CHAPTER SIX

SIMULATION RESULTS AND DISCUSSION

6.1 Fuzzy Controller Architectre:

The fuzzy controller has four main components [9,10]:

- ✓ The fuzzification interface simply modifies the inputs so that they can be interpreted and compared to the rules in the rule-base converts the crisp input into fuzzy variables.
- ✓ The Rule-base holds the knowledge, in the form of a set of rules, of how best to control the system.
- ✓ The inference mechanism evaluates which control rules are relevant at the current time and then decides what the input to the plant should be.
- ✓ The defuzzification interface converts the conclusions reached by the inference mechanism into the inputs (crisp) to the plant. In this work, Center Of Area (COA) is used as a defuzzification method.

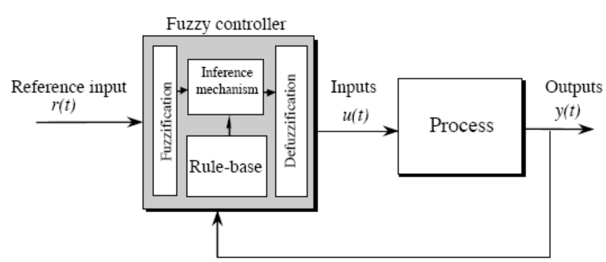

Fig. 6.1: Fuzzy controller architecture.

In this thesis the fuzzy controller uses both the speed error (e) and its rate of change (ce) as inputs, and the change in electromagnetic torque (ΔTe) as output. In motor control system, the function of fuzzy controller is to convert linguistic control rules into control strategy based on heuristic information or expert knowledge.

Fig. 6.2. shows the fuzzy sets and corresponding triangular MF description of each signal, the membership function of the associated input and output linguistic

variables is generally predefined on a common universe of discourse : NL (Negative Large), NM (Negative Medium), Z (Zero), PM (Positive Medium), PL (Positive Large).

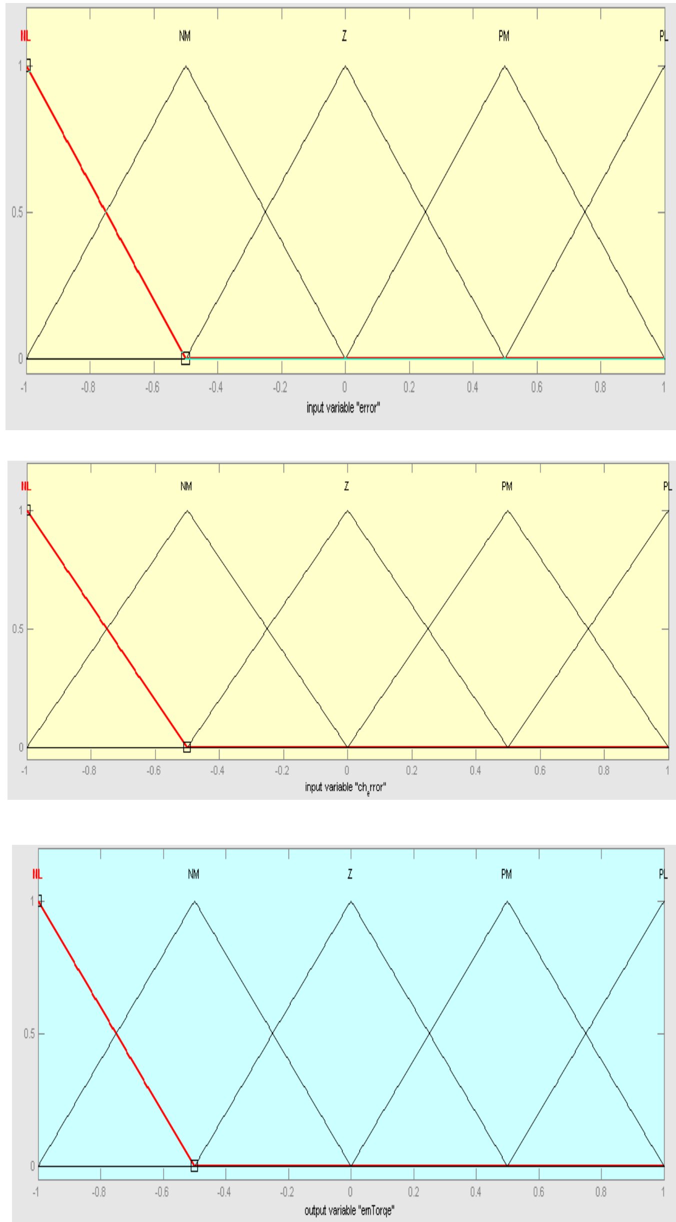

Fig. 6.2:Triangular membership functions for fuzzy controller input (e and ce) and output (ΔTe)

The rules are drived by help of fuzzy inference systems in the Matlab/Fuzzy Logic Toolbox as in Fig. 6.3, then rules represented in rule tables .

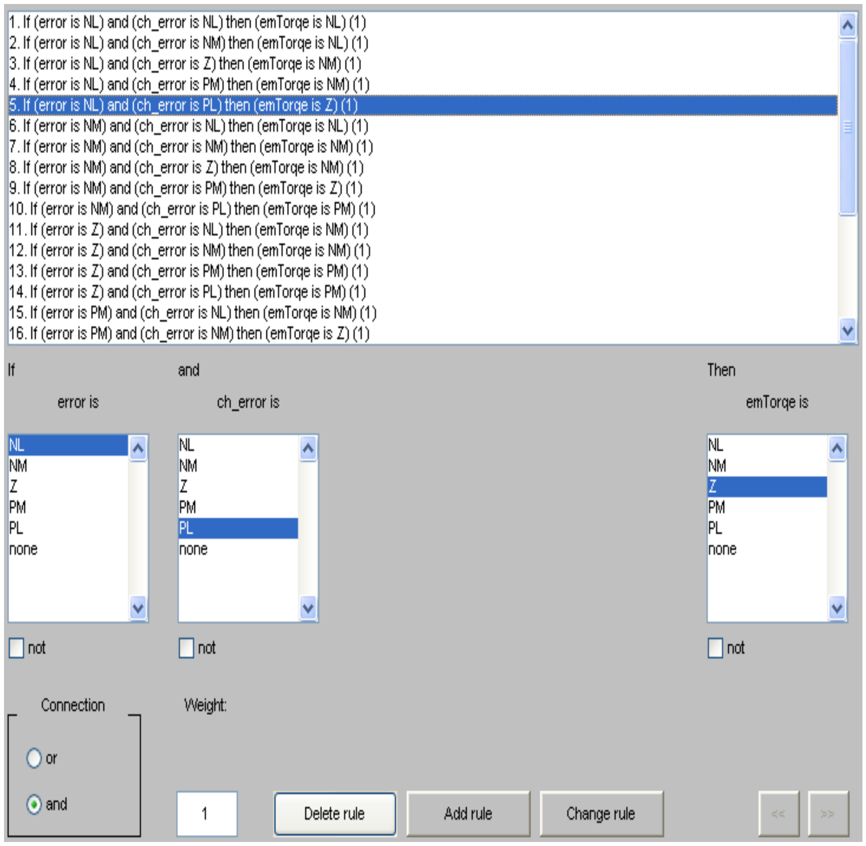

Fig. 6.3. Constructor of rules.

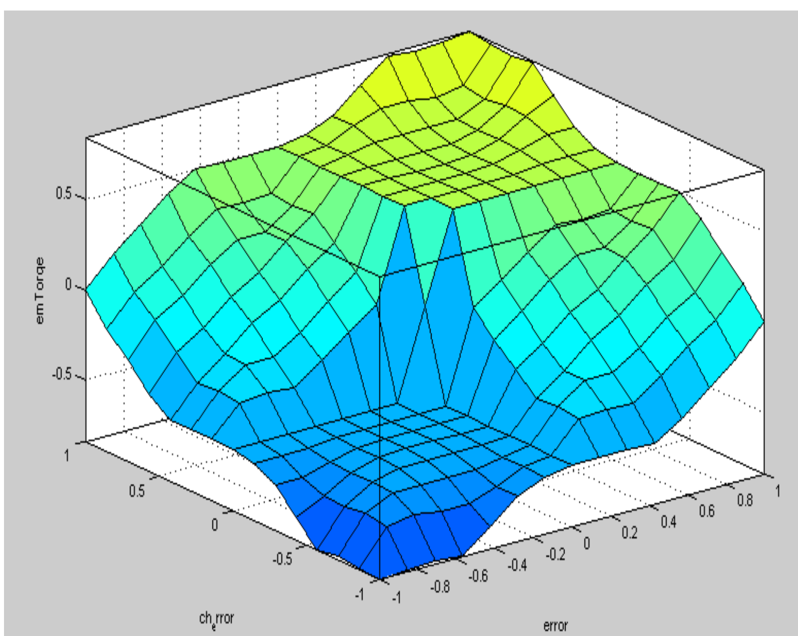

Fig. 6.4 Surface viewer fuzzy rules.

Table 6.1 Fuzzy rules table of FC

e / ce	NL	NM	Z	PM	PL
NL	NL	NL	NM	NM	Z
NM	NL	NM	NM	Z	PM
Z	NM	NM	Z	PM	PM
PM	NM	Z	PM	PM	PL
PL	Z	PM	PM	PL	PL

6.2 Control System Design**:**

Fig. 6.5 shows the Indirect Field Oriented Control of Induction Motor Drive Using PD Fuzzy Controller, and the same figure represents Indirect Field Oriented Control of Induction Motor Drive Using conventional PD Controller, when replace the fuzzy controller by conventional controller. Figs. 6.6 and 6.7, show the Scalar Control of Induction Motor Drive and direct operation of Induction Motor Drive respectively.

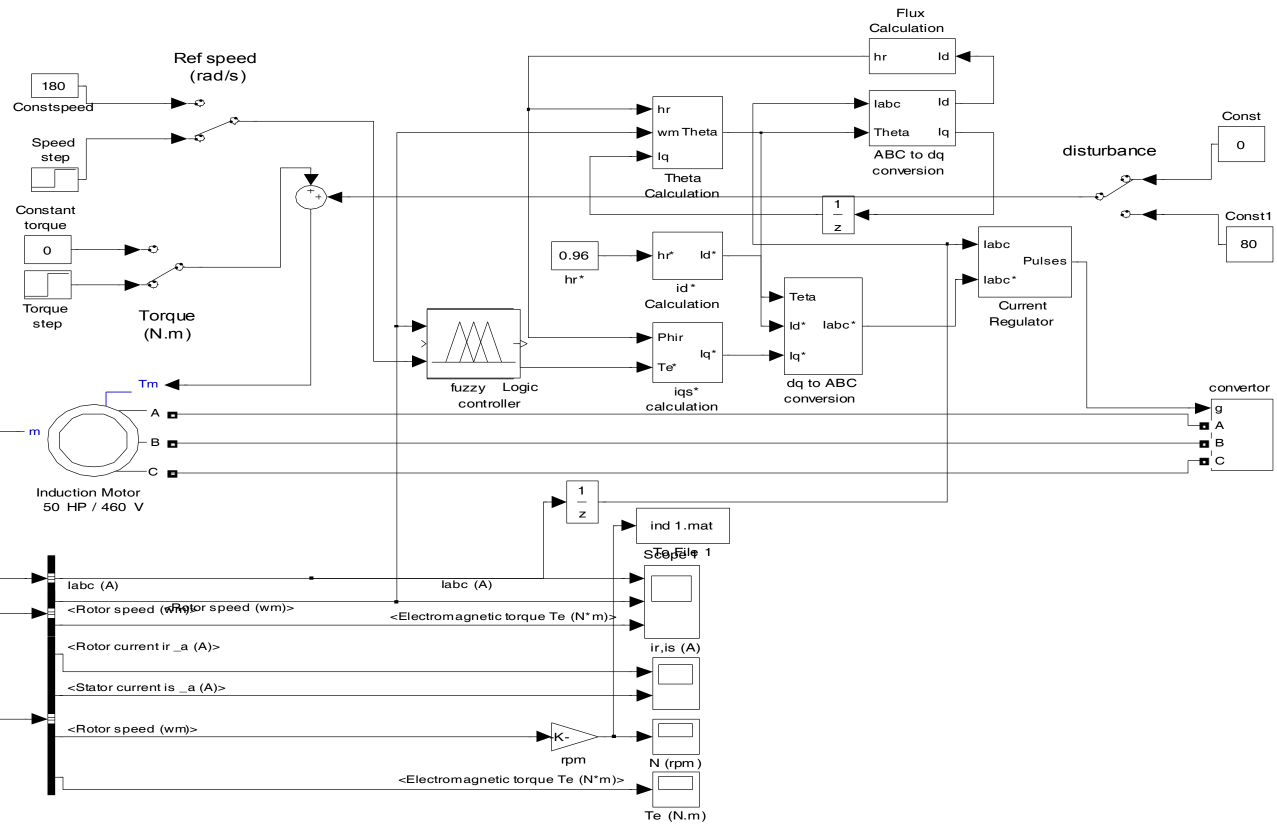

Fig. 6.5 Indirect Field Oriented Control of Induction Motor Drive Using PD Fuzzy Controller in Matlab/Simulink.

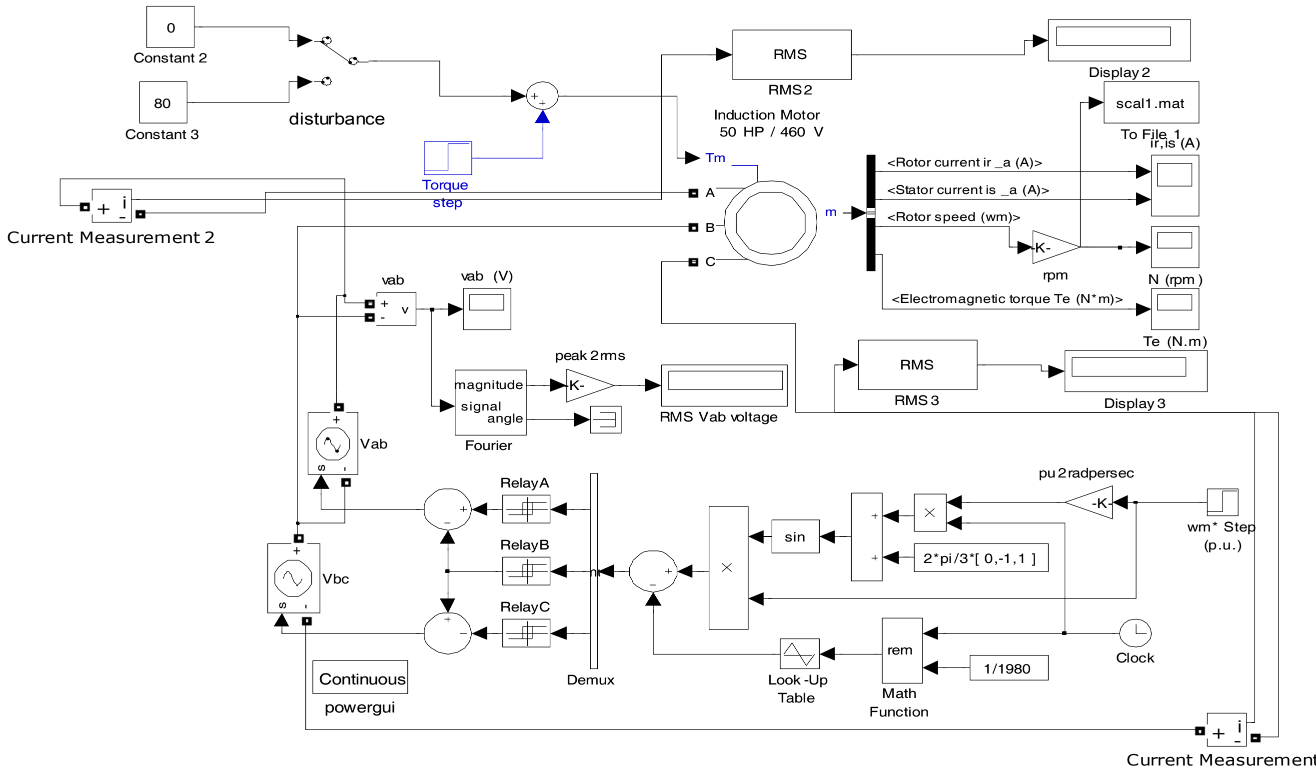

Fig. 6.6 Scalar Control of Induction Motor Drive in Matlab/Simulnk.

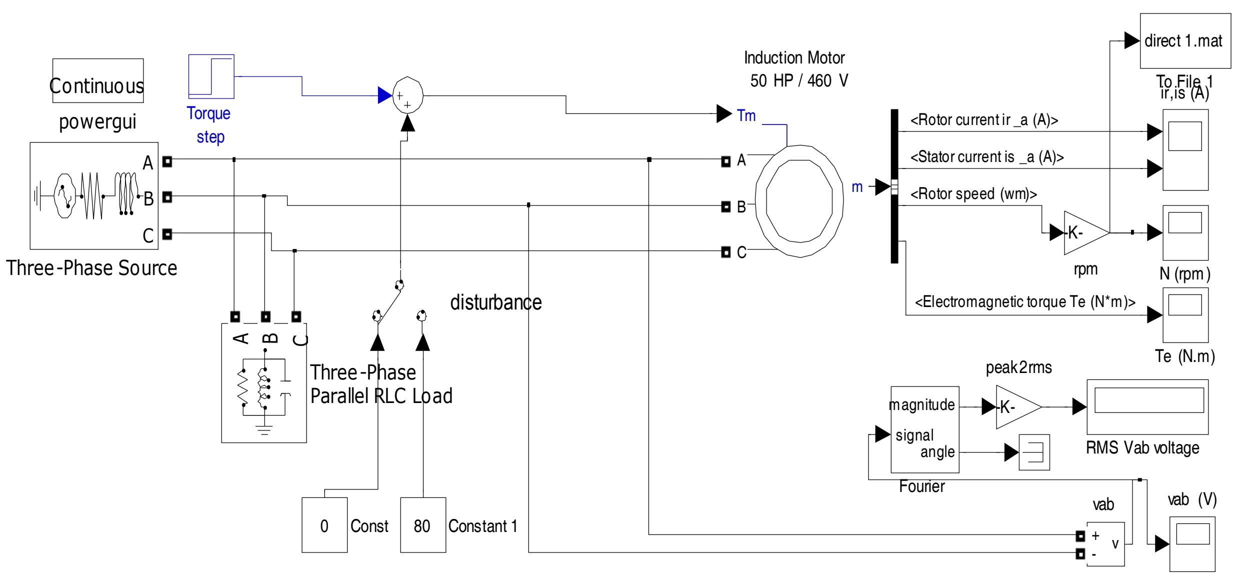

Fig. 6.7 direct operation of Induction Motor Drive in Matlab/Simulink.

6.3 Simulation Results And Discussions:

Many simulation tests were carried out on the four types of control, and their results were compared.Fig. 6.8, and Table 2 show the speed response of induction motor on full load.

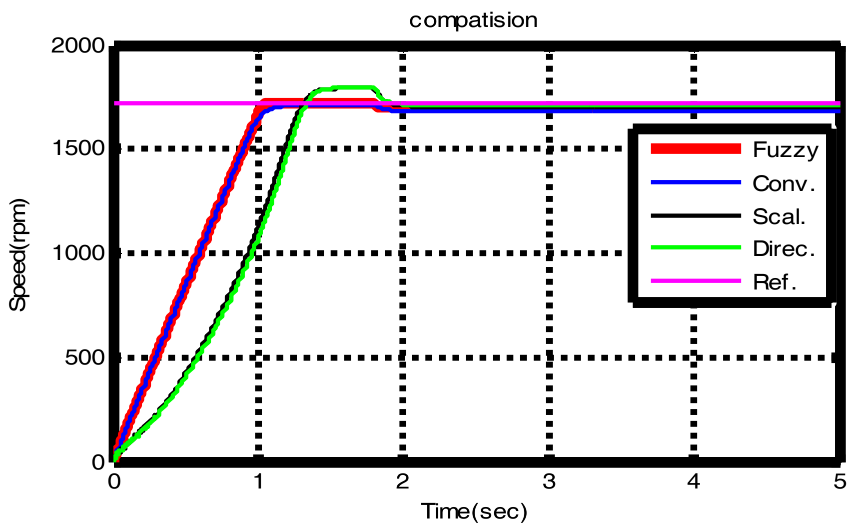

Fig. 6.8 Speed response comparison at full load.

Table 6.2 summarizes numerical values of rising time, peak overshoot, time to the peak and settling time.

Table 6.2 : Speed response comparison at full load

Type of control	Property			
	Rising time (10%-90%) (sec)	Settling time ±2(sec)	Overshoot (%)	Time to the peak (sec)
Direct on line	1.020	2.20	4.272	1.65
Scalar control	0.985	2.2O	4.285	1.74
PD conv. IFOC	0.825	2.35	-	1.37
PD fuz. IFOC	0.820	1.90	-	1.10

Fig. 6.9, 6.10 and 6.11 and Tble 6.3 show the speed response copmarison and stator current and rotor current (Amps) changes with load disturbance.

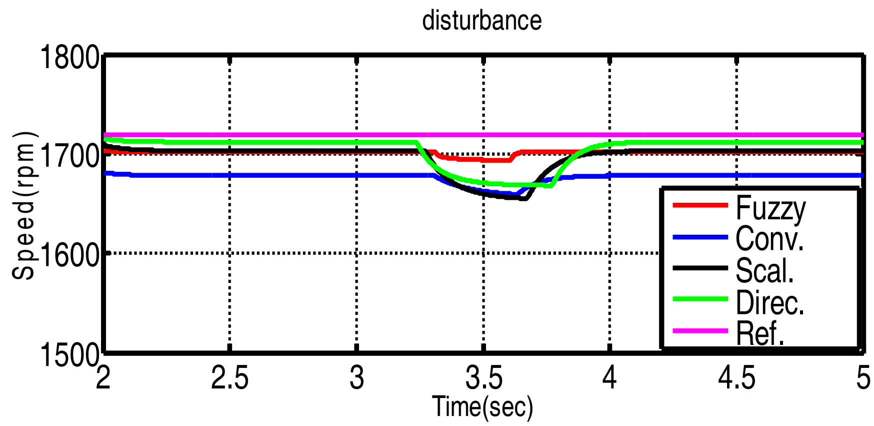

Fig. 6.9: Speed response comparison with load disturbance.

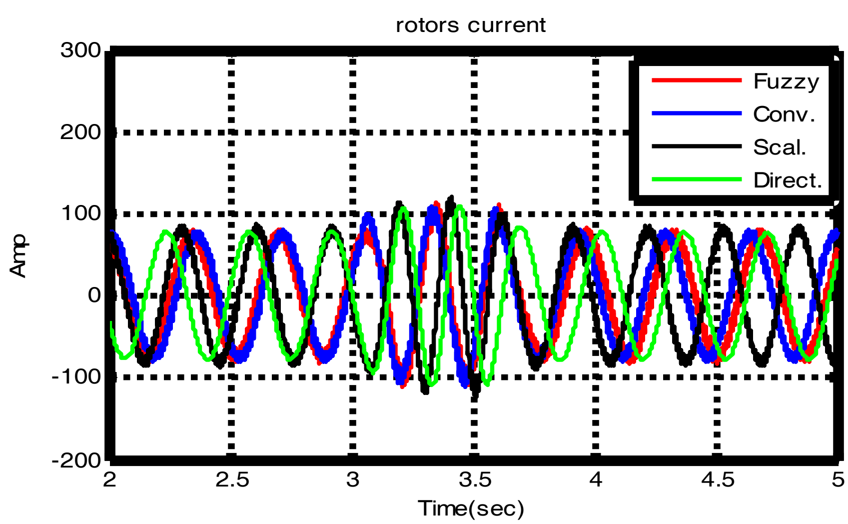

Fig. 6.10 change in rotor currents at disturbance.

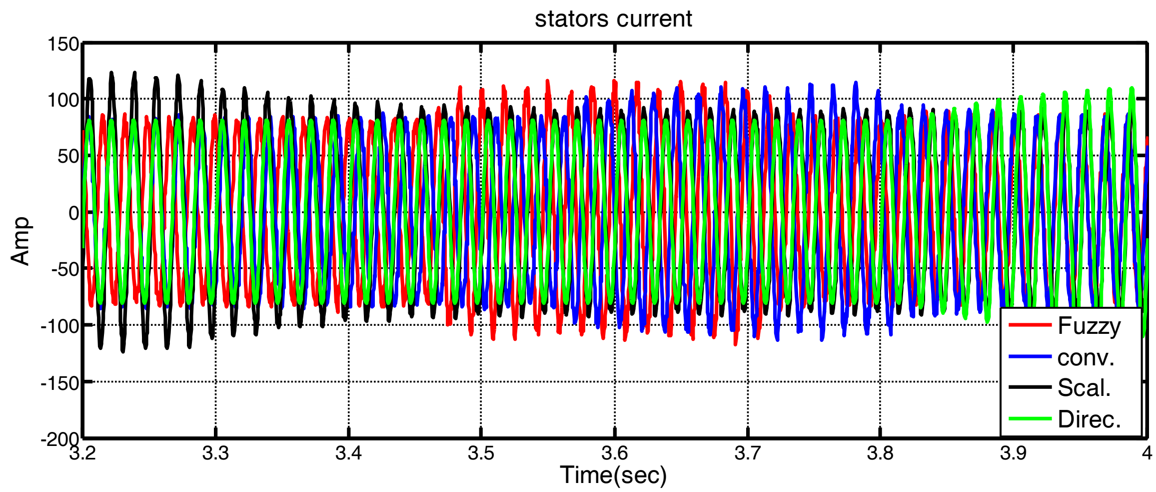

Fig.6.11 change in stator currents at disturbance.

Table 6.3 the effect of disturbance

Type of control	Property		
	Drop in speed (e_{ds}%)	Increase in stator current %	Increase in rotor current %
Direct on line	2.94	39.77	45.00
Scalar control	2.88	36.56	43.02
PD conv. control	1.43	35.63	38.27
PD fuzzy cont.	0.47	34.83	36.14

FLC performed better with respect to rise time, settling time, overshoot and time to peak compared to conventional, scalar, and direct operation as shown in figure 6.8. On the same way, the load disturbance response shown in figure 6.9 demonstrates that the FLC produces a better response than the other three systems. Table 6.2 summarizes the numerical values of rising time, settling time, overshoot and time to peak, the overshoot is the same in FLC and conventional control system, but better than scalar and direct operation systems. FLC shows a shorter rise time, settling time and time to peak. It is found that the FLC is more robust and did not show significant changes in its response due to load disturbance as shown on table 6.3.