Product manual

ABB i-bus® EIB

Light controller LR/S 2.2.1 and light sensor LF/U 1.1

Intelligent Installation Systems

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1 Notes

If the LR/S 2.2.1 is used for constant light control, the sensor measures the luminance of the illuminated surfaces in its detection range e.g. the luminance of the floor or desks.

With the lux meter however, which is used to set the constant light control, we measure the light intensity i.e. the luminous flux that falls on the sensor head of the lux meter.

These different measuring methods can – but need not – result in the constant light control system not functioning correctly in practice. This is however not a problem that is specific to ABB but one that affects all constant light control systems that operate according to this principle.

The terms of "light intensity" and "luminance" will first be clarified before advice is given about solving the problems.

2 Light intensity and luminance

An illumination meter (called a lux meter) measures the **light intensity** (E), i.e. the intensity with which an area is illuminated, in lux.

The light intensity (E) is defined as follows:

$$\mathbf{E = \Phi / A}$$

Φ = luminous flux in lumens
A = illuminated area

The light intensity therefore records the luminous flux radiating from a luminaire that is falling on a particular area. In order to measure the light intensity, the lux meter must be pointed at the light source i.e. at the luminaire or the sun.

Some examples of light intensity levels:

Cloudless summer's day	up to 100 000 lux
Dull summer's day	20 000 lux
Office lighting	500 lux
Dull winter's day	400 lux
Night of a full moon	0.3 lux

The lux meter for measuring the light intensity can be compared with an exposure meter used by professional photographers that has a direct measurement function. It is held directly at the sun and thus determines the values for the correct exposure of the film.

The light intensity itself does not convey the visual perception of brightness as the brightness level of the area in question is not recorded together with the light intensity.

The **luminance** L in cd/m^2 (cd = candela) is the measurement of the impression of brightness that an illuminated area produces on the eye.

A luminance meter records the reflected light i.e. the brightness of an illuminated area.

The effect created by the lighting can only be judged by measuring the luminance of all the areas in the field of vision.

The luminance of a visual object is not dependent on the optical distance. The brightness level therefore does not change if the distance is increased.

If white paper is exposed to a light intensity of 500 lux, the luminance is approx. 130...150 cd/m^2. With the same level of light intensity, recycled paper has a luminance level of only 90...100 cd/m^2.

It is also possible to calculate the approximate luminance (L) in cd/m^2 without using a luminance meter from the set aperture value and the exposure time for a specific film speed, since a „standard" exposure meter operates like a luminance meter.

If the luminance is to be measured for example using a „standard" exposure meter, the following process must be carried out:

For a 200 ASA film (24° DIN), the luminance for the part of the room seen in the viewfinder is:

$$L = 0.2 \times \frac{(\text{aperture value})^2}{\text{exposure time}}$$

With an aperture value of 4 and a set exposure time of 1/60s, the resulting luminance is approximately 200 cd/m^2.

2.1 Practical application

The light sensor of the LR/S 2.2.1 measures the luminance in its field of detection and converts this into a resistance value.

The luminance is dependent on the one hand on the light intensity i.e. the intensity of the daylight or artificial light and on the other hand on the characteristics of the areas that are illuminated.

For example, if the areas that are in the field of detection of the light sensor are completely covered in bright white paper, then the light sensor measures a different luminance value at the same light intensity than if the areas are covered with grey recycled paper.

When setting the setpoint value, the luminance is recorded by the light sensor and stored as a setpoint value. The controller will then regulate the artificial lighting in the room to achieve this setpoint as accurately as possible i.e. the controller attempts to keep the luminance value constant and not the light intensity level.

If the constant light control is then set to 500 lux in a room that has not yet been fully fitted out and changes are then carried out in the room e.g. furniture is rearranged or the floor covering is altered, the light intensity will be modified as the constant light control attempts to keep the luminance value constant and not the light intensity level.

As the light sensor measures the luminance and the luminance is not dependent on the optical distance, the mounting height of the light sensor does not influence the measurement of the luminance. It should of course also be noted that the light sensor has a considerably wider field of vision at a greater mounting height.

For example, if the floor in a gymnasium has the same structure through the hall, the position of the light sensor does not make a difference to the constant light control provided that only the floor is in the field of detection i.e. no walls or windows. With a constant level of light intensity, the light sensor will measure the same luminance value regardless of the height i.e. it will have the same resistance value.

However, as soon as people start moving in its field of detection, the luminance and thus its resistance value are modified.

3 Location of the light sensor

Step 1
Observe the walls and ceilings in a darkened room and with the lights switched on. Note the shadows produced by the lamps on the ceilings and walls. Those areas that are not directly lit by the lamps are suitable for placing the light sensor.

Step 2
Observe the walls and ceilings in a bright room and with the lights switched off. Observe the shadows created by direct light falling on the walls and ceilings. Those areas that are not directly lit by daylight are suitable for locating the light sensor.

Step 3
Place the light sensor in one of the positions which has been established using the methods above as a suitable location for the sensor both in daylight and artificial light. Then connect a resistance meter to the light sensor.

Step 4
Darken the room, set a lux value of 500 lux via the luminaires and measure and note the resistance value of the light sensor.

Step 5
Put the room in semi-darkness. Dim the luminaires so that the lux meter indicates 500 lux. Measure and note the resistance value of the light sensor.

Step 6
Switch off the luminaires and open the shutter slightly so that the lux meter indicates 500 lux again. Measure and note the resistance value of the light sensor.

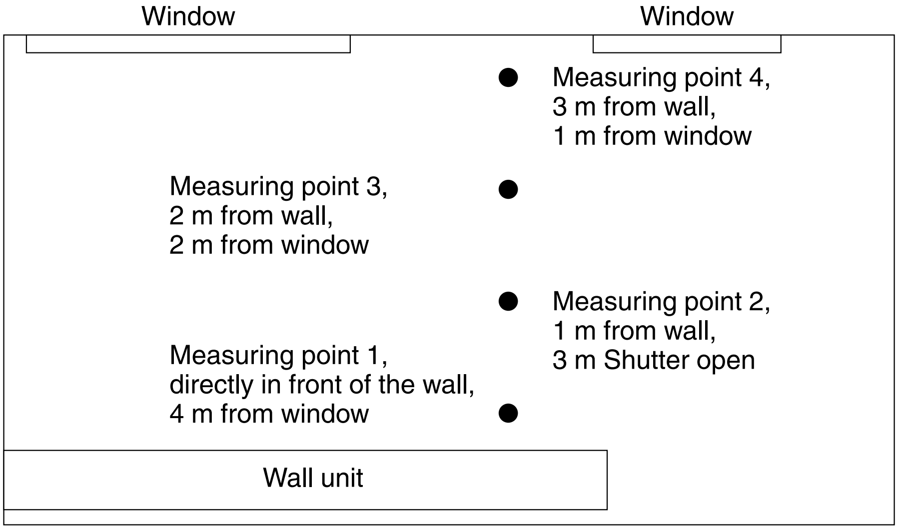
Step 7
Carry out steps 4 to 6 in further suitable locations. The location with the least deviation in the resistance values is the most appropriate for positioning the light sensor.

3.1 Practical examples

The following measurements were carried out in a sample office in order to substantiate the theoretical statements using a practical example:

Measurement 1

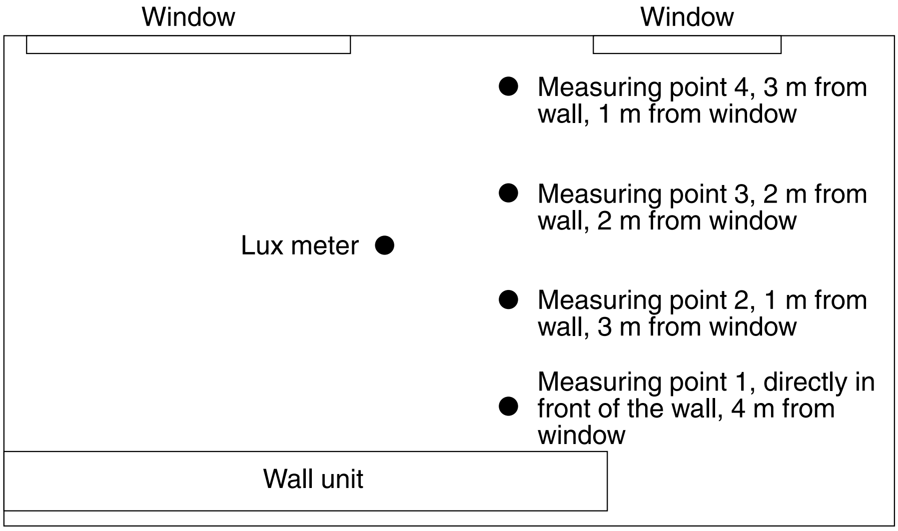
The light sensor was placed in various locations in a fully furnished office and the lux meter was positioned directly below the light sensor at a height of approx. 80 cm above the floor. A light intensity of 500 lux was set each time with the shutters open, half open and closed and the resistance value of the light sensor was measured.



	Measuring point 1	**Measuring point 2**	**Measuring point 3**	**Measuring point 4**
Shutter open	4.2 kOhm	3.3 kOhm	2.3 kOhm	2.2 kOhm
Shutter half open	4.9 kOhm	3.7 kOhm	2.7 kOhm	2.6 kOhm
Shutter closed	5.4 kOhm	3.9 kOhm	3.1 kOhm	3 kOhm
Percentage deviation from highest value	22 %	14 %	23 %	26 %

Measurement 2

The lux meter was placed on the desk in the same office. A light intensity of 500 lux was set each time with the shutters open, half open and closed and the resistance values were measured at measuring points 1 … 4.



	Measuring point 1	**Measuring point 2**	**Measuring point 3**	**Measuring point 4**
Shutter open	4.0 kOhm	3.8 kOhm	2.8 kOhm	1.8 kOhm
Shutter half open	4.7 kOhm	4.2 kOhm	3.6 kOhm	2.5 kOhm
Shutter closed	5.5 kOhm	4.7 kOhm	3.9 kOhm	3.2 kOhm
Percentage deviation from highest value	27 %	19 %	28 %	40 %

4 Evaluation of the measurements

The measurements confirm the experiences made in various EIB installations that the location of the sensor is responsible for the control precision.

It may not be possible in practice to find a location where the resistance value remains constant with different lighting conditions but at a constant level of light intensity.

It is however possible to find a mounting site where the deviations from the setpoint are as low as possible.

The basic rule: Place the sensor as far into the room as possible but not directly in front of any reflecting walls. Neither daylight nor artificial light should fall directly on the sensor.

5 Conditions for setting the setpoint value

If the most suitable location has been found for the light sensor, the setpoint value must be set. This setting can be carried out in the dark (i.e. the shutters are lowered and only the artificial lighting is switched on), in semi-darkness (i.e. some daylight is coming through the half-lowered shutter and there is a high percentage of additional artificial light) or in brightness (i.e. the shutters are open and there is only a low level of artificial light).

There may be deviations from the setpoint value, depending on the setting.

As the measurements show, the light sensor has different resistance values when there is a constant level of light intensity, depending on the lighting conditions: daylight only, daylight and artificial light, or artificial light only.

This is because the light sensor does not measure the light intensity which is present at the measuring point used for setting the lux meter. To do this, it would need to be placed in exactly the same position as the lux meter, be pointed in the same direction and use the same method of measurement as a lux meter.

It rather records light that falls within its field of detection and converts it into a resistance value. The light sensor is usually mounted on the ceiling or the wall and primarily detects the light reflected from the floor, walls and items of furniture i.e. it detects the luminance of the areas that are illuminated by natural and artificial light. To a lesser extent, the natural light coming in above the windows and the artificial light from the lamps that is falling directly on it are also recorded, depending on the position of the light sensor.

In the measurements carried out in our example, the following resistance values of the light sensor were measured at the most suitable measuring point with a constant luminance of 500 lux.

	Measuring point 2
Shutter open	3.8 kOhm
Shutter half open	4.2 kOhm
Shutter closed	4.7 kOhm

If the setpoint value is now set with the shutter closed, the light controller notes the resistance value of 4.7 kOhm and attempts to keep this resistance value constant i.e. if the shutter is opened, it readjusts the artificial lighting.

During the measurements, it was established that when the shutter is open and the light intensity is set to 500 lux, the resistance value of the light sensor is 3.8 kOhm. That means that the light controller will reduce the artificial lighting until the light sensor achieves the setpoint value of 4.7 kOhm. The level of light intensity is however well below 500 lux.

If the setpoint is now set when the shutter is open, the light controller notes the resistance of 3.8 kOhm and attempts to keep this resistance value constant when the shutter is closed.

During the measurements, it was established that when the shutter is closed and the light intensity is set to 500 lux, the resistance value of the light sensor is 4.7 kOhm. That means that the light controller will increase the artificial lighting until the light sensor achieves the setpoint value of 3.8 kOhm. The level of light intensity is however well above 500 lux.

If the most suitable location has been found for the light sensor according to the methods described above, the setpoint value should be set in the following way:

Take the lowest value among the measured resistance values, in this case 3.8 kOhm. Recreate the environmental conditions under which these values were recorded, in this case open shutters.

Set the setpoint value e.g. 500 lux for these environmental conditions.

This method guarantees that the deviations from the setpoint can only be higher than the setpoint i.e. the light intensity can under no circumstances be less than 500 lux at the measuring point.

If the setpoint is set at the highest resistance value i.e. when the shutters are closed, then the light intensity will be less than 500 lux at the measuring point when the shutters are opened.

6 Ideal situation

The ideal situation would be if the controller were to not only keep the resistance value of the light sensor constant but also the light intensity at the measuring point of the lux meter.

To do this, the following conditions must be met:

– the light sensor must be positioned so that it is only influenced by the light that is reflected in the immediate vicinity of the lux meter

– it thus does not detect any daylight or artificial light falling directly on it. It also does not record any light that is reflected on it from any other area than the immediate vicinity of the lux meter

– the nature of the reflected areas in the immediate vicinity of the lux meter should be such that – regardless of whether the light coming in is only daylight, only artificial light or both together – the influence produced by the reflected light on the light sensor, with the same light intensity at the lux meter, means that the same resistance value is always present.

This is not feasible in practice and the light sensor will also perceive direct daylight for example.

If a measurement of 500 lux has now been recorded when setting the setpoint in the dark, and there is only 250 lux for example in broad daylight, this is due to the fact that the light sensor lights up in a different way to the lux meter. In this case, the light sensor also sees direct daylight in addition to the light reflected from the surrounding area of the lux meter.

If it is not possible to find a more suitable mounting site for the light sensor, then the next best choice must be made.

This means either

a measurement of 500 lux for open shutters, slightly more than 500 lux for half-open shutters and significantly more than 500 lux for closed shutters

or

a measurement of slightly less than 500 lux for open shutters, 500 lux for half-open shutters and slightly more than 500 lux for closed shutters

or

a measurement of significantly less than 500 lux for open shutters, slightly less than 500 lux for half-open shutters and 500 lux for closed shutters

The best solution is however in this case to place the light sensor so that the same resistance values are present at the light sensor with the same lux values as for the lux meter – regardless of the type of lighting.

7 Causes of errors

When many controllers switch on, it is „too dark“, with others it is „too bright“

If a “1” is sent to the switching object of the controller, it first measures the current actual value and then calculates the control variable required for controlling the lamps.

The algorithm that is used specifically for the calculation is very simple due to the limited storage capacity of the BCU. The control variable can thus be initially too small (i.e. it is too dark) or too large (it is too bright). The controller then dims slowly up or down until it reaches the setpoint.

The degree of accuracy is at its highest if the setpoint is selected and the controller is switched on while the room is in darkness or if the setpoint is selected and the controller is switched on in a bright room.

If the setpoint has been set when the room is lit and then the controller is switched on when the room is in darkness, the control variable is initially too small and the controller then dims up until it reaches the setpoint value.

If the setpoint has been set in a darkened room and then the controller is switched on when the room is bright, the control variable is initially too large and the controller then dims down until it reaches the setpoint value.

The controller does not switch on

Once the application has been loaded in the LR/S 2.2.1 and the parameter setting:

Function: *closed loop control and dimmer*

has been selected, the internal controller in the LR/S 2.2.1 is already activated and uses a setpoint value that has been preset internally.

If one of the lamps that is connected to the LRS 2.2.1 (e.g. via a device with electronic ballast) does not light up at this stage i.e. once the application has been loaded, then the current actual value lies above the setpoint value i.e. it is simply too bright for the controller and it therefore does not switch on.

If a “1” is then sent via a push button to the switching object of the controller and the controller does not switch on, this is also due to the fact that the actual value is larger than the setpoint i.e. the natural light is sufficient and no artificial light is required.

To cause the controller to switch on, the sensor can for example be covered or the shutters lowered.

Setting a second setpoint

When setting the setpoint, the luminance that is measured by the light sensor in its field of detection and converted into a resistance value is used as a setpoint (luminance = measurement for the level of brightness perceived for an illuminated area).

If now a telegram with the value “128” is sent to the 8 bit object of the light controller and then the value “1” is sent immediately afterwards to the object “Set setpoint”, the luminance that is measured by the light sensor is stored as the new setpoint.

If it was dark outside for example when the setpoint was reset, the luminance is considerably lower then if it is very bright outside when the new setpoint is set. The two setpoints are therefore different.

This means that the value that has been sent to the 8 bit object cannot be used to set the controller to a specified new setpoint value. This setting is purely accidental.

It is therefore not possible to set a defined second setpoint with the LR/S 2.2.1.

8 Testing the light controller

The following should be carried out in order to establish the function of the controller both quickly and simply:

Test 1: Switch on with the actual value smaller than the setpoint

1. Sensor cable should be short-circuited (low resistance = bright)
2. Dim to maximum brightness either via the 4 bit or 8 bit objects
3. Set the setpoint
4. Switch off the controller via the 1 bit object
5. Leave the sensor cable open (high resistance = dark)
6. Switch on the controller via the 1 bit object. The controller must now switch on with maximum brightness

Test 2: Switch on when actual value = setpoint

1. Sensor cable should be short-circuited (low resistance = bright)
2. Dim to maximum brightness either via the 4 bit or 8 bit objects
3. Set the setpoint
4. Switch off the controller via the 1 bit object
5. Leave the sensor cable shorted (low resistance = bright)
6. Switch on the controller via the 1 bit object. The controller cannot be switched on

Notes

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