

# COMPUTERGESTÜTZTES EXPERIMENTIEREN I (Computer-Assisted Experimentation I)

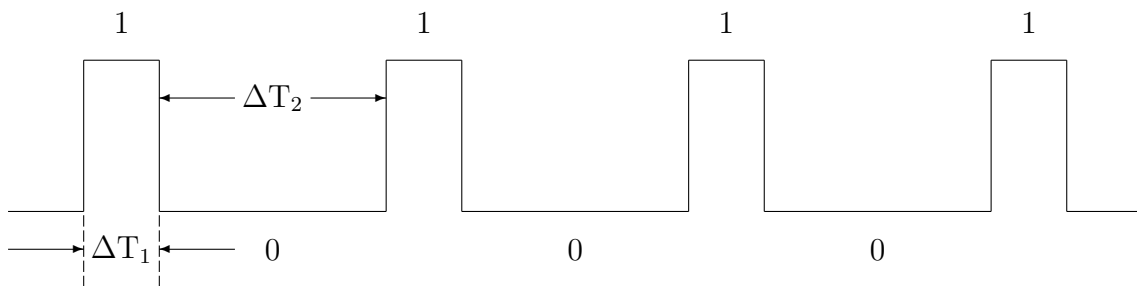
## P R A C T I C A L Programming in LabVIEW

### Aperture Experiment

In the Aperture Experiment a light beam is imaged onto a slit aperture behind which a light detector measures the amount of the incoming light. The slit aperture can be opened and closed using a stepping motor. In the first part of the exercise you will learn to control the stepping motor, in the second part you will learn to acquire the signal using an analog/digital converter (ADC) that measures the light intensity, and in the third part you will implement a feedback control that keeps a given light intensity shining on the detector.

#### 1. Controlling a stepping motor

The stepping motor will be controlled using the digital output of a NI USB-6009 Interface. Bit0 and bit1 of port0 will be used. Bit0 controls the rotation (1 = clockwise, 0 = counterclockwise, i.e. opening the aperture slit). Bit1 generates impulses that trigger a step of the motor. Setting and resetting bit1 creates these impulses:



For impulses we have  $\Delta T_1 \ll \Delta T_2$ . The duration of a pulse  $\Delta T_1$  may be rather short, e.g. a few  $\mu s$ . The time the computer needs for setting and resetting the bit is sufficient. The time between pulses  $\Delta T_2$  should be in the order of 100 ms and may be generated using the VI Wait(ms).

The slit aperture is moved, - opened or closed-, using the stepping motor. There are stops on the aperture when it is completely opened or closed. Two switches sense when the

aperture reaches a stop. The switches are connected to port1 (configured for input). Bit0 = 1 signals when the aperture is completely opened and bit1 = 1 indicates the completely closed aperture.

For the operation of the stepping motor the code of the following functionality should be implemented, and, optionally, converted into SubVIs:

SwitchState	read the switches and return two booleans, one for completely closed and one for completely open aperture
Step(direction)	the motor does one step in the given direction. Before a step is executed the SwitchState is checked and only if it is allowed the step is executed: if the direction is open, i.e. counterclockwise, and the aperture is not completely opened or if the direction is close, i.e. clockwise, and the aperture is not completely closed.

Create a VI (main program) that uses the code specified above. The front pannel should have a toggle switch that defines the direction open/close and a control that defines the number of steps to be done.

Optionally, if you have time, add a button when pressed the experiment is reset; i.e. it is set in a well defined state which should be that the aperture is completele closed. Starting from this position the absolute position of the aperture can be recorded in terms of steps and shown by an indicator.

Objectives: control of a stepping motor, waiting times of different magnitude, factorization of an automization task into elementary control functions.

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#### 2. Data acquisition using an ADC

The intensity of the light passing through the aperture is measured using a light detector, which is a simple photo resistor. The detector creates a signal between 0 V and 5 V, that is proportional to the intensity. The signal voltage is measured with the analog/digital converter (ADC) provided by the NI USB-6009 Interface. Details of its functionality may be found in the separate document Appendix NIDAQmx.

Implement the code that sets up the ADC and that performs the A/D conversion. The latter may be encapsulated into a SubVI. The signal of the light detector is connected to channel0 of the multiplexer. The set up is done in the Create Virtual Channel VI: on the selector choose Analog Input/Voltage, on input terminal configuration choose Differential, on physical channel choose ai0, and on units choose Volts.

Add an option to the VI (main program) that measures the curve of the signal voltage as a function of the aperture's width given in steps of the motor

$$\text{voltage} = f(\text{steps})$$

and that displays the curve in a graph (Build XY Graph VI). It is recommended to proceed in the following way: first, close the aperture completely, second, open the aperture for 200 steps (as there is no signal due to the overlapping blades of the aperture) and, third, measure the curve over 2000 steps.

Objectives: acquisition and processing of analog signals, low level programming of interfaces

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#### 3. Feedback control

In this exercise you will write a program that controls the aperture such that a given intensity of the light on the detector remains constant (closed loop feedback control).

If, for illustration, the intensity of the beam is reduced by partially blocking the light source, the aperture has to be opened until the preset intensity is reached.

Based on the program/VI of the previous exercise add an option, that first records and displays the "response curve". Then the desired value shall be given e.g. by using a graphic cursor. While the system performs the feedback control and approaches the desired value, the actual value shall be tracked in the graph.

Objectives: implementation of a feedback control.