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Performance Improvement for Direct Torque Control Induction Motor Drives

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Abstract**—***This paper presents the modified integrator which we can use in the controlling scheme of an induction motor (IM). The modification tends to some advancement in direct torque control of induction motor. The undesirable variations which occur in the form of offset, gain error, etc can be eliminate by means of the involvement of the new integrator in the direct torque and flux control (DTFC) method. The PI controller is introduced in new torque and speed control model. By observing the flux the offset can be maintained. Thus by using the new integrator method we can overcome the variations occurs because of the errors.*

Keywords**—** *DTFC, offset error, induction motor, stator flux.*

I. INTRODUCTION

Induction motor is the backbone of industrial and household applications. Because of many of the features induction motor is preferable over other motors available. Three phase induction motor have many similarities to the transformer which is having air gap. Thus induction motor is also known as generalized transformer. Induction motors have the capability to run stably. But still likewise any other motor induction motor needs the controlling. The various controlling techniques likewise direct torque control, field oriented control, etc are available. Among all the method direct torque and flux control (DTFC) is more preferable because of the advantages it offers to consumer end.

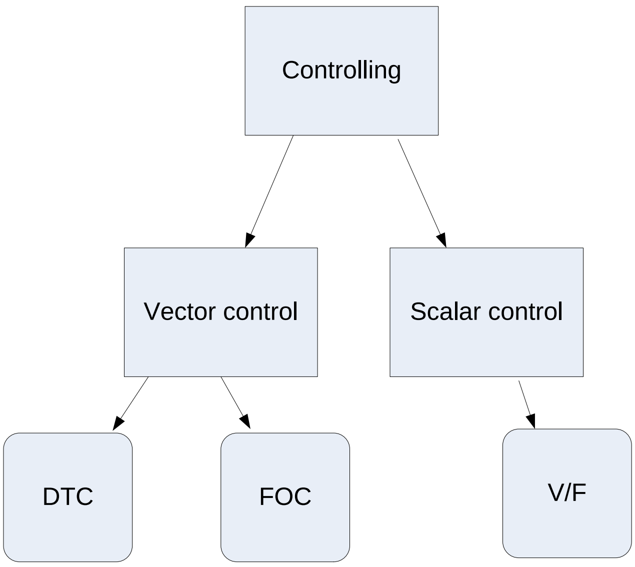

Fig. 1. Comparison of control methods.

In any motor torque, speed, frequency is the main parameters which should be controlled. And therefore the control methods mainly used to control these parameters. There are two types of controlling methods viz. scalar control and vector control. These main methods are further divided into number of methods. Variable frequency drives are divided into scalar and vector method. The method use to control frequency comes under scalar control method. The method known as v/f control method also known as frequency control method. Whereas to control speed and torque parameters vector control method is used. Field oriented control (FOC) and direct torque and flux control (DTFC) are the vector control methods.

DTFC is again classified in direct self control (DSC) and space vector modulation (SVM) method respectively.

The project deals with the direct torque control method of an induction motor drives. By means of the new model proposed in this paper the drawbacks which are present in conventional DTC technique is tried to compensate. Though DTC is most preferable method there are still bugs likewise gain error, undesirable offset, etc. these bugs can be compensate if we replace the pure integrator in conventional control method by modified integrator method. The new integrator method may have some more number of high pass filters or a high pass filter which is connected in back to back fashion with first order low pass filter which is by default present in pure integrator of DTC.

II. DIRECT TORQUE AND FLUX CONTROL OF INDUCTION MOTOR

The conventional direct torque control consist of components like rectifier, DC link, inverter, flux and torque estimator, flux and torque controller , etc. The demo version present in the MATLAB consists of the same components but the format is somehow different. For example for induction motor AC4 block is being used in the demo version. For inverter, rectifier, etc also the different blocks are used in the demo version. The demo version consists of pure integrator which consists of the low pass filter. This can reduce offset but can't remove completely. To modify the integrator we have to replace pure integrator in DTC method by modified integrator. The pure integrator is formed by integrating the back emf (E_b). The equation of pure integrator is formed by the stator voltage equations of an induction motor drives.

In DTC method stator flux is estimated therefore it is also called as stator flux estimation method. In DTC there are two types of methods viz. current control method and voltage control method. Bang-bang controller is employed in the DTC method. The result like stator flux locus, electromagnetic torque, etc we get from the DTC method. The stator flux locus should not consist any drift but incase if we find any drift in the locus then it is understood that the offset or gain error affects the DTC method. Because of the close loop operation the stator flux locus always looks like the perfect circle. Whereas in case of electromagnetic torque the noise level should be as low as possible for desirable condition. The results of rotor flux angle, stator current should also taken into consideration.

III. Project Overview

The conventional DTC of induction method have some slight errors likewise gain error, DC offset, etc. So to overcome these lacunas the pure integrator should be replace by the new one or we can use the PID controller in the DTC method. We can also modify the induction motor model by the new compensation formula by virtue of which we get the more satisfactory results. So in this project three phase inverter, stator voltage selector, induction motor sub-system in arbitrary reference frame are taken into the consideration

IV. Modelling of System

In this DTFC modeling the three phase inverter is used.

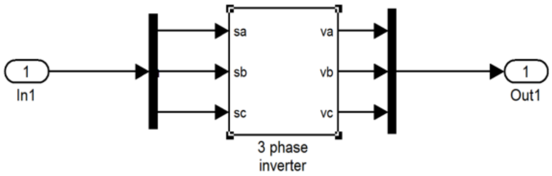

Fig. 2. Three phase inverter.

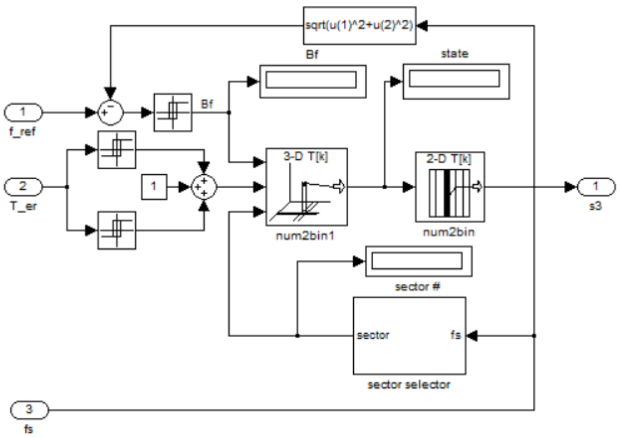

Fig. 3. Stator voltage selector.

Along with the three phase inverters the important parameter in this modified model are stator voltage selector, modified induction motor model, PID controller, mechanical system, speed calculator.

The induction motor modeling of this DTFC method consist of two low pass filters so that the undesirable offset can compensate. The induction motor modeling is done by means of following equations,

Electrical system equations:

vs = Rs is + 1/wo (dfs/dt) + wk M(π/2) fs (1)

vr = Rr ir + 1/wo (dfr/dt) + (wk - wm) M(π/2) fr (2)

where the variables i, v, and f are 2-dimensional space vectors; for instance

is = [ids iqs] (3)

wk is the speed of the reference frame, wm the rotor speed, and M(π/2)represents a 90 degree space rotator namely M(π/2) = [0 -1;1 0]

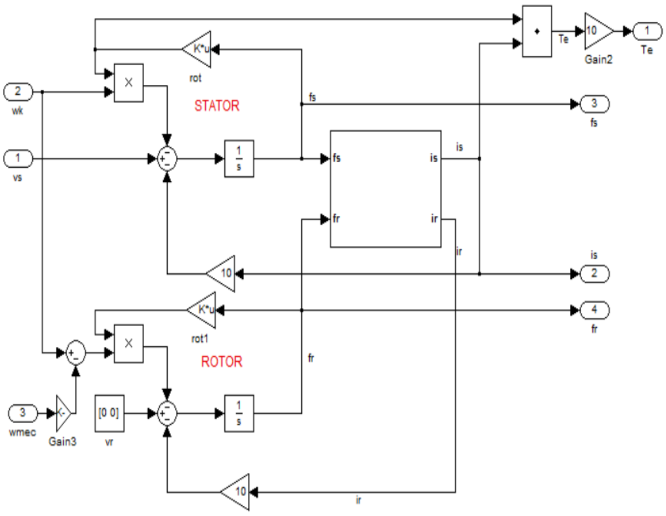

Fig. 4. Modified Induction motor modeling.

The flux linkage current relations are:

fds = Ls ids + Lm idr (4)

fdr = Lm ids + Lr idr (5)

fqs = Ls iqs + Lm iqr (6)

fqr = Lm iqs + Lr iqr (7)

Induction motor modeling based on the above equation is as follows,

The stator and rotor part are shown in fig. 3 separately. The low pass filter in terms of laplace is shown in the new induction motor designing.

The complete modified DTFC model consist of all the component along with additional elements. The modified DTFC modeling is as follows,

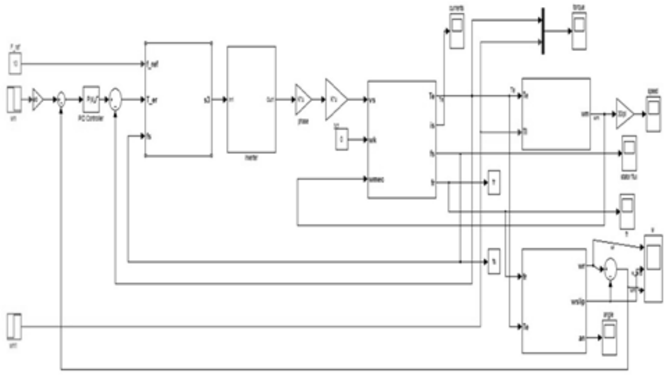

Fig. 5. Modified DTFC model.

The above DTFC model shown in fig. 4 consist of inverter, induction motor drive,etc. The AC supply is given to the assembly but for the DC link operation it gets converted into DC and then given to three phase inverter. The torque, flux and speed calculate in the model. The calculated electromagnetic torque is depends on the current measurement accuracy and stator flux calculation method. The command stator flux and torque magnitude are compared with the respective calculated values. And the error processed in hysteresis control loop.

V. RESULTS

The desirable DTFC method can be determined on the basis of its stator flux locus. if the stator flux locus is perfect circle then we can say that the offset is minimized or removed. So to see the difference between the error containing result and error free result we have to compare both. So to see the offset effect we can vary the initial stage parameters and we can disturb the controlling system.

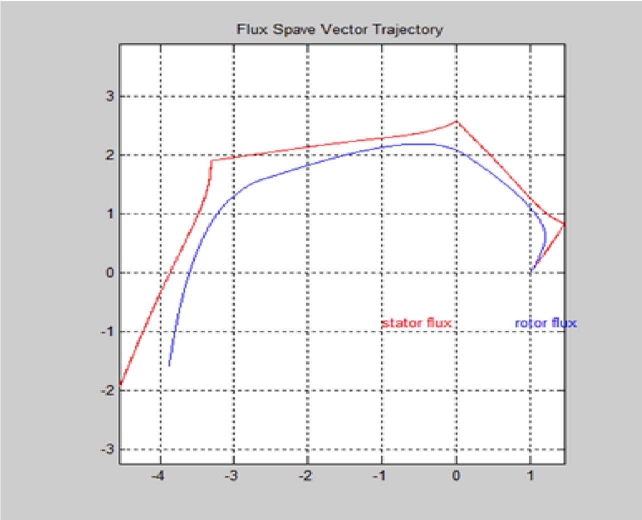

Fig. 6. locus with offset.

Fig. 6 doesn't form the circular locus thus in this case the variations cause degradation of the motor. Now let's see the stator flux locus with using two LPF i.e. the new DTFC with modified integrator. Integrator modification is takes place in the new induction motor model.

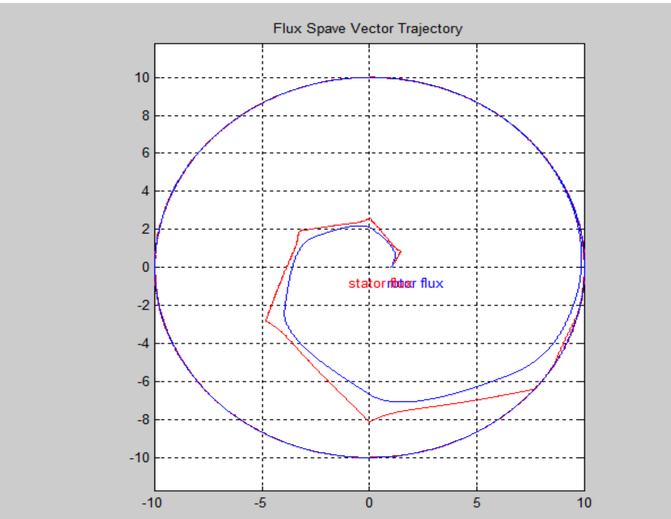

Fig. 7 locus without offset

Fig. 7 shows the stator flux locus without offset. The locus is perfect circle without any drifts. In this case there is no variation in the system thus controlling is satisfactory.

Along with the stator flux locus the electromagnetic torque characteristics are also improved. Comparatively less noise is produce by means of new DTFC model. Lets see the electromagnetic torque characteristics of the modified model.

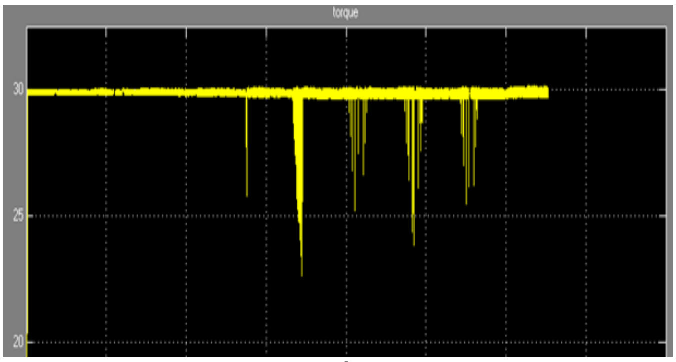

Fig. 8 Torque characteristics.

VI. CONCLUSION

So by means of this modified DTFC method the undesirable offset which is caused because of the DC component as well as the gain error can be minimized and thus we get the satisfactory outputs.

VII. ACKNOWLEDGMENT

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