Tutorial for Wake Up Schemes and Requirements for Automotive Communication Networks

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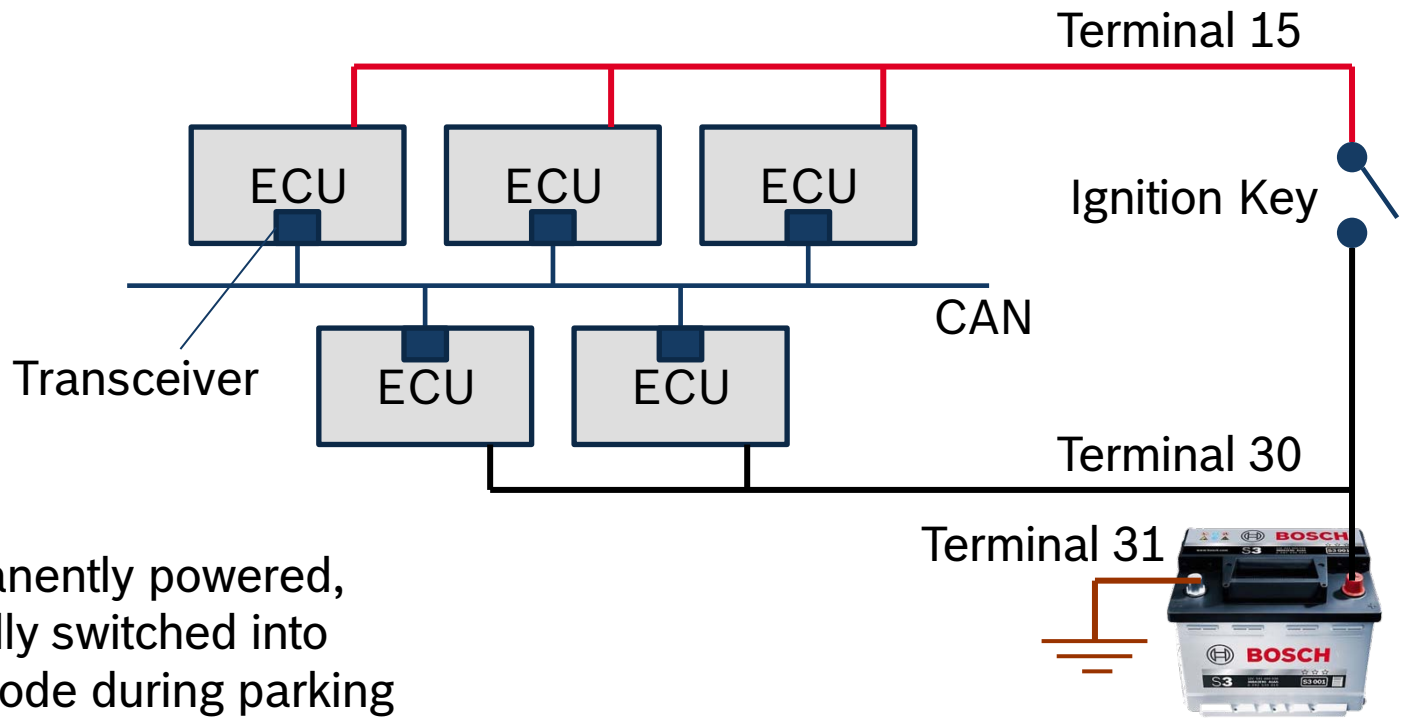
Terminal Control

- Wake-up is mainly realized via terminal control (German “Klemmensteuerung”)
- Different terminals are switch on / off based on vehicle states
  - Switching on a terminal means, that ECUs connected to this terminal are powered up
- Some ECUs (e.g. Keyless Comfort Entry, Body Computer) are permanently powered, also while the vehicle is parked
  - During parking, these ECUs are switched into Sleep Mode (to minimize power consumption)
  - At Sleep Mode: (CAN, LIN, FlexRay-) Transceiver is powered, µC not powered
  - ECUs are re-activated not via terminal control but via other wake-up mechanisms (local wake-up / bus wake-up)
  - Often Power Control, (Wake-UP) Transceiver and other functions are collected in so called “System Basis Chips”

Terminal Control

powered based on vehicle state



permanently powered,
usually switched into
Sleep Mode during parking

Terminal Control – Vehicle States

- Typically, the terminal control differentiates some general vehicle states
  - Vehicle parked and switched off (locked)
  - Infotainment mode: Driver is in the car but ignition is off
  - Ignition
  - Crank
  - Engine running
  - Pre- / Post-run
- As a result there are some typical terminals used in most vehicles, e.g.:
  - Terminal 15: Switched on with ignition on
  - Terminal 30: Permanently on
  - Terminal 30x: Switched on under certain conditions, e.g. for a certain time to allow for post-run
  - Further terminal numbers can be found at DIN 72552

Bus Wake-Up

- ECUs attached to terminal 30 are switched on permanently, also while the vehicle is parked and locked. The power consumption during this time is taken out of the car battery.
- Therefore, the Sleep Mode current of these ECUs must be extremely low (in the range of µA). → 100 µA requirement
- To re-activate the ECUs, there could be a local wake-up source (e.g. a switch attached to the ECU of a receiver for a remote key) or a bus wake-up.
- Normally, the first ECU is woken up by a local wake-up source and then (if needed) wakes up all other ECUs within this cluster via bus wake-up

Sleep Mode, Current Consumption Considerations

Car level

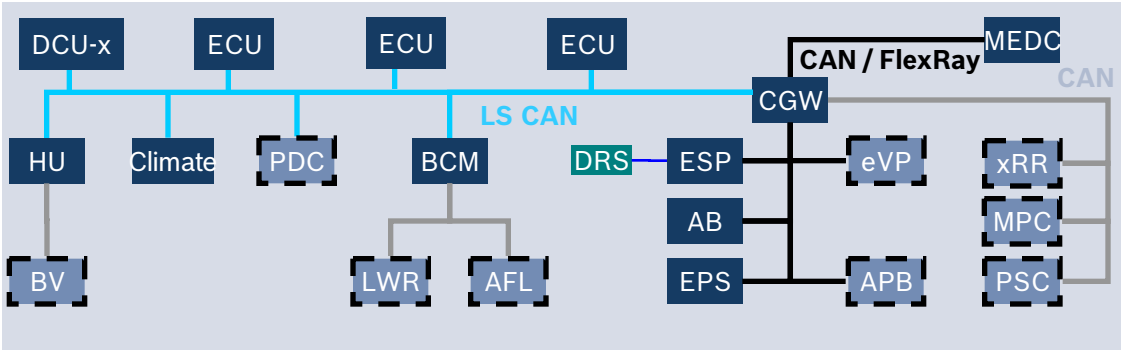
Battery capacity [Ah]	80
Min. SOC (State of Charge) for cold start (worst case) [%]	50
Remaining capacity for ECU Sleep Mode [Ah]	40
Car consumption (Sleep Mode) [mA]	40
Max. no. of days the car could remain in Sleep Mode beeing able to start [days] European Vacation Test Case ☺	41

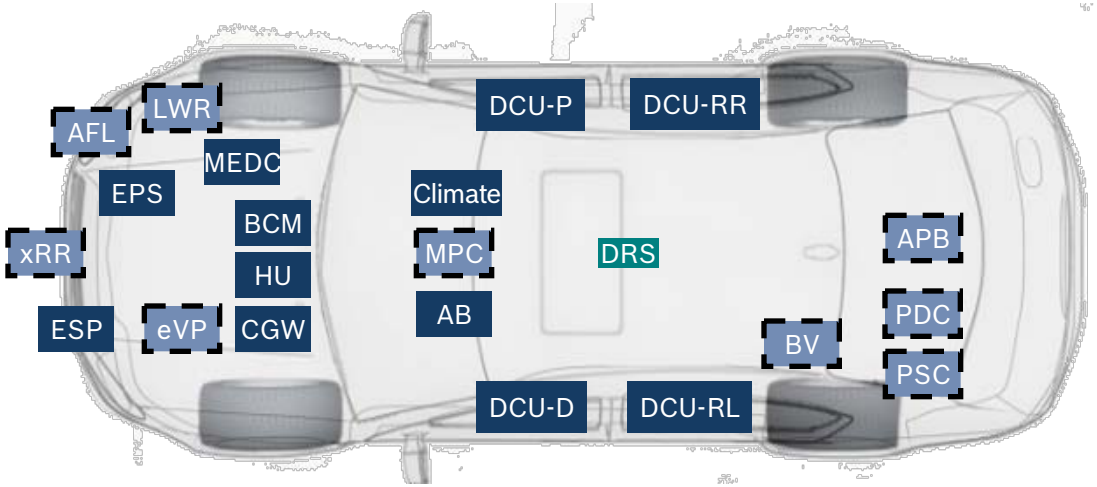
ECU level

Sleep Mode current consumption [µA]	< 100
Exceptions possible (e.g. large ECUs)	

Phy level

Target stand by consumption [µA]	10
LIN Transceiver [µA]	1-8
CAN Transceiver [µA]	18-30
FlexRay Transceiver [µA]	20-30





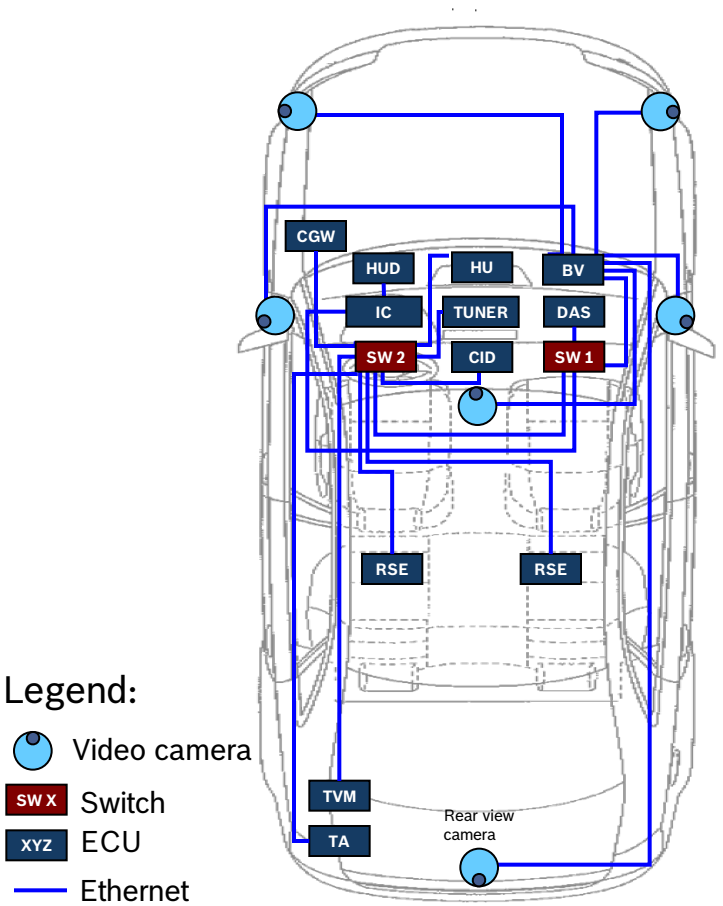
Wake up requirements based on back over avoidance

Use case for wake up by switched power

- Rear view camera is in Sleep Mode
- Driver engages the rear gear
- Rear view camera is woken up
- Rear view camera has to deliver within short time valid video signal

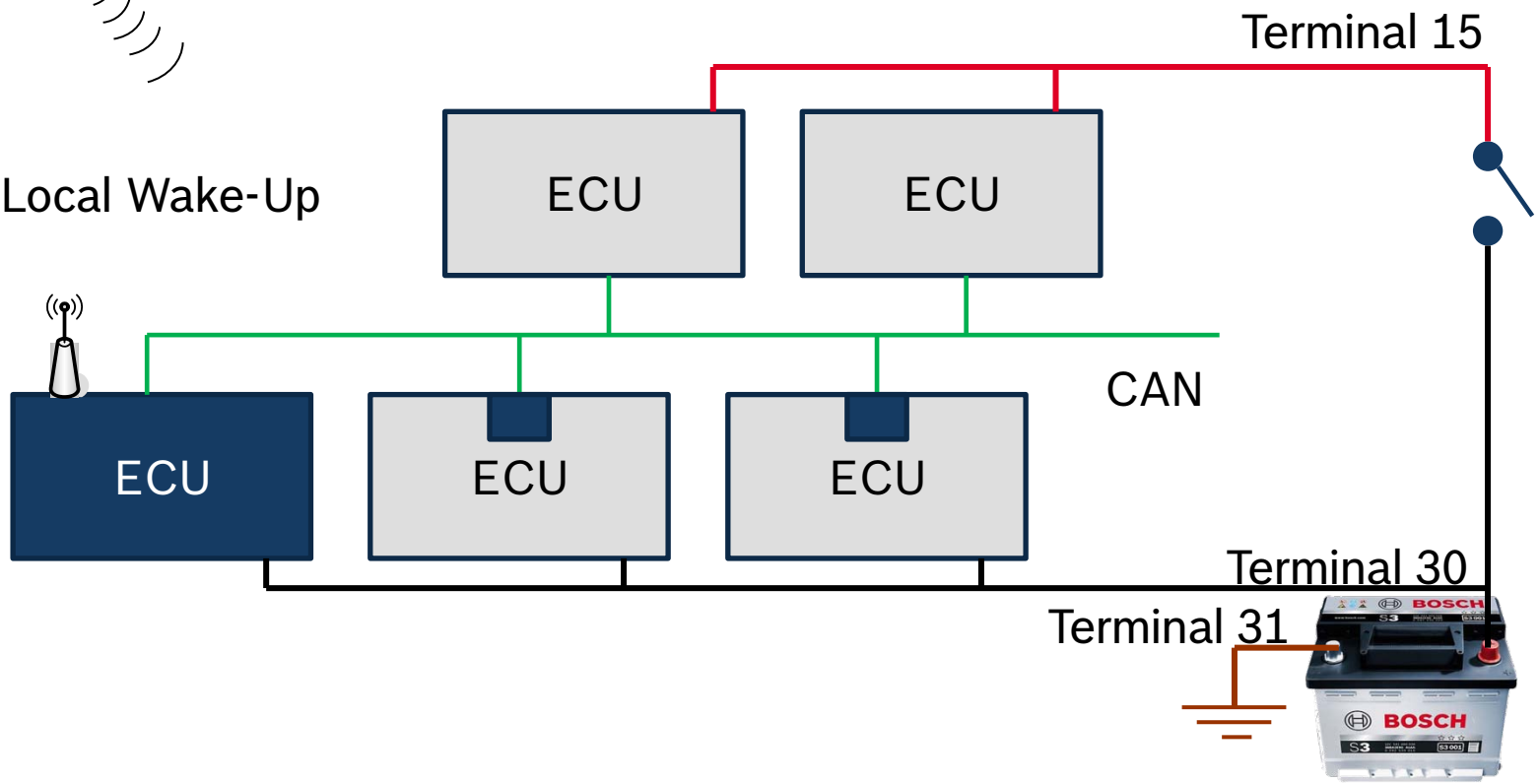
ISO 17386 recommendation for parking aid systems to establish a video link:

350 ms

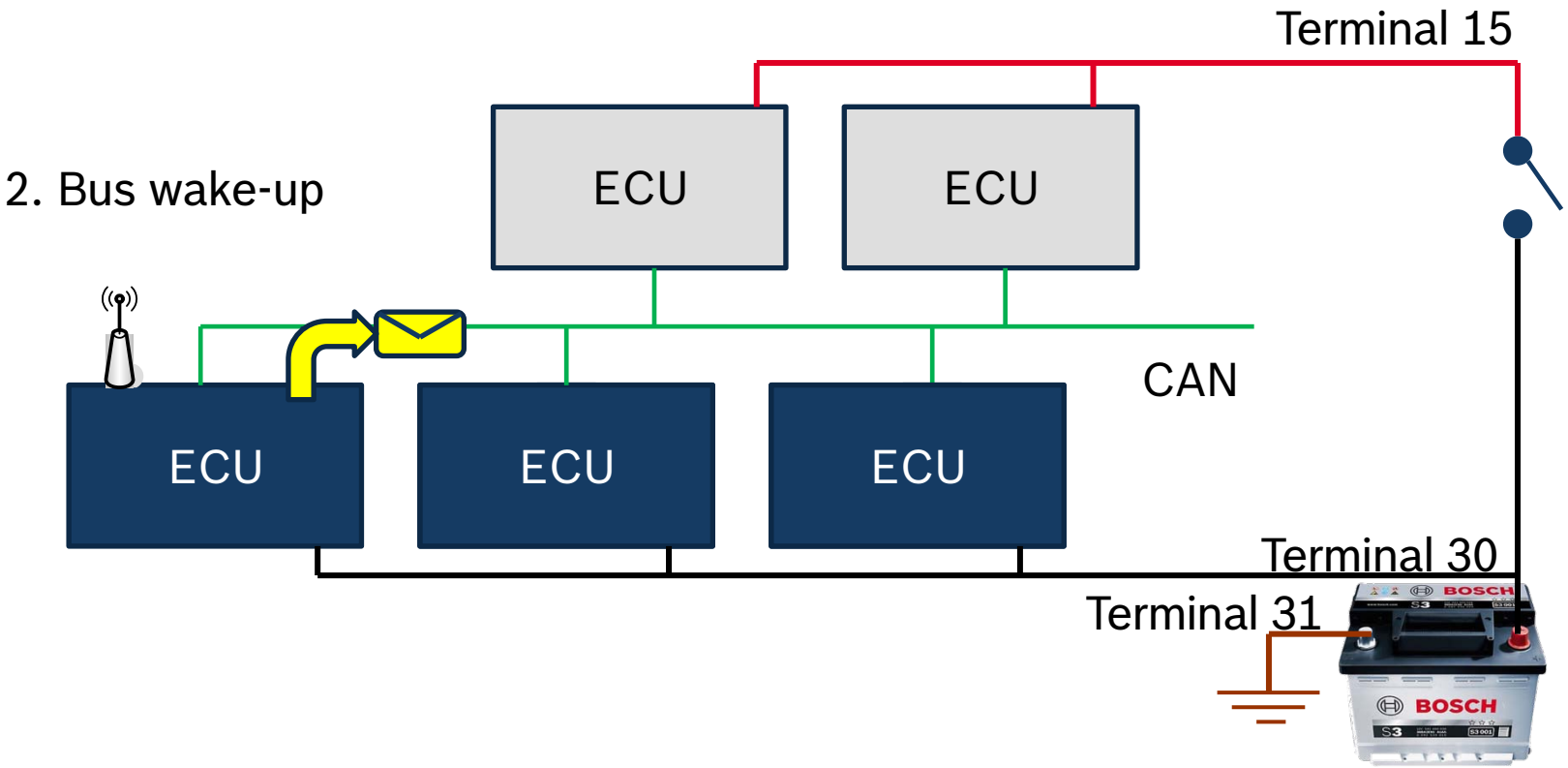


Wake-Up

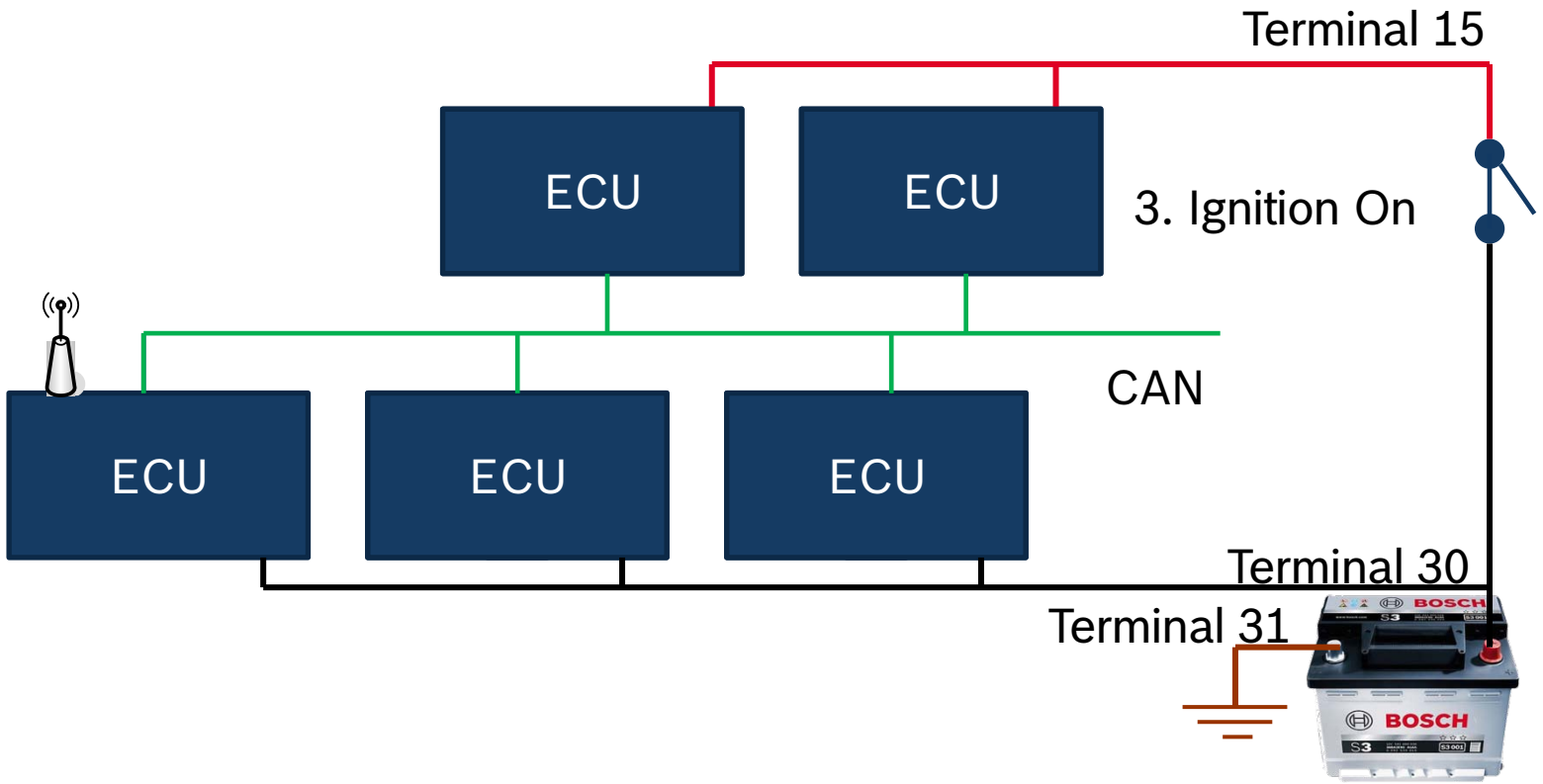
1. Local Wake-Up



Wake-Up

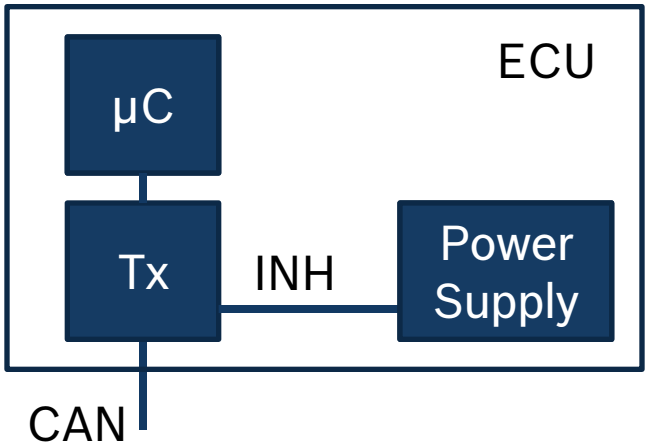

Terminal 15
2. Bus wake-up
ECU
ECU
ECU
ECU
ECU
CAN
Terminal 30
Terminal 31
BOSCH
BOSCH

Wake-Up


Terminal 15
ECU
ECU
3. Ignition On
CAN
ECU
ECU
ECU
Terminal 30
Terminal 31
BOSCH
BOSCH

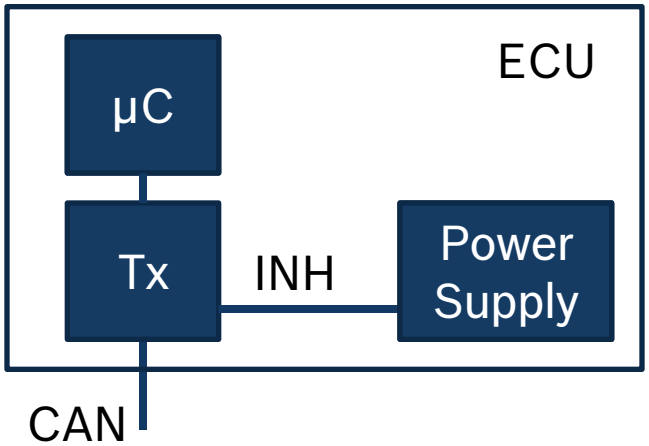
Bus Wake-Up in ECU

- Bus wake-up is initiated via simple signal patterns
  - CAN: Dominant bus level
  - FlexRay: Simple pattern of a long high / low signal
- Simple signal patterns allow a low power design (e.g. RC-circuit) for wake-up detection
- Upon wake-up detection, the transceiver Tx switches on the power supply of the ECU (via inhibit pin INH) and wakes up the complete ECU

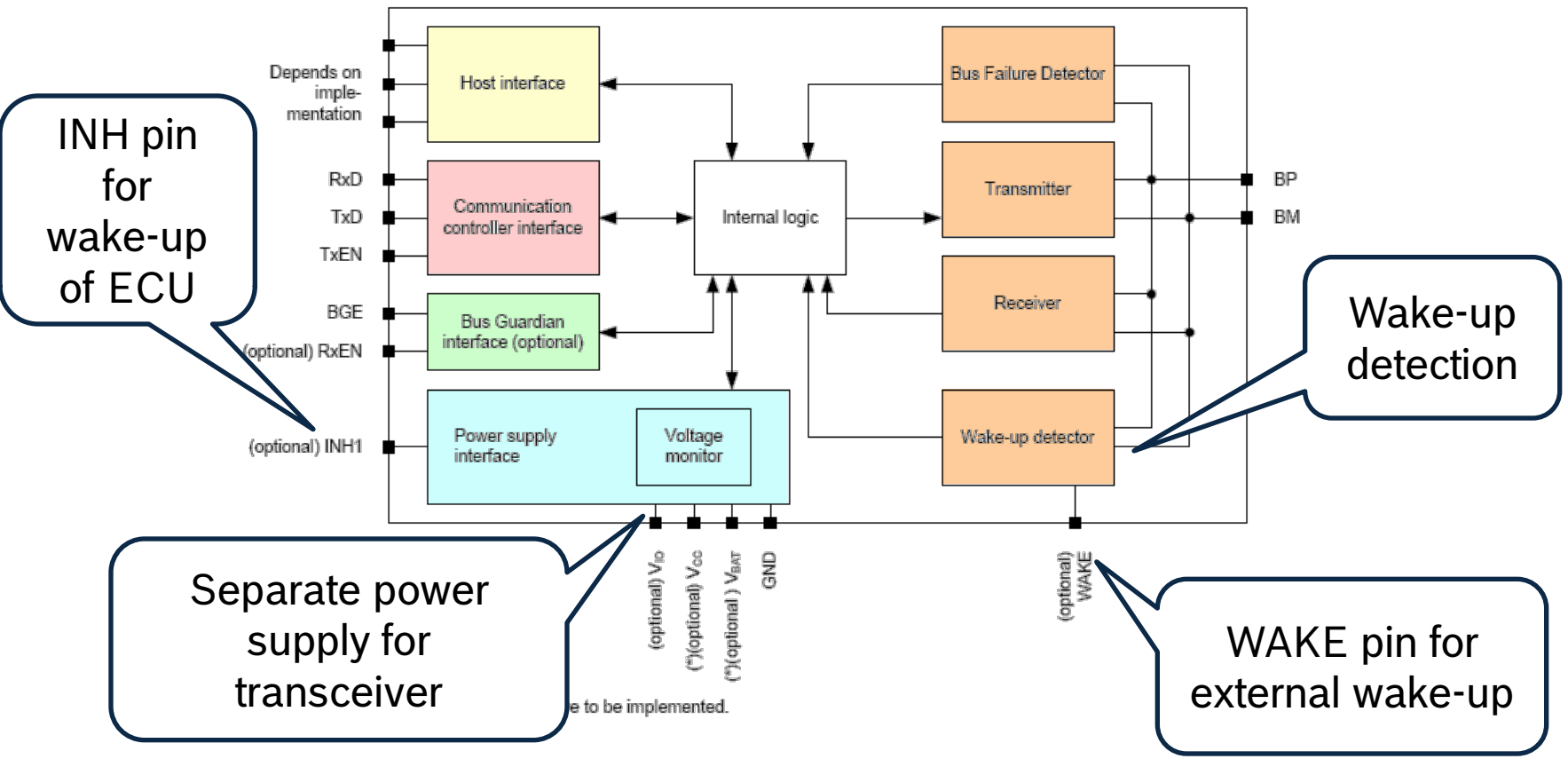


Bus Wake-Up - Requirements

- For bus wake-up, transceiver Tx needs to have a separate power supply
  - Stand-alone transceiver
  - System basic chip: Separate power supply for SBC with integrated Tx
- While in Sleep Mode (only wake-up detection enabled) the power consumption must be very low
- Transceiver must be able to trigger on power supply (via INH)
- Switching on power supply causes the ECU to boot.

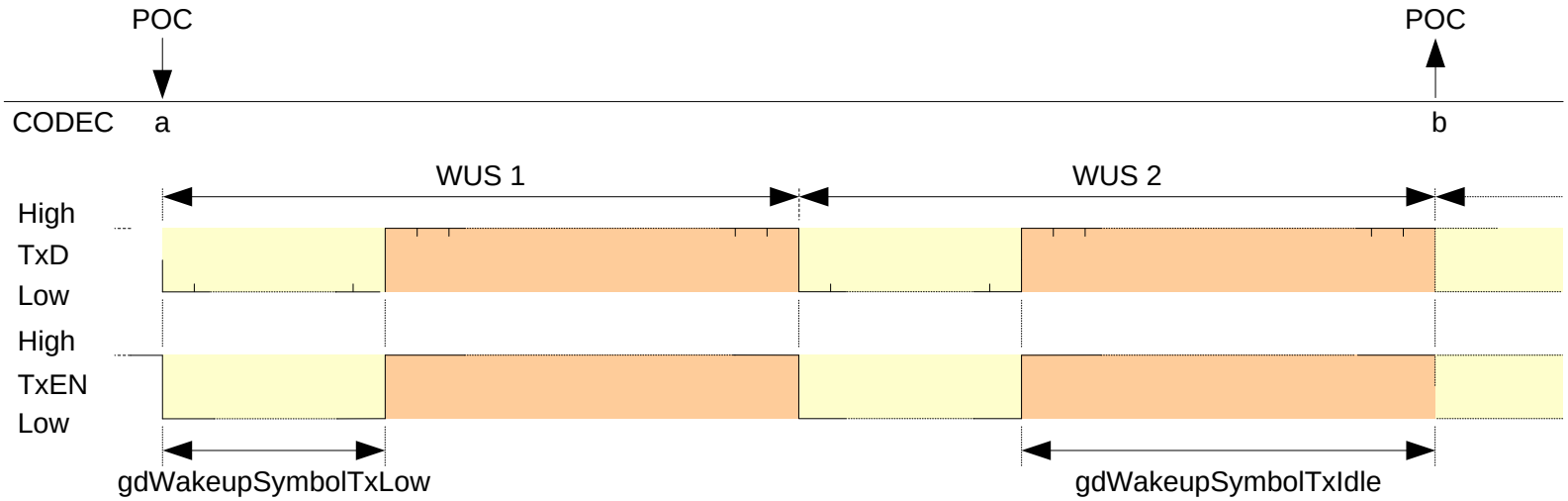


Backup: FlexRay Transceiver



Backup: FlexRay Wakeup Pattern

- Wakeup pattern consisting out of two wakeup symbols
- WUS: Wakeup signal



Conclusion

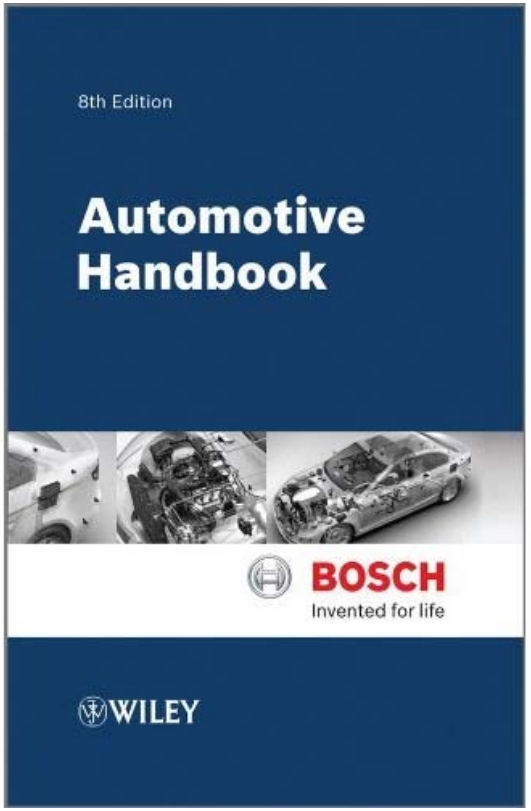
- We need a fast “standardized” wake-up mechanism to guaranty 100 ms link acquisition time
- We need “reliable” wake up
  - We must wake up when needed
  - We need to avoid false wake ups (airport test case!)
- We need a power efficient Sleep Mode (10 µA quiescent current for PHY)
- We need to solve the automotive power voltage issue (12 V)

- Possibilities for wakeup over PoE will be discussed separately

Literature Recommendation

- Please don't take it as commercial advertisement (we don't make money with it) but if you want to learn more about automotive this is probably of interest.

- Amazon Link
- Description from Amazon:



As progress in the field of automotive engineering has grown apace it has expanded from 96 pages in 1936, to 1258 pages today. This new edition is significantly updated, with key changes including more emphasis on electrical systems, and a new chapter on driver assistance systems. Very highly regarded throughout the automotive industry, it is used as a quick easy reference and to deliver the detail necessary for more complex ideas.