Arab Academy

for Science , Technology and Maritime Transport

The International Maritime Transport and Logistics Conference

“MARLOG 13”

Towards Smart Green Blue Infrastructure

3-5 March 2024 - Alexandria, Egypt

Ibrahim M. Gaber

Research and Innovation Center,
AASTMT, Alamein, Egypt

RECOVERY BRAKING IN ELECTRIFIED BOATS USING DUAL ACTIVE BRIDGE DC-DC CONVERTER WITH ULTRACAPACITOR

Ibrahim M. Gaber (1), **Mostafa S. Hamad** (1) **and Ayman S. Abdel-Khalik** (2)
(1) Research and Innovation Center, Arab Academy for Science, Technology and Maritime Transport, Alamein , Egypt, I.Mohamed16165@student.aast.edu, Mostafa.hamad@staff.aast.edu
(2) Department of Electrical Engineering, Alexandria University, Alexandria 21544, Egypt, ayman.abdel-khalik@alex.edu.eg

Outline

1. Introduction
2. Proposed System Overview
3. Role Of DAB in The Proposed Topology
4. The Proposed Control Strategies For The DAB
5. Simulation Results
6. Conclusion

according to
topics

1. Introduction

1. **Electrified boats (EBs) are gaining attention as a sustainable alternative to traditional boats.**
2. **Combining batteries with ultracapacitors can overcome challenges like limited power performance and restricted recharging cycles.**
3. **Recovery braking in EBs converts mechanical energy into electrical energy, making ultracapacitors ideal for hybrid applications.**

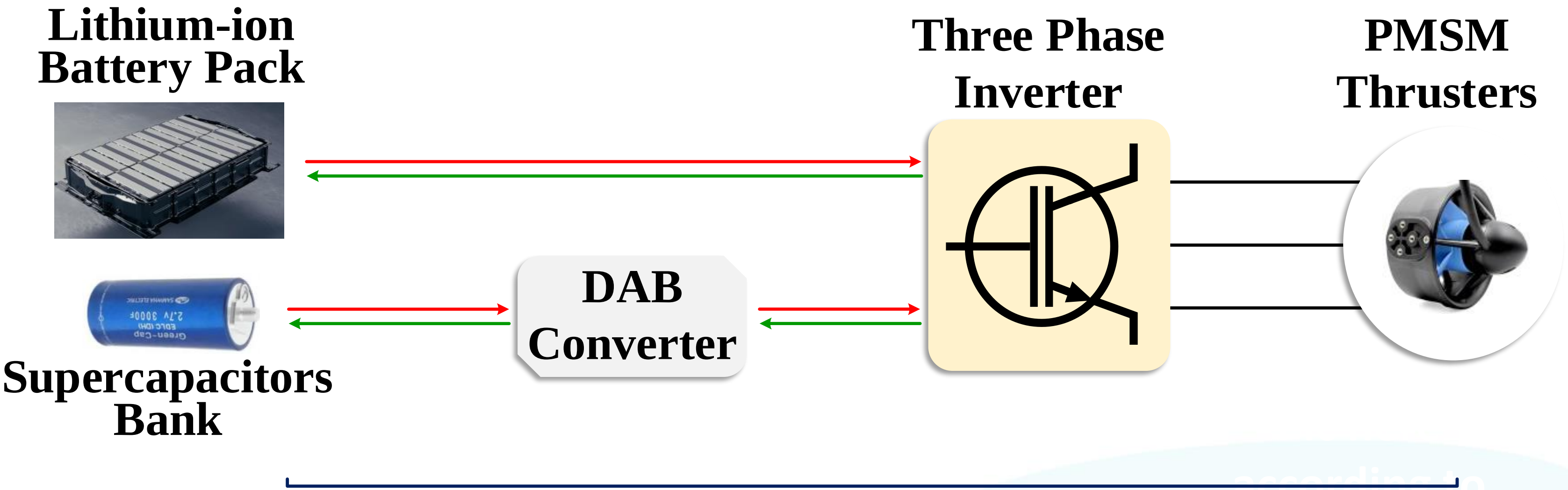
topics

2. Proposed System Overview

1. The recovery braking system for Permanent Magnet Synchronous Motor (PMSM) drivetrain in Electric Boats (EBs) uses a bidirectional DC-DC converter to link an ultracapacitor to a DC bus.
2. A Proportional-Integral (PI) controller assesses charging and discharging states, regulating terminal inverter voltage.
3. The system is modeled and tested using MATLAB/Simulink software, comparing outcomes against two control strategies.
4. The architecture of electric hybrid boats typically includes multiple energy sources and converters, with the recovery braking system involving the parallel connection of batteries and ultracapacitors to store kinetic energy during braking events.

according to topics

2. Proposed System Overview



Lithium-ion Battery Pack

Supercapacitors Bank

DAB Converter

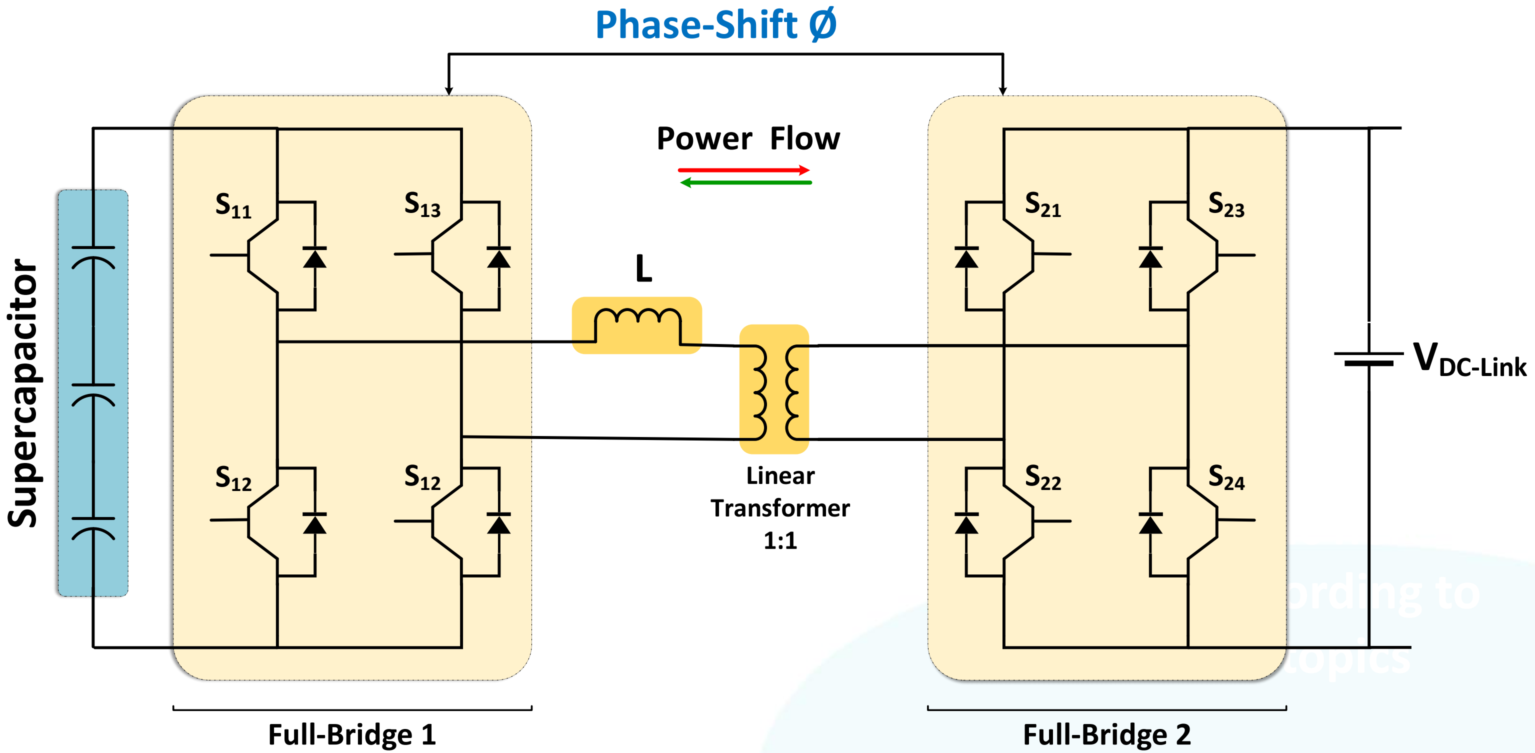
Three Phase Inverter

PMSM Thrusters

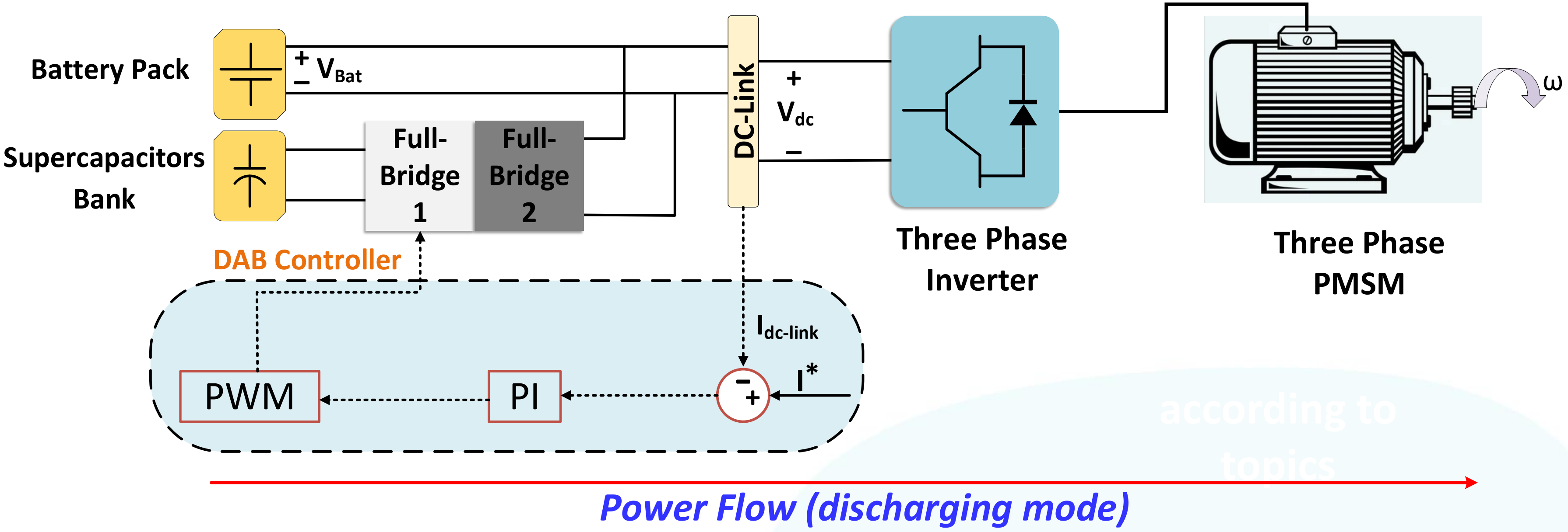
Electric Boat (EB) Propulsion System

according to topics

3. Role Of DAB In The Proposed Topology

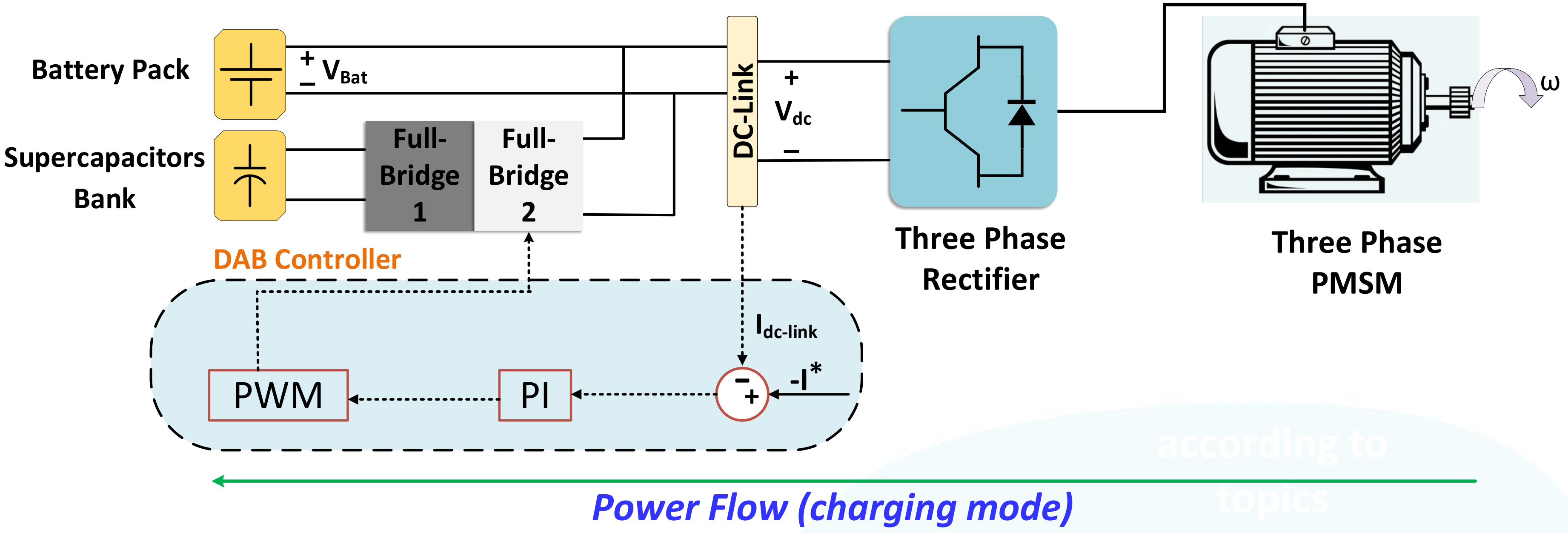


4. The Proposed Control Strategies For The DAB



according to topics

4. The Proposed Control Strategies For The DAB



Battery Pack

$+ V_{Bat} -$

Supercapacitors Bank

Full-Bridge 1

Full-Bridge 2

DC-Link

$+ V_{dc} -$

Three Phase Rectifier

Three Phase PMSM

ω

DAB Controller

$I_{dc\text{-}link}$

$-I^*$

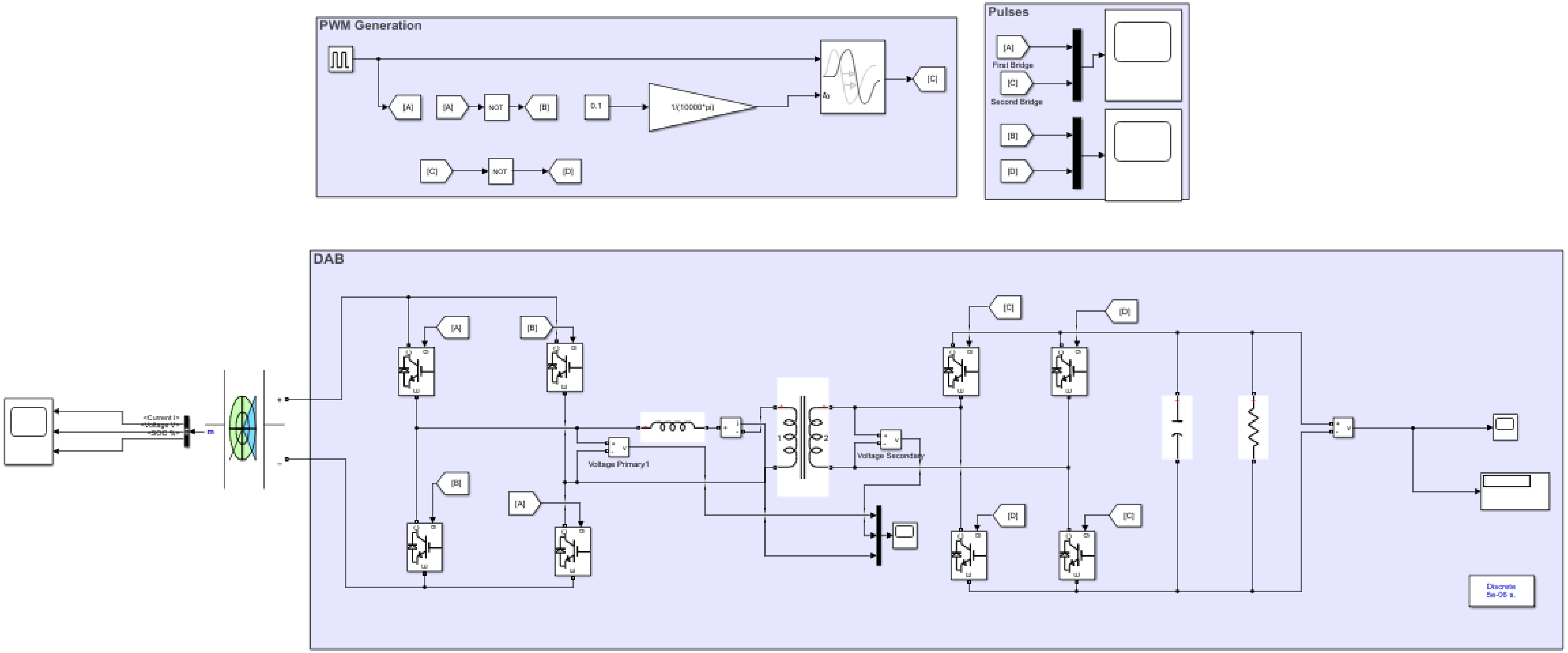
PWM

PI

Power Flow (charging mode)

according to topics

4. The Proposed Control Strategies For The DAB



5. Simulation Results

Table 1. Ultracapacitor specifications

Parameter	Value
Rated capacitance	80 F
Equivalent DC series resistance	8..93 mΩ
Rated voltage	400 V

Table 2. Parameters of DAB

Quantity	Value
Turns ratio N1/N2	2/1
Coupling inductance of the DAB	0.0102 mH
Switching frequency of the DAB	5 KHz

Table 3. Motor Specifications

Description	Value
Torque	0.8 Nm
Input Voltage	300 V
Rated Speed	3000 rpm

according to
topics

5. Simulation Results

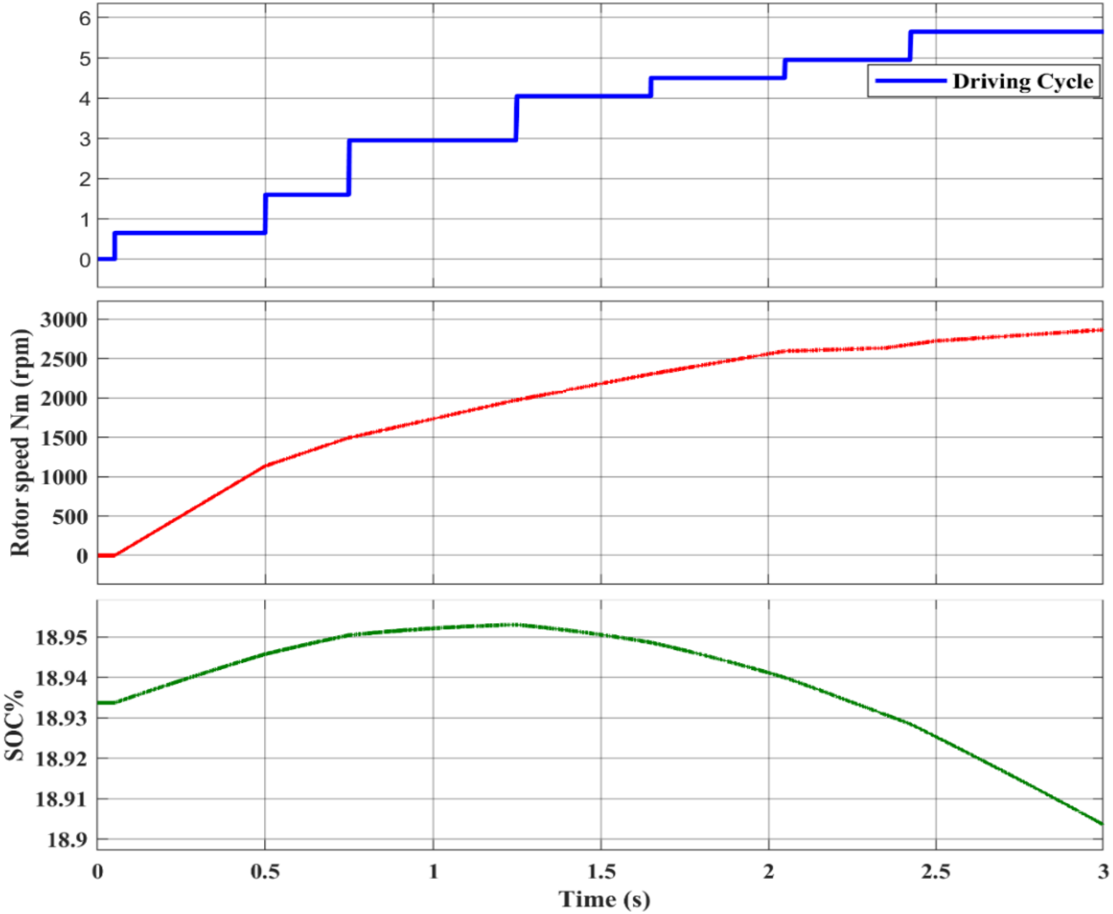


Figure : Driving behavior, motor speed, and SOC waveforms of the ultracapacitors (discharging mode)

5. Simulation Results

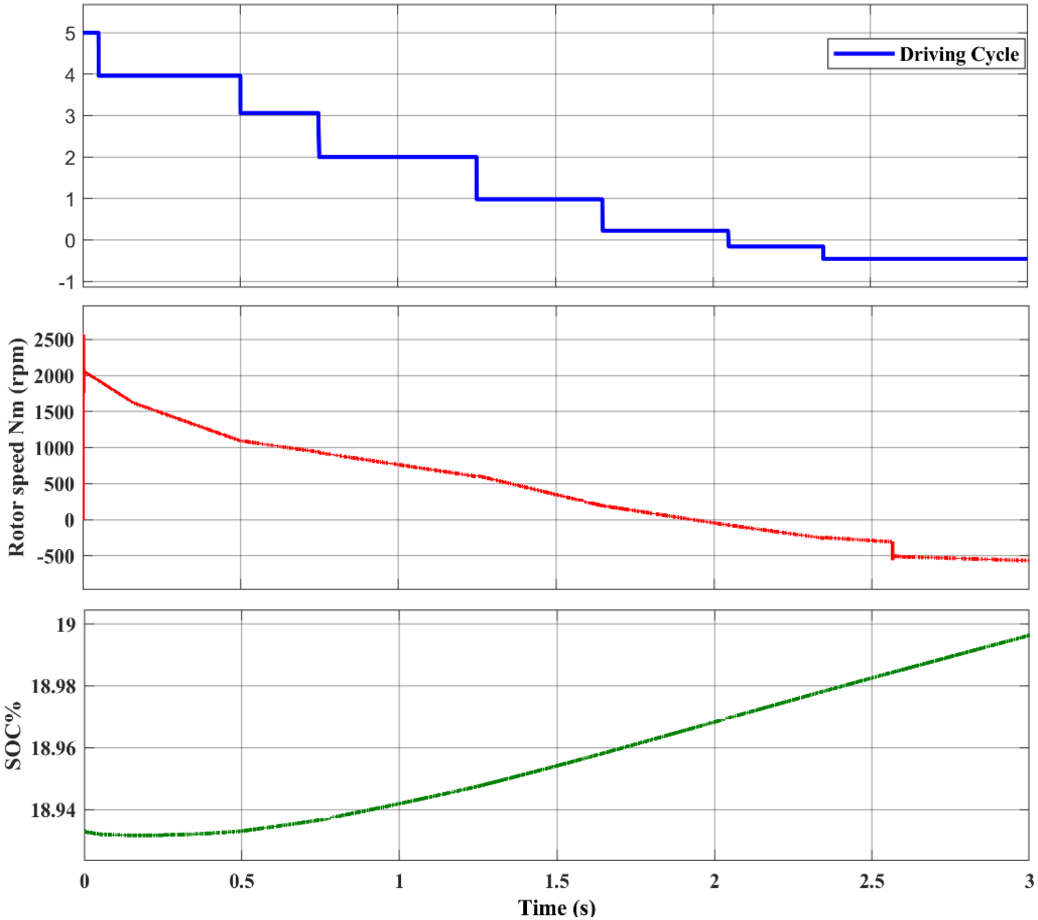
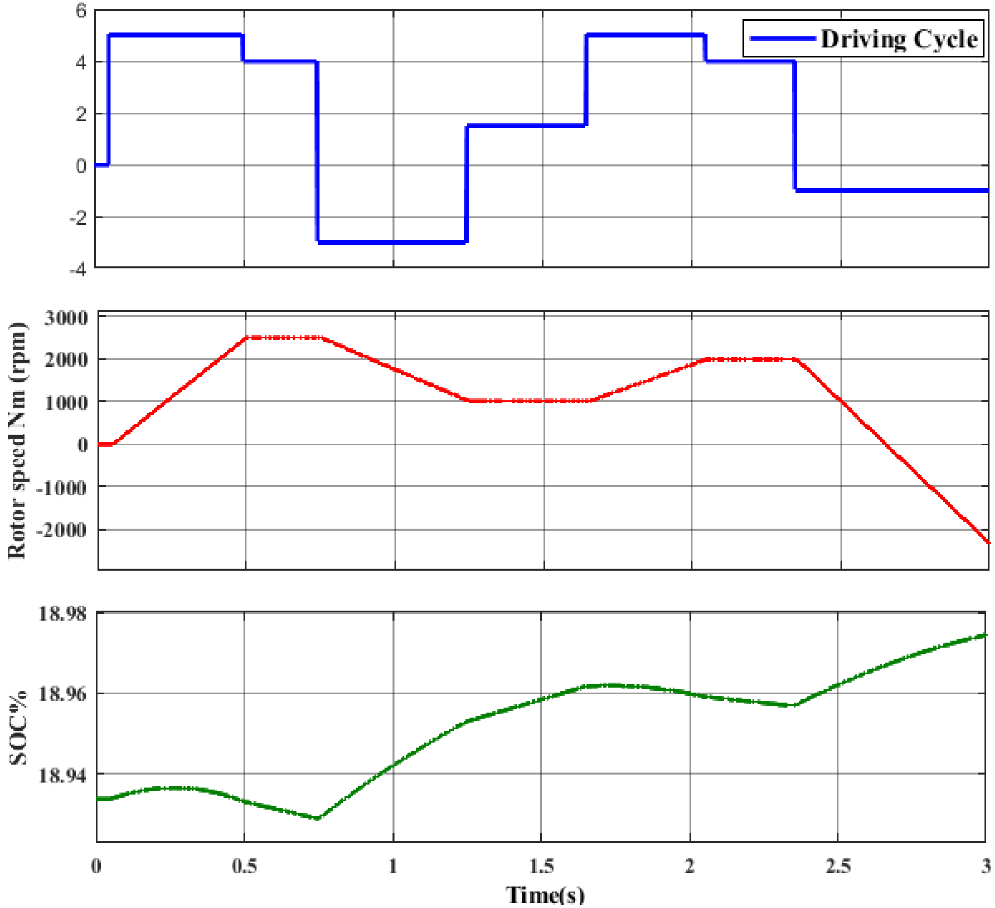


Figure : Driving behavior, motor speed, and SOC waveforms of the ultracapacitors (charging mode)

5. Simulation Results

Figure : Driving behavior, motor speed, and SOC waveforms of the ultracapacitors (hybrid mode)



5. Simulation Results

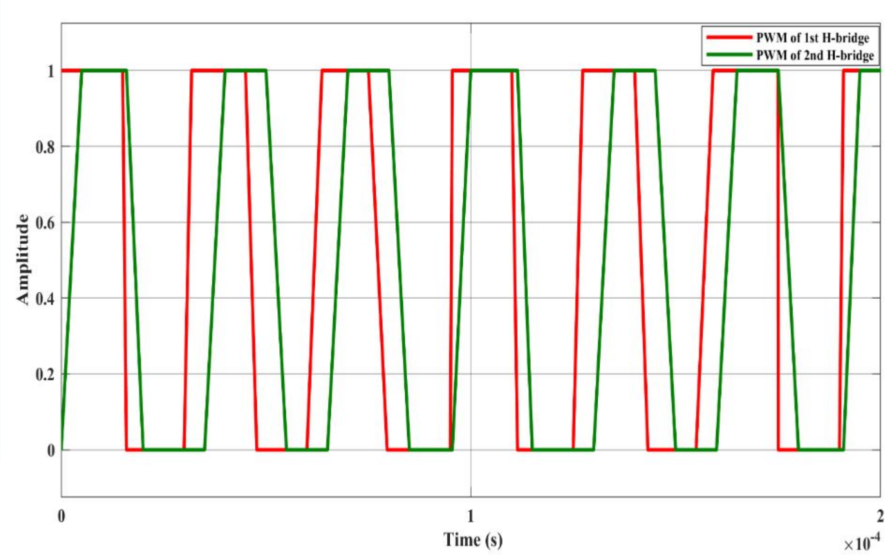


Figure : Gate pulses of the DAB
(discharging mode)

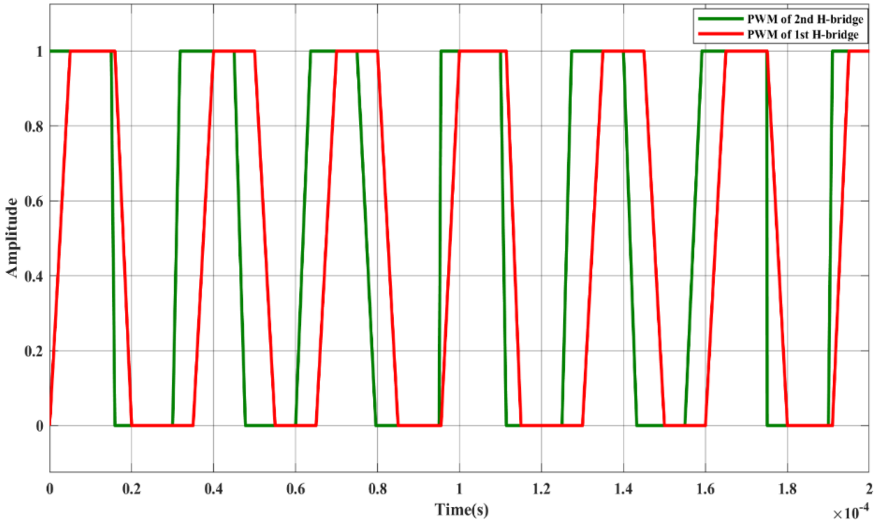


Figure : Gate pulses of the DAB
(charging mode)

6. Conclusion

1. The study proposes a Dual Active Bridge (DAB) converter-based interface system for ultracapacitor charging and discharging during regenerative braking of PMSM.
2. The system uses a Proportional-Integral controller for efficient operation.
3. Simulation results show fast response and accurate performance of ultracapacitors, highlighting the importance of energy-saving technologies in rising petrol prices.
4. The research highlights the importance of advancements in energy-saving technologies driven by rising petrol prices, with the proposed DAB converter system showcasing effective energy load distribution and stability in electrified boat propulsion systems.

Arab Academy
for Science , Technology and Maritime Transport

13 Marlog 2024

The International Maritime Transport and Logistics Conference
“MARLOG 13”

Thank You