Bluetooth Embedded Portable Oscilloscope powered by Android

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Abstract— **With the rapid technological enhancement , enormous no of electronic gadgets & devices are present in market. Each device is advance in a step of the earlier in technology.Our project "BLUETOOTH EMBEDDED PORTABLE OSCILLOSCOPE POWERED BY ANDROID" is more powerful tool towards to work of an distinct level more easy. Imagine how simple it would be to measure & display waveforms in our smart phone a simple touch………**

Portable oscilloscopes currently in the market are very costly, less efficient in power consumption and have displays with low resolutions . This paper illustrates & also implements low cost, portable, light-weight, power with low consumption, 2-mode channel oscilloscope, consisting of a hardware device and a software application. Proposed device is consist of Bluetooth module to provide wireless connectivity to a device with Bluetooth, running the Android operating system (OS), to visualize the respected waveforms. Android OS is choosen because in present there are around large number of users which uses Android device and many of them satisfy the basic features of the oscilloscope's. The hardware includes circuitry to sense the input buffer voltage signals and an equipped Bluetooth module for transferring of sensed signal information to an Android operated device for visualize the waveforms. The Software application designed for Android receives the data transferred from the hardware and displays detected signal waveform according to the user configured display settings. These display screen configurations are passed to the hardware modules once they are reconfigured by the user, and hardware device uses to set the sampling rate and the values of samples.

For minimum usage of the Bluetooth bandwidth, the application provides dual of operation, i.e. single channel mode where one of channel is operational and 2-mode channel where both channels 1 and 2 are in operation. The user is able to choose a mode from the GUI designed application, which in turn transfers a signals to the AVR microcontroller which then sets the frequency of sampling accordingly: a higher rate of sampling for single channel and half of that for dual channel.

Index Terms— Android , Bluetooth , Oscilloscope, GUI

I. INTRODUCTION

This paper demonstrates an oscilloscope implemented using newer technology, with lowest power consumption. It is a Bluetooth embedded equipment which will sensed input voltage signals and sends them to an smartphone i.e., android. AS the Bluetooth device is wireless device it uses android phone's display screen and processing power.

The implementation of an oscilloscope with Bluetooth was earlier invented, by Yus in 2010 [1]. It is for public prototype project called the "Android Bluetooth Oscilloscope", which equipped with Bluetooth configured transmitter circuit to transfer data to an Android phone which plots the waveforms on its display. The transmitter circuit designed with PIC Microchip's IC Bluetooth 2.0 serial module.

The allowable input voltage to the circuit is +5 V to -5 V. & not elaborated about the bandwidth usage of the system in detail, it is mentioned that the GUI application was designed only for Samsung Galaxy GT- i5700 Spica (rooted Android 2.1 OS) phone.

In this Project our objective is :

1. To develop a system to measure the signals and display it wirelessly on an Android OS based Phone.

2.To make the transmitter circuit compact and easy to mount on the scope itself.

3.To implement a low – cost and effective Measuring Device The Inputs given will be processed by an embedded system and will be transmitted via a wireless communication protocol (in our case Bluetooth Module).

A java based application will be developed on the Android OS platform which will accept this incoming data and visualize the same. We will be developing a system which will compute two signals at a time.

II. LITERATURE SURVEY

According to our project goals, we divided our product into different modules:
1.) Input Buffering (Probe Front-End)
2.) Digital Signal Processing using a Microcontroller
3.) Wireless Communication
4.) System Power

Therefore, a background research was conducted in all the above areas, which is presented in the upcoming pages of this chapter.

A. Limitations of CRO

CRO's are bulky and not portable to use. They are not easily available to students because of high budget involved.

CRO's as now a days replaced with DSO which are comparatively less bulky but again the cost factor is a major drawback.

Our goal is to implement a portable embedded system which will process signals and display it wirelessly on a portable device.

B. Bluetooth Data Rate Restrictions

From research carried out earlier it was found that data rates upto 2 Mbps are not attainable with the existing software stacks designed on the module's PIC controller. Therefore, the approach recommended to fully utilize the bandwidth accessable by Bluetooth , was to use the module in Host

Controller Interface (HCI) mode .

In HCI mode, the on-board stack is eliminated and the module is placed in a state that executes the Bluetooth module bandwidth. Therefore, the Bluetooth stack is not properly on the Bluetooth designed module, so it is compulsory to be designed on the interfacing basic PIC processor. So the module is designed for a radio broadcasting, executing the lower level MAC operations, while the application stack runs on the basic PIC processor. The advantage of HCI mode is that it permits to achieve maximum throughput and also to execute custom profiles on the Bluetooth module.

C. Problems with HCI Mode

However practical matters exist because of the absence of sources, on how HCI mode can be designed. It is essential to be a registered developer at the Bluetooth module's chip developer, and have documentation and support on how to access the HCI layer protocols. Implementing the Bluetooth stack is a complex process which requires a efficient, high-end microcontroller with complex firmware and hardware design module. The Android device interconnects in the RFCOMM layer using the SPP UART, but in HCI mode it will have to perform in the lesser baseband layer protocols. The support currently available for such an approach in Android is inadequate.

D. Alternative Approach

A widely used, more reliable Bluetooth HC-05 module, was selected. The module was used in normal mode because of high level of complexity involved in HCI mode layers. With the standard firmware having the Bluetooth stack on board, a throughput of 240 kbps can be attained in slave mode.

III. METHODOLOGY

A. System Overview

The proposal and design stage of project, involves the Bluetooth embedded hardware device implementation and the software designed GUI application designed for Android. The Bluetooth embedded device is a microcontroller powered structured. Figure 1 shows a block diagram of the overall system requires in this project & Figure 2 shows a block diagram of the Bluetooth embedded device.

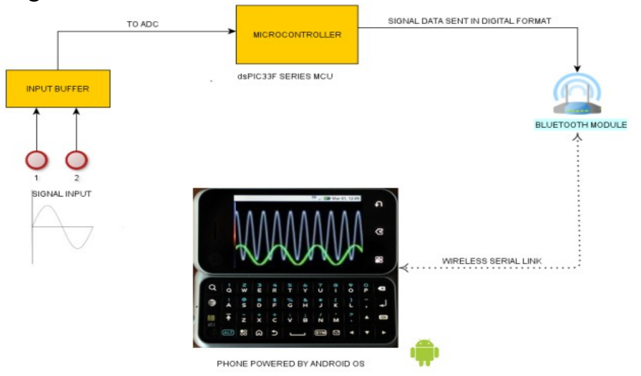

Figure 1 : Functional Block diagram of Wireless Graphical probe system.

The input signal is directly linked to the front end input buffer circuit. The maximum voltage range allowed into the front end circuit is 33 Vpp. Voltages above this will be controlled at the described maximum.

If higher voltages required as a input, a probe with a simple resistive divider or a high voltage probe can be used.

B. Basic Features of the Bluetooth Embedded Device

Number of input channels: 2

Bandwidth: 2.5 kHz (dual channel mode) and 5 kHz (single channel mode)

Input voltage range: -16.5 V to +16.5 V with 1:1 probe

Sampling frequency: 10 kHz (dual channel mode) and 20 kHz (single channel mode)

C. Android Application

The Android application is developed using the software development kit (SDK) of Android 2.2 Froyo OS, API (Application Program interface) level 8.

The Android device used for testing a Samsung Galaxy Y (GT-S5360) smartphone with Android version 2.3.5 Gingerbread OS, an 832 MHz processor and RAM of 290 MB. The smartphone of a 3.0" QVGA 240x320 LCD screen with Bluetooth v3.0 + HS (High Speed). It is one of the low cost Android smartphones available in the market to-date.

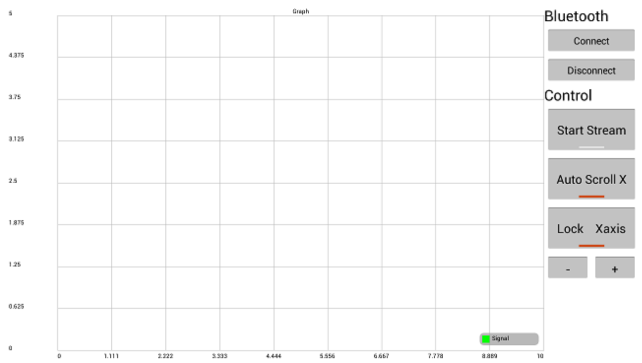

Figure 2 gives the layout of the application on the phone's screen.

The screen measures 320 by 640 pixels and, the waveform grid area for drawing waveforms is 240 by 480 pixels & Various buttons uses further screen.

The waveform grid area has 9 Div on X-axis and 8 Div on Y-axis, similar to a standard CRO. Hence, each division in both the vertical (voltage) axis and horizontal (time) axis consists of 25 pixels (200 px / 8 and 225 px / 9).

The ground (0 V) line is the horizontal line at the middle of the waveform grid pattern. The waveform plotting is done as defined by the canvas class in the android graphics package, where the drawing is done with reference to pixels of smartphone's display screen, since it is the minor part on the display., 240 voltage levels can be demonstrated on the grid pattern of screen as voltage is in range of 240 V. Hence 8-bits are necessary for showing these 240 levels. Similarly the time axis has 250 pixels so 250 samples of one input channel can be displayed on the grid.

A sample from the AVR's ADC is 10-bits which signifies 1024 levels of voltage. Because the phone's waveform grid has only 240 voltage levels, the 1024 levels can be compressed in this described range. Because AVR's ADC is not able to handle voltages below 0 V, if a 3.3 Vpp sinusoidal signal described in Figure 3 (a), requires to be sampled, it has to be first level shifted by a dc offset threshold voltage of 1.65 V, so that it is within 0 V and 3.3 V as in Figure 3 (b).

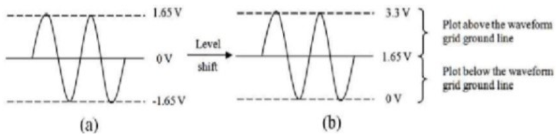

Figure 3(a) & Figure 3(b)

When the signal is drawn on the waveform grid it should look like Figure 3 (a), centered on zero. Therefore, as in Figure 3 (b), the voltages above 1.65 V should be greater than the ground line in the waveform grid and which are less than 1.65 V to be below the ground voltage line. Essentially, this process is what is require to accomplish the 10-bit sample to 8-bits to represent the 240 levels on the display grid screen pattern.

Voltage = ADC reading x ADC resolution
if ADC reading < 512
Voltage = ADC midvoltage - Voltage
New voltage = (Voltage x Pixels per division) / Volts per division
Transmit value = Display ground point + New voltage
if Transmit value > 230
Transmit value = 230
else
Voltage = Voltage - ADC mid voltage
New voltage = (Voltage x Pixels per division) / Volts per division
if New voltage >= Display ground point
Transmit value = 0;
else
Transmit value Display ground point - New voltage

D. Modes of Operation

The device provides two modes of operation, as in Figure 4, namely single channel mode where only channel 1 is in operation, with the full bandwidth available for one channel mode and, dual channel mode where both channels are in operation, with the bandwidth shared between these channels. The sampling frequency in single mode of channel is 20 kHz which is double the sampling frequency per channel of 10 kHz in dual channel mode. The user can choose a mode from the GUI design for android device, which gives a message to the AVR to alert the user configured mode, so it can change the frequency of sampled signals. This helps in reliable use of the available bandwidth when only one channel is required.

As,hardware is consist of 2-modes of channels,so both input channels are sampled. After sampling and Channel 1 (CH1) and Channel 2 (CH2) samples are converted to a byte and are instantly written to the AVR's UART buffer for transmission with Bluetooth devices. Figure 4 gives the sequence in which the samples are written to the UART buffer.

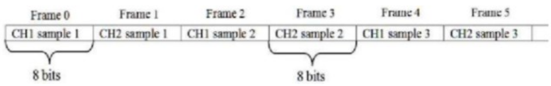

Figure 4

The even number sequence and odd number sequence frames contain data of single & dual mode channels , respectively. In single channel mode the frames contain samples of 1-mode channel only. 1.8. Waveform Plotting Algorithm The transmission format in Figure 4 also gives the reception of data very easy. The application reads the data stream from its Bluetooth data buffer and distinguishes out the channel 1 and channel 2 data in the form of 2 arrays. Reading this continuous data stream with the un-rooted Android operated smart-phone and coordinating with the transmission rate was the main aim in developing the GUI on android phone for user. Thereafter, the waveform of the particular channel is drawn on the grid by linking the data points (samples) with straight lines.

E. Android Application User Interface

Figure 5 gives the Menu screen of the application's user interface

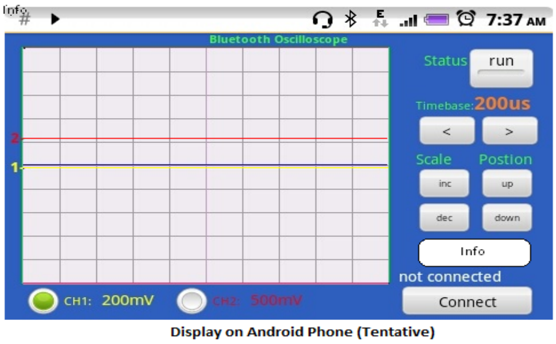

Figure 5 : Menu screen of application

Figure 5 gives the Menu screen of the application on Menu button press on the main interface. Here, the user is able to change the settings as per requirements, such as the voltage and time knobs settings, the channel to be displayed on the grid and the operating mode.

IV. RESULTS

The performed operation of the android phone was tested by providing test signals from the signal generator and dc voltages from the dc regulated supplied power . Both modes of operation of the android phone were tested with different voltages and frequencies applied to the channels.
Figure 6 illustrates screen shots of the application displaying the waveforms of three test conditions.

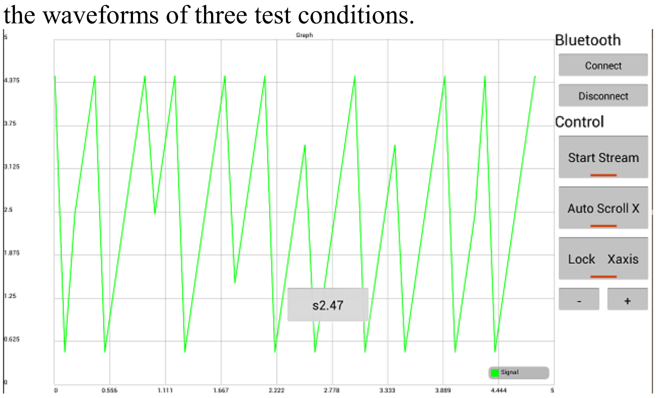

Figure 6 : Screenshot for designed GUI application system

IV. CONCLUSION AND FUTURE WORK

This project can be used to compute & display required waveforms efficiently. The project developed is low cost and low power consumption. The Bluetooth modules were successfully detected by the reader and data was successfully displyed on lcd as well as on android phone.

With the completion of this project we can conclude that the portable oscilloscope not only reduces the effort of human being but also it can be used in other important and beneficial applications .

Bluetooth 3.0+HS which has a much higher data rate of 24 Mbps can be used instead of v2.1+EDR. It can improve the bandwidth of the device. Still similar issues related to the effective data rate may arise due to the limitations in communication profiles and software stacks used. Wi-Fi (802.11) could be the other option, to achieve higher data transmission speeds and rise in bandwidth.

The prototype contains majorly through-hole components. Surface mount components could be used to reduce the size of the PCBs and make the device more portable.

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