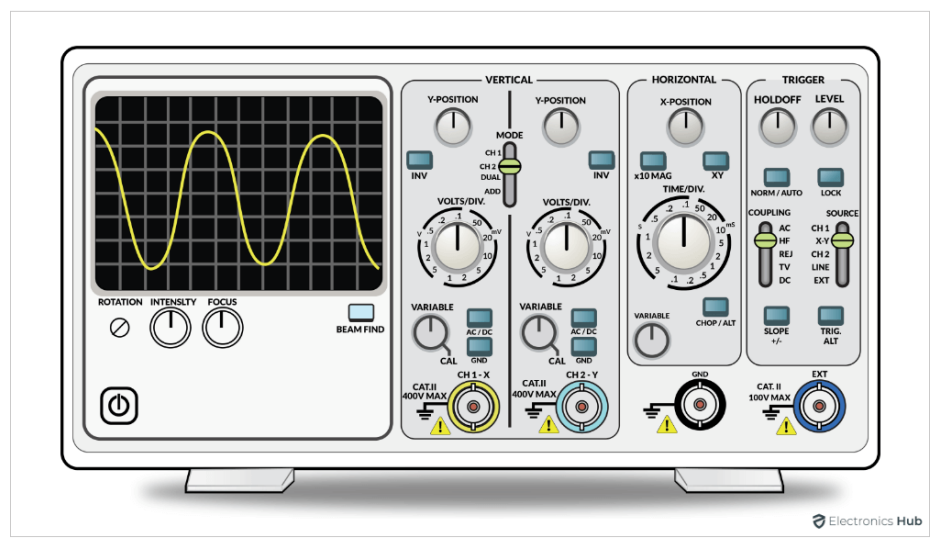
M-Oscilloscope: Mobile Oscilloscope for Students

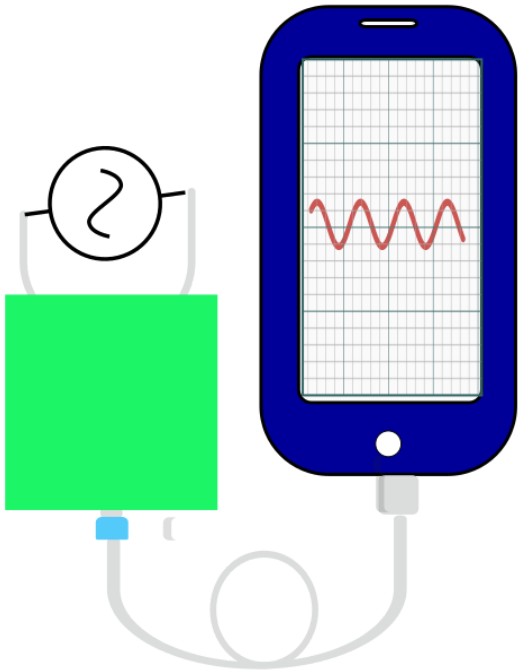
Introduction

An oscilloscope, a particular kind of electronic test tool, uses a two-dimensional plot of one or more signals as a function of time to graphically depict changing electrical voltages. The primary goals are to display repeating or single wave-form that would otherwise occur too quickly for the human eye to notice on the screen. It is mostly used by personnel in the field of electrical study to analyze the response of various circuits and in communications to analyze different parameters of a signal such as shape, amplitude, frequency, time period, etc. Users can change different settings to see the signal such as zooming, panning, stretching, etc.
An oscilloscope is shown in the picture above (*image courtesy:*



https://www.electronicshub.org). Conventionally, it is a *heavy* and *expensive* device lying in the laboratory for students and teachers to use. But, unfortunately, due to its high price, most of the students cannot afford it, and, even if affordable, it cannot be ported easily. It raises some demand for a lightweight and cheaper alternative that can be used by the students. This gives us the idea for a cheaper and more portable tool, and we would like to call it ***M-Oscilloscope***.

Functionalities and features

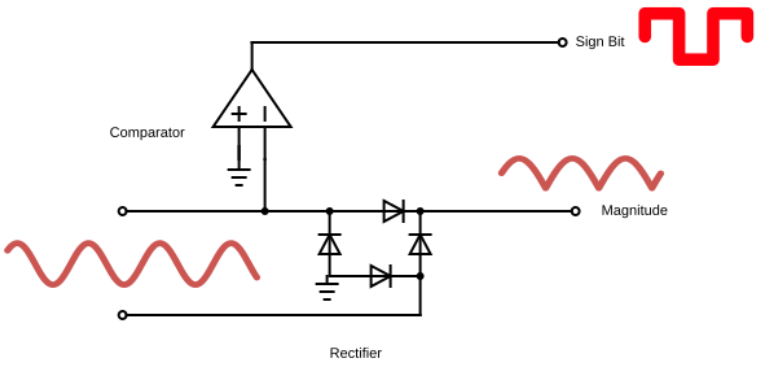


In the context of an oscilloscope, a signal generator generates some kind of signal by varying its voltage level with some frequencies, and the signal is found at the probe. Usually, the probes are in pairs, one is (let us say probe 1) phase, and the other is ground or neutral (probe 2). When two probes of the oscilloscope are connected to the corresponding probes of the signal generator, it provides the user with a real-time sampling of the wave. The signal can be of any shape and any frequency, be it a square wave, sawtooth wave, triangle wave, sine wave, etc. The oscilloscope plots just the real-time values of the wave. In our M-Oscilloscope, we would also provide the same functionality. But instead of using a built-in display show plot the signals, the tool would be connected to a smartphone with a USB cable and the software would plot the graph. Hence, the user can zoom and pan the wave very intuitively. Hence, there would be no cost for the LCD and also, and the software may provide a lot of functionalities that would be discussed later.

Challenges

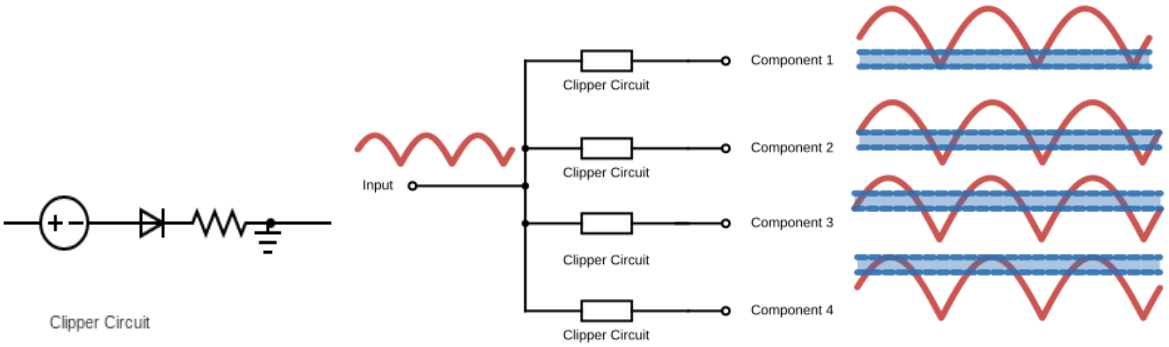
To design the tool, we may have to face the following challenges:

1. **Negative Input:** A microcontroller cannot take negative voltage at input it takes positive voltages. To overcome this issue we can convert the voltage to a positive voltage and signify its polarity in other digital input pins. To indicate the polarity of the input voltage we may use a comparator a circuit that compares a signal with its reference voltage. If the input voltage is then the reference voltage it would output 5 volts which can be denoted as 1 in digital electronics. If the reference voltage is greater than the input voltage, it would output 0 volts which can be interpreted as zero in digital electronics. Hence the output of this comparator can be used as a sign bit of the signal. after passing through this comparator the signal can be rectified which would convert the negative cycle into a positive half cycle. Thus, the signal can proceed to be processed.



2. **High Voltage:** A microcontroller can take only 5V as input. If the given voltage is higher than this, the microcontroller may be burnt from excessive heat. To achieve the goal of taking high input voltage, we may use the advantage of the clipper circuit. In brief, a clipper circuit is a type of circuit that clips some portion of the input wave and passes the remaining portion. Hence, we can divide the input voltage into several 5V clipper circuits and pass each of the continent components into a separate port of the

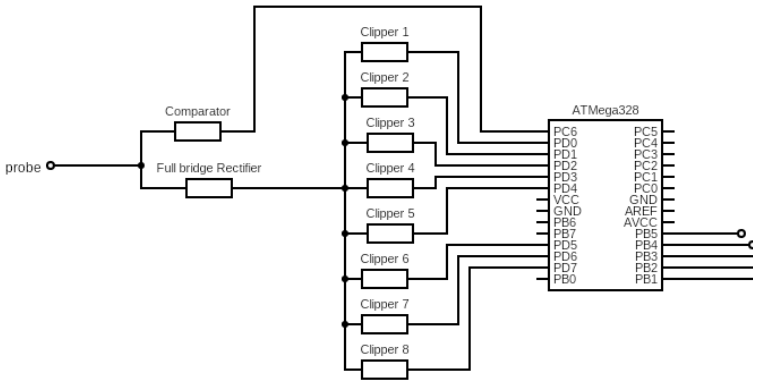
microcontroller. Hence, the microcontroller would receive all the components of the wave and can reconstruct the value easily from the sign bit and the magnitude of the voltage.



3. **Data Transmission:** This tool needs a lot of real-time data to be transferred. If we keep our sampling rate to 4 million per second, we may need to transfer about 4 million floating numbers per second which are about 16 million bytes or 16 megabytes per second. To accomplish this, we may use a USB cable as the way of transferring the data because if we use any wireless technique, we may lose many data points due to the low data transfer rate. The USB cable has another advantage of being mostly secure, as the data we transfer would not reach any wrong device. Our microcontroller can also get the power supply from the phone if we use a USB cable. The USB cable has a very simple implementation and would not require any heavy coding (which, on the other hand, is required for wireless or other techniques), which would be very simple to execute for the microcontroller and the microcontroller would be fast enough to sample the data precisely.
4. **Smartphone Display:** The cost of the display has a big impact on the cost of the conventional oscilloscope. In addition to that, neither the display has any touchscreen functionality nor is user friendly. On the other hand, it can be assumed that most engineering students have smartphones with a touchscreen. If we can transfer our data to the smartphone where our customized software would receive the data and would plot the data accordingly, we may save the cost of the display and offer a cheaper price. Modern smartphones have a very optimized CPU capable of doing many floating-point operations in one cycle. If we send our raw data to the smartphone, our software can process these raw data efficiently and we can

also cut down the cost of an expensive powerful microcontroller to do the processing.

Complete Circuit



Further Development and Conclusion

It is just a proposition and a unique roadmap idea to build a tool at a comparatively low cost. This has a lot of potential and development scope. For example, the smartphone software may be programmed to stream the data to any cloud server or save the data into any local storage. As smartphone software can be programmed easily, many options could be added to the software through plugins or user-defined programs. Besides, if we can develop further, we may use the toolkit as a multimeter.

Idea and Research Credits

- ***Nazmul Haque Naqib***
  Roll: **2010029**
  Undergraduate Student
  Department of *Electrical And Computer Engineering*
  Rajshahi University of Engineering & Technology, Rajshahi

- ***Nazat Kabir***
  Roll: **2010026**
  Undergraduate Student
  Department of *Electrical And Computer Engineering*
  Rajshahi University of Engineering & Technology, Rajshahi

References and Acknowledgements

1. *ElectronicHub (https://www.electronicshub.org)*
2. *Desmos (https://www.desmos.com/calculator) to plot some AC signal graphics.*
3. *Circuit-Diagram.org (https://www.circuit-diagram.org/) for designing these circuits*
4. *Inkscape for creating the illustrative images*
5. *Google Docs to write this paper*