IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 13, Issue 4, April 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.317

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.13040010 |

Innovative Multiport Converter Design for High-Speed Electric Vehicle Charging

Daniel Sathyaraj.J[1,] Sheik Fazil.M[2], Hariprasad.A[3], Muthuraj.A[4] , Vetrivel Sudalai.S[5]

Assistant Professor, Department of EEE, Francis Xavier Engineering College, Tirunelveli, India[1]

UG Students, Department of EEE, Francis Xavier Engineering College, Tirunelveli, India[2,3,4,5]

ABSTRACT : As electric vehicles (EVs) continue to gain traction, the demand for efficient and high-power fast-charging stations is on the rise. This project proposes a novel Ring-Connected Dual Active Bridge (RC-DAB) based DC-DC multiport converter for EV fast-charging stations. The converter is designed to utilize the advanced features of the dspic30f2010 Digital Signal Processor (DSP) for enhanced control and performance. The RC-DAB architecture is chosen for its ability to provide bidirectional power flow and isolation between multiple ports, making it suitable for simultaneous charging of various types of batteries and power distribution in EV charging stations. The ring connection ensures fault tolerance and reliability in the converter operation .The hardware implementation employs the dspic30f2010 DSP to achieve precise control of the power conversion process. The DSP is utilized for real-time monitoring, control algorithm implementation, and feedback adjustments, enhancing the overall efficiency and reliability of the charging system**.**

KEYWORDS: MOSFET IRF40,TLP350,CONTROLLER DSPIC30F2010,BRIDGE INVERTER,DUAL ACTIVE BRIDGE CONVERTER,MULTITAP TRANSFORMER,INDUCTOR 1 MH,CAPACITOR 1000 UF,DIODE FR 207,HIGH FREQUENCY TRANSFORMER**.**

I.INTRODUCTION

Electric vehicle (EV) market has been growing extensively all over the world due to its promising advantages of high energy efficiencies and environmentally friendly performance due to zero emissions and the remarkable drop in its price. Therefore, the need for charging stations is increased to meet the growing number of EVs. EV chargers which are based on DC-DC converters, are two port-based chargers where individual power converters can be used to control the power flow among multiple sources in addition to the energy storage devices.

Traditional charging infrastructure often faces challenges in meeting the increasing power demands and compatibility requirements of modern EVs. To address these issues, an innovative multiport converter design emerges as a promising solution. This design integrates advanced power electronics and control algorithms to deliver faster charging while ensuring compatibility. Most existing topologies in EV chargers, which are based on DC-DC converters, are two port-based chargers where individual power converters can be used to control the powerflow among multiple sources in addition to the energy storage devices and EVs. However, multiport converters are better candidates for this application because multiport topologies utilize a lower number of components and, hence, achieve lower cost and higher power density compared to traditional systems that use individual power converters.

Various multiport topologies have been reported in the literature, where each of them has its pros and cons. Non isolated multiport topologies are the most common topologies for low power applications and low-to-medium voltage stepping ratios. Non-isolated multiport converters consist of different combinations of basic converter cells like a buck, boost, and/or buck-boost. Others combine half-bridge and full-bridge converters to form non isolated multiport converters. In addition, In, a multiple-input power converter (MIPC) is proposed, which is composed of multiple legs inverter so that each leg can be connected to a different port. It provides low switch count; however, it cannot tolerate DC faults. Other groups of non-isolated multiport topologies use simpler construction of one or two basic converters such as buck or boost or other non-isolated converters but require relays or low switching devices to reconfigure the power flow between multiple ports.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.13040010 |

II. PROPOSED METHOD AND DESCRIPTION

The proposed system introduces a innovative multiport converter design for high speed electric vehicle (EV) fast-charging stations, employing the dspic30f2010 Digital Signal Processor (DSP) for enhanced control. The RC-DAB topology enables bidirectional power flow and fault tolerance, making it well-suited for multiport applications. Leveraging the dspic30f2010 DSP allows real-time control, ensuring precise regulation of voltage and current with advanced control algorithms for optimal power flow. With multiport functionality, the system facilitates simultaneous charging of diverse EVs, accommodating varying battery types and voltages.The integration of the RC-DAB architecture and dspic30f2010 DSP not only enhances efficiency and reliability but also improves fault detection and tolerance, ensuring continuous operation even in the presence of faults, making it a promising solution for robust and efficient EV fast-charging infrastructure. The proposed system block diagram is displayed in Fig. 1 below

III. BLOCK DIAGRAM

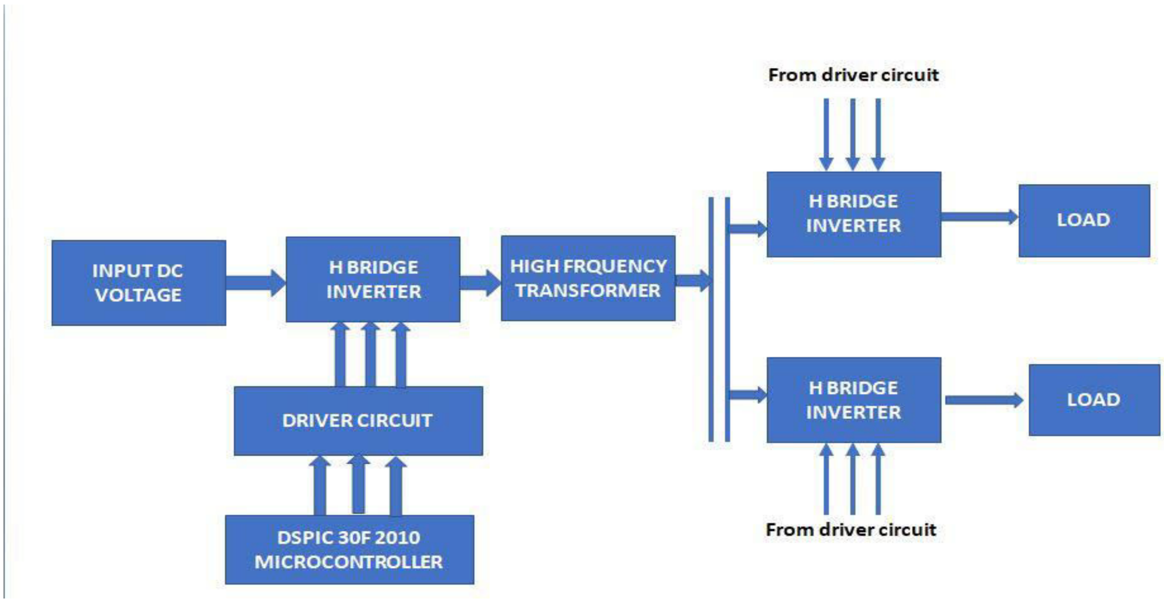


FIG 1-BLOCK DIAGRAM OF PROPOSED SYSTEM

Digital Signal Processing: A Digital Signal Processor (DSP) is a specialized microprocessor designed to efficiently process digital signals in real-time. DSPs excel at performing mathematical operations on digital signals, such as filtering, convolution, Fourier transforms, and modulation/demodulation. They are optimized for tasks like audio and video processing, telecommunications, and control systems.

High Frequency Transformer: High frequency transformer is a component that converts alternating voltage, current, and impedance. When an alternating current flows through the primary coil, an alternating magnetic flux is generated in the iron core (or magnetic core). At the same time, the voltage (or current) is induced in the secondary coil.

Dual Active Bridge Converter: The H-bridges in the DAB are operated to generate high frequency square wave voltage at the transformer terminals. One side of the H-bridge act as a DC/AC converter whereas the other side act as an AC/DC converter. The power flow in the converter is controlled by the phase shift (Φ) between the two square waves. Due to a high RMS current (hence conduction losses), and high switching losses, phase-shift modulation cannot be used for high-efficiency applications.

H-Bridge Inverter: An H-bridge inverter is an electronic circuit that allows a voltage to be applied across a load in either direction. It uses four controlled electronic switches that toggle states pairwisely. The term H-bridge is derived from the typical graphical representation of such a circuit. An H-bridge is built with four switches. When the switches S1 and S4 (according to the first figure) are closed (and S2 and S3 are open) a positive voltage is applied across the motor. By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed, allowing reverse operation of the motor.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.13040010 |

MultiTap Transformer: A Multi-tap transformer is a step-up or step-down transformer that has multiple taps on the primary or secondary winding, allowing it to adjust the volts/turn ratio. This can compensate for line drop and percent voltage regulation. Any increase in the number of turns in the primary will reduce the volts per turn ratio, thus lowering the secondary voltage.Any decrease in the number of turns in the primary will increase the volts per turn ratio, thus increasing the secondary voltage.

TLP: TLP250 stands for MOSFET IGBT driver optocoupler. It's an isolated IGBT/Mosfet driver IC that consists of an infrared emitting diode and an integrated photodetector. The TLP250 is suitable for gate driving circuits of IGBT or power MOS FET. It has an input threshold current of 5mA(max) and a supply current of 11mA(max).The TLP250 uses light to transmit electrical impulses. It has an input side GaAlAs light-emitting diode, and an integrated photodetector that provides a driving signal to the output side.

Diode: A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction.A diode is an electronic component with two terminals, the anode and the cathode, that conducts electricity in one direction. Diodes have low resistance in one direction and high resistance in the other.

Inductor: An inductor is a passive electrical component that stores energy in a magnetic field when electric current passes through it.Inductive charging is a technology that allows an electric vehicle (EV) to be charged without physical connectionsInductive Power Transfer (IPT) is one of the fastest evolving technologies in the development of Electric Vehicles (EVs).

Capacitor: A capacitor is a device that is used for storing electrical energy in an electric fieldCDE's custom-engineered DC Link capacitors are designed specifically for Level 3 EV charging applications. The high-power demands of Level 3 charging require robust DC link capacitors, having exceptional life and reliability over a broad range of operating conditions.Ultracapacitors are used in some electric vehicles to store rapidly available energy with their high power density, in order to keep batteries within safe resistive heating limits and extend battery life.

IV. CIRCUIT DIAGRAM

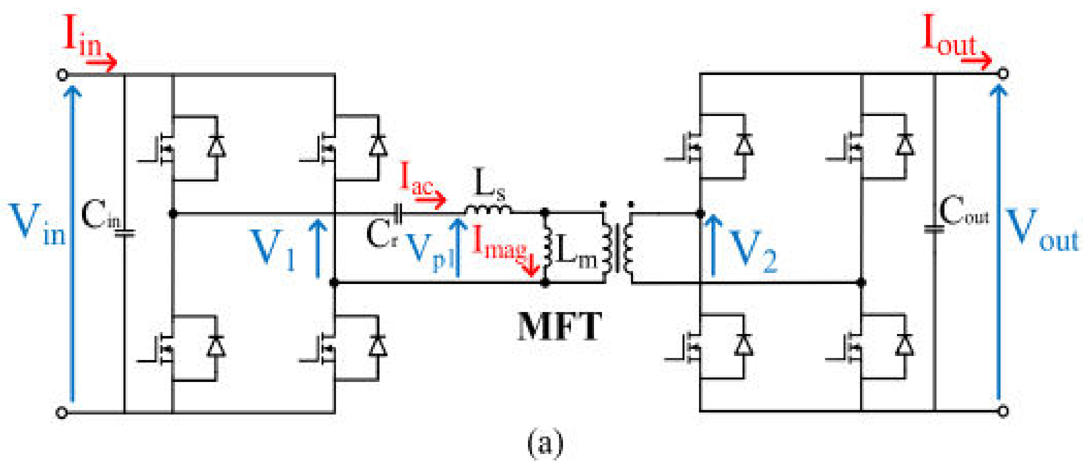


FIG 2-CIRCUIT DIAGRAM OF PROPOSED SYSTEM

V. CONCLUSION

A new multiport DC-DC converter has been proposed for electric vehicles’ fast-charging stations namely RCDAB topology. Since the RCDAB converter consists of ring-connected DABs with a theoretically infinite number of internal power flow solutions, a novel closed-loop control has been developed to determine the optimal operating point of each DAB that achieves the lowest total RMS current.It has a fully modular structure that is easily scalable to include additional ports, provides short circuit fault tolerance, open circuit fault tolerance (better availability due to redundant paths for power flow to/from each port).The RCDAB is a promising topology for multiport DC-DC converters in EV fast-charging stations, given the highly favorable features it has proven.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.13040010 |

VI. RESULTS AND DISCUSSION

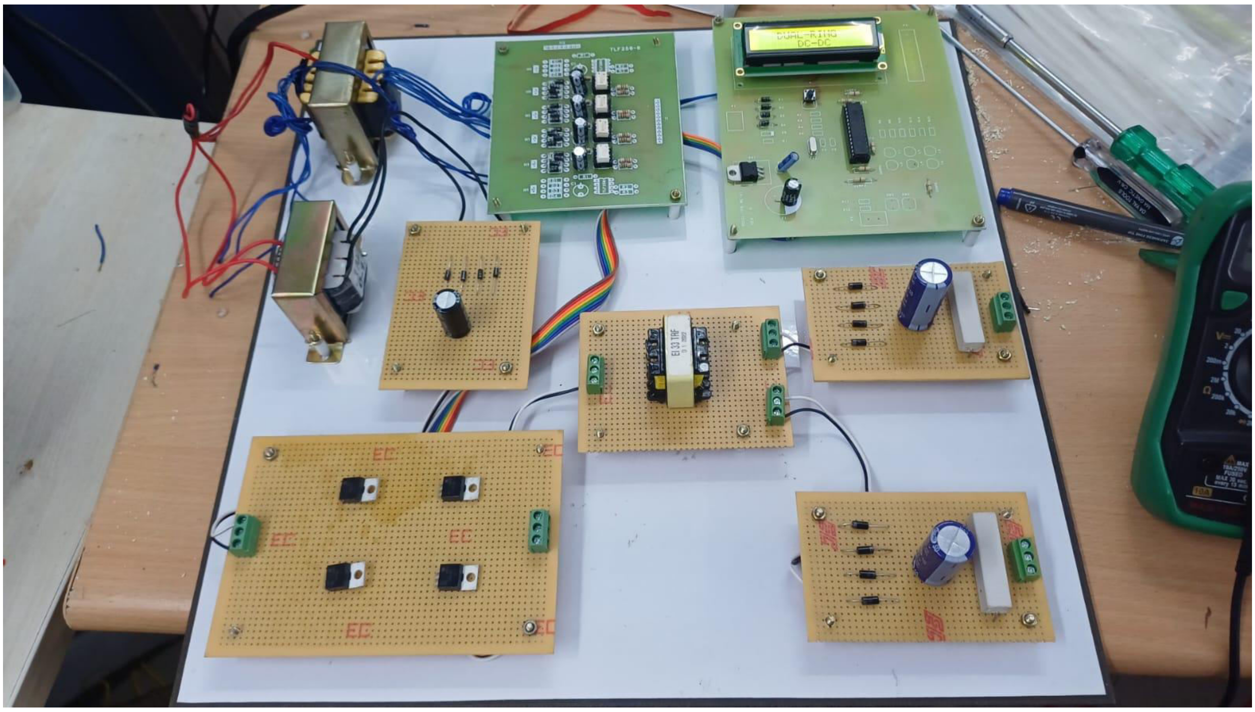


FIG 3-RESULT OF THE PROJECT

The Results and Discussion section of a paper on an innovative multiport converter design for high-speed EV fast-charging would typically present findings from experiments, simulations, or analyses related to the performance, efficiency, and feasibility of the proposed design. It may include comparisons with existing solutions, discussions on design trade-offs, and insights into potential applications and future improvements. Key points might cover aspects like charging efficiency, power density, thermal management, cost-effectiveness, and scalability. The section aims to provide a comprehensive understanding of the design's capabilities and limitations while contextualizing its significance within the field of EV charging technology.

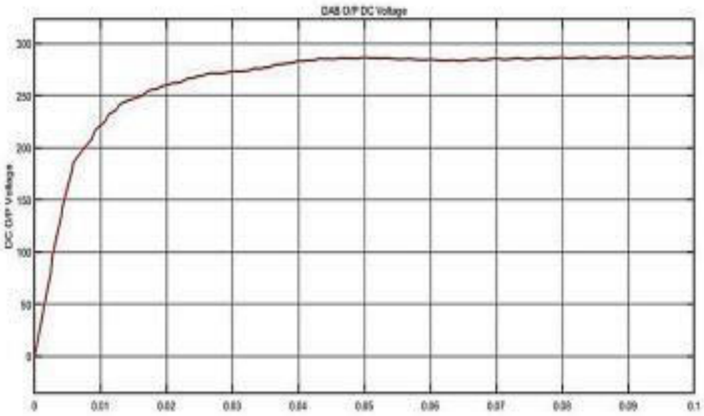


FIG 4-OUTPUT VOLTAGE WAVEFORM

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.317|| A Monthly Peer Reviewed & Referred Journal |

||Volume 13, Issue 4, April 2024||

| DOI:10.15662/IJAREEIE.2024.13040010 |

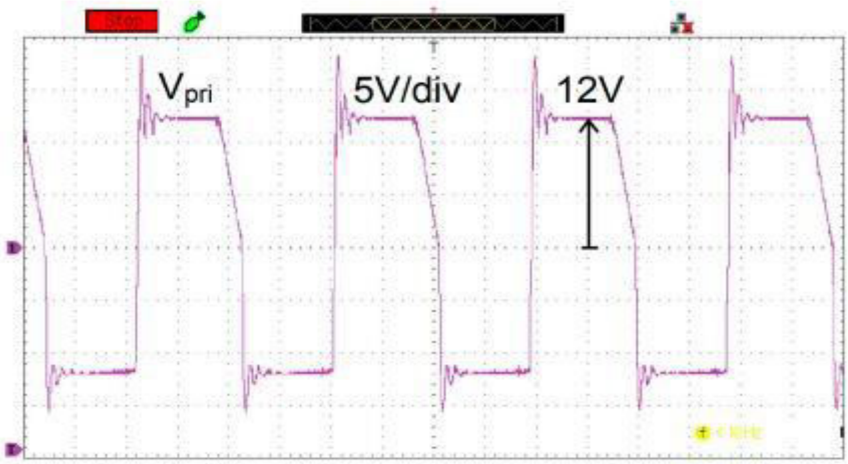


FIG 5-OUTPUT VOLTAGE OF H-BRIDGE AND INPUT TO HIGH-FREQUENCY TRANSFORMER.

REFERENCES

[1] J. Y. KIM, J. H. JEON, S. K. KIM, C. CHO, J. H. PARK, H.-M. KIM, AND K.Y. NAM, "COOPERATIVE CONTROL STRATEGY OF ENERGY STORAGE SYSTEM AND MICROSOURCES FOR STABILIZING THE MICROGRID DURING ISLANDED OPERATION," *IEEE TRANS. POWER ELECTRON.*, VOL. 25, NO. 12, PP. 3037-3048, DEC. 2010.

[2] H. QIAN, J. ZHANG, J. S. LAI, AND W. YU, "A HIGH-EFFICIENCY GRID-TIE BATTERY ENERGY STORAGE SYSTEM," *IEEE TRANS. ON POWER ELECTRON*., VOL. 26, NO. 3, PP. 886-896, 2011.

[3] J. HE AND Y. W. LI, "HYBRID VOLTAGE AND CURRENT CONTROL APPROACH FOR DG-GRID INTERFACING CONVERTERS WITH LCL FILTERS," *IEEE TRANS. ON IND. ELECTRON*., VOL. 60, NO. 5, PP.1797-1809, MAR. 2013.

[4] S. SRDIC AND S. LUKIC, ''TOWARD EXTREME FAST CHARGING: CHALLENGES AND OPPORTUNITIES IN DIRECTLY CONNECTING TO MEDIUM-VOLTAGE LINE,'' IEEE ELEC-TRIFIC. MAG., VOL. 7, NO. 1, PP. 22–31, MAR. 2019.

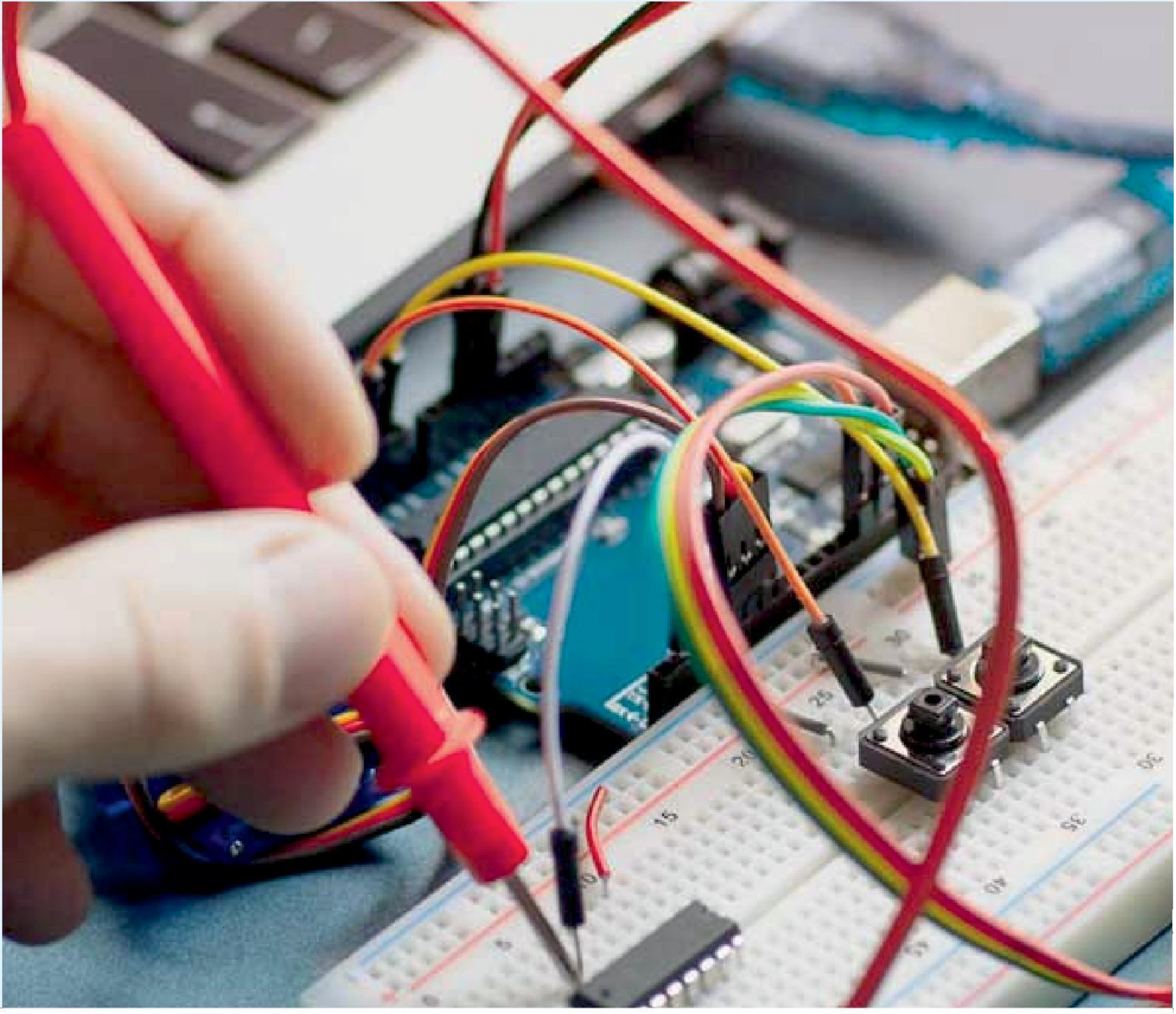
[5] C. BOTSFORD AND A. SZCZEPANEK, ''FAST CHARGING VS. SLOW CHARGING: PROS AND CONS FOR THE NEW AGE OF ELECTRIC VEHICLES,'' IN PROC. INT. BATTERY HYBRID FUEL CELL ELECTR. VEHICLE SYMP., 2009, PP. 1–9.

[6] H. TU, H. FENG, S. SRDIC, AND S. LUKIC, ''EXTREME FAST CHARGING OF ELECTRIC VEHICLES: A TECHNOLOGY OVERVIEW,'' IEEE TRANS. TRANSPORT. ELECTRIFIC.,VOL. 5, NO. 4, PP. 861–878, DEC. 2019.

[7] IEEE STANDARD TECHNICAL SPECIFICATIONS OF A DC QUICK CHARGER FOR USE WITH ELECTRIC VEHICLES, IEEE STANDARD 2030.1.1-2015, 2016, PP. 1–97.

[8] IEEE DRAFT STANDARD TECHNICAL SPECIFICATIONS OF A DC QUICK AND BI-DIRECTIONAL CHARGER FOR USE WITH ELECTRIC VEHICLES, DOCUMENT IEEE P2030.1.1/D1, FEB. 2021, PP. 1–159.

[9] M. GRENIER, T. THIRINGER, AND M. G. H. AGHDAM, ''DESIGN OF ON-BOARD CHARGER FOR PLUG-IN HYBRID ELECTRIC VEHICLE,'' IN PROC. 5TH IET INT. CONF. POWER ELECTRON., MACH. DRIVES (PEMD), 2010, P. 152.



INNO SPACE
SJIF Scientific Journal Impact Factor

doi crossref

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

Scan to save the contact details

www.ijareeie.com