Chapter 5
FlexRay™ Electrical Physical Layer: Theory, Components, and Examples

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ABSTRACT

Modern medium and high end vehicles are no longer imaginable without using technologies to broadcast local available data. The speed information for example is used by many well known functions: the anti blocking system, the radio, the dashboard, the cruise control, the electronic stability program, etc. Usually, this data is distributed among vehicle’s electronic control units by various serial bus systems. The succeeding sections introduce the automotive communication system named FlexRay™. The development of FlexRay™ had been initialized by requirements expected for drive-by-wire systems. The content is focused on its electrical physical layer beginning with active components like bus interfaces as well as passive components like common mode filters and bus-cables. Comparisons to the state of the art systems CAN and LIN are used to support the comprehensibility.

ELECTRICAL PHYSICAL LAYER FLEXRAY™

Scope

The section “Electrical Physical Layer FlexRay™” introduces FlexRay™ focused on the electrical physical layer specifications and application notes version 3.0.1. All main features are taken into consideration. Dedicated detail information is skipped; examples for them are: bus-guardian, wake-up procedures, implementation variants, timing constrains, timing clusters, gateways, system design rules, and EMC tests.

INTRODUCTION

Flexray™ System

FlexRay™ had been specified by an industrial consortium consisting of American, European and
Japanese car makers and their suppliers. The basic requirements were reasoned by the expected communication requirements of safety relevant drive by wire applications end of the last millennium. On one hand the protocol and the physical layer were inspired additionally by the known CAN system and on the other hand by a time triggered approach of a university research laboratory and by a proprietary automotive bus implementation. FlexRay™ specifications are available in the version 3.x. Rausch (2008) explained how to understand and use FlexRay™ focused on protocol’s view. The succeeding sections summarize the published properties from physical layer’s point of view.

The FlexRay™ communication is based on synchronized distributed clocks (relative time). Wake-up, start-up and synchronization procedures are included. A final accuracy in the range of few 100 ns is achievable. Additional properties are (the succeeding list points out some important properties only):

- Up to 64 nodes can participate in the system.
- Three baud rates are supported: 2.5 Mbit/sec, 5 Mbit/sec and 10 Mbit/sec.
- A 1st channel interconnects all nodes. It consists of passive lines and optionally of an active star.
- An active star (AS) may be extended by a communication node optionally.
- A 2nd channel may be used optionally enabling redundant communication or increasing the gross data rate.
- The communication scheme shall be fixed during compile time; however flexible multiplexing procedures are possible.
- The communication scheme contains a single communication cycle.
- The communication cycle contains a static part and/or a dynamic part.
- The static part contains several timing slots; each of these slots may contain one FlexRay™ frame transmitted by one of the nodes.
- The dynamic part enables an event driven communication comparable approximately with CAN’s arbitration procedure.

All protocol procedures are implemented in a communication controller (CC). The connection between the communication controller and the passive bus lines is done by the bus driver (BD).

The basic range of application for FlexRay™ can be seen on one hand in (safety relevant) distributed closed loop control systems and on the other hand in communication systems which require a gross data rate not achievable with CAN. Ongoing developments like automotive Ethernet or CAN FD may modify this state.

The FlexRay™ specifications are done in a way which gives maximum flexibility to the system designer. However the system designer cannot follow a straight forward plug and play approach. A lot of necessary components are specified very loosely. From the electrical physical layer point of view it is specified in detail: bus-driver, active stars and procedures to cover and evaluate the system behavior; however passive components like connectors, bus-cables, common mode chokes, electro static discharge protection elements, printed circuit board layouts or termination circuits are specified more or less roughly.

**Electrical Physical Layer**

The ISO OSI seven layer model defines as level 0 a so called “physical layer”. This layer applied to FlexRay™ (or CAN) contains all hard-ware components which are involved in transferring protocol information (e.g. frames, messages, symbols, in-frame bits etc.) among the mathematically perfect working digital protocol machines.
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