SIMULTANEOUS SPEED AND ROTOR TIME CONSTANT IDENTIFICATION OF AN INDUCTION MOTOR DRIVE BASED ON THE MODEL REFERENCE ADAPTIVE SYSTEM COMBINED WITH A FUZZY RESISTANCE ESTIMATOR

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ABSTRACT - In this paper , simultaneous estimation of rotor speed and time constant for a voltage source inverter (VSI) fed induction motor drive are disccussed .
The theory is based on the Model Reference Adaptive System (MRAS) . The identifier executes Simultaneous rotor speed and time constant so that vector control of the induction may be achieved in the rotor - flux oriented reference frame . Furthermore , to eliminate the offset error caused by the change in the stator resistance , a fuzzy resistance regulator is also designed which operates in parallel with the rotor speed and time constant identifier.

1 - INTRODUCTION

Field Oriented control Of induction motor drive has deen discussed in literatures , [1].
This method gives an elegant way of achieving high performance control of induction motor drives One way of estimating the magnitude and phase of the rotor vector flux is using an indirect phase flux model which is excited by measured machine variables , like speed , currents and voltages.
the accuracy of this model depends very much on the accuracy of its parameters , especially rotor time constant which inturn depends on the accuracy of rotor resistance and inductance.

The advantages of using speed sensorless drives are clear : the machine setup andmaintenance are simple since no shaft sensor is required , the system becomes more robust and less sensitive to the environmerital noise , and the overall system cost is reduced .
Like the system using the actual measured speeds sensorless schemes have the disadvantage of being sensitive to motor capacity . For high performance drive , this is a serious drawback which can be eliminated by the simultaneous estimation of the rotor speed and time constant .
Up to know, a few papers have been published about the simultaneous adaptation of the rotor speed and time constant , [2-4]. Because the present paper continues the research work described in [4] , therefore ,this reference is explained briefly.
In [4] , Shinzo Tamai and his colleuges proposed a rotor speed indentification method of an induction motor which is based on the the MARS with induction motor is to be vector controlled simultaneously . They emoloyed a PWM current controlled VSI to supply the induction motor . Although the mothed is simple but has some inaccuracy due to error exsist in the speed adaptation because of the inaccuracy exsiting in the rotor time constant. In addition ,an offset error is also produced due to the smooth change in the stator

resistance with temparature , especially at low speed operation . In order to eliminate the above mentioned errors , using the MRAS method described in [4], in this paper a simultaneous rotor speed and time constant identifier is designed .

This identfier operates in parallel with a fuzzy resistance estimater which is designed to indentify the exsisting error in the stator resistance and corrects it . Consequently , the drive / system performance may by improved especially at low speed operation .

Instead of PWM current controlled VSI imployed in ,[4] , a PWM VSI with a new type of trapezoidal modulator voltage wavefrom is used to supply the induction motor ,[5] . This inverter considerably reduces the machine loss and torque pulsation.

2- THE THEORY OF PAPER

Fig .(1) shows the block system control of a VSI - fed induction motor drive which is indirectly vector controlled in the rotor - flux field oriented reference frame . As can be seen in Fig .(1) ,the rotor speed and time constant are estimated simultaneously by an identifier which is based on the MRAS theory . The stator resistance is also corrected by a a fuzzy regulator . The flux model shown in Fig .(1) is used to calculate the magnitude and the velocity of rotor vector flux . Applying the MRAS adaption method , a rotor speed and time constant identifier is shown in Fig .(1). In this Figure, the reference model is an induction motor and the adjustable model is an ideal vector controlled induction motor , when the rotor speed in the adjustable model changed so that the error between and that of the adjustable model tends toward zero then , the induction motor is also vector controlled Simultaneously .

Simultaneous esitimation of rotor speed and time constant can be achieved in such away that at each of time step Δt , during estimation of rotor time constant , the identified rotor speed (obtained in the pervious step) may be used as the operating speed of the machine and in the subsequent step , the rotor speed is estimated by assuming the identified rotor time constant as the steady - state point .

3 - THE TRAPEZOIDAL PWM VSI

A new PWM startegy suitable for an inverter - fed induction motor has been proposed in ,[5]. the proposed modulator signal is obtained by superposing a rectangular wave whose flat portion is 120 degrees . By using this modulating signal , the amplitude of the fundamental component is increased by about 17% more than that of a conventional sine-wave inverter . In contrast to conventional sine-wave inventer , the amplitude of higher harmonics are reduced inversely proportional to thier orders .

4- FUZZY RESISTANCE ESTIMATER

The offset error caused by the change in the stator resitance manifests itself as an error as ($i_s r_s$)resistive voltage drop which inturn effects both the voltage decoupler circuits and the rotor variables indentifier .

In order to eliminate this error, a fuzzy regulator is designed .

With reference to Fig .(1), it may be noted that below the base speed operation and at a constant motor load torque condition (ignoring the motor rotational losses), the stator current componets i_{sy} and i_{sx} and consequently, the magnitude of the stator vector current i_s are constant .

In this condition, any change in i_s is only due to the change in the stator resistance . Therfore , at each of time step Δt ,the fuzzy resistance estimator requires the error of the stator current Δi_s as well as the change in this error . The Mamdani's minimum operation rule is applied and the obtained results are shown in Fig .(3).

5- COMPUTER RESULTS

A computer program has been developed to predict the dynamical performance of the drive/system .Because the nature of drive / system nonlinearity, the coefficients of PI regulators has been found by trial and error on P.C.

The obtained computer results are demonstrated in the subsquent pages and from these results , the following conclusions are summarized .

6- CONCLUSIONS

Based on the theory of MRAS, simultaneous estimation of rotor speed and time constant has been described in this paper . Comparing to other adaption techniques , this method is simple and needs a low computation power and has a high speed adaption even at zero speeds .

These important features are very well shown in the obtained resuts. Comparing to method described in ,[4] , this method because eliminates the produced error in the speed adaptation due to inaccuracy exsisting in the rotor time constant therefore , is more stable and robust .

By imploying a new trapezoidal PWM VSI , the predicted results show that the torque pulsation and motor loss are low and also a quick dynamic response has been achieved .

By employing a fuzzy resistance estimater in combination with rotor speed and time constant identifier, a very well adaption has been achieved for the drive / system.

The software developed in this paper can be used for the actual vector controlling of induction motors by P.C. However , for any particular machine, it is required to design the PI controllers .

7-REFERENCES

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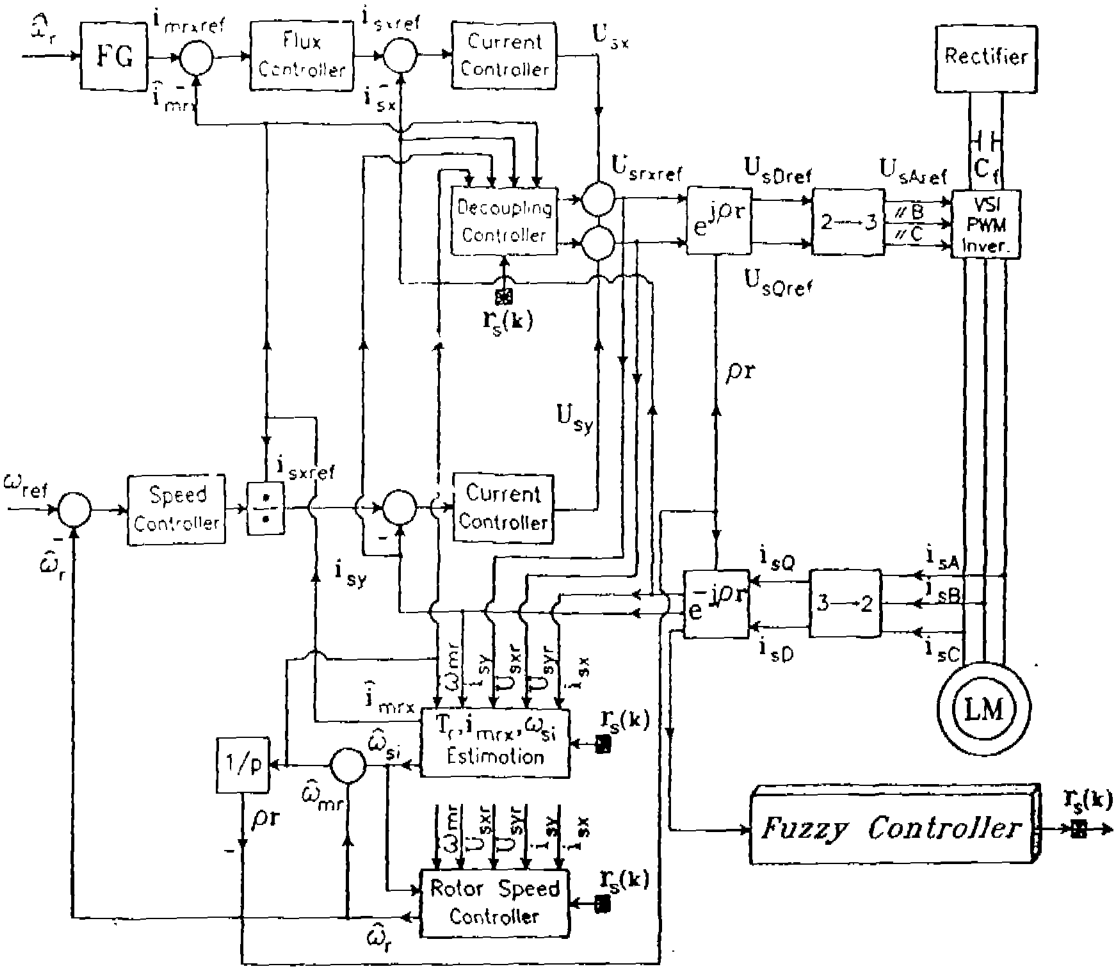
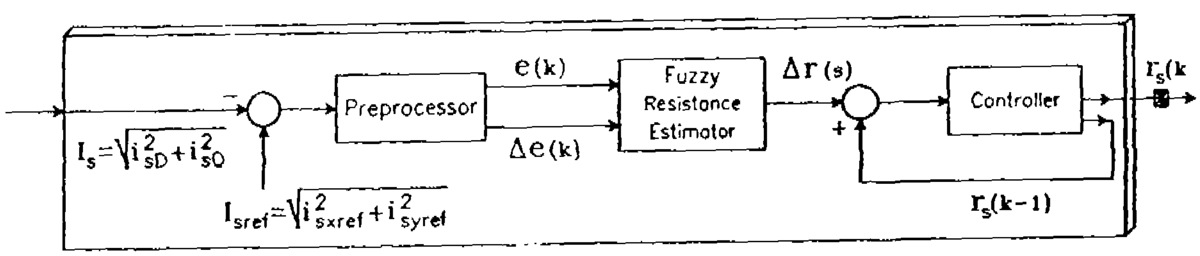




Fuzzy Controller

Fig .(1)-The shematic of rotor flux oriented control of a VSI-PWM , induction motor with simultaneonsly on-line estimation of speed and rotor time constant .

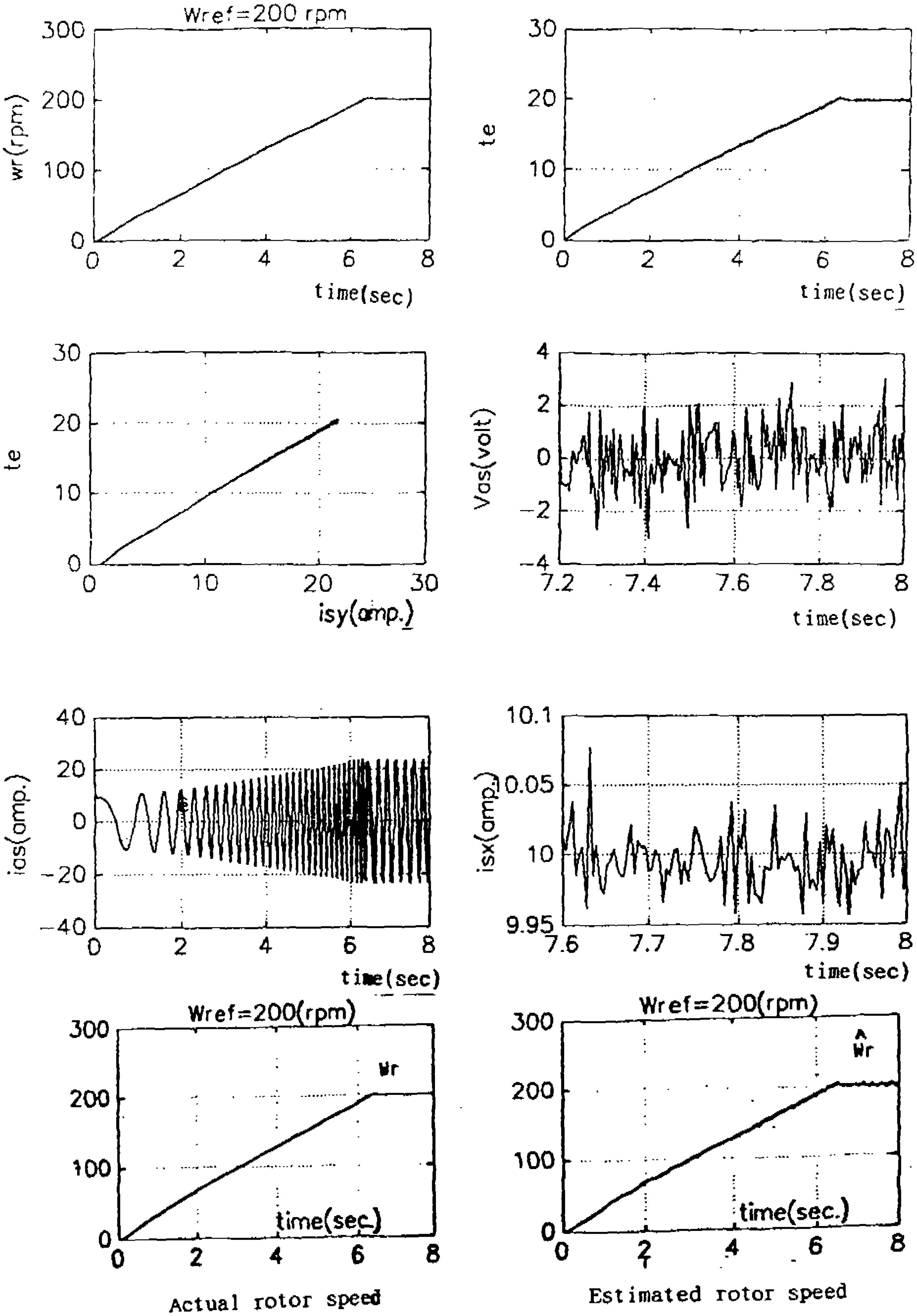


Fig .(2). Dynamic Performance of the motor during starting
Tl=20 N-M,Wo=0.0,Wref=200 rpm

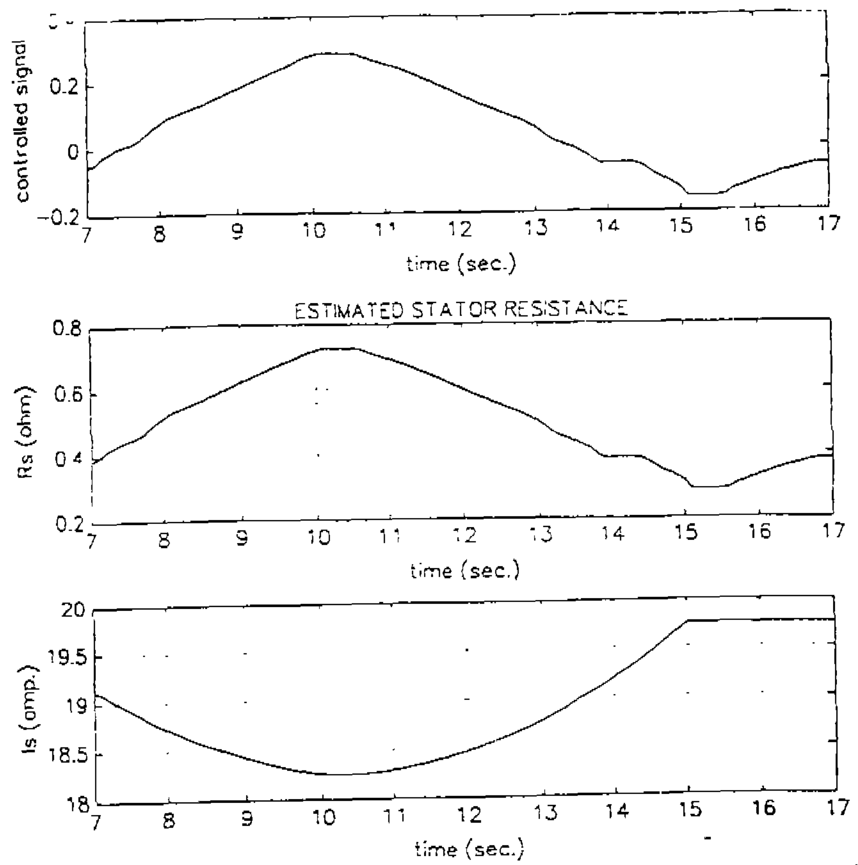
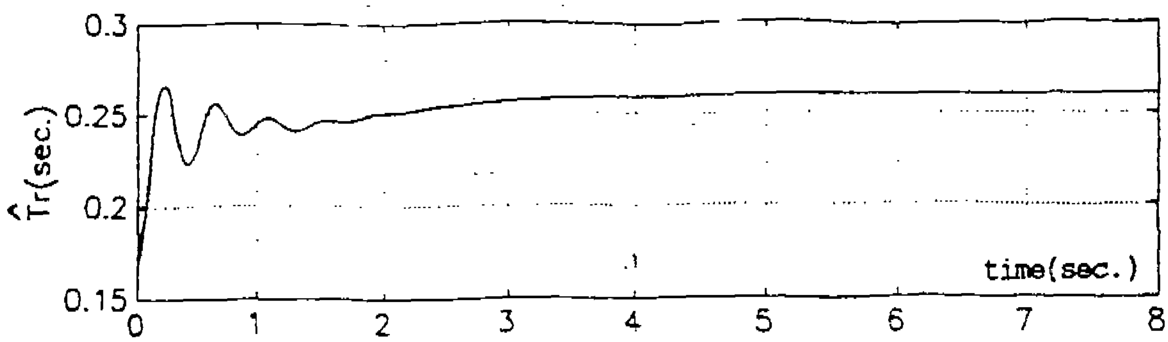
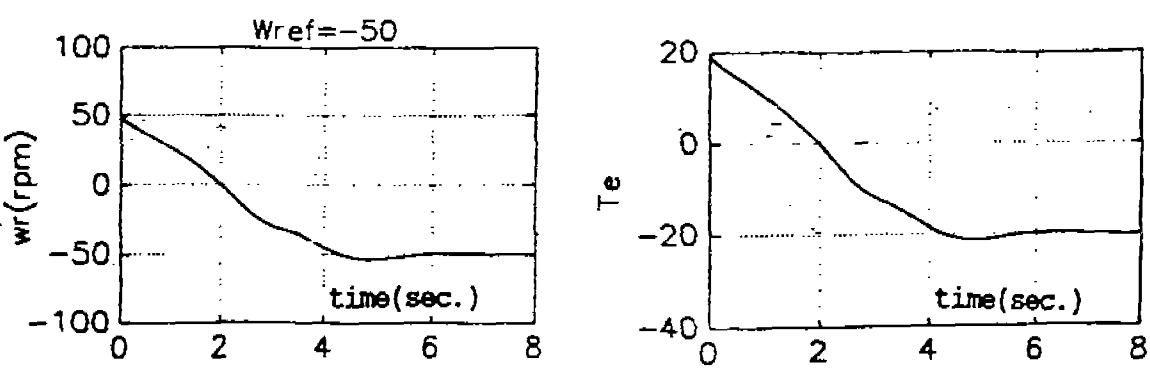


Fig. (3). Fuzzy resistance estimator results



Rotor time constant estimation(Tr(initial)=0.17 sec. ,Tr(actual)=0.2772 sec.)

Fig. (4). Rotor time constant estimation



Initial speed=50 rpm   Reference speed=-50 rpm   Tl=20 N-M

Fig. (5). Dynamical performance of drive/system during speed change