Design (E) 344
Technical Report

Analogue Signal Generator

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	27163296
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BFJ KROG	23 Oct 2025
Voorletters en van / *Initials and surname*	Datum / *Date*

Abstract

This will be where you write your abstract, e.g.:

An analogue signal generator with square, triangle and sine wave output was developed. This report...

Contents

List of Figures

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List of Abbreviations

List of Symbols

1 Introduction

Here you describe your overall project briefly, context, specifications, limitations, aims etc. Please note that this is a template, and you can add subsections as you require.

Take great care to reference sources when ideas from publications, textbooks, internet sources and more are used during your design process.

2 System description

Here you will describe your system. Be sure to include a system diagram, and reference it, for instance, as: The system diagram is shown in Figure **??**. An external regulated power supply provides a single supply voltage of +30 V to the system. The output to the load is from a BNC socket... dq

3 Hardware design and implementation

Describe hardware design and verification with SPICE simulation in this section. When equations are used, these must be place (and numbered) as follows:

3.1 Hardware block diagram and description of interaction

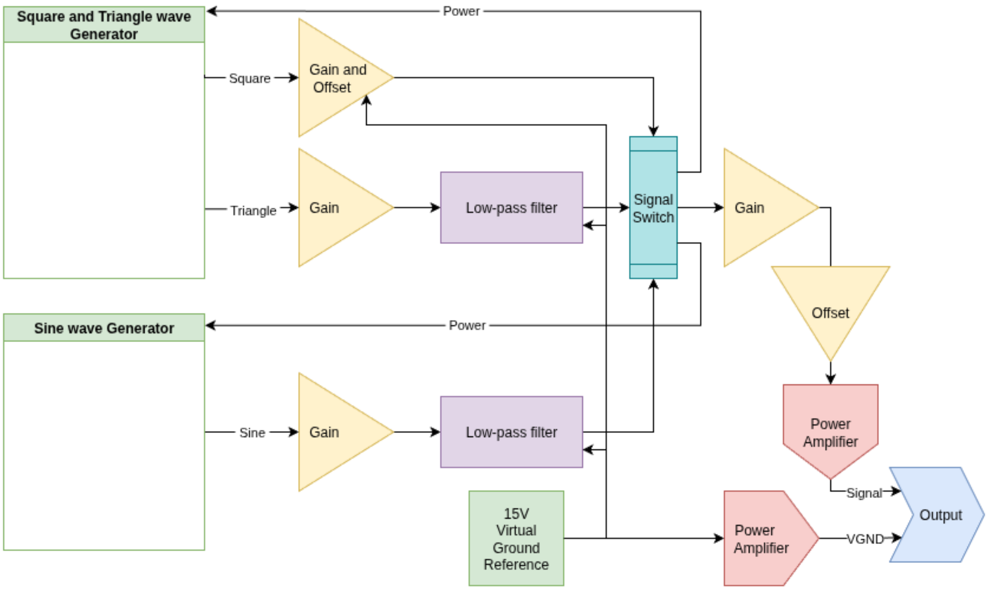

Figure 1: Hardware design overview block diagram

Briefly describe the subsystems, and how each is connected to other subsystems in the full system.

3.2 Square and Triangle wave generator

A good way to generate a linear triangle wave is to exploit the rate of change of voltage to current relationship of a capacitor by using the well known equation rewritten in the form[1]:

$$\frac{i}{C} = \frac{dV}{dt} \tag{1}$$

Where C is the capacitance of the capacitor, i is the current flowing through the capacitor and V the voltage over the capacitor. The voltage can therefore be linearly increased and decreased when applying a constant current to charge and discharge the capacitor periodically which will result in a triangle wave. The skew of the triangle can be adjusted by varying the amount of current charging and discharging asymmetrically, due to a larger current charging the capacitor faster and therefore lowering the charge time and vice-versa. The equation for calculating the time require to charge the capacitor is:

$$T_{charge\_time} = \frac{C\Delta V}{i} \tag{2}$$

The period and frequency of the resulting wave can thus be calculated:

$$\begin{aligned} T &= T_{charge\_time} + T_{discharge\_time} \\ &= C\Delta V(\frac{1}{i_{charging}} + \frac{1}{i_{discharging}}) \end{aligned} \tag{3}$$

$$\begin{aligned} f &= \frac{1}{T} \\ &= \frac{i_{charging} i_{discharging}}{C\Delta V(i_{charging} + i_{discharging})} \end{aligned} \tag{4}$$

The duty cycle can be calculated as:

$$
\begin{aligned}
D_{positive} &= \frac{T_{charge\_time}}{T} \\
&= \frac{\frac{C\Delta V}{i}}{C\Delta V(\frac{1}{i_{charging}} + \frac{1}{i_{discharging}})} \\
&= \frac{i_{discharging}}{i_{charging} + i_{discharging}}
\end{aligned} \tag{5}
$$

Describe the square wave generator design, circuit diagram, frequency adjustment, pulse-width modulation adjustment, frequency range selection and any other relevant design steps (such as the use of dual pots to control frequency while keeping duty cycle constant).

Describe the triangle wave generator design, circuit diagram, frequency adjustment (if different from the square wave), frequency range selection, skew adjustment and any other relevant design steps (for instance: how to keep frequency constant as skew is adjusted).

3.3 Sine wave generator

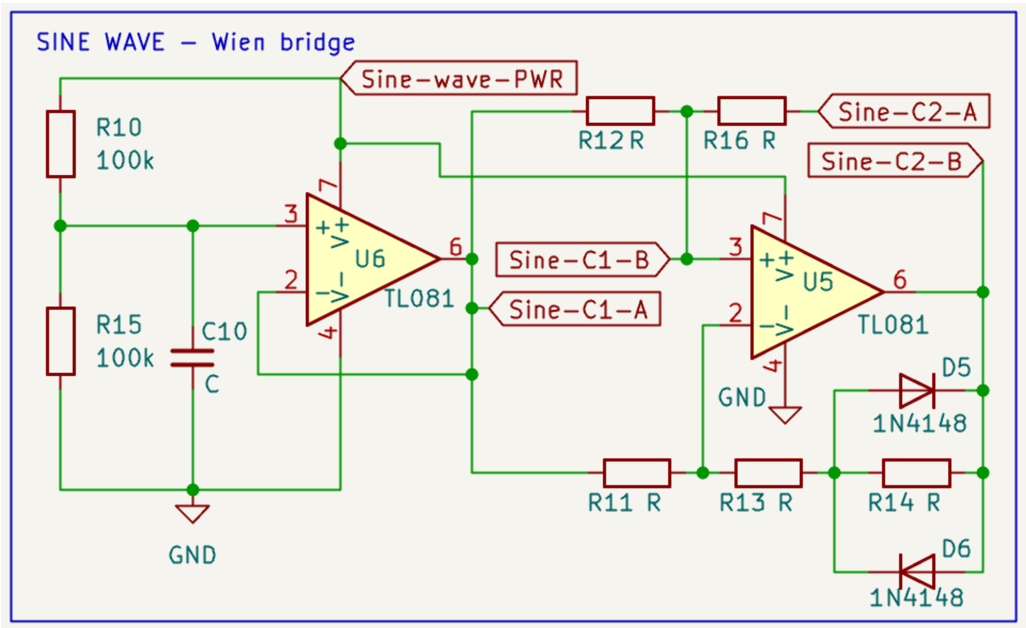

Figure 2: Wien bridge circuit (Sine Wave)

Describe the sine wave generator design, circuit diagram, frequency adjustment, frequency range selection and any measures taken to guarantee a very low THD.

3.4 Summing, signal selection and Level adjustment

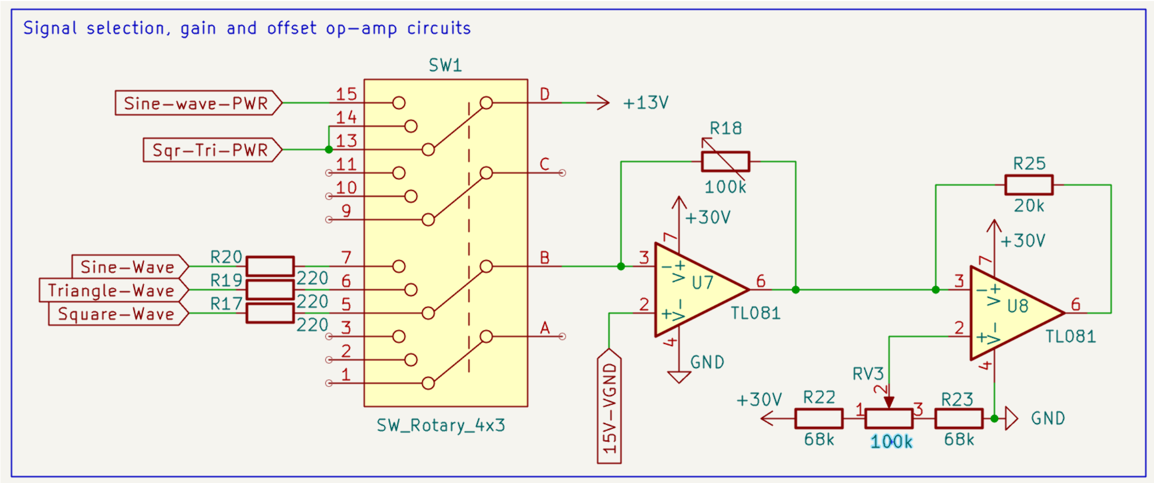

Figure 3: Signal selection, gain and offset op-amp circuits

Describe the design and circuit diagram of level adjustment functionality.

Describe the design and circuit diagram of the signal selection switch, pathways and gain matching resistors.

3.5 Frequency range selection

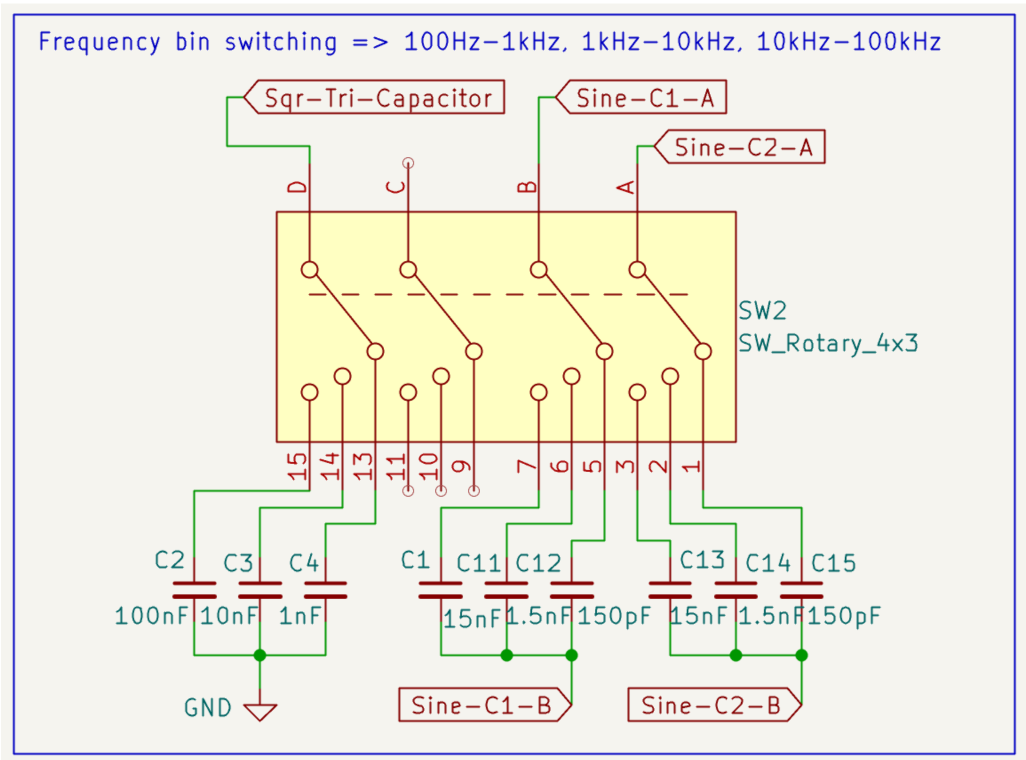

Figure 4: Frequency binning circuit

3.6 Full push-pull Amplifier

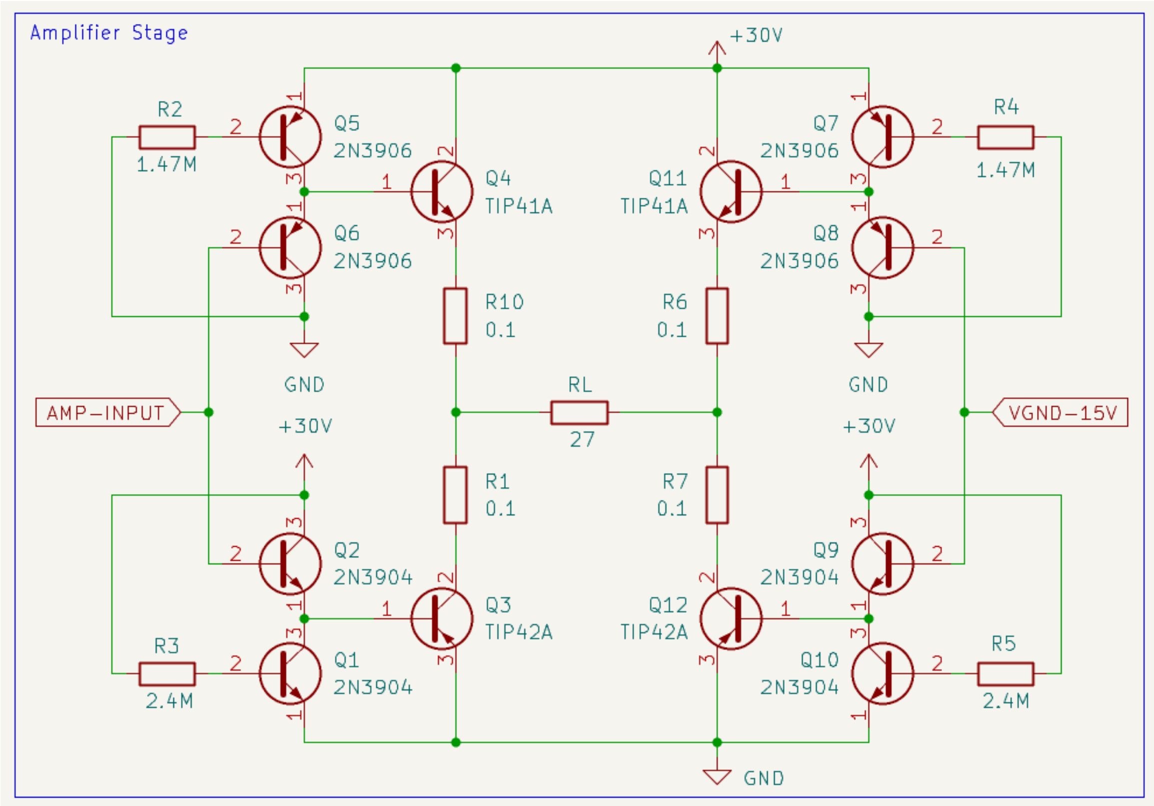

Figure 5: Full push-pull amplifier circuit

Describe the design and circuit diagram of the amplification stage to meet the signal amplitude adjustment requirements.

3.7 Voltage regulation, virtual ground and output drive capability

Describe the design of any voltage regulation circuitry, the virtual ground and the driver design to meet the output source and sink current requirements. Include circuit schematics.

3.8 Other

If you have other subsystems, add these.

3.9 Construction

Discuss the construction of the system, from selection of component placement, to grounding, decoupling, input/output accessibility, packaging, etc. Include photographs of the final system.

4 Software design and implementation

Discuss top-level software design and implementation, using design tools, like flow diagrams where needed.

4.1 Programming language

Python was chosen as the language of choice for this project for its vast library support, simple syntax and the fact that modern LLMs are able to understand and write python very well with few mistakes. The draw backs of Python are that it is an interpreted language requiring a runtime making the final binary very large for a simple program.

mention pyinstaller

Discuss the selected programming language, the motivation for this selection, and the advantages and disadvantages of the selected programming language.

4.2 Software block diagram and description of interaction

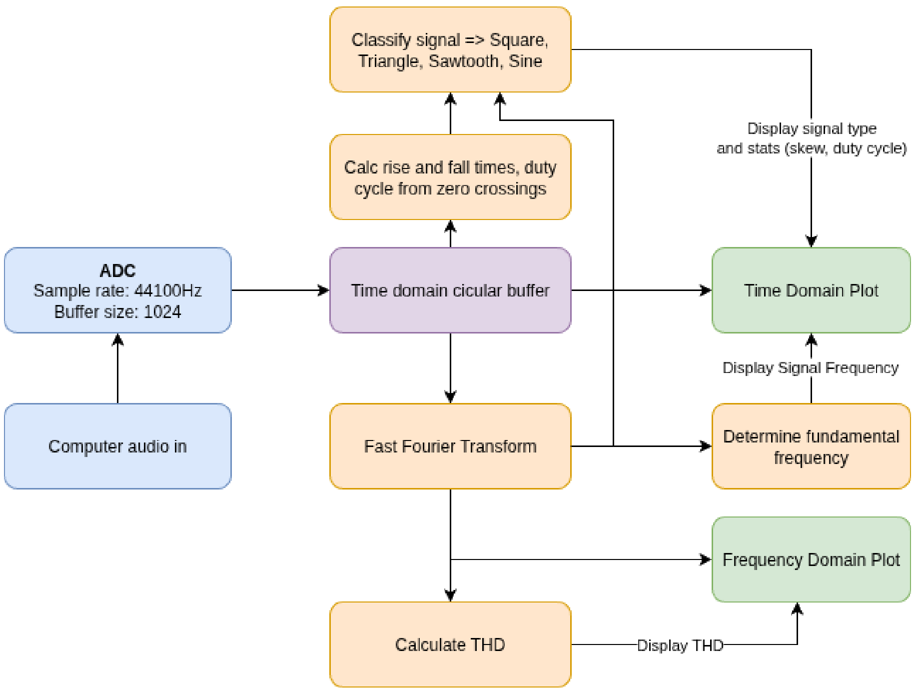

Figure 6: Software design overview block diagram

Describe the code functionality by block diagram.

4.3 Use of AI tools

Describe any use of AI tools to generate sections of the software. Include a discussion on prompting the AI, as well as verifying the correctness and robustness of AI generated code.

4.4 Data read-in and calibration

Describe read-in of measurements, especially in terms of how data is read in through a computer's audio input, how it is calibrated and displayed.

4.5 Software functions

Describe and show results for functions such as amplitude measurement, duty cycle/skew determination, frequency analysis (FFT), total harmonic distortion calculation, etc.

5 Measurements and Results

Describe your measurements and results to determine where your system meets or does not meet the requirements/specifications. Show the results by selected subsystem, as well as for the complete system.

5.1 Square, triangle and sine waves

Show oscilloscope measurements at the output of the system into a 27 Ω load if possible at 100 Hz, 1 kHz and 10 kHz, for 10 V peak amplitude. Discuss the load resistance and the output current achieved. Analyse the results and discuss shortcomings. Specifically show how the single supply voltage is handled, and measure any characteristics necessary to demonstrate that the virtual ground and the output drivers (source/sink) function as designed.

5.2 Duty cycle and skew

Show duty cycle and skew at the required limits (10% to 90%, or 0.1 to 10) at representative frequencies. Analyse and discuss. Compare oscilloscope measurements with those from your own software to validate the software and the circuit results.

5.3 Sine wave total harmonic distortion

Measure the THD for the sine wave with your software if possible, and present FFT plots. Analyse and discuss results.

5.4 Level adjust

Measure and discuss the level adjustment capability.

5.5 Other

Any other measurements or subsystem characterisation unique to your system.

6 Conclusions

Use experimental results, design limitations and system performance, explain your conclusions drawn.

Use experimental results, design limitations and system performance, explain your conclusions drawn. Highlight noise, oscillations and mitigation. Discuss signal quality (harmonic distortion). Do not forget to reference ALL REFERENCES in text using IEEE Documentation Style [**?**]. All applicable documents should be in references list, specifically datasheets and application notes [2] used as references for designs, explanations of device operation etc.

References

[1] (2006) Introduction to electronic signals and measurement - capacitor and inductors. [Online]. Available: https://ocw.mit.edu/courses/6-071j-introduction-to-electronics-signals-and-measurement-spring-2006/eac1995aca830cfd0de6bab60a8abf10_capactr_inductr.pdf

[2] *Highly stable 555 timer*, LM555 datasheet, Texas Instruments, Oct. 2014.