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Investigation of Standalone PV Fed Switched Reluctance Motor Drives Using C Dump Converter

Dr. S. Sujitha
Department of EEE, New Horizon College of Engineering,
Bengaluru, Karnataka, India.
E-mail: prof.sujitha@gmail.com

Abstract

The execution of the four phases SRM is researched particularly determined by independent PV sustained module with C Dump Converters. In order to play out the great working state of engine, the fundamental conduct of SRM ought to be looked into. Due to rich sun oriented vitality sources the application is presented in rapid drives, for example, SRM in this paper. The outcomes additionally contrasted and SRM driven by DC source offers predominant execution in reproduction examination.

Keywords*:* Battery, Charger, C Dump Converter, PV, SRM.

1. INTRODUCTION

Elite however bounteous energy source is required in a hefty portion of businesses and artworks on requiring fast control. One clear thing for bottomless energy is maintainable solar based energy sources which related with high speed drive as switched reluctance motor drives.

This paper is sorted out as takes after, the sun powered photovoltaic cells are module as per the scientific outline of the independent associations with drives, and known as sunlight based generator is planned in segment 2. In segment 3, for putting away vitality from PV generator, charging innovation is done through batteries and the model can be audited utilizing truth table. In segment 4, the four stage switched reluctance motor which can be driven by utilizing the C Dump converters is actualized. The correlation and results are shown in segment 5. At long last the conclusion and practicality of this paper is talked about in area 6.

Like other electrical machines, SRM is a vitality converter which can put away vitality in the attractive field made by four phase windings and is traded between the electrical and mechanical subsystems. In order to drive the motor, C Dump converter is presented.

2. LITERATURE SURVEY

The C-dump converter topology for switched reluctance motor drives that is able to act as an active power factor controller. According to the features of the proposed circuit a conventional PFC stage is unnecessary to comply with the European standards on power quality, thus reducing the cost and the complexity of SR motor drives aimed to equip home appliances, a very cost-sensitive market field. [10].

Proposed energy efficient converter topologies in conventional C – Dump converter is to overcome the limitations of the conventional C-Dump converter resulting in improved performance, lower cost and simpler control. [11]

3. 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 upto 300Wp modules [5]. But in this experimental analysis based on SRM ratings the power rating of PV modules is designed. Basic rating (ie) P=80 W and OCV = 22 V and SCI = 4.7A is introduced i.e. 36 cells totally 9 x 4 rows.

3.1 Parameters of solar module

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

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

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. [1]

3.1.1 Short Circuit Current

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

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

3.1.2 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

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

3.1.3 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.

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

3.1.4 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}

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

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

3.2 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 1.

Table 1. 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.

4. 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].

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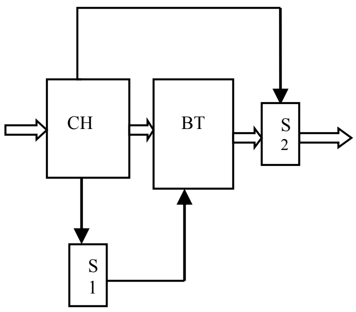

Fig.1. Block diagram of Charger- battery

5. CONVERTER AND SRM

The 8/6 SRM with C Dump Converter is regulated to PV system using MATLAB /Simulink library components in this proposed research is shown in fig.2.

The C-dump converter is shown in *Fig.2* with an energy recovery circuit. The stored magnetic energy is partially diverted to the capacitor Cd and recovered from it by the single quadrant chopper comprising of Z_{13}, Lr, and Dr and sent to the dc source. Assume that T1 is turned on to energize phase A and when the A-phase current exceeds the reference,T1 is turned off.

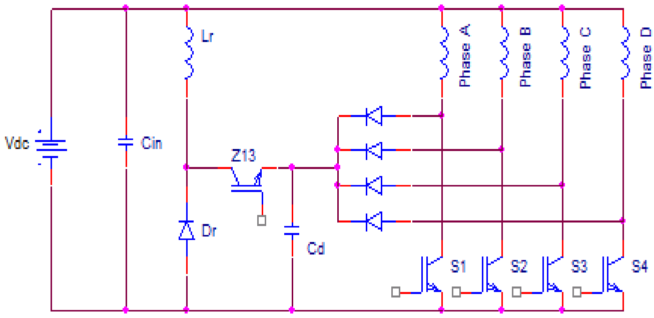

Fig. 2 Circuit of four-phase C Dump Converter

This enables the diode D1 to be forward biased, and the current path is closed through Cd which increases the voltage across it. This has the effect of reducing the A-phase current, and, when the current falls below the reference by Δi (i.e., current window), T1 is turned on to maintain the current close to its reference. When current has to be turned off completely in phase A, T1 is turned off, and partially stored magnetic energy in phase A is transferred to energy dump capacitor, Cd . The remaining magnetic energy in the machine phase has been converted to mechanical energy. [12]

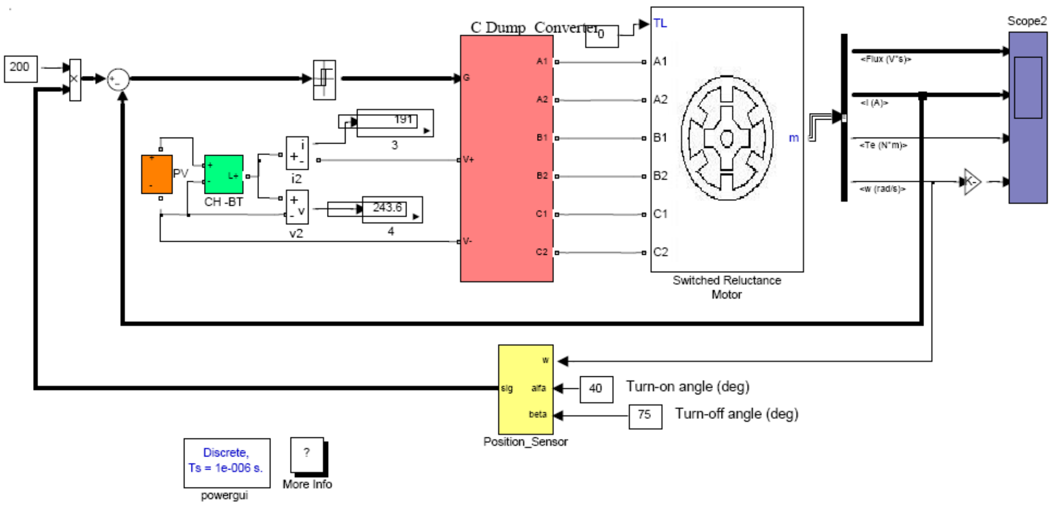

Fig.3. MATLAB/SIMULINK Block diagram model for Regulated SRM drive

This converter has the advantage of minimum switches allowing independent phase current control. The main disadvantage of this circuit is that the current commutation is limited by the difference between voltage across Cd, Voltage across each phase vo, and the dc link voltage. Speedy commutation of currents requires larger vo, which results in increasing the voltage rating of the power devices. Further, the energy circulating between Cd and the dc link results in additional losses in the machine, Z_{13}, Lr, and Dr, thereby decreasing the efficiency of the motor drive.

The energy recovery circuit is activated only when T1, T2, T3, or T4 switches are conducting to avoid freewheeling of the phase currents. The control pulses to Z_{13}, end with the turn-off of the phase switches. The control pulse is generated based on the reference and actual value of E with a window of hysteresis to minimize the switching of Z_{13}. This circuit has gained in popularity since its introduction in the early stages of SRM drive research and development; therefore, an analysis of this circuit is presented here. Analysis in the following sections considers computation of switching losses of the power devices, maximum voltage, and current ratings of the power devices for an SRM drive of known power rating; ratings of the energy recovery capacitor, Cd, inductor Lr, and its duty cycle; and the efficiency of the overall circuit. [11].

The advantages of C-Dump converter are summarized as follows

- Requirement of minimum number of switches.
- Independent phase current control is possible in C-Dump converter.

The disadvantages of C-Dump converter are summarized as follows

- Current commutation is limited by the difference between the voltage across Cd and the link.
- C-Dump converter is not suitable for high speeds.
- Efficiency of the C-Dump converter is lower.
- C-Dump converter is unable to provide zero voltage.

The application of the C-Dump converter is in the low speed applications.

6. SIMULATION RESULTS

The switches and diode used per phase in C-Dump converter are described here. The number of switches used per phase in C-Dump converter is one. The number of diodes used per phase in C-Dump converter is one.

Table 2. Specifications for C Dump Converter

Switches and Components	Symbol	C Dump Converter
IGBT	R	1.00E-03
	Vf	1
	Rs	200
	Cs	1.00E-07
Diode	R	1
	Vf	0.8
	Rs	1000
	Cs	Inf
Passive Components	Lr	1.00E-05
	Cd	2.50E-04
	Rd	-
	C	-
	R*2	-

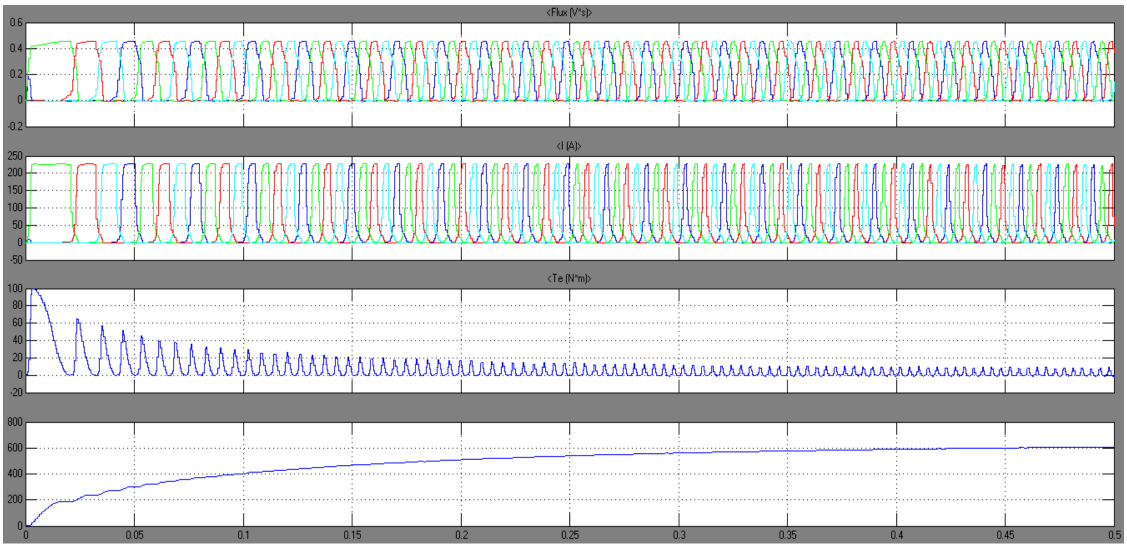

Fig.4. Simulation Results for SRM driven by DC link Voltage of 240 V

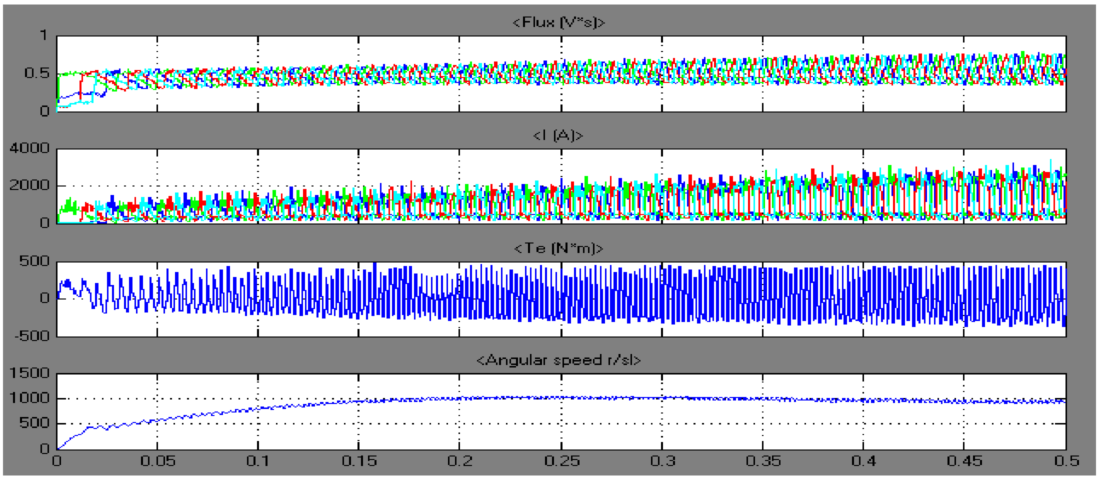

Fig.5. Simulation Results for SRM driven by Regulated PV System

The Table 3 for the corresponding simulation results for C Dump converter indicates that the motor attains a speed of 1020 radians per second at the simulation time of 0.35 seconds, corresponding torque, speed and phase current are also discussed.

Table 3: Performance analysis for C Dump Converter

Voltage (V)	Flux (wb)	Current (mA)	Toque (Nm)	Angular Speed (rad/sec)	Speed (RPM)
242	0.712	2370	61	1020	4093

7. 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. 4 and 5 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.

To confirm the outcomes for standalone controlled PV related SRM drive acquired using MATLAB Simulation is finished by contrasting outcomes and SRM driven by accessible DC Source. Looking at these two outcomes using fig. 4 and 5 the independent SRM is generally sparing. Additionally torque keeps up steady which controls the speed. Consequently this sort might be utilized for rapid applications where the wealth of sun oriented source for all intents and purposes

8. CONCLUSIONS

In this paper, a brief analysis of Regulated PV fed SRM drive using C Dump 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 contollers and position sensors. The usefulness of the model has been established by applying it to various conditions and applications.

9. APPENDIX

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

PV Cell:

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

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