



Control of Axial Flux DC Motor with Permanent Magnet Dedicated to Electric Traction

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Abstract: In this paper we present a control strategy of a DC motor with permanent magnets ensuring the variation of the speed, the electric braking of electric cars and guaranteeing to reach the maximum speed set at 80 km / h. This control strategy is implanted under the simulation environment Matlab-Simulink. Simulation results are encouraging and open the avenue of research work to optimize the performance of the electric car structure studied.

Keywords: DC motor, Axial flux, Control, Modeling, Simulation, Electric cars

1. Introduction

The electrification of vehicles has become a current project in light of strong oil crises and undeniable air pollution. In this context, the choice of the type of electric motor used for varying the speed of the cars is a determining factor in the cost, energy economics and reliability of the onboard electrical system. Several types of motors are used to solve the problem electric cars drive which are [1-10]:

- Synchronous motors with permanent magnets.
- Synchronous motors with wound rotor.
- Asynchronous motors
- DC motors.

Our choice fell on an axial structure DC motor with permanent magnets since it has multiple benefits include for example:

- High power density.
- Modularity (possibility of increasing the power available by stacking of modules on the motor shaft).
- Reduced manufacturing costs (simple structure).
- High efficiency (lack of rotor iron losses and copper losses).
- Simplicity of the control.
- Ability to overcome speed.
- Ability to achieve high powers (rotor flux negligible compared to the inductive flux).

In this context, this paper describes a control strategy for this type of engine designed by the finite-element/analytic

joint method and presents the main results of simulations [1-10].

2. Motor Structure

A new engine innovated structure DC permanent magnet axial flux is retained as part of this study. This structure is simple to manufacture and modular, it can be stacked to increase available power (adding modules on the motor shaft). It has the advantage of high efficiency leading to the improved autonomy of the car and high power density.

A front view of this structure is illustrated in Figure 1.

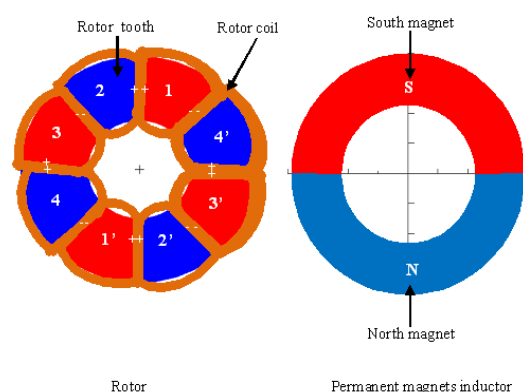


Figure 1. Front view of the DC motor with axial flux.

A spread cylindrical sectional plane of the engine is shown

speed of response. The comparator output signals attack a controller (proportional integral PI). The output signals of the controller pulse at the rate of the variation of the motor supply voltage necessary to attain the speed desired by the driver of the car.

The speed controller is implemented in MATLAB / SIMULINK according to the figure 5:

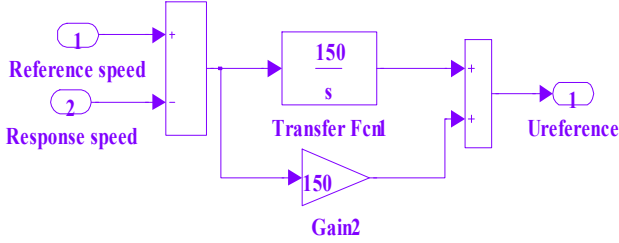


Figure 5. Simulink model of the speed controller.

6. Control Signals Generator

The control signal generator used to modulate the reference voltage generated by the regulator and convert into digital signals at the rate of pulsing the supply voltage of the rotor winding, necessary to achieve the desired speed. Indeed, the reference voltage is compared with a triangular signals of significantly high frequency. The comparator output drives a hysteresis between 0 and 1 logic. The outgoing hysteresis

points corresponds to the signal S1. The S2 signal is found by reversing the signals S1. The signal S1' has the same shape as the signals S1 and S2' signal has the same shape as the signal S2.

Simulink model of the control signals generator is shown in Figure 6.

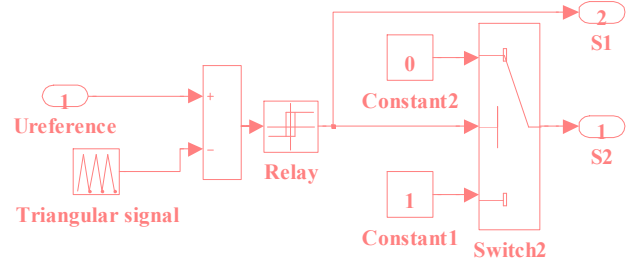


Figure 6. Simulink model of the control signals generator.

7. Overall Model of the Power Chain

The coupling of different models leads to the overall architecture of the power chain model implanted under the simulation environment MATLAB / Simulink according to Figure 7:

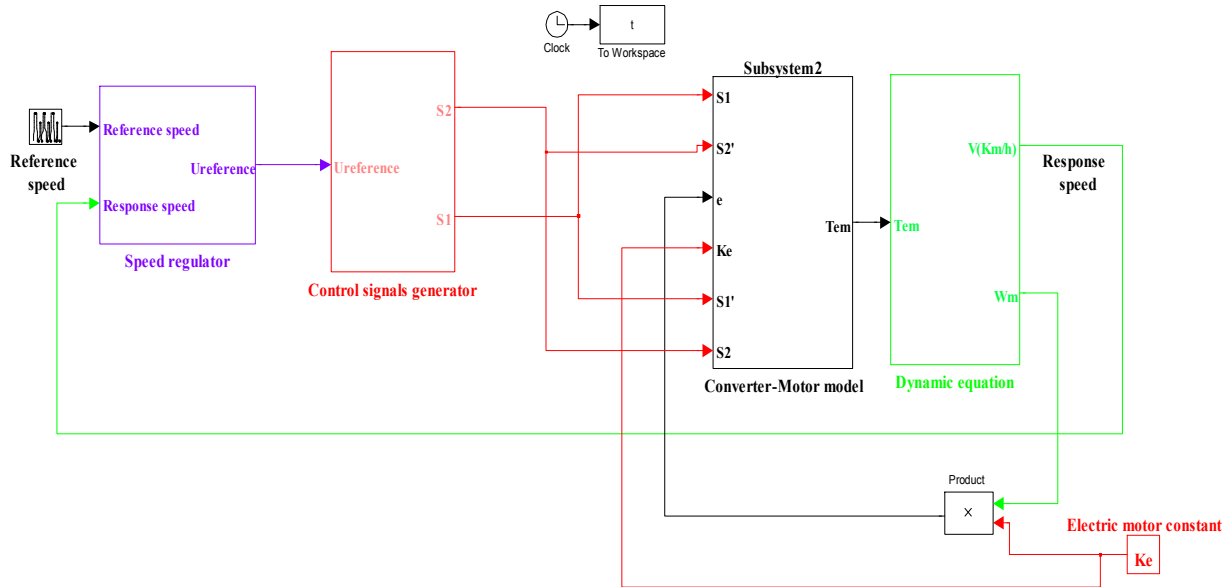


Figure 7. Model of the overall power chain.

8. Descriptions of Simulation Results

The speed of response to a circulation mission is shown in Figure 8.

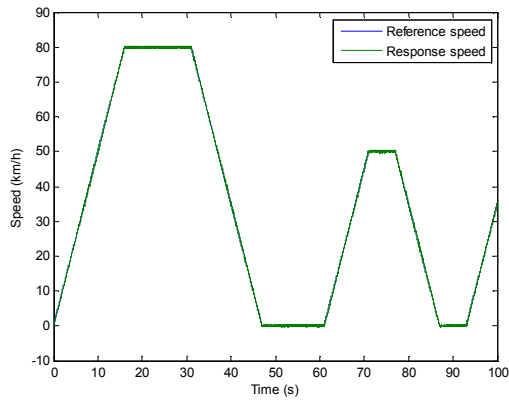


Figure 8. Speed Response to a circulation mission.

The speed of response accurately follows the reference speed indicating the effectiveness of the control strategy developed.

The rotor current is shown in Figure 9.

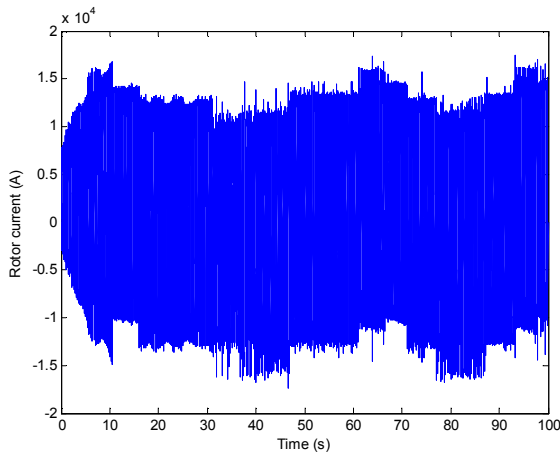


Figure 9. Rotor current.

Figure 9 shows that during phases of high acceleration, the current is greatly reduced which validates the right choice of speed controller parameters.

Figure 10 shows the curves of the rotor voltage and rotor current.

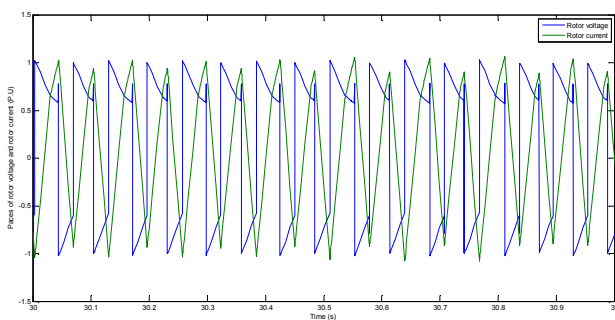


Figure 10. Paces of the rotor voltage and rotor current.

The deformation of the rotor voltage is due to the voltage drop across the IGBT transistors.

The electromagnetic torque is shown in Figure 11.

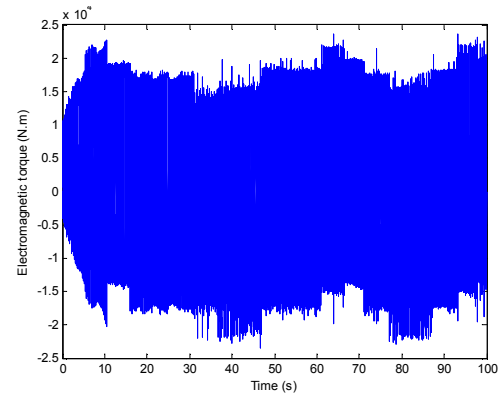


Figure 11. Electromagnetic torque.

The passage of the electromagnetic torque from positive values to negative values is mainly due to the low time constant of the engine and the average value of the switching frequency. This frequency is chosen in a way to minimize the losses in the converter.

The energy consumed by the car to the mission of circulation shown in Figure 8 is shown in Figure 12.

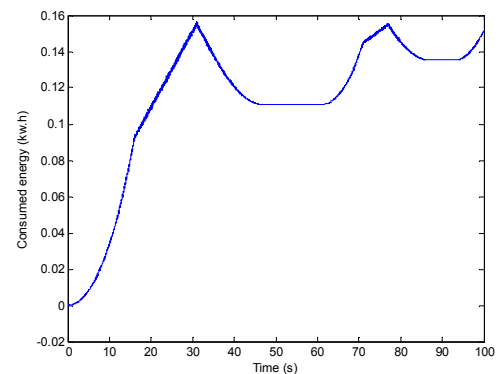


Figure 12. Energy consumed by the car.

The car consumes 0.15 kw. h browsing this circulation mission, although optimized value.

The energy recovered from the car to the mission of circulation shown in Figure 8 is shown in Figure 13.

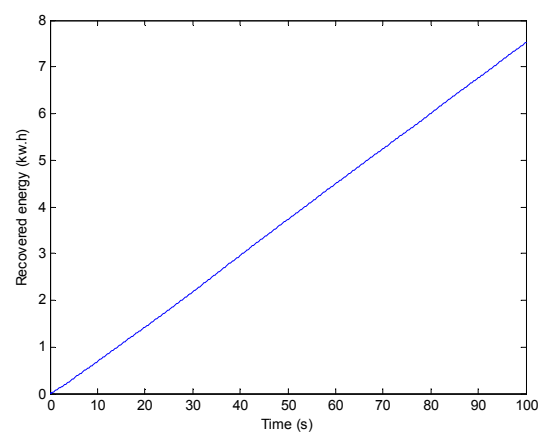


Figure 13. Energy recovered by the car.

The car gets 7.5 kw.h browsing this circulation mission, an important value which shows the correct choice of the method of calculation of the DC bus voltage.

9. Conclusion

In this paper, we presented a control strategy dedicated to a new innovated axial DC motor with permanent magnet permitting an electrical braking and allowing the car to reach the maximum speed set at 80 km / h. This control strategy is implanted under the simulation environment Matlab-Simulink. The results of simulations found are encouraging. As perspective to this work, it will be very interested as a future work to study the problem of the autonomy maximization and to integrate this control laws on an autonomous electronic card.

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