NOMENCLATURE

Abbreviations:

Cas	cascade temperature control approach
C/Liq	cascade liquid flow control case
Con	conventional control approach
C/Vap	cascade vapour flow control case
DIM	Dynamic Interaction Measure
Dir	direct temperature control approach
DPC	dominant pole cancelling
HP	high pressure
IOIA	Input / Output Interaction Array
IP	intermediate pressure
ISE	integral square error
JEC	Jacobi Eigenvalue Criterion
L1/L3	control case in which L1 and L3 are controlled
L2/L3	control case in which L2 and L3 are controlled
LP	low pressure
MIMO	multi input multi output
MRI	Morari Resiliency Index
NI	Niederlinski Index
PI	proportional integral controller
PIM	Performance Interaction Measure
PRGA	Performance Relative Gain Array
RGA	Relative Gain Array
RIA	Relative Interaction Array
SFG	signal flow graph

SISO	single input single output
SVD	singular value decomposition
μIM	μ Interaction Measure

General:

A	Antoine Equation coefficient
a	constant in Equation 3.11
AR	heat transfer area (m^2)
B	Antoine Equation coefficient
C	Antoine Equation coefficient
C1-C6	specific heat capacity equation coefficients
C11-C13	first compressor's head equation coefficients
C21-C25	second compressor's head equation coefficients
CINT	communication interval
CPI	specific heat capacity at compressor suction line (J/(kg.K))
CPO	specific heat capacity at compressor discharge line (J/(kg.K))
CS	total number of control schemes
CVL	valve constant - liquid line ($kg/(s.bar^{0.5})$)
CVG	valve constant - vapour line ($kg/(s.bar^{0.5})$)
e1-e4	compressor's polytropic efficiency equation coefficients
ER	controller error
FCP	mass flowrate times the specific heat capacity of the process stream or the condenser cooling (J/(K.s))
FG	vapour refrigerant mass flowrate from the evaporator (kg/s)
FGCD	compressor discharge vapour refrigerant mass flowrate (kg/s)
FGCS	compressor suction vapour refrigerant mass flowrate (kg/s)
FGV	vapour refrigerant volumetric flowrate into the compressor (m^3/s)
FL	liquid refrigerant mass flowrate from the evaporator condenser / receiver (kg/s)
g	gravitational acceleration (m/s^2)
H	enthalpy content (J)
h	compressor head (m)

HFG	specific enthalpy of vapour refrigerant (J/kg)
HFL	specific enthalpy of liquid refrigerant (J/kg)
HS	integration step size
hs	scaled head (m)
K	controller gain
k	constant in Equation 3.24
km	flow characteristic constant (-)
L	liquid refrigerant level in evaporators and receiver (m^3)
MAXTERVAL	upper bound on integration step size
MINTERVAL	lower bound on integration step size
Mw	RMM (kg/kmol)
N	fractional compressor's speed (-)
n	polytropic exponent
NSTEP	number of integration steps in a communication interval
P	pressure in evaporator / condenser (bar)
p	constant in Equation 3.22
Pa	maximum allowable pressure drop across a valve (bar)
PD	compressor's discharge pressure (bar)
PF	performance factor
PS	compressor's suction pressure (bar)
Pv	liquid vapour pressure (bar)
Q	heat transferred in evaporator / condenser (J/s)
q	constant in Equation 3.21
R	gas constant (J/mol.K)
rc	critical pressure ration (-)
s	derivative in Laplace transform
T	temperature in evaporator / condenser / receiver (K)
TD	compressor's discharge temperature (K)
TI	integral action (s)
TPi	process stream inlet temperature (K)
TPo	process stream outlet temperature (K)
TS	compressor's suction temperature (K)
TX	intermediate variable in Equation 3.41
U	overall heat transfer coefficient ($J/(m^2.K)$)

u	manipulated variable
V	volume of evaporator / condenser / receiver (m^3)
vf	specific volume of liquid refrigerant (m^3/kg)
vg	specific volume of vapour refrigerant (m^3/kg)
VV	combined vapour refrigerant volume in the condenser and receiver (m^3)
W	refrigerant holdup (kg)
WL	liquid refrigerant holdup (kg)
WLV	liquid refrigerant volumetric holdup (m^3)
WV	vapour refrigerant holdup (kg)
x	state variable
y	controller measured value
ysp	controller set point
XV	valve opening in the model program
XVic	initial condition of the valve opening
XVL	valve opening - liquid line
XVlin	dummy variable in the linearisation of the ACSL model
XVG	valve opening - vapour line
y	measured / controlled variable
z	compressibility factor

Greek symbols:

δ_1-δ_2	coefficients in Equation 3.31
ϕ	RIA element
ϕ_1-ϕ_2	coefficients in Equation 3.29
γ	condition number
γ_{av}	Average of specific heat capacities of compressor's discharge and suction (J/(kg.K))
η	compressor polytropic efficiency
η_I	Input effectiveness
η_O	Output effectiveness
λ	eigenvalue
λ_1-λ_2	coefficients in Equation 3.32

μ	structured singular value
θ	DIM
ρ	spectral radius (absolute value of largest eigenvalue of a matrix)
σ	singular value
τ	PIM
ζ_1-ζ_2	coefficients in Equation 3.30

Subscripts and superscripts:

c	condenser
N	non-square
r	receiver
T	transpose of a matrix
wcv	weighted controlled variable

Matrices:

A	Jacobian matrix
B	state/manipulated variables matrix
C	state/measured variables matrix
D	measured/manipulated variables matrix
De	Direct Effect in the IOIA
E	transformed measured variables matrix
E1	error matrix in μIM calculation
E2	error matrix in μIM calculation
F	transformed measured/manipulated variables matrix
G	system matrix
$\mathbf{G_d}$	diagonal system matrix
H	closed loop transfer function matrix
$\mathbf{H_d}$	diagonal closed loop transfer function matrix
I	identity matrix
Ie	Indirect Effect in the IOIA
J	Jacobi interaction matrix
K	controllers matrix

$\mathbf{K_d}$	diagonal controller matrix
S1	Scaling matrix in minimised condition number calculation
S2	Scaling matrix in minimised condition number calculation
T	complementary sensitivity matrix in RPN calculation
T1	scaling matrix
T2	scaling matrix
U	left singular vectors in SVD
V	right singular vector in SVD
W	intermediate matrix in DIM calculation
$\boldsymbol{\Delta}$	uncertainty block diagonal matrix in μ calculation
$\boldsymbol{\Gamma}$	performance relative gain array
$\boldsymbol{\Lambda}$	RGA matrix
$\boldsymbol{\Sigma}$	diagonal matrix of singular values in SVD

Other:

$\|\ \|$	matrix norm
$\otimes$	matrix element by element multiplication
$\in$	controller error