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Low Cost Handheld Digital Oscilloscope

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Abstract. This paper discusses the design and development of handheld digital oscilloscope at low cost using embedded microcontroller system. Oscilloscope is an important instrument that must exist in every electrical and electronic laboratory, but the oscilloscope price is relatively expensive so the purpose of this paper will be describe of research to create oscilloscope using a low cost digital system. Unlike general oscilloscopes that have large dimensions, the oscilloscopes planned and built in this research will have smaller dimensions with smaller packages, so the oscilloscope will be easy to held and mobile, easy to carry anywhere, and easy to use. Performance will be measured from capability of accuracy measurement parameter and efficiency will be describe about cost and other parameter specification are obtained from comparation with other existing oscilloscope. This Research is using experimental method, outcome from research is prototype of low cost handheld digital Oscilloscope.

1. Introduction

Oscilloscope is a basic needs at engineering laboratory which is used on telecommunication, electrical, electronic analog, or digital fields. Oscilloscope is different from any measurement instruments, because oscilloscope is able to show visualization from electrical signal form which it can make user could analysis further and get deeper comprehension. Digital oscilloscope is better than analog oscilloscope (CRT) seen from the shape, efficiency capability, and storage capability [1].

There are various kinds of standalone oscilloscope product from any brand which has a high price. As an example, the price of Fluke digital oscilloscope is around 1000-1500 US $ [2]. Another product like Digilent Analog Discovery Kit and myDAQ which has been made by National [3, 4]. The instruments are fulfill the student needs, but it need a computer to show the output and data processing. In another research before, couple electrical or electronic measurement instruments are using computer help as data processing and also showing output data which has been made [5]. Digital oscilloscope in virtual form using Visual Basic (VB) software which is installed on computer has been successfully created [6].

Digital oscilloscope also can make by using Field Programmable Gate Arrays (FPGA) which is a compact electronic board. Inside the FPGA there is a Microprocessor which has been equipped with various Input/Output (I/O) and programmable. FPGA has embedded system form that could be more practical for user because it is standalone. After it has been programmed using computer for special purpose, FPGA is already working well alone without any computer, but for the FPGA board price is expensive than other programmable embedded system. The research about designing oscilloscope using

FPGA has been done. Where Terasic DE0 used as a hardware and Quartus II as a software. For the result, this design could measure and display the data with chart form from any signal which produced by Function Generator. And it can display the monitor output screen with 640x480 resolution [7].

This research is focused on discussing the design and the construction of portable oscilloscope which has a small size and can be grab with hand. This oscilloscope has many advantages such as practical, easy to used, easy to carried anywhere, and it is using low power than others oscilloscope.

The oscilloscope is designed by using an embedded system namely Arduino. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects [8]. Arduino can be developed to become the main brain from various electronic device according with the purposes of the program and the design made by the user. The advantages of Arduino from any others platform embedded system is more cheaper from the price aspect, easy to used, and there are many literature, program code, hardware or project which is shared free on internet by others Arduino user. The Arduino user usually using or develop with Arduino on their project. Beside of that, Arduino is open source and also can build the Arduino hardware by ourselves.

2. Methods

The method used in this research is experiment. It started with case study, formulation of the problem including solution design, finding the literature about the problem to find the solution, designing hardware and software and then examination.

2.1. Block diagram system

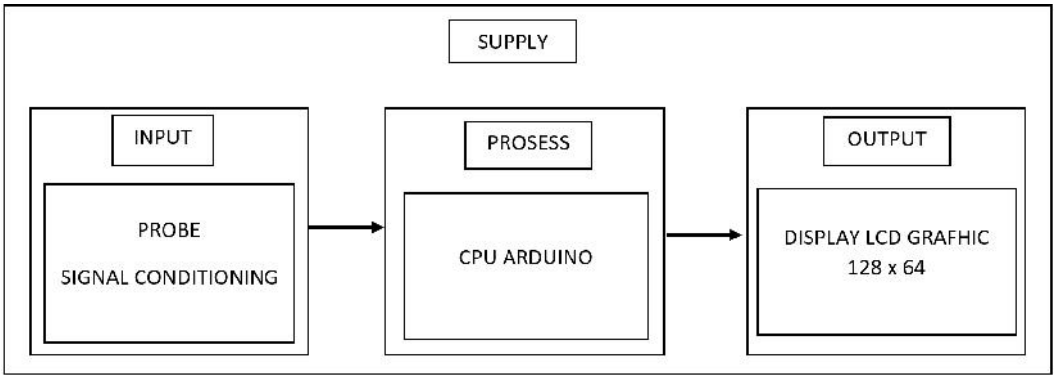

Figure 1. Block diagram.

Based on Figure 1, there are three part of system block from Handheld Digital Oscilloscope sequence. First, input system block has probe part which used to receive input signal then the signal will forwarded to Arduino processing unit part. The probe is consist signal conditioning circuit which also used as voltage scalers in hardware. After that is the process system block, in this block the data from input signal will be processed to become digital data and it will be ready to display on output block. Arduino have a role as “brain” to processing the data. And the last is output block. In this block has LCD graphic 128x64 as a digital data display that will show several parameters like peak to peak voltage (Vpp), Average Voltage (Vavg), Root mean square voltage (Vrms), Frequency and also shown the form of input signal wave. All the component from every system block is working with DC voltage that supplied by Battery or DC Power Supply.

2.2. Hardware

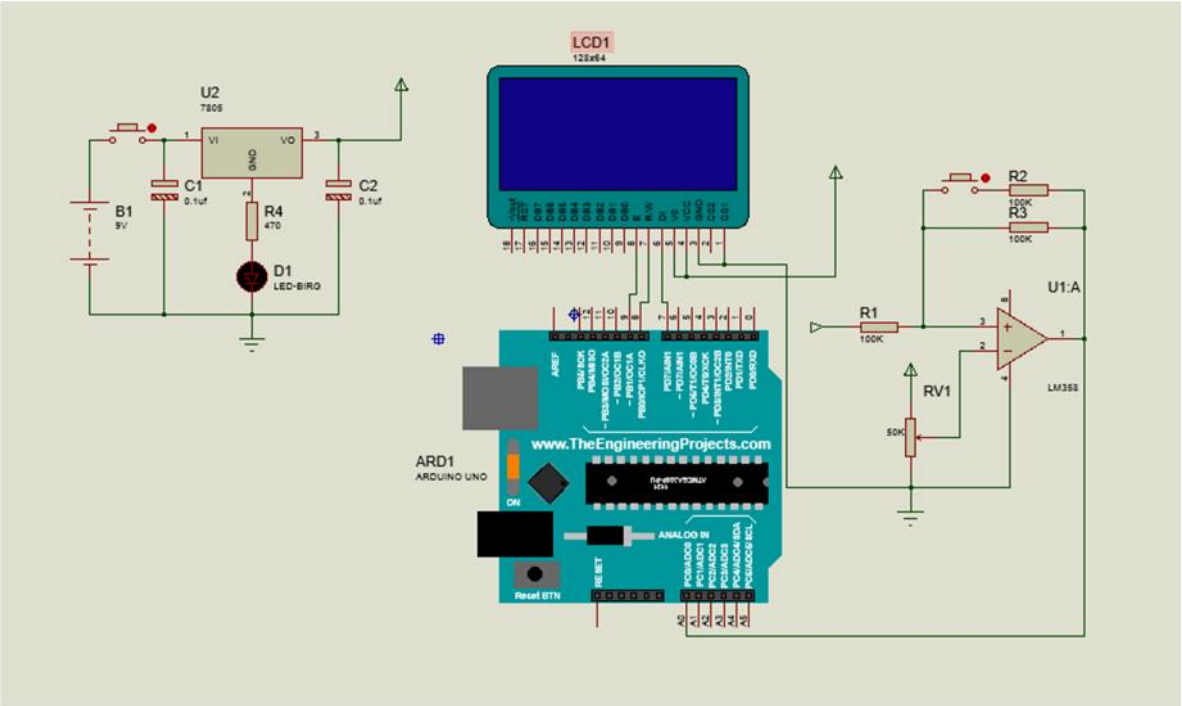

Figure 2. Hardware circuit.

Based on Figure 2, the hardware design begins with a signal conditioning circuit formed from the OPAMP IC LM358 which is configured as an inverting amplifier and it can be set in the great strengthening of 1x and ½ times. This circuit will receive signals from the input device in the form of electrical waves and then adjusted to the calibration voltage on a non-inverting input. Whose magnitude can be set through a potensio that is mounted on a non-inverting input to produced voltage. The result of voltage corresponds to the signal conditioner output will be inputted to the Arduino as a data processor. The potensio on non-inverting input LM358 will served as a horizontal line position calibrator on screen of the Oscilloscope LCD display.

The functions of Arduino as a data processor, the signal sent from the signal conditioner and it will be read by the analogue input of the Arduino. Using the ADC feature of the signal in the form of analog data is converted into digital data. And then the digital data will be processed and formed values from the parameters to be displayed on LCD Graphic with 128x64 pixel resolution. The LCD will displayed voltage, frequency, and wave form from input signal.

2.3. Algorithm

Generally the workflow of the device which created in this research is shown as seen on the flowchart on Figure 3.

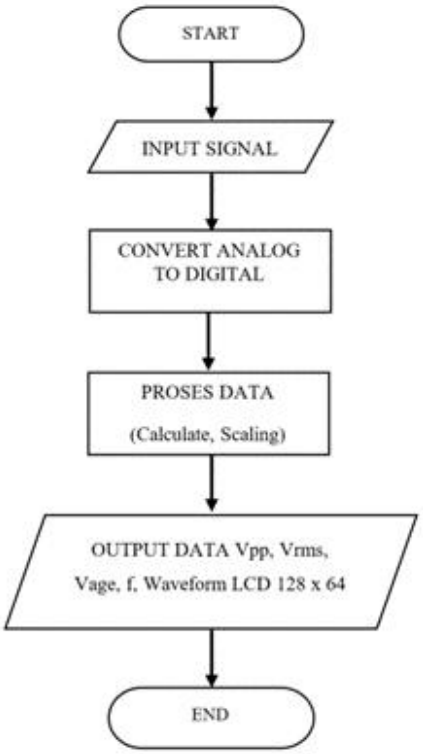

Figure 3. Algorithm flowchart.

The analog signal from the signal conditioner is converted to the digital data by ADC feature on Arduino then the digital data will be processed to get parameter value of voltage and frequency which it will be displayed. In addition, it will be processed of scaling manipulation to make the data appear on the LCD graphic. The data will show the signal waveform image or character data for information of voltage and frequency.

3. Results and discussion

Low Cost Handheld Digital Oscilloscope has been tested to know about accuration rate of voltage and frequency parameter and also the capability to display waveform from signal which has been inputted. The oscilloscope performance was tested in a way to give a big voltage signal and the frequency will came out with various from accurate signal source to oscilloscope input. And then it will displaying the result of signal reader, involve the reading of value pertinence from voltage and frequency parameter and also the perfection of waveform which is displayed on oscilloscope screen.

The signal source for the testing is from GATTEN Function waveform generator with ATF05C type. The test done with giving 3 kind of signal waveform, there are sinus, square, and triangle waveform. With voltage value is 1 Vpp and 2 Vpp, and for the frequency value it was variative. It started with 1-90 Hz with measurement interval is in every 10 Hz, if 100-900 Hz the interval measurement is in every 100 Hz and for 1-7 KHz the interval measurement is in every 1 KHz. The result of oscilloscope performance seen on table 1.

Table 1. Performance measurement.

No.	f	Voltage Accuracy		Frequency	Waveform Signal		
		1 Vpp	2 Vpp	Accuracy	Sine	Square	Triangle
1	0- 90 Hz	96.18%	94.36%	70.46%	Appear	Appear	Appear
2	100 - 900 Hz	95.77%	94.44%	79.98%	Appear	Appear	Appear
3	1 KHz - 3 KHz	94%	95.66%	92.94%	Appear	Appear	Appear
4	4 KHz - 6 KHz	94%	96%	90%	Disappear	Disappear	Disappear
	Average Sub Total	94.99%	95.12%	83.23%			
	Total Average Accuracy	**91.11%**					

As seen at Table 1 the oscilloscope capability for displayed signal waveform is around 10 Hz until 3 KHz, meanwhile for the voltage and frequency value measurement until 6 KHz with accuration mean value is 94.99% for 1 Vpp voltage measurement, and 95.12% for 2 Vpp, and 83.23% for frequency measurement until 6 KHz with the total Average Accuracy is 91,11%.

Figure 4. Signal perform on Oscilloscope display.

Beside did test to the performance of the oscilloscope tool that has been made, it is also done with comparative specification and price of couple oscilloscope variants which is show on table 2.

Table 2. Comparation of specification with existing product.

No.	Specification	Gwistek 1072	ATTEN ATH 01	Low-cost Handhold Digital Oscilloscope
1	Power Supply Range Voltage	220V AC	220V AC/ 12V DC	9V DC
2	Input	50 vpp	50 Vpp	20 Vpp
3	Bandwidth	70 MHz	10Hz - 50 MHz	10 Hz - 3 KHz
4	Dimension	30 cm x 11,5 cm x 13,7	20 cm x 13,5 cm x 5,2 cm	14,5 cm x 9,5 cm x 5 cm
5	Cost	8.500.000	Rp. 4.500.000	Rp. 350.000

In Table 2 appears that the advantages of the oscilloscope that has been made are on the price aspect and size dimensions.

4. Conclusions

This paper presents results of research about design and development Laboratory Kit, which is quite important for electrical and electronic laboratory, that is the oscilloscope with low price with tiny dimensional size, so it is easy to grip with hand (Handheld) and also it is easy to carry everywhere. Besides that, another advantage of this oscilloscope is the low power consumption, even it can be run

by using batteries 9V which has been sold in the market. So, it can be concluded from the advantages the oscilloscope is named Low Cost Handheld Digital Oscilloscope.

There are many limitation from input frequency segment, however this oscilloscope is ready to use for research or electrical/electronic practical needed which is no need high frequency measurement, as an example is Electrical or Basic Electronics. The efforts to fixing input frequency rate (bandwidth) and the resolution could be done for increase oscilloscope performance.

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