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Energy Efficient operation in Switched Reluctance Motor by Controlling the Voltage

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Abstract— **This paper introduces a new method for reducing the cost of the power electronic components in Switched Reluctance Motor (SRM). A new control circuit has been designed to improve the performance and efficiency of the motor. This paper also explained the energy savings of SRM by using voltage controller. This proposed method is compared with existing method. This method is more advantages to increase the efficiency of SRM. This converter does not require resister. Hence the cost of the drive system is reduced. Suppressing voltage present in off-going phase winding is once again reused to increase the efficiency.**

Index Terms— **Motor drives control, Power electronics, and Switched reluctance motor (SRM) drives**

I. Introduction

Electrical drive is one of the important equipment for any industries.60% of total energy is consumed by only electric motor. SRM is only considering for home appliance because it's simple construction and absence of permanent magnet and rotor windings. SRM is one of the first invented high speed motor but due to lack of fast switching power devices and control electronics. Hence the application of the SRM is limited. Matlab/simulink leads to design the voltage controller of the SRM. There are two types of SRM are available namely,

1. Sensor type SRM
2. Sensor less SRM

Rotor position of SRM is directly sensed by using sensor is called sensor type SRM. Sensor less SRM is indirect sensing the rotor position. In this paper introduce a new methodology to develop the indirect method of rotor position Procedure for Paper Submission

II. Sensor less type SRM

Most of the sensor less methods is depending upon the Magnetic characteristics of SRM. Magnetizing characteristic of SRM is based on the stator currents and flux linkages with rotor position angle. This characteristic is used for explaining the relationship between the stator current and rotor angle. Magnetizing characteristics of SRM is already described by some researchers [1]-[4], which help to sense the rotor position of the SRM. In [5], [6] Magnetization curves are explained by 'Gage curve' method. Interaction between the two phases in the stator winding is not considered in Existing method. Hence Magnetic theory have been developed [7], [8] in the non linear model of SRM. Finite Element Analysis [1] method is already explaining the Magnetizing characteristics of SRM. Disadvantages of FEA method is less accuracy, complex modeling. Hence the proposed method is developed by new algorithm for measuring the Magnetizing characteristics of SRM. It helps to sense the correct rotor position with respect to inductance and phase current. Some of the proposed indirect sensor elimination techniques are published and rotor position methods are identified in literature survey. It is already described by Acarnley et-al [9] the flux current detection technique by Lyons et-al [10] the modulation techniques by Ehsani et-al [11], [12].Husain introduced the mutually induced voltage

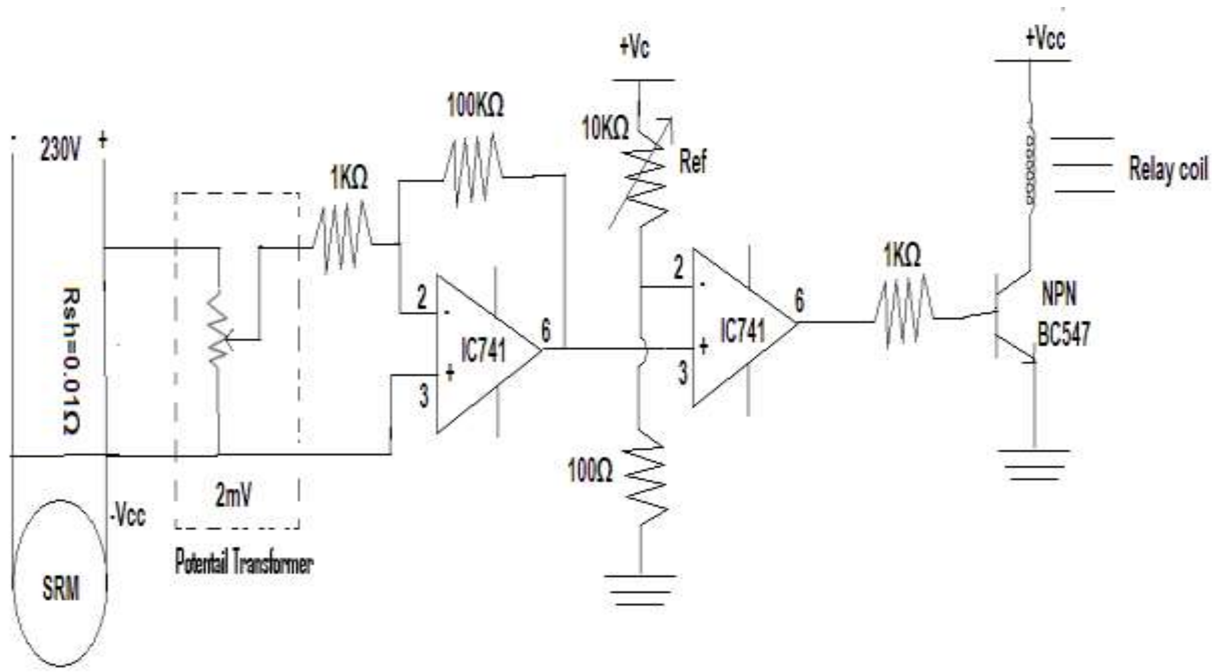

Fig: 1.Circuit diagram for conventional voltage control Method

[13]. Laurent et al proposed the resonant method [14] and Bass et al introduced the open loop control [15]. Lumsdain [16] presented the more sophisticated method.

III. Principal and Operation of Energy Efficient Sensor less SRM

SRM inductance value is variable due to current or voltage signal present in each phase winding. There are two operations are available in SRM like motoring operation and generating operation. The motoring operation is depending upon the negative inductance slope. The Inductance value of the Switched reluctance motor is changed by the rotor position.

IV. Experimental Set up

A. Conventional methods of Energy Efficient Drives

Voltage across each phase winding is equal to current through it. Turn ON is proportional to load condition. This voltage across winding is connected to the input of amplifier. This Amplified output is compared with some reference voltage using a comparator. Comparator output is having two voltage levels (high or low). It is depending upon amplified voltage of winding. If the comparator output is high, Transistor is turned ON and hence the relay coil is energized. If the relay coil is energized, supply is available to SRM. It is shown in fig.1.

At no load condition, voltage across winding is high so that comparator output is low. Transistor is turns off and hence relay is also used to disconnect the supply to the SRM. There are two types of modules are available

B. Motoring Mode

A fractional horse power 4/2 SRM was used to investigate the efficiency and performance of the proposed method. Brake drum was mechanically coupled with SRM. The complete setup is as shown figure 1. This experiment is used for measuring the sensor less pulse, type of inductance, stator current with load and no load condition. It is also identify the rotor position and speed of the SRM. There are two conditions are available for calculating the efficiency of the SRM.

1. No load condition
2. Load condition

Fig:2 Control circuit for 4/2 SRM.

Fig: 3. Energy Saving Control Panel for SRM

Fig: 4. Photo for 4/2 SRM.

1) No load condition

At no load condition voltage across phase winding is increased. Due to presence of inductance, corresponding stator current is calculated, since speed of the SRM is increased. The current in stator winding is controlled by micro controller. Excess suppressing voltage present in the stator winding is stored by static capacitors. Hence switching frequency of the SRM is also reduced when the speed of the SRM is decreased.

2) Load condition

SRM current is increased at load condition when voltage across winding is decreased. At this time inductance value is changed by low voltage. Switching frequency is increased by microcontroller. If the switching frequency of the SRM is increased, the speed of the motor is also increased. Suppressing voltage present in the capacitor is once again used in the winding. The power circuit consists of controller and hysteresis type control for controlling the current during low and high speed operations.

C. Generating module

A resistance loaded D.C. machine is act as a load of Switched reluctance Motor. In the generating mode each phase in Switched reluctance motor is excited during the negative inductance position slope region. This Switched reluctance motor is loaded with a resistance. The same procedure is used at no load and load condition but only difference is the winding is excited at negative inductance position slop region. Proto type 4/2 SRM is shown in fig 2, 3 and 4.

V. Proposed Voltage Controller Drive

SRM is controlled by correct positioning of the phase current pulses with respect to rotor position. The turn on time and the total conduction period are used for determining the torque and efficiency of the SRM. The current should be limited by either controlling the voltage or regulating the current. It is shown in fig. 5.

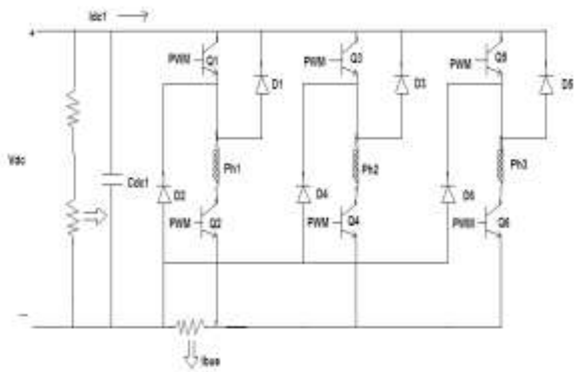

Fig: 5 Circuit diagram of proposed Voltage control drive

In general PWM voltage control with variable duty cycles are very useful to control the SRM. Variable speed drive is having voltage PWM with closed loop position for high efficient operation. More number of blocks is available in voltage controller for maintaining the high speed operation. Function of angle controller is mainly generating the turn- on and turn-off angles for each phase winding. It helps to determine the conduction period with respect to rotor position.

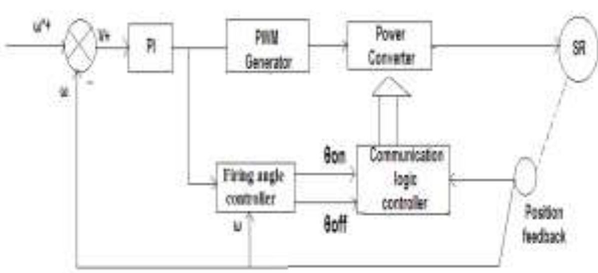

Fig: 6 Block diagram of current controlled Switched Reluctance drive

Table: 1. Torque-Speed Analysis of SRM

SlNo	Speed in RPM	Torque in Nm
1	0	0.6
2	800	0.6
3	1200	0.4
4	2000	0.25
5	4000	0.1
6	6000	0.05

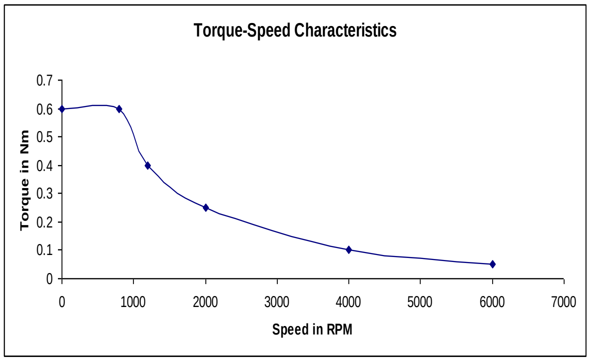

Fig: 8. Torque-Speed Characteristics of SRM.

Table: 2 Rotor Position-Phase current Analysis of SRM

SlNo	Rotor position in θ	Phase current in Amp
1	0	0
2	5	0.6
3	10	1.2
4	15	1.4
5	20	1.6
6	25	1
7	30	0
8	35	0.6
9	40	1.2
10	45	1.4
11	50	1.6
12	60	0

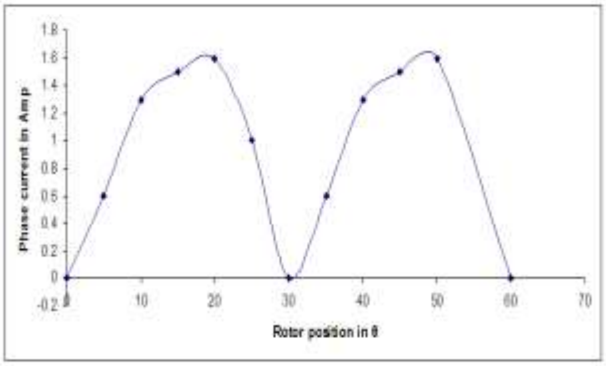

Fig: 7. Rotor Position-Phase current Analysis of SRM.

VI. Results

The speed of SRM for various turn-on and turn-off are tested by controlling the voltage. The experimental results are obtained and tabulated. From the proposed method the rotor position verses phase current and different torque verses speed are shown in fig 7, and 8. The results are tabulated in table 1 and 2.

VII. Conclusion

For the first time a new proposed converter is presented for energy efficient operation of Switched reluctance motor (SRM). This proposed work is validated with experimental work. The proposed new scheme can be easily applied to SRM for determining the rotor position by signals of stator current and flux linkages with respect to voltage across winding. Hence the efficiency of the switched reluctance motor is improved with low cost.

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