Simple Beat Matrix Drum Machine using an ARM M4 CPU

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Acknowledgements

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Summary

Opsomming

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List of Abbreviations

IC Integrated Circuit

MIDI Musical Instrument Digital Interface

PCB Printed Circuit Board

SIPO Serial In Parallel Out

μ**C** Micro-Controller

Chapter 1

Introduction

1.1 Project Background

1.2 Project Aims

Chapter 2

Literature Study

To design a drum machine one must first determine what that is and could be. Unfortunately it is not as straight-forward as one would believe as there are several forms of drum machines. The complexity and mere perception of what it is has changed since its beginnings in the 1930s, thus a point in time will need be selected to be the basis of this project.

2.1 The Beginning of Drum Machines

Before drum machines could be programmed to the musician's liking it would make simple or pre-recorded sounds on a schedule. This meant that the *drum machines* of the time, the 1930s into the 1950s, acted mostly as timing to be used in conjunction with other instruments [1].
The earliest device one could conceive as a drum machine was the *Rhythmicon* by Léon Theremin and commissioned by Henry Cowell [1], [2]. The *Rhythmicon* was completed in 1931 and could only produce sixteen different rhythms [3]. These rhythms would all be more rapid than the previous, all based on a periodic base rhythm. This device would, however, only act as a concept for the next two decades.
In the late 1950s large devices such as the *Chamberlin Rhythmate* or the *Wurlitzer Sideman* came on the market. These two offered a more pleasant sound to listen to by playing back audio tapes (at various speeds), and a system similar to a music box respectively [1], [2]. The latter, the *Sideman*, had rhythms styles including the Samba, Waltz and more[4].
Progressing to the 1960s, drum machines started to be manufactured with, at the time, new solid-state transistors. These transistors allowed for the units to shrink in size drastically. In Japan a new trend was encouraged by companies such as Ace Tone, and Keio-Giken to create organ accessories. Outside of Japan, the idea would be taken in a different perspective by creating pre-set rhythm boxes, such as the *Elka Drummer One*. For these devices to progress, a new level of control would be required [1].

2.2 Programmable Drum Machines

First one will have to understand what is meant by *programmable*: this refers to the ability for musicians to create their own patterns of internal sounds [1].
The first programmable drum machines came about in the 1970s with the *Eko Compute Rhythm* in 1972, as seen in Figure 2.1. This product featured a beat matrix, something

Figure 2.1: An Eko Compute Rhythm in Use [5]

that can still be found today [2]. Beat Matrices will be discussed in Section **??**. Roland introduced the first drum machine to feature a microprocessor in 1978 with the *CR-78 CompuRhythm*. This allowed the user to store entire sequences [6]. Several years later they brought out the *TR-808* with a set of programmable synthesized analogue sounds [2], [7]. At this point the demand for real drum sounds was high and thus came the Sample-Based Drum Machines.

In 1980, the *Linn Electronics LM-1* was released to be the first drum machine to use recorded samples as opposed to synthesized sounds [2]. Synth manufacturers began to enter the rhythmic device market with product that made use of swappable memory cards, had Musical Instrument Digital Interface (MIDI) integration, among other features [1].

The most important feature to be added in the forthcoming years was being able to sample sounds on the device itself. This was pioneered by the *Akai MPC* series of drum machines. These featured sixteen responsive pad controllers and had all the features of a drum machine [1], [2]. This wave of new machines throughout the 1980s paved the way for stations such as the more recent *Native Instruments Maschine* series [1], an example of which can be seen in Figure 2.2.

Figure 2.2: Native Instruments Maschine Mk3 [8]

Chapter 3

Hardware Design

3.1 μC

Before even being able to design the circuit as a whole the main controller needs to be chosen. To

3.2 LED Matrix Driver

3.2.1 Other

To drive the LED matrix of 16 columns by 5 rows a circuit with shift registers is used. These shift registers will be Serial In Parallel Out (SIPO) so that the micro-controller can communicate in serial to the matrix. Three shift registers will be hooked up in series allowing for the serial signal to be passed from one Integrated Circuit (IC) to the next. To conserve the amount of pins needed on the micro-controller both the rows and columns will be controlled by one serial signal. To further update the shift registers two clock signals are required. One for the Shift Register and another for the Register.
The chosen ICs are the 74HC595 latched shift registers and the ULN2803A Darlington transistor arrays. In conjunction, these

3.3 Button Matrix Driver

3.4 Tempo and Volume Control with LCD

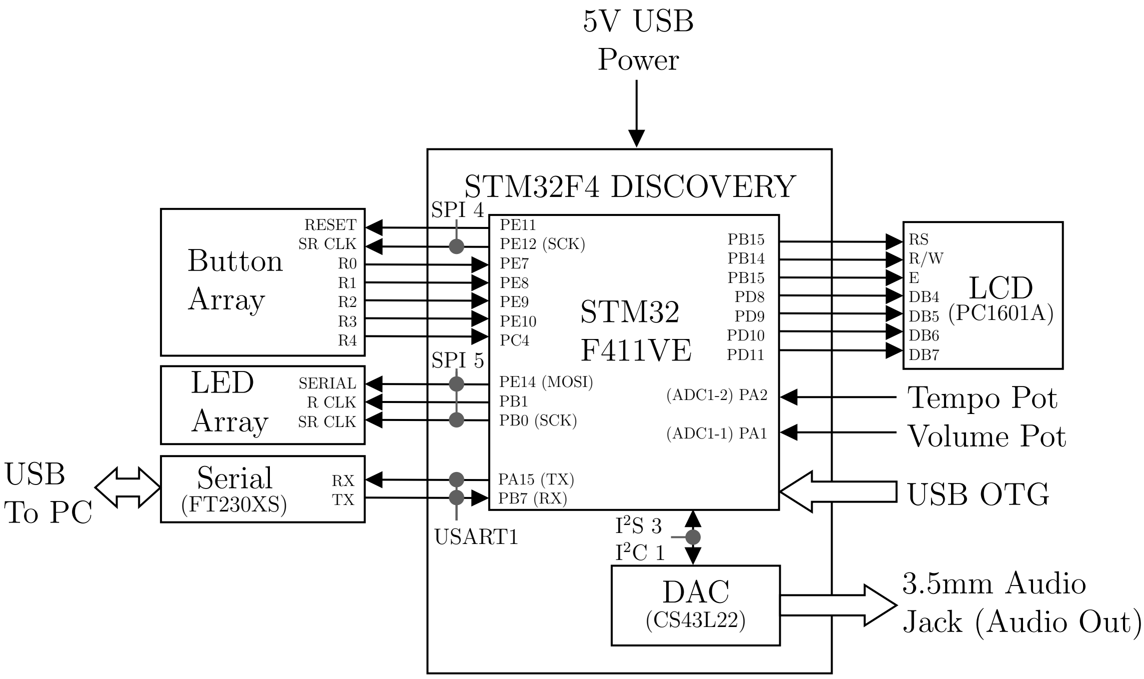

Figure 3.1: Complete System Diagram

Chapter 4

Software Design

Chapter 5

Conclusions and Recommendations

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Appendix A

Project Planning Schedule

Appendix B

ECSA Outcome Compliance

ECSA ELO	Compliance
ELO 1. Problemsolving: Identify, formulate, analyse and solve complex engineering problems creatively and innovatively.	
ELO 2. Application of scientific and engineering knowledge: Apply knowledge of mathematics, natural sciences, engineering fundamentals and an engineering speciality to solve complex engineering problems.	
ELO 3. Engineering Design: Perform creative, procedural and nonprocedural design and synthesis of components, systems, engineering works, products or processes.	
ELO 4. Investigations, experiments and data analysis: Demonstrate competence to design and conduct investigations and experiments.	
ELO 5. Engineering methods, skills and tools, including Information Technology: Demonstrate competence to use appropriate engineering methods, skills and tools, including those based on information technology.	

ECSA ELO	Compliance
ELO 6. Professional and technical communication: Demonstrate competence to communicate effectively, both orally and in writing, with engineering audiences and the community at large.	
ELO 8. Individual work: Demonstrate competence to work effectively as an individual.	
ELO 9. Independent Learning Ability: Demonstrate competence to engage in independent learning through well-developed learning skills.	

Table B.1: ECSA ELO Compliance

Appendix C

Circuit Diagram

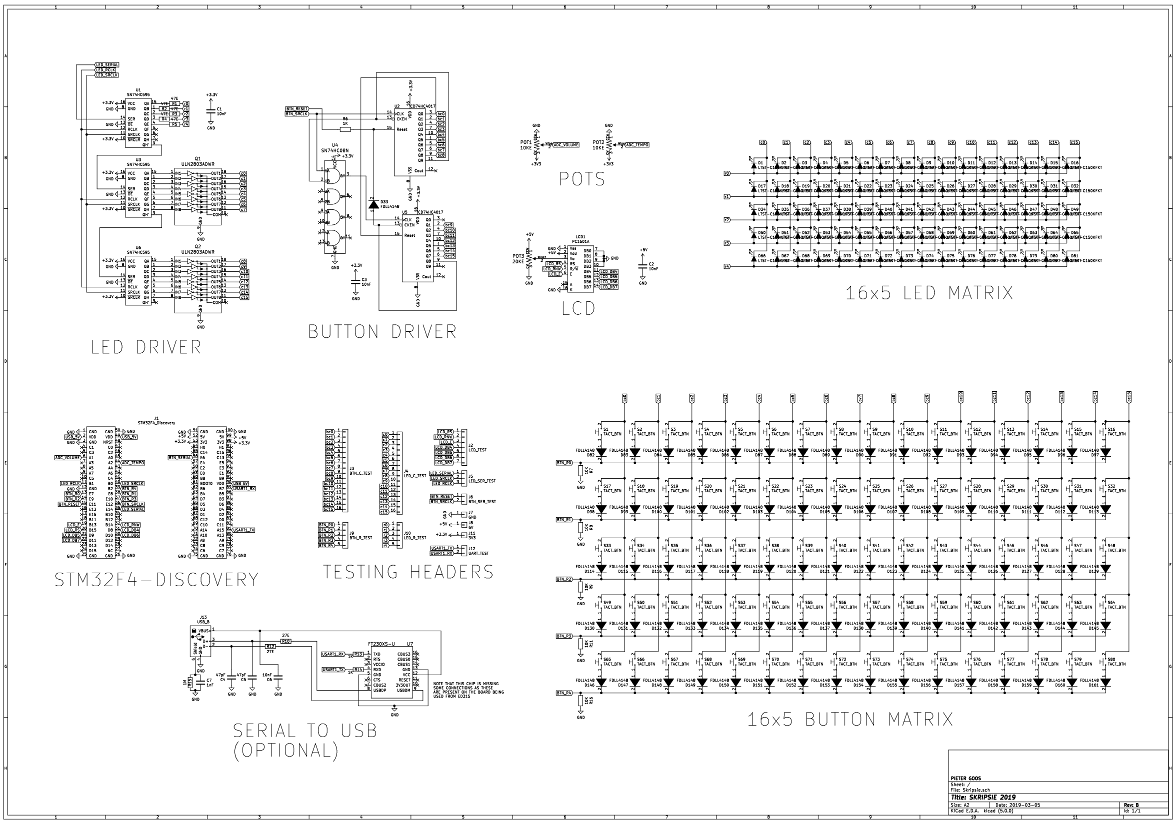

Figure C.1: The Final Revision (Rev. B) of the Circuit Diagram

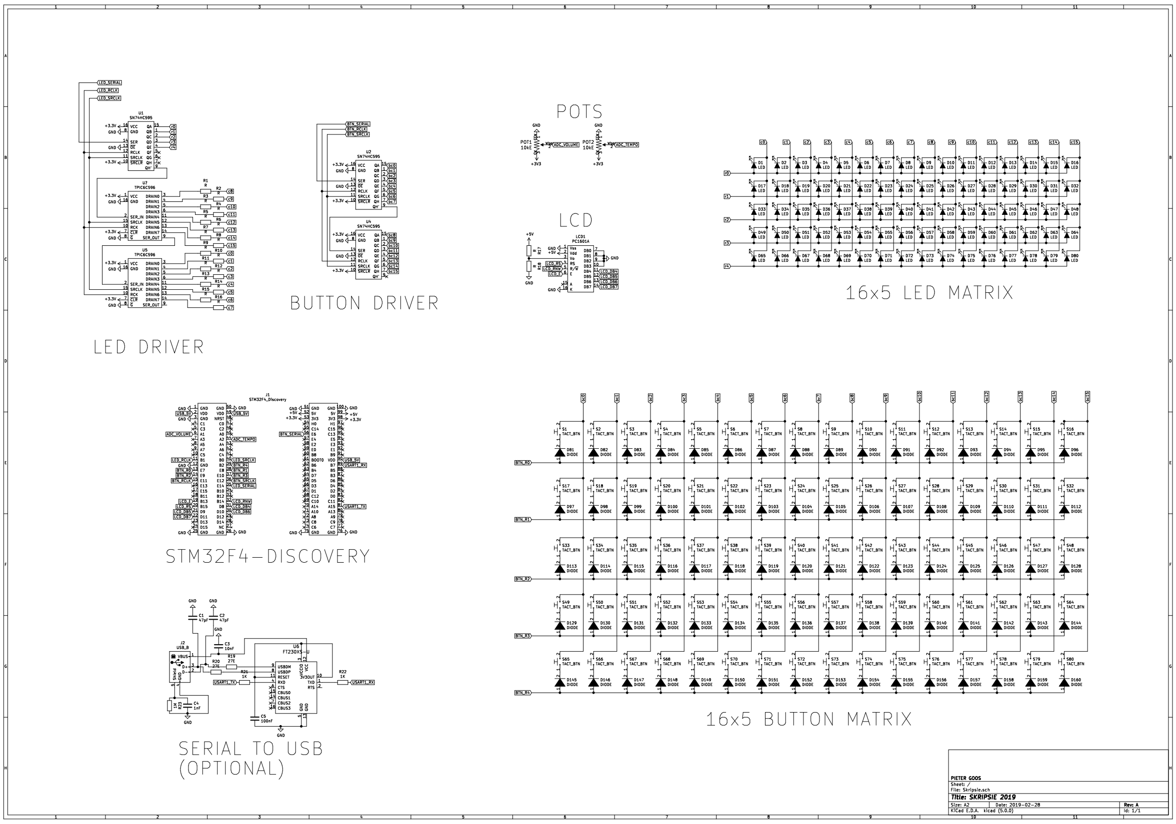

Figure C.2: Revision A of the Circuit Design

Appendix D

PCB Design

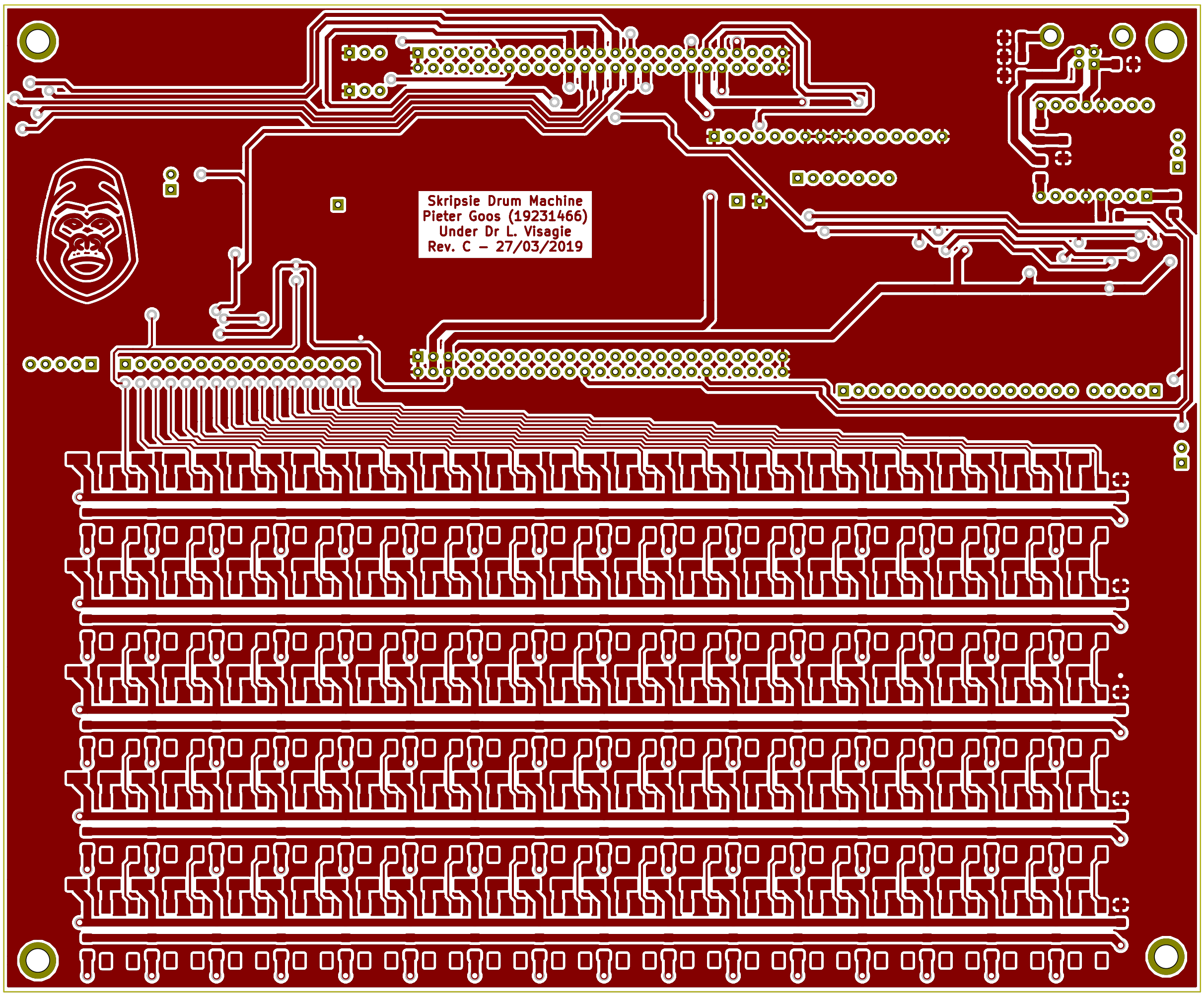

Figure D.1: Front Copper Layer of Revision C of the PCB

It is worth noting that this board (See Figures D.1 and D.2) shown is Revision C, however the board used to construct this project on is Revision B. The changes made between the two versions are simply forgotten traces, and mounting holes have been added.
When looking at the reverse of the board (As in Figure D.2) it is worth noting that the

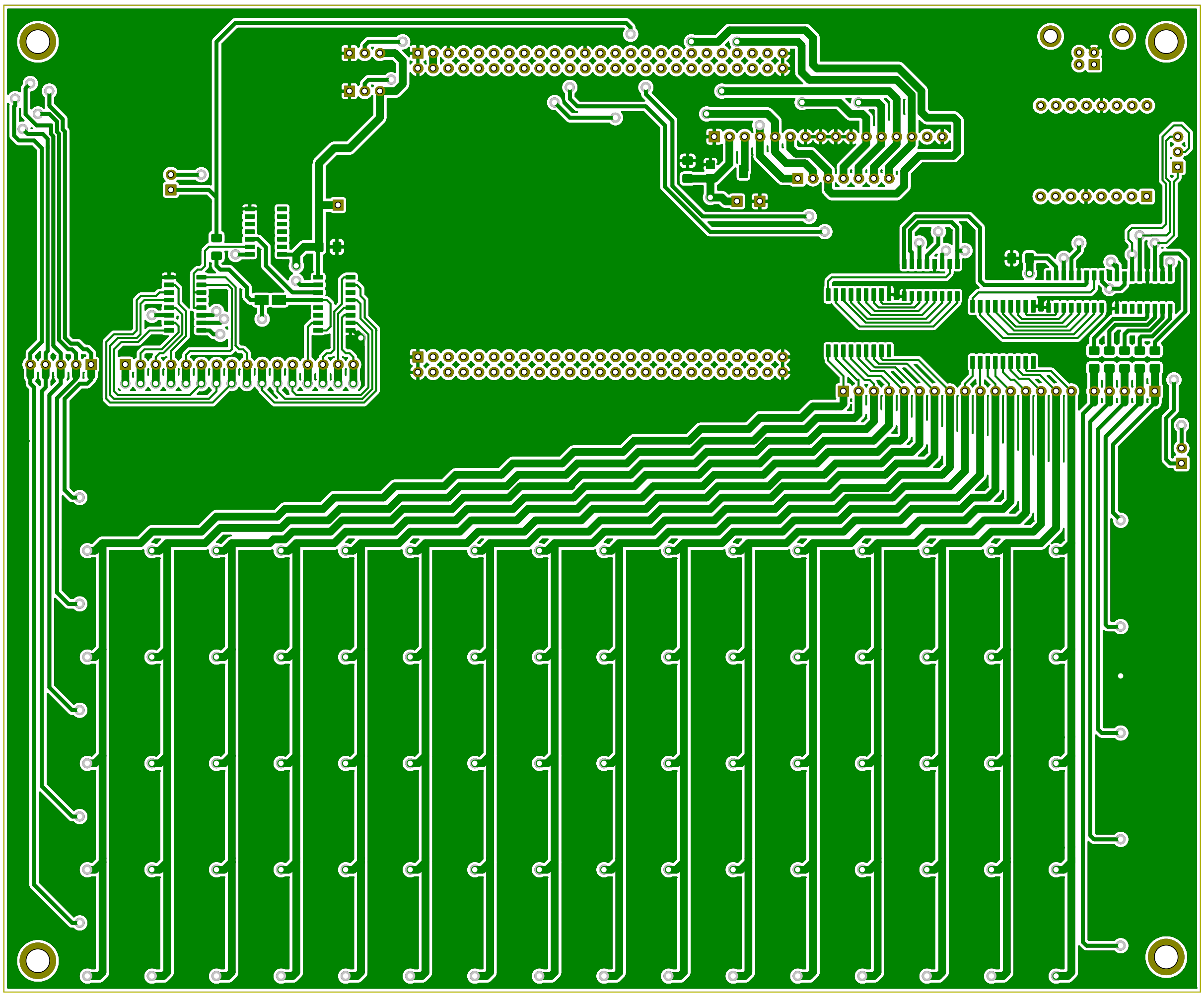

Figure D.2: Back Copper Layer of Revision C of the PCB

shown diagram is not mirrored. This implies that the diagram shown's top left corner matches that of the front copper layer, thus one would have to mirror this from left to right to see what you would see in reality.