# Towards a live-electronic setup with a sensor-reed saxophone and Csound

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## Abstract

This paper presents a setup to pick up saxophone reed vibrations directly, in an attempt to monitor the saxophone signal without risky feedbackloops despite drastic dynamic manipulations. We prepared synthetic saxophone reeds with strain gauge sensors and proposed a circuit to connect the sensor reed to a line-level soundcard input. Furthermore, we discussed possible open-source software to emulate classic stompbox effects. Finally, we presented a Csound instrument design, that allows on-the-fly signal routing between multiple effects in an ongoing live performance.

## 1 Introduction

On the electric guitar, the coil pickup converts the vibrations of the steel strings directly into an alternating current through electromagnetic induction [Campbell et al., 2004]. This makes it possible to amplify the instrument without risking feedback loops between a microphone and the speaker system [Lemme, 1994]. To enrich the sound possibilities of the electric guitar, musicians and instrument makers developed several circuits to modify the clean pickup signal. These circuits were build into little boxes, which the performer turns on and off by foot (stompboxes) during live performance [Bacon, 1984; Collins, 2009].

With todays processing speed of portable computers, digital signal processing can replace analog signal modifiers on stage [Noble, 2009; Boulanger and Lazzarini, 2011]. Besides stand alone guitar effect software (e.g., on Linux: Rakarrack, Guitarix), computer music languages like Csound or Supercollider provide ready-made signal processing modules (Csound opcodes, SuperCollider Ugens) to rebuild classic stompbox effects [Mikelson, 2000]. New effects can easily be designed and tested live with such toolboxes [Ervik and Brandtsegg, in press; Waerstad, 2010].

When playing wind instruments, like the saxophone, the sound source is usually picked up with a microphone. Drastic, dynamic modifying sound effects like distortion or resonating filters are difficult to apply to a microphone signal in a live situation. The high volume levels on stage lead to an increased risk of microphone-speaker feedback loops, which might disturb the performance.

Sensor saxophone reeds were developed in acoustic research to investigate single reed behavior under real playing conditions [Hofmann et al., 2012a]. In this paper, we will discuss applications for such sensor-reeds within an electronic live performance setup with the open source audio software Csound.

## 2 Method

### 2.1 Saxophone reed pickup

We attached a strain gauge sensor to a synthetic alto saxophone reed, to directly capture the vibrations of the reed during performance (Figure 1). A detailed description of how to prepare synthetic reeds with strain gauge sensors is given in [Hofmann et al., 2013].

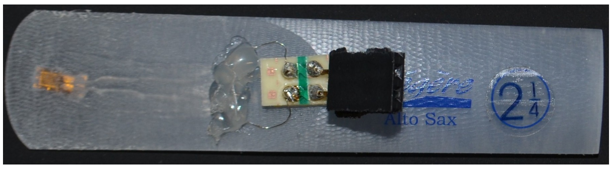


Figure 1: Synthetic alto-saxophone reed with 2 mm strain gauge attached

The standard measurement setup foresees the strain gauge as one resistor in a quarter Wheatstone bridge [Scott and Owens, 1989]. The range of the resulting signal depends on the supply voltage of the bridge (+3V, -3V). An instrumentation amplifier (INA 126) is used to adjust the signal amplitude of the differential bridge voltage. A first order RC filter removes the DC offset. Figure 2 (C) depicts a circuit with two operational amplifiers (LM358N) to

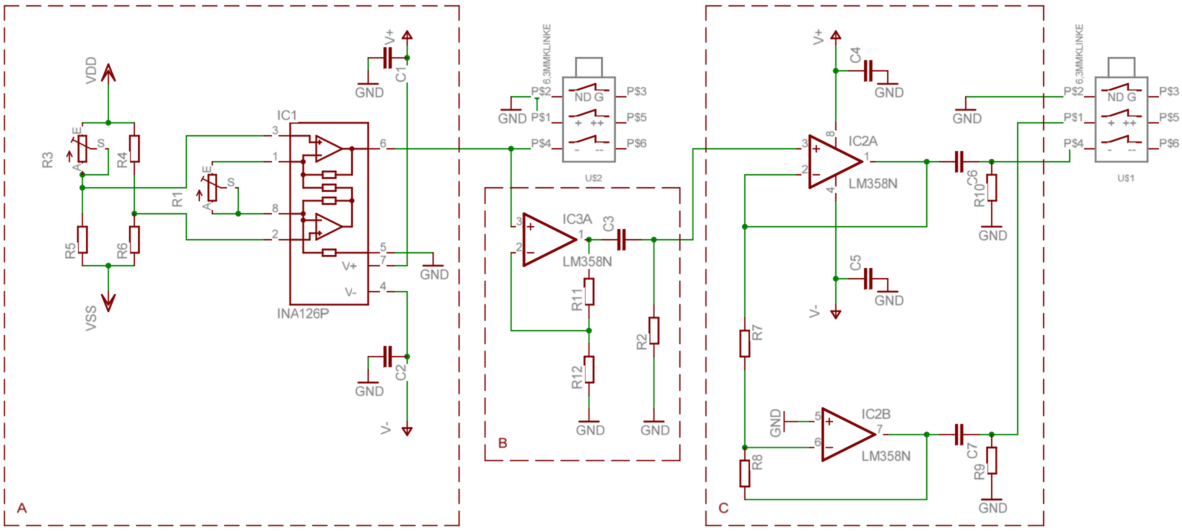


Figure 2: Circuit with a quarter Wheatstone bridge and an instrumentation amplifier (A), a RC filter (B), and two operation amplifiers for symmetric signal output (C)

gain symmetric output. This allows direct plugging into the symmetric *Line-Input* of a professional soundcard for A/D conversion.

## 2.2 Effect Setup

We decided to build signal modifying sound effects with Csound, a well documented, flexible, open source, platform independent audio programming language [Heintz et al., 2011].

We will encapsulate the signal modifiers (effects) as independent *Csound Instruments* and use the *subinstr* opcode to enable signal rerouting in real-time, during performance.

## 2.3 Signal Flow

The current system is intended for mono sound input and stereo sound output. Two global audio rate variables (gaOutL, gaOutR) are keeping the main output of the system. A simple audio input to output patch looks like shown in Figure 3.

The main controller Csound Instrument (instr 1) is used to receive MIDI note messages during performance. Received MIDI notes determine which sub-instrument's effect is processed. A sub-instrument reads audio samples from the global audio variables (gaOutL, gaOutR), modifies them and then overwrites them.

Usually Csound instruments are calculated by the order of their instrument number. During one audio processing cycle, instrument 10 is always calculated before instrument 30, independent of their sequence in the Csound score. The use of sub-instruments (*subinstr*) makes it possible to start multiple versions of instrument 1 by MIDI note messages. Csound treats each instance like a voice of instrument 1. According to the received MIDI note number, instrument 1 is holding a different sub-instrument each time. This method allows to shift calculations of sub-instrument 30 before sub-instrument 10 within the current audio cycle.

```
<CsInstruments>
gaOutL init 0.0
gaOutR init 0.0

instr 1 ;Main Controller Instrument
  inote  notnum
  ichn midichn
   if inote == 10 then
     gaOutL, gaOutR subinstr 10, 0, -1
   elseif inote == 30
     gaOutL, gaOutR subinstr 30, 0, -1
   elseif inote == 31
     gaOutL, gaOutR subinstr 31, 0, -1
   elseif ..
   endif
endin
```

### 2.3.1 Input and Output

In our setup, the soundcard input is also implemented as a sub-instrument (instr 10). For example, this can be useful to loop an audio sequence by routing the soundcard input into a delay (Figure 4, top). When the soundcard input instrument is later released and triggered

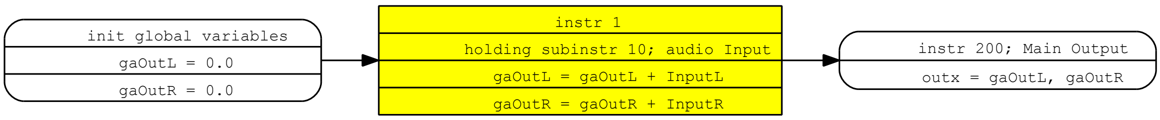


Figure 3: Signal flow of a simple input-to-output routing

again, it is automatically placed after the delay and you can play over the recorded loop without changing it (Figure 4, bottom).

```
instr 10 ;Soundcard Input Instrument
  aIn inch 1
  outs gaOutL + aIn, gaOutR + aIn
endin


instr 30  ;Loop-Delay
  aDelayL delayr 3 ;init 3 sec. delayline
   aWetL deltapi 3 ;read from delayline
   delayw gaOutL+(aWetL) ;write to dlyln.
  aDelayR delayr 3
   aWetR deltapi 3
   delayw gaOutR+(aWetR)
  outs gaOutL + aWetL, gaOutR + aWetR
endin


instr 31  ;Amplitude Modulation Effect
  aMod oscils 0.5, 300, 0 ;Sinus 300 Hz
  aL = gaOutL * (aMod+0.5)
  aR = gaOutR * (aMod+0.5)
  outs aL, aR
endin
```

To make sure the overall audio output to the soundcard is never overwritten, an output instrument with the highest instrument number (here instr 200) is started directly from the Csound score.

```
instr 200 ;Main Output
outs gaOutL, gaOutR
gaOutL = 0.0
gaOutR = 0.0
endin

</CsInstruments>
<CsScore>
i 200 0 3600 ;Output runs for one hour
e
</CsScore>
</CsoundSynthesizer>
```

This technique allows on-the-fly re-routing of sub-instruments and supports the creation of various effect chains also with any number of effects.

Additionally we recommend to add a cross-fade function to the sub-instruments to avoid clicks when changing the order of effects.

## 3 Discussion

We developed a live-electronic performance setup, that monitored and processed the saxophone's reed vibrations directly. With this method we can work at a wide range of amplitude levels on stage and apply drastic sound effects to the signal without the risk of feedback loops. Also when playing in an ensemble, the reed signal is free of surrounding noise from other instruments. This makes the reed signal also more suitable for frequency-domain feature detection (e.g., pitch-tracking, onset detection). In addition, we explained a setup within Csound, which allows re-routing of sound effects on-the-fly during live performance.

One disadvantage of this pickup method is that the characteristic air noise is missing in the sound. For compensation a synthetic noise signal could be added to the output.

An other difficulty is the overall high amount of background noise in the signal, which is a common problem with strain gauge measurements [Scott and Owens, 1989]. Further research on the characteristics of each single component is intended to improve the signal to noise ratio.

In future work, we also plan to optimize articulation detection algorithms, based on findings from performance research [Hofmann et al., 2012b], in terms of real-time onset detection applications.

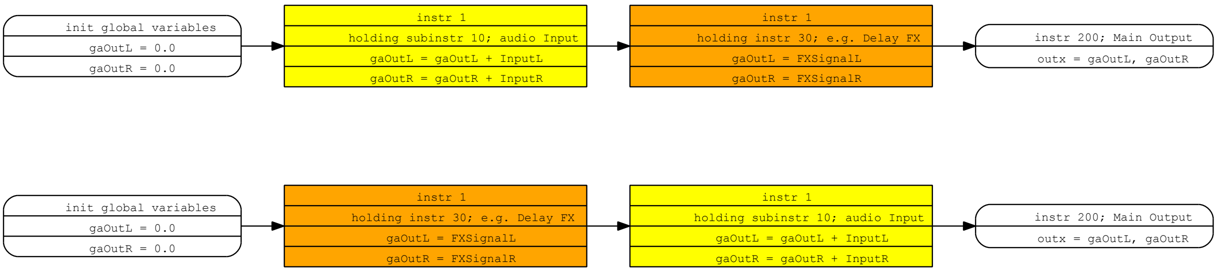


Figure 4: Top: Routing of soundcard input into an (delay) effect instrument. Bottom: Changed processing order. The input is placed after the (delay) effect.

## 4 Acknowledgements

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