A NEW VECTORIZED CONTROL OF THREE PHASE INVERTER DRIVEN THREE PHASE INDUCTION MOTOR DRIVE

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Abstract— In an AC propulsion system, before the actual implementation, a detailed mathematical modeling of the various components (comprising of mainly the induction machine, inverter, alternator and rectifier), needs to be done. Usually there are six wheel-axle sets which are driven by six set of inverter-motor combinations. Simulation of these six set of inverter-motor combination consumes a lot of simulation time which may result in an overall cumbersome simulation process.

This paper proposes a method to lessen the overall simulation time by significantly reducing the simulation times of the six inverter-fed Induction motors.

Index Terms— Inverter motor combination, Simulation time, vectorized control

I. INTRODUCTION

In a modern day general case of an integrated three phase induction motor driven locomotives [1],[3] as shown in figure (1), a diesel engine drives a three phase alternator whose three phase low frequency output is rectified by an uncontrolled rectifier. The rectifier output is duly filtered before giving it as input to each of the six inverters as shown in the figure. The high frequency inverter outputs are fed to six (three phase) Induction motors whose six shafts are connected mechanically to six gearboxes which, acting like a mechanical transformers, convert the high speed low torque input to high torque, low speed output before feeding the axles which in turn drive the wheels.

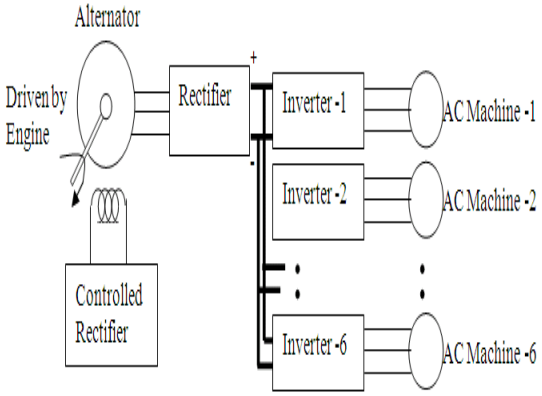

Figure 1: Schematic of an AC propulsion System

II. THE USUAL APPROACH

If such a locomotive has to be modeled, in order to bring a real simulation picture it will require the simulations of six different inverter-motor models running in a serial manner. The total simulation time taken in this approach will be high and this would hamper the development of an integrated simulation platform encompassing all the parts of a locomotive system i.e. alternator, rectifier, inverter and motor. Especially the simulation time consumed by the six inverter/motor sets will be a very high percentage of the total simulation time. Figure (2) shows the difficult situation that arises when all the six inverters and six induction motors are simulated simultaneously.

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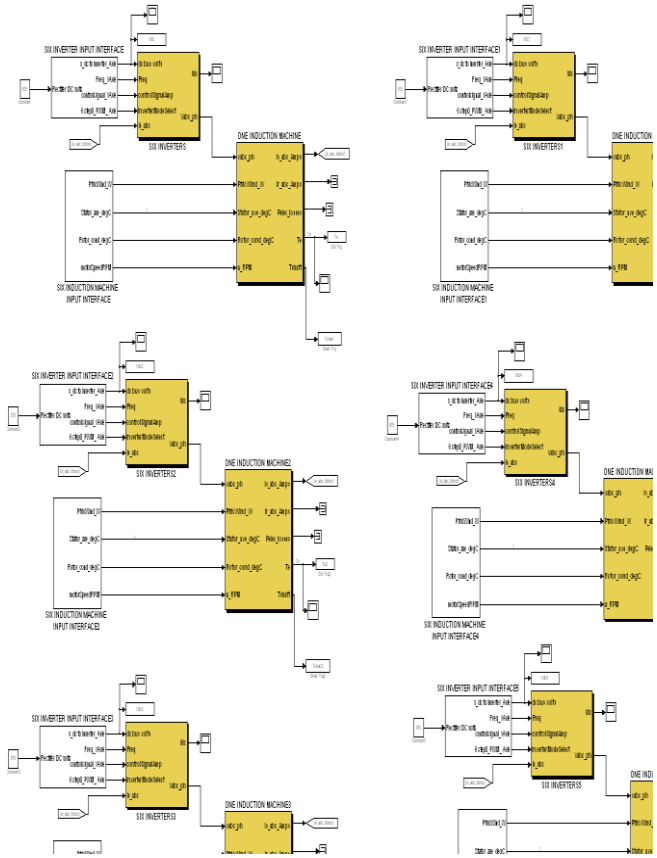

Figure 2: Usual modeling approach would lead to a slower and difficult-to-manage model

III. The Vectorized Approach

In order to model six machines and six inverters that form part of an AC locomotive, the induction machine and inverter models are vectorized. The model obtained by this approach runs faster than a model that would use six sets of inverters and motor models. A snapshot of this model is shown figure (2). Here the block six induction machine input interface is designed to carry four inputs to the motor block. Each of the four inputs is actually an VECTOR ARRAY containing six elements. Thus friction and windage losses, stator and rotor temperatures and the desired speed values are all having a dimension of six. Similarly the inverter outputs also give six various voltages one for each motor. There are thirty six gate pulses if the PWM is resorted to. As shown in the figure (3) below, the six inverter input interface block consists of four different inputs. The first input decides whether a fixed DC value has to be given to the inverter input or the rectifier output should be given.

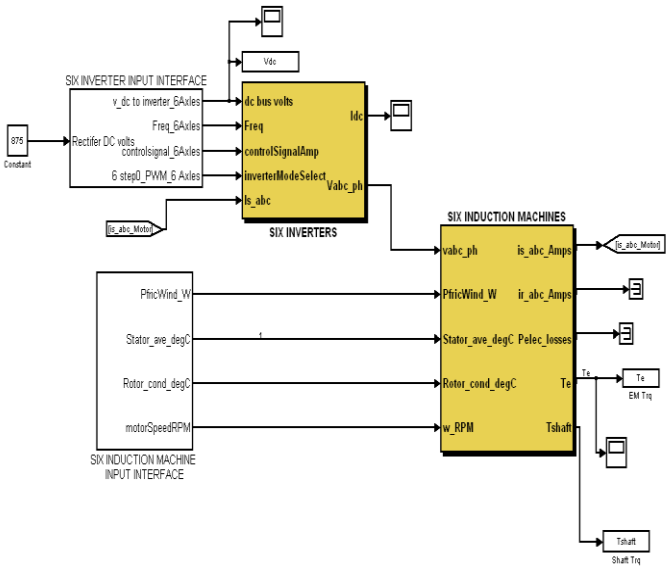

Figure 3 : Snapshot of the SIMULINK model – 6 inverters and 6 machines using vectorized modeling approach.

The second input is a constant block for giving the vector containing six elements as the six frequencies of the control signal for the pulse width modulation operation. Similarly the third input is also a vector containing six elements for giving the six magnitudes of the control signals.

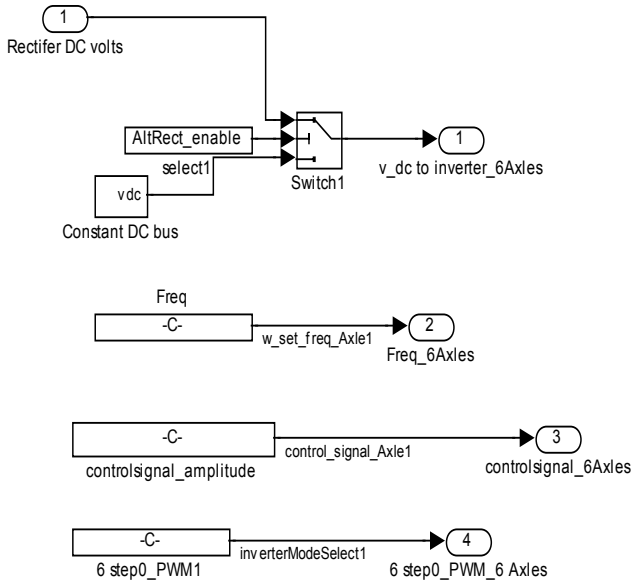

Figure 4: Internal details of the six inverter input interface block

Finally the last input is also a vector of six elements whose values are kept so as to decide whether the operation in that particular inverter is pulse width modulated or not.

Thus a sort of parallel simulation is performed and this brings down the overall simulation time considerably.

Real time taken for simulating 0.7 seconds –

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i) Single inverter single motor model = 14.5 seconds

ii) Six inverters six motors separate model = 407 seconds

iii) Six inverters six motors vectorized model = 52 seconds

As can be seen from the above data, the time taken in the vectorized model is much less than the six- axle separate model.

IV. CONCLUSION

The swift control of torque in ac drives has always been a topic of investigation despite of its preference over dc drives in industry. The concept of the vectorized control decreases the overall simulation time of all the four/six/eight inverter-motor combinations used in high power multi-machine drives and this advantage reduces the effect of the cumbersome nature of the improved induction motor model developed in this paper. A battery of six inverters and six machines was modeled using an elegant approach that just extends the SIMULINK single axle model by use of vector signals instead of scalars.

This modeling approach is elegant and faster (found to be around 8 times faster) compared to connecting multiple copies of the inverter and machine subsystem model. In short, if motor equations are solved on vectors of size six instead of on scalars, it generates six signals for each quantity-current, flux, torque thus simulating six motors. Thus huge time savings are obtained which aid in improved modeling standards.

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