



Designing a Computer-Based Electrical and Non-Electrical Measurement System

Nguyen Thanh Phong¹, Le Ngoc Giang^{2*}

¹Master, Lecturer, Faculty of Fundamental Technics, AD-AF Academy of Viet Nam, Ha Noi, Vietnam

²PhD, Head of Metrology Department, Faculty of Fundamental Technical, AD-AF Academy of Vietnam

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ABSTRACT

An oscilloscope, also known as a waveform monitor, is a device that plots electrical signals on three axes: the X-axis represents time, the Y-axis represents voltage, and the Z-axis represents brightness. With an appropriate converter, an oscilloscope can measure various physical phenomena such as sound, mechanical pressure, light, or temperature. It is a tool for signal analysis that helps users troubleshoot hardware and software issues. The oscilloscope can accurately display waveforms and determine voltage values, frequency, and signal distortion. However, these devices are often expensive. An alternative solution proposed is the "PC Oscilloscope".

Keywords: Oscilloscope, measurement, computer

1. Introduction

The PC Oscilloscope operates by attaching a specialized device to a computer's USB port or audio port. This device, which is much cheaper than a real oscilloscope, provides one or more input channels. When combined with specialized Scope-1.4 software, a window is displayed on the computer screen to replace the display screen of a CRT electron beam or LCD oscilloscope. Instead of using a processor, the computer is used to analyze and measure signals. This window displays all the information, just like on a traditional oscilloscope. The signal can be displayed with "Voltage/division" and "Time/division," allowing multiple cycles to be displayed with sufficient amplitude. On USB devices with multiple input channels, two or more signals can be observed simultaneously with different colors, making it easy to compare signal properties.

2. PC Oscilloscope Design

With the aim of maximizing support for learning and research in the fields of electrical engineering, electronics, and telecommunications, this article provides guidance on how to turn a computer into an inexpensive digital oscilloscope. The method involves using the computer's sound card with the microphone input as the signal input. However, to avoid the risk of confusion that could damage the computer, the proposed solution is to use a USB sound card.

Signals supplied to the oscilloscope can be taken from internal sources within the computer (such as MP3 players, function generators producing sine, square, triangle, and sawtooth waves, etc.) or external sources (such as microphones). For external sources, care must be taken not to exceed the voltage range of the inputs. The typical range is only $\pm 1V$. If the voltage is higher, a voltage divider should be used. It is also recommended to use additional protective diodes to prevent any damage to the sound card and computer.



Fig.1. USB sound card is used as the signal input.

The PC oscilloscope receives data from the sound card with a resolution of 44.1 kHz and 16 bits. The frequency range depends on the sound card, but 20–20,000 Hz is achievable with modern sound cards. The low-frequency limit is determined by the AC coupling of the input signal. Note that most microphone inputs are mono.

The PC oscilloscope has the following operating modes:

- Trigger mode: Off, Auto, Normal, and Single.
- Channel mode: The signals of two channels can be added, subtracted, or multiplied.
- XY Graph mode: Plots characteristic curves.
- Frequency Spectrum Analysis mode:
 - Waterfall chart (frequency spectrum as a function of time).
 - Frequency filters: low, high, band-pass, and band-stop.
 - Cursors for measuring amplitude, time, and frequency in the main window.
- Signal Generation mode: Two-channel signal generator for sine, square, triangle, sawtooth, and various noise spectra in the frequency range of 0 to 20 kHz. The signal can also be defined by a mathematical formula.
- Extra Recording Mode: Save data to a waveform file.
- For systems with multiple sound cards, the selected sound card can be chosen in the Settings tab.

Depending on the type of USB communication device, various voltage and frequency measurements can be taken. Most devices can measure up to one million samples per second in a single read. If multiple reads are performed, measurements can be taken at up to 20 million cycles per second, equivalent to 20 MHz. Some models are designed to read logic voltage levels at 5 volts or lower or at higher voltages.

One notable feature of this signal analysis method is the "snapshot" of the signal that can be captured at any time. Some software packages can also record statistical data about a changing signal. The resulting data can be used to generate reports or create charts. Even a printer can be connected to capture signal snapshots. Visual representations of the signals can be stored as multimedia files using external video capture software. These capabilities are typically only available on very expensive oscilloscopes.

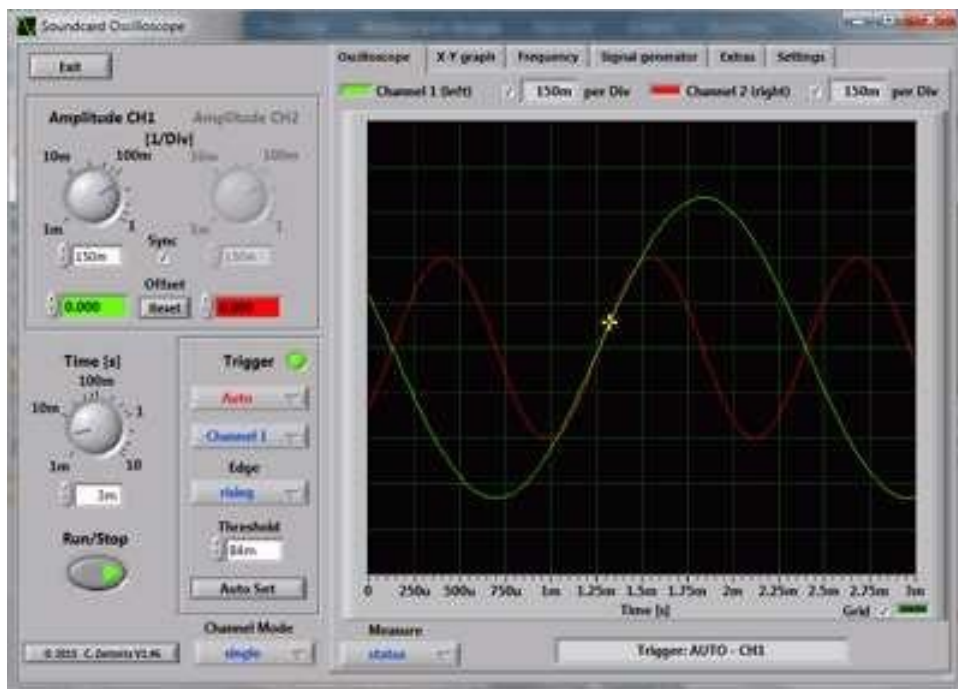


Fig.2. PC Oscilloscope Scope-V1.47.

2. Probe design

Basically, the waveform to be tested is directly plugged into the microjack of the computer. Note that if the input is not reduced and separated, it may damage your microinput. An idea is to build a "probe" to protect the sound card and also easily perform measurements.

List of parts:



Fig.3. Signal cable, 3.5 mm audio jack



Fig.4. 47uF or 100uF capacitor, rated at 16V



Fig.5. Electrical connector clamp



Fig.6. 10K voltage divider

Solder the ground of the audio cable (which can be the largest wire, or it can be black) to the left pin of the voltage divider. Solder the negative terminal of the capacitor to one of the inputs of the audio cable. There are two inputs here (stereo audio), one red and one black. The positive terminal of the capacitor is connected to the middle pin of the voltage divider. The right pin of the voltage divider is the "input" probe, which is soldered to half of the clamp cable.



Fig.7. Connection of attenuator circuit with audio cable

When twisting the voltage divider, it will change the attenuation of the input. Start in the middle and then twist up or down until you see the entire waveform. The PC sound card interface presented above has improved I/O characteristics. The waveforms displayed by the PC oscilloscope are actual images of the received signals. This offset adjustment can also be performed offline on.csv-format data provided by MS Excel software.

3. Conclusion

The prominent advantages of a PC oscilloscope are its compact size, low cost, and the ability to display electrical signals in real-time on a computer. By observing the electrical signals, the technician can analyze various factors related to the signal, such as frequency, voltage amplitude, peak voltage, RMS voltage, period, pulse width, etc. Based on these parameters, the technician can conclude whether the signal is stable or not and whether it matches the expected waveform. This enables the technician to provide appropriate solutions to troubleshoot any issues.

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REFERENCES

- E. Martinez, V. Carbonell, M. Florez, and J. Amaya, Simulations as a new physics teaching tool, *Comput Appl Eng Educ*. Published online in Wiley InterScience; DOI: 10.1002/cae.20266.
- C. Elmas, and Y. Sonmez, An educational tool for power electronic circuits, *Comput Appl Eng Educ* 18 (2010) 157–165.
- R. Trumper and M. Gelbman, Investigating electromagnetic induction through a microcomputer-based laboratory, *Phys Educ* 35 (2000), 90–95.