ra}, i_{rb}, i_{rc}	instantaneous values of the rotor currents in rotor phases ra, rb, rc respectively	A
i_{rd}, i_{rq}	instantaneous values of direct- and quadrature-axis rotor currents expressed in the stator reference frame	A
$i_{r\alpha}$, $i_{r\beta}$	instantaneous values of direct- and quadrature-axis rotor current components respectively and expressed in the rotor reference frame	A
i_{rx}, i_{ry}	instantaneous values of the direct- and quadrature-axis rotor current components respectively and expressed in the general or special reference frames	A
$\bar{i}_s$ ($\bar{I}_s$)	space phasor of the stator current expressed in the stator reference frame	A
$\bar{i}'_s$ ($\bar{I}'_s$)	space phasor of the stator currents expressed in the rotor reference frame	A
$\bar{i}_{sg}$ ($\bar{I}_{sg}$)	space phasor of the stator currents expressed in the general reference frame	A
$\bar{i}_{sm}$ ($\bar{I}_{sm}$)	space phasor of the stator currents expressed in the magnetizing-flux-oriented reference frame	A

$\bar{i}_{s\psi r}$ ($\bar{i}_{s\psi r}$)	space phasor of the stator currents expressed in the rotor-flux-oriented reference frame	A
$\bar{i}_{s\psi s}$ ($\bar{i}_{s\psi s}$)	space phasor of the stator currents expressed in the stator-flux-oriented reference frame	A
i_{sA}, i_{sB}, i_{sC}	instantaneous values of the stator currents in stator phases sA, sB, sC respectively	A
i_{sD}, i_{sQ}	instantaneous values of direct- and quadrature-axis stator current components respectively and expressed in the stationary reference frame	A
i_{sd}, i_{sq}	instantaneous values of the direct- and quadrature-axis stator current components respectively and expressed in the rotor reference frame	A
i_{sx}, i_{sy}	instantaneous values of the direct- and quadrature-axis stator current components respectively and expressed in the general or special reference frames (flux and torque producing stator current components respectively)	A
i_{s0}	instantaneous value of zero-sequence stator current component	A
J	polar moment of inertia	kgm^2
L	dynamic inductance	H
L_{DQ}	cross-magnetizing coupling inductance	H
L_F	inductance of filter	H
L_m	magnetizing inductance	H
L_s, L_{sl}	self- and leakage inductances of the stator respectively	H
L_r, L_{rl}	self- and leakage inductances of the rotor respectively	H
L'_s, L'_r	stator and rotor transient inductances respectively	H
$p = d/dt$	differential operator	
p_s, p_r	instantaneous powers of the stator and rotor respectively	W
P	number of pole-pairs	
R_F	resistance of filter	Ohm
R_s, R_r	resistances of a stator and rotor phase winding respectively	Ohm
t	time	s
t_e	instantaneous value of the electromagnetic torque	Nm
t_l	load torque	Nm
T	time lag	s
T_s, T_r	stator and rotor time constants respectively	s
T'_s, T'_r	stator and rotor transient time constants respectively	s
u_D	instantaneous output voltage of rectifier	V
u_{dx}, u_{dy}	instantaneous values of the direct- and quadrature-axis decoupling voltage components expressed in the special reference frames	V

$\bar{u}_s$	space phasor of the stator voltages expressed in the stator reference frame	V
$\bar{u}_{sg}$	space phasor of the stator voltages expressed in the general reference frame	V
$\bar{u}_{sm}$	space phasor of the stator voltages expressed in the magnetizing-flux-oriented reference frame	V
$\bar{u}_{s\psi s}$	space phasor of the stator voltages expressed in the stator-flux-oriented reference frame	V
$\bar{u}_{s\psi r}$	space phasor of the stator voltages expressed in the rotor-flux-oriented reference frame	V
u_{sA}, u_{sB}, u_{sC}	instantaneous values of the stator voltages in phases sA, sB, sC respectively	V
u_{sD}, u_{sQ}	instantaneous values of direct- and quadrature-axis stator voltage components respectively and expressed in the stationary reference frame	V
u_{sx}, u_{sy}	instantaneous values of the direct- and quadrature-axis stator voltage components respectively and expressed in the general or special reference frames	V
$\bar{u}_r$	space phasor of the rotor voltages expressed in the rotor reference frame	V
$\bar{u}'_r$	space phasor of the rotor voltages expressed in the stator reference frame	V
$\bar{u}_{rg}$	space phasor of the rotor voltages expressed in the general reference frame	V
$\bar{u}_{r\psi s}$	space phasor of the rotor voltages expressed in the stator-flux-oriented reference frame	V
u_{rd}, u_{rq}	instantaneous values of the direct- and quadrature-axis rotor voltages respectively and expressed in the stator reference frame	V
u_{rx}, u_{ry}	instantaneous values of the direct- and quadrature-axis rotor voltages respectively and expressed in the general or special reference frames	V
$u_{r\alpha}, u_{r\beta}$	instantaneous values of the direct- and quadrature-axis rotor voltages respectively and expressed in the rotor reference frame	V
u_{r0}	instantaneous value of the zero-sequence rotor voltage	V
W_{mech}	instantaneous value of mechanical output energy	J
$z = e^{sT}$	discrete Laplace variable	
δ	load angle	rad
θ_r	rotor angle	rad
μ_m	phase angle of the magnetizing flux linkage space phasor with respect to the direct-axis of the stator reference frame	rad

ρ_r	phase angle of the rotor flux linkage space phasor with respect to the direct-axis of the stator reference frame	rad
ρ_s	phase angle of stator flux linkage space phasor with respect to the direct-axis of the stator reference frame	rad
σ	resultant leakage constant	
σ_r	rotor leakage constant	
ψ_f	excitation flux linkage	Wb
$\bar{\psi}'_m$	space phasor of magnetizing flux linkages expressed in the stator reference frame	Wb
$\bar{\psi}_{m\psi r}$	space phasor of magnetizing flux linkages expressed in the rotor-flux-oriented reference frame	Wb
$\bar{\psi}_{m\psi s}$	space phasor of magnetizing flux linkages expressed in the stator-flux-oriented reference frame	Wb
ψ_{md}, ψ_{mq}	instantaneous values of the direct- and quadrature-axis magnetizing flux linkage components expressed in the rotor reference frame	Wb
$\bar{\psi}_r$	space phasor of rotor flux linkages expressed in the rotor reference frame	Wb
$\bar{\psi}'_r$	space phasor of the rotor flux linkages expressed in the stator reference frame	Wb
$\bar{\psi}_{rg}$	space phasor of the rotor flux linkages expressed in the general reference frame	Wb
$\bar{\psi}_{r\psi r}$	space phasor of the rotor flux linkages expressed in the rotor-flux-oriented reference frame	Wb
$\psi_{ra}, \psi_{rb}, \psi_{rc}$	instantaneous values of the flux linkages in rotor phases ra, rb, rc respectively	Wb
ψ_{rx}, ψ_{ry}	instantaneous values of the direct- and quadrature-axis rotor flux linkage components respectively and expressed in the general or special reference frames	Wb
$\bar{\psi}_s$	space phasor of stator flux linkages expressed in the stator reference frame	Wb
$\bar{\psi}'_s$	space phasor of the stator flux linkages expressed in the rotor reference frame	Wb
$\bar{\psi}_{sg}$	space phasor of the stator flux linkages expressed in the general reference frame	Wb
$\bar{\psi}_{sm}$	space phasor of the stator flux linkages expressed in the magnetizing-flux-oriented reference frame	Wb
$\bar{\psi}_{s\psi s}$	space phasor of the stator flux linkages expressed in the stator-flux-oriented reference frame	Wb
$\psi_{sA}, \psi_{sB}, \psi_{sC}$	instantaneous values of stator flux linkages in stator phases sA, sB, sC respectively	Wb
ψ_{sd}, ψ_{sq}	instantaneous values of the direct- and quadrature-axis stator flux linkages expressed in the rotor reference frame	Wb

ψ_{sD}, ψ_{sQ}	instantaneous values of the direct- and quadrature-axis stator flux linkage components expressed in the stator reference frame	Wb
ψ_{sx}, ψ_{sy}	instantaneous values of the direct- and quadrature-axis stator flux linkage components respectively and expressed in the general or special reference frames	Wb
ω_m	angular speed of the magnetizing-flux-oriented reference frame	rad/s
ω_{mr}	angular speed of the rotor-flux-oriented reference frame	rad/s
ω_{ms}	angular speed of the stator-flux-oriented reference frame	rad/s
ω_r	angular rotor speed	rad/s
ω_{sl}	angular slip frequency	rad/s

Subscripts

A, B	upper and lower cages respectively
b	base
g	general reference frame
i	induced
m	magnetizing
n	normalized
r	rotor
ra, rb, rc	rotor phases
ref	reference
s	stator
sA, sB, sC	stator phases
x	direct-axis component in general reference frame or in special reference frames (fixed to the stator flux linkage, rotor flux linkage or magnetizing flux linkage space phasors respectively)
y	quadrature-axis component in general reference frame or in special reference frames (fixed to the stator flux linkage, rotor flux linkage or magnetizing flux linkage space phasors respectively)

Mathematical symbols

$\times$	cross vector product
*	complex conjugate

Contents