CURRICULUM VITAE

Dr. Shambhu Sau

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AREAS OF INTEREST

Modular Multilevel Converters, Cascaded H-Bridge Converter, Medium Voltage Drives, Grid Integration of Large Capacity Solar Photovoltaic Plant, Transformer-less High Power Converters

ACADEMIC DETAILS

Degree	University/Institute	Year
Ph.D. Specialization	Indian Institute of Technology Bombay, Mumbai, India *Power Electronics and Power System*	2018
M.Tech Specialization	Indian Institute of Technology Bombay, Mumbai, India *Power Electronics and Power System*	2013
B.E. Specialization	Indian Institute of Engineering Science and Technology, Shibpur, India *Electrical Engineering*	2005
Intermediate/+2	Radhamohanpur Vivekananda High School, West Bengal, India	2001
Matriculation	Radhamohanpur Vivekananda High School, West Bengal, India	1999

PUBLICATIONS AND PATENTS

- **Journals**

J1. **Shambhu Sau**, Saurabh P. Nikam, and B. G. Fernandes, "Coupled Inductor Based Regenerative Cascaded Multicell Converter for Drives with Multilevel Voltage Operation at both Input and Output Sides", *IEEE Transactions on Industrial Electronics,* Vol.67, no. 1, pp. 147-158, Jan 2020. Available here

J2. **Shambhu Sau** and B. G. Fernandes, "Modular Multilevel Converter Based Variable Speed Drive with Reduced Capacitor Ripple Voltage", *IEEE Transactions on Industrial Electronics,* vol. 66, no. 5, pp. 3412-3421, May 2019. Available here

J3. **Shambhu Sau**, Saikat Karmakar, and B. G. Fernandes, "Modular Transformer-Based Regenerative-Cascaded Multicell Converter for Drives With Multilevel Voltage Operation at Both Input and Output Sides", *IEEE Transactions on Industrial Electronics,* vol. 65, no. 7, pp. 5313-5323, July 2018. Available here

- **Patents**

P1. **Shambhu Sau**, Saurabh P Nikam, and B. G. Fernandes, "Regenerative Cascaded Multicell Converter(CMC)", Indian Patent Applied.(App. No.:201821032623).

P2. **Shambhu Sau**, and and B. G. Fernandes, "Modular Multilevel Converter(MMC)", Indian Patent Applied.(App. No.:201821047042).

- **Conferences**

C1. **Shambhu Sau**, Arun C Nair, B. G. Fernandes, "Theoretical Analysis and Comparison of Capacitor Requirement in Modular Converters for Grid Integration of High Power Solar PV", in *IEEE Energy Conversion Congress and Exposition, ECCE, Baltimore, MD, USA, Sep., 2019.* Available here

C2. **Shambhu Sau** and B. G. Fernandes, "Modular Multilevel Converter based Variable Speed Drives with Constant Capacitor Ripple Voltage for Wide Speed Range", in *43rd Annual Conference of the IEEE Industrial Electronics Society, IECON, Beijing, China, Dec., 2017.* Available here

C3. **Shambhu Sau**, Saikat Karmakar, and B. G. Fernandes, "Reduction of Capacitor Ripple Voltage and Current in Modular Multilevel Converter based Variable Speed Drives", in *IEEE Future Energy Electron. Conf. (IFEEC), Kaohsiung, Taiwan, Jun., 2017*. Available here

C4. **Shambhu Sau** and B. G. Fernandes, "Analysis and Reduction of Capacitor Ripple Current in Modular Multilevel Converter for Variable Speed Drives," in *European Conference on Power Electronics and Applications (EPE'16 ECCE-Europe), Karlsruhe, Germany, Sep., 2016*. Available here

C5. **Shambhu Sau** and B. G. Fernandes, "High-power regenerative cascaded multicell converter with multilevel input and output," in *IEEE International Conference on Industrial Technology (ICIT), Taipei, Taiwan, Mar., 2016*. Available here

C6. **Shambhu Sau** and B. G. Fernandes, "Cascaded U-Cell multilevel converter for STATCOM applications", in *European Conference on Power Electronics and Applications (EPE'15 ECCE-Europe), Geneva, Switzerland, Sep., 2015*. Available here

C7. **Shambhu Sau**, R Vandana and B. G. Fernandes, "A new direct torque control method for switched reluctance motor with high torque/ampere", in *39th Annual Conference of the IEEE Industrial Electronics Society, IECON, Vienna, Austria, Nov., 2013*. Available here

C8. S. P. Nikam, **Shambhu Sau**, and B. G. Fernandes, "Design of switched reluctance motor based electric drive-train for intra-campus two wheeler", in *39th Annual Conference of the IEEE Industrial Electronics Society, IECON, Vienna, Austria, Nov., 2013*. Available here

RESEARCH HIGHLIGHTS

Ph.D. thesis title: *Modular Converter Topologies with Reduced Transformer Rating and Capacitor Size for High-Power Regenerative Drives*
Thesis Supervisor : Prof. B. G. Fernandes

The high-power drives, in general, are operated at medium voltage (MV) are being used in various applications. The recent trend is to use modular structured converter such as cascaded H-bridge (CHB) and modular multilevel converter (MMC) in high-power drives instead of a monolithic converter to improve the overall reliability of the system. The conventional CHB converter based drives, commonly known as cascaded multicell converter (CMC) requires an isolated power supply for each module, which is obtained using a multi-winding transformer. This transformer contributes to around 20-25% of the total manufacturing cost of the drive, 30-50% of the total drive size, and 50-70% of system weight. Further, the diode-bridge rectifier at the input side of each cell restricts the use of this converter in applications which require frequent regeneration mode of operation. One the other hand, due to the presence of common dc-bus the MMC eliminates the need of isolated power supply for each module. However, the main drawback of this converter in variable speed drive is the presence of high voltage ripple in SM capacitor, which varies inversely with the output frequency. Although the ripple can be reduced by injecting high-frequency circulating current, this increases the converter rating and losses significantly. The major contribution of the thesis are

1. **Regenerative Cascaded Multicell Converter:** [*Publication reference:* J3, C5]

   In order to enable the drive with regeneration capability three-phase or single-phase pulse width modulated (PWM) rectifiers can be used at the front end. However, two-level operation at the input side of these existing regenerative CMCs requires the devices to be operated at higher switching frequency to reduce the filter size. Further, the presence of harmonic components in the current of the transformer secondary winding increases the winding eddy current losses. A new configuration of regenerative CMC with single-phase PWM rectifier based power cells and single-phase modular transformer is proposed for high-power drives to obtain multilevel operation at input and output sides. The multilevel operation at the input side allows the devices to be operated at lower switching frequency and reduces the harmonic content in the current without using additional filter circuit. In addition, the winding losses and kVA rating of the transformer are reduced significantly. Experimental validation of the proposed converter configuration is carried out on a 4.5-kVA prototype which produces seven levels in input and output voltages.

2. **Coupled Inductor Based Regenerative Cascaded Multicell Converter:** [*Publication reference:* J1, P1]

   In this work, a regenerative CMC with coupled inductors is proposed to achieve multilevel voltage waveform at the secondary side of the transformer. The modules are connected in parallel at the input side, which allows the bypassing of the faulty cell without increasing the voltage rating of the healthy cells. The use of coupled inductor ensures equal input current sharing among the cells and thus a single three-phase current controller is sufficient to regulate all cell currents. The proposed converter is validated through experimental studies performed on a laboratory prototype.

3. **Analysis and reduction of capacitor ripple voltage and current:** [*Publication reference:* C2, C4]

   Although the capacitor ripple current is one of the important parameters in selecting the electrolytic capacitor and determining its capacitance value in high-power drives, all the research is focused on reducing the capacitor ripple voltage in MMC based drives. In this work, the capacitor ripple current is analysed and an expression for the rms value of capacitor ripple current in MMC is derived. This analysis reveals that the ripple current increases with the reduction in operating speed for constant output current. The use of variable dc-bus voltage is suggested to reduce the capacitor ripple current at lower speeds. This also reduces the capacitor ripple voltage without injecting any high-frequency circulating current. A back-to-back MMC configuration is proposed to vary the dc-bus voltage at lower speeds. The simulation study is carried out in Matlab/Simulink to verify the claims and the results are compared for different values of dc-bus voltage at various operating speeds.

4. **Reduction of capacitor ripple voltage in non-regenerative MMC based drive:** [*Publication reference:* J2, C3]

   In non-regenerative drives, multipulse rectifier is normally used to feed the dc-bus. This work presents a new configuration of multipulse diode-bridge rectifier circuit is proposed to reduce the dc-bus voltage at low speeds while maintaining the module capacitor voltages at their rated value. The kVA rating of the converter reduces compared to the existing techniques due to the absence of high-frequency circulating current. The proposed converter with 24-pulse rectifier configuration is simulated in MATLAB/Simulink, and the experimental validation is carried out on a prototype with 12-pulse rectifier.

KEY ACADEMIC PROJECTS and INTERNSHIP

- **Post Graduate Dissertation:**
  Supervisor: Prof. B. G. Fernandes, IIT Bombay
  Title: "Switched Reluctance Motor Drives for Two Wheeler".
  Design and implementation of power electronics converter and control circuit for switched reluctance motor drive to be used in electric two wheeler.

- **Graduate Dissertation:**
  Supervisor: Prof. S. K. Mallik, IIEST Shibpur
  Title: "Computation of Squirrel Cage Rotor Slot Resistance and Reactance for Different Slot Shape".
  Study of the variation of conductor impedance and eddy current loss as function of frequency for different slot shapes.

HONORS, AWARDS and ACHIEVEMENTS

1. Innovative Student Projects Award at Doctoral Level, Indian National Academy of Engineering, 2019
2. IEEE IES student paper travel award in 2016.
3. IBM Bravo Award in 2007 & 2008.

PROFESSIONAL EXPERIENCE

1. R & D Engineer, ABB Global Industries and Services Pvt Ltd, Chennai (Sep 2018 - Apr 2019)
   Investigation on Transformer-less Modular Multilevel Converter based HVDC.
2. Research Associate, Indian Institute of Technology Bombay (May 2018 - Aug 2018)
   Design and prototype testing on Single DC-link Modular Multilevel Converter.
3. Application Developer, IBM India Pvt Ltd, Kolkata (Jul 2005 - Dec 2010)
   Developer, on-site coordinator and team leader in Philip Morris International – iSMS project
   End-to-end module development in TDC – Integrated Financial Modelling (IFM) project

DECLARATION

I hereby declare that all information furnished above are true, complete and correct to the best of my knowledge and belief.

Date: August 16, 2020 Shambhu Sau
Place: Kharagpur, India