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Development of an Oscilloscope using Android Smart Device

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Abstract— The project at task proposes a hardware interface module and an Android Application, which contributes to a highly-efficient and fully-functional virtual oscilloscope on an Android Smart Device. The primary objective of this project is to build an interface which facilitates an Android based smart device to function as an electrical signal plotter. The Android based smart device will process the input electrical signal and display it on the screen to be viewed. The secondary objective is that in the future with the help of this project any physical quantity, converted into electrical signals with the help of transducers, can be viewed and analysed.

Keywords— Android, Oscilloscope, Smart device, Signal Processing, Signal Plotting

I. INTRODUCTION

In electrical and electronics engineering, signal analysis plays a very important role to study the characteristics of the signal in time domain. The most commonly used instrument for this purpose is an oscilloscope from classroom experiments to effectuating research and development tasks. But this instrument is characterized by relatively huge dimensions and it is relatively expensive.

Nowadays, everybody use smart phones or tablets for most of their day to day work. With the ever increasing market requirements, the mobile devices are also evolving very rapidly. Most of the smart phones operate from the popular Google's Android OS. The Android devices have quite a large display and an efficient enough processor to evaluate the data and visualize it on their screen for signal analysis.

These factors gave us an idea to develop a portable instrument which acts like a conventional oscilloscope but always handy. It is obvious that the device can be used to plot some electrical signal on their screens. The main benefit of using the Android Smart Device is that the signals can be evaluated and visualized on the screen without losing the mobility of the user. This is a really helpful feature for a research instrument.

An Android OS is selected because there are more Android device users and most of these devices satisfy the requirements of the oscilloscope applications. The Android device has connectivity like USB, Wi-Fi, Bluetooth and also Audio jack to input electrical signals with some minor additional interface circuit. This input signal can be processed and plotted graphically based on the optional settings that are configured by the user.

With the continuous improvement of electronic technology, smart terminal devices have been developed greatly, and equipped with Central Processing Unit (CPU) and Graphics Processing Unit (GPU) possess strong ability of data and image processing. Therefore, they could complete many tasks that previously could only be achieved on the computer. Based on this view a low cost, portable and light weight oscilloscope is proposed. The system consists of both a hardware interface and a software application.

II. RELATED WORKS

Authors of [1] have proposed a version of a universal multifunctional instrument for an Android device which is an alternative to a bulky cabinet with expensive instruments. The multi-purpose measurement and analysing instrument needs only a smart phone with Bluetooth capability. The presented measurement instrument safe and easy to use since there is no direct cable connection between the smart phone and the instrument. A wireless oscilloscope using an android mobile operating system is proposed in [2] by the authors. With the help of this system, outputs of different kinds of wave shaping signal can be saved in the mobile system. The systems proposed in [1] and [2] use Bluetooth technology which can lose connection in certain conditions and also less economically feasible when compared to our project. Authors in [3] present a system in which wireless communication technology (Wi-Fi) and intelligent terminal (Android) is used to design a compact, low-power, and full-function wireless intelligent virtual oscilloscope. This design will optimize the key technology of signal interaction and waveform display system to make the whole system a good waveform observation capability and improves the man-machine interaction experience.

The disadvantage of using the Wi-Fi technology is that it is slower and wireless networking signals are subject to a wide variety of interferences as well as complex propagation effects. A smart voltage and current monitoring system (SVCMS) has been proposed in [4]. It is designed and implemented to measure and monitor three-phase voltages and currents. It consists of two major parts which are the control and monitoring parts. The control part has four branches which are: a voltage sensor unit, a current sensor unit, the Arduino unit, and the wireless communication unit. The monitoring system uses a new Android smart phone application designed by MIT App Inventor 2. The system proposed in [5] acquires data from a vehicle's sensors and transmits it to the user's mobile phone. The sensor inputs are fed into a microcontroller which generates an audio signal based on the data acquired and an audio jack inserted into the phone is used to transfer the data collected by the sensor devices to the cell phone. Once the data is obtained by the mobile application, it is processed and the decoded sensor values are displayed on the cell phone. In a similar way, audio jack is used in our project to input the signals to the Android smart device.

III. METHODOLOGY

Fig. 1 shows the functional flow of the project. The input signal given from an external source has different formats and weights, so signal conversion is employed to convert the signals into the required format and weights based on the compatibility to input to the Android smart device. Isolation and protection is required to safeguard the Android smart device from signal source variations that can cause damage to the device.

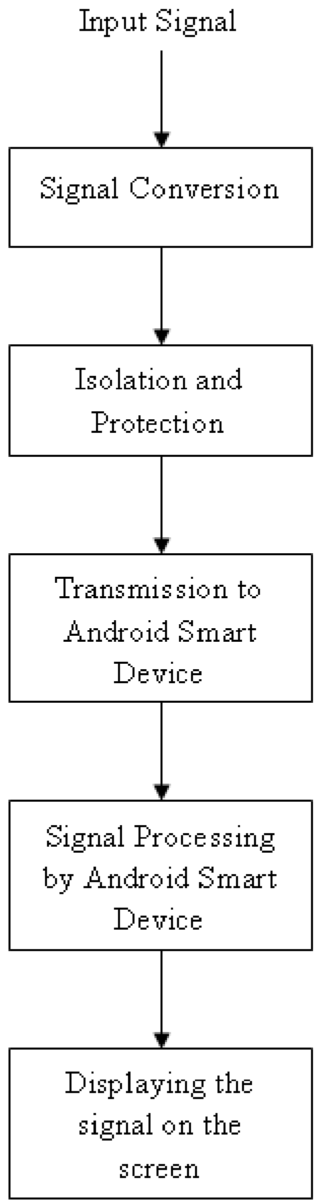

Fig. 1 Functional flow chart of the project

The signal is then fed to the Android device for processing either through wired or wireless channel. In the case of wireless communication Wi-Fi or Bluetooth can be used whereas in wired communication either USB or Audio jack can be used. We are using Audio jack to input the signal to the Android device as it make signal processing and displaying much efficient and easier when compared to other options. Once the conditioned signal is fed to the Android device, it is processed and displayed on the screen.

IV. PROJECT IMPLEMENTATION

The proposed project consists of both a hardware interface and a software application.

A. *Hardware Implementation*

Based on the methodology shown in Fig. 1, the functional block diagram is shown in Fig. 2. For signal conversion, a rotary switch with potential divider resistor circuit with as many poles required based on the input signal weight range as required for Android device compatibility. In simplest form a zener diode is used to limit the input signal voltage at audio jack point because Android audio input cannot take more than around 3 volts. This protects the Android device from damage due to signal source variation. A capacitor is used for isolation and avoids DC interference. Thus conditioned signal is then input to the Android device with the help of an Audio jack through microphone input. The signal is then processed and displayed on the Android device screen with the help of Android application.

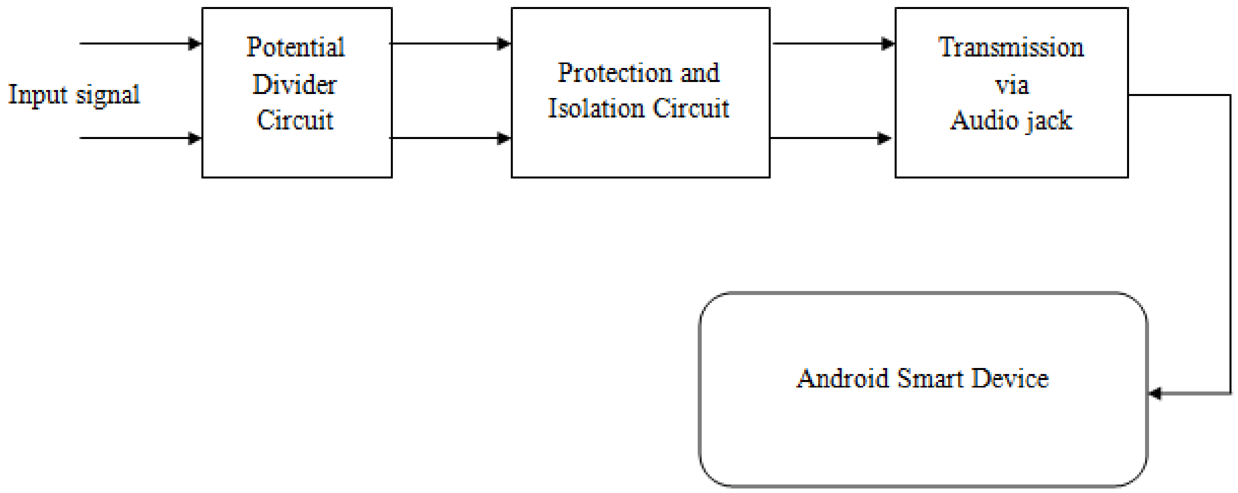

Fig. 2 Functional Block Diagram

B. *Software Implementation*

For developing this Application using the Android device, the basic knowledge required are Audio jack specification for Android devices, Android APIs (Application Programming Interfaces) that provide access to audio hardware of device and the integration of both to achieve scope functionality. Fig. 3 shows the Android application flow chart. Initially we need to specify the sampling rate, encoding format and the buffer size. Sampling rate is the number of audio samples taken per second and almost all mobile devices support sampling rate of 44100Hz. Audio encoding describes the bit representation of the audio data. Here we use PCM 16-bit encoding. Buffer size is in byte units and the size of the buffer should be sufficient enough to hold the data until it is read. Once the parameters are specified, the input signal is sampled, encoded and stored in the audio buffer. Now the audio buffer has the audio data as a signed 16-bit value. This data needs to be read from the buffer. An object of the AudioRecord (Android API) class is used to read the audio buffer from the audio hardware as and when required using the read( ) method. An appropriate trigger needs to be found for the sampled data. Then it is plotted with desired time divisions on a chart to completely implement the scope functionality. To integrate plotting of the audio buffer, another thread needs to be created which captures audio data and updates the UI (User Interface) with the processed buffer data. Once the samples are plotted, re-queue the buffer, read and plot the next data. The process is repeated continuously from reading the data from the buffer to re-queuing the buffer until there is a user intervention. Thus functionality of an oscilloscope is achieved with Android device.

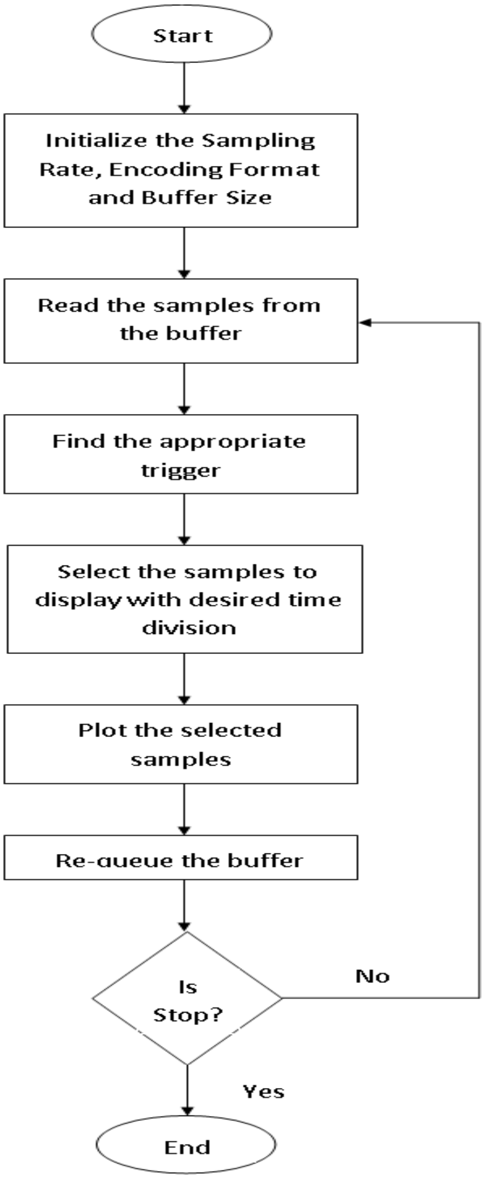

Fig. 3 Android Application flow chart

V. Results

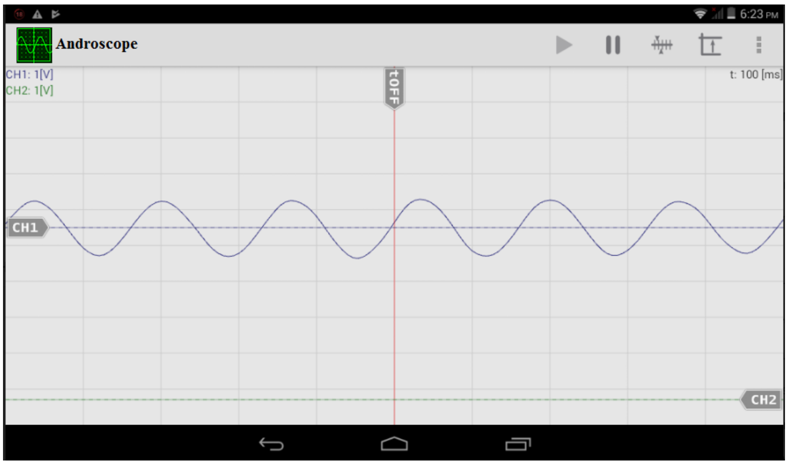

Fig. 4 Project output

The project is built by using discrete components for hardware implementation and android application is developed using Android Studio IDE (Integrated Development Environment). To test, the app is loaded on an Android tablet and a sine wave signal is given as input. The project output on the Android tablet screen is shown in Fig. 4

VI. CONCLUSION

The project shows that a simple and handy oscilloscope can be built using Android Smart device with signal input through audio jack. But the limitation here is audio jack cannot hold the voltage more than 3 volts and of frequency above audio range. This limitation can be overcome by using sophisticated external signal conditioning circuits to handle voltage and frequency limits with the help of operational amplifiers.

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