

Capacitive Sensors

Functional principle

Capacitive proximity switches detect conductive and non-conductive materials that can be in a solid or liquid state. They serve the purpose of monitoring product levels in containers, checking contents in filling and packaging systems as well as detecting, positioning, monitoring and counting objects, e.g. in sequence control systems, conveyor belts.

Used for detecting media such as:

- **solid:**
wood, ceramic, glass, paper stacks, plastic, stone, rubber, ice, nonferrous metals, potatoes
- **liquid:**
water, oil, beverages, adhesives, paints
- **granular:**
plastic pellets, granulated products, grain, fodder, wood chip
- **powder:**
dyes, detergents, sand, cement, fertilizer, salt, sugar, flour, coffee

Technical description

The function of the capacitive proximity switch is based on evaluating the influence exerted by an actuator on the electrical field at the active face of the switch. The approach of an influencing object increases the capacitance of the capacitor, which consists of a sensor electrode located behind the active face and the actuator connected to earth / mass. This increase in capacitance is dependent on the conductance and the dielectric constant of the actuator as well as its mass, surface area and its distance from the sensor electrode. The capacitive limit switch is equipped with an RC oscillator with a gain factor that increases as a result of the rise in capacitance of the previously described capacitor to such an extent that oscillation is induced. In limit switches, the capacitance required to induce oscillation can be determined by the built-in potentiometer intervening in the feedback of the oscillator.

The response sensitivity, i.e. the sensing distance with a given actuator can be adjusted in this way. The oscillator output signal is fed to an evaluation circuit that actuates the switching amplifier.

In response to the approach of **conductive** material the actuating object and the active face of the sensor form the plates of a capacitor. The change in capacitance and the consequently achievable sensing distance are large.

In response to the approach of **non-conductive** material $\epsilon > 1$ only the change in the dielectric constant is effective. The increase in capacitance is less than is the case for conductive materials. The resulting sensing distance is small.

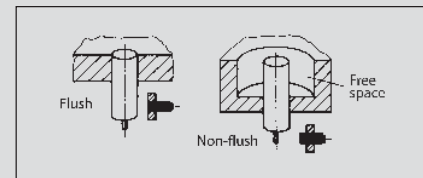
Sensitivity table	
St37 or other metals, earthed	1.00
Surface of water	1.00
St37 150 x 150 x 1 mm, not earthed	0.85
Marble 150 x 150 x 12.5 mm	0.65
Glass 150 x 150 x 7.5 mm	0.55
Stack of paper DIN A 4, 80 g/m ² , 500 sheets	0.55
Fibre board 150 x 150 x 16 mm	0.45
Ceramic tile 150 x 150 x 6 mm	0.25
PVC 150 x 150 x 4 mm	0.15

These values only indicate the expected magnitude of the response sensitivity as the specific properties of the actuating object and of the surroundings in actual applications have a considerable influence on the response distance. It is important to take into account the influence of moisture in order to ensure trouble-free operation. A high water content in the material to be detected, e.g. wood or paper, increases the sensing distance considerably.

In terms of capacitive proximity switches a distinction is made between

- flush mount and
- non-flush mount

limit switches.



In the case of non-flush mount limit switches a clearance that must contain no influencing material must be created about the switch. Due to the adjustment facility available in capacitive proximity switches, the installation of non-flush mount devices is not problematic in connection with reduced clearance. Non-flush mount capacitive proximity switches are characterised by low sensitivity to soiling or condensation.

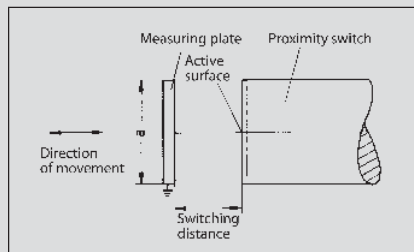
A screening electrode built into flush mount limit switches is connected to circuit ground. As both electrodes of the capacitor are now close together, flush mount capacitive proximity switches are particularly suitable for sensing dielectrics. The disadvantage is that this configuration has an increased sensitivity to condensation or soiling.

Capacitive proximity switches can mutually influence each other if they are mounted next to or opposite each other. In such configurations, the response of flush mount switches is considerably less sensitive than non-flush mount switches. Trials under actual application conditions should be carried out at distances from $> 2x$ to $< 8x$ enclosure diameter. Arrangements with distances $> 8x$ enclosure diameter are not problematic.

Active face: The active face of a capacitive proximity switch is the point at which the electrical field emerges. This point is located at the end face on types designed as threaded sleeves or smooth cylinders. Non-cylindrical limit switches are identified by a symbol on the corresponding face.

Influencing: In relation to a capacitive proximity switch the term influencing refers to the change in the switching status in response to the medium to be detected entering the electrical field.

Standard target: The standard target is defined as a square plate, 1 mm thick and made from FE 360.



The side length "a" of the square target corresponds to the diameter of the circle described by the active face. The length of its side is defined as the larger of either the active face diameter or three times the nominal sensing distance. The target must be earthed in order to ensure comparable sensing distances. The sensing distance of rectangular, capacitive proximity switches is determined by means of an earthed target with a size equal to the surface of the active side of the limit switch.

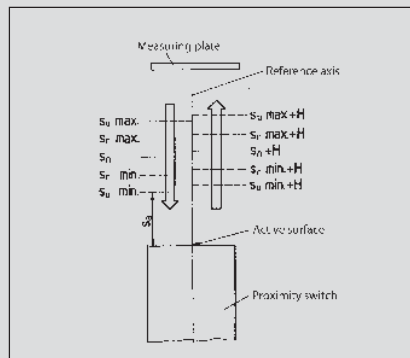
Sensing distance: The sensing distance, that changes the status of the output stage, is the distance of the influencing object in relation to the active face.

Nominal sensing distance (s_n): This is a device-specific characteristic value that does not take into account influences such as tolerance, temperature and changes in voltage.

Real sensing distance (s_r): The real sensing distance is measured at a rated voltage and an ambient temperature of 23 °C +/- 5 °C. It must be between 90 % and 110 % of the nominal sensing distance.

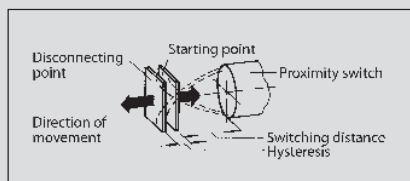
Useable sensing distance (s_u): The useable sensing distance is measured within the permissible temperature and voltage ranges and is 80 % – 120 % of the real sensing distance.

Assured sensing distance (s_a) (operational sensing distance): This is the distance that can be used effectively under the influence of temperature, voltage as well as tolerance variables. It is between 0 % and 72 % of the nominal sensing distance.

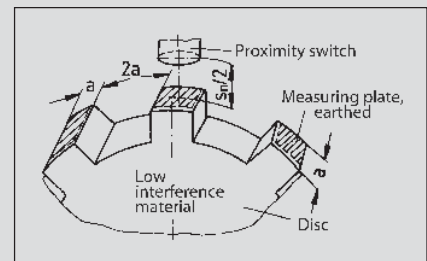


Reproducibility: The reproducibility of the switching distance is the repeat accuracy of the real sensing distance of two successive switching operations within a period of 8 hours at an ambient temperature between 18 °C and 28 °C and a supply voltage that may not deviate by more than 5 % from the rated voltage. The difference between any two measurements must not be more than 10 % of the real sensing distance.

Switching hysteresis: The switching hysteresis refers to the difference between the switch-on point as an object approaches the target and the switch-off point as the object moves away from the proximity switch. The value is specified as a percentage of the real sensing distance.



Switching frequency: The switching frequency is measured in accordance with EN 60947-5-2. The standard targets with the side length "a" are mounted on a plate that exerts minimum influence at "2a" intervals and are moved passed the proximity switch to be tested at half the nominal sensing distance. The maximum switching frequency is reached when the switch-on or switch-off time of the proximity switch is 50 µs. In the case of AC proximity switches, the maximum switching frequency is reached when the switch-on and switch-off time is equal to the half wave period of the supply frequency.



Temperature range: In accordance with DIN, the temperature range is from -25 °C to +70 °C. Reliable operation is ensured within this range.

Protection class

Corresponding to their ID code, the enclosures are dustproof and waterproof in accordance with IP 65 or IP 67 (DIN 40050).

Connection cable

A PVC-insulated connection cable is supplied as standard. Special versions with silicone sheathing, polyurethane sheathing, irradiation cross-linked PVC or Teflon insulation are also available.

Plug connection

Nowadays the plug connection is just as significant as the fixed cable on electronic proximity switches. The capacitive proximity switches in the BERNSTEIN range can be equipped with a wide variety of plug connections. As standard, this catalogue contains connector versions of virtually all types of limit switch.

Standards

All sensors conform to EN 60947-5-2



Capacitive Sensors

Important information

Capacitive sensors are able to detect conductive and non-conductive materials in solid, liquid, granular or powder form. However, certain criteria must be taken into account in practical applications.

Sensing distance

The nominal sensing distances are specified and set at the factory in accordance with DIN EN 60947-5-2/98. The maximum sensing distance is achieved on approach of **conductive** materials of corresponding size.

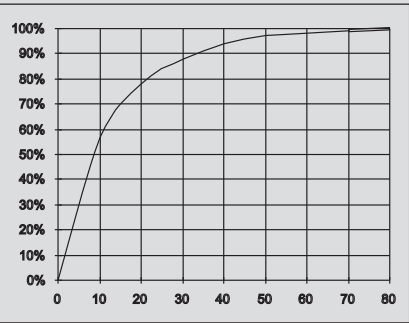
On approach of **non-conductive** materials, the dielectric constant ϵ of the material to be detected is of decisive significance. Depending on the application, the specified sensing distances vary by a certain factor in relation to the dielectric constant. The values determined according to the table only indicate the expected magnitude of the response sensitivity as the specific properties of the actuating object (diameter, thickness, moisture content etc.) and of the surroundings (earthing) in actual applications have a considerable influence on the response distance. In most cases adaptation to the specific application can be achieved by adjustment with the built-in potentiometer.

Clearance

In the case of non-flush mount capacitive sensors a clearance that must contain no influencing material must be created about the sensor. Non-flush mount capacitive sensors are characterised by low sensitivity to soiling or condensation. On account of their design, flush mount capacitive sensors are particularly suitable for sensing dielectrics. The increased sensitivity, however, may be detrimental in terms of the above mentioned parasitic effects.

If capacitive proximity switches are to be mounted opposite or next to each other, trials under actual application conditions should be carried out at distances between 2x and 8x enclosure diameter. Thanks to the adjustment facility, however, adaptation to specific applications is almost always possible.

Examples of dielectric constants	
Glass	3 ... 14
Rubber	2.5 ... 3
Laminated paper	3.5 ... 6
Wood	2.5 ... 6.8
Marble	8.4 ... 14
Mineral oil	2.15
Epoxy resin	3.3 ... 3.6
Petroleum	2.2
Plexiglas	3.6
Polyamide	3 ... 8
PVC	3.3 ... 4.1
Porcelain	4.2 ... 6.5
Teflon PTFE	2
Air	1
Water	80.8
Paper (dry)	2



Variance of sensing distance as a function of ϵ

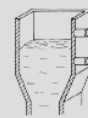
Application descriptions

A particular application of capacitive proximity switches is to detect levels in non-metallic containers from the outside. Advantage: There is no need to make a hole in the container wall for the purpose of detecting product level. The medium to be detected does not come in contact with the limit switch. The prerequisite is that the dielectric constant and the mass of the material to be detected are greater than that of the container. The response sensitivity of the proximity switch must be reduced with the built-in potentiometer to such an extent that the limit switch does not respond to the container wall but rather to the medium to be detected.

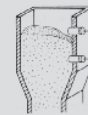


Above: Insulation glass production lines equipped with BERNSTEIN capacitive sensors

Further fields of application are illustrated below.



Level monitoring in non-metallic containers



Level monitoring of bulk material, e.g. granulated material, fodder



Stack height scanning, e.g. paper, chip board



Fill level monitoring in paint and adhesive containers



Registering, counting, sorting or monitoring in conveyor belt systems



Detecting, positioning in sequence control systems



Detection in woodworking applications



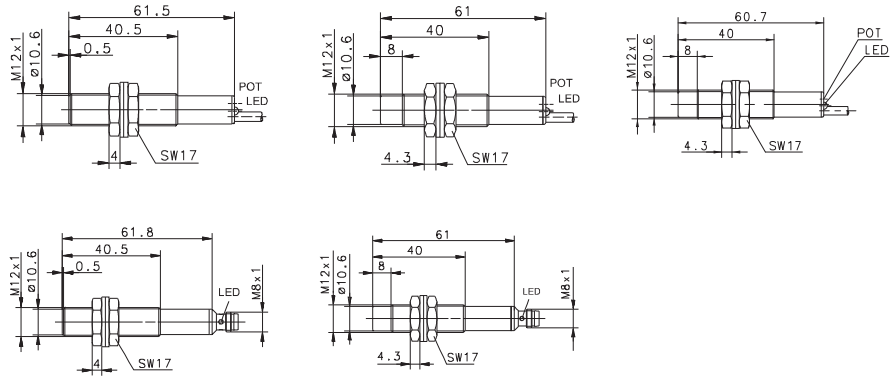
Belt breakage signalling



Level monitoring in packing systems

Capacitive Sensors (Type M12, M18)

Type	M12		M12		M12
Type of installation	Flush	Flush	Non-flush	Non-flush	Non-flush
Nominal sensing distance	2 mm	2 mm	4 mm	4 mm	6 mm
Type of connection	Cable 2 m	Connector M8	Cable 2 m	Connector M8	Cable 2 m
Special feature					Sensing dist.



PNP	DC	NO contact	6507903001 KCB-M12PS/002-KLP2	6507903004 KCB-M12PS/002-KLSM8	6507919001 KCN-T12PS/004-KLP2	6507919004 KCN-T12PS/004-KLSM8	6607919110 KCN-T12PS/006-KLP2E
		Type NC contact Type Antivalent NO/NC Type					
NPN	DC	NO contact	6507303001 KCB-M12NS/002-KLP2	6507319001 KCN-T12NS/004-KLP2			
		Type NC contact Antivalent NO/NC					
PNP/NPN	DC	NO/NC prog. push-pull operation					
NAMUR	DC						
Analogue	DC						
2-wire	DC	NO contact					
		NC contact					
	AC	NO contact					
		Type					
		NC contact					
		Type					
		Changeover contact					

Technical data

Rated operating voltage	U_b	10–36 VDC	10–36 VDC	10–36 VDC	10–36 VDC	10–36 VDC
Rated operating current	I_b	≤ 200 mA	≤ 200 mA	≤ 200 mA	≤ 200 mA	≤ 200 mA
Switching frequency (max)	F	25 Hz	25 Hz	25 Hz	25 Hz	25 Hz
Short circuit-protection		Cyclic	Cyclic	Cyclic	Cyclic	Cyclic
Function/operating voltage indicator		LED/-	LED/-	LED/-	LED/-	LED/-
Sensing distance, adjustable		Poti	-	Poti	-	Poti

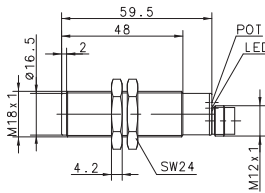
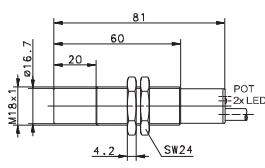
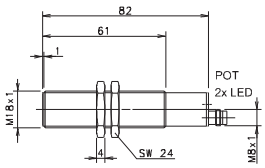
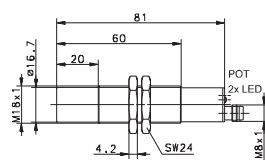
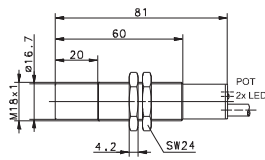
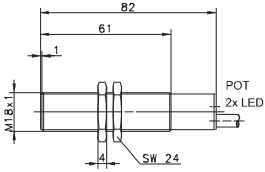
Mechanical data

Ambient temperature (min/max)	-25°C/+70°C	-25°C/+70°C	-25°C/+70°C	-25°C/+70°C	-25°C/+70°C
Protection class in accordance with IEC 529, EN 60529	IP65	IP65	IP65	IP65	IP65
Enclosure material	CuZn39Pb3	CuZn39Pb3	PBT, black	PBT, black	PBT, black
Connection	3 x 0.14 mm ²	M8 x 1	3 x 0.14 mm ²	M8 x 1	3 x 0.14 mm ²

Please refer to Accessories for cable couplers, mounting brackets and sensor tester.



M18		M18		M18	
Flush	Flush	Non-flush	Non-flush	Non-flush	Non-flush
5.0 mm	5.0 mm	8.0 mm	8.0 mm	8.0 mm	13.5 mm
Cable 2 m	Connector M8	Cable 2 m	Cable 2 m	Connector M8	Connector M12 Sensing dist.



6507905001 KCB-M18PS/005-KLP2	6507905004 KCB-M18PS/005-KLPSM8	6507921724 KCN-T18PS/008-KLP2	6507921002 KCN-T18PS/008-KLPSM8	6507921004 KCN-T18PS/013-KLPS12V		
		6507821001 ^① KCN-T18PU/008-KLP2V				
6507305001 KCB-M18NS/005-KLP2		6507321723 KCN-T18NS/008-KLP2				
			6508521001 KCN-T18AS/008-LP2 6508421001 KCN-T18AÖ/008-LP2			

10–60 VDC	10–60 VDC	10–60 VDC	20–250 V AC	10–60 VDC	10–60 VDC
≤ 200 mA	≤ 200 mA	≤ 200 mA	≤ 300 mA	≤ 200 mA	≤ 200 mA
25 Hz	25 Hz	25 Hz	15 Hz	25 Hz	25 Hz
Cyclic	Cyclic	Cyclic	–	Cyclic	Cyclic
LED/LED	LED/LED	LED/LED	LED/LED	LED/LED	LED/LED
Poti	Poti	Poti	Poti	Poti	Poti

–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C
IP65	IP65	IP65	IP65	IP65	IP65
CuZn39Pb3	CuZn39Pb3	PBT, black	PBT, black	PBT, black	PBT, black
3 x 0.5 mm ²	M8 x 1	3 x 0.5 mm ²	2 x 0.5 mm ²	M8 x 1	M12 x 1

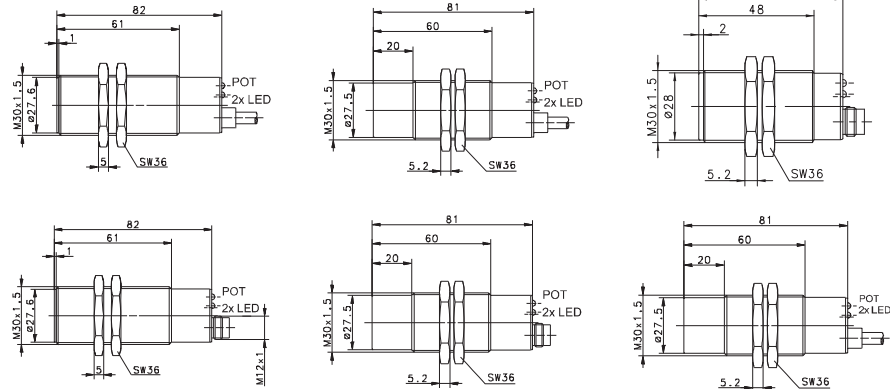
You will find detailed data sheets to the products under www.bernstein.eu

① Length 65 mm



Capacitive Sensors (Type M30, M32)

Type	M30		M30		M30	
Type of installation	Flush	Flush	Non-flush	Non-flush	Non-flush	Non-flush
Nominal sensing distance	10 mm	10 mm	20 mm	20 mm	20 mm	20 mm
Type of connection	Cable 2 m	Connector M12	Cable 2 m	Connector M12	Connector M12	Cable 2 m
Special feature					Short form	



PNP	DC	NO contact Type NC contact Antivalent NO/NC Type	6507907001 KCB-M30PS/010-KLP2	6507907004 KCB-M30PS/010-KLPS12	6507923727 KCN-T30PS/020-KLP2	6507923004 KCN-T30PS/020-KLPS12	6507923006 KCN-T30PS/020-KLPS12V
NPN	DC	NO contact Type NC contact Antivalent NO/NC Type	6507707001 KCB-M30PÖ/010-KLP2		6507323001 KCN-T30NS/020-KLP2		
PNP/NPN	DC	NO/NC prog. Type push-pull operation Type					
NAMUR	DC						
Analogue	DC						
2-wire	DC	NO contact NC contact					
	AC	NO contact Type NC contact Type Changeover contact Type					6508523001 KCN-T30AS/020-LP2 6508423001 KCN-T30AÖ/020-LP2

Technical data

Rated operating voltage	U_b	10–60 VDC	10–60 VDC	10–60 VDC	10–60 VDC	10–60 VDC	20–250 V AC
Rated operating current	I_b	≤ 400 mA	≤ 400 mA	≤ 400 mA	≤ 400 mA	≤ 400 mA	≤ 300 mA
Switching frequency (max)	F	25 Hz	25 Hz	25 Hz	25 Hz	25 Hz	15 Hz
Short circuit-protection		Cyclic	Cyclic	Cyclic	Cyclic	Cyclic	–
Function/operating voltage indicator		LED/LED	LED/LED	LED/LED	LED/LED	LED/LED	LED/LED
Sensing distance, adjustable		Poti	Poti	Poti	Poti	Poti	Poti

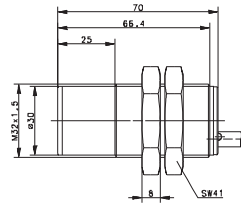
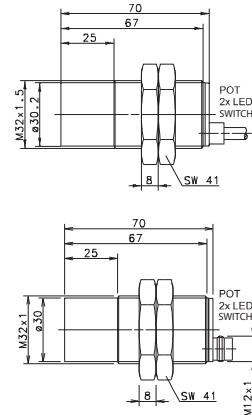
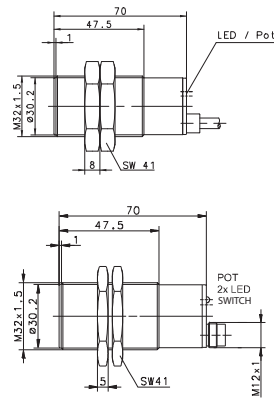
Mechanical data

Ambient temperature (min/max)		–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C
Protection class in accordance with IEC 529, EN 60529		IP65	IP65	IP65	IP65	IP65	IP65
Enclosure material		CuZn39Pb3	CuZn39Pb3	PBT, black	PBT, black	PBT, black	PBT, black
Connection		3 x 0.5 mm ²	M12 x 1	3 x 0.5 mm ²	M12 x 1	M12 x 1	2 x 0.5 mm ²

Please refer to Accessories for cable couplers, mounting brackets and sensor tester.



M32		M32		M32	
Flush	Flush	Non-flush	Non-flush	Non-flush	
15 mm	15 mm	30 mm	30 mm	30 mm	
Cable 6 m	Connector M12	Cable 2 m	Connector M12	Cable 2 m	Timer/Relay



6507013013 KCB-M32DP/015-KLP6	6507013015 KCB-M32DP/015-KLPS12	6507013001 KCN-T32DP/030-KLP2	6507013004 KCN-T32DP/030-KLPS12		
6507013012 KCB-M32GP/015-KLP2					
				6508613001 KCN-T32RU/030-LP2	

10–60 VDC	10–60 VDC	10–60 VDC	10–60 VDC	180–250 V AC
≤ 400 mA	≤ 400 mA	≤ 400 mA	≤ 400 mA	≤ 8 A
25 Hz	25 Hz	25 Hz	25 Hz	–
Cyclic	Cyclic	Cyclic	Cyclic	–
LED/LED	LED/–	LED/–	LED/–	LED/LED
Poti	Poti	Poti	Poti	Poti

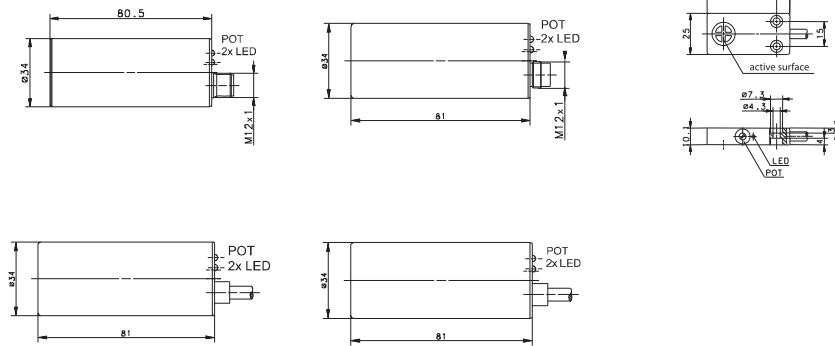
–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C
IP65	IP65	IP65	IP65	IP65
CuZn39Pb3	CuZn39Pb3	PBT, black	PBT, black	PBT, black
3 x 0.5 mm ²	M12 x 1	3 x 0.5 mm ²	M12 x 1	5 x 0.5 mm ²

You will find detailed data sheets to the products under www.bernstein.eu



Capacitive Sensors (Type Ø 34 mm, E50, E68)

Type	Ø 34 mm		Ø 34 mm		E50
Type of installation	Flush	Non-flush	Non-flush	Non-flush	Flush
Nominal sensing distance	20 mm	30 mm	30 mm	30 mm	8 mm
Type of connection	Connector M12	Cable 2 m	Connector M12	Cable 2 m	Cable 2 m
Special feature					



PNP	DC	NO contact Type NC contact Antivalent NO/NC	6507915006 KCB-D34PS/020-KLPS12	6507915001 KCN-R34PS/030-KLP2	6507915004 KCN-R34PS/030-KLPS12	6507990001 KCB-E50PS/008-KLP2
NPN	DC	NO contact Type NC contact Antivalent NO/NC		6507315001 KCN-R34NS/030-KLP2		6507390001 KCB-E50NS/008-KLP2
PNP/NPN	DC	NO/NC prog. push-pull operation				
NAMUR	DC					
Analogue	DC					
2-wire	DC	NO contact NC contact				
	AC	NO contact Type NC contact Type Changeover contact			6508515001 KCN-R34AS/030-LP2 6508415001 KCN-R34AÖ/030-LP2	

Technical data

Rated operating voltage	U_B	10–60 VDC	10–60 VDC	10–60 VDC	20–250 V AC	10–36 VDC
Rated operating current	I_B	≤ 200 mA	≤ 400 mA	≤ 400 mA	≤ 300 mA	≤ 200 mA
Switching frequency (max)	F	25 Hz	25 Hz	25 Hz	15 Hz	25 Hz
Short circuit-protection		Cyclic	Cyclic	Cyclic	–	Cyclic
Function/operating voltage indicator		LED/LED	LED/LED	LED/LED	LED/LED	LED/–
Sensing distance, adjustable		Poti	Poti	Poti	Poti	Poti

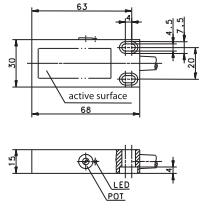
Mechanical data

Ambient temperature (min/max)		–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C	–25°C/+70°C
Protection class in accordance with IEC 529, EN 60529		IP65	IP65	IP65	IP65	IP65
Enclosure material		CuZn39Pb3	PBT, red	PBT, red	PBT, red	PBT, black
Connection		M12 x 1	3 x 0.5 mm ²	M12 x 1	2 x 0.5 mm ²	3 x 0.34 mm ²

Please refer to Accessories for cable couplers, mounting brackets and sensor tester.



E68			
Flush			
10 mm			
Cable 2 m			



6507956001							
KCB-E68PS/010-KLP2							

10-36 VDC			
≤ 200 mA			
25 Hz			
Cyclic			
LED/-			
Poti			

-25°C/+70°C			
IP65			
PBT, black			
3 x 0.5 mm ²			

You will find detailed data sheets to the products under www.bernstein.eu

