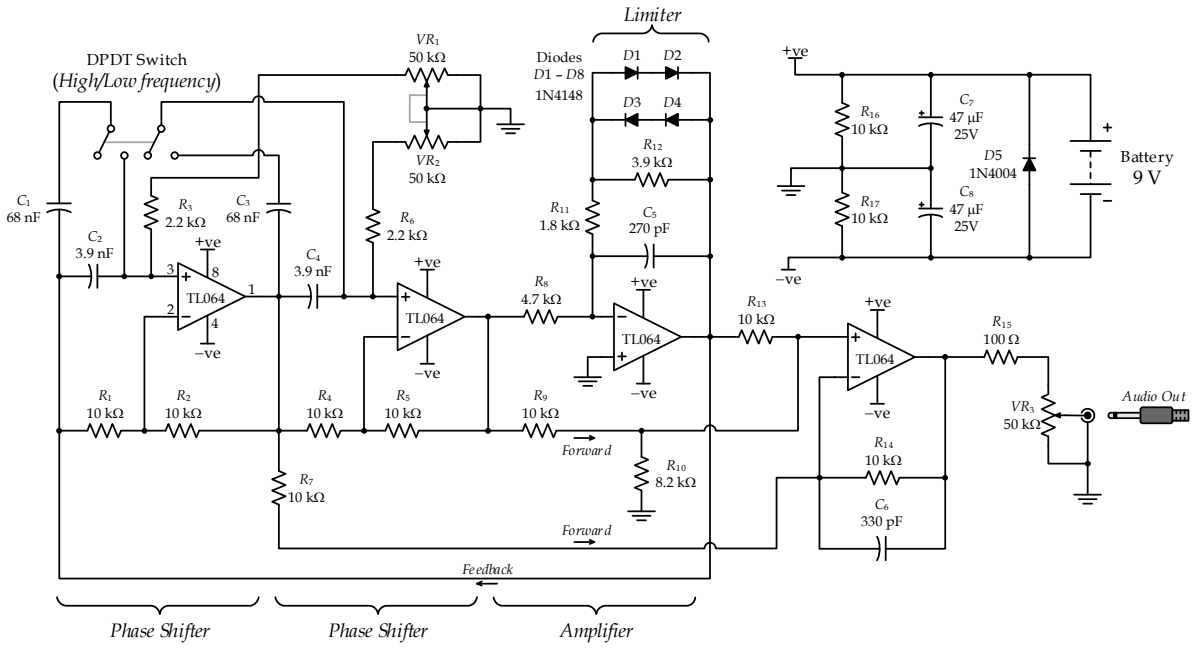
EE 423: Communication Electronics
Prof. Mohammed Hawa

Project: Audio Oscillator (Hardware)

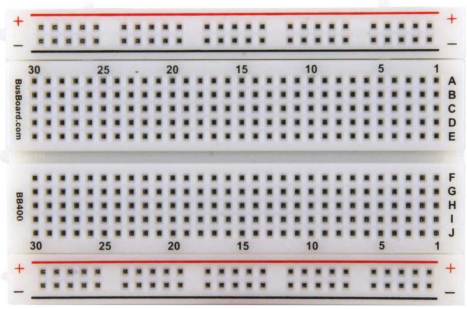
In this project, you are required to **understand, build and test** the oscillator circuit shown below and **get it to work**. This circuit is an oscillator that generates Audio frequencies, which you will use perform some hearing tests.



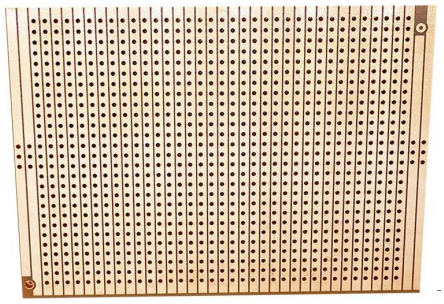
The first two stages of the circuit are 90° phase shifters (providing a total of 180° phase shift), followed by the third stage, which is an amplifier stage. The back-to-back diodes plus resistor in the third stage provide non-linear behavior to the amplifier (i.e., as the output voltage increases the diodes conduct and limit the gain of the amplifier). The amplifier also inverts the signal (providing an additional 180° phase shift). The output of the amplifier is then fed back to the first stage.

Some distortion of the output sinusoidal signal peaks results because of the diodes. To reduce this distortion, parts of the signal are fed forward to the fourth stage, which combines such signals to reduce the third and higher odd harmonic distortion components generated by the diodes, resulting in almost pure sinusoidal wave at the output.

You have the option to build the circuit on top of a breadboard, or a stripboard (see below). You are not required, nor allowed, to build a PCB for this project in case we need to tweak the design later.



Breadboard



Stripboard

The above oscillator circuit is operated from a 9 V battery and provides low distortion output. You can use one quad op-amp chip, which is the TL064, or two dual op-amp chips, the TL062. The DIP-14 form factor for the TL064 and DIP-8 form factor for the TL062 are the easiest to work with when it comes to breadboards and stripboard, but surface mount chips can also be used with proper adapters or via soldering.

TL064

TL062

The TL064 low-power JFET-Input Operational Amplifier (Op-Amp) was selected because of its advantages:

- Very low power consumption (around 200 µA supply current per amplifier). This is well suited for a battery-operated circuit.
- High input impedance (JFET-input stage).
- High slew rate: 3.5 V/µs.
- 18/-18 V maximum supply voltage.
- 3/-3 V minimum supply voltage.

Power from a standard 9V battery is fed to a voltage divider to provide +4.5 V and -4.5 V rails. The 1 A diode protects the IC from accidental reverse connection of the battery. Notice that a standard 9 V battery voltage can vary from 9.5 V (when full) down to 6.3 V (when empty). Hence, the need to support small supply voltage.

If the ICs mentioned above are not available, we will try to find a replacement that has as close properties as possible, such as RC4558 (Dual General-Purpose Operational Amplifier), which provides wide bandwidth but consumes more power. Other choices include TL084/TL082 or TL074/TL072 (wider bandwidth by not low-power), and include LF355 or LF356 or LF353, but since supply voltage cannot be as low as 3/-3 V, we might need to use two 9 Volt batteries in series or a well-regulated 12V DC power supply to increase the available supply voltage.

The frequency of oscillation is controlled by R and C in the first two stages, where

$$f_{res} = \frac{1}{2\pi RC}$$

where R is $R_3 + VR_1$ or $R_6 + VR_2$ and C is C_2 or C_4 or (or when the switch is flipped $C_1 + C_2$ or $C_3 + C_4$). Do you know why?

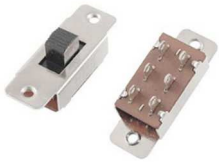
The **ganged potentiometer** (VR1 and VR2) are used to control (sweep) the frequency of oscillation. A ganged potentiometer versus regular potentiometer is shown here:

Ganged Potentiometer

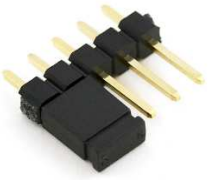
Single Potentiometer

The DPDT (double-pole, double-throw) switch is used connect or disconnect capacitors C_1 and C_3 to the circuit to change frequency between low range (around 45 Hz - 1 kHz) and high range (around 780 Hz - 18 kHz). If you do not want to use a switch, you can use jumpers instead.

DPDT Switch (high current)



DPDT Switch (low current)



Jumpers

The output level potentiometer can increase or decrease the output voltage level, which has a maximum of about 1.25 V_{rms}. This prevents damaging the speakers or headphone you use to test the circuit. Always set the potentiometer to mid-point or minimum volume before connecting the speakers or headphone.

I suggest you use MKT type (Metallized Polyester Film) capacitors (see below) since they are more rugged and can withstand multiple connections and disconnections, except for the 47 uF capacitors, which need to be electrolytic.

MKT Capacitor

Electrolytic Capacitor

At the time of **project submission** please:

- Make sure that you understand how the different parts of the circuit work. Op-Amp circuits are well explained in textbooks and in many online resources.
- Read about how to conduct hearing tests. Can you perform one?
- Read about Fletcher–Munson curves. Understand what they mean.
- Be prepared to answer questions about oscillators in general and this oscillator in particular.