A Review on Steer-By-Wire System Using Flexray

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Abstract—**Flexray is inclusive solution to managing communication between multiple ECUs (Electronic Control Units) in the vehicles. The Flexray protocol specifies versatile message identifiers that can be mapped to specific control information categories. Communications may occur at a maximum recommended rate of 10 Mbit/sec. FlexRay is a next-generation automotive control and communication protocol projected for safety-critical automotive applications such as X-by-Wire system, where electronic connections will replace the mechanical linkages. In this paper, we have presented a review, how the Flexray is expanding its area of working and applications in automotive Electronics.**

Keywords- Steering-by-wire; FlexRay; Automotive Electronics;

I. INTRODUCTION

CAN is slowly getting replaced by Flexray. At present, controller area network (CAN) is the preferred technology for interconnecting electronic control units in vehicles to carry out tasks such as engine management, antilock, brakes, cruise control, and so on. However CAN is suffering from a number of drawbacks. For example, CAN allows for the maximum transmission speed, in fact, is 1Mbit/s at most for bus lengths up to about 40m. What is worse, the bit rate cannot be increased above such limit because of the access strategy, which is based on bitwise arbitration. To satisfy the requirements of auto systems, FlexRay communication protocol has been developed in the recent past. FlexRay is a new standard of network communication system which provides a high speed serial communication, time triggered bus and fault tolerant communication between electronic devices for future automotive applications. FlexRay supports a time-triggered scheme and an optional event triggered protocol with the data rate 10Mbit/s and it provides two channels for redundancy [1, 2].

FlexRay was developed for next generation automobiles by a consortium founded by BMW, Bosch, DaimlerChrysler and Philips in 2000[3]. Nowadays, almost all the leading automotive, semiconductor and electronic systems manufacturers have become the member of the FlexRay Consortium. The consortium consists of several automotive and semiconductor industries members including Freescale Semiconductors, Bosch, General Motors, and Hyundai Motors, who contribute their product solutions and applications. In 2006, FlexRay protocol was first applied to the electronically controlled dampers of BMW X5 series.

FlexRay transmits frames repeated periodically by bus cycle. FlexRay cycle is composed of static and dynamic segment. The static segment is similar to TTP, which employs a time division multiple access (TDMA) scheme, while the dynamic segment of the FlexRay protocol is similar to Byte flight and uses flexible TDMA (FTDMA) bus access scheme [4].

In a SBW (Steering-by-wire) system, a large number of signals to be transmitted, very strict latency time requirements and time deviations require not only a fast communication system, but also Time-triggered one. For this kind of system FlexRay is optimal, because of its time triggered communication method with characteristics as deterministic, Fault-tolerant and high data rates. Except for X-by-wire systems, it is also interesting for the safety critical and real time system related field in advanced automotive control applications.

II. FLEXRAY SYSTEM ARCHITECTURE

A. Network Topology

Network topology is defined in electrical physical layer 2.1B is about: Linear passive bus structures, Passive stars, Active stars. Nodes can be connected in these topologies. The FlexRay communication network can also be a single bus. In this case, all nodes are connected to the single bus. The use of two active stars, as shown here, might not be possible [2].

B. Flexray Node Architecture

FlexRay node architecture is shown in Fig. 2. Each FlexRay node consists of a host, communication controller (CC), bus guardian (BG) and bus driver (BD).

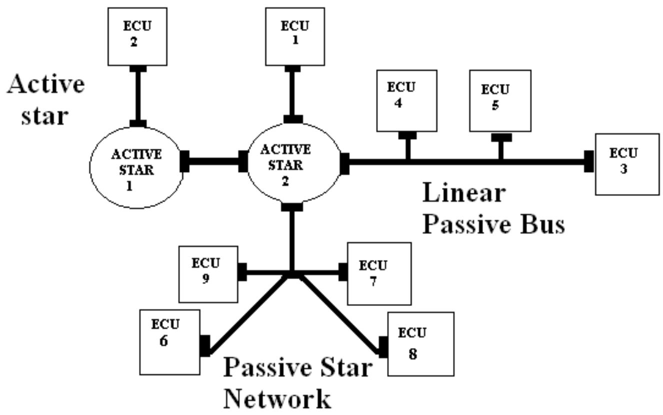

Figure 1. Network Topology

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Host is the user software which controls the communication process. CC is responsible for implementing the protocol aspects of the FlexRay communications system and core of the FlexRay protocol specification. BG is an electronic component which protects slots against faulty media access and is optional [8]. BD is consisted of a transmitter and a receiver that connects a communication controller to one communication channel.

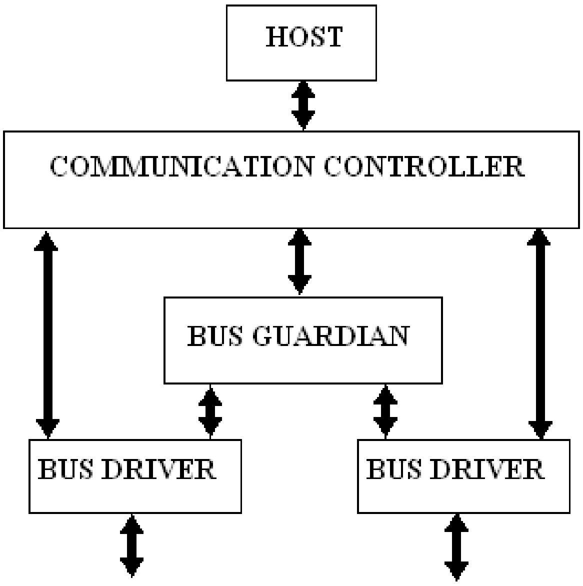

Figure 2. Flexray Node Architecture.

III. THE FLEXRAY COMMUNICATION IN AUTOMOTIVE

The trend towards replacing mechanical controls with electronic x-by-wire solutions has been consequently followed in aeronautic technology since the 1980s [5]. But not implemented in road vehicles. Most current automotive systems depend on wired electronic communication. This has brought us to a point where the weight and complexity of the electrical harness is no longer negligible. The overall weight of the electrical harness and some mechanical linkage can become a main cause in increasing weight of the whole vehicle. Since a decrease in weight results decreased fuel consumption, as well as reducing the intrinsic complexity of the wiring and cost, the current trend is to replace point-to-point connections with shared data buses and to reduce the number of data buses by integration of functionalities.

Dr Michael contributes a valuable modern embedded design in ARTIST Industrial Seminar. Modern embedded systems contain several distributed ECUs, which communicate in real-time with each other over a fault tolerant communication system like FlexRay. But sometimes software becomes a big problem. Formal methods where proofs are used to ensure software correctness are written in a language that only a few experts worldwide truly understand. Further, real-time case tools in the 1980s aided design, but did not provide an easy path to final code [6].

In the paper presented by Joachim Langenwalter and Tom Erkkinen, framework of processes, methods, and tools for the design of automotive embedded systems is presented [7]. They have designed a model, which satisfied requirements, such as time or event-based simulation and frequency domain analysis. This can be implementing in a steer-by-wire system. This paper described a full software engineering framework for model based design and production code generation. Specific methods and tools were shown to illustrate that this is not just theory, but rather it is both practical and available. Also the idea about the steer-by-wire is presented in a simplified form, as shown in the Fig. 3.

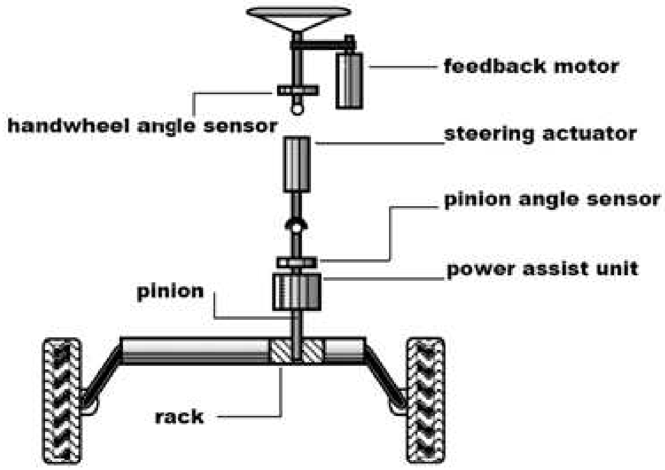

Figure 3. Steering-by-wire.

The paper presented by Cedric Wilwert, Nicolas Nave et al reviewed the fault-tolerant services and the Communication protocols (TTP/C, FlexRay and TTCAN) that are needed for SBW systems. Methods for designing a dependable X-by-Wire system were described and a SBW system based on TTP/C was then used as a case study. They showed how to build a fault-tolerant architecture by choosing the necessary redundant components and the schedule of transmission. A method for evaluating the probability that the real-time constraints would be violated under a simple perturbation model was also proposed [8].

It is now widely believed that FlexRay will emerge as the predominant protocol for in-vehicle automotive communication systems. As a result, there has been a lot of recent interest in timing and predictability analysis techniques that are specifically targeted towards FlexRay. A design is proposed by Andrei Hagiescu, in that a compositional performance analysis framework for a network of electronic control units (ECUs) is given, that communicate via a FlexRay bus [10]. They have specified the tasks running on the different ECUs, the scheduling policy used at each ECU, and a specification of the FlexRay bus. They presented a compositional performance model for a network of ECUs communicating via a FlexRay bus. The main contribution of the paper is a formal model of the protocol leading the dynamic segment of FlexRay. As the majority of vehicle automated systems is either critical or at least safety applicable, there is increasing need for unfailing high data rate buses ECU communication. At present most of the systems are dealing with CAN.

Another example is at Embedded Technology 2007, regeneration demonstrated two sets of SBW model via FlexRay and CAN, in the interest of showing that the SBW model equipped by FlexRay could drive the tires acting more smoothly when steering. Moreover it is qualified by two transmitting paths as well as double ECU, which has the capability when one falls cross failure, the other one can also work fluently [11]. Actual implementation with the result as a proof is given in the paper presented by Yi-Nan Xu, I. G. Jang, Y. E. Kim, and J. G. Chung, a design of Steering-by-Wire system is introduced, in which a FlexRay control and communication network is setup. According to the requirement of SBW, there are three FlexRay nodes are created.

For control and communication purpose, a protocol for communication cluster is developed; the parameters such as signal characteristic, slot, communication time schedule and cycle are defined in the protocol. A SBW FlexRay network simulation is providing much more clear idea about the establishment of the communication network. The network topology, communication messages; control parameters are configurable in the simulation system. The simulation result shows that the SBW system is capable communication system. The hardware and the software of the FlexRay nodes are developed respectively; all these nodes are connected as a physical FlexRay cluster.

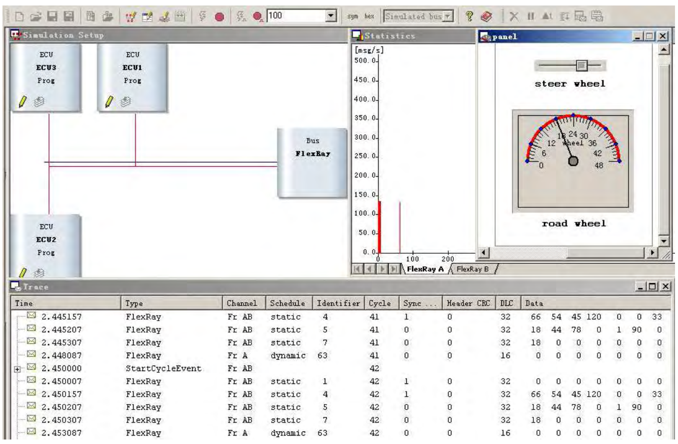

Figure 4. Expected Result of the simulation

They have used simulator and editing software's: CANoe, Flexray, CAPLE Editor, and CANdb++ Editor for the design of the nodes. After studying this paper one can realize characteristics of extraordinarily deterministic, fault-tolerant and comparatively high data rate of Flexray.

As per the information released, the probability of encountering a critical safety failure shall not exceed 5.10^{-10} per hour and per system, but other studies have been realized with a maximal bound of 10^{-9}. This quantification can be translated in terms of Safety Integrity Level (SIL) and a maximal bound of 10^{-9} corresponds to a SIL4 system. In fact, SIL4 conformance is reached below 10^{-8} [12].

It is becoming necessary to implement an automotive protocol in reachable language so it can become easy to modify the things and to make cost effective. Yi-Nan Xu, I. G. Jang, Y. E. Kim, and J. G. Chung Sung-Chul Lee, presented a design of the FlexRay communication controller, bus guardian protocol specification and function parts using SDL is presented [15]. Then, the system is redesigned using Verilog HDL based on the SDL source. The FlexRay system is synthesized using Samsung 0.35μm technology. It is shown that the designed system can operate in the frequency range up to 76 MHz. In addition, the FlexRay system is implemented using ALTERA Excalibur ARM EPXA4F672C3 with a bus driver chip AS8211. To show the validity of the system they have used automobile advance alarm system in vehicle applications. It can be a great success for the designers and manufacturers.

Also same system is implemented by same team with another application of the Flexray with the robot system. To show the validity of the designed FlexRay CC system, the FlexRay CC system was combined with sound source localization system in Robot applications. The paper by Robert Shaw, Brendan Jackman, is dealing with the key features of the FlexRay protocol and comparison with CAN and the existing Field bus technologies such as further defined areas of the network scheme such as frame coding/decoding and symbol as well as start-up of and integration of a node into a network that are detailed in the FlexRay protocol specification [16]. It happens first time to implement the protocol using C.

In the paper presented by Chuanyan Xu, Yong Zhang, investigates communication control based on C computer language and simulates the communication process on two personal computers. All modules are achieved in this approach, such as parameters capture, data collecting, standard communication frame creating, coding checkout, transmitting stream coding accession and receiving stream decoding, and the validity of the simulative system is verified by experimental testing. This research offers a very useful way for both improving and developing the chip and standard of FlexRay in the future. The paper approaches the limits of the Flexray by Christoph Heller, Josef Schalk, and Stefan Schneele Reinhard Reichel and derives worst case signal integrity criteria for FlexRay and applies them to an excellent aeronautic topology with six nodes and an overall length of 90m. The paper highlights the fact that reliable communication is conditionally possible on the topology at data rates up to 5 Mbit/s [18].

The latest paper presented by Khaled Chaaban and Patrick Leserf presents the development of an embedded architecture for a safety steer-by-wire system. They have described the basic architecture of a steer-by-wire system, the safety requirements of the system and the identified failures modes. They have used only two Flexray nodes to design steering-by-wire system.

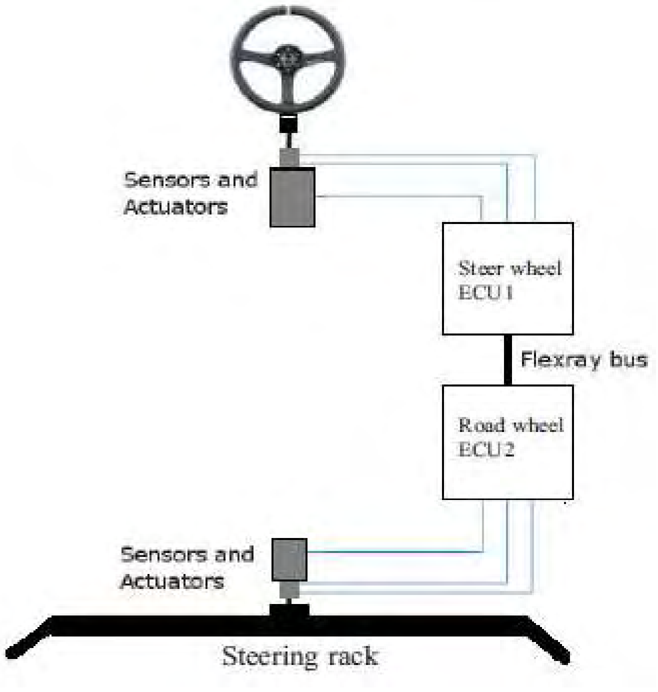

Figure 5. Basic architecture of a steer-by-wire system

They have given a short description of the simulation and implementation keys of the proposed architecture [20]. Again they have presented the development of a Steer-By-Wire system using AUTOSAR methodology. Some aspects of safety and timing requirements are analyzed. They have shown how AUTOSAR model permits to design and implement a safety embedded system. The system is made authenticated by simulation [21]. And proposed a Sensors arbitration algorithm to determine the state of sensors improve the reliability of the system. The FlexRay Consortium expired on 2009-12-31. In the past the FlexRay Consortium has released several specifications of the FlexRay Communications System. But the specifications made by the FlexRay Consortium are not to be changed and available at [3].

CONCLUSION

The FlexRay protocol developed by the FlexRay consortium has already found applications in the automotive industry and making a trend to set the network scheme especially in X-by-wire applications and other safety critical systems. There is on-going research into the migration from CAN based systems to FlexRay based systems and as such the protocol could find itself being used in many areas outside the automotive industry. With its deterministic time-triggered approach and the high data rates achievable it is also suitable for safety and control applications. This paper has a review of some researches. Now it has been proved by many researches, there is no option for Flexray in an automotive electronics and in industrial electronics for the communication between ECUs.

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