March 21

Configure working environment

Download plugins for Latex in VSCode

Use linux commands to install Latex:

```
sudo pacman -s texlive-most
```

Install LaTeX Workshop plugin from the Visual Studio Code Marketplace.

Figure 1: A Latex plugin in VSCode market

Create a LaTeX project

Select a place in your PC and create a directory.

Change your workspace into the directory and create a main.tex file in which you will edit your LaTeX code.

LaTeX+Git

'If you are only editing it locally, it is just as simple as creating any other repository. But this starts shining when you want to work with others, or you want people to be able to check your work without you heaving to send it to them every time. On top of that, uploading your content to a remote GIT repository can protect you in case of a catastrophic failure in your personal machine.'

Writing LaTeX Documents In Visual Studio Code With LaTeX Workshop

Ahead of all, we should change local git branch name to main:

```
git config --global init.defaultBranch main
```

Then we can do the following to push out LaTeX project to the git repository:

```
git init
git add .
git commit -m "My first try to sync overleaf with Github"
git remote add origin https://github.com/username/repo
git push -u origin main
```

'It is recommended to use a .gitignore file to keep your repository free of temporary files, and any side products created during compilation.'

Synchronize overleaf with Github

When creating a new project, there is a option to import it from Github:

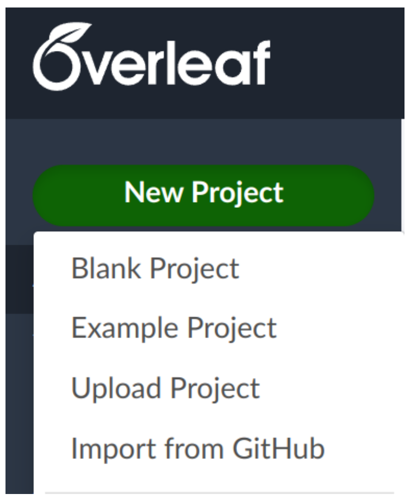

Figure 2: Import overleaf project from Github

However, this feature works only for premium users. It costs 9$ per month for students to get access to this feature.

Enjoy the fast editor and preview now

With all these done, you can just edit your LaTeX project locally and compile much more faster than what overleaf does. Just update your projects by using git and sync your project on overleaf by clicking a blue button.

March 22

Producing Graduation Thesis

I will spend four weeks starting this week to finish my graduation thesis. It consists of three parts - AGC hardware, MCU code and Android Apps. Today I will finish the first part, AGC hardware.

Automatic Gain Control

Automatic gain control(AGC) is a closed-loop feedback regulating circuit in an amplifier or chain of amplifiers, the purpose of which is to maintain a suitable signal amplitude at its output, despite variation of the signal amplitude at the input. The average or peak output signal level is used to dynamically adjust the gain of the amplifiers, enabling the circuit to work satisfactorily with a greater range of input signal levels. It is used in most radio receivers to equalize the average volume (loudness) of different radio stations due to differences in received signal strength, as well as variations in a single station's radio signal due to fading. Without AGC the sound emitted from an AM radio receiver would vary to an extreme extent from a weak to a strong signal; the AGC effectively reduces the volume if the signal is strong and raises it when it is weaker. In a typical receiver the AGC feedback control signal is usually taken from the detector stage and applied to control the gain of the IF or RF amplifier stages.

— From Wikipedia

AGC IC selection

I use a low noise, voltage-controlled amplifier AD603 to design peripheral circuit:

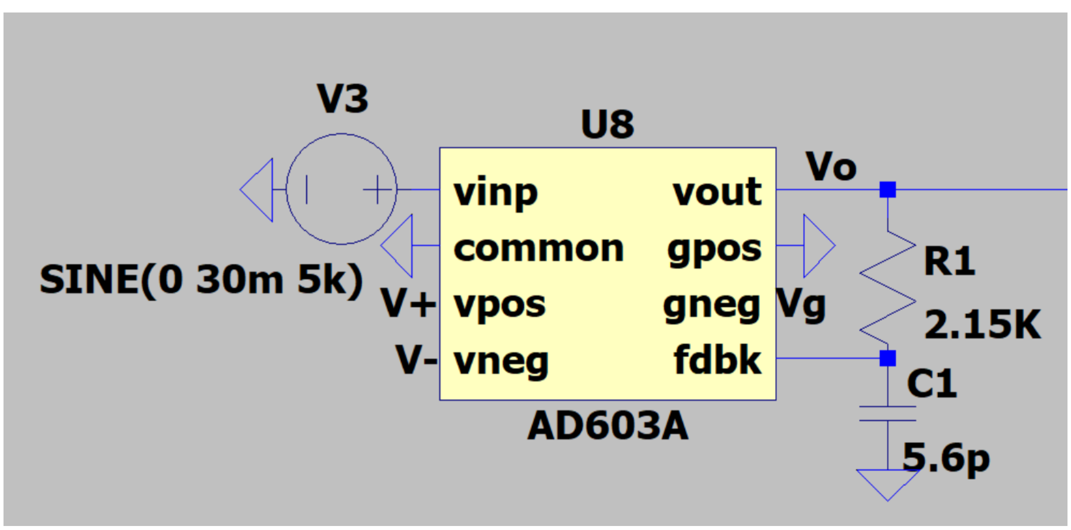

Figure 3: AD603 Circuit

V_g is the voltage signal that is fed back from the rear stage to control the gain.

Envelope Detection

For the AGC output signal V_o, an envelope detector is required to obtain the amplitude information. The following envelope detector circuit is used:

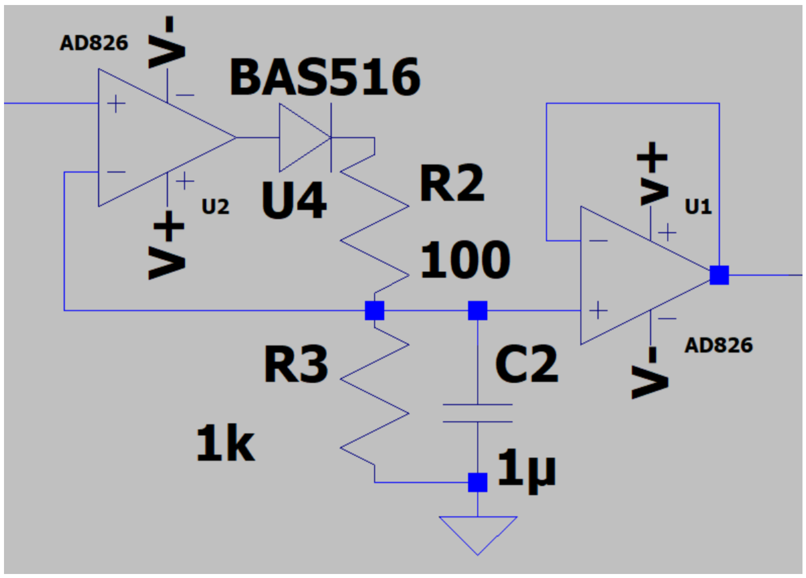

Figure 4: Envolop Detect

As is shown above, the amplitude info can be dectected by the OPA at the first stage and the voltage will be applied across the capacitor $C2$. $R3$ and $C2$ form a RC circuit. The circuit can discharge through R3 when the signal amplitude drops. The rate of discharge depends on the time constant $\tau = R3 \cdot C2$. The time constant should not be too large or the discharge rate will be too slow as is shown below:

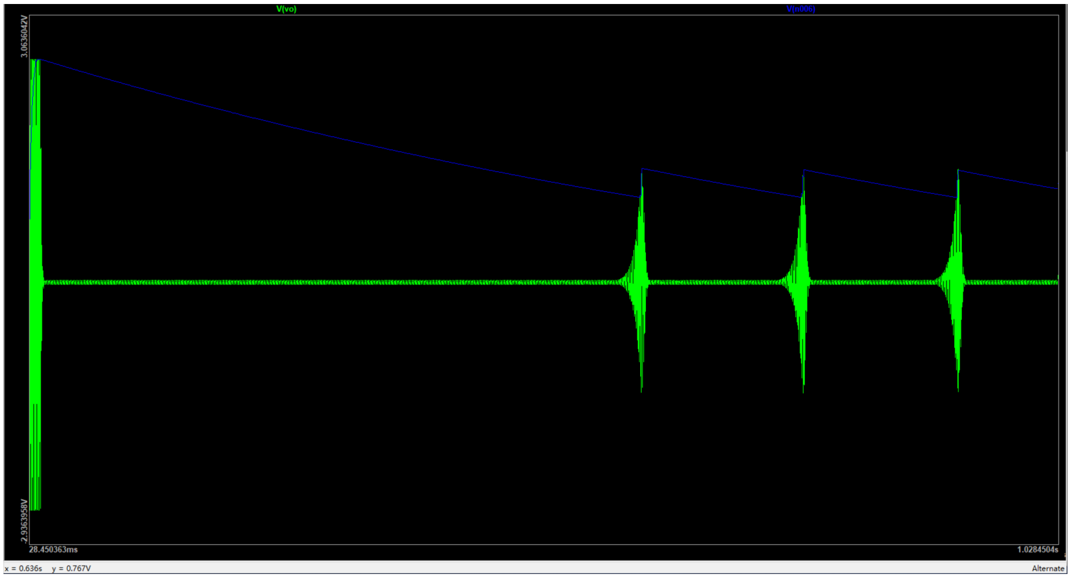

Figure 5: The discharge rate is too slow

We need to set up an appropriate time constant τ. The correct graph line is shown below:

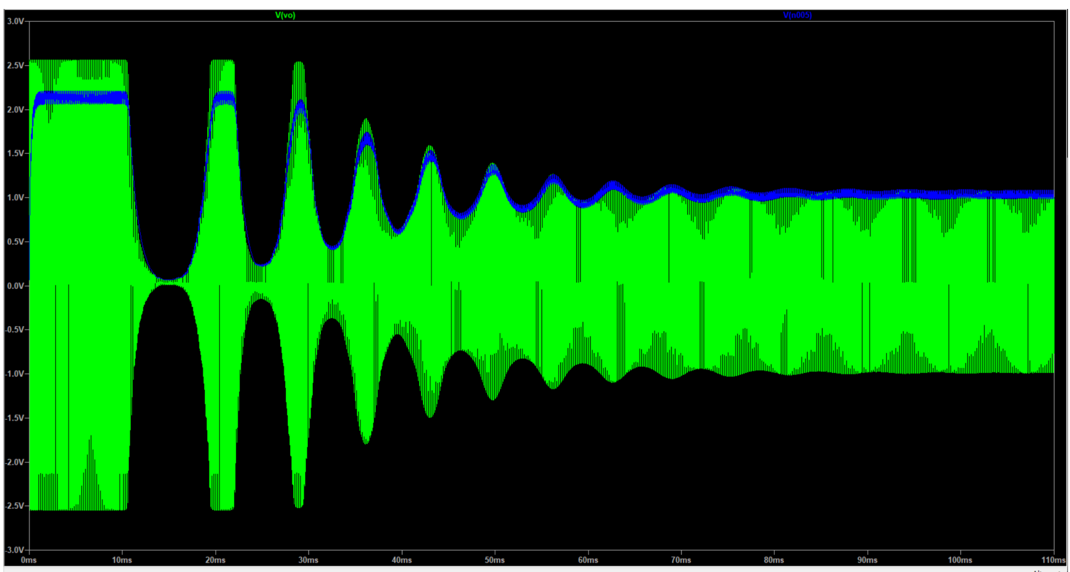

Figure 6: Correct envelope detect graph line

It can be clearly seen that the circuit accurately detects the envelope signal output by the AGC, and under the action of the post-stage feedback, after a period of oscillation, the output signal is controlled within a reasonable amplitude range.

Calculate the feedback signal

After obtaining the amplitude of the AGC output signal, we can obtain a reasonable AGC control signal Vg through the linear operation of the operational amplifier.

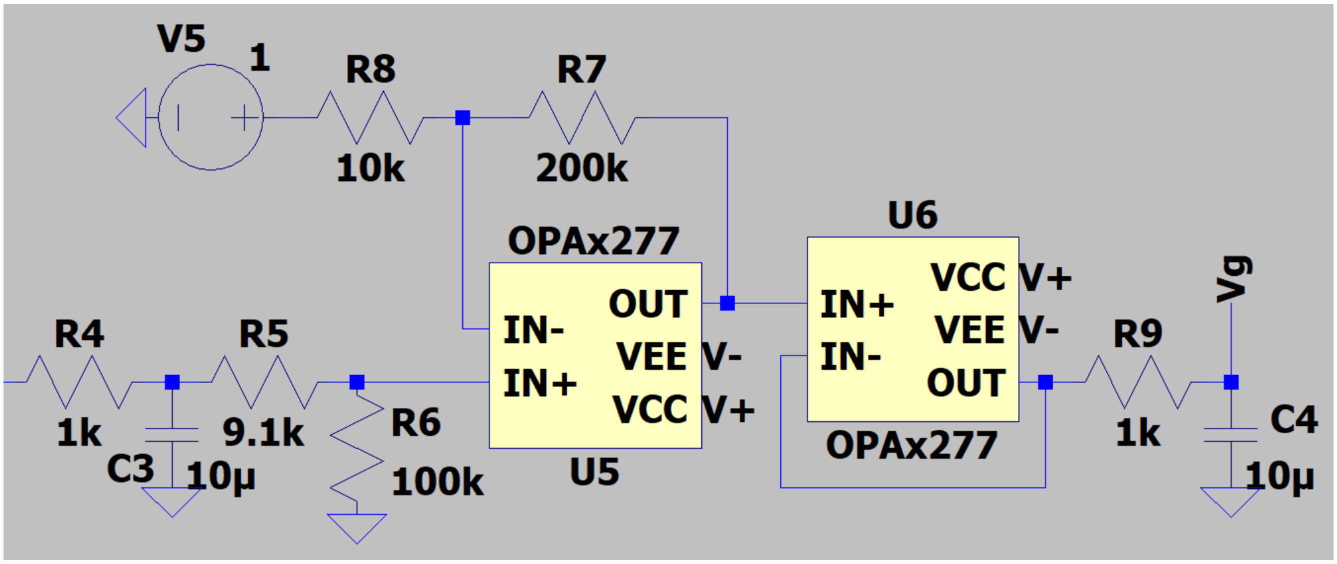

Figure 7: Linear operation of the operational amplifier

In the schematic, we conduct **high-pass filter** and **divided voltage** on the result of envelope detection, and then calculate the difference with the standard voltage reference, and feed back the result V_g to the control terminal of AD603.

Add DC bias

Since the analog input pin of the MCU has a certain input voltage range limitation, we need to add a DC bias to the AC signal output by the AGC. Here we use a rail-to-rail OPA OPA340.

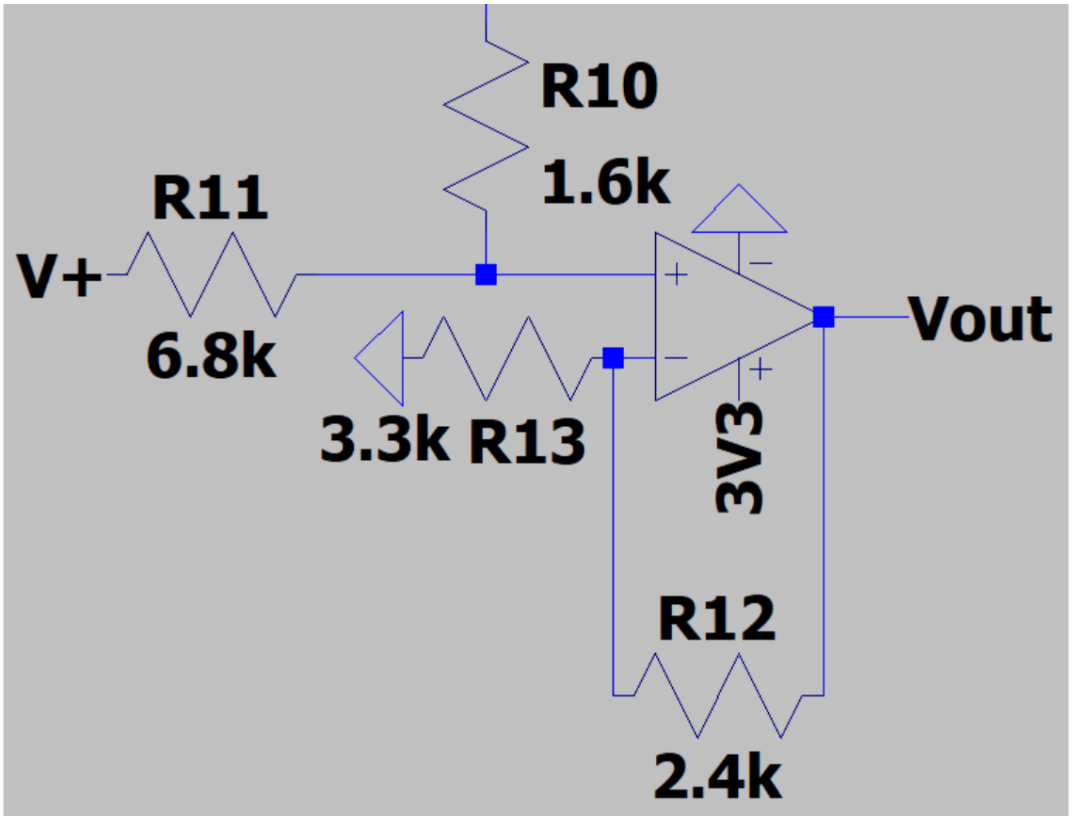

Figure 8: Add DC bias

The waveforms before and after adding DC bias are as follows:

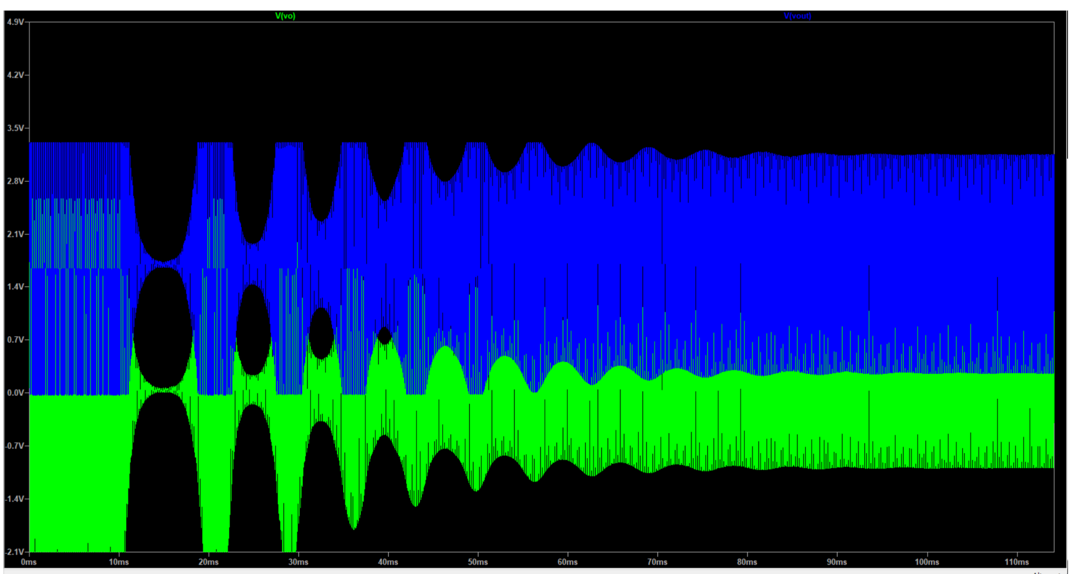

Figure 9: Waveforms before and after adding DC bias

System

We use LTspice, a free simulation tool provided by ADI, to build the simulation circuit.

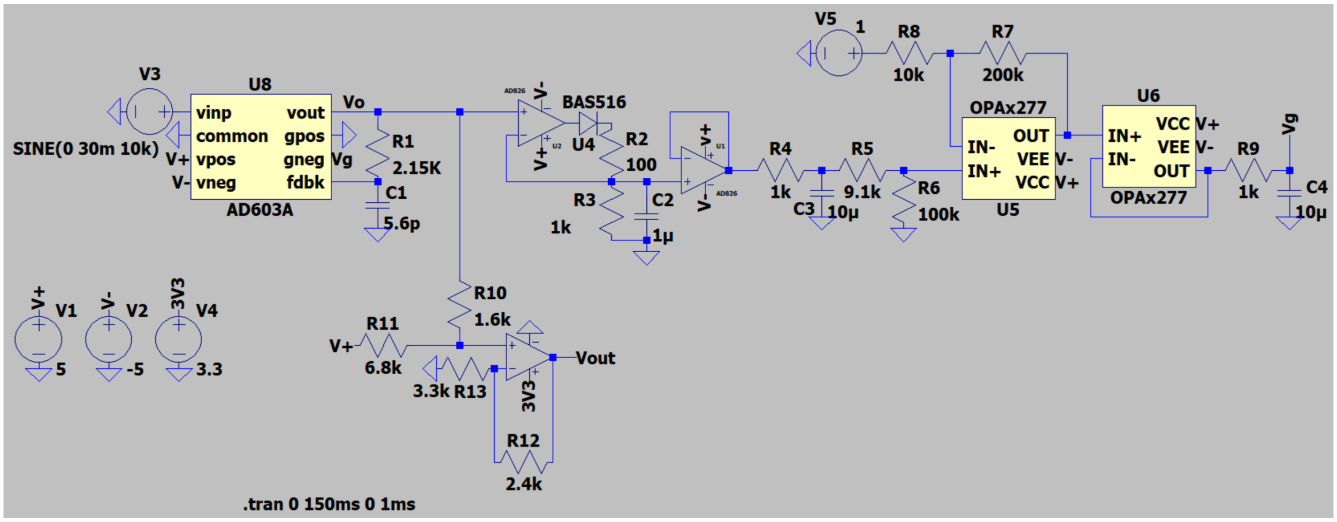

Figure 10: The whole system

Set the simulation type to transient response simulation, with a total duration of 150ms and a step of 1ms. We can see the waveform of each node as follows:

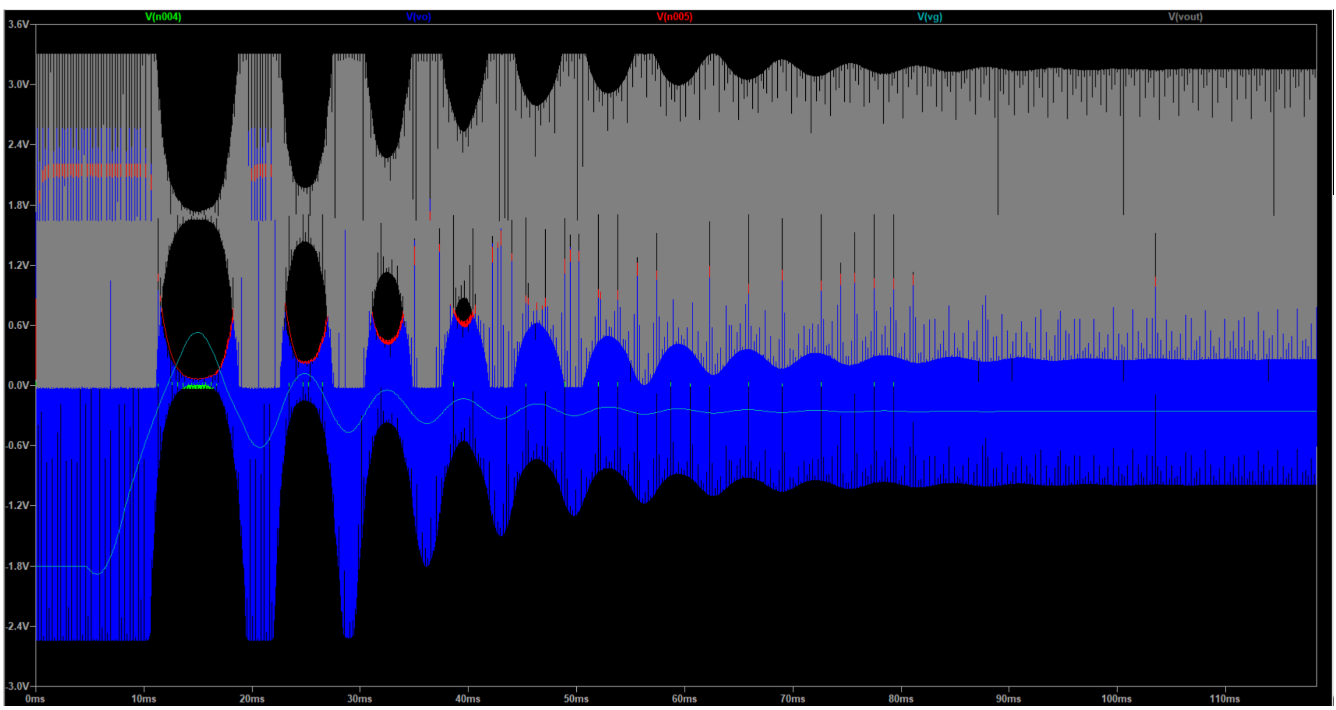

Figure 11: Waveform of each node

After the system become stable, the details are shown below:

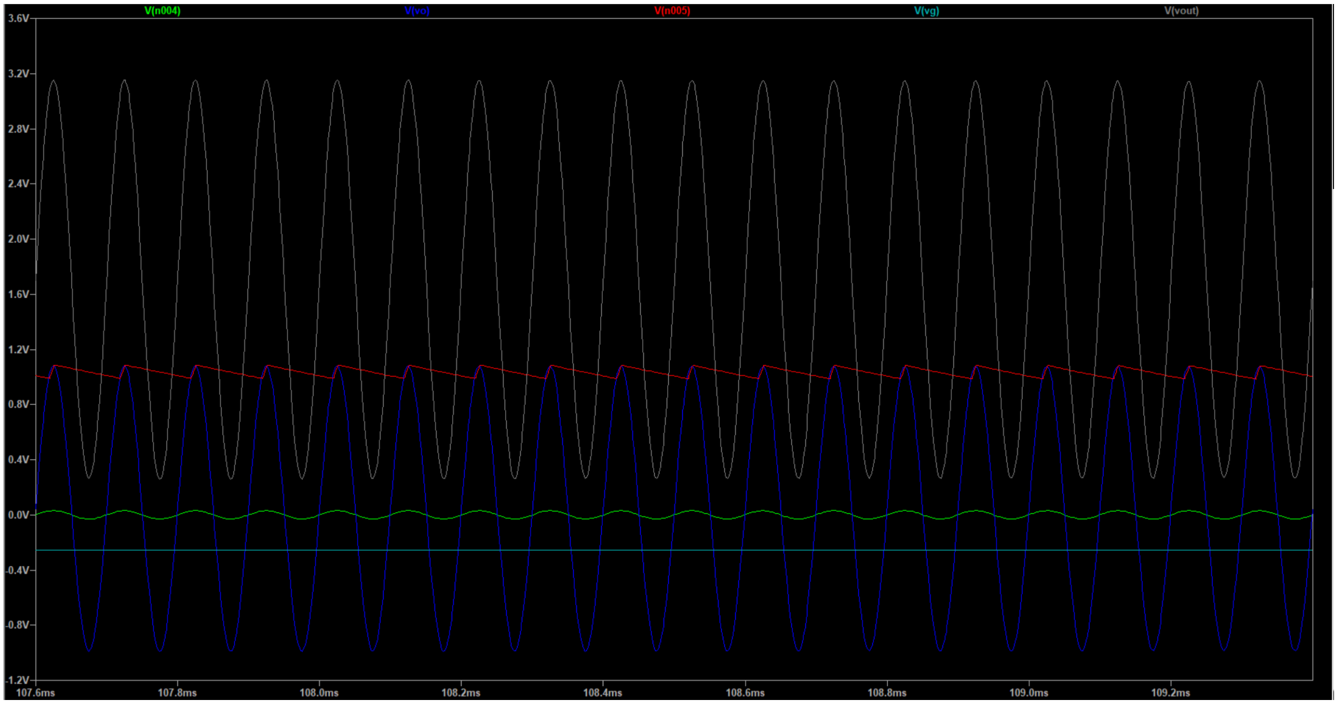

Figure 12: Details

The white line is the final output result.

March 28

Droop Control

Power transmission of single inverter

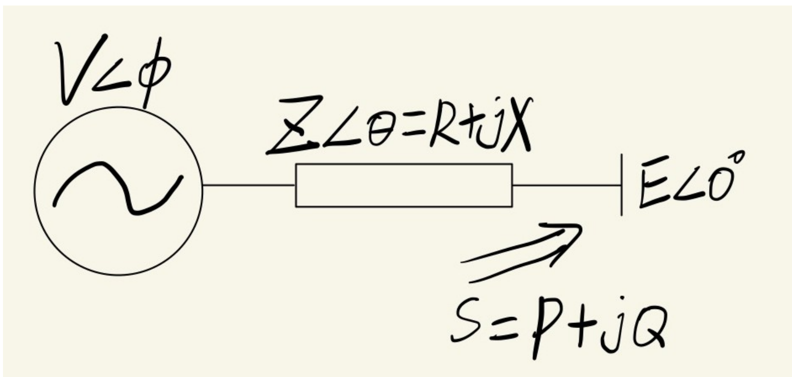

Figure 13: Single inverter

$$\begin{aligned} S &= P + jQ = \dot{E}\dot{I}^* \\ &= E \cdot \left(\frac{V\cos\phi + jV\sin\phi - E}{Z\cos\theta + jZ\sin\theta} \right)^* \\ &= \frac{1}{Z}[(EV\cos\phi - E^2)\cos\theta + EV\sin\phi\sin\theta] \\ &+ j\frac{1}{Z}[(EV\cos\phi - E^2)\sin\theta - EV\sin\phi\cos\theta] \end{aligned} \tag{1}$$

So, the power is:

Derivation

$$\begin{cases} P = (\frac{EV}{Z}\cos\phi - \frac{E^2}{Z})\cos\theta + \frac{EV}{Z}\sin\phi\sin\theta \\ Q = (\frac{EV}{Z}\cos\phi - \frac{E^2}{Z})\sin\theta - \frac{EV}{Z}\sin\phi\cos\theta \end{cases} \tag{2}$$

High terminal impedance transmission line

When the terminal impedance of the inverter $R \gg X$, X is neglected, at this time θ is treated as **0 (purely resistive circuit)**, and the voltage phase angle ϕ does not differ much from 0, $\sin\phi = \phi$, $\cos\phi = 1$. The formula can be simplified to:

$$\begin{cases} P \doteq \dfrac{E}{R}(V - E) \\ Q \doteq -\dfrac{EV}{R}\phi \end{cases} \tag{3}$$

High voltage transmission line

When the transmission line is a high voltage line, $X \gg R$, at this time θ is treated as $\frac{\pi}{2}$ **(purely inductive circuit)**, and the voltage phase angle ϕ is relatively small, $\sin\phi = \phi$, $\cos\phi = 1$. The formula can be simplified to:

$$\begin{cases} P \doteq \dfrac{EV}{X}\phi \\ Q \doteq \dfrac{E}{X}(V - E) \end{cases} \tag{4}$$

It is clear that we can modify P by changing the phase ϕ, which is the integration of ω, and Q is related to V.

Usually, the voltage angular frequency of the inverter is easier to monitor than the phase angle difference, so the droop control formula can be obtained by substituting the angular frequency for the phase angle difference:

$$\begin{cases} \omega = \omega_0 - m_p P \\ V = V_0 - n_q Q \end{cases} \tag{5}$$

If P grows larger, ω becomes smaller.