

In-Vehicle Networking

Lecture 2 Introduction to LIN bus networks
BAE 5030 - 003
Fall 2008
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Biosystems and Agricultural Engineering
Oklahoma State University

LIN protocol reference

Presentation taken largely from:
LIN Sub Bus
W. Specks and H. C. Wense
Freescale Inc.
May 1, 2003



<http://www.lin-subbus.org>

LIN (Local Interconnect Network)

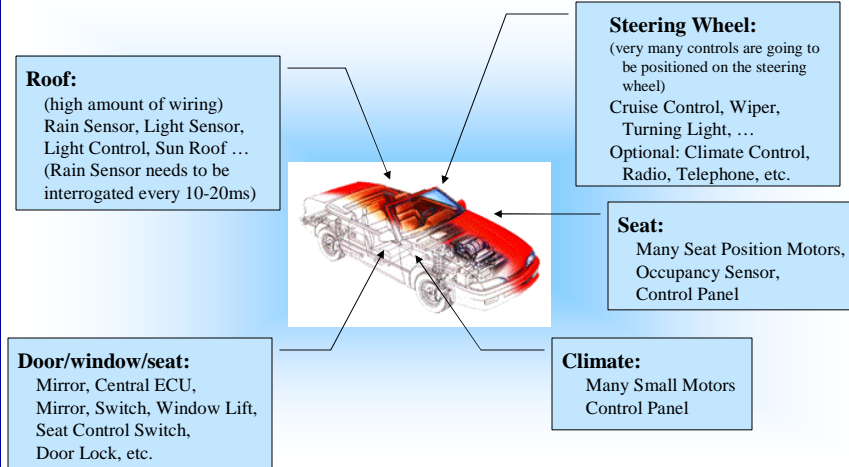
- Low speed serial network designed for body control in automotive applications
- Physical layer based on ISO 9141 (the K-line).
 - Single wire plus ground
 - Voltage level signaling
 - Dominant/recessive bit levels
 - Max 40 m wire length
 - 1-20 kbit/s
- Data Link
 - Media Access Control: Master/slave
 - Serial asynchronous byte oriented communication
 - UART compatible
 - 64 uniquely identified messages
- Transport layer for diagnostic support
- Includes application layer development framework

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Typical LIN Applications

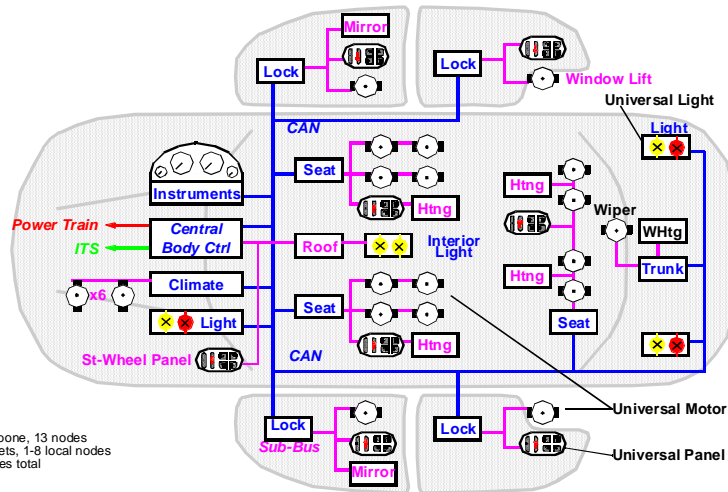


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Automotive Body Network



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SAE Network classification

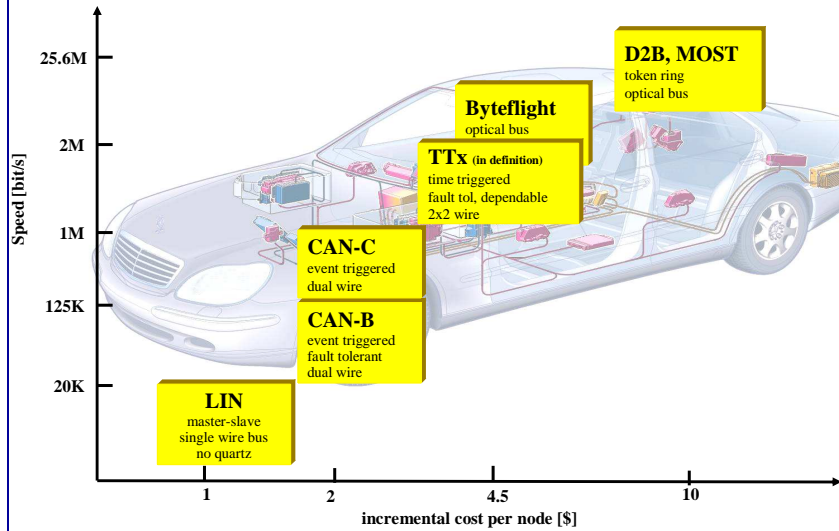
- Class A networks
 - Low Speed (<10K bits/second)
 - Convenience features
 - entertainment
 - audio
 - trip computer, etc.
- Class B networks
 - Medium Speed (10K b/s to 125K b/s)
 - General information transfer
 - instrument cluster
 - vehicle speed
 - legislated emissions data/diagnostics, etc.
- Class C networks
 - High Speed (125K b/s to 1M b/s or greater)
 - Real-time control
 - powertrain control
 - braking
 - vehicle dynamics, etc.

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Costs and Speeds for Automotive Networks



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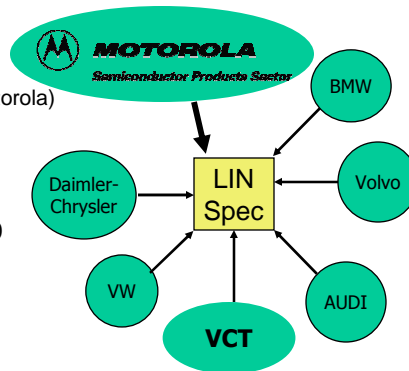
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LIN Consortium

- Consortium formed in 1998.
 - Five Car manufacturers
 - ONE Semiconductor Supplier (Motorola)
 - One tool Supplier (VCT)

- Specification finalised on 02/02/00
- Official Launch at SAE March '00
- Open Specification.

- Motorola Ready to support LIN with extensive
 - device families and new parts already in the discussion/ spec finalization loop.
 - First dedicated LIN part available Q3 '00

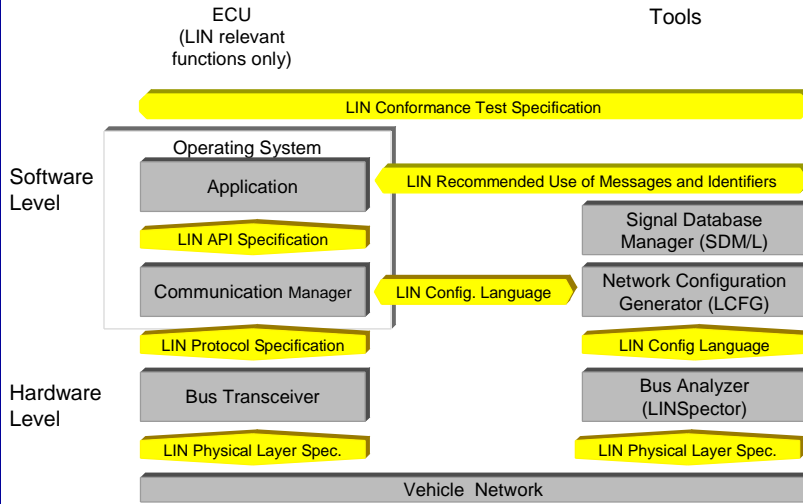


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LIN Standard - Overview



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Hierarchical Network Structure

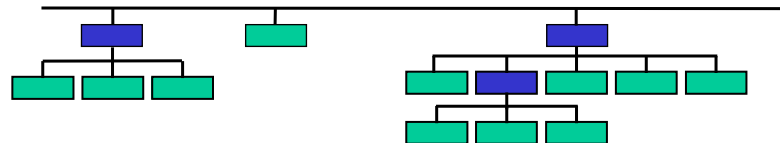
- CAN based network

Flat Network



- CAN + LIN

Hierarchical Network



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Sub Bus Concept

- **Basic Requirements:**
 - Satisfy Need for a Standard for Sub Busses
 - Cost driven: The solution must be cheaper than CAN
 - Reliability: Same Level as CAN expected
 - Long Term Solution
 - Logical Extension to CAN
 - Scalable: Capability to extend Systems with additional nodes
 - Lowering Cost of Satellite nodes:
 - No Crystal or Resonator
 - Easy implementation
 - Simple State Machines
 - Low Reaction Time (100 ms max)
 - Predictable Worst Case Timing

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LIN Concept

- **Technical Solution**
 - Low cost single-wire implementation (enhanced ISO 9141)
 - Speed up to 20Kbit/s (limited for EMI-reasons)
 - Single Master / Multiple Slave Concept
 - No arbitration necessary
 - Low cost silicon implementation based on common UART/SCI interface hardware
 - Almost any Microcontroller has necessary hardware on chip
 - Self synchronization without crystal or ceramics resonator in the slave nodes
 - Significant cost reduction of hardware platform
 - Guaranteed latency times for signal transmission (Predictability)

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Master / Slave Protocol

- **Master Task**
 - Determines order and priority of messages.
 - Monitors Data and check byte and controls the error handler.
 - Serves as a reference with its clock base (stable clock necessary)
 - Receives Wake- Up Break from slave nodes
- **Slave Task**
 - Is one of 2-16 members on the bus
 - Receives or transmits data when an appropriate ID is sent by the master.
 - The node serving as a master can be slave, too!

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Master / Slave Protocol

- **Master**
 - has control over the whole Bus and Protocol
The master controls which message at what time is to be transferred over the bus. It also does the error handling.
To accomplish this the master
 - sends Sync Break
 - sends Sync Byte
 - sends ID-Field
 - monitors Data Bytes and Check Byte, and evaluates them on consistence
 - receives WakeUp Break from slave nodes when the bus is inactive and they request some action.
 - serves as a reference with it's clock base (stable clock necessary)

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Master/Slave Protocol

- Slave
 - Is one of 2-16 Members on the Bus and receives or transmits Data when an appropriate ID is sent by the master.
 - Slave snoops for ID.
 - According to ID, slave determines what to do.
 - either receive data
 - or transmit data
 - or do nothing.
 - When transmitting the slave
 - sends 1, 2, 4, or 8 Data Bytes
 - sends Check-Byte
 - The node serving as a master can be slave, too!

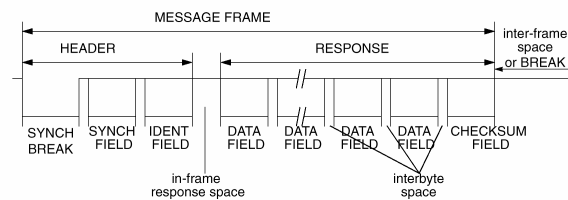
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LIN protocol offers message timing predictability

- Time Triggered Approach
- Message Length is known
 - Number of transmitted data bytes is known
 - Minimum length can be calculated
 - Each Message has length budget of 140% of it's minimum length
 - maximum allowed length is known
 - distance between beginning of two messages

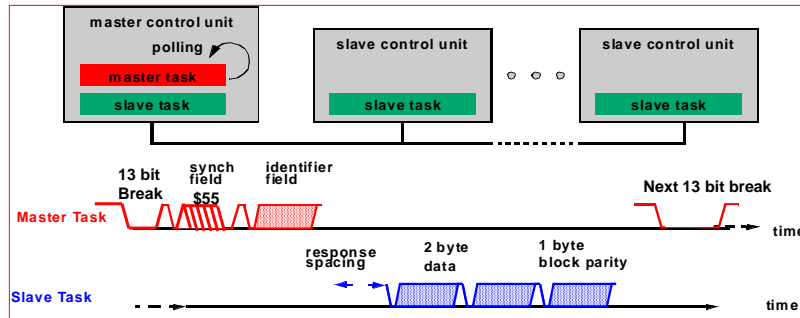


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Data Transmission



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Message Frame

- Synch Byte:
 - Specific Pattern for Determination of Time Base (Determination of the time between two rising edges)
 - A Synch Byte precedes any Message Frame
- ID-Field:
 - Message Identifier: Incorporates Information about the sender, the receiver(s), the purpose, and the Data field length.
 - Length 6 Bits, 64 Message Identifiers are possible.
 - 4 classes of 1/2/4/8 Data Bytes. The length coding is in the 2 LSB of the ID-Field. Each class has 16 Identifiers.

ID range	Frame length
0-31 0x00 – 0x1f	2
32-47 0x20 – 0x2f	4
48-63 0x30 – 0x3f	8

- 2 Parity Bits protect the highly sensitive ID-Field.

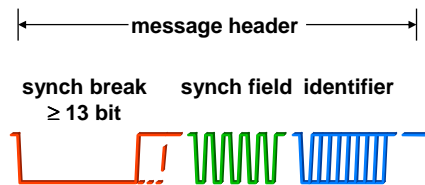
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Identifier

- The identifier field is sent by the master node to all LIN nodes
- This identifier normally contains one of 64 different values and includes 2 parity bits in the 8 bit data
- The identifier is normally associated with a collection of signals that are subsequently transmitted on the LIN bus
- In a specific case this can initiate SLEEP mode in the LIN slave nodes – in this case no further data is transmitted on the LIN bus

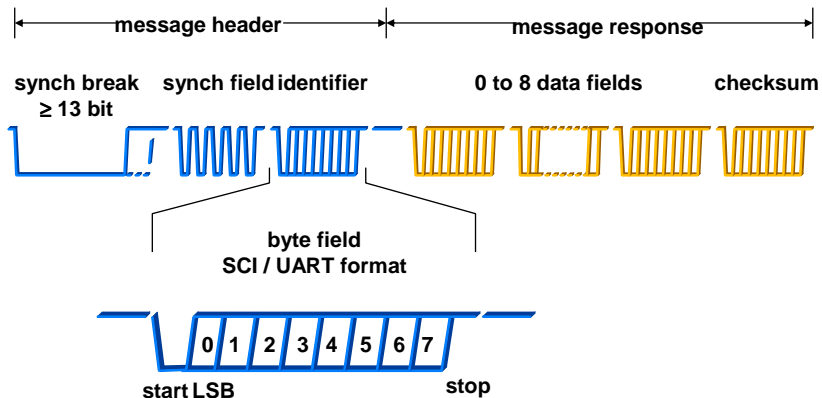


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LIN Message Frame

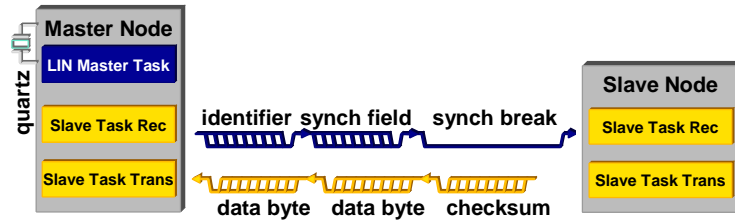


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LIN Communication - Data from Slave to Master



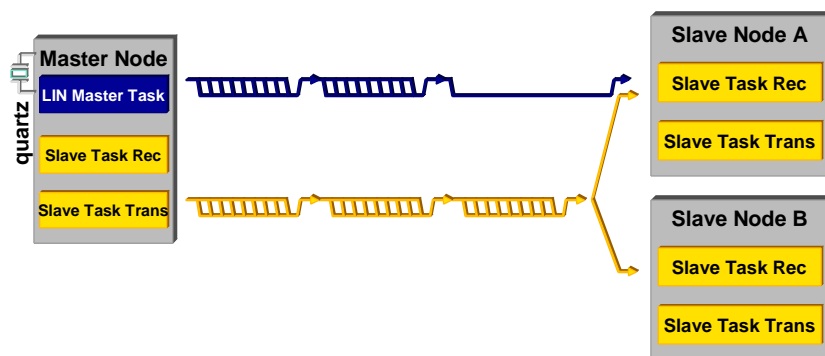
- Single-master / multi-slave protocol
- Time triggered, no arbitration
- Identifier denotes message content, not physical address
- Multicast messages
- Baud rate synchronization through protocol
- Power saving sleep mode

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LIN Communication - Data from Master to Slave(s)

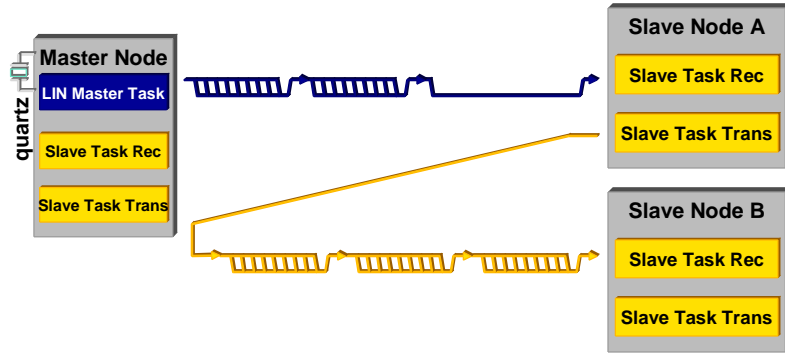


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LIN Communication - Data from Slave to Slave

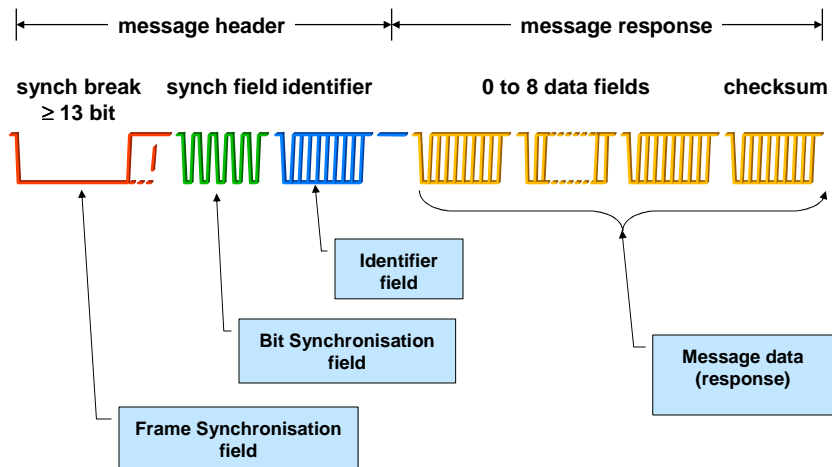


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LIN Message Frame



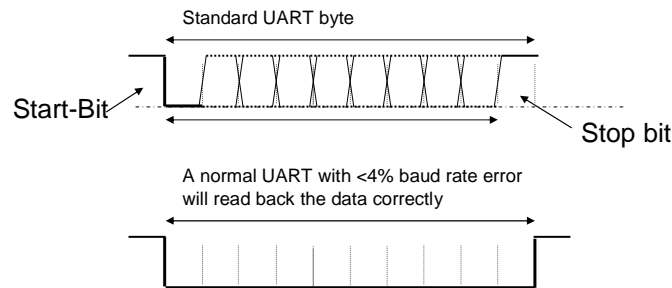
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Frame Synchronisation (1)

- Initial conditions: $\pm 4\%$ baud rate accuracy relative the transmitting source
- A standard transmission of data will require matched send and receiver baud rates



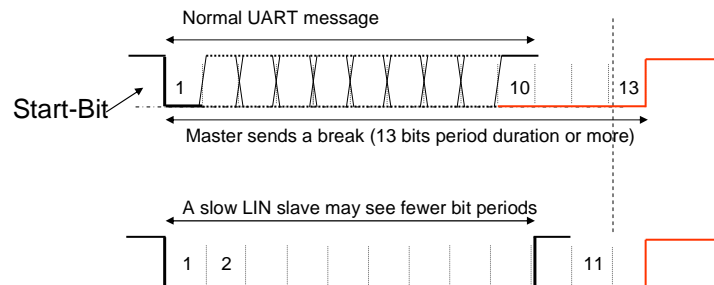
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Frame Synchronisation (2)

- Initial conditions: $\pm 15\%$ baud rate accuracy relative the the LIN master transmitting the synchronisation frame
- A synch break must be at least 13 bit periods in duration to allow for this initial variation in oscillator accuracy within the LIN slave



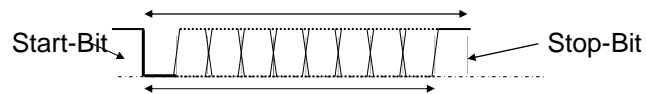
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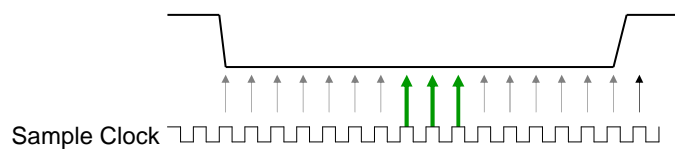
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Bit-Synchronisation

- A start bit transition to a low logic level (dominant) indicates a start of a byte, least significant first and completing with a logic high level (resessive) bit to indicate the STOP bit

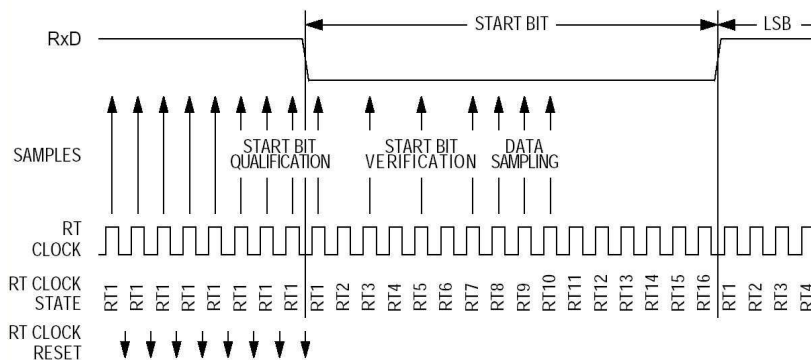


Data is sampled in the middle of the bit field:

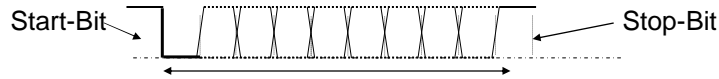


Bit Sampling

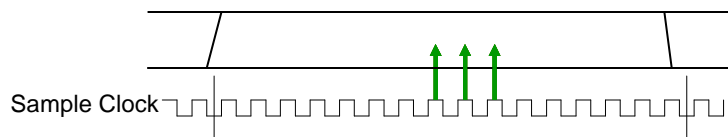
- Within a UART, clocked high speed sampling is used to aquire bit state



Bit-Synchronisation



- After recognition of a Low level in the start bit, the data is sampled at a rate 16 times the bit rate expected. The middle 3 samples must all agree for an error free reception of the data.
- A stop bit is expected after 1 start bit and 8 data bits in a typical message



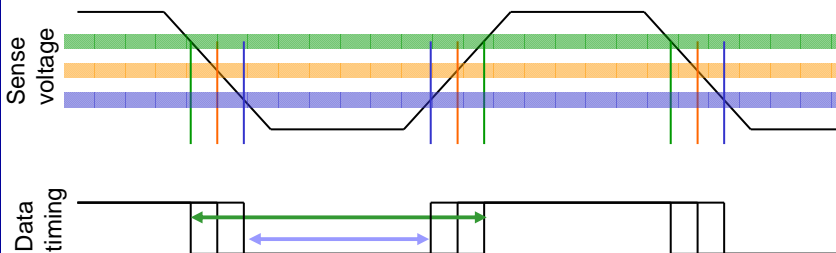
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Taking account of Ground-Shift

- The detection point for data transitions can be affected by voltage references. Ground shift can change this reference by a significant amount, affecting the bit timing of the data



- Available bit sampling zone can reduce worst case bit width to around 40us at 20k baud
 - Affects the overall baud rate tolerance required for safe LIN communications

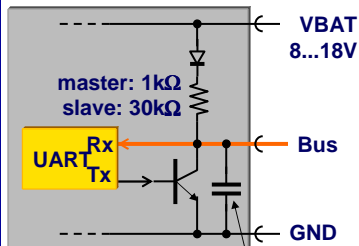
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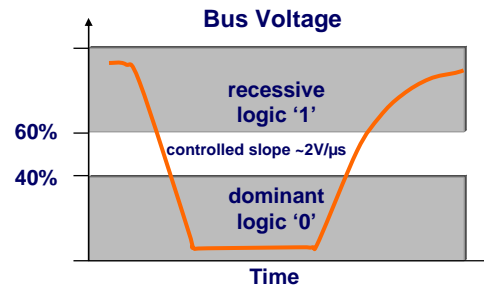
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LIN Physical Interface

Electronic Control Unit



Example capacitances
master: 2.2nF
slave: 220pF



Note: The LIN specification refers to the ECU connector voltages !

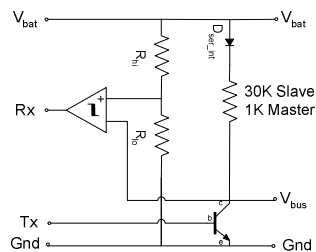
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Laboratory: LIN Bus Transceiver

- For laboratory
 - Design a discrete LIN transceiver using the following circuit.
 - Demonstrate the functionality of the transceiver
 - Test on a bus with your lab partner team



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