
# Preliminary Report on

# Guitar effects pedal (Analog)

by

Sajjad Ullah

This Report is submitted in partial fulfilment of the requirements of the Honours Degree in Electrical and Electronic Engineering (DT021A) of the Dublin Institute of Technology

Feb 4th, 2022

Supervisor: Kevin Chubb

# Table of Contents

# 1 Introduction & Objectives

This project is about building an analogue guitar pedal, this is  a device controlled by the guitarist's feet to change the sound of the guitar. In its most simple form, a guitar pedal takes in the guitar signal as an input, applies a specified effect to the signal and this becomes the output.

Figure 1 shows an example of a guitar effects pedal called the “Boss DS-1”, this is a distortion pedal and is an example of the type of device we aim to create by the end of the project.


*Figure 1 Boss DS-1 distortion pedal [1]*

We will research a selection of different guitar effects pedals and select the most suitable to implement for the project given the limited time window for the project and other considerations such as component availability. Once built we aim to have a working device for testing with a ukulele.

## *1.1* Objectives

The project aims to create one guitar pedal effect via analogue means, with the end goal of having a device capable that we can connect to a ukulele for use.

**Objectives of the project:**

- Research a suitable effect to implement
- Breakdown pedal effects into categories for assessment.
- Identify analogue processing techniques required on signal to produce the effect
- Break up the circuits filter stages and start designing circuit sections.
- Derive component values for intended operating parameters.
- Preform filter analysis.
- Use simulation software to validate the design
- Implement design onto breadboard
- Test and verify the hardware

Guitar Pedals can be connected in series, giving a multitude of effects to explore, if time allows, we will create another pedal to connect in series.

# 2 Ethics

During research into the pedals there was a prevalence of clone guitar pedals which leads to open the discussion about the ethics of creating clones. With readily available circuit designs available online for certain pedals, the barriers to preventing one from using the same designs is low, however there are legal considerations that one must consider as the designs are likely to be patented and the intellectual property (IP) of the brand or manufacturer. Infringing upon the IP of an organisation is not only morally unethical as a graduate engineer but could include legal ramifications under areas of patent & design infringement. In the EU Directive 98/71/EC provides legal protection of designs.

It is important to be aware of patent, design and copyright law as an engineer, particularly during a project such as this where designs of guitar effect pedals are readily available online.

Engineers Ireland Code of Ethics in section 2.3 states to “Know and respect existing rules pertaining to professional work” (http://ethics.acm.org/code-of-ethics/), the term “Rules” include national, and international laws and regulations.

# 3 Background Research

## 3.1 Guitar pedal categories

The aim is to create an analogue guitar effect, for this to happen we will start by breaking down the guitar pedals into categories. Guitar pedals use filters to produce a desired effect, we first compile a selection of pedal effects into a mind map broken down by filter effect employed[2].

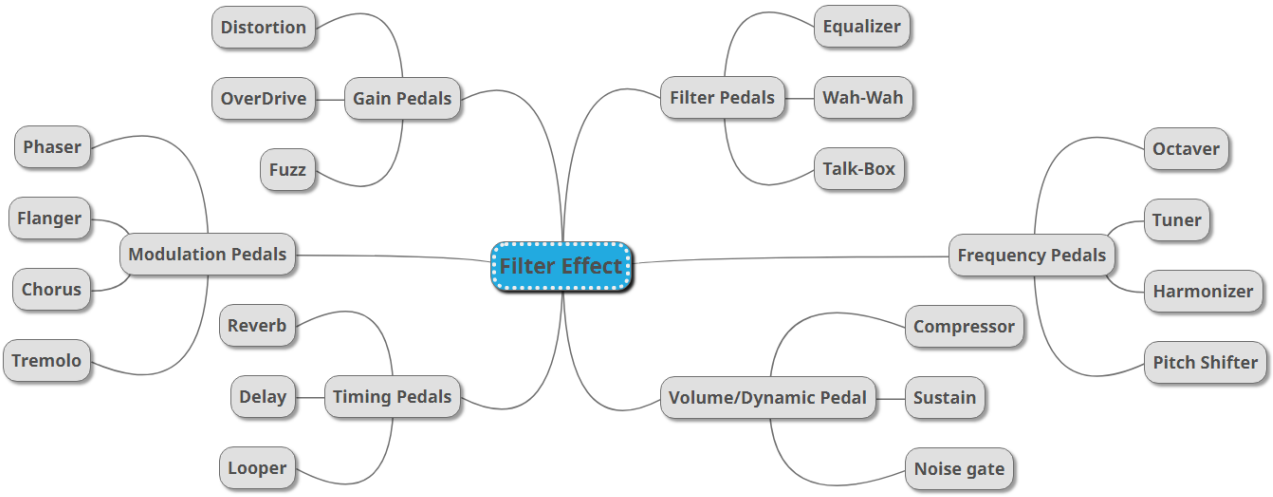



*Figure 2 Mind map of filter effects with pedal types*

Figure 2 contains a selection of filter effects and names of several pedals that implement the effect. Due to time constraints for the preliminary report will discuss two pedals of each filter effect for now.

## Filter Pedals

Equalizer: An equalizer (EQ) is a filter that can isolate a range of frequencies for amplification, attenuation or allow though unchanged[3].

Wah-Wah: Inside this is a device called a potentiometer which is a variable resistor. As the rocker plate in a wah-wah pedal moves the potentiometer will enable to a degree either a low-pass (low frequencies pass through and higher frequencies are blocked) or a high-pass filter (high frequencies pass through and low frequencies are blocked). Rocking the pedal back and forth will create the "Wah effect"[4].

## Frequency Pedals

Octaver: The octave effect is where the input guitar signal is mixed with a synthesised signal that is one or more octave lower or higher than the original. An Octave occurs in music when the higher note has a frequency that is twice that of its lower note[5].

Pitch Shifter: As the name suggests it, works in real time to shift the frequencies of the input signal. They can be set to only output the shifted signal or a combination of the shifted and original signal[6].

## Volume/Dynamic Pedals

Compressor: These are used to reduce the dynamic range (the ratio of the loudest to the quietest discernible sound) of a signal by reducing the amplitude of the input signal by a certain ratio if it reaches beyond a set threshold[7].

Noise Gate: This is a common pedal used to attenuate a signal if it drops below a set threshold. It is typically used to prevent unwanted noise from forming and getting amplified by the amplifier[8].

## Timing Pedals

Reverb: This pedal simulates the effect caused by sound reflection. Reverb decays the signal as opposed to an echo pedal which delays the signal[9].

Looper: This type of pedal records a time interval of the audio and plays it back in a loop. The pedal itself contains controls to start and stop the recording[10].

## Modulation Pedals

Phasor: This pedal creates a copy of the signal, this copy is phase shifted and mixed back in with the original signal for the output[11].

Flanger: This pedal is similar to the Phasor; it also creates a copy of the signal. The copied signal is played at slower speed by modulating the delay time of the copied signal using a low frequency oscillator (LFO). This creates a "whooshing" sound effect due to two recordings playing at the same time[12].

## Gain Pedals

Overdrive: when the signal voltage level reaches the max limit of what the hardware can output. This leads to the signal getting truncated and some frequencies getting cut off. When this happens, it's termed "clipping" and this is an overdrive pedal. It causes the signals to clip on purpose[13].

Distortion: Similar to the overdrive pedal except they use multiple stages for more clipping of the signal. The more stages the higher distortion gain[13].

## 3.2 Digital vs Analogue

The guitar pedal effect can be created by either digital or analogue means, with the latter being more common due to embedded processors capable of applying the pedal effect digitally without the need of specialised circuitry for a particular pedal effect.

A digital pedal takes in the input guitar signal and passes it into an analogue-to-digital (A/D). Computer algorithms apply the desired effect onto the sampled digitized signal. This result is passed through a digital to analogue (D/A) converter which becomes the output signal.

The critical part of a digital pedal is the algorithms applying the desired effect. While in an analogue pedal the circuit once built, can only be used for implementing the pedal effect it was designed for. There is no way to implement a different effect once built as it would require circuit redesign and need to be built again for the new design.

In digital systems the pedal effect can be applied down to decimal accuracy of the sampled signal. An analogue system would be using discrete component values. Using discrete component values will inherently affect how precise we can expect to implement the pedal effect on the signal. Components such as resistors come in discrete values where each unit comes with a certain degree of tolerance. Tolerances indicate the percentage error of how much variance to expect in the components measured value when compared to the stated value.

## *3.3 Alternative methodologies*

Alternative methods to fulfilling the objectives of this project would be to use study material created during the course from modules such as Analogue Electronics, Signals & Systems, Field and Circuit Theory to design the circuit. For circuit analysis we have two ways of doing so that are known to the student, these were learned during various lab and lecture work.

**Nodal analysis** is used to determine voltages by solving equations for incoming and outgoing currents at each node. This method uses Kirchhoff's Current Law (KCL).

**Mesh analysis** is used to determine currents in a circuit loop by solving equations for the voltages across each component in the loop. This method uses Kirchhoff's Voltage Law (KCL).

## *3.4 Chosen Effect to implement*

From the initial research, the Wah-Wah pedal effect is chosen because it uses audio filters which will complement the knowledge gained during the course of study. Basic audio filters such as the low-pass, high-pass, band-pass and band-stop filters were covered during the course of study and now we have the opportunity to further enhance and use this knowledge in producing a guitar pedal for practical use.

- A Low-Pass filter is one which allows only low frequencies to pass thorough while the higher frequencies are attenuated.
- A High-Pass filter is one which allows only high frequencies to pass thorough while the low frequencies are attenuated.
- A Band-Pass filter allows a particular range of frequencies to pass through while a Band-Stop filter would stop a range of frequencies to pass.

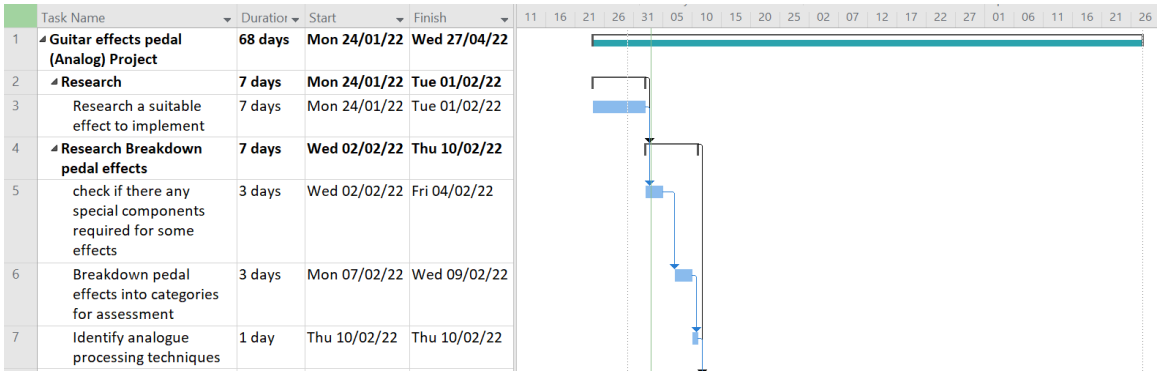
Since the Wah-Wah effect modifies the frequencies in the guitar signal, these changes in frequencies will be easily perceptible to the human ear and will not require heavy reliance on equipment such as the oscilloscope to test is if the device works as intended.

For effects such as the delay and reverb which produces changes in time to the signal would require particular reliance on oscilloscope to ensure the changes in time to the signal occur at the designed time interval.

# 4 Work Plan

The research has led to use choosing to implement the Wah-Wah effect. We will use the objectives to create a conservative timeline of the project, ensuring to give an adequate amount of time for each task.

The objectives were broken into research, design and implementation phases.

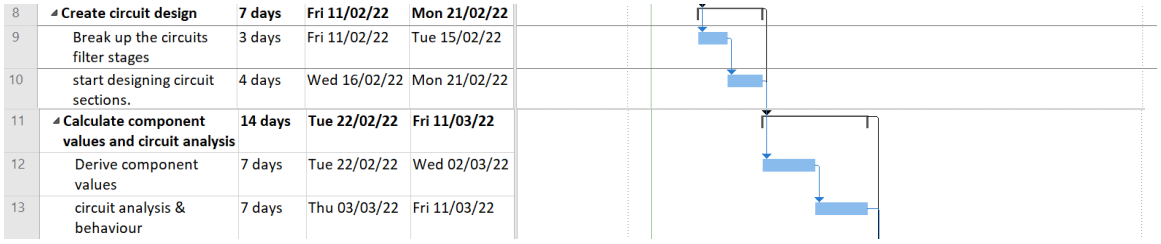


| | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Guitar effects pedal (Analog) Project** | **68 days** | **Mon 24/01/22** | **Wed 27/04/22** |
| 2 | **Research** | **7 days** | **Mon 24/01/22** | **Tue 01/02/22** |
| 3 | Research a suitable effect to implement | 7 days | Mon 24/01/22 | Tue 01/02/22 |
| 4 | **Research Breakdown pedal effects** | **7 days** | **Wed 02/02/22** | **Thu 10/02/22** |
| 5 | check if there any special components required for some effects | 3 days | Wed 02/02/22 | Fri 04/02/22 |
| 6 | Breakdown pedal effects into categories for assessment | 3 days | Mon 07/02/22 | Wed 09/02/22 |
| 7 | Identify analogue processing techniques | 1 day | Thu 10/02/22 | Thu 10/02/22 |



*Figure 3 Research Phase part of Gantt Chart*

The first two weeks which are shown as row 2-7 in figure 3 are allocated time for conducting research. Two weeks was chosen because it would give enough time for research collecting. While one week was seen as insufficient and three weeks as seen as too long in our project time frame.



| | | | | |
|---|---|---|---|---|
| 8 | **Create circuit design** | **7 days** | **Fri 11/02/22** | **Mon 21/02/22** |
| 9 | Break up the circuits filter stages | 3 days | Fri 11/02/22 | Tue 15/02/22 |
| 10 | start designing circuit sections. | 4 days | Wed 16/02/22 | Mon 21/02/22 |
| 11 | **Calculate component values and circuit analysis** | **14 days** | **Tue 22/02/22** | **Fri 11/03/22** |
| 12 | Derive component values | 7 days | Tue 22/02/22 | Wed 02/03/22 |
| 13 | circuit analysis & behaviour | 7 days | Thu 03/03/22 | Fri 11/03/22 |

*Figure 4 Design Phase part of Gantt Chart*

In figure 4, The next three weeks are reserved for creating circuit designs, calculating component values and circuit analysis, this is assumed to take the longest due to lab experience in Digital Communications and Electronics modules where it was common for circuit analysis and building to take multiple weeks.

| | | | | |
|---|---|---|---|---|
| 16 | **catch-up week** | **7 days** | **Wed 23/03/22** | **Thu 31/03/22** |
| 17 | Use this week to catch up on work not completed | 7 days | Wed 23/03/22 | Thu 31/03/22 |
| 18 | **Hardware implemetation** | **7 days** | **Fri 01/04/22** | **Mon 11/04/22** |
| 19 | build onto breadboard | 4 days | Fri 01/04/22 | Wed 06/04/22 |
| 20 | conduct hardware debugging | 1 day | Thu 07/04/22 | Thu 07/04/22 |
| 21 | Conduct full test with ukulele | 1 day | Fri 08/04/22 | Fri 08/04/22 |
| 22 | Implement onto copper stripboard | 1 day | Mon 11/04/22 | Mon 11/04/22 |
| 23 | **work on report** | **12 days** | **Tue 12/04/22** | **Wed 27/04/22** |
| 24 | complete report | 12 days | Tue 12/04/22 | Wed 27/04/22 |

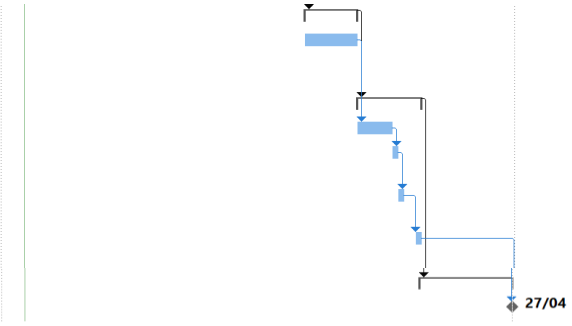



*Figure 5 Implementation Phase part of Gantt Chart*

In figure 5, one week is given for a "catch-up week" for any unforeseen setbacks that would be encountered. While it will not take long to build the design on breadboard or prototyping board perhaps a few days for this. It is imagined there will be difficulty in organising a suitable lab and time slot with access to the equipment required for the building process. This is due to most labs at TU Dublin Grangegorman campus being inaccessible to students outside of lab allotted slots.

# 5 References


[1] "Boss DS-1 | The Sound Factory", *The Sound Factory | Musical Instruments and Equipment*. [Online]. Available: https://thesoundfactory.town.ie/product/boss-ds-1/. [Accessed: 31- Jan- 2022].

[2] C. D. Schiebel, "The 23 Types of Guitar Pedals Explained (2022) - Guitar Lobby", *Guitar Lobby*, 2021. [Online]. Available: https://www.guitarlobby.com/types-of-guitar-pedals/. [Accessed: 04- Feb- 2022].

[3] "Music 101: What Is an Equalizer? Plus: Best Equalizer Settings for Drums and Guitar", *www.masterclass.com*,2021.[Online].Available: https://www.masterclass.com/articles/music-101-what-is-an-equalizer-plus-best-equalizer-settings-for-drums-and-guitar#:~:text=An%20equalizer%20(also%20called%20an,Car%20stereo%20systems. [Accessed: 03- Feb- 2022].

[4] "Guitar 101: What Is a Wah-Wah Pedal? Learn About the Different Types of Wah-Wah Pedals", *www.masterclass.com*, 2021. [Online]. Available: https://www.masterclass.com/articles/guitar-101-what-is-a-wah-wah-pedal-learn-about-the-different-types-of-wah-wah-pedals#how-does-the-wahwah-pedal-work. [Accessed: 04- Feb- 2022].

[5] "Music 101: What Is an Octave?", *www.masterclass.com*, 2021. [Online]. Available: https://www.masterclass.com/articles/music-101-what-is-an-octave#what-is-an-octave. [Accessed: 01- Feb- 2022].

[6] A. Fox, "What Are Pitch-Shifting Guitar Pedals & How Do They Work? | My New Microphone", *My New Microphone*. [Online]. Available: https://mynewmicrophone.com/what-are-pitch-shifting-guitar-pedals-how-do-they-work/. [Accessed: 02- Feb- 2022].

[7] A. Fox, "What Are Compressor Pedals (Guitar/Bass) & How Do They Work? | My New Microphone", *My New Microphone*. [Online]. Available:

https://mynewmicrophone.com/what-are-compressor-pedals-guitar-bass-how-do-they-work/. [Accessed: 02- Feb- 2022].

[8] S. Beattie, "Guitar Noise Gate Pedals - Your Ultimate Guide from Andertons Music Co.", *Andertons Music Co.*. [Online]. Available: https://www.andertons.co.uk/guitar-noise-gate-pedal-guide#:~:text=A%20noise%20gate%20pedal%20will,to%20prevent%20that%20annoying%20hum. [Accessed: 02- Feb- 2022].

[9] "How Does A Reverb Pedal Work? - Best Guitar Equipment Q&A", *Best Guitar Equipment*. [Online]. Available: https://www.bestguitarequipment.com/blog/how-does-a-reverb-pedal-work/. [Accessed: 03- Feb- 2022].

[10] A. Fox, "What Are Looper Pedals (Guitar/Bass FX) & How Do They Work? | My New Microphone", *My New Microphone*. [Online]. Available: https://mynewmicrophone.com/what-are-looper-pedals-guitar-bass-fx-how-do-they-work/. [Accessed: 01- Feb- 2022].

[11] J. Chiffey, "Flanger vs Phaser – Understanding the Key Differences - Guitar Space", *Guitar Space*, 2021. [Online]. Available: https://guitarspace.org/sound-pedals/flanger-vs-phaser/#:~:text=Phasers%20work%20is%20frequency%2Dbased,and%20plays%20both%20back%20together. [Accessed: 01- Feb- 2022].

[12] "Guitar 101: What Are Flangers and Phasers? Learn About the Best Flanger and Phaser Pedals for Electric Guitar Players", *www.masterclass.com*. [Online]. Available: https://www.masterclass.com/articles/guitar-101-what-are-flangers-and-phasers-learn-about-the-best-flanger-and-phaser-pedals-for-electric-guitar-players#:~:text=A%20flanger%20works%20by%20mixing,slightly%20slower%20than%20the%20other. [Accessed: 02- Feb- 2022].

[13] R. Pulgar, "The Difference Between Overdrive and Distortion Explained | Gearank", *Gearank.com*, 2020. [Online]. Available: https://www.gearank.com/articles/overdrive-v-distortion. [Accessed: 04- Feb- 2022].