KEYENCE

96M1133

Instruction Manual

CCD Laser Displacement Sensor

LK-3100 Series

CONTENTS

⚠ CAUTION This is a class A (EN55011: EMI standard) product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

SAFETY PRECAUTIONS

This manual describes how to install the LK-3100 series as well as its operating procedures and precautions. Please read this manual carefully to get the best from your LK-3100 series.

Safety precautions

Symbols

The following symbols alert you to important messages. Be sure to read these messages carefully.

⚠ WARNING Failure to follow instructions may lead to injury. (electric shock, burn, etc.)

⚠ CAUTION Failure to follow instructions may lead to product damage.

Note Provides additional information on proper operation.

General precautions

- At startup and during operation, be sure to monitor the functions and performance of the LK-3100 series.
- We recommend that you take substantial safety measures to avoid any damage in the event a problem occurs.
- Do not open or modify the LK-3100 series or use it in any way other than described in the specifications.
- When the LK-3100 series is used in combination with other instruments, functions and performance may be degraded, depending on operating conditions and the surrounding environment.
- Do not use the LK-3100 series for the purpose of protecting the human body.

LASER SAFETY PRECAUTIONS

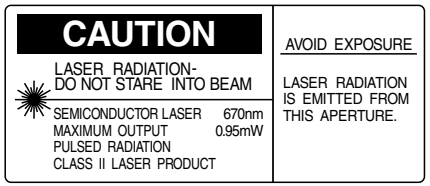
1. Classification

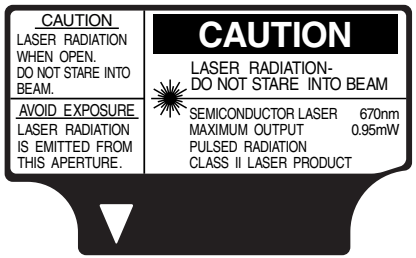
Model	LK-011
FDA (CDRH)	Class II
IEC/EN 60825-1: 1993 + A2: 2001	Class 2
DIN EN 60825-1 2001	Klasse 2

2. Warning labels

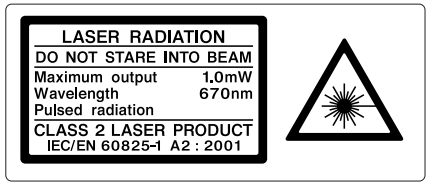
1) Warning labels
2) Aperture label
3) Protective housing label

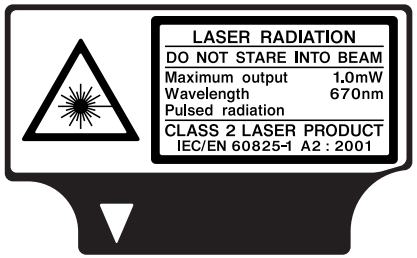
FDA Class II





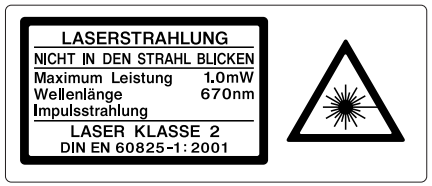
IEC Class 2

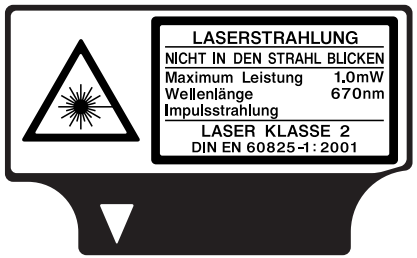




IEC (French) Class 2

DIN Klasse 2

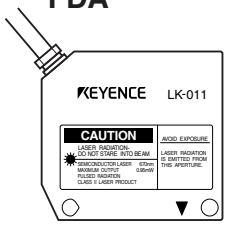


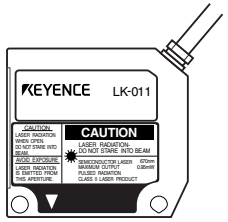


3. Labels location

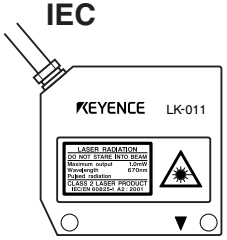
Warning labels are attached to the sensor head, as shown below.

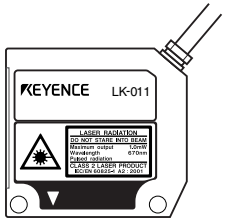
FDA



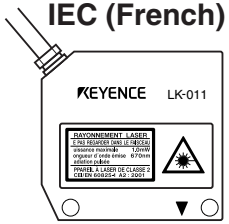


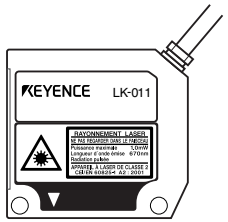
IEC



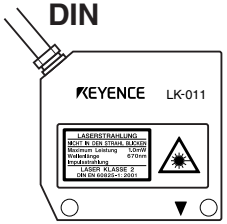


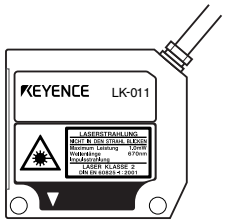
IEC (French)





DIN





4. Safety consideration

⚠ CAUTION

Use of controls or adjustments or the performance of procedures other than those specified herein may result in hazardous radiation exposure.

The laser beam is not harmful to the skin. There is, therefore, no danger in exposing arms or hands to the beam. The only possible health hazard is in exposing the eyes to the laser beam. Damage to the eyes can occur if the operator stares directly into the beam.

⚠ WARNING

Follow the safety precautions below to ensure operator safety:

- **Operate the LK-3100 series only according to the procedures described in this instruction manual.**
  Otherwise, injury may occur due to exposure to the laser beam.

- **Do not disassemble the sensor head.**
  Laser emission from the LK-3100 series is not automatically stopped if the sensor head is disassembled. If you disassemble the sensor head for inspection or repair, you may be exposed to the laser beam. If the LK-3100 series malfunctions, contact KEYENCE immediately.

- **Do not look directly at the laser beam.**
  Looking directly at the laser beam may result in serious eye injury.

- **Protective enclosure**
  We recommend that you install a protective enclosure around the sensor head to prevent any person from getting near the sensor head during operation.

- **Protective goggles**
  We recommend that you wear protective goggles when using the LK-3100 series.

- **Stop laser emissions before cleaning the laser emission port.**
  Failure to stop the laser emission may expose eyes or skin to the laser beam.

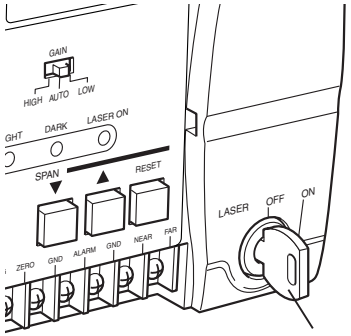
- **Check the laser beam path.**
  To prevent exposure to the laser beam due to specular or diffuse reflection, install a screen which offers the appropriate reflectance and temperature characteristics to interrupt the reflected laser beam. Do not install the LK-3100 series in such a way that the laser beam passes at eye height.

5. Safety features provided with the LK-3100 series

The LK-3100 series is provided with the following safety features. Make sure these features function correctly before operating.

■ Key-operated laser switch

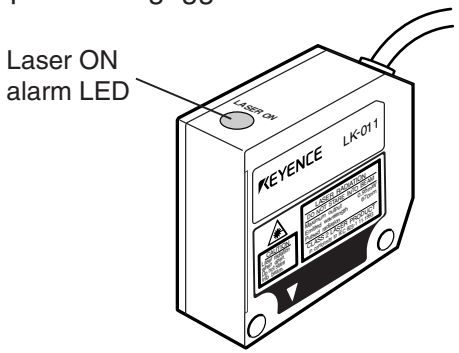
A key-operated switch controls the LK-3100 series laser. Remove the key when the laser is not in use.



Key-operated laser switch

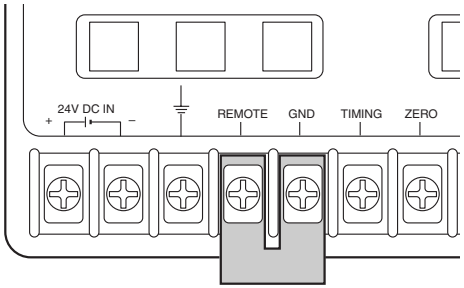
■ Laser ON alarm LED (lights during laser emission.)

After the key-operated laser switch is set to the ON position, the laser ON alarm LED flashes for approximately 3 seconds before laser emission. The LED lights during laser emission. The LED light can be checked through protective goggles.



■ Remote interlock terminal

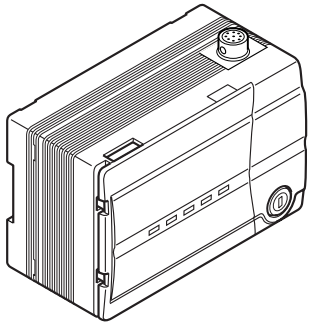
Laser emission can be stopped by disconnecting the REMOTE terminal from the GND terminal.



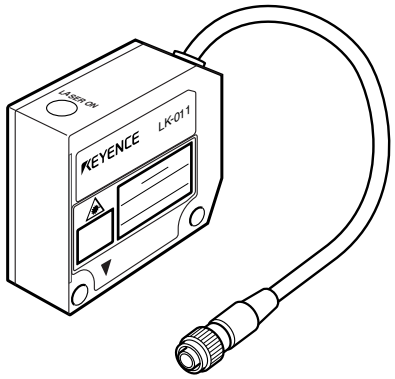
CHECKING THE PACKAGE CONTENTS

The LK-3100 series package includes the following parts and equipment. Ensure that these items are included in your package before using the unit.

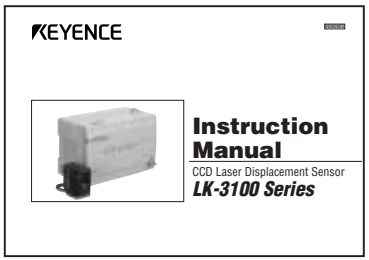
Controller



Sensor head



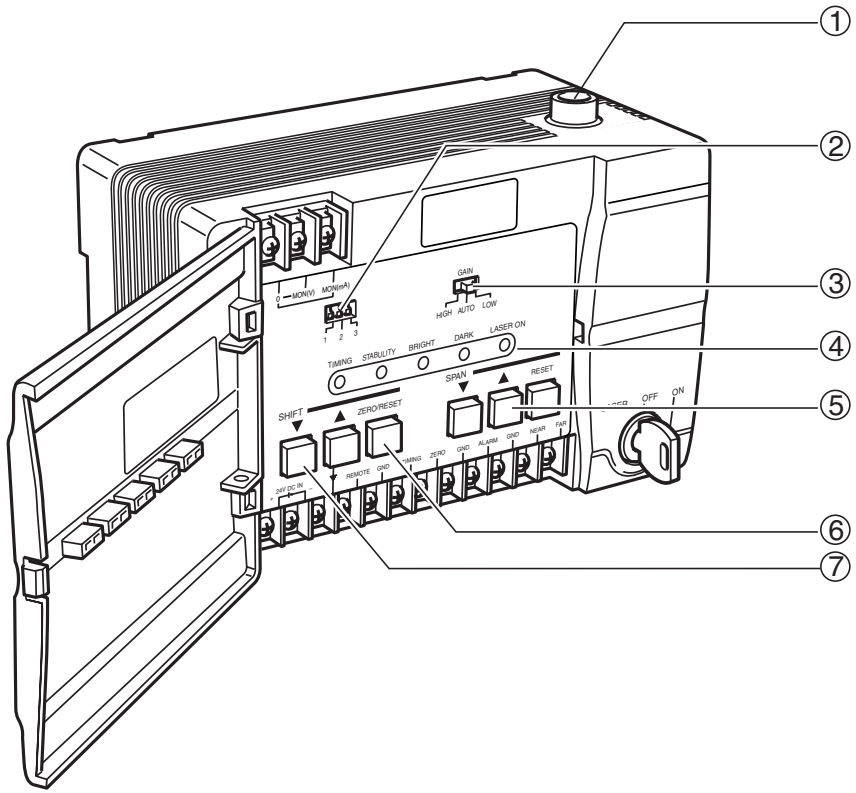
Instruction manual (1)



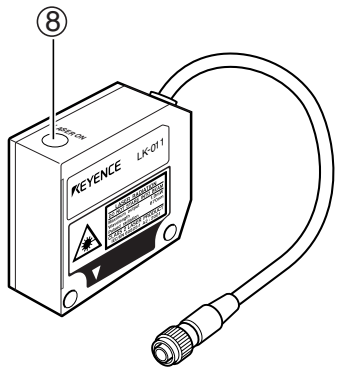
Keys (2)

PART NAMES

Controller



Sensor head



① **DIP switches**
Set alarm hold function, key-lock function, and averaging function.

② **Sensor head connector**

③ **Sensitivity setting switch**
Changes the received light sensitivity according to the reflectance of the target. (*Refer to p. 14*)

④ **Indicators**
TIMING: Lights during synchronous (timing) input.

STABILITY: Lights yellow or green when a target is within the measuring range. Lights red when a target is out of the measuring range, or when the light quantity is insufficient or excessive.

BRIGHT: Lights when the light quantity is excessive.

DARK: Lights when the light quantity is insufficient.

LASER ON: Lights during laser emission.

⑤ **SPAN adjustment keys**
Finely adjusts the inclination of the analog output.

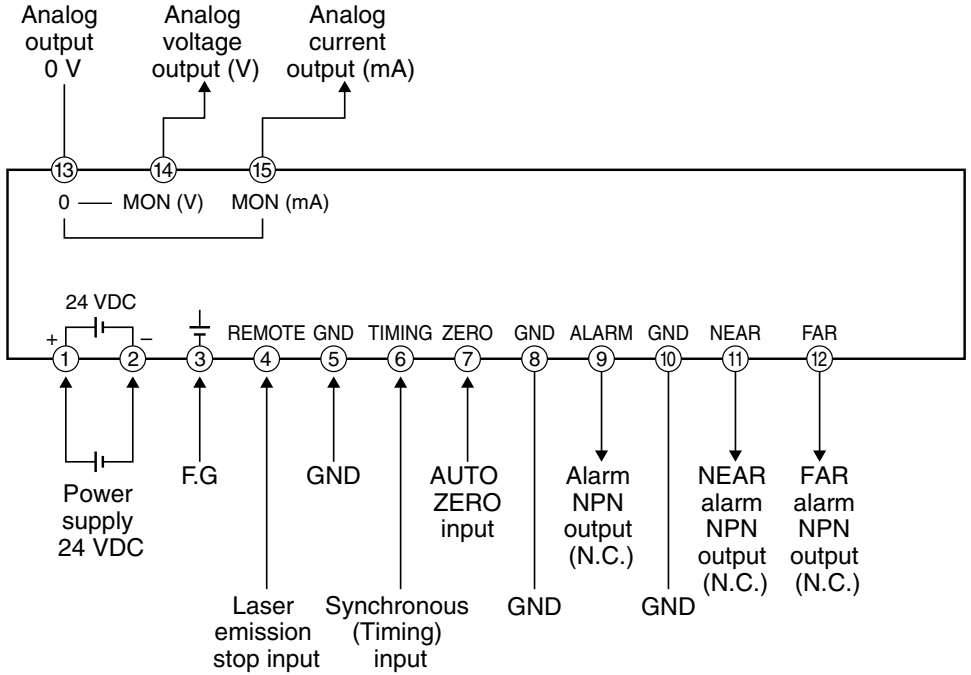
⑥ **AUTO ZERO/RESET keys**
Resets the analog output to 0 V (12 mA) at any point. Cancels AUTO ZERO function.

⑦ **SHIFT adjustment key**
Finely adjusts the 0-point position of the analog output.

⑧ **Operation indicator**
Lights yellow or green when a target is within the measuring range. Flashes yellow when a target is out of the measuring range, or when the light quantity is insufficient or excessive.

CONNECTIONS

This section describes each terminal.



①, ② Power supply input terminal

③ Frame grounding (F.G.) terminal
Earth-ground this terminal.

④ Laser emission stop input
Disconnecting this terminal from the GND terminal (⑤, ⑧, ⑩) stops laser emission. Use this terminal in an emergency to stop laser emission.

⑥ Synchronous (timing) input
Connecting this terminal to the GND terminal (⑤, ⑧, ⑩) retains the analog output value just prior to the synchronous input, and stops laser emission.

⑦ AUTO ZERO input
Connecting this terminal to the GND terminal (⑤, ⑧, ⑩) resets the analog output to 0 V (12 mA). The input is a one-shot input.

⑨ Alarm output (N.C.)
The output contact opens when measurement is impossible due to an insufficient or excessive light quantity, or due to the target being out of the measuring range. The output is normally closed.

⑪ NEAR alarm output (N.C.)
The output contact opens when a target is positioned closer than the measuring range. The output is normally closed.

⑫ FAR alarm output (N.C.)
The output contact opens when a target is positioned further than the measuring range. The output is normally closed.

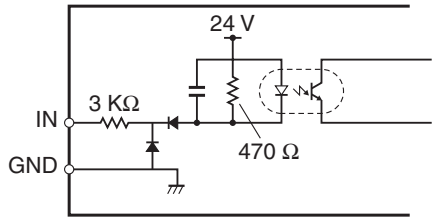
⑬, ⑭ Analog voltage output
A voltage of ±10 V relative to the full measurement range is output. +12 V is output when measuring is impossible.

⑬, ⑮ Analog current output
A current of 4 to 20 mA relative to the measuring range of the analog voltage output of -10 to +10 V is output. A current of 21.6 mA is output when measurement is impossible.

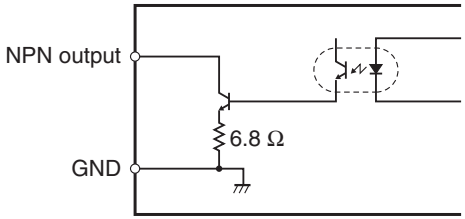
INPUT/OUTPUT CIRCUIT

This section describes the input/output circuit diagram of the controller.

Input circuit (AUTO ZERO, Synchronous, and laser emission stop)



Output circuit (Alarm, NEAR, and FAR)



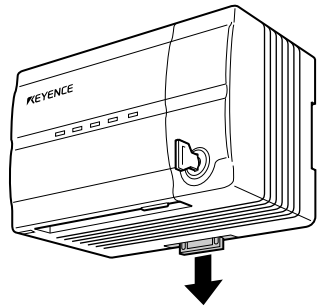
Note: Use a non-voltage contact to connect or disconnect the input terminals.

INSTALLATION

This section describes how to mount the controller and the sensor head and how to connect the cables.

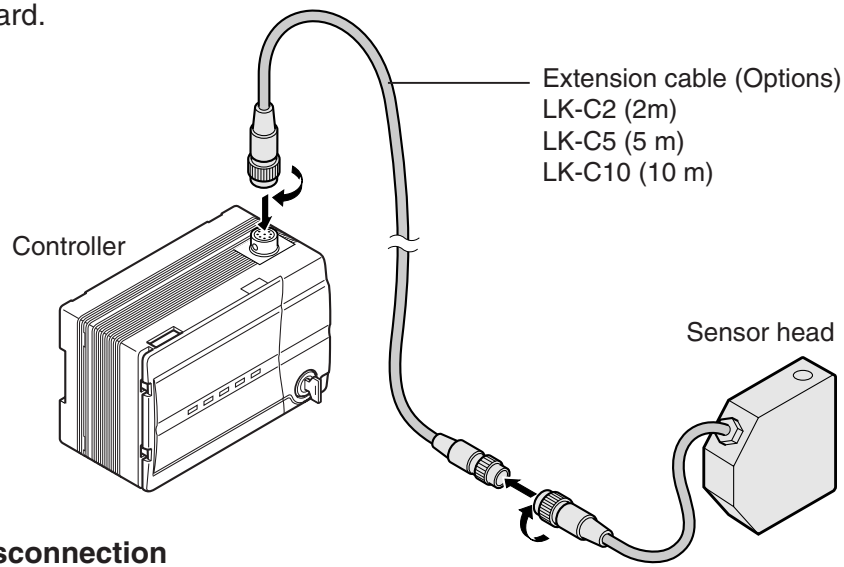
Controller

The controller can be mounted to a DIN rail. When mounting or removing the controller, pull the claw at the bottom center in the direction of the arrow.



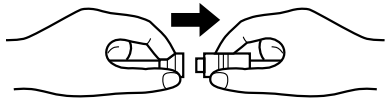
Connecting sensor head and controller

Connect the sensor head to the extension cable(s), and the extension cable(s) to the controller as shown below.
To join the connectors, gently press them together and turn them to the right or left to locate the engagement position, then press until a click is heard.



Disconnection

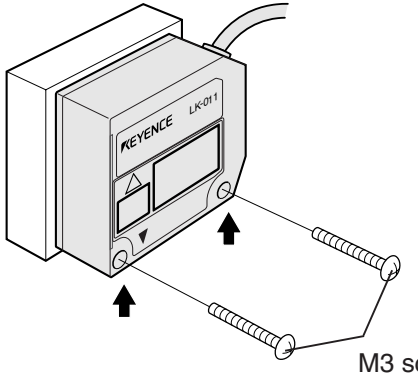
To remove the connectors, hold the connecting sleeve as shown on the right, and pull it out in the direction of the arrow.



INSTALLATION

Sensor head

Secure the sensor head using M3 screws through the two mounting holes indicated by the arrows in the figure. Limit the tightening torque to 0.2 Nm (2 kgf·cm) or less.



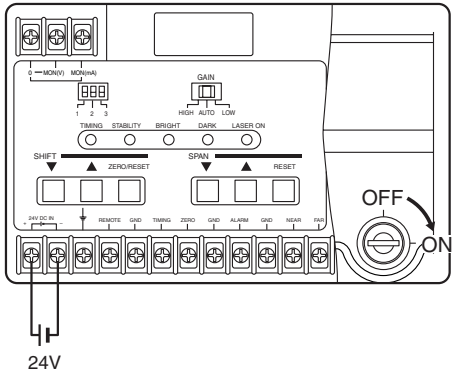
⚠ CAUTION

• Tightening torque
If a tightening torque of more than 0.2 Nm (2 kgf•cm) is applied, the sensor head may be distorted and become deformed, resulting in a lower performance than the specifications.

POWER-ON

1. Provide a 24 VDC power supply to terminals No. 1 and 2.

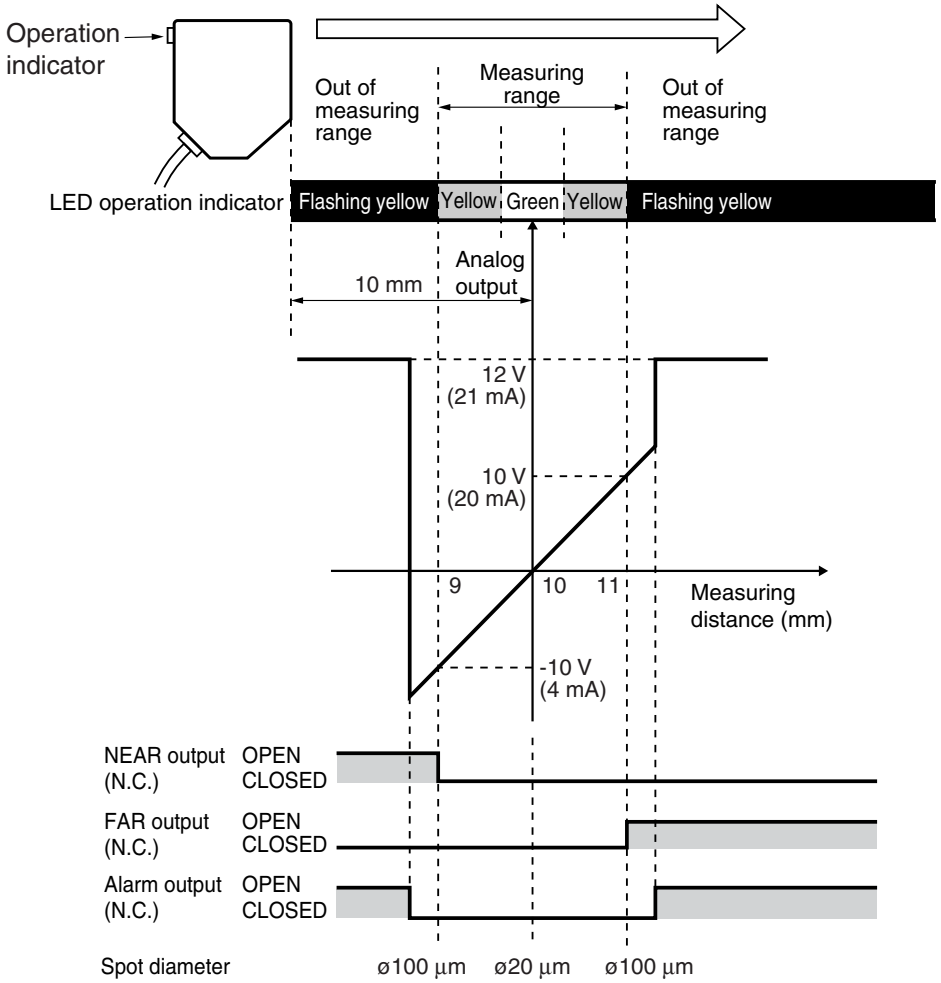
2. Turn the key-operated laser switch as shown in the figure.
   - Laser emission is triggered to enable measurement.
   - The REMOTE and GND terminals (terminals ④ and ⑤) are short-circuited with a short bar during shipment



Reference: Disconnecting the REMOTE and GND terminals stops laser emission.

OUTPUT CHARACTERISTICS AND LED INDICATOR

Adjust the distance between the sensor head and target by checking the sensor head's LED operation indicator.



Note 1: The NEAR or FAR output turns on only when the target moves slowly from the inside to the outside of the measuring range.
Note 2: When measurement is affected by the scattered reflection of a mirror-surfaced target, the operation indicator remains in the normal status, and the alarm output is not turned on even if the target is out of the measuring range.

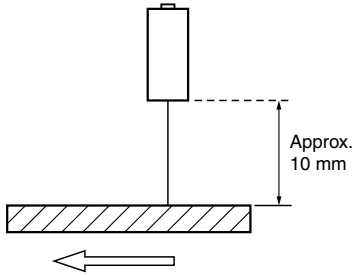
SETTING

This section describes how to mount the sensor head according to the target.

Measuring distance

LK-011: Approx. 10 mm

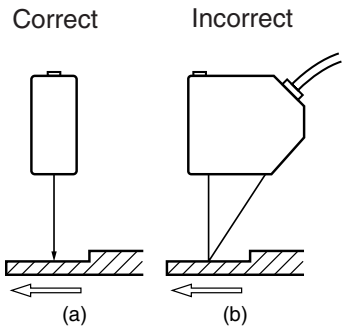
When measuring the thickness of a moving object, use the LK-011 at the reference distance as much as possible. This ensures the most reliable detection.



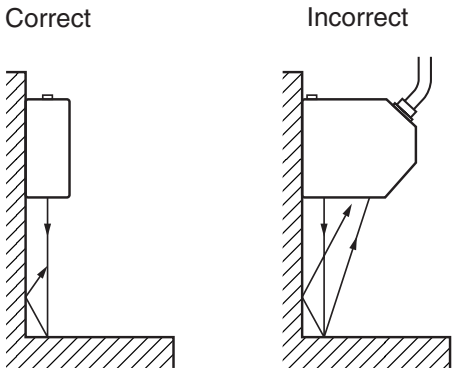
Target shape and recommended setting

The LK-3100 series is less affected by the sensor head orientation by employing the CCD as the light-receiving element. For the following applications, however, mount the sensor head with the recommended orientation, if possible.

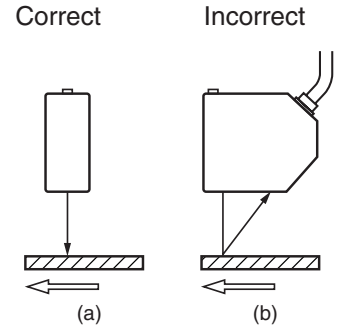
Height-difference



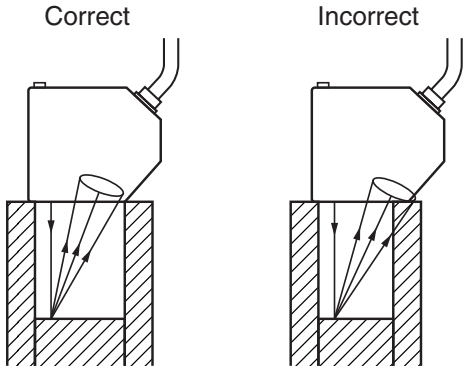
By a wall



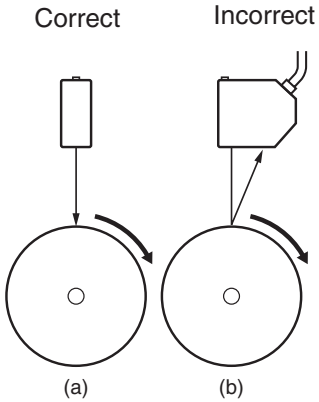
Border of different color or luster



Displacement in a hole



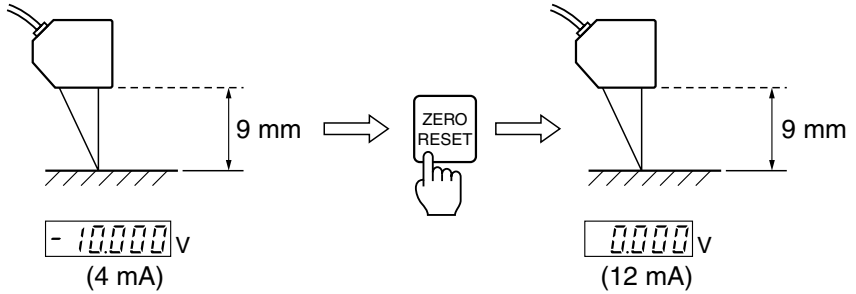
Moving object



This section describes each function to help you make effective use of the LK-3100 series.

AUTO ZERO function

Resets the output voltage to 0 V at the desired point within the measuring range.
Changing the zero position enables the output range to be set at either -10 to 0 V, or 0 to 10 V.



Canceling AUTO ZERO:
Press the ZERO RESET key for approximately 2 seconds. AUTO ZERO is canceled and 0 V (12 mA) is output when the target is at the reference position.

External terminal input:
Short-circuiting the external AUTO ZERO input terminal and the GND terminal also sets the AUTO ZERO input.

Relationship between the key-lock function and AUTO ZERO function

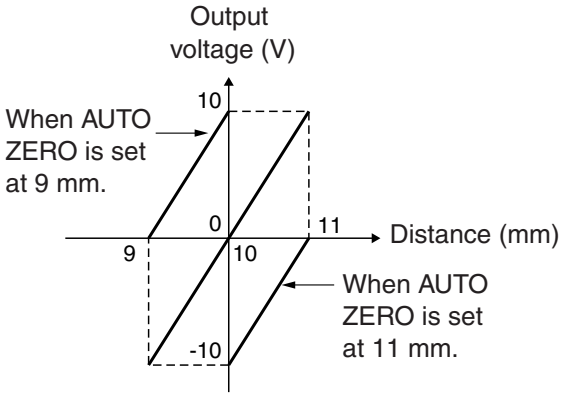
➪ *Refer to p.15 for the key-lock function.*

When FREE is set:
The value of the AUTO ZERO input is internally stored and retained even the power is turned off.

When LOCK is set:
The AUTO ZERO input is available only from the external input terminal. When the power is turned off, the value of the AUTO ZERO input is not stored, and the zero point is reset to the reference position. However, once a value is stored as zero during the FREE setting, the value is retained even if LOCK is set and the power is turned off.

Note: If the AUTO ZERO input is used frequently, set the key-lock function to LOCK, and set the AUTO ZERO externally.

AUTO ZERO position and output characteristics

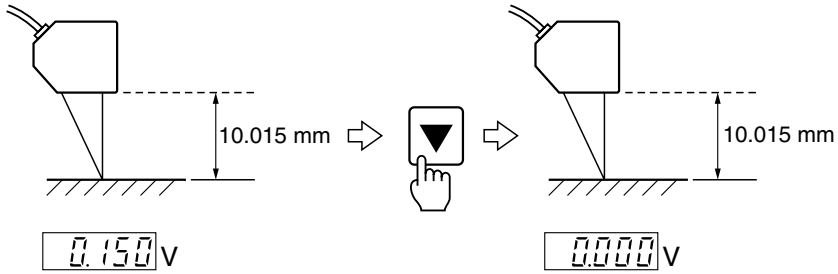


Note: When the AUTO ZERO input is turned ON, there may be some errors due to the temperature characteristics of the internal circuit

Shift adjustment function

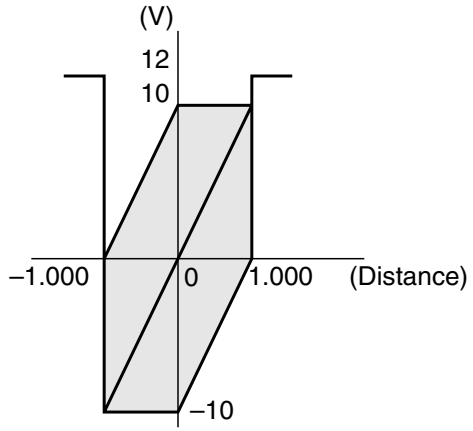
▼ ▲ ZERO RESET

Adjusts the analog value zero point using the UP/DOWN keys for shift adjustment.



Holding down the ▲ / ▼ keys to change the shift value faster.
Pressing the ZERO RESET key for 2 seconds cancels the shift adjustment value, and 0 V (12 mA) is output when the target is at the reference position.

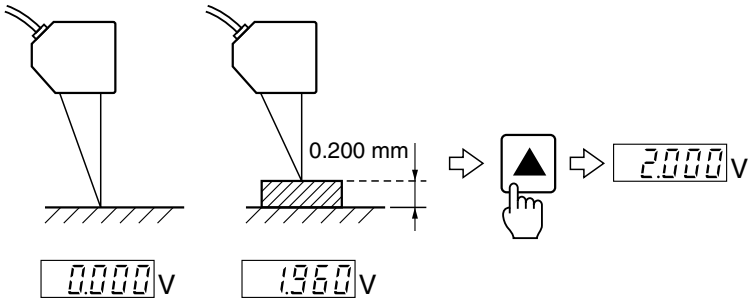
■ Shift adjustment range



Span adjustment function

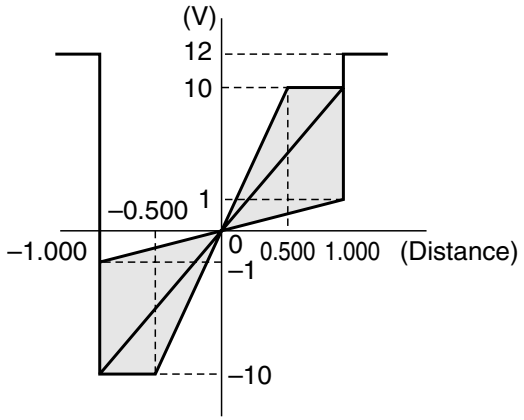
▼ ▲ RESET

Adjusts the analog value inclination using the UP/DOWN keys for span adjustment. Use the span adjustment when the sensor head is tilted or the target surface condition affects the analog output characteristics.



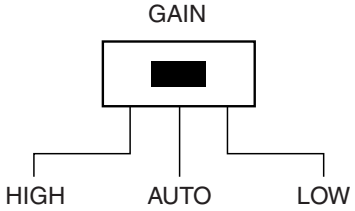
Holding down the ▲ / ▼ keys to change the span value faster.
Pressing the RESET key for 2 seconds cancels the span adjustment value, and the output characteristics are reset to the factory-set values.

■ Span adjustment range



USING EACH FUNCTION SENSITIVITY SETTING

Sets an appropriate sensitivity according to the change in target surface condition.



Set the sensitivity to AUTO for normal use.

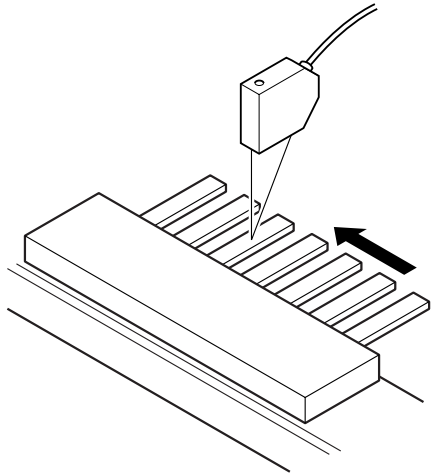
AUTO:
Used to measure various objects: from objects with low reflectance such as black rubber, to ones with high reflectance such as metals.

Note: If the reflectance of the target changes greatly during a short cycle, the analog output may become unstable with the AUTO setting. In this case, set the sensitivity to HIGH or LOW.

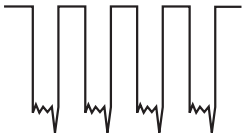
HIGH:
Fix the sensitivity to high. Used to measure a part with low reflectance (black) in the above condition.

LOW:
Fix the sensitivity to low. Used to measure a part with high reflectance in the above condition.

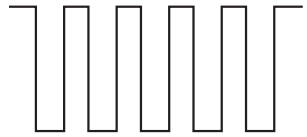
Example: Measurement of pin warpage
In measuring the warp of moving connector pins, the reflectance of the pin and gap changes greatly, causing a change in the analog output in a short time period. In such a case, set the sensitivity setting switch to LOW and measure only pins that have a high reflectance.



Output waveform obtained with AUTO



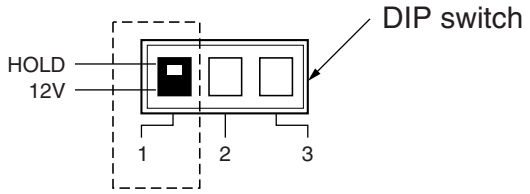
Output waveform obtained with LOW

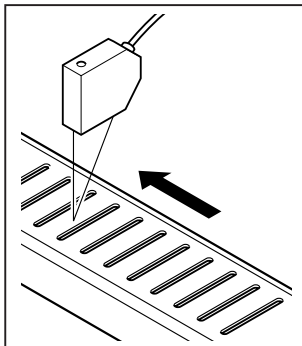


Alarm hold function

• Setting DIP switch 1 to the upper position (HOLD)
The sensor does not produce the 12 V (approx. 21 mA) analog output during alarm output (range over/light quantity alarm), but retains the analog output value just prior to the alarm output. This function is canceled when measurement is again possible.

• Setting DIP switch 1 to the lower position (12 V)
The sensor produces the 12 V (21.6 mA) analog output during alarm output.





• DIP switch to lower position (12V)

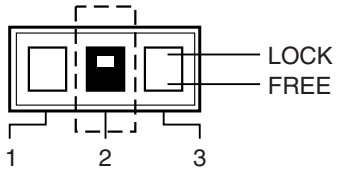
• DIP switch to upper position (HOLD)

The condition in which the measurement is impossible can be ignored, eg. the detection of holes in a target.

Note: The alarm output is produced in the alarm condition even if the alarm hold function is used.

Key-lock function

• Setting DIP switch 2 to the upper position
The sensor locks the shift adjustment, span adjustment, ZERO/RESET and RESET keys so that each function cannot change. The shift (AUTO ZERO) and span values are fixed just prior to the lock operation.



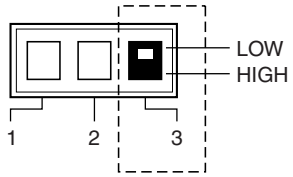
Use this function to prevent the output voltage from being accidentally reset to zero.

• Setting DIP switch 2 to the lower position (FREE)
The key-lock function is set to FREE and the lock operation is canceled.

Reference: The AUTO ZERO input through the external input terminal is effective regardless of the LOCK or FREE setting. (However, with the LOCK set, the data will not be stored when the power is turned off.)

Response speed selection function

Set DIP switch 3 to select whether to output every measured value or the average of 8 measured values (moving average).

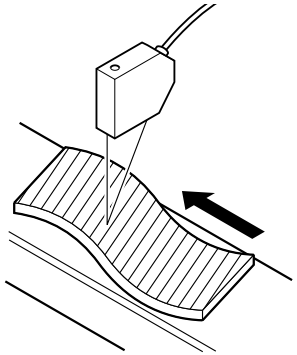


LOW:
Outputs the value of the average of 8 measured values. Offers more stable detection when the luster of the target varies greatly.

HIGH:
Outputs every measured value. Offers high-speed response when the target vibrates or moves quickly.

Sampling cycle		128 µs	256 µs	512 µs	2048 µs
Average response time	**LOW**	Approx. 1 ms	Approx. 2.0 ms	Approx. 4.0 ms	Approx. 17 ms
	HIGH	Approx. 0.1 ms	Approx. 0.2 ms	Approx. 0.5 ms	Approx. 2 ms

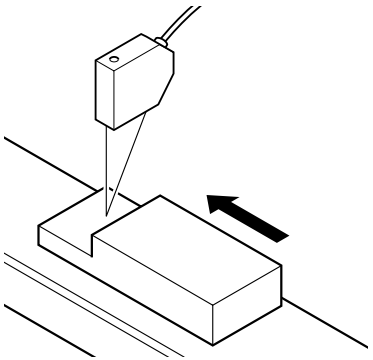
Example: To cancel the influence by surface roughness, LOW is recommended.



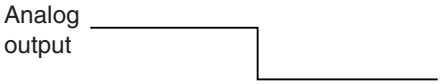
• DIP switch (HIGH)

• DIP switch (LOW)

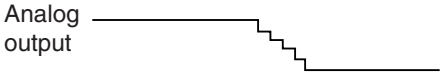
Example: To detect abrupt changes such as height differences, HIGH is recommended.



• DIP switch (HIGH)



• DIP switch (LOW)



The LK-011 offers two measurement modes to be used according to the measurement conditions.

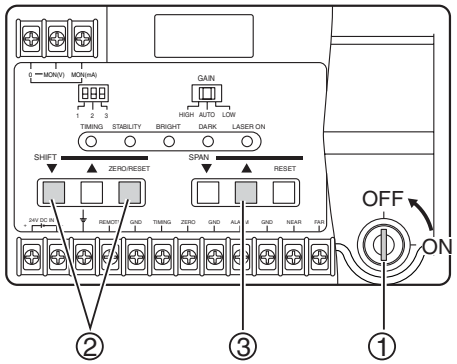
Normal mode:
Used to measure targets other than mirror-surfaced or transparent objects.
The LK-011 is initially set to the normal mode.

Mirror-surface measurement mode:
Used to measure mirror-surfaced objects. To measure such targets, change the measurement mode by using the following procedure. Also, tilt the sensor head in the direction that enables it to receive the specular reflection as shown below.

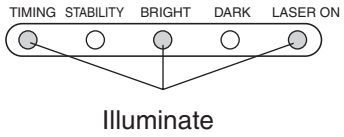
■ Setting the mirror-surface measurement mode

1. Turn off the key-operated laser switch.

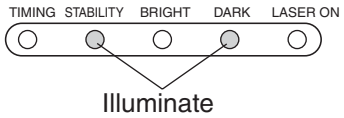
2. Hold down both the ▼ key, for the SHIFT adjustment, and the ZERO RESET key, and then press the ▲ key for the SPAN adjustment.
   - This operation toggles between the normal and mirror-surface measurement modes.
   - The current mode can be confirmed with the indicators at the center of the controller front panel.



■ **Normal mode**

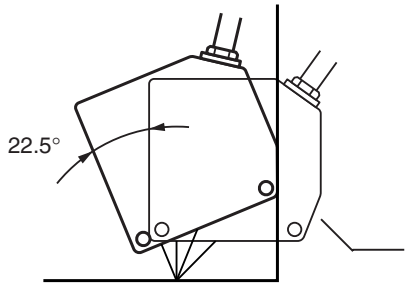


■ **Mirror-surface measurement mode**



■ Mounting the sensor head for mirror-surface measurement

When the mirror-surface measurement mode is set, the sensor head should be tilted to receive the specular reflection. Since the LK-011 receives light that is reflected at 45°, the sensor head should be tilted to 22.5°, half of the reflection angle. The LK-011 is designed so that it can be easily tilted to any angle needed to receive the specular reflection by setting the bottom of the sensor head vertically.



The LK-011 is designed so that it can be tilted to the proper angle to receive the specular reflection by putting this part against a vertical wall.

- **When measuring a target that reflects a small amount of light, such as black rubber:**
  Set a longer sampling cycle.

Note: When a short sampling cycle is set for measuring a target that has low reflectance, detection may become unstable or an alarm output is produced due to the extremely small amount of light being received.

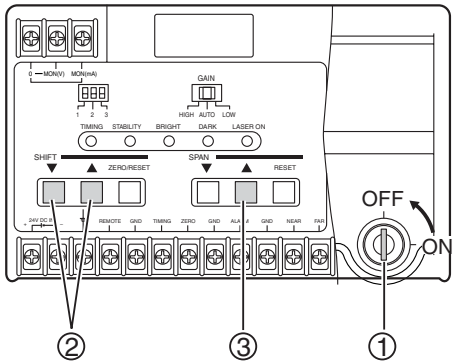
- **When measuring a target that reflects a large amount of light such as a mirror-surfaced or metallic object:**
  Detection is available with a short sampling cycle setting.
  Make sure it operates with the actual target.
  There are four available settings for the sampling cycle: 128, 256, 512, and 2048 μs. The initial setting is 2048 μs.

■ Setting the sampling cycle

1. Turn off the key-operated laser switch.

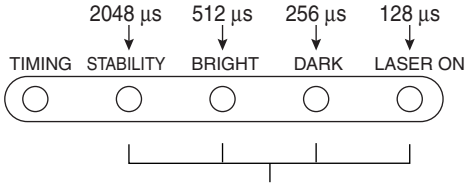
2. Hold down both the ▲ and ▼ keys for the SHIFT adjustment, and then press the ▲ key for the SPAN adjustment.

   The sampling cycle setting changes in sequence.



■ Checking the sampling cycle setting

The LED corresponding to the current sampling cycle setting illuminates.



One of these LEDs illuminates.

The LED corresponding to the current sampling cycle setting illuminates.

HINTS ON CORRECT USE

■ **Noise interference (The sensor head is case-grounded.)**

⚠ CAUTION

Isolate the sensor cable and extension cable(s) from high-tension lines or power lines, otherwise the sensor may malfunction or the laser diode may deteriorate due to noise interference.

- If noise is present at the surface where the sensor head is mounted, install insulator between the mounting surface and the sensor head.
- Earth-ground the frame grounding terminal.

⚠ CAUTION

Do not connect the sensor head while the controller is turned on. The sensor head may be damaged.

■ **Compatibility**

The LK-3100 series controller and sensor head have been calibrated in pairs. Be sure to use a sensor head and controller having the same serial number, otherwise the values given in the specifications cannot be attained.

■ **Environment**

⚠ CAUTION

Keep the sensor head free of water or oil. Any substance that refracts light may cause unstable measurement.

Do not allow extraneous light to enter the lens of the sensor head directly.

* When highly accurate measurement is required, attach shielding to the sensor head. If extraneous light enters the lens when no target is present, use a synchronous input to ignore it.

■ **Ambient light**

Although up to 10,000 lux ambient light is allowed by the specifications, avoid using the sensor near lighting equipment that emits light in recurring pulses, if possible. If the sensor must be positioned near such equipment, minimize the effect by using a light shielding plate.

■ **Warm-up**

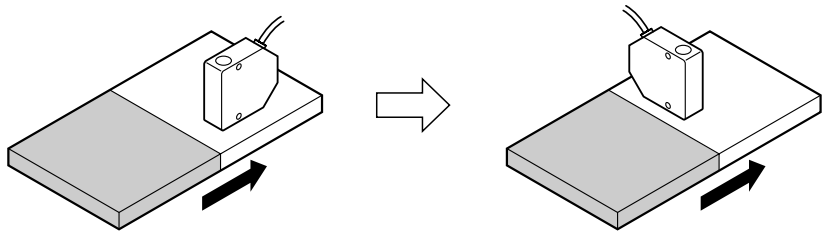
Allow approximately 30 minutes after the power is turned on before using the LK-3100 series. The measurement value may gradually fluctuate because the circuit is not stable immediately after the power is turned on.

■ **Cable extension between the controller and the sensor head**

To minimize the influence of noise, make the distance between the controller and the sensor head as short as possible (20 m max.).
For an extension cable, use the LK-C2 (2 m), the LK-C5 (5 m), or the LK-C10 (10 m).

■ **Sensor head orientation**

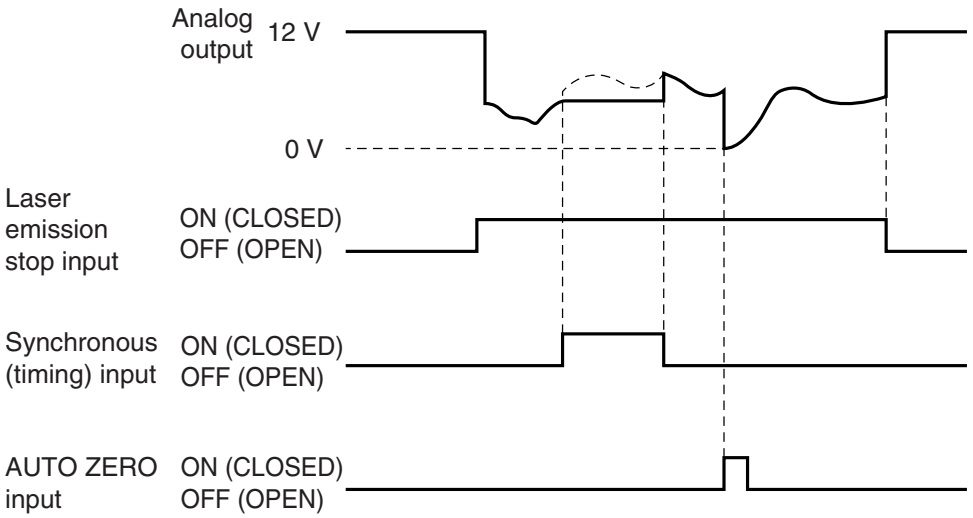
When a target consists of different colored portions or different materials separated by a border, measurement error may result depending on the orientation of the sensor head. To minimize measurement deviation, install the sensor head parallel to the border line, as shown below.



Incorrect　　Correct

INPUT CHARACTERISTICS

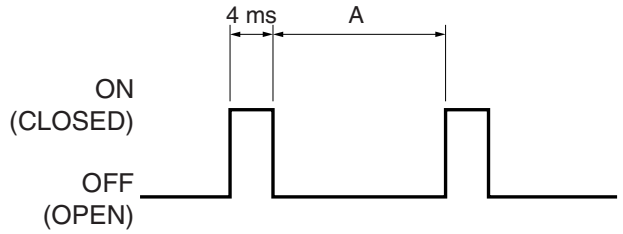
Timing diagram



- Laser emission only starts approximately 3 seconds after the laser emission stop input terminal is connected.
- While the timing input is connected, laser emission stops. The analog output will hold the last value before the timing input signal turns on.

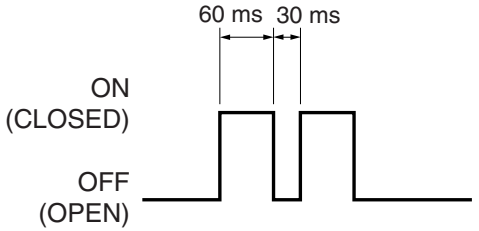
Minimum input time

Synchronous (timing) input



Sampling cycle	A (ms)	
	HIGH	LOW
128 µs	6	7
256 µs	7	9
512 µs	10	15
2048 µs	30	45

AUTO ZERO input



Note: According to the settings of the sampling cycle and response speed, the analog output is retained for the time A, shown in the figure, after the synchronous input terminal is disconnected.

SPECIFICATIONS

Model	**Sensor head**	**LK-011**	
	Controller	**LK-3101**	
Measurement mode		Normal	Mirror-surface measurement
Reference distance		10 mm	7.2 mm
Measuring range		±1 mm	±0.9 mm
Light source		Red semiconductor laser	
	Wavelength	670 nm (visible beam)	
	Output	1.0 mW max.	
Spot diameter		Approx. 20 μm (at the reference distance)	
Linearity [1.]		±0.25% of F.S.	±0.25% of F.S.
Resolution [2.]		0.1 μm	
Analog output [3.]	**Voltage output**	±10 V (0.1 μm/mV)	±9 V (0.1 μm/mV)
	Output impedance	100 Ω	
	Current output	4 to 20 mA (350 Ω max.)	
Alarm output		NPN open-collector (N.C.), 100 mA max. (40 V max.), Residual voltage 1 V max.	
Sampling cycle		128/256/512/2048 μs selectable	
Other functions		AUTO ZERO, Analog output hold during alarm, GAIN selection, Response speed selection, Mirror-surface measurement mode, Span/Shift adjustment, Sampling cycle selection	
Power supply		24 VDC±10%, Ripple (p-p): 10% max.	
Current consumption		400 mA max.	
Temperature fluctuation	**Sensor head**	0.04% of F.S. / °C (+20 to +30°C (68 to 86°F))	
	Controller	0.05% of F.S. / °C (0 to +50°C (32 to 122°F))	
Enclosure rating		IP-64	
Ambient light		Incandescent or fluorescent lamp: 10,000 lux max.	
Ambient temperature		0 to +50°C (32 to 122°F), No condensation	
Relative humidity		35 to 85%, No condensation	
Material	**Sensor head**	Aluminum die-cast	
	Controller	Polycarbonate	
Weight	**Sensor head**	Approx. 80 g	
	Controller	Approx. 515 g	

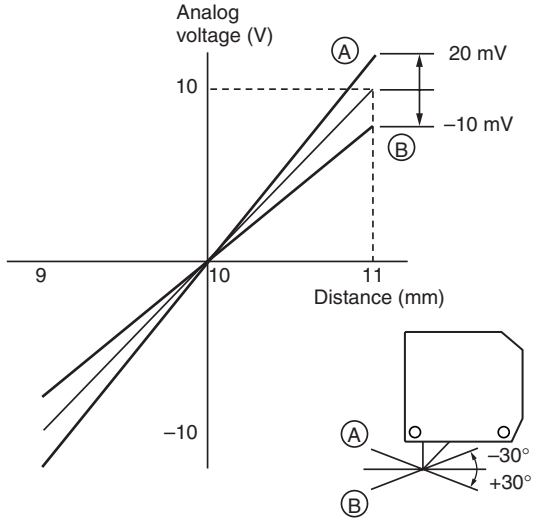
1. Linearity was obtained using KEYENCE's standard target (zirconia block gauge) with the sampling cycle set to 2048 μs.
2. Resolution was obtained using KEYENCE's analog sensor controller RD-50 with the sampling cycle set to 2048 μs and the number of measurements to be averaged set to 64.
   Note: The ripple of the analog output may be 1 mV or more due to common mode noise when observed with an oscilloscope or high-speed A/D conversion board.
3. When measurement is impossible, 12 V (21 mA) is output.

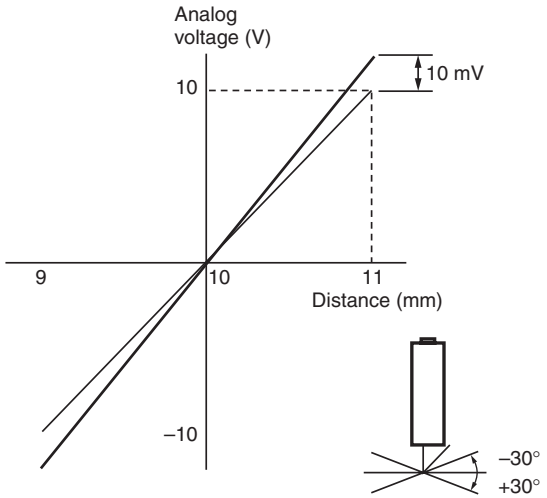
CHARACTERISTICS

Angle characteristics

Changes the span of the analog output when a white ceramic target is tilted by ±30° (Typical)

Normal mode

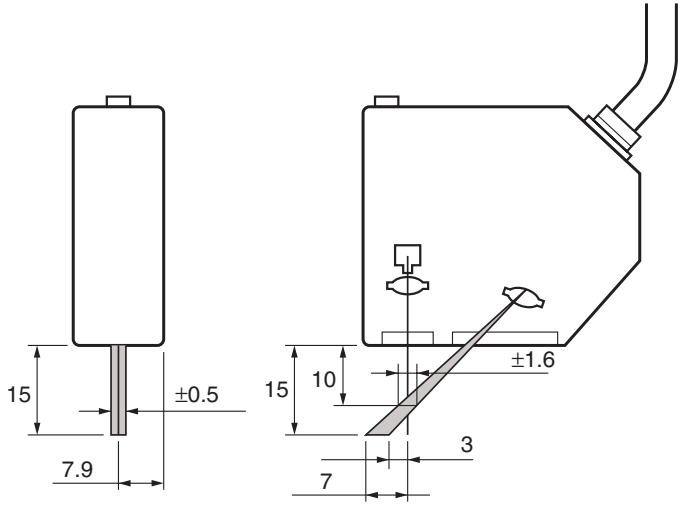




MUTUAL INTERFERENCE

Interference will occur only when the beam spot of another sensor is positioned inside of the shadowed area.

Unit: mm



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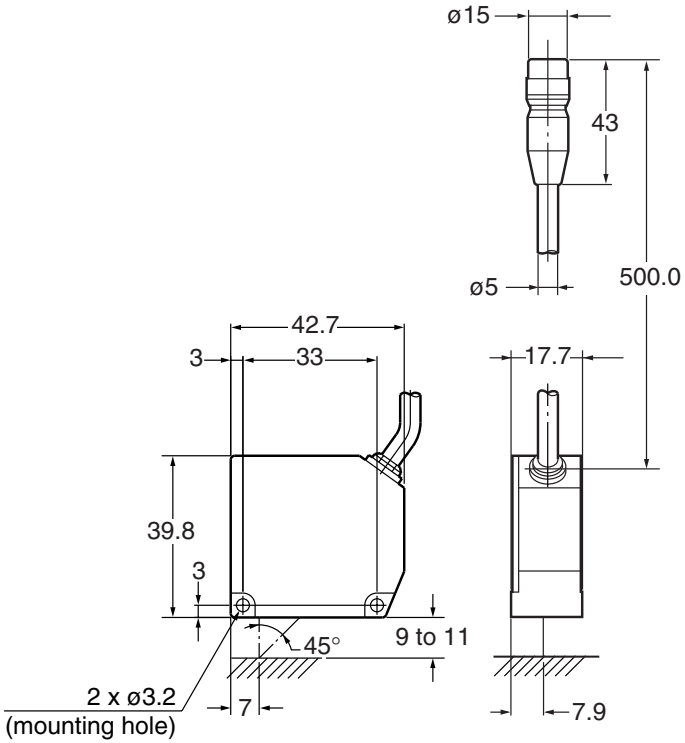
DIMENSIONS

Unit: mm

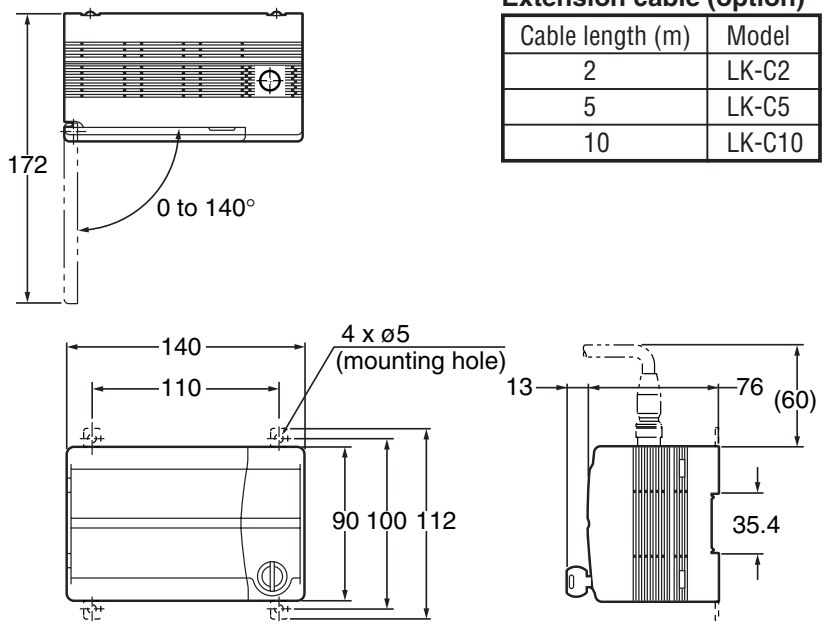
Sensor head

LK-011



Controller

LK-3101



Extension cable (option)

Cable length (m)	Model
2	LK-C2
5	LK-C5
10	LK-C10

Specifications are subject to change without notice.

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