GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3735407
Semester – III
Subject Name: Automotive Electronics and In Vehicle Networking Protocols

Type of course: Professional Elective-V

Prerequisite: Basic Knowledge of Computer Networking

Rationale: Electronics components are becoming important for automobile. Automotive electronics are electronic systems used in vehicles, including engine management, ignition, telematics and others. Ignition, engine, and transmission electronics are also found in trucks, motorcycles, off-road vehicles, and other internal combustion-powered machinery such as forklifts, tractors, and excavators. There are about 100 microcontrollers are available in latest automobile and communication between all is done through vehicle networking protocolas. This course will high light automotive electronics system and CAN protocol.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	2	3	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Automotive Systems, Design Cycle and Automotive Industry Overview:** Overview of Automotive Industry: Leading players, Automotive supply chain, Global challenges, Role of technology in Automotive Electronics and interdisciplinary design, Tools and processes. Introduction to Modern Automotive Systems and need for electronics in automobiles and application areas of electronic systems in modern automobiles. Spark and Compression Ignition Engines: Ignition systems, Fuel delivery systems, Engine control functions, Fuel control, Electronic systems in engines. Automotive transmissions: Transmission fundamentals, Types MT, AT, CVT and DCT. Vehicle Braking Fundamentals: Vehicle dynamics during braking, Hydraulic brake system components, Introduction to antilock braking systems ECU Design Cycle: V-Model development cycle, Components of ECU, Examples of ECU on chassis, and in body electronics, infotainment and clusters. Overview of hybrid vehicles	9
2	**Automotive Sensors and Actuators** Systems Approach to Control and Instrumentation: Concept of a system, Analog and digital systems, Basic measurement systems, Analog and digital signal processing, Sensors, Sensor characteristics, Sensor response, Sensor error,	9

	Redundancy of sensors in ECUs, Avoiding redundancy, Sensor modeling, Smart Nodes. Examples of Sensors: Accelerometers, Wheel speed, Brake pressure, Seat occupancy, Engine speed, Steering wheel angle, Vehicle speed, Throttle position, Turbine speed, Temperature, Mass air flow (MAF) rate, Exhaust gas oxygen concentration, Throttle plate angular position, Crankshaft angular position/RPM, Manifold Absolute Pressure (MAP), Differential exhaust gas pressure and Air bag sensors. Actuators used: Solenoids, Various types of electric motors and piezoelectric force generators. Examples of Actuators: Relays, Solenoids and motors. Chassis control systems and Automatic transmission control systems.	
3	**Microcontrollers/Microprocessors in Automotive domain**, Critical review and overview of development within the automotive context of microprocessors, microcontrollers and digital signal processors (architecture of 8/16 bit microcontrollers with emphasis on Ports, Timer/Counters, Interrupts, Watchdog timers and PWM). Criteria to choose the right microcontroller/processor for various automotive applications. Understanding various architectural attributes relevant to automotive applications. Automotive grade processors viz. Renesas, Quorivva, Infineon. Understanding and working on tool chains for different processors. Development of control algorithms for different automotive subsystems, Look-up tables and maps, Need of maps, Procedure to generate maps, Fuel maps/tables, Ignition maps/tables, Engine calibration, Torque table	**9**
4	**Basics of Data Communication Networks and Automotive Communication Protocols:** Need for networks, Types of networks, Need for standards, TCP/IP model, Topologies, Error detection and correction mechanisms, Encoding schemes, Serial/parallel transmission, Bits, Baud and bandwidth, Synchronous and asynchronous, Need and benefits of IVN, Classes of IVN protocols, Multiplexed electrical systems, Vehicle multiplexing, Bitwise contention, Network elasticity, Error processing and management and Case Study	**9**
5	**Controller Area Network (CAN) Protocol:** History and foundation of CAN, CAN Applications, Main characteristics of CAN, CAN in OSI Reference Model, CAN Data Link Layer, Principles of data exchange in CAN, Arbitration, Data Frame, Remote Frame, Error detection and management in CAN, CAN physical Layer, Bit encoding, Bit timing and synchronization, Relationship between data rate and bus length, Single wire and twin wire media, CAN repeaters, Medium-to-medium gateway, Protocol handlers, Micro-controllers and line drivers, Time Triggered CAN (TTCAN), Comparison with other IVN protocols, CANoe based applications development	**6**
6	**CAN Higher Layer Protocols and LIN:** CAN Higher Layer Protocols: CAN in Automation (CiA), CANopen, CANopen device model, CANopen features, DeviceNet, DeviceNet Model, Device Object Model, DeviceNet Features. Local Interconnect Network (LIN) Protocol: Introduction to LIN, LIN consortium, LIN	**6**

	specification, LIN features, Technical overview, Work flow concept, LIN operation, LIN frame format, Scheduling table, Network management of LIN cluster, LIN Transport Layer, LIN node configuration and identification, LIN diagnostics, LIN physical layer	
7.	**FlexRay and MOST Protocol**: FlexRay Protocol: Future on board systems, Need for FlexRay, Origin of FlexRay, FlexRay consortium, FlexRay Objectives, FlexRay Features, Application requirements, Working of FlexRay, Network topologies, ECU architecture, Segment Configuration, Communication Cycles, FlexRay frame format, Timing of configuration protocol, Error control, and FlexRay core mechanisms, Coding and Decoding, Medium Access Control, Frame and Symbol Processing, Clock Synchronization, FlexRay Components, Comparison with other IVN protocols and Case Study Media Oriented System Transport (MOST) Protocol: Emerging in car systems, Introduction to MOST, MOST goals, Features, Cables and Connectors, Data Types, Topology, Frame Format, Application Areas, System Description, Specification, Device Model, Device Implementation, Diagnostics and Case Study	**6**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Williams. B. Ribbens: "Understanding Automotive Electronics", 6th Edition, Elsevier Science, Newnes Publication, 2003.
2. Robert Bosch: "Automotive Electronics Handbook", John Wiley and Sons, 2004.
3. Gilbert Held. (2007) Inter- and Intra-Vehicle Communications, CRC Press.
4. Behrouz Forouzan. (2003) Data Communications and Networking, McGraw-Hill.
5. Ronald k. Jurgen. (1999) Automotive Electronics Handbook, McGraw-Hill.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand automotive system and design cycle. Explain and analyze the principles and functionalities of various Automotive Communication Protocols (ACPs)	30
CO-2	Proficiently use CANoe tool to develop IVN applications as well as to simulate, analyze and Troubleshoot ACP based IVNs	20
CO-3	Utilize CAN and LIN based automotive embedded network based Microcontrollers and DSP.	20

CO-4	Understand the basic functionality of Automobile Communication	30

List of Experiments:

1. To establish communication using CAN protocol between different controllers.
2. To establish communication using LIN protocol between different controllers.
3. To develop, simulation and testing of FlexRay Protocol.
4. To develop, simulation and testing of MOST Protocol.
5. To study and design IVN application using CANoe tool.

Major Equipment:

1. CANoe Tool
2. NETCAR analyzer tool
3. Embedded Board to test various protocols
4.

List of Open Source Software/learning website:

www.flexray.com
www.ti.com/lit/an/sloa101b/sloa101b.pdf
https://www.vector.com/int/en/products/products-a-z/software/canoe/