Figure No.	Details	Page No
2.1	Observer Schematics	12
2.2	Adaptive Observer schematic	14
2.3	MATLAB Desktop	36
24	Observer-Estimator Output	39
2.5	Block Diagram Representation of Dynamic System	40
26	Faculties : SIMULINK	43
2.7	Mechanization: Optimal observer	44
2.8	H ⁸ problem formulation.	46
2.8(a)	Flow chart of execution of H ⁸ controller.	47
2.9	System in augmented form with H ⁸ Controller	47
2.10	Block diagram of H ⁸ Controller	47
2.11	Implementation of system in augmented space.	49
2 12	Implementation of H ⁸ controller.	49
2.13	SIMULINK MODEL H ⁸ Controller	54
2.14	Estimated Output (y-hat) of H ⁸ Controller	54
3.1	The Architecture of Fuzzy Control.	59
32	Simple model of an Artificial Neuron	61
3 3	Multi-layer Network.	62
3.4(A)	A schematic diagram of Main features: MATLAB	68
3.4	MATLAB command window	69
3.5	SIMULINK library Borwser	70
3.6	Constant volts/hertz. Speed Control with slip regulation	74
3.7	Block Diagram representation of the system	75
3.8	Block Diagram with $k_n = 1 \text{ v/rad/sec}$	77
3.9	Combined Block Diagram; Plant, with PID and with FLC	78
3.10	Feedback Gain (FBG) = 0.01	84
3.11	FLC = 1.4, $PID = 1.1 FBG = 0.1$	84
3.12	FLC = 1.3, $PID = 1.1 FBG = 0.1$	84
3.13	FFG = 1.1, FBG = 0.001	84
3.14	SIMULINK setup for Lookup Table based FCL	85

Figure No.	re Details	
3 15	Step response for Lookup Table FLC	85
3.16	Controller Surface view for Lookup Table FLC	85
3 17	ANFIS Training	88
3.18	Output Response of NFC for input 1 & 2	88
3.19	Experimental Set-up	89
3 20(a)	Membership Function Editor	91
3.20(b)	Membership Function Editor	92
3.21	Rule Base Editor for Creation of a Rule Base	93
3.22	Combined SIMULINK set up including dead-zone for Plant,	94
	Plant with PID and Plant with FLC	
3 23 (i),	Simulation Response	95
(1i).(iii) and (iv))	
3 24	FLC Based Compensator	99
3.25	Single Layer FLC	103
3.26	Two Layer FLC	103
3 27	Output Red - with FL Pre compensation; Blue - without FL	104
	compensation; Green – with PID	
3 28	Response of two layer FLC with Backlash	104
5.1	Gain Mismatch	138
5.2	Dead-zone	138
5.3	Backlash	139
5.4	Saturation Fault	139
5 5	Plant used in the ACC benchmark.	140
5.6(a)	Plant P with Series Compensator in a negative feedback loop.	141
5.6(b)	Fuzzy Controller with State Estimator	147
5.7	Input and output membership function of the Spring Observer.	149
58	PI Observer block.	153
5.9	Observer-based regulator block	153
5.10	Response to a step input disturbance, din= 0 2, Adaptive Observer	154
	Benchmark plant: (a). Integral offset, v , from the PI (b) the cumulative	
	error estimating the hidden state x^2 for P and PI observer.	

VI

Figure No.	Details	Page No.
5.11	PI Adaptive Observer.	155
5.12	Response of open-loop P and PI adaptive observer to a step input	156
	disturbance, $din = 0$ 2,	
5 13(a)	Response of closed-loop P and PI adaptive observer to a step input	156
	disturbance, $din = 0.2$	
5.13(b)	Estimates of a and b parameters from the closed-loop PI (solid line) and	157
	the P (dashed line) Adaptive Observer (triangular Disturbance	
5.14	The performance of the LQR (dashed line), the P observer-based regulator	158
	(gray dashed line) and the PI observer-based regulator in the presence of	
	four common actuator faults is compared in the first two columns	
	(a) plant output (b) Cumulative output error. Column (c) Actuator	
	disturbance	
5 15	The performance of the LQR (dashed line), the P adaptive observer-based	159
	regulator (gray dashed line) with/without common actuator faults is	
	compared in the first two columns, (a) Plant output (b) Cumulative output	
	error (c) Actuator disturbance (gray line) and its estimate by the integral	
	action (black line).	
(a)	The effects of process noise and integral fading on the rejection of a un	nıt
	160	
	impulse to $m2$ for a perturbed plant with spring constant k =0 8.	
	(a) output for a PI Kalman Filter-based controller over a range of p	
	(b) output of the correspond PFI Kalman Filter-based controller	
	(KI = -20) for a range of KF.	
	(c) and (d) give the respective error in estimating the state xI .	
5.17	A comparison of the P, PFI Kalman Filter-based regulators and a LQR	161
	with full state feedback for a perturbed plant with spring constant $k = 0.8$	
	(a) Output y , (b) Regulator output u , (c) Respective estimating error, for	
	state xl and (d) the estimate BIv of the perturbation term ?x from the	
	PFI Kalman Filter.	
5.18	Peak regulator output versus plant spring constant for a P Kalman	162
	Filter -based controller and for a PFI Kalman Filter-based regulator.	

vn

Figure No.	Details	Page No. 162	
5 19	Plant used for Robust Control Benchmark.		
5 20	Robust Control Benchmark system with series compensation.		
5 21	Comparison of the two tracking behaviors using only output feedback,		
(a)	Performance comparison of two full state feedback controllers: the fuzzy		
	controller (black and the LQR (gray) and Fuzzy Controller (black) after		
	unit impulse disturbance to $m2$ for $k = 1, 2, 3, 4$.		
	(a) Plant output y (b) Spring length L (c) Compensator output u		
	(d) Cumulative compensator output $2u$ (for $k = 0.5$ to 4.5 in steps of 0.5)		
5.22	Performance comparison of fuzzy controller using state estimates from a	166	
	PFI Kalman filter (black lines) and Comp1, a 5th order H2 compensator		
	from Marrison and Stengel (gray lines)		
	(a) Output response to a unit impulse disturbance to m^2		
	for $k = 0.6$ to $k = 2.0$ in steps of 0.2		
	(b) for $ml = 0.6$ to $ml = 2.0$ in steps of 0.2, and		
	(c) for $m2 = 0.8$ to $m2 = 2.0$ in steps of 0.2		
	(d) Tracking of a unit step command for $k = 0.6$ to $k = 2.0$ in steps of 0.2.		
5.23	Responses to an impulse at $m2$ for the nominal plant ($k = 1.0$) for Fuzzy	168	
	controllers QRC A and QRC B and the linear controllers Comp1 and		
	Comp3. (a) The fuzzy compensators have a lower overshoot in o/p		
	(b) The fuzzy controllers dampen vibrations faster.		
6.1	Inverted robot arm	181	
6.2	Modes of operation. System block	181	
6.3	SIMULINK model for Inverted Robot Arm	182	
6.4	SIMULINK setup for Manual Signal Generator	183	
6.5	Data set generation. Learning mode	183	
6.6	Classical SIMULINK setup	185	
67	Response after running Simulation	185	
68	Robot arm animation	1 86	

No.

8 30

List	of	Figui	res	

6.9 Response of Signal Generator 186 Phasor diagram of a 3-phase induction motor 196 81 Equivalent two phase machine 203 82 83 Stationary a-b-c to ds-gs axes transformation 204 Stationary frame d^s-q^s to synchronously rotating frame d^e-q^e transformation 8.4 204 85 Separately excited dc motor, vector-controlled induction motor 208 86 Vector control with Machine de-ge model 209 8.7 Phasor diagram of indirect vector control 210 8.8 Synchronous Current Control 212 8 9(a) Dynamic de-qe equivalent circuit of machine qe-axis circuit 213 8.9(b) Dynamic de-qe equivalent circuit of machine de-axis circuit 213 8 10 Complex synchronous frame dqs equivalent circuit. 214 8 1 1 Flux and current vectors in d^e-q^e frame. 215 8.12 Synchronously rotating frame machine model with input voltage and 216 output current transformations. 8 13 SIMULINK implementation of Induction Machine Model 220 SIMULINK set-up of de-qe flux linkage model of Induction motor 8.14 221 Complete Induction machine SIMULINK model 8 1 5 223 Induction machine model initialization file 8 16 224 Simulation Test Results 8 17 224 V/Hz control- SIMULINK Model 8.18 225 8 19 V/Hz Control 225 8.20 Indirect vector control SIMULINK model 226 Indirect vector control SIMULINK model Response 226 821 8.22 Training and goal versus Epochs 228 8 2 3 Cascade operation 230 8 2 4 Block diagram for speed control of induction motor. 232 Layout Editor 233 8 25(a) Parts of GUI implementation. 234 8 25(b) 8.26 M-file Execution path. 234 8.27 Graphical User Interface Generation of ANN Estimator 236 Graphical User Interface. Generation of ANN Training Set 8 2 8 237 8.29 Generated Block ANN Estimator 237

SIMULINK Model ANN based Speed Control of Induction Motor

ix

No.

238