

# INF5470, exercise 4: A Second Order Filter

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## Abstract

In this exercise a resonant second order low-pass filter will be built and analysed. This filter expresses similar properties when exposed to electrical signals as the basilar membrane in the cochlea when exposed to hydrodynamic waves.

## 1 Tools

- **Oscilloscope HP54622D**

A manual can be found in the lab. *DO NOT REMOVE IT!* Only consult it in the lab. Traces can be loaded to the computer via the GPIB interface or using floppy disks. The GPIB bus interface can be handled by matlab functions. You must tell matlab where to find those functions first by setting the search paths correctly. Remember to turn it on first.

Example session:

```
>> %Add the GPIB tools to the matlab path:
>> addpath(genpath('~mes/src/matlab/gpib/linux'))
>> % Get traces from the oscilloscope:
>> [time,chan] = HP54622_GetData2;
>> % Plot the results:
>> plot(time,chan(1,:), 'g', time,chan(2,:), 'r');
>> xlabel('Time [s]'); ylabel('Voltage [V]');
```

This should plot the trace from channel 1 in green and channel 2 in red. *Please note* that both channels on the oscilloscope must be turned on for this script to work. You may use the Run/Stop and Single buttons to find a suitable trace for dumping.)

*Also note* that there is a bug in the HP54622\_GetData2 script, in order to not get weird results, you need to

make sure that none of the two plots on the oscilloscope cross each other's paths. There will be an offset in the plotted graph in matlab, but this can easily be corrected in matlab afterwards.

For measuring amplitude on the oscilloscope, the command `HP54622_MeasVPP(channel)` can be used. Replace `channel` with the channel number of the probe that is measuring the output signal.

- **Voltage sources**

Use the 'Agilent E3631A' triple output voltage source. It has two independent voltage outputs. Use the one labeled with +6V for the one bias voltage that is needed and the +25V for the power supply.

- **Agilent 34401A multi-meter**

The 34401A is a multi-meter that you can use to verify that constant voltage are where they are supposed to be.

- **An Agilent 33250A wave form generator**

Its use is quite intuitive. When you have set a waveform type, a frequency, offset, and amplitude, you also need to activate the 'output'.

To initialize and set the wave form generator, you can use the following commands:

- `HP33120_Init` - Initializes the wave form generator. This needs to be run only once per matlab-session.
- `HP33120_SetSignal('SIN',0.3)` - makes the wave form generator create a sinus wave with amplitude 300mA.
- `HP33120_SetDCoff(1.5)` - sets the offset of the output signal to 1.5V.

- **A bread board**

The board into which you plug the discrete electronic components to make your circuit. Pins are connected if they are pushed into the same column on the board.

- **Operational Amplifiers**

The chip ICL7621 contains two operational amplifiers. The data sheet is available on the courses home page at the link 'pensum/læringskrav'.

- **Capacitors**

Be very careful with tantal capacitors! They can only used with the right polarity. A huge negative voltage over a tantal capacitor can even burst the capacitor physically and endanger eyes and skin of people nearby. If you need to have both negative and positive voltages across a capacitor, another type of capacitor must be used.

- **Resistors**

You will need to use a few resistors. A good selection is available in the cupboard in the lab for the master students. At the inside of the door there is a description of the colour code that indicates the resistance.



## 2.2 Build and characterize the filter

Build the filter on a breadboard using two ICL7621 chips, capacitors and resistors. Use small amplitude sine waves (e.g. 300mV) with an offset that places them in the middle between the supply rails from the Agilent 33250A waveform generator to test the circuits amplification. Draw output gain versus input frequency with sufficient resolution on a log-log plot. Have a good resolution especially around the cut-off frequency. Do you see any resonance or at least some increase in the gain close to the cut-off frequency? How steep is the 'roll-off'? The roll-off is the slope of the gain in the log-log plot once the cut-off frequency is exceeded. On a log-log plot this roll off should be linear. For a first order filters it is 1 decade (equivalent to 20dB) per decade. For a second order filter it should be 2 decades (40dB) per decade. What is it you measure for this circuit?