Solar Power Based PMSM Drive Employed Refrigeration Plants For Isolated Areas

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Abstract- *For heating and cooling purposes, significant portion of generated energy around the globe are consumed. As the reasonable high time constant of heating and cooling systems, the application of renewable energy sources (solar and wind) to cater such load demands are establishing as a better alternative solution. In power generation and its control these solar-PV systems are highly intermittent, offers extensive challenges for optimum energy extraction. There are several techniques reported in literature for MPPT (Maximum Power Point Tracking) in solar-PV systems integrated have also been reported in complying with power quality standards.*

Keywords- MPPT (Maximum Power Point Tracking) solar PV systems, renewable energy sources.

I. INTRODUCTION

In between solar-PV panel and a DC bus of VSI (Voltage Source Inverter), the boost converter based two stage power conversion is the most popular topology used. Due to increased switching losses at high frequency, the hard switching reduces the conversion efficiency of boost converter. With low switching losses and high efficiency, in high gain boost converter was proposed.

To achieve high switching frequency with low switching losses, to improve power density and efficiency, the soft-switching techniques are emerging solutions for converters. To minimize switching losses, voltage current stresses, these techniques employ ZVS (Zero Voltage Switching) or ZCS (Zero-Current Switching) on power semiconductor switches. Quassi parallel resonant DC link based PWM inverters have been presented in and it was further improved with more flexible PWM (Pulse Width Modulated) capability and easy in control in .A soft switched PWM inverter employing snubber for each switch to achieve ZCS and ZVS operation this reported by H.

The DTC(Direct Torque Control) and the FOC (Field Oriented Control) have been investigated mostly for power converters switching to reduce torque pulsation and to minimize harmonics injection in the SPMSM in modern high-performance AC drives in controlling the flux and motor torque in spite of the change in load torque and machine parameter variation, these control strategies are effective. To accurately track the reference value of torque and speed they force the motor. For industrial AC drives application, the FOC is an established control.

II. PMSM DRIVE EMPLOYED REFRIGERATION PLANT

The acceptable solar photovoltaic (PV) applications may be a water pumping system. the only solar PV pumping system consists of PV array, DC-DC converter, DC motor, and pump . during this paper, water pumping system sizing for Libya is evaluated supported a daily demand using HOMER software, and dynamic modeling of a solar PV water pumping system employing a static magnet DC (PMDC) motor is presented in Matlab/Simulink environment.

The system performance with maximum point tracking (MPPT)supported Fractional circuit Voltage (FOCV) is evaluated with and without A battery storage system. In some applications, a rated voltage is required to attach a PMDC motor to a PV array through a DC-DC converter and in other applications the input voltage can vary.

The evaluation of the system is predicated on the performance during a change in solar irradiation. Using Matlab/Simulink, simulation results are assessed to ascertain the efficiency of the system when it's operating at a selected speed or at the MPPT. The results show that an improvement within the system efficiency are often achieved when the PMDC motor is running at a selected speed instead of at the height PV point.

III. SOLAR POWER

Standard Solar, Inc. recently completed one among the primary solar microgrid systems with a grid interactive battery bank within the country. Being a primary was a challenge–it took months of dedication, innovative engineering and coordination with key partners, utilities and government offices to form this project a reality. the primary half this paper will set the stage by explaining how the microgrid is setup, its functionality and what makes it special. Then i will be able to explore what it takes to style and install a solar microgrid system, the teachings learned from this groundbreaking projectand what technical considerations should be made when implementing this new technology.

The PV system will still produce electricity as long as there's sufficient sunlight to get and sufficient load or battery capacity to soak up it. The energy storage system acts as a buffer between the PV and therefore the load in order that the user doesn't notice any fluctuation in power as a results of unstable sky conditions. The duration that the energy supply will last is difficult to predict because it's a function of the quantity of sunlight available, the demand of the chosen back-up loads and therefore the state of charge of the battery system at the instant of isolation from the grid.

A. MPPT ALGORITHM

Maximum point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar battery to stay the PV system operating at, or on the brink of , the height point of the PV panel under varying conditions, like changing solar irradiance, temperature, and load. Engineers developing solar inverters implement MPPT algorithms to maximise the facility generated by PV systems.

The algorithms control the voltage to make sure that the system operates at "maximum power point" (or peak voltage) on the facility voltage curve, as shown below. MPPT algorithms are typically utilized in the controller designs for PV systems. The algorithms account for factors like variable irradiance (sunlight) and temperature to make sure that the PV system generates maximum power.

B.QUASI-BOOST CONVERTER

A Boost converter may be a switch mode DC to DC converter during which the output voltage is bigger than the input voltage. it's also called as intensify converter.

The name intensify converter comes from the very fact that analogous to intensify transformer the input voltage is stepped up to A level greater than the input voltage. By law of conservation of energy the input power has got to be adequate to output power (assuming no losses within the circuit).

Input power (Pin) = output power (Pout)________(1)

Since Vin <Vout____________________(2)

during a boost converter, it follows then that the output current is a smaller amount than the input current. Therefore in boost converter.

Vin<Vout and Iin>Iou_________________(3)

III. PWM SWITCHING

PWM control (Pulse Width Modulation) PWM represents the most commonly employed voltage control method. In this method, at fixed cycles the amount of power corresponding to the power that needs to be output is switched on to extract it from the input. Consequently, the ratio between on and off, the duty cycle, changes as a function of the required output electric power.Fig.3.1. shows the frequency is constant, and output voltage is adjusted with duty cycleAn advantage of PWM control is that because the frequency is fixed, any switching noise that arises can be predicted, thus facilitating the filtering process. A drawback of the method is that also due to constant frequency, the number of switching operations remains the same whether the load is high or low, and consequently, the self-consuming current does not change. As a result, at times of light loads the switching loss becomes predominant, which reduces the efficiency significantly.

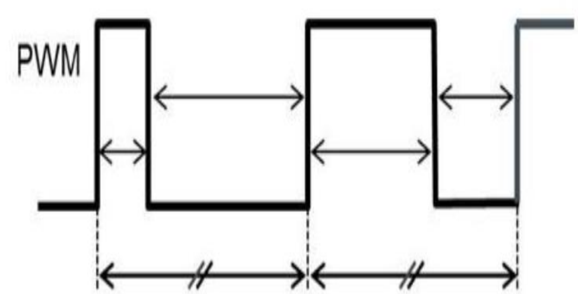


Fig. 3.1 The frequency is constant, and output voltage is adjusted with duty cycle

- **Three-phase inverter**

Three phase bridge inverters can be viewed as extensions of the single-phase bridge circuit. The switching signals for each inverter leg are displaced by 120 degree with respect to the adjacent legs. The output line- line voltages are determined by the potential differences between the output terminals of each leg.

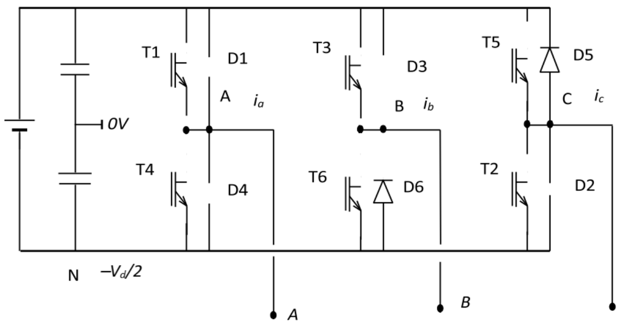


Fig. 3.2 Three- phase inverter

Symmetrical three phase voltages across a three-phase load can be produced by switching the devices ON for either 180 degree or 120 degree of the output voltage waveform. With 180 degree conduction, the switching sequence is T1T2T3 – T2T3T4 – T3T4T5 –T4T5T6 – T5T6T1 – T6T1T2 – T1T2T3 -……. .for the positive A-B-C phase sequence and the other way round for the negative (A-C-B) phase sequence. With 120 degree conduction, the switching pattern is T1T2 – T2T3 – T3T4 – T4T5 – T5T6 – T6T1 – T1T2for the positive A- B-C sequence and the other way round for the negative (A-C-B) phase.

IV. SYSTEM TOPOLOGY AND WORKING PRINCIPLE

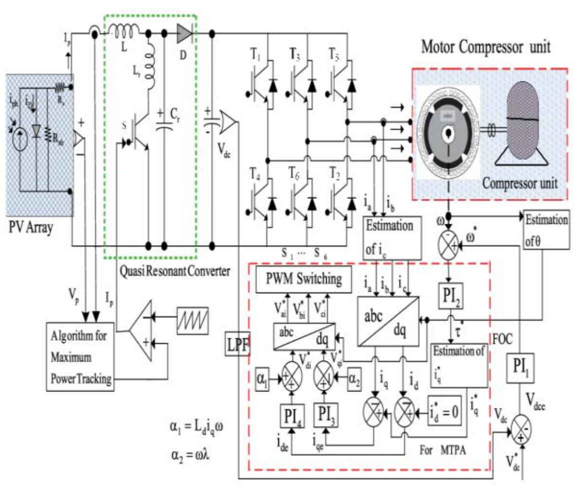


Fig.4.1 System configuration of Solar-PV power based SPMSM drive for refrigeration plants

The proposed system configuration of a solar PV fed SPMSM drive for refrigeration plant is shown in Fig.2.2.1.. The system is comprised with various segments. There is a PV array, a three phase VSI, an intermediate QRBC (Quasi Resonant Boost Converter), 8 pole SPMSM (Surface mounted Permanent magnet synchronous Motor) coupled with a vapor compressor unit for a refrigeration system. The PV array is made using a solar cell unit. The series and parallel configuration of solar cell assemble a larger unit called photo voltaic panel or array. Because of low energy conversion efficiency of solar PV, it is beneficial to use a highly efficient power conversion system to utilize the PV generated power at its maximum.

In the proposed system, PV array is connected to the QRBC to increase the output voltage level and reduce the switching losses. The boost converter is always operated in continuous conduction mode to reduce the stress on the passive components and semiconductor devices. Further, the intermediate converter feeds power to the VSI, supplying the SPMSM coupled with a compressor unit. The MTPA based field oriented control is used for the VSI to obtain fast-dynamic response of the SPMSM under change in solar irradiations. The DC bus voltage Vdc is kept constant using power balance concept on speed control of the PMSM.
The working principle of proposed system is based on extraction of maximum power from solar-PV system. The SPMSM speed is a function of power available at DC bus of VSI and it is controlled in such a manner that balances between input and output power must remain constant.

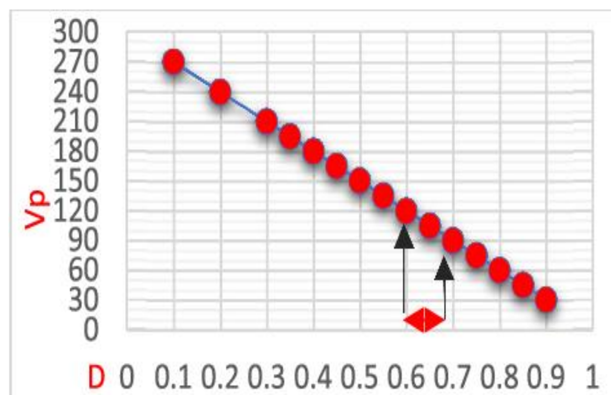


Fig. 3.2 PV voltage v/s duty cycle (D) with constant DC link voltage

Fig. 3.2 shows the variation of PV voltage and duty cycle under the constant output DC link voltage of VSI. It is clear that third term of Eq. (20) is positive only within typical range of duty cycle (0.6-0.7). Therefore, the system is stable under the range. It is also verified from the typical PV characteristics at fixed temperature (250C) as shown in Fig 3(a-b). At low irradiations (less than 100W/m2), the PV power is very less but there is not much fall in PV voltage. It is further observed that with increase in ambient temperature, the power generatio necreases rapidly and duty cycle increases towards maximum point to increasing boosting factor. At the same time, the speed of SPMSM decreases to balance the power generation with load demand. However due to large mechanical time constant of motor-drive system in comparison to solar-PV system, a temporary fall in DC link voltage of VSI occurs to help the system to achieve stable operating point.

V. CONTROL ALGORITHM

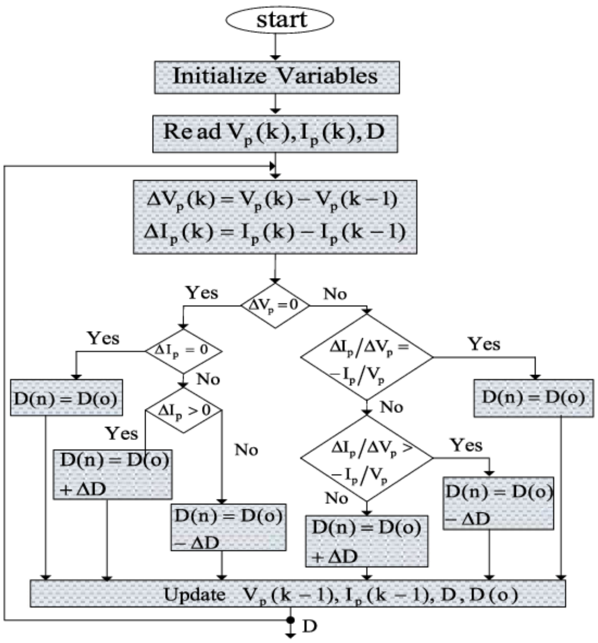


Fig. 5.1 MPPT Control Algorithm for solar-PV system

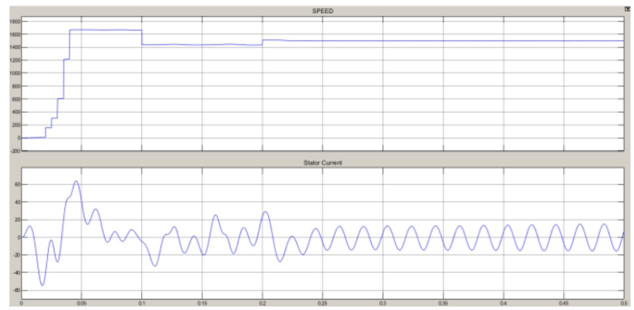
Fig.5.1 presents the comprehensive control approach used in this implementation. The control scheme is presented in two sections, i.e. control of PV fed ZCS quasi resonant converter to operate at PV panel at MPP and control of VSI using field oriented control with MTPA for good transient response under change in reference SPMSM speed due to change in solar irradiation.

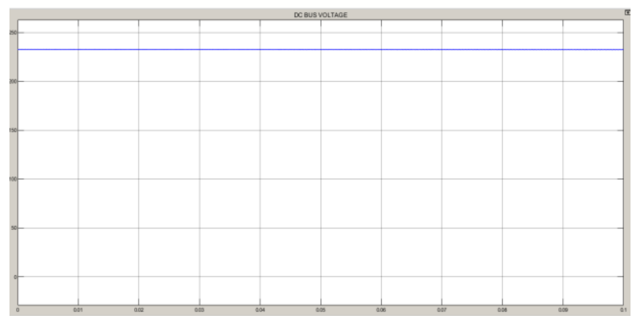
- **Control of QRBC**

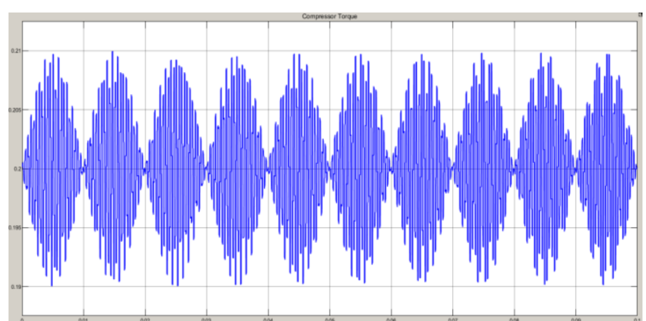
The incremental conductance based MPPT technique is used to track the optimum power from the PV array. This technique is most commonly used for PV systems because of good dynamic performance and less sensitive nature in presence of system noise [1]. The technique is based on the fact that the sum of the instantaneous conductance I/V and the incremental conductance ΔI/ΔV is zero at the MPP, negative on the right side of the MPP, and positive on the left side of the MPP. Selection of increment step-size is key feature for this method. Fast tracking can be achieved with bigger increments but the system might not operate exactly at the MPP and oscillate about it instead. The flowchart of MPPT control algorithm used in this implementation. The output signal is compared with saw-tooth wave of fixed frequency to generate the gating signal for IGBT of boost converter. Thus, the QRBC forces the PV output voltage to reach VMPP with reduced switching losses.

VI. RESULTS AND CONCLUSION

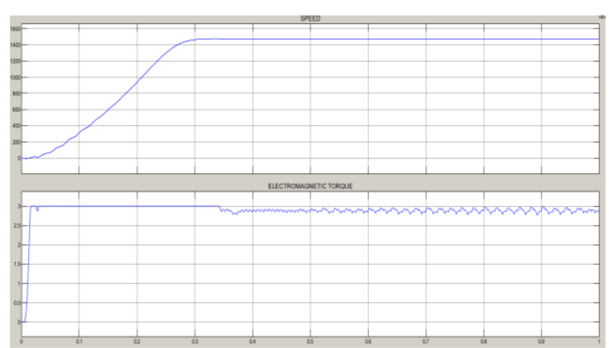
- **With Compressor**

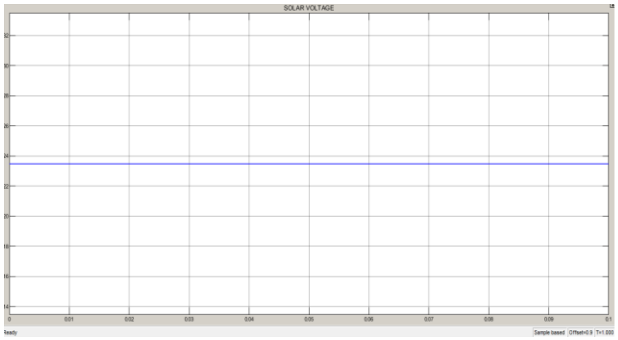


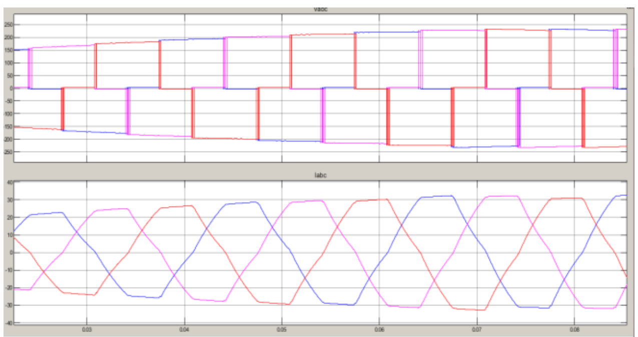




- **Without compressor**







VII. CONCLUSION

The proposed QRBC based SPMSM drive has been designed, modeled and implemented. A laboratory prototype of proposed system has been developed for the compressor load of a refrigeration system. The VSI has been controlled in field oriented control with MTPA operation to get fast transient response.

The proposed solar PV based cooling system is simple in structure, easy in control with short response time, reduces environment pollution and energy efficient.

It has been shown that developed system provides excellent control on SPMSM coupled with compressor loads under wide variation in solar irradiation. The performance of developed approach has been found satisfactory under various conditions.

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