# PARAMETER AND EVENT REGISTRATION SYSTEM OF VEHICLE

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**Abstract.** It is well known, that great economy of fuel can be achieved by proper exploitation of vehicle. At the same time it is difficult to monitor work style and habits of driver. New generation of trucks already has some factory built-in monitoring means, mostly targeted to driver's personal use but less for fleet owner. Some companies offer additional memory equipped or telemetry systems, which may be installed on vehicle to supervise different parameters and events, including fuel consumption. At the same time practically all systems in the market do not measure amount of fuel filled in tanks and its consumption in time with acceptable accuracy. System presented in this article allows with high accuracy measure amount of fuel in tanks of vehicle and its consumption independently from on-board computer system and record it together with other selected parameters and events in recorder memory. These parameters may include vehicle speed, engine rpm and temperature, cargo department and outside air temperature, geographical position from GPS, etc. Device has modular design to give flexibility at installation and future upgrades. It may be equipped with GSM-GPRS telemetry, driver identification and immobilizer, wireless data reading and programming as an option. Other part of this system is evaluation software, giving possibility to owner or fleet administrator to analyze records from equiped trucks in details.

**Keywords:** fuel, economy, level, consumption, parameter, recorders, telemetry.

## Introduction

Modern fleet management requires new advanced solutions of parameter and event registration and monitoring. On-board electronics of new generation trucks are already capable to record in time a part of parameters during trip of vehicle. Unfortunately these records are mostly used for service and supervision needs by vendor authorized service personnel [1], but less for its owner [2, 3, 4]. Only some parameters, like peak and average speed or fuel consumption are available for driver [5]. There is a line of additional recorder devices in the market giving possibility to fix extended range of events with a possibility to evaluate records after trip or to transmit them „on-line" via mobile communication means [10].

We have find out that practically all these devices are not able to record with acceptable accuracy fuel amount filled in tanks of vehicle, being very important for good fleet management. This is due to use of readings from float type fuel level sensor being used as a standard in motorized transport [7, 8]. It has relatively low resolution (5-25 liters/step) [6] due its rheostat type design, and usually is nonlinear (does not take into account form factor of tank) being acceptable only for indicator purposes. Some of devices use additional flow meters inserted in forward and return fuel lines, what gives accurate measurement of fuel consumption, but cannot measure fuel amount in tanks.

Another problem is that practically all existing methods does not allow to measure fuel level on moving vehicle, caused by float swings together with fuel during driving. This effect is mechanically eliminated by inertial mechanism in fuel gauge, but does not allow achieving acceptable level calculation from sensor electrical output signal. In most cases supervision devices are connected to existing on-board parameter sensors if electrical circuit of vehicle allows this. Modern systems contains computerized engine and body electronic control units (ECU) as input using output from "smart sensors" with digitized signal, making parallel connection method technically problematic or even impossible from safety reasons. Usually this is solved by installation of additional sensors causing increase of necessary equipment overall costs.

The main task of research work was to find a compromise design of parameter and event registration system that at least partially solves above mentioned problems.

## Research work, methods and design results

First research was done on available fuel level measurement methods and possibility to improve them. Other research concerns existing technical solutions used in on-board recorder design of supervision systems in the market. The third part of work is dedicated to the embedded and analysis software design. Short overall description of research and development work is presented below.

***Fuel Level Measurement Module of the System***

There are not many non expensive alternatives for fuel level measurement methods in tanks of vehicle to traditionally used float system. Our choice for research and tests was use of capacitive sensor, having simple design without moving parts and being relatively easy to implement in fuel tank. Sensor consists of two isolated metallic tubes, vertically inserted one into another and forming two layers of capacitor. Dielectric material is diesel fuel (oil) or air. As oil has higher dielectric constant in comparison with air, more the sensor is immersed in it, greater the capacitance. Usually RC generator circuit is used to convert capacitance to frequency or period being easier to measure.

Simple replacement of float sensor to single capacitive sensor does not solve measurement problems of moving vehicle, for this additional sensor, located at possibly far distance in tank is required. If corresponding layers of both devices are connected in parallel, capacitance changes due fuel swings in tank are partially compensated. This method is protected by Latvian Patent Nr.13255 [6]. With a permission of patent holder in the frames of project we obtained and tested this device. Test results showed, that using this method, really high fuel level measurement accuracy may be achieved – up to ±1 liter in 500 liter tank (±0.2 %). At the same time it was found that system is sensitive to temperature changes, depending on temperature difference between readings in time and error may be up to ±10 liters or more. This is mostly caused by tank and fuel volume and measuring electronic component parameter changes from temperature. Problem analysis and experiments proved that solution is to add a temperature sensor measuring actual temperature of tank and electronics, see Fig. 1.

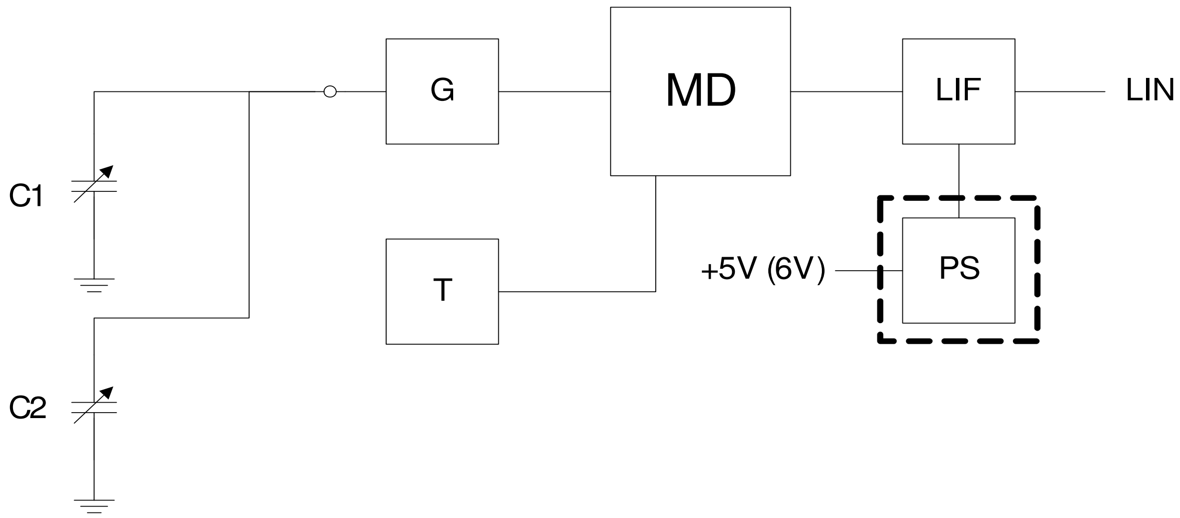


Fig. 1. **Fuel level measurement module functional schematic:** C1, C2 – capacitive sensors; G – generator; MD – microcomputer; T – temperature sensor; LIF – LIN buss interface; PS – additional voltage stabilizer (if required)

Presented device differs from described in [6] not only by additional temperature sensor T, but also by connection method to recorder device. It is realized by means of Local Interconnect Network (LIN) buss recommended for use in vehicles for „smart sensors" since 2001, but is simpler than traditionally used Control Area Network (CAN). This allows connecting 2 or even more tanks to one recorder. For LIN support local microcomputer MD contains necessary hardware and embedded software and additional line interface (LIF) device. Measurement module is directly powered from LIN buss by means of built-in power converter in LIF chip. In some cases generator G circuit requires higher voltage (6-9V) than provided 5V by LIF, and module may contain additional power source PS to achieve suggested accuracy from G.

During tests was proved that most influence to system overall accuracy comes from electronic component parameter temperature dependence. We found experimentally necessary temperature relations and corrections that can be used by the microcomputer MD to calculate accurate fuel amount in tank. It was proved that these correction factors can be generalized and applied for all units if devices are built from components, received from the one and the same vendor, as used during tests. Nevertheless, as previously, to eliminate tank form factor and other system dependences, calibration, now corrected by temperature, is essential to achieve required accuracy. Calibration curve is stored in MD memory, and module „reports" real calculated amount of fuel in tank with close to above declared possible accuracy. Described system and solution is registered as Latvian Patent Announcement Nr. P-07-141.

***Modular Device for Parameter and Event Recording of Motorized Vehicle***

As found during research activities, from existing in the market there are two major design solutions for mentioned systems:

- All-in-one – basic system unit contains all necessary devices, circuits, and electrical chains to realize required tasks, but sometime only few of them are required and used to reach final aim of the design;
- Modular solution – system may contain only required modules providing dedicated task in the system, but their design expenses may be much higher due to necessity of interdevice interface (buss), and additional hardware and software means.

Our approach was to design an intermediate system, having capabilities of both above, but with possible fewer expenses. Modular schematic of system is presented in Fig. 2.

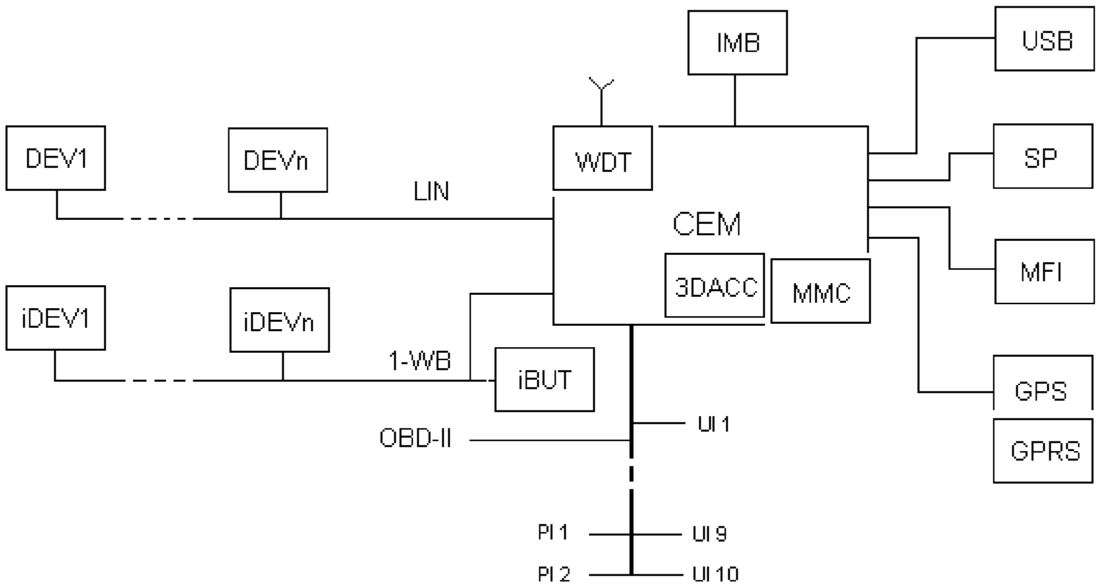


Fig. 2. **Modular schematic of Parameter and Event Recording Device of Motorized Vehicle:** CEM – central Electronic Module, main module with internal sockets for optional (WDT, 3DACC and OBD-II coprocessor devices); DEV1-DEVn – LIN buss devices; iDEV1- iDEVn – „1-wire buss" devices; OBD-II – Connection to „On Board Diagnostics" and Monitoring Interface (optional); UI 1...UI 10 – Universal Direct Registration Signal Inputs (Analogue or Digital); PI 1, PI 2 – Pulse Signal Inputs (Engine RPM and Vehicle Speed); WDT – Wireless Bluetooth or WLAN interface, used for acquired data readout and system calibration; 3DACC – 3 dimensional activity sensors (accelerometer, optional); MMC – MMC card for data record; IMB – immobilizer device (optional); GPS – GPRS Global Positioning Device – separate device (module) to fix vehicle position and record its current coordinates in MCC or combined module with GPS-GSM-GPRS functionality to transmit them together with other selected data to host system (optional); USB – (slave) basic interface for data readout and calibration of system; MFI – multifunctional indicator for driver, bicolor LED with dedicated displayed color and time meaning; SP – audio warning device; iBUT – driver identification device

Modularity is realized by means of two external buses LIN and "1-wire buss" used to connect measuring devices and smart sensors to central electronics module CEM. In current design LIN bus is used to connect fuel measurement modules and in future load on axle measurement devices. Smart temperature sensors and i-Button key for driver identification are connected via “1-wire buss”. Third general connection goes to On Board Diagnostics (OBD) connector of vehicle. Existing standards allow using this connection for monitoring means. This radically reduces amount of wiring and sensors to gather required parameters. In case if OBD connection is not available, CEM has 10 universal measurement inputs for analog or digital signals and 2 for pulse signals like those from RPM or speed sensors.

Design of CEM is based on 16-bit microcomputer. Most of CEM functionality is realized by software. To reduce necessary amount of modules in system and its cost some optional devices are placed directly on electronics board by means of connectors. They are:

- OBD-II coprocessor containing all necessary software to recognize, support and monitor all 6 existing protocols of SAE J1979 standard (not shown in Fig. 2.)
- 3-dimensional accelerometer (3DACC)
- MMC type memory card with capacity 32 to 512 MB
- Wireless data transmission module (WDT), using Bluetooth or WLAN technology

Mentioned solution simplifies system hardware configuration according customers requirements. GPS-GPRS module (modem) is optional external device connected to RS232 interface.

Acquired data from sensors are normalized, averaged were required and packed in frames for storage in MCC card. Minimal time between frames equals 1 second, but in most cases 60 second interval is used. Information from device may be downloaded for analysis and storage using any of possible connections – USB, local wireless or GSM-GPRS. GSM-GPRS may be used also for vehicle tracking in real time.

Described system is registered as Latvian Patent Announcement Nr. P-07-142.

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