Voltage Source Inverter Fed Hybrid Electric Vehicle

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Abstract*— The depletion of fossil fuel, increasing atmospheric pollution and need for energy conservation. The air pollution caused by road transportation the carbon dioxide present in the exhaust gas released by the internal combustion engine greatly affects both the environment and the human being.The global desire to reduce the vehicle emission and improve fuel economy to development of hybrid electric vehicle . The three phase 50 Hz, 6KW,120deg , conduction mode of voltage source inverter. Voltage source inverters are increasingly applied in many new industrial applications that require superior performance.Recently, developments in power electronics and semiconductor technology have lead improvements in power electronic systems. Hence, different circuit configurations namely multilevel inverters have become popular and considerable interest by researcher. Variable voltage and frequency supply to a.c drives is invariably obtained from a three-phase voltage source inverter. A number of Pulse width modulation schemes are used to obtain variable voltage and frequency supply. The most widely three-phase voltage source inverters are carrier-based sinusoidal PWM. This project focuses on step by step development voltage source inverter in hybrid vehicle implemented on an Induction motor. The model of a three-phase a voltage source inverter is discussed based on vehicle. Simulation results are obtained using MATLAB/Simulink environment for effectiveness.

I. INTRODUCTION

Three phase voltage-fed inverters are recently showing growing popularity for multi-megawatt industrial drive applications. The main reasons for this popularity are easy sharing of large voltage between the series devices and the improvement of the harmonic quality at the output as compared to a two level inverter. In the lower end of power, GTO devices are being replaced by IGBTs because of their rapid evolution in voltage and current ratings and higher switching frequency.

On our planet the number of the cars increases continuously and nearly doubled in the last 10 years. With increasing number of cars entered in circulation every year is held and increasing fuel consumption, increased environmental pollution due to emissions from internal combustion engines (ICE), used to their propulsion. Reducing oil consumption takes into account the limited availability of petroleum reserves and reducing emissions that affect the health of population in large urban areas.

The car needs a propulsion source to develop a maximum torque at zero speed. This can be achieved with the classic ICE. For ICE power conversion efficiency is weak at low speeds and it has the highest values close to the rated speed. Pollution reduction can be achieved by using electric vehicles (EV), whose number is still significant. The idea of an electrical powered vehicle (EV) has been around for almost 200 years.

The first electric vehicle was built by Thomas Davenport in 1834 Westbrook, 2005 But over time, the batteries used for energy storage could provide the amount of electricity needed to fully electric propulsion vehicles. Electric vehicles are powered by electric

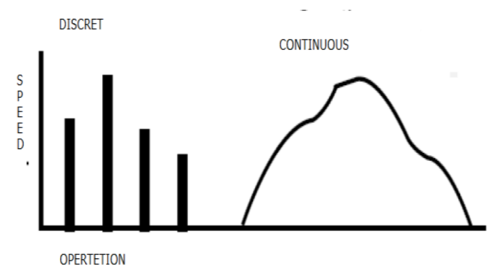


fig 1 comparison of range process speed control

II. DESCRIPTION

Hybrid-electric vehicles make use of high-power density ac propulsion systems to provide comparable performance with vehicles using internal combustion engine technology. Customer demands for greater acceleration, performance, and vehicle range in pure EVs plus mandated requirements to further reduce emissions in HEVs increase the appeal for combined onboard energy storage systems and generators. Electric motor, inverter, and associated control technology has made substantial progress during the past decade and it is not the limiting factor to either vehicle performance or the large scale production of EVs and HEVs.

The compact, light weight and efficient energy storage system battery and combination of other emerging technologies, Including ultra capacitors, flywheel energy storage system, advanced batteries, and fuel cells that is both affordable and has acceptable cycle life remains the major roadblock to Large-scale production of EVs and HEVs.

A battery storage unit can be employed combined with a fuel cell stack in order to achieve the operating voltage-current point of maximum efficiency for the FC system. In such a conventional arrangement, the battery is sized to deliver the difference between the energy required by the traction drive and the energy supplied by the FC system, as well as it has to deal with power peaks being on demand during acceleration or overtaking phases resulting from the driving cycle on which the vehicle is expected to operate.

1.Super capacitors called BEV (Battery Electric Vehicles).
2. Hybrid electric vehicles which combine conventional propulsion based on ICE engine with petroleum fuel and electric propulsion with motor powered by batteries or super capacitors called HEV (Hybrid Electric Vehicles),
3. Electric vehicles equipped with fuel cells, called FCEV (Fuel Cell Electric Vehicles).

There are two types of voltage-source inverters which are generally used t o drive the permanent-magnet synchronous machine the 120° and the 180°.The 120° inverter system offers advantages for certain applications due to the inherently larger timing tolerances which prevent inverter malfunction due to "shoot through." Also, with the 120° inverter it is possible to program the switching of the inverter using the back emf of the machine.

An average-value model is established and its accuracy determined by comparison with the variables calculated using a detailed representation of the 120° inverter system. This model should be very useful in the analysis of linear and nonlinear control systems.

III BLOCK DIAGRAM:

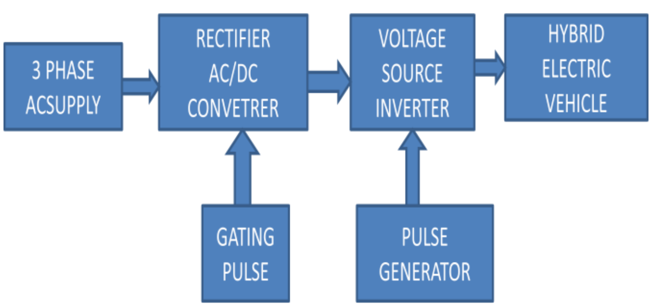


Fig2 block diagram of hybrid electric vehicle.

A.HALF BRIDGE VOLTAGE SOURCE INVERTER:

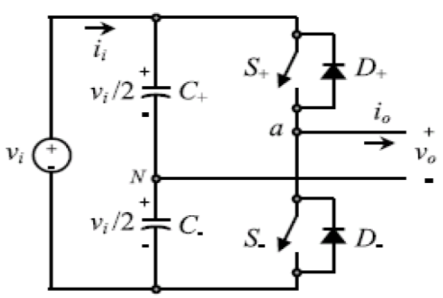


Fig 3 half bridge voltage source inverter

B.FULL BRIDGE VOLTAGE SOURCE INVERTER:

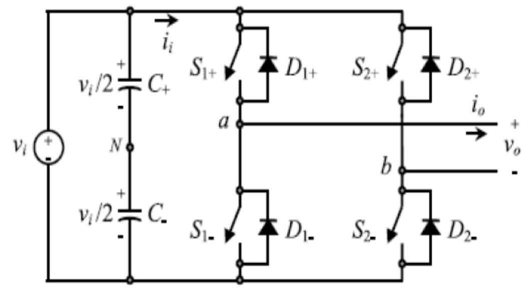


Fig4 full bridge voltage source inverter

C.THREE PHASE VOLTAGE SOURCE INVERTER:

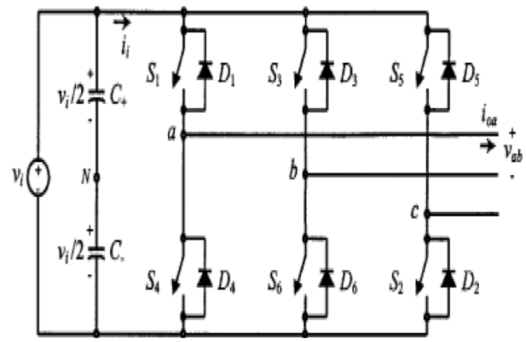


Fig5 three phase voltage source inverter

The motors are the only propulsion system for electric vehicles. Hybrid electric vehicles have two propulsion systems: ICE and electric motor, which can be used in different configurations serial, parallel, mixed. Compared with ICE electric motors has some important advantages: they produce large amounts couples at low speeds, the instantaneous power values exceed 2-3 times the rated ICE, torque values are easily reproducible, adjustment speed limits are higher. With these characteristics ensure good dynamic performance: large accelerations and small time both at startup and braking.

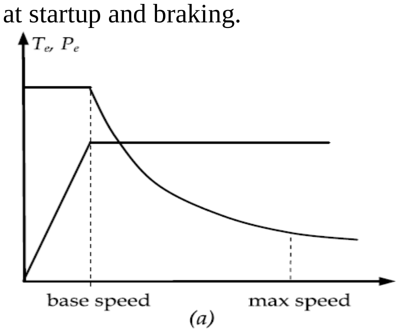


Fig9 Characteristic of traction motor

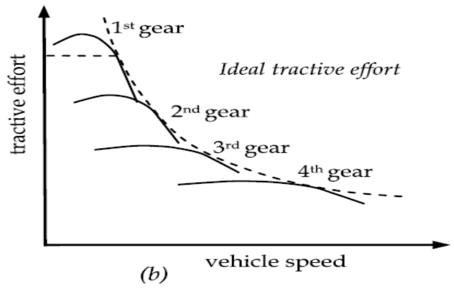


Fig10 Traction effort characteristic of an vehicle

IV MOTOR INVERTER CIRCUIT:

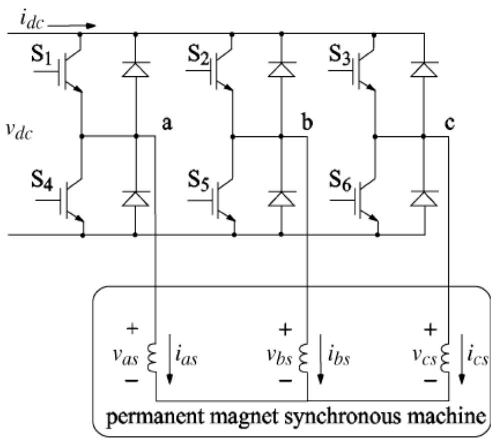


Fig11 motor inverter circuit

PULSE DESIGN FOR 120 DEGREE:

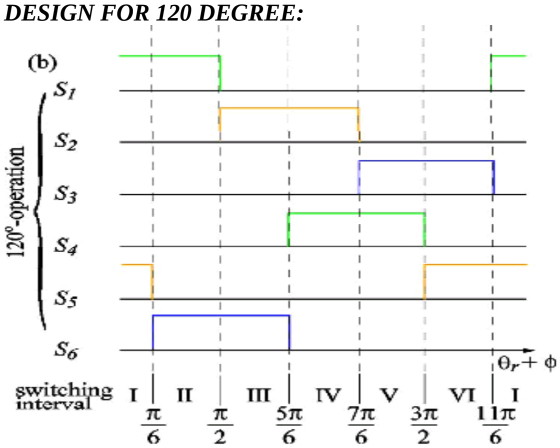


Fig 12 Switching signals

SWITCHING SIGNALS FOR 120 DEGREES:

	Switching Interval	Transistors On
I	$-30° - \phi < \theta_r < 30° - \phi$	1, 6
II	$30° - \phi < \theta_r < 90° - \phi$	1, 2
III	$90° - \phi < \theta_r < 150° - \phi$	2, 3
IV	$150° - \phi < \theta_r < 210° - \phi$	3, 4
V	$210° - \phi < \theta_r < 270° - \phi$	4, 5
VI	$270° - \phi < \theta_r < 330° - \phi$	5, 6

V INVERTER OPERATION

The inverter is connected to a 3-phase permanent magnet synchronous machine.

We can write

Vag = Vas + Vng --------- →(1)

Vbg = Vbs + Vng --------- →(2)

Vcg = Vcs +Vng ---------- →(3)

Since the sum of the stator currents is zero and the stator windings are symmetrical, the sum of vas, Vbs, and Vcs is zero.

Therefore, if (1)-(3) are added we obtain

$$\mathbf{v}_{ng} = \frac{1}{3}(\mathbf{v}_{ag} + \mathbf{v}_{bg} + \mathbf{v}_{cg})$$ **---------- →(4)**

Substituting (4) into (1) - (3) yields,

$$\mathbf{v}_{abcs} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\mathbf{v}_{abcg}$$ **---------- →(5)**

Where

$$\mathbf{v}_{abcg} = (\mathbf{v}_{ag} \;\; \mathbf{v}_{bg} \;\; \mathbf{v}_{cg})^T$$

In the inverter, two transistors are "gated on" at any given time. The switching intervals for the **120'** inverter. Note that the firing pattern is composed of six interval

$$\mathbf{f}(\theta_r + \frac{\pi}{3}) = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & -1 \\ -1 & 0 & 0 \end{bmatrix}\mathbf{f}(\theta_r)$$

Where f =V_{abcs}, i_{abcs}, or λ_{abcs}. Therefore, for steady-state conditions, it is only necessary to calculate the currents for one particular SI from which the complete system behavior can be determined

VI OPEN LOOP CONTROL DIAGRAM:

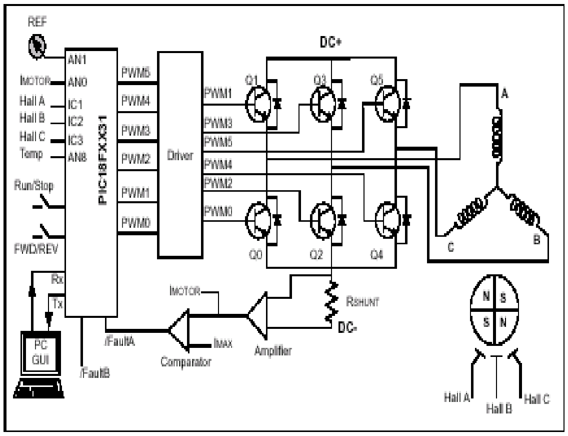


Fig 13 open loop control

The Hall Sensor signals may have 60° or 120 degree electrical phase difference to each other. A sequence table is entered in the program memory based on the type of Hall Sensor placement. The sequence can be taken from the motor data sheet. The sequence may be different for clockwise and counter clockwise rotations. The following section explains how PCPWM, IC and ADCs are used for open-loop control.

Hall Sensors A, B and C are connected to IC1, IC2 and IC3, on the Input Capture (IC) module. The Input Capture module is used in "Input Capture on State Change" mode. In this mode, the IC module interrupts every transition on any of the IC pins. Also, Timer5 is captured on every transition and cleared at the beginning of the next clock cycle. The captured Timer5 value is useful in determining the speed of the motor.

Measuring the speed and controlling the motor in closed loop is discussed in detail in the section "Closed-Loop Control Using Hall Sensors". Upon IC interrupt, in the IC Interrupt Service Routine, the status of all three input capture pins is read and the combination is used to pick up the correct sequence.

VII CLOSED LOOP CONTROL DIAGRAM:

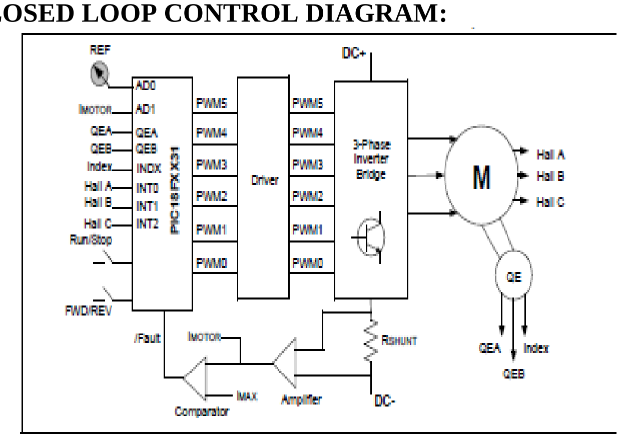


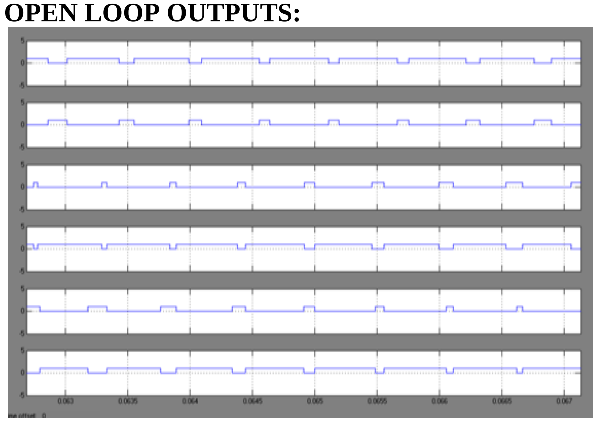
Fig 14 closed loop control

The speed can be controlled in a closed loop by measuring the actual speed of the motor. The error in the set speed and actual speed is calculated. A Proportional plus Integral plus Derivative (P.I.D.) controller can be used to amplify the speed error and dynamically adjust the PWM duty cycle.

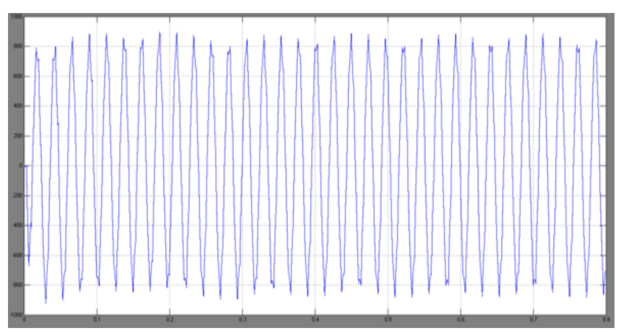
For low-cost, low-resolution speed requirements, the Hall signals can be used to measure the speed feed-back. A timer from the PIC18FXX31 can be used to count between two Hall transitions. With this count, the actual speed of the motor can be calculated. For high resolution speed measurements, an optical encoder can be fitted onto the motor, which gives two signals with 90 degrees phase difference.

Using these signals, both speed and direction of rotation can be determined. Also, most of the encoders give a third index signal, which is one pulse per revolution. This can be used for positioning applications. Hall Sensors can be alternatively connected to the external interrupt pins (INT0, INT1 and INT2). These pins can cause interrupts on the rising or falling edge, based on the respective "Interrupt Edge Select" bits. In external interrupt ISR, the interrupt edge select bit should be toggled in the correct direction to get interrupts on both the falling edge and rising edge on all three INT pins.

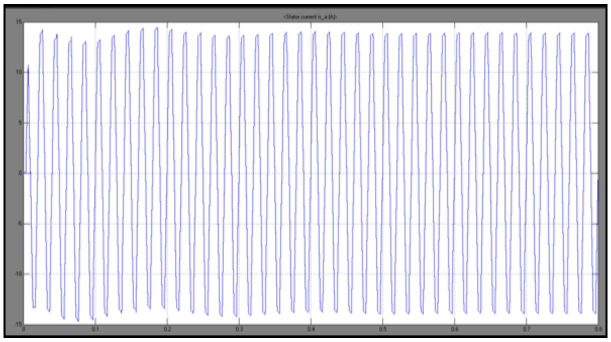
OPEN LOOP OUTPUTS:



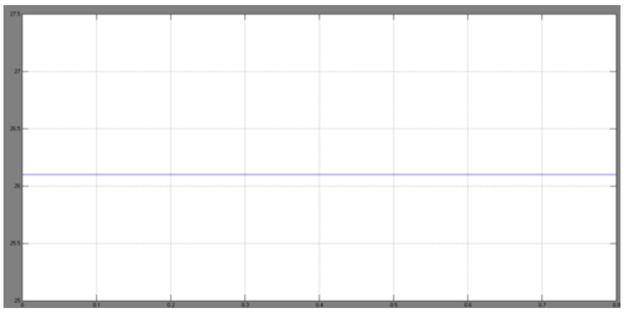
Rotor current:



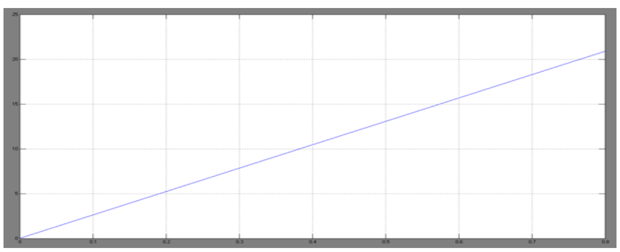
Stator current:



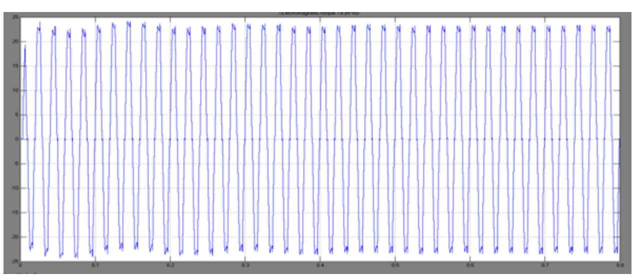
Rotor speed:



Rotor angle:

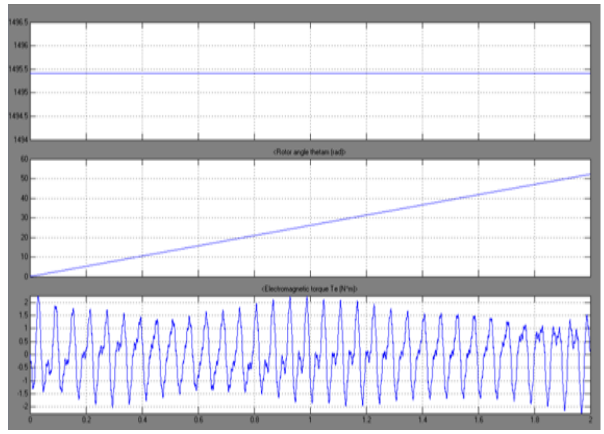


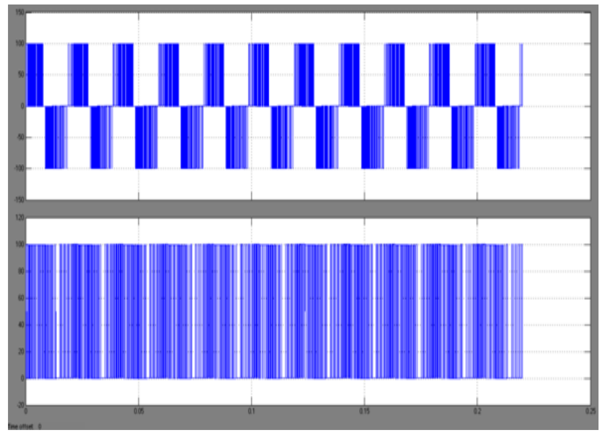
Electromagnetic torque:



CLOSED LOOP OUTPUT:

Rotor speed, Rotor angle, electromagnetic torque:





Load	Rotor speed	Electromagnetic torque	Rotor angle	Stator current
26.5	1518	2	265	8.5
100	5730	1.8	278	8.1
150	8594	1.4	1475	4

Table 1. performance of open loop VSI

S.no	Load	Rotor speed	Electromagnetic torque	Rotor angle
1	26.5	1518	2.4	53
2	100	3819	2	35
3	150	5729	1	40

Table 2. performance of closed loop VSI

CONCLUSION:

Hybrid electric vehicle is the emerging technology for present and future generation. The hybrid electric vehicles are very complex dynamic systems .

Three phase inverters are used in high power applications. The phase voltage waveform for open loop and closed loop wave forms. In voltage source inverter for 120 degree conduction mode, the harmonic losses is less and copper winding less to get the exact output wave form in the open loop and closed loop for rotor speed, rotor angle and electromagnetic torque .

The model of a three-phase voltage source inverter is discussed based on open loop and close loop control of the motor. Simulation results are obtained using MATLAB/simulink environment for effectiveness of the study.

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