2017 2nd IEEE International Conference On Recent Trends in Electronics Information & Communication Technology (RTEICT), May 19-20, 2017, India

# CAN-LIN Bridge for Driver Assistance and Passenger Comfort An Optimized Resource Approach

Ashish Srivastava,
Department of E&TC Engineering,
MIT Academy of Engineering, Pune, MH, India,
aksrivastava@entc.mitaoe.ac.in

Debashis Adhikari,
Department of E&TC Engineering,
MIT Academy of Engineering, Pune, MH, India
dadhikari@entc.mitaoe.ac.in

**Abstract— The expansion of automation in automobiles have paved way for connecting subsystems by using communication protocols CAN and LIN. CAN provides serial communication that efficiently supports distributed real time support with a high level of security. LIN is designed to communicate at low data rates at low cost. The main contribution of this paper is that a CAN-LIN bridge is proposed that will connect two chips of above mentioned protocols. There by providing passenger comfort (back rest lean forward-backward and seat slide forward-backward) and Driver Assistance (wiper operation) using MCP2021 & MCP2551.**

***Keywords*— Piccolo board, CAN, LIN, Passenger Comfort, Driver Assistance**

## I. INTRODUCTION

The technological advancements in the field of automobiles are revolutionary sweeping through automotive in-vehicle, vehicle-to-vehicle and infrastructure of communication networking.

Several field-bus networks have been developed to fulfill the need for low-speed, low-cost communication inside a mechatronic based sub-systems generally made of an Electronic Control Unit (ECU) and its set of sensors and actuators. Controller Area Network (CAN) is a vehicle bus standard designed to allow ECU and devices to communicate with each other in applications without a host computer. As an alternative to conventional multi-wire looms, wired and other electronic components throughout the vehicle to communicate on a single or dual-wire network data bus up to 1 Mbps. Local Interconnect Network (LIN) is a universal asynchronous receiver-transmitter (UART) based, single-master, multiple-slave networking architecture originally developed for automotive sensor and actuator networking applications. It also provides cost-effective networking option for connecting motors, switches, sensors and lamps in the vehicle. Implementing a CAN-LIN bridge that complement each other in communication protocols thereby providing a new dimension in automotive domain is the idea placed in this paper. Passenger Comfort has to be recognized when the person sitting on the seat adjusts itself automatically by the successful execution of bridge algorithm. Driver Assistance is also a novelty that leverages the integration of ECU into an embedded system application. The comparison among the available boards presented in this paper has been given in Table. 1. The differences as depicted is among the three microcontroller boards, that is Piccolo-16 bit-RISC and 32 bit-ARM. Various criterions are considered in the below table as far as selection of the right board is concerned. The difference between the boards with respect to listed parameters mark an important tool for the selection of right microcontroller for the proposed system.

TABLE I.

| Processor | Comparison of Microcontroller Boards | | |
|---|---|---|---|
| | *Piccolo* | *16-bit RISC* | *32-bit ARM* |
| Vendor | TI | TI | ST |
| Manufacturer | LAUNCHXL-F28027 | MSP430 | STM32F103CBT6 |
| Max Speed | 60Mhz | 16Mhz | 72Mhz |
| Flash Memory | 64Kbytes | 92Kbytes | 128Kbytes |
| RAM | 12Kbytes | 8Kbytes | 20Kbytes |
| I/O Pins | 22 pins | 46 pins | 37 pins |
| Wake-Up time | 1ms | 1ms | 1.6ms |

Many contemporary automobiles, have replaced mechanical controlling with ECU [1]. The CAN is a multi-master message broadcast system that supports a maximum signaling rate of 1Mbps. In [2] the LIN specification has been envisioned as a UART based protocol which would allow the use of inexpensive, readily available components to enable a serial communication standard. The seat adjustment mechanism presented in [3] deals with automating the seat of an automobile through the use of microcontroller and image processing toolkit of MATLAB. According to [1] LIN protocol supports the control of high level networks, complementing the existing characteristics of LIN in [2]. In [4] the design of a new seat-adjustable power wheelchair for preventing long periods of sitting is proposed. LIN bus in [5] is simulated using LabVIEW and a USB-LIN smart card. The embedded program mainly handles the LIN communication while the PC software undertakes the simulation, configuration and monitoring function of system. In [6] the modeling of two dimensional mathematical model of wiper system using Newtonian Law to increase the maintenance as well as the visibility of the driver is presented. CAN-LIN specifies the new challenges to automakers as these specifications and solutions mentioned in [2] [4] will further deliver the promise of evolution through these protocols. The parameters of [3] that are related to comfort ability of different individuals as well as the relationship of contact angle and input shaping scheme in automotive wiper system in [5] are the two main applications of implementing a CAN-LIN bridge.

The main contributions of this paper are as follows:-

The comprehensive simulation in proteus has been done as the implementation of programs provides an integration of all tools and operations required.

- The goal was to connect MCP2021 with MCP2551. CAN & LIN are two separate protocols which will function in conjunction for embedded automotive application when bridged together.
- Designing algorithm for the communication protocol i.e. CAN-LIN bridge with an objective of giving dimension to automotive domain by providing both passenger comfort and driver assistance.
- Programming has been performed in code composer and the respective code for transmitter (Tx) and receiver (Rx) has been dumped in the Piccolo Boards which is thereby providing the field of embedded automotive system a new concept.

## II. SYSTEM MODEL

Automobiles are becoming more and more sophisticated and techno savvy. Technology has completely changed the face of automobile industry. As a result, consumer expectations in terms of performance have also risen. In this paper we propose to take the automation of automobiles one step further by developing a prototype which enables passenger comfort as in [4] and driver assistance [6]. A CAN LIN Bridge will solve the economical restrictions in the low segment cars while at the same time providing similar passenger comfort available as in high end cars. It will reduce the overall cost of the implementation of application like driver assistance i.e. wiper operation and passenger comfort by backrest lean forward-backward and seat slide forward-backward.

### A. The Structure

The structural model as shown in Fig.1 contains two ECU's one each for Tx and Rx. Two push buttons (PB) are indicated for simplicity of representation. For each required application system will have two PBs. CAN is a main communication connection that transmits data between modules, but requires more bandwidth. LIN protocol is designed to communicate at low data rates with less cost.

There are basically three sub-blocks which divide passenger comfort and driver assistance respectively. 'Leaning' and 'Sliding' are the two main aspects. Including an additional wiper system constitutes the third block of the system model.

When Tx pin of ECU1 is connected to transmitter MCP2551, the CAN bus has two states: Dominant and Recessive. A dominant state occurs when the differential voltage between CANH and CANL is greater than a defined voltage (say, 1.2V). A recessive mode occurs when the differential voltage is less than a defined voltage (typically 0V). Dominant and Recessive mode correspond to the low and high state of TXD pin. In the proposed system if an extended low state on TXD is detected CANH and CANL output will be disabled. This will prevent corruption of data on CAN bus.

CANH and CANL of Tx CAN chip is connected to CANH and CANL of bridge MCP2551. For bridge configuration the TXD and RXD of MCP2551 are connected to RXD and TXD of LIN chip respectively. If an activity is detected on the RXD of LIN chip (power-down mode) Tx is off. On detection of high level chip will go through ready mode then to operation mode. MCP2021 of the bridge will be connected to the Rx LIN chip. The MCP2021 will provide a +5V, 50mA regulated power output. This output is suitable for the piccolo board (ECU2). At the ECU2 the message frame containing the ASCII values of transmitted characters are converted back. The ECU2 will be connected to the actuator for target application.

#### Electronic Control Unit

In automotive electronics, ECU is a generic term for any embedded system that controls one or more of the electrical system or subsystems in a transport vehicle. The use of networks for communications between ECU's of a vehicle in production that requires different domain that have developed a large number of automotive networks such as CAN, LIN, Flex Ray, MOST etc.

#### Controller Area Network

CAN was designed by Bosch in the mid 1980's for multiplexing communication between ECUs in-vehicles and decreasing the overall wire harness. The CAN chip MCP2551 used in the proposed system is shown, in Fig.2. CAN is robust and reliable serial network protocol that offers high speed communication rate up to 1Mbps in real time control. The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 device provides differential transmit and receive capability for the CAN protocol controller.

#### Local Interconnect Network

The LIN protocol supports the control of mechatronic elements of the automobile applications. The LIN specification was originally envisioned as a UART based protocol. This allows the use of inexpensive, readily available components that enables serial communications standard. It is economically viable for use with sensors and actuators. The LIN chip MCP2021 used in the proposed system is shown, in Fig.2. The MCP2021 provides a physical interface between a microcontroller and a LIN half-duplex bus. It is intended for automotive and industrial applications with serial bus speeds up to 20Kbaud. The MCP2021 provides a half-duplex, bidirectional communications interface between a microcontroller and the serial network bus.

### B. The Transmitter ECU

The Transmitter flowchart is shown in Fig.3. It consists of starting with initialization of variables. The system will wait for a key press. On a press of a push button character 1/2/.../6 will be transmitted. If the pressed key is say for forward slide operation character '1' will get transmitted. For rest all

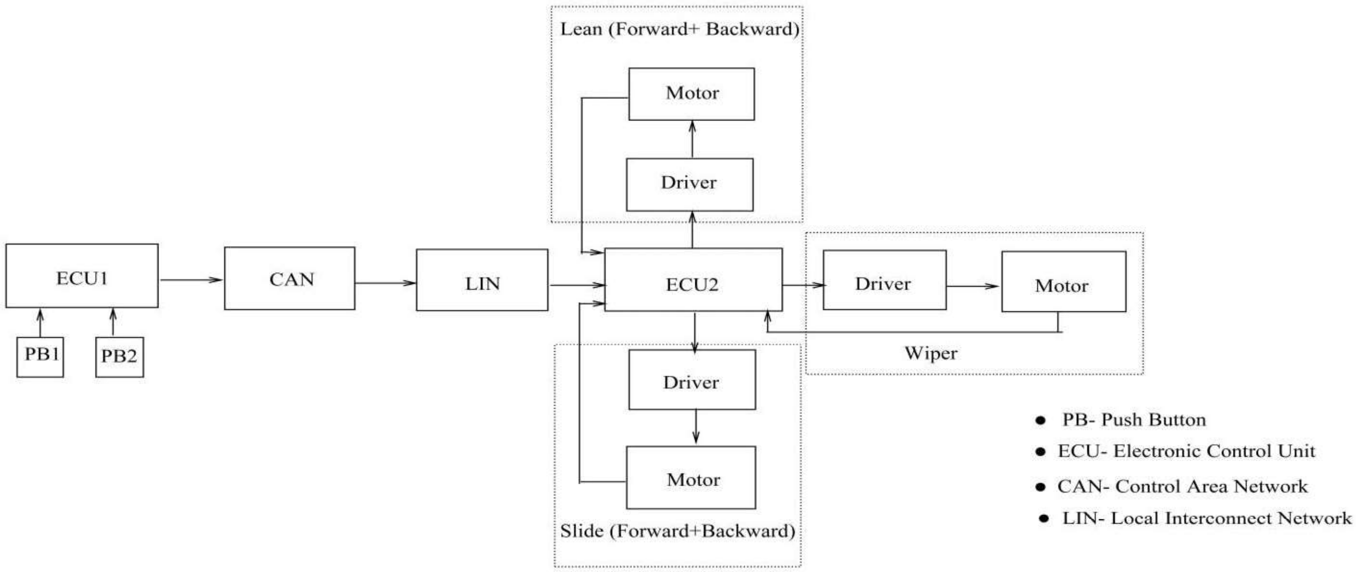


Figure 1: The System Model

application similar logic is followed. For slide backward, lean forward and lean backward character '2, 3 and 4' are assigned respectively. For wiper start and stop on press of push buttons '5' and '6' will be transmitted. Instructions that are allotted to the respective characters will execute and stop the loop consecutively.

### C. The Reciever ECU

The 'ECU2' will wait for the character transmitted from the 'ECU1'. If character '1' is received slide forward operation will take place. On reception of character '2, 3, 4, 5 or 6', slide backward, lean forward, lean backward and wiper star-stop will happen. The characters that are used in the flowchart Fig.4 holds values which are sequential. If a certain function does not respond then it is passed onto the next character that is in sequence.

## III. SIMULATION

The simulation for driver assistance has been done in proteus and shown in Fig.5. The application has been simulated using two piccolo ECU's. The TX pin of ECU1 has been connected to TXD of MCP2551. The CANH & CANL of the transmitter MCP2551 has been connected to the CANH & CANL of bridge MCP2551. To make message frame of MCP2551 recognizable by MCP2021, a cross connection has been established between CAN chip & LIN chip used in the bridge i.e. the TXD of CAN chip has been connected to RXD of LIN chip. Similarly, RXD of CAN chip is connected to TXD of LIN chip. The Vbb & lbus of bridge's LIN chip are connected to Vbb & lbus of LIN chip at Rx side. RXD of LIN chip at Rx side is connected to RXE pin of ECU2. The target actuator for wiper is connected to the piccolo board via a motor driver IC L293D. The waveforms of different points in the system are depicted in Fig.6. The first signal is the transmitted signal which is sent from 'ECU1'. The signal next to be taken by placing virtual probe at the start of the bridge. The third signal is shown is after the bridge. The fourth signal shown in the Fig.6 is the signal between the actuator and 'ECU2'.

## IV. HARDWARE

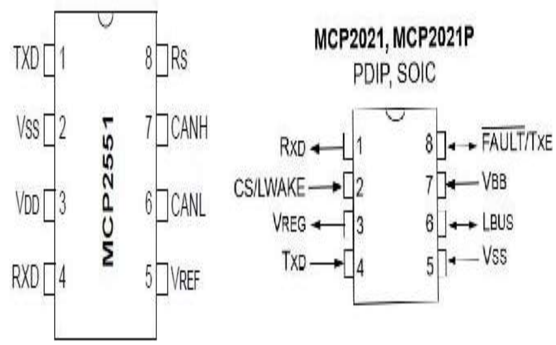


Figure 2: CAN LIN Chip Pin Diagram

As shown in Fig.7, a Stepper Motor has been used for wiper operation. The wiper operation will not get interrupted if simultaneous process of passenger comfort is employed. There are mainly 2 push buttons which is installed for switching ON and OFF the wiper.

In Fig.8 the mechanical structure for sliding operation is shown. There is a provision of 2 PB's which will be located on the dashboard for slide forward and backward. In Fig.9 a motor with encoder has been used at the joint of back-rest and seat-rest. Using the push buttons the backrest can be adjusted to lean forward and backward respectively. Fig.10 shows the complete prototype that is designed to validate the proposed concept.

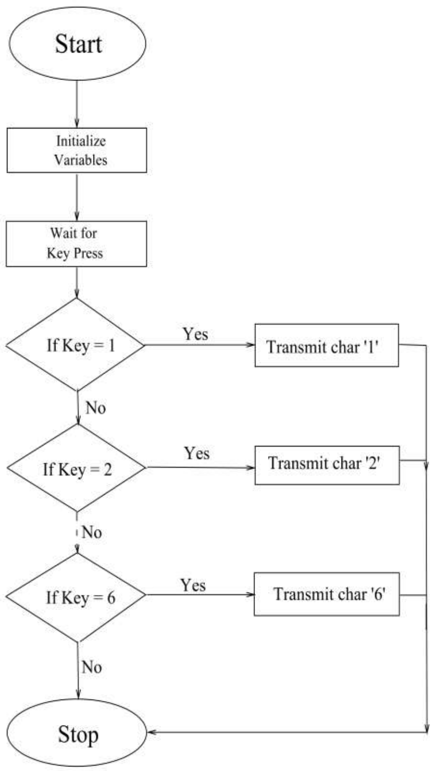


Figure 3: The Transmitter ECU

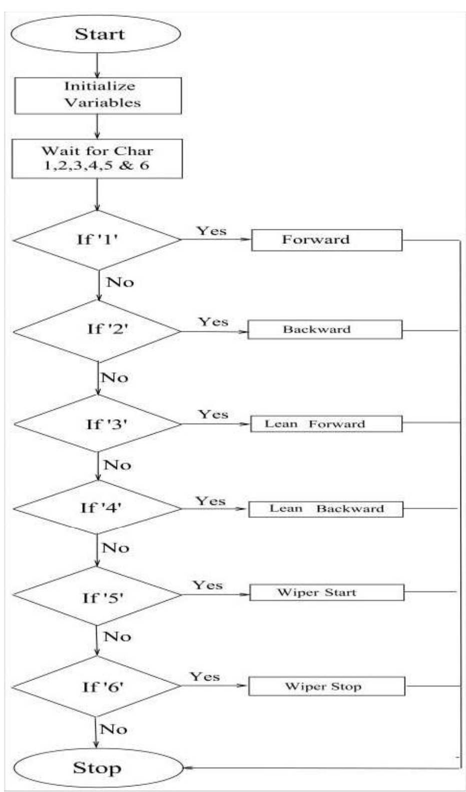


Figure 4: The Receiver ECU

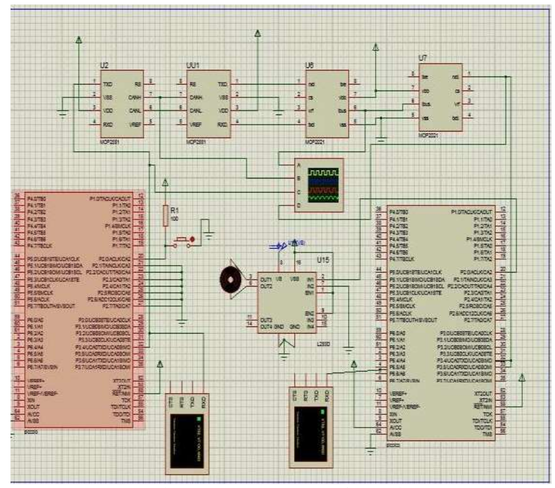

Figure 5: CAN-LIN schematic


Figure 6: CAN-LIN simulation graph

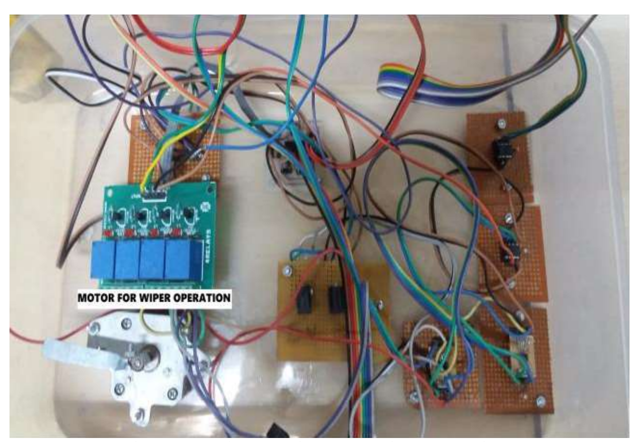


Figure 7: Driver Assistance- Wiper operation

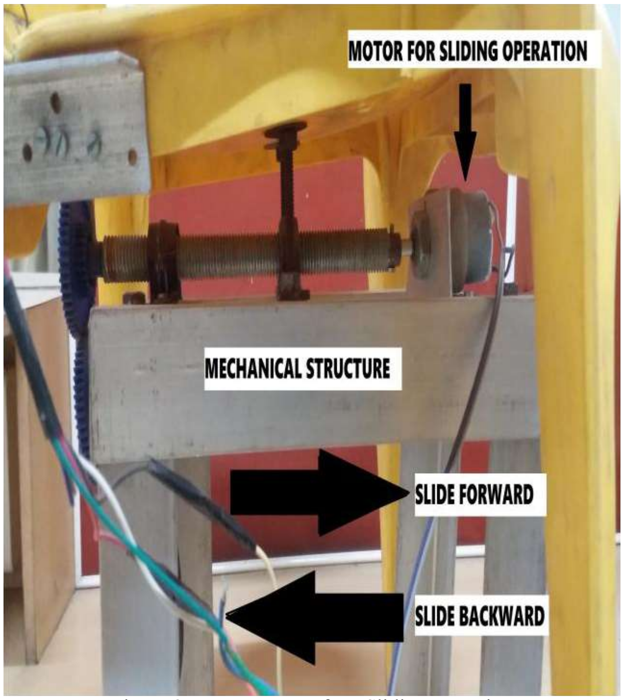


Figure 8: Passenger comfort- Sliding operation


Figure 9: Passenger comfort- Leaning operation

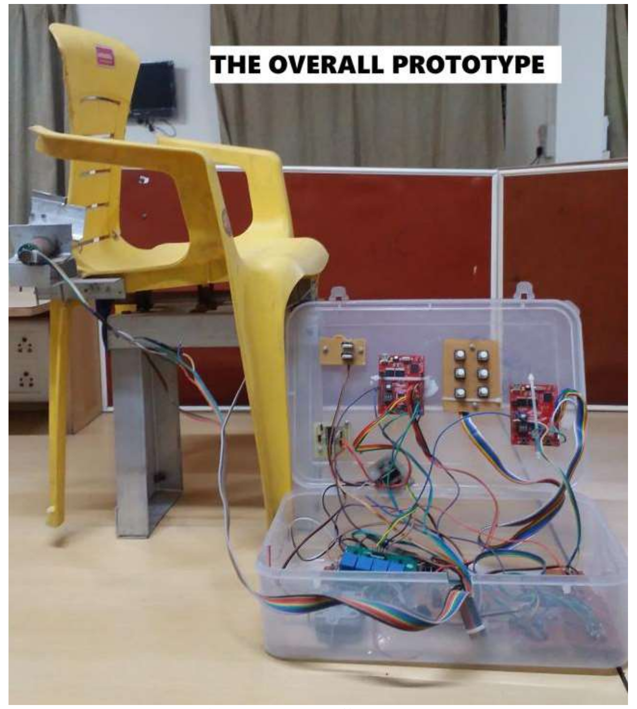


Figure 10: Overall Prototype

## CONCLUSION

In this paper we have proposed a CAN LIN Bridge for low end automobiles that would provide the same facilities available in higher class vehicles. Our proposed concept is also validated through a prototype design. The concept discussed in this paper is a novel one. It is expected that high end applications could be made available to the user at a lower cost.

## REFERENCES

[1] S.H.Kim, S.H.Seo, “A Gateway System for an Automotive System: LIN, CAN, and FlexRay,” IEEE International Conference on Industrial Informatics “, pp. 967-972, July 2008.

[2] Matthew Ruff, “ Evolution of LIN solutions,” IEEE International Conference on Vehicular Technology, pp. 3382-3389,vol 3, October 2003.

[3] Akshay Lahiry, Samarth Chanana, Sourabh Kanwar, “ Automation in Automobiles: Power Seat,” IEEE International Conference on machine vision, pp.158-160, 2010.

[4] Wei-Chen Lee, Chung-Hsein Kuo, “Development of a seat adjustable power wheelchair,” in Proceedings IEEE International Conference on System Science and Engineering, pp. 495-497,June 2011.

[5] Feng Luo, Renjun Li, “LIN network simulation system based on LabVIEW,” IEEE International Conference on computer design and applications, pp. 299-303,vol 5, June 2010.

[6] M.A.Salim, A. Noordin, F.A.Munir, “The Relationship of contact angle and input shaping scheme in automotive wiper system,” IEEE International Conference on computing and communication technologies,July 2012.