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Modeling and Control of multimachines System Using Fuzzy Logic

***Abstract**. This work is devoted to modeling and vector control by fuzzy logic of a multimachines system connected in series. A six-phase asynchronous machine connected in series with a three-phase asynchronous machine fed by a single inverter and controlled independently. Thanks to the powerful means of calculation, which made possible the control of such a system and this allows its integration in applications where the constraints of space and weight require a particular attention*

***Streszczenie.** W artykule opisano zastosowanie układu fuzzy logic do sterowania wielomaszynowym systemem sześciofazowej maszyny asynchronicznej I trójfazowej maszyny asynchronicznej połączonych szeregowo.Do sterowania każdej z maszyn użyto niezeleżnego przekształtnika. (**Modelowanie i sterowanie systemem wielomaszgnowym z wykorzystaniem fuzzy logic**).*

Keywords: Multimachines system (MSCS), Vector control, Hexa-phase inverter, Fuzzy control (FLC).
Słowa kluczowe:system wielomaszynowy, sterowanie fuzzy logic.

Introduction

AC machines, induction in particular have dominated the field of electric machines. Recently, researchers are interested in machines with a number of phases greater than three. These machines are often called «multiphase machines». This type of machine have large losses and to exploit these, it is possible to connect in series several machines supplied by a single static power converter with each machine in the group have an independent speed control. However, the use of multiphase converters associated with polyphase machines, generates additional degrees of freedom. Thanks to these, several polyphase machines can be connected in series in an appropriate transposition phases [1], [4].

For some applications, series connection of multi-phases induction machines can be very interesting.

The global system is defined as the domination of a series connected multi-machines mon-converter system (MSCS). This system consists of several machines connected in series in an appropriate transposition of phases. The whole system is supplied by a single converter via the first machine. The control of each machine must be independent of others [5], [7].

In [17], the author uses a classical PI controller to perform a speed control of series connected machines. However, PI controller parameters are highly affected by the system parameters, a temperature rise can cause a degradation of the control quality.

Seen from this major drawback, our contribution is to change conventional controllers “PI” with fuzzy logic controllers and test its robustness.

Modeling of Multi-machine System

The drive system is composed by two induction machines. The first one is a symmetrical six-phase induction motor M(1) which its windings are series connected with that of a second three-phase induction motor M(2). The two motors are supplied by a single power converter which is a six-phase Voltage Source Inverter (VSI).

Fig. 1 presents the connecting and suppling schematic of the two motors and the converter [7], [9]. The six-phase machine has the spacial displacement between any two consecutive stator phases equal to 60° (i.e. α=2π/6).

Only phases 1, 3 and 5 are used by the second machine M(2), this phases are electrically displaced to each other by and angle of 2π/3.

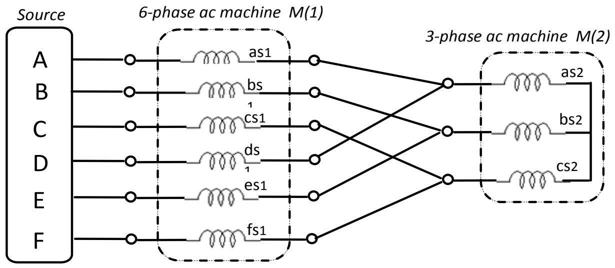

Fig. 1. Connection diagram for series connection of a six-phase and a three-phase machine

We note that a simple series connection of stator windings fails to ensure the desired performances. A solution is adopted to overcome this constraint consists of using an adequate stator windings transposition [10], [11]. This transposition resides of connecting in one point each two (electrically displaced to each other by π) of six-phase windings and connect them in series with the windings of the M(1) [12], [14].

In this way, currents pass through the six-phase windings going to neutralize at the connecting point. And in the same context, the current passing through the one winding of M(2) will be the half when passing through the windings of M(1). This will generate in air-gap of the M(1) a two (equal in magnitude and opposed in phase) Magneto-Motive Force (MMF). Therefore, a natural decoupling of the two motors will be possible by adopting the connection diagram shown in Fig. 1.

According to Fig. 1, the stator and rotor voltages of the two machines can be written as follows [1], [4]:

$$[v_s]=\begin{bmatrix} V_A \\ V_B \\ V_C \\ V_D \\ V_E \\ V_F \end{bmatrix}=\begin{bmatrix} v_{as1}+v_{as2} \\ v_{bs1}+v_{bs2} \\ v_{cs1}+v_{cs2} \\ v_{ds1}+v_{as2} \\ v_{es1}+v_{bs2} \\ v_{fs1}+v_{cs2} \end{bmatrix} \quad (1)$$

The relationship between the current source and the stator currents of each machine are given as follows:

$$
(2)\qquad \begin{aligned}[i_s] &= [I_A \quad I_B \quad I_C \quad I_D \quad I_E \quad I_F] \\ &= [i_{as1} \quad i_{bs1} \quad i_{cs1} \quad i_{ds1} \quad i_{es1} \quad i_{fs1}] \\ &= [i_{s1}]\end{aligned}
$$

$$
(3)\qquad [i_{s2}] = \begin{bmatrix} i_{as2} \\ i_{bs2} \\ i_{cs2} \end{bmatrix} = \begin{bmatrix} I_A + I_D \\ I_B + I_E \\ I_C + I_F \end{bmatrix}
$$

The electrical equations:

$$
(4)\qquad \begin{cases} [V_{sk}] = [R_{sk}].[i_{sk}] + \dfrac{d}{dt}[\varphi_{sk}] \\ [0] = [R_{rk}].[i_{rk}] + \dfrac{d}{dt}[\varphi_{rk}] \end{cases}
$$

Where

$$
(5)\qquad \begin{cases} [\varphi_{sk}] = [L_{ssk}].[i_{sk}] + [M_{srk}].[i_{rk}] \\ [\varphi_{rk}] = [L_{rrk}].[i_{rk}] + [M_{rrk}].[i_{sk}] \end{cases}
$$

Knowing that k=1 for the M(1) and k=2 for the M(2) with:

$$
[R_{seq}] = [R_{s1}] + \begin{bmatrix} [R_{s2}] & [R_{s2}] \\ [R_{s2}] & [R_{s2}] \end{bmatrix} ;
$$

$$
[L_{seq}] = [L_{s1}] + \begin{bmatrix} [L_{s2}] & [L_{s2}] \\ [L_{s2}] & [L_{s2}] \end{bmatrix}
$$

Modeling of Multimachines System into three subspaces(α,β), (x,y), (o+,o-):

The original six dimensional systems of the MSCS can be decomposed into three orthogonal subspaces, (α, β), (x, y) and (o+, o-) [1], using the following transformation $X_{\alpha\beta o} = [T_6(\theta)]^{-1}.X_{abc}$ and $X_{dqo} = [T_6(\theta)]^{-1} X_{\alpha\beta o}$

Where: X represents stator currents, stator flux, stator voltages in MSCS.

The matrix $[T_6(\theta)]$ is given by:

$$
(6)\qquad [T_6] = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & cos(\alpha) & cos(2\alpha) & cos(3\alpha) & cos(4\alpha) & cos(5\alpha) \\ 0 & sin(\alpha) & sin(2\alpha) & sin(3\alpha) & sin(4\alpha) & sin(5\alpha) \\ 1 & cos(2\alpha) & cos(4\alpha) & cos(6\alpha) & cos(8\alpha) & cos(10\alpha) \\ 0 & sin(2\alpha) & sin(4\alpha) & sin(6\alpha) & sin(8\alpha) & sin(10\alpha) \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1/\sqrt{2} & -1/\sqrt{2} & 1/\sqrt{2} & -1/\sqrt{2} & 1/\sqrt{2} & -1/\sqrt{2} \end{bmatrix}
$$

$$
(7)\qquad [T_3] = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & cos\,2\alpha & cos\,4\alpha \\ 0 & sin\,2\alpha & sin\,4\alpha \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}
$$

$$
(8)\qquad [\rho(\theta)] = \begin{bmatrix} \begin{bmatrix} cos(\theta_i) & -sin(\theta_i) \\ -sin(\theta_i) & cos(\theta_i) \end{bmatrix} & [0]_{2\times4} \\ [0]_{4\times1} & [I]_{4\times4} \end{bmatrix}
$$

where:

$$
(9)\qquad \begin{cases} [T_6]^{-1}[\varphi_{s,abcdef}] = [\varphi_{s\alpha} \quad \varphi_{s\beta} \quad \varphi_{sx} \quad \varphi_{sy} \quad \varphi_{so^+} \quad \varphi_{so^-}]^t \\ [T_6]^{-1}[i_{s,abcdef}] = [i_{s\alpha} \quad i_{s\beta} \quad i_{sx} \quad i_{sy} \quad i_{so^+} \quad i_{so^-}]^t \end{cases}
$$

and

$$
\begin{cases} [T_6]^{-1}[\varphi_r] = [0 \quad 0 \quad 0]^t \\ [T_6]^{-1}[i_r] = [i_{r\alpha} \quad i_{r\beta} \quad i_{ro^+}]^t \end{cases}
$$

Application of the transformations matrix (6) and (7) in conjunction with the first row of (4) lead to the decoupled model of the six-phase two-motor drive system. Source voltage equations that include equations of the two stator windings connected in series can be given as:

$$
(10)\qquad \begin{cases} V_{s\alpha} = R_{s1} i_{s\alpha1} + L_{s1}\dfrac{di_{s\alpha1}}{dt} + M_1 \dfrac{di_{r\alpha1}}{dt} \\ V_{s\beta} = R_{s1} i_{s\beta1} + L_{s1}\dfrac{di_{s\beta1}}{dt} + M_1 \dfrac{di_{r\beta1}}{dt} \end{cases}
$$

$$
(11)\qquad \begin{cases} V_{sx} = R_{eq} i_{sx1} + (l_{s1} + 2L_{s2})\dfrac{di_{sx1}}{dt} + \sqrt{2}M_2 \dfrac{di_{r\alpha2}}{dt} \\ V_{sy} = R_{eq} i_{sy1} + (l_{s1} + 2L_{s2})\dfrac{di_{sy1}}{dt} + \sqrt{2}M_2 \dfrac{di_{r\beta2}}{dt} \end{cases}
$$

$$
(12)\qquad \begin{cases} V_{so+} = R_{eq} i_{so+1} + (l_{s1} + 2L_{s2})\dfrac{di_{so+1}}{dt} \\ V_{so-} = R_{eq} i_{so-1} + l_{s1}\dfrac{di_{so-1}}{dt} \end{cases}
$$

Rotor voltage equations of six-phase machine and three-phase machine are:

$$
(13)\qquad \begin{cases} 0 = R_{r1}.i_{r\alpha1} + L_{m1}\dfrac{di_{s\alpha1}}{dt} + L_{r1}\dfrac{di_{r\alpha1}}{dt} + \omega_{r1}(L_{m1} i_{s\beta1} + L_{r1} i_{r\beta1}) \\ 0 = R_{r1}.i_{r\beta1} + L_{m1}\dfrac{di_{s\beta1}}{dt} + L_{r1}\dfrac{di_{r\beta1}}{dt} + \omega_{r1}(L_{m1} i_{s\beta1} + L_{r1} i_{r\alpha1}) \end{cases}
$$

$$
(14)\qquad \begin{cases} 0 = R_{r2}.i_{r\alpha2} + \sqrt{2}L_{m2}\dfrac{di_{sx1}}{dt} + L_{r2}\dfrac{di_{r\alpha1}}{dt} + \omega_{r2}(\sqrt{2}L_{m2} i_{sy1} + L_{r2} i_{r\beta2}) \\ 0 = R_{r2}.i_{r\beta2} + \sqrt{2}L_{m2}\dfrac{di_{sy1}}{dt} + L_{r2}\dfrac{di_{r\beta2}}{dt} - \omega_{r2}(\sqrt{2}L_{m2} i_{sx1} + L_{r2} i_{r\alpha2}) \end{cases}
$$

with:

$$
(15)\qquad \begin{cases} L_{s1} = l_{s1} + \dfrac{3}{2}L_{ms1} \\ M_1 = \dfrac{3}{\sqrt{2}}L_{sr1} \\ L_{r1} = l_{r1} + \dfrac{3}{2}L_{mr1} \end{cases} ; \begin{cases} L_{s2} = l_{s2} + \dfrac{3}{2}L_{ms2} \\ M_2 = \dfrac{3}{\sqrt{2}}M_{sr2} \\ L_{r2} = l_{r2} + \dfrac{3}{2}L_{mr2} \end{cases}
$$

Application of (6) in conjunction with (1) yields:

$$
(16)\qquad \begin{bmatrix} v_{s\alpha} \\ v_{s\beta} \\ v_{sx} \\ v_{sy} \\ v_{so+} \\ v_{so-} \end{bmatrix} = [T_6] \begin{bmatrix} v_{sa1} + v_{sa2} \\ v_{sb1} + v_{sb2} \\ v_{sc1} + v_{sc2} \\ v_{sd1} + v_{sa2} \\ v_{se1} + v_{sb2} \\ v_{sf1} + v_{sc2} \end{bmatrix} = \begin{bmatrix} v_{s\alpha} \\ v_{s\beta} \\ v_{sx1} + \sqrt{2}v_{s\alpha2} \\ v_{sy1} + \sqrt{2}v_{s\beta2} \\ v_{so+} \\ v_{so-} \end{bmatrix}
$$

and

$$
(17)\qquad \begin{cases} i_{s\alpha} = i_{s\alpha1} \\ i_{s\beta} = i_{s\beta1} \end{cases} ; \begin{cases} i_x = i_{sx1} = \dfrac{i_{s\alpha2}}{\sqrt{2}} \\ i_y = i_{sy1} = \dfrac{i_{s\beta2}}{\sqrt{2}} \end{cases} ; \begin{cases} i_{o+} = i_{so+1} \\ i_{o-} = i_{so-1} \end{cases}
$$

Torque equations of the two machines are:

$$
(18)\qquad \begin{cases} T_{em1} = P_1 M_1 (i_{rd}\, 1_{isq1} - i_{sd} i_{rq1}) \\ T_{em2} = P_2 M_2 (i_{rd2} i_{sy1} - i_{sx} i_{rq2}) \end{cases}
$$

As can be seen to equations (10)-(14) and (18), that flux/torque producing stator currents of the six-phase machine are the source (α, β) current components, while the flux/torque producing stator currents of the three-phase machine are the source (x, y) current components. This indicates the possibility of independent vector control of two machines. It therefore follows that independent vector control of the two machines can be realized with a single six-phase inverter.

Vector Control of the two-Motor Drive

With the transformation (8), the components of the plane (α, β) to equations (10)-(14) can be expressed in the (*d, q*) plane. The two series-connected machines can be controlled independently using rotor-flux oriented control principles (Fig. 2).

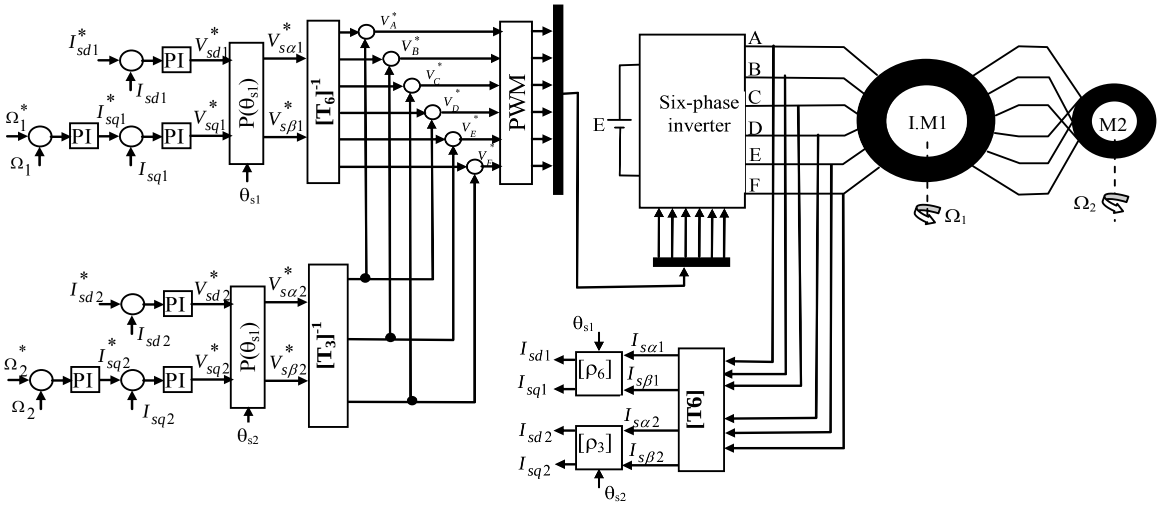

Fig. 2. Indirect rotor flux oriented controller for the two-motor drive

Model Simplifies of the Multimachines System

If the plane (*d, q*) is perfectly directed, we suppose that the component $\varphi_{rq,k}$ = 0. This simplifies the model of the MSCS as follows:

$$(19)\qquad \begin{cases} \dfrac{d\varphi_{r\alpha 1}}{dt} = \dfrac{M_1}{T_{r1}} i_{s\alpha 1} - \dfrac{1}{T_r}\varphi_{r\alpha 1} \\ \dfrac{d\varphi_{r\beta 1}}{dt} = \dfrac{M_1}{T_{r1}} i_{s\beta 1} - (\omega_{s1} - p_1 \Omega_{m1})\varphi_{r\alpha 1} \\ \dfrac{d\Omega_{m1}}{dt} = \dfrac{p_1 M_1}{J_1 L_{r1}}\varphi_{r\alpha 1} i_{s\alpha 1} - \dfrac{1}{J_1} C_{r1} \end{cases}$$

$$(20)\qquad \begin{cases} \dfrac{d\varphi_{r\alpha 2}}{dt} = \sqrt{2}\dfrac{M_2}{T_{r2}} i_{sx} - \dfrac{1}{T_{r2}}\varphi_{r\alpha 2} \\ \dfrac{d\varphi_{r\beta 2}}{dt} = \sqrt{2}\dfrac{M_2}{T_{r2}} i_{sy} - (\omega_{s2} - p_2 \Omega_{m2})\varphi_{r\alpha 2} \\ \dfrac{d\Omega_{m2}}{dt} = \sqrt{2}\dfrac{p_2 M_2}{J_2 L_{r2}}\varphi_{r\alpha 2} i_{s\alpha 2} - \dfrac{1}{J_2} C_{r2} \end{cases}$$

By introducing the angular speeds of sliding, the obtained equation is the following shape:

$$(21)\qquad \frac{d\theta_{sl}}{dt} = \omega_{sl,k} = (\omega_{s,k} - p_k \Omega_{m,k}) = \frac{M_k}{T_{r,k}} . \frac{i^s}{\varphi_{rd,k}}$$

with

$$i^s = \begin{cases} i_{s\beta} & pour \quad k = 1 \\ \sqrt{2}.i_{sy} & pour \quad k = 2 \end{cases}$$

With this condition, the flux and torques for MSCS as:

$$(22)\qquad \begin{cases} \varphi_{r\alpha 1} = \dfrac{M_1}{1 + T_{r1} p} i_{s\alpha 1} \\ T_{em1} = \dfrac{p_1 M_1}{L_{r1}}\varphi_{r\alpha 1} i_{s\beta 1} \end{cases}$$

$$(23)\qquad \begin{cases} \varphi_{r\alpha 2} = \sqrt{2}\dfrac{M_2}{1 + T_{r2} p} i_{sx} \\ T_{em2} = \sqrt{2}\dfrac{p_2 M_2}{L_{r2}}\varphi_{r\alpha 2} i_{sy} \end{cases}$$

According to 22 and 23, six-phase machine's flux/torque are controllable by inverter (α, β) axis current components, while flux and torque of the three-phase machine can be controlled using inverter (*x, y*) current components.

Fuzzy Logic Controller

Fuzzy logic controller (FLC) is usually used in induction machine drives. Due to its simplicity, (no mathematical model or speed closed-loop is required), the FLC method became very useful in induction machine drives used in speed control systems.

The membership function (MF) of the associated input and output variables is generally predefined on a common universe of discourse. For the successful design of FLC's proper selection of input and output scaling factors (gains) or tuning of the other controller parameters are crucial jobs, which in many cases are done through trial and error to achieve the best possible control performance [15].

The fuzzy logic control is based on these four elements: a bases rule, an inference mechanism, a fuzzification interface and a defuzzification interface.

The interface used in this work is Mamdani's procedure based on max-min decision. For the defuzzification, the Center of Area (COA) method is employed.

The structure of FLC is shown in Fig. 3. For our study, the input of the fuzzy controller is the error of speed E, as well as its variation ΔE, the output of the regulator will be the Torque's increment ΔT_{em}.

It is enough to integrate him to have the value of the electromagnetic couple of command T_{em}.

The fuzzy control scalar used in the speed control will have 49 IF-THEN rules. Fig. 4 (a), (b) and (c) shows membership functions of input variables E and ΔE

respectively and output variable, which are with in conventional triangular shapes. Each membership is divided into 7 fuzzy.

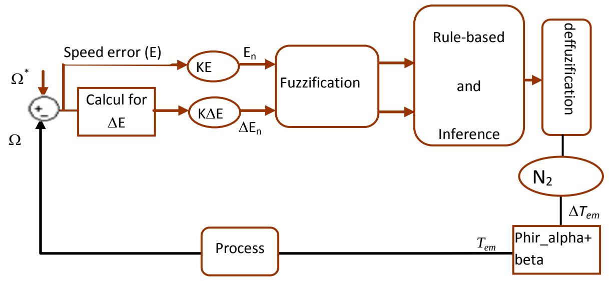

Fig. 3. Block diagram of fuzzy controller

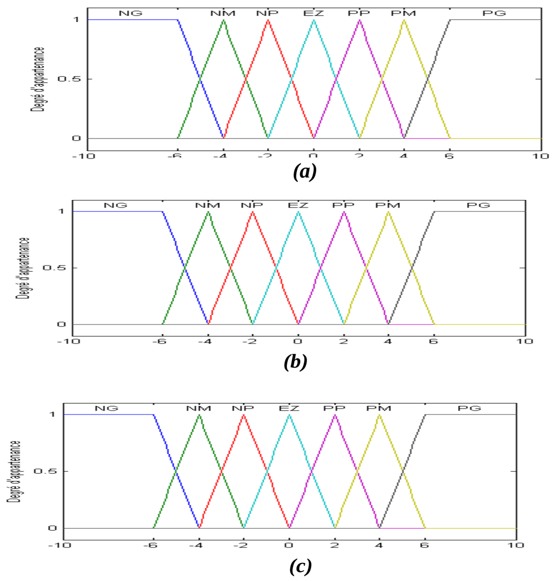

Fig. 4. Membership functions of input/output variables

a) input speed error; b) input change speed error; c) output

The membership is divided into seven fuzzy sets:
NH: Negative High, PS: Positive Small, ZE: Zero
NM: Negative Medium, PM: Positive Medium
NS: Negative Small, PH: Positive High

The rule-based table for output variable was shown in table 1, it was consist of 49 linguistic rules and give the change of the output of fuzzy logic controller in terms of two inputs E and ΔE

Table 1. Shows the rule base for controlling the speed

ΔE_Ω \ E_Ω	NH	NM	NS	ZE	PS	PM	PH
NH	NH	NH	NH	NH	NM	NS	ZE
NM	NH	NH	NH	NM	NS	ZE	PS
NS	NH	NH	NM	NS	ZE	PS	PM
ZE	NH	NM	NS	ZE	PS	PM	PH
PS	NM	NS	ZE	PS	PM	PH	PH
PM	NS	ZE	PS	PM	PH	PH	PH
PH	ZE	PS	PM	PH	PH	PH	PH

In Table 1, some of the rules are interpreted:

If E is PM and ΔE is PM Then ΔT_{em} is PH. Here, both the speed error and the change error are positive medium. Therefore, we need positive high ΔT_{em} to achieve a fast response. The same steps used for the conception of the speed controller will be repeated for the currents controller, only we have:

Input error E : instead of being equal to $E = \Omega^* - \Omega$, it will be equal in $E = i_{ds}^* - i_{ds}$ for the first fuzzy controller of current i_{ds} and $E = i_{qs}^* - i_{qs}$ for the second fuzzy controller of current i_{qs} ;

The output of the fuzzy controller is V_{ds} or the ids current controller and V_{qs} or the controller of the current iqs current.

So that the internal loop is faster than the external one (condition of subjection). We represent the input/output variables by membership function, as show in Fig. 5, each one divided into 3 fuzzy. The rule-based table for output variable is presented in table 2, it consist of 9 linguistic rules and gives the change of the output of fuzzy logic controller in terms of two inputs E and ΔE for each current's controller (i_{ds2} and i_{qs2}).

Each membership function is also assigned with three fuzzy sets: P (positive), N (negative) and ZE (zero).

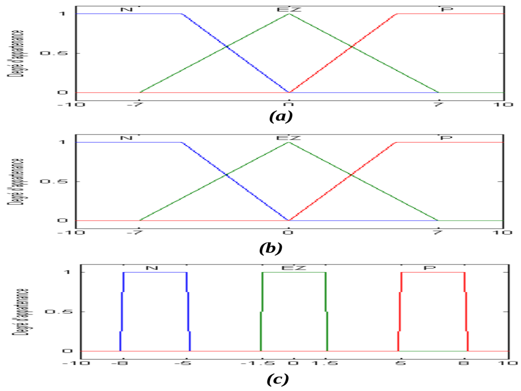

Fig. 5. Membership functions of input/output variables

a) input current error; b) input change speed error; c) output

Table2. Shows the rule base for controlling the currents

ΔE_i \ E_i	N	ZE	P
N	N	N	ZE
ZE	N	ZE	P
P	ZE	P	P

Simulation Results

The simulation results of vector speed control of the two series connected machines in (MSCS) with the implementing of the fuzzy controller is developed in the MATLAB. The decoupling and independent control of the two machines is demonstrated

The first test consists in presentation of the global system simulation results: two series-connected machine with their drive: The three-phase induction machine is accelerating from standstill to reference speed N_2 = 100rad/s, a load torque of 4N.m is applied between time t =1s and t = 2.5s, where the six-phase induction machine is started at t =1.5s after the acceleration transient time expired the speed settled at N_1 = 50rad/s a torque of 39N.m is applied to it at the time t = 2s. Fig. 6 shows the speeds, torques and stator currents. It is clear that the dynamic performances are good and we can notice that the I.M(2)'s electromagnetic torque and speed are not affected by the starting operation of the I.M(1).

In the Fig. 7 : The six-phase induction machine turn at a constant speed equal to 50rad/s, a load torque of 39N.m is applied at t =1s while the three-phase motor is started at t = 1.5s to settle at speed of 100rad/s at the end of acceleration transient time. We notice that, the speed and torque of the I.M(1) are not affected by the acceleration period of the I.M(2).

Figs. 8 and 9 shows the performances when the speed of I.M(1) is changed from + 50rad/s to -50rad/s at t =1.5s while the other I.M(2) direction is kept unchanged and vice versa, the direction of the I.M(2) is changed from +100 to -100rad/s while that of I.M(1) is kept unchanged. Simulation results show that the performances (the electro-mechanical quantities) of both machines are unaffected and decoupled control is preserved.

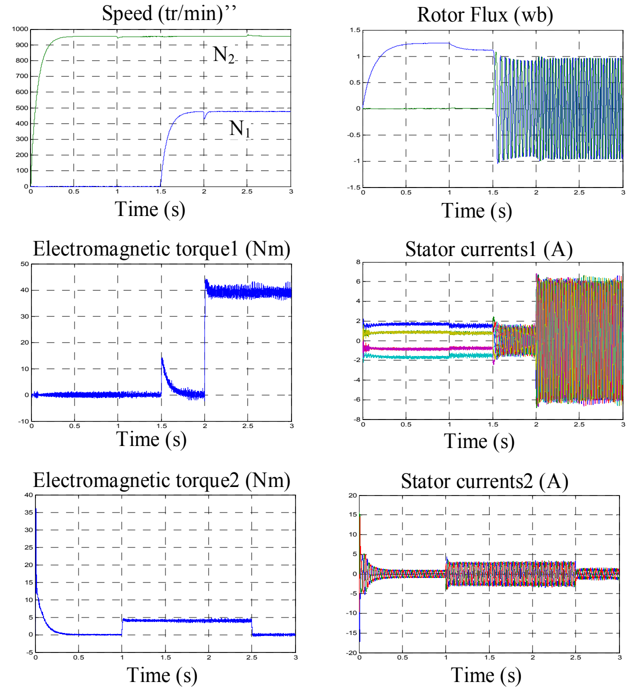

Fig .6. Performance of indirect vector controlled system: Acceleration of I.M(2) from 0 to 100 rad/s using fuzzy controller

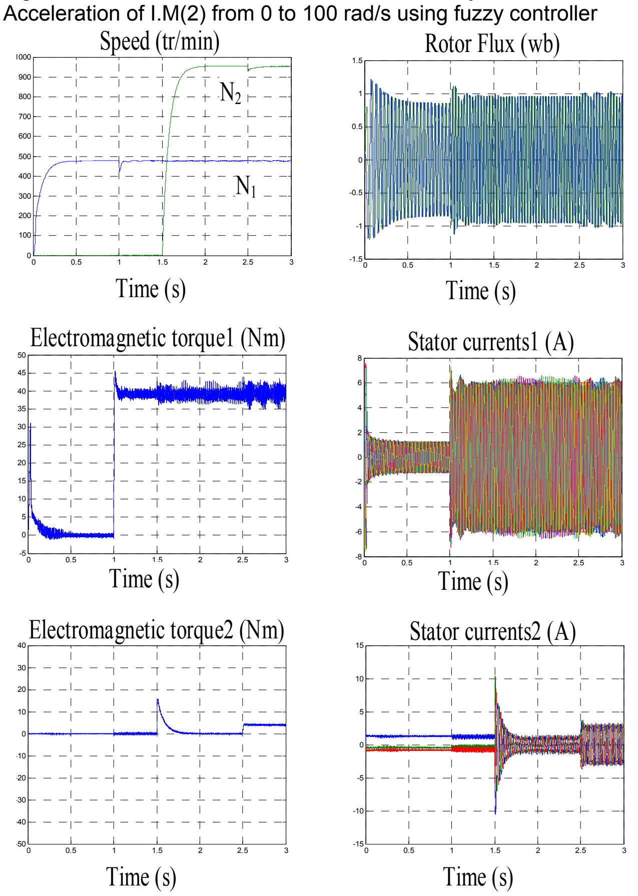

Fig .7. Performance of indirect vector controlled system: Acceleration of I.M(1) from 0 to 50 rpm using fuzzy controller

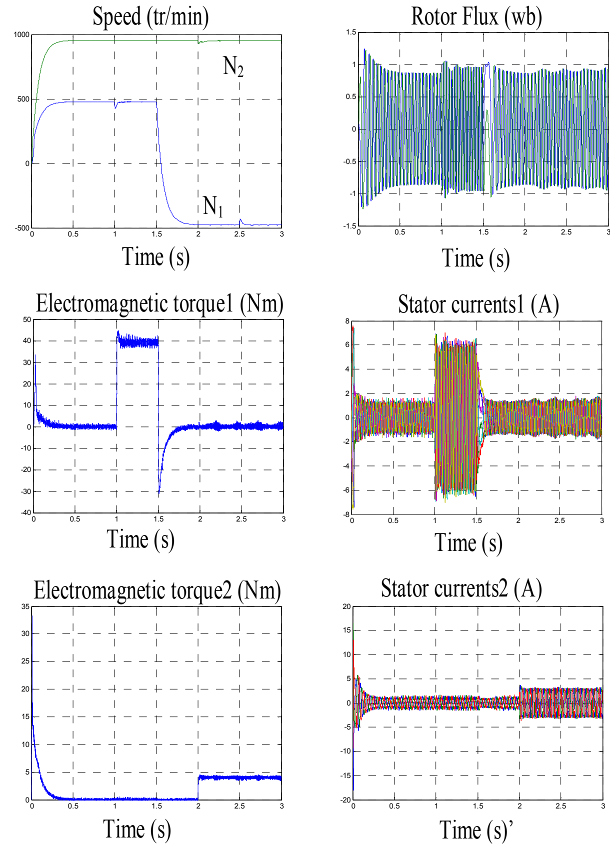

Fig .8. Performance of indirect vector controlled system: The I.M(1) reverses from +50 to -50 rad/s using fuzzy controller.

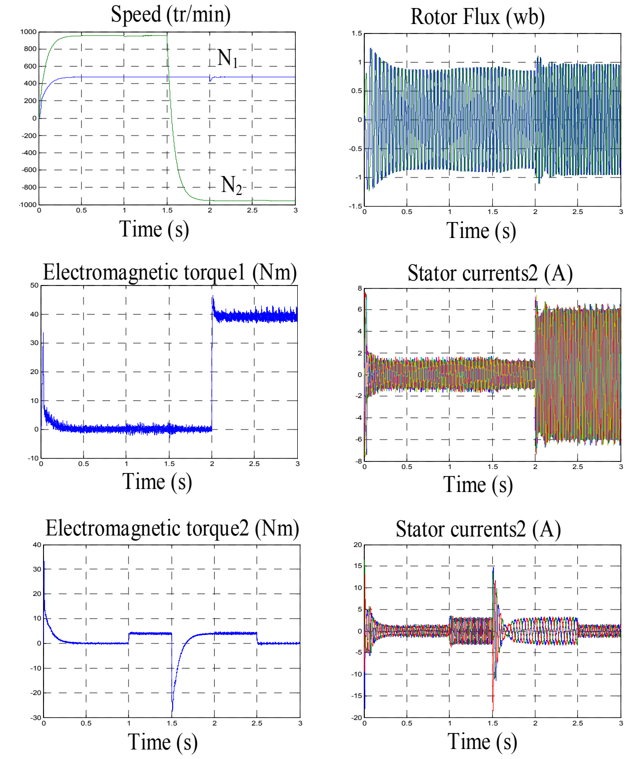

Fig .9. Performance of indirect vector controlled system: The I.M(2) reverses from +100 to -100 rad/s using fuzzy controller

The second test consists of the robustness test of the system under fuzzy logic controller. After changing (adding) 100% of the moment inertia J, we present in Fig. 10 the speed N and the enlargement of the speed during the transitory regime. According to this figure, the result shows that the fuzzy logic controller present a very big robustness.

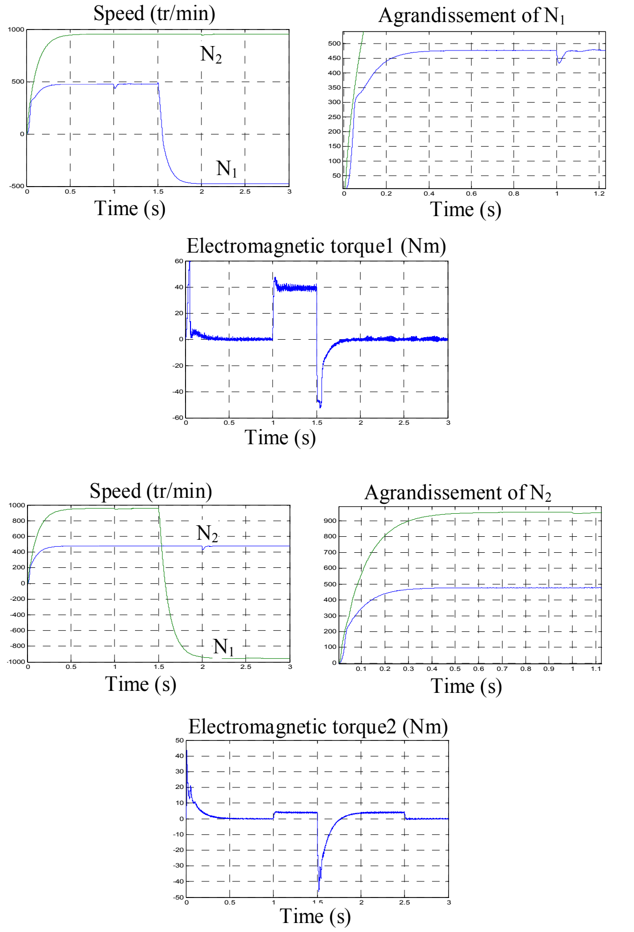

Fig .10. Test of robustness of the fuzzy regulator with applied load torque and the change of rotation direction during a variation of the moment of inertia ($J = 2J_n$) for M(1) and ($J_2=2J_{n2}$) for M (2).

Table 3. The values parameters for the Six-phase induction motor.

Rated power:	P_n = 5.5kw
Nominal currant:	I_n = 6A
Stator resistance:	R_s = 2.3 Ω
Rotor resistance:	R_r = 3 Ω
Stator inductance:	L_s = 0.203H
Rotor inductance:	L_r = 0.203H
Mutual inductance:	L_m =0.2H
Rated phase stator voltage:	V_n = 220v
Pole pair number.:	P = 1
Rotor speed:	N = 1000 tr/min
Friction coefficient:	Kf = 0.006 Nms/rad
Moment of inertia :	J = 0.06Kg.m²

Table 4.The values parameters for the Three-phase induction motor.

Puissance nominale:	P_{n2} = 1 kw
Stator resistance:	R_{s2} = 4.67 Ω
Rotor resistance:	R_{r2} = 8 Ω
Stator inductance:	L_{s2} = 0.374H
Rotor inductance:	L_{r2} = 0.374H
Mutual inductance:	L_{m2} =0.2433H
Rated phase stator voltage:	V_{n2} = 220v
Pole pair number.:	P_2 = 3
Rotor speed:	N_2 = 2830 tr/min
Friction coefficient:	Kf $_2$ = 0.001 N.m.s/rd
Moment of inertia :	J_2 = 0.023Kg.m²

Conclusion

With the aim of improving the behavior of a MSCS the object of the study presented in this paper is the application of a fuzzy controller, with its main modules such as Fuzzification, Rules, Inferences, and Deffuzification. The results of simulation showed a good dynamic performances of the two machines and a very big robustness towards a 100 % change in inertia ($J = 2J_n$). For a further work in this subject, we propose: a faults diagnostic of the system.

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