Audio Signal Generation

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1/22/18

Please send corrections (or suggestions) to youngwlim@hotmail.com.

This document was produced by using OpenOffice.

Based on

Signal Processing with Free Software : Practical Experiments
F. Auger

SOX information

http://sox.sourceforge.net/Docs/Documentation

http://www.thegeekstuff.com/2009/05/sound-exchange-sox-15-examples-to-manipulate-audio-files/

http://billposer.org/Linguistics/Computation/SoxTutorial.html

Audacity information

http://www.library.kent.edu/files/SMS_Audacity_Basics.pdf

http://manual.audacityteam.org/man/tutorials.html

https://multimedia.journalism.berkeley.edu/tutorials/audacity/

http://ctlt.jhsph.edu/help/views/tutorials/audacity/GuideToUsingAudacity.pdf

Visual Analyser

http://www.sillanumsoft.org/

Installing sox

sudo apt-get install sox

sudo apt-get install libsox-fmt-mp3

Generating signals using sox

sox -n s1.wav synth	3.5	sine	440
sox -n s2.wav synth	90000s	sine	660:1000
sox -n s3.wav synth	1:20	triangle	440
sox -n s4.wav synth	1:20	trapezium	440
sox -n s5.wav synth	6	square	440 0 0 40
sox -n s6.wav synth	5	noise	

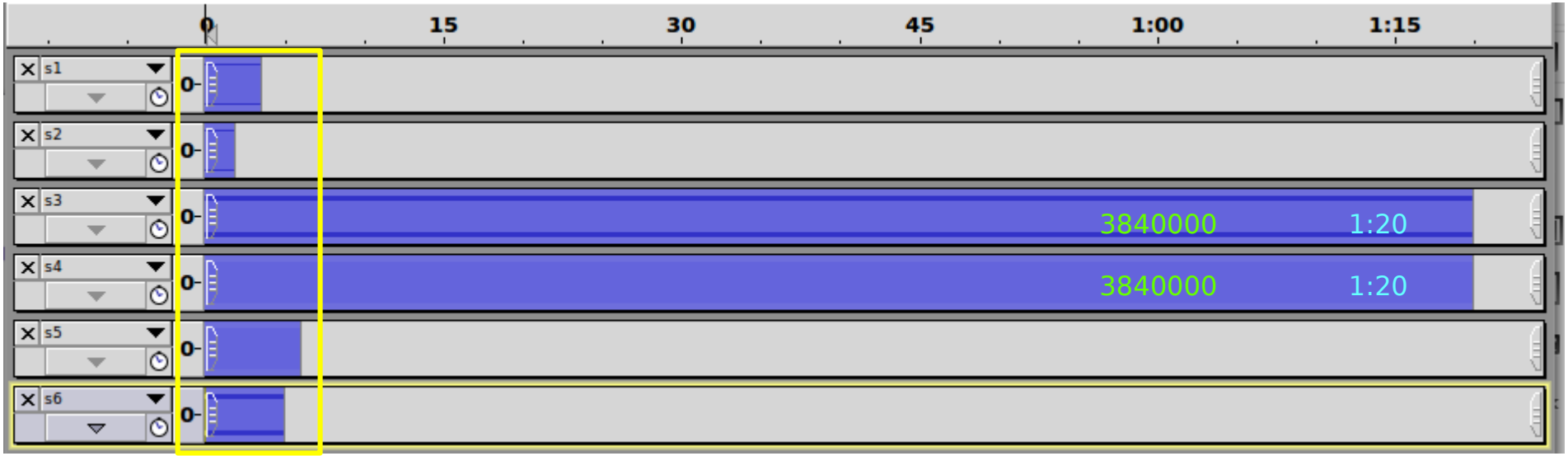
time duration

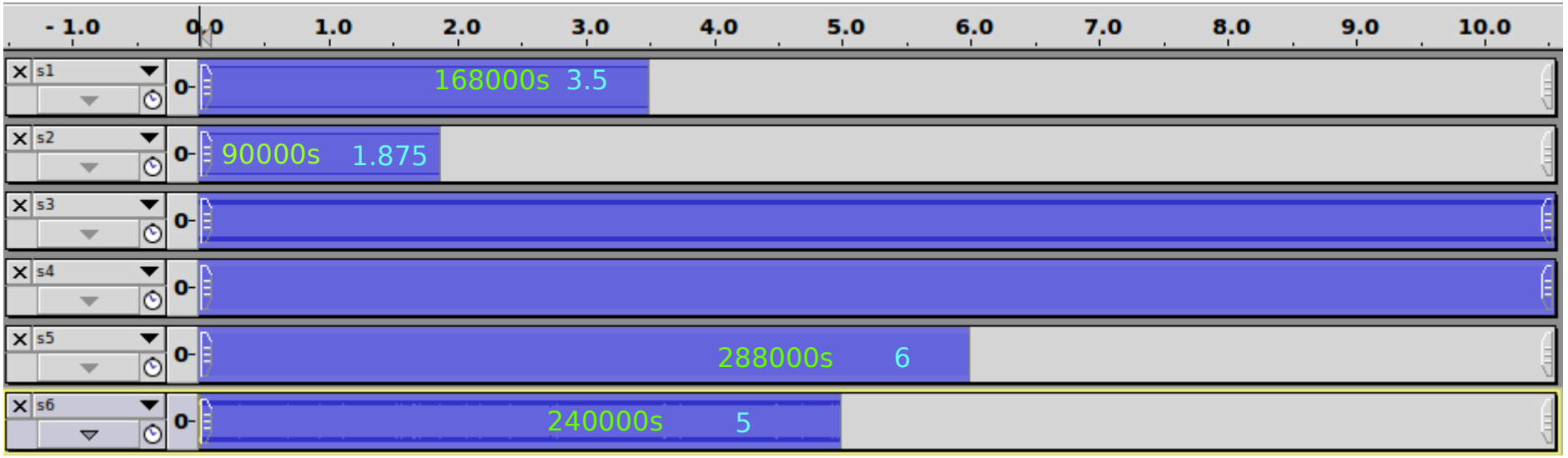
frequency

-V0, -V1, -V2, -V3, -V4 : verbosity levels

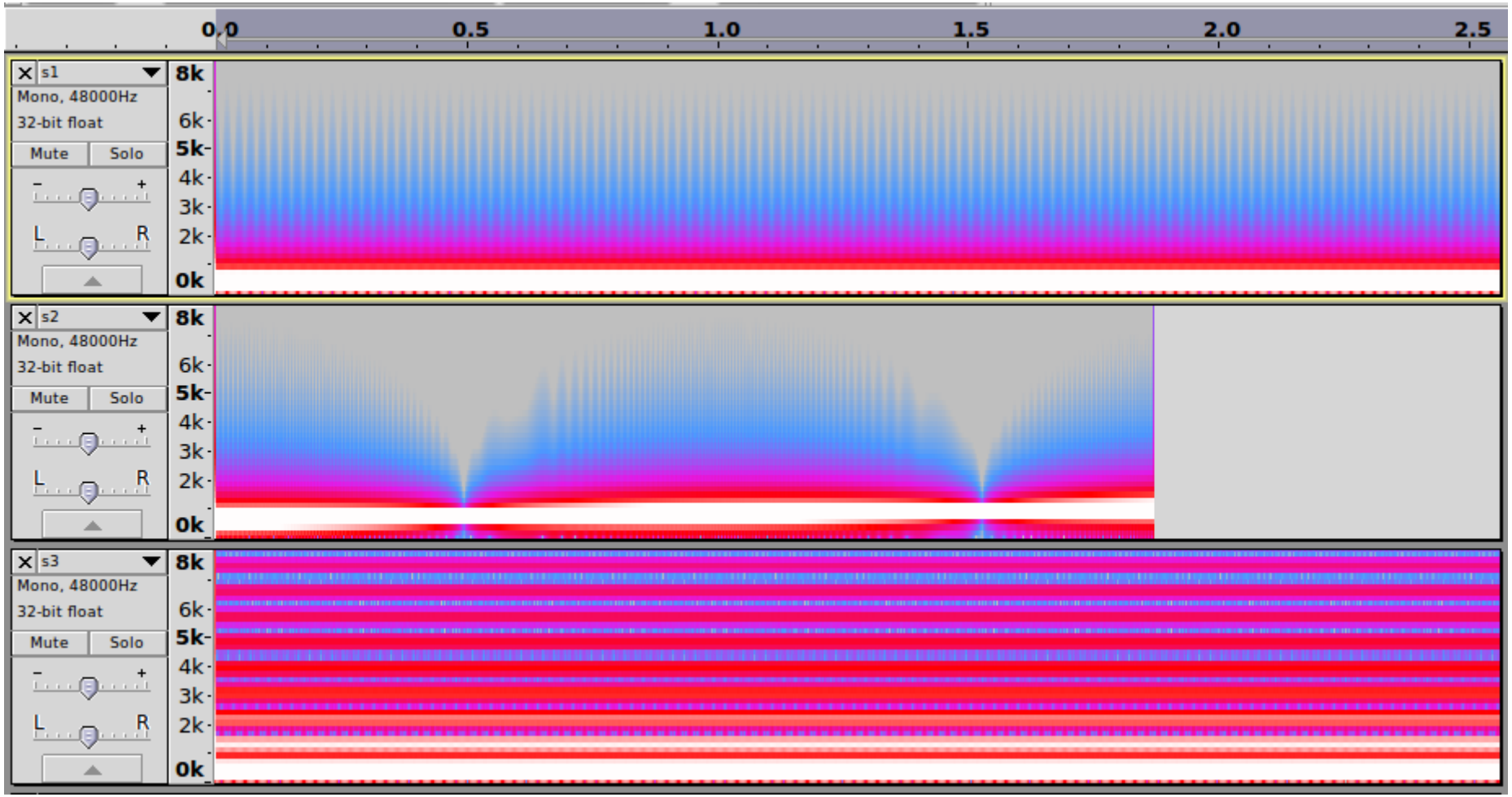
-n (null) : absence of an input signal

Generating signals using sox

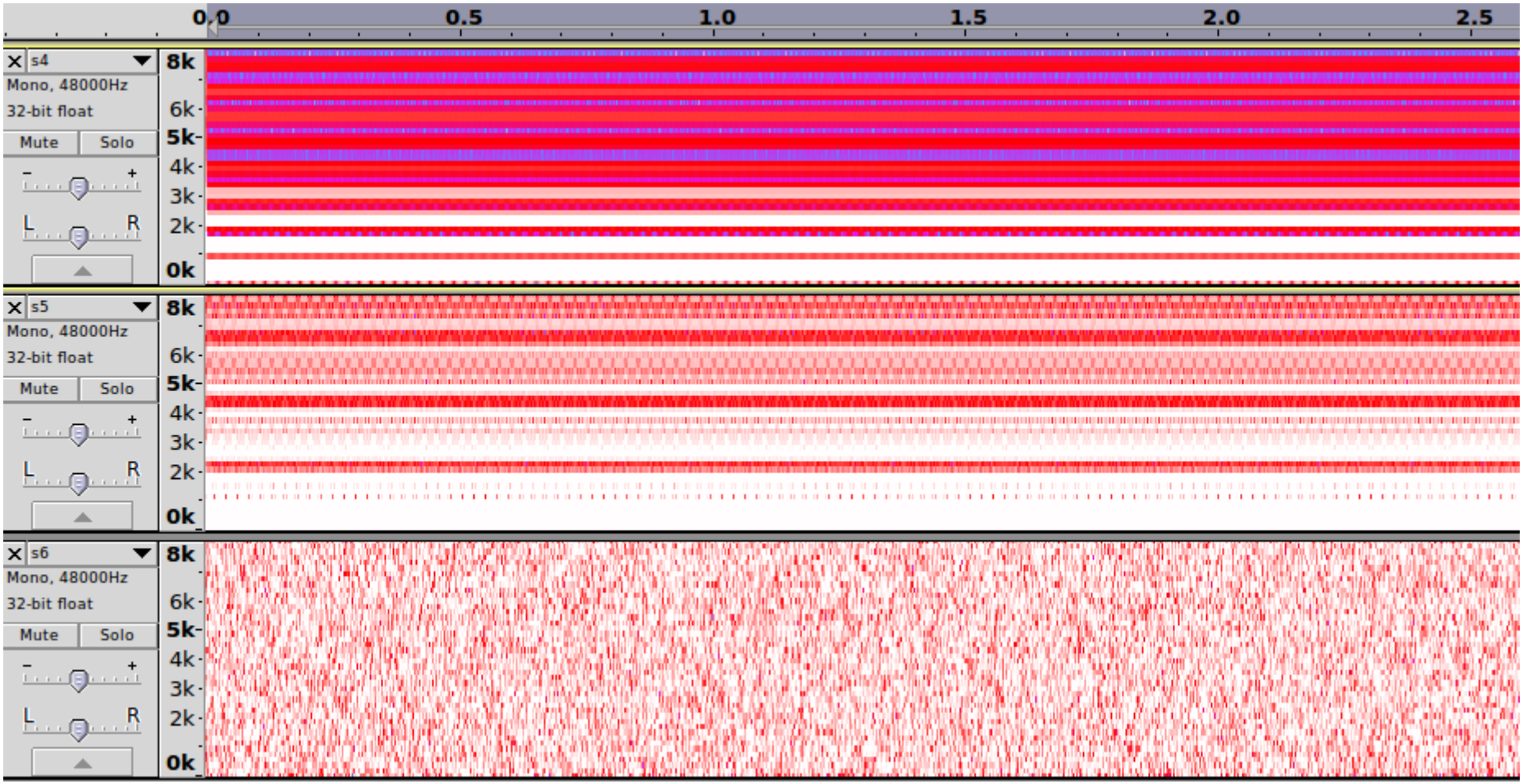




Generating signals using sox



Generating signals using sox



A. sox -n s1.wav synth 3.5 sine 440

3.5 seconds

A sinusoid with a frequency of 440 Hz

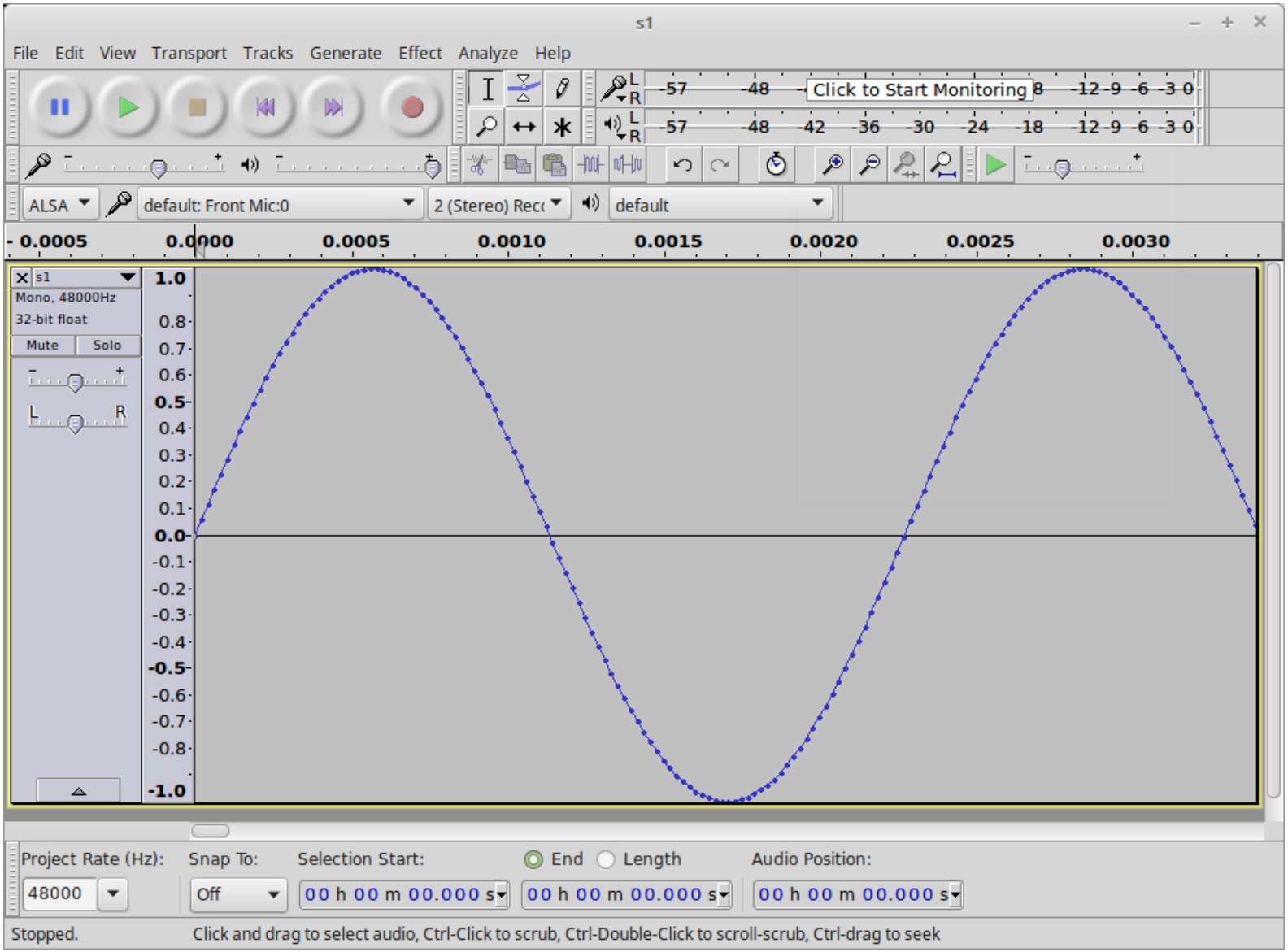
$1/48000 = 2.0833\text{e-}05$

$T_s = 0.0208\ msec$

$T/T_s = 3.5 \cdot 48000 = 168000\ samples$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s1.wav'

Output File    : 's1.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

A. sox -n s1.wav synth 3.5 sine 440



B. sox -n s2.wav synth 90000s sine 660:1000

90000 samples

A sinusoidal signal with a frequency

That varies in a linear manner from 660 to 1000 Hz

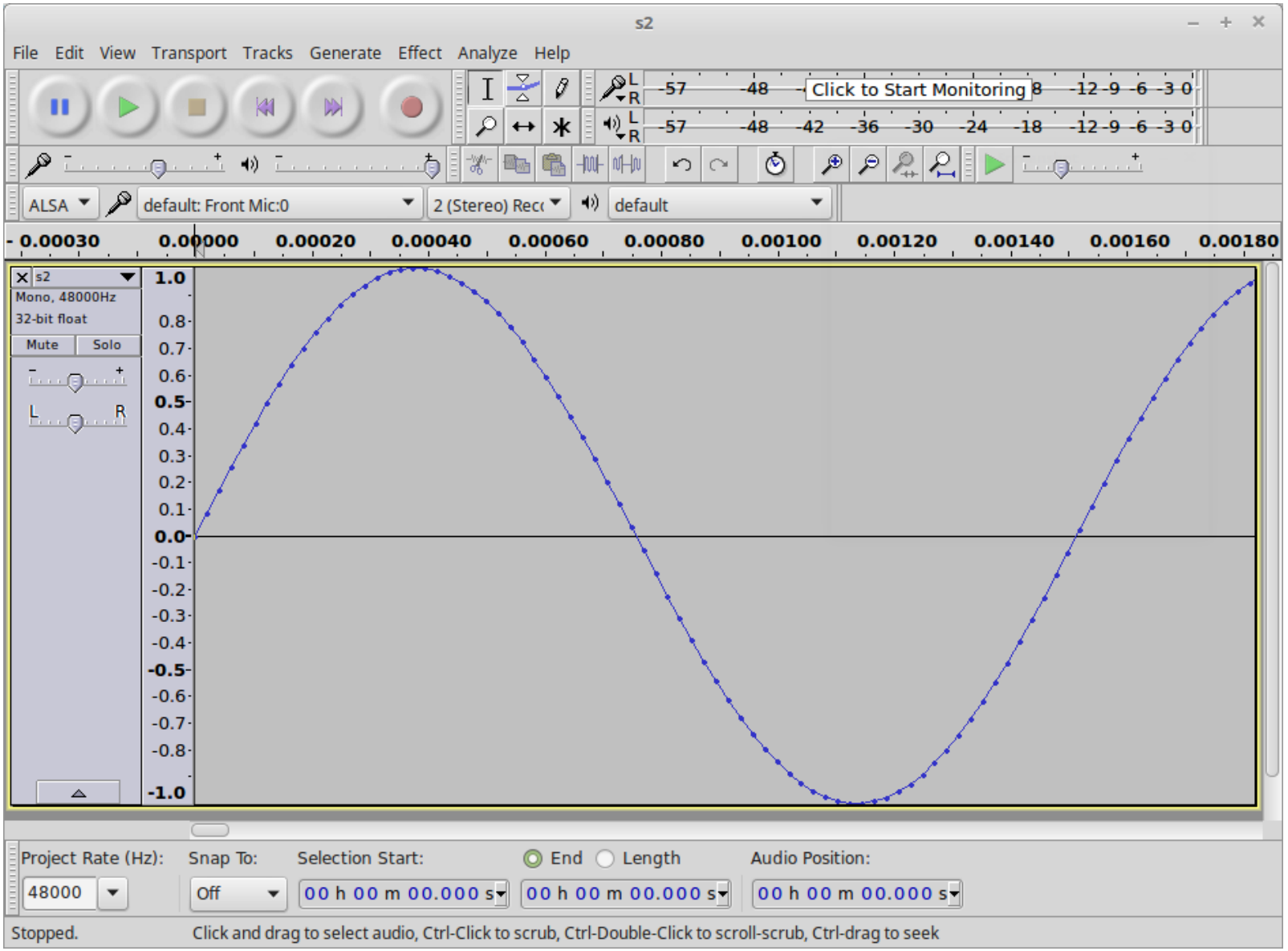
$1/48000 = 2.0833e\text{-}05$

$T_s = 0.0208\ msec$

$T = 90000 / 48000 = 1.875\ sec$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s2.wav'

Output File    : 's2.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

B. sox -n s2.wav synth 90000s sine 660:1000



C. sox -n s3.wav synth 1:20 triangle 440

1 minutes and 20 seconds
A triangular signal
A frequency of 440 Hz

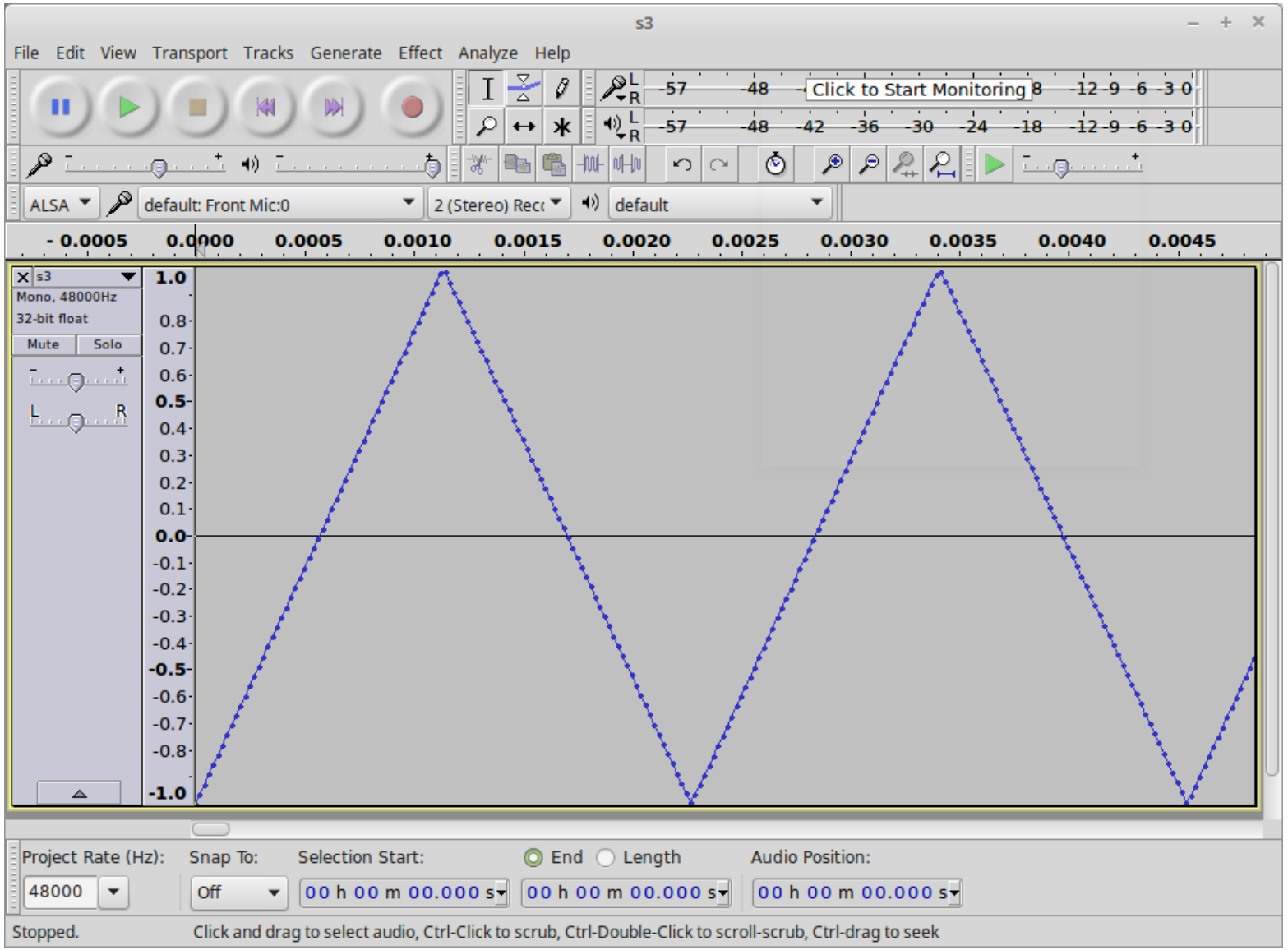
$1/48000 = 2.0833\text{e-}05$

$T_s = 0.0208\ msec$

$T/T_s = 80 \cdot 48000 = 3840000\ samples$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s3.wav'

Output File    : 's3.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

C. sox -n s3.wav synth 1:20 triangle 440



D. sox -n s4.wav synth 1:20 trapezium 440

1 minutes and 20 seconds
A trapezoidal signal
A frequency of 440 Hz

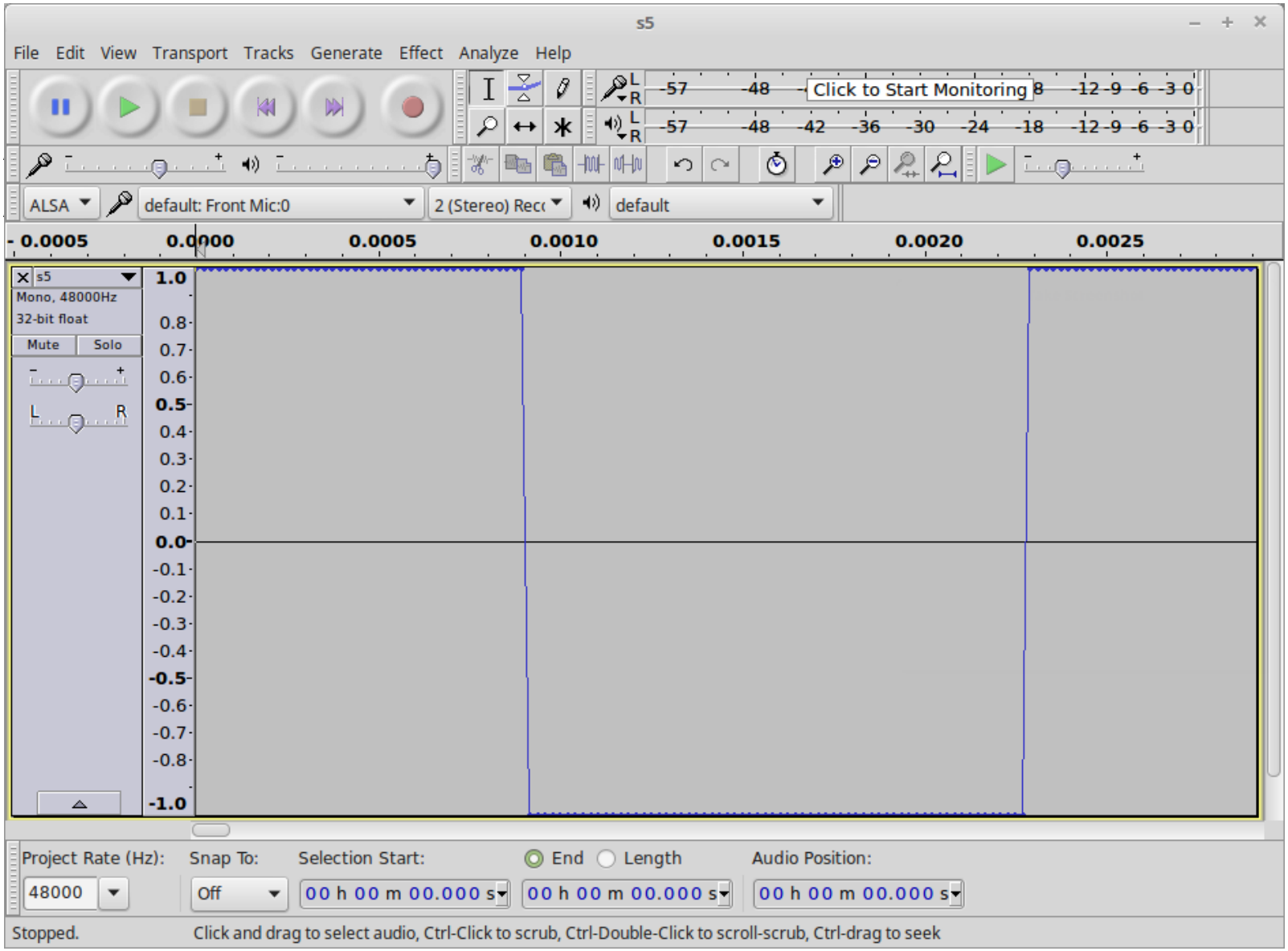
$1/48000 = 2.0833\text{e-}05$

$T_s = 0.0208\ msec$

$T/T_s = 80 \cdot 48000 = 3840000\ samples$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s4.wav'

Output File    : 's4.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

D. sox -n s4.wav synth 1:20 trapezium 440



E. sox -n s5.wav synth 6 square 440 0 0 40

6 seconds
A square signal
A null offset (no continuous component)
A null phase
A duty cycle of 40 %

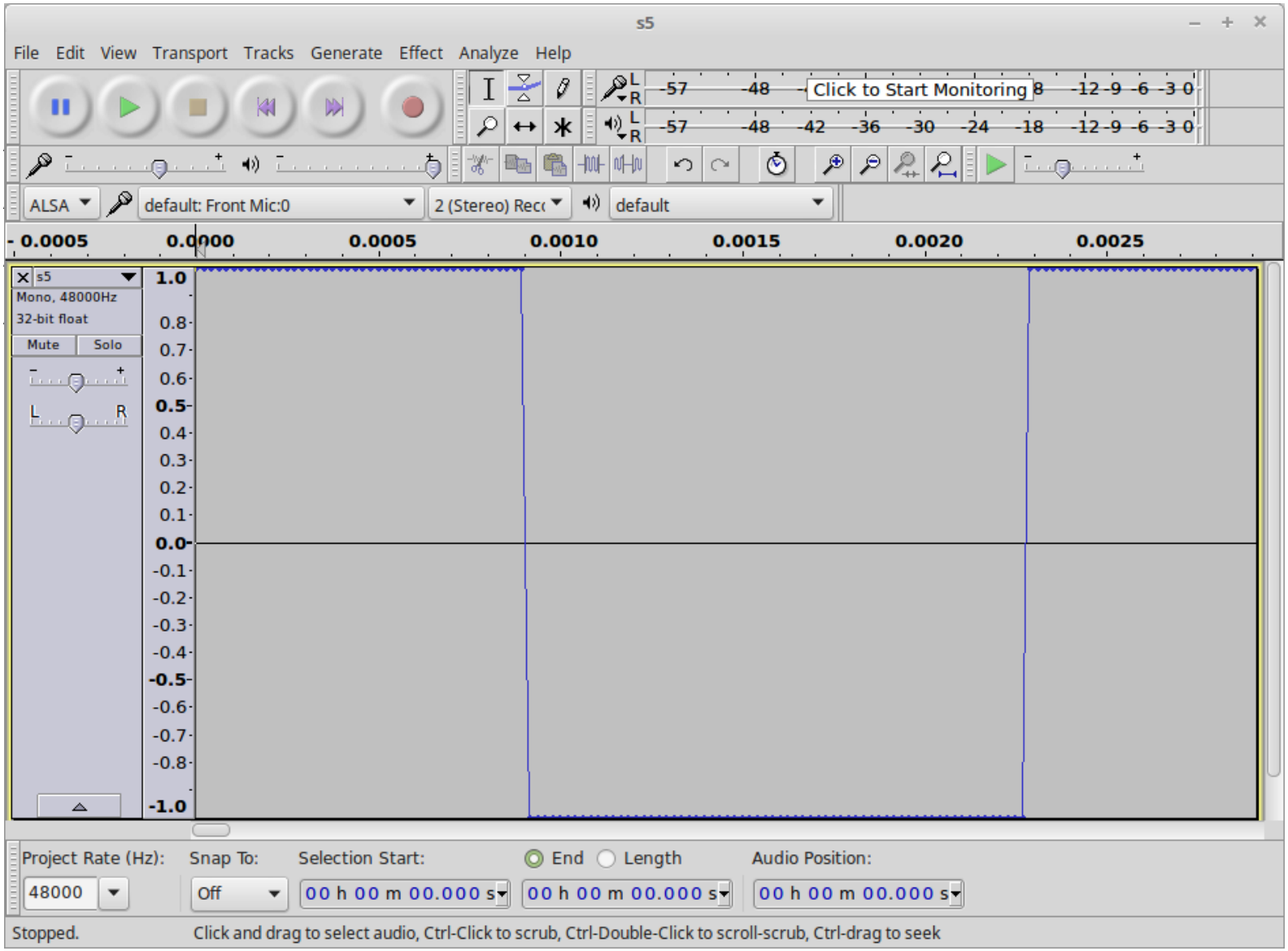
$1/48000 = 2.0833\text{e-}05$

$T_s = 0.0208\ msec$

$T/T_s = 6 \cdot 48000 = 288000\ samples$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s5.wav'

Output File    : 's5.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

E. sox -n s5.wav synth 6 square 440 0 0 40



F. sox -n s6.wav synth 5 noise

5 seconds

A white noise

A value ranging from -1 to +1

An average value of 0

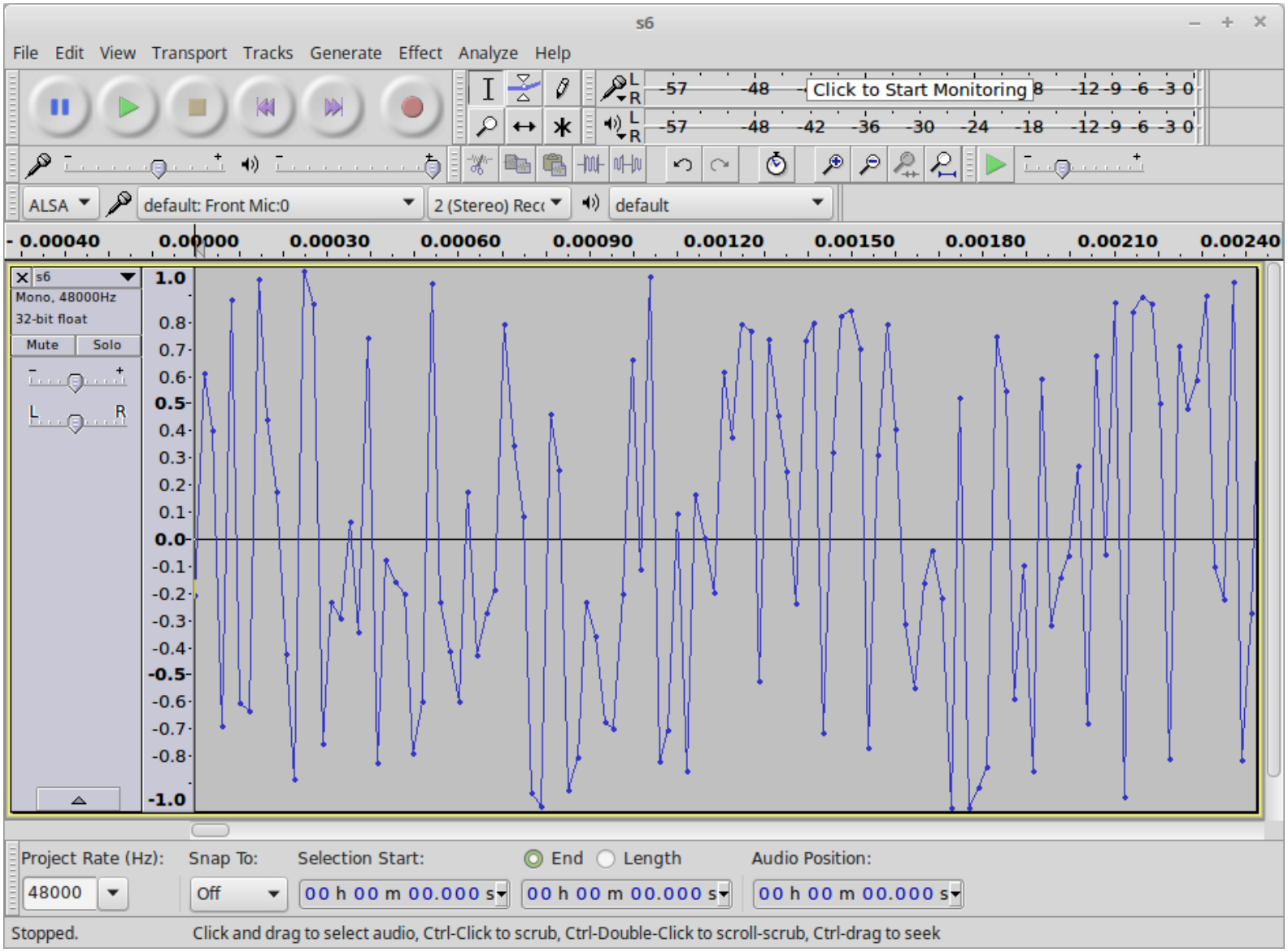
$1/48000 = 2.0833\text{e-}05$

$T_s = 0.0208\ msec$

$T/T_s = 5 \cdot 48000 = 240000\ samples$

```
sox:      SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000

Input File     : '' (null)
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit

sox INFO sox: Overwriting `s6.wav'

Output File    : 's6.wav'
Channels       : 1
Sample Rate    : 48000
Precision      : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type    : little
Reverse Nibbles: no
Reverse Bits   : no
Comment        : 'Processed by SoX'

sox INFO sox: effects chain: input        48000Hz  1 channels
sox INFO sox: effects chain: synth        48000Hz  1 channels
sox INFO sox: effects chain: output       48000Hz  1 channels
```

F. sox -n s6.wav synth 5 noise



Time and Frequency

sox -n s1.wav synth 3.5	sine	440
sox -n s2.wav synth 90000s	sine	660:1000
sox -n s3.wav synth 1:20	triangle	440
sox -n s4.wav synth 1:20	trapezium	440
sox -n s5.wav synth 6	square	440 0 0 40
sox -n s6.wav synth 5	noise	

3.5	3.5 sec	440	440 Hz
90000s	90000 samples	660:1000	660 Hz to 1000 Hz
1:20	1 min 20 sec	440	440 Hz
1:20	1 min 20 sec	440	440 Hz
6	6 sec	440	440 Hz
5	5 sec		

Signal Processing Operations (1)

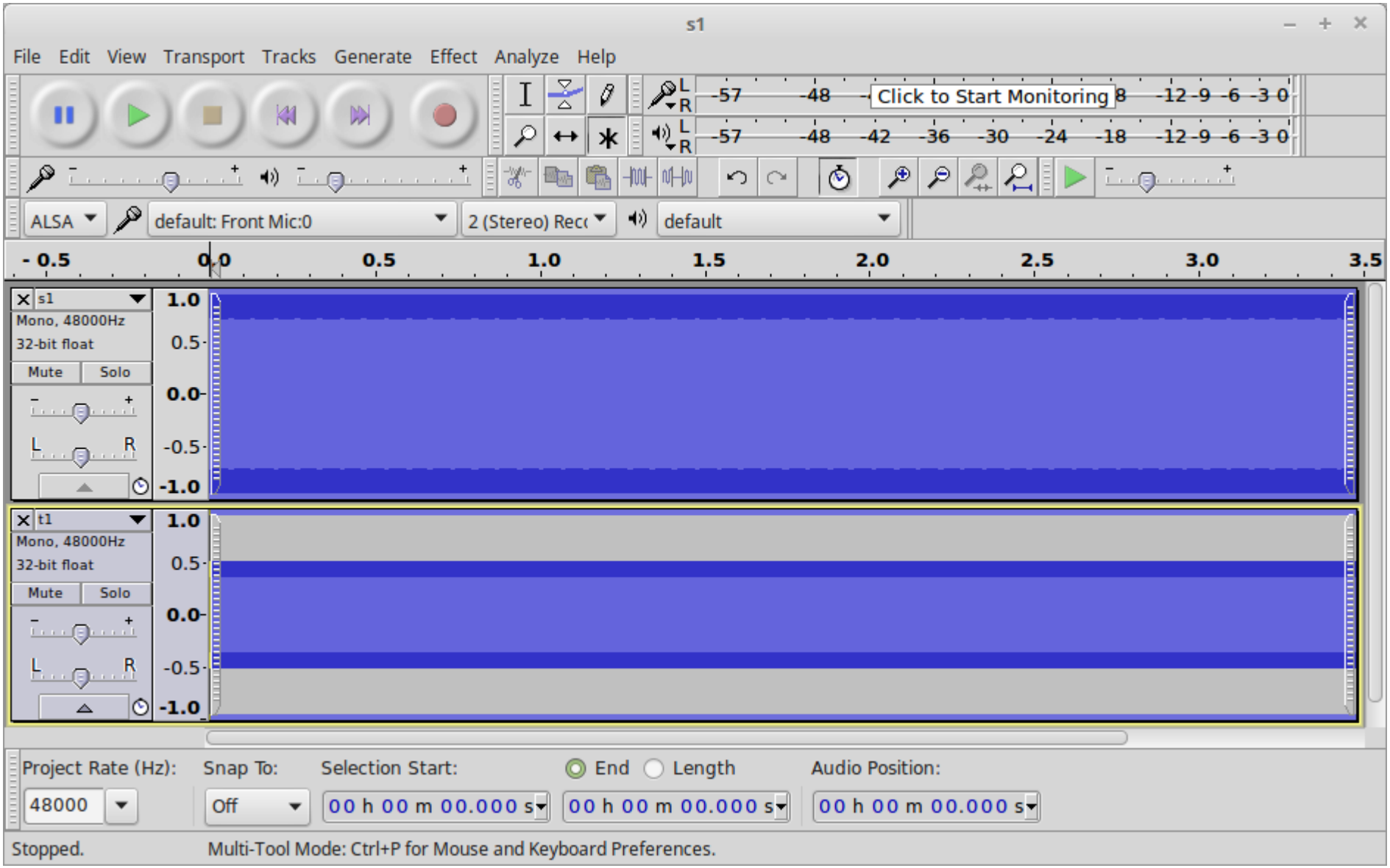
```
for %%i in (200, 300, 400) do ^
sox -n s7_%%i.mp3 synth 15 sine %%i
```

```
sox -n s7_200.mp3 synth 15 sine 200
sox -n s7_300.mp3 synth 15 sine 300
sox -n s7_400.mp3 synth 15 sine 400
```

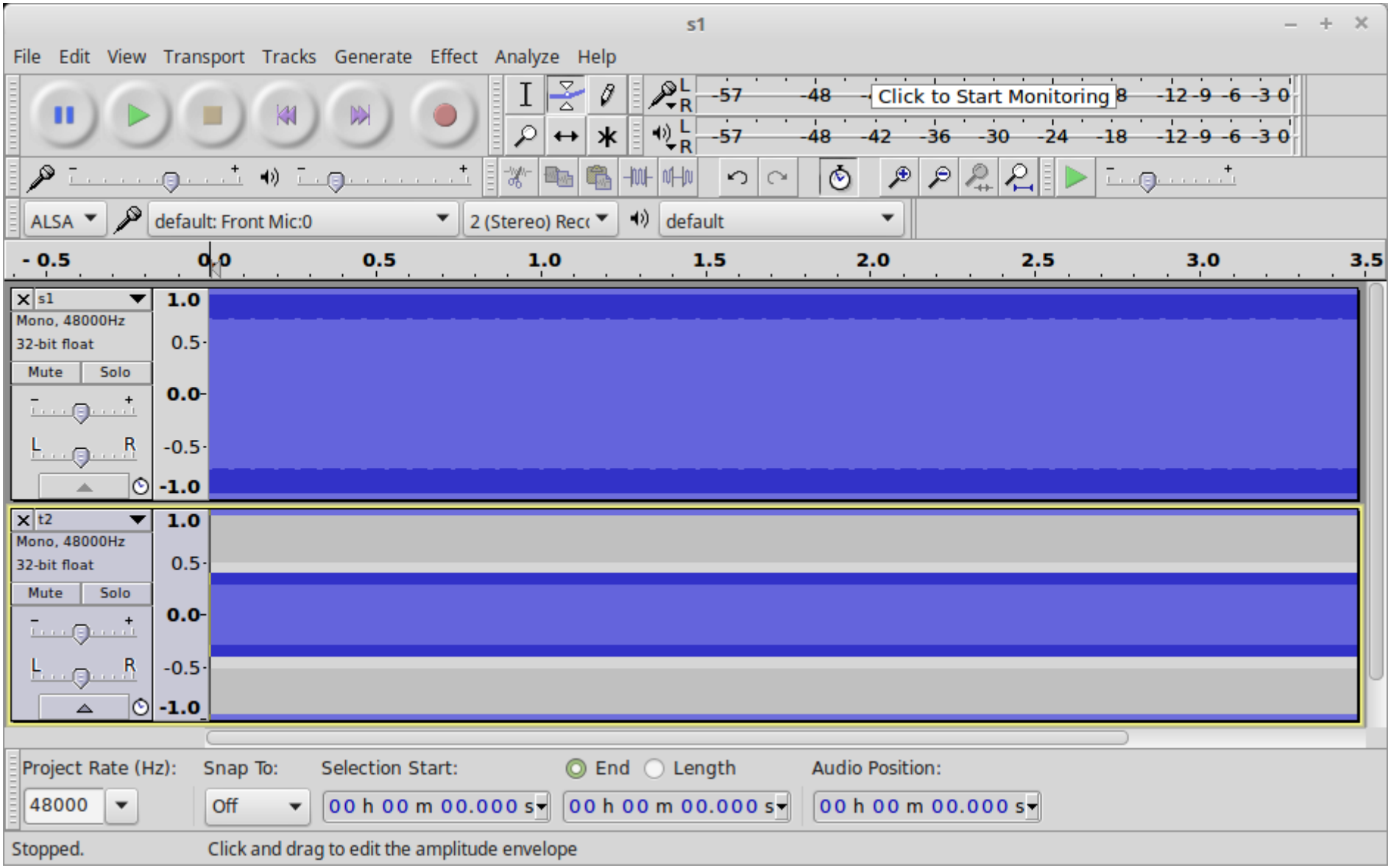
Signal Processing Operations (1)

```
sox s1.wav t1.wav vol -6 dB
sox s1.wav t2.wav vol -0.4 amplitude

sox s1.wav s2.wav t3.wav
sox s2.wav -v 0.6 t1.wav t4.wav

sox s1.wav t5.wav pad 1
sox s1.wav t6.wav pad 1 0.5
sox s1.wav t7.wav pad 1 5000@3 0.5

sox -m s3.wav s4.wav t8.wav
```

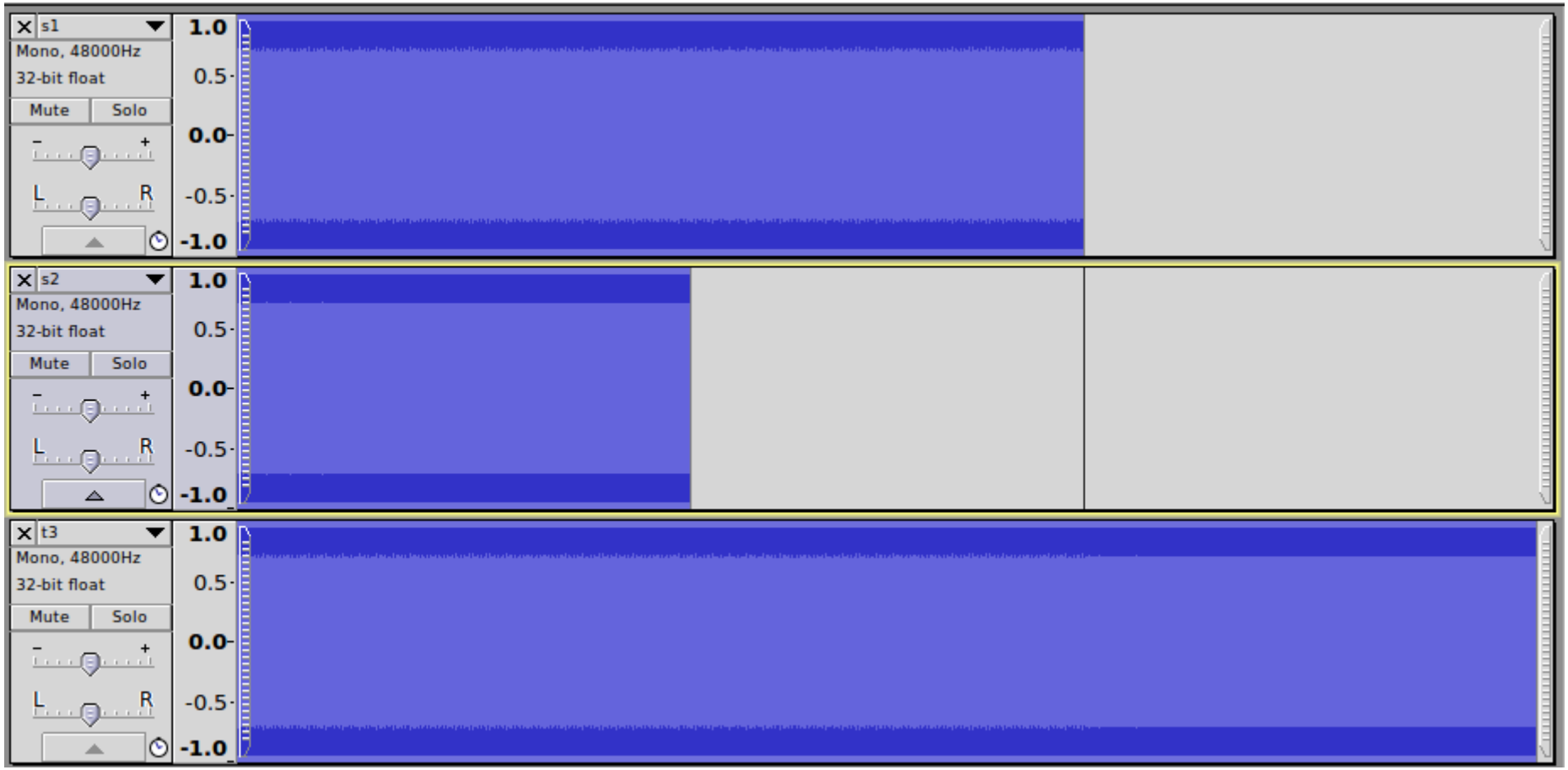
sox s1.wav t1.wav vol -6 dB



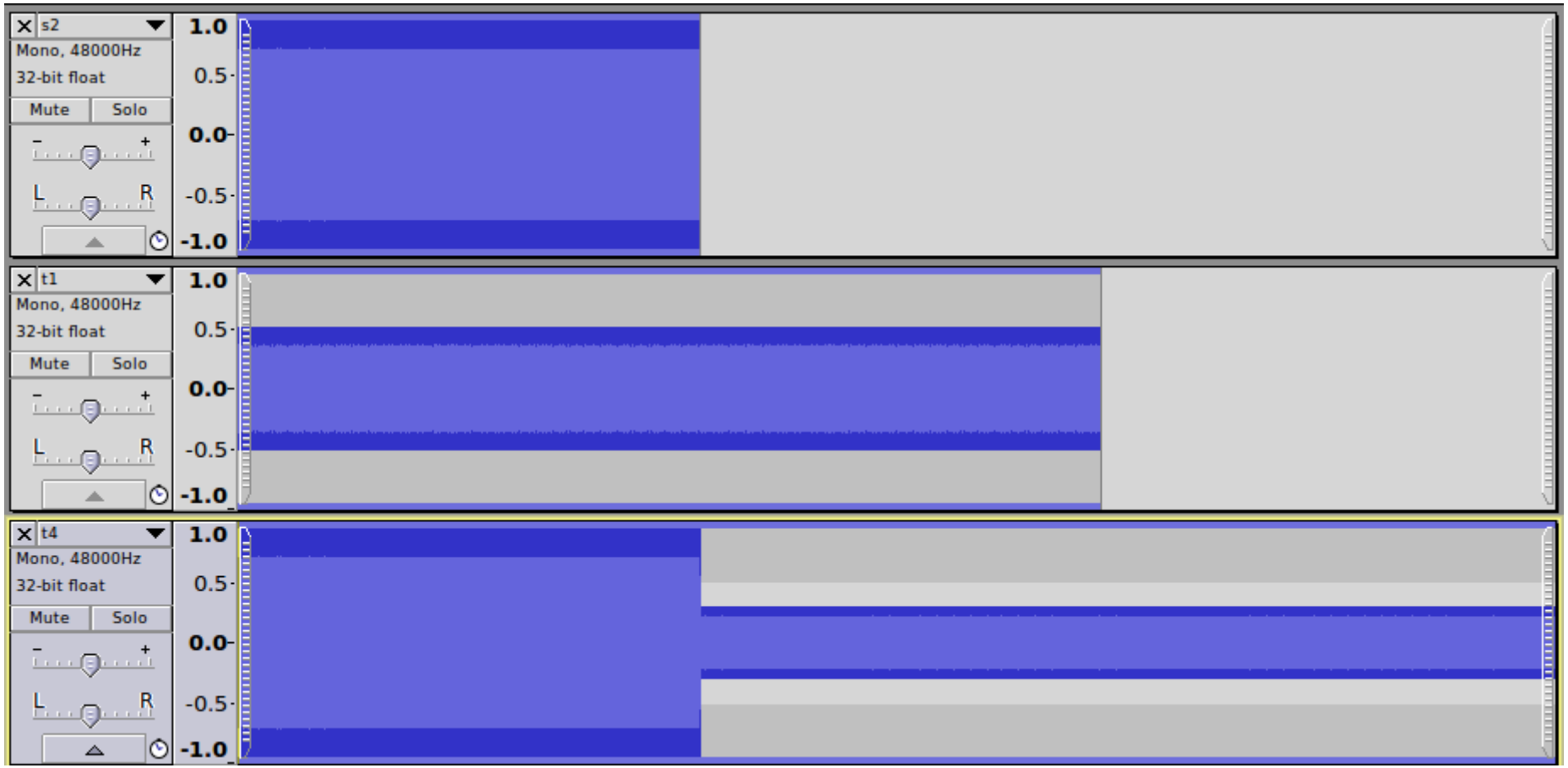
sox s1.wav t2.wav vol -0.4 amplitude



sox s1.wav s2.wav t3.wav



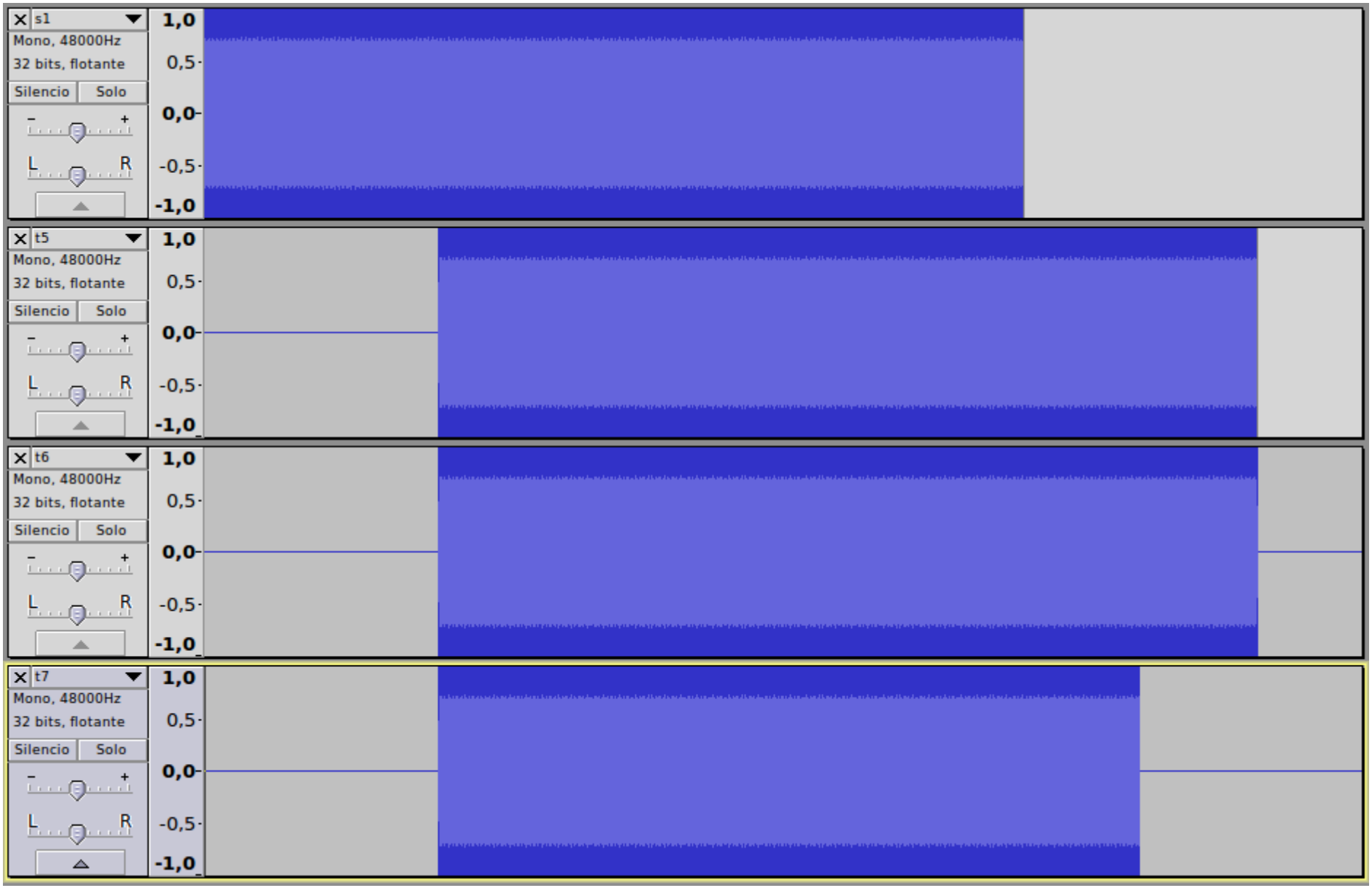
sox s2.wav -v 0.6 t1.wav t4.wav



Signal Processing Operations (1)

```
sox s1.wav t5.wav pad 1
sox s1.wav t6.wav pad 1 0.5
sox s1.wav t7.wav pad 1 5000@3 0.5
```

Signal Processing Operations (1)



Signal Processing Operations (2)

sox s1.mp3 t9.mp3 dcshift 0.05

sox s1.mp3 t10.mp3 reverse

sox s3.mp3 t11.mp3 trim 1.5 2

sox s3.mp3 t12.mp3 t 10 1:00 20

Statistics and Information

```
soxi  s1.wav
sox   s1.wav -n stat
sox   s1.wav -n stats
```

soxi s1.wav

```
Input File     : 's1.wav'
Channels       : 2
Sample Rate    : 48000
Precision      : 16-bit
Duration       : 00:00:20.65 = 991232 samples ~ 1548.8 CDDA sectors
File Size      : 3.96M
Bit Rate       : 1.54M
Sample Encoding: 16-bit Signed Integer PCM
```

sox s1.wav -n stat

```
Samples read:           1982464
Length (seconds):     20.650667
Scaled by:         2147483647.0
Maximum amplitude:     0.007813
Minimum amplitude:    -0.003174
Midline amplitude:     0.002319
Mean    norm:          0.000202
Mean    amplitude:    -0.000016
RMS     amplitude:     0.000255
Maximum delta:         0.008545
Minimum delta:         0.000000
Mean    delta:         0.000142
RMS     delta:         0.000180
Rough   frequency:         5413
Volume adjustment:     128.000
```

sox s1.wav -n stats

```
             Overall     Left      Right
DC offset  -0.000016 -0.000016 -0.000016
Min level  -0.003174 -0.001190 -0.003174
Max level   0.007812  0.001282  0.007812
Pk lev dB     -42.14    -57.84    -42.14
RMS lev dB    -71.88    -71.73    -72.05
RMS Pk dB     -67.08    -67.08    -68.21
RMS Tr dB     -74.06    -73.44    -74.06
Crest factor       -      4.95     31.27
Flat factor     0.00      0.00      0.00
Pk count        2.50         3         2
Bit-depth       9/16      7/16      9/16
Num samples     991k
Length s      20.651
Scale max   1.000000
Window s       0.050
```

References

[1] F. Auger, Signal Processing with Free Software : Practical Experiments