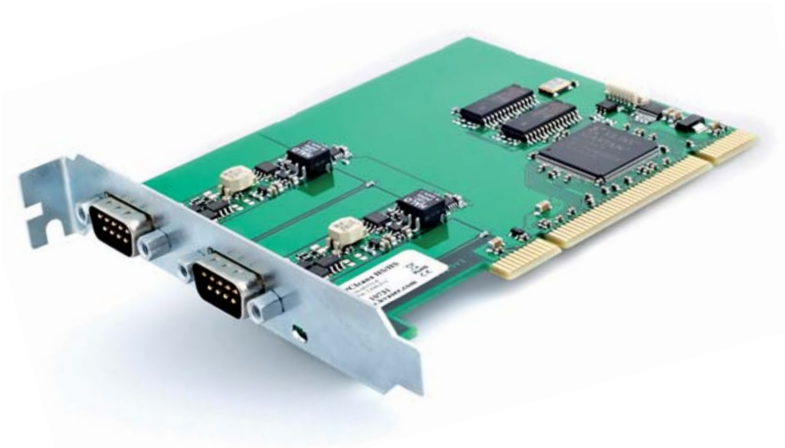
# Finding CAN communication faults before they happen



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***CAN-to-USB interface***

*The Leaf Light interface module connects the CAN network to a mobile equipment such as PCs or iPhones. The CAN side supports bit-rates up to 1 Mbit/s. The 100-g module does not loose CAN messages to be received or to be transmitted. The time-stamp precision is specified as 100 μs. The power consumption is 70 mA.*

CAN communication fault finding in modern cars is a highly precise science, if the work of Systems & Advanced Technologies Engineering (SATE) is anything to go by. The Italian company is specialized in the simulation and fault diagnosis of machinery and plant, with automotive systems being a key market. One of its key customers is a well-known Italian luxury car manufacturer, which has used the company's software and consultancy services to diagnose incipient breakdowns in car prototypes during endurance testing.

The company creates a simulated model of a system, using data from the CAN network to generate algorithms that monitor the devices and predict faults, as well as the impact of wear and tear. The simulations use either 'transparent box' models that base their analysis on the physical laws governing a system's interactions, or 'black box' models. The latter are algorithm-based, created using neural networks that are 'trained' on a set of real world input and output signals.

Whichever type of simulation model is involved, highly-accurate signal logging from the vehicle's CAN network is needed in order to develop and then implement the model e.g. during the training phase in the case of black-box models or parameter tuning for transparent box models. During algorithm training or tuning, signals are logged on the system under normal conditions. Any mismatch between the model's output and the real-world corresponding quantity implies a fault or an evolving anomaly, such as engine lubrication issues, problems within the cooling system, alternator, clutch or gearbox.

An important benefit of using an algorithmic approach for faultfinding is that there is no need for additional sensors on the CAN network, which can be a source of potential failures, aside from those already present. So in the case of a vehicle, its already-interconnected ECUs will be able to provide enough information about the components and subsystems to give a picture of the reliability and lifetime of the whole car.

A vehicle has three main sources of sensor-based information: vehicle kinematics (speed, acceleration), engine operation (rotation per minute, water temperature), and driver control actions (steering wheel angle, brake, accelerator pedal position). From these parameters (i.e. without adding more sensors), information such as tire pressure and temperature can be estimated using the Italian company's models. Among the conditions this method is capable of detecting are sensorless tire deflation, driver behavior and anomalous driving pattern detection, gearshift classification and synchronizer diagnostics. SATE's algorithms have also been used to accurately predict small ▷

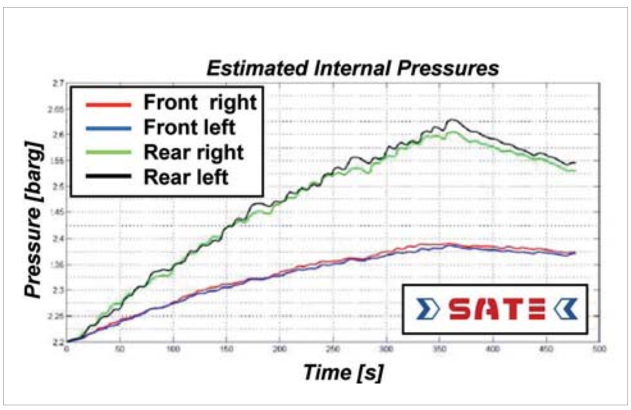


*Figure 1: Simulated and estimated tire pressures*


leakages or control anomalies in the engine coolant system, where early detection can prevent potentially severe damage to the motor. Another example is the detection of insufficient oil pressure, whilst it was still within the regular range. In the latter case, SATE provided an OEM with a warning of this as early as 5000 to 11000 km before engine break down, and well before a test driver could detect it.

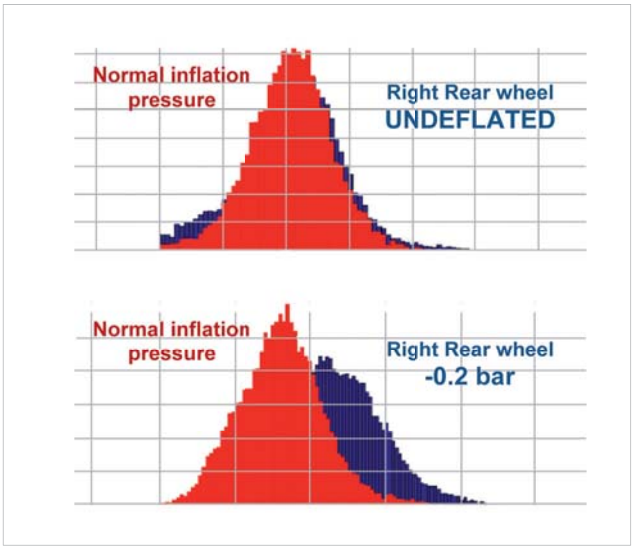


*Figure 2: Tire pressure and temperature sensorless monitoring*

The Italian company uses the Leaf Light CAN-to-USB interface by Kvaser (Sweden) to connect to the vehicle CAN network, design on-board diagnostic systems and deploy prototype demonstration applications, such as the smart fuel consumption monitoring application. It was developed for an Hewlett-Packard iPaq for use on trucks. The USB/CAN dongle provides time-accurate and loss free transmission and reception of standard and extended CAN messages, as well as easy connection between any CAN network and commercial devices equipped with USB ports, such as PDAs, mobile PCs or desktop PCs.

At present, the most-commonly employed strategy for fault location by modern vehicle manufacturers is threshold-based signal monitoring, whereby faults are detected when signals exceed a set of thresholds. However, this approach fails to detect incipient faults, which are usually tolerable in the early stages of their development, but which will cause a deterioration of the system performance over time. The model-based strategy effectively sets dynamic residual thresholds, resulting in faults being detected earlier and averting the false alarms that are often associated with a 'threshold-based' method, where excessively narrow or low thresholds have been set. ◀

***Conclusion***

*With these low-cost mobile computing options, from mobile PCs to iPhones, the advanced predictive diagnostic solutions – connected via Kvaser's CAN-to-USB or CAN-to-wireless interfaces – have the potential to be applied to a much wider range of end applications than previously. Where once this kind of dynamic systems modeling was restricted to research and system prototyping applications, it can now be applied to road-going cars, trucks, machinery and plant, to provide early-warning information for fleet managers and maintenance teams. This type of information is also proving beneficial to OEMs that are responsible for providing long-term warranties or full life support of their equipment. And, with CAN network technology found in so many applications beyond the automotive sector, it is no surprise to hear that the software and service provider is applying its simulation expertise to fields as diverse as marine and underwater systems, energy generation, and oil and gas.*