OPERATIONAL ANALYSIS OF A SWITCHED RELUCTANCE MOTOR FED BY PV SYSTEM

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Abstract - This paper is focused on analyzing an actual system that consist of a switched reluctance motor (SRM) and photovoltaic (PV) generation to determine operational characteristics under different conditions. According to this aim, a system that includes such structures is constructed physically. System is operated and observed for various loading and weather conditions. As the proposed system is aimed to be used in agricultural applications, results are discussed by using graphs that obtained from various points, especially in terms of this approach.

Indexterms - SRM, Photovoltaic system, Renewable energy sources, Power system analysis.

I. INTRODUCTION

Energy demand increases in acceleration, approximately 4 to 8 percent by year, as the conventional energy sources cannot meet this demand. It is vital to integrate renewable energy sources to main grid for supplying quality and continuous energy tocustomers. One of the major loads in power systems are motor loads. As it is known that motor parameters are directly affect from supply parameters like voltage and current, in this study, a switched reluctance motor (SRM) that supplied by a photovoltaic (PV) system is analyzed during various operating conditions. It is aimed to obtain operational data to determine the motor efficiency while supplied by a renewable energy source. This allows researchers to test the motor in limited supply capacity conditions. There are several studies in literature on PV applications, which include design [1-3] and analysis [4-6] of such systems.It necessary to analyze the PV modules for energy output characteristics because of the mismatch losses and shading losses of such structures.PV system studies are divided into two in general as grid connected [7-10] and islanded or standalone [11-13] modes of operation. Also researchers are focused on the various types of motors as loads for PV systems. These papers are classified as induction motor [14-17] and DC motor [18-21] supplement. In this research, SRM is chosen to use its advantages as given in following sections. The paper is designed as following; in section II PV system that is used for study is described, in section III details of SRM is given, in section IV system design is proposedand in section V whole system is analyzed for different scenarios.

II. PV SYSTEM

In this study, a PV system that is physically installed at BitlisEren University Rahva Campus is used as energy source. Properties of this structure is given in Table I.

Table 1: PV System Properties

Component	Properties	Piece
PV Panel	150 W	6
Full Sine Inverter (24/220V)	3000 VA	1
Battery	12V/190 Ah	4

These components are used to design the whole system; PV panel installation is given Figure 1, where other components are shown in Figure 2.



Figure 1: PV Panel Installation

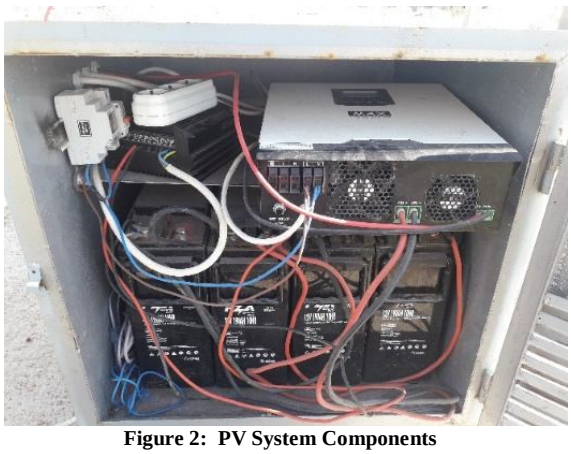

Figure 2: PV System Components

III. SWITCHED RELUCTANCE MOTOR

The Switched Reluctance Motor (SRM), which has been considered as an alternative to conventional electric machines because of improvements in motor drive technology over the last forty years, is cheaper and simpler than the same powerful conventional machines.Because of such advantages, switched reluctance motors are being widely used in industrial and agricultural applications [22-26]. General structure of a 6/4 switched reluctance motor is given in Figure 3.

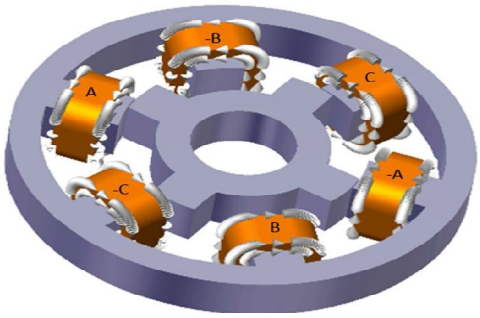

Figure3. Structure of the 6/4 pole SRM [27-28]

Switched reluctance motors are defined by ratio of their stator poles to rotor poles. The torque $T_e$that can obtained from the motor is given:

$$T_e = \frac{1}{2} i^2 \frac{dL(\theta, i)}{d\theta} \qquad (1)$$

where i is the current in amperes and θ is rotor angle [28].

The SRM used in this study is given in Figure 4. This motor includes an intelligent control unit, which is given in Figure 5.



Figure 4: Switched Reluctance Motor



Figure 5: Control Unit

General properties of the used SRM is summarized in Table II.

Table 2: SRM Properties

Variable	Value
Phase	1 ϕ
Nominal Voltage	220 V
Max. Power at Nom. Voltage	1500 W
Rot. Speed	50 to 5000 rpm

As mentioned before, SRM is controlling by an intelligent controller. This controller has capabilities of fast speed regulation, external programming and pre-saving various operating characteristics in its memory. In addition, loading conditions and other motor data can be observed from its screen.

IV. SYSTEM DESIGN

Components that given in sections II and III are used to design the study system. Physically installed system is give in Figure 6.



Figure 6: Study System

As the connection is established, analyzes are performed. Results and system data is collected by using Fluke 435 power and energy analyzer. Results are discussed in detail in section V by using the obtained graphs.

V. OPERATIONAL ANALYSIS AND EXPERIMENTAL RESULTS

As the purpose of the study, the system that designed by using PV system and SRM is analyzed for various operating conditions. These analyzes are performed in two cases.

A. Case 1 – SRM Fed from PV System with Storage Unit

In this case, SRM is fed from battery-connected system and analysis is performed Motor is loaded with 25 % to obtain the operating behavior for limited

capacity supply and effects of motor on battery life. In Figure 7, motor speed graph is given, where Figure 8 shows the battery capacity.

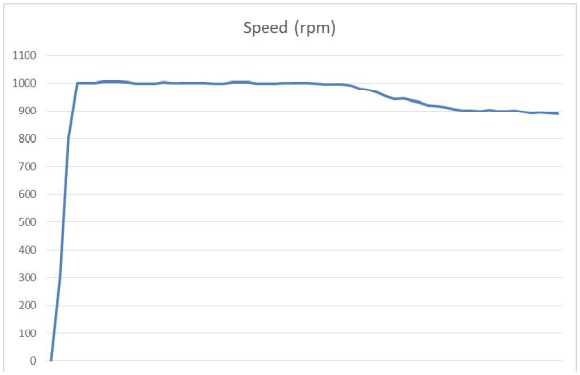

Figure 7: Motor Speed Graph for Case 1

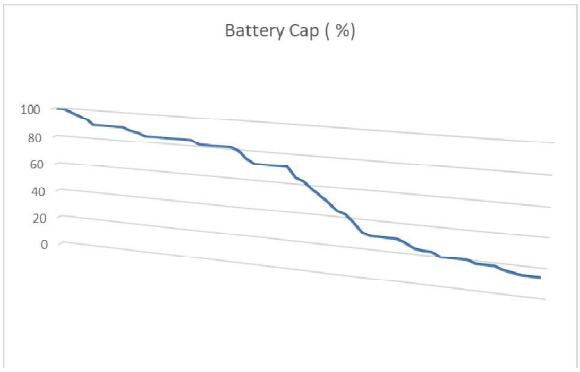

Figure 8: Battery Capacity Change

It is clear from Figures 7 and 8, motor speed starts to reduce dramatically when battery capacity reduces to near 65 %, where there is no extreme change before this level.

B. Case 2 – SRM Fed from PV Panels Directly

As there is no storage unit support in this case, two analyzes are performed. First motor is loaded with 25 % to observe the behavior during maximum irradiance. Motor speed is given in Figure 9 for such operation.

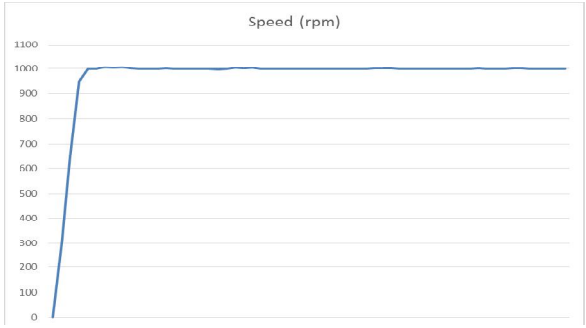

Figure 9: Motor Speed Graph for Max. Irradiance

Motor speed keeps its stability during maximum irradiance as shown in Figure 9.

For the same loading conditions, motor behavior is observed in case of partially shading of PV panels. Speed graph is shown in Figure 10 for this transient condition.

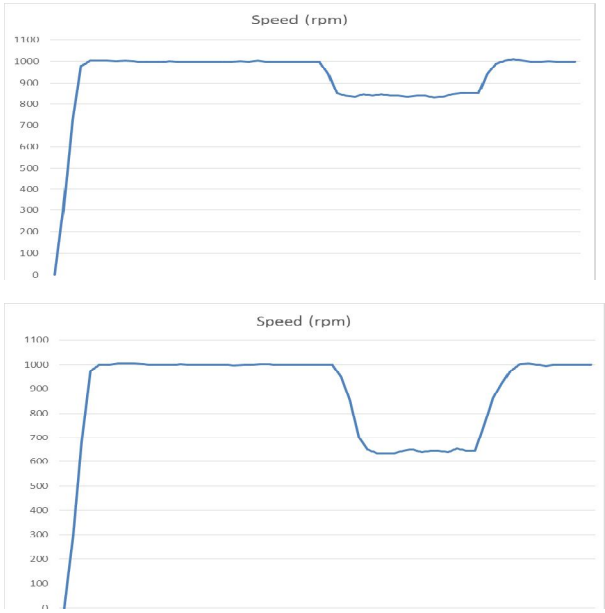

Figure 10: Motor Speed Graph for Partially Shading a) with control unit b) without control unit

As the system includes an intelligent motor controller, it is clear from figure 10 that an appropriate controlling unit can regulate motor speed in case of transients.

CONCLUSION

In this study, a SRM is analyzed for different operating conditions to obtain the behaviors in case of limited supplement capacity. These behaviors are vital for agricultural applications and especially to use SRM in PV supplied electric cars. For such aim, system is analyzed for both battery supplied and direct fed modes of operation. Results are discussed by using system graphs. It is clear that SRM is appropriate in using non-storage unit systems that have limited capacity of energy with an appropriate controlling unit. It should be noted that all meteorological effects are applied to experimental system and these affect results directly. Authors are continuing to determine data for various conditions.

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