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Optimized control of Hybrid Electric Vehicle using intelligent technique

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ABSTRACT: Electric vehicles are considered as better solutions for green technology in the field of transportation due to their user and eco-friendly interface. Generally speaking the hybrid electric vehicle system, they are prone to multiple errors regarding the speed performance and an intelligent monitoring layer can ensure smooth operation and inform any maintenance issues. In this paper, hybrid vehicle technology has been analyzed, with Power split configuration having internal combustion engine and battery as the power source. Initially the analysis of hybrid electric vehicle performance is done with battery of higher amp-hr capacity. In advanced state the converter circuit is implemented to reduce the battery rating. Hybrid electric vehicles are admired because of their ability to achieve related performance to a standard automobile while prominently improving fuel efficiency and tailpipe emissions. In this work we present signal processing techniques to control the functioning of hybrid vehicles and monitoring the speed by ensuring smooth performance in a very short span of time. Here a comparative study will be shown between integral controller and ANFIS controller. We demonstrate the thought process, simulation, final software interface and test results to confirm its effectiveness.

KEYWORDS: Hybrid Electric Vehicle, ANFIS, Battery, converter, System efficiency.

I.INTRODUCTION

HEV s are those which use two or more sources for their drive system. In present automobiles are an important part of our daily life. The significant growth of today's cities has led to an increased use of transportation, resulting in increased pollution and other serious environment a problem. But the exhaust emissions of conventional Internal Combustion Engine (ICE) are to blame as a major source of pollution leading to global warming. Hence HEV is the only replacement of conventional. But their low power density facing greatest challenge in research activities today is developing near zero- emission powered vehicles. So their will be a proposed model in which mitigate these shortcomings. Already the control of HEV are doing by conventional control but here we replace this controller by using an intelligent controller (i.e. ANFIS). The system of HEV is series parallel combination of sources.

Artificial intelligence, ANN, Fuzzy Logic, hybrid networks, etc. have been recognized as main tools to improve the performance of power electronics-based drives in the industrial sectors. Currently, the combination of this intelligent control with adaptiveness appears as the most promising research area in the practical implementation and control of electrical drives. A review of the research carried out by various researchers regarding the ANFIS control of electrical machines was discussed briefly in literature review. The responses (speed) had taken a long time to reach the set value. In the research work presented in this chapter, an attempt is made to reduce the settling time of the responses (speed) and make the response very fast by designing an efficient controller using a hybrid type of ANFIS-based control strategy taking into account. The block diagram of HEV is shown in fig 1, which depicts the idea of power transformation from source to wheel.

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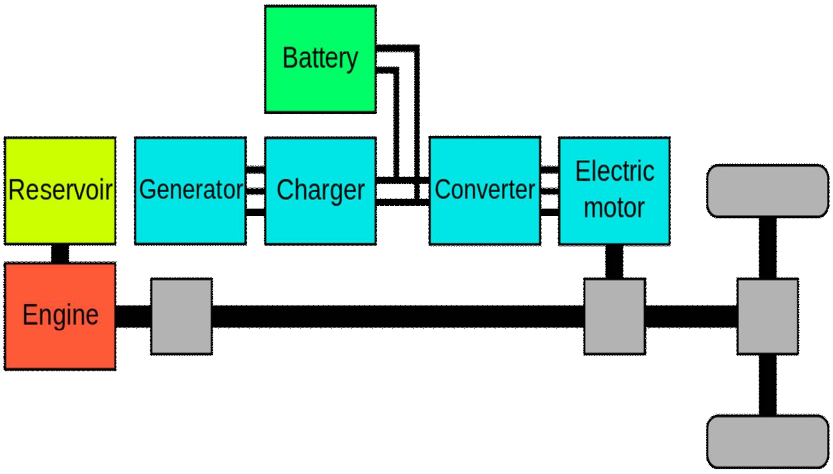

Fig 1 Block diagram of series parallel HEV

II.SYSTEM MODEL

In this section, the model of series parallel HEV powertrain parts is presented. In following sections, first in part A, the HEV powertrain architecture, and then in parts B to D the models of each part of vehicle, that will be used in our simulation, are briefly explained.

A. Parallel Hybrid Electric Vehicle Architecture Fig. 2 presents the block diagram of a HEV powertrain with an electrical machine and an ICE that are combined together to drive the vehicle [3]. The electrical machine works as generator when the state of charge (SOC) of batteries is low and there is need to charge the batteries, and works as motor when a torque is needed for driving the vehicle. The controller, designed by neuro-fuzzy method, controls the engine by changing the throttle angle in order to produce the required torque. The torque requested from electric motor is calculated by subtracting the real engine output torque, from the desired torque at any time.

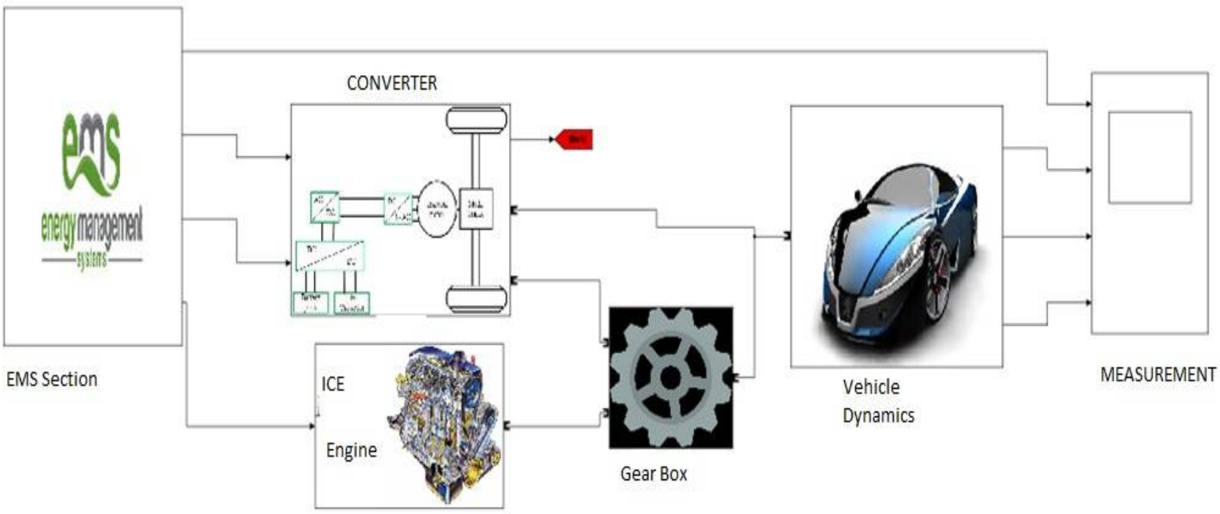

Fig 2 Simulink model of series parallel HEV

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B. Engine Dynamic Model

We use a simple model of engine introduced in [4]. This model includes a two-state dynamic model, whose output is the ICE torque. The states of the model are the speed of engine and the manifold pressure. It should be noted that SOC is a function of current and temperature and can be estimated with variety of methods. In this paper, we use Ampere-hour counting technique for calculating the SOC [7].

C. Electric Motor and its Controller Model

We use an electric motor and its controller model, which has been defined in ADVISOR 2002 software [8]. In this software, the losses in the electric motor and its controller as well as the rotor inertia, and the dependency of speed to the toque have been considered. Motor controller ensures that the maximum motor current is not exceeded and that the electric motor is not working when it is not needed [9].

D. ANFIS Design

The designing of ANFIS controller is shown below in fig 3 constitute in five layers. It is a neural network based adaptive controller, which sense like human brain. This is an intelligent controller which only mimics the training of PID controller

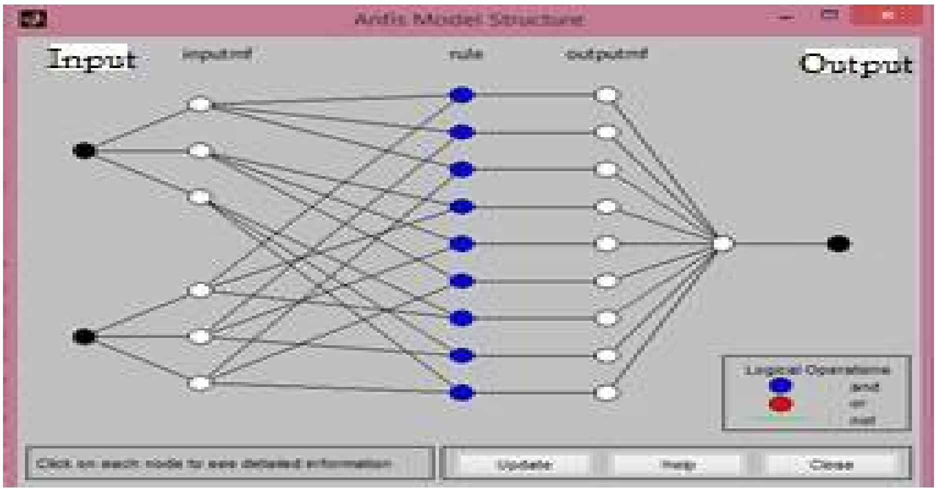

Fig 3 ANFIS modelling Structure

III. PROBLEM FORMULATION

This paper shows a multi-domain simulation of a HEV power train based on SimPowerSystems and SimDriveline. The HEV power train is of the series-parallel type, such as the one found in the Toyota Prius car [18]. This HEV has two kinds of motive power sources: an electric motor and an internal combustion engine (ICE), in order to increase the drive train efficiency and reduce air pollution. It combines the advantages of the electric motor drive (no pollution and high available power at low speed) and the advantages of an internal combustion engine (high dynamic performance and low pollution at high speeds). The Electrical Subsystem is composed of four parts: The electrical motor, the generator, the battery, and the DC/DC converter.

The electrical motor is a 450 Vdc, 50 kW interior Permanent Magnet Synchronous Machine with the associated drive . This motor has 8 pole and the magnets are buried. A flux weakening vector control is used to achieve a maximum motor speed of 6 000 rpm.

The generator is a 450 Vdc, 2 pole, 30 kW PMSM with the associated drive. A vector control is used to achieve a maximum motor speed of 13000 rpm. The battery is a 6.5 Ah, 200 Vdc, 21 kW Nickel-Metal-Hydride battery.

The DC/DC converter (boost type) is voltage-regulated. The DC/DC converter adapts the low voltage of the battery (200 V) to the DC bus which feeds the AC motor at a voltage of 500 V.

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The Planetary Gear Subsystem models the power split device. It uses a planetary device, which transmits the mechanical motive force from the engine, the motor and the generator by allocating and combining them.
The Hybrid Management System controls the reference power of the electrical motor by splitting the power demand as a function of the available power of the battery and the generator. The required generator power is achieved by controlling the generator torque and the ICE speed.

IV. SIMULATION RESULT AND DISCUSSION

The section shows different operating modes of the HEV over one complete cycle: accelerating, cruising, recharging the battery while accelerating and regenerative braking. Start the simulation. It should run for about one minute when you use the accelerator mode. You can see that the HEV speed starts from 0 km/h and reaches 73 km/h at 14 s, and finally decreases to 61 km/h at 16 s. This result is obtained by maintaining the accelerator pedal constant to 70% for the first 4 s, and to 10% for the next 4 s when the pedal is released, then to 85% when the pedal is pushed again for 5 s and finally sets to -70% (braking) until the end of the simulation. Open the scope Car in the main system. The following explains what happens when the HEV is moving and the stator current after the implementation of ANFIS is shown in fig 4.

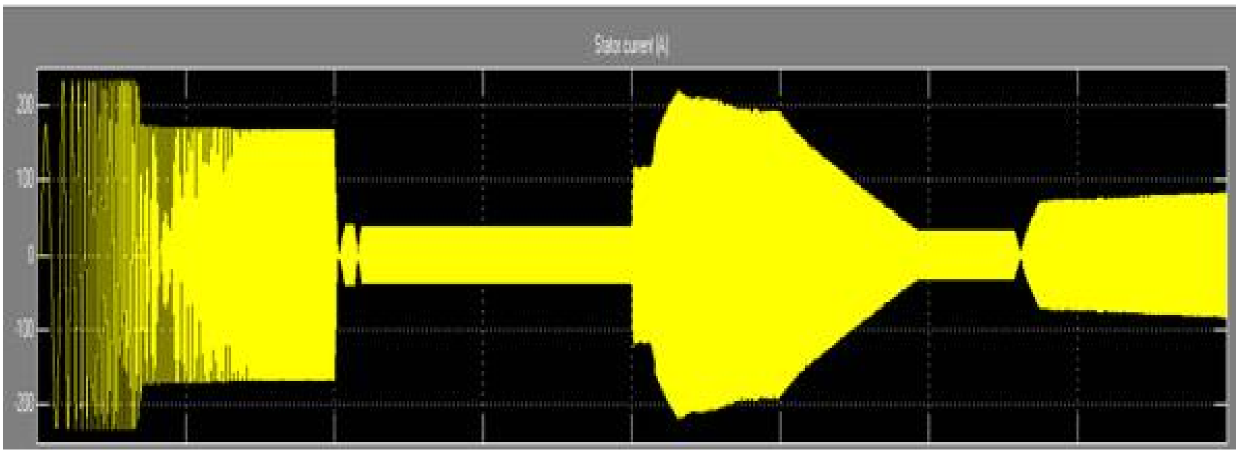

Fig 4 Stator current incorporated with ANFIS

At t = 0 s, the HEV is stopped and the driver pushes the accelerator pedal to 70%. As long as the required power is lower than 12 kW, the HEV moves using only the electric motor power fed by the battery. The generator and the ICE provide no power.
At t = 1.4 s, the required power becomes greater than 12 kW triggering the hybrid mode. In this case, the HEV power comes from the ICE and the battery (via the motor). The motor is fed by the battery and also by the generator. In the planetary gear, the ICE is connected to the carrier gear, the generator to the sun gear and the motor and transmission to the ring gear. The ICE power is split to the sun and the ring. This operating mode corresponds to acceleration of rotor current shown in fig 5.

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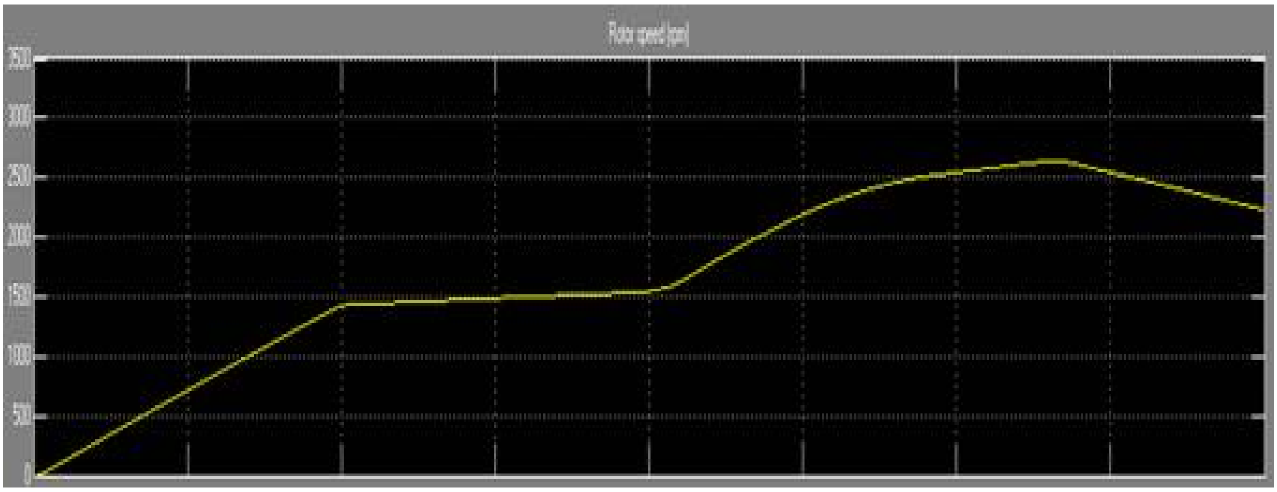

Fig 5 Rotor current

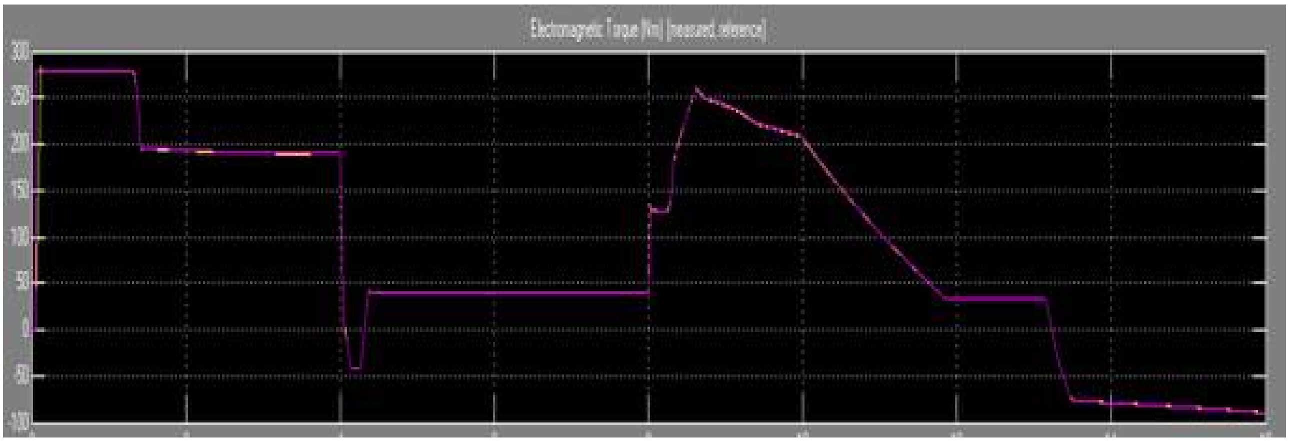

Fig 6 Torque development with ANFIS controller

At t = 4 s, the accelerator pedal is released to 10% (cruising mode). The ICE cannot decrease its power instantaneously; therefore the battery absorbs the generator power in order to reduce the required torque.
At t = 4.4 s, the generator is completely stopped. The required electrical power is only provided by the battery.
At t = 8 s, the accelerator pedal is pushed to 85%. The ICE is restarted to provide the extra required power. The total electrical power (generator and battery) cannot reach the required power due to the generator-ICE assembly response time. Hence the measured drive torque is not equal to the reference.
At t = 8.7 s, the measured torque reaches the reference. The generator provides the maximum power.

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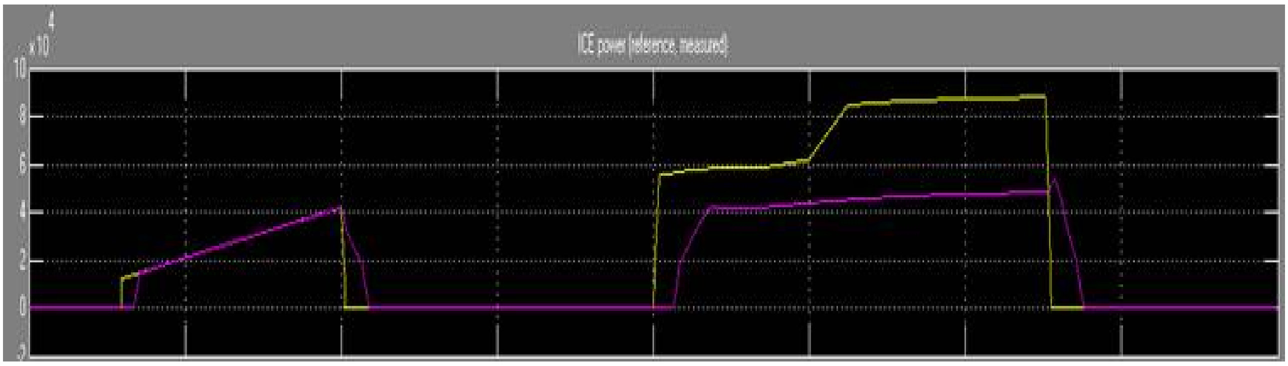

Fig 7 ICE measured and reference power

At t = 10 s, the battery SOC becomes lower than 40% (it was initialised to 41.53 % at the beginning of the simulation) therefore the battery needs to be recharged. The generator shares its power between the battery and the motor. You can observe that the battery power becomes negative. It means that the battery receives power from the generator and recharges while the HEV is accelerating. At this moment, the required torque cannot be met anymore because the electric motor reduces its power demand to recharge the battery.
At t = 13 s, the accelerator pedal is set to -70% (regenerative braking is simulated). This is done by switching off the generator (the generator power takes 0.5 s to decrease to zero) and by ordering the motor to act as a generator driven by the vehicle s wheels. The kinetic energy of the HEV is transformed as electrical energy which is stored in the battery. For this pedal position, the required torque of -250 Nm cannot be reached because the battery can only absorb 21 kW of energy.
At t = 13.5 s, the generator power is completely stopped.
Some interesting observations can be made in each scope. During the whole simulation, you can observe the DC bus voltage of the electrical system well regulated at 500 V. In the planetary gear subsystem, you can observe that the Willis relation is equal to -2.6 and the power law of the planetary gear is equal to 0 during the whole simulation.

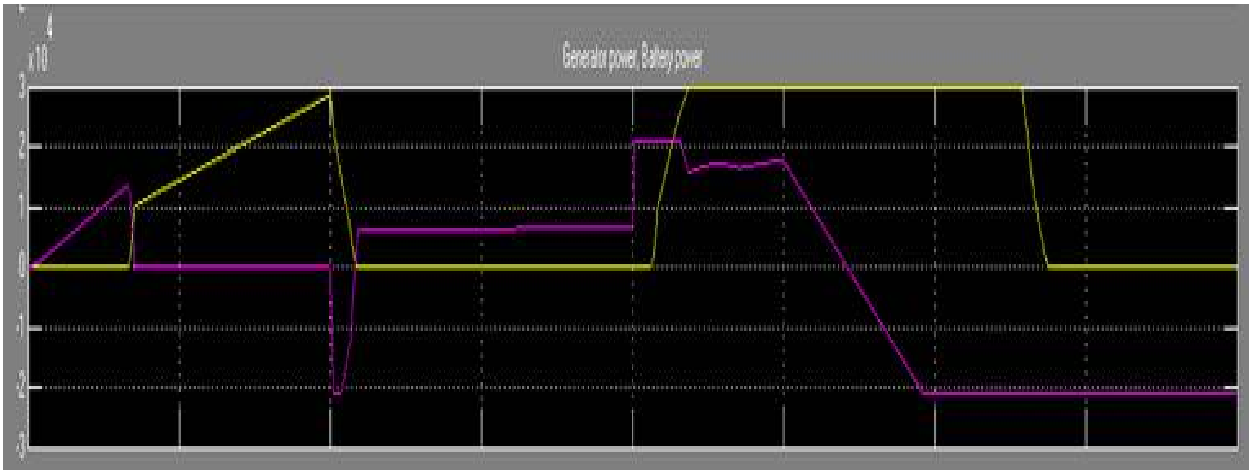

Fig 8 Generator Power and Battery output power

V. CONCLUSION AND FUTURE SCOPE

In this paper we presented a method for controlling HEVs in order to find an optimal solution between minimizing fuel consumption, maximizing vehicle torque, and minimizing exhaust emissions. For this reason, an ANFIS controller was

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designed and used in a modified version. The data for training ANFIS network gathered from two methods used in PID one of them designed only for minimizing the fuel consumption and another one is designed only for reaching maximum torque and efficiency of engine. Simulations show promising results as compared to two different conventional control modes.

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