SPICE Simulation of a Switched Reluctance Motor with Novel Driving Circuit

SPICE SIMULATION OF A SWITCHED RELUCTANCE MOTOR WITH NOVEL DRIVING CIRCUIT

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Introduction

Switched Reluctance Motor (SRM) exhibits desirable features including a simple construction, high reliability and low cost. However, the drive circuit is not necessarily suitable. Fig. 1 shows the basic drive circuit for SRM. This is an asymmetry half bridge converter with 2 switching devices and 2 diodes per phase, and can't compose using a general 3-phase power module such as Intelligent Power Module (IPM). It is disadvantage for cost that SRM can't use the circuit similar to other ac motors. At the efficiency, this circuit is poor because of 2 device drops per phase. This circuit needs 2 wires per phase from the converter to the motor, which number is more than that of other motors, so they require more space and cost.

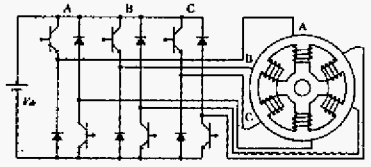


Fig. 1 Basic drive circuit for SRM.

In order to overcome their difficulty, various drive circuits for SRM are proposed. C-dump converter is one of them. But, it needs an external large inductor and a high voltage capacitor. And, the additional circuit to maintain the capacitor voltage causes additional loss. In this paper, we propose a new drive circuit of SRM for advantages of cost, space, and efficiency, based on C-dump converter.

Our Proposal Circuit and its Operation

Fig. 2 shows our new drive circuit for 3-phase SRM. This is similar to that of general 3-phase ac motors. So, it can be constructed using IPM at low cost, high efficiency, and compactness. This motor system needs 1 wire per phase and 1 common wire only. A capacitor and a dc voltage source are connected in series, and the common wire is connected to between the source and the capacitor.

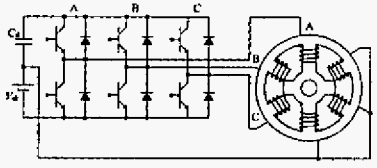
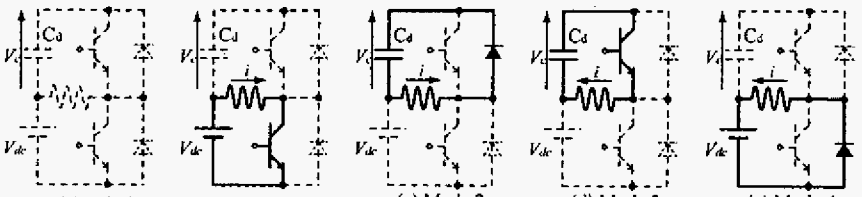


Fig.2 Proposed drive circuit for SRM.

Fig. 3 shows the excitation mode of our proposal circuit. First, the current doesn't flow and both devices are off (mode 0). If the capacitor voltage V_c is lower than source voltage V_{dc} and the rotor position is suitable, turn on the lowside device and the current flows from the voltage source to the device through the winding (mode 1). After that, turn off the device at excitation end position, then the current commutates from the lowside device to the highside diode and the capacitor is charged (mode 2). If V_c is higher than V_{dc}, turn on the highside device. Then, the capacitor is discharged and the current through the winding flows opposite to mode 1 (mode 3). Turn off the device, the current commutate from the highside to the lowside diode, and the energy is back to the source (mode 4).

That means that V_c can be controlled as V_{dc} by choosing the highside device or the lowside device to excite the winding. The current direction is changed by the choice of switching device, but the torque of SRM is not affected.

At the efficiency, this method has no additional loss for controlling V_c and the device drops are only 1 per phase. At the device ratings, the voltage ratings of the devices are same $2V_{dc}$ as that of C-dump converter, but the voltage rating of the capacitor is V_{dc} which is half of that of C-dump converter, so it makes the size of the capacitor small remarkably.



(a) Mode 0 (b) Mode 1 (c) Mode 2 (d) Mode 3 (e) Mode 4

Fig. 3 Excitation mode of the proposed circuit.

Simulation

We simulated the proposed circuit using the general-purpose circuit simulator "SPICE". The SRM model is based on magnetic circuit calculated using FEM [2]. The specification of SRM for examination is shown in Fig. 4. The simulation conditions are V_{dc} as 60 V and load torque as 1.0 Nm.

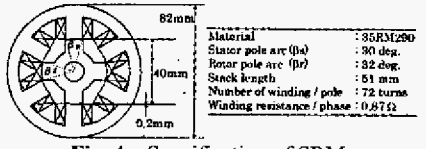


Fig. 4 Specification of SRM.

The result is shown in Fig. 5. When V_c is low, the phase current direction is plus. Or, the phase current direction is minus. Therefore, V_c is controlled surely.

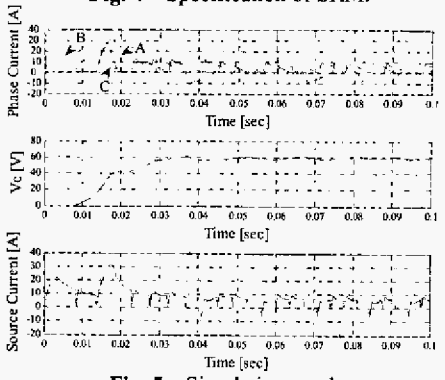


Fig. 5 Simulation result.

Conclusion

We proposed a new drive circuit for SRM using general inverter. This circuit is high efficient, low cost, and compact.

References

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[2] O. Ichinokura, S. Suyama, T. Watanabe, H. J. Guo, *IEEE Trans. Magn.*, Vol. 37, pp. 2834-2836 (2001)

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