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HYBRID ELECTRIC VEHICLES (HEV)- DC MOTOR COUPLE THREE PHASE INDUCTION MOTOR FOR AUTOMOTIVE APPLICATIONS

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Abstrak

An electric vehicle control system controls motor response based upon monitored vehicle characteristics to provide consistent vehicle performance under a variety of conditions for a given accelerator manipulation. ***.*** *With emphasis on a cleaner environment and efficient operation, vehicles today rely more and more heavily on electrical power generation for success. With the oil price shocks of the past few decades, as well as an increasing awareness of the emissions of air pollutants and greenhouse gases from cars and trucks, the interest to investigate alternative vehicle propulsion systems has grown. This challenge of fuel economy standards is promoting optimised and sometimes novel vehicle power automotive architectures, which combine the traditional internal combustion engine (ICE) with various forms of electric drives. The different types of the hybrid electric vehicles (HEV) are real competitors of the classical ICE driven cars. The controller of induction motor (IM) is designed based on input-output feedback linearization technique. It allows greater electrical generation capacity and the fuel economy and emissions benefits of hybrid electric automotive propulsion. Finally, a typical series hybrid electric vehicle is modelled and investigated. Control system integrated starter dc motor couple three phase induction motor for automotive applications. Various tests, such as acceleration traversing ramp, and fuel consumption and emission are performed on the proposed model of 3 phase induction motor coupler dc motor in electric hybrid vehicles drive.*

Keywords: *Hybrid Electrical Vehicle, Induction Motor, Dc Machine*.

I. INTRODUCTION

With the oil price shocks of the past few decades, as well as an increasing awareness of the emissions of air pollutants and greenhouse gases from cars and trucks, the interest to investigate alternative vehicle propulsion systems has grown. This challenge of fuel economy standards is promoting optimised and sometimes novel vehicle powertrain architectures, which combine the traditional internal combustion engine (ICE) with various forms of electric drives. The different types of the hybrid electric vehicles (HEV) are real competitors of the classical ICE driven cars.

In an all-electric vehicle (EV) there is no ICE, but all other components exist including batteries with excessive power. EVs and HEVs are studied by numerous authors in the past, one comprehensive study is that of Chan [1]. First full-scale hybrid vehicle work in Turkey is Doblo/Tofas example realized at Marmara Research Center [2]. There have been university theses and an industry project constitutes the basics of this paper [3-7]. One of the main contribution is that of Gokce [4], energy conservation and energy balance method is adopted. The input-output feedback linearization technique combined with an adaptive backstopping observer in stator reference frame the induction motor [5] using in series hybrid electric vehicle is controlled.

This paper focus on a new HEV modelling to make a couple two electric motor IM and DCM close loop sinusoidal PWM inverter to control the speed of a three phase induction motor. This compact inverter had its hardware reduced to a minimum through the use of a programmable integrated circuit (PIC) micro-controller (PIC16C73A). In this sense a microcomputer interface was avoided. At the end, a typical HEV is modelled and investigated. Simulation results obtained show the IM and other components performances for a typical city drive cycle.

II. THEORETICAL BACKGROUND

2.1 Management control system HEV

A hybrid electrical vehicle may consist of an internal combustion engine (ICE), electric motor (EM), electric generator (EG), power electronic circuits, advanced electronic control units (ECU), a complex mechanical transmission and a battery bank.

Fig.1 shows the structure of drive assembly of a hybrid electric car. There are 3 electrical machines, generator and starter (M/G), starter and the main motor (M), in the figure. G/M is an integrated started and generator (ISG) which connects with the internal combustion engine (ICE) using a couple . The starter is a standby one. The M, which is subject of this paper, is called main motor. It connects with the wheels through the final gear. Main motor is a three phase asynchronous Motor. The battery pack is a 288V, 10Ah NiH one. Fig.1

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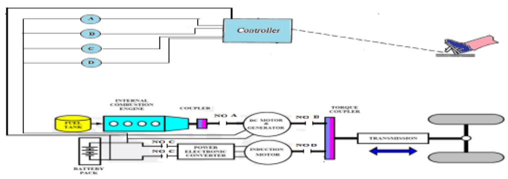


Fig.1 Management control system HEV

The hybrid electric car has 8 working modes: idle stop, ICE drive motor drive, serial mode, parallel mode, serial & parallel mode, ICE drive, battery charge and regenerative braking. Fig.1 shows four of the modes. ICE stops running when it is in the idle running state, and may be restarted in less than 100ms by the M/G. The idle stop mode will reduce fuel consumption and emissions in idle running state. The ICE drive mode is the same as the traditional car and will occur in most efficient working area of ICE. The motor drive mode is the same as the battery electric car and will occur at very low speed. In variasi mode which is shown in Fig.1, the ICE drags the M/G to charge the battery, and the main induction motor.

The first step in vehicle performance modelling is to write an equation for the electric force . This is the force transmitted to the ground through the drive wheels, and propelling the vehicle forward. This force must overcome the road load and accelerate the vehicle as shown in Fig.2

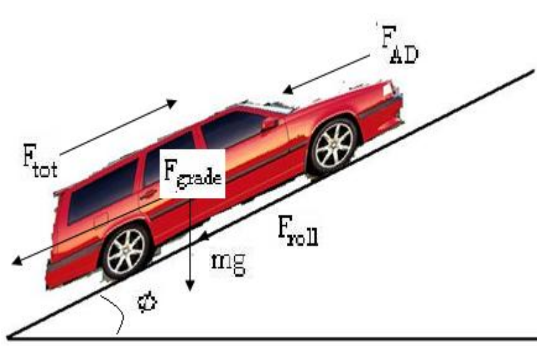


Fig.2 Basic of forces on a vehicle

The rolling resistance is primarily due to the friction of the vehicle tires on the road and can be written as:

$f_{roll} = f_r Mg$, (1)

where M is the vehicle mass, f , is the rolling resistance coefficient and g is gravity acceleration .

The aerodynamic drag is due to the friction of the body of vehicle moving through the air. The formula for this component is as in the following .Dynamic modelling and simulation of an induction motor with

$f_{AD} = \frac{1}{2} \xi C_D AV^2$ (2)

The gravity force due to the slope of the road can be expressed by:

$f_{grade} = Mg. \sin \alpha$ (3)

Where α is the grade angle.

In addition to the forces shown in Fig.3, another one is needed to provide the linear acceleration of the vehicle given by:

$f_{acc} = M\alpha = M \frac{dV}{dt}$ (4)

The propulsion system must now overcome the road loads and accelerate the vehicle by the tractive force, F_{tot} , as follows :

$F_{tot} = f_{roll} + f_{AD} + f_{garde} + f_{acc}$ (5)

Whells and axels convert F_{tot} and the speed of vehicle to torque and angular speed requirements for differential as follow :

$T_{whell} = F_{tot}\, r_{wheel}$, $\omega_{wheel} = V / r_{wheel}$ (6)

Where T_{whell} , r_{wheel} and ω_{wheel} are the tractive torque, the radius, and the angular velocity at the wheels, respectively.

The angular torque velocity and torque of the wheels are converted to motor rpm and motor torque requirements using the gears ratio at differential and gearbox as follows :

$\omega_m = G_{fd} G_{gb}\ \omega_{wheel}$, $T_m = T_{whell} / G_{fd} G_{gb}$ (7)

Where G_{fd} and G_{gb} are respectively differential and gear box gears ratios.

III. PROPOSED METHOD

3.1.Controllers couple IM and DCM

The coupling of these two components can be in parallel or in series. In the parallel configuration, both the IM and the DC electric motor contribute to the traction force that moves the vehicle. Power is split between them according to a control strategy, which is usually implemented by a supervisory controller. Two different sub-controllers independently control the IM and the DC motor. Both sub-controllers receive their commands from the supervisory controller. Among these commands are the two torque requests required from both sub-systems as shown in Fig.3.

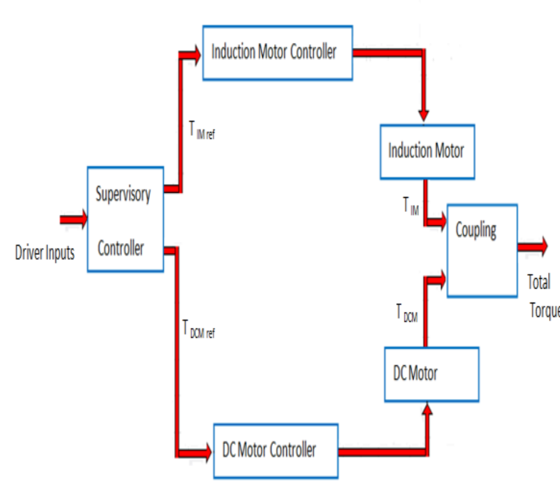


Fig.3 Controllers IM and DCM in a typical HEV application

3.2. CONTROLLER SIMULATION MODEL

To study the performance of the developed Transient torque and current model, a closed loop torque control of the drive is simulated using Matlab/Simulink simulation package. Fig.4 shows the simulation block diagram[9]. The drive cycle gives the required vehicle speed then the torque and speed requested from the electric motor. The current drawn from IM power supply shows the battery performance. The dynamic behaviour of the IM in the DCM+IM drive cycle. Power assembly diagram of HEV Normal Condition the ECE drive cycle. IM torque and average torque, power assembly diagram of HEV in Hybrid Electric. The block diagram of the simulink model is shown in Fig.4.

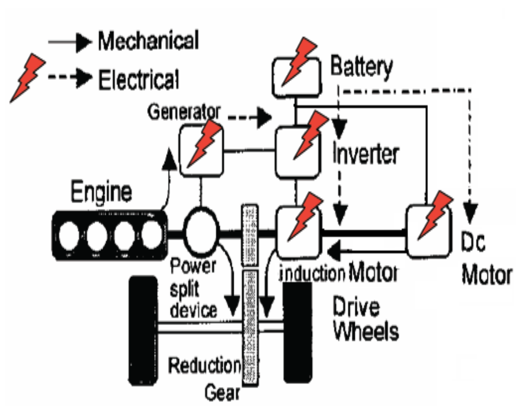


Fig.4. Simulation block diagram for stability control

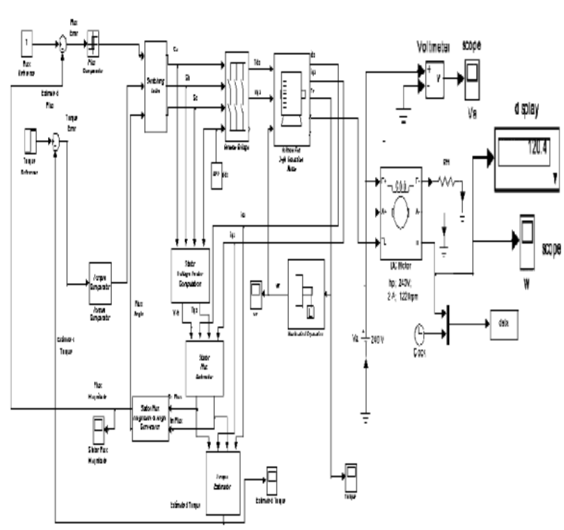


Fig.5. Developed model of transient torque and current control of induction machine

IV. PROPOSED CONTROL SYSTEM

4.1 Simulation model of induction motor couple dc motor

Simulation of the IM couple DC motor drive system is performed in Matlab/Simulink and SimPower environments. Voltage sags of types A-G, produced by software, are applied to the test system. Schematic diagram of the simulated system is shown in Fig. 6. The point here is to show how easy it is to take the SIMULINK blocks from the Library and turn them into a simulation and then into a real-time implementation

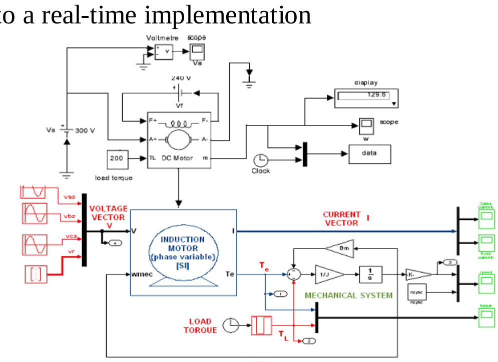
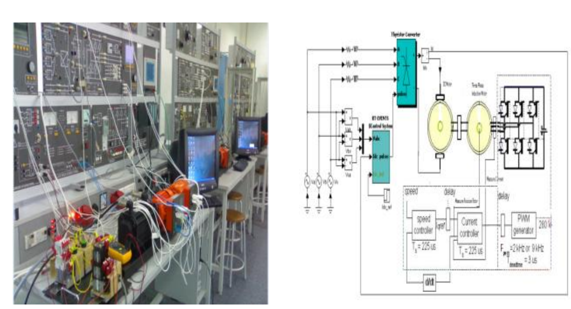


Fig.6 Three phase induction motor couple dc motor

changing conditions. Careful choice of the method of combining the controllers may result in a highly adequate yet non-oscillatory response. To take advantage of the rapid response of the PI-type controller, one needs to keep the system responding under the PI controller for a majority of the time and use the electric controller only when the system behaviour is oscillatory or tends to overshoots

5.2 Experiment setup

This paper describes the development of a experiment library of control and modelling algorithms for the various types of induction motor drives considered for Hybrid Electric Vehicles (HEVs). The wiring diagram control of three phase induction motor coupler dc motor in Fig.7.b and the set up experiment LAB in Fig.7.a



a. Experiment set up

b. Wiring diagram control of three phase induction motor coupler dc motor

Fig. 7. Experimental wiring diagram control

V. SIMULATION AND. EXPERIMENTAL RESULTS

5.1. The Simulation Results

To demonstrate the proposed hybrid Electric control scheme success, it has been tested by simulation, in order to evaluate the performances under a variety of operating conditions. The numerical values for the tested induction motor are summarized in Table I.

Table 1 Rating of tested Induction motor

Rated values	Power	0.3	kW
	Frequency	50	Hz
	Voltage Δ/Y	240/415	V
	Current Δ/Y	15/8,6	A
	Motor Speed	1440	rpm
	pole pair (p)	2	
Rated parameters	Rs	1,2	Ω
	Rr	1,8	Ω
	Ls	0,1554	H
	Lr	0,1564	H
	M	0,15	H
Constant	J	0,013	kg.m²

The controller algorithm is housed inside the personal computer with Pentium-4 microprocessor and all numerical values of the simulation model are obtained either by measurements. The software environment used of these simulation experiments is Matlab-software with Simulink Toolboxes. For all simulations performed in this paper, the best gain, found experimentally to be kp =0.56 and ki = 10.04.

After designing the best stand alone PI and electric controllers, all effectiveness of combining the two controllers to produce a hybrid design is demonstrated. Simulation results are given for motor sped tracking with the desired speed changing from the level to another (square-wave reference track with amplitude 150 rad/s).

Figs. 8 show the speed trajectory when the desired speed changes from one value to another, using the PI controller and the electric controller, respectively. The measured speed is superimposed on the specified desired speed in order to compare tracking accuracy. Clearly, the electric controller reduces both the overshoot and extent of oscillations under the same operating conditions. To demonstrate the robustness of the proposed controller a different type of trajectory was considered in this test. High tracking accuracy is observed at all speed. One can see from these figures that the results using electric controller, were very successful.

To illustrate the effectiveness of the switching strategy further, the hybrid controller was applied to control the motor under variable load torque. It is observed from Fig.8, that the hybrid controller closely tracks the motor speeds, even under changing conditions. Rejection of an external disturbances is also achieved. Compared with the motor speed response with variable load, it can be seen that the undesirable oscillatory response is clearly evident.

All test results show that the proposed hybrid electric control strategy is very effective in tracking the selected tracks at all time, while the system transients are effectively reduced. The results presented in Fig. 8 show that the proposed control system works correctly. The plots of these figures show the performance as the proposed scheme of hybrid-electric controller for variety of step changes in the desired set point. It can be observed that, the application of external force of 1.0 (N.m) to induction motor, the control and set-point following are satisfactory. In order to examine the robustness of the proposed control scheme, we assume that the parameters of rotor resistance Rr and load inertia J have been perturbed from their nominal values.

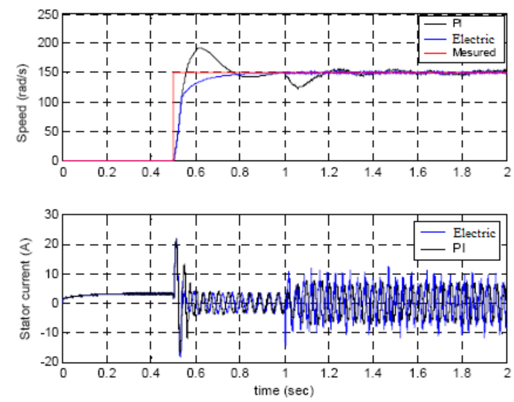
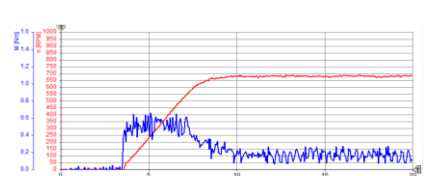


Fig.8 Speed control system of Induction motor couple dc motor using PI Controller and electric controller Speed step response under load and rotor resistance changes.

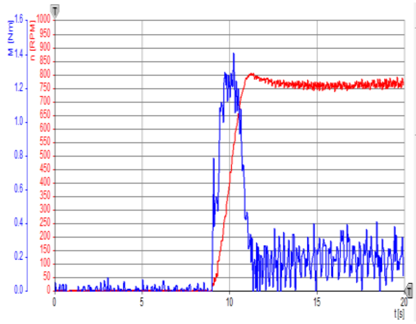
The parameters of stator resistance, inductances and viscous friction *f* maintain their nominal values. It is evident that the speed response of the proposed control scheme is not significantly affected by these variations. One can see from these all figures the results were very successful and the obtained results confirm the validity of the proposed control scheme. These figures reveal that the proposed controller based on the hybrid electric scheme was superior to the conventional controllers, such as the Proportional Integral PI-type. The controller envisaged is capable of maintaining a high tracking accuracy even in the presence of sudden disturbances such as load of electric transients.

5.2. The Experimental Results

Results is explained by the pact that, in experimental test were observed a strong influence of motor inductance in coupler to dc motor, more precisely, in the power system, however in the simulation such influence was not considered, and also non-linearity and additional losses.



a.



b.

Fig. 9 Speed & torque control system of a. Only Induction motor and Induction motor couple dc motor

VI. CONCLUSIONS

In this paper, the couple of the two electric motors with input-output state feedback controller combined with adaptive back stepping observer and batteries of a typical series HEV is investigated and simulated by Matlab/Simulink, has been presented and the performance and ability of control strategy is investigated. The proposed control system was analysed and implemented and its effectiveness in tracking application was verified. From the above results it is clear that the controller despite of its simple structure has all of the futures of a high precision speed controller for operating in the whole of speed range and for any loading and environmental conditions and had a good speed response regardless of parameter variation or external force.

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