

Basic research in translating biological, mechanical and chemical principles into electronic musical instrument language and vice versa

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Abstract

English

Basic research in translating biological, mechanical and chemical principles into electronic musical instrument language and vice versa.

The subject of this diploma is exploration of all possible and impossible biological, mechanical and chemical events and their application in the field of electronic music. Electronic musical instruments can communicate between each other by standardized languages, either analog (CV) or digital (MIDI, OSC). In the first part of the research the translators from the real world events into the musical protocols and vice versa are produced. The second part of the research applies these technical solutions in the musical exploration of these real world principles. All of this is done in the open source fashion.

Deutsch

Die Grundlagenforschung zur Übersetzung biologischer, mechanischer und chemischer Grundlagen in die Sprache elektronischer Musikinstrumente und umgekehrt.

Das Thema der Diplomarbeit ist die Untersuchung von allen möglichen und unmöglichen biologischen, mechanischen und chemischen Grundlagen und deren Anwendung im Bereich der elektronischen Musik. Elektronische Musikinstrumente können untereinander durch standardisierte Sprachen kommunizieren, entweder analog (CV) oder digital (MIDI, OSC). Im ersten Teil der Forschung werden Translatore von realen Welt-Prinzipien in musikalische Protokolle und umgekehrt produziert. Der zweite Teil der Forschung ist, diese technischen Lösungen in der musikalischen Erforschung dieser realen Welt-Prinzipien anzuwenden.

Introduction

Motivation

I have been creating electronic musical instruments for about 5 years now and I've already managed to bring some of them to the small market of unique musical instruments. This scene is a very vivid space full of innovation and great ideas where makers from all around the world try to bring the most interesting aspects of the DIY culture to musicians and sound experimenters. The innovation reaches from the cutting edge technology to lo-fi / limited elegant solutions to certain technical issues. Most of the people involved in these innovations are musicians, designers, hackers, artists, scientists and other creators ranging in between all these disciplines. Technological research in the field of electronic music has been connected with performing on these instruments from the earliest days of electronic music.

I was always concerned about the limited number of easily accessible inputs and outputs that can take part in the musical processes and therefore I decided to conduct this research. Thanks to the open source knowledge base created by online community (Arduino, Processing, Fritzing etc.), I was able to learn to grasp some of the interesting events and translate their properties into the language that common electronic musical instrument speak (CV or MIDI). All these translational technical solutions will be published as open source.

Background

My background is deeply musical. I studied the piano play for almost 9 years. I produced several albums of electronic music, but also composed for acoustic instruments. I briefly studied at the Composition Department at Musical Faculty of the Janáček Academy of Performing Arts, in Brno. I have played in various bands ranging from free improvisation to electro folk, made performances with orchestra and also composed an opera. The reason, why I actually went on in studying at the fine arts universities (FaVU in Brno and die Angewandte in Vienna) instead was, that it allowed me to work with sound and music in a much more liberating way than I experienced at the Composition Department. For the past few years I have been working mostly on the intersection of sound and image, performing on these hardware instruments and while also giving workshops. The experimental approach making my music has led me to become a maker of musical instruments myself, which has resulted in establishing a company together with my colleague Ondřej Merta. In the last year, these activities have become my profession and a way of earning my livelihood.

Kea orchestra

Before I decided to make this basic research, I was involved in a project called Kea Orchestra, which aimed to give various musical (mostly electronic) instruments to Kea parrots from New Zealand and let them make sounds on them. This project was a cooperation between the Art & Science department at The University of Applied Arts in Vienna and the Kea Lab at research station Haidlhof run by the Messerli Institute at University of Veterinary Medicine in Vienna. The project was supervised by Dr. rer. nat. Gyula K. Gajdon. Keas are very curious species and they interact immediately with everything they find.

Within this project, I was able to listen to different kinds of dynamic and rhythmical structures a bird can produce out of curiosity to interact with an object. The aim of the research was to find out, whether there is a difference in the bird's interaction with silent or sonified objects.

While carrying out this project, I realized that the dynamics and time scaling humans are used to in music is strictly human. There are several examples of animals producing sounds just for the sake of producing sounds (such as African gray parrots imitating the sounds around them), but the parameters of such sounds are not musical from the human point of view. However, it might be a humans' intention to use these non-human dynamics and structures in music. This is explored especially in specific genre of experimental music called Biomusic.

Context Aim

Usually every piece of work has a context where it aims to be recognized. In interdisciplinary practice this might no longer be true. One of the things I have learnt during the 3 years at the Art & Science department is that it doesn't matter, whether a work fulfills the parameters of a particular discipline at all. What matters is, whether there is any valuable impact of the work at all. This impact might also be observed in unexpected contexts. I can imagine my work to succeed in various contexts and some of them are more valuable for me than others. And therefore in this thesis I would like to range between the contexts I consider more appropriate than others. The most valuable for me would be appreciation among musicians and sound experimenters and possible impact on the music itself. This is also connected to the possible commercial success of my work when applied on a product level. Although I could see my work easily presentable in the media / sound art's context, I don't seek for a gallery presentation, but rather for its performative or social application. For example to organize a workshop with a performance would be a very nice option for me to present my work.

Research

I decided to carry out an artistic research in the field of exploration of different events and principles, their translation into sound and application in music. I am interested in music exploration in general. Nowadays, the concept of music is being extended by creating new instruments and interfaces. Most of the extensions come from technology however classical musicians are also being inspired by the music created by machines.

Different mechanical, chemical and biological processes produce interesting dynamics and functions. Sensing these and translating them into the language of musical instruments can result in original sound structures that can be used in music. Producing simple technical interfaces enables free exploration of these principles. Because I call this a basic research I am mostly interested in the exploration and experimentation with these principles. Modularity and easy reconfiguration are key factors for limitless exploration. The method also enables messy and unconscious patching between events and processes represented by voltages.

Method

The first stage of the research is about producing technical translation modules to be used as parts of modular synthesizers. There are various form factors of how to design modules for such synthesizers and I have decided to work in the most popular and accessible format today - the Eurorack. Since there are no such modules available on the market, I needed to produce them on my own.

The second stage of the research is the direct exploration and experimentation. I have made diagrams to design understand the principles (see the Principles / Events chapter page 32) . I am making audio and video recordings of these principles and processes.

Hypothesis

The hypothesis is that building such complex machine should deliver a relatively limitless environment with high probability of occurrence of unexpected events, connections and feedbacks. Such findings will lead to more defined hypotheses for the further research.

There will also be potential to create sequential micro narratives between the events which opens a vast field for artistic expression.

Intersecting art, science and business

To define the above mentioned creative process, I use the popular, ambivalent term of "artistic research", since its outcome can neither be seen as an autonomous artistic artifact nor as a

proper scientific research. However, I think the outcome of this research is valuable especially for musicians, sound artists and experimenters. I have already seen some modular synthesizer setups in the gallery context of sound art - for example the works by Gies Gieskes, Alwin Weber or Derek Holzer. I was also asked to show my work at the Essence – a gallery showcase of the University of Applied Arts. Furthermore, many scientific papers on different circuit designs of electronic musical instruments or on digital signal processing have been published in various journals and magazines (such as Signal Processing, Digital Signal Processing, Sound On Sound, Computer Music Journal and many others).

But most interestingly for me, in the online open source communities (such as Arduino, Music From Outer Space, Muffwiggler, Processing, Supercollider etc.) nobody cares whether something is more artistic or scientific. What matters is whether something works or not: people respond to interesting and valuable contributions. When somebody posts an interesting circuit or circuit board design in a forum, there are always users who want to have it and buy it instantly, so the border line between the development and the market dissolves. Because I am owner and creative director of a company (Bastl Instruments) focused on development and production of unique musical instruments, I will work further to apply some of the findings from this research in real products.

Brief look into the history

In this part, I intend to list the key moments of the history relevant for my research. It is an introduction to the current discourse I am entering by means of my work, which is supposed to pose a basis for the following key theoretical part of the thesis entitled "Thoughts". In the first part, I will concentrate on art and music. Second part will be dedicated to modular synthesizers, engineering and science of electronic musical instruments.

This part can be also read as a collection of my inspirational sources and a mention of the artists and scientists who influenced me. The list of all relevant people, projects, companies and organizations together with the reference links can be found in the appendix.

About various real world principles in the history of music and art

I am not sure if I can track back the earliest uses of real world principles in the history of modern music, but usually the story starts with the futurists and Luigi Russolo's manifesto entitled Art of Noises from 1913. He urges to "break out of this limited circle of sound and conquer the infinite variety of noise-sounds" and in another passage predicts electricity to be used in music. Then he went on to create bizarre acoustic noise maker musical instruments and makes compositions for them. Similar thinking can be found in the Russian avantgarde symphony by Arseny Avraamov The Symphony of Sirens composed to celebrate the soviet revolution. Avraamov literally used the whole military machinery: fleets, machines, guns and sirens were organized in a composition. Before the second world war, there was a lot of experiments in terms of sound carried out by the fine arts avantgardes, but as far as I know there wasn't much happening in this respect (besides the use of the first electronic instruments such as Theremin or Martenot waves for performing classical compositions) in the world of serious music.

It gets interesting after the war. Olivier Messiaen translated birds' singing into music. From 1940's on Pierre Schaeffer pioneered Musique Concrète in Paris using recorded and manipulated real world sound using a gramophone and tapes, while Karelheinz Stockhausen pioneered electronic music in WDR Studio for Electronic Music (est. 1951) in Cologne. These pioneers of electro-acoustic music (and their engineers) were especially innovative in using mechanical and acoustic tricks to work with technology not intended for creative use.

1952 John Cages composed his legendary 4'33" where the focus of the music is everything except the music itself and soon he became an intellectual guru of the euro-american music

and art for the next decades. He theorised that modern art is good only when able to adopt all the surroundings in itself. Soon, he began to translate random principles into music in *Music of Changes* (1951). In *Chess piece* (1943) he also turned a chess play (later by duelling with Marcel Duchamp) into music. In *Child of Tree* (1975) and *Branches* (1976) he asked performers to improvise music by using plants. Most interesting was playing on amplified spikes of cactus. He had a large impact on the international art movement of Fluxus and on his students at the Black Mountain College. This is how such principles started to appear in the art of 60's and 70's.

Alvin Lucier was certainly one of the most interesting musicians working with such principles. In his piece *Music for Solo Performer* (1965), he attached sensors to capture his alpha brain waves and amplified them by speakers which were shaking and rattling objects in the concert hall. In his piece *Clocker* (1978) the ticking of a clock was amplified and echoed according either to the skin resistance of the performer, or of a philodendron (very resistance reactive to environment), depending on the version of the performance. Nicolas Collins, one of the most important figures in handmade electronic music assisted Lucier with this piece. A member of the American movement *Composers Inside Electronics* David Tudor (he was also a pianist and John Cage composed some of his pieces specifically for him) created electronic circuits designed to self-destruct themselves during the musical performance, which also determined the length of such composition. Tudor and Collins are especially interesting artists to me, because they composed on the level of creating electronic circuits and then performed on them.

Minimalist generation of composers (Steve Reich, Terry Riley) made huge impact on music by showcasing rhythmical mathematical variations performed on classical instruments. Such sonic experiences can be found in nature, too.

About modular synthesizers

What is a modular synthesizer?

A modular synthesizer is a technical device enabling a free routing of signals from and to the modules of certain functions with cables. These cables are often called patchcords and the process of connecting is called patching. The final functional setup is called a patch. An intuitive way of interconnecting modules, blocks or objects of different functions is the key form factor for the experimentation with sound.

Modular synthesizers allow a natural way for a person creating a synthesizer to divide individual functional elements of the whole synthesizer, test them individually and then interconnect them.

Since this is so natural, most of the first synthesizers made for the market were modular.

Later on the synthesizers left this approach and were manufactured pre-routed, sometimes with a few switches and knobs for the most frequent patching options.

A brief history of modular synthesizers

I will try to briefly mention the key moments of the history of these devices, which I consider important for the current state of art.

The classical US Modular Story

Now we are in the early 60's in the United States of America. In New York there is young engineer Robert Moog, constructing his famous Moog Modular synthesizer. Bob (as everybody calls him in the world of synthesizers) invented the classical way of how a subtractive synthesizer model works (starting with signal full of harmonics that are filtered by a filter). He also established unified tuning standard called Control Voltage with one volt per octave tuning range for his instruments. At first he sold the Moog Modular synthesizer which was a huge rack of modules. It was very expensive piece of hardware and only Universities or recording studios were able to purchase one. When he had all the modules developed, he connected them in the way most of musicians would intuitively use them and created the MiniMoog in the early 70's - the first accessible and high selling electronic musical instrument which also defined the way many of the coming synthesizers would look like. An important feature of Moog design was the use of traditional piano keyboard which made these instruments accessible for musicians. In the meanwhile on the west coast of the US Don Buchla developed his Buchla synthesizer

system. In the liberating west coast atmosphere of the emerging hippies generation, he worked on an instrument which was more intended to explore un-heard sound scales, leaving out the traditional tuning schemes and rather focusing on a liberating way of sonic expression. Also the interface Buchla gave to his instruments looked more like taken from a spaceship than from a musical classroom and that is also how they sounded like.

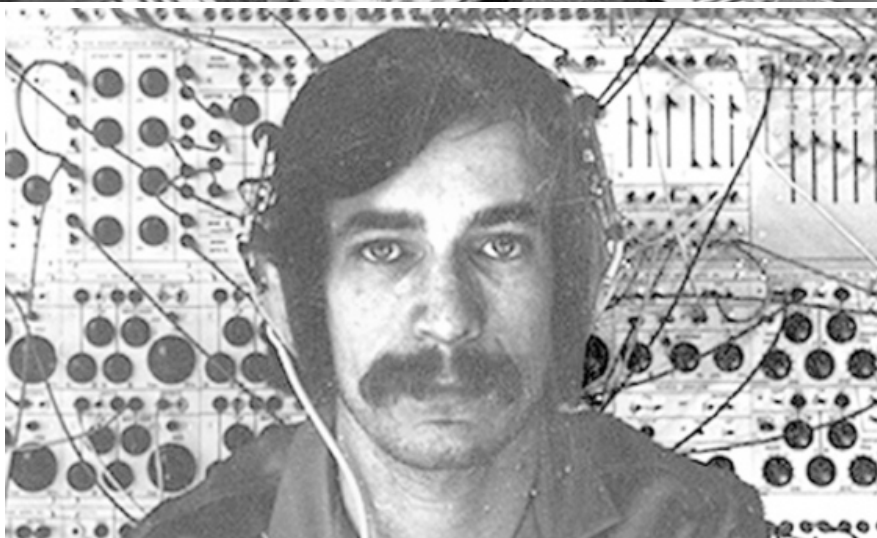
The contrast between the west and east coast approach to electronic music can be shown on an example of two recordings from 1968. The Switched on Bach by Wendy Carlos performed on the Moog Modular was an interpretation of classical Baroque music and a manifestation of the use of synthesizer as a "new organ" with new sonic possibilities. In the Morton Subotnick`s record Silver Apples of the Moon recorded on the Buchla synthesizer, you cannot hear any traditional concepts of western music. You rather experience spiritual, psychedelic and always evolving soundscapes.

In 1971 in London, the EMS company produced their Synthi 100 synthesizer which was used in the BBC studio to enhance the needs of broadcasting and especially influenced the way of how sci-fi stories "sounded like" (most famous is music composed by Delia Derbyshire for Doctor Who).

Robert Moog



Don Buchla



Timeline

1960's

Was the era of Moog modular and emerging new companies for synthesizers such as Buchla, EMS, Korg etc. Various forms of control voltages were used.

1970's

The first non-modular instruments hit the market (such as Mini Moog). 1978 the famous semi-modular Korg MS-20 was released. Electronic music established itself in the music industry.

1980's

Yamaha introduced the DX7 - digital FM synthesizer and the general interest switched to digital synthesizers. Hybrid synthesizers and programmable drum machines were pioneered by Roland. In late 80's analogue synthesizers were getting cheap and were used by musicians to pioneer new musical styles. MIDI standard for digital communication between musical instruments was established in 1983. Computers were widely used in music and 1985 Atari ST with MIDI support became a widely used workstation for musicians.

1990's

In the early 90's the computer software Max (developed from mid 80's at IRCAM) was released commercially and later developed into open-source Pure Data. It was a software modular system for visual programming and interaction between objects. Due to its open source nature, it became widely used by musicians and developed by online communities.

The hype of electronic dance music created thirst for discontinued analogue synthesizer again. In 1994, Dieter Doepfer from Germany made MS-404 analogue MIDI synthesizer and earned great success. A year after, he introduced the A-100 modular synthesizer system which established the most used modular synthesizer format - the Eurorack. A unified form factor enabled users to create cross manufacturer customisable musical instruments.

2000's

Computers were widely used to create music. Software emulations of analogue synthesizers became very popular. Software and plugins used with USB and MIDI controllers to add haptic feeling to the software became a big part of the electronic music instrument market. Open source got fashionable and people started to share codes and schematics online. In 2005 Arduino prototyping platform was introduced which boosted the interest in open hardware and also brought new energy into DIY synthesizers. In 2006 a book Handmade Electronic Music: The Art of Hardware Hacking by Nicolas Collins was published and inspired many people and boosted the "Circuit Bending" phenomenon. Musicians and artists began to develop their own hardware for performances widely (such as Onyx Ashanti, Imogen Heap and many others).



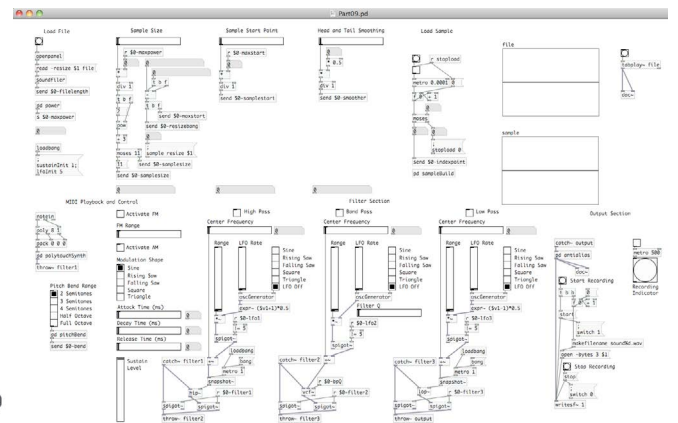
Korg MS-20



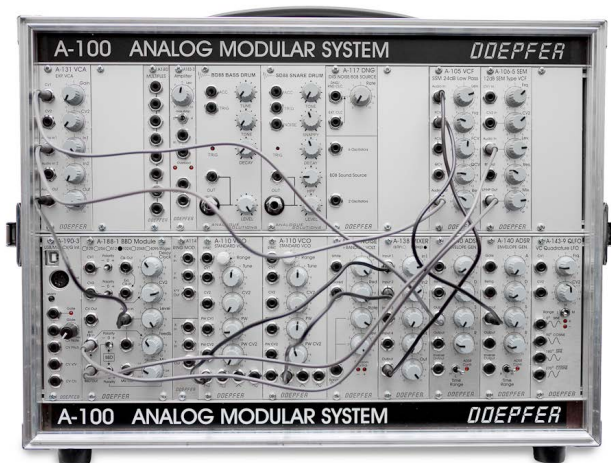
Yamaha DX 7



Atari ST



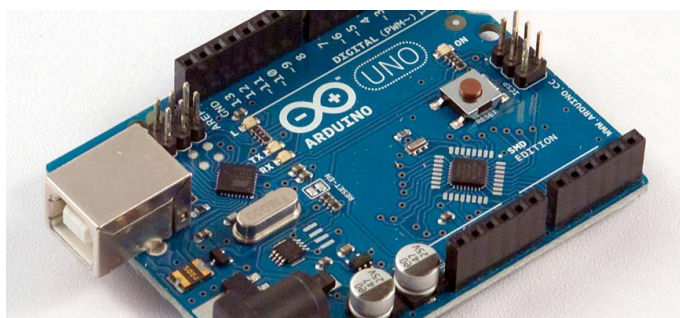
Pure Data



Doepfer A-100



Circuit bent Casio keyboard



Arduino



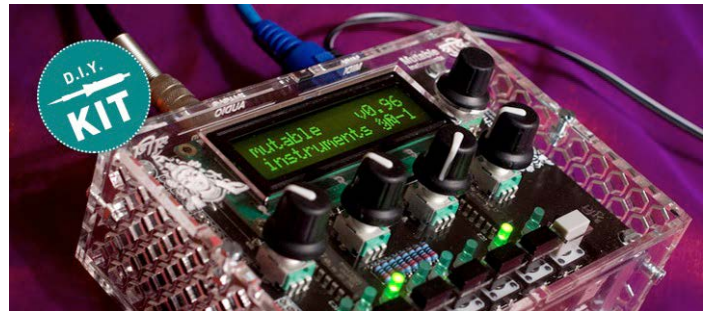
Onyx Ashanti

2010's

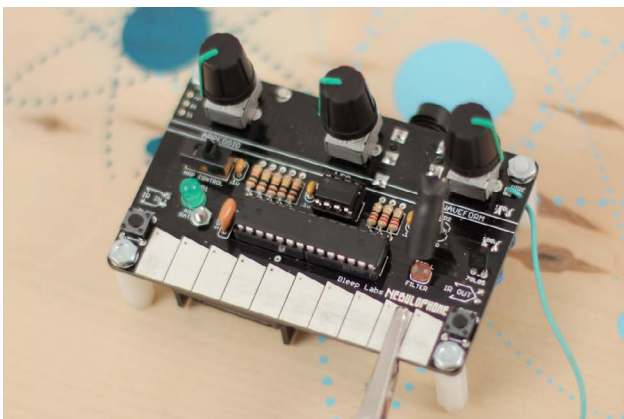
A lot of electronic musicians are moving from software back to hardware instruments and bigger companies start to reflect this trend and also modular synthesizers are becoming very popular again. In 2010 Korg started to sell Monotron – a small cheap analogue synthesizer that was designed to make it easy for hackers and circuit benders to expand its functionality. Korg also published the schematics for the Monotron and also released their first open source hardware project in cooperation with Little Bits in 2013. In 2010, Mutable Instruments launched open source hybrid synthesizer Shruthi sold only as a DIY Kit and also many other manufacturers start to sell DIY kits and share their inventions.



Korg Monotron



Mutable Instruments Shruthi DIY Kit



Bleep Labs Nebulophone



Bastl Instruments MicroGranny 2.0

Outside of the official time line and the western history look

Because I come from the eastern part of Europe, I cannot mention that in the post-communist countries there was a lot happening under the hood, too. Of course the mentioned success stories of western companies developing synthesizers and becoming legendary and sustainable at least in a way that they sustained up until nowadays is important. The East German company Vermona should be mentioned as an interesting story of a company for electronic musical instruments. Vermona produced a lot for the soviet region and decayed after the fall of the regime arguably because it was not ready for the world of aggressively competitive western companies. However, Vermona and former employees of the company took their know-how and jumped back into the market as a maker of exclusive and rare analog synthesizers and also modular synthesizers. Maybe that is the reason why East German producers are becoming such a vivid and active part of this specific market today.

There was a lot happening in Russia too and the Russian synthesizers such as Polivoks are very appreciated among the collector of synthesizers. The current Austrian documentary movie "Elektro Moskva" tells the story of the reality of making these devices as side products of the military industry.

If I could speak for my region of eastern Europe, I would tell a story about the powerful DIY scene that was flourishing in the communist times not only because people wanted to build what they couldn't buy, but also because the society was not driven by the strict division of producers and consumers and the people were simply both at the same time. The market economy wasn't pushing anybody to the "do not repair - throw away - buy new one" model. Rather than a market for electronic musical instruments, there was something we would call today an open source database of schematics published in many magazines. People could just make and modify them if they wanted, so you can find many instruments that are one of the kind pieces.

Regarding Czech Republic, I have to mention the so called Bastl generation (now 50+) that metaphorically grew up with a soldering iron in hands. One persona of that generation, Standa Filip was a maker of unique electric guitars, drum machines and other electronic instruments (lo-fi modular too). He also inspired me to start to make my own instruments and in general the eastern point of view is crucial for me as a maker of such instruments.



Polivoks



Standa Filip

Thoughts

This chapter is my contribution to the current discourse and can be also read as my artistic statement. I called this chapter simply Thoughts, because it is important for me to write down concrete thoughts about my work to orientate myself more easily in my priorities and directions. The following is a collection of my current hypothesis and statements.

Music is not sound

This claim is ironic in relation to the modernist view of music, but nowadays it is true more than anytime before and I will try to explain why. To me, music is a social interaction using sound as a medium. On quite a wide scale people do not distinguish in music according to classical musical qualities such as harmony, rhythm or instrumentation. Usually, when people have musical preferences, it is a part of their lifestyle and marketing quality of such musicians. Pop musicians are people fulfilling such lifestyles. Even in the underground type of music, the aura of a legendary DJ, producer or band doesn't necessarily correlate with the musical innovation or sound qualities they can produce, but very highly corresponds to the enjoyment and expectations of the audience of the performance. Therefore the aura and the social importance of a musician count for the musical quality.

Today we are overwhelmed by a high number of possibilities when it comes to creating sound electronically. Computer software is easy to obtain and there is more or less no limit to the sound they can produce, although many people claim that computers can never sound the same as analog synthesizers or especially drum machines. I don't think it is not true anymore and it seems rather as a marketing trick. Computers surely can emulate anything in sound. Back in the days we could talk about specific electronic instruments "defining the sound of...".

"Yamaha DX7 defined the sound of 80's."

"Roland TB 303 defined the sound of Acid House."

I do not think that this model is still possible today either. Although we can see these old truths to be used in the mass marketing today, there is not much innovation regarding the instruments produced by the big companies. As for the sound and for the ways you can play them. Now,



the innovation is coming from the artists and musicians who became engineers and are able to satisfy their needs for unique instruments and interfaces.

I count myself among musicians that got horrified by the countless software plugins and the limitless possibilities of computers in music. When there is too many routes to go, you do not know which one to take anymore. This is one of the reasons why people are shifting back to electronic hardware instruments.

Software and Hardware Modular

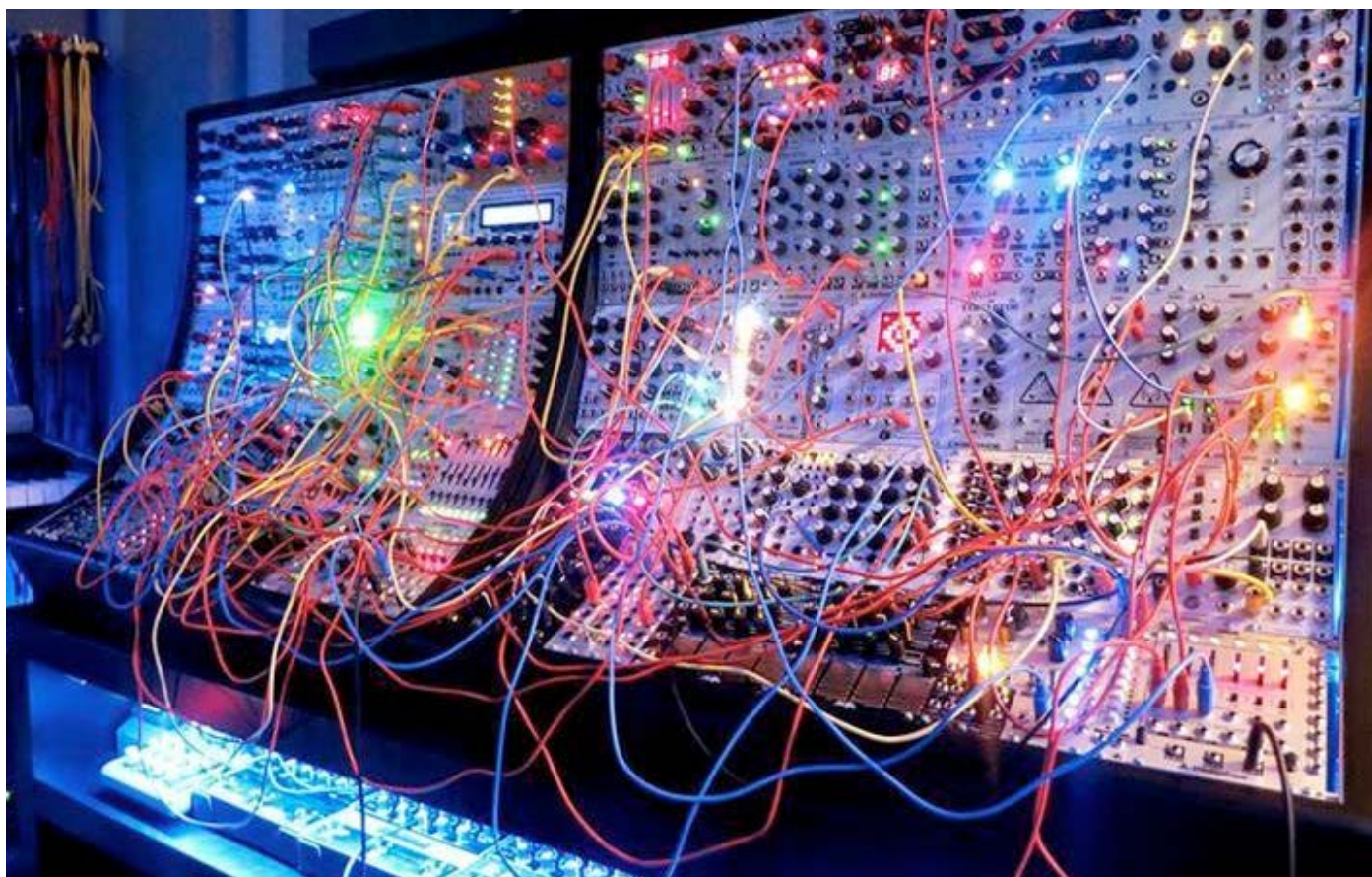
In the mid 80's, Miller Puckette developed a computer software called Max (later transformed to open source Pure Data) which enabled the users to visually program patches by connecting functional blocks to create custom instruments for music, video or almost anything. Thanks to talks with people involved in the community driven development of such software tools, I know that actually creating the instrument and the patching was often more exciting than using the instruments for a subsequent performance with predefined controls. Therefore a form of musical performance called live-coding emerged, where creating the instrument on the fly is part of the music. Also the visual appearance of such patches is appealing.

From the very beginning of this phenomenon, the users have been connecting hardware controllers of different kinds to control the parameters of the patch physically rather than by using a computer mouse and a keyboard. But the patching itself remained mostly in the domain of the mouse. This in-depth approach of making sound was also implemented into several user friendly softwares including apps for smartphones (for example Reactor, Max for Live, Audulus etc.).

After the end of the 90's , when the analogue hardware modular synthesizers became popular again, a lot of people started to shift from the virtual patching to the real world patching. The real patching is much more fun and can be easily used as a musical performance technique. It also makes you lost in the machine, in the wires, in the principles. The visual side of such hardware synthesizer is also visually way more appealing than the software, thanks to its physicality. It is also much less frustrating to start to "play such synthesizer" than to learn the "visual programming".

I think that for most of the people, who purchase a modular synthesizer, the computer represents a working tool. Therefore, when they want to relax, make music or occupy themselves with their hobbies, they want to leave the computer in favour of a different realm to not to be distracted by anything.

Despite the fact, that hardware module are often very expensive and cannot be multiplied just by a click of a mouse, people tend to build big systems. With every module coming from a small manufacturer somewhere in the world, they also get a little story behind the product.



Charm, Trans and Obsession in the Modular

What I find especially fascinating about modular synthesizers is that many people do not use it to produce a finished piece of music. From my personal experience, I can spend hours finding out various different combinations, tweaking the knobs and working out my own patch. In this activity, the brain gets into a trance, hypnotized by the sound and motivated to explore further. It might get so exciting to explore and experiment that you just do not want to spoil it and record a specific piece of music. Modular synthesizers provide hours of long sonic pleasure, but only for one person at one time.

Playing such an instrument makes you think in very abstract terms of signals influencing each other so you can get absolutely distracted from the stress of everyday life. I could even talk about moments of transcendence, when certain sounds appear as miracles out from behind what you can grasp with your reason. This getting lost in abstract fantasies and sounds can very easily grow up into obsession.

There is absolutely no need to be a musician to enjoy this. Anybody can do it and achieve such a state. Modular synthesizers have simply everything! I think they are a very hot candidate to become one of the most popular hobbies next to model building or RC cars.

Being a manufacturer of fascinating modules that keep pushing you into exploration certainly requires a lot of aesthetic and creative thinking, especially when you try to see the machine as a link to inner meditation. Some of the following principles I explored in this research have a big potential to do exactly that (such as the pulse sensor).

Humans Imitating and Misusing Machines

Interesting recent trend across different human activities is concept of humans imitating machines. In music it is especially strong concept which became very popular with beatbox. Recently bands such as Austrian Elektro Guzzi play club dance music that we know very well but they perform it on classical instruments as if they were imitating the classic workflow of working with drum machines and sequencers. One of my most recent favourite bands Dawn of Midi plays acoustic instruments in very mechanical way almost achieving trance states which is touching something deeply human.

I think that by creating and using machines people get inspired. The machines themselves enhance human thinking especially when somebody finds a way how to use machine in a way that was not intended by the designer. This was happening from the very beginning of electronic music. This phenomenon was also reflected in the post-digital theory. So called glitch artifacts tend to reveal the nature of digital algorithms. Exploration of such artifacts was exposed by the visual programming (such as Pure Data) and methods of trial and error. Similar tendency to reveal such artifacts might be found in the modular synthesizers. These synthesizers were already repurposed for video signals and with my effort can extend into real world. I hope such extensions and interfaces will enforce a lot of interesting experiments.

Playing music along with a system

From my experience it is very interesting to play on a musical instrument along with some sonic events happening on its own in the real world. Such experiences should be made instantly available with my extensions to the modular synthesizer. Although you can get very similar musical structures by electronic emulation of almost any real world event, the visual connection to the real process and the consciousness that these things are not just arbitrary soulless emulations makes this experience much more enjoyable.

Technical details on specific modules

This chapter serves as technical description of the development of the translational modules I developed as first part of the research. I include short user note, pictures and schematics (if completed for specific module).

ASCM - Analog Sensor Calibration Module

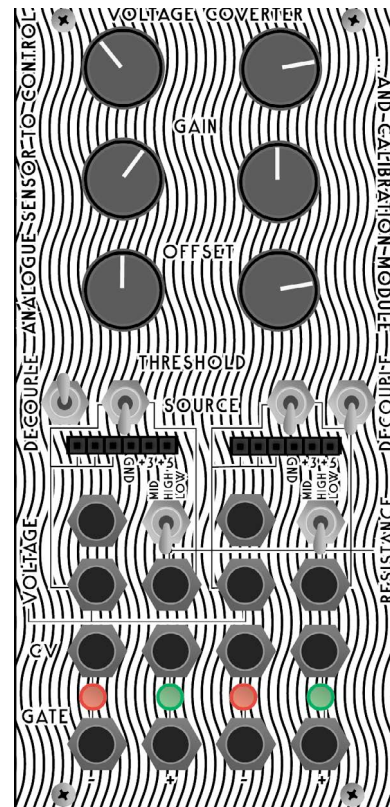
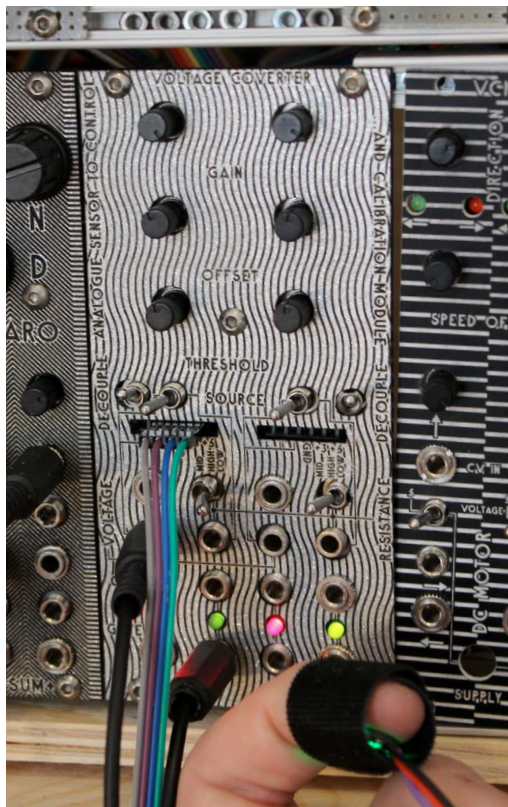
ASCM is designed to read voltages or resistance of all sensors based on outputting analogue voltage or variable resistance and translate them into CV and Gate signals.

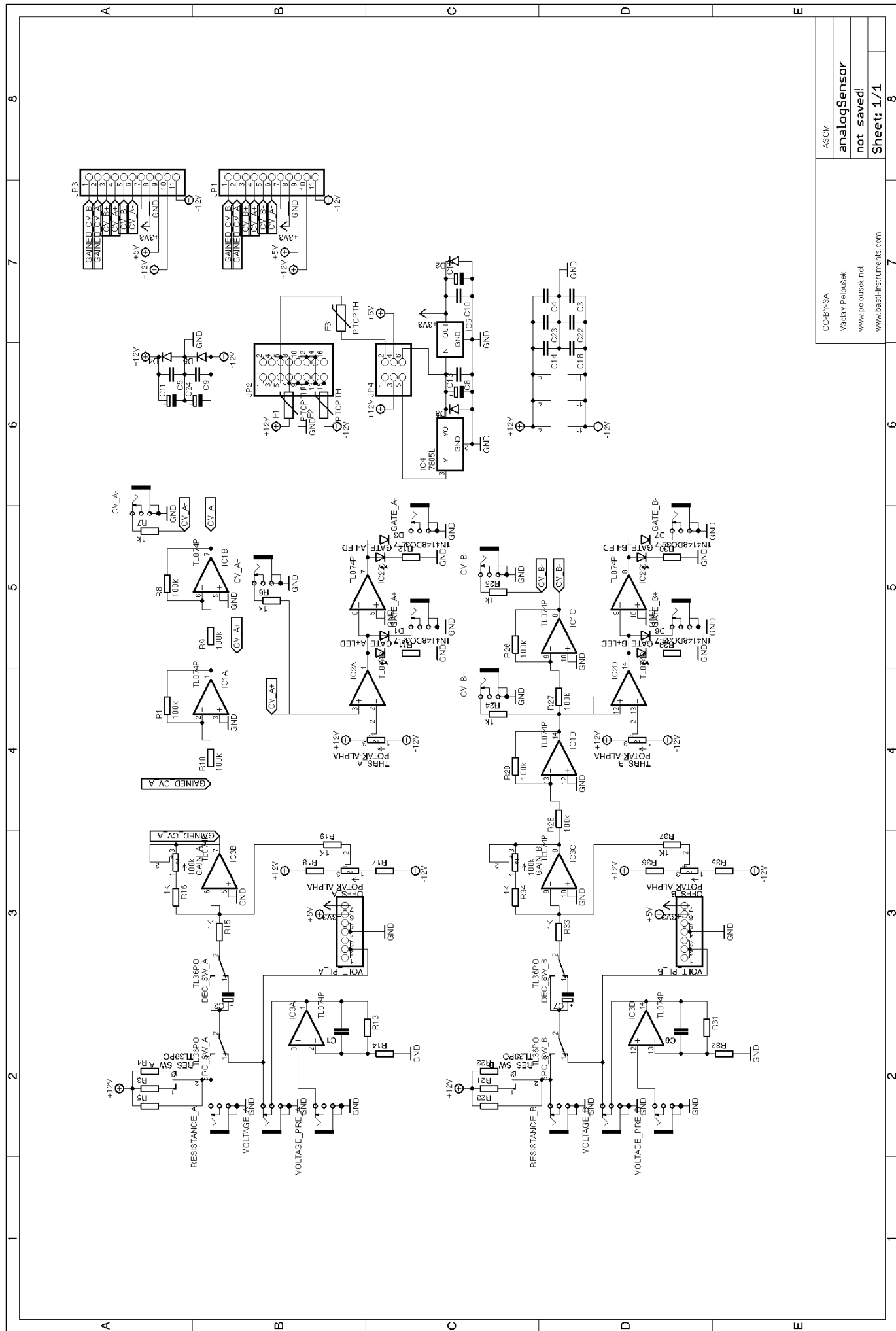
Calibration

- 1 - Set the gain of the signal
- 2 - Set the voltage offset of the signal
- 3 - Set gate threshold

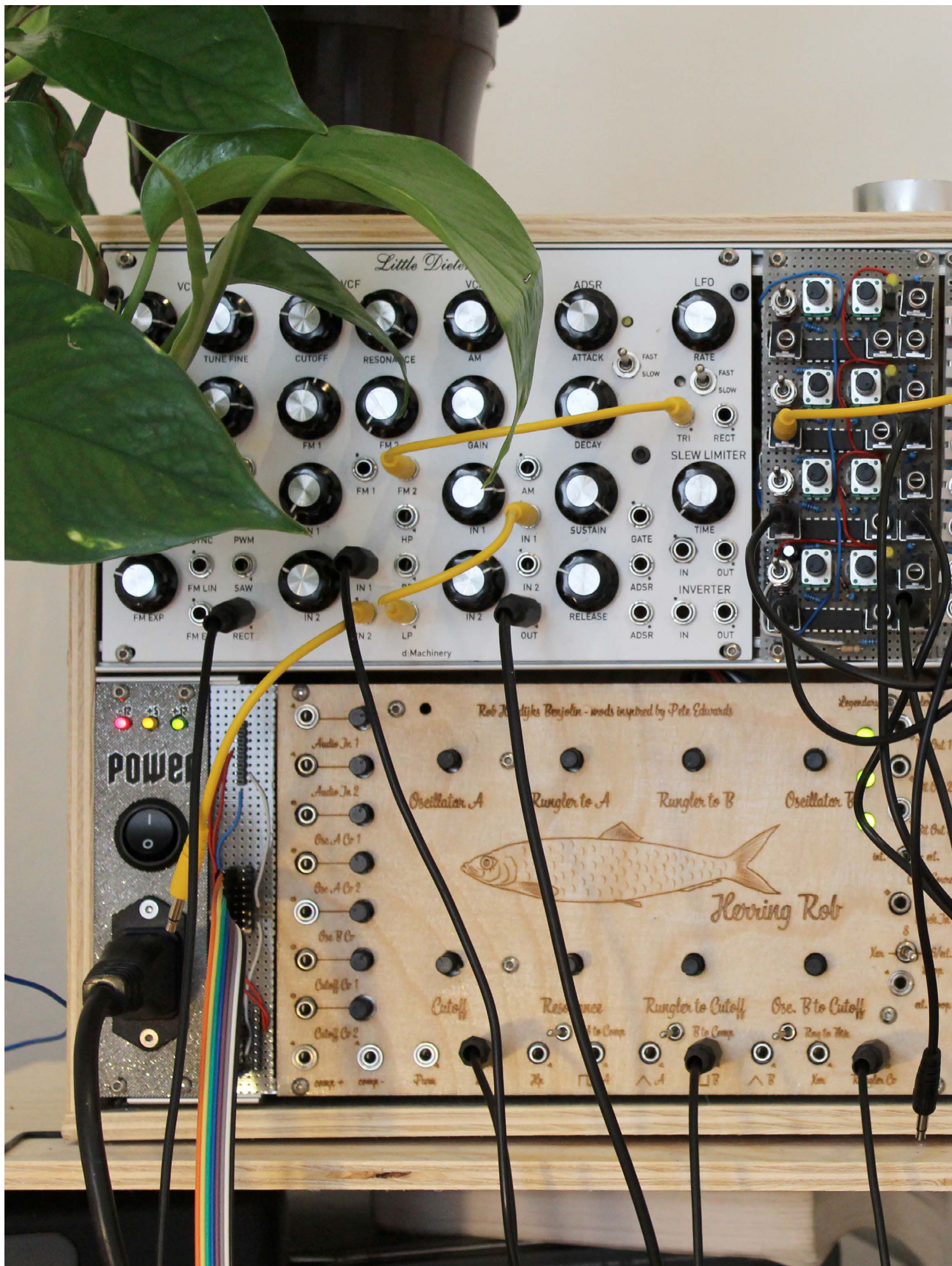
It is necessary to set up the switches to the desired configuration, too.

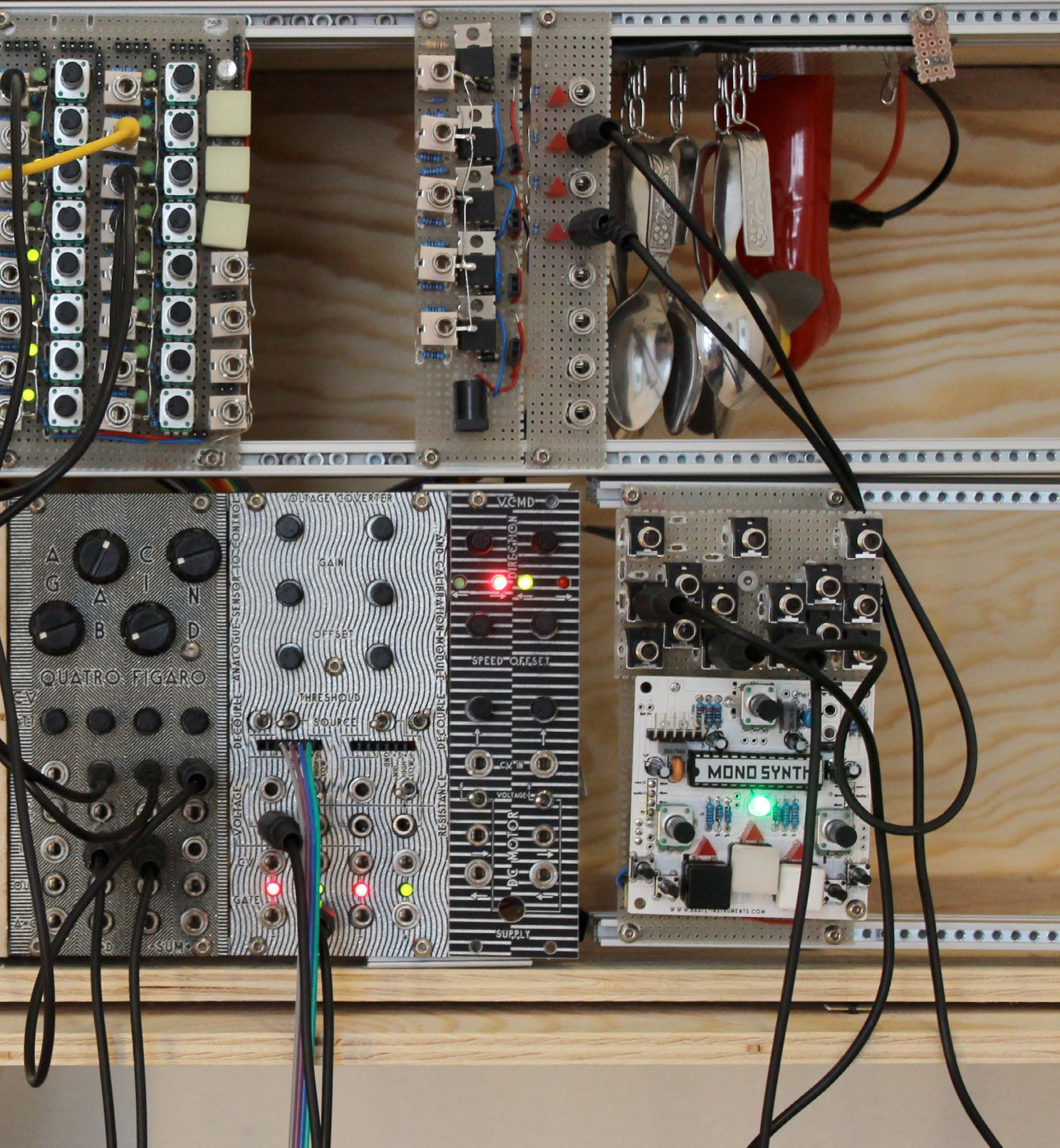
- 1 - Select between voltage based or resistance based sensor
- 2 - Select whether the signal should be decoupled or not (decoupling is great option for faster signals - pulse sensor, electromagnetic field)
- 3 - Setup pre-amplification (for non-amplified voltage sensors such as inductors, microphones etc.)





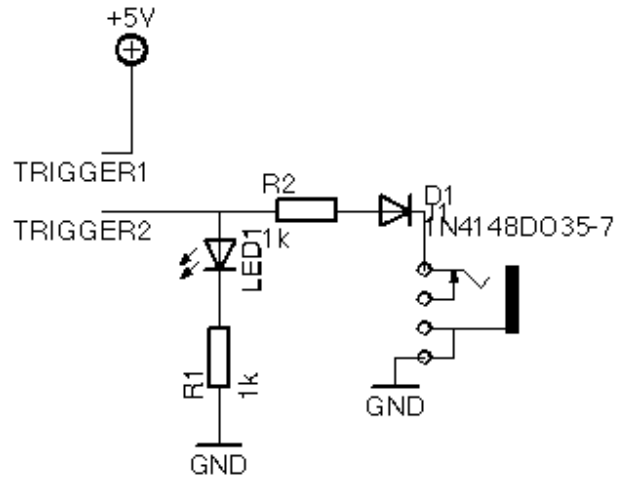
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Václav Peloušek	analogSensor
www.pelousek.net	not saved!
www.bast-instruments.com	Sheet: 1/1





Simple Trigger

This circuit is used for generating simple trigger signals when two conductive poles touch each other. This is used in the Wind Chimes Trigger Generator or in the Hamster CV and Clock Generator.

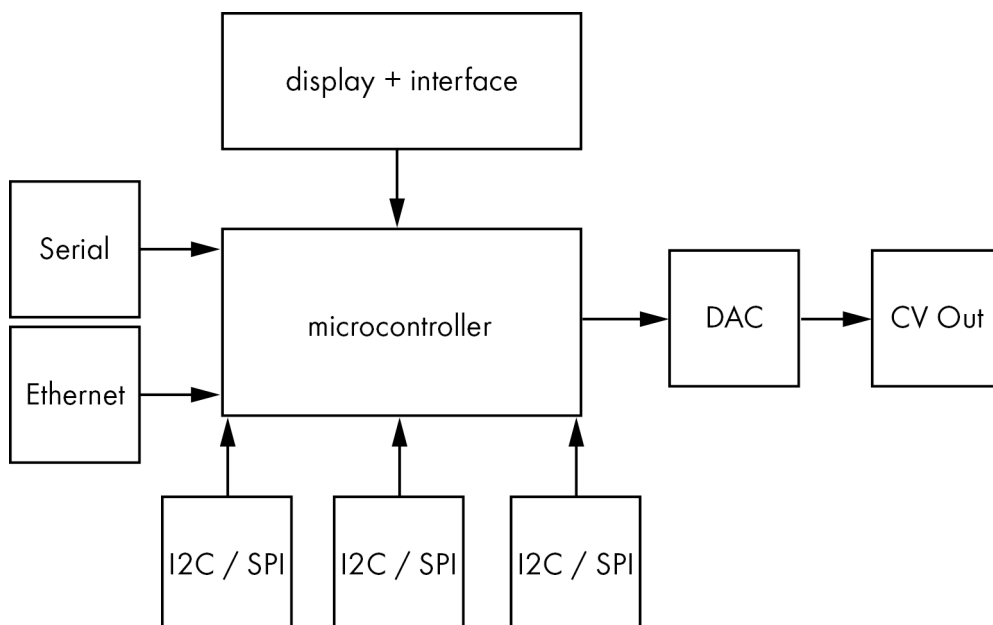


DSCM - Digital Sensor Calibration Module

This module exist only in form of a sketch, but is technically doable. It is designed to read most of the available digital sensors of the most common digital protocols (I2C, SPI, Serial, Ethernet) and convert the data from the sensors into CV.

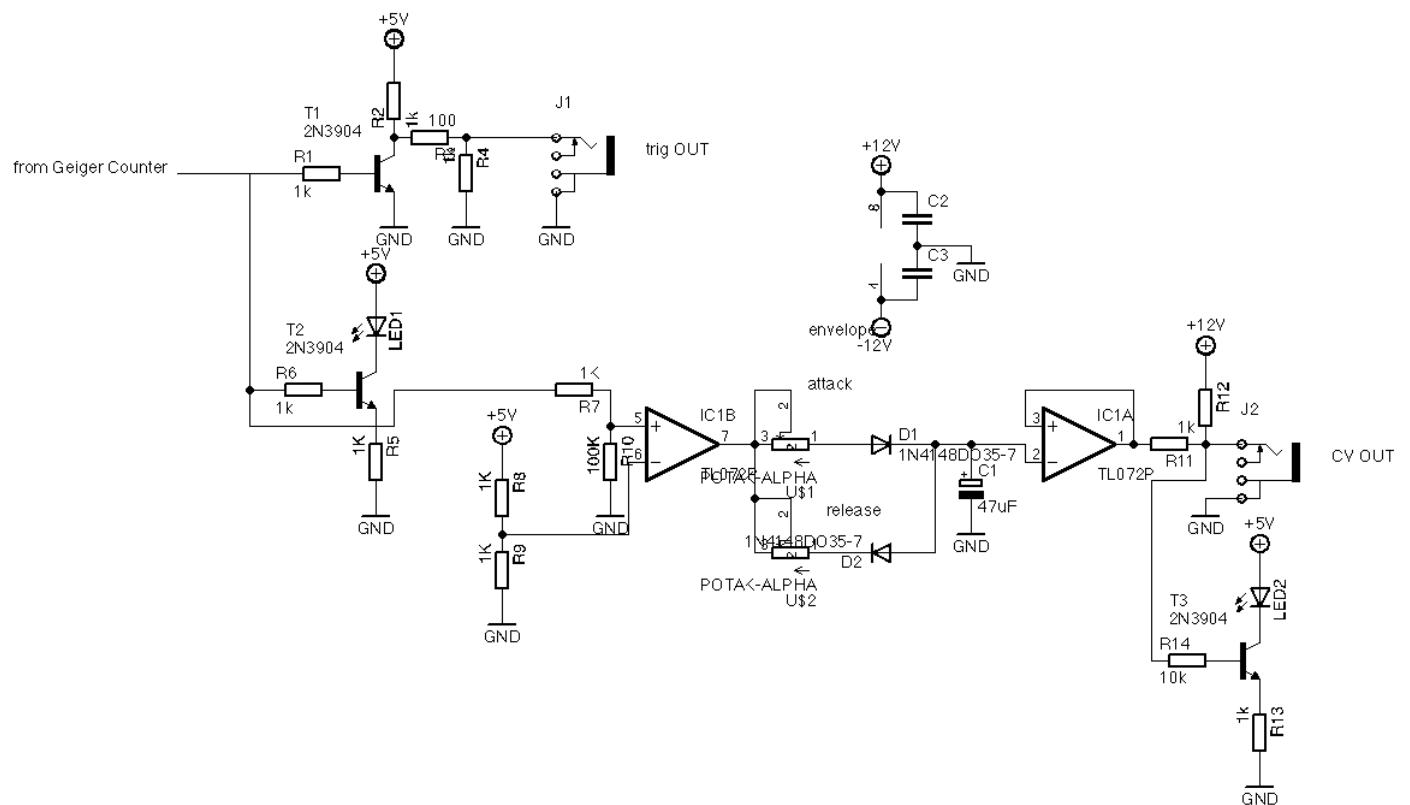
This module provides a lot of narrative potential because of the possibility of use of data being streamed over the internet in RSS feeds. For instance with this module you could be able to trigger your drums by airplanes being airborne in different countries and sound modulated by radioactivity in Japanese rivers. The amount and type of data this module can interpret into CV is limited only by the existence and accessibility of such data.

Many advanced motion sensors can be interfaced by a bluetooth to serial converter.



Geiger Counter to Trigger and CV

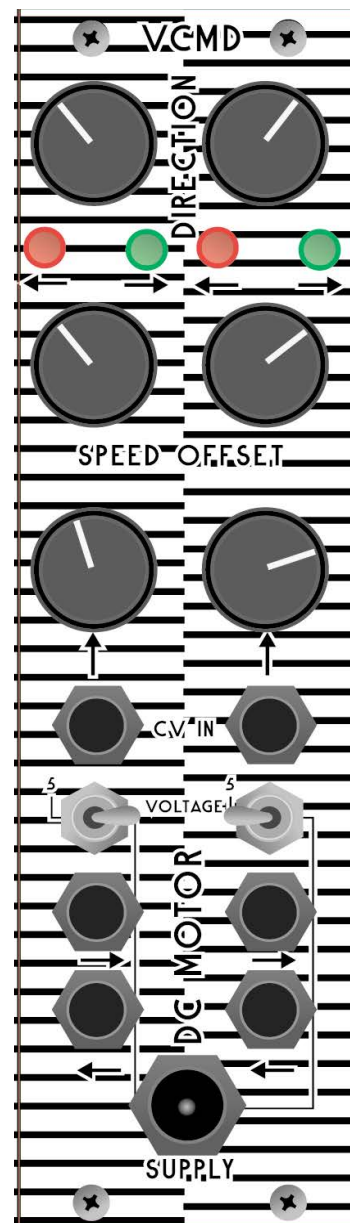
This module converts detection signals from Geiger Counter into standardized CV trigger signals indicated by LED. It also has configurable envelope for CV representation of the radiation amount.

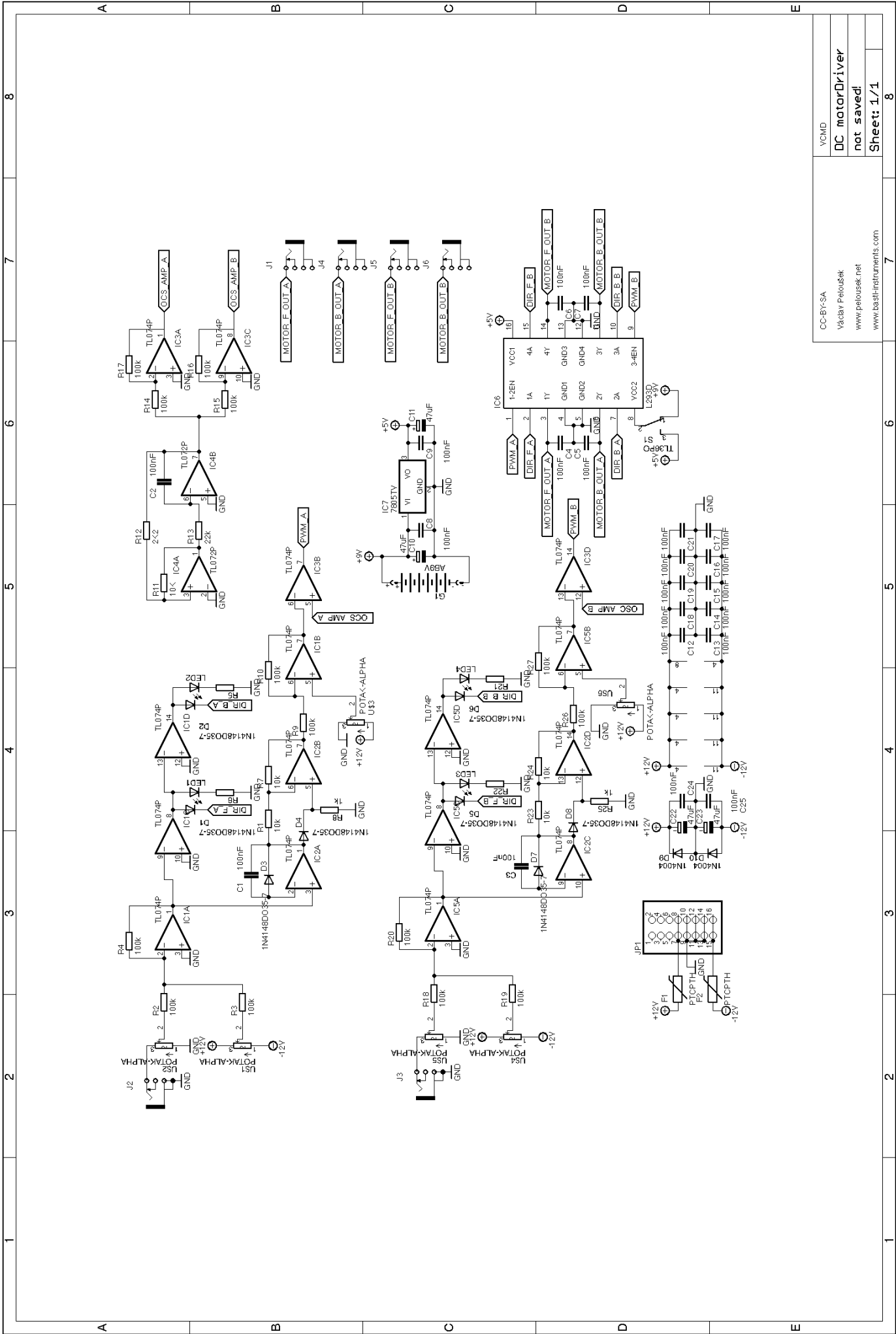


VCMD - Voltage Controlled Motor Driver

This module delivers 2 channel fully analog conversion from CV to DC motor driving signals. It is bidirectional and continuously responsive to CV in terms of the final motor speed achieved by PWM technique.

The interface consist of Directional Offset which can also convert unipolar CV into bipolar, Speed Offset to adjust the initial PWM level for adjustment for individual motors and CV attenuator. Simple switch is used to select between regulated 5V motor power supply or direct connection of the motor driver to the connected power supply. This module is useful for driving fans, simple motors or for moving with CD-ROM drives.

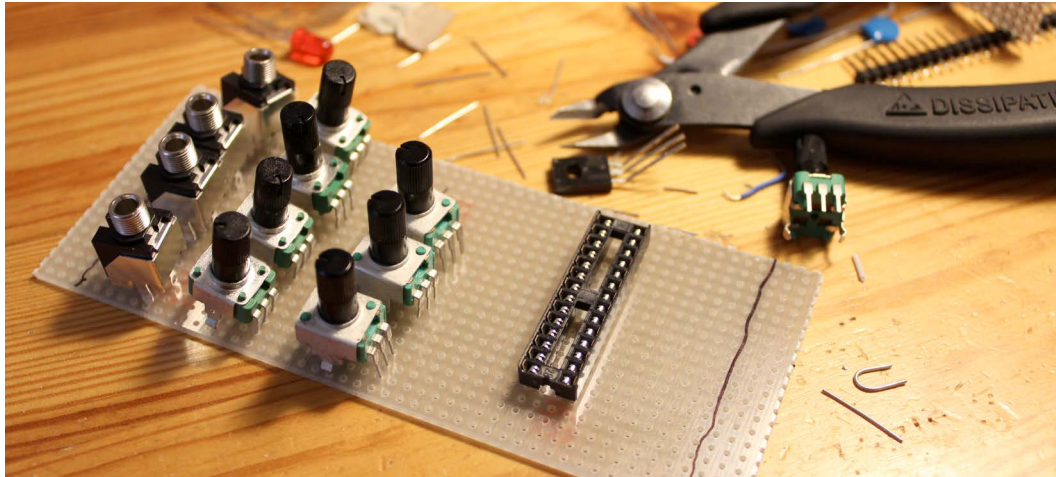




CC-BY-SA	VCMD
Václav Peloušek	DC motorDriver
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www.bast-instruments.com	Sheet: 1/1

CV 2 Servo

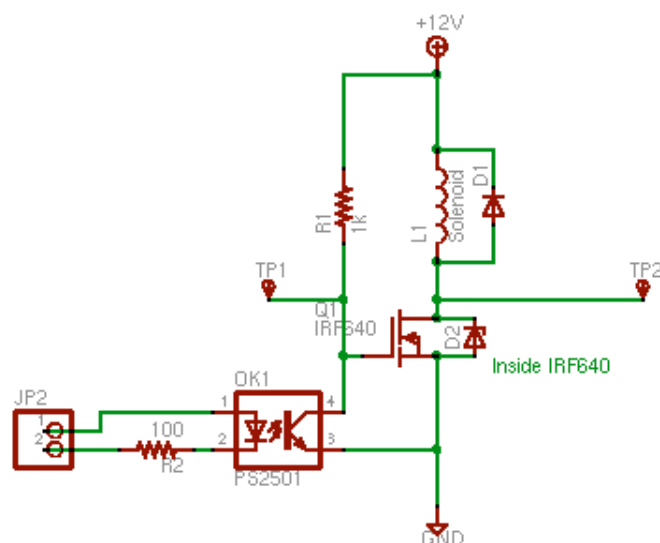
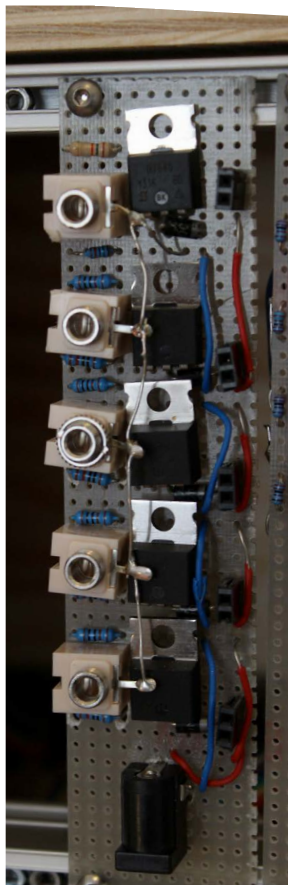
This module is a conversion from CV into servo motor movement. Servos are controlled by giving them an information about the angle. To calibrate the servo motor to proper response to CV there is an CV attenuator and offset parameter. This module can also responds to trigger signal that result into the popular servo triggers for drums.

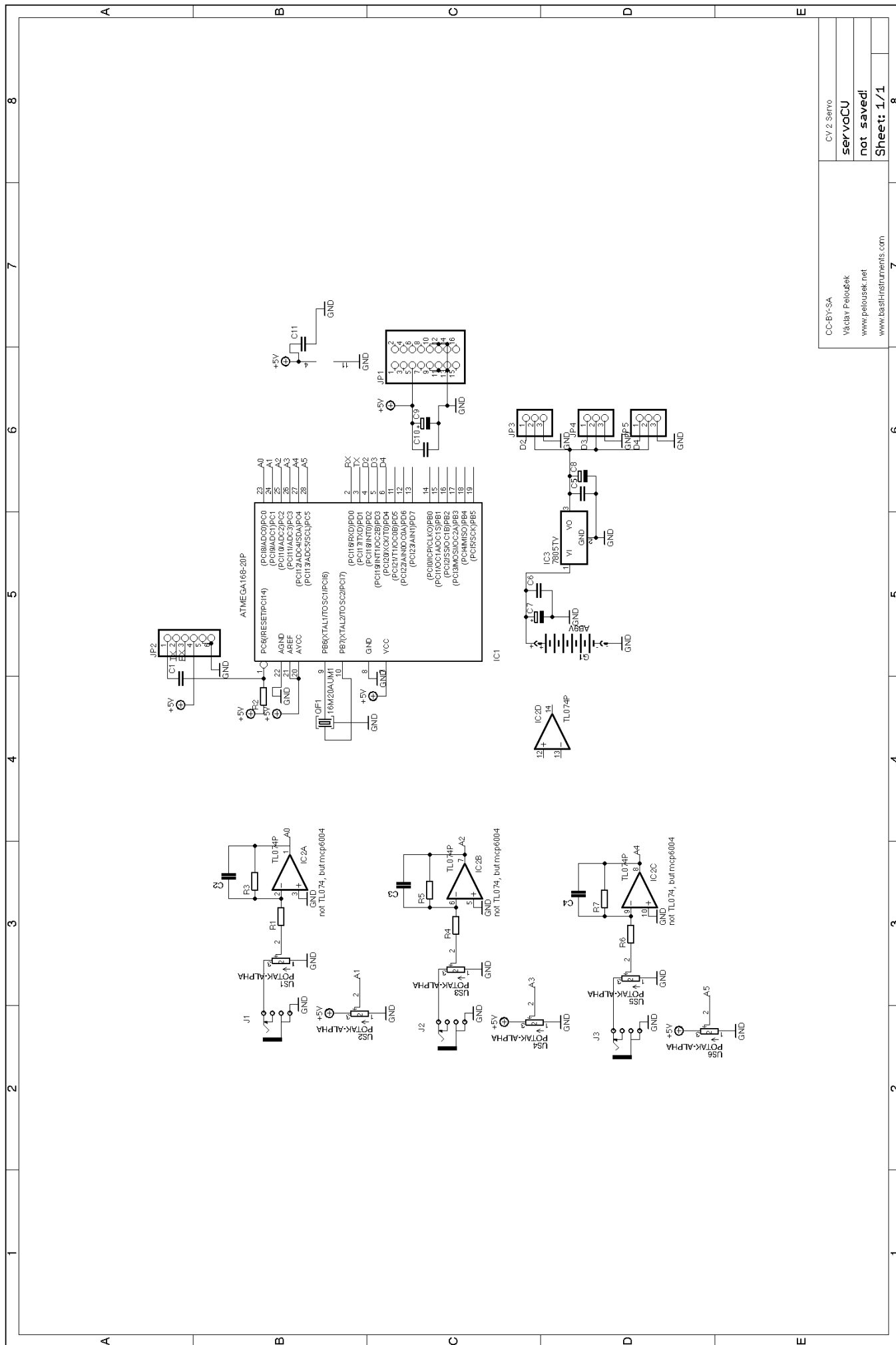


4 channel version of CV 2 Servo under construction

Trigger 2 Solenoid

Simple amplification of trigger signals into high current signals provides enough power to trigger solenoids. This might be used in variety of applications. Circuit version with optically isolated inputs is advisable for larger motors. This circuit is taken from the official Arduino playground.





Principles / Events

In this chapter I would like to describe the principles and events I have already tested or will test very soon. By connecting these principles with each other I can create systems and small poetic narratives. I am listing also principles / events I have not tested yet.

Biological

Fish gates fig 1.

Strong source of light above an aquarium with fish results into shadows underneath the fishes. These shadows can be easily sensed by light dependant resistors to act as gates. As extension CV controlled feeding machine can be mounted on top of the aquarium simply by attaching a food can to a servo motor controlled by the CV 2 Servo module.

Hamster Clock and optical CV Generator fig 2.

Spinning wheels designed for hamsters often have regular wires along the whole diameter of the wheel. Therefore when a hamster is running in the wheel simple trigger can sense the impulses. Such wheel can also be extended by attaching a foil with printed optical patterns that can be sensed by a light sensor to achieve various low frequency oscillation patterns.

Philodendron Theremin fig 3.

Philodendron is famous for being very responsive to outer stimuli such as presence of other species. The response can be easily measured by attaching electrodes to the plant and measuring resistance. Philodendron was used in some compositions by Alvin Lucier.

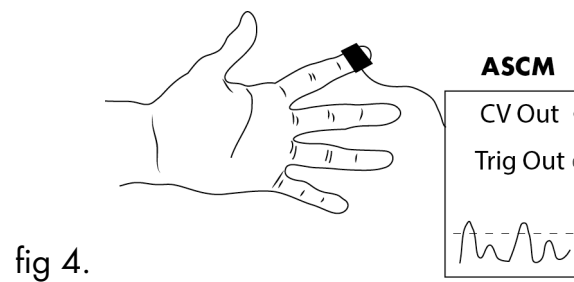
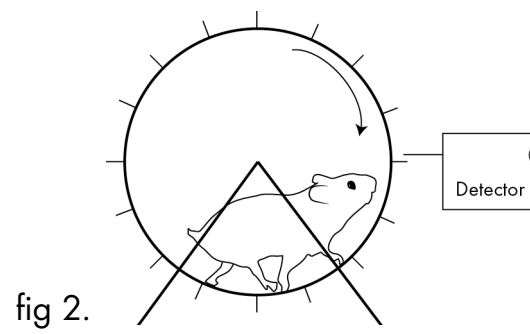
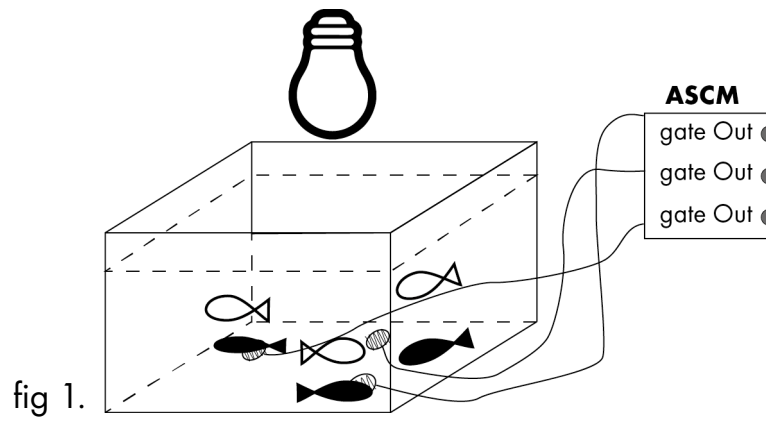
Pulse sensor fig 4.

I have been playing a lot with the pulse sensor using ASCM to translate it into the trigger / clock signals and CV signals. When the heartbeat is used as master clock for generating rhythms and I play along with some instrument it is especially fascinating and hypnotizing. I could play like that endlessly for hours.

Off-beat anecdote

I was recording a video with bass guitar and my pulse connected to modular synthesizer in a way to generate rhythm. This was meant to be a sketch video of how such video could look like, but something very interesting happened. Something I haven't notice at all while recording the video. When I was trying to make final phrases I reached behind to adjust the mixer to pull down the volume of the beat. When I moved my arm back I found myself not intentionally pulling some cables. I tried to get rid of them and to make the final tones on the bass guitar. That is what I experienced and how I remember it.

But when I saw the video I realized that the moment of being distracted by pulling the cables produced another beat of my heart which was out of the rhythm. I would have known if something arrhythmical happened while playing but I haven't! This made me think that the rhythm



when so connected with the heart gives me the timing. The time consciousness so important in music might be delivered by the heart beat. Maybe the time perception itself has a strong connection to the heartbeat.

Lie sensor fig 5.

Lie sensor is measuring skin conductance of a person. When a person is stressed or has some other stimuli the sweating of skin increases and therefore the skin resistance lowers.

Chemical

CV controlled flame CV generator fig 6.

Any flame can be giving variable light, temperature and gas data that can be converted to CV by using basic sensors with ASCM. Producing wind nearby alters the generated CV.

Radioactivity trigger and CV generator fig 7.

Geiger counter was one of the first measuring devices using sound as the main output. The typical clicking of a geiger counter can be used as a trigger signal or can trigger simple slow envelope to get representation of the radioactivity amount in CV.

Lava lamp random generator fig 8.

Lava lamps were used by Silicon Graphics to create hardware random number generator. By attaching several light sensors to the lamp and summing the voltages, slow changing random CV generator is made.

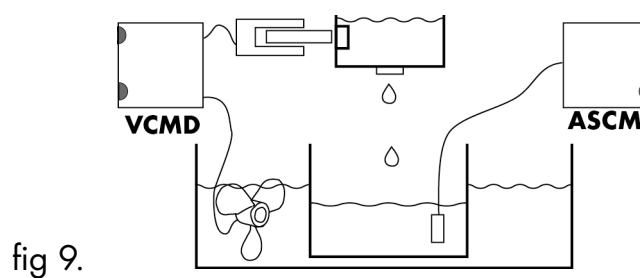
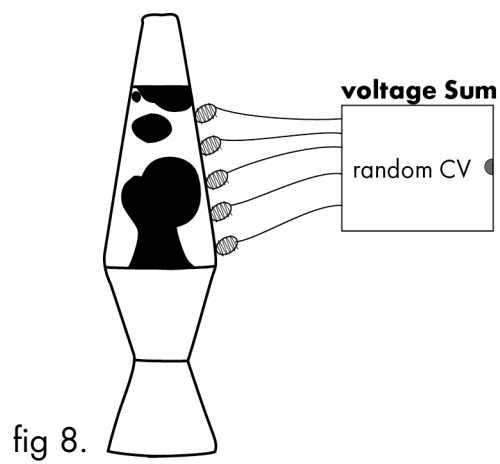
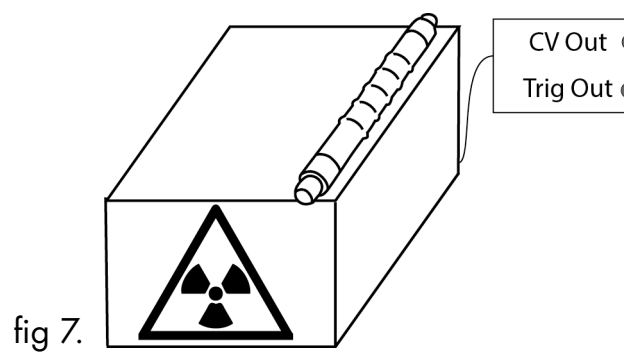
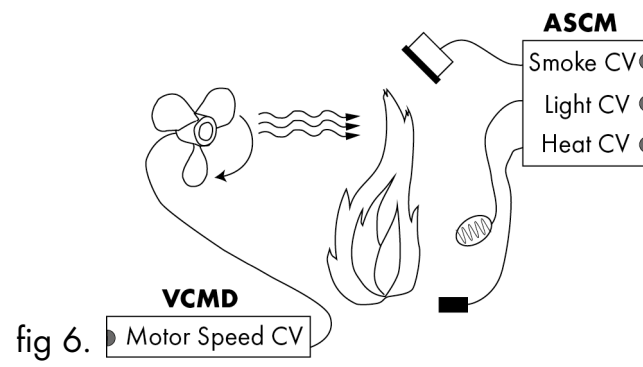
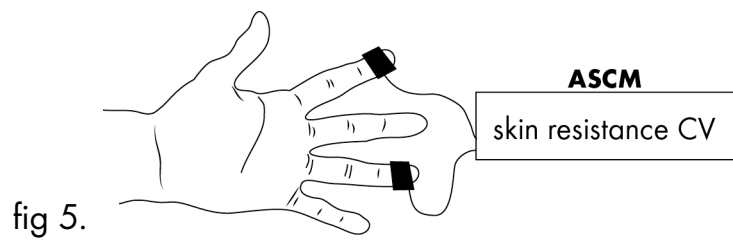
Thermochemical Envelope Generator fig 9.

I was not able to test this principle because I haven't figured out yet the best chemical components to be used. In principle when chemical A is being dropped in to chemical B a thermal reaction begins. A temperature sensor records the temperature change which is being converted into CV. To make cooling of chemical B faster a cooling tank with water and a propeller might be added.

Other

Light amplified electromagnetic field sonifier

Amplifying an inductor results in sonification of electromagnetic fields coming from various device such as laptop, phone, speaker etc. The amplification might be controlled by another sensor to create a micro narrative.



Mechanical

CV controlled Bow fig 10.

Continuous movement ideal for bow playing can be achieved by attaching a violin bow to a CD-ROM drive (controlled by the VCMD module) or to servo motor (controlled by CV 2 Servo module).

Fan VCO fig 11.

This module was originally developed by Gijs Gieskes who is a big inspiration for this whole research. The light passing thru a CV controlled fan (by VCMD module) is gated by the propeller and results into audible signal (when sensed by light dependant resistor and amplified by the ASCM module).

Water drop clock generator fig 12.

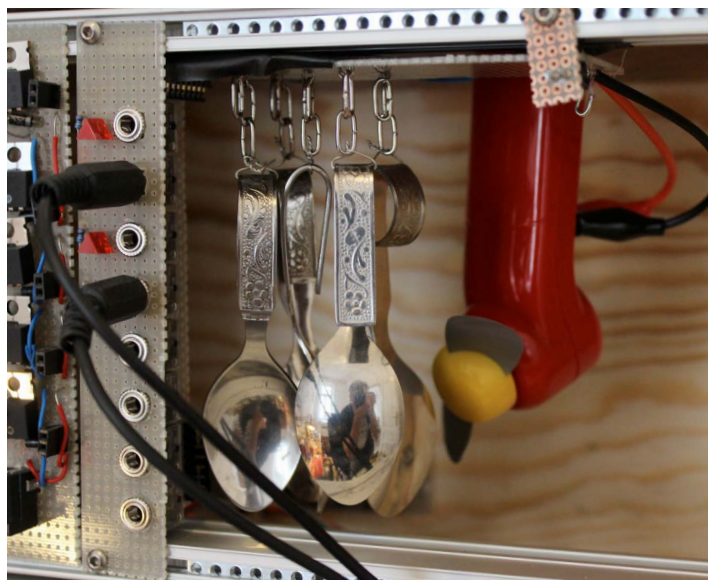
Dripping water is one of the most familiar repetitive rhythmic structures found in nature. When the water drops hit piezo sensor and the signal gets amplified it can be used as a source of a tempo. The tempo is then adjusted by the tap.

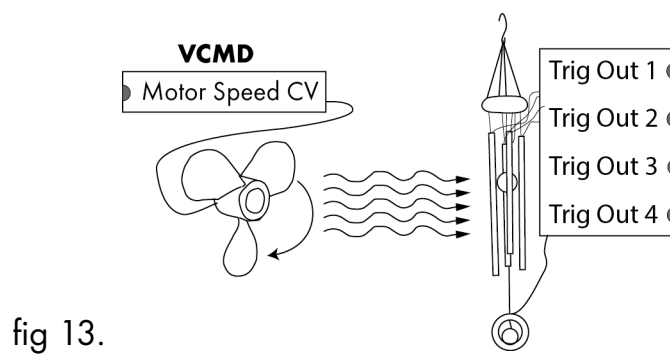
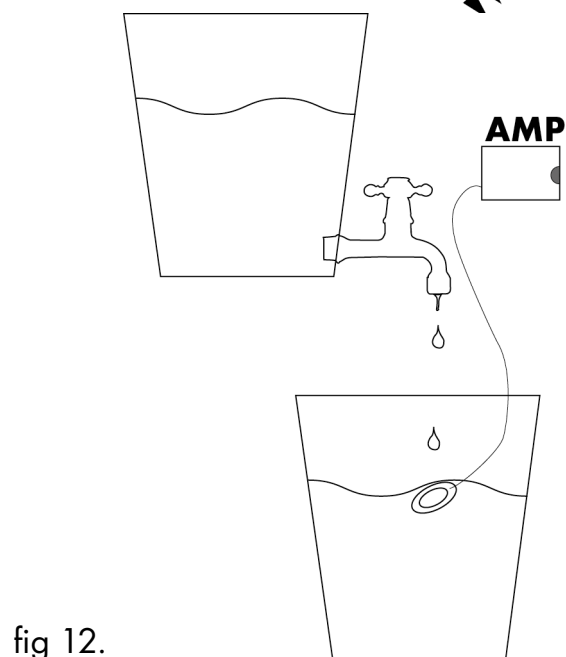
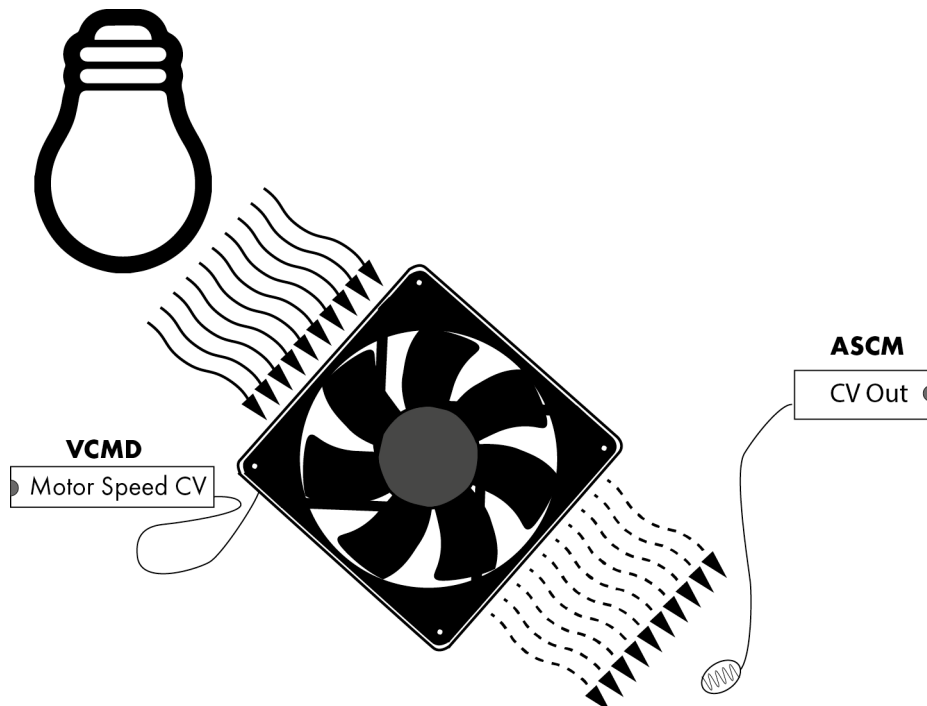
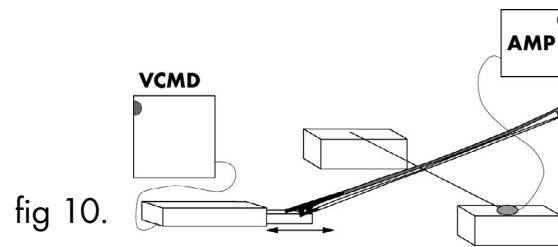
Push interference

Solenoids can be used to hit any surface or object in order to produce sound of vibration (for example hitting an amplified string). This might be used to interfere with some other principles (shaking water drop tank, shocking the hamster etc.)

Wind chimes trigger generator fig 13.

Wind chimes are classical way of sonifying wind (or ghosts). When metal chimes are used and connected to the Simple Trigger circuit the original acoustic sound can be transformed into any synthesized sound or any other event in the system. When used outside or inside with window opened it is a stand alone environmental trigger generator. In hermetic conditions a CV controlled fan can be attached to produce the wind instead. I have built this into a module that fits into the Eurorack format. Instead of classical wind chimes (too long) I used small spoons and made LED indicated trigger outputs.





Systems

Developing systems by interconnecting the individual principles and events was not originally intended to be part of this thesis, because it is such a huge topic on its own. I already managed to try to interconnect some of the events between each other and describe them in these diagrams. By taking a patchcord and making a connection between two events a narrative structure is already established. Such structure might be looped or can start to self oscillate. The final dynamics might fade out on its own and then re-appear again, or the system might be designed to require human interaction. Because of the nature of the language of the modular synthesizers which I used to represent the real world events, the errors and misconnections will occur on its own. This will result into new narratives or misinterpretation of ongoing narratives. I am especially interested in using such diagrams of systems as a score of a composition where a lot of interpretation is necessary. I tend to interpret these diagrams in very poetic way where each of the principles or events represents an element of broader meaning. Pulse sensor might represent mankind, wind might represent the climate, fire might represent the wildness of the universe, radiation detector might represent a quantum aspects of the world etc.

Contemplating wind and fire

This is elementary human contemplative structure that might be staged somewhere outside in the nature. It is an electronic enhancement of abstract thinking situation of a man sitting and contemplating fire, while perceiving wind and sounds of the environment.

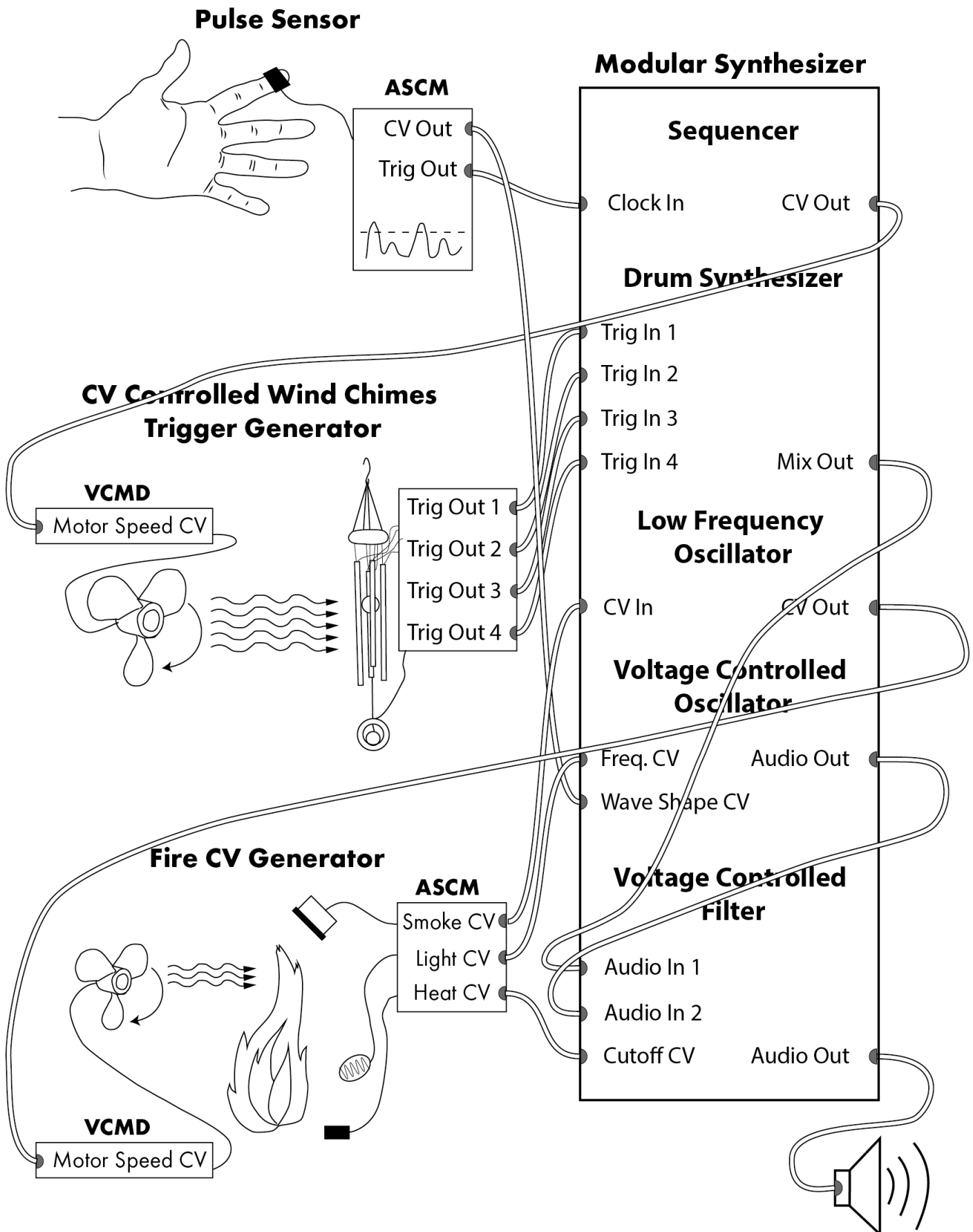
Self replicating wind

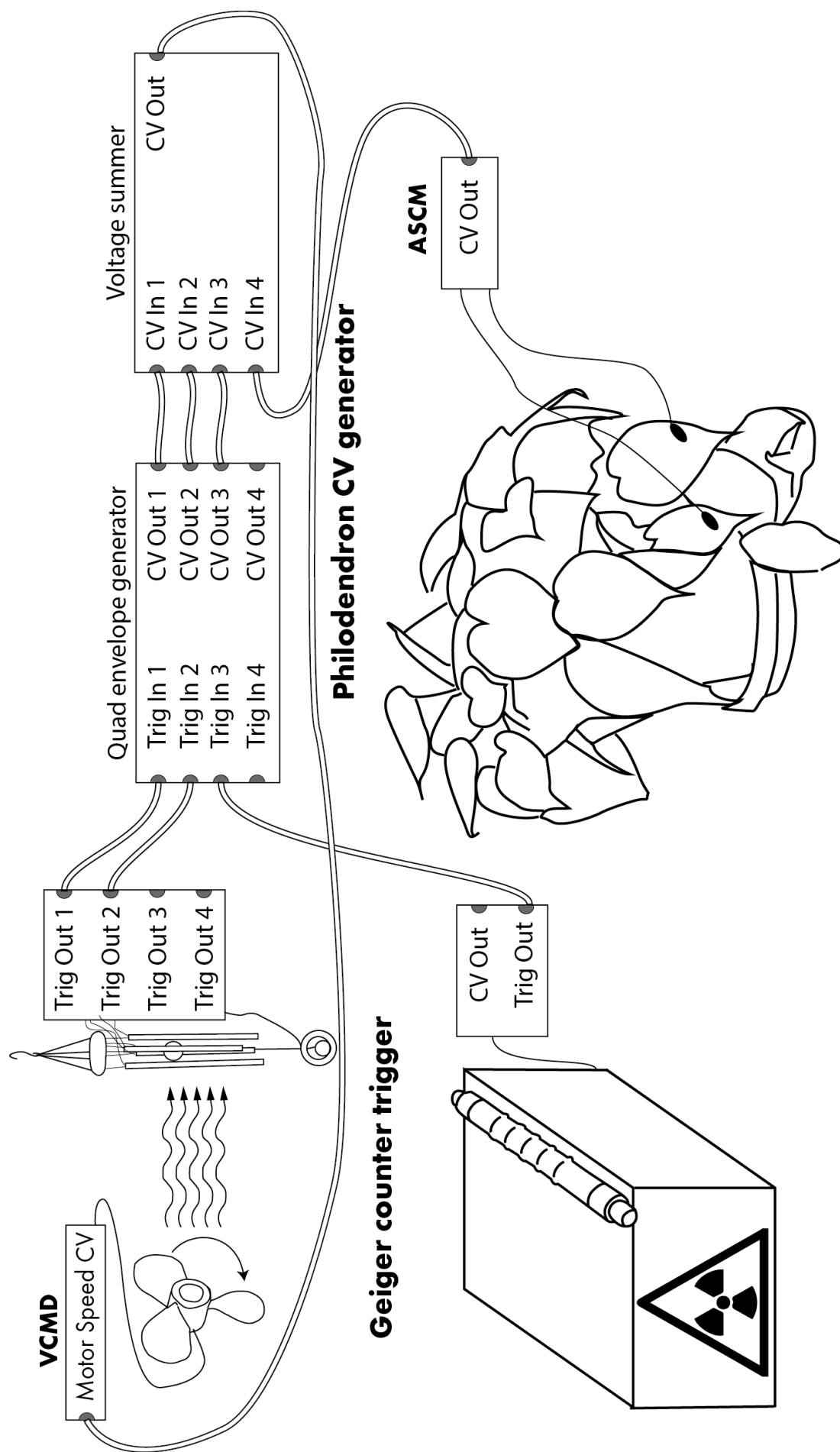
Especially interesting are procedures of self oscillation and feedback loops between real world principles without any electronic sounds involved. As in nature the wind fades out and re-appears again for various environmental reasons. In such setup it is easy to substitute the natural conditions by completely new stories to generate the wind.

Windy Heart Beat

This system might be read as a sonified allegory of a human presence on earth affecting the climate and environment which has direct consequences on various events such as extinction of certain species. Such events are represented by the electronic sounds.

Contemplating Wind and Fire

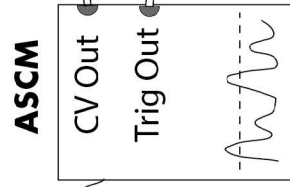
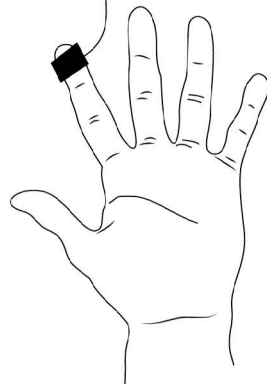




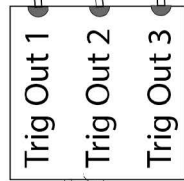
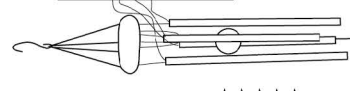
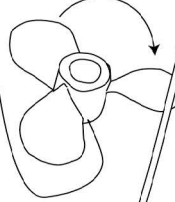
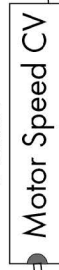
Windy Heart Beat

CV Controlled Wind Chimes Trigger Generator

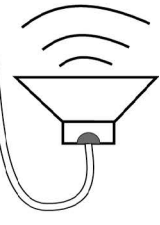
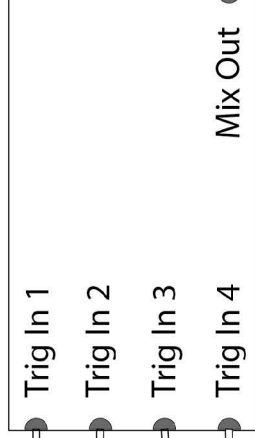
Pulse Sensor



VCMD



Drum Synthesizer



Conclusion

This basic research showed me fascinating moments and I have plenty of hypotheses to for further experimentation and work. As probably in almost any such research, the deadlines are not very fruitful in terms of leaving out some of the important work in favour of necessary documenting and describing of the processes. For instance in this written part of my research I did not include all the progress from the past few days which was very fascinating. On the other hand the written part helped me to sort out some of my thoughts and focus better in the directions I will take in further in my work.

Setting myself into the framework of research gave me incredibly powerful mindset for experimenting which I wouldn't be able to get in my everyday work routine. My mind was more focused on picking up small events and interpreting them precisely in my thoughts. Exploring further principles and creating systems out of them seems as a natural continuation of my artistic work.

I am already making living by designing musical instruments now and this work gave me new impulses of how to think and design the instruments. I am no longer possessed by the perfection of the sound of my instruments. I am rather interested in the story they can tell and in the possibility of giving such instruments to other people to tell their stories. I do not feel constrained by technological limits (such as computational power of a microchip), because I see so many unexplored ways of how to combine simple technical tricks to achieve big results.

In the sensor module I designed for this research there are two LEDs to indicate whether the signal is positive or negative voltage. Although the circuit allows only one of the LEDs to be turned on at time, you can many times see both of them turned on at the same time (especially when a sensor that picks up some higher frequency signals is attached). At first I thought it was an error in the circuit but then I realised that they are blinking so fast that I cannot see anymore that they are blinking. Such fast changing of two poles is a nice allegory to finish this written work and my studies in the Art & Science department. Shifting my mind between the artistic viewpoint and the pragmatic eye of an engineer became so fast that both of these poles seem to be online all the time. There is no problem anymore.

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- Monoskop <http://monoskop.org/Monoskop>
- Muffwiggler <http://www.muffwiggler.com/>
- Music From Outter Space <http://www.musicfromouterspace.com/>
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- Processing <http://www.processing.org/>
- Sonic State <http://sonicstate.com/>
- Sound on Sound <http://www.soundonsound.com/>
- Synthtopia <http://www.synthtopia.com/>
- Vintage synth explorer h <http://www.vintagesynth.com/>
- Wikipedia h <https://www.wikipedia.org/>

Documentary movies

- Elektro Moskva <http://www.elektromoskva.com/>
- I dream of wires <http://www.idreamofwires.org/>

Appendix

People

Laurie Anderson
Onyx Ashanti
Don Buchla
John Cage
Nicolas Collins
Danyk
Dieter Doepfer
Pete Edwards
Klaus Filip
Standa Filip
Gijs Gieskes
Olivier Gillet
Jonáš Gruska
Milan Guštar
Imogen Heap
Rob Hordijk
Hans W. Koch
Zdeněk Liška
Alvin Lucier
Olivier Messiaen
Moldover
Robert Moog
Nam June Paik
Miller Puckette
Pierre Schaffer
Andreas Schneider
Karl Heinz Stockhausen
Morton Subotnick
Nikola Tesla
David Tudor
Steina Wasulka
Woody Wasulka
Michael Weiswitch

Projects / Organisations

Steim
Arduino
Ircam
Kitchen
Composers Inside Electronics

Companies

Bleep Labs
Buchla
Casper Electronics
Citter and Guitari
Koma Elektronik
Korg
LOM Instruments
Monome
Moog
Mutable Instruments
Teenage Engineering
Reactable

CV

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Standuino - with Ondřej Merta, www.standuino.eu

Member of:

4AM – mediaLab

Residencies, Internships:

2013 - artist in residence at Locatie Spatie, Arnhem, Netherlands (with Standuino project)

2012-2013 – Kea Lab, research station Haidlhof, Messerli Institute, University of Veterinary Medicine, Vienna, supervisor: Dr. rer. nat. Gyula K. Gajdon

2012 – artist in residence at Opekta Ateliers, Cologne, Germany (with Standuino project)

2010 – New Media, Winchester School of Art, UK, studio of Alex Schady

2008 – Body Design department, FFA, doc. Jana Preková

Studies:

2011 – 2014, Universität für angewandte Kunst, Wien (University for Applied Arts, Vienna), Art & Science department, Univ. Prof. Virgil Widrich, Dr. Bernd Kräftner

2007 – 2011, BcA. at Faculty of Fine Arts, Brno University of Technology, Multimedia department, Petr Zubek (2010-2011), doc. Richard Fajnor (2007-2010), MgA. Tomáš Hrůza

2009 – 2011, Janaček Academy of Performing Arts, Musical Faculty, Multimedia Composition

1999 – 2007, Gymnázium Křenová 36

