Analysis of Regulated PV Fed Switched Reluctance Motor Drives Using Repression Resistor Converter

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Abstract - The performance of the four phases SRM is investigated especially driven by standalone PV fed module with Repression Resistor converter. Inorder to perform the good working condition of motor, the basic behavior of SRM should be researched. Because of abundant solar energy sources the application is introduced in high speed drives such as SRM in this paper. The results also compared with SRM driven by DC source offers superior performance in simulation analysis.

Keyword - Battery, Charger, RR Converter, PV, SRM.

I. INTRODUCTION

High performance but abundant energy source is required in many of industries and crafts on requiring high speed control. One obvious thing for abundant energy is sustainable solar energy sources which associated with high speed drive as switched reluctance motor drives.

This paper is organized as follows, the solar photovoltaic cells are module according to the mathematical design of the standalone connections to drives, and known as solar generator is designed in section-II. In section-III, for storing energy from PV generator, charging technology is done through batteries and the model can be reviewed using truth table. In section IV, the four phase switched reluctance motor which can be driven by using the RR converters is implemented. The comparison and results are illustrated in section V. Finally the conclusion and effectiveness of this paper is discussed in section VI.

Like other electrical machines, SRM is an energy converter which can store energy in the magnetic field created by four phase windings and is exchanged between the electrical and mechanical subsystems. Inorder to drive the motor, RR converter is introduced.

II. SOLAR PV GENERATOR

PV modules used in PV system for generating electricity. PV modules are available in range of power ratings that vary from small 2 Wp modules to up to 300Wp modules [5]. But in this experimental analysis based on SRM ratings the power rating of PV modules is designed. Basic rating P=80 W and OCV = 22 V and SCI = 4.7A is introduced i.e. 36 cells totally 9 x 4 rows.

A. *Parameters of solar module*

The current voltage relationship of PV module can be given by the following equation:

$$I = I_L - [\, I_0\, e^{q(V+ I R_s)/nkT} - 1] \tag{1}$$

V_{oc} depends on short circuit current ($I_{sc} = I_L$) and saturation current (I_0).Where I_L is current generated due to light, R_s is series resistance of PV modules, n is ideality factor, I_o is reverse saturation current, T is temperature and k is the Boltzmann constant, q is the charge of the electron.

B. *Short Circuit Current*

Short circuit current I_{sc} is the maximum current produced by a solar PV module when its terminals are shorted.

$$I_{sc} = I_L \tag{2}$$

C. *Open circuit voltage*

Open circuit voltage V_{OC} is the maximum voltage that can be obtained from a solar PV Module when its terminals are left open.

$$V_{oc} = kT/q\ (\ln [(I_L/I_0) +1) \tag{3}$$

D. Maximum Power

This is defined as the maximum power P_m output of a PV module under standard test condition STC, which corresponds to 1000 W/m^2 and 25^o C cell temperature in PV module. Under the STC the power output of PV Module is maximum, therefore it is also referred as peak power or watt (peak) or W_p which is the product of V_m and I_m.

$$P_m = V_m \times I_m \qquad (4)$$

E. Fill factor

The fill factor is defined as the squareness of the I-V curve and mainly related to the resistive loss in solar module. It can be defined as the ratio of actual maximum power output to the ideal maximum power output. In ideal case, its value can be 100% corresponding to square I-V curve. But it is not feasible to have square I-V. There are always some losses which reduces the value of FF. the best value of FF that can be obtained for a solar module can empirically be written as a function of $V_{oc.}$

$$[V_{oc} - \ln(V_{oc} + 0.72)] / (V_{oc} + 1) \qquad (5)$$

Based on the above parameters, the solar cell is mathematically modeled using MATLAB/Simulink.

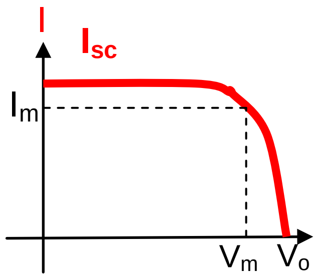

Fig. 1. VI Curve of Solar PV Module

F. Designing of Solar Module

Standard Single Solar Cell Rating available in market based on short circuit current and open circuit voltage is given in table I.

TABLE I
Solar Cell Rating

Cell Rating	
Im	= 3 A
Vm	= 0.5 V
Pm	= 2.5 W

The Solar PV modules are arranged in series and parallel combination to drive the SRM. In this study 36 single solar cells are arranged in series pattern to attain open circuit voltage of 18 V single solar module and corresponding short circuit current of 5 A. The 14 such modules are arranged in series and parallel to obtain OCV of 252 V.

III. BATTERY AND CHARGER

The battery is used when non shine hour or night time operation of the load is required. Batteries in PV System contribute the recurring cost as the life of the batteries is significantly shorter than the life of the PV cell [3]. Overcharging and over-discharging reduces the life of the battery and increasing the operative cost of PV system. Therefore, together with batteries, a proper control circuit is required which is known as charge controller [1].

The truth table evaluated for set points of the battery and controlling the charger using switch S2.The switch SW1 is modeled to OFF state for any value of the battery voltage above VR value (100% Charged). Similarly the switch SW2 is designed to OFF state once the battery voltage drops and reaches LVD (20% charge left) [4]. The truth table for charge control states for both the switches is given in Table II and Table III. The value one represents closed switch and zero represents open switch [2]

TABLE II
Set points of battery voltage used for charge controllers

S.No	Parameter	Threshold Value
1	Voltage Regulation limit [VR]	247
2	Low voltage Hysteresis [VRH]	235
3	Low Voltage Disconnect [LVD]	220
4	LVD Hysteresis [LVDH]	230

Table III
Truth table used for controlling SW2

S.No	Battery Voltage	<=LVD	>=VRH	Previous state SW2	Present state SW2
1	Between VRH and	0	0	0	0
		0	0	1	1
2	Greater than or equal to	0	1	0	1
		0	1	1	1
3	Less than or equal to	1	0	0	0
		1	0	1	0
4	None	1	1	0	0
		1	1	1	0

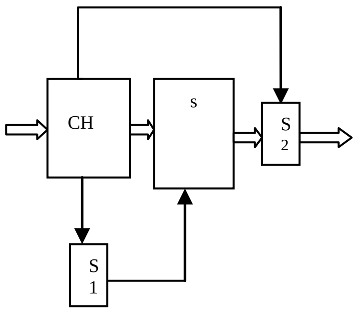

Fig.2.Block diagram of Charger- battery

IV. CONVERTER AND SRM

The 8/6 SRM with RR Converter is regulated to PV system using MATLAB/Simulink library components in this proposed research is shown in fig.4.

The Repression Resistor converter shown in fig.3 is one of the most economical of SRM converters suitable for low-cost, low performance applications. This converter requires only one switch and one diode per phase and the stored energy is dumped into the resistor R during free wheeling. The circuit is nevertheless used because of the reduction is no of switches and simplicity of control in low- performance applications [6].

In RRC, when the switch Q is turned off, the current flows through the dump resistor R and free wheeling diode. Some electrical energy stored in the coil is converter to mechanical energy and remaining energy is drained through coil resistance and dump resistor R. The drained energy depends on the dump resistor value R. Hence the effect of R is proportional to the torque production and the efficiency of motor.Hence production of torque is higher compared to other converters.

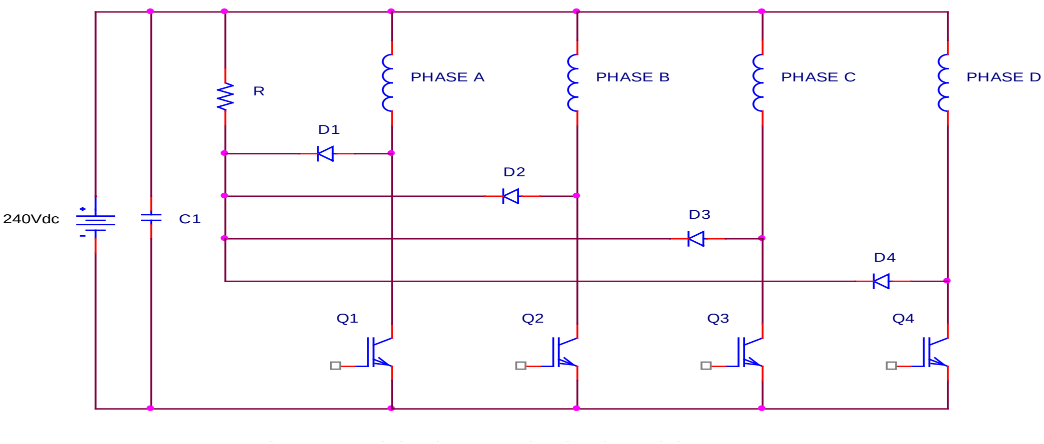

Fig 3. Repression Resistor Converter

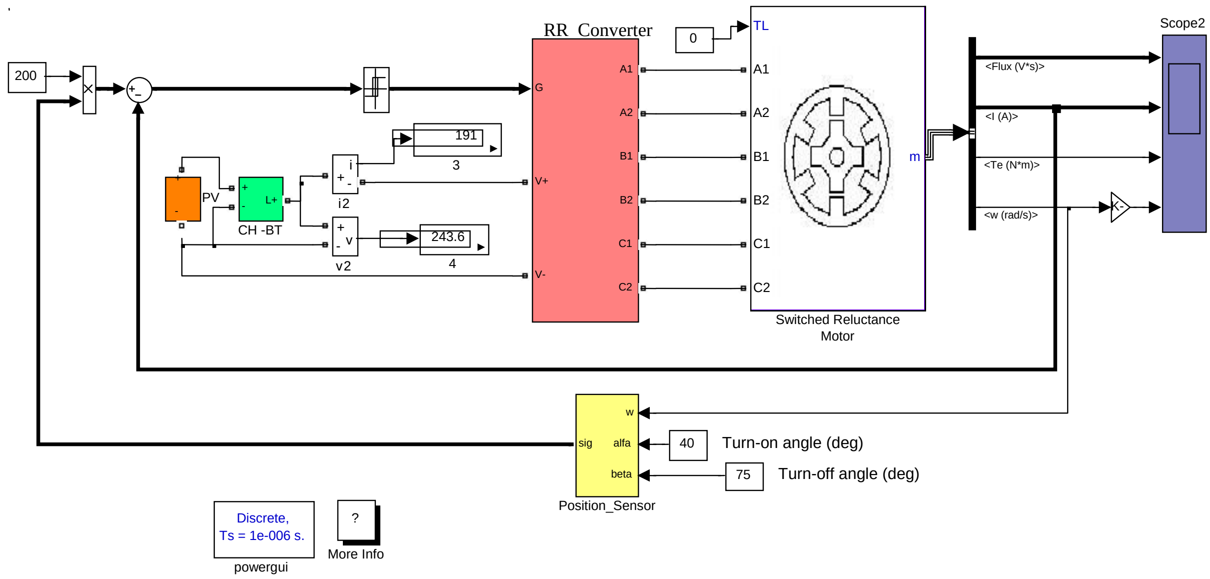

Fig.4. MATLAB/SIMULINK Block diagram model for Regulated SRM drive

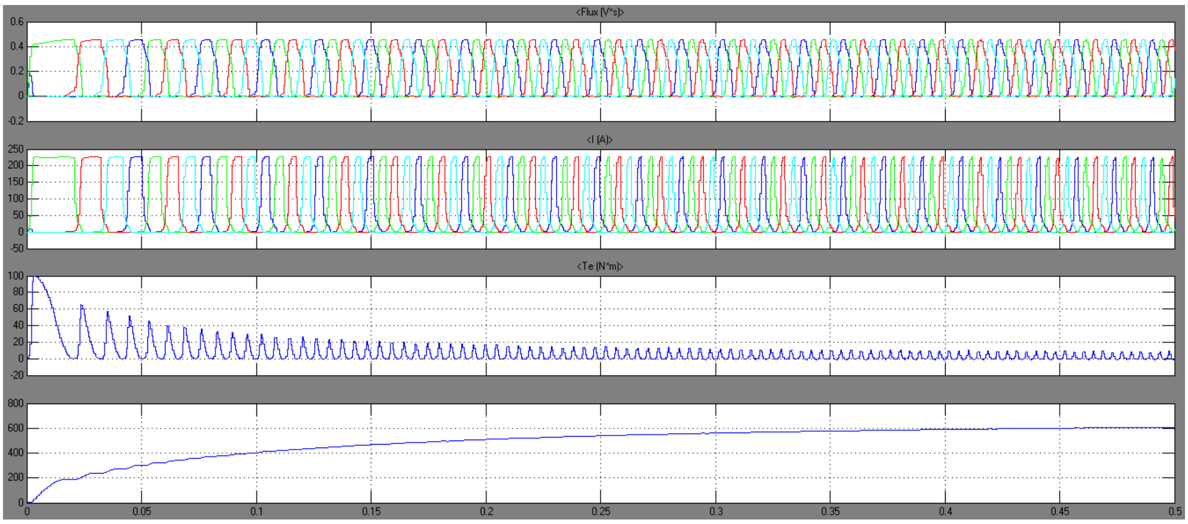

Fig.5.Simulation Results for SRM driven by DC link Voltage of 240 V

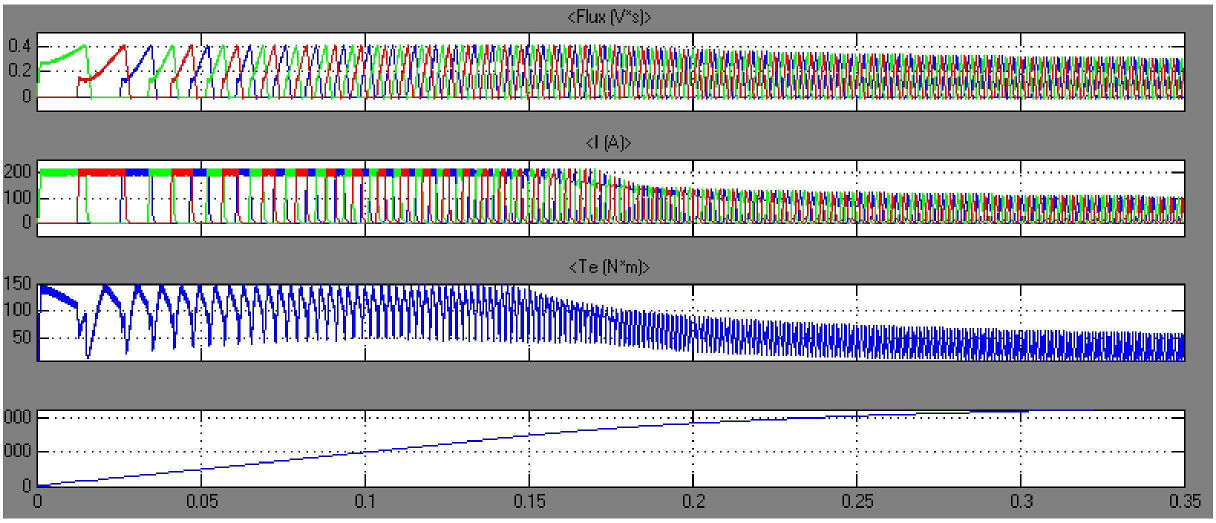

Fig.6.Simulation Results for SRM driven by Regulated PV System

V. VERIFICATION

To verify the results for stand alone regulated PV associated SRM drive obtained using simulation is done by comparing results with SRM driven by available DC Source. Comparing these two results using fig.5 and 6, the standalone SRM is most economical. Also torque maintains constant which regulates the speed. Hence this type may be used for high speed applications where the abundance of solar source practically.

VI. CONCLUSIONS

In this paper, a brief analysis of Regulated PV fed SRM drive using Repression Resistor converter configuration is made. The comparison is based on the performance of 8/6 pole SRM with a DC link voltage of 240 V. It is found that the energy stored in dump resistor is proportional to the torque production and increase in performance of the motor [7] and [8]. The Photo voltaic module connected to 4 phase SRM is regulated by RRC through battery and Charge controllers and position sensors. The usefulness of the model has been established by applying it to various conditions and applications.

VII. APPENDIX

A. *SRM Specifications*

4 Phase, 8/6 pole, 240 V

Stator Resistance R_s = 0.05 ohm

Moment of Inertia J = 0.05 kg-m^2

B. *PV Cell Ratings*

14 PV modules are arranged in series and parallel combinations to get 242 V.

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