Electronics

Open- and closed-loop control

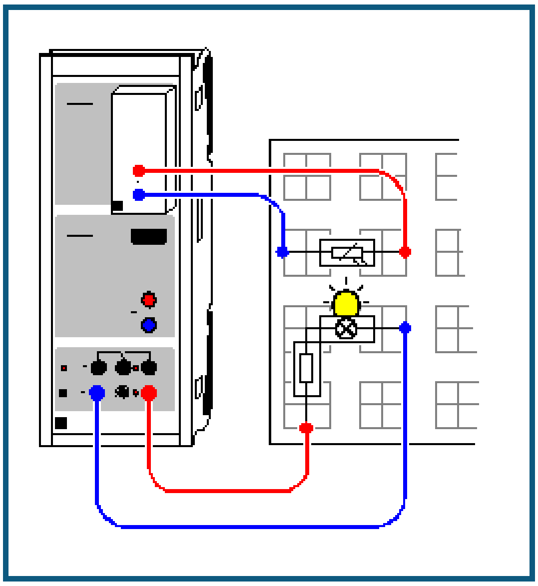
Closed-loop control

Brightness control with CASSY

Description from CASSY Lab 2

For loading examples and settings, please use the CASSY Lab 2 help.

Brightness control



Experiment description

This experiment realizes a brightness control for a light bulb using variable series resistors. A PI controller is used here. A PI controller determines the system deviation w-x from the measured value x = R_{A1} (resistance of an LDR) and the reference variable w (set value of the LDR resistance).

Together with the base load y_0, this gives us the manipulated variable y = y_0 + K_P*(w-x) + K_I*∫(w-x)*dt for the PI controller. The proportional-action coefficient K_P and the integral-action coefficient K_I as control parameters can be optimized so that after a deviation (e.g. an additional series resistor, a change in the reference variable w or the base load y_0) the system returns to a system deviation w-x of about 0 as soon as possible.

If only a P-controller is used (K_I = 0), a residual system deviation w-x occurs which does not disappear until an I-component is applied.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	Current source box	524 031
1	Plug-in board DIN A4	576 74
1	Lamp socket E10, side	579 05
1	Set of 10 lamps 3.8 V/0.07 A	505 10
1	Toggle-switch, single-pole	579 13
1	Photoresistor LDR05	578 02
1	STE resistor 10 Ω, 2 W	577 20
1	STE resistor 20 Ω, 2 W	577 23
1	STE resistor 47 Ω, 2 W	577 28
1	STE resistor 100 Ω, 2 W	577 32
2	Pairs of cables, 100 cm, red and blue	501 46
1	PC with Windows XP/Vista/7/8	

Experiment setup (see drawing)

The voltage source S supplies the lamp via a 100 Ω protective resistor. The brightness of the lamp is measured using a light-dependent resistor together with the current source box at CASSY input A.

Additional series resistors can be switched on with the toggle switch to produce deviations. A closed toggle switch shorts the series resistor, and an open toggle switch leaves it in the circuit.

Carrying out the experiment

- Load settings
- Turn the potentiometer of the voltage source S all the way to the right.

- The lamp lights up already, as a base load y_0 of 0.5 has been set. This means that PWM output S is operating at a duty factor of 50 %.
- Change the base load y_0 as you like, by setting the corresponding parameter value in the Settings y0 (right mouse button).
- Enter the measured resistance as the reference variable w by moving the pointer of the display instrument with the mouse or changing the value of the parameter in the Settings w (right mouse button).
- Start the control with ⏱ and stop it at the appropriate time with ⏱.
- During control, a deviation can be applied, e.g. by switching a series resistor or changing the reference variable or base load.
- You can optimize your controller by varying the proportional-action (K_P) and integral-action (K_I) coefficients; set the corresponding values in Settings KP or KI (right mouse button).

Evaluation

The recorded curves clearly illustrate the quality of the controller. The black line represents the reference variable w (set value). The red curve represents the controlled variable x (measured value) and should converge with the black curve quickly following a deviation. The blue curve represents the manipulated variable y and thus corresponds to the lamp voltage.

Empirically optimizing the PI brightness controller

Set negative values for K_P and K_I, as the measured resistance value of the sensor box becomes less the greater the voltage at the voltage source S is.

- Set K_I to 0, and increase K_P in moderate steps (e.g. by -0.1) until the control loop oscillates.
- Reduce K_P again until the oscillations die out. A residual system deviation is created.
- Increase K_I in moderate steps (e.g. by 10*K_P) until the system oscillates again.
- Reduce K_I again until the oscillations die out. Note that the controller becomes slower, the lower K_I becomes.

In this example, we have used K_P = 0.5 and K_I = 5 /s.

Automatically varying the reference variable

The reference variable w (set value) can be varied not only manually, but automatically as well. We can do this, for example, by entering the formula **1+0.5*sin(360*t/20)** in the Settings w. This results in control of a sinusoidal resistance curve of the LDR between 0.5 kΩ and 1.5 kΩ with a period of 20 s.