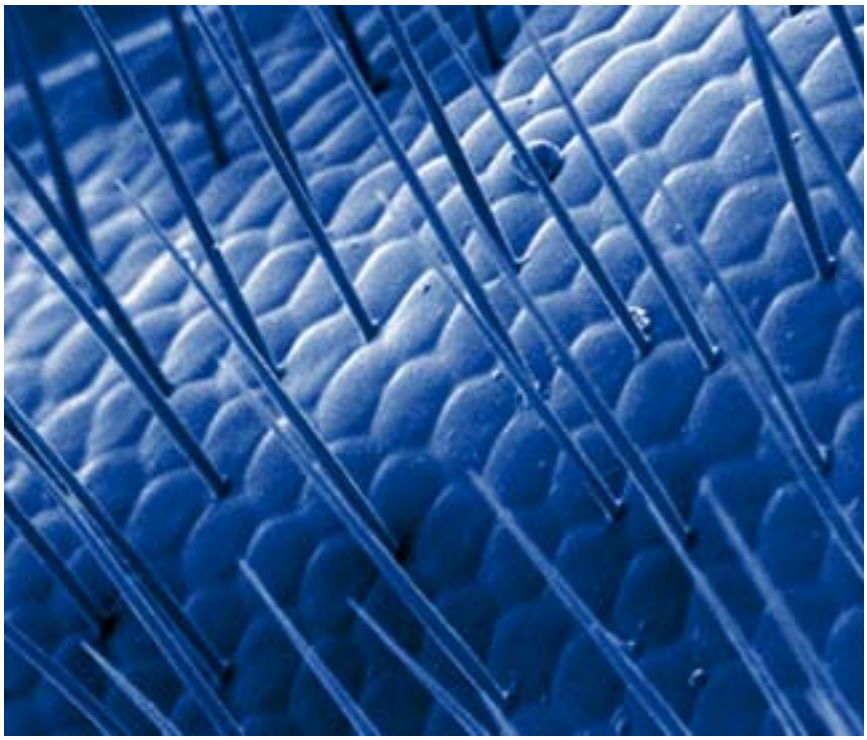


CAN-connected sensors

Standardized sensor profiles for CAN-based higher-layer protocols simplify device design and system integration.

Single sensor modules with CAN interfaces do not require additional I/O module connections.

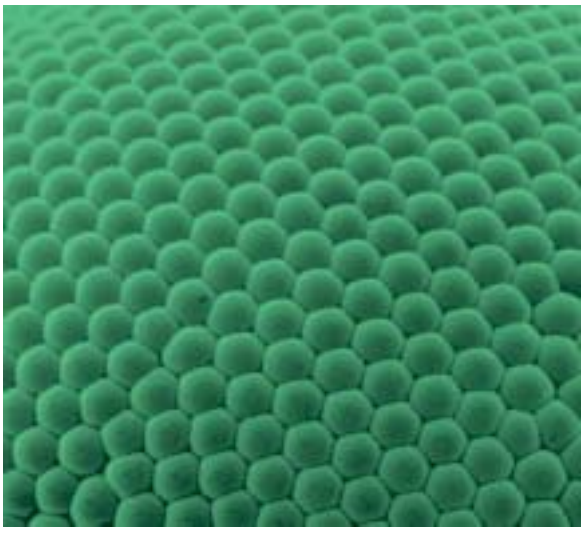
CAN and sensors

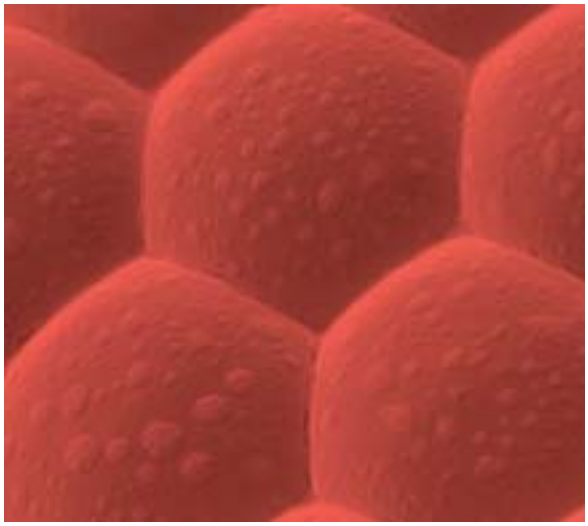
Controller Area Network (CAN) was originally developed for in-vehicle networking in passenger cars. The internationally standardized data link layer protocol (ISO 11898-1) and the high-speed physical layer (ISO 11898-2) as well as the fault-tolerant physical layer (ISO 11898-3) have been implemented in silicon by many chipmakers.

Nowadays, the CAN controller and transceiver chips are not only used in automotive electronic control units (ECU) but also in industrial controllers and devices as well as in other application fields. There are many embedded networks based on CAN.

In the past, many sensors were connected indirectly to CAN networks via analog input/output (I/O) modules. Sensors providing low-level digital interfaces (e.g. LIN, I^2C, SPI, USB, etc.) were linked via appropriate gateway modules. Some of these digital interfaces for analog sensors have been standardized (e.g. IEEE 1451). In recent years, an increasing number of sensors with an integrated CAN interface has been developed. Sensors with an integrated CAN interface avoid cost-intensive I/O or gateway modules.

Depending on the application fields such sensors with CAN connectivity support higher-layer protocols such as CANopen, DeviceNet, or J1939. These CAN-based





higher layer protocol specifications include sensor profile definitions in order to achieve interconnectivity and exchangeability.

Sensors with integrated CAN interfaces that do not support any standardized higher-layer protocol are also available. They provide a proprietary CAN communication protocol and application behavior.

Single sensor CAN devices

Single sensor modules comprise of one sensor module and one CAN interface module. These devices are housed in a single casing and can directly connect to the CAN bus-lines.

Some of the simple sensors for different physical measurements available are:

- Temperature
- Shaft speed
- Inclination
- Flow
- Voltage
- Radioactivity
- Pressure
- Photoelectric
- Acceleration
- Length
- Current
- And many more

Multi-sensor CAN devices

Multi-sensor devices combine several sensor modules and one bus-coupler module. Typically, these are complex sensor systems such as:

- Camera systems
- Engine exhaust measurement systems
- Joystick devices
- Garbage truck weighing units
- General positioning systems (GPS)

DeviceNet sensor devices

DeviceNet is a CAN-based higher layer protocol dedicated to factory automation. It is used as sensor/actuator network. The DeviceNet device profile specifications include definitions for rotating and linear encoders measuring rotations, length, and speed. Other DeviceNet profiles describe the communication of generic analog input modules as well as specific input modules such as photoelectric sensors, residual gas analyzers, resolvers, etc.

The DeviceNet device profiles identify the minimum set of objects, configuration options, and the I/O data formats. Devices that follow one of the standardized profiles have the same I/O data and configuration options, respond to all the same commands and have the same behavior as other devices that follow that same profile.

Several single sensor devices with DeviceNet connectivity are readily available. Several manufacturers offer speed sensors, temperature sensors, and electro-pneumatic transducers in particular.

CANopen sensor devices

CANopen is a CAN-based higher layer protocol dedicated to generic embedded networking applications. The CANopen specifications include several device profiles for sensor devices. The CANopen device profile for measuring devices and closed-loop controllers can be used for single and multiple sensor modules. Additionally there are specific device profiles for inclinometer, joystick, dosimeter and other sensing devices.

Some of the CANopen application profiles define very specific sensor interfaces (e.g. fingerprint detectors and lift-specific sensors), and the CANopen diesel locomotive application profile specifies several temperature sensor interfaces.

The CANopen device profile for measuring devices and closed-loop controllers specifies generic analog inputs, which may be parameterized by SI unit, offset, scaling, sample rate, auto-calibration, interrupt delta, and other objects.

The analog functional block describes how filed values are converted to process values.

Examples for field values are:
- Non-linear readings from an analog-to-digital converter
- Counter readings from an incremental encoder
- Calibrated electrical value at the input terminal of measuring transformer (mA, V, mV/V)

These field values are converted to the real physical dimension of the measured quantity, and the result is called process value. Examples for process values are:

- Weight measurement (in kg)
- Temperature measurement (in Centigrade)
- Displacement measurement (in mm)
- Pressure measurement (in bar)

The conversion from the field value to process value is generally defined as a linear transformationby the two pairs of field values and process values called calibration points 1 and 2. Non-linear transformations may be defined for different sensor types (e.g. PT100).

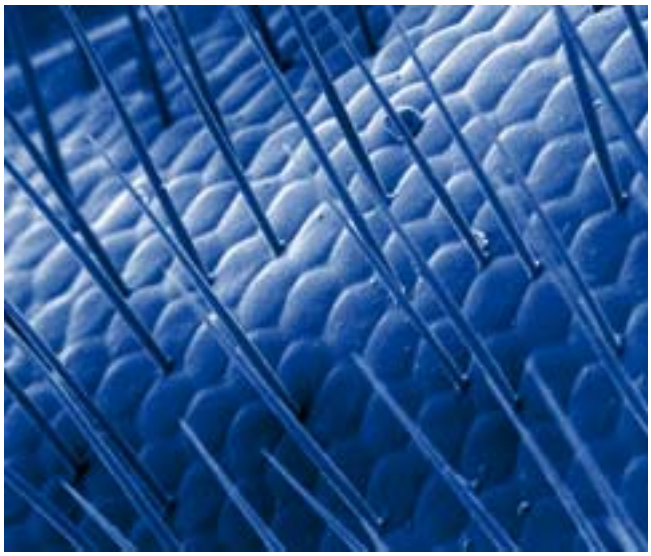
J1939-based sensor devices

J1939 is a CAN-based higher layer for in-vehicle networking in trucks, buses, off-highway vehicles, etc. J1939-based application profiles define the sensor signals by means of the physical unit, offset, value range, and other attributes in order to achieve plug-and-play capability.

As an example, the J1939-71 specification defines the following sensor signal:

Steering Axle Temperature (temperature of lubricant in steering axle)
Data Length: 1 byte
Resolution: 1 °C/bit gain, -40 °C offset
Data Range: -40 to +210 °C (-40 to 410 °F)
Type: Measured
Suspect Parameter Number: 75
This signal is mapped into the CAN message as the Parameter Group Number (PGN) 65,273 ($00FEF9_{16}$). Similar definitions of signals and parameter groups are given in other J1939-based specifications, too.

Some manufacturers have introduced pressure and temperature sensors as well as Hall sensors supporting the J1939 protocols.



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