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Efficiency Improvement in Passenger car by using Integrated ISG system

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ABSTRACT: With the constant increase in fuel price and the stringent norms by different government to control the CO_2 emission in vehicle it become the top most priority for all Automotive company to reduce the CO_2 emission and improve the efficiency of the vehicle. To achieve this we need to focus on all the items in the vehicle including reducing the weight of the vehicle, introducing more electronic for precise control, improving the operating strategy of the vehicle, Introducing electric drive system for short distance, Use hybrid systems. In the Present work the IGS is used to improve the efficiency of the vehicle by managing the different strategy in vehicle control and drive management. In this we will be discussing different type of motor and the electronic systems used to meet the hybrid system are discussed in this paper.

I.INTRODUCTION

Integrated starter generator (ISG) uses one machine to replace conventional starter and alternator onboard vehicles and provides greater electrical generation capacity and improves the fuel economy and emissions. The idea is not new, but needs a high complexity control system because of the differences between motoring and generating regimes, so that only modern motors and high-developed power electronics and digital signal processors made it practically possible. Integrated starter generator (ISG) systems are among these improvements. An ISG in a HEV is a component that regulates both the starter motor and the generator, which stops the engine when the car stops by activating the idle stop-and-go function. This reduces the fuel consumption by collecting energy through regenerative braking. To maximize the efficiency of the ISG, the motor must be matched with an inverter, which is crucial for determining the performance of the ISG. Global Automotive OEM's are working on different technology to reduce the CO2 emission and increase the efficiency of the vehicle. Different technologies are in research in-order to reduce the CO2 emission from the vehicle. Also different countries are deploying norms in-order to regulate the emission control like EURO 5, EURO 6, NEDC cycle. This paper reviews the opportunities and expected performances brought by the new resulted ISG-based automotive architecture.

In-order to reduce the emission from automotive vehicle several norms are set by different country government to reduce the CO2 emission from the vehicle. To achieve this type of standard we can't meet the only by improving the engine efficiency but we have to completely change the way vehicle is managed so that we can increase the mileage of the vehicle and meet the norms mentioned below by different countries.

ISSN: 2350-0328
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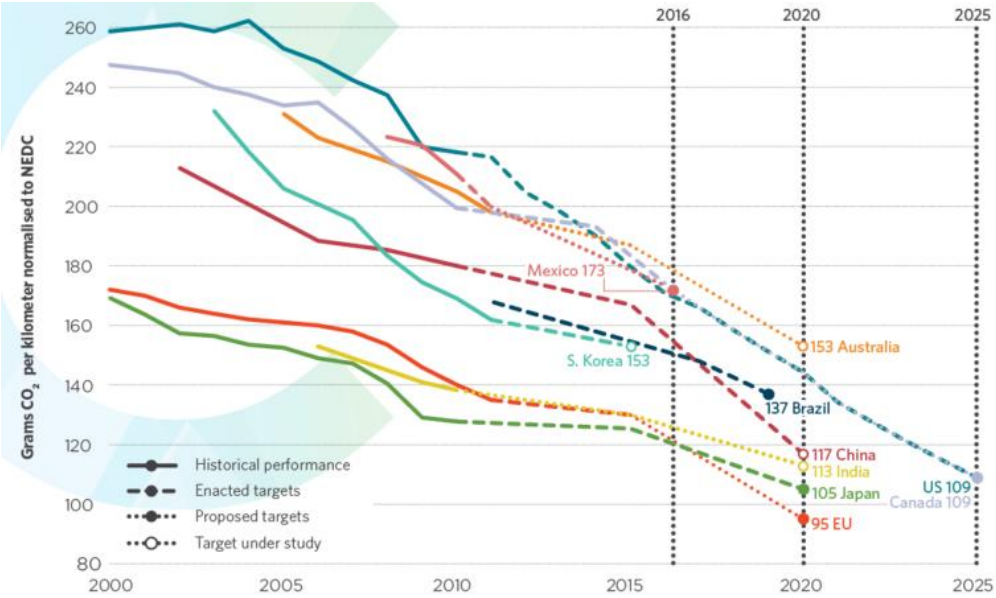

Fig -1 - Comparison of light vehicle CO2 emission rate projections, 2000–2025 [8]

A.System configuration and Operation modes

The fig 2 shows the ISG system performing both engine cranking and battery charging for modern automobiles and HEVs, which offers three major modes of operation for HEVs.

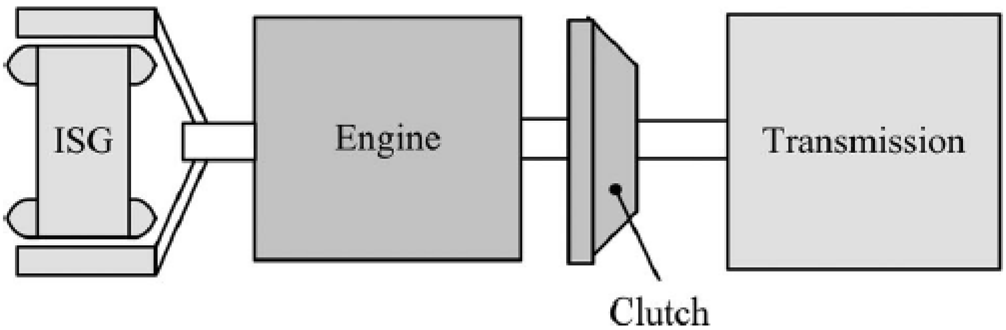

Fig -2 – ISG layout in passenger car [9]

Mode 1 – Engine cranking

When an HEV is started from long-term parking, the ISG works to bring the cold engine up to the required minimum operating speed, the so-called cold cranking. Therefore, the ISG needs to instantaneously provide a high starting torque so as to overcome the substantial resistance of the kinematic mechanism when the engine is cold. For modern HEVs, the engine should be shut down when the vehicle is at rest, the so-called idle stop feature, hence improving fuel economy and reducing exhaust emission for city driving. Therefore, the ISG needs to provide cranking regularly, the so-called warm cranking. Since the engine is warm, the required starting torque is less stringent than that of cold cranking.

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Mode II: Battery Charging

The engine speed generally varies with the vehicle speed, the ISG-generated voltage, and hence the battery voltage, is time-varying. In order to avoid battery overvoltage, and hence to prolong the battery life, the ISG-generated voltage should be kept as less fluctuating as possible. Moreover, when the HEV is braked or runs downhill, the ISG performs regenerative braking to charge the battery, provided that the battery is not yet full or overcharged.

Mode III: Torque Boosting

When the HEV needs to run uphill or overtaking, the ISG needs to operate in the torque-boosting mode, namely, on top of the full-throttle torque given by the engine, the ISG provides additional instantaneous torque to satisfy the desired command.

B.Proposed ISG System

The permanent magnet hybrid brushless system is shown in Fig. 3, which consists of a new PMHB machine, it has a unique feature of hybrid excitation, namely, both PMs and field windings are employed to produce the magnetic field. Different from the traditional PM brushless machine, this machine has a doubly salient structure with 36 salient poles in the stator and 24 salient poles in the rotor. It incorporates armature windings, PMs, and field windings in the stator, while the rotor is simply solid iron core. The outer stator accommodates the armature windings, while the inner stator accommodates both the PMs and field windings. The armature windings adopt a fractional-slot concentrated winding connection, whereas the field windings adopt a simple dc winding connection. Moreover, there is a pair of air bridges in shunt with each PM pole, which functions to suppress the PM flux leakage via the inner stator iron.

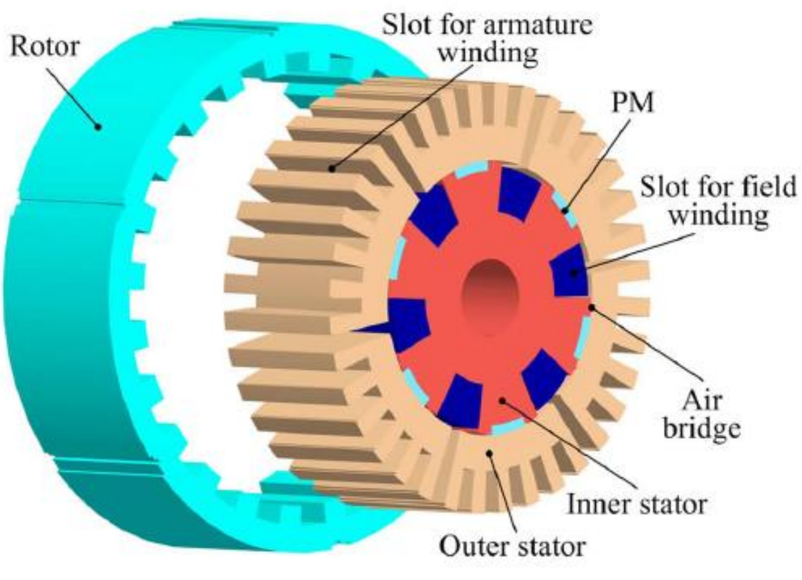

Fig -3 – Permanent Magnet Hybrid Brushless system [9]

With this unique structure, the proposed ISG system offers the following distinct advantages.

1) By tuning the magnitude and direction of the dc-field current, the machine can flexibly regulate the airgap flux. Hence, with flux strengthening, the proposed machine can instantaneously provide high starting torque for cold cranking and boosting torque for hill climbing or overtaking. In addition, with online flux control, the machine can maintain constant generated voltage for battery charging over wide ranges of speeds and loads. Additionally, the air bridge functions to amplify the effect of flux weakening when the field MMF is opposing the PM flux.

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2) The outer-rotor topology is adopted so that the inner space of the stator can be fully utilized to accommodate the PMs and dc-field windings, hence reducing the overall machine size and improving the torque density. In addition, the rotor has neither PMs nor windings, hence offering high robustness to withstand high-speed or intermittent operation.
3) The fractional-slot armature windings can shorten the magnetic-flux path and the span of end windings, which leads to reduce both iron and copper materials, thus further improving the torque density. In addition, this multipole concentrated winding structure can significantly reduce the cogging torque which usually occurs in conventional PM brushless machines.
4) The full-bridge inverter topology can provide a fault-tolerant capability for electrical isolation among phases, and a full-bridge dc–dc converter topology can provide bidirectional dc current control of the field windings, hence offering flexible flux strengthening and flux weakening.

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The electrical layout of the ISG system is given in fig 4, which include a system of electric motor (Stator and Rotor system) and an power electronic which can transfer the power between the motor assembly and the vehicle battery.

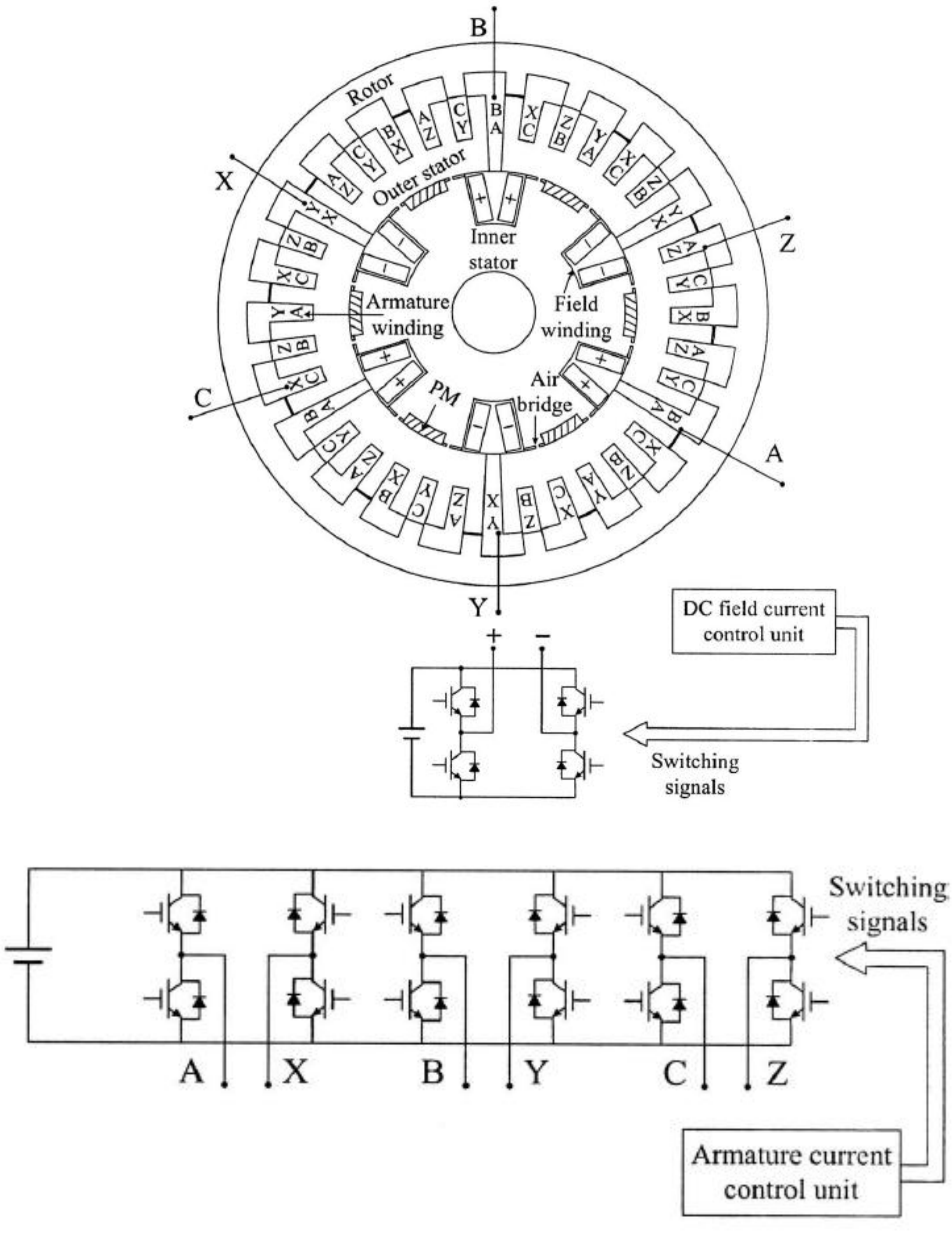

Fig -4 – Layout of the complete Hybrid ISG system [9]

According to different ISG operation modes, this machine works in the following ways.

1) When the ISG works in Mode I, this machine acts as a motor. A temporary positive dc-field current is applied to instantaneously strengthen the airgap flux, hence achieving a high starting torque for engine cold cranking.
2) When the ISG runs in Mode II, this machine serves as a generator. A positive or negative dc-field current is applied to strengthen or weaken the airgap flux, hence producing a constant generated voltage for battery charging.
3) When the ISG operates in Mode III, this machine also acts as a motor. A short-term positive dc-field current is applied to strengthen the airgap flux, leading to providing a supplementary torque for boosting the engine.

C.Selection of ISG Component

Motor selection

Parameter for motor selection

Torque	-	150 to 300 Nm
Initial acceleration time	-	3 to 5 Sec
Power density	-	High power density
Efficiency	-	High

Controller of ISG system

The most suited for the ISG control system is the field-oriented control that transforms the control problem of the induction machine into the classical control problem of a separately excited dc machine and creates independent flux and torque control loops. The stator current phase is decomposed in two orthogonal components, one along the rotor flux, and one in quadrature with it, when the rotor flux position is known. The rotor flux position must be known on this purpose. Therefore, the accurate instantaneous position of the rotor flux is crucial for the success of the field-oriented structures.

An experimental testing structure is shown in Fig 8, the whole test bed structure is controlled by a dSPACE 1104 board shown in figure 6 and Control Desk software. dSPACE has a MPC8240 processor with PPC 603e core and on-chip peripherals, 32MB memory and 4 general purpose timer. The block diagram of the dSPACE board is shown in Fig 7.

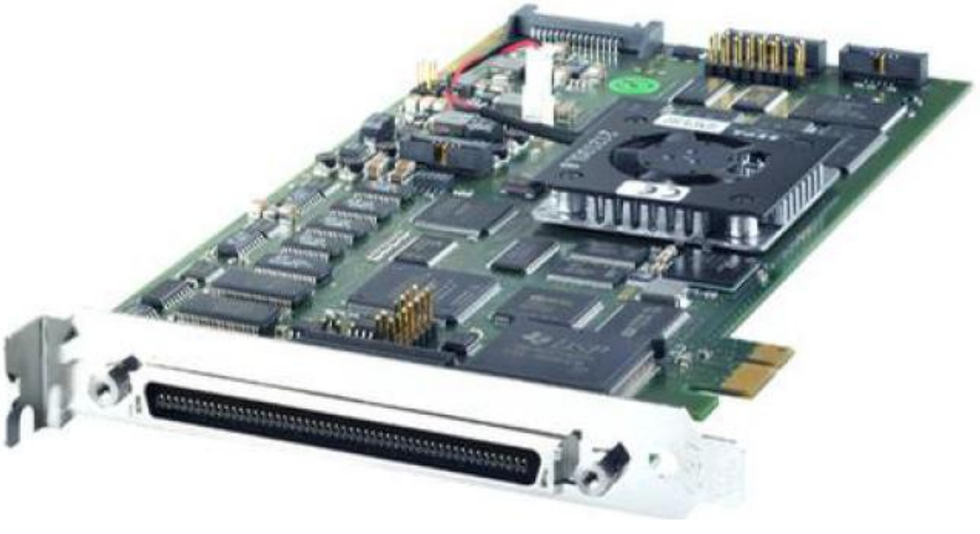

Fig -6 – dSPACE 1104 board

By using the control desk application we are able to control the ISG in different mode of operation.

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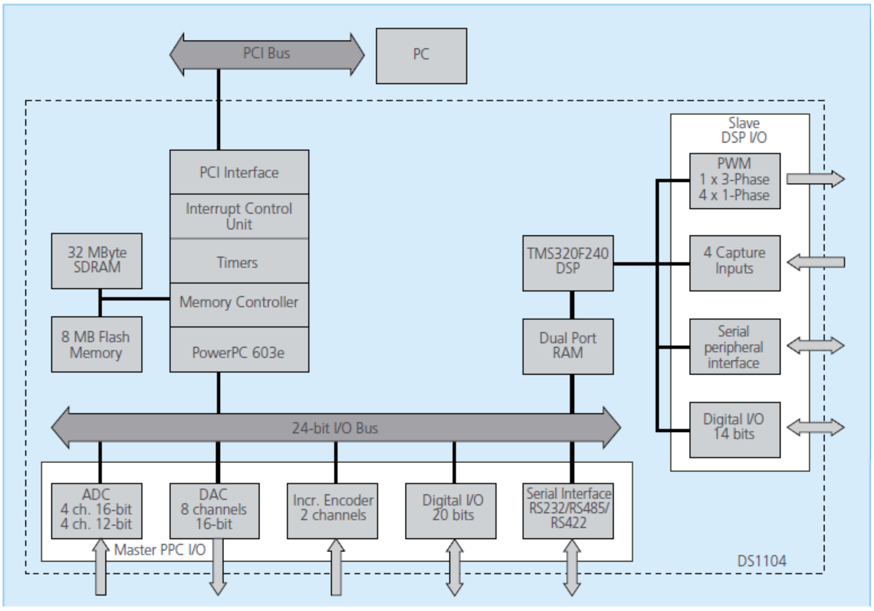

Fig -7 – Block diagram of dSPACE 1104 module

Depending on the engine operating-mode the control topology changes. During the start-up, the active current reference, is determined by the reference electromagnetic torque, which has a greater value that the engine restoring torque. After a certain speed value the engine fires and becomes to develop an accelerating torque. For a short time the both motors generate a positive torque. Then, the ISG switch in the generating mode and the active current, is determined by the needed power pumped to the dc line load. Therefore, a dc bus voltage regulator can be used to determine them. The engine speed can vary at any time. This variation affects the ISG rotor speed, and the variation in rotor speeds affects the output voltage in generating mode, unless there is well-designed control system. The test bed simulate the different operating condition and drive pattern and determine the efficiency of the thermal engine with the integration of ISG system.

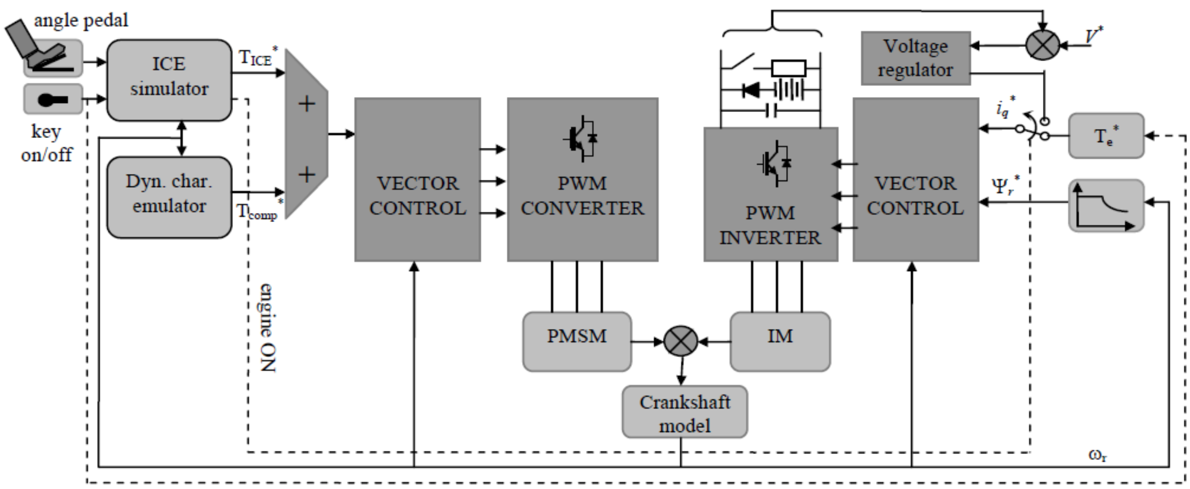

Fig -8 – ISG test bed structure

II.CONCLUSION

Present work shows the usage of different motor for ISG module and defines the suitable controller in order to operate the motor in different modes like motor mode, charging mode and Torque assist mode. The controller is used to

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Vol. 3, Issue 4 , April 2016

manage the start of the ideal engine and once the engine speed is reached then the ISG controller switch the motor into generator and regulate the DC bus voltage irrespective the speed of the engine and generator. Also the speed and the driver usage and based on need it help the engine and change the generator mode to Torque assist mode is considered. The investor of the ISG is the special part which needs to handle high power and need to operator at high temperature and vibration condition. We defined the integration of the ISG system in the vehicle architecture and the implementation of the hybrid system in vehicle, which shows the improvement in the efficiency of the vehicle.

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