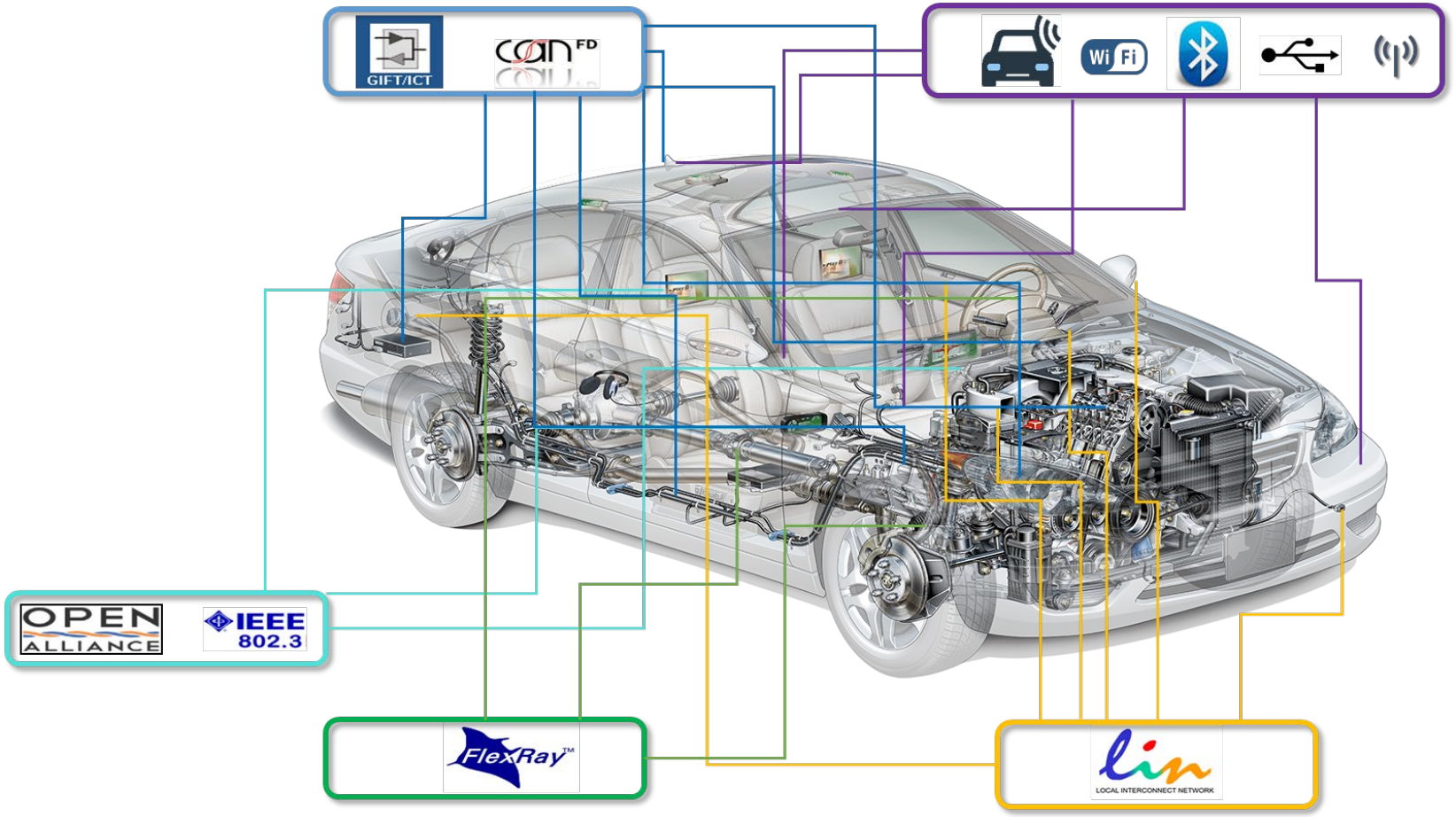
Basics of In-Vehicle Networking (IVN)
onsemi products

Major IVN technologies overview

This presentation deals with basics of LIN, CAN (FD), FlexRay and automotive Ethernet technologies



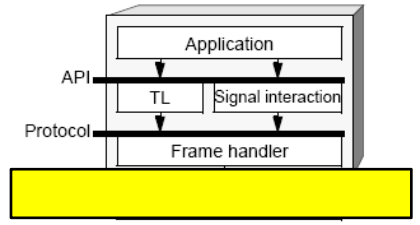
LIN Overview

Like in a classroom situation, the LIN 'master' initiates the response of the other participants

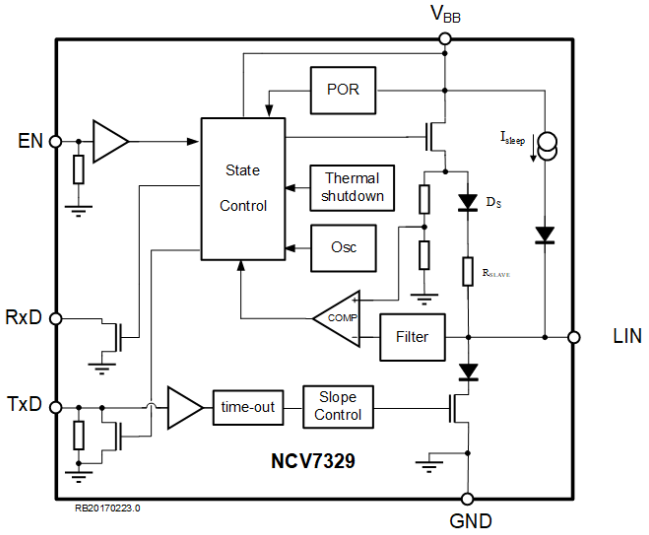
- LIN = 12 V, single-wire serial communications protocol based on the common SCI (UART) byte-word interface
- Maximum speed = 20 kb/s (EMC/clock synchronisation)
- Master controls the medium access: no arbitration or collision management, guaranteed latency times
- Clock synchronization mechanism by slave nodes (no need for quartz or ceramics resonator)
- Nodes added without HW/SW changes in other slave nodes
- Typically < 12 nodes, (64 identifiers & relatively low transmission speed)

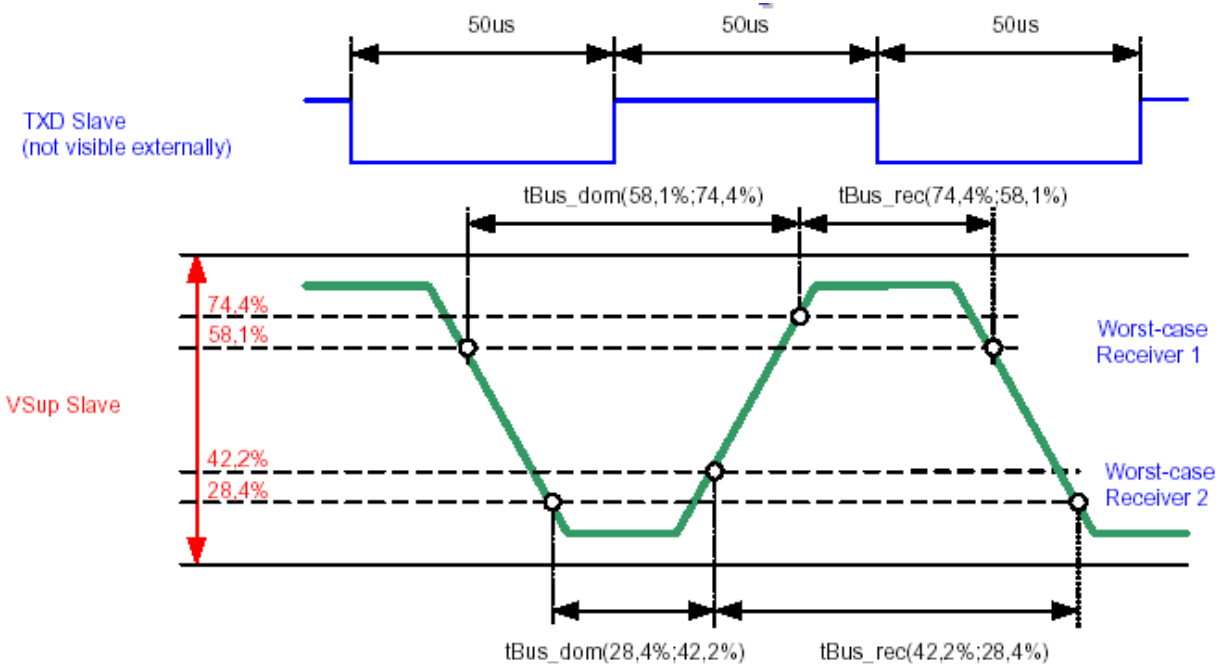
LIN details

Physical Layer



- Vsup between 7 V and 18 V
- Strict requirements for slope and symmetry
- Duty-cycle: Min = 39.6 %, Max = 58.1% (Bus-load: time-constant between 1 µs and 5 µs: 1k/1 nF 660/6.8 nF 500/10 nF) (not-synchronized oscillator <14% tolerance)

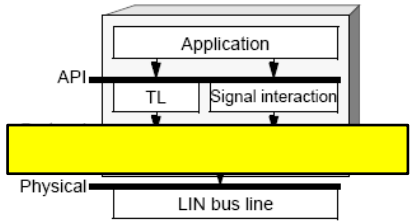




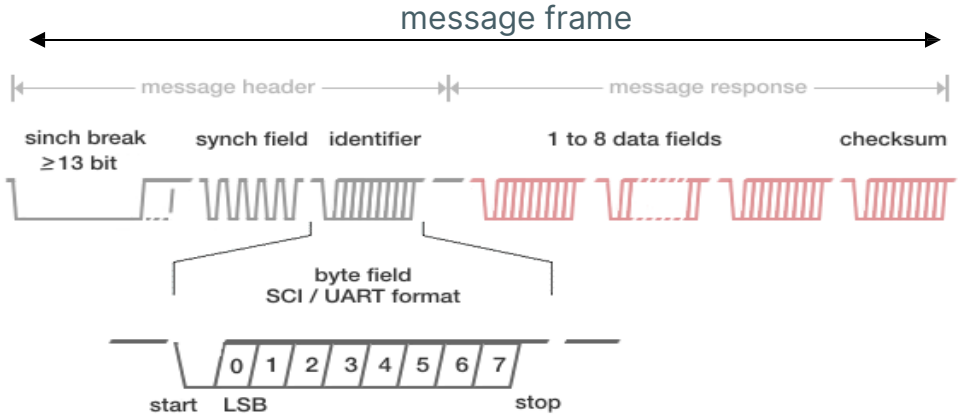
10.1.9	V_{BUSdom}			0.4	V_{SUP}	receiver dominant state
10.1.10	V_{BUSrec}	0.6			V_{SUP}	receiver recessive state
10.1.11	V_{BUS_CNT}	0.475	0.5	0.525	V_{SUP}	$V_{BUS\_CNT} = (V_{th\_dom} + V_{th\_rec})/2$
10.1.12	V_{HYS}			0.175	V_{SUP}	$V_{HYS} = V_{th\_rec} - V_{th\_dom}$

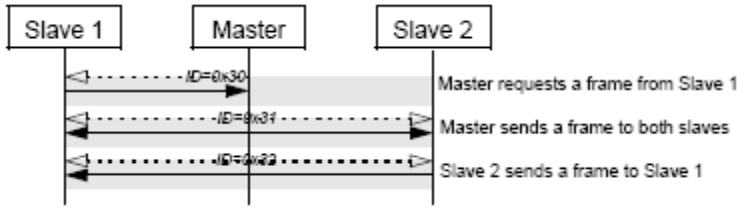
LIN details

Communication concept

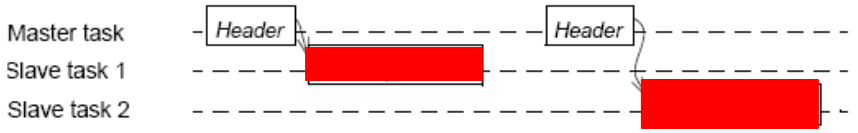


- Communication initiated by the master task (message header)
- Slave task activated upon recognition of identifier - starts the message response (1-8 data bytes + 1 checksum byte)
- Data correctness: parity, checksum
- Identifier = content, not the destination!
  - Exchange of data in various ways:
    - M S(s)
    - S M
    - S S(s)



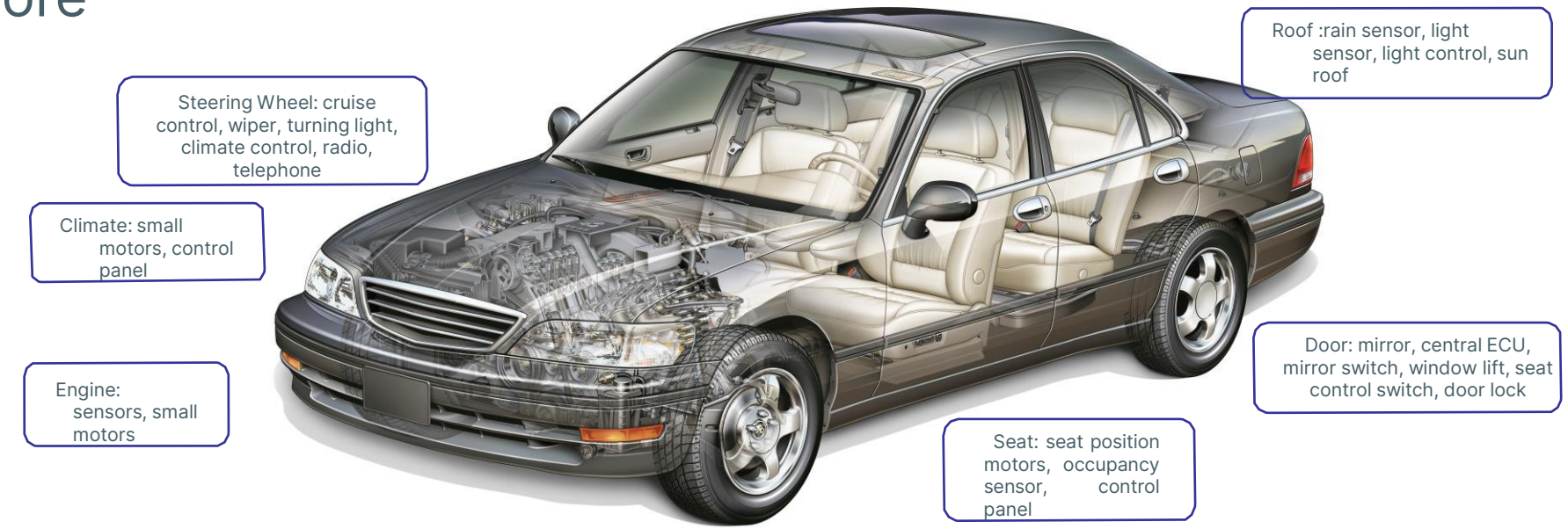


0 = “dominant” state
1 = “recessive” state
Not used = recessive



LIN Applications

- Mirrors, window lift, doors switches, door lock, HVAC motors, control panel, engine sensors, engine cooling fan, seat positioning motors, seat switches, wiper control, light switches, interface switches to radio/navigation/phone, rain sensor, light control, sun roof, RF receivers, body computer/smart junction box, interior lighting, and more



CAN Overview

In CAN communication, all partners are equal and are able to communicate at any time. In case of conflicts (two speaking at the same time), arbitration is used to ensure messages are understood.

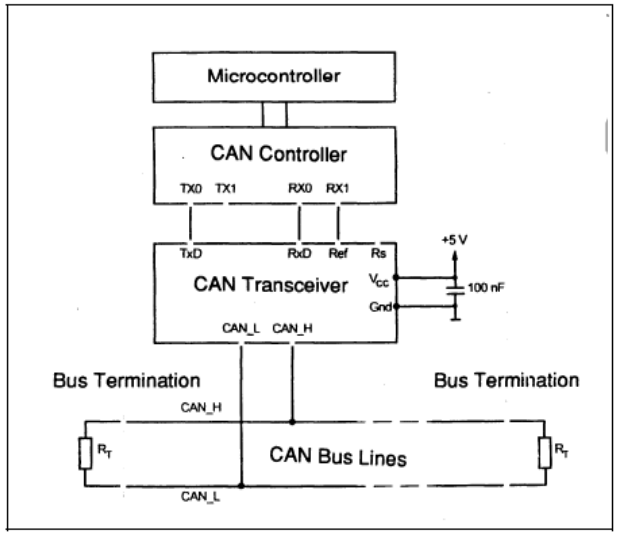
- Controller Area Network is a fast serial bus designed to provide an efficient, reliable and very economical link between sensors and actuators
- CAN connects the vehicle's electronic equipment
- These connections facilitate the sharing of information and resources among the distributed applications
- All nodes can send a message at any time, when two nodes are accessing the bus together, arbitration decides who will continue

CAN Applications

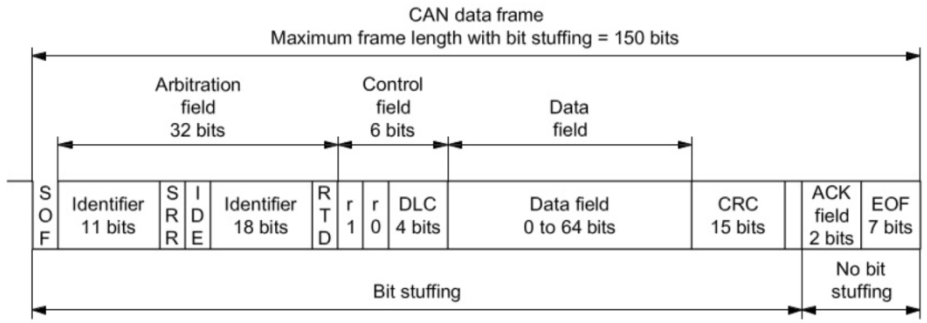
- CAN was developed in early 1980's for automotive and is widely used in all car parts (Powertrain, Chassis, Body). Every car developed in Europe, USA, and Japan has at least a few CAN nodes; CAN is being adopted in Asia as well.
- An increasing number of products have a CAN transceiver implemented together with other functionality (e.g. in system basis chips, stepper motors, park assist, …)
- CAN also found its way into Industrial Applications. See http://www.can-cia.de/

CAN – details
Characteristics

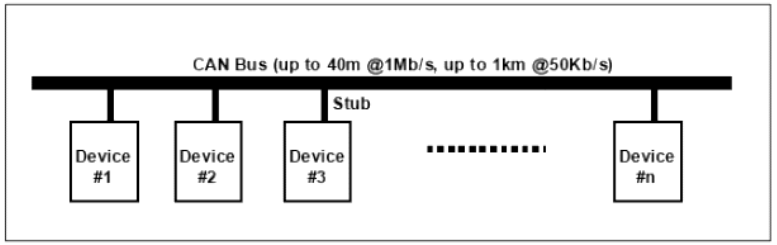
- Asynchronous communication (Event Triggered)
- Any node can access the bus when the bus is quiet
- Non-destructive arbitration, 100% use of the bandwidth without loss of data, large latency for low priority messages, low latency for high priority messages
- Variable message priority based on 11-bit (or extended 29 bit) packet identifier
- Automatic error detection, signaling and retries
- CAN uses a twisted pair cable to communicate at speeds up to 1 Mb/s with up to 40 devices.



Physical CAN Connection according to ISO 11898



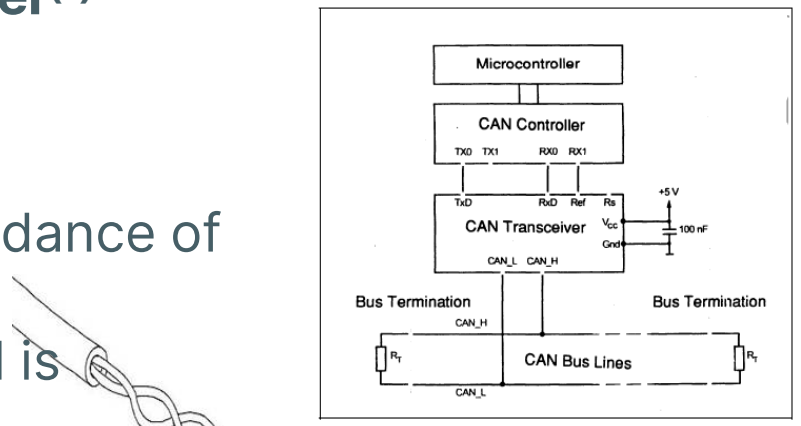
Extended CAN frame (ISO 11898)



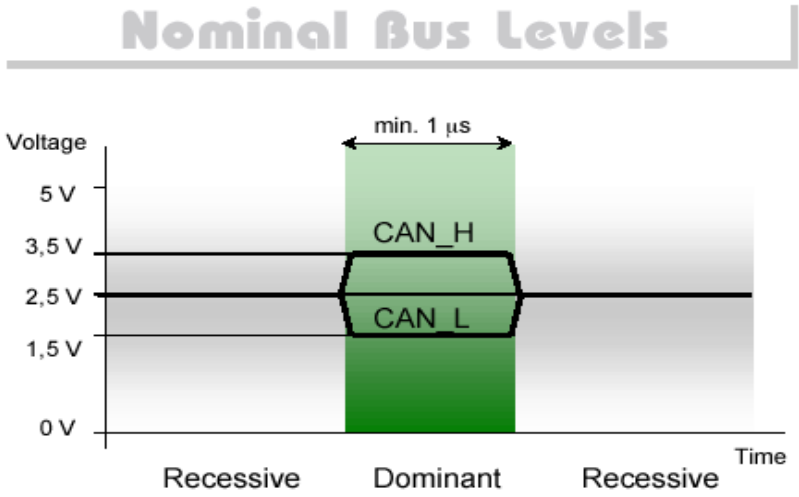
CAN – details

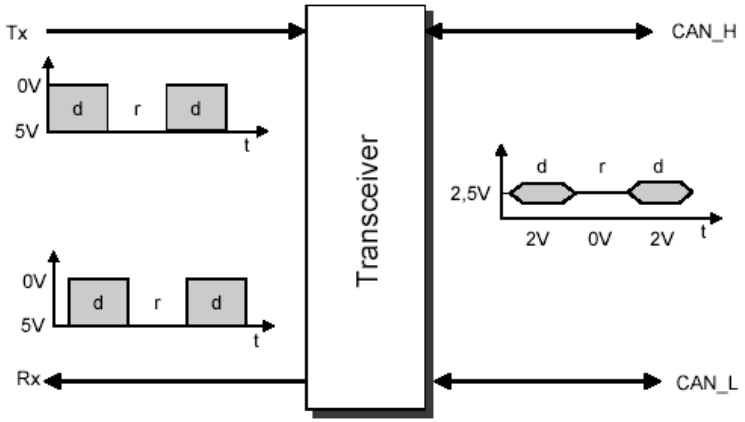
Physical Layer(*)

- CAN bus requires line termination
- ISO 11898 standard define the impedance of the cable as 120 ± 12 Ω.
  Twisted pair, shielded or unshielded is requested.



Physical CAN Connection according to ISO 11898



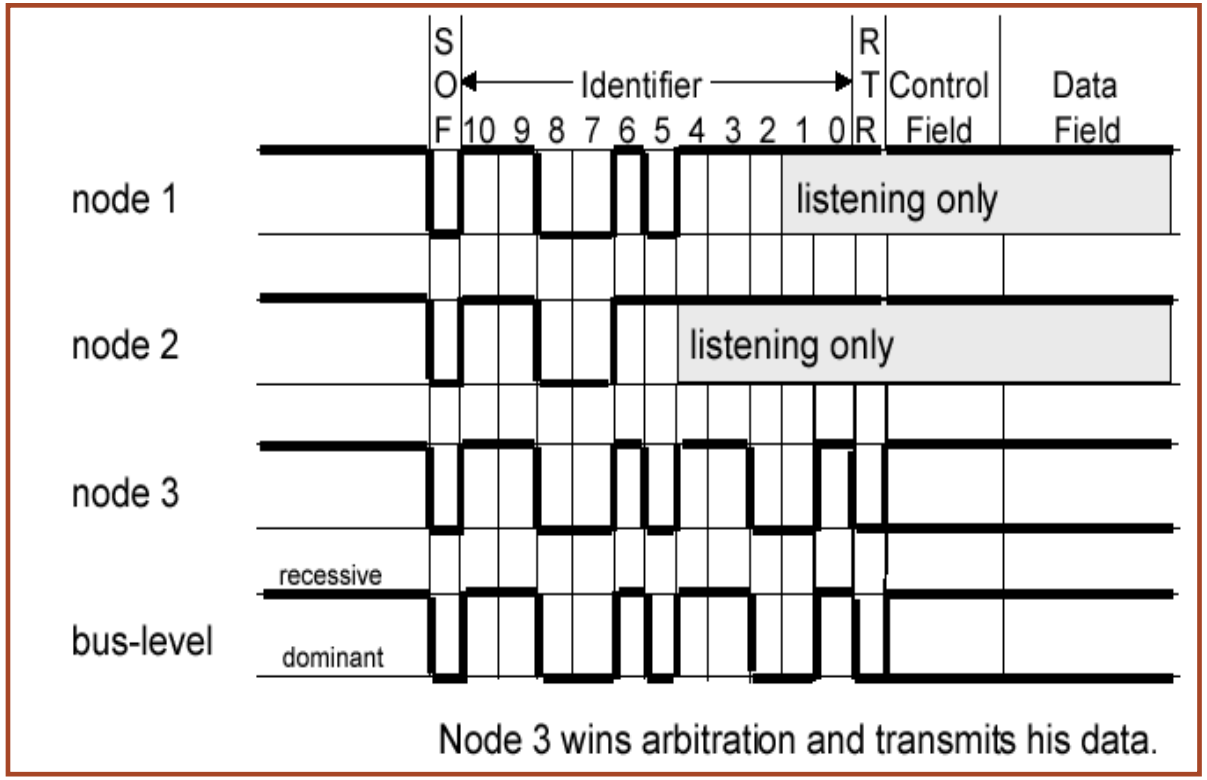


(*) Single wire CAN (SEA2411, 33,3 kbit/s) and low speed CAN (ISO11898-3, 125Kbit/s) are not covered by above description

CAN – details

Bus arbitration in more details

- If two messages are simultaneously sent over the CAN bus, the bus takes the “logical AND” of the signal.
- Hence, the messages identifiers with the lowest binary number gets the highest priority.
- Every device listens on the channel and backs off as and when it notices a mismatch between the bus’s bit and its identifier’s bit.

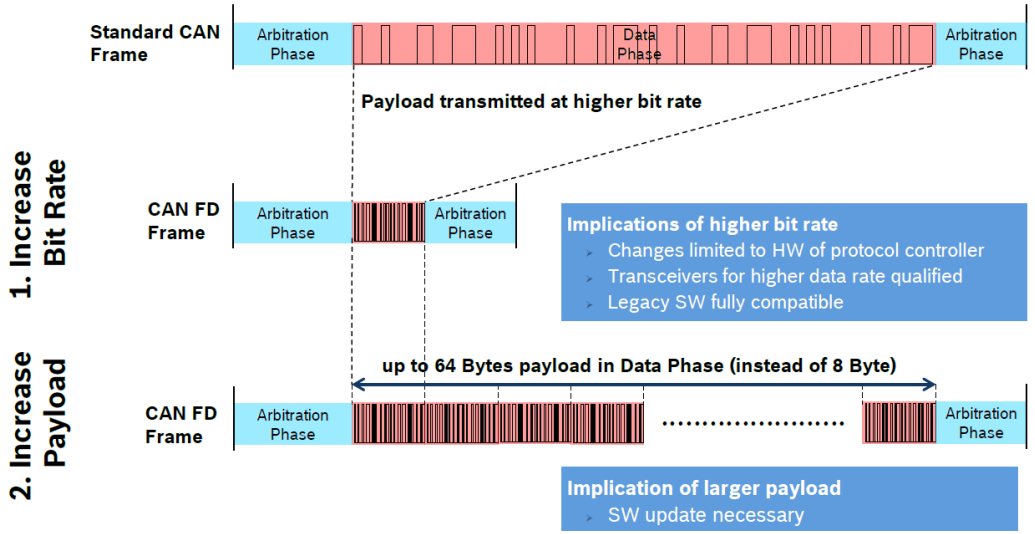


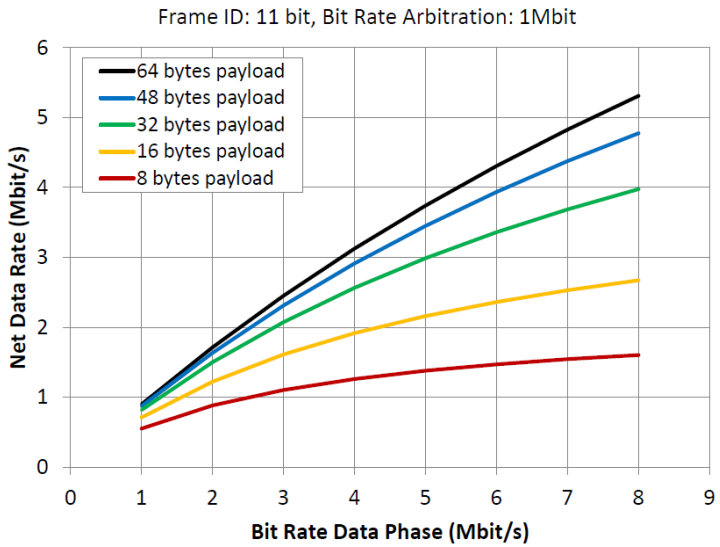
Node 3 wins arbitration and transmits his data.

CAN Flexible Data-rate

- For increased bandwidth, CAN Flexible Data-rate has been introduced as an extension to CAN

Two techniques are used:
1. Increase of the bit rate of the payload
2. Increase of the number of bytes in the payload





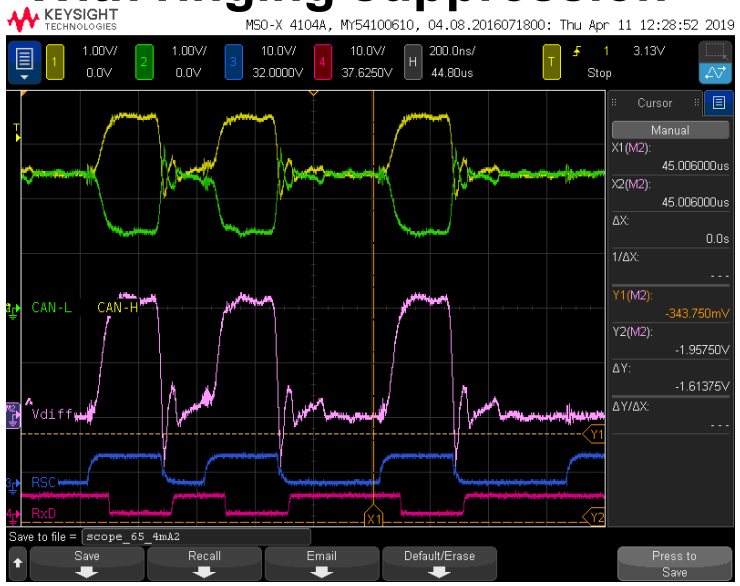
CAN Flexible Data-rate, CAN SIC

- CAN SIC – CAN with **S**ignal **I**mprovement **C**apability

CAN SIC suppress the ringing causes by the not optimized network topology. These SIC transceivers are specified in CiA 601-4. There are two implementations available: one suppresses the ringing when transmitting; the other filters the ringing when receiving.
Results from ONSEMI CAN SIC solution:

Without ringing suppression

With ringing suppression



Flexray Overview

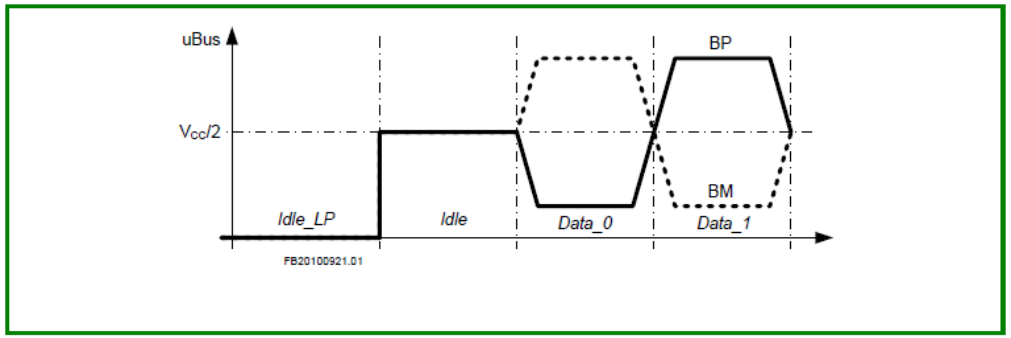
- High data rates (up to 10 Mb/s)
- Time- and event-triggered behavior
- Redundancy
- Fault-tolerance
- Deterministic (use of “time-slots”)

As in a train-schedule, all FlexRay traffic on the bus is nicely scheduled using time-slots.

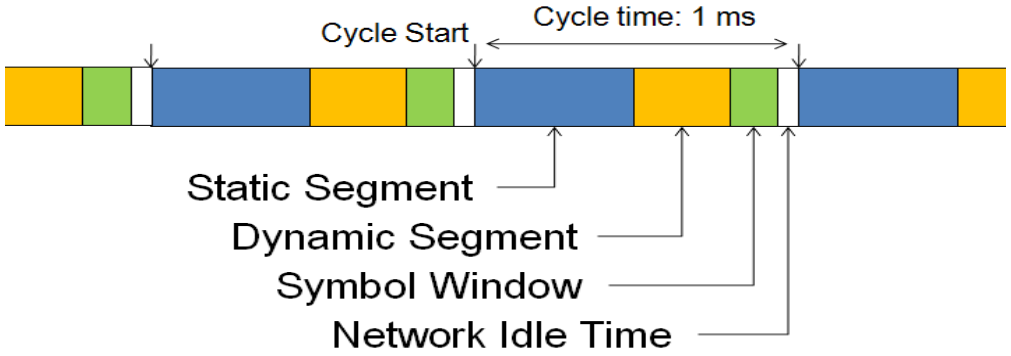
FlexRay delivers the error tolerance, speed and time-determinism performance requirements for x-by-wire applications (i.e. drive-by-wire, steer-by-wire, brake-by-wire, etc.).

FlexRay – Details

Physical Layer



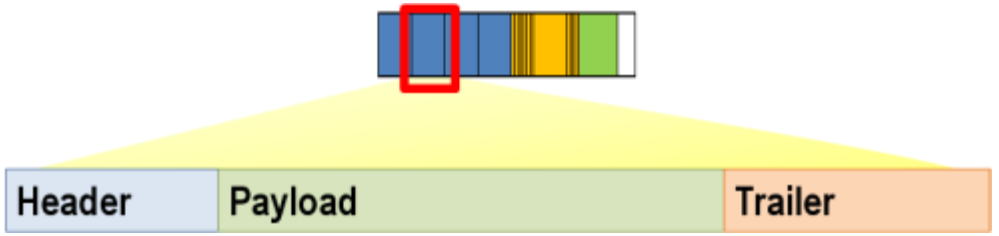
Communication cycle

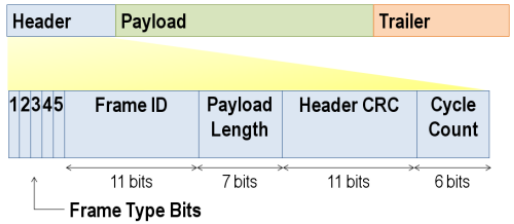


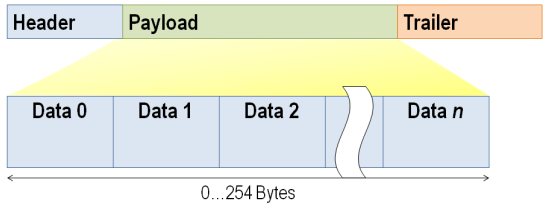
Static Segment: Reserved slots for deterministic data that arrives at a fixed period.
Dynamic Segment: Is used for a wider variety of event-based data that does not require determinism (cfr.CAN)
Symbol Window: Typically used for network maintenance and signaling for starting the network.
Network Idle Time: A known "quiet" time used to maintain synchronization between node clocks.

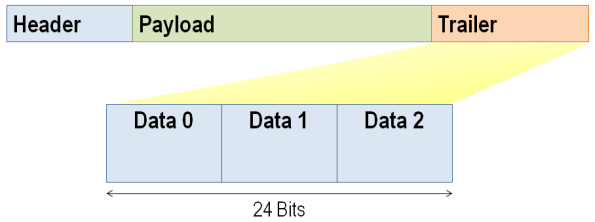
FlexRay – Details

Frame Format

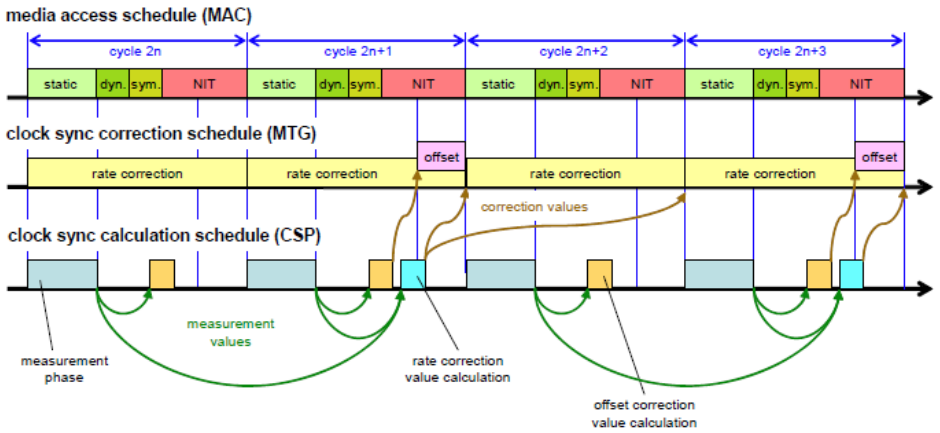








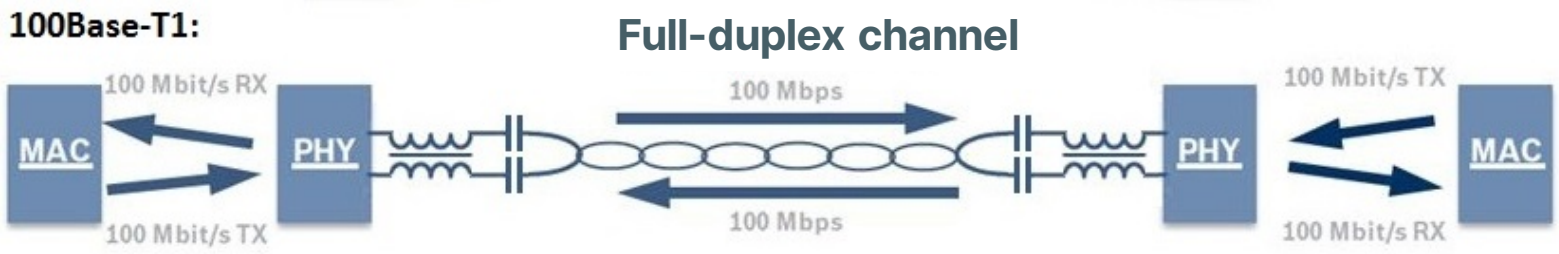
Clock Synchronization



See chapter 8 of FlexRay Protocol Specification

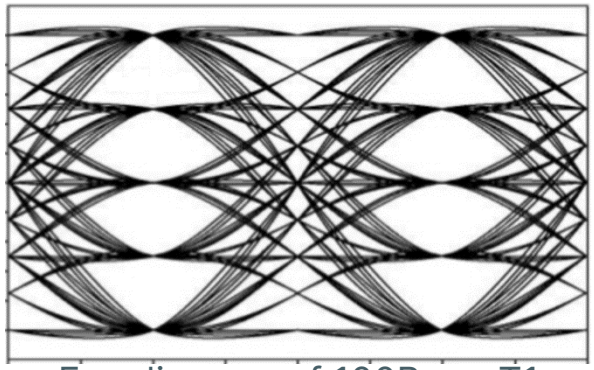
Ethernet Overview: 100Base-T1, 1000Base-T1

- Single twisted pair, full-duplex, 100/1000 Mbps.
- Cable length of up to at least 15 m.
- Differential signal is coupled into a twisted pair via capacitors.
- PHY converts bits to symbols (3 bits -> 2 symbols). Symbol can have value +1, 0 or -1, what corresponds to three different differential voltage levels.
- Peer to peer communication, switches are needed for more complex network.
- To keep synchronization, communication is ongoing even if none of nodes intend to send data.

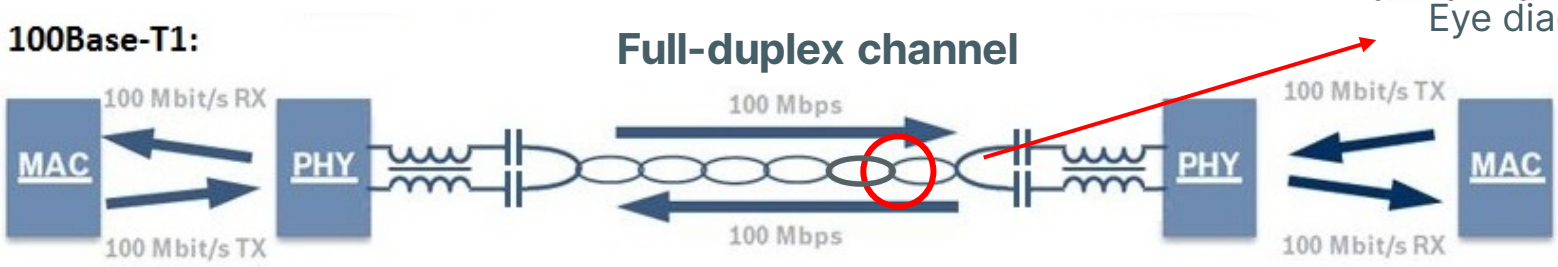


Ethernet Overview: 100Base-T1
Physical layer details

- One of link partners is Master (initiate training) and the second one is Slave (synchronize its clock with Master's using clock recovery form data stream).
- As PHY uses PAM3 (3 bits -> 2 symbols) baud rate is 66 MBd/s.
- Both link partners transmits symbols simultaneously, so there might be 5 different differential voltage levels observed.
- Data to be transmitted are combined with side stream
- scrambler (pseudorandom stream) for better EMC
- performance (emissions).

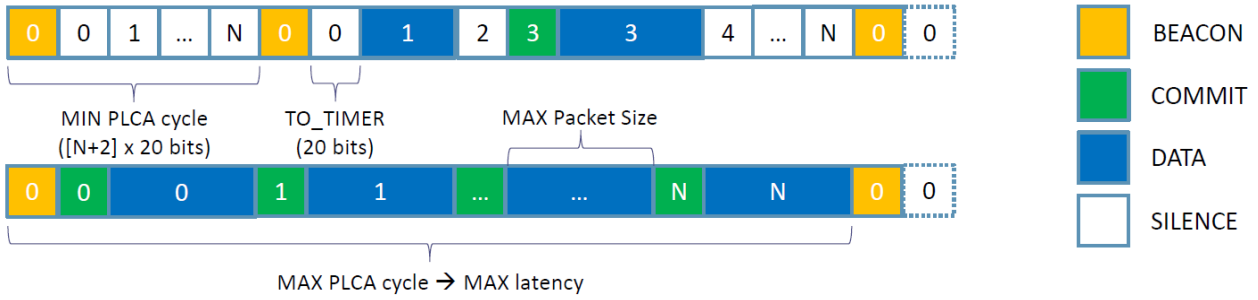


Eye diagram of 100Base-T1 link



Ethernet Overview: 10Base-T1S

- 10 Mbps over single twisted pair cable, length of up to at least 15 m.
- Peer to peer half-duplex communication, optionally it can have capability of:
  - Full-duplex peer to peer operation
  - Half-duplex multidrop (BUS topology like CAN, FlexRay, LIN…) operation
- Multidrop: One Master, up to at least 8 Slaves. Master initiates communication by BEACON and then each Slave have an opportunity to send data. This protocol is called Physical Layer Collision Avoidance (PLCA).



onsemi™

Intelligent Technology. Better Future.

Follow Us @onsemi

www.onsemi