

DIGITAL SOUND SYNTHESIS

01



DIGITAL SOUND SYNTHESIS #01

- **Introduction**

Digital sound | Waveforms & Oscillators

- **Synthesis methods**

Additive | Subtractive | FM synthesis | Granular synthesis ...

- **Hands-on**

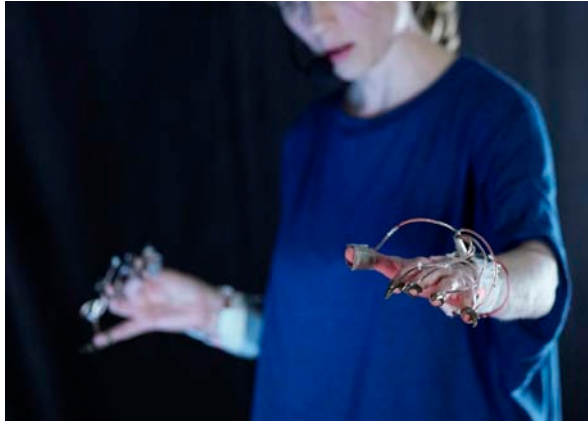
Programming examples with Pure data

- **Instruments & Artworks**

using different digital synthesis methods

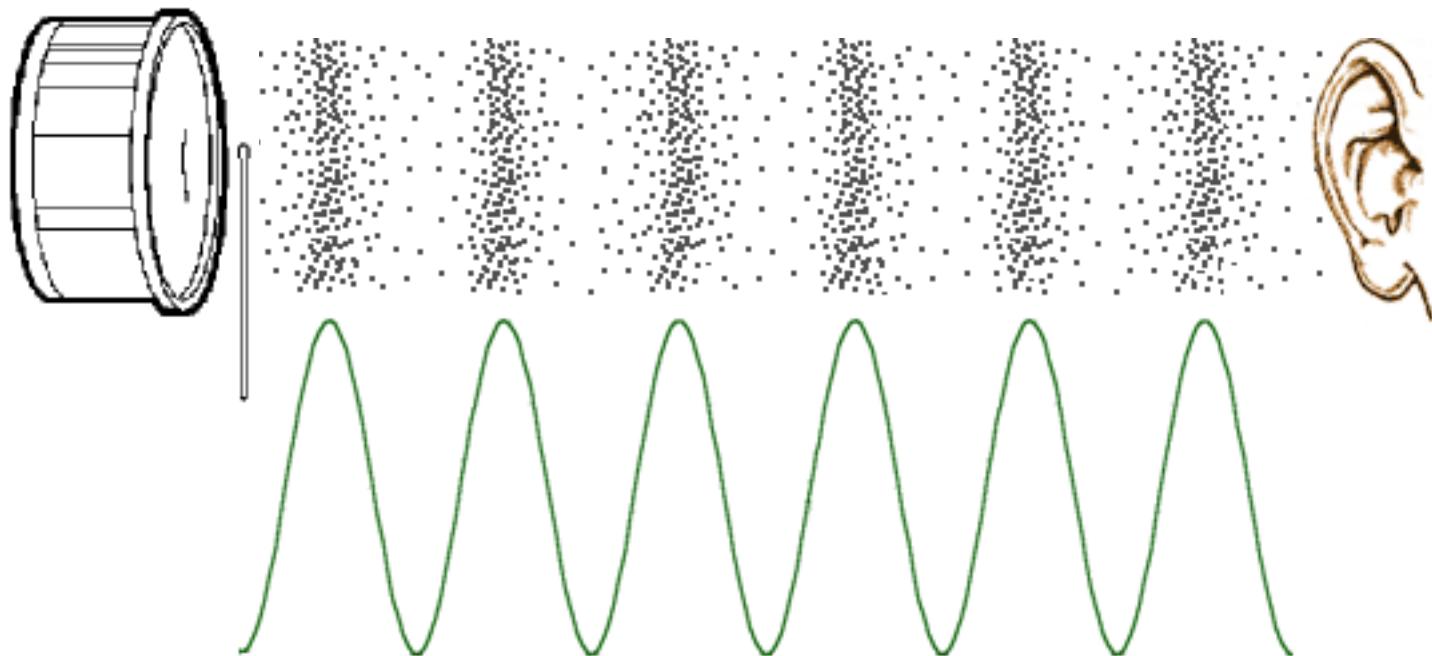
Ulla Rauter

www.ullarauter.com



ANALOG / DIGITAL AUDIO

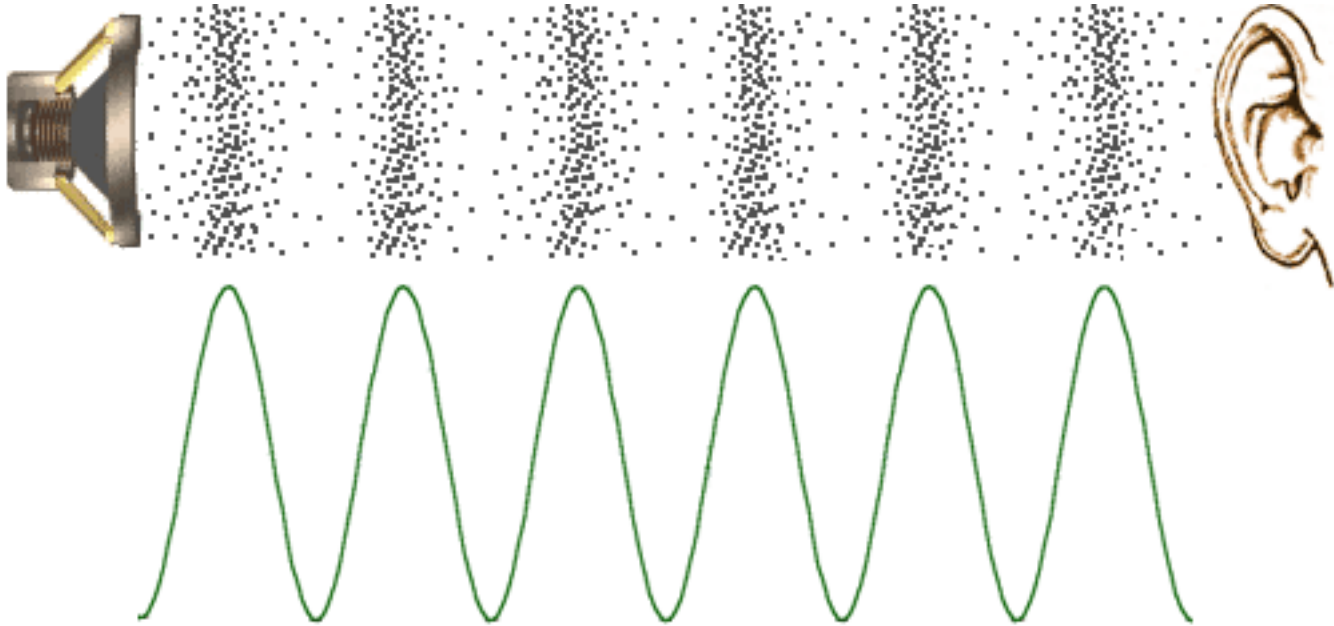
What is sound?



Laurie Anderson | Handphone Table



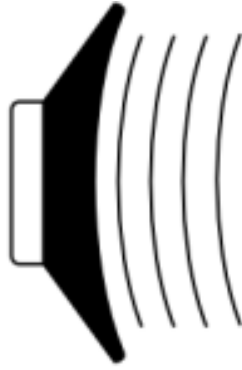
ANALOG / DIGITAL AUDIO



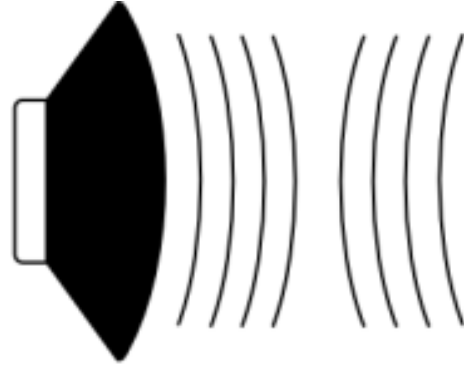
LOUDSPEAKER



1. speaker at rest

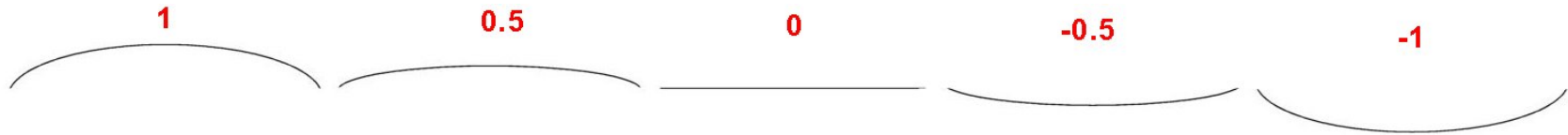


2. speaker with negative voltage

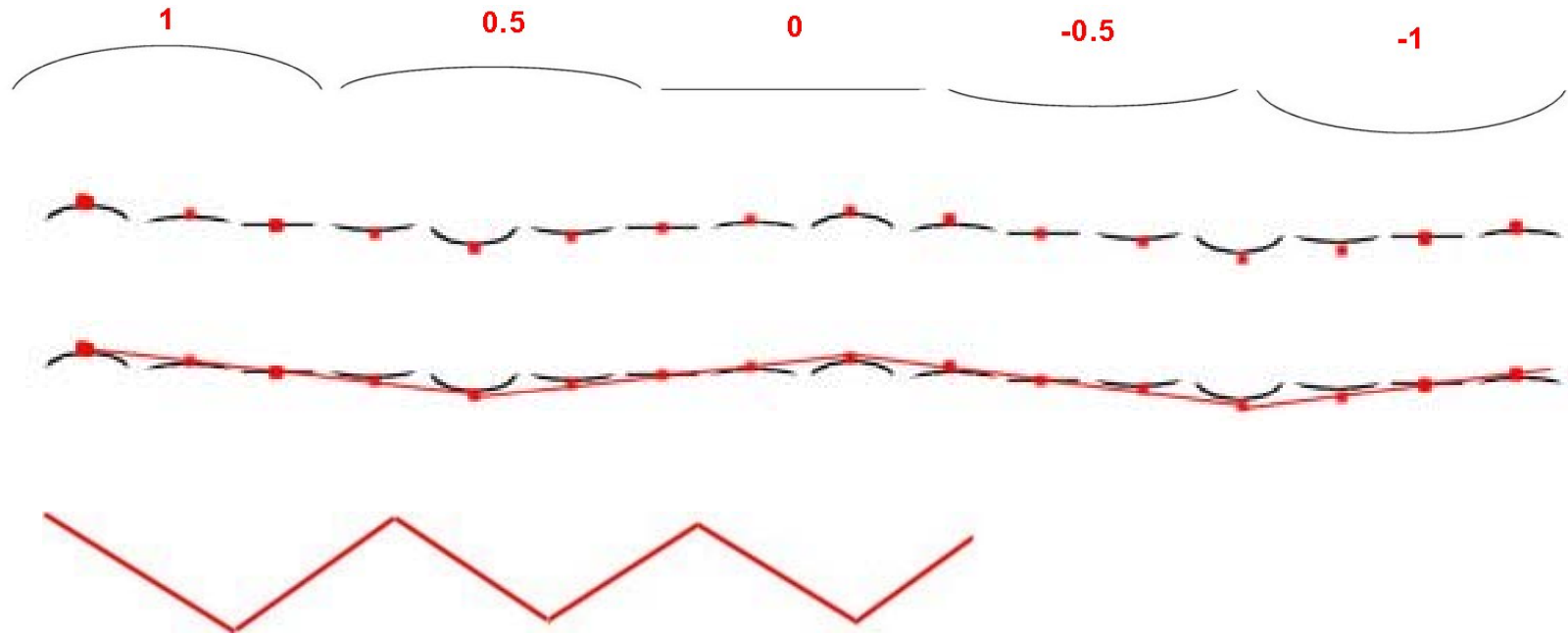


3. speaker with positive voltage

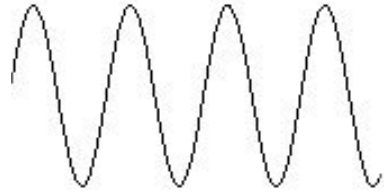
Position of the loudspeaker membrane



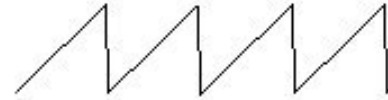
Position of the loudspeaker membrane



Waveforms



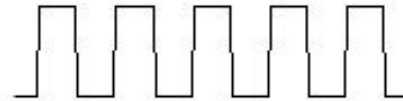
Sine



Sawtooth

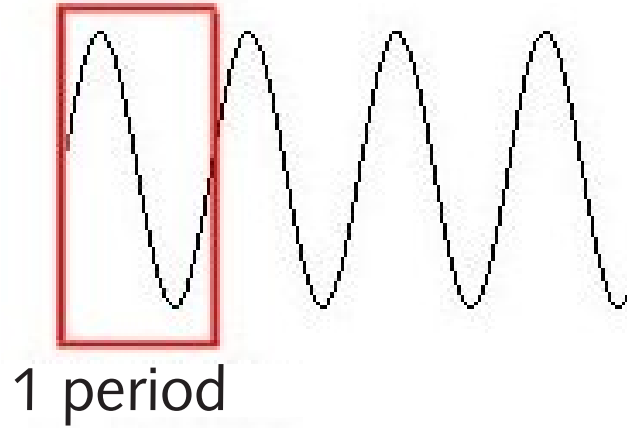


Triangle



Square

Periodic vibration (tone)



Difference tone / noise



periodic (pitch)

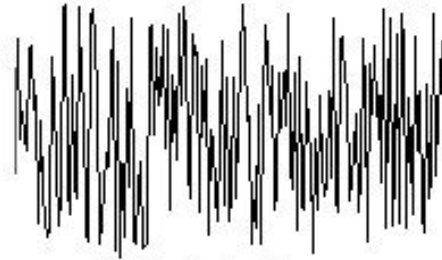


aperiodic (noise)

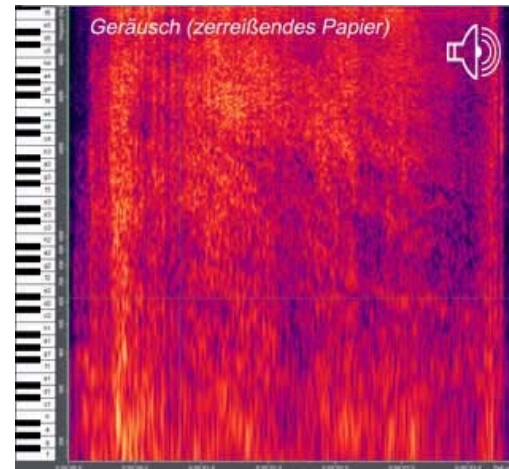
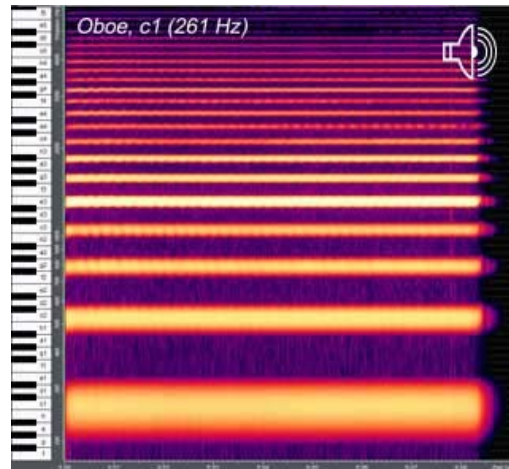
Difference tone / noise



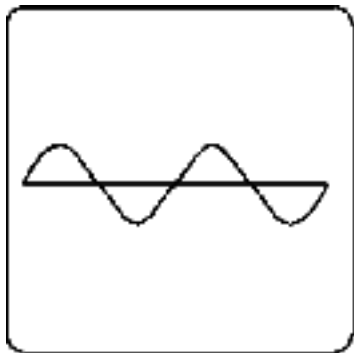
periodic (pitch)



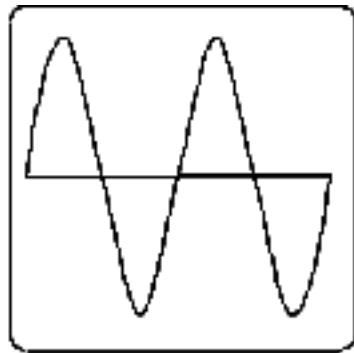
aperiodic (noise)



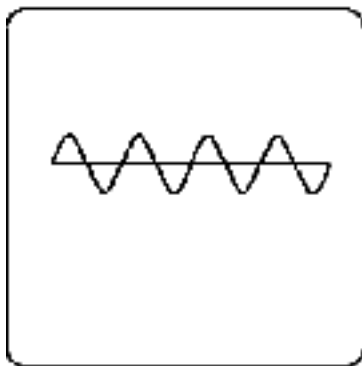
Volume and pitch



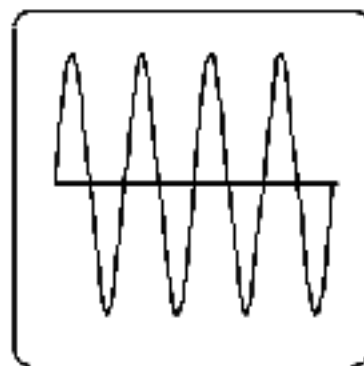
low & quiet



low & loud

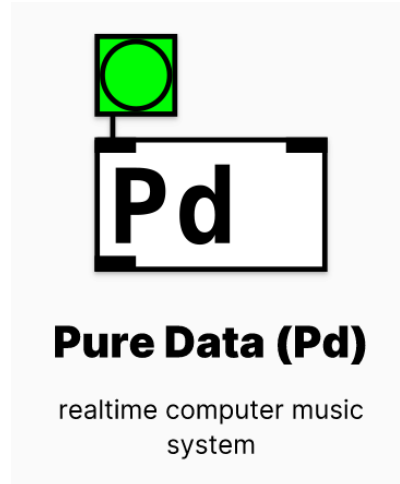


high & quiet

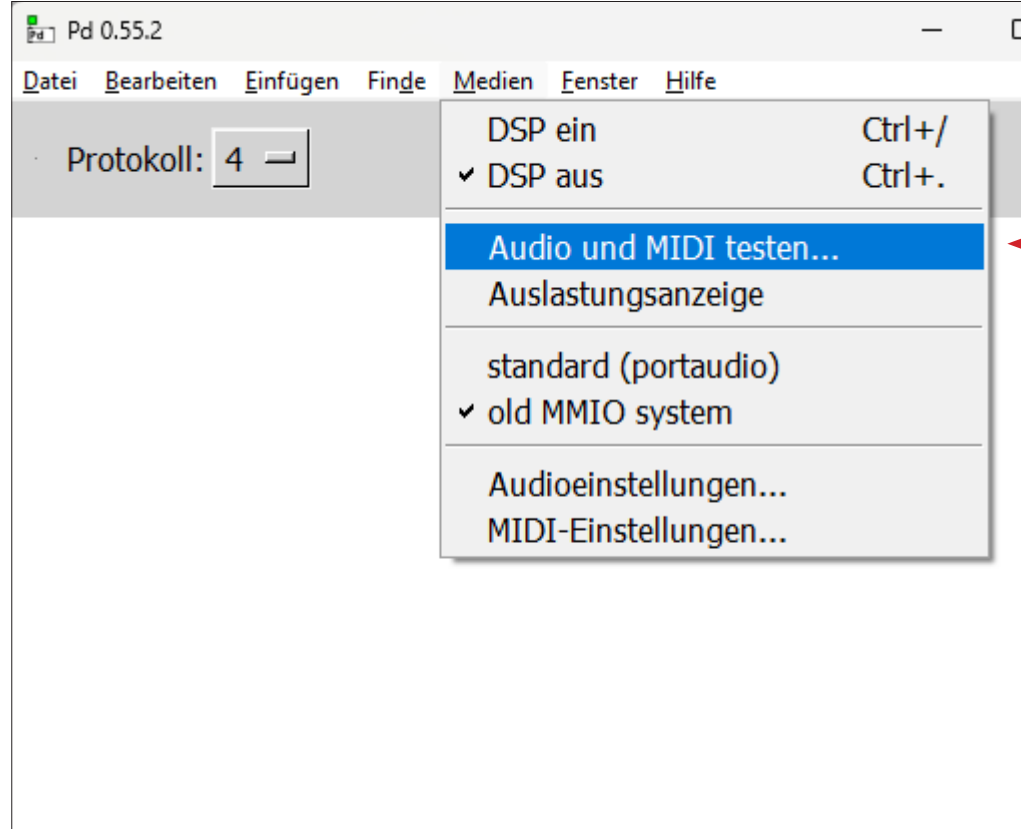


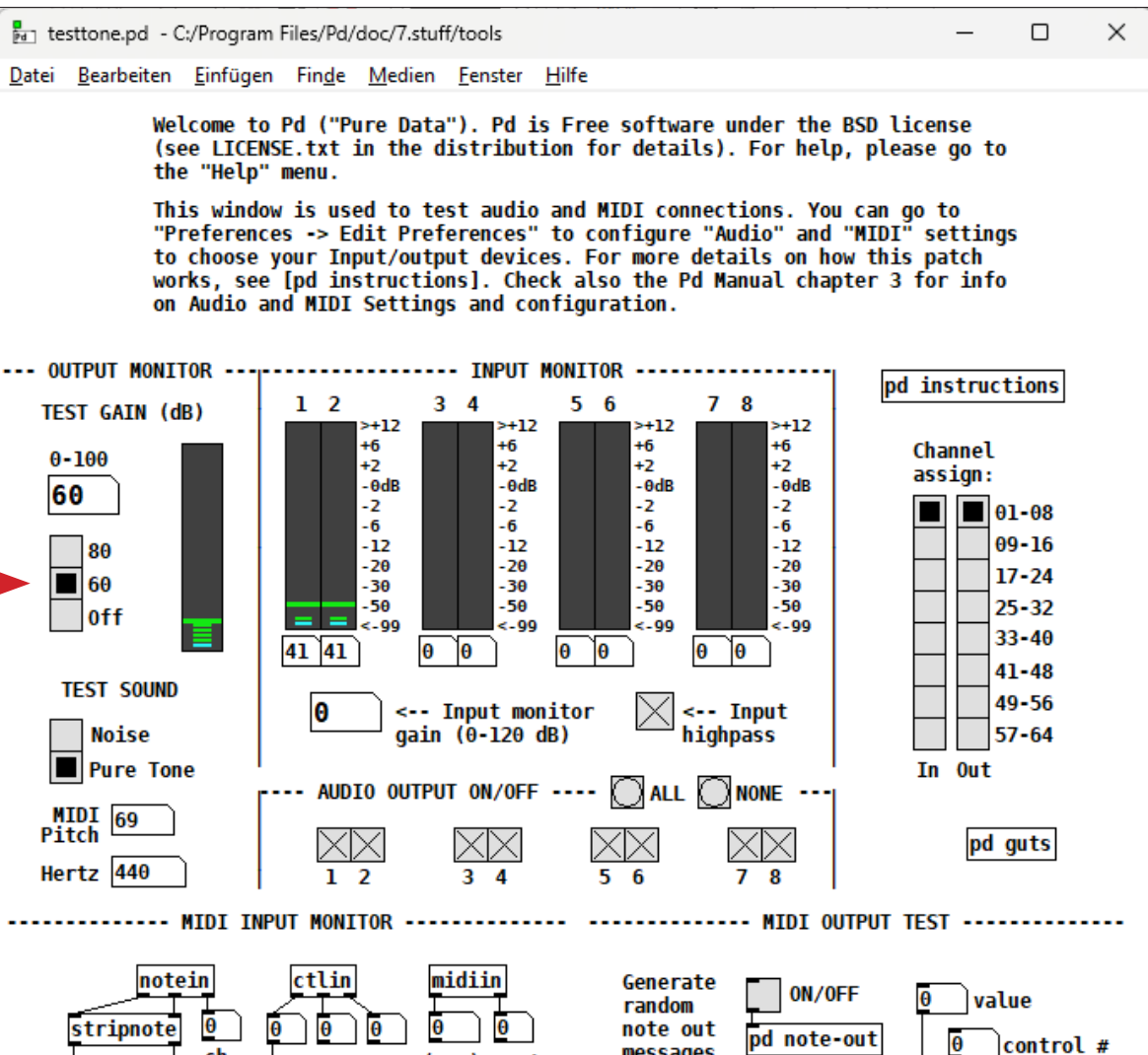
high & loud

PURE DATA



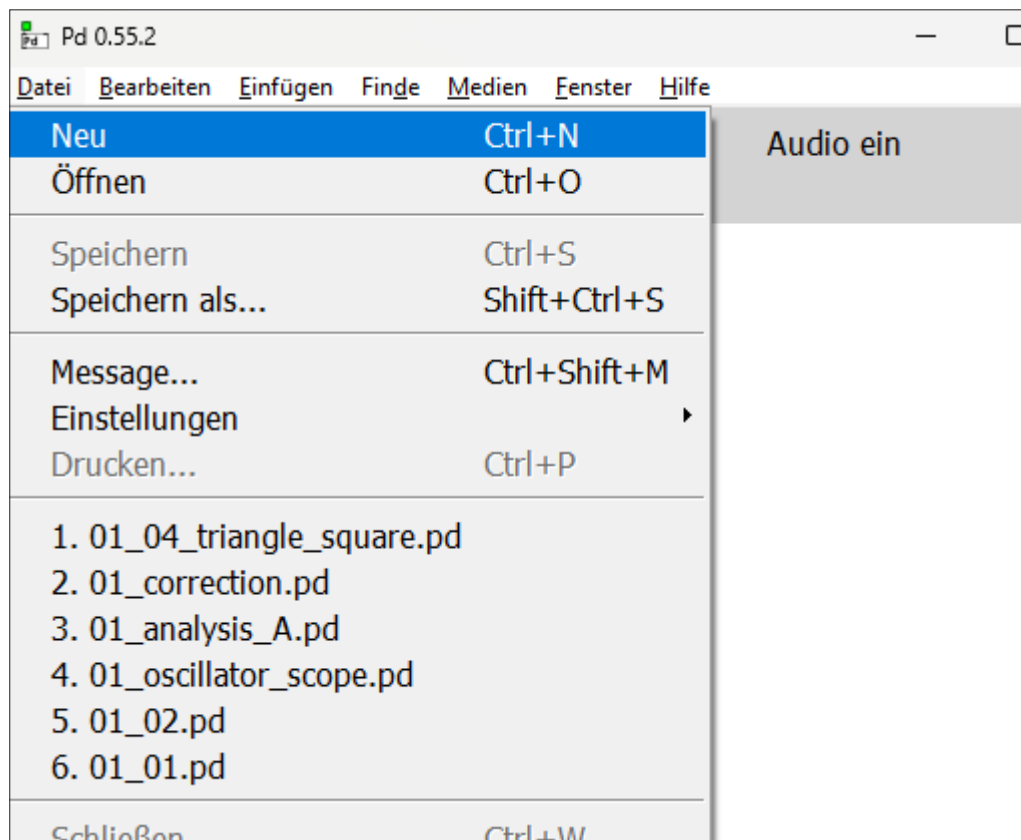
<https://puredata.info/downloads>

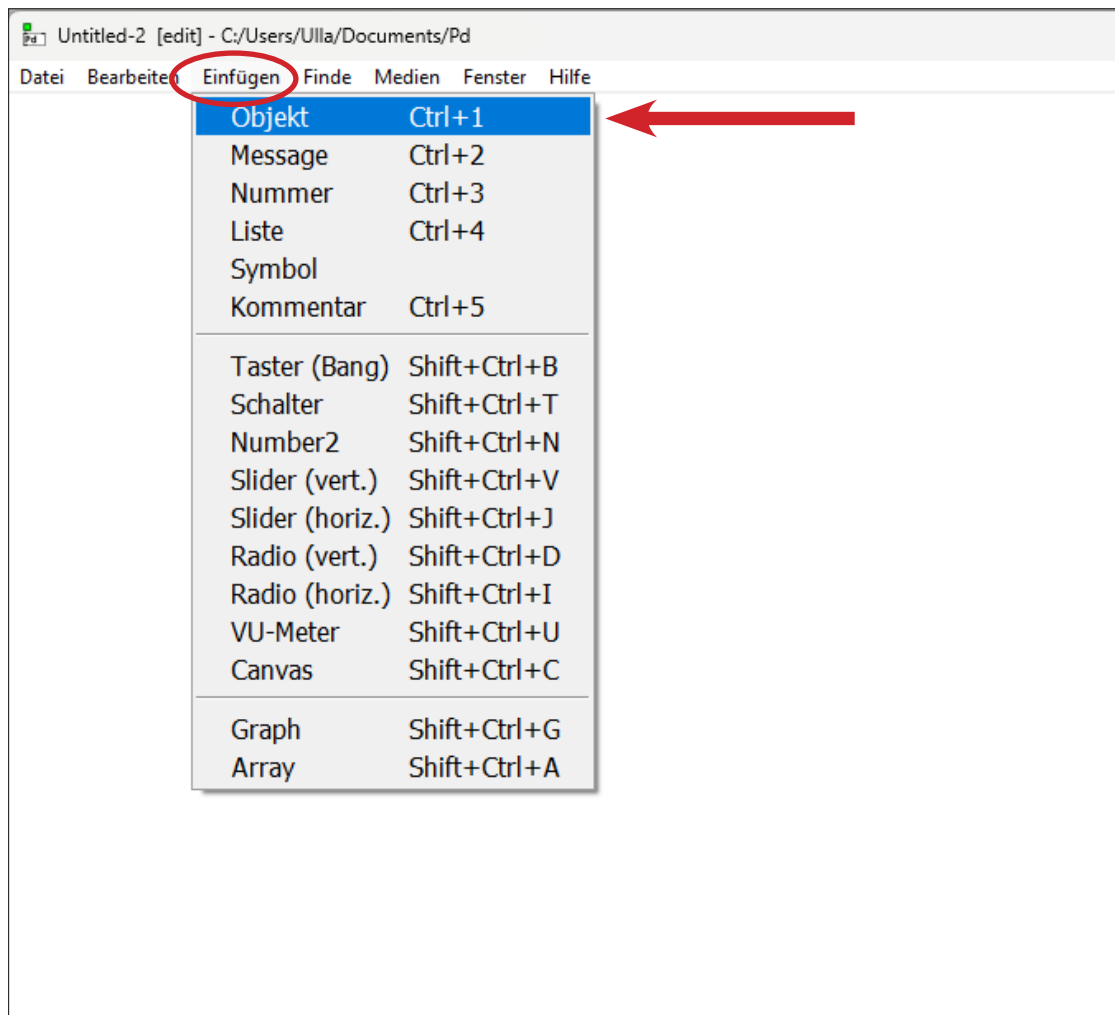




test tone



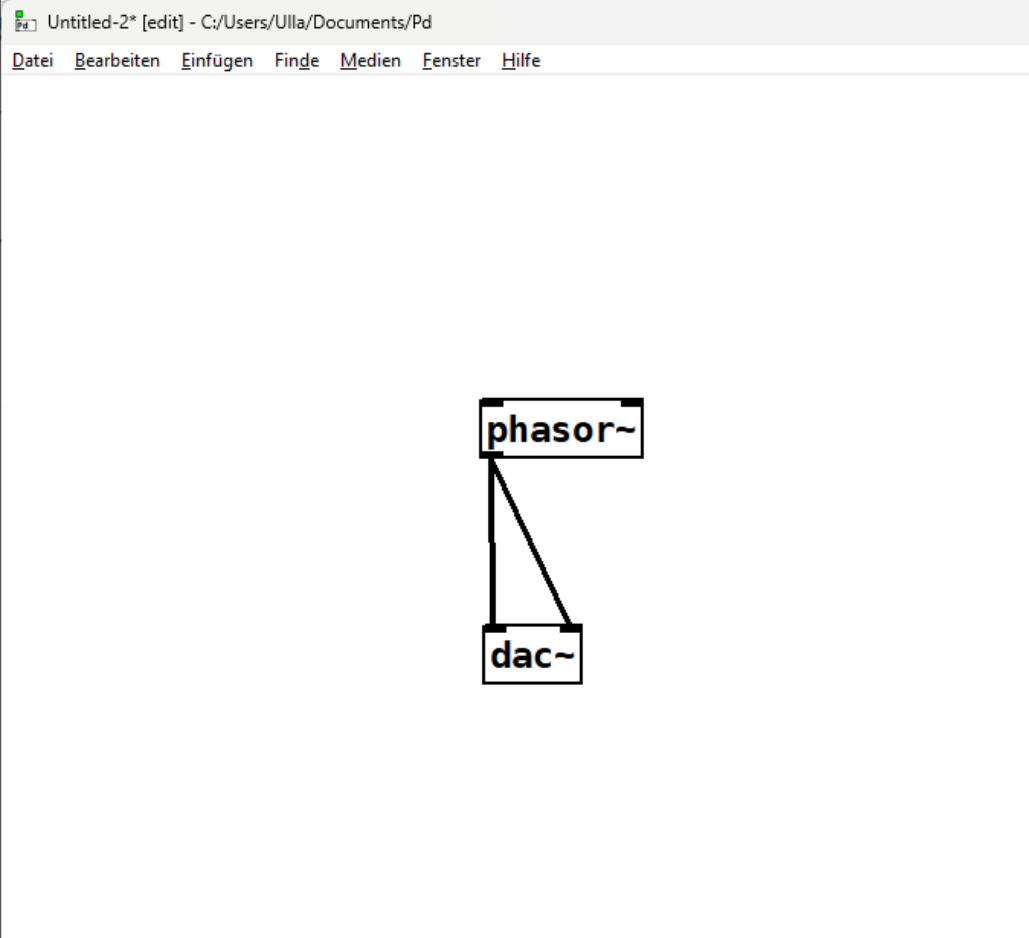


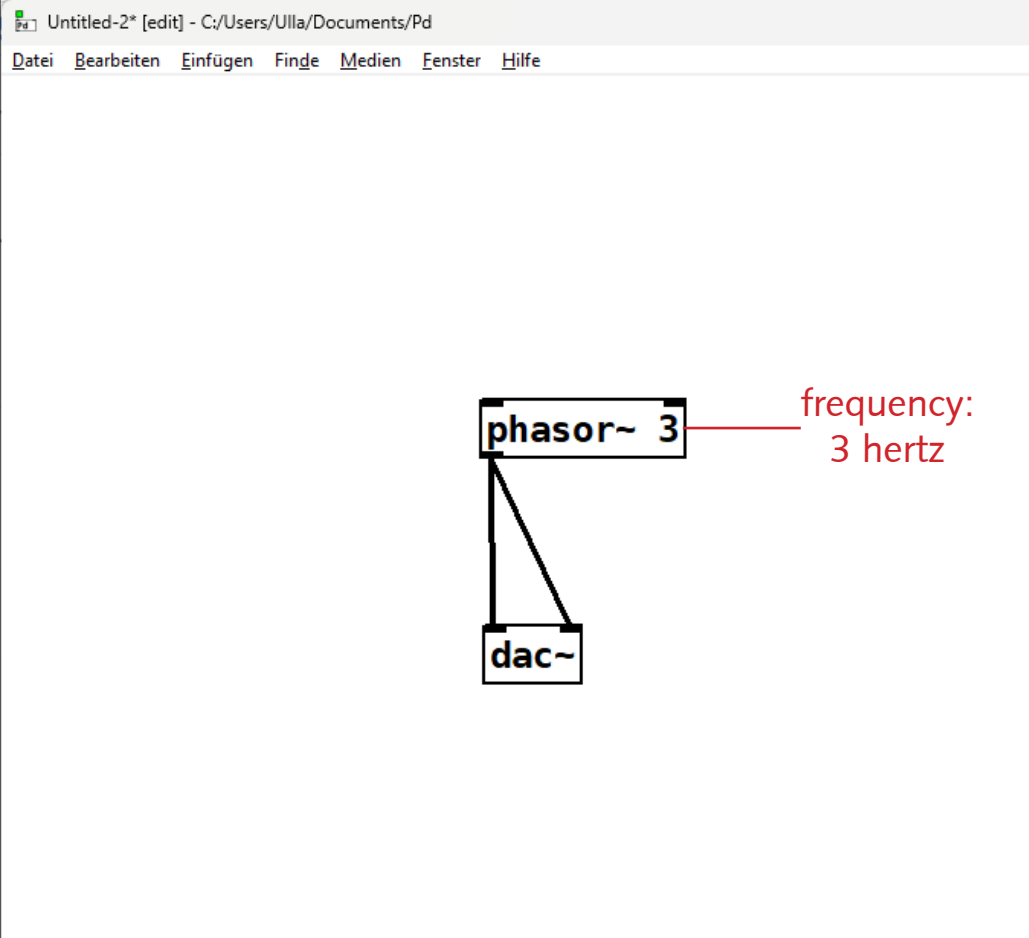


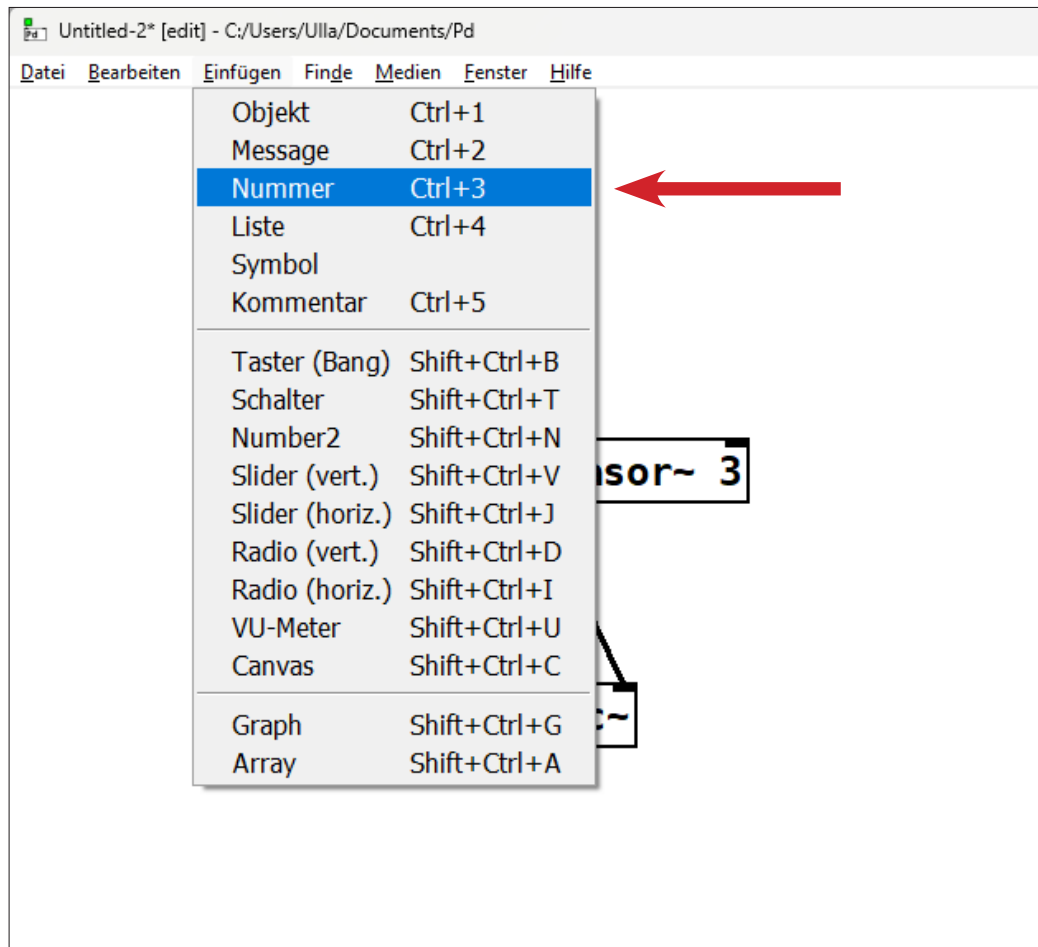
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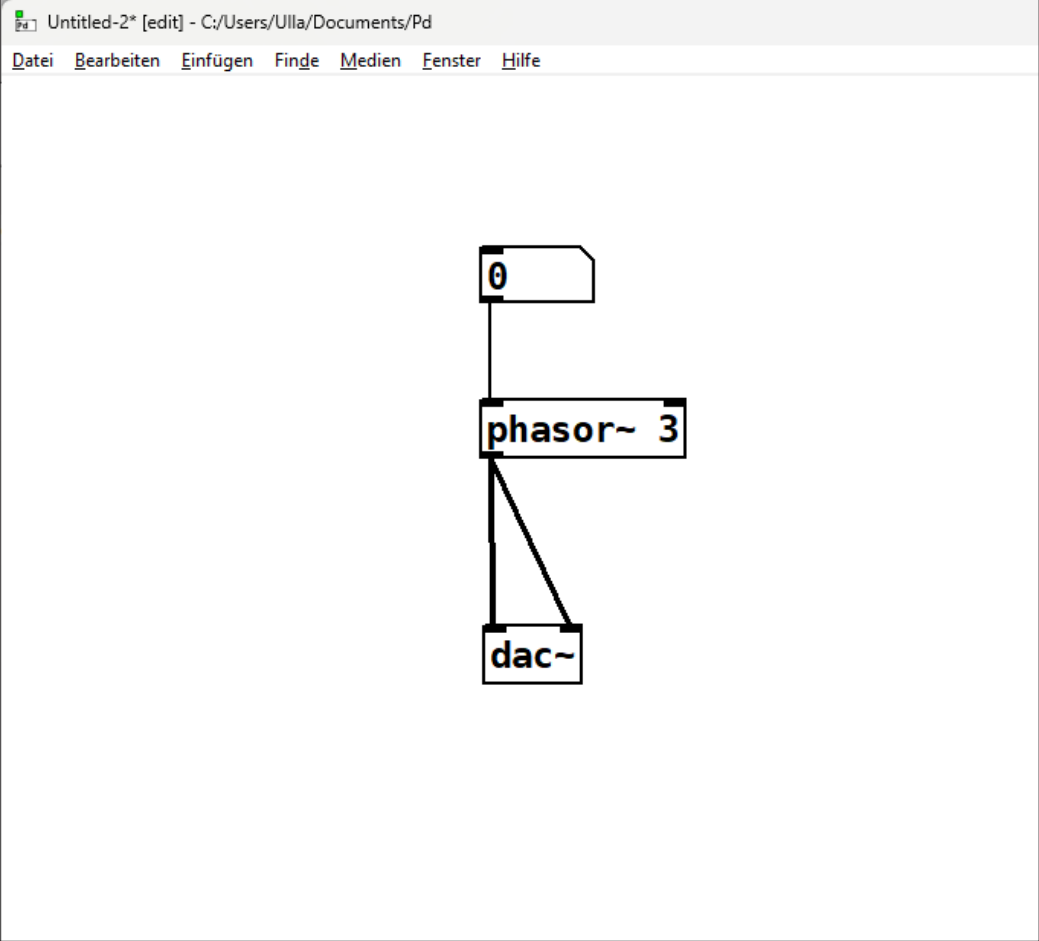
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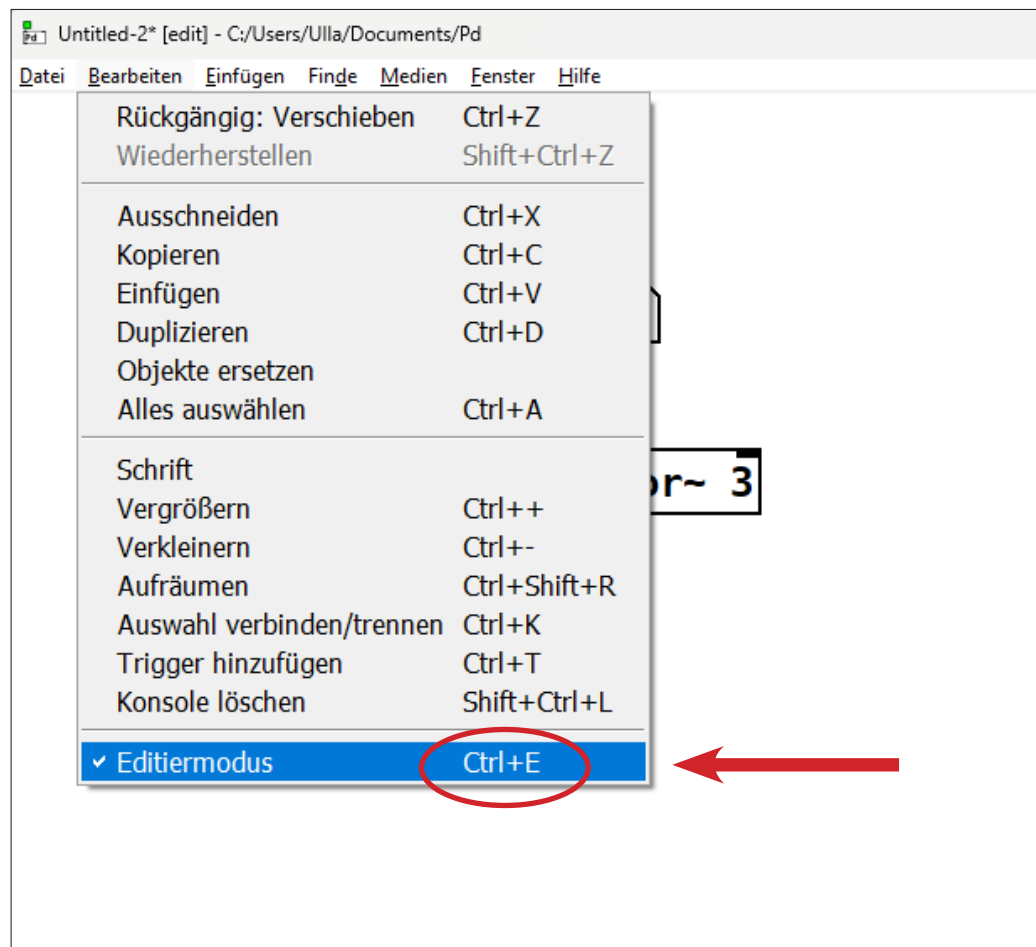
phasor~

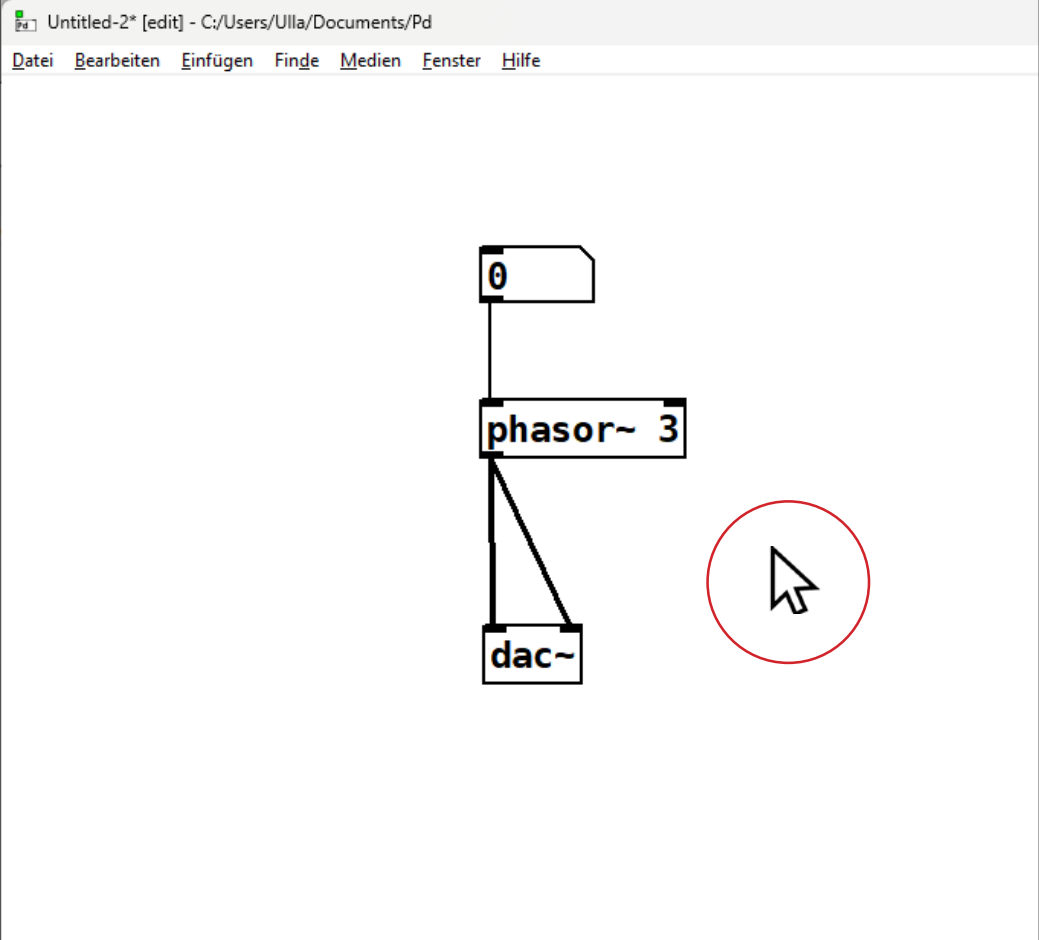


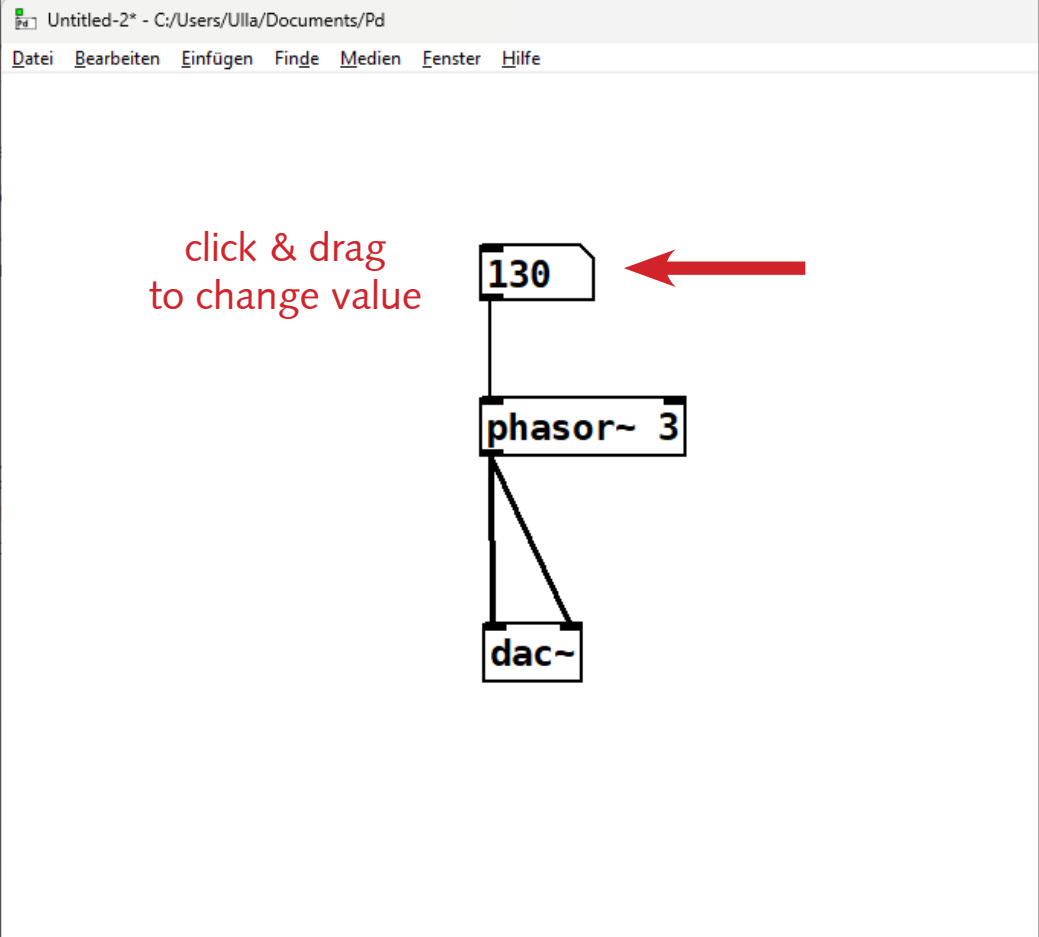


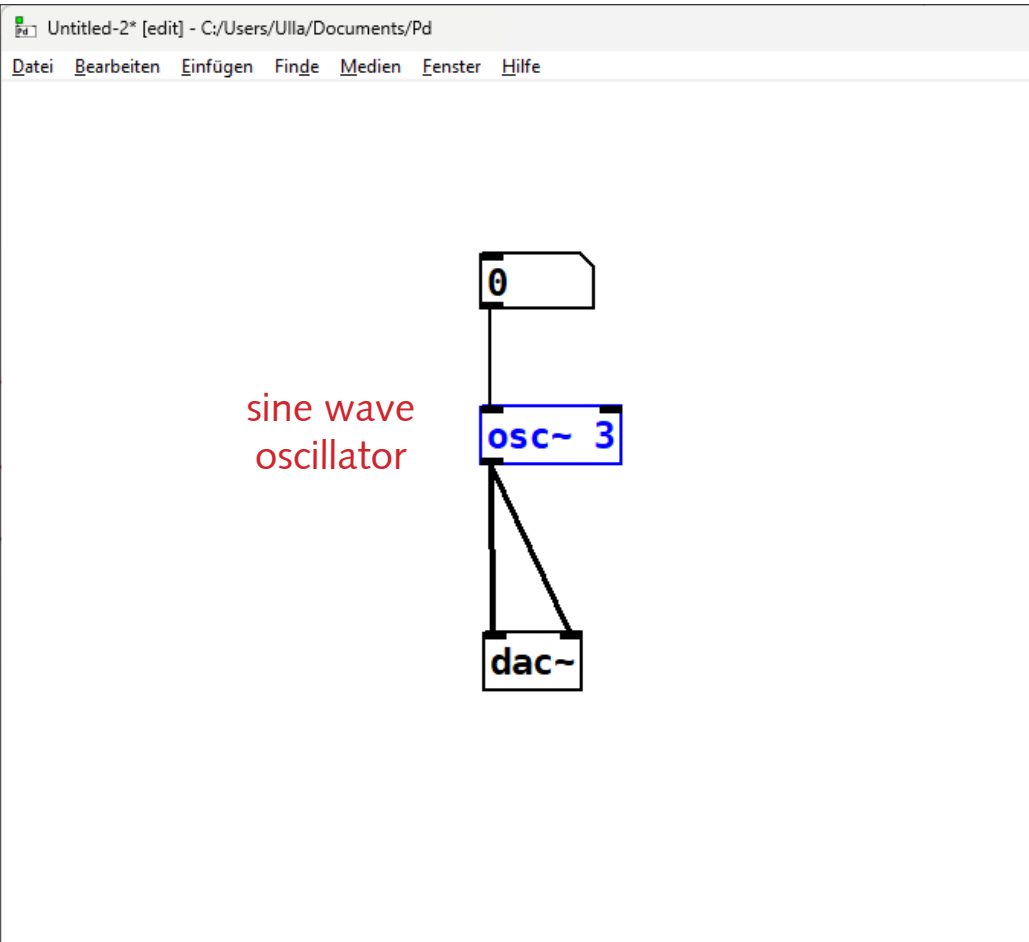


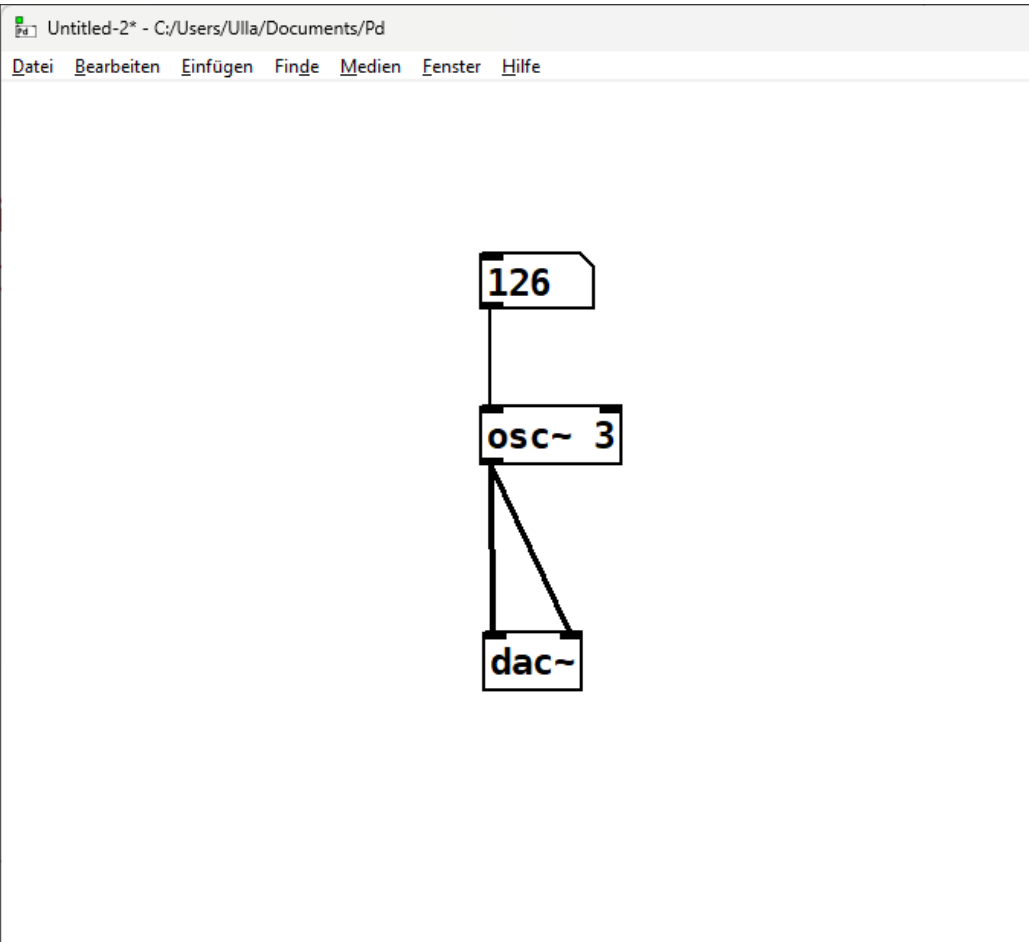


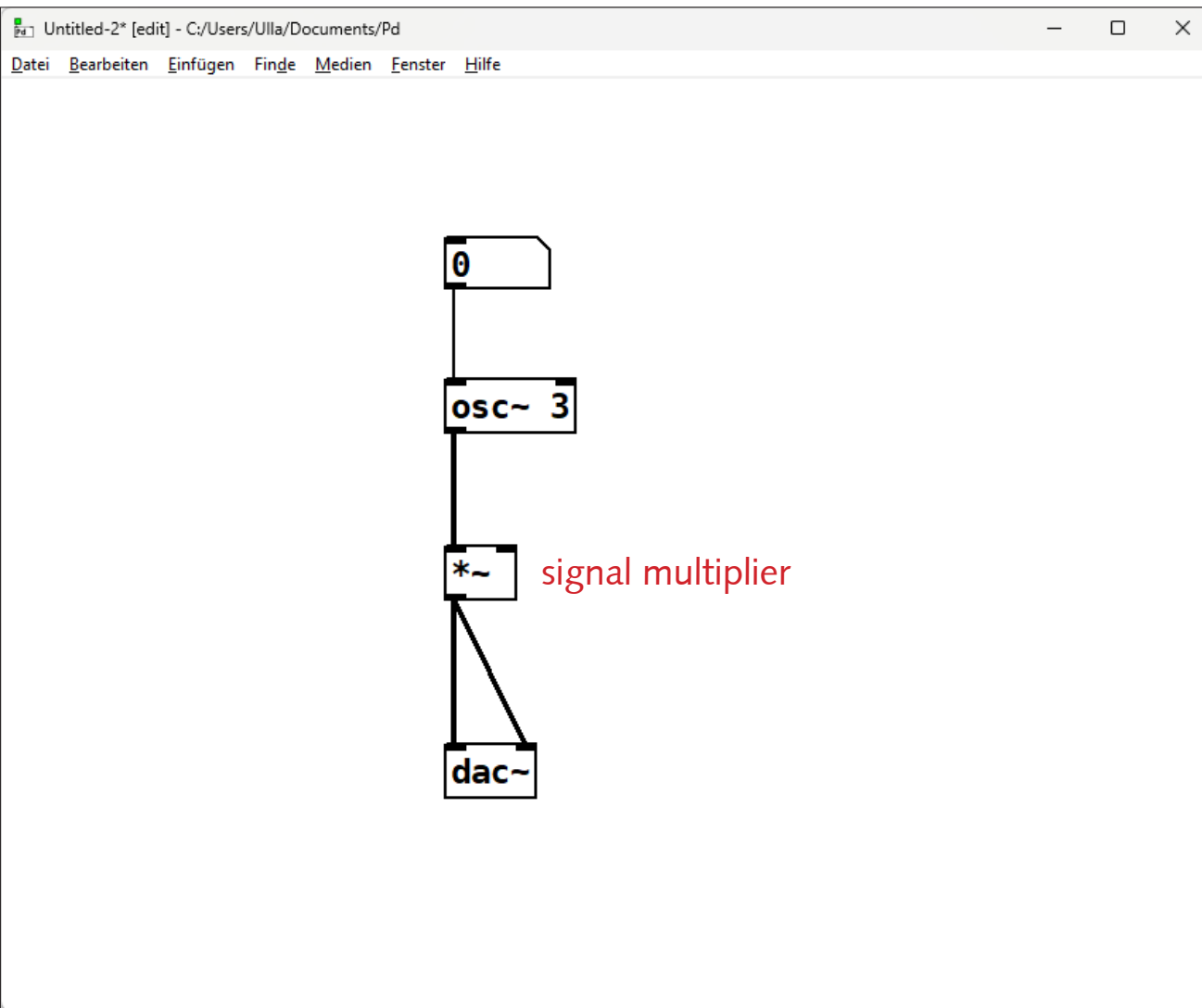


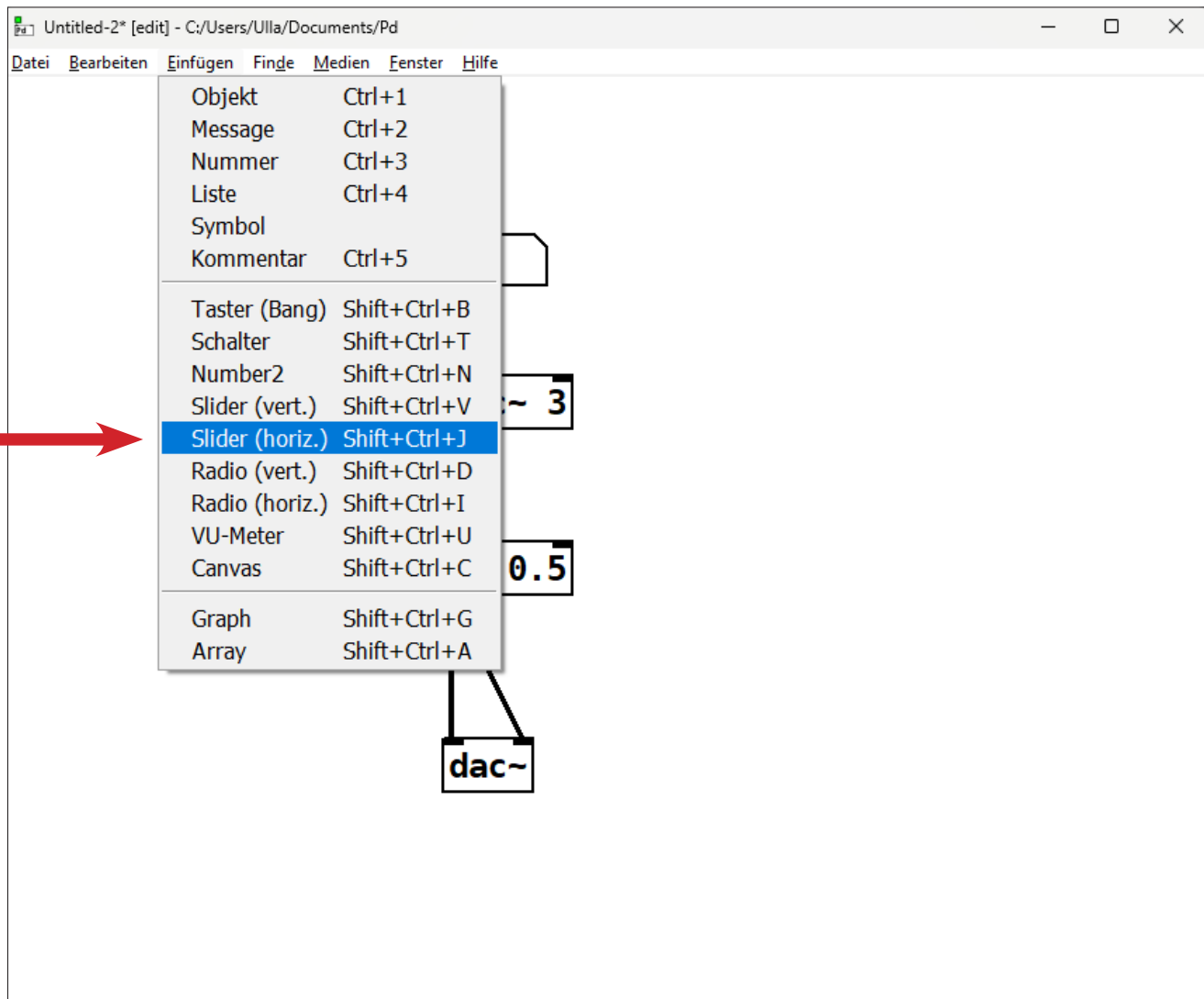


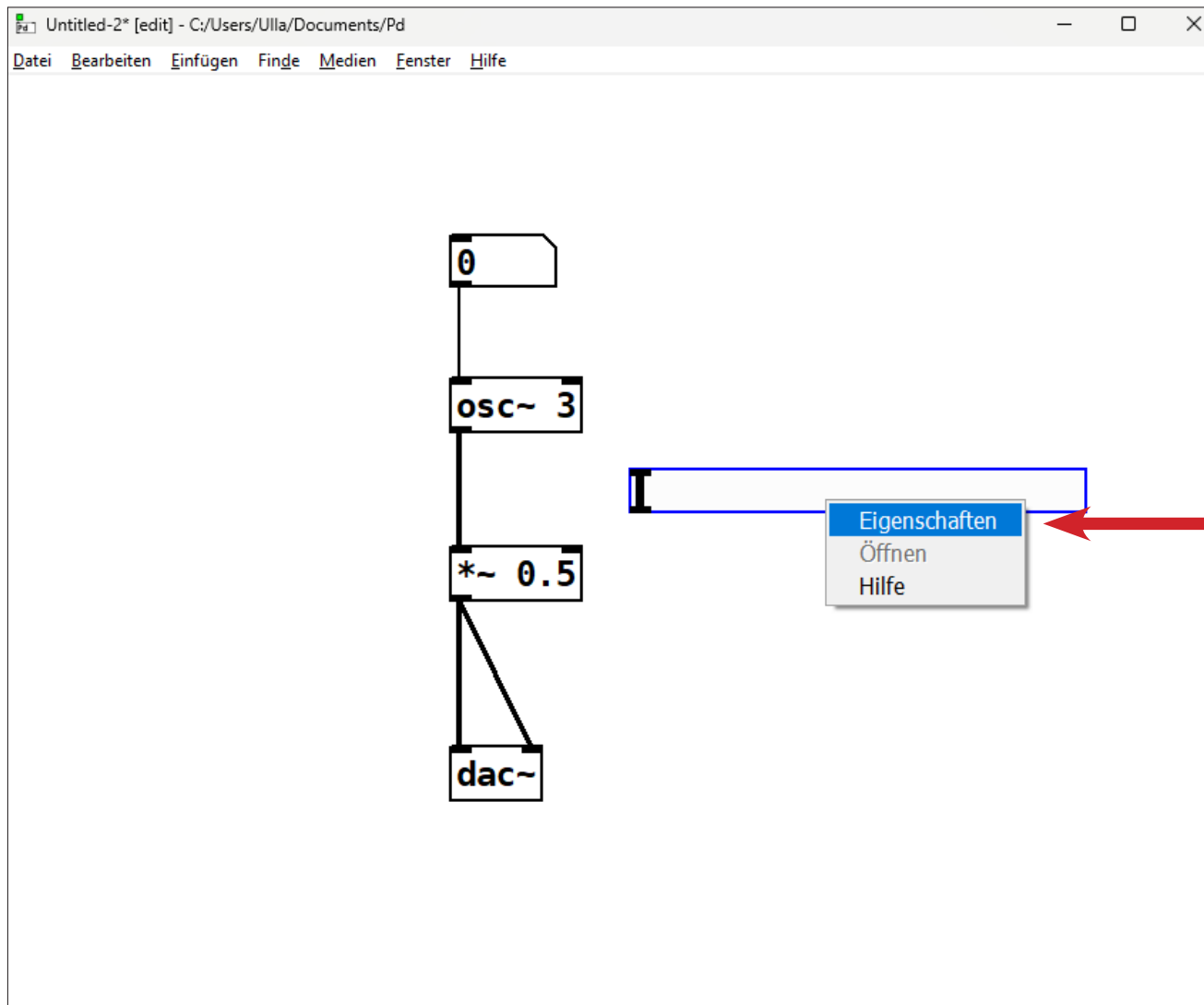












Slider (horiz.) Eigenschaften

Breite: 155 Höhe: 15

Ausgabebereich

Unterer: 0 Oberer: 1

Parameter

linear Kein Init Gleichbleibend bei Klick

Messages

Sendesymbol:

Empfangssymbol:

Beschriftung

X-Versatz: -2 Y-Versatz: -10

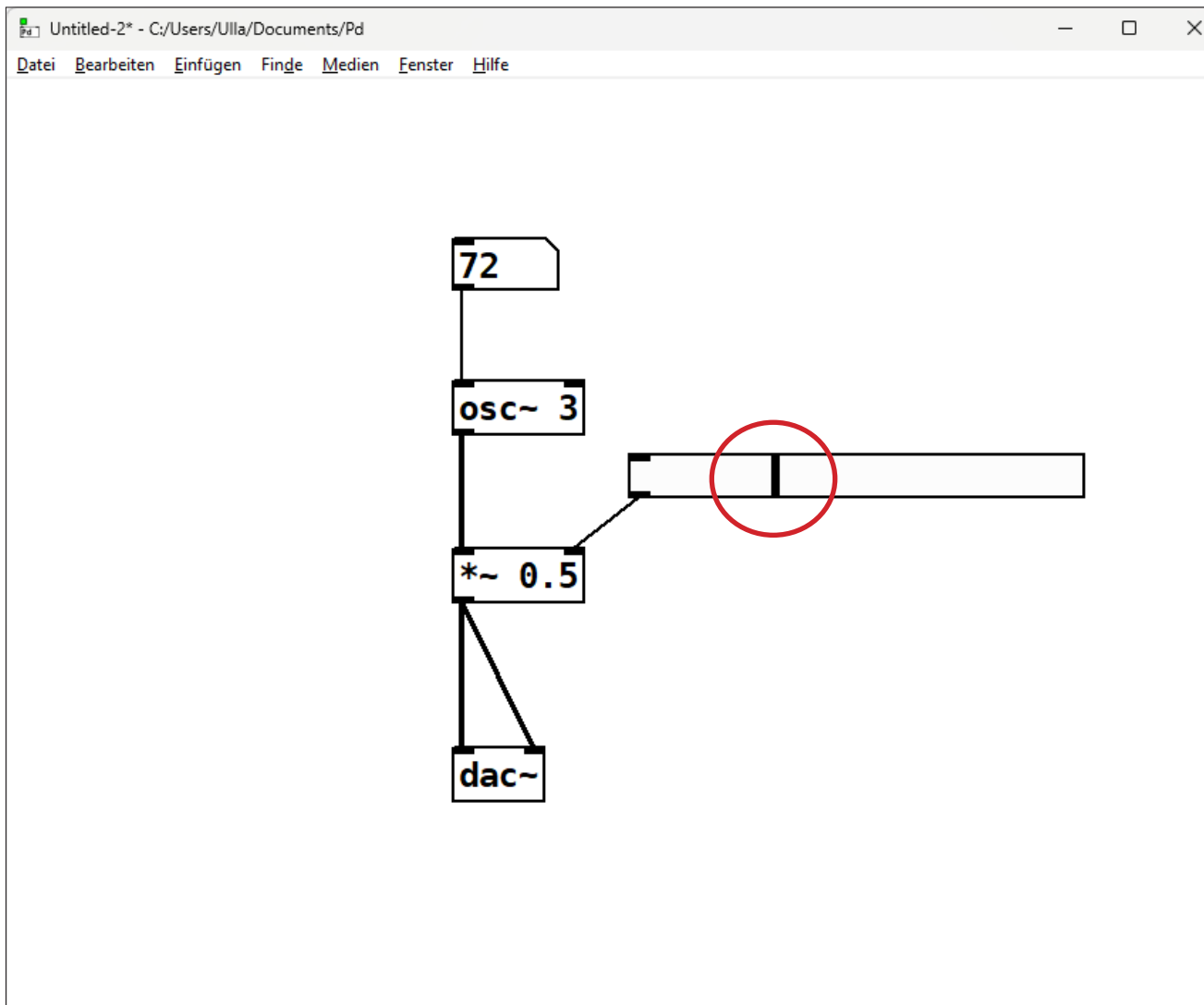
DejaVu Sans Mono Größe: 12

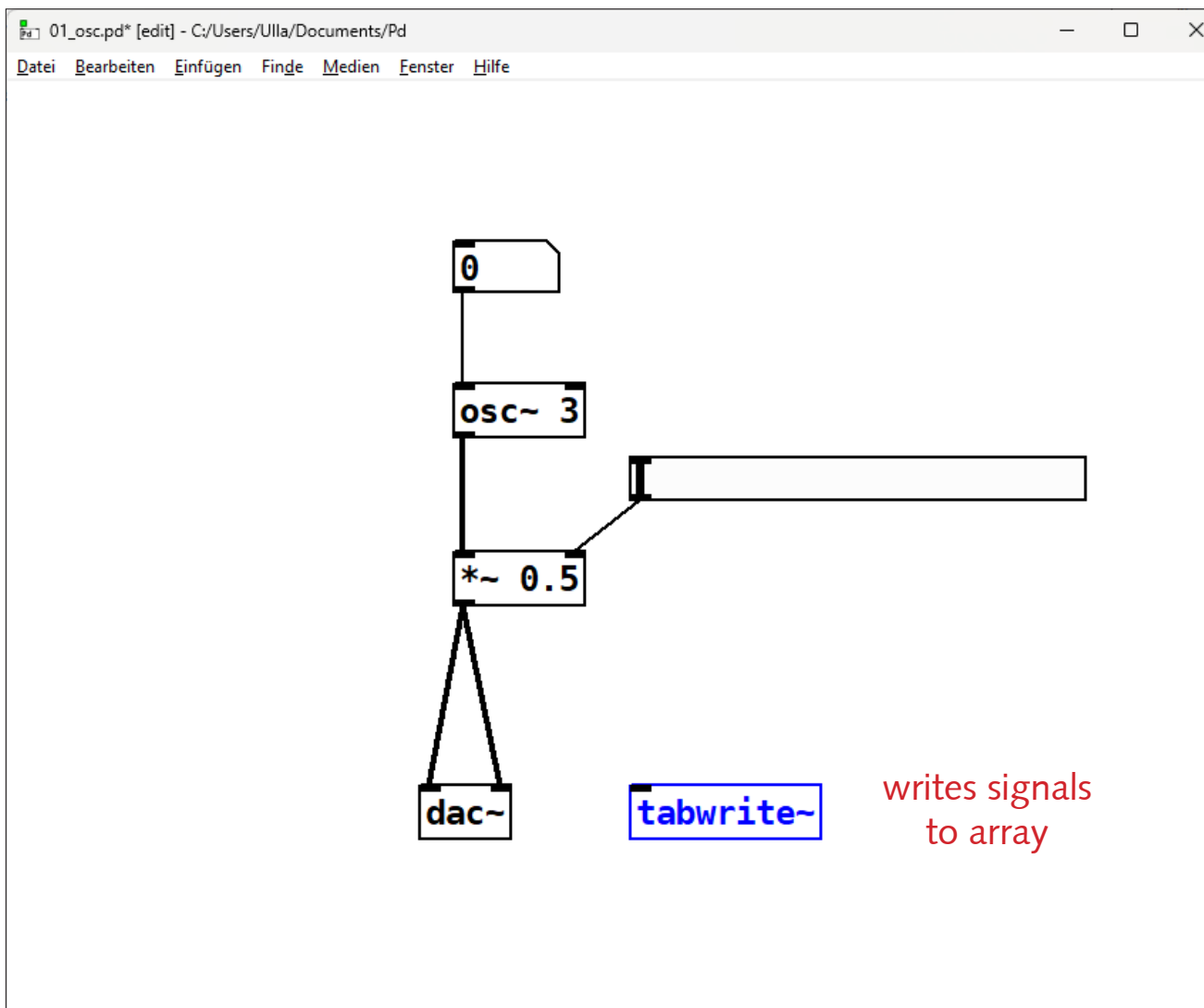
Farben

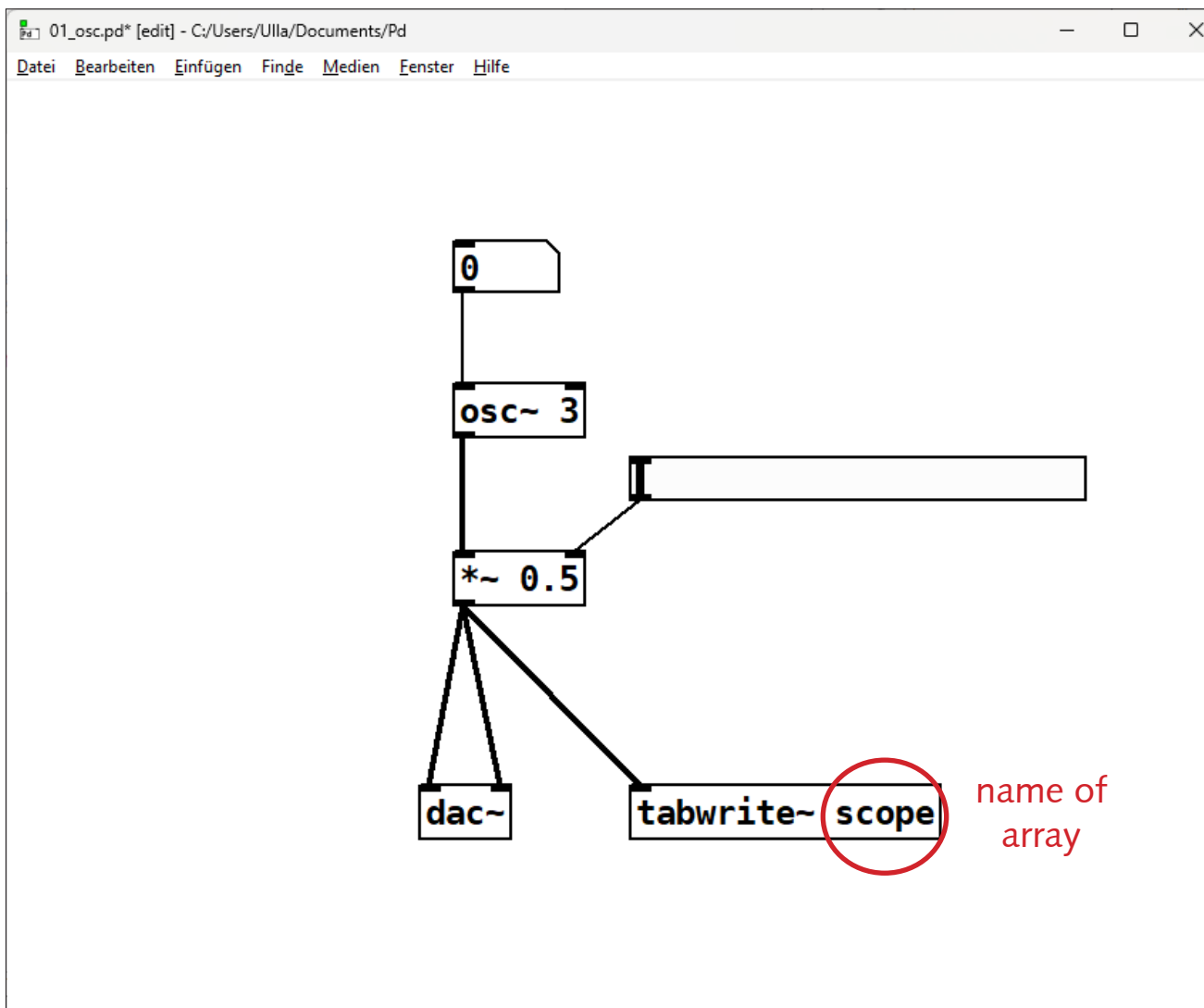
☒ Hintergrund ☐ Vordergrund ☐ Beschriftung

Farbe einstellen o= || =o Test Beschriftung

Abbrechen Anwenden OK







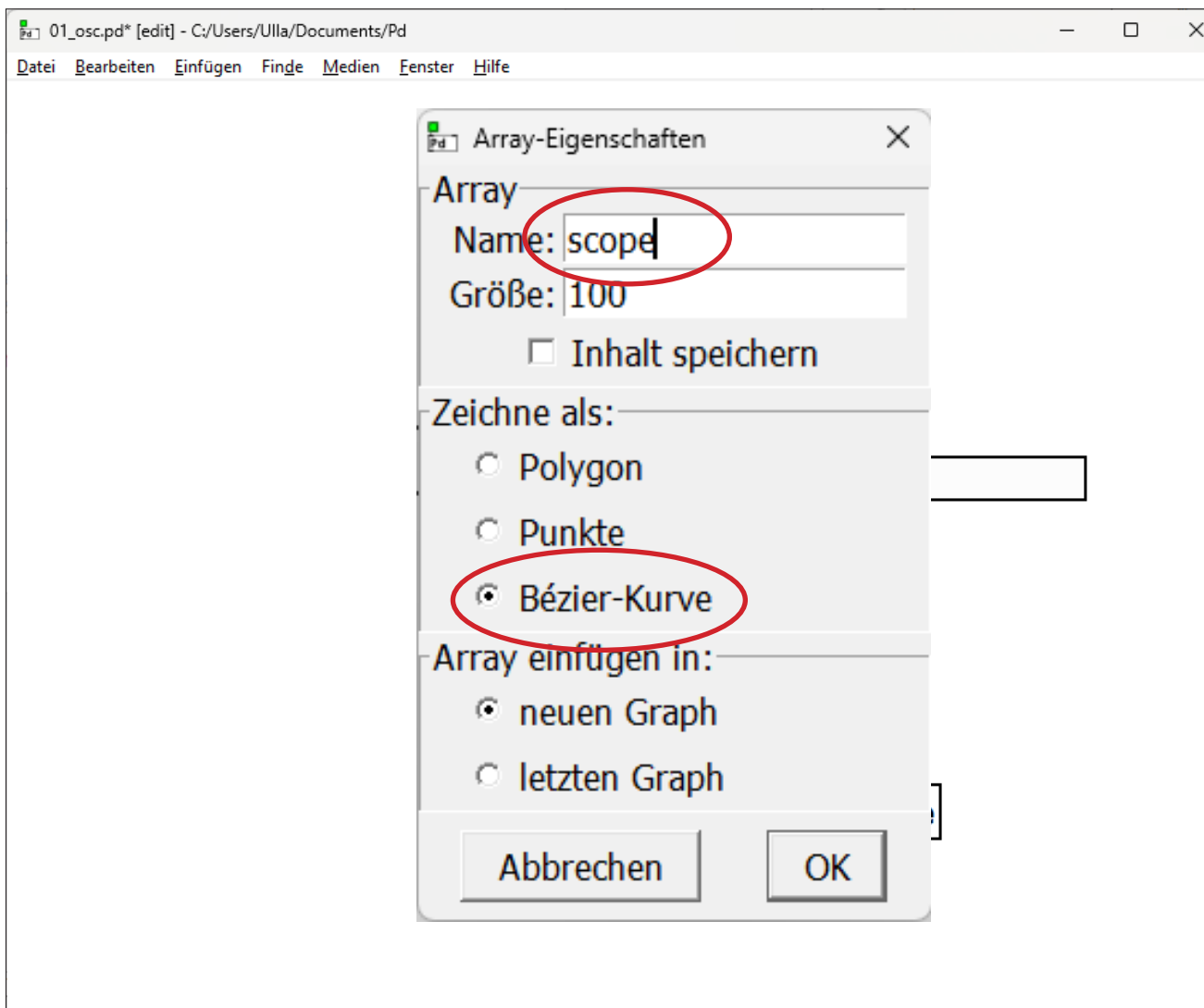
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Message	Ctrl+2
Nummer	Ctrl+3
Liste	Ctrl+4
Symbol	
Kommentar	Ctrl+5

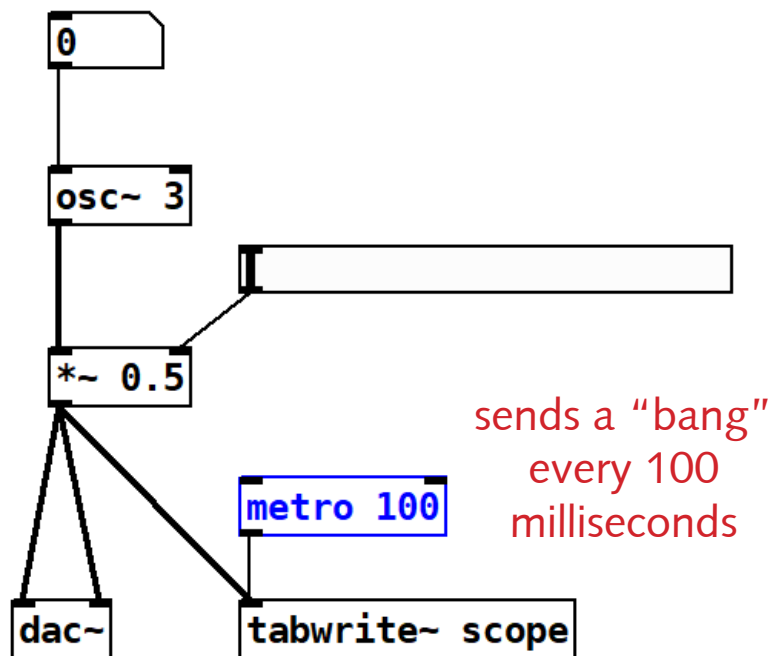
Taster (Bang)	Shift+Ctrl+B
Schalter	Shift+Ctrl+T
Number2	Shift+Ctrl+N
Slider (vert.)	Shift+Ctrl+V
Slider (horiz.)	Shift+Ctrl+J
Radio (vert.)	Shift+Ctrl+D
Radio (horiz.)	Shift+Ctrl+I
VU-Meter	Shift+Ctrl+U
Canvas	Shift+Ctrl+C

Graph	Shift+Ctrl+G
Array	Shift+Ctrl+A

dac~

tabwrite~ scope





scope



Objekt	Ctrl+1
Message	Ctrl+2
Nummer	Ctrl+3
Liste	Ctrl+4
Symbol	
Kommentar	Ctrl+5

Taster (Bang)	Shift+Ctrl+B
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Schalter	Shift+Ctrl+T
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Number2	Shift+Ctrl+N
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Slider (vert.)	Shift+Ctrl+V
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Slider (horiz.)	Shift+Ctrl+J
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Radio (vert.)	Shift+Ctrl+D
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Radio (horiz.)	Shift+Ctrl+I
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VU-Meter	Shift+Ctrl+U
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Canvas	Shift+Ctrl+C
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Graph	Shift+Ctrl+G
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Array	Shift+Ctrl+A
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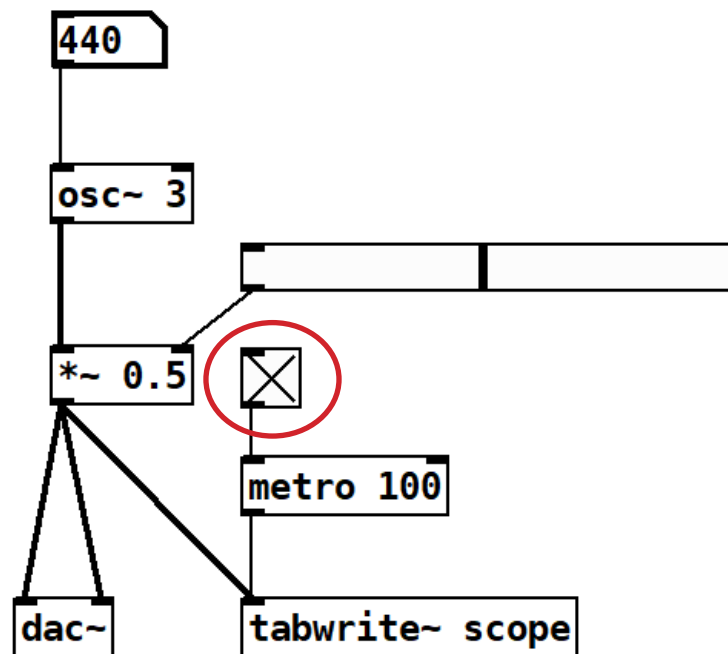
metro 100

dac~

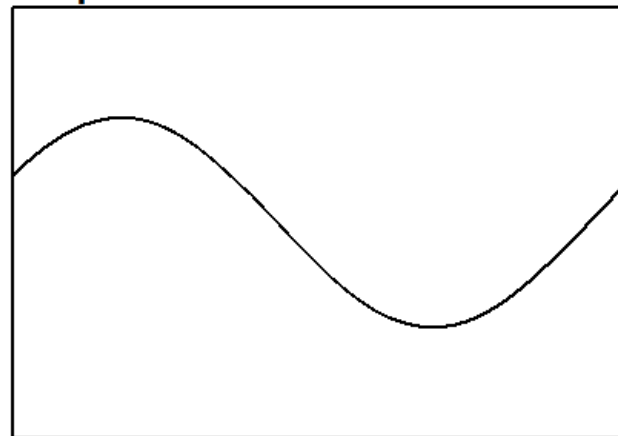
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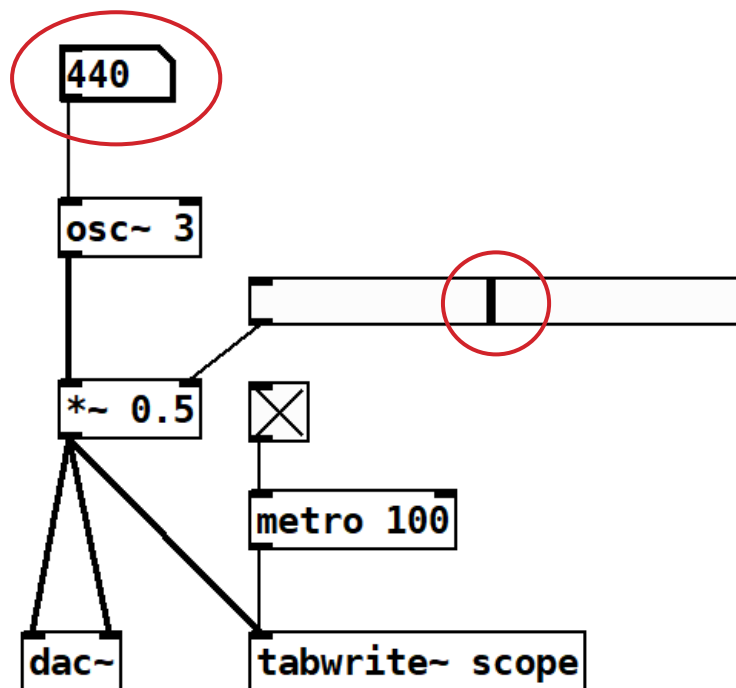
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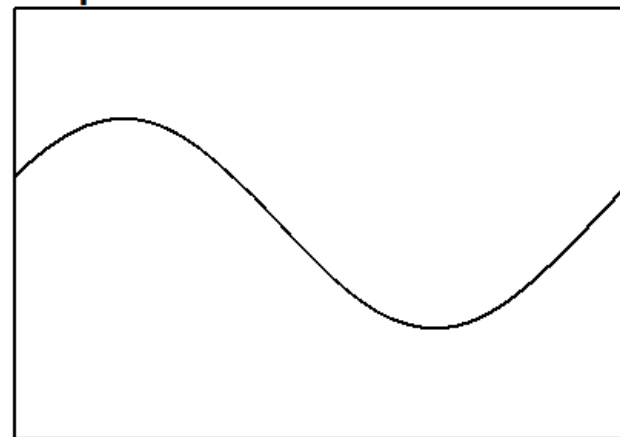


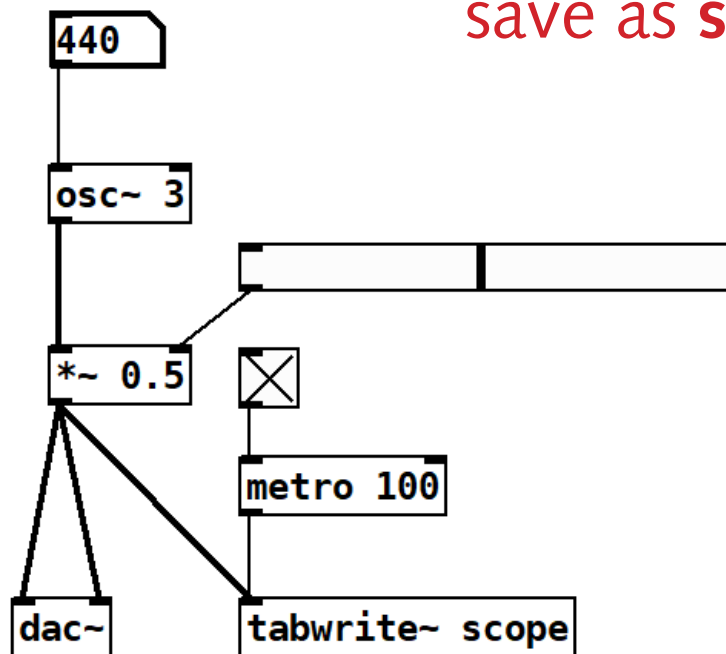
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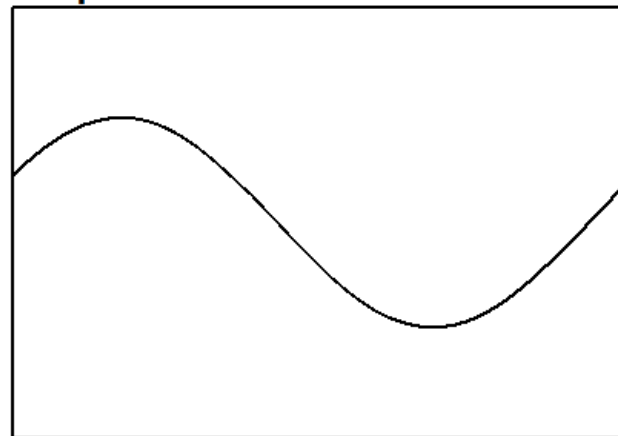
scope

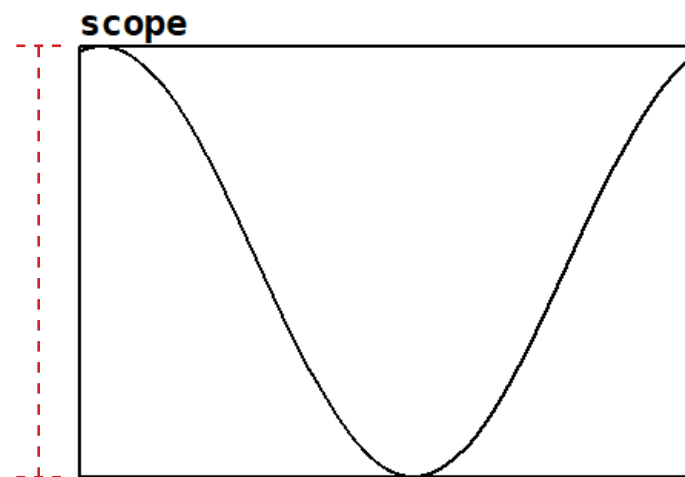
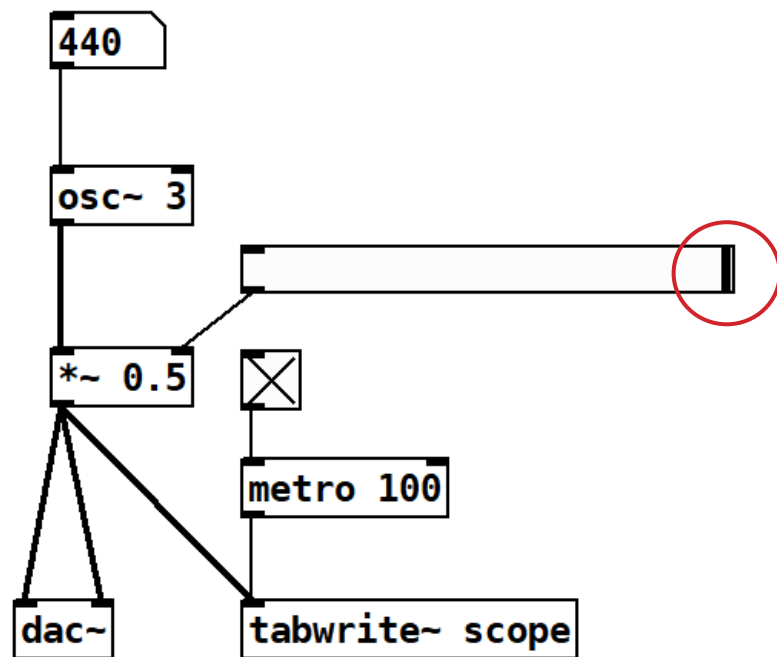


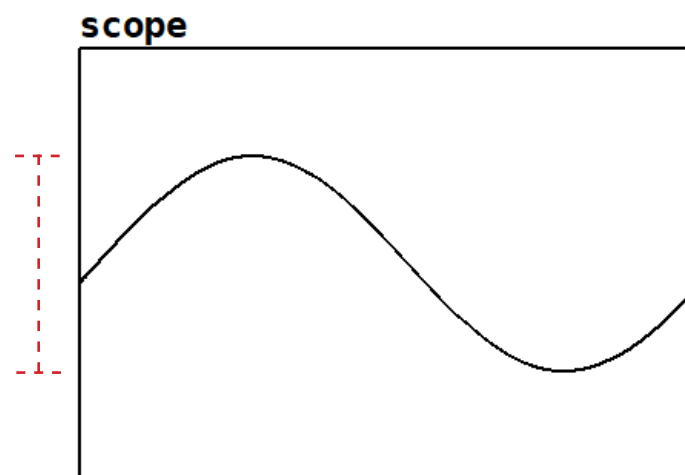
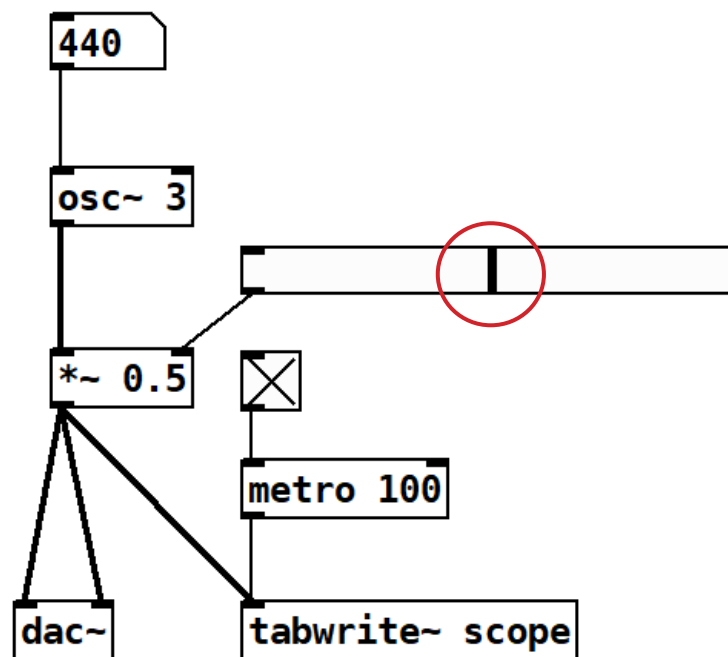


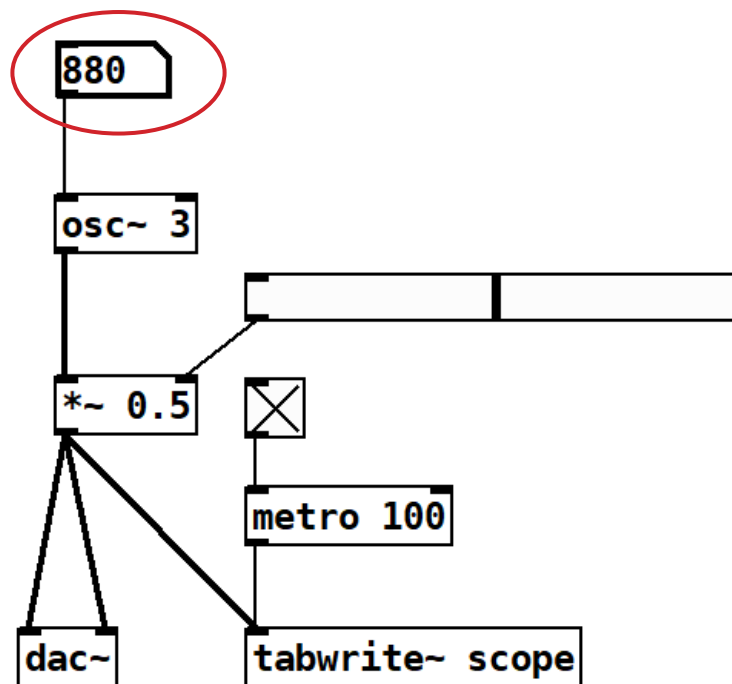
save as **scope.pd**

scope

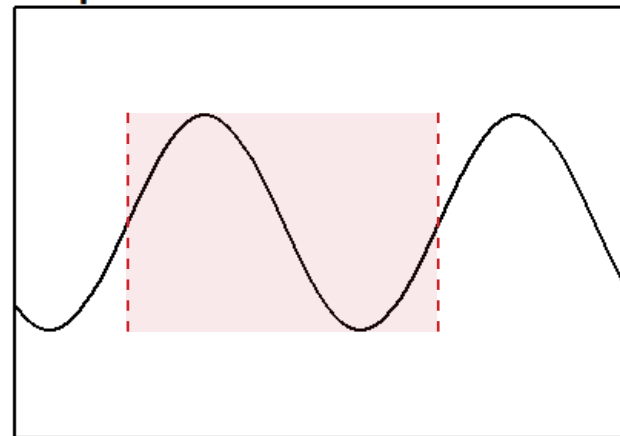


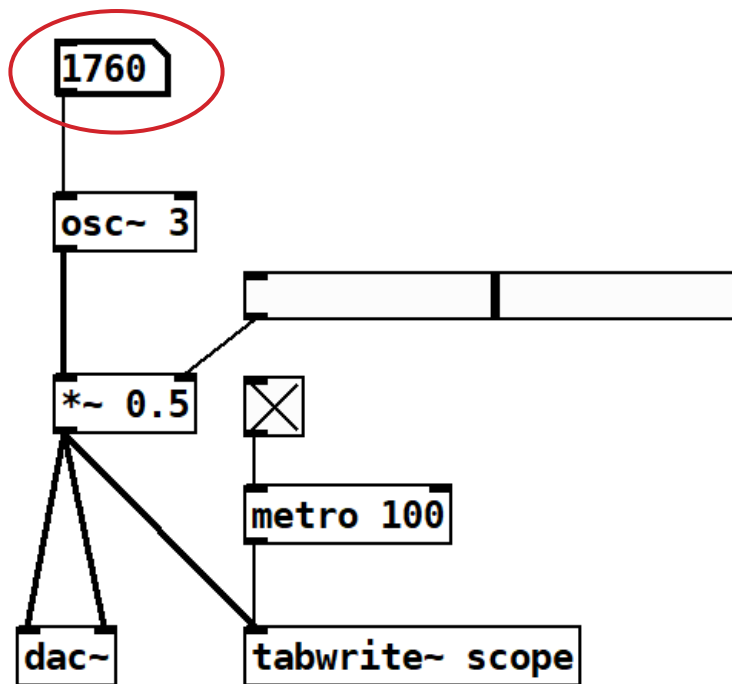




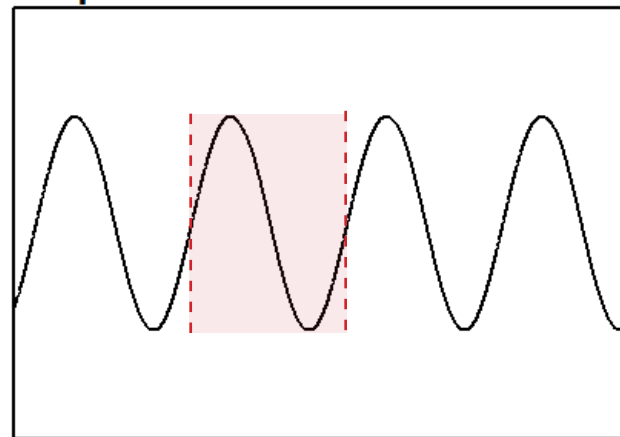


scope





scope



01_sine.pd* [edit] - C:/Users/Ulla/Documents/Pd

Datei Bearbeiten Einfügen Finge Medien Fenster Hilfe

Neu Ctrl+N

Öffnen Ctrl+O

Speichern Ctrl+S

Speichern als... Shift+Ctrl+S

Message... Ctrl+Shift+M

Einstellungen

Drucken... Ctrl+P

1. 01_sine.pd

2. 01_osc.pd

3. 02_scope.pd

4. 03_sawtooth.pd

5. 03_phasor.pd

6. 02_spectrum.pd

Schließen Ctrl+W

Beenden Ctrl+Q

3

0.5

metro 100

dac~

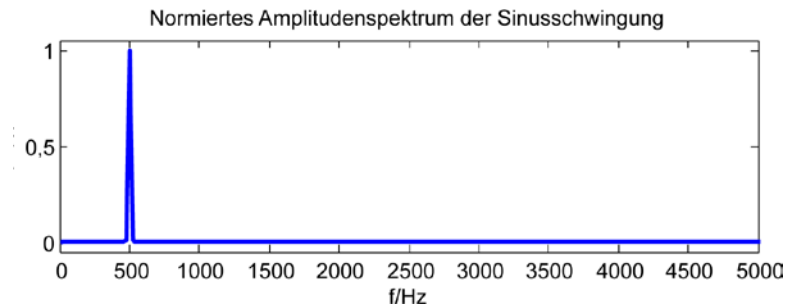
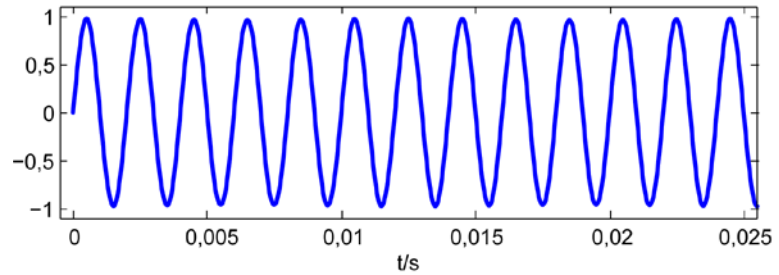
tabwrite~ scope

save as "sine.pd"

BETTER: "TAM_sine.pd"

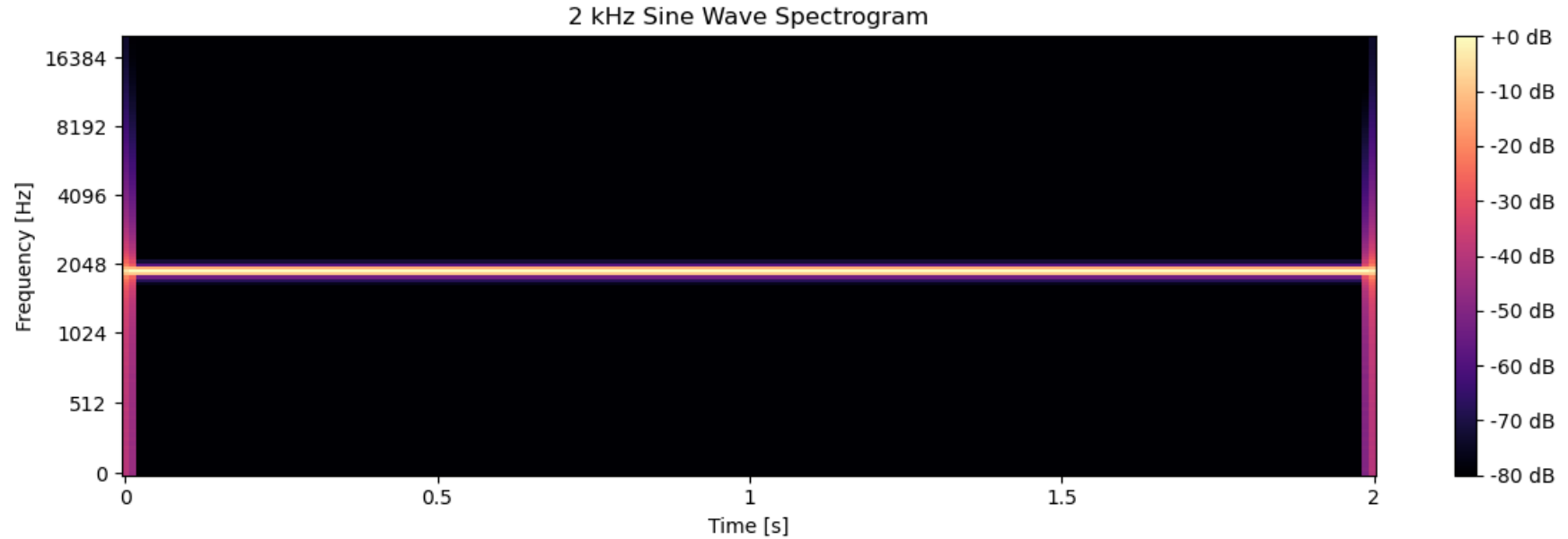
scope

Spectrum of a sine wave



<https://de.wikipedia.org/wiki/Sinuston>

Spectrogram of a sine wave



<https://www.velotio.com/engineering-blog/kickstart-your-critical-listening-skills-learn-to-analyze-hi-res-high-quality-audio-with-a-spectrogram>

SINE WAVE

- **No overtones**

Only the fundamental frequency

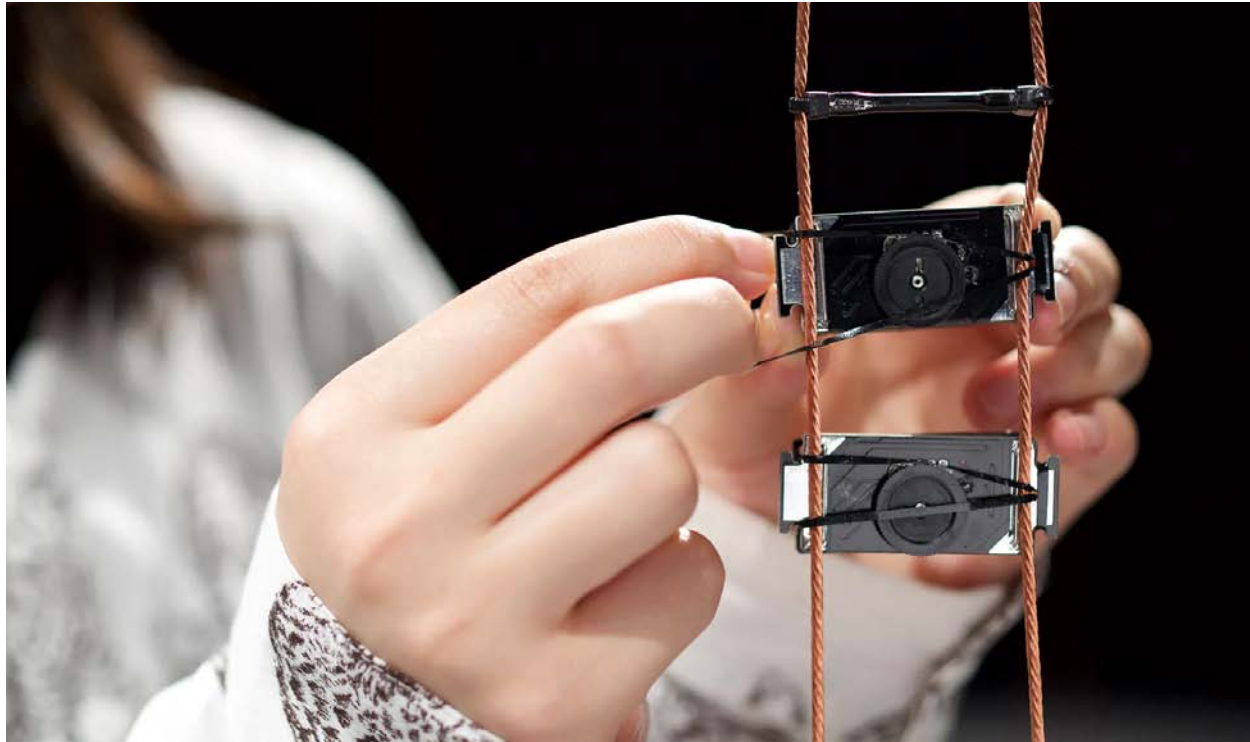
- **Does not occur in nature**

Can only be reproduced through electronic synthesis

- **A sine tone sounds...**

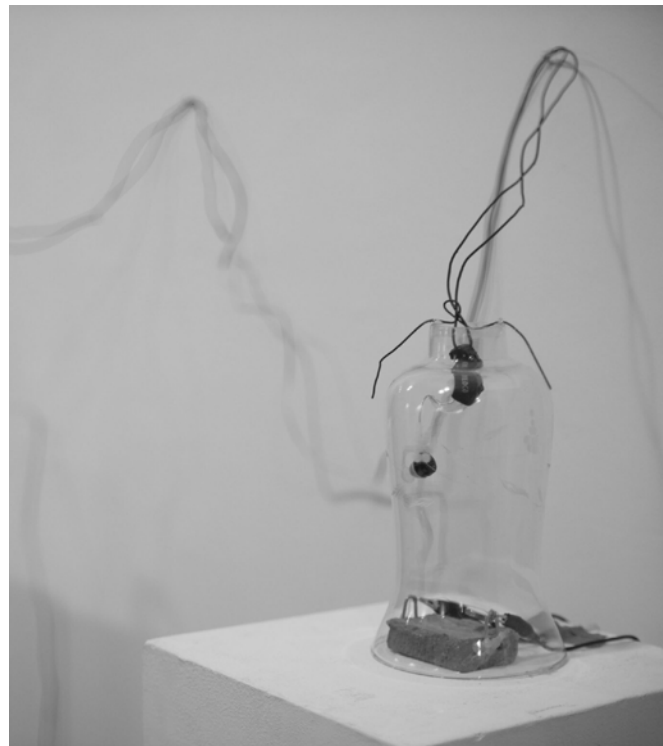
How does it sound to you?

THE SINE WAVE ORCHESTRA



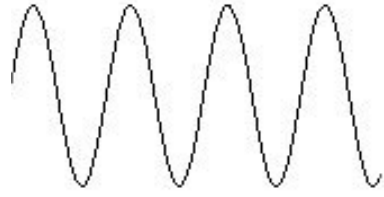
<https://ars.electronica.art/outofthebox/de/orchestra/>

RYOKO AKAMA | Inefficient Ways To Comprehend The Matter

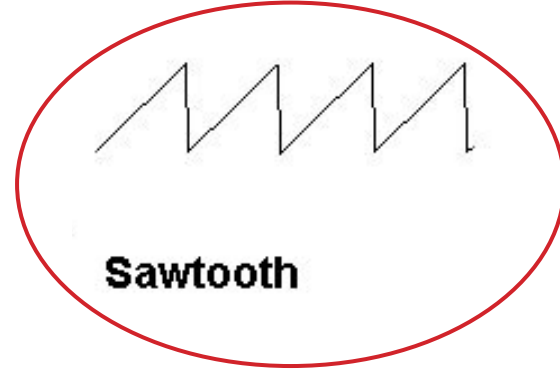


<https://ryokoakama.com/installation/tasw2021>

Waveforms



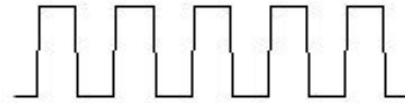
Sine



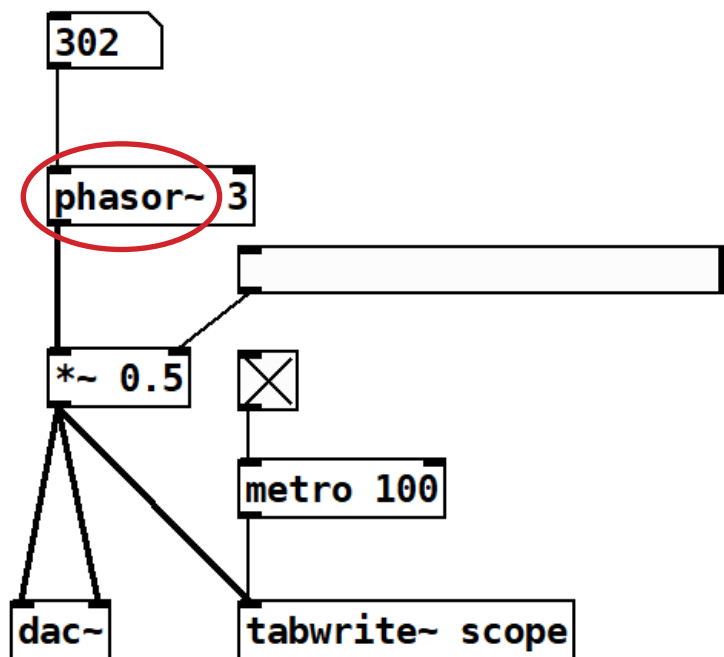
Sawtooth



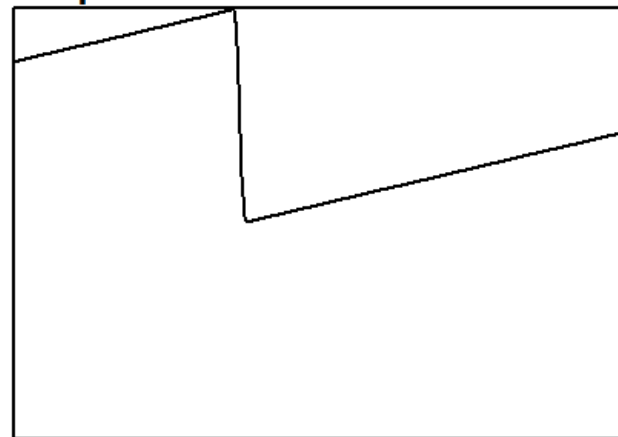
Triangle

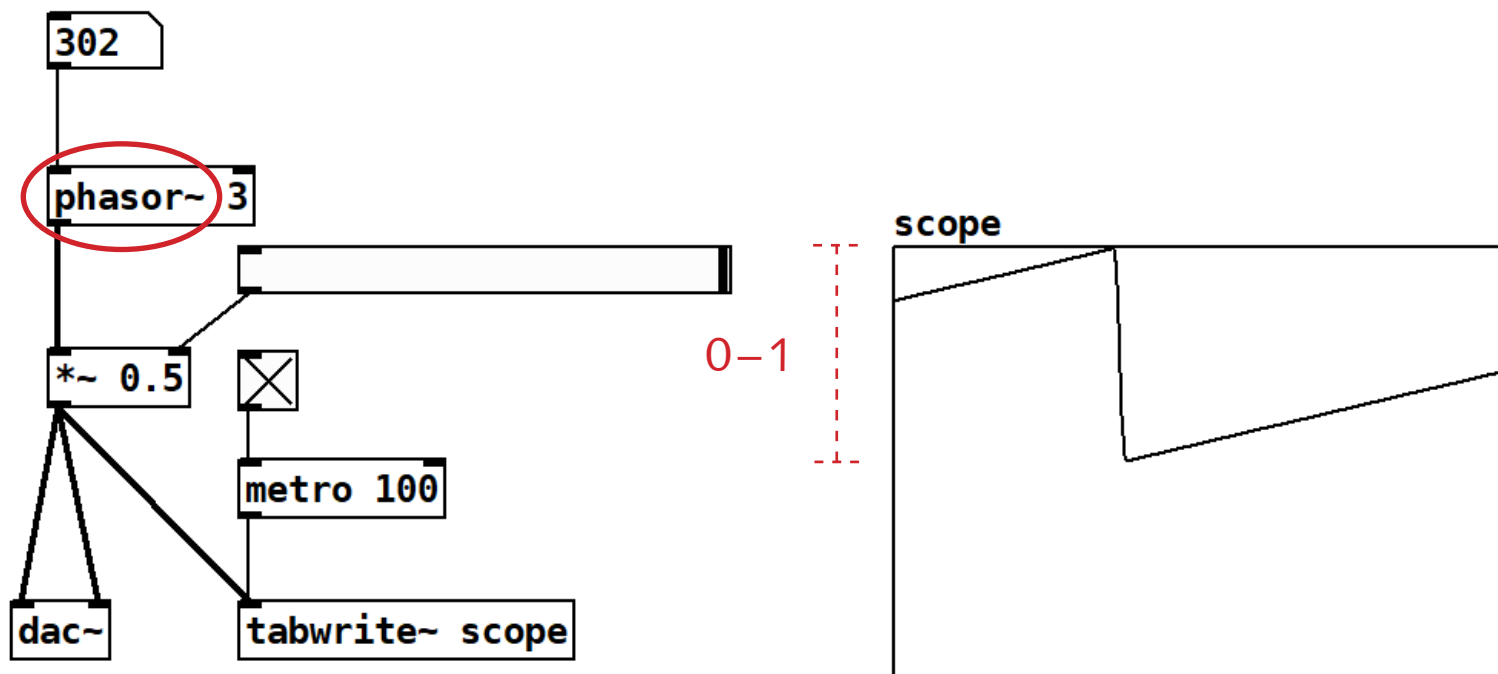


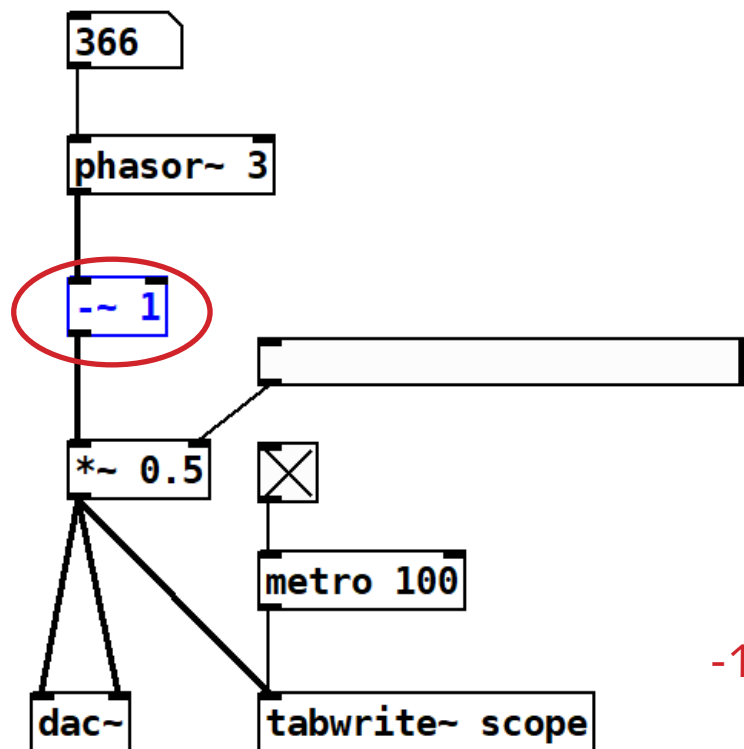
Square



scope

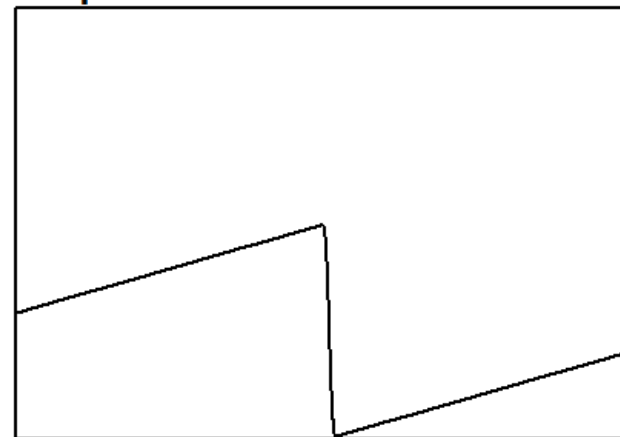


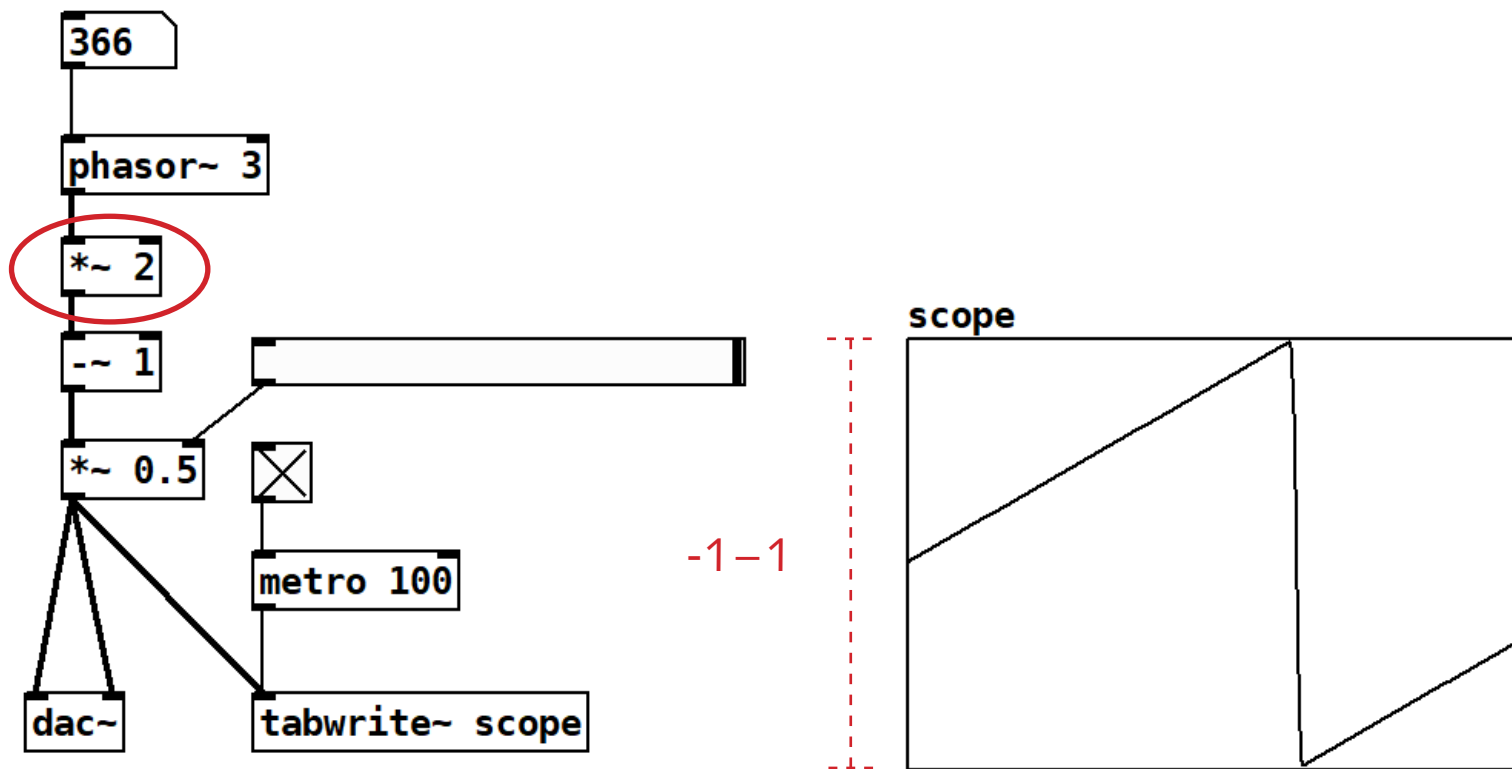


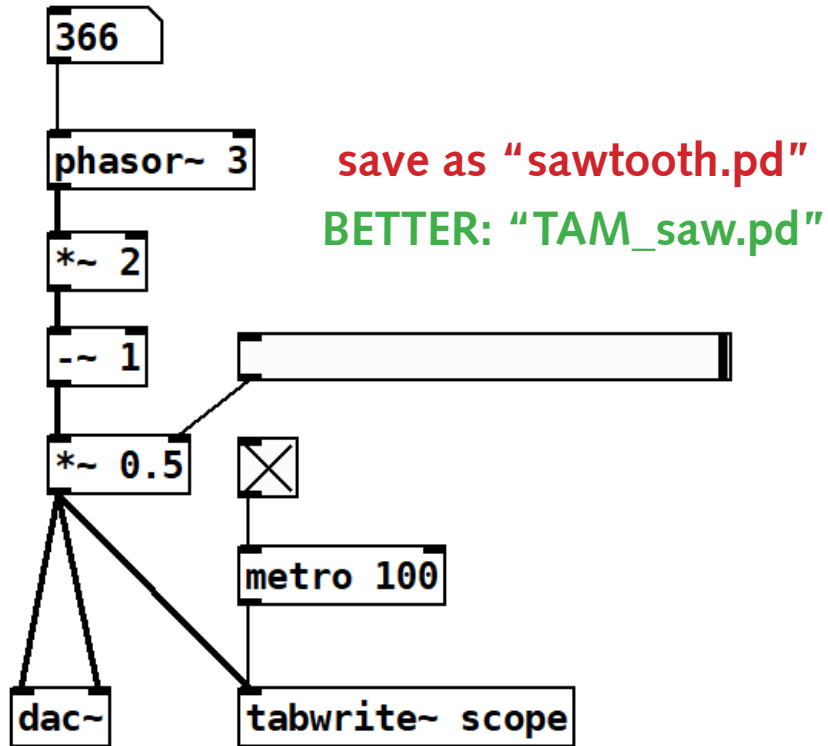


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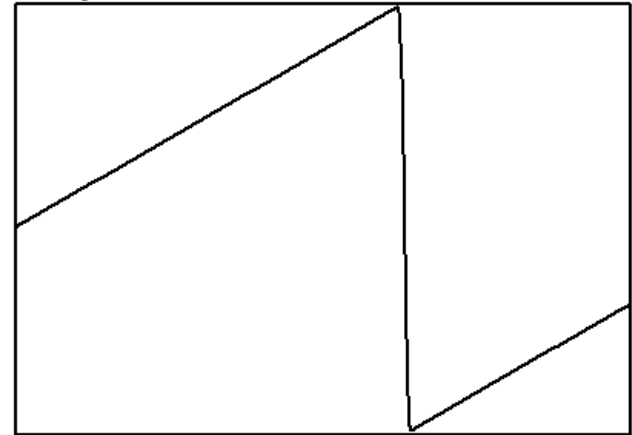
scope



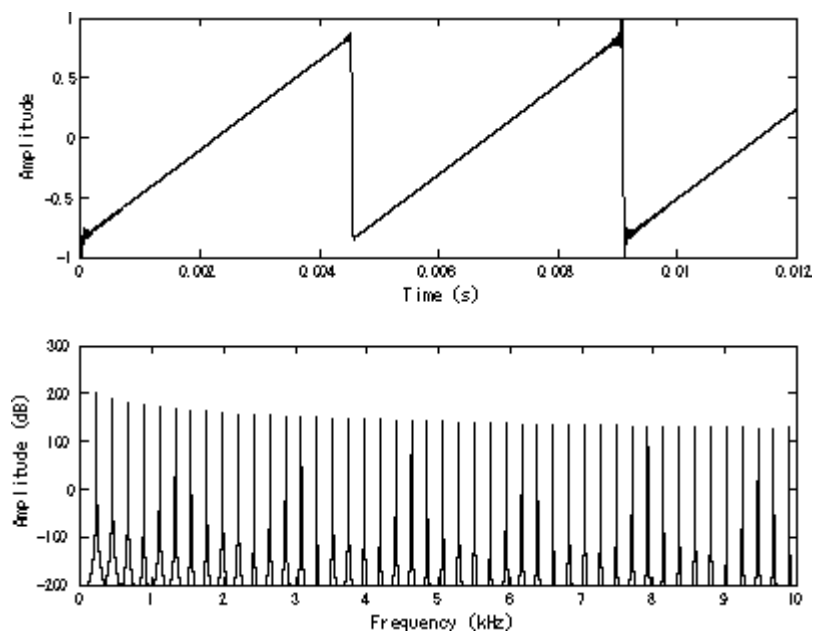




scope

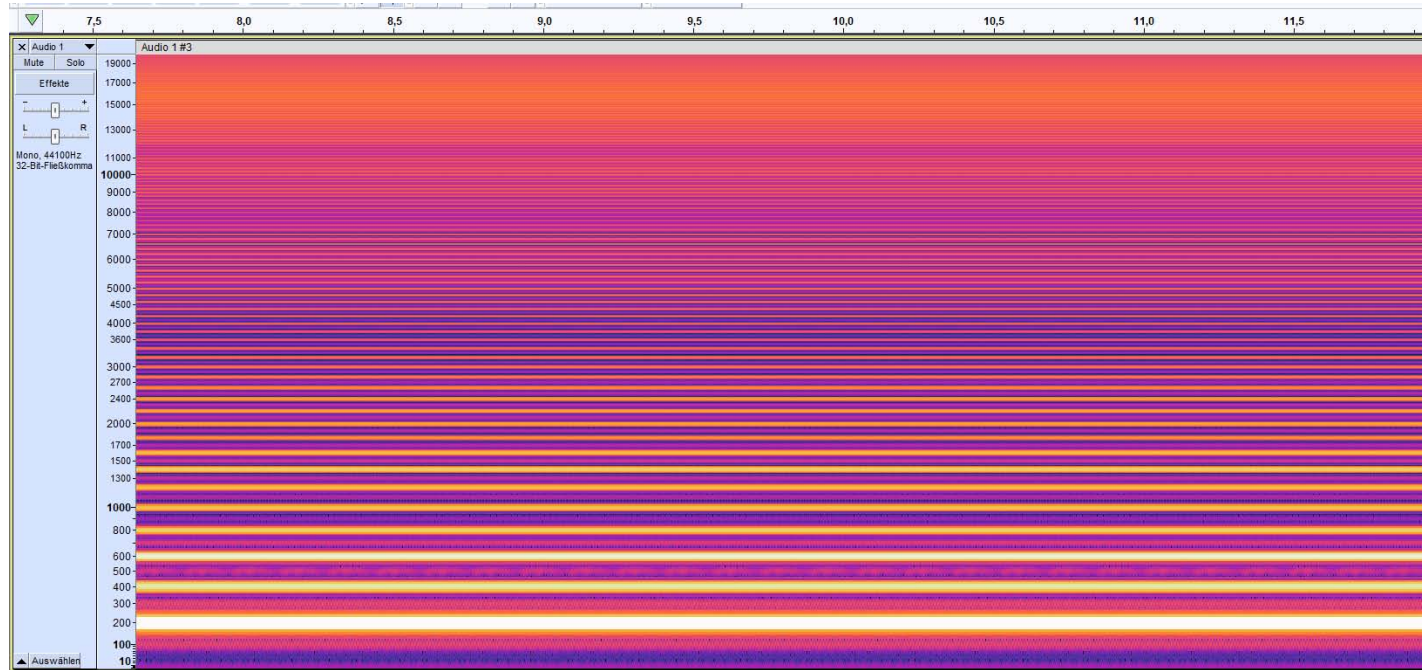


Spectrum of a sawtooth wave

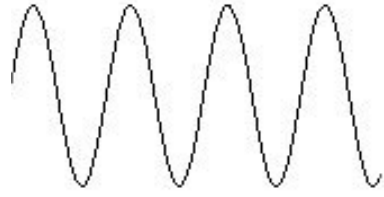


https://en.wikipedia.org/wiki/Sawtooth_wave

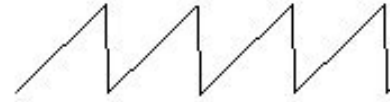
Spectrogram of a sawtooth wave



Waveforms



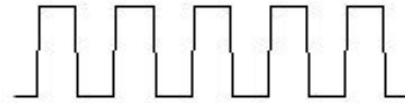
Sine



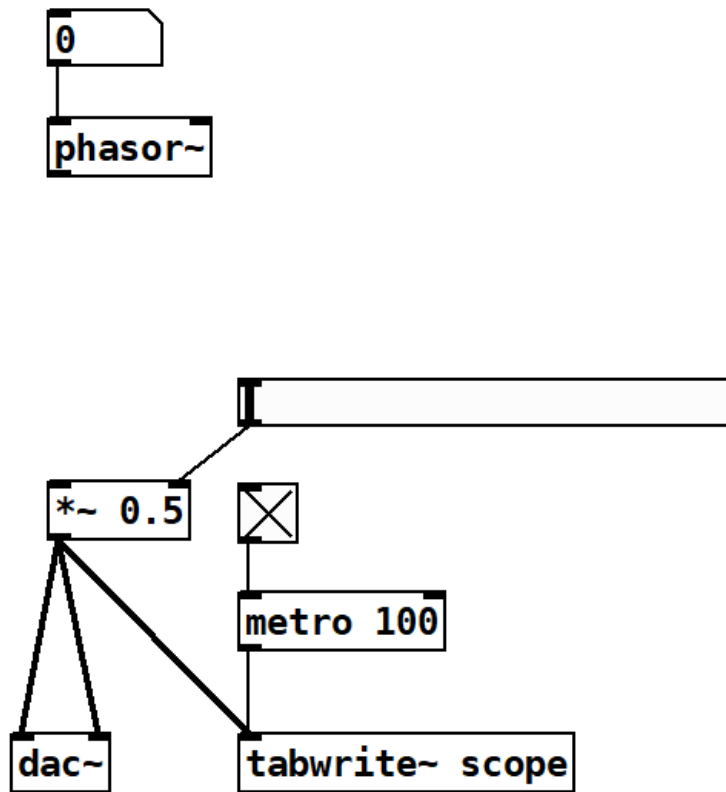
Sawtooth



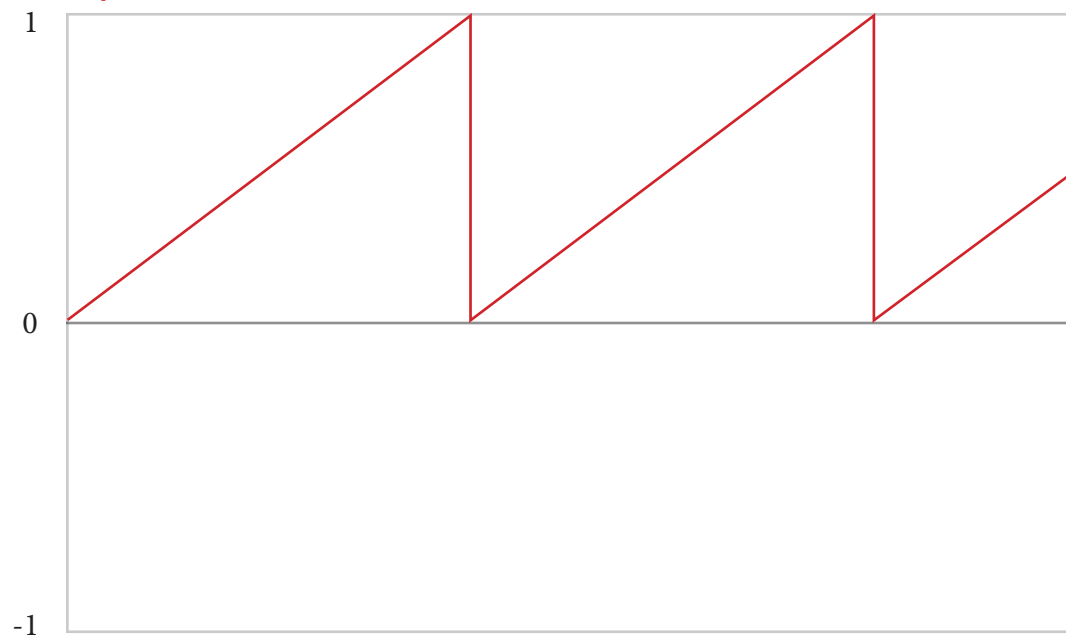
Triangle



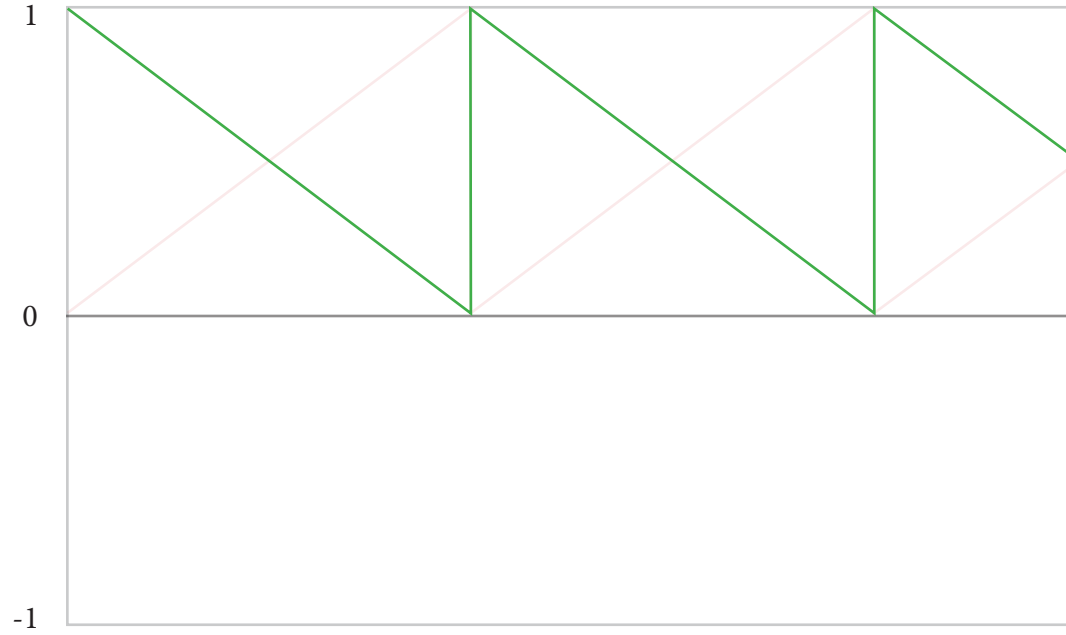
Square



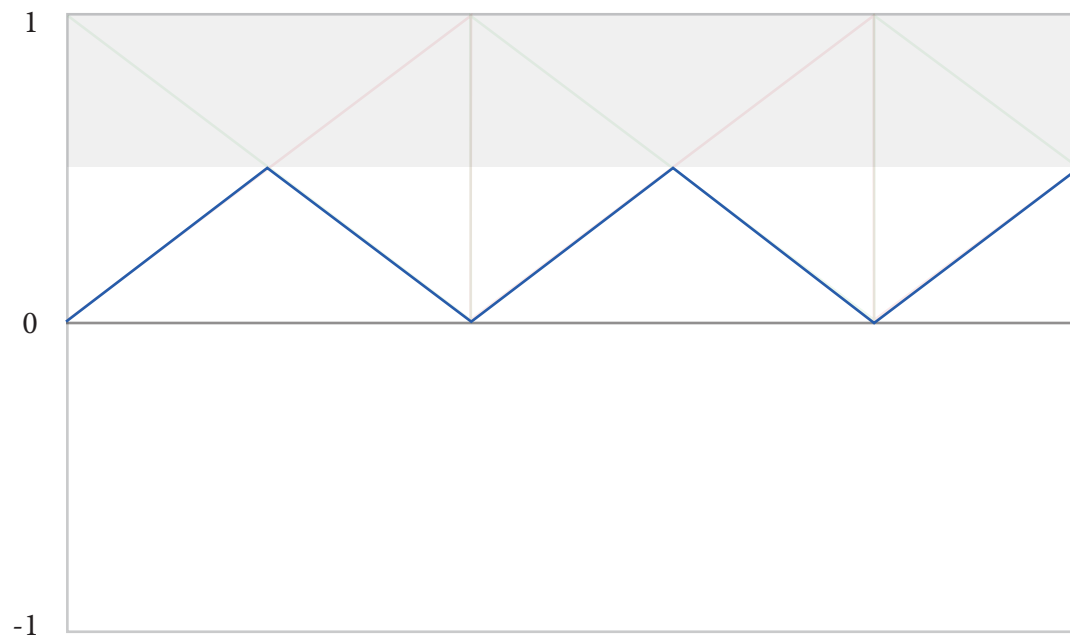
phasor

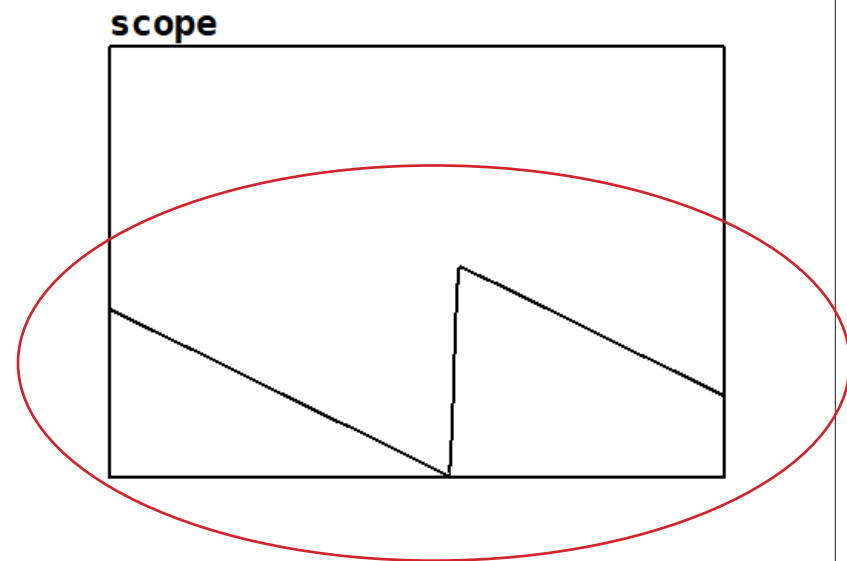
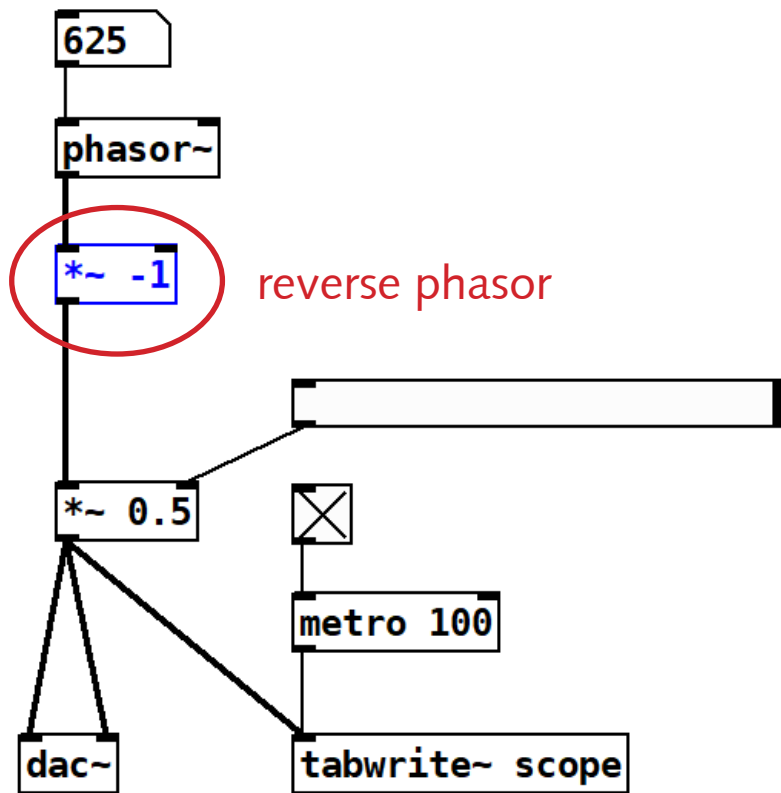


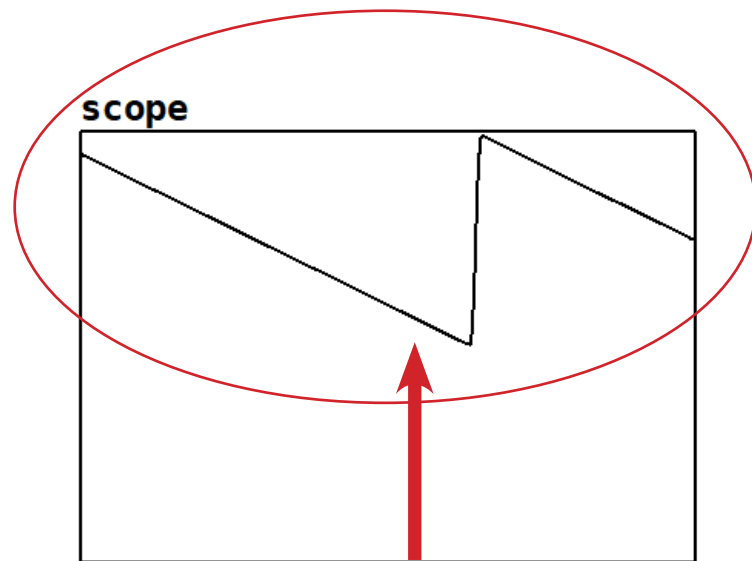
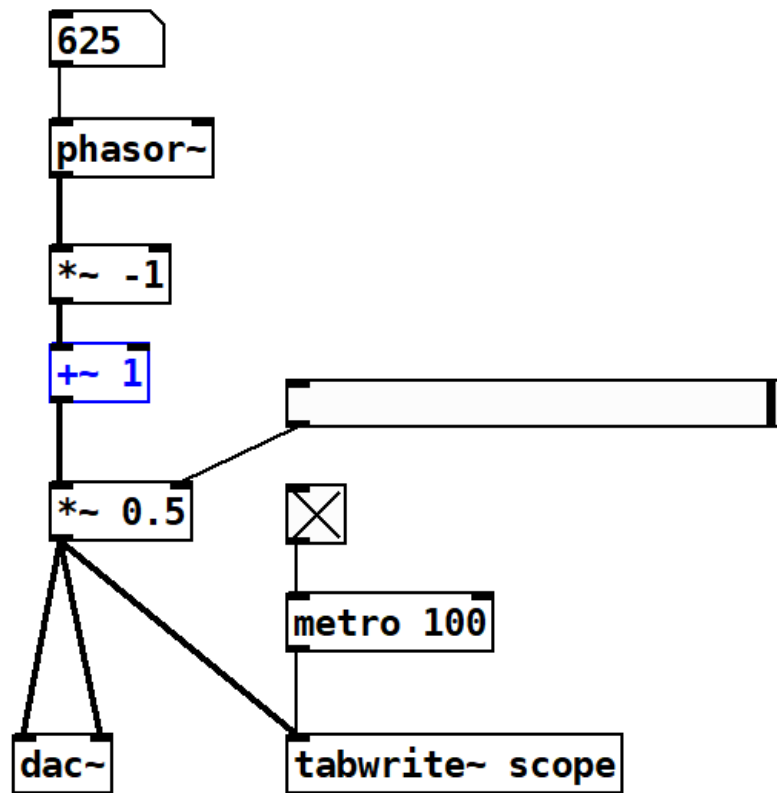
reversed phasor



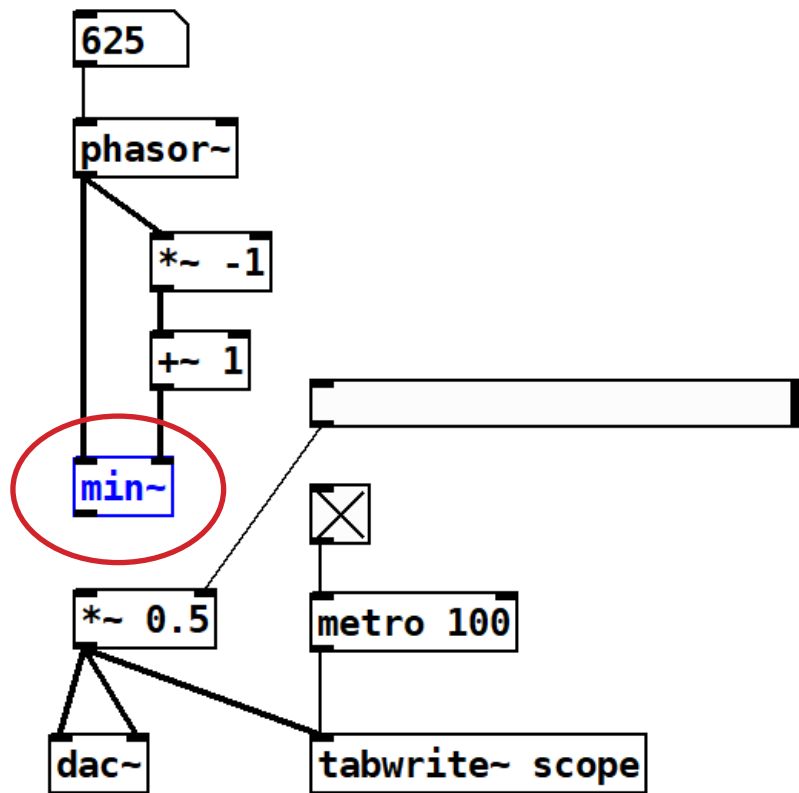
combination





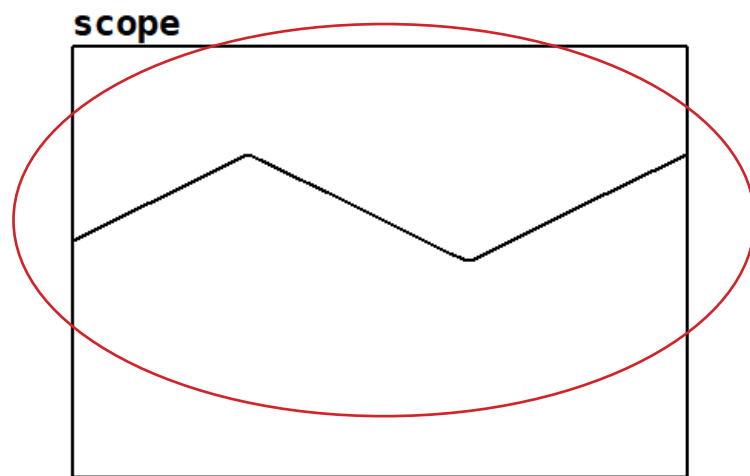
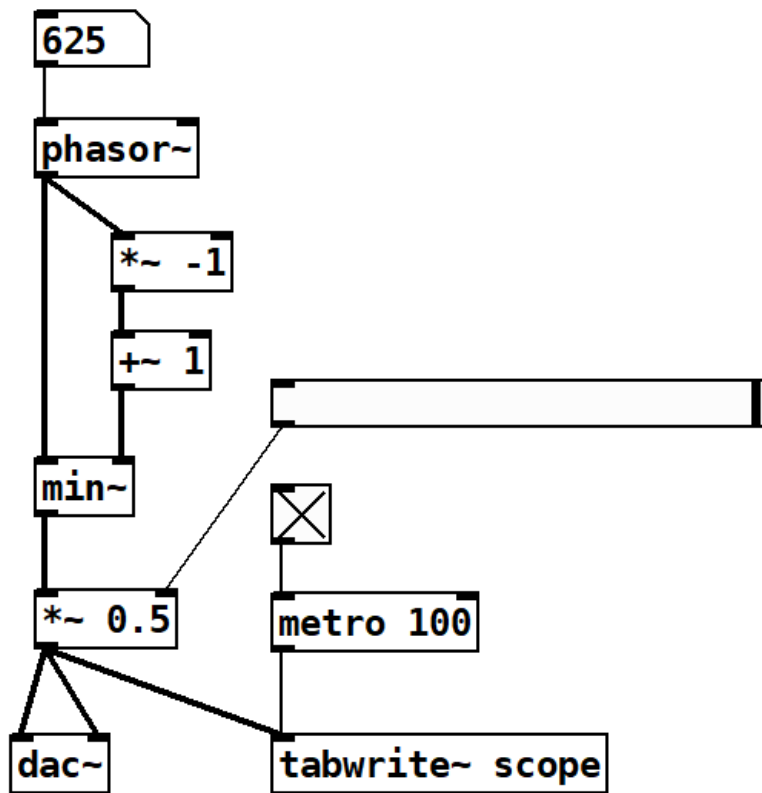


outputs the
minimum
of both

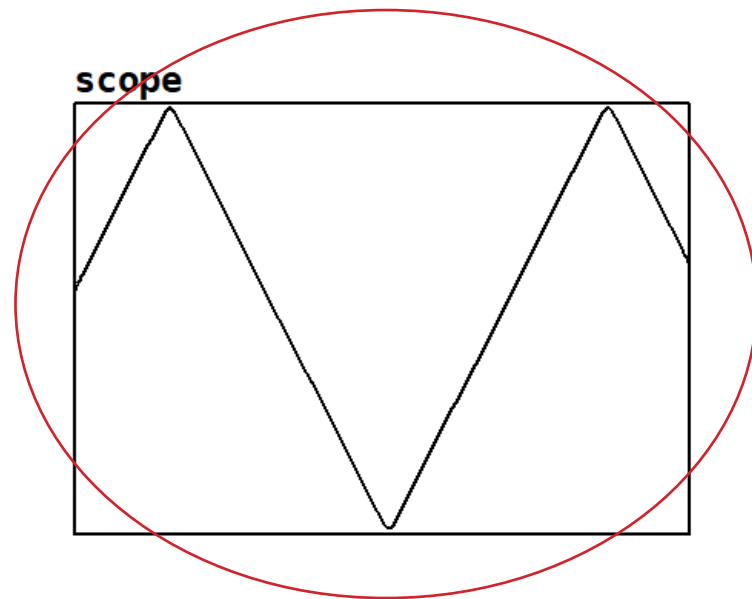
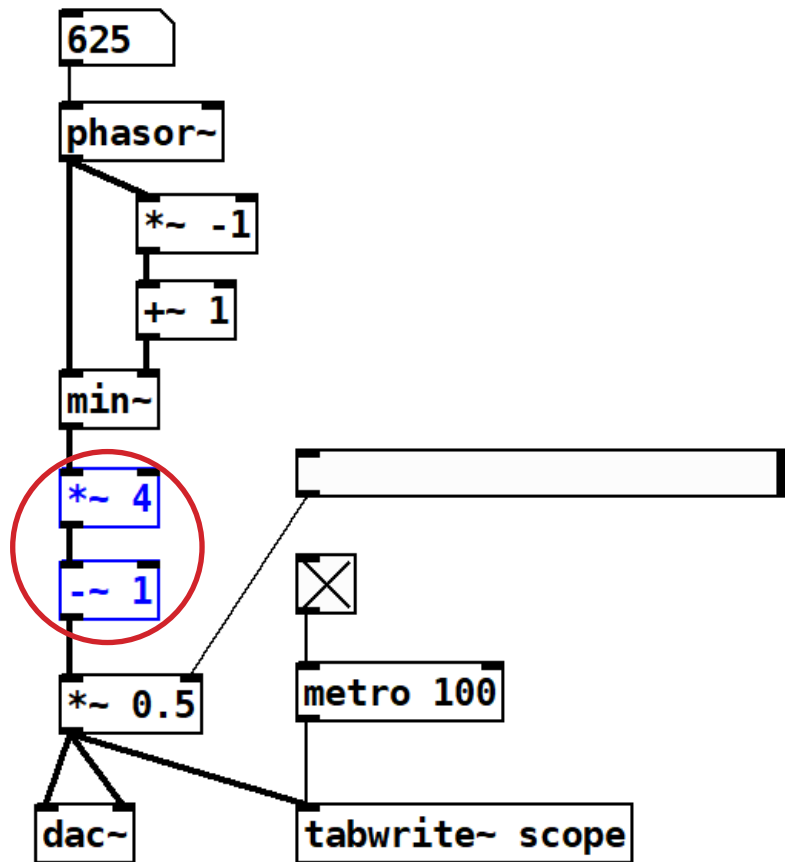


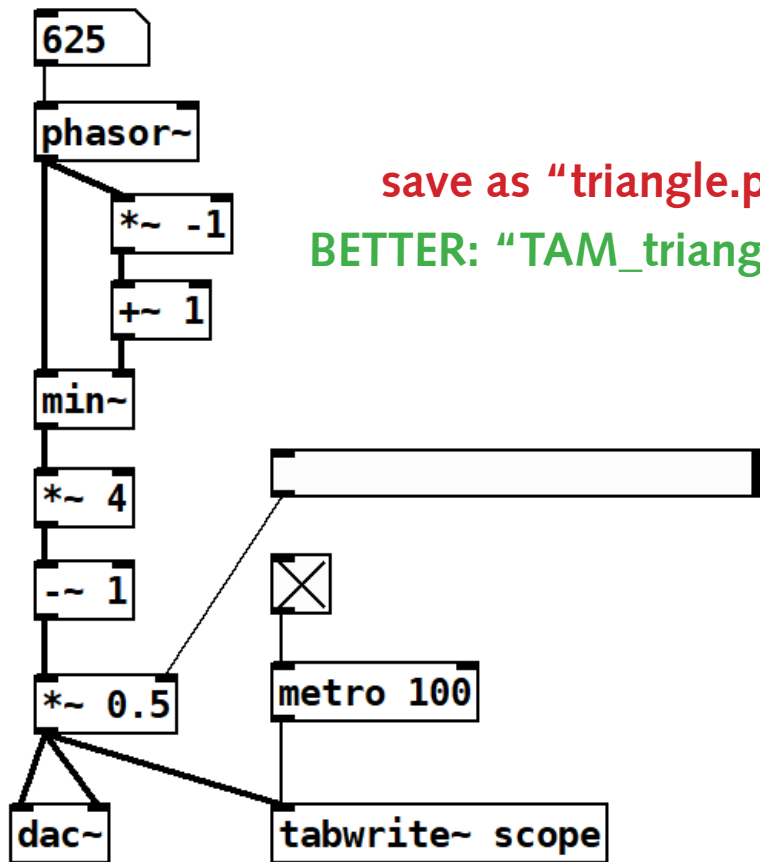
scope





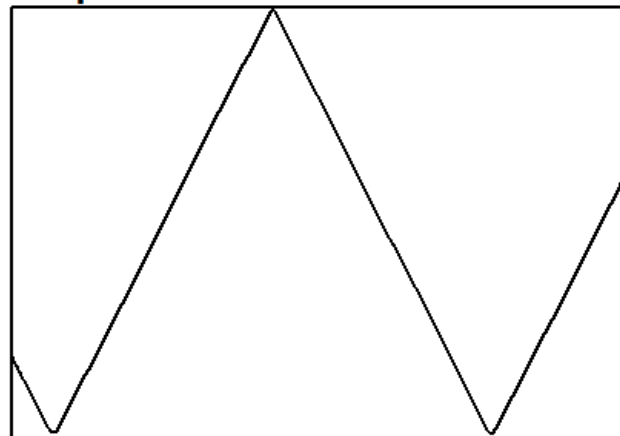
scale it to
-1-1



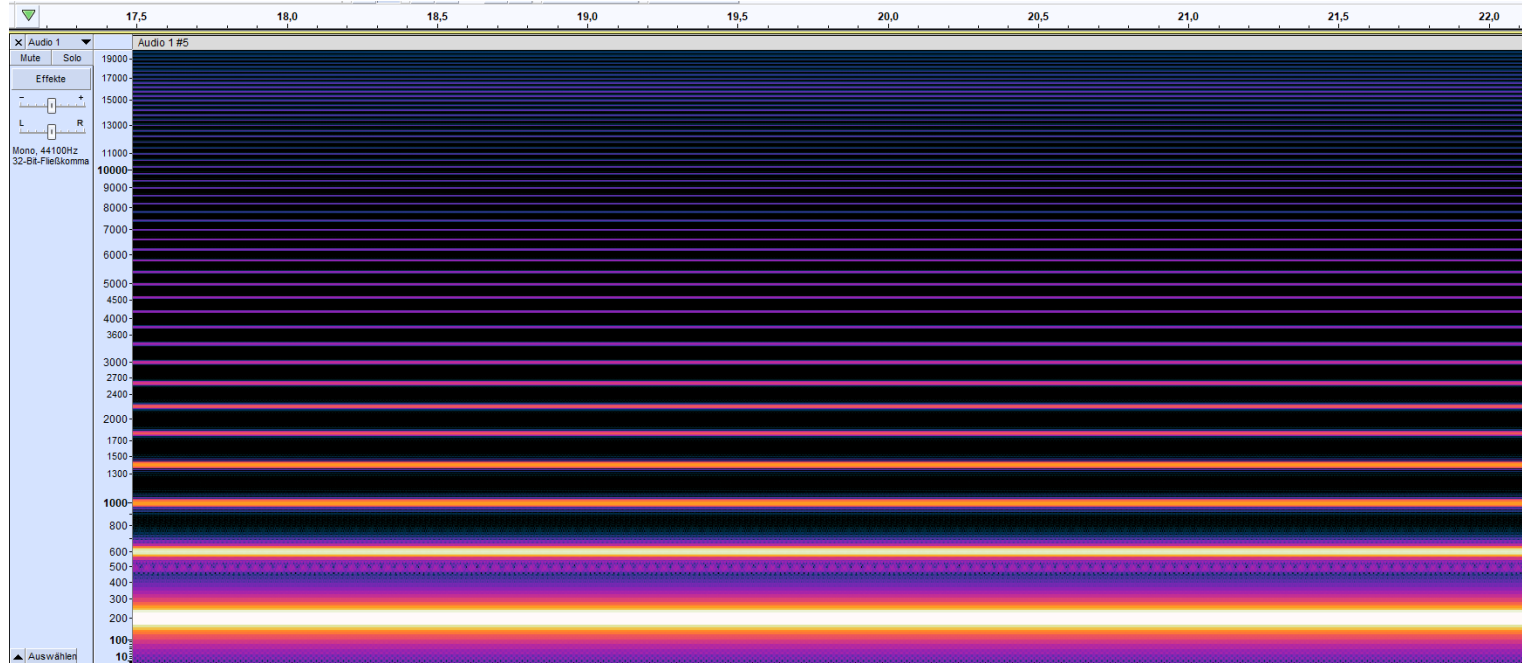


save as "triangle.pd"
BETTER: "TAM_triangle.pd"

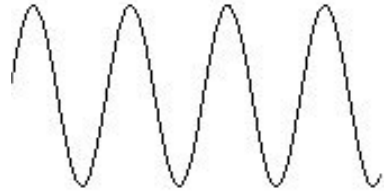
scope



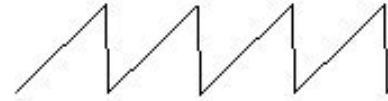
Spectrogram of a triangle wave



Waveforms



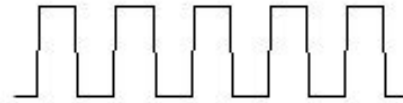
Sine



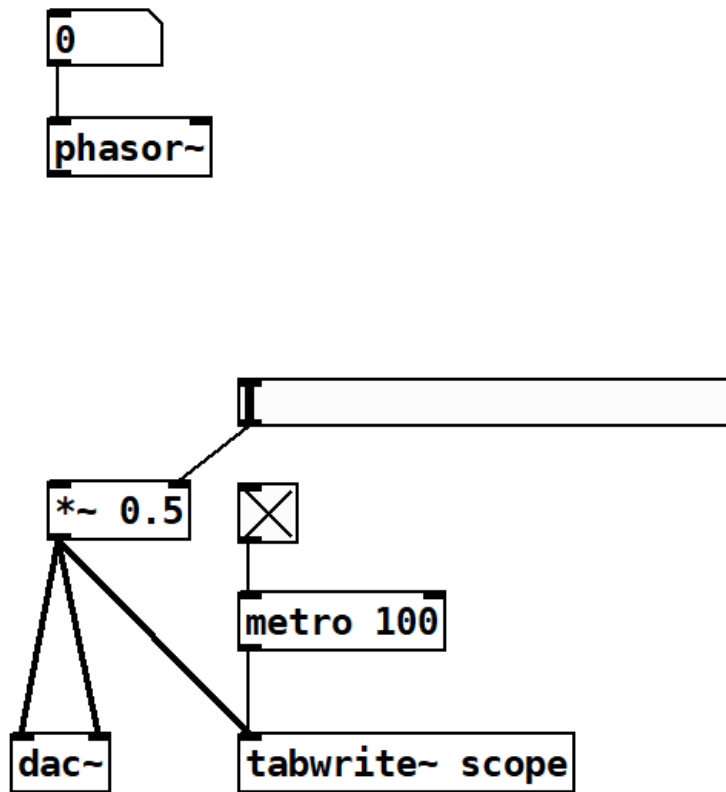
Sawtooth

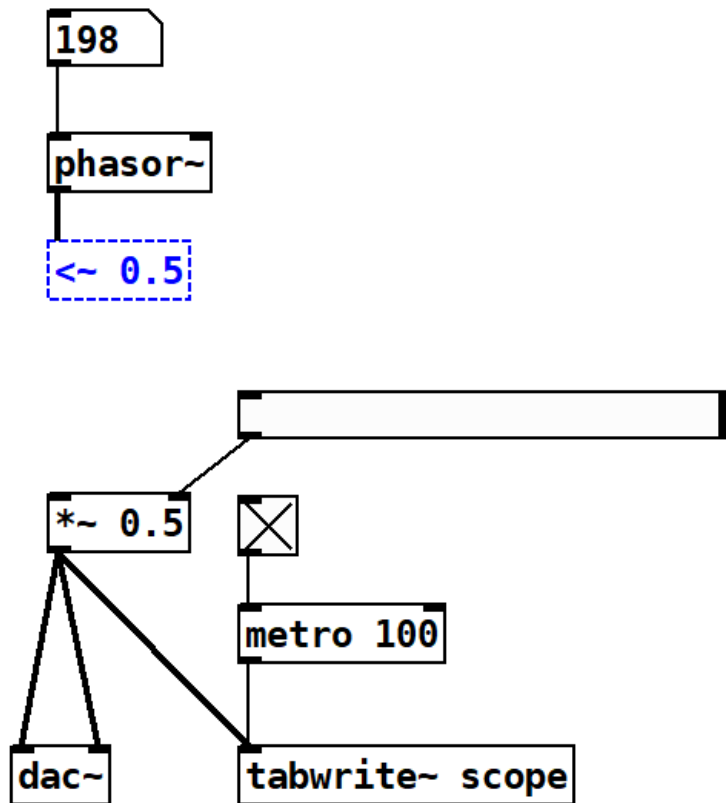


Triangle



Square





scope



198

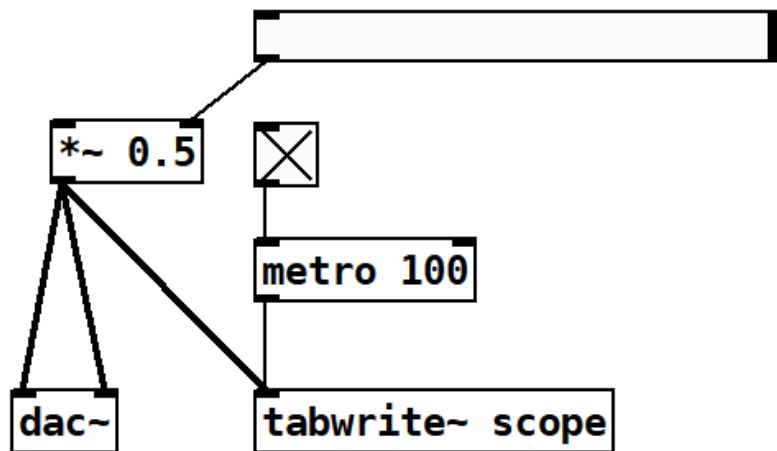
phasor

<~ 0.5

Über Pd
HTML-Anleitung...
Patch-Browser... Ctrl+B
Liste aller Objekte...

puredata.info
Nach Updates suchen
Fehlerbericht erstellen

Finde Externals online



scope



<~|

search for libraries containing this object

Suche

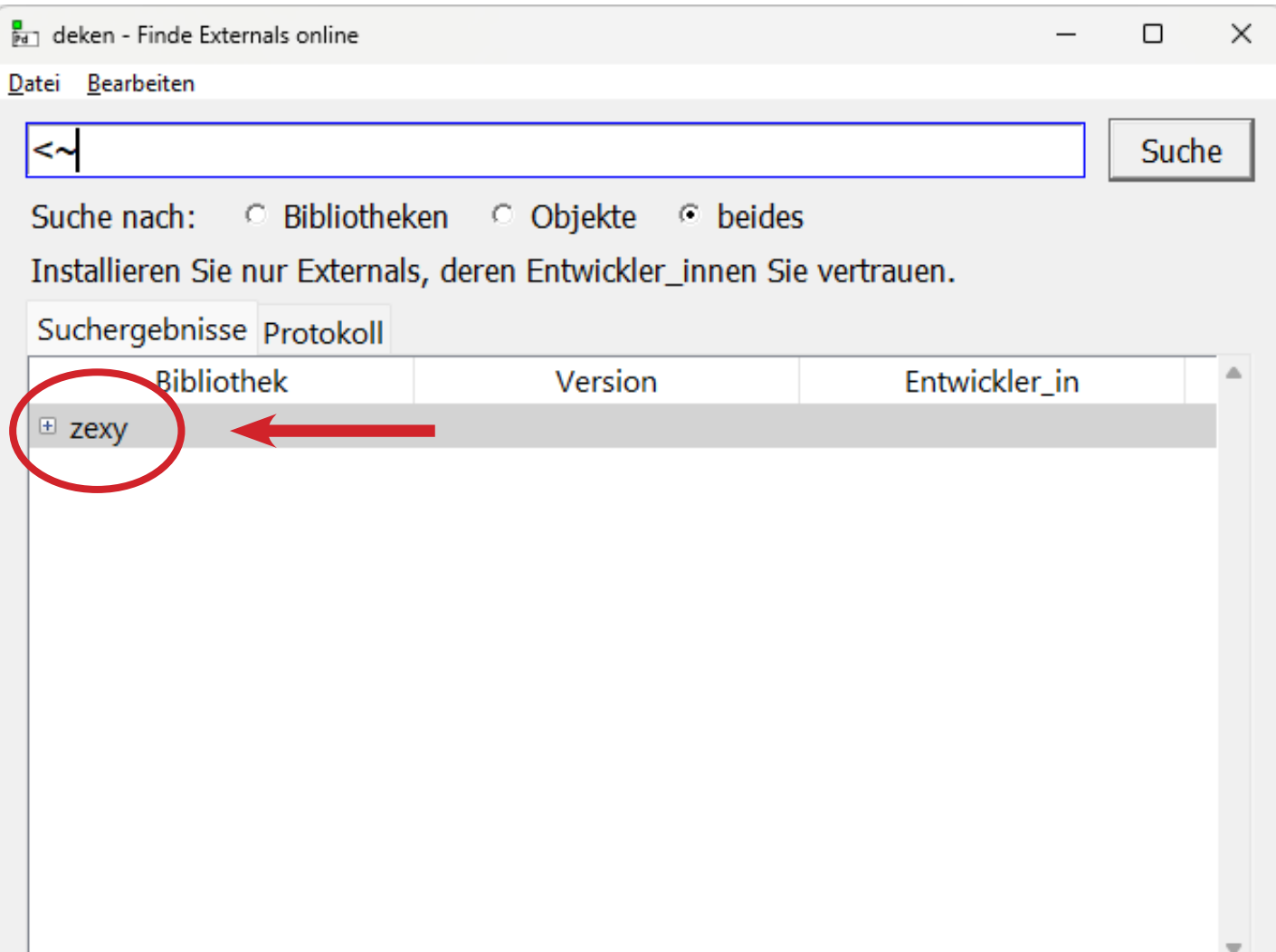


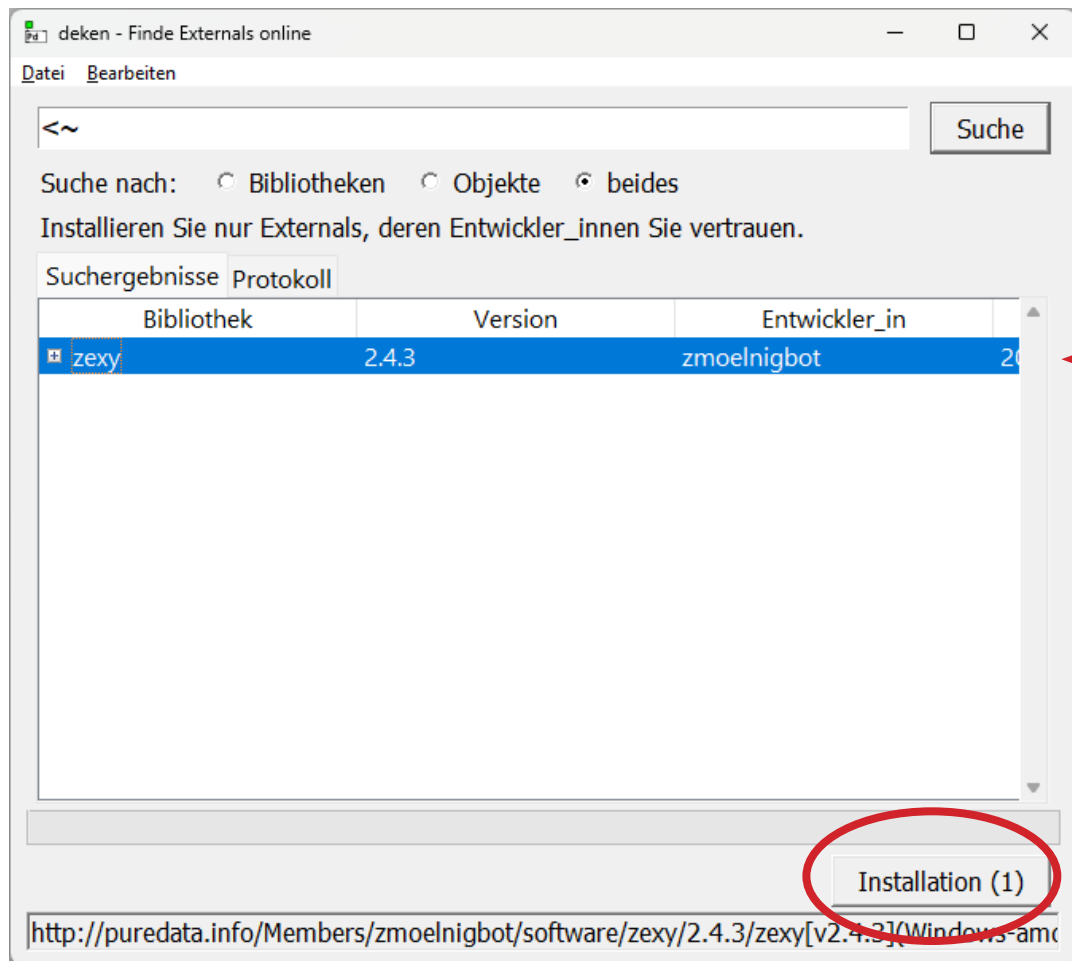
Suche nach: ☐ Bibliotheken ☐ Objekte ☒ beides

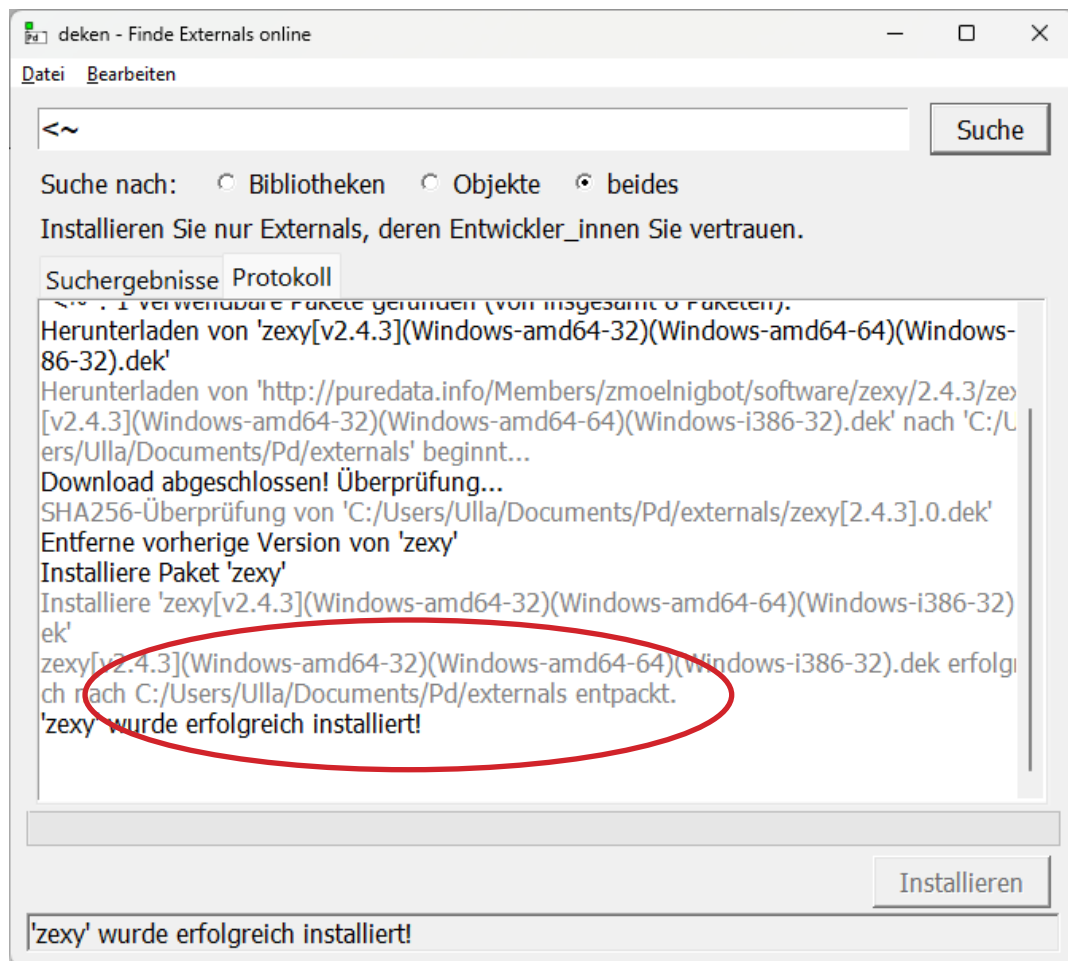
Installieren Sie nur Externals, deren Entwickler_innen Sie vertrauen.

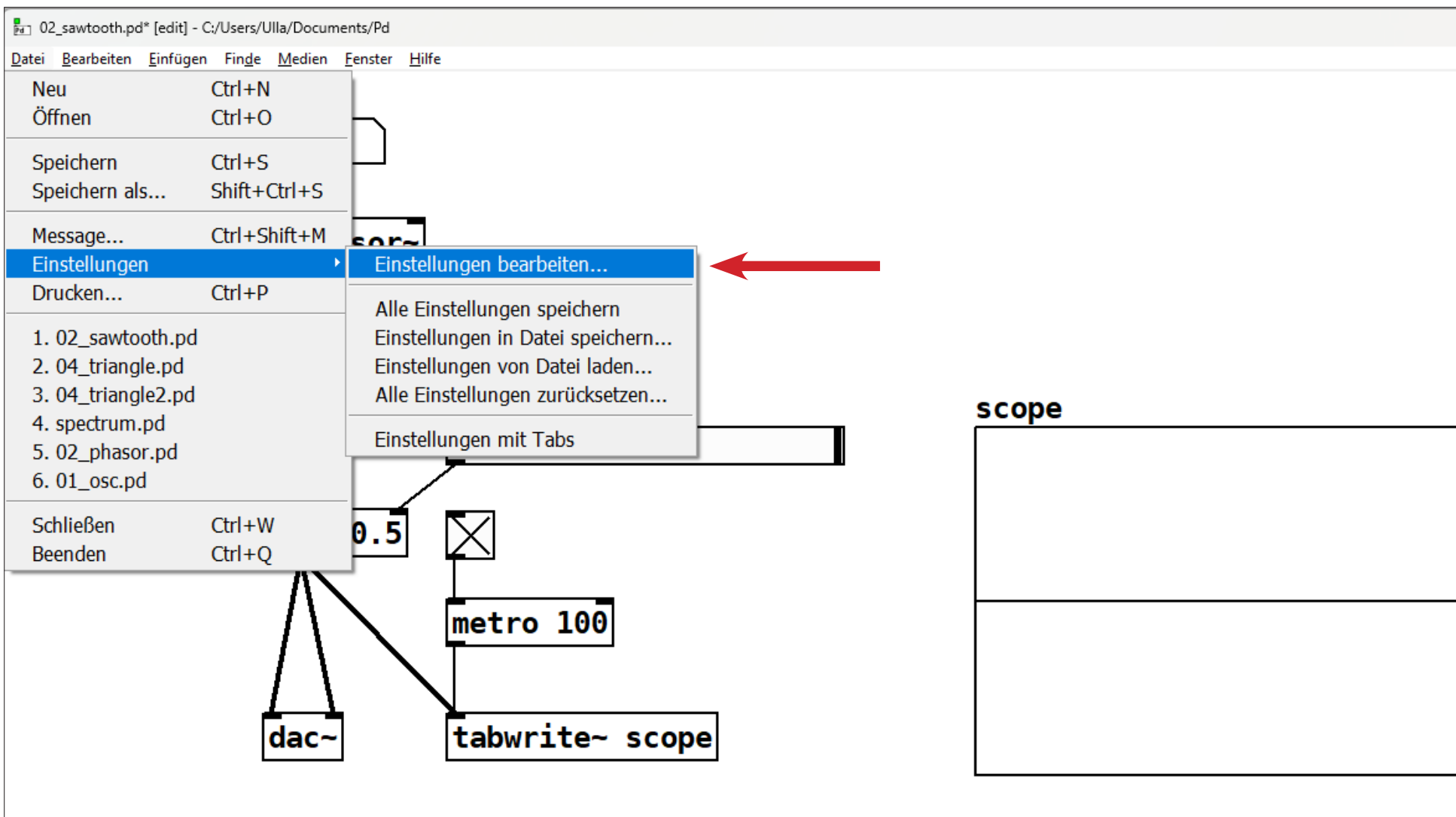
Suchergebnisse Protokoll

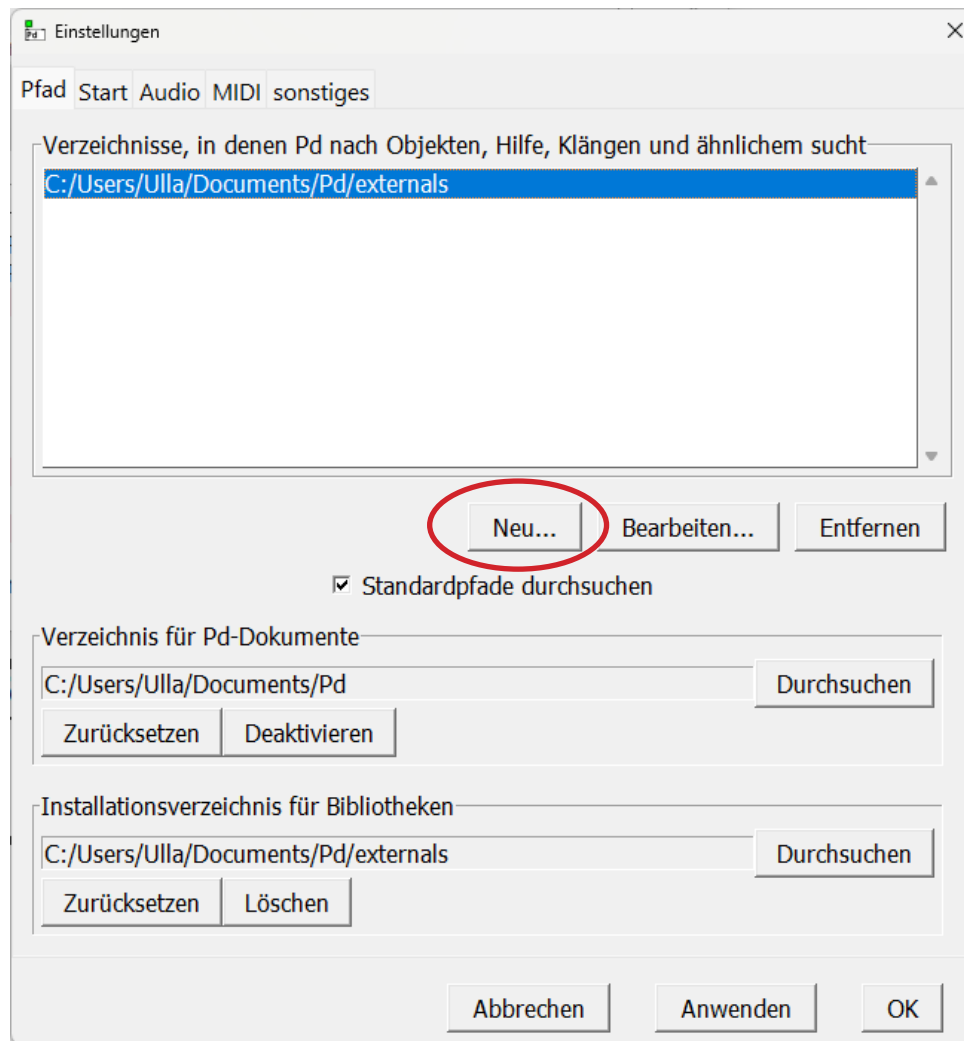
Bibliothek	Version	Entwickler_in
+ zexy		

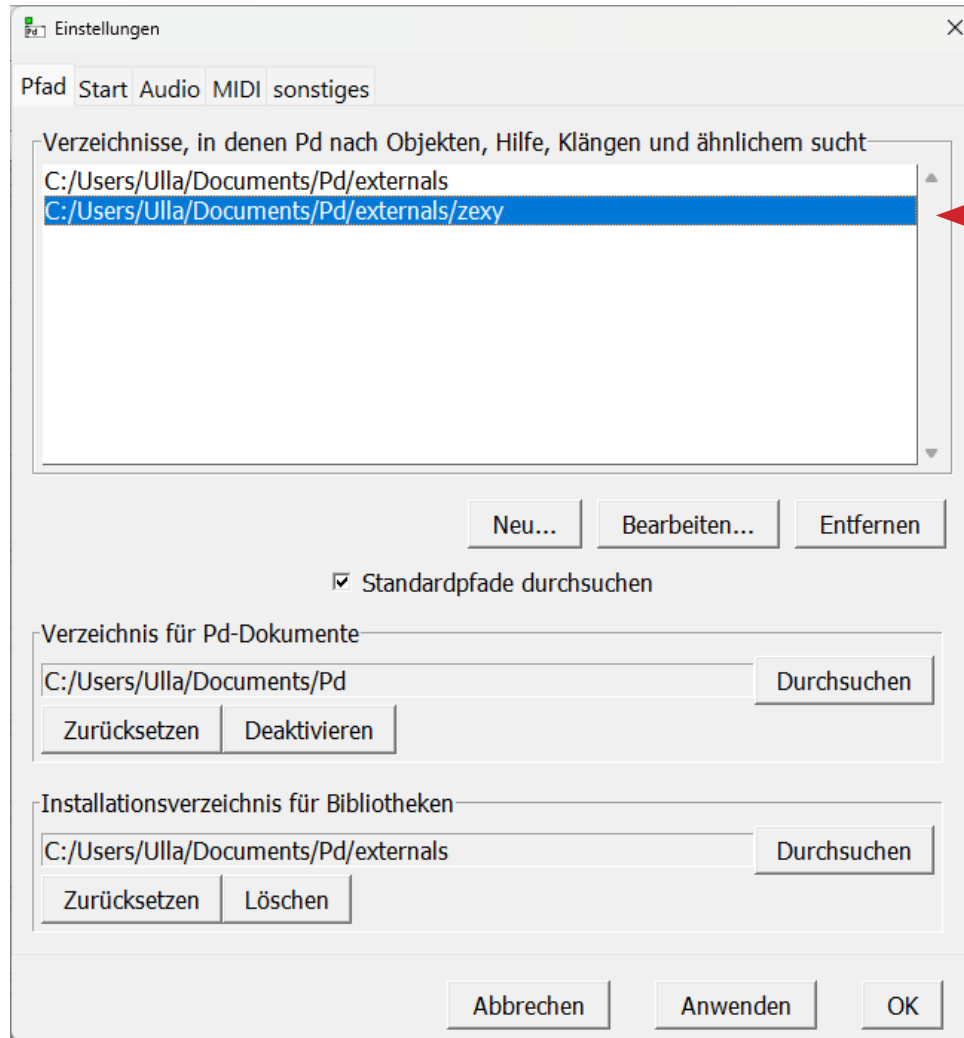


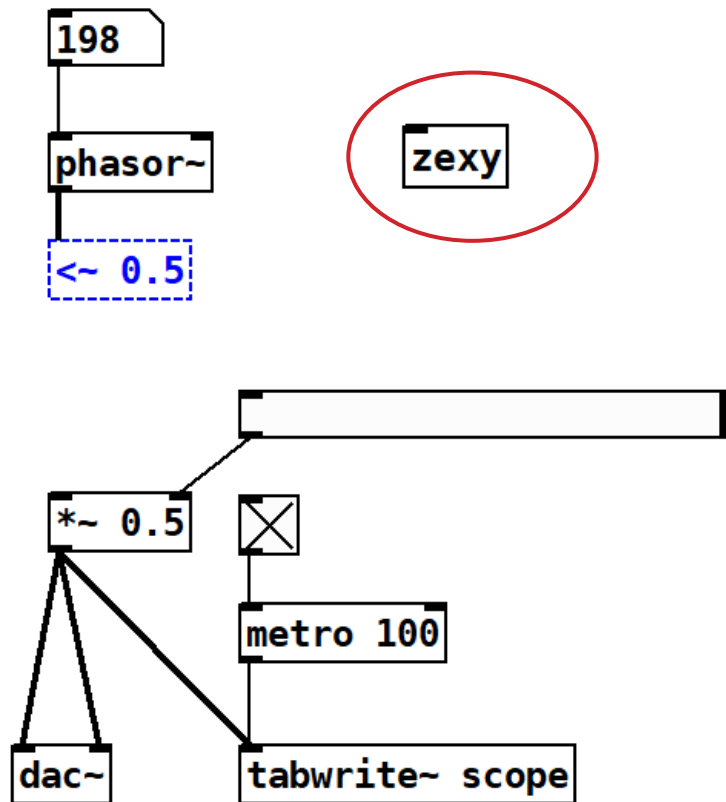






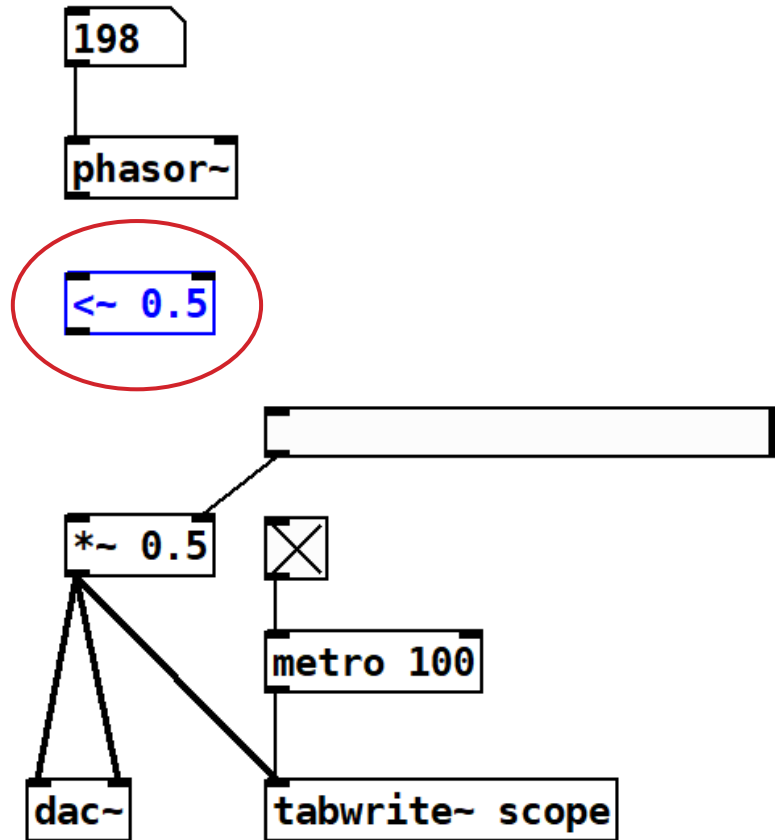






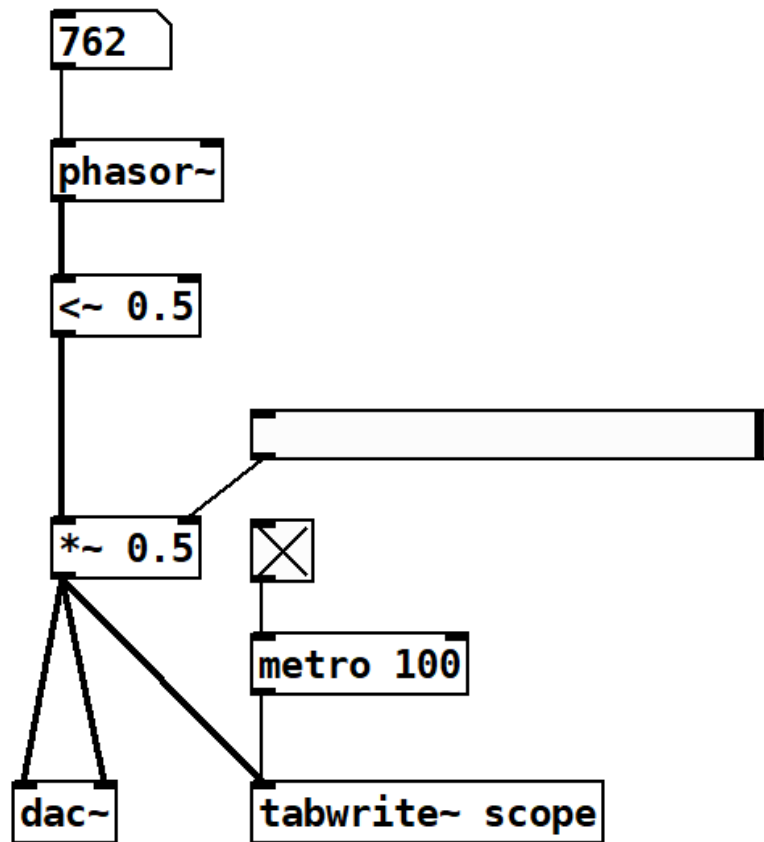
scope



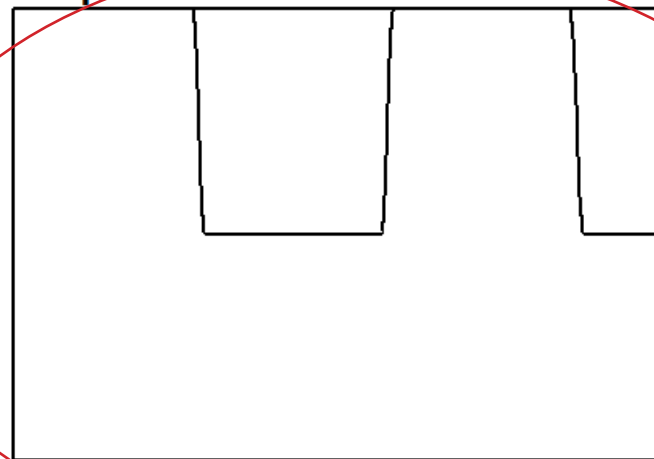


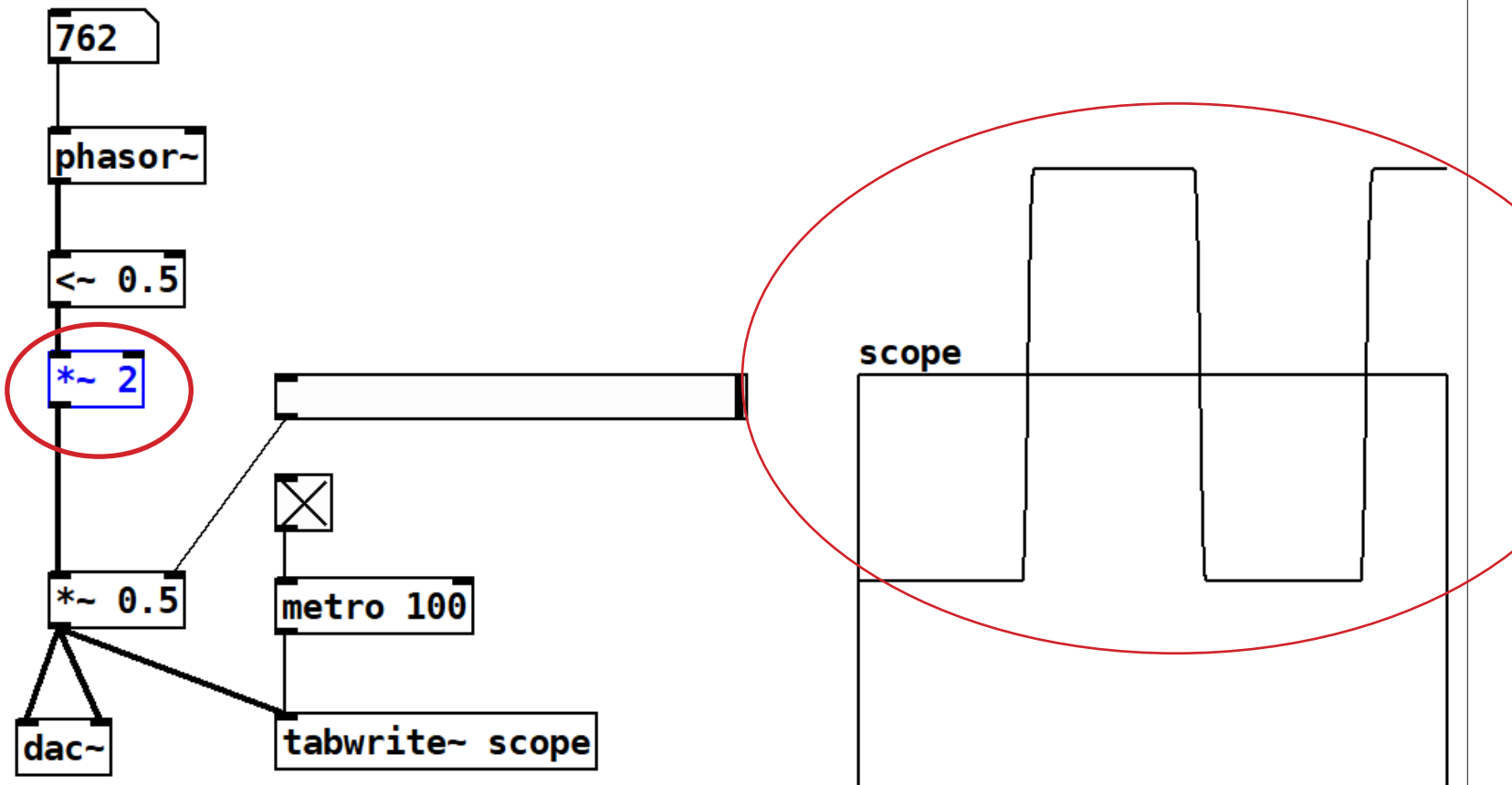
scope

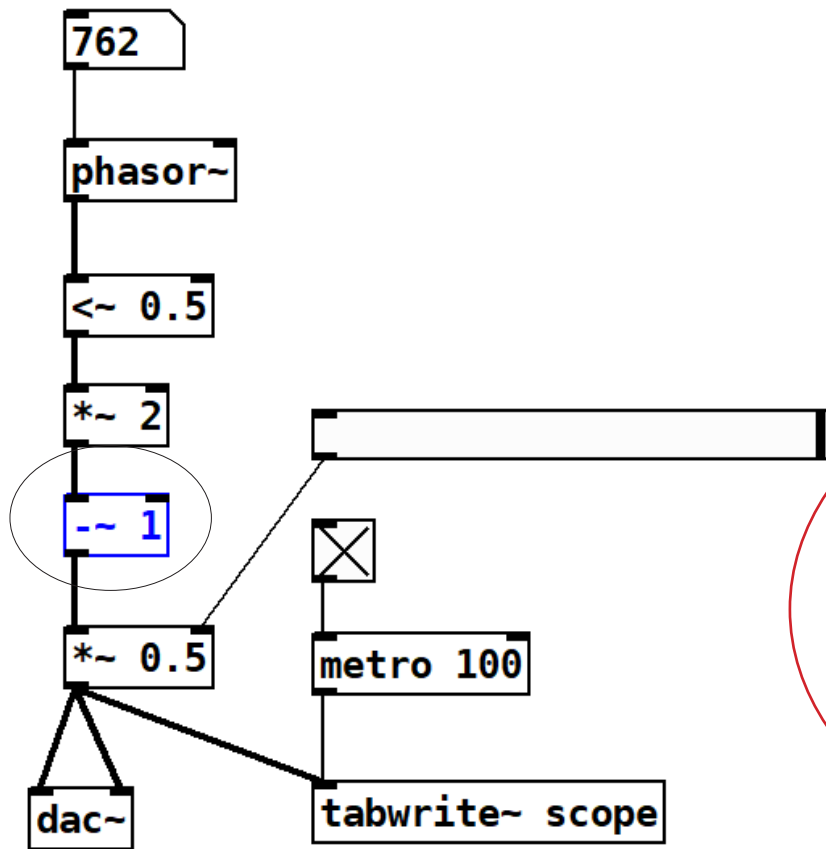




scope

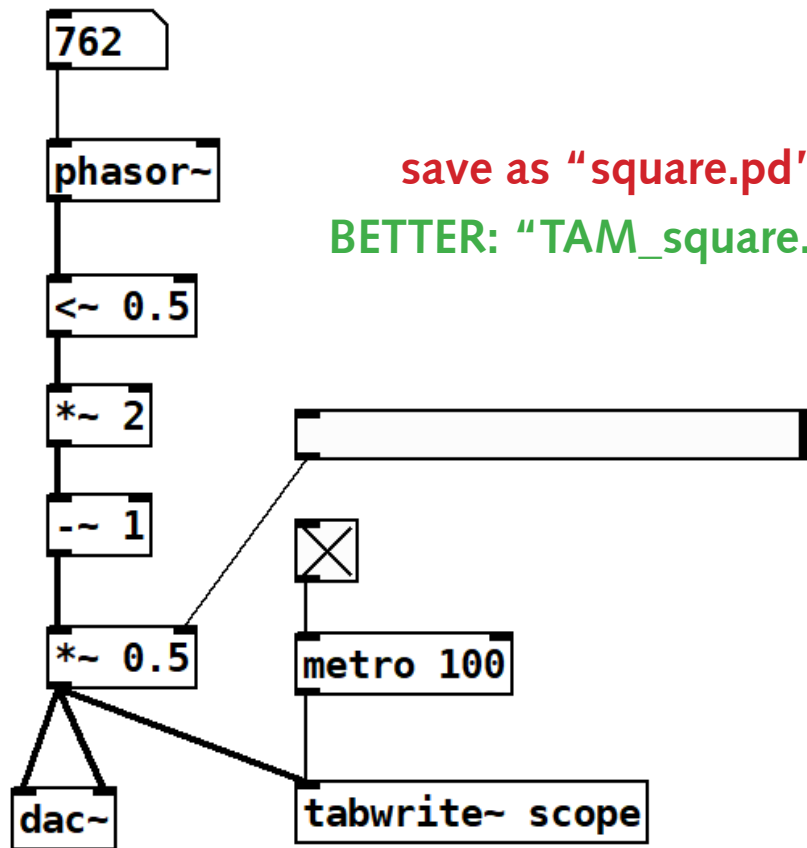






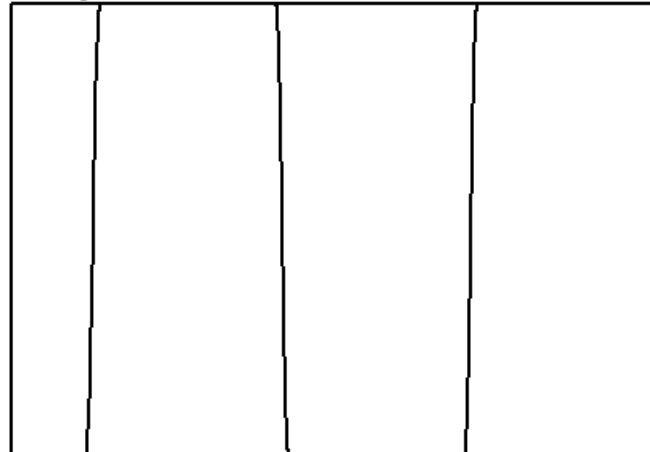
scope

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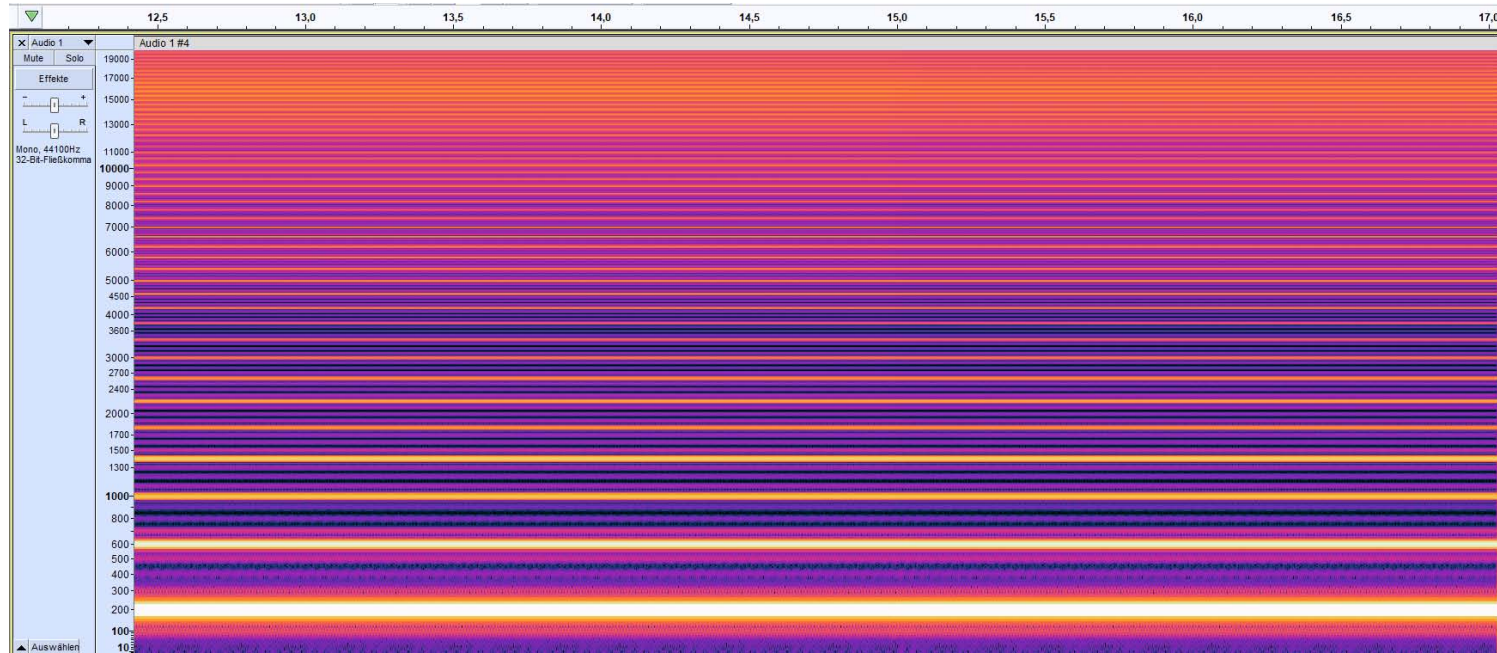


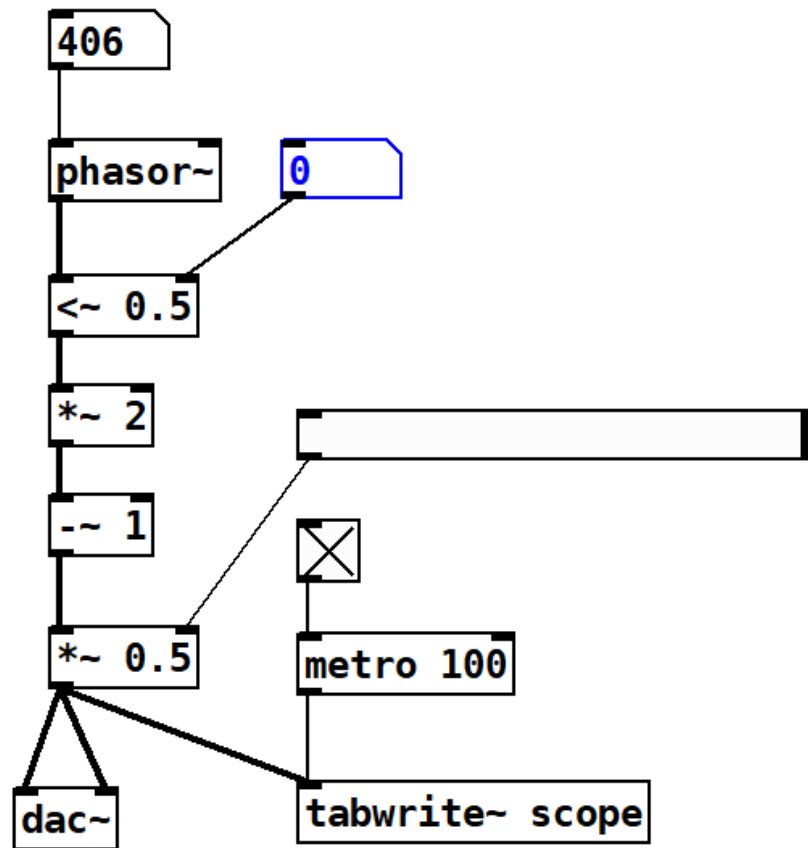
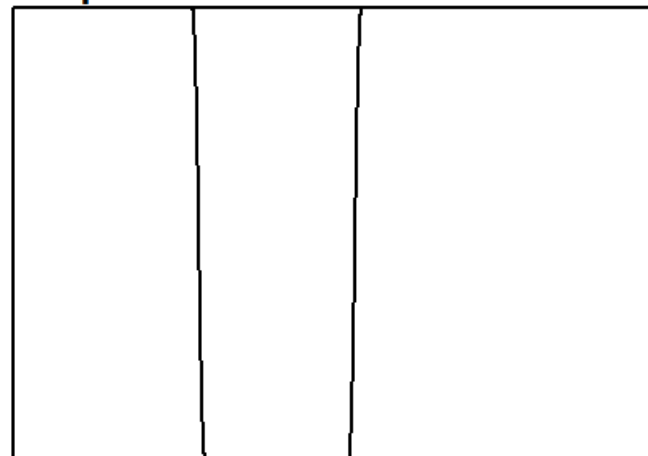
save as "square.pd"
BETTER: "TAM_square.pd"

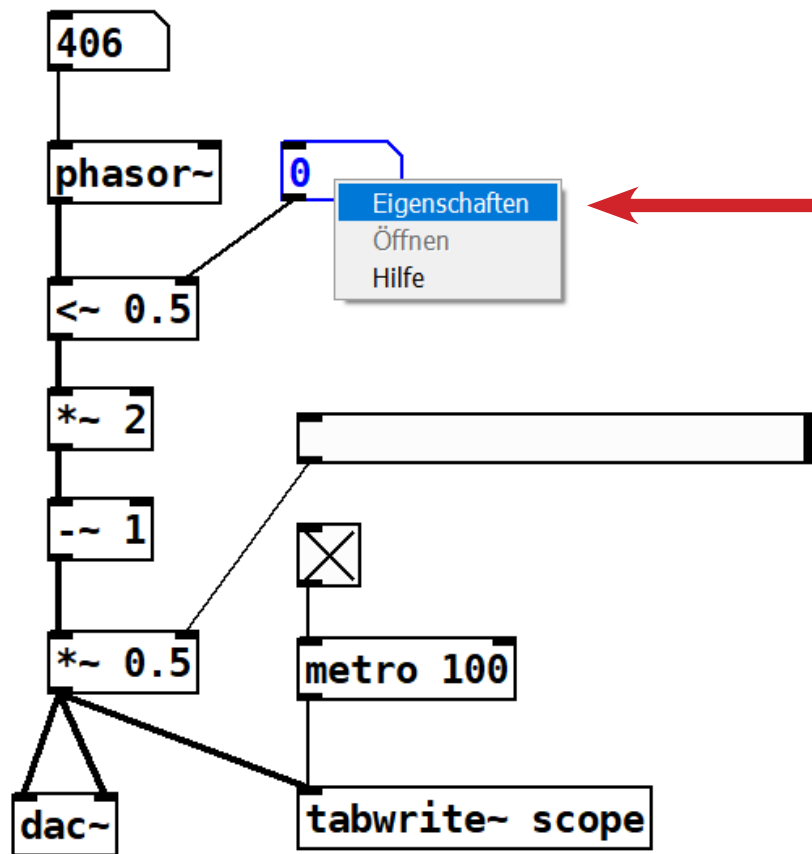
scope



Spectrogram of a square wave



**scope**



GUI-Box-Eigenschaften

Breite:

Bereich

Unterer: Oberer:

Beschriftung

☒ Links ☐ Oben ☐ Rechts
☐ Unten

Schriftgröße

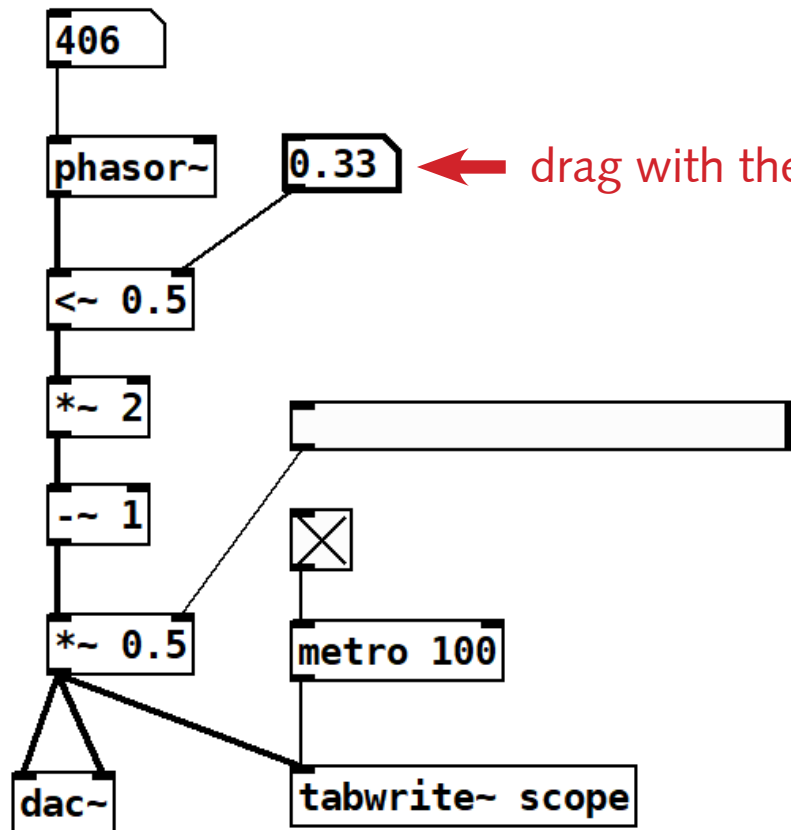
☒ auto
☐ 8
☐ 10
☐ 12
☐ 16
☐ 24
☐ 36

Messages

Sendesymbol:

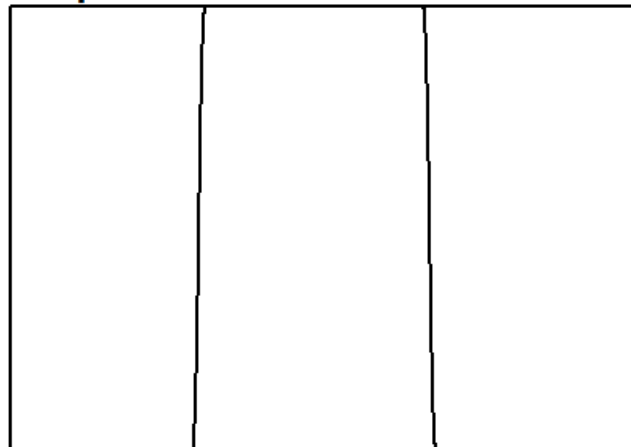
Empfangssymbol:

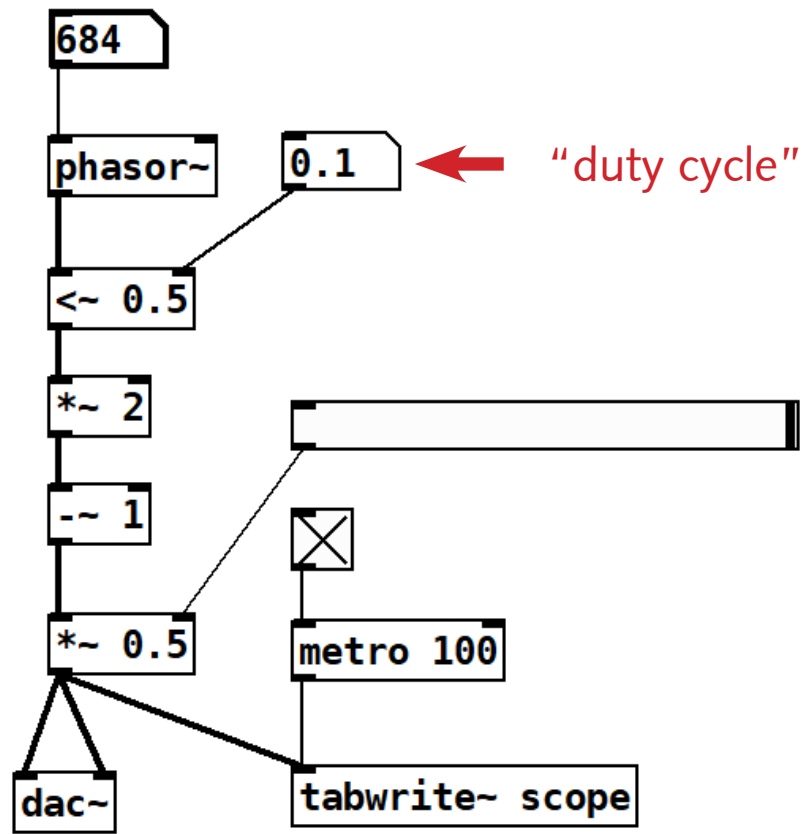
Abbrechen Anwenden **OK**



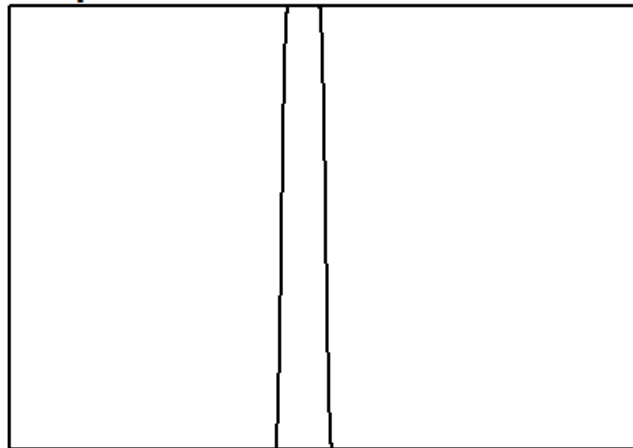
← drag with the mouse button pressed

scope

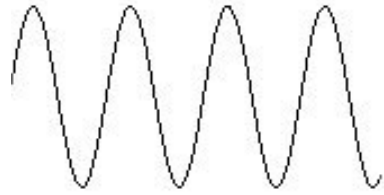




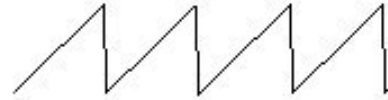
scope



Waveforms



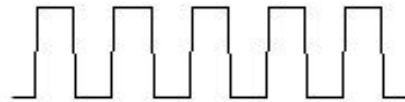
Sine



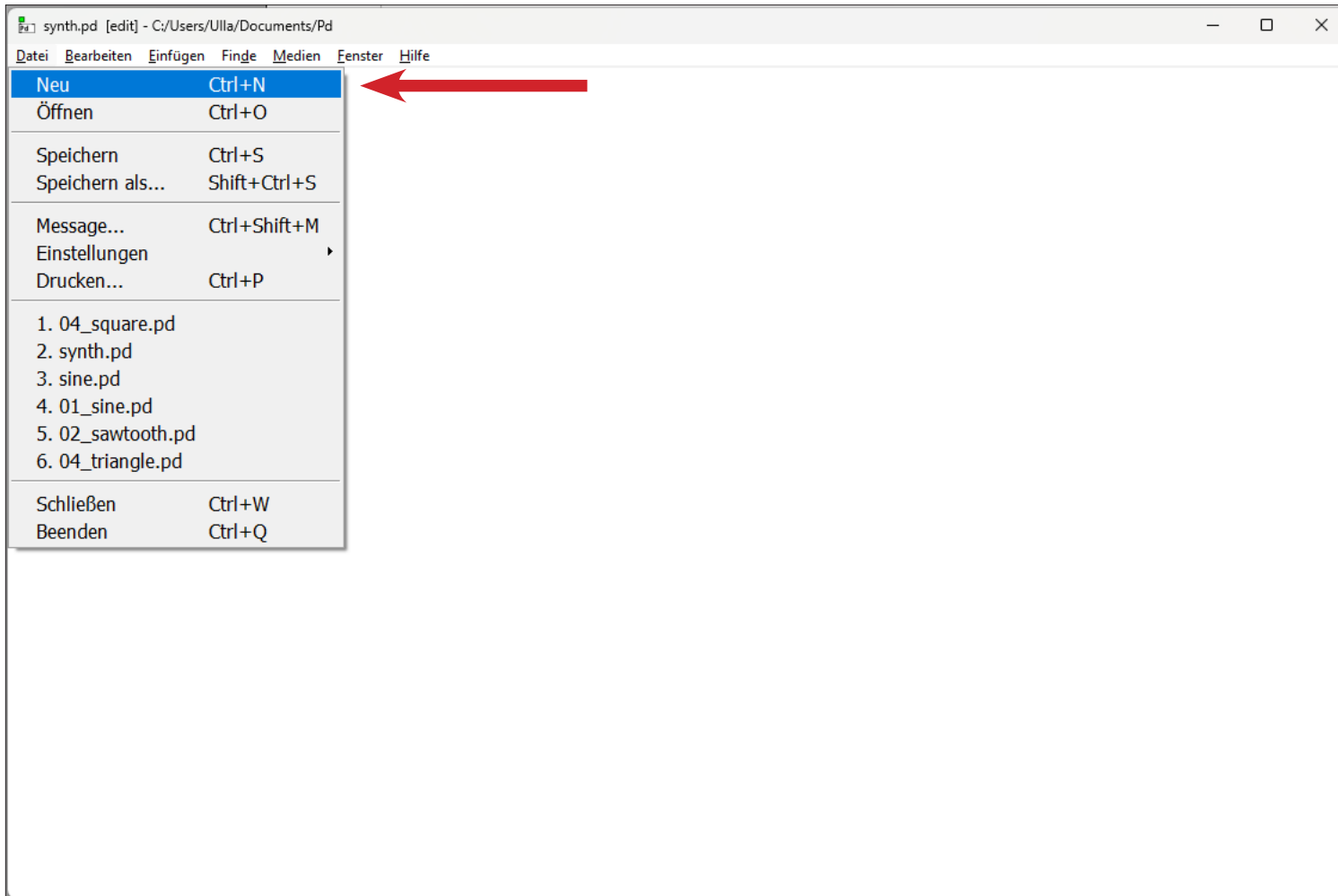
Sawtooth

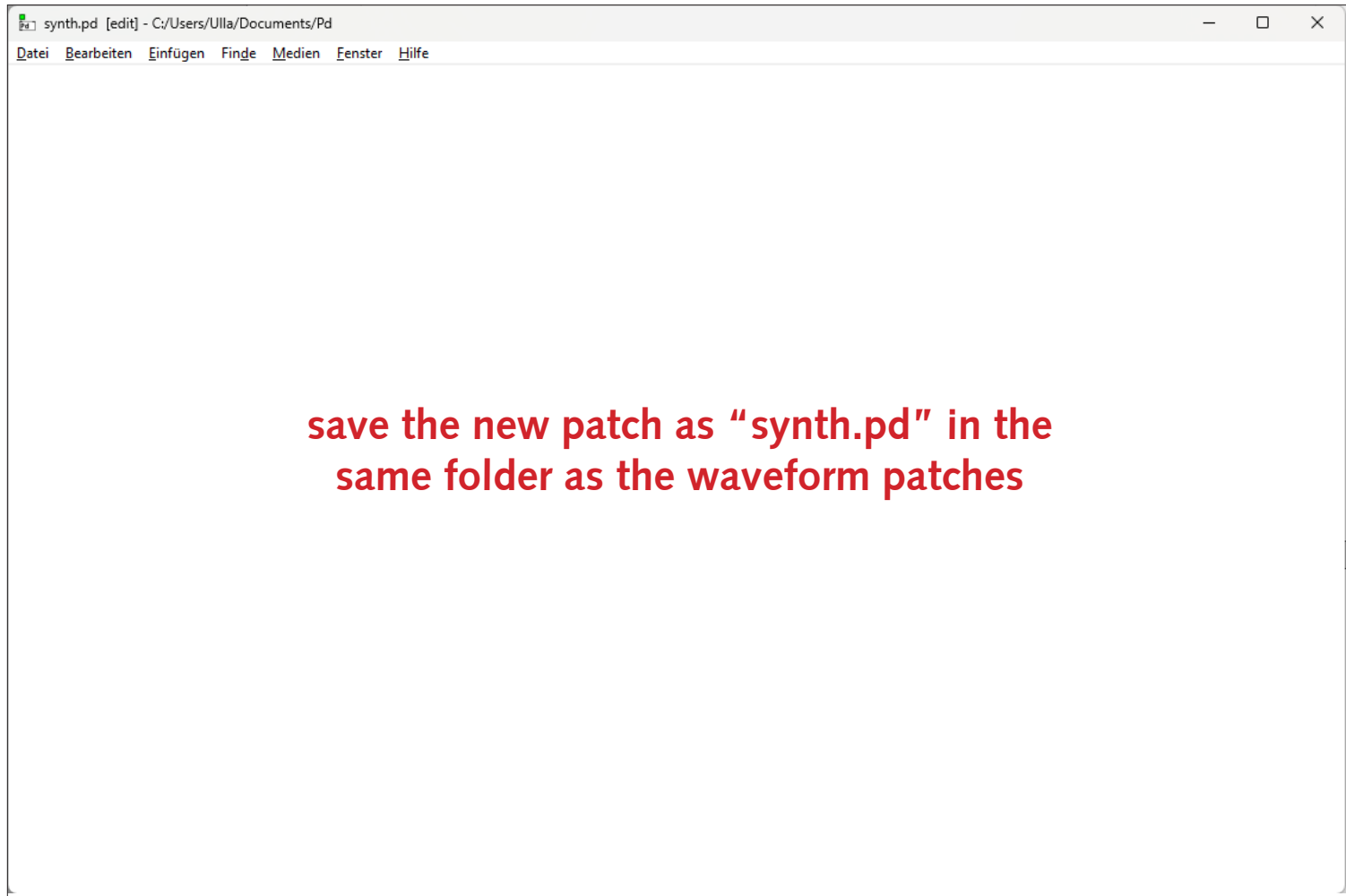


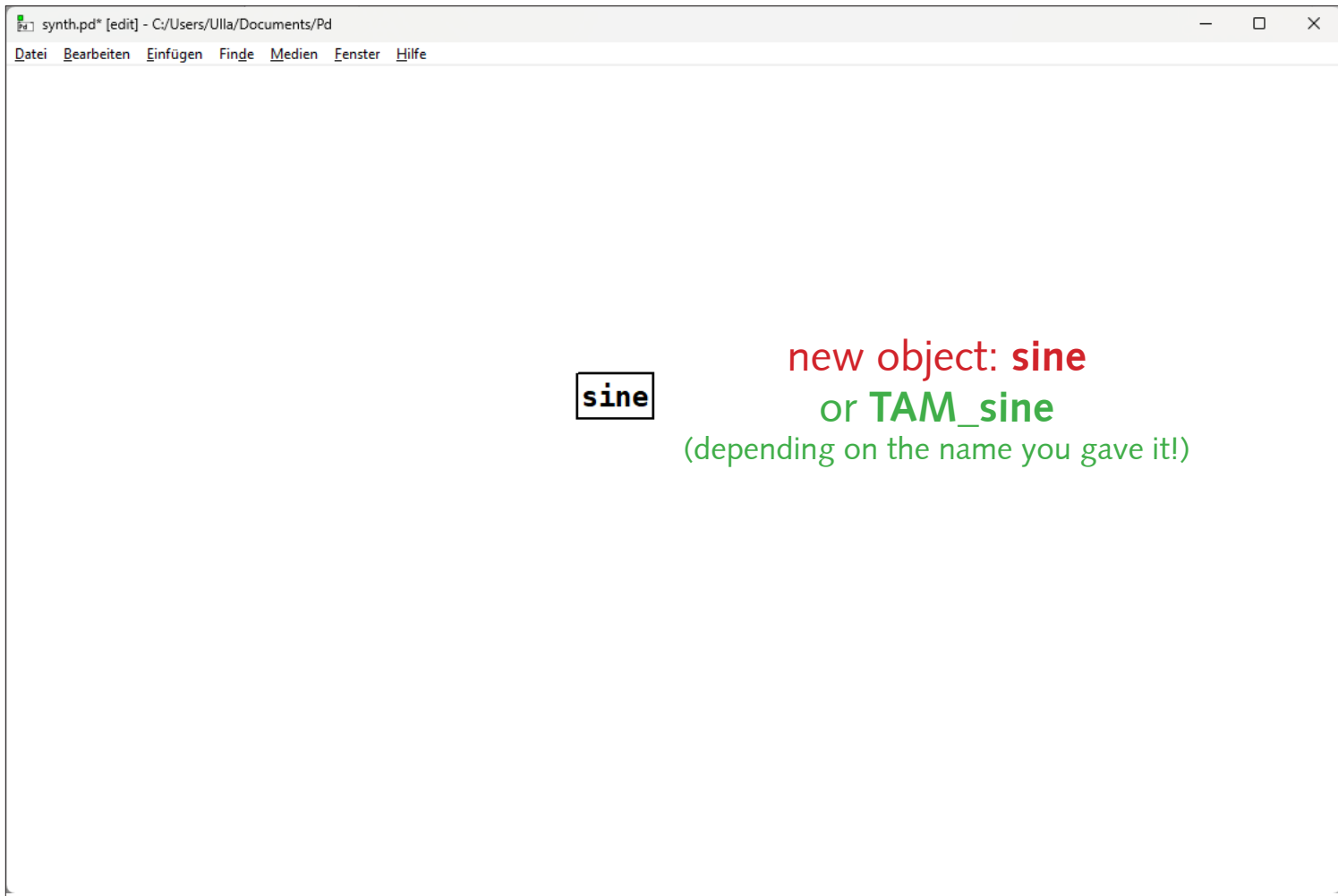
Triangle



Square

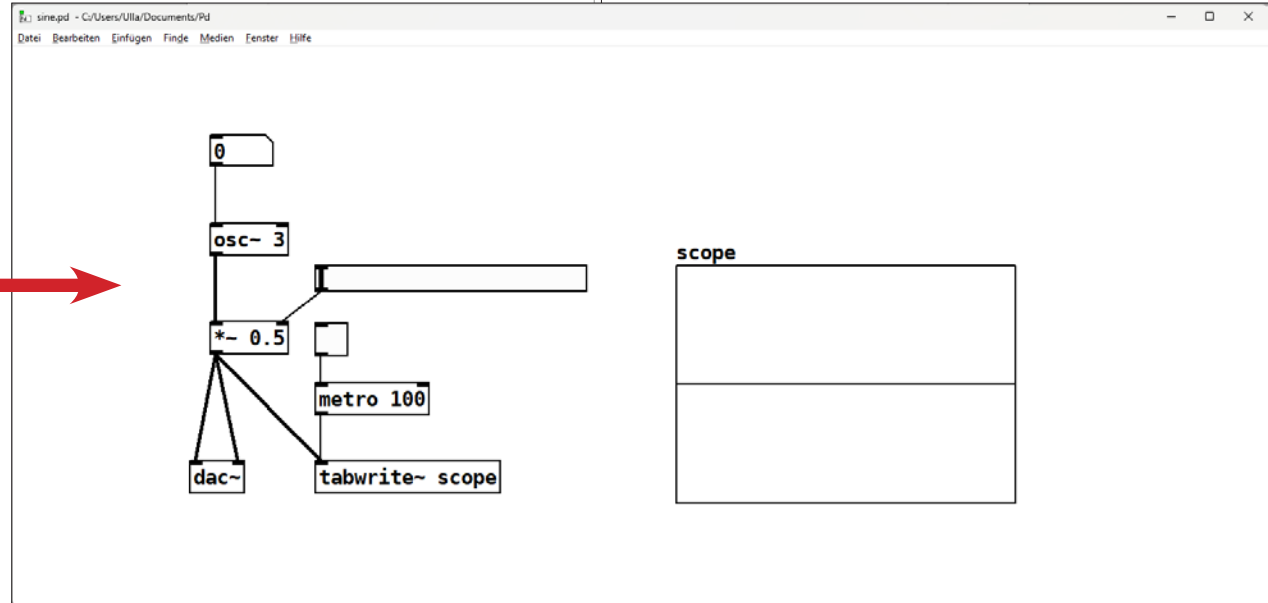


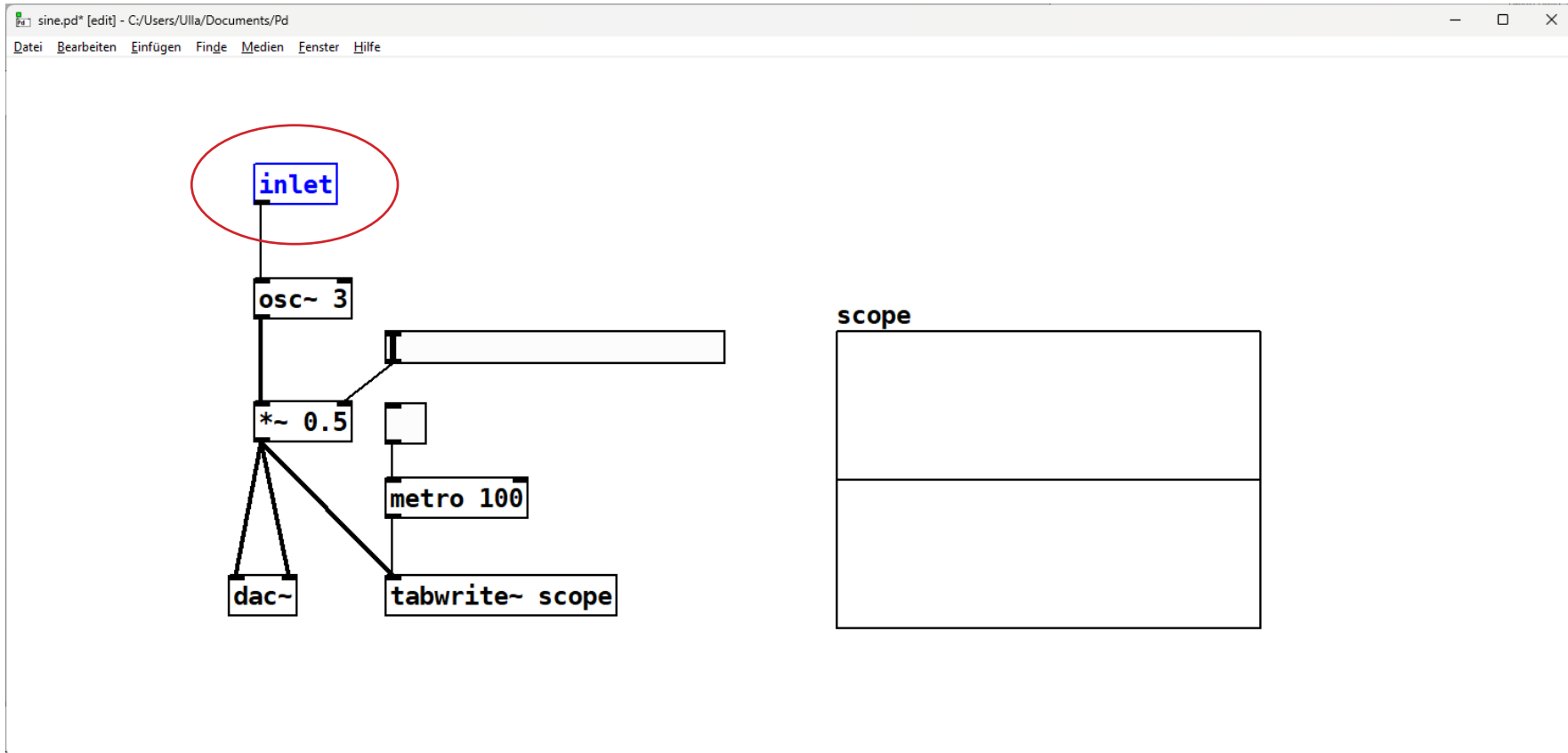


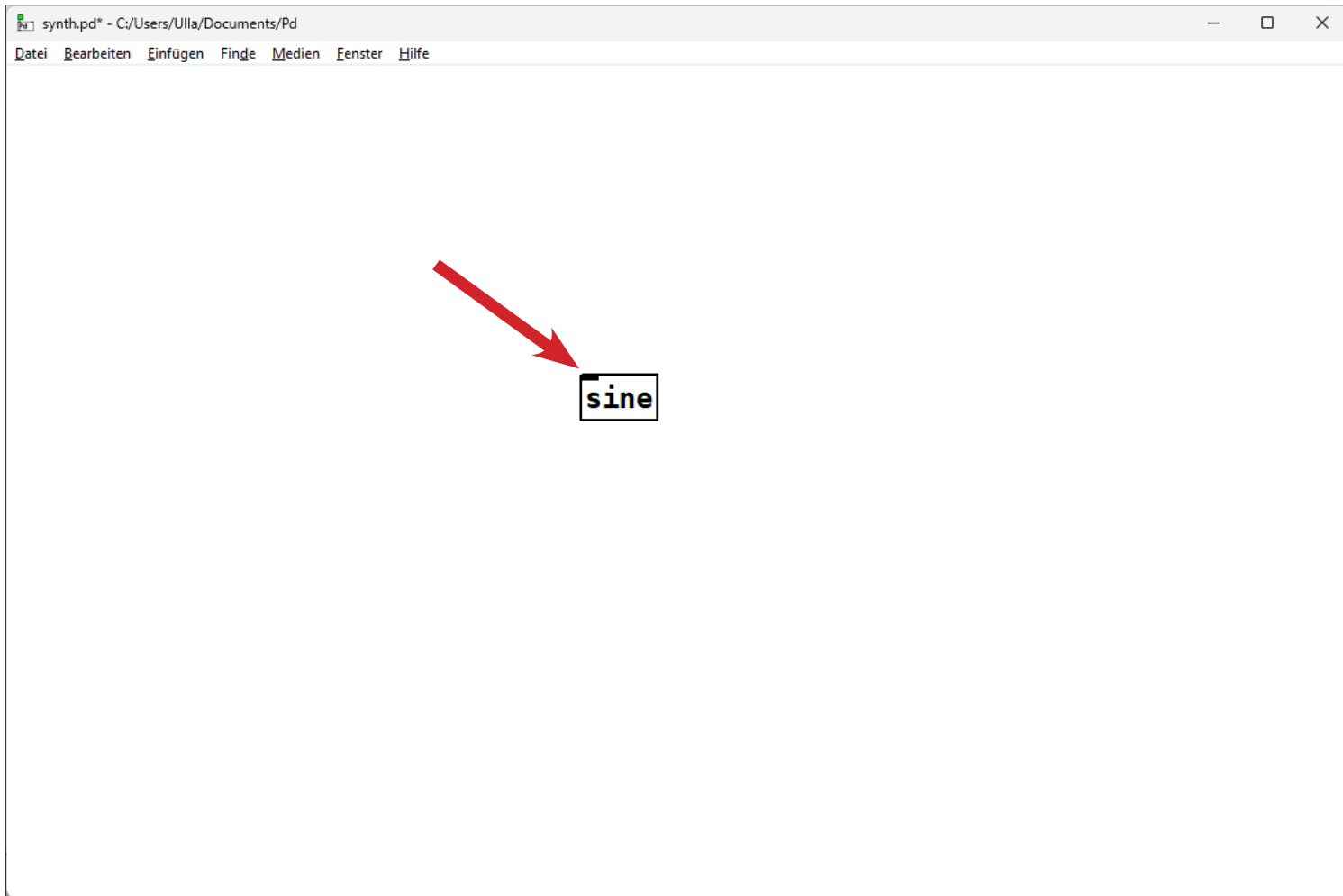


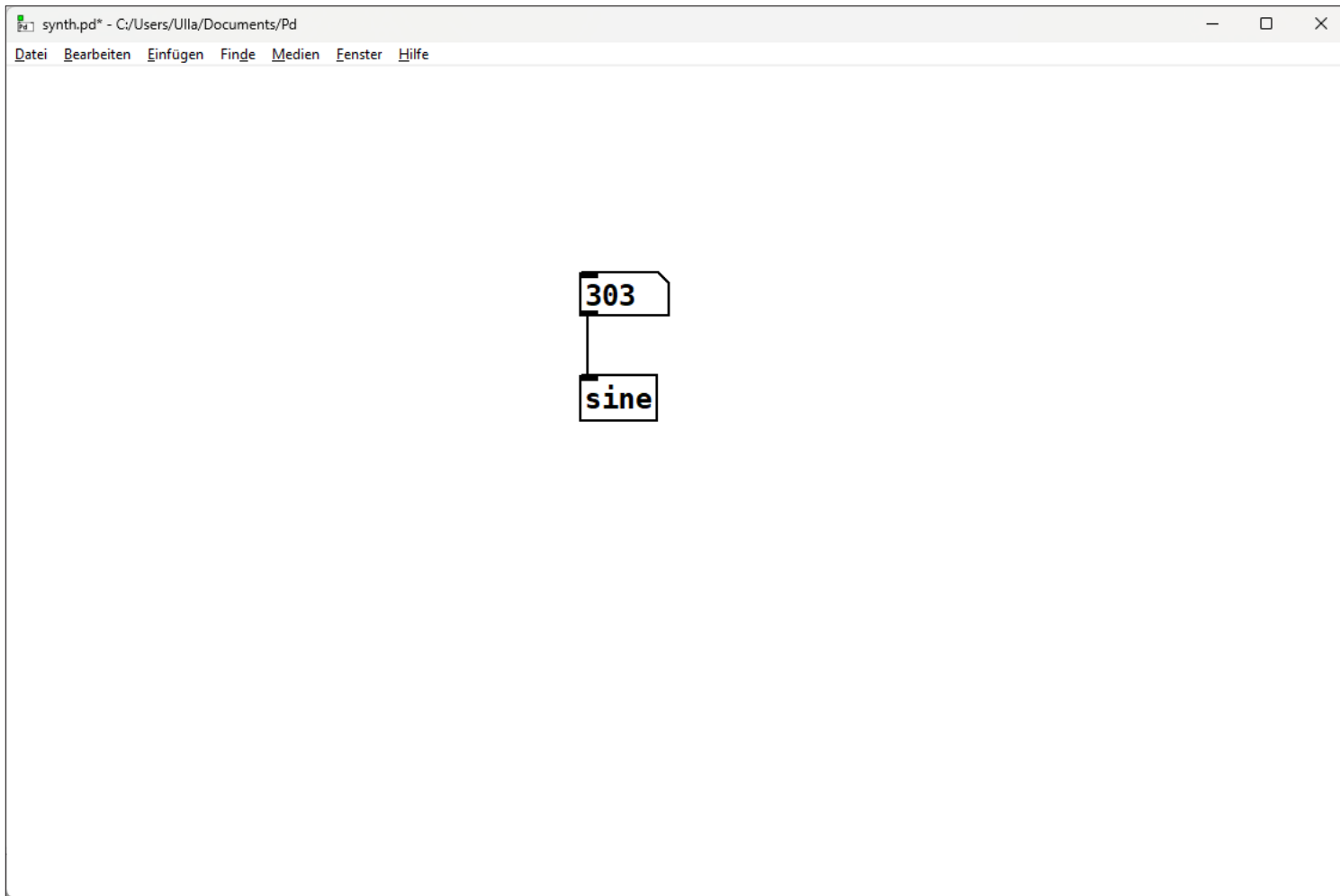


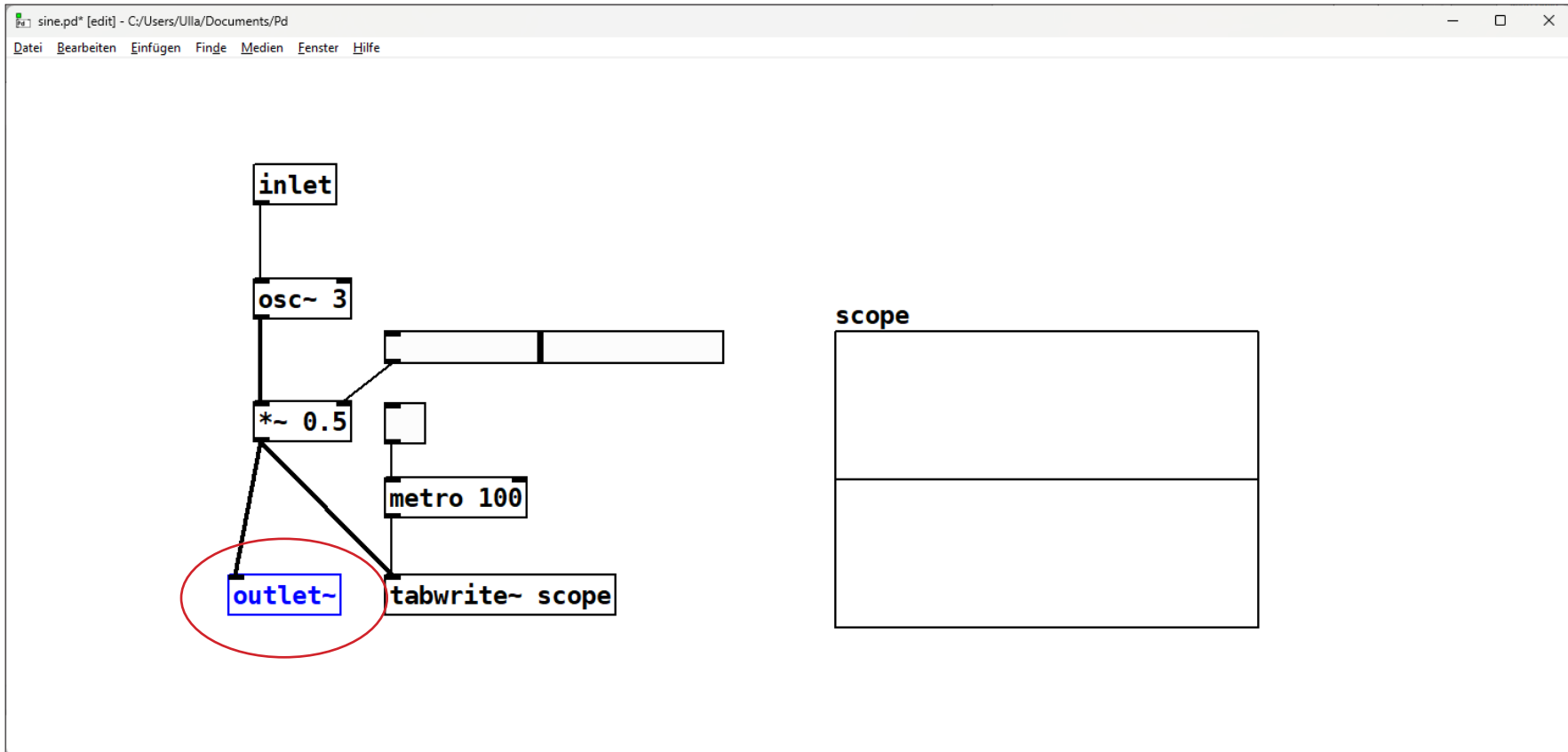
sine

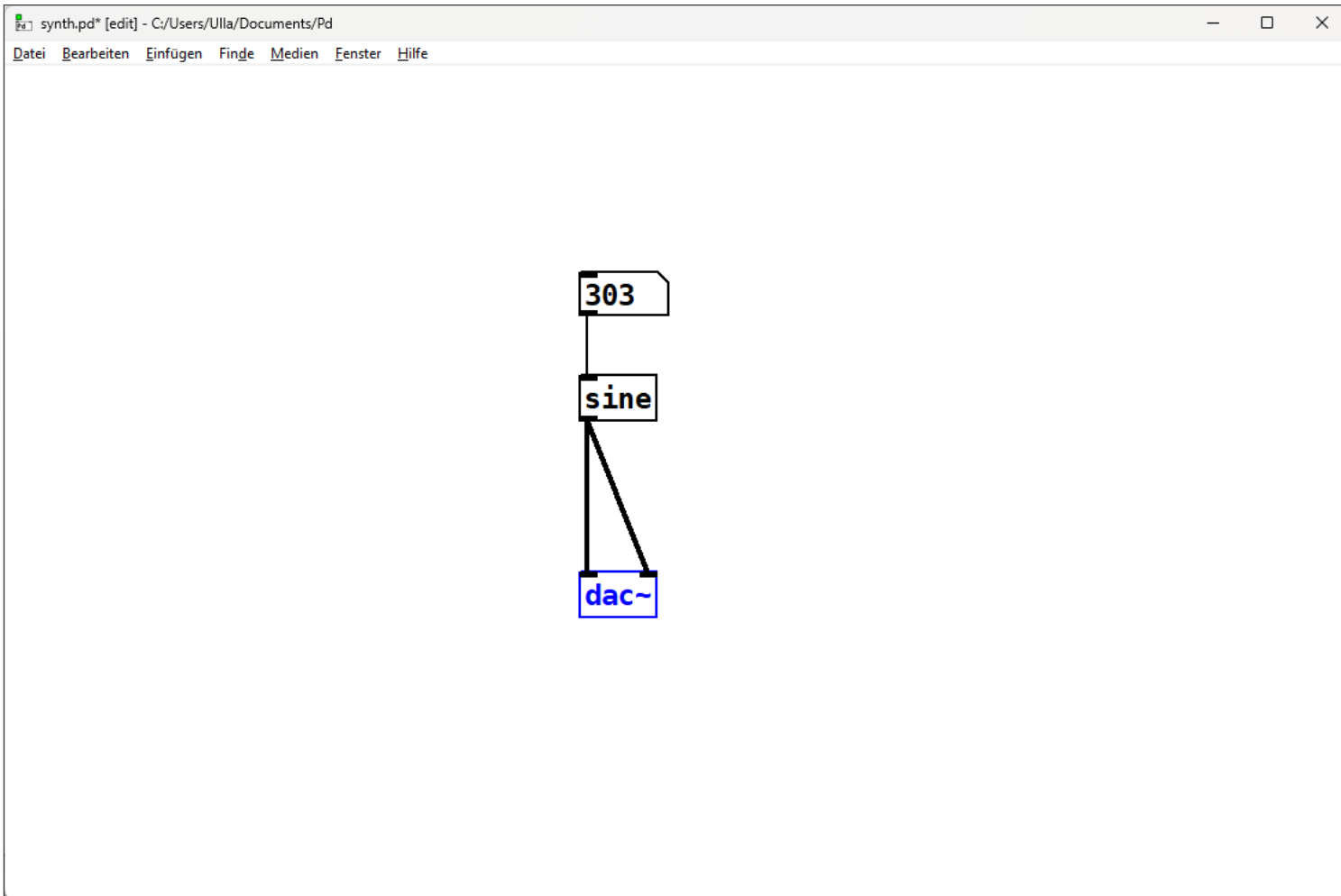


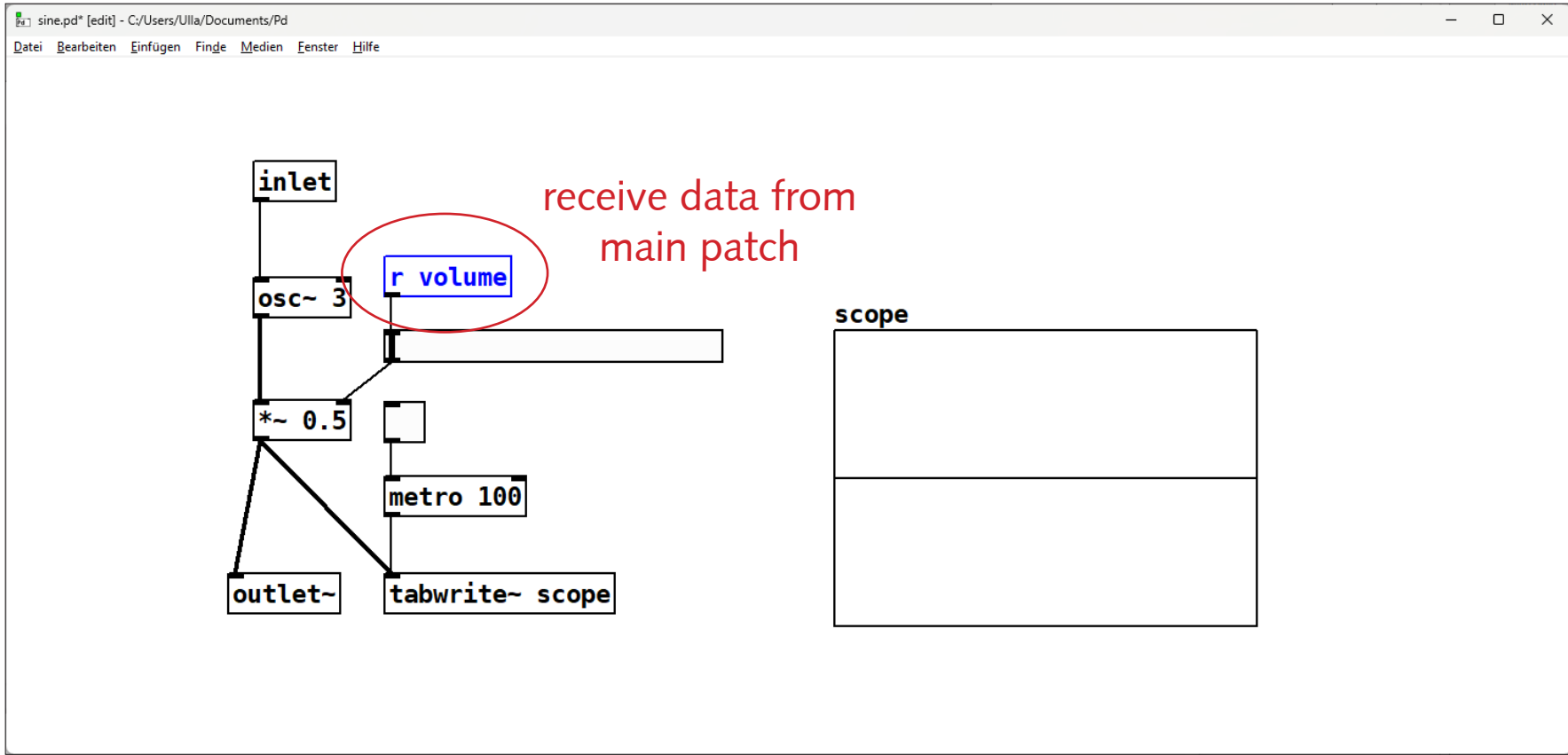


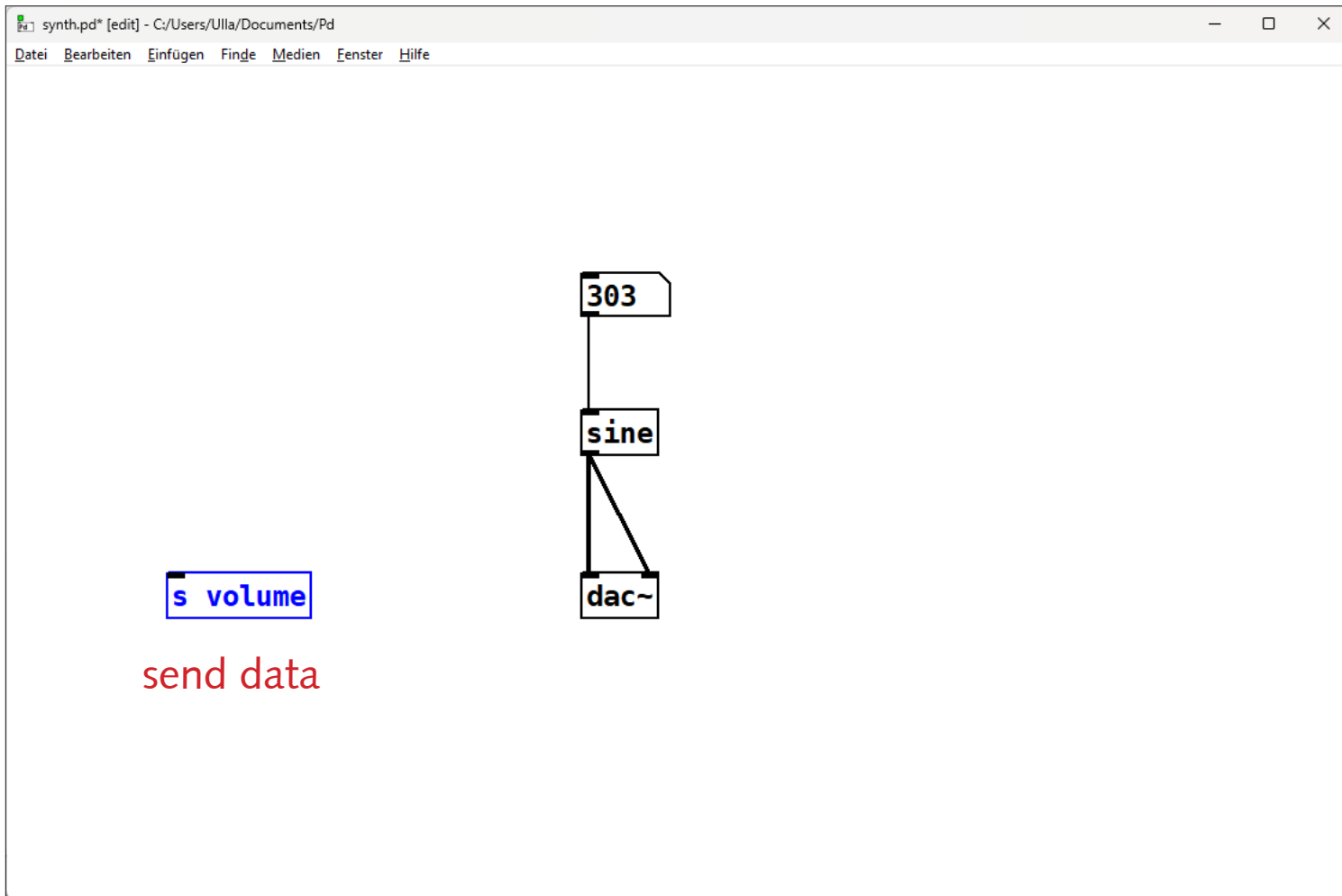


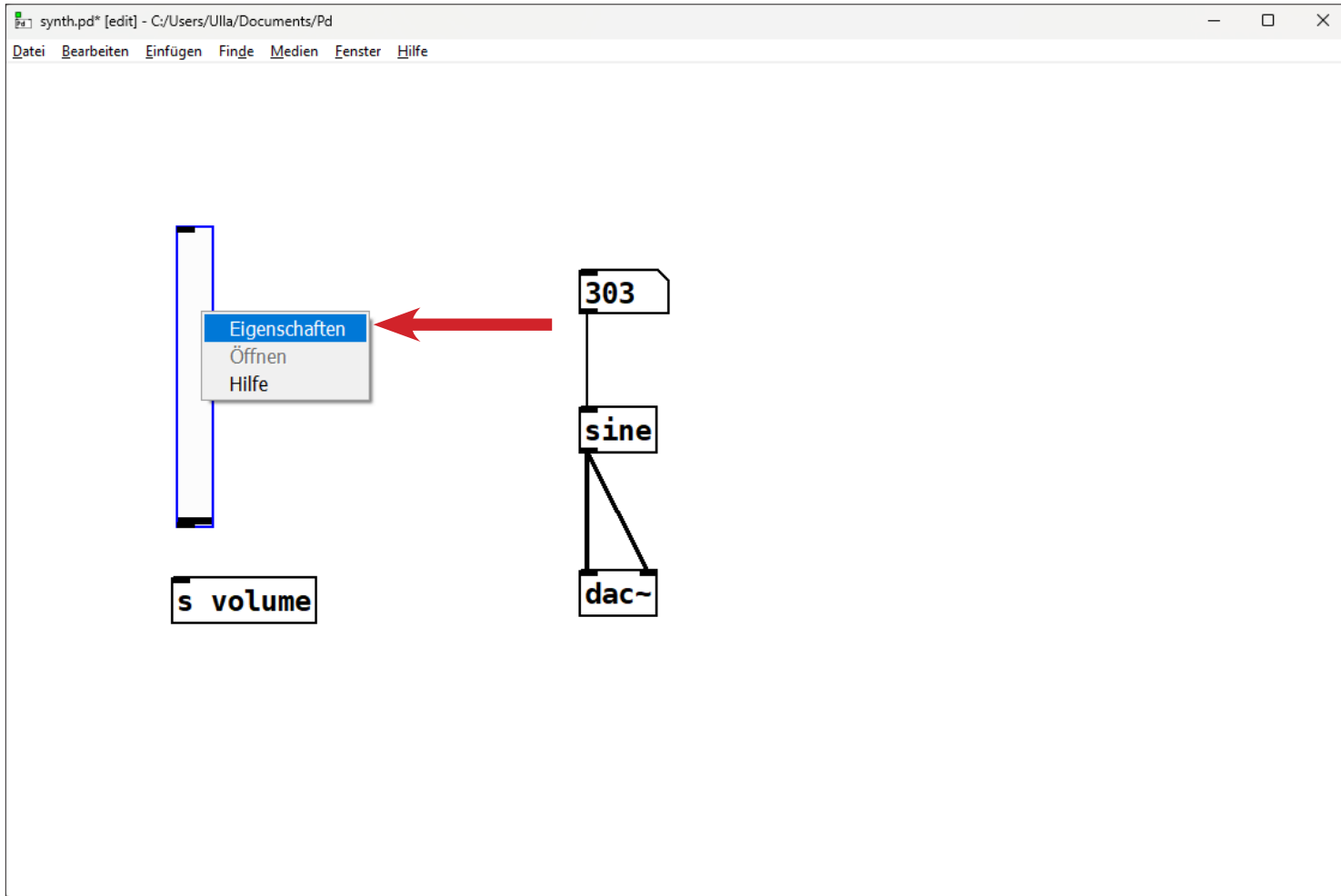


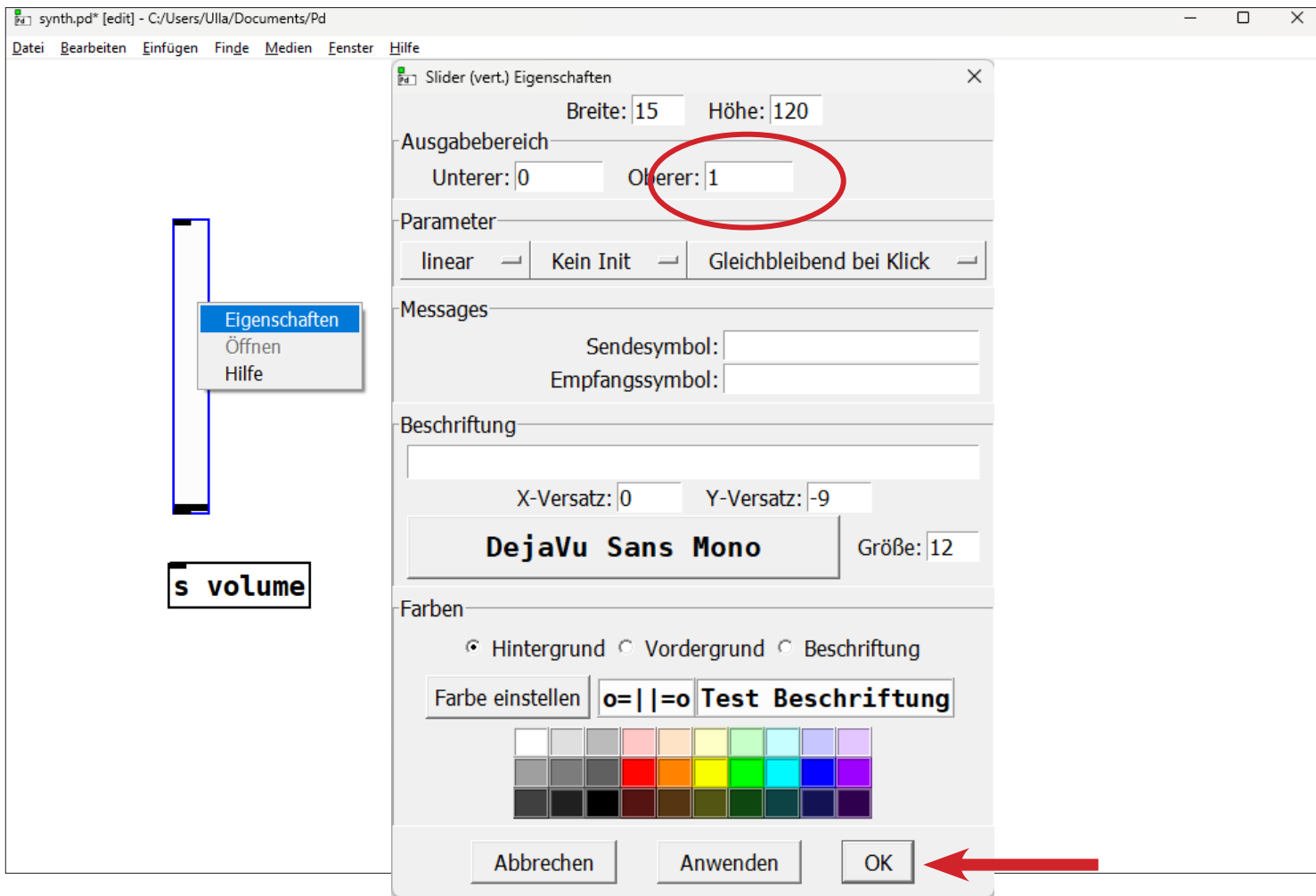


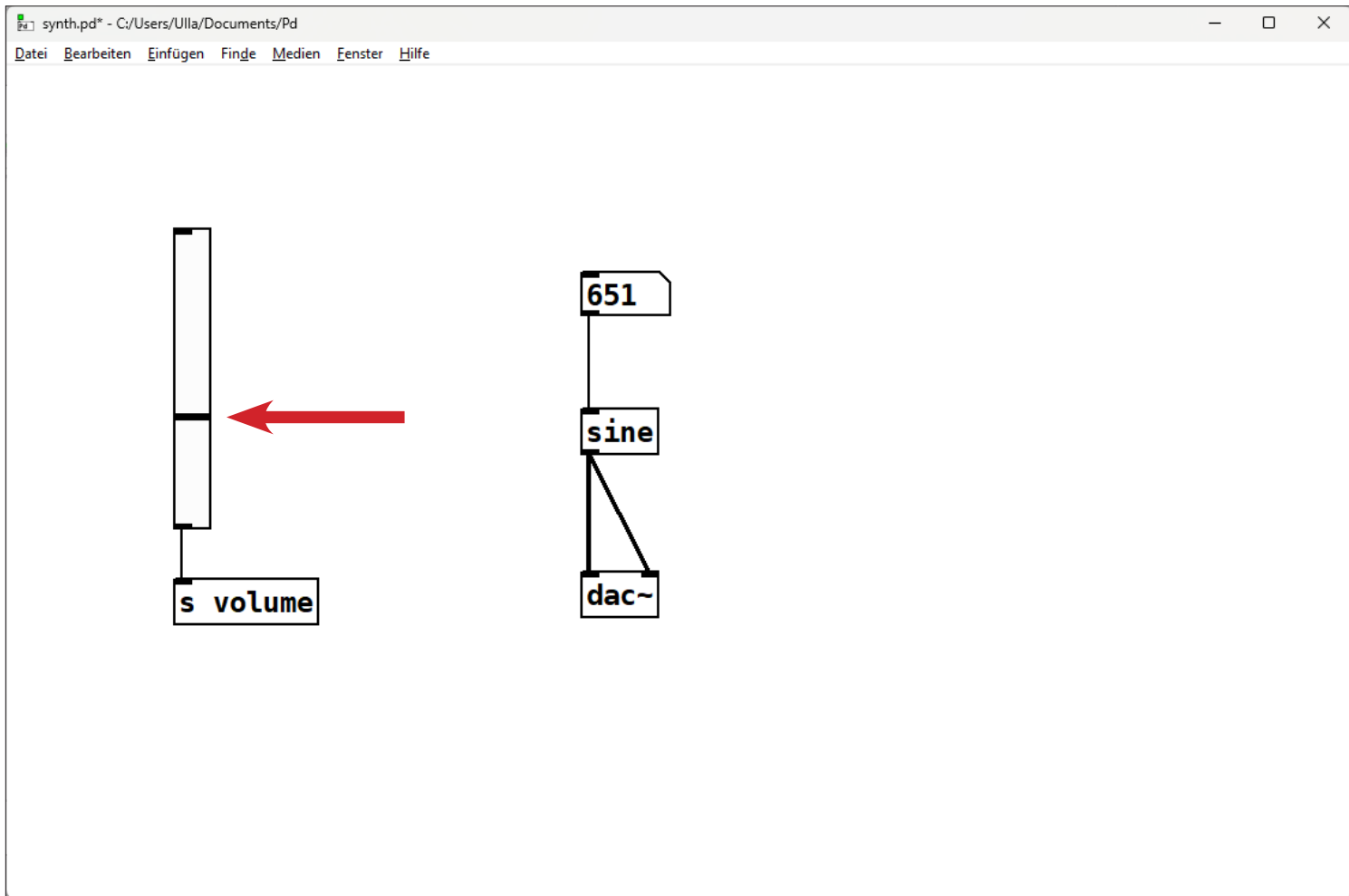




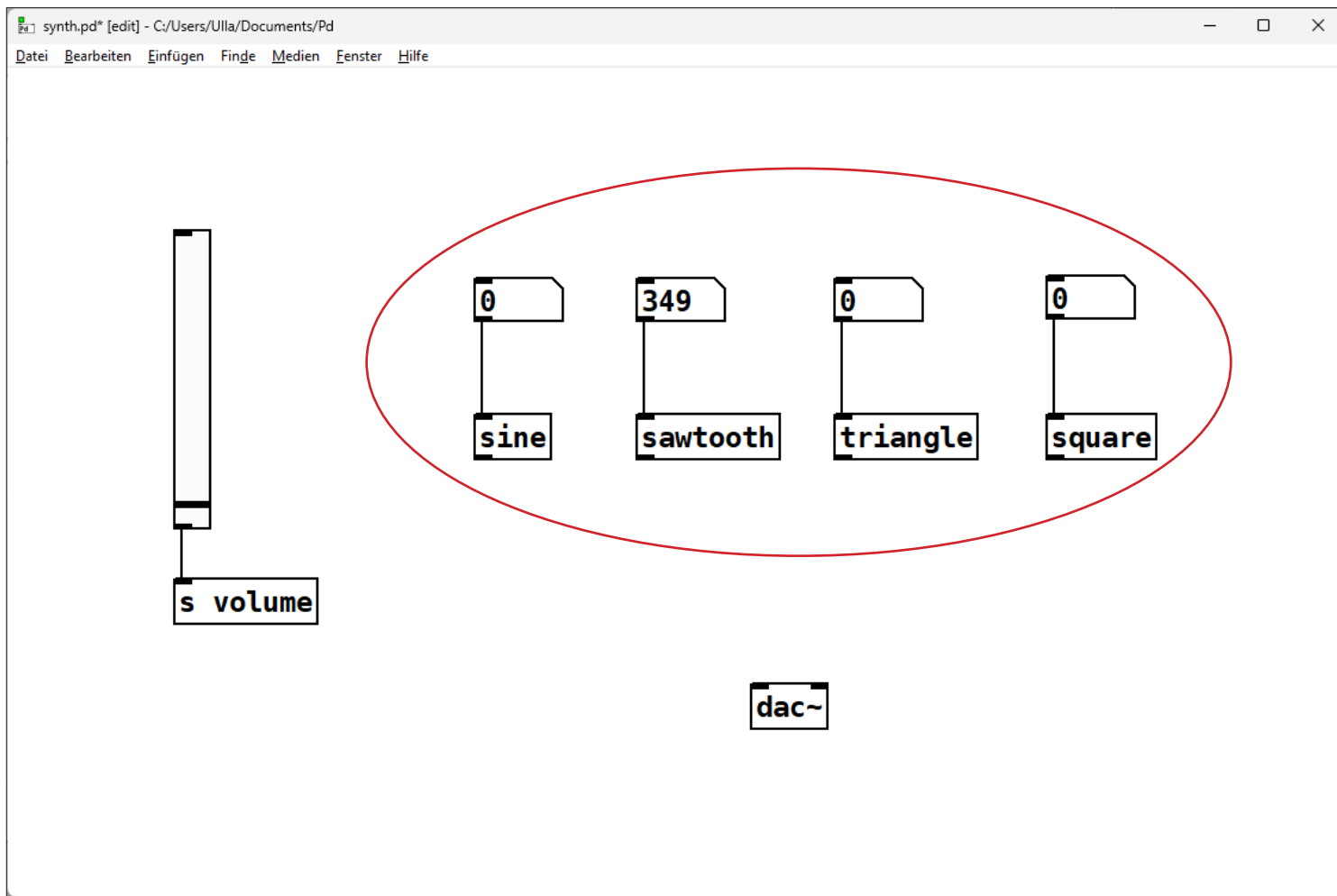


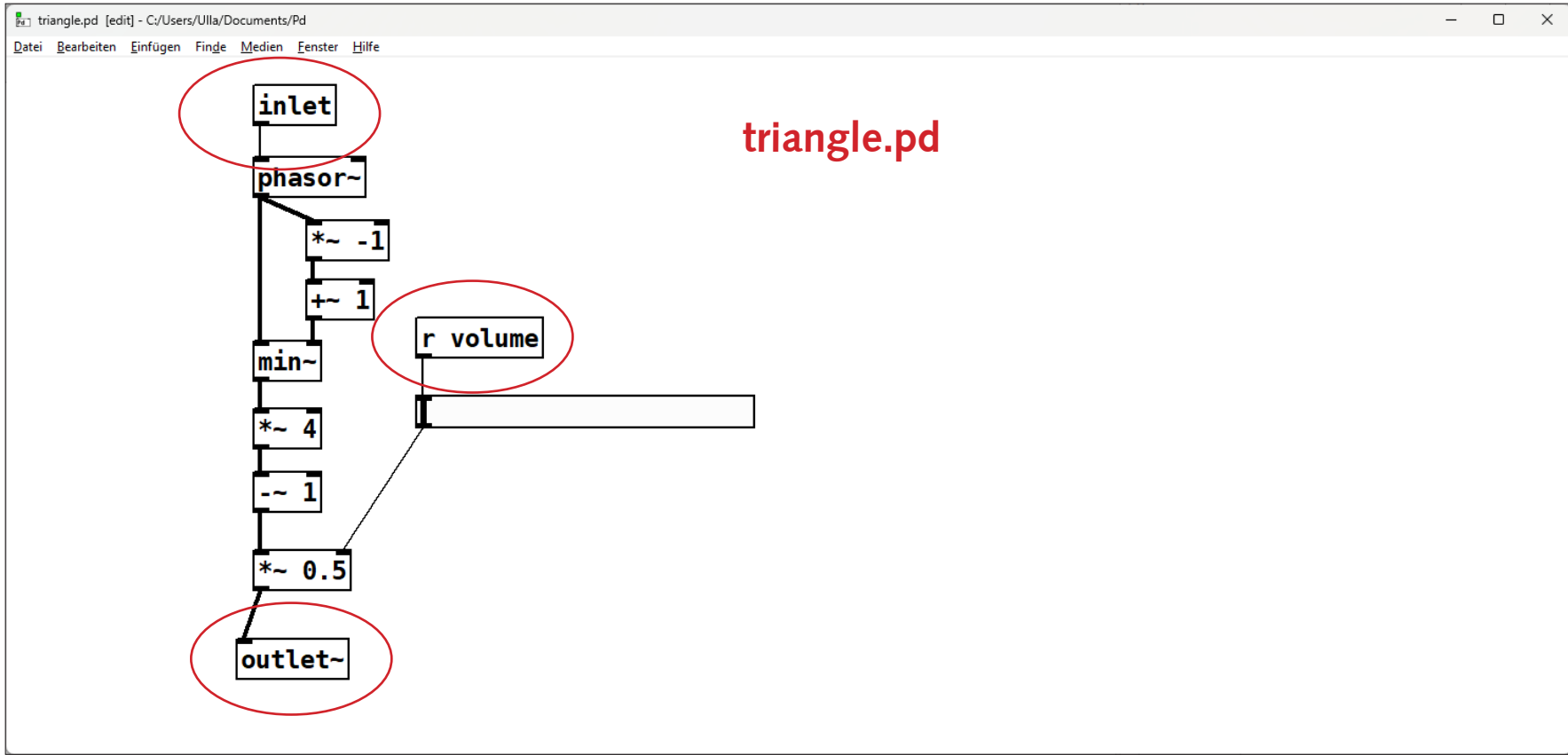




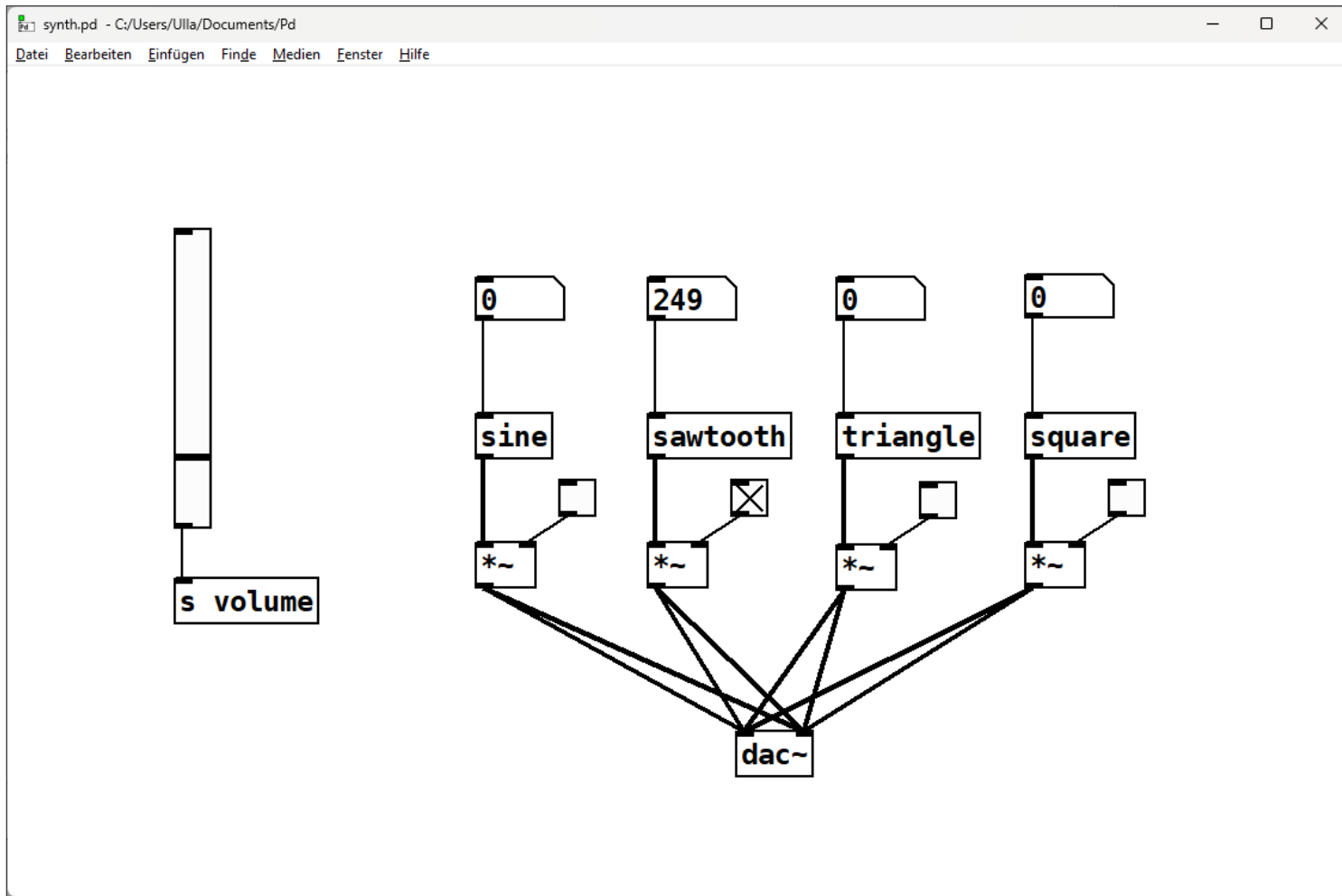


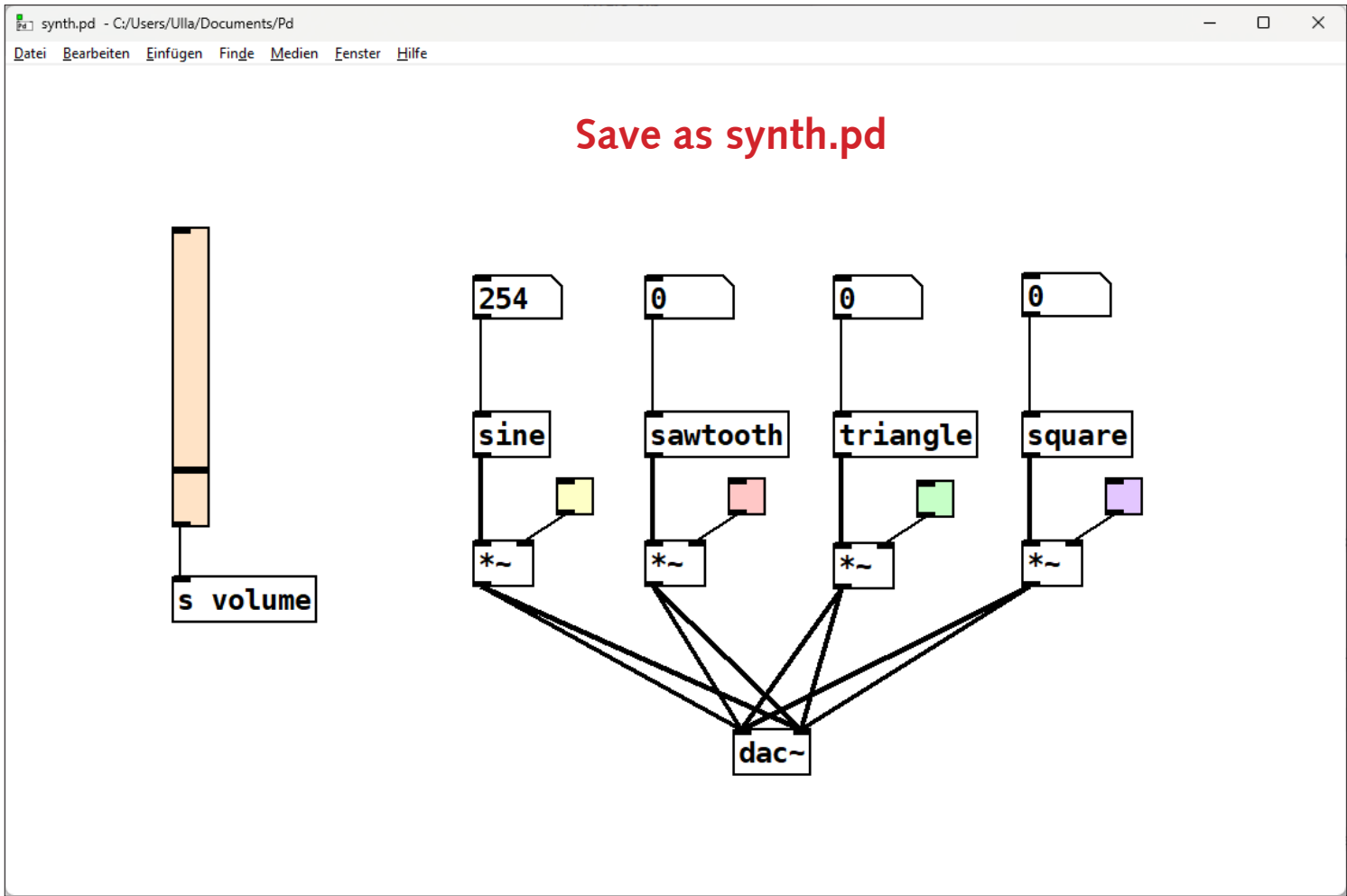


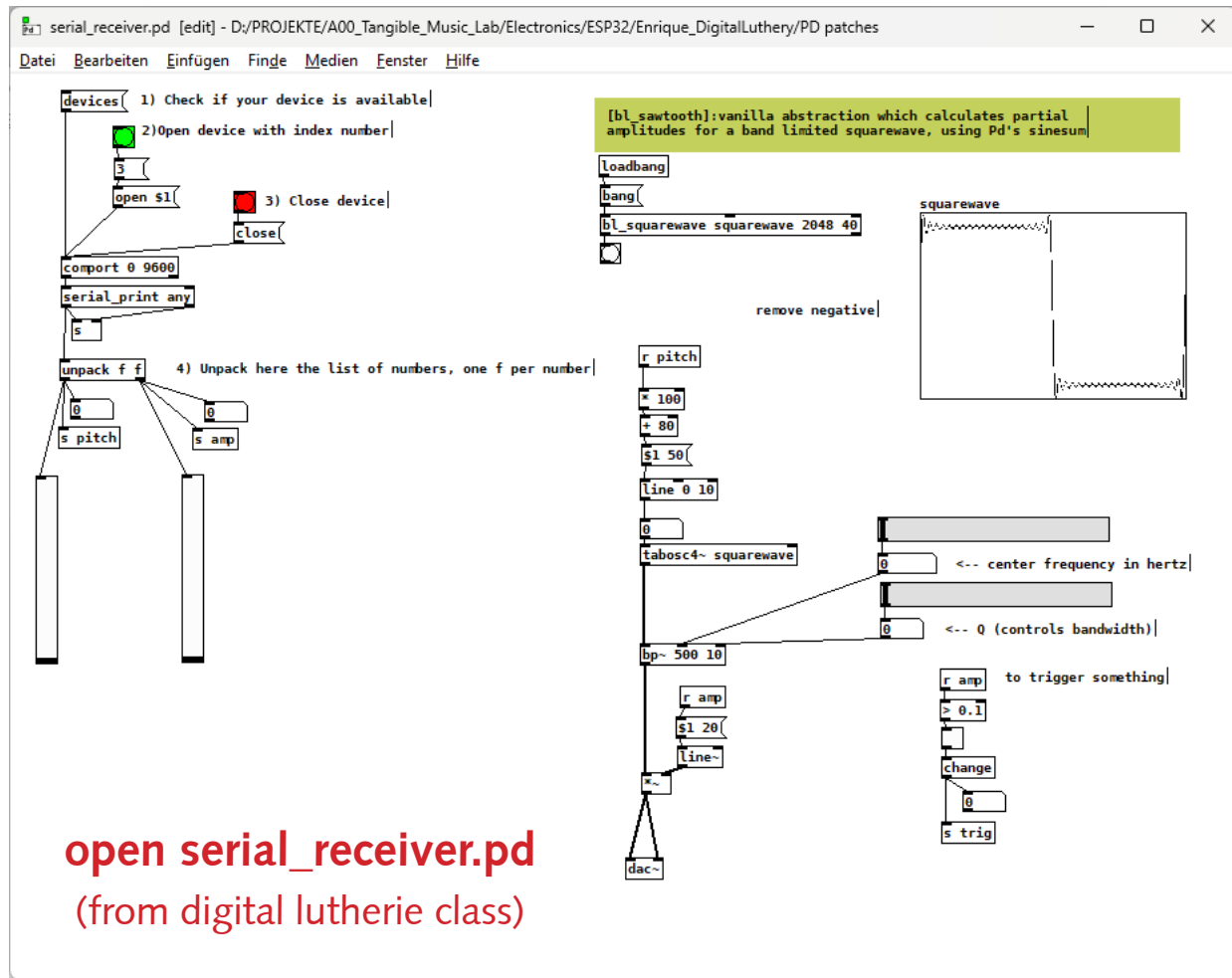




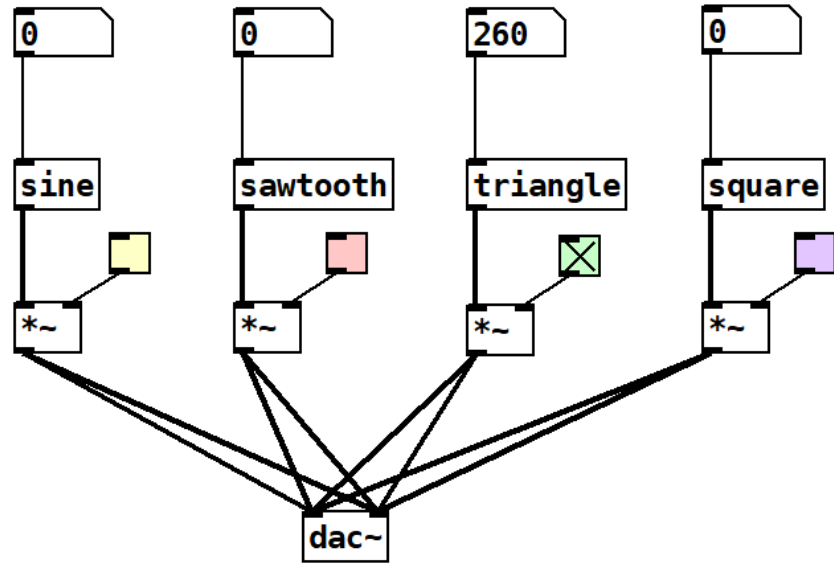
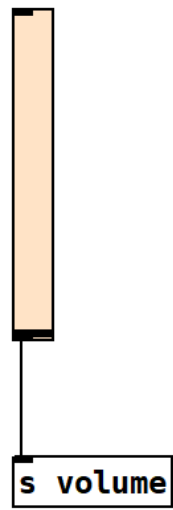


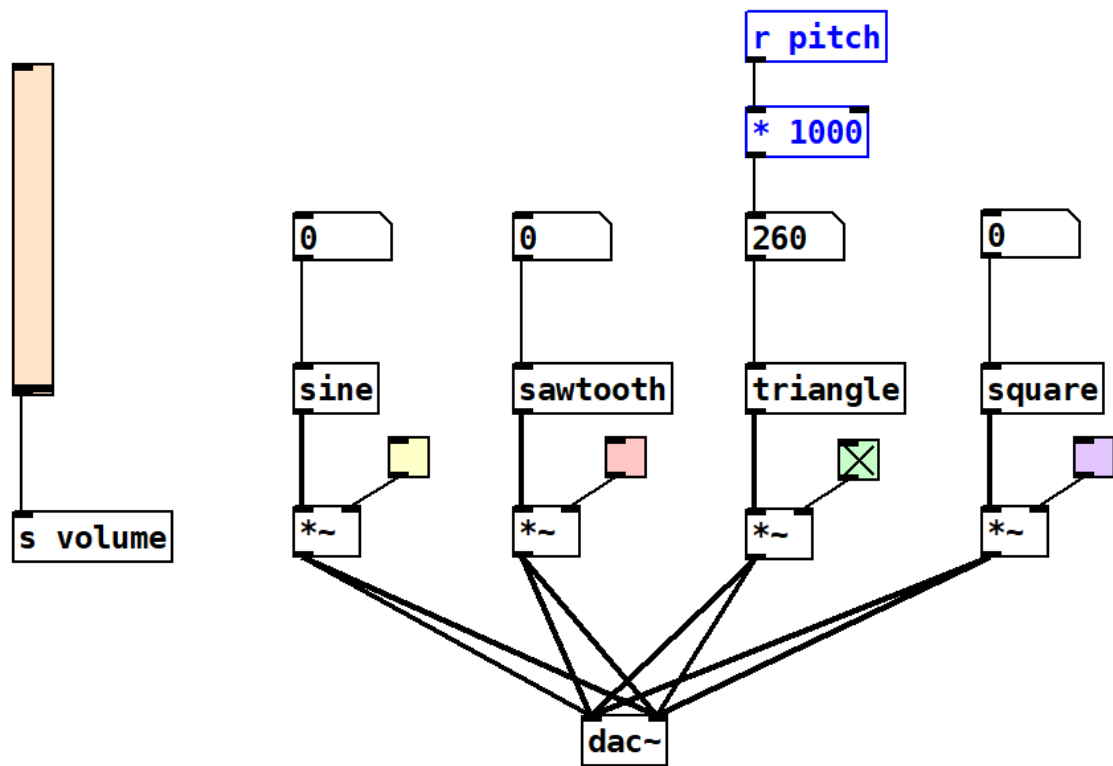


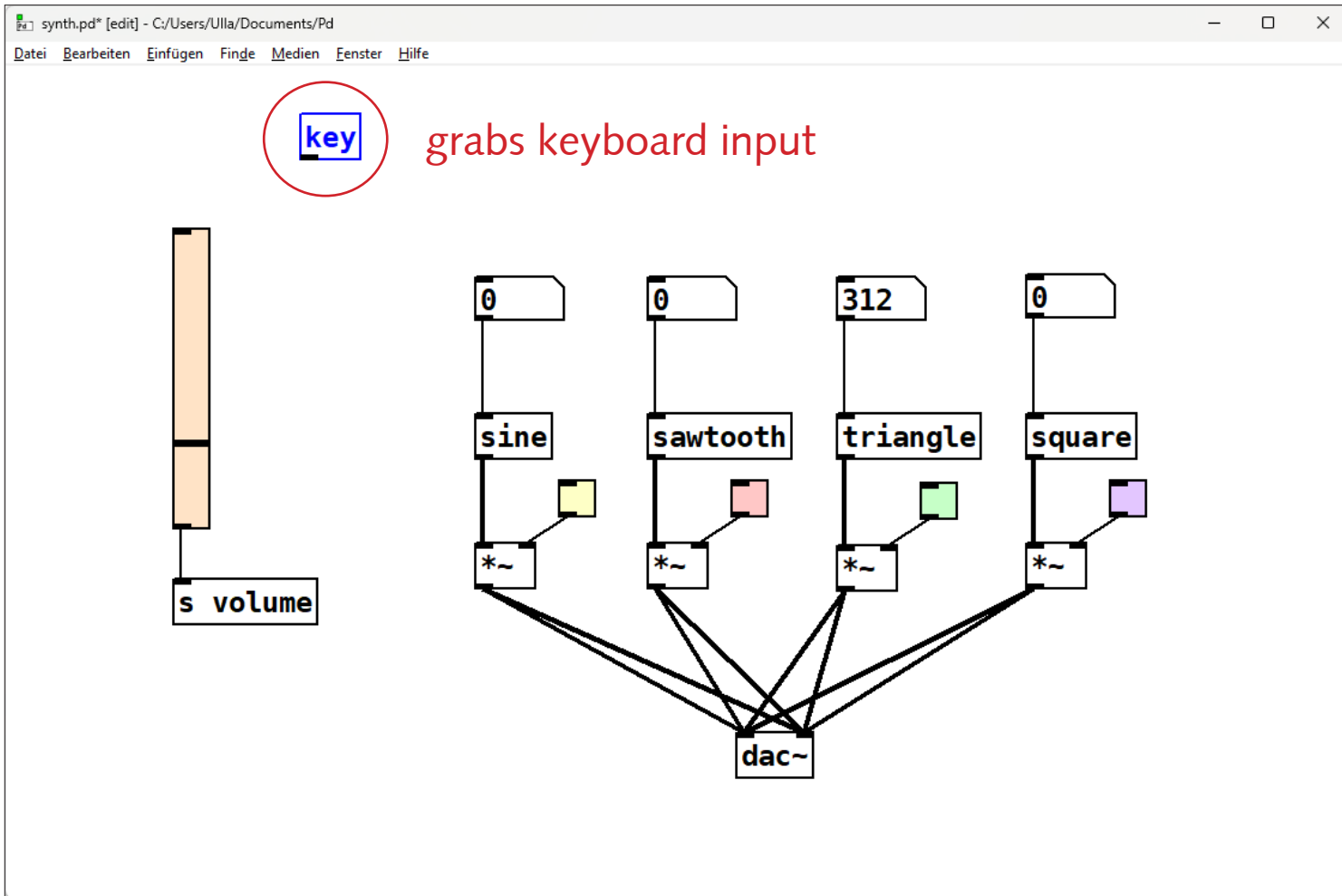


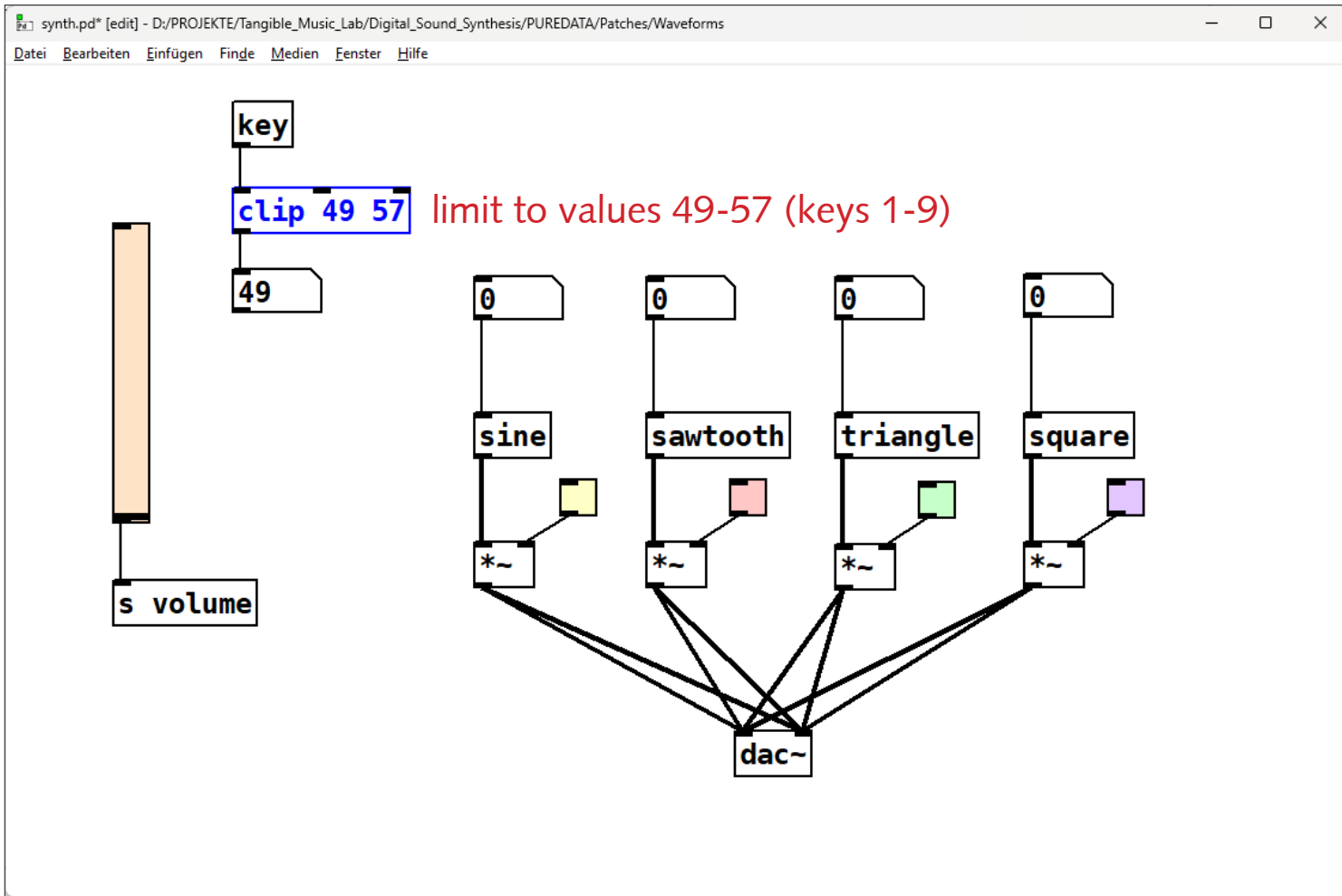


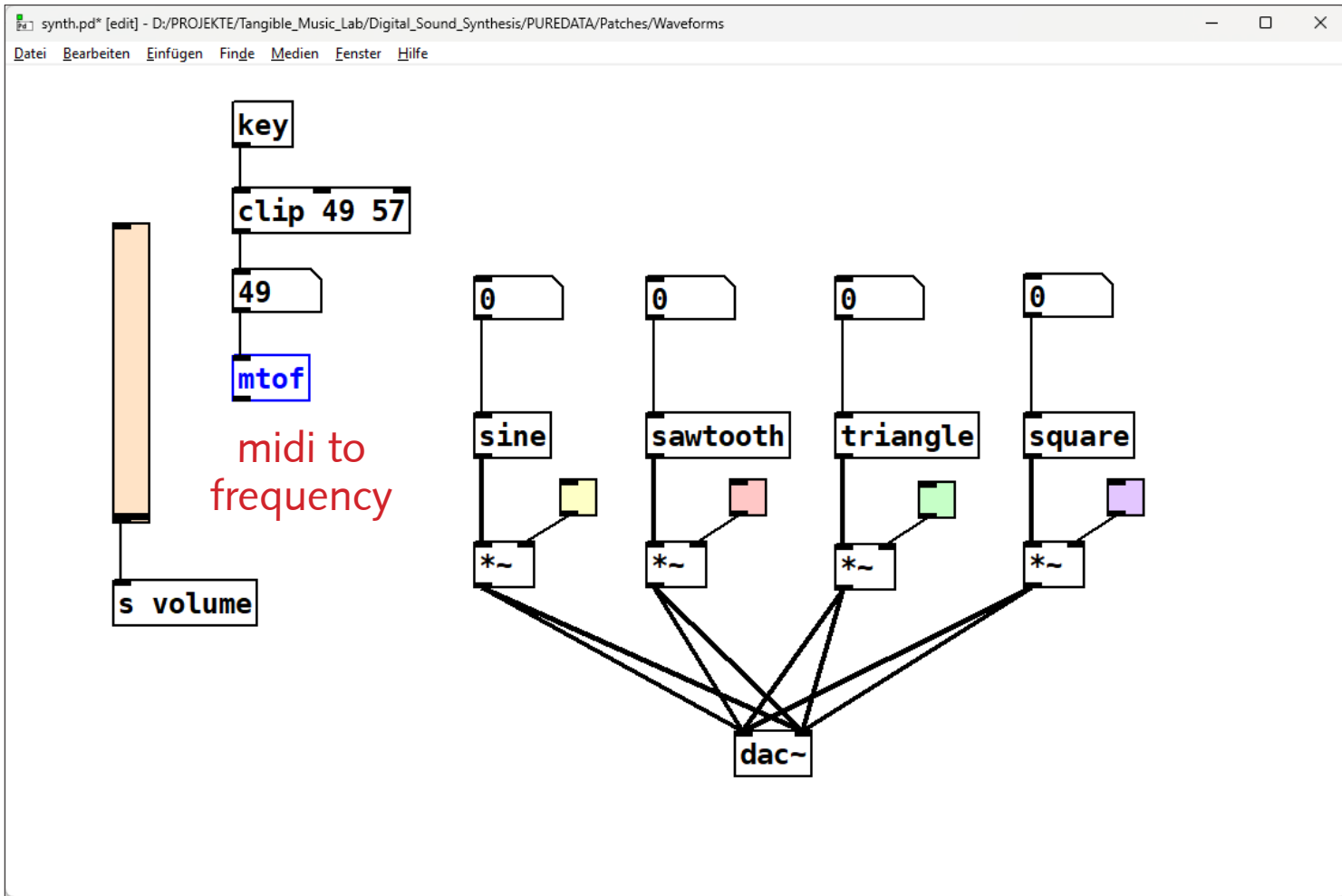
r pitch

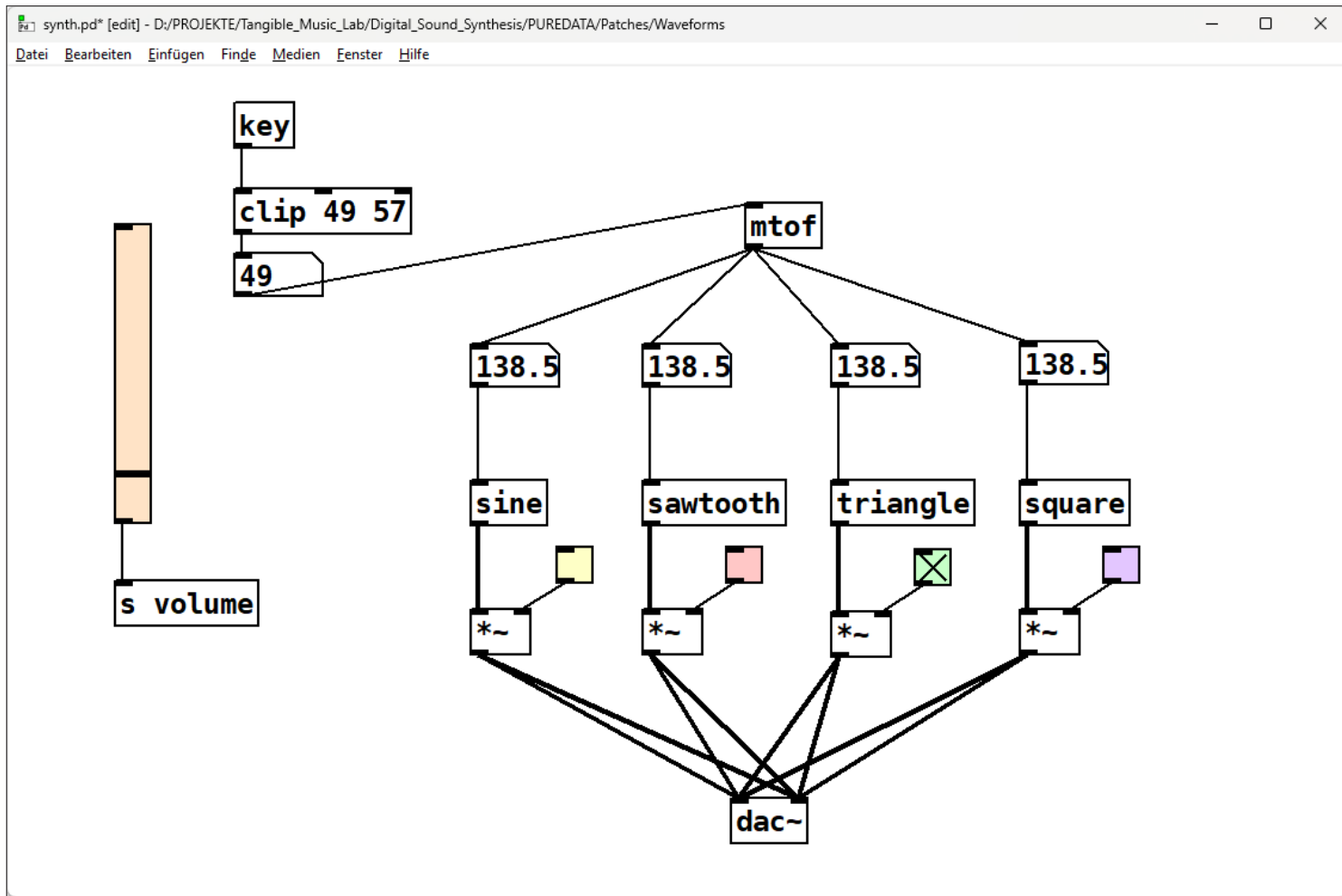




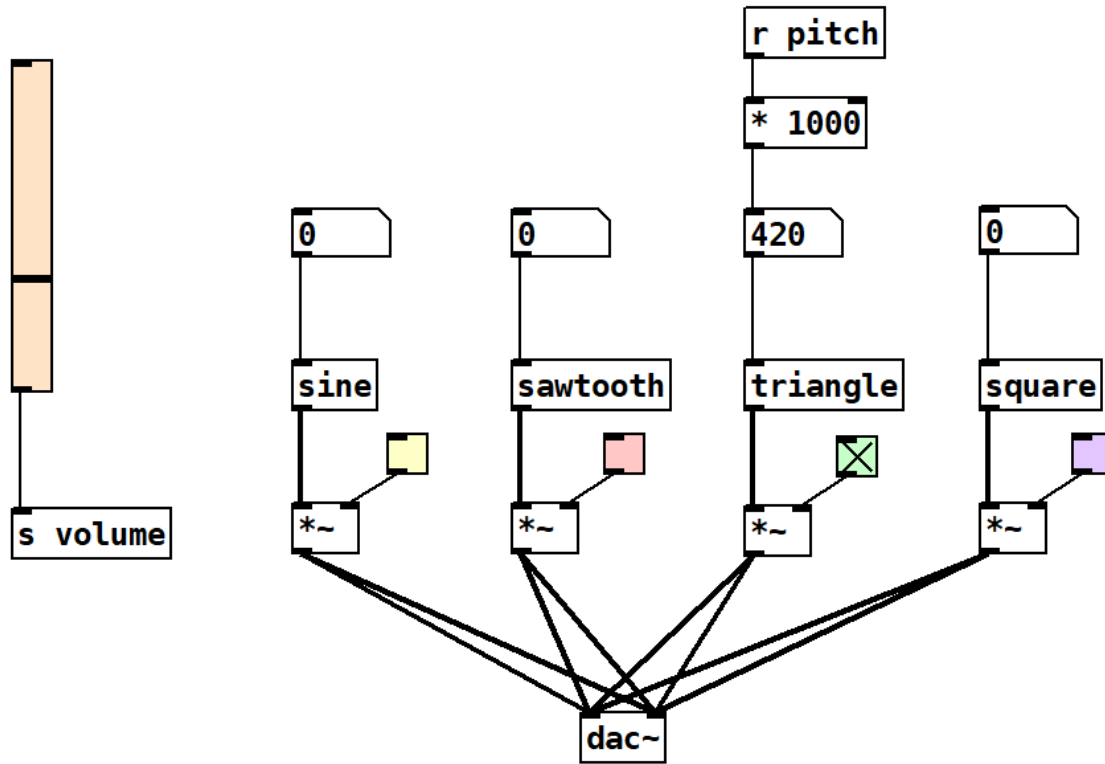


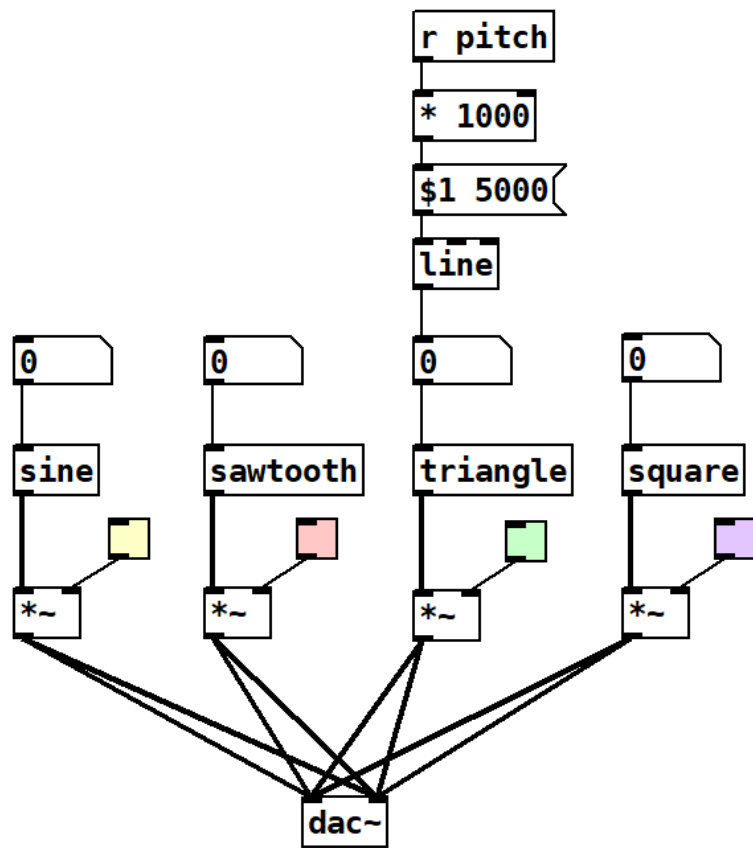
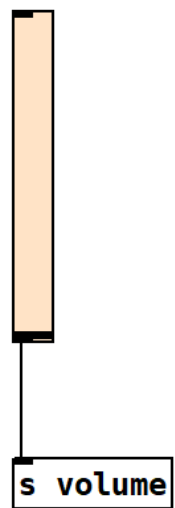






GROUP CHALLENGE:
change the patch to make it easier to hit the pitch with the sensor





FOR NEXT MEETING:

Bring a piece / artwork / instrument
that uses digital sound synthesis
(excerpt as video/soundfile)