# Fuzzy Controller Based Torque Control of Single Phase Induction MotorUsing Dynamic Capacitor

V. Mohanapriya, V.Manimegalai, B.Indurani

***Abstract---*** ***This thesis proposes a completely unique technique for the performance improvement of SPIM with dynamic capacitor by suggesting fuzzy logic con-troller by comparing with electrical condenser. In order to get the better performance various control techniques are used for 3Φ induction motor. The Voltage Source Inverter (VSI) is controlled by changeable capacitor in SPIM. The maximum torque is developed by the series connected variable capacitor and auxiliary winding which maintains the currents in 90° out of phase with each other .The proposed system is simulated in MATLAB 7.6 / simulink environment***

***Keywords Single phase Induction motor, phase angle, Fuzzy Controller,Fixed capacitor, Dynamic capacitor***

## 1. INTRODUCTION

In the area of electric drives ,1Φ induction motors gains attention in the research area due to their ease of control and operation. To get the high performance of 1Φ motor drives, SPIM acts as a 2Φ motor, in which the windings exhibit different characteristics [1]-[3].The capacitor is connected in series with the auxiliary winding to produce starting torque in capacitor-run SPIM to obtain higher performance.
Some of the high performance SPIM drives with rotor field oriented control principle have been reported in the literature [4].

To create a balanced two phase machine the PWM inverter control technique has been used [5][6].

In order to control SPIM under open loop conditions, voltage control of converters has been presented in the literature for PWM voltage control of VSI [7-8].

For low cost operatuion of SPIM this paper proposes a new method to control the inverter which extract the maximum torque [9 -10].

The fuzzy logic controller is used to extract the maximum torque which maintains the currents in 90° out of phase with each other .[11]. Simulation results are obtained using Matlab / Simulink to exehibit its improved performance.

## 2. SYSTEM DESCRIPTION

The VSI with a capacitor which acts as the dynamic capacitor is used for the indirect current control of SPIM.A figure representing the existing single phase induction motor with a variable capacitor is shown in the Fig.2.1

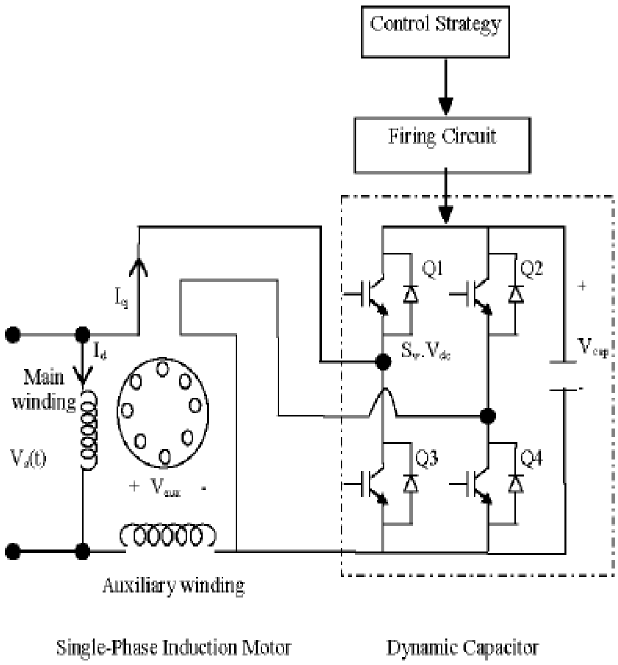


**Fig.2.1 Existing dynamic capacitor run SPIM**

The switching action of VSI maintains the voltage across capacitor and is controlled by secondary current. The existing system is shown in Fig.2.1

The maximum torque is developed by new current control of Inverter in which the winding currents are made in 90° out of phase with each other. The gating sequence of inverter changes according to main winding current of SPIM which in turn controls secondary currents under any condition.

## 3. THE FUZZY CONTROLLER

It has been found to be superior to traditional controllers particularly once data being analyzed is inexact or un-certain. A typical diagram of fyzzy logic controller is shown in Fig. 4. It mainly consists of a fuzzification interface, a fuzzy abstract thought machine and a defuzzification interface.

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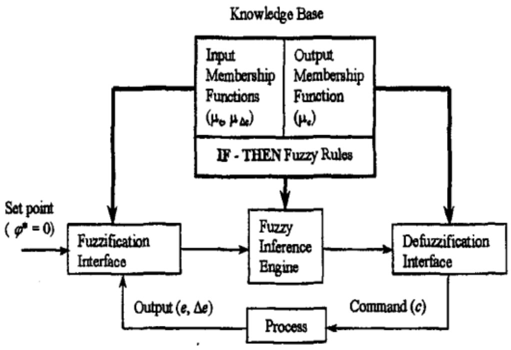



**Fig.3.1 Basic fuzzy controller**

*3.1 MEMBERSHIP FUNCTION*

It is the graphical representation of the magnitude of participation of each input.. The commonly used shape to describe the membership function is triangular, but bell, trapezoid and exponential can also be used. The membership functions are processed, they are defuzzified into a valuable output that drives the system.If-then rules, were used to formulate the conditional statements that comprise symbolic logic.

*3.2 FUZZY RULES AND FUZZY INTERFACE*

Based on the practice and the understanding about the system , the rules are decided. Each rule can be represented using the state variables e and Δe:

R: if (e is A) and (Δe is B) then (c is C)

where ***A, B*** and ***C*** represent the fuzzy segments.

A 7 x 7 rules shown in table 1 and it is applied to decrease the angle variation to zero and it generates a controllable output. This phase is called defuzzification.

| Error / Change in error | NB | NM | NS | ZE | PS | PM | PB |
|---|---|---|---|---|---|---|---|
| NB | PB | PB | PB | PB | PB | PS | PS |
| NM | PM | PM | PM | PM | PS | PS | PS |
| NS | PS | PS | PS | PS | PS | PS | PS |
| ZE | ZE | ZE | ZE | ZE | ZE | ZE | ZE |
| PS | NS | NS | NS | NS | NS | NS | NS |
| PM | NS | NS | NM | NM | NM | NM | NM |
| PB | NB | NB | NB | NB | NB | NB | NB |

**Table 1.Fuzzy rules formed for the speed Controller.**

*3.3* FUZZY *CONTROL SCHEME*

The fuzzy logic is an combination of rules, supported by the input variable condition with a corresponding required output. According to the principle two input variable are considered, the error and the change in error. Fuzzy logic control is used to achieve zero error difference between the two winding currents.

The Second state variable is the error variation

$\Delta e\,(k) = e\,(k) - e(k-1)$

$C = \Delta t_1\,(k)/T = t_1\,(k) - t_1(k-1)/T$

The 2 fuzzy input variables and the output variable are classified into seven *fuzzy* sets each shown in the table1. Fig.3.2 indicates the membership diagram of *fuzzy* variables.

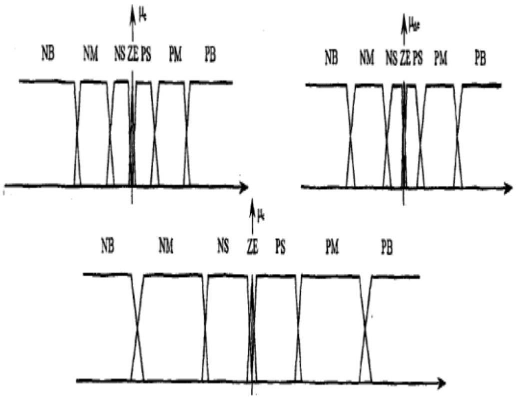



**Fig.3.2 The Membership Diagram**

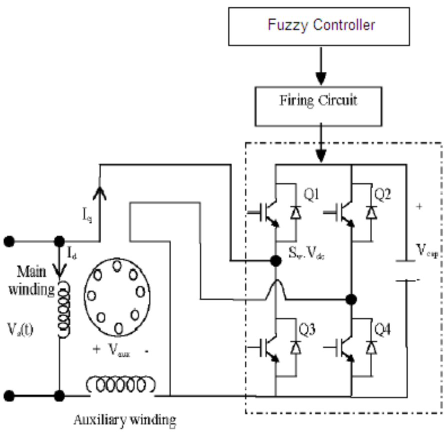
*3.4 DETAILS OF FUZZY CONTROLLER*

- Implication method - mamdani type
- Number of inputs - 2
- Number of outputs - 1
- Number of rules - 49
- Defuzzifcation - Centroid method

The fuzzy controller output is rounded-off to convert it into a crisp value and the appropriate switching is done so as to minimize the errors.

## 4. PROPOSED SYSTEM USING FUZZY CONTROLLER

The circuit diagram of the proposed method is shown in the fig.4.1




Single phase induction motor dynamic capacitor

**Fig.4.1 Circuit diagram of proposed method**

The voltage across the DC capacitor is maintained by controlling VSI. The Fig.4.1 indicates the circuit diagram.The fuzzy control of VSI makes the winding current in phase quadrature with each other and maintains it, so that it generates the maximum torque.

## 5. SIMULATION RESULTS AND DISCUSSIONS

The simulation diagram for the proposed method is shown in fig 5.1.The results for main and auxiliary winding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current, speed and torque with fixed and Dynamic capacitor are shown in Fig 5.2.

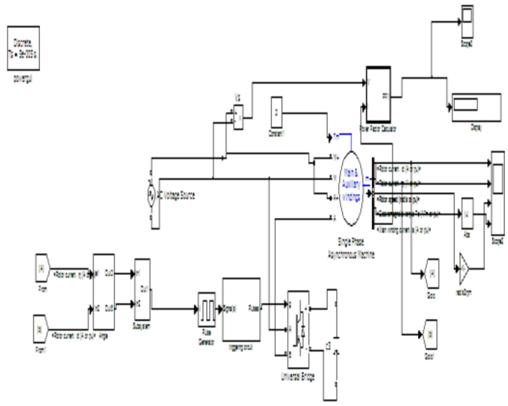

**Fig 5.1 Simulation diagram of the proposed method**

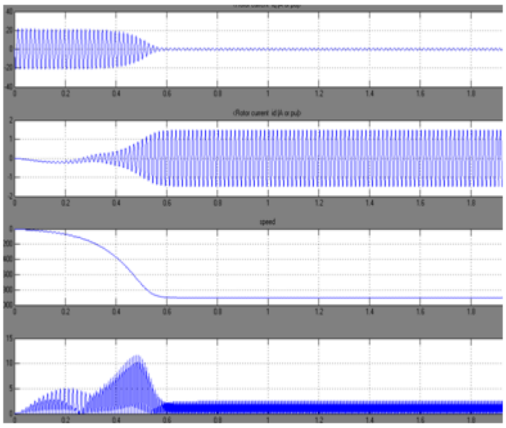

**Fig 5.2 Simulation Results With Fixed Capacitor**

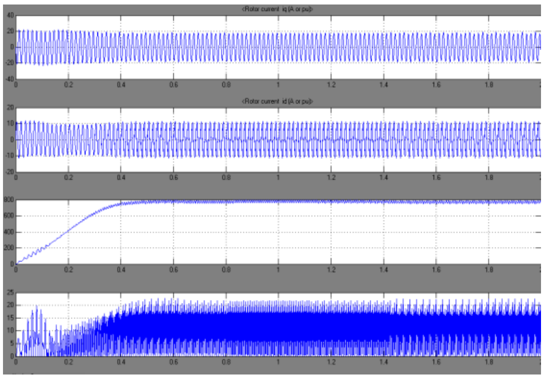

**Fig 5.3 Simulation Results With Dynamic Capacitor**

| Load values | Power factor value with dynamic capacitor | Power factor value with fixed capacitor |
|---|---|---|
| 0 | 0.9994 | 0.8356 |
| 0.1 | 0.9996 | 0.0279 |
| 0.3 | 0.9998 | 0.0455 |
| 0.5 | 0.9998 | 0.1159 |
| 0.7 | 0.9994 | 0.1822 |
| 1 | 0.9984 | 0.2727 |

**Table 2.Power factor values for different loads**

The performance of proposed method is done for various load values and corresponding power factor values is compared with fixed capacitor and dynamic capacitor. The resultant power factor of above methods is listed in Table 2.

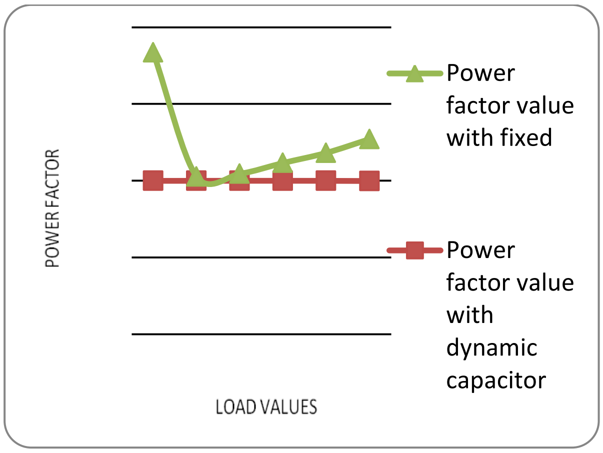


**Fig.5.4 Comparison of Torque curve**

| Load values | Torque value with dynamic capacitor | Torque value with fixed capacitor |
|---|---|---|
| 0 | 8.27 | 0.07 |
| 0.1 | 7.87 | 0.78 |
| 0.3 | 7.32 | 0.37 |
| 0.5 | 6.39 | 0.42 |
| 0.7 | 5.26 | 0.45 |
| 0.9 | 3.28 | 0.49 |
| 1 | 1.86 | 0.52 |

**Table 3.Torque values for different loads**

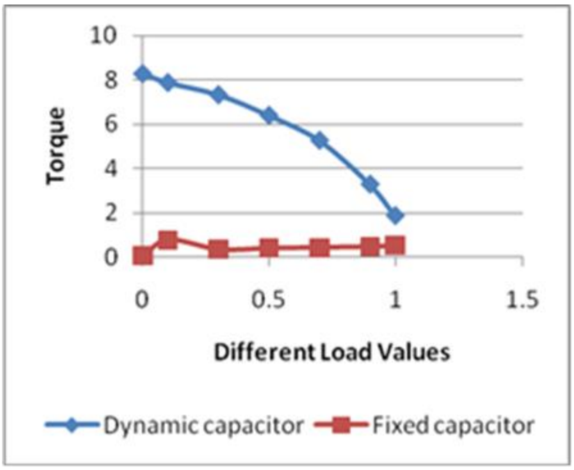


**Fig.5.5 Comparison of Torque curve**

| Load values | Efficiency value with dynamic capacitor | Efficiency value with fixed capacitor |
|---|---|---|
| 0 | 62.4 | 53 |
| 0.1 | 62.4 | 55 |
| 0.3 | 62.5 | 44 |
| 0.5 | 62.3 | 12 |
| 0.7 | 61.7 | 18 |
| 0.9 | 59.9 | 23 |


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| | | |
|---|---|---|
| 1 | 58 | 28 |

**Table 3.Efficiency values for different loads**

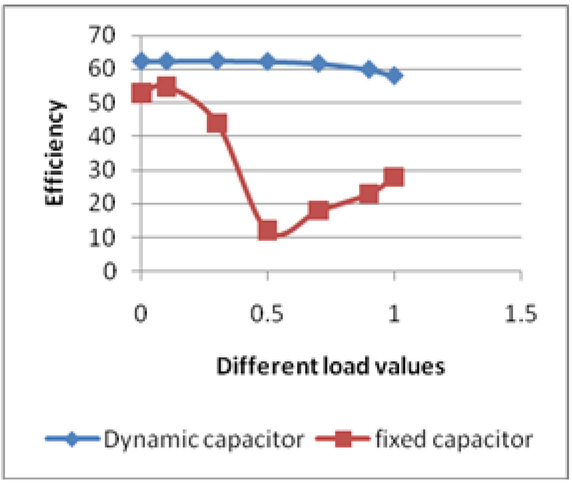


**Fig.5.6 comparison of efficiency curve**

## 6. CONCLUSION

The practical results of SPIM with proposed method has proved that it can able to operate at maximum torque, power factor and efficiency. The new technique using Fuzzy logic controller controls the VSI. By using the proposed method, the power factor, torque, efficiency are enhanced for different load values. The curves for power factor, torque and efficiency are plotted.The whole model is simulated in MATLAB 7.6/ Simulink environment.

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