

Electronics

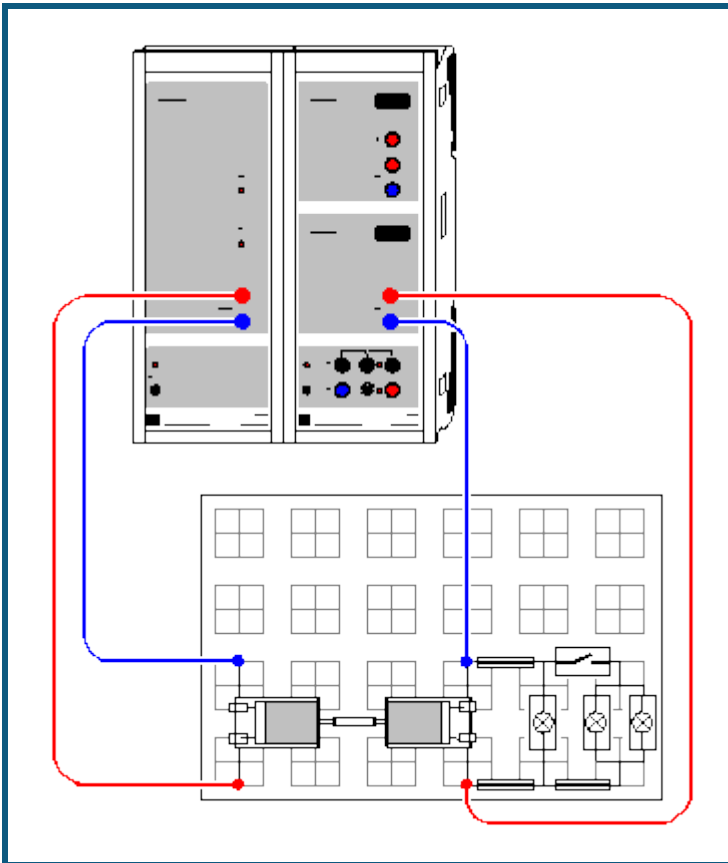
Open- and closed-loop control
Closed-loop control

Voltage control with CASSY

Description from CASSY Lab 2

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

Voltage control



Experiment description

This experiment realizes voltage control of a generator under a variable load. A PI controller is used here. A PI controller determines the system deviation $w-x$ from the measured value $x = U_{B2}$ (voltage of the generator) and the reference variable w (set value of the generator).

Together with the base load y_0 , this gives us the manipulated variable $y = y_0 + K_P \cdot (w-x) + K_I \cdot \int (w-x) \cdot dt$ 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 load, 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	Power-CASSY	524 011
1	CASSY Lab 2	524 220
1	Plug-in board DIN A4	576 74
2	DC motors and tacho generators	579 43
1	Toggle-switch, single-pole	579 13
3	Lamp socket E10, top	579 06
1	Set of 10 lamps 3.8 V/0.07 A	505 10
1	Plastic tubing, 6 mm	307 641
1	Set of bridging plugs	501 48
2	Pairs of cables, 100 cm, red and blue	501 46
1	PC with Windows XP/Vista/7/8	



Experiment setup (see drawing)

Power-CASSY supplies the motor (left), which drives the generator (right) via a section of plastic tubing approx. 25 mm long. The voltage of the generator is measured at input B of Sensor-CASSY. Make sure that the connections of either the motor or the generator are reversed, as the motor and the generator are linked in opposing directions.

The load on the generator is varied using three light bulbs, two of which can be switched on using a toggle switch.

Carrying out the experiment

■ Load settings

- The motor is already turning, as a base load y_0 of 6 V has been set.
- Change the base load y_0 as you like, by setting the corresponding parameter value in the [Settings \$y_0\$](#) (right mouse button).
- Check the measured voltage U_{B2} ; this must be positive (reverse polarity if necessary).
- Enter the measured voltage 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 varying the generator load 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 \$K_P\$ or \$K_I\$](#) (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 motor voltage.

Empirically optimizing the PI voltage controller

- 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 $10 \cdot K_P$) 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 $K_I=4$ /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 [4+sin\(360*t/20\)](#) in the **Settings w** . This controls a sinusoidal voltage curve between 3 V and 5 V with a period of 20 s.

Other control loops

This example can also be adapted to other control loops. As long as the controlled variable is a voltage, it is only necessary to modify the correcting range and the measuring range as well as the control parameters K_P and K_I .

If the controlled quantity is provided by a sensor box, first of all the channel U_{B2} has to be deleted by switching it off in the selection box in [Settings \$U_{B2}\$](#) . Then, in [Settings → CASSYs \(Window → Show CASSY Modules\)](#), activate the sensor box with the mouse and again select **Averaged Values**. The unit and symbol of the reference variable w and the system deviation $w-x$ must also be modified, as well as the calculation formula for system deviation (e.g. **w-RB2** instead of **w-UB2**). As in all CASSY experiments, you can change the settings by clicking on channel w or $w-x$ with the right mouse button.