Tampere University of Applied Sciences

# Combining Drum Machines & Samplers with Acoustic Drums

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Music Production

**ABSTRACT**

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The aim of this thesis was to explore the differences and similarities between electronic sequences and human played percussion instruments, and how these two can co-exist. The hypothesis before studying and conducting the experiments was, that the combination of electronic rhythms and human performed percussion can introduce creative approaches to songwriting and performance in a band environment.

The thesis consists of a theoretical and a practical part. The theory part includes a brief history of drum machines and samplers, and a basic explanation of how they work. The use of drum machines and samplers were studied through associated literature such as drum machine manuals, and interviews of artists and producers. Furthermore, different approaches to the matter were gathered from recorded examples of popular music. In the practical part of this thesis, I examined a few selected songs from two projects I have been working with, in relation to the hypothesis and theoretical background. These examples were then deconstructed and discussed through analysing how well they succeeded from theoretical standpoint as well as from the practical viewpoint.

The research and practical experiments of this thesis supported the hypothesis that drum machines and acoustic drums can be combined both in performance and as a compositional tool. This method opens up possibilities to implement more electronic aesthetics to the traditional band playing, as well as act as an inspirational tool in songwriting.

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Key words: drum machines, samplers, drums

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## ABBREVIATIONS AND TERMS

| | |
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| TAMK | Tampere University of Applied Sciences |
| ADSR | Attack decay sustain and release; the most common audio envelope generator |
| DAW | Digital Audio Workstation software on computer that allows audio recording and editing |
| Envelope | Demonstrates the change in sound over time |
| Grid | Equally divided framework for rhythm |
| Loop | Repeated section of audio material |
| MIDI | Musical Instrument Digital Interface |
| Quantization | Process of eliminating musical imperfections of a performance |
| Sequencer | A music playback device that handles note and performance information |
| Synthesis | Sounds generated by synthesizer |
| Transient | Short burst of energy in the beginning of the audio |

# 1 INTRODUCTION

Drums and rhythms are one of the most essential parts of music, forming the foundation and backbone which ties everything together. Technological advancements have offered fresh approaches and sounds to traditional percussive instruments, as the tonality of an acoustic drum kit and its performance have been altered and enriched by drum machines, samplers and computer software. To a certain extent, these instruments and devices are programmable electronic versions of acoustic drums, and they are often seen as the opposite to human performed drums. But where do these two different worlds meet and what common ground do they share?

The idea for this topic was inspired by my personal history of working, performing, and writing songs in various bands. Many of the bands I have been involved with have used improvisation and ensemble playing as tools and methods of songwriting. Over time, we started developing more interest towards electronic music and its aesthetics, which led me to conduct research on how to bring elements of rhythm machines and electronic sequences into the music without sacrificing the organic band element of the performance. The hypothesis of this thesis is that the drum machines and sequencers can be used together with acoustic drums to push a bands' musical capabilities further. When introduced in an early stage of the pre-production phase, they can have a positive effect in the songwriting process by offering new approaches, or they can emphasize live performances by adding synthetic elements to compliment traditional band instruments. An ideal configuration would consist of a drummer and a separate drum machine programmer to create interaction between the instruments. To test the hypothesis, the questions examined in this thesis are: ''What are the differences between human played acoustic drums and human programmed drum machines?'' and ''What possible problems might emerge from this combination and how can these problems be solved?''

It came to my knowledge during studying this subject, that the combination has not been researched extensively. Drum machines have been layered on top of acoustic drums generally throughout the recorded music since the 1980s (Horn

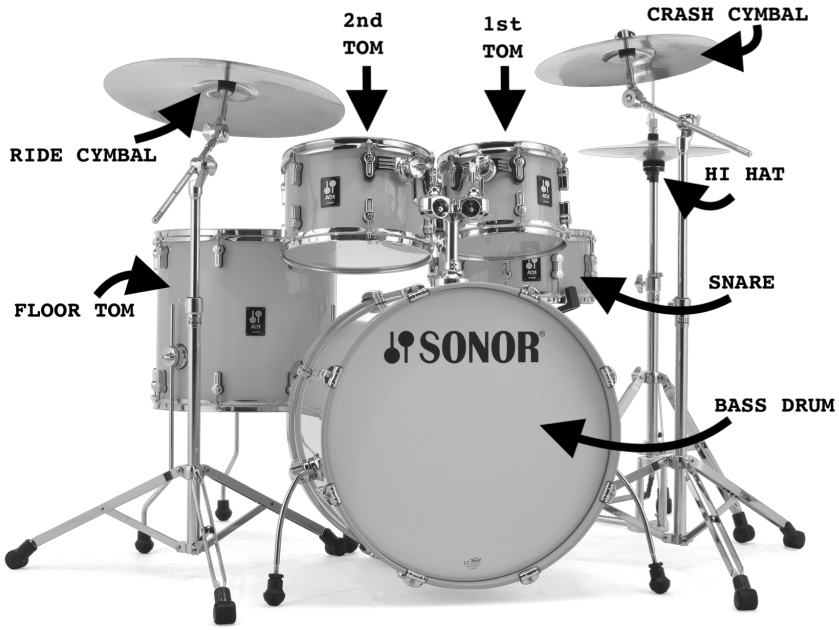
2011), but it seemed that examples of them used together as separate instruments are harder to find. A current trend in music production is to sample replace drum sounds afterwards in the postproduction phase (Dunkley & Houghton 2011), but in my opinion, this method is more related to the mixing than the songwriting process.

The theoretical part of this thesis examines the functionality and history of drum machines and how they have evolved and been used throughout history. In the practical part, a series of recording experiments are analysed. The recordings consist of performances that combine acoustic drums with a drum machine, and they are from two different bands' studio recording sessions. These examples are then analysed both against the theoretical standpoint, as well as from an aesthetic viewpoint. The analysis includes a further look into the techniques that have been utilized as well as deconstructing arrangement and the roles that the percussive instruments have.

# 2 THEORETICAL BACKGROUND

This section introduces a general configuration of acoustic drum kit and explores the history of drum machines and samplers. A brief explanation of the mechanics of drum machines and samplers, and an overview of the general terminology is also included.

## 2.1 Acoustic drum kit




PICTURE 1. Drum kit (Dr. Richard Hemmings 2020).

An acoustic drum kit is a configuration of multiple drum parts (Hemmings 2020). Picture 1 shows a standard 5-piece kit, which often consists of, but is not limited to, a combination of the following:

- Bass drum
- Snare drum
- Two rack toms
- Floor tom
- Ride cymbal
- Crash cymbal
- Hi-hat

## 2.2 Drum machine

A drum machine is an electronical device that can produce percussive sounds, rhythms, and patterns. It creates its sounds by synthesis or pre-recorded samples that can be played back by the unit's built-in sequencer. (Kanter 2020.) Drum machines have been utilized in a record production since the late 1970s, continuing to this day. Originally drum machines were separate units, but nowadays their capabilities, such as step-sequencers and quantization, can be found in the most popular DAWs. (Orkin & Gustafson 2018.)

PICTURE 2. Drum machines and samplers (Peter Kirn 2022).

## 2.3 Sampling

According to the MOT Oxford English Dictionary (MOT 2022), sampling is the technique of digitally encoding music or sound and reusing it as part of a composition or recording. Sampling revolutionized music production by making it possible to use pre-recorded audio creatively in a new context (Brennan 2020, 291-292).

## 2.4 Main principles of samplers and drum machines

Drum machines and samplers may have existed since the late 1950s, but the basic principles have not changed drastically. Drum machines and samplers share a lot of similarities, as both devices are capable of creating percussive sounds. Their biggest difference is that while a drum machine contains preinstalled drum sounds, or uses its own synthesizer to create them, a sampler can record, edit and playback digital audio. (McDonough 2019.) However, the technology we have today has diminished many of the differences between these machines and many modern devices could be described as drum machine / sampler hybrids.

According to the user manuals of Elektron's Octatrack (Elektron 2021) sampler and Roland TR-808 (Roland 1980) drum machine, drum machines and sampler hardware usually share the following features:

- Sequencer
- Visible steps of a sequencer
- Metronome
- Transport controllers e.g., play-stop-record buttons
- Tonal shaping controls for individual sounds


PICTURE 3. Elektron Octatrack -sampler (Mark Mosher 2017).


PICTURE 4. Roland TR-808 (Hanif Abdurraqib 2020).

As seen in the picture 2 and 3, an Octatrack has 16 buttons of steps in a row similarly to the TR-808. These buttons are multifunctional in both devices but are generally used to represent the 16 steps that the built-in sequencer utilizes. Both rhythm machines have pages of steps, each page representing a set of 16 steps. This means that the maximum steps the user can sequence is 64 in Octatrack and 32 in TR-808. The tempo parameter determines the time in which the steps are triggered by the sequencer, and the transport controllers are used to launch and stop the sequencer. (Elektron 2021, 11-13; Roland 1980, 2-11.)

TR-808 produces each of its 12 sounds by synthesis. Each of these sounds have their individual volume controls and few of them have tonal shaping parameters, such as decay and tone. Octatrack has 8 audio tracks which can be turned into any of the following five algorithms:

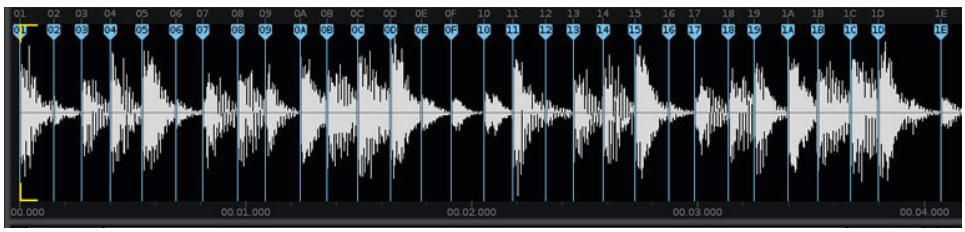
- **Flex** and **Static** for sample playback
- **Thru** for mixing the input signal
- **Pickup** for looping audio
- **Neighbor** for combining audio tracks together

Therefore, the sampler can have eight individual samples and 16 step buttons can be used as sound triggers for these samples.
To demonstrate where the sequence is moving on the time basis, the drum machines and samplers use steps, bars, and numbers. (Elektron 2021, 12-22; Roland 1980, 2-11.) For example, Octatrack and TR-808 light their steps depending

on where the sequence is at a specific point of time. The user can decide which steps trigger which sound by placing sounds on the steps. This technique is referred to as step programming.

The other option for step programming is real time sequencing. In this technique the sequencer records the patterns, which are played by the user in real-time. (Elektron 2021 68- 70; Roland 1980, 13-14.) For example, if a drum machine has a kick drum sound and a snare sound, the user can record a pattern of those two sounds by triggering them at the same time as the sequence is recording. When the sequence starts from the beginning, it repeats what the user has played. Drum machines usually quantize the performance by default. This means that all the imperfections in a rhythm will be moved to the closest step on a grid. (Scarth & Curry 2013.) The closest step will be determined by the note or step resolution, and quantizing can be done in Octatrack as precise as in 1/348 step resolution. (Elektron 2021, 33.) Keeping the performance unquantized is also possible on many devices.

Samplers, such as Octatrack, often have audio editing capabilities. The user can edit audio information by cutting its length, looping different parts of it, dividing it to smaller sections, and changing its pitch, et cetera. One popular technique for longer audio loops is slicing, which is sometimes referred to as chopping (Picture 5). For example, if a user has a 15 second drum loop, it can be divided into smaller parts. The user can then insert the sliced parts to the machine's trigger pads and record the slices to the sequencer in their order of choice. (Elektron 2021, 80-86.)



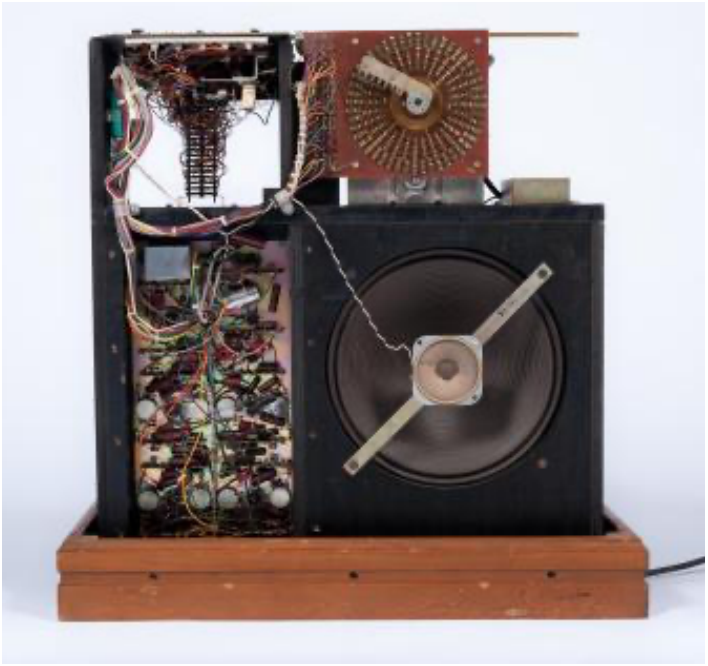
PICTURE 5. DAW demonstration of a chopped audio (Jared Hobbs 2021).

## 2.5 History of drum machines & samplers

The development of drum machines started as early as in 1930s, when American composer Henry Cowell commissioned Leon Theremin to build a machine which could play multiple rhythms and polyrhythms at once. The unit had only a little resemblance to drum machines of the future, but it laid the groundwork to a machine that was able to play loops or bars of a rhythm. (Orkin & Gustavson 2018.)

The next advancement took place in the 1950s, when the Chamberlin Rhythmate and the Wurlizter Sideman were introduced. These devices were designed for organists to trigger backing rhythms for their performances. The units contained huge machinery, including their own amplifier and speakers. Inside the Chamberlin Rhythmate was a 1” reel-to-reel tape, on which different drum parts were prerecorded and divided across the length of the tape. The user could access each of the 40 different rhythm styles by moving the playhead to one of the 14 spots shown on the front panel. Furthermore, the user could adjust the speed of the tape and the sound of the in-built amplifier by a simple tone control. (Orkin & Gustavson 2018.)

When the Wurlitzer Sideman was released in 1959, its technological advancements had discarded the reel-to-reel tapes. The sounds were created by vacuum-tubes and electromechanical circuitry capable of generating drum synthesis. The machine also had a primitive sequencer; a round metal disc – shown in picture 6 – which had contact points spaced in correlation to the predefined rhythms. The contact points also triggered sounds built of programmed noise bursts of different pitch and length, mimicking real percussive instruments. (Williston 2000; Orkin & Gustavson 2018.) Both of the 1950s drum machines consisted of set of rhythms, all which imitated the popular dance styles of the era.



PICTURE 6. Wurlitzer Sideman and its machinery (NMC 2021).

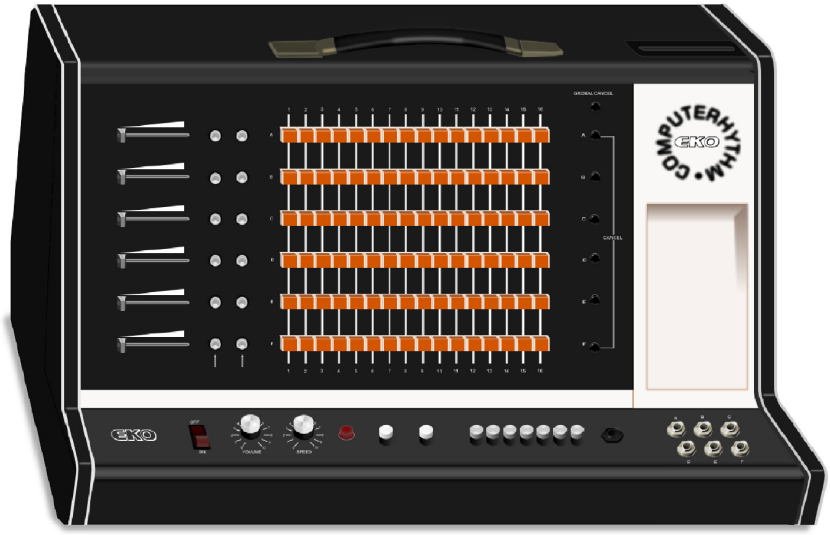
The use of the solid-state transistors became more common during the 1960s, which made it possible to manufacture smaller, portable devices. In America, the Thomas Band Master Model 55 was one of the firsts to appear in the market while in Japan new companies such as Keio-Giken and Ace-Tone – later to be re-branded as Korg and Roland – were the most notable examples. (Orkin & Gustavson 2018.)

The drum machines of the 1960s were similarly bound to predefined sequences as their predecessors. However, many new program features started to appear in some of the units; Ace Tone FR1 (1967) allowed the user to cancel out some of the sounds on a sequence, Elka Drummer One (1969) had a volume adjustment for each of its drum sounds and Maestro Rhythm King MRK-1 (ca.1965) had one shot triggers for the individual drum sounds. (Orkin & Gustavson 2018; Brennan 2022, 286.)


PICTURE 7. Maestro Rhythm King 1 (Soundgas 2015).

Closer to the 1970s, bands started to implement these machines to their artistic expression. Two of the most remarkable examples being American funk group Sly and The Family Stone on their 1970 release There's Riot Goin On and German electronic music pioneers Kraftwerk on their 1974 release Autobahn. (Brennan 2022, 286.)

The first drum machines' sequences were pre-programmed, which meant that the user was not able to modify the patterns outside the presets. Released in 1972 the Eko Computerhythm, was supported by a matrix, in which the user could program their own patterns. The matrix had six rows of 16 push buttons, which were trigger locations for each of the six sounds. When the user started the sequence, the machine would visit each of the 16 buttons and play sounds according to which buttons were pushed in. (Hainbach 2021.) This is still the basic principle of how step sequencers work today, even in DAWs. The machine was so ahead of its time, that the Eko Computerhythm's matrix programmability was not explored widely until the 1980s.




PICTURE 8. Eko Computerhythm (Vinny's Vintage Keys 2023).

In 1978, Roland released the first drum machine that included a microprocessor. CR-78 had the feature to save user created patterns to its memory, which was the main reason why the device became popular among artists. The most notable examples of CR-78 use at the time were by Phil Collins, whose hit song In The Air Tonight, had an entire intro backed up by CR-78, and by American new wave band Blondie, whose song Heart of Glass had a drum machine beat layered with acoustic drums. (Orkin & Gustavson 2018; Brennan, 286-287.)

In the 1980s, Roland released TR-808, which was the company's first fully programmable drum machine. TR-808 had 12 programmable drum sounds and a 32-step sequencer. It allowed the user to place individual sound triggers on a timeline, save sequences, and program unusual time signatures. The user could also adjust the tonality and have variation within the sounds by using accents on each drum sound. (Orkin & Gustavson 2018; TR-808.) The machine was not a huge success at first, as by the time of its release there was generally more demand for realistic drum sounds. TR-808 and its sounds were found too futuristic at the time, which led Roland to discontinue the product after only three years. Following its discontinuation, these units were found cheap in second-hand markets and the TR-808 became a priced tool for beat makers to use and experiment, eventually leading it to become a key element in the evolution of hip-hop music. (808, 2015.) TR-808 has provided rhythm for multiple hit songs, such as Whitney

Houston's I Wanna Dance with Somebody (1987) and Afrika Bambaata's Planet Rock (1983) (Orkin & Gustavson 2018).

In addition to synthesis-based drum machines, the microchip technology started to pave the way for sample-based drum machines in the 1980s. These drum machines consisted of pre-recorded acoustic drum samples installed to the device. In addition to sequencing the sounds, the capability of triggering sounds freely via buttons started to appear on the units. These machines in general contained 10 to 20 drum sounds, which some devices were able to edit further by changing the volume, pitch and tonality. (Orkin & Gustavson 2018; Linn Electronic, Inc 1980, 1982.)

The first sample-based machine, released on the market in 1980, was Linn Electronics LM-1. Roger Linn, who invented the machine, wanted to create a new songwriting tool for artists and producers. However, the machine's advanced programmability and more realistic sounds made it possible for these units to replace acoustic drums entirely. (Linn Electronic, Inc 1980; Orkin & Gustavson 2018.) One of the most known users of the LM-1 machine was the funk artist Prince, who extensively used the particular drum machine on his 1984 album Purple Rain (Carlozo 2019).


PICTURE 9. LM-1 (Reverb 2019).

New features started to appear rather quickly within the sample-based drum machines. In addition to the basic step programming, the LM-1 and its descendant

LM-2 both had new swing and quantization functions, as well as a real-time performance recording feature. Released a few years later in 1984, the Linn 9000 had 18 velocity and pressure sensitive pads, which could be used to trigger samples. In 1982, The Oberheim DMX introduced additional memory cards, with which the user could swap different pre-recorded samples to the machine. Sequential Circuits Drumtraks had a MIDI input and output, so that users could exchange information between different instruments. (Linn Electronics, Inc 1980, 1982; Oberheim Electronic, Inc 1982; Orkin & Gustavson 2018.) Drum machines in general started to feature more open-end programmability, which gave users less limitations and more possibilities to experiment,

From 1986 to 1990, the evolution of next generation of drum machines was heavily influenced by the abilities and aesthetics of the Linn 9000. The machine already had some primitive sampling features, which gave users the possibility to insert their own pre-recorded audio clips into the device. Unfortunately, the Linn 9000 was very prone to problems caused by overheating and software bugs, all of which could not be fixed due to technological limitations of the time. (Orkin & Gustavson 2018.)

Released in 1986, the E-mu 12 is often cited to be the first commercial sampler / drum machine hybrid. With this machine the user could play sounds that came pre-recorded in device or transfer their own recorded samples and beats to its digital memory. The machine also allowed editing and mixing different samples within its software by using sliders. Sampling was limited to four seconds and it used low quality converters – yet this factor gave, according to many users, the machine its unique sound. After just one year E-mu released its successor, the E-mu 1200, which upgraded a lot of the sampling capabilities and was in production from 1987 to 1998. (Orkin & Gustavson 2018; Siarri 2019.) Because of the samplers' punchy tone, the E-mu samplers were used extensively in the hip hop and trip hop scenes of the early 1990's. One famous example of its use is found in Beastie Boys' song Rhymin & Stealin, which used an E-mu SP-12 sampled loop of Led Zeppelin's When The Levee Breaks. (Siarri 2019.)

In 1988, Akai released their multi-functional songwriting tool: the Akai MPC 60, which was designed for them by Roger Linn. The Akai MPC 60 was not only a

drum machine and a sampler, but a diverse music production tool all in the same unit. The Akai MPC 60 shared features with Linn's earlier designs, notable LM-1 and LM-2, but it also came with a variety of new programming capabilities, which allowed the user to both sample and sequence sounds in more advanced ways than before. The MPC 60 was fully integrated with MIDI, allowing its 99-tracks to be used for internal sequencing or sending data to external instruments. The user could assign soft pads to trigger samples of their desired audio, the only limitation being the memory; the machine was capable of sampling 13.1 seconds of audio.The larger memory storage gave producers and artists the opportunity to start recording entire beats and parts from already released music. (Orkin & Gustavson 2018; Boardway & Laughton 2021.) This was utilized a lot in hip-hop, where artists and producers sampled different instrumental bits, especially drum breaks, to create new songs.

The AKAI MPC 60 was a huge step in the evolution of drum machines, as it made it possible for artists and producers to make complete albums using only this sampler – to such a great degree that it could be seen as a DAW of its time. Even though AKAI made many updates and successors for the MPC series, the basic concept did not change drastically from the first generation. The MPC 60 and its later models have been used by countless hip-hop and electronic music pioneers, including critically acclaimed J Dilla, Kanye West and DJ Shadow. (Boardway & Laughton 2021.)


PICTURE 10. AKAI MPC 60 (Samples From Mars 2023).

After the MPC series, further advancements in computer technology laid the foundations for Digital Audio Workstations, referred to as DAWs. DAWs are computer software for audio recording, audio editing and songwriting. Many of the DAWs nowadays serve as a multioperational audio workstations, in which the user can do anything from recording and mixing to using the software as an instrument. (Orkin & Gustavson 2018; Boardway & Laughton 2021.) The basic principles are very similar to early drum machines, sequencers, and synthesizers – only the processing power has increased remarkably. Some popular DAW's nowadays are Pro Tools, Ableton, Logic Pro, Studio One, Reaper and Cubase.

# 3 TECHNIQUES

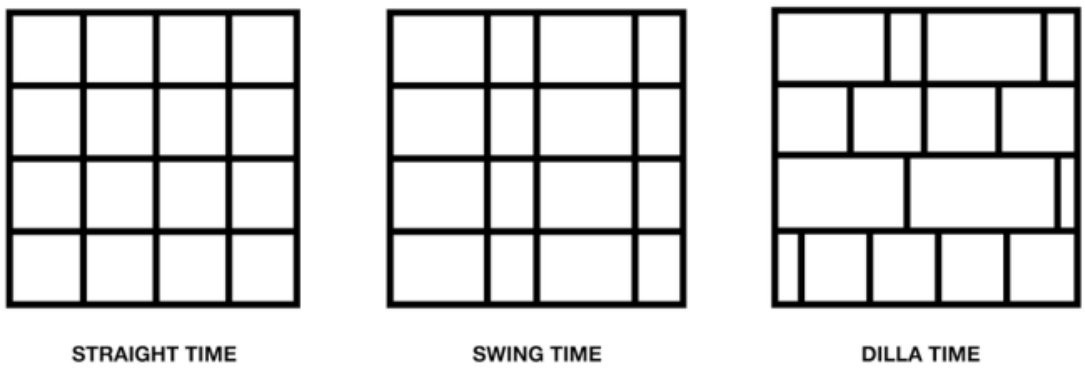
In this chapter different techniques are discussed, based on examples of drum machine usage and techniques from albums and interviews. The functionality of using drum machines and how this affects the end results in each example is also examined.

## 3.1 Timing

A drum machine's original purpose was to replicate a real drum kit. While attempting to do so, its creators also succeeded in developing new approaches and methods to make music. Prior to the Linn Drum LM-1, all the commercially available drum machines were creating sounds by drum synthesis. (Brennan 2022, 289.) In contrast to the traditional sound of acoustic drums, the synthetic soundscapes of drum machines were considered futuristic at the time. In addition, the early machines were strictly tied to a metronome and a grid, often referred to as step-based drum machines. Even though the quantization could be overridden already in the LM-1, this feature was not utilized so much as the general goal at the time was leaning towards perfect, and thus rigid rhythm expression. The perfect timing of a drum machine creates a very distinctive sound compared to that of acoustic drums played by a person, as a human is not capable of playing with the precision of a machine. Thus, individual's ears often perceive perfect rhythmic performance as artificial. (Hennig, Fleischmann, Geisel 2012.) It could be argued that our ears have been accustomed to rhythmic imperfections and therefore the variation it brings is perceived as organic and familiar. Even though drum machines and samplers could not perfectly replace a human drummer, their precise performance brought such intensity and firmness to songs, that was not possible to achieve prior to drum machines. On the flip side, too machine-like rhythms may sound alienatingly artificial to the listener. To counter this, rhythm editing features were introduced – first by adding swing and shuffle features to drum machines during the early 1980s and then editing the time error correction capabilities as much as taking the quantization off (Linn Electronics, Inc 1980; Scarth & Curry 2013). All these functions can be seen as humanizing attributes, with which users could diminish the space between the notes. Swing function was influenced by

jazz and swing music, using the dotted rhythm at its core by moving every other note closer to the next note. (Scarth & Curry 2013.)

During the 1990s producers, most famously J Dilla, started to create beats consisting of notes and sounds that were off beat. By using unusual timing and not quantizing his drum performances, J Dilla created imperfections to his rhythmic expression. The drummer Questlove describes J Dilla as a drummer who influenced him to switch his colder, precise drumming style – which was influenced by the drum machines – to a more ragged and laid-back style of J Dilla's beats (Brennan 2022, 301-302). This comment underlines the increasing overlapping of drum machines and acoustic drums. With certain performers, both of these approaches share similarities, resulting in both artificial and organic sound aesthetics. Picture 11 demonstrates visually how straight and on-grid notes differ from swing, and how J Dilla creatively combined both rhythm spacings in his work.

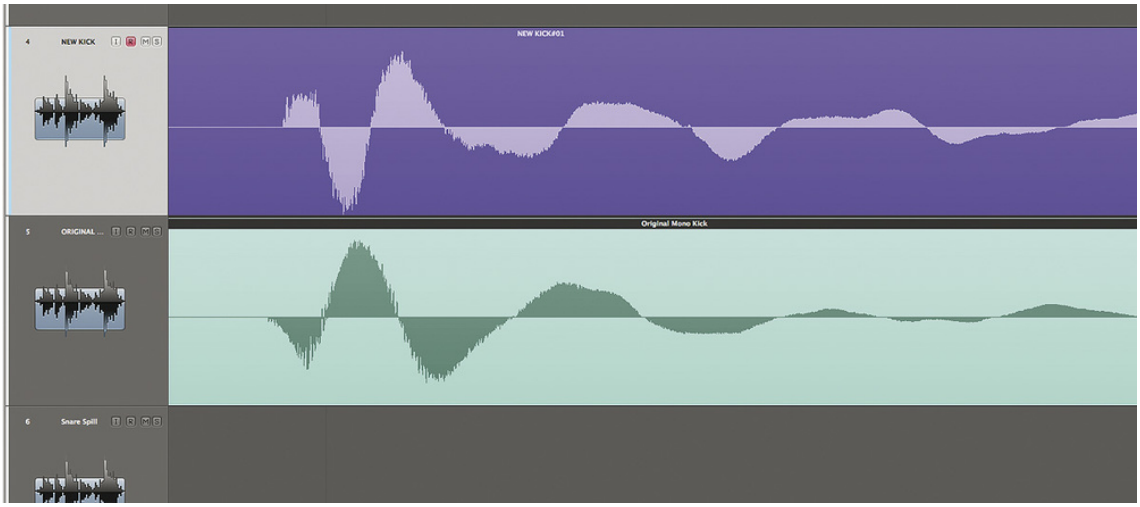



PICTURE 11. Visually determined differences between different rhythm spacing (Dan Charnas 2022).

The current computer technology makes it possible to record a drummer's live performance and accurately convert it to MIDI, as DAWs are able to transform audio information, such as transients, into MIDI notes. A technically skilled drummer can also mimic the swing functions and general precision of a drum machine. (Scarth & Curry 2013.) The gap between a drummer's and a drum machine's timing may be closing, but these different approaches are not fully interchangeable, as the final result is always dependent on the desired outcome and the artist's vision and implementation.

### 3.2 Issues

Timing can cause problems when multiple percussive instruments are playing at the same time. If sounds – or in this case transients – occur in similar frequency range at the same time, there is a possibility of phase cancellation. Waveforms can also partially cancel each other across the frequency range. The audible result is usually a thin and weak sounding transient. Phase issues are more prone to occur in the lower frequencies, as lower waveforms are slower and longer. (Senior 2015, 133; Dunkley & Houghton 2011.) The phase issues can be solved by avoiding sounds that accompany the same frequency area. In Radiohead's (Radiohead 2008) performance of the song 15 steps, as the drummer Phil Selway joins in the beat, the drum machine lowers in volume, taking a bigger role in the upper register. This technique gives room for kick and snare drum to become more audible in the mix. This example shows, that by arranging and giving space to each element, the most crucial issues can be avoided.




PICTURE 12. An example of an audio clip, where two frequencies cancel one another (Sound on Sound 2011).

In order to successfully execute a performance with electronic sequences, monitoring must be planned correctly. The drummer needs to be able to follow the beat, as it is easier to accustom the rhythm to existing sequence than the other way around. To achieve this, it would be preferable to send either a click track or different drum parts for monitoring. Sending a loose percussive part or a click

track with a larger resolution can influence the performance by giving the drummer more freedom in terms of rhythm. If the click track is dense and has small resolution, it may encourage to perform more strictly. (Senior 2015; 46.)

### 3.3 Usage in popular music

It could be argued that drum machine use in popular music often falls into either of the two categories: to improve imperfections of human performance, or to use the devices as creative songwriting tools. These two methods, or schools, also often overlap with one other, as while technology supports artists in performances, the human interaction also adds more depth and creativity to what technology can offer.

A drum machine's capability to fix imperfections and emphasize drummers' performances started to gather more attention among producers during the 1980s. Drum machines were often used as an alternative to a metronome in recording sessions; a well-known example of this are the studio session of thrash metal band Metallica. The drum tracks on Metallica's early albums were constructed from different drum takes, typically overdubbing the parts where the drummer fell off the beat. (Brenner 2022, 304.) American music producer Trevor Horn (2011) recalls that during the 1980s, he was one of the first producers who had his own rig consisting of TR-808 drum machine with the set of triggers and Minimoog synthesizer together with the sequencer. With this setup, Horn had drummers playing drums on top of the drum machine (Horn 2011). Similar to the Metallica sessions, the goal was more or less to get the most rhythmically precise performance as possible, and this was something where the use of drum machines was very useful.

One of the earliest examples of creative drum machine use can be found on Sly Jones and the Family Stone's album There's Riot Goin' On. The album featured Maestro Rhythm King drum machine as the leading percussion element in many of its songs. (Brennan 2020.) Programmed by the band leader Sly Jones, the beats were often accompanied with acoustic drums, which created a dense mix of percussive elements throughout the album. The drum kit brought realism to the

rhythm patterns, as the drum machine was not able to do much variation within the patterns. Therefore, the fills and accents are solely played with the acoustic kit, which places the elements in question louder in the mix. Another pioneer in their field, Kraftwerk, during their early years, switched from preset loops of a drum machine to human performed drumming via drum pads (Orkin & Gustavson 2018; Brenner 2022, 286-287). This technique connected two different worlds together: human controlled rhythm guided by synthetic sounds.

In the early 1980s, funk artist Prince started to apply drum machines into his creative output and was known to have used especially Roger Linn's LM-1. According to his recording engineer Susan Rogers (Crane 2017), Prince's reason for favouring this particular drum machine was its ability of tuning individual drum tracks, as well as featuring individual outputs. Prince would send drum sounds from the individual outputs through his guitar pedals to achieve the sounds he envisioned. Rogers also states that Prince would finger-drum most of the fills and ideas straight to tape. (Crane 2017.) This style shares likeness to the earlier mentioned Kraftwerk's drum pad technique and precedes the idea that the producer J Dilla used and evolved further during the 1990s and 2000s. Once the technological advancements allowed it, sampling and chopping became the favoured tools for hip-hop producers, to the extent that these techniques have become a modern songwriting staple. J Dilla was an example of an artist widely known for the use of these techniques in his work, one of his main methods being tapping rhythms and sliced audio loops in real time to his AKAI MPC sampler. Through this technique, J Dilla was able to create unique rhythm textures to his music. His beats and rhythms are described to sound as if the notes are in-between straight and swing. (Brennan 2022, 301-302.) J Dilla's often unquantized beats had separate drum notes usually spaced off beat with one another, which contributed to the sound of beat "dragging" or "pulling".

Slicing and chopping musical bits, such as drum breaks found on old records, were also common practise for the pioneers of the 90s electronic dance music scene. An excellent example of a drum break turning into a bigger phenomenon outside of its original source can be found on The Winstons' song Amen, Brother (1969), which contains a 6-second-long drum solo. This short section has since

been used in over 5000 different songs in various forms: chopped to smaller segments, looped, and played in different order with increased tempo, etc. (Brennan 2022, 300-301; WhoSampled 2022.) The Amen break – as it was later labelled – perfectly illustrates the endless possibilities of sample manipulation. Old ideas can quickly turn into new ideas with creative use of techniques such as slicing, reversing, or slowing down and speeding up the tempo.

Closely associated with electronic dance genres, the Icelandic artist Björk used drum machines as a part of her creative songwriting process during the 1990s. Her song Hunter features the Roland TR-909 drum machine, which was operated by producer Mark Bell. (Björk 2022.) The song is built around a militaristic beat being continuously manipulated as the song progresses. This manipulation creates an interactive nature between the beat and other track elements. Even though the sequence repeats itself endlessly, the small nuances that Bell brings into it implement a very organic progression to the song.

Hip hop, rap and electronic music may be some of the most known genres in which sampling has widely been used, but as the colourful history of how this technology and methods have developed illustrates, the creative use of sampling has no respect for genre borders or gatekeeping. In the 90s, the industrial band Nine Inch Nails favoured drum machines and samplers instead of live acoustic drums. The band experimented with pre-recorded and edited drum sounds which were used to create new patterns. In addition to sound manipulation, one of the band's techniques was to play drum sounds and samples through speakers in different rooms and re-record the sounds by microphone. (AudioTechnology 2000.) This technique added another layer of realism to the pre-recorded samples in the sense of a real acoustic space. The band also sampled sounds from other albums. The kick drum sound of their hit song Closer (1994), is taken from Iggy Pop's Nightclubbing (Buskin 2012). According to Trent Reznor (Brennan 2022, 306), his idea of drums has always been a button on a machine. He explains how in many situations when recording drums, he has found the recorded drum sounds lacking, and in many of those times adding a sample makes uninspiring drum sounds better (Brennan 2022, 306; AudioTechnology 2000). Trent Reznor's views on the matter serve as an illustrative example of how the concept

and aesthetics of an ideal drum sound have evolved over time as the technology advances.

An example of more performative drum machine usage can be found in the alternative rock band Radiohead's catalogue. The band started experimenting with implementing sequencers and drum machines to their music during the 2000s. Their 2008 live version of the song 15 steps consists of pre-programmed drum machine beats, which are triggered by the bands' guitarist Jonny Greenwood via a MIDI controller, and the acoustic drums which are performed on top of the beats (Radiohead 2008). The rhythm section's performance can be seen highly interactive, as Greenwood is switching the drum machine's patterns at the same time as drummer Phil Selway is following them. This is one example of how the machine and drummer can perform in a co-operational manner. The math-rock trio Battles went even further with experimenting the mixture – the band uses complicated loops and sequences created by loopers, drum machines and Ableton DAW on stage. The guitarist Ian Williams and bassist Dave Konopka are creating most of their loops and sequences on spot without a click track or MIDI syncing their devices. Acoustic drums are performed on top of the loops in their live shows and in studio environment. (Battles 2015.) On top of the performative nature of the drum machine and sampler usage, it seems that using percussive elements in cooperatively is also the band's way of composing and arranging new material.

These examples show that the use of drum machines is extensive and versatile. In creative use, the possibilities are endless and evolving constantly and there is a certain pattern to be found following the history of technological advancements. As the devices are evolving, new possibilities and techniques evolve with them, and new artists and producers emerge to further develop the techniques to which the earlier experimenters have laid the groundwork. Drum machines are usually used solely or to emphasize the drum performance, but as history shows, experimenting with both the technical and the creative elements at the same time has led to successful results. At the core of drum machine usage are the technical features, with which producers and artists can support, enhance, and complete human imperfections. However, the innovative and rich manner of using drum machines to create art does not necessarily require any technical knowledge. The

user interfaces of drum machines and samplers have always been quite intuitive, which encourages the user to experiment.

# 4 THESIS PROJECT

In this part I shall discuss the experiments I have conducted. Examples are gathered from various studio sessions, where I have been a part of producing and/or performing as a drum machine programmer between the years 2019-2022. The goal of these experiments was to combine acoustic drums and electronic sequences together so that the final result would support the song. After each example, I will analyse the techniques that have been utilized and what results these experiments provided. Acoustic drums and drum machines were played and recorded simultaneously, and these performances were not edited timewise, or sample replaced afterwards. On each example the drummer is receiving a cue track for monitoring purposes. The cue track consists of song specific array of drum machine tracks, which helps the drummer to keep the beats synchronised with the drum machine patterns. For each example, unmixed stems of drum parts are included (see Appendix 1) with drum notation to visually demonstrate the patterns. The final released versions are available and can be listened to on all the common streaming services, e.g. Spotify, Tidal. Song name and artist is referred to in each example.

## 4.1 Gear

This section consists of a brief introduction of the instruments and devices, that were used to conduct the tests. The main reason of selecting these specific instruments is referred to in the text.

### 4.1.1 Drum machine

The drum machine in all the following examples is Elektron’s Octatrack. I chose this device because I needed to have as much open-end programmability as possible. Octatrack is capable of being a mixer, sampler, drum machine and sequencer at the same time. Therefore, offering flexibility and creativity for different configurations. The device has two stereo outputs, one of which can be used to send selected track or click audio to drummer. The user can also define which of

the tracks is being sent to which output. It is important to be in control of what the drummer is monitoring from the drum machine, as some of the on-going sequences could possibly disturb the drummer's performance. Octatrack also has advanced MIDI features, which allows an exchanging of information between Octatrack, effect pedals and synthesizers. In most of these examples, the drum machine is triggered and controlled by MIDI footswitches and expression pedals, as I am performing with other instruments simultaneously.

### 4.1.2 Drum kit

The drum kit of the first two examples consists of:

- 22'' bass drum
- 14''x 5,5'' snare drum
- 12'' rack tom
- 14'' floor tom
- Various hi-hats, ride and crash cymbals

The drum kit of the latter two examples consists of:

- 22'' bass drum
- 14'' x 6,5'' snare drum
- 13'' rack tom
- 16'' floor tom
- Various hi-hats, ride and crash cymbals.

## 4.2 Kuulen ääniä maan alta

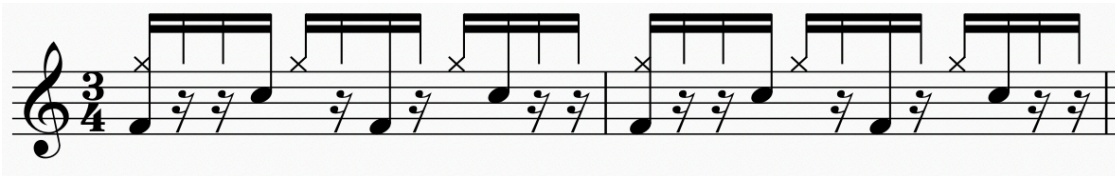
The first example is from the song Kuulen ääniä maan alta by Oranssi Pazuzu. The song was recorded in 2019 at Headline studios in Tampere and released in April 2020. The idea for the sequences and rhythms came from an improvisation session the band conducted prior recording. Kuulen ääniä maan alta has four different parts; intro, part A, part B and outro. The song's percussive elements consist of a mixture of drum machine and live acoustic drums, layered and performed in real time.

The song is in 3/4 time signature and the drum machine beat is a 12 step long sequence, in which every step represents 16th note. The steps are divided into:

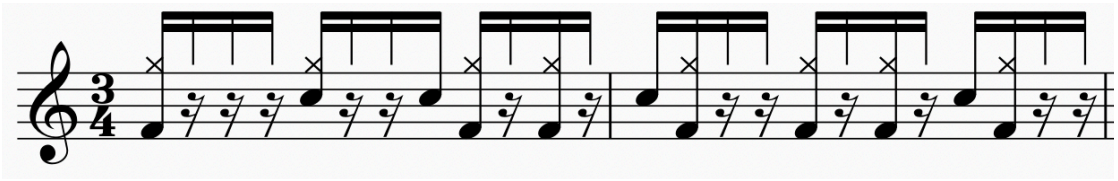
- Kick on 1st and 7th step
- Snare on 4th and 10th step
- Hi-hat on 1st, 5th and 9th step
- Additional snare starting 4th, 11th and 12th steps, eventually improvising through all of the steps.

The acoustic drumbeat is two bars long, which is equivalent to 24 steps on a drum machine. The drum machine's sample sounds are tonally more compressed and tonally synthetic to create contrast between the percussive elements. However, the general goal was to pursue similar tonality with the bass and the snare drum to create an illusion that all the rhythmic elements come from the same drum set. The sounds blend together well, and timing errors or phase issues are not audible in the final mix. The biggest challenge was to combine the two bass drums together. The synthetic bass drum's ADSR has been adjusted to obtain slow attack and long release. This makes room for the attack of the acoustic bass drum. The synthetic bass drum's amplitude is lower compared to the acoustic bass drum, but the lowest note still decays off audibly. Once the song progresses, the emphasis of the drum machine gradually shifts more towards higher frequencies, gaining the role of supportive percussion instrument.

The drum machine beat stays similar throughout parts A and B. The variation comes from the acoustic drumming and an additional improvised snare pattern, which evolves into more complex patterns before part B. The additional snare improvisation is conducted as step programming. It consists of 12 steps, which are triggered and untriggered throughout the sequence. In addition, the additional snare drum is being manipulated by loopers and Octatrack's delay effects. The part offers a mild distraction, before settling fully on 16th notes from the B-part until to the very end. In the outro part, all of the drums are fading out manually to give space for the final ambient, which ends the song. Pictures 13 and 14 demonstrate how the patterns are intertwining and supporting each other by making room for all of the drum notes.



PICTURE 13. Drum machine rhythm for Kuulen ääniä maan alta (Niko Lehdontie 2023).



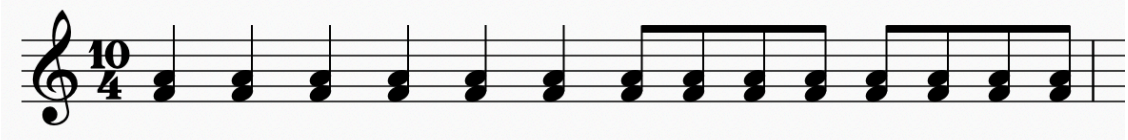
PICTURE 14. Acoustic drum kit rhythm for Kuulen ääniä maan alta (Niko Lehdontie 2023).

### 4.3 Ilmestys

The second example is from the same recording session. The name of the song is Ilmestys and it is performed by Oranssi Pazuzu in 2019 at Headline Studios. The song was released in 2020 and it can be described as an industrial metal song. Ilmestys consists of five parts: intro, part A, bridge, part B and outro. The composition evolves around a hypnotic and repetitive bass drum and floor tom pattern. Even though the drum machine tracks in this song lean more towards the sound design aspects of sequencing, they have a rather percussive nature, which is the reason why it is included as an example here. As before, the drums and drum machines are performed live simultaneously.

The composition is in 10/4 time signature. The pattern is programmed to include 40 steps in Octatrack, which are represented as 16$^{th}$ notes. The main elements of the acoustic drum kit are the bass drum and floor tom, both of which are sharing the same rhythm throughout part A and the bridge (Picture 15). Drum machine is playing a 16$^{th}$ note cymbal pattern, which is created by step programming. In addition to this, the track is manually manipulated with the effects to create variation to an otherwise static pattern. Drum machine is sending a pre-programmed MIDI

sequence of 16th notes to a synthesizer, which starts to trigger the notes in the middle of part A. The drum machine takes a bigger role in the bridge part of the song, which is included to appear as a dreamy sequence, going away from sharp and tension filled rhythms. In this part, one longer audio track has been chopped to 16 audio slices, which are triggered in improvisational manner. Each of the 16 steps are acting as slices of audio. The chopped audio is also manipulated by controlling individual tonal parameters of each slice. The dreamy bridge part makes a transition to part B by crescendo of audio loops and vocals. Once the chorus begins, the sharp cymbal sequence starts again and continues until the end. Overall, the composition consists of multiple percussion patterns, but the sounds deviate greatly from one another, which creates space for each element, so that the end result is not too chaotic. The drum machine's main role is to support the song's brooding industrial atmosphere in the background and to act as a replacement of the cymbals of the acoustic drums during part A and the bridge.



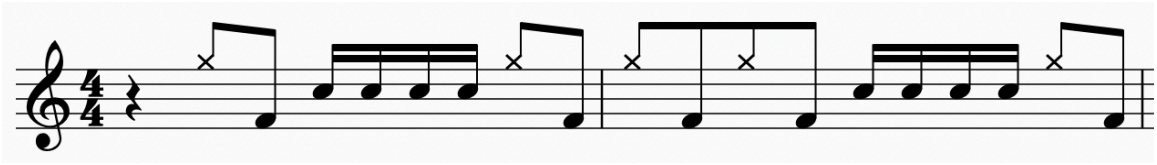
PICTURE 15. Acoustic drum kit rhythm for Ilmestys (Niko Lehdontie 2023).

### 4.4 Psionic Static

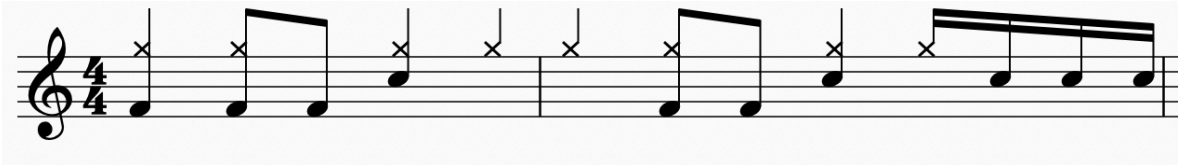
The third example is a song called Psionic Static by Kairon; IRSE!. It was recorded at Magnusborg Studios in 2019 and released in 2020. The song is a mixture between alternative rock and dreamy electronica. Psionic Static consists of intro, bridge, part A, part B and outro. The percussion arrangement consists of a drum kit and a drum machine playing similar drum patterns on top of each other. The acoustic drums and drum machines were performed live simultaneously.

Psionic Static is in 4/4 time signature. The intro starts with a rhythm played on the drum machine, switching to acoustic drums during the bridge. The drums and the drum machine are played together during the second part A, second part B and the outro. The goal was to sound as similar as the acoustic drums as possible, to create an illusion of both sounds coming from the same kit. The sample

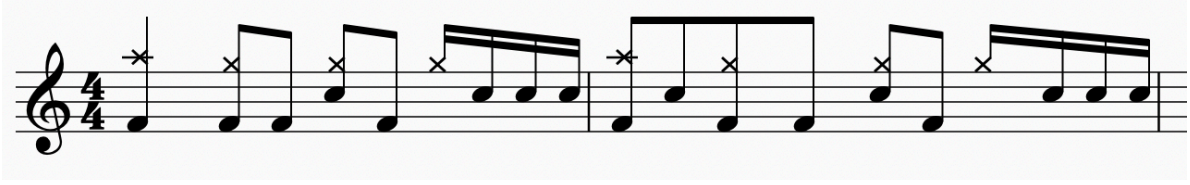
that the drum machine is sequencing is a two-bar long loop, which was created by programming and performing with a MIDI keyboard. It is unquantized, and therefore it has its own rhythmic imperfection included. The Drum patterns were arranged and rehearsed carefully to avoid phase and timing issues. As pictures 16 and 17 illustrate, in part A the snare rolls are executed one after another, to create the illusion of continuation. The pictures also demonstrate how both bass drums avoid repeating the same notes. Once part B starts (picture 18), the drum kit pattern expands to more notes, still maintaining the illusion of a single hectic drum kit. The drum machine's sound is changed during the performance by an expression pedal which is programmed to change the effect parameters of Octatrack. It is present most audibly in the outro, where the reverb of the drum pattern is increased towards the end of the part. Overall, the mix is dense, as the percussion arrangement is full of notes and the composition has a fast tempo. However, the balance between other tracks makes it blend together well. The bass is focusing on long distorted notes and the guitars on creating a wall of noise, which leaves space for the hectic rhythm patterns.



PICTURE 16. Drum machine rhythm for Psionic Static (Niko Lehdontie 2023).



PICTURE 17. Drum kit rhythm for Psionic Static's part A (Niko Lehdontie 2023).

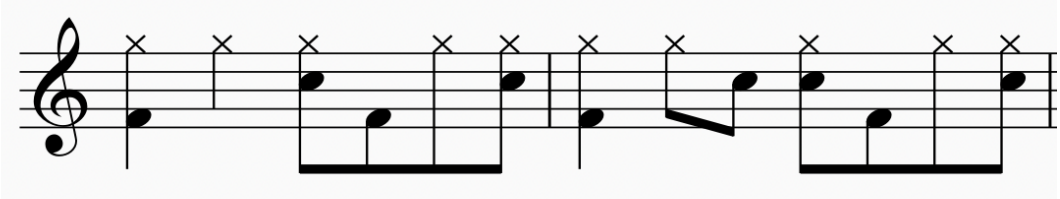


PICTURE 18. Drum kit rhythm for Psionic Static's part B (Niko Lehdontie 2023).

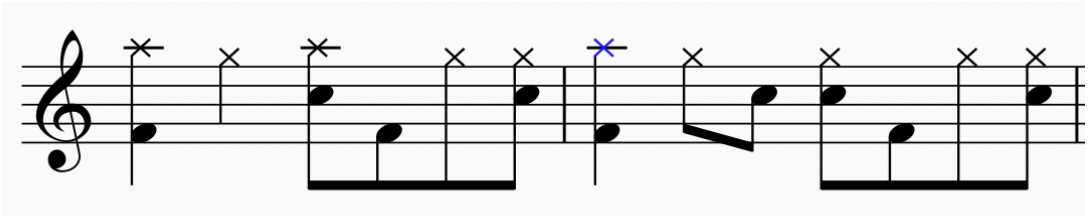
### 4.5 Polysomn

The fourth song is called Polysomn, and it is performed by Kairon; IRSE! at Magnusborg studios in 2019 and released in 2020. The song is entirely instrumental and has only one part. It consists of a drum machine and drum kit performing at the same time in live situation. Both percussion elements occupy same timing and are tonally close to each other.

The purpose of the drum machine in this composition was to act as a heavily effected version of an acoustic drum kit. Therefore, both percussive elements occupy similar patterns (Pictures 16 and 17). The only difference between the patterns is that the drum kit is emphasizing the changes of the bass notes with the crash cymbal. The drum machine pattern was programmed by performing it on a MIDI keyboard first before sampling it to the drum machine. Octatrack is controlled by footswitches and expression pedal, triggering the start and ending sequences as well as changing effect parameters. The pattern in Octatrack is heavily manipulated with delays and modulations, which is the reason why the phase issues and timing errors are not audible in the final mix. In the mix, the drum machine has greater amplitude compared to the acoustic kit, the most prominent element being a loud crash cymbal. The acoustic kit was performed softly to prevent possible timing issues and collision with drum machine patterns. The drum arrangement works due to amplitude differences, and heavy effect manipulation of the drum machines' sound. Since the delays and modulation effects are disturbing the drum machines phasing and timing, it creates an illusion of one single drum kit being performed over the song.



PICTURE 19. Polysomn drum machine pattern (Niko Lehdontie 2023).

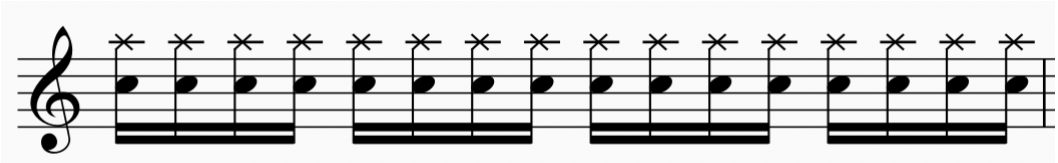


PICTURE 20. Polysomn drum kit pattern. (Niko Lehdontie 2023).

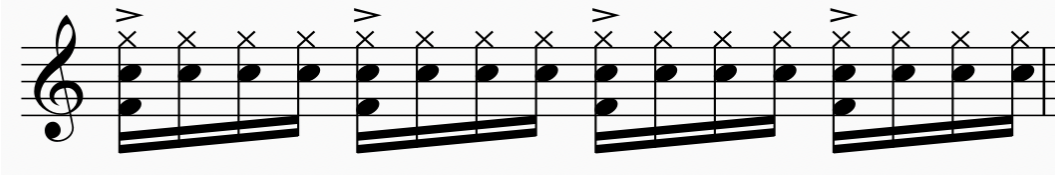
### 4.6 Altaïr Descends

The fifth example is a song called Altaïr Descends by Kairon; IRSE!, recorded at Magnusborg studio in 2019 and released in 2020. The song can be described as an electronic alternative song, heavily leaning towards the use of drum machine and sequencers. Altaïr Descends consists of intro, part A, bridge, part B and outro.

The song is in 4/4 time signature and uses multiple different steps on a drum machine. For example, the 16$^{th}$ note drum beat has 16 steps represented as 16$^{th}$ notes and the droning bass sequence is 48 steps long represented as 8$^{th}$ notes. The drum machine pattern revolves around the 16$^{th}$ note pattern and stays the same, except the small amount of manipulation it is receiving, throughout the song (Picture 21). The droning bass sequence is sampled and utilizes triggered LFOs of Octatrack throughout the sequence, creating pitch movement to the static synth bass line. The acoustic drum pattern, seen in Picture 22, uses a similar note placement as the drum machine pattern, but with the hi-hat accenting and bass drum joining for every quarter note. In part B, the drum machine adds a bass drum sound on every 16$^{th}$ note. The similar patterns are not creating issues with each other, as the drum machine pattern resembles more white noise than an actual drum kit. Its transients are greatly smoothed out, providing free space to the droning elements and sharper rhythms of the acoustic drum kit.



PICTURE 21. Altaïr Descends drum machine pattern during part A (Niko Lehdontie 2023).



PICTURE 22. Altaïr Descends drum kit pattern during part A (Niko Lehdontie 2023).

Altaïr Descends builds on pre-recorded and edited samples, loops, and step programming, which are then manipulated throughout the song with the drum machine via MIDI. The acoustic drums are only audible during verses, while in other sections the drum machine works alone with the heavily distorted instruments. The drum machine's focus during the verses is on sound design elements, whereas in the chorus the sequenced bass and drum part provides the crucial rhythmic information for the composition. The part transitions between the verse and chorus are guitar loops, that have been reversed and were performed at the same time with the real guitar.

# 5 DISCUSSION & CONCLUSION

The goal of this thesis was to test the hypothesis that a drum machine or sampler could be a valuable asset in performing music and writing songs, combined with acoustic drums. The experiments I conducted, were supporting my theory of drum machines' possibilities with inspiring the band environment and bringing new creative influences on songwriting. The results of these experiments show that the conjunction of two separate rhythm instruments can pave the way for a new musical language; within these examples this approach broadened both bands' expressional abilities. These methods made it possible for the bands to introduce more electronic aesthetics to their music, without sacrificing the performance of band ensemble playing. It is worth noting, that this approach will benefit from a well together performing band or a technically skilled drummer, as playing together with a drum machine requires specific rhythmic execution to keep time with the sequencers. All the songs in the practical part were composed, arranged, and rehearsed with acoustic drums and drum machine present at each band's rehearsal spaces. This supports my theory of using the combination as a songwriting tool.

Drum machines and samplers share a common ground with acoustic drums, despite their differences. The differences largely consists of timing execution and quantity of variation. Human performed drums lack of perfect timing execution but have more dynamic variation between the notes tonally. However, there are multiple ways to bring drum machine closer to the human performance as earlier shown through the recorded music history, examples and conducted recording sessions. As the technology has increased abilities of rhythm devices, under creative programming, it can achieve similar interaction with human performance as any instrument can. On the other hand, acoustic drum kit can be manipulated with external hardware processors or software plug-ins to have less dynamic range, similar to the drum machines and samples.

Theoretically, the issues that emerged from the combination of the rhythm elements were all a matter of arranging or changing the sound tonalities. Most of the sound tonality problems were connected to the drum machine sounds that bore a resemblance to either bass drum or snare drum sounds. The issues were fixed by changing the amplitude of sound, changing the samples, taking an advantage

of equalization of the sound or in other ways creating differences between the similar sounds, all of which could be done within a drum machine. The most reliable way to avoid phase issues and timing errors was concentrating on a good arrangement. Giving each drum pattern their own space and room to co-exist within a song also gives more room for human performance. When an arrangement is too dense with percussive instruments, it might underline the differences between the drums in tonality and rhythmicality. In the examples provided in the practical part, the drum performances were not edited afterwards but if the drum performance seems lacking or colliding too much with the drum machine, it can be fixed in postproduction to a certain point. Otherwise rehearsing with drum machine and making sure that the arrangement works will take care of the issues. Even when the drum machine patterns are quantized, if drum arrangement is well done, the human performed drums can maintain balance in the rhythm as a whole.

The history of drum machines and samplers shows that they can be used in almost endless configurations. Most commonly they are utilized either as the sole rhythm provider or to strengthen the drummer's performance in the postproduction phase. However, the examples from different artists and producers across the history show how artists have creatively used drum machines in varying configurations with great results. Examples of drum machine use in conjunction with acoustic drums is found extensively in the history of modern music, but I still feel this technique is not utilized as much as it could be, and the full potential of this combination is still to be discovered. This thesis supports the idea of experimenting with merging drum machines and acoustic drums to achieve different sound tonalities, to enhance one's musical diversity and to use as an ever evolving source of inspiration.

**REFERENCES**

AudioTechnology 2000. Recording Nine Inch Nails. Issue 10. Published on 2000. Read on 08.11.2022. https://www.audiotechnology.com/PDF/10/AT10_Recording_Nine_Inch_Nails.pdf

Battles. 2015. Battles: The Art of The Repetition. Youtube. Released on 22.07.2015. Watched on 12.12.2022. https://www.youtube.com/watch?v=jS5ltxihivA

Björk. 2022. Björk: Sonic Symbolism - Homogenic. Podcast. Spotify. Released on 09.2022. Listened on 11.12.2022. https://open.spotify.com/episode/6x5kSEtDp91pCWg79XMi3P?si=d4947b605adf44b4

Boardway, C & Laughton, J. 2021. A Brief History of AKAI MPC. Released on 10.03.2021. Read on 08.08.2022. https://reverb.com/news/a-brief-history-of-the-akai-mpc

Brennan, M. 2020. Kick it - A Social History Of A Drum Kit. 1st Ed. New York: Oxford University Press.

Buskin, R. 2012. Classic Tracks: Nine Inch Nails ''Closer''. Published on 09.2012. Read on 08.11.2022. https://www.soundonsound.com/techniques/classic-tracks-nine-inch-nails-closer

Carlozo, Lou. 2019. Released on 24.06.2019. Read on 08.11.2022. https://reverb.com/news/prince-and-the-linn-lm-1

Crane, L. 2017. ''Susan Rogers: From Prince To Ph.D.''. Released on 01.2017. Read on 11.23.2022. https://tapeop.com/interviews/117/susan-rogers/

Dr. Hemmings, R. 2020. Released on 08.2020. Read on 01.03.2023. https://usercontent.one/wp/leicesterdrumschool.co.uk/wp-content/uploads/2020/08/Free-Drum-Book.pdf

Dunkley, J & Houghton, M. 2011. Replacing & Reinforcing Recorded Drums. Released on 03/2011. Read on 02.11.2022. https://www.soundonsound.com/techniques/replacing-reinforcing-recorded-drums

Elektron. 2021. Manual for the Octatrack MKII. Released on 14.04.2021. Read on 14.04.2021. https://cdn.www.elektron.se/media/downloads/octatrack-mkii/Octatrack-MKII-User-Manual_ENG_OS1.40A_210414.pdf

Hainbach. 2021. The First Modern Drum Machine / Eko Computerhythm. Youtube. Released on 30.08.2021. Watched on 11.11.2022. https://www.youtube.com/watch?v=XYFg_t8Hjxs

Hennig, H. Fleischmann, R. Geisel, T. 2012. Musical rhythms: The science of being slightly off. Released on 7.2022. Read on 12.12.2022. https://physicstoday.scitation.org/doi/10.1063/PT.3.1650?journalCode=pto

Horn, T. 2011. Transcription of Trevor Horn's lecture at 2011 Red Bull Music Academy. Released on 12.04.2018. Read on 08.11.2022. https://www.redbullmusicacademy.com/lectures/trevor-horn-buggles-in-the-bassbin

Kanter, J. 2020. Use These Drum Machines to Drop Your Beat. Released on 03.06.2020. Read on 08.11.2022. https://www.rollingstone.com/product-recommendations/electronics/best-drum-machines-1008334/

Linn Electronic, Inc. 1980. Product Manual of LM-1 Drum Machine. Released on 1980. Read on 08.11.2022. https://www.manualslib.com/manual/1350735/Linn-Lm-1.html

Linn Electronic, Inc. 1982. Product Manual of LM-2 Drum Machine. Released on 1982. Read on 04.11.2022. https://archive.org/details/synthmanual-linndrum-owners-manual/page/n23/mode/2up

Mcdonough, M. 2019. Released on 24.07.2019. Read on 10.10.2022. https://www.sweetwater.com/insync/drum-machine-vs-sampler-whats-the-difference/

MOT Oxford Dictionary of English. English dictionary. Read on 2022. https://www.sanakirja.fi/oxford_english/english-english/sampling

Oberheim Electronics, Inc. Product Manual of Oberheim DMX Drum Machine. Released on 1982. Read on 02.11.2022. http://www.synthfool.com/docs/Oberheim/Oberheim_DMX_Owners_Manual.pdf

Orkin, D. Gustavson, N. 2018. A Brief History of the Drum Machine. Released on 04.10.2018. Read on 10.10.2022. https://reverb.com/news/video-a-brief-history-of-the-drum-machine

Radiohead. 2008. In Rainbows From The Basement. YouTube. Released on 04.2008. Watched 12.12.2022. https://www.youtube.com/watch?v=DWuAn6C8Mfc

Roland. Product manual of TR-808. Released in 1980. Read on 08.2022. http://cdn.roland.com/assets/media/pdf/TR-808_OM.pdf?_ga=2.70340112.1809030506.1670438604-285916592.1670438604

Scarth, G & Curry, O. 2013. DAW & Drum Machine Swing. Released on 01.07.2013. Read on 11.11.2022. https://www.attackmagazine.com/technique/passing-notes/daw-drum-machine-swing/

Siarri, P. 2019. SP-1200: The Genesis of modern Hip-Hop production. Released on 09.05.2019. Read on 01.11.2022. https://philsiarri.medium.com/sp-1200-the-genesis-of-modern-hip-hop-production-1f1aa155b500

Senior, M. 2015. Recording Secrets For The Small Studio. 1st Ed. New York & London: Focal Press.

WhoSampled. 2022. Database of sampled music. Read on 12.12.2022. https://www.whosampled.com/

Williston, J. 2000. Wurlitzer Sideman. Released on 2000. Read on 02.11.2022. https://www.synthmuseum.com/wurl/wursideman01.html

808. 2015. Direction: Alexander Dunn. Production: You Know Films, You Know Ltd, Atlantic Films. Production country: United States of America.

## APPENDICES

Appendix 1. Playlist of drum stems

https://soundcloud.com/nikolehdontie/sets/thesis-project/s-J8m8pN4359b?si=85ceae8a31084ad9bb525a83c34fd7f9&utm_source=clip-board&utm_medium=text&utm_campaign=social_sharing