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SENSORS

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RFbeam

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INTEGRITY
TATEYAMA KAGAKU GROUP
TATEYAMA

TEWA
Electronics Group

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1 | TEMPERATURE SENSORS – THERMISTORS

NTC (Negative Temperature Coefficient) thermistors are resistors which show a decrease in resistance as temperature increases, available as semiconductor type or thick film type. The benefits of NTCs based on semiconducting ceramics are high precision whereas thick film types are more cost-efficient. The current flowing through a thermistor may cause some heat which increases the thermistor's temperature above the temperature of the environment. For small currents this effect of self-heating is negligible (unloaded thermistor). We will describe only unloaded NTC thermistors in this application note.

Temperature dependence of the resistance

The resistance of an NTC as a function of temperature can be approximated by the following equation:

$$R(T_1) = R(T_2) \exp (B (1/T_1 - 1/T_2)) \qquad (1)$$

$R(T_1)$: resistance in unit Ω at temperature T_1 in unit K
$R(T_2)$: resistance in unit Ω at temperature T_2 in unit K
B: B-value, material-specific constant of the NTC

This exponential law only roughly describes the characteristics of an NTC. This formula is suitable for describing the resistance in a small range around the temperature T_2-see Fig.1. If a more precise formula is needed the STEINHART-HART equation provides a more accurate description of the behaviour of the NTC. The parameters used in this equation (STEINHART-HART-coefficients) are dependent on the material of the NTC and are available on request.

B-value

The B value is dependent on the NTC technology and the materials used. It describes the slope of the R/T curve in a ln R-T diagram. The B value can be calculated by using two points of the R-T curve $R(T_1)$ and $R(T_2)$, i. e.:

$$B = T_1 \cdot T_2 / (T_1 - T_2) \cdot \ln (R(T_2)/R(T_1))$$

The B-values of this catalogue are calculated based on temperatures 25 °C (T_1) and 85 °C (T_2).

Dissipation factor δ_{th}

The dissipation factor δ_{th} is defined as the ratio of the electrical power dissipated in the NTC and the resulting change of the thermistor´s temperature. It is expressed in mW/K and is a measure for the load which causes a thermistor in steady state to raise its body temperature by 1 K.

$\delta_{th} = dP/dT$

Tolerance

The resistance R_{25}- and the B-value are subject to manufacturing tolerances. Due to those tolerances of the B and R_{25}-value, the resistance of a NTC varies within a certain tolerance area above and below the theoretical curve. The tolerance in resistance of the NTC thermistor is specified for one temperature point (usually 25°C). Using those tolerance values the temperature accuracy of the NTC can be calculated, i. e. the maximum error of temperature measurement at a given temperature.

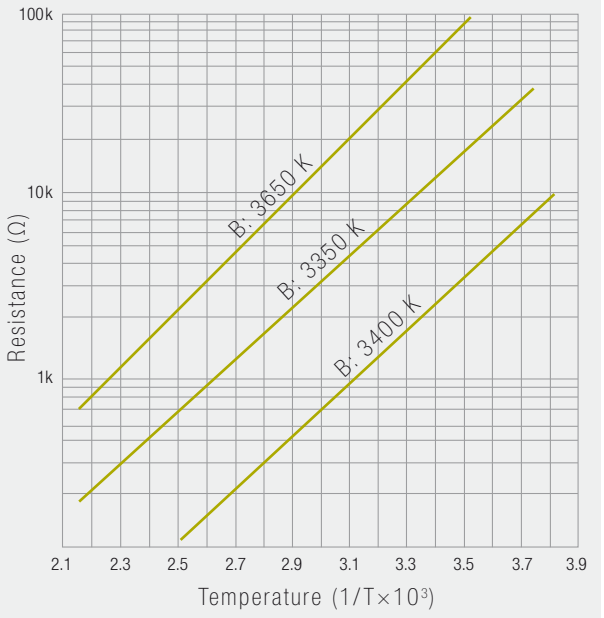
Zero-power measurement

The zero-power resistance is the resistance value measured at a given temperature with the electrical load kept so small that there is no noticeable change in the resistance value if the load is further decreased. If the electrical load is increased the self-heating will distort the measuring result.

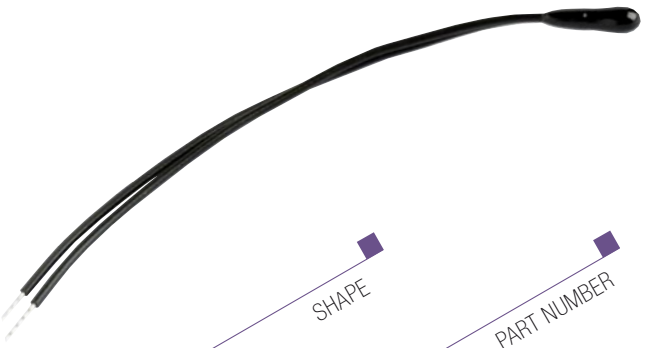
Thermal time constant

In most cases the NTC has to measure the temperature of the surrounding air or the temperature of an object, which has to be in thermal contact with the NTC. If the temperature of the air or the object changes, the NTC has to adopt the new temperature which does not happen instantaneously but needs some time. The so called thermal time constant refers to the time it takes for an unloaded thermistor to raise its temperature from 25 °C to 62.9 °C when it is immersed in a medium having a temperature of 85 °C.

Fig. 1 - Characteristic resistance curve of NTC



1.1 LEADED THERMISTORS



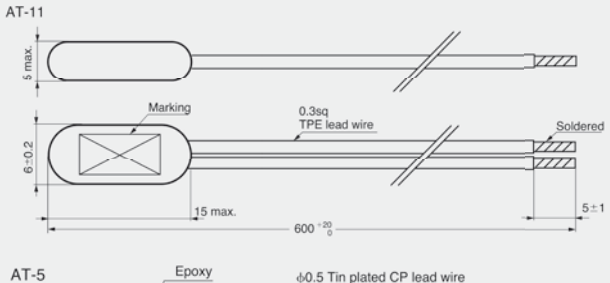
Endrich offers a wide range of different leaded thermistors. These high precision thermal sensing devices feature extremely small B-value tolerance and resistance. Their fast reponse time and reliability make them particularly suitable for use in high precision applications, e. g. medical equipments, battery packs …

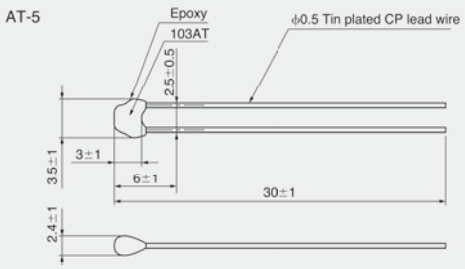
SHAPE | PART NUMBER | RESISTANCE VALUE R_{25} [kΩ] | TOLERANCE OF R_{25} [%] | B-VALUE (25/85) [K] | TOLERANCE OF B-VALUE [%]

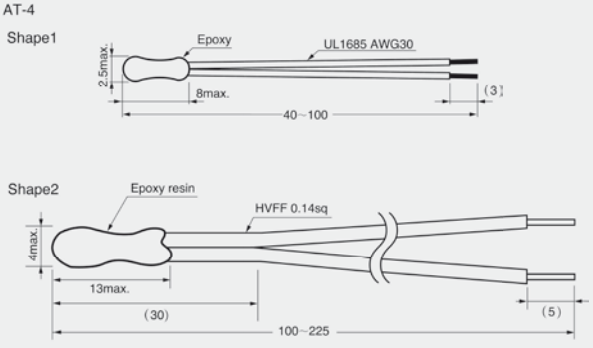
Specifications of AT series

	102AT-2	1.00	±1	3100	±1
	202AT-2	2.00	±1	3182	±1
	502AT-2	5.00	±1	3324	±1
	103AT-2	10.0	±1	3435	±1
	203AT-2	20.0	±1	4013	±1
	104AT-2	100.0	±1	4665	±1
	102AT-11	1.00	±1	3100	±1
	202AT-11	2.00	±1	3182	±1
	502AT-11	5.00	±1	3324	±1
	103AT-11	10.0	±1	3435	±1
	103AT-4 Shape 1	10.0	±1	3435	±1
	682AT-4	6.8	±1	3975	±1
	103AT-4 Shape 2	10.0	±1	3435	±1
	682AT-4	6.8	±1	3975	±1
	103AT-5	10.0	±1	3435	±1

Dimensions (mm)







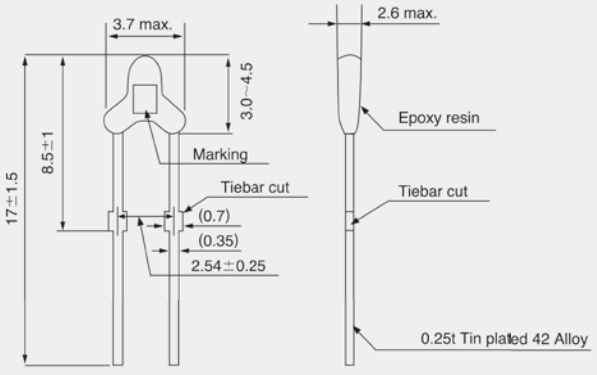
1.2 HIGH ACCURACY THERMISTORS

This semiconducting based high accuracy NTC thermistor features higher accuracy and higher resistance to heat than other existing high-precision thermistors. With the R_{25}/B_{25}-tolerance of 0.5 % and an operating temperature range of -60 °C to +150 °C it is suitable excellently for high-accuracy applications, e.g. medical, security and measurement equipments, battery packs and automotive.

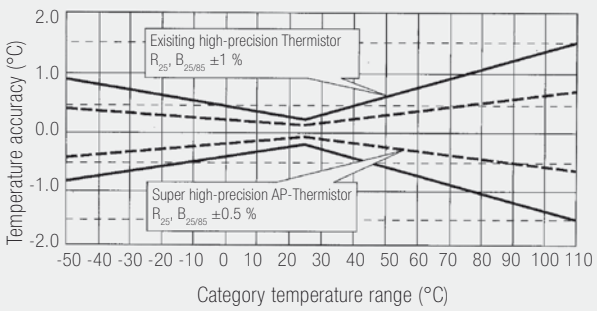
Specifications of AP series

PART NUMBER	RESISTANCE VALUE R_{25} [kΩ]	B-VALUE (25/85) [K]	DISSIPATION FACTOR [mW/°C]	THERMAL TIME CONSTANT [s]	MAX. POWER DISSIPATION [mW]	TEMPERATURE RANGE [°C]
202AP-2	2.000 ± 0.5 %	3976 ± 0.5 %	1.2	15	6	-60 ... +150
232AP-2	2.252 ± 0.5 %	3976 ± 0.5 %				
502AP-2	5.000 ± 0.5 %	3976 ± 0.5 %				
103AP-2	10.00 ± 0.5 %	3435 ± 0.5 %				
103AP-2-A	10.00 ± 0.5 %	3976 ± 0.5 %				
203AP-2	20.00 ± 0.5 %	3976 ± 0.5 %				
503AP-2	50.00 ± 0.5 %	4220 ± 0.5 %				
104AP-2	100.0 ± 0.5 %	4261 ± 0.5 %				
204AP-2	200.0 ± 0.5 %	4470 ± 0.5 %				

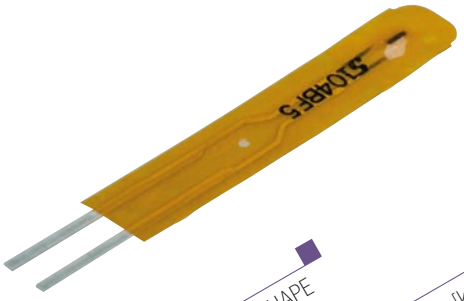
Dimensions (mm)



Temperature accuracy



1.3 FILM TYPE THERMISTOR



JT thermistors feature an ultra thinness of 500 µm and a superior electrical insulation. The usage in battery packs and heat allocators is possible.

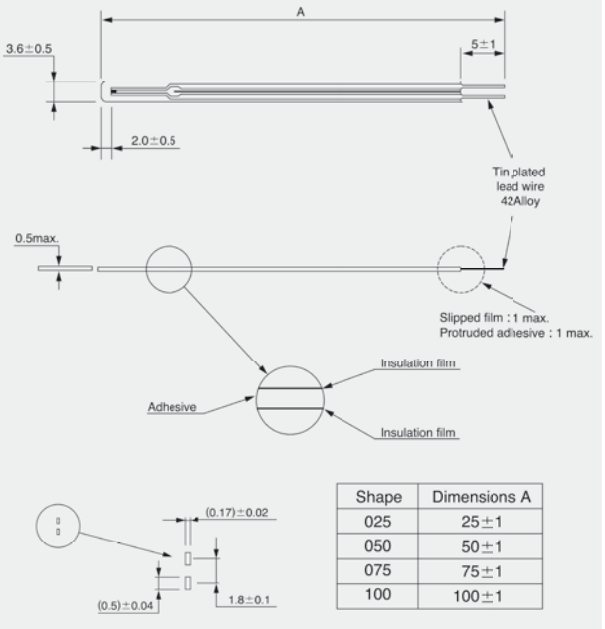
Specifications of JT series

PART NUMBER, XXX = SHAPE	RESISTANCE VALUE R_{25} [kΩ]	B-VALUE (25/85) [K]	DISSIPATION FACTOR [mW/°C]	THERMAL TIME CONSTANT [s]	MAX. POWER DISSIPATION [mW]	TEMPERATURE RANGE [°C]
103JT-XXX	10 ± 1 %	3435 ± 1 %	0.7	5	3.5	-50 ... +90
104JT-XXX	100 ± 1 %	4390 ± 1 %	0.7	5	3.5	-50... +125

Resistance-Temperature-Table

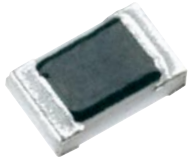
TEMPERATURE (°C)	103JT (UNIT: Ω)	104JT (UNIT: Ω)
-50	367.7	9584
-40	204.7	4572
-30	118.5	2282
-20	71.02	1191
-10	43.67	647.2
0	27.70	365.0
10	18.07	212.5
20	12.11	127.7
30	8.301	78.88
40	5.811	50.03
50	4.147	32.51
60	3.011	21.61
70	2.224	14.66
80	1.668	10.13
90	1.267	7.135
100		5.111
110		3.720
120		2.746
125		2371

Dimensions (mm)



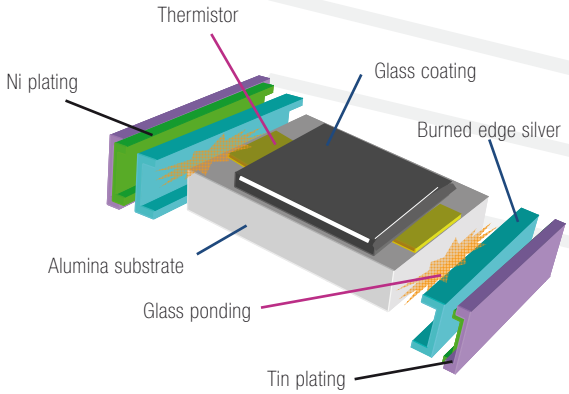
Shape	Dimensions A
025	25±1
050	50±1
075	75±1
100	100±1

1.4 SMD-THERMISTORS



Thick film chip thermistors offer high mechanical strength and reliability due to the thermistor film and glass-coated structure on an alumina substrate. The thickness is fixed and not related to the resistance value. High solderability and heat resistance are available due to triple structure electrodes.
The thermistor element material, based on Mn, Co and Ni, is produced in-house. This core material technology allows to adjust the thermistor feature.
The thermistors are TS16949 and AECQ-200 certified.

Specifications of TFT series	PART NUMBER	RESISTANCE VALUE R_{25} [Ω]	TOLERANCE R_{25} [%]	B-VALUE (25/85) [K]	TOLERANCE B-VALUE [%]	DISSIPATION FACTOR [mW/°C]	THERMAL TIME CONSTANT [s]	MAX. POWER DISSIPATION [mW]	TEMPERATURE RANGE [°C]
	TFT6G	100 ... 2 M	±1 ... ±10	2700 ... 4900	±1 ... ±5	1.3	2.5	5	-40 ... +150
	TFT3G				±1 ... ±5	1.2	2.0	5	
	TFT16G				±1 ... ±5	1.1	1.5	5	
	TFT20G				±3, ±5	1.1	1.5	5	



Applications

- Heat cost allocators
- Automotive (climate control, air conditioning, etc.)
- Blood sugar measurement
- White goods

PART NUMBER	SMD SIZE (INCH)	QUANTITY PER REEL
TFT 6G	0805	5,000 pcs.
TFT 3G	0603	5,000 pcs.
TFT 16G	0402	10,000 pcs.
TFT 20G	0201	15,000 pcs.

1.5. TEMPERATURE PROBES

WATERPROOF SENSORS

TT-0 SERIES

The TT-0 series sensors are IP68 waterproof temperature probes encapsulated with thermoplastic elastomer materials in overmolding technology (single or double insulated). The TT-0 overmoulded probes are a perfect solution for applications where the best waterproof and moisture protection is required.

Applications

- Refrigerators
- Air conditioning and climate control systems
- Underfloor heating

Features

- Insulation resistance: 100 MΩ at 1000 V_{DC}
- Dielectric strength: 3750 V_{AC}
- Flexible size and tolerance: (smallest ø 4.5 mm)
- Cable length: 100 mm ... 100 m
- IP68 waterproof protection
- Wide range of R/T curves available
- Standard temperature range: -50°C ... +105°C
- High temperature probes: up to +150°C
- Tight resistance tolerances: ±2°C, ±1 %...±5 %

GLASS ENCAPSULATED NTC THERMISTORS

TT-2 SERIES

The TT-2 series thermistors are glass encapsulated sensing devices with standard and also customized electrical characteristics. The glass encapsulation provides excellent stability and durability in an established product style. TT-2 series thermistors are available with dumet wire with or without polyimide tubes for insulation.

Applications

- Temperature measurement control and compensation
- HVAC products, white goods, industrial applications
- Intracardiac catheder (YSI 400 standard) ø 0.5 mm (marked above with *)

Features

- Resistance values: 10kΩ ... 68 kΩ
- Resistance tolerances: ±10 %, ±20 %
- B-values (25/85): 2668K ... 4535K
- Operating temperature range: -25°C ... +200°C
- Dissipation factor: 0.24 ...1.5 mW/°C typ. in still air at 25°C
- Well-established glass encapsulation method provides moisture protection and interchangeability
- Proven stability and reliability

TEMPERATURE PROBES

WHITE GOODS SENSORS

Exa Thermometrics has started from nano-particle transition metal oxides, through to semiconductor sintering, multiple electroding, dicing and calibration and they manufacture top of the range NTC thermistors, matched to accuracies better than ±0.05 %.

Exa Thermometrics India has a world-class reliability test facility to validate the performance of all its temperature sensors, from thermistor elements to fully assembled products for all kind of applications.

Applications

» Washer fill funnel temperature sensor
» Drum water temperature sensor
» Freezer sensor

Features

» Fast response time
» Hermetically sealed
» Thermally conductive plastic overmold
» Food grade plastic caps
» UL approved
» Operating temperature -20 °C ... +125 °C

PIPE CLIP SENSORS

Features

» Typically 13,15,17 and 22 mm diameter pipe fit
» Ultra fast response time <3.0 s
» Overmoulded housing
» Corrosion resistant shoe
» Alumina electrical insulation

Applications

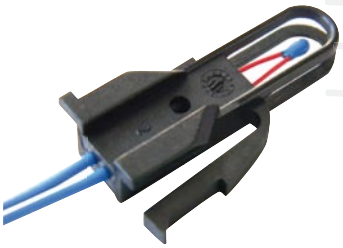
» Condensing heating systems
» Home heating systems
» Convection heating systems
» Radiator temperature sensing

TEMPERATURE PROBES

AUTOMOTIVE SENSORS – HVAC SYSTEM

Features

- Fast response time
- Hermetically sealed
- Thermally conductive plastic overmold
- Food grade plastic caps
- UL approved
- Operating temperature -20 °C ... +125 °C
- Protective overmould



Applications

- Outside air & cabin temperature
- Seat heater temperature
- Air quality
- Solar/light
- Windscreen temperature
- Heaters
- Climate control systems
- Air conditioning

AUTOMOTIVE SENSORS – ENGINE MANAGEMENT SYSTEM

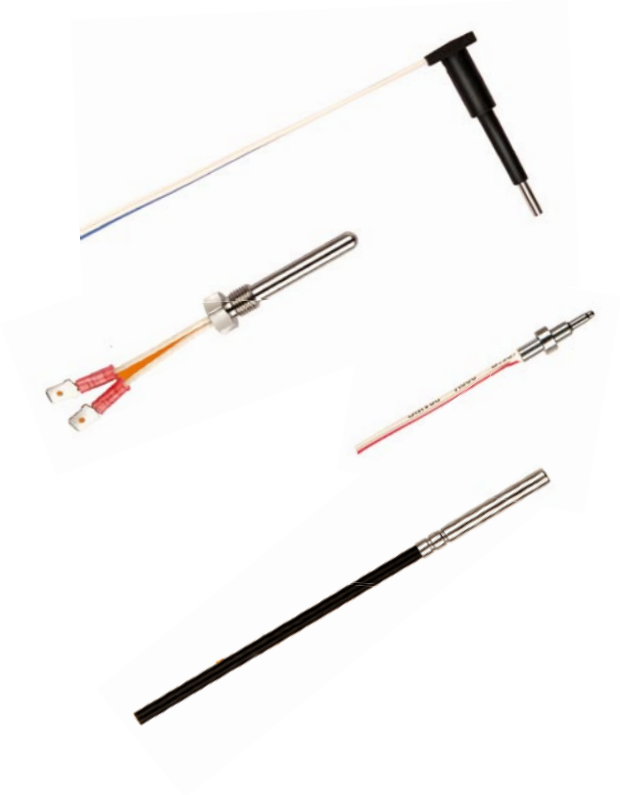
Features

- Brass overmoulded construction
- Fast response time
- Ultra high stability and reliability
- Corrosion resistant composition
- Operating temperature -20 °C ... +85 °C

Applications

- Coolant temperature
- Air temperature
- Exhaust gas temperature
- EGR temperature
- Oil, battery and fuel temperature
- Diesel fuel air intake filter safety

1.6 CUSTOMIZED TEMPERATURE PROBES



Endrich provides a wide range of standard and customized temperature sensors designed according to individual requirements covering applications in temperature range between -80°C and +800°C. TT-4 series group contains temperature sensors consisting of chip, disc or glass NTC/PTC thermistors, and other sensing elements assembled in different metal/plastic housings.

Applications

- Automotive (air conditioning, cabin climate control and management, external temperature monitoring, heated seats, heated steering wheels, etc.)
- Consumer products
- Instrumentation
- Industrial ovens
- Electric shower valves
- HVAC and refrigeration
- Fire detectors
- Pools and spa bath tubes

Features

- Proven stability and reliability
- Low cost
- Variety of metal and plastic housings and tubings designed for specific applications
- Potted with different kinds of resin for reliable sensor protection
- Available with special cables (2-core cables or stranded with PVC, teflon or kynar insulation, cables with screen & other), connectors and other attachments
- Provides good protection from the environmental conditions
- Proven high voltage and dynamic strength
- Wide range of resistance and temperature characteristics
- Designed for temperature measurement, temperature control and temperature compensation

Optical sensors detect electromagnetic radiation with wavelengths between 0.2 µm (ultraviolet) and several 10 µm (far infrared). Two different classes of optical sensor applications have to be distinguished.

In the first group of applications the light source is given by **external sources of the application**, e.g. the sun as a source of visible light or the human body as a source of far infrared radiation in the range of 5 µm to 10 µm. In most of these cases the purpose of the optical sensors is to measure the intensity of this electromagnetic radiation like a photometer in a photo camera. The radiation is converted into an electrical signal which is a measure of the intensity of the electromagnetic radiation. Since the different types of optical sensors only cover a certain bandwidth, the most important task for the engineer is to select a sensor with a sensitivity range that matches the spectral distribution of the given light source.

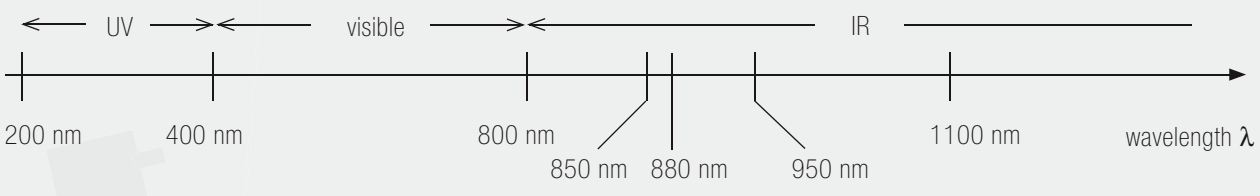
The second group are **applications with an internal light source**. The electromagnetic radiation is only a means to an end to detect e.g. the position, size or shape of an object. In this case the sensing system not only contains an optical sensor, but also a light source and the engineer is free in choosing the light source and the optical sensor. Very often it is convenient to choose infrared light between 800 nm and 1000 nm which is not visible for the human eye. For these wavelengths powerful LEDs as a light source are available (see table 1) and the spectral sensitivity of phototransistors and photodiodes made of silicon match perfectly to these infrared LEDs. Well-known examples are optical interrupters where the light, generated by an infrared LED, is detected by a silicon phototransistor.
Optical sensor solutions with internal light source sometimes compete with magnetic solutions (hall sensors). The advantages of magnetic solutions are that the hall sensors are not sensitive to dirty environments and fluids like oil or water. Further the output signals of digital hall sensors are TTL compatible and there is only one sensing device necessary (the hall sensor) because it is easy to generate magnetic fields by permanent magnets.

Table 1 – IRED features

Wave-length	Chip material	Output power	Speed	Price level
950 nm	GaAs	low	low	cheap
880 nm	GaAlAs	medium	high	medium
850 nm	GaAlAs	high	medium	high

On the other hand magnetic fields cannot be shielded easily which limits the downsizing of the magnetic sensor assemblies. Using light guides, optical grids and apertures, optical systems can have a very small design with a high resolution.
The sensing distance using optoelectronic solutions can easily reach some meters, while magnetic solutions only work on small distances of a few centimeters. Electromagnetic radiation like visible or infrared light can be used to detect objects of different materials like paper or wood, because the radiation is at least partially reflected by these objects. The magnetic field more or less penetrates most substances (except iron, nickel and cobalt) which makes those materials not detectable by magnetic sensor solutions.

Optical sensors – sensitivity ranges



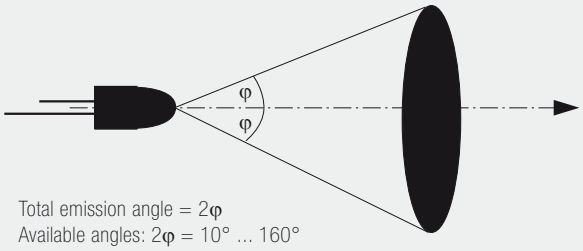
2.1 INFRARED-LED

IREDs are LEDs which emit infrared light with a wavelength in the range of 780 nm to 1550 nm. Although there is a variety of different wavelengths possible in this range, only few of them are used in standard optoelectronic sensors. The most important ones are 950nm, 880 nm and 850 nm. In some special applications like optical spectroscopy or blood oximetry special wavelengths are used. Similar to the LEDs in the visible range the material of the chip determines the wavelength.
Table 1 on page 11 gives a short summary about the different chip materials and their technical features.

There is a wide variety of different housings available for LEDs. Besides the basic elements like semiconductor chip and the substrate to stick the chip onto, the LEDs may be composed of lenses and/or reflectors (mirrors) to collect and focus the radiation which is emitted by the chip. Two different LED constructions are used: In a **lead-frame-type LED** the semiconductor chip is mounted (bonded) onto a solid metal substrate called "lead frame". After bonding the chip onto the lead frame the epoxy housing is molded in a molding tool. In **Chip-LEDs** the semiconductor chips are bonded onto a non-metallic substrate (FR-4 or ceramic material, plated with a gold layer as a terminal and sometimes also as an optical reflector) and the housing is molded with epoxy or silicone.

The emission angle φ of the IRED is defined as the direction where the radiant intensity has decreased to a value of 50% of the radiant intensity on the optical axis (forward direction). In the data sheet, usually 2φ is given as the total emission angle. The distance of the chip to the lens determines the emission angle of the LED (see Fig. 1). The IRED also emits some infrared radiation in directions outside the cone with angle 2φ. Since the size of the IRED-chip (typically 300 µm) is usually not negligible compared to the diameter of the lens of the IRED, there is a minimum emission angle of about 2φ=10° for standard IREDs. If there is no lens or other optical elements the theoretical emission angle is 2φ = 120° (Lambert-radiator).
During production process minor displacements of the chip location from the optical axis are inevitable. For small emission angles this may lead to an essential unsymmetrical emission characteristics which is called **cross-eye-effect**. This effect always has to be taken into account if the application requires an extremely symmetrical emission characteristics of the IRED.
Quite generally the cross-eye-effect is more pronounced for lead-frame LED. For chip LED the chip position is controlled by image processing during the chip bonding process.

Emission angle (Fig. 1)



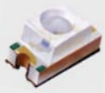
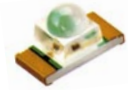
Total emission angle = 2φ
Available angles: 2φ = 10° ... 160°

The **radiant intensity** of the IREDs is defined as the optical power which is emitted into a cone of 1 sr (sterad, spherical angle) along the optical axis of the system. The unit is mW/sr. In most sensor applications the radiant intensity of an IRED is much more important than the **total optical power** in mW. The radiant intensity is dependent on the emission angle while the total optical power is independent from the emission angle. The radiant intensity is always measured at direction 0° (i.e. on the optical axis) and most IRED are classified into classes (ranks) of different radiant intensity.

Infrared light penetrates most unfilled plastic materials, even if those materials are **not** transparent for the visible light. This should always be kept in mind during the design of the application. Especially in case of IR-reflection sensors it is almost impossible to distinguish e.g. black and white areas on a white substrate if the black areas are printed onto the substrate with black lacquer. With the use of digital photo cameras or cameras in mobile phones, infrared light in the range of wavelength 800 nm ...1000 nm can be observed very easily. This may be a useful tool to trace a light path or to check the IR-transmission of some plastic materials.
For data transmission, the **speed** of an infrared LED is important. Quite generally the GaAs-chips (950nm) are slow (raise/fall time some µs), whereas the GaAlAs-chips are much faster (up to 20ns). For most of the sensor-applications, however, the speed of GaAs is sufficient.

The selection of a proper IRED-type for a given application depends strongly on the **emission direction** of the LED. Available emission directions of the IREDs are **upright (u), sideways (s) and downwards (d)**.

Specifications of IR-LEDs

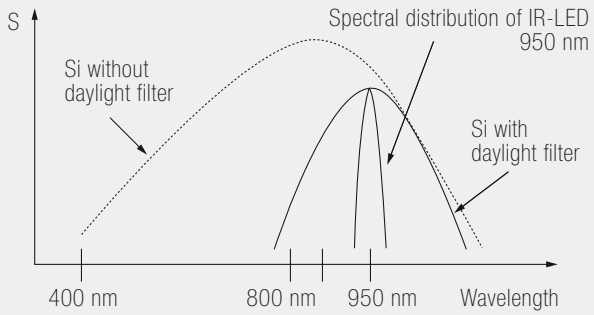
SHAPE	PART NUMBER	DESCRIPTION	WAVELENGTH [nm]	EMISSION ANGLE 2 φ [°]	EMISSION DIRECTION, u = up, d = down, s = side	RADIANT INTENSITY TYP. [mW/sr]
	IR204-A	ø 3 mm	950 (880 & 850 available)	35	u	5.6 @ 20 mA
	IR333-A	ø 5 mm	950 (880 & 850 available)	20	u	20 @ 20 mA
	IR333/H0/ L10	ø 5 mm	950 (880 & 850 available)	40	u	12 @ 20 mA
	IR908-7C	rectangular housing	950 (880 & 850 available)	60	s	n. a.
	IR15-21C/ TR8	SMD size 1206	950 (880 & 850 available)	160	u	0.8 @ 20 mA
	IR17-21C/ TR8	SMD size 0805	950 (880 & 850 available)	120	u	0.8 @ 20 mA
	IR19-21C/ TR8	SMD size 0603	950 (880 & 850 available)	150	u	0.7 @ 20 mA
	IR11-21C/ TR8	SMD 1206 with inner lens	950 (880 & 850 available)	100	u	1.6 @ 20 mA
	IR26-21C/ L110/TR8	SMD with lens	950 (880 & 850 available)	20	u, d	3.5 @ 20 mA
	IR12-21C/ TR8	SMD	950 (880 & 850 available)	160	s	0.8 @ 20 mA
	IR26-51C/ L110/TR8	SMD with lens	950 (880 & 850 available)	20	s	3.5 @ 20 mA
	IR67-21C/ TR8	SMD, PLCC2, TOPLED	950 (880 & 850 available)	120	u	1.5 @ 20 mA
	IR91-21C/ TR7	SMD, with lens small angle	950 (880 & 850 available)	25	u, d	5 @ 20 mA
	HIR89-01C	SMD with reflector	850	30	u	55 @ 70 mA
	OIS150-XXX	SMD, 1206	xxx = 800 ... 980	150	u	~3 @ 50 mA
	HIR83-01B	SMD with lens	850	40 (X) 100 (Y)	s	5 @ 20 mA

2.2 PHOTODIODES AND PHOTOTRANSISTORS

In most optoelectronic sensor applications with infrared LEDs a detecting device is also needed. It is a fortunate coincidence of nature that the spectral sensitivity of photodiodes and phototransistors made of silicon match perfectly with the infrared range of the electromagnetic radiation of IREDs around 900 nm. Silicon as a material for photodiodes and phototransistors has many advantages: it is cheap, the production process is very sophisticated and optimized, and the photodetector can be integrated into a silicon integrated circuit. In the following the expression **photodetector** is valid for both, photodiodes and phototransistors.

The sensitivity of silicon is shown in the following diagram. The minimum wavelength which can be detected by silicon is around 400 nm (using special blue-enhancement technology also shorter wavelengths are possible). At about 880 nm a maximum of sensitivity is reached and then sensitivity decreases and is almost zero at 1100 nm. Hence silicon devices can be used for detection of the visible range (400 nm to 800 nm) and for the infrared range of electromagnetic radiation (800 nm to 1100 nm).

Sensitivity range of silicon with and without daylight filter

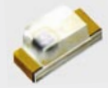
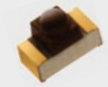


For applications where infrared LEDs are used as a light source there is no need for the detector to be sensitive in the visible range. In these cases photodetectors with so called "daylight filters" are used. This is simply a black epoxy mold instead of clear epoxy mold. It is blocking the radiation in the range of 400 nm to 800 nm whereas the radiation above 800 nm will pass the epoxy with almost no loss. The transition range of wavelength between IR-blocking and IR-passing is dependent on the type of epoxy material. The expression daylight filter is misleading in the following sense: The sun, incandescent lamps, fluorescent lamps etc. do not emit only visible light but also infrared light. If a detector with a "daylight filter" is exposed to the radiation of those light sources there will be an essential signal detected because of the IR-radiation contained in the spectrum.
Quite often the brightness of the daylight should be detected. Photodetectors made of silicon work quite well during the bright day and after the sun has gone down completely. But during dawn a problem may occur (so called red-sky-effect): when the sun goes down the fraction of visible light is decreasing drastically, but there is still a lot of infrared radiation present. As the sensitivity of the silicon detectors has its maximum in the infrared range the signal of silicon detectors under "red-sky" conditions is too high compared to the impression created by the human eye.

Features photodiode/phototransistor (table 1)

Item	Chip size	Speed	Photo-current	Price level
Photodiode	large	fast	low	expensive
Photo-transistor	small	slow	high	cheap

The above mentioned spectral behaviour is valid for both, photodiodes and phototransistors. Electrically, these two types are quite different.
The photo current of phototransistors is quite high compared to the current of photo diodes. The phototransistor is composed of a photodiode and an amplifying transistor. In most cases the amplification factor of phototransistors is between 1000 and 1500 which results in photocurrent of some 100 µA or even few mA.
On the other hand, photodiodes are much faster than phototransistors. The raise time of photodiodes is typically a few ns, whereas the raise time of phototransistors is a couple of microseconds. The photo current of the photodiodes is proportional to the size of the chip. To get a high photo current in an application the chip size has to be chosen as big as possible. Quite generally the photodiode chips are much larger than the size of the phototransistor dice. As a consequence many photodiode chips do not fit in the same housings as phototransistors and hence much less housings are available for photo diodes. If a linear behaviour of the photo current as a function of incident light is requested it is better to use a photo diode instead of a photo transistor. Table 1 gives a summary of the comparison of photodiodes and phototransistors.

	SHAPE	PART NUMBER WITHOUT DAYLIGHT FILTER	PART NUMBER WITH DAYLIGHT FILTER	DESCRIPTION	RISE/FALL TIME	SENSITIVITY DIRECTION, u = up, d = down, s = side	LIGHT CURRENT
Phototransistors		PT204-6C	PT204-6B	3 mm	15 µs	u	2 mA (typ.)
		PT333-3C	PT333-3B	5 mm	15 µs	u	3 mA (typ.)
		PT908-7C	PT908-7B	rectangular	15 µs	s	0.8 mA (min.)
		PT15-21C/ TR8	PT15-21B/ TR8	SMD size 1206	15 µs	u	0.3 mA (typ.)
		PT11-21C/ L41/TR8	PT11-21B/ L41/TR8	SMD size 1206 with lens	15 µs	u	0.8 mA (typ.)
		PT12-21C/ TR8	PT12-21B/ TR8	SMD	15 µs	s	1.14 mA (typ.)
		PT19-21C/ L41/TR8	PT19-21B/ L41/TR8	SMD size 0603	15 µs	u	0.6 mA (typ.)
		PT26-21C/ TR8	PT26-21B/ TR8	SMD size 1206 with lens	15 µs	u, d	2.6/1 mA (typ.)
		PT26-51C/ TR8	PT26-51B/ TR8	SMD with lens	15 µs	s	1 mA (typ.)
		PT67-21C/ L41/TR8	PT67-21B/ L41/TR8	SMD TopLED (PLCC2)	15 µs	u	0.3/0.016 mA (min.)
		PT91-21C/ TR7/9/10	PT91-21B/ TR7/9/10	SMD with lens	15 µs	u, d	1.5 mA (typ.)
Photodiodes		PD204-6C	PD204-6B	3 mm	6 ns	u	3 µA (typ.)
		PD333-3C/ H0/L2	PD333-3B/ H0/L2	5 mm	45 ns	u	35 µA (typ.)
		PD438C	PD438B	5 mm	50 ns	s	18 µA (typ.)
		PD15-21C/ TR8	PD15-21B/ TR8	SMD size 1206	6 ns	u	0.8 µA (typ.)
		PD15-22C/ TR8	PD15-22B/ TR8	SMD size 2 mm × 2 mm	10 ns	u	6.5 µA (typ.)
		PD70-01C/ TR7/10	PD70-01B/ TR7/10	SMD size 3 mm × 3 mm	50 ns	u, d	25 µA (typ.)
		PD95-21C/ TR7/10	PD95-21B/ TR7/10	SMD with lens	6 ns	u, d	4 µA (typ.)
		PD12-21C/ L458/TR8	PD12-21B/ L458/TR8	SMD with lens 3 × 2 × 1 mm	6 ns	s	1.5 µA (typ.)

2.3 PHOTOINTERRUPTERS

Photointerrupters are a smart solution for the detection of rotation or linear movement of an object. The basic principle behind photo interrupters is well known to everybody who ever used an elevator: interruption of a light beam is used to detect whether there is an object between the light source and the detector. Both are placed face to face at the left and right hand side of the elevator door.

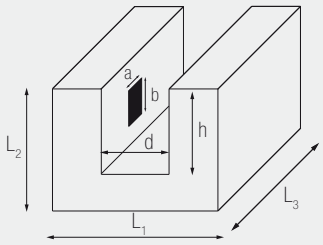
On a much smaller scale, the same principle is used for photointerrupters. In most photointerrupters the light source is an IR-LED and the IR-detecting device is a phototransistor. This is the most convenient combination because the output signal of the phototransistor can be used without additional amplifier in the evaluation circuit.

Some barrier is moving within the gap between the IRED and the phototransistor. Depending on the position and the shape of the barrier the light beam is interrupted or not. For most mechanical applications the speed of the phototransistor is sufficient to detect the movement of the barrier within the gap of the interrupter.

The basic characteristic of an optical interrupter is the width (d) and depth (h) of the gap as well as the dimensions (a) and (b) of the aperture in front of the phototransistor. The gap dimensions are important parameters for the mechanical construction of the system and mechanical tolerances of the whole system (e.g. position of the interrupter and the barrier moving within the gap) should be considered very carefully. The size of the aperture in front of the phototransistor determine the position resolution of the barrier moving in the gap of the interrupter.

Few interrupters have two phototransistors on the detecting side. This allows to detect the direction of movement of the barrier within the gap.

Dimensions of photointerrupters



Specifications of photointerrupters

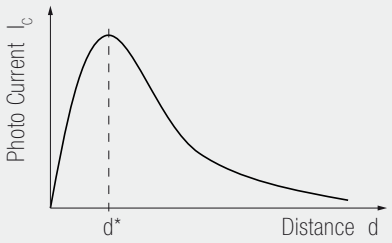
SHAPE	PART NUMBER	SMD / PINS	GAP-WIDTH d [mm]	DIMENSION L_1 [mm]	DIMENSION L_2 [mm]	DIMENSION L_3 [mm]	NUMBER OF PHOTOTRANSISTORS
	CPI-210	SMD	2	5	4	4	1
	CPI-250	SMD	2	5	4	4	2
	ITR-20402	Pins	1.2	4.2	4	4	1
	ITR-8105	Pins	2.6	9.6	9	5.6	1
	ITR-20403	Pins	3	6.4	5.4	4.2	1
	ITR-9606-F	Pins	5	14	10	6	1
	ITR-9707	Pins	5.2	12.8	6.9	6.4	1
	ITR-8402-F-A	Pins	6	14	11.6	6	1

Other types acc. to customer's needs are available on request!

2.4 PHOTOREFLECTORS

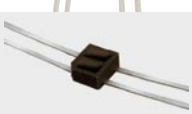
Photoreflectors (or sometimes called reflective interrupters) are composed of an infrared LED and a phototransistor in one housing, similar to the previously discussed transmissive photointerrupters. The main difference is, that the IR emitting LED and the phototransistor are not positioned face to face like in the transmissive interrupters, but the emission and detection direction of both devices are oriented parallel to each other in the same direction. If there is no reflecting surface positioned above the device, the IR radiation emitted by the IR-LED "disappears" in the space above the device and there is no photo current through the phototransistor. If there is a reflecting surface present within distances smaller than the detection range, the infrared radiation is reflected to the phototransistor and a photocurrent is generated. The magnitude of the photo current not only depends on the radiant intensity of the IR-LED, but also on the reflection properties of the reflecting surface and on the distance between the reflecting surface and the photoreflector. Approaching the reflecting surface to the photoreflector the photocurrent increases with decreasing distance. At a certain distance (d*) the photocurrent reaches a maximum value. If the distance of the reflecting surface is decreased below (d*) the photocurrent decreases with decreasing distance because the window of the IR-LED is shut more and more. At d=0 the IR-LED is shut completely and there is no photocurrent through the phototransistor.

I_c-d – Characteristics



In sensor applications where photoreflectors are used, the engineer should consider very carefully the role of mechanical tolerances of the distance between the reflecting surface and the photoreflector and estimate the consequences of these tolerances on the photocurrent. This has to be compared with the tolerance of the device sensitivity. Last, but not least, the optical properties of material used for the reflecting surface play an important role. Polished metal surfaces usually are well reflecting materials, whereas most plastic materials are more or less transparent for infrared-radiation (even if appearing non-transparent for the human eye) and hence are not recommended as reflecting surfaces.

Specifications of photoreflectors

SHAPE	PART NUMBER	SMD / PINS	OPERATION DISTANCE, TYP. [mm]	DIMENSIONS L×W×H [mm]
	PR-30	SMD	1	2.18 × 1.9 × 0.75
	PR-40	SMD	1	1.5 × 1.375 × 0.6
	ITR-20004	Pins	2	4.0 × 3.0 × 1.7
	ITR-8307	SMD/Pins	2	3.4 × 2.7 × 1.5
	ITR-20510	SMD	2	3.4 × 2.7 × 2.2
	ITR-9904	Pins	5	11.5 × 4.2 × 6

Other types acc. to customer's needs are available on request!

2.5 AMBIENT LIGHT SENSORS (ALS)

In many applications the intensity of visible light has to be measured. The crucial point is that the word "visible" introduces a physiological element into the problem. The output signal of the sensor has to correspond to the subjective impression of the human eye, i. e. if the subjective impression of the human eye is "bright", the sensor signal should also be high. And for the impression "dark" the sensor should show a low signal.

Standard silicon photodetectors work quite well during the bright day and at complete darkness some hours after the sun has set. But during dawn a problem may occur (so called red-sky-condition): when the sun goes down the fraction of visible light is decreasing drastically, but there is still a lot of infrared radiation present. As the sensitivity of the silicon detectors has its maximum in the infrared range the signal of silicon detectors under "red-sky" conditions is too high compared to the brightness impression of the human eye. Figure 1 on page 21 shows the sensitivity curve of the human eye (which is known as V (λ) -curve), the spectral sensitivity of silicon and the sensitivity spectrum of an ambient light sensor of EVERLIGHT. Using a standard silicon photodiode as a light sensor for garden lights, it would be tough to find an adjustment where the light would switch on during dawn. In most cases it would switch on after complete darkness.

Many of the ambient light sensors are based on silicon photodiode chips which are plated by some optical filter layers. These optical filters absorb the infrared light from the incident radiation and therefore restrict the sensitivity of the silicon photodiode chip to the visible area. Due to the small photo currents at low incident light levels it is convenient to use an ambient light sensor-IC, which has an amplifier on the same chip. For higher light intensity levels, also photodiodes and phototransistors are available as ambient light sensors.

In the past photoresistors (LDR, photo cells) were very popular as ambient light sensors because their spectral sensitivity matches the V(λ)-curve quite well and the price is low. The disadvantages of the photoresistors are the wide spread and the memory effect of resistance values. The main problem, however, is that photoresistors contain Cadmium which is banned by RoHS. Thus LDRs can only be used in applications which are not covered by RoHS.

In some special applications it is convenient to use an amorphous solar cell as an ambient light sensor. The spectral sensitivity of amorphous silicon does not show essential sensitivity in the infrared region like crystalline silicon and is quite similar to the human eye. Since the area of solar cells is usually much larger than the size of the silicon chips of ambient light sensors, the photo current is much higher for solar cells. This current can be used not only to detect the ambient light, but also as an energy source for the application itself.

Specifications of photo cells (LDR)

SHAPE	PART NUMBER	HOUSING	MIN. LIGHT RESISTANCE R_L [kΩ]	MIN. DARK RESISTANCE R_D [MΩ]	SPECTRAL PEAK λ_p [nm]
	NSL-19M51	TO-18 ceramic package	20 at 10 lx	20	550
	NSL-5110	TO-18 hermetic package	10 at 2 ftc	0.67	550
	NORPS-12	Plastic package ø 13 mm	5.4 at 1 ftc	1	550

Specifications of ambient light sensors

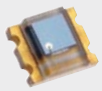
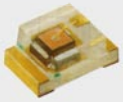
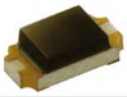
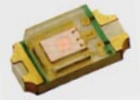
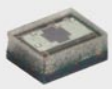
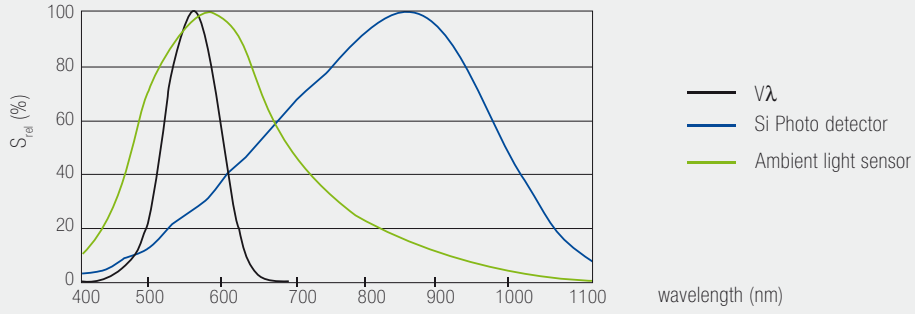
SHAPE	PART NUMBER	SENSOR ELEMENT	ANALOG/DIGITAL	REMARKS	LIGHT CURRENT [µA]	ILLUMINATION CONDITIONS	DIMENSIONS [mm]
	ALS-PD15-22C	Photo Diode	Analog	Linear, low cost	0.14	100 lx	2.3 × 2.1 × 1.1
	ALS-PD70-01C	Photo Diode	Analog	Linear, large chip size	1.1	100 lx	4.4 × 3.9 × 1.2
	ALS-PT243-3C/L177	Photo Transistor	Analog	Linear	10	100 lx	ø 5, flat
	ALS-PT204-6C/L177	Photo Transistor	Analog	Linear	200	100 lx	ø 3
	ALS-PT19-315C/L177	Photo Transistor	Analog	Linear, small size	15	100 lx	1.7 × 0.8 × 0.6
	ALS-PT17-51C/L177	Photo Transistor	Analog	Linear, standard type	15	100 lx	2.0 × 1.25 × 0.8
	ALS-PDIC15-21B	Photodiode +Amplifier IC	Analog	Linear, with daylight filter	17	100 lx	3.2 × 1.5 × 1.1
	ALS-PDIC15-21C	Photodiode +Amplifier IC	Analog	Linear	56	100 lx	3.2 × 1.5 × 1.1
	ALS-PDIC17-55C	Photodiode +Amplifier IC	Analog	Linear, small size	50	100 lx	2.1 × 1.35 × 0.8
	ALS-PDIC17-71B	Photodiode +Amplifier IC	Analog	Log.	30	1000 lx	2.95 × 2.35 × 1.25
	ALS-OPIC17-59B	Photodiode +Amplifier IC	Digital	Linear	-	-	2.0 × 2.0 × 0.45
	LSS 100	Photodiode +Amplifier IC	Analog	Linear	260	100 lx	3.2 × 2.0 × 1.0
	LSL 100	Photodiode +Amplifier IC	Analog	Linear	260	100 lx	ø 5, flat
	LMSS-101	Photodiode +Amplifier IC	Analog	Linear, high sensitive type	0.15 A/W		2.1 × 1.6 × 0.88

Figure 1 – spectrum comparison

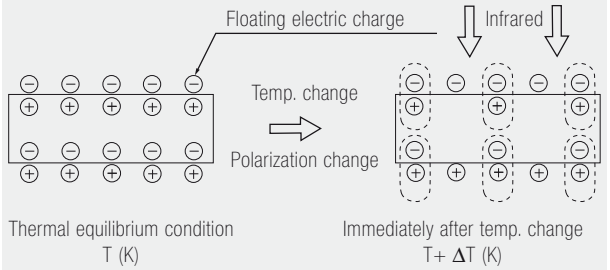


2.6 PYROSENSORS

In the past pyrosensors were used as detectors for non-contact temperature measurement. The basic principle behind this was the fact, that a black, solid body of temperature T emits electromagnetic radiation with an energy distribution, that depends only on the temperature of the body. The wavelength where the energy distribution shows a maximum, is given by λ_{max} (unit µm)= 2899 / T(unit K). For a human body with a temperature of 37°C the emitted radiation has its maximum at a wavelength of 9.4 µm.

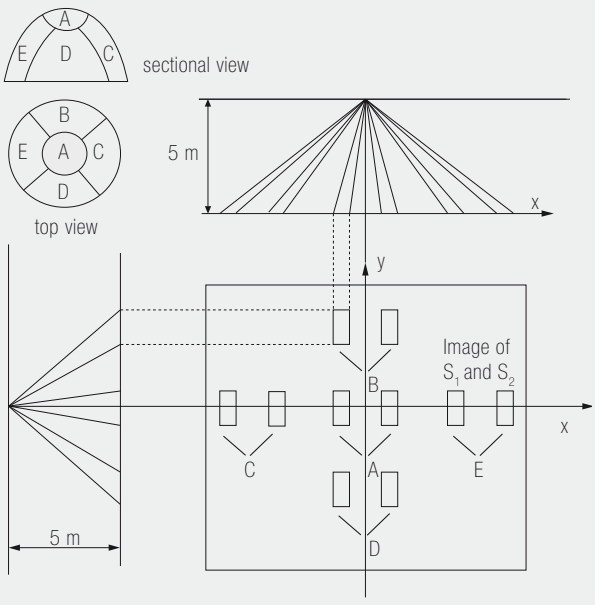
In the last years it became very popular to use pyrosensors to detect the presence (or more precise the movement) of a human body. These sensors consist of two or four pyroelectric elements in a hermetic housing with a silicon window which is transparent in the range of 5 to 10 µm. The pyroelectric elements show ferroelectric behaviour and are characterized by some permanent electrical polarization on the surface of the elements, see Fig.1. However, the polarization is not detectable because the surface charges are compensated by some charged ions in the environment of the surface. If infrared radiation hits the pyroelectric elements their temperature increases by a very small amount. Due to the thermal expansion, the crystal structure has to rearrange and thus the polarization on the surface of the elements changes. This change in polarization can be detected by electrodes on the top and bottom side of the pyroelectric elements. The electrical charge necessary to compensate the change in electrical polarization is detected and amplified by an internal FET, see Fig.3. Each temperature change of the elements leads to a short spike in the output signal of the FET which is used to detect the presence of a human body. The changes in polarization are very small and therefore it is necessary that the changes are fast enough in order to be detectable by the FET. As a consequence, only moving infrared emitting sources can be detected. In order to cancel false signals due to temperature change of the environment there are at least two pyroelectric elements connected in series with antiparallel polarization (Fig. 3).

Fig. 1 - Pyroelectric principle



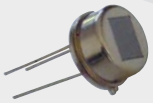
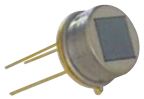
For movement sensors usually a Fresnel lens (sometimes also a mirror) is used to focus the infrared radiation onto the detecting elements of the pyrosensor. In most cases the Fresnel lenses are divided into several zones and each zone acts as a separate lens. As soon as the infrared radiation source starts to move there are many images of the infrared source in the plane of the sensing elements which pass the pyroelectric element. Each time one of the images passes the elements a spike in output voltage is created. The more zones the lens has, the more images are created. This makes it possible to detect even slowly moving objects. To describe the optical properties of a Fresnel lens it is convenient to look at the field of view pattern, see Fig. 2. In this drawing the sensing elements are facing to the plane of the moving object. The rectangular images of the two sensor elements created by the 5 zones of the lens are shown in a plane at a distance of z=5 m from the sensor. Whenever an object is moving from one rectangular area to its neighbouring area, the sensor will detect the moving object. If the object is moving only in the x-direction (e.g. for wall mounted pyrosensor modules) a pyrosensor with two elements is sufficient. If the object is moving in x- and y-direction (e.g. for ceiling mounting of the sensor module) a four element pyrosensor is recommended.

Fig. 2 - Field of view pattern



Field of view pattern for a lens with 5 zones A ...E in a distance of 5 m (pyrosensor with two elements S_1 and S_2)

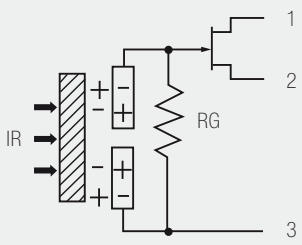
Specifications of Pyrosensors

SHAPE	PART NUMBER	HOUSING	NUMBER OF SENSITIVE ELEMENTS	SIZE OF SENSITIVE ELEMENTS	SIGNAL OUTPUT	FIELD OF VIEW (W/O LENS)
	RE200B-EBV-P	TO 5	2	2 mm × 1 mm	2.5 Vp-p min.	x: 138° y: 125°
	RE46BRN-EBV-P	TO 5	4	1 mm × 1 mm	4.0 Vp-p min.	x: 132° y: 132°
	CSL-051-STD-P	Flat package	2	2 mm × 1 mm	1.8 Vp-p min.	x: 50° y: 50°

Specifications of Fresnel lenses

SHAPE	PART NUMBER	NUMBER OF LENS ZONES	SENSITIVITY ANGLES FOR 2-ELEMENT SENSORS	REMARKS
	NCL-9 (S)	1	x: 12° y: 12°	mainly for 1 element sensors
	NCL-9 (10)	10	x: 120° y: 50°	mainly for wall mounting pyrosensor modules
	NCL-9 (26)	26	x: 100° y: 100°	mainly for ceiling mounting modules (4-element pyrosensor)
	NCL-3S	1	x: 27° y: 21°	single or dual element pyrosensors
	NCL-3B	4	x: 40° y: 40°	dual or 4 element pyrosensors
	NCL-3IL	3	x: 70° y: 20°	dual element pyrosensor

Fig. 3 - Equivalent circuit



Pyrosensor module

Pyrosensor module
PSUP-02-NCL-9S
with Fresnel lens

Other pyrosensors, pyrosensor modules and lenses are available on request!

RFbeam

3.1 RADAR SENSORS – GENERAL

written by K. Mezger, RFbeam, St. Gallen, Switzerland

What does K-band mean?

K-band stands for the radio frequency range of 18...27 GHz. A portion of this range from 24...24.250 GHz is a so called ISM (Industrial, Science and Medical) radio band. RFbeam sensors use the ISM K-band. The ISM K-band allows operating our sensors in nearly all countries worldwide.

What does "Radar transceiver" mean?

Transceivers are devices containing a transmitter and a receiver. RFbeam radar devices contain always a transmitter and at least one receiver in order to send an electromagnetic wave and to receive the echo of this wave. Radar transceivers are often simply called radar sensors.
Radar transceivers can be operated in different modes (Doppler, FMCW, FSK, ...) depending on the physical quantity that has to be detected, e. g. speed, distance, presence of objects.

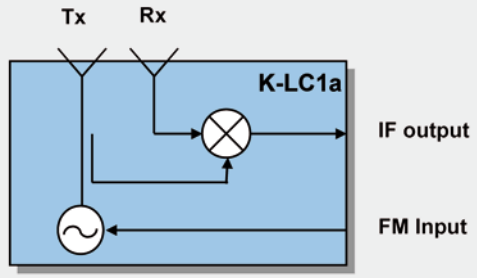
What does Doppler sensor mean?

Doppler Radar is used to detect moving objects and evaluate their velocity. A reflective moving object in sight of the sensor generates a low frequency sine wave at the sensor output. The amplitude depends on the distance and the reflectivity of the moving objects. The output frequency is proportional to the object speed: 158 Hz per m/s or 44 Hz per km/h for a radial moving object. Some RFbeam sensors are "stereo" sensors with 2 outputs, called I (In phase) and Q (Quadrature). These sensors allow detecting the moving direction (approaching, receding).

About Doppler radar

A more precise tiltle would be, "CW (Continuous Wave) Doppler Radar", when using RFbeam radar sensors. These sensors do not produce pulses, but send continuously in the K-band (24.125 GHz).

Fig. 1 - Typical radar transceiver



RFbeam radar transceivers (Fig. 1) return a so called IF signal, that is a mix-product of the transmitted (Tx) and the received (Rx) frequency. A moving object generates a slightly higher or lower frequency at the receiver. The IF signal is the absolute value of the difference between transmitted and received frequency. These transceivers operate in the CW (Continuous Wave) mode as opposed to the pulse radars, that measure time of flight. CW radars can operate with very low transmitting power (< 20 dBm resp. 100 mW).

Calculating the Doppler frequency

$$f_d = \frac{2 \cdot f_{Tx} \cdot v}{c_0} \cdot \cos \alpha \quad (1)$$

or

$$v = \frac{c_0 \cdot f_d}{2 \cdot f_{Tx} \cdot \cos \alpha} \quad (2)$$

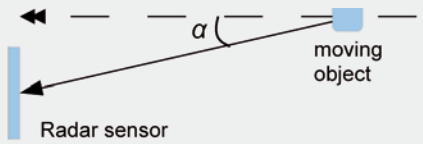
f_d = Doppler frequency
f_{Tx} = Transmitting frequency (24 GHz)
c_0 = Speed of light (3×10^8 m/s)
v = Object speed in m/s
α = Angle between beam and object moving direction (see Fig. 2)

At a transmitting frequency of f_{Tx}= 24 GHz we get a Doppler frequency for a moving object at the IF output of

$$f_d = v \frac{44 \text{ Hz}}{\text{km/h}} \cdot \cos \alpha \, .$$

RADAR SENSORS – GENERAL

Fig. 2 - Definition of angle α



The angle α reduces the measured speed by a factor of cos α. This angle varies with the distance of the object. To evaluate the correct speed, you need a trigger criteria at a known point. This can be accomplished by measuring the distance with the radar sensor (e.g. using FSK technology) or by measuring the angle using a monopulse radar such as K-MC4.

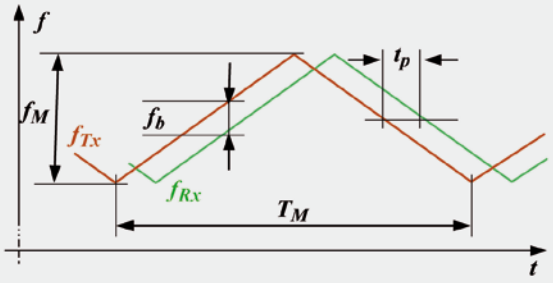
About FMCW

FMCW stands for Frequency Modulated Continuous Wave. This technique allows the detection of stationary objects. FMCW needs radar sensors with an FM input. This input accepts a voltage that causes a frequency change. There are also sensors with digital frequency control based on digital PLL designs. Modulation depth is normally a very small amount of the carrier frequency. In the K-band most countries allow a maximum frequency range of 250 MHz. Description of many effects such as velocity-range unambiguities go beyond the scope of this paper. Please refer to radar literature for more detailed explanations.

Triangle modulation

The transmitting frequency is modulated by a linear up and down ramp. Figs. 3a+3b show a typical signal f_{Rx} returned by stationary and constantly moving objects. Note, that the difference frequency f_b is constant throughout nearly the whole ramp up time. At the output of the radar transceiver we get a low frequency signal f_b called beat frequency. This is the result of mixing (=multiplying) transmitted and received frequencies.

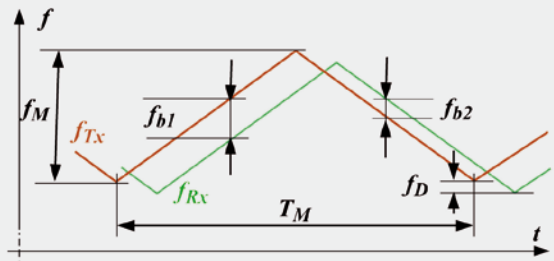
Fig. 3a - Triangle modulation - stationary object



Returned echo from stationary object

f_M	Modulation depth
T_M	Modulation period
f_{Tx}	Transmitted frequency
f_{Rx}	Received frequency
t_p	Signal propagation time (time of flight)
f_b	Beat frequency f_{Tx} - f_{Rx}
f_d	Doppler frequency

Fig. 3b - Triangle modulation - moving object



Returned echo from moving object

The received frequency f_{Rx} is shifted by f_d. This is the Doppler frequency caused by a receding object moving at a constant speed.

By measuring during up and down ramp, the Doppler frequency f_d is the diffence between f_{b1} and f_{b2}.

Distance can be calculated as follows:

$$R = \frac{c_0}{2} \cdot \frac{f_b}{f_M} \cdot \frac{T_M}{2}$$

For legend refer to Fig. 3a

R = Range, distance to target

c_0 = Speed of light (3×10^8 m/s)

RADAR SENSORS – GENERAL

Maximum unambiguous range:

$$R_{max} = \frac{c_0}{2} \cdot \frac{T_M}{2}$$

For legend refer to Fig. 3a
R_{max} = Max. unambiguous target distance
c_0 = Speed of light (3×10^8 m/s)

Distance and resolution

In K-Band (24 GHz), the maximum allowed frequency modulation depth f_M is <250 MHz. We also have to take in account tolerances and temperature influences. This limits the usable frequency shift f_M to typically 150 MHz.

For measuring f_b to evaluate distance we need at least one period of f_b during T_M, the range resolution is limited to

$$R_{min} = \frac{c_0}{2 \cdot f_M} = \frac{3^8 \text{ m/s}}{2 \cdot 250 \text{ MHz}} = 0.6 \text{ m}$$

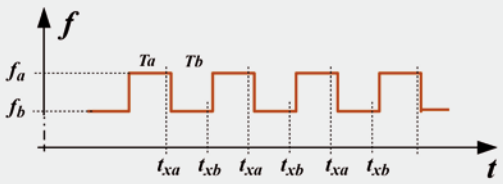
This is a theoretical value, because we have to consider drifts and tolerances in order to stay in the allowed frequency band.
Working with the more realistic value of f_M = 150 MHz, we get a minimum distance and resolution of R = 1 m.
Resolution may be enhanced by using phase conditions, correlation and other sophisticated algorithms.

About FSK mode

FSK stands for Frequency Shift Keying. FSK uses two discrete carrier frequencies f_a and f_b, (Fig. 4) while FMCW uses linear ramps.

For each carrier frequency, separate IF signals must be sampled in order to get 2 buffers for separate FFT processing. Due to the very small step f_a-f_b a moving target will appear nearly with the same Doppler frequency at both carriers, but with a different phase (Fig. 5). Phase shift due to the modulation timing and sampling must also be taken into account.

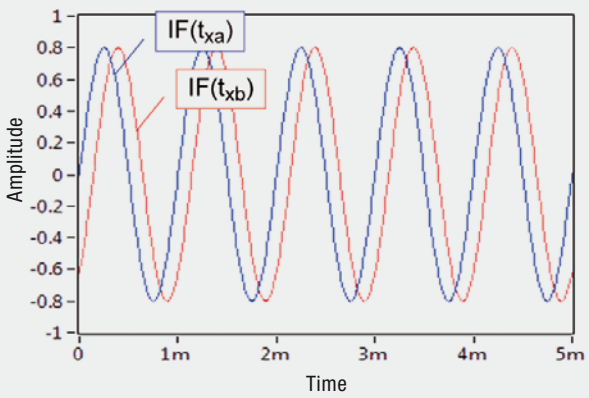
Fig. 4 - FSK modulation scheme



f_a Carrier Frequency a
f_b Carrier Frequency b
t_{xa} Sampling point for Doppler a
t_{xb} Sampling point for Doppler b

Switching must be performed at a sampling rate high enough to meeting the Nyquist criteria for the Doppler signal acquisition.

Fig. 5 - Resulting Doppler frequencies



$IF(t_{xa})$ Sensor output signal at carrier frequency f_a
$IF(t_{xb})$ Sensor output signal at carrier frequency f_b

Doppler signals of the same moving target have thesame frequency, but are phase shifted by $\Delta\varphi$.
For both IF signals, phase must be determined at the spectral peak of the object.

$$R = \frac{c_0 \cdot \Delta\varphi}{4\pi \cdot (f_a - f_b)}$$

$\Delta\varphi$ = Phase shift of $IF(t_{xa})$ and $IF(t_{xb})$

The smaller the frequency step, the higher the maximum range. To achieve an unambigous distance range of 150 m, a frequency step of 1MHz is required.

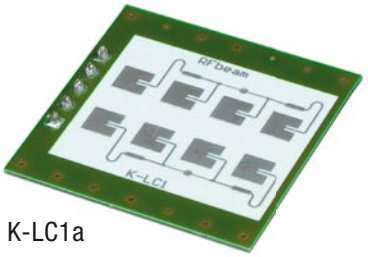
Remarks

- FSK can only be used for moving objects
- Multiple objects at different speeds may be detected
- Distance resolution depends mainly on signal processing and is not limited by the carrier bandwidth limitations
- FSK has the advantage of simple modulation and does not suffer from linearity problems
- VCO signal generation is simple, but sampling and phase measurement is challenging

3.2 RADAR SENSORS – PRODUCT SELECTION

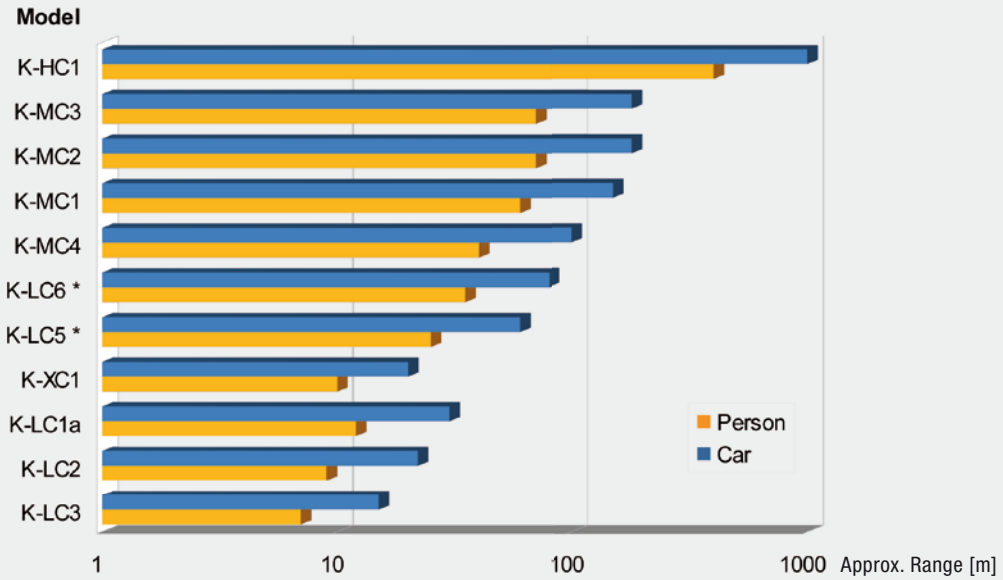
Selection by detection range

These are indicative values only and cannot be guaranteed. Range depends on many parameters like size of object, direction of movement and data processing method.



K-LC1a

Selection by detection range



Selection by parameters

PART NUMBER	MIN. RANGE PERSON [m] [1]	MIN. RANGE CAR [m]	FIELD PATTERN VERTICAL [°]	FIELD PATTERN HORIZONTAL [°]	OUTPUT I/Q	IF AMPLIFIER	SUPPLY VOLTAGE [VDC] [2]	CURRENT CONSUMPT. [mA]	FM/VCO	SIZE [mm]
K-LC3	7	15	138	132	no	no	5	35	no	25 × 25 × 6
K-LC2	9	22	80	34	yes	no	5	35	yes	25 × 25 × 6
K-LC1a	12	30	80	34	no	no	5	35	yes	25 × 25 × 6
K-XC1	10	20	Ext. ant.	Ext. ant.	yes	yes	12…24	300	n. a.	
K-LC5	25	60	80	34	yes	no	5	45	yes	25 × 25 × 6
K-LC5-v2	25	60	80	34	yes	no	5	45	no	25 × 25 × 6
K-LC6	35	80	80	12	yes	no	5	45	yes	66 × 25 × 6
K-LC6-v2	35	80	80	12	yes	yes	5	47	yes	66 × 25 × 6
K-MC4	40	100	30	12	yes	yes	5	120/10	yes	98 × 78 × 7
K-MC1	60	150	25	12	yes	yes	5	100/10	yes	65 × 65 × 6
K-MC2	70	180	25	7	yes	yes	5	100/10	yes	138 × 65 × 6
K-MC3	70	180	25	7	yes	yes	5	100/10	yes	105 × 85 × 5
K-HC1	400	1000	25	12	yes	yes	15…30	220	digital	110 × 77 × 19

[1] - values with simple comparator detector, [2] - 3.3 V on request

3.3 RADAR SENSORS – DEVELOPMENT TOOLS

ST100 starter kit, ST200 evaluation kit and ST500 lighting evaluation board

These kits allow to learn radar basics and evaluating radar technology for your specific application. STxxx kits can save a lot of initial time and money in order to get first radar experience.

ST100 starter kit vs. ST200 evaluation kit vs. ST500 lighting evaluation board	ST100	ST200	ST500	COMMENTS
Learning Doppler basics	x	x		
Exploring Doppler sensors	x	x		
Developping movement sensors	x	x	x	
Analyzing Doppler frequency spectra	x	x		
Working with complex FFT		x		important for separating multiple objects, suppressing interferences...
Recording and playback of Doppler signals	x	x		
Output of recorded Doppler signals	x			Very helpful for analyzing real world signals in the laboratory
Exploring FSK ranging		x		Ranging of moving objects
Exploring FMCW ranging		x		Ranging of moving and stationary objects
Exploring different sampling conditions		x		Predict behavior of final embedded solutions
Exploring monopulse principle		x		Detect direction angle of moving objects
Kit contains K-LC1a module	x	x	x	Good for learning basics
Kit contains also K-LC2 and K-MC1 modules		x		For advanced investigations
Kit contains also K-LC6 and K-LC1 modules			x	
For LED lighting applications (distance ≤30 m)			x	
1 V ... 10 V Output			x	
Suppression of false triggering			x	in a later version of ST500

3.4 RADAR SENSORS – TEST AND MEASUREMENT SYSTEMS

K-DT1 portable Doppler simulator

K-DT1 is a portable moving target simulator for K-band radar transceivers. It can be used for calibrating and testing speed displays, door openers, safety systems and other radar based Doppler sensors. K-DT1 comes with the Windows software DT-Remote. This software allows configuring and real time speed simulations with the K-DT1 device connected via USB port.

System features

- Handheld K-band Doppler target simulator
- Battery operation
- Programmable speed range 1... 200 km/h
- Programmable movement direction
- Programmable signal time
- 3 programmable presets
- Stand-alone or hosted operation via USB interface
- DT1-remote PC software included

Typical applications

- Mobile test equipments
- Production final inspection
- Incoming components inspection
- System tuning and adjustment

K-TS1 radar test system

K-TS1 is a multi-functional test system for K-band transceivers.

System features

- Multifunctional K-band test system
- CW VCO transmitter 23...25 GHz, 20 dBm
- Received signal frequency measurement
- Received signal power meter
- Active Doppler target simulator
- Auxiliary IF power meter
- Stand-alone or hosted operation via USB interface

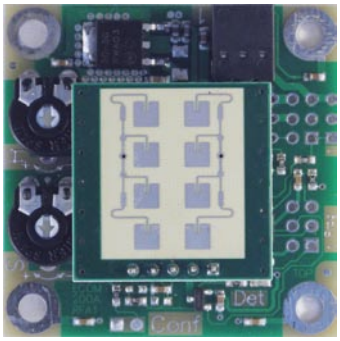
Typical applications

- Complete radar test systems including power and frequency measurement
- Production final inspection
- System tuning and adjustment
- Automatic microwave test equipment

TSview Lite software

TSview Lite is a graphical user interface for the ultra compact RFbeam K-TS1 testsystem. It communicates with K-TS1 via a serial USB interface. Measuring results are presented by large analog and digital read outs.

3.5 RADAR SENSORS – RADAR ACTIVATOR RFA1



RFA1 is a radar based movement detector for objects moving up to 80 km/h in continuous mode. It consists of a radar sensor and a processing board. The output is an open collector driver with adjustable hold time from 1 second to 30 minutes. Advanced pulsed technology allows a low current operation at less than 10 mA. Sensitivity is adjustable between 1 m and 10 m for persons.

Applications

- Energy saving applications
- General movement and presence detection
- Surveillance applications
- Equipment activation on presence
- Automatic advertising applications
- Lighting control

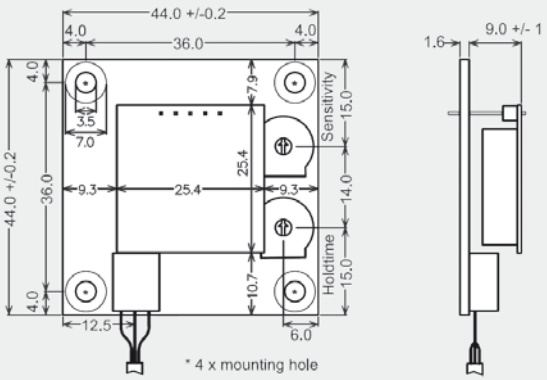
Features

- Low power radar movement detector
- Adjustable sensitivity 1 m to 10 m for persons
- Adjustable hold 1 sec. … 30 min.
- Object detection from 1cm/s … 80 km/h
- Selectable continuous and pulsed mode
- Power supply 6 V_{DC} … 15 V_{DC}
- 7 mA supply current in pulsed mode
- Fluorescent lamp interference suppression

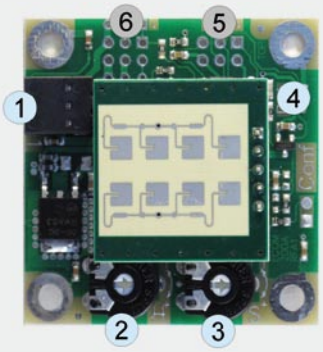
PARAMETER	SYMBOL	MINIMUM	TYPICAL	MAXIMUM	UNIT	CONDITIONS/NOTES
Characteristics of RFA1 radar activator						
Supply voltage	V_{cc}	6		24	V_{DC}	
Supply current	I_{cc}		6.5	8	mA	Pulsed mode (no detection)
	I_{cc}		10	12	mA	Pulsed mode (detection)
	I_{cc}		35	45	mA	Continuous mode
Output sink current	I_{out}			20	mA	Vout < 1.5 V
Operating temperature	T_{op}	-20		+80	°C	
Storage temperature	T_{st}	-20		+80	°C	
Capturing range	R_{Cap}			10	m	Persons frontal
Detectable object speed range	v	0.1		80	km/h	
Transmitter frequency	f_{TX}	24.050	24.150	24.250	GHz	
Output power	P_{TX}	+12	+15	+17	dBm	EIRP
Spurious emission	P_{spur}			+30	dBm	
Horizontal -3 dB beamwidth	W_{φ}		80		-	E-Plane
Vertical -3 dB beamwidth	W_{θ}		34		-	H-Plane

RADAR SENSORS – RADAR ACTIVATOR RFA1

Dimensions (mm)



Control elements

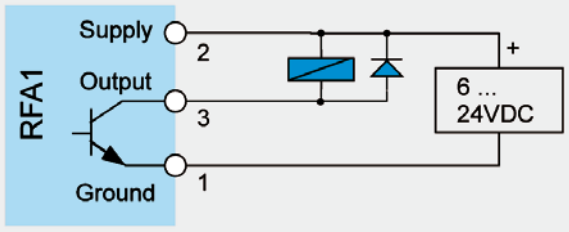


(1) Power and output connector
(2) Hold time setting
(3) Sensitivity setting
(4) Detection indicator LED
(5) Programming pads
(6) Expansion pads

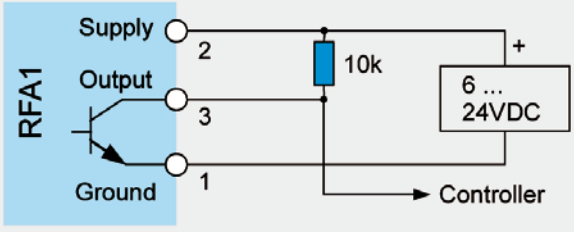
Connection diagrams

Open collector output is universal and allows many different configurations. Fig. 1 shows two typical situations. Output and RFA1 operating voltage may also be connected to separate power supplies. Maximum output current should not exceed 20 mA. Maximum supply current is 45 mA (continuous mode) or 10 mA (energy saving mode).

Fig. 1 – Examples (relais & controller)



Relais



Controller

Principle of operation

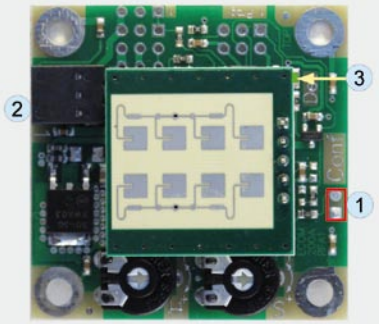
RFA1 is a movement sensor containig a Doppler Radar module K-LC1a. Signal acquisition, amplifier and digitizer are built in hardware, while timing and output are processed in a microcontroller.

RFA1 can operate in two modes:

» Continuous mode, where the radar module is always powered
» In pulsed mode, the radar module is powered during approx. 4 µs and switched off during 200 µs (i.e. duty cycle of around 2 %). During the off time, the signal is stored in a sample & hold (S&H) circuit.

The signal output frequency of the Radar module is 44 Hz/km/h or 158 Hz/m/s. The radar output voltage depends on reflectivity, distance and direction of the moving object. It ranges from a few µV to some mV. This input signal is filtered and passes a band-stop at 100 Hz. This reduces the influence of fluorescent lights in countries with a mains frequency of 50 Hz.

Setting the operation mode

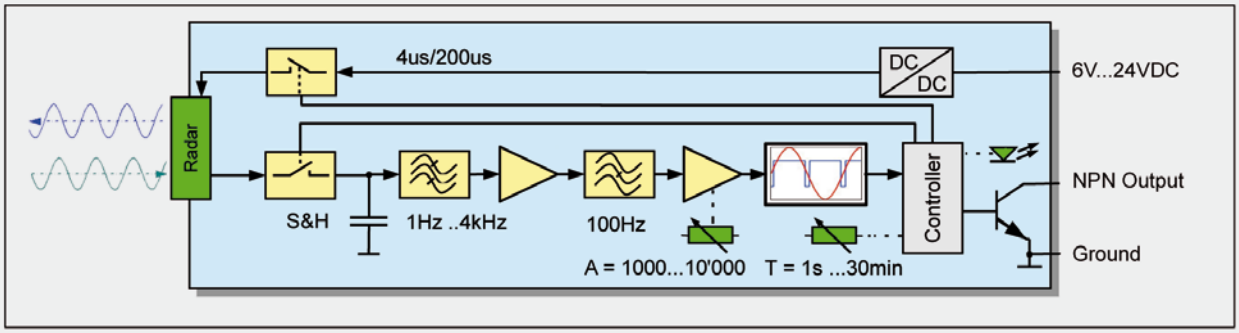


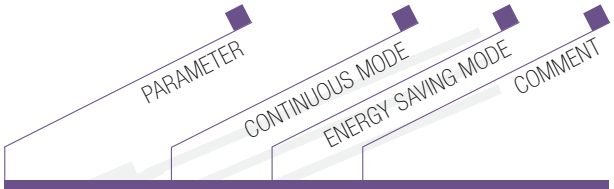
(1) Short circuit 2 pins with screw driver
(2) Switch power on
(3) LED blinks
1× = continuous mode
3× = energy saving pulsed mode

RADAR SENSORS – RADAR ACTIVATOR RFA1

After a gain-adjustable amplifier, see Fig. 2, the amplified signal passes a window comparator. The comparator signal contains double frequency of the input signal and is read by a microcontroller. The microcontroller performs some digital filtering, timing and output control.

Fig. 2 – RFA1 block diagram





Major differences between the two modes			
Current consumption	35 mA	6.5 mA	No detection
Current consumption	38 mA	10 mA	During detection / hold time
Max. sensitivity	10 m	7 m	Walking person
Max. detectable speed	80 km/h	60 km/h	Higher speeds decrease sensitivity

Installation tips

Sensitivity and maximum range

Sensitivity defines the necessary signal strength at the radar sensor to trigger the output. RFA1 allows to adjust sensitivity by a potentiometer.

Trigger distance at same sensitivity setting can vary depending on:

- Type of moving object (person, car etc.).
- Moving direction of the object or the angle of RFA1 to the moving direction respectively

Frontal distance for detecting persons can be adjusted from approximately 1 m to 10 m. This corresponds to approximately 2 m to 20 m for cars.

False trigger situations

Radar for movement detection is a very reliable and robust technology. It is insensitive to heat, wind, dust, sunlight and other influences.

However, there are some important issues to take into consideration:

- Sensitivity to fluorescent light
- Rain
- Sensitivity to vibrations
- Material and thickness of cover

RADAR SENSORS – RADAR ACTIVATOR RFA1

Fluorescence light

» Do not mount RFA1 facing directly to fluorescent lamps
» Use RFA1 at the lowest possible sensitivity for your distinctive application

Radar is susceptible to fluorescent lamps, even if controlled by electronic ballasts. These lamps produce a 100 Hz (50 Hz mains, in Europe) or 120 Hz (60 Hz mains, in USA) radar signal that is similar to the signals produced by a person walking at about 2 km/h. RFA1 is equipped with a 100 Hz filter, that can absorb a certain amount of fluorescent light interference. However, 100% protection against fluorescent light susceptibility is technically not possible.

Rain

» Prevent cover to get wet
» The larger the distance to rainy environment, the smaller the rain effect.

Raindrops can be interpreted by radar as moving objects and may trigger the output.

Vibrations, ventilators etc.

» RFA1 and its cover should be mounted solidly to prevent vibrations
» Try to prevent objects like ventilators in the sight of RFA1

RFA1 Radar detects moving objects. Vibrations, ventilators, moving plants etc can also be interpreted as moving objects. Such objects can therefore trigger RFA1.

Material and thickness of cover (Radom)

Unlike other sensor technologies, radar sensors may be completely hidden. Of course, the microwaves must be able to pass the cover with losses as low as possible. Therefore, metal covers are not appropriate! Radar antenna covers are also called Radom (derived from radar dome).

Every cover has some influence on the shape of detection field and the achievable maximum distance. Radar can „view“ through plastic and glass of any color. This gives a high degree of design freedom. Nevertheless, some rules should be considered:

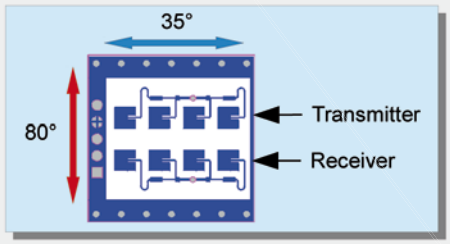
» Cover must not be metallic
» Plastic coating with colors NOT containing metallic or carbon particles
» Distance between cover and front of Radar sensor >1 cm
» Best cover material is polycarbonat or ABS
» Best cover thickness is 3-4 mm
» Vibrations of radar sensor relatively to the cover should be avoided, because this generates Doppler-like signals

Remarks

What does antenna pattern or beam width mean?

RFbeam defines antenna pattern (also called beam width) as the angular width of the beam, where the (Doppler) output signal amplitude drops to 50% (-6dB). K-LC1 example 80° × 35°: This is an asymmetrical beam. Sometimes, the horizontal beam width is called azimuth, vertical beam width is called elevation. These expressions are misleading, because the sensor can be mounted in either direction. Most RFbeam sensor antennas are so called patch antennas. Each single patch (rectangle) builds a small antenna. In a combination, they build an array, that focuses the beam. The more patches, the narrower the beam.

K-LC1 antenna pattern



Most RFbeam sensors have 2 antennas, one for transmitting and one for receiving signals. For transceivers, antenna pattern designates the resulting combination of transmitter and receiver characteristics. In this example both antennas have the same characteristics.

4 I HALL SENSORS

In 1879, Edwin H. Hall (1855-1938), an American physicist, discovered this effect. The electrons of the current flowing in an electrical conductor are diverted from their normal direct path by an outer magnetic field perpendicular to their motion. Due to the so-called Lorentz force, a potential difference (the Hall voltage) is created, proportional to the field strength of the magnetic field and to the current. Silicon is used almost exclusively as a basic material for the technical implementation of magnetic field sensors, as the Hall-effect is most pronounced in semiconductors. In modern Hall-effect sensor devices, the magnetic field sensitive Hall element is combined with the signal processing on a single silicon chip. Three different types of sensor architecture are available today:

- Digital switches
- Linear sensors
- Direct angle sensors

Hall switches

The simplest application is to use the sensor as a "digital switch". The magnetic field strength is measured and compared with a fixed threshold level predefined or programmable in the sensor. As soon as this value is exceeded (switching point) the switching state at the output of the sensor changes and the output transistor is switched on or off. Two types of switches are available: 3-wire version with an open-drain output or 2-wire versions with current-coded output.

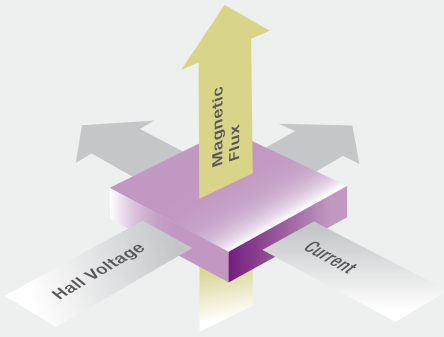
Linear hall sensors

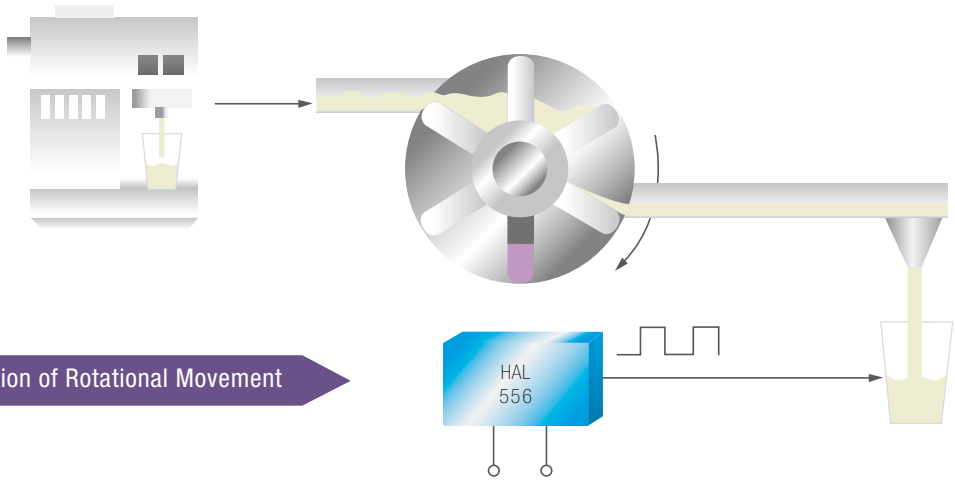
Linear Hall sensors differ from the switches as follows: Depending on the magnetic field, the output does not have a discrete switching state, but provides a signal proportional to the magnetic field strength.
This output signal can be delivered as an analog output voltage, a pulse-width-modulated signal (PWM) or even as a modern bus protocol (LIN, SENT).

Direct angle sensors

New types of Hall-effect sensors do not measure the absolute magnetic field anymore. So-called direct angle sensors capture the field vector by measuring sine and cosine components of the magnetic field. This is possible due to the new 3D-HAL technology from MIcronas. Vertical Hall plates measure the magnetic field components in the chip plane and not the components perpendicular to the chip surface. These kind of sensors provide angular and position information directly via an output signal proportional to the measured angle or position.

Principle of the hall effect

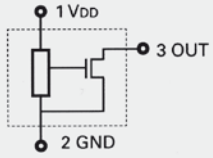




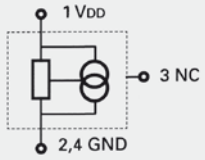
Application example: Detection of Rotational Movement

HALL SENSORS

Configuration

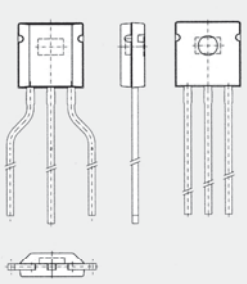


3-Wire Switch:
The voltage is monitored and the switch operates as indicated according to the type of switch.

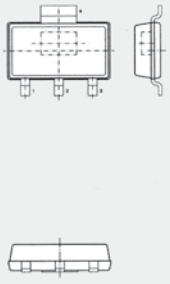


2-Wire Switch:
The current is monitored and the switch operates as indicated according to the type of switch. Current level is specified within the data sheet.

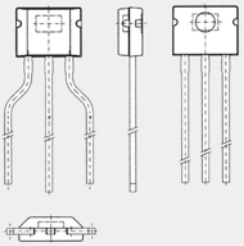
Packages



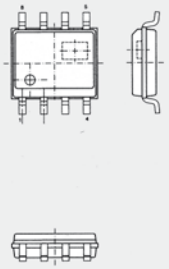
TO92UT package



SOT89B package



TO92UA package



SOIC8 package

Hall Sensor Ordering Code

HAL 502 PA - T - C - P - Q - SP

Hall Sensor

Sensor Type

Package

UA/JQ = TO92UA
UT = TO92UT
SF/TQ = SOT89B
DJ = SOIC8

Temperature Range

C: T_J = 0°C ... +85°C
I: T_J = -20°C ... +125°C
E: T_J = -40°C ... +100°C
K: T_J = -40°C ... +140°C
A: T_J = -40°C ... +170°C

Configuration

1 = TO92 - inline, spread
2 = TO92 - inline, not spread
4 = SOT89 - blister pack

Packaging

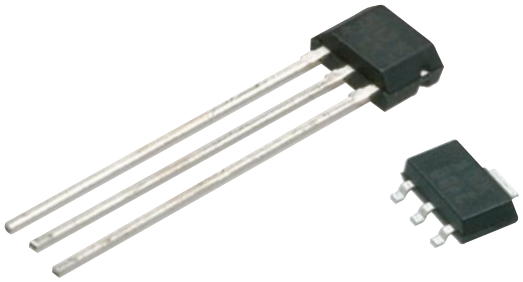
B = Bulk (TO-92UA/UT)
A = Ammopack (TO-92UA/UT)
R = Reel (SOT-89B only)

Quantity

1 = 2,000 per box (2 reels, each 1,000 pcs.)
2 = 2,000 per box (Ammopack)
5 = 15,000 per box (3 reels, each 5,000 pcs.)

Special Procedure

4.1 HALL SWITCH FAMILY HAL 1xy



These **Hall sensors** are produced in CMOS technology and include a temperature-compensated Hall plate with active offset compensation, a comparator, and an open-drain output transistor. The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off.

Specifications of HAL 1xy						
PART NUMBER	MAGNETIC CHARACTERISTICS B_{ON} [mT], TYP. @ 25°C	MAGNETIC CHARACTERISTICS B_{OFF} [mT], TYP. @ 25°C	TYPE	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
HAL 101	34.0	24.0	unipolar, low sensitivity	3-wire	TO92 SOT89	C, I
HAL 102	2.6	-2.6	latching, high sensitivity,	3-wire	TO92 SOT89	C, I
HAL 103	7.6	-7.6	latching, medium sensitivity	3-wire	TO92 SOT89	C, I
HAL 104	14.0	-14.0	latching, low sensitivity	3-wire	TO92 SOT89	C, I
HAL 106	12.0	6.5	unipolar, high sensitivity	3-wire	TO92 SOT89	C, I
HAL 107	26.5	22.5	unipolar, low sensitivity	3-wire	TO92 SOT89	C, I
HAL 108	17.0	15.0	unipolar, medium sensitivity	3-wire	TO92 SOT89	C, I
HAL 109	7.9	5.7	unipolar, high sensitivity	3-wire	TO92 SOT89	C, I

Applications

» White goods:
- Selector switches
- Door lock detection
- RPM detection

» Power tools
- Speed control
- Direction switch

» Home automation
- Garage and door opener

» Industrial applications
- Endposition detection
- RPM measurement
- Brushless DC motors
- RPM measurements in flow meters
- Replacement of micro switches

Features

» Temperature ranges:
C (commercial): 0°C ... +85°C
I (industrial): -20°C ... +125°C

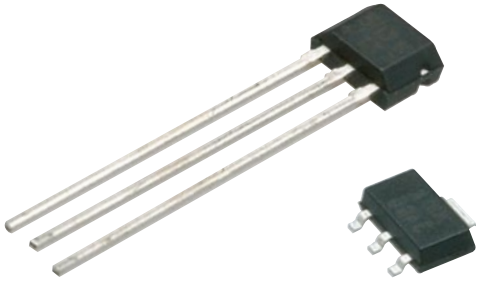
» Supply voltage: 3.8 V ... 24 V

» Operates with static magnetic fields and dynamic fields up to 10 kHz

» Overvoltage protection at all pins

» Reverse-voltage protection at V_{DD} pin

4.2 LOW-COST HALL SWITCH FAMILY HAL 2xy



The **Hal 2xy Hall switch** family is produced in CMOS technology. The sensors include a temperature-compensated Hall plate with active offset compensation, a comparator, and an open-drain output transistor.

The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off.

The active offset compensation leads to magnetic parameters, which are robust against mechanical stress effects. In addition, the magnetic characteristics are constant in the full supply voltage and temperature range.

Specifications of HAL 2xy

PART NUMBER	MAGNETIC CHARACTERISTICS B_{ON} [mT], TYP. @ 25°C	MAGNETIC CHARACTERISTICS B_{OFF} [mT], TYP. @ 25°C	TYPE	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
HAL 201	34.0	24.0	unipolar, low sensitivity	3-wire	TO92 SOT89	K
HAL 202	2.6	-2.6	latching, high sensitivity	3-wire	TO92 SOT89	K
HAL 203	7.6	-7.6	latching, medium sensitivity	3-wire	TO92 SOT89	K
HAL 204	14.0	-14.0	latching, low sensitivity	3-wire	TO92 SOT89	K
HAL 206	12.0	6.5	unipolar, high sensitivity	3-wire	TO92 SOT89	K
HAL 207	26.5	22.5	unipolar, low sensitivity	3-wire	TO92 SOT89	K
HAL 208	17.0	15.0	unipolar, medium sensitivity	3-wire	TO92 SOT89	K
HAL 210	7.9	5.7	unipolar, high sensitivity	3-wire	TO92 SOT89	K
HAL220	2.6	-2.6	latching, high sensitivity	3-wire	TO92 SOT89	K
HAL221	18.5	12.0	unipolar, low sensitivity	3-wire	TO92 SOT89	K

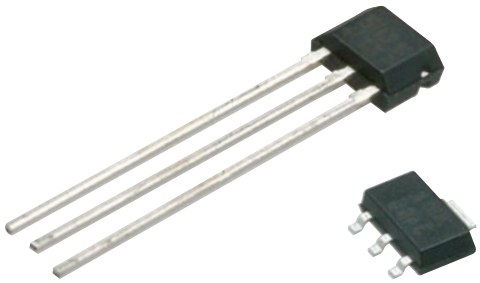
Applications

- Endposition detection
- RPM measurement of motors in various applications, such as power window
- Brushless DC motors
- RPM measurements in flow meters
- Replacement of micro switches

Features

- Supply voltage: 3.8 V ... 24 V
- Operates with static magnetic fields and dynamic fields up to 10 kHz
- Overvoltage protection at all pins
- Reverse-voltage protection at V_{DD} pin

4.3 MULTIPURPOSE HALL SENSOR FAMILY HAL 5xy



The **Hal 5xy** family consists of different Hall switches produced in CMOS technology. All sensors include a temperature-compensated Hall plate with active offset compensation, a comparator, and an open-drain output transistor. The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off.

The sensors of this family differ in the switching behavior and the switching points. The active offset compensation leads to constant magnetic characteristics over supply voltage and temperature range. In addition, the magnetic parameters are robust against mechanical stress effects.

PART NUMBER	MAGNETIC CHARACTERISTICS B_{ON} [mT], TYP. @ 25°C	MAGNETIC CHARACTERISTICS B_{OFF} [mT], TYP. @ 25°C	TYPE	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
Specifications of HAL 5xy						
HAL 501	0.5	-0.7	bipolar, high sensitivity	3-wire	TO92/SOT89	K, A
HAL 502	2.6	-2.6	latching, high sensitivity	3-wire	TO92/SOT89	K, A
HAL 503	8.0	-8.0	latching, medium sensitivity	3-wire	TO92/SOT89	K, A
HAL 504	12.0	7.0	unipolar, medium sensitivity	3-wire	TO92/SOT89	K, A
HAL 505	13.5	-13.5	latching, low sensitivity	3-wire	TO92/SOT89	K, A
HAL 506	5.5	3.5	unipolar, high sensitivity	3-wire	TO92/SOT89	K, A
HAL 508	18.0	16.0	unipolar, medium sensitivity	3-wire	TO92/SOT89	K, A
HAL 509	26.8	23.2	unipolar, low sensitivity	3-wire	TO92/SOT89	K, A
HAL 516	3.5	5.5	unipolar inverted, high sens.	3-wire	TO92/SOT89	K, A
HAL 519	-3.6	-5.5	unipolar inverted, high sens.	3-wire	TO92/SOT89	K, A
HAL 523	34.5	24.0	unipolar, low sensitivity	3-wire	TO92/SOT89	K, A

PART NUMBER	MAGNETIC CHARACTERISTICS B_{ON} [mT], TYP. @ 25°C	MAGNETIC CHARACTERISTICS B_{OFF} [mT], TYP. @ 25°C	TYPE	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
Specifications of HAL 5xy						
HAL 526	14.0	-14.0	latching, low sensitivity	3-wire	TO92/SOT89	E, K
HAL 542	2.6	-2.6	latching, high sensitivity	3-wire	TO92/SOT89	E, K
HAL 543	27.0	21.0	unipolar, low sensitivity	3-wire	TO92/SOT89	E, K
HAL 546	5.5	3.5	unipolar, high sensitivity	3-wire	TO92/SOT89	E, K
HAL 548	18	12	unipolar, medium sensitivity	3-wire	TO92/SOT89	E, K
HAL 549	-5.5	-3.6	unipolar, high sensitivity	3-wire	TO92/SOT89	E, K
HAL 556	6.0	3.8	unipolar, high sensitivity	2-wire	TO92/SOT89	E, K
HAL 565	2.7	4.4	unipolar inverted, high sens.	2-wire	TO92/SOT89	E
HAL 566	3.9	5.9	unipolar inverted, high sens.	2-wire	TO92/SOT89	E, K
HAL 573	43.5	41.5	unipolar, low sensitivity	2-wire	TO92/SOT89	E, K
HAL 574	9.2	7.2	unipolar, medium sensitivity	2-wire	TO92/SOT89	E, K
HAL 575	4.0	-4.0	latching, medium sensitivity	2-wire	TO92/SOT89	E, K
HAL 576	5.7	4.2	unipolar, medium sensitivity	2-wire	TO92/SOT89	E, K
HAL 579	12.0	-12.0	latching, medium sensitivity	2-wire	TO92/SOT89	E, K
HAL 581	10.0	12.0	unipolar inverted, med. sens.	2-wire	TO92/SOT89	E, K
HAL 584	7.2	9.2	unipolar inverted, med. sens.	2-wire	TO92/SOT89	E, K

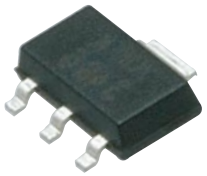
Applications

- Endposition detection
- RPM measurement of motors in various applications, such as power window
- Brushless DC motors
- RPM measurements in flow meters

Features

- Supply voltage: 3.8 V ... 24 V
- Temperature ranges: A: -40°C ... +170°C
  K: -40°C ... +140°C
  E: -40°C ... +100°C
- Operates with static magnetic and dynamic fields up to 10 kHz

4.4 DUAL HALL SENSOR WITH TWO INDEPENDENT OUTPUTS HAL 7xy



Features

- Supply voltage: 3.8 V ... 24 V
- Operates with static magnetic and dynamic fields up to 10 kHz
- Generation of direction signal
- Medium sensitivity

Applications

- Endposition detection
- RPM measurement of motors in various applications, such as power window
- RPM measurements in flow meters
- Replacement of micro switches

This **HAL 7xy** is a family of monolithic integrated hall sensors manufactured in CMOS technology with two independent hall plates S1 and S2. The Hall sensors have two open-drain outputs.

The sensors HAL 710 and HAL 730 are particularly featuring a count and a direction output. The count output operates like a single latched Hall switch according to the magnetic field present at Hall plate S1. The direction output indicates the direction of a linear or rotating movement of magnetic objects.

In combination with an active target providing a sequence of alternating magnetic north and south poles, the sensors generate the signals required to control position, speed, and direction of the target movement.

The HAL 7xy sensors include temperature compensation and active offset compensation. These features provide excellent stability and matching of the switching points in the presence of mechanical stress, over the whole temperature and supply voltage range.

The HAL 7xy family is designed for industrial and automotive applications and operate with supply voltages from 3.8 V to 24 V in the junction temperature range from -40°C up to +140°C.

Specifications of HAL 7xy

PART NUMBER	MAGNETIC CHARACTERISTICS B_{ON} [mT], TYP. @ 25°C	MAGNETIC CHARACTERISTICS B_{OFF} [mT], TYP. @ 25°C	SWITCHING BEHAVIORS	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
HAL 700	14.9	-14.9	S1: latching S2: latching	4-wire	SOT89	E, K
HAL 710	14.9	-14.9	output high, when , edge of comparator 1 precedes edge of comparator 2	4-wire	SOT89	E, K
HAL 730	14.9	-14.9	output high, when , edge of comparator 2 precedes edge of comparator 1	4-wire	SOT89	E, K
HAL 740	11.5	12.5	S1: unipolar north sensitive S2: unipolar south sensitive	4-wire	SOT89	E, K

4.5 PROGRAMMABLE HALL SWITCH HAL 1000

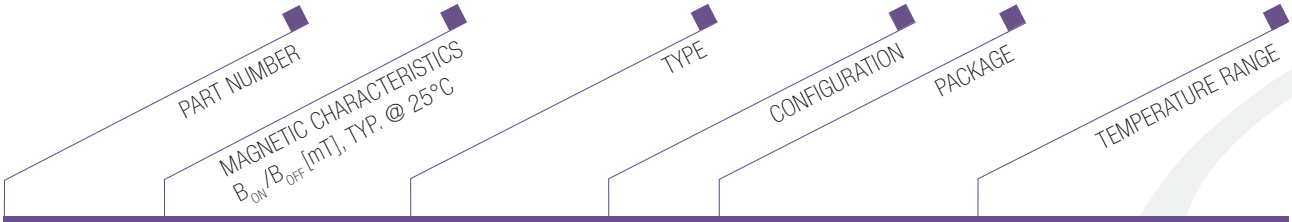
The **HAL 1000** is a programmable hall switch. The major sensor characteristics, the two switching points B_{ON} and B_{OFF}, and the output behavior are programmable for the specific application.

The HAL 1000 features a temperature-compensated Hall plate with choppered offset compensation, an A/D converter, digital signal processing, a push-pull output stage, an EEPROM memory with redundancy and lock function for the calibration data, a serial interface for programming the EEPROM, and protection devices at all pins. Due to the digital signal processing, analog offsets, temperature shifts, and mechanical stress effects do not degrade the sensor accuracy.

The HAL 1000 is programmable by modulating the supply voltage. No additional programming pin is needed. The tolerances of the sensors, the magnet, and the mechanical positioning can be compensated via programming for the final assembly. This offers a low-cost alternative for all applications that presently require mechanical adjustment. The sensor is designed for the use in harsh industrial and automotive applications with nominal supply voltage of 5 V in the junction temperature range from -40°C up to +170°C. The HAL 1000 is available in the leaded package TO92UT.

Applications

- Endposition detection
- Liquid-level position
- Electronic fuse



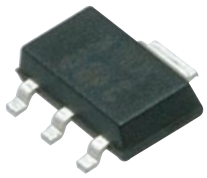
Specifications of HAL 1000

HAL 1000	programmable	unipolar, unipolar inverted, latching	3-wire	TO92	K, A

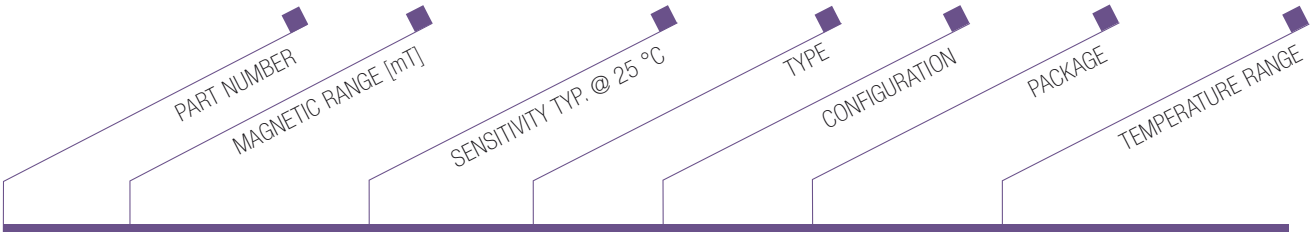
Features

- High-precision hall switch with programmable switching points and switching behavior
- Switching points programmable from -150 mT up to 150 mT in steps of 0.5 % of the magnetic field range
- Operates with static magnetic fields and dynamic magnetic fields up to 2 kHz
- Multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function
- Temperature characteristics programmable to match all common magnetic materials
- Programmable by modulation of the supply voltage
- Supply voltage: 4.5 V ... 5.5 V

4.6 LINEAR HALL SENSOR IC FAMILY HAL 4x1



The **HAL 4x1 sensors** include a temperature-compensated hall plate with choppered offset compensation, two linear output stages, and protection devices.
The output voltage is proportional to the magnetic flux density through the Hall plate. The choppered offset compensation leads to stable magnetic characteristics over supply voltage and temperature.
The HAL 4x1 family can be used for magnetic field measurements, current measurements, and detection of any mechanical movement. Accurate angle measurements or distance measurements can also be done. The sensor is very robust and can be used in electrical and mechanical hostile environments.



Specifications of HAL 4x1

	MAGNETIC RANGE [mT] min.	MAGNETIC RANGE [mT] max.	SENSITIVITY TYP. @ 25 °C	TYPE	CONFIGURATION	PACKAGE	TEMPERATURE RANGE
HAL 401	-50	50	48.5 mV/mT	analog	4-wire	SOT-89	K, A
HAL 411	-50	50	42.5 mV/mT	analog	4-wire	SOT-89	E

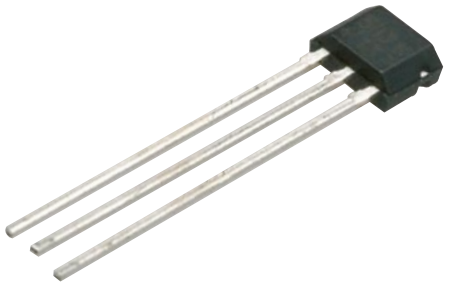
Applications

- Current measurement
- Position measurement
- Angle measurements

Features

- Switching offset compensation at 147 kHz
- Low magnetic offset
- Extremely sensitive
- Wide temperature range: -40°C ... +170°C (HAL 401)
- Supply voltage: 4.8 V ... 12 V (HAL 401)
  4.9 V ... 5.1 V (HAL 411)
- On-chip temperature compensation

4.7 PROGRAMMABLE LINEAR HALL SENSORS HAL 81x



The **HAL 810** and **HAL 815** are programmable linear Hall sensors which can be used for angle or distance measurements. The major characteristics are programmable in a non-volatile memory.

The HAL 815 has a ratiometric output characteristic; its output voltage is proportional to the magnetic flux and the supply voltage. The HAL 810 provides a pulse-width modulated (PWM) output signal.

The sensors feature a temperature-compensated Hall plate with choppered offset compensation, an A/D converter, an EEPROM memory with redundancy and lock function for the calibration data and protection devices at all pins. Due to the digital signal processing, analog offsets, temperature shifts, and mechanical stress do not degrade the sensor accuracy.

The tolerances of the sensor, the magnet, and the mechanical positioning can be compensated via programming by customer/user in the final assembly. This offers a low-cost alternative for all applications that presently need mechanical adjustment or laser trimming for calibration.

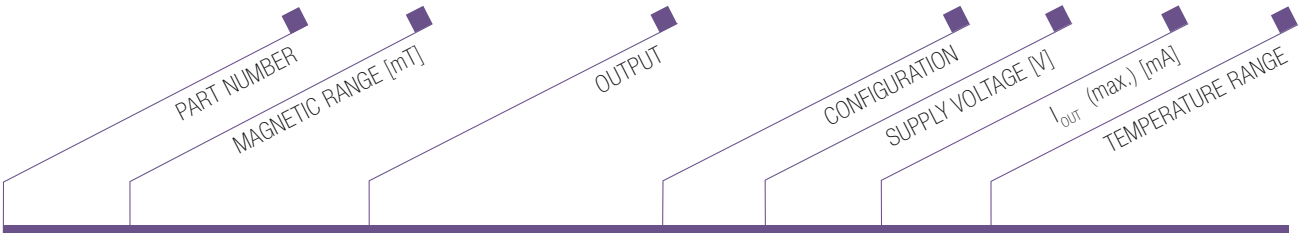
Both sensors are available in the very small leaded packages TO92UT-1 and TO92UT-2.

Features

- High-precision linear Hall sensors with digital signal processing
- PWM output signal with refresh rate of typically 125 Hz and up to 11 bit resolution (HAL 810)
- D/A converter with output driver (HAL 815)
- Multiple programmable magnetic characteristics in a non-volatile memory (EEPROM) with redundancy and lock function
- Open-circuit feature (ground and supply line break detection)
- Overvoltage and reverse voltage detection
- For programming an individual sensor within several sensors in parallel to the same supply voltage, a selection can be done via the output pin (HAL 815)
- Programmable clamping function
- Digital signal processing
- Temperature characteristics programmable to match all common magnetic materials
- Programmable by modulation of the supply voltage
- Junction temperature range: K: -40°C ...+140°C
  A: -40°C ...+170°C
- Supply voltage: 4.5 V ... 5.5 V

Applications

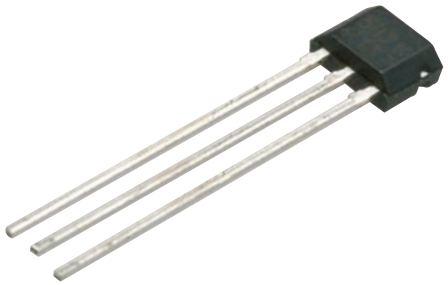
- Rotary position measurements
- Level measurement
- Linear position detection
- Force/pressure measurement



Specifications of HAL 81x

	min.	max.					
HAL 810	±30	±150	2 setpoints, PWM	3-wire	4.5 ... 5.5	1	K, A
HAL 817	±30	±150	2 setpoints, analog	3-wire	4.5 ... 5.5	1	K, A

4.8 HIGH-PRECISION PROGRAMMABLE HALL SENSORS HAL 82x



This **HAL 824** and the **HAL 825** complement the existing Hall sensor family HAL 8xy. Both high-precision magnetic field sensors provide a ratiometric, linear output signal. This sensor family is designed to fulfil high requirements in respect of low temperature drifts of sensitivity and offset.

Due to the very low drifts of this sensor family, it can be used for applications with very high requirements on offset and sensitivity drift stability. This is mandatory for applications like throttle position detection, accelerator pedal sensing, or current measurement. The sensors provide either a ratiometric analog output signal or a multiplexed analog output. In multiplex analog output mode, the sensors transmit a signal with 14-bit accuracy. Major characteristics like magnetic field range, output format, sensitivity, VOQ (output voltage at zero magnetic field), and the temperature coefficients can easily be adjusted to the magnetic circuit (linear and quadratic) by programming the non-volatile memory. Both sensors are available in the very small leaded package TO92UT.

Applications

- Contactless potentiometers
- Rotary position measurements, like throttle position or accelerator pedal
- Linear movement
- Current measurements

PART NUMBER | MAGNETIC RANGE [mT0] | OUTPUT | CONFIGURATION | SUPPLY VOLTAGE [V] | I_{OUT} (max.) [mA] | TEMPERATURE RANGE

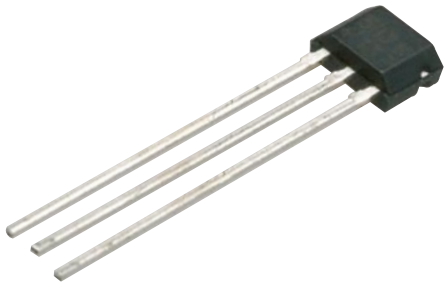
Specifications of HAL 82x

	min.	max.					
HAL 824	±30	±100	2 setpoints, analog	3-wire	4.5 ... 5.5	1	K, A
HAL 825	±30	±100	2 setpoints, analog	3-wire	4.5 ... 5.5	1	K, A

Features

- Sensitivity drift over temperature: < ±1%, ±2% (HAL825)
- Offset drift over temperature: < ±0.2%, ±0.3% (HAL825) of V_{DD}
- DNL of analog output: ±0.9 LSB (±2 LSB for HAL825)
- Wire break detection with 5 kΩ pull-up or pull-down resistor
- Four programmable magnetic ranges: ±30, ±60, ±80, ±100mT
- Two programmable 3 dB filter frequ.: 500 Hz and 1 kHz
- Programmable sensitivity and offset (VOQ)
- 12-bit ratiometric analog output
- 14-bit signal path
- Programmable sensitivity and offset (VOQ)
- Digital signal processing
- Temperature characteristics programmable to match all common magnetic materials
- 13 customer data bits
- Programmable by modulation of the supply voltage

4.9 PROGRAMMABLE HALL SENSORS WITH ARBITRARY OUTPUT HAL 85x



The **HAL 85x** complements the existing Hall sensor family HAL 8xy. Both universal magnetic field sensors provide an arbitrary output signal. The sensors are produced in submicron CMOS technology.

In combination with a rotating or moving magnet, the sensors can be employed for angle, distance, and level measurements. The sensors provide either a pulse-width-modulated (PWM) output signal or a serial Biphase-M output.

Major characteristics like magnetic field range, output characteristic, output format sensitivity, shift (duty cycle of the PWM output signal or the serial output word), PWM period, low and high current, and the temperature coefficients can easily be adjusted to the magnetic circuit (linear and quadratic) by programming the non-volatile memory. The output characteristic can be set via 32 setpoints.

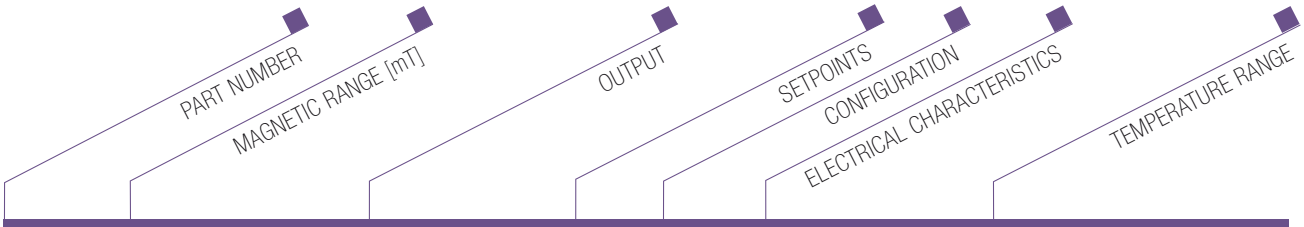
The sensors were designed to translate a linear magnetic field into an arbitrary output signal or a non-linear magnetic field into a linear output signal.

The sensors are available in the very small leaded package TO92UT.

Applications

Due to the sensor's versatile programming characteristics, the HAL 85x is the optimal system solution for applications, such as:

- Rotary position measurements
- Level measurement
- Linear position detection
- Magnetic field detection



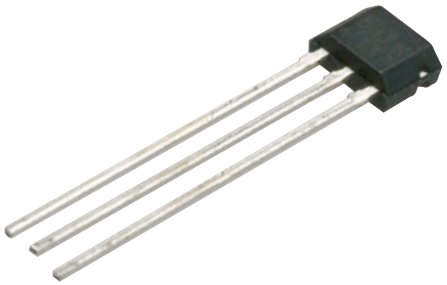
Specifications of HAL 85x

	min.	max.				V_{DD} (V)	I_{out} (mA) max	
HAL 855	±30	±150	PWM or biphase-M	32	3-wire	4.5 ... 14	20	K, A
HAL 856	±30	±150	PWM or biphase-M	32	2-wire	4.5 ... 14	progr.	K, A

Features

- High-precision linear Hall sensors with different output formats
- Various programmable magnetic characteristics with non-volatile memory
- Programmable output characteristics (32 setpoints)
- Programmable output formats (PWM or serial Biphase-M)
- Open-drain output for HAL 855
- Digital signal processing
- Temperature characteristics programmable to match all common magnetic materials
- Programmable by modulation of the supply voltage
- Junction temperature range: -40°C ...+170°C
- Supply voltage: 4.5 V ... 14 V

4.10 PROGRAMMABLE LINEAR HALL SENSOR – HAL 880



The **HAL 880** is designed to fulfil the requirements of today's state-of-the-art applications for linear and angular measurements that require flexibility to compensate system tolerances. Due to its programmability, it also offers the additional advantage of compensation of system tolerances. This is mandatory for applications like accelerator pedal sensing, current measurement, bending light, or head light adjustment.

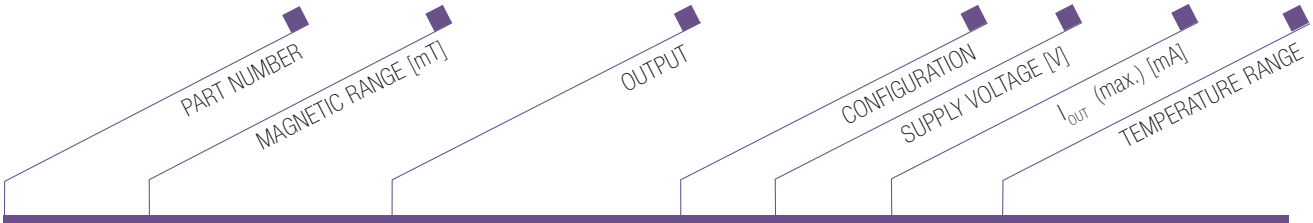
The sensor provides a linear, ratiometric analog output signal with implemented wirebreak detection working with pull-up or pull-down resistor.

Major characteristics like magnetic field range, sensitivity, VOQ (output voltage at zero magnetic field), and the temperature coefficients can easily be adjusted to the magnetic circuit (linear and quadratic) by programming the non-volatile memory.

The HAL 880 is available in a very small leaded package TO92UT.

Applications

- Linear movement
- Current measurements
- Rotary position measurements
- Level measurement



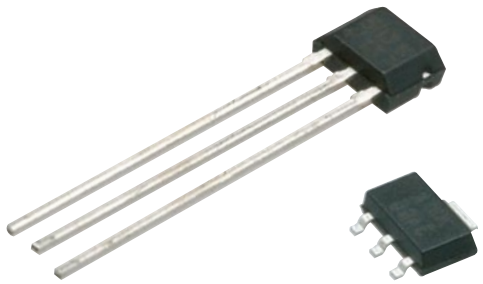
Specifications of HAL 880

	min.	max.					
HAL 880	±30	±100	2 setpoints, analog	3-wire	4.5 ... 5.5	1	K

Features

- Sensitivity drift over temperature less than ±6 %
- Offset drift over temperature less than ±15 µT/K
- Integral non-linearity error of output signal ±1 %
- Low output noise of 25 mV peak-peak
- Wire-break detection with 5 kΩ pull-up or pull-down resistor
- Four programmable magnetic ranges: ±30, ±60, ±80, and ±100 mT
- Two programmable 3 dB filter frequencies: 500 Hz and 1 kHz
- Programmable sensitivity and offset (VOQ)
- 12-bit ratiometric analog output
- Digital signal processing
- Temperature characteristics programmable to match all common magnetic materials
- 13 customer data bits
- Programming by modulation of the supply voltage
- Junction temperature: -40°C ... +140°C
- Supply voltage: 4.5 V ... 5.5 V

4.11 LINEAR HALL SENSOR FAMILY HAL 18xy



HAL 18xy is a new family of universal Hall sensors with ratiometric, linear analog output. The family members can be used for magnetic field measurements, current measurements and detection of any mechanical movement, as well as very accurate angle or distance measurements. The sensors are very robust and can be used in harsh electrical and mechanical environments. The HAL 1820 is programmable by modulating the supply voltage of the sensor. No additional programming pin is needed. The major characteristics like magnetic field range, sensitivity, offset, and the temperature coefficients are programmable in a non-volatile memory. The tolerances of the sensor, the magnet, and the mechanical positioning can be compensated via programming in the final assembly. This offers a low-cost alternative for all applications that presently need mechanical adjustment or laser trimming for calibrating the system.

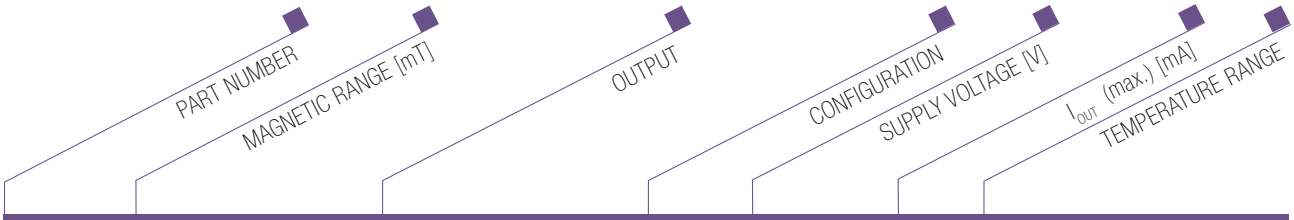
HAL 1821/1822/1823 offer excellent performance/price trade-off. The different family members are pre-programmed and vary by preset sensitivity levels. The sensors are designed for use in automotive or industrial applications.

The sensors are available in the very small leaded package TO92UA and SMD package SOT89B.

Applications

The HAL 18xy is the optimal system solution for applications, such as:

- Linear movement
- Rotary position measurements
- Level measurement



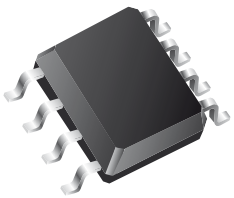
Specifications of HAL 18xy

	min.	max.					
HAL 1820	±20	±160	programmable, 2 setpoints, analog	3-wire	4.5 ... 5.5	1	K, A
HAL 1821	-50	+50	pre-programmed	3-wire	4.5 ... 5.5	1	K, A
HAL 1822	-80	+80	pre-programmed	3-wire	4.5 ... 5.5	1	K, A
HAL 1823	-100	+100	pre-programmed	3-wire	4.5 ... 5.5	1	K, A

Features

- Linear Hall sensors with ratiometric analog output
- Various programmable magnetic characteristics with non-volatile memory (HAL 1820 only)
- Digital signal processing
- Continuous measurement ranges: ±20 mT... ±160 mT (HAL 1820 only)
- Preset sensitivity of 25 mV/mT, 31.25 mV/mT, or 50 mV/mT (HAL 1821/1822/1823)
- Temperature characteristics programmable to match all common magnetic materials (HAL 1820 only)
- Programmable via supply voltage (HAL 1820 only)
- Lock function and built-in redundancy for EEPROM memory (HAL 1820 only)
- Junction temperature range: A: -40°C ...+170°C
  K: -40°C ...+140°C
- Supply voltage: 4.5 V ... 5.5 V

4.12 PROGRAMMABLE DIRECT ANGLE HALL SENSORS – HAL 36xy/38xy



The **HAL 36xy/38xy** families represent a new level of performance for hall-effect sensors enabling a significant simplification in the design of magnetic systems. The sensors are based on Micronas' innovative 3D HAL technology, which combines standard lateral with vertical Hall plates. Whereas the HAL 36xy family is targeted for rotational movement detection up to 360°, the HAL 38xy targets extended linear movement detection up to 40 mm.

HAL 36xy:
The devices of this family measure the X and Y component of a magnetic field in the sensor plane. Monitoring the relative strength of both components leads to a stable output even if the distance between magnet and sensor varies. The result is angular rotation measurement from 0° to 360° with very high accuracy over a wide temperature range. The first member of this family is the HAL 3625.

HAL 38xy:
The devices of this family measure either the X or Y component in conjunction with the Z-component of a magnetic field. Together with its 32-setpoint linearization feature, this family offers superior system performance for extended linear movement detection while using small magnet circuitry. The first member of this family is the HAL 3855.

The sensors are housed in a small SOIC8 SMD package, producing an analog, radiometric output. They include an integrated wire-break detection feature that works in conjunction with a pull-up or pull-down resistor to detect fault conditions. Internal digital signal processing algorithms in conjunction with integrated non-volatile memory enable customization and robust calibration for application-specific impairments. Easy-to-use LabVIEW™-based software and high quality application notes accelerate development, even for novice magnet system designers. The result is a quickly developed, customized sensor system with extremely low temperature drift and insensitivity to air gap variations.

Features

- Operates from -40°C ... +170°C junction temperature
- Angular accuracy of better than ±1° over 360° range (HAL 36xy)
- Temperature drift <±1° over entire temperature range
- Stable performance with air gap variation
- Output noise less than 0.2° rms
- Programming via output pin
- Wire-break detection with pull-up or pull-down resistor
- Lock function and built-in redundancy for EEPROM memory
- Operates from 4.5 V ... 5.5 V supply voltage
- Output response time >1 ms
- Overvoltage and reverse-voltage protection on V_{DD} pin
- Short-circuit protected output

Functions

The HAL 3625 is the optimal system solution for functions such as:

- Angular measurement

The HAL 3855 is the optimal system solution for functions such as:

- Linear movement detection

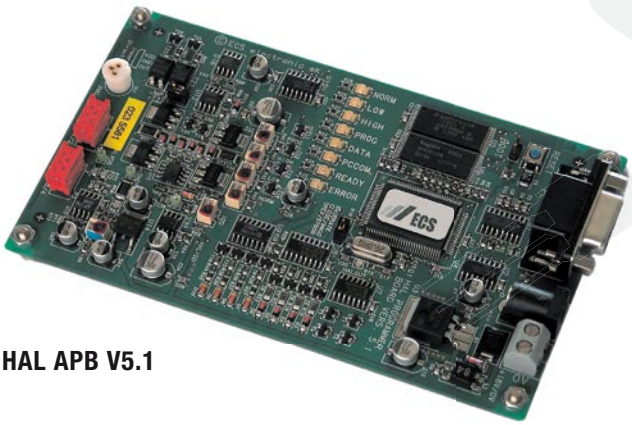
Applications

- Rotary position
- Leveling
- Torque sensing

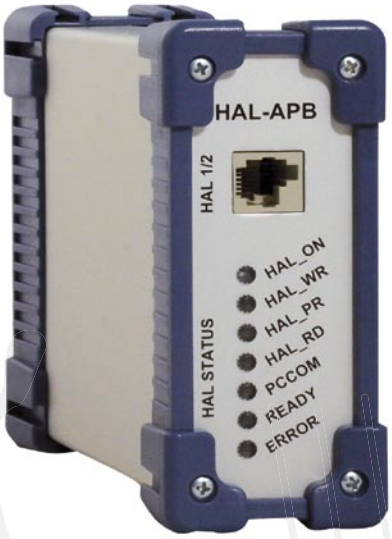
License Note

The HAL 36xy/38xy uses licenses of the Fraunhofer Institute for integrated circuits IIS.

4.13 TOOL CHAIN FOR HALL-EFFECT SENSORS



HAL APB V5.1



HAL APB V1.5

Micronas provides two dedicated programming boards supporting all programmable sensors. These two programming boards are used as a general-purpose programming interface, which is capable of addressing all programmable Micronas Hall-ef fect sensor families within the Micronas sensor portfolio.
The application board V1.5 (APB) can be used for the new products HAL 1820, HAL 28xy, HAL 3625, HAL 3855, CUR 31xy.
The application board V5.1 supports the following products: HAL 810, HAL 817, HAL 82x, HAL 85x, HAL 880, HAL 1000, and CUR 31xy.

Both boards provide an application software supporting a command interface for the communication with a PC. This allows the implementation of specific PC software for engineering purposes or in-line calibration.

For each of the programmable Hall sensor families, a specific PC software exists. This software provides a graphical user interface based on Microsoft® Visual Basic® or LabVIEW™ values on a PC.

4.14 HALL SENSOR ELEMENTS – NHE SERIES

Digital hall sensors as described in the previous pages are a very convenient magnetic sensor solution because they include the Hall element, amplifier and the signal evaluation circuit on one single chip. In some special cases, however, it is necessary to develop an individual signal evaluation circuit, e.g. if very low electrical power consumption is required. For these applications we offer Hall elements in the very small SOT-23 housing. In this case the vertical magnetic field component that is perpendicular to the PC board is measured. A vertical type is also available which detects horizontal magnetic field components parallel to the PC board (NHE529).

Specifications of hall sensor elements

SHAPE	PART NUMBER	DIMENSIONS AND DETECTION DIRECTION	HALL OUTPUT VOLTAGE V_H V_C = 1 V, B = 50 mT	OFFSET VOLTAGE V_O V_C = 1 V, B = 0 mT	INPUT/OUTPUT RESISTANCE R_{IN}/R_{OUT} @ 1 mA
	NHE520 NHE520R	SOT-23 (2.9×2.9×1.1) mm (vertical field detection)	122 mV ... 320 mV	-7 mV ... 7 mV	240 Ω ... 550 Ω
	NHE520SR	(2.9×3.83×1.1) mm (vertical field detection)			
	NHE524	(2.9×2.9×2.67) mm (vertical field detection)			
	NHE528	(2.1×2.1×0.8) mm (vertical field detection)			
	NHE529	(2.7×2.1×1.57) mm (horizontal field detection)			

Features

- High sensitive type hall element of evaporated InSb film
- High sensitivity for effective performance in low magnetic fields
- Appropriate input and output resistances for transistor circuits
- Operating temperature: -20 °C ... +110 °C
- Power dissipation: 150 mW
- Max. input current: 20 mA at 25 °C

Applications

- Brushless motors, e. g. CD-ROM drive
- Noncontacting magnetic sensors, e. g. position sensors, rotation sensors or other magnetic flux sensors

There is a wide variety of sensor applications and the previous chapters cover the most common sensor applications like temperature measurement, optical and magnetic sensors. There are still a lot of interesting sensor products left in our product portfolio, which do not fit into these three categories. We have decided to present some of them in this chapter "Special sensors". At first glance some products seem to have nothing to do with sensors like solar cells or ultraviolet LEDs. But these products may become more and more interesting for some innovative applications like for example in "Green Sensor Products".

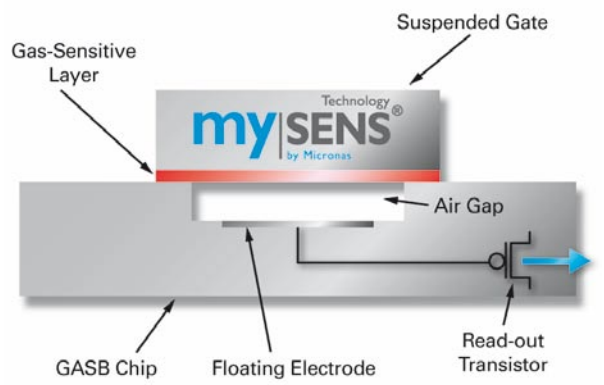
MICRONAS

5.1 GAS SENSOR CHIP mySENS®

The **Micronas CCFET sensor** (CCFET = Capacitive-Coupled Field-Effect Transistor) represents a new versatile integrated sensor technology. This sensor technology aims at the detection of concentration changes of selected gases in ambient environments in a broad variety of different applications.

The fabrication process is embedded into Micronas' CMOS manufacturing technology. Thus, the sensor is integrated with control and evaluation electronics into one single chip, profiting from both miniaturization, as well as design experience of advanced semiconductor technology. The sensor is based on a conventional MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) with its floating gate connected to a large sensing electrode. The electrode is capacitively coupled to a gas-sensitive layer on a suspended gate that is mounted on top of the chip, with an air gap in between. Any gas induced change of the sensitive layer's surface potential induces a modulation of the read out transistor, that is detected by the integrated electronics.

The interaction between sensitive layer and ambient gas molecules is a dynamic process that reacts directly to gas concentration changes. As these processes already take place at room temperature, an unheated low-power operation is possible for certain gas species.



The CCFET sensor platform can be individually tailored to a specific sensing task by choosing the appropriate sensitive layer for the suspended gate. A variety of different materials is available, including noble metals, metal oxides or organic layers, depending on the application.

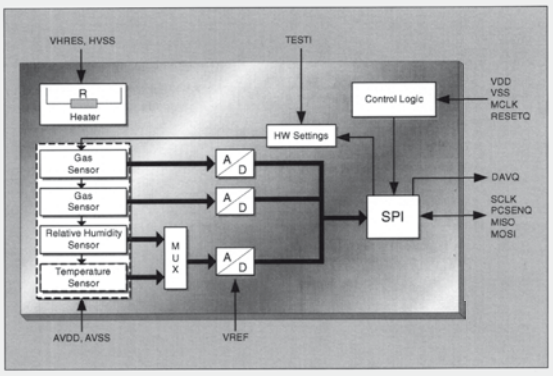
Micronas has developed a patented sensor set-up for drift reduction and temperature compensation. The latest sensor chip generation includes two individual CCFET modules, a temperature sensor, a relative humidity sensor, and electronic components, such as voltage and power regulators, A/D and D/A devices and a digital control interface.

The CCFET sensor solution provides significant advantages in system size and power consumption.

For prototype evaluation, the sensor is mounted in a standard small form factor package, sealed against dust by a diffusion membrane. Different package options are possible.
Contact us and find out about the benefits of mySENS®.

GAS SENSOR CHIP mySENS®

GASB block diagram



With the GAS 85xyB sensor chip, Micronas introduces a patented set-up for drift reduction and temperature compensation. This IC contains two CCFET gas sensing channels (CC1, CC2), a temperature and a humidity sensor (RH). Each sensor channel has its own ADC which can digitally be read by the use of a SPI interface. The SPI interface is also used to configure and control this IC.

Technology

- Versatile, integrated digital gas sensor technology
- CCFET technology for gas detection
- No heating required for most target gases
- Fast detection of concentration changes of selected ambient trace gases
- Adjustable detection spectrum (by sensing layer and algorithms)
- Fabrication process embedded into Micronas' CMOS manufacturing technology

Features

- Two independent gas sensor units
- Integrated temperature sensor
- Integrated relative humidity sensor
- Digital SPI interface
- Integrated heating option
- Measurement ranges from ca. 100 ppb to 1% gas concentration (exact values vary by target gas)
- Target gases: NO_2, NH_3, H_2, VOC (volatile organic compounds)
- Robust against overdose gas concentration exposure
- Operates from -40 °C up to +85 °C ambient temperature
- Operates from 5 % up to 95 % relative humidity
- Low current consumption (unheated average operation <20 µA, @ 1 measurement per second)
- Long product life time (qualification acc. to JEDEC standard)
- Small 11.5 mm × 11.5 mm ceramic LCC sensor package with integrated Teflon™ particle filter

Generic applications

GAS85xyB is the optimal system solution for:

- Detection of presence or concentration changes of ambient trace gases
- Upgrading temperature and relative humidity applications with gas detection

Applications examples

- Early fire detection
- Indoor / in-cabin air quality
- Demand-controlled ventilation/HVAC
- Coolant leakage (NH_3 or CO_2)
- Nuisance prevention (NH_3 or NO_2)

GAS sensor chip application areas

Building technology

- Building automation (HVAC, air quality, DCV)
- Fire detection

Medical technology

- Breath analysis

Automotive

- Air quality
- H_2 leakage (fuel cell vehicles)

Consumer

- Air quality, e. g. ozone
- Portable fire detector, e. g. cell phone

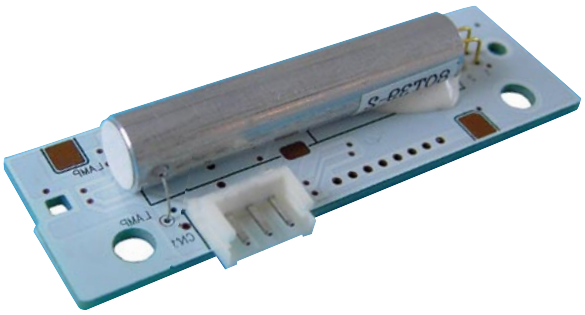
Industrial and environmental analytics

- Process monitoring and control, storage applications, e. g. food
- Work place security, e. g. CO_2, NH_3...

GASB product versions

Target gases	Product code
H_2 + NH_3	GAS 8514B
H_2 + NO_2	GAS 8516B
NH_3 + VOC	GAS 8545B
NH_3 + NO_2	GAS 8546B
VOC + NO_2	GAS 8556B

5.2 CO_2-GAS SENSOR MODULE



Features

- » Size of PCB (L×W×H): 65 mm×20 mm ×9 mm max.
- » General / electrical characteristics:
  - Output: PWM, Open Collector to GND max. 5 mA
  - Operating temperature:: +5°C ... +30°C
  - Operating humidity: 20% ... 100% non-condensing
  - Supply voltage: 5 VDC ±0.5 VDC
  - Current consumption: 80 mA (ave.), <150 mA (peak)
- » CO_2 - measurement:
  - Type of measurement: NDIR
  - Measurement range: 400 ppm ... 4,000 ppm CO_2 by volume
  - Resolution: < 20 ppm CO_2
  - Response time (90%): < 180 seconds
  - Warm-up time: < 30 seconds operational < 15 minutes full accuracy
- » PWM - output cycle:
  - Cycle period: 1004 ms ± 5 %
  - Cycle start high level: 2 ms (nominal)
  - Cycle end low level: 2 ms (nominal)

The **module CO2-4K-3M-P** is designed to measure the concentration of carbon dioxide in the air. This concentration is a reliable indicator for the "quality" of the air in e.g. a conference room. The higher the concentration of CO_2 the worse is the quality of the air. High values of CO_2 concentration in the air make a person tired and the mental performance will decrease. In "fresh air" the concentration of CO_2 is 0.034% (vol) which corresponds to 340 ppm. The indoor concentration in offices should not exceed 1000 ppm, and the maximum allowable concentration is 5000 ppm.

The CO_2 module CO2-4K-3M-P is based on an optical mesurement principle. Infrared radiation of wavelength 15 µm is emitted from a light source and is detected by a wavelength selective detector. Depending on the length of the optical path and the concentration of CO_2 the light is absorbed (and re-emitted in all directions).

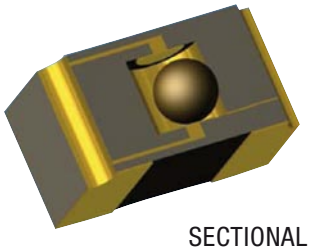
Measurement range is 400 ppm ... 4000 ppm with a resolution of 20ppm. The response time is about 180 seconds and there is no pump necessary to drive the module. Output format is PWM.

Applications

Typical applications of CO_2 level control in:

- » Public buildings
- » Offices
- » Vehicles

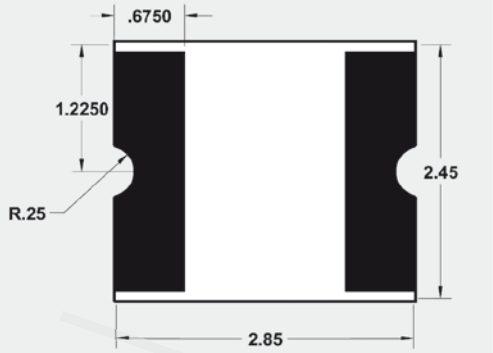
5.3 VIBRATION SENSORS VS1 AND VS2



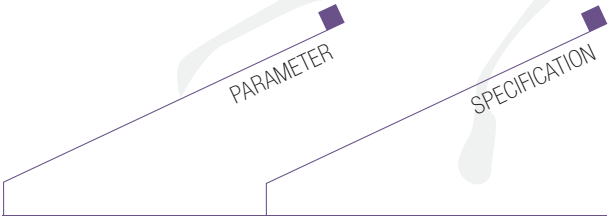
SECTIONAL VIEW VS2

2 CONTACT AREAS

Dimensions (mm)



Height: 1.7 mm



Specifications of VS1/2

Rated voltage	+15 V max.
Reaction point	50 mg approx.
On-resistance	less than 100 Ω
Dimensions	2.45 mm × 2.85 mm × 1.7 mm
Operating temperature	-20°C ... +70°C
Rec. soldering conditions	260°C, 10 s

Energy saving aspects of products (‚green products') get more and more important. A common method to achieve this, is to put the system in a low power state as long as the system is not used (sleep mode), and to wake up the system as soon as it is used. Normally a sensor is needed to switch from sleep mode to normal operation. Our VS1 and VS2 are perfectly suited to detect movements of handheld devices and to trigger the wake up of the system.

Endrich provides these surface mountable micro vibration sensors VS as a replacement of a mercury switch. The sensors detect vibrations by bridging a high ohmic gap in a P.C.B. with a micro ball (ø 0.8 mm). During vibration the resistance between both contact areas changes from some MΩ to less than 100 Ω.

Compared to VS1 type, VS2 has contacts on both sides (top and bottom) of the cylindric tube, whereas VS1 only has a contact at the bottom side. Therefore VS2 has nearly omnidirectional sensitivity characteristics.

Features

- Small size 2.45 mm × 2.85 mm × 1.7 mm
- Mercury-free, RoHS compliant
- Low R_{ON}: 100 Ω
- low noise
- Surface mountable
- Material:
  - housing: FR4 glass fibre reinforced
  - internal switching contact: Cu/Ni/Au
  - ball: steel, gold-plated
- Packaging: 1,000 pcs./reel or 2,000 pcs./reel
- Minimum order quantity: 100 pcs.

New:

Vibration sensor with reduced sensitivity available soon, please contact us!

Applications

- Motion detection
- System wake up-low power
- Presence detection

5.4 UV-LED – OCU-400 (LOW POWER) / OCU-440 (HIGH POWER)

The extension of the LED wavelength towards the near UV region requires both, new chip material and new packaging technologies. Our supplier has developed two new LED packages to meet the high reliability expactations especially for UV-LEDs. These SMD UV-LEDs are lead-free reflow solderable and RoHS compliant. They provide a low level of internal fluorescence for low background radiant sources.

Applications

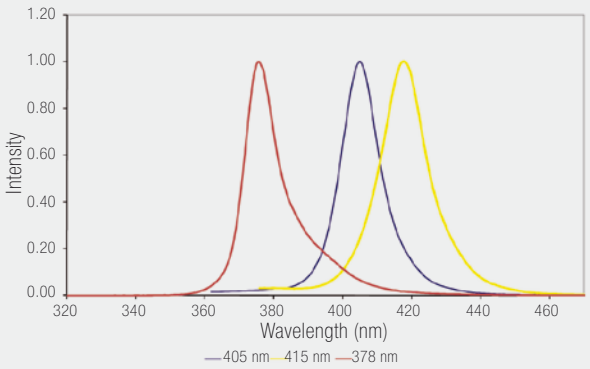
- Genuineness of a document
- Hardening of lacquer and glue
- Hardening of dental fillings

OCU-400 family

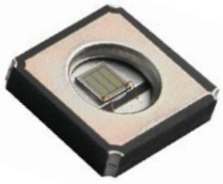
The package family **OCU-400,** based on Al_2O_3 substrate, meets the requirements of low power applications with electrical power dissipation of max. 80 mW. Available wavelengths are in the range of 378 nm ... 430 nm.
Dimensions: 3.0 mm(L)×2.0 mm(W) ×1.0 mm(H)

PART NUMBER	WAVELENGTH (nm)		OPTICAL POWER (mW)	
	min.	max.	min.	max.
OCU-400 UA375	375	380	1.5	4
OCU-400 UE400	400	405	8	16
OCU-400 UE410	410	415	8	16
OCU-400 UE415	415	420	8	16

UV-spectrum range



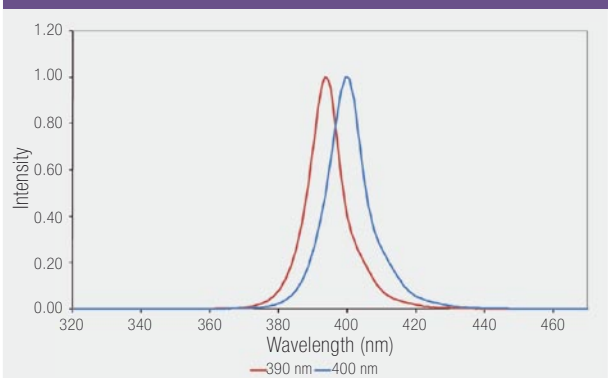
OCU-440 family



The package family **OCU-440,** based on AIN ceramics substrate, enables high power applications up to 1.5 W electrical power dissipation. At present the available wavelengths are between 365 nm and 430 nm.
Dimensions: 3.8 mm(L)×3.8 mm(W) ×0.9 mm(H)

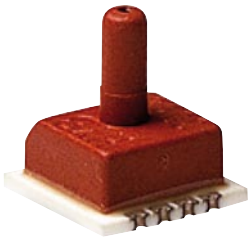
PART NUMBER	WAVELENGTH (nm)		OPTICAL POWER (mW)	
	min.	max.	min.	max.
OCU-440 UE365	365	370	40	90
OCU-440 UE380	380	385	90	160
OCU-440 UE390	390	395	130	260
OCU-440 UE400	400	405	190	310

UV-spectrum range



NEW: OLU-T18, 260 nm, 280 nm, 310 nm in TO-39 package.

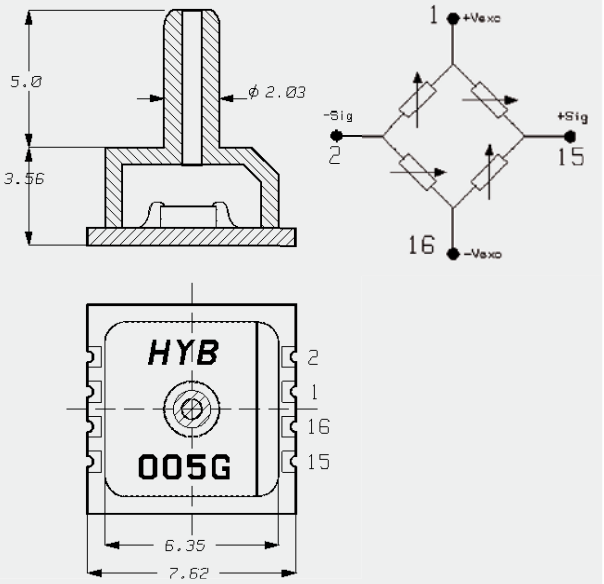
5.5 PRESSURE TRANSDUCER – HPSA 1000



Features / Benefits

- Low cost
- Easy to use package – SMD (surface mount device)
- Compact and light weight
- High sensitivity
- High performance, stable silicon chip and package
- Industrial temperature operating range (-25 up to 85°C)
- Gage and absolute configurations

Dimensions (mm) / pinout



Applications

- Medical instrumentation
- Respirators
- Air flow monitoring
- Process control
- Leak detection
- Pneumatic controls
- Altimeters

Pressure transducer model HPSA 1000 is a SMT pressure sensing device with close bridge configuration for mounting on PCB boards or other substrates. High performance and accuracy enables the use of this transducer in many applications, and with its compact and handy design it is very suitable for users. This transducer is suitable for any type of application with dry air or non-corrosive gases.
The model HPSA 1000 family consists of pressure ranges from **50 mbar up to 7 bar**.

The digital version **HPSD 1000** with I²C output is also available.

PARAMETER SPECS

Specifications of HPSA 1000-100M (100mbar)	
Pressure range	100 mbar (1.5 psi)
ID group	HPSA 1000-100M
V_{OUT}	30 mV ... 130 mV
$V_{OFS(MAX)}$	-100 mV / + 40 mV
Operating temperature	-25 °C ... +85 °C
Over pressure	1 bar
Burst pressure	1.5 bar

T_{AMB}=25 °C, V_{CC}=5 V, unless otherwise noted

PARAMETER SPECS

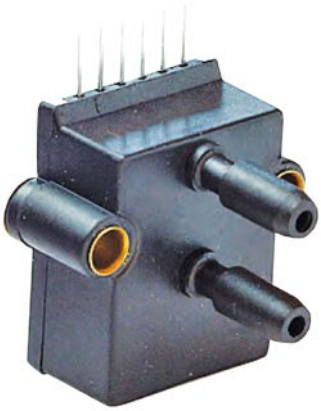
Performance characteristics	
Excitation current	1 mA typ. / 3 mA max.
Excitation voltage	5 V typ. / 10 V max.
Bridge resistance	2 kΩ min. / 6 kΩ max.
TC Span (0°C to 70°C)	typ. -0.20 %FS/°C
TC Offset (0°C to 70°C)	typ. -0.01 %FS/°C
TC Resistance (0°C to 70°C)	typ. 0.27 %FS/°C
Pressure hysteresis & nonlinearity	0.2 %FS typ. 0.5 %FS max.

T_{AMB}=25 °C, V_{CC}=5 V, unless otherwise noted

PRESSURE TRANSDUCERS – HPSAC 300 & HPSAV 4000

Pressure transducer model HPSAC 3000 is a temperature compensated pressure sensing device with zero calibrated output.
High performance and accuracy enables the use of this transducer in many applications, and with its compact and handy design it is very suitable for end users. The HPSAC 3000 pressure transducers are constructed on 1 mm thick ceramic substrate with one or two pressure tubes. Thick film resistors printed on the substrate are individually laser trimmed to provide temperature compensation and zero calibration. An additional resistor is trimmed according to individual transducer span to provide easy transducer amplification with an external differential amplifier. The pressure media compatible with this transducer family are dry air or non-corrosive gases and liquids.

The model HPSAC 3000 is designed for constant current excitation. The whole family includes pressure ranges from 10 mbar up to 7 bar.



The pressure transducer model HPSAV 4000 is an OEM pressure sensing device with temperature compensated and calibrated output.
This transducer was specially designed to provide a stable output signal (offset and span) over a wide temperature range from 0 to 70°C. Thick film resistors printed on a substrate are individually laser trimmed to provide temperature compensation, zero and span calibration. Two additional pins provide a temperature signal for external temperature measurement if required. The pressure transducer is intended for use with non-corrosive gases and fluids.

The HPSAV 4000 is designed for constant voltage excitation for pressure ranges from 10 mbar up to 7 bar.

Features for HPSAC 3000 and HPSAV 4000

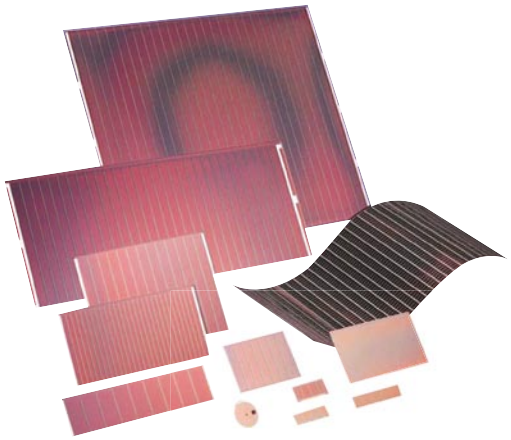
- Constant current excitation (HPSAC 3000)
- Constant voltage excitation (HPSAV 4000)
- Easy to use DIP package
- Wide compensated range (0°C ... +70°C)
- Zero calibration (HPSAC 3000)
- Zero and span calibration (HPSAV 4000)
- Radiometric 90 mV full scale output (HPSAV 4000)
- Differential and absolute configurations (HPSAV 4000)
- Differential, gage and absolute configurations (HPSAC 3000)
- Wide pressure range from 10 mbar ... 7 bar

Applications

- Medical instrumentation
- Respirators
- HVAC
- Process control
- Leak detection
- Pneumatic controls
- Altimeters

Please contact us for models with other parameters!

5.6 AMORPHOUS SILICON SOLAR CELLS – AMORTON



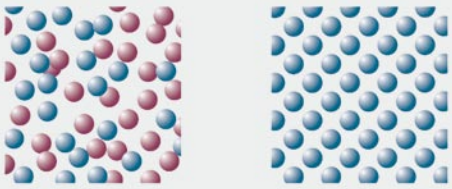
Solar cells are classified acc. to the material employed, i. e., crystal silicon, amorphous silicon, and compound semiconductor solar cells. Unlike crystal silicon, in which atomic arrangements are regular, amorphous silicon features irregular atomic arrangements as shown in the figures below.

Amorton is an integrated amorphous silicon solar cell which has been developed by SANYO. Amorton uses silane (SiH_4) as its source gas and is fabricated using a plasma CVD method. Three amorphous silicon layers – p-layer, i-layer, and n-layer – are formed consecutively on a glass substrate. This p-i-n junction corresponds to the p/n junction of a crystal silicon solar cell. In the process of this junction formation, a number of cells are connected in series on a substrate at one time. This allows any desired voltage to be obtained for a variety of equipment operation.

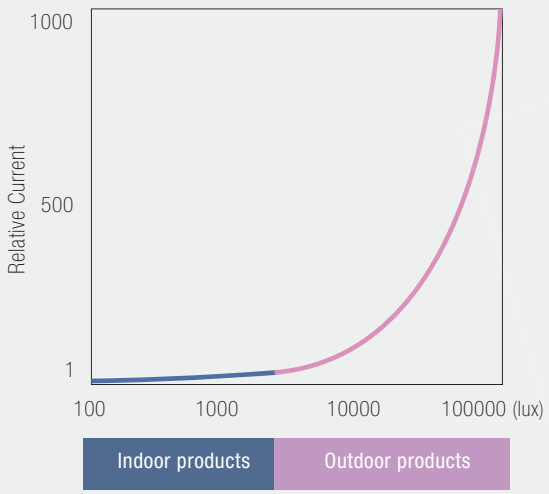
Features

- For indoor and outdoor use
- Glass substrate:
  low price (basic substrate)
- Stainless steel substrate:
  Thin, light weight, unbreakable, can easily be formed in arbitrary shapes, highly precise dimensions
- Film substrate:
  Thin, light weight, unbreakable, bendable, can easily be formed in arbitrary shapes
- Solar cells with a variety of voltages can be created
- Solar cells with a variety of shapes can be created

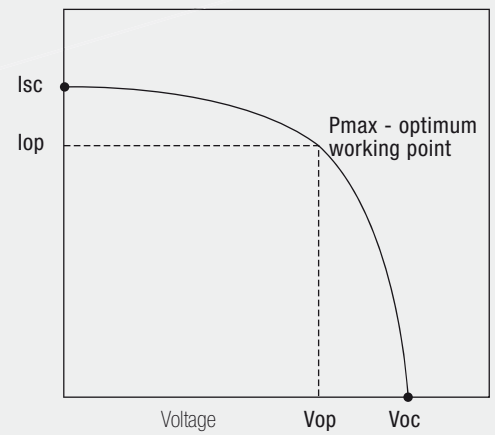
Amorphous atomic arrangement



Relationship between illumination level and output



Current-voltage curve



Voc: open-circuit voltage
Isc: short-circuit current
Vop: optimum operating voltage
Iop: optimum operating current
Pmax: maximum output

AMORTON – INDOOR

Amorton Products for Clocks (Application Example)

STAINLESS STEEL | GLASS | FILM

Applications

- Wrist watches (solar watches)
- Sensor lights
- Battery chargers
- Clocks
- LED blinkers (curbstone markers)
- Solar driven GSM/GPS modules

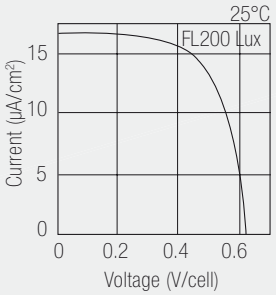
Output characteristics — indoor use Amorton

Indoors, artifical light, such as fluorescent and incandescent light, is used. The illuminance of these light sources ranges from 20 lux to 1,000 lux. Indoors, therefore, Amorton is most suitable for small equipment such as electronic calculators. Please use indoor Amorton solar cells under 1,000 lux.

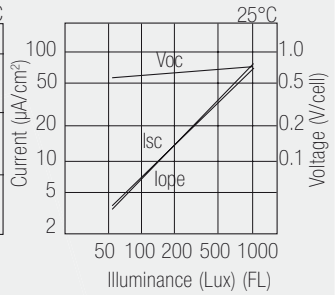
OPEN-CIRCUIT VOLTAGE	SHORT-CIRCUIT CURRENT	MAX. OUTPUT	LIGHT SOURCE
0.63 V/cell	17.0 μA/cm²	7.0 μW/cm²	FL200 lux

Output characteristics

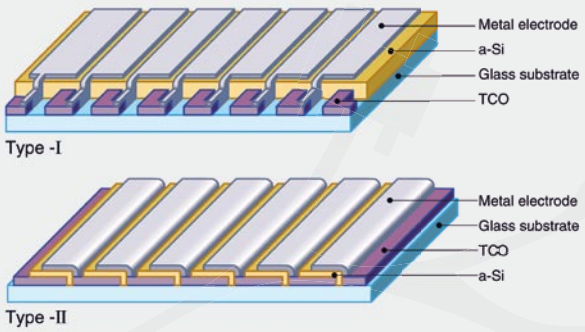
Current - Voltage Characteristics of a Cell



Output Illuminance Depency Characteristics



Configurations



Configurations of indoor use Amorton

Amorphous silicon solar cells can be directly connected in series using appropriate electrode patterns. Amorton, an integrated amorphous silicon solar cell, allows many cells to be arranged on one substrate and connected in series. There are two types of Amorton for indoor use:

Type I, in which cells are connected at their edges, and

Type II, in which cells are connected along the entire length of their sides.

AMORTON – OUTDOOR

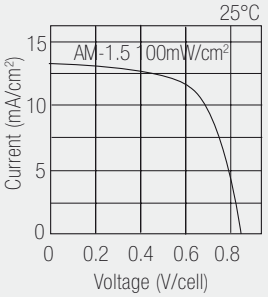
Output Characteristics — Outdoor Use Amorton

Natural light ranges in illuminance from 10,000 lux to 100,000 lux (AM-1.5, 100mW/cm²) or more.

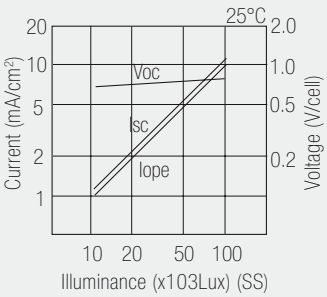
OPEN-CIRCUIT VOLTAGE	SHORT-CIRCUIT CURRENT	MAX. OUTPUT	LIGHT SOURCE
Typical cell characteristics			
0.84 V/cell	13.3 mA/cm²	7.48 mW/cm²	AM-1.5 100 mW/cm²

Output characteristics

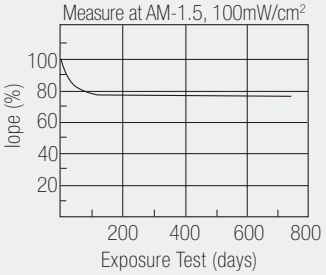
Current - Voltage Characteristics of a Cell



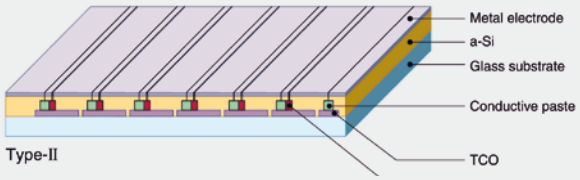
Output Illuminance Depency Characteristics



Lightproof (Leaving Outdoors)



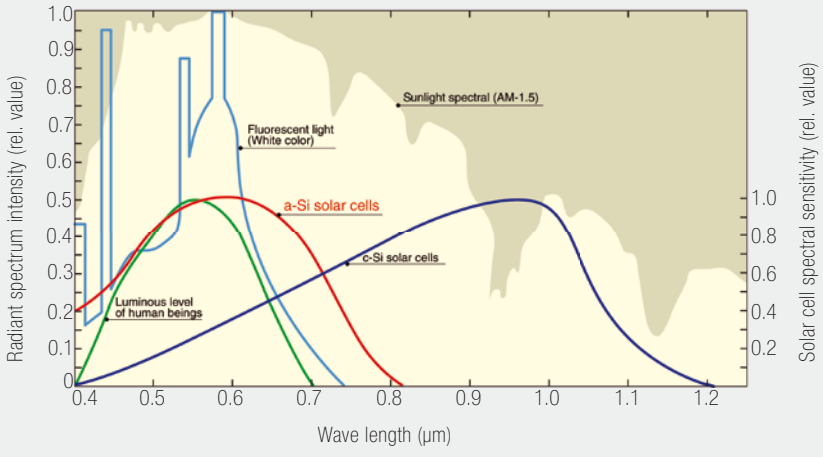
Configurations



Configurations of Outdoor Use Amorton

Amorton for outdoor use has the adjoining-mentioned Type II configuration to reduce output loss under high illuminance.

Radiant spectrum of ligt source and spectral sensitivity of solar cells



PART NUMBER	TYPICAL OPERATING CHARACTERISTICS (FL-200 lux)	TYPICAL OPERATING CHARACTERISTICS (Ref:FL-50 lux)	EXTERNAL DIMENSIONS (mm)	WEIGHT (g)
Specifications of Amorton glass substrate – indoor products				
AM-1407	1.5 V / 11.5 µA	1.4 V / 2.85 µA	38.0 × 12.5	1.30
AM-1417	1.5 V / 12.5 µA	1.4 V / 3.10 µA	35.0 × 13.9	1.30
AM-1424	1.5 V / 20.0 µA	1.4 V / 5.00 µA	53.0 × 13.8	2.00
AM-1437	1.5 V / 8.0 µA	1.4 V / 2.00 µA	29.6 × 11.8	1.00
AM-1454	1.5 V / 31.0 µA	1.4 V / 7.75 µA	41.6 × 26.3	3.00
AM-1456	1.5 V / 5.3 µA	1.4 V / 1.30 µA	25.0 × 10.0	0.70
AM-1513	1.8 V / 15.0 µA	1.6 V / 3.75 µA	55.0 × 13.5	2.00
AM-1801	3.0 V / 18.5 µA	2.6 V / 4.60 µA	53.0 × 25.0	3.60
AM-1805	3.0 V / 15.5 µA	2.6 V / 3.85 µA	55.0 × 20.0	3.00
AM-1815	3.0 V / 42.0 µA	2.6 V / 10.50 µA	58.1 × 48.6	7.80
AM-1816	3.0 V / 84.0 µA	2.6 V / 21.00 µA	96.7 × 56.7	15.6

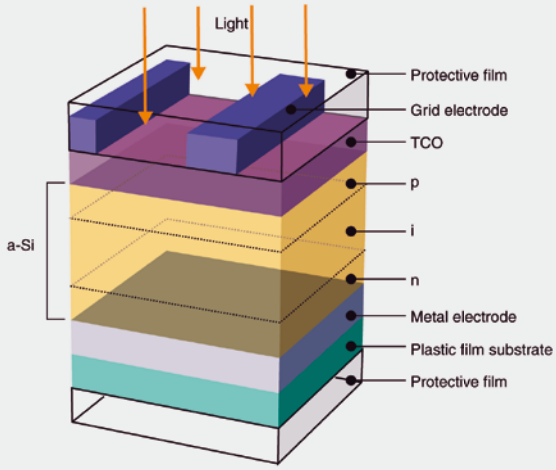
PART NUMBER	TYPICAL OPERATING CHARACTERISTICS (100 mW/cm^2)	TYPICAL OPERATING CHARACTERISTICS (Ref:SS 50 klux)	EXTERNAL DIMENSIONS (mm)	WEIGHT (g)
Specifications of Amorton glass substrate – outdoor products				
AM-5302	1.5 V / 105.0 mA	1.5 V / 47.0 mA	31.2 × 117.8	16.3
AM-5412	2.0 V / 39.0 mA	2.0 V / 17.2 mA	50.1 × 33.1	7.30
AM-5413	2.0 V / 16.3 mA	2.0 V / 7.2 mA	33.0 × 23.9*	2.10
AM-5416	2.0 V / 49.9 mA	2.0 V / 22.0 mA	60.1 × 36.7	9.80
AM-5605	3.0 V / 113.0 mA	3.0 V / 51.0 mA	62.3 × 117.8	32.5
AM-5608	3.0 V / 36.0 mA	3.0 V / 16.0 mA	60.1 × 41.3	11.0
AM-5610	3.0 V / 5.0 mA	3.0 V / 2.2 mA	25.0 × 20.0	2.20
AM-5611	3.0 V / 3.2 mA	3.0 V / 1.4 mA	33.4 × 10.0*	0.90
AM-5613	3.0 V / 31.5 mA	3.0 V / 14.0 mA	60.1 × 36.7	9.80
AM-5706	3.5 V / 45.0 mA	3.5 V / 20.0 mA	70.0 × 60.0	15.5
AM-5710	3.5 V / 32.0 mA	3.5 V / 14.0 mA	62.3 × 37.0*	6.30
AM-5812	4.0 V / 19.5 mA	4.0 V / 8.5 mA	59.0 × 28.7	4.60
AM-5902	4.5 V / 60.0 mA	4.5 V / 27.0 mA	150.0 × 37.5	25.0
AM-5904	4.5 V / 10.0 mA	4.5 V / 4.3 mA	40.1 × 33.1	5.90
AM-5907	4.5 V / 44.7 mA	4.5 V / 19.7 mA	75.0 × 55.0	18.3
AM-5909	4.5V / 22.2 mA	4.5 V / 9.8 mA	60.1 × 41.3	11.0
AM-5910	4.5 V / 88.5 mA	4.5 V / 9.8 mA	60.1 × 41.3	11.0
AM-5912	4.5 V / 15.4 mA	4.5 V / 6.8 mA	42.9 × 47.2*	5.60
AM-5913	4.5 V / 30.1 mA	4.5 V / 13.3 mA	60.1 × 55.1	14.7
AM-5914	4.5 V / 23.2 mA	4.5 V / 10.2 mA	50.1 × 55.1*	7.50
AM-5C03	6.0 V / 28.0 mA	6.0V / 12.5 mA	75.0 × 55.0	18.3
AM-5D01	6.5 V / 11.0 mA	6.5 V / 4.8 mA	100.0 × 18.0	8.00
AM-5E02	7.0 V / 23.3 mA	7.0 V / 10.3 mA	75.0 × 55.0	18.3
AM-5S04	15.0 V / 22.0 mA	15.0 V / 9.7 mA	124.5 × 57.0*	19.3
AM-5S05	15.0 V / 15.0 mA	15.0 V / 6.5 mA	124.5 × 39.3*	13.4
AM-5S06	15.0 V / 11.0 mA	15.0 V / 4.9 mA	124.5 × 29.5*	10.0
AM-7A03	5.3 V / 250.0 mA	5.3 V / 113.0mA	150.0 × 165.0	110
AM-7D08	7.0 V / 190.0 mA	7.0 V / 85.0 mA	150.0 × 165.0	110
AM-7E04	7.5 V / 115.0 mA	7.5 V / 50.0 mA	150.0 × 110.0	74.0
AM-7S03	15.0 V / 77.0 mA	15.0 V / 34.5 mA	150.0 × 165.0	110

Glass thickness with * is 1.1 mm, glass thickness without * is 1. 8 mm

AMORTON – FILM

Amorton Flexible Film is an exceptionally thin, light and flexible amorphous silicon solar cell fabricated on plastic film. In addition to these advantages, Amorton Film is also resistant to cracks. Its standard configuration includes a protective film covering the amorphous silicon solar cell which measures about 0.4 mm in overall thickness.

Amorton film configuration



Specifications of Amorton flexible film

PART NUMBER	TYPICAL OPERATING CHARACTERISTICS (100 mW/cm²)	TYPICAL OPERATING CHARACTERISTICS (Ref.SS 50 klux)	EXTERNAL DIMENSIONS (mm)	WEIGHT (g)
AT-7664	3.0V / 104mA	3.0V / 46.5mA	73..0 × 112.0 × 0.4	4
AT-7665	3.0V / 38.6mA	3.0V / 17.3mA	58..4 × 56.0 × 0.4	2
AT-7666	3.0V / 343.0mA	3.0V / 154.0mA	146.0 × 167.5 × 0.4	13
AT-7963	4.5V / 223.0mA	4.5V / 100.0mA	146.0 × 167.5 × 0.4	13
AT-7S63	15.0V / 134.0mA	15.0V / 60.5mA	292.0 × 168.0 × 0.4	25
AT-7S64	15.0V / 269.0mA	15.0V / 121.0mA	292.0 × 336.0 × 0.4	50

5.7 WIEGAND SENSOR – AN ENERGY HARVESTING COMPONENT

The Wiegand sensor - a member of the family of energy harvesting components.

The construction of Wiegand sensors is simple: It consists of a small piece of a so-called Wiegand wire, and a sensing coil which is wound around this Wiegand wire. If a magnet of suitable strength passes the sensor, the sensor delivers an electrical pulse at the output of the sensing coil. The crucial point is that this voltage peak is independent of the speed of the magnet, passing the sensor. This behavior is achieved by the special construction of the Wiegand wire inside the sensor.

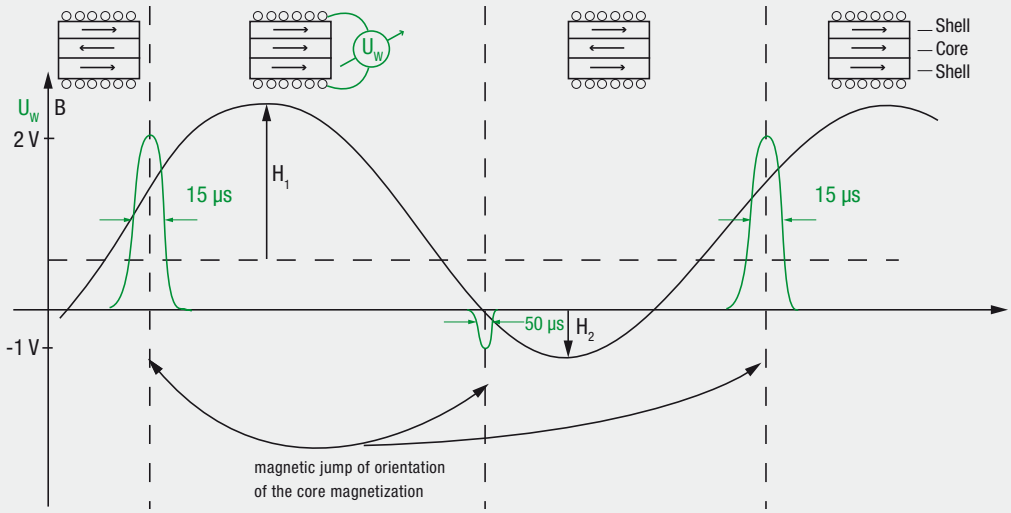
The Wiegand wire has a soft magnetic center (core) and an outer region (shell) with a higher magnetic coercivity. A fixed external field B_{offset} is applied which is enough to keep the shell polarized until its maximum, but not strong enough to turn the magnetization of the core into the same direction. As soon as an alternating magnetic field of proper strength is applied, the magnetization of the core will change its magnetization direction suddenly. At this moment, a voltage $U_W \sim \Delta B \cdot v$ is induced inside the coil which is only dependent on the speed of the magnetic domain movement (material constant) and the absolute change in magnetic flux density (ΔB), but not from ΔH/Δt.

A typical pulse width is some µs at a voltage of 1 V to 2 V.

To make the WIEGAND sensor work, it is necessary that the external, alternating magnetic field is within a given range of field strength. The alternating field can e.g. be created by a rotating wheel with some small magnets mounted on the wheel edge.

With a Wiegand sensor mounted in a proper distance of this wheel the rotations of the wheel can be detected. The sensor can also be used for detecting switching events without the need of an external power supply. The energy created by this sensor is enough to operate a suitable controller, thus these products could be interesting for all **energy harvesting** systems.

Functional principle



PART NUMBER
TRIGGERING MAGNETIC FLUX DENSITY B [mT]
OUTPUT AMPLITUDE [V]
PULSE WIDTH [µs]
OPERATING TEMPERATURE [°C]

Specifications of Wiegand sensor

	min.	typ.	max.			
WG112	2.5	7 ... 8	12	≥1.5	10 ... 50	-20 ... +125
WG311	2.5	7 ... 8	12	≥1.5	10 ... 50	-20 ... +125

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France

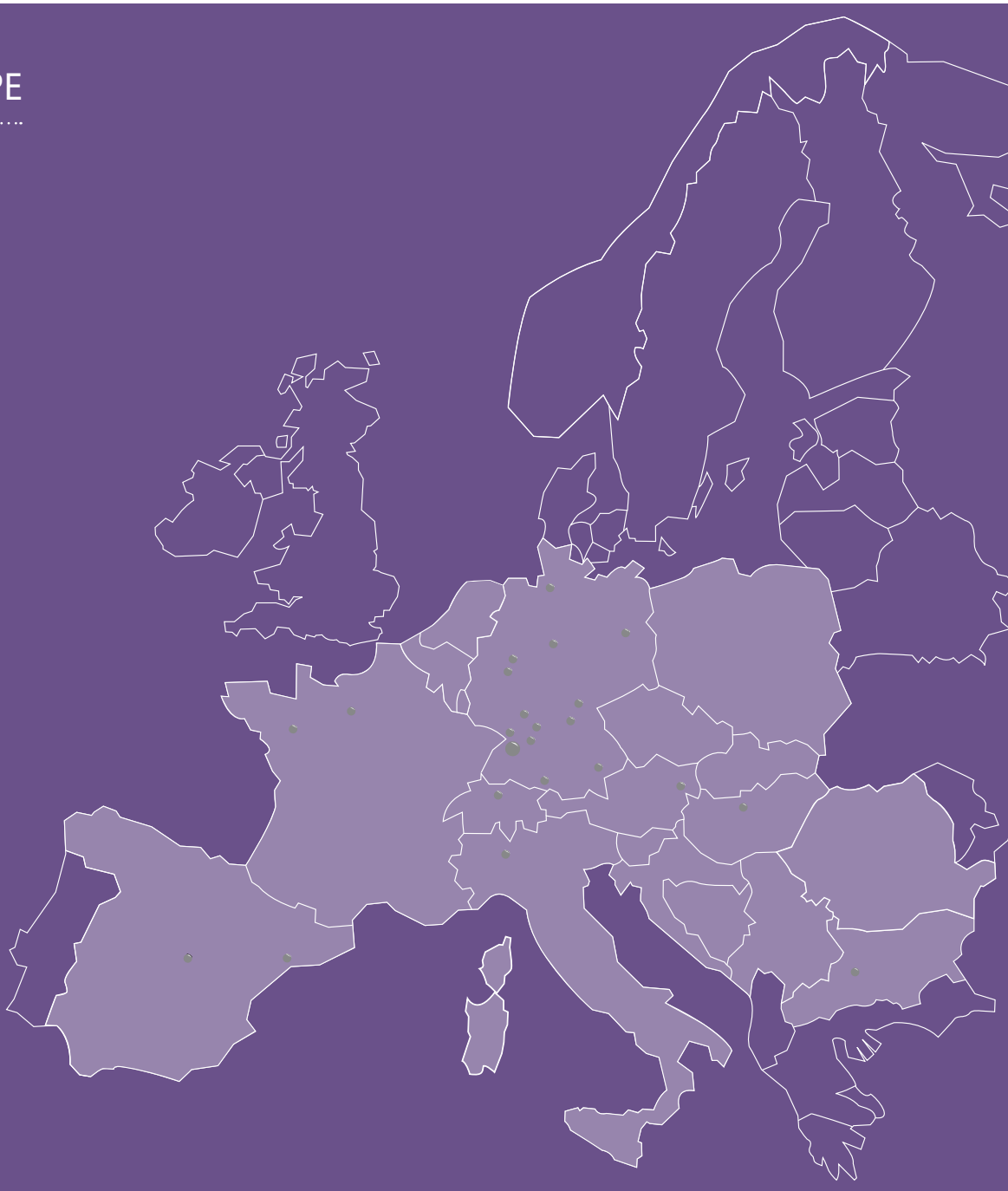
Hungary

Italy

Spain

Switzerland
novitronic
powered by endrich

Bulgaria



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