International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 10 Oct 2021, pp: 299-304 www.ijaem.net ISSN: 2395-5252

On Development of a Portable Touch Screen Oscillo scope

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Submitted: 30-09-2021 Revised: 05-10-2021 Accepted: 08-10-2021

ABSTRACT: Oscilloscope is very important equipment in the industry as a measuring instrument. There are few types of oscilloscopes: digital, analog, digital storage and digital sampling oscilloscope. The easiest and earliest type of oscilloscope also called as cathode ray (C.R.O.) consist of a vertical amplifier, a time base, a cathode ray tube (CRT), a horizontal amplifier and a power supply. In contrary, a digital oscilloscope is a complex electronic device composed of various software and electronic hardware modules that work together to capture, process, display and store data that represents the signals of interest of an operator. In general oscilloscopes are also massive in size and so they are not easy to carry. Therefore, in industries, whenever there is a need of measurement of the parameters it was often hectic because of the oscilloscope's size and weight. However portable and touch screen oscilloscope can be very small in size, lighter in weight, cheap in cost and also having less maintenance which means lucrative from all point of views. With low cost and open source electronics and software it is possible to develop an oscilloscope in house. Therefore the project discussed in this paper discusses on the development of a portable touch screen oscilloscope.

Keywords: Oscilloscope, instrumentation, portable, touch screen, measurements

I. INTRODUCTION

Most of the studies haven't shown the essential upgradation in the field of oscilloscope [1][2][3]. In industries, whenever there is a need of measurement of the parameters it was often hectic because of the oscilloscope's size and weight. Also, for small businesses it becomes impractical financially to conduct maintenance on regular basis, and therefore these industries run their equipment at its maximum extend and after some time in future this results in huge cost of repairing that machine or instrument. Nonetheless, in big industries the reason to avoid the maintenance of the equipment is because of the impractical field environment, temperature and space to carry such heavy devices. Cathode ray oscilloscope (C.R.O.) is very important part in the industry as a measuring instrument. In any industry every instrument require calibration and also, they want to save money. In these cases, the cost of calibration is very high because the C.R.O. present nowadays is having the Knob, Switches and because of that the cost of calibration and cost of maintenance is high. These C.R.O.s are also massive in size and so they are not easy to carry. So, portable and touch screen oscilloscope which is very small in size, lighter in weight, cheap in cost and also having less maintenance which means lucrative from all point of views, and therefore We can carry it in any industry from one place to another place easily. The portable touch screen oscilloscope, which is suggested in this paper has lucrativeness in terms of weight, size, cost and it's result calculating speed which ultimately saves time, efforts and calculations.

II. LITERATURE REVIEW

There are few types of oscilloscopes: digital, analog, digital storage and digital sampling oscilloscope. When attempting to build an oscilloscope, it is thought by someone to understand how conventional oscilloscopes work. There are 2 main kinds of oscilloscopes – the analogue and digital oscilloscopes and both shall be discussed in the next few sections as follows

A. ANALOG OSCILLOSCOPE

The easiest and earliest type of oscilloscope consist of a vertical amplifier, a time base, a cathode ray tube (CRT), a horizontal amplifier and a power supply. These are commonly known as the "analog" oscilloscopes. Generally used for numerous applications, oscilloscopes are specifically utilized in testing the circuitry of advanced digital equipment, the voltage and working situation of an electronic instrument or the new software of a digital instrument. An analog oscilloscope is easiest in theory compared to a digital oscilloscope, which became popular between 90s. It directly connects measured signal voltage to the vertical axis which is also represented in the electron beam that passes on the display screen of the oscilloscope. Compared to other oscilloscopes, analog oscilloscopes have several advantages. One of them is the scope's focus and intensity controls, which can be conveniently adjusted to reveal a more legible and sharper display. An analog oscilloscope also features phosphor-based display to provide brighter trace during occurrence of signal features. Also known as intensity grading, this capability helps users distinguish details of signals easily. Connecting the analog oscilloscope's probe to a circuit enables the voltage signal to travel to the scope's vertical system, or to the cathode ray tube's vertical deflection plates near the screen.

Depending on how the vertical scale (volts/div control) has been set up, an amplifier helps increase the signal voltage. To reduce the signal voltage, users should use the attenuator. The signal then directly travels to the vertical deflection plate of the CRT. The applied voltage to the deflection plates produces a glowing dot, which is an electron beam hitting the phosphor within the CRT. A negative voltage causes the downward movement of the dot, while a positive voltage moves the dot upward [3]. The signal travels to the trigger system of the oscilloscope to trigger a "horizontal sweep" or to start. A horizontal sweep is the action of the horizontal system which moves the glowing dot across the screen. Thus, the horizontal time base moves the glowing dot across the screen within a specific time interval only when the horizontal system has been triggered. Many sweeps in fast sequence cause the glowing dot's movement to blend into a solid line. The glowing dot can also sweep up to 500,000 times each second across the screen [4].

The vertical deflection and the horizontal sweeping action draw a graph of the signal on the display. To produce a clear picture, the trigger stabilizes repeating signals and ensures that the sweep starts at a similar point of a repeating signal [4].

B. DIGITAL OSCILLOSCOPE

A digital oscilloscope is a complex electronic device composed of various software and electronic hardware modules that work together to capture, process, display and store data that represents the signals of interest of an operator. Digital oscilloscopes are often referred to as digital storage oscilloscope (DSO) or digital sampling oscilloscopes (DSO). In its simplest form, a digital oscilloscope features six elements — the analog vertical input amplifiers, analog-to-digital converter and a digital waveform memory, a time base which features a triggering and clock drive, the circuits for waveform display and reconstruction, the LED or LCD display, and the power supply. Digital oscilloscopes periodically sample a time varying analog signal and stores in the waveform memory the signal's values in correlation with time. Using an internal clock, digital oscilloscopes chops input signals into separate time points. The instantaneous amplitude values are then quantized by the oscilloscope at those points.

The resulting digital representations are then stored in a digital memory. At a predetermined clock rate, the display is regenerated from the device's memory and is consequently viewed as connected dots or a series of dots. Digital Oscilloscopes provides powerful features on how they trigger the digitized data from its memory. Some of the advantages of a digital oscilloscope over analog oscilloscope include the scope's ability to store digital data for later viewing, upload to a computer, generate a hard copy or store on a diskette and its capacity to instantly make measurements on the digital data. After a trigger event, digital oscilloscopes can be made to display the waveforms as compared to an analog oscilloscope that needs to be triggered first before it starts a trace. A digital oscilloscope also has the ability to examine digitized information stored in its memory and make automatic measurements based on the selected parameters of the user, such as voltage excursion, frequency and rise times. It can also display similar captured data in various ways. This capability is attributed to the presence of more captured data than what shown on the screen. It also offers the flexibility of providing a vast array of storage, processing and display options, such as graphics and one-quarter and one-half screen displays and multiple step processing programs.

A digital oscilloscope is ideal for displaying intricate signal waveforms where calculations and measurements on specific portions

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of the waveforms must be made to provide numerical and waveform output displays which reflects the chosen parameters of the waveforms. The two general categories of digital oscilloscopes are single shot oscilloscopes and random interleave or equivalent time sampling oscilloscopes. Single shot oscilloscope starts real-time sampling of an event after a trigger condition has been satisfied. The speed of the analog-to-digital converter determines the limitations of the sampling speed of single shot oscilloscopes. The size of the device's acquisition memory, which receives the output from the converter, limits the time on which a single event can be sampled. Meanwhile, random interleave oscilloscope or equivalent time sampling oscilloscope relies on sampling repetitive events at different points over certain periods of time [5]. The project discussed in this paper is based on digital oscilloscope.

III. MATERIAL AND METHODS

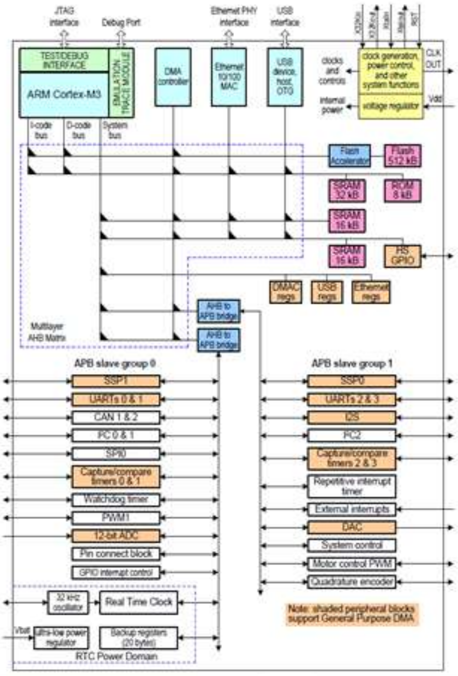

Figure 1. Block/Architecture diagram of the LPC1768 [6] .

A. NXP ARM LPC 1768 CORTEX M3 (controller)

The processor used to build a portable touch screen oscilloscope is a low-power processor that features low gate count, low interrupt latency, and low-cost debug. It is intended for deeply embedded applications that require fast interrupt response features. As shown in figure 1 the processor implements the ARM architecture v7-M [6] .

B. ER-TFTM070-5 (display)

The processor incorporates the Processor core. A low gate count core, with low latency interrupt processing that features ARMv7-M. 16-bit and 32-bit, and excluding blocks for media, Single Instruction Multiple Data (SIMD), enhanced Digital Signal Processor (DSP) instructions (E variants), and ARM system access with Banked Stack Pointer (SP) only, Hardware divide instructions, SDIV and UDIV, Handler and Thread modes, Thumb and Debug states, Interruptible-continued LDM/STM, PUSH/POP for low interrupt latency, Automatic processor state saving and restoration for low latency Interrupt. Service Routine (ISR) entry and exit. ARM architecture v6 style BE8/LE support, ARMv6 unaligned accesses. Nested Vectored Interrupt Controller (NVIC) closely integrated with the processor core to achieve low latency interrupt processing. Features include the External interrupts of 1 to 240 configurable size, Bits of priority of 3 to 8 configurable size, Dynamic reprioritization of interrupts, Priority grouping. This enables selection of pre-empting interrupt levels and non-pre-empting interrupt levels, Support for tail-chaining and late arrival of interrupts. This enables back-to-back interrupt processing without the overhead of state saving and restoration between interrupts and Processor state automatically saved on interrupt entry, and restored on interrupt exit, with no instruction overhead [6]

Item	Standard Value	Unit
Display Format	800 (RGB) x 480 Dots	--
Display Connector	FFC or Pin Header	--
Operating Temperature	-20 ~ +70	℃
Storage Temperature	-30 ~ +80	℃
Touch Panel Optional	Yes	--
Sunlight Readable	No	--

Figure 2. Display specifications [7].

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Figure 3. Front image of the display [7].

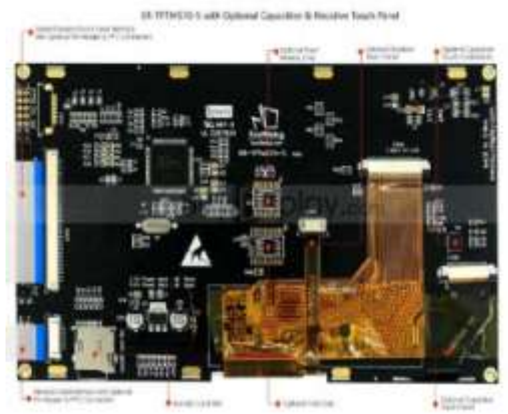

Figure 4. Back side of the display [7].

The table in figures 2-4 shows the display specifications as well as the front and back sides of the unit. It is 800x480 RGB pixel with inbuilt touch panel. Operating temperature of the display is -20 to +70 which means it can work in the extreme cold and hot environment without any technical problem. The display supports two types of interfaces with the LPC 1768, these are nothing but series interface connection and parallel interface connection. The best suitable interface in consideration of the speed of the oscilloscope to show real time results is parallel connection. Here we have liberty to send all data from controller to the display as once which is not the case with series connection where we have to send each bit one by one and eventually there is addition of lag in the results [7] .

C. CALCULATION OF WORKING FREQUENCY

First and foremost, specification of any digital or analog oscilloscope is it's working frequency which is nothing but the combined result of the controller frequency and displays working frequency. The mentioned ARM controller has working frequency up to 100 MHz which is offered by its CPU, while the TFT display has frequency of 10 MHz which is only related to the displaying procedure i.e., this does not affect on the signal conversion and manipulation rate which is the subject of concern. Apart from this, LPC 1768 is packed with one 8-channel 12-bit analog to digital converter which is capable to work at maximum conversion frequency of 13MHz/ 65 clock cycles. From this information we can calculate our final working frequency of the suggested digital Oscilloscope [6].

D. EQUATION FOR CONVERSION TIME OF ADC

Theoretically the frequency or the conversion time of the ADC of LPC1768 is as follows.

The ADC is of 12 bit which means it needs 12 cycles. On the other hand, it has sampling time of 65 clocks therefore its conversion time is

Conversion time = clock cycles/ frequency

= 65/(13x106)

= 5 microseconds

In another words, it is capable of sampling rate up to 200Khz

E. RESOLUTION OF THE ADC

As mentioned, it is 12-bit ADC

Here,

Fc = frequency of the ADC

Tc = Clock cycles

Also, its maximum voltage is 3.3V and its range is 0-3.3V this means the ADC can have total of 212 equal parts of the range with each part of 0.805 mV and the 200KHz frequency means the samplings are multiplexed among up to 8 inputs.

The resulting maximum sample rate per input is distributed on the used inputs.

- 1 input only- max 200kHZ per input
- 2 inputs – max 100kHz per input
- 3 inputs – max 66.67kHz per input
- Etc.

There are still some lags which are not yet calculated. These are directly related to the processor's instruction execution time.

IV. CONSTRUCTION DETAILS

A. DISPLAY

As shown in figure 5, the device below has size of 8 inches with display size of 7 inches and thickness of 2 inches, this is the 3D view. It has one switch to turn on the device and then it can be controlled by touch screen mechanism. Input signals are given through USB port which supports voltage up to 5V and therefore there is one signal conditioner is used which is capable of conditioning voltage signal up to 230V and voltage regulator is used to regulate the voltage to 5V for USB port. If there is high voltage signal needs to be measure then use of other type of signal conditioner and voltage regulator is possible.

Figure 5. Shows side views of the device.

B .GRAPHICAL USER INTERFACE (GUI):

The Graphical User Interface was built into LABVIEW which shows real time output of the device before installing it in the device itself [8]. After adding appropriate delays which are associated with the LPC 1768's instruction processing time and it's ADC conversion time. To add these delays, LabVIEW's delay block is used and expected results are mentioned further. After the successful working of GUI, it can be installed on the device.

V. RESULT AND DISCUSSION

Figure 6. The sample output 1 of the device.

Figure 7. The sample output 2 of the device.

Figure 8. The sample output 3 of the device.

Figure 9. The sample output 4 of the device.

After installing the GUI onto the LPC1768 there is very minimum lag in its working when compared to the theoretical values. Apart from this, the device has accuracy same as the CRO (cathode ray oscilloscope). Distortion in the waveform can be a result of lose connection of its. Figures 6 - 9 show the sample outputs in the form of waveforms on the touch screen.

VI. CONCLUSION

The project discussed in this paper discusses on the development of a portable touch screen oscilloscope. It is clear from above sections that oscilloscope is very important equipment in the industry as a measuring instrument. It is possible to develop a portable touch screen oscilloscope which is a digital type. It can be implemented using readily available hardware components such as an arm processor, display screen, touch sensor screen, an analog to digital converter system and a specially designed graphical user interface. The working frequency should be taken into account before selecting all above. Considering the low cost and open source electronics and software availabilities, it is possible to develop an oscilloscope of such type in house.

ACKNOWLEDGMENT

The authors would like to express special thanks to HoD of Department of Instrumentation Engineering, and Principal of P.V.P.I.T. Budhgaon Sangli for their support in terms of providing laboratory facility during conduction of the project. Also would like to thank to Mr. K.M. Bhagawat, Ms. M.D. Mane, and Mr. S. Kadam for their

contributions in design, development and testing of the prototype.

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