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Mobiles Hardware-Praktikum
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Lab 2
Fundamentals of Analog and Digital Circuits

In the following lab we are going to make a device that measures capacitance utilizing the PICee microprocessor. In this lab you will see how we use the computers limited ability to only read a logic "1" or a logic "0" (no intermediate values) to measure the size of a wide range of capacitors. This is done by converting the capacitance measurement into a time measurement by allowing the microprocessor to keep track of how long it take for a certain event to happen.

Illustration 1 shows a simple RC circuit that has the form of a low-pass filter. In this lab we will not review all the theory relating to RC time constants but for more information you can refer to *Halbleiter-Schaltungstechnik*, by U. Tietze und C. Schenk, page 9ff. The basic equation is "T = R·C" where R is resistance, C is capacitance, and T is the time required by the circuit before its output has reached 63.2% (= 1-1/e) of the input voltage. Since this circuit has an input voltage of 5V, an output voltage of 3.15V is used for the RC time constant. For example, in Illustration 1, where R is 1 kΩ and C is 100 μF:

$$T = 1000 \Omega \cdot 0,0001 \text{ F} = 0,1 \text{ s} = 100 \text{ ms}$$

The load time T in this equation is strictly proportionally to the capacitance. This means that the result of doubling the capacitance while maintaining a constant resistance is that the load time also doubles. The above equation has also another advantage when used with a 1 KΩ resistor in that the calculated time is equal to the capacitance in μF (0.1 s requires a 0.1 μF capacitor).

The following two exercises require you to build this capacitance-measuring instrument using the PICee development system and the extension board. Your design should follow the design shown in Illustration 1. Also, make sure all the power and programming cables are connected properly as you will need to program the PIC16F84 microprocessor.

To help get you started, illustration 2 shows the pseudo code for this measuring instrument. The pseudo code begins by setting PORTB1 to a logical "1" and then starting the time measurement. Then, while the program waits for the capacitor to charge it increments a counter that keeps track of how many timer interrupts have occurred. When PORTA1 = "0" it then stops the time measurement. Lastly, the program discharges the capacitor so that another measurement can be made.

The normal threshold voltage for PORTA1 of the PIC16F84 microprocessor are not really close to the 3.15V that is require for us to measure the RC time constant. That is why the circuit uses the 74HC14 Schmitt-Trigger. This ensures that the PIC microprocessor reads a

logical "0" and a logical "1" at the right times (refer to *Data Sheet 74HC14* and *Das PICee++ System*, page 14ff).

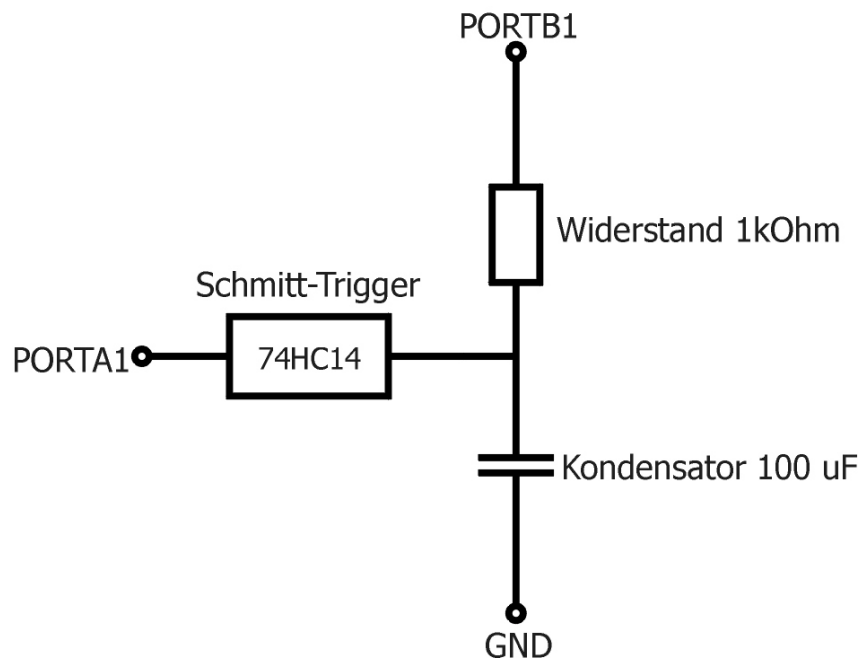


Illustration 1: Low-pass Filter setup

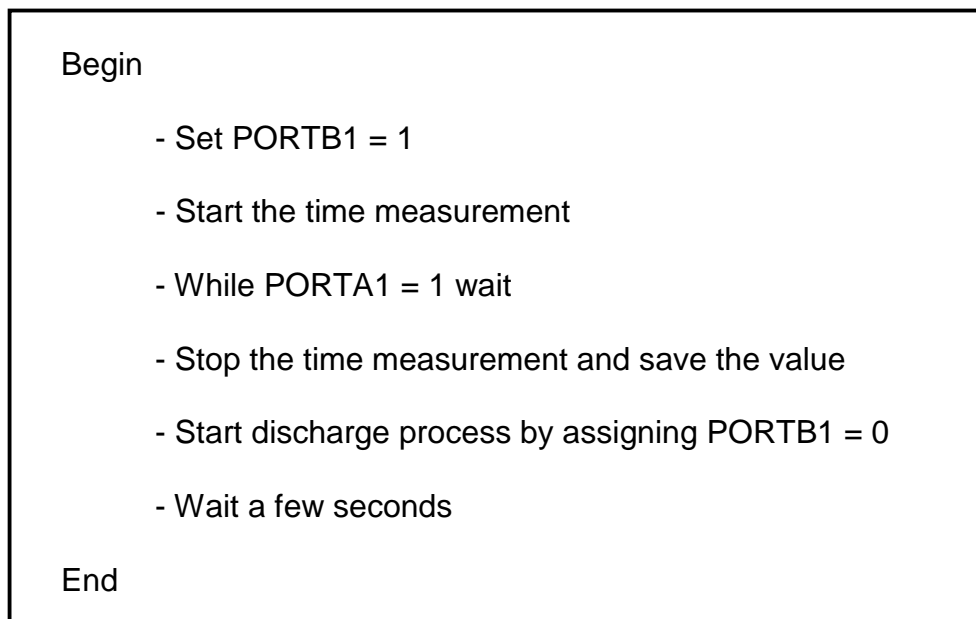


Illustration 2: Pseudo code of the capacitance-measuring instrument

Exercise 1

Modify your stopwatch program from the first series of labs (lab 3, exercise 2) in such a way that the time in millisecond can be measured exactly. Then allow the time measurement to be stopped by a change in the value at the PORTA1 input. Lastly, add a bit more functionality so that the program can wait for a specific discharging time so the circuit can reset.

If your stopwatch program was incorrect you can use the sample solution that will be posted on the web after the stopwatch lab is complete (available from 30.05.2003).

Exercise 2

Now, build the entire circuit from illustration 1 with the flexible connecting wires. Make sure the PIC microprocessor is properly connecting to the circuit. Then measure the value of all the capacitors you have. Once all the measurements are complete comment on possible inaccuracies in the design and the circuit.

Note: When programming the PIC16F84 microprocessor no connection to PORTB can be present. This will result in the microprocessor being programmed incorrectly.

When you are finished with the lab you are required to hand in sketches, pin assignments, and other results obtained from the lab. Compress all appropriate files into one ZIP file and then submit it through the courses Web Site Portal.