

## How does HALIOS<sup>®</sup> work?

A typical HALIOS<sup>®</sup>-control loop consists of two LEDs, one photodiode with amplifier, one synchronous demodulator and one PI-regulator. Figure 1 shows the connection of the elements.

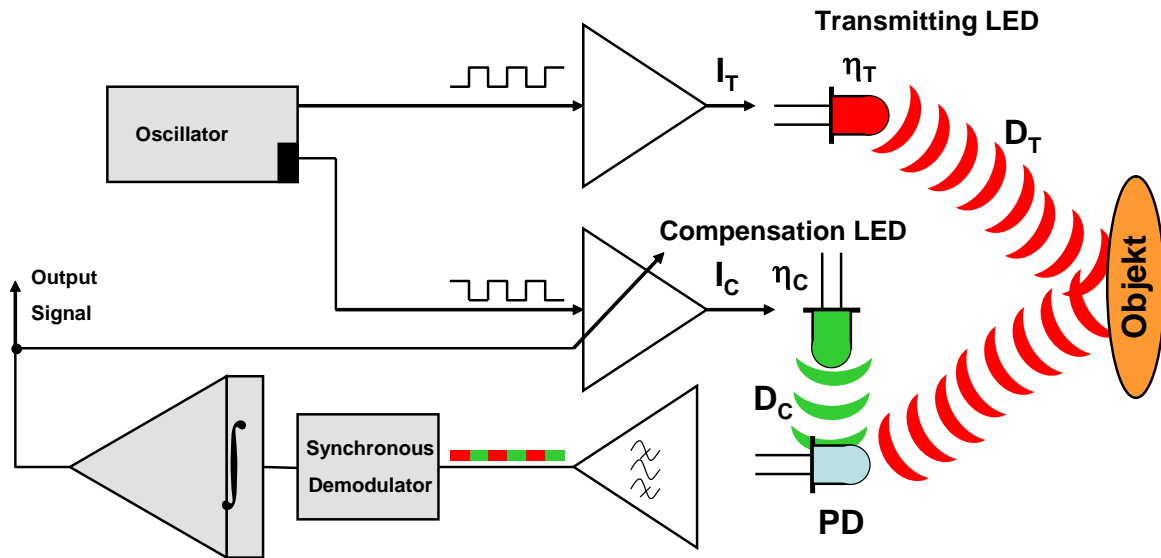


Figure 1: typical HALIOS<sup>®</sup>-control loop

The sending LED (the red LED in the figure) emits rectangular shaped amplitude-modulated light. Part of this light is reflected by the object and sent back to the photodiode. A second LED, the compensation LED (the green LED) also emits rectangular shaped amplitude-modulated light to the photodiode, but 180° phase-shifted. At the receiver both light signals are superimposed cancelling each other out, if both signals are showing the same amplitude. The synchronous demodulator is therefore able to easily detect, which LED is emitting more light. This information is then transmitted to the regulator, which consequently adjusts the transmitting amplitude of the compensation LED (green), so the received amplitude is zero (necessary condition).

As soon as the object changes its position, the fraction of light, which the sending LED emits to the photodiode, also changes. This leads to a tracking of the intensity of the compensation LED by the regulator to ensure that the necessary condition is still fulfilled. The tracking by the regulator leads to an adjustment of the control signal functioning as output signal. Therefore the control signal functions as a rate for the reflection by the object.

Using the symbols introduced in figure 1 as reference, the necessary condition is:

$$f_{PD}(I_C \cdot \eta_C \cdot D_C) = f_{PD}(I_T \cdot \eta_T \cdot D_T) \quad (\text{equation 1})$$

As the transfer function  $f_{PD}$  of both signals is identical and monotone, the following applies:

$$I_C \cdot \eta_C \cdot D_C = I_T \cdot \eta_T \cdot D_T \quad (\text{equation 2})$$

According to figure 1 the sending current of LED 2 is constant. Therefore the following applies:

$$\text{mit: } I_T = I_0$$

$$I_C = \frac{I_0 \cdot \eta_T}{\eta_C \cdot D_C} \cdot D_T \quad (\text{equation 3})$$

From equation 3 it can be concluded that the control signal ( $I_C$ ) is directly proportional to the optical coupling  $D_T$ .

## What is the advantage of HALIOS®?

Conventional optical reflecting light barriers have two disadvantages:

1. The receiving signal has a large dynamic range.
2. The receiving signal is dependent on ambient light and temperature.

Disadvantage 1:

Usually disadvantage 1 is solved by using logarithmic amplifiers. These are complex, expensive and need a lot of calibration.

HALIOS®, in contrast, is able to always intensify the receiving signal to maximum intensity, as the alternating component is zero, as soon as it is adjusted by the regulator. Therefore the system is always sensitive to a maximum extent. As there is no amplifier path (cf. Equation 2), the exact characteristics of the amplifier and its changes over time are not relevant.

Disadvantage 2:

Normally interferences are suppressed using relatively cost-intensive optical filters or complex modulation techniques.

With HALIOS®, in contrast, such regulations are not necessary. Especially the non linear dependency of the sensitiveness of the photodiode on the ambient light (ambient light effect) is suppressed at any time, as the characteristics of the receiving path (cf. equation 2) does not take the measurements into account. In addition the temperature-sensitive optical efficiency is also neglected during the measurements, as long as both LEDs are showing the same temperature. The same is true for changes in the efficiency of the LED over time (ageing).

Conclusion:

As the receiving path is eliminated from the measurement with the use of the compensation principle (balance principle) a significant improvement of reflective and absorptive working measurement systems is reached. Particularly the problem of ambient light sensitiveness is solved by HALIOS®. It is therefore possible to implement low-cost optical sensor systems with an extremely high quality, suitable for every day use.