Sensors in production engineering - The product range at a glance

BERO proximity switches
SIWAREX weighing systems
MOBY identification systems
SIMODRIVE sensors
SIMATIC Machine Vision
Sensors for production engineering
Optimum solutions for all tasks

Sensors play an important role in many machines and plants, for example:

- Detecting the position of an object
- Acquiring the speed of a shaft
- Detecting and checking the shape of objects
- Detecting contrast and markers invisible to the naked eye
- Identifying objects, with mobile data memories as well
- Measuring forces, torques and weights

Examples for these tasks are abundant in all areas of industry:

- In conveyor technology, countless contactless sensors control complex processes.
- In assembly lines, mobile data memories accompany products through the assembly stages.
- In industrial production, machine vision systems check products for rejects or packaging for intactness.
- In transport logistics and traffic control, sensors are used to identify automobiles, even at great distances, as well as containers, and to monitor main assembly lines.

This overview presents the sensor technology solutions of Siemens Automation and Drives Group.

<table>
<thead>
<tr>
<th>Page</th>
<th>Sensor system</th>
<th>Hardware</th>
</tr>
</thead>
</table>
| 3    | BERO® proximity switches          | • IQ-Sense® sensors  
|      |                                   | • Sonar-BERO  
|      |                                   | • Opto-BERO  
|      |                                   | • Inductive BERO  
|      |                                   | • Capacitive BERO  |
| 7    | SIWAREX® weighing systems         | • Weighing processors (for force and torque measurements, container weighing, mixture, proportioning, filling scales, etc.)  
|      |                                   | • Weighing cells and installation accessories  |
| 8    | MOBY® identification systems      | • Mobile data memories  
|      |                                   | • Write/read devices  
|      |                                   | • Interfaces  |
| 10   | SIMODRIVE® sensors                | • Optoelectronic incremental encoders  
|      |                                   | • Optoelectronic absolute value encoders  
|      |                                   | • Hollow shaft measuring systems  |
| 12   | SIMATIC® Machine Vision           | • Intelligent vision sensor  SIMATIC VS 100 range  
|      |                                   | • Intelligent cameras  SIMATIC VS 700 range  |
BERO proximity switches
IQ-Sense

Introduction
The current trend in industry and commerce is quite clear: increasingly comprehensive automation with increasingly complex sequences. A decisive factor is complete control of all processes. The complete range of BERO proximity switches covers all automation requirements. Whether solids, liquids or powders are involved, whether recording, counting, measuring, monitoring or positioning: BERO proximity switches are the automation sensors. They are available in five versions:

- **Opto-BERO** are photoelectric proximity switches which can record objects at distances up to 50 m using visible or invisible light.
- **Sonar-BERO** operate using ultrasonics, and can record many different materials (even transparent ones) independent of the brightness. The distances extend from 3 cm up to approx. 10 m.
- **Inductive BERO** record metallic objects even under harsh environmental conditions. They provide degree of protection IP 68/69K and switching frequencies up to 3000 Hz, and can be used for distances from 0.6 up to 75 mm.
- **Capacitive BERO** record conductive and non-conductive materials as powders, solids or liquids.
- **IQ-Sense®**: intelligent communication for direct connection to the ET 200S distributed I/O system.

IQ-Sense® - sensor and controller in one system
The newly developed IQ-Sense® technology offers a completely new concept for intelligent linking of sensors for automation engineering.

Up to four sensors can be connected using two-wire cables to the new 4DI IQ-Sense® sensor module for ET 200S. A new feature is the connection of up to 8 sonar and optical sensors to the IQ-Sense module for S7-300/ET 200M. This module can be used centrally in an S7-300 or distributed in an ET 200M.

Advantages of IQ-Sense®
- Extremely simple interfaces eliminate faults in all phases from configuring up to wiring.
- Channel-specific diagnostics for open-circuit, short-circuit, maladjustment, failure.
- New types of IntelliTeach® functions mean that all settings for the IQ-Sense® devices can be parameterized directly in the PLC and downloaded onto other sensors.

Complex adjustment of each individual sensor is omitted.
- When replacing sensors (even during runtime), all settings are automatically re-established by the PLC.
- High degree of protection IP 67.
- Adjustment of operating mode and checking of sensor version for the ultrasonic sensor.

Overview of IQ-Sense

<table>
<thead>
<tr>
<th>Technical specifications</th>
<th>K80 IQ-Sense®</th>
<th>C40 IQ-Sense®</th>
<th>M18 IQ-Sense®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffuse sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2 m</td>
<td>70 cm</td>
<td>6 to 30 cm or 20 cm to 1 m</td>
</tr>
<tr>
<td>Transmitter (type of light)</td>
<td>IR LED 880 nm</td>
<td>Red LED 660 nm</td>
<td>Ultrasonic</td>
</tr>
<tr>
<td>Dimensions (in mm)</td>
<td>83 x 65 x 25</td>
<td>40 x 40 x 53</td>
<td>M18 x 105</td>
</tr>
<tr>
<td>Order No. group</td>
<td>3SF7 210-3IQ..</td>
<td>3SF7 240-3IQ..</td>
<td>3SF6 23...</td>
</tr>
<tr>
<td>Retroreflective sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>8 m</td>
<td>6 m</td>
<td></td>
</tr>
<tr>
<td>Transmitter (type of light)</td>
<td>Red LED 660 nm, polarized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions (in mm)</td>
<td>83 x 65 x 25</td>
<td>40 x 40 x 53</td>
<td></td>
</tr>
<tr>
<td>Order No. group</td>
<td>3SF7 211-3IQ..</td>
<td>3SF7 241-3IQ..</td>
<td></td>
</tr>
<tr>
<td>Diffuse sensor with background suppression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.2 m to 1 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmitter (type of light)</td>
<td>Infrared 880 nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions (in mm)</td>
<td>40 x 40 x 53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order No. group</td>
<td>3SF7 214-3IQ..</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
BERO proximity switches
Sonar-BERO

Using ultrasonic technology, the Sonar-BERO can recognize objects of any constitution, i.e. also liquids and powders, colored or transparent. It is irrelevant whether the surface is rough or smooth, clean or contaminated, wet or dry, glossy or mat. Sonar-BERO are also extremely rugged, and insensitive to contamination, vibration, ambient light and external sound. Sonar-BERO measure the propagation time of the transmitted ultrasound reflected by the object, and can then calculate the distance to the object. The Sonar-BERO can measure extremely small (6 cm) or extremely large distances (10 m) without problem. Measurement of the ultrasound is carried out in different manners:

- The **compact range** with integral evaluation and adjustment on the Sonar-BERO. These compact devices are mainly for applications where the parameters need only be set once during commissioning, and where modifications are carried out by experts. The SONPROG software permits extremely simple adjustment for the object and switching range (e.g. minimum level).
- The **Sonar sensors** for recording fast movements under difficult ambient conditions, e.g. steam, transparent materials, spraying with water etc.

**Advantages of Sonar-BERO**
The decisive advantages of the Sonar-BERO are:

- Non-contact recording at distances from 5 cm up to 10 m.
- Insensitive to contamination, vibration, ambient light or external sound as a result of oscillating ultrasonic converter.
- Independent of color, even for transparent objects.
- Temperature compensation: recording of distance with 1.5% accuracy from -25 °C to 70 °C.

**Sonar-BERO from the compact range**

<table>
<thead>
<tr>
<th>Design</th>
<th>M18S</th>
<th>K08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>20 V to 30 V DC</td>
<td>≤ 20 mA</td>
</tr>
<tr>
<td>Current consumption without load</td>
<td>≤ 20 mA</td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>3A800: 1 NO, diffuse sensor with background suppression</td>
<td>3CC00: diffuse sensor, NON/NC selectable</td>
</tr>
<tr>
<td></td>
<td>3BB00: 1 NO, retroflective sensor</td>
<td>3RS00: frequency output</td>
</tr>
<tr>
<td>Switching frequency</td>
<td>10 Hz</td>
<td>5 Hz</td>
</tr>
<tr>
<td>Sensing range (in cm)</td>
<td>3 to 20</td>
<td>10 to 70</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 1 mm</td>
<td>± 2.5 mm</td>
</tr>
<tr>
<td>Status displays</td>
<td>Yellow LED</td>
<td>Yellow/green LED</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-25 °C to +70 °C</td>
<td>-25 °C to +70 °C</td>
</tr>
<tr>
<td>Dimensions with connector (in mm)</td>
<td>M18 x 63 (straight head), M18 x 81 (angled head)</td>
<td>47 x 38 x 15</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 67</td>
<td>IP 67</td>
</tr>
<tr>
<td>Order No. group</td>
<td>3RG6432-..., 3RG6422-..., 3RG6433-..., 3RG6423-...</td>
<td>3RG6451-...</td>
</tr>
</tbody>
</table>

- Simple and fast parameterization by PC via SONPROG interface.
- Different frequency values can be programmed for each Sonar-BERO.
- One single Sonar-BERO can thus handle the tasks of several optical sensors.
- Maintenance-free.
BERO proximity switches
Opto-BERO

The comprehensive range of Opto-BERO proximity switches operate with infrared, red or laser light. These photoelectric sensors recognize all objects independent of their constitution, whether metal, wood or plastic. Even transparent objects are recorded by the Opto-BERO K20 in miniature housing. Different colors or differences in contrast can even be detected using special devices such as the color sensor or printed mark reader. Extremely exact clearance measurements and position checks are possible with the analog laser.

The Opto-BERO can be adjusted rapidly and conveniently using Teach-In or potentiometers. A large selection of cubic, cylindrical and miniature designs satisfies all requirements.

Opto-BERO K21
The new Opto-BERO K21 range with its various designs is used as:
- **Diffuse sensor**
  This uses the object as the reflector, and evaluates the quantity of reflected light using a sensor.
- **Retroreflective sensors**
  are irritation-free even with ambient light. They operate using polarized light up to a distance of 3 m.

---

**Technical specifications for Opto-BERO**

<table>
<thead>
<tr>
<th>Opto-BERO K21 diffuse sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing distance</td>
</tr>
<tr>
<td>Type of light</td>
</tr>
<tr>
<td>Connection</td>
</tr>
<tr>
<td>Output</td>
</tr>
<tr>
<td>Order No. group</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opto-BERO K21 retroreflective sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing distance</td>
</tr>
<tr>
<td>Type of light</td>
</tr>
<tr>
<td>Connection</td>
</tr>
<tr>
<td>Output</td>
</tr>
<tr>
<td>Order No. group</td>
</tr>
</tbody>
</table>

---

One domain for Opto-BERO are high-bay warehouses

Application example of Opto-BERO K20

Overview of optical BERO
BERO proximity switches

Inductive BERO

Inductive BERO are non-contact proximity switches which contain no parts subject to mechanical wear and which are largely insensitive to environmental influences.

Inductive BERO implement a change in signal if a highly electrically or magnetically conductive object approaches or disappears.

Inductive BERO are available with many different ranges and designs depending on the requirements:

- For normal requirements:
  power supply range 15 to 34 V DC,
  switching frequency up to 3000 Hz

- For PLCs (two-wire):
  power supply range 15 to 34 V DC,
  switching frequency up to 1500 Hz

- For increased electrical requirements:
  problem-free adaptation to various operating voltages

- For extreme ambient conditions:
  with degree of protection IP 68/69K
  (e.g. under water, in oil emulsions, etc.)

- For increased switching clearance:
  significantly above the standard (3 times)

- In explosion proof design:
  up to 500 bar, switching frequency up to 400 Hz

- Without reduction factor:
  for non-ferrous metals, resistant to welding magnet fields

- With analog output:
  i.e. with voltage output 0 to 5 V DC,
  current output 1 to 5 mA

Capacitive BERO

These non-contact proximity switches detect conducting and non-conducting solids, powders or liquids. Typical applications include level signaling or monitoring, bottle counting, all types of quantity counting.

Further information

More details on all BERO are available in the Catalog “NS BERO” or on the Internet at www.siemens.com/bero

---

<table>
<thead>
<tr>
<th>Technical specifications for inductive BERO 3RG4...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching distance $S_n$</td>
</tr>
<tr>
<td>Mounting</td>
</tr>
<tr>
<td>Designs</td>
</tr>
<tr>
<td>Housing material</td>
</tr>
<tr>
<td>Degree of protection</td>
</tr>
<tr>
<td>Power supply range</td>
</tr>
</tbody>
</table>

---

Overview of inductive BERO

Overview of capacitive BERO
Introduction
Nowadays, in areas of automation and process technology that involve measurement of forces or weights, state-of-the-art weighing systems are used to monitor and control a wide variety of production processes. Their use extends from simple applications, such as the monitoring of belt tension or filling level measurement of containers and bins, to complex proportioning tasks, such as making of mixtures based on specified recipes. Weighing systems are particularly suitable for measuring tasks requiring high accuracy and for applications for which other measuring techniques are unsuitable (e.g. filling level measurement of foam-forming substances, measurement of aggressive substances that may cause sensor damage, or measurements subjects to hygienic restrictions). These weighing systems are to be found in the production of food and animal feed, in the chemical and pharmaceutical industries, and in general mechanical engineering.

Complete integration of SIWAREX into the SIMATIC world is a primary characteristic
· Implementation of central automation concepts through direct integration in SIMATIC S5 and S7
· Implementation of distributed automation concepts through integration in SIMATIC NET (PROFIBUS DP)
· Integration in process control systems through SIMATIC PCS 7
· Integration in fault-tolerant S7 and PCS 7 systems
· Operator control and monitoring through SIMATIC HMI
· Uniform configuring and programming through SIMATIC software

Additional information
More details on SIWAREX weighing systems are available in catalog “SIWAREX Weighing Systems” WT 01 and in the electronic catalog CA 01.

Weighing electronics
The following weighing modules are available to meet different requirements and applications.
- SIWAREX P for fill level measurement and overload protection mechanisms. Directly integrated in SIMATIC S5-90U to SIMATIC S5-100U, or in stand-alone mode.
- SIWAREX U for load and force measurement using load cells and sensors with one or two measuring channels. Directly integrated in SIMATIC S7-300.
- SIWAREX M for weighing and proportioning systems and for applications that require official calibration. Directly integrated in SIMATIC S7-300 or for implementation as a stand-alone unit.
- SIWAREX A – the proportioning control for filling and bagging plants is used for weighing free-flowing solid materials and liquids with maximum precision and speed.

Load cells
The SIWAREX load cells deliver a voltage to the weighing electronics that is proportional to the force. Different cells are available depending on the weighing task, load range and required accuracy.

Suitable installation accessories ensure that the forces are guided into the load cells, thereby preventing measuring errors that might lead to damages. SIWAREX R load cells are equipped with strain gauges. They are used for static and dynamic weight measurements and are approved for applications with calibration capability and in hazardous areas.

The load cell series SIWAREX R cover rated loads between 10 kg and 280 tons.

Load cells

<table>
<thead>
<tr>
<th>Technical data</th>
<th>SIWAREX P</th>
<th>SIWAREX U</th>
<th>SIWAREX M</th>
<th>SIWAREX A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>20,000</td>
<td>65,000</td>
<td>500,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Measuring interval</td>
<td>100 ms</td>
<td>20 ms</td>
<td>20 ms</td>
<td>20 ms</td>
</tr>
<tr>
<td>Calibration capability</td>
<td>--</td>
<td>--</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Order No. group</td>
<td>7MH4 205-1A.01</td>
<td>7MH4 601-1A01</td>
<td>7MH4 553-1AA4</td>
<td>7MH4 421-1AA0</td>
</tr>
</tbody>
</table>
Identification systems must be adequate for many and often very individual requirements. One person might want economical Smart Labels for logistics, another rugged data storage for assembly lines. In the automotive industry, these mobile data memories (MDS) must, above all, be heat-resistant, and in traffic control and transport logistics, "long range" data memories are an indispensable component.

No matter what your requirements may be: MOBY, the clever electronic identification systems from Siemens, are always the perfect solution. They provide reliable, fast and economical identification, are impervious to dirt and air pollutants, and store data right on the product. This way, it is possible to not only control material flow, but also to optimize it.

**Function principle of MOBY**

MOBY basically consists of the following compatible devices:

- **Mobile Data memories (MDS)**
  Mobile data memories (MDS or tag/transponder) are attached to the product, product carrier or packaging. They are written on without contact. The memories contain all application-specific data. Up to 32 KB data can be stored, and edited or read back when required.

- **Read/write units (SLG/SIM)**
  handle the fast and secure data transfer to the mobile data memories. Data is transferred inductively (electromagnetically) through an electromagnetic field or by radio. A serial connection couples them to ASM and to higher level systems (PLC, PC, ...).

- **Interfaces (ASM)**
  Interfaces (ASM) integrate the identification systems MOBY into SIMATIC, SINUMERIK, and effect the connection to PROFIBUS, TCP/IP 1), PC and other systems. Once they are fed with appropriate parameters and data, they handle the data traffic autonomously. Then the results and data is made available. Corresponding software modules (FB/FC for SIMATIC, C libraries for PC running under Windows) let you incorporate MOBY into your application effortlessly and fast.

**Advantages of MOBY**

Compared to other information media, e.g. barcode, MOBY offers a host of advantages:

- insensitive to temperature changes and dirt
- long life cycle
- up to 32 KB can be stored directly on the product
- re-usable
- 100% secure data transmission

**Technical data**

<table>
<thead>
<tr>
<th></th>
<th>MOBY D</th>
<th>MOBY F</th>
<th>MOBY E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>13.56 MHz</td>
<td>125 kHz</td>
<td>13.56 MHz</td>
</tr>
<tr>
<td>Memory (EEPROM)</td>
<td>up to 1 KB</td>
<td>192 byte</td>
<td>752 byte</td>
</tr>
<tr>
<td>Write/read distance</td>
<td>up to 0.8 m</td>
<td>up to 0.4 m</td>
<td>up to 0.1 m</td>
</tr>
<tr>
<td>Temperature range</td>
<td>up to +70 °C, or 200 °C</td>
<td>up to +130 °C</td>
<td>up to +150 °C</td>
</tr>
<tr>
<td>Standard</td>
<td>ISO 15693</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

MOBY D is a new RF identification system acc. to standard 15693 in the 13.56 MHz range.

The field of application ranges from simple identification such as electronic barcode substitution, barcode extension or delivery note in a harsh environment, through storage and distribution logistics, all the way to product identification. Due to the low cost of SmartLabels in high volume applications and the ease with which they can be integrated into systems, MOBY D is the ideal identification system for the applications mentioned above. Depending on the read/write distance, various read/write devices are available.

MOBY E and F have been used for many years in many applications in logistics and distribution, e.g. where containers have to be identified automatically, reliably, fast and without contact. Different data memories and read/write units with integrated or separated antenna are available, depending on the requirements (fixed code/EEPROM, size, ambient conditions, larger distances, etc.).

Typical areas of application include:

- Parts identification for textiles (e.g. rented clothes, hospital garments) in laundries
- Logistics (identification of e.g. pallets, goods carriers, containers, etc.)
- Parts identification, for luggage, gas bottles, etc., in a logistics chain
- Goods distribution in open distribution chains
- Assembly lines (identification of workpieces, etc.)

1) available soon
RF identification system MOBY I for industrial production

The MOBY I contactless identification system has been successfully used in a wide range of applications worldwide for many years now. It has been specially designed for applications in industrial production in which high demands are placed on

- reliability,
- reading and writing in dynamic mode,
- a high degree of protection,
- automatic identification.

Different data memories and read/write units are available depending on the requirements (EEPROM/FRAM, size, ambient conditions, larger distances, etc.).

The main applications for MOBY I are:

- Assembly lines (data memory is attached to workpiece carrier).
- Manufacturing processes (data memory is attached e.g. to product carrier).
- Conveyor technology (data memory is attached e.g. to overhead monorail conveyor).
- Assembly lines in the automotive industry (e.g. heat-resistant data memories).

RF identification system MOBY U for assembly lines, transportation

MOBY U is based on the new standard ISO18000-4 and was designed for international applicability. It offers multitag-capability and a continuously adjustable range of up to three meters. With these features MOBY U focuses on:

- Main assembly lines in the automotive industry (body-in-white, surface and installation).
- Vehicle identification/access control in haulage companies, car parks, etc.
- Container-/freight carrier identification in transport logistics and distribution.

By integrating UMTS/GSM technology all known noise inductions (e.g. overreach) were eliminated. New functions, e.g. automatic selection of free frequency channels (Frequency hopping), permit it to optimally cooperate with other 2.4 GHz systems like Wireless LAN or Bluetooth. Rugged housing and power-saving circuit engineering enable years of maintenance-free operation in even the most rugged production environment.

Identification and localization system MOBY R

MOBY R is a real-time localization system that can identify objects within a range of up to 300 meters and an accuracy of 3 meters.

The system can be used to localize any object in real time and in all kinds of surroundings (e.g. material boxes, container, etc.) and even in large premises (e.g. airports, car rentals, automobile factories, etc.).

Areas of applications include, for example

- Cars: localizing, tracing
- Containers: localizing, tracing, theft protection
- Access checks
- Loading zone supervision
- Trucks: localizing the trailer
- Guiding cars
- Material flow monitoring and requests, e.g. in hospitals and production lines

Additional information

More details of MOBY identification systems are available in catalog "Identification Systems MOBY" KT 21 or on the Internet:

www.siemens.com/moby

<table>
<thead>
<tr>
<th>Technical data</th>
<th>MOBY I</th>
<th>MOBY U</th>
<th>MOBY R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency data/energy</td>
<td>1.81 MHz/134 kHz</td>
<td>2.4 - 2.483 GHz</td>
<td>2.4 GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>8 or 32 KB FRAM</td>
<td>32 KB RAM</td>
<td>32 Bit (fixed)</td>
</tr>
<tr>
<td>Write/read distance</td>
<td>up to 150 mm</td>
<td>up to 3 m</td>
<td>up to 300 m (read only)</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-25 to +85 °C or 220 °C cyclic</td>
<td>-25 °C to +85 °C or 220 °C cyclic</td>
<td>up to +65 °C</td>
</tr>
</tbody>
</table>

Identification system MOBY I

Identification system MOBY U

Identification system MOBY R
**Introduction**

SIMODRIVE sensors are built-on opto-electronic encoders for the recording of paths, angles, or rotary speeds of machines. They can be used in conjunction with numerical controllers, programmable logic controllers, drives and position displays, e.g.:

- SIMOTION; motion control systems
- SINUMERIK; CNC controls
- SIMATIC; programmable logic controllers
- SIMODRIVE; drive systems

A distinction is made between

- incremental and
- absolute measuring procedures.

All encoders are available in synchro flange and clamp flange versions. Encoders with a synchro flange can be attached to the machine by means of three clamps. Mounting with axial screws is also possible. The encoder is driven by means of a push-on coupling or a spring disk coupling. Alternatively, pulleys can also be used.

The power supply for the encoder is 5 V DC, or optionally between 10 V and 30 V DC. The versions between 10 V and 30 V DC allow longer cables to be used.

Most control systems supply the voltage direct from the measurement circuit.

**Incremental measuring methods**

These encoders deliver a defined number of electrical pulses for each rotation, which represent the measurement of the distance or angle moved.

Incremental encoders operate on the principle of optoelectronic scanning of index disks operating on the transmitted light principle. The light source is a light emitting diode (LED). The light-dark modulation generated as the encoder shaft rotates is picked up by optoelectronic elements.

In the case of incremental encoders, the machine must travel to a reference point after each power-off state, as the position is not usually stored in the controller, and movements of the machine while the power is off are not recorded.

**Absolute measuring methods**

Absolute value encoders, on the other hand, also record these movements while the power is off and return the actual position at power-on. Travel to a reference point is not necessary.

Absolute value encoders (absolute shaft encoders) are designed on the same scanning principle as incremental encoders, but have a greater number of tracks. For example, if there are 13 tracks, then $2^{13} = 8192$ steps are included in the case of single turn encoders. The code used is a one-step code (gray code), which prevents any scanning errors from occurring.

**Additional information**

More details on SIMODRIVE sensor is available in the catalog “Cables, Connectors and System Components” NC Z and in the electronic catalog CA 01.

**Technical data**

<table>
<thead>
<tr>
<th>Encoder with TTL (RS 422)</th>
<th>Encoder with sin/cos 1 Vpp</th>
<th>Encoder with HTL</th>
<th>Twin track encoder with TTL (RS 422)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>5 V and 10 - 30 V DC</td>
<td>5 V DC ±10%</td>
<td>5 V DC ±5%</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-40 to +100 °C</td>
<td>-40 to +100 °C</td>
<td>-40 to +85 °C</td>
</tr>
<tr>
<td>Speed (max.)</td>
<td>12,000 min⁻¹</td>
<td>2500 p/r</td>
<td>Track 1: 1024 p/r</td>
</tr>
<tr>
<td>Resolution (max.)</td>
<td>5000 p/r</td>
<td>2500 p/r</td>
<td>Track 2: 9000 p/r</td>
</tr>
</tbody>
</table>
Absolute value encoders

Absolute value encoders (absolute shaft encoders) are designed on the same scanning principle as incremental encoders, but have a greater number of tracks. For example, if there are 13 tracks, then \(2^{13} = 8192\) steps are included in the case of single turn encoders. The code used is a one-step code (gray code), which prevents any scanning errors from occurring.

After switching on the machine, the position value is transmitted immediately to the controller. There is no need to travel to a reference point. The data are transmitted between encoder and controller either via the synchronous serial interface (SSI), through EnDat or through PROFIBUS DP.

SSI and EnDat have advantages in time-critical applications. In plants with a large number of encoders, PROFIBUS DP is more of an advantage due to the reduced wiring expense. The encoders with PROFIBUS DP are programmable.

Single turn encoders resolve one rotation (360 degrees mechanical) into a specific number of steps, e.g. 8192. A unique code word is assigned to each position. After 360 degrees the position values are repeated.

Multiturn encoders also record the number of revolutions, in addition to the absolute position within one revolution. To do this, further code discs which are coupled through gear stages with the encoder shaft are scanned. When evaluating 12 additional tracks, this means that \(2^{12} = 4096\) revolutions can be included.

Hollow shaft measuring system SIMAG H

SIMAG H is an incremental measuring system capable of obtaining rotational angles and speeds.

Its area of application includes hollow shafts with direct drive units 1 FE1, 1 PH2, and for self-sustaining spindle encoders.

The electrical signals and the flange are compatible to existing motor measuring systems. SIMAG H can operate in conjunction with inverter SIMODRIVE 611 analog/digital and with all available control systems for motor measuring purposes, or as a direct measuring system. The measuring system SIMAG H consists of the following three components:

- **Gearwheel**
  The gearwheel carries a magnetic imprint. The gearwheel is mounted on the shaft.

- **Scanning head**
  The scanning head scans the incremental and reference tracks located on the gear wheel without touching it.

- **Cable assembly**
  This assembly is completely pre-fabricated. Signal lines are connected to it. Hollow shaft measuring system SIMAG H can be adapted individually to existing space requirements.

Technical data SIMAG H

<table>
<thead>
<tr>
<th>Output signals</th>
<th>Two voltage signals shifted by 90°, reference signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>5 V DC ±5%</td>
</tr>
<tr>
<td>Resolution</td>
<td>256 p/r</td>
</tr>
<tr>
<td>Limit speed</td>
<td>≤ 24,000 min⁻¹</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-20 to +100 °C</td>
</tr>
<tr>
<td>Type of protection</td>
<td>IP 65</td>
</tr>
<tr>
<td>Inner diameter</td>
<td>up to 60 mm</td>
</tr>
</tbody>
</table>

Hollow shaft measuring system SIMAG H with clamp flange

Technical data Absolute value encoders

<table>
<thead>
<tr>
<th></th>
<th>With synchronous serial interface SSI</th>
<th>With EnDat</th>
<th>With PROFIBUS DP (EN 50170)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>10 V to 30 V DC</td>
<td>5 V DC ±10%</td>
<td>10 V to 30 V DC</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-30 °C to +85 °C</td>
<td>-40 °C to +100 °C</td>
<td>-30 °C to +70 °C</td>
</tr>
<tr>
<td>Speed (max.)</td>
<td>12,000 min⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution (max.)</td>
<td>18,192 bit single turn (4096 increments)</td>
<td>13 bit single turn (8192 increments)</td>
<td>13 bit single turn (4096 increments)</td>
</tr>
<tr>
<td></td>
<td>25 bit multi turn (4096 x 8192 increments)</td>
<td>25 bit multi turn (4096 x 8192 increments)</td>
<td>25 bit multi turn (4096 x 8192 increments)</td>
</tr>
</tbody>
</table>

Hollow shaft measuring system SIMAG H with clamp flange
SIMATIC Machine Vision

Introduction

The SIMATIC Machine Vision image processing systems are designed for automatic visual inspection and identification of parts in production processes:

- Use in quality assurance
- Use for automatic identification of parts in production processes

Application

The optical inspection and identification of products in production processes is becoming an increasingly important topic as the demands for quality and production speed increase. Arguments supporting their use are clear:

- Fewer rejects
- Delivery of tested products

These general requirements are specified by DIN ISO 9000 and in product liability laws.

Monotonous visual inspection or identification by persons is expensive. At the same time, concentration and mood are subject to natural variations. Furthermore, increasing cycle rates make checking by personnel increasingly difficult. The use of an image processing system is applicable here:

- Automatic visual inspection during quality assurance; the system checks objectively, rapidly and reliably the dimensions, contours, shapes, presence, correct assembly, position and completeness of parts which can even be microscopically small.
- Automatic identification of parts using shapes, dimensions, patterns, colors, codes and characters.

The following SIMATIC Machine Vision products are available:

- **SIMATIC VS 110**
  The intelligent vision sensor for visual form inspection of the shape of small parts.

- **SIMATIC VS 120**
  For object locating using incident light procedure.

- **SIMATIC VS 130**
  For automatic locating and reading of data matrix codes.

- **SIMATIC VS 710 and ProVision**
  The compact, multi-purpose image processing system for automatic inspection, product monitoring and parts identification.

- **SIMATIC VS 720 and Spectation**
  The general-purpose VS 720 systems for increased speed and resolution, with additional color detection and Ethernet connection.

Intelligent vision sensors from the VS 100 range

These intelligent vision sensors with application-specific image processing are complete packages comprising:

- Sensor head
- Infrared illumination
- Processing unit

A decisive advantage of the vision sensors from the VS 100 range is the commissioning by training. The operator need only place a good unit in the correct position in front of the camera. The system saves these data after pressing of a key, and can immediately commence working. This means that operators need not have any image processing know-how, and that products can be changed without delay.

Furthermore the following functions are common to all devices of the VS 100 range:

- External triggering
- Parameterization and configuration on the device
- Simple linking using PROFIBUS DP (not with VS 110) or serial interface
- Live picture on PC during setting-up
SIMATIC Machine Vision
VS 100 range

<table>
<thead>
<tr>
<th>Technical specifications</th>
<th>VS 110</th>
<th>VS 120</th>
<th>VS 130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor head (camera)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCD chip 640 x 480, quadratic pixels, digital transmission of image data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanning rate</td>
<td>58 images/s</td>
<td>Max. 58 images/s</td>
<td>30 images/s</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor versions</td>
<td>2 with fixed focus (fixed image field size)</td>
<td>3 with fixed focus (fixed image field size)</td>
<td>1 with C/CS-mount with any image field size</td>
</tr>
<tr>
<td>Illumination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strobe light as transmitted light</td>
<td>Strobe light as incident light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light source</td>
<td>Infrared LEDs</td>
<td>Red LEDs</td>
<td></td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 40</td>
<td></td>
<td>IP 65</td>
</tr>
<tr>
<td>Processing unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 15 different types of unit under test can be saved non-volatile in the processing unit, and selected manually or via digital inputs, e.g. by a PLC.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. parts rate</td>
<td>25 units/s</td>
<td>20 units/s (depends on object)</td>
<td>5 units/s (depends on code)</td>
</tr>
<tr>
<td>Max. permissible parts velocity</td>
<td>250 mm/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible quality statements</td>
<td>OK_A (good part in view A)</td>
<td>OK_B (good part in view B)</td>
<td>NOK (wrong or damaged part, or good part in wrong view)</td>
</tr>
<tr>
<td>Permissible height offset of units under test adjustable</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Interfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 x DI (24 V DC), 1 of which as trigger input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 DO (24 V DC), 3 of which suitable for direct connection of pneumatic valves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehensive remote control using separate PLC, incl. releasing/locking of manual input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital image data interface for connection of sensor head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface for connection of illumination unit (power supply, strobe control)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFIBUS V 1.0 (not with VS 110)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface for display of sensor image during setting up</td>
<td>Serial RS 232 for connecting a standard PC</td>
<td>Ethernet for connecting a standard PC</td>
<td>Serial RS 232 for connecting a standard PC</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 40, suitable for installation without control cabinet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Three versions are available per type: two with a fixed image field, one with C/CS-mount lens connection for any image field sizes

VS 110 vision sensor

The intelligent SIMATIC VS 110 vision sensor optically inspects small parts during material feeding for correct shape and position, and signals faulty parts or incorrectly positioned parts by means of an NOK signal.

It is possible to monitor e.g. bolts, screws, injection-moulded parts, small metal parts, chocolates etc.

The following properties can be monitored:

- Checking according to object type: is the object of the correct type (differentiation of types)
- Checking according to correctly oriented supply: two different positions can be trained and evaluated
- Checking for absence of damage and correct processing

Visual inspection is carried out with infrared transmitted light. The object to be checked is located between the light source and the sensor, thus generating a shadow image. The test can be started in two manners, either externally, e.g. using a light barrier, or the VS 110 vision sensor automatically recognizes an object in its image field (automatic triggering).

The following units are examples of those which may be used to transport the parts:

- Oscillating conveyors (spiral conveyor, linear conveyor), conveyor belts
- Workpiece holder revolving systems
- Grab equipment (handling systems, robots)

VS 120 vision sensor

The intelligent VS 120 vision sensor works using incident light, i.e. in the ideal case the light comes from the direction of the camera. This means that not only the shape and position of the test piece can be recognized. Detection of patterns on the surface permit additional conclusions. For example, the completeness of printing can be checked. This information can be used for evaluations, e.g. to control subsequent handling units.

The VS 120 vision sensor passes on the position (with x/y coordinates) and the rotation via a PROFIBUS or serial interface to a PLC which in turn can control e.g. handling equipment.
SIMATIC Machine Vision
VS100 range
VS 710

VS 710 intelligent camera
The SIMATIC VS 710 vision sensor is a complete image processing system (gray scale evaluation) for automatic inspection, production monitoring and parts identification in production engineering.

Applications include e.g.:
• Assembly systems for vehicles and electrical equipment; recognition of position of fed components, testing for completeness (presence, position, dimensions, shape, contour, surface)
• Bottle filling in the drinks, cosmetics and pharmaceutical industries; checking of labels, checking of lids, level detection, bottle sorting, inspection of empties
• Packaging machines for folding boxes and blister packs; form inspection (contour), seal and completeness
• Conveyor and lifting systems; identification and recognition of position of packages, identification of parts, position control of cranes, etc.

Any image processing application can be executed on the SIMATIC VS 710. The test program is configured using a PG/PC with the ProVision software, where knowledge of high-level languages is unnecessary.

VS 130 DMC vision sensor
This intelligent vision sensor has been specially designed to read data matrix code according to ECC200. The data matrix code (DMC) is a two-dimensional code for machine-readable identification of components and products. The DMC consists of a matrix of bright and dark dots. The matrix can comprise up to 144 x 144 dots depending on the quantity of data to be coded, corresponding to a data quantity of 3000 characters.

The matrix size only depends on the resolution of the marking system.
The information density of the matrix is 100 times greater than that of a barcode of identical size. This means that more information can be accommodated in the same area, or that the ID coding is possible on an extremely small area.
The VS 130 vision sensor automatically finds the code in the image even under difficult conditions. The sensor head need only be roughly positioned so that the code is within its image area. The rotational and translational positions are unimportant. This provides the advantage that only low demands are placed on the mechanics of the conveyor system, permitting cost savings.

Lasered, printed or drilled code is recognized on plane or slightly curved surfaces. Non-readable codes are separated by an NOK signal. The information of a read code can be:
• compared with the defined value (digital output) or
• passed on via PROFIBUS or a serial interface to a PLC which then controls appropriate handling equipment.

Technical specifications

<table>
<thead>
<tr>
<th>VS 710</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pixels 768 x 580 (CCD)</td>
</tr>
<tr>
<td>Image data Full-frame shutter 1/50 – 1/10,000 s</td>
</tr>
<tr>
<td>Lens connection C-mount standard</td>
</tr>
<tr>
<td>Program memory Several test programs can be saved on the camera</td>
</tr>
<tr>
<td>Image memory 2 MB</td>
</tr>
<tr>
<td>Image format 380 x 280 to 768 x 512, freely-programmable</td>
</tr>
<tr>
<td>Integral interfaces 1 x RS 232 1 x PROFIBUS DP</td>
</tr>
<tr>
<td>Digital inputs for 24 V DC 2</td>
</tr>
<tr>
<td>Digital outputs for 24 V DC 4</td>
</tr>
<tr>
<td>Monitor connection 1 SVGA</td>
</tr>
<tr>
<td>Degree of protection IP 40, IP 64 with protective housing</td>
</tr>
<tr>
<td>Order No. group 6GF1710-...</td>
</tr>
</tbody>
</table>

SIMATIC VS 120 and VS 130 vision sensors have the same appearance.

Data matrix code with the contents “SIMATIC Machine Vision”
SIMATIC Machine Vision
VS 720 range

The general-purpose VS 720 systems with five vision sensors offer maximum possible scalability for solving many different image processing tasks. They feature high speed and resolution, and the facility for color recognition. A further advantage of the VS 720 range is the Industrial Ethernet connection.

The intelligent cameras of the VS 720 range have a number of functions which can be flexibly combined using the SIMATIC Spectation configuration software.

- Presence check for objects or parts of objects/aspects in the testing area
- Completeness test for parts in assembly sequences
- Checking of supply and position of parts to automatic assembly units
- Comparison of pattern between current object and learned object
- Proof of quality using surface check for quality and deviation
- Geometric measurement of bodies
- Determination of the position of an object with x/y coordinates and associated angle
- Reading of the 1D/2D codes of different standards
- Reading and comparison of text (OCR/OCV)

Script tool for development of user-specific mathematical models
Via Industrial Ethernet it is possible to simultaneously display and evaluate live and/or fault displays from several cameras at a central position. It is additionally possible to display test results in tabular form. The interface to the monitor is the VS Link, which is also required for the PROFIBUS connection (see graphic below with configuration example).

Further technical specifications are common to all VS 720 vision sensors:
- Lens connection using CS-mount or C-mount (adapter)
- Checking of parts via VGA interface (VS Link) by up to 16 sensors
- 8 freely-configurable digital I/Os are integrated
- Communication via PROFIBUS (connected through VS Link) or Ethernet
- Dimensions of compact vision sensor: 112 x 60 x 34 mm (without lens)
- Up to 4 illumination systems can be connected

Via Industrial Ethernet it is possible to simultaneously display and evaluate live and/or fault displays from several cameras at a central position. It is additionally possible to display test results in tabular form. The interface to the monitor is the VS Link, which is also required for the PROFIBUS connection (see graphic below with configuration example).

Connections of the SIMATIC VS 720 vision sensors (power supply and I/O on left, Industrial Ethernet on right)

VS 721 CMOS
As a low-cost starter model, the VS 721 CMOS operates in monochrome mode. Its serial image recording means that it is primarily suitable for static detection of objects.
- Resolution: CMOS 640 x 480 pixels
SIMATIC Machine Vision
VS 720 range

VS 722 Basic
The VS 722 Basic also works in monochrome mode. The CCD sensor element permits parallel evaluation of image information at maximum speed. Thus moving objects are also detected at high performance. The unit can therefore be used for any checking operations and for the handling of parts by robots in association with position detection.

- Resolution: CCD 640 x 480 pixels

VS 723 Performance
The VS 723 Performance differs from the VS 722 Basic in that it has an even higher performance for the hardware architecture.

It is then possible to implement complex test programs and also image processing rates up to 8 times faster. The VS 723 is recommendable for filling plants, packaging plants and web printing.

- Resolution: CCD 640 x 480 pixels

VS 724 High Resolution
The VS 724 High Resolution was developed for measurements with maximum possible precision, and for applications where large image areas have to be checked.

The high-resolution sensor permits extremely exact checking with a resolution previously unknown to compact cameras.

Special checking functions: e.g. wafer checking including measurements in the semiconductor industry, checking of plastics, glass, laminates, magnetic tape, tinplate, foils, electroplated steel or copper.

- Resolution: CCD 1280 x 1024 pixels

VS 725 Color
The VS 725 Color features color detection and very fast testing. This permits a number of additional applications: checking of color quality, color falsification, progressions, pattern recognition.

Tasks for which the VS 725 Color is particularly suitable: e.g. division and sorting of color-coded elements, printed and colored characters and pictures on packaging, surface analysis for color and deficiencies in the food industry, fault detection, color consistency and deviations in the printing industry, color sequences on components (e.g. on cables, components on PCBs).

- "One touch" function in order to train colors and color segments
- Checking of process via the Internet
- Resolution: CCD 640 x 480 pixels

GUI of the SIMATIC Spectation configuration software for the VS 720 vision systems

Further information regarding sensor technology is included in the Internet:
www.siemens.com/automation

To get in touch with your contact person near you, look in the Internet at:
www.siemens.com/automation/partner

With the A&D Mall you can order electronically using the Internet:
www.siemens.com/automation/mall

All designations in this Overview marked with a ® are registered trademarks of the Siemens AG.

The information provided in this Overview contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract. Availability and technical specifications are subject to change without notice.