Industry Day Theme # Clean Energy for Sustainable Economy and Environment

Solar PV Array Powered SRM Drive for Water Pumping with Both Grid And Battery Support

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Abstract:

This work deals with the development of an efficient and robust power management scheme for a grid supported photovoltaic (PV)/battery configuration for water pumping system (WPS) employing a Switched Reluctance Motor (SRM) Drive. Due to the substantial compatibility between natural characteristics of SRM drive and WPS, a four-phase switched reluctance motor (SRM) with fundamental switching, is utilized in the proposed scheme. A deviation free Maximum Power Point Tracking (MPPT) algorithm is used in the system to optimize the solar power under all environmental situations. The behavior of the developed system is examined through both simulated and experimental results and found adequate under all operational modes.

Introduction:

Solar powered water pumping systems have been increasingly popular in remote areas where ac grid is not accessible, or is too costly to lay down. An introducing battery energy storage in the system not only increases the overall cost and maintenance however, it also reduces its service life and saving credits. Hence, it is appreciative to use pump-storage, which stores solar energy as the potential energy in water reservoir to be consumed according to the demand.

Therefore, in order to incorporate the advantages of SRM drive in grid-connected PV/battery WPS and to handle the grid side disturbances including other limitations of previous work, this work proposes an efficient and reliable solution for WPS. A PV power dependent dynamic loop feed-forward loop is also unified in the designed controller, which contributes to improving the dynamic response of the overall system and sag/swell conditions present in the grid supply. An efficient control technique for bidirectional DC-DC converter is also developed for proposed WPS.

Conclusions:

A reliable and cost-effective grid supported PV/battery system is proposed for water pumping system employing a switched reluctance motor drive. The unique characteristics of SRM drive like fault tolerant capability, wide speed range, high-grade performance, and resilience to the harsh environment, make the proposed system highly rugged and efficient. The system exhibits seamless operation under all possible modes of operation. The fundamental switching of a mid-point converter helps to minimize the semiconductor as well as to eliminate the requirement of any current sensor on the drive side. The experimental responses are demonstrated for all possible mode of operations and for different operating conditions, like varying irradiance levels, grid abnormalities conditions, the mode change from a solar photovoltaic system running water pumping system to the grid powered water pump and vice versa, etc. The present scheme follows all the IEEE recommended standers for grid-tied solar/PV integrated system such as IEEE-519 and IEEE-1564 standards.

Industrial Significance:

The prototype of present system is developed and its effectives has been tested for real time implementation. The system is well suited for the critical places, where continuous water supply is needed. It is also become the source of earning for the consumer, when pumping is not required.

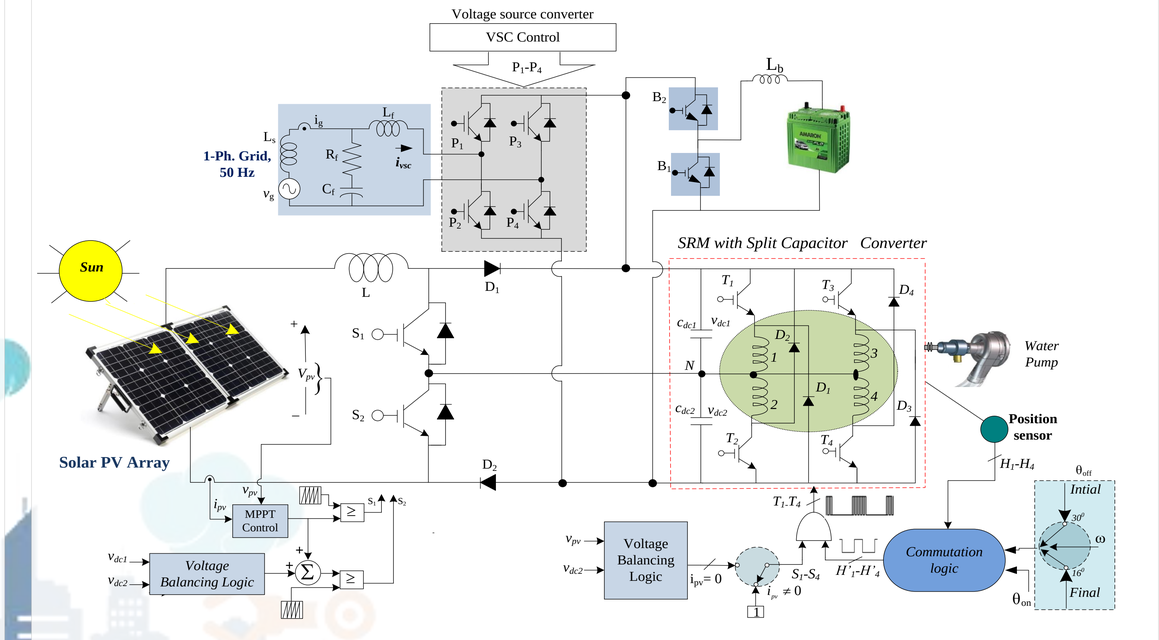
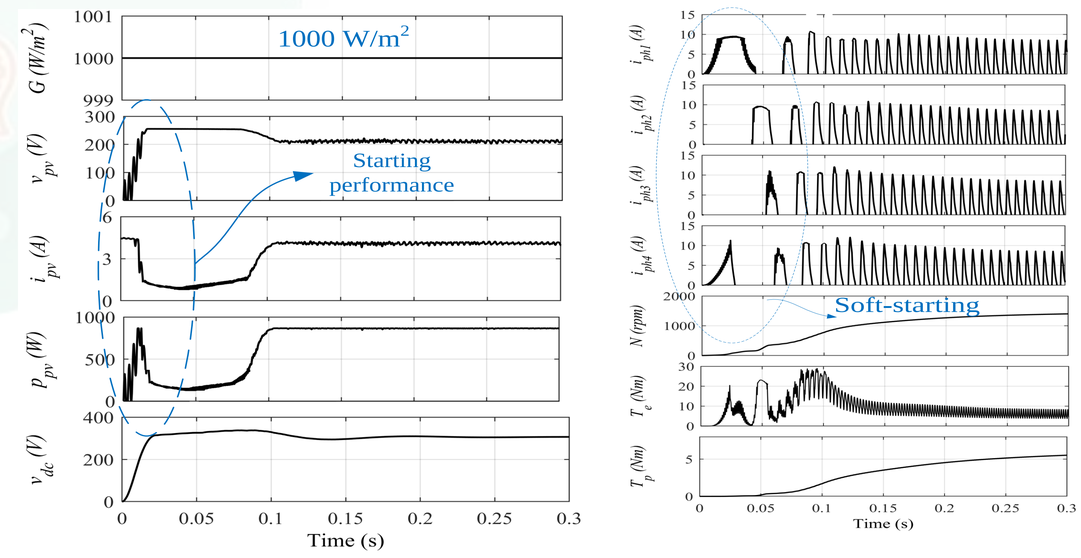
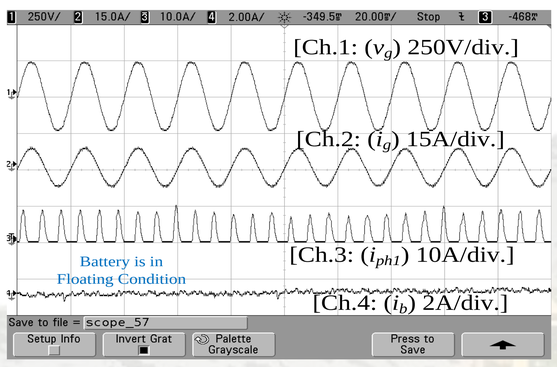


Fig. Circuit diagram of grid-interactive PV/Battery arrangement for SRM driven SPWPS

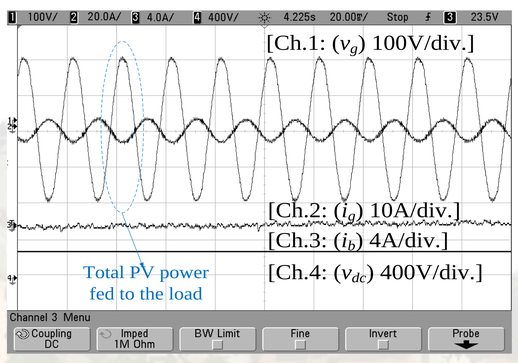
SRM-Pump is Powered by PV Array Only

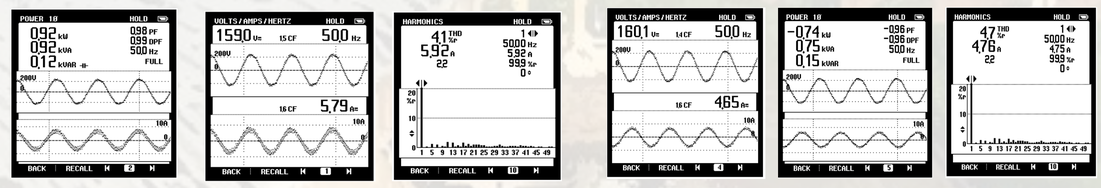


SRM-Pump is Powered by Grid Only



PV Array Feeds Power to Utility Grid





Major Publications:

1. Anjanee Kumar Mishra and Bhim Singh, "Solar photovoltaic array dependent dual output converter based water pumping using switched reluctance motor drive," ***IEEE Transactions on Industry Applications***, vol. 53, no. 6, pp. 5615-5623, Nov.-Dec. 2017.
2. Anjanee Kumar Mishra and Bhim Singh, "Grid interactive single stage solar powered water pumping system utilizing improved control technique," ***IEEE Transactions on Sustainable Energy***, *2019*. (Early Access).
3. Anjanee Kumar Mishra and Bhim Singh, "An Efficient Control Scheme of Self-Reliant Solar Powered Water Pumping System using a Three Level DC-DC Converter," ***IEEE Journal of Emerging and Selected Topics in Power Electronics (JESTPE),* 2019.** (Early Access)
4. Anjanee Kumar Mishra and Bhim Singh, "High Gain Single Ended Primary Inductor Converter with Ripple Free Input Current for Solar Powered Water Pumping System Utilizing Cost-effective Maximum Power Point Tracking Technique," ***IEEE Transactions on Industry Applications, 2019.*** (Early Access).
5. Anjanee Kumar Mishra and Bhim Singh, "Control of SRM drive for a photovoltaic powered water pumping system," ***IET Electric Power Applications***, vol. 11, no. 6, pp. 1055-1066, July 2017.

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1. Rahul Rawat, S.C. Kaushik and Ravita Lamba, "A review on modeling, design methodology and size optimization of photovoltaic based water pumping, standalone and grid connected system," *Renewable and Sustainable Energy Reviews*, vol. 57, pp. 1506-1519, May 2016.
2. Kala Meah, Steven Fletcher, and Sadrul Ula, "Solar photovoltaic water pumping for remote locations," *Renewable and Sustainable Energy Reviews*, vol. 12, no. 2, pp. 472-487, February 2008.
3. R. Krishnan, *Switched Reluctance Motor Drives: modeling, simulation, analysis, design and applications*, CRC Press, 2001.

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