JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	Jaipur Engineering college and research centre, Shri Ram ki Nangal, via Sitapura RIICO Jaipur- 302 022.	**Academic year- 2024-2025**

Jaipur Engineering College and Research Centre, Jaipur.

Department of Electronics and Communication Engineering

Faculty Development Program

on

CAEV: Connected Autonomous Electric Vehicle

(6 Days)

Introduced by JSW MG Motor India Pvt. Ltd.,

under MG Nurture initiative from 12th Aug'24 to 22nd Aug'24.

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Purchase Order

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Ref.No. JECRC/PRIN/2024-25/014 Date: 07/08/2024

PURCHASE ORDER

To,
Mr. Manish Rao,
Associate Director - Enterprise Partnerships.

Subject: Purchase Order for CAEV (Connected, Autonomous, Electric Vehicle) Course.

Please issue an invoice for registration in CAEV (Connected, Autonomous, Electric Vehicle) Course to ***Dr. Sandeep Vyas, Professor in the Department of Electronics and Communication Engineering***, an additional faculty. (Email: dr.sandeepvyas.ee@jecrc.ac.in, Contact No.: +91-9413965018). The details are as follows:

1. **Client Name:** Jaipur Engineering College & Research Centre
2. **Client Full Address:** Shri Ram Ki Nangal Via RIICO, Tonk Road, Sitapura, Jaipur, Rajasthan 302022.
3. **Client PAN Number (if applicable) :** AAATN2986L
4. **Client GST Number:** N.A.
5. **Purchase Order Number (if applicable):** JECRC/PRIN/2024-25/014
6. **Name of the Course or Project (to be mentioned on the invoice):** JSW MGI NURTURE-2024
7. **Payment Terms:** Immediate
8. **Mode of Delivery (Online/Virtual/On Ground etc.):** Hybrid (3 days Live Virtual and 3 days On Ground at JSW MGI's Halol Plant)
9. **Amount for which Performa Invoice should be prepared (excluding GST):** Rs. 20,000/-

Prof. (Dr.) V. K. Chandna
PRINCIPAL
Jaipur Engineering College & Research Centre
Tonk Road, Jaipur-302022

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Training Schedule

Week	Day	Course title	Time	Content delivery	Mode of delivery
WEEK 1 (Live virtual)	Day 1	Introduction to EV systems and battery technology	2 hr	EV Basics, Vehicle Dynamics (Governing Equations and Simulations), Component sizing(Battery Pack, Electrical Machine, Traction Inverter, DC-DC Convertor and Onboard Charger)	Live virtual
			2 hr	Drive cycle Simulation of EV Components in Matlab and Simulink (Battery cell, Power Electronics, Electrical Machine simulation)	
			2 hr	Basics of Lithium-ion cells, Battery Management System, Hardware, Software Function	
			0.5 Hr	EV Simulation using MATLAB and Simulink	
	Day 2	Autonomous Vehicle Essentials	1 hr	Overview of ADAS and Autonomous vehicle Technology- SAE levels of ADAS/ AD Software Stack Architecture	Live virtual
			2 hr	Overview of ADAS Features LDW/ LCA /LKA , ACC, IHC, Blind Spot Detection, Forward Collision Warning, Automatic Emergency Braking	
			1.5 hr	Introduction to Simulation for ADAS/ AD- Commons tools and Platform sensors , Map , Traffic	
			1.5 hr	Introduction to ADAS Software Testing Process- Unit/ System/ Integration Testing	
				Tool practice	
			0.5 Hr	ASSESSMENT: MCQ	
	Day 3	Connected Vehicle Fundamental	1 hr	Overview of Wireless Network for Connected Vehicles	Live virtual
			1 hr	Standards for Autonomous Vehicle Applications	

			1 hr	Transmission & Receiver Systems , Radio Transmission Concepts for Automotive Application	
			1 hr	Wireless Networking and Applications to Vehicle Autonomy	
			1 hr	Basics of Computer Networking – the Internet of Things	
			1.5 hr	Wireless Networking Fundamentals & Overview to 2G to 5G Networks for Automotive Application	
Weekend Projects for Learners: To be evaluated during on ground training					
WEEK 2 (On ground)	Day 4	Computer Vision for Autonomous Vehicle TOOLS: Python, OpenCV	3 hr	Intro to Computer Vision , Image processing technique	On ground
				Edge and Line Detection Techniques- CANNY/ HOUGH Transformation	
				Projective and Stereo Geometry, 3D Computer Vision	
				Feature Extraction- Image Classification using ANN,CNN, PCA (Principal Component Analysis)	
		Connected Car Technology	3 hr	Integration of Wireless Networking and On-Board Vehicle Networks	
				Review of On-Board Networks – Use & Function for Cars	
				Navigation and Other Applications	
				Connectivity Fundamentals (Car to Networks and within Car)	
				Vehicle-to-Vehicle Technology and Applications - V2V	
				Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications - V2X	
				Wireless Security Overview And how it impacts Connected cars	

				In Car Assistance, Multimedia and Infotainment, Android Auto/ Apple Car play, Car as a Platform, Fastag, GPS, Introduction to Automotive Cybersecurity	
				Building a connected Vehicle Platform connecting vehicles, storing and analysing data and building consumer application as a Case Study	
			0.5 Hr	ASSESSMENT: MCQ	
	Day 5	Introduction to EV systems and battery technology	2 hr	Simulation model for battery packs/BMS	On ground
			2 hr	Communication Protocol, Battery Thermal Management System	
			2 hrs	Function Safety associated with Battery Pack and BMS System, Battery charging system: On board charger and charging station	
			0.5 Hr	Hands On Activity(S/W and H/W), Battery pack simulation, CC-CV charging mode design, Battery Thermal amangement system simulation	
	Day 6	EV Traction system and DiagnosticTOOLS: Simscape	2 hrs	Traction System Topology for EV Applications, EV Powertrain Architecture and design, High voltage safety	On ground
			1 hr	Onboard charger and Charging Station	
			1.5 hr	Failure mode Analysis and Diagnostic, Maintenance Guidelines and Troubleshooting for EV	
			1 hr	Design of Converter circuits, Simulation of motor design and its control techniques, Lab session , MG motors Training Room	
			1 Hr	ASSESSMENT: MCQ	

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Report

Introduction to EV systems and battery technology

Day 1 - Duration: 6.5 Hours

1. Introduction to Electric Vehicles (EVs)

Electric vehicles (EVs) are transforming the automotive industry by providing an alternative to traditional internal combustion engine (ICE) vehicles. This session covers the fundamental aspects of EV technology, including its advantages, key components, and challenges.

Topics Covered:

- **EV Basics:** Overview of electric vehicles, different types (BEV, PHEV, HEV), and market trends.
- **Vehicle Dynamics:** Governing equations, forces acting on the vehicle, and simulation of motion.
- **Component Sizing:** Determining the appropriate specifications for key EV components.

2. Vehicle Dynamics and Component Sizing

Vehicle dynamics govern how an EV moves and responds to different driving conditions. Component sizing ensures that each part of the vehicle is optimized for efficiency and performance.

Key Areas:

- **Governing Equations and Simulations:** Newton's laws, power and energy calculations, rolling resistance, aerodynamic drag, and regenerative braking.
- **Battery Pack Sizing:** Energy and power requirements, battery chemistry, and thermal management.
- **Electrical Machine:** Motor types (BLDC, PMSM, Induction), efficiency mapping, and torque-speed characteristics.
- **Traction Inverter:** Role in controlling motor speed and torque, power electronics overview.

- **DC-DC Converter and Onboard Charger:** Conversion efficiency, power flow management, and charging infrastructure.

3. Drive Cycle Simulation of EV Components in MATLAB and Simulink

Drive cycle simulations help in analyzing vehicle performance under various operating conditions.

Topics Discussed:

- **MATLAB and Simulink Environment:** Introduction to simulation tools, model creation, and system configuration.
- **Battery Cell Simulation:** SOC (State of Charge), voltage, and current characteristics.
- **Power Electronics Simulation:** Inverter modeling, switching dynamics, and efficiency analysis.
- **Electrical Machine Simulation:** Motor control strategies, field-oriented control (FOC), and performance evaluation.

4. Basics of Lithium-Ion Cells and Battery Management System (BMS)

Lithium-ion batteries are the preferred choice for EVs due to their high energy density and efficiency.

Topics Covered:

- **Battery Chemistry and Working Principles:** Different types of lithium-ion cells, charge/discharge cycles.
- **Battery Management System (BMS):** Importance of BMS, state estimation (SOC, SOH), cell balancing, and thermal management.
- **Hardware Components:** Sensors, microcontrollers, and power management ICs.
- **Software Functions:** Battery protection algorithms, CAN communication, and fault diagnosis.

5. EV Simulation Using MATLAB and Simulink

Simulation plays a crucial role in designing and testing EV components before implementation.

Key Learning Outcomes:

- **Modeling an EV System:** Creating a virtual prototype of an electric vehicle.
- **Control Strategies:** Implementing energy management strategies for improved efficiency.
- **Performance Analysis:** Evaluating acceleration, range, and efficiency under different conditions.
- **Validation and Optimization:** Testing the developed model and optimizing component performance.

Conclusion

The first day of training provided a comprehensive understanding of electric vehicles, their key components, and simulation techniques. By integrating MATLAB and Simulink, participants gained hands-on experience in drive cycle simulation, component modeling, and system-level optimization. This foundational knowledge sets the stage for more advanced topics in EV development and real-world applications.

Autonomous Vehicle Essentials

Day 2 - Duration: 6 Hours

1. Recap of ADAS and Autonomous Vehicle Technology

Day 2 began with a recap of key concepts from Day 1, reinforcing the fundamentals of ADAS and autonomous vehicle technology.

Topics Covered:

- **SAE Levels of Automation:** Review of automation levels from Level 0 (No Automation) to Level 5 (Full Automation).
- **ADAS/AD Software Stack Architecture:** Reiteration of perception, decision-making, and control layers in the ADAS software stack.
- **Industry Use Cases:** Real-world applications of ADAS in modern vehicles.

2. In-depth Analysis of ADAS Features

Expanding on the previous session, a deeper dive into ADAS features was conducted, with case studies and real-world implementation examples.

Key Features Discussed:

- **Lane Departure Warning (LDW) & Lane Keep Assist (LKA):** Detailed algorithms used for lane tracking and corrective steering.
- **Lane Change Assist (LCA):** Advanced sensor fusion techniques to monitor and predict vehicle movement in adjacent lanes.
- **Adaptive Cruise Control (ACC):** Implementation of radar-based distance control and vehicle-following algorithms.
- **Intelligent High Beam Control (IHC):** Adaptive headlight systems to improve night-time visibility.
- **Blind Spot Detection:** Object recognition techniques using radar and cameras.
- **Forward Collision Warning (FCW):** Risk assessment methodologies for collision prevention.
- **Automatic Emergency Braking (AEB):** Threshold-based and AI-driven braking activation strategies.

3. Advanced Simulation for ADAS/AD

Simulation tools play a critical role in the development and validation of ADAS systems. Day 2 introduced more complex scenarios and tools for ADAS simulation.

Topics Covered:

- **Simulation Tools:** Review and hands-on practice with MATLAB, Simulink, CarSim, PreScan, and IPG CarMaker.
- **Platform Sensors:** Detailed analysis of LiDAR, Radar, Ultrasonic, and Camera integration in simulation environments.
- **Map and Traffic Simulation:** Creating real-world traffic conditions and testing ADAS functionalities in simulated urban and highway scenarios.

- **Scenario-Based Testing:** Setting up different driving conditions (e.g., pedestrian crossings, sudden braking scenarios) to evaluate ADAS performance.

4. ADAS Software Testing Process - Advanced Level

The focus shifted towards detailed ADAS software validation and quality assurance methodologies.

Topics Covered:

- **Unit Testing:** More complex unit test cases for verifying ADAS module functionality.
- **System Testing:** Automated system tests using simulation environments.
- **Integration Testing:** Advanced methods for testing sensor fusion and ADAS module interaction.
- **Model-in-the-Loop (MIL) & Software-in-the-Loop (SIL) Testing:** Utilizing these methodologies for early-stage validation.
- **Hardware-in-the-Loop (HIL) Testing:** Introduction to HIL testing with real ECUs and ADAS components.

5. Practical Tool Session

Participants engaged in a more extensive hands-on session with ADAS simulation and testing tools.

Activities:

- **Advanced Scenario Development:** Setting up complex driving conditions in simulation environments.
- **Debugging and Testing:** Running simulations, analyzing test results, and debugging software issues.
- **Data Analysis and Reporting:** Evaluating system performance based on test case execution and data-driven insights.

Conclusion

Day 2 of the training provided an advanced understanding of ADAS functionalities, simulation techniques, and software testing methodologies. By engaging in hands-on tool practice and real-world scenario simulations, participants strengthened their expertise in ADAS and autonomous vehicle technologies, preparing for further deep-dive sessions in the upcoming training days.

Connected Vehicle Fundamental

Day 3 - Duration: 6 Hours

1. Overview of Wireless Networks for Connected Vehicles

Wireless networks play a crucial role in enabling vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) communications. This session covered the fundamental concepts of wireless communication for connected vehicles.

Topics Covered:

- **Introduction to Connected Vehicle Networks:** Importance of communication in modern vehicles.
- **Types of Vehicle Communications:** V2V, V2I, and V2X.
- **Benefits and Challenges:** Enhancing safety, traffic management, and reliability concerns.
- **Existing Wireless Technologies:** Wi-Fi, DSRC (Dedicated Short-Range Communications), and cellular networks.

2. Standards for Autonomous Vehicle Applications

This session focused on industry standards and regulatory frameworks that define wireless communication for autonomous vehicles.

Topics Covered:

- **Overview of Communication Standards:** IEEE 802.11p, C-V2X (Cellular Vehicle-to-Everything), and 5G-V2X.
- **Government Regulations:** Policies governing the deployment of wireless communication in autonomous vehicles.

- **Data Security and Privacy:** Cybersecurity concerns and solutions for vehicle networks.
- **Global Standardization Efforts:** Contributions from SAE, ETSI, and ISO.

3. Transmission & Receiver Systems and Radio Transmission Concepts

Wireless communication in automotive applications requires robust transmission and reception systems to ensure reliability and efficiency.

Topics Covered:

- **Fundamentals of Transmission and Reception:** Signal propagation, modulation techniques, and antenna design.
- **Radio Transmission Concepts:** Frequency bands, interference management, and signal integrity.
- **Automotive Applications:** Role of transmission systems in ADAS, infotainment, and remote diagnostics.
- **Latency and Bandwidth Considerations:** Optimization techniques for real-time applications.

4. Wireless Networking and Applications to Vehicle Autonomy

Wireless networking facilitates communication between autonomous vehicles and their environment, enabling safe and efficient driving.

Topics Covered:

- **Role of Wireless Networking in Autonomous Vehicles:** Data exchange between vehicles, sensors, and control centers.
- **Edge Computing and Cloud Integration:** Data processing methods for real-time decision-making.
- **AI and Machine Learning for Network Optimization:** How AI enhances connectivity and network efficiency.
- **Case Studies:** Real-world applications of wireless networking in self-driving cars.

5. Basics of Computer Networking – The Internet of Things (IoT)

IoT technology is crucial for enabling smart transportation systems and connected vehicle ecosystems.

Topics Covered:

- **IoT in Automotive Applications:** Smart traffic management, remote diagnostics, and predictive maintenance.
- **Network Protocols:** TCP/IP, MQTT, and CoAP for automotive communication.
- **Edge vs. Cloud Computing:** Benefits of localized vs. centralized data processing.
- **Security Considerations:** Preventing cyber threats in IoT-enabled vehicles.

6. Wireless Networking Fundamentals & Overview of 2G to 5G Networks for Automotive Applications

The evolution from 2G to 5G has significantly impacted vehicle communication, enabling high-speed, low-latency data transmission.

Topics Covered:

- **Comparison of Wireless Generations:** Key differences between 2G, 3G, 4G, and 5G.
- **Role of 5G in Autonomous Vehicles:** Ultra-reliable low-latency communication (URLLC) for critical applications.
- **Network Slicing and Edge Computing:** Enhancing vehicle communication efficiency with 5G.
- **Future Trends:** Upcoming advancements in wireless networking for connected and autonomous vehicles.

Conclusion

Day 3 of the training provided an in-depth understanding of wireless networking concepts, communication standards, and applications for connected and autonomous vehicles. Participants gained insights into wireless transmission techniques, network security, and the transition to 5G, preparing them for advanced topics in automotive networking.

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Computer Vision for Autonomous Vehicle

TOOLS: Python, OpenCV

Day 4 - Duration: 3 Hours (On-Ground Session)

1. Introduction to Computer Vision and Image Processing Techniques

Computer vision enables machines to interpret and process visual information similarly to human vision. This session provided an overview of computer vision fundamentals and common image processing techniques.

Topics Covered:

- **Fundamentals of Computer Vision:** Understanding how computers interpret images and videos.
- **Image Processing Techniques:**
  - Image filtering (Gaussian Blur, Median Filtering)
  - Contrast enhancement (Histogram Equalization)
  - Noise reduction techniques
- **Applications of Computer Vision:** Real-world implementations in autonomous vehicles, medical imaging, and industrial automation.

2. Edge and Line Detection Techniques – Canny and Hough Transform

Edge and line detection are crucial for object recognition and image segmentation. This session covered popular methods used in image processing.

Topics Covered:

- **Edge Detection:**
  - **Canny Edge Detection:** Step-by-step breakdown of the algorithm (Noise Reduction, Gradient Calculation, Non-maximum Suppression, Double Threshold, Edge Tracking by Hysteresis).
  - Applications in road lane detection and medical imaging.
- **Line Detection:**

- **Hough Transform:** Explanation of the algorithm and its role in identifying straight lines in an image.
- Use cases in detecting road boundaries, markings, and lane lines in autonomous vehicles.

3. Projective and Stereo Geometry, 3D Computer Vision

3D computer vision is essential for reconstructing spatial information from 2D images. This session introduced projective geometry concepts and stereo vision techniques.

Topics Covered:

- **Projective Geometry:**
  - Understanding camera projections, homographies, and transformations.
  - Applications in object tracking and augmented reality.
- **Stereo Vision:**
  - Depth perception using two-camera setups.
  - Epipolar geometry and disparity mapping.
  - Real-world applications in robotics and 3D mapping.
- **3D Reconstruction Techniques:**
  - Point cloud generation from images.
  - Structure from Motion (SfM) and Multi-View Stereo (MVS).

4. Feature Extraction – Image Classification Using ANN, CNN, and PCA

Feature extraction is a critical step in image classification and object detection. This session introduced various techniques used for extracting and classifying visual information.

Topics Covered:

- **Feature Extraction Techniques:**
  - Traditional methods (HOG, SIFT, SURF) vs. deep learning-based techniques.
- **Artificial Neural Networks (ANN) for Image Classification:**
  - Basics of neural networks and their application in vision tasks.
- **Convolutional Neural Networks (CNN):**

- CNN architecture and working principles (convolution layers, pooling, fully connected layers).
- Real-world applications in facial recognition and object detection.

- **Principal Component Analysis (PCA):**
  - Dimensionality reduction for image datasets.
  - Application in feature selection and enhancement of classification models.

Conclusion

The on-ground training session provided participants with a solid understanding of computer vision principles, edge detection techniques, 3D vision concepts, and deep learning-based feature extraction. Hands-on exercises helped reinforce the theoretical knowledge, preparing participants for advanced applications in autonomous systems and AI-driven image processing.

Connected Car Technology

Day 4 - Duration: 3 Hours (On-Ground Session)

1. Integration of Wireless Networking and On-Board Vehicle Networks

Modern vehicles incorporate advanced wireless networking technologies to facilitate communication between components and external networks. This session provided insights into how these networks integrate within vehicles.

Topics Covered:

- **Wireless Networking in Vehicles:** Basics of Wi-Fi, Bluetooth, and cellular connectivity.
- **On-Board Networks:** Communication between vehicle components using CAN, LIN, MOST, and Ethernet.
- **Integration Challenges and Solutions:** Addressing latency, security, and interoperability issues.

2. Review of On-Board Networks – Use & Function for Cars

On-board networks are crucial for vehicle functionality, enabling seamless communication between various electronic control units (ECUs).

Topics Covered:

- **Overview of On-Board Networks:** CAN (Controller Area Network), LIN (Local Interconnect Network), MOST (Media Oriented Systems Transport), and FlexRay.
- **Real-World Applications:** How these networks facilitate powertrain control, safety features, and infotainment systems.
- **Data Transmission Protocols:** Understanding high-speed vs. low-speed networks in automotive applications.

3. Navigation and Other Applications

Modern vehicles rely on advanced navigation systems that integrate with other connected applications.

Topics Covered:

- **GPS and Navigation Systems:** Role of GPS in route planning and real-time navigation.
- **Connected Navigation:** Use of cloud-based mapping services for real-time traffic updates.
- **Integration with ADAS:** How navigation systems support autonomous and semi-autonomous driving.

4. Connectivity Fundamentals (Car to Networks and within Car)

Connectivity is key to the functionality of modern smart vehicles. This session focused on fundamental concepts of vehicle connectivity.

Topics Covered:

- **Types of Vehicle Connectivity:** Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and cloud-based systems.
- **Intra-Vehicle Communication:** How ECUs communicate within a vehicle using wired and wireless methods.
- **Emerging Technologies:** 5G and edge computing in automotive networking.

5. Vehicle-to-Vehicle Technology and Applications (V2V)

V2V communication enables vehicles to share real-time data, improving road safety and efficiency.

Topics Covered:

- **V2V Communication Protocols:** DSRC (Dedicated Short-Range Communications) and C-V2X (Cellular Vehicle-to-Everything).
- **Collision Avoidance and Traffic Management:** Use of V2V data to enhance safety.
- **Autonomous Driving Support:** How V2V assists in automated driving environments.

6. Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications (V2X)

V2X extends connectivity beyond vehicles to roadside infrastructure, improving transportation efficiency.

Topics Covered:

- **V2I Communication:** Interaction between vehicles and smart traffic signals, toll booths, and parking systems.
- **V2X Use Cases:** Intelligent traffic management, congestion reduction, and automated toll collection.
- **Future Trends:** AI and machine learning applications in V2X communication.

7. Wireless Security Overview and How It Impacts Connected Cars

Security is a major concern in connected vehicle networks. This session covered potential vulnerabilities and security solutions.

Topics Covered:

- **Cybersecurity Threats:** Hacking risks, data breaches, and vehicle control exploits.
- **Encryption and Secure Communication:** Techniques for ensuring secure V2X and in-car communications.
- **Industry Standards:** Overview of cybersecurity regulations for automotive networks.

8. In-Car Assistance, Multimedia, and Infotainment

Modern vehicles offer a range of in-car assistance and entertainment options integrated with connectivity features.

Topics Covered:

- **Infotainment Systems:** Android Auto, Apple CarPlay, and custom OEM systems.

- **In-Car Assistance Features:** Voice recognition, AI-based assistants, and driver monitoring.
- **Automotive Cybersecurity:** Addressing vulnerabilities in infotainment and multimedia systems.

9. Building a Connected Vehicle Platform – Case Study

The session concluded with a hands-on case study focused on building a connected vehicle platform.

Topics Covered:

- **Data Collection and Storage:** How vehicles collect and store data.
- **Cloud-Based Analysis:** Processing vehicle data for insights and automation.
- **Consumer Applications:** Developing user-facing apps for smart vehicle interactions.

Conclusion

This session provided participants with an in-depth understanding of connected vehicle technologies, including wireless communication, V2X networking, infotainment, and cybersecurity. Practical insights and case studies helped reinforce the knowledge required to work with modern automotive connectivity solutions.

Introduction to EV systems and battery technology

Day 5 - Duration: 6.5 Hours (On-Ground Session)

1. Simulation Model for Battery Packs/BMS

This session covered the development and implementation of simulation models for battery packs and Battery Management Systems (BMS), which are crucial for analyzing performance, efficiency, and safety.

Topics Covered:

- **Battery Pack Simulation:** Modeling battery cell behavior and pack-level performance.
- **BMS Architecture:** Functional components including state estimation, protection circuits, and balancing algorithms.

- **Simulation Tools:** Introduction to MATLAB/Simulink and other software for BMS modeling.

2. Communication Protocol & Battery Thermal Management System

Communication and thermal management are critical for the efficiency and longevity of battery packs.

Topics Covered:

- **Communication Protocols:** CAN (Controller Area Network), Modbus, and other communication standards used in BMS.
- **Battery Thermal Management:** Strategies for passive and active cooling/heating mechanisms.
- **Implementation Challenges:** Handling real-time data transmission and thermal runaway prevention.

3. Functional Safety & Battery Charging System

Ensuring functional safety in battery packs and understanding charging systems are essential aspects of electric vehicle (EV) and stationary energy storage applications.

Topics Covered:

- **Functional Safety Standards:** ISO 26262 and its application to battery safety.
- **Battery Charging Systems:** Overview of onboard chargers, charging stations, and fast charging techniques.
- **Safety Measures:** Techniques to prevent overcharging, overheating, and short circuits.

4. Hands-On Activity (Software & Hardware)

A practical session was conducted to provide participants with hands-on experience in BMS and battery pack simulations.

Activities Performed:

- **Battery Pack Simulation:** Testing cell balancing, state-of-charge (SOC), and state-of-health (SOH) calculations.

- **CC-CV Charging Mode Design:** Implementing Constant Current-Constant Voltage (CC-CV) charging algorithms.
- **Battery Thermal Management Simulation:** Simulating temperature regulation strategies in software and validating hardware implementations.

Conclusion

The session provided an in-depth understanding of BMS simulations, communication protocols, functional safety measures, and hands-on implementation techniques. Participants gained both theoretical knowledge and practical exposure to industry-relevant tools and techniques used in battery management and charging systems.

EV Traction system and DiagnosticTOOLS: Simscape

Day 6 - Duration: 5.5 Hours (On-Ground Session at MG Motors Training Room)

1. Traction System Topology for EV Applications, EV Powertrain Architecture, and High Voltage Safety

This session focused on the core components of EV powertrains, their configurations, and safety protocols.

Topics Covered:

- **EV Traction System Topology:** Series, parallel, and complex hybrid architectures.
- **Powertrain Architecture and Design:** Role of inverters, electric motors, and transmissions in EVs.
- **High Voltage Safety:** Protective measures, insulation techniques, and handling procedures for high-voltage systems.

2. Onboard Charger and Charging Station

Charging infrastructure is vital for the widespread adoption of EVs. This session delved into onboard chargers and external charging stations.

Topics Covered:

- **Onboard Charger Design:** Working principles, power conversion, and efficiency considerations.
- **Charging Station Infrastructure:** AC vs. DC fast charging, charging protocols (CCS, CHAdeMO, Tesla Superchargers).
- **Smart Charging and Communication:** Integration with the grid, Vehicle-to-Grid (V2G) communication, and load management.

3. Failure Mode Analysis, Diagnostic, Maintenance Guidelines, and Troubleshooting for EV

Understanding failure modes and diagnostics is essential for maintaining EV reliability.

Topics Covered:

- **Common Failure Modes:** Battery degradation, thermal management failures, inverter malfunctions.
- **Diagnostic Techniques:** Onboard diagnostics (OBD-II), predictive maintenance, and sensor-based fault detection.
- **Maintenance Guidelines:** Periodic inspection schedules, software updates, and preventive measures.
- **Troubleshooting Procedures:** Case studies on motor control failures, charging issues, and thermal faults.

4. Design of Converter Circuits, Motor Simulation, and Control Techniques (Lab Session at MG Motors Training Room)

A practical session was conducted to reinforce theoretical concepts through real-time simulations and lab experiments.

Activities Performed:

- **Converter Circuit Design:** Understanding DC-DC and DC-AC conversion for EV applications.
- **Motor Design and Control Simulation:** Implementing control algorithms for traction motors.

- **Hands-on Lab Session:** Testing powertrain components in a controlled environment at MG Motors Training Room.

Conclusion

The session provided a deep understanding of EV powertrain systems, onboard chargers, failure diagnostics, and maintenance procedures. The hands-on lab reinforced theoretical learning, equipping participants with practical skills in EV technology and troubleshooting techniques.

Future Scope of the Course

The rapid advancements in EV technology make this course highly relevant for future developments in the industry. The key areas of future scope include:

- **Emerging Battery Technologies:** Solid-state batteries, fast-charging advancements, and extended battery life solutions.
- **Autonomous Electric Vehicles:** Integration of AI and ADAS in EVs for self-driving capabilities.
- **Sustainable Energy Integration:** EVs as energy storage solutions for renewable energy sources.
- **Advanced Power Electronics:** More efficient inverters, converters, and wireless charging technologies.
- **EV Industry Expansion:** Growing job opportunities in research, development, and manufacturing sectors.

Advantages of the Training Program

- **Comprehensive Understanding:** Covers all major aspects of EV technology from powertrains to diagnostics.
- **Hands-on Experience:** Practical lab sessions for real-world implementation.
- **Industry-Relevant Skills:** Prepares participants for careers in the fast-growing EV sector.
- **Exposure to Latest Trends:** Insights into advanced battery management, high-voltage safety, and emerging charging technologies.

Conclusion

The 6-day training program provided a holistic understanding of electric vehicles, including their design, simulation, charging systems, safety protocols, networking, and troubleshooting techniques. The combination of theoretical knowledge and hands-on sessions equipped

participants with essential skills needed for careers in the EV industry. As the global shift toward sustainable transportation continues, the knowledge gained from this program will play a crucial role in driving innovation and excellence in the field of electric mobility.

Certificate

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CERTIFICATE

OF PARTICIPATION

This certificate is presented to

for participating and qualifying as a teaching faculty in **CAEV: Connected Autonomous Electric Vehicle course** introduced by JSW MG Motor India Pvt. Ltd., under **MG NURTURE** initiative from **12th Aug'24 to 22nd Aug'24**

Sameer Jindal
Technical Director
VAVE and MG Nurture
JSW MG Motor India Pvt. Ltd.

Yeshwinder Patial
Senior Director
Human Resources
JSW MG Motor India Pvt. Ltd.

Suryanarayanan
Program Director
Skill-Lync

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	Jaipur Engineering college and research centre, Shri Ram ki Nangal, via Sitapura RIICO Jaipur- 302 022.	**Academic year- 2024-2025**

Photographs:

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	Jaipur Engineering college and research centre, Shri Ram ki Nangal, via Sitapura RIICO Jaipur- 302 022.	**Academic year- 2024-2025**