



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** X **Month of publication:** October 2026

DOI: <https://doi.org/10.22214/ijraset.2026.85096>

www.ijraset.com

Call: ☎ 08813907089

E-mail ID: ijraset@gmail.com

Simulation of a PV-Integrated Dual Active Bridge Converter for EV Charging

Aditya G. Ghavat¹, Suhani A. Alone², Sanika G. Umak³, Subodh V. Wadaskar⁴, Nilesh R. Dasgupta⁵, Dr. A. A. Deosant⁶

^{1, 2, 3, 4, 5}UG Students, Department of Electrical Engineering

⁶Department of Electrical Engineering, Priyadarshini College of Engineering, Hingna Road, Nagpur – 440019, Maharashtra, India

Abstract: The increasing use of renewable energy and electric vehicles (EVs) has created a growing need for efficient power-electronic interfaces that can integrate solar energy with high-voltage battery-charging systems. This work presents the design and MATLAB/Simulink analysis of an approximately 11.56 kW photovoltaic (PV)-fed Dual Active Bridge (DAB) DC-DC converter for isolated and controllable power transfer in EV battery-charging applications. The PV array consists of 33 modules rated at approximately 350 W each, configured as 11 series-connected modules per string and three parallel strings, providing approximately 423.5 V and 27.3 A at the maximum power point. The DAB converter employs two active full bridges coupled through an 11 kVA, 50 kHz high-frequency transformer with 419/409 V windings and a 29 μ H series transfer inductor. A 220 μ F DC-link capacitor is connected at the output. Power transfer is controlled using single-phase-shift (SPS) modulation, where both bridges operate at approximately 50% duty cycle and the relative phase angle between their switching signals determines the transferred power. For closed-loop control, the measured DC output voltage is compared with a predefined reference, and the resulting error is processed by a PI controller to generate the required phase-shift command. A MATLAB Function block dynamically produces the phase-shifted switching references using the controller output and simulation time. These references are converted into complementary gate pulses for the primary and secondary bridges, allowing controlled adjustment of the DAB power flow and output voltage. Initial simulation results confirm the generation of complementary switching pulses, the required phase displacement between the bridges, and controlled power transfer from the PV source to the DC output. The developed model provides a foundation for further battery-charging analysis, efficiency evaluation, transient studies, and experimental implementation.

Keywords: Dual Active Bridge Converter, Photovoltaic System, Electric Vehicle, Battery Charging, Single-Phase-Shift Control, PI Controller, MATLAB/Simulink.

I. INTRODUCTION

The parallel growth of solar photovoltaic (PV) generation and electric-vehicle (EV) adoption has increased the demand for compact and electrically isolated DC-DC conversion stages for renewable-energy-based battery charging. The Dual Active Bridge (DAB) converter is well suited to this role because it uses two actively controlled full bridges coupled through a high-frequency transformer, providing galvanic isolation, controllable power transfer, and bidirectional operating capability.

Under single-phase-shift (SPS) modulation, both bridges operate with approximately 50% duty cycle, while the transferred power is primarily regulated by varying the phase difference between their switching signals. The use of a high-frequency transformer also reduces the size of the magnetic components and supports a compact, high-power-density converter structure suitable for PV-assisted EV charging applications.

When the DAB is supplied from a PV source, the control system must maintain regulated power transfer as source and load conditions vary. In the proposed scheme, the measured DC output voltage is compared with a preset reference, and the resulting error is processed by a PI controller to determine the required phase-shift command. The switching logic then produces phase-displaced references and complementary gate pulses for the two full bridges, allowing closed-loop regulation of the DAB power flow and DC output voltage.

This work develops a MATLAB/Simulink model of an approximately 12 kW PV-fed DAB converter intended for a reference 409 V lithium-ion battery-charging application. The study focuses on the integration of the PV source, high-frequency isolated DAB stage, SPS modulation, and PI-based voltage control. Emphasis is placed on converter parameter and switch selection, complementary gate-signal generation, verification of the required phase displacement, and controlled PV-to-DC power transfer before detailed battery-charging analysis.

A. Problem Statement

The increasing integration of photovoltaic (PV) generation with electric-vehicle battery systems requires an efficient and electrically isolated DC-DC converter capable of regulating power between a variable DC source and a high-voltage battery. Conventional non-isolated conversion methods do not provide galvanic isolation, while uncontrolled power transfer can lead to variations in the DC output voltage and charging conditions. Therefore, a suitable power-conversion and control strategy is required to provide isolation, regulate the DC output, and control the power transferred from the PV array to the battery. This work addresses the problem through a PV-fed Dual Active Bridge (DAB) converter using phase-shift-based closed-loop control.

B. Scope of the Present Work

The present work focuses on the design and MATLAB/Simulink analysis of an approximately 11.56 kW PV-fed Dual Active Bridge converter for high-voltage battery charging. The system comprises a 33-module PV array in an 11-series, 3-parallel configuration, two active full bridges, a 50 kHz high-frequency transformer, a 29 μ H transfer inductor, and an output DC-link capacitor. Power flow is regulated using single-phase-shift modulation with PI-based feedback control of the inter-bridge phase angle. The study evaluates converter operation, complementary gate generation, phase-shift control, output-voltage regulation, and PV-to-DC power transfer, with the model forming a basis for later integration with a 409 V lithium-ion battery, current limiting, loss analysis, and experimental validation.

II. LITERATURE SURVEY

A focused review of published work on photovoltaic (PV)-integrated and battery-oriented Dual Active Bridge (DAB) converters was carried out to identify converter structures, modulation methods, and control approaches relevant to the present work. Table I summarizes the studies most closely related to PV-assisted power conversion, electric-vehicle battery charging, single-phase-shift control, and closed-loop DAB operation.

Table I. Summary of Reviewed Literature

Sr. No.	Title	Authors	Journal / Year	Findings
1	Bidirectional Electric Vehicle Battery Charger Assisted by Photovoltaic Panels	S. Atanalian, K. Al-Haddad, R. Zgheib, H. Y. Kanaan	IECON 2020, IEEE / 2020	Presented a PV-assisted bidirectional EV charger in which the DC-DC conversion stage is implemented using a DAB. MATLAB/Simulink studies were used to examine charging and discharging operation, showing the suitability of the DAB for isolated battery interfacing with renewable-energy support.
2	Systematic Analysis of Control Techniques for the Dual Active Bridge Converter in Photovoltaic Applications	D. A. Herrera-Jaramillo, D. González Montoya, E. E. Henao-Bravo, C. A. Ramos-Paja, A. J. Saavedra-Montes	International Journal of Circuit Theory and Applications / 2021	Reviewed DAB operation and control specifically for PV systems. The study examined PV-voltage regulation, load-disturbance rejection, and control requirements, and compared DAB-based PV conversion with a conventional boost-converter approach.
3	Comparative Analysis of Dual Active Bridge DC-DC Converter Employing Si, SiC and GaN MOSFETs for G2V and V2G Operation	S. S. Trivedi, A. V. Sant	Energy Reports / 2022	Evaluated an SPS-controlled DAB for grid-to-vehicle and vehicle-to-grid operation using Si, SiC, and GaN devices. Operation was studied from 20 kHz to 200 kHz, including 50 kHz, and experimental results confirmed phase-shift-based bidirectional power transfer.
4	An Improved Modelling and Dynamic Control of the Dual Active Bridge Converter for Fast Battery Charging of Electric Vehicles	A. A. Nkemb, P. Cova, I. Kortabarria, E. Sacchi, N. Delmonte	IET Conference Proceedings / 2023	Investigated the dynamic behaviour of a DAB used for high-power EV battery charging. A single-phase-shift control structure with feedback and feedforward action was studied for constant-current and constant-voltage charging, with MATLAB/Simulink results used to evaluate the charging response.

5	Analysis, Design, and Control of the Dual Active Bridge Converter for EV Battery Charging	K. Srivastava, D. Firake, R. Maurya, S. Kumar	IEEE ICPC2T / 2024	Presented mathematical modelling, design, and control of a DAB battery charger. SPS modulation was applied during constant-current and constant-voltage charging modes, and a laboratory-scale prototype was used to verify converter behaviour under varying supply conditions.
6	Dual Active Bridge Converter with Interleaved and Parallel Operation for Electric Vehicle Charging	B. Muhammetoglu, M. Jamil	Energies / 2024	Developed a bidirectional DAB converter for EV charging with a 5.6 kW base design and reconfigurable operation up to 11.2 kW. The work emphasized high-frequency transformer design, high-current power transfer, converter scalability, and suitability for future bidirectional charging applications.

The reviewed studies establish the DAB as a practical isolated DC-DC topology for renewable-energy and EV charging systems, while showing different priorities such as PV-side control, CC-CV charging, semiconductor selection, and advanced converter design. In the present project, the focus is placed on a clearly parameterized MATLAB/Simulink implementation of an approximately 11.56 kW PV-fed DAB using single-phase-shift modulation and PI-based output-voltage regulation. The model is used to verify phase-controlled power transfer and forms the basis for subsequent integration with a 409 V lithium-ion battery

III. OBJECTIVES

- Selection of Suitable switch for DAB Converter.
- To study the role of DAB converter in EV charging applications for efficient power supply and galvanic isolation.
- To understand phase-shift control in DAB for regulating power flow between source and load.
- To investigate soft-switching (ZVS) operation for reducing switching losses and improving efficiency.
- To develop a reliable and efficient DC-DC conversion system for EV charging.
- To Charge EV Battery using Renewable Energy Source.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed system integrates a photovoltaic (PV) source with an isolated Dual Active Bridge (DAB) converter and a closed-loop phase-shift control system. The PV array supplies DC power to the primary full bridge, while the DAB transfers energy through a series transfer inductor and a high-frequency transformer to the secondary side. The secondary bridge and DC-link capacitor form the output stage, which can be connected either to a DC load for initial validation or to a lithium-ion battery for charging analysis. Output-voltage feedback is used by the controller to regulate the phase shift between the two bridges and thereby control the transferred power. The overall system architecture is shown in Fig. 1.

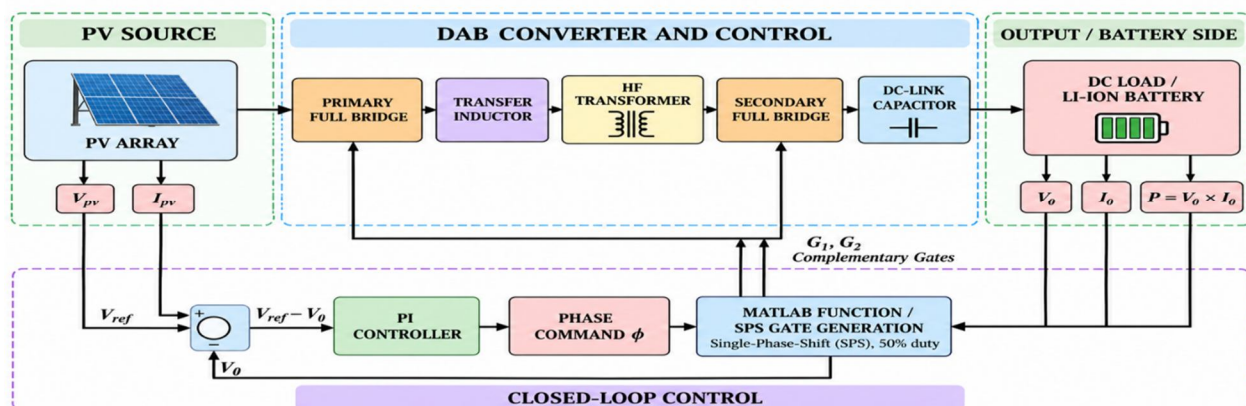


Fig. 1. Block diagram of the proposed PV-fed Dual Active Bridge converter with closed-loop single-phase-shift control and DC load/battery interface.

A. PV Source

The PV array serves as the main DC energy source for the proposed converter and is directly connected to the primary side of the DAB power stage. The PV voltage V_{pv} and PV current I_{pv} are measured during simulation to monitor the operating condition of the source and evaluate the power delivered by the photovoltaic system. These measurements are also used to study the interaction between the PV array and the DAB converter under different operating conditions.

B. Dual Active Bridge Power Stage

The DAB power stage consists of a primary full bridge, a series transfer inductor, a high-frequency transformer, and a secondary full bridge. The primary bridge converts the PV-side DC voltage into a high-frequency alternating square-wave voltage. Power is then transferred through the series inductor and transformer to the secondary side, where the second active bridge converts it back into DC. The high-frequency transformer provides galvanic isolation between the PV source and the output side, while the transfer inductor plays an important role in controlling the current and power exchanged between the two bridges. A DC-link capacitor is connected at the converter output to support a stable DC voltage.

C. Closed-Loop Phase-Shift Control

The DAB converter is operated using single-phase-shift (SPS) modulation. The measured output voltage V_o is fed back and compared with the reference voltage V_{ref} . The resulting voltage error is processed by a PI controller, which generates the required phase-shift command ϕ . This command is then applied to a MATLAB Function block to produce phase-displaced switching references for the primary and secondary bridges. Complementary gate signals are generated from these references and applied to the corresponding bridge switches. By adjusting the relative phase displacement between the two bridges, the controller regulates the power transferred through the DAB and maintains the required DC output condition.

D. Output and Battery Side

The secondary side of the DAB converter supplies the DC output through the DC-link capacitor. During the initial stage of simulation, a DC load is connected to verify converter operation, output-voltage regulation, and closed-loop power transfer before introducing the battery model. The output voltage V_o and output current I_o are measured, and the transferred output power is calculated as: $P = V_o \times I_o$

After stable operation with the DC load is achieved, the output stage is connected to the lithium-ion battery model for further evaluation of battery-charging performance. This step-by-step procedure enables the DAB power stage and phase-shift controller to be verified before detailed battery-side analysis.

V. METHODOLOGY AND WORKING PRINCIPLE

The operating sequence of the proposed PV-fed DAB converter proceeds through the following stages.

- 1) PV power generation. The photovoltaic array acts as the main DC source and supplies power to the primary side of the Dual Active Bridge converter. The PV voltage V_{pv} and current I_{pv} are monitored during simulation to observe the operating condition of the source and the power delivered to the converter.
- 2) Primary-side conversion. The primary active full bridge converts the DC input from the PV array into a high-frequency bipolar voltage waveform. The bridge switches are operated with complementary gate pulses and approximately 50% duty cycle.
- 3) Phase-shift generation. The DAB operates using single-phase-shift (SPS) modulation. A phase difference is introduced between the switching signals of the primary and secondary bridges so that the amount of power transferred through the converter can be controlled.
- 4) Isolated power transfer. The high-frequency waveform produced by the primary bridge is transferred through the series transfer inductor and high-frequency transformer. The transformer provides electrical isolation between the PV source and the output side, while the transfer inductor forms the main power-transfer path of the DAB converter.
- 5) Secondary-side conversion. The secondary active full bridge converts the high-frequency transformer-side waveform back into DC. The DC-link capacitor at the output supports the DC voltage and reduces the effect of switching variations on the output side.
- 6) Closed-loop voltage control. The output voltage V_o is continuously measured and compared with the selected reference voltage V_{ref} . The resulting voltage error is processed by a PI controller, which generates the required phase-shift command ϕ for the DAB converter.

- 7) Gate-pulse generation. The phase-shift command and simulation time are supplied to a MATLAB Function block, which generates the phase-displaced switching references for the two active bridges. Complementary gate signals are then produced and applied to the corresponding bridge switches.
- 8) Output monitoring and power calculation. The output voltage V_o and output current I_o are measured during simulation. The transferred output power is evaluated using: $P = V_o \times I_o$
- 9) Load and battery operation. The converter is initially tested with a DC load to verify switching operation, phase-shift control, output-voltage regulation, and stable power transfer. After satisfactory closed-loop operation is obtained, the output stage can be connected to the lithium-ion battery model for further battery-charging analysis.

The control strategy is based on continuous output-voltage feedback. Any deviation of V_o from V_{ref} changes the PI-controller output and therefore the phase-shift angle between the primary and secondary bridge switching signals. This variation in phase displacement changes the power transferred through the DAB converter, allowing the output voltage to be regulated under closed-loop operation.

VI. COMPONENT SPECIFICATIONS

The principal power-stage, control, measurement and signal-processing blocks used in the MATLAB/Simulink model are listed in Table II. Numerical specifications are included only where they directly define converter operation; utility, routing and monitoring blocks are identified by their functional role.

Table II. Component and Simulink Block Specifications of the Proposed System

Sr. No.	Component / Simulink Block	Model Setting / Specification	Function in the System
1	PV Array	AU Optronics PM072MW0_350W module; 11 modules in series and 3 parallel strings; module $P_m = 350.168$ W, $V_m = 38.48$ V, $I_m = 9.1$ A.	Provides the photovoltaic DC source for the primary side of the DAB converter.
2	Irradiance Constant	Constant input = 1000 W/m ² .	Defines the solar-irradiance input applied to the PV Array block.
3	Temperature Constant	Constant input = 45 °C.	Defines the PV-cell temperature input used by the PV Array model.
4	Input DC-Link Capacitor (Series RLC Branch5)	Capacitive branch; $C = 1200$ μ F.	Supports the PV-side DC bus and reduces high-frequency voltage variation at the bridge input.
5	Primary Full Bridge (4 MOSFET Blocks)	Four MOSFET blocks; $R_{on} = 0.01$ Ω per switch in the model.	Converts PV-side DC into a high-frequency bipolar bridge voltage.
6	Series Transfer Inductor (Series RLC Branch3)	RL branch; $L = 72$ μ H and $R = 1$ m Ω .	Provides the DAB coupling/transfer inductance and limits the high-frequency power-transfer current.
7	High-Frequency Linear Transformer	Nominal rating = 11 kVA at 50 kHz; primary and secondary nominal voltages = 420 V / 409 V.	Provides galvanic isolation and transfers high-frequency power between the two active bridges.
8	Secondary Full Bridge (4 MOSFET Blocks)	Four MOSFET blocks; $R_{on} = 0.01$ Ω per switch in the model.	Performs synchronous secondary-side conversion and establishes the phase-shifted bridge voltage.
9	Output DC-Link Capacitor (Series RLC Branch2)	Capacitive branch; $C = 500$ μ F.	Supports the battery-side DC bus and reduces switching-frequency voltage ripple.
10	Lithium-Ion Battery Block	Nominal voltage = 409 V; nominal capacity = 193.15 Ah; initial SOC = 50%; internal resistance = 0.021175 Ω .	Represents the EV battery connected at the DAB output in the attached simulation model.
11	Voltage Measurement Blocks	Four Specialized Power Systems voltage-measurement blocks.	Measure converter and DC-bus voltages for feedback, observation and waveform analysis.
12	Current Measurement Blocks	Four Specialized Power Systems current-measurement blocks.	Measure bridge, transfer-path and output currents used for monitoring and power evaluation.
13	PV Bus Selector	Outputs V_{PV} and I_{PV} from the PV measurement bus.	Extracts the measured PV voltage and current required by the MPPT/controller path.
14	MPPT_Controller (MATLAB Function)	Perturb-and-Observe logic; V_{ref} is updated from measured PV voltage and current.	Generates the PV operating-voltage reference used by the closed-loop phase-shift controller.
15	Sum1	Two-input summation block in the MPPT tracking loop.	Forms the tracking error between the measured PV voltage and the reference generated by the MPPT block.

16	PI Controller (PI2)	Parallel PI structure; Kp = 0.0005, Ki = 0.0001, Kd = 0; integrator initial condition = 1.	Processes the tracking error and produces the phase-control correction.
17	Phase-Bias Constant and Sum3	Bias constant stored as 25; Sum3 adds the PI output and bias signal.	Establishes the operating phase command supplied to the dynamic gate-generation block.
18	Clock Block	Simulation time signal t.	Provides instantaneous simulation time to the switching-function logic.
19	MATLAB Function - SPS Gate Generation	Internal switching frequency = 20 kHz; inputs ϕ and t; outputs G1, G2, J1 and J2.	Generates phase-displaced sinusoidal references and binary bridge-gate commands for SPS operation.
20	Logical Operator (NOT) Blocks	Two Boolean NOT blocks.	Generate complementary gate signals for the opposite devices of each bridge leg.
21	Goto / From Blocks	Tags include S1, S2, S11, S12, G1, G2, Vp, Vs, Ip, Is, V0, I0 and PV_data.	Route measurement and gate signals across the Simulink model without long physical signal lines.
22	Battery Bus Selector	Outputs SOC, battery current and battery voltage.	Separates battery measurements for monitoring and post-processing.
23	Transfer Function Block	First-order block with denominator [0.001 1].	Filters the battery-current signal for monitoring.

VII. DESIGN CALCULATIONS

The following design expressions establish the electrical sizing procedure of the proposed PV-fed Dual Active Bridge converter. The equations follow the PV-system design sequence used in the G5 progress work, while the DAB power-transfer relation is based on single-phase-shift operation as presented in the Texas Instruments reference design [1]. Numerical substitution is omitted so that the equations can be applied directly to the selected system parameters.

A. PV System Design

The required EV charging power is determined from the nominal battery voltage and the required charging current:

$$P_{EV} = V_{bat} \times I_{bat}$$

where P_{EV} is the required EV charging power, V_{bat} is the nominal battery voltage, and I_{bat} is the battery charging current.

Considering the power conversion efficiency of the DAB stage, the required photovoltaic array power is expressed as:

$$P_{PV} = \frac{P_{EV}}{\eta_{DAB}} \quad (2)$$

where P_{PV} is the required PV-array power and η_{DAB} represents the DAB converter efficiency.

For the series connection of PV modules, the required number of modules is determined as:

$$N_s = V_{string} / V_{mp} \quad (3)$$

The corresponding PV-string voltage is:

$$V_{string} = N_s \times V_{mp} \quad (4)$$

where N_s is the number of modules connected in series and V_{mp} is the maximum-power-point voltage of one PV module.

For the parallel configuration, the required number of strings is given by:

$$N_p = \left\lceil \frac{P_{PV}}{P_{string}} \right\rceil \quad (5)$$

The total PV-array current is then obtained as:

$$I_{array} = N_p \times I_{mp} \quad (6)$$

where N_p is the number of parallel strings, P_{string} is the power available from one series string, and I_{mp} is the module current at the maximum power point.

The total number of PV modules and the resulting PV-array power are therefore expressed as:

$$N_{total} = N_s \times N_p \quad (7)$$

$$P_{pv} = N_{total} \times P_{panel} \quad (8)$$

These relations define the series-parallel PV configuration required to supply the designed DAB converter.

B. SiC MOSFET Rating Calculation

The semiconductor switches used in both active bridges must be selected to withstand the maximum voltage and current stresses expected during converter operation. Suitable safety factors are therefore applied while determining the required MOSFET ratings.

The required drain-to-source voltage rating is expressed as:

$$V_{DS, rated} = K_V \times V_{DS, max} \quad (9)$$

and the selected device should satisfy:

$$V_{DS, rated} \geq K_V \times V_{DS, max} \quad (10)$$

where $V_{DS, rated}$ is the MOSFET voltage rating, $V_{DS, max}$ is the maximum voltage appearing across the switch, and K_V is the voltage safety factor.

Similarly, the required drain-current rating is:

$$I_{D, rated} = K_I \times I_{peak} \quad (11)$$

and the selected device should satisfy:

$$I_{D, rated} \geq K_I \times I_{peak} \quad (12)$$

where $I_{D, rated}$ is the MOSFET drain-current rating, I_{peak} is the maximum current through the DAB switch, and K_I is the current safety factor.

These conditions ensure that the selected SiC MOSFET operates within the required voltage and current limits of the DAB power stage.

C. DAB Leakage Inductance Calculation

The high-frequency transformer establishes the voltage relationship between the primary and secondary bridges. Its turns ratio is determined from the corresponding DC-side voltages as:

$$N = \frac{V_1}{V_2} \quad (13)$$

where N is the primary-to-secondary transformer turns ratio, V_1 is the primary-side DC voltage, and V_2 is the secondary-side DC voltage.

For single-phase-shift operation, the power transferred through the DAB converter is given by:

$$P = \frac{NV_1V_2\phi(\pi-|\phi|)}{2\pi^2f_sL} \quad (14)$$

where P is the transferred power, ϕ is the phase-shift angle in radians, f_s is the switching frequency, and L is the total leakage or transfer inductance.

Rearranging the power-transfer equation, the required DAB transfer inductance is obtained as:

$$L = \frac{NV_1V_2\phi(\pi-|\phi|)}{2\pi^2f_sP} \quad (15)$$

VIII. MATLAB/SIMULINK MODEL OF THE PROPOSED PV-FED DAB CONVERTER

The complete PV-fed Dual Active Bridge converter is implemented in MATLAB/Simulink by integrating the PV source, primary and secondary full bridges, series transfer inductor, high-frequency transformer, DC-link capacitors, closed-loop controller, and lithium-ion battery. Voltage and current measurement blocks are included to monitor the electrical behaviour of the PV source, DAB stage, and battery during operation.

The measured PV quantities are supplied to the MPPT control block to generate the operating reference. The feedback error is processed by a PI controller, which determines the phase-shift command for the DAB converter. A MATLAB Function block generates the phase-displaced switching signals, while complementary gate pulses are produced for both active bridges. By varying the relative phase displacement, the controller regulates the power transferred through the isolated DAB stage.

On the output side, the secondary bridge supplies the lithium-ion battery through the DC-link capacitor. Battery SOC, charging current, terminal voltage, and output power are monitored using simulation scopes to evaluate PV-to-battery power transfer and charging behaviour.

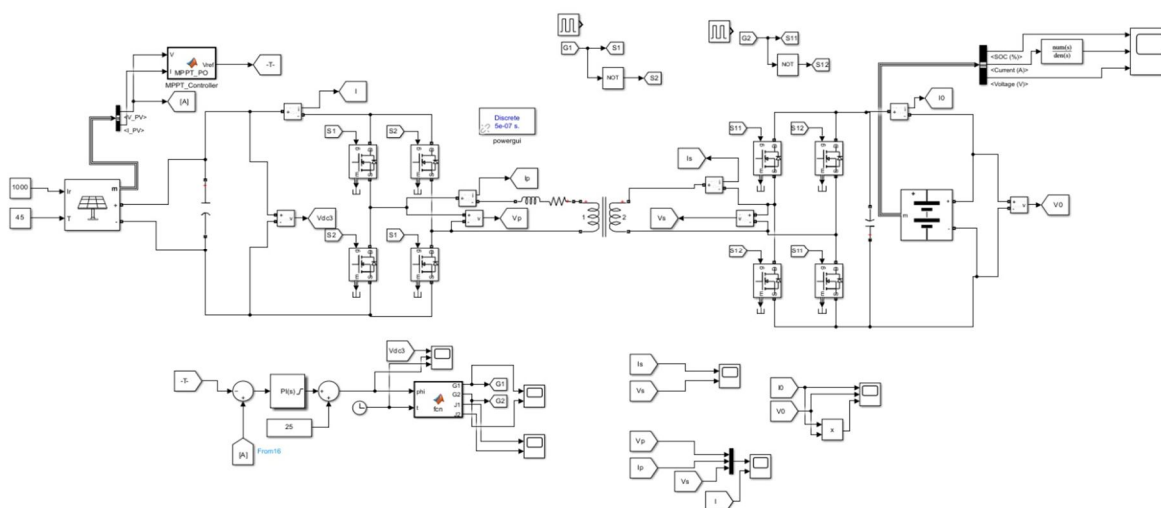


Fig. 2. MATLAB/Simulink model of the proposed PV-fed Dual Active Bridge converter with MPPT, closed-loop phase-shift control, and lithium-ion battery interface.

IX. RESULTS AND DISCUSSION

The final MATLAB/Simulink model demonstrates the operation of the proposed PV-fed Dual Active Bridge converter with the lithium-ion battery directly connected at the output. The PV source, two active bridges, high-frequency transformer, transfer inductor, phase-shift control and battery stage operate as an integrated system. The closed-loop controller generates the required phase displacement between the primary and secondary bridges, enabling controlled transfer of power from the PV array to the battery.

The battery waveforms confirm charging operation during the simulated interval. After the initial transient, the battery terminal voltage stabilizes at approximately 441 V, while the charging-current magnitude settles in the range of approximately 20–24 A. The negative sign observed in the current waveform is due to the selected measurement direction in the Simulink battery model and represents current flowing into the battery. The State of Charge increases from approximately 50.0000% to 50.0008% during the 0.3 s simulation period, confirming that energy is being supplied to the battery. Overall, the results verify successful PV-to-battery power transfer through the DAB converter and demonstrate the effectiveness of the closed-loop phase-shift control during battery charging. Since the simulation period is very short compared with the actual charging time of an EV battery, only a small increase in SOC is expected. The obtained voltage, current and SOC responses therefore provide direct simulation evidence that the developed converter can operate as an isolated PV-fed battery-charging interface.

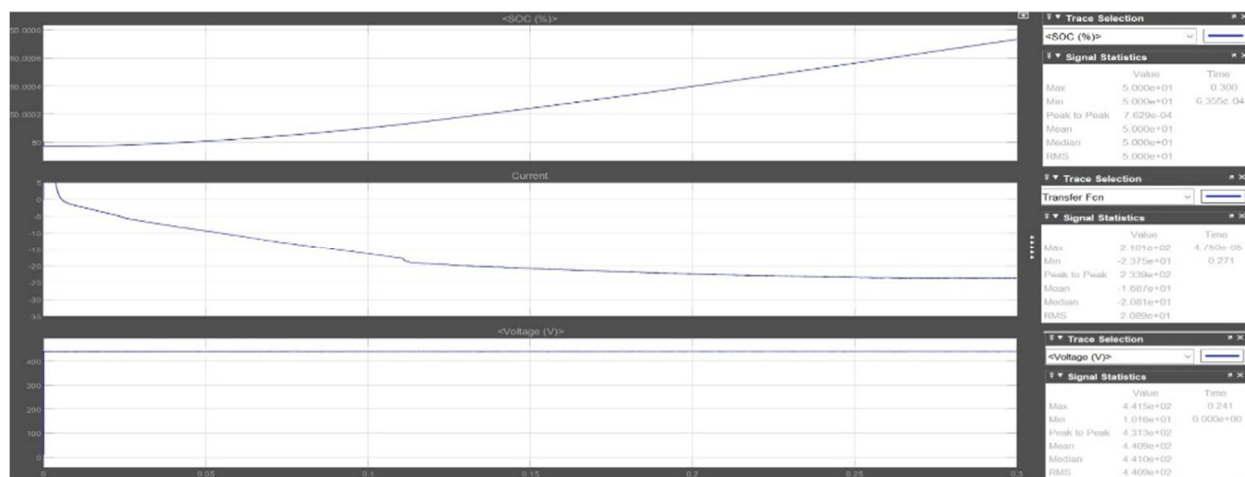


Fig. 3. Simulated lithium-ion battery response showing SOC, charging-current variation, and terminal-voltage behaviour during PV-fed DAB operation.

X. CONCLUSION AND FUTURE SCOPE

This paper presents the design and MATLAB/Simulink implementation of an approximately 11.56 kW PV-fed Dual Active Bridge converter for high-voltage EV battery charging. The developed system integrates the PV source, primary and secondary active bridges, high-frequency transformer, transfer inductance, single-phase-shift modulation, PI-based closed-loop control and a lithium-ion battery model. The phase-shift control regulates the power exchanged between the two bridges while the high-frequency transformer provides electrical isolation between the PV source and battery side.

The final simulation successfully demonstrates direct battery-charging operation. The battery voltage reaches a stable operating level of approximately 441 V, the charging current settles at approximately 20–24 A in magnitude, and the battery SOC shows a measurable increase from its initial value during the simulation period. These results confirm that power generated by the PV source is transferred through the DAB stage to the lithium-ion battery, thereby validating the proposed converter and control structure for PV-based EV charging.

A. Future Scope

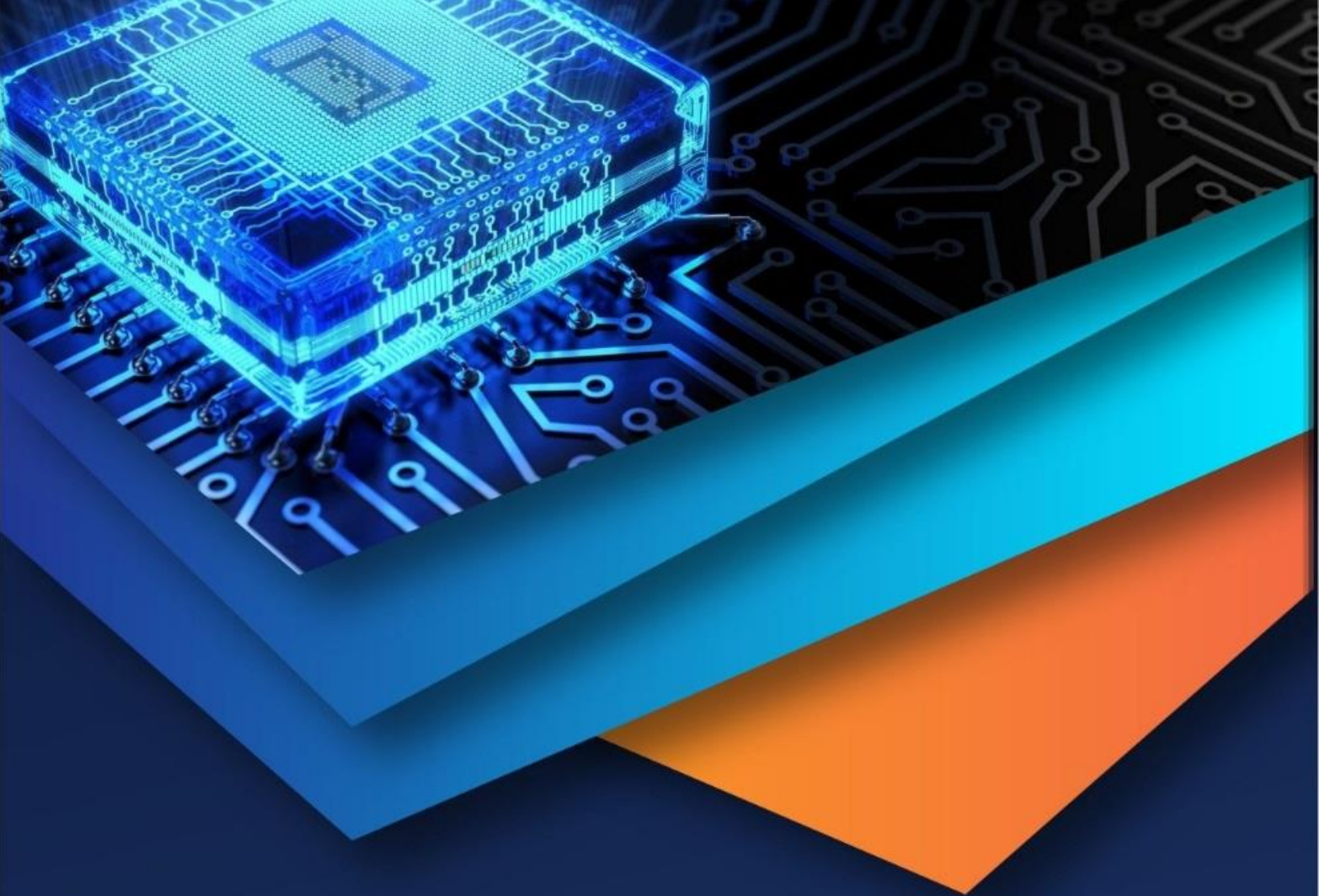
- Extend the simulation duration to study the complete battery-charging profile and SOC variation.
- Further tune the PI controller and phase-shift limits to improve dynamic response and voltage regulation.
- Incorporate battery current limiting and a suitable CC-CV charging strategy.
- Evaluate converter efficiency, semiconductor losses and transformer losses at different operating conditions.
- Study the system response under varying solar irradiance and PV operating conditions.
- Investigate Zero Voltage Switching (ZVS) and its effect on converter switching losses and efficiency.
- Develop a hardware prototype for experimental validation of the proposed PV-fed DAB battery-charging system.

XI. ACKNOWLEDGMENT

The authors gratefully acknowledge the guidance and continuous support of Dr. A. Deosant, Department of Electrical Engineering, Priyadarshini College of Engineering, Nagpur. The authors also thank the Head of the Department and the faculty of the Department of Electrical Engineering for providing the laboratory facilities and encouragement necessary for carrying out this work.

REFERENCES

- [1] Texas Instruments, "Bidirectional, Dual Active Bridge Reference Design for Level 3 Electric Vehicle Charging Stations," Design Guide TIDA-010054, Rev. F, Apr. 2026. [Texas Instruments](https://www.ti.com/lit/guide/tida-010054)
- [2] M. N. Kheraluwala, R. W. Gascoigne, D. M. Divan, and E. D. Baumann, "Performance Characterization of a High-Power Dual Active Bridge DC-to-DC Converter," *IEEE Transactions on Industry Applications*, vol. 28, no. 6, pp. 1294–1301, 1992.
- [3] D. A. Herrera-Jaramillo, D. González Montoya, E. E. Henao-Bravo, C. A. Ramos-Paja, and A. J. Saavedra-Montes, "Systematic Analysis of Control Techniques for the Dual Active Bridge Converter in Photovoltaic Applications," *International Journal of Circuit Theory and Applications*, vol. 49, no. 9, pp. 3031–3052, 2021.
- [4] S. Shao, L. Chen, Z. Shan, F. Gao, H. Chen, D. Sha, and T. Dragičević, "Modeling and Advanced Control of Dual-Active-Bridge DC–DC Converters: A Review," *IEEE Transactions on Power Electronics*, vol. 37, no. 2, pp. 1524–1547, 2022.
- [5] S. Atanalian, K. Al-Haddad, R. Zgheib, and H. Y. Kanaan, "Bidirectional Electric Vehicle Battery Charger Assisted by Photovoltaic Panels," in *Proc. 46th Annual Conference of the IEEE Industrial Electronics Society (IECON)*, Singapore, 2020, pp. 2327–2332.
- [6] S. S. Trivedi and A. V. Sant, "Comparative Analysis of Dual Active Bridge DC–DC Converter Employing Si, SiC and GaN MOSFETs for G2V and V2G Operation," *Energy Reports*, vol. 8, pp. 1011–1019, 2022.
- [7] A. A. Nkembi, P. Cova, I. Kortabarria, E. Sacchi, and N. Delmonte, "An Improved Modelling and Dynamic Control of the Dual Active Bridge Converter for Fast Battery Charging of Electric Vehicles," *IET Conference Proceedings*, vol. 2023, no. 17, pp. 247–254, 2023.
- [8] K. Srivastava, D. Firake, R. Maurya, and S. Kumar, "Analysis, Design, and Control of the Dual Active Bridge Converter for EV Battery Charging," in *2024 Third International Conference on Power, Control and Computing Technologies (ICPC2T)*, 2024, doi: 10.1109/ICPC2T60072.2024.10474716.
- [9] B. Muhammetoglu and M. Jamil, "Dual Active Bridge Converter with Interleaved and Parallel Operation for Electric Vehicle Charging," *Energies*, vol. 17, no. 17, Art. no. 4258, 2024.
- [10] J. Wang, B. Wang, L. Zhang, J. Wang, N. I. Shchurov, and B. V. Malozyomov, "Review of Bidirectional DC–DC Converter Topologies for Hybrid Energy Storage System of New Energy Vehicles," *Green Energy and Intelligent Transportation*, vol. 1, no. 2, Art. no. 100010, 2022.



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)