Control of the AC Induction Motor by Using Fuzzy Logic

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Abstract

The main aim of this thesis is studying and recognize the specifications and main concepts of (Fuzzy Logic) and its components and studying the practical experiments of the (Fuzzy Logic) techniques in the electrical engineering field through by using the (Fuzzy Logic) for controlling the three-phase AC induction motor by using (Matlab_ simulation_7) for modeling the system by using the computer.

1) Introduction:

The term fuzzy logic was developed in 1965 by Professor Lutffi zadeh. The term is used to describe the groups of multiple values. The concept of multi-valued logic was found in 1920, at the University of Heisenberg to deals with quantum mechanics. Lotffi zadeh applied the logic of multi-values and developed the term (fuzzy sets) which is the group that its elements return to different values, and it's considered as transformation from the classical logic which reflects the wrong or right, and the number one or zero to become a fuzzy logic of multi values between zero to one and it is considered as a moving from traditional mathematics and numbers to the philosophical and linguistic mathematics [1].

2) The concept of fuzzy logic:

It is conventional organization based on the popularization the traditional logic of binary values. It is used as indication to an uncertain conditions. This concept consists of theories and techniques that use the fuzzy sets which are sets without interrupted borders . This logic is a way to describe and represent the human experience;

also it offers practical solutions to the problems of realism, with reasonable and effective cost in comparing with the solutions provided by other techniques [1],[2].

3) Traditional sets and fuzzy sets:

a) The Traditional Set:

In the traditional or classical sets an element can be either belong to a set or does not belong to it at all. For example, Group A and Group U. If we define the function μA, which gives each of the elements of group U the degree of belonging to Group A, by giving it the number 1 i.e. μA (X) = 1. If the element belongs to the group U i.e. element X belongs to Group A. However, if the element X is not belongs to A, so the function μA gives number zero i.e. μA (X) = zero. As such, it can be expressed as follows on function μA [2]:

μA:U→{ zero, 1}

X →μA (X)

b) Fuzzy Sets:

In the fuzzy group an element can be belonging to a certain extent for the group. For example, if the group A was the temperatures that are classified as cold (cold for humans) and considers the group U is all temperatures .

Let us take the example of the element X = -100, U This temperature is very cold and this is exactly belong to group A i.e. μA (X) = 1. However, if we take a temperature X= +500, this temperature is very warm so the element X dose not belong to A. till now We did not go far from the use of classical logic as A was belong or not belong. But let's take for example the temperature X =12. In the traditional

logic, we have two possibilities either belongs or not belongs to A. In the fuzzy logic can we say that X belongs to a score of 50% to A that is to say temperature 12 is half cold and half moderate for example, A(X) = 0.5. Here we see a difference in the definition of function μA. where it known mathematically as [3]:

$\mu A: U \rightarrow \{0,1\}$

$X \rightarrow \mu A(X)$

Where the function can give results between 1,0 on reverse it in the classical logic, where the function give either number 1 or number 0 [2],[3].

4) The Operations On The Fuzzy Sets :

1_The Contrary: the symbol of the process is - A or À.
2_The Intersection: the symbol of the process is ∩ or Λ.
3_ The Integration: The symbol of the process is U or V.

a) The Contrary:

Let us take, for example - A or À. the reverse process of A which is moderate temperatures and B is - A. known as non moderate temperatures, where in the classical logic, for example, moderate temperatures must be belong as whole for A, while at the same time they totally do not belong to B. for example, a temperature is 20 to be subject to the relationship μA (20) = 1, and at the same time μA (20) = 0. This is an embodiment of the Classical logic, where temperature is 20 either calculated on the moderate group or non moderate. It is not possible to 20 degrees to be at the same time moderate and non moderate. This can be achieved if the membership function μA=μB [3].

b) The Intersection:

The intersection can be defined in the both fuzzy logic and classical logic. As in the case for the contrary process by using mathematical operations on the membership function μ, but in the intersection instead of the use of the subtraction process we usually use min process.

c) The Integration:

The integration can be defined in both fuzzy logic and classical logic as in the contrary process. i.e. by using of mathematical operations on the membership function μ, but in the Integration instead of using the subtraction process we use max process [3],[4]. Some of the terminologies that are used in the context of fuzzy logic given in table (1):

Term	Contextual usage
Bandwidth	Narrowband , broadband
Blur	Some what , quite , very
Correlation	Low , medium , high , perfect
Errors	Large , medium , small , a lot of , not so great ,very large ,very small
Frequency	High , low , ultra
Resolution	Low , high
Sampling	Low rate , medium rate

Table(1): context of fuzzy logic

5) The Fuzzy Systems of controlling:

There are five preliminary components of systems for controlling fuzzy:

1- fuzzy form.

2- base of knowledge.

3- base of laws.

4- information engine.

5- fuzzy opening form.

Automatic change in the design of programs for any five elements it will form adaptive fuzzy controller [4].

Fuzzy control system consists of fixed elements, and non-fixed elements are part of the control system which includes conversion sensors from waveform to the digital system and the adapter from conversion from to digital system to waveform system and normalization circuits. There are two types of normalization circuits, the first type to scheduling of an input physical values from controller to natural values. The second type converts the natural values to the physical values[4],[5].

6) AC induction motor:

the AC induction motor is the most commonly used type among motors and it is the most famous in the systems of control in the industrial field. In addition to it is widespread usage in the main home devices. Also, its design is simple and low cost compared to other engines and it connects the AC induction motor directly to AC power sources.

There are different types of induction motors present in the work market and the difference in these species varies according to the desired application. The speed and torque are tools for controlling multiple types of AC induction motor. All kinds of AC induction

motors contain a rotor part and fixed part and use the generated magnetic field to rotate the rotor part [5].

7) Speed of induction motor:

The magnetic field generates within the fixed part in asynchronous quick where Its symbol is (Ns) and the equation of speed is: Ns = 120 F/Pwhere:

Ns: is the synchronous speed in the fixed part.

P: is the number of polars.

F: is the frequency of the source.

The magnetic field is generated inside the rotor part because of the alternating inductive voltage. Where the rotor part rotates in a fixed field at lower speed called (NB), and the difference between the Ns and Nb is called the slip and the last changes according to the equation [5],[6]:

slip = ((Ns - Nb) / Ns) * 100

8) Technology of Matlab_simulink:

In recent years, the technology of simulink became a broader software packages, from both academic and industrial aspects for modeling and representing of the systems. The benefit of this system or any system similar to it will enable the researcher or user to do the tests that he needs it, so he can build the required forms or taking an older model and do any additions or changes.

Here, the process of simulation is an interactive process, so it is possible to change some variables and observing the changing in the results directly on the circuit. Such models are converting the computer to a laboratory for modeling and analyzing of circuits that

can not be represented simply in the practical field [7].

We have used in this research the (Matlab_simulink_7) technique in the representation of the three-phase AC induction motor, and it was used technology of fuzzy logic for controlling it, where laws related to fuzzy logic were formulated to deal with the changes of speed and torque in the three-phase AC induction motor, and it can be viewed by clicking on the button of fuzzy logic controller as is shown in the following figure (1) [8].

9) The laws of fuzzy logic to control:

The laws of fuzzy logic have been applied to process different situations of expected changes according to the nature of the system, and we will find that the laws are verbal which distinguishes fuzzy logic from other applications:

If (slip is VS) then (freqw is VSO).

If (slip is S) then (freqw is SO).

If (slip is M) then (freqw is MO).

If (slip is I) then (freqw is IO).

If (slip is VI) then (freqw is VIO) [8],[9].

And these laws can be seen in the program (Matlab_simulink_7) by this path:

start _ toolboxes _ fuzzy logic _FIS editor viewer.

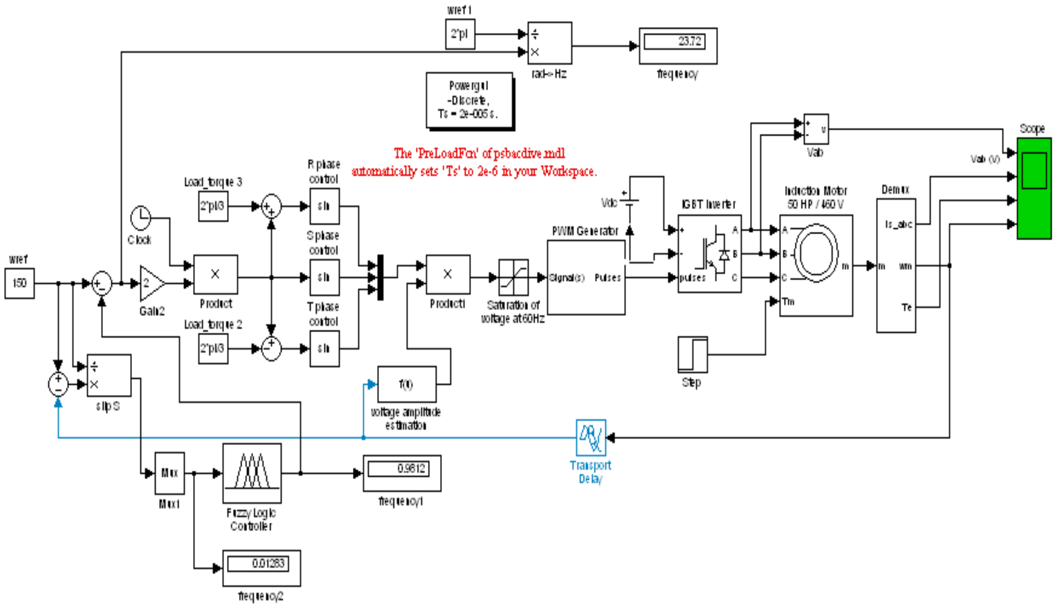

Fig (1): the full form of the system in the program

(Matlab_simulink_7)

the results can be shown by pressing button of output which is represented by showing of output curves called (scop), where shows the coordinates of four curves and the coordinates are represented as follows: The First: represents a voltage with time.

The second: represents the current with time.

The third: represents the torque with time.

The fourth: represents the deviation of speed curve.

When we press the button of (scop), the following image will appear.

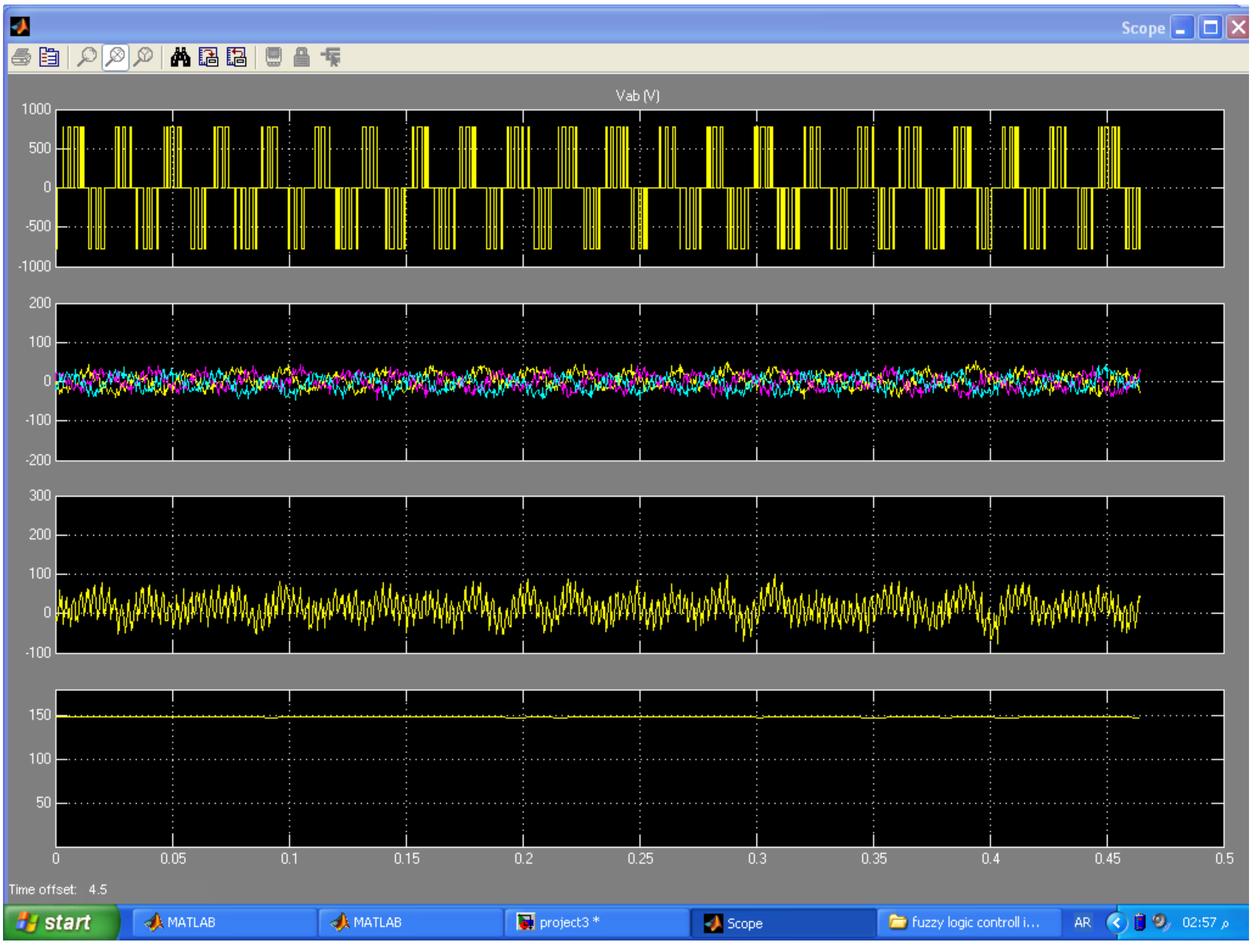

Fig (2): explain output curves

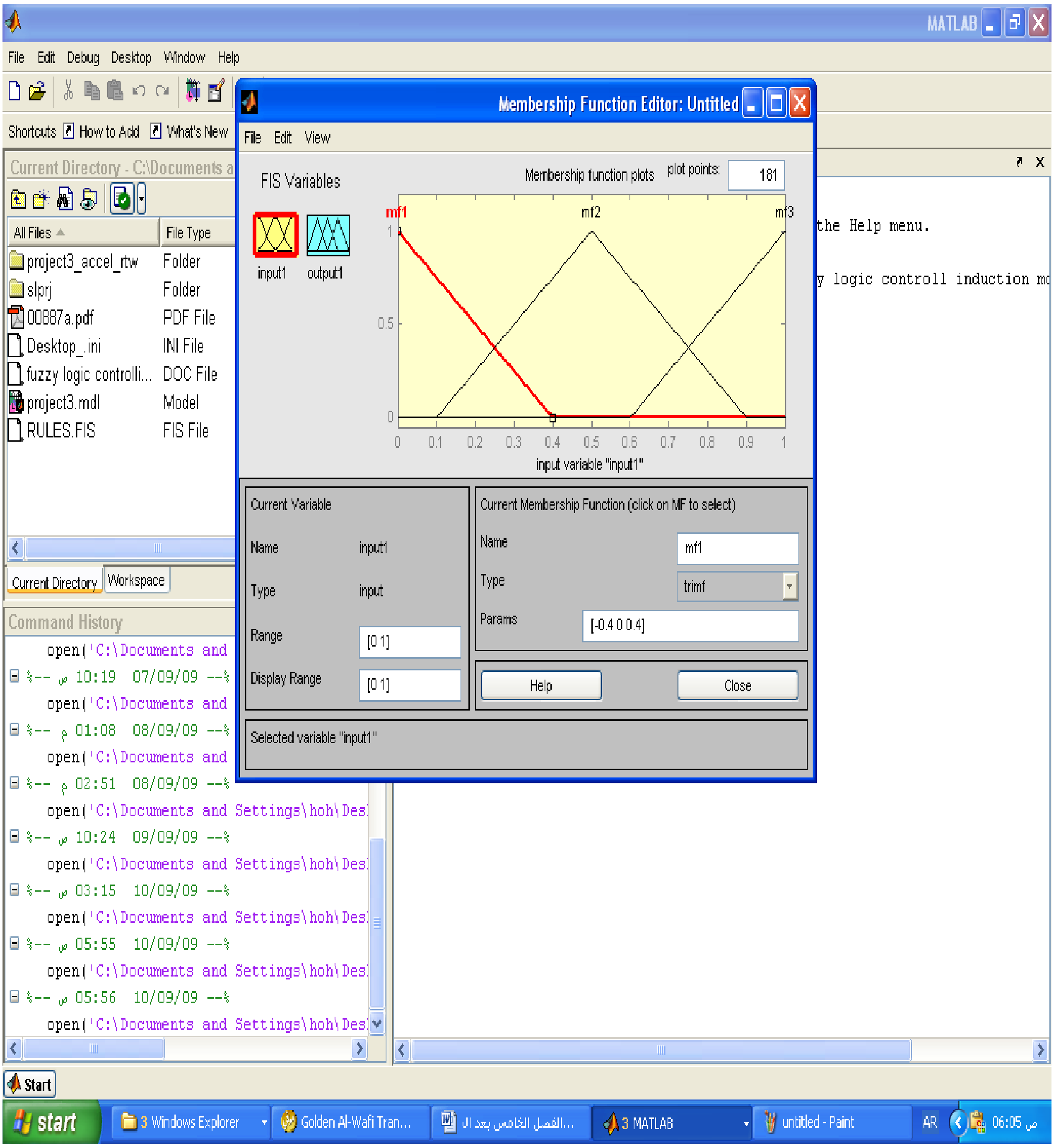

Fig (3): represents the membership function for the input signal

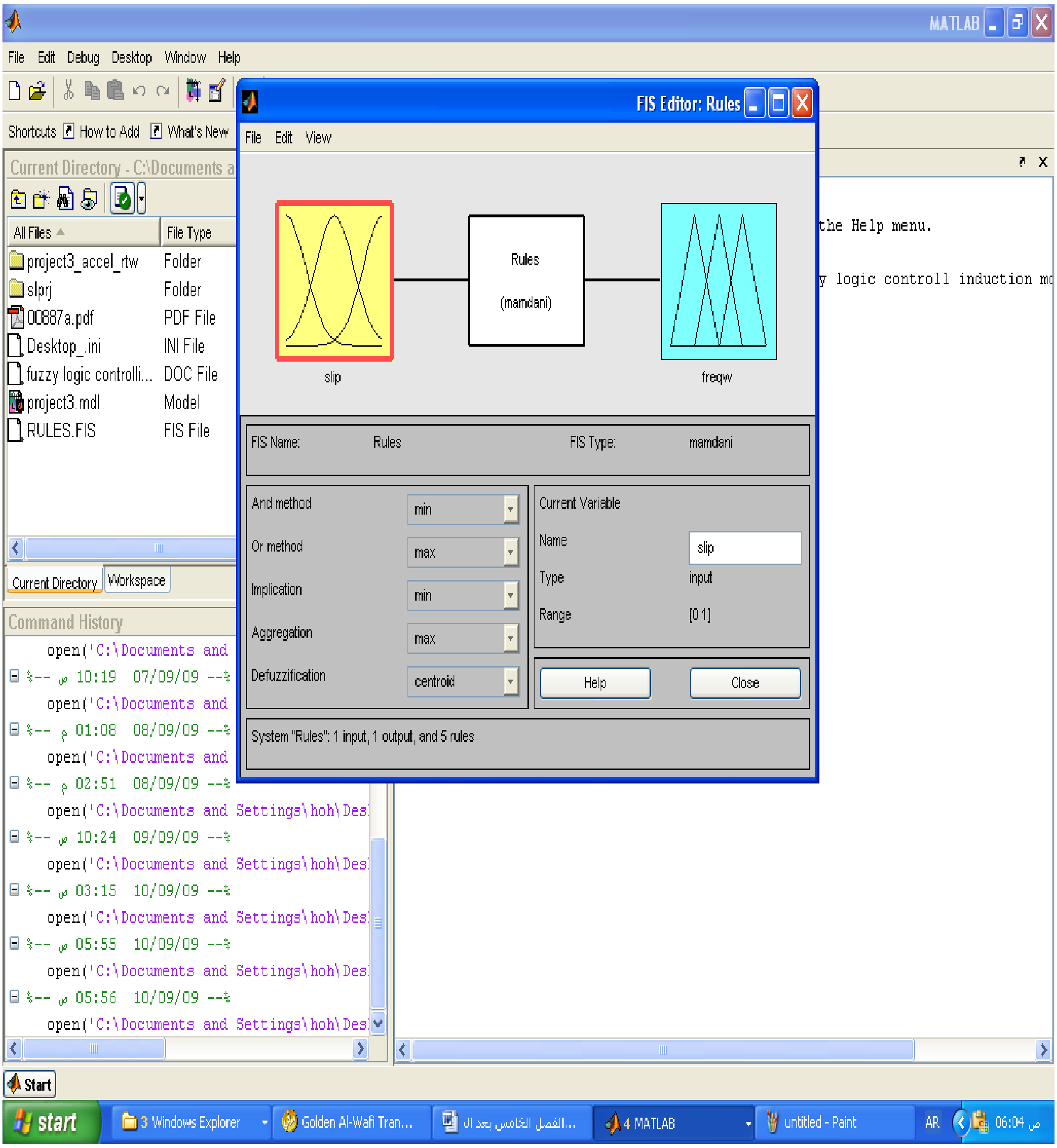

Fig (4): shows specifications of the suggested fuzzy logic controller in the system

Conclusions:

After studying the previous applications in fuzzy logic technique. We chose the technique of fuzzy logic because the flexibility of this application in the formulation of the laws, but for example, if we used

the application of artificial neural network we may need a large number of programming steps or we may need to very complicated calculations in the case of using the application of genetic algorithms. The fuzzy logic controller was applied on the three-phase AC inductive motor which was modulated by the (Matlab_simulink_7). The technique of fuzzy logic is used to deal with uncertain information or fuzzy information through relations and laws applied by the applicator according to the changes in the work environment (inputs). For this reason, we recommended for using it in the projects that give different situations for particular entrance more than giving numbers or data.

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باستخدام المنطق الضبابي AC للسيطرة على موتور التعريفي

أوس محمود عبد الله

باللغة العربية

إن الهدف الرئيسي من هذا البحث هو دراسة والتعرف على الخصائص والمفاهيم الأساسية للمنطق الضبابي (Fuzzy Logic) وأجزائه ودراسة التجارب العملية لتقنيات المنطق الضبابي (Fuzzy Logic) في مجال الهندسة الكهربائية من خلال تطبيق المنطق الضبابي(Fuzzy Logic) للقيام بالسيطرة على المحرك الكهربائي ألحثي المتناوب ثلاثي الطور باستخدام برنامج الـ (Matlab_simulation_7) للقيام بنمذجة النظام حاسوبيا.