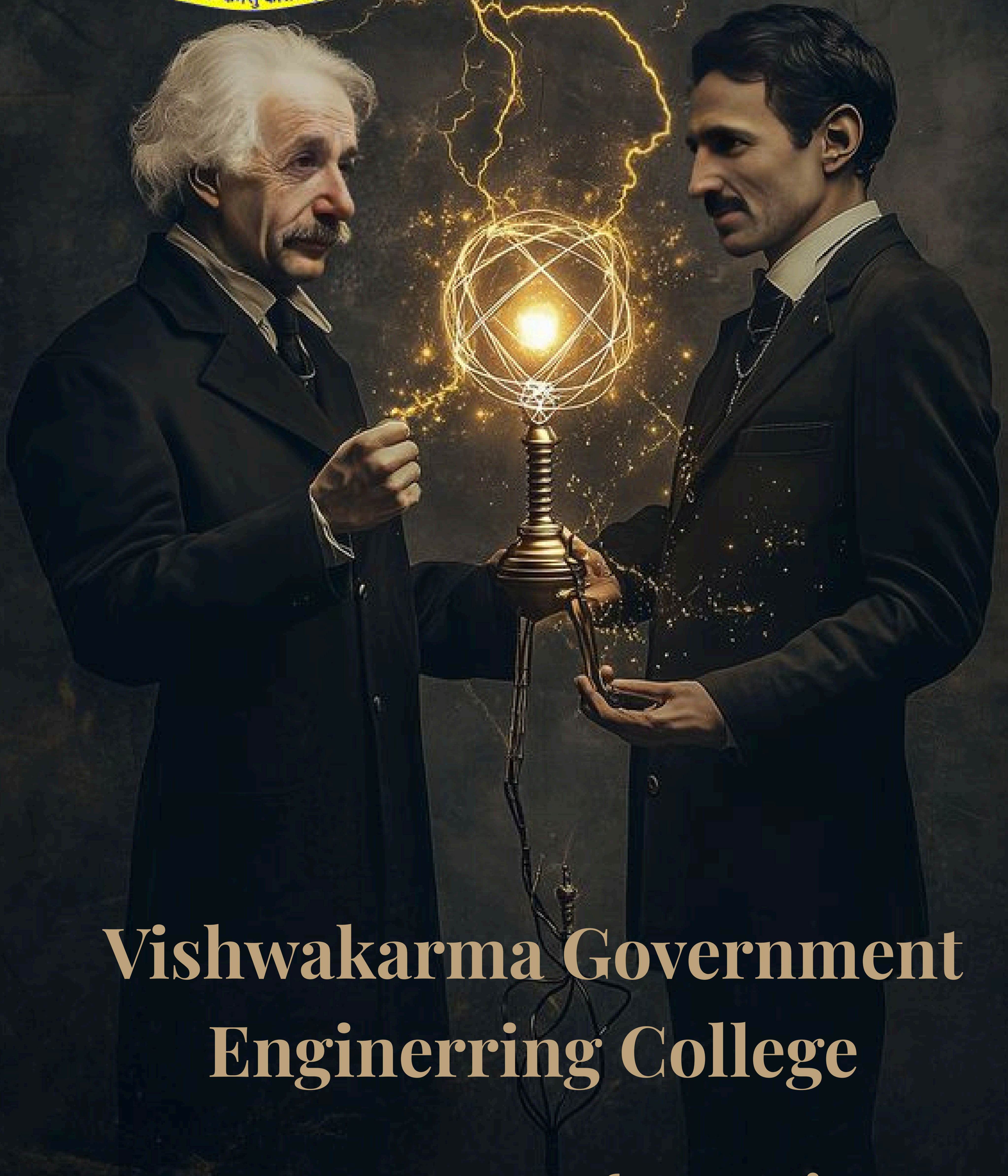




tarang

MARCH 2025



**Vishwakarma Government
Engineering College**

**Department of Electrical
Engineering**

VISION

To produce comprehensively trained, socially responsible and innovative electrical graduates to contribute to the society.

MISSION

- To develop well equipped laboratories and infrastructure for conducive learning.
- To produce competent and disciplined electrical engineers to serve the nation.
- To help in building national capabilities for excellent energy management and to explore nonconventional energy sources.
- To produce electrical engineers with an attitude to adapt themselves to changing technological environment.
- To enhance entrepreneurship skills through startup.

PEOs

- Develop and conduct appropriate electrical experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- Acquire and apply new knowledge as needed, using appropriate learning strategies through innovation.
- Work independently on a project or as a team leader.
- Get an employment in various government and private sector Companies, pursue research and innovation.

PSOs

- Apply electrical engineering knowledge to analyze, test, and develop innovative solutions for industries and entrepreneurship which aim to address the relevant societal and environmental issues.
- Utilize various modern electrical instruments and simulation tools to design, analyze, and optimize complex electrical circuits and networks, incorporating existing and emerging technologies.
- Exhibit technical expertise in evaluating and modifying electrical systems for energy efficiency, automation, interdisciplinary collaboration, and real-world problem-solving.

HOD's Message



On the Importance of MMC and Software Tools in Modern Electrical Engineering

Dear Students and Readers,

In today's rapidly evolving energy landscape, two key developments are significantly shaping the future of electrical engineering: Modular Multilevel Converters (MMC) and the use of advanced software tools in system design and control.

MMC technology has become essential in modern power electronics due to its scalable, efficient, and modular design. It plays a critical role in HVDC transmission systems, renewable energy integration, and industrial drives, offering better voltage quality, reduced harmonics, and improved system reliability.

Alongside this hardware innovation, software tools such as MATLAB/Simulink, Typhoon HIL, and PSCAD have transformed how engineers work. These platforms allow us to model, simulate, and test complex electrical systems with high accuracy—making engineering work faster, safer, and more cost-effective. Students now have the opportunity to test real-time systems virtually, gaining experience that closely mirrors industry practices.

Our department ensures that students are trained not just in theoretical concepts but also in using these powerful tools, preparing them to solve real-world problems and contribute to future technologies.

Let us continue to build an engineering community that embraces both technical excellence and digital innovation.

Warm regards,
Dr. S. N. PANDYA
Head of Department
Department of Electrical Engineering
VGEC-Chandkheda

Editorial Committee

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SEM 8



PARTH VADHVANA
SEM 8

The Marvel of Modular Multilevel Converters: Unveiling the MMC-Wizard

Introduction

In the dynamic world of power electronics, where efficiency, reliability, and scalability are paramount, the Modular Multilevel Converter (MMC) stands as a groundbreaking innovation. This advanced power electronic converter excels in bidirectional power conversion, efficiently transforming DC to AC and vice versa. Its unique capabilities make it indispensable in high-voltage and high-power applications, including HVDC (High Voltage Direct Current) transmission, advanced electric drives, renewable energy integration, and modern power grids.

The MMC has emerged as a superior alternative to traditional converters, including conventional Multilevel Inverters (MLIs), for a variety of compelling reasons. Let's explore the technological strengths that make the MMC a true marvel in power electronics.



Prof. Nilesh J. Patel

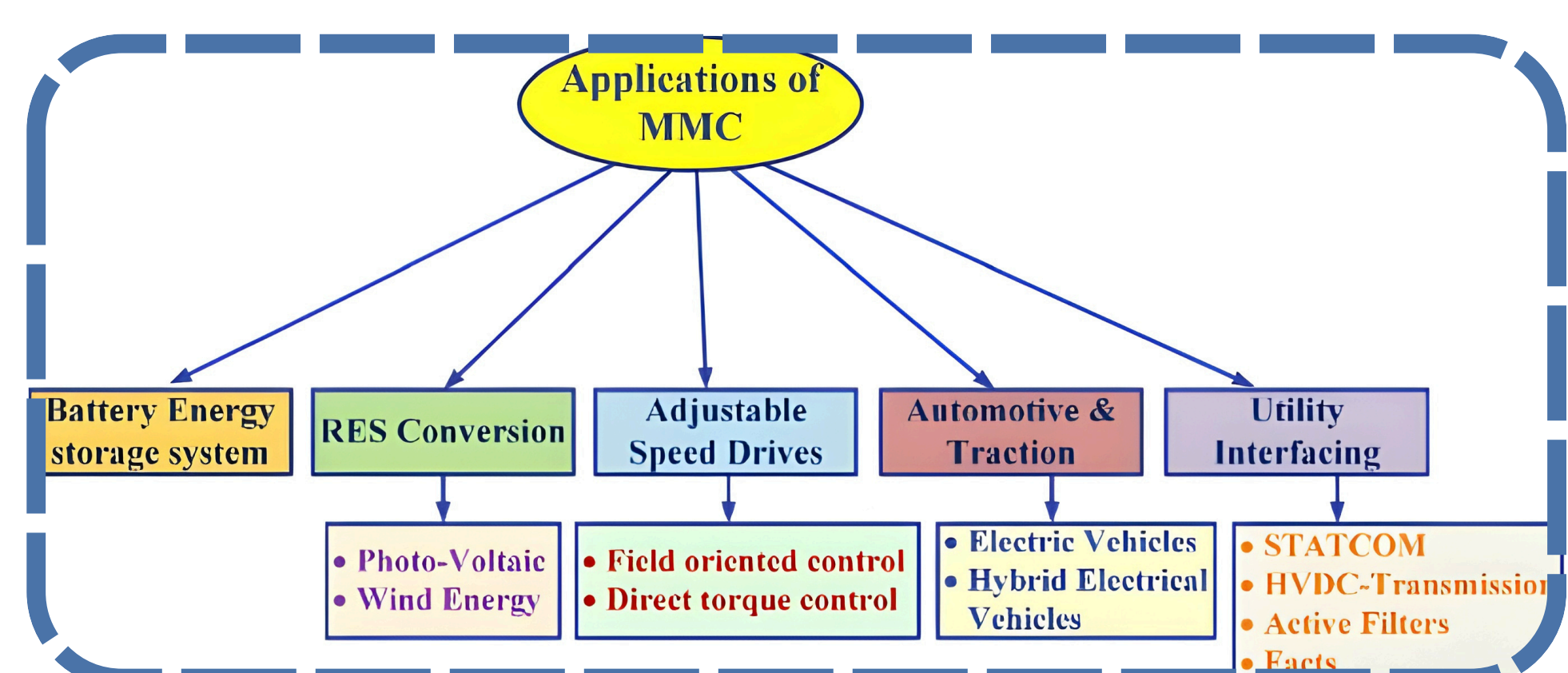
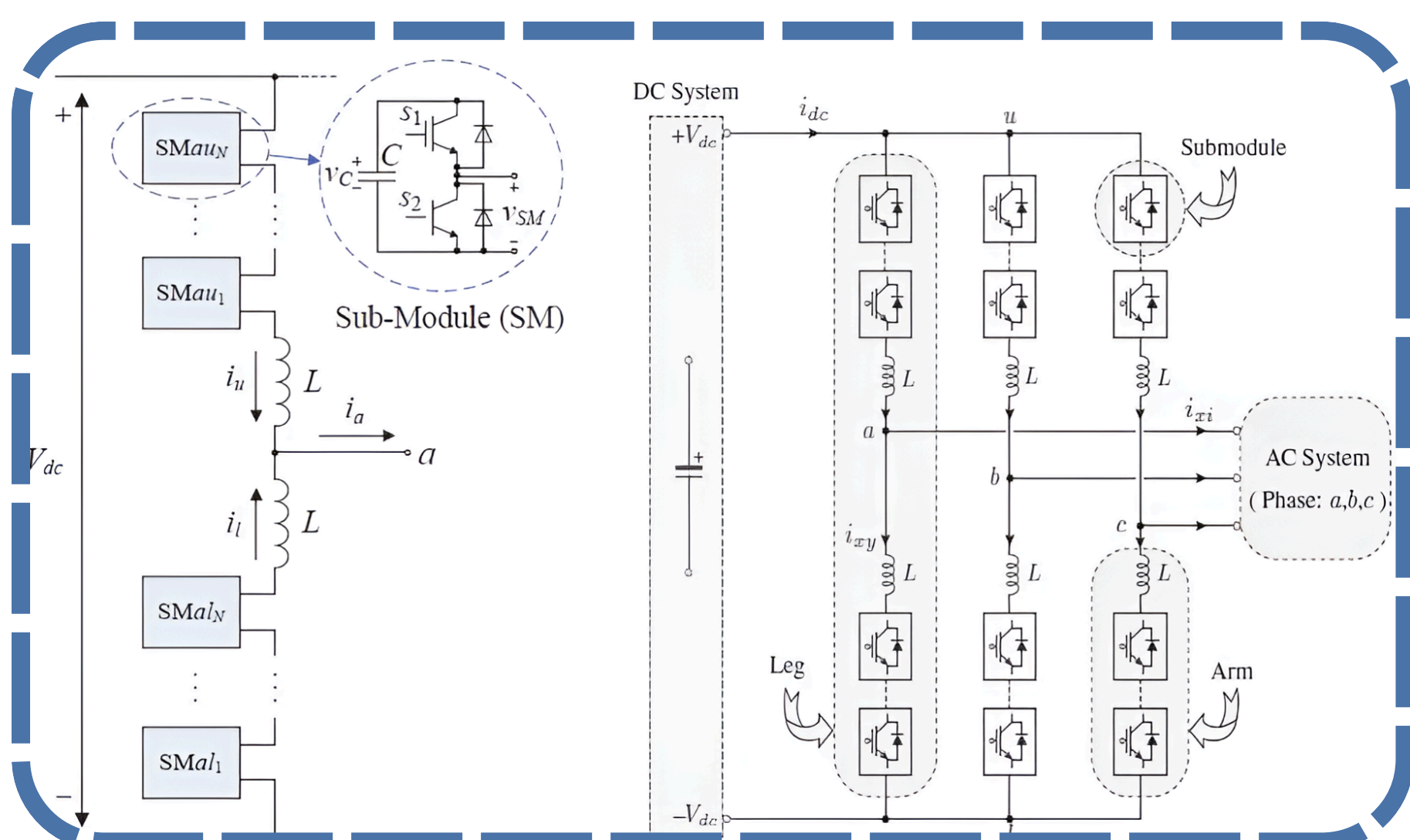
1. Superior Output Quality: Taming the Harmonics

A hallmark of the MMC is its ability to generate exceptionally smooth and sinusoidal output voltages. It achieves this by synthesizing the output from numerous small voltage steps, contributed by individual sub-modules. This results in a waveform that closely resembles a pure sine wave, significantly reducing harmonic distortion. In contrast, conventional converters like 2-level or 3-level inverters often produce more distorted waveforms, which require bulky and costly filters to suppress harmonics. The MMC often eliminates the need for such large filters, leading to space savings, reduced cost, and better system efficiency.

2. Unparalleled Scalability: Modular Building Blocks for Power

The core brilliance of the MMC lies in its modular architecture. Built from many identical sub-modules, the converter can be scaled easily by adding more modules in series to meet higher voltage or power demands. This modularity allows designers to adapt the system architecture with minimal redesign—akin to stacking more bricks to build a stronger wall.

In contrast, scaling up conventional MLIs or 2-level inverters typically requires complex and time-consuming redesign, making the MMC far more flexible for future expansion.



3. High Efficiency and Low Switching Losses

The MMC achieves high energy efficiency primarily due to its low switching frequency. Power devices like IGBTs operate at lower frequencies, which reduces switching losses and minimizes heat generation. Consequently, less cooling infrastructure is needed, further enhancing the system's overall efficiency.

Other converter topologies often resort to higher switching frequencies to improve output quality, which unfortunately increases losses and thermal stress. The MMC strikes an excellent balance between output quality and thermal performance.

4. Maintenance-Friendly Modular Design

The MMC's modular structure not only supports scalability but also simplifies maintenance. In the event of a failure, a single faulty sub-module can be easily replaced without disrupting the entire system—similar to swapping out a battery in a remote control.

Traditional converter systems, being more integrated, often require a complete shutdown for maintenance or repair, leading to longer downtimes. The plug-and-play nature of MMC modules makes them ideal for critical applications where uptime is crucial.

5. Robust Fault Handling Capabilities

MMC systems offer advanced fault-tolerant mechanisms. In case of a module failure, the converter can block or bypass the faulty module, allowing continued operation—though possibly at reduced capacity. This capability is especially vital in HVDC transmission or large-scale renewable integration, where abrupt shutdowns can have wide-reaching impacts.

Most conventional converters lack such robust fault-handling features, often necessitating full system shutdown during fault conditions.



Modular Multilevel Inverter

Key Points:

- Scalability & Modularity: Easy to expand and maintain.
- High Efficiency: Lower switching losses and better power handling.
- Reduced Harmonics: Improves output quality and reduces filtering needs.
- Voltage Stress Management: Uniform voltage sharing across switches.
- Application Versatility: Widely used in HVDC, renewables, and industrial drives.
- Future Ready: Ideal for smart grids and energy-efficient technologies.

The MMC isn't just a converter—it's the silent force empowering the energy revolution.

Conclusion: The Rise of the MMC-Wizard

Modular Multilevel Converters (MMCs) represent a major leap in power conversion technology. With their modular design, high efficiency, and low harmonic distortion, MMCs are redefining how power is transmitted, distributed, and utilized—especially in high-voltage and renewable energy applications. Their ability to scale easily, reduce stress on components, and improve power quality makes them a cornerstone of next-generation power systems. As industries shift toward greener and smarter energy, MMCs stand at the heart of this transformation, enabling a more reliable and sustainable electrical future.

India's Power Sector Year-End 2024: Technical Advances & Infrastructure Outlook

Introduction

India's power sector witnessed significant progress in 2024, with advancements in generation capacity, grid modernization, storage, and consumer-oriented reforms. This document provides a technical summary of the Ministry of Power's key initiatives and outcomes.



Prof. R.R. Surani

Record Demand & Improved Reliability

Peak demand met: 250 GW in FY 2024-25, reflecting robust generation and transmission capabilities.

- Energy shortage reduced from ~4.2% (2013-14) to just 0.1% (2024-25).
- Per capita electricity consumption in India has surged to 1,395 kWh in 2023-24, marking a 45.8% increase (438 kWh) from 957 kWh in 2013-14.



Electrification & Access

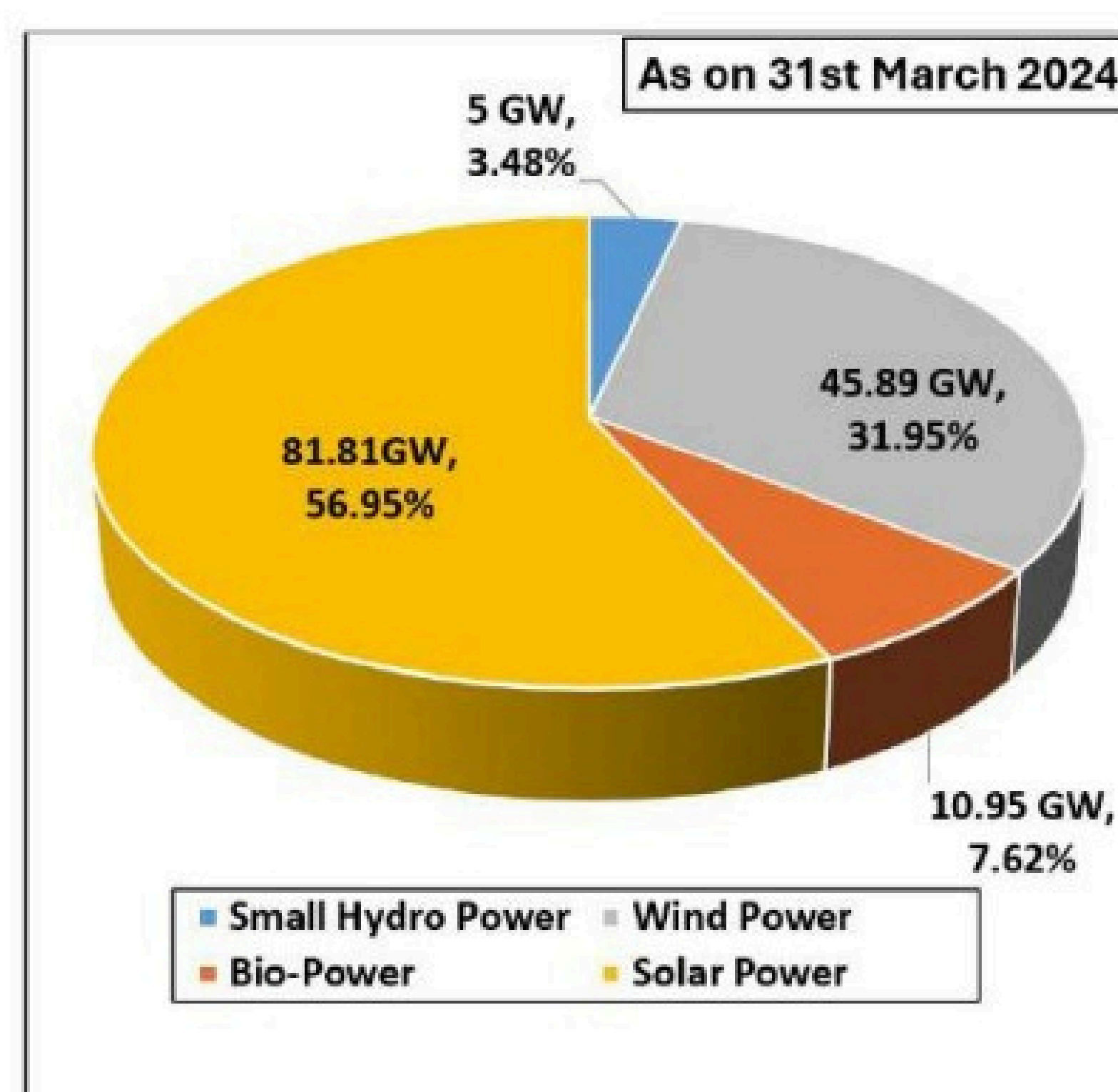
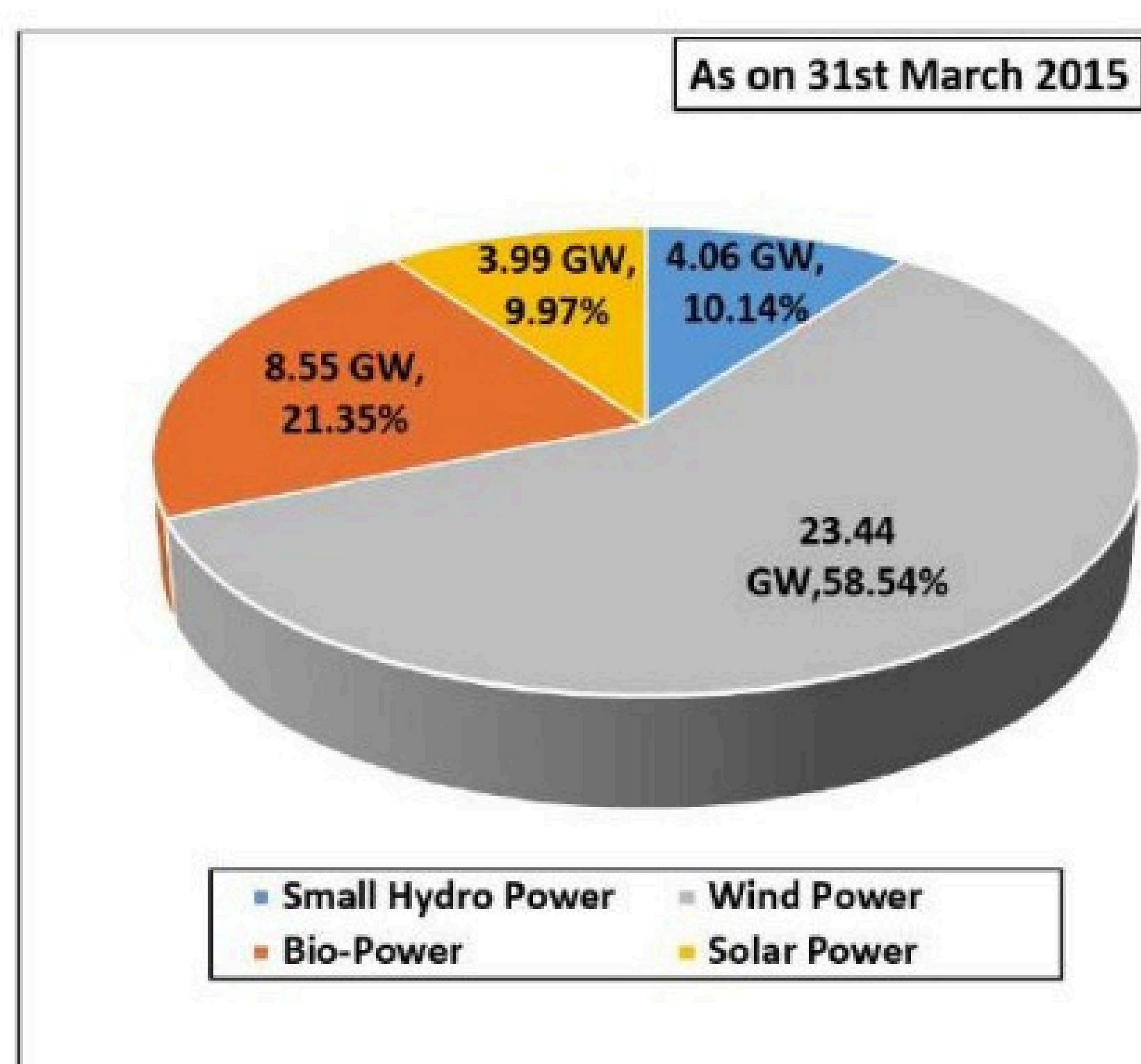
- Universal household electrification has been achieved in both rural and urban areas.
- Rural power supply increased to ~21.9 hours/day; urban supply averages ~23.4 hours/day.

Generation Capacity Expansion

- Installed capacity increased from 249 GW (2014) to 457 GW (2024).
- Renewable capacity added since 2014: 91 GW solar, 27 GW wind, 3.2 GW biomass, 1.3 GW small hydro, 6.3 GW large hydro.
- Thermal: 217.5 GW existing, 29.2 GW under construction, 36.3 GW planned.

Energy Storage Initiatives

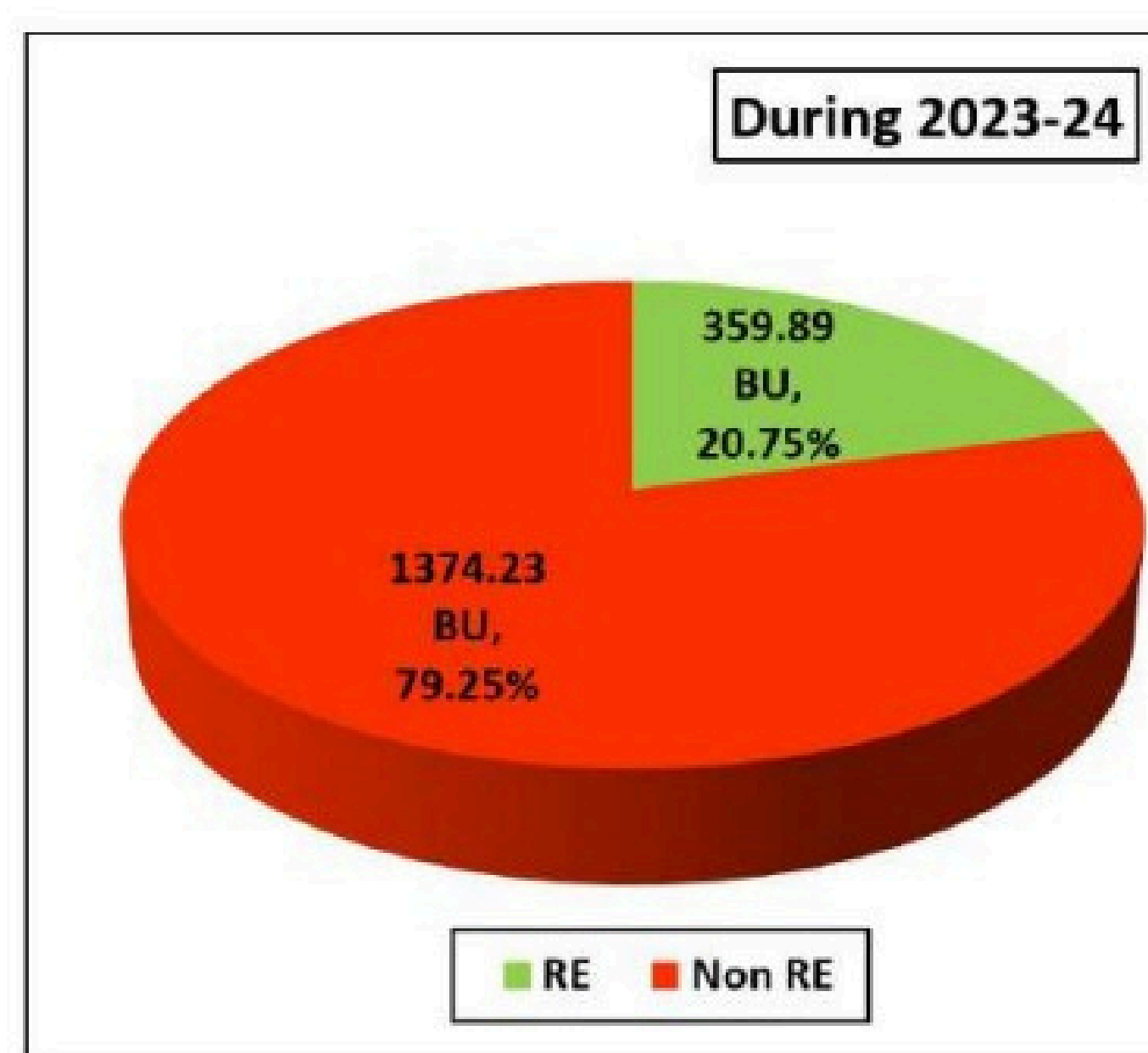
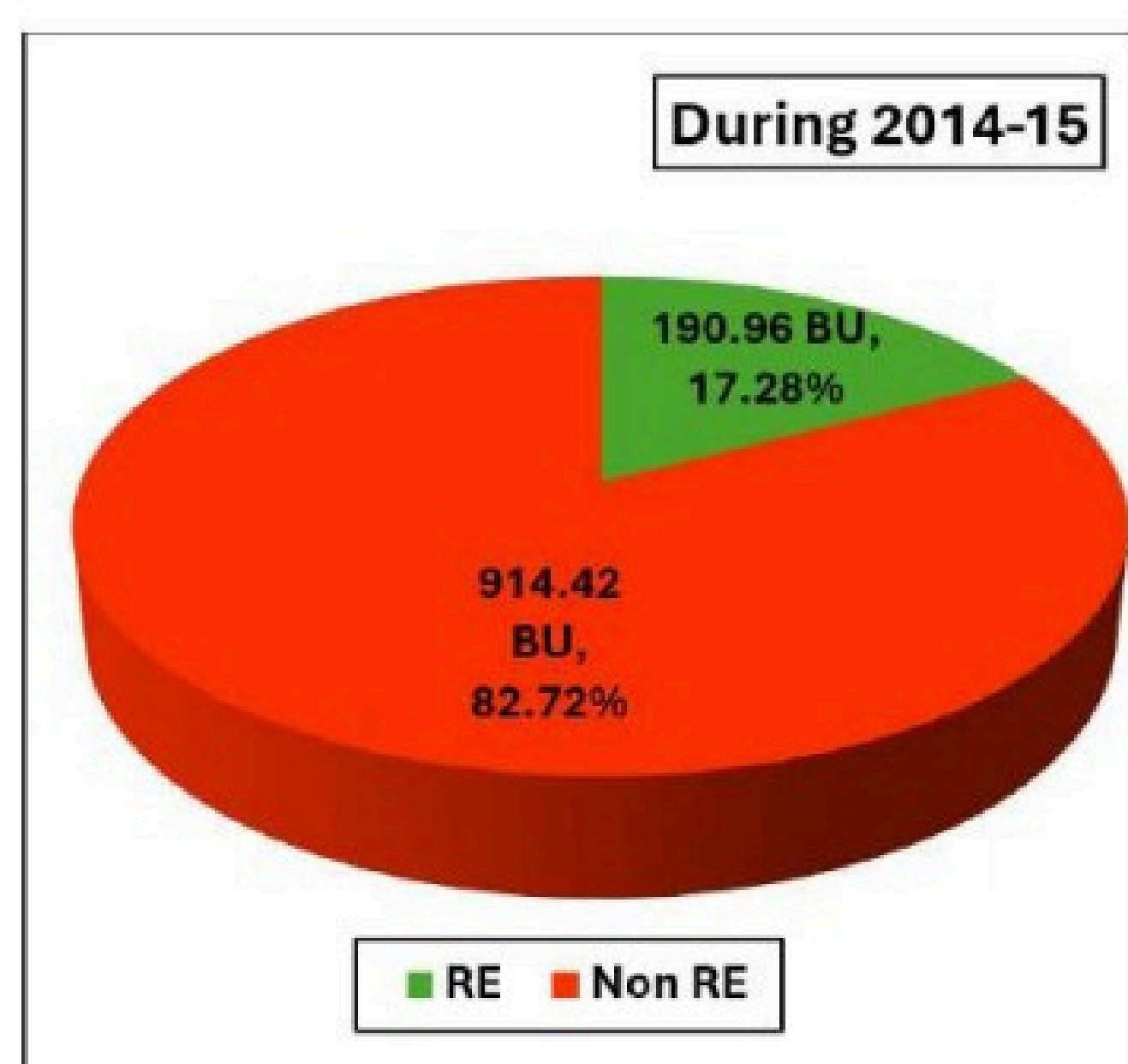
- Pumped storage potential estimated at 181 GW; only ~5 GW developed; 35 GW target set by 2032.
- 13,000 MWh of battery energy storage supported under Viability Gap Funding.



Share of various sources in RES Cumulative Installed capacity

Transmission Network & Planning

- Transmission capacity to grow from 4.91 lakh ckm (2024) to 6.48 lakh ckm (2032).
- Transformation capacity to increase from 1290 GVA to 2342 GVA.
- 50.9 GW of ISTS transmission projects approved to support 280 GW renewables by 2030.
- Right-of-Way compensation improved to accelerate project execution.



During last 9 years, contribution of Renewable Energy sector to total Energy generation increased from 17.28% of 2014-15 to 20.75% by 2023-24

Distribution & Consumer-Centric Reforms

- Smart meter rollout: 20 million prepaid meters, 5.25 million DT meters, 0.21 million feeder meters under RDSS.
- AT&C losses reduced to 15.37%; ACS-ARR gap reduced to ₹0.45/kWh.
- New consumer rules: faster connections, simplified rooftop solar, and separate EV metering.

Cybersecurity & EV Infrastructure

- CSIRT-Power launched as a dedicated cybersecurity team for the power sector.
- EV charging infrastructure to grow from 34,000 to 100,000 chargers by 2030.



India needs 13 lakh charging stations by 2030 to support EV mission: CII

Technical Significance & Outlook

(in BU)

Year	Non-RE		RE			Grand Total	Share (%)	
	Thermal	Nuclear	Large Hydro	RES*	Total		RE	RES*
2014-15	878.32	36.10	129.24	61.72	190.96	1105.38	17.28	5.58
2015-16	943.79	37.41	121.38	65.78	187.16	1168.37	16.02	5.63
2016-17	994.22	37.92	122.38	81.55	203.93	1236.08	16.50	6.60
2017-18	1037.10	38.30	126.10	101.84	227.94	1303.34	17.49	7.81
2018-19	1072.22	37.81	134.89	126.76	261.65	1371.68	19.08	9.24
2019-20	1042.75	46.47	155.77	138.34	294.11	1383.33	21.26	10.00
2020-21	1032.51	43.03	150.30	147.25	297.55	1373.09	21.67	10.72
2021-22	1114.71	47.11	151.63	170.91	322.54	1484.36	21.73	11.51
2022-23	1206.15	45.83	162.10	203.55	365.66	1617.58	22.61	12.58
2023-24	1326.29	47.94	134.05	225.84	359.89	1734.12	20.75	13.02
Gr (2014-15 to 2023-24)	51.00%	32.80%	3.72%	265.89%	88.46%	56.88%		
CAGR (2014-15 to 2023-24)	4.69%	3.20%	0.41%	15.50%	7.29%	5.13%		

Source: CEA, Ministry of Power (MoP)

*RES constitutes Solar, Wind, Bio-Power & Small Hydro Power

Gr=Growth (%)

CAGR=Compound Annual Growth Rate

During last 9 years, Renewable Energy sector has a remarkable contribution in the total installed capacity with a significant share of 43.12% in 2023-24 from 29.44% of 2014-15.

The Ministry of Power’s 2024 initiatives reflect a robust and technically advanced trajectory for India’s energy sector. Key outcomes include system resiliency, renewable integration, smart grid deployment, and cybersecurity measures. India’s focus on low-carbon, digital, and resilient infrastructure places it on a firm path toward its 2030 energy goals.

Reference

Ministry of Power, Government of India. (2024). Year-End Review – 2024: Major Achievements and Initiatives in the Power Sector. Press Information Bureau. Retrieved from <https://pib.gov.in/PressReleasePage.aspx?PRID=2089243>

TMS320 DSP Controller: Powering the Next Generation of Power Electronics Engineers

Introduction

In the rapidly evolving landscape of electrical and power electronics engineering, Digital Signal Processors (DSPs) have become essential tools for advanced control and signal processing tasks. Among them, Texas Instruments' TMS320 series has emerged as a leading choice for engineers designing inverters, motor drives, power converters, and other high-performance embedded systems.

The TMS320 series offers high-speed, real-time processing capabilities along with robust peripheral support, making it ideal for applications in smart grids, renewable energy systems, and electric vehicles. For electrical engineering students and professionals, understanding and utilizing TMS320 controllers is a stepping stone to working with the very systems shaping our energy future.



Karan Menariya

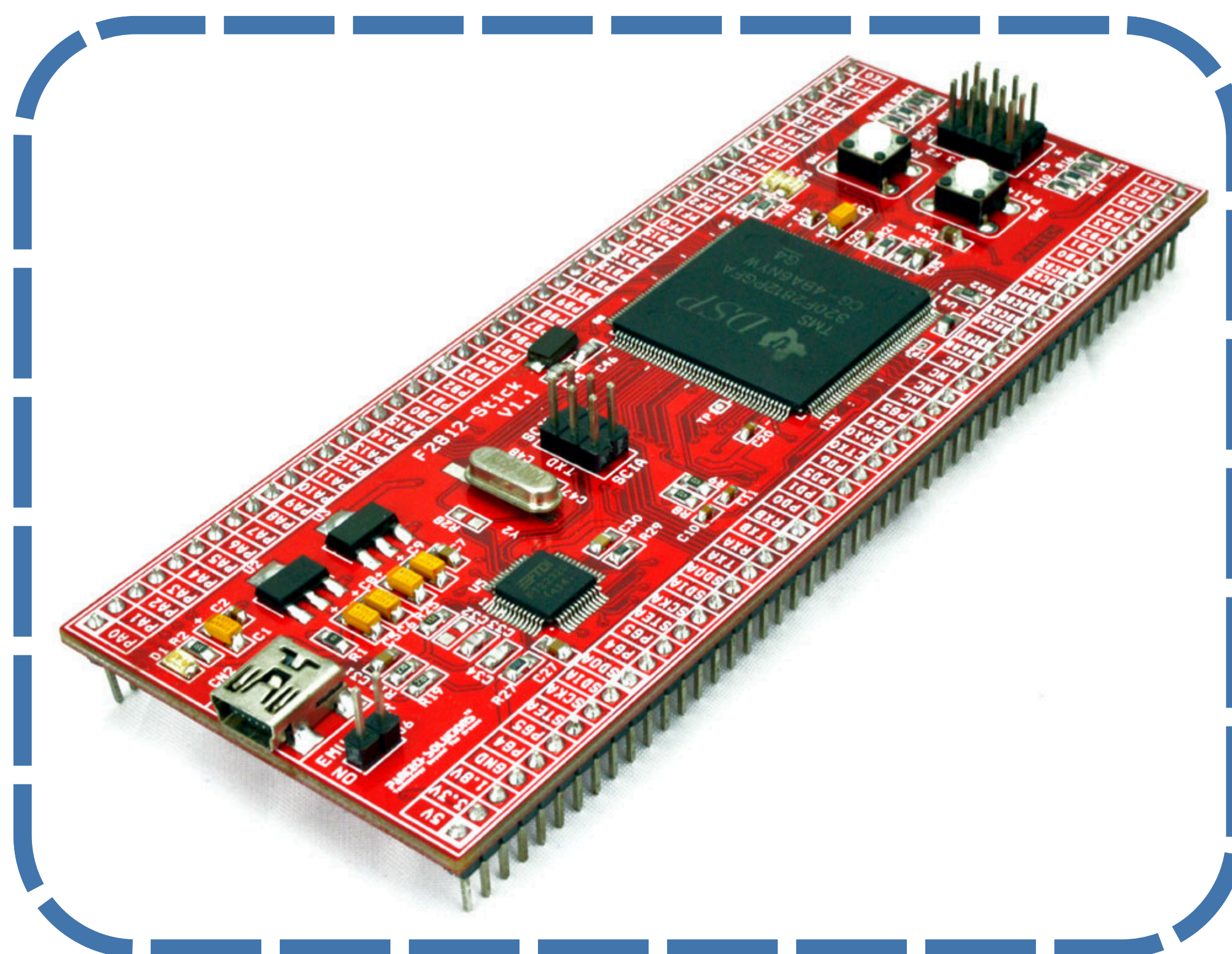
Usage of TMS320 in Power Electronics

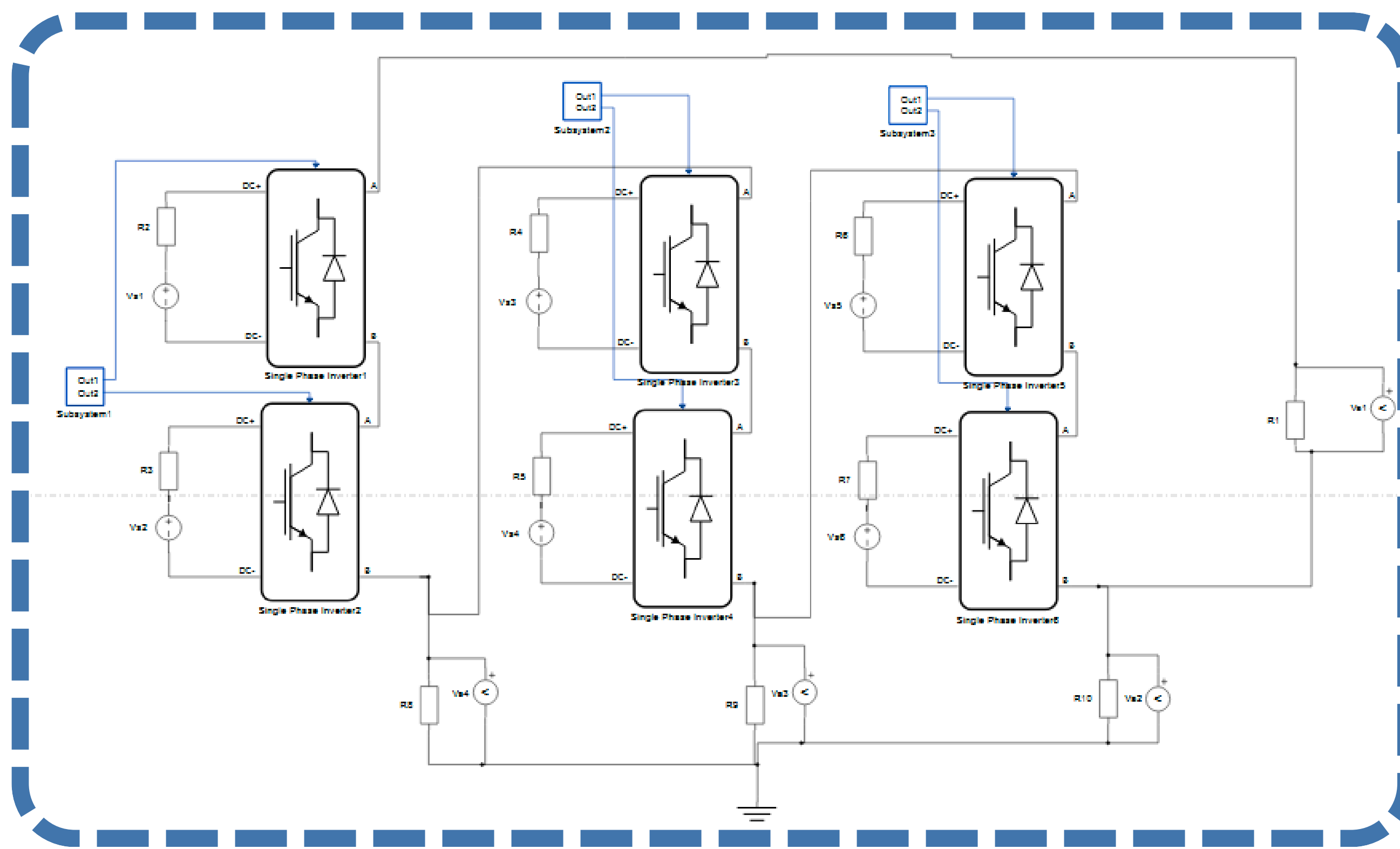
The TMS320 family, particularly models like the TMS320F28335 or TMS320F28069, is widely used in power electronics and embedded control systems due to its:

- High-speed floating-point processing
- On-chip PWM generation modules
- Integrated ADCs and GPIOs for sensor interfacing
- Compatibility with Code Composer Studio for real-time debugging
- Real-time control library support (IQMath, DCL, etc.)

Typical applications include:

- Multilevel inverters (NPC, CHB, flying capacitor)
- BLDC/PMSM motor control
- Power factor correction (PFC) systems
- Grid synchronization (PLL implementations)
- DC-DC converter control





TMS320 DSP Controller

The project involved the design and implementation of a 5-level, 3-phase Cascaded H-Bridge (CHB) inverter controlled by the TMS320F28335 Digital Signal Processor (DSP) from Texas Instruments. The system utilized the DSP's high-speed PWM generators, integrated 12-bit ADC modules, and real-time processing capabilities to achieve accurate and synchronized control of multiple switching devices.

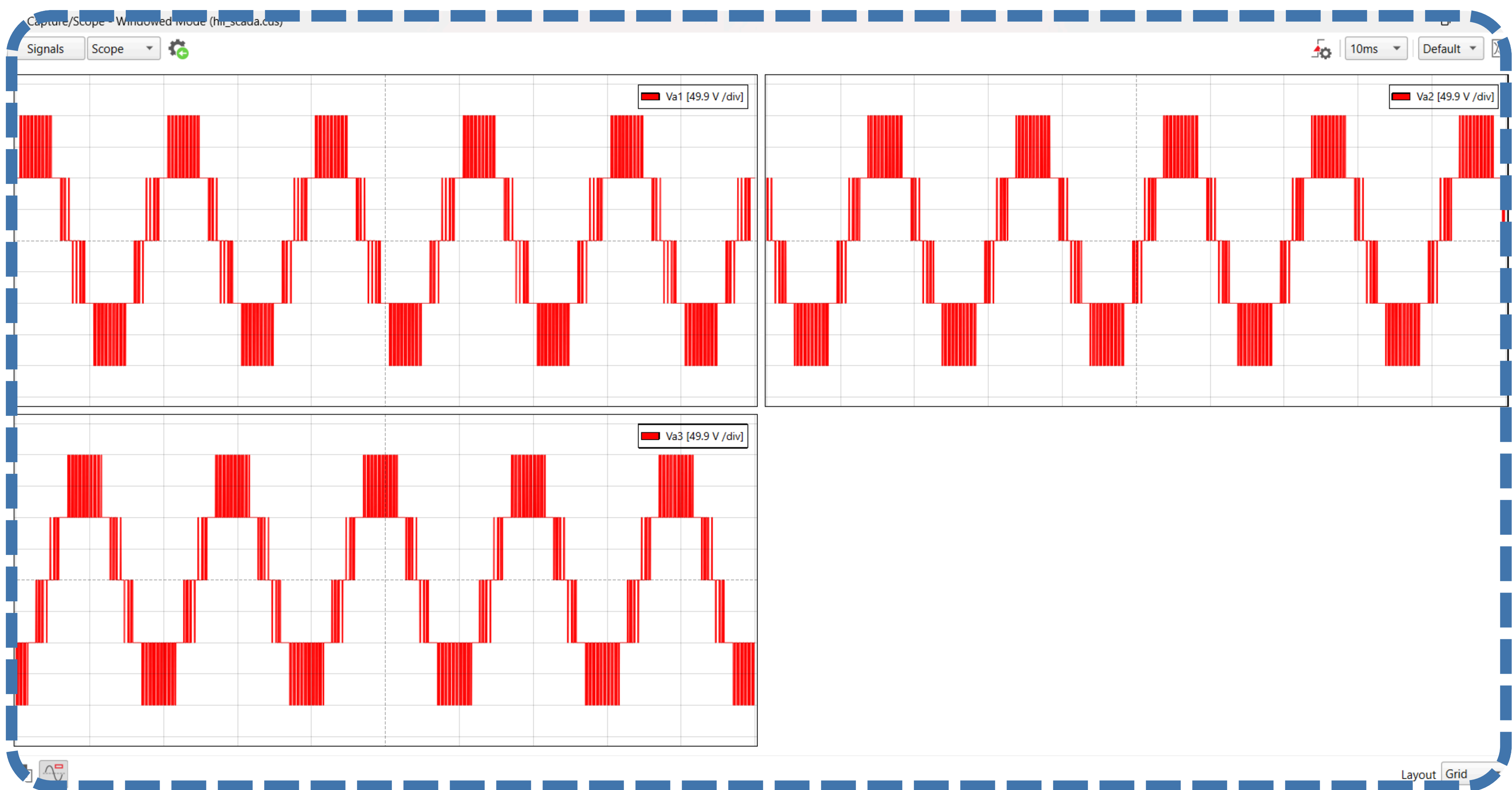
Embedded C code was developed using Matlab inbuilt code generator, which provided real-time debugging and variable monitoring. A Phase-Shifted PWM (PSPWM) strategy was applied for all three phases, with the ePWM modules configured to generate precise gate pulses for 24 IGBT switches. The ADC channels were employed to sample inverter output voltages, and this feedback was used in closed-loop control algorithms to minimize Total Harmonic Distortion (THD).

The implementation demonstrated the practical integration of multilevel inverter hardware with digital signal processing, highlighting advanced modulation, real-time control, and experimental validation of inverter performance.

Educational Benefits of TMS320 DSP for Students

Using the TMS320 DSP offers numerous academic and skill-based advantages for B.Tech students:

- Real-Time System Learning
- Students gain practical experience in designing systems that operate under real-time constraints, crucial in power control applications.
- C Programming for Embedded Control
- Encourages strong coding fundamentals, essential for embedded and IoT-related careers.
- Practical Understanding of PWM and ADC
- Teaches how to generate precise control signals and read sensor data in real-world scenarios.
- Debugging and Troubleshooting Skills
- The integrated debugger in CCS improves students' ability to identify and fix hardware-software interaction problems.
- Closed-Loop Control Implementation
- Enables hands-on design of feedback systems using PI or PID controllers.
- Preparation for Industry 4.0 Roles
- TMS320 is used in electric vehicles, renewable energy inverters, motor drives, and automation – aligning student training with modern industry demands.
- Affordable Hardware Platforms
- TI offers low-cost development kits and plenty of educational support for colleges.
- Boosts Research and Innovation Skills
- Ideal for final-year projects, research papers, and prototype development.



Future Applications and Relevance

In the near future, engineers will increasingly work on smart and adaptive energy systems – from renewable integration and microgrid control to battery management systems and vehicle-to-grid (V2G) communication. All of these require real-time, deterministic control, which platforms like TMS320 are perfectly designed for. TMS320 DSPs will be key enablers in:

- EV motor drive and charger control
- Digital control of PV inverters
- Smart appliance energy optimization
- Advanced power quality monitoring
- Real-time digital twins for power electronics systems

By mastering TMS320 controllers now, students will be fully prepared to contribute to these future developments with confidence and technical strength.

Key Highlights of Using TMS320 DSP

Real-Time Processing:

- Handles complex control algorithms with microsecond precision.

PWM Control Flexibility:

- Multiple ePWM modules make it ideal for multilevel and multiphase inverter control.

Code Composer Studio Integration:

- Easy debugging, real-time variable monitoring, and simulation interface.

Robust Community and Documentation:

- TI forums, GitHub libraries, and application notes available for free.

Hands-On Hardware Experience:

- Learning on real hardware sharpens engineering intuition and industry readiness.

Conclusion

The TMS320 DSP controller is more than just a microcontroller – it is a gateway into the world of intelligent, high-performance control systems. From my experience building a 3-phase 5-level CHB inverter, I gained invaluable insights into embedded programming, control theory, and real-time power electronics design.

For any B.Tech Electrical Engineering student, getting hands-on with the TMS320 platform is a vital step toward bridging the gap between academic theory and industry practice. As we move into a future dominated by smart energy, electric mobility, and digital power systems, the knowledge of TMS320 DSPs will not only be relevant – it will be essential.

The Importance of Power Electronics-Based Products in Today's Era

Introduction

Power electronics is a key enabling technology that deals with the efficient conversion, control, and conditioning of electric power using electronic systems. In the modern world, where energy efficiency, sustainability, and automation are at the forefront, power electronics-based products play a critical role across all sectors—residential, industrial, transportation, renewable energy, and more.

With increasing dependence on electricity for daily life and the push toward clean energy, the demand for advanced power electronic systems has never been higher.



Prof. N.B. Panchal

What is Power Electronics?

Power electronics refers to the application of solid-state electronics to the control and conversion of electric power. It primarily involves devices such as:

- Power diodes
- Transistors (IGBTs, MOSFETs)
- Thyristors (SCRs)
- Rectifiers
- Inverters
- Converters (AC-DC, DC-DC, AC-AC)

These components are used to build systems that efficiently manage and control electrical power.

Key Applications of Power Electronics in Today's Era

1. Renewable Energy Systems

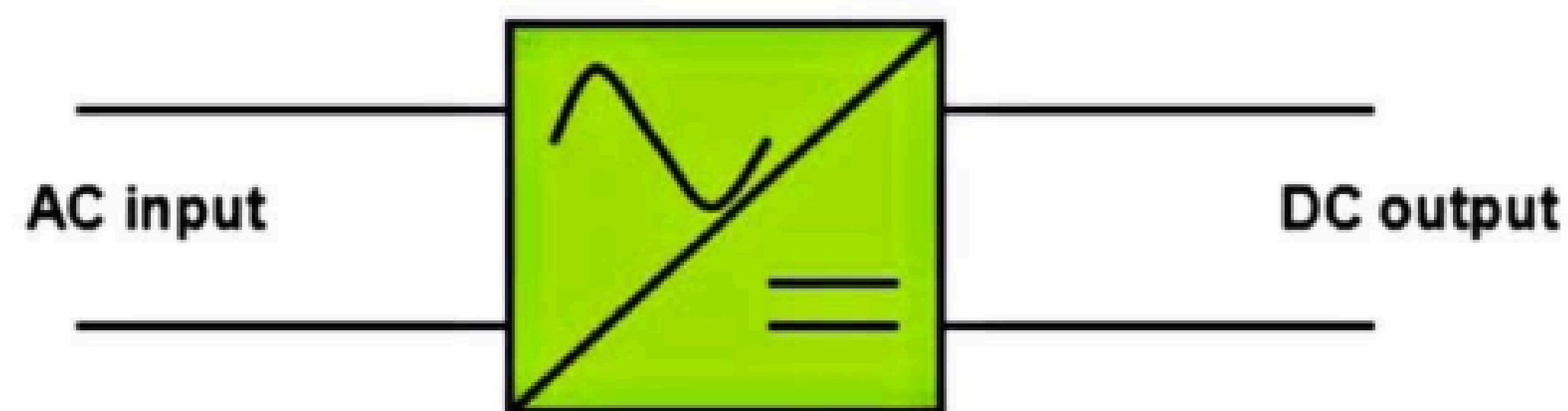
Power electronics is the backbone of renewable energy applications. It is used in:

- Solar Inverters: Converting DC from photovoltaic panels to AC.
- Wind Power Converters: Managing variable frequency AC from wind turbines.
- Grid Integration: Power conditioning for grid synchronization and stability.

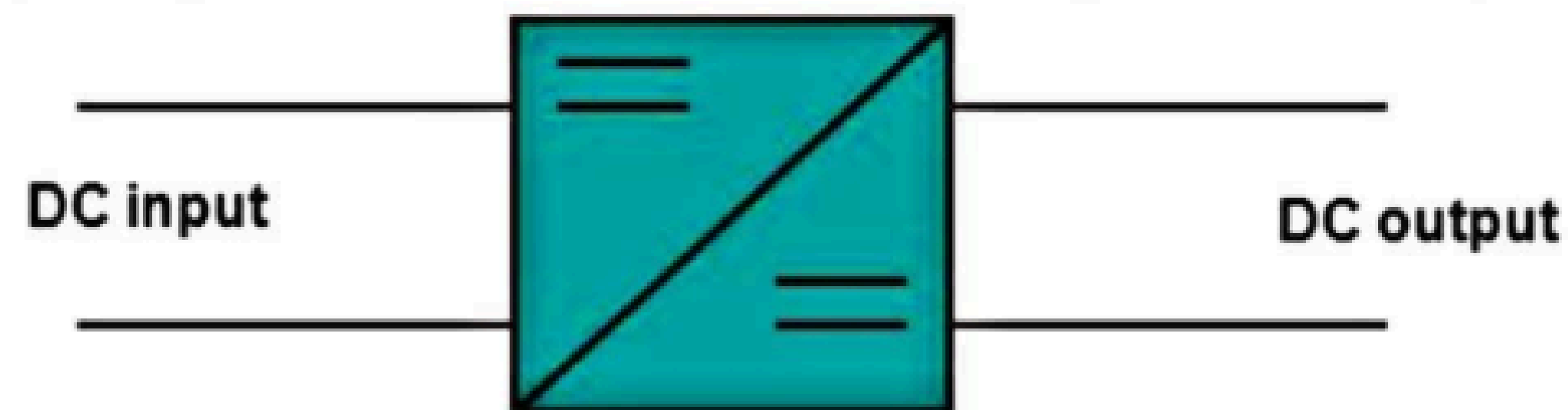
2. Electric Vehicles (EVs)

- The EV revolution relies heavily on power electronics for:
- Motor Drives: Using inverters for variable speed motor control.
- Battery Management: Efficient charging and discharging through DC-DC converters.
- Regenerative Braking: Energy recovery via bidirectional power converters.

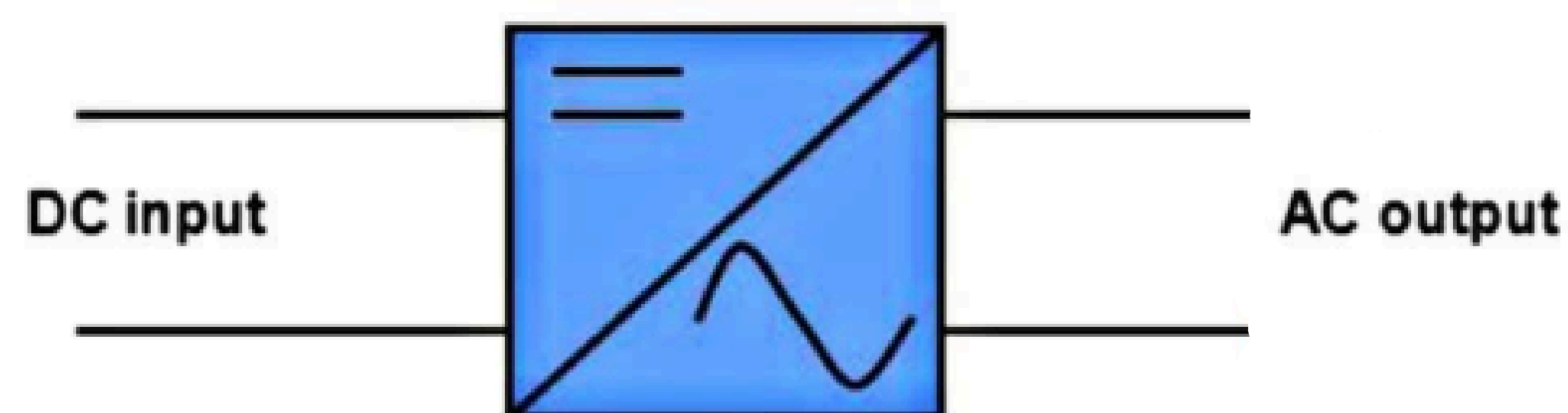
Rectifier : AC-DC Converter



DC CHOPPER : DC-DC Converter



INVERTER : DC-AC Converter



3. Consumer Electronics

In devices like laptops, smartphones, TVs, and chargers:

- Switch Mode Power Supplies (SMPS) ensure compact size, low heat generation, and energy efficiency.
- Adapters and UPS use rectifiers and inverters for stable power.

4. Industrial Automation

Power electronics enables precise control in:

- Robotics
- Machine tools
- HVAC systems
- CNC machines

This leads to higher productivity, energy savings, and process optimization.

5. Smart Grids and Energy Storage

Modern grids use power electronics for:

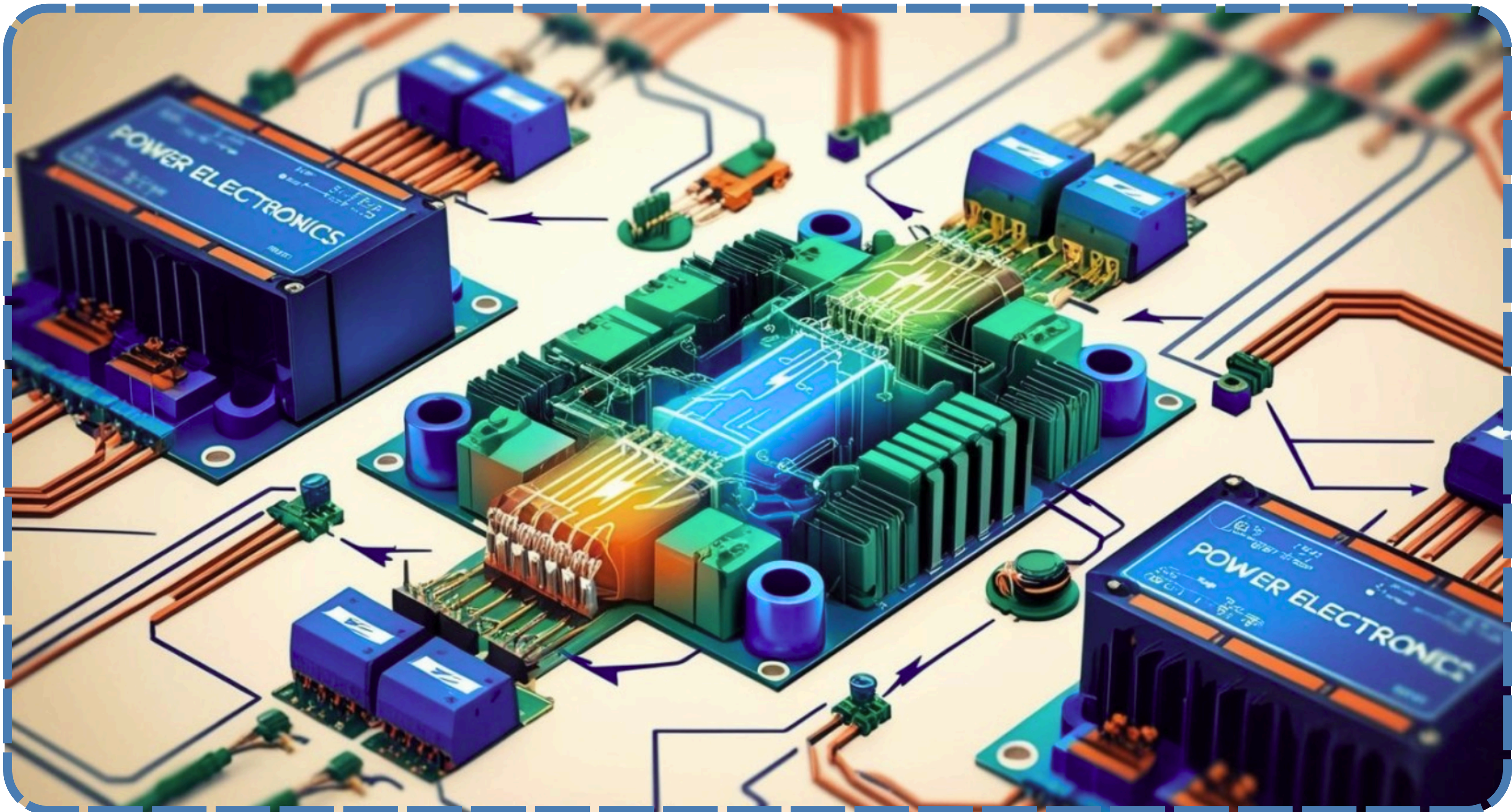
- Load balancing
- Voltage/frequency regulation
- Integration of energy storage systems

Power electronics helps in creating flexible, reliable, and responsive grids.

6. Aerospace and Defense

Aircraft and satellites depend on highly reliable power converters and inverters for:

- Actuator control
- Radar and communication systems
- Power conditioning units (PCUs)



7. Telecommunication Infrastructure

Base stations, servers, and data centers rely on:

- Rectifiers
- Power amplifiers
- Backup power system
- All of which are managed by advanced power electronics.

Benefits of Power Electronics-Based Products

- Energy Efficiency: Reduced losses through advanced switching and control.
- Compact Size: High-frequency operation allows for smaller components.
- Cost Reduction: Long-term savings via energy conservation and automation.
- Reliability and Durability: Solid-state designs with minimal moving parts.
- Precision Control: Fine regulation of voltage, current, and frequency.

Trends and Future Outlook

- Wide Bandgap Semiconductors (SiC, GaN): Offering faster switching, higher efficiency, and compact size.
- AI and IoT Integration: Smarter systems for predictive maintenance and adaptive control.
- Wireless Power Transfer: Emerging in EV charging and consumer electronics.
- High Power Density Designs: For space- and weight-constrained applications like drones and wearable tech.

Conclusion

Power electronics is an indispensable part of modern technological advancement. From reducing our carbon footprint to enabling smart and efficient systems, power electronics-based products are revolutionizing how we use and manage electrical power. As the world shifts toward electrification and sustainability, the role of power electronics will only grow, driving innovation in every sector of society.