2.3 Signal Processing for Automotive Applications

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1 Sensor Signals as Input for Automotive Control Units

Engine and Transmission Control, as well as many other functions of automotive systems (safety, comfort, environmental protection, ...) require effective control concepts in order to fulfill the requirements from legislation and the customers. These control concepts can be basically reduced to a control loop: sensor measures the controlled variable - control unit processes the sensor input and drives the actuator - actuator adjusts the controlled variable.

Fig. 1. Block Diagram of a Typical Engine Control Unit (ECU) [1]

In modern cars up to 70 control units are working. Most of the implemented control concepts are rather complex and involve a number of sensor signals to handle. As an example the block diagram of an engine control unit (ECU) is shown in Fig. 1. A typical ECU provides several interfaces to sensors:
- analog input
- digital input (on/off)
- pulse width modulated (PWM) input
- CAN interface

In order to protect the electronics from overvoltage all sensor signals have to pass input protection circuits (passive: \(R, RC\) circuits; active: specific semiconductors) and filters. These circuits suspend noise and limit the signals to the allowed input range of the microcontroller (0 V to 5 V). After analog to digital conversion, the sensor signals are typically processed fully digital by the microcontroller.

In addition to these wire-based interfaces, also optical and telemetric interfaces are under development (see chapter 4). Today a typical control unit is able to handle the following signals:

**Analog signals**

Analog signals are the input from analog sensors like lambda probe, pressure sensor and potentiometer. The signal information is described be the voltage with a typical range of 0 V to 5 V (typically 0.5 V and 4.5 V for a defined range of the measurand). This normalisation of the input voltages requires that analog signal processing has to be included in the sensor.

**Pulsed signals**

A typical example for pulsed signals is the output of a inductive rotational speed sensor. Its voltage range is up to 100 V. Usually the signal is converted to a digital signal and then be handled by a counter. Typical ECUs have specific input interfaces that perform this conversion. Another example for pulsed signals is the pulse width modulated output of e.g. mass air flow sensors and manifold absolute pressure sensors.

**Digital signals**

The digital input interface handles the digital signals (on/off) of switches with a voltage range of 0 V to battery voltage. The voltage is limited to 5 V by the input protection circuit. In addition to this, also digitalised pulsed signals like that of a hall probe with digital output are handled by the digital input interface. The voltage of digitalised pulsed signals ranges usually from 0 V to 5 V.

**Data transferred via bus**

The communication interface of the ECU is designed to exchange digital information with sensors via bus. This requires a smart bus capable sensor with integrated analog to digital conversion and communication interface. The signal form has to follow the bus protocol, usually CAN.