The power of CAN partial networking in the software-defined electrical vehicles

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The automotive industry is moving towards the Software-Defined Vehicle (SDV) in combination with the trend of electrification, which requires a different approach to design a vehicle and its network architecture. Both functional flexibility and power optimization will be key in achieving the highest performance and cost efficiency for the Software-Defined Electric Vehicle (SDEV). CAN Partial Networking with Signal Improvement (CAN SIC) is expected to play a vital role in this transformation.

Hardware and the software upgradable car

When buying a new car from a dealer today, you select the options you want on the car, the carmaker installs the hardware and delivers the vehicle. If you want additional options later, this must be done aftermarket and it's usually very costly.

One of the goals of the Software-Defined Vehicle is to have a software upgradable car, adding features by digital purchases and over-the-air (OTA) updates, without needing any new hardware installed. This means that hardware for any foreseen future feature should already be installed in the car at the time of purchase. This creates initial overhead costs for newly sold cars at the carmaker, as they sell the car offthe-shelf with more hardware options. However, these options should initially be disabled and powered-off, and quickly start to generate new revenue streams as soon as the end customer is purchasing features – with that enabling and powering-on this overhead hardware. Similarity can be drawn to purchasing new applications on a smartphone.

SDEVs require the capability to power on/off ECUs dynamically and selectively

When combining this concept with the challenges of the Electric Vehicle (EV), where driving range is fully dependent on the battery charge and power consumption of the vehicle, the ECUs should not be fully enabled and powered-on when not in use. Doing so will drain the battery and it will electrically degrade when exposed to power. Instead, we want to power these ECUs down fully or as much as possible and only enable them when they are needed to serve a certain functionality in the car. This reduces power consumption (which also translates into CO_2 reduction when not charged by pure green energy), extends the driving range and prevents ECU electrical component lifetime degradation by minimizing power exposure to the ECU's components (e.g. MCU, resistors, capacitors, etc.).

Selective ECU wake-up enables advanced use cases

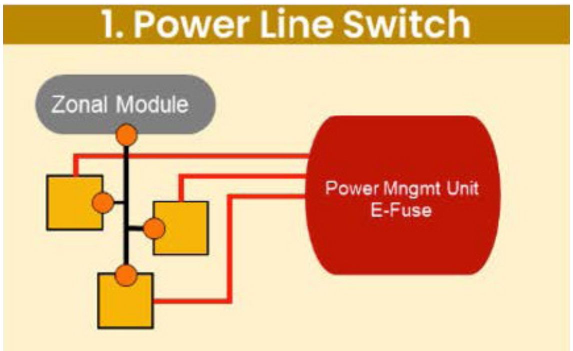
When taking advantage of the availability of the selective wake-up capabilities, even more advanced use cases can be considered. Imagine a shared car concept (rental, co-owned or even carmaker-owned) where each user (driver or passengers) of the vehicle could have a personalized feature set. The vehicle recognizes who is sitting in the car, potentially even in which seat, and enables these personal features for each individual. Person A might have all features enabled (navigation, seat heating and ventilation, chair massage function, ADAS functions, interior light effects, etc.) while person B only has one or two functions enabled. No matter which car they are using, these features will always be enabled for that person.

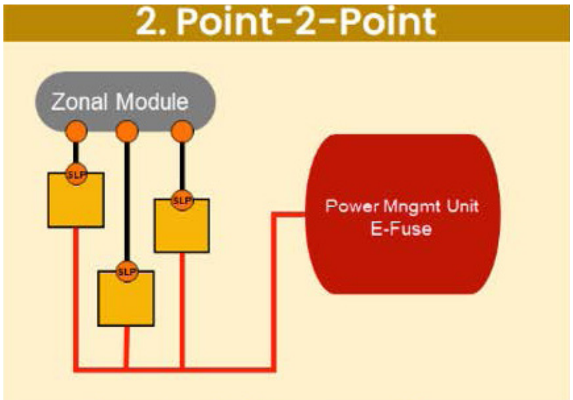
Also imagine a low battery mode, similar to the low battery mode of a mobile phone. Once the battery reaches 10 percent, only the vital functions remain enabled. When a destination is set into the navigation system, the car can dynamically select which features should be disabled to make it to the next charging station if the battery is running low.

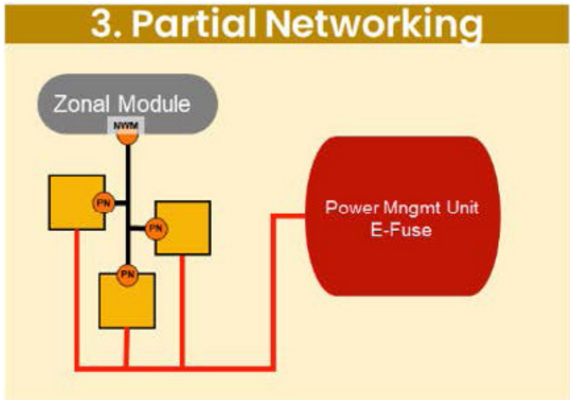
Implementation options to switch on/off ECUs

Looking to the possibilities for dynamically and selectively switching on/off ECUs, there are a few implementations possible to achieve this:

- Power line switching using e-fuses, but e-fuses are expensive and introduce additional power cabling, adding cost and weight to the vehicle. E-fuses are and will remain part of the power architecture as they also support monitoring and safety features. But having an e-fuse for every single ECU is cost-prohibitive, hence e-fuses usually supply a group of ECUs, located physically or logically in the same area of the vehicle.
- Point-to-point data connections between a central ECU (e.g., gateway, domain controller, or zonal controller) to the edge node ECUs, in combination with transceivers that support a low power mode, which can bring an ECU in complete power-down. This solution requires multiple data connections and connectors at the central ECU, resulting in additional cost, additional points of failure (connectors are sensitive to failures) and longer cabling, as every edge node needs to be connected through its own cable.
- Sleep mode transceivers with partial networking/selective wake-up capability. This solution requires one connection at the central ECU and allows stub node connections with optimized cable routing for all edge nodes. Software will be slightly more complex as it requires network management software to run on the branch which controls the functional wake-up requests on the bus.



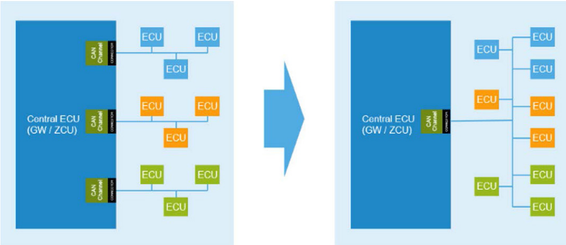




Managing speed and topology complexity

In a complete vehicle with many ECUs communicating on the same communications bus, bandwidth requirements will also be higher. Sensors like radar and LiDAR will generate more accurate pictures which need more data and bandwidth.

When looking at the possibilities of Classical CAN (CAN CC) and CAN FD, although the standards support up to 5Mbit/sec, with actual implementations of a stub-node topology with multiple nodes, the realistic speeds will not exceed 2Mbit/sec due to signal ringing. When 5Mbit/sec is needed, the topology complexity and node count need to be reduced. In this case, many smaller sub-branches are created, all which serve one or two functions within the vehicle.



With the introduction of CAN Signal Improvement Capability (CAN SIC), this trade-off between speed and topology complexity has disappeared (up to a certain degree) and many more nodes can be connected to a single branch. This branch then shares many more vehicle functions which can still be addressed separately through the concept of "virtual branching". When utilizing the option for larger branches it will help the carmaker to reduce cabling complexity, reducing the required number of
CAN channels on the MCU, as well as the number of connectors needed. This translates into direct cost and weight reduction.

Optimization through CAN Partial Networking with CAN SIC

There is a clear need in the SDEV to be able to switch all ECUs on and off dynamically and selectively. Doing minimizes power waste, provides for SDV feature flexibility and minimizes ECU degradation – extending the vehicle lifetime.

CAN Partial Networking provides the most system cost optimized solution for controlling ECUs. CAN Signal Improvement with partial networking enables further optimization by supporting higher node count on a single branch and activating functions through virtual branching. This is the power of CAN Partial Networking in the Software-Defined Electric Vehicle.

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